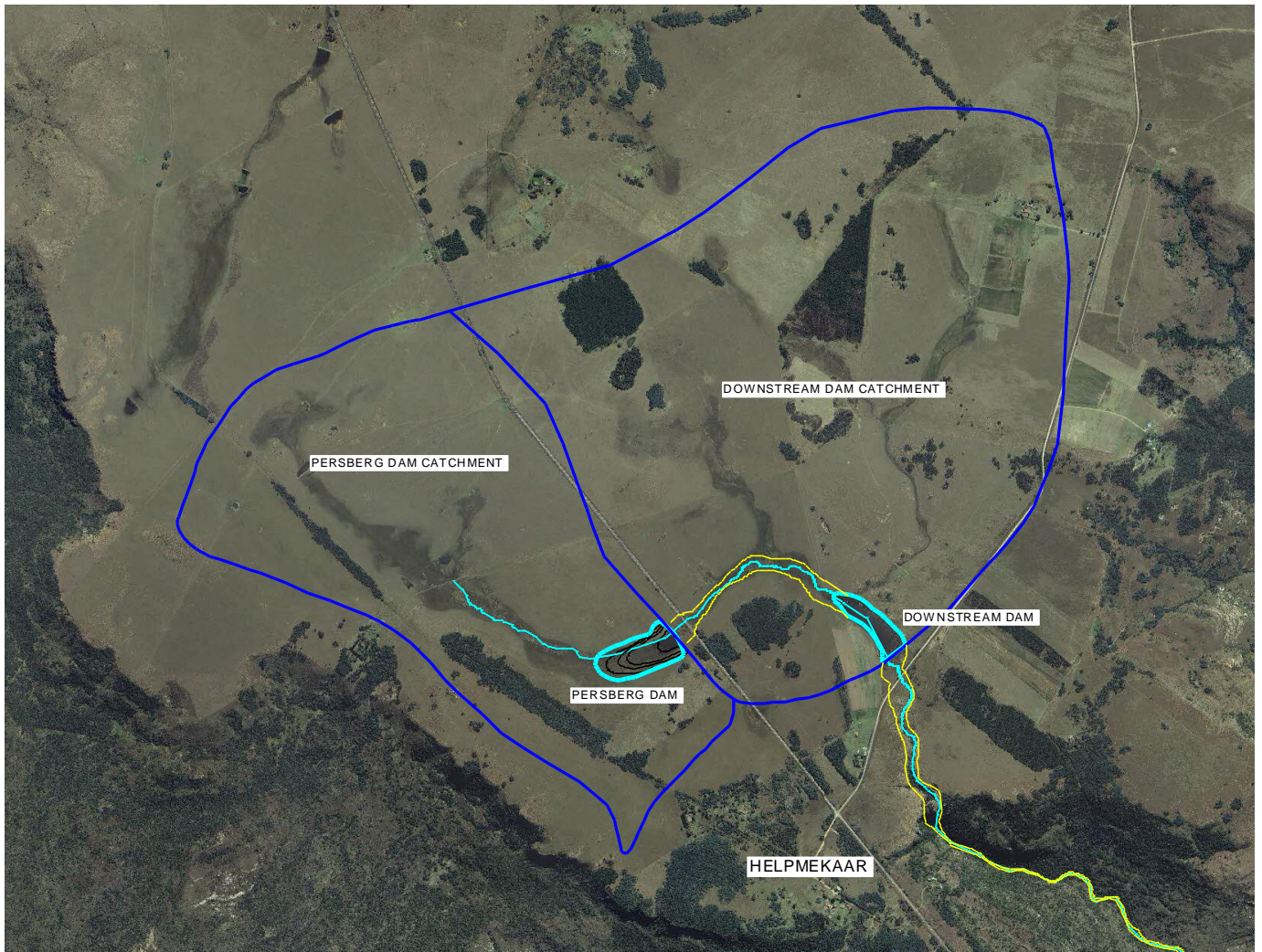


PERSBERG FARM DAM NEAR HELPMEKAAR
RESERVE DETERMINATION FOR WATER USE LICENSE APPLICATION
14 AUGUST 2018



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PERSBERG FARM DAM

RESERVE DETERMINATION FOR WATER USE LICENSE APPLICATION

14 AUGUST 2018

CONTENTS

1. QUALITY MANAGEMENT AND APPROVALS.....3

2. INTRODUCTION AND GENERAL PARTICULARS.....6

3. GENERAL CLIMATOLOGICAL DATA.....7

4. RESERVE REQUIREMENT 10

4.1. ENVIRONMENTAL WATER REQUIREMENTS 10

4.2. STOCK AND DOMESTIC WATER REQUIREMENTS..... 19

4.3. TOTAL RESERVE REQUIREMENT..... 19

5. ANNEXURE.....20

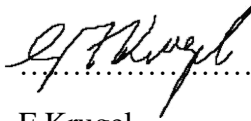
5.1. RESERVE REQUIREMENT: AFFECTED AREA LAYOUT PLAN- G 2018/06/01/01... 20

PERSBERG FARM DAM NEAR HELPMEKAAR
RESERVE DETERMINATION FOR WATER USE LICENSE APPLICATION
14 AUGUST 2018

1. QUALITY MANAGEMENT AND APPROVALS

STATUS OF REPORT: FINAL
RELATED REPORTS: DRAFT 7 AUGUST 2018
HYDROLOGY REPORT 28 MAY 2016

Approved by GFK Consulting Engineers cc


.....
F.Krugel

14/08/2018.....
Date

Accepted and Approved by the Employer

.....
Employer

.....
Date

..... (Print name)

PERSBERG FARM DAM NEAR HELPMEKAAR
RESERVE DETERMINATION FOR WATER USE LICENSE APPLICATION
14 AUGUST 2018

EXECUTIVE SUMMARY

The dam will have a positive impact on at least the drought low flow environmental water requirement as water is only flowing into the dam at irregular intervals. With the dam in place, there will be a constant stream from normal leak water intercepted by a toe drain for embankment safety, regardless of inflow into the dam, unless the dam is obviously pumped dry frequently, which is unlikely as the outlet pipe is not installed at the lowest point of the dam. In other words, there will be unusable storage capacity in the dam, which will at least provide leak water, basically at all times. Additional to the normal leak water, controlled environmental releases through the outlet valve, will improve the situation even more during dry periods. At the worst, the dam will not negatively impact on the downstream water requirement, providing the required water is released, either through leak water or a combination of leak water and releases through the outlet valve. As the required amount to be released is insignificant related to what will be required for planned future irrigation, depending on receipt of a Water Use Licence, it will be more than viable to release the required downstream demand.

Drought flow: The release requirement, including leak water, is indicated in the table below for drought low flow environmental demand conditions.

Month	Environmental Drought (litre/h)	Livestock (Litre/h)	Domestic (litre/h)	Total flows (l/h)
Oct	783	146	35	964
Nov	946	146	35	1127
Dec	718	146	35	899
Jan	1664	146	35	1845
Feb	1794	146	35	1975
Mar	1696	146	35	1877
Apr	1305	146	35	1486
May	913	146	35	1094
Jun	652	146	35	833
Jul	587	146	35	768
Aug	587	146	35	768
Sep	685	146	35	866
Average	1028	146	35	1209

The requirement for maintenance low flow environmental demand is more than for the drought flow demand, refer to the table on the following page.

Maintenance flow: The release requirement, including leak water, is indicated in the table below for maintenance low flow conditions.

Month	Environmental Maintenance (litre/h)	Livestock (Litre/h)	Domestic (litre/h)	Total flows (l/h)
Oct	3099	146	35	3280
Nov	3914	146	35	4095
Dec	5676	146	35	5857
Jan	7013	146	35	7194
Feb	7568	146	35	7749
Mar	7176	146	35	7357
Apr	5382	146	35	5563
May	3556	146	35	3737
Jun	2479	146	35	2660
Jul	2153	146	35	2334
Aug	2153	146	35	2334
Sep	2642	146	35	2823
Average	4401	146	35	4582

A 300 mm PVC pipe is installed at the bottom of the embankment. This existing outlet pipe and valve is more than adequately sized to release the required downstream maintenance Environmental Water Requirement, as well as downstream domestic and livestock requirement, for the affected area.

The mean monthly spills from the dam through the spillway will automatically release more than the required high flow Environmental Water Requirements, with no additional releases required by opening the outlet valve, else than for maintenance flow as required.

It is recommended that a measuring weir is constructed downstream of the dam, to measure the required maintenance flow to be released. This weir will also measure the leak water. The total maintenance flow required is the total flow from leak water and water released by opening of the outlet valve, combined. Thus, the release amount required from the dam, is the additional amount required, if any, over and above the leak water, to satisfy the total maintenance release required. The high flow requirement will automatically be met by spills over the spillways, as the dam volume only comprise a small fraction of the total catchment runoff.

Regardless whether there is very seldom visible normal flow in the natural drain into the dam, it is still recommended to construct an upstream measuring weir to measure the flow during such seldom normal flow conditions. Only a maximum of the incoming flow needs to be released to satisfy the downstream requirement.

The owner of this Persberg farm dam, is only responsible for the release from this dam. It was not determined how much water is actually being released from the downstream dam, by its owner, but it can be argued that the same requirements are applicable.

2. INTRODUCTION AND GENERAL PARTICULARS

General:

GFK Consulting Engineers were appointed by Mr Erich Müller to undertake a Desktop Reserve Determination for the recently raised dam on the farm Persberg, for water use licencing purposes. GFK only become involved when the dam was already completed/raised.

The embankment of the present dam is constructed on top of a dam embankment that was constructed in the 1960's to provide water needed for road construction. A new cut off trench was constructed and all unsuitable material removed from the existing embankment and new footprint, for the present embankment. The old embankment was approximately 4 m high according to Mr. Müller and apparently held water till just before construction when water was released from the dam for construction purposes of the new higher embankment. The previous spillway size was only a fraction of the present one but surprisingly very little erosion took place downstream of the old spillway indicating that the soil does not erode easily.

Owner and person who is in control of the dam:

Erich Müller (Montrose Farming Trust)

P O Box 479

Dundee

Tel: 082 443 8049

Email: erich@dundeekzn.co.za

Dam location:

Lat: 28° 26' 01" Long: 30° 24' 39", indicated on Figure 1.

Umzinyathi District Municipality, KwaZulu Natal

Endumeni (Dundee) Local Municipality

Nearest town: Dundee, 37km north of dam

Purpose of the dam, catchment size and capacity:

The main purpose of the dam is to supply water for irrigation and livestock. The dam catchment size is 3.5km², the full supply area 8ha and the gross volumes approximately 152 000m³.

Construction materials:

Earth fill embankment, incorporating a rubble toe drain and a 300mm PVC outlet pipe with outlet valve on the downstream side, with grass lined by-wash spillways on either side of the embankment,

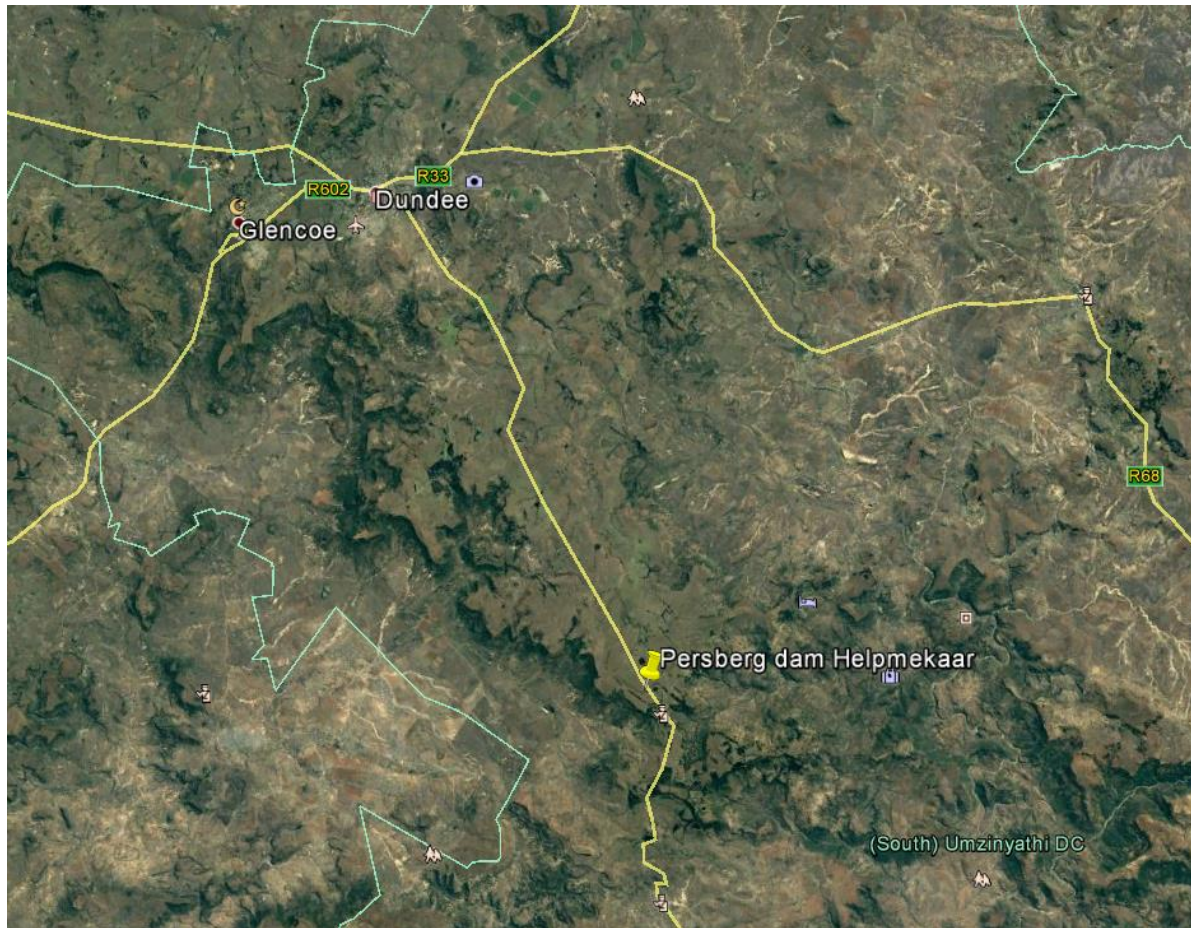


Figure 1: Persberg dam location

3. GENERAL CLIMATOLOGICAL DATA.

The site lies within quaternary catchment number V33B. The dam is situated in the upper most corner of the quaternary catchment. The dam catchment area only comprises 0.86% of the total quaternary catchment area.

Quaternary catchment details extracted from WR 2012 are as follows:

Table 1: Quaternary Catchment Details

Quaternary Catchment	Catchment Area		Forestry	Alien Vegetation	Irrigation	Rainfall		S Pan	MAR
	Gross (km ²)	Net (km ²)	Area (km ²)	Area (km ²)	Area (km ²)	Zone	MAP (mm)	(mm)	Net (mcm)
V33B	407	407	0	1	0.09	V3D	736	1500	24.61

Climatological data from rainfall station 335746W was used to determine the mean annual precipitation used for the analysis, namely 736mm. This station lies approximately 3 km south of the site. The monthly Symons Pan evaporation was obtained from station W2E004 and adjusted using the MAE of the quaternary catchment as published by the Water Research Commission (WRC). Station W2E004 is situated at Klipfontein dam just south of Vryheid. The A-Pan evaporation was determined from the SA Atlas isohyets at the site of the dam.

The evaporation and rainfall indicated in Table 2, 3 and 4 are as follows:

Table 2: Evaporation

Evaporation (mm)	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Symons Pan	141	149	158	153	131	127	104	95	83	94	123	142	1500
A-Pan	164	166	194	187	157	146	125	108	94	104	140	159	1744

Table 3: Monthly evaporation (mm) station for W2E004 adjusted for local Mean Annual Evaporation.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1985	169	158	139	130	93	93	97	142	139	151	182	149	1641
1986	153	48	149	104	101	95	104	140	155	155	152	177	1533
1987	184	162	141	114	129	91	113	122	104	129	127	170	1585
1988	167	156	140	123	101	90	100	126	126	140	153	147	1569
1989	155	102	141	106	92	78	102	144	170	166	138	169	1563
1990	167	146	134	110	92	94	95	119	140	143	193	163	1595
1991	151	131	113	137	106	78	102	142	143	151	170	173	1597
1992	169	174	150	135	134	113	107	141	161	198	185	192	1858
1993	189	118	129	119	110	89	105	124	150	131	152	165	1581
1994	154	139	138	101	94	107	106	120	158	156	168	188	1629
1995	194	173	138	113	89	84	112	144	168	152	152	160	1679
1996	147	126	126	103	68	95	82	119	201	165	171	194	1596
1997	169	155	106	116	90	104	87	135	129	129	152	146	1519
1998	154	144	142	105	119	102	96	126	150	140	147	162	1585
1999	176	147	152	126	102	94	101	127	130	127	147	123	1552
2000	110	94	106	79	70	59	88	108	140	110	117	140	1223
2001	152	111	126	82	80	70	73	110	129	118	118	140	1308
2002	159	111	129	102	94	69	89	82	116	140	145	136	1371
2003	153	132	148	103	86	54	82	128	114	164	134	174	1471
2004	130	107	84	87	80	68	69	101	111	153	162	153	1306
2005	138	122	118	85	93	84	87	113	146	136	155	156	1433
2006	124	112	97	85	89	64	93	105	118	132	132	179	1331
2007	168	164	137	97	107	75	108	125	149	109	135	147	1521
2008	128	145	122	85	71	57	96	123	144	145	142	161	1418
2009	137	110	112	94	81	70	76	105	118	112	114	153	1282
2010	125	130	128	84	100	70	75	116	167	139	137	158	1429
2011	153	131	127	105	95	78	94	123	142	141	149	158	1496
2012	153	131	127	104	95	87	94	123	142	141	149	139	1485
2013	128	119	102	102	102	97	83	139	148	138	163	115	1435
2014	147	135	110	92	92	98	95	118	173	125	126	145	1457
2015	148	129	120	99	98	82	89	122	120	141	149	158	1455
Average	153	131	127	104	95	83	94	123	142	141	149	158	1500

Patched data

Table 4: Monthly rainfall data (mm) for rainfall station 335746

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1920	101	142	165	89	173	79	11	14	0	0	0	67	841
1921	55	71	247	159	118	62	4	41	45	9	82	32	926
1922	126	167	136	91	97	13	5	0	11	9	12	0	666
1923	45	104	94	174	160	87	36	21	0	0	16	46	782
1924	70	129	137	159	141	80	53	6	1	9	0	65	850
1925	92	75	123	126	50	59	19	25	55	0	0	75	698
1926	137	150	128	97	181	86	2	0	0	18	20	22	839
1927	99	78	167	183	65	70	11	27	0	0	13	64	776
1928	72	26	58	60	66	163	21	4	37	28	15	102	651
1929	21	139	98	97	58	79	60	0	0	5	12	28	597
1930	40	22	193	119	59	37	8	0	0	7	0	0	485
1931	90	42	30	70	284	112	0	46	11	5	0	17	706
1932	14	99	140	78	108	55	24	0	0	32	0	2	552
1933	45	186	169	260	139	69	12	47	0	52	50	0	1029
1934	59	153	182	93	82	66	89	11	9	0	1	22	766
1935	18	52	155	143	150	121	5	112	3	1	0	27	785
1936	78	248	64	210	137	124	11	0	7	0	0	26	905
1937	27	35	288	128	124	22	7	0	74	67	8	24	804
1938	113	41	173	78	148	55	0	44	0	40	6	59	755
1939	37	207	239	102	66	73	0	15	64	0	0	79	882
1940	25	86	298	164	133	27	128	0	0	6	0	21	888
1941	17	62	98	205	137	81	20	21	19	0	27	57	745
1942	69	146	159	158	77	94	128	69	7	85	128	10	1131
1943	194	126	143	152	144	53	0	3	61	0	0	116	993
1944	78	48	96	107	61	185	11	15	0	0	0	6	606
1945	11	35	8	106	22	49	0	0	0	1	0	3	234
1946	130	129	40	36	85	70	28	0	42	0	4	33	597
1947	62	192	134	143	124	101	64	0	0	0	0	34	853
1948	122	156	147	188	198	116	96	1	9	4	0	41	1077
1949	82	135	148	72	36	95	43	29	0	0	21	9	670
1950	79	150	114	61	69	181	33	18	9	0	110	42	866
1951	76	6	151	218	40	55	41	11	4	46	6	3	656
1952	58	124	153	158	256	64	51	0	6	0	61	30	958
1953	24	123	55	73	148	138	27	61	14	2	0	54	720
1954	162	203	126	252	162	74	30	4	0	0	0	5	1016
1955	71	103	68	29	180	120	0	41	0	0	3	35	650
1956	45	209	272	127	56	41	87	0	12	77	38	158	1122
1957	114	54	31	114	52	44	126	0	0	0	0	20	555
1958	85	114	89	67	136	26	25	40	0	28	9	23	643
1967	68	139	172	119	31	91	12	14	0	0	50	18	711
1968	29	76	143	101	125	239	70	27	8	25	0	14	854
1969	123	30	152	141	144	49	19	0	4	14	121	82	878
1970	85	67	58	117	59	71	46	112	0	25	54	14	707
1971	157	101	172	167	113	107	20	53	12	10	17	3	929
1972	94	112	89	97	210	40	83	7	0	0	53	60	843
1973	9	122	30	191	17	53	55	6	24	0	21	5	532
1974	20	121	59	88	104	12	66	0	0	0	8	84	559
1975	14	80	110	105	116	88	14	48	0	1	0	18	593
1976	108	31	55	182	51	107	11	0	0	0	9	92	644
1977	99	50	118	332	84	65	0	0	0	0	0	64	813
Average	73	106	129	132	111	81	34	20	11	12	19	38	767

4. RESERVE REQUIREMENT

4.1. ENVIRONMENTAL WATER REQUIREMENTS

The Desktop Environmental Status (ERC) for catchment V33B in which the dam is situated is B. Refer to Figure 10. The environmental flows required are indicated in Table 3 below. These parameters are obtained from SPATSIM.

Table 3: Desktop Environmental flows required at dam (%MAR)

Estimation of IFR components (Generic Data)

File Output Set IFR Rules Return

Select Monthly Distribution Type

Manual Adjustment

Drought Lows Drought Dist. 0.65

Maint. Lows Maint. Dist. 0.81

Maint. Highs

Display Units

%MAR

MCM

M³/s

BFI = 0.33 : T0 = 0.0 : Index = 10.6

Total IFR as %MAR = 29.90

Maint. Lowflow IFR as %MAR = 16.18

Drought Lowflow IFR as %MAR = 3.78

Month	Low Flows (%MAR)		High flows (%MAR)
	Maint.	Drought	Maintenance
Oct	0.95	0.24	0.84
Nov	1.20	0.29	1.33
Dec	1.74	0.22	1.24
Jan	2.15	0.51	5.78
Feb	2.32	0.55	2.47
Mar	2.20	0.52	1.67
Apr	1.65	0.40	0.39
May	1.09	0.28	0.00
Jun	0.76	0.20	0.00
Jul	0.66	0.18	0.00
Aug	0.66	0.18	0.00
Sep	0.81	0.21	0.00

Final ERC

A C

A/B C/D

B D

B/C

Parameter Source

Site Specific (SPATSIM)

Default National Data

Defined IFR Table

Percentages (%)													
	Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Low flows (%MAR)	Maintenance	0.95	1.2	1.74	2.15	2.32	2.2	1.65	1.09	0.76	0.66	0.66	0.81
	Drought	0.24	0.29	0.22	0.51	0.55	0.52	0.4	0.28	0.2	0.18	0.18	0.21
High Flows (%MAR)	Maintenance	0.84	1.33	1.24	5.78	2.47	1.67	0.39	0	0	0	0	0

There is an existing 300mm diameter PVC outlet pipe constructed in the dam wall. This outlet pipe has a capacity of approximately 85 litre/sec. This is more than enough capacity for the releases required, refer to Table 5: Average monthly environmental release requirements (l/h) .

The storage capacity of the dam of 152 000m³, is only 0.62% of the total quaternary catchment run-off, thus, there will be significant spills to satisfy the high flow requirement. The average monthly projected spills from this dam are indicated in Table 4 below. The spills were obtained from a WRSM 2000 (Pitman model) analysis which considers the inflows and outflows from the dam, including the irrigation water volumes. The spills are obtained after the irrigation demands from this dam are met. From Table 4 it can be seen that the maximum average annual spill is as high as 13 l/s. This is higher than the required total IFR release of 5.4.1 l/s. It is therefore clear that no additional high flow water requirement needs to be released from the dam, other than what will automatically spill over the spillways (15m wide on each side, thus 30 m wide in total)

A downstream measuring weir is required to determine if the release requirements are met.

Table 4: Average monthly outflows from dam over spillway from WRSM 2000 (l/h)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Average monthly spills (l/h)	9322	17197	32144	44198	48859	41466	16393	4179	1286	1286	2572	9161	19005

Table 5: Average monthly environmental release requirements (l/h)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Low flows (l/h)	Maintenance	3099	3914	5676	7013	7568	7176	5382	3556	2479	2153	2642	4401
	Drought	783	946	718	1664	1794	1696	1305	913	652	587	587	685
High Flows (l/h)	Maintenance	2740	4338	4045	18854	8057	5448	1272	0	0	0	0	3730

The average monthly spills over the spillway is significantly more than the required high flow environmental demand.

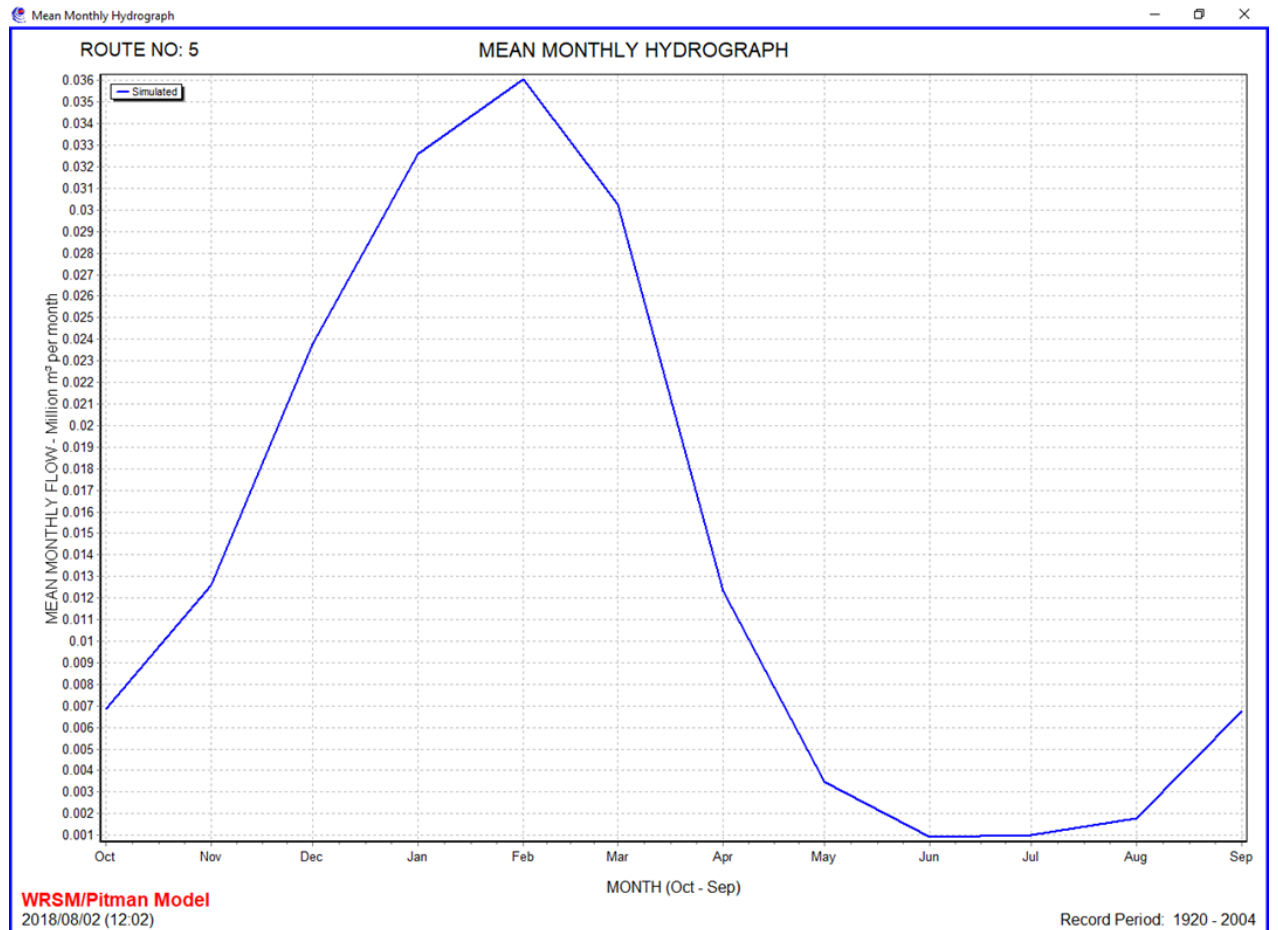


Figure 2: Mean monthly dam spillway flows (Million m³)

Table 6: Monthly Environmental Maintenance Low flow in litres/hour.

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Average
1920	2623	3555	14238	6634	10797	6235	1939	760	437	323	266	1084	4074
1921	1635	3688	46307	19028	4429	2566	950	570	1198	1331	2604	2547	7238
1922	4201	11139	7946	4201	3365	1692	456	171	209	323	380	266	2862
1923	247	1065	3289	4182	5228	3707	1787	950	570	380	418	779	1884
1924	1597	9315	9619	15188	8364	118181	42087	2110	798	646	532	1217	17471
1925	2547	2072	1882	2205	1350	988	722	665	1331	1293	684	1787	1461
1926	8022	7052	3840	2110	3498	11120	4828	779	285	399	646	551	3594
1927	1007	1027	2414	14086	6216	1540	817	418	285	247	304	855	2435
1928	1483	912	494	513	798	3650	3213	1388	1065	1407	1084	1996	1500
1929	2319	3498	2984	3156	2756	2072	1540	874	437	342	437	779	1766
1930	1179	874	1616	4239	3194	1331	589	323	228	247	247	171	1186
1931	646	627	627	570	48379	20264	2775	1863	1616	988	513	513	6615
1932	456	684	2091	1464	1274	1065	608	342	228	494	551	323	798
1933	323	9676	13059	52047	19294	3631	2110	1293	893	950	1692	1255	8852
1934	1293	2984	27544	10854	2262	2205	2813	1996	969	570	361	285	4512
1935	247	380	893	3783	18040	8763	1996	2756	2566	1160	494	380	3455
1936	1027	15017	6482	3650	7490	5399	2205	684	323	323	266	304	3598
1937	361	741	14466	8136	7642	4201	2034	1141	1521	3156	2471	1027	3908
1938	2642	2604	14827	7699	27830	11387	1521	912	760	893	950	1179	6100
1939	1255	14542	9067	3612	1863	1426	1160	8611	7014	3270	1179	1692	4557
1940	1749	1711	25263	10721	2984	2965	4866	3308	1122	513	380	380	4664
1941	513	855	1521	29654	20454	8212	3346	1160	665	551	589	1084	5717
1942	1768	3745	27164	17622	5665	2718	12888	8345	3365	4106	32715	12793	11074
1943	22830	16842	6026	2585	3783	2737	1046	399	1160	1388	760	2224	5148
1944	3346	2129	2053	2870	2433	11120	5513	1350	608	380	304	228	2695
1945	209	152	114	1293	1198	1122	836	437	285	247	228	228	529
1946	2414	4315	2927	2053	3194	3517	2167	950	1065	1103	646	570	2077
1947	1084	13896	7186	2927	3460	4182	2946	1312	551	361	285	323	3209
1948	1768	2851	3232	16652	13497	6558	3821	1844	741	494	399	418	4356
1949	1863	2832	4695	3156	1578	1863	1616	1027	627	437	513	456	1722
1950	646	1540	4087	3022	1692	2167	1768	969	570	418	2604	3060	1879
1951	2281	950	2357	17489	7376	1616	1103	779	551	874	855	437	3056
1952	684	1635	3080	3935	53283	19599	1920	1007	532	399	855	874	7317
1953	608	2129	1939	1274	2471	3194	2129	1920	1559	874	494	988	1632
1954	7889	22431	8516	28932	21823	6900	2110	893	456	342	285	228	8401
1955	1217	2433	2642	1255	21728	10493	2091	893	646	437	342	513	3724
1956	1350	15455	53644	20473	3631	2053	2224	1540	741	1749	2433	32316	11467
1957	27849	7490	893	2224	2756	1749	3194	2509	950	418	304	342	4223
1958	1027	2186	2528	2737	9923	4771	1179	1179	1027	760	627	513	2371
1959	1597	2376	4467	3669	3194	3003	3003	1844	741	380	342	551	2097
1960	1350	3536	25035	9486	1863	2224	3003	2547	1483	779	437	684	4369
1961	988	1939	1445	1578	1692	2300	2129	1255	608	399	475	513	1277
1962	703	2129	9239	5075	1312	2110	2756	1654	1198	10208	5760	1274	3618
1963	1464	4239	2718	10265	4657	988	1084	874	722	722	589	836	2430
1964	9600	5798	2946	2262	2167	1141	418	304	1007	1464	1350	1255	2476
1965	1920	3422	2395	10379	6026	1749	722	627	551	437	551	589	2447
1966	589	817	1787	4258	16823	15892	6463	2015	722	475	437	323	4217
1967	1046	2794	2794	2148	1141	1255	969	494	304	266	627	665	1209
1968	475	1027	2091	1958	2015	24731	10911	2243	1046	665	494	399	4005
1969	2148	1825	2148	2737	4258	2870	1255	665	494	456	1711	2946	1960

1970	3479	2889	1597	1331	1369	1198	1388	3631	3060	1635	1426	988	1999
1971	3327	3764	5418	7908	6387	4486	2034	1122	950	722	551	361	3086
1972	969	2680	2547	2186	13554	6748	2832	1711	703	380	1217	1939	3122
1973	1312	2509	1863	13002	6292	2110	1730	1122	817	760	684	437	2720
1974	323	1958	4638	5418	4961	2642	1920	1369	665	380	323	2509	2259
1975	2376	1996	3194	4771	5266	8003	4581	2186	1217	627	399	399	2918
1976	2528	2547	2547	7262	4733	3707	2205	798	361	285	304	1007	2357
1977	2889	3022	1749	37448	15150	2224	1464	950	513	342	418	1007	5598
1978	16462	7566	1730	1540	3099	2110	798	418	323	684	1578	2338	3220
1979	1806	1217	1483	2319	1616	969	665	456	323	266	247	1141	1042
1980	1559	1673	2851	4847	3384	1122	418	361	741	893	912	1217	1665
1981	1007	2034	1426	2167	1825	2300	1730	741	361	418	418	646	1256
1982	3992	3650	2224	1673	893	703	665	494	361	532	798	589	1381
1983	874	15702	12489	80143	29008	4410	4182	2224	874	836	1445	1274	12788
1984	3289	3878	2642	2699	50051	18154	855	228	171	190	190	228	6881
1985	2338	3327	2813	55583	20321	4239	5133	2794	1122	684	456	380	8266
1986	703	1122	13668	9048	5817	7052	3764	1160	494	418	950	75809	10000
1987	29065	3783	2680	4410	6463	5304	2528	817	513	1046	1027	893	4877
1988	2414	2585	3783	2509	9543	4714	950	399	399	399	323	247	2356
1989	1122	34103	125746	76779	42391	24351	8668	2775	950	437	2585	2319	26852
Average	3142	4699	8539	10216	9204	6768	3059	1439	911	897	1296	2611	4398

Table 7: Virgin catchment run off (l/h)

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual Average
1920	16213	21970	87997	41003	66732	38536	11984	4699	2702	1997	1645	6697	25181
1921	10104	22792	286197	117604	27374	15861	5874	3525	7402	8224	16096	15743	44733
1922	25964	68847	49109	25964	20795	10456	2820	1057	1292	1997	2350	1645	17691
1923	1527	6579	20325	25847	32309	22910	11044	5874	3525	2350	2585	4817	11641
1924	9869	57568	59448	93872	51694	730413	260115	13041	4934	3995	3290	7519	107980
1925	15743	12806	11631	13628	8342	6109	4464	4112	8224	7989	4230	11044	9027
1926	49579	43587	23732	13041	21617	68730	29842	4817	1762	2467	3995	3407	22215
1927	6227	6344	14921	87057	38418	9516	5052	2585	1762	1527	1880	5287	15048
1928	9164	5639	3055	3172	4934	22557	19855	8577	6579	8694	6697	12336	9272
1929	14333	21617	18445	19503	17036	12806	9516	5404	2702	2115	2702	4817	10916
1930	7284	5404	9986	26199	19738	8224	3642	1997	1410	1527	1527	1057	7333
1931	3995	3877	3877	3525	299003	125240	17153	11514	9986	6109	3172	3172	40885
1932	2820	4230	12923	9046	7872	6579	3760	2115	1410	3055	3407	1997	4934
1933	1997	59801	80713	321678	119249	22440	13041	7989	5522	5874	10456	7754	54709
1934	7989	18445	170238	67085	13981	13628	17388	12336	5992	3525	2232	1762	27883
1935	1527	2350	5522	23380	111495	54161	12336	17036	15861	7167	3055	2350	21353
1936	6344	92814	40063	22557	46290	33366	13628	4230	1997	1997	1645	1880	22234
1937	2232	4582	89407	50284	47230	25964	12571	7049	9399	19503	15273	6344	24153
1938	16331	16096	91639	47582	172000	70374	9399	5639	4699	5522	5874	7284	37703
1939	7754	89877	56041	22322	11514	8811	7167	53221	43352	20208	7284	10456	28167
1940	10809	10574	156139	66262	18445	18328	30077	20443	6932	3172	2350	2350	28823
1941	3172	5287	9399	183279	126415	50754	20678	7167	4112	3407	3642	6697	35334
1942	10926	23145	167888	108910	35011	16801	79656	51577	20795	25377	202194	79068	68446
1943	141101	104093	37243	15978	23380	16918	6462	2467	7167	8577	4699	13746	31819
1944	20678	13158	12689	17740	15038	68730	34071	8342	3760	2350	1880	1410	16654
1945	1292	940	705	7989	7402	6932	5169	2702	1762	1527	1410	1410	3270
1946	14921	26669	18093	12689	19738	21735	13393	5874	6579	6814	3995	3525	12835
1947	6697	85883	44410	18093	21383	25847	18210	8107	3407	2232	1762	1997	19836
1948	10926	17623	19973	102918	83415	40533	23615	11396	4582	3055	2467	2585	26924
1949	11514	17505	29019	19503	9751	11514	9986	6344	3877	2702	3172	2820	10642
1950	3995	9516	25260	18680	10456	13393	10926	5992	3525	2585	16096	18915	11612
1951	14098	5874	14568	108087	45585	9986	6814	4817	3407	5404	5287	2702	18886
1952	4230	10104	19033	24320	329314	121128	11866	6227	3290	2467	5287	5404	45222
1953	3760	13158	11984	7872	15273	19738	13158	11866	9634	5404	3055	6109	10084
1954	48757	138634	52634	178814	134874	42648	13041	5522	2820	2115	1762	1410	51919
1955	7519	15038	16331	7754	134287	64852	12923	5522	3995	2702	2115	3172	23018
1956	8342	95516	331546	126533	22440	12689	13746	9516	4582	10809	15038	199727	70874
1957	172117	46290	5522	13746	17036	10809	19738	15508	5874	2585	1880	2115	26102
1958	6344	13511	15626	16918	61328	29489	7284	7284	6344	4699	3877	3172	14656
1959	9869	14686	27609	22675	19738	18563	18563	11396	4582	2350	2115	3407	12963
1960	8342	21852	154730	58626	11514	13746	18563	15743	9164	4817	2702	4230	27002
1961	6109	11984	8929	9751	10456	14216	13158	7754	3760	2467	2937	3172	7891
1962	4347	13158	57098	31369	8107	13041	17036	10221	7402	63090	35598	7872	22362
1963	9046	26199	16801	63443	28784	6109	6697	5404	4464	4464	3642	5169	15019
1964	59331	35833	18210	13981	13393	7049	2585	1880	6227	9046	8342	7754	15303
1965	11866	21148	14803	64148	37243	10809	4464	3877	3407	2702	3407	3642	15126
1966	3642	5052	11044	26317	103975	98219	39945	12454	4464	2937	2702	1997	26062
1967	6462	17270	17270	13276	7049	7754	5992	3055	1880	1645	3877	4112	7470
1968	2937	6344	12923	12101	12454	152850	67437	13863	6462	4112	3055	2467	24750
1969	13276	11279	13276	16918	26317	17740	7754	4112	3055	2820	10574	18210	12111

1970	21500	17858	9869	8224	8459	7402	8577	22440	18915	10104	8811	6109	12356
1971	20560	23262	33484	48874	39475	27727	12571	6932	5874	4464	3407	2232	19072
1972	5992	16566	15743	13511	83768	41708	17505	10574	4347	2350	7519	11984	19297
1973	8107	15508	11514	80361	38888	13041	10691	6932	5052	4699	4230	2702	16810
1974	1997	12101	28667	33484	30664	16331	11866	8459	4112	2350	1997	15508	13961
1975	14686	12336	19738	29489	32544	49462	28314	13511	7519	3877	2467	2467	18034
1976	15626	15743	15743	44880	29254	22910	13628	4934	2232	1762	1880	6227	14568
1977	17858	18680	10809	231448	93637	13746	9046	5874	3172	2115	2585	6227	34600
1978	101743	46760	10691	9516	19150	13041	4934	2585	1997	4230	9751	14451	19904
1979	11161	7519	9164	14333	9986	5992	4112	2820	1997	1645	1527	7049	6442
1980	9634	10339	17623	29959	20913	6932	2585	2232	4582	5522	5639	7519	10290
1981	6227	12571	8811	13393	11279	14216	10691	4582	2232	2585	2585	3995	7764
1982	24672	22557	13746	10339	5522	4347	4112	3055	2232	3290	4934	3642	8537
1983	5404	97044	77189	495322	179284	27257	25847	13746	5404	5169	8929	7872	79039
1984	20325	23967	16331	16683	309342	112199	5287	1410	1057	1175	1175	1410	42530
1985	14451	20560	17388	343530	125593	26199	31721	17270	6932	4230	2820	2350	51087
1986	4347	6932	84473	55923	35951	43587	23262	7167	3055	2585	5874	468536	61808
1987	179637	23380	16566	27257	39945	32779	15626	5052	3172	6462	6344	5522	30145
1988	14921	15978	23380	15508	58978	29137	5874	2467	2467	2467	1997	1527	14559
1989	6932	210770	777172	474527	261995	150500	53574	17153	5874	2702	15978	14333	165959
Average	19417	29043	52773	63137	56884	41830	18907	8892	5629	5544	8011	16134	27183

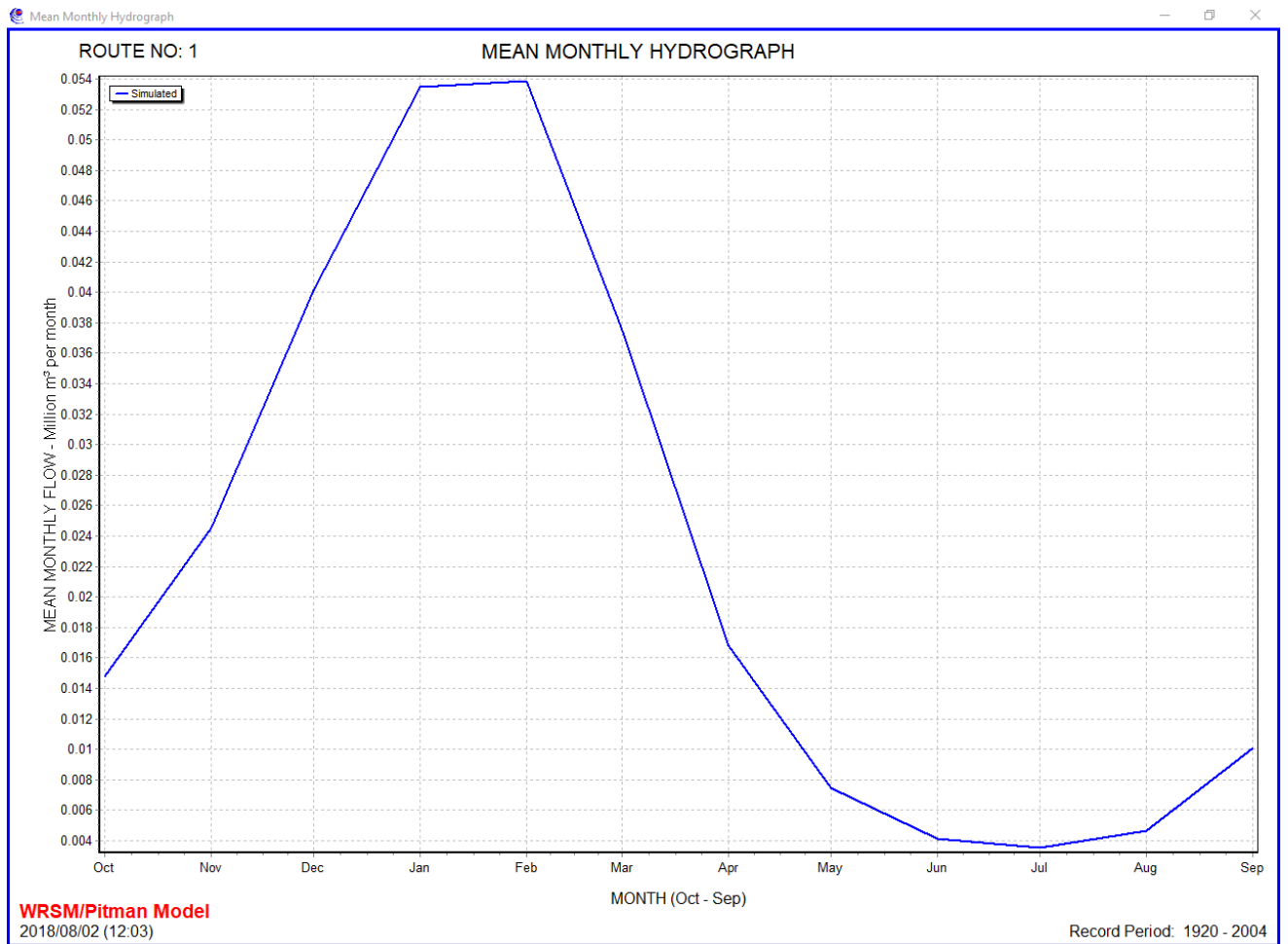
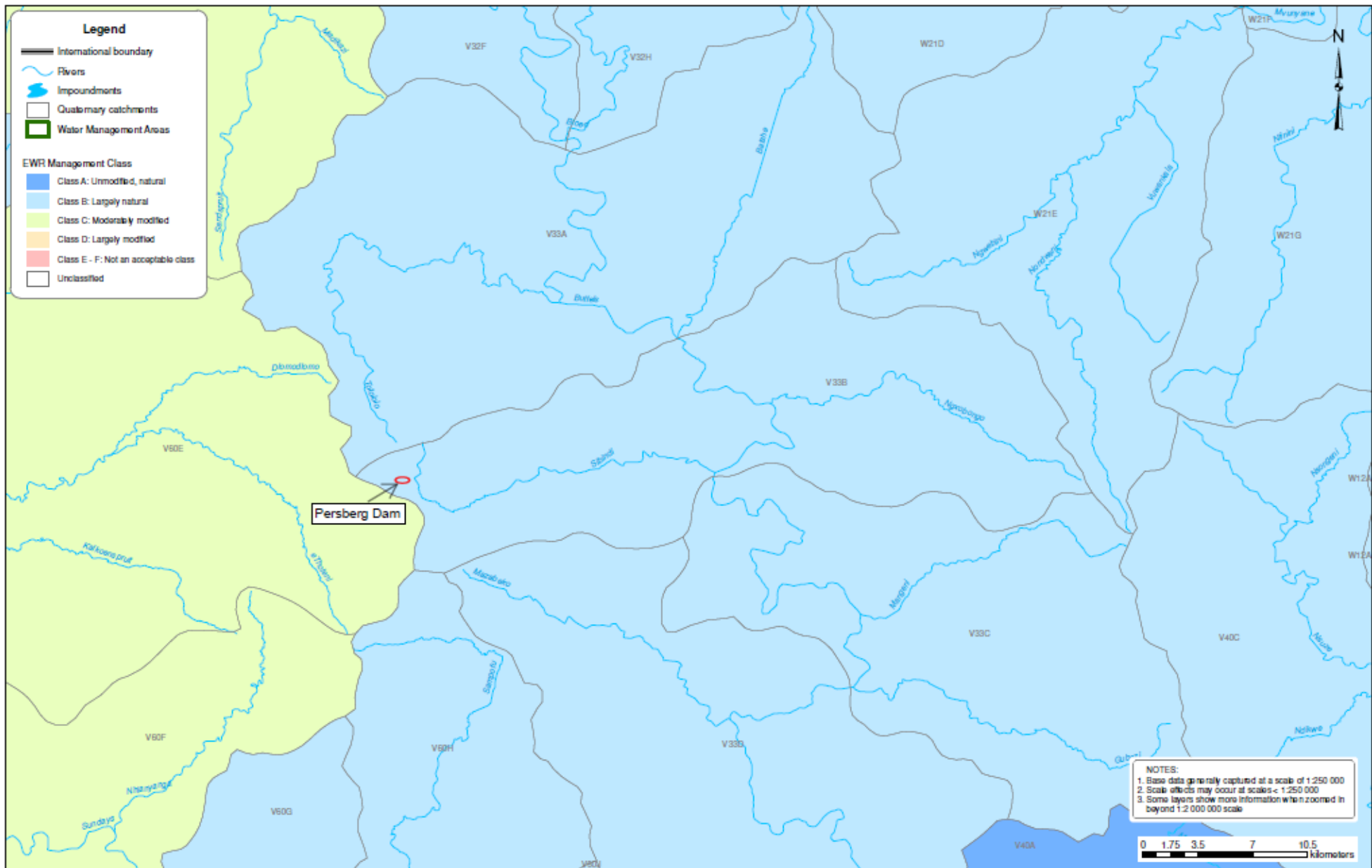


Figure 3: Mean monthly catchment inflows (Million m³)

Table 8: Mean monthly spills from dam (l/h)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
1920	0	0	0	0	0	27322	13661	0	0	0	0	0	3415
1921	0	40984	327869	95628	0	13661	0	0	0	0	0	0	39845
1922	13661	68306	54645	0	0	13661	0	0	0	0	0	0	12523
1923	0	0	0	0	0	0	0	0	0	0	0	0	0
1924	0	13661	95628	81967	54645	765027	259563	13661	0	0	0	0	107013
1925	0	0	0	0	0	0	0	0	0	0	0	0	0
1926	0	13661	0	0	0	109290	40984	0	0	0	0	0	13661
1927	0	0	0	54645	13661	13661	0	0	0	0	0	0	6831
1928	0	0	0	0	0	0	0	0	0	0	0	0	0
1929	0	13661	0	0	0	0	0	0	0	0	0	0	1138
1930	0	0	0	0	0	0	0	0	0	0	0	0	0
1931	0	0	0	0	259563	136612	13661	13661	0	0	0	0	35291
1932	0	0	0	0	0	0	0	0	0	0	0	0	0
1933	0	0	81967	382514	109290	27322	13661	0	0	0	0	0	51230
1934	0	0	191257	40984	0	0	27322	13661	0	0	0	0	22769
1935	0	0	0	0	95628	68306	13661	13661	0	0	0	0	15938
1936	0	95628	13661	13661	81967	54645	13661	0	0	0	0	0	22769
1937	0	0	27322	27322	81967	40984	13661	0	13661	13661	0	0	18215
1938	0	0	109290	27322	191257	81967	0	0	0	0	0	0	34153
1939	0	109290	54645	0	0	0	0	40984	40984	0	0	0	20492
1940	0	0	191257	54645	0	27322	54645	13661	0	0	0	0	28461
1941	0	0	0	136612	163934	68306	13661	0	0	0	0	0	31876
1942	0	0	191257	150273	27322	13661	122951	68306	13661	27322	191257	40984	70583
1943	163934	136612	13661	0	0	13661	0	0	0	0	0	0	27322
1944	0	0	0	0	0	68306	40984	0	0	0	0	0	9107
1945	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	0	0	0	0
1947	0	81967	27322	0	0	27322	27322	0	0	0	0	0	13661
1948	0	0	0	109290	136612	54645	27322	13661	0	0	0	0	28461
1949	0	0	0	0	0	0	0	0	0	0	0	0	0
1950	0	0	0	0	0	0	0	0	0	0	0	0	0
1951	0	0	0	81967	27322	13661	0	0	0	0	0	0	10246
1952	0	0	0	0	355191	136612	13661	0	0	0	0	0	42122
1953	0	0	0	0	0	0	0	0	0	0	0	0	0
1954	13661	163934	13661	232240	163934	54645	13661	0	0	0	0	0	54645
1955	0	0	0	0	81967	81967	13661	0	0	0	0	0	14800
1956	0	54645	382514	150273	0	13661	13661	0	0	0	0	177596	66029
1957	191257	40984	0	0	0	0	0	0	0	0	0	0	19353
1958	0	0	0	0	27322	40984	0	0	0	0	0	0	5692
1959	0	0	0	0	0	0	27322	13661	0	0	0	0	3415
1960	0	0	177596	27322	0	0	27322	13661	0	0	0	0	20492
1961	0	0	0	0	0	0	0	0	0	0	0	0	0
1962	0	0	40984	13661	0	0	13661	0	0	40984	13661	0	10246
1963	0	40984	0	54645	0	0	0	0	0	0	0	0	7969
1964	0	27322	0	0	0	0	0	0	0	0	0	0	2277
1965	0	0	0	13661	13661	13661	0	0	0	0	0	0	3415
1966	0	0	0	0	122951	163934	54645	13661	0	0	0	0	29599
1967	0	0	0	0	0	0	0	0	0	0	0	0	0
1968	0	0	0	0	0	150273	81967	13661	0	0	0	0	20492
1969	0	0	0	0	0	0	0	0	0	0	0	0	0
1970	0	13661	0	0	0	0	0	0	0	0	0	0	1138
1971	0	13661	54645	54645	27322	27322	13661	0	0	0	0	0	15938
1972	0	0	0	0	40984	54645	13661	0	0	0	0	0	9107
1973	0	0	0	68306	27322	13661	13661	0	0	0	0	0	10246
1974	0	0	0	13661	13661	13661	13661	0	0	0	0	0	4554
1975	0	0	0	13661	27322	95628	40984	13661	0	0	0	0	15938

1976	0	0	0	13661	13661	27322	13661	0	0	0	0	0	5692
1977	0	0	0	218579	81967	13661	13661	0	0	0	0	0	27322
1978	81967	54645	0	0	0	0	0	0	0	0	0	0	11384
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	54645	136612	655738	191257	40984	27322	13661	0	0	0	0	93352
1984	0	13661	0	0	368852	136612	0	0	0	0	0	0	43260
1985	0	0	0	368852	109290	40984	40984	13661	0	0	0	0	47814
1986	0	0	81967	163934	109290	136612	40984	0	0	0	0	560109	91075
1987	218579	27322	0	68306	122951	68306	13661	0	0	0	0	0	43260
1988	0	0	54645	0	136612	54645	0	0	0	0	0	0	20492
1989	0	204918	327869	68306	0	0	27322	13661	0	0	0	0	53506
1990	0	0	0	27322	95628	54645	13661	0	0	0	0	0	15938
1991	0	0	0	0	40984	40984	13661	0	0	0	0	0	7969
1992	0	0	0	0	0	54645	40984	0	0	0	0	0	7969
1993	109290	68306	13661	0	0	13661	13661	0	0	0	0	0	18215
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	204918	601093	204918	13661	0	0	0	0	0	85383
1996	0	0	0	0	0	0	0	13661	27322	13661	0	0	4554
1997	0	95628	0	0	13661	40984	13661	0	0	0	0	0	13661
1998	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	27322	27322	27322	13661	0	0	0	7969
2000	0	0	68306	13661	0	13661	13661	13661	0	0	0	0	10246
2001	0	13661	0	0	0	0	0	0	0	13661	13661	0	3415
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	54645	122951	54645	13661	0	0	0	0	0	20492
AVERAGE	9322	17197	32144	44198	48859	41466	16393	4179	1286	1286	2572	9161	19005



4.2. STOCK AND DOMESTIC WATER REQUIREMENTS

It is assumed that a conservative maximum of 15% of the quaternary catchment V33B will be affected downstream of the dam. This means that the downstream catchment area applicable will be 61km².

This catchment area can be classified as Highveld Sourveld and Dohne type veld. For this veld type, the stock carrying capacity is estimated to be 5ha/MSU maximum. This equates to 1220 MSU's in the area. Each mature stock unit (MSU) has a demand of 50 l/MSU/day. Taking into consideration the number of livestock and their daily demand, the proportional release requirement for the livestock is **146 l/h**. This is conservative as there are some areas that are fenced off for dwellings and there are also large areas of thick bush, reducing the grazing area.

For human consumption, 35 households were counted in the applicable area from the latest orthographic aerial photos. It is assumed that each household has up to 7 people. As this is a rural area, a daily consumption of 60 l/capita/day was used. This equates to a release requirement of **35 l/h**.

There are also no known major pumped river water abstraction works up to the Buffalo river and no known other uses, therefore:

The water requirement, other than environmental requirements, is 181 l/h.

4.3. TOTAL RESERVE REQUIREMENT

The total reserve release requirements are indicated in Table 9 below. The environmental release is based on the total IFR release requirement which is 29.9% of the MAR.

Table 9: Total release requirements with maintenance environmental low flow (l/h)

Month	Environmental Maintenance (litre/h)	Livestock (Litre/h)	Domestic (litre/h)	Total flows (l/h)
Oct	3099	146	35	3280
Nov	3914	146	35	4095
Dec	5676	146	35	5857
Jan	7013	146	35	7194
Feb	7568	146	35	7749
Mar	7176	146	35	7357
Apr	5382	146	35	5563
May	3556	146	35	3737
Jun	2479	146	35	2660
Jul	2153	146	35	2334
Aug	2153	146	35	2334
Sep	2642	146	35	2823
Average	4401	146	35	4582

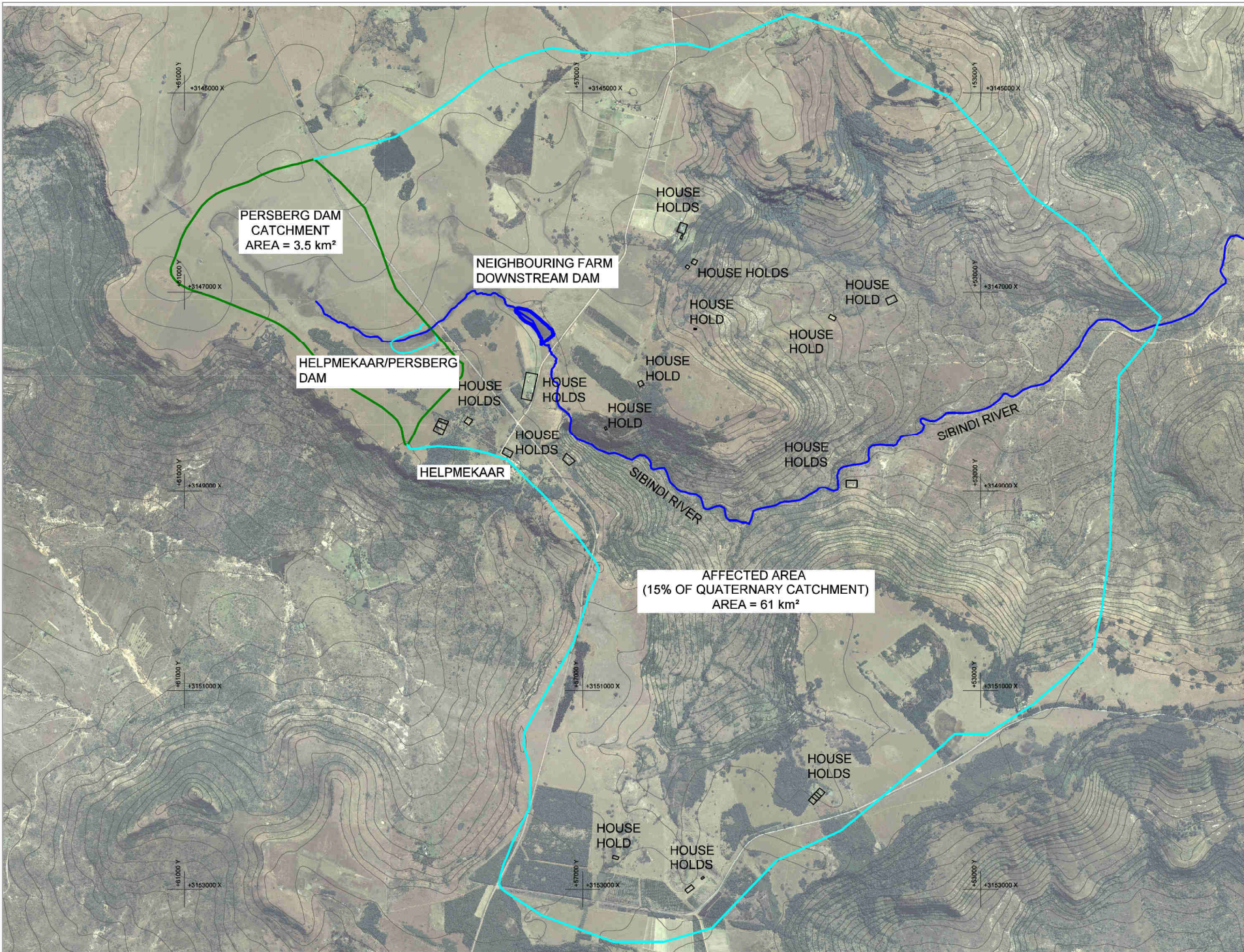
Table 10: Total release requirements with drought environmental low flow (l/h)

Month	Environmental Drought (litre/h)	Livestock (Litre/h)	Domestic (litre/h)	Total flows (l/h)
Oct	783	146	35	964
Nov	946	146	35	1127
Dec	718	146	35	899
Jan	1664	146	35	1845
Feb	1794	146	35	1975
Mar	1696	146	35	1877
Apr	1305	146	35	1486
May	913	146	35	1094
Jun	652	146	35	833
Jul	587	146	35	768
Aug	587	146	35	768
Sep	685	146	35	866
Average	1028	146	35	1209

Note that only a maximum of the total requirement, or the incoming flow will have to be released to a maximum of the release requirement. In the event that the incoming flow is more than the total release requirement, only the release requirement will have to be released. It is therefore recommended to also install an upstream measuring weir.

5. ANNEXURE

5.1. RESERVE REQUIREMENT: AFFECTED AREA LAYOUT PLAN- G 2018/06/01/01



Notes:
20m contours indicated

PROJECTION: TRANSVERSE MERCATOR
DATUM: WGS 84
LO: 31° E

References	
Drawing No.	Title

Amendments			
Date	Checked	Done by	Description





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Designed: F KRUGEL
 Drawn: B MUHL
 Checked: F KRUGEL

Client:
MONTROSE FARMING TRUST
ERICH MÜLLER
 Tel: 082 443 8049

Approvals:
 Engineer
 F. Krugel  Date: _____
 ECSA Reg No 910142
 Client
 Signature: _____ Date: _____

Project Name:
HELPMEKAAR-PERSBERG DAM

Drawing Description:
RESERVE REQUIREMENT: AFFECTED AREA LAYOUT PLAN

Scale: 1:35 000	Plot Date: 2018/08/07
Project N°: G 2018/06/01	Drawing Sequence No°: G 2018/06/01/01