water & forestry

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DIRECTORATE: RESOURCE DIRECTED MEASURES

LETABA CATCHMENT RESERVE DETERMINATION STUDY – SPECIALIST REPORT : **RIVER HYDRAULICS**

FINAL

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ABBREVIATIONS AND ACRONYMS

CWE	Centre for Water in the Environment
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EWR	Ecological Water Requirement
PES	Present Ecological State
Area	Cross-sectional flow area (m^2)
Average flow depth	Cross-sectional flow area (m^2) divided by the width of the water surface (m)
Discharge	Volumetric flow rate (m^3/s)
Flow depth	Maximum flow depth, measured from the lowest bed elevation (m)
Stage/water level	Elevation of the water surface relative to local datum (m)
Velocity	Average velocity through cross-section (m/s)
Wetted perimeter	Surface of channel in contact with flow, measured along the cross-section (m)
n	Manning's resistance coefficient
a, b, c	Regression coefficients in the rating relationship

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1. BACKGROUND

The river hydraulics of the Letaba River were undertaken by A Jordanova and A Birkhead. A Jardanova undertook the hydraulic studies at EWR Sites 1, 2, 4 and 5. A Birkhead undertook the hydraulic modeling at EWR Sites 3 and 7 (Appendix 1)

Scientists evaluating the ecological water requirements (EWR) for rivers are required to quantify the needs of the various biotic components of the system in terms of hydraulic parameters such as flow depth, flow velocity, wetted perimeter and water surface width. The product of the hydraulics modelling as a series of relationships between flow rate and, amongst others, flow depth, flow velocity and wetted perimeter has been used for the ecological Reserve determination (Rowlston et al, 2000). The procedure for generating hydraulic information for different levels of Reserve determination has been documented (DWAF, 1999; Birkhead, 2002). New developments (Jordanova et al, in press) related to analysis and use of hydraulic information in the Reserve determination studies is present in Section 1.1, Appendix A 2.

This report provides the hydraulic information used for the assessment of the ecological water requirements for the Letaba River for the EWR sites 1, 2, 4, 5 and 6 as well as for an additional site located downstream of the Prieska weir (EWR site 3*) that has been selected for vegetation purposes only.

Hydraulic information and modelling of EWR sites 3 and 7, and a brief introduction of further developments of the role of hydraulics in flow assessments are included in Appendix A 2.

2. DATA COLLECTION

During the site selection trip EWR sites were selected. At each site, the study team located the number of cross-sections required for the Reserve determination. Temporary bench marks were installed, discharges were measured, and water surface slopes were surveyed. Temporary bench marks and survey of water slopes at each EWR site were performed by surveyors from the Geomatics Directorate of the DWAF. Water slope data collected was supposed to be part of the survey reports. One month later the same surveyors and their teams surveyed the selected cross-sections, and hard and electronic copies of the reports were received. However, the data related to water slopes surveyed during the site selection trip were not included in the reports. After numerous requests over a period of more than one year to obtain these data, the data for the two Kruger Park sites and Prieska (EWR 6, EWR 7 and EWR 3) is still outstanding. Generally, the collection of the hydraulic data during the site selection trip is the responsibility of the hydraulic engineer involved, and if any hydraulic data is collected by anyone else it is the responsibility of the hydraulic engineer to ensure the quality and reliability of the data. In this study, A Jordanova is fully responsible for outstanding data.

Information of the coordinates (Cape datum LO 25°) and elevation of the fixed stations at the EWR sites are given in Table 1. Cross-sectional profiles of selected EWR sites are presented in Figures 1 to 10.

Table 1: Coordinates of fixed survey stations at the EWR sites

River	Site no.	Coordinate system	Station	Remark	Y-Coord (m)	X-Coord (m)	Z-Coord (m)
Great Letaba	1	Cape datum Lo 31	A 1	IPC	96609.81	2646233.89	823.27
			A 2	IPC	96610.00	2646205.00	822.00
		Local CS (GPS)	A 3	IPC	96598.10	2646194.69	822.21
Letsitele	2	Cape datum Lo 31	LE 1	IPC	65045.14	2642825.14	502.79
			LE 2	IPC	65037.64	2642815.96	502.84
		Local CS (GPS)	LE 3	IPC	65013.00	2642789.00	503.00
Great Letaba	3*	Cape datum Lo 31	PR 1	IPC	28665.27	2615671.41	401.63
			PR 2	IPC	28628.54	2615646.96	402.24
			PR 3	IPC	28584.06	2615625.61	401.71
Great Letaba	4	Local CS (GPS)	LR 1	IPC	-9904.00	2619132.36	502.75
			LR 2	IPC	-10082.69	2619278.29	502.15
		Cape datum Lo 31	LR 3	IPC	-10106.34	2619300.62	502.90
			LR 4	IPC	-10157.00	2619310.00	500.00
		Local CS (GPS)	LR 5	IPC	-10158.35	2619352.12	510.16
Klein Letaba	5	Cape datum Lo 31	KL 1	IPC	51798.86	2571977.86	487.48
			KL 2	IPC	51748.16	2572008.08	486.22
		Local CS (GPS)	KL 3	IPC	51690.00	2572057.00	489.00
			KL 4	IPC	51648.25	2572100.79	488.79
			KL 5	IPC	51598.20	2572127.13	488.03
Letaba	6	Harbeeshoek94 datum Lo 31	DW 1 A	IPC IP	-41472.538 -41449.679	2628117.976 2627961.484	258.120 251.041
			DW 2 B	IPC IP	-41546.686 -41522.533	2628115.626 2627950.835	258.199 250.996
			DW 3 C	IPC IP	-41585.249 -41560.045	2628116.575 2627945.317	257.783 250.781

CS: Coordinate System
IPC: Iron Peg in Concrete
IP: Iron Peg

The stage-discharge data collected at the EWR sites together with the dates when the data were collected are provided in Table 2.

Table 2: Hydraulic data collected at EWR Sites

River	Site no.	Date	Discharge Q (m^3/s)	Max. flow depth, y (m)			
				Sec. 1	Sec. 2	Sec. 4	Sec. 5
Great Letaba	1	13/08/03	0.264		0.34		
		02/09/03	0.310		0.43		
		23/03/04	2.200		0.73		
Letsitele	2	16/09/03	0.080	0.24	0.17		
		23/03/04	6.225	0.86	0.85		
		24/04/04	2.560	0.64	0.61		
		29/05/04	0.850	0.44	0.37		
Great Letaba	3*	16/09/03	0.01		0.37		
		23/03/04	42.63		2.61		

River	Site no.	Date	Discharge Q (m^3/s)	Max. flow depth, y (m)			
				Sec. 1	Sec. 2	Sec. 4	Sec. 5
Great Letaba	4	13/08/03	0.141	0.16[a]		1.16	
		23/03/04	110.800	1.665[a]		3.29	
		24/04/04	3.720	0.48[a]		1.53	
		29/05/04	0.653	0.27[a]		1.25	
Klein Letaba	5	13/08/03	0.06		0.56	0.26	0.20
		02/09/03	0.025		0.52	0.22	0.16
		23/03/04	42.00		1.47	1.11	1.06
		24/04/04	0.955		0.83	0.48	0.42
		29/05/04	0.270		0.79	0.44	0.38
Letaba	6	13/08/03	0.15		0.13[R] 0.39[P]		
		23/03/04	85.00		0.93[R] 1.37[P]		
		24/04/04	6.80		0.43[R] 0.82[P]		
		29/05/04	1.95		0.27[R] 0.68[P]		

R: Riffle
P: Pool
a: active channel

3. MODELLING

Flow resistance in natural channels is generally a function of stage, particularly at low flows where the flow depth is of the same order of magnitude as the size of the roughness elements constituting the bed (Birkhead et al., 1997; Broadhurst et al., 1997). With increased discharge, the local hydraulic controls become inundated, resulting in a tendency towards uniform water surface gradients and asymptotic resistance coefficient values (Birkhead et al., 2002). The observed rating data at the EWR sites were extended using the Manning's *n* resistance relationship and the regional bed slope (Table 3) obtained from topographical map. The values of Manning's *n* resistance coefficients required for extending of the observed rating data were estimated using experience and existing resistance coefficients given in the literature (Barnes, 1967; Hicks and Mason, 1991 and Chow, 1959). The measured and modelled stage-discharge data are given in Table 4.

A general depth-discharge power relationship for open channel flow (Birkhead and James, 1998) is given by

$$y = aQ^b + c \qquad \text{equation 1}$$

where y is the maximum flow depth (m), Q is the discharge rate (m^3/s), and a, b and c are regression coefficients.

Continuous rating functions of the form given by equation 1 have been fitted to the measured and modelled data, and these are plotted in Figure 11 to Figure 20. The rating relationship coefficients in equation 1 for FWR sites are given in Table 5. Modelled hydraulic data for the cross-sections at the IFR sites are listed in Table 6 to 16.

Table 3: Regional channel slope

River	Site no.	Channel slope
Great Letaba	1	0.0318
Letsitele	2	0.0014
Great Letaba	3*	0.0020
Great Letaba	4	0.0012
Klein Letaba	5	0.0016
Letaba	6	0.0013

Table 4: Hydraulic data used to extend the measured rating data

River	Site no.	Cross-section	Discharge (m^3/s)	Manning's resistance, *n*	Max. flow depth, *y* (m)		Energy slope, *S*	Ave. velocity *v* (m/s)	
Great Letaba	1	2	0.26			0.34			0.25
			0.34			0.43			0.22
			0.79	*0.15*		*0.50*	*0.0230*		*0.40*
			2.20	0.10		0.73	0.0200		0.64
			25.00	*0.13*		*2.00*	*0.0200*		*0.97*
			300.00[F]	0.18		5.00	0.0318		1.84
Letsitele	2	1	0.08			0.24	0.0108		0.05
			0.85			0.438	0.0100		0.21
			2.56	0.13		0.64	0.0080		0.33
			6.225	0.05		0.86	0.0014		0.50
			13.00	*0.06*		*1.35*	*0.0014*		*0.55*
			500.00[F]	0.06		7.74	0.0014		1.67
Letsitele	2	2	0.08			0.17	0.0108		0.11
			0.85			0.373	0.0100		0.22
			2.56	0.15		0.61	0.0080		0.31
			6.225	0.06		0.85	0.0014		0.47
			13.00	*0.06*		*1.35*	*0.0014*		*0.56*
			500.00[F]	0.06		7.82	0.0014		1.64
Great Letaba	3*	2	0.01			0.37			
			42.60			2.54			0.24
			2800.00[F]	0.045		7.09	0.002		2.74
Great Letaba	4	1	0.141		0.16[a]	0.39		0.46[a]	0.09
			0.653		0.27[a]	0.50		0.72[a]	0.16
			3.720	0.037[a]	0.48[a]	0.71	0.025[a]	1.61[a]	0.38
			17.50	*0.032*		*0.92*	*0.0022*	*1.90[a]*	*0.71*
			110.80	0.031		1.90	0.0018		1.07
			4400.00[F]	0.023		8.00	0.0012		4.40
Great Letaba	4	4	0.141						
			0.653						
			3.720						
			110.80	0.044		3.28	0.0011		0.87
			4400.00[F]	0.028		10.00	0.0012		3.43
Klein Letaba	5	2	0.025			0.52	0.00025		0.02
			0.060			0.56	0.00025		0.03
			0.270			0.79	0.00030		0.06
			0.955			0.83	0.00030		0.07
			42.00	0.039		1.47	0.00090		0.55
			500.00	*0.035*		*3.20*	*0.00130*		*1.42*
			2000.00[F]	0.030		4.90	0.00160		2.99

River	Site no.	Cross-section	Discharge (m^3/s)	Manning's resistance, *n*	Max. flow depth, *y* (m)	Energy slope, *S*	Ave. velocity *v* (m/s)
Klein Letaba	5	4	0.025 0.060 0.270 0.955 42.00 *500.00* 2000.00[F]	 0.039 *0.037* 0.030	0.22 0.26 0.44 0.48 1.11 *2.79* 4.53	0.00025 0.00025 0.00030 0.00030 0.00090 *0.00130* 0.00160	0.02 0.03 0.07 0.08 0.57 *1.48* 2.99
Klein Letaba	5	5	0.025 0.060 0.270 0.955 42.00 *500.00* 2000.00[F]	 0.044 *0.040* 0.032	0.16 0.20 0.38 0.42 1.06 *2.72* 4.53	0.00025 0.00025 0.00030 0.00030 0.00090 *0.00130* 0.00160	0.02 0.02 0.05 0.06 0.43 *1.44* 2.86
Letaba	6	2	0.15 1.95 6.80 85.00 *550.00* 7000.00[F]	 *0.033* 0.032	0.13[a] 0.39 0.27[a] 0.68 0.43[a] 0.82 0.93[a] 1.37 *2.90* 8.43	 *0.0013* 0.0013	 1.16[a]; 0.95 *1.47* 3.60

Italic – modelled
F – Flood estimated by DWAF
a – active channel

Table 5: Regression coefficients in equation 1

River	Site no.	Cross-section	Discharge Q (m^3/s)	Rating coefficients		
				a	***b***	***c***
Great Letaba	1	2	all	0.577	0.377	0.000
Letsitele	2	1	$0 < Q \leq 2.9$ $2.9 < Q$	0.478 0.386	0.278 0.481	0.000 0.000
Letsitele	2	2	$0 < Q \leq 2.5$ $2.5 < Q$	0.418 0.372	0.363 0.490	0.000 0.000
Great Letaba	3*	2	all	1.081	0.235	0.000
Great Letaba	4	1	$0 < Q \leq 17.5$ $17.5 < Q$	0.316[a]; 0.551 0.3	0.359[a]; 0.181 0.392	0.000 0.000
Great Letaba	4	4	$0 < Q \leq 85$ $85 < Q$	0.266 0.780	0.453 0.303	1.043 0.000
Klein Letaba	5	2	$0 < Q \leq 42.0$ $42.0 < Q$	0.870 0.459	0.140 0.312	0.000 0.000
Klein Letaba	5	4	$0 < Q \leq 47.0$ $47.0 < Q$	0.506 0.285	0.216 0.365	0.000 0.000
Klein Letaba	5	5	$0 < Q \leq 55.0$ $55.0 < Q$	0.435 0.260	0.250 0.376	0.000 0.000
Lonely Bull	6	2	$0 < Q \leq 82.0$ $82.0 < Q \leq 500$ $82.0 < Q$	0.231[a]; 0.574 0.064[a] 0.228	0.313[a]; 0.197 0.608[a] 0.407	0.000 0.000 0.000

a – active channel

4. RESULTS

4.1 CROSS-SECTIONAL PROFILES

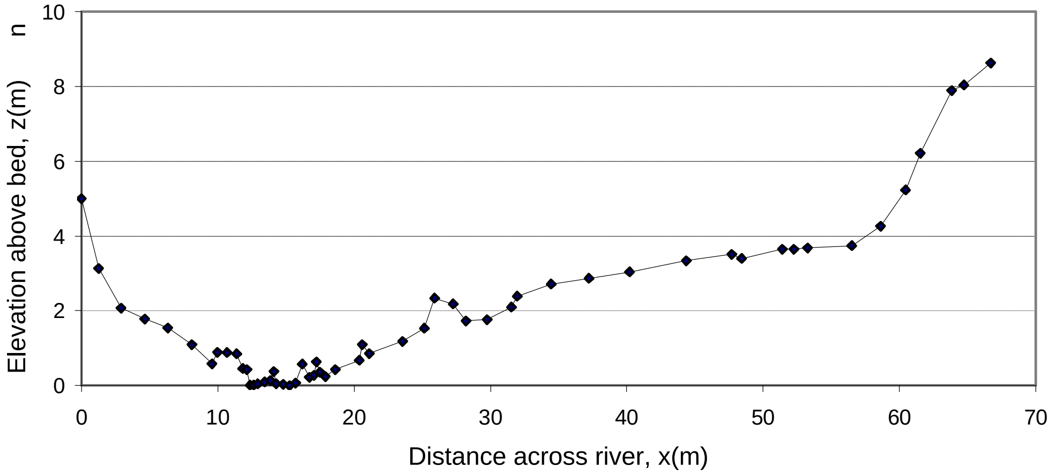

Figure 1: Cross-sectional profile for EWR Site 1 cross-section 2 (Riffle) on the Great Letaba River.

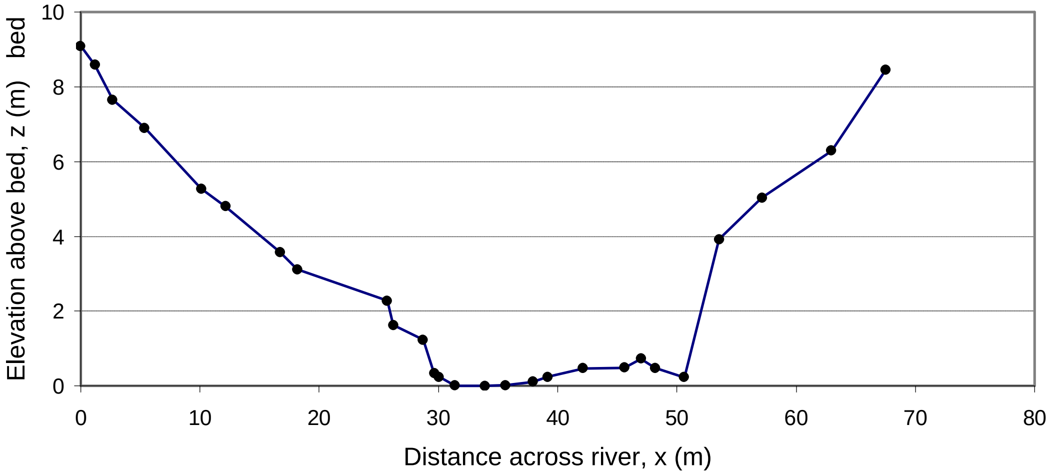

Figure 2: Cross-sectional profile for EWR Site 2 cross-section 1 (Run) on the Letsitele River.

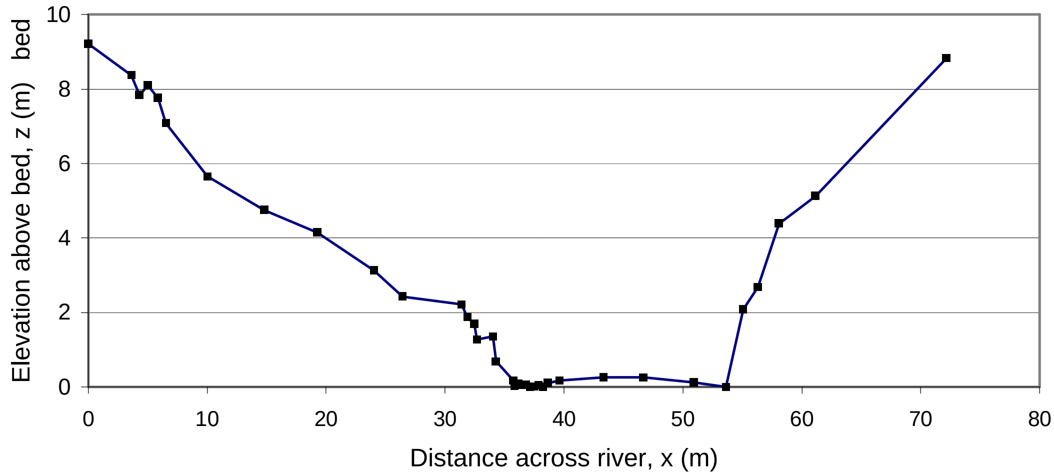

Figure 3: Cross-sectional profile for EWR Site 2 cross-section 2 (Riffle) on the Letsitele River.

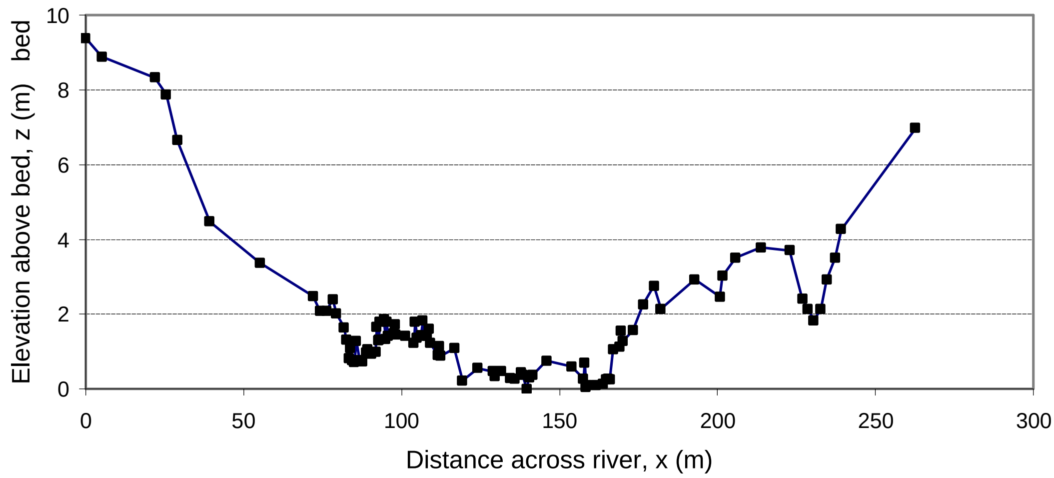

Figure 4: Cross-sectional profile for EWR Site 3 downstream of Prieska weir cross-section 2 (Rapid) on the Great Letaba River.

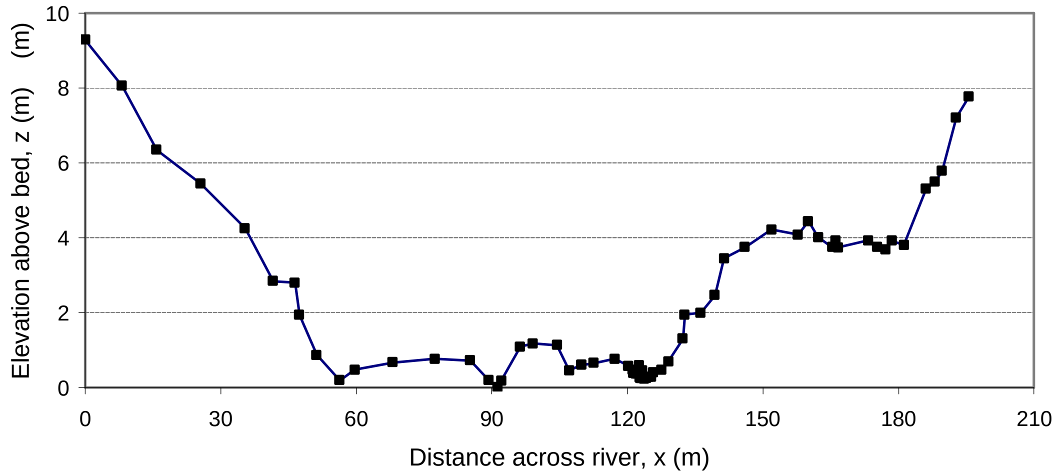

Figure 5: Cross-sectional profile for EWR Site 4 cross-section 1 (Riffle) on the Great Letaba River.

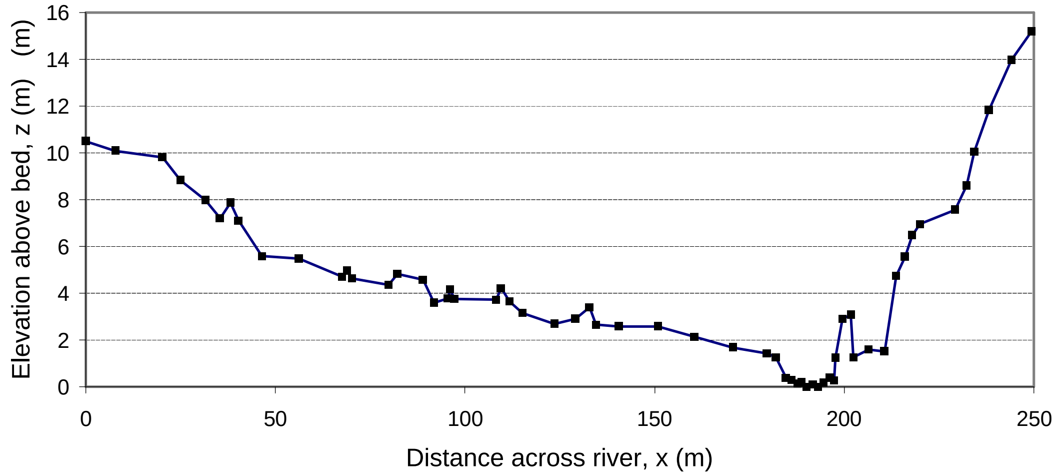

Figure 6: Cross-sectional profile for EWR Site 4 cross-section 4 (Rapid) on the Great Letaba River.

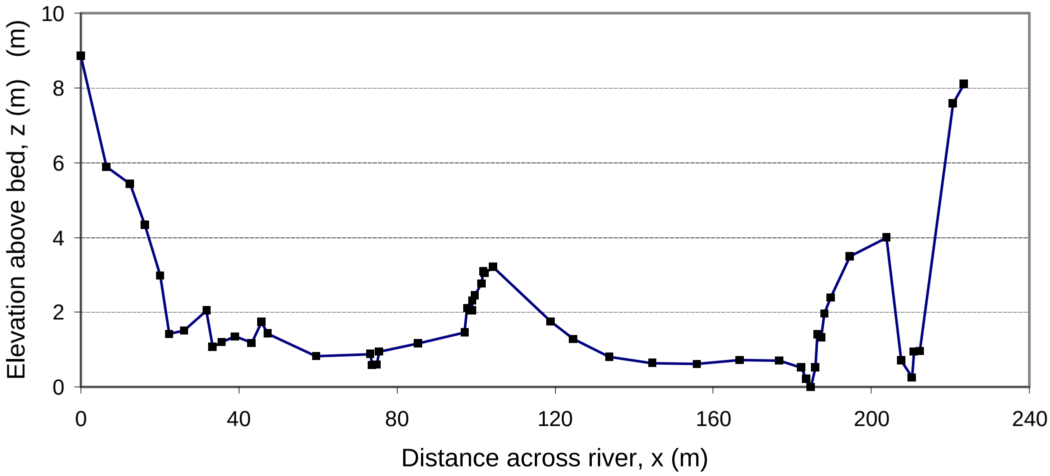

Figure 7: Cross-sectional profile for EWR Site 5 cross-section 2 on the Klein Letaba River.

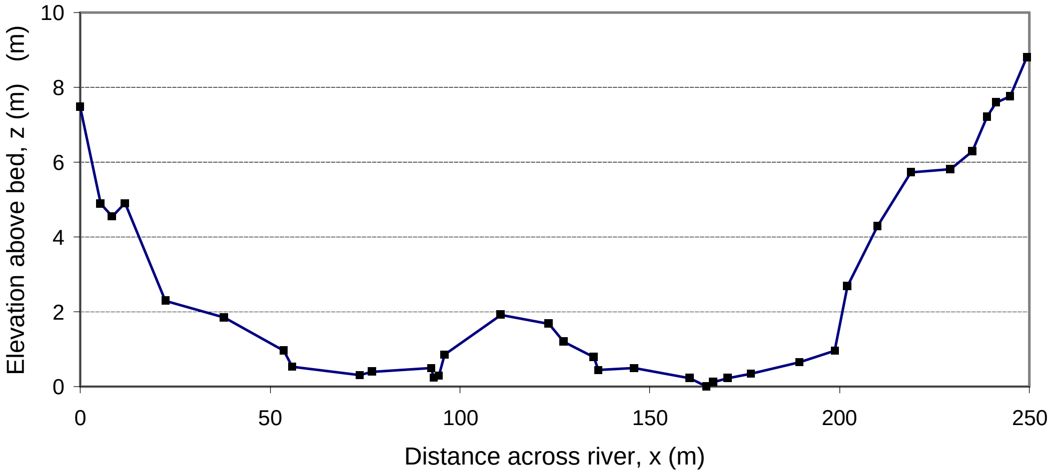

Figure 8: Cross-sectional profile for EWR Site 5 cross-section 4 on the Klein Letaba River

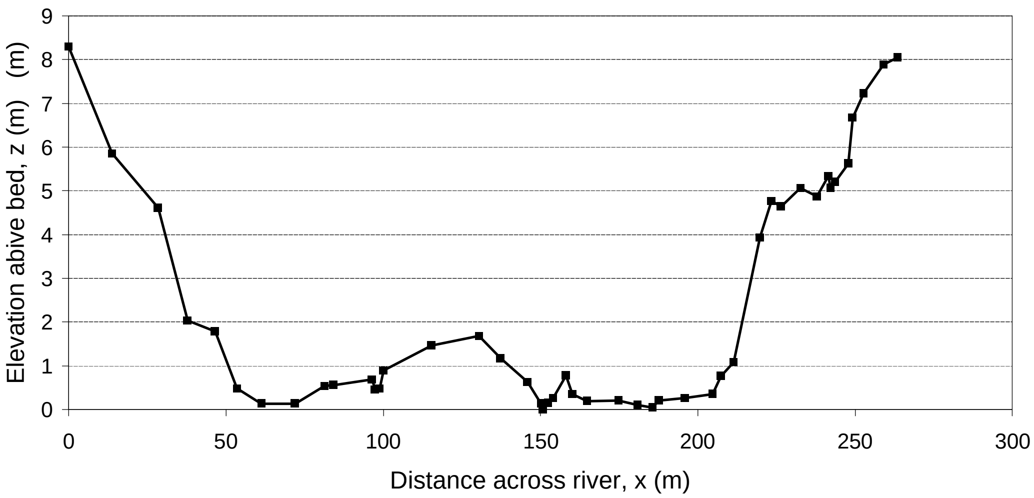

Figure 9: Cross-sectional profile for EWR Site 5 cross-section 5 on the Klein Letaba River.

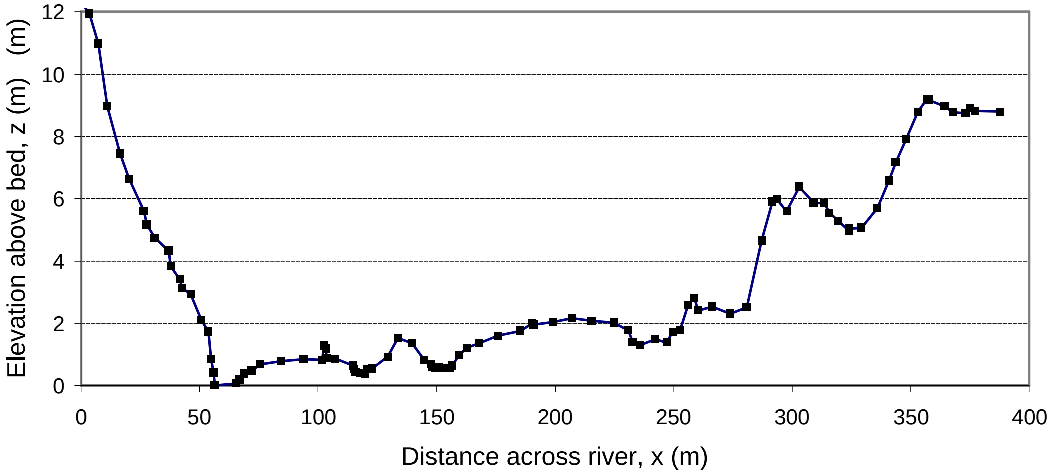

Figure 10: Cross-sectional profile for EWR Site 6 cross-section 2 on the Letaba River.

4.2 RATING DATA AND FUNCTIONS

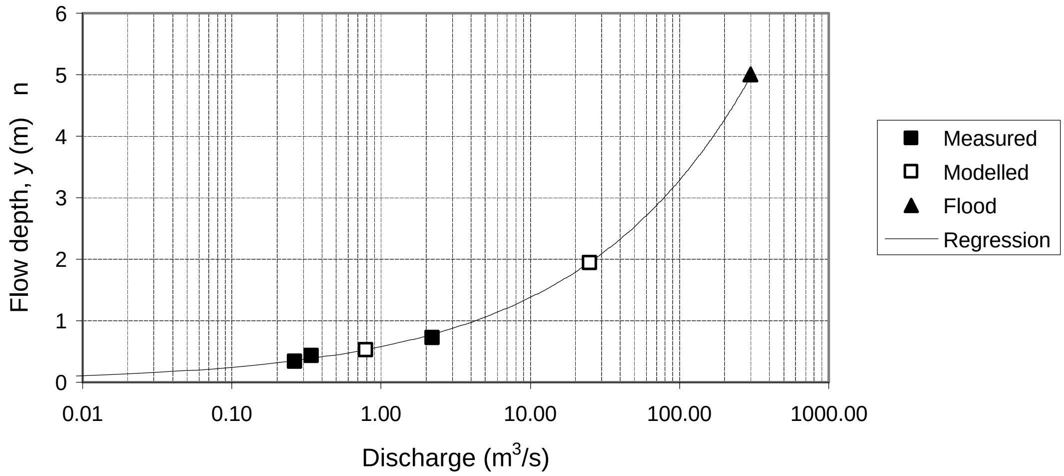

Figure 11: Measured and modelled rating data and functions for the cross-sectional profiles at EWR Site 1 cross-section 2 on the Great Letaba River.

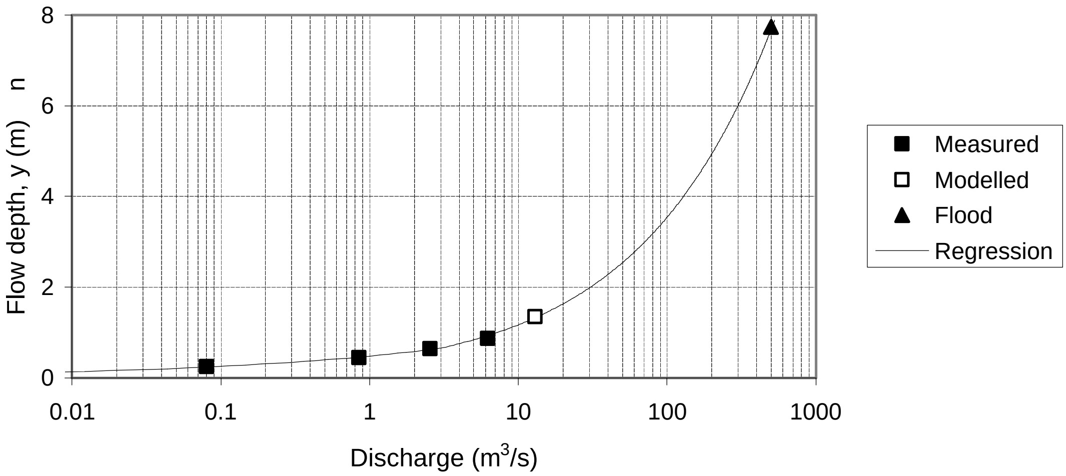

Figure 12: Measured and modelled rating data and function for the cross-sectional profiles at EWR Site 2 cross section 1 on the Letsitele River.

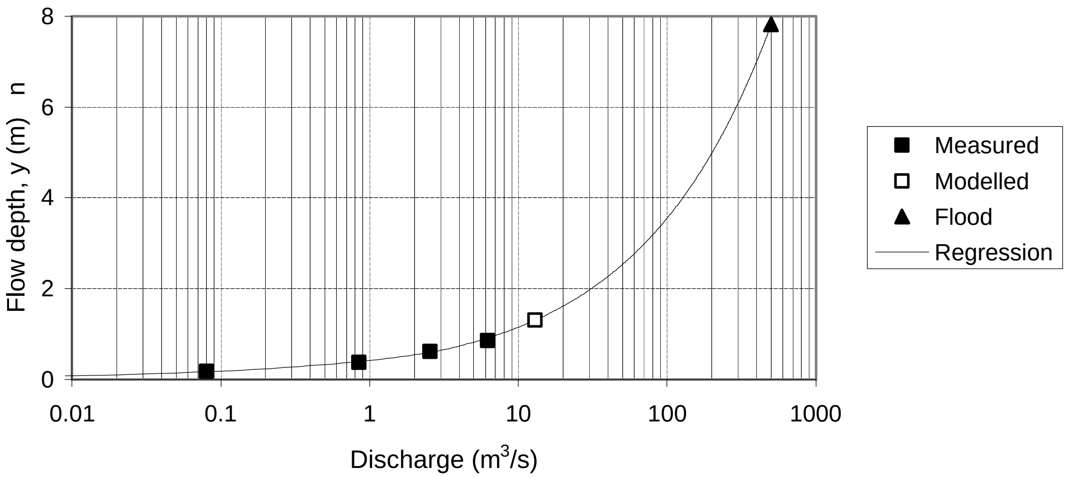

Figure 13: Measured and modelled rating data and function for the cross-sectional profiles at EWR Site 2 cross section 2 on the Letsitele River.

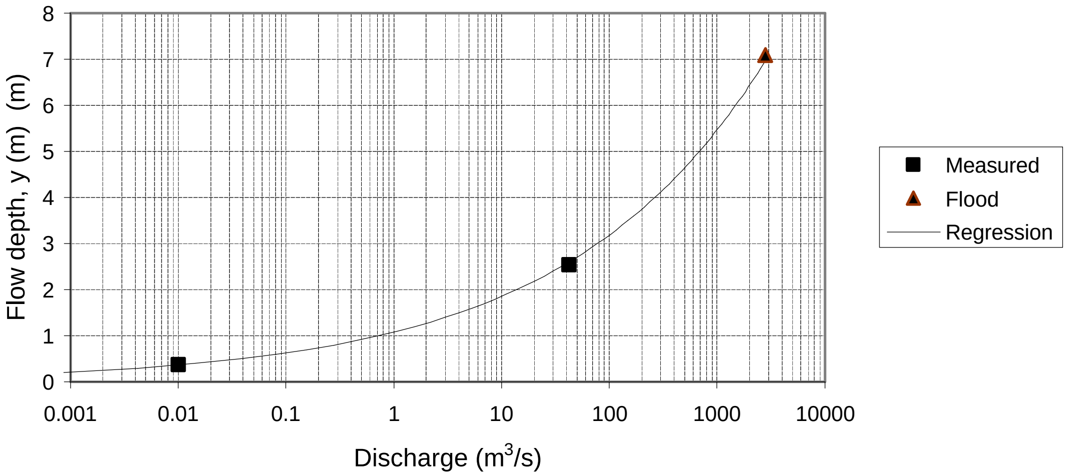

Figure 14: Measured and modelled rating data and function for the cross-sectional profiles at EWR Site 3* cross section 3 on the Great Letaba River.

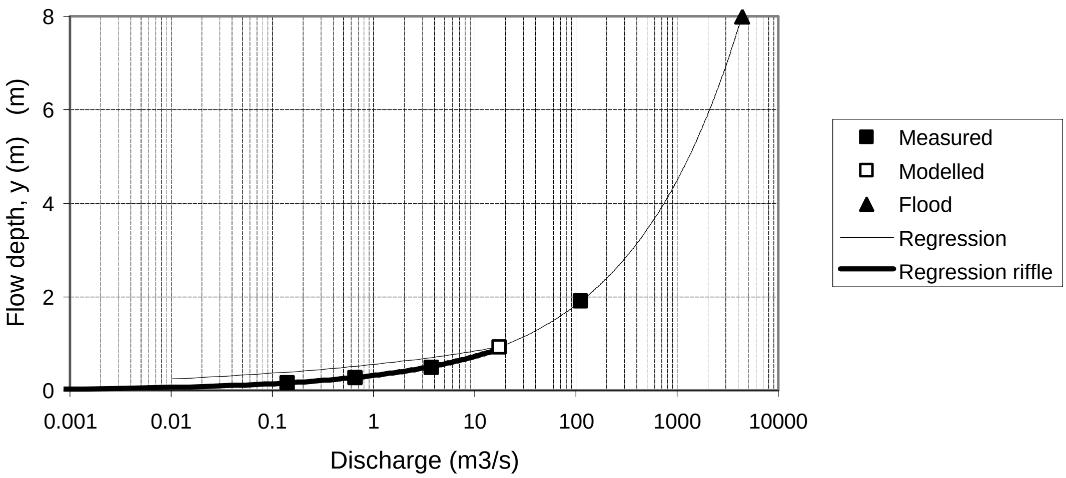

Figure 15: Measured and modelled rating data and function for the cross-sectional profiles at EWR Site 4 cross section 1 on the Great Letaba River.

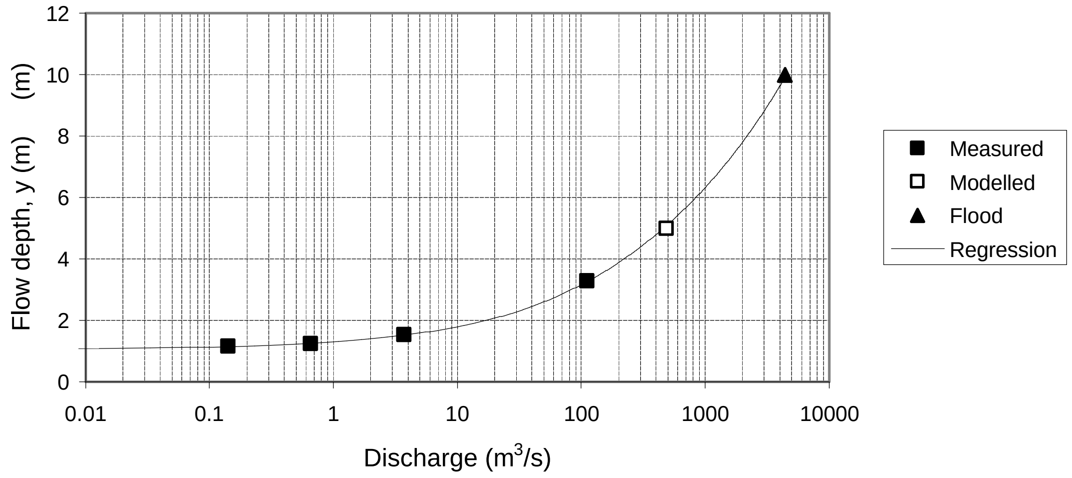

Figure 16: Measured and modelled rating data and function for the cross-sectional profiles at EWR Site 4 cross section 4 on the Great Letaba River.

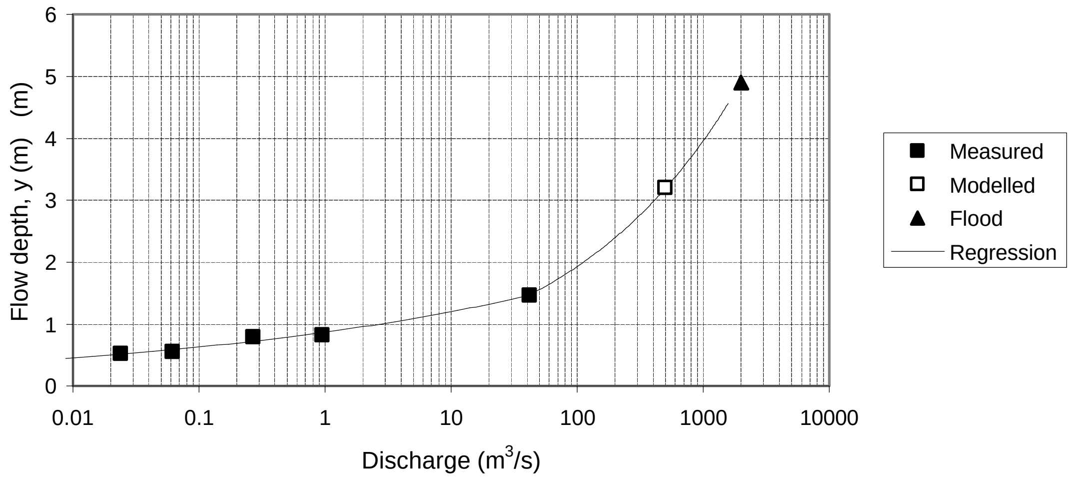

Figure 17: Measured and modelled rating data and function for the cross-sectional profiles at EWR Site 5 cross section 2 on the Klein Letaba River.

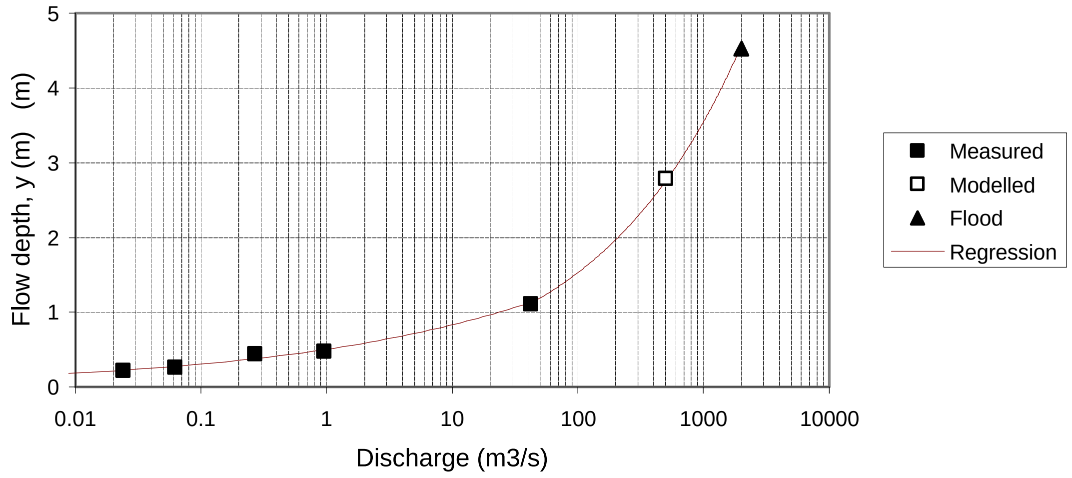

Figure 18: Measured and modelled rating data and function for the cross-sectional profiles at EWR Site 5 cross section 4 on the Klein Letaba River.

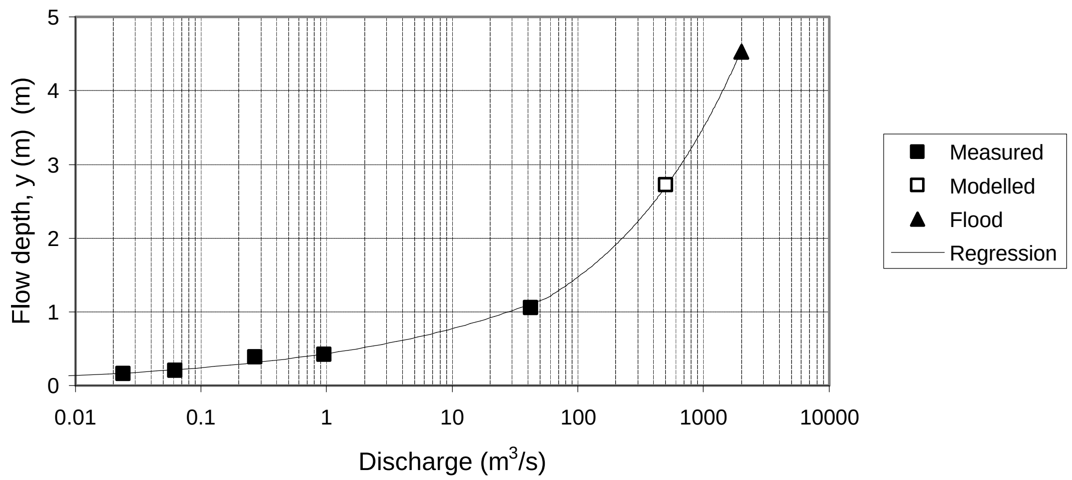

Figure 19: Measured and modelled rating data and function for the cross-sectional profiles at EWR Site 5 cross section 5 on the Klein Letaba River.

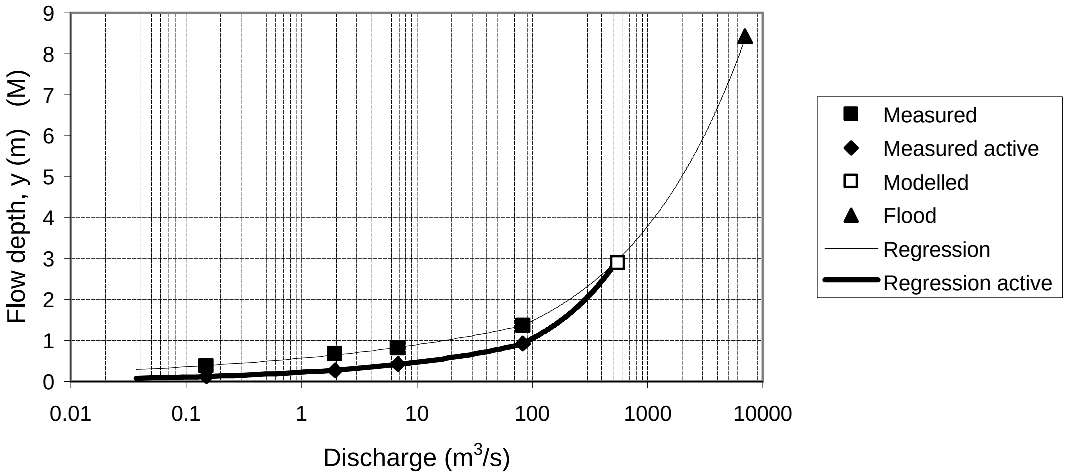

Figure 20: Measured and modelled rating data and function for the cross-sectional profiles at EWR Site 6 cross section 2 on the Letaba River.

4.3 TABULATED MODELLED HYDRAULIC DATA

Table 6: Tabulated hydraulic data for EWR Site 1 cross-section 2 on the Great Letaba River

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.00	0.01	0.01	0.70	0.71	0.02
0.04	0.00	0.02	0.03	1.57	1.59	0.03
0.06	0.00	0.03	0.07	2.17	2.22	0.04
0.08	0.01	0.05	0.11	2.47	2.54	0.05
0.10	0.01	0.06	0.17	2.69	2.80	0.06
0.12	0.02	0.08	0.22	2.90	3.04	0.07
0.14	0.02	0.09	0.28	3.11	3.28	0.08
0.16	0.03	0.11	0.34	3.17	3.38	0.10
0.18	0.05	0.13	0.41	3.23	3.49	0.11
0.20	0.06	0.14	0.47	3.29	3.59	0.13
0.22	0.08	0.16	0.54	3.35	3.69	0.14
0.24	0.10	0.17	0.61	3.57	3.96	0.16
0.26	0.12	0.17	0.68	3.94	4.38	0.18
0.28	0.15	0.18	0.77	4.24	4.74	0.19
0.30	0.18	0.19	0.85	4.49	5.05	0.21
0.32	0.21	0.20	0.95	4.74	5.36	0.22
0.34	0.25	0.21	1.04	4.98	5.67	0.24
0.36	0.29	0.22	1.15	5.23	5.98	0.25
0.38	0.33	0.23	1.25	5.43	6.25	0.26
0.40	0.38	0.24	1.36	5.60	6.47	0.28
0.42	0.43	0.26	1.48	5.76	6.68	0.29
0.44	0.49	0.26	1.59	6.11	7.08	0.31
0.46	0.55	0.26	1.72	6.49	7.50	0.32
0.48	0.61	0.27	1.85	6.74	7.79	0.33
0.50	0.68	0.28	1.99	6.98	8.07	0.34
0.52	0.76	0.30	2.13	7.22	8.36	0.36
0.54	0.84	0.31	2.28	7.46	8.65	0.37
0.56	0.92	0.32	2.43	7.71	8.93	0.38
0.58	1.01	0.33	2.59	7.92	9.19	0.39
0.60	1.11	0.34	2.75	8.20	9.50	0.40
0.62	1.21	0.34	2.91	8.47	9.82	0.42
0.64	1.32	0.35	3.09	8.74	10.11	0.43
0.66	1.43	0.36	3.26	8.98	10.38	0.44
0.68	1.55	0.37	3.45	9.23	10.64	0.45
0.70	1.67	0.39	3.63	9.34	10.79	0.46
0.72	1.80	0.40	3.82	9.46	10.93	0.47
0.74	1.93	0.42	4.01	9.57	11.08	0.48
0.76	2.08	0.43	4.20	9.69	11.22	0.49
0.78	2.22	0.45	4.40	9.80	11.37	0.51
0.80	2.38	0.46	4.59	9.92	11.51	0.52
0.82	2.54	0.48	4.79	10.04	11.66	0.53
0.84	2.71	0.49	5.00	10.15	11.81	0.54
0.86	2.88	0.50	5.20	10.49	12.17	0.55
0.88	3.06	0.48	5.42	11.24	12.95	0.56
0.90	3.25	0.46	5.66	12.21	13.94	0.57
0.92	3.44	0.47	5.90	12.47	14.23	0.58
0.94	3.64	0.48	6.16	12.73	14.51	0.59
0.96	3.85	0.49	6.41	13.00	14.80	0.60
0.98	4.07	0.50	6.68	13.26	15.08	0.61

Flow depth (m)	**Discharge (m^3/s)**	**Av. flow depth (m)**	**Area (m^2)**	**Width (m)**	**Perimeter (m)**	**Av. velocity (m/s)**
1.00	4.29	0.51	6.94	13.52	15.37	0.62
1.02	4.53	0.52	7.22	13.78	15.65	0.63
1.04	4.76	0.53	7.49	14.05	15.93	0.64
1.06	5.01	0.54	7.78	14.31	16.22	0.64
1.08	5.26	0.55	8.07	14.57	16.50	0.65
1.10	5.53	0.56	8.36	14.83	16.79	0.66
1.12	5.80	0.57	8.66	15.07	17.02	0.67
1.14	6.08	0.59	8.96	15.30	17.26	0.68
1.16	6.36	0.60	9.27	15.53	17.49	0.69
1.18	6.66	0.61	9.58	15.76	17.73	0.69
1.20	6.96	0.62	9.90	15.93	17.91	0.70
1.22	7.27	0.63	10.22	16.11	18.08	0.71
1.24	7.59	0.65	10.55	16.28	18.26	0.72
1.26	7.92	0.66	10.87	16.45	18.44	0.73
1.28	8.26	0.67	11.20	16.62	18.61	0.74
1.30	8.60	0.69	11.54	16.79	18.79	0.75
1.32	8.96	0.70	11.88	16.97	18.97	0.75
1.34	9.32	0.71	12.22	17.14	19.14	0.76
1.36	9.70	0.73	12.56	17.31	19.32	0.77
1.38	10.08	0.74	12.91	17.48	19.50	0.78
1.40	10.47	0.75	13.26	17.65	19.67	0.79
1.42	10.87	0.76	13.61	17.82	19.85	0.80
1.44	11.28	0.78	13.97	18.00	20.02	0.81
1.46	11.70	0.79	14.33	18.17	20.20	0.82
1.48	12.13	0.80	14.70	18.34	20.38	0.83
1.50	12.57	0.81	15.07	18.51	20.55	0.83
1.52	13.02	0.83	15.44	18.68	20.73	0.84
1.54	13.48	0.84	15.82	18.82	20.87	0.85
1.56	13.95	0.85	16.19	18.98	21.04	0.86
1.58	14.42	0.87	16.57	19.14	21.21	0.87
1.60	14.91	0.88	16.96	19.30	21.39	0.88
1.62	15.41	0.89	17.35	19.46	21.56	0.89
1.64	15.92	0.90	17.74	19.62	21.73	0.90
1.66	16.44	0.92	18.13	19.78	21.90	0.91
1.68	16.97	0.93	18.53	19.94	22.07	0.92
1.70	17.51	0.94	18.93	20.10	22.24	0.93
1.72	18.06	0.95	19.33	20.26	22.41	0.93
1.74	18.62	0.94	19.74	20.96	23.11	0.94
1.76	19.20	0.91	20.17	22.19	24.36	0.95
1.78	19.78	0.92	20.62	22.49	24.68	0.96
1.80	20.37	0.93	21.07	22.77	24.98	0.97
1.82	20.98	0.93	21.53	23.05	25.27	0.97
1.84	21.59	0.94	21.99	23.32	25.56	0.98
1.86	22.22	0.95	22.46	23.60	25.86	0.99
1.88	22.86	0.96	22.94	23.88	26.15	1.00
1.90	23.51	0.97	23.42	24.15	26.45	1.00
1.92	24.17	0.98	23.90	24.43	26.74	1.01
1.94	24.84	0.99	24.40	24.71	27.03	1.02
1.96	25.53	1.00	24.89	24.99	27.33	1.03
1.98	26.22	1.01	25.40	25.26	27.62	1.03
2.00	26.93	1.01	25.90	25.54	27.92	1.04

Table 7: Tabulated hydraulic data for EWR Site 2 cross-section 1 on the Letsitele River

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.02	0.00	0.01	0.06	4.32	4.32	0.00
0.04	0.00	0.03	0.15	4.94	4.94	0.00
0.06	0.00	0.05	0.25	5.56	5.56	0.00
0.08	0.00	0.06	0.37	6.17	6.18	0.00
0.10	0.00	0.07	0.50	6.79	6.80	0.01
0.12	0.01	0.09	0.64	7.26	7.27	0.01
0.14	0.01	0.10	0.79	7.56	7.58	0.02
0.16	0.02	0.12	0.94	7.87	7.89	0.02
0.18	0.03	0.13	1.10	8.18	8.20	0.03
0.20	0.04	0.15	1.27	8.49	8.51	0.03
0.22	0.06	0.16	1.44	8.79	8.82	0.04
0.24	0.08	0.18	1.62	9.21	9.24	0.05
0.26	0.11	0.19	1.81	9.76	9.81	0.06
0.28	0.15	0.20	2.01	10.32	10.38	0.07
0.30	0.19	0.20	2.23	10.88	10.95	0.08
0.32	0.24	0.21	2.45	11.44	11.53	0.10
0.34	0.29	0.22	2.68	11.96	12.07	0.11
0.36	0.36	0.24	2.93	12.45	12.58	0.12
0.38	0.44	0.25	3.18	12.95	13.09	0.14
0.40	0.53	0.26	3.45	13.44	13.60	0.15
0.42	0.63	0.27	3.72	13.93	14.11	0.17
0.44	0.74	0.28	4.00	14.42	14.62	0.19
0.46	0.87	0.29	4.30	14.91	15.14	0.20
0.48	1.01	0.27	4.61	17.00	17.25	0.22
0.50	1.17	0.26	4.97	18.92	19.19	0.24
0.52	1.35	0.28	5.36	19.17	19.46	0.25
0.54	1.54	0.30	5.74	19.42	19.73	0.27
0.56	1.76	0.31	6.13	19.67	19.99	0.29
0.58	2.00	0.33	6.53	19.92	20.26	0.31
0.60	2.26	0.34	6.93	20.16	20.53	0.33
0.62	2.54	0.36	7.33	20.41	20.80	0.35
0.64	2.86	0.37	7.75	20.66	21.07	0.37
0.66	3.05	0.39	8.16	20.91	21.34	0.37
0.68	3.24	0.41	8.58	21.15	21.61	0.38
0.70	3.45	0.42	9.01	21.40	21.88	0.38
0.72	3.65	0.44	9.44	21.65	22.15	0.39
0.74	3.87	0.45	9.87	21.79	22.31	0.39
0.76	4.09	0.47	10.31	21.83	22.36	0.40
0.78	4.31	0.49	10.75	21.87	22.42	0.40
0.80	4.55	0.51	11.18	21.90	22.47	0.41
0.82	4.79	0.53	11.62	21.94	22.53	0.41
0.84	5.03	0.55	12.06	21.98	22.58	0.42
0.86	5.28	0.57	12.50	22.01	22.64	0.42
0.88	5.54	0.59	12.94	22.05	22.69	0.43
0.90	5.81	0.61	13.38	22.09	22.75	0.43
0.92	6.08	0.62	13.82	22.12	22.80	0.44
0.94	6.36	0.64	14.27	22.16	22.85	0.45
0.96	6.64	0.66	14.71	22.20	22.91	0.45
0.98	6.93	0.68	15.16	22.23	22.96	0.46
1.00	7.23	0.70	15.60	22.27	23.02	0.46
1.02	7.53	0.72	16.05	22.31	23.07	0.47
1.04	7.84	0.74	16.49	22.34	23.13	0.48
1.06	8.16	0.76	16.94	22.38	23.18	0.48

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.08	8.48	0.78	17.39	22.42	23.24	0.49
1.10	8.81	0.79	17.84	22.45	23.29	0.49
1.12	9.15	0.81	18.29	22.49	23.34	0.50
1.14	9.49	0.83	18.74	22.53	23.40	0.51
1.16	9.84	0.85	19.19	22.56	23.45	0.51
1.18	10.20	0.87	19.64	22.60	23.51	0.52
1.20	10.56	0.89	20.09	22.64	23.56	0.53
1.22	10.93	0.91	20.54	22.67	23.62	0.53
1.24	11.31	0.92	21.00	22.76	23.72	0.54
1.26	11.69	0.94	21.45	22.90	23.87	0.54
1.28	12.08	0.95	21.91	23.04	24.02	0.55
1.30	12.47	0.97	22.38	23.18	24.18	0.56
1.32	12.87	0.98	22.84	23.33	24.33	0.56
1.34	13.28	0.99	23.31	23.47	24.48	0.57
1.36	13.70	1.01	23.78	23.61	24.63	0.58
1.38	14.12	1.02	24.25	23.75	24.78	0.58
1.40	14.55	1.04	24.73	23.89	24.94	0.59
1.42	14.98	1.05	25.21	24.03	25.09	0.59
1.44	15.43	1.06	25.69	24.17	25.24	0.60
1.46	15.87	1.08	26.18	24.31	25.39	0.61
1.48	16.33	1.09	26.66	24.45	25.55	0.61
1.50	16.79	1.10	27.15	24.59	25.70	0.62
1.52	17.26	1.12	27.65	24.73	25.85	0.62
1.54	17.73	1.13	28.14	24.87	26.00	0.63
1.56	18.22	1.14	28.64	25.02	26.15	0.64
1.58	18.71	1.16	29.14	25.16	26.31	0.64
1.60	19.20	1.17	29.65	25.30	26.46	0.65
1.62	19.70	1.19	30.16	25.44	26.61	0.65
1.64	20.21	1.20	30.67	25.52	26.71	0.66
1.66	20.73	1.22	31.18	25.56	26.76	0.66
1.68	21.25	1.24	31.69	25.59	26.81	0.67
1.70	21.78	1.26	32.20	25.62	26.86	0.68
1.72	22.31	1.28	32.71	25.65	26.91	0.68
1.74	22.86	1.29	33.23	25.68	26.97	0.69
1.76	23.41	1.31	33.74	25.71	27.02	0.69
1.78	23.96	1.33	34.25	25.74	27.07	0.70
1.80	24.53	1.35	34.77	25.78	27.12	0.71
1.82	25.10	1.37	35.29	25.81	27.17	0.71
1.84	25.67	1.39	35.80	25.84	27.22	0.72
1.86	26.26	1.40	36.32	25.87	27.27	0.72
1.88	26.85	1.42	36.84	25.90	27.32	0.73
1.90	27.44	1.44	37.36	25.93	27.37	0.73
1.92	28.05	1.46	37.87	25.97	27.42	0.74
1.94	28.66	1.48	38.39	26.00	27.48	0.75
1.96	29.27	1.50	38.91	26.03	27.53	0.75
1.98	29.90	1.51	39.44	26.06	27.58	0.76
2.00	30.53	1.53	39.96	26.09	27.63	0.76

Table 8: Tabulated hydraulic data for EWR Site 2cross-section 2 on the Letsitele River

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.02	0.00	0.01	0.01	0.98	1.00	0.03
0.04	0.00	0.02	0.04	2.12	2.16	0.04
0.06	0.00	0.02	0.04	2.12	2.16	0.13
0.08	0.01	0.04	0.17	4.28	4.36	0.06
0.10	0.02	0.05	0.26	4.96	5.07	0.07
0.12	0.03	0.07	0.37	5.62	5.75	0.09
0.14	0.05	0.07	0.49	6.53	6.68	0.10
0.16	0.07	0.08	0.63	7.55	7.72	0.11
0.18	0.10	0.09	0.79	8.79	8.98	0.12
0.20	0.13	0.10	0.98	10.25	10.46	0.13
0.22	0.17	0.10	1.20	11.71	11.93	0.14
0.24	0.22	0.11	1.45	13.17	13.41	0.15
0.26	0.27	0.12	1.73	14.63	14.88	0.16
0.28	0.33	0.11	2.08	18.40	18.66	0.16
0.30	0.40	0.13	2.45	18.47	18.75	0.16
0.32	0.48	0.15	2.82	18.54	18.83	0.17
0.34	0.57	0.17	3.19	18.61	18.91	0.18
0.36	0.66	0.19	3.56	18.68	19.00	0.19
0.38	0.77	0.21	3.93	18.75	19.08	0.20
0.40	0.89	0.23	4.31	18.82	19.16	0.21
0.42	1.01	0.25	4.69	18.89	19.25	0.22
0.44	1.15	0.27	5.07	18.96	19.33	0.23
0.46	1.30	0.29	5.45	19.03	19.42	0.24
0.48	1.47	0.31	5.83	19.10	19.50	0.25
0.50	1.64	0.32	6.21	19.17	19.58	0.26
0.52	1.83	0.34	6.59	19.24	19.67	0.28
0.54	2.03	0.36	6.98	19.31	19.75	0.29
0.56	2.24	0.38	7.37	19.38	19.83	0.30
0.58	2.47	0.40	7.75	19.45	19.92	0.32
0.60	2.66	0.42	8.14	19.52	20.00	0.33
0.62	2.84	0.44	8.53	19.59	20.08	0.33
0.64	3.03	0.45	8.93	19.66	20.17	0.34
0.66	3.23	0.47	9.32	19.72	20.25	0.35
0.68	3.43	0.49	9.72	19.79	20.33	0.35
0.70	3.64	0.51	10.11	19.84	20.40	0.36
0.72	3.85	0.53	10.51	19.86	20.45	0.37
0.74	4.07	0.55	10.91	19.88	20.49	0.37
0.76	4.30	0.57	11.30	19.90	20.54	0.38
0.78	4.54	0.59	11.70	19.93	20.58	0.39
0.80	4.78	0.61	12.10	19.95	20.63	0.39
0.82	5.02	0.63	12.50	19.97	20.67	0.40
0.84	5.28	0.65	12.90	19.99	20.72	0.41
0.86	5.54	0.66	13.30	20.01	20.77	0.42
0.88	5.80	0.68	13.70	20.03	20.81	0.42
0.90	6.07	0.70	14.10	20.05	20.86	0.43
0.92	6.35	0.72	14.50	20.07	20.90	0.44
0.94	6.64	0.74	14.90	20.10	20.95	0.45
0.96	6.93	0.76	15.31	20.12	20.99	0.45
0.98	7.23	0.78	15.71	20.14	21.04	0.46
1.00	7.53	0.80	16.11	20.16	21.08	0.47
1.02	7.84	0.82	16.52	20.18	21.13	0.47
1.04	8.16	0.84	16.92	20.20	21.18	0.48
1.06	8.48	0.86	17.32	20.22	21.22	0.49

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.08	8.81	0.88	17.73	20.25	21.27	0.50
1.10	9.15	0.89	18.13	20.27	21.31	0.50
1.12	9.49	0.91	18.54	20.29	21.36	0.51
1.14	9.84	0.93	18.94	20.31	21.40	0.52
1.16	10.20	0.95	19.35	20.33	21.45	0.53
1.18	10.56	0.97	19.76	20.35	21.50	0.53
1.20	10.93	0.99	20.17	20.37	21.54	0.54
1.22	11.30	1.01	20.57	20.39	21.59	0.55
1.24	11.68	1.03	20.98	20.42	21.63	0.56
1.26	12.07	1.05	21.39	20.44	21.68	0.56
1.28	12.47	1.06	21.80	20.61	21.89	0.57
1.30	12.87	1.06	22.21	20.95	22.26	0.58
1.32	13.27	1.06	22.64	21.28	22.63	0.59
1.34	13.69	1.07	23.07	21.61	22.99	0.59
1.36	14.11	1.07	23.50	21.95	23.36	0.60
1.38	14.53	1.09	23.94	21.97	23.41	0.61
1.40	14.97	1.11	24.38	22.00	23.46	0.61
1.42	15.41	1.13	24.82	22.02	23.51	0.62
1.44	15.85	1.15	25.26	22.05	23.55	0.63
1.46	16.31	1.16	25.70	22.07	23.60	0.63
1.48	16.76	1.18	26.14	22.10	23.65	0.64
1.50	17.23	1.20	26.59	22.12	23.70	0.65
1.52	17.70	1.22	27.03	22.15	23.74	0.65
1.54	18.18	1.24	27.47	22.17	23.79	0.66
1.56	18.67	1.26	27.92	22.20	23.84	0.67
1.58	19.16	1.28	28.36	22.22	23.89	0.68
1.60	19.66	1.29	28.80	22.25	23.93	0.68
1.62	20.16	1.31	29.25	22.27	23.98	0.69
1.64	20.67	1.33	29.70	22.30	24.03	0.70
1.66	21.19	1.35	30.14	22.33	24.07	0.70
1.68	21.71	1.37	30.59	22.35	24.12	0.71
1.70	22.24	1.39	31.04	22.40	24.19	0.72
1.72	22.78	1.40	31.49	22.48	24.28	0.72
1.74	23.33	1.42	31.94	22.56	24.37	0.73
1.76	23.88	1.43	32.39	22.63	24.46	0.74
1.78	24.43	1.45	32.84	22.71	24.55	0.74
1.80	25.00	1.46	33.30	22.79	24.64	0.75
1.82	25.57	1.48	33.75	22.86	24.74	0.76
1.84	26.14	1.49	34.21	22.94	24.83	0.76
1.86	26.73	1.51	34.67	23.02	24.92	0.77
1.88	27.32	1.52	35.13	23.08	24.99	0.78
1.90	27.91	1.54	35.59	23.12	25.05	0.78
1.92	28.52	1.56	36.06	23.16	25.11	0.79
1.94	29.13	1.57	36.52	23.20	25.17	0.80
1.96	29.74	1.59	36.98	23.24	25.22	0.80
1.98	30.36	1.61	37.45	23.29	25.28	0.81
2.00	30.99	1.63	37.92	23.33	25.34	0.82

Table 9: Tabulated hydraulic data for EWR Site 3 cross-section 2 on the Great Letaba River.

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.20	0.00	0.09	0.66	7.20	7.35	0.00
0.30	0.00	0.12	1.59	13.21	13.50	0.00
0.40	0.01	0.12	1.59	13.21	13.50	0.01
0.50	0.04	0.19	6.02	31.44	32.10	0.01
0.60	0.08	0.25	9.59	38.35	39.17	0.01
0.70	0.16	0.25	9.59	38.35	39.17	0.02
0.80	0.28	0.36	18.68	51.23	52.32	0.01
0.90	0.46	0.45	23.89	53.31	54.61	0.02
1.00	0.72	0.45	23.89	53.31	54.61	0.03
1.10	1.08	0.54	35.86	66.64	68.55	0.03
1.20	1.56	0.62	42.66	68.78	70.91	0.04
1.30	2.19	0.70	49.63	70.97	73.36	0.04
1.40	3.01	0.70	49.63	70.97	73.36	0.06
1.50	4.04	0.70	49.63	70.97	73.36	0.08
1.60	5.32	0.70	49.63	70.97	73.36	0.11
1.70	6.88	0.70	49.63	70.97	73.36	0.14
1.80	8.78	0.99	91.73	92.37	97.23	0.10
1.90	11.06	1.06	101.14	95.61	100.54	0.11
2.00	13.76	1.13	110.82	98.03	102.99	0.12
2.10	16.93	1.18	120.76	102.24	107.24	0.14
2.20	20.65	1.23	131.17	106.30	111.39	0.16
2.30	24.95	1.28	142.03	110.98	116.15	0.18
2.40	29.91	1.32	153.37	115.80	121.05	0.20
2.50	35.60	1.37	165.14	120.20	125.53	0.22
2.60	42.07	1.40	177.50	126.92	132.34	0.24
2.70	49.41	1.43	190.53	133.63	139.15	0.26
2.80	57.69	1.46	204.22	139.93	145.54	0.28
2.90	67.00	1.50	218.49	145.61	151.29	0.31
3.00	77.41	1.56	233.27	149.26	155.01	0.33
3.10	89.01	1.63	248.36	152.61	158.39	0.36
3.20	101.91	1.69	263.79	156.09	161.91	0.39
3.30	116.18	1.75	279.57	159.58	165.43	0.42
3.40	131.94	1.81	295.70	162.93	168.82	0.45
3.50	149.29	1.88	312.15	165.97	171.90	0.48
3.60	168.32	1.93	328.97	170.73	176.69	0.51
3.70	189.17	1.97	346.30	175.69	181.70	0.55
3.80	211.93	1.93	364.60	188.91	194.94	0.58
3.90	236.73	2.01	383.57	190.59	196.65	0.62
4.00	263.70	2.09	402.71	192.28	198.36	0.65
4.10	292.95	2.18	422.03	193.97	200.07	0.69
4.20	324.63	2.26	441.51	195.66	201.78	0.74
4.30	358.87	2.33	461.16	197.53	203.67	0.78
4.40	395.80	2.41	481.03	199.83	205.98	0.82
4.50	435.57	2.48	501.13	201.92	208.09	0.87
4.60	478.33	2.57	521.38	203.19	209.37	0.92
4.70	524.23	2.65	541.76	204.46	210.66	0.97
4.80	573.43	2.73	562.27	205.72	211.94	1.02
4.90	626.09	2.82	582.91	206.99	213.23	1.07
5.00	682.37	2.90	603.67	208.26	214.51	1.13
5.10	742.44	2.98	624.56	209.53	215.80	1.19
5.20	806.48	3.06	645.58	210.79	217.08	1.25
5.30	874.66	3.14	666.72	212.06	218.37	1.31

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
5.40	947.17	3.23	687.99	213.33	219.65	1.38
5.50	1024.20	3.31	709.38	214.59	220.94	1.44
5.60	1105.92	3.39	730.91	215.86	222.22	1.51
5.70	1192.55	3.47	752.56	217.13	223.51	1.58
5.80	1284.28	3.55	774.33	218.40	224.79	1.66
5.90	1381.31	3.62	796.23	219.66	226.08	1.73
6.00	1483.85	3.70	818.26	220.93	227.36	1.81
6.10	1592.13	3.78	840.42	222.20	228.65	1.89
6.20	1706.34	3.86	862.70	223.46	229.93	1.98
6.30	1826.73	3.94	885.11	224.73	231.22	2.06
6.40	1953.51	4.02	907.65	226.00	232.50	2.15
6.50	2086.91	4.09	930.31	227.27	233.79	2.24
6.60	2227.18	4.17	953.10	228.53	235.07	2.34
6.70	2374.55	4.25	976.02	229.80	236.36	2.43
6.80	2529.28	4.32	999.06	231.07	237.64	2.53
6.90	2691.60	4.40	1022.23	232.33	238.93	2.63
7.00	2861.77	4.48	1045.53	233.60	240.21	2.74

Table 10: Tabulated depth and velocity data for EWR Site 4 cross-section 1 on the Great Letaba River.

Discharge (m^3/s)	Flow depth (m)	Av. velocity (m/s)	Flow depth^A (m)	Av. Velocity^A (m/s)
0.01	0.24	0.02	0.06	0.11
0.02	0.26	0.03	0.07	0.14
0.02	0.28	0.03	0.08	0.16
0.03	0.30	0.04	0.09	0.19
0.05	0.32	0.05	0.11	0.25
0.07	0.34	0.06	0.12	0.28
0.10	0.36	0.06	0.14	0.35
0.13	0.38	0.09	0.15	0.43
0.17	0.40	0.09	0.17	0.49
0.22	0.42	0.10	0.18	0.47
0.29	0.44	0.11	0.20	0.53
0.37	0.46	0.13	0.22	0.59
0.47	0.48	0.14	0.24	0.66
0.58	0.50	0.16	0.26	0.72
0.73	0.52	0.18	0.28	0.79
0.89	0.54	0.19	0.30	0.85
1.09	0.56	0.21	0.33	0.96
1.33	0.58	0.23	0.35	1.02
1.60	0.60	0.25	0.37	1.09
1.92	0.62	0.27	0.40	1.20
2.29	0.64	0.30	0.43	1.31
2.71	0.66	0.32	0.45	1.38
3.20	0.68	0.34	0.48	1.48
3.75	0.70	0.37	0.51	1.57
4.38	0.72	0.39	0.54	1.66
5.10	0.74	0.41	0.57	1.73
5.91	0.76	0.44	0.60	1.79
6.82	0.78	0.46	0.63	1.83
7.85	0.80	0.48	0.66	1.85
8.99	0.82	0.51	0.70	1.86
10.27	0.84	0.54	0.73	1.86
11.70	0.86	0.58	0.76	1.85

Discharge (m^3/s)	Flow depth (m)	Av. velocity (m/s)	Flow depth[A] (m)	Av. Velocity[A] (m/s)
13.29	0.88	0.61	0.80	1.86
15.04	0.90	0.65	0.84	1.87
17.44	0.92	0.71	0.88	1.90
18.42	0.94	0.71	0.90	1.92
19.44	0.96	0.71	0.92	1.94
20.49	0.98	0.72	0.93	1.95
21.57	1.00	0.72	0.95	1.98
22.69	1.02	0.72	0.97	2.00
23.84	1.04	0.72	0.99	2.03
25.03	1.06	0.73	1.00	2.04
26.25	1.08	0.73	1.02	2.07
27.51	1.10	0.74	1.04	2.10
28.80	1.12	0.74	1.06	2.13
30.13	1.14	0.75	1.07	2.14
31.50	1.16	0.75	1.09	2.17
32.90	1.18	0.76	1.11	2.21
34.35	1.20	0.76	1.12	2.22

A – Active channel

Table 11: Tabulated hydraulic data for EWR Site 4 cross-section 1 on the Great Letaba River.

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.22	35.82	0.57	46.63	81.90	82.87	0.77
1.24	37.34	0.59	48.27	82.08	83.06	0.77
1.26	38.90	0.61	49.91	82.25	83.24	0.78
1.28	40.49	0.63	51.56	82.43	83.42	0.79
1.30	42.13	0.64	53.21	82.61	83.60	0.79
1.32	43.80	0.66	54.87	82.69	83.70	0.80
1.34	45.51	0.68	56.52	82.78	83.80	0.81
1.36	47.26	0.70	58.18	82.87	83.90	0.81
1.38	49.06	0.72	59.83	82.96	84.00	0.82
1.40	50.89	0.74	61.49	83.04	84.10	0.83
1.42	52.77	0.76	63.16	83.13	84.20	0.84
1.44	54.68	0.78	64.82	83.22	84.30	0.84
1.46	56.64	0.80	66.49	83.30	84.40	0.85
1.48	58.64	0.82	68.15	83.39	84.50	0.86
1.50	60.69	0.84	69.82	83.48	84.60	0.87
1.52	62.77	0.86	71.49	83.57	84.70	0.88
1.54	64.90	0.87	73.16	83.65	84.80	0.89
1.56	67.07	0.89	74.84	83.74	84.90	0.90
1.58	69.29	0.91	76.51	83.83	85.00	0.91
1.60	71.55	0.93	78.19	83.92	85.10	0.92
1.62	73.85	0.95	79.87	84.00	85.20	0.92
1.64	76.20	0.97	81.55	84.09	85.30	0.93
1.66	78.59	0.99	83.23	84.18	85.40	0.94
1.68	81.03	1.01	84.92	84.26	85.50	0.95
1.70	83.51	1.03	86.60	84.35	85.60	0.96
1.72	86.04	1.05	88.29	84.44	85.70	0.97
1.74	88.62	1.06	89.98	84.53	85.80	0.98
1.76	91.24	1.08	91.67	84.61	85.90	1.00
1.78	93.91	1.10	93.37	84.70	86.00	1.01
1.80	96.62	1.12	95.06	84.79	86.10	1.02

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.82	99.39	1.14	96.76	84.87	86.20	1.03
1.84	102.20	1.16	98.46	84.96	86.30	1.04
1.86	105.05	1.18	100.16	85.05	86.40	1.05
1.88	107.96	1.20	101.86	85.14	86.49	1.06
1.90	110.91	1.22	103.56	85.22	86.59	1.07
1.92	113.92	1.23	105.27	85.31	86.69	1.08
1.94	116.97	1.25	106.97	85.37	86.77	1.09
1.96	120.07	1.25	108.69	86.81	88.21	1.10
1.98	123.22	1.25	110.45	88.24	89.66	1.12
2.00	126.42	1.26	112.22	89.03	90.46	1.13

Table 12: Tabulated hydraulic data for EWR Site 4 cross-section 4 on the Great Letaba River.

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.06	0.00	0.79	11.96	15.13	15.85	0.00
1.08	0.01	0.81	12.26	15.20	15.94	0.00
1.10	0.03	0.82	12.57	15.27	16.02	0.00
1.12	0.07	0.84	12.87	15.34	16.11	0.01
1.14	0.11	0.86	13.18	15.41	16.20	0.01
1.16	0.16	0.87	13.49	15.48	16.29	0.01
1.18	0.23	0.89	13.80	15.55	16.37	0.02
1.20	0.31	0.90	14.11	15.62	16.46	0.02
1.22	0.41	0.92	14.43	15.69	16.55	0.03
1.24	0.52	0.94	14.74	15.76	16.63	0.04
1.26	0.64	0.95	15.06	15.84	16.72	0.04
1.28	0.78	0.94	15.38	16.41	17.31	0.05
1.30	0.93	0.93	15.71	16.97	17.90	0.06
1.32	1.10	0.92	16.06	17.54	18.49	0.07
1.34	1.28	0.91	16.41	18.11	19.08	0.08
1.36	1.48	0.90	16.78	18.67	19.67	0.09
1.38	1.69	0.89	17.16	19.24	20.26	0.10
1.40	1.92	0.89	17.55	19.80	20.84	0.11
1.42	2.17	0.88	17.95	20.37	21.43	0.12
1.44	2.43	0.86	18.37	21.30	22.39	0.13
1.46	2.71	0.85	18.81	22.23	23.34	0.14
1.48	3.00	0.83	19.26	23.17	24.30	0.16
1.50	3.31	0.82	19.73	24.10	25.25	0.17
1.52	3.64	0.81	20.22	25.03	26.21	0.18
1.54	3.99	0.76	20.75	27.16	28.37	0.19
1.56	4.35	0.73	21.31	29.29	30.53	0.20
1.58	4.73	0.70	21.92	31.42	32.69	0.22
1.60	5.13	0.69	22.56	32.84	34.14	0.23
1.62	5.54	0.69	23.23	33.55	34.88	0.24
1.64	5.98	0.70	23.91	34.26	35.62	0.25
1.66	6.43	0.70	24.60	34.96	36.36	0.26
1.68	6.90	0.71	25.30	35.67	37.09	0.27
1.70	7.38	0.72	26.02	36.28	37.73	0.28
1.72	7.89	0.73	26.75	36.78	38.26	0.29
1.74	8.41	0.74	27.49	37.28	38.79	0.31
1.76	8.96	0.75	28.25	37.78	39.33	0.32
1.78	9.52	0.76	29.01	38.29	39.86	0.33
1.80	10.10	0.77	29.78	38.79	40.39	0.34

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.82	10.69	0.78	30.56	39.29	40.92	0.35
1.84	11.31	0.79	31.35	39.79	41.45	0.36
1.86	11.95	0.80	32.15	40.29	41.99	0.37
1.88	12.60	0.81	32.96	40.80	42.52	0.38
1.90	13.28	0.82	33.78	41.30	43.05	0.39
1.92	13.97	0.83	34.61	41.80	43.58	0.40
1.94	14.68	0.84	35.45	42.30	44.12	0.41
1.96	15.42	0.85	36.30	42.80	44.65	0.42
1.98	16.17	0.86	37.17	43.31	45.18	0.44
2.00	16.94	0.87	38.04	43.81	45.71	0.45
2.02	17.73	0.88	38.92	44.31	46.24	0.46
2.04	18.54	0.89	39.81	44.81	46.78	0.47
2.06	19.37	0.90	40.71	45.31	47.31	0.48
2.08	20.22	0.91	41.62	45.81	47.84	0.49
2.10	21.09	0.92	42.54	46.32	48.37	0.50
2.12	21.99	0.93	43.47	46.82	48.91	0.51
2.14	22.90	0.94	44.42	47.32	49.44	0.52
2.16	23.83	0.95	45.37	47.79	49.94	0.53
2.18	24.78	0.96	46.33	48.27	50.44	0.53
2.20	25.75	0.97	47.30	48.74	50.95	0.54
2.22	26.75	0.98	48.28	49.21	51.45	0.55
2.24	27.76	0.99	49.27	49.68	51.95	0.56
2.26	28.79	1.00	50.26	50.16	52.46	0.57
2.28	29.85	1.01	51.27	50.63	52.96	0.58
2.30	30.92	1.02	52.29	51.10	53.46	0.59
2.32	32.02	1.03	53.32	51.57	53.96	0.60
2.34	33.14	1.04	54.35	52.05	54.47	0.61
2.36	34.28	1.05	55.40	52.52	54.97	0.62
2.38	35.44	1.07	56.45	52.99	55.47	0.63
2.40	36.62	1.08	57.52	53.47	55.98	0.64
2.42	37.82	1.09	58.59	53.94	56.48	0.65
2.44	39.04	1.10	59.67	54.41	56.98	0.65
2.46	40.29	1.11	60.77	54.88	57.48	0.66
2.48	41.55	1.12	61.87	55.36	57.99	0.67
2.50	42.84	1.13	62.98	55.83	58.49	0.68
2.52	44.15	1.14	64.10	56.30	58.99	0.69
2.54	45.48	1.15	65.23	56.77	59.50	0.70
2.56	46.83	1.16	66.37	57.25	60.00	0.71
2.58	48.21	1.17	67.52	57.72	60.50	0.71
2.60	49.60	0.99	68.79	69.18	72.00	0.72
2.62	51.02	0.99	70.19	70.96	73.81	0.73
2.64	52.46	0.98	71.63	72.74	75.61	0.73
2.66	53.92	0.98	73.10	74.52	77.42	0.74
2.68	55.40	1.00	74.59	74.61	77.55	0.74
2.70	56.91	1.02	76.08	74.71	77.68	0.75
2.72	58.44	1.03	77.59	75.68	78.68	0.75
2.74	59.99	1.03	79.11	76.65	79.69	0.76
2.76	61.56	1.04	80.65	77.62	80.69	0.76
2.78	63.15	1.05	82.22	78.59	81.70	0.77
2.80	64.77	1.05	83.80	79.56	82.70	0.77
2.82	66.41	1.06	85.40	80.52	83.71	0.78
2.84	68.07	1.07	87.02	81.49	84.71	0.78
2.86	69.75	1.08	88.66	82.46	85.71	0.79
2.88	71.46	1.08	90.32	83.43	86.72	0.79

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
2.90	73.19	1.09	92.00	84.40	87.72	0.80
2.92	74.94	1.10	93.69	85.49	88.84	0.80
2.94	76.71	1.10	95.41	86.35	89.73	0.80
2.96	78.51	1.11	97.15	87.21	90.62	0.81
2.98	80.33	1.12	98.90	88.07	91.51	0.81
3.00	82.17	1.13	100.67	88.93	92.40	0.82

Table 13: Tabulated hydraulic data for EWR Site 5 cross-section 2 on the Klein Letaba River.

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.40	0.00	0.17	0.65	3.80	4.02	0.01
0.42	0.01	0.18	0.73	4.07	4.31	0.01
0.44	0.01	0.19	0.82	4.33	4.59	0.01
0.46	0.01	0.20	0.91	4.60	4.87	0.01
0.48	0.01	0.21	1.00	4.86	5.16	0.01
0.50	0.02	0.21	1.10	5.13	5.44	0.02
0.52	0.03	0.22	1.21	5.39	5.72	0.02
0.54	0.03	0.21	1.32	6.15	6.51	0.03
0.56	0.04	0.21	1.45	6.91	7.29	0.03
0.58	0.06	0.21	1.60	7.67	8.08	0.03
0.60	0.07	0.18	1.77	9.71	10.14	0.04
0.62	0.09	0.19	1.97	10.53	11.00	0.05
0.64	0.11	0.09	2.33	24.84	25.34	0.05
0.66	0.14	0.10	2.87	29.09	29.62	0.05
0.68	0.17	0.10	3.49	33.33	33.91	0.05
0.70	0.21	0.11	4.20	37.58	38.19	0.05
0.72	0.26	0.10	5.09	51.21	51.85	0.05
0.74	0.31	0.12	6.13	52.59	53.28	0.05
0.76	0.38	0.13	7.19	53.97	54.70	0.05
0.78	0.46	0.15	8.28	55.35	56.12	0.06
0.80	0.55	0.17	9.41	56.73	57.55	0.06
0.82	0.66	0.18	10.55	57.67	58.53	0.06
0.84	0.78	0.19	11.76	63.15	64.05	0.07
0.86	0.92	0.19	13.08	68.62	69.56	0.07
0.88	1.09	0.20	14.50	74.10	75.08	0.07
0.90	1.27	0.21	16.00	74.97	75.99	0.08
0.92	1.49	0.23	17.50	75.84	76.89	0.09
0.94	1.74	0.25	19.03	76.71	77.80	0.09
0.96	2.02	0.26	20.59	79.83	80.93	0.10
0.98	2.34	0.27	22.21	81.53	82.67	0.11
1.00	2.70	0.29	23.86	83.24	84.40	0.11
1.02	3.11	0.30	25.54	84.95	86.14	0.12
1.04	3.58	0.31	27.25	86.66	87.87	0.13
1.06	4.10	0.33	29.00	88.37	89.61	0.14
1.08	4.69	0.34	30.79	90.27	91.54	0.15
1.10	5.34	0.35	32.62	92.37	93.68	0.16
1.12	6.08	0.37	34.48	94.47	95.81	0.18
1.14	6.89	0.38	36.39	96.57	97.94	0.19
1.16	7.81	0.39	38.35	98.67	100.08	0.20
1.18	8.82	0.40	40.34	100.75	102.19	0.22
1.20	9.94	0.41	42.38	103.38	104.85	0.23
1.22	11.19	0.42	44.48	106.09	107.60	0.25
1.24	12.57	0.43	46.63	108.80	110.34	0.27

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.26	14.09	0.44	48.83	111.51	113.09	0.29
1.28	15.77	0.45	51.09	114.22	115.84	0.31
1.30	17.62	0.46	53.40	116.79	118.44	0.33
1.32	19.64	0.47	55.76	119.35	121.03	0.35
1.34	21.87	0.47	55.76	119.35	121.03	0.39
1.36	24.31	0.49	60.64	124.39	126.16	0.40
1.38	26.99	0.50	63.14	126.28	128.09	0.43
1.40	29.91	0.51	65.69	128.16	130.02	0.46
1.42	33.10	0.53	68.27	129.93	131.82	0.48
1.44	36.57	0.54	70.89	132.28	134.21	0.52
1.46	40.36	0.55	73.56	134.48	136.45	0.55
1.48	42.62	0.56	76.26	135.90	137.91	0.56
1.50	44.50	0.58	79.00	137.31	139.37	0.56
1.52	46.43	0.59	81.76	138.43	140.53	0.57
1.54	48.41	0.61	84.53	139.23	141.39	0.57
1.56	50.46	0.62	87.33	140.04	142.24	0.58
1.58	52.56	0.64	90.13	140.85	143.10	0.58
1.60	54.72	0.66	92.96	141.66	143.95	0.59
1.62	56.95	0.67	95.80	142.46	144.80	0.59
1.64	59.23	0.69	98.66	143.27	145.66	0.60
1.66	61.58	0.70	101.53	144.08	146.51	0.61
1.68	63.99	0.72	104.42	144.89	147.37	0.61
1.70	66.46	0.74	107.33	145.69	148.22	0.62
1.72	69.00	0.75	110.25	146.50	149.08	0.63
1.74	71.60	0.77	113.19	147.31	149.93	0.63
1.76	74.27	0.79	116.14	147.90	150.56	0.64
1.78	77.01	0.80	119.10	148.46	151.17	0.65
1.80	79.82	0.82	122.08	149.03	151.78	0.65
1.82	82.70	0.84	125.06	149.60	152.39	0.66
1.84	85.65	0.85	128.06	150.16	153.00	0.67
1.86	88.67	0.87	131.07	150.73	153.61	0.68
1.88	91.76	0.89	134.09	151.29	154.22	0.68
1.90	94.92	0.90	137.12	151.86	154.83	0.69
1.92	98.16	0.92	140.16	152.43	155.44	0.70
1.94	101.48	0.94	143.22	152.99	156.05	0.71
1.96	104.87	0.95	146.28	153.56	156.66	0.72
1.98	108.34	0.97	149.36	154.15	157.29	0.73
2.00	111.89	0.99	152.45	154.76	157.94	0.73

Table 14: Tabulated hydraulic data for EWR Site 5 cross-section 4 on the Klein Letaba River.

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.02	0.00	0.01	0.01	0.70	0.70	0.00
0.04	0.00	0.02	0.03	1.40	1.40	0.00
0.06	0.00	0.03	0.06	2.10	2.10	0.00
0.08	0.00	0.04	0.11	2.80	2.80	0.00
0.10	0.00	0.05	0.18	3.50	3.50	0.00
0.12	0.00	0.06	0.25	4.20	4.20	0.01
0.14	0.00	0.06	0.35	5.34	5.35	0.01
0.16	0.00	0.07	0.47	6.49	6.50	0.01
0.18	0.01	0.08	0.61	7.64	7.65	0.01
0.20	0.01	0.09	0.77	8.78	8.79	0.02

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.22	0.02	0.10	0.96	9.93	9.94	0.02
0.24	0.03	0.09	1.18	12.44	12.46	0.03
0.26	0.05	0.10	1.46	15.26	15.28	0.03
0.28	0.06	0.10	1.79	18.07	18.10	0.04
0.30	0.09	0.10	1.79	18.07	18.10	0.05
0.32	0.12	0.10	2.63	25.06	25.09	0.05
0.34	0.16	0.11	3.18	29.57	29.62	0.05
0.36	0.21	0.11	3.81	33.94	34.00	0.05
0.38	0.26	0.12	4.54	38.31	38.38	0.06
0.40	0.34	0.12	5.35	43.87	43.94	0.06
0.42	0.42	0.12	6.30	50.62	50.70	0.07
0.44	0.52	0.13	7.38	57.37	57.45	0.07
0.46	0.64	0.13	8.63	67.94	68.04	0.07
0.48	0.78	0.13	10.09	78.51	78.62	0.08
0.50	0.95	0.14	11.75	85.08	85.20	0.08
0.52	1.13	0.15	13.48	87.64	87.76	0.08
0.54	1.35	0.17	15.24	88.69	88.82	0.09
0.56	1.60	0.19	17.02	89.73	89.88	0.09
0.58	1.88	0.21	18.83	90.78	90.93	0.10
0.60	2.20	0.22	20.66	91.83	91.99	0.11
0.62	2.57	0.24	22.50	92.88	93.05	0.11
0.64	2.97	0.26	24.37	93.93	94.11	0.12
0.66	3.43	0.28	26.26	94.74	94.93	0.13
0.68	3.94	0.29	28.16	95.56	95.76	0.14
0.70	4.51	0.31	30.08	96.38	96.58	0.15
0.72	5.13	0.33	32.02	97.20	97.41	0.16
0.74	5.83	0.35	33.97	98.01	98.24	0.17
0.76	6.60	0.36	35.94	98.83	99.06	0.18
0.78	7.44	0.38	37.92	99.65	99.89	0.20
0.80	8.37	0.40	39.92	100.62	100.87	0.21
0.82	9.39	0.41	41.95	101.76	102.01	0.22
0.84	10.50	0.43	43.99	102.89	103.15	0.24
0.86	11.71	0.44	46.06	104.14	104.41	0.25
0.88	13.02	0.46	48.16	105.50	105.77	0.27
0.90	14.45	0.47	50.28	106.86	107.14	0.29
0.92	16.00	0.48	52.43	108.22	108.50	0.31
0.94	17.68	0.50	54.61	109.58	109.87	0.32
0.96	19.50	0.51	56.81	110.67	110.95	0.34
0.98	21.45	0.53	59.04	111.72	112.02	0.36
1.00	23.56	0.54	61.28	112.78	113.08	0.38
1.02	25.83	0.56	63.55	113.84	114.14	0.41
1.04	28.26	0.57	65.84	114.89	115.21	0.43
1.06	30.87	0.59	68.15	115.95	116.27	0.45
1.08	33.67	0.60	70.48	117.00	117.33	0.48
1.10	36.66	0.62	72.83	118.06	118.40	0.50
1.12	39.86	0.63	75.20	119.12	119.46	0.53
1.14	43.27	0.65	77.59	120.17	120.52	0.56
1.16	46.79	0.66	80.00	121.23	121.59	0.58
1.18	49.04	0.67	82.44	122.29	122.65	0.59
1.20	51.35	0.69	84.90	123.34	123.71	0.60
1.22	53.73	0.70	87.37	124.17	124.55	0.61
1.24	56.17	0.72	89.86	125.00	125.39	0.63
1.26	58.69	0.73	92.37	125.83	126.22	0.64
1.28	61.28	0.75	94.90	126.66	127.06	0.65

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.30	63.94	0.76	97.44	127.49	127.90	0.66
1.32	66.67	0.78	100.00	128.32	128.74	0.67
1.34	69.47	0.79	102.57	129.15	129.58	0.68
1.36	72.35	0.81	105.16	129.99	130.41	0.69
1.38	75.30	0.82	107.77	130.82	131.25	0.70
1.40	78.33	0.84	110.39	131.65	132.09	0.71
1.42	81.43	0.85	113.04	132.48	132.93	0.72
1.44	84.61	0.87	115.69	133.31	133.76	0.73
1.46	87.87	0.88	118.37	134.14	134.60	0.74
1.48	91.21	0.90	121.06	134.97	135.44	0.75
1.50	94.63	0.91	123.77	135.80	136.28	0.76
1.52	98.12	0.93	126.49	136.63	137.12	0.78
1.54	101.70	0.94	129.23	137.46	137.95	0.79
1.56	105.36	0.95	131.99	138.29	138.79	0.80
1.58	109.10	0.97	134.76	139.12	139.63	0.81
1.60	112.93	0.98	137.55	139.95	140.47	0.82
1.62	116.84	1.00	140.36	140.78	141.30	0.83
1.64	120.83	1.01	143.19	141.61	142.14	0.84
1.66	124.91	1.03	146.03	142.44	142.98	0.86
1.68	129.08	1.04	148.88	143.27	143.82	0.87
1.70	133.33	1.05	151.77	144.99	145.55	0.88
1.72	137.68	1.05	154.68	146.72	147.28	0.89
1.74	142.11	1.06	157.63	148.44	149.01	0.90
1.76	146.63	1.07	160.62	150.17	150.74	0.91
1.78	151.24	1.08	163.64	151.89	152.47	0.92
1.80	155.94	1.09	166.70	153.61	154.20	0.94
1.82	160.73	1.09	169.79	155.34	155.93	0.95
1.84	165.62	1.10	172.91	157.06	157.66	0.96
1.86	170.60	1.11	176.07	158.96	159.57	0.97
1.88	175.67	1.11	179.27	161.03	161.65	0.98
1.90	180.84	1.12	182.51	163.11	163.72	0.99
1.92	186.10	1.12	185.79	165.18	165.80	1.00
1.94	191.46	1.14	189.10	165.92	166.55	1.01
1.96	196.91	1.15	192.43	166.66	167.29	1.02
1.98	202.47	1.17	195.77	167.40	168.04	1.03
2.00	208.12	1.18	199.13	168.14	168.78	1.05

Table 15: Tabulated hydraulic data for EWR Site 5 cross-section 5 on the Klein Letaba River.

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.02	0.00	0.01	0.00	0.30	0.30	0.00
0.04	0.00	0.02	0.01	0.60	0.61	0.01
0.06	0.00	0.02	0.03	1.81	1.82	0.01
0.08	0.00	0.02	0.09	3.92	3.93	0.01
0.10	0.00	0.03	0.19	6.03	6.05	0.01
0.12	0.01	0.04	0.33	7.97	7.99	0.02
0.14	0.01	0.02	0.51	20.41	20.44	0.02
0.16	0.02	0.04	0.94	23.25	23.28	0.02
0.18	0.03	0.05	1.44	26.12	26.16	0.02
0.20	0.04	0.07	1.99	28.99	29.03	0.02
0.22	0.07	0.06	2.76	43.33	43.38	0.02
0.24	0.09	0.08	3.68	48.72	48.77	0.03
0.26	0.13	0.09	4.70	54.11	54.16	0.03

Flow depth (m)	**Discharge (m^3/s)**	**Av. flow depth (m)**	**Area (m^2)**	**Width (m)**	**Perimeter (m)**	**Av. velocity (m/s)**
0.28	0.17	0.10	5.82	57.79	57.85	0.03
0.30	0.23	0.11	7.02	61.48	61.54	0.03
0.32	0.29	0.13	8.28	65.17	65.23	0.04
0.34	0.37	0.14	9.62	68.86	68.92	0.04
0.36	0.47	0.15	11.04	72.27	72.34	0.04
0.38	0.58	0.17	12.50	73.75	73.82	0.05
0.40	0.71	0.19	13.99	75.22	75.31	0.05
0.42	0.87	0.20	15.50	76.70	76.79	0.06
0.44	1.05	0.22	17.05	78.18	78.28	0.06
0.46	1.25	0.23	18.63	80.18	80.28	0.07
0.48	1.48	0.25	20.26	82.69	82.81	0.07
0.50	1.75	0.26	21.93	83.96	84.09	0.08
0.52	2.04	0.28	23.62	85.24	85.38	0.09
0.54	2.37	0.29	25.34	86.51	86.67	0.09
0.56	2.75	0.30	27.10	90.07	90.24	0.10
0.58	3.16	0.31	28.93	92.73	92.92	0.11
0.60	3.62	0.32	30.81	95.40	95.60	0.12
0.62	4.13	0.33	32.75	98.07	98.28	0.13
0.64	4.69	0.34	34.74	100.80	101.03	0.13
0.66	5.30	0.36	36.78	103.60	103.84	0.14
0.68	5.97	0.37	38.88	106.40	106.65	0.15
0.70	6.71	0.38	41.03	108.22	108.48	0.16
0.72	7.51	0.40	43.21	109.07	109.34	0.17
0.74	8.37	0.41	45.39	109.92	110.20	0.18
0.76	9.32	0.43	47.60	110.76	111.06	0.20
0.78	10.34	0.45	49.83	111.68	111.99	0.21
0.80	11.44	0.46	52.07	112.43	112.75	0.22
0.82	12.63	0.48	54.32	113.18	113.50	0.23
0.84	13.90	0.50	56.59	113.93	114.25	0.25
0.86	15.28	0.51	58.88	114.68	115.01	0.26
0.88	16.75	0.53	61.18	115.42	115.76	0.27
0.90	18.32	0.55	63.50	116.40	116.75	0.29
0.92	20.01	0.56	65.84	117.62	117.97	0.30
0.94	21.80	0.57	68.20	118.84	119.19	0.32
0.96	23.72	0.59	70.59	120.05	120.41	0.34
0.98	25.76	0.60	73.01	121.27	121.63	0.35
1.00	27.93	0.62	75.44	122.48	122.85	0.37
1.02	30.23	0.63	77.90	123.70	124.07	0.39
1.04	32.67	0.64	80.39	124.92	125.29	0.41
1.06	35.26	0.66	82.90	126.13	126.50	0.43
1.08	38.00	0.67	85.44	127.35	127.72	0.44
1.10	40.89	0.69	87.99	128.35	128.73	0.46
1.12	43.95	0.70	90.57	129.35	129.74	0.49
1.14	47.17	0.71	93.17	130.36	130.75	0.51
1.16	50.57	0.73	95.78	131.36	131.76	0.53
1.18	55.56	0.74	98.42	132.37	132.77	0.56
1.20	58.10	0.76	101.08	133.33	133.75	0.57
1.22	60.71	0.77	103.75	134.30	134.72	0.59
1.24	63.39	0.79	106.45	135.27	135.69	0.60
1.26	66.14	0.80	109.17	136.23	136.67	0.61
1.28	68.96	0.82	111.90	137.20	137.64	0.62
1.30	71.86	0.83	114.65	138.17	138.61	0.63
1.32	74.84	0.84	117.43	139.13	139.58	0.64
1.34	77.88	0.86	120.22	140.10	140.56	0.65

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.36	81.01	0.87	123.03	141.07	141.53	0.66
1.38	84.21	0.89	125.86	142.03	142.50	0.67
1.40	87.49	0.90	128.71	143.00	143.48	0.68
1.42	90.85	0.91	131.58	143.97	144.45	0.69
1.44	94.29	0.93	134.47	144.93	145.42	0.70
1.46	97.81	0.94	137.38	145.90	146.40	0.71
1.48	101.41	0.95	140.31	147.32	147.83	0.72
1.50	105.09	0.96	143.27	149.20	149.71	0.73
1.52	108.85	0.97	146.28	151.08	151.60	0.74
1.54	112.70	0.98	149.32	152.97	153.49	0.75
1.56	116.63	0.98	152.39	154.85	155.37	0.77
1.58	120.64	0.99	155.51	156.73	157.26	0.78
1.60	124.74	1.00	158.66	158.61	159.15	0.79
1.62	128.92	1.01	161.85	160.49	161.04	0.80
1.64	133.20	1.02	165.08	162.37	162.92	0.81
1.66	137.55	1.02	168.35	164.25	164.81	0.82
1.68	142.00	1.03	171.65	166.13	166.70	0.83
1.70	146.53	1.05	174.98	166.30	166.87	0.84
1.72	151.16	1.07	178.31	166.46	167.04	0.85
1.74	155.87	1.09	181.64	166.63	167.21	0.86
1.76	160.67	1.11	184.97	166.79	167.38	0.87
1.78	165.57	1.13	188.31	166.96	167.55	0.88
1.80	170.56	1.14	191.65	167.43	168.03	0.89
1.82	175.64	1.16	195.01	168.21	168.81	0.90
1.84	180.81	1.17	198.38	169.00	169.60	0.91
1.86	186.08	1.19	201.77	169.78	170.39	0.92
1.88	191.44	1.20	205.17	170.56	171.17	0.93
1.90	196.90	1.22	208.59	171.34	171.96	0.94
1.92	202.45	1.23	212.02	172.13	172.74	0.95
1.94	208.10	1.25	215.47	172.91	173.53	0.97
1.96	213.85	1.26	218.94	173.69	174.32	0.98
1.98	219.69	1.27	222.42	174.47	175.10	0.99
2.00	225.63	1.29	225.92	175.26	175.89	1.00

Table 16: Tabulated hydraulic data for EWR Site 6 cross-section 2 on the Letaba River.

Discharge (m^3/s)	Flow depth (m)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)	Flow depth[A] (m)	Av. Velocity[A] (m/s)
0.01	0.22	0.17	1.85	11.12	11.21	0.00	0.05	0.03
0.01	0.24	0.18	2.07	11.33	11.42	0.01	0.06	0.04
0.02	0.26	0.20	2.30	11.54	11.64	0.01	0.07	0.05
0.03	0.28	0.22	2.54	11.74	11.85	0.01	0.07	0.05
0.04	0.30	0.23	2.77	11.95	12.07	0.01	0.08	0.06
0.05	0.32	0.25	3.01	12.16	12.28	0.02	0.09	0.08
0.07	0.34	0.26	3.26	12.36	12.50	0.02	0.10	0.09
0.09	0.36	0.28	3.51	12.57	12.71	0.03	0.11	0.11
0.12	0.38	0.28	3.77	13.56	13.71	0.03	0.12	0.12
0.16	0.40	0.26	4.06	15.64	15.80	0.04	0.13	0.14
0.20	0.42	0.25	4.39	17.80	17.97	0.05	0.14	0.15
0.26	0.44	0.25	4.77	19.29	19.47	0.05	0.15	0.16
0.32	0.46	0.26	5.16	20.21	20.40	0.06	0.16	0.19
0.40	0.48	0.26	5.57	21.14	21.33	0.07	0.17	0.21
0.49	0.50	0.27	6.01	21.91	22.11	0.08	0.19	0.25
0.60	0.52	0.29	6.45	22.60	22.81	0.09	0.20	0.27

Discharge (m^3/s)	Flow depth (m)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)	Flow depth[A] (m)	Av. Velocity[A] (m/s)
0.73	0.54	0.28	6.92	24.63	24.84	0.11	0.21	0.29
0.88	0.56	0.29	7.43	25.82	26.05	0.12	0.22	0.32
1.05	0.58	0.26	7.99	31.12	31.35	0.13	0.23	0.34
1.25	0.60	0.24	8.67	35.52	35.76	0.14	0.25	0.39
1.48	0.62	0.25	9.39	36.89	37.13	0.16	0.26	0.42
1.73	0.64	0.27	10.14	38.25	38.50	0.17	0.27	0.44
2.03	0.66	0.27	10.92	39.96	40.23	0.19	0.29	0.49
2.36	0.68	0.28	11.74	42.03	42.31	0.20	0.30	0.52
2.73	0.70	0.28	12.61	45.17	45.45	0.22	0.32	0.58
3.15	0.72	0.28	13.55	48.31	48.60	0.23	0.33	0.61
3.62	0.74	0.28	14.54	51.45	51.75	0.25	0.35	0.67
4.15	0.76	0.29	15.60	54.59	54.89	0.27	0.36	0.70
4.73	0.78	0.29	16.73	57.73	58.04	0.28	0.38	0.76
5.38	0.80	0.29	17.92	61.75	62.07	0.30	0.39	0.79
6.10	0.82	0.29	19.20	67.16	67.49	0.32	0.41	0.85
6.89	0.84	0.26	20.66	78.14	78.48	0.33	0.42	0.89
7.77	0.86	0.27	22.28	81.95	82.30	0.35	0.44	0.96
8.73	0.88	0.28	23.96	86.50	86.87	0.36	0.46	1.02
9.78	0.90	0.29	25.69	87.28	87.68	0.38	0.47	1.06
10.94	0.92	0.31	27.45	88.05	88.48	0.40	0.49	1.13
12.20	0.94	0.33	29.22	88.68	89.13	0.42	0.51	1.20
13.57	0.96	0.35	30.99	89.25	89.72	0.44	0.52	1.24
15.07	0.98	0.37	32.79	89.82	90.31	0.46	0.54	1.31
16.70	1.00	0.38	34.59	90.51	91.03	0.48	0.56	1.38
18.46	1.02	0.40	36.41	91.21	91.75	0.51	0.58	1.45
20.38	1.04	0.42	38.24	91.90	92.47	0.53	0.59	1.49
22.44	1.06	0.43	40.08	92.60	93.19	0.56	0.61	1.56
24.68	1.08	0.45	41.94	93.30	93.92	0.59	0.63	1.64
27.09	1.10	0.47	43.81	94.00	94.64	0.62	0.65	1.72
29.68	1.12	0.48	45.70	94.70	95.36	0.65	0.67	1.79
32.47	1.14	0.50	47.60	95.39	96.08	0.68	0.69	1.87
35.47	1.16	0.52	49.52	96.09	96.81	0.72	0.71	1.94
38.68	1.18	0.53	51.44	96.79	97.53	0.75	0.73	2.01
42.13	1.20	0.55	53.39	97.61	98.37	0.79	0.75	2.09
45.82	1.22	0.56	55.35	98.65	99.43	0.83	0.77	2.23
49.76	1.24	0.57	57.34	99.88	100.67	0.87	0.79	2.30
53.97	1.26	0.59	59.35	101.11	101.92	0.91	0.81	2.30
58.46	1.28	0.60	61.38	102.34	103.17	0.95	0.83	2.37
63.25	1.30	0.61	63.44	103.99	104.84	1.00	0.85	2.43
68.34	1.32	0.62	65.54	106.34	107.20	1.04	0.87	2.50
73.76	1.34	0.62	67.69	108.69	109.55	1.09	0.89	2.37
79.53	1.36	0.63	69.89	111.04	111.91	1.14	0.91	2.63

4.4 HABITAT TYPE ABUNDANCE ASSESSMENTS AND VELOCITY DISTRIBUTION INFORMATION

A method of using standard hydraulic information as the basis for quantifying habitat types for fish is described in the methodology (Section 1.1, Appendix A 2). The method was still in a stage of development when the first specialist meeting took place. Therefore only the results of EWR Site 6 that were analysed during the second specialist meeting are provided (Table 17). Velocity distribution information using the distribution model of Lamouroux et al (1995) is provided in Table 18 to 24.

Table 17: Ratings of habitat type abundance for EWR Site 6 on the Letaba River.

Discharge (m^3/s)	Ecologist assessment (on-site)				Hydraulic rating (calculated)				Final rating			
	SS	SD	FS	FD	SS	SD	FS	FD	SS	SD	FS	FD
0.15	5	2	1	0	5.0	0.0	3.6	3.6	5	1	1	0
0.26	4	2	2	0	5.0	5.0	5.0	5.0	4	1	2	0
0.60	4	3	3	2	5.0	1.5	5.0	0.0	4	3	3	0
1.95	4	3	4	2	5.0	3.3	3.8	5.0	4	3	4	1
6.10	4	4	4	4	5.0	3.3	1.6	1.6	4	4	4	4
6.83	4	5	4	5	5.0	3.6	1.8	1.8	4	5	4	5

Table 18: Velocity distributions for EWR Site 1 cross-section 2 (Riffle).

Discharge (m^3/s)	Average velocity (m/s)	Lamouroux *et al* (1995)			
		Max. velocity (m/s)	Frequency (%) of velocity (m/s)		
			=0.1	=0.3	=0.6
0.01	0.06	0.10-0.15	40	100	100
0.023	0.07	0.20-0.25	68	100	100
0.06	0.13	0.35-0.40	60	92	100
0.177	0.21	0.60-0.65	41	77	98
0.264	0.25	0.70-0.75	35	68	96
0.614	0.33	0.95-1.00	24	52	88

Table 19: Velocity distributions for EWR Site 2 cross-section 1 (Run).

Discharge (m^3/s)	Average velocity (m/s)	Lamouroux *et al* (1995)			
		Max. velocity (m/s)	Frequency (%) of velocity (m/s)		
			=0.1	=0.3	=0.6
0.032	0.03	0.05-0.10	100	100	100
0.087	0.05	0.10-0.15	88	100	100
0.156	0.08	0.20-0.25	67	100	100
0.820	0.20	0.55-0.60	30	79	100
1.460	0.26	0.70-0.75	22	62	97

Table 20: Velocity distributions for EWR Site 2 cross-section 2 (Riffle).

Discharge (m^3/s)	Average velocity (m/s)	Lamouroux *et al* (1995)			
		Max. velocity (m/s)	Frequency (%) of velocity (m/s)		
			=0.1	=0.3	=0.6
0.032	0.09	0.20-0.25	64	100	100
0.087	0.11	0.30-0.35	52	97	1000
0.156	0.14	0.35-0.40	42	95	100
0.820	0.21	0.60-0.65	28	76	99
1.460	0.25	0.65-0.70	23	65	97

Table 21: Velocity distributions for EWR Site 4 cross-section 1 (Riffle).

Discharge (m^3/s)	Average velocity (m/s)	Lamouroux *et al* (1995)			
		Max. velocity (m/s)	Frequency (%) of velocity (m/s)		
			=0.1	=0.3	=0.6
0.047	0.28	0.70-0.75	20	57	95
0.077	0.317	0.80-0.85	17	49	91
0.305	0.54	1.30-1.40	6	21	56
0.915	0.87	2.00-2.20	0	6	92
1.930	1.19	2.70-3.00	0	1	10
3.700	1.57	3.60-3.90	0	0	2

Table 22: Velocity distributions for EWR Site 5 cross-section 2.

Discharge	Average velocity	Lamouroux *et al* (1995)

(m^3/s)	(m/s)	Max. velocity (m/s)	Frequency (%) of velocity (m/s)		
			=0.1	=0.3	=0.6
0.005	0.008	0.01-0.02	100	100	100
0.013	0.013	0.03-0.04	100	100	100
0.031	0.025	0.07-0.08	100	100	100
0.089	0.045	0.12-0.14	92	100	100
0.336	0.052	0.14-0.16	88	100	100
0.523	0.056	0.14-0.16	87	100	100

Table 23: Velocity distributions for EWR Site 5 cross-section 4.

Discharge (m^3/s)	Average velocity (m/s)	Lamouroux *et al* (1995)			
		Max. velocity (m/s)	Frequency (%) of velocity (m/s)		
			=0.1	=0.3	=0.6
0.005	0.010	0.02-0.04	100	100	100
0.013	0.017	0.04-0.05	100	100	100
0.031	0.027	0.07-0.08	100	100	100
0.089	0.049	0.14-0.15	90	100	100
0.336	0.063	0.16-0.18	83	100	100
0.523	0.071	0.20-0.22	76	100	100

Table 24: Velocity distributions for EWR Site 6 cross-section 2 active channel (Riffle).

Discharge (m^3/s)	Average velocity (m/s)	Lamouroux *et al* (1995)			
		Max. velocity (m/s)	Frequency (%) of velocity (m/s)		
			=0.1	=0.3	=0.6
0.15	0.135	0.30-0.40	39	95	100
0.26	0.160	0.40-0.50	33	89	100
0.60	0.270	0.70-0.80	19	59	96
1.95	0.490	1.20-1.30	7	25	63
6.10	0.850	1.80-2.10	1	7	26
6.83	0.890	2.10-2.40	1	7	24

5. CONFIDENCE IN THE HYDRAULIC CHARCATERISATIONS

The confidence in the characterisations of the hydraulic relationships related to measured and recommended flows is provided in Table 25.

Table 25: Confidence in the hydraulic characterisations

Site no.	Site character	Available data	Reference to PES or recommended EC	
			Low flows	**High flows**
1	3.5	3	4	3
Measured flows of 0.260 and 2.200 m^3/s. DWAF estimated flood (2000) of 200-300m^3/s. Recommended low-flows are in the range 0.010 to 0.614 m^3/s and high flows in the range 1.2 to 94 m^3/s.				
2	3	3	4	3
Measured flows of 0.080 and 6.225 m^3/s. DWAF estimated flood (2000) of 500m^3/s Recommended low-flows are in the range 0.032 to 1.46 m^3/s and high flows in the range 2.5 to 15 m^3/s.				
4	2.5	3	4	2.5
Measured flow of 0.141 and 110.8 m^3/s. DWAF estimated flood (2000) of 5000-5500m^3/s Recommended low-flows are in the range 0.047to 3.700 m^3/s and high flows in the range 4-1000 m^3/s.				
5	2	2.5	2.5-3	2.5-3
Measured flows of 0.024 and 42.00 m^3/s. DWAF estimated flood (2000) of 2050-2500m^3/s Recommended low-flows are in the range 0.005 to 0.523 m^3/s and high flows in the range 8 to 480m^3/s.				
6	2	3	3	2
Measured flows of 0.150 and 85.00 m^3/s. DWAF estimated flood (2000) of 7000m^3/s Recommended low-flows are in the range 0.150 to 6.83 m^3/s and high flows in the range 5 to 300 m^3/s.				

Confidence rating: 0=none, 1=low, 2=low/medium, 3=medium, 4=medium/high, 5=high
PES: Present Ecological State
EC: Ecological Category

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APPENDIX 1
HYDRAULIC MODELLING

ABBREVIATIONS AND ACRONYMS

CWE	Centre for Water in the Environment
DTM	Digital Terrain Model
DWAF	Department of Water Affairs and Forestry
Eamsl	Elevation above mean sea level
EC	Ecological Category
EWR	Ecological Water Requirement
FS-R	Flow Stressor-Response
H-FS-R	Habitat-Flow Stressor-Response
PES	Present Ecological State
RDM	Resource Directed Measures
3D Spatial	Three-dimensional Spatial model

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1. INTRODUCTION AND AIMS OF THIS REPORT

The role of hydraulics and procedure for generating hydraulic information for ecological reserve studies have been documented for the Comprehensive and Intermediate levels of determination (DWAF, 1999), with subsequent periodic updates (Birkhead, 2002 and Jordanova *et al*, in press). This report provides the hydraulic information (data collection and modelling) for EWR Sites 3 and 7 for the Letaba Ecological Reserve study. The remaining four sites are covered in Appendix A1.

A brief explanation of more recent developments in the analysis and use of hydraulic information is presented first in Section 1.1.

2. METHODOLOGY

The application of holistic methods for ecological flow determination (refer to Tharme, 1996) requires water requirements to be expressed as discharge rates (including its temporal characteristics) through assessments of the presence of suitable habitat for certain biota at different flows. The interface between the way in which flow requirements are assessed and expressed is through the results of hydraulic measurements, analyses and modelling of sites along rivers. The primary product of these hydraulic analyses are relationships between discharge and the following determinants, which have been found over the course of numerous flow assessments, to be the most useful: depth (maximum and average), velocity (average), wetted perimeter, and width of the water surface. The discharge-depth (or rating) relationship is fundamental to hydraulic analysis, and is generally derived from a combination of measured and synthesized data (refer to Rowlston *et al* (2000) and Birkhead (2002) for descriptions of procedures for deriving hydraulic information for use in ecological flow requirements (or Reserves) in South Africa). Once the rating relationship for a river section has been developed, the relationships between discharge and the other hydraulic parameters (listed above) may readily be computed using the cross-sectional geometry, and are generally provided in tabular format using look-up tables (see Section 4.3).

The cross-sectional profile plots and look-up tables comprise the "standard hydraulic data" used in Reserve determinations in South Africa at the Rapid III, Intermediate and Comprehensive levels. Ecologists use these standard hydraulic data with the aid of site assessments, photographs and video exposure, to determine the quantity and quality of hydraulic habitat at different flows. Substantial experience and interpretation are required to provide assessments of site-based and reach-based biological habitats using cross-sectional surveys and the results of one-dimensional hydraulic analyses (biological habitat refers to the integration of the different components defining habitat (eg. hydraulic, substrate and cover attributes for fish)). For this reason, a procedure has been developed for using standard hydraulic information as the basis for quantifying hydraulic habitat for fish (refer to Jordanova *et al* (in press) for a detailed explanation of the method). The method allows the assessment of abundance of different habitat types to be applied more consistently in Reserve determinations.

Procedure for assessing the habitat flow response of fish

The procedure applies the concept of hydraulic habitat types (or classes) in the determination of ecological flows for fish using the FS-R methodology. It differs from the original FS-R method

(O'Keeffe et al, 2002; O'Keeffe and Hughes, 2004) in that the hydraulic habitat is interpreted in terms of biological habitat requirements (eg. fish), and should preferably be referred to the Habitat-Flow Stressor-Response (H-FS-R) method. It is a working method, and will benefit from future development and refinement by applied research and during the course of future ecological Reserve assessments. There has been a need to further develop the role of hydraulics in flow assessments for fish, which applies an integrated assessment of hydraulic habitat through the use of different habitat types. These types have been defined using two basic hydraulic parameters, depth (D) and depth-averaged velocity (V), as suggested by Kleynhans (1999). Water surface width or perimeter is also incorporated as a scaling factor. Together with substrate and vegetation cover information, these parameters are sufficient to broadly describe fish habitat. Further, Kleynhans suggests that velocity and depth need only be specified coarsely, and has proposed the following four velocity-depth classes (hydraulic habitat types), as adapted from Oswood and Barber (1982):

- Slow (<0.3 m/s) and shallow (<0.5 m): This includes shallow pools and backwaters.
- Slow (<0.3 m/s) and deep (>0.5m): This includes deep pools and backwaters.
- Fast (>0.3 m/s) and shallow (<0.3 m): Shallow runs, rapids and riffles fall in this class
- Fast (>0.3 m/s) and deep (>0.3 m): Deep runs, rapids and riffles fall under this class.

A graphical representation of the velocity-depth domain and its division into four classes is provided in Figure 1.

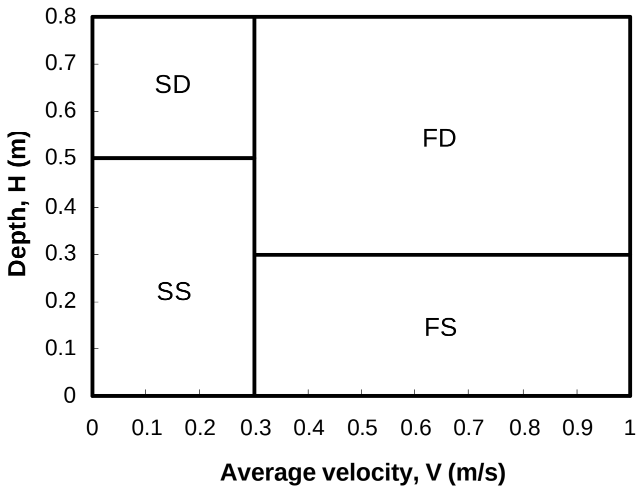

Figure 1: Kleynhans (1999) hydraulic habitat descriptions for fish (SS=slow and shallow, SD=slow and deep, FS= fast and shallow, FD=fast and deep). The velocity and depth axes are truncated for plotting purposes at 0.8 and 1.0, respectively.

Although the procedure (described below) has been developed within the context of the H-FS-R ecological flow assessment methodology, it is applicable for use in other holistic flow determination methods (eg. DRIFT – Downstream Response to Imposed Flow Transformation) that require a quantitative assessment of habitat suitability and abundance at different flows.

The method involves the follow three steps:

1 Rating observed habitat- type abundance

The first step in the method is the site scoring of the four habitat types defined for fish, taking cognisance of the substrate, cover and water column features provided at the site. The presence of these hydraulic habitat types is quantified using a relative abundance scale with associated proportional percentage occurrence, an example of which is given in Table 1.

Table 1: Abundance scorings of habitat types for fish

Descriptor	Score	Occurrence (%)
None	0	0
Rare	1	0-10
Sparse	2	10-30
Moderate	3	30-60
Abundant	4	60-80
Very abundant	5	80-100

The on-site assessment is best undertaken jointly by the hydraulician and fish ecologist, since it provides an opportunity for the specialists to develop an appreciation and understanding of relevant influences from the related disciplines. Secondly, the hydraulician is required to collect hydraulic data during the course of flow assessment studies, and it would be valuable to provide habitat type abundance scorings for each of these (since they are associated with a measured discharge rate). Although this assessment is subjective, it provides valuable information to compliment the abundance scorings of hydraulic habitat type from more quantitative hydraulic modelling.

2 Modelling hydraulic habitat information

Riverine biota including fish, macroinvertebrates and vegetation display strong preferences for certain values of water depth, velocity, and bed shear stress, or combinations of these hydraulic variables (Lamouroux, 1998). Hydraulic descriptions used by ecologists differ from traditional hydraulic applications: river biota responds to sets of point hydraulic variables, whereas traditional hydraulic engineering has been concerned with larger spatial scales (eg. flood analyses). Modelling point hydraulic variables in river reaches at low-flows with large resistance elements using high resolution multi-dimensional hydraulic modelling is imprecise and requires accurate topographical information (Lamouroux, 1998). An alternative method for providing this information is by modelling characteristic spatial-probability distributions of hydraulic parameters to describe typical variability in hydraulic habitats. The standard hydraulic information synthesized for a cross-section is used to represent average values for the morphological feature (eg. rapid, riffle, pool, etc.), and can therefore be used to estimate typical depth and velocity distributions. Methods for predicting distributions of the two ecologically relevant hydraulic parameters of depth and velocity are described in the following sections:

3 Predicting frequency-depth distributions

The frequency-occurrence of flow depth may be computed using surveyed cross-sectional profiles and associated rating function to provide measurement-based data. For a specified maximum depth (and related discharge), the actual depths along a cross-section are computed at equal distance increments. This is preferable to using actual surveyed ordinates across the river bed, since these are usually measured at changes in slope and with a higher density of bed elevations in the low-flow channel (ie. not valid data for a statistical analysis). The range of depths (zero to maximum) along cross-sections are divided into equal depth class increments, and the frequency of occurrence of depths less than and greater than the threshold values (ie. 0.3m and 0.5m used to distinguish between shallow and deep habitat for fast and slow velocities, respectively). If a three-dimensional spatial model has been set-up, frequency distributions of depth may be more accurately determined by calculating the proportion of inundated area that is shallow or deep (refer to Section 5).

4 Predicting probability-velocity distributions

Of the available velocity distribution models in the literature, the model of Lamouroux *et al* (1995) appears to be the most robust and tested (Jordanova *et al*, in press). A drawback, however, is that the model has been developed for pool-riffle sequences and not homogeneous geomorphological features. The velocity distribution model of Lamouroux *et al* (1995) requires estimates of average depth, average velocity and dominant bed roughness. The first two parameters are available from the standard hydraulic (cross-sectional) information. The dominant bed roughness is defined as the roughness element occupying the largest fraction of the bed, which may be determined from a visual assessment of the bed, or preferably from measured sediment size distributions (the size occupying the largest fraction of the bed is computed from the product of the projected sediment area and its frequency of occurrence).

5 Predicting habitat-type abundance as a function of discharge

An example of predicted frequency-depth and probability-velocity distributions for a riffle are given in Table 2. The maximum and average depth, average velocity, and perimeter are obtained from the standard hydraulic analysis. The analysis is undertaken for a range of discharges (in the low-flow range), including measured values for which site assessments and/or photographs exist (indicated by the shaded rows in Table 2). Experience with measuring velocities in riffle and rapid morphologies has indicated that the maximum value is generally 2 to 3 times the average, and this information has been used by ecologists during previous flow assessments. The velocity distribution model of Lamouroux *et al* (1995) supports this field-based experience, with maximum estimates approximately three times the average (refer to Table 2), and approximately 10% of the velocities are greater than twice the average value.

Using depth and velocity distributions (Table 2), the probability of occurrence for each habitat-type category (expressed as a percentage) may be assessed by assuming that depth and velocity are mutually exclusive parameters. Based on this assumption, the overall abundance of a habitat type is calculated by the product of the individual frequencies or probabilities. At low flows, the hydraulic habitat may be dominated by a particular habitat type (generally slow/shallow for riffles, eg. in Table 2), but the corresponding river size may represent only a small proportion of the active channel size. To account for river scale, the habitat-type probabilities are proportioned using the relative perimeter, which is defined as the ratio of the perimeter to the value where the active channel bed becomes inundated. The active channel perimeter may be determined by an inflection on the perimeter-discharge plot. The abundance of hydraulic habitat type is converted from probability of occurrence to relative numeric values (or scores) in the range 0 to 5 using a scoring system such as that given in Table 1.

Table 3 provides an example of site abundance assessments for measured discharges as well as predictions based on the hydraulic modelling described above. It is necessary to reconcile the observed site assessments with values determined from modelling to provide a final assessment. Reasons for differences include the subjectivity inherent with site observations, the use of cross-sectional specific data to represent characteristic hydraulic habitat, and the use of a reach-based velocity distribution model. Agreement in the abundance scorings derived from the hydraulic predictions and site evaluations needs to take cognisance of the above considerations. Measured flows are generally accompanied by site photographs, which provide additional visual information to verify the modelled predictions as well as the extent and suitability of cover. Hydraulic modelling forms the basis for interpolating between assessments based on observation as well as extending the discharge range. The assessments should consider the range of morphologies and hydraulic conditions (ie. both rapid/riffle and pool) to ensure that the habitat-types present are covered by the analysis.

The abundances may also be expressed in terms of the amount of channel perimeter contributed by each of the habitat-type classes (eg. Table 4). This has been used in the DRIFT flow determination method to present hydraulic information.

In the H-FS-R method, a simplified habitat suitability index for a particular “target” species or group of species is used to represent the habitat stress response index (refer to Jordanova *et al*, in press). The suitability of the habitat (velocity-depth class, substrate and cover) under known (observed) and modelled flow conditions is scored for each of the following components: breeding, survival and abundance, cover, health, and water quality.

Table 2: Example of modelled habitat-type frequency distributions for a riffle

Discharge (m^3/s)	Depth, *D* (m)						Velocity, *v* (m/s)				Perimeter (m)	Habitat abundance (HA) (%)				Perimeter factored HA (%)			
												SS	SD	FS	FD	SS	SD	FS	FD
	Max.	Ave.	%<0.5	%>0.5	%<0.3	%>0.3	Ave.	Max.	%<0.3	%>0.3		V<0.3 D<0.5	V<0.3 D>0.5	V>0.3 D<0.3	V>0.3 D>0.3	V<0.3 D<0.5	V<0.3 D>0.5	V>0.3 D<0.3	V>0.3 D>0.3
0.05	0.36	0.16	100	0	94	6	0.02	<0.05	100	0	13.4	100	0	0	0	84	0	0	0
0.24	0.44	0.22	100	0	71	29	0.07	0.2	100	0	15.1	100	0	0	0	94	0	0	0
0.44	0.48	0.25	100	0	58	42	0.11	0.3	100	0	15.7	100	0	0	0	98	0	0	0
1.16	0.56	0.32	97	3	45	55	0.25	0.7	68	32	16.7	66	2	14	18	69	2	15	18
2.82	0.63	0.34	84	16	32	68	0.48	1.4	36	64	18.9	30	6	20	44	36	7	24	51
4.36	0.70	0.38	66	34	30	70	0.63	1.8	25	75	20.6	17	9	23	53	21	11	29	68

Table 3: Rated habitat-type abundances using the relative scale in Table 1

Discharge (m^3/s)	Ecologists site assessment				Hydraulic prediction				Final assessment			
	SS	SD	FS	FD	SS	SD	FS	FD	SS	SD	FS	FD
	V<0.3 D<0.5	V<0.3 D>0.5	V>0.3 D<0.3	V>0.3 D>0.3	V<0.3 D<0.5	V<0.3 D>0.5	V>0.3 D<0.3	V>0.3 D>0.3	V<0.3 D<0.5	V<0.3 D>0.5	V>0.3 D<0.3	V>0.3 D>0.3
0.05					5	5	0	0	3	5	0	0
0.24	4	5	2	0	5	5	0	0	4	5	1	0
0.44	3	5	3	1	5	5	0	0	4	5	2	1
1.16	3	5	4	2	4	5	2	2	3	5	3	2
2.82	2	5	3	3	3	5	2	3	3	5	3	3
4.36	2	5	1	4	2	5	2	4	2	5	2	4

Table 4: Modelled habitat-type abundances

Discharge (m^3/s)	Perimeter (m)			
	SS	SD	FS	FD
	V<0.3 D<0.5	V<0.3 D>0.5	V>0.3 D<0.3	V>0.3 D>0.3
0.05	13.4	0.0	0.0	0.0
0.24	15.1	0.0	0.0	0.0
0.44	15.7	0.0	0.0	0.0
1.16	11.0	0.3	2.4	2.9
2.82	5.7	1.1	3.9	8.2
4.36	3.4	1.8	4.6	10.8

Providing velocity information for assessing the habitat flow response of invertebrates

The probability-velocity distribution model of Lamouroux *et al* (1995) is also applied to provide velocity estimates for assessing habitat flow response of invertebrates. Three velocity classes are used: 0-0.1m/s (very slow), 0.1-0.3m/s (slow), 0.3-0.6m/s (fast) and >0.6m/s (very fast) (refer to Jordanova *et al*, in press). Table 5 provides an example of the velocity class predictions for a riffle type morphology (shaded rows represent measured flows).

Table 5: Probability velocity class predictions

Discharge (m^3/s)	Velocity class (m/s)			
	0-0.1	0.1-0.3	0.3-0.6	>0.6
0.01	100	0	0	0
0.04	85	15	0	0
0.2	65	35	0	0
0.5	47	44	9	0
1.0	35	37	25	3
2.0	26	29	35	10
5.0	14	18	31	37
11.8	6	10	19	65
22.8	3	5	12	80

3 DATA COLLECTION

Fixed stations were installed at the EWR sites by DWAF, who were responsible for undertaking the cross-sectional and topographical surveys used for the three-dimensional spatial modelling. The coordinates and elevation (above mean sea level) of the fixed stations are given in Table 6.

Table 6: Coordinates of fixed survey stations at EWR sites 3 and 7 on the Letaba River

River	Site no.	Station	Y-Coord (m)	X-Coord (m)	Eamsl (m)
Letaba	3	DW1	34668.15	2616519.45	412.73
		DW2	34628.87	2616524.44	412.75
		DW3	34601.06	2616523.72	412.57
		A	34666.83	2616503.15	410.21
		B	34628.28	2616494.94	409.29
		C	34597.85	2616497.60	409.63
		D	34656.56	2616493.47	410.00
		E	34646.16	2616492.53	408.61
Letaba	7	DW1	-60095.49	2634599.79	226.20
		DW2	-60165.09	2634604.49	226.57
		DW3	-60261.85	2634623.02	226.73
		A	-60090.43	2634397.06	216.95
		B	-60158.71	2634359.30	217.03
		C	-60250.66	2634290.57	216.76
		D	-60206.39	2634353.87	217.11

The measured discharges and flow depths are provided in Table 7 together with the dates when the data were collected. In addition to the stage levels in Table 7, water elevations between cross-sections were surveyed for the DTM used in the 3D spatial modelling (see Section 5).

Table 7: Hydraulic data collected at EWR Sites 3 and 7

River	Site no.	Date	Discharge Q (m^3/s)	Stage amsl, *z* (m) Cross-section		
				A	B	C
Letaba	3	12/08/2004[1]	0.24			
		04/02/2004	0.95	405.15	404.99	404.93
		24/04/2004	31		406.01	405.91
		25/04/2004	2.9	405.46	405.21	405.17
		30/05/2004	1.0	405.28	405.04	
Letaba	7	13/08/2003[1]	0. 069			
		14/09/2003[2]	0.021		216.33	216.05
		02/02/2004	9.2	216.88	216.69	216.45
		23/04/2004	85	217.45	217.35	217.21
		24/04/2004	6.8	216.90	216.75	216.45
		29/05/2004	2.0	216.66	216.51	

update fields[1] no stage level data supplied for site-selection by DWAF
[2] Reserve training exercise

4 MODELLING

The observed rating data at the EWR sites have been extended using Manning's resistance relationship. The surveyed water surface and regional (1:50 000 topographical) channel slopes are given in Table 8 and Table 9, and these have been used in conjunction with estimates of Manning's resistance coefficient (Table 10) to synthesize rating data for discharges higher than those measured. Continuous rating functions of the form given by equation 1 have been fitted to the measured and modelled data, and these are plotted in Figure 6 and Figure 7 for EWR Sites 3 and 7, respectively.

$$Q = ayb + c \qquad \text{equation 1}$$

where y is the flow depth (m), Q is the discharge (m^3/s), and a, b and c are regression coefficients, listed in Table 11.

Table 8: Regional 1:50 000 channel slope

River	Site no.	Channel slope
Letaba	3	0.0023
Letaba	7	0.0099[1]

[1]Changes to 0.0014 in the downstream reach

Table 9: Surveyed water surface slopes

River	Site no.	Discharge (m^3/s)	Water surface slope
Letaba	3	0.95 31.1	0.0022(73)[3] 0.0028(32)[2];0.0042(58)[3]
Letaba	7	0.021 2.0 6.8 9.2 85	0.0096(5.3)[1];~0[2];0.0033(89) 0.0022[1](39);0.0011(197) 0.0014(287) 0.0015(39)[1];0.0022(34)[2];0.0015(311) 0.0013(142)[1];0.0014(47)[2];0.0011(357)

(x) Distance over which slope surveyed (m)

[1]Surveyed at cross-section A

[2]Surveyed at cross-section C

[3]Surveyed from cross-section C to upstream of section B

Table 10: Hydraulic data used to extend the measured rating data

River	Site no.	Discharge (m^3/s)	Manning's resistance, *n*	Max. flow depth, *y* (m)[1]	Stage amsl, *z* (m)[1]	Energy slope, *S*	Ave. velocity *v* (m/s)
Letaba	3	1176 4179[2]	*0.05*	6.0 9.7	410.47 414.18	*0.003*	
Letaba	7	*3683*	*0.023*	5.0	221.17	*0.0011*	

Italic – modelled

[1]Cross-section B

[2]Extrapolated rating function (equation 1 and Table 11) – compares reasonably with DWAF estimated flood peak at Letaba Ranch (downstream) of 5000-5500m^3/s in 2000. Stage level from survey of flood debris.

Table 11: Regression coefficients in equation 1

River	Site no.	Discharge Q (m^3/s)	Cross-section	Rating coefficients			
				a	*b*	*c* relative to	
						bed	sea level
Letaba	3	all	A B C	0.405 0.370 0.360	0.380 0.390 0.390	0.28 0.15[1] 0.42	404.74 404.62 404.58
Letaba	7	all	A B C	0.196 0.200 0.205	0.390 0.390 0.390	0.08 0.08 0.39	216.40 216.25 216.01

[1]Reduces to zero depth in the active channel, which is 0.15m above the lowest cross-section elevation

5 RESULTS

5.1 CROSS-SECTIONAL PROFILES

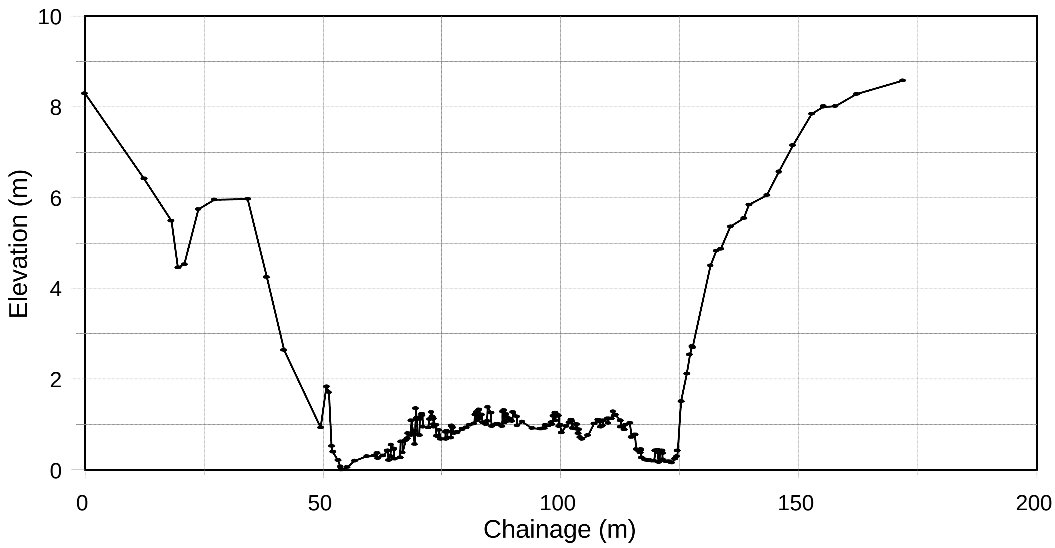

Figure 2: Cross-sectional profile for EWR Site 3B (rapid/riffle) on the Letaba River

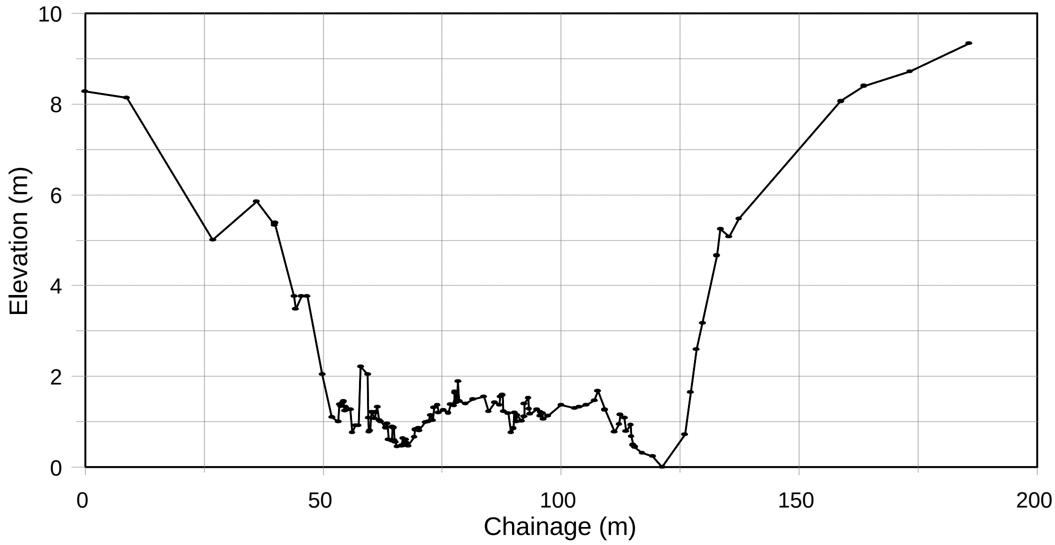

Figure 3: Cross-sectional profile for EWR Site 3C (shallow pool) on the Letaba River

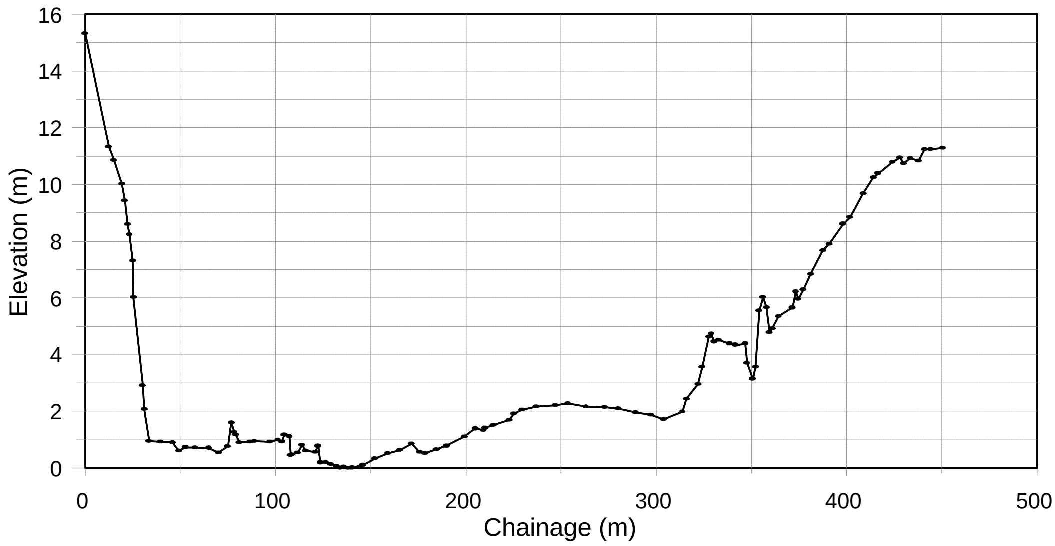

Figure 4: Cross-sectional profile for EWR Site 7B (riffle) on the Letaba River

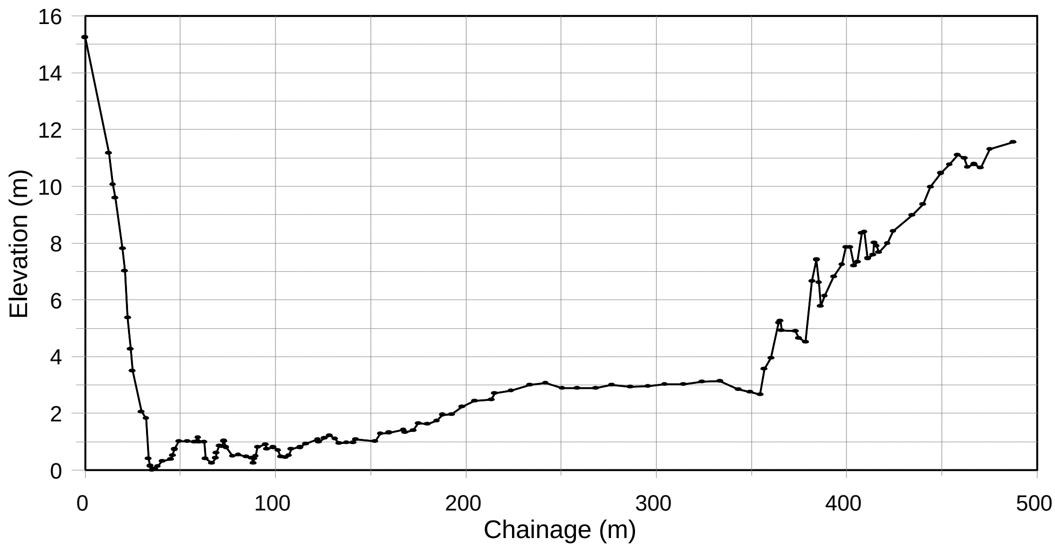

Figure 5: Cross-sectional profile for EWR Site 7C (shallow pool) on the Letaba River

5.2 RATING DATA AND FUNCTIONS

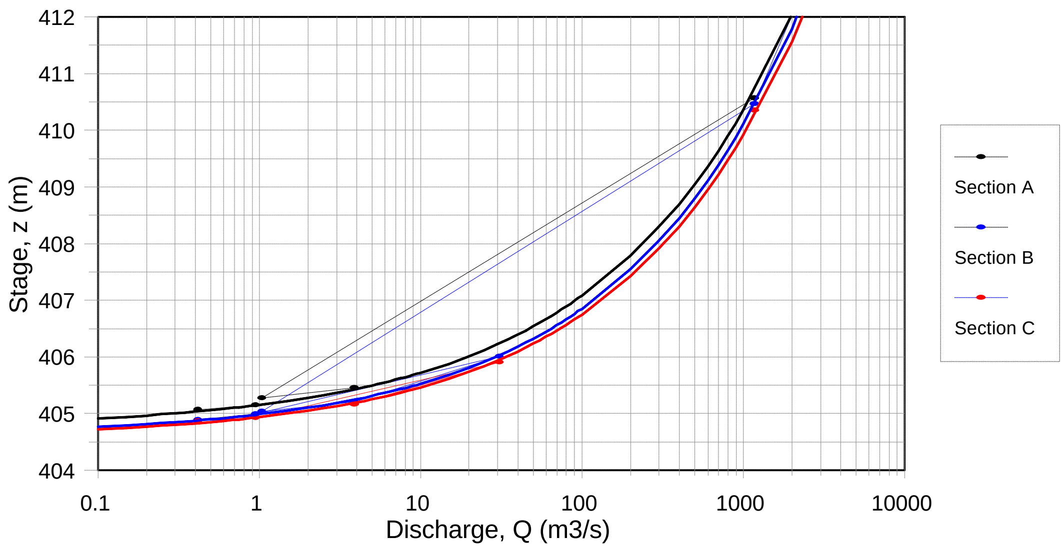

Figure 6: Measured and modelled rating data and functions for the cross-sectional profiles at EWR Site 3 on the Letaba River. Cross-sections A, B and C lie upstream of a rapid, through a riffle, and shallow pool, respectively

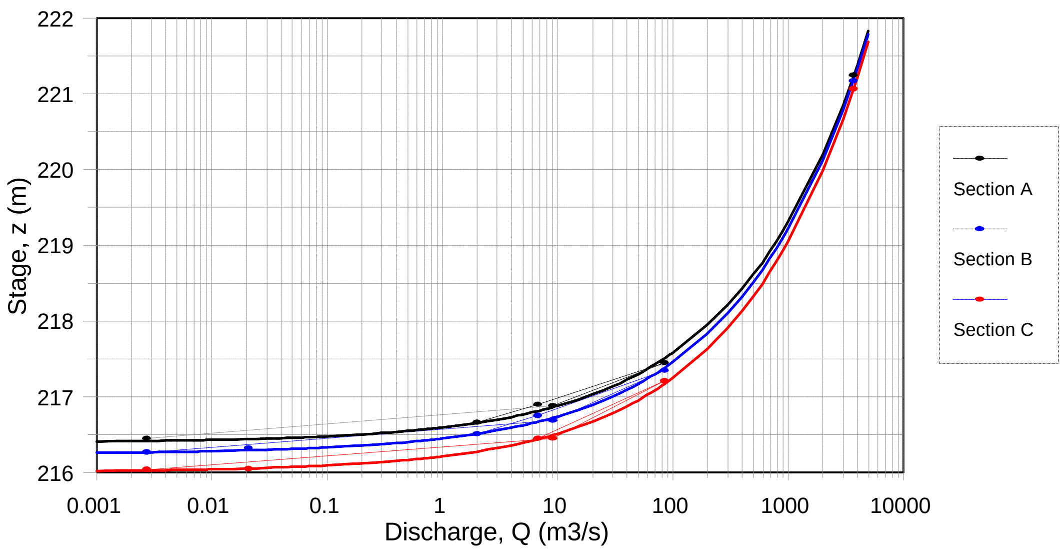

Figure 7: Measured and modelled rating data and functions for the cross-sectional profiles at EWR Site 7 on the Letaba River. Cross-sections A, B and C lie through a run, riffle, and shallow pool, respectively

5.3 TABULATED MODELLED HYDRAULIC DATA

Table 12: Tabulated hydraulic data for EWR Site 3B (rapid/riffle)

Flow depth (m)[1]	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.00	0.01	0.01	0.63	0.63	0.11
0.04	0.00	0.02	0.03	1.84	1.87	0.12
0.06	0.01	0.02	0.08	3.05	3.10	0.12
0.08	0.02	0.03	0.16	4.64	4.73	0.13
0.10	0.03	0.05	0.25	5.16	5.30	0.14
0.12	0.06	0.06	0.36	5.67	5.85	0.15
0.14	0.08	0.08	0.48	5.90	6.13	0.17
0.16	0.12	0.10	0.60	6.09	6.38	0.19
0.18	0.16	0.12	0.72	6.20	6.54	0.22
0.20	0.21	0.13	0.85	6.30	6.71	0.24
0.22	0.26	0.15	0.97	6.43	6.89	0.27
0.24	0.33	0.16	1.10	6.71	7.22	0.30
0.26	0.40	0.17	1.24	7.18	7.73	0.33
0.28	0.49	0.18	1.39	7.83	8.43	0.35
0.30	0.58	0.18	1.56	8.57	9.20	0.37
0.32	0.69	0.20	1.73	8.70	9.35	0.40
0.34	0.81	0.22	1.91	8.73	9.40	0.42
0.36	0.93	0.24	2.08	8.76	9.45	0.45
0.38	1.07	0.26	2.26	8.79	9.50	0.47
0.40	1.22	0.28	2.43	8.82	9.55	0.50
0.42	1.38	0.29	2.61	8.85	9.60	0.53
0.44	1.56	0.31	2.79	8.88	9.65	0.56
0.46	1.75	0.33	2.96	8.91	9.70	0.59
0.48	1.95	0.35	3.14	8.94	9.75	0.62
0.50	2.16	0.37	3.32	8.97	9.80	0.65
0.52	2.39	0.39	3.50	9.00	9.85	0.68
0.54	2.64	0.40	3.68	9.13	10.00	0.72
0.56	2.89	0.40	3.87	9.70	10.59	0.75
0.58	3.17	0.39	4.07	10.36	11.27	0.78
0.60	3.45	0.39	4.28	10.98	11.93	0.81
0.62	3.76	0.39	4.51	11.54	12.52	0.83
0.64	4.08	0.40	4.74	11.89	12.90	0.86
0.66	4.41	0.41	4.98	12.08	13.12	0.89
0.68	4.76	0.42	5.23	12.41	13.49	0.91
0.70	5.13	0.43	5.48	12.80	13.92	0.94
0.72	5.51	0.44	5.74	13.18	14.36	0.96
0.74	5.91	0.44	6.01	13.57	14.79	0.98
0.76	6.33	0.43	6.28	14.53	15.80	1.01
0.78	6.77	0.37	6.61	17.79	19.11	1.02
0.80	7.22	0.37	6.98	19.03	20.43	1.03
0.82	7.69	0.35	7.38	20.88	22.39	1.04
0.84	8.19	0.33	7.82	23.34	25.02	1.05
0.86	8.69	0.31	8.32	26.64	28.46	1.05
0.88	9.22	0.31	8.87	28.87	30.82	1.04
0.90	9.77	0.31	9.47	30.58	32.67	1.03
0.92	10.34	0.32	10.09	31.86	34.12	1.02
0.94	10.92	0.33	10.74	32.88	35.29	1.02
0.96	11.53	0.33	11.41	34.28	36.87	1.01
0.98	12.15	0.34	12.11	35.39	38.14	1.00
1.00	12.80	0.35	12.83	36.68	39.59	1.00
1.02	13.47	0.37	13.57	37.18	40.25	0.99
1.04	14.15	0.38	14.32	37.71	40.93	0.99
1.06	14.86	0.39	15.09	38.98	42.34	0.99
1.08	15.59	0.40	15.88	39.97	43.45	0.98
1.10	16.34	0.41	16.68	40.54	44.12	0.98

Flow depth (m)[1]	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.12	17.11	0.43	17.50	41.05	44.72	0.98
1.14	17.91	0.44	18.32	41.39	45.12	0.98

[1]Active channel

Table 13: Tabulated hydraulic data for EWR Site 3C (shallow pool)

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.42	0.00	0.19	1.56	8.19	8.24	0.00
0.44	0.00	0.20	1.73	8.54	8.59	0.00
0.46	0.00	0.21	1.90	9.09	9.14	0.00
0.48	0.01	0.20	2.10	10.30	10.37	0.00
0.50	0.02	0.21	2.31	10.98	11.06	0.01
0.52	0.04	0.22	2.54	11.57	11.68	0.01
0.54	0.06	0.23	2.77	12.15	12.30	0.02
0.56	0.09	0.24	3.02	12.71	12.89	0.03
0.58	0.13	0.25	3.28	13.28	13.49	0.04
0.60	0.17	0.25	3.56	14.24	14.49	0.05
0.62	0.22	0.26	3.85	15.05	15.35	0.06
0.64	0.28	0.27	4.16	15.45	15.81	0.07
0.66	0.35	0.28	4.47	15.80	16.20	0.08
0.68	0.43	0.30	4.79	16.05	16.50	0.09
0.70	0.52	0.31	5.11	16.25	16.76	0.10
0.72	0.63	0.33	5.44	16.43	17.00	0.12
0.74	0.74	0.35	5.77	16.54	17.18	0.13
0.76	0.86	0.37	6.10	16.62	17.32	0.14
0.78	1.00	0.38	6.43	16.82	17.59	0.16
0.80	1.15	0.39	6.77	17.50	18.37	0.17
0.82	1.31	0.39	7.13	18.46	19.46	0.18
0.84	1.48	0.38	7.51	19.62	20.75	0.20
0.86	1.67	0.38	7.92	20.95	22.19	0.21
0.88	1.87	0.38	8.35	22.08	23.44	0.22
0.90	2.09	0.38	8.80	23.20	24.67	0.24
0.92	2.32	0.38	9.28	24.70	26.28	0.25
0.94	2.57	0.38	9.78	25.49	27.18	0.26
0.96	2.83	0.39	10.30	26.17	27.96	0.27
0.98	3.10	0.41	10.83	26.71	28.60	0.29
1.00	3.40	0.41	11.37	27.52	29.50	0.30
1.02	3.71	0.42	11.93	28.49	30.60	0.31
1.04	4.03	0.42	12.51	29.57	31.80	0.32
1.06	4.37	0.43	13.11	30.59	32.96	0.33
1.08	4.73	0.43	13.74	31.86	34.38	0.34
1.10	5.11	0.43	14.39	33.38	36.04	0.35
1.12	5.50	0.43	15.07	34.88	37.70	0.37
1.14	5.91	0.44	15.78	36.28	39.27	0.37
1.16	6.34	0.44	16.52	37.51	40.66	0.38
1.18	6.79	0.45	17.28	38.44	41.75	0.39
1.20	7.26	0.45	18.06	40.10	43.56	0.40
1.22	7.75	0.44	18.89	42.54	46.14	0.41
1.24	8.25	0.44	19.76	44.70	48.43	0.42
1.26	8.78	0.44	20.68	46.73	50.60	0.42
1.28	9.33	0.45	21.63	48.34	52.35	0.43
1.30	9.89	0.46	22.60	49.43	53.58	0.44
1.32	10.48	0.46	23.61	51.70	55.99	0.44
1.34	11.09	0.45	24.68	54.52	58.94	0.45
1.36	11.72	0.45	25.79	57.33	61.86	0.45
1.38	12.37	0.45	26.97	59.87	64.53	0.46
1.40	13.04	0.46	28.18	61.19	65.98	0.46
1.42	13.73	0.47	29.42	63.14	68.04	0.47
1.44	14.45	0.47	30.71	65.12	70.13	0.47

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
1.46	15.18	0.48	32.03	66.91	72.03	0.47
1.48	15.94	0.49	33.38	68.00	73.25	0.48
1.50	16.73	0.50	34.74	68.91	74.30	0.48
1.52	17.53	0.51	36.14	70.17	75.68	0.49
1.54	18.36	0.53	37.55	71.37	77.00	0.49
1.56	19.21	0.54	38.99	72.43	78.18	0.49
1.58	20.09	0.55	40.44	73.01	78.86	0.50
1.60	20.99	0.57	41.91	73.43	79.38	0.50
1.62	21.91	0.59	43.38	73.70	79.74	0.51
1.64	22.86	0.61	44.86	73.97	80.10	0.51
1.66	23.84	0.62	46.34	74.38	80.60	0.51
1.68	24.83	0.64	47.83	74.63	80.92	0.52
1.70	25.86	0.66	49.32	74.74	81.09	0.52
1.72	26.91	0.68	50.82	74.84	81.26	0.53
1.74	27.98	0.70	52.32	74.95	81.43	0.53
1.76	29.08	0.72	53.82	75.05	81.60	0.54
1.78	30.21	0.74	55.32	75.16	81.77	0.55
1.80	31.36	0.75	56.83	75.27	81.94	0.55
1.82	32.54	0.77	58.33	75.37	82.11	0.56
1.84	33.74	0.79	59.84	75.48	82.28	0.56
1.86	34.97	0.81	61.35	75.59	82.45	0.57
1.88	36.23	0.83	62.86	75.69	82.62	0.58
1.90	37.52	0.85	64.38	75.80	82.79	0.58
1.92	38.83	0.87	65.90	75.88	82.91	0.59
1.94	40.17	0.89	67.41	75.96	83.04	0.60
1.96	41.54	0.91	68.93	76.04	83.16	0.60
1.98	42.94	0.93	70.46	76.12	83.28	0.61
2.00	44.37	0.94	71.98	76.21	83.41	0.62

Table 14: Tabulated hydraulic data for EWR Site 7B (riffle)

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.08	0.00	0.05	0.65	13.28	13.29	0.00
0.10	0.00	0.06	0.93	14.58	14.58	0.00
0.12	0.02	0.08	1.23	15.90	15.90	0.01
0.14	0.05	0.09	1.56	17.25	17.25	0.03
0.16	0.10	0.10	1.92	18.59	18.59	0.05
0.18	0.17	0.12	2.31	19.92	19.93	0.07
0.20	0.27	0.13	2.72	21.26	21.27	0.10
0.22	0.40	0.13	3.18	25.23	25.24	0.13
0.24	0.56	0.14	3.69	25.82	25.84	0.15
0.26	0.76	0.16	4.22	26.41	26.43	0.18
0.28	1.00	0.18	4.75	27.00	27.03	0.21
0.30	1.28	0.19	5.30	27.59	27.63	0.24
0.32	1.60	0.21	5.85	28.19	28.22	0.27
0.34	1.96	0.22	6.42	28.78	28.82	0.31
0.36	2.37	0.24	7.01	29.46	29.50	0.34
0.38	2.83	0.25	7.60	30.22	30.28	0.37
0.40	3.34	0.27	8.21	30.99	31.05	0.41
0.42	3.90	0.28	8.84	31.76	31.82	0.44
0.44	4.51	0.29	9.48	32.53	32.59	0.48
0.46	5.19	0.30	10.14	33.48	33.55	0.51
0.48	5.91	0.31	10.83	34.62	34.71	0.55
0.50	6.70	0.32	11.53	36.14	36.24	0.58
0.52	7.55	0.33	12.27	37.66	37.78	0.62
0.54	8.46	0.32	13.05	40.46	40.59	0.65
0.56	9.44	0.31	13.90	45.09	45.23	0.68
0.58	10.48	0.30	14.85	49.70	49.86	0.71
0.60	11.59	0.29	15.89	55.26	55.43	0.73

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.62	12.77	0.27	17.07	62.56	62.75	0.75
0.64	14.01	0.27	18.36	67.18	67.39	0.76
0.66	15.33	0.28	19.75	71.45	71.68	0.78
0.68	16.73	0.28	21.22	75.69	75.94	0.79
0.70	18.19	0.28	22.78	79.92	80.19	0.80
0.72	19.74	0.28	24.44	87.50	87.79	0.81
0.74	21.36	0.26	26.30	99.92	100.23	0.81
0.76	23.06	0.28	28.33	102.98	103.30	0.81
0.78	24.83	0.29	30.42	105.82	106.17	0.82
0.80	26.69	0.30	32.56	108.03	108.39	0.82
0.82	28.64	0.32	34.74	110.13	110.51	0.82
0.84	30.66	0.33	36.96	112.04	112.44	0.83
0.86	32.78	0.35	39.22	113.34	113.75	0.84
0.88	34.97	0.36	41.49	114.19	114.62	0.84
0.90	37.26	0.38	43.79	115.05	115.49	0.85
0.92	39.63	0.38	46.14	120.80	121.25	0.86
0.94	42.10	0.37	48.65	133.07	133.54	0.87
0.96	44.66	0.35	51.53	148.35	148.84	0.87
0.98	47.30	0.36	54.52	151.18	151.69	0.87
1.00	50.05	0.37	57.58	154.01	154.54	0.87
1.02	52.88	0.39	60.66	154.92	155.48	0.87
1.04	55.82	0.41	63.77	155.83	156.41	0.88
1.06	58.85	0.43	66.90	156.75	157.34	0.88
1.08	61.98	0.44	70.04	157.66	158.28	0.88
1.10	65.21	0.46	73.20	158.57	159.21	0.89
1.12	68.53	0.48	76.38	159.41	160.07	0.90
1.14	71.96	0.50	79.58	160.30	160.97	0.90
1.16	75.50	0.51	82.80	161.85	162.54	0.91
1.18	79.13	0.52	86.06	164.30	165.00	0.92
1.20	82.88	0.54	89.35	164.94	165.65	0.93
1.22	86.72	0.56	92.66	165.58	166.30	0.94
1.24	90.68	0.58	95.98	166.22	166.95	0.94
1.26	94.74	0.60	99.31	166.86	167.61	0.95
1.28	98.91	0.61	102.65	167.50	168.26	0.96
1.30	103.20	0.63	106.01	168.11	168.88	0.97

Table 15: Tabulated hydraulic data for EWR Site 7C (shallow pool)

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.39	0.00	0.14	2.27	16.38	16.48	0.00
0.41	0.00	0.15	2.61	17.84	17.95	0.00
0.43	0.02	0.16	2.98	18.66	18.79	0.01
0.45	0.04	0.17	3.37	20.19	20.34	0.01
0.47	0.09	0.17	3.79	22.69	22.87	0.02
0.49	0.16	0.16	4.28	26.24	26.44	0.04
0.51	0.25	0.17	4.83	28.93	29.15	0.05
0.53	0.38	0.17	5.44	32.22	32.47	0.07
0.55	0.53	0.17	6.11	35.07	35.35	0.09
0.57	0.72	0.19	6.84	36.87	37.17	0.10
0.59	0.94	0.20	7.58	37.60	37.94	0.12
0.61	1.20	0.22	8.34	38.34	38.71	0.14
0.63	1.50	0.23	9.12	39.12	39.51	0.16
0.65	1.84	0.25	9.91	39.95	40.36	0.19
0.67	2.22	0.26	10.71	40.77	41.22	0.21
0.69	2.65	0.28	11.54	41.60	42.07	0.23
0.71	3.13	0.29	12.38	42.42	42.92	0.25
0.73	3.66	0.30	13.24	43.61	44.13	0.28
0.75	4.24	0.32	14.12	44.79	45.34	0.30
0.77	4.87	0.31	15.06	48.63	49.20	0.32

Flow depth (m)	Discharge (m^3/s)	Av. flow depth (m)	Area (m^2)	Width (m)	Perimeter (m)	Av. velocity (m/s)
0.79	5.55	0.31	16.07	52.46	53.06	0.35
0.81	6.29	0.30	17.15	56.30	56.92	0.37
0.83	7.09	0.32	18.29	57.88	58.52	0.39
0.85	7.94	0.32	19.48	61.38	62.05	0.41
0.87	8.86	0.33	20.73	63.26	63.95	0.43
0.89	9.84	0.34	22.01	65.13	65.84	0.45
0.91	10.88	0.35	23.33	67.00	67.74	0.47
0.93	11.98	0.36	24.68	68.05	68.82	0.49
0.95	13.15	0.38	26.05	69.24	70.03	0.50
0.97	14.39	0.38	27.46	72.47	73.28	0.52
0.99	15.70	0.36	28.99	79.56	80.40	0.54
1.01	17.08	0.36	30.62	86.07	86.93	0.56
1.03	18.53	0.34	32.43	96.34	97.24	0.57
1.05	20.05	0.34	34.40	101.39	102.30	0.58
1.07	21.64	0.34	36.48	106.39	107.32	0.59
1.09	23.31	0.35	38.66	110.90	111.85	0.60
1.11	25.06	0.36	40.91	113.54	114.50	0.61
1.13	26.88	0.38	43.19	114.88	115.86	0.62
1.15	28.78	0.39	45.50	116.35	117.35	0.63
1.17	30.76	0.41	47.84	117.58	118.60	0.64
1.19	32.83	0.42	50.21	118.81	119.84	0.65
1.21	34.97	0.44	52.59	120.04	121.08	0.66
1.23	37.20	0.45	55.01	121.27	122.32	0.68
1.25	39.52	0.47	57.44	122.00	123.06	0.69
1.27	41.92	0.49	59.89	122.22	123.29	0.70
1.29	44.40	0.51	62.33	122.44	123.52	0.71
1.31	46.98	0.52	64.80	124.80	125.88	0.72
1.33	49.64	0.53	67.32	127.15	128.25	0.74
1.35	52.39	0.54	69.90	130.08	131.19	0.75
1.37	55.24	0.55	72.53	133.01	134.13	0.76
1.39	58.17	0.55	75.22	135.94	137.07	0.77
1.41	61.20	0.56	77.96	138.87	140.01	0.79
1.43	64.33	0.58	80.76	140.05	141.20	0.80
1.45	67.55	0.60	83.56	140.30	141.46	0.81
1.47	70.87	0.61	86.37	140.56	141.73	0.82
1.49	74.28	0.63	89.18	140.81	141.99	0.83
1.51	77.79	0.65	92.00	141.07	142.26	0.85
1.53	81.40	0.67	94.83	141.33	142.53	0.86
1.55	85.12	0.69	97.66	141.58	142.79	0.87
1.57	88.93	0.71	100.49	141.84	143.06	0.88
1.59	92.85	0.73	103.33	142.09	143.33	0.90
1.61	96.87	0.75	106.17	142.35	143.59	0.91
1.63	100.99	0.76	109.02	142.61	143.86	0.93

5.4 HABITAT TYPE ABUNDANCE AND VELOCITY DISTRIBUTION ANALYSES

The results the habitat-type abundance assessments (fish) are provided in Table 16 and Table 17 for EWR Sites 3 and 7, respectively. The shaded rows denote scorings corresponding to measured flows and/or photographic records. Velocity distribution information using the distribution model of Lamouroux *et al* (1995) is provided in Table 18 and Table 19.

Table 16: Ratings of habitat type abundance for EWR Site 3

Discharge (m^3/s)	Ecologist assessment (on-site & photographic)				Hydraulic rating (calculated)				Final rating			
	SS	SD	FS	FD	SS	SD	FS	FD	SS	SD	FS	FD
0.05					3.7	0.7	0.6	0.0	3	2	0	0
0.10					3.8	0.8	1.3	0.0	4	2	1	0
0.24	4	3	3	1	5.0	2.0	2.3	0.8	4	3	3	1
0.50					5.0	2.0	1.8	2.7	4	3	3	3
0.90	3	3	5	3					3	3	5	3
0.95	3	3	5	4	4.2	2.1	2.1[1]	4.1	3	3	5	4
3.91	4	3	5	5	5.0	3.8	4.1	5.0	4	3	5	5
10					5.0	5.0	5.0	5.0				

[1]Additional FS upstream of modelled site

Table 17: Ratings of habitat type abundance for EWR Site 7

Discharge (m^3/s)	Ecologist assessment (on-site & photographic)				Hydraulic rating (calculated)				Final rating			
	SS	SD	FS	FD	SS	SD	FS	FD	SS	SD	FS	FD
0.021					3.2	0.0	0.6	0.0	3	0	0	0
0.069					3.4	0.0	0.7	0.0	3	0	0	0
0.20					3.9	0.0	0.8	0.0	4	0	2	0
0.50	4	1	3	0	5.0	1.0	2.0	0.0	4	1	3	0
2.0	4	2	4	3	5.0	1.1	3.4	3.4	4	1	3	3
6.8	5	2	4	4	4.7	1.6	3.1	5.0	5	2	3	5
9.2	5	2	5	5	5.0	1.8	3.6	5.0	5	2	4	5

Table 18: Velocity distributions for EWR Site 3B (riffle)

Discharge (m^3/s)	Average velocity (m/s)	Lamouroux *et al* (1995)			
		Max. velocity (m/s)	Frequency (%) of velocity (m/s)		
			=0.1	=0.3	=0.6
0.05	0.15	0.45	41	92	100
0.10	0.18	0.55	37	84	100
0.24	0.27		22	66	86
0.50	0.35	1.0	22	49	86
0.95	0.45	1.3	17	38	72
3.91	0.85	2.4	5	15	32
10.0	1.02	2.8	4	11	24

Table 19: Velocity distributions for EWR Site 7B (riffle)

Discharge (m^3/s)	Average velocity (m/s)	Lamouroux *et al* (1995)			
		Max. velocity (m/s)	Frequency (%) of velocity (m/s)		
			=0.1	=0.3	=0.6
0.021	0.01	<0.05	100	100	100
0.069	0.03	0.05-0.10	100	100	100
0.20	0.07	0.20	90	100	100
0.50	0.15	0.45	46	92	100
2.00	0.31	0.9	25	50	93
6.8	0.58	1.6	11	19	51
9.2	0.68	1.8	9	14	39

6. THREE-DIMENSIONAL SPATIAL MODELLING

The 3D spatial modelling was undertaken using RiverCAD and HEACRAS and examples of the graphical output are provided in Sections 5.1 and 5.2 for EWR Sites 3 and 7, respectively.

6.1 EWR SITE 3

Figure 8 is an example of the results from the 3D spatial modelling for EWR Site 3. The yellow transects indicate the positions of cross-sections cut from the DTM. Transects 1, 5 and 9 correspond to Sections A, B and C (respectively), and flow is from right to left. The green numbers indicate the positions of surveyed riparian vegetation. For a measured discharge of 3.9 m^3/s (refer to Table 7), dark and light blue hatching illustrates regions of shallow (<0.3m) and deep (>0.3m) flow. Post-processing of inundated areas was used to compare with results of the cross-sectional analyses described in Section 1.1.

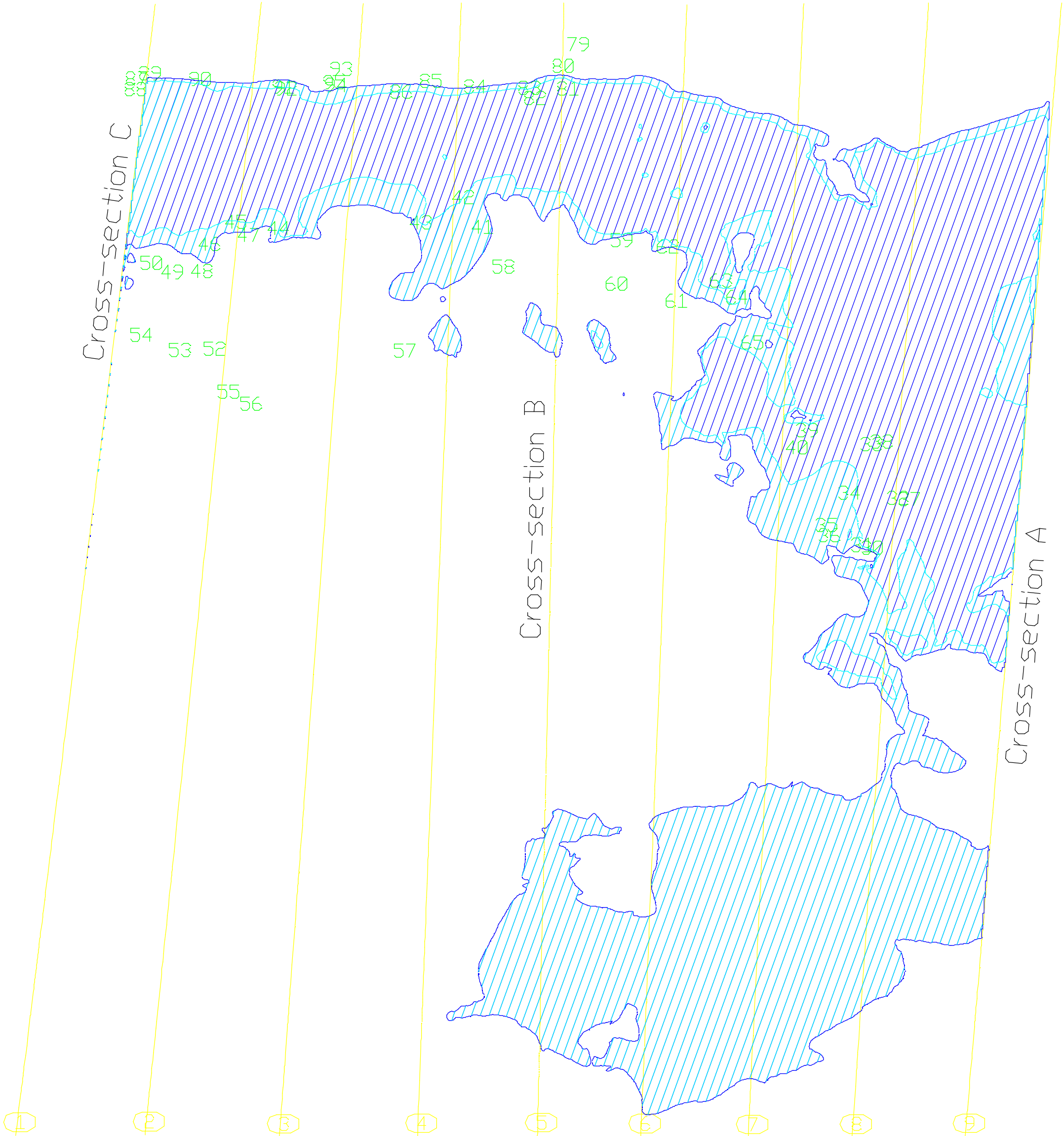

Figure 8: Example of the graphical output from the 3D spatial modelling for EWR Site 3.

6.2 EWR SITE 7

Figure 9 is an example of the results from the 3D spatial modelling for EWR Site 7. The yellow transects indicate the positions of cross-sections cut from the DTM. Transects 1, 5 and 8 correspond to Sections A, B and C (respectively), and flow is from right to left. The green numbers indicate the positions of surveyed riparian vegetation, and zones have been demarcated where appropriate. For a measured discharge of 2.0 m^3/s (refer to Table 7), dark and light blue hatching illustrates regions of shallow (<0.3m) and deep (>0.3m) flow. The red numbering indicates the position and stages for the highest recorded discharge of approximately 85m^3/s.

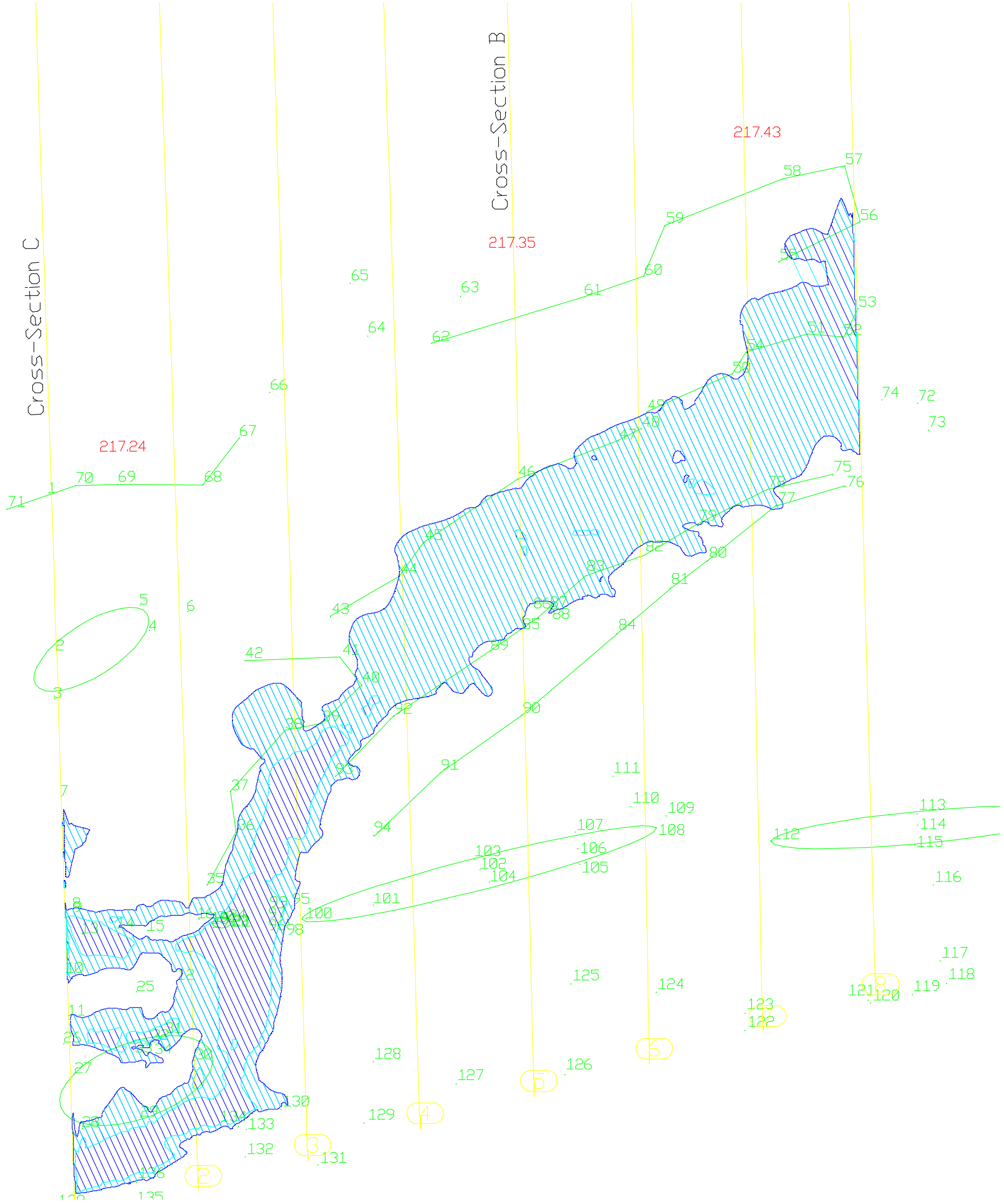

Figure 9: Example of the graphical output from the 3D spatial modelling for EWR Site 7.

7. CONFIDENCE IN THE HYDRAULIC CHARACTERISATIONS

The confidence in the characterisations of the hydraulic relationships are provided in Table 20. "Site character" refers to the suitability of the site for hydraulic modelling, "available data" refers to the range of measured rating data, and the final column refers to the confidence in the hydraulic characterisations with reference to the ecological low and high flow recommendations.

Table 20: Confidence in the hydraulic characterisations

Site no.	Site character	Available data	Reference to PES or recommended EC	
			Low flows	High flows
3	2	3	3-4	4
Measured flows in the range 0.42 to 31m^3/s. Recommended low-flows are in the range 0.001 to 0.77m^3/s and high flows in the range 6 to 220m^3/s.				
7	4	4	4	4
Measured flows in the range 0.021 to 85m^3/s.				

Confidence rating: 0=none, 1=low, 2=low/medium, 3=medium, 4=medium/high, 5

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water & forestry

Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

DIRECTORATE: RESOURCE DIRECTED MEASURES

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

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Inception report
Heath RG
DWAF Report No. RDM/B800/00/CON/COMP/0404X

Main Report
Heath RG
DWAF Report No.RDM/B800/00/CON/COMP/1304

Summary of Results (Non technical)
Heath RG
DWAF Report No. RDM/B800/00/CON/COMP/1304

Groundwater Scoping Report
Haupt C & Sami K
DWAF Report No. RDM/B800/02/CON/COMP/0504

Wetland Scoping Report
Marneweck G
DWAF Report No. RDM/B800/03/CON/COMP/0604

Resource Units Report
Heath R G
DWAF Report No. RDM/B800/00/CON/COMP/0704

→ **Resource Units Report: Appendix 1**
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Fouche, P & Moolman
Appendix 2: Systems operation report
Haumann, K.
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RDM/B800/00/CON/COMP/0704

EWR Report: Quantity
Palmer RW
DWAF Report No. RDM/B800/01/CON/COMP/0904

→ **EWR Report: Quantity:**
Appendices
Specialist reports

- Fish
- Invertebrates
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DWAF Report No.
RDM/B800/01/CON/COMP/0904

EWR Report: Quality
Scherman P
DWAF Report No. RDM/B800/01/CON/COMP/0804

Ecological consequences of flow scenarios
Heath, RG & Palmer R
DWAF Report No. RDM/B800/01/CON/COMP/1004

Hydrology support & water resource evaluation
Haumann, K
DWAF Report No. RDM/B800/01/CON/COMP/1104

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SPECIALISTS REPORT: GEOMORPHOLOGY

This report documents the data collected for the Letaba River Comprehensive Reserve Determination study conducted in 2003 and 2004. The methodology, particularly relating to the potential bed material transport (PBMT) modelling aspects of the study, are discussed in detail in section 1 of this report (IFR 1), and referred to from thereon in the sections relating to other IFR sites. The description and delineation of macro-reaches is described in Appendix A.

1. IFR 1 (APPEL)

1.1 DATA AVAILABILITY

Aerial photographic information for this site was good, with the earliest photographs being available for 1938. Modelled hydrological data was provided for the present day and virgin catchment conditions, and sediment transport analyses performed on these data using the method developed by Dollar and Rowntree (2003).

1.2 REFERENCE CONDITION

1.2.1 Aerial Photographic Analysis

Aerial photographs from 1938 were used to obtain an indication of the condition of the site prior to development in the catchment, and the subsequent aerial photographs used to assess the ranges and rates of morphological change at the site. From previous work on Mpumalanga lowveld rivers (Rountree et al, 2001; Rountree et al 2004) we have a good idea of the differing rates of change in different channel patterns/types, and which pathways of change are common versus those that are likely to be determined by flow modifications. We additionally are able to understand much of the medium term (50-100 year) dynamics of the lowveld rivers; particularly the effects of large flooding events (such as the 2000 event) and the role that these events play in channel pattern changes.

The results of the aerial photographic analysis indicated that in August 1938 the site and section in the immediate vicinity was characterised by a pool rapid channel type with some isolated occurrences of braiding where the floodplain is wider. Vegetated instream bars were fairly common. Extensive farming was occurring on the slopes near the river and there were small, isolated occurrences of forestry in the catchment. By the late 1950's channel engineering had straightened the braided sections to a single-thread pattern and the vegetated instream bars had been reduced. Forestry had expanded in the catchment. The quality of aerial photography from the 1960's was too poor for river analysis. By June 1977 the active channel has narrowed, coincident with the development of the large upstream Ebenezer Dam. Forestry had expanded in catchment and into the floodplain pockets of the river, and further expansions of forestry are evident in the June 1981 aerial photographs. The aerial photographs from July 1989 indicate that channel narrowing is continuing, with the active channel having changed from wide, open channel to narrow, almost closed-canopy channel. The July 1998 aerial photographs indicated that the channel has opened up slightly from 1989 condition; probably as a result of the moderate 1996 floods. By June 2002 the channel opened up further and is no longer a closed canopy system. This has been caused by the extreme 2000 floods. However the wide of the current active channel is still less than 50% of the 1938 condition of the river.

The site has maintained its pool rapid pattern, and is thus close to its reference condition. However the width of the active channel, and thus extent of available instream habitat, is much reduced from the historical condition.

1.2.2 Potential Bed Material Transport Modelling

Bed material was sampled at each IFR site in 2003 to provide an indication of the calibre of bed material being transported by the system (Table 1). A step point survey of a minimum of 500 sample points was undertaken at each site. This information was then used to model the potential bed material transport (PBMT) at each site, using a method developed by Dollar and Rowntree (2003). All sites indicated reductions in the potential to transport sediment. A summary of the results is presented here (Table 2), with detailed results presented in Appendix B.

Table 1: Sediment size distribution at the IFR sites

Diameter size of sediment (mm)	**Sediment Size Distribution (%)**						
	IFR 1	**IFR 2**	**IFR 3**	**IFR 4**	**IFR 5**	**IFR 6**	**IFR 7**
1024	0.00	0.00	0.00	0.00	0.00	0.00	0.00
512	5.00	0.00	0.40	0.00	0.00	0.00	0.00
256	33.00	0.40	1.20	0.00	0.00	0.00	0.00
128	36.00	1.60	2.00	0.80	1.00	0.00	0.10
64	13.00	35.60	6.00	4.80	1.20	1.10	3.50
32	7.00	34.40	13.80	5.80	4.00	7.90	8.30
16	1.00	5.60	4.60	4.60	4.00	9.60	5.30
8	1.00	3.20	10.80	11.20	5.40	12.60	11.80
2	2.00	5.60	6.80	15.60	8.20	6.20	6.50
1.18	1.00	1.60	8.80	11.60	9.80	4.90	6.10
0.6	1.00	3.20	13.60	19.80	24.00	5.30	6.50
0.3	0.00	5.20	20.60	18.40	20.20	20.00	26.00
0.15	0.00	2.40	4.00	6.40	14.60	8.30	11.90
0.075	0.00	0.80	7.20	0.80	5.60	16.40	11.10
0.01	0.00	0.40	0.20	0.20	2.00	7.90	3.00

Table 2: Summary of the PBMT results

Site	Reduction in PBMT
IFR 1	61 %
IFR 2	29 %
IFR 3	48 %
IFR 4	45 %
IFR 5	26 %
IFR 6	38 %
IFR 7	38 %

At IFR 1, mean daily flows of 5, 10 and 20 m^3/s were associated with particularly high rates of sediment transport (Appendix B). The reduction in the frequencies of these flows under the present-day flow conditions has reduced the potential for sediment transport at this site by approximately 61%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

1.3 PES

The present state of the site is a low C category. The site is characterised by a pool rapid channel type with floodplain terraces on the right bank. The lower terrace is less than 1m above the low flow active channel, narrow (2-4m wide near the pool) and composed of fine sands and silts. The upper terrace, about 2m above the active channel, is more than 15m wide and composed of fine sands. The left bank is a steep cut bank with much bedrock influence. The upstream pool (cross-section 1) is composed of large boulders and cobbles with gravels and sands in the interstitial spaces. The downstream riffle (cross-section 2) has large boulders in the approximately 8m wide active channel, with some gravels on the margin of the active channel.

As mentioned previously, the active channel has narrowed considerably through the historic photographic record, but the channel pattern is stable.

PES	CAUSES	SOURCES	FLOW / NON -FLOW RELATED
C	Channel narrowing; vegetation encroachment	Reduced flood frequency/ magnitude/ duration; elevated base flow releases; reduced sediment transport potential	Flow related: reduced high flows from upstream dam have caused the active channel to narrow, allowing vegetation to encroach and stabilise lateral bars.

1.4 TREND AND REASONS

The 2000 floods widened the active channel slightly, but not to a condition similar to that prior to Ebenezer Dam. It is expected that the narrowing will continue in the coming years, but a channel pattern change is not expected. Under present flow conditions the trajectory is slightly negative, but within the current class.

PES	TREND	RESULTING PES	TIME	REASONS
C (low C: 61%)	slight negative	Upper D	~10 years	Continued narrowing of the active channel is likely unless higher floods are provided

1.5 ALTERNATIVE ECS

An upper "D" classification for the site is likely if the narrowing of the active channel continues. Narrowing would accelerate if flow reduction activities increase, and this could possibly lead to a more alluvial-influenced channel pattern if flow is further significantly reduced. If floods are restored to the system, a higher C is possible but is it highly unlikely that the system will change to a "B" classification due to the severe channel narrowing that has occurred here.

2. IFR 2 (LETSITELE)

2.1 DATA AVAILABILITY

A substantial record of aerial photographs was available from 1938 to 2002. Modelled hydrological data was provided for the present day and virgin catchment conditions, and sediment transport analyses performed on these data using the method developed by Dollar and Rowntree (2003).

2.2 REFERENCE CONDITION

2.2.1 Aerial Photographic Analysis

In May 1938 the active channel was a wide, single thread channel with reeds along the edges and occasional vegetated bars that appear to be associated with bedrock outcrops. By the late 1960's the active channel had narrowed significantly. Vegetated instream and lateral bars had encroached on the active channel. By June 1977 no further narrowing was evident. Crop farming (probably irrigated) in the upstream catchment was more extensive, and had further expanded by July 1989. No change was apparent from the July 1998 aerial photography. In the June 2002 aerial photographs some isolated removal of vegetation, certainly related to the 2000 floods, was apparent. The bars appeared stable in this latter period.

A wide, sandy channel existed at this site in the 1930's, but changed to a narrow, incised channel by the 1990's. Due to the extreme nature of the channel pattern change, we do not anticipate a reversion to the 1930's condition.

2.2.2 Potential Bed Material Transport

The potential for sediment transport at this site has been reduced by approximately 29% (Table 2). The PBMT modelling identified mean daily flows of 2.7 and 15 m^3/s that had, under the virgin flow conditions, been important for sediment transport. The reduced frequency and duration of these flows under the present-day flow conditions has negatively impacted the potential of the site to transport sediment. The detailed results from this section of the study can be found in Appendix B.

2.3 PES

The site is characterised by an incised pool-riffle channel pattern. It was discovered in the last Letaba IFR project that this site is not good for high flow hydraulics (as the site experiences backup from the Letaba), and consequently the riparian vegetation and geomorphology specialists had low confidence at this site during the previous study. Prior to the 2000 floods, specialists working on the previous IFR study indicated that there was a deep pool at the site which has subsequently changed to the current incised pool-riffle pattern.

However, since the geomorphologist was required to visit the site during the site surveying trip (in conjunction with the DWAF surveyors) it was decided to sample the site in an effort to improve the high flow requirements for this resource unit.

PES	CAUSES	SOURCES	FLOW / NON -FLOW RELATED
D/E	Narrowing and incision of channel, channel pattern change, loss of vegetation	Reduced flows and possibly high grazing pressure	Both flow related (reduced flows) and non-flow related (high grazing pressures)

2.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
D/E	Slight negative	D/E	10 years	Further losses of moderate floods are anticipated due to recent raising of Thabena Dam (has no outlet for releases)

2.5 ALTERNATIVE ECS

It is possible that, with the provision of higher flows and reduced grazing pressure, some vegetation could re-establish along the channel margins. The site could then improve from the current D/E category to a D category.

3. IFR 3 (EILAND)

At IFR 3 two sites in close proximity were hydraulically modelled. The upstream site ("Eiland") was used for geomorphology, fish and invertebrate analyses. The second, downstream site (located immediately downstream of the Prieska Weir) was used for vegetation analyses. Due to the weir upstream trapping sediment and scouring the site, resulting in a highly bedrock influenced state, this downstream site was not considered in the geomorphological analysis and was therefore excluded from the aerial photography section of the analysis. The section below thus deals only with the upstream ("Eiland") site.

3.1 DATA AVAILABILITY

A substantial record of aerial photographs was available from 1938 to 2002. Modelled hydrological data was provided for the present day and virgin catchment conditions, and sediment transport analyses performed on these data using the method developed by Dollar and Rowntree (2003).

3.2 REFERENCE CONDITION

3.2.1 Aerial Photographic Analysis

In May 1938 the active channel was very wide (about half the width of the macro-channel floor) with numerous small vegetated (*Phragmites*) in-channel bars. Extensive macro-channel lateral bars, largely existed, covered by large areas of exposed sediment but also with small areas of reeds and riparian shrubs. By 1954 vegetation establishment on the macro-channel lateral bars had increased slightly. No change is evident from the aerial photographs of the mid-1960's.

By July 1977 vegetation encroachment on macro-channel features appears to have continued, and dramatic increases in irrigated crop agriculture adjacent to the river occurred. The photography from 1989 shows further increases in land under irrigation and continued vegetation encroachment. In many places on the macro-channel floor reeds have been replaced by trees. By July 1998 trees are the dominant vegetation type on the macro-channel floor. The aerial photography following the 2000 floods (taken in June 2002) shows that the active channel has been widened considerably and much of the macro-channel floor vegetation and sedimentary bars have been removed. Exposed bedrock is prominent.

In studies on the lowveld rivers in the Kruger National Park, Carter and Rogers, (1995) identified patterns of vegetation establishment, expansion and loss. We see these patterns at this site, with a prolonged establishment and expansion phase set back by the vegetation loss associated with the 2000 floods.

3.2.2 Potential Bed Material Transport Modelling

At IFR 3, mean daily flows in the ranges of 15, 70-100 and 150-200 m^3/s were associated with particularly high rates of sediment transport (Appendix B) under virgin flow conditions. The reduction in the frequencies of these flows under the present-day flow conditions has reduced the potential for sediment transport at this site by approximately 48%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

3.3 PES

This site is located about 7km upstream of Preiska Weir, but does not experience backwater effects from the weir. It is characterised by a bedrock pool-rapid channel type with small gravels, cobbles and sand bars amongst the exposed bedrock. There are currently steep banks with no benches or terraces, as the macro-channel floor has been scoured by the 2000 floods.

The causes of change at this site are related to the reduction in frequency, magnitude and duration of moderate and large floods (which result in decreased removal and scouring of sediment and vegetation from the bed of the macro-channel) and reduction in low flows (which aids vegetation encroachment of the active channels). The many weirs and dams in this section of the river have also caused enhanced sedimentation and accumulation of finer material in some sections of the river. In some places these processes appear to have disrupted sediment transport patterns and channel patterns.

Also, although the dynamics of the vegetation on the macro-channel floor appear natural, the large-scale removal of vegetation along bank tops for irrigation farming may impact bank stability and vegetation recruitment lower down on the macro-channel banks.

PES	CAUSES	SOURCES	FLOW / NON -FLOW RELATED
C	Vegetation encroachment, channel narrowing, sediment trapped in weirs	Numerous weirs trap sediment and reduce flows; potential bed material transport is reduced by almost 50%	Flow related: reductions in flows and sediment transport potential due to weirs and associated water abstraction.

3.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C (63%)	Negative	D (45%)	5-20 years	Reduced moderate floods very likely to cause accelerated vegetation encroachment and loss of geomorphic dynamics

3.5 ALTERNATIVE ECS

The restoration of moderate floods would cause increased frequency of scouring on the macro-channel floor and retard accelerated vegetation encroachment, leading to an improved PES. The natural condition and dynamics of the channel form can thus be maintained with these increased flows.

Alternatively, if further moderate and high flows are removed the channel form will lose bedrock influence and change to a single thread, more alluvial-influenced channel pattern. Nearby multi-channel anastomosing sections will change to relatively less diverse single thread patterns. Riparian vegetation encroachment after the 2000 floods is likely to be accelerated (compared to previous encroachment following 1925/33 large floods) due to removal of moderate floods. This will accelerate channel floor sedimentation and stabilisation. Already some changes in channel pattern in this section of the river appear related to the disruption of sediment transport patterns as a result of numerous weirs.

4. IFR 4 (LETABA RANCH)

4.1 DATA AVAILABILITY

Aerial photographic information for this site was good, with the earliest photographs being available for 1938. Modelled hydrological data was provided for the present day and virgin catchment conditions, and sediment transport analyses performed on these data using the method developed by Dollar and Rowntree (2003).

4.2 REFERENCE CONDITION

4.2.1 Aerial Photographic Analysis

In August 1938 the site was characterised by a mixed anastomosing channel pattern with numerous active channels separated by vegetated bars. Extensive pool features were also present. By 1954 the instream bars had consolidated, resulting in a primarily single active channel with riffle and pool features. The floor of the macro-channel was becoming well vegetated. In the mid 1960's, vegetation encroachment on the macro-channel floor was extensive. The active channel had narrowed further to a thin, single channel with confined pool and riffle features. However some extensive pools were still present. Following this there appears to have been a flood, since the aerial photography from the late 1960's shows that some of the macro-channel floor vegetation had been removed and seasonal channels opened up. However, there was still only a single main active channel. In July 1977 the macro-channel floor had remained stable and highly vegetated. The now single active channel was slightly wider than in the 1960's; presumably as a result of the moderate flood events in the mid 1970's. By August 1989 vegetation encroachment and succession had progressed at the site. On many sections of the bars, trees had replaced reeds as the dominant vegetation type. No change from 1989 condition is evident in the July 1998 aerial photography. Following the 2000 floods, the June 2001 aerial photography shows that most of the trees from the margins of the active channel and much of the vegetation from the macro-channel floor had been removed. However the macro-channel, relative to the 1938 condition, is still encroached with vegetation and the active channel more confined. Some small sections of braiding have developed, but no anastomosing sections have reappeared. In the June 2002 photography, herbaceous and/or reed vegetation can be seen to be re-establishing strongly on the macro-channel floor.

The site has shown a progressive reduction in the number and extent of active channels, progressive vegetation encroachment on the macro-channel floor and a loss of bedrock influence as the channel patterns in the area changed from mixed anastomosing to single thread pool-rapid.

4.2.2 Potential Bed Material Transport Modelling

At IFR 4, mean daily flows of 6, 60 and 130 m^3/s were associated with particularly high rates of sediment transport (Appendix B) under virgin flow conditions. The reduction in the frequencies of these flows under the present-day flow conditions has reduced the potential for sediment transport at this site by approximately 45% (compared to the MAR reduction of about 50%). To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

4.3 PES

The main cross-section (cross-section 1) is characterised by a single active channel with an extensive, largely non-vegetated seasonal bar on the left bank. The right bank is dominated by a high ephemeral lateral terrace. Some vegetation encroachment and loss of bedrock-influenced channel patterns has occurred.

PES	CAUSES	SOURCES	FLOW / NON -FLOW RELATED
C/D	Sediment accumulation/loss of bedrock influence and associated channel pattern changes; vegetation encroachment	Reduced flood frequency/ magnitude/ duration; reduced sediment transport potential	Flow related: reduced high flows have deceased sediment transport potential, allowing narrowing of the active channel and vegetation encroachment.

4.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C/D	Negative	D	10 years	Continuing flow reductions and vegetation encroachment will continue to alter the site.

4.5 ALTERNATIVE ECS

The restoration of the moderate floods could reverse the aggradation (sediment storage) trend of the channel pattern, improving the ecological state to a C. These floods would scour the macro-channel bed, preventing enhanced sediment accumulation and retarding vegetation encroachment. This could change some channel patterns back to the more bedrock-influenced patterns that occurred in historical times.

However, if the current conditions persist, the ecological state is likely to decrease to a D category. Under such flow conditions, the loss of moderate floods will continue to degrade the condition of the channel pattern and enhance sediment storage (aggradation). This trend will become increasingly difficult to reverse.

5. IFR 5 (KLEIN LETABA)

5.1 DATA AVAILABILITY

Aerial photographic information for this site was good, with the earliest photographs being available for 1937. Modelled hydrological data was provided for the present day and virgin catchment conditions, and sediment transport analyses performed on these data using the method developed by Dollar and Rowntree (2003).

5.2 REFERENCE CONDITION

5.2.1 Aerial Photographic Analysis

The aerial photographic record shows that in 1937 the site was characterised by a meandering/braided active channel flowing across sandy macro-channel. No vegetation occurred on the macro-channel floor. This condition persisted through 1951, 1971 and 1977. However, in July 1989, trees and other vegetation are observed for the first time to be established on the macro-channel floor; particularly along edges of active channels. The reach still exhibits a braided pattern. This encroachment of vegetation on to the macro-channel floor coincides with the completion of the nearby Middle Letaba dam, which has no release capacities. Following the 2000 floods, the June 2001 aerial photographs show that almost all vegetation has been removed from the macro-channel floor. The meandering/braided pattern of the active channel still persists within the sandy macro-channel.

The site was very stable from the beginning of the photographic record (1937) until the last aerial photograph (1977) before the completion of the Middle Letaba Dam. However, thereafter rapid, extensive vegetation encroachment of the macro-channel floor occurred. Although this has been reversed by the 2000 floods, it is almost certain to follow that pattern of change again in the coming years.

5.2.2 Potential Bed Material Transport Modelling

At IFR 5, mean daily flows of 14, 70 and 500 m^3/s were associated with particularly high rates of sediment transport (Appendix B) under virgin flow conditions. The reduction in the frequencies of these flows under the present-day flow conditions has reduced the potential for sediment transport at this site by approximately 26%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

5.3 PES

The site has terraces on the right- and left-hand banks, a sandy active channel and seasonal mid-channel bar composed of sand, armoured by gravels and cobbles. The area is heavily grazed by cattle.

This reach of the river is largely unmodified, being exposed to limited direct human changes. Some sand mining occurs at the site and in other isolated places in the reach, but the effects are small-scale and isolated. As mentioned above, the Middle Letaba Dam appears to be promoting rapid vegetation encroachment on to the macro-channel floor because of the reduced flows and floods downstream of this impoundment. These effects are widespread.

PES	CAUSES	SOURCES	FLOW / NON -FLOW RELATED
C	Vegetation encroachment, associated stabilisation of sediment and of the active channel.	Reduced base- and flood-flows due primarily to the Middle Letaba dam, which does not release any water downstream.	All flow related.

5.4 TREND AND REASONS

PES	TREND	RESULTING PES	TIME	REASONS
C	Negative	D	10-20 years	Sediment supply is still high, but sediment transport potential much reduced. Additionally, continued vegetation encroachment is likely and will further stabilise sediments in the river.

5.5 ALTERNATIVE ECS

If the current flow patterns are maintained, the trajectory of change is negative and we would expect to drop a class in the 10-20 year time frame. Continued reduced middle and high flows, due to decreased flow from the effects of Middle Letaba Dam, will result in more rapid vegetation encroachment on the macro-channel floor. This will continue and stabilise sediments, causing aggradation of the bed. This could possibly lead to subsurface low flows as the elevation of the sandy bed increases.

However, the current negative trajectory of change could be reversed by the provision of moderate and high flow events. This would prevent excessive sedimentation of the system and maintain vegetation on the terraces and keep encroachment on to the macro-channel floor in check.

6. IFR 6 (LONELY BULL)

6.1 DATA AVAILABILITY

Aerial photographic information for this site was good, with the earliest photographs being available for 1942. Modelled hydrological data was provided for the present day and virgin catchment conditions, and sediment transport analyses performed on these data using the method developed by Dollar and Rowntree (2003).

6.2 REFERENCE CONDITION

6.2.1 Aerial Photographic Analysis

In May 1942 the reach was characterised by a braided/meandering channel pattern with large sandy mid-channel bars and an anastomosing section downstream. Active-channel margins are well-vegetated (reeds) but sand dominated the macro-channel floor. By the mid-1960's, narrowing of the active channel and some loss of macro-channel floor vegetation had occurred. The anastomosing section downstream had been reduced to a single-thread section. In the early 1970's the macro-channel had been scoured – some vegetation was removed and active channels widened and the anastomosing section downstream was reactivated. In June 1977 there was no vegetation on the macro-channel floor. Instead wide, sandy bars and active channel/distributaries meandered over the width of the macro-channel floor. Vegetation and sediment had been scoured from the downstream anastomosing section.

Vegetation had re-established on the macro-channel floor and on most bars by 1989. The active channel width's had decreased and the downstream anastomosing section had filled with sediment (and thus changed from a bedrock to mixed anastomosing channel pattern). As with previous sites, the 2000 floods scoured the macro-channel floor, leaving it sandy and unstable. The active channels were wide and the downstream anastomosing section had been scoured back to a bedrock anastomosing pattern again.

6.2.2 Potential Bed Material Transport Modelling

At IFR 6, mean daily flows of 20, 80, 200 and 2000 m^3/s were associated with particularly high rates of sediment transport (Appendix B) under virgin flow conditions. The reduction in the frequencies of these flows under the present-day flow conditions has reduced the potential for sediment transport at this site by approximately 38%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

6.3 PES

The site is located inside the Kruger National Park and is characterised by a wide macro-channel with two active channels. Bedrock outcrops occur on the MC floor and terraces on the right bank. Moderate flows have been reduced at this site, but not as much as at other sites upstream that are closer to large dams. At the broad scale, the dynamics of vegetation change appear to be largely natural. Enhanced sedimentation has caused some channel pattern changes, but many of these have been reversed by the 2000 floods.

The causes of change are related to the reduction in frequency, magnitude and duration of moderate and large floods (which result in decreased removal and scouring of sediment from the bed of the macro-channel) and severe reduction in low flows and increase in zero flow periods (which inhibits marginal vegetation establishment and therefore prevents active channel stabilisation).

PES	CAUSES	SOURCES	FLOW / NON -FLOW RELATED
C (high C)	Enhanced sedimentation, channel pattern changes	Reduced moderate & high flows/floods coupled with continuing high sediment loads.	Flow related: caused by reduced flows due the effects of dams and weirs upstream.

6.4 TREND AND REASONS

The trajectory of change, under current conditions, is stable. The site was scoured by the 2000 floods, but similar changes are evident throughout the aerial photographic record. Subsequent channel stabilisation and increasing diversity of instream morphology (deepening of active channels etc) is to be expected as part of the natural readjustment following the 2000 floods.

PES	TREND	RESULTING PES	TIME	REASONS
C (high C)	Stable	C (high C)	10-20 years	The aerial photo analysis does not suggest negative long term trends in channel pattern change.

6.5 ALTERNATIVE ECS

If adequate low flows in the Kruger National Park section of the Letaba River were to be restored, it is likely that this section of river's geomorphological ecostatus could be improved from a "C" to a "B" class. At IFR sites 6 and 7, low (dry season base flows) flows of 0.4-0.5 m^3/s would allow stable riparian vegetation (specifically reeds) to develop along the active channel margins. The stable fringe vegetation would stabilise the active channel/s, and thus promote scouring of these active channels during elevated flows in the wet season. Without a stable fringe vegetation, the active channels would infill with sediment during elevated flows and possibly migrate frequently over the macro-channel floor, further retarding the development of deep sections or stable riparian fringe vegetation.

However, if further moderate and high flows are removed from the flow regime the channel form will continue to increase alluvial influence as more sediment becomes stored on the macro-channel floor. A loss of bedrock and cobble riffles would be expected. The downstream multi-channel anastomosing section would change to relatively less diverse single thread pattern and ecostatus would drop to a D in the long (20 year) term.

7. IFR 7 (LETABA BRIDGE)

7.1 DATA AVAILABILITY

Aerial photographic information for this site was good, with the earliest photographs being available for 1942. Modelled hydrological data was provided for the present day and virgin catchment conditions, and sediment transport analyses performed on these data using the method developed by Dollar and Rowntree (2003).

7.2 REFERENCE CONDITION

7.2.1 Aerial Photographic Analysis

In May 1942 the reach was characterised by a single thread active channel meandering across a sandy macro-channel floor with reeds in some places along the active channel margins. No changes from this condition were evident in the subsequent 1960's or 1970's aerial photographs. By 1977 some braiding was developing, but otherwise no changes were evident. The dam downstream of Letaba Restcamp has been commissioned. The 1989 aerial photographs indicate no changes at the site. Following the 2000 floods, the active channel has eroded into the outer bed of the macro-channel, removing terraces and the associated trees and reed vegetation thereon and extensive braiding now occurs downstream.

Overall the site appears very stable from the aerial photographic record, but due to it's highly alluvial nature, increases in sediment storage would be difficult to detect from aerial photographs.

7.2.2 Potential Bed Material Transport Modelling

At IFR 7, mean daily flows of 22, 90, 220 and 2500 m^3/s were associated with particularly high rates of sediment transport (Appendix B) under virgin flow conditions. The reduction in the frequencies of these flows under the present-day flow conditions has reduced the potential for sediment transport at this site by approximately 38%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

7.3 PES

The macro-channel floor at the site is dominated by sand and gravel, with some vegetation at the active channel margins. The small single active channel is on the extreme left of the macro-channel floor.

As with the nearby IFR site 6, the causes of change at this site are related to the reduction in frequency, magnitude and duration of moderate and large floods (which result in decreased removal and scouring of sediment from the bed of the macro-channel) and severe reduction in low flows and increase in zero flow periods.

The moderate flows have been reduced, but not as much as at other sites upstream. The dynamics of vegetation change appear natural, and few channel pattern changes are evident from the aerial photographic record until the occurrence of the 2000 floods. A terrace and associated trees have been eroded during this extreme flood, but these changes are not considered unnatural.

PES	CAUSES	SOURCES	FLOW / NON -FLOW RELATED
C (high C)	Reduced potential bed material transport likely to have resulted in bed aggradation.	Reduced moderate & high flows/floods coupled with continuing high sediment loads.	Flow related: caused by reduced flows due the effects of dams and weirs upstream.

7.4 TREND AND REASONS

The trajectory of change, under current conditions, is stable. The site was scoured by the 2000 floods, but prior to this the site was very stable and no adjustments to altered flow regimes are evident. Active channel stabilisation and increasing diversity of instream morphology (deepening of active channels etc) is to be expected as part of the natural readjustment following the 2000 floods.

PES	TREND	RESULTING PES	TIME	REASONS
C (high C)	Stable	C (high C)	10-20 years	The channel type will not adjust to further sediment storage increases.

7.5 ALTERNATIVE ECS

A change up to a "B" class for geomorphology is possible if significant restoration of lower flows occurred. This would promote promote the development of a stabilised active channel and associated marginal vegetation, especially reeds. This would allow scouring of the active channel during higher flows (rather than sediment redistribution and infilling if the channel was unconfined/unstable). This would allow for increased instream morphological diversity (refer to section 6.5 for a full motivation and detailed explanation).

The continued removal of moderate floods and increased low flow/no flow periods would degrade the site to a lower C, as this would prevent the development of a stabilised active channel and associated marginal vegetation. This would cause sediment redistribution and channel infilling to occur during the occasional high flows as the active channels would not be able to confine even moderate flows. This would decrease morphological diversity and result in a wide, shallow, sandy active channel. Continued removal of moderate floods will also inhibit bench/terrace reformation and their stabilisation by vegetation.

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APPENDIX A
GEOMORPHOLOGICAL MACRO-REACH DELINEATION

The aim of the macro-reach analysis is to subdivide the longitudinal profile into morphologically uniform reaches. Channel gradient has been shown to be well correlated with many channel properties including channel pattern, channel type, bed material and reach type (Rowntree, 2000). Changes in gradient down a longitudinal profile usually mark morphological changes and thus provide the basis for the delineation of macro-reaches. These breaks are usually due to changes in lithology, but can also be as a result of tectonic activity or the upstream migration of knick points (Dollar, 1998). Macro-reaches were delineated on the basis of significant breaks in the longitudinal profile. The macro-reaches were then classified using the system of Wadeson (1999).

Six macro-reaches were identified along the (Groot) Letaba main stem channel. Macro-reaches 1, 4 and 5 were further sub-divided in to two sub-categories (*a* and *b*) due to major slope differences and/or tributary junctions. A further 2 macro-reaches were identified in the Klein Letaba.

CHARACTERISTICS OF THE GROOT LETABA MACRO-REACHES

Six macro-reaches were identified on the Letaba mainstem channel, which were further subdivided into 9 units.

Macro-reach 1: Macro-reaches 1(a) and 1(b) represent the extreme upper reaches of the river as they flow over and off of the upper escarpment (Fig. 1). These reaches are generally characterised by the Pietersberg group (schists and amphibolites) from the Swazian period. Macro-reach 1(a) is found above 1500 masl and is only 9kms long with an average slope of 0.0138. Macro-reach 1(b) found between 1500-1300 metres above sea level (masl) and is 39kms long and relatively steep (average slope 0.0051). The main channel is still small and represents a small section of the catchment. The catchment is heavily afforested in this region.

Macro-reach 2: This short (16km) macro-reach is representative of the river as it flows down the steep escarpment (Fig. 1) between 1300 and 800 masl. The average slope is 0.0318 in this macro-reach. Its granite geology is exposed in the bed of the river, resulting in the creation of steep bedrock gorges typified by bedrock rapids, pools and occasional small waterfalls. The confined gorge opens out into a slightly wider valley where boulders and cobbles begin to dominate the bed and bedrock pool/rapid and later pool/riffle becomes the dominate channel patterns. Small floodplain pockets begin to occur as well as occasional instream depositional bars which are not found further upstream.

IFR 1 (Appel) is located in this macro-reach. The site, a pool/riffle sequence dominated by boulders and cobbles, is fairly typical of the macro-reach.

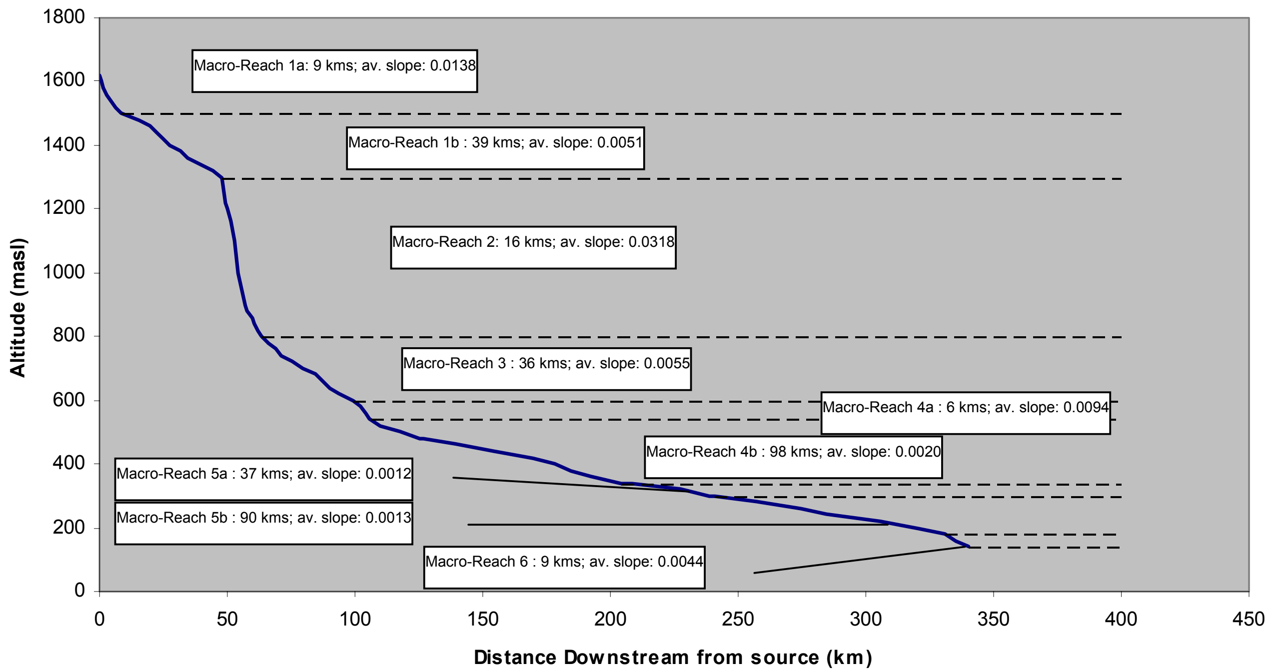

Figure 1: Longitudinal profile of the mainstem Letaba River showing the macro-reach boundaries.

Macro-reach 3: This macro-reach is found between 800 and 600 masl. It is 36kms long and much flatter than macro-reach 2, but is dominated by the Tzaneen (formerly Fanie Botha) Dam. Both macro-reaches 2 and 3 flow over Vaalian Group granites. Long pools with isolated bedrock rapids/riffle outcrops and an almost continuous floodplain occur upstream of the Tzaneen Dam. The area is highly afforested. Downstream of the dam the channel pattern is pool/riffle with occasional small bedrock anastomosing sections. Bedrock influence in the channel is high. However, at the lower end of the macro-reach, more alluvial-influenced channel patterns begin to occur due to the influence of the Yamorna Weir.

Macro-reach 4: This macro-reach is found between 600 and 340 masl. The macro-reach, which is dominated by Swazian gneiss geology, was subdivided into two sub-units. Macro-reach 4(a), although only 9kms long, is much steeper than 4(b). Macro-reach 4(a) is found between 600 and 540 masl. Here the channel pattern changes to a more alluvial-influenced mixed pool/rapid channel type. Bedrock influence remains high in the active channel, but instream depositional features, such as bedrock core bars, as well as lateral deposits of sediment, are more common. Both these features and the macro-channel banks are well-vegetated.

Macro-reach 4(b) is 98kms long and much flatter (0.0020) than 4(b). The macro-reach maintains a strong in-channel bedrock influence and mixed pool/rapid and bedrock anastomosing channel patterns are common. Further downstream, as more sediment is introduced from lowveld tributaries, the more alluvial channel patterns of braiding and alluvial single thread occur. Some sandy lateral bar deposits also begin to appear, but the general absence of braid bars (and other instream sand bars) may be caused by the retention of bed sediments in the numerous dams and weirs in this section of the river and adjoining tributaries.

The IFR site located at Prieska Weir is in this macro-reach. The site is more confined than is typical for this macro-reach, but the bedrock influence on the macro-channel bed is typical of the macro-reach. The site is thus fairly typical of the macro-reach.

Macro-reach 5: Macro-reach 5 is much flatter than upstream. This macro-reach was divided into two subunits due to the influence of the Klein Letaba confluence in this macro-reach. Macro-reach 5(a) represents the river below 540 masl until the confluence with the Klein Letaba 37kms downstream. Again, Swazian Gneiss is the dominant geology here. Extensive sections of the mixed braided channel type, separated by occasional pool-rapid sections associated with large bedrock (dyke) outcrops, are typical of this subunit. The confluence with the Molototsi provides a locally high sediment load to the main channel, but this soon reverts back to the sandy braided sections interspersed with bedrock pool-rapid sections seen upstream. The valley is unconfined, the macro-channel quite shallow and both the macro-channel and active channels are wide.

Although there is almost no change in slope between Macro-reach 5(a) and 5(b), the channel pattern is altered by the high sediment inputs from the Klein Letaba. Macro-reach 5(b) extended for 90kms from the confluence with the Klein Letaba until 180 masl. This macro-reach represents most of the Letaba River within the Kruger National Park.

Swazian Gneiss, with ultramafic schist and gabbro intrustions, is initially the geology over which the river flows. However in the middle of this macro-reach the river flows through quaternary sediments which overly Letaba formation basalts.

More alluvial-influenced channel patterns, such as alluvial anastomosing and alluvial single thread, become the dominant patterns in this macro-reach. However there are still some small, uncommon, bedrock-influenced anastomosing and pool-rapid sections. The macro-channel floor here tends to be wide and sandy with a small misfit active channel flowing within it.

Two IFR sites (Lonely Bull and Letaba Bridge) are found in the long macro-reach 5 (b). Both these sites can be considered to be typical of the macro-reach.

Macro-reach 6: This is a short (9km long), steep (slope 0.0044) macro-reach, which represents the section of river which flows over the Letaba formation granites at the western edge of the Kruger National Park before its confluence with the Olifants River near the Mozambique border. Here the river has incised into the underlying bedrock, creating a steep, confined, highly bedrock-influenced section of river.

CHARACTERISTICS OF THE KLEIN LETABA MACRO-REACHES

The Klein Letaba was divided into two macro-reaches (Fig.2) based on slope characteristics.

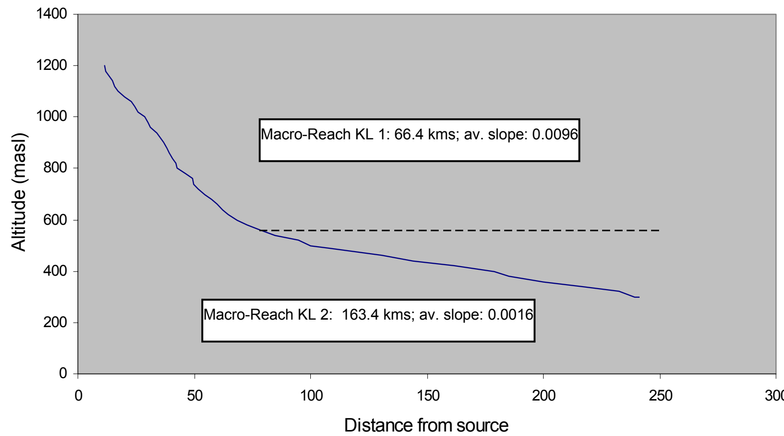

Figure 2: Longitudinal profile of the Klein Letaba River showing the macro-reach boundary.

Macro-reach KL 1: Macro-reach 1 represents that section of the river from the lower escarpment down to 560 masl. This is the steeper (slope 0.0096), smaller (66 kms long) of the two macro-reaches.

Macro-reach KL 2: This macro-reach represents that section of the river from 560 masl downstream until the confluence with the Groot Letaba. The semi-arid nature of the extensive catchment, which is dominated by Gneiss, results in a high sediment production. This is delivered to the tributaries and, due to the low slope of the area, stored in them and in the main stem of the Klein Letaba. The channel is therefore dominated by extensive alluvial sections with occasional bedrock outcrops causing local controls. The IFR site (Klein Letaba) located here is typical of the macro-reach.

Table 1: Summary of the macro-reach characteristics

Macro-reach	Altitude (masl)	Length (km's)	Average slope	Channel characteristics (based on slope after Wadeson, 1999)
1a	above 1500	9	0.0138	Mountain stream (0.01-0.1)
1b	1500-1300	39	0.0051	Foothills (cobble bed) (0.005-0.01)
2	1300-800	16	0.0318	Rejuvenated Bedrock Fall (0.01-0.5)*
3	800-600	36	0.0055	Rejuvenated Foothills (0.001-0.01)*
4a	600-540	6	0.0094	Rejuvenated Foothills (0.001-0.01)*
4b	540-340	98	0.0020	Rejuvenated Foothills (0.001-0.01)*
5a	340-297	37	0.0012	Rejuvenated Foothills (0.001-0.01)*
5b	297-180	90	0.0013	Rejuvenated Foothills (0.001-0.01)*
6	180-140	9	0.0044	Gorge
KL 1	above 560	66	0.0096	Rejuvenated Foothills (0.001-0.01)*
KL 3	560-297	163	0.0016	Rejuvenated Foothills (0.001-0.01)*

* zones associated with rejuvenated river profiles

APPENDIX B
POTENTIAL BED MATERIAL TRANSPORT MODELLING RESULTS

INTRODUCTION

Conventional wisdom has it that river systems experience periods of metastability or quasi-stability interrupted by periods of rapid change. Over geological time, morphological adjustments are either due to tectonic activity or climate change. During modern time, it is the observed discharge of water and sediment that determine channel form in alluvial systems. Where a change in sediment transport capacity or discharge occurs, the channel boundary will adjust its geometry in sympathy with the imposed change. This is of significance as the channel boundary provides the physical habitat for riverine biota.

The theoretical position taken in this report is that two sets of discharges are significant in maintaining channel form; a set of effective discharges in the 5-0.1% range on the 1-day daily flow duration curve, and larger 're-set' flood events such as the flood events of 2000. The theoretical basis for these assumptions is presented in Dollar & Rowntree (2003). These sets of discharges are identified using the methodologies developed by Dollar & Rowntree (2003) and have been used in various reserve determination studies in South Africa including the Thukela, Elands, Waterval and Inkomati studies.

METHODS

To determine channel forming discharge and sediment-maintenance flushing flows the following methods were applied. Simulated present-day and virgin daily flow data for each of the sites was obtained from the hydrologist. Although there are some problems with simulated daily data over- and under-estimating the low and high flows respectively, the observed flow records at many sites were extremely short and, due to the rapid and extensive development of water resources in the catchment, are unlikely to represent current flow conditions.

The flow data were used to generate 1-day daily flow duration curves. These were divided into flow classes. The geometric mean was taken to represent each flow class. Table 1 lists the flow classes and geometric mean discharges for the present-day and virgin flow conditions at each IFR site.

Table 1: Geometric means of the flow classes for virgin (V) and present-day (PD) flow conditions.

% time exceeded	Geometric Mean Q (m^3/s)													
	IFR 1		IFR 2		IFR 3		IFR 4		IFR 5		IFR 6		IFR 7	
	V	PD	V	PD	V	PD	V	PD	V	PD	V	PD	V	PD
0.01	53.5	42.5	135.3	127.5	432.3	372.3	531.9	475.6	556.4	468.6	1017.5	908.0	1100.6	908.0
0.10	38.5	28.9	70.2	64.9	287.8	230.3	339.6	290.9	219.8	161.1	554.0	473.2	585.9	473.2
0.20	32.9	24.3	56.3	51.2	228.0	183.5	265.7	222.0	139.3	98.5	440.8	366.1	463.9	366.1
0.30	29.6	21.5	47.7	43.2	202.1	159.3	236.8	188.1	105.2	70.5	376.5	303.0	395.0	303.0
0.40	27.2	19.8	41.7	37.9	181.7	143.6	213.2	169.3	84.2	54.5	337.6	264.3	352.8	264.3
0.50	25.5	18.5	37.5	33.9	166.8	128.6	195.8	153.9	68.6	44.6	303.9	239.2	319.4	239.2
0.60	24.1	17.5	34.3	31.0	155.7	117.1	180.4	140.2	59.2	37.1	275.2	220.1	291.2	220.1
0.70	22.9	16.7	31.8	28.7	145.8	108.9	166.7	129.7	52.5	30.9	254.8	202.4	267.8	202.4
0.80	22.0	15.9	29.7	26.6	136.9	101.7	156.0	121.5	46.1	26.7	239.0	186.1	248.0	186.1
0.90	21.2	15.1	27.9	24.9	129.1	95.2	147.0	115.0	40.8	23.7	222.9	173.7	229.5	173.7
1.00	18.0	12.5	21.8	19.4	101.2	72.2	115.8	87.2	27.3	14.6	169.8	128.2	174.5	128.2
2.00	14.0	8.6	15.5	13.5	71.2	47.7	80.9	57.1	15.6	7.2	114.5	82.5	118.7	82.5

3.00	11.4	6.0	12.2	10.5	55.6	34.9	62.8	41.7	11.0	4.5	87.2	59.6	90.5	59.6
4.00	9.4	4.5	10.0	8.5	45.1	26.3	50.8	31.6	8.5	3.2	70.3	44.4	72.3	44.4
5.00	7.9	3.5	8.4	7.0	37.9	20.4	42.4	24.6	7.0	2.5	58.3	34.3	60.0	34.3
6.00	6.7	2.9	7.3	5.9	32.7	16.4	36.3	19.8	5.8	2.0	49.7	26.9	51.0	26.9
7.00	5.8	2.3	6.4	5.1	28.6	13.5	31.7	16.2	5.0	1.7	43.0	21.6	44.0	21.6
8.00	5.2	1.8	5.7	4.5	25.5	11.3	28.0	13.6	4.4	1.4	37.3	17.7	38.2	17.7
9.00	4.7	1.5	5.2	4.0	23.0	9.5	25.2	11.4	3.8	1.2	32.8	14.7	33.6	14.7
10.00	3.2	0.9	3.7	2.7	16.1	5.2	17.4	6.1	2.3	0.7	21.9	7.4	22.3	7.4
20.00	1.9	0.5	2.4	1.6	9.8	2.3	10.4	2.6	1.2	0.3	12.7	2.9	12.8	2.9
30.00	1.4	0.4	1.9	1.1	7.2	1.2	7.5	1.4	0.7	0.2	9.1	1.5	9.1	1.5
40.00	1.2	0.3	1.5	0.8	5.6	0.7	5.9	0.8	0.5	0.1	7.0	0.8	7.1	0.8
50.00	1.0	0.3	1.2	0.6	4.6	0.4	4.8	0.4	0.3	0.1	5.7	0.4	5.7	0.4
60.00	0.9	0.3	1.0	0.4	3.7	0.2	3.9	0.2	0.2	0.1	4.6	0.2	4.6	0.2
70.00	0.8	0.2	0.8	0.3	2.9	0.1	3.1	0.1	0.1	0.0	3.6	0.1	3.6	0.1
80.00	0.7	0.2	0.6	0.1	2.1	0.0	2.2	0.0	0.1	0.0	2.7	0.0	2.7	0.0
90.00	0.0	0.0	0.0	0.0	0.6	0.0	0.6	0.0	0.0	0.0	0.7	0.0	0.7	0.0

The geometric means of the flow classes were used in conjunction with the hydraulic data and cross-sections so that parameters such as width, depth, hydraulic radius, slope, perimeter and so on could be calculated. This information and the bed material data was used together with Yang's (Yang, 1973) total load equations to determine the effective discharge (the discharge that over a long period of time transports the most bed material). This modelling technique assumes:

1) The bed material sampled at each IFR site is representative of the supply of bed material to the channel (hence potential bed material load as opposed to bed load).
2) Bed material sampling can be averaged for the whole IFR site and used to represent each cross-section.
3) The supply of bed material to each IFR site is based on the existing bed material and its size distribution, and is available for transport at all discharges.
4) Average conditions can be used.

A full, detailed description of the technique can be found in Dollar & Rowntree (2003).

RESULTS

IFR 1 (Appel)

At IFR 1, mean daily flows of approximately 5, 10 and 20 m^3/s were associated with particularly high rates of sediment transport under virgin flow conditions (Figure 1a). The reduction in the frequencies of these flows under the present-day flow conditions (Figure 1b) has reduced the potential for sediment transport at this site by approximately 61%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

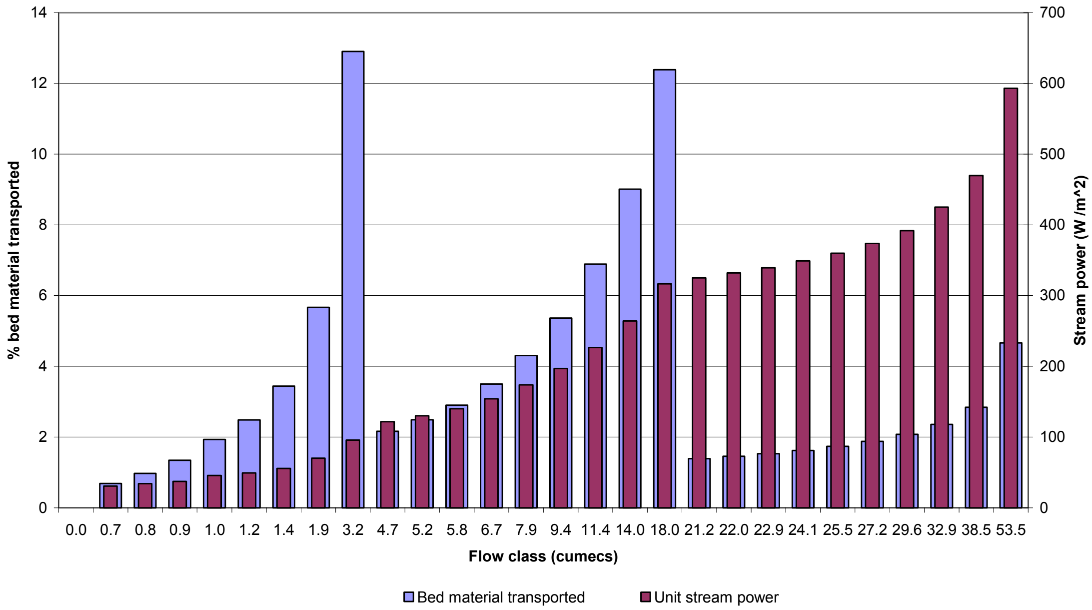

Figure 1a: Potential bed material transport (Yang) for IFR 1 under virgin flow conditions

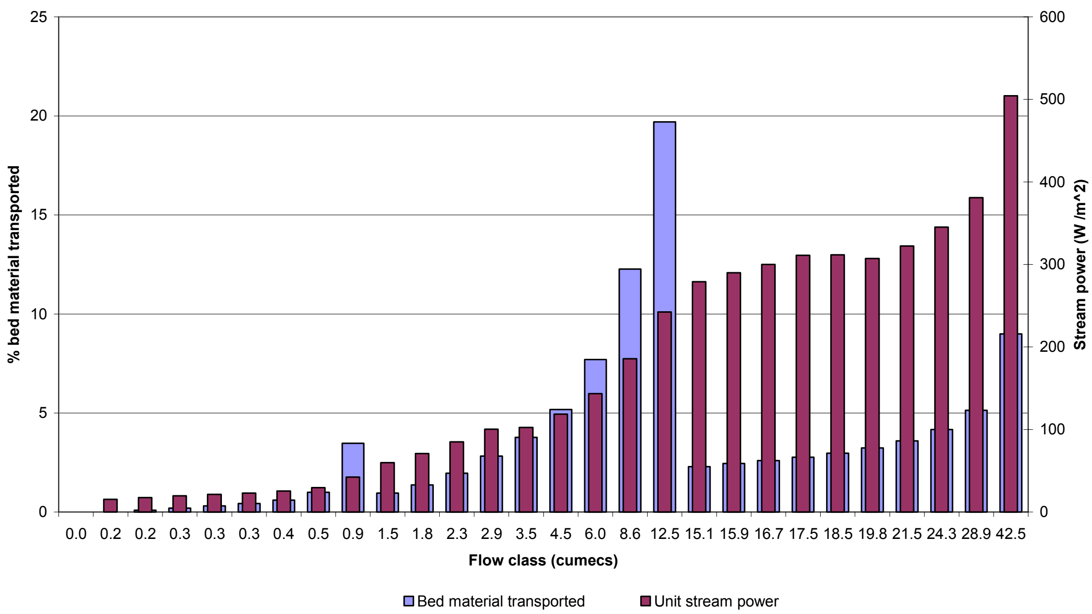

Figure 1b: Potential bed material transport (Yang) for IFR 1 under present-day flow conditions

IFR 2 (Letsitele)

The potential for sediment transport at this site has been reduced by approximately 29%. The PBMT modelling identified mean daily flows of approximately 2.7 and 15 m^3/s that had, under the virgin flow conditions (Figure 2a), been important for sediment transport. The reduced frequency and duration of these flows under the present-day flow conditions (Figure 2b) has negatively impacted the potential of the site to transport sediment.

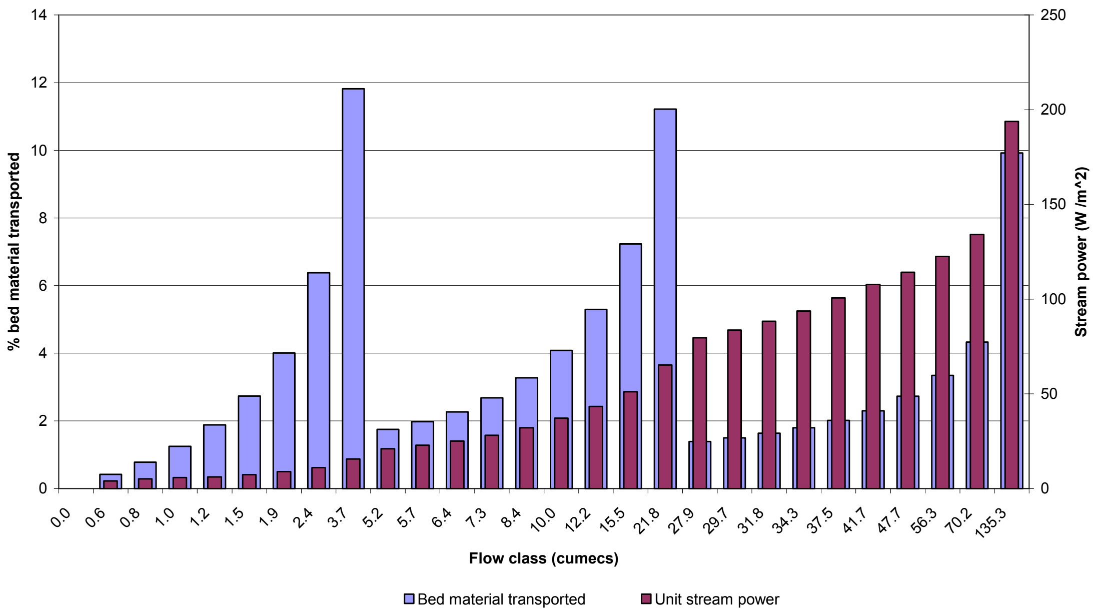

Figure 2a: Potential bed material transport (Yang) for IFR 2 under virgin flow conditions

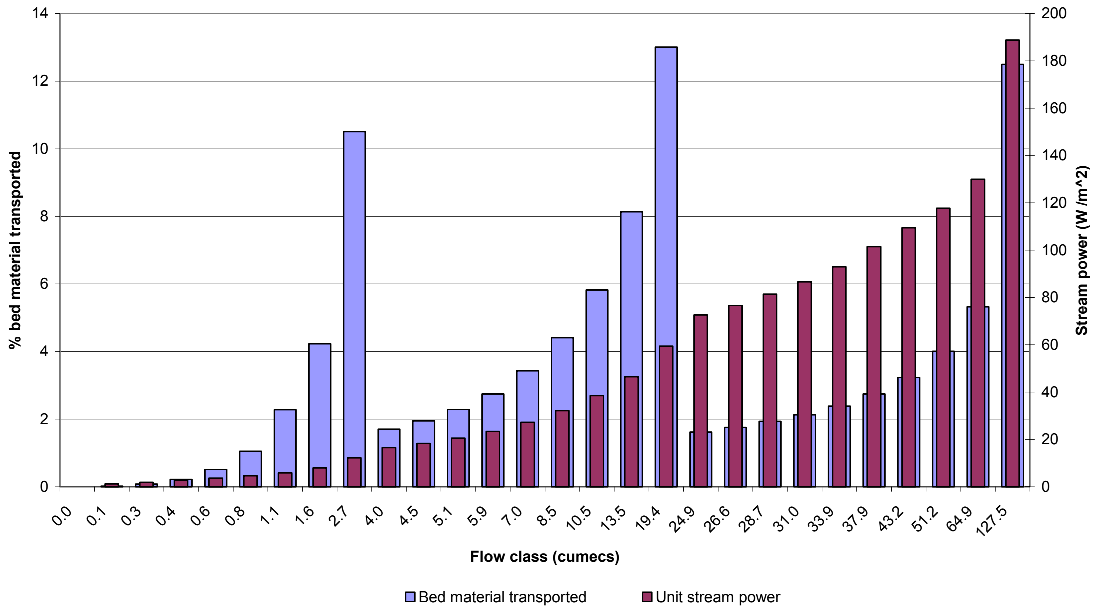

Figure 2b: Potential bed material transport (Yang) for IFR 2 under present-day flow conditions

IFR 3 (Eiland)

At IFR 3, mean daily flows in the ranges of 15, 70-100 and 150-200 m^3/s were associated with particularly high rates of sediment transport under virgin flow conditions (Figure 3a). The reduction in the frequencies of these flows under the present-day flow conditions (Figure 3b) has reduced the potential for sediment transport at this site by approximately 48%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

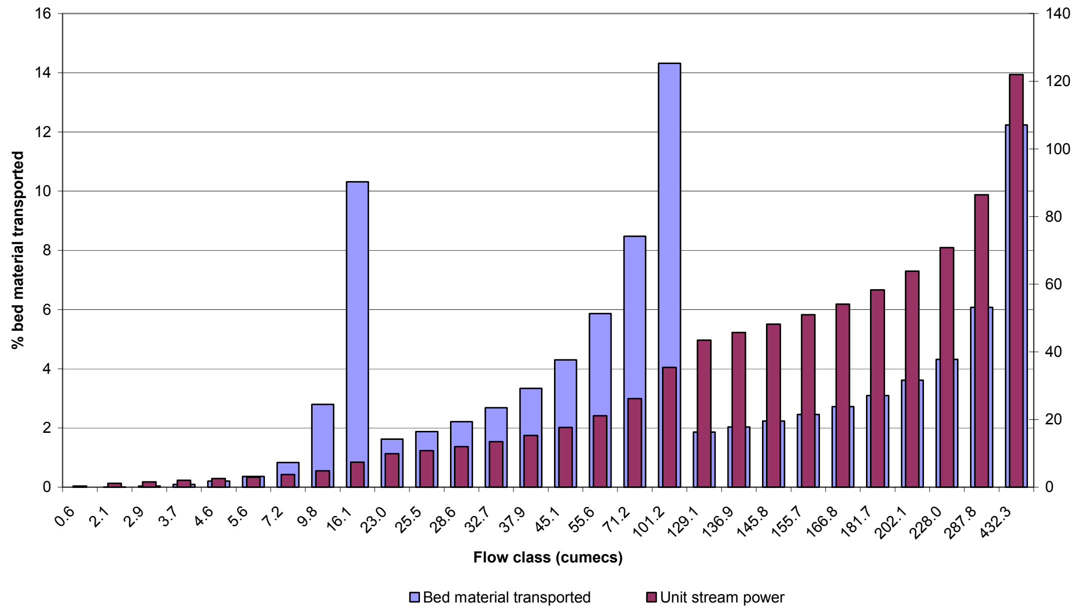

Figure 3a: Potential bed material transport (Yang) for IFR 3 under virgin flow conditions

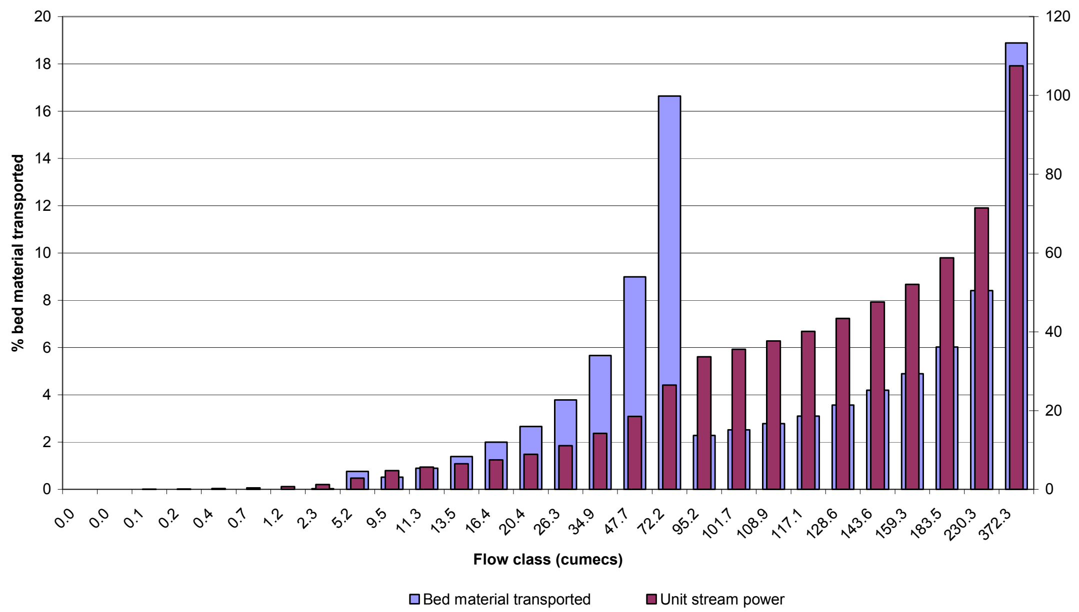

Figure 3b: Potential bed material transport (Yang) for IFR 3 under present-day flow conditions

IFR 4 (Letaba Ranch)

At IFR 4, mean daily flows of approximately 6, 60 and 130 m^3/s were associated with particularly high rates of sediment transport under virgin flow conditions (Figure 4a). The reduction in the frequencies of these flows under the present-day flow conditions (Figure 4b) has reduced the potential for sediment transport at this site by approximately 45%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

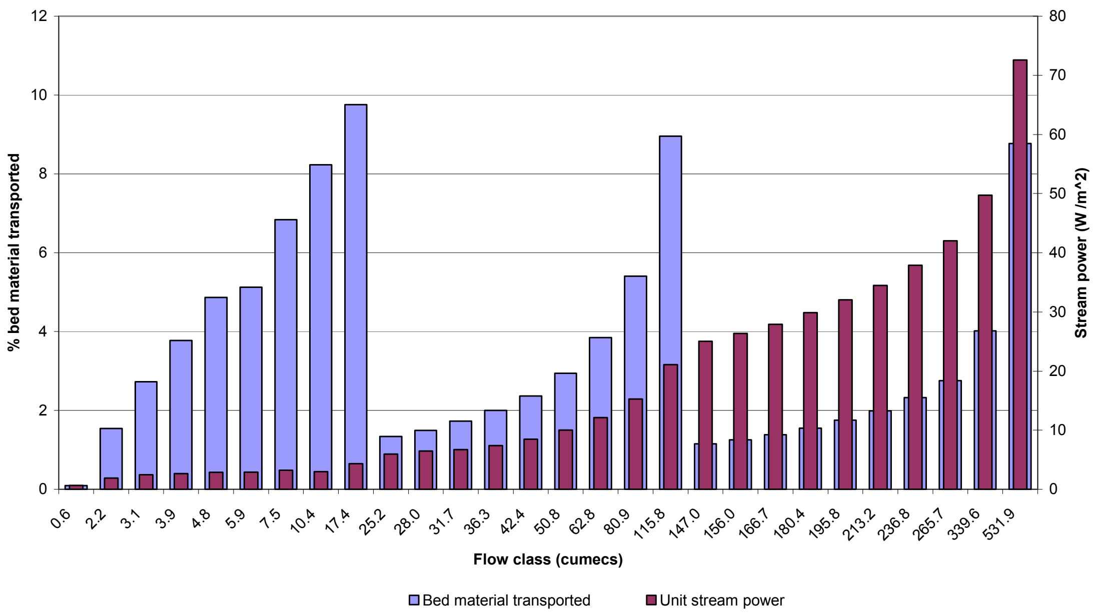

Figure 4a: Potential bed material transport (Yang) for IFR 4 under virgin flow conditions

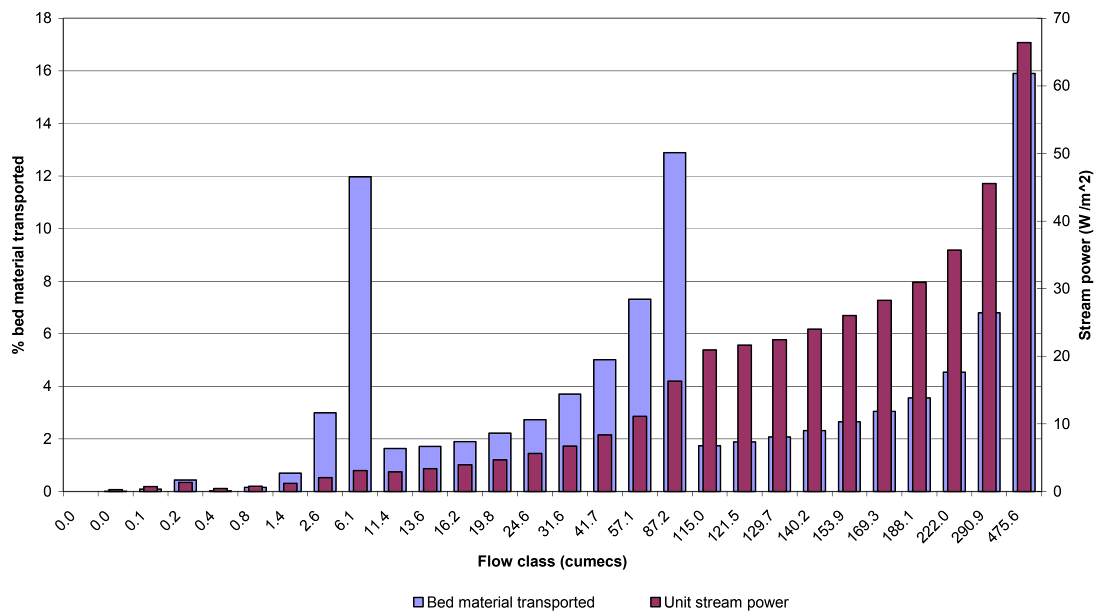

Figure 4b: Potential bed material transport (Yang) for IFR 4 under present-day flow conditions

IFR 5 (Klein Letaba)

At IFR 5, mean daily flows of approximately 14, 70 and 500 m^3/s were associated with particularly high rates of sediment transport under virgin flow conditions (Figure 5a). The reduction in the frequencies of these flows under the present-day flow conditions (Figure 5b) has reduced the potential for sediment transport at this site by approximately 26%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

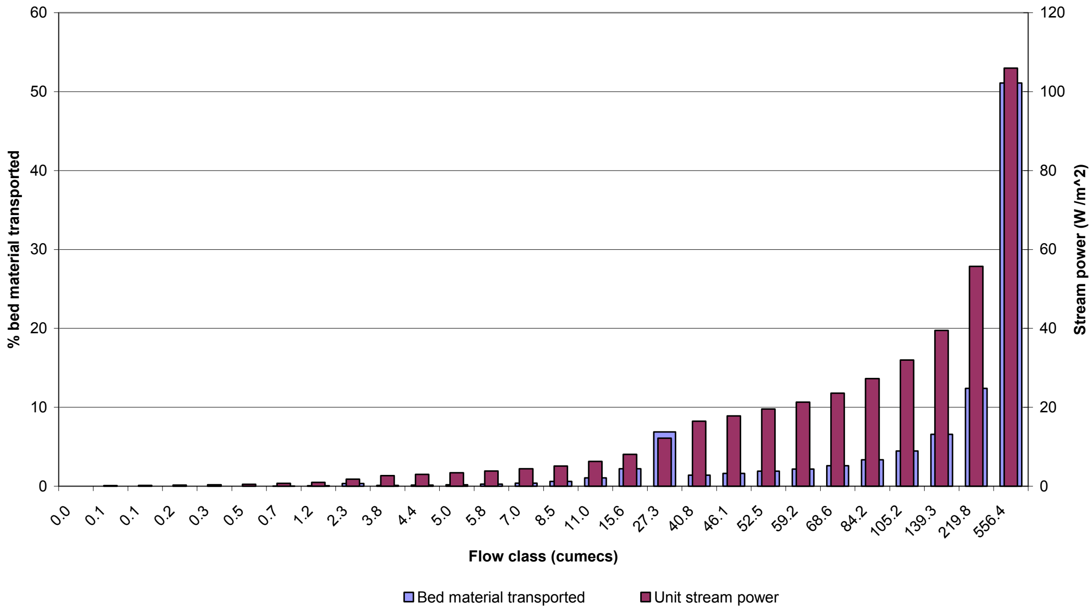

Figure 5a: Potential bed material transport (Yang) for IFR 5 under virgin flow conditions

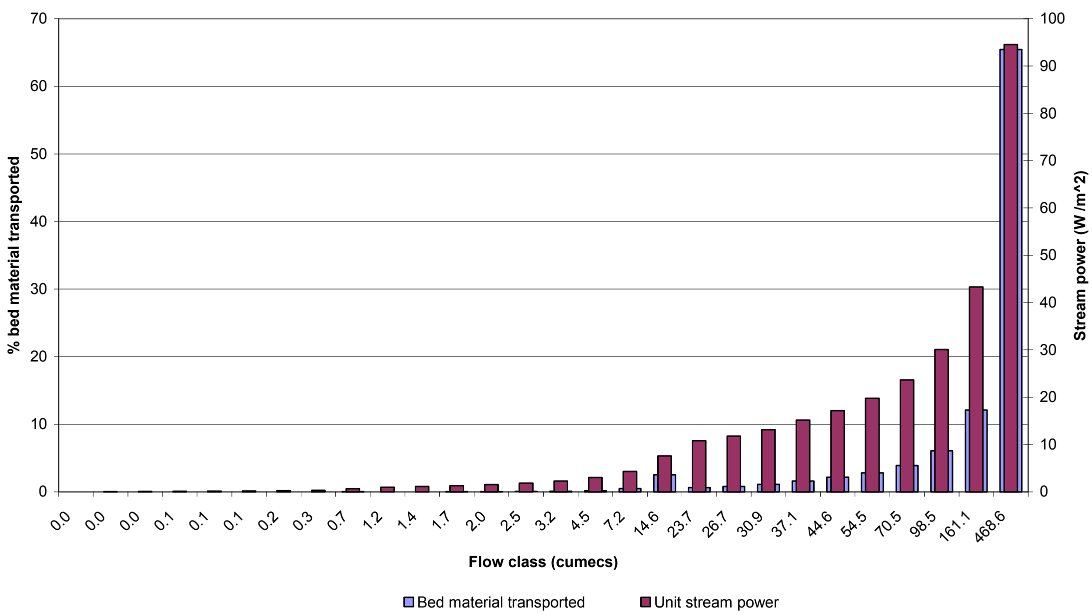

Figure 5b: Potential bed material transport (Yang) for IFR 5 under present-day flow conditions

IFR 6 (Lonely Bull)

At IFR 6, mean daily flows of approximately 20, 80, 200 and 2000 m^3/s were associated with particularly high rates of sediment transport under virgin flow conditions (Figure 6a). The reduction in the frequencies of these flows under the present-day flow conditions (Figure 6b) has reduced the potential for sediment transport at this site by approximately 38%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

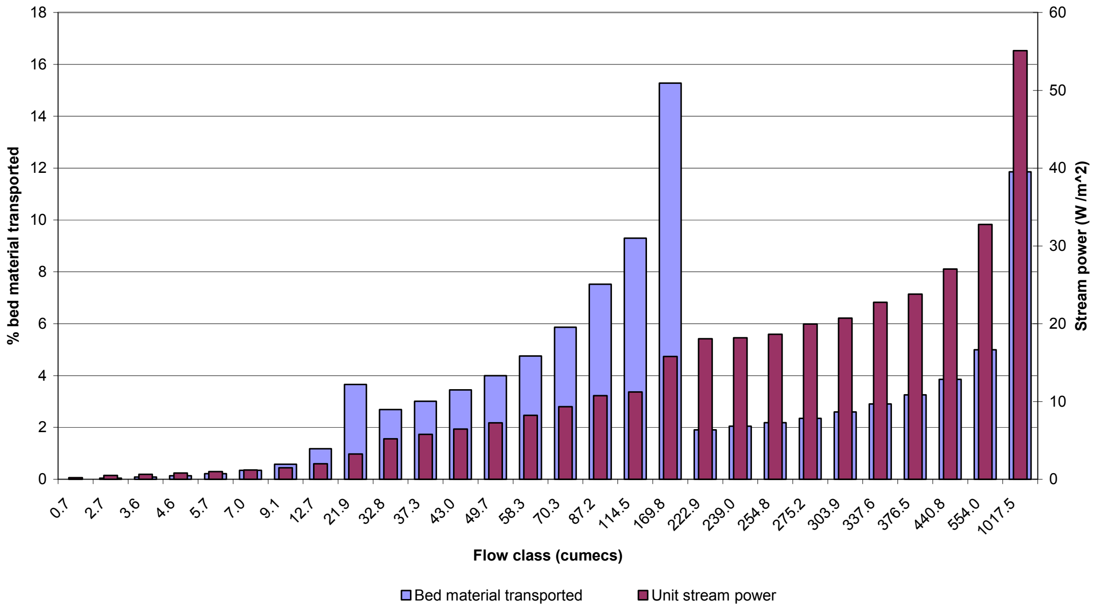

Figure 6a: Potential bed material transport (Yang) for IFR 6 under virgin flow conditions

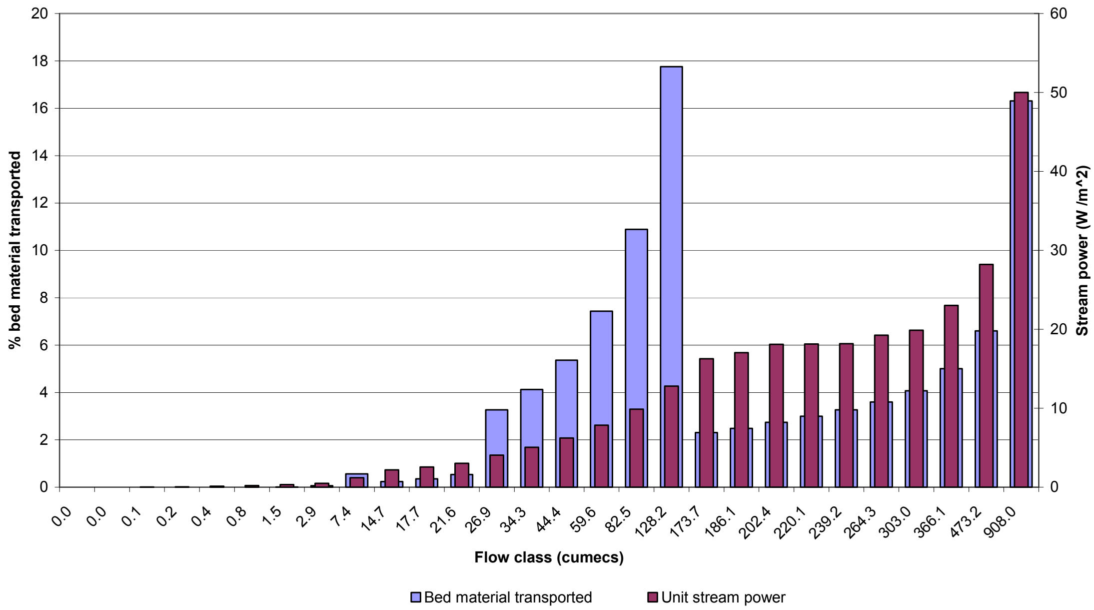

Figure 6b: Potential bed material transport (Yang) for IFR 6 under present-day flow conditions

IFR 7 (Letaba Bridge)

At IFR 7, mean daily flows of approximately 22, 90, 220 and 2500 m^3/s were associated with particularly high rates of sediment transport under virgin flow conditions (Figure 7a). The reduction in the frequencies of these flows under the present-day flow conditions (Figure 7b) has reduced the potential for sediment transport at this site by approximately 38%. To maintain and/or improve the condition of the site, particular emphasis should be placed on the provision of these flows.

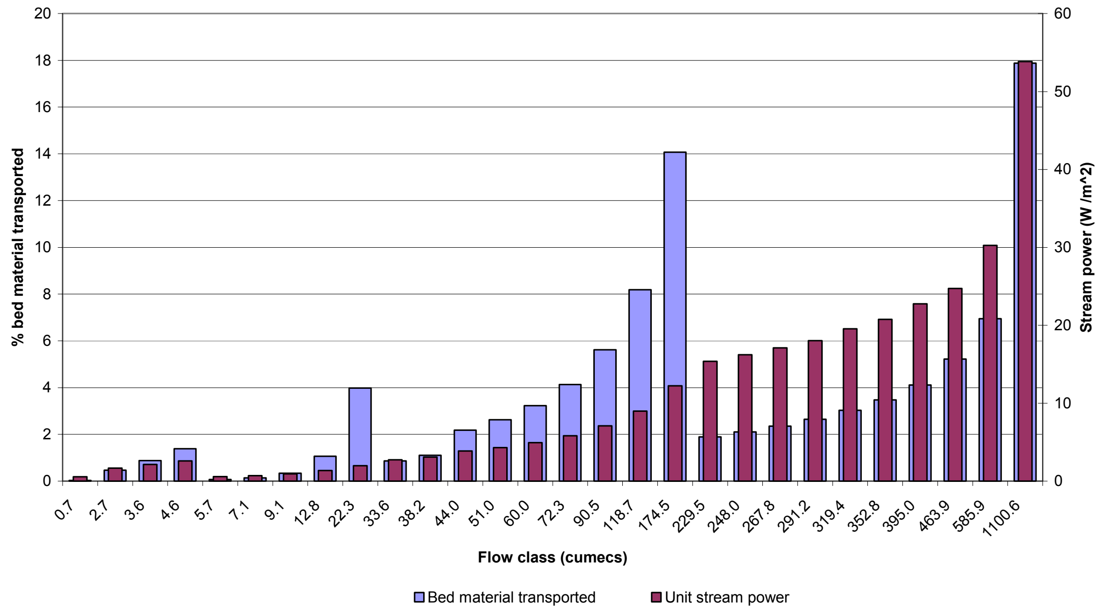

Figure 7a: Potential bed material transport (Yang) for IFR 7 under virgin flow conditions

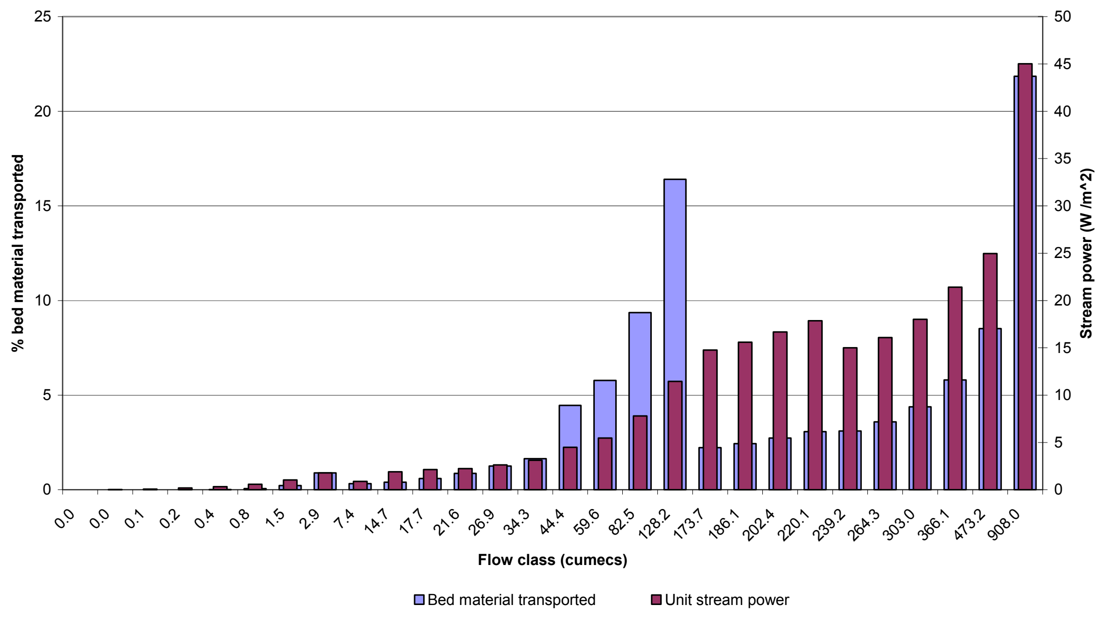

Figure 7b: Potential bed material transport (Yang) for IFR 7 under present-day flow conditions

REFERENCES

Dollar, E.S.J and Rowntree, K.M. 2003. Geomorphological Research for the Conservation and Management of Southern African Rivers. Volume 2: Managing Flow Variability: the geomorphological response. Water Research Commission Report No. 849/2/04, Pretoria.

Yang, C.T., 1973: Incipient motion and sediment transport, Journal of the Hydraulics Division, American Society of Civil Engineers, 99, HY10, 1679-1704.

APPENDIX C
TABLES OF PRESENT ECOLOGICAL STATE (PES) AND POSSIBLE TRAJECTORIES (“UP” AND “DOWN” SCENARIOS, WHERE APPLICABLE) OF CHANGE

IFR 1: PES

SCORING GUIDELINES							
			GEOMORPHOLOGY DRIVERS				
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	2.5	0.53	3.95	4.00	5.00
RIPARIAN VEGETATION	3.00	40.00	0.50	0.21	0.32	1.00	2.00
CHANNEL PATTERN & MORPHOLOGY	2.00	50.00	2.00	0.26	1.58	0.00	5.00
TOTALS		190.00	2.50	1.00	5.84		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**61.00**		
HABITAT DRIVER CATEGORY					**C**	PES	

IFR 1: DOWN TRAJECTORY

SCORING GUIDELINES							
	GEOMORPHOLOGY DRIVERS						
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	2.5	0.53	3.95	4.00	5.00
RIPARIAN VEGETATION	3.00	40.00	0.50	0.21	0.32	1.00	2.00
CHANNEL PATTERN & MORPHOLOGY	2.00	50.00	2.00	0.26	1.58	0.00	5.00
TOTALS		190.00	2.50	1.00	5.84		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**61.00**		
HABITAT DRIVER CATEGORY					**C**	PES	

IFR 2: PES

SCORING GUIDELINES							
			GEOMORPHOLOGY DRIVERS				
COMPONENTS	RANK	% Weight	RATING	WEIGHT	Weighed score	Flow-related (event hydrology;high flows, floods)	CONFIDENCE
EVENT HYDROLOGY & SEDIMENT SUPPLY	3.00	60.00	1	0.26	0.78	3.00	3.00
RIPARIAN VEGETATION	2.00	70.00	3.00	0.30	2.74	2.00	3.00
CHANNEL PATTERN & MORPHOLOGY	1.00	100.00	4.00	0.43	5.22	3.50	4.00
TOTALS		230.00	7.00	1.00	8.74		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**41.00**	PES	
HABITAT DRIVER CATEGORY					**D**	D/E	

IFR 2: UP TRAJECTORY

SCORING GUIDELINES							
	GEOMORPHOLOGY DRIVERS						
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	3.00	60.00	1	0.26	0.78	3.00	3.00
RIPARIAN VEGETATION	2.00	70.00	2.50	0.30	2.28	2.00	3.00
CHANNEL PATTERN & MORPHOLOGY	1.00	100.00	3.00	0.43	3.91	3.50	4.00
TOTALS		230.00	5.50	1.00	6.98		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**53.00**		
HABITAT DRIVER CATEGORY					**D**		

IFR 3: PES

Eiland/Prieska Upstream

SCORING GUIDELINES							
	GEOMORPHOLOGY DRIVERS						
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	3	0.48	4.29	3.00	3.00
RIPARIAN VEGETATION	3.00	50.00	0.50	0.24	0.36	1.00	3.00
CHANNEL PATTERN & MORPHOLOGY	2.00	60.00	1.00	0.29	0.86	0.00	4.00
TOTALS		210.00	1.50	1.00	5.50		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**63.00**		
HABITAT DRIVER CATEGORY					**C**		

IFR 3: UP TRAJECTORY

SCORING GUIDELINES							
GEOMORPHOLOGY DRIVERS							
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	1.5	0.48	2.14	3.00	3.00
RIPARIAN VEGETATION	3.00	50.00	0.50	0.24	0.36	1.00	3.00
CHANNEL PATTERN & MORPHOLOGY	2.00	60.00	0.80	0.29	0.69	0.00	4.00
TOTALS		210.00	1.30	1.00	3.19		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**78.00**		
HABITAT DRIVER CATEGORY					**C**	B/C	

IFR 3: DOWN TRAJECTORY

Eiland/Prieska Upstream

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS							
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	3.5	0.48	5.00	3.00	3.00
RIPARIAN VEGETATION	3.00	50.00	2.00	0.24	1.43	1.00	3.00
CHANNEL PATTERN & MORPHOLOGY	2.00	60.00	2.00	0.29	1.71	0.00	4.00
TOTALS		210.00	4.00	1.00	8.14		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**45.00**		
HABITAT DRIVER CATEGORY					**D**		

IFR 4: PES

SCORING GUIDELINES							
GEOMORPHOLOGY DRIVERS							
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	2.4	0.56	4.00	4.00	5.00
RIPARIAN VEGETATION	2.00	50.00	1.50	0.28	1.25	3.00	2.00
CHANNEL PATTERN & MORPHOLOGY	3.00	30.00	1.20	0.17	0.60	4.00	5.00
TOTALS		180.00	5.10	1.00	5.85		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**61.00**	(PES)	
HABITAT DRIVER CATEGORY					**C**	C/D	

IFR 4: UP TRAJECTORY

SCORING GUIDELINES							
			GEOMORPHOLOGY DRIVERS				
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	2	0.56	3.33	4.00	5.00
RIPARIAN VEGETATION	2.00	50.00	1.50	0.28	1.25	3.00	2.00
CHANNEL PATTERN & MORPHOLOGY	3.00	30.00	0.40	0.17	0.20	4.00	5.00
TOTALS		180.00	3.90	1.00	4.78		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**68.00**		
HABITAT DRIVER CATEGORY					**C**		

IFR 4: DOWN TRAJECTORY

SCORING GUIDELINES							
GEOMORPHOLOGY DRIVERS							
COMPONENTS	RANK	% Weight	RATING	WEIGHT	Weighed score	Flow-related (event hydrology;high flows, floods)	CONFIDENCE
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	3.2	0.56	5.33	4.00	5.00
RIPARIAN VEGETATION	2.00	50.00	1.50	0.28	1.25	3.00	2.00
CHANNEL PATTERN & MORPHOLOGY	3.00	30.00	2.00	0.17	1.00	4.00	5.00
TOTALS		180.00	6.70	1.00	7.58		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**49.00**		
HABITAT DRIVER CATEGORY					**D**		

IFR 5: PES

SCORING GUIDELINES							
GEOMORPHOLOGY DRIVERS							
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	2.8	0.48	4.00	4.00	5.00
RIPARIAN VEGETATION	2.00	70.00	1.50	0.33	1.50	4.00	3.50
CHANNEL PATTERN & MORPHOLOGY	3.00	40.00	0.00	0.19	0.00	1.00	2.00
TOTALS		210.00	4.30	1.00	5.50		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**63.00**	PES	
HABITAT DRIVER CATEGORY					**C**		

IFR 5: UP TRJECTORY

SCORING GUIDELINES							
	GEOMORPHOLOGY DRIVERS						
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	2.2	0.48	3.14	4.00	5.00
RIPARIAN VEGETATION	2.00	70.00	1.20	0.33	1.20	4.00	3.50
CHANNEL PATTERN & MORPHOLOGY	3.00	40.00	0.00	0.19	0.00	1.00	2.00
TOTALS		210.00	3.40	1.00	4.34		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**71.00**		
HABITAT DRIVER CATEGORY					**C**		

IFR 5: DOWN TRAJECTORY

SCORING GUIDELINES							
GEOMORPHOLOGY DRIVERS							
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	3	0.48	4.29	4.00	5.00
RIPARIAN VEGETATION	2.00	70.00	2.50	0.33	2.50	4.00	3.50
CHANNEL PATTERN & MORPHOLOGY	3.00	40.00	0.00	0.19	0.00	1.00	2.00
TOTALS		210.00	5.50	1.00	6.79		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**54.00**		
HABITAT DRIVER CATEGORY					**D**		

IFR 6: PES

Lonely Bull

SCORING GUIDELINES							
			GEOMORPHOLOGY DRIVERS				
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	2	0.43	2.55	3.00	3.00
RIPARIAN VEGETATION	2.50	65.00	0.50	0.28	0.41	1.00	3.00
CHANNEL PATTERN & MORPHOLOGY	2.00	70.00	0.50	0.30	0.45	0.00	4.00
TOTALS		235.00	1.00	1.00	3.41		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**77.00**		
HABITAT DRIVER CATEGORY					**C**		

IFR 6: UP TRAJECTORY

Lonely Bull

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS							
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	1.5	0.43	1.91	3.00	3.00
RIPARIAN VEGETATION	2.50	65.00	0.50	0.28	0.41	1.00	3.00
CHANNEL PATTERN & MORPHOLOGY	2.00	70.00	0.30	0.30	0.27	0.00	4.00
TOTALS		235.00	0.80	1.00	2.60		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**82.00**		
HABITAT DRIVER CATEGORY					**B**		

IFR 6: DOWN TRAJECTORY

Lonely Bull

SCORING GUIDELINES							
	GEOMORPHOLOGY DRIVERS						
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	3.5	0.43	4.47	3.00	3.00
RIPARIAN VEGETATION	2.50	65.00	1.00	0.28	0.83	1.00	3.00
CHANNEL PATTERN & MORPHOLOGY	2.00	70.00	2.00	0.30	1.79	2.00	3.00
TOTALS		235.00	3.00	1.00	7.09		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**52.00**		
HABITAT DRIVER CATEGORY					**D**		

IFR 7: PES

Letaba Bridge

SCORING GUIDELINES							
	GEOMORPHOLOGY DRIVERS						
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	2	0.42	2.50	3.00	3.00
RIPARIAN VEGETATION	2.50	65.00	0.50	0.27	0.41	1.00	3.00
CHANNEL PATTERN & MORPHOLOGY	2.00	75.00	0.50	0.31	0.47	0.00	4.00
TOTALS		240.00	1.00	1.00	3.38		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**77.00**		
HABITAT DRIVER CATEGORY					**C**		

IFR 7: UP TRAJECTORY

Letaba Bridge

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS							
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	1.2	0.42	1.50	3.00	3.00
RIPARIAN VEGETATION	2.50	65.00	0.40	0.27	0.33	1.00	3.00
CHANNEL PATTERN & MORPHOLOGY	2.00	75.00	0.50	0.31	0.47	0.00	4.00
TOTALS		240.00	0.90	1.00	2.29		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**84.00**		
HABITAT DRIVER CATEGORY					**B**		

IFR 7: DOWN TRAJECTORY

Letaba Bridge

SCORING GUIDELINES

GEOMORPHOLOGY DRIVERS							
COMPONENTS	**RANK**	**% Weight**	**RATING**	**WEIGHT**	**Weighed score**	**Flow-related (event hydrology;high flows, floods)**	**CONFIDENCE**
EVENT HYDROLOGY & SEDIMENT SUPPLY	1.00	100.00	3	0.42	3.75	3.00	3.00
RIPARIAN VEGETATION	2.50	65.00	3.00	0.27	2.44	1.00	3.00
CHANNEL PATTERN & MORPHOLOGY	2.00	75.00	0.50	0.31	0.47	0.00	4.00
TOTALS		240.00	3.50	1.00	6.66		
Driver status:(%): >89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F					**55.00**		
HABITAT DRIVER CATEGORY					**D**		

APPENDIX D:
SEDIMENT CHARACTERISATION DATA FROM THE IFR SITES

IFR 1				
Date collected:	2/9/2003			
X section 1 (upstream pool)			X section 2 (riffle)	
Diameter (mm)	**% distribution**		**Diameter (mm)**	**% distribution**
2048	0		2048	0
1024	0		1024	0
512	5		512	5
256	11		256	33
128	38		128	36
64	7		64	13
32	0		32	7
16	1		16	1
8	0		8	1
2	5		2	2
1.18	10		1.18	1
0.6	14		0.6	1
0.3	7		0.3	0
0.15	2		0.15	0
0.075	0		0.075	0
0.01	0		0.01	0
	100			100

IFR 2	
Date collected:	4/9/2003
Riffle XS	
Diameter (mm)	**% distribution**
2048	0.00
1024	0.00
512	0.00
256	0.40
128	1.60
64	35.60
32	34.40
16	5.60
8	3.20
2	5.60
1.18	1.60
0.6	3.20
0.3	5.20
0.15	2.40
0.075	0.80
0.01	0.40
	100.00

IFR 3	
Date collected:	16-09-03
Diameter (mm)	**% distribution**
2048	0
1024	0.4
512	1.2
256	2
128	6
64	13.8
32	4.6
16	10.8
8	6.8
2	8.8
1.18	13.6
0.6	20.6
0.3	4
0.15	7.2
0.075	0.2
0.01	0
	100

IFR 4	
Date collected:	17-09-03
Riffle XS	
Diameter (mm)	**% distribution**
2048	0.00
1024	0.00
512	0.00
256	0.00
128	0.80
64	4.80
32	5.80
16	4.60
8	11.20
2	15.60
1.18	11.60
0.6	19.80
0.3	18.40
0.15	6.40
0.075	0.80
0.01	0.20
	100.00

IFR 5	
Date collected:	3/9/2003
Diameter (mm)	**% distribution**
2048	0.00
1024	0.00
512	0.00
256	0.00
128	1.00
64	1.20
32	4.00
16	4.00
8	5.40
2	8.20
1.18	9.80
0.6	24.00
0.3	20.20
0.15	14.60
0.075	5.60
0.01	2.00
	100.00

IFR 6	
Date collected:	18-09-2003
Diameter (mm)	**% distribution**
2048	0.00
1024	0.00
512	0.00
256	0.00
128	1.06
64	7.87
32	9.57
16	12.55
8	6.17
2	4.89
1.18	5.32
0.6	20.00
0.3	8.30
0.15	16.38
0.075	7.87
0.01	0.00
	100

IFR 7	
Date collected:	18-09-2003
Diameter (mm)	**% distribution**
2048	0.00
1024	0.00
512	0.00
256	0.12
128	3.50
64	8.25
32	5.25
16	11.75
8	6.50
2	6.13
1.18	6.50
0.6	26.00
0.3	11.88
0.15	11.13
0.075	3.00
0.01	0.00
	100

APPENDIX E:
RESULTS FROM THE WORKSHOPS: TABLES OF FLOOD RECOMMENDATIONS AND MOTIVATIONS

IFR 1

FLOOD CLASS I				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**

FLOOD CLASS II				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20% representing the 3-5.9 m3/s discharge range) was responsible for 12% of the total bedload transport. In particular it was important for the flushing and transport of sands.	Velocity (stream power).	Any		10% of the Daily Flow Duration Curve	To maintain sediment transport patterns; specifically the flushing and transport of fines.		Reduced from the "C" class.	To maintain some of the historical sediment transport patterns.

FLOOD CLASS III				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	Maintain present bed form and sediment transport characteristics. This portion (around 5%) of the flow duration curve was responsible for more than 10% of the total bedload transport. In particular it was important for the flushing and transport of sands	Velocity (stream power).	Any	2		To maintain sediment transport patterns; specifically the flushing and transport of fines.	1		To maintain some of the potential for sediment transport to flush and transport fines.

FLOOD CLASS IV				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph.	Maintain present bed form and sediment transport characteristics. This flow duration class (1-2% representing the 18-32 m3/s discharge range) was responsible for 11% of the total bedload transport. In particular it was important for the activation and transport of gravels.	Velocity (stream power)	Any	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels.	1	1: 2 year return interval	To maintain some of the historical sediment transport potential.

IFR 2

FLOOD CLASS I				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: D/E			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20% representing the 1.7-4 m3/s discharge range) is responsible for about 10% of the total bedload transport. In particular it was important for the flushing and transport of sands.	Velocity (stream power).	Any		10% of the Daily Flow Duration Curve	To maintain sediment transport patterns; specifically the flushing and transport of fines.		10% of the Daily Flow Duration Curve	To maintain sediment transport patterns; specifically the flushing and transport of fines.

FLOOD CLASS III				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: D/E			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geom.	Maintain present bed form and sediment transport characteristics. This flow duration class (1-5% representing the 7.5-20.8 m3/s discharge range) was responsible for about 27% of the total bedload transport. In particular these flows should activate some of the gravels on the bed and are responsible for about 27% of the sand transport.	Velocity (stream power)	Any	1	Annual	To maintain potential for sand transport and activate some of the gravels.	1	1: 2 year return interval	To maintain the potential for sand transport and activate some of the gravels

IFR 3

FLOOD CLASS I				Recommended EC: C/D			Alternative EC: D		
				Fish ; Inverts ; Rip veg; Geomorph: C			Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**

FLOOD CLASS II				Recommended EC:			Alternative EC:		
				Fish ; Inverts ; Rip veg; Geomorph: C			Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20%) was responsible for about 10% of the total bedload transport. In particular it was important for the flushing and transport of sands.	Velocity (stream power).	Any		3*	To maintain sediment transport patterns; specifically the flushing and transport of fines.		2	To maintain some of the historical sediment transport patterns.

FLOOD CLASS III				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geom.	The maintenance of moderate floods is important in this section to prevent narrowing and vegetation encroachment. This flow duration class (1-5%) is important also for activating the gravel beds.	Velocity (stream power)	Any	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels.	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels.

FLOOD CLASS IV				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geom.	These large floods are doing the bulk of the sediment transport in this system, as well as preventing channel narrowing.	Velocity (stream power)	Any	1	1:2 yr return interval	Transport fines, activate gravels and retard further vegetation encroachment and channel narrowing.	1	1: 3 yr return interval	Transport fines, activate gravels and retard further vegetation encroachment and channel narrowing.

* Geomorphologist requested more of these events, but the hydrologist said that the observed records suggest that only 3 events (of 3 day duration) occur per annum.

FLOOD CLASS I				Recommended EC: C					
				Fish ; Inverts ; Rip veg; Geomorph: C					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			

FLOOD CLASS II				Recommended EC:					
				Fish ; Inverts ; Rip veg; Geomorph: C					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20%) was responsible for about 10% of the total bedload transport. In particular it was important for the flushing and transport of sands.	Velocity (stream power).	Any		3	To maintain sediment transport patterns; specifically the flushing and transport of fines.			

FLOOD CLASS III				Recommended EC:					
				Fish ; Inverts ; Rip veg; Geomorph: C					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geom.	The maintenance of moderate floods is important in this section to prevent narrowing and vegetation encroachment. This flow duration class (1-5%) is important also for activating the gravel beds.	Velocity (stream power)	Any	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels.			
FLOOD CLASS IV				**Recommended EC:**					
				Fish ; Inverts ; Rip veg; Geomorph: C					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geom.	These large floods are doing the bulk of the sediment transport in this system, as well as preventing channel narrowing.	Velocity (stream power)	Any	1	1:2 yr return interval	Transport fines, activate gravels and retard further vegetation encroachment and channel narrowing.			

IFR 4

FLOOD CLASS I				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: C/D			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: C		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20% representing the 6-14.7 m3/s discharge range) was responsible for 13% of the total bedload transport. It is important for the flushing and transport of fines and the activation and transport of about 30% of gravels.	Velocity (stream power).	Any		10% of the (annual) Daily Flow Duration Curve	To maintain sediment transport patterns; specifically the flushing and transport of fines and activation of gravels.		Close to 15% of the (annual) Daily Flow Duration Curve	To maintain and improve the potential for the flushing and transport of fines and activation of gravels.

FLOOD CLASS III				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: C/D			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: C		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geom.	Maintain present bed form and sediment transport characteristics. This flow duration class (1-5% representing the 29-107 m3/s discharge range) was responsible for about 23% of the total bedload transport.	Velocity (stream power). The stage of the upper end of this flow duration class (1.9m) also corresponds with a bench. These floods might be related to the construction and maintenance of this instream feature.	Any	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.

FLOOD CLASS IV				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: C/D			Alternative EC: Fish ; Inverts ; Rip veg; Geomorph: C		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geom.	Maintain present bed form and sediment transport characteristics. This flow duration class (0.1-0.01% representing the 445-713 m3/s discharge range) was responsible for about 18% of the total bedload transport.	Velocity (stream power). The stage of the upper end of this flow duration class (3.9 m) also corresponds with the large macro-channel terrace feature. This flow class is likely to be related to the maintenance of this terrace and associated vegetation.	Any	1	1:10 year return interval	These large flows should overtop the terraces (discharges presented here represent daily means, but we would expect the peaks to be higher) and flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.	1	1:10 year return interval	These large flows should overtop the terraces (discharges presented here represent daily means, but we would expect the peaks to be higher) and flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.

FLOOD CLASS I				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: D					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20% representing the 6-14.7 m3/s discharge range) was responsible for 13% of the total bedload transport. It is important for the flushing and transport of fines and the activation and transport of about 30% of gravels.	Velocity (stream power).	Any		Close to 10% of the (annual) Daily Flow Duration Curve	To maintain some of the sediment transport patterns forthe flushing and transport of fines and activation of gravels.			

FLOOD CLASS III				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: D					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geom.	Maintain present bed form and sediment transport characteristics. This flow duration class (1-5% representing the 29-107 m3/s discharge range) was responsible for about 23% of the total bedload transport.	Velocity (stream power). The stage of the upper end of this flow duration class (1.9m) also corresponds with a bench. These floods might be related to the construction and maintenance of this instream feature.	Any	1	Annual	To maintain some of the sediment transport patterns for the activation and overturning of gravels and flushing and transport of fines.			

FLOOD CLASS IV				Recommended EC: Fish ; Inverts ; Rip veg; Geomorph: D					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geom.	Maintain present bed form and sediment transport characteristics. This flow duration class (0.1-0.01% representing the 445-713 m3/s discharge range) was responsible for about 18% of the total bedload transport.	Velocity (stream power). The stage of the upper end of this flow duration class (3.9 m) also corresponds with the large macro-channel terrace feature. This flow class is likely to be related to the maintenance of this terrace and associated vegetation.	Any	1	1:10 year return interval	These large flows should overtop the terraces (discharges presented here represent daily means, but we would expect the peaks to be higher) and flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will reduce excessive aggradation and loss of bedrock influence on the macro-channel floor.			

IFR 5

FLOOD CLASS I				Recommended EC: C Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: D Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**

FLOOD CLASS II				Recommended EC: C Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: D Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	Maintain sediment transport characteristics. This flow duration class (1-2%) is important for the flushing and transport of fines.	Velocity (stream power).	Any		2	To maintain sediment transport patterns; specifically the flushing and transport of fines.		1:2	To maintain some of the sediment transport patterns; specifically the flushing and transport of fines.

FLOOD CLASS III				Recommended EC: C Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: D Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class accounts for about 30% of the potential bed material transport.	Velocity (stream power).	Any		1:2	These flows account for a large proportion of the potential bed material transport. They would thus maintain sediment transport potential and prevent excessive sedimentation which could result in an increase in subsurface flows.		1:3	These flows account for a large proportion of the potential bed material transport. They would thus maintain sediment transport potential and prevent excessive sedimentation which could result in an increase in subsurface flows.

FLOOD CLASS V				Recommended EC: C Fish ; Inverts ; Rip veg; Geomorph: C			Alternative EC: D Fish ; Inverts ; Rip veg; Geomorph: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
	Scour the macro-channel, remove vegetation, transport fines and gravels from the bed.	Velocity (stream power).			1:10	These high flows should prevent vegetation encroachment on the macro-channel floor which has been observed following the completion of the Middle Letaba dam		1:10	These high flows should prevent vegetation encroachment on the macro-channel floor which has been observed following the completion of the Middle Letaba dam

IFR 6

FLOOD CLASS I				Recommended EC:C			Alternative EC: B		
				Fish ; Inverts ; Rip veg; Geomorph:			Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**

FLOOD CLASS II				Recommended EC:C			Alternative EC: B		
				Fish ; Inverts ; Rip veg; Geomorph:			Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	Restore sediment transport characteristics. This flow duration class (5-10%) was responsible for transporting fines.	Velocity (stream power).	Any	3		To restore some of the sediment transport patterns; specifically the flushing and transport of fines.	4		To restore sediment transport patterns; specifically the flushing and transport of fines.

FLOOD CLASS III				Recommended EC:C			Alternative EC: B		
				Fish ; Inverts ; Rip veg; Geomorph:			Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	These flows around from the 5-1 of the flow duration curve transport a large proportion of the sandy bedload and flush and deepen the active channels.	Velocity (stream power).	Any	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.

FLOOD CLASS IV				Recommended EC:C			Alternative EC: B		
				Fish ; Inverts ; Rip veg; Geomorph:			Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geom.	Maintain present bed form and sediment transport characteristics. These flows are responsible for about 50% of the potential bed material transport. Large floods at this site are very important.	Velocity (stream power).	Any	1		To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.	1		To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.

FLOOD CLASS V				Recommended EC:C			Alternative EC: B		
				Fish ; Inverts ; Rip veg; Geomorph:			Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geom.	Scour the macro-channel and remove encroaching vegetation; transport fine sediment and gravels.	Velocity (stream power).	Any	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.

FLOOD CLASS I				Recommended EC: D Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			

FLOOD CLASS II				Recommended EC: D Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geomorph	Restore sediment transport characteristics. This flow duration class (5-10%) was responsible for transporting fines.	Velocity (stream power).	Any	2		To restore some of the sediment transport patterns; specifically the flushing and transport of fines.			

FLOOD CLASS III				Recommended EC: D Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geomorph	These flows around from the 5-1 of the flow duration curve transport a large proportion of the sandy bedload and flush and deepen the active channels.	Velocity (stream power).	Any	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.			

FLOOD CLASS IV				Recommended EC: D Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geom.	Maintain present bed form and sediment transport characteristics. These flows are responsible for about 50% of the potential bed material transport. Large floods at this site are very important.	Velocity (stream power).	Any		1:2	To maintain some of the sediment transport patterns for the activation and overturning of gravels and flushing and transport of fines.			

FLOOD CLASS V				Recommended EC: D Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geom.	Scour the macro-channel and remove encroaching vegetation; transport fine sediment and gravels.	Velocity (stream power).	Any	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.			

IFR 7

FLOOD CLASS I				Recommended EC:C			Alternative EC: B		
				Fish ; Inverts ; Rip veg; Geomorph:			Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**

FLOOD CLASS II				Recommended EC:C			Alternative EC: B		
				Fish ; Inverts ; Rip veg; Geomorph:			Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	Restore sediment transport characteristics. This flow duration class (5-10%) was responsible for transporting fines.	Velocity (stream power).	Any	3		To restore some of the sediment transport patterns; specifically the flushing and transport of fines.	4		To restore sediment transport patterns; specifically the flushing and transport of fines.

FLOOD CLASS III				Recommended EC:C			Alternative EC: B		
				Fish ; Inverts ; Rip veg; Geomorph:			Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geomorph	These flows around from the 5-1 of the flow duration curve transport a large proportion of the sandy bedload and flush and deepen the active channels.	Velocity (stream power).	Any	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.

FLOOD CLASS IV				Recommended EC:C Fish ; Inverts ; Rip veg; Geomorph:			Alternative EC: B Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geom.	Maintain present bed form and sediment transport characteristics. These flows are responsible for about 50% of the potential bed material transport. Large floods at this site are very important.	Velocity (stream power).	Any		1:3	To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.		1:2	To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.

FLOOD CLASS V				Recommended EC:C Fish ; Inverts ; Rip veg; Geomorph:			Alternative EC: B Fish ; Inverts ; Rip veg; Geomorph:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Geom.	Scour the macro-channel and remove encroaching vegetation; transport fine sediment and gravels.	Velocity (stream power).	Any	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.

FLOOD CLASS I				Recommended EC: D					
				Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
FLOOD CLASS II				**Recommended EC: D**					
				Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geomorph	Restore sediment transport characteristics. This flow duration class (5-10%) was responsible for transporting fines.	Velocity (stream power).	Any	2		To restore some of the sediment transport patterns for the flushing and transport of fines.			
FLOOD CLASS III				**Recommended EC: D**					
				Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geomorph	These flows around from the 5-1 of the flow duration curve transport a large proportion of the sandy bedload and flush and deepen the active channels.	Velocity (stream power).	Any	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.			

FLOOD CLASS IV				**Recommended EC: D**					
				Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geom.	Maintain present bed form and sediment transport characteristics. These flows are responsible for about 50% of the potential bed material transport. Large floods at this site are very important.	Velocity (stream power).	Any		1:3	To maintain some of the sediment transport patterns for the activation and overturning of gravels and flushing and transport of fines.			

FLOOD CLASS V				**Recommended EC: D**					
				Fish ; Inverts ; Rip veg; Geomorph:					
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Geom.	Scour the macro-channel and remove encroaching vegetation; transport fine sediment and gravels.	Velocity (stream power).	Any	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.			

water & forestry

Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

DIRECTORATE: RESOURCE DIRECTED MEASURES

LETABA CATCHMENT RESERVE DETERMINATION STUDY – SPECIALIST REPORT : **RIPARIAN VEGETATION COMPONENT**

FINAL

APRIL 2005

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Inception report
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Main Report
Heath RG
DWAF Report No.RDM/B800/00/CON/COMP/1304

Summary of Results (Non technical)
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Groundwater Scoping Report
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Wetland Scoping Report
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1. INTRODUCTION

1.1 RIPARIAN VEGETATION DISTRIBUTION PATTERNS

Hydrological and fluvial processes are key determinants of vegetation distribution patterns in riparian corridors (Hupp and Osterkamp, 1996). Vegetation is influenced by the hydrology of the river through floods, droughts and water table fluctuations, while fluvial processes of erosion and sedimentation both destroy and create sites for the establishment of new individuals (Cordes, Hughes and Getty, 1997). The interaction between the hydrology, water availability and the fluvial geomorphology is therefore critical to understanding vegetation distribution patterns along the Letaba River and its tributaries.

1.1.1 The influence of flooding

Flooding in particular directly affects plants through inundation and physical damage or uprooting of individuals, resulting in reduced growth or even mortality (Mackenzie, van Coller, and Rogers, 1999). Species differ substantially in their ability to tolerate these affects of flooding (Blom, Bogemann, Laan, van der Sman, van de Steeg and Voesenek, 1990), which are reflected in different species distributions along a flooding frequency gradient (Auble, Friedman and Scott, 1994). Species close to the channel are predominantly hydrualically tolerant (i.e. able to survive the physical stress of flooding), while species on higher elevated sites, the top of banks or upland areas, are generally hydraulically intolerant. Of the many factors that influence the recruitment of plants (Grubb, 1977; McBride and Strahan, 1984; Cordes, Hughes and Getty, 1997), the influence of flooding is particularly important during the regeneration phase of riparian plant populations. This is because flooding has the potential to alter the availability of sites and/or remove the seedling layer thus affecting the opportunities for replacement. (Streng, Glitzenstein and Harcombe, 1989). In semi-arid areas in particular, sites may be abundant following flooding, but water availability is generally a limiting factor (Hughes, 1978).

Since flooding plays a key role during germination and establishment, the phenology of plant species relative to the timing of floods becomes important (Tissue and Wright, 1995; Mackenzie, unpublished data). In semi-arid regions, if plant species are to regenerate successfully following flood events, seed or propagule dispersal must coincide with floods. Along the Sabie River, for example, this is generally the case, but more so for species growing along seasonally and ephemerally flooded features. The viability of seeds and propagules of riparian species is also generally low and few form seed banks. Thus, dispersal of seeds or propagules too soon before, or too late after, a flood event will result in missed opportunities for regeneration.

1.1.2 The influence of water availability

Fluctuations in the groundwater table in river banks may be directly associated with fluctuations of water levels in the river (Birkhead, van Coller, James and Heritage, 1996). Water availability from the water table is regarded as a major limiting resource to riparian plant species, (Adams, 1989) influencing growth, performance and survival. This is especially true of woody riparian species which are rooted in the water table (Smith, Wellington, Nachlinger and Fox, 1991; Ellery, Ellery and McCarthy, 1993). Woody riparian species have little resistence to drought stress, since they need to obtain sufficient water to compensate for their large daily transpirational losses (Smith et al., 1991; Birkhead, Olbrich, James and Rogers, 1997). An inability to obtain this water due to drought or unnatural flow regulation, will in many cases lead to extreme stress in trees which may result in mortality (van Coller & Rogers, 1996).

The depth to the water table becomes especially important during the establishment phase of germinants, and the rate of water table decline following overbank flows is a key determinant of the probability of survival of germinants and seedlings (Manders & Smith, 1992). A rapid decline in the level of the water table may be too fast for the growth rates of the roots of germinants. This phenomenon is particularly true in riparian corridors in semi-arid regions such as along the middle to lower reaches of the Letaba River catchment. Rivers such as the Letaba however, are likely to have some complexity to this general rule because of the presence of bedrock which influences the dynamics and structure of the water table. Perched water tables which need to be recharged by flooding events often exist.

1.1.3 The influence of fluvial geomorphology

Close relationships exist between riparian vegetation distribution patterns and different geomorphic landforms (van Coller, Rogers and Heritage, 1997). In semi-arid regions, the relationship is related more to infrequent flood events that create new sites for the establishment of individuals (Friedman, Osterkamp and Lewis, 1996). Therefore in river systems such as the Letaba, the vegetation / geomorphology interactions are more event driven, and flow frequency associated with the different landforms is less important

In riparian systems associated with rivers such as the Letaba, there is often a clear distinction in species composition between the vegetation types that are associated with the macro-channel bank and the vegetation types that are associated with the macro-channel floor (van Coller, Rogers and Heritage, 1997). Although the macro-channel bank is generally relatively stable and experiences low sedimentation, the steep slopes result in strong vertical gradients of flooding frequency and availability of water from the water table. Consequently vertical gradients exist in the distribution of the vegetation.

In contrast to the macro-channel bank, frequent flooding, sedimentation and erosion along the macro-channel floor provides a dynamic and geomorphologically diverse setting for the establishment of riparian plants (van Coller and Rogers, 1996). The degree of bedrock influence along the macro-channel floor is seen to be critical in influencing the distribution of the vegetation (van Coller, Rogers and Heritage, 1997). There is a trend from species such as *Breonadia salicina* in bedrock dominated areas (e.g. bedrock influenced channel types), to species such as *Phyllanthus reticulatus* and *Phragmites mauritianus* in both bedrock and alluvial dominated areas (e.g. pool-rapid, and braided channel types) to species of the *Combretum erythrophyllum* in alluvial dominated areas.

While the vegetation along the macro-channel floor also appears closely related to differences in the degree of bedrock control and the type of morphological units on which they occur, there are also apparent differences in vertical distribution relative to the active channel. This indicates a likely relationship with flooding frequency. Species such as *Breonadia salicina* and the *Phragmites mauritianus* occur at lower elevations above the channel and are therefore more frequently inundated than species such as *Phyllanthus reticulatus* and *Combretum erythrophyllum,* which are found at higher elevations above the active channel.

Feedback mechanisms of riparian vegetation on fluvial geomorphology also exist, which contribute to the relationship between them (Hicken, 1984). Vegetation can therefore also exert considerable control over fluvial processes and morphology through five mechanisms: flow resistance, bar sedimentation, bank strength and stabilization, and the formation of log jams (MacKenzie, van Coller and Rogers, 1999).

1.1.4 Other influences

According to van Coller and Rogers (1996), a useful approach to understanding the determinants of the species distribution patterns is to focus attention on the causes of succession, and what ecological processes and relationships are associated with these causes. These authors state that fundamental causes of succession that generally apply to any situation, have been identified as (1) different sites becoming available; (2) species being differentially available at an open site; and (3) species behaving differentially at the site (Pickett *et al.* 1987). Determinants of species distribution patterns will be discussed under these three causes of succession and the following excerpts were taken directly from the discussion given by van Coller and Rogers as given in van Coller and Rogers (1996).

1.1.4.1 Site availability

"Site availability for the establishment of riparian seedlings is determined largely by the disturbance of flooding. Disturbance by flooding results in the removal of existing vegetation and/or sediment, as well as deposition of sediment and vegetation on existing sites, giving rise to new available sites (patches) of bedrock and alluvial sediment, ranging in nutrient and resource availability".

"Exposed patches of bedrock in close proximity to active or seasonal channels have been found to be important sites for the establishment of certain species (see Table 1A, Appendix 1). Cracks in the rocks form important microsite conditions for the anchorage of the roots of an individual as well as increasing moisture availability"

"Patches of alluvial sediment deposition in close proximity to the channel also provide important sites for the regeneration and establishment of certain species. These sites can vary in texture as well as the proportion of organic material, resulting in very different moisture and nutrient conditions. Unlike bedrock sites, alluvial sediment does not provide the same anchorage medium, thus reducing the survivorship of germinants. Survival depends on the root being able to reach the water table in a relatively short space of time and forming a firm anchorage (possibly even on the underlying bedrock)".

"Gravel deposits along seasonal distributaries may also provide important microsite conditions for certain species, by increasing the potential to trap seeds, increase the anchorage facility for roots as well as increase moisture availability. Rain may also act as a process whereby existing sites of well developed alluvial deposits or even parent material on the macro-channel bank become available through increased moisture availability. The removal of vegetation through flooding also alters the light availability, which plays an important role in determining the nature of available sites".

1.1.4.2 Species Availability

"Differential species availability is affected by the processes of dispersal and the nature of the propagule pool. The river acts as an important dispersal agent for propagules of most species in close proximity to active or seasonal channels (especially *Breonadia salicina, Nuxia oppositifolia, Syzygium guineense, Combretum erythrophyllum*, and *Ficus sycomorus*). In addition to hydrochory, the fruits of tree species such as *Syzygium guineense, Syzygium cordatum, Ficus sycomrus, Diospyros mespiloformis, and Acacia robusta*, and fruits of shrub species such as *Phyllanthus reticulatus, Lantana camara* (exotic), *Ficus capreifolia* and *Kraussia floribunda* are dispersed by birds or animals (zoochory). Fruits of species such as *Combretum erythrophyllum, Phragmites mauritianus, Breonadia salicina*, and *Nuxia floribunda* are dispersed by wind. Another important mechanism of dispersal is in the form of vegetative dispersal where certain species are able to regenerate from broken parts of the plant that are carried and deposited down river following a flood event (e.g. broken roots, stems, branches and even a leaf (*Ficus sycomorus*) as well as rhizomes (*Phragmites mauritianus)*".

"Regarding the nature of propagule pools, three main sources appear to be important along the Sabie River in the Kruger National Park, namely, seed on the plant, nursery bars (seed covered in alluvial deposits), and vegetative coppicing from roots, buried stems and branches. The timing of seed maturity appears to an important factor for many species. Species such as *Breonadia salicina, Syzygium guineense, Nuxia oppositifolia* and *Phragmites mauritianus* all grow in close proximity to the active channel and all reach maturity from mid summer to the end of summer, when the likelihood of new sites becoming available are highest. It is also during this time that moisture availability is likely to be most favourable for enabling the roots of germinants to reach the water table, and when the probability of flooding inundation is decreasing. Seeds of other species such as *Combretum erythrophyllum* mature at the end of winter, and appear to geminate in response to the first summer rain events".

"Nursery bars have been observed to be an important propagule pool for certain species. *Combretum erythrophyllum, Syzygium guineense*, and *Ficus sycomorus* have been observed to germinate from seeds buried on active channel bars. The length of viability of these seeds is not however known".

"Vegetative coppicing is an important propagule source for many species occurring along the macro-channel floor. Many tree species such as *Combretum erythrophyllum, Nuxia oppositifolia, Ficus sycomorus, Breonadia salicina* and shrub species such as *Phyllanthus reticulatus, Maytenus senegalensis* and *Ficus capreifolia* are all able to coppice from their roots, stems and branches following damage or covering by sediment. The reed *Phragmites mauritianus* coppices from its rhizomes or buried stems, giving rise to reedbeds that show a distinct pattern of being parallel to the direction of river flow. These patterns have also been observed with the tree species *Combretum erythrophyllum* and *Nuxia oppositifolia*. This form of regeneration has important implications for increasing the stability of channel bars".

1.1.4.3 Species Performance

The landscape of the Letaba River, much like that of the Sabie River (van Coller and Rogers, 1996), also appears to facilitate the development of strong hydrological gradients in the form of availability of water from the water table and flooding frequency.

Differential species performance on different available sites and morphology types plays an important role in determining vegetation distribution patterns. Species show different distributions on the different available sites based largely on differences in ecophysiology and life history characteristics (van Coller and Rogers, 1996), during both germination and establishment. These relationships are described in Table A1, Appendix 1 (from van Coller and Rogers, 1996).

Species also perform differentially in relation to availability of water from the water table. This is largely a function of differences in the water use efficiencies of species (van Coller and Rogers, 1996). Riparian species on the whole have higher transpiration rates than terrestrial species from the surrounding savanna and usually require a permanent supply of water for at least part of the year (van Coller and Rogers, 1996). Particularly those riparian trees occurring along the macro-channel floor and along poorly connected channels (i.e. strongly bedrock influenced channel types) are most vulnerable to low flows of extended periods because of their high transpirational demands (van Coller and Rogers, 1996). According to van Coller and Rogers (1996) While it is difficult to separate out the influence of water availability and flooding in determining species distribution, height (elevation) of an individual above a fixed stage discharge can be regarded to be a rough estimate of distance above the water table (this is not true for flooding frequency, where the same discharge can flood very different elevations depending on the dimension of the macro-channel).

Differential species performance in relation to flooding is largely due to differences in the species ability to tolerate anaerobiosis and shear stress during inundation (van Coller and Rogers, 1996). This influences the distribution of a species in terms of how near it is able to establish to the active channel. According to van Coller and Rogers (1996), there appear to be four broad groups of species, namely, those that are restricted in their distribution by perennial to seasonal floods, seasonal floods, seasonal to ephemeral floods, and ephemeral floods along the Sabie River [Table A2, Appendix 1, taken from van Coller and Rogers, 1996)

1.2 DETERMINING THE FLOW REQUIREMENTS FOR THE MAINTENANCE OF RIPARIAN VEGETATION

Van Coller and Rogers (1996) identified four main issues relating to the instream flow requirements for the maintenance of the riparian vegetation and the functioning of the ecosystem as a whole. They are, 1) flows to meet transpirational needs of the vegetation along the macro-channel floor in both alluvial and bedrock influenced sites, 2) flows that prevent terrestrialisation of the macro-channel floor, 3) flows to meet the regeneration requirements of riparian species and maintain diversity of sites for regeneration, and 4) flows indirectly related to sedimentation and changes in the geomorphology in river.

1.2.1 Flows to meet transpirational needs

While the transpirational needs of the dominant riparian tree species along the macro-channel floor have been shown to be relatively similar (Birkhead, Olbrich, James and Rogers, 1996), the availability of water differs markedly in relation to the degree of bedrock influence. According to van Coller and Rogers (1996), flows required to meet the transpirational demands of the vegetation should be addressed separately for vegetation in alluvial dominated areas where subsurface water storage is connected to the active channel, compared to vegetation in bedrock dominated areas where subsurface water storage is not well connected to the active channel.

1.2.1.1 Bedrock influenced sites - poorly connected underground water table

In areas largely influenced by bedrock, such as bedrock anastomosing channel types, there are hydraulically isolated areas (e.g. seasonal distributaries) when the river drops below a certain stage. As a result, trees growing in hydraulically isolated alluvial deposits will experience water stress once the subsurface water storage has been depleted (van Coller and Rogers, 1996). Thus, the frequency and magnitude of river stage fluctuations play a fundamental role in determining the level of water stress amongst trees growing in bedrock influenced areas. It is therefore essential that flow regimes from impoundments be designed in such a way as to meet the rehydration of isolated aquifers in these sections to ensure the survival of the trees that have established there, through maintaining flow variability.

1.2.1.2 Alluvial sites -well connected underground water table

In alluvial dominated systems were there is little bedrock influence, the subsurface water storage is connected directly to the active channel. In these areas therefore, the water availability to the vegetation therefore depends on the water in the active channel. According to van Coller and Rogers (1996), the question that needs to be addressed then, is what flow in the active channel is necessary to meet the transpirational demands of the vegetation? Birkhead e*t al* (1996) used three different approaches to address this question, the general findings of which were discussed by van Coller and Rogers (1996) and are not presented here. These are however expected to be relevant to the IFR determination, particularly with regard to the estimated consumptive water use (transpirational) values of the riparian vegetation. However, according to van Coller and Rogers (1996), a number of factors need to be considered before deciding what value or level is critical to meet the transpirational needs of vegetation in alluvial areas. Firstly, it needs to be decided which method of Birkhead e*t al* (1996) is the most accurate; and secondly, it is important that low flows be kept at an adequate level to ensure that the trees do not account for the entire low flow (this needs to be considered not only for the winter low flows, but also the summer low flows during drought periods when transpirational demands are highest).

1.2.2 Flows to prevent "terrestrialisation" of the macro-channel floor

A reduction in flooding frequency will increase the availability of sites along the macro-channel floor for the establishment of species less tolerant of flooding. These will include some of those species that grow on the macro-channel bank and in the surrounding savanna. In addition, the longer the periods between floods, the higher the chance of persistence. This is because individuals become older and more firmly rooted as well as more tolerant of inundated conditions as they grow older and bigger. In turn, such changes will reduce available sites for the regeneration of riparian vegetation (van Coller and Rogers, 1996). It is therefore necessary that a flooding frequency of a given discharge takes place in order to prevent the colonising of the more terrestrial type species. Weedy exotic invader species are also a concern in this regard. The flows necessary for removing terrestrial species and inhibiting their establishment along the macro-channel floor however are generally larger than can be managed (van Coller and Rogers, 1996). As such, it is important therefore to ensure enough flow for long enough periods during the year to prevent species less tolerant of flooding from establishing.

1.2.3 Flows to meet the regeneration requirements of riparian species

According to van Coller and Rogers (1996), there are two main issues that need to be considered that relate to the maintenance of a high diversity of available sites for the regeneration of riparian species. Firstly, a degree of variability in the flow regime needs to be maintained in order to maintain diversity of site characteristics. This includes flows that allow riparian species to establish at relatively high stages within the macro-channel. In addition, steps to prevent the progressive buildup of sediment leading to a more alluvial dominated system need to be considered in order to keep open bedrock sites available for establishment of species such as *Breonadia salicina* (e.g. flows released from impoundments carry less sediment load). Secondly, the availability of species at available sites due to a) dispersal (phenology) and b) propagule banks (post-dispersal propagule viability) needs to coincide with temporal hydrological conditions that are conducive to the colonization of those sites. For example, van Coller and Rogers (1996) observed that the dispersal of *Syzygium spp* and *Ficus sycomorus* at the time of the 1996 floods on the Sabie River resulted in high numbers of post flood germinants on newly created or disturbed sites. This was not the case for *Combretum erythrophyllum* for instance, where propagule dispersal did not coincide with a flooding event.

1.2.4 Flows indirectly related to sedimentation and changes in the geomorphology in river

Since there is a close relationships between riparian vegetation distribution patterns and different geomorphic landforms (van Coller, Rogers and Heritage, 1997), changes in flows that can affect the geomorphology of the river will have a direct influence on the riparian vegetation. Since the vegetation / geomorphology interactions are more event driven in a system such as the Letaba, it is essential to recognise the importance of large floods in determining the vegetation dynamics.

2. APPROACH

2.1 BACKGROUND TO THE APPROACH AND ASSUMPTIONS

In this report, information on the distribution of riparian vegetation at the identified IFR sites, which were selected during the planning workshop and site visit during 2003, is presented. The occurrence of riparian trees along surveyed profiles was used to provide a framework for determining riparian species distributions at the IFR sites. This was based on the broad assumption that individually surveyed trees at or near a surveyed transects correlate to the distribution of riparian plant species laterally and vertically along the profiles. This, together with a general understanding of the determinants of riparian vegetation distribution patterns was used to motivate for flows for maintaining/improving the riparian zone at the two integration workshops during August and October 2004.

Central to the approach is the recognition that the interaction between the geomorphology, water availability and hydrology is key to providing an understanding of vegetation distribution patterns at each of the IFR sites. Each of the IFR sites has different geomorphological features resulting in distinct environmental gradients (vertically, laterally and longitudinally) which in turn can be related to flooding frequency, water availability (from the water table) and fluvial dynamics. An important consideration with respect to the interpretation of the vegetation distribution and structure on the profiles is the effect of the 2000 flood. This flood had a profound influence on the pre-2000 morphology of the river and thus the distribution and structure of the riparian vegetation at certain of the IFR sites. As such, the profiles represent a “reset state” in most cases, complicating the expected links between flows and vegetation distribution patterns. Direct interpretation of the distribution patterns in most cases resulted in an expectation of unrealistically high flows at higher elevations on the profiles. Since the method applied for recommending flows (by using vegetation linked to cross sectional profiles) is set in terms of the Reserve determination process, the challenge during the workshops was in recognizing when this was the case. Where this arose during the workshop, a combination of actual profile data, common sense, experience and understanding of the dynamics of the affected rivers, rather than the direct interpretation of the profiles, was necessary to extract relevant information for recommending flows. This in turn influenced the confidence in the flows recommended.

2.2 METHODS USED

During a field visit in October 2003, individual trees as well as other riparian and instream vegetation were surveyed for one cross section at each of the IFR sites apart from Letsitele and including the site below Prieska weir. The cross sections where the vegetation was surveyed were:

- Appel 2
- Klein Letaba 5
- Eiland 2
- Prieska 2
- Letaba Ranch 1
- Lonely Bull 2
- Letaba Bridge 2

The Letsitele IFR site was excluded from the study because of the artificial influence on the vegetation due backflooding in the river (Louw, PC). Some information on the riparian vegetation was however already available for the site from previous work by Kemper (Department of Water Affairs and Forestry, 1996) and this was used to supplement the geomorphology motivations during the workshops For each of the profiles at the other seven sites, the vegetation was plotted and the position of all relevant indicator and other species shown relative to the survey line. This information is presented as vegetation plots in this report as well as diagrammatically in the form of large plans that were used in the integration workshop. A literature review was undertaken to support the motivations used in the integration workshop. Air photos of the IFR sites dating back to the 1930’s were examined to provide an indication of the changes that have occurred in the riparian vegetation at each site (apart from Appel where the resolution was inadequate for such an assessment) over the last 70 years. The reference condition for each site was determined based on discussion with Mark Rountree, thus with due consideration of the geomorphological changes that have taken place in the river systems. The reference states for each IFR site were also viewed in the context of the state changes that would have occurred “naturally”. This is in line with the thinking and conceptual model of river-landscape change for the successional development of riparian vegetation in the Groot Letaba River (Carter, 1995).

3. FINDINGS

3.1 REFERENCE STATE IN RELATION TO THE TEMPORAL CHANGES IN RIPARIAN DISTRIBUTION PATTERNS ALONG THE LETABA RIVER AND ITS TRIBUTARIES

Information relating to changes in the distribution of vegetation over time along the Letaba River and its tributaries is limited predominantly to the examination of the historical air photos and the report by Carter (1995). In this report, Carter (1995) described river-landscape change in the Letaba, Sabie, Crocodile and Olifants River systems using a series of aerial photographs dating back to 1940. He showed that landscape-change in the Letaba River, as was the case with the other rivers, appeared to follow a directional process involving the sequential colonisation of non-vegetated areas by herbaceous vegetation, reeds and woody vegetation, which became more strongly directional with time (Figure 1). According to Carter (1995), prior to the large floods in 2000, the Letaba River lay between the sand and reeds stages with a trajectory towards woody vegetation establishment.

Following the 2000 floods which caused extensive vegetation loss, particularly on the macro-channel floor and in the lower riparian areas, the state of the river was reset to somewhere between water or rock and herbaceous vegetation. Since the floods, reedbeds have started to re-establish. The Letaba River therefore naturally appears to move between states representing what Carter (1995) refers to as dynamic landscape-change. The river does not, and it would appear, historically did not, reach a stage where it had a well established woody riparian component. The examination of the historical air photos obtained for the purpose of this study appears to support this argument, at least for some of the IFR sites, and certainly for the upper riparian component. It would appear that it was the woody components on the macro-channel floor that underwent the most change following 2000. This intuitively makes sense since these were the sites that were exposed to the most scour during the flood.

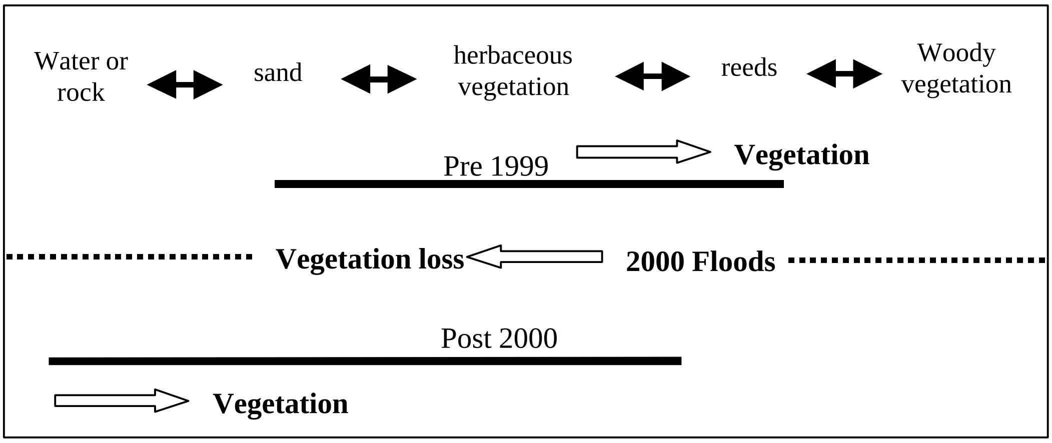


Figure 1: A conceptual model of river-landscape change involving five sequential stages in the successional development of riparian vegetation in the Groot Letaba River (based on and modified from Carter, 1995). The dark lines indicate the current interpretation of the range of successional stages in the river prior to, and after the floods of 2000.

3.2 IFR SITES

The data for each of the IFR sites surveyed according to the cross sections given in 2.2 is presented below starting with IFR 1 (Appel) and ending with IFR 7 (Letababa Bridge). The data and discussions for each site are provided as follows:

- PES information, reference conditions and trajectory of change;
- Cross sections;

The cross sectional profiles of the IFR sites show the position of individually marked and surveyed trees. All the key indicator species recorded during the field survey are marked on the profile. A list of these species and their abbreviations is given in Table A3, Appendix 2. Other relevant information which was useful during the IFR workshop (such as debris levels and substrate type) is also recorded on the profiles. The elevation:distance ratios were reduced to between 2.5:1 and 7:1 to provide for easier interpretation. More realistic representations of each of the profiles are shown in the diagrammatic cross sections in Appendix 4.

- Flood motivations; PES up and down information; and
- Confidence.

With respect to the flow motivations, as far as was reasonably possible, the five general points relating to the flow requirements of the riparian vegetation as provided by van Coller and Rogers (1996) served as guidance for setting the flows at each IFR site. These are as follows:

- There needs to be a base flow that is not surpassed at any time, in order to meet the transpiration needs of the riparian vegetation (it is important that this base flow is higher than the consumptive requirements of the riparian vegetation, so that the vegetation does not account for the entire low flow);

- There needs to be variability in the flow regime in order to activate seasonal channels in areas where aquifers are isolated;

- There needs to be variability in the flow regime in order to increase the diversity of available sites for regeneration of riparian species;

- There need to be floods large enough and often enough to prevent terrestrialisation of the macro-channel floor; and

- Sedimentation which is indirectly related to the flow regime needs to be considered as there are long term implications for increased sedimentation.

3.2.1 IFR 1 – Appel

3.2.1.1 Present Ecological Status

The flow and vegetation dynamics at this site have changed since the 1930's. Air photo coverage for the site was not that good (mainly due to scale issues), but nevertheless indicated that the active channel narrowed over a number of decades, partly as a result of vegetation encroachment.

Indications were that these changes occurred in the lower and marginal riparian vegetation zones. The long-term flow related impacts (reduction in baseflows) probably contributed to a gradual increase in the abundance of vegetation in these zones. The floods of 2000 removed much of the marginal vegetation. Compared to reference, the marginal and lower riparian zone vegetation at present does not appear that different from the 1930's. In places along the river, vegetation cover changes were evident probably due to the exotic giant reed *Arunda donax* which has encroached into the lower riparian zones. The changes in the upper riparian zones have been more gradual mainly as a result of afforestation. As such some non-flow related impacts occur, including alien tree encroachment and some vegetation removal (chopping of mid-sized and larger trees). The 2000 floods appear to have had little influence on this zone. As such species richness and composition are unlikely to have been affected substantially due to flow related impacts. Based on the scores and weightings used in the PES model (see Appendix 3), the PES score for the vegetation is 65.29 (C).

3.2.1.2 Reference state

Using the air photos from 1938 as an indication of the reference condition, the site was characterized by a pool rapid channel type with some isolated occurrences of braiding where the floodplain of the river widened. Vegetated instream bars were fairly common. Even in the 1930's there was extensive farming on the slopes near the river. Forestry was however far more limited in the catchment. As already mentioned, compared to reference, the marginal and lower riparian zone vegetation at present does not appear that different from the 1930's.

3.2.1.3 Trajectory of change

The trajectory of change is likely to be negative but not necessarily related to flows. If only flows are considered the system is more likely to be stable. The upper zone vegetation is likely to continue to survive but there is likely to be a gradual deterioration due to encroachment of alien invasive plants. The marginal vegetation zone is likely to start to encroach into the active channel again as vegetation continues to expand under the lower baseflow conditions.

3.2.1.4 Cross section

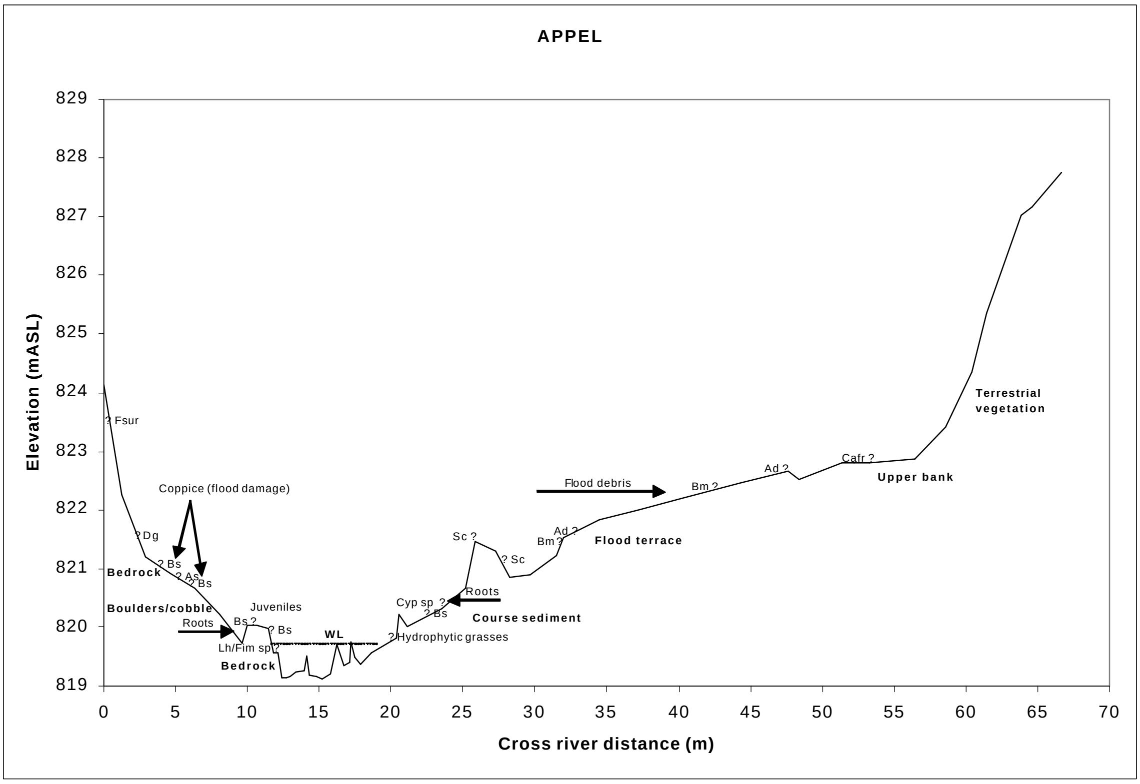
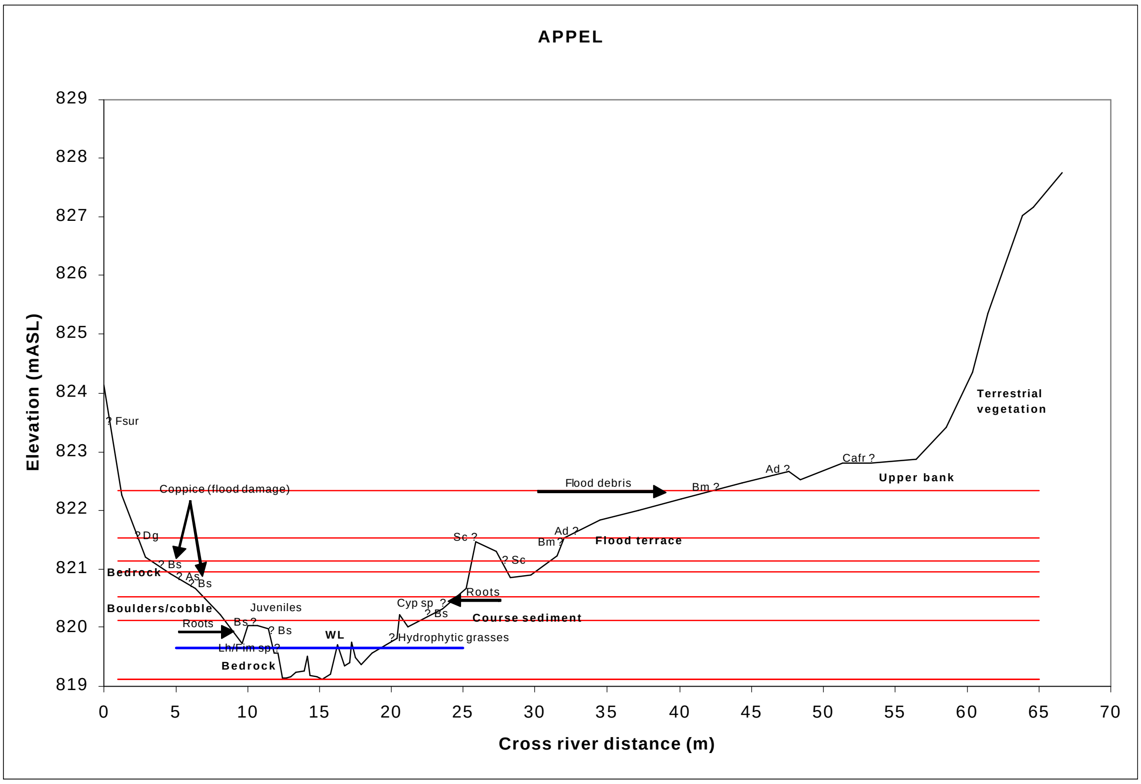


Figure 2: Vegetation data plotted on the cross section at IFR 1 (for abbrev. see Table A3, Appendix 2).

3.2.1.5 Flood motivations



Depth (m)	Discharge (m^3sec^{-1})	Flood Class (m^3sec^{-1})
1.0	4.29	4.5-10.5
1.4	10.47	
1.8	20.37	20-27
2.0	26.93	
2.4	43.65	43-94
3.2	93.54	

Figure 3: Vegetation data and the motivated flood levels plotted on the cross section at IFR 1.

Table 1: Flood Class motivations for the riparian vegetation at IFR 1.

FLOOD CLASS III: 4.5-10.5m³/s				Recommended : C			Alternative : D		
	Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
	Inundate the marginal vegetation zones including the hydrophytic grasses eg. *L. hexandra* prior to the dry season. Will also increase microsite availability for *B. salicina* germinants as seeds are dispersed between April and July	Inundates to an elevation of between 1 and 1.4 m at a reasonably slow average velocity of less than 0.8 m/sec with minimal disturbance of the marginal vegetation.	April	1	Per year	A late summer flood for supporting the marginal vegetation and flow dependent riparian tree species (*B. salicina* and *S. cordatum*) .	0	Per year	Accept that in a lower class, this flood will happen sporadically and therefore no motivation for this flood is given.

FLOOD CLASS IV: 20-27m³/s				Recommended : C			Alternative : D		
	Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
	Inundates to the base of the flood terrace to stimulate the reproduction of the hydrophytic sedges and grasses, raise the water table in the flood terrace to support the large riparian trees on the terrace, and to disperse riparian tree seeds.	Inundates to an elevation of between 1.8 and 2 m.	Mid summer (February)	1	Per year	Mid summer floods at this elevation are important for the reproduction of hydrophytic grasses and sedges in the marginal vegetation zones. Also raises the water table in the flood terrace to support the growth of the larger riparian trees on the terrace and their transpirational requirements.		1:2 years	Will still play some role in terms of the reproduction of the hydrophytic grasses and sedges in the marginal vegetation zones. Despite a reduced frequency, this flood will still play a role (reduced) in supporting the transpirational requirements larger riparian trees on the terrace.

FLOOD CLASS V: 43-94m³/s				Recommended : C			Alternative : D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
	To prevent terrestrialisation of the flood terrace and disperse high flood terrace riparian tree seeds.	Inundates to 3.2 m	Summer		1:10 years	Inundates to upper levels of the riparian zone thereby saturating the soil to the roots of terrestrial saplings thereby helping to prevent terrestrialisation of the flood terraces.		1:10 years	As occurs naturally. The main change is expected in the lower riparian and marginal vegetation zones so no flow reduction is motivated for the large floods.

Motivation for a higher PES

At the workshop it was decided that it would not be feasible to consider motivating for flows for a higher PES.

Motivation for a lower PES (D)
To move down to a D, it is anticipated there would have to be a reduction in smaller and mid-sized floods. The effects will be restricted predominantly to the lower riparian zone. This is likely to affect the vigor of the lower riparian species and will also reduce the opportunities for seedling establishment and support. It is also likely to decrease riparian habitat diversity in the long-term. Since the changes relate to decreased low flows, the changes in the PES model were made mainly in the marginal zone (predominantly in terms of composition, cover and abundance) and lower riparian zones. In the upper zone, flow related impacts are expected to be stable.

3.2.1.6 Confidence

The site is fairly representative of the resource unit. There was limited flood damage in terms of the structure of the terraces and vegetation structure and thus a number of individuals of indicator species were present for assisting with setting the flows. The air photo record for the site did not help much in the assessment simply because of scale (the minimum mapping units were too small for providing any meaningful data on the vegetation). Apart from the profile data collected and the aerial photography, there was no other available riparian vegetation data for the reach. Due to the stressor-response not being applicable to the riparian vegetation, the low flows were directly based on the flows motivated by the fish and invertebrate specialists. These were only reviewed for the riparian component. The poor confidence in the observed hydrological data used in modeling the large floods reduced the overall confidence in the high flows. There was not accurate information on actual return periods for various high flows which also made it difficult to consider scenarios in terms of likely vegetation response. The confidence scores for each of the attributes listed are given in the Table 2 below.

Table 2: Confidence ratings for the riparian vegetation at IFR 1.

IFR SITE	AVAILABLE DATA	ECOLOGICAL CLASSIFICATION	OUTPUT LOW FLOW	OUTPUT HIGH FLOW
3	1	3	2	1

3.2.2 IFR 2 – Letsitele

3.2.2.1 Present Ecological Status

The right bank at the site is dominated by a few large figs *Ficus sycomorus* closer to the waters edge with *Diospyros mespiliformis* towards the upper parts of the terrace. The left bank is characterized by *Combretum erythrophyllum* and *Acacia polyacantha*. The vegetation composition at the site appears to have changed since 1938. Based on the air photo analysis, in May 1938 the active channel was a wide, single thread channel with reeds along the edges and occasional vegetated bars that appear to be associated with bedrock outcrops. By the late 1960's the active channel had narrowed significantly with vegetated instream and lateral bars encroaching on the active channel. Aerial photographs from June 2002 showed some isolated removal of vegetation, probably related to the 2000 flood. There is evidence of terrestrialisation of the upper banks. The site is characterized by a poor riparian vegetation structure with few to no juveniles and only a few large remaining adult trees. Based on the scores and weightings used in the PES model (see Appendix 3), the PES score for the vegetation is 41.15 (D/E).

3.2.2.2 Reference state

A wide, sandy channel with reed beds existed at this site in the 1930's, but changed to a narrow, incised channel by the 1990's. Due to the extreme nature of the channel pattern (see Rountree and Dollar, 2004) change, the site is not likely to revert back to the 1930's condition.

3.2.2.3 Trajectory of change

The trajectory of change is likely to be negative in the long-term. The upper bank vegetation is likely to continue to deteriorate due to anthropogenic impacts associated with wood removal and because of increased terrestrialisation. Since most of the lower bank riparian vegetation was totally removed by the floods of 2000, there may be some re-growth response in the lower zones. Trampling and grazing along the edges of the lower terraces are however likely to limit any longer-term recovery. With the provision of higher flows and reduced grazing pressure, some vegetation could re-establish along the channel margins. With active intervention at the site to prevent trampling and grazing, it may be possible fro the site to improve from the current D/E category to a D class but this is unlikely given the intense utilization of the area. In addition, further losses of moderate floods are anticipated due to recent raising of Thabena Dam which has no outlet for releases. This is likely to further impact negatively on the lower and certainly upper riparian zones. It is thus likely that the site will remain in a D/E category

3.2.2.4 Flood motivations

When the recent profile of the site from Angelina Jordanova was compared with the profile of the site as given in the 1996 report of the Department of Water Affairs and Forestry, it was evident that the profile of the macro-channel had changed as a result of the 2000 floods. This was most evident in the lower terraces. Since this site was not surveyed for riparian vegetation for the reasons given in section 2.2 of this report, some extrapolation based on the photographs of the site, the initial visit to the site, and based on discussions with Mark Rountree at the August workshop, were used to establish the flood classes. The same flood classes as per the geomorphology component therefore apply for this site. The alluvial nature of the riparian terraces indicated that bank storage may be important for riparian vegetation maintenance at this site. Summer

There is therefore a need for higher flows as well as low flows to assist with the recharge of the banks and associated flood terraces at this site in order to maintain the marginal, lower and upper riparian zone vegetation. Maintaining the low flows will ensure the survival of the fig trees while higher flows (flood classes I and II) will help with the inundation and recharge of the lower terraces as well as sediment deposition on these. Not much can be done about the upper bank where flows have been reduced and where anthropogenic impacts and terrestrialisation is likely to continue. In addition, further losses of moderate floods are anticipated due to recent raising of Thabena Dam which has no outlet for releases. This is likely to further impact negatively on the lower and certainly upper riparian zones. If the effects of trampling and overgrazing are removed, it may be possible to improve the situation by enabling the longer-term recovery of the marginal and lower riparian zones. This is however highly unlikely given the human-related pressure at the site.

3.2.2.5 Confidence

While the site is fairly representative of the riparian vegetation in the resource unit, the effects of backflooding reduced the confidence of this assumption. While a few individuals of indicator species were present at the site, these did not really assist with setting the higher flows since they were mostly rooted to take advantage of the low flows. The air photo record for the site was useful in the assessment. The profile data collected during 1996 had however been modified by the 2000 floods, and as such was not much use in the workshop. There was also no other available riparian vegetation data for the reach. Despite the stressor-response being motivated by the fish and invertebrate specialists, these seemed adequate for maintaining this aspects of the riparian vegetation. There was not accurate information on actual return periods for various high flows which also made it difficult to consider scenarios in terms of likely vegetation response. The flows set were thus highly dependent on the geomorphology component. The confidence scores for each of the attributes listed are given in the Table 3 below.

Table 3. Confidence ratings for the riparian vegetation at IFR 2.

IFR SITE	AVAILABLE DATA	ECOLOGICAL CLASSIF.	OUTPUT LOW FL	OUTPUT HIGH FL
1	1	3	2	1

3.2.3 IFR 3 – Eiland

3.2.3.1 Present Ecological Status

The site has changed dramatically since 1954 but has been reset to a similar state seen in the 1930's. Flow related impacts (reduction in flows) plus the 2000 flood appear to have been the main factors in this regard. This is a dynamic river since there is evidence of continual state changes in the riparian vegetation over time. This was exacerbated by the reduction in flows since the 1930's, particularly the middle order floods. Vegetation continued to encroach onto the macro-channel floor until it had formed an extensive riparian forest along the macro-channel floor in the late 1980's. The active channel had been considerably narrowed with extensive marginal and lower riparian vegetation. There were dramatic changes (removal) as a result of the 2000 floods, particularly if compared to the riparian zone in the late 1980's. Based on the scores and weightings used in the PES model (see Appendix 3), the PES score for the vegetation is 55.41 (D). The low PES score is largely as a result of the reduction in smaller floods and baseflows and extensive agricultural encroachment that has taken place in the reach. In places the upper riparian zone in particular has been heavily impacted by the latter.

3.2.3.2 Reference state

For this site it was difficult to decide on a reference state for the vegetation. The air photos from 1938 indicated that the site was characterized by a wide active channel (approximately half the width of the macro-channel floor) with numerous small vegetated (*Phragmites*) in-channel bars (Rountree PC). The extensive macro-channel lateral bars also had some reeds and riparian shrubs with large areas of exposed sediment. Vegetation establishment on the macro-channel lateral bar features only started to increase after the 1930's. By the 1950's, the macro-channel at both the Eiland and Prieska IFR sites was vegetated again. State changes are therefore common and the system appears to be naturally quite dynamic, with the state changes in this dynamic being exacerbated by the changes in flows and land-use since the 1930's.

3.2.3.3 Trajectory of change

The trajectory of change is likely to be stable unless flows are improved. The upper bank vegetation is likely to continue to deteriorate due to loss of high flows and agricultural impacts while the marginal and lower bank riparian zones are likely to improve slightly due to encroachment again since the baseflows have decreased. Terrestrialisation is likely to continue on upper bank. Since the lower bank riparian vegetation was totally removed by the floods of 2000, there is likely to be a fairly rapid re-growth response in the lower zones, which together with the marginal vegetation zone is likely to improve (in terms of cover and abundance) over time. All in all, the trajectory is likely to balance out and the system as a whole is likely to remain in a state of dynamic flux.

3.2.3.4 Cross section

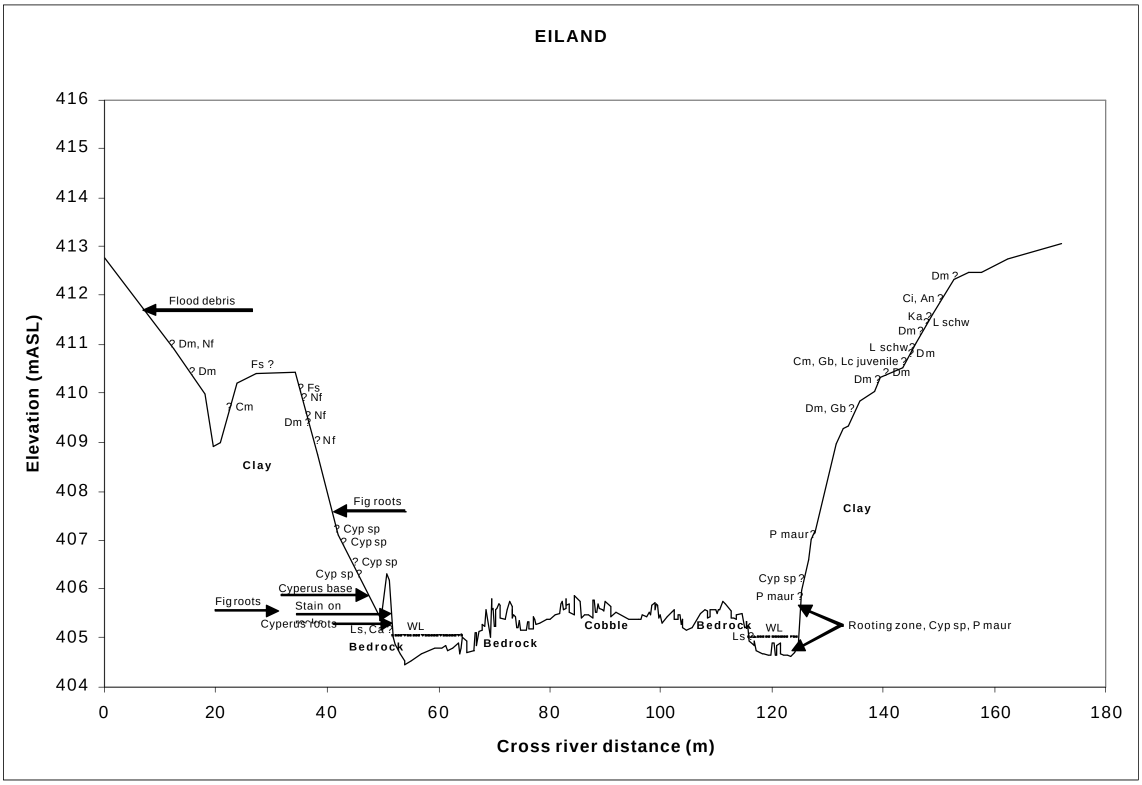


Figure 4: Vegetation data plotted on the cross section at IFR 3 Eiland (for abbrev. see Table A3, Appendix 2).

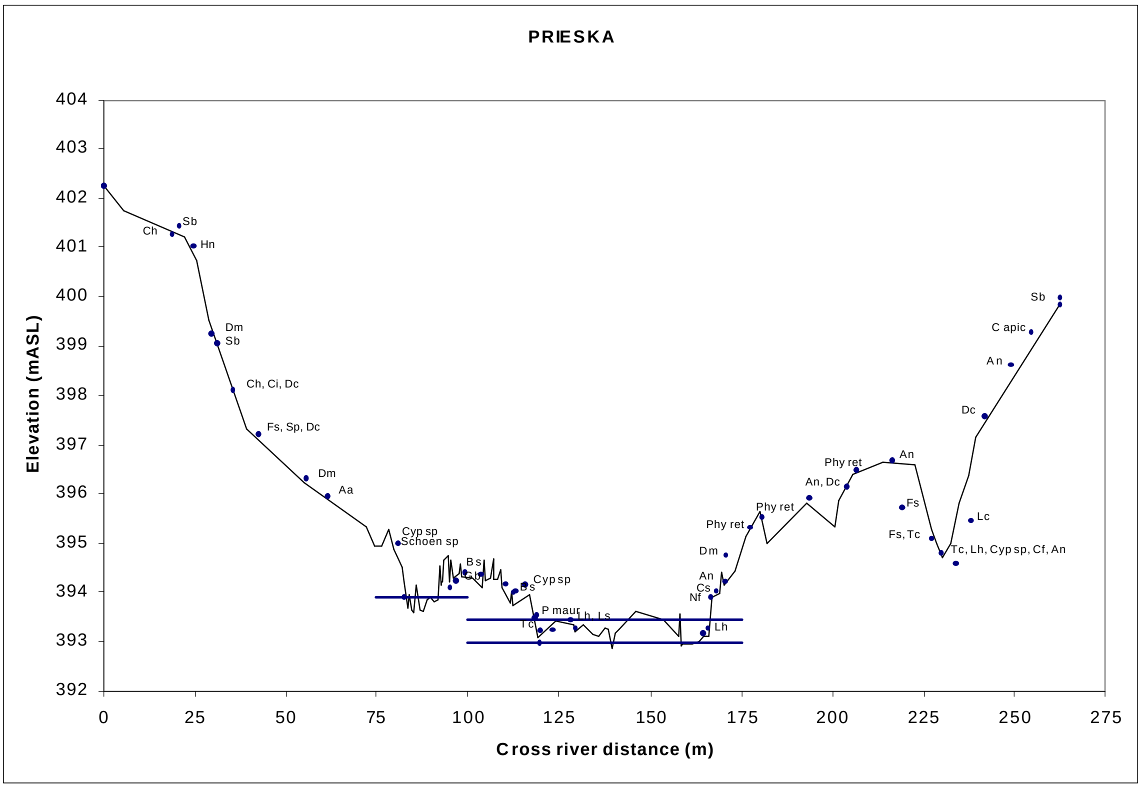
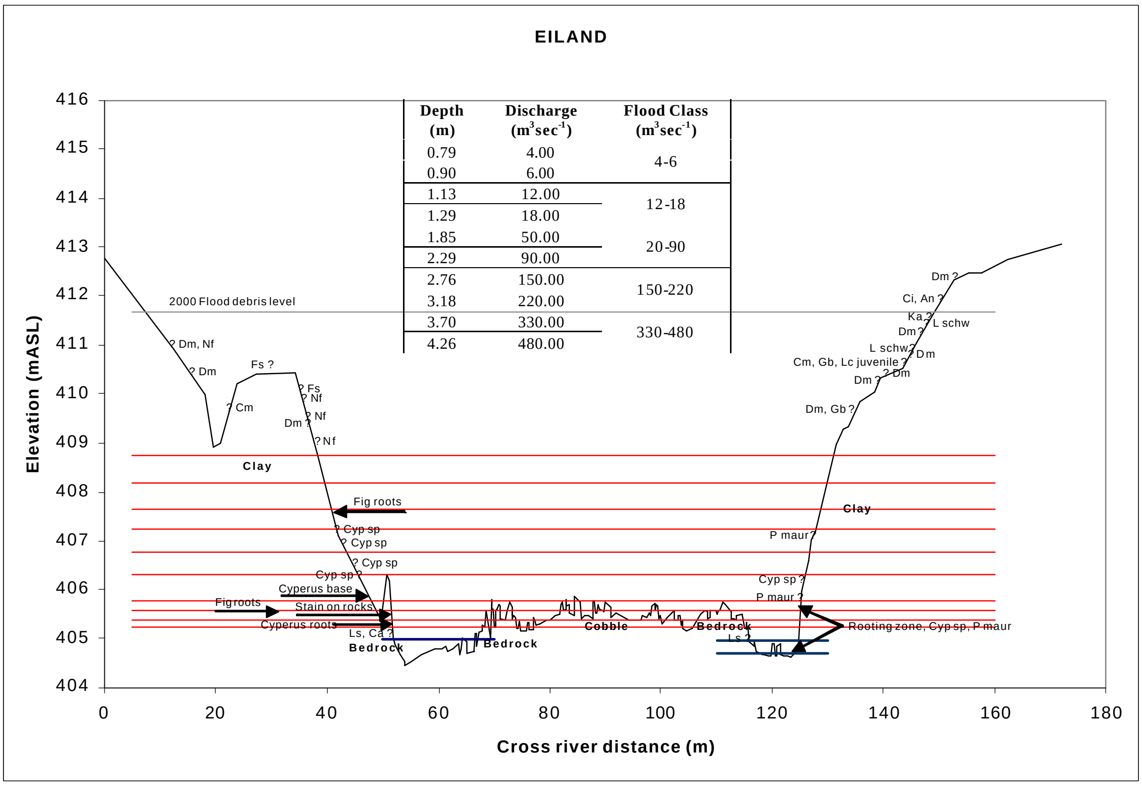


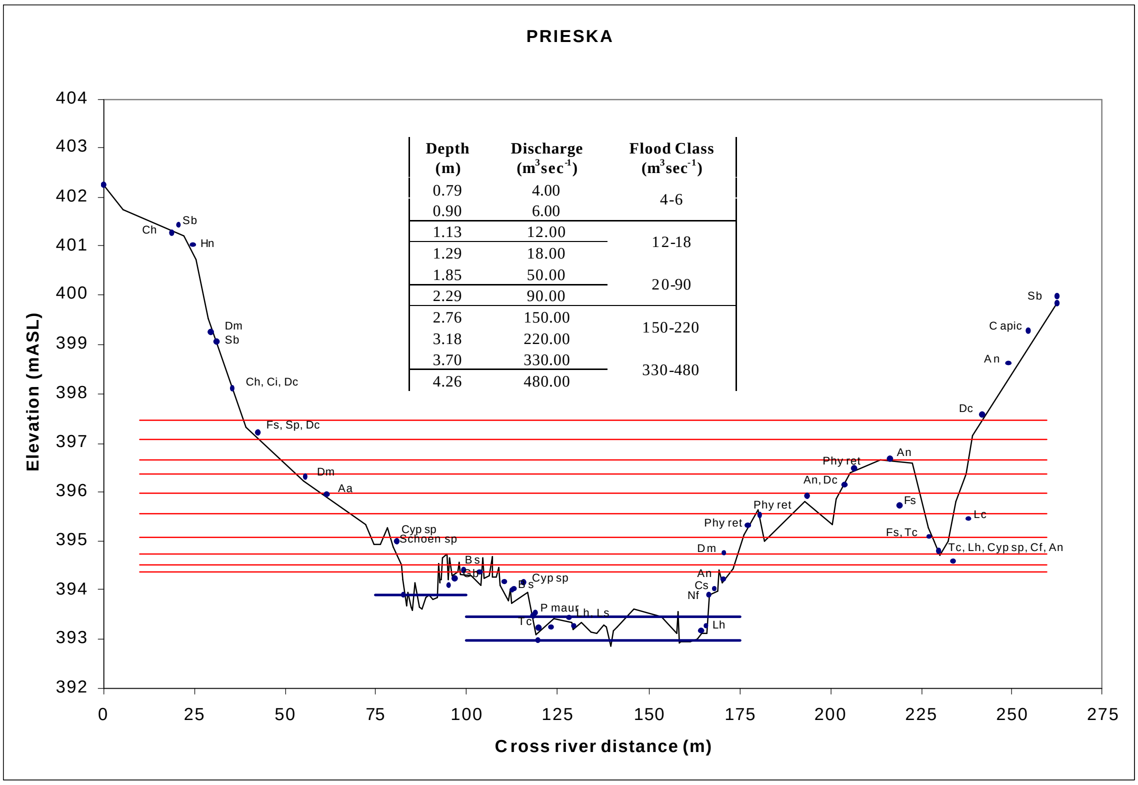
Figure 5: Vegetation data plotted on the cross section at IFR 3 Prieska (for abbrev. see Table A3, Appendix 2).

3.2.3.5 Flood motivation



Depth (m)	Discharge (m^3sec^{-1})	Flood Class (m^3sec^{-1})
0.79	4.00	4-6
0.90	6.00	
1.13	12.00	12-18
1.29	18.00	
1.85	50.00	20-90
2.29	90.00	
2.76	150.00	150-220
3.18	220.00	
3.70	330.00	330-480
4.26	480.00	

Figure 6: Vegetation data and the motivated flood levels plotted on the cross section at IFR 3 Eiland.



Depth (m)	Discharge (m^3sec^{-1})	Flood Class (m^3sec^{-1})
0.79	4.00	4-6
0.90	6.00	
1.13	12.00	12-18
1.29	18.00	
1.85	50.00	20-90
2.29	90.00	
2.76	150.00	150-220
3.18	220.00	
3.70	330.00	330-480
4.26	480.00	

Figure 7: Vegetation data and the motivated flood levels plotted on the cross section at IFR 3 Prieska.

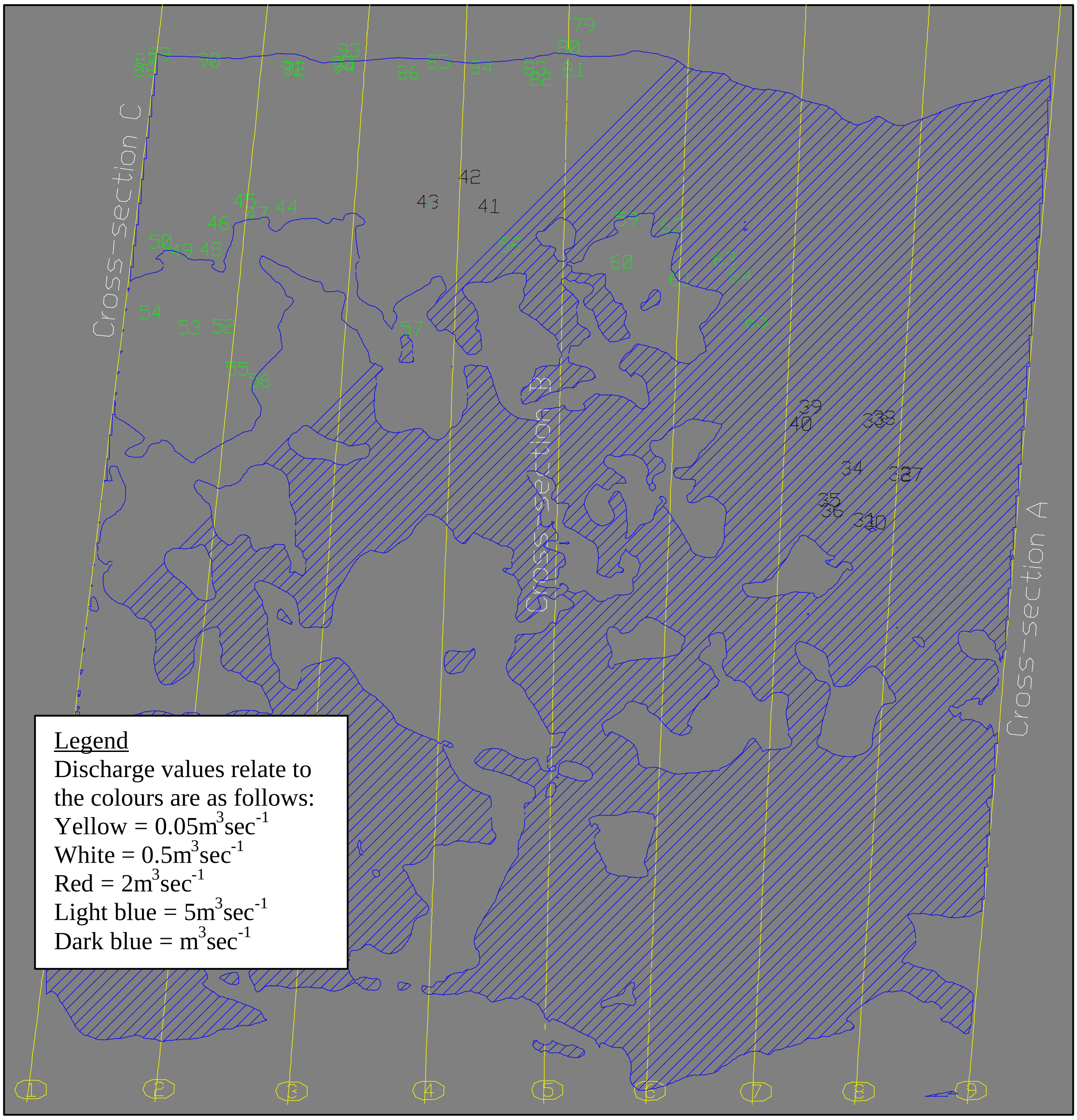


Figure 8: Habitat model for IFR 3 Eiland with various flows as indicated and vegetation survey points in green.

The vegetation data to support the habitat model is provided in Table 3 below with the numbers in green corresponding to the survey points in the table.

Table 4: Vegetation data in support of the habitat model for IFR 3.

Surveyor: I McIlrae, Vegetation: GC Marneweck, Date: 14 October 2003, Elevation: MASL, WGS 84/31, Constant = 2600000.00

EILAND HABITAT MODEL DATA, VEGETATION				
Survey point	X	Y	Z	Comment
30	34651.48	16451.66	405.20	Water level (edge)
31	34650.70	16451.86	405.27	Cyperus
32	34653.40	16455.37	405.24	Cyperus
33	34651.42	16459.41	405.14	Cyperus, Schoenoplectus, and some Phragmites mauritianus
34	34649.75	16455.78	405.36	Cyperus, Schoenoplectus, and some Phragmites mauritianus
35	34648.02	16453.37	405.32	Cyperus, Schoenoplectus, and some Phragmites mauritianus
36	34648.25	16452.58	405.34	Cyperus, Schoenoplectus, and some Phragmites mauritianus
37	34654.27	16455.28	405.14	Water level (edge), Ludwigia zone
38	34652.19	16459.61	405.10	Water level (edge), Ludwigia zone
39	34646.58	16460.44	404.80	Ludwigia in pool
40	34645.82	16459.16	405.06	Water level (edge), pool
41	34622.18	16475.69	405.06	Ludwigia
42	34620.73	16477.92	404.92	Water level (edge), Ludwigia zone
43	34617.54	16476.03	404.91	Water level (edge), Ludwigia zone
44	34606.86	16475.60	404.90	Water level (edge), Ludwigia zone
45	34603.64	16476.06	404.90	Water level (edge), Ludwigia zone
46	34601.65	16474.41	404.90	Water level (edge), Ludwigia zone
47	34604.59	16475.09	405.03	Dry edge of Ludwigia zone
48	34601.08	16472.39	405.30	Cyperus sp and Phragmites zone
49	34598.85	16472.30	405.18	Cyperus sp and Phragmites zone
50	34597.29	16472.97	405.17	Cyperus sp and Phragmites zone
51	34597.10	16474.20	406.49	Water level (edge)
52	34602.04	16466.56	405.76	Cyperus
53	34599.45	16466.47	405.88	Breonardia salicina (0.5 m high), juvenile
54	34596.54	16467.61	405.73	Cyperus
55	34603.10	16463.33	405.74	Cyperus
56	34604.80	16462.45	405.78	Cyperus
57	34616.34	16466.40	406.03	Dead Breonardia salicina
58	34623.75	16472.72	405.33	Cyperus
59	34632.63	16474.69	405.33	Phragmites mauritianus clump (1X1m)
60	34632.26	16471.44	405.39	Cyperus
61	34636.76	16470.14	405.62	Juvenile Ficus syccamorus
62	34636.12	16474.20	405.24	Juvenile Ficus syccamorus
63	34640.10	16471.67	405.12	Schoenoplectus sp and Cyperus sp3
64	34641.32	16470.41	405.01	Typha capensis
65	34642.47	16467.02	405.28	Cyperus
79	34629.36	16489.38	407.03	Phragmites mauritianus
80	34628.25	16487.74	406.12	Cyperus
81	34628.62	16486.05	404.94	Water level (edge) - depth 0.15 m (steep bank)
82	34626.13	16485.35	404.44	Water level (edge) - depth 0.43 m (steep bank)
83	34625.71	16486.11	405.53	Culm/root transition with roots extending 1.1m
84	34621.63	16486.21	405.70	Start of Phragmites mauritianus (upper edge along the bank)
85	34618.31	16486.63	405.77	Start of Cyperus sp 2 (upper edge along the bank)
86	34616.08	16485.82	404.72	Water level (edge)
87	34596.18	16486.79	406.09	Start of Phragmites mauritianus (upper edge along the bank)
88	34596.09	16486.02	404.33	Channel floor on edge (measurement of depth)
89	34597.19	16487.20	405.36	Start of Phragmites mauritianus (upper edge along the bank)
90	34600.96	16486.76	405.82	Start of Phragmites mauritianus (upper edge along the bank)
91	34607.21	16486.18	405.54	Start of Phragmites mauritianus (upper edge along the bank)
92	34607.40	16486.06	404.79	Rooting depth
93	34611.57	16487.52	405.92	Start of Cyperus (upper edge along the bank)
94	34611.18	16486.31	404.73	Cyperus sp 2 (in water along the edge)
95	34611.03	16486.51	405.34	Culm/root transition of Cyperus

Table 5: Flood Class motivations for the riparian vegetation at IFR 3, Eiland and Prieska.

FLOOD CLASS I: 4-6m^3/s			Recommended : C/D			Alternative : C		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates the low flow backwater to provide water to the *F. sycomorus* roots that are tapping into this source. Also reaches the rooting zone of the *Cyperus* species around the rock pool. Inundates the rooting zone of the *P. mauritianus* along the edge of the active channel.	Inundates to a depth of between 0.8 and 0.9 m in the low flow backwater area.	Nov to April	6	Per year	A small flood of this size will fill the low flow backwater pool to meet the evapo-transpiration needs to the *F. sycomorus* (upper riparian at this site) and lower riparian species that are rooted here. The number of these floods ensures that the backwater does not dry up for any length of time. Estimating evaporation at 5 mm/day, it was estimated that water will remain in the pool for approximately 2 months after a flood of 5 m^{3}sec^{-1}.	8	Per year	The slightly higher frequency of supply compared to the recommended Class will ensure flushing of the backwater and will mean the water level remains high to support the vegetation.
			Alternative : lower D					
			No of events	**Freq**	**Reasoning**			
			4	Per year	The lower frequency of supply compared to the recommended Class will reduce the water in the backwater which will mean the water level will drop stressing the vegetation. There are however likely to be enough flows that the vegetation will not drop a Class.			

FLOOD CLASS II: 12-18m^3/s			Recommended : C/D			Alternative : C		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates the entire macro-channel floor. It inundates the marginal vegetation across the macro-channel floor. It also inundates many of the juvenile *B. salicina* trees.	The duration of flow needs to be adequate to saturate the marginal zones that dry out on a regular basis. The low average velocity will have minimal impact on the vegetation including the juvenile trees rooting in amongst the rocks.	Dec to Mar	3	Per year	Inundation stimulates growth and reproduction of flow dependent vegetation that comprises the marginal vegetation zone. It also inundates the microsites where the macro-channel floor flow dependent riparian tree *B. salicina* is germinating.	3	Per year	More of these floods will improve the vigour and abundance of the marginal vegetation on the macro-channel floor.
			Alternative : lower D					
			No of events	**Freq**	**Reasoning**			
			2	Per year	Unlikely to result in a drop in a class but will probably put the riparian vegetation in a low D.			

FLOOD CLASS III: 50-90m^3/s			Recommended : C/D			Alternative : C		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates the lower riparian zone particularly where sedges and reeds occur along the lower bank. This is important for supporting the overhanging vegetation along the lower bank. Also inundates the terrace dominated by *P. reticulatus* at the site below the weir.	Stage and duration, with the flood reaching the first terrace at the IFR site below the weir.	Feb	1	Per year	Inundation is also required to meet the life-history requirements of many of the lower riparian species.	1	Per year	Same.
			Alternative : lower D					
			No of events	**Freq**	**Reasoning**			
			1	Per year	Same			

FLOOD CLASS IV: 150-220m^3/s			Recommended : C/D			Alternative : C		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Flood inundates the upper terraces to raise the water table in the terraces and support the riparian trees that grow there. Are also important for increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes.	Stage and duration, with the flood reaching the second terrace at the IFR site below the weir.	Mar		1:2	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also stimulate reproduction in many of the riparian tree species on the terraces.		1:2	Same.
			Alternative : lower D					
			No of events	**Freq**	**Reasoning**			
				1:3	Reducing the frequency of this flood will reduce the flooding of the upper terrace but is unlikely to result in a drop in a Class.			

FLOOD CLASS V: 330-480m³/s			Recommended : C/D			Alternative : C		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Floods at this elevation are important raising the water table in the banks.	Stage.	When it arrives		1:10	Floods at this elevation are important raising the water table in the banks. This is important for meeting the transpiration requirements of the riparian trees in the upper riparian zone.		1:10	Same
			Alternative : lower D					
			No of events	**Freq**	**Reasoning**			
				1:10	Same			

Motivation for a higher PES (C)
To improve to a C, there is a need for higher flows to assist with the re-establishment of the marginal and lower riparian zone vegetation. The main change expected is in terms of cover and abundance. As such all changes in the PES model were made in lower riparian and marginal zones (predominantly cover and abundance). Not much can be done about the upper bank where flows have been reduced and where agricultural impacts and alien invasion is likely to continue. Even alien clearing is unlikely to improve the situation in the long-term since the agricultural impacts on the upper bank are likely to continue.

Motivation for a lower PES (Lower D)
In most instances, reducing the frequency of the larger floods will reduce the flooding of the upper terrace but is unlikely to result in a drop in a Class.

3.2.3.6 Confidence

The site is fairly representative of the resource unit. Two sites were used for the assessment. One could therefore also check the high flows between the two which were close and in the same reach. The air photo record for the site was also good. The habitat model was used to assist with setting the lower range of the high flows. This was particularly useful in the backwater area where the riparian vegetation was rooting. One could also check inundation zones for groups of species as well as indicator species (specifically *F. sycomorus* and *B. salicina*) on the macro-channel floor. The poor confidence in the observed hydrological data used in the modeling for the large floods reduced the overall confidence in the high flows. Having a second site for comparison provided extra confidence in the vegetation data. The confidence ratings are shown in Table 5 below.

Table 5: Confidence ratings for the riparian vegetation at IFR 3.

IFR SITE	AVAILABLE DATA	ECOLOGICAL CLASSIF.	OUTPUT LOW FL	OUTPUT HIGH FL
3.5	4	3	2	3.5

3.2.4 IFR 4 – Letaba Ranch

3.2.4.1 Present Ecological Status

The system is naturally in a dynamic state, fluctuating between states from vegetated to non-vegetated along the macro-channel floor. The change in the vegetation abundance in the upper riparian zone has surprisingly not been that dramatic despite the 2000 floods. Long-term flow related impacts (reduction in flows) appear to have contributed to the negative changes observed over time. The reduction in middle order floods is probably most important in this regard. The marginal vegetation zone is naturally dynamic and thus the change has not been that dramatic relative to the reference state which has to be considered in the context of dynamic states. In contrast, the change in the lower riparian zone has been more dramatic with a substantial loss of cover and abundance, particularly on the flood terraces. The changes in the upper riparian zones have been more gradual. While the 2000 floods had an influence on the upper riparian zone, species richness and composition is unlikely to have been affected substantially. The change is mostly reflected in cover, abundance and structure. Based on the scores and weightings used in the PES model (see Appendix 3), the PES score for the vegetation is 57.40 (D).

3.2.4.2 Reference state

Again using the air photos from 1938 as an indication of the reference condition, the reach where the site is located had a mixed anastomosing channel pattern with numerous active channels separated by vegetated bars. Extensive pool features were also present. It should however be pointed out that by the mid 1950's the instream bars had consolidated, resulting in a primarily single active channel with riffle and pool features and the floor had become well vegetated. If the state of the river in the 1950's was used to define the reference state, then it would have been different to the 1930's and the same can be said for the 1960's and 1980's. Defining a reference state is therefore difficult since the river historically had sequential stages in the successional development of riparian vegetation. For the purpose of this study however, the current state was compared mostly with the situation in the 1930's.

3.2.4.3 Trajectory of change

The trajectory of change is likely to be stable unless flows are improved. The upper riparian zone vegetation is likely to continue to survive but there is likely to be a gradual deterioration due to loss of high flows and terrestrialisation. Terrestrialisation may extend to the lower bank as flows remain reduced and larger floods are needed to reach the terraces. The marginal vegetation zone is likely to improve slightly due to encroachment and the re-establishment of vegetation. While some recovery (increase in abundance) is expected in the lower riparian zone on the terraces, it is likely to be limited as a result of the reduction in middle order floods. All in all, the trajectory is likely to balance out and the system as a whole is likely to remain in a state of dynamic flux.

3.2.4.4 Cross section

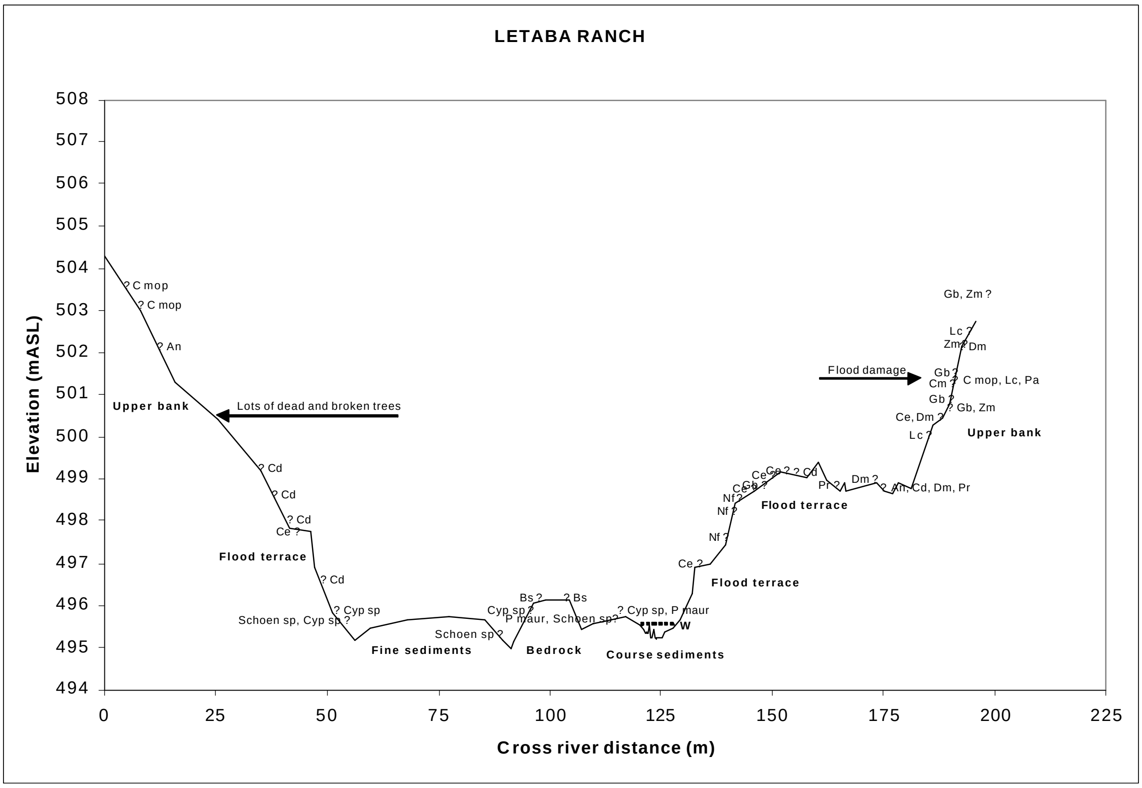
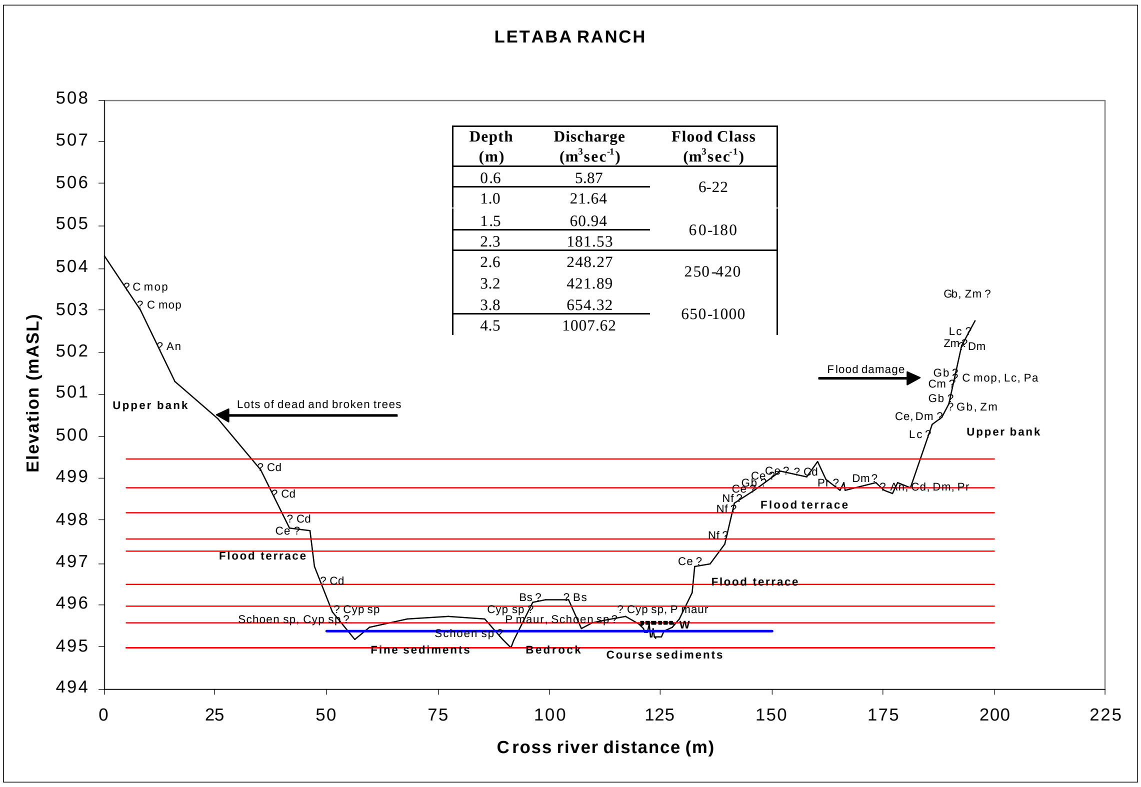


Figure 9: Vegetation data plotted on the cross section at IFR 4 (for abbrev. see Table A3, Appendix 2).

3.2.4.5 Flood motivations



Depth (m)	Discharge (m^3sec^{-1})	Flood Class (m^3sec^{-1})
0.6	5.87	6-22
1.0	21.64	
1.5	60.94	60-180
2.3	181.53	
2.6	248.27	250-420
3.2	421.89	
3.8	654.32	650-1000
4.5	1007.62	

Figure 10: Vegetation data and the motivated flood levels plotted on the cross section at IFR 4.

Table 7: Flood Class motivations for the riparian vegetation at IFR 4.

FLOOD CLASS II: 6-22m^3/s			Recommended : C/D			Alternative : C		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates the seasonal channels and marginal vegetation zones including the mixed sedge zone and reedbeds. Also important for the re-establishment of macro-channel floor riparian species such as *B. salicina*	Inundates up to 1 m depth in active channel, as well as inundates the seasonal channels. Inundates up to approximately 0.4 m in the mixed sedge zones away from the active channel and on the in-channel bars. The low average velocity will have minimal impact on the vegetation in these areas.	Nov, Dec, Jan, Feb, Mar, April	4	Per year	A small flood of this size will support the marginal vegetation, stimulating the growth and reproduction of the species that comprise this zone including *P. mauritianus* and the *Cyperus* species.	6	Per year	The slightly higher frequency of supply compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are expected to increase in abundance. This will stabilise the margins of the active channel, redirect sediment movement, direct flow along the active channel, and ultimately improve the instream habitats.
			Alternative : D					
			No of events	**Freq**	**Reasoning**			
			4	Per year	Reducing this flood by two per annum compared to the requirement for the recommended Class will affect the marginal vegetation resulting in exposure during the hot summer months. Exposure will affect the more flow dependent species such as reeds, which are expected to decrease in abundance. The dominance of herbaceous forbs is expected to increase. These do not stabilise the sediment, which together with a decrease in the abundance of reeds, is likely to result in a decrease in instream habitat quality.			

FLOOD CLASS III: 60-180m^3/s			Recommended : C/D			Alternative : C		
Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning	No of events	Freq	Reasoning
Inundates to the bench dominated by *N. floribunda* and *C. erythrophyylum* and raises the water table in the terrace to support the lower riparian zone including the trees on the terrace.	Stage and duration with inundation between 1.5 and 2.3 m in depth.	Mid summer (February)	1	Per year	Mid summer floods at this elevation are important for the re-establishment of the lower riparian zone. Also raises the water table in the benches and lower flood terraces to support the growth of the larger riparian trees on the terraces and for meeting their transpiration requirements.	2	Per year	The higher frequency of supply compared to the recommended Class will improve the vigour and growth of the lower riparian vegetation which is expected to increase in abundance. This will result in an improvement in the habitat diversity of the riparian zone.
			Alternative : D					
			No of events	Freq	Reasoning			
			1	Per year	Same as for the C/D class			

FLOOD CLASS IV: 250-420m^3/s			Recommended : C/D			Alternative : C		
Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning	No of events	Freq	Reasoning
Flood inundates the middle terraces to raise the water table in the terraces and support the riparian trees (particularly the stands of *C. erythrophyllum*) that grow there. Is also important for increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes on the terraces.	Stage and duration, with the flood reaching the middle terraces at between 2.6 and 3.2 m above the active channel bed at the site.	Feb or Mar	1*	Per year	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also stimulate reproduction in many of the riparian tree species on the terraces.	2**	Per year	Same.
			Alternative : D					
			No of events	Freq	Reasoning			
			1*	Per year	Same.			

* Initially one of these floods was requested per annum, but according to the present day flood record, the flood is more likely to be a 1:2 to 1:5 year event.

** Based on the note above, it is likely that the request for two of these floods per annum will not be met according to the present day flood record.

FLOOD CLASS V: 650-1000m^3/s			Recommended : C/D			Alternative : C		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Flood inundates the higher terraces to raise the water table in the terraces and support the riparian trees that grow there. Stands of remnant *C. erythrophyylum* still occur despite the 2000 flood damage). Is also important for increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes.	Stage and duration, with the flood reaching the higher terrace at the site.	When it arrives (summer)		Estimated at 1:10	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also stimulate reproduction in many of the riparian tree species on the terraces.		Estimated at 1:10	Same.
			Alternative : D					
			No of events	**Freq**	**Reasoning**			
				Estimated at 1:10	Same.			

Motivation for a higher PES (C)

To improve to a C, and since it will not be possible to increase the high flows (floods), there will need to be higher low flows to assist with the re-establishment of the marginal and lower riparian zone vegetation. Given that sedimentation is likely to continue to occur even with increased low flows, reedbeds are likely to increase. Increased reedbeds will stabilize sediment and direct flow that will assist with scouring in the active channels between reedbeds. The associated increase in vegetation cover and abundance and localized scouring is likely to maintain or possibly even increase habitat diversity in the short-term. Since the changes relate to increased low flows, the changes in the PES model were made in the marginal zones (predominantly cover and abundance) and only slightly in the lower riparian. The lower riparian zone may be improved slightly if the low flows are increased. Not much can be done about the upper zone where flows have been reduced and where terrestrialisation is likely to continue. Without increasing high flows (mid-sized to large floods), this zone is not expected to influence the improvement in the Class.

Motivation for a lower PES

At the workshop it was decided that it would not be feasible to consider motivating for flows for a lower PES for the riparian vegetation.

3.2.4.6 Confidence

The site is fairly representative of the resource unit. There was however extensive flood damage in terms of the structure of the terraces and vegetation structure. There was still however a number of individuals of indicator species present for assisting with setting the flows. Apart from the profile data collected and aerial photography, there were no other available riparian vegetation data for the reach. The air photo record for the site did help with the assessment, but because of the scale (the minimum mapping units were too small for providing any meaningful data on the vegetation), only limited information could be extracted from these. Due to the stressor-response not being applicable to the riparian vegetation, the low flows were directly based on the flows motivated by the fish and invertebrate specialists. These were only reviewed for the riparian component. The poor confidence in the observed hydrological data used in the modeling for the large floods reduced the overall confidence in the high flows. One did not have accurate (long enough record) information on actual return periods for various high flows which also made it difficult to consider scenarios in terms of likely vegetation response. The confidence ratings are shown in Table 8 below.

Table 8: Confidence ratings for the riparian vegetation at IFR 4.

IFR SITE	AVAILABLE DATA	ECOLOGICAL CLASSIF.	OUTPUT LOW FL	OUTPUT HIGH FL
3	3	3	2	2

3.2.5 IFR 5 – Klein Letaba

3.2.5.1 Present Ecological Status

Flow in the system has changed considerably as a result of the Middle Letaba Dam. Despite this, the change in the vegetation abundance in the upper riparian zone has surprisingly not been that dramatic, even after the 2000 floods. The long-term flow related impacts (reduction in flows) appear to have contributed to a gradual increase in abundance of marginal vegetation until 2000, after which much of the marginal vegetation was removed. Compared to reference, the marginal vegetation was however not that different. The marginal vegetation zone is naturally dynamic and thus the change has to be viewed in the context of dynamic state changes. The change in the lower riparian zone has been more dramatic with a substantial loss of cover and abundance. Up until 2000, the loss of middle order floods was probably the most important factor that affected the lower riparian zone with the 2000 floods having a major sudden impact. Some non-flow related impacts occur, particularly vegetation removal (chopping of mid-sized and larger trees) and subsistence agriculture. While the 2000 floods had an influence on this zone, species richness and composition is unlikely to have been affected substantially. The changes are mostly reflected in cover, abundance and structure. Alien tree invasion does not appear to be a major problem at this stage. Based on the scores and weightings used in the PES model (see Appendix 3), the PES score for the vegetation is 67.39 (C).

3.2.5.2 Reference state

Using the air photos from 1937 as an indication of the reference condition, the reach where the site is located had a meandering/braided active channel flowing across sandy macro-channel.

There was little to no vegetation on the macro-channel floor but the lower and upper riparian zones were reasonably well vegetated, much like what is visible at present

3.2.5.3 Trajectory of change

The trajectory of change is likely to be negative unless flows are improved. The upper zone vegetation is likely to continue to survive but there is likely to be a gradual deterioration due to loss of high flows and terrestrialisation. Terrestrialisation may extend to the lower bank as flows remain reduced. The marginal riparian zone is likely to improve in the short-term as reeds and sedge zones re-establish. This zone will continue to adjust to the lower flows and inevitably cover and abundance is expected change. Since much of the lower riparian zone vegetation and terraces on which it was growing were removed by the 2000 floods, the cover and abundance of this zone has changed. Again, while some recovery (increase in abundance) is expected, it is likely to be limited as a result in the reduction in middle order floods. All in all, the trajectory is likely to deteriorate and the riparian zone as a whole is likely to reduce. The influence of bank storage (groundwater) may help to buffer this change.

3.2.5.4 Cross section

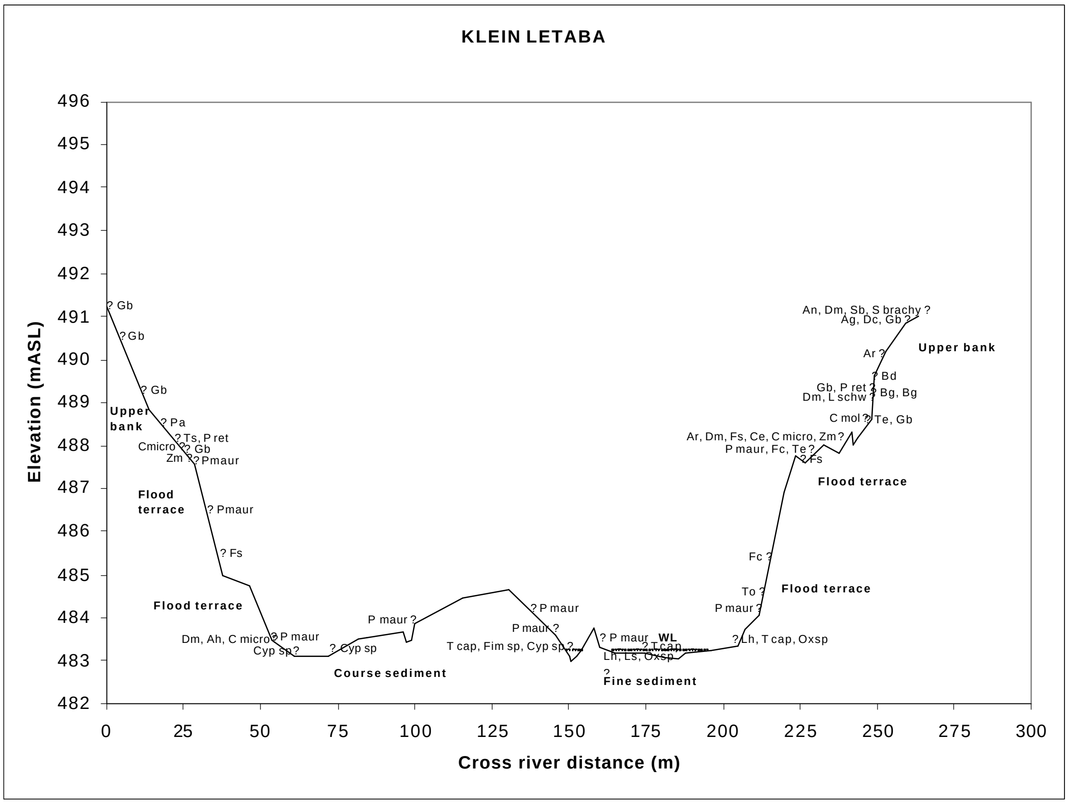


Figure 11: Vegetation data plotted on the cross section at IFR 5 (for abbrev. see Table A3, Appendix 2).

3.2.5.5 Flood motivations

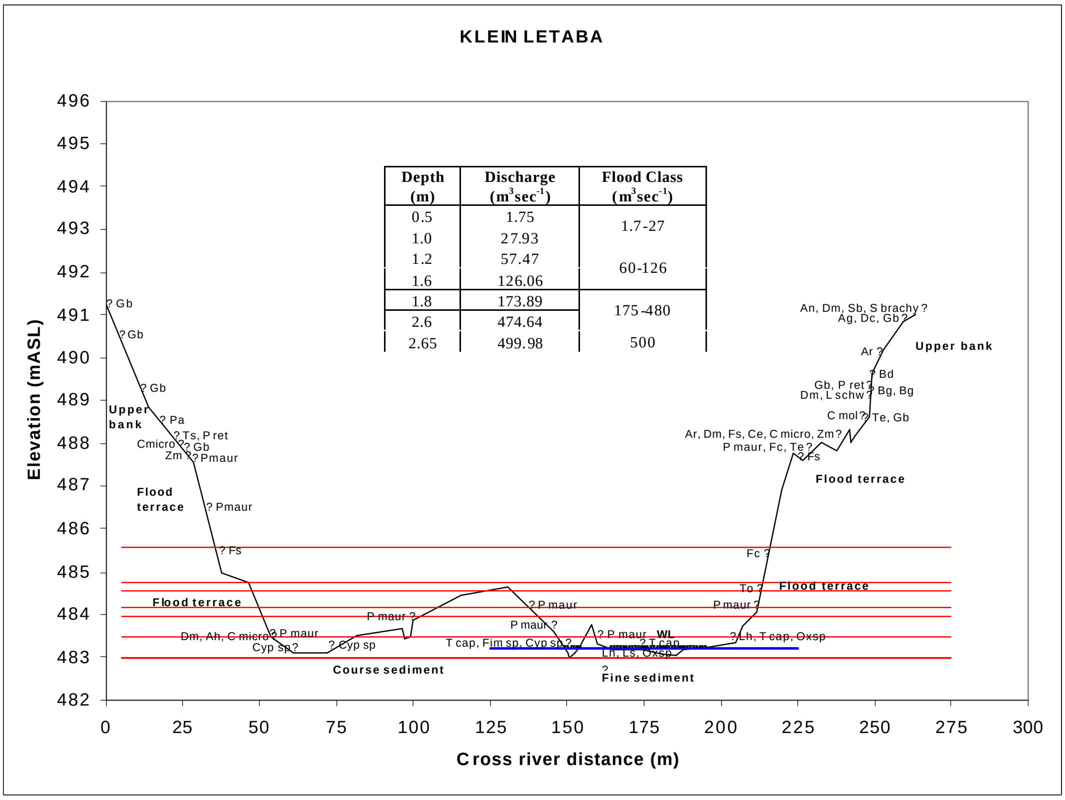


Figure 12: Vegetation data and the motivated flood levels plotted on the cross section at IFR 5.

Table 9: Flood Class motivations for the riparian vegetation at IFR 5.

FLOOD CLASS I and II: 1.7-27m^3/s			Recommended : C			Alternative : D		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates the seasonal channels and marginal vegetation zones adjacent to the active channel. Is important for the re-establishment of the marginal vegetation zones that include inundation dependent species such as *T. capensis* and *L. hexandra*, both of which depend on flooding inundation for completion of their lifecycles.	Inundates up to 1 m depth in active channel, as well as inundates the seasonal channels. The relatively low average velocity will have minimal impact on the other marginal vegetation in these areas.	Nov to April	9 (6 of between 8-12 m^{3}sec^{-1} and 3 between 14-27 m^{3}sec^{-1} integrated classes)	Per year	A small flood of this size will support the extensive marginal vegetation zone in this river, stimulating the growth and reproduction of the flow dependent vegetation that comprise this zone. The frequency of flooding will improve the vigour and growth of the marginal vegetation, particularly reeds, which will stabilise the margins of the active channel, redirect sediment movement and direct flow along the active channel.	6 (4 of between 8-12 m^{3}sec^{-1} and 2 between 14-27 m^{3}sec^{-1} integrated classes)	Per year	Reducing this flood by two per annum compared to the requirement for the recommended Class will affect the marginal vegetation resulting in exposure during the hot summer months. Exposure will affect the more flow dependent species such as reeds, which are expected to decrease in abundance. The dominance of herbaceous forbs is expected to increase. These do not stabilise the sediment, which together with a decrease in the abundance of reeds, is likely to result in a decrease in instream habitat quality.

FLOOD CLASS III: 60-126m^3/s			Recommended : C			Alternative : D		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
With this flood, the reedbeds at the site are completely inundated above the rhizome/culm interface. Also inundates up to the lower edge of the first flood terrace, thereby raising the water table to support the re-establishment of trees on this terrace.	Stage and duration with the flood inundating the active channel to a depth of 1.6 m.	Dec or Mar	1	Per year	These floods would ensure that the marginal vegetation on the bars, adjacent to the active channel, and in the seasonal channels is inundated at least once during the summer months. This will help recharge the bars and stimulate the growth and reproduction of the marginal vegetation. This flood also reaches the lower riparian zone and helps recharge the lower terraces.		1:2	Reducing this flood to one every two years compared to the requirement for the recommended Class is likely to reduce the recruitment opportunities for the lower riparian zone vegetation, which is not expected to recover well given this reduced frequency of flooding.

FLOOD CLASS IV: 175-480m^3/s			Recommended : C			Alternative : D		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Flood inundates the lower terraces to raise the water table in the terraces and support the riparian trees that grow there. Is also important for establishing new terraces and increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes on the existing terraces.	Stage and duration, with the flood overtopping the lower terraces. Reaches 2.6 m above the active channel bed at the site.	When it happens in summer		Estimated at 1:10	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the terraces. The flows also stimulate reproduction in many of the riparian tree species on the banks and terraces.		Estimated at 1:10	Same.

FLOOD CLASS V: 500m^3/s				Recommended : C			Alternative : D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
	Same as class IV*					Same as class IV*			Same as class IV*

* Initially wanted to motivate for a much larger flood (in the region of 2800 m^{3}sec^{-1}) to reach the upper terraces at the site but according to the present day flood record these are very infrequent events that are not well represented in the flood data record - equivalent to the 2000 floods. The motivation for such a large flood for the riparian vegetation was probably skewed by the effects of the 2000 floods which substantially altered the channel morphology. Benches and terraces or sections of the terraces were probably removed during the 2000 floods. This left intermediate flow indicators species (such as *C. erythrophyllum*) at high elevations on remnant sections of terraces that now (due to changes in the width of the macro-channel) are unlikely to get flooded very often, if at all. It was also apparent that the vegetation on the upper terraces and banks could have been influenced by groundwater at the site. The occurrence of *P mauritianus*, for example, particular at high elevations on the profile, is possibly evidence of a groundwater influence. Another possible explanation for this species occurring so high on the profile might have to do with clumps being deposited with sediment during the drawdown of the 2000 floods and establishing. Without a groundwater influence however, these clumps are unlikely to survive. The influence of groundwater at the site and in the reach is however unknown.

Motivation for a higher PES (B)

At the workshop it was agreed that it would be unrealistic to consider increasing the PES to a B since it will not be possible to increase the high flows (floods). With higher low flows however, it is likely that the re-establishment of the marginal and lower riparian zone vegetation could be expedited and this could improve the Class. Given that sedimentation is likely to continue to occur even with increased low flows, reedbeds are likely to increase. Increased reedbeds will stabilize sediment and direct flow that will assist with scouring in active channels between reedbeds. The associated increase in vegetation cover and abundance and localized scouring is likely to maintain or possibly even increase habitat diversity in the short-term. Since the changes relate to increased low flows, the changes in the PES model were made in the marginal zones (predominantly cover and abundance) and only slightly in the lower riparian. The lower riparian zone is only likely to improve substantially if the larger floods come back into the system which is currently not possible given the abstractions and Middle Letaba Dam. Not much can be done about the upper zone where flows have been reduced and where terrestrialisation is likely to continue. Without increasing high flows, there is not expected to be an improvement in the Class.

Motivation for a lower PES (D)

To move down to a D, it is anticipated there would have to be a reduction in low flows (smaller flood events). The effects will be restricted predominantly to the marginal vegetation zones although increased stress may be expected in the lower riparian zone. Given that sedimentation is likely to continue to occur, herbaceous and more drought tolerant vegetation is likely to increase. The extent of reedbeds is likely to decrease since sections of the river are likely to become drier. More extensive non-vegetated sandy areas are expected with a decrease in riparian vegetation composition, abundance and cover. This is likely to decrease habitat diversity in the long-term. Since the changes relate to decreased low flows, the changes in the PES model were made mainly in the marginal zone (predominantly in terms of composition, cover and abundance) and lower riparian zones. Some changes were made in the upper zone too since the high flows (larger floods) will remain reduced, terrestrialisation will continue and the riparian vegetation is likely to continue to be lost.

3.2.5.6 Confidence

The site is representative of the resource unit. There was however extensive flood damage in terms of the structure of the lower terraces and benches and this had affected vegetation structure. Apart from the profile data collected and aerial photography, there were no other available riparian vegetation data for the reach. The air photo record for the site did help with the assessment, but because of the scale (the minimum mapping units were too small for providing any meaningful data on the vegetation), only limited information could be extracted from these. Due to the stressor-response not being applicable to the riparian vegetation, the low flows were directly based on the flows motivated by the fish and invertebrate specialists. These were only reviewed for the riparian component. The poor confidence in the observed hydrological data used in the modeling for the large floods reduced the overall confidence in the high flows. There was no accurate (long enough record) information on actual return periods for various high flows which also made it difficult to consider scenarios in terms of likely vegetation response.

Despite being an excellent site in terms of riparian indicator species, there were certain complexities on the site that made it difficult to set high flows. Firstly, the 2000 floods had probably substantially altered the channel morphology with benches and terraces or sections of the terraces being altered thus leaving intermediate flow indicators species (such as *C. erythrophyllum*) at high elevations. The increase in channel width as a result meant that these terraces are now unlikely to get flooded very often, if at all, considering the flow data. It was also apparent that the vegetation on the upper terraces and banks could be influenced by groundwater at the site. The occurrence of *P mauritianus*, for example, particular at high elevations on the profile, is possibly evidence of a groundwater influence. An alternative explanation is that clumps of this species may have been deposited with sediment at high elevations during the drawdown of the 2000 floods and then established well away from active flow areas. Given the distribution of reeds on these terraces however, it is more likely that they are being influenced by groundwater. These complexities made setting the high flows difficult and also contributed to the reduced confidence in these. The confidence ratings are shown in Table 9 below.

Table 10: Confidence ratings for the riparian vegetation at IFR 5.

IFR SITE	AVAILABLE DATA	ECOLOGICAL CLASSIF.	OUTPUT LOW FL	OUTPUT HIGH FL
3	2	4	2	2

3.2.6 IFR 6 – Lonely Bull

3.2.6.1 Present Ecological Status

The system is naturally in a dynamic state, fluctuating between states from vegetated to non-vegetated along the macro-channel floor. Long-term flow related impacts (reduction in flows) appear to have contributed to the negative changes observed over time. The reduction in middle order floods are probably most important in this regard. The marginal vegetation zone is naturally dynamic and thus the change has not been that dramatic relative to the reference state which has to be considered in the context of dynamic states. In contrast, the change in the lower riparian zone has been more dramatic with a substantial loss of cover and abundance. The changes in the upper riparian zones have been more gradual and despite a negative trajectory, have not been that substantial relative to reference conditions. While the 2000 floods had an influence on this zone, species richness and composition is unlikely to have been affected substantially. The change is mostly reflected in cover, abundance and structure. Based on the scores and weightings used in the PES model (see Appendix 3), the PES score for the vegetation is 71.85 (C).

3.2.6.2 Reference state

Using the air photos from 1942 as an indication of the reference condition, the reach where the site is located had a meandering/braided active channel with large sandy mid-channel bars and an anastomosing section downstream. Active-channel margins were well-vegetated with reeds but sand dominated the macro-channel floor (Rountree PC).

3.2.6.3 Trajectory of change

The trajectory of change is likely to be stable. The upper zone vegetation is likely to continue to survive. There is however likely to be a gradual deterioration due to loss of high flows and terrestrialisation in the long-term. Terrestrialisation may extend to the lower bank as flows remain reduced. The marginal riparian zone is likely to improve in the short-term as reeds and sedge zones re-establish. This zone will continue to adjust to the lower flows. Since much of the lower riparian zone vegetation and terraces on which it was growing were removed by the 2000 floods, the cover and abundance of this zone is likely to increase. Again, while some recovery (increase in abundance) is expected, it is likely to be limited as a result in the reduction in middle order floods. All in all, it is expected to balance out and the system as a whole is likely to remain in a state of dynamic flux.

3.2.6.4 Cross section

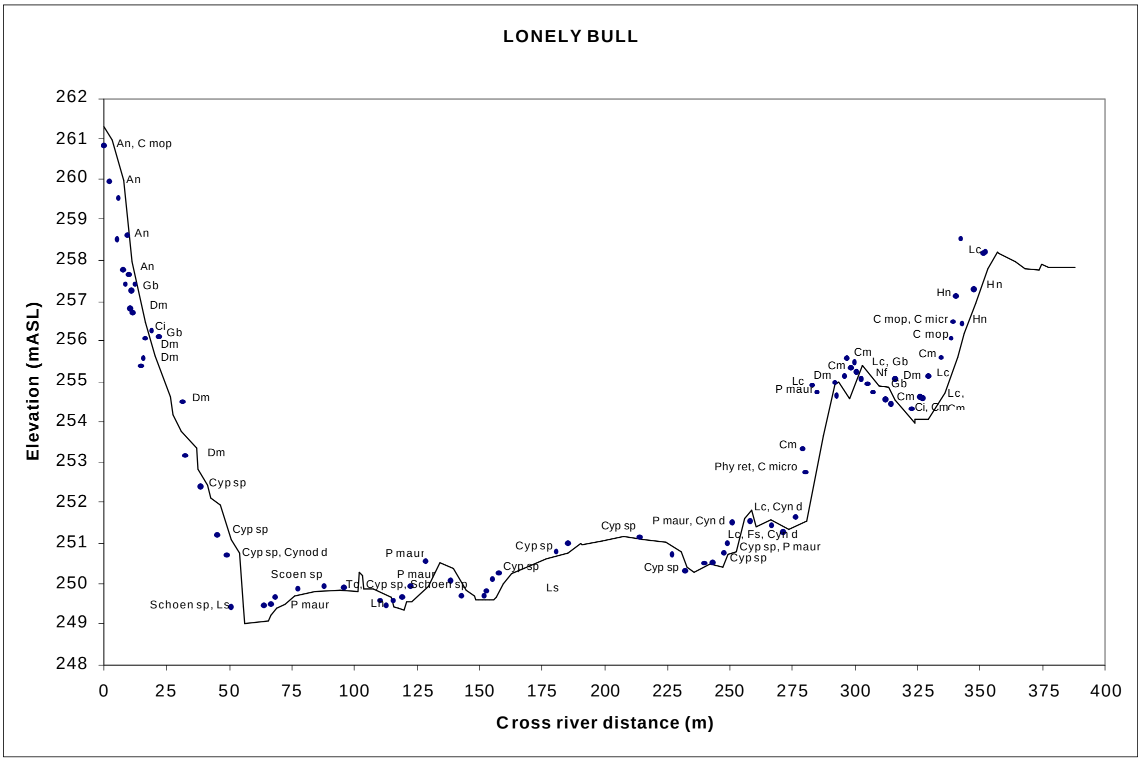
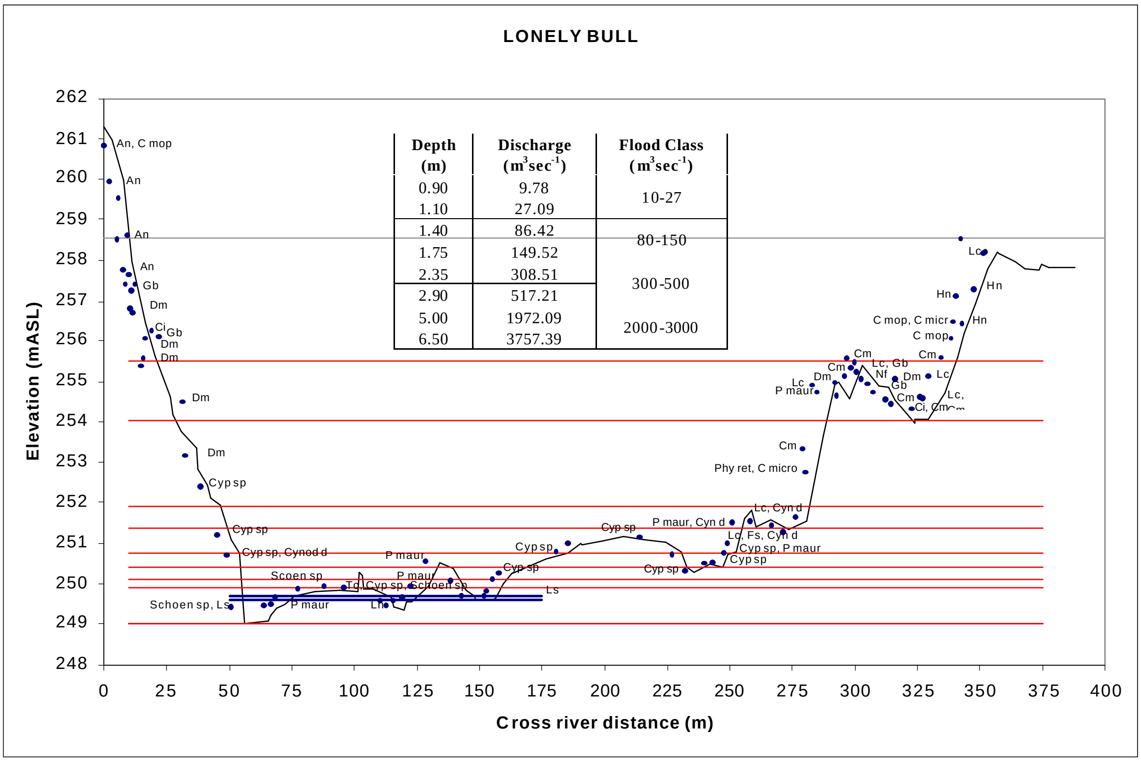


Figure 13: Vegetation data plotted on the cross section at IFR 6 (for abbrev. see Table A3, Appendix 2).

3.2.6.5 Flood motivations



Depth (m)	Discharge (m^3sec^{-1})	Flood Class (m^3sec^{-1})
0.90	9.78	10-27
1.10	27.09	
1.40	86.42	80-150
1.75	149.52	
2.35	308.51	300-500
2.90	517.21	
5.00	1972.09	2000-3000
6.50	3757.39	

Figure 14: Vegetation data and the motivated flood levels plotted on the cross section at IFR 1.

Table 11: Flood Class motivations for the riparian vegetation at IFR 6.

FLOOD CLASS II: 10-27m³/s			Recommended : C			Alternative : B		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates the seasonal channels adjacent to the active channel and the marginal vegetation between these channels.	Stage and duration with the flood inundating the active channel to a depth of between 0.9 and 1.1 m.	Nov, Ded, Jan, Mar, Apr	5	Per year	A small flood of this size will overtop the in-channel bar and flood the seasonal channel. The number of these floods ensures that the marginal vegetation on the bar, adjacent to the active channel, and in the seasonal channel is inundated regularly during the summer months. Inundation stimulates growth and reproduction of flow dependent vegetation that comprises the marginal vegetation zone.	6	Per year	The slightly higher frequency of supply compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are expected to increase in abundance. This will stabilise the margins of the active channel, redirect sediment movement, direct flow along the active channel, and ultimately improve the instream habitats.
			Alternative : D					
			No of events	**Freq**	**Reasoning**			
			3	Per year	Reducing this flood by two per annum compared to the requirement for the recommended Class will affect the marginal vegetation resulting in exposure during the hot summer months. Exposure will affect the more flow dependent species such as reeds, which are expected to decrease in abundance. The dominance of herbaceous forbs is expected to increase. These do not stabilise the sediment, which together with a decrease in the abundance of reeds, is likely to result in a decrease in instream habitat quality.			

FLOOD CLASS III: 80-150m^3/s			Recommended : C			Alternative : B		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates all the seasonal channels at the cross section. It also inundates the marginal vegetation between these channels.	Stage and duration with the flood inundating the active channel to a depth of between 1.5 and 1.75m.	Jan, Mar	2*	Per year	A flood of this size will overtop both the in-channel bars and flood all the seasonal channels at the site. These floods would ensure that the marginal vegetation on the bars, adjacent to the active channel, and in the seasonal channels is inundated at least once during the summer months. This will help recharge the bars and stimulate the growth and reproduction of the marginal vegetation.	3**	Per year	An additional flood of this size compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are expected to increase in abundance. This will also increase the extent of the marginal vegetation zone thereby further stabilising sections of the macro-channel floor.
			Alternative : D					
			No of events	**Freq**	**Reasoning**			
			1	Per year	Reducing this flood to one per annum compared to the requirement for the recommended Class will at least help maintain some of the higher elevation marginal vegetation, but due to the relatively short duration and lack of a follow-up flood will not support the more flow dependent species such as reeds, which are expected to decrease in abundance.			

* Initially two of these floods were requested per annum, but according to the present day flood record, only one actually occurs.

** Based on the note above, it is likely that the request for three of these floods per annum will not be met according to the present day flood record.

FLOOD CLASS IV: 300-500m^3/s			**Recommended : C**			**Alternative : B**		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates the lower riparian zone along the lower bank. This is important for supporting the vegetation along the lower bank. Also inundates the lower terrace where there is some *P. mauritianus* as well as small re-establishing riparian trees.	Stage and duration, with the flood overtopping the first terrace at the site.	Feb	1*	Per year	Inundation is also required to meet the life-history requirements of many of the lower riparian species.	1*	Per year	Same.
			Alternative : D					
			No of events	**Freq**	**Reasoning**			
				1:2*	Inundation is also required to meet the life-history requirements of many of the lower riparian species.			

* Initially one of these floods was requested per annum for both the C and alternative B Class, but according to the present day flood record, the frequency of only 1:5 years is probably more realistic.

** Based on the note above, it is likely that the request for this flood of 1:2 years will also not be met according to the present day flood record.

FLOOD CLASS V: 2000-3000m^3/s			**Recommended : C**			**Alternative : B**		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Flood inundates the upper terraces to raise the water table in the terraces and support the riparian trees that grow there. Are also important for increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes.	Stage and duration, with the flood reaching the higher terrace at the site.	Summer (when it arrives)		Estimated at 1:10	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also stimulate reproduction in many of the riparian tree species on the terraces.		Estimated at 1:10	Same.
			Alternative : D					
			No of events	**Freq**	**Reasoning**			
				Estimated at 1:10	Same			

Motivation for a higher PES (B)

To improve to a B, and since it will not be possible to increase the high flows (floods), there will need to be higher low flows to assist with the re-establishment of the marginal and lower riparian zone vegetation. Given that sedimentation is likely to continue to occur even with increased low flows, reedbeds are likely to increase. Increased reedbeds will stabilize sediment and direct flow that will assist with scouring in active channels between reedbeds. The associated increase in vegetation cover and abundance and localized scouring is likely to maintain or possibly even increase habitat diversity in the short-term. Since the changes relate to increased low flows, the changes in the PES model were made in the marginal zones (predominantly cover and abundance) and only slightly in the lower riparian. The lower riparian zone may be improved slightly if the low flows are increased. Not much can be done about the upper zone where flows have been reduced and where terrestrialisation is likely to continue. Without increasing high flows, this zone is not expected to influence the improvement in the Class.

Motivation for a lower PES (D)
To move down to a D, it is anticipated there would have to be a reduction in low flows (smaller flood events). The effects will be restricted predominantly to the marginal vegetation zones although increased stress may be expected in the lower riparian zone. Given that sedimentation is likely to continue to occur, herbaceous and more drought tolerant vegetation is likely to increase. The extent of reedbeds is likely to decrease since sections of the river are likely to become drier. More extensive non-vegetated sandy areas are expected with a decrease in riparian vegetation composition, abundance and cover. This is likely to decrease habitat diversity in the long-term. Since the changes relate to decreased low flows, the changes in the PES model were made mainly in the marginal zone (predominantly in terms of composition, cover and abundance). In the upper zone where high flows will remain reduced, terrestrialisation and riparian vegetation loss is likely to continue.

3.2.6.6 Confidence

The site is representative of the resource unit. There was however extensive flood damage in terms of the structure of the lower terraces and benches and this had affected vegetation structure. Apart from the profile data collected and aerial photography, there were no other available riparian vegetation data for the reach. The air photo record for the site did help with the assessment, but because of the scale (the minimum mapping units were too small for providing any meaningful data on the vegetation), only limited information on the vegetation could be extracted from these. Due to the stressor-response not being applicable to the riparian vegetation, the low flows were directly based on the flows motivated by the fish and invertebrate specialists. These were only reviewed for the riparian component. The poor confidence in the observed hydrological data used in the modeling for the large floods reduced the overall confidence in the high flows. There was no accurate (long enough record) information on actual return periods for various high flows which also made it difficult to consider scenarios in terms of likely vegetation response. In addition to being limited in terms of lower riparian indicator species, the influence of the 2000 floods made it difficult to set high flows. The 2000 floods altered the channel morphology with benches and terraces or sections of the terraces having been removed. The increase in channel width as a result meant that these terraces are now unlikely to get flooded very often, if at all, considering the flow data. In contrast, vegetation indicators supported a scenario with more frequent flooding at these elevations. This ambiguity made setting the high flows difficult and also contributes to the reduced confidence in these. The confidence ratings are shown in Table 11 below.

Table 12: Confidence ratings for the riparian vegetation at IFR 6.

IFR SITE	AVAILABLE DATA	ECOLOGICAL CLASSIF.	OUTPUT LOW FL	OUTPUT HIGH FL
3	2	3	2	2

3.2.7 IFR 7 – Letaba Bridge

3.2.7.1 Present Ecological Status

The system is naturally in a dynamic state, fluctuating between states from vegetated to non-vegetated along the macro-channel floor. Long-term flow related impacts (reduction in flows) appear to have contributed to the negative changes observed over time. The reduction in middle order floods are probably most important in this regard. The marginal vegetation zone is naturally dynamic and thus the change has not been that dramatic relative to the reference state which has to be considered in the context of dynamic states. In contrast, the change in the lower riparian zone has been more dramatic with a substantial loss of cover and abundance. The changes in the upper riparian zones have been more gradual and despite a negative trajectory, have not been that substantial relative to reference conditions and despite the 2000 floods. While the 2000 floods had an influence on this zone, species richness and composition is unlikely to have been affected substantially. The change is mostly reflected in cover, abundance and structure. Based on the scores and weightings used in the PES model (see Appendix 3), the PES score for the vegetation is 69.02 (C).

3.2.7.2 Reference state

Again using the air photos from 1942 as an indication of the reference condition, the reach where the site is located had a single thread active channel meandering across a sandy macro-channel floor. There were reeds in some places along the channel margins (Rountree PC).

3.2.7.3 Trajectory of change

The same comment is given as for IFR 6. The trajectory of change is likely to be stable. The upper zone vegetation is likely to continue to survive. There is however likely to be a gradual deterioration due to loss of high flows and terrestrialisation in the long-term. Terrestrialisation may extend to the lower bank as flows remain reduced. The marginal riparian zone is likely to improve in the short-term as reeds and sedge zones re-establish. This zone will continue to adjust to the lower flows. Since much of the lower riparian zone vegetation and terraces on which it was growing were removed by the 2000 floods, the cover and abundance of this zone is likely to increase. Again, while some recovery (increase in abundance) is expected, it is likely to be limited as a result in the reduction in middle order floods. All in all, it is expected to balance out and the system as a whole is likely to remain in a state of dynamic flux.

3.2.7.4 Cross section

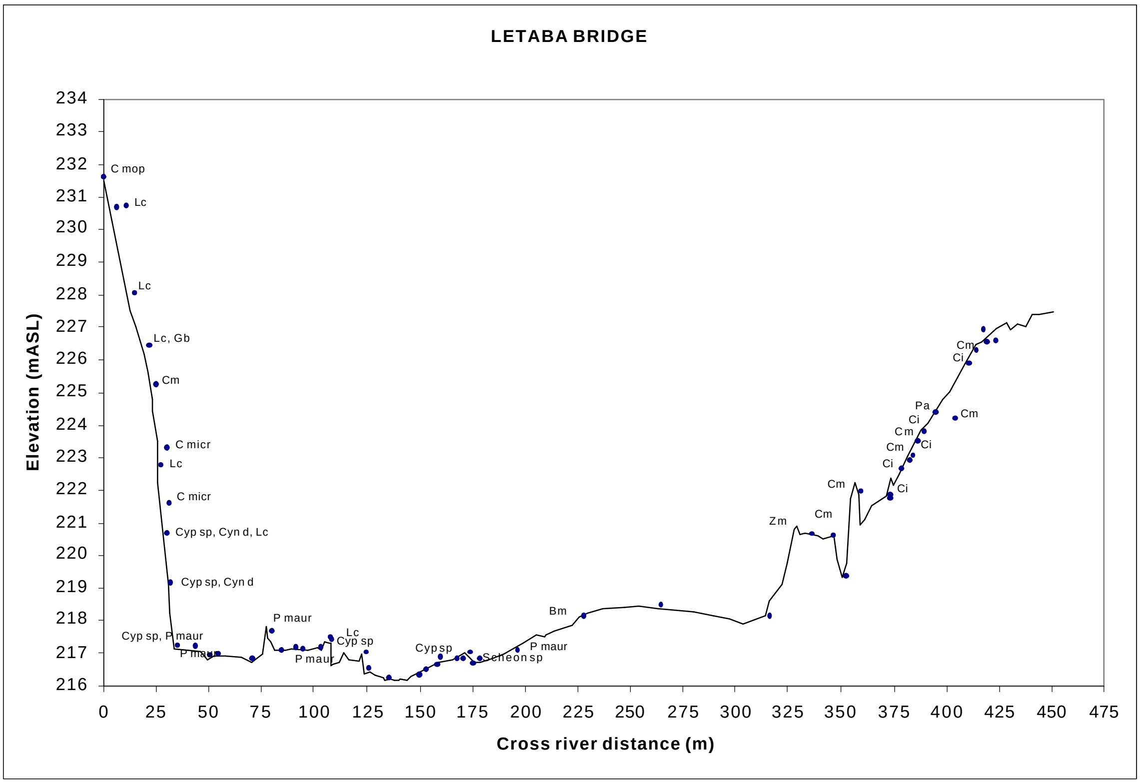
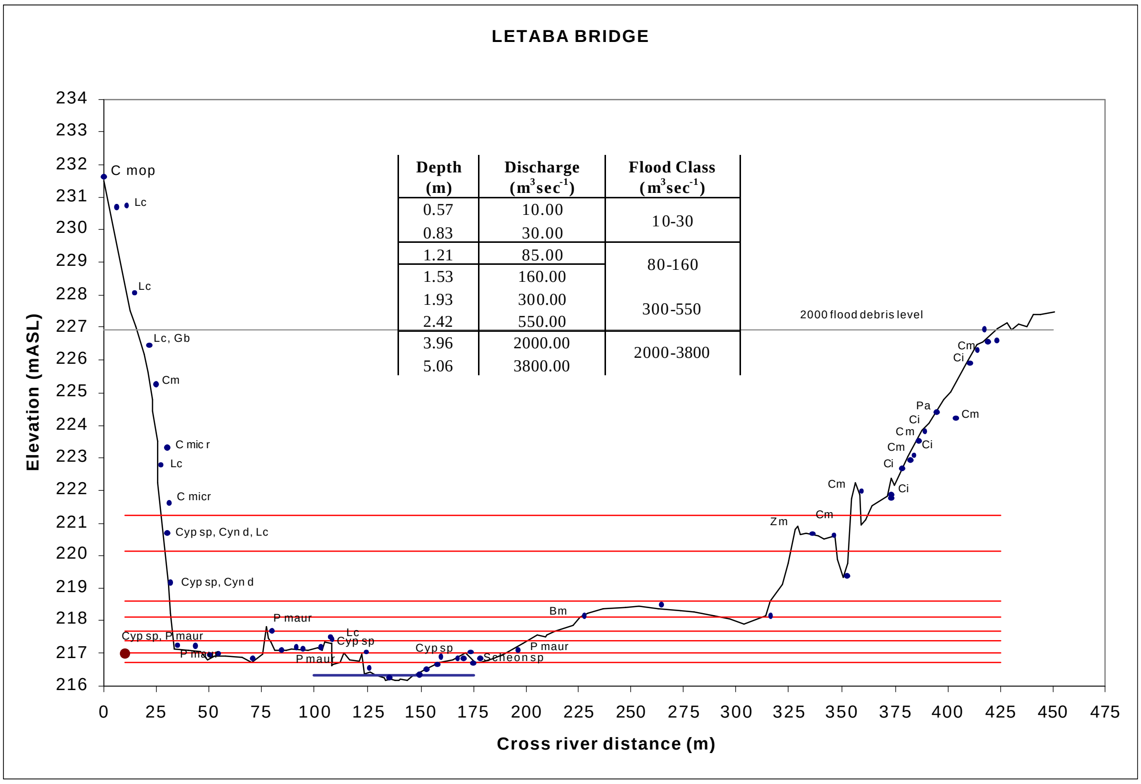


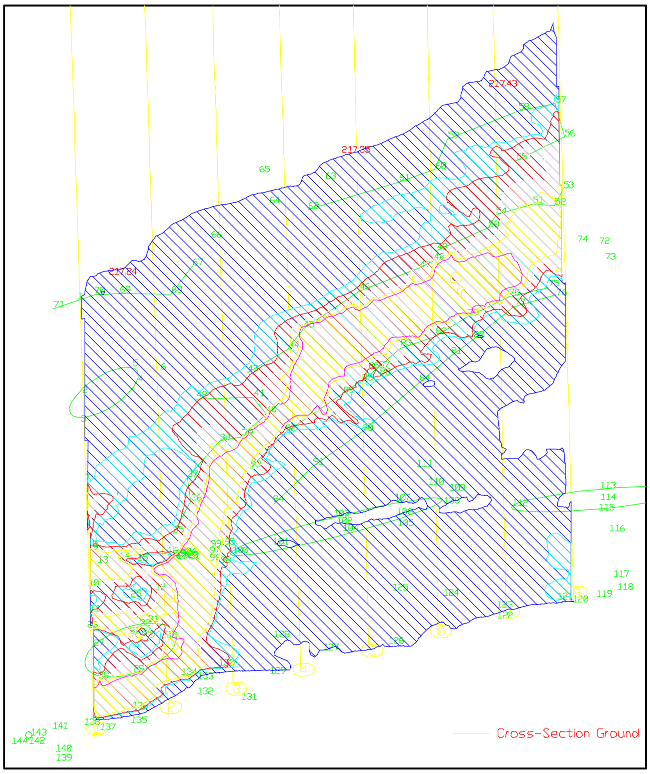
Figure 15: Vegetation data plotted on the cross section at IFR 7 (for abbrev. see Table A3, Appendix 2).

3.2.7.5 *Flood motivations*



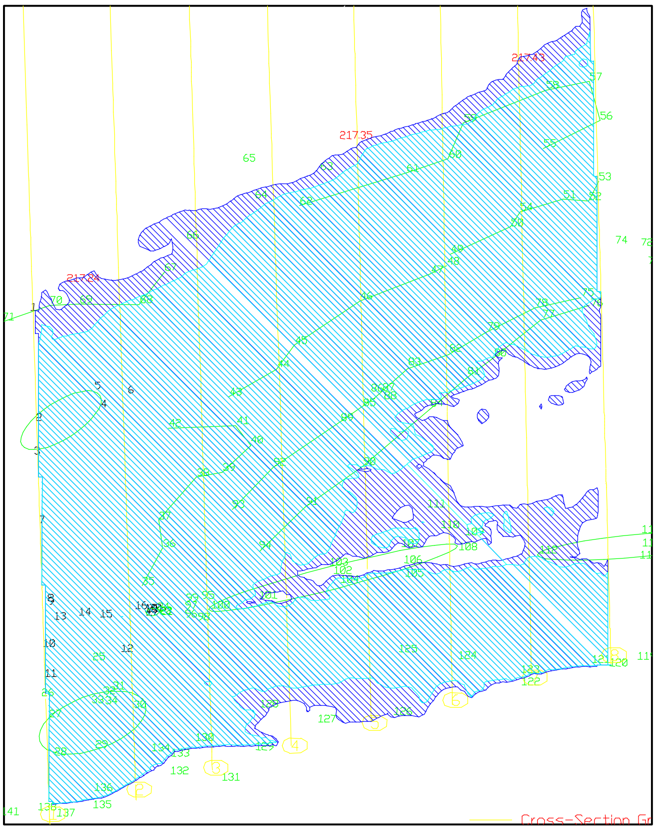
Depth (m)	Discharge (m^3sec^{-1})	Flood Class (m^3sec^{-1})
0.57	10.00	10-30
0.83	30.00	
1.21	85.00	80-160
1.53	160.00	
1.93	300.00	300-550
2.42	550.00	
3.96	2000.00	2000-3800
5.06	3800.00	

Figure 16: Vegetation data and the motivated flood levels plotted on the cross section at IFR 7.



Legend

Pink = 0.02 m^3sec^{-1}
Yellow = 0.2 m^3sec^{-1}
White = 1 m^3sec^{-1}
Red = 5 m^3sec^{-1}
Light blue = 10 m^3sec^{-1}
Dark blue = 85 m^3sec^{-1}



Legend

Light blue = 30 m^3sec^{-1}
Dark blue = 50 m^3sec^{-1}

Figure 17: Habitat models for IFR 7 with various flows as indicated and vegetation survey points in green. The vegetation data to support the habitat model is provided in Table 13 below with the numbers in green corresponding to the survey points in the table.

Table 13: Vegetation data in support of the habitat model for IFR 3.

Surveyor: I McIlrae, Vegetation: GC Marneweck, Date: 16 October 2003, Elevation: MASL, WGS 84/31, Constant = 2600000.00

LETABA BRIDGE HABITAT MODEL DATA, VEGETATION				
Survey point	X	Y	Z	
1	-60252.54	34338.76	217.21	Cyperus sp1 and some Phragmites mauritianus
2	-60250.96	34307.28	216.75	Bare patch (edge)
3	-60251.49	34297.48	216.71	Bare patch (edge)
4	-60232.32	34311.04	216.64	Bare patch (edge)
5	-60234.21	34316.31	216.85	Bare patch (edge)
6	-60224.66	34314.98	216.83	Cynodon dactylon, Phragmites mauritianus zone (some Asclepias fruticosa)
7	-60250.14	34277.88	216.48	Edge of Cynodon dactylon, Phragmites mauritianus zone (some Asclepias fruticosa)
8	-60247.64	34255.25	216.50	Edge of Phragmites mauritianus zone
9	-60247.47	34254.38	216.02	Waters edge (backflooded pool)
10	-60249.03	34242.55	216.15	Waters edge (backflooded pool)
11	-60248.57	34233.71	216.10	Waters edge (backflooded pool)
12	-60226.79	34240.89	216.44	Edge of Phragmites mauritianus clump extending into main channel
13	-60245.83	34250.26	215.99	Start of Phragmites mauritianus clump in backflooded area (approx 2m long)
14	-60238.66	34251.36	216.06	Edge of Phragmites mauritianus clump (towards channel) in backflooded area
15	-60232.67	34250.85	216.64	Top of bar (covered in Phragmites mauritianus) that extends into channel
16	-60222.33	34253.18	216.04	Edge of Phragmites mauritianus clump on bar extending into main channel
17	-60219.60	34251.54	216.51	Phragmites mauritianus clump in main channel (top of clump)
18	-60219.88	34252.25	216.27	Phragmites mauritianus clump in main channel (culm/root interface)
19	-60219.91	34252.59	216.00	Phragmites mauritianus clump in main channel (rhizome level on channel floor front)
20	-60218.81	34252.68	215.70	Phragmites mauritianus clump in main channel (rhizome level on channel floor back) Water surface 0.34 m above
21	-60215.41	34251.74	216.10	Phragmites mauritianus clump in main channel (culm/root interface)
22	-60215.55	34251.76	216.10	Water level (main channel)
23	-60215.67	34251.91	215.79	End of root zone
24	-60216.34	34253.03	215.55	Channel floor (imediately adjacent to the Phragmites clump)
25	-60234.93	34238.61	216.97	Top of bar (covered in Phragmites mauritianus) that extends into channel
26	-60249.65	34228.21	216.00	Edge of Phragmites mauritianus clump (last clump that extends towards channel) where river bends (pool)
27	-60247.43	34222.11	216.71	Top of above bar (covered in Phragmites mauritianus)
28	-60245.88	34211.16	216.30	Outer edge of above bar (covered in Phragmites mauritianus)
29	-60234.17	34213.46	216.45	Outer edge of above bar (covered in Phragmites mauritianus)
30	-60223.22	34224.82	216.25	Outer edge of above bar extending into main channel (covered in Phragmites mauritianus)
31	-60229.26	34230.02	216.05	Outer edge of above bar (covered in Phragmites mauritianus)
32	-60231.83	34228.71	216.02	Water level (at the edge of the above bar)
33	-60231.74	34228.58	216.29	Above Phragmites mauritianus clump (culm/root interface)
34	-60231.29	34228.50	216.59	Above Phragmites mauritianus clump (top of bar)
35	-60220.83	34260.02	216.36	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
36	-60214.91	34270.69	216.37	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
37	-60216.04	34278.79	216.49	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
38	-60205.18	34291.04	216.28	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
39	-60197.88	34292.43	216.25	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
40	-60189.73	34300.08	216.31	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
41	-60194.11	34305.75	216.39	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
42	-60213.19	34305.07	216.44	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
43	-60195.97	34313.91	216.42	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)

LETABA BRIDGE HABITAT MODEL DATA, VEGETATION				
Survey point	X	Y	Z	
44	-60182.30	34321.89	216.49	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
45	-60177.26	34328.82	216.44	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
46	-60158.34	34341.58	216.50	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
47	-60138.26	34349.24	216.63	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
48	-60133.63	34351.64	216.54	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa) Typha capensis
49	-60132.45	34355.01	216.48	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa) Typha capensis
50	-60115.23	34362.70	216.49	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
51	-60100.23	34370.62	216.52	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
52	-60092.96	34369.98	216.55	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
53	-60090.00	34375.81	216.58	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
54	-60112.54	34367.05	216.67	Edge of Cynodon dactylon, Phragmites mauritianus and Schoenoplectus zone (some Asclepias fruticosa)
55	-60105.91	34385.17	216.59	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
56	-60089.63	34393.22	216.71	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
57	-60092.72	34404.44	216.92	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
58	-60105.11	34401.84	217.01	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
59	-60128.72	34392.47	217.07	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
60	-60133.07	34382.24	216.93	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
61	-60145.09	34378.12	216.95	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
62	-60175.72	34368.84	217.03	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
63	-60169.89	34378.23	217.05	Cyperus
64	-60188.54	34370.32	217.12	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
65	-60192.10	34380.89	217.46	Cyperus sp1
66	-60208.27	34358.96	217.22	Cynodon dactylon and Cyperus sp 1
67	-60214.30	34349.71	217.19	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
68	-60221.66	34340.46	217.09	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
69	-60238.83	34340.48	217.15	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
70	-60247.24	34340.30	217.16	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
71	-60260.97	34335.54	217.16	Edge of Phragmites mauritianus and Cyperus zone (some forbs and shrubs as well as Asclepias fruticosa)
72	-60078.01	34356.79	216.69	Edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
73	-60075.96	34351.41	217.12	Outer edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
74	-60085.29	34357.44	216.44	Water level (edge)
75	-60095.10	34342.47	216.52	Inner edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
76	-60092.61	34340.12	217.43	Outer edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
77	-60106.55	34336.27	216.91	Outer edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
78	-60108.29	34339.42	216.52	Inner edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone plus Cyperus sp3
79	-60122.18	34332.56	216.59	Inner edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
80	-60120.19	34325.06	217.37	Outer edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
81	-60127.79	34319.63	217.34	Large clumps of Cyperus (outer edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone)
82	-60132.92	34326.34	216.43	Typha capensis (inner edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone

LETABA BRIDGE HABITAT MODEL DATA, VEGETATION				
Survey point	X	Y	Z	
83	-60144.64	34322.18	216.52	Inner edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
84	-60138.55	34310.56	217.20	Outer edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
85	-60154.26	34313.77	216.38	Inner edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
86	-60151.70	34315.58	216.26	Phragmites mauritianus at water level
87	-60151.57	34315.44	216.70	Root/culm interface of Phragmites mauritianus
88	-60151.40	34315.46	216.90	Top of terrace with Phragmites mauritianus
89	-60163.80	34307.03	216.51	Inner edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
90	-60157.55	34294.20	217.50	Outer edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone (Phragmites on edge plus juvenile Lonchocarpus capassa
91	-60173.90	34282.63	217.15	Outer edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
92	-60183.23	34294.01	216.41	Inner edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
93	-60195.06	34281.86	216.27	Inner edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
94	-60187.33	34270.04	216.92	Outer edge of Cynodon dactylon, Cyperus, Phragmites mauritianus and Schoenoplectus zone
95	-60203.79	34255.80	216.19	Cyperus
96	-60204.72	34253.01	215.88	Channel floor (imediately adjacent to the Phragmites clump)
97	-60204.71	34253.20	215.92	Root/culm interface of Phragmites mauritianus
98	-60204.52	34252.47	216.86	Top of Phragmites mauritianus clump running along a bar extending laterally
99	-60204.44	34253.76	215.99	Water level (edge)
100	-60200.93	34253.26	216.98	Top of Phragmites mauritianus clump running along a bar extending laterally
101	-60187.38	34256.04	217.08	Top of Phragmites mauritianus clump running along a bar extending laterally
102	-60166.03	34263.12	217.72	Top of Phragmites mauritianus clump running along a bar extending laterally
103	-60167.11	34265.21	217.23	Edge (bottom) of Phragmites mauritianus clump running along a bar extending laterally
104	-60164.09	34260.67	216.79	Edge (bottom) of Phragmites mauritianus clump running along a bar extending laterally
105	-60145.95	34264.27	216.99	Edge (bottom) of Phragmites mauritianus clump running along a bar extending laterally
106	-60146.31	34267.44	217.83	Top of Phragmites mauritianus clump running along a bar extending laterally
107	-60146.82	34270.61	217.17	Edge (bottom) of Phragmites mauritianus clump running along a bar extending laterally
108	-60130.55	34271.57	217.31	End of the bar of Phragmites mauritianus
109	-60128.70	34273.89	217.36	Cyperus
110	-60135.76	34275.87	217.21	Cyperus
111	-60139.25	34281.87	217.31	Cyperus
112	-60107.53	34268.87	217.28	Start of a bar of Phragmites mauritianus
113	-60078.19	34274.29	217.44	Edge of Phragmites mauritianus on bar
114	-60078.13	34271.99	217.70	Top of Phragmites mauritianus on bar
115	-60078.76	34268.08	217.18	Edge of Phragmites mauritianus on bar
116	-60074.86	34260.07	216.96	Start of a new clump of Phragmites mauritianus
117	-60073.56	34244.82	216.95	Edge of Phragmites mauritianus on channel floor next to bank
118	-60072.22	34240.32	217.71	Clump of Phragmites mauritianus on bank
119	-60079.24	34238.09	217.44	Clump of Cyperus
120	-60087.51	34236.38	217.95	Clump of Cyperus
121	-60087.98	34236.85	217.07	Channel floor (dry)
122	-60112.74	34230.85	219.30	Cyperus and Cynodon dactylon on bank
123	-60112.75	34234.22	216.88	Channel floor (dry)
124	-60130.56	34238.50	216.99	Schoenoplectus sp and Cyperus sp1
125	-60147.68	34240.20	216.88	Edge of Phragmites mauritianus on channel floor next to bank
126	-60148.94	34222.04	217.12	Edge of Phragmites mauritianus on channel floor next to bank
127	-60170.82	34220.19	217.34	Edge of Phragmites mauritianus on channel floor next to bank
128	-60187.45	34224.58	217.23	Edge of Phragmites mauritianus on channel floor next to bank (next to main channel)
129	-60189.31	34212.24	217.37	Edge of Phragmites mauritianus on channel floor next to bank (next to main channel and bank)
130	-60206.04	34215.02	217.33	Edge of Phragmites mauritianus on channel floor next to bank (next to main channel)
131	-60198.51	34203.92	220.23	Cyperus
132	-60213.19	34205.47	217.50	Cyperus
133	-60212.98	34210.96	217.33	Top of Phragmites mauritianus on bank (terrace)
134	-60214.56	34211.61	216.03	Water level below Phragmites
135	-60235.46	34196.72	218.40	Cyperus sp1
136	-60235.00	34200.41	216.04	Water level below terrace
137	-60245.45	34193.15	218.14	Cyperus

LETABA BRIDGE HABITAT MODEL DATA, VEGETATION				
Survey point	X	Y	Z	
138	-60247.10	34194.54	217.69	Cynodon dactylon
139	-60260.62	34185.70	219.87	Cyperus
140	-60260.55	34186.66	219.20	Cynodon dactylon
141	-60261.40	34194.02	216.04	Water level (edge)
142	-60268.97	34192.16	216.08	Channel floor below Phragmites mauritianus clump (water depth = 0.4m)
143	-60269.04	34191.81	216.32	Root/culm interface of Phragmites clump
144	-60269.58	34191.85	216.87	Top of the above Phragmites mauritianus clump

Table 14: Flood Class motivations for the riparian vegetation at IFR 7.

FLOOD CLASS II: 10-30m^3/s			Recommended : C			Alternative : B		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates the seasonal channels adjacent to the active channel and gets water into the backwater that supports the reedbeds adjacent to the pool at the meander bend. Also inundates to the base of the *P. mauritianus* stands along the active channel.	Stage and duration with the flood inundating the active channel to a depth of between 0.6 and 0.8 m.	Nov, Dec, Jan, Mar, Apr	5	Per year	A small flood of this size will overtop the small in-channel bars and flood the seasonal channels. The number of these floods ensures that the marginal vegetation on the bars, adjacent to the active channel, in the backwaters, and in the seasonal channels is inundated regularly during the summer months. Inundation stimulates growth and reproduction of flow dependent vegetation that comprises the marginal vegetation zone.	6	Per year	The slightly higher frequency of supply compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are expected to increase in abundance. This will stabilise the margins of the active channel, redirect sediment movement, direct flow along the active channel, and ultimately improve the instream habitats.
			Alternative : D					
			No of events	**Freq**	**Reasoning**			
			3	Per year	Reducing this flood by two per annum compared to the requirement for the recommended Class will affect the marginal vegetation resulting in exposure during the hot summer months. Exposure will affect the more flow dependent species such as reeds, which are expected to decrease in abundance. The dominance of herbaceous forbs is expected to increase. These do not stabilise the sediment, which together with a decrease in the abundance of reeds, is likely to result in a decrease in instream habitat quality.			

FLOOD CLASS III: 80-160m^3/s			Recommended : C			Alternative : B		
Function/s (what does it have to do)	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inundates the seasonal channels at the cross section and the marginal vegetation between these channels. In particular, the reedbeds in the backwaters at the site are completely inundated above the rhizome/culm interface. Also inundates up to the edge (at the higher elevations) of the *C. dactylon*, *P. mauritianus*, *Schoenoplectus* zone.	Stage and duration with the flood inundating the active channel to a depth of between 1.2 and 1.5m.	Feb	2*	Per year	A flood of this size will overtop all the in-channel bars and flood all the seasonal channels at the lower elevations on the macro-channel floor. These floods would ensure that the marginal vegetation on the bars, adjacent to the active channel, and in the seasonal channels is inundated at least once during the summer months. This will help recharge the bars and stimulate the growth and reproduction of the marginal vegetation.	3*	Per year	An additional flood of this size compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are expected to increase in abundance. This will also increase the extent of the marginal vegetation zone thereby further stabilising sections of the macro-channel floor.
			Alternative : D					
			No of events	**Freq**	**Reasoning**			
			1	Per year	Reducing this flood to one per annum compared to the requirement for the recommended Class will at least help maintain some of the higher elevation marginal vegetation, but due to the relatively short duration and lack of a follow-up flood will not support the more flow dependent species such as reeds, which are expected to decrease in abundance.			

* Initially two of these floods were requested per annum, but according to the present day flood record, only one actually occurs.

** Based on the note above, it is likely that the request for three of these floods per annum will not be met according to the present day flood record.

FLOOD CLASS IV: 300-550m³/s			Recommended : C			Alternative : B		
Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning	No of events	Freq	Reasoning
Inundates the entire macro-channel floor. This is important for supporting the vegetation along the floor and getting water to the foot of the lower terrace to help with the re-establishment of lower riparian trees.	Stage and duration, with the flood inundating the entire macro-channel floor.	Feb	1*	Per year	This will help recharge the sediments along the macro-channel floor and stimulate the growth and reproduction of the marginal vegetation. Inundation across the floor will also assist with the re-establishment of lower riparian species.	1*	Per year	Same.
			Alternative : D					
			No of events	Freq	Reasoning			
				1:2	Reducing this flood to one every two years compared to the requirement for the recommended Class is likely to reduce the recruitment opportunities for the lower riparian zone vegetation, which is not expected to recover well given this reduced frequency of flooding.			

* One of these floods was requested per annum, but according to the present day flood record, this flood is presently more like a 1:5 year event.

FLOOD CLASS V: 2000-3800m³/s			Recommended : C			Alternative : B		
Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning	No of events	Freq	Reasoning
Flood inundates the higher terraces to raise the water table in the terraces and support the riparian trees that grow there. Is also important for increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes.	Stage and duration, with the flood reaching the higher terrace at the site.	When it arrives (summer)		Estimated at 1:10	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also stimulate reproduction in many of the riparian tree species on the terraces.		Estimated at 1:10	Same.
			Alternative : D					
			No of events	Freq	Reasoning			
				Estimated at 1:10	Same.			

Motivation for a higher PES (B/C)
To improve to a B/C and since it will not be possible to increase the high flows (floods), there will need to be higher low flows to assist with the re-establishment of the marginal and lower riparian zone vegetation. Given that sedimentation is likely to continue to occur even with increased low flows, reedbeds are likely to increase. Increased reedbeds will stabilize sediment and direct flow that will assist with scouring in active channels between reedbeds. The associated increase in vegetation cover and abundance and localized scouring is likely to maintain or possibly even increase habitat diversity in the short-term. Since the changes relate to increased low flows, the changes in the PES model were made in the marginal zones (predominantly cover and abundance) and lower riparian only. The lower riparian may be improved slightly if the low flows are increased. Not much can be done about the upper zone where flows have been reduced and where terrestrialisation is likely to continue. Without increasing high flows, this zone is not expected to influence the improvement in the Class

Motivation for a lower PES (D)
To move down to a D, it is anticipated there would have to be a reduction in low flows. The effects will be restricted predominantly to the marginal vegetation zones although increased stress may be expected in the lower riparian zone. Given that sedimentation is likely to continue to occur, herbaceous and more drought tolerant vegetation is likely to increase. The extent of reedbeds is likely to decrease since sections of the river are likely to become drier. More extensive non-vegetated sandy areas are expected with a decrease in riparian vegetation composition, abundance and cover. This is likely to decrease habitat diversity in the long-term. Since the changes relate to decreased low flows, the changes in the PES model were made mainly in the marginal zone (predominantly in terms of composition, cover and abundance). In the upper zone where high flows will remain reduced, terrestrialisation and riparian vegetation loss is likely to continue.

3.2.7.6 Confidence

The site is representative of the resource unit. There was however some flood damage in terms of the structure of the lower terraces and benches and this had affected vegetation structure. Apart from the profile data collected and aerial photography, there were no other available riparian vegetation data for the reach. The air photo record for the site did help with the assessment, but because of the scale (the minimum mapping units were too small for providing any meaningful data on the vegetation), only limited information on the vegetation could be extracted from these. Due to the stressor-response not being applicable to the riparian vegetation, the low flows were directly based on the flows motivated by the fish and invertebrate specialists. These were only reviewed for the riparian component.

The habitat model was used to assist with setting the lower range of the high flows. This was particularly useful in the backwater areas where there was extensive marginal vegetation. One could also check inundation zones for groups of species as well as indicator species (specifically *P. mauritianus*) on the macro-channel floor. This provided higher confidence in the lower end of the high flows. However, the poor confidence in the observed hydrological data used in the modeling for the large floods reduced the overall confidence in the high flows. In addition to being limited in terms of lower and upper riparian indicator species, the influence of the 2000 floods also made it difficult to set the higher end of the high flows. The 2000 floods altered the channel morphology with benches and terraces or sections of the terraces having been removed. The increase in channel width as a result meant that these terraces are now unlikely to get flooded very often, if at all, considering the flow data. This reduced the confidence in these. The confidence ratings are shown in Table 14 below.

Table 15: Confidence ratings for the riparian vegetation at IFR 7.

IFR SITE	AVAILABLE DATA	ECOLOGICAL CLASSIF.	OUTPUT LOW FL	OUTPUT HIGH FL
2	3.5	2	2	3.5

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APPENDIX 1

Table A1. Qualitative data of the distribution of germinants and established individuals of some common riparian species found along the Sabie River on different surface substrata (Mckenzie pers obs). Species are categorised as being absent (A), in low (L) abundance, and in high (H) abundance. The table is taken from van Coller and Rogers (1996).

Species	Class	Bedrock	Gravel	Mud	Firm Alluv	Loose Sands	Non Alluv
Acacia robusta	germinant (g) established (e)	A A	A A	L L	H L	A L	L L
Breonadia salicina	g e	L H	L L	A A	H L	H A	A A
Combretum erythrophyllum	g e	A A	L A	A A	H L	L L	A A
Diospyros mespiliformis	g e	A A	A A	A A	H L	A A	H H
Ficus sycomorus	g e	A L	L A	H A	L L	A A	A A
Syzygium spp.	g e	A L	L L	L A	L L	H H	A A
Nuxia oppositifolia	g e	A -	A -	L -	A -	A -	A -
Spirostachys africana	g e	A A	A A	A A	L L	A A	H H
Trichilia emetica	g e	A A	A A	A A	L L	A A	A A
Maytenus senegalensis	g e	A A	A A	A A	H L	H L	A A
Grewia flavescens	g e	A A	A A	L A	H L	A A	A L

Table A2. Groupings of species on the basis of their relationship with flooding frequency on the Sabie River. Species are grouped according to the lower quartile of their distribution (see van Coller and Rogers, 1996). Corresponding to the lower quartile distributions of the species in each group are the return periods as presented by van Coller and Rogers (1996). Table taken from van Coller and Rogers (1996).

Flood Type	Species	Geomorphology	Return Period
Perennial to Seasonal	***Breonadia salicina, Syzygium guineense, Kraussia floribunda***	Bedrock dominated areas - MC Floor	1 in 1 to 1.05 year flood
	Ficus capreifolia, Phragmites mauritianus	Alluvial dominated areas - MC Floor	
Seasonal	***Securinega virosa, Ficus sycomorus, Phyllanthus reticulatus, Nuxia oppositifolia***	Bedrock and Alluvial dominated areas - MC Floor	1 in 1.25 to 1.8 year flood
Seasonal to Ephemeral	***Combretum erythrophyllum***	Alluvial dominated Areas - MC Floor MC Bank & Alluvial dominated areas - MC Floor	1 in 2.2 to 3.6 year flood
	Acacia robusta, Grewia flavescens, Trichilia emetica, Diospyros mespiliformis, Maytenus senegalensis	MC Bank & occasionally MC Floor	
Ephemeral	***Lantana camara, Euclea natalensis, Dichrostachys cinerea, Spirostachys africana, Lonchocarpus capassa***		1 in 7.9 to 46 year flood

APPENDIX 2

Table A3. A table of the key indicator and other riparian plant species recorded at the IFR sites showing the abbreviations used for each as depicted on the cross sectional profiles.

Species name	Abbreviation
Acacia ataxacantha	Aa
*Arunda donax**	Ad
Acacia galpinii	Ag
Albizia harveyi	Ah
Acacia nigrescens	An
Acacia robusta	Ar
Acacia sieberiana	As
Berchemia discolor	Bd
Bauhinia galpinii	Bg
Bridelia macrantha	Bm
Breonadia salicina	Bs
Commelina Africana	Ca
Combretum apiculatum	C apic
Celtis Africana	C afri
Cynodon dactylon	Cd
Combretum erythrophyllum	Ce
Cyperus species	Cyp sp
Combretum hereroense	Ch
Combretum imberbe	Ci
Croton megalobotrys	Cm
Combretum microphyllum	C micro
Combretum molle	C mol
Colophospermum mopane	C mop
Cyperus sp	Cs
Carex sp	Car sp
Dichrostachys cinerea	Dc
Dietes grandiflora	Dg
Diospyros mespilliformis	Dm
Euclea divinorum	Ed
Euclea natalensis	En
Ehretia rigida	Er
Euclea sp	Es
Ficus capreifolia	Fc
Ficus syccamorus	Fs
Fimbristylis sp	Fim sp
Ficus sur	F sur
Hyphanae natalensis	Hn
Lonchocarpus capassa	Lc
Leersia hexandra	Lh
Ludwigia stolonifera	Ls
Lannea scweinfurthii	L schw
Gymnosporia buxifolia	Gb

Species name	**Abbreviation**
Nuxia floribunda	Nf
Oxalis sp	Ox sp
Peltophorum africanum	Pa
Phragmites mauritianus	P maur
Phoenix reclinata	Pr
Phyllanthus reticulates	P retic
Sclerocarya birrea	Sb
Schotia brachypetala	S brachy
Syzigium cordatum	Sc
Schoenoplectus sp	Sp
Typha capensis	T cap
Trichelia emitica	Te
Trema orientalis	To
Terminalia sericea	Ts
Ziziphus mucronata	Zm

* = exotics

APPENDIX 3
PES MODEL TABLES

IFR 1

PES

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-1.00	0.14	5.00	50.00
Vegetation cover	MCO	-1.00	0.16	4.00	60.00
Species richness/diversity	MSR	0.00	0.19	3.00	70.00
Species composition	MSC	0.00	0.27	1.00	100.00
Vegetation structure	MST	-1.00	0.24	2.00	90.00
Proportional change in marginal and in-channel vegetation	10.81		1.00	4.00	370.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	3.0	0.14	5.00	50.00
Vegetation cover	LRCO	3.0	0.16	4.00	60.00
Species richness/diversity	LRSR	-1.0	0.19	3.00	70.00
Species composition	LRSC	-3.0	0.27	1.00	100.00
Vegetation structure	LRST	-4.0	0.24	2.00	90.00
Proportional change in marginal and in-channel vegetation	57.30		1.00	4.00	370.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-1.0	0.12	4.00	50.00
Vegetation cover	URCO	-1.0	0.17	3.00	70.00
Species richness/diversity	URSR	-2.0	0.24	1.00	100.00
Species composition	URSC	-2.0	0.24	1.00	100.00
Vegetation structure	URST	-1.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	29.76		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		28.54	2.0	80.0
LOWER ZONE		17.08	1.0	100.0
UPPER ZONE		19.67	3.0	70.0
				250.00
Riparian vegetation PES score	65.29			
Riparian vegetation PES Category	C			

DOWN

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-3.00	0.14	5.00	50.00
Vegetation cover	MCO	-2.00	0.16	4.00	60.00
Species richness/diversity	MSR	-1.00	0.19	3.00	70.00
Species composition	MSC	-2.00	0.27	1.00	100.00
Vegetation structure	MST	-3.00	0.24	2.00	90.00
Proportional change in marginal and in-channel vegetation	43.78		1.00	4.00	370.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	4.0	0.14	5.00	50.00
Vegetation cover	LRCO	4.0	0.16	4.00	60.00
Species richness/diversity	LRSR	-2.0	0.19	3.00	70.00
Species composition	LRSC	-4.0	0.27	1.00	100.00
Vegetation structure	LRST	-5.0	0.24	2.00	90.00
Proportional change in marginal and in-channel vegetation	77.30		1.00	4.00	370.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-1.0	0.12	4.00	50.00
Vegetation cover	URCO	-1.0	0.17	3.00	70.00
Species richness/diversity	URSR	-2.0	0.24	1.00	100.00
Species composition	URSC	-2.0	0.24	1.00	100.00
Vegetation structure	URST	-1.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	29.76		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		17.99	2.0	80.0
LOWER ZONE		9.08	1.0	100.0
UPPER ZONE		19.67	3.0	70.0
				250.00
Riparian vegetation PES score	46.74			
Riparian vegetation PES Category	D			

IFR 3

PES

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-2.00	0.14	5.00	50.00
Vegetation cover	MCO	-2.00	0.16	4.00	60.00
Species richness/diversity	MSR	-2.00	0.19	3.00	70.00
Species composition	MSC	-2.00	0.27	1.00	100.00
Vegetation structure	MST	-2.00	0.24	2.00	90.00
Proportional change in marginal and in-channel vegetation	40.00		1.00	4.00	370.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-3.0	0.14	5.00	50.00
Vegetation cover	LRCO	-3.0	0.16	4.00	60.00
Species richness/diversity	LRSR	-3.0	0.19	3.00	70.00
Species composition	LRSC	-3.0	0.27	1.00	100.00
Vegetation structure	LRST	-3.0	0.24	2.00	90.00
Proportional change in marginal and in-channel vegetation	60.00		1.00	4.00	370.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-3.0	0.12	4.00	50.00
Vegetation cover	URCO	-3.0	0.17	3.00	70.00
Species richness/diversity	URSR	-1.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	36.10		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		13.64	3.0	50.0
LOWER ZONE		12.73	2.0	70.0
UPPER ZONE		29.05	1.0	100.0
				220.00
Riparian vegetation PES score	55.41			
Riparian vegetation PES Category	D			

UP

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	2.00	0.14	5.00	50.00
Vegetation cover	MCO	0.00	0.16	4.00	60.00
Species richness/diversity	MSR	-1.00	0.19	3.00	70.00
Species composition	MSC	2.00	0.27	1.00	100.00
Vegetation structure	MST	-1.00	0.24	2.00	90.00
Proportional change in marginal and in-channel vegetation	24.86		1.00	4.00	370.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-1.0	0.14	5.00	50.00
Vegetation cover	LRCO	-1.0	0.16	4.00	60.00
Species richness/diversity	LRSR	-3.0	0.19	3.00	70.00
Species composition	LRSC	-3.0	0.27	1.00	100.00
Vegetation structure	LRST	-1.0	0.24	2.00	90.00
Proportional change in marginal and in-channel vegetation	38.38		1.00	4.00	370.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-3.0	0.12	4.00	50.00
Vegetation cover	URCO	-3.0	0.17	3.00	70.00
Species richness/diversity	URSR	-1.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	36.10		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		17.08	3.0	50.0
LOWER ZONE		19.61	2.0	70.0
UPPER ZONE		29.05	1.0	100.0
				220.00
Riparian vegetation PES score	65.73			
Riparian vegetation PES Category	C			

IFR 4

PES

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-3.00	0.26	1.00	100.00
Vegetation cover	MCO	-3.00	0.18	2.00	70.00
Species richness/diversity	MSR	-2.00	0.18	2.00	70.00
Species composition	MSC	-2.00	0.26	1.00	100.00
Vegetation structure	MST	-3.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	51.28		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-4.0	0.15	4.00	60.00
Vegetation cover	LRCO	-4.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-1.0	0.21	3.00	80.00
Species composition	LRSC	-1.0	0.26	1.00	100.00
Vegetation structure	LRST	-3.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	47.69		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-3.0	0.17	3.00	70.00
Species richness/diversity	URSR	0.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-3.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	33.17		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		9.74	3.0	50.0
LOWER ZONE		20.92	1.0	100.0
UPPER ZONE		26.73	1.0	100.0
				250.00
Riparian vegetation PES score	57.40			
Riparian vegetation PES Category	D			

UP

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-1.00	0.26	1.00	100.00
Vegetation cover	MCO	-1.00	0.18	2.00	70.00
Species richness/diversity	MSR	-1.00	0.18	2.00	70.00
Species composition	MSC	-1.00	0.26	1.00	100.00
Vegetation structure	MST	-1.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	20.00		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-2.0	0.15	4.00	60.00
Vegetation cover	LRCO	-3.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-1.0	0.21	3.00	80.00
Species composition	LRSC	-1.0	0.26	1.00	100.00
Vegetation structure	LRST	-2.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	33.85		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-3.0	0.17	3.00	70.00
Species richness/diversity	URSR	0.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-3.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	33.17		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		16.00	3.0	50.0
LOWER ZONE		26.46	1.0	100.0
UPPER ZONE		26.73	1.0	100.0
				250.00
Riparian vegetation PES score	69.19			
Riparian vegetation PES Category	C			

IFR 5

PES

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-1.00	0.26	1.00	100.00
Vegetation cover	MCO	-2.00	0.18	2.00	70.00
Species richness/diversity	MSR	-1.00	0.18	2.00	70.00
Species composition	MSC	-2.00	0.26	1.00	100.00
Vegetation structure	MST	-1.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	28.72		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-3.0	0.15	4.00	60.00
Vegetation cover	LRCO	-3.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-1.0	0.21	3.00	80.00
Species composition	LRSC	-1.0	0.26	1.00	100.00
Vegetation structure	LRST	-2.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	36.92		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-2.0	0.17	3.00	70.00
Species richness/diversity	URSR	-1.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	30.24		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		14.26	3.0	50.0
LOWER ZONE		25.23	1.0	100.0
UPPER ZONE		27.90	1.0	100.0
				250.00
Riparian vegetation PES score	67.39			
Riparian vegetation PES Category	C			

UP

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	1.00	0.26	1.00	100.00
Vegetation cover	MCO	1.00	0.18	2.00	70.00
Species richness/diversity	MSR	0.00	0.18	2.00	70.00
Species composition	MSC	0.00	0.26	1.00	100.00
Vegetation structure	MST	0.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	8.72		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-1.0	0.15	4.00	60.00
Vegetation cover	LRCO	-1.0	0.15	4.00	60.00
Species richness/diversity	LRSR	0.0	0.21	3.00	80.00
Species composition	LRSC	0.0	0.26	1.00	100.00
Vegetation structure	LRST	-1.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	10.77		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-2.0	0.17	3.00	70.00
Species richness/diversity	URSR	-1.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	30.24		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		18.26	3.0	50.0
LOWER ZONE		35.69	1.0	100.0
UPPER ZONE		27.90	1.0	100.0
				250.00
Riparian vegetation PES score	81.85			
Riparian vegetation PES Category	B			

DOWN

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-3.00	0.26	1.00	100.00
Vegetation cover	MCO	-3.00	0.18	2.00	70.00
Species richness/diversity	MSR	-1.00	0.18	2.00	70.00
Species composition	MSC	-2.00	0.26	1.00	100.00
Vegetation structure	MST	-3.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	47.69		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-4.0	0.15	4.00	60.00
Vegetation cover	LRCO	-4.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-2.0	0.21	3.00	80.00
Species composition	LRSC	-2.0	0.26	1.00	100.00
Vegetation structure	LRST	-3.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	56.92		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-3.0	0.12	4.00	50.00
Vegetation cover	URCO	-3.0	0.17	3.00	70.00
Species richness/diversity	URSR	-1.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-3.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	40.49		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		10.46	3.0	50.0
LOWER ZONE		17.23	1.0	100.0
UPPER ZONE		23.80	1.0	100.0
				250.00
Riparian vegetation PES score	51.50			
Riparian vegetation PES Category	D			

IFR 6

PES

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-2.00	0.26	1.00	100.00
Vegetation cover	MCO	-2.00	0.18	2.00	70.00
Species richness/diversity	MSR	0.00	0.18	2.00	70.00
Species composition	MSC	-1.00	0.26	1.00	100.00
Vegetation structure	MST	-2.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	27.69		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-3.0	0.15	4.00	60.00
Vegetation cover	LRCO	-3.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-1.0	0.21	3.00	80.00
Species composition	LRSC	-1.0	0.26	1.00	100.00
Vegetation structure	LRST	-2.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	36.92		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-2.0	0.17	3.00	70.00
Species richness/diversity	URSR	0.0	0.24	1.00	100.00
Species composition	URSC	0.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	20.49		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		15.06	3.0	50.0
LOWER ZONE		23.65	2.0	90.0
UPPER ZONE		33.13	1.0	100.0
				240.00
Riparian vegetation PES score	71.85			
Riparian vegetation PES Category	C			

UP

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	0.00	0.26	1.00	100.00
Vegetation cover	MCO	0.00	0.18	2.00	70.00
Species richness/diversity	MSR	0.00	0.18	2.00	70.00
Species composition	MSC	0.00	0.26	1.00	100.00
Vegetation structure	MST	0.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	0.00		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-1.0	0.15	4.00	60.00
Vegetation cover	LRCO	-1.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-1.0	0.21	3.00	80.00
Species composition	LRSC	-1.0	0.26	1.00	100.00
Vegetation structure	LRST	-1.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	20.00		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-2.0	0.17	3.00	70.00
Species richness/diversity	URSR	0.0	0.24	1.00	100.00
Species composition	URSC	0.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	20.49		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		20.83	3.0	50.0
LOWER ZONE		30.00	2.0	90.0
UPPER ZONE		33.13	1.0	100.0
				240.00
Riparian vegetation PES score	83.96			
Riparian vegetation PES Category	B			

DOWN

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-4.00	0.26	1.00	100.00
Vegetation cover	MCO	-4.00	0.18	2.00	70.00
Species richness/diversity	MSR	-2.00	0.18	2.00	70.00
Species composition	MSC	-2.00	0.26	1.00	100.00
Vegetation structure	MST	-3.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	60.00		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-4.0	0.15	4.00	60.00
Vegetation cover	LRCO	-3.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-2.0	0.21	3.00	80.00
Species composition	LRSC	-2.0	0.26	1.00	100.00
Vegetation structure	LRST	-3.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	53.85		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-3.0	0.17	3.00	70.00
Species richness/diversity	URSR	-1.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	33.66		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		8.33	3.0	50.0
LOWER ZONE		17.31	2.0	90.0
UPPER ZONE		27.64	1.0	100.0
				240.00
Riparian vegetation PES score	53.28			
Riparian vegetation PES Category	D			

IFR 7

PES

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-3.00	0.26	1.00	100.00
Vegetation cover	MCO	-2.00	0.18	2.00	70.00
Species richness/diversity	MSR	0.00	0.18	2.00	70.00
Species composition	MSC	-1.00	0.26	1.00	100.00
Vegetation structure	MST	-2.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	32.82		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-2.0	0.15	4.00	60.00
Vegetation cover	LRCO	-2.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-1.0	0.21	3.00	80.00
Species composition	LRSC	-1.0	0.26	1.00	100.00
Vegetation structure	LRST	-2.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	30.77		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-2.0	0.17	3.00	70.00
Species richness/diversity	URSR	-1.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	30.24		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		14.00	3.0	50.0
LOWER ZONE		25.96	2.0	90.0
UPPER ZONE		29.07	1.0	100.0
				240.00
Riparian vegetation PES score	69.02			
Riparian vegetation PES Category	C			

UP

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	0.00	0.26	1.00	100.00
Vegetation cover	MCO	0.00	0.18	2.00	70.00
Species richness/diversity	MSR	0.00	0.18	2.00	70.00
Species composition	MSC	0.00	0.26	1.00	100.00
Vegetation structure	MST	0.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	0.00		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-1.0	0.15	4.00	60.00
Vegetation cover	LRCO	-1.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-1.0	0.21	3.00	80.00
Species composition	LRSC	0.0	0.26	1.00	100.00
Vegetation structure	LRST	-1.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	14.87		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-2.0	0.17	3.00	70.00
Species richness/diversity	URSR	-1.0	0.24	1.00	100.00
Species composition	URSC	-1.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	30.24		1.00	4.00	410.00

PES

RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		20.83	3.0	50.0
LOWER ZONE		31.92	2.0	90.0
UPPER ZONE		29.07	1.0	100.0
				240.00
Riparian vegetation PES score	81.82			
Riparian vegetation PES Category	B			

DOWN

Marginal

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE MARGINAL AND INSTREAM VEGETATION CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	MAB	-4.00	0.26	1.00	100.00
Vegetation cover	MCO	-3.00	0.18	2.00	70.00
Species richness/diversity	MSR	-1.00	0.18	2.00	70.00
Species composition	MSC	-3.00	0.26	1.00	100.00
Vegetation structure	MST	-3.00	0.13	3.00	50.00
Proportional change in marginal and in-channel vegetation	57.95		1.00	4.00	390.00

Lower

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE LOWER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	LRAB	-3.0	0.15	4.00	60.00
Vegetation cover	LRCO	-3.0	0.15	4.00	60.00
Species richness/diversity	LRSR	-2.0	0.21	3.00	80.00
Species composition	LRSC	-2.0	0.26	1.00	100.00
Vegetation structure	LRST	-3.0	0.23	2.00	90.00
Proportional change in marginal and in-channel vegetation	50.77		1.00	4.00	390.00

Upper

TO WHAT EXTENT HAS THE FOLLOWING CHARACTERISTICS OF THE UPPER RIPARIAN ZONE CHANGED FROM THE EXPECTED REFERENCE?	CODE	Rated degree of change (observed or expected under present conditions). Can be none (=0) or a loss (-) or increase (+)	Calculated Weight of flow, depth preference metric	RANKING OF METRICS	% WEIGHT
Vegetation abundance	URAB	-2.0	0.12	4.00	50.00
Vegetation cover	URCO	-2.0	0.17	3.00	70.00
Species richness/diversity	URSR	-2.0	0.24	1.00	100.00
Species composition	URSC	-2.0	0.24	1.00	100.00
Vegetation structure	URST	-2.0	0.22	2.00	90.00
Proportional change in marginal and in-channel vegetation	40.00		1.00	4.00	410.00

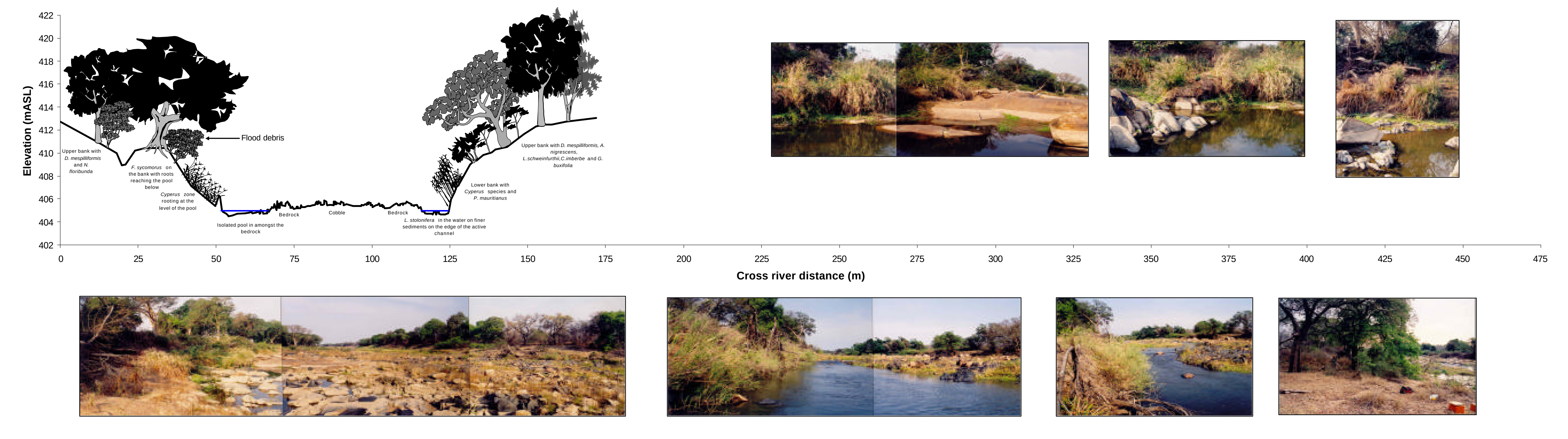
PES

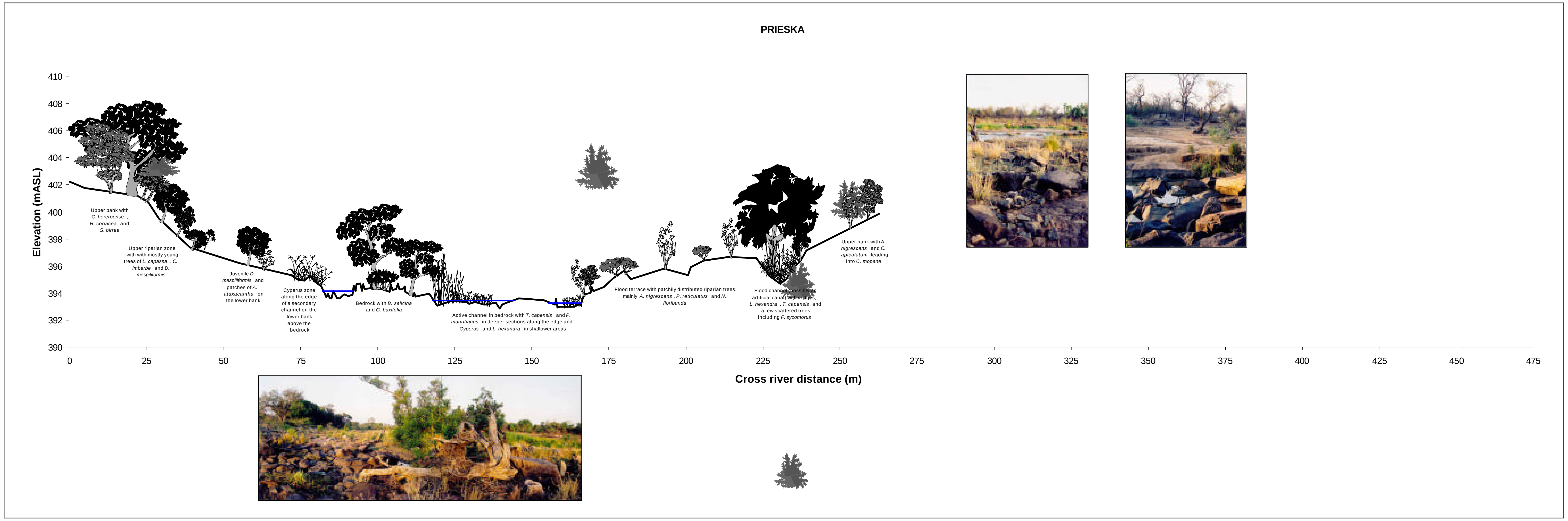
RIPARIAN VEGETATION PES METRIC GROUP		WEIGHTED SCORE FOR GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP
MARGINAL ZONE		8.76	3.0	50.0
LOWER ZONE		18.46	2.0	90.0
UPPER ZONE		25.00	1.0	100.0
				240.00
Riparian vegetation PES score	52.22			
Riparian vegetation PES Category	D			

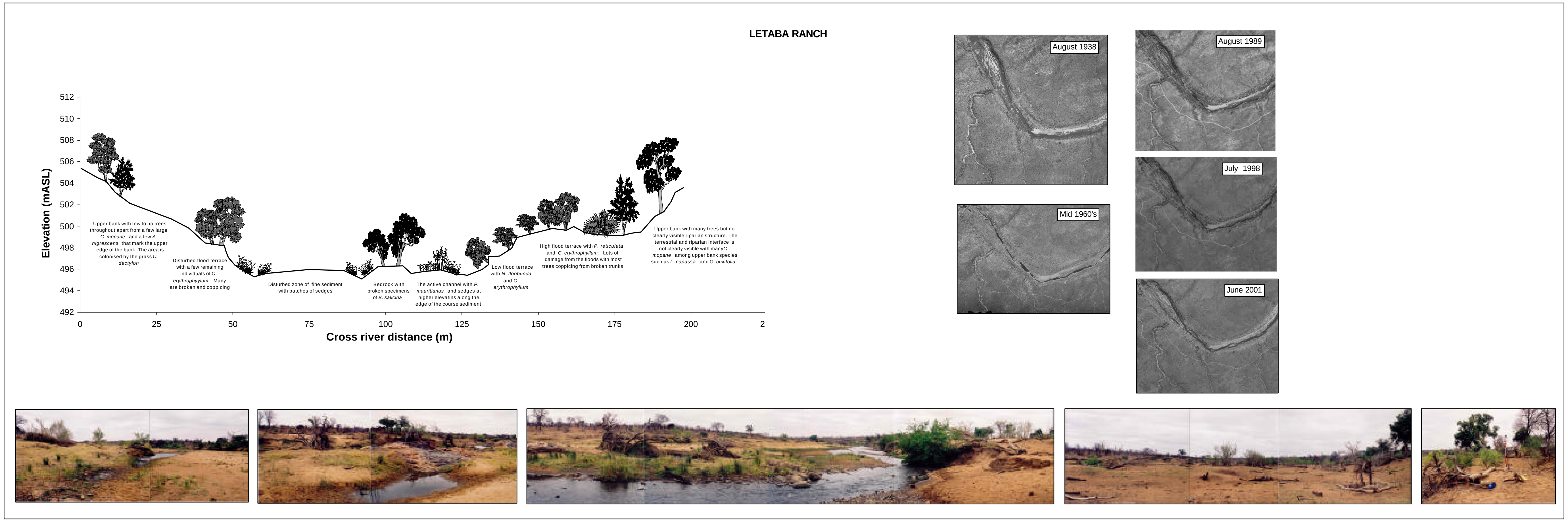
APPENDIX 4
CROSS SECTION PLANS OF THE IFR SITES

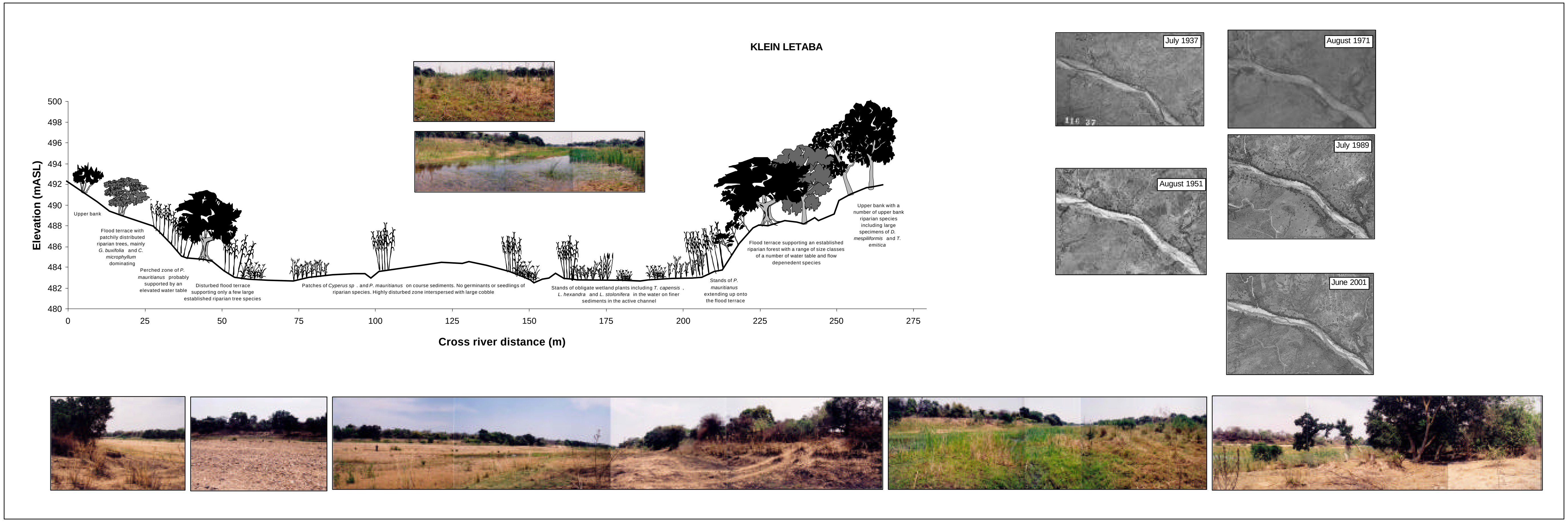
APPEL

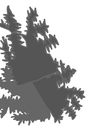
EILAND

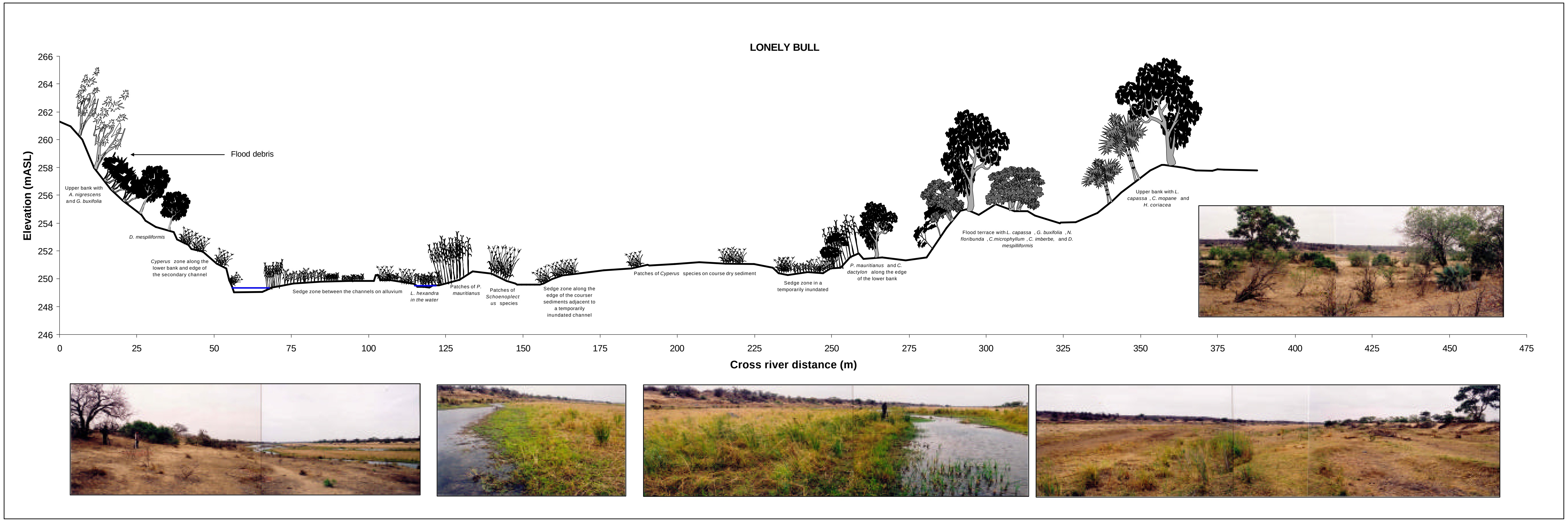


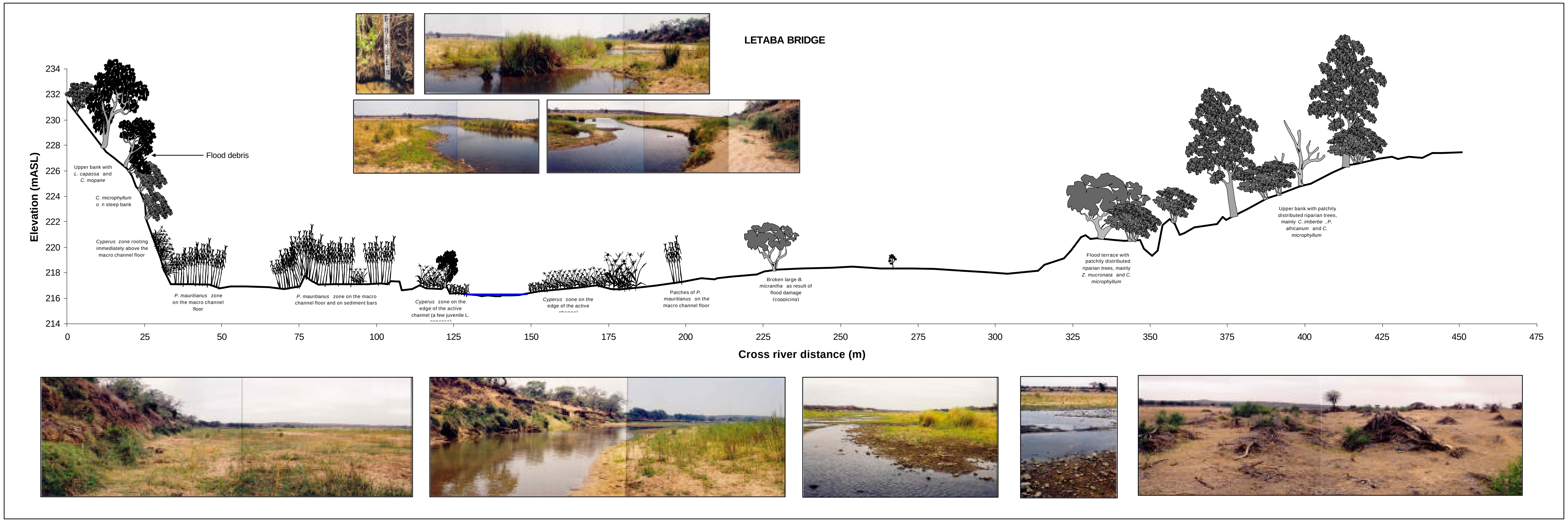

PRIESKA
Elevation (mASL)
410
408
406
404
402
400
398
396
394
392
390
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
450
475
Cross river distance (m)
Upper bank with C. hereroense, H. coriacea and S. birrea
Upper riparian zone with with mostly young trees of L. capassa, C. imberbe and D. mespiliformis
Juvenile D. mespiliformis and patches of A. ataxacantha on the lower bank
Cyperus zone along the edge of a secondary channel on the lower bank above the bedrock
Bedrock with B. salicina and G. buxifolia
Active channel in bedrock with T. capensis and P. mauritianus in deeper sections along the edge and Cyperus and L. hexandra in shallower areas
Flood terrace with patchily distributed riparian trees, mainly A. nigrescens, P. reticulatus and N. floribunda
Flood channel (possibly an artificial canal) with sedges, L. hexandra, T. capensis and a few scattered trees including F. sycomorus
Upper bank with A. nigrescens and C. apiculatum leading into C. mopane


LETABA RANCH
Elevation (mASL)
512
510
508
506
504
502
500
498
496
494
492
0
25
50
75
100
125
150
175
200
2
Cross river distance (m)
Upper bank with few to no trees throughout apart from a few large C. mopane and a few A. nigrescens that mark the upper edge of the bank. The area is colonised by the grass C. dactylon
Disturbed flood terrace with a few remaining individuals of C. erythrophyylum. Many are broken and coppicing
Disturbed zone of fine sediment with patches of sedges
Bedrock with broken specimens of B. salicina
The active channel with P. mauritianus and sedges at higher elevatins along the edge of the course sediment
Low flood terrace with N. floribunda and C. erythrophyllum
High flood terrace with P. reticulata and C. erythrophyllum. Lots of damage from the floods with most trees coppicing from broken trunks
Upper bank with many trees but no clearly visible riparian structure. The terrestrial and riparian interface is not clearly visible with many C. mopane among upper bank species such as L. capassa and G. buxifolia
August 1938
August 1989
July 1998
Mid 1960's
June 2001


KLEIN LETABA
Elevation (mASL)
500
498
496
494
492
490
488
486
484
482
480
0
25
50
75
100
125
150
175
200
225
250
275
Cross river distance (m)
Upper bank
Flood terrace with patchily distributed riparian trees, mainly G. buxifolia and C. microphyllum dominating
Perched zone of P. mauritianus probably supported by an elevated water table
Disturbed flood terrace supporting only a few large established riparian tree species
Patches of Cyperus sp . and P. mauritianus on course sediments. No germinants or seedlings of riparian species. Highly disturbed zone interspersed with large cobble
Stands of obligate wetland plants including T. capensis , L. hexandra and L. stolonifera in the water on finer sediments in the active channel
Stands of P. mauritianus extending up onto the flood terrace
Flood terrace supporting an established riparian forest with a range of size classes of a number of water table and flow depenedent species
Upper bank with a number of upper bank riparian species including large specimens of D. mespiliformis and T. emitica
July 1937
August 1971
July 1989
August 1951
June 2001




LONELY BULL
Elevation (mASL)
266
264
262
260
258
256
254
252
250
248
246
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
450
475
Cross river distance (m)
Flood debris
Upper bank with A. nigrescens and G. buxifolia
D. mespiliformis
Cyperus zone along the lower bank and edge of the secondary channel
Sedge zone between the channels on alluvium
L. hexandra in the water
Patches of P. mauritianus
Patches of Schoenoplectus species
Sedge zone along the edge of the courser sediments adjacent to a temporarily inundated channel
Patches of Cyperus species on course dry sediment
Sedge zone in a temporarily inundated
P. mauritianus and C. dactylon along the edge of the lower bank
Flood terrace with L. capassa , G. buxifolia , N. floribunda , C.microphyllum , C. imberbe, and D. mespilliformis
Upper bank with L. capassa , C. mopane and H. coriacea


LETABA BRIDGE
Elevation (mASL)
234
232
230
228
226
224
222
220
218
216
214
Cross river distance (m)
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400
425
450
475
Flood debris
Upper bank with L. capassa and C. mopane
C. microphyllum o n steep bank
Cyperus zone rooting immediately above the macro channel floor
P. mauritianus zone on the macro channel floor
P. mauritianus zone on the macro channel floor and on sediment bars
Cyperus zone on the edge of the active channel (a few juvenile L.
Cyperus zone on the edge of the active
Patches of P. mauritianus on the macro channel floor
Broken large B. micrantha as result of flood damage (coppicing)
Flood terrace with patchily distributed riparian trees, mainly Z. mucronata and C. microphyllum
Upper bank with patchily distributed riparian trees, mainly C. imberbe , P. africanum and C. microphyllum

water & forestry

Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

DIRECTORATE: RESOURCE DIRECTED MEASURES

LETABA CATCHMENT RESERVE DETERMINATION STUDY – **INVERTEBRATES REPORT**

FINAL

JANUARY 2006

Prepared for:

Department of Water Affairs and Forestry
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1200

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Senqu Consultants

January 2006

Inception report
Heath RG
DWAF Report No. RDM/B800/00/CON/COMP/0404X

Main Report
Heath RG
DWAF Report No.RDM/B800/00/CON/COMP/1304

Summary of Results (Non technical)
Heath RG
DWAF Report No. RDM/B800/00/CON/COMP/1304

Groundwater Scoping Report
Haupt C & Sami K
DWAF Report No. RDM/B800/02/CON/COMP/0504

Wetland Scoping Report
Marneweck G
DWAF Report No. RDM/B800/03/CON/COMP/0604

Resource Units Report
Heath R G
DWAF Report No. RDM/B800/00/CON/COMP/0704

→ **Resource Units Report: Appendix 1**
Habitat Integrity Index
Fouche, P & Moolman
Appendix 2: Systems operation report
Haumann, K.
DWAF Report No.
RDM/B800/00/CON/COMP/0704

EWR Report: Quantity
Palmer RW
DWAF Report No. RDM/B800/01/CON/COMP/0904

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1. IFR SITE 1 (APPEL)

The EWR site is situated on the Groot Letaba River, downstream of the Ebenezer Dam and upstream of the Tzaneen Dam. The river at this site is a mountain stream characterised by the presence of boulders, cobbles, pebbles and pools.

This river at this EWR site, is highly regulated with flows largely determined by releases from the upstream dams. The present day discharge is approximately 30% of the virgin MAR.

1.1 DATA AVAILABILITY

No historical macro-invertebrate species data are available for this river. SASS data is however available for this site (RHP).

Two field surveys were undertaken on 2nd September 2003 and 6th February 2004. A detailed list of the number of samples collected, as well as the associated depth, current speed and substrate for each sample are included in Appendix A (Field Trip Data).

Confidence in this data - 3 (High level of field collected data in previous year).

1.2 REFERENCE CONDITION

Under reference conditions the river at this EWR site would be a fast flowing mountain stream. The dominant substrate would be boulders and cobbles with a wide range of velocities over riffles and chutes. Other substrates would include gravel and sand as well as marginal and fringing vegetation. There would be a large range of macro-invertebrate habitats (in terms of velocity, depth and substrate).

It would be a significantly larger river than present day with a higher discharge, greater wetted area, larger range in velocities, and a higher range and duration of flood events. It is also likely that lower discharges would be seen during times of drought (non-regulated).

We would expect to see the total number of taxa to be in excess of 35 (SASS 5 taxa definitions). The Emphemeroptera would include Baetidae, Caenidae, Heptageniidae, Leptophlebiidae and Tricorythidae. There would be at least five different species of baetids (*Baetis harrisoni*, *Baetis bellus*, *Baetis glaucus*, *Afroptilum excisum*, *Afroptilum flavum* etc) as well as several species of Trichoptera (*Cheumatopsyche afra*, *Cheumatopsyche thomasetti*, *Hydropsyche longifurca*, *Macrostenum* sp., *Amphisyche scottae*, *Ecnomus* sp. and Hydroptilidae). There would be several species of Simulidae.

Taxa with a preference for high velocities (>0.6m/s) such as Tricorythidae, Perlidae, Hydropsychidae and Simuliidae would be of relatively high importance.

1.3 PES

The Present Ecological Status (PES) was C

A list of the taxa recorded at this site and their numbers is shown in Appendix A.

Four baetid species were recorded at this site (*Baetis harrisoni*, *Afroptilum excisum* and two unverified baetids). The baetid community was dominated by *Baetis harrisoni* which has a wide range of habitat references. Caenids which prefer loose cobbles were also common.

Tricorythus sp., which has a preference for moderately to fast flowing water (>0.3m/s) was also common. One specimen of *Neoperla spio* (Stone fly) which has a preference for fast flowing water (>0.6m/s) was also recorded. Two specimens of *Afronurus peringueyi*, which is very specific in its preferred velocity range (0.2m/s-0.5m/s - Skoroszewski and de Moor, 1999) were also recorded.

Three species of Hydropsychidae (*Cheumatopsyche thomasetti*, *Hydropsyche longifurca* and *Amphisyche scottae* were recorded as well as two Hydroptilids (*Hydroptila capensis* and *Hydroptila* "sand grain") and Ecnomidae in two of the twelve samples.

PES	CAUSES	SOURCES	FLOW/NON-FLOW RELATED
C	Reduction in discharge impacts on taxa with a preference for very fast and moderately fast flowing water	Upstream Dam (flow reduction)	Flow-related
	Reduction in available habitat impacts on taxa with a preference for boulders/bedrock, vegetation and loose cobbles	Upstream Dam (flow reduction)	Flow-related
	Reduction in flushing of riffles and dilution of pollutants. Impact on the abundance of taxa with a high and moderate preference for unmodified water quality.	Upstream Dam	Flow-related

The PES sheets and Stress Tables used at the EWR workshop are shown in Appendix B and Appendix C respectively.

1.4 TREND (PREVIOUSLY TRAJECTORY OF CHANGE) AND REASONS

PES	TREND	RESULTING PES	REASONS
C	Neutral	C	The macro-invertebrate community is stable and has adjusted to the present regulated flow regime

1.5 ALTERNATIVE ECOLOGICAL SCENARIOS (ECS)

EC = D

Flow modification

The abundance of taxa with a preference for fast and moderately fast flowing water would be reduced.

Habitat Preference

The abundance for taxa with a preference for loose cobbles and vegetation as well as the proportion of taxa with a preference for vegetation would be reduced.

Water Quality

There would be a reduction in the number of taxa and their abundance with a high preference for unmodified water quality.

2. IFR SITE 2 (LETSITELE)

This EWR site is situated on the Letsitele River, which is at present unregulated (no large upstream impoundments). The main impacts on water quantity and water quality at this site are upstream stream flow reduction (forestry) and a township with no formal sewer system immediately upstream.

The river channel at this site is largely degraded due to bank erosion and local sources of water pollution. The reduced discharge (from natural) has resulted in the siltation of riffles and a reduction in the range of velocities.

2.1 DATA AVAILABILITY

No historical macro-invertebrate species data are available for this river. SASS data is however available for this site (RHP).

Two field surveys were undertaken on 16th September 2003 and 5th February 2004. A detailed list of the number of samples collected, as well as the associated depth, current speed and substrate for each sample are included in Appendix A (Field Trip Data).

Confidence in this data - 2 (RBA samples collected as well as a limited range of velocity-related samples).

2.2 REFERENCE CONDITION

Under reference conditions this stretch of river would be characterised be a series of cobble riffles interspersed with shallow pools. The cobbles would be regularly flushed out by a wide range (size and duration) of flood events. There would be significant marginal and fringing vegetation habitat as well as gravel and sand.

We would expect to see the total number of taxa to be in excess of 35 (SASS taxa definitions). The Ephemeroptera would include Baetidae, Caenidae, Heptageniidae, Leptophlebiidae and Tricorythidae. Taxa with a preference for higher velocities (Tricorythidae and Perlidae) would be present in significant numbers. The Trichoptera would include *Cheumatopsyche afra*, *Cheumatopsyche thomasetti*, *Hydropsyche longifurca*, *Amphisyche scottae* and Hydroptilidae. There would be a rich and diverse fringing/marginal vegetation community dominated by Hemiptera (Corixidae, Gerridae, Naucoridae, Notonectidae and Veliidae etc) and Odonata (Chorolestidae and Coenogridae).

2.3 PES

The Present Ecological State (PES) was D.

A list of the taxa recorded at this site and their numbers is shown in Appendix A.

The baetid community was dominated by *Baetis harrisoni*, which has a wide habitat preference range, with four other baetids recorded (*Afroptilum excisum*, *Afroptilum medium* and two unverified baetid species). Caenidae and *Choroterpes* sp. were fairly common. *Afronurus peringueyi* and *Demoreptus (Acentrella)* sp. were also present. One specimen of *Tricorythus* sp. was also recorded.

Cheumatopsyche thomasetti and *Hydropsyche longifurca* were the dominant Trichoptera with smaller numbers of three Hydroptilid sp, (*Hydroptila* "sand grain", *Hydroptila* "caraway seed" and *Hydroptila* C (*Orthotrichia barnardi*?) recorded. Two specimens of *Amphisyche scottae* were recorded.

No *Neoperla spio* were recorded.

PES	CAUSES	SOURCES	FLOW/NON-FLOW RELATED
D	Negative impact on taxa with a preference for very fast and moderately fast flowing water	Upstream abstraction	Flow-related
	Reduction and degradation in available habitat	Upstream abstraction	Flow related (Habitat degradation)
	Local sources of water pollution associated with a reduction in the capacity of the system to flush out sediment and dilute pollutants	Local sources of pollution/reduced flow	Non-Flow and Flow related

The PES sheets and Stress Tables used at the EWR workshop are shown in Appendix B and Appendix C respectively.

2.4 TREND (PREVIOUSLY TRAJECTORY OF CHANGE) AND REASONS

PES	TREND	RESULTING PES	REASONS
D	Neutral	D	The macro-invertebrate community is stable and has adjusted to the present flow/water quality and habitat degradation

2.5 ALTERNATIVE ECOLOGICAL SCENARIOS (ECS)

No Alternative Ecological Scenarios (ECs) were assessed.

3. IFR SITE 3 (DIE EILAND)

This EWR site is situated on the Groot Letaba River, downstream of the Tzaneen Dam and upstream of the Molototsi River. The river at this site is characterised by the presence of boulders, cobbles, pebbles and pools. The main impacts at this site are the reduction in flow due to upstream impoundments (Tzaneen and Ebenezer Dams) as well as direct abstraction for irrigation.

3.1 DATA AVAILABILITY

Historical macro-invertebrate data was available for this EWR site both upstream and downstream of the Prieska Weir (Chutter F.M. and Heath, R.G.M. 1993).

Two field surveys were undertaken on 12th September 2003 and 4th February 2004. A detailed list of the number of samples collected, as well as the associated depth, current speed and substrate for each sample are included in Appendix A (Field Trip Data).

Confidence in this data - 3 (High level of field collected data in previous year as well as some historic data for the reach).

The discharge at this EWR site has been severely restricted due to upstream impoundments as well as by direct abstraction from irrigation farmers. The present day discharge is approximately 30% of the virgin MAR.

3.2 REFERENCE CONDITION

Under reference conditions, this stretch of river would be a strong flowing river dominated by boulder/bedrock and cobble substrate. There would be wide range of flow velocities over cobble riffles interspersed with deep pools.

The habitat available for macro-invertebrates would include bedrock, cobble, gravel, and sand substrate over a range of flow velocities and fringing/marginal vegetation.

It would be a significantly larger river in terms of discharge than present day with a wider range of flow velocities. Flood events would be more frequent with a larger range and duration.

We would expect to see the total number of taxa to be in excess of 40 (SASS5 taxa definitions). The Ephemeropterans would include at least seven species of Baetidae (*Baetis harrisoni*, *Baetis bellus*, *Baetis glaucus*, *Afroptilum excisum*, *Afroptilum flavum*, *Afroptilum medium* and *Demoreptus* (*Acentrella*) sp.) etc, Caenidae, Heptagaeniidae, Leptophlebiidae, Oligoneuridae, Prosopistomatidae and Tricorythidae. The Trichopterans would include *Aethaloptera maxima*, *Amphisyche scottae*, *Cheumatopsyche afra* and *Cheumatopsyche thomasetti*, *Ecnomus* sp., *Chimarrha* sp., and various Hydroptilids. Habitat would be favourable for taxa with a preference for high velocities (>0.6 m/s) such as Oligoneuridae and Tricorythidae.

3.3 PES

The Present Ecological State (PES) was D

A list of the taxa recorded at this site and their numbers is shown in Appendix A. Four baetid species were recorded at this site. These included *Baetis harrisoni*, *Cloeon*? sp., *Centroptilum medium* and *Centroptilum excisum.* *Choroterpes* sp. was the dominant Ephemeropteran with Caenidae and *Tricorythus* sp. also present.

The dominant Trichopteran was *Amphisyche scottae* with *Hydropsyche longifurca*, *Cheumatopsyche thomasetti* and Philopotamidae also being common. Six hydroptilid species were also recorded as well as Leptoceridae.

In the 1991-1992 survey of sites in this reach (Chutter F.M. and Heath, R.G.M., 1993) ten baetid species were recorded as well as twelve species of Trichoptera.

PES	CAUSES	SOURCES	FLOW/NON-FLOW RELATED
D	Reduction in flow velocities impacts on taxa with a preference for very fast and moderately fast flowing water	Upstream abstraction	Flow-related
	Impact on taxa with a preference for boulders/bedrock, vegetation and loose cobbles	Upstream abstraction	Flow-related
	Reduction in flushing of riffles and dilution on pollutants impacts on the abundance of taxa with a high preference for unmodified water quality	Upstream abstraction	Flow-related

The PES sheets and Stress Tables used at the EWR workshop are shown in Appendix B and Appendix C respectively.

3.4 TREND (PREVIOUSLY TRAJECTORY OF CHANGE) AND REASONS

PES	TREND	RESULTING PES	REASONS
D	Neutral	D	The macro-invertebrate community is stable and has adjusted to the present flow regime

3.5 ALTERNATIVE ECOLOGICAL SCENARIOS (ECS)

EC = C

Flow modification

The abundance of taxa with a preference for fast and moderately fast flowing water as well as the presence of taxa for fast flowing water would marginally increase. The most significant change would be an increase in the number of taxa with a preference for moderately flowing water.

Habitat Preference

The abundance and proportion of taxa with a preference for loose cobbles and vegetation would marginally increase.

Water Quality

There would be an increase in the number and abundance with a high preference for unmodified water quality.

4. IFR SITE 4 (LETABA RANCH)

This EWR site is situated on the Groot Letaba River, downstream of the Molototsi River and upstream of the confluence with the Klein Letaba River. The river channel at this site is large (> 150m) and is characterised by the presence of bedrock, large boulders, cobbles, pebbles and pools. The main impacts at this site are the reduction in flow due to upstream impoundments (Tzaneen and Ebenezer Dams) as well as direct abstraction for irrigation.

4.1 DATA AVAILABILITY

Historical macro-invertebrate data was available for this EWR site at two sampling points in the Letaba Ranch Reserve (Chutter F.M. and Heath, R.G.M., 1993).

Two field surveys were undertaken on 17th September 2003 and 5th February 2004. A detailed list of the number of samples collected, as well as the associated depth, current speed and substrate for each sample are included in Appendix A (Field Trip Data).

Confidence in this data - 3 (High level of field collected data in previous year as well as some historic data for the reach).

4.2 REFERENCE CONDITION

Under reference conditions the river at this EWR site would be a large, strongly flowing river. This stretch of river would be characterised by sections of boulder and cobble riffles, interspersed with large pools. There would be significant gravel and sand substrate with a large variation in depth.

The river would be considerable larger than present day with a much higher discharge, a much greater range of velocities and a higher range and duration of flood events.

We would expect the total number of taxa to be in excess of 40 (SASS5 taxa definitions). The Ephemeroptera would include Baetidae (*Baetis harrisoni*, *Baetis bellus*, *Baetis glaucus*, *Afroptilum excisum*, *Afroptilum medium*, *Afroptilum flavum*, *Afroptilum varium*), Prosopistomatidae, Caenidae, Heptagaeniidae. Leptophlebiidae, Oligoneuridae and Tricorythidae.

The Trichoptera would include *Aethaloptera maxima*, *Amphisyche scottae*, *Cheumatopsyche afra* and *Cheumatopsyche thomasetti*, *Ecnomus* sp., *Chimarrha* sp., and various hydroptilids.

4.3 PES

The Present Ecological Status (PES) was D

A list of the taxa recorded at this site and their numbers is shown in Appendix A.

Four baetid species were recorded at this site. These included *Baetis harrisoni*, *Afroptilum medium*, *Afroptilum excisum* as well as an unverified baetid species. Caenidae and *Choroterpes* sp. were present in a number of samples. *Tricorythu*s sp. was uncommon with only a remnant population existing.

The dominant Trichopteran was *Amphisyche scottae* which were all found, with the exception of one individual in the February samples. Three hydroptilid species were recorded in small numbers.

In the 1991-1992 survey of sites in this reach (Chutter F.M. and Heath, R.G.M., 1993) fourteen baetid species were recorded as well as thirteen species of Trichoptera.

PES	CAUSES	SOURCES	FLOW/NON-FLOW RELATED
D	Reduction in flow velocities impacts on taxa with a preference for very fast and moderately fast flowing water	Upstream Abstraction	Flow-related
	Reduced discharge impacts on taxa with a preference for	Upstream Abstraction	Flow-related

PES	CAUSES	SOURCES	FLOW/NON-FLOW RELATED
	boulders/bedrock, vegetation and loose cobbles		
	Low flows resulting in limited flushing of riffles and more variation in physical water quality variables such as temperature causes impact on the abundance of taxa with a high, medium and low preference for unmodified water quality. General reduction in taxa	Upstream Abstraction	Flow-related

The PES sheets and Stress Tables used at the EWR workshop are shown in Appendix B and Appendix C respectively.

4.4 TREND (PREVIOUSLY TRAJECTORY OF CHANGE) AND REASONS

PES	TREND	RESULTING PES	REASONS
D	Neutral	D	The macro-invertebrate community is stable and has adjusted to the present (very low) flow regime

4.5 ALTERNATIVE ECOLOGICAL SCENARIOS (ECS)

EC = C

Flow modification

There would be an increase in the presence and abundance of taxa with a preference for very fast flowing water. There would also be an increase in the abundance of taxa with a preference for moderately flowing water.

Habitat Preference

There would be an increase in the proportion and abundance of taxa with a preference for bedrock (including large cobbles and boulders) and vegetation.

Water Quality

There would be a slight increase in the number of taxa with a preference for unmodified water quality.

5. IFR SITE 5 (KLEIN LETABA)

This EWR site is situated on the Klein Letaba River, downstream of the Middle Letaba Dam.

The river at this site has a predominantly sandy bed with an upstream bedrock control associated with a large pool. There has been extensive encroachment by vegetation of the active river channel with very limited stones-in-current habitat. A short run consisting of a few small cobbles and pebbles was sampled at the lower end of the site.

5.1 DATA AVAILABILITY

No historical macro-invertebrate data was available for this EWR site.

Two field surveys were undertaken on 3rd September 2003 and 4th February 2004. A detailed list of the number of samples collected, as well as the associated depth, current speed and substrate for each sample are included in Appendix A (Field Trip Data).

Confidence in this data - 2 (limited stones in current data with a very limited velocity range).

5.2 REFERENCE CONDITION

Under reference conditions the river at this EWR site would be a wide and slow flowing river, dominated by a sand substrate with limited sections of bedrock and cobble riffles. There would be significant sections of marginal and fringing vegetation.

We would expect to see the total number of taxa to be in excess of 38 (SASS5 taxa definitions). The sandy pool areas would be characterised by taxa such as Gomphidae, Gyrinidae, Ceratopogonidae and Chironomidae. The limited riffle sections would include several species of Baetidae, as well as Caenidae, Heptogeniidae. Leptophlebiidae, Tricorythidae and Prosopistomatidae. The Trichoptera would include Hydropsychidae (*Cheumatopsyche afra*, *Cheumatopsyche thomasetti*) Ecnomidae, Leptoceridae and Hydroptilids.

5.3 PES

The Present Ecological State (PES) was D

A list of the taxa recorded at this site and their numbers is shown in Appendix A.

Six species of Baetidae were recorded at this site. These included *Baetis harrisoni, Afroptilum excisum, Afroptilum medium* and three unverified baetid species. Caenidae were present in a number of samples and *Choroterpes* sp. was also recorded.

Very few Trichoptera were recorded due primarily to the very low flows and associated shallow depths and low velocities. *Cheumatopsyche thomasetti* was recorded in one sample (juveniles) and *Hydroptila capensis* in another.

PES	CAUSES	SOURCES	FLOW/NON-FLOW RELATED
D	Low discharge impacts on taxa with a preference for very fast and moderately fast flowing water	Upstream Abstraction	Flow-related
	Low discharge impacts on taxa with a preference for boulders/bedrock, vegetation in current and loose cobbles	Upstream Abstraction	Flow-related
	Low flows resulting in siltation of riffle areas, limiting available habitat and increased variation in physical water quality variables (such as temperature). Large impact on the abundance of taxa with a high and medium preference for unmodified water quality. General reduction in numbers of taxa.	Upstream Abstraction	Flow-related

The PES sheets and Stress Tables used at the IFR workshop are shown in Appendix B and Appendix C respectively.

5.4 TREND (PREVIOUSLY TRAJECTORY OF CHANGE) AND REASONS

PES	TREND	RESULTING PES	REASONS
D	Neutral	D	The macro-invertebrate community is very limited with remnant populations of velocity dependent taxa.

5.5 ALTERNATIVE ECOLOGICAL SCENARIOS (ECS)

EC = C

Flow modification

There would be a slight increase in the presence of taxa with a preference for moderately fast flowing water. There would also be an increase in abundance of taxa with a preference for moderately fast flowing water.

Habitat Preference

There would be a slight increase in the abundance of taxa with a preference for bedrock/boulders. There would also be an increase in the abundance of taxa with a preference for loose cobbles and vegetation as well as the proportion of taxa with a preference for vegetation.

Water Quality

There would be an increase in the presence and abundance of taxa with a moderate requirement for unmodified water quality.

6. IFR SITE 6 (LONELY BULL)

This EWR site is situated on the Groot Letaba River, downstream of the confluence with the Klein Letaba River. The river channel at this site is large (> 150m) and is characterised by the presence of bedrock controls, small cobbles, sand and pebbles.

There was very little stones-in-current habitat due to the low flows experienced at the time of sampling.

The main impacts at this site are the reduction in flow due to upstream impoundments as well as direct abstraction for irrigation (both lawful and unlawful).

6.1 DATA AVAILABILITY

Historical macro-invertebrate data was available for this EWR site at two sampling points in the Letaba Ranch Reserve (Moore C. and Chutter F.M., 1988).

Two field surveys were undertaken on 18th September 2003 and 3rd February 2004. A detailed list of the number of samples collected, as well as the associated depth and current speed for each sample are included in Appendix A (Field Trip Data).

The discharge at this EWR site has been severely restricted due to upstream impoundments and direct abstraction from irrigation farmers. The present day discharge is approximately 30% of virgin MAR.

Confidence in this data - 3 (High level of field collected data in previous year as well as some historic data).

6.2 REFERENCE CONDITION

Under reference conditions the river at this EWR site would be a very large slow flowing river. The dominant substrate would be gravel and sand with infrequent bedrock controls and associated cobble/gravel riffles. There would be several large pools at this site with associated marginal/fringing vegetation.

The discharge would be significantly larger than present day with a wider wetted area, larger range of velocities and depths as well as a wider range and duration of flood events.

We would expect to see the total number of taxa to be in excess of 38 (SASS5 taxa definitions). The Ephemeroptera would include Baetidae (*Baetis bellus*, *Baetis glaucus*, *Demoreptus* (*Acentrella* sp.), *Afroptilum excisum*, *Afroptilum medium*, *Afroptilum flavum* plus other baetid species), Leptophlebiidae, Caenidae, Oligoneuridae, Prosopistomatidae and Tricorythidae. The Trichoptera would include Ecnomidae, Hydropsychidae (*Amphisyche scottae, Cheumatopsyche thomasetti*, *Hydropsyche longifurca*), Leptoceridae and Hydroptilidae.

6.3 PES

The Present Ecological State (PES) was D.

A list of the taxa recorded at this site and their numbers is shown in Appendix A.

Five baetid species were recorded at this site. These included *Baetis harrisoni*, *Afroptilum excisum* and three unverified baetids. Caenidae and *Choroterpes* sp. were present in a number of samples. *Tricorythus* sp. was uncommon with only a remnant population existing.

The dominant Trichopterans were *Hydropsyche longifurca* (September samples) and *Amphisyche scottae*. Five hydroptilid species were recorded in small numbers.

The only significant riffle section at the site was dominated by Thiaridae (snails), particularly in the September samples.

In the 1991-1992 survey of sites in this reach (Chutter F.M. and Heath, R.G.M., 1993) fourteen baetid species were recorded as well as thirteen species of Trichoptera.

PES	CAUSES	SOURCES	FLOW/NON-FLOW RELATED
D	Reduction in flow velocity - impact on taxa with a preference for very fast and moderately fast flowing water	Upstream abstraction	Flow-related
	Reduction in discharge - impact on taxa with a preference for boulders/bedrock, vegetation and loose cobbles	Upstream abstraction	Flow-related
	Low flows resulting in limited flushing of riffles and greater variation in physical water quality variables - impact on abundance of taxa with a high, medium and low preference for unmodified water quality. General reduction in taxa	Upstream abstraction	Flow-related

The PES sheets and Stress Tables used at the IFR workshop are shown in Appendix B and Appendix C respectively.

6.4 TREND (PREVIOUSLY TRAJECTORY OF CHANGE) AND REASONS

PES	TREND	RESULTING PES	REASONS
D	Neutral	D	The macro-invertebrate community is stable and has adjusted to the present (very low) flow regime

6.5 ALTERNATIVE ECOLOGICAL SCENARIOS (ECS)

EC = C

Flow modification

There would be a slight increase in the number of taxa with a preference for very fast flowing unmodified water quality. There would also be an increase in the abundance of taxa with a preference for very fast and moderately flowing water.

Habitat Preference

There would be an increase in the proportion and abundance of taxa with a preference for vegetation.

Water Quality

There would be a slight increase in the number and proportion of taxa with a high requirement for unmodified water quality.

7. IFR SITE 7 (LETABA BRIDGE)

This EWR site is situated on the Groot Letaba River, downstream of the confluence with the Klein Letaba River. The river channel at this site is large (> 150m) and is characterised by the presence of bedrock controls, small cobbles, sand and pebbles.

There were very little stones-in-current habitat due to the low flows experienced at the time of sampling.

The main impacts at this site are the reduction in flow due to upstream impoundments as well as direct abstraction for irrigation (both lawful and unlawful).

7.1 DATA AVAILABILITY

Historical macro-invertebrate data was available for this EWR site at two sampling points in the Letaba Ranch Reserve (Moore C. and Chutter F.M., 1988).

Two field surveys were undertaken on 18th September 2003 and 3rd February 2004. A detailed list of the number of samples collected, as well as the associated depth and current speed for each sample are included in Appendix A (Field Trip Data).

Confidence in this data - 3 (High level of field collected data in previous year as well as some historic data for the reach).

7.2 REFERENCE CONDITION

Under reference conditions the river at this EWR site would be a very large slow flowing river. The dominant substrate would be gravel and sand with infrequent bedrock controls and associated cobble/gravel riffles. There would be significant areas of fringing/marginal vegetation in the wetted area.

The discharge would be significantly larger than present day with a wider wetted area, larger range of velocities and depths as well as a wider range and duration of flood events.

We would expect to see the total number of taxa to be in excess of 35 (SASS5 taxa definitions). The Ephemeroptera would include Baetidae (*Baetis bellus*, *Baetis glaucus*, *Demoreptus* (*Acentrella* sp.), *Afroptilum excisum*, *Afroptilum medium*, *Afroptilum flavum* plus other baetids), LeptophlebIidae, Caenidae, Oligoneuridae, Prosopistomatidae and Tricorythidae. The Trichoptera would include Ecnomidae, Hydropsychidae (*Aethaloptera maxima*, *Amphisyche scottae*, *Cheumatopsyche thomasetti*, *Hydropsyche longifurca*), Leptoceridae and Hydroptilidae.

7.3 PES

The Present Ecological State (PES) was D.

A list of the taxa recorded at this site and their numbers is shown in Appendix A.

Four baetid species were recorded at this site (*Baetis harrisoni*, *Afroptilum excisum* and two unverified baetids). Caenidae and *Choroterpes* sp. and *Adenophlebia auriculata* were also present in a number of samples. Only one specimen of *Tricorythus* sp. was recorded indicating that only a remnant population exists.

Seven species of Trichoptera were recorded (mostly in the September samples) including *Aethaloptera maxima*, *Ecnomus* sp., *Cheumatopsyche thomasetti, Hydropsyche longifurca* and three hydroptilid species. Note: there was a high flow during the February sampling trip, with a large increase in recently inundated riverbed.

In the 1991-1992 survey of sites in this reach (Chutter F.M. and Heath, R.G.M., 1993) fourteen baetid species were recorded as well as thirteen species of Trichoptera.

PES	CAUSES	SOURCES	FLOW/NON-FLOW RELATED
D	Impact on taxa with a preference for very fast and moderately fast flowing water	Reduction in discharge	Flow-related

PES	CAUSES	SOURCES	FLOW/NON-FLOW RELATED
	Impact on taxa with a preference for boulders/bedrock (non mobile), vegetation and loose cobbles	Reduction in available habitat	Flow-related
	Limited impact on the abundance of taxa with a high, medium and low preference for unmodified water quality. General reduction in taxa	Water Quality	Flow-related (very low flows resulting in limited flushing of riffles and more variation in physical water quality variables such as temperature)

The PES sheets used at the workshop are shown in Appendix B.

7.4 TREND (PREVIOUSLY TRAJECTORY OF CHANGE) AND REASONS

PES	TREND	RESULTING PES	REASONS
D	Neutral	D	The macro-invertebrate community is stable and has adjusted to the present (very low) flow regime

7.5 ALTERNATIVE ECOLOGICAL SCENARIOS (ECS)

EC = C

Flow modification

There would be an increase in the presence and abundance of taxa with a preference for fast flowing water as well the abundance of taxa with a preference for moderately flowing water.

Habitat Preference

There would be an increase in the number and proportion of taxa with a preference for loose cobbles and vegetation.

Water Quality

There would be an increase in the number of taxa with a high requirement for unmodified water quality.

8. REFERENCES

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APPENDIX A

FIELD TRIP DATA
(NUMBER OF INDIVIDUALS PER TAXA, DATE OF SAMPLING, WATER DEPTH AND VELOCITY AT POINT OF SAMPLING)

IFR 1 APPEL														
Taxa	**No. Individualsper sample**													
	September 2003							**February 2004**						
Date	**02/09/03**	**02/09/03**	**02/09/03**	**02/09/03**	**02/09/03**	**02/09/03**	**02/09/03**	**02/09/03**	**02/09/03**	**02/09/03**	**02/09/03**	**06/02/04**	**06/02/04**	**06/02/04**
Depth	**23**	**30**	**18**	**15**	**20**	**22**	**SASS**	**SASS**	**SIC**	**SOC**	**FV**	**SASS**	**28**	**26**
Velocity (m/sec)	**1.07**	**0.36**	**0.39**	**0.24**	**0.67**	**0.57**	**Stones**	**SOC**	**-**	**-**	**-**	**-**	**0.71**	**0.67**
Planaria	1	4				1								
Oligochaeta								2				1		
Hydracarina								2						2
Neoperla spio						1								
Baetis harrisoni	82	34	44	10	59	43		2	177	17		4	21	28
Centroptilum excisum										4		1		
Baetid A (two cerci)						11								
Baetid C (Cloeon.sudaf)	5											4		
Baetid juv.	1						2							
Caenidae	1	6		2	1	7		1	11	12			10	14
Afronurus								1				1		
Choroterpes		4	6			5	1		4	8		1	10	3
Tricorythus	47	21	9	11	6	28	24	26	80			31	13	13
Coenagridae											3			
Aeshna										2				
Gomphidae	2									7		4		1
Libelludidae	2													
Corixidae											3			
Naucoridae											1	11		
Vellidae											1			1
Aethaloptera maxima	2	3	6	1		2			4	1			3	3
Ecnomus							1	5						
Cheumat. thomasetti	21	29	1	4	2	3	14	6	11			19	20	13
Hydropsyche longifurca	13	3	9	1	8	24		4	1			1	18	31
Hydropsyche juv/pupa.	13				2	3						1		
Hydroptila capensis		1					2							
Hydro (sand grain)			1	1		1	112	3		8			8	8
Leptocerus									1				1	1
Elmidae	2	1	1	1	1	3	1	2	15	2		9	12	12
Dytiscidae													1	1
Gyrinidae										1				
Blepharoceridae							1							
Ceratopogonidae					1									
Orthocladinae	41	9	11	3	2	10	31	12	4	2		1	12	19
Tanytarsini	1							6					2	
Pentaneura		1					1	1						5
Simulidae	69	6	1		1	1	2		3			1	2	2
Tabanidae									4					
Tipulidae	1	1	2			3	3		1	3				1
Muscidae	2				1	2								2
Rhagionidae			1									3	2	1
Lymnaeidae											4			
Planorbidae									1	8	4			
Potomanautes					1	1			4	2		1		

IFR 2 LETSITELE						
Taxa	**No. Individuals per sample**					
	September 2003			**February 2004**		
Date	**16/09/03**	**16/09/03**	**16/09/03**	**05/02/03**	**05/02/03**	**05/02/03**
Depth	**10**	**SASS**	**SASS**	**9**	**0.63**	**SASS**
Velocity (m/sec)	**1.12**	**SIC**	**Veg**	**12**	**0.85**	**Stones**
Planaria	1			11	10	2
Oligochaeta		2		1	8	38
Leech			2			
Baetis harrisoni	76	100	64	5	6	6
Centroptilum medium		1				2
Centroptilum excisum		12	1			
Baetid C (Cloeon.sudaf)		9				
Baetid D (Black)						2
Acentrella (Demoreptus sp.)	1					
Caenidae	10	43	5		3	98
Afronurus	1	1				1
Choroterpes	13	172	4		2	14
Tricorythus	1					
Coenagridae			13			
Gomphidae		10	3			
Libelludidae	1					
Corixidae			12			
Naucoridae			3			2
Vellidae			27			
Cheumatopsyche thomasetti	20			3	3	
Hydropsyche longifurca		22	2	17	49	88
Aethaloptera maxima?				2		
Hydroptila A (sand grain)					1	
Hydroptila B (Carraway seed)	1					
Hydroptila C (Ortho barnardi?)				10	15	
Leptocerus						
Dytiscidae						
Elmidae	1	5	3	4	27	81
Orthocladinae	24	4	16	31	34	4
Tanytarsini			1	1	5	
Pentaneura		1			2	
Simulidae	373	8	34	38	88	6
Tabanidae		5				17
Tipulidae			1		1	
Rhagionidae		2	3			
Planorbidae			1			
Corbulicidae		15				4
Potomanautes						1
Tadpoles			217			
Spider			9			

IFR 3 Die Eiland												
Taxa	**No. Individuals per sample**											
	September 2003						**February 2004**					
Date	**16/09/03**	**16/09/03**	**16/09/03**	**16/09/03**	**16/09/03**	**16/09/03**	**SASS**	**SASS**	**04/02/04**	**04/02/04**	**04/02/04**	**04/02/04**
Depth	**20**	**15**	**31**	**26**	**26**	**35**	**SIC**	**SOC**	**21**	**25**	**24**	**28**
Velocity (m/sec)	**0.62**	**0.62**	**0.68**	**0.41**	**0.68**	**0.87**			**1.14**	**0.76**	**0.67**	**0.61**
Planaria					1							
Oligochaeta						2		3				
Leech								1				
Baetis harrisoni	8	16	14	1	18	12		6	1			8
Cloeon?					4						2	
Centroptilum medium		4						1	1	2		
Centroptilum excisum							5	35			1	
Caenidae		7			1		10	5	5	14	5	2
Choroterpes	72	59		10	35		185	3	48	4	37	18
Tricorythus	1					4			52	8	4	11
Coenagridae	2											
Gomphidae							1					
Libelludidae										1		
Naucoridae								5				
Aethaloptera maxima	14	11	100	2	190	78	6		75	69	27	47
Ecnomus			14	4	5							
Cheumatt. thomasetti	82	2										
Hydropsyche longifurca					25	12	1		53	15	30	14
Philopotamidae	28	2	2	7	7	1	1					
Hydroptila capensis					1							
Hydroptila A (sand grain)			1									2
Hydrop. (Carraway seed)			2	1	2	11						
Hydropt.(Ortho barnardi?)			1	2	1	2		1				
Hydroptilid sp.(brown)						3			28	7		
Hydroptilid sp.										1	5	1
Leptocerus				1	2	2						
Dytiscidae									2			
Elmidae	23	10	11	1	19	5	48	1	59	17	4	4
Corixidae								1				
Blepharoceridae									2			1
Orthocladinae	5	1	5	1	30	20		3	7	1	7	4
Tanytarsini						1		10	31	5	6	10
Pentaneura					6	1			1	6	4	2
Simulidae	6	19	10	2	26	156	2					
Tipulidae		2					1					
Thiaridae								1				
Corbulicidae		24	2		23	2		2	5	3		1

IFR 4 LETABA RANCH											
Taxa	**No. Individuals per sample**										
	September							**February**			
Date	**17/09/03**	**17/09/03**	**17/09/03**	**17/09/03**	**17/09/03**	**17/09/03**	**17/09/03**	**05/02/04**	**05/02/04**	**05/02/04**	**05/02/04**
Depth	**14**	**15**	**15**	**14**	**SOC**	**SASS**	**SASS**	**18**	**13**	**13**	**11**
Velocity (m/sec)	**0.82**	**0.5**	**0.44**	**0.25**	**-**	**SIC**	**Veg**	**2.07**	**1.47**	**1.04**	**0.77**
Oligochaeta								1	3		
Baetis harrisoni	9	5		1			44		2	1	
Centroptilum medium							4	4	2	1	1
Centroptilum excisum					2		7				1
Baetid C (Cloeon.sudaf)		4									
Caenidae	3	3		8			22	4	6	9	2
Choroterpes	5	14		2					1		3
Tricorythus	1							4	3	3	
Coenagridae							3				
Gomphidae							1				
Libelludidae		1									
Pyralidae									2		
Naucoridae					2		6				
Vellidae							39				
Aethaloptera maxima	1							282	142	31	195
Ecnomus								2		2	
Cheumat. thomasetti				1							
Hydropsyche longifurca		4							7		9
Hydroptila capensis	3			2			8		1		
Hydrop. Carraway seed)	3							1	8		5
Hydrop. (Ortho barnardi?)							2			8	1
Dytiscidae										1	
Elmidae	1	4		1			1	20	46	7	76
Gyrinidae									1		7
Ceratopogonidae	1			1							
Orthocladinae	5			3				2	3	8	2
Cricotopus	1										
Tanytarsini											2
Pentaneura								1			1
Simulidae	402	142		4			4	2			
Rhagionidae								4	1		
Corbulicidae				2				4	19	11	6

IFR 5 KLEIN LETABA									
Taxa	**No. Individuals per sample**								
	September 2003					**February 2004**			
Date	**03/09/03**	**03/09/03**	**03/09/03**	**SASS**	**SASS**	**04/02/04**			**SASS**
Depth	**14**	**18**	**6**	**Veg**	**Sand/Mud**	**17**	**23**	**18**	**Stones**
Velocity (m/sec)	**0.36**	**0.31**	**0.39**			**0.79**	**0.57**	**0.5**	
Oligochaeta		1	1			1		1	5
Ostracod									1
Baetis harrisoni	5	1	41			20	18	56	5
Centroptilum excisum				3	6	10	28		1
Centroptilum medium						15			13
Baetid B (9th seg-marbled)							4		9
Baetid x						2			2
Baetid y									3
Caenidae	23	1	32	2		3	11	7	28
Choroterpes	2		1					1	10
Hydropsyche longifurca								2	
Aethaloptera maxima						1			
Coenagridae				9					
Aeshna				1					
Libellulid									1
Gomphidae		6		24	34				13
Corixidae		1		3					
Naucoridae	15	4	2	3	31			1	1
Vellidae			2	34					
Cheumat. thomasetti			3						
Hydroptila capensis			12				2	7	26
Hydroptils (Caraway seed)						4			
Hydropt. (Ortho barnardi?)	1					19		1	
Elmidae									2
Dytiscidae						1		1	2
Hydrophilidae							1		
Gyrinidae									2
Ceratopogonidae			1			1			
Culicidae				2					
Orthocladinae	1		5	2		2	6	5	
Tanytarsini						3	1	11	
Pentaneura									1
Simulidae			27			18		2	2
Tipulidae				2	1				1
Rhagionidae				1		1			
Lymnaeidae		1		24	2		1		23
Planorbidae			1				3		14
Thiaridae		1							3
Ancylidae									2
Atyidae								1	6
Spider				3					

IFR 6 LONELY BULL												
Taxa	**No. Individuals per sample**											
	September 2003						**February 2004**					
Date	**18/09/03**	**18/09/03**	**18/09/03**	**18/09/03**	**18/09/03**	**18/09/03**	**18/09/03**	**02/02/04**	**02/02/04**	**02/02/04**	**02/02/04**	**02/02/04**
Depth	**19**	**16**	**18**	**15**	**SASS**	**SASS**	**SASS**	**32**	**39**	**33**	**SASS**	**SASS**
Velocity (m/sec)	**0.99**	**0.68**	**0.94**	**0.64**	**SIC**	**SOC**	**FV**	**0.85**	**0.96**	**1**	**SIC**	**FV**
Planaria			1	1								
Oligochaeta					2	3				1		
Baetis harrisoni	7	6	10	4						1	3	6
Centroptilum excisum		1		2	5		3		2			10
Baetid D (Black)				1								
Baetid (Brown)							2					2
Baetid x							1					
Cloeon sp.					4							
Demoreptus sp)												3
Caenidae	1			6	9	1	2	9	11	11	24	
Choroterpes	28	76	15	10	69	1						
Tricorythus			2									
Coenagridae							1					
Gomphidae		4		2	1		2				1	
Libelludidae			1				1					
Corixidae							3					
Naucoridae							5					7
Gerridae							1					
Vellidae							3					
Aethaloptera maxima		6	9					4	8	5	2	
Ecnomus							1					
Cheumat. thomasetti		5										
Hydropsyche longifurca	21	57	71	3	7	1						
Philopotamidae	1	1										
Hydroptila capensis						5			1			
Hydroptila A (sand grain)	1											
Hydropt. Carraway seed	1		6									
Hydroptila Ortho barnardi?								2	6	2		
Hydroptilid sp.	4	13										
Dytiscidae								2	1	1	3	
Elmidae	80	80	235	35	148		3				2	
Hydrophilidae				1								
Ceratopogonidae	1									6		
Orthocladinae	2	14	18	7				21	27	3	1	
Tanytarsini								1		1		
Pentaneura		10		9	1			1		1	2	
Simulidae	20	26	85	18	2							
Tabanidae	1		1								1	
Tipulidae				2				1				
Pyralidae			1									7
Ancylidae												1
Lymnaeidae							10				1	90
Planorbidae				1			8			1		
Thiaridae	32	59	5	134	1000+	74	235	10	17	96	128	
Corbulicidae	23	5	15	20	16	1	5	1	2	6	10	

IFR 7 LETABA BRIDGE

Taxa	**No. Individuals per sample**										
	September 2003							**February 2004**			
Date	18/09/03	18/09/03	18/09/03	18/09/03	18/09/03	18/09/03	18/09/03	03/02/04	03/02/04	03/02/04	03/02/04
Depth	9	8	20	SASS	SASS	SASS	SASS	56	80	48	SASS
Velocity (m/sec)	0.37	0.38	0	Stones	SOC	Veg.	Sand/Mud	1.47	0.69	0.77	Stones
Planaria		3									
Oligochaeta			4								9
Baetis harrisoni	67	63	1	4	1	2					2
Centroptilum excisum	11	1		10		1		1			25
Baetid (9th seg-marbled)	3										
Baetid (simi. medium)											4
Caenidae	131	59	5	90	55	2	7	2	3		11
Adenophlebia		3			1						
Choroterpes	7	1		27		1	1				
Tricorythus	1										
Gomphidae	2	1		14	3	17					1
Libelludidae		1		4			1				
Corixidae	2										
Naucoridae				3							
Aethaloptera maxima	2	11		1			7				
Ecnomus		1									
Cheumatopsyche thomasetti	2	30	2								
Hydropsyche longifurca	5	5		2			4				
Hydroptila capensis	11	32		2			3				
Hydroptila (sand grain)									1		
Hydroptila (Caraway seed)	2	8									
Elmidae	3	4		3	1						
Ceratopogonidae	1	5									
Dixidae			1								
Orthocladinae	38	65	11	4	8	3			1	1	4
Cricotopus											2
Tanytarsini		2						3		4	
Pentaneura	15	10		1		1					
Simulidae	93	45	1	6			2				
Tipulidae											1
Muscidae				5							
Lymnaeidae											3
Thiaridae				1	1	2			4		22
Corbulicidae	1			1		3			2	1	3
Potomanautes				1							
Polymarticidae							1				

APPENDIX B.1
IFR SITE 1 - APPEL

INDICATORS OF *FLOW MODIFICATION*		Velocity preference scores	Weight	Weighted score	Rank	% Weight	Std to sum to 1
Presence of taxa with a preference for very fast flowing water	**FT**	2	0.27	0.54	2	90	0.27
Abundance of taxa with a preference for very fast flowing water	**FTA**	3	0.30	0.90	1	100	0.30
Presence of taxa with a preference for moderately fast flowing water	**MT**	2	0.18	0.36	4	60	0.18
Abundance of taxa with a preference for moderately fast flowing water	**MTA**	2	0.19	0.39	3	65	0.19
Presence of taxa with a preference for slow flowing water	**ST**	1	0.03	0.03	5	10	0.03
Abundance of taxa with a preference for slow flowing water	**STA**	1	0.03	0.03	5	10	0.03
Proportional change in average flow dependence of the assemblage			1	**44.78**		**335**	**1**

INDICATORS OF *HABITAT PREFERENCE*		Habitat preference scores	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Has the proportion of invertebrates with a preference for bedrock changed relative to expected?	**BT**	2	0.18	0.36	2	95	0.18
Has the abundance of any of the taxa with a preference for bedrock/boulders changed?	**BTA**	3	0.19	0.56	1	100	0.19
Has the proportion of invertebrates with a preference for mobile cobbles changed relative to expected?	**CT**	2	0.12	0.24	6	65	0.12
Has the abundance of any of the taxa with a preference for mobile cobbles changed?	**CTA**	2	0.13	0.26	5	70	0.13
Has the proportion of invertebrates with a preference for vegetation changed relative to expected?	**VT**	2	0.15	0.30	4	80	0.15
Has the abundance of any of the taxa with a preference for vegetation changed?	**VTA**	3	0.16	0.48	3	85	0.16
Has the proportion of invertebrates with a preference for sand, gravel or mud changed relative to expected?	**GT**	1	0.02	0.02	7	10	0.02
Have the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	**GTA**	1	0.02	0.02	7	10	0.02
Has the proportion of invertebrates with a preference for the water column or water surface changed relative to expected?	**WT**	1	0.02	0.02	7	10	0.02
Has the abundance of any of the taxa with a preference for the water column/water surface changed?	**WTA**	1	0.02	0.02	7	10	0.02
			1			535	1.00
Overall change in habitat assemblages				**43.93**			

INDICATORS OF ***WATER QUALITY***		Water quality requirement score	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Are any taxa with a high requirement for unmodified water quality absent?	**HQ**	1	0.19	0.1882	3	80	0.19
Have the abundance of any of the taxa with a high requirement for unmodified water quality been decreased?	**HQA**	2	0.24	0.4706	1	100	0.24
Are any taxa with a moderate requirement for unmodified water quality absent?	**MQ**	1	0.18	0.1765	4	75	0.18
Have the abundance of any of the taxa with a moderate requirement for unmodified water quality been decreased?	**MQA**	2	0.21	0.4235	2	90	0.21
Are any taxa with a low requirement for unmodified water quality present?	**LQ**	1	0.09	0.0941	5	40	0.09
Have the abundance of any of the taxa with a low requirement for unmodified water quality been increased?	**LQA**	1	0.09	0.0941	5	40	0.09
How does the total SASS score differ from expected?	**SASS**		0.00	0.0000			0.00
			1			425	
Overall change to indicators of modified water quality				**25.18**			

PES metrics	Estimated indicator score	Weight	Weighted score	Expected Natural Reference Weighted Score	*Calc weight*	READ	Rank	% Weight	Std to sum to 1	Weight relative to 1
FLOW MODIFICATION	55.2	0.301	16.6	30.1	*0.301*	FT	1	100	0.385	1
HABITAT	56.1	0.432	24.2	43.2	*0.432*	CT	2	90	0.346	0.9
WATER QUALITY	74.8	0.267	20.0	26.7	*0.267*	HQ	3	70	0.269	0.7
	186.1	1		100	1.000				0.385	
Invert PES			**60.8**					260	1	
Category	37.22		**C**	**(C/D)**						

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

APPENDIX B.2
IFR SITE 2 - LETSITELE

INDICATORS OF *FLOW MODIFICATION*		Velocity preference scores	Weight	Weighted score	Rank	% Weight	Std to sum to 1
Presence of taxa with a preference for very fast flowing water	**FT**	2	0.21	0.42	3	80	0.21
Abundance of taxa with a preference for very fast flowing water	**FTA**	3	0.26	0.79	1	100	0.26
Presence of taxa with a preference for moderately fast flowing water	**MT**	3	0.20	0.59	4	75	0.20
Abundance of taxa with a preference for moderately fast flowing water	**MTA**	4	0.22	0.89	2	85	0.22
Presence of taxa with a preference for slow flowing water	**ST**	1	0.05	0.05	5	20	0.05
Abundance of taxa with a preference for slow flowing water	**STA**	1	0.05	0.05	5	20	0.05
Proportional change in average flow dependence of the assemblage			1	**56.05**		**380**	**1**

INDICATORS OF *HABITAT PREFERENCE*		Habitat preference scores	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Has the proportion of invertebrates with a preference for bedrock changed relative to expected?	**BT**	2	0.06	0.12	6	30	0.06
Has the abundance of any of the taxa with a preference for bedrock/boulders changed?	**BTA**	2	0.06	0.12	6	30	0.06
Has the proportion of invertebrates with a preference for mobile cobbles changed relative to expected?	**CT**	3	0.18	0.55	2	90	0.18
Has the abundance of any of the taxa with a preference for mobile cobbles changed?	**CTA**	3	0.20	0.61	1	100	0.20
Has the proportion of invertebrates with a preference for vegetation changed relative to expected?	**VT**	3	0.14	0.43	4	70	0.14
Has the abundance of any of the taxa with a preference for vegetation changed?	**VTA**	4	0.14	0.57	3	70	0.14
Has the proportion of invertebrates with a preference for sand, gravel or mud changed relative to expected?	**GT**	1	0.08	0.08	5	40	0.08
Have the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	**GTA**	1	0.08	0.08	5	40	0.08
Has the proportion of invertebrates with a preference for the water column or water surface changed relative to expected?	**WT**	2	0.02	0.04	7	10	0.02
Has the abundance of any of the taxa with a preference for the water column/water surface changed?	**WTA**	2	0.02	0.04	7	10	0.02
			1			490	1.00
Overall change in habitat assemblages				**48.16**			

INDICATORS OF *WATER QUALITY*		Water quality requirement score	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Are any taxa with a high requirement for unmodified water quality absent?	**HQ**	2	0.23	0.4571	2	80	0.23
Have the abundance of any of the taxa with a high requirement for unmodified water quality been decreased?	**HQA**	4	0.29	1.1429	1	100	0.29
Are any taxa with a moderate requirement for unmodified water quality absent?	**MQ**	3	0.14	0.4286	4	50	0.14
Have the abundance of any of the taxa with a moderate requirement for unmodified water quality been decreased?	**MQA**	4	0.17	0.6857	3	60	0.17
Are any taxa with a low requirement for unmodified water quality present?	**LQ**	2	0.09	0.1714	5	30	0.09
Have the abundance of any of the taxa with a low requirement for unmodified water quality been increased?	**LQA**	2	0.09	0.1714	5	30	0.09
How does the total SASS score differ from expected?	**SASS**						
How does the total ASPT score differ from expected?	**ASPT**						
			1			350	
Overall change to indicators of modified water quality				**54.29**			

PES metrics	Estimated indicator score	Weight	Weighted score	Expected Natural Reference Weighted Score	*Calc weight*	READ	Rank	% Weight	Std to sum to 1	Weight relative to 1
FLOW MODIFICATION	43.9	0.194	8.5	19.4	*0.194*	FT	3	50	0.208	0.5
HABITAT	51.8	0.450	23.3	45.0	*0.450*	CT	2	90	0.375	0.9
WATER QUALITY	45.7	0.357	16.3	35.7	*0.357*	HQ	1	100	0.417	1
	141.5	1		100	1.000				0.417	
Invert PES			**48.1**					240	1	
Category	28.30		**D**							

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

APPENDIX B.3
IFR SITE 3 - DIE EILAND

INDICATORS OF *FLOW MODIFICATION*		Velocity preference scores	Weight	Weighted score	Rank	% Weight	Std to sum to 1
Presence of taxa with a preference for very fast flowing water	**FT**	4	0.24	0.95	1	100	0.24
Abundance of taxa with a preference for very fast flowing water	**FTA**	4	0.21	0.86	2	90	0.21
Presence of taxa with a preference for moderately fast flowing water	**MT**	3	0.17	0.50	3	70	0.17
Abundance of taxa with a preference for moderately fast flowing water	**MTA**	4	0.17	0.67	3	70	0.17
Presence of taxa with a preference for slow flowing water	**ST**	1	0.11	0.11	4	45	0.11
Abundance of taxa with a preference for slow flowing water	**STA**	1	0.11	0.11	4	45	0.11
Proportional change in average flow dependence of the assemblage			1	**63.81**		**420**	**1**

INDICATORS OF *HABITAT PREFERENCE*		Habitat preference scores	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Has the proportion of invertebrates with a preference for bedrock changed relative to expected?	**BT**	2	0.05	0.10	6	30	0.05
Has the abundance of any of the taxa with a preference for bedrock/boulders changed?	**BTA**	2	0.05	0.10	6	30	0.05
Has the proportion of invertebrates with a preference for mobile cobbles changed relative to expected?	**CT**	2	0.16	0.32	2	95	0.16
Has the abundance of any of the taxa with a preference for mobile cobbles changed?	**CTA**	3	0.17	0.50	1	100	0.17
Has the proportion of invertebrates with a preference for vegetation changed relative to expected?	**VT**	3	0.13	0.40	4	80	0.13
Has the abundance of any of the taxa with a preference for vegetation changed?	**VTA**	3	0.14	0.43	3	85	0.14
Has the proportion of invertebrates with a preference for sand, gravel or mud changed relative to expected?	**GT**	1	0.10	0.10	5	60	0.10
Have the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	**GTA**	1	0.10	0.10	5	60	0.10
Has the proportion of invertebrates with a preference for the water column or water surface changed relative to expected?	**WT**	1	0.05	0.05	6	30	0.05
Has the abundance of any of the taxa with a preference for the water column/water surface changed?	**WTA**	2	0.05	0.10	6	30	0.05
			1			600	1.00
Overall change in habitat assemblages				**43.83**			

INDICATORS OF *WATER QUALITY*		Water quality requirement score	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Are any taxa with a high requirement for unmodified water quality absent?	**HQ**	2	0.22	0.4318	2	95	0.22
Have the abundance of any of the taxa with a high requirement for unmodified water quality been decreased?	**HQA**	2	0.23	0.4545	1	100	0.23
Are any taxa with a moderate requirement for unmodified water quality absent?	**MQ**	1	0.18	0.1818	4	80	0.18
Have the abundance of any of the taxa with a moderate requirement for unmodified water quality been decreased?	**MQA**	1	0.19	0.1932	3	85	0.19
Are any taxa with a low requirement for unmodified water quality present?	**LQ**	1	0.09	0.0909	5	40	0.09
Have the abundance of any of the taxa with a low requirement for unmodified water quality been increased?	**LQA**	1	0.09	0.0909	5	40	0.09
			1			440	
Overall change to indicators of modified water quality				**28.86**			

PES metrics	Estimated indicator score	Weight	Weighted score	Expected Natural Reference Weighted Score	*Calc weight*	READ	Rank	% Weight	Std to sum to 1	Weight relative to 1
FLOW MODIFICATION	36.2	0.249	9.0	24.9	*0.249*	FT	3	75	0.294	0.75
HABITAT	56.2	0.474	26.6	47.4	*0.474*	CT	1	100	0.392	1
WATER QUALITY	71.1	0.278	19.8	27.8	*0.278*	HQ	2	80	0.314	0.8
	163.5	1		100	1.000				0.392	
Invert PES			**55.4**					255	1	
Category	32.70		**D**							

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

APPENDIX B.4
IFR SITE 4 - LETABA RANCH

INDICATORS OF *FLOW MODIFICATION*		Velocity preference scores	Weight	Weighted score	Rank	% Weight	Std to sum to 1
Presence of taxa with a preference for very fast flowing water	**FT**	3	0.24	0.73	1	100	0.24
Abundance of taxa with a preference for very fast flowing water	**FTA**	4	0.22	0.88	2	90	0.22
Presence of taxa with a preference for moderately fast flowing water	**MT**	2	0.18	0.37	4	75	0.18
Abundance of taxa with a preference for moderately fast flowing water	**MTA**	3	0.21	0.62	3	85	0.21
Presence of taxa with a preference for slow flowing water	**ST**	1	0.07	0.07	5	30	0.07
Abundance of taxa with a preference for slow flowing water	**STA**	1	0.07	0.07	5	30	0.07
Proportional change in average flow dependence of the assemblage			1	**54.88**		**410**	**1**

INDICATORS OF *HABITAT PREFERENCE*		Habitat preference scores	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Has the proportion of invertebrates with a preference for bedrock changed relative to expected?	**BT**	3	0.10	0.31	4	75	0.10
Has the abundance of any of the taxa with a preference for bedrock/boulders changed?	**BTA**	4	0.10	0.41	4	75	0.10
Has the proportion of invertebrates with a preference for mobile cobbles changed relative to expected?	**CT**	2	0.12	0.25	2	90	0.12
Has the abundance of any of the taxa with a preference for mobile cobbles changed?	**CTA**	3	0.14	0.41	1	100	0.14
Has the proportion of invertebrates with a preference for vegetation changed relative to expected?	**VT**	3	0.12	0.37	4	90	0.12
Has the abundance of any of the taxa with a preference for vegetation changed?	**VTA**	4	0.12	0.47	3	85	0.12
Has the proportion of invertebrates with a preference for sand, gravel or mud changed relative to expected?	**GT**	1	0.10	0.10	4	75	0.10
Have the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	**GTA**	1	0.10	0.10	4	75	0.10
Has the proportion of invertebrates with a preference for the water column or water surface changed relative to expected?	**WT**	1	0.04	0.04	5	30	0.04
Has the abundance of any of the taxa with a preference for the water column/water surface changed?	**WTA**	1	0.04	0.04	5	30	0.04
			1			725	1.00
Overall change in habitat assemblages				**44.55**			

INDICATORS OF *WATER QUALITY*		Water quality requirement score	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Are any taxa with a high requirement for unmodified water quality absent?	**HQ**	2	0.24	0.4878	1	100	0.24
Have the abundance of any of the taxa with a high requirement for unmodified water quality been decreased?	**HQA**	2	0.22	0.4390	2	90	0.22
Are any taxa with a moderate requirement for unmodified water quality absent?	**MQ**	2	0.15	0.2927	3	60	0.15
Have the abundance of any of the taxa with a moderate requirement for unmodified water quality been decreased?	**MQA**	2	0.15	0.2927	3	60	0.15
Are any taxa with a low requirement for unmodified water quality present?	**LQ**	2	0.12	0.2439	4	50	0.12
Have the abundance of any of the taxa with a low requirement for unmodified water quality been increased?	**LQA**	2	0.12	0.2439	4	50	0.12
			1			410	
Overall change to indicators of modified water quality				**30.24**			

PES metrics	Estimated indicator score	Weight	Weighted score	Expected Natural Reference Weighted Score	*Calc weight*	READ	Rank	% Weight	Std to sum to 1	Weight relative to 1
FLOW MODIFICATION	45.1	0.340	15.4	34.0	*0.340*	FT	1	100	0.417	1
HABITAT	55.4	0.421	23.4	42.1	*0.421*	CT	2	70	0.292	0.7
WATER QUALITY	69.8	0.238	16.6	23.8	*0.238*	HQ	2	70	0.292	0.7
	170.3	1		100	1.000				0.417	
Invert PES			**55.3**					240	1	
Category	34.07		**D**							

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

APPENDIX B.5
IFR 5 - KLEIN LETABA

INDICATORS OF *FLOW MODIFICATION*		Velocity preference scores	Weight	Weighted score	Rank	% Weight	Std to sum to 1
Presence of taxa with a preference for very fast flowing water	**FT**	4	0.25	1.00	1	100	0.25
Abundance of taxa with a preference for very fast flowing water	**FTA**	4	0.23	0.90	2	90	0.23
Presence of taxa with a preference for moderately fast flowing water	**MT**	4	0.20	0.80	3	80	0.20
Abundance of taxa with a preference for moderately fast flowing water	**MTA**	4	0.18	0.70	4	70	0.18
Presence of taxa with a preference for slow flowing water	**ST**	1	0.08	0.08	5	30	0.08
Abundance of taxa with a preference for slow flowing water	**STA**	1	0.08	0.08	5	30	0.08
Proportional change in average flow dependence of the assemblage			1	**71.00**		**400**	**1**

INDICATORS OF *HABITAT PREFERENCE*		Habitat preference scores	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Has the proportion of invertebrates with a preference for bedrock changed relative to expected?	**BT**	3	0.08	0.24	6	60	0.08
Has the abundance of any of the taxa with a preference for bedrock/boulders changed?	**BTA**	4	0.08	0.32	6	60	0.08
Has the proportion of invertebrates with a preference for mobile cobbles changed relative to expected?	**CT**	3	0.09	0.26	5	65	0.09
Has the abundance of any of the taxa with a preference for mobile cobbles changed?	**CTA**	3	0.09	0.26	5	65	0.09
Has the proportion of invertebrates with a preference for vegetation changed relative to expected?	**VT**	3	0.12	0.36	2	90	0.12
Has the abundance of any of the taxa with a preference for vegetation changed?	**VTA**	3	0.14	0.41	1	100	0.14
Has the proportion of invertebrates with a preference for sand, gravel or mud changed relative to expected?	**GT**	1	0.11	0.11	3	80	0.11
Have the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	**GTA**	1	0.11	0.11	3	80	0.11
Has the proportion of invertebrates with a preference for the water column or water surface changed relative to expected?	**WT**	1	0.09	0.09	4	70	0.09
Has the abundance of any of the taxa with a preference for the water column/water surface changed?	**WTA**	1	0.09	0.09	4	70	0.09
			1			740	1.00
Overall change in habitat assemblages				**37.30**			

INDICATORS OF *WATER QUALITY*		Water quality requirement score	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Are any taxa with a high requirement for unmodified water quality absent?	**HQ**	2	0.20	0.4091	2	90	0.20
Have the abundance of any of the taxa with a high requirement for unmodified water quality been decreased?	**HQA**	2	0.23	0.4545	1	100	0.23
Are any taxa with a moderate requirement for unmodified water quality absent?	**MQ**	2	0.16	0.3182	4	70	0.16
Have the abundance of any of the taxa with a moderate requirement for unmodified water quality been decreased?	**MQA**	2	0.17	0.3409	3	75	0.17
Are any taxa with a low requirement for unmodified water quality present?	**LQ**	1	0.11	0.1136	6	50	0.11
Have the abundance of any of the taxa with a low requirement for unmodified water quality been increased?	**LQA**	1	0.13	0.1250	5	55	0.13
			1			440	
Overall change to indicators of modified water quality				**30.45**			

PES metrics	Estimated indicator score	Weight	Weighted score	Expected Natural Reference Weighted Score	*Calc weight*	READ	Rank	% Weight	Std to sum to 1	Weight relative to 1
FLOW MODIFICATION	29.0	0.387	11.2	38.7	*0.387*	FT	1	100	0.476	1
HABITAT	62.7	0.358	22.4	35.8	*0.358*	VTA	3	50	0.238	0.5
WATER QUALITY	69.5	0.255	17.8	25.5	*0.255*	HQA	2	60	0.286	0.6
	161.2	1		100	1.000				0.476	
Invert PES			**51.4**					210	1	
Category	32.25		**D**							

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

APPENDIX B.6
IFR SITE 6 - LONELY BULL

INDICATORS OF *FLOW MODIFICATION*		Velocity preference scores	Weight	Weighted score	Rank	% Weight	Std to sum to 1
Presence of taxa with a preference for very fast flowing water	**FT**	3	0.22	0.65	2	90	0.22
Abundance of taxa with a preference for very fast flowing water	**FTA**	4	0.24	0.96	1	100	0.24
Presence of taxa with a preference for moderately fast flowing water	**MT**	2	0.19	0.39	4	80	0.19
Abundance of taxa with a preference for moderately fast flowing water	**MTA**	3	0.20	0.61	3	85	0.20
Presence of taxa with a preference for slow flowing water	**ST**	1	0.07	0.07	5	30	0.07
Abundance of taxa with a preference for slow flowing water	**STA**	1	0.07	0.07	5	30	0.07
Proportional change in average flow dependence of the assemblage			1	**55.18**		**415**	**1**

INDICATORS OF *HABITAT PREFERENCE*		Habitat preference scores	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Has the proportion of invertebrates with a preference for bedrock changed relative to expected?	**BT**	1	0.05	0.05	6	30	0.05
Has the abundance of any of the taxa with a preference for bedrock/boulders changed?	**BTA**	2	0.05	0.10	6	30	0.05
Has the proportion of invertebrates with a preference for mobile cobbles changed relative to expected?	**CT**	2	0.14	0.28	3	85	0.14
Has the abundance of any of the taxa with a preference for mobile cobbles changed?	**CTA**	2	0.14	0.28	3	85	0.14
Has the proportion of invertebrates with a preference for vegetation changed relative to expected?	**VT**	3	0.16	0.47	2	95	0.16
Has the abundance of any of the taxa with a preference for vegetation changed?	**VTA**	4	0.17	0.66	1	100	0.17
Has the proportion of invertebrates with a preference for sand, gravel or mud changed relative to expected?	**GT**	1	0.08	0.08	4	50	0.08
Have the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	**GTA**	1	0.08	0.08	4	50	0.08
Has the proportion of invertebrates with a preference for the water column or water surface changed relative to expected?	**WT**	1	0.07	0.07	5	40	0.07
Has the abundance of any of the taxa with a preference for the water column/water surface changed?	**WTA**	1	0.07	0.07	5	40	0.07
			1			605	1.00
Overall change in habitat assemblages				**42.81**			

INDICATORS OF *WATER QUALITY*		Water quality requirement score	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Are any taxa with a high requirement for unmodified water quality absent?	**HQ**	2	0.25	0.5000	2	95	0.25
Have the abundance of any of the taxa with a high requirement for unmodified water quality been decreased?	**HQA**	2	0.26	0.5263	1	100	0.26
Are any taxa with a moderate requirement for unmodified water quality absent?	**MQ**	1	0.16	0.1579	4	60	0.16
Have the abundance of any of the taxa with a moderate requirement for unmodified water quality been decreased?	**MQA**	1	0.17	0.1711	3	65	0.17
Are any taxa with a low requirement for unmodified water quality present?	**LQ**	1	0.08	0.0789	5	30	0.08
Have the abundance of any of the taxa with a low requirement for unmodified water quality been increased?	**LQA**	1	0.08	0.0789	5	30	0.08
			1			380	
Overall change to indicators of modified water quality				**30.26**			

PES metrics	Estimated indicator score	Weight	Weighted score	Expected Natural Reference Weighted Score	*Calc weight*	READ	Rank	% Weight	Std to sum to 1	Weight relative to 1
FLOW MODIFICATION	44.8	0.272	12.2	27.2	*0.272*	FT	2	80	0.314	0.8
HABITAT	57.2	0.495	28.3	49.5	*0.495*	CT	1	100	0.392	1
WATER QUALITY	69.7	0.233	16.3	23.3	*0.233*	HQ	3	75	0.294	0.75
	171.7	1		100	1.000				0.392	
Invert PES			**56.8**					255	1	
Category	34.35		**D**							

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

APPENDIX B.7
IFR SITE 7 - LETABA BRIDGE

INDICATORS OF *FLOW MODIFICATION*		Velocity preference scores	Weight	Weighted score	Rank	% Weight	Std to sum to 1
Presence of taxa with a preference for very fast flowing water	**FT**	3	0.20	0.61	2	90	0.20
Abundance of taxa with a preference for very fast flowing water	**FTA**	4	0.23	0.91	1	100	0.23
Presence of taxa with a preference for moderately fast flowing water	**MT**	2	0.17	0.34	4	75	0.17
Abundance of taxa with a preference for moderately fast flowing water	**MTA**	3	0.18	0.55	3	80	0.18
Presence of taxa with a preference for slow flowing water	**ST**	1	0.10	0.10	6	45	0.10
Abundance of taxa with a preference for slow flowing water	**STA**	2	0.11	0.23	5	50	0.11
Proportional change in average flow dependence of the assemblage			1	**54.77**		**440**	**1**

INDICATORS OF *HABITAT PREFERENCE*		Habitat preference scores	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Has the proportion of invertebrates with a preference for bedrock changed relative to expected?	**BT**	1	0.05	0.05	5	30	0.05
Has the abundance of any of the taxa with a preference for bedrock/boulders changed?	**BTA**	2	0.05	0.10	5	30	0.05
Has the proportion of invertebrates with a preference for mobile cobbles changed relative to expected?	**CT**	3	0.16	0.49	2	95	0.16
Has the abundance of any of the taxa with a preference for mobile cobbles changed?	**CTA**	3	0.17	0.51	1	100	0.17
Has the proportion of invertebrates with a preference for vegetation changed relative to expected?	**VT**	3	0.15	0.44	3	85	0.15
Has the abundance of any of the taxa with a preference for vegetation changed?	**VTA**	4	0.15	0.58	3	85	0.15
Has the proportion of invertebrates with a preference for sand, gravel or mud changed relative to expected?	**GT**	1	0.09	0.09	4	50	0.09
Have the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?	**GTA**	1	0.09	0.09	4	50	0.09
Has the proportion of invertebrates with a preference for the water column or water surface changed relative to expected?	**WT**	1	0.05	0.05	5	30	0.05
Has the abundance of any of the taxa with a preference for the water column/water surface changed?	**WTA**	1	0.05	0.05	5	30	0.05
			1			585	1.00
Overall change in habitat assemblages				**48.89**			

INDICATORS OF *WATER QUALITY*		Water quality requirement score	Weight	Weighted score	Rank	%Weight	Std to sum to 1
Are any taxa with a high requirement for unmodified water quality absent?	**HQ**	2	0.26	0.5195	1	100	0.26
Have the abundance of any of the taxa with a high requirement for unmodified water quality been decreased?	**HQA**	2	0.25	0.4935	2	95	0.25
Are any taxa with a moderate requirement for unmodified water quality absent?	**MQ**	1	0.17	0.1688	3	65	0.17
Have the abundance of any of the taxa with a moderate requirement for unmodified water quality been decreased?	**MQA**	1	0.17	0.1688	3	65	0.17
Are any taxa with a low requirement for unmodified water quality present?	**LQ**	1	0.08	0.0779	4	30	0.08
Have the abundance of any of the taxa with a low requirement for unmodified water quality been increased?	**LQA**	1	0.08	0.0779	4	30	0.08
			1			385	
Overall change to indicators of modified water quality				**30.13**			

PES metrics	Estimated indicator score	Weight	Weighted score	Expected Natural Reference Weighted Score	*Calc weight*	READ	Rank	% Weight	Std to sum to 1	Weight relative to 1
FLOW MODIFICATION	45.2	0.387	17.5	38.7	*0.387*	FT	1	100	0.408	1
HABITAT	51.1	0.360	18.4	36.0	*0.360*	CT	3	70	0.286	0.7
WATER QUALITY	69.9	0.254	17.7	25.4	*0.254*	HQ	2	75	0.306	0.75
	166.2	1		100	1.000				0.408	
Invert PES			**53.6**					245	1	
Category	33.24		**D**							

>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F

APPENDIX C

STRESS TABLES

STUDY	LETABA
RIVER	Groot Letaba
IFR SITE	Appel - 1
LATS	
LONGS	
DATE	
PRESENT STRESS	
SASS5	**IHAS**
FLOW	

Site Advantages
Site Disadvantages

Habitat Flow Response Index	HABITAT ABUNDANCE AND SUITABILITY: SIC	SOC	VIC	VOC	GSM	TOTAL	MODIFIER	FLOW	HABITAT RESPONSE	HABITAT CHARACTERISTICS
Rating (site at observed flow)	4	1	3	1	2	11		0.45		
0	5	2	3	2	2	14		1.1	All habitat in excess, very high quality: Very Fast, Very deep, very wide WP	max depth: 0.60; avg depth: 0.34; avg vel: 0.4; width 9.5; WP0.34; Area 2.75
1	4	1	3	2	2	12		0.685	All plentifull, high quality; Fast, Deep, wide WP	max depth: 0.50; avg depth: 0.28; avg vel: 0.34; width 6.98; WP:8.09; Area 1.99
2	4	1	3	1	2	11		0.45	Critical habitats sufficient; quality slightly reduced: Fast, Deep, Wide WP slightly reduced	max depth: 0.44; avg depth: 0.26; avg vel: 0.31; width 6.11; WP 7.08; Area 1.59
3	3	2	2	1	2	10		0.331	Reduced critical habitat, reduced critical quality; Moderate velocity, fairly deep, WP slightly/moderately reduced	max depth: 0.38; avg depth: 0.23; avg vel: 0.26; width 5.43; WP 6.25; Area 1.25
4	3	2	1	0	1	7		0.26	Critical habitats limited; moderate quality: Moderate velocity, Some deep areas, Wide WP moderately reduced	max depth: 0.34; avg depth: 0.21; avg vel: 0.24; width 4.98; WP 5.67; Area 1.04
5	2	2	1	0	1	6		0.147	Critical habitat very reduced; moderate/ low quality; Moderate/slow velocity, few deep areas WP moderately/very reduced	max depth: 0.28; avg depth: 0.18; avg vel: 0.19; width 4.24; WP 4.74; Area 0.77
6	2	1	1	0	1	5		0.098	Critical habitat residual. Low quality; Moderate/slow velocity, no deep areas Narrow WP	max depth: 0.24; avg depth: 0.17; avg vel: 0.16; width 3.57; WP3.96; Area 0.61
7	2	1	0	0	1	4		0.033	No critical habitat, Other habitats moderate quality; Slow, shallow,	max depth: 0.16; avg depth: 0.11; avg vel: 0.010; width 3.17; WP 3.38; Area 0.34
8	1	1	0	0	1	3		0.005	Flowing water habitats residual Low quality: Slow Trickle, very narrow WP	max depth: 0.08; avg depth: 0.05; avg vel: 0.005; width 2.47; WP 2.54; Area 0.11
9	0	1	0	0	1	2		0	Standing water habitats only, very low quality, no flow	max depth: 0.02; avg depth: 0.01; avg vel: 0.002; width 0.7; WP 0.71; Area 0.01
10	0	0	0	0	0	0		0	Only hyporheic refugia, no surface water	

Habitat Flow Response Index	BIOTIC RESPONSE: Trichorythus	Flow	SPECIES STRESS	CRIT STRESS
Rating (site at observed flow)				
0	All very abundant, All healthy, all species persist	0.43	0	1.8
1	All abundant, All healthy, all species persist		1	2
2	Slight reduction for sensitive rheophilic species, All healthy in some areas, all species persist		2	2.8
3	Reduction for all rheophilic species, All healthy in limited areas, All species persist	0.246	3	3.2
4	Further reduction for all rheophilic species; All viable in limited areas, critical life stages of some sensitive rheophilic species at risk, all species persist		4	4
5	Limited populations of all rheophilic species. Critical life-stages of sensitive rheophilic species at risk or non-viable; All species persist		5	5
6	Sensitive rheophilic species rare, critical stages of sensitive rheophilic species non-viable, and at risk for some less sensitive species. All species persisit in the short-term	0.177	6	6
7	Most rheophilic species rare; All life-stages of sensitive rheophilic species at risk or non-viable. Most sensitive rheophilic species disappear		7	7
8	Remnant populations of some rheophilic species; All life stages of most rheophilic species at risk or non-viable, many rheophilic species disappear		8	8
9	Mostly pool dwellers, All life stages of most rheophilic species non-viable; Most or all rheophilic species disappear		9	9
10	No rheophilic species present	0.06	10	10

Habitat Flow Response Index	SPECIES STRESS	CRIT STRESS	REC C (CD invertebrates): DRY SEASON REQUIREMENTS (Lowest Flow Month - September): Dur	Comment	REC C: WET SEASON REQUIREMENTS (February): Dur	Comment	REC D: DRY SEASON REQUIREMENTS: Dur	Comment	REC D: WET SEASON REQUIREMENTS: Dur	Comment
Rating (site at observed flow)										
0	0	1.8								
1	1	2								
2	2	2.8								
3	3	3.2			**30**	Maintenance values. Variety of velocities to ensure a healthy Tricorythus population (breeding/growing)				
4	4	4	**30**	Maintenance values. Minimum value to maintain viable over-wintering population of Tricorythus indicator populations					**30**	Maintenance Values - Driest months - No loss of species - serious loss of abundance - breeding viable
5	5	5								
6	6	6			10	Drought Values - Ensure that Tricorythus indcator sp. Survives. Note: Too high	**30**	Maintenance Values - Driest months - No loss of species - serious loss of abundance	10	Drought Values - Ensure that Tricorythus indcator sp. Survives. Note: Too high
7	7	7	10	Drought Values - Ensure that Tricorythus indcator sp. Survives. Minimum			10	Drought Values - Ensure that Tricorythus indcator sp. survives		
8	8	8								
9	9	9								
10	10	10	0		0		0		0	

Definitions

SIC	Partially submerged hard substrate in current >0.1m/s
SOC	Partally submerged hard substrate in current <0.1m/s
VIC	Submerged vegetation (at least 2-3cm submerged) in current >0.1m/s
VOC	Submerged vegetation (at least 2-3cm submerged) in current<0.1m/s
GSM	Small particles submerged

STUDY	LETABA
River	Letsitele
IFR SITE	Letsitele - 2
LATS	
LONGS	
DATE	
PRESENT STRES	
SASS5	**IHAS**
FLOW	

Site Advantages
Site Disadvantages

Habitat Flow Response Index	HABITAT ABUNDANCE AND SUITABILITY					TOTAL	MODIFIER	FLOW	HABITAT RESPONSE	HABITAT CHARACTERISTICS	BIOTIC RESPONSE	Flow	SPECIES STRESS		SPECIES STRESS
	SIC	SOC	VIC	VOC	GSM						Trichorythus				
Rating (site at observed flow)	3	3	5	3	2	16	Filamentous algae, reasonable velocities	**0.85**							
0	5	5	5	4	3	22		1.4	All habitat in excess, very high quality: Very Fast, Very deep, very wide WP	max depth:0.48; avg depth:0.3; avg vel:0.252; width:19.097; area:5.826; WP:19.499	All very abundant, All healthy, all species persist		0	1.46	0
1	4	4	5	4	3	20		1.153	All plentifull, high quality; Fast, Deep, wide WP	max depth:0.44; avg depth:0.26; avg vel:0.228; width:18.953; area:5.065; WP:19.331	All abundant, All healthy, all species persist	1.4	1	1.4	1
2	3	3	5	3	2	16	Filamentous algae, reasonable	**0.85**	Critical habitats sufficient; quality slightly reduced: Fast, Deep, Wide WP slightly reduced	max depth:0.4; avg depth:0.22; avg vel:0.206; width:18.8; area:4.3; WP:19.16	Slight reduction for sensitive rheophilic species, All healthy in some areas, all species persist		2	1.15	2
3	3	2	4	3	2	14		0.332	Reduced critical habitat, reduced critical quality; Moderate velocity, fairly deep, WP slightly/moderately reduced	max depth:0.28; avg depth:0.11; avg vel:0.16; width:18.401; area:2.076; WP:18.663	Reduction for all rheophilic species, All healthy in limited areas, All species persist	0.887	3	0.887	3
4	2	2	4	2	2	12	Filamentous algae, shallow water, reasonable velocities	**0.087**	Critical habitats limited; moderate quality: Moderate velocity, Some deep areas, Wide WP moderately reduced	max depth:0.17; avg depth:0.08; avg vel:0.12; width:8; area:0.7; WP:8	Further reduction for all rheophilic species; All viable in limited areas, critical life stages of some sensitive rheophilic species at risk, all species persist		4	0.7	4
5	2	2	3	2	2	11		0.049	Critical habitat very reduced; moderate/ low quality; Moderate/slow velocity, few deep areas WP moderately/very reduced	max depth:0.14; avg depth:0.07; avg vel:0.101; width:6.525; area:0.487; WP:6.677	Limited populations of all rheophilic species. Critical life-stages of sensitive rheophilic species at risk or non-viable; All species persist		5	0.5	5
6	2	2	2	2	1	9		0.019	Critical habitat residual. Low quality; Moderate/slow velocity, no deep areas Narrow WP	max depth:0.1; avg depth:0.05; avg vel:0.075; width:4.955; area:0.261; WP:5.066	Sensitive rheophilic species rare, critical stages of sensitive rheophilic species non-viable, and at risk for some less sensitive species. All species perisit in the short-term	0.332	6	0.332	6
7	2	2	1	2	1	8		0.011	No critical habitat, Other habitats moderate quality; Slow, shallow, narrow WP	max depth:0.08; avg depth:0.04; avg vel:0.063; width:4.225; area:0.168; WP:4.362	Most rheophilic species rare; All life-stages of sensitive rheophilic species at risk or non-viable. Most sensitive rheophilic species disappear		7	0.2	7

8	1	1	1	2	1	6		0.002	Flowing water habitats residual Low quality: Slow Trickle, very narrow WP	max depth:0.04; avg depth:0.02; avg vel:0.041; width:2.123; area:0.038; WP:2.158	Remnant populations of some rheophilic species; All life stages of most rheophilic species at risk or non-viable, many rheophilic species disappear	0.098	8	0.098	8
9	0	1	0	2	1	4		0	Standing water habitats only, very low quality, no flow	max depth:0.02; avg depth:0.01; avg vel:0.033; width:0.982; area:0.007; WP:.996	Mostly pool dwellers, All life stages of most rheophilic species non-viable; Most or all rheophilic species disappear		9	0.075	9
10	0	0	0	0	0	0		0	Only hyporheic refugia, no surface water		Only specialists persist, virtually no development.	0.049	10	0.049	10

Definitions

SIC Partially submerged hard substrate in current >0.1m/s

SOC Partally submerged hard substrate in current <0.1m/s

VIC Submerged vegetation (at least 2-3cm submerged) in current >0.1m/s

VOC Submerged vegetation (at least 2-3cm submerged) in current<0.1m/s

GSM Small particles submerged

	REC D							
CRIT STRESS	DRY SEASON REQUIREMENTS (September)		WET SEASON REQUIREMENTS (February)		DRY SEASON REQUIREMENTS		WET SEASON REQUIREMENTS	
	Dur	Comment	Dur	Comment	Dur	Comment	Dur	Comment
0								
1								
2								
3								
4			30	Maintenance				
5								
6			10%	Drought				
7	30	Maintenance						

8								
9	10%	Drought						
10								

STUDY	LETABA
RIVER	Letaba
IFR SITE	Die Eiland - 3
LATS	
LONGS	
DATE	
PRESENT STRESS	
SASS5	**IHAS**
FLOW	

Site Advantages
Site Disadvantages

Velocity Distributions	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge
	0.05	**0.1**	**0.2**	**0.5**	**0.95**	**3.91**	**10**
<0.1	41	37	30	22	17	5	4
<0.3	92	84	69	49	38	15	11
<0.6	100	100	98	86	72	32	24
0.1-0.3	51	47	39	27	21	10	7
0.3-0.6	8	16	29	37	34	17	13
>0.6	0	0	2	14	28	68	97

Rheophiles defined as all spp requiring >0.3m/s

Habitat Flow Response Index	HABITAT ABUNDANCE AND SUITABILITY					TOTAL	MODIFIER	FLOW	HABITAT RESPONSE	HABITAT CHARACTERISTICS (Hydraulic parameters as measured by ALB)
	SIC	SOC	VIC	VOC	GSM					
Rating (site at observed flow)	3	3	2	2	3	13		**0.2**		
0	4	4	5	4	3	20		0.95	All habitat in excess, very high quality: Very Fast, Very deep, very wide WP	Max depth:0.36 Av depth:0.24 Area:2.08 Width:8.76 WP:9.45 Av. velocity:0.45
1	4	4	4	3	3	18		0.69	All plentifull, high quality; Fast, Deep, wide WP	Max depth:0.32 Av depth:0.2 Area:1.73 Width:8.7 WP:9.35 Av. velocity:0.4
2	4	4	3	3	3	17		0.5	Critical habitats sufficient; quality slightly reduced: Fast, Deep, Wide WP slightly reduced	Max depth:0.28 Av depth :0.18 Area:1.39 Width:7.83 WP:8.43 Av. velocity:0.35
3	3	3	2	2	3	13		0.2	Reduced critical habitat, reduced critical quality; Moderate velocity, fairly deep, WP slightly/moderately reduced	Max depth:0.20 Av depth:0.13 Area:0.85 Width:6.3 WP:6.71 Av. velocity:0.24
4	3	3	2	2	2	12		0.1	Critical habitats limited; moderate quality: Moderate velocity, Some deep areas, Wide WP moderately reduced	Max depth:016 Av depth:0.1 Area:0.6 Width :6.09 WP :6.38 Av. velocity :0.19
5	2	2	1	2	2	9		0.08	Critical habitat very reduced; moderate/ low quality; Moderate/slow velocity, few deep areas WP moderately/very reduced	Max depth: 0.14 Av depth:0.08 Area:0.48 Width:5.9 WP:6.13 Av. velocity :0.17
6	2	2	0	1	2	7		0.05	Critical habitat residual. Low quality; Moderate/slow velocity, no deep areas Narrow WP	Max depth:0.12 Av depth:0.06 Area :0.36 Width:5.67 WP :5.85 Av. velocity:0.15
7	1	2	0	1	2	6		0.03	No critical habitat, Other habitats moderate quality; Slow, shallow, narrow WP	Max depth :0.10 Av depth:0.05 Area:0.25 Width:5.16 WP:5.30 Av. velocity :0.14
8	1	1	0	1	2	5		0.02	Flowing water habitats residual Low quality: Slow Trickle, very narrow WP	Max depth :0.08 Av depth:0.03 Area:0.16 Width:4.64 WP:4.73 Av. velocity :0.13
9	0	1	0	1	2	4		0	Standing water habitats only, very low quality, no flow	Max depth:0.04 Av depth:0.02 Area:0.03 Width:1.84 WP:1.87 Av. velocity:0.12
10	0	0	0	0	0	0		0	Only hyporheic refugia, no surface water	

BIOTIC RESPONSE Using the full community of inverts present	Flow	COMMUNITY STRESS	CRIT STRESS
All very abundant, All healthy, all species persist	0.95	0	1.2
All abundant, All healthy, all species persist	0.77	1	2
Slight reduction for sensitive rheophilic species, All healthy in some areas, all species persist	0.5	2	3
Reduction for all rheophilic species, All healthy in limited areas, All species persist	0.35	3	3.9
Further reduction for all rheophilic species; All viable in limited areas, critical life stages of some sensitive rheophilic species at risk, all species persist	0.22	4	4.8
Limited populations of all rheophilic species. Critical life-stages of sensitive rheophilic species at risk or non-viable; All species persist	0.2	5	5.5
Sensitive rheophilic species rare, critical stages of sensitive rheophilic species non-viable, and at risk for some less sensitive species. All species persisit in the short-term	0.12	6	6.8
Most rheophilic species rare; All life-stages of sensitive rheophilic species at risk or non-viable. Most sensitive rheophilic species disappear	0.05	7	9
Remnant populations of some rheophilic species; All life stages of most rheophilic species at risk or non-viable, many rheophilic species disappear		8	9.5
Mostly pool dwellers, All life stages of most rheophilic species non-viable; Most or all rheophilic species disappear		9	9.8
Only specialists persist, virtually no development.	0	10	10

SPECIES STRESS	CRIT STRESS	REC D				Alternative C			
		DRY SEASON REQUIREMENTS		WET SEASON REQUIREMENTS		DRY SEASON REQUIREMENTS		WET SEASON REQUIREMENTS	
		Dur	Comment	Dur	Comment	Dur	Comment	Dur	Comment

Definitions

SIC Partially submerged hard substrate in current >0.1m/s

SOC Partally submerged hard substrate in current <0.1m/s

VIC Submerged vegetation (at least 2-3cm submerged) in current >0.1m/s

VOC Submerged vegetation (at least 2-3cm submerged) in current<0.1m/s

GSM Small particles submerged

STUDY	LETABA
RIVER	Letaba
IFR SITE	Letaba Ranch - 4
LATS	
LONGS	
DATE	
PRESENT STRESS	
SASS5	**IHAS**
FLOW	

Site Advantages

Site Disadvantages

Habitat Flow Response Index	HABITAT ABUNDANCE AND SUITABILITY SIC	SOC	VIC	VOC	GSM	TOTAL	MODIFIER	FLOW	HABITAT RESPONSE	HABITAT CHARACTERISTICS
Rating (site at observed flow)	4	3	2	2	4	15		0.653		
0	4	4	2	2	4	16		1.184	All habitat in excess, very high quality: Very Fast, Very deep, very wide WP	max depth:0.330; avg depth:0.205; avg vel:1.002; width:5.761; area:1.182; WP:6.302
1	4	3	2	2	4	15		0.915	All plentifull, high quality; Fast, Deep, wide WP	max depth:0.300; avg depth:0.186; avg vel:0.902; width:5.438; area:1.014; WP:5.940
2	4	3	2	2	3	14		0.688	Critical habitats sufficient; quality slightly reduced: Fast, Deep, Wide WP slightly reduced	max depth:0.27; avg depth:0.167; avg vel:0.804; width:5.114; area:0.856; WP:5.579
3	3	3	2	1	3	12		0.446	Reduced critical habitat, reduced critical quality; Moderate velocity, fairly deep, WP slightly/moderately reduced	max depth:0.23; avg depth:0.141; avg vel:0.675; width:4.683; area:0.660; WP:5.096
4	3	2	1	1	2	9		0.23	Critical habitats limited; moderate quality: Moderate velocity, Some deep areas, Wide WP moderately reduced	max depth:0.18; avg depth:0.107; avg vel:0.522; width:4.100; area:0.440; WP:4.410
5	2	2	1	1	2	8	Low abundance SIC, Fines on cobbles, depth (11-15), Diversity of sizes (mostly	0.141	Critical habitat very reduced; moderate/ low quality; Moderate/slow velocity, few deep areas WP moderately/very reduced	max depth:0.15; avg depth:0.095; avg vel:0.475; width:3.117; area:0.295; WP:3.336
6	2	2	1	0	2	7		0.077	Critical habitat residual. Low quality; Moderate/slow velocity, no deep areas Narrow WP	max depth:0.12; avg depth:0.089; avg vel:0.321; width:2.693; area:0.239; WP:2.873
7	2	2	0	0	2	6		0.012	No critical habitat, Other habitats moderate quality; Slow, shallow, narrow WP	max depth:0.06; avg depth:0.037; avg vel:0.135; width:2.368; area:0.087; WP:2.440
8	1	2	0	0	2	5		0.002	Flowing water habitats residual Low quality: Slow Trickle, very narrow WP	max depth:0.030; avg depth:0.018; avg vel:0.067; width:1.483; area:0.027; WP:1.504
9	0	1	0	0	2	3		0	Standing water habitats only, very low quality, no flow	max depth:0.010; avg depth:0.003; avg vel:0.031; width:0.93; area:0.003; WP:0.93
10	0	0	0	0	0	0		0	Only hyporheic refugia, no surface water	

BIOTIC RESPONSE Tricorythus	Flow	SPECIES STRESS	CRIT STRESS
All very abundant, All healthy, all species persist	0.446	0	3.5
All abundant, All healthy, all species persist		1	3.8
Slight reduction for sensitive rheophilic species, All healthy in some areas, all species persist		2	4
Reduction for all rheophilic species, All healthy in limited areas, All species persist	0.23	3	4.4
Further reduction for all rheophilic species; All viable in limited areas, critical life stages of some sensitive rheophilic species at risk, all species persist		4	4.9
Limited populations of all rheophilic species. Critical life-stages of sensitive rheophilic species at risk or non-viable; All species persist		5	5
Sensitive rheophilic species rare, critical stages of sensitive rheophilic species non-viable, and at risk for some less sensitive species. All species persist in the short-term	0.141	6	6
Most rheophilic species rare; All life-stages of sensitive rheophilic species at risk or non-viable. Most sensitive rheophilic species disappear	0.077	7	7
Remnant populations of some rheophilic species; All life stages of most rheophilic species at risk or non-viable, many rheophilic species disappear		8	8
Mostly pool dwellers, All life stages of most rheophilic species non-viable; Most or all rheophilic species disappear		9	9
Only specialists persist, virtually no development.	0.012	10	10

SPECIES STRESS	CRIT STRESS	REC D: DRY SEASON REQUIREMENTS (September) Dur	Comment	REC D: WET SEASON REQUIREMENTS (February) Dur	Comment	EC C: DRY SEASON REQUIREMENTS (September) Dur	Comment	EC C: WET SEASON REQUIREMENTS (February) Dur	Comment
0	3.5							30%	Maintenance
1	3.8								
2	4			30%	Maintenance				
3	4.4								
4	4.9								
5	5			10%	Drought	30%	Maintenance	10%	Drought
6	6	30%	Maintenance						
7	7								
8	8	10%	Drought			10%	Drought		
9	9								
10	10	0%				0%			

Definitions

SIC	Partially submerged hard substrate in current >0.1m/s
SOC	Partally submerged hard substrate in current <0.1m/s
VIC	Submerged vegetation (at least 2-3cm submerged) in current >0.1m/s
VOC	Submerged vegetation (at least 2-3cm submerged) in current<0.1m/s
GSM	Small particles submerged

STUDY	LETABA					
River	Klein Letaba					
IFR SITE	Klein Letaba - 5					
LATS						
LONGS						
DATE						
PRESENT STRESS						
SASS5				IHAS		
FLOW						

Site Advantages
Site Disadvantages

Habitat Flow Response Index	HABITAT ABUNDANCE AND SUITABILITY					TOTAL	MODIFIER	FLOW	HABITAT RESPONSE	HABITAT CHARACTERISTICS
	SIC	SOC	VIC	VOC	GSM					
Rating (site at observed flow)	1	1	4	4	4	14		**0.27**		
0	1	2	5	5	5	18		0.783	All habitat in excess, very high quality: Very Fast, Very deep, very wide WP	max depth:0.48; avg depth:0.129; avg vel:0.078; width:78.511; area:10.093; WP:78.62
1	1	2	5	4	5	17		0.523	All plentifull, high quality; Fast, Deep, wide WP	max depth:0.44; avg depth:0.129; avg vel:0.071; width:57.365; area:7.375; WP:57.452
2	1	2	4	4	5	16		0.421	Critical habitats sufficient; quality slightly reduced: Fast, Deep, Wide WP slightly reduced	max depth:0.42; avg depth:0.124; avg vel:0.063; width:50.618; area:6.295; WP:50.697
3	1	2	4	4	4	15		0.336	Reduced critical habitat, reduced critical quality; Moderate velocity, fairly deep, WP slightly/moderately reduced	max depth:0.4; avg depth:0.122; avg vel:0.063; width:43.872; area:5.351; WP:49.943
4	1	1	4	4	4	14		**0.27**	Critical habitats limited; moderate quality: Moderate velocity, Some deep areas, Wide WP moderately reduced	max depth:0.38; avg depth:0.118; avg vel:0.058; width:38.314; area:4.535; WP:38.377
5	1	1	3	4	4	13		**0.089**	Critical habitat very reduced; moderate/low quality; Moderate/slow velocity, few deep areas WP moderately/very reduced	max depth:0.3; avg depth:0.099; avg vel:0.049; width18.074; area:1.791; WP:18.096
6	1	1	2	4	4	12		**0.046**	Critical habitat residual. Low quality; Moderate/slow velocity, no deep areas Narrow WP	max depth:0.26; avg depth:0.095; avg vel:0.031; width15.259; area:1.457; WP:15.277
7	1	1	2	4	3	11		**0.025**	No critical habitat, Other habitats moderate quality; Slow, shallow, narrow WP	max depth:0.23; avg depth:0.095; avg vel:0.024; width11; area:1.; WP:11
8	1	0	1	2	3	7		0.003	Flowing water habitats residual Low quality: Slow Trickle, very narrow WP	max depth:0.14; avg depth:0.065; avg vel:0.007; width5.343; area:0.347.; WP:5.351
9	0	0	0	1	3	4		0	Standing water habitats only, very low quality, no flow	max depth:0.08; avg depth:0.040; avg vel:0.002; width: 2.798; area:0.112.; WP:2.802
10	0	0	0	0	0	0			Only hyporheic refugia, no surface water	

BIOTIC RESPONSE Riffle community	Flow	SPECIES STRESS	CRIT STRESS
All very abundant, All healthy, all species persist	0.52	0	0.1
All abundant, All healthy, all species persist	0.27	1	2.7
Slight reduction for sensitive rheophilic species, All healthy in some areas, all species persist		2	2.9
Reduction for all rheophilic species, All healthy in limited areas, All species persist		3	3.5
Further reduction for all rheophilic species; All viable in limited areas, critical life stages of some sensitive rheophilic species at risk, all species persist	0.089	4	4
Limited populations of all rheophilic species. Critical life-stages of sensitive rheophilic species at risk or non-viable; All species persist	0.051	5	5
Sensitive rheophilic species rare, critical stages of sensitive rheophilic species non-viable, and at risk for some less sensitive species. All species persisit in the short-term	0.031	6	6
Most rheophilic species rare; All life-stages of sensitive rheophilic species at risk or non-viable. Most sensitive rheophilic species disappear	0.018	7	7
Remnant populations of some rheophilic species; All life stages of most rheophilic species at risk or non-viable, many rheophilic species disappear	0.013	8	8
Mostly pool dwellers, All life stages of most rheophilic species non-viable; Most or all rheophilic species disappear	0.005	9	9
Only specialists persist, virtually no development.	0.003	10	10

	SPECIES STRESS	CRIT STRESS	REC D				EC C			
			DRY SEASON REQUIREMENTS (September)		WET SEASON REQUIREMENTS (February)		DRY SEASON REQUIREMENTS (September)		WET SEASON REQUIREMENTS (February)	
			Dur	Comment	Dur	Comment	Dur	Comment	Dur	Comment
0.52	0	0.1								
0.27	1	2.7							**50%**	**Maintenance**
0.2	2	3			**50%**	**Maintenance**				
0.15	3	3.5					**50%**	**Maintenance**		
0.089	4	4								
0.051	5	5	50%	Maintenance						
0.031	6	6			10%	Drought			10%	Drought
0.018	7	7	10%	Drought			10%	Drought		
0.013	8	8								
0.005	9	9								
0.003	10	10								

Definitions

SIC	Partially submerged hard substrate in current >0.1m/s
SOC	Partally submerged hard substrate in current <0.1m/s
VIC	Submerged vegetation (at least 2-3cm submerged) in current >0.1m/s
VOC	Submerged vegetation (at least 2-3cm submerged) in current<0.1m/s
GSM	Small particles submerged

STUDY	LETABA				
RIVER	Letaba				
IFR SITE	Lonely Bull - 6				
LATS					
LONGS					
DATE					
PRESENT STRESS					
SASS5				IHAS	
FLOW					

Site Disadvantages

Velocity Distributions						
	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge
	0.13	**0.34**	**1.215**	**2**	**3.6**	**4.63**
<0.1	44	28	9	8	32	12
<0.3						
<0.6						
0.1-0.3	44	54	13	19	6	9
0.3-0.6	12	18	70	40	12	12
>0.6	0	0	8	33	50	67

Rheophiles defined as all spp requiring >0.3m/s

Habitat Flow Response Index	HABITAT ABUNDANCE AND SUITABILITY SIC	SOC	VIC	VOC	GSM	TOTAL	MODIFIER	FLOW	HABITAT RESPONSE	HABITAT CHARACTERISTICS (Hydraulic parameters)
						0				
0	3	2	5	4	4	18		4.6	All habitat in excess, very high quality: Very Fast, Very deep, very wide WP	Max depth: 0.44 Av depth: 0.31 Area: 5.16 Width: 16.67 WP:16.72 Av. velocity: 0.96
1	3	3	4	3	4	17		4.3	All plentifull, high quality; Fast, Deep, wide WP	Max depth:0.42 Av depth: 0.3 Area: 4.8 Width: 16.2 WP: 16.2 Av. velocity:0.89
2	3	3	3	3	4	16		3.6	Critical habitats sufficient; quality slightly reduced: Fast, Deep, Wide WP slightly reduced	Max depth:0.4 Av depth: 0.28 Area: 4.5 Width:15.8 WP: 15.9 Av. velocity:0.82
3	3	3	2	2	4	14		1.215	Reduced critical habitat, reduced critical quality; Moderate velocity, fairly deep, WP slightly/moderately reduced	Max depth:028 Av depth0.2 Area 2.74 Width13.76 WP 13.78 Av. velocity0.47
4	3	3	2	1	4	13		0.6	Critical habitats limited; moderate quality: Moderate velocity, Some deep areas, Wide WP moderately reduced	Max depth 0.22 Av depth0.16 Area 1.95 Width12.25 WP12.27 Av. velocity0.32
5	2	2	2	1	4	11		0.34	Critical habitat very reduced; moderate/ low quality; Moderate/slow velocity, few deep areas WP moderately/very reduced	Max depth 0.18 Av depth 0.13 Area1.48 Width 11.12 WP 11.14 Av. velocity0.23
6	2	2	1	1	4	10		0.13	Critical habitat residual. Low quality; Moderate/slow velocity, no deep areas Narrow WP	Max depth 0.14 Av depth 0.11 Area 1.06 Width 9.99 WP 10 Av. velocity0.15
7	1	1	1	1	3	7		0.031	No critical habitat, Other habitats moderate quality; Slow, shallow, narrow WP	Max depth 0.08 Av depth 0.06 Area0.5 Width 8.79 WP 8.8 Av. velocity 0.061
8	1	1	0	1	2	5		0.004	Flowing water habitats residual Low quality: Slow Trickle, very narrow WP	Max depth 0.04 Av depth 0.02 Area 0.17 Width 7.9 WP 7.9 Av. velocity 0.023
9	0	1	0	1	2	4		0	Standing water habitats only, very low quality, no flow	Max depth 0.02 Av depth 0.01 Area0.04 Width4.4 WP 4.4 Av. velocity 0.012
10	0	0	0	0	0	0		0	Only hyporheic refugia, no surface water	

BIOTIC RESPONSE Using the full community of inverts present	Flow	COMMUNITY STRESS	CRIT STRESS
All very abundant, All healthy, all species persist	1.215	0	4.5
All abundant, All healthy, all species persist		1	4.8
Slight reduction for sensitive rheophilic species, All healthy in some areas, all species persist	0.6	2	5
Reduction for all rheophilic species, All healthy in limited areas, All species persist		3	6
Further reduction for all rheophilic species; All viable in limited areas, critical life stages of some sensitive rheophilic species at risk, all species persist	0.34	4	6.5
Limited populations of all rheophilic species. Critical life-stages of sensitive rheophilic species at risk or non-viable; All species persist		5	7.8
Sensitive rheophilic species rare, critical stages of sensitive rheophilic species non-viable, and at risk for some less sensitive species. All species persisit in the short-term	0.13	6	9
Most rheophilic species rare; All life-stages of sensitive rheophilic species at risk or non-viable. Most sensitive rheophilic species disappear		7	9.5
Remnant populations of some rheophilic species; All life stages of most rheophilic species at risk or non-viable, many rheophilic species disappear		8	9.7
Mostly pool dwellers, All life stages of most rheophilic species non-viable; Most or all rheophilic species disappear	0.031	9	9.9
Only specialists persist, virtually no development.	0	10	10

SPECIES STRESS	CRIT STRESS	REC B DRY SEASON REQUIREMENTS Dur	Comment	WET SEASON REQUIREMENTS Dur	Comment	REC C DRY SEASON REQUIREMENTS Dur	Comment	WET SEASON REQUIREMENTS Dur	Comment

Definitions

SIC Partially submerged hard substrate in current >0.1m/s

SOC Partally submerged hard substrate in current <0.1m/s

VIC Submerged vegetation (at least 2-3cm submerged) in current >0.1m/s

VOC Submerged vegetation (at least 2-3cm submerged) in current<0.1m/s

GSM Small particles submerged

STUDY	LETABA
RIVER	Letaba
IFR SITE	Letaba Bridge - 7
LATS	
LONGS	
DATE	
PRESENT STRESS	
SASS5	IHAS
FLOW	

Site Advantages
Site Disadvantages

Velocity Distributions	Discharge	Discharge	Discharge	Discharge	Discharge
	0.021	**0.5**	**2**	**6.8**	**9.2**
<0.1	100	75	46	23	9
<0.3	100	100	92	50	14
<0.6	100	100	100	93	39
0.1-0.3	0	25	46	27	5
0.3-0.6	0	0	8	43	25
>0.6	0	0	0	7	61

Rheophiles defined as all spp requiring >0.3m/s

Habitat Flow Response Index	HABITAT ABUNDANCE AND SUITABILITY					TOTAL	MODIFIER	FLOW	HABITAT RESPONSE	HABITAT CHARACTERISTICS (Hydraulic parameters)
	SIC	SOC	VIC	VOC	GSM					
Rating (site at observed flow)	4	4	4	4	4	20		6.8		
0	4	4	5	5	5	23		7.5	All habitat in excess, very high quality: some very fast, most moderately fast, deep, very wide WP	Max depth:0.52 Av depth:0.33 Area:12.27 Width:37.66 WP:37.78 Av. velocity:0.62
1	4	4	4	4	4	20		6.8	All plentiful, high quality; fast and moderately fast, deep, very wide WP	Max depth: 0.5 Av depth: 0.32 Area: 11.53 Width: 36.14 WP: 36.24 Av. velocity:0 58
2	4	4	3	3	4	18		4	Critical habitats sufficient; quality slightly reduced: slow and moderately fast, Deep, Wide WP slightly reduced	Max depth: 0.42 Av depth: 0.28 Area: 8.84 Width: 31.76 WP: 31.82 Av. velocity: 0.44
3	3	3	3	3	4	16		2	Reduced critical habitat, reduced critical quality; Moderate velocity, fairly deep, WP slightly/moderately reduced	Max depth: 0.34 Av depth: 0.22 Area: 6.42 Width: 28.78 WP: 28.82 Av. velocity: 0.31
4	3	3	2	2	3	13		0.5	SIC limited, of reasonable quality, VIC virtually absent.	Max depth: 0.24 Av depth: 0.14 Area: 3.69 Width: 25.82 WP: 25.84 Av. velocity: 0.15
5	3	3	1	1	3	11		0.27	Critical habitat very reduced; moderate/ low quality; Moderate/slow velocity, few deep areas WP moderately/very reduced	Max depth: 0.20 Av depth: 0.13 Area: 2.72 Width: 21.26 WP: 21.27 Av. velocity: 0.1
6	2	2	1	1	3	9		0.069	Critical habitat (SIC and VIC) residual. Low quality; Slow velocity, limited deep areas. Moderate WP	Max depth: 0.15 Av depth: 0.09 Area:1.70 Width: 18 WP: 18 Av. velocity: 0.04
7	1	2	1	1	2	7		0.05	No critical habitat, Other habitats moderate quality; Slow, shallow, narrow WP	Max depth: 0.14 Av depth: 0.09 Area: 1.5 Width:17.25 WP: 17.25 Av. velocity:0.03
8	1	1	1	1	2	6		0.021	Flowing water habitats residual Low quality: Slow Trickle, moderate WP	Max depth:0.12 Av depth: 0.08 Area:1.23 Width:15.9 WP:15.9 Av. velocity: 0.01
9	0	1	0	0	2	3		0	Standing water habitats only, very low quality, no flow	Max depth: 0.1 Av depth: 0.06 Area: 0.93 Width: 14.58 WP:14.58 Av. velocity:0
10	0	0	0	0	0	0		0	Only hyporheic refugia, no surface water	

Habitat Flow Response Index	BIOTIC RESPONSE — Using the full community of inverts present	Flow	COMMUNITY STRESS	CRIT STRESS
Rating (site at observed flow)				
0	All very abundant, All healthy, all species persist	6.8	0	
1	All abundant, All healthy, all species persist		1	1.5
2	Slight reduction for sensitive rheophilic species, All healthy in some areas, all species persist	4	2	2
3	Reduction for all rheophilic species, All healthy in limited areas, All species persist	3.3	3	3
4	Further reduction for all rheophilic species; All viable in limited areas, critical life stages of some sensitive rheophilic species at risk, all species persist	2.6	4	4
5	Limited populations of all rheophilic species. Critical life-stages of sensitive rheophilic species at risk or non-viable; All species persist	2	5	5
6	Sensitive rheophilic species rare, critical stages of sensitive rheophilic species non-viable, and at risk for some less sensitive species. All species persisit in the short-term	1.2	6	6
7	Most rheophilic species rare; All life-stages of sensitive rheophilic species at risk or non-viable. Most sensitive rheophilic species disappear	0.5	7	7
8	Remnant populations of some rheophilic species; All life stages of most rheophilic species at risk or non-viable, many rheophilic species disappear	0.021	8	9.7
9	Mostly pool dwellers, All life stages of most rheophilic species non-viable; Most or all rheophilic species disappear		9	9.8
10	Only specialists persist, virtually no development.	0	10	10

Habitat Flow Response Index	SPECIES STRESS	CRIT STRESS	REC B				REC C			
			DRY SEASON REQUIREMENTS		WET SEASON REQUIREMENTS		DRY SEASON REQUIREMENTS		WET SEASON REQUIREMENTS	
			Dur	Comment	Dur	Comment	Dur	Comment	Dur	Comment
Rating (site at observed flow)										
0										
1					50	To allow suficient habitat for a diverse invertebrate population				
2					30	Maintenance values. Variety of velocities to ensure a healthy invertebrate community			50	To allow suficient habitat for the remaining invertebrate population
3			70	To allow healthy population of highly flow dependent taxa					30	Maintenance values. Variety of velocities to ensure that the remaining invertebrate community stays in a healthy community
4			30	Maintenance values	10	Allow survival of highly flow dependent taxa that require velocitities >0.6 m/s	70	To allow healthy population of moderately flow dependent taxa	20	Allow survival of remaining highly flow dependent taxa that require velocitities >0.6 m/s
5			10	Ensure that a viable population of highly flow dependendent taxa	0	Higher stress values will result in the loss of highly flow sensitive taxa	30	Maintenance values	0	Higher stress values will result in the loss of highly flow sensitive taxa
6			5	drought values			5	drought values		
7										
8										
9										
10										

Definitions

SIC	Partially submerged hard substrate in current >0.1m/s
SOC	Partally submerged hard substrate in current <0.1m/s
VIC	Submerged vegetation (at least 2-3cm submerged) in current >0.1m/s
VOC	Submerged vegetation (at least 2-3cm submerged) in current<0.1m/s
GSM	Small particles submerged

water & forestry

Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

DIRECTORATE: RESOURCE DIRECTED MEASURES

LETABA CATCHMENT RESERVE DETERMINATION STUDY – SPECIALIST REPORT : **FISH**

FINAL

DECEMBER 2004

Prepared for:

Department of Water Affairs and Forestry
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December 2004

Inception report
Heath RG
DWAF Report No. RDM/B800/00/CON/COMP/0404X

Main Report
Heath RG
DWAF Report No.RDM/B800/00/CON/COMP/1304

Summary of Results (Non technical)
Heath RG
DWAF Report No. RDM/B800/00/CON/COMP/1304

Groundwater Scoping Report
Haupt C & Sami K
DWAF Report No. RDM/B800/02/CON/COMP/0504

Wetland Scoping Report
Marneweck G
DWAF Report No. RDM/B800/03/CON/COMP/0604

Resource Units Report
Heath R G
DWAF Report No. RDM/B800/00/CON/COMP/0704

→

Resource Units Report: Appendix 1
Habitat Integrity Index
Fouche, P & Moolman
Appendix 2: Systems operation report
Haumann, K.
DWAF Report No.
RDM/B800/00/CON/COMP/0704

EWR Report: Quantity
Palmer RW
DWAF Report No. RDM/B800/01/CON/COMP/0904

→

EWR Report: Quantity:
Appendices
Specialist reports

- Fish
- Invertebrates
- Hydraulics
- Riparian vegetation
- Geomorphology
- Socio-cultural

DWAF Report No.
RDM/B800/01/CON/COMP/0904

EWR Report: Quality
Scherman P
DWAF Report No. RDM/B800/01/CON/COMP/0804

Ecological consequences of flow scenarios
Heath, RG & Palmer R
DWAF Report No. RDM/B800/01/CON/COMP/1004

Hydrology support & water resource evaluation
Haumann, K
DWAF Report No. RDM/B800/01/CON/COMP/1104

Ecospecs and monitoring report
Heath, RG
DWAF Report No. RDM/B800/00/ CON/COMP/1204

Capacity Building
Heath RG
DWAF Report No. RDM/B800/00/ CON/COMP/1404

Socio –economics flow scenarios
Tlou T *et al.*
DWAF Report No.

Ecological Data
DWAF Report No.
RDM/RB800/00/CON/COMP/1604

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SPECIALIST APPENDAGE: FISH

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 low-veld 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

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APPENDIX A.1
ASSESSMENT OF FISH POPULATIONS

Prepared by:
P.S.O. Fouche

1. INTRODUCTION

A comprehensive Reserve Determination Study on the Letaba River Catchment commenced in 2003. The study entails the investigation of the status of both biotic and abiotic factors in the catchment at selected Instream Flow Requirement (IFR) sites.

This report addresses the status of fish communities.

2. STUDY SITES

Sites for the IFR survey were selected in a multi disciplinary field survey undertaken from 10th – 13th August 2003.

Site Coordinates. (Supplied by Rountree)

Klein Letaba (Canal)	S23^{o} 15 02.9	E30^{o} 29 44.6
Letsitele (Tank)	S23^{o} 53 17.0	E30^{o} 21 40.5
Groot Letaba (Appel)	S23^{o} 55 03.7	E30^{o}03 03.0
Groot Letaba (Merensky)	S23^{o} 38 57.8	E30^{o}39 38.3
Groot Letaba (Letaba Ranch)	S23^{o} 40 39.1	E31^{o} 05 55.1

3. APPROACH OF THE STUDY

The study assessed fish communities at the above 5 IFR sites. Historical data was then analyzed to permit the extrapolation of the site specific data generated during the field survey, to resource units within the catchment. Due to numerous earlier fish surveys within the Letaba Catchment, it was deemed appropriate to follow the eco region approach as adopted in the 2001 State of Rivers Report.

The response of key indicator species to those flow regimes observed was assessed using all available data and expert judgement (following guidelines developed by Kleynhans (in prep) for the Tugela reserve determination).

The Present Ecological State (PES) of each resource unit was determined according to guidelines developed by Kleynhans (in prep) for the Tugela reserve determination. (See Table 1 below).

4. FIELD SURVEY METHODS

A field study was undertaken along the river between 14th February and 17th February 2004.

4.1 FISH

During the survey of the Letaba Catchment IFR sites, fish were gathered using a variety of methods. Table 2. illustrates the diversity and status of the fish of this catchment.

Table 1. Assessment of the PES based on Fish.

DETERMINANTS CONSIDERED FOR ESTIMATION	RIVER ZONE OR DEFINED RESEOURCE UNIT (scoring /assessment criteria: provide comments for each score)
Native species richness	Number of species expected: number of species currently present (most recent). Score according to: None of expected present = 0: Only few expected present = 1-2: Majority of expected species present = 3-4: All/almost all of expected present = 5.
Presence of native intolerant species	No intolerant species present = 0: Few intolerant species = 1-2: Majority of intolerant species present = 3 - 4: All/almost all intolerant species present (OR no intolerant naturally present) = 5.
Abundance of native species	No fish = 0: Only few individuals = 1-2: Moderate abundance = 3-4: Abundance as expected for natural conditions = 5.
Native species Frequency of Occurrence	Fish absent at all sites = 0: Fish present at only very few sites = 1-2: Fish present at most sites 3-4: Fish present at all sites =5.
Health/condition: native and introduced species	All fish seriously affected/fish absent = 0: Most fish affected = 1-2: Most fish unaffected = 3-4: Only single/few individuals affected = 5:
Presence of introduced fish species	Predaceous species and/or habitat modifying species with a critical impact on native species = 0 Predaceous species and/or habitat modifying species with a serious impact on native species = 1-2 Predaceous species and/or habitat modifying species with a moderate impact on native species = 3-4 Predaceous species and/or habitat modifying species with no impact on native species = 5
Instream habitat modification	Water quality/flow/stream bed substrate, critically modified, no suitable conditions for expected species = 0: Water quality/flow/stream bed substrate, seriously modified, little suitable conditions for expected species = 1-2: Water quality/flow/stream bed substrate, moderately modified, moderately suitable conditions for expected species = 3-4: Water quality/flow/stream bed substrate, little /no modification, abundant suitable conditions for expected species = 5:
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	TAKING INTO ACCOUNT THE ABOVE INFORMATION: RATE FISH ASSEMBLAGE INDEX CATEGORY A - F BASED ON GENERAL SCORING GUIDELINES: Category % of total expected score A: 90 - 100 B: 80 - 90 C: 60 - 80 D: 40 - 60 E: 20 - 40 F: 0 - 20

- Electro - shocking apparatus: a two to three man operation, whereby fish are stunned using 220 volt AC electric current. The stunned fish are collected in hand held scoop nets positioned down stream. The method is suited to shallow (< 1 metre depth) swift flowing water over assorted substrates. Also useful around snags, undercut banks and in heavily vegetated but shallow pools.

- Seine net: a net measuring 15 metres in length by 3.5 metres deep, with 10 mm knotless nylon netting. The net is pulled through the water by 2 - 4 people and fish are collected in a central bag. Suitable for deep pools which are clear of snags. (This method was not used during the survey outside of the KNP)

- Pole net: a small piece of seine netting attached to two wooden poles. This two man net measures 2.5 metres by 1.5 metres deep, and again has 10 mm mesh. The net is useful for sampling in small pools, but is particularly designed for use under and amongst overhanging and marginal vegetation.

- Cast or throw net: a 1.6 metre radius, circular monofilament net, with 12 mm mesh size. Cast nets can be used by an individual in any habitat that is clear of snags and obstructions.

Most fish caught were identified on site and returned to the river alive. A limited number of fish were kept and preserved in formalin for reference purposes. When possible, individual fish were examined for parasite loads.

Each site was subjected to exhaustive searches using the most appropriate collecting techniques. At all sites, multiple habitats were sampled. At all sites, habitats of similar velocity depth classes and cover types were sampled at different localities. A reach of river approaching two hundred metres was sampled at each site.

4.2 HABITAT ASSESSMENTS

The habitat at the site was categorized, and where possible individual habitats sampled. The effort used to catch fish in each habitat at each site was recorded.

Fish habitat was categorized into four velocity depth classes, and allocated a subjective score based upon their abundance using a five point scale proposed by Kleynhans (1997)

Fast Deep (F/D); Fast Shallow (F/S); Slow Deep (S/D); Slow Shallow (S/S)
(0=Absent; 1=Rare; 2=Sparse; 3=Moderate; 4=Extensive)

The same scale was utilized to assess the availability of cover types, for each velocity depth class. Five cover types are assessed. (Overhanging vegetation; Undercut bank and root wads; Substrate; Aquatic macrophytes and water column).

Fast Habitats:	Deep water = > 0.3 metres;	Fast water = > 0.3 m/sec.
Slow habitats:	Deep water = > 0.5 metres;	Fast water = > 0.3 m/sec.

Table 2: Fishes of the Letaba Catchment, abbreviations and summarized status. Names and abbreviations from Skelton (1993). Historical data from Limpopo Environmental Affairs Fish Distribution Data Base.

Scientific name	Abbrev.	Migratory	Red data	Prov. rare	Rheophilic	Semi Rheophilic
Amphilius uranoscopus	AURA				x	
Anguilla bengalensis	ABEN	x		x		
Anguilla marmorata	AMAR	x		x		
Anguilla mossambica	AMOS	x		x		
Barbus afrohamiltoni	BAFR					
Barbus annectens	BANN					
Barbus eutaenia	BEUT				x	
Barbus lineomaculatus	BLIN			x		x
Barbus mattozi	BMAT					
Barbus neefi	BNEE					x
Barbus paludinosos	BPAU					
Barbus radiatus	BRAD					
Barbus toppini	BTOP					
Barbus trimaculatus	BTRI					
Barbus unitaeniatus	BUNI					
Barbus viviparus	BVIV					x
Brycinus imberi	BIMB					
Chiloglanis paratus	CPAR				x	x
Chiloglanis pretoriae	CPRE				x	
Chiloglanis swierstrai	CSWI			x	x	
Clarias gariepinus	CGAR					
Glossogobius callidus	GCAL	x				
Glossogobius giuris	GGIU	x				
Hydrocynus vittatus	HVIT	x		x		x
Labeo congoro	LCON			x		
Labeo cylindricus	LCYL					x
Labeo molybdinus	LMOL					x
Labeo rosae	LROS					
Labeo ruddi	LRUD					
Labeobarbus marequensis	LMAR					x
Marcusenius macrolepidotus	MMAC					
Mesobola brevianalis	MBRE					
Micralestes acutidens	MACU					
Opsaridium peringueyi	OPER		x		x	
Oreochromis mossambicus	OMOS					
Petrocephalus wesselsi	PWES					
Pseudocrenilabrus philander	PPHI					
Schilbe intermedius	SINT					
Synodontis zambezensis	SZAM					
Tilapia rendalli	TREN					
Tilapia sparrmanii	TSPA					

Velocities were measured at various points in the site and the fastest velocities recorded were noted. At two sites (Groot Letaba above Prieska weir and Letsitele tank) a transect was established at a point of flow control and velocities measured at 20cm intervals in order to later determine the approximate flow rate at the time of the survey. At the three other sites, the points of flow control were narrow and uniformly structured and velocity was measured in one or two selected points where flow was deemed the fastest.

A detailed photographic record of each site was made. In addition a sketch of the site was made and annotated.

4.3 IN SITU WATER QUALITY

Temperature, conductivity and pH were measured at each site using hand held meters.

5. RESULTS

Except for the water quality results listed in Table 3, the results for each site are presented separately in tabular format.

Table 3: In situ water quality at each of the IFR sites

	Temp.	**pH**	**Conductivity (mS/m)**
Klein Letaba (Canal)	30.2	7.8	47.8
Letsitele (Tank)	27.7	7.5	39.6
Groot Letaba (Appel)	22.9	7.9	5
Groot Letaba (Merensky)	27.5	7.8	12.9
Groot Letaba (Letaba Ranch)	27.8	8.2	24

5.1 KLEIN LETABA: CANAL

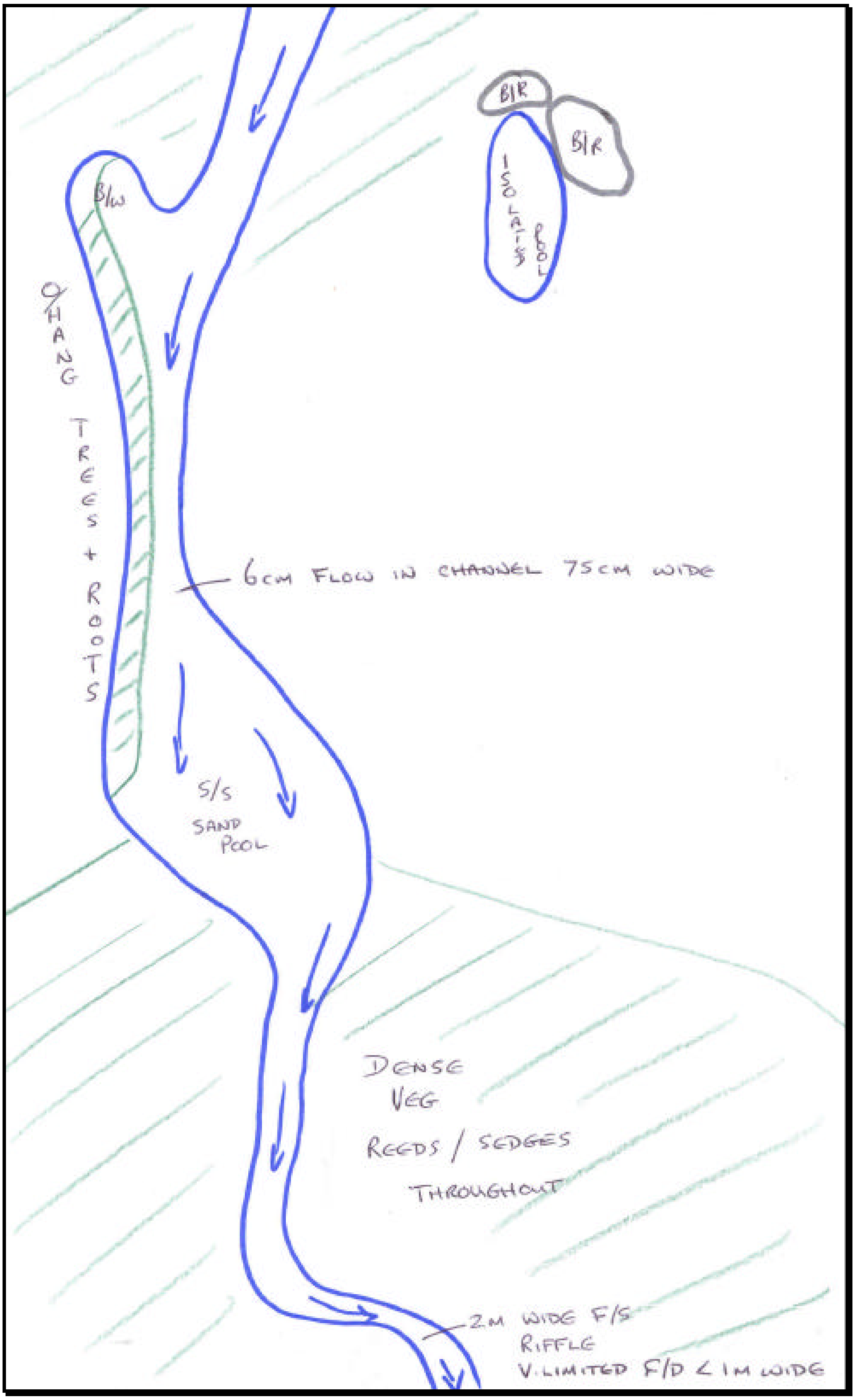

Figure 1: Klein Letaba: Canal Site Map

Table 3a: Fish species recorded and expected in the Klein Letaba 5.05 eco region, and those numbers of fish collected during the IFR survey of February 2004. ((Historical records available between 1995 and 2003 obtained from Limpopo Province Department of Environmental Affairs Fish Distribution Data Base (updated December 2003)

RIVER NAME	**Klein Letaba**
ECO REGION:	**5.03**
SURVEYOR:	**Fouche et al**
DATE:	**14.02.04**
Barbus afrohamiltoni	
Barbus paludinosus	
Barbus toppini	
Barbus trimaculatus	10
Barbus unitaeniatus	
Barbus viviparus	47
Chiloglanis paratus	
Clarias gariepinus	2
Glossogobius callidus	1
Labeo cylindricus	
Labeo molybdinus	5
Labeo rosae	
Labeo ruddi	
Labeobarbus marequensis	
Mesobola brevianalis	7
Oreochromis mossambicus	>200
Pseudocrenilabrus philander	34
Schilbe intermedius	
Synodontis zambezensis	
Tilapia rendalli	28
20 Species expected	**8 species collected**

Table 3b: Fish caught in Slow Deep and Slow Shallow habitats using a pole seine.

Method	**Pole Seine**
Habitat	**S/D pools and Mveg**
BTRI	4
BVIV	25
GCAL	1
LMOL	3
MBRE	7
OMOS	>100
PPHI	15

Table 3c: Fish caught in Slow Deep habitats using a cast net

Method	**Cast Net**
Habitat	**S/D sandy pools**
BTRI	1
OMOS	35
TREN	18

Table 3d: Fish caught in Slow Shallow and Fast Shallow gravel runs and riffles using an electro shocker

Method	**Shock**
Habitat	**S/S and F/S runs and riffles**
BTRI	5
BVIV	22
CGAR	2
LMOL	2
OMOS	54
PPHI	19
TREN	10

Table 3e: Fish Habitat assessment for the Klein Letaba site and resource unit

KLEIN LETABA	**SITE:**	**CANAL**	**DATE:**	**14.02.04**	**TIME:**	**08.00am**	
RELATIVE FLOW-DEPTH RATING:0=NONE;1=RARE;2=SPARSE;3=MODERATE;4=ABUNDANT;5=VERY ABUNDANT)							
FAST DEEP	**1**	FAST SHALLOW	**2**	SLOW DEEP	**3**	SLOW SHALLOW	**4**
COVER TYPES ASSOCIATED WITH EACH FLOW-DEPTH CLASS							
Overhanging vegetation:	**3**	Overhanging vegetation:	**3**	Overhanging vegetation:	**3**	Overhanging vegetation:	**3**
Undercut banks & root wads:	**2**	Undercut banks & root wads:	**2**	Undercut banks & root wads:	**3**	Undercut banks & root wads:	**2**
Substrate:	**2**	Substrate:	**3**	Substrate:	**2**	Substrate:	**2**
Water Column:	**2**	Water Column:	**1**	Water Column:	**3**	Water Column:	**1**
Aquatic macrophytes:	**0**	Aquatic macrophytes:	**0**	Aquatic macrophytes:	**2**	Aquatic macrophytes:	**4**
Remarks:	**Narrow channels between Typha capensis**	Remarks:		Remarks:		Remarks:	**Potamageton and Marsilea spp.**
Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**1**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**

Table 3f: Fish species response: habitat suitability for the different life-stage requirements for the Canal site in the Klein Letaba River.

FISH SPECIES RESPONSES: HABITAT SUITABILITY FOR DIFFERENT LIFE-STAGE REQUIREMENTS					
Semi Rheophilic spp = Species 1.	**CPAR (not recorded on survey date)**	Semi-rheophilic spp= Species 2	**LMOL**	Non-rheophilic spp=	**MBRE**
Breeding and early life-stages=	**1**	Breeding and early life-stages=	**2**	Breeding and early life-stages=	**2**
Survival /Abundance =	**1**	Survival /Abundance =	**2**	Survival /Abundance =	**2**
Cover =	**1**	Cover =	**2**	Cover =	**3**
Health and condition=	**3**	Health and condition=	**3**	Health and condition=	**3**
Water quality=	**2**	Water quality=	**3**	Water quality=	**3**
Habitat flow stress response with breeding requirements	**6.8**	**Habitat flow stress response with breeding requirements**	**5.2**	**Habitat flow stress response with breeding requirements**	**4.8**
Habitat flow stress response without breeding requirements	**6.5**	**Habitat flow stress response without breeding requirements**	**5**	**Habitat flow stress response without breeding requirements**	**4.5**

Table 3g: Assessment of the PES for the Klein Letaba

DETERMINANTS CONSIDERED FOR ESTIMATION	**KLEIN LETABA CANAL**	**Score / 5**
Native species richness	8 out of a potential 22 species were recorded in the Feb survey. All 22 species have been recorded since 1990. Current drought cycle probably caused some species to be absent. River only flowing for limited period.	**2**
Presence of native intolerant species	Only CPAR (semi rheophilic) is expected but was not found on this particular survey.	4
Abundance of native species	Those species caught were abundant.	4
Native species Frequency of Occurrence	Records dating from 1990 indicate that the fish occur frequently at each monitoring site within the eco region.	4
Health/condition: native and introduced species	No obvious deformities or disease was noted.	4
Presence of introduced fish species	No records of alien fish have been made in the Klein Letaba River. However, *Micropterus salmoides* and *Cyprinus carpio* are known to exist in the upstream dam. Neither are expected to survive in the seasonal extremes of the river but their presence cannot be discounted.	4

DETERMINANTS CONSIDERED FOR ESTIMATION	**KLEIN LETABA CANAL**	**Score / 5**
Instream habitat modification	Stream flow has been reduced by the placement of the Middel Letaba Dam. However, seepage from the dam may contribute to a more perennial state in this river reach. Sewage inflows at Majosi are the only known water quality issue upstream, while Giyani Sewage Works and agricultural returns are significant downstream factors. Stream bed modification is slight.	3
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	**25 / 35 = 71% = CLASS C**	

5.2 LETSITELE: TANK

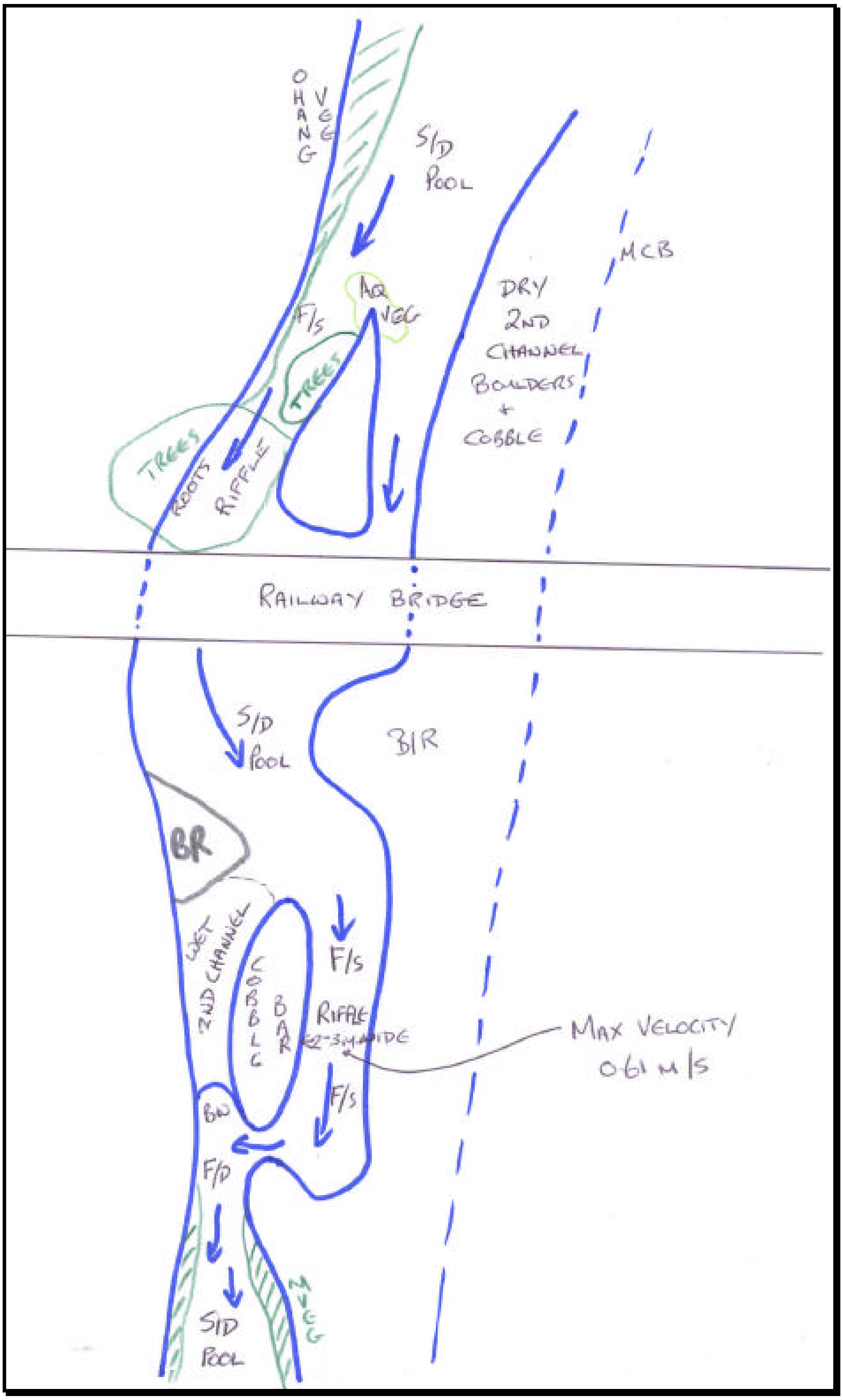

Figure 2: Letsitele: Tank Site map

Table 4a: Fish species recorded and expected in the Letsitele (and Groot Letaba), 5.05 eco region and those numbers of fish collected during the IFR survey of February 2004. (Historical records available between 1995 and 2003 obtained from Limpopo Province Department of Environmental Affairs Fish Distribution Data Base (updated December 2003)

RIVER NAME	**Letsitele**
ECO REGION:	**5.05**
SURVEYOR	**Fouche et al.**
DATE	**15.02.04**
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 catostoma	
Pseudocrenilabrus philander	64
Schilbe intermedius	
Synodontis zambezensis	
Tilapia rendalli	>100
Tilapia sparrmanii	
33 Species expected	**13 species collected**.

Table 4b: Fish caught in Slow Deep and Slow Shallow habitats using a pole seine.

Method	**Pole seine**
Habitat	**S/D & S/S pools**
BVIV	24
LCYL	2
LMAR	2
MACU	18
MBRE	19
OMOS	40
PPHI	38
TREN	>100

Table 4c: Fish caught in Fast Deep and Fast Shallow gravel and cobble riffles using an electro shocker.

Method	**Shock**
Habitat	**F/S & F/D riffle**
BEUT	1
BVIV	59
CGAR	3
CPAR	1
CPRE	70
LCYL	6
LMAR	28
LMOL	5
MACU	2
MBRE	1
OMOS	26
PPHI	26
TREN	7

Table 4d: Fish Habitat assessment of the Letsitele site and resource unit.

LETSITELE	**SITE:**	**TANK**	**DATE:**	**15.02.04**	**TIME:**	**08.30am**	
RELATIVE FLOW-DEPTH RATING:0=NONE;1=RARE;2=SPARSE;3=MODERATE;4=ABUNDANT;5=VERY ABUNDANT)							
FAST DEEP	**1**	FAST SHALLOW	**4**	SLOW DEEP	**3**	SLOW SHALLOW	**4**
COVER TYPES ASSOCIATED WITH EACH FLOW-DEPTH CLASS							
Overhanging vegetation:	**3**	Overhanging vegetation:	**2**	Overhanging vegetation:	**3**	Overhanging vegetation:	**3**
Undercut banks & root wads:	**3**	Undercut banks & root wads:	**3**	Undercut banks & root wads:	**3**	Undercut banks & root wads:	**2**
Substrate:	**2**	Substrate:	**4**	Substrate:	**3**	Substrate:	**2**
Water Column:	**2**	Water Column:	**2**	Water Column:	**3**	Water Column:	**1**
Aquatic macrophytes:	**3**	Aquatic macrophytes:	**2**	Aquatic macrophytes:	**2**	Aquatic macrophytes:	**2**
Remarks:	**S/D on Bends below riffles**	Remarks:		Remarks:	**Very Silty water. Max depth 600mm**	Remarks:	**Lemna spp. present.**
Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**

Table 4e: Fish species responses: habitat suitability for the different life-stage requirements for the Letsitele tank site.

FISH SPECIES RESPONSES: HABITAT SUITABILITY FOR DIFFERENT LIFE-STAGE REQUIREMENTS						
Rheophilic spp =	**CPRE**	**BEUT**	Semi-rheophilic spp=	**CPAR**	Non-rheophilic spp=	**MACU**
Breeding and early life-stages=	**2**	**1**	Breeding and early life-stages=	**2**	Breeding and early life-stages=	**2**
Survival /Abundance =	**3**	**1**	Survival /Abundance =	**4**	Survival /Abundance =	**3**
Cover =	**3**	**2**	Cover =	**3**	Cover =	**2**
Health and condition=	**3**	**2**	Health and condition=	**2**	Health and condition=	**3**
Water quality=	**3**	**2**	Water quality=	**3**	Water quality=	**3**
Habitat flow stress response with breeding requirements	**4.4**	**6.8**	**Habitat flow stress response with breeding requirements**	**4.4**	**Habitat flow stress response with breeding requirements**	**4.8**
Habitat flow stress response without breeding requirements	**4**	**6.5**	**Habitat flow stress response without breeding requirements**	**4**	**Habitat flow stress response without breeding requirements**	**4.5**

Table 4f: Assessment of the PES for the Letsitele River

DETERMINANTS CONSIDERED FOR ESTIMATION	LETSITELE TANK	Score / 5
Native species richness	13 out of a potential 33 species were recorded in the Feb survey.	**2**
Presence of native intolerant species	CPRE, BEUT and CPAR (semi rheophilic) were recorded. AURA is expected but was not found on this survey. It was however recorded in the earlier surveys. No migratory species were recorded. OPER (Red Data) is expected but not recorded in this and other recent surveys. No migratory eel species were recorded.	**3**
Abundance of native species	Those species caught were abundant. Many juvenile LMAR were recorded.	**4**
Native species Frequency of Occurrence	Records dating from 1990 indicate that the fish occur frequently at each monitoring site within the eco region. As the region is considered a foothill zone, seasonal variations may be expected which may not be reflected in a once off survey.	**3**
Health/condition: native and introduced species	No obvious deformities or disease was noted.	**4**
Presence of introduced fish species	No records of alien fish have been made in the Letsitele or Groot Letaba River. However, *Micropterus salmoides* and *Cyprinus carpio* are known to exist in the upstream Tzaneen Dam. *Micropterus salmoides* also exists in farm dams of the upper Letsitele catchment. If they are present, they are in low abundance and likely to be having limited effect on the fish assemblage.	**4**
Instream habitat modification	Stream flow has been reduced by the placement of many upstream farm dams. Catchment condition and riparian forest is poor and there is considerable sedimentation taking place. In addition there are water quality impacts from rural communities and serious problems of waste disposal in the rivers lower reach.	**2**
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	**22 / 35 = 62% = CLASS C**	

5.3 GROOT LETABA: APPEL

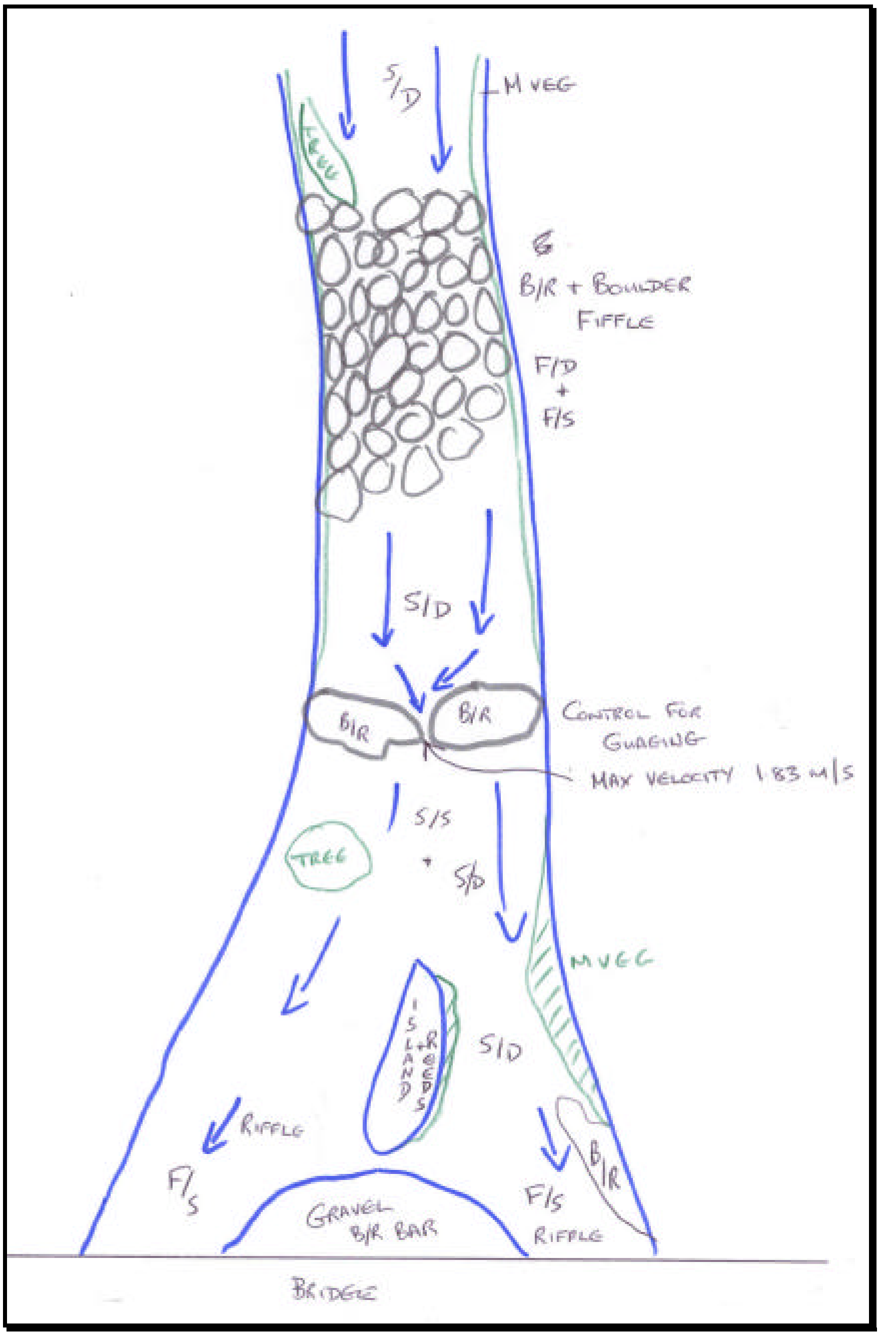

Figure 3: Groot Letaba: Appel Site map.

Table 5a: Fish species recorded and expected in the Groot Letaba, 2.15 eco region and those numbers of fish collected during the IFR survey of February 2004. ((Historical records available between 1995 and 2003 obtained from Limpopo Province Department of Environmental Affairs Fish Distribution Data Base (updated December 2003))

RIVER	**GROOT LETABA**
ECO REGION:	**2.15**
SURVEYOR:	**Fouche et al.**
DATE:	**15.02.04**
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	
Labeobarbus marequensis	51
Marcusenius macrolepidotus	
Mesobola brevianalis	
Micralestes acutidens	
Opsaridium peringueyi	
Petrocephalus catostoma	
Pseudocrenilabrus philander	2
Tilapia sparrmanii	23
22 Species expected	**6 species collected.**

Table 5b: Fish caught in Slow Deep and Slow Shallow habitats using a pole seine.

Method	**Pole seine**
Habitat	**S/D & S/S pools**
LMAR	4
PPHI	2
TSPA	17

Table 5c: Fish caught in Fast Deep and Fast Shallow cobble riffles and bedrock rapids using an electro shocker.

Method	**Shock**
Habitat	**F/S & F/D riffle & rapid**
AURA	11
CGAR	1
CPRE	42
LMAR	27
TSPA	6

Table 5d: Fish caught in Fast Deep habitats using a cast net.

Method	**Cast net**
Habitat	**F/D rapid**
LMAR	20

Table 5e: Fish Habitat assessment of the Groot Letaba Appel site and resourse unit.

GROOT LETABA	**SITE:**	**APPEL**	**DATE:**	**15.02.04**	**TIME:**	**15.00am**	
RELATIVE FLOW-DEPTH RATING:0=NONE;1=RARE;2=SPARSE;3=MODERATE;4=ABUNDANT;5=VERY ABUNDANT)							
FAST DEEP	**4**	FAST SHALLOW	**4**	SLOW DEEP	**3**	SLOW SHALLOW	**3**
COVER TYPES ASSOCIATED WITH EACH FLOW-DEPTH CLASS							
Overhanging vegetation:	**2**	Overhanging vegetation:	**2**	Overhanging vegetation:	**3**	Overhanging vegetation:	**2**
Undercut banks & root wads:	**3**	Undercut banks & root wads:	**2**	Undercut banks & root wads:	**3**	Undercut banks & root wads:	**2**
Substrate:	**4**	Substrate:	**4**	Substrate:	**2**	Substrate:	**2**
Water Column:	**4**	Water Column:	**2**	Water Column:	**4**	Water Column:	**2**
Aquatic macrophytes:	**0**	Aquatic macrophytes:	**0**	Aquatic macrophytes:	**2**	Aquatic macrophytes:	**1**
Remarks:		Remarks:		Remarks:	**Sedges, Arundo donax and Potamageton spp.**	Remarks:	
Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**

Table 5f: Fish species responses: habitat suitability for the different life-stage requirements for the Appel site in the Groot Letaba River.

FISH SPECIES RESPONSES: HABITAT SUITABILITY FOR DIFFERENT LIFE-STAGE REQUIREMENTS					
Rheophilic spp =	**AURA**	Semi-rheophilic spp=	**LMAR**	Non-rheophilic spp=	**TSPA**
Breeding and early life-stages=	**4**	Breeding and early life-stages=	**4**	Breeding and early life-stages=	**4**
Survival /Abundance =	**4**	Survival /Abundance =	**4**	Survival /Abundance =	**4**
Cover =	**4**	Cover =	**4**	Cover =	**4**
Health and condition=	**4**	Health and condition=	**4**	Health and condition=	**4**
Water quality=	**4**	Water quality=	**4**	Water quality=	**4**
Habitat flow stress response with breeding requirements	**2**	**Habitat flow stress response with breeding requirements**	**2**	**Habitat flow stress response with breeding requirements**	**2**
Habitat flow stress response without breeding requirements	**2**	**Habitat flow stress response without breeding requirements**	**2**	**Habitat flow stress response without breeding requirements**	**2**

Table 5g: Assessment of the PES for the Groot Letaba River (Appel).

DETERMINANTS CONSIDERED FOR ESTIMATION	GROOT LETABA APPEL.	Score / 5
Native species richness	Only 6 out of a potential 22 species were recorded in the Feb survey.	**2**
Presence of native intolerant species	AURA and CPRE, were recorded. BEUT is expected but was not found. No migratory species were recorded. The only red data species OPER as again absent and is feared lost from the system.	**2**
Abundance of native species	Those species caught were abundant.	**4**
Native species Frequency of Occurrence	Records dating from 1995 indicate that most fish occur frequently at each monitoring site within the eco region.	**3**
Health/condition: native and introduced species	No obvious deformities or disease was noted.	**4**
Presence of introduced fish species	No records of alien fish have been made in the Groot Letaba River. However, *Micropterus salmoides, Oncorhynchus mykiss* and *Cyprinus carpio* are known to exist in the upstream Ebenezer Dam. *Micropterus salmoides* also exists in farm dams of the upper catchment. If they are present, they are in low abundance. However habitat is ideal and it is possible that these species may be affecting recruitment in the upper river. Although also present in Tzaneen Dam, access is restricted by irrigation weirs.	**3**
Instream habitat modification	Stream flow has been affected by the placement of Ebenezer Dam and numerous upper catchment farm dams. The forestry industry is also expected to negatively influence stream flow and water quality.	**3**
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	**21 / 35 = 60% = CLASS C**	

5.4 GROOT LETABA: MERENSKY

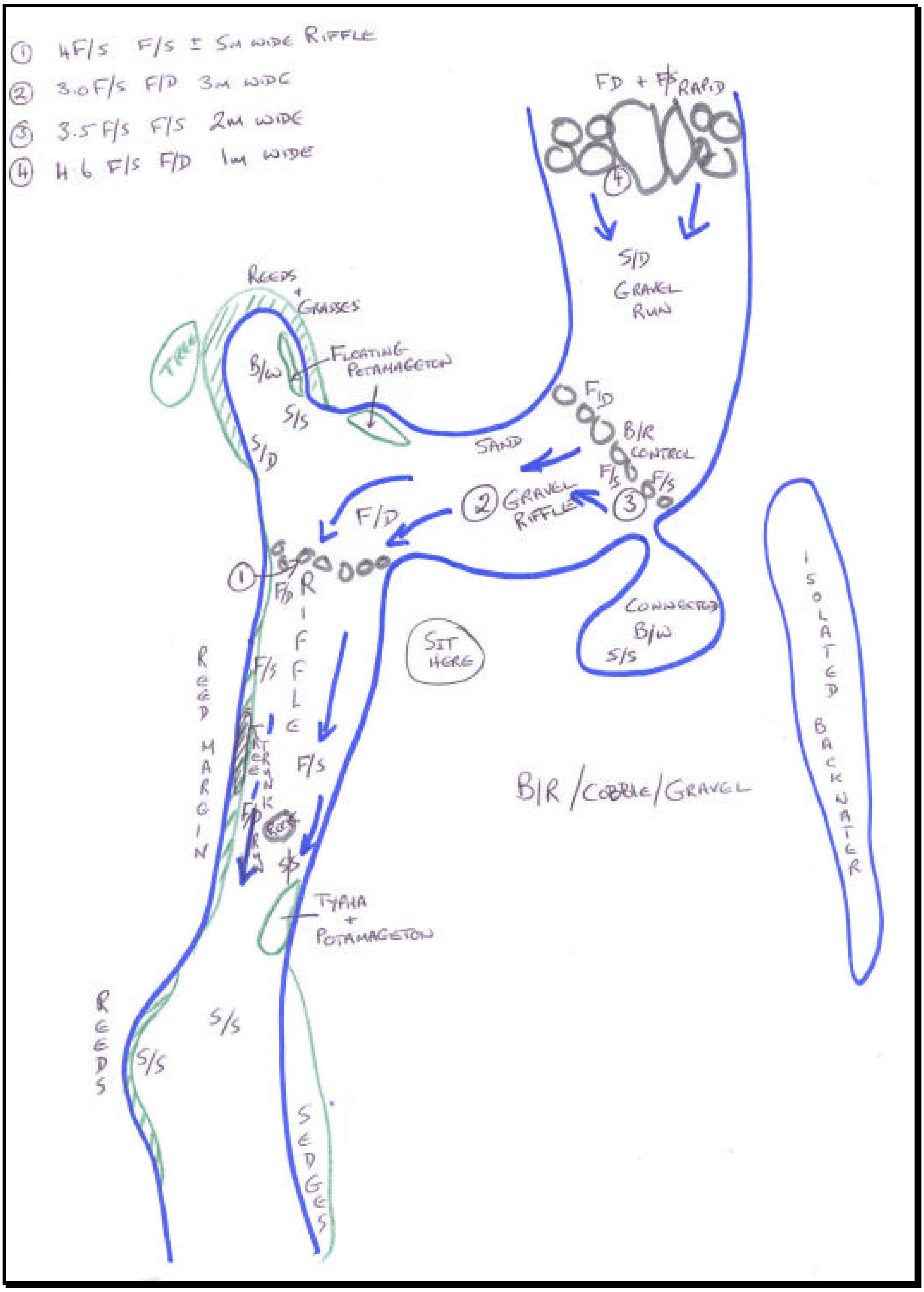

Figure 4. Groot Letaba: Merensky Site Map.

Table 6a: Fish species recorded and expected in the Groot Letaba, 5.02A eco region (above Prieska Weir) and those numbers of fish collected during the IFR survey of February 2004. ((Historical records available between 1991 and 2003 obtained from Limpopo Province Department of Environmental Affairs Fish Distribution Data Base (updated December 2003).

RIVER	**GROOT LETABA**
ECO REGION:	**5.02a (ABOVE PRIESKA)**
SURVEYOR:	**Fouche et al.**
DATE:	**16.02.04**
Anguilla marmorata	
Anguilla mossambica	
Barbus eutaenia	
Barbus paludinosos	
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	
Labeobarbus 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 collected.**

Table 6b: Fish caught in Slow Deep and Slow Shallow habitats using a pole seine.

Method	Pole seine
Habitat	**S/D & S/S pools**
BTOP	3
BTRI	4
BUNI	1
BVIV	6
CGAR	1
LMAR	66
LMOL	1
MACU	>200
MBRE	50
OMOS	45
PPHI	1
TREN	23

Table 6c: Fish caught in Fast Deep habitats using a cast net.

Method	Cast net
Habitat	**rapid and pools**
BTRI	1
CPAR	2
LMAR	30

Table 6d: Fish caught in Fast Deep and Fast Shallow cobble riffles and bedrock rapids using an electro shocker.

Method	Shock
Habitat	**F/S & F/D riffle & rapid**
BTRI	1
BVIV	1
CPAR	40
CPRE	10
LCYL	6
LMAR	16
LMOL	25
MACU	1

Table 6e: Fish Habitat assessment of the Groot Letaba Merensky site and Resource Unit.

GROOT LETABA	**SITE:**	**MERENSKY**	**DATE:**	**16.02.04**	**TIME**	**08.30am**	
RELATIVE FLOW-DEPTH RATING:0=NONE;1=RARE;2=SPARSE;3=MODERATE;4=ABUNDANT;5=VERY ABUNDANT)							
FAST DEEP	**3**	FAST SHALLOW	**5**	SLOW DEEP	**3**	SLOW SHALLOW	**3**
COVER TYPES ASSOCIATED WITH EACH FLOW-DEPTH CLASS							
Overhanging vegetation:	**2**	Overhanging vegetation:	**2**	Overhanging vegetation:	**3**	Overhanging vegetation:	**2**
Undercut banks & root wads:	**2**	Undercut banks & root wads:	**2**	Undercut banks & root wads:	**3**	Undercut banks & root wads:	**1**
Substrate:	**4**	Substrate:	**4**	Substrate:	**2**	Substrate:	**2**
Water Column:	**4**	Water Column:	**3**	Water Column:	**3**	Water Column:	**2**
Aquatic macrophytes:	**0**	Aquatic macrophytes:	**1**	Aquatic macrophytes:	**2**	Aquatic macrophytes:	**1**
Remarks:		Remarks:		Remarks:		Remarks:	
Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**1**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**4**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**4**

Table 6f: Fish species responses: habitat suitability for the different life-stage requirements for the Merensky site in the Groot Letaba River.

FISH SPECIES RESPONSES: HABITAT SUITABILITY FOR DIFFERENT LIFE-STAGE REQUIREMENTS					
Rheophilic spp =	**CPRE**	Semi-rheophilic spp=	**LMAR**	Non-rheophilic spp=	**MACU**
Breeding and early life-stages=	**4**	Breeding and early life-stages=	**3**	Breeding and early life-stages=	**3**
Survival /Abundance =	**4**	Survival /Abundance =	**4**	Survival /Abundance =	**4**
Cover =	**4**	Cover =	**4**	Cover =	**4**
Health and condition=	**4**	Health and condition=	**3**	Health and condition=	**4**
Water quality=	**3**	Water quality=	**3**	Water quality=	**3**
Habitat flow stress response with breeding requirements	**2.4**	**Habitat flow stress response with breeding requirements**	**3.2**	**Habitat flow stress response with breeding requirements**	**2.8**
Habitat flow stress response without breeding requirements	**2.5**	**Habitat flow stress response without breeding requirements**	**3**	**Habitat flow stress response without breeding requirements**	**2.5**

Table 6g: Assessment of the PES for the Groot Letaba River (Merensky).

DETERMINANTS CONSIDERED FOR ESTIMATION	**GROOT LETABA MERENSKY.**	**Score / 5**
Native species richness	15 out of a potential 29 species were recorded in the Feb survey.	**3**
Presence of native intolerant species	CPRE, were recorded in abundance. CPAR was also abundant. CSWI has not been recorded since before the 2000 floods and there are concerns for the status of this fish. BEUT is expected in very low abundance but was not found. No migratory species were recorded.	**3**
Abundance of native species	Those species caught were abundant.	**4**
Native species Frequency of Occurrence	Records dating from 1990 indicate that most fish occur frequently at each monitoring site within the eco region. Many juveniles were recorded which indicated that breeding had recently taken place.	**3**
Health/condition: native and introduced species	Many *Argulus* parasites were noted on LMAR. All other species appeared healthy.	**3**
Presence of introduced fish species	No records of alien fish have been made in the Groot Letaba River and although present in the upper catchment, few are thought to be capable of surviving and breeding in this river environment.	**5**

DETERMINANTS CONSIDERED FOR ESTIMATION	GROOT LETABA MERENSKY.	Score / 5
Instream habitat modification	Stream flow has been affected by the placement of Tzaneen Dam and numerous in channel and off channel farm dams. The citrus industry is also expected to negatively influence water quality and the concentration of pesticides is high. Sedimentation has affected stream bed characteristics.	**3**
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	**23 / 35 = 65% = CLASS C**	

5.5 GROOT LETABA: LETABA RANCH

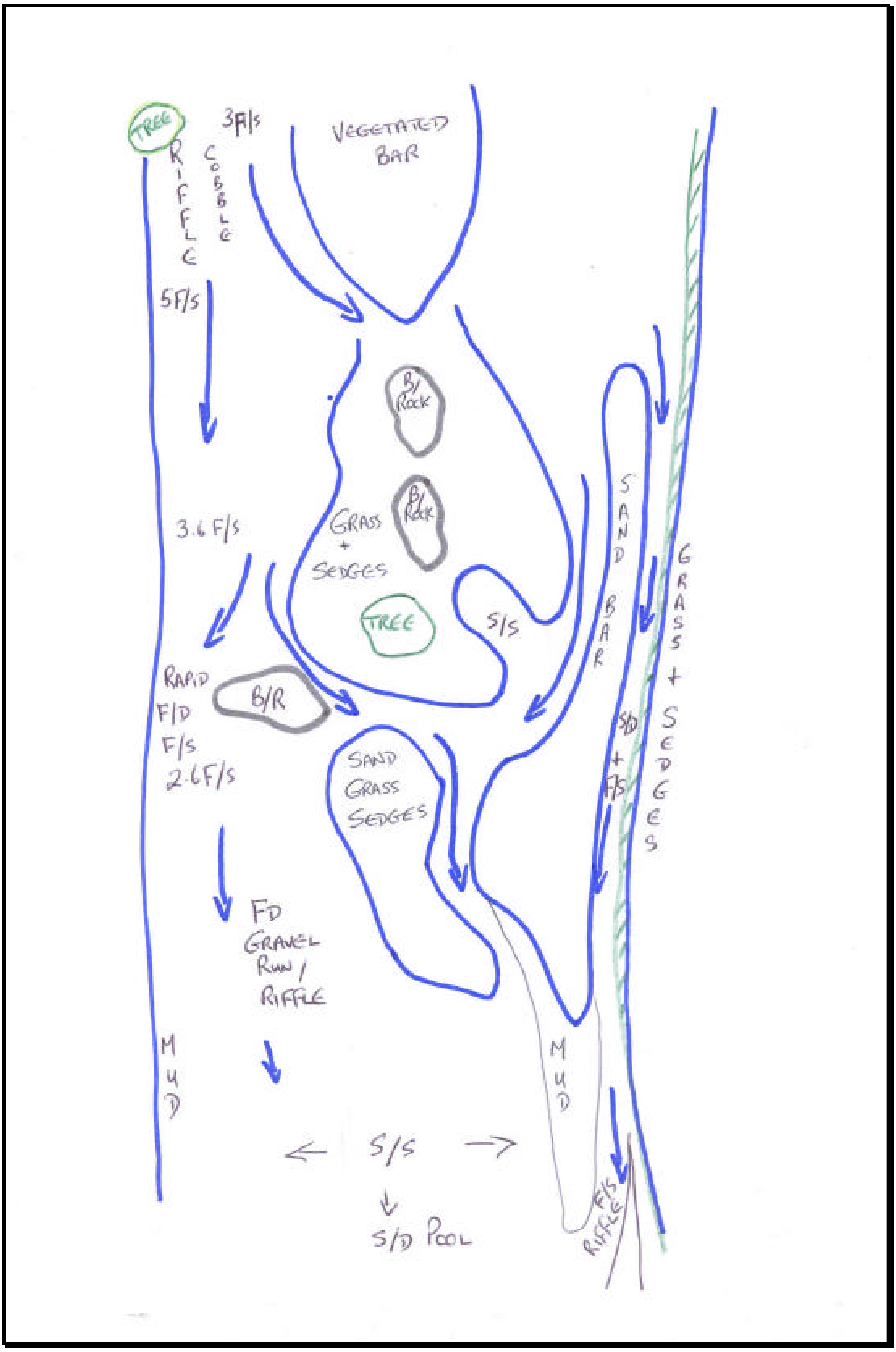

Figure 5a: Groot Letaba: Letaba Ranch Site Map.

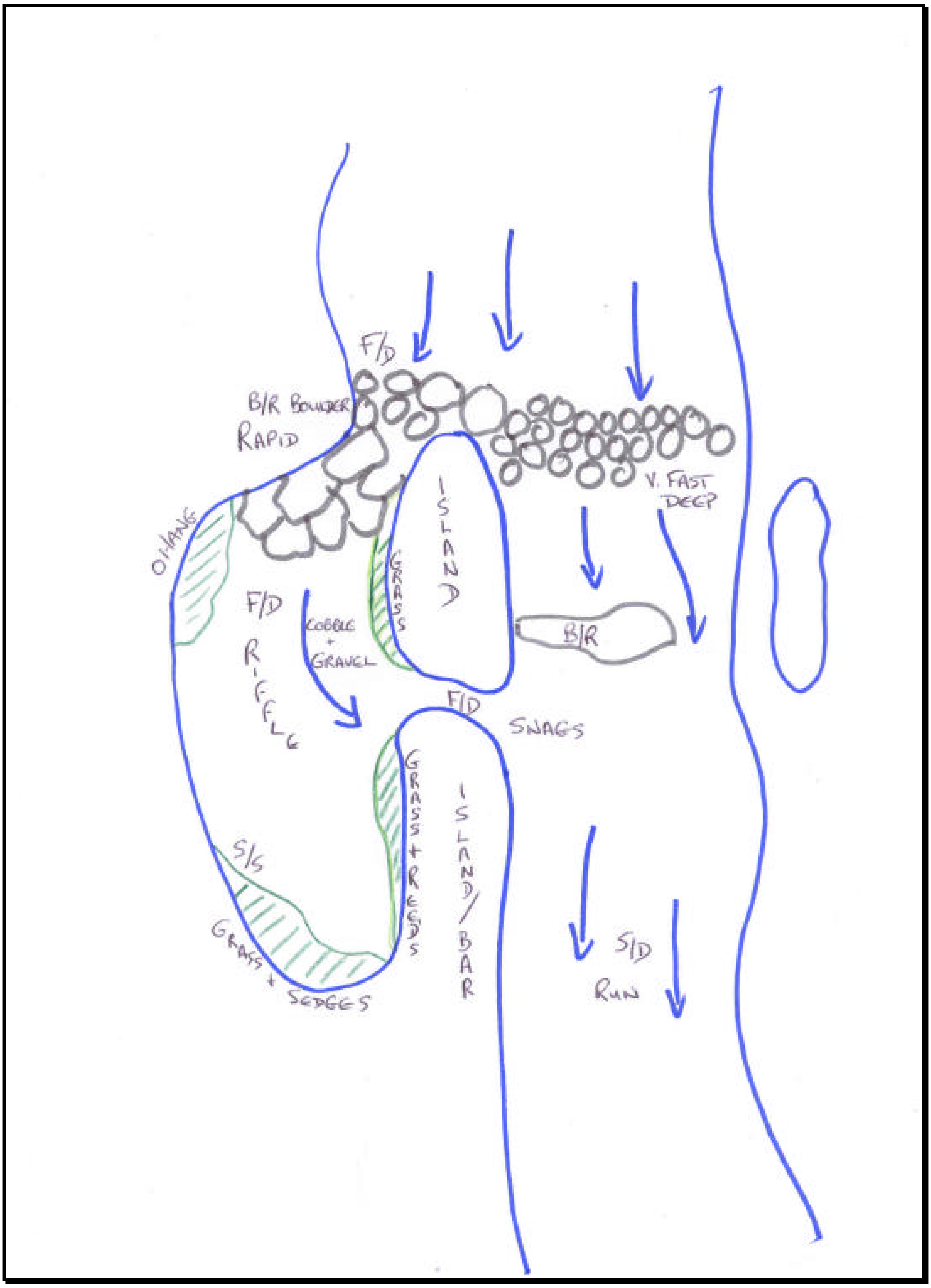

Figure 5b: Groot Letaba: Letaba Ranch Site Map - Island section.

Table 7a: Fish species recorded and expected in the Groot Letaba, 5.02B eco region (below Prieska Weir) and those numbers of fish collected during the IFR survey of February 2004 at Letaba Ranch. ((Historical records available between 1991 and 2003 obtained from Limpopo Province Department of Environmental Affairs Fish Distribution Data Base (updated December 2003)

RIVER	**GROOT LETABA**
ECO REGION:	**5.02b (BELOW PRIESKA) at Letaba Ranch**
SURVEYOR:	**Fouche et al.**
DATE:	**17.02.04**
Anguilla bengalensis	
Anguilla marmorata	
Anguilla mossambica	
Barbus afrohamiltoni	8
Barbus annectens	
Barbus mattozi	
Barbus neefi	
Barbus paludinosos	
Barbus radiatus	
Barbus toppini	21
Barbus trimaculatus	28
Barbus unitaeniatus	50
Barbus viviparus	8
Brycinus imberi	
Chiloglanis paratus	35
Chiloglanis pretoriae	10
Chiloglanis engiopsi	
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
36 species expected	**16 species collected**

Table 7b: Fish caught in Slow Deep and Slow Shallow habitats using a pole seine.

Method	**Pole seine**
Habitat	**S/D & S/S pools**
BAFR	1
BTOP	21
BTRI	25
BUNI	50
BVIV	8
LMAR	2
MACU	>100
MBRE	>100
OMOS	>100
PPHI	2
TREN	20

Table 7c: Fish caught in slow Deep habitats using a cast net.

Method	**Cast net**
Habitat	**rapid and pools**
BAFR	7
CPAR	2
LMAR	4
OMOS	23

Table 7d: Fish caught in Fast Deep and Fast Shallow cobble riffles and bedrock rapids using an electro shocker.

Method	**Shock**
Habitat	**F/S & F/D riffle & rapid**
BTRI	3
CPAR	33
CPRE	10
LCYL	2
LMAR	23
LMOL	52
LRUD	1
OMOS	2

Table 7e: Fish Habitat assessment of the Groot Letaba, Letaba Ranch site and Resource Unit.

GROOT LETABA	**SITE:**	**LETABA RANCH**	**DATE:**	**17.02.04**	**TIME:**	**09.00am**	
RELATIVE FLOW-DEPTH RATING:0=NONE;1=RARE;2=SPARSE;3=MODERATE;4=ABUNDANT;5=VERY ABUNDANT)							
FAST DEEP	**5**	FAST SHALLOW	**5**	SLOW DEEP	**5**	SLOW SHALLOW	**4**
COVER TYPES ASSOCIATED WITH EACH FLOW-DEPTH CLASS							
Overhanging vegetation:	**3**	Overhanging vegetation:	**5**	Overhanging vegetation:	**4**	Overhanging vegetation:	**3**
Undercut banks & root wads:	**3**	Undercut banks & root wads:	**3**	Undercut banks & root wads:	**3**	Undercut banks & root wads:	**2**
Substrate:	**5**	Substrate:	**4**	Substrate:	**2**	Substrate:	**2**
Water Column:	**5**	Water Column:	**4**	Water Column:	**5**	Water Column:	**3**
Aquatic macrophytes:	**1**	Aquatic macrophytes:	**3**	Aquatic macrophytes:	**3**	Aquatic macrophytes:	**3**
Remarks:		Remarks:		Remarks:		Remarks:	
Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**

Table 7f: Fish species responses: habitat suitability for the different life-stage requirements for the Letaba Ranch site in the Groot Letaba River.

FISH SPECIES RESPONSES: HABITAT SUITABILITY FOR DIFFERENT LIFE-STAGE REQUIREMENTS

Rheophilic spp =	CPRE	Semi-rheophilic spp=	LMAR	Non-rheophilic spp=	BUNI
Breeding and early life-stages=	5	Breeding and early life-stages=	5	Breeding and early life-stages=	5
Survival /Abundance =	5	Survival /Abundance =	5	Survival /Abundance =	5
Cover =	5	Cover =	5	Cover =	5
Health and condition=	5	Health and condition=	3	Health and condition=	5
Water quality=	4	Water quality=	4	Water quality=	4
Habitat flow stress response with breeding requirements	0.4	**Habitat flow stress response with breeding requirements**	1.2	**Habitat flow stress response with breeding requirements**	0.4
Habitat flow stress response without breeding requirements	0.5	**Habitat flow stress response without breeding requirements**	1.5	**Habitat flow stress response without breeding requirements**	0.5

Table 7g: Assessment of the PES for the Groot Letaba River (Letaba Ranch).

DETERMINANTS CONSIDERED FOR ESTIMATION	GROOT LETABA LETABA RANCH.	Score / 5
Native species richness	16 out of a potential 36 species were recorded in the Feb survey.	**3**
Presence of native intolerant species	CPRE, were recorded in abundance. CPAR was also abundant. CSWI and HVIT were expected but were not found. No other migratory species were recorded.	**2**
Abundance of native species	Those species caught were abundant.	**4**
Native species Frequency of Occurrence	Records dating from 1990 indicate that most fish occur frequently at each monitoring site within the eco region. Many juveniles were recorded which indicated that breeding had recently taken place. In addition ripe running LMAR were recorded, indicating good breeding conditions for this semi rheophilic species.	**3**
Health/condition: native and introduced species	Many Argulus parasites and sores were noted on LMAR. All other fish appeared healthy.	**3**
Presence of introduced fish species	No records of alien fish have been made in the Groot Letaba River and although present in the upper catchment, few are thought to be capable of surviving and breeding in this river environment.	**5**
Instream habitat modification	Stream flow has been seriously affected by the placement of Tzaneen Dam and Nondweni Dam and numerous in channel and off channel farm dams. The Citrus industry is also expected to negatively influence water quality and the concentration of pesticides is moderate at this point. Sedimentation has affected stream bed characteristics.	**2**
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	**22 / 35 = 62% = CLASS C**	

6. ECOLOGICAL REQUIREMENTS OF FISH SPECIES USED AS INDICATORS FOR THIS REPORT

Angliss (1999) compiled a workshop report, which through later development undertaken by Kleynhans, (unpublished) provided the current intolerance ratings for all of those fish species occurring in the Letaba Catchment. The workshop report summarized all documented information available at that time relating to the water quality and flow requirements of those species listed. In addition, the workshop subjectively assessed the expert opinion of a wide audience of regional ichthyologists.

A very limited amount of documented factual information is also now available to substantiate the ecological water requirements of those indicator species used at each site in this study. The following is a brief summary of information that was used in the above assessments.

6.1
Amphilius uranoscopus., Barbus eutaenia, Barbus unitaeniatus, Chiloglanis paratus, Labeo molybdinus, Micralestis acutidens., Mesobola brevianalis, Tilapia sparrmanii,

No new information available.

6.2 *Chiloglanis pretoriae.*

Source: de Villiers (1991). (omitted form the 2000 workshop summary)
Habitat velocities 0.8 - 1.0 m/s rocky substrates.
Well oxygenated water (>0.6mg/l) with a turbidity ranging from 1.7 - 47 NTU
Breeding cues re provided by increases in water temperature and photo period.

6.3 *Labeobarbus marequensis*

Source. Engelbrecht and Roux.
Spawning habitat: Velocities > 0.7m/s and 200mm depth. Spawns as temperature reaches 24 ^{o}C in the early summer.
Source. Fouche, Vlok and Angliss 2003.
Concurred that Labeobarbus marequensis is semi rheophilic due to abundances recorded in different velocity depth classes.

LMAR	Site	SS	SD	FS	FD
	Mutale	67	0	33	0
	Luvuvhu	4	0	85	11

7. CONCLUSIONS

The Letaba River catchment appears to fall within the low Class C PES. These results concur with the generally poor status of fish communities as described within the 2001 State of Rivers Report. The habitat quality also concurs favorably with that assessed in the 2001 study.

The field surveys (outside of the Kruger National Park) reveal that nearly all migratory fishes are absent from the river at this time. This is largely due to fragmentation of the system caused by the numerous weirs and dams and the imposition of a regulated flow regime.

The system has however maintained some level of perenniality and this is evidenced by the continuing presence of most of the intolerant and flow dependant species. However, at this time the absence of *Chiloglanis swierstrai* in the lower reaches of the river is of concern and may be linked to changes in flow patterns. The only red data species known to occur in the upper catchment (*Opsaridium peringueyi)* is thought to now be lost due to flow regulation in the upper catchment.

There are no invasive fish species, which have ever been recorded in the rivers of this catchment, although they are known to be abundant in dams.

Although many species remain unaccounted for at each site during this survey, the majority have been recorded in the catchment in more comprehensive surveys undertaken in recent years.

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APPENDIX A.2
ASSESSMENT OF FISH POPULATIONS
KRUGER NATIONAL PARK

Prepared by:
A Deacon

1. INTRODUCTION

A comprehensive Reserve Determination Study on the Letaba River Catchment commenced in 2003. The study entails the investigation of the status of both biotic and abiotic factors in the catchment at selected Instream Flow Requirement (IFR) sites.

This report addresses the status of fish communities.

2. STUDY SITES

Sites for the IFR survey were selected in a multi disciplinary field survey undertaken from 10th – 13th August 2003.

Site Coordinates. (Supplied by Rountree)

Lonely Bull (KNP, downstream of Shimuweni bridge) ***S23 45 09.5; E31 24 26.3***

Letaba Bridge (KNP, near Letaba restcamp) S23 48 35.4; E31 35 26.9

3. APPROACH OF THE STUDY

The study assessed fish communities at the above 2 IFR sites. Historical data was then analyzed to permit the extrapolation of the site-specific data generated during the field survey, to resource units within the catchment. Due to numerous earlier fish surveys within the Letaba Catchment, it was deemed appropriate to follow the eco region approach as adopted in the 2001 State of Rivers Report.

The response of key indicator species to those flow regimes observed was assessed using all available data and expert judgement. (following guidelines developed by Kleynhans (in prep) for the Tugela reserve determination)

The Present Ecological State (PES) of each resource unit was determined according to guidelines developed by Kleynhans (in prep) for the Tugela reserve determination. (See Table A below).

4. FIELD SURVEY METHODS

A field study was undertaken along the river on 16th – 18th February and 19th – 21st April 2004. During the first survey the Letaba Bridge site was sampled, but before the Lonely Bull site was sampled, the Letaba River came down in flood, making it impossible to survey the site. The Lonely Bull site was then surveyed during April and the Letaba Bridge site was again surveyed during the 7th June 2004.

The initial surveys were done after the river started to flow following an extended period of no-flow. The April and June 2004 surveys were planned to record the recovery of the river since the drought.

4.1 FISH

During the survey of the Letaba Catchment IFR sites, fish were gathered using a variety of methods.

- Electro - shocking apparatus: a two to three man operation, whereby fish are stunned using 220 volt AC electric current. The stunned fish are collected in hand held scoop nets positioned down stream. The method is suited to shallow (< 1 metre depth) swift flowing water over assorted substrates. Also useful around snags, undercut banks and in heavily vegetated but shallow pools.

- Seine net: a net measuring metres length by 3.5 metres deep, with 10 mm knotless nylon netting. The net is pulled through the water by 2 - 4 people and fish are collected in a central bag. Suitable for deep pools which are clear of snags.

- Pole net: a small piece of seine netting attached to two wooden poles. This two man net measures 2.5 metres by 1.5 metres deep, and again has 10 mm mesh. The net is useful for sampling in small pools, but is particularly designed for use under and amongst overhanging and marginal vegetation.

- Cast or throw net: a 1.6 metre radius, circular monofilament net, with 12 mm mesh size. Cast nets can be used by an individual in any habitat which is clear of snags and obstructions.

Most fish caught were identified at site and returned to the river alive.

Each site was subjected to exhaustive searches using the most appropriate collecting techniques. At all sites, multiple habitats were sampled. At all sites, habitats of similar velocity depth classes and cover types were sampled at different localities. A reach of river approaching two hundred metres was sampled at each site.

4.2 HABITAT ASSESSMENTS

The habitat at the site was categorized, and where possible individual habitats sampled. The effort used to catch fish in each habitat at each site was recorded.

Fish habitat is categorized into four velocity depth classes, and allocated a subjective score based upon their abundance using a five point scale. (Kleynhans 1997)

Fast Deep (F/D); Fast Shallow (F/S); Slow Deep (S/D); Slow Shallow (S/S)
(0=Absent; 1=Rare; 2=Sparse; 3=Moderate; 4=Extensive)

The same scale is utilized to assess the availability of cover types, for each velocity depth class. Four cover types are assessed.
(Overhanging vegetation; Undercut bank and root wads; Substrate; Aquatic macrophytes and water column).

Fast Habitats: Deep water = > 0.3 metres; Fast water = > 0.3 m/sec.
Slow habitats: Deep water = > 0.5 metres; Fast water = > 0.3 m/sec.

A detailed photographic record of the site was made (see Photo points).

4.3 RESULTS

Results were combined and are presented in tabular format for each site.

Table 1: Assessment of the PES based on Fish.

DETERMINANTS CONSIDERED FOR ESTIMATION	RIVER ZONE OR DEFINED RESEOURCE UNIT (scoring /assessment criteria: provide comments for each score)
Native species richness	Number of species expected: number of species currently present (most recent). Score according to: None of expected present = 0: Only few expected present = 1-2: Majority of expected species present = 3-4: All/almost all of expected present = 5.
Presence of native intolerant species	No intolerant species present = 0: Few intolerant species = 1-2: Majority of intolerant species present = 3 - 4: All/almost all intolerant species present (OR no intolerant naturally present) = 5.
Abundance of native species	No fish = 0: Only few individuals = 1-2: Moderate abundance = 3-4: Abundance as expected for natural conditions = 5.
Native species Frequency of Occurrence	Fish absent at all sites = 0: Fish present at only very few sites = 1-2: Fish present at most sites 3-4: Fish present at all sites =5.
Health/condition: native and introduced species	All fish seriously affected/fish absent = 0: Most fish affected = 1-2: Most fish unaffected = 3-4: Only single/few individuals affected = 5:
Presence of introduced fish species	Predaceous species and/or habitat modifying species with a critical impact on native species = 0 Predaceous species and/or habitat modifying species with a serious impact on native species = 1-2 Predaceous species and/or habitat modifying species with a moderate impact on native species = 3-4 Predaceous species and/or habitat modifying species with no impact on native species = 5
Instream habitat modification	Water quality/flow/stream bed substrate, critically modified, no suitable conditions for expected species = 0: Water quality/flow/stream bed substrate, seriously modified, little suitable conditions for expected species = 1-2: Water quality/flow/stream bed substrate, moderately modified, moderately suitable conditions for expected species = 3-4: Water quality/flow/stream bed substrate, little /no modification, abundant suitable conditions for expected species = 5
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	TAKING INTO ACCOUNT THE ABOVE INFORMATION: RATE FISH ASSEMBLAGE INDEX CATEGORY A - F BASED ON GENERAL SCORING GUIDELINES: Category % of total expected score A: 90 - 100 B: 80 - 90 C: 60 - 80 D: 40 - 60 E: 20 - 40 F: 0 - 20

Figure 1: Ecoregion Map - Letaba River

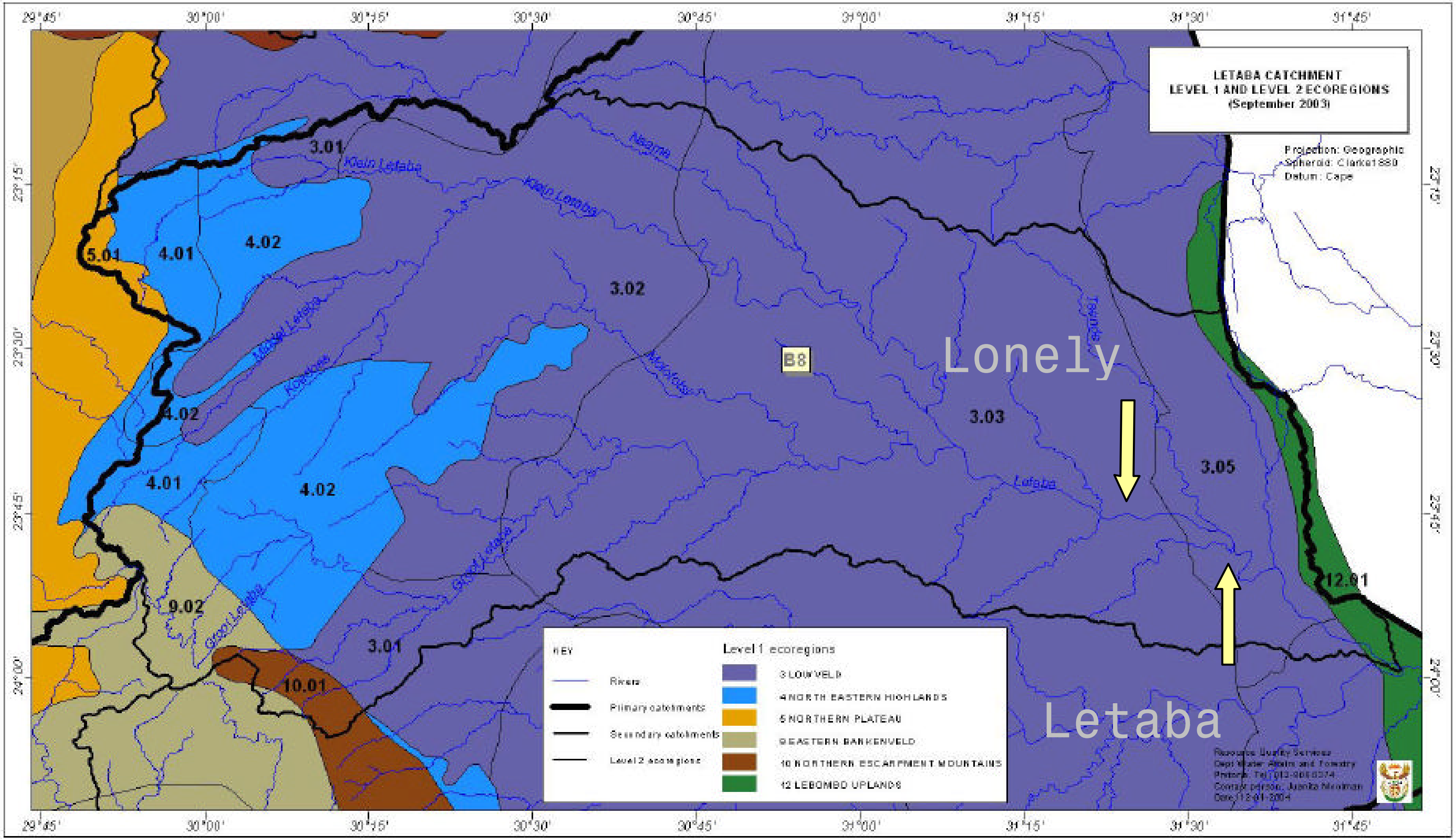
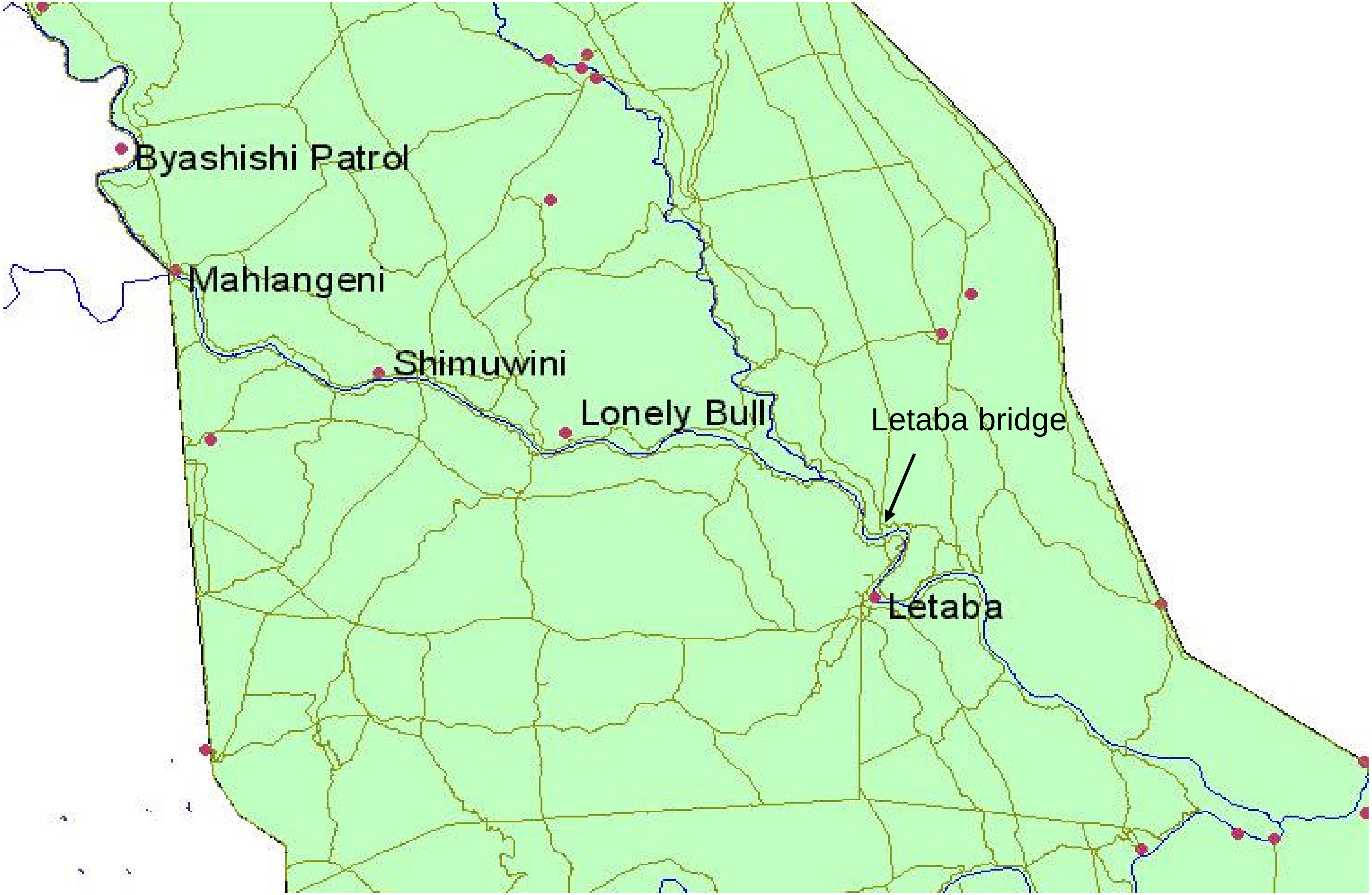


Figure 2: Letaba IFR Sites in the KNP



5. BACKGROUND TO THE STATUS OF THE LETABA RIVER AND THE RESPONSE OF THE FISH ASSEMBLAGE

The last few decades the Letaba River experienced periodical periods of no flow. This happened because of the over-utilization of the river, mainly by irrigation. During November 2003 through to January 2004 the river stopped flowing again. Leaching of fertilizers into the river has enriched the water unnaturally with additional nutrients.

During 1996 and 2000 the river experienced massive floods, identified as 75-year floods. This has changed the river considerably, especially regarding the geomorphology.

The Massingire Dam in Mozambique is a very large impoundment that can be a formidable migration barrier even to eels. When they install the sluice gates it will even be more of a barrier.

The current situation due to the above-mentioned impacts can be summarized as follow:

- A great deal of the established riverbed has been scoured out by the floodwaters, including islands, reedbeds and marginal vegetation
- Massive amounts of sediment had been deposited in the river after the floods
- Large amounts of sediment has been mobilized in tributaries and deposited into the Letaba River
- These tributaries also experienced siltation of pools and other habitats
- The sediment in the river has silted up many important biotopes, including pools and backwaters
- Other habitats such as channels and runs became much shallower due to the deposition
- Riffles and rapids became smothered in advancing sediment layers, while undercut banks and rootwads were buried in the sand
- The sand in the riverbed was deposited flat and wide, creating a “clean slate” for future geomorphological processes
- Remainders of old channels are still visible or has been re-instated as the main channel
- In other areas the rivers changes course during high flows due to the unstable nature of the deposited sediment
- Establishment of new stable vegetated islands takes time and might only be secured much later
- The layers of sediment deposited currently may be to an extent different from the bottom substrate present before 1996
- Due to the immense amounts of sediment in the system, the river might commence to flow subsurface much sooner than pre-1996
- Therefore the no-flow situation might be reached sooner with the current state of the riverbed
- First habitats to be influenced during a no-flow situation are the controls (riffles and rapids)
- Thereafter the water edge leaves the marginal areas and the overhanging vegetation and undercut banks lose their inundation
- With the receding water levels due to subsurface flows and evaporation, the water quality also degrades as water is concentrated in pools

- Algae forming on all surfaces covers food sources and degrades habitats

Whereas Ecoregion 3.03 is more of a braided reach that is sand bed dominated, ER 3.05 is rather more bedrock dominated with large pool areas connected by sand braids.

Table 2: Fish distribution and presence during surveys

X = found during surveys * = found only in the tributaries and not main stream

Researcher	Pienaar 1978		Russell 1997		Heath 1991*	Ecoregion 3.03 Deacon		Ecoregion 3.05 Deacon	
Ecoregion	**3.03**	**3.05**	**3.03**	**3.05**	**3.05**	**Pre 2000**	**Post 2000**	**Pre 2000**	**Post 2000**
Anguilla marmorata	X								
Anguilla mossambica	*	*	X						
Awaous aeneofuscus		X							
Barbus afrohamiltoni	X	X	X	X	X	X	X	X	X
Barbus annectens	*	X			X	X		X	
Barbus paludinosos	*	X		X	X			X	X
Barbus radiatus	X	X	X	X	X	X	X	X	X
Barbus toppini	X	X	X	X	X	X		X	
Barbus trimaculatus	X	X	X	X	X	X	X	X	X
Barbus unitaeniatus	X	X	X	X	X	X	X	X	X
Barbus viviparus	X	X	X	X	X	X	X	X	X
Brycinus imberi	X	X	X	X	X	X	X	X	X
Chiloglanis paratus	X	X	X	X	X	X	X	X	X
Chiloglanis pretoriae		X			X			X	
Chiloglanis swierstrai		X							
Clarias gariepinus	X	X	X	X	X	X	X	X	X
Glossogobius callidus									
Glossogobius giuris	X	X	X	X	X	X	X	X	X
Hydrocynus vittatus	X	X		X			X	X	X
Labeo congoro	X	X				X		X	
Labeo cylindricus	X	X	X	X	X	X	X	X	X
Labeo molybdinus	X	X	X	X	X	X	X	X	X
Labeo rosae	X	X	X	X	X	X	X	X	X
Labeo ruddi	X	X	X	X	X	X	X	X	X
Labeobarbus marequensis	X	X	X	X	X	X	X	X	X
Marcusenius macrolepidotus	X	X	X	X	X	X	X	X	X
Mesobola brevianalis	X	X	X	X	X	X	X	X	
Micralestes acutidens	X	X	X	X	X	X	X	X	X
Oreochromis mossambicus	X	X	X	X	X	X	X	X	X
Petrocephalus wesselsi		X		X			X		
Pseudocrenilabrus philander	*	X		X	X			X	
Schilbe intermedius	X	X	X	X	X	X	X	X	X
Synodontis zambezensis	X	X	X	X		X	X	X	X
Tilapia rendalli	X	X	X	X	X	X	X	X	X
Tilapia sparrmanii		*							

*It must be noted that Heath (1992) only worked in Ecoregion 3.05 in KNP

Table 3: Status in Ecoregions (ER) 3.03 and 3.05 in KNP

Species	Status in Ecoregions (ER) 3.03 and 3.05 in KNP
Anguilla marmorata	This species was only sampled by Pienaar (pre 1970) at the area where the Letaba River enters the KNP (Mahlangene - most probably a single specimen), and then downstream of the confluence in the Olifants River. Since the building of the Massingir Dam in Mozambique it might experience problems to cross this barrier. **Status:** Since monitoring started, this eel was never common in the Letaba River. However, the fact that they reached the point at Mahlangene indicates that they have to transverse the whole Letaba River in the KNP. Methods of monitoring them might be inadequate, or the migration obstruction of the Massingir Dam excludes them from the upstream areas. No eels were indicated in the upstream areas by Angliss (current IFR - FRAI project). **Status for FRAI 2004:** 3.03 – present; 3.05 – absent. **Current status:** 3.03 – not found; 3.05 – N/A **Overall status:** 3.03 – declined - extinct; 3.05 – N/A
Anguilla mossambica	Pienaar (pre 1970) found this eel only in tributaries quite far removed from the main stream in ER 3.03. Russell (1980s) found this species at Shimoweni (ER 3.03). This might indicate that eels possibly are able to overcome the Massingir Dam barrier. **Status:** Since monitoring started, this eel was never common in the Letaba River. However, the fact that they reached the tributaries and ER 3.03, indicates that they have to transverse most of the Letaba River in the KNP. Methods of monitoring them might be inadequate, or they are just very rare. No longfinned eels were found in the upstream areas by Angliss (current IFR - FRAI project). **Status for FRAI 2004:** 3.03 – present; 3.05 – absent. **Current status:** 3.03 – not found; 3.05 – N/A **Overall status:** 3.03 – declined - extinct; 3.05 – N/A
Awaous aeneofuscus	Not a common fish and found by Pienaar (pre 1970) only in the lower reaches of the Letaba River. Never found by any other researcher afterwards. **Status:** A rare fish in the lowveld systems. **Status for FRAI 2004:** 3.03 – absent; 3.05 – present. **Current status:** 3.03 – N/A; 3.05 – not found **Overall status:** 3.03 – N/A; 3.05 – declined
Barbus afrohamiltoni	**Status:** Abundant **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – increased; 3.05 – increased
Barbus annectens	Pienaar (pre 1970) found these barbs in tributaries quite far removed from the main stream in ER 3.03, and in the mainstream in ER 3.05. Russell (1980s) did not find it at all in the Letaba River. Heath (1992) found it in ER 3.03. Deacon (1992-2004) recorded it in both the ER's before the 2000 floods, but since the floods none were found in the Letaba River. **Status:** The 2000 floods might have changed the habitats in such a way that it is currently unsuitable for these barbs.

Species	Status in Ecoregions (ER) 3.03 and 3.05 in KNP
	Status for FRAI 2004: 3.03 – present; 3.05 – present. **Current status:** 3.03 – not found; 3.05 – not found **Overall status:** 3.03 – declined; 3.05 – declined
Barbus paludinosus	Pienaar (pre 1970) found these barbs in tributaries in ER 3.03, and in the mainstream in ER 3.05. This might be why Russell (1980s) only found it in ER 3.05, his research (and the other researchers) concentrated on the main stream. Heath (1992) found it in ER 3.03. Deacon (1992-2004) did not monitored any before the 2000 floods, but after the floods it was recorded in both ER 3.03 and ER 3.05 in the Letaba River. **Status:** Present throughout the Letaba River, populations might have been washed out of the abundant backwaters of the tributaries during the 2000 flood. **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Barbus radiatus	**Status:** Abundant **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Barbus toppini	Pienaar (pre 1970), Russell (1980s) and Heath (1992) found it in both ER 3.03 and ER 3.05. Deacon (1992-2004) recorded it in both the ER's before the 2000 floods, but since the floods none were found in the Letaba River. **Status:** The 2000 floods might have changed the habitats in such a way that it is currently unsuitable for these barbs. **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – not found; 3.05 – not found **Overall status:** 3.03 – declined; 3.05 – declined
Barbus trimaculatus	**Status:** Abundant **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – unchanged; 3.05 – unchanged
Barbus unitaeniatus	**Status:** Abundant **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Barbus viviparus	**Status:** Abundant **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – unchanged; 3.05 – unchanged
Brycinus imberi	**Status:** Present **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – unchanged; 3.05 – unchanged
Chiloglanis paratus	**Status:** Abundant – underwent a population decline during the past drought.

Species	Status in Ecoregions (ER) 3.03 and 3.05 in KNP
	Status for FRAI 2004: 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – declined; 3.05 – declined
Chiloglanis pretoriae	Pienaar (pre 1970), Heath (1992) and Deacon (1992-2004) found these chiloglanids in ER 3.05 (Deacon after the 1996 flood), but Russell (1980s) was unable to record it in the Letaba River. **Status:** Scarce, maybe a vagrant from the Olifants River or it was washed down with the 1996 flood. **Status for FRAI 2004:** 3.03 – absent; 3.05 – present. **Current status:** 3.03 – N/A; 3.05 – present **Overall status:** 3.03 – N/A; 3.05 – declined
Chiloglanis swierstrai	Pienaar (pre 1970) found abundant *C. swierstrai* in ER 3.05. Since then none of the researchers found this fish in the Letaba River in the KNP. **Status:** Maybe affected by the no-flow situations in the Letaba River since 1970. **Status for FRAI 2004:** 3.03 – absent; 3.05 – present. **Current status:** 3.03 – N/A; 3.05 – not found **Overall status:** 3.03 – N/A; 3.05 – declined - extinct
Clarias gariepinus	**Status:** Abundant **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Glossogobius callidus	Since it was only recently discovered that there are two *Glossogobius* species in the KNP rivers, all *Glossogobius* species will be as considered as *Glossogobius giuris*
Glossogobius giuris	**Status:** Unsure **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – declined; 3.05 – declined
Hydrocynus vittatus	Pienaar (pre 1970) found the tigerfish in the length of the river. Russell (1980s) did not find this fish in ER 3.03, though it was present in ER 3.05. On the other hand, Heath (1992) did not find any tigerfish in ER 3.05. Deacon (1992-2004) found tigerfish only in ER 3.05 pre 2000, but after the flood they were widely dispersed in the Letaba River. The extremely high flows of the flood did facilitate passage over formidable migration obstacles (dams, gorges, rapids). Due to the fact that most researchers make use of electro-shocking as a sampling method, larger fish that inhabit the deeper pools and channels are not readily sampled. Tiger fish is one of those fish and that is probably the reason why it is not collected during monitoring. **Status:** Present – floods enhanced migration/dispersion; sedimentation and no-flow situations jeopardize well being. **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – unchanged; 3.05 – unchanged

Species	Status in Ecoregions (ER) 3.03 and 3.05 in KNP
Labeo congoro	As *Labeo congoro* is a large fish mostly found in deep pools and channels, it is not readily collected during monitoring (methods used and fear of crocodiles and hippos). Pienaar (pre 1970) found them in most of the Letaba River since he made use of seine nets during sampling. Deacon (1992-2004) found this fish in deep pools before the 2000 floods when using cast and seine nets. The Letaba River became shallower due to sedimentation after the 2000 floods and might have influenced the fish population, however there are enough deep pools left to accommodate this species. The reason for the current absence might be the fact that these deeper pools had not been sampled properly with seine nets. **Status:** Scarce– floods enhanced migration/dispersion; sedimentation and no-flow situations jeopardize well being. **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – declined; 3.05 – declined
Labeo cylindricus	**Status:** Abundant; especially in riffles and rapids **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – unchanged; 3.05 – unchanged
Labeo molybdinus	**Status:** Abundant; especially in riffles and rapids **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – unchanged; 3.05 – unchanged
Labeo rosae	**Status:** Abundant, increased after the 2000 floods due to the sedimentation of the river. **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Labeo ruddi	**Status:** Abundant **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Labeobarbus marequensis	**Status:** Abundant; during droughts (no-flow situations) the numbers of these fish declined alarmingly, but bounce back after the river starts to flow again. **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – declined; 3.05 – declined
Marcusenius macrolepidotus	**Status:** Present, elusive and not so easy to sample. **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – declined; 3.05 – declined
Mesobola brevianalis	Collected by all the researchers in the entire river. Deacon (1992-2004) failed to obtain specimens in the lower Letaba after the 2000 floods. Habitats might have been changed due to the floods (less backwaters, less overhanging vegetation) and the river sardine might be in a similar situation than some of the barbs that are currently absent.

Species	Status in Ecoregions (ER) 3.03 and 3.05 in KNP
	Status: Rare; currently not found in ER 3.05. **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – not found **Overall status:** 3.03 – declined; 3.05 – declined
Micralestes acutidens	**Status:** Present **Status for FRAI 2004:** 3.03 – present; 3.05 – present **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – declined; 3.05 – declined
Oreochromis mossambicus	**Status:** Abundant **Status for FRAI 2004:** 3.03 – present; 3.05 – present. **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Petrocephalus wesselsi	Not a common fish. Pienaar (pre 1970) and Russell (1980s) only found it in ER 3.05, while Deacon (1992-2004) only once found it in large numbers in a deeper pool in ER 3.03. **Status:** Rare and secretive. **Status for FRAI 2004:** 3.03 – present; 3.05 – present **Current status:** 3.03 – present; 3.05 – not found **Overall status:** 3.03 – declined; 3.05 – declined
Pseudocrenilabrus philander	Not a common fish. Pienaar (pre 1970), Russell (1980s) and Heath (1992) only found it in the main stream of ER 3.05, while Pienaar also found these fish in tributaries quite far removed from the main stream in ER 3.03. Deacon (1992-2004) only once found it in ER 3.05 before the 2000 floods. **Status:** Scarce. **Status for FRAI 2004:** 3.03 – absent; 3.05 – present **Current status:** 3.03 – N/A; 3.05 – not found **Overall status:** 3.03 – N/A; 3.05 – declined
Schilbe intermedius	**Status:** Present **Status for FRAI 2004:** 3.03 – present; 3.05 – present **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Synodontis zambezensis	**Status:** Present; not found by Heath (1992). **Status for FRAI 2004:** 3.03 – present; 3.05 – present **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Tilapia rendalli	**Status:** Present **Status for FRAI 2004:** 3.03 – present; 3.05 – present **Current status:** 3.03 – present; 3.05 – present **Overall status:** 3.03 – improved; 3.05 – improved
Tilapia sparrmanii	Pienaar (pre 1970) only found these fish in tributaries quite far removed from the main stream in ER 3.03.

Species	Status in Ecoregions (ER) 3.03 and 3.05 in KNP
	Status: Absent from main stream **Status for FRAI 2004:** 3.03 – absent; 3.05 – absent **Current status:** 3.03 – N/A; 3.05 – N/A **Overall status:** 3.03 – N/A; 3.05 – N/A

Table 4: Summary of fish distribution and presence during surveys (P = present; A = absent)

	Expected P= Present A= Absent		Present (-) decline (+) improve (0) no change	
Ecoregion	ER 5.03	ER 5.05	ER 5.03	ER 5.05
Anguilla marmorata	P		A-	
Anguilla mossambica	P		A-	
Awaous aeneofuscus		P		A-
Barbus afrohamiltoni	P	P	P+	P+
Barbus annectens	P	P	A-	A-
Barbus paludinosos	P	P	P+	P+
Barbus radiatus	P	P	P+	P+
Barbus toppini	P	P	A-	A-
Barbus trimaculatus	P	P	P 0	P 0
Barbus unitaeniatus	P	P	P+	P+
Barbus viviparus	P	P	P 0	P 0
Brycinus imberi	P	P	P 0	P 0
Chiloglanis paratus	P	P	P-	P-
Chiloglanis pretoriae		P		P-
Chiloglanis swierstrai		P		A-
Clarias gariepinus	P	P	P+	P+
Glossogobius giuris	P	P	P-	P-
Hydrocynus vittatus	P	P	P 0	P 0
Labeo congoro	P	P	P-	P-
Labeo cylindricus	P	P	P 0	P 0
Labeo molybdinus	P	P	P 0	P 0
Labeo rosae	P	P	P+	P+
Labeo ruddi	P	P	P+	P+
Labeoarbus marequensis	P	P	P-	P-
Marcusenius macrolepidotus	P	P	P-	P-
Mesobola brevianalis	P	P	P-	A-
Micralestes acutidens	P	P	P-	P-
Oreochromis mossambicus	P	P	P	P
Petrocephalus wesselsi	P	P	P-	A-
Pseudocrenilabrus philander		P		A-
Schilbe intermedius	P	P	P+	P+
Synodontis zambezensis	P	P	P+	P+
Tilapia rendalli	P	P	P+	P+
Tilapia sparrmanii				

6. CURRENT SAMPLING OF IFR SITES

6.1 GROOT LETABA: LONELY BULL

Table 5. Fish species recorded and expected in the Groot Letaba, 5.02 eco region (in Kruger National Park) and those numbers of fish caught during the IFR survey of April 2004 (20.04.04 Deacon et al.). (Historical records available between 1993 and 2003 obtained from KNP Fish monitoring Data Base (updated February 2004)

Method	**Electro shocking**	**Electro shocking**	**Cast net**	**GROOT LETABA**
Habitat	**F/S & F/D riffles**	**S/D & S/S overhang**	**S/D overhang**	**5.02 (KNP)**
Anguilla marmorata				
Anguilla mossambica				
Barbus afrohamiltoni		37		37
Barbus annectens				
Barbus paludinosos				
Barbus radiatus		21		21
Barbus toppini				
Barbus trimaculatus	7	18		25
Barbus unitaeniatus	1	57		58
Barbus viviparus	5	143		148
Brycinus imberi	3		5	8
Chiloglanis paratus	71	4		75
Clarias gariepinus	4	10		14
Glossogobius giuris				
Hydrocynus vittatus		1		1
Labeo congoro				
Labeo cylindricus	49	1		50
Labeo molybdinus	32	6		38
Labeo rosae	5	5	1	11
Labeo ruddi		11		11
Labeobarbus marequensis	135	7	1	143
Marcusenius macrolepidotus				
Mesobola brevianalis		1		1
Micralestes acutidens				
Oreochromis mossambicus	3	8	3	14
Petrocephalus wesselsi				
Schilbe intermedius	41	16		57
Synodontis zambezensis		1		1
Tilapia rendalli	1			1

Table 6:

GROOT LETABA	SITE:	LONELY BULL		DATE:	20.04.2004	TIME:	09.00am
RELATIVE FLOW-DEPTH RATING:0=NONE;1=RARE;2=SPARSE;3=MODERATE;4=ABUNDANT;5=VERY ABUNDANT)							
FAST DEEP	**2**	FAST SHALLOW	**4**	SLOW DEEP	**5**	SLOW SHALLOW	**4**
COVER TYPES ASSOCIATED WITH EACH FLOW-DEPTH CLASS							
Overhanging vegetation:	**1**	Overhanging vegetation:	**2**	Overhanging vegetation:	**4**	Overhanging vegetation:	**3**
Undercut banks & root wads:	**1**	Undercut banks & root wads:	**0**	Undercut banks & root wads:	**3**	Undercut banks & root wads:	**2**
Substrate:	**4**	Substrate:	**3**	Substrate:	**3**	Substrate:	**2**
Water Column:	**5**	Water Column:	**2**	Water Column:	**4**	Water Column:	**3**
Aquatic macrophytes:	**0**	Aquatic macrophytes:	**2**	Aquatic macrophytes:	**3**	Aquatic macrophytes:	**4**
Remarks:		Remarks:		Remarks:		Remarks:	
Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**

Table 7: Assessment of the PES for the Groot Letaba River (Lonely Bull)

DETERMINANTS CONSIDERED FOR ESTIMATION	GROOT LETABA LONELY BULL	Score / 5
Native species richness	19 out of a potential 29 species were recorded in the April survey.	**3**
Presence of native intolerant species	CPAR, were recorded in abundance. CSWI was expected but not found. HVIT was observed.	**3**
Abundance of native species	Those species caught were abundant – signs of good recruitment	**4**
Native species Frequency of Occurrence	Records dating from 1993 indicate that most fish occur frequently at each monitoring site within the eco region. Many juveniles currently recorded indicates that breeding had recently taken place. It was experienced that fish such as LMAR were adversely influenced during the no-flow situation of the 2003-4 drought, but populations are recovering since January higher flows.	**3**
Health/condition: native and introduced species	Fish appear healthy.	**5**
Presence of introduced fish species	No records of alien fish have been made in the Groot Letaba River in the KNP.	**5**
Instream habitat modification	Sedimentation has affected streambed characteristics. The 2000 floods also scoured and altered the streambed but improvement in marginal vegetation and channel formation are promoting diversity.	**3**
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	**19 / 29 = 65% = CLASS C**	

Table 8: Groot Letaba - Letaba Bridge

Fish species recorded and expected in the Groot Letaba, 5.01 eco region (in Kruger National Park) and those numbers of fish caught during the IFR survey of February 2004 soon after the no-flow situation in the river. ((Historical records available between 1993 and 2003 obtained from KNP Fish monitoring Data Base (updated February 2004))

RIVER:	**GROOT LETABA**		
ECO REGION:	**5.01 (KNP)**		
SURVEYOR:	**Deacon et al.**		
DATE:	**28.07.03**	**20.04.04**	**07.05.04**
Anguilla marmorata			
Anguilla mossambica			
Awaous aeneofuscus			
Barbus afrohamiltoni			151
Barbus annectens			
Barbus paludinosos			
Barbus radiatus			10
Barbus toppini			
Barbus trimaculatus		1	32
Barbus unitaeniatus			
Barbus viviparus		2	159
Brycinus imberi	5		8
Chiloglanis paratus	11	5	56
Chiloglanis pretoriae			
Chiloglanis engiops			
Clarias gariepinus	1	14	8
Glossogobius giuris			1
Hydrocynus vittatus		2	
Labeo congoro			
Labeo cylindricus	9	5	7
Labeo molybdinus	55	20	10
Labeo rosae	13	16	15
Labeo ruddi			39
Labeobarbus marequensis	58	1	49
Marcusenius macrolepidotus			
Mesobola brevianalis			
Micralestes acutidens			4
Oreochromis mossambicus	46	111	216
Petrocephalus wesselsi			
Schilbe intermedius			5
Synodontis zambezensis			
Tilapia rendalli	2	5	9
32 species expected	**9 species recorded**	**11 species recorded.**	**17 species recorded**

Table 9:

GROOT LETABA	**SITE:**	**LETABA BRIDGE**		**DATE:**	**20.04.2004**	**TIME:**	**09.00am**
RELATIVE FLOW-DEPTH RATING:0=NONE;1=RARE;2=SPARSE;3=MODERATE;4=ABUNDANT;5=VERY ABUNDANT)							
FAST DEEP	**2**	**FAST SHALLOW**	**4**	**SLOW DEEP**	**3**	**SLOW SHALLOW**	**5**
COVER TYPES ASSOCIATED WITH EACH FLOW-DEPTH CLASS							
Overhanging vegetation:	**2**	Overhanging vegetation:	**3**	Overhanging vegetation:	**3**	Overhanging vegetation:	**4**
Undercut banks & root wads:	**0**	Undercut banks & root wads:	**0**	Undercut banks & root wads:	**2**	Undercut banks & root wads:	**1**
Substrate:	**4**	Substrate:	**3**	Substrate:	**3**	Substrate:	**2**
Water Column:	**4**	Water Column:	**2**	Water Column:	**4**	Water Column:	**3**
Aquatic macrophytes:	**3**	Aquatic macrophytes:	**2**	Aquatic macrophytes:	**2**	Aquatic macrophytes:	**4**
Remarks:		Remarks:		Remarks:		Remarks:	
Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**

Table 10: Assessment of the PES for the Groot Letaba River (Letaba Bridge) soon after the river started to flow again

DETERMINANTS CONSIDERED FOR ESTIMATION	GROOT LETABA: LETABA BRIDGE.	Score / 5
Native species richness	Due to the earlier effect of the drought only 11 out of a potential 32 species were recorded in the Feb survey.	**2**
Presence of native intolerant species	Few CPAR, were recorded and only 1 LMAR. CSWI was expected but not found. HVIT was sampled.	**3**
Abundance of native species	Less fish were caught than expected.	**2**
Native species Frequency of Occurrence	It was experienced that fish such as LMAR and CPAR were adversely influenced during the no-flow situation of the 2003-4 drought. Very few minnows were recorded.	**2**
Health/condition: native and introduced species	Fish appear healthy.	**4**
Presence of introduced fish species	No alien fish were recorded in the Letaba River.	**5**
Instream habitat modification	Sedimentation has affected streambed characteristics. The 2000 floods also scoured and altered the streambed but improvement in marginal vegetation and channel formation is promoting diversity. Drought had influenced the marginal vegetation.	**3**
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	**11 / 32 = 34% = CLASS E**	

Table 11: Re-evaluating the Bridge site

GROOT LETABA	**SITE:**	**LETABA BRIDGE**	**DATE:**	**07.05.04**	**TIME:**	**08.00am**	
RELATIVE FLOW-DEPTH RATING:0=NONE;1=RARE;2=SPARSE;3=MODERATE;4=ABUNDANT;5=VERY ABUNDANT)							
FAST DEEP	**3**	**FAST SHALLOW**	**4**	**SLOW DEEP**	**2**	**SLOW SHALLOW**	**4**
COVER TYPES ASSOCIATED WITH EACH FLOW-DEPTH CLASS							
Overhanging vegetation:	**3**	Overhanging vegetation:	**2**	Overhanging vegetation:	**3**	Overhanging vegetation:	**3**
Undercut banks & root wads:	**3**	Undercut banks & root wads:	**0**	Undercut banks & root wads:	**2**	Undercut banks & root wads:	**0**
Substrate:	**1**	Substrate:	**4**	Substrate:	**1**	Substrate:	**1**
Water Column:	**3**	Water Column:	**4**	Water Column:	**2**	Water Column:	**1**
Aquatic macrophytes:	**0**	Aquatic macrophytes:	**0**	Aquatic macrophytes:	**3**	Aquatic macrophytes:	**0**
Remarks:		Remarks:		Remarks:		Remarks:	
Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**2**	Approx Width classes: 1-2m=1; 2-4m=2; 4-8m=3; 8-10m=4; 10-15m=5; >15m=6	**3**

Table 12: Re-assessment of the PES for the Groot Letaba River (Letaba Bridge) after the river had time to recover since the drought.

DETERMINANTS CONSIDERED FOR ESTIMATION	GROOT LETABA: LETABA BRIDGE.	Score / 5
Native species richness	The good flows after the drought revitalized the fish populations and the species have increased from 11 to 17 out of a potential 32 species during the June survey.	**3**
Presence of native intolerant species	CPAR were present in numbers and the LMAR numbers have recovered completely. CSWI was expected but not found.	**3**
Abundance of native species	Fish recruitment evident and young fish abundant.	**4**
Native species Frequency of Occurrence	Sedimentation during the preceding floods created shallow habitats, influencing the site somewhat adversely.	**3**
Health/condition: native and introduced species	Fish appear healthy.	**5**
Presence of introduced fish species	No alien fish were recorded in the Letaba River.	**5**
Instream habitat modification	Sedimentation during the preceding floods (February 2004) created shallow habitats, influencing the site somewhat adversely.	**3**
FISH PES: ESTIMATED OVERALL FISH ASSEMBLAGE INTEGRITY	**17 / 32 = 53% = CLASS D**	

7. CONCLUSIONS

Although the attached Excel files (Fish PES) shows the Letaba River in the KNP to be that of a Class D, it must be mentioned that this has been obtained by using a baseline of all the fish collected in the past.. Some of these fish might have been stragglers or vagrants, or they were marginal species brought into the system by floods or other reasons.

Tables 7 and 12 indicate the two sites as follow: Lonely Bull: Class C (65%) and Letaba Bridge (recovered from drought): Class D (53%). The Fish PES tables indicate the scores as: Lonely Bull: Class D (46%) and Letaba Bridge: Class D (53%).

The 2000 flood, which can be seen as quite natural, (although the sediment been brought in, might not be that natural) has changed things drastically in the system. This may change again in time as new channels being carved into the sediment and vegetation settles in areas as beforehand. As sand is shifted controls might open again and the system may improve again.

The Massigire Dam is unfortunately a permanent migration obstruction.

8. REFERENCES

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Appendix I: Class rating for integrity classes

Class rating	Description of generally expected conditions for integrity classes	Relative FAII score (% of expected)
A	Unmodified, or approximate natural condition closely.	90 to 100
B	Largely natural with few modifications. A change in community characteristics may have taken place but species richness and presence of intolerant species indicate little modification.	80 to 89
C	Moderately modified. A lower than expected species richness and presence of most intolerant species. Some impairment of health may be evident at the lower limit of the class.	60 to 79
D	Largely modified. A clearly lower than expected species richness and absence or much lowered presence of intolerant and moderately intolerant species. Impairment of health may become more evident at the lower limit of the class.	40 to 59
E	Seriously modified. The striking lower than expected species richness and general absence of intolerant and moderately intolerant species. Impairment of health may become very evident.	20 to 39
F	Critically modified. An extremely lowered species richness and an absence of intolerant and moderately intolerant species. Only tolerant species may be present with a complete loss of species at the lower limit of the class. Impairment of health generally very evident.	0 to 19

APPENDIX B

FISH SURVEY - PHOTOS

1. Mid Letaba canal site – outflow from pool (velocity measured here

2. Mid Letaba – canal site - lowest pool where fish was collected


3. Mid Letaba – canal site Same pool as in 2


4. Mid Letaba – canal site – top pool showing marg vegetation


5. Mid Letaba canal site – sampling fish under marg veg in upper pool


6. Mid Letaba – canal site – upper pool where inflow occurs


7. Mid Letaba – canal site – sampling with small seine net in upper pool


8. Mid Letaba – canal site – attracting crocs

9. Mid letaba – canal site same pool as picture 1 – shows aquatic vegetation and outflow

10. Mid Letaba – canal site – same as previous picture – shows algae


11. Mid Letaba - canal site – pool where flow was measures – illustrates vegetation.


12 – Mid Letaba – site at weir – riffles and pool where fish was collected.


13 . Letsitele tank – riffle/ cobble bed where flow was measured.


14. Letsitele tank – shallow pool downstream of bridge

15. Letsitele tank – same riffle as in picture 13

16. Letsitele tank – same riffle as in picture 15 illustrates cobble bed in riffle


17. Letsitele tank – sampling in overhanging veg in pool downstream of riffle

18 Ltsitele tank – sampling with small seine in pool upstream of bridge


19. Letsitele tank – upstream of bridge – roots.


20. Letsitele tank – pool upstream of bridge


21. Appel – channel – where velocity was measured


22. Appel – same as picture 21


23. Appel – sampling of riffles upstream of pool where velocity was measured


24. Merensky - pool upstream of riffle where we crossed


25. Merensky – view downstream of crossing


26. Merensky - general view


27. Meremsky – deep fast habitat upsteam of crossing and upstream of picture 29

28. Merensky – Deep slow area immediately upstream of fast deep of picture 27


29. Merensky – riffles immediately upstream of crossing – entrance to back water pool in left hand upper corner.

30. Merensky – picture 29 was a close up of this one


31. Mernsky – some smaller bacwater pools – same spot as picture 30.

32. Merensky – upstream boundary of riffle where we crossed


33. Merensky – view upstream of crossing to show backwater pool and merg veg.

34. Merensky – riffle at crossing – velocity was determined here


35. Merensky – pool below downstream of uppermost fast/deep water (where we found large labeos) – the large yellow was collected here

36. Merensky – example cobble/gravel substrate similar to pool where large yellow was collected.


37. Merensky – view of pool where large yellow was collected

38. Mernsky – close up of backwater pool


39. Letaba Ranch – main channel of flow show marg veg


40. Letaba Ranch – view of secondary channels

41. Letaba Ranch – view from LHB of main channel

42. Letaba Ranch – main channel – picture 39 was taken at inflow upstream of first overhanging tree


43 . Leataba Ranch – main channel velocity was measured at rocky outcrop in center of the picture

Appendix F: Driver Rule Based Models

Table of Contents

1. IFR SITE 1: APPLE

RECOMMENDED EC: C

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	61.00	0.24	14.54
HYDROLOGY	70.26	0.58	40.44
WATER QUALITY	86.00	0.19	15.99
Weighted driver status (%)		1.00	**70.98**
Unweighted driver status (%)	72.42		
HABITAT DRIVER CATEGORY	**C**		**C**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	2.00	0.23	0.46
ZERO FLOW DURATION	1	100	0.00	0.26	0.00
SEASONALITY	3	80	2.00	0.21	0.41
MODERATE EVENTS	4	60	2.50	0.15	0.38
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	4	60	1.50	0.15	0.23
TOTALS		390	8.00	1.00	1.49
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**70.26**
HABITAT DRIVER CATEGORY					**C**

NOTE: The driver components (water quality, geomorphology) are presented in the relevant Specialist Reports.

ALTERNATIVE EC: D

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	53.00	0.20	10.76
HYDROLOGY	56.92	0.49	27.90

WATER QUALITY	62.00	0.31	19.03
Weighted driver status (%)		1.00	**57.69**
Unweighted driver status (%)	57.31		
HABITAT DRIVER CATEGORY	D		**D**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	3.00	0.23	0.69
ZERO FLOW DURATION	1	100	0.00	0.26	0.00
SEASONALITY	3	80	3.00	0.21	0.62
MODERATE EVENTS	4	60	3.00	0.15	0.46
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	4	60	2.50	0.15	0.38
TOTALS		390	11.50	1.00	2.15
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**56.92**
HABITAT DRIVER CATEGORY					**D**

2. SITE 2: LETSITELE

RECOMMENDED EC: D

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	41.00	0.25	10.22
HYDROLOGY	67.75	0.46	30.92
WATER QUALITY	62.00	0.29	18.24
Weighted driver status (%)		1.00	**59.39**
Unweighted driver status (%)	56.92		
HABITAT DRIVER CATEGORY	**D**		**C/D**

Hydrology

HYDROLOGY CHANGES

COMPONENTS	1. Rank	2. %wt	3. RATING	WEIGHT	Weighed score
LOW FLOWS	2	90	3.00	0.23	0.68
ZERO FLOW DURATION	1	100	2.00	0.25	0.50
SEASONALITY	3	70	0.00	0.18	0.00
MODERATE EVENTS	3	70	1.50	0.18	0.26
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	3	70	1.00	0.18	0.18
TOTALS		400	7.50	1.00	1.61
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**67.75**
HABITAT DRIVER CATEGORY					**C**

3. SITE 3: PRIESKA

RECOMMENDED EC: C/D

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	63.00	0.22	13.83
HYDROLOGY	57.27	0.51	29.27
WATER QUALITY	71.00	0.27	19.13
Weighted driver status (%)		1.00	**62.23**
Unweighted driver status (%)	63.76		
HABITAT DRIVER CATEGORY	C		**C/D**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	3.00	0.20	0.61
ZERO FLOW DURATION	1	100	1.00	0.23	0.23
SEASONALITY	2	90	1.00	0.20	0.20
MODERATE EVENTS	3	80	3.00	0.18	0.55
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	3	80	3.00	0.18	0.55
TOTALS		440	11.00	1.00	2.14
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**57.27**
HABITAT DRIVER CATEGORY					**D**

ALTERNATIVE EC: C

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	78.00	0.20	15.21
HYDROLOGY	69.55	0.45	31.58
WATER QUALITY	83.00	0.35	29.12
Weighted driver status (%)		1.00	**75.92**
Unweighted driver status (%)	76.85		
HABITAT DRIVER CATEGORY	C		**C**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	2.00	0.20	0.41
ZERO FLOW DURATION	1	100	0.00	0.23	0.00
SEASONALITY	2	90	1.00	0.20	0.20
MODERATE EVENTS	3	80	2.00	0.18	0.36
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	3	80	3.00	0.18	0.55
TOTALS		440	8.00	1.00	1.52
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**69.55**
HABITAT DRIVER CATEGORY					**C**

ALTERNATIVE EC: D

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	45.00	0.19	8.60
HYDROLOGY	52.73	0.44	23.46
WATER QUALITY	55.00	0.36	20.02

Weighted driver status (%)		1.00	**52.08**
Unweighted driver status (%)	50.91		
HABITAT DRIVER CATEGORY	**D**		**D**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	3.00	0.20	0.61
ZERO FLOW DURATION	1	100	2.00	0.23	0.45
SEASONALITY	2	90	1.00	0.20	0.20
MODERATE EVENTS	3	80	3.00	0.18	0.55
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	3	80	3.00	0.18	0.55
TOTALS		440	12.00	1.00	2.36
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**52.73**
HABITAT DRIVER CATEGORY					**D**

4. SITE 4: LETABA RANCH

RECOMMENDED EC: C/D

Driver

COMPONENTS	**Unweighted driver score**	**Weight**	**Weighted driver score**
GEOMORPHOLOGY	61.00	0.24	14.60
HYDROLOGY	55.29	0.57	31.25
WATER QUALITY	79.00	0.20	15.44
Weighted driver status (%)		1.00	**61.29**
Unweighted driver status (%)	65.10		
HABITAT DRIVER CATEGORY	**C**		**C/D**

Hydrology

HYDROLOGY CHANGES

COMPONENTS	1. Rank	2. %wt	3. RATING	WEIGHT	Weighed score
LOW FLOWS	2	85	3.00	0.20	0.60
ZERO FLOW DURATION	1	100	2.00	0.24	0.47
SEASONALITY	3	70	1.00	0.16	0.16
MODERATE EVENTS	2	85	3.00	0.20	0.60
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	85	2.00	0.20	0.40
TOTALS		425	11.00	1.00	2.24
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**55.29**
HABITAT DRIVER CATEGORY					**D**

ALTERNATIVE EC: C

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	68.00	0.25	16.91
HYDROLOGY	66.35	0.59	38.95
WATER QUALITY	83.00	0.16	13.64
Weighted driver status (%)		1.00	**69.50**
Unweighted driver status (%)	72.45		
HABITAT DRIVER CATEGORY	**C**		**C**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	85	2.00	0.20	0.40
ZERO FLOW DURATION	1	100	0.50	0.24	0.12
SEASONALITY	3	70	1.00	0.16	0.16
MODERATE EVENTS	2	85	3.00	0.20	0.60
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	85	2.00	0.20	0.40
TOTALS		425	8.50	1.00	1.68
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**66.35**
HABITAT DRIVER CATEGORY					**C**

ALTERNATIVE EC: D

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	49.00	0.23	11.44
HYDROLOGY	55.29	0.55	30.47
WATER QUALITY	62.00	0.22	13.36
Weighted driver status (%)		1.00	**55.27**
Unweighted driver status (%)	55.43		
HABITAT DRIVER CATEGORY	D		**D**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	1. Rank	2. %wt	3. RATING	WEIGHT	Weighed score
LOW FLOWS	2	85	3.00	0.20	0.60
ZERO FLOW DURATION	1	100	2.00	0.24	0.47
SEASONALITY	3	70	1.00	0.16	0.16
MODERATE EVENTS	2	85	3.00	0.20	0.60
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	85	2.00	0.20	0.40
TOTALS		425	11.00	1.00	2.24
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**55.29**
HABITAT DRIVER CATEGORY					**D**

5. SITE 5: KLEIN LETABA

RECOMMENDED EC: C

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	63.00	0.28	17.88
HYDROLOGY	50.24	0.55	27.84
WATER QUALITY	80.00	0.16	12.97

Weighted driver status (%)		1.00	**58.69**
Unweighted driver status (%)	64.41		
HABITAT DRIVER CATEGORY	C		**C/D**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	3.00	0.22	0.66
ZERO FLOW DURATION	3	70	3.00	0.17	0.51
SEASONALITY	4	60	1.00	0.15	0.15
MODERATE EVENTS	1	100	3.00	0.24	0.73
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	90	2.00	0.22	0.44
TOTALS		410	12.00	1.00	2.49
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**50.24**
HABITAT DRIVER CATEGORY					**D**

ALTERNATIVE EC: D

Driver

COMPONENTS	**Unweighted driver score**	**Weight**	**Weighted driver score**
GEOMORPHOLOGY	54.00	0.27	14.84
HYDROLOGY	50.24	0.54	26.96
WATER QUALITY	76.00	0.19	14.32
Weighted driver status (%)		1.00	**56.13**
Unweighted driver status (%)	60.08		
HABITAT DRIVER CATEGORY	C		**D**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	3.00	0.22	0.66
ZERO FLOW DURATION	3	70	3.00	0.17	0.51

SEASONALITY	4	60	1.00	0.15	0.15
MODERATE EVENTS	1	100	3.00	0.24	0.73
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	90	2.00	0.22	0.44
TOTALS		410	12.00	1.00	2.49
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**50.24**
HABITAT DRIVER CATEGORY					**D**

6. SITE 6: LONELY BULL

RECOMMENDED EC: C

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	77.00	0.23	17.62
HYDROLOGY	47.56	0.49	23.15
WATER QUALITY	77.00	0.28	21.90
Weighted driver status (%)		1.00	**62.67**
Unweighted driver status (%)	67.19		
HABITAT DRIVER CATEGORY	**C**		**C**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	4.00	0.20	0.80
ZERO FLOW DURATION	1	100	3.00	0.22	0.67
SEASONALITY	3	80	2.00	0.18	0.36
MODERATE EVENTS	2	90	3.00	0.20	0.60
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	90	1.00	0.20	0.20
TOTALS		450	13.00	1.00	2.62
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**47.56**
HABITAT DRIVER CATEGORY					**D**

ALTERNATIVE EC: B

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	77.00	0.26	19.91
HYDROLOGY	75.42	0.52	39.32
WATER QUALITY	86.00	0.22	18.93
Weighted driver status (%)		1.00	**78.16**
Unweighted driver status (%)	79.47		
HABITAT DRIVER CATEGORY	C		**C**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	2.00	0.20	0.40
ZERO FLOW DURATION	1	100	0.00	0.22	0.00
SEASONALITY	3	80	0.50	0.18	0.09
MODERATE EVENTS	2	90	2.70	0.20	0.54
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	90	1.00	0.20	0.20
TOTALS		450	6.20	1.00	1.23
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**75.42**
HABITAT DRIVER CATEGORY					**C**

ALTERNATIVE EC: D

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	52.00	0.22	11.68
HYDROLOGY	42.49	0.48	20.31
WATER QUALITY	51.00	0.30	15.17
Weighted driver status (%)		1.00	**47.16**
Unweighted driver status (%)	48.50		

HABITAT DRIVER CATEGORY	**D**		**D**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	5.00	0.20	1.00
ZERO FLOW DURATION	1	100	3.00	0.22	0.67
SEASONALITY	3	80	2.30	0.18	0.41
MODERATE EVENTS	2	90	3.00	0.20	0.60
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	90	1.00	0.20	0.20
TOTALS		450	14.30	1.00	2.88
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**42.49**
HABITAT DRIVER CATEGORY					**D**

7. SITE 7: LETABA BRIDGE

RECOMMENDED EC: C

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	77.00	0.22	17.29
HYDROLOGY	47.56	0.47	22.25
WATER QUALITY	77.00	0.31	23.68
Weighted driver status (%)		1.00	**63.22**
Unweighted driver status (%)	67.19		
HABITAT DRIVER CATEGORY	**C**		**C**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	4.00	0.20	0.80
ZERO FLOW DURATION	1	100	3.00	0.22	0.67
SEASONALITY	3	80	2.00	0.18	0.36
MODERATE EVENTS	2	90	3.00	0.20	0.60

EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	90	1.00	0.20	0.20
TOTALS		450	13.00	1.00	2.62
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**47.56**
HABITAT DRIVER CATEGORY					**D**

ALTERNATIVE EC: B

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	84.00	0.26	21.45
HYDROLOGY	75.42	0.53	40.12
WATER QUALITY	86.00	0.21	18.30
Weighted driver status (%)		1.00	**79.86**
Unweighted driver status (%)	81.81		
HABITAT DRIVER CATEGORY	**B**		**B**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	2.00	0.20	0.40
ZERO FLOW DURATION	1	100	0.00	0.22	0.00
SEASONALITY	3	80	0.50	0.18	0.09
MODERATE EVENTS	2	90	2.70	0.20	0.54
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	90	1.00	0.20	0.20
TOTALS		450	6.20	1.00	1.23
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**75.42**
HABITAT DRIVER CATEGORY					**C**

ALTERNATIVE EC: D

Driver

COMPONENTS	Unweighted driver score	Weight	Weighted driver score
GEOMORPHOLOGY	55.00	0.23	12.56

HYDROLOGY	42.49	0.48	20.21
WATER QUALITY	51.00	0.30	15.10
Weighted driver status (%)		1.00	**47.86**
Unweighted driver status (%)	49.50		
HABITAT DRIVER CATEGORY	**D**		**D**

Hydrology

HYDROLOGY CHANGES					
COMPONENTS	**1. Rank**	**2. %wt**	**3. RATING**	**WEIGHT**	**Weighed score**
LOW FLOWS	2	90	5.00	0.20	1.00
ZERO FLOW DURATION	1	100	3.00	0.22	0.67
SEASONALITY	3	80	2.30	0.18	0.41
MODERATE EVENTS	2	90	3.00	0.20	0.60
EVENT HYDROLOGY(HIGH FLOWS-FLOODS)	2	90	1.00	0.20	0.20
TOTALS		450	14.30	1.00	2.88
Driver status:(%):>89=A;80-89=B;60-79=C;40-59=D;20-39=E;<20=F					**42.49**
HABITAT DRIVER CATEGORY					**D**

Appendix G: Ecostatus Rule Based Models

Query on site 6 (see blue highlight)

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1. IFR SITE 1: APPLE

RECOMMENDED EC: C

Instream PES

Criteria	*rating (0=low, 5=high)*				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**5**				
Diversity of **fish** species with different flow requirements	*5*				
Diversity of **fish** species with a preference for different cover types	*3.5*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*4.5*	4.25	0.515	68.0	C
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*4*				
Diversity of **invertebrate** taxa with different velocity requirements	*4*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*4*	4	0.485	60.8	C/D
		8.25	**1**	**64.5**	**C**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***4.5***			
Fish: What is the general level of trophic specialisation		***3.5***			
What is the general level of habitat specialisation		***3.5***			
What is the general level of flow intolerance		***5***	4.13		**0.69**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***3***			
How sensitive are hydraulic habitats to flow change?		***1***			
How sensitive is water quality to flow change?		***1.5***	1.83		**0.31**
Total			5.96		1
	PES	**Category**			
INSTREAM CATEGORY	**64.50**	**C**			
DRIVER CATEGORY	**71.0**	**C**			
ECOSTATUS	**66.49**	**C**			

ALTERNATIVE EC: D

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	Ave	Weight	PES	Category
*Availability of high confidence **fish** information*	**5**				
Diversity of **fish** species with different flow requirements	*5*				
Diversity of **fish** species with a preference for different cover types	*3.5*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*4*	4.13	0.553	54.7	D
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*4*				
Diversity of **invertebrate** taxa with different velocity requirements	*3*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*3*	3.33	0.447	51.8	C/D
		7.46	**1**	**53.4**	**D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***4***			
Fish: What is the general level of trophic specialisation		***3.5***			
What is the general level of habitat specialisation		***3.5***			
What is the general level of flow intolerance		***4.5***	3.88		**0.68**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***3***			
How sensitive are hydraulic habitats to flow change?		***1***			
How sensitive is water quality to flow change?		***1.5***	1.83		**0.32**
Total			5.71		1
	PES	**Category**			
INSTREAM CATEGORY	**53.42**	**D**			
DRIVER CATEGORY	**57.7**	**D**			
ECOSTATUS	**54.79**	**D**			

2. SITE 2: LETSITELE

RECOMMENDED EC: D

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	Ave	Weight	PES	Category
*Availability of high confidence **fish** information*	**5**				

Diversity of **fish** species with different flow requirements	*3.5*				
Diversity of **fish** species with a preference for different cover types	*3*				
Diversity of **fish** species with a preference for different flow depth classes	*3*				
Diversity of **fish** species with various tolerances to modified water quality	*3*	3.125	0.540	65.3	C
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*3*				
Diversity of **invertebrate** taxa with different velocity requirements	*2.5*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2.5*	2.66667	0.460	48.1	D
		5.79	**1**	**57.4**	**D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3.5***			
Fish: What is the general level of trophic specialisation		***3***			
What is the general level of habitat specialisation		***3.5***			
What is the general level of flow intolerance		***3***	3.25		**0.52**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***3***			
How sensitive are hydraulic habitats to flow change?		***3***			
How sensitive is water quality to flow change?		***3***	3		**0.48**
Total			6.25		1
	PES	**Category**			
INSTREAM CATEGORY	**57.39**	**D**			
DRIVER CATEGORY	**59.4**	**C/D**			
ECOSTATUS	**58.35**	**D**			

3. SITE 3: PRIESKA

RECOMMENDED EC: C/D

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**4**				
Diversity of **fish** species with different flow requirements	*3*				
Diversity of **fish** species with a preference for different cover types	*4*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*2*	3.25	0.565	64.0	C
*Availability of high confidence **invertebrate** information*	*3*				

Diversity of **invertebrate** biotopes	*3*				
Diversity of **invertebrate** taxa with different velocity requirements	*2.5*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2*	2.5	0.435	55.4	D
		5.75	**1**	**60.2**	**C/D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3***			
Fish: What is the general level of trophic specialisation		***4***			
What is the general level of habitat specialisation		***4***			
What is the general level of flow intolerance		***3***	3.5		**0.72**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***1***			
How sensitive are hydraulic habitats to flow change?		***1.5***			
How sensitive is water quality to flow change?		***1.5***	1.33		**0.28**
Total			4.83		1
	PES	**Category**			
INSTREAM CATEGORY	**60.24**	**C/D**			
DRIVER CATEGORY	**62.2**	**C/D**			
ECOSTATUS	**60.79**	**C/D**			

ALTERNATIVE EC: C

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**2**				
Diversity of **fish** species with different flow requirements	*3*				
Diversity of **fish** species with a preference for different cover types	*4*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*2*	3.25	0.534	80.2	B/C
*Availability of high confidence **invertebrate** information*					
Diversity of **invertebrate** biotopes	*3*				
Diversity of **invertebrate** taxa with different velocity requirements	*3*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2.5*	2.83333	0.466	67.4	C
		6.08	**1**	**74.3**	**C**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3***			
Fish: What is the general level of trophic specialisation		***4***			
What is the general level of habitat specialisation		***4***			
What is the general level of flow intolerance		***3***	3.5		**0.72**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***1***			
How sensitive are hydraulic habitats to flow change?		***1.5***			
How sensitive is water quality to flow change?		***1.5***	1.33		**0.28**
Total			4.83		1
	PES	**Category**			
INSTREAM CATEGORY	**74.26**	**C**			
DRIVER CATEGORY	**75.9**	**C**			
ECOSTATUS	**74.72**	**C**			

ALTERNATIVE EC: D

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**4**				
Diversity of **fish** species with different flow requirements	*3*				
Diversity of **fish** species with a preference for different cover types	*4*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*2*	3.25	0.565	56.7	D
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*3*				
Diversity of **invertebrate** taxa with different velocity requirements	*2.5*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2*	2.5	0.435	55.4	D
		5.75	**1**	**56.1**	**D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3***			
Fish: What is the general level of trophic specialisation		***4***			
What is the general level of habitat specialisation		***4***			
What is the general level of flow intolerance		***3***	3.5		**0.72**

Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***1***			
How sensitive are hydraulic habitats to flow change?		***1.5***			
How sensitive is water quality to flow change?		***1.5***	1.33		**0.28**
Total			4.83		1
	PES	**Category**			
INSTREAM CATEGORY	**56.14**	**D**			
DRIVER CATEGORY	**52.1**	**D**			
ECOSTATUS	**55.02**	**D**			

4. SITE 4: LETABA RANCH

RECOMMENDED EC: C/D

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**5**				
Diversity of **fish** species with different flow requirements	*3*				
Diversity of **fish** species with a preference for different cover types	*3*				
Diversity of **fish** species with a preference for different flow depth classes	*3*				
Diversity of **fish** species with various tolerances to modified water quality	*2*	2.75	0.541	67.8	C
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*2.5*				
Diversity of **invertebrate** taxa with different velocity requirements	*2*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2.5*	2.33333	0.459	55.3	D
		5.08	**1**	**62.1**	**C/D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***2.5***			
Fish: What is the general level of trophic specialisation		***2.5***			
What is the general level of habitat specialisation		***2***			
What is the general level of flow intolerance		***2***	2.25		**0.42**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***3.5***			
How sensitive are hydraulic habitats to flow change?		***3***			
How sensitive is water quality to flow change?		***3***	3.17		**0.58**
Total			5.42		1
	PES	**Category**			

INSTREAM CATEGORY	**62.09**	**C/D**			
DRIVER CATEGORY	**61.3**	**C/D**	C/D		
ECOSTATUS	**61.62**	**C/D**	C/D		

ALTERNATIVE EC: C

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*					
Diversity of **fish** species with different flow requirements	*3*				
Diversity of **fish** species with a preference for different cover types	*3*				
Diversity of **fish** species with a preference for different flow depth classes	*3*				
Diversity of **fish** species with various tolerances to modified water quality	*2*	2.75	0.478	78.0	C
*Availability of high confidence **invertebrate** information*					
Diversity of **invertebrate** biotopes	*3*				
Diversity of **invertebrate** taxa with different velocity requirements	*3*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*3*	3	0.522	64.8	C
		5.75	**1**	**71.1**	**C**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3***			
Fish: What is the general level of trophic specialisation		***2.5***			
What is the general level of habitat specialisation		***2***			
What is the general level of flow intolerance		***2.5***	2.5		**0.45**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***3***			
How sensitive are hydraulic habitats to flow change?		***3***			
How sensitive is water quality to flow change?		***3***	3		**0.55**
Total			5.50		1
	PES	**Category**			
INSTREAM CATEGORY	**71.14**	**C**			
DRIVER CATEGORY	**69.5**	**C**			
ECOSTATUS	**70.25**	**C**			

ALTERNATIVE EC: D

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*					
Diversity of **fish** species with different flow requirements	*3*				
Diversity of **fish** species with a preference for different cover types	*3*				
Diversity of **fish** species with a preference for different flow depth classes	*3*				
Diversity of **fish** species with various tolerances to modified water quality	*2*	2.75	0.541	58.9	D
*Availability of high confidence **invertebrate** information*					
Diversity of **invertebrate** biotopes	*2.5*				
Diversity of **invertebrate** taxa with different velocity requirements	*2*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2.5*	2.33333	0.459	55.3	D
		5.08	**1**	**57.3**	**D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***2.5***			
Fish: What is the general level of trophic specialisation		***2.5***			
What is the general level of habitat specialisation		***2***			
What is the general level of flow intolerance		***2***	2.25		**0.42**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***3.5***			
How sensitive are hydraulic habitats to flow change?		***3***			
How sensitive is water quality to flow change?		***3***	3.17		**0.58**
Total			5.42		1
	PES	**Category**			
INSTREAM CATEGORY	**57.26**	**D**			
DRIVER CATEGORY	**55.3**	**D**			
ECOSTATUS	**56.10**	**D**			

5. SITE 5: KLEIN LETABA

RECOMMENDED EC: C

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**5**				
Diversity of **fish** species with different flow requirements	*2.5*				
Diversity of **fish** species with a preference for different cover types	*2.5*				
Diversity of **fish** species with a preference for different flow depth classes	*2*				
Diversity of **fish** species with various tolerances to modified water quality	*2*	2.25	0.574	76.6	C
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*1.5*				
Diversity of **invertebrate** taxa with different velocity requirements	*1.5*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2*	1.66667	0.426	51.4	D
		3.92	**1**	**65.9**	**C**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***2***			
Fish: What is the general level of trophic specialisation		***2***			
What is the general level of habitat specialisation		***2***			
What is the general level of flow intolerance		***2***	2		**0.50**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***2***			
How sensitive are hydraulic habitats to flow change?		***1***			
How sensitive is water quality to flow change?		***3***	2		**0.50**
Total			4.00		1
	PES	**Category**			
INSTREAM CATEGORY	**65.89**	**C**			
DRIVER CATEGORY	**61.3**	**C**			
ECOSTATUS	**63.59**	**C**			

ALTERNATIVE EC: C

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**5**				
Diversity of **fish** species with different flow requirements	*2.5*				
Diversity of **fish** species with a preference for different cover types	*2.5*				
Diversity of **fish** species with a preference for different flow depth classes	*2*				
Diversity of **fish** species with various tolerances to modified water quality	*2*	2.25	0.551	80.1	B
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*1.5*				
Diversity of **invertebrate** taxa with different velocity requirements	*2*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2*	1.83333	0.449	60.4	C
		4.08	**1**	**71.3**	**C**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***2***			
Fish: What is the general level of trophic specialisation		***2***			
What is the general level of habitat specialisation		***2***			
What is the general level of flow intolerance		***2***	2		**0.50**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***2***			
How sensitive are hydraulic habitats to flow change?		***1***			
How sensitive is water quality to flow change?		***3***	2		**0.50**
Total			4.00		1
	PES	**Category**			
INSTREAM CATEGORY	**71.25**	**C**			
DRIVER CATEGORY	**66.2**	**C**			
ECOSTATUS	**68.75**	**C**			

ALTERNATIVE EC: D

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**5**				
Diversity of **fish** species with different flow	*2.5*				

requirements					
Diversity of **fish** species with a preference for different cover types	*2.5*				
Diversity of **fish** species with a preference for different flow depth classes	*2*				
Diversity of **fish** species with various tolerances to modified water quality	*2*	2.25	0.574	59.0	D
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*1.5*				
Diversity of **invertebrate** taxa with different velocity requirements	*1.5*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2*	1.66667	0.426	51.4	D
		3.92	**1**	**55.8**	**D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***2***			
Fish: What is the general level of trophic specialisation		***2***			
What is the general level of habitat specialisation		***2***			
What is the general level of flow intolerance		***2***	2		**0.50**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***2***			
How sensitive are hydraulic habitats to flow change?		***1***			
How sensitive is water quality to flow change?		***3***	2		**0.50**
Total			4.00		1
	PES	**Category**			
INSTREAM CATEGORY	**55.79**	**D**			
DRIVER CATEGORY	**56.1**	**D**			
ECOSTATUS	**55.96**	**D**			

6. SITE 6: LONELY BULL

RECOMMENDED EC: C

Instream PES

Criteria	*rating (0=low, 5=high)*				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**4**				
Diversity of **fish** species with different flow requirements	*3*				
Diversity of **fish** species with a preference for different cover types	*3.5*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various	*3*	3.375	0.628	63.7	C

tolerances to modified water quality					
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*2.5*				
Diversity of **invertebrate** taxa with different velocity requirements	*1.5*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2*	2	0.372	56.8	D
		5.38	**1**	**61.1**	**C/D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3***			
Fish: What is the general level of trophic specialisation		***4***			
What is the general level of habitat specialisation		***4***			
What is the general level of flow intolerance		***3***	3.5		**0.60**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***2***			
How sensitive are hydraulic habitats to flow change?		***2***			
How sensitive is water quality to flow change?		***3***	2.33		**0.40**
Total			5.83		1
	PES	**Category**			
INSTREAM CATEGORY	**61.10**	**C/D**			
DRIVER CATEGORY	**64.2**	**C**			
ECOSTATUS	**62.33**	**C**			

ALTERNATIVE EC: B

Instream PES

Criteria	*rating (0=low, 5=high)*				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**4**				
Diversity of **fish** species with different flow requirements	*3*				
Diversity of **fish** species with a preference for different cover types	*3.5*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*3*	3.375	0.609	85.1	B
*Availability of high confidence **invertebrate** information*	*2.5*				
Diversity of **invertebrate** biotopes	*2.5*				
Diversity of **invertebrate** taxa with different velocity requirements	*2*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2*	2.16667	0.391	67.6	C
		5.54	**1**	**78.2**	**B/C**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3***			
Fish: What is the general level of trophic specialisation		***4***			
What is the general level of habitat specialisation		***4***			
What is the general level of flow intolerance		***3***	3.5		**0.60**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***2***			
How sensitive are hydraulic habitats to flow change?		***2***			
How sensitive is water quality to flow change?		***3***	2.33		**0.40**
Total			5.83		1
	PES	**Category**			
INSTREAM CATEGORY	**78.22**	**B/C**			
DRIVER CATEGORY	**78.2**	**C**			
ECOSTATUS	**78.20**	**B/C**			

? Is a C in Ecostatus up, request change to B/C but in PES SUM it is a B?

ALTERNATIVE EC: D

Instream PES

Criteria	*rating (0=low, 5=high)*				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**4**				
Diversity of **fish** species with different flow requirements	*3*				
Diversity of **fish** species with a preference for different cover types	*3.5*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*3*	3.375	0.628	57.5	D
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*2.5*				
Diversity of **invertebrate** taxa with different velocity requirements	*1.5*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2*	2	0.372	56.8	D
		5.38	**1**	**57.2**	**D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3***			
Fish: What is the general level of trophic specialisation		***4***			
What is the general level of habitat specialisation		***4***			

What is the general level of flow intolerance		***3***	3.5		**0.60**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***2***			
How sensitive are hydraulic habitats to flow change?		***2***			
How sensitive is water quality to flow change?		***3***	2.33		**0.40**
Total			5.83		1
	PES	**Category**			
INSTREAM CATEGORY	**57.20**	**D**			
DRIVER CATEGORY	**52.8**	**D**			
ECOSTATUS	**55.43**	**D**			

7. SITE 7: LETABA BRIDGE

RECOMMENDED EC: C

Instream PES

Criteria	*rating (0=low, 5=high)*				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**4**				
Diversity of **fish** species with different flow requirements	*3.5*				
Diversity of **fish** species with a preference for different cover types	*3.5*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*3*	3.5	0.677	69.1	C
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*2*				
Diversity of **invertebrate** taxa with different velocity requirements	*1.5*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*1.5*	1.667	0.323	53.6	D
		5.17	**1**	**64.1**	**C**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3.5***			
Fish: What is the general level of trophic specialisation		***4***			
What is the general level of habitat specialisation		***4***			
What is the general level of flow intolerance		***4***	3.88		**0.59**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***3***			
How sensitive are hydraulic habitats to flow change?		***2***			
How sensitive is water quality to flow change?		***3***	2.67		**0.41**
Total			6.54		1

	PES	Category			
INSTREAM CATEGORY	**64.09**	**C**			
DRIVER CATEGORY	**64.2**	**C**			
ECOSTATUS	**64.13**	**C**			

ALTERNATIVE EC: B

Instream PES

Criteria	*rating (0=low, 5=high)*				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**4**				
Diversity of **fish** species with different flow requirements	*3.5*				
Diversity of **fish** species with a preference for different cover types	*3.5*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*3*	3.5	0.618	85.4	B
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*2.5*				
Diversity of **invertebrate** taxa with different velocity requirements	*2*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*2*	2.16667	0.382	64.1	C
		5.67	**1**	**77.2**	**C**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3.5***			
Fish: What is the general level of trophic specialisation		***4***			
What is the general level of habitat specialisation		***4***			
What is the general level of flow intolerance		***4***	3.88		**0.62**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***3***			
How sensitive are hydraulic habitats to flow change?		***2***			
How sensitive is water quality to flow change?		***2***	2.33		**0.38**
Total			6.21		1
	PES	**Category**			
INSTREAM CATEGORY	**77.25**	**C**			
DRIVER CATEGORY	**85.0**	**B**			
ECOSTATUS	**80.16**	**B**			

ALTERNATIVE EC: D

Instream PES

Criteria	rating (0=low, 5=high)				
	Confidence Rating	**Ave**	**Weight**	**PES**	**Category**
*Availability of high confidence **fish** information*	**4**				
Diversity of **fish** species with different flow requirements	*3.5*				
Diversity of **fish** species with a preference for different cover types	*3.5*				
Diversity of **fish** species with a preference for different flow depth classes	*4*				
Diversity of **fish** species with various tolerances to modified water quality	*3*	3.5	0.677	54.1	D
*Availability of high confidence **invertebrate** information*	*3*				
Diversity of **invertebrate** biotopes	*2*				
Diversity of **invertebrate** taxa with different velocity requirements	*1.5*				
Diversity of **invertebrate** taxa with different tolerances to modified water quality	*1.5*	1.66667	0.323	53.6	D
		5.17	**1**	**53.9**	**D**

Integrated Ecostatus

Separating out the proportions for Driver : Response	Rating (0=low, 5=high)				
-	Response	Score	Ave		**Weight**
Instream Response questions		-			
What is the general level of sensitivity to modified water quality		***3.5***			
Fish: What is the general level of trophic specialisation		***4***			
What is the general level of habitat specialisation		***4***			
What is the general level of flow intolerance		***3***	3.63		**0.61**
Habitat Driver Questions					
How sensitive is channel type to change in geomorphological drivers?		***3***			
How sensitive are hydraulic habitats to flow change?		***2***			
How sensitive is water quality to flow change?		***2***	2.33		**0.39**
Total			5.96		1
	PES	**Category**			
INSTREAM CATEGORY	**53.95**	**D**			
DRIVER CATEGORY	**47.9**	**D**			
ECOSTATUS	**51.56**	**D**			

Appendix H: Ecological Importance and Sensitivity

Table of Contents

1. IFR SITE 1: APPLE

DETERMINANTS	NATURAL SCORE (0-4)	NATURAL CONF	PRESENT SCORE (0-4)	PRESENT CONF	COMMENTS
BIOTA (RIPARIAN & INSTREAM)					
Rare & endangered (range: 4=very high - 0= none)	4	4	0	2	Oper
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)	2	4	2	4	Blin
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)	4	4	4	4	5 species (4 present) dependant on flow whole year
Species/taxon richness (range: 4=very high - 1=low/marginal)	4	4	4	3	22 natural -= about 17 present - rich for transitional zone
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)	4	4	4	4	Pools, rapids, runs, riffles, overhanging veg, waterfalls cascades - fish and inverts abundant habitat
Refugia (4=Very high - 1=marginal/low)	3	3	2	3	Pools important on a local scale
Sensitivity to flow changes (4=Very high - 1=marginal/low)	2	3	2	3	
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1	3	1	3	
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)	4	4	1	4	
Importance of conservation & natural areas (range, 4=very high - 0=very low)			1	4	Scenic areas
MEDIAN OF DETERMINANTS	4		2		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)	**VERY HIGH**		**MODERATE**		

2. SITE 2: LETSITELE

DETERMINANTS	NATURAL SCORE (0-4)	NATURAL CONF	PRESENT SCORE (0-4)	PRESENT CONF	COMMENTS
BIOTA (RIPARIAN & INSTREAM)					
Rare & endangered (range: 4=very high - 0= none)	4	4	0	2	Oper
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)	2	4	2	4	Blin
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)	4	4	4	4	5 species (4 present) dependant on flow whole year
Species/taxon richness (range: 4=very high - 1=low/marginal)	4	4	4	3	33 natural, about 25 present
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)	3	4	2	4	Limited under present conditions
Refugia (4=Very high - 1=marginal/low)	2	3	2	3	Letsitele good refuge for Letaba under no flow conditions as well as the Thabina
Sensitivity to flow changes (4=Very high - 1=marginal/low)	2	3	2	3	
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1	3	2	3	
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)	2	4	2	4	
Importance of conservation & natural areas (range, 4=very high - 0=very low)			0	4	
MEDIAN OF DETERMINANTS	2		2		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)	**MODERATE**		**MODERATE**		

3. SITE 3: PRIESKA

DETERMINANTS	NATURAL SCORE (0-4)	NATURAL CONF	PRESENT SCORE (0-4)	PRESENT CONF	COMMENTS
BIOTA (RIPARIAN & INSTREAM)					
Rare & endangered (range: 4=very high - 0= none)	4	4	4	4	Crocodile
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)	0	4	0	4	
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)	3	4	3	4	C pretoria, B eutenia (missing)
Species/taxon richness (range: 4=very high - 1=low/marginal)	4	4	3	3	29 expected fish species
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)	4	4	3	4	Riffles, Pools, Rapids, Backwaters, Runs,
Refugia (4=Very high - 1=marginal/low)	3	3	3	3	
Sensitivity to flow changes (4=Very high - 1=marginal/low)	3	3	2	3	
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1	3	2	3	
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)	4	4	2	4	Instream hugely fragmented
Importance of conservation & natural areas (range, 4=very high - 0=very low)			2	4	
MEDIAN OF DETERMINANTS	3		2.5		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)	**HIGH**		**HIGH**		

4. SITE 4: LETABA RANCH

DETERMINANTS	NATURAL SCORE (0-4)	NATURAL CONF	PRESENT SCORE (0-4)	PRESENT CONF	COMMENTS
BIOTA (RIPARIAN & INSTREAM)					
Rare & endangered (range: 4=very high - 0= none)	4	4	4	2	Crocodiles, White backed night heron
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)	0	4	0	4	
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)	2	4	1	4	2 (natural - 1 present) species out of 35 dependant on flow whole year
Species/taxon richness (range: 4=very high - 1=low/marginal)	4	4	3	4	35 natural, lost 6
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)	4	4	4	4	Pools, rapids, riflles, overhanging veg, undercut banks, backwaters, high diversity of riparian zone types
Refugia (4=Very high - 1=marginal/low)	3	3	2	3	Pools important on a local scale
Sensitivity to flow changes (4=Very high - 1=marginal/low)	2	3	3	3	
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1	3	1	3	
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)	4	4	2	4	fragmentation
Importance of conservation & natural areas (range, 4=very high - 0=very low)			4	4	No fences between KNP so rated as national

MEDIAN OF DETERMINANTS	3	2.5
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)	**HIGH**	**HIGH**

5. SITE 5: KLEIN LETABA

DETERMINANTS	NATURAL SCORE (0-4)	NATURAL CONF	PRESENT SCORE (0-4)	PRESENT CONF	
BIOTA (RIPARIAN & INSTREAM)					COMMENTS
Rare & endangered (range: 4=very high - 0= none)	4	4	4	2	Saddle billed stork, white-backed night heron, osprey
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)	0	4	0	4	0
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)	2	4	2	4	6 (natural - 5 present) species out of 20 dependant on flow whole year
Species/taxon richness (range: 4=very high - 1=low/marginal)	3	4	3	4	20
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)	4	4	4	4	Pools, rifles, bedrock overhanging veg, undercut banks, backwaters, high diversity of riparian zone types
Refugia (4=Very high - 1=marginal/low)	3	3	1	3	Deep Pools have disappeared.
Sensitivity to flow changes (4=Very high - 1=marginal/low)	1	3	1	3	
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	2	3	2	3	
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)	3	4	2	4	fragmentation

Importance of conservation & natural areas (range, 4=very high - 0=very low)			1	4	
MEDIAN OF DETERMINANTS	3		2		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)	**HIGH**		**MODERATE**		

6. SITE 6: LONELY BULL

DETERMINANTS	NATURAL SCORE (0-4)	NATURAL CONF	PRESENT SCORE (0-4)	PRESENT CONF	
BIOTA (RIPARIAN & INSTREAM)					COMMENTS
Rare & endangered (range: 4=very high - 0= none)	4	4	4	4	Crocodile, white backed night heron, saddle billed stork
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)	2	4	2	4	Tigerfish
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)	2	4	2	4	*Chiloglanis swierstrai*
Species/taxon richness (range: 4=very high - 1=low/marginal)	4	4	4	3	35 expected fish species, presently probably 30 species - still high
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)	2	4	2	4	Riffles, Pools, Backwaters, Runs, rapids, flood terraces
Refugia (4=Very high - 1=marginal/low)	2	3	3	3	Large pools - river stops flowing
Sensitivity to flow changes (4=Very high - 1=marginal/low)	2	3	2	3	
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1	3	3	3	
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)	4	4	2	4	Due to fish ladders, can move. Birds

Importance of conservation & natural areas (range, 4=very high - 0=very low)			4	4	
MEDIAN OF DETERMINANTS	2		2.5		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)	**MODERATE**		**HIGH**		

7. SITE 7: LETABA BRIDGE

DETERMINANTS	NATURAL SCORE (0-4)	NATURAL CONF	PRESENT SCORE (0-4)	PRESENT CONF	COMMENTS
BIOTA (RIPARIAN & INSTREAM)					
Rare & endangered (range: 4=very high - 0= none)	4	4	4	4	Crocodile, white backed night heron, saddle billed stork, Pels fishing owl
Unique (endemic, isolated, etc.) (range: 4=very high - 0= none)	2	4	2	4	Tigerfish
Intolerant (flow & flow related water quality) (range: 4=very high - 0= none)	2	4	2	4	Chiloglanis swierstrai
Species/taxon richness (range: 4=very high - 1=low/marginal)	4	4	4	3	35 expected fish species, presently probably 31 species - still high
RIPARIAN & INSTREAM HABITATS					
Diversity of types (4=Very high - 1=marginal/low)	2	4	2	4	Riffles, Pools, Backwaters, Runs, rapids,
Refugia (4=Very high - 1=marginal/low)	2	3	3	3	Large pools - river stops flowing
Sensitivity to flow changes (4=Very high - 1=marginal/low)	2	3	2	3	
Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1	3	3	3	
Migration route/corridor (instream & riparian, range: 4=very high - 0= none)	4	4	2	4	Due to fish ladders, can move. Birds
Importance of conservation & natural areas (range, 4=very high - 0=very low)			4	4	
MEDIAN OF DETERMINANTS	2		2.5		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CLASS (EISC)	**MODERATE**		**HIGH**		

APPENDIX I
SOCIO CULTURAL REPORT

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DEFINITIONS

Goods and services:
Goods and Services refer to the resources and activities that people benefit from as a result of utilisation of the river (extracting water, fishing, swimming, performing traditional customs, etc.).

Ancestral sites:
These are areas of birth or where people's fore fathers resided or areas where the gods are worshipped.

Archaeological sites:
Archaeological sites are places that are deemed to have historical importance and value and which sites impact on learnings of past life forms, both human and animals (these may included places where fossils are found)

Religious sites:
Religious sites refer to areas where religious activities take place, such as baptism, worshipping.

LETABA CATCHMENT RESERVE DETERMINATION STUDY

RESEARCH FINDINGS ON THE SOCIO-CULTURAL IMPORTANCE OF WATER IN THE LETABA CATCHMENT

1. INTRODUCTION

The Department of Water Affairs and Forestry (DWAF) appointed Pules Howard and de Lange (PHD) Incorporated to undertake a Reserve Determination Study for the Letaba Catchment. PHD subsequently appointed PD Naidoo & Associates (PDNA) to undertake some components of the project, among others, the Socio/cultural importance research. Diversity & Transformation Solutions (D&TS), as specialist Institutional and Social Development consulting firm was sub-contracted by PDNA to assist in the socio/cultural research exercise.

This report details the findings of the research study and has been compiled collectively be D&TS and PDNA.

2. PURPOSE OF THE RESEARCH STUDY

As per the terms of reference the purpose of the research study was:

"To determine the importance to communities of the goods and services provided by the river"

3. METHODOLOGY

The methodology used in this assignment entailed mainly interviews with members of the communities who rely directly on the resources of the river to fulfill subsistence, spiritual, cultural or recreational needs in the catchment. These were among others: rural women, traditional healers, spiritual leaders, subsistence fisher folk and members of the community at large. A combination of all age groups was also applied in the survey. A questionnaire was used to gather Information, and a spreadsheet was developed to capture the results, emanating from which an analysis was made (a copy of the questionnaire is included in Appendix 1).

In some cases, depending on access to the rivers, personal observations were also made by visiting the rivers to observe the extent of activities in the rivers.

A literature search was also included as part of the investigations though the only previous study that proved useful was The State of the Rivers Report (2001), Letaba and Luvuvhu River Systems.

There was a problem in getting the co-operation of the people to participate in the survey. The following were the main reasons given for the unwillingness to participate:

- Fear to pay for using water resources
- Fear of being arrested because they do not have permits (fishing)
- Fear to express feelings in the absence of leaders

- Lack of understanding of the whole study objective

All communities relying on the surveyed tributaries were classified on the rivers these tributaries source water from. For instance, N'wanedzi tributary between Tzaneen Dam and Hans Marensky Nature Reserve is classified as Groot Letaba river, because it (N'wanedzi) sources its water resources from Groot Letaba river and therefore falls in the reach: Tzaneen Dam to Hans Marensky.

4. RESEARCH FINDINGS

4.1 SUMMARY

This section of the report details an overall picture of the findings. Details per reaches are provided on 3.2 below.

A total of 67 villages were visited and only 43 villages surveyed with 262 respondents contributing to the research. The un-surveyed 24 villages were due to the following:

- Communities not willing to participate
- The river normally dry
- Communities not having access to the river
- Communities not residing within close proximity to the river
- Commercial farming areas

A list of villages that were included in the study programme is attached in Appendix 1.

4.1.1 Water Supply

Results show that there is a high level (up to 99%) of dependence on the rivers for water supply purposes. These may include watering, drinking, washing etc, due to poor running water in the water supply systems at villages.

4.1.2 Riparian plants

The survey results show that 50% of those interviewed use the river resources for riparian plants for building, thatching and medicinal plants. However some of the resources are seasonally available (e.g. reeds).

4.1.3 Subsistance fishing

Approximately 62% of the respondents depend on the river for subsistence fishing. The State of the Rivers Report (2001), Letaba and Luvuvhu River Systems shows that subsistence fishing comprise of about 55% of activities in the reach between Tzaneen Dam and Kruger National Park. This figure ties in closely with our findings in that in this reach a total of 158 respondents was recorded, out of which about 57% said they depend on subsistence fishing.

4.1.4 Recreation

The use of the river for recreational purposes is very low, with 3.82% of the respondents indicating that they mainly use the river resources for bathing when they do not have enough domestic water. However there are also no facilities for recreational purposes in the river and this may contribute to this low dependence on the river for this purpose.

4.1.5 Sacred places and religious /historical sites

About 69% of the respondents use the river resources for mainly religious purposes, mainly baptism.

Over 40% of the respondents recognise historical/archaeological sites on the river with the highest number recorded in the reach between Hans Marensky and KNP. The sites are mainly for ancestral and initiation purposes.

Similarly about 42% of the respondents recognise special features and beauty spots on the river.

Statistically there doesn't seem to be any regard for the general aesthetic value of the river, with 24.05% recorded.

4.1.6 Potential for eco-tourism and recreation

About 51% of the respondents thought that there is great potential for eco-tourism if the rivers could have water on a regular basis. Contrary to current reality, which is 3.82%, about 44% thought that the rivers could potentially be used for recreational purposes.

An overwhelming number of people (72%) are convinced that Water Resources Determination will one way or the other be of benefit to the river and to them in terms of developments attraction, which will in turn create jobs for the local communities.

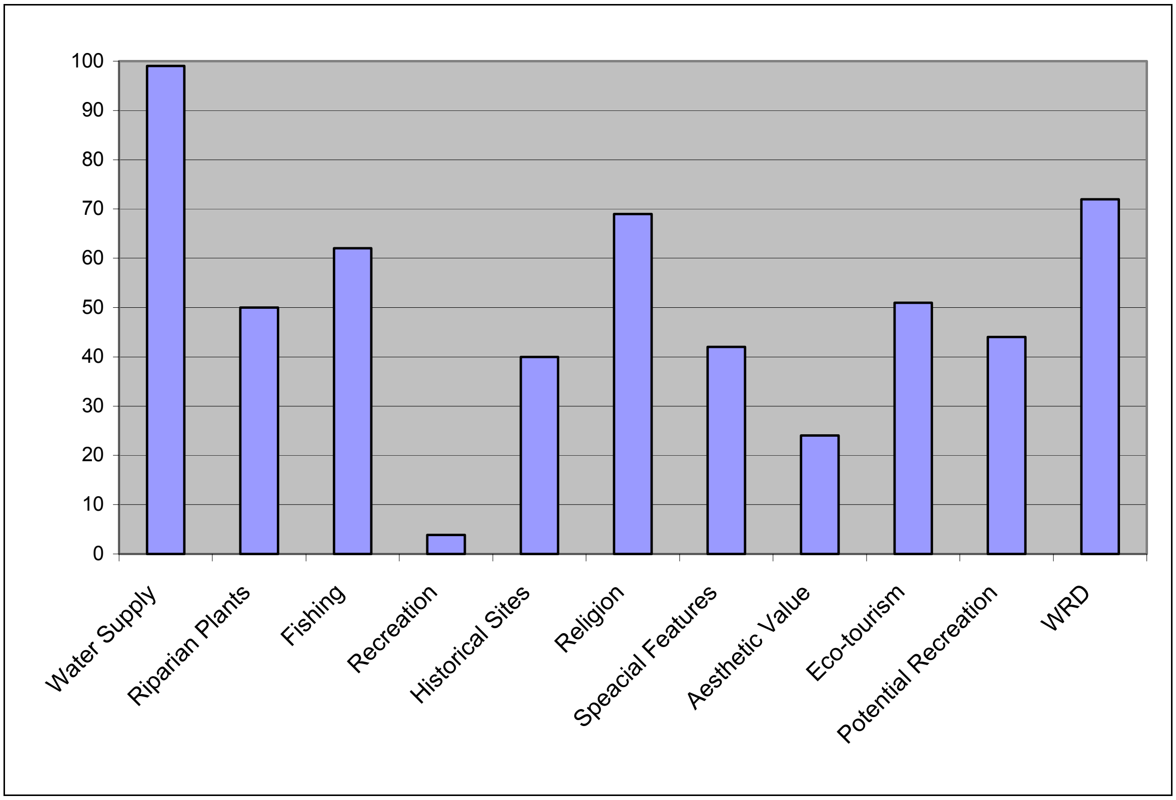

Figure 1: Graphical representation of the Survey Results for the Socio-cultural importance of the river resources in the Letaba Catchment

4.2 FINDINGS PER RIVER REACH

This section details findings per reach. Spreadsheets, which indicate confidence levels for our findings and associated comments, are included in Appendix 2. It should be noted that the margin of error on the confidence levels reflected in these spreadsheets (Appendix 2) could be high because of reasons given in Section 3 above.

Tables found in this section reflect the number of respondents in each reach and the percentages for each determinant.

4.2.1 Upstream Tzaneen Dam

There is no unregulated use of water in this reach as there are no communities informally dependent on the river resources.

There is however a community of farm labourers that live in close proximity to the river.

Comments:

This reach is dominated by commercial activities (farming, accommodation and plantations) and has no informal settlements or communities living adjacent to the river.

While a limited number of farm workers may probably be using the river resources in this reach it proved difficult to ascertain this fact because attempts to interview them were not successful.

4.2.2 Letsiteli

The following 10 villages occur and 56 people were interviewed in this river reach:

- Serare
- Marumofasi
- Mbalati
- Matlala
- Lusaka
- Sangoma
- Dan
- Khujwana
- Ramalema
- Nyanyukani

There is a high level of dependence on the river resources for water supply purposes and the same goes for subsistance fishing in this reach with a 100% dependence for the former and 82% for the latter. Less than 6% of respondents recorded their dependence on the both riparian plants (5.4%) and use of the river for recreational purposes (1.8%).

Another high level of dependence on the river is in the area of religious purposes with a 100% recorded.

There are no known historical/archaeological sites on the river and only 13% identify beauty spots in this reach.

About a third (30.1%) of the respondents feel that the reach has a potential for recreation with eco-tourism accounting for 23% but a very large percentage (89%) think that WRD will benefit them.

LETSITELI		
Determinants	**56 respondents**	**Percentage**
SOCIO/CULTURAL IMPORTANCE		
1. People directly dependent on a health flowing river for water supplies	56	100.00
2. People dependent on riparian plants for building, thatching and medicinal plants	3	5.36
3. People dependent on the river for subsistance fishing	46	82.14
4. People using the river for recreational purposes that requires ecologically healthy river	1	1.79
CULTURAL/HISTORICAL VALUES		
1. Sacred places on the river, and religious cultural events associated with the river	56	100.00
2. Historical/archaeological sites on the river	0	0.00
3. Special features and beauty spots	7	12.50
4. General aesthetic value on the river	0	0.00
CONSERVATION ASPECTS IN A SOCIAL CONTEXT		
1. Potential for eco-tourism	13	23.21
2. Present recreation, and potential for recreation	17	30.36
3. People feeling that Water Resource Determination will be of benefit	50	89.29

Comments:
This reach is dominated by private owners, more especially in the upper part of Letsiteli, and this limits the irregular use of the river. Dependence on the river for informal purposes happens at the lower end of the river, as this is where communities are found.

4.2.3 Tzaneen Dam to Hans Marensky

The following 15 villages occur and 68 people were interviewed in this river reach:

- Nkambako
- Nwamitwa
- Mandlakazi
- Thapane
- Jopi
- Mavele
- Pjapjamela
- Botludi
- Polaseng
- Mabulane
- Abel
- Koranta
- Peterson
- Ga-Ntata
- Ikageng

As much as 100% of the respondents recorded a dependence on this reach for water supply purposes with about 34% using it for riparian plants. There is a low level of subsistance fishing in this reach (16%) and almost no recreation activities (3%) going on.

The dependence on this reach for religious purposes and availability of special features and beauty spots is recorded at 40% with low percentages recorded for both the historical sites (26.5%) and the general aesthetic value on the river (29%)

However more than 50% of respondents feel that the river has potential for both eco-tourism (51.5%) and recreation (53%).

The majority (79.4%) of the respondents also feel that WRD will be of value to them if the study can market the environmental beauty to relevant organisations.

TZANEEN DAM TO HANS MARENSKY		
Determinants	**68 respondents**	**Percentage**
SOCIO/CULTURAL IMPORTANCE		
1. People directly dependent on a health flowing river for water supplies	68	100.00
2. People dependent on riparian plants for building, thatching and medicinal plants	23	33.82
3. People dependent on the river for subsistance fishing	11	16.18
4. People using the river for recreational purposes that requires ecologically healthy river	2	2.94
CULTURAL/HISTORICAL VALUES		
1. Sacred places on the river, and religious cultural events associated with the river	27	39.71
2. Historical/archaeological sites on the river	18	26.47
3. Special features and beauty spots	27	39.71
4. General aesthetic value on the river	20	29.41
CONSERVATION ASPECTS IN A SOCIAL CONTEXT		
1. Potential for eco-tourism	35	51.47
2. Present recreation, and potential for recreation	36	52.94
3. People feeling that Water Resource Determination will be of benefit	54	79.41

Comments:

There are a significant number of communities living adjacent to the river and a high level of dependence on the river. Subsistance fishing is very common in this reach though it is not reflected in the statistics provided here. The main reason behind this is the fact that people do not have permits to do fishing and are therefore sceptical to disclose the reality.

4.2.4 Hans Marensky to KNP

The following 12 villages occur and 90 people were interviewed in this river reach:

- Mariveni
- Gaselwana
- Nyakelane
- Xitlakati
- Mashiane
- Matsotsosela
- Mzilela
- Mayephu
- Zava

- Khaxani
- Makhushani
- Maseke

Dependence on the river for water supply purposes is recorded at 100%, while riparian plants accounts for 74% with subsistance fishing as high as 88% and recreation as little as 3%

Seventy (70%) use the river resources for religious purposes and the same number has been recorded for special features and beauty spots in the river, with a high number (80%) using it for historical sites and about 29% feeling the general aesthetic value of the river.

Of the 90 respondents 61% feel that the river has a potential for eco-tourism while 60% think recreation can also be a potential usage and about 55% thinking that WRD will be of benefit to them.

HANS MARENSKY TO KNP		
Determinants	**90 respondents**	**Percentage**
SOCIO/CULTURAL IMPORTANCE		
1. People directly dependent on a health flowing river for water supplies	90	100.00
2. People dependent on riparian plants for building, thatching and medicinal plants	67	74.44
3. People dependent on the river for subsistance fishing	79	87.78
4. People using the river for recreational purposes that requires ecologically healthy river	3	3.33
CULTURAL/HISTORICAL VALUES		
1. Sacred places on the river, and religious cultural events associated with the river	63	70.00
2. Historical/archaeological sites on the river	72	80.00
3. Special features and beauty spots	63	70.00
4. General aesthetic value on the river	26	28.89
CONSERVATION ASPECTS IN A SOCIAL CONTEXT		
1. Potential for eco-tourism	55	61.11
2. Present recreation, and potential for recreation	54	60.00
3. People feeling that Water Resource Determination will be of benefit	50	55.56

Comments:

Although the area is dominated by private land owners, the informal use of water is high and subsistance fishing is also very high. However, access to the water resources is very difficult.

4.2.5 Kruger National Park

While the area is a designated National Park and therefore it is expected that no unregulated use of water should occur the reality is that there are people (from the nearby village: Mtititi) who find a way to using the river resources within KNP for fishing. This, however, does not happen systematically. It has also been confirmed (Dr. Andrew Deacon) that there are Rest Camps (Letaba and Shimuwini), which are using the resources for water supply purposes (drinking and washing) within the KNP. Further more a household in Mahlangeni Game Reserve is using the water for the same purposes and tourists also use the river resources.

Aesthetics and the natural beauty of the KNP are important for tourism.

4.2.6 Klein Letaba

The following 5 villages occur and 40 people were interviewed in this river reach:

- Mtoti
- Msengi
- Rotter Dam
- Ximavusa
- Mtititi

There is a high level of dependence on the river resources for water supply (95%) purposes and the same goes for riparian plans (85%). Subsistance fishing in this reach accounts for 62.5% while use of the river for recreational purposes stands at about 10%.

Another high level of dependence on the river is in the area of religious purposes with 70% recorded.

Thirty-five percent of the respondents identify historical/archaeological sites on the river and about 37.5% identify beauty spots in this reach while 42.5% of the respondents feel the general aesthetic value of the river.

Potential for eco-tourism accounts for 67.5% of the respondents and the same number (67.5%) think that WRD will benefit them, with only 17.5% of the respondents recognising recreation as a potential usage activity.

KLEIN LETABA		
Determinants	**40 respondents**	**Percentage**
SOCIO/CULTURAL IMPORTANCE		
1. People directly dependent on a health flowing river for water supplies	38	95
2. People dependent on riparian plants for building, thatching and medicinal plants	34	85
3. People dependent on the river for subsistance fishing	25	62.5
4. People using the river for recreational purposes that requires ecologically healthy river	4	10
CULTURAL/HISTORICAL VALUES		
1. Sacred places on the river, and religious cultural events associated with the river	28	70
2. Historical/archaeological sites on the river	14	35
3. Special features and beauty spots	15	37.5
4. General aesthetic value on the river	17	42.5

CONSERVATION ASPECTS IN A SOCIAL CONTEXT		
1. Potential for eco-tourism	27	67.5
2. Present recreation, and potential for recreation	7	17.5
3. People feeling that Water Resource Determination will be of benefit	27	67.5

4.2.7 Middle Letaba

Only residents of the Sekgopo village were interviewed in this river reach, with 8 people participating in the survey.

Dependence on the river for water supply purposes is recorded at 88%, riparian plants at 63% and subsistance fishing at 15%. A zero percent is recorded fro recreation, historical sites, special features and beauty spots, general aesthetic value of the river and potential for recreation.

Eighty-eight (88) percent use the river for religious reasons and the same number think that WRD will be of benefit to them. Potential for eco-tourism stands at 50%.

MIDDLE LETABA		
Determinants	**8 respondents**	**Percentage**
SOCIO/CULTURAL IMPORTANCE		
1. People directly dependent on a health flowing river for water supplies	7	87.50
2. People dependent on riparian plants for building, thatching and medicinal plants	5	62.50
3. People dependent on the river for subsistance fishing	1	12.50
4. People using the river for recreational purposes that requires ecologically healthy river	0	0.00
CULTURAL/HISTORICAL VALUES		
1. Sacred places on the river, and religious cultural events associated with the river	7	87.50
2. Historical/archaeological sites on the river	0	0.00
3. Special features and beauty spots	0	0.00
4. General aesthetic value on the river	0	0.00
CONSERVATION ASPECTS IN A SOCIAL CONTEXT		
1. Potential for eco-tourism	4	50.00
2. Present recreation, and potential for recreation	0	0.00
3. People feeling that Water Resource Determination will be of benefit	7	87.50

Comments:

The only community depended on the river is the Sekgopo. When the river is not flowing people usually dig the sand to get water. A large number of informal settlements are the main users of water in this reach. Fishing only takes place when the river flows and in most cases this does not happen.

5. CONCLUSSIONS AND RECOMMENDATIONS

The study was limited in nature and this prevented consultations will all relevant parties (for example, formal structures like farmer associations and local governments, chieftaincies) which means that more information may have not been sourced. The implication of this may be that the degree to which the results reflect the reality is not as high as it should be.

Notwithstanding the challenges during the execution of the project and the limited extent of participation by all relevant stakeholders the survey results can be relied upon.

It is recommended that a full public participation process be embarked upon to include formal structures if the accuracy of information captured is to be increased. The exclusion of these formal structures could hamper support throughout the whole sphere of the local communities dependent directly or indirectly on the rivers.

APPENDIX I.1: QUESTIONNAIRE

DEPARTMENT OF
WATER AFFAIRS AND FORESTRY

LETABA SOCIAL, CULTURAL WATER DEPENDENCY STUDY

QUESTIONNAIRE

1. SETTLEMENT /AREA NAME:				
POPULATION ESTIMATE				
NAME:				
ADDRESS:				
AGE:				
GENDER:	Female		Male	
EDUCATIONAL LEVEL:				
STATUS OF EMPLOYMENT:	Yes		No	
2. WHICH PART OF LETABA RIVER ARE YOU USING?				
3 WHAT ARE YOU DIRECTLY DEPENDING ON THE RIVER FOR	Drinking water			
	Washing			
	Fishing/Hunting			
	Watering			
	Sport			
	Traditional Customs or religion			
	Riparian plants			
	Stock			
	Recreational			
4. FREQUENCY OF USE?	Yearly			
	Monthly			
	Weekly			
	Daily			
5. DO YOU HAVE ANY HISTORICAL OR ARCHAEOLOGICAL SITE ON THE RIVER?	Yes (if yes, please state where)			
6. IN YOUR OPINION, WILL WATER RESOURCE DETERMINATION ON THE RIVER BENEFIT YOU?	Yes (if yes, please state how)			
	No			
7. DO YOU HAVE AREAS ON THE RIVER THAT ARE POTENTIAL FOR ECOTOURISM?	Yes (if yes, please state where)			
	No			
8. DO YOU HAVE ANY BEAUTY SPOTS OR AESTHETIC VALUE ON THE RIVER?	Yes (if yes, please specify)			
	No			

FOR OFFICE ONLY

ASSURANCE RATING			
LOW	**MEDIUM**	**HIGH**	**VERY HIGH**

COMMENTS

APPENDIX I.2: SPREADSHEETS

RIVER: **Middel Letaba**

REACH/RU/IFR: **RU A**

SOCIO/CULTURAL

DETERMINANTS	SCORE	CONFIDENCE	COMMENTS
A) SOCIO/CULTURAL IMPORTANCE	(0-4)		
1. People directly dependant on a healthy flowing river for water supplies	3.00	4.00	No operational water reticulation systems (they even dig sand to get water)
2. People dependant on riparian plants for building, thatching and medicinal plants	2.00	4.00	Witnessed houses with thatching and reeds are used
3. People dependant on the river for subsistance fishing	2.00	4.00	When water flowing and in pools
4. People using the river for recreational purposes that requires ecologically healthy river	1.00	4.00	When water in the river - recreational fishing
B) CULTURAL/HISTORICAL VALUES	(0-4)		
1. Sacred places on the river, and religous cultural events associated with the river	3.00	4.00	Baptism
2. Historical/archaeological sites on the river	0.00	1.00	No literature to prove this
3. Special features and beauty spots	0.00	3.00	Ignorable from a cultural background
4. General aesthetic value of the river	0.00	3.00	Ignorable from a cultural background
C) CONSERVATION ASPECTS IN A SOCIAL CONTEXT	(0-4)		
1. Potential for ecotourism	2.00	2.00	lack of knowledge about what attract toursits
2. Present recreation, and potential for recreation	0.00	0.00	May change if river has water regularly
3. People feeling that Water Resource Determination will be of benefit	4.00	4.00	Community believe that study can attract development
MEDIAN OF DETERMINANTS	1.50		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	MODERATE		

RIVER: **Letsiteli**

REACH/RU/IFR: **RU B**

SOCIO/CULTURAL

DETERMINANTS	SCORE	CONFIDENCE	
A) SOCIO/CULTURAL IMPORTANCE	(0-4)		COMMENTS
1. People directly dependant on a healthy flowing river for water supplies	4.00	4.00	Reticulation systems is not fully operational
2. People dependant on riparian plants for building, thatching and medicinal plants	1.00	2.00	Used but not abaundant (reed & thatch grass used)
3. People dependant on the river for subsistance fishing	4.00	4.00	Lots of fish sellers
4. People using the river for recreational purposes that requires ecologically healthy river	1.00	4.00	No Swimming or raleted activities witnessed
B) CULTURAL/HISTORICAL VALUES	(0-4)		
1. Sacred places on the river, and religous cultural events associated with the river	4.00	3.00	Ancestral and initiation area
2. Historical/archaeological sites on the river	0.00	2.00	None observed
3. Special features and beauty spots	1.00	2.00	No spots identified
4. General aesthetic value of the river	0.00	2.00	There are few picnic areas
C) CONSERVATION ASPECTS IN A SOCIAL CONTEXT	(0-4)		
1. Potential for ecotourism	1.00	2.00	There are few lodges on the area
2. Present recreation, and potential for recreation	1.00	2.00	No enough facilities
3. People feeling that Water Resource Determination will be of benefit	4.00	4.00	Community believe that study can attract development
MEDIAN OF DETERMINANTS	1.00		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	LOW		

RIVER: **Klein Letaba**

REACH/RU/IFR: **RU C**

SOCIO/CULTURAL

DETERMINANTS	SCORE	CONFIDENCE	COMMENTS
A) SOCIO/CULTURAL IMPORTANCE	(0-4)		
1. People directly dependant on a healthy flowing river for water supplies	4.00	3.00	Some areas are not fully water retculated
2. People dependant on riparian plants for building, thatching and medicinal plants	3.00	3.00	Witness reeds used
3. People dependant on the river for subsistance fishing	3.00	4.00	Fishermen use nets and catch in pools
4. People using the river for recreational purposes that requires ecologically healthy river	1.00	4.00	Facilities not enough
B) CULTURAL/HISTORICAL VALUES	(0-4)		
1. Sacred places on the river, and religous cultural events associated with the river	2.00	4.00	Witness baptism
2. Historical/archaeological sites on the river	1.00	4.00	Few ancestral areas
3. Special features and beauty spots	1.00	4.00	There are few picnic areas
4. General aesthetic value of the river	1.00	4.00	The river not well known by communities
C) CONSERVATION ASPECTS IN A SOCIAL CONTEXT	(0-4)		
1. Potential for ecotourism	3.00	3.00	Currently few tourist I experienced area
2. Present recreation, and potential for recreation	1.00	4.00	Currently there is no facilities, but area got potential
3. People feeling that Water Resource Determination will be of benefit	3.00	3.00	Community believe that study can attract development
MEDIAN OF DETERMINANTS	1.50		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	MODERATE		

RIVER: **Upstream Tzaneen Dam**

REACH/RU/IFR: **RU D**

SOCIO/CULTURAL

DETERMINANTS	SCORE	CONFIDENCE	COMMENTS
A) SOCIO/CULTURAL IMPORTANCE	(0-4)		
1. People directly dependant on a healthy flowing river for water supplies	1.00	4.00	No communities but water used by farmers
2. People dependant on riparian plants for building, thatching and medicinal plants	0.00	0.00	
3. People dependant on the river for subsistance fishing	1.00	2.00	
4. People using the river for recreational purposes that requires ecologically healthy river	1.00	2.00	
B) CULTURAL/HISTORICAL VALUES	(0-4)		
1. Sacred places on the river, and religous cultural events associated with the river	0.00	0.00	
2. Historical/archaeological sites on the river	2.00	0.00	
3. Special features and beauty spots	0.00	0.00	
4. General aesthetic value of the river	0.00	0.00	
C) CONSERVATION ASPECTS IN A SOCIAL CONTEXT	(0-4)		
1. Potential for ecotourism	3.00	3.00	
2. Present recreation, and potential for recreation	2.00	2.00	
3. People feeling that Water Resource Determination will be of benefit	0.00	0.00	
MEDIAN OF DETERMINANTS	0.50		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	LOW		

RIVER: **Tzaneen Dam to Hans Marensky**

REACH/RU/IFR: **RU E**

SOCIO/CULTURAL

DETERMINANTS	SCORE	CONFIDENCE	COMMENTS
A) SOCIO/CULTURAL IMPORTANCE	(0-4)		
1. People directly dependant on a healthy flowing river for water supplies	4.00	4.00	Reticulation not fully operational
2. People dependant on riparian plants for building, thatching and medicinal plants	2.00	4.00	Witness sangoma's medical plants
3. People dependant on the river for subsistance fishing	1.00	1.00	Communities afraid to disclose
4. People using the river for recreational purposes that requires ecologically healthy river	1.00	4.00	Not enough facilities
B) CULTURAL/HISTORICAL VALUES	(0-4)		
1. Sacred places on the river, and religous cultural events associated with the river	2.00	3.00	Baptism take place
2. Historical/archaeological sites on the river	1.00	3.00	There are few ancestral areas
3. Special features and beauty spots	2.00	2.00	There is number of camping areas
4. General aesthetic value of the river	2.00	3.00	Ignorable from a cultutal background
C) CONSERVATION ASPECTS IN A SOCIAL CONTEXT	(0-4)		
1. Potential for ecotourism	2.00	3.00	The area has a Nature Resreve with tourism
2. Present recreation, and potential for recreation	2.00	3.00	There are few accessble facilities
3. People feeling that Water Resource Determination will be of benefit	3.00	3.00	Communities interested on the study
MEDIAN OF DETERMINANTS	2.00		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	MODERATE		

RIVER: Hans Marensky to KNP

REACH/RU/IFR: RU L

SOCIO/CULTURAL

DETERMINANTS	SCORE	CONFIDENCE	COMMENTS
A) SOCIO/CULTURAL IMPORTANCE	(0-4)		
1. People directly dependant on a healthy flowing river for water supplies	4.00	4.00	No operational reticulation system
2. People dependant on riparian plants for building, thatching and medicinal plants	3.00	4.00	Houses roofed with thatch grass
3. People dependant on the river for subsistance fishing	4.00	4.00	Lots of fish sellers
4. People using the river for recreational purposes that requires ecologically healthy river	1.00	4.00	No swimming, but bathing do take place
B) CULTURAL/HISTORICAL VALUES	(0-4)		
1. Sacred places on the river, and religous cultural events associated with the river	3.00	4.00	Witness baptism
2. Historical/archaeological sites on the river	4.00	4.00	Ancesstral and intiation areas
3. Special features and beauty spots	3.00	4.00	Few picnic areas
4. General aesthetic value of the river	2.00	4.00	River not well known by community
C) CONSERVATION ASPECTS IN A SOCIAL CONTEXT	(0-4)		
1. Potential for ecotourism	3.00	4.00	The area have number of reserves and lodges
2. Present recreation, and potential for recreation	3.00	4.00	The are have number of potential areas
3. People feeling that Water Resource Determination will be of benefit	2.00	4.00	Community believe that study can attract development
MEDIAN OF DETERMINANTS	3.00		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	HIGH		

RIVER: **KNP**

REACH/RU/IFR: **RU M**

SOCIO/CULTURAL

DETERMINANTS	SCORE	CONFIDENCE	
A) SOCIO/CULTURAL IMPORTANCE	(0-4)		COMMENTS
1. People directly dependant on a healthy flowing river for water supplies	2.00	4.00	No communities but KNP camps
2. People dependant on riparian plants for building, thatching and medicinal plants	0.00	0.00	No communities
3. People dependant on the river for subsistance fishing	0.00	0.00	No communities
4. People using the river for recreational purposes that requires ecologically healthy river	0.00	0.00	No communities
B) CULTURAL/HISTORICAL VALUES	(0-4)		
1. Sacred places on the river, and religous cultural events associated with the river	0.00	0.00	
2. Historical/archaeological sites on the river	0.00	0.00	
3. Special features and beauty spots	4.00	4.00	National Park
4. General aesthetic value of the river	2.00	4.00	National Park
C) CONSERVATION ASPECTS IN A SOCIAL CONTEXT	(0-4)		
1. Potential for ecotourism	4.00	4.00	
2. Present recreation, and potential for recreation	4.00	4.00	
3. People feeling that Water Resource Determination will be of benefit	4.00	4.00	
MEDIAN OF DETERMINANTS	1.00		
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EISC)	LOW		

APPENDIX I.3: LIST OF VILLAGES

VILLAGES	
AREA NAME	RIVER NAME
GREATER TZANEEN	
NKOWANKOWA	GROOT LETABA
MARIVENI	GROOT LETABA
KHWITINI	THABINA
DAN	GROOT LETABA
SANGOMA	THABINA
RAMALEMA	THABINA
MARUMUFASI	THABINA
SERARE	THABINA
MATLALA	THABINA
MAFARANA	RIGUDWE
MANGWENI	RIGUDWE
GABAZA	RIGUDWE
NEW NYANYUKANA	NGWABITSI
MATAWA	NGWABITSI
SEBELA	NGWABITSI
MASHILWANA	NGWABITSI
PETANENGE	LEISITEL
MOKGOLOBOTHA	LEISITEL
KHUJWANA	LEISITEL
LONGVALLEY	LEISITEL
MOGOBOYA	LEISITEL
NKAMBOKO	NWANEDZI
NWAMITWA	NWANEDZI
MANDLAKAZI	NWANEDZI
THAPANE	NWANEDZI
MAPITLULA	NWANEDZI
JOPI	PHATLE
MAVELE	PHATLE
PJAPJAMELA	PHATLE
BOTLUDI	PHATLE
POLASENG	MOLOTOTSI
SENOPELWA	MOLOTOTSI
LENOKWE	MOLOTOTSI
MABULANE	MOLOTOTSI
IKETLENG	MOLOTOTSI
MARAKA	MOLOTOTSI
MOSHAKGE	MOLOTOTSI
RAPITSI	MOLOTOTSI
GREATER LETABA	
ABEL	KLEIN-LETABA
SEKHIMING	KLEIN-LETABA
KORANTA	KLEIN-LETABA
PETERSON(GY)	KLEIN-LETABA
GA-NTATA	KLEIN-LETABA
MUHLAHLANDELA	MIDDE-LETABA
XIMAVUSA	MIDDE-LETABA
MSENGI	MIDDE-LETABA
ROTTER DAM	MIDDE-LETABA
MIDDELWATER	MIDDE-LETABA
LEMONDOKOP	MIDDE-LETABA
SEKGOPO	MIDDE-LETABA
MOOKETSI	MIDDE-LETABA
BA-PHALABORWA	
MAKHUSHANI	GA-SALATI
MASEKE	GA-SALATI
MASHIMALE	GA-SALATI
RUBBERVALE	MOLATLE
MULATI	MOLATLE
XI-HOKO	PHATLE
ZAVA	KLEIN-LETABA
KHAXANI	KLEIN-LETABA
GASELWANA	KLEIN-LETABA
NYAKELANE	KLEIN-LETABA
MOHALE	KLEIN-LETABA
MUKHWANANA	KLEIN-LETABA
XITLAKATI	KLEIN-LETABA
MASHIYANI	KLEIN-LETABA
MATSOTSOSELA	KLEIN-LETABA
MZILELA	KLEIN-LETABA
MAYEPHI	KLEIN-LETABA

Appendix J: Flood Motivations

Table of Contents

1. IFR SITE 1: APPLE

1.1 CLASS I

FLOOD CLASS I: 1.2 –2.5 m^3/s				Recommended EC C:			Alternative EC D:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	Flush fine material out of riffles	Velocities high enough to flush fines	October	1		Spring breeding, maintaining riffles	1		Spring breeding, maintaining riffles
Fish	Freshes to provide high seasonal variability in flows in a mountain stream.	Velocity Numerous Velocity (av) 0.45m/s Discharge of 1.546 cumecs Dmax 0.68m Dav 0.373 m Range 1.5 – 2.5 cumec	Sept – March	12		Providing food, gonad development and health.	6		Providing food, gonad development and health.
Vegetation	N/A								
Geomorph	N/A								

1.2 CLASS II

FLOOD CLASS II: 2 -5 m^3/s	Recommended EC: C	Alternative EC: D

Com.	Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning	No of events	Freq	Reasoning
Inverts	Flush fine material out of riffles and inundate the macro channel floor (wet channel, seasonal channels and marginal riparian zone)	Velocities high enough to flush fines and Inundate macro channel floor.	Feb, Apr	2	O,A	Maintenance of riffles	2	O,A	Maintenance of riffles
Fish	N/A								
Vegetation	N/A								
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20% representing the 3-5.9 m3/s discharge range) was responsible for 12% of the total bedload transport. In particular it was important for the flushing and transport of sands.	Velocity (stream power).	Any	6	10% of the Daily Flow Duration Curve	To maintain sediment transport patterns; specifically the flushing and transport of fines.	4	Reduced from the "C" class.	To maintain some of the historical sediment transport patterns.

1.3 CLASS III

FLOOD CLASS III: 4.5-10.5m^3/s	Recommended EC: C	Alternative EC: D

Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Inundate the marginal vegetation zones including the hydrophytic grasses eg. *L. hexandra* prior to the dry season. Will also increase microsite availability for *B. salicina* germinants as seeds are dispersed between April and July	Inundates to an elevation of between 1 and 1.4 m at a reasonably slow average velocity of less than 0.8 m/sec with minimal disturbance of the marginal vegetation.	April	1	Per year	A late summer flood for supporting the marginal vegetation and flow dependent riparian tree species (*B. salicina* and *S. cordatum*) .	0	Per year	Accept that in a lower class, this flood will happen sporadically and therefore no motivation for this flood is given.
Geomorph	Maintain present bed form and sediment transport characteristics. This portion (around 5%) of the flow duration curve was responsible for more than 10% of the total bedload transport. In particular it was important for the flushing and transport of sands	Velocity (stream power).	Any	2		To maintain sediment transport patterns; specifically the flushing and transport of fines.	1		To maintain some of the potential for sediment transport to flush and transport fines.

1.4 CLASS IV

FLOOD CLASS IV: 20-27m³/s				Recommended EC: C			Alternative EC: D		
Com.	Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning	No of events	Freq	Reasoning
Inverts	N/A								
Fish	N/A								
Vegetation	Inundates to the base of the flood terrace to stimulate the reproduction of the hydrophytic sedges and grasses, raise the water table in the flood terrace to support the large riparian trees on the terrace, and to disperse riparian tree seeds.	Inundates to an elevation of between 1.8 and 2 m.	Mid summer (February)	1	Per year	Mid summer floods at this elevation are important for the reproduction of hydrophytic grasses and sedges in the marginal vegetation zones. Also raises the water table in the flood terrace to support the growth of the larger riparian trees on the terrace and their transpirational requirements.		1:2 years	Will still play some role in terms of the reproduction of the hydrophytic grasses and sedges in the marginal vegetation zones. Despite a reduced frequency, this flood will still play a role (reduced) in supporting the transpirational requirements larger riparian trees on the terrace.
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (1-2% representing the 18-32 m3/s discharge range) was responsible for 11% of the total bedload transport. In particular it was important for the	Velocity (stream power)	Any	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels.	1	1: 2 year return interval	To maintain some of the historical sediment transport potential.

	activation and transport of gravels.								

1.5 CLASS V

FLOOD CLASS V: 43-94m^3/s				Recommended EC: C			Alternative EC: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	To prevent terrestrialisation of the flood terrace and disperse high flood terrace riparian tree seeds.	Inundates to 3.2 m	Summer		1:10 years	Inundates to upper levels of the riparian zone thereby saturating the soil to the roots of terrestrial saplings thereby helping to prevent terrestrialisation of the flood terraces.		1:10 years	As occurs naturally. The main change is expected in the lower riparian and marginal vegetation zones so no flow reduction is motivated for the large floods.
Geomorph	N/A								

2. SITE 2: LETSITELE

2.1 CLASS I

FLOOD CLASS I: 2.5-4 m^3/s				PES EC D:			Recommended EC D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**			
Inverts	Flush fine material out of riffles and inundate the macro channel floor (wet channel, seasonal channels and marginal riparian zone)	Velocities high enough to flush fines and Inundate macro channel floor.	Oct, Feb, Apr				3	O,F,A	Spring breeding, and maintenance of riffles
Fish	Flush to overtop 2ndary channels to clear sediment and leaf litter. General improvement of water quality, prior to spawning activity	Velocity (av) 0.339m/s Discharge of average of 3 cumecs Dmax 0.64 m Dav 0.443 Range 2.5 – 3.5 cumec	Oct – Ma				8	O - M	Preparation for breeding by flushing out of sediment between substrate particles
Vegetation	N/A								
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20% representing	Velocity (stream power).	Any		10% of the Daily Flow Duration Curve	To maintain sediment transport patterns; specifically the flushing and transport of fines.		10% of the Daily Flow Duration Curve	To maintain sediment transport patterns; specifically the flushing and transport of fines.

	the 1.7-4 m3/s discharge range) is responsible for about 10% of the total bedload transport. In particular it was important for the flushing and transport of sands.								

2.2 CLASS II

FLOOD CLASS II: 3.5-6 m^3/s				**PES EC D:**			**Recommended EC D**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	Creation of suitable spawning habitat for Beut and other rheophilic and semi-rheophilic species Cues for spawning migration and reproduction. Depths of 300mm and velocities of 0.5m/s in secondary channels where cobbles and marginal vegetation occur.	Velocities coinciding with suitable breeding temperatures (23 degrees) Velocity (av) 0.4m/s Discharge of 5.0 cumecs (average) Dmax 0.82 m Dav 0.61 m Range 3.5 – 6.0 cumec	Mid November				1	N	For breeding and habitat maintenance

Vegetation	N/A								
Geomorph	N/A								

2.3 CLASS III

FLOOD CLASS III: 15 m^3/s				**PES EC D:**			**Recommended EC D**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	N/A								
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (1-5% representing the 7.5-20.8 m3/s discharge range) was responsible for about 27% of the total bedload transport. In particular these flows should activate some of the gravels on the bed and are responsible for about 27% of the sand	Velocity (stream power)	Any	1	Annual	To maintain potential for sand transport and activate some of the gravels.	1	1: 2 year return interval	To maintain the potential for sand transport and activate some of the gravels

	transport.								

3. SITE 3: PRIESKA

3.1 CLASS I

FLOOD CLASS I: 6-10 m^3/s				Recommended EC C/D:			Alternative EC C:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	Creation of suitable spawning habitat for Lmar and Cpre, Growth and hatching of eggs layed on cobble beds.	Velocities coinciding with suitable breeding temperatures (23 °C) Velocity (av) 1.05m/s Discharge of 8 cumecs Dmax 1. m Dav 0.43 m Range 7-10 cumec Minimum flow to be continuous with item 2 above. (single hydrograph) Velocities to keep sediment from eggs. Velocity (av) 0.98 m/s Discharge of 6 cumecs Dmax 0.89m	October - April	6	Nov - April	Sufficient depths in secondary channels where cobbles occur and moderate velocities in pool and backwaters and marginal habitats. 6 floods required to provide somey hydraulic diversity to the end of the wet season, providing good healthy river conditions for growth. The river is providing an abundance of food and good water quality for the coming dry season.	8	Oct –Apr.	Sufficient depths in secondary channels where cobbles occur and moderate velocities in pool and backwaters and marginal habitats. 8 floods required to supply hydraulic diversity to the end of the wet season, providing good healthy river conditions for growth. The river providing an abundance of food and good water quality for the coming dry season.

		Dav 0.44 m Range 5 - 8 cumecs							
Vegetation	Inundates the low flow backwater to provide water to the *F. sycomorus* roots that are tapping into this source. Also reaches the rooting zone of the *Cyperus* species around the rock pool. Inundates the rooting zone of the *P. mauritianus* along the edge of the active channel.	Inundates to a depth of between 0.8 and 0.9 m in the low flow backwater area.	Nov to April	6	Per year	A small flood of this size will fill the low flow backwater pool to meet the evapo-transpiration needs to the *F. sycomorus* (upper riparian at this site) and lower riparian species that are rooted here. The number of these floods ensures that the backwater does not dry up for any length of time. Estimating evaporation at 5 mm/day, it was estimated that water will remain in the pool for approximately 2 months after a flood of 5 m^3sec^{-1}.	8	Per year	The slightly higher frequency of supply compared to the recommended Class will ensure flushing of the backwater and will mean the water level remains high to support the vegetation.
Geomorph	N/A								

FLOOD CLASS I: 6-10 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	Creation of suitable spawning habitat for Lmar and Cpre, Growth and hatching of eggs layed on cobble beds.	Velocities coinciding with suitable breeding tempera-tures (23 °C) Velocity (av) 1.05m/s Discharge of 8 cumecs Dmax 1. m	March & April	2	M, A	Sufficient depths in secondary channels where cobbles occur and moderate velocities in pool and backwaters and marginal habitats.

		Dav 0.43 m Range 7-10 cumec Minimum flow to be continuous with item 2 above. (single hydrograph) Velocities to keep sediment from eggs. Velocity (av) 0.98 m/s Discharge of 6 cumecs Dmax 0.89m Dav 0.44 m Range 5 - 8 cumecs				
Vegetation				4	Per year	The lower frequency of supply compared to the recommended Class will reduce the water in the backwater which will mean the water level will drop stressing the vegetation. There are however likely to be enough flows that the vegetation will not drop a Class.
Geomorph	N/A					

3.2 CLASS II

FLOOD CLASS II: 12-18 m³/s				**Recommended EC C/D:**			**Alternative EC C:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**

Inverts	Flush fine material out of riffles and inundate the macro channel floor (wet channel, seasonal channels and marginal riparian zone)	Velocities high enough to flush fines and Inundate macro channel floor.l	Oct, Feb, Apr	2	O,A	Spring breeding, maintaining riffles	3	O,F,A	Spring breeding, maintaining riffles
Fish	Spike to overtop 2ndary channels to clear sediment and leaf litter.	Discharge of 12 cumecs Velocity av 1.0m/s Dmax 1.13 m Dav 0..34m Range 10 – 15 cumecs.	November	1	N	General improvement of water quality, prior to spawning activity	1	N	General improvement of water quality, prior to spawning activity
Vegetation	Inundates the entire macro-channel floor. It inundates the marginal vegetation across the macro-channel floor. It also inundates many of the juvenile *B. salicina* trees.	The duration of flow needs to be adequate to saturate the marginal zones that dry out on a regular basis. The low average velocity will have minimal impact on the vegetation including the juvenile trees rooting in amongst the rocks.	Dec to Mar	3	Per year	Inundation stimulates growth and reproduction of flow dependent vegetation that comprises the marginal vegetation zone. It also inundates the microsites where the macro-channel floor flow dependent riparian tree *B. salicina* is germinating.	3	Per year	More of these floods will improve the vigour and abundance of the marginal vegetation on the macro-channel floor.
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20%) was responsible for about 10% of the total bedload transport. In particular it was important for the flushing and transport of sands.	Velocity (stream power).	Any		3*	To maintain sediment transport patterns; specifically the flushing and transport of fines.		3	To maintain sediment transport patterns; specifically the flushing and transport of fines.

* Geomorphologist requested more of these events, but the hydrologist said that the observed records suggest that only 3 events (of 3 day duration) occur per annum.

FLOOD CLASS II: 12-18 m^3/s				Alternative EC D:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts				2		
Fish	Spike to overtop 2ndary channels to clear sediment and leaf litter.	Discharge of 12 cumecs Velocity av 1.0m/s Dmax 1.13 m Dav 0..34m Range 10 – 15 cumecs.	November	1	N	General improvement of water quality, prior to spawning activity
Vegetation				2	Per year	Unlikely to result in a drop in a class but will probably put the riparian vegetation in a low D.
Geomorph					2	To maintain some of the historical sediment transport patterns.

3.3 CLASS III

FLOOD CLASS III: 50-90 m^3/s				Recommended EC C/D:			Alternative EC C:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								

Vegetation	Inundates the lower riparian zone particularly where sedges and reeds occur along the lower bank. This is important for supporting the overhanging vegetation along the lower bank. Also inundates the terrace dominated by *P. reticulatus* at the site below the weir.	Stage and duration, with the flood reaching the first terrace at the IFR site below the weir.	Feb	1	Per year	Inundation is also required to meet the life-history requirements of many of the lower riparian species.	1	Per year	Same.
Geomorph	The maintenance of moderate floods is important in this section to prevent narrowing and vegetation encroachment. This flow duration class (1-5%) is important also for activating the gravel beds.	Velocity (stream power)	Any	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels.	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels.

FLOOD CLASS III: 50-90 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					

Vegetation				1	Per year	Same
Geomorph				1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels.

3.4 CLASS IV

FLOOD CLASS IV: 150-220 m^3/s				Recommended EC C/D:			Alternative EC C:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Flood inundates the upper terraces to raise the water table in the terraces and support the riparian trees that grow there. Are also important for increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes.	Stage and duration, with the flood reaching the second terrace at the IFR site below the weir.	Mar		1:2	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also stimulate reproduction in many of the riparian tree species on the terraces.		1:2	Same.
Geomorph	These large floods are doing the bulk of the sediment	Velocity (stream power)	Any	1	1:2 yr return interval	Transport fines, activate gravels and retard further vegetation encroachment and	1	1:2 yr return interval	Transport fines, activate gravels and retard further vegetation encroachment and channel

	transport in this system, as well as preventing channel narrowing.					channel narrowing.			narrowing.

FLOOD CLASS IV: 150-220 m³/s				Alternative EC D:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation					1:3	Reducing the frequency of this flood will reduce the flooding of the upper terrace but is unlikely to result in a drop in a Class.
Geomorph				1	1: 3 yr return interval	Transport fines, activate gravels and retard further vegetation encroachment and channel narrowing.

3.5 CLASS V

FLOOD CLASS V: 330-480 m³/s				Recommended EC C/D:			Alternative EC C:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								

Fish	N/A								
Vegetation	Floods at this elevation are important raising the water table in the banks.	Stage.	When it arrives		1:10	Floods at this elevation are important raising the water table in the banks. This is important for meeting the transpiration requirements of the riparian trees in the upper riparian zone.		1:10	Same
Geomorph	N/A								

FLOOD CLASS VI: 330-480 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation					1:10	Same
Geomorph	N/A					

4. SITE 4: LETABA RANCH

4.1 CLASS I

FLOOD CLASS I: 4-8 m³/s				Recommended EC C/D:			Alternative EC C:		
Com.	Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning	No of events	Freq	Reasoning
Inverts	N/A								
Fish	Freshes to provide seasonal variability in flows.	Velocity (av) 1.7m/s Discharge of average of 6 cumecs Dmax 0.61 m Range 4 - 8 cumec	Oct – April	5	J,M,A,N, D	Providing food, gonad development and health.	7	Oct - April	Providing food, gonad development and health.
Vegetation	N/A								
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20% representing the 6-14.7 m3/s discharge range) was responsible for 13% of the total bedload transport. It is important for the flushing and transport of fines and the activation and	Velocity (stream power).	Any		10% of the (annual) Daily Flow Duration Curve	To maintain sediment transport patterns; specifically the flushing and transport of fines and activation of gravels.		Close to 15% of the (annual) Daily Flow Duration Curve	To maintain and improve the potential for the flushing and transport of fines and activation of gravels.

	transport of about 30% of gravels.								

FLOOD CLASS I: 4-8 m^3/s				Alternative EC D:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	Freshes to provide seasonal variability in flows. Providing food, gonad development and health.	Velocity (av) 1.7m/s Discharge of average of 6 cumecs Dmax 0.61 m Range 4 - 8 cumec	Oct – April	3	J,F,D	General improvement of water quality, prior to spawning activity
	Creation of suitable spawning habitat for Cpre and other rheophilic and semi-rheophilic species Depths of 300mm and velocities of 0.5m/s in secondary channels where cobbles and marginal vegetation occur.	As above	November	1		Cues for spawning migration and reproduction.
	Freshes to provide seasonal variability in flows. Providing food, gonad development and	As above		1		

	health.					
Vegetation	N/A					
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (10-20% representing the 6-14.7 m3/s discharge range) was responsible for 13% of the total bedload transport. It is important for the flushing and transport of fines and the activation and transport of about 30% of gravels.	Velocity (stream power).	Any		Close to 10% of the (annual) Daily Flow Duration Curve	To maintain some of the sediment transport patterns for the flushing and transport of fines and activation of gravels.

4.2 CLASS II

FLOOD CLASS II: 10-22 m^3/s				**Recommended EC C/D:**			**Alternative EC C:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**

Inverts	Flush fine material out of riffles and inundate the macro channel floor (wet channel, seasonal channels and marginal riparian zone)	Velocities high enough to flush fines and Inundate macro channel floor.	Oct, Feb, Apr	2			3	O,F,A	Spring breeding, maintaining riffles
Fish	Flush to overtop 2ndary channels to clear sediment and leaf litter. Creation of suitable spawning habitat for Cpre and other rheophilic and semi-rheophilic species. Depths of 300mm and velocities of 0.5m/s in secondary channels where cobbles and marginal vegetation occur.	Velocity (av) 1.7m/s Discharge of average of 20 cumecs Dmax 1.0 m Dav 0.50m Range 18 –22 cumec Velocities coinciding with suitable breeding temperatures (23 degrees) Velocity (av) 1.7m/s Discharge of 10 cumecs (average) Dmax 0.75 m Range 8-12 cumec	November	1	November	General improvement of water quality, prior to spawning activity Cues for spawning migration and reproduction	1	November	General improvement of water quality, prior to spawning activity Cues for spawning migration and reproduction.
Vegetation	Inundates the seasonal channels and marginal vegetation zones including the mixed sedge zone and reedbeds. Also important for the re-establishment of macro-channel floor riparian species such as *B. salicina*	Inundates up to 1 m depth in active channel, as well as inundates the seasonal channels. Inundates up to approximately 0.4 m in the mixed sedge zones away from the active channel and on the in-channel bars. The low average velocity will have minimal impact on the vegetation in these	Nov, Dec, Jan, Feb, Mar, April	4	Per year	A small flood of this size will support the marginal vegetation, stimulating the growth and reproduction of the species that comprise this zone including *P. mauritianus* and the *Cyperus* species.	6	Per year	The slightly higher frequency of supply compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are expected to increase in abundance. This will stabilise the margins of the active channel, redirect sediment movement, direct flow along the active channel, and ultimately improve the instream habitats.

		areas.							
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (1-5% representing the 29-107 m3/s discharge range) was responsible for about 23% of the total bedload transport.	Velocity (stream power). The stage of the upper end of this flow duration class (1.9m) also corresponds with a bench. These floods might be related to the construction and maintenance of this instream feature.	Any	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.	1	Annual	To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.

FLOOD CLASS II: 10-22 m^3/s				**Alternative EC /D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts				2	O,A	Spring breeding, maintaining riffles
Fish	Flush to overtop 2ndary channels to clear sediment and leaf litter. Creation of suitable spawning habitat for Cpre and other rheophilic and semi-rheophilic species. Depths of 300mm and velocities of 0.5m/s in secondary channels where cobbles and marginal	Velocity (av) 1.7m/s Discharge of average of 20 cumecs Dmax 1.0 m Dav 0.50m Range 18 –22 cumec Velocities coinciding with suitable breeding temperatures (23 degrees) Velocity (av) 1.7m/s Discharge of 10 cumecs (average)	November	1	November	General improvement of water quality, prior to spawning activity Cues for spawning migration and reproduction

	vegetation occur.	Dmax 0.75 m Range 8-12 cumec				
Vegetation				4	Per year	Reducing this flood by two per annum compared to the requirement for the recommended Class will affect the marginal vegetation resulting in exposure during the hot summer months. Exposure will affect the more flow dependent species such as reeds, which are expected to decrease in abundance. The dominance of herbaceous forbs is expected to increase. These do not stabilise the sediment, which together with a decrease in the abundance of reeds, is likely to result in a decrease in instream habitat quality.
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (1-5% representing the 29-107 m3/s discharge range) was responsible for about 23% of the total bedload transport.	Velocity (stream power). The stage of the upper end of this flow duration class (1.9m) also corresponds with a bench. These floods might be related to the construction and maintenance of this instream feature.	Any	1	Annual	To maintain some of the sediment transport patterns for the activation and overturning of gravels and flushing and transport of fines.

4.3 CLASS III

FLOOD CLASS III: 60-180 m^3/s	Recommended EC C/D:	Alternative EC C:

Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Inundates to the bench dominated by *N. floribunda* and *C. erythrophyylum* and raises the water table in the terrace to support the lower riparian zone including the trees on the terrace.	Stage and duration with inundation between 1.5 and 2.3 m in depth.	Mid summer (February)	1	Per year	Mid summer floods at this elevation are important for the re-establishment of the lower riparian zone. Also raises the water table in the benches and lower flood terraces to support the growth of the larger riparian trees on the terraces and for meeting their transpiration requirements.	2	Per year	The higher frequency of supply compared to the recommended Class will improve the vigour and growth of the lower riparian vegetation which is expected to increase in abundance. This will result in an improvement in the habitat diversity of the riparian zone.
Geomorph	N/A								

FLOOD CLASS III: 60-180 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation				1	Per year	Same as for the C/D class
Geomorph	N/A					

4.4 CLASS IV

FLOOD CLASS IV: 250-420 m^3/s				Recommended EC C/D:			Alternative EC C:		
Com.	Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning	No of events	Freq	Reasoning
Inverts	N/A								
Fish	N/A								
Vegetation	Flood inundates the middle terraces to raise the water table in the terraces and support the riparian trees (particularly the stands of *C. erythrophyllum*) that grow there. Is also important for increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes on the terraces.	Stage and duration, with the flood reaching the middle terraces at between 2.6 and 3.2 m above the active channel bed at the site.	Feb or Mar	1*	Per year	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also stimulate reproduction in many of the riparian tree species on the terraces.	2**	Per year	Same.
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (0.1-0.01% representing the 445-	Velocity (stream power). The stage of the upper end of this flow duration class (3.9 m) also corresponds with the large macro-channel terrace feature. This flow	Any	1	1:10 year return interval	These large flows should overtop the terraces (discharges presented here represent daily means, but we would expect the peaks to be higher) and flush sediment from the system which will	1	1:10 year return interval	These large flows should overtop the terraces (discharges presented here represent daily means, but we would expect the peaks to be higher) and flush sediment from the system which will have been deposited by the seasonal lowveld

	713 m3/s discharge range) was responsible for about 18% of the total bedload transport.	class is likely to be related to the maintenance of this terrace and associated vegetation.				have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.			tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.

FLOOD CLASS IV: 250-420 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation				1*	Per year	Same.
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class (0.1-0.01% representing the 445-713 m3/s discharge range) was responsible for about 18% of the total bedload transport.	Velocity (stream power). The stage of the upper end of this flow duration class (3.9 m) also corresponds with the large macro-channel terrace feature. This flow class is likely to be related to the maintenance of this terrace and associated vegetation.	Any	1	1:10 year return interval	These large flows should overtop the terraces (discharges presented here represent daily means, but we would expect the peaks to be higher) and flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will reduce excessive aggradation and loss of bedrock influence on the macro-channel floor.

*Initially one of these floods was requested per annum, but according to the present day flood record, the flood is more likely to be a 1:2 to 1:5 year event.

**Based on the note above, it is likely that the request for two of these floods per annum will not be met according to the present day flood record.

4.5 CLASS V

FLOOD CLASS V: 650-1000 m^3/s				Recommended EC C/D:			Alternative EC C:		
Com.	Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning	No of events	Freq	Reasoning
Inverts	N/A								
Fish	N/A								
Vegetation	Flood inundates the higher terraces to raise the water table in the terraces and support the riparian trees that grow there. Stands of remnant *C. erythrophyylum* still occur despite the 2000 flood damage). Is also important for increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes.	Stage and duration, with the flood reaching the higher terrace at the site.	When it arrives (summer)		Estimated at 1:10	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also stimulate reproduction in many of the riparian tree species on the terraces.		Estimated at 1:10	Same.
Geomorph	N/A								

FLOOD CLASS V: 650-1000 m^3/s	Alternative EC D:

Com.	Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning
Inverts	N/A					
Fish	N/A					
Vegetation					Estimated at 1:10	Same.
Geomorph	N/A					

5. SITE 5: KLEIN LETABA

5.1 CLASS I

FLOOD CLASS I: 8-12 m^3/s				Recommended EC: C			Alternative EC: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	Flush the active channel and marginal riparian zone)	Velocities high enough to flush channels	Oct, Feb, Apr	3	O,F,A	Spring breeding	2	O,F,	Spring breeding, maintaining macro-channel floor
Fish	Creation of suitable spawning habitat for Lmol and other semi-rheophilic and limnophilic species Cues for spawning migration and reproduction.	Velocities coinciding with suitable breeding temperatures (23 degrees) Velocity (av) 0.239m/s Discharge of 10.4 cumecs (average) Dmax 0.84 m Dav 0.428 m Range 8-12 cumec	November	1	N	Inundation of secondary channels where cobbles and marginal vegetation occur.	1	N	Inundation of secondary channels where cobbles and marginal vegetation occur.
	Flush to just overtop 2ndary channels to clear sediment and leaf litter.	Velocity (av) 0.239m/s Discharge of 10.4 cumecs (average) Dmax 0.84 m Dav 0.428 m Range 8-12 cumec	December				1	D	General improvement of water quality, prior to spawning activity
	Late season recharge to boost water quality	Velocity (av) 0.239m/s Discharge of 10.4	April				1	A	

	and to recharge aquifers prior to dry season. Intended to maintain surface flow and pools.	cumecs (average) Dmax 0.84 m Dav 0.428 m Range 8-12 cumec							
Vegetation	Inundates the seasonal channels and marginal vegetation zones adjacent to the active channel. Is important for the re-establishment of the marginal vegetation zones that include inundation dependent species such as *T. capensis* and *L. hexandra*, both of which depend on flooding inundation for completion of their lifecycles.	Inundates up to 1 m depth in active channel, as well as inundates the seasonal channels. The relatively low average velocity will have minimal impact on the other marginal vegetation in these areas.	Nov to April	9 (6 of between 8-12 m^3sec^{-1} and 3 between 14-27 m^3sec^{-1} integrated classes)	Per year	A small flood of this size will support the extensive marginal vegetation zone in this river, stimulating the growth and reproduction of the flow dependent vegetation that comprise this zone. The frequency of flooding will improve the vigour and growth of the marginal vegetation, particularly reeds, which will stabilise the margins of the active channel, redirect sediment movement and direct flow along the active channel.	6 (4 of between 8-12 m^3sec^{-1} and 2 between 14-27 m^3sec^{-1} integrated classes)	Per year	Reducing this flood by two per annum compared to the requirement for the recommended Class will affect the marginal vegetation resulting in exposure during the hot summer months. Exposure will affect the more flow dependent species such as reeds, which are expected to decrease in abundance. The dominance of herbaceous forbs is expected to increase. These do not stabilise the sediment, which together with a decrease in the abundance of reeds, is likely to result in a decrease in instream habitat quality.
Geomorph	N/A								

5.2 CLASS II

FLOOD CLASS II: 14-25 m^3/s				**Recommended EC: C**			**Alternative EC: D**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								

Fish	Flush to overtop 2ndary channels to clear sediment and leaf litter.	Velocity (av) 0.384m/s Discharge of average of 23.56 cumecs Dmax 1.0 m Dav 0.543m Range 16-25 cumec	November	1	N	General improvement of water quality, prior to spawning activity	N/A		
	Late season recharge to boost water quality and to recharge aquifers prior to dry season.	Velocity (av) 0.384m/s Discharge of average of 23.56 cumecs Dmax 1.0 m Dav 0.543m Range 16-25 cumec	April	1	A	Intended to maintain surface flow and pools.	N/A		
Vegetation	Inundates the seasonal channels and marginal vegetation zones adjacent to the active channel. Is important for the re-establishment of the marginal vegetation zones that include inundation dependent species such as *T. capensis* and *L. hexandra*, both of which depend on flooding inundation for completion of their lifecycles.	Inundates up to 1 m depth in active channel, as well as inundates the seasonal channels. The relatively low average velocity will have minimal impact on the other marginal vegetation in these areas.	Nov to April	9 (6 of between 8-12 m^3sec^{-1} and 3 between 14-27 m^3sec^{-1} integrated classes)	Per year	A small flood of this size will support the extensive marginal vegetation zone in this river, stimulating the growth and reproduction of the flow dependent vegetation that comprise this zone. The frequency of flooding will improve the vigour and growth of the marginal vegetation, particularly reeds, which will stabilise the margins of the active channel, redirect sediment movement and direct flow along the active channel.	6 (4 of between 8-12 m^3sec^{-1} and 2 between 14-27 m^3sec^{-1} integrated classes)	Per year	Reducing this flood by two per annum compared to the requirement for the recommended Class will affect the marginal vegetation resulting in exposure during the hot summer months. Exposure will affect the more flow dependent species such as reeds, which are expected to decrease in abundance. The dominance of herbaceous forbs is expected to increase. These do not stabilise the sediment, which together with a decrease in the abundance of reeds, is likely to result in a decrease in instream habitat quality.
Geomorph	Maintain sediment transport characteristics. This flow duration class (1-2%) is important for the flushing and	Velocity (stream power).	Any		2	To maintain sediment transport patterns; specifically the flushing and transport of fines.		1:2	To maintain some of the sediment transport patterns; specifically the flushing and transport of fines.

	transport of fines.								

5.3 CLASS III

FLOOD CLASS III: 60-126 m^3/s				Recommended EC: C			Alternative EC: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	With this flood, the reedbeds at the site are completely inundated above the rhizome/culm interface. Also inundates up to the lower edge of the first flood terrace, thereby raising the water table to support the re-establishment of trees on this terrace.	Stage and duration with the flood inundating the active channel to a depth of 1.6 m.	Dec or Mar	1	Per year	These floods would ensure that the marginal vegetation on the bars, adjacent to the active channel, and in the seasonal channels is inundated at least once during the summer months. This will help recharge the bars and stimulate the growth and reproduction of the marginal vegetation. This flood also reaches the lower riparian zone and helps recharge the lower terraces.		1:2	Reducing this flood to one every two years compared to the requirement for the recommended Class is likely to reduce the recruitment opportunities for the lower riparian zone vegetation, which is not expected to recover well given this reduced frequency of flooding.
Geomorph	Maintain present bed form and sediment transport characteristics. This flow duration class accounts for about 30% of the potential	Velocity (stream power).	Any		1:2	These flows account for a large proportion of the potential bed material transport. They would thus maintain sediment transport potential and prevent excessive sedimentation which could result in an increase in		1:3	These flows account for a large proportion of the potential bed material transport. They would thus maintain sediment transport potential and prevent excessive sedimentation which could result in an increase in subsurface flows.

	bed material transport.					subsurface flows.			

5.4 CLASS IV

FLOOD CLASS IV: 175-480 m^3/s				Recommended EC: C			Alternative EC: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Flood inundates the lower terraces to raise the water table in the terraces and support the riparian trees that grow there. Is also important for establishing new terraces and increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes on the existing terraces.	Stage and duration, with the flood overtopping the lower terraces. Reaches 2.6 m above the active channel bed at the site.	When it happens in summer		Estimated at 1:10	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the terraces. The flows also stimulate reproduction in many of the riparian tree species on the banks and terraces.		Estimated at 1:10	Same.
Geomorph	N/A								

5.5 CLASS V

FLOOD CLASS V: 500 m^3/s				Recommended EC: C			Alternative EC: D		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Same as class IV*					Same as class IV*			Same as class IV*
Geomorph	Scour the macro-channel; remove vegetation, transport fines and gravels from the bed.	Velocity (stream power).			1:10	These high flows should prevent vegetation encroachment on the macro-channel floor which has been observed following the completion of the Middle Letaba dam		1:10	These high flows should prevent vegetation encroachment on the macro-channel floor which has been observed following the completion of the Middle Letaba dam

* Initially wanted to motivate for a much larger flood (in the region of 2800 m^3sec^{-1}) to reach the upper terraces at the site but according to the present day flood record these are very infrequent events that are not well represented in the flood data record - equivalent to the 2000 floods. The motivation for such a large flood for the riparian vegetation was probably skewed by the effects of the 2000 floods which substantially altered the channel morphology. Benches and terraces or sections of the terraces were probably removed during the 2000 floods. This left intermediate flow indicators species (such as *C. erythrophyllum*) at high elevations on remnant sections of terraces that now (due to changes in the width of the macro-channel) are unlikely to get flooded very often, if at all. It was also apparent that the vegetation on the upper terraces and banks could have been influenced by groundwater at the site. The occurrence of *P mauritianus*, for example, particular at high elevations on the profile, is possibly evidence of a groundwater influence. Another possible explanation for this species occurring so high on the profile might have to do with clumps being deposited with sediment during the drawdown of the 2000 floods and establishing. Without a groundwater influence however, these clumps are unlikely to survive. The influence of groundwater at the site and in the reach is however unknown.

6. SITE 6: LONELY BULL

6.1 CLASS I

FLOOD CLASS I: 5-8 m³/s				Recommended EC C:			Alternative EC B:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	Growth and hatching of eggs laid on gravel beds.	Minimum flow to be continuous with item 2 above. (single hydrograph) Velocities to keep sediment from eggs. Discharge of 6.1 cumecs Dmax 0.82m Dav 0.41 m Range 5 - 8 cumecs	Dec – April	5 November (5 in total Dec – April		Sufficient depths in secondary channels where cobbles occur and moderate velocities in pool and backwaters and marginal habitats. 5 floods required to supply hydraulic diversity to the end of the wet season, providing good healthy river conditions for growth. The river providing an abundance of food and good water quality for the coming dry season.	8		Sufficient depths in secondary channels where cobbles occur and moderate velocities in pool and backwaters and marginal habitats. 8 floods required to supply hydraulic diversity to the end of the wet season, providing good healthy river conditions for growth. The river providing an abundance of food and good water quality for the coming dry season.
Vegetation	N/A								
Geomorph	N/A								

FLOOD CLASS I: 5-8 m³/s	Alternative EC D:

Com.	Function/s (what does it have to do)	Description (what is the flood characteristic that does that)	Season	No of events	Freq	Reasoning
Inverts	N/A					
Fish			1 in April & 1 in March	2		Sufficient depths in secondary channels where cobbles occur and moderate velocities in pool and backwaters and marginal habitats. 8 floods required to supply hydraulic diversity to the end of the wet season, providing good healthy river conditions for growth. The river providing an abundance of food and good water quality for the coming dry season.
Vegetation	N/A					
Geomorph	N/A					

6.2 CLASS II

FLOOD CLASS II: 10-27 m^3/s				Recommended EC C:			Alternative EC B:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**

Inverts	Flush fine material out of riffles and inundate the macro channel floor (wet channel, seasonal channels and marginal riparian zone)	Velocities high enough to flush fines and Inundate macro channel floor.l	Oct, Feb, Apr	2	O,A	Spring breeding, maintaining riffles	3	O,F,A	Spring breeding, maintaining riffles
Fish	Spike to overtop 2ndary channels to clear sediment and leaf litter.	Discharge of 12 cumecs Dmax 0.94 m Dmain 0.51m Range 10 – 15 cumecs.	November	1		General improvement of water quality, prior to spawning activity	1		General improvement of water quality, prior to spawning activity
	Creation of suitable spawning habitat for Cswi,	Velocities coinciding with suitable breeding temperatures (23 degrees) Discharge of 8.7 cumecs Dmax 0.88 m Dmain 0.46 m Range 7-10 cumec	Mid November	1		Cues for spawning migration and reproduction. Max depths of approx 1m providing depths of 460mm in channels where cobbles occur and appropriate velocities	1		Cues for spawning migration and reproduction. Max depths of approx 1m providing depths of 460mm in channels where cobbles occur and appropriate velocities
Vegetation	Inundates the seasonal channels adjacent to the active channel and the marginal vegetation between these channels.	Stage and duration with the flood inundating the active channel to a depth of between 0.9 and 1.1 m.	Nov, Ded, Jan, Mar, Apr	5	Per year	A small flood of this size will overtop the in-channel bar and flood the seasonal channel. The number of these floods ensures that the marginal vegetation on the bar, adjacent to the active channel, and in the seasonal channel is inundated regularly during the summer months. Inundation stimulates growth and reproduction of flow dependent vegetation that comprises the marginal vegetation zone.	6	Per year	The slightly higher frequency of supply compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are expected to increase in abundance. This will stabilise the margins of the active channel, redirect sediment movement, direct flow along the active channel, and ultimately improve the instream habitats.
Geomorph	Restore sediment	Velocity (stream power).	Any	3		To restore some of the	4		To restore sediment transport

	transport characteristics. This flow duration class (5-10%) was responsible for transporting fines.					sediment transport patterns; specifically the flushing and transport of fines.			patterns; specifically the flushing and transport of fines.

FLOOD CLASS II: 10-27 m^3/s				Alternative EC D:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	?			2		
Fish		.	November	1		General improvement of water quality, prior to spawning activity
			Mid November	1		Cues for spawning migration and reproduction. Max depths of approx 1m providing depths of 400mm in channels where cobbles occur and appropriate velocities
Vegetation				4	Per year	Reducing this flood by two per annum compared to the requirement for the recommended Class will affect the marginal vegetation resulting in exposure during the hot summer months. Exposure will affect the more flow dependent species such as reeds, which are expected to decrease in abundance. The

						dominance of herbaceous forbs is expected to increase. These do not stabilise the sediment, which together with a decrease in the abundance of reeds, is likely to result in a decrease in instream habitat quality.
Geomorph	Restore sediment transport characteristics. This flow duration class (5-10%) was responsible for transporting fines.	Velocity (stream power).	Any	2		To restore some of the sediment transport patterns; specifically the flushing and transport of fines.

6.3 CLASS III

FLOOD CLASS III: 80-150 m³/s				Recommended EC C:			Alternative EC B:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Inundates all the seasonal channels at the cross section. It also inundates the marginal vegetation between these channels.	Stage and duration with the flood inundating the active channel to a depth of between 1.5 and 1.75m.	Jan, Mar	2*	Per year	A flood of this size will overtop both the in-channel bars and flood all the seasonal channels at the site. These floods would ensure that the marginal vegetation on the bars, adjacent to the active channel,	3**	Per year	An additional flood of this size compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are expected to increase in abundance. This will also increase the extent of

						and in the seasonal channels is inundated at least once during the summer months. This will help recharge the bars and stimulate the growth and reproduction of the marginal vegetation.			the marginal vegetation zone thereby further stabilising sections of the macro-channel floor.
Geomorph	These flows around from the 5-1 of the flow duration curve transport a large proportion of the sandy bedload and flush and deepen the active channels.	Velocity (stream power).	Any	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.

*Initially two of these floods were requested per annum, but according to the present day flood record, only one actually occurs.

**Based on the note above, it is likely that the request for three of these floods per annum will not be met according to the present day flood record.

FLOOD CLASS III: 80-150 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation				1	Per year	Reducing this flood to one per annum compared to the requirement for the recommended Class will at least help maintain some of the higher elevation marginal vegetation, but due to the relatively short duration and

						lack of a follow-up flood will not support the more flow dependent species such as reeds, which are expected to decrease in abundance.
Geomorph	These flows around from the 5-1 of the flow duration curve transport a large proportion of the sandy bedload and flush and deepen the active channels.	Velocity (stream power).	Any	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.

6.4 CLASS IV

FLOOD CLASS IV: 300 m^3/s				**Recommended EC C:**			**Alternative EC B:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Inundates the lower riparian zone along the lower bank. This is important for supporting the vegetation along the lower bank. Also inundates the lower terrace where there is	Stage and duration, with the flood overtopping the first terrace at the site.	Feb	1*	Per year	Inundation is also required to meet the life-history requirements of many of the lower riparian species.	1*	Per year	Same.

	some *P. mauritianus* as well as small re-establishing riparian trees.								
Geomorph	Maintain present bed form and sediment transport characteristics. These flows are responsible for about 50% of the potential bed material transport. Large floods at this site are very important.	Velocity (stream power).	Any	1		To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.	1		To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.

FLOOD CLASS IV: 300 m^3/s				Alternative EC D:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation					1:2*	Inundation is also required to meet the life-history requirements of many of the lower riparian species.
Geomorph	Maintain present bed form and sediment transport characteristics. These flows are responsible for about 50% of the	Velocity (stream power).	Any		1:2	To maintain some of the sediment transport patterns for the activation and overturning of gravels and flushing and transport of fines.

	potential bed material transport. Large floods at this site are very important.					

* Initially one of these floods was requested per annum for both the C and alternative B Class, but according to the present day flood record, the frequency of only 1:5 years is probably more realistic.

** Based on the note above, it is likely that the request for this flood of 1:2 years will also not be met according to the present day flood record.

6.5 CLASS V

FLOOD CLASS V: 2000 m³/s				Recommended EC C:			Alternative EC B:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Flood inundates the upper terraces to raise the water table in the terraces and support the riparian trees that grow there. Are also important for increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes.	Stage and duration, with the flood reaching the higher terrace at the site.	Summer (when it arrives)		Estimated at 1:10	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also stimulate reproduction in many of the riparian tree species on the terraces.		Estimated at 1:10	Same.

Geomorph	Scour the macro-channel and remove encroaching vegetation; transport fine sediment and gravels.	Velocity (stream power).	Any	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.

FLOOD CLASS V: 2000 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation					Estimated at 1:10	Same
Geomorph	Scour the macro-channel and remove encroaching vegetation; transport fine sediment and gravels.	Velocity (stream power).	Any	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.

7. SITE 7: LETABA BRIDGE

7.1 CLASS I

FLOOD CLASS I: 5-8 m^3/s				Recommended EC C:			Alternative EC B:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	Spike to overtop 2ndary channels to clear sediment and leaf litter. Creation of suitable spawning habitat for Ceng, Growth and hatching of eggs laid on gravel beds.	Discharge of 12.7 cumecs Dmax 0.62 m Dave 0.27m Vave 0.75m/s Range 7 – 15 cumecs.	November	7	1	General improvement of water quality, prior to spawning activity	10	1	General improvement of water quality, prior to spawning activity
			November		1	Cues for spawning migration and reproduction. Max depths of approx 1m providing depths of 460mm in channels where cobbles occur and appropriate velocities		1	Cues for spawning migration and reproduction. Max depths of approx 0.6m providing depths of 270mm in channels where gravel occur and appropriate velocities
			between Dec – April		5	Sufficient depths in secondary channels where cobbles occur and moderate velocities in pool and backwaters and marginal habitats. 5 floods required to supply hydraulic		8	Sufficient depths in secondary channels where cobbles occur and moderate velocities in pool and backwaters and marginal habitats. 8 floods required to supply hydraulic diversity to the end of the

						diversity to the end of the wet season, providing good healthy river conditions for growth. The river providing an abundance of food and good water quality for the coming dry season			wet season, providing good healthy river conditions for growth. The river providing an abundance of food and good water quality for the coming dry season
Vegetation	N/A								
Geomorph	N/A								

FLOOD CLASS I: 5-8 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish			November	4	1	General improvement of water quality, prior to spawning activity Cues for spawning migration and reproduction. Max depths of approx 0.6m providing depths of 270mm in channels where cobbles occur and appropriate velocities
			3 between Dec – April		3	Sufficient depths in secondary channels where cobbles occur and moderate velocities in pool and backwaters and marginal habitats. 3 floods required to supply hydraulic diversity to the end of the wet

						season, providing good healthy river conditions for growth. The river providing an abundance of food and good water quality for the coming dry season
Vegetation	N/A					
Geomorph	N/A					

7.2 CLASS II

FLOOD CLASS II: 10-30 m³/s				Recommended EC C:			Alternative EC B:		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	Flush fine material out of riffles and inundate the macro channel floor (wet channel, seasonal channels and marginal riparian zone)	Velocities high enough to flush fines and Inundate macro channel floor.l	Oct, Feb, Apr	2	O,A	Spring breeding, maintaining riffles	3	O,F,A	Spring breeding, maintaining riffles
Fish	N/A								
Vegetation			Nov, Dec, Jan, Mar, Apr	5	Per year	A small flood of this size will overtop the small in-channel bars and flood the seasonal channels. The number of these floods ensures that the marginal vegetation on the bars, adjacent to the active	6	Per year	The slightly higher frequency of supply compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are expected to increase in abundance. This will

						channel, in the backwaters, and in the seasonal channels is inundated regularly during the summer months. Inundation stimulates growth and reproduction of flow dependent vegetation that comprises the marginal vegetation zone.			stabilise the margins of the active channel, redirect sediment movement, direct flow along the active channel, and ultimately improve the instream habitats.
Geomorph	Restore sediment transport characteristics. This flow duration class (5-10%) was responsible for transporting fines.	Velocity (stream power).	Any	3		To restore some of the sediment transport patterns; specifically the flushing and transport of fines.	4		To restore sediment transport patterns; specifically the flushing and transport of fines.

FLOOD CLASS II: 10-30 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts				2		
Fish	N/A					
Vegetation				3	Per year	Reducing this flood by two per annum compared to the requirement for the recommended Class will affect the marginal vegetation resulting in exposure during the hot summer months. Exposure will affect the more flow dependent species such

						as reeds, which are expected to decrease in abundance. The dominance of herbaceous forbs is expected to increase. These do not stabilise the sediment, which together with a decrease in the abundance of reeds, is likely to result in a decrease in instream habitat quality.
Geomorph	Restore sediment transport characteristics. This flow duration class (5-10%) was responsible for transporting fines.	Velocity (stream power).	Any	2		To restore some of the sediment transport patterns for the flushing and transport of fines.

7.3 CLASS III

FLOOD CLASS III: 80-160 m^3/s				**Recommended EC C:**			**Alternative EC B:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Inundates the seasonal channels at the cross section and the marginal vegetation between	Stage and duration with the flood inundating the active channel to a depth of between 1.2 and 1.5m.	Feb	2*	Per year	A flood of this size will overtop all the in-channel bars and flood all the seasonal channels at the lower elevations on the macro-channel floor. These	3*	Per year	An additional flood of this size compared to the recommended Class will improve the vigour and growth of the marginal vegetation, particularly reeds, which are

	these channels. In particular, the reedbeds in the backwaters at the site are completely inundated above the rhizome/culm interface. Also inundates up to the edge (at the higher elevations) of the *C. dactylon*, *P. mauritianus*, *Schoenoplectus* zone.					floods would ensure that the marginal vegetation on the bars, adjacent to the active channel, and in the seasonal channels is inundated at least once during the summer months. This will help recharge the bars and stimulate the growth and reproduction of the marginal vegetation.			expected to increase in abundance. This will also increase the extent of the marginal vegetation zone thereby further stabilising sections of the macro-channel floor.
Geomorph	These flows around from the 5-1 of the flow duration curve transport a large proportion of the sandy bedload and flush and deepen the active channels.	Velocity (stream power).	Any	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.

FLOOD CLASS III: 80-160 m³/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation				1	Per year	Reducing this flood to one per annum compared to the

						requirement for the recommended Class will at least help maintain some of the higher elevation marginal vegetation, but due to the relatively short duration and lack of a follow-up flood will not support the more flow dependent species such as reeds, which are expected to decrease in abundance.
Geomorph	These flows around from the 5-1 of the flow duration curve transport a large proportion of the sandy bedload and flush and deepen the active channels.	Velocity (stream power).	Any	1		To transport the sandy bed material at this site and scout active channels to deepen and widen them.

*Initially two of these floods were requested per annum, but according to the present day flood record, only one actually occurs.

**Based on the note above, it is likely that the request for three of these floods per annum will not be met according to the present day flood record.

7.4 CLASS IV

FLOOD CLASS IV: 300-550 m^3/s				**Recommended EC C:**			**Alternative EC B:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Inundates the entire macro-channel floor.	Stage and duration, with the flood inundating the	Feb	1*	Per year	This will help recharge the sediments along the macro-	1*	Per year	Same.

	This is important for supporting the vegetation along the floor and getting water to the foot of the lower terrace to help with the re-establishment of lower riparian trees.	entire macro-channel floor.				channel floor and stimulate the growth and reproduction of the marginal vegetation. Inundation across the floor will also assist with the re-establishment of lower riparian species.			
Geomorph	Maintain present bed form and sediment transport characteristics. These flows are responsible for about 50% of the potential bed material transport. Large floods at this site are very important.	Velocity (stream power).	Any		1:3	To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.		1:2	To maintain sediment transport patterns; specifically the activation and overturning of gravels and flushing and transport of fines.

FLOOD CLASS IV: 300-550 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation					1:2	Reducing this flood to one every two years compared to the requirement for the recommended Class is likely to reduce the recruitment

						opportunities for the lower riparian zone vegetation, which is not expected to recover well given this reduced frequency of flooding.
Geomorph	Maintain present bed form and sediment transport characteristics. These flows are responsible for about 50% of the potential bed material transport. Large floods at this site are very important.	Velocity (stream power).	Any		1:3	To maintain some of the sediment transport patterns for the activation and overturning of gravels and flushing and transport of fines.

*One of these floods was requested per annum, but according to the present day flood record, this flood is presently more like a 1:5 year event.

7.5 CLASS V

FLOOD CLASS VI: 2000-3800 m³/s				**Recommended EC C:**			**Alternative EC B:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A								
Fish	N/A								
Vegetation	Flood inundates the higher terraces to raise the water table in the terraces and support the riparian trees that grow there. Is also important for	Stage and duration, with the flood reaching the higher terrace at the site.	When it arrives (summer)		Estimated at 1:10	Floods at this elevation are important raising the water table in the flood terraces. This is important for meeting the transpiration requirements of the riparian trees on the upper terraces. The flows also		Estimated at 1:10	Same as REC C

	increasing the availability of sites for the germination and establishment of new riparian trees through depositional processes.					stimulate reproduction in many of the riparian tree species on the terraces.			
Geomorph	Scour the macro-channel and remove encroaching vegetation; transport fine sediment and gravels.	Velocity (stream power).	Any	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.

FLOOD CLASS VI: 2000-3800 m^3/s				**Alternative EC D:**		
Com.	**Function/s (what does it have to do)**	**Description (what is the flood characteristic that does that)**	**Season**	**No of events**	**Freq**	**Reasoning**
Inverts	N/A					
Fish	N/A					
Vegetation					Estimated at 1:10	Same as REC C
Geomorph	Scour the macro-channel and remove encroaching vegetation; transport fine sediment and gravels.	Velocity (stream power).	Any	1	1:10 year return interval	These large flows should flush sediment from the system which will have been deposited by the seasonal lowveld tributaries. This will prevent excessive aggradation and loss of bedrock influence on the macro-channel floor.

Appendix K: Detailed EWR results presented as EWR Tables

Ken Hauman, PD Naidoo

Table of Contents

1. EWR SITE 1: APPLE

1.1 CATEGORY C

```
        Desktop Version 2, Printed on 12/11/2004
        Summary of EWR estimate for: EWR1 Virgin
        Determination based on defined BBM Table with site specific assurance
rules.

        Annual Flows (Mill. cu. m or index values):
        MAR                =   71.691
        S.Dev.             =   50.236
        CV                 =    0.701
        Q75                =    2.270
        Q75/MMF            =    0.380
        BFI Index          =    0.487
        CV(JJA+JFM) Index  =    1.330

        PES = C

        Total EWR          =   18.800 (26.22 %MAR)
        Maint. Lowflow     =    7.503 (10.47 %MAR)
        Drought Lowflow    =    3.148 ( 4.39 %MAR)
        Maint. Highflow    =   11.297 (15.76 %MAR)

        Monthly Distributions (cu.m./s)
        Distribution Type : E.Escarp
```

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	0.756	0.183	0.090	0.170	0.080	0.000	0.170
Nov	0.984	0.435	0.171	0.190	0.090	0.310	0.500
Dec	1.765	1.704	0.360	0.220	0.100	0.749	0.969
Jan	3.640	4.283	0.439	0.250	0.110	0.203	0.453
Feb	6.444	7.645	0.490	0.300	0.130	2.123	2.423
Mar	5.341	5.692	0.398	0.300	0.120	0.300	0.600
Apr	3.151	2.606	0.319	0.290	0.120	0.773	1.064
May	1.602	0.674	0.157	0.270	0.110	0.000	0.270
Jun	1.209	0.256	0.082	0.250	0.100	0.000	0.250
Jul	1.002	0.176	0.066	0.220	0.090	0.000	0.220
Aug	0.883	0.152	0.064	0.210	0.080	0.000	0.210
Sep	0.811	0.149	0.071	0.190	0.070	0.000	0.190

1.2 CATEGORY D

Desktop Version 2, Printed on 12/07/2005
Summary of EWR estimate for: EWR1 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	71.691
S.Dev.	=	50.236
CV	=	0.701
Q75	=	2.270
Q75/MMF	=	0.380
BFI Index	=	0.487
CV(JJA+JFM) Index	=	1.330

PES = D

Total EWR	=	10.428 (14.55 %MAR)
Maint. Lowflow	=	3.578 (4.99 %MAR)
Drought Lowflow	=	3.141 (4.38 %MAR)
Maint. Highflow	=	6.851 (9.56 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	0.756	0.183	0.090	0.110	0.090	0.000	0.110
Nov	0.984	0.435	0.171	0.115	0.100	0.163	0.278
Dec	1.765	1.704	0.360	0.120	0.115	0.542	0.662
Jan	3.640	4.283	0.439	0.125	0.125	0.158	0.283
Feb	6.444	7.645	0.490	0.135	0.130	1.532	1.667
Mar	5.341	5.692	0.398	0.120	0.110	0.158	0.278
Apr	3.151	2.606	0.319	0.110	0.100	0.163	0.273
May	1.602	0.674	0.157	0.105	0.095	0.000	0.105
Jun	1.209	0.256	0.082	0.105	0.090	0.000	0.105
Jul	1.002	0.176	0.066	0.100	0.087	0.000	0.100
Aug	0.883	0.152	0.064	0.110	0.085	0.000	0.110
Sep	0.811	0.149	0.071	0.108	0.070	0.000	0.108

2. SITE 2: LETSITELE

2.1 CATEGORY D

```
        Desktop Version 2, Printed on 14/11/2005
        Summary of EWR estimate for: EWR2 Virgin flow
        Determination based on defined BBM Table with site specific assurance
rules.

        Annual Flows (Mill. cu. m or index values):
        MAR                 =   86.057
        S.Dev.              =   65.613
        CV                  =    0.762
        Q75                 =    2.660
        Q75/MMF             =    0.371
        BFI Index           =    0.491
        CV(JJA+JFM) Index =      1.582

        PES = C

        Total EWR           =   37.196 (43.22 %MAR)
        Maint. Lowflow      =   27.593 (32.06 %MAR)
        Drought Lowflow     =    3.720 ( 4.32 %MAR)
        Maint. Highflow     =    9.603 (11.16 %MAR)

        Monthly Distributions (cu.m./s)
        Distribution Type : E.Escarp
```

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	0.921	0.321	0.130	0.700	0.060	0.000	0.700
Nov	1.246	0.833	0.258	0.800	0.100	0.163	0.963
Dec	2.379	2.678	0.420	0.900	0.140	1.427	2.327
Jan	4.620	5.317	0.430	1.000	0.180	0.316	1.316
Feb	7.617	10.835	0.588	1.170	0.190	1.339	2.509
Mar	5.682	6.957	0.457	1.100	0.180	0.316	1.416
Apr	3.368	2.512	0.288	0.950	0.160	0.163	1.113
May	2.113	0.835	0.148	0.900	0.130	0.000	0.900
Jun	1.700	0.576	0.131	0.850	0.100	0.000	0.850
Jul	1.343	0.422	0.117	0.800	0.080	0.000	0.800
Aug	1.123	0.333	0.111	0.700	0.060	0.000	0.700
Sep	0.989	0.287	0.112	0.650	0.040	0.000	0.650

3. SITE 3: PRIESKA

3.1 CATEGORY C

```
        Desktop Version 2, Printed on 14/11/2004
        Summary of EWR estimate for: EWR3 Virgin
        Determination based on defined BBM Table with site specific assurance
rules.

        Annual Flows (Mill. cu. m or index values):
        MAR                 =  364.494
        S.Dev.              =  260.530
        CV                  =    0.715
        Q75                 =   11.390
        Q75/MMF             =    0.375
        BFI Index           =    0.480
        CV(JJA+JFM) Index =      1.465

        PES = C

        Total EWR           =   58.304 (16.00 %MAR)
        Maint. Lowflow      =   13.612 ( 3.73 %MAR)
        Drought Lowflow     =    1.488 ( 0.41 %MAR)
        Maint. Highflow     =   44.692 (12.26 %MAR)

        Monthly Distributions (cu.m./s)
        Distribution Type : E.Escarp
```

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	3.701	1.064	0.107	0.300	0.030	0.316	0.616
Nov	4.958	2.810	0.219	0.400	0.040	0.327	0.727
Dec	9.461	9.560	0.377	0.450	0.060	1.490	1.940
Jan	19.976	25.928	0.485	0.550	0.070	1.152	1.702
Feb	34.317	43.348	0.522	0.700	0.100	5.640	6.340
Mar	25.754	28.924	0.419	0.550	0.070	8.002	8.552
Apr	14.251	11.141	0.302	0.500	0.050	0.327	0.827
May	7.934	2.940	0.138	0.450	0.040	0.000	0.450
Jun	6.343	1.609	0.098	0.400	0.035	0.000	0.400
Jul	5.199	1.209	0.087	0.350	0.030	0.000	0.350
Aug	4.465	0.996	0.083	0.300	0.025	0.000	0.300
Sep	4.002	0.916	0.088	0.250	0.020	0.000	0.250

3.2 CATEGORY C/D

Desktop Version 2, Printed on 14/11/2004
Summary of EWR estimate for: EWR3 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	364.494
S.Dev.	=	260.530
CV	=	0.715
Q75	=	11.390
Q75/MMF	=	0.375
BFI Index	=	0.480
CV(JJA+JFM) Index	=	1.465

PES = C/D

Total EWR	=	47.653	(13.07 %MAR)
Maint. Lowflow	=	4.715	(1.29 %MAR)
Drought Lowflow	=	0.832	(0.23 %MAR)
Maint. Highflow	=	42.938	(11.78 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	3.701	1.064	0.107	0.100	0.010	0.000	0.100
Nov	4.958	2.810	0.219	0.120	0.015	0.327	0.447
Dec	9.461	9.560	0.377	0.130	0.020	1.152	1.282
Jan	19.976	25.928	0.485	0.180	0.045	1.152	1.332
Feb	34.317	43.348	0.522	0.380	0.085	5.640	6.020
Mar	25.754	28.924	0.419	0.190	0.045	8.002	8.192
Apr	14.251	11.141	0.302	0.170	0.030	0.327	0.497
May	7.934	2.940	0.138	0.165	0.020	0.000	0.165
Jun	6.343	1.609	0.098	0.130	0.018	0.000	0.130
Jul	5.199	1.209	0.087	0.100	0.015	0.000	0.100
Aug	4.465	0.996	0.083	0.080	0.010	0.000	0.080
Sep	4.002	0.916	0.088	0.068	0.008	0.000	0.068

3.3 CATEGORY D

Desktop Version 2, Printed on 14/11/2004
Summary of EWR estimate for: EWR3 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	364.494
S.Dev.	=	260.530
CV	=	0.715
Q75	=	11.390
Q75/MMF	=	0.375
BFI Index	=	0.480
CV(JJA+JFM) Index	=	1.465

PES = D

Total EWR	=	17.412	(4.78 %MAR)
Maint. Lowflow	=	2.482	(0.68 %MAR)
Drought Lowflow	=	0.841	(0.23 %MAR)
Maint. Highflow	=	14.930	(4.10 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	3.701	1.064	0.107	0.050	0.008	0.000	0.050
Nov	4.958	2.810	0.219	0.060	0.012	0.373	0.433
Dec	9.461	9.560	0.377	0.100	0.040	1.084	1.184
Jan	19.976	25.928	0.485	0.120	0.055	0.361	0.481
Feb	34.317	43.348	0.522	0.145	0.075	0.771	0.916
Mar	25.754	28.924	0.419	0.120	0.055	2.710	2.830
Apr	14.251	11.141	0.302	0.100	0.030	0.373	0.473
May	7.934	2.940	0.138	0.061	0.012	0.000	0.061
Jun	6.343	1.609	0.098	0.058	0.011	0.000	0.058
Jul	5.199	1.209	0.087	0.052	0.010	0.000	0.052
Aug	4.465	0.996	0.083	0.045	0.009	0.000	0.045
Sep	4.002	0.916	0.088	0.038	0.006	0.000	0.038

4. SITE 4: LETABA RANCH

4.1 CATEGORY C

Desktop Version 2, Printed on 15/09/2005
Summary of EWR estimate for: EWR4 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	402.260
S.Dev.	=	299.562
CV	=	0.745
Q75	=	11.820
Q75/MMF	=	0.353
BFI Index	=	0.465
CV(JJA+JFM) Index	=	1.553

PES = C

Total EWR	=	126.789	(31.52 %MAR)
Maint. Lowflow	=	21.012	(5.22 %MAR)
Drought Lowflow	=	3.339	(0.83 %MAR)
Maint. Highflow	=	105.777	(26.30 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	3.852	1.138	0.110	0.600	0.050	0.000	0.600
Nov	5.306	3.283	0.239	0.650	0.055	1.416	2.066
Dec	10.836	12.387	0.427	0.680	0.060	6.491	7.171
Jan	23.690	35.619	0.561	0.730	0.062	2.574	3.304
Feb	39.171	50.697	0.535	0.750	0.065	15.327	16.077
Mar	28.118	32.115	0.426	0.780	0.653	13.844	14.624
Apr	15.018	12.132	0.312	0.700	0.060	1.416	2.116
May	8.240	3.081	0.140	0.680	0.055	0.000	0.680
Jun	6.580	1.695	0.099	0.650	0.050	0.000	0.650
Jul	5.388	1.273	0.088	0.630	0.050	0.000	0.630
Aug	4.626	1.047	0.085	0.600	0.050	0.000	0.600
Sep	4.152	0.973	0.090	0.550	0.050	0.000	0.550

Category C/D

Desktop Version 2, Printed on 15/09/2005
Summary of EWR estimate for: EWR4 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	402.260
S.Dev.	=	299.562
CV	=	0.745
Q75	=	11.820
Q75/MMF	=	0.353
BFI Index	=	0.465
CV(JJA+JFM) Index	=	1.553

PES = C/D

Total EWR	=	75.065 (18.66 %MAR)
Maint. Lowflow	=	11.349 (2.82 %MAR)
Drought Lowflow	=	1.783 (0.44 %MAR)
Maint. Highflow	=	63.717 (15.84 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	3.852	1.138	0.110	0.260	0.052	0.000	0.260
Nov	5.306	3.283	0.239	0.300	0.055	1.416	1.716
Dec	10.836	12.387	0.427	0.350	0.058	1.370	1.720
Jan	23.690	35.619	0.561	0.430	0.060	1.370	1.800
Feb	39.171	50.697	0.535	0.520	0.065	14.196	14.716
Mar	28.118	32.115	0.426	0.460	0.063	5.485	5.945
Apr	15.018	12.132	0.312	0.420	0.060	1.416	1.836
May	8.240	3.081	0.140	0.400	0.057	0.000	0.400
Jun	6.580	1.695	0.099	0.360	0.055	0.000	0.360
Jul	5.388	1.273	0.088	0.320	0.053	0.000	0.320
Aug	4.626	1.047	0.085	0.270	0.051	0.000	0.270
Sep	4.152	0.973	0.090	0.240	0.050	0.000	0.240

4.2 CATEGORY D

Desktop Version 2, Printed on 15/09/2005
Summary of EWR estimate for: EWR4 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	402.260
S.Dev.	=	299.562
CV	=	0.745
Q75	=	11.820
Q75/MMF	=	0.353
BFI Index	=	0.465
CV(JJA+JFM) Index	=	1.553

PES = D

Total EWR	=	68.429	(17.01 %MAR)
Maint. Lowflow	=	6.610	(1.64 %MAR)
Drought Lowflow	=	1.793	(0.45 %MAR)
Maint. Highflow	=	61.819	(15.37 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	3.852	1.138	0.110	0.150	0.053	0.000	0.150
Nov	5.306	3.283	0.239	0.220	0.055	1.050	1.270
Dec	10.836	12.387	0.427	0.250	0.058	1.370	1.620
Jan	23.690	35.619	0.561	0.270	0.060	1.370	1.640
Feb	39.171	50.697	0.535	0.280	0.065	14.591	14.871
Mar	28.118	32.115	0.426	0.270	0.063	5.129	5.399
Apr	15.018	12.132	0.312	0.260	0.060	1.050	1.310
May	8.240	3.081	0.140	0.230	0.057	0.000	0.230
Jun	6.580	1.695	0.099	0.190	0.055	0.000	0.190
Jul	5.388	1.273	0.088	0.160	0.054	0.000	0.160
Aug	4.626	1.047	0.085	0.130	0.053	0.000	0.130
Sep	4.152	0.973	0.090	0.110	0.050	0.000	0.110

5. SITE 5: KLEIN LETABA

5.1 CATEGORY D

Desktop Version 2, Printed on 14/11/2005
Summary of EWR estimate for: EWR5 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	95.013
S.Dev.	=	111.192
CV	=	1.170
Q75	=	1.580
Q75/MMF	=	0.200
BFI Index	=	0.368
CV(JJA+JFM) Index	=	2.657

PES = D

Total EWR	=	18.071	(19.02 %MAR)
Maint. Lowflow	=	3.141	(3.31 %MAR)
Drought Lowflow	=	0.377	(0.40 %MAR)
Maint. Highflow	=	14.930	(15.71 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Foothill

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	0.692	0.605	0.327	0.050	0.009	0.000	0.050
Nov	1.277	1.650	0.498	0.090	0.010	0.373	0.463
Dec	2.907	4.917	0.632	0.120	0.012	1.084	1.204
Jan	10.242	25.289	0.922	0.150	0.016	0.361	0.511
Feb	9.119	16.168	0.733	0.170	0.018	0.771	0.941
Mar	6.362	16.250	0.954	0.160	0.017	2.710	2.870
Apr	1.829	2.240	0.472	0.140	0.014	0.373	0.513
May	1.039	0.465	0.167	0.100	0.012	0.000	0.100
Jun	0.912	0.385	0.163	0.070	0.011	0.000	0.070
Jul	0.787	0.305	0.145	0.060	0.010	0.000	0.060
Aug	0.699	0.255	0.136	0.050	0.009	0.000	0.050
Sep	0.643	0.236	0.142	0.040	0.006	0.000	0.040

Category C

Desktop Version 2, Printed on 14/11/2005
Summary of EWR estimate for: EWR5 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	95.013
S.Dev.	=	111.192
CV	=	1.170
Q75	=	1.580
Q75/MMF	=	0.200
BFI Index	=	0.368
CV(JJA+JFM) Index	=	2.657

PES = C

Total EWR	=	30.662 (32.27 %MAR)
Maint. Lowflow	=	8.053 (8.48 %MAR)
Drought Lowflow	=	0.343 (0.36 %MAR)
Maint. Highflow	=	22.609 (23.80 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Foothill

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	0.692	0.605	0.327	0.180	0.008	0.000	0.180
Nov	1.277	1.650	0.498	0.200	0.010	1.120	1.320
Dec	2.907	4.917	0.632	0.300	0.012	0.361	0.661
Jan	10.242	25.289	0.922	0.320	0.014	0.361	0.681
Feb	9.119	16.168	0.733	0.350	0.017	1.200	1.550
Mar	6.362	16.250	0.954	0.330	0.015	4.467	4.797
Apr	1.829	2.240	0.472	0.300	0.012	1.120	1.420
May	1.039	0.465	0.167	0.280	0.011	0.000	0.280
Jun	0.912	0.385	0.163	0.250	0.010	0.000	0.250
Jul	0.787	0.305	0.145	0.220	0.009	0.000	0.220
Aug	0.699	0.255	0.136	0.180	0.008	0.000	0.180
Sep	0.643	0.236	0.142	0.160	0.005	0.000	0.160

6. SITE 6: LONELY BULL

Category D

Desktop Version 2, Printed on 16/11/2004
Summary of EWR estimate for: EWR6 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	546.593
S.Dev.	=	449.417
CV	=	0.822
Q75	=	13.730
Q75/MMF	=	0.301
BFI Index	=	0.431
CV(JJA+JFM) Index	=	1.780

PES = D

Total EWR	=	43.448	(7.95 %MAR)
Maint. Lowflow	=	5.087	(0.93 %MAR)
Drought Lowflow	=	2.320	(0.42 %MAR)
Maint. Highflow	=	38.362	(7.02 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	4.643	1.631	0.131	0.125	0.016	1.016	1.141
Nov	6.970	5.175	0.286	0.134	0.050	1.050	1.184
Dec	16.104	21.119	0.490	0.160	0.100	0.000	0.160
Jan	39.445	78.038	0.739	0.180	0.150	1.016	1.196
Feb	54.613	70.225	0.532	0.200	0.200	11.357	11.557
Mar	37.586	51.559	0.512	0.185	0.150	1.016	1.201
Apr	17.741	16.525	0.359	0.180	0.100	0.000	0.180
May	9.408	3.400	0.135	0.175	0.035	0.000	0.175
Jun	7.567	1.913	0.098	0.170	0.030	0.000	0.170
Jul	6.236	1.439	0.086	0.162	0.024	0.000	0.162
Aug	5.375	1.185	0.082	0.147	0.019	0.000	0.147
Sep	4.869	1.160	0.092	0.120	0.018	0.000	0.120

Category C

Desktop Version 2, Printed on 16/11/2004
Summary of EWR estimate for: EWR6 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	546.593
S.Dev.	=	449.417
CV	=	0.822
Q75	=	13.730
Q75/MMF	=	0.301
BFI Index	=	0.431
CV(JJA+JFM) Index	=	1.780

REC = C

Total EWR	=	54.854 (10.04 %MAR)
Maint. Lowflow	=	11.874 (2.17 %MAR)
Drought Lowflow	=	5.103 (0.93 %MAR)
Maint. Highflow	=	42.981 (7.86 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	4.643	1.631	0.131	0.250	0.010	1.016	1.266
Nov	6.970	5.175	0.286	0.300	0.050	1.050	1.350
Dec	16.104	21.119	0.490	0.400	0.100	1.370	1.770
Jan	39.445	78.038	0.739	0.500	0.150	1.016	1.516
Feb	54.613	70.225	0.532	0.550	0.200	11.357	11.907
Mar	37.586	51.559	0.512	0.500	0.170	0.000	0.500
Apr	17.741	16.525	0.359	0.450	0.140	1.416	1.866
May	9.408	3.400	0.135	0.400	0.120	0.000	0.400
Jun	7.567	1.913	0.098	0.350	0.900	0.000	0.350
Jul	6.236	1.439	0.086	0.300	0.065	0.000	0.300
Aug	5.375	1.185	0.082	0.280	0.045	0.000	0.280
Sep	4.869	1.160	0.092	0.250	0.010	0.000	0.250

Category B

Desktop Version 2, Printed on 16/11/2004
Summary of EWR estimate for: EWR6 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	546.593
S.Dev.	=	449.417
CV	=	0.822
Q75	=	13.730
Q75/MMF	=	0.301
BFI Index	=	0.431
CV(JJA+JFM) Index	=	1.780

PES = B

Total EWR	=	72.034	(13.18 %MAR)
Maint. Lowflow	=	26.332	(4.82 %MAR)
Drought Lowflow	=	3.095	(0.57 %MAR)
Maint. Highflow	=	45.702	(8.36 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	4.643	1.631	0.131	0.200	0.010	1.016	1.216
Nov	6.970	5.175	0.286	0.600	0.050	1.050	1.650
Dec	16.104	21.119	0.490	0.800	0.100	1.370	2.170
Jan	39.445	78.038	0.739	1.400	0.150	1.016	2.416
Feb	54.613	70.225	0.532	1.500	0.200	11.357	12.857
Mar	37.586	51.559	0.512	1.450	0.170	1.016	2.466
Apr	17.741	16.525	0.359	1.200	0.150	1.416	2.616
May	9.408	3.400	0.135	0.950	0.120	0.000	0.950
Jun	7.567	1.913	0.098	0.850	0.100	0.000	0.850
Jul	6.236	1.439	0.086	0.520	0.070	0.000	0.520
Aug	5.375	1.185	0.082	0.350	0.055	0.000	0.350
Sep	4.869	1.160	0.092	0.250	0.010	0.000	0.250

7. SITE 7: LETABA BRIDGE

Category B

Desktop Version 2, Printed on 09/09/2005
Summary of EWR estimate for: EWR7 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	561.668
S.Dev.	=	472.698
CV	=	0.842
Q75	=	13.760
Q75/MMF	=	0.294
BFI Index	=	0.425
CV(JJA+JFM) Index	=	1.817

PES = B

Total EWR	=	98.324 (17.51 %MAR)
Maint. Lowflow	=	52.622 (9.37 %MAR)
Drought Lowflow	=	0.906 (0.16 %MAR)
Maint. Highflow	=	45.702 (8.14 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	4.658	1.659	0.133	1.500	0.006	1.016	2.516
Nov	7.066	5.311	0.290	1.600	0.020	1.050	2.650
Dec	16.750	22.688	0.506	1.650	0.030	1.370	3.020
Jan	41.255	84.665	0.766	1.750	0.045	1.016	2.766
Feb	56.925	74.680	0.542	2.000	0.050	11.357	13.357
Mar	38.419	53.134	0.516	1.800	0.045	1.016	2.816
Apr	17.872	16.897	0.365	1.750	0.040	1.416	3.166
May	9.415	3.416	0.135	1.700	0.035	0.000	1.700
Jun	7.567	1.913	0.098	1.650	0.030	0.000	1.650
Jul	6.236	1.439	0.086	1.600	0.025	0.000	1.600
Aug	5.375	1.185	0.082	1.550	0.015	0.000	1.550
Sep	4.878	1.187	0.094	1.500	0.005	0.000	1.500

Category D

Desktop Version 2, Printed on 09/09/2005
Summary of EWR estimate for: EWR7 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	561.668
S.Dev.	=	472.698
CV	=	0.842
Q75	=	13.760
Q75/MMF	=	0.294
BFI Index	=	0.425
CV(JJA+JFM) Index	=	1.817

PES = D

Total EWR	=	46.596	(8.30 %MAR)
Maint. Lowflow	=	8.235	(1.47 %MAR)
Drought Lowflow	=	1.199	(0.21 %MAR)
Maint. Highflow	=	38.362	(6.83 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	4.658	1.659	0.133	0.200	0.005	1.016	1.216
Nov	7.066	5.311	0.290	0.250	0.040	1.050	1.300
Dec	16.750	22.688	0.506	0.270	0.050	0.000	0.270
Jan	41.255	84.665	0.766	0.300	0.055	1.016	1.316
Feb	56.925	74.680	0.542	0.350	0.060	11.357	11.707
Mar	38.419	53.134	0.516	0.310	0.058	1.016	1.326
Apr	17.872	16.897	0.365	0.280	0.055	0.000	0.280
May	9.415	3.416	0.135	0.270	0.050	0.000	0.270
Jun	7.567	1.913	0.098	0.250	0.040	0.000	0.250
Jul	6.236	1.439	0.086	0.240	0.030	0.000	0.240
Aug	5.375	1.185	0.082	0.220	0.010	0.000	0.220
Sep	4.878	1.187	0.094	0.200	0.005	0.000	0.200

Category C

Desktop Version 2, Printed on 09/09/2005
Summary of EWR estimate for: EWR7 Virgin
Determination based on defined BBM Table with site specific assurance rules.

Annual Flows (Mill. cu. m or index values):

MAR	=	561.668
S.Dev.	=	472.698
CV	=	0.842
Q75	=	13.760
Q75/MMF	=	0.294
BFI Index	=	0.425
CV(JJA+JFM) Index	=	1.817

PES = C

Total EWR	=	61.144 (10.89 %MAR)
Maint. Lowflow	=	18.163 (3.23 %MAR)
Drought Lowflow	=	0.500 (0.09 %MAR)
Maint. Highflow	=	42.981 (7.65 %MAR)

Monthly Distributions (cu.m./s)
Distribution Type : E.Escarp

Month	Natural Flows			Modified Flows (EWR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	4.658	1.659	0.133	0.370	0.005	1.016	1.386
Nov	7.066	5.311	0.290	0.500	0.010	1.050	1.550
Dec	16.750	22.688	0.506	0.600	0.015	1.370	1.970
Jan	41.255	84.665	0.766	0.700	0.020	1.016	1.716
Feb	56.925	74.680	0.542	0.950	0.025	11.357	12.307
Mar	38.419	53.134	0.516	0.800	0.023	0.000	0.800
Apr	17.872	16.897	0.365	0.650	0.021	1.416	2.066
May	9.415	3.416	0.135	0.580	0.020	0.000	0.580
Jun	7.567	1.913	0.098	0.550	0.019	0.000	0.550
Jul	6.236	1.439	0.086	0.470	0.018	0.000	0.470
Aug	5.375	1.185	0.082	0.400	0.010	0.000	0.400
Sep	4.878	1.187	0.094	0.370	0.005	0.000	0.370

APPENDIX L:
ENNVIRONMENTAL FLOW AND LONG TERMS MEANS AS PERCENTAGE OF MAR

		IFR as % of MAR			Long term mean as % of Virgin MAR			
Site	**Category**	**Total**	**Maint.**	**Drought**	**Low Flow**		**Total Flow**	
		% MAR	% MAR	% MAR	mcm	% MAR	mcm	% MAR
1	C	26.22%	10.47%	4.39%	8.413	11.73%	19.755	27.56%
	D	14.55%	4.99%	4.38%	6.515	9.09%	14.276	19.91%
2	D	43.22%	32.06%	4.32%	25.477	29.60%	33.371	38.78%
3	C	16.00%	3.73%	0.41%	14.558	3.99%	61.294	16.82%
	C/D	13.07%	1.29%	0.23%	5.997	1.65%	51.569	14.15%
	D	4.78%	0.68%	0.23%	3.904	1.07%	20.161	5.53%
4	C	31.52%	5.22%	0.83%	29.120	7.24%	135.097	33.58%
	C/D	18.66%	2.82%	0.44%	17.544	4.36%	83.499	20.76%
	D	17.01%	1.64%	0.45%	11.604	2.88%	76.270	18.96%
5	C	32.27%	8.48%	0.36%	6.890	7.25%	23.063	24.27%
	D	19.02%	3.31%	0.40%	3.627	3.82%	16.801	17.68%
6	B	13.18%	4.82%	0.57%	26.504	4.85%	72.609	13.28%
	C	10.04%	2.17%	0.93%	14.549	2.66%	58.680	10.74%
	D	7.95%	0.93%	0.42%	8.542	1.56%	50.090	9.16%
7	B	17.51%	9.37%	0.16%	47.376	8.43%	93.511	16.65%
	C	10.89%	3.23%	0.09%	19.085	3.40%	63.246	11.26%
	D	8.30%	1.47%	0.21%	12.595	2.24%	54.173	9.65%

Used C as D EC to fit reqmts curve