Ministry of Works
Dunedin

MANUHERIKIA RIVER — CATCHMENT Nº752630
WATER RESOURCES

PRELIMINARY REPORT
ON IRRIGATION DEVELOPMENT

VOLUME 2
APPENDICES B-G

Water & Soil Division

DUNEDIN

JANUARY 1974

P.W. 15/3/1

MINISTRY OF WORKS
DUNEDIN

MANUHERIKIA RIVER - CATCHMENT NO. 752630

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PRELIMINARY REPORT ON IRRIGATION DEVELOPMENT

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G.P. Keller
District Commissioner of Works
DUNEDIN.

APPENDICES

APPENDIX B - HYDROLOGICAL DATA

Attached are the following data tabulations.

1. Daily mean flows (smoothed) Ophir 1919-1930 (c.f.s.)
2. Daily mean flows, Ophir 1971, 1972, 1973 (metric)
3. Monthly mean flows for above periods (metric)
4. Comparative gaugings uncorrected for irrigation (metric)
5. Comparative gauging corrected for irrigation (metric)
6. Notes on recent Ophir ratings, catchment areas

Using the above, following the procedure outlined in Fig. 1, a proportional flow model was constructed, and the following derived data obtained.

1. Annual yields.
2. Irrigation Season Yields
3. Winter Yields

STAGE DISCHARGE RATING TABLE FOR OPNIR BRIDGE

RATING A. PERIOD 1·10·19 TO 31·12·30

GAUGE ZERO UNKNOWN

DWG. No. L 5901/3

G.H.	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
0·0	50	61	72	83	95	107	119	131	144	157
1·0	170	183	196	209	223	237	251	265	280	295
2·0	310	325	341	357	373	389	406	423	441	460
3·0	480	501	523	546	570	595	620	646	673	701
4·0	730	760	790	822	855	889	924	960	998	1038
5·0	1080	1124	1170	1219	1271	1325	1382	1441	1502	1565
6·0	1630	1697	1765	1835	1907	1981	2057	2135	2215	2297
7·0	2380	2465	2552	2640	2730	2822	2915	3009	3105	3202
8·0	3300	3400	3501	3603	3706	3811	3917	4024	4132	4241
9·0	4351	4461	4572	4683	4793	4904	5015	5126	5236	5347
10·0	5458	5568	5679	5790	5900	6011	6122	6232	6343	6454
11·0	6565	6675	6786	6897	7007	7118	7229	7340	7450	7561
12·0	7672	7782	7893	8004	8114	8225	8336	8447	8557	8668
13·0	8779	8889	9000	9110	9221	9332	9443	9553	9664	9775
14·0	9886	9996	10107	10218	10328	10439	10550	10661	10771	10882
15·0	10993	11103	11214	11325	11435	11546	11657	11768	11878	11989
16·0	12100	12210	12321	12432	12542	12653	12764	12875	12985	13096
17·0	13207	13317	13428	13539	13649	13760	13871	13982	14092	14203
18·0	14314	14424	14535	14646	14756	14867	14978	15098	15199	15310
19·0	15421	15531	15642	15753	15863	15974	16085	16196	16306	16417
20·0	16528	16638	16749	16860	16970	17081	17192	17303	17413	17524
21·0	17635	17745	17856	17967	18077	18188	18299	18410	18520	18631
22·0	18742									

RATING B. PERIOD 16·6·55 TO 31·12·65

GAUGE ZERO UNKNOWN

DWG. No. E.D.H.S. 75244/1965

91	0	45	90	140	190	240	290	340	395	450
92	505	560	615	675	735	795	855	920	985	1050
93	1120	1190	1260	1330	1400	1470	1540	1610	1680	1750
94	1820	1890	1960	2035	2110	2185	2260	2340	2420	2500
95	2580	2660	2745	2830	2915	3000	3085	3170	3255	3340
96	3425	3510	3600	3690	3780	3870	3960	4050	4140	4230
97	4320	4410	4500	4590	4680	4770	4860	4950	5040	5130
98	5220	5310	5400	5490	5580	5670	5760	5850	5940	6030
99	6120	6210	6300	6390	6480	6570	6660	6750	6840	6930
100	7020	7110	7200	7290	7380	7470	7560	7650		

MANUHERIKIA R. AT OPHIR. STATION NUMBER. 9009 29/09/67

DATA INCOMPLETE FOR 1919.

DAILY MEAN DISCHARGE IN CUSECS DURING 1919.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1										3222	834	375
2										3139	1593	357
3										2718	2180	357
4										2180	1653	362
5										1981	1325	362
6										1919	1303	349
7										1743	1181	383
8										1630	1200	375
9										1657	1399	357
10										1657	1471	353
11										1630	1333	337
12										1630	1137	322
13										1630	984	316
14										1657	889	310
15										1504	889	304
16										1348	809	298
17										1863	875	298
18										1118	862	298
19										1080	834	291
20										1137	768	284
21										1175	572	284
22										1175	605	278
23										1215	565	273
24										1215	507	273
25										1175	480	273
26										1136	537	345
27										1098	585	403
28										1045	555	349
29										994	507	291
30										920	434	273
31										862		273
MIN										862	434	273
MEAN										1544	968	323
MAX										3222	2180	403

47514 [illegible] 16013

ANNUAL MEAN DISCHARGE 1920. 361 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1920.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
273	117	120	112	189	186	232	237	627	1890	463	480
273	117	123	112	173	225	382	237	565	1800	447	456
267	117	120	112	178	243	902	237	534	1800	447	432
249	117	117	112	186	243	1477	255	534	1772	447	411
237	117	117	109	175	237	1180	310	534	1687	521	389
231	117	114	107	167	237	662	334	534	1477	627	371
529	117	112	107	165	237	627	316	534	1202	627	331
517	117	112	107	162	237	627	520	507	1063	529	310
208	127	112	107	157	231	574	796	480	1013	448	310
208	132	112	107	154	226	544	796	480	964	619	310
208	127	109	107	154	219	632	597	507	933	768	310
225	122	107	105	151	208	730	448	534	998	662	310
237	117	107	102	148	197	695	456	534	1080	574	310
237	117	107	102	145	186	617	456	565	1045	544	297
237	112	102	102	140	180	555	365	565	994	555	284
215	107	97	100	138	175	507	285	507	948	564	278
192	107	95	97	138	170	463	260	463	861	642	267
186	105	90	97	138	170	425	248	432	756	742	249
175	105	87	107	138	170	403	243	403	672	742	231
165	112	133	143	138	186	389	261	383	627	730	226
154	112	170	159	143	208	343	243	389	615	755	219
138	105	149	143	154	213	304	256	417	605	720	213
127	100	132	132	154	213	298	331	425	595	588	213
127	97	122	122	148	213	285	506	410	595	498	213
127	117	117	114	145	208	260	733	396	585	456	213
127	132	117	120	140	202	243	1139	389	575	448	213
127	122	117	154	143	197	237	1496	396	575	455	301
122	117	114	180	148	192	237	1250	396	575	455	371
117	117	112	191	154	186	237	934	1009	575	472	313
117		112	200	154	180	237	809	1805	555	480	255
117		112		154		237	695		507		237
117	97	87	97	138	170	232	237	383	507	447	213
209	115	115	122	154	206	501	518	542	966	568	301
529	132	170	200	189	243	1477	1496	1805	1890	768	480
[illegible]	[illegible]	3565	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2.2	1.1	1.2	1.2	1.6	2.1	5.4	5.5	5.5	10.9	4.5	3.2

MANUHERIKIA R. AT UPPER. STATION NUMBER. 9009 22/06/67

ANNUAL MEAN DISCHARGE 1921. 438 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1921.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

AY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	231	213	192	226	304	464	334	472	464	680	660	331
	219	213	192	219	291	464	375	472	455	847	627	331
	208	219	192	213	284	426	403	455	447	809	565	310
	214	219	192	208	278	375	417	439	447	684	525	331
	219	208	192	202	273	354	417	425	447	617	507	331
	208	202	192	197	273	334	403	410	432	742	488	297
	202	197	197	192	291	316	403	396	403	889	537	284
	197	215	202	192	310	310	389	389	389	847	537	284
	192	231	202	192	310	310	365	389	389	733	463	284
	181	226	202	291	310	310	353	411	411	597	439	284
	170	219	197	375	310	310	331	456	456	621	432	284
	170	213	186	375	304	310	310	570	537	756	425	316
	170	213	175	349	291	331	331	774	537	834	403	328
	170	208	170	291	284	353	350	1042	472	905	383	310
	170	202	165	255	284	392	347	1087	448	919	365	310
	170	202	160	237	284	411	538	920	425	934	408	304
	170	202	160	231	284	371	1077	847	449	1013	529	298
	170	202	160	226	297	392	1156	769	480	1338	555	291
	175	197	198	307	310	411	809	694	472	3710	507	278
	186	192	220	349	310	371	672	670	464	4545	456	267
	186	192	186	310	304	353	615	637	772	2840	411	261
	180	192	234	304	291	357	615	605	1730	2032	383	261
	175	192	262	298	291	362	605	565	2277	1602	365	261
	170	192	231	285	304	357	537	507	1490	1446	331	254
	170	192	231	273	310	350	463	472	806	1326	331	248
	170	192	226	313	310	334	439	464	756	1181	353	279
	181	192	226	350	520	322	417	464	672	1029	350	273
	192	192	226	328	768	322	396	464	722	934	328	261
	192		226	310	710	322	403	464	722	847	331	284
	203		226	310	547	322	441	472	596	768	331	278
	213		226		472		464	472		695		237
	170	192	160	192	273	310	310	389	389	597	328	237
N	188	205	202	274	346	357	490	570	652	1217	445	289
	231	231	262	375	768	464	1156	1087	2277	4545	660	331
	2.0	1.8	2.2	2.8	3.7	3.6	5.3	6.1	6.6	13.1	4.5	3.1

ANNUAL MEAN DISCHARGE 1922. 390 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1922.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	202	347	273	369	357	403	362	304	278	304	202	284
2	202	347	267	354	353	396	382	291	297	328	202	316
3	202	538	254	347	353	389	396	284	438	334	202	354
4	202	755	248	347	350	383	375	278	500	316	202	375
5	202	731	297	334	354	376	357	273	411	328	243	375
6	202	599	334	316	362	383	353	291	361	347	284	354
7	197	482	322	304	357	383	435	310	328	431	284	316
8	186	432	316	298	350	376	419	297	304	467	284	261
9	175	403	310	291	397	369	316	284	291	390	278	225
10	173	375	304	297	432	362	474	273	316	336	267	213
11	224	357	291	304	397	357	3546	261	405	304	254	208
12	255	337	284	310	376	353	4417	254	519	291	243	220
13	237	316	316	458	369	357	2005	248	527	273	237	483
14	255	291	328	586	362	362	1355	243	441	254	237	768
15	376	376	304	529	357	362	943	225	396	243	231	744
16	1112	456	285	463	353	362	768	295	389	231	219	638
17	1558	404	273	447	371	369	695	365	383	219	208	556
18	1144	365	273	455	718	376	627	331	369	213	197	467
19	812	331	273	448	1013	376	565	304	354	208	186	506
20	651	310	278	425	880	369	507	291	328	202	175	595
21	537	304	291	410	731	362	449	278	310	202	170	688
22	456	298	298	403	638	357	403	267	304	202	165	755
23	411	298	291	396	574	353	375	285	298	202	166	695
24	396	291	291	383	535	353	362	328	291	220	213	627
25	403	278	322	376	507	365	357	316	297	231	203	537
26	403	273	350	383	488	383	350	297	328	226	186	434
27	389	273	453	383	472	389	347	310	328	219	175	368
28	369	273	517	369	455	375	334	304	310	213	170	316
29	357		456	362	439	362	322	78	310	213	186	297
30	350		417	362	425	362	316	291	304	213	243	328
31	347		389		410		310	284		208		347
MN	173	273	248	291	350	353	310	225	278	202	165	208
AN	419	387	320	384	469	371	749	289	357	270	218	440
X	1558	755	517	586	1013	403	4417	365	527	467	284	768
	4.5	3.9	3.4	3.9	5.1	3.7	8.1	3.1	3.6	2.7	2.2	4.7

ANNUAL MEAN DISCHARGE 1923, 804 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1923.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	836	1333	389	310	781	984	482	267	5238	731	649	237
2	1477	1087	375	310	706	956	404	254	3256	755	969	220
3	1715	934	375	310	660	757	375	248	2005	706	1083	197
4	1861	847	389	297	1375	864	403	254	1477	670	921	192
5	1951	768	396	273	2017	954	432	261	1202	720	781	181
6	1726	755	403	261	1889	796	463	346	1029	781	672	170
7	1314	744	396	267	1857	632	463	514	934	755	605	181
8	1037	683	383	278	1828	565	342	556	934	706	595	192
9	861	670	369	297	1987	595	237	507	1029	681	574	215
10	847	638	362	310	2078	595	237	422	1355	638	517	249
11	809	574	357	297	1805	585	249	328	1935	556	463	325
12	706	535	350	284	1477	575	273	273	2048	516	482	371
13	670	498	368	284	5218	575	273	237	1689	498	482	331
14	649	456	559	284	7838	555	237	249	1401	581	425	297
15	617	432	662	284	5735	516	225	285	1219	706	396	273
16	585	425	556	284	4102	488	255	485	1083	809	389	254
17	564	425	516	284	3061	395	291	774	949	809	524	243
18	535	425	482	278	2498	371	297	774	809	706	588	225
19	498	418	418	267	2016	411	273	627	730	681	490	213
20	449	410	389	261	1743	368	261	938	706	660	426	208
21	418	417	389	261	1687	450	249	908	681	638	383	202
22	486	456	389	471	1745	535	237	544	670	617	376	197
23	4389	498	383	3070	1687	482	237	564	660	595	369	186
24	5524	498	369	4379	1743	378	225	564	649	595	357	180
25	2687	456	369	2948	1857	297	213	564	617	585	353	175
26	2176	439	383	2288	1919	273	225	564	605	575	350	181
27	1660	432	389	1805	2046	249	255	553	627	575	328	181
28	1848	403	389	1456	1816	273	291	574	638	564	310	170
29	2421		375	1146	1423	395	331	617	660	553	291	170
30	2233		354	921	1202	498	331	1730	681	544	255	159
31	1636		328		984		291	4583		525		148
N	418	403	328	261	660	249	213	237	605	498	255	148
EAN	1458	595	407	816	2219	546	302	657	1251	646	513	217
X	5524	1333	662	4379	7838	984	482	4583	5238	809	1083	371
	45198	[illegible]	[illegible]	[illegible]	68789	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	15.7	5.2	4.4	8.2	23.8	3.5	3.3	7.1	12.6	6.9	5.2	2.3

ANNUAL MEAN DISCHARGE 1924. 370 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1924.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	159	254	132	160	660	285	349	449	278	417	840	349
2	170	237	132	160	649	261	328	472	273	396	742	297
3	215	226	122	165	617	261	354	448	267	434	808	297
4	249	219	112	170	537	261	375	411	261	570	988	328
5	237	208	112	167	472	267	375	371	254	683	1047	334
6	237	197	117	165	455	273	357	331	248	651	1029	316
7	225	192	122	162	482	273	350	297	243	537	1118	316
8	213	186	160	160	556	273	328	278	237	421	1101	337
9	213	170	245	160	565	278	304	267	243	362	968	331
10	208	154	304	160	507	284	298	254	248	369	809	304
11	208	138	304	162	449	284	291	254	254	383	781	291
12	225	117	285	162	418	291	316	267	261	383	847	284
13	249	117	267	156	410	298	375	285	267	349	808	297
14	267	149	249	153	396	291	389	304	267	303	644	291
15	285	170	231	151	383	284	365	520	249	243	608	273
16	291	165	226	148	369	278	331	662	220	220	617	278
17	284	160	226	148	357	273	343	521	202	509	517	284
18	273	160	219	148	337	273	404	432	197	731	463	278
19	261	154	213	148	310	267	404	403	192	881	886	273
20	254	148	208	148	285	254	343	375	186	1181	1137	278
21	248	143	202	148	260	254	336	357	175	1181	840	284
22	254	138	197	439	254	249	354	350	186	984	706	297
23	254	132	192	888	267	350	328	347	208	798	648	331
24	260	127	192	877	278	1047	297	334	225	683	595	365
25	267	122	186	718	291	1477	273	322	237	660	536	404
26	249	112	180	662	304	1167	273	316	261	606	464	397
27	225	112	175	688	297	870	291	310	647	517	411	336
28	203	122	170	755	291	662	310	304	870	456	375	520
29	215	127	165	695	322	529	342	298	652	411	369	718
30	249		160	660	354	426	375	291	503	453	383	1168
31	261		160		336		403	284		733		1805
N	159	112	112	148	254	249	273	254	175	220	369	273
AN	239	161	192	323	402	418	341	359	294	565	736	409
X	291	254	304	888	660	1477	404	662	870	1181	1137	1805
	2.5	1.5	2.1	3.2	4.3	4.2	3.7	3.8	3.0	6.1	7.4	4.4

ANNUAL MEAN DISCHARGE 1925. 706 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1925.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1805	296	231	231	213	285	226	597	1282	800	939	499
2	1355	208	220	237	339	316	237	507	1258	1451	1046	537
3	984	219	202	273	448	316	489	498	1235	4488	1028	472
4	809	268	208	268	425	297	695	498	1258	5735	980	622
5	706	273	2282	226	441	278	695	472	1164	4351	891	930
6	660	255	2990	226	551	267	768	529	1046	3825	781	984
7	559	255	1320	219	617	254	756	837	1046	2840	662	875
8	449	225	870	213	537	248	661	971	1063	2310	574	847
9	403	208	730	219	449	243	539	784	1063	2310	509	781
10	371	202	605	231	390	237	448	683	968	2310	448	823
11	331	202	472	237	369	231	425	627	809	2110	456	889
12	297	208	455	231	389	226	403	546	1180	1751	559	784
13	273	213	455	219	410	226	403	516	1657	1950	559	641
14	249	213	529	208	449	226	403	565	1714	3365	472	564
15	220	208	585	202	537	219	368	546	2062	4081	455	517
16	186	208	527	214	537	213	322	488	2310	3769	447	472
17	227	219	463	231	434	213	267	480	2110	3513	463	433
18	278	226	411	231	403	213	261	463	2110	3261	498	396
19	260	219	365	231	351	213	297	463	2176	3139	556	389
20	237	208	350	231	261	219	349	537	2046	2939	537	383
21	214	202	328	226	231	226	396	617	1919	2283	472	365
22	202	197	304	231	268	231	403	672	1919	1833	529	337
23	197	203	291	237	364	237	410	798	1805	2151	662	316
24	192	237	266	231	390	225	418	949	1477	2757	581	304
25	232	254	243	226	336	213	410	835	1152	2757	432	285
26	376	243	231	226	273	219	396	683	948	2180	417	273
27	456	231	209	219	237	226	396	1543	903	1530	499	267
28	411	226	203	213	243	231	433	2601	809	1045	506	254
29	383		213	213	243	237	472	2401	684	980	418	248
30	365		219	213	231	231	507	1653	596	919	410	243
31	371		226		243		597	1303		860		237
IN	186	197	202	202	213	213	226	463	596	800	410	237
EAN	454	226	549	227	375	241	447	828	1392	2568	593	515
AX	1805	296	2990	273	617	316	768	2601	2310	5735	1046	984
	4.9	2.0	5.9	2.3	4.0	2.4	4.7	8.9	14.0	7.6	6.0	5.5

ANNUAL MEAN DISCHARGE 1926. 667 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1926.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	225	464	4379	426	432	613	455	396	847	1657	1612	650
2	227	455	3300	464	425	488	447	403	860	1500	1374	637
3	227	763	2465	472	432	480	447	396	889	1225	1260	615
4	208	905	1477	472	447	480	439	389	809	1080	1137	584
5	202	672	1202	455	455	472	432	396	695	1080	1063	544
6	202	661	984	432	464	464	432	410	637	1045	998	507
7	197	694	809	403	448	455	425	486	637	1028	964	605
8	192	670	662	383	439	447	418	517	670	1046	920	706
9	181	588	565	369	455	447	418	463	706	1028	821	660
10	175	482	516	357	464	439	410	425	730	1190	781	596
11	180	447	488	350	455	432	403	396	695	1805	767	525
12	209	455	456	334	439	439	403	389	660	1805	754	516
13	292	441	417	316	514	625	396	383	660	1303	754	525
14	350	403	396	304	617	744	389	369	649	1157	754	498
15	350	349	403	298	660	589	389	362	638	1118	754	745
16	322	279	410	291	670	497	389	357	638	1118	866	994
17	291	243	410	284	670	480	383	353	638	1300	994	854
18	261	249	403	284	660	464	376	350	649	1339	1010	695
19	225	273	371	284	617	455	369	347	670	943	1045	637
20	203	284	331	278	855	447	362	334	718	796	1003	584
21	192	278	297	273	1373	455	357	334	793	847	1046	535
22	203	260	278	267	2005	464	350	836	860	781	1028	498
23	225	347	278	267	2638	472	361	1202	984	718	980	463
24	237	463	297	278	2263	472	389	1015	1118	707	949	439
25	237	434	331	284	1477	464	410	828	1118	683	919	523
26	231	396	357	291	1260	455	432	694	1045	660	875	1019
27	226	441	362	298	1137	447	447	670	963	649	796	1527
28	226	2969	357	304	1029	491	439	683	823	2954	718	1551
29	198		353	343	948	507	425	828	809	3933	707	1398
30	246		357	404	874	472	403	919	1286	2418	683	1202
31	393		375		781		389	875		2020		1045
N	175	243	278	267	425	432	350	334	637	649	683	439
AN	237	549	777	342	852	489	406	542	797	1320	947	738
X	393	2969	4379	472	2638	744	455	1202	1286	3933	1612	1551
	7347	15372	24087	10260	26412	14670	12586	16802	23910	40920	28410	22878
	2.5	4.8	8.3	3.5	9.1	4.9	4.4	5.8	8.0	14.2	9.5	7.9

STATION NUMBER 9009 22/06/67

ANNUAL MEAN DISCHARGE 1927. 490 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1927.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	870	249	584	1101	439	369	170	784	371	617	564	707
2	730	261	500	982	425	354	165	602	353	595	544	694
3	718	261	378	849	418	347	160	443	350	585	534	660
4	683	254	291	755	410	334	235	371	334	564	525	617
5	637	243	255	613	396	316	733	337	316	535	507	565
6	627	237	231	589	383	304	876	322	371	490	488	516
7	559	237	226	681	369	298	537	316	1031	464	559	480
8	480	243	249	694	357	298	434	331	1477	455	672	455
9	463	260	255	718	353	291	375	350	1186	447	683	425
10	432	267	231	755	350	284	357	347	954	439	637	382
11	403	261	219	806	347	284	337	328	761	439	584	336
12	375	254	280	793	334	273	316	336	683	439	493	304
13	357	243	328	718	322	261	364	357	683	425	432	343
14	353	237	279	628	316	254	410	353	606	418	417	349
15	357	237	237	527	328	243	396	350	517	1024	403	297
16	375	231	231	480	397	231	375	334	472	1575	396	297
17	389	219	273	480	472	219	357	377	448	1401	389	304
18	349	213	297	488	464	208	331	456	448	1130	418	291
19	304	219	278	497	404	191	310	472	772	729	886	278
20	298	214	273	480	330	175	304	448	984	537	1186	260
21	291	197	310	448	284	170	298	514	809	605	900	237
22	284	186	328	432	278	181	291	756	695	627	674	219
23	278	175	1603	439	267	192	284	823	660	672	537	208
24	338	170	2822	447	261	203	284	706	683	730	463	191
25	356	165	2637	463	418	213	316	648	843	742	447	175
26	285	154	2284	507	595	219	413	595	920	730	463	165
27	261	404	1921	507	661	231	547	555	795	662	480	160
28	254	637	1890	472	630	225	637	516	706	595	527	154
29	248		1919	464	493	203	819	472	670	565	607	148
30	243		1664	455	417	181	1013	418	649	544	672	148
31	237		1314		389		954	389		564		148
N	237	154	219	432	261	170	160	316	316	418	389	148
AN	414	247	793	609	397	252	432	465	685	656	570	339
K	870	637	2822	1101	661	369	1013	823	1477	1575	1186	707
	12834	6916	24583	18270	12307	7560	13392	14415	20550	20336	17100	10509
	4.4	2.2	8.5	6.1	4.3	2.6	4.7	5.0	6.9	7.0	5.7	3.6

STATION NUMBER. 9009 22/0676.6

ANNUAL MEAN DISCHARGE 1928. 485 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1928.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	159	97	117	117	1063	310	225	248	411	403	2648	48(
2	170	97	117	117	998	310	237	248	557	441	2020	45:
3	170	97	112	117	823	304	231	248	660	517	1585	43(
4	170	97	107	117	662	298	219	243	577	642	1283	42:
5	192	97	107	112	537	298	213	237	498	982	1102	40:
6	219	102	112	107	463	350	213	237	463	1353	963	37:
7	231	112	117	178	455	389	225	231	425	1726	889	35:
8	255	112	132	243	455	365	237	226	396	1530	1009	35:
9	267	107	175	225	439	350	335	219	383	984	1083	36:
10	261	178	197	208	425	347	448	213	365	1233	949	35:
11	261	231	181	202	418	334	455	208	350	1278	919	35:
12	254	197	170	232	410	322	472	202	347	994	933	44:
13	248	180	165	318	403	316	545	202	347	1217	849	95:
14	279	180	160	455	396	310	574	225	350	1309	767	229(
15	310	180	154	555	383	304	544	243	365	1087	754	257:
16	297	175	148	555	369	291	499	225	404	934	742	151(
17	278	165	175	555	362	284	448	208	425	860	718	101(
18	237	160	214	519	357	278	411	202	410	956	694	83:
19	181	154	214	420	353	273	383	202	396	1276	648	73(
20	133	148	202	361	353	267	376	197	389	1525	584	69(
21	107	148	191	322	350	254	369	215	383	1525	535	62(
22	107	143	170	298	347	248	357	249	376	1447	498	53(
23	107	138	144	285	334	243	350	354	376	1397	463	46(
24	122	132	127	260	322	237	334	728	369	1283	432	42:
25	132	127	122	237	342	237	322	858	362	1260	410	41(
26	127	127	117	237	357	231	316	630	369	3209	410	42:
27	117	122	122	364	350	226	304	500	376	5331	476	41(
28	107	117	127	570	334	226	298	432	369	4337	597	40(
29	102	117	122	947	322	226	291	410	362	3081	627	41(
30	97		117	1140	316	219	278	396	382	3567	546	43(
31	97		117		310		260	389		3567		43(
MIN	97	97	107	107	310	219	213	197	347	403	410	353
MEAN	187	139	147	346	446	288	347	311	408	1653	871	659
MAX	310	231	214	1140	1063	389	574	858	660	5331	2648	2572
	5797	4031 —	4557	10380	13826	8640	10757	9641	12240	51243	26130	20429
	2.0	1.3	1.6	3.5	4.8	2.9	3.7	3.3	4.1	17.8	8.8	7.1

ANNUAL MEAN DISCHARGE 1929. 684 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1929.

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	432	382	107	383	447	237	660	694	712	694	350	46
2	432	357	107	365	432	237	617	670	3616	744	347	41
3	456	337	107	337	397	231	565	649	4822	861	354	38
4	472	316	107	322	376	226	499	627	2522	874	397	36
5	441	316	127	316	349	219	455	615	1608	860	483	36
6	397	322	154	310	310	225	439	605	1398	847	845	35
7	365	316	160	304	298	237	464	574	1202	768	1118	35
8	331	297	154	298	298	676	516	525	1118	768	930	33
9	310	278	143	291	310	1645	516	488	1241	847	755	31
10	310	255	138	284	334	1627	488	517	1220	919	730	31
11	310	237	138	278	334	905	463	574	1032	919	684	30
12	349	231	132	273	316	1265	439	565	891	860	607	29
13	371	225	122	273	297	2848	493	507	781	757	555	29
14	331	219	117	267	278	3105	544	472	695	638	516	28
15	304	203	117	267	273	1972	516	455	649	565	488	28
16	291	181	112	455	273	1477	589	439	684	555	463	27
17	278	165	107	559	267	1220	2423	456	706	641	432	58
18	273	160	107	434	261	1016	3732	729	799	756	403	84
19	273	154	160	375	254	1194	3061	854	917	793	383	79
20	273	148	2603	354	248	1893	2568	755	889	767	369	75
21	376	143	3687	334	243	2685	2147	806	821	730	362	70
22	434	138	1852	316	237	2519	1805	832	755	683	404	67
23	337	132	1220	297	237	1832	1477	806	718	649	432	316
24	337	127	1002	273	231	1483	1202	755	694	596	410	479
25	418	122	821	249	231	1181	1015	718	694	500	389	283
26	447	117	730	231	243	998	964	694	718	432	389	199
27	463	112	683	226	248	874	905	660	742	390	425	302
28	570	107	627	237	243	781	769	617	742	362	500	309
29	578		546	297	237	718	756	574	718	362	535	227
30	472		464	397	237	694	793	544	707	357	498	273
31	425		411		237		744	534		353		291
MIN	273	107	107	226	231	219	439	439	649	353	347	278
MEAN	382	218	550	320	290	1207	1052	623	1160	673	519	1180
MAX	578	382	3687	559	447	3105	3732	854	4822	919	1118	4798
	11862	6104	17050	9600	8990	36210	32612	19313	34800	20867	15570	36180
	4·1	1·9	5·9	3·2	3·1	12·2	11·3	6·7	11·7	7·2	5·2	12·7

STATION NUMBER 9009

ANNUAL MEAN DISCHARGE 1930. 531 CUSECS.

DAILY MEAN DISCHARGE IN CUSECS DURING 1930. 5926 589

NEGATIVE SIGN ON DAILY FLOW SIGNIFIES INTERPOLATED VALUE.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2023	2601	273	138	273	219	255	254	1252	847	627	486
2	1446	2118	273	132	291	226	273	243	1447	847	660	507
3	1303	1526	267	127	284	219	267	231	1551	847	649	498
4	1157	1120	261	122	278	208	254	219	1630	768	627	472
5	1118	954	261	127	267	202	243	213	1500	718	661	441
6	1023	796	254	138	254	197	225	225	1303	744	911	432
7	835	706	248	138	237	192	213	231	1195	2040	961	463
8	744	628	243	143	219	197	208	219	1136	3467	722	463
9	683	536	237	148	213	208	202	225	1063	3467	596	432
10	617	488	231	148	208	219	197	237	980	2874	535	403
11	555	472	226	159	197	231	192	237	905	2152	498	375
12	516	448	219	175	186	231	186	237	889	1526	463	357
13	497	425	213	175	175	219	175	243	948	1102	463	357
14	488	418	213	159	170	213	170	248	1068	949	480	429
15	480	403	208	154	181	208	175	254	1314	875	488	516
16	472	383	197	160	277	202	191	261	1664	834	525	462
17	448	507	192	165	336	197	225	267	1640	780	517	389
18	417	559	192	170	291	192	273	273	1309	742	449	383
19	396	456	186	175	273	197	310	352	1120	718	410	369
20	418	404	175	186	267	202	342	756	1063	694	396	354
21	763	369	170	192	254	208	354	1137	1118	660	389	334
22	984	362	165	192	243	213	334	1013	1118	617	383	316
23	732	357	160	186	231	219	322	806	1045	574	376	304
24	555	337	160	180	219	231	334	755	1102	544	369	291
25	507	310	154	175	208	243	350	809	1412	525	362	278
26	463	291	148	170	202	248	350	847	1432	507	404	267
27	439	284	148	170	202	243	347	756	1195	497	553	251
28	483	278	148	181	197	237	328	694	1118	488	627	254
29	1355		143	245	192	231	291	670	1029	498	556	248
30	4093		138	273	197	231	267	720	934	535	498	243
31	4417		138		208		261	930		574		237
IN	396	278	138	122	170	192	170	213	889	488	362	237
EAN	982	662	201	167	233	216	262	470	1216	1065	538	375
AX	4417	2601	273	273	336	248	354	1137	1664	3467	951	516
	30462	18536	6231	5010	7223	6480	8122	14570	36480	33015	16140	11625
	5169.	3504	4253	3930	6183	4591	5329.	5632	8754	11579	6518	5462
	470	319	387	357	562	417	485	512	796	1055	593	497

								SEPT.	OCT.	NOV.	DEC.
	38	27	63	54	162	165	96	142	243	134	115
	35	26	62	52	146	153	82	136	263	121	112
	33	28	60	51	130	148	72	122	302	119 (14)	108 (17)
	32	29	57	48	139	142	72	121	315	125	106 (24)
	31	31	51	48	155	215	85	142	363	108	102
	31	32	47	48	207	165	102	131	323	99	97
	28	30	47	54	1270	142	101	131	262	99	90
	30	28	49	56	1140	136 (3)	99	128	248	104	83 (18)
	30	27	49	62	598	130	97	125	243	104 (15)	72
	30	27	49	59	410	125	99	216	243	99	61
	30	30	49	55	339	125	99	615	231	94	58
	30	27	49	55	320	122	99	548	221	93	51
	30	27	57	62	304	119	99	450	208	197	45
	29	27	114	69	271	117	99	350	195	278	38
	28	26	116	81	265	112	99	325	182	397	29
	27	27	94	123	247	112	99	306 (10)	197	495	20
	26	31	85	147	228	105	94 (7)	285	214	459	14
	26	31	82	129	217	102	94	274	221	415	12
	25	29	78	115	211	99	91	268	200	357 (6)	12
	25	29	75	98	203	95	91	274	170	307	29
	26	30	72	93	194	92	91	268	213	287	25
	26 (1)	30	70	91	186	97	91	274	143	267	20
	28	28	66	90	178	95	130	300	110	244	14
	28	30	71	88	172	94	125	250	104	212	12
	28	43	69	86	165	94	121	267	90	200	26
	27	78	68	85	165	95	116 (9)	267	81	198	35
	27	92	64	82	165	96	110	267	76	151	58
	27	84	63	82	165	96	112	250	197	128	46
	—	70	61	82	158	97	131	270	176	121	44
	—	54	55	81	165	97 (6)	164	250	165	121	46
	—	49	—	81	—	97	153	—	151	—	58
	29	37	66	77	316	119	124	321	205	204	53
								D	D	D	D

	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
	NOV											
1	51	32	10	51	74 (12)	197	220	200	163	260	218	96
2	38	26 (23)	10 (15)	49	61	191	436	190	191	240	200 (13)	90
3	38	20	10	43	58	184	393	191	181	228	210	75
4	38	18	10	38	51	177	303	172	173	220	235	70
5	38	12	36	36	46	174	279	163	170 (6)	220	232	80
6	47	12	51	34	45	167	242	155	181	319	225	93
7	51	12	36	32	45	158	200	146	212	558	217	85
8	51	12	26 (22)	31	45	151	167	153	260	558	211	80
9	47	12	26	30	45	147	163	156	1174	444	204	75
10	36	15 (24)	36	28	45	138	167	151	1620	371	190	70
11	30	20	51	27	45	134	178	151	806 – 16 586	335	220	70
12	18	26	45	26 (24)	36	152	175	209	557	371	195	70
13	90 (21)	30	30	26	51	160	170	284	485	322	164	70
14	90	30	34	26	110	177	151	249	493	304	152	65
15	76	26	30	26	94	175 (21)	212	200	460	286	147	60
16	58	26	26	45	76	195	200	180	500	282	136	55
17	51	26	51	51	412	208	180	240	425	268	127	55
18	46	22	47	56 (28)	412	200	169	220	408	265	114	50
19	51	20	45	55	222	175 (43)	191	213	400	265	102	50
20	38	20	38	54 (30)	287	175	171	200	373	260	89	48
21	36	18	34	54	269	168	273	183	357	257	77	45
22	34	11	30	54	247	168	412	180 (48)	298	250	55	45
23	30	11	26 (21)	54	213	168	430	178	294	250	52	48
24	28	10	34	125	220	165	267	175	294	335	51	50
25	26 (22)	10	49	107	200	155	249	173	291	335	48	55
26	18	10	47	105	185	110	242 (44)	170	333	328	53	55
27	12	10	45	76 (21)	185	103	232	168	295	270	60	48
28	26	10	45	76	205	110	220	167	290	241	71	45
29	38	10	44	76	200	117	203	163	270	225	71	40
30	34	–	43	76	195	117	203	160	278	225	71 (62)	45
31	32	–	51	–	195	–	203	160	–	225	–	45
		–										
	42	18	36	51	147	161	236	184	405	300	137	63
	D	D	D	D					D	D	D	D

	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
	MANJHERIA + DPHR						Litre / Second x 10^{-2}					
MIN.		end of season →										
MEAN												
										432	274	92
32	59	33	33	35	44	58	142	147	154	274	161	85
44	53	58	57	78	98	101	139	162	185	345	126	82
42	119	112	91	109	133	105	212	82	101	77	62	125
80	414	169	115	231	630	155	86	182	355	183	146	62
55	68	46	55	92	114	119	97	102	84	160	209	116
47	107	64	156	64	106	68	127	235	395	729	168	146
48	53	156	221	98	241	139	115	154	226	374	269	209
48	117	70	225	173	113	72	123	132	194	186	162	96
47	53	39	42	98	126	82	99	88	116	469	247	187
52	108	62	156	91	82	341	299	177	329	191	147	325
51	276	188	57	47	66	61	74	133	348	302	153	106
74	1427	997	1208	1116	1753	1298	1513	1594	2484	3692	2124	1631
62	130	91	110	101	159	118	138	145	226	334	177	136
		29 M	37 M	66 M	77 M	316	119	124	321 C	223 C	225 C	76 C
	52 C	19 C	47 C	60 C	164 C	161	236	184	405 C	303 C	163 C	87 C
	44 C	22 C	27 C	64 C	135 C	103	68	147				
	1523	1044	1282	1240	2052	1876	1936	2049	3210	4218	2512	1794
	13	13	13	13	13	14	14	14	13	14	14	14
3	117	80	98	95	158	134	138	146	247	301	179	128

M = MODIFIED BY IRRIGATION

NOT INCLUDED

C = CORRECTED

	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APRIL
MANUHERIKIA – OPHIR (Litres Sec. $\times 10^{-2}$) – Irrigation Season												Bl
KUNDAL SAN							IRRIGATION		SEASON.			
						432	274	92	59	33	33	35
109	44	55	142	147	159	274	161	85	53	55	57	78
139	98	101	139	162	185	345	126	82	119	112	91	109
152	133	105	212	82	101	77	62	125	414	169	115	231
172	130	155	86	182	355	183	146	62	68	46	55	92
116	114	110	97	102	84	160	209	116	107	64	156	64
208	106	68	127	237	395	729	168	146	53	156	221	98
193	241	139	115	154	226	374	269	209	117	70	225	173
109	113	72	123	132	194	186	162	96	53	39	42	98
152	126	82	99	83	116	469	247	187	108	62	156	91
205	82	341	299	177	389	191	147	325	276	188	57	47
	66	61	74	133	345	302	153	106				
555	1753	1298	1513	1594	2494	3692	2124	1631	1427	997	1208	1116
55	159	118	138	145	226	334	177	136	130	91	110	101
										29 M	37 M	66
88	77 M	316	119	124	321 C	223 C	225 C	76 C	52 C	19 C	47 C	60
56	164 C	161	236	184	405	303 C	163 C	87 C	44 C	28 C	27 C	64
	135 C	103	68	147								
	2052	1878	1936	2049	3210	4218	2512	1794	1523	1044	1282	124
	13	14	14	14	13	14	14	13	13	13	13	13
53	158	134	138	146	247	301	179	128	117	80	98	95

M = MODIFIED BY IRRIGATION: NOT INCLUDE

C = CORRECTED FOR IRRIGATION

Waimakariri at Oxford 75 253

Some Notes on ratings

Rating 004 23.11.70 - 7.6.71

005

005a 7.6.71 - 10.8.71

005b 20.8.71 - 12.9.71

006 12.9.71 - present

but, use 006 less 10% from 11.9.72 provisionally

Rating curves plotted & held WRS, Dunedin.

S.C.C. Form 17A B

AGE DISCHARGE RATING TABLE IN I/IO FT

Sheet 1 of 1

Punch the information from this square only

$ RATAB I Manuherikia at Ophir 75253

23.11.70 00 00 7.6.71 16 00 P

$ 075253 P

$ 75253/004 P

No.

ing No.

west G. Ht. 0.5

hest G. Ht. 7.8

e and time start 23 / 11 / 70 00 Hrs. 00 Min.

e and time end of period. 7 / 6 / 71 16 Hrs. 00 Min.

004

FT/CUSECS

					15	30	50	70	95	0
120 34	145	175	210	245	280	315	355	395	435	1
475 134	520	565	610	660	710	760	810	860	910	2
960 285	1,015	1,070	1,125	1,185	1,245	1,310	1,375	1,440	1,505	3
575 440	1,645	1,715	1,790	1,865	1,940	2,020	2,100	2,180	2,260	4
340 610	2,425	2,510	2,600	2,695	2,790	2,885	2,980	3,075	3,170	5
265 925	3,360	3,460	3,560	3,660	3,765	3,870	3,980	4,095	4,215	6
340 1250	4,470	4,600	4,730	4,865	5,000	5,135	5,275	5,420 1535		7
0	1	2	3	4	5	6	7	8	9	
							FT	l/sec/100		
					4.2	8.4	14.2	19.8	26.9	
34	41	49.5	59.5	69.3	79.3	89	101	112	123	
34.5	147.5	160	173	187	201	216	230	244	258	
72	287	303	319	336	353	370	388	417	426	
46	466	486	507	529	550	572	595	617	640	
63	687	721	736	763	791	818	845	871	898	
027	951	980	1010	1038	1068	1098	1129	1161	1195	
32	1267	1306	1343	1383	1419	1457	1490	1535		

owriter—Operator please punch newline and haltcode at end of table and write the site number on the tape.

PROVISIONAL

S.C.C. Form 17A

STAGE DISCHARGE RATING TABLE IN ~~XXCKKK~~ METRIC

Sheet 1 of 2

Punch the information from this square only

Title $ RATAB I MANUHERIKIA AT OPHIR 75253 ?

7.6.71 16 00 to 12.9.71 ?

Site No. $ 075253 ?

Rating No. $ 75253/005 ?

Lowest G. Ht. 0.17 m

Highest G. Ht. 2.38 m

Date and time start 7 / 6 / 71 16 Hrs. 00 Min.

Date and time end of period. 12 / 9 / 71 Hrs. Min.

005

M / CUMECS

0	1	2	3	4	5	6	3.3 7	3.5 8	3.7 9
3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0	6.3	6.6
6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.0	9.3	9.6
9.9	10.2	10.5	10.8	11.1	11.4	11.7	12.1	12.5	12.9
13.3	13.7	14.1	14.5	14.9	15.3	15.7	16.1	16.5	16.9
17.3	17.7	18.1	18.5	18.9	19.3	19.7	20.1	20.5	20.9
21.4	21.9	22.4	22.9	23.4	23.9	24.4	24.9	25.4	25.9
26.4	26.9	27.4	27.9	28.4	28.9	29.4	29.9	30.4	30.9
31.4	31.9	32.4	32.9	33.4	33.9	34.4	34.9	35.4	36.0
36.6	37.2	37.8	38.4	39.0	39.6	40.2	40.8	41.4	42.0
42.6	43.2	43.8	44.4	45.0	45.6	46.2	46.8	47.4	48.0
48.6	49.2	49.8	50.4	51.0	51.6	52.2	52.8	53.5	54.2
54.9	55.6	56.3	57.0	57.7	58.4	59.1	59.8	60.5	61.2
61.9	62.6	63.3	64.0	64.7	65.4	66.1	66.8	67.5	68.2
68.9	69.6	70.3	71.0	71.7	72.4	73.1	73.8	74.6	75.4
76.2	77.0	77.8	78.6	79.4	80.2	81.0	81.8	82.6	83.4
84.2	85.0	85.8	86.6	87.4	88.2	89.0	89.8	90.6	91.4
92.3	93.2	94.1	95.0	95.9	96.8	97.7	98.6	99.5	100.4
101.3	102.2	103.1	104.0	104.9	105.8	106.7	107.6	108.5	109.4

Flexowriter — Operator please punch newline and haltcode at end of table and write the site number on the tape.

PROVISIONAL

S.C.C. Form 17A

STAGE DISCHARGE RATING TABLE IN ~~XXXXX~~ METRIC

Sheet 2 of 2

Punch the information from this square only

Title: $ RATAB I MANUHERIKIA AT OPHIR 75253 7.6.71 16 00 ?

Site No.: $ 075253 ?

Rating No.: $ 75253/005 ?

Lowest G. Ht.: 0.17 m

Highest G. Ht.: 2.38 m

Date and time start: 7/6/71 16 Hrs. 00 Min.

Date and time end of period: 12/9/71 Hrs. Min.

005

P2.

M-CUMECS

110.3	111.3	112.3	113.3	114.3	115.3	116.3	117.3	118.3	119.4
120.5	121.6	122.7	123.8	124.9	126.0	127.1	128.2	129.3	130.4
131.5	132.6	133.7	134.8	135.9	137.1	138.3	139.5	140.7	141.9
143.1	144.3	145.6	146.9	148.2	149.5	150.9	152.3	153.7	
0	1	2	3	4	5	6	7	8	9

Flexowriter — Operator please punch newline and haltcode at end of table and write the site number on the tape.

PROVISIONAL

S.C.C. Form 17A

AGE DISCHARGE RATING TABLE IN XXXXX

Sheet ..1.. of ..2..

Punch the information from this square only

S RATAB I ..... MANUHERIKIA at OPHIR ..... 75253 .....

12 9 71 15 00 .....P

No. $ ..... 075253 ..... P

ng No. $ ..... 75253/006 ..... P

est G. Ht. ..... 0.06 m .....

est G. Ht. ..... 2.46 m .....

Q = litres/sec (Multiply by 100)

..12/..9../..71 ..15... Hrs..00.. Min.

end time start

end time end of period. ...../...../..... .....Hrs..... Min.

006

See note... attached.

0	1	2	3	4	5	6	7	8	9
						9	10	11	12
7	15	17	19	21	23	25	28	31	34
37	40	43	46	50	54	58	62	66	70
74	78	82	86	90	95	100	105	110	115
20	125	130	135	140	145	150	155	160	165
70	175	180	185	190	195	200	205	211	217
23	229	235	241	247	253	259	265	271	277
83	289	295	301	307	313	319	325	331	338
45	352	359	366	373	380	387	394	401	408
15	422	429	437	445	453	461	469	477	485
93	501	509	517	525	533	541	549	557	565
23	582	591	600	609	618	627	636	645	654
53	672	681	690	699	708	718	728	738	748
58	768	778	788	798	808	818	828	838	848
58	868	878	889	900	911	922	933	944	955
56	977	988	999	1010	1021	1032	1043	1054	1065
76	1087	1099	1111	1123	1135	1147	1159	1171	1183
95	1207	1219	1231	1243	1255	1267	1279	1291	1303
15	1327	1339	1351	1364	1377	1390	1403	1416	1429

owriter—Operator please punch newline and haltcode at end of table and write the site number on the tape.

0 1 2 3 4 5 6 7 8 9

PROVISIONAL

S.C.C. Form 17A B2

GE DISCHARGE RATING TABLE IN METRIC ~~IMPERIAL~~

Sheet 2 of 2

Punch the information from this square only

$ RATAB I MANUHERIKIA at OPHIR 75253

12.9.71 15.00 P

$ 075253 P

$ 75253/006 P

006

No.

ng No.

est G. Ht. 0.06 m

est G. Ht. 2.46 m

Q = litres/sec (Multiply by 100)

P2.

and time start 12/9/71 15 Hrs. 00 Min.

and time end of period. /// Hrs. Min.

See note... Method.

442	1455	1468	1481	1494	1507	1520	1533	1546	1559
572	1585	1598	1612	1626	1640	1654	1668	1682	1696
710	1724	1738	1752	1766	1780	1794	1808	1822	1836
850	1864	1878	1892	1906	1920	1935	1950	1965	1980
995	2010	2025	2040	2055	2070	2085	2100	2115	2130
145	2160	2176	2192	2208	2224	2240			
0	1	2	3	4	5	6	7	8	9

Writer—Operator please punch newline and haltcode at end of table and write the site number on the tape.

JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
RATING		1006 – 10%.									
	0.	1	2	3	4	5	6	7	8	9.	
FT.											
0.			8	12	18	25	32	40	47	54	6[illegible]
1.	71	82	96	109	122	135	150	165	179	194	[illegible]
2.	206	221	238	256	269	292	310	328	346	365	
3.	382	402	423	444	464	483	503	530	557	584	
4.	610	637	664	692	720	749	779.				

$l/sec \times 10^{-2}$

P.W. 377 (Rev. 10/70) (CALCULATION SHEET)

Ministry of Works New Zealand

Office WES

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Job No. File

Description COMPARATIVE GAUGINGS UNCORRECTED

Sheet No. 2

PROJECT MANUHERIKIA WATER RESOURCES

Date / No.	MANUHERIKIA. Omarama Bridge	St. Bath Bridge	Becks Br.	Ophir	Other? Galloway	TRIBUTARIES Dunstan Ck.	Lauder Ck.	Thomsons Ck.	Podmore D/S gorge	Ophir Ck.	Notes
22/2/71 1	8.8 / 33		4.1 / 16	126 / 100	5 / 19	1.1 / 4	0.5 / 2	0.8 /	0.6 / 3	0.4 / 2	Litres/sec x10⁻²
8/7/71 3				123.2 / 100						8.5 ✓ / 7	
30/7/71 5				101.2 / 100 ✓			6.5 ✓ / 6				
17/8/71 7			49.5 ✓ / 53	94 ✓ / * 100				4 ✓ / 4	17.3 ✓ / 18	5.2 ✓ / 6	* new recorder
26/8/71 9	14.7 ✓ / 13		57.3 ✓ / 50	116 ✓ / * 100			8 ✓ / 7		39.8 ✓ / 27	✓	
16/9/71 10				262.9 ✓ / 100						8.8 / 3 ✓	
3/11/71 14				119 ✓ / * 100			3.7 / 3 ✓	4.6 / 4 ✓	3.4 / 3 ✓		
9/11/71 15				85.2 ✓ / 100			2.3 / 3 ✓	4.6 / 5 ✓	2.3 / 3 ✓	6.2 / 7 ✓	
19/11/71 16				540.5 ✓ / 100							
3/12/71 17				80.5 ✓ / 100						5.4 / 7 ✓	
8/12/71 18	29.4			62.6 ✓ / 100			4.4 / 7 ✓	2.6 / 4 ✓	3.0 / 5 ✓	4.2 / 7 ✓	

~~indicates~~ indicates period where flows are modified by irrigation draw-off/races etc.

2,000 pads/10/71—2358 D

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Job No. File

Description COMPARATIVE GAUGINGS UNCORRECTED

Sheet No. 3

PROJECT MANUHERIKIA WATER RESOURCES

Date / No.	MANUHERIKIA. Omarama Bridge	St. Bath Bridge	Beeks Br.	Other? Ophir	TRIBUTARIES Duncan Ck.	Lauder Ck.	Thomsons Ck.	Podmore D/S Gorge	Duffys Ck.	Notes
14/12/71	21.16			14.3		2.5	4.1	1.3	2.16	Litres/sec ×10⁻²
20	46			100		5	9	4	6	
13/1/72				38			5.3		2.7	
21				* 100			14		7	* from rotodike
25/1/72				33.4			3.4	2.4	1.9	
22				100			10	7	6	
2/2/72	13.2			34.9		2.0	3.4	2.1	1.6	
23	38			100		6	10	6	5	
10/2/72	15.3			43.7		1.8	1.9	1.9	1.2	
24	44			100		5	5	5	3	
2/3/72				26.1			2.8		0.8	
25				100			11		3	
8/3/72	13.6			26		1.8		2.3		
26	92			* 100		7		9		
23/3/72				37		2.5	6.8	1.2	3.4	
27				100		7	18	3	9	
12/4/72	12.6			39.1		3.3	8		5.3	
28	32			100		8	20		14	
19/4/72			30.9	56		5.8		3.3	4.4	
29			55	* 100		10		6	8	
20/4/72				54		4.9	9	3.2	4.9	
30				* 100		9	17	6	9	

? See D2.

B21

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Job No. .... File ....
Description COMPARATIVE GAUGINGS
UNCORRECTED

Sheet No. 4
PROJECT MANUHERIKIA WATER RESOURCES

Date / No.	MANUHERIKIA: Omarama Bridge	St. Bath Bridge	Becks Br.	Ophir	Other ?: Falls	TRIBUTARIES: Dunstan Ck.	Lauder Ck.	Thomsons Ck.	Poolburn D/S gorge	Chatto Ck.	Notes
27/9/72 31		22.8 ✓ / 30		77.3 ✓ / 100					5.5. / 8		litres/sec ×10⁻²
1/5/72 32				74 ✓ * / 100				7.4 / 10		8.6 / 12	* from recorder.
15/6/72 37				175 * / 100				1.3 / 1		10.1 / 6	* from recorder
19/7/72 42				191 * / 100			12.4 / 7	1 / 5		6.8 / 3.5	* from recorder
26/7/72 44				242 * / 100			15	1.3		8.6	
23/8/72 48				183.7 / 100				1 / 4			
5/9/72 50				170 * / 100			15.5 / 9				* from recorder
2/11/72 58				185.5 ✓ / 100							
30/11/72 62		41.7 ✓ / 50		71 ✓ * / 100				3.2 ✓ / 4	3.2 ✓ / 4	2.1 ✓ / 3	* from recorder
29/1/73 64				28 ✓ * / 100			0.7 / 3	1.4 / 5	1.9 / 7	0.6 / 2	* from recorder.
22/2/73 65				20 ✓ * / 100			0.7 / 4	0.9 / 5	1.2 / 6	0.8 ✓ / 4	* from recorder

} See D2.

P.W. 377 (R... 10/70)

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Job No. File

Description COMPARATIVE GAUGINGS
UNCORRECTED

Sheet No. 5

PROJECT MANUHERIKIA
WATER RESOURCES

Date / No.	MANUHERIKIA: Omakau Bridge	St. Bath. Bridge	Becks Br.	Ophir	Other?: Falls	TRIBUTARIES: Dunstan Ck.	Lauder Ck.	Thomsons Ck.	Poolburn D/S Gorge	Chatto Ck.	Notes
2/4/73 68				12 ✓ * / 100							litres/sec x10^-2 *corrected
				100							
				100							
				100							
				100							
				100							
				100							
				100							
				100							
				100							
				100							

? see D2.

Ministry of Works New Zealand

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Job No. .... File ....
Description: COMPARATIVE GAUGINGS
DO NOT REQ. CORRECTN

Sheet No. 1
PROJECT: MANUHERIKIA WATER RESOURCES

Date / No.	MANUHERIKIA: Omarama Bridge	St. Bath Bridge	Becks Br.	Ophir	Other ?	TRIBUTARIES: Dunstan Ck.	Lauder Ck.	Thomsons Ck.	Poolburn D/S gorge	Chatto Ck.	Notes
28/2/22	29.7 / 18			168.3 / 100		26.3 / 16					
4/3/22	85.8 / 34			255.6 / 100		51.6 / 20	8.6 / 3	11.9 / 5	4.4 / 2		corrected for missing recs ✓
12/4/22		88.4 / 33	184.5 / 80 ¢	/ 100		43.9 / 22	7.6 / 3	4.5 / 2	3.4 / 1½		Becks assumed as 80 ¢
23/5/22	135.8 / 21	206.3 / 33	555.4 / 88	630.9 / 100		132.5 / 21					corrected for missing recs ✓
19/6/22		61.2 / 28	152.9 / 69	221.6 / 100		41.6 / 19					
?		176 / 36	256 / 93	276.7 / 100		857 / 31		6.0 / 2			corrected for missing recs. ✓
14/12/22		378.7 / 50	650 / 85	761 / 100		159.2 / 21					
6/2/23		272.2 / 42	416.7 / 64	654.5 / 100		110.6 / 17			76.3 / 12		
22/3/28		67.0 / 53	95.5 / 75	127 / 100		17.1 / 13					
				/ 100							
				/ 100							
											NB. CUSECS

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Checked / /19

Job No. .... File ....

Description
COMPARATIVE GAUGINGS
CORRECTED

Sheet No. 2A

PROJECT
MANUHERIKIA
WATER RESOURCES

Date / No.	MANUHERIKIA Omarama Bridge	St. Bath Bridge	Becks Br.	Ophir	Other ?	TRIBUTARIES Dunstan Ck.	Lauder Ck.	Thomsons Ck.	Poolburn D/S Gorge	Chatto Ck.	Notes
22/2/71				/ 100							[illegible] correct.
8/7/71				123.2 / 100						8.5 / 7	
30/7/71				101.2 / 100			6.5 / 6				
17/8/71			49.5 / 53	94 * / 100				4 / 4	17.3 / 18	5.2 / 6	* [illegible] corrected
26/8/71	14.7 / 13		57.3 / 49	116 * / 100			8 / 7		30.8 / 27		*
16/9/71				263 / 100						8.8 / 3	
3/11/71				150 * / 100			6.7 / 4	9.6 / 6	3.6 / 2		*
9/11/71				115.2 / 100			4.7 / 4	7.3 / 6	2.3 / 2	7.6 / 7	
19/11/71				549 / 100							
3/12/71				105 / 100						6.8 / 7	
8/12/71	29.4 / 35			84.6 / 100			5.4 / 6	5.6 / 6	3.0 / 4	5.6 / 6	

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Job No. .... File ....
Description: COMPARATIVE GAUGINGS
CORRECTED

Sheet No. 3A
PROJECT: MANUHERIKIA
WATER RESOURCES

Date / No.	MANUHERIKIA: Omarama Bridge	St. Bath Bridge	Becks Br.	Ophir	Other?: Falls	TRIBUTARIES: Dunstan Ck.	Lauder Ck.	Thomsons Ck.	Poolburn D/S gorge	Chatto Ck.	Notes
14/12/71 20	21.6 / 32			67.3 / 100	33 / 49		3.5 / 5	7.1 / 10	1.9 / 3	4.2 / 6	
13/1/72 21				49 * / 100	21 / 43			7.3 / 15		2.7 / 5	* recorders corrected
26/1/72 22				44.4 / 100	21 / 47			4.4 / 10	2.4 / 5	3.5 / 7	
2/2/72 23	13.2 / 34			38.9 / 100	11 / 28		3.0 / 8	5.4 / 11	2.1 / 5	3.2 / 8	
10/2/72 24	15.3 / 40			38.7 / 100	5 / 13		2.8 / 7	5.9 / 15	1.8 / 5	2.2 / 6	
2/3/72 25				27.1 / 100	19 / 70			5.8 / 21		2.4 / 9	
8/3/72 26	13.6 / 41			33 * / 100	20 / 60		3.8 / 11		2.3 / 7		*
29/3/72 27				44 / 100	16 / 36		2.5 / 6	7.8 / 18	1.2 / 3	4.4 / 10	
12/4/72 28	12.6 / 27			47.1 / 100	8 / 17		4.3 / 9	8.0 / 17		6.3 / 13	
18/4/72 29			36.9 / 59	62 * / 100	20 / 32		5.8 / 9		3.3 / 5	5.4 / 9	*
20/4/72 30				60 * / 100	20 / 33		4.9 / 8	9.0 / 15	3.2 / 5	5.9 / 10	*

P.W. 377

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Job No. File.
Description COMPARATIVE GAUGINGS CORRECTED

Sheet No. 4A
PROJECT MANUHERIKIA WATER RESOURCES

Date / No.	MANUHERIKIA: Omarama Bridge	St. Bath Bridge	Becks Br.	Ophir	Other?: Ells	TRIBUTARIES: Dunstan Ck.	Lauder Ck.	Thomsons Ck.	Poolburn D/S Gorge	Chatto Ck.	Notes
27/4/72 31		49.8 / 48		104.3 / 100	41 / 39				5.9 / 6		
1/5/72 32				111 * / 100	37 / 33			7.4 / 7		8.6 / 8	* recorded corrected
15/6/72 37				175 * / 100				1.3 / 1		10.1 / 6	
19/7/72 42				191 * / 100			12.4 / 6	1 / 1/2		6.8 / 4	
24/7/72 44				242 * / 100			15 / 6	1.3 / 1/2		8.6 / 4	
22/8/72 48				183.7 / 100				1 / 1/2			
5/9/72 50				170 * / 100			15.5 / 9				
2/11/72 58				200.5 / 100							
30/11/72 62		41.7 / 41		102 * / 100				6.2 / 6	3.2 / 3	3.4 / 3	
29/1/73 64				30 * / 100	20 / 67		3.7 / 12	4.4 / 15	1.9 / 6	1.9 / 6	
22/2/73 65				21 * / 100	5 / 24		3.7 / 18	2.9 / 14	1.2 / 5.7	2.3 / 11	

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Description COMPARATIVE GAUGINGS CORRECTED

Sheet No. 6A

PROJECT MANUHERIKIA WATER RESOURCES

Date / No.	MANUHERIKIA: Omarama Bridge	MANUHERIKIA: St. Bath Bridge	MANUHERIKIA: Becks Pbr.	MANUHERIKIA: Ophir	Other ?: Falls	TRIBUTARIES: Dunstan Ck.	TRIBUTARIES: Lauder Ck.	TRIBUTARIES: Thomsons Ck.	TRIBUTARIES: Poolburn D/S Gorge	TRIBUTARIES: Chatto Ck.	Notes
2/4/73 68				11.5 * / 100	.16 / ?						* recorder corrected
				/ 100							
				/ 100							
				/ 100							
				/ 100							
				/ 100							
				/ 100							
				/ 100							
				/ 100							
				/ 100							
				/ 100							

MANUHERIKIA ABOVE CONFLUENCE WITH CHATTO CREEK CATCHMENT = 2273 km²

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Job No. File
Description CONTRIBUTING CATCHMENT AREAS

Sheet No.
PROJECT MANUHERIKIA W.R.

		Δ	sq. miles	%
MANUHERIKIA				
OMARAMA RD		64.48	64.48	13%
FALLS DAM		40.51	104.99	21%
LOOP RD		8.50	113.49	23%
BLACKSTONE INTAKE		40.59	153.98	
OMAKAU INTAKE		6.53	160.61	
BECKS	G	11.73	172.34	35%
DUNSTAN CK.				
DAM SITE		63.40	63.40	18%
BROWNS CK	G	22.83	86.23	
DUNSTAN INTAKE		28.70	114.93	
BECKS		15.17	130.10	27%
MANUHERIKIA AT BECKS			302.44	61.5%
BECKS CK		13.65		
(LAUDER CK AT GRAVEL PIT)	G	(35.62)		(7.5%)
LAUDER CK.		59.98		
MUDDY, DRYSDALE, LEFT BANK		67.05	99.4	
(THOMSONS AT MATAKANUI)	G	(30.00)		(6%)
THOMSONS CK.		48.46		
MANUHERIKIA AT OPHIR	G		491.58	100%
(CHATTO CK AT S.H.85)	G	52.58		
CHATTO CK		68.01		(11%)
LEFT BANK		26.28		
MANUHERIKIA AT GALLOWAY			586.87	119%

N.B. EXCLUDING IDA VALLEY

G = GAUGING SITE

4029

ANNUAL YIELDS : Years ending April.

Season	Ophir l/sec. x 100	Ml x 10^3 Yield	20% Dunstan	37% Fells	57% Bott	30% Tnbs.
20/21	109	344	69	127	197	103
21	139	438	87.5	162.5	250	131.5
22	152	479	96	177.5	273.5	144
23	172	542	108.5	200	308.5	162.5
24	116	366	73	135.5	208.5	110
25	208	656	131	242.5	373.5	197
26	193	608	121.5	225	346.5	182.5
27	109	344	69	127	196	103
28	152	479	96	177.5	273.5	144
29/30	205	647	129.5	240	369	194
71/72	138	435	87	161	248	130.5
72/73	156	492	98.5	182	280.5	147.5
Av.	153	483	96.5	178.5	275	145
Drought.	105	331	66.2	122.5	188.5	99.25

Wett Report 189 000 Ml.
Worst Season 55/56 18,300 Ml.

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Description .....
ANNUAL YIELDS

PROJECT .....
MANUHERIKIA

Sheet No. ..... B 5/6

IRRIGATION SEASONS : YIELDS (200 Dep.)

Season	Option l/sec x100	Ratio to Corresp. yr.	Mil x 10^3 Yield	20% Dunstan	37% Falls	57% Both	30% Tribs
19/20	137	N/A	237	47	87		
20	109	1.00	188.5	37.7	70		56.5
21	141	1.01	244	48.5	90		73
22	185	1.22	320	64	108		96
23	93	0.54	161	32.2	60		48.5
24	125	1.08	216.5	43.3	80		65
25	224	1.08	388	79.6	147		116
26	205	1.06	355	71	131		106.5
27	97	0.88	167.5	33.5	62		50
28	190	1.25	329	66	122		98.5
29/30	176	0.86	305	61	113		91.5
71/72	100	0.73	173	34.6	64		
72/73	102	0.65	176.5	35.3	66		
Av.	145	0.95	250	50	92.5	142.5	75
Drought.	83	(0.79)	143	28.5	53	81.5	40 *

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Description .... PROJECT ....
SEASON YIELDS MANUHEAHEA

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Job No. .... File ....
Description WINTER YIELDS

Sheet No. [illegible]
PROJECT MANUHERIKIA

WINTER YIELDS : May - Sept.

Season	(Ophir - M l x 10³) Annual	–	In Season	Winter Yield	20% Dunstan	37% Falls	30% Tricks
			237				
20/21	344	–	189	155	31	57	47
21	438	–	244	194	39	72	59
22	479	–	320	159	32	59	48
23	542	–	161	381	76	148	113
24	366	–	217	149	50	93	75
25	656	–	388	268	54	100	81
26	608	–	355	253	51	94	77
27	344	–	168	176	35	65	53
28	479	–	329	150	30	56	45
29/30	647	–	305	342	68	133	102
71/72	435	–	173	262	52	96	77
72/73	492	–	177	315	63	107	95
AV	483		250	233	47	87	71
Drought							

APPENDIX C - STORAGE CHARACTERISTICS

Some Notes.

1. Falls Reservoir S 125 : 620924

Refer to S 125/6 (20 ch. to 1 in.) and to Aerial Plan 669A (Alexandra A2104), (5 ch. to 1 in.). Also see Dn 5229 (60 ft to 1 in.) for dam site. Gains and evaporation calculations (J.D. Watt and others) in foolscap notebook.

Existing dam built 1935-36 with reinforced concrete "glory hole" spillway crest of 1840'. Raised to 1842' in 1955. Storage capacity at 1842' is 11,000 Ml approx. Under present operations reservoir is drawn fully down before the end of each irrigation season and spills most of the winter.

Concrete cut-off wall on upstream face of dam is designed for pressures allowing raising to 1900'. However, spillway would be extremely awkward to raise 58 ft, involving the construction of a smilar bell-mouth and complicated buttressing above and below water level with minimum prejudice to the operation of the present spillway and to irrigation operations. The alternative would be an expensive r.c. spillway channel over the downstream face of the raised dam and down the gorge.

Construction of a new dam to 1940'-1950' just downstream of the existing structure would allow a much simpler and cheaper spillway involving only some earthworks and the loss of some rough grazing and utilising, in the main, the watercourse of Shamrock Gully. (Refer to Fig. VI). This spillway it is estimated would carry water on a return period of approx. 5 years and a maintenance allowance for loss of pasture and remedial earthworks would have to be allowed for.

The site is an ideal one and should be exploited fully. Indeed the additional input ex Dunstan raises the optimum size to 1960'. The raising of a 30' structure at Shamrock Gully saddle to achieve this has not been investigated however.

2. Dunstan Creek - Gorge Site (S125 : 475048)

The site for which the storage curve is plotted is at the northern entrance to the gorge and is in schist country. The degree of fracturing is unknown, but it is reasonable to assume a massive gravity structure. constructed from that material could be built in excess of 200'. Spillway provision could be made easier by a shoulder on the right bank; this would help to minimise structural concrete work.

The basin at present runs cattle on summer grazing and is difficult of access either following up the creek from Cambrian (27 fords) or from the Lindis (over 3000' passes).

Storage curve is plotted from 20 ch. to 1 in. sheets (Fig. III).

3. Cambrian (S125 : 519958)

This site was briefly considered in view of the fact that the proposed Race No. 8 from Dunstan Ck to Falls Dam would provide a large quantity of excavation adjacent to this location which could very cheaply be used to form a dam or weir.

The economics of providing additional storage would depend largely on the findings of investigations along the scree face above the site but it is certain that should the proposed Race No. 8 be constructed some 0.5×10^6 m^3 of material would be available even if only to provide a small weir for additional storage for local use. The flats are, however, a valuable part of farm units in that area.

As Race No. 8 would divert a very large proportion of the Dunstan Creek yield, it is unlikely that a large structure would be worthwhile, however the 30' high structure is presented in the estimates shown in Appendix E for comparison only.

4. Pennyweight (S125 : 500850)

A small site for additional storage which could be topped up by the Dunstan-Falls Race, can be found between the terraces above the Manuherikia-Pennyweight Gully confluence.

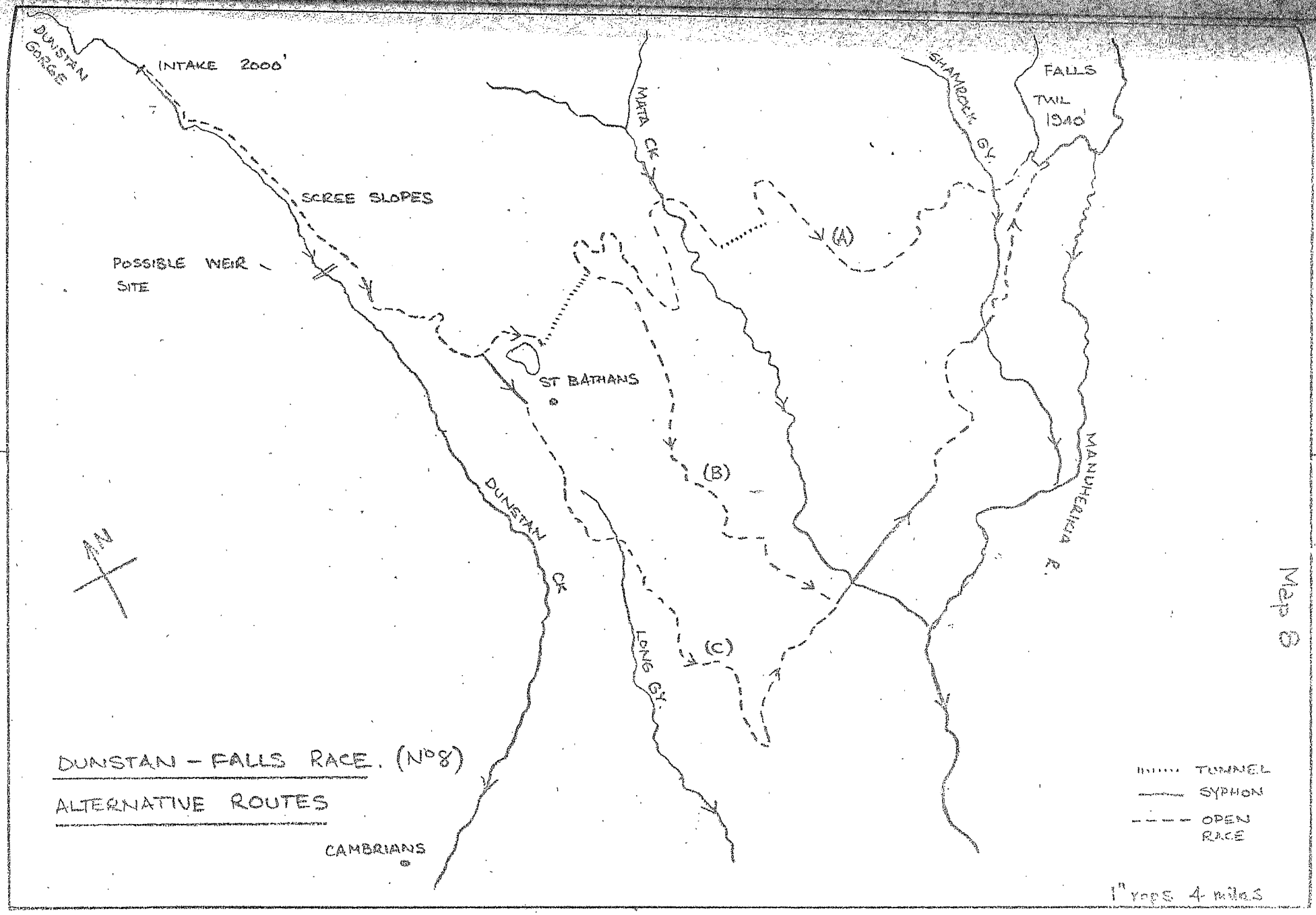
5. Thomson's Creek

Two possible sites, investigated as early as the 1930's both shown immediately to have prohibitive costs.

6. Dunstan to Falls Race

As an alternative to expensive storage in the Dunstan it could be possible to convey winter flows ex Dunstan to Falls.

With Falls raised to say 1940', intake in the Dunstan would have to be at around the 2000' level in the Dunstan, this is about the exit from the Gorge.



DUNSTAN – FALLS RACE. (No 8)

ALTERNATIVE ROUTES

Map 8

There is evidence of small races having served the diggings at St Bathans but the first 15,000' through difficult scree faces would be a major problem in the construction of a large race of 3 cumec. capacity with vehicle access berm.

Detailed investigations would be required to ascertain the depth to bedrock under the loose faces and if this is minimal then a narrow race of rectangular section (suitable for machine cleaning) would seem to be in order. However, the quantity of loose material could be of the order of ½ million m^3 and it was this that prompted the investigation of an adjacent storage dam/weir.

Various alternative routes are possible and 3 were roughed out on contour plans costing variously $0.7M to $1.0M. The cheapest route is the longest and follows contours around Gidding Downs with a large syphon at Mata and Shemrock Creeks. Refer Map 8, Route (C).

Examination of the estimated flows in Dunstan Creek show that a race of 3 cumec. size would be appropriate and would convey an estimated 40,000 Ml. each winter to Falls. Maintenance could be carried out in summer.

- D -

APPENDIX D

P.W. 74/61/1/4
P.W. 15/3/1
29 October 1973

MANUHERIKIA WATER RIGHTS

Some Notes

The following notes are the result of a search of the records of the Warden's Courts of Blacks, Naseby, Clyde, Cromwell and Alexandra, now held by the Otago Regional Water Board.

In an effort to clarify the position as regards water rights in the Manuherikia and its tributaries subsequent to notification of uses under the new Act, an attempt was made to trace all the rights listed in the following sources:

1. List of notifications of use, Otago Catchment Board, April 1973.
2. List of rights for operational priority, R.E. Alexandra, undated
3. List of notification of existing use for irrigation, M.O.W., March 1969, File P.W. 74/61.
4. Alexandra file 33/2 periods December 1921 to August 1930 and February 1936 to October 1938 (intermediate file missing) held at W. & S. Dunedin, in particular lists dated 5/12/23 and 16/1/24, but also individual items of correspondence concerning private rights.

All right numbers mentioned in the above sources were traced through the registers and enabled the following tables to be drawn up. The search was not an exhaustive search of the registers and there may be other rights still current in the registers, but which have not been notified, and therefore may not be recognised under the new Act as current privileges.

The investigation covers all "taking" rights and privileges in the Manuherikia Valley with the exception of all points on the Poolburn upstream of its confluence with the Manuherikia River.

ining Privilege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
				752630	
R 415	L.L. Thomson & I.L. Thomson	23.8.1905	3	Manuherikia R. S.134:401652	
R 747B	J.K. Leask, E.C. Nelson & M.A. Nelson	14.12.1912	2	S.134:402652?	
R 915C	Crown		100	S.134:330609	Manuherikia Scheme
R 4363	Crown		12	S.125:564828	Blackstone Hill Race
R 5785	Crown		80	S.134:532797	Omakau Scheme
W Act	Crown		15	S.134:250522	Galloway Scheme
R 442B				Notified, but previously struck off	
				752631	
R 1700	J.W.M. Sanders		2	Bickerstaff Ck.	
R 2175	I.B. Sanders		0.5	Graveyard Gully	
R 179,181	Crown		90	Manorburn	Ida Valley Scheme
R 2060	Crown		8	Manorburn	Galloway Scheme
R 519A	J.W.M. Sanders & Alex. Boro.		2	Mt Campbell Ck.	B also exists
R 517A	J.C. Sanders & Alex. Boro.		2	Speargrass Ck.	B also exists
R 2231	J. Sanders		3.5	Speargrass Ck.	

ining Privilege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
				752632	
? 1124C	Crown	6.4.27	4	S.134:216508 Scrubby Gully Un-named Ck.	Manuherikia Scheme
.W.Act	Crown		2W	McArthurs Ck. S.133.200549	
? 450C	G.A. Kelliher	21.6.02	1	Springvale Ck.	
? 319(2777)	Crown		3	Brassknocker Ck. S.134:242552	Manuherikia Scheme
.W.Act	Crown		5	Brassknocker Ck. S.134:245543	Manuherikia Scheme
? 519B	Crown		10		Lands & Survey Dept
? 1540	Crown		10	Chatto Ck. S.134:280633	Manuherikia Scheme "Mining only" but Crown not bound by Mining Act. Subject of dispute at time of transfer.
? 902	J.D. & B.F. Duncan	26.6.13	1	Younghill Ck. S.134:270572	
?.1001A	Crown	6.1.1864	6	Younghill Ck. S.134:262591	See also Laheys Ck and Campbells Ck. Lease to Moutere Station Ltd.
?.1125C	Crown	11.5.27	5	Younghill Ck S.134:266584	Manuherikia Scheme
			7.5 cusec. days per month	Trib.Younghill Ck. S.134:254605	Now Right 577

lining Privilege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
R.855C	Moutere Station Ltd	1.4.22	1	Turnipy Ck. S.134:215641	Renewed 7.2.67.
R 512	Crown	28.6.06	10	Campbells Ck	Lands & Survey Dept
R 1001A	Crown	21.1.1864	4	Campbells Ck. S.134:220653 S.134:230653 S.134:232653	See also Laheys and Younghill Cks. Leased to Moutere Station Ltd with certain rights under Deed 3068 held by M.D.Cook
R 704A	J.L. Ferris	27.6.03	1	Metcalfe's Gully	
R 514B	Crown	28.6.06	10	Lahey's Ck.	Lands & Survey Dept
R 1001A	Crown	16.4.1864	4	Lahey's Ck.	Leased to Moutere Stn Ltd. See also Younghill & Campbells Cks.
R 517B	Crown	28.6.06	2	Ned's Ck.	Lands & Survey Dept
R 1180	Matakanui Station Ltd		3	Ned's Ck.	
R 1182	Matakanui Station Ltd		2	Ned's Ck.	
R 521B	Crown	28.6.06	5	Middle Ck	Lands & Survey Dept

ote: Creek shown as Buster Ck on NZMS 1 inch to 1 mile maps is in fact Middle or Shepherd's Ck. Buster Ck. is ot the name applying only to the South Branch of Shephers and is shown in the wrong location. The North ght Branch of Shepherds Ck, in addition to being known as Middle Ck is also believed to be Centre Ck.

R 634C	W.S. McIntosh	1.9.06	2	Middle Ck S.134:242674 Centre Ck.	Now right No.454

D 4

ıing Priv- ege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
.516	Crown	28.6.06	1	Coal Ck S.134:266709	Omakau Scheme Also notified by L. & S. Dept as 5.
.518B	Crown	28.6.06	3	Trib. Coal Ck. S.134:277712	Omakau Scheme Also notified by L.& S Dept
520	Crown	28.6.06	10	Sheepshead Ck	Lands & Survey Dept
507	C.N. & J.W.G. White	2.5.06	2	Scotts Ck	
515B	Crown	28.6.06	2	Scotts Ck S.134:284724	Omakau Scheme Also notified by L. & S. Dept
301	Crown	6.3.89	1	Devonshire Ck. S.134:289727	Omakau Scheme via Vincent County Cl Formerly for 8 cusecs
1191	G.W. Naylor & E.B. Naylor	29.3.30	3	Devonshire Ck.	Renewed 7/11/72.
817	(A.E. Marslin)		3	Insleys Gully	Struck off.
576	C.N. & J.W.G. White		2	Expired	
580	C.N. & J.W.G. White		1	Expired	
				752634	
172B	E.F. Donnelly	11.11.01	4	Blackbush Ck	
178B	E.F. Donnelly	18. 3.91	2	Blackbush Ck S.134:299746	

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lining Privilege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
R 184B	E.J. Berry, G. Harvey F.B.P. Donnelly, T. Duggan G.C. Wilson, S.D. Clouston etc.	2.11.1865	8	Blackbush Ck.	Includes permission to run water under WR.4076, 4077 and 4079.
.W.Act	Crown		2	Blackbush Ck S.134:325721	Omakau Scheme
.W.Act	Crown		2	Blackbush Ck S.134:315736	Omakau Scheme
R 182B	Crown	20.6.1867	2	Candler's Ck	Not notified, not use
R 679B	G.C. Wilson	16.11.09	2	Sailor Jack's Ck	
R 680B	G.C. Wilson	27.11.09	1	Sailor Jack's Ck	
R 186B	E.F. Donnelly	26.5.1866	2	Brickfield Ck	
R 188B	E.J. Berry	8.8.1865	2	Brickfield Ck	Includes permission t run water taken under WR 4078.
R 156B	E. & R. Huddlestone		Notified but previously struck off		
R 190B	T. Duggan		1	Donnellys Gully	Renewed 1944 for 42 years.
-	C.G. Wilson		?	Trib.Long.Gully S134:333703	Not traceable
R 139B?	H.M. Ferry		1	Smoker's Ck	Dredging Claim surren dered absolutely.
R 289	Crown				Omakau Scheme
R 295	Crown			Thomson's Ck	Omakau Scheme
R 1464	Crown	12.7.34	15	S.134:327781	Omakau Scheme
R 303B	Crown				Omakau Scheme Formerly for total 20 cusecs.

ining Privilege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
R 961	Crown		2	Thomson's Ck	Notified by T.F. Stafford and not by Crown
R 977	D. Fraser		Notified but previously lapsed. Covenant to Crown not exercised.		
R 1165	T.J. Quigley		Notified but previously surrendered absolutely		
R 1240 } R 306 }	Crown	23.9.20 7.3.88	10	Thomson's Ck S.134:363696	(see 963) Omakau Scheme
.W.Act	Crown		1	S.134:358755	Omakau Scheme
.W.Act	Crown		3	S.134:367724	Omakau Scheme
				752635	
R 378B	O.O.Gordon-Glassford	29.5.65	2	Shepherd's Gully Drybread?	
R 446	O.McI.Gordon-Glassford	4.2.91	2	Rocky Gully	
R 219(213)	Crown	4.5.87	1	Muddy Ck S.134:377762	Omakau Scheme Formerly for 2 cusecs
R 432B	J.T. Moran		6?	Muddy Ck	
R 600B	J.T. Moran		2	Trib.Muddy Ck	Drainage Channel only
60/99	Crown				Alluvial Claim only
R 382B	O.McI. Gordon-Glassford	24.11.1865	3	Trib.Lauder Ck	1st
R 488	R.V. Wilson	28.5.1869	4	Chimney Gully Trib.Lauder Ck	2nd Partially forfeited. WR 1266,10.8.38
R 490	G.S. Hamilton	24.5.1872	4	Chimney Ck Trib. Lauder Ck	3rd

Mining Privilege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
MR 7714	Crown	6.3.1889	4	Lauder Ck.	4th Ex 509B & 1096B
MR 380B	O.M. Glassford	28.5.1889	3	Irishman's Ck Trib.Lauder Ck	5th
MR 386B	J. Clouston	6.11.1889	2	Lauder Ck	6th Run in 432B
MR 271	Crown	9.3.1903	6	Lauder Ck	7th
MR 432B	Moran Brown & Clouston	24.11.1905	6	Lauder Ck.	8th See 386B above
MR 478B	Brown Moran Corrigal	17.2.06	2	Trib.Lauder Ck	9th Expires 22.4.74
MR 513B	Crown	28.6.06	15	Lauder Ck	10th Omakau Scheme
MR 590	A.N.A. Brown	27.6.07	2	Lauder Ck	11th
MR 611B	A.J. Alexander	21.11.07	4	Lauder Ck	12th
MR 631	A.S. & F.J.Samuels	11.5.08	2	Lauder Ck	13th
MR 642	-	-	Struck off		-
MR 756	-	17.6.18	Struck off		-
MR 1067	Leith	25.3.24	1	Lauder Ck	14th
MR 1255B	G.S. Hamilton		0.125 domestic	Mellors Ck	Also known as Millers
MR 2013N	R. Wilson		2	Mellors Ck	
MR 2122N			2	Mellors Ck S.134:452772	Now Right No.54 Struck off N. registe
MR 492	N.M. Hamilton		3	Becks Ck	Also known as "No.2 Ck" Now Right No.216
MR 1338	H.F. Passmore		Struck off		Branch Race only
MR 3034			1	S.125:432841 Becks Ck	Now Right 475

ning Privilege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
W. Act	Crown		2	Becks Ck S.134:485765	Omakau Scheme
W. Act	Crown		4	S.134:483778	Omakau Scheme
				752638	
4384N	G.F. Waldron and Z.M.Waldron		3	Browns Gully S.125:514949	
1531N)			2	Donald Stuarts Ck S.125:466879	
1532N)	S.E.J.W. Harley		2	S.125:466879	
1533N)			2	S.125:466879	
?	C.W. Harrex		2.5	Firewood Ck	May be Donald Stuarts Ck
1889N	Crown 1	1.10.72	6	Dunstan Ck	Near Becks
641	(O'Hara) -		6	Dunstan Ck	Struck off
633	(O'Hara) -		6	Dunstan Ck	Struck off

te

attie surrendered his 10? heads to L. & S. in early 1930's, on condition that he received 1½ from the wns Race. Correspondence on file P.W.33/2 (Alex) indicates that Downs Settlers were "promised" 10 + 3 heads L. & S. Dept on signing up. This might indicate that 2639 and 4690 were combined and 3 heads to give 4892 heads. Register shows all 3 rights to be independent of each other and all still current as Crown rights. W.D. installation of Dunstan Intake (Omakau Scheme) in 1936 led to dispute, L. & S. Settlers and P.W.D. n. Minister of Works settled dispute (see P.W.33/2 of 26.8.36) assigning "1st 10 heads" to L. & S. and P.W.D. ereafter. This "1st 10 heads" applied to the 1st 10 Crown heads, as at that time there existed at least o prior mining rights of 3 cusecs each (returning above the irrigation intakes and also a prior private right 6 cusecs at unknown location, downstream of the intakes. This 6 heads may refer to one of 641 or 633 ruck off, or may be 1889 subsequently acquired by the Crown. (See P.W.33/2 R.E. Alex. of 4/9/37).

ıing Priv-ege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
1534 N	Crown 2	22.6.03	8	Dunstan Ck	Not notified?
2639 N	Crown 3	20.9.07	5	Dunstan Ck	Lands & Survey Dept ex Beattie
4384 N	Beattie 4	31/10/22	3	Dunstan Ck	
4397	Morgan Bros	20/12/22	3	Dunstan Ck	Expired. Deed of Covenant for transfer to Crown not exercised
4690N	Crown 5	15/7/27	5	Dunstan Ck	L. & S. Dept (ex Beattie)
4892N	Crown 6	29/5/30	13	Dunstan Ck	L. & S. Dept
5784N	Crown 7	25/7/38	15	Dunstan Ck S.125:496869	But notified as 18. Omakau Scheme.
4202N?	M.H. Mee		?	Trib. Dunstan	? Not traceable.
8697Cr	J.A. Harley	7/11/56	2	Shepherds Ck	Covenant to Crown expires 1978.
1434N	S.E.J.W. Harley		1	Three-Mile Ck	Woolshed Ck?
4204N	G.D. Hamilton		2	Woolshed Ck S.125:481837	
4710N	F.M. Pyle	7/11/27	2	Clear Ck	Below Falls Ck probably Mata Ck Expires 1987.
1899N	C.P.,J.C.& A.J. Harrex	27/1/1865	25	Commences 2 miles above forks of Manuherikia ends near St Bathans.Collects all tributaries	Probably "Scandinavian"

lning Privilege No.	Holder	Priority Date	Quantity (cusecs)	Location	Remarks
R 1887N	C.P.,J.C.& A.J. Harrex	21/1/1864	17	Wild Duck to St Bathans (with 60 tribs)	
R 1877N	C.P.,J.C.& A.J. Harrex				(previously 635N) Struck off
R 1885N	C.P.,J.C.& A.J. Harrex	1/5/1866	12	Mountain Ck & Rocks Ck to St Bathans	M.& E.Race, then Kildare consolidated.Jus below Scandinavian Race.
				752637	
.W.Act	Crown,Hawkdun Scheme		3	Big Bremner Ck	S.125:646 047
"	"		5	Big German Ck	S.116:636 101
"	"		6	Boundary Ck	S.125:630 087
"	"		3	Gate Ck	S.125:675 945
"	"		8	Healeys Ck	S.125:663 005
"	"		6	Hut Ck	S.125:673 969
"	"		10	Johnston Ck	S.116:626 125
WR 5930	Dillon Mason & Mason		3	Johnstons Gully	As notified
WR 5984	"		11½	"	Notified as 4
P.W. Act	Crown		16	Johnstones Ck	S.125:702 898
"	"		3	Little Bremner Ck	S.125:645 059
"	"		3	Little German Ck	S.116:635 107
"	"		8	Manuka Ck	S.116:623 117
"	"		3	Peepoes Ck	S.116:688 928

.ning Priv- .ege No.	Holder	Quantity (cusecs)	Location	Remarks
: 5979	B.E. Dillon	1	Pegley Gully	S.125:610 872
W. Act	Crown, Hawkdun Scheme	8	Pierces Gorge Ck	S.125:687 940
W. Act	Crown	10	Shepherds Hut Ck	S.125:651 036

APPENDIX E ENGINEERING ESTIMATES

SUMMARY

1. Storage alternatives (Refer to Appendix C for Notes).

Optimum Falls	$ 600,000	$ 67/ha.
Optimum Dunstan	$1,075,000	$ 215/ha.
Cambrain	$1,100,000	$1,600/ha.
Pennyweight	$ 100,000	$1,000/ha.
Thomson	$1,800,000	$2,670/ha.

Dunstan/Falls "top-up" race $ 700,000
OptimumFalls plus "top-up" $1,300,000 $ 82/ha.

2. Distribution systems

(1) Enlarged Omakau Main Race	$1,750,000	
(2) Higher Omakau Main Race	$2,420,000	
(3) Enlarged Dunstan Race	$ 306,000	
(4) High tributaries system	$ 280,000	
(5) Moutere Link Race)		
(6) Moutere-Waikerikeri System)	$1,010,000	
(7) Alexandra System	$ 614,000	
(9) Upgrade Downs Race	$ 40,000	
(10) Upgrade Blackstone Hill Race	$ 40,000	

Upgrade Existing Manuherikia Scheme $962,500
Upgrade Existing Omakau Scheme $230,000
(both, to present duty)

Estimated "creditable" items to new scheme.

$1,192,500

or say $1,000,000

Comment on Estimates - Engineering Standards

The following estimates, of necessity very "preliminary" have been prepared with the following points in mind.

(a) Massive storage earthfill gravity structures with steel/concrete cut-off membranes.

(b) All main and distributary races fully fenced trapezoidal with at least one berm formed for vehicle access for maintenance.

(c) All syphons reinforced concrete pipes with reinforced concrete inlet and outlet works.

(d) All drops, weirs, distributors reinforced concrete structures with steel control gates.

(e) Race lines roughed out at grade 1:3500

Falls Dam 5, 7, 8, 9.

Massive earthfill structure; suitable material in abundance adjacent to site. Neglect existing structure and resite downstream to clear. Cut-off membrane rather than impervious core. Optimum TWL is around 1950' elev. this will involve low dam across saddle and earth spillway training banks.

0.75×10^6 yd^3 at \$0.35	\$260,000
Spillway Earthworks	\$ 65,000
Cut-off, U/S face, 6" conc.	\$200,000
Valves, fittings	\$ 75,000
TOTAL :	\$600,000

Alternative r.c. spillway in gorge at TWL less than \$300,000

Dunstan Dam

As above. Access is difficult.

1.08×10^6 yd^3 at \$0.40	\$ 430,000
Spillway	\$ 300,000
Cut-off	\$ 200,000
Fittings, etc.	\$ 75,000
Access	\$ 70,000
	\$1,075,000

Cambrian Low Dam

Possible sites for additional low storage exist; fill could be excavation from race (8) along scree face, valuable flats submerged (10,000 Ml).

5.5×10^6 yd^3 at \$0.20 — \$1,100,000
or \$1,600/ha.

Pennyweight Low Dam

Possible site for additional low storage below St Bathan's loop road (1500 Ml)
estimated L.S. — \$100,000
or \$1000/ha.

Thomson's Dam

Previously investigated in 1930's. Estimated cost of rockfill dam (10,000 Ml). \$1,800,000
or \$2670/ha. (!)

Distribution Systems

1. Enlarged Omakau Main Race
(360 c.f.s. to 200 c.f.s. at pump)

Intake, etc., using existing weir	\$ 100,000
Race 75,000' at \$5	\$ 375,000
43,000' at \$3	\$ 129,000
Pipes 10,000' at \$50	\$ 500,000
Structures 30 at \$5000	\$ 150,000
Race to River 11000' at \$3	\$ 33,000
	\$1,287,000
+ 20% distribution	\$ 257,400
	\$1,544,400
Add for pumping to Link Race (5) 150' Lift	\$ 200,000
	\$1,744,400
Say	\$1,750,000 (1)

2. Higher Omakau Main Race
(360 c.f.s. to 200 c.f.s.)

\$1,544 (from above) $\times \frac{16}{12} \times 1.10$	\$2,270,000
Add for pumping to Link Race (5) (100' lift)	\$ 150,000
	\$2,420,000 (2)

3. Enlarged Dunstan Main Race

Utilising present intake tidy up	$ 10,000
Flume 700' at $10	$ 7,000
Race 5000' at $10	$ 50,000
25000' at $ 4	$100,000
19000' at $2	$ 38,000
Structures 10 at $5000	$ 50,000
	$255,000
+ 20% distribution	$ 51,000
	$306,000

4. Tributaries above Main Race served by Lauder, Thomson, Devonshire

Intakes, upgrading	$100,000
Distribution	$180,000
	$280,000

5. Moutere Link Race

& 6. Moutere-Waikerikeri System

(pumping included in 4, but could be less)

Race	50,000' at $5	$250,000
	10,000' at $10	$100,000
	30,000' at $4	$120,000
Pipes	6,000' at $45	$270,000
Structures	20 at $5000	$100,000
		$840,000
	+ 20% distribution	$170,000
		$1,010,000

7. Alexandra System (80-100 c.f.s.)
(Served from Moutere)

Race 18,000' at $3	$ 54,000
Structures, drops	$100,000
Distribution 40,000' at $4	$160,000
50,000' at $3	$150,000
Structures 30 at $5000	$150,000
	$614,000

8. See under storage

9. Upgrade Downs Race, up to $40,000

10. Upgrade Blackstone Hill race, up to $40,000

11. To upgrade existing Manuherikia Scheme,[11, 13] to present duty,

Headworks refer report [13] proposal 5.2 (See appendix F)	$400,000
Chinky Gully flume renewal	$200,000
Chatto Creek. Syphon remewal , present	$ 50,000
ten years hence	$ 50,000
Main Race (loess country)	
65,000' at $2.50	$162,500
Structures, etc.	$100,000
Total "Capital" Expenditure	$962,500

12. To upgrade existing Omakau Scheme [12], to present duty

Intake		
Gates and Weir repairs	$ 20,000	
Protection	$ 30,000	
54" pipe 2000' at $45	$ 90,000	
Silt trap	$ 10,000	
	$150,000	
Race Upgrading	$ 50,000	
Manuherikia Syphon Pipes 620' at $50	$ 30,000	
Total "Capital" Expenditure	$230,000	

APPENDIX F

P.W.15/3/2

The District Commissioner of Works,
DUNEDIN.

MANUHERIKIA IRRIGATION SCHEME
MAIN INTAKE AND MANUHERIKIA GORGE SECTION

Reference: Letter dated 19.4.67 from the Central Otago Irrigation Advisory Council requesting a report on the Manuherikia Gorge race covering such aspects as:-

Present Conditions

Possibility of Damage

Access for repair purposes

Alternatives, etc.

1. History and General:

The Manuherikia Irrigation Scheme was the first constructed as an irrigation project, as distinct from being founded on the remains of mining enterprise, although the scheme does incorporate some early mining races and water rights. Construction was commenced in 1917 and was mainly complete by 1922 when first water was delivered.

The main intake is in the very rugged Manuherikia gorge, leading directly into a 1550' long tunnel through a spur forming an acute bend in the river. The tunnel delivers into s ilt trap, which is above flood level, and the construction originally continued as a concrete lined race along an extremely rough sidling until it was possible to get away from the gorge and onto easier country overlooking Chatto Creek; this was crossed by a siphon 1800' long and the rest of the system was by normal gravity race distribution.

The concrete lined race in the gorge gave much trouble and in 1936/37 the worst section was bypassed by a 644' tunnel, 5181' long, set back in solid rock country. The initial section of the scheme now consists of Intake tunnel 1550', silt trap, concrete lined sidling race 60 chains, tunnel 5181', flume 500', open race 85 chains and Chatto Creek siphon 1800'. It is the remaining 60 chains of gorge race that is now concerning the Advisory Council, with specific mention of its physical condition relative to continuity of supply; this report, however, will also deal with more general aspects of the scheme such as usage and quantity of water, quality of water as regards bedload and extension of irrigation, as all of these affect design of replacement or alternative works.

2. Present Conditions:

A general report on headworks was made by the Resident Engineer, Alexandra, two years ago (Alex. P.W.15 of 14.6.65), and this included the following comments on the Manuherikia Scheme:-

> "The intake system is a tunnel which starts directly in the river (a stone weir being used to bring the water level up to that required) with gates to control the flow, and which leads to a gravel trap about three quarters of a mile away. The gravel trap is connected directly to the measuring flume and thence into a concrete channel sidling down the Manuherikia gorge, and finally into another tunnel. The whole structure up to this second tunnel is a cause for great concern."

"The concrete intake gate structure is in good condition, except that it leaks very badly. This leak prevented a proper investigation of the tunnel being undertaken. Three years ago, however, an inspection was made and the condition of the tunnel reported to be very bad. This statement is supported by the evidence at the mouth of the tunnel. Most of the concrete of the invert has been scoured away together with the flat strips of reinforcing steel, leaving scarcely ¼ inch of concrete in most of the length, and none at all in some places. In the soft schist country in which this tunnel is situated, any leak which develops could be serious. The gravel trap is in equally poor condition, two channels 6 inches deep being scoured in the floor exposing the bedrock. There is also a large diagonal crack in the well wall, the top section having moved about two inches. The metering device is a rectangular orifice - this has developed a slight crack at one of the corners. The measuring flume is in reasonable condition, but the sidling race is the opposite. Twenty foot sections have moved, and have been patched up, and then moved again. This largely due to the instability of the sides of the gorge".

The Resident Engineer's report gives a true enough picture of the situation (except for the length of the intake tunnel) as it has existed for say the last twenty years and as it is today. All sections of the headworks are functioning but are in poor condition; it is impossible to say that any one section is in immediate danger of collapse or failure, but it is equally as difficult to put a life on the works due to the vagaries of the river and the country and the unknown aspects of materials and design.

In operation, the intake tunnel entrance is neither screened nor protected in any way. It is located on the concave bank of a bend in the river and is wide open to collect any gravel or vegetation that may wash into it. The intake tunnel is 6' x 4'6" and is designed to take 350 cusecs when the silt trap at its lower end is scouring. Vertical steel slide gates are located at the inlet end, and these are connected to an arrangement of floats, levers and trips which, in theory, drop the gates in times of high flood. In practice, the float chambers get silted up and the linkage is prone to jamming by floating debris, leaving the tunnel wide open for acceptance of river bedload. As a result, all the invert gets continually scoured from the inlet gates to the outlet of the gravel trap.

From the gravel trap to the inlet of the lower tunnel, the race sidles for 60 chains down the right bank of the gorge which is steep and unstable in places, and it is the safety of this section which is of concern to the Council. The race traverses solid rock, made ground and slip country; it is concrete lined all its length but the concrete leaves much to be desired, being of poor quality, porous, unreinforced and of minimal thickness - in some cases consisting of only a thin veneer over the earth/boulder bank behind.

Failures have occurred from time to time - three or four down this length of race - but details are not available as repair was carried out immediately by the maintenance gang and records are not on file. A typical failure sequence starts with leakage through the concrete, or a crack, washing away earth fill between boulders which then slump, allowing the bottom to fall out of the race, together with all the flow. The fill materials on which the race has been built appear to have been placed solely to support the concrete flume and not to act as a water resistant structure. When a slump occurs, either in made ground or in slip country, the unreinforced concrete cracks badly.

giving rise to minor rockfalls; these are of nuisance

Trouble is also caused by sheep or frost loosening boulders in the steep slopes above the race, value mainly but can do superficial damage to the race structure and give rise to additional maintenance.

A short distance downstream of the gravel trap an access track has been formed down the right wall of the gorge and the race underneath this has been roof slabbed and covered over for protection.

The race has a steep grade in sections giving rise to high water velocities (over 1 ft/chain, 12 ft/sec. velocity); capacity is approximately 100 cusecs with maximum flows normally in the 80-90 cusec range.

Once the flow enters the lower tunnel, the supply is not of the same concern; admittedly rockfall could occur in the tunnel, but unless the movement was major any break in supply would only amount to a few days. The tunnel is of 100 cusecs capacity, is 5181 ft long, fully lined 6' x 3' for 2387 feet, concrete invert and sides for 1,222 feet, and the remainder unlined but 7' high x 6' wide

3. Possibility of Damage

This can largely be gauged from the above description of the works and their present condition. Damage can be classified under three headings:-

(a) Superficial damage caused by falling stone which can occur at any time but is of minor consequence.

(b) Scour damage of the inlet tunnel and gravel trap, which is continuous and severe during river floods, and which is inherent with this particular design of headworks. Apart from periodic repair, nothing can be done to relieve the problem without major amendments to the intake design.

(c) Structural damage to the works due to movement of the country, either from above or below the race, and which can be natural or aggravated by leakage from the race.

It is damage in Category (c) that is of most concern as this can occur at any time, often without warning and during the irrigation season, and as many unknown quantities are involved such as stability of hillside or foundation fill, rainfall, concrete quality, etc., failure cannot be forecast or calculated for. There is virtually nothing that can be done to help the situation apart from reconstruction of the race or recasting the headworks system, as described below. It is recognised that the present condition of the race is indeed poor and that its life must be limited; it nevertheless continues to do its job and within the present Irrigation Superintendent's knowledge, has suffered only two major breaks in the last 15 years, both of which have been quickly repaired, causing minimum interruption to supply, in spite of difficult repair conditions owing to poor access.

It is only fair to state that the uncertainty of life and the susceptibility to damage must be allied to the low standard of concrete construction of the race. If the concrete used had complied with modern structural standards, had been reinforced, and had been to a minimum thickness of 6 inches as specified, then the race would have been more resistant to pressure from the hillside, to deformation by subsidence, to unrestricted opening of cracks and to leakage.

4. Access for Repair Purposes

Difficulty of access is the greatest problem to be overcome in any repair works and it must have been a major factor affecting the original construction. Access is possible to the upstream end of the intake tunnel by foot or by tractor (tracked) with difficulty, and to a point on the race below the silt trap also by foot or tracked machine. Access along the race in either direction, to the lower tunnel or to the gravel trap, is by foot only along a narrow and undulating path which is impossible for a wheelbarrow. When the race is dry, freer access is available along the concrete race bottom. All equipment and materials for repairs have to be manhandled along the race, or winched or chuted down the gorge walls to the site.

Both tracks down into the gorge could be improved to make them usable by say a four-wheel drive utility type vehicle, but to the tunnel intake only with considerable difficulty. The race formation however was constructed during the days when manpower was the accepted construction equipment (as distinct from bulldozers, drillrigs etc.,) and the addition now of anything more than a higher standard footpath is not possible without complete reconstruction.

5. Alternatives:

A number of alternatives to the present headworks layout do exist, none of which, unfortunately, are particularly attractive with respect to cost, but two are definite improvements on the existing system from the functional engineering viewpoint. The alternatives are:

5.1 Construction of a dam at the entrance of the lower tunnel

Such a dam would be solely to gain head and would give no storage but this would be no disadvantage on the Manuherikia scheme. The dam would completely obviate the need for all the existing headworks down to the No.2 tunnel intake, it would be a silt and boulder trap for the system but would have to be provided with a sluice gate for periodically releasing accumulations, it could be built without disrupting the present irrigation supply with an access road up the now disused portion of the gorge race. It is reasonable to expect that a suitable site can be readily found, as solid rock outcrops are very much in evidence on both walls of the gorge.

On the debit side is the size of the structure. A cross section taken at the tunnel entrance gives a dam height of 70 feet above river water level and crest width of 260 feet; the most probable choice would be a concrete arch with spillway crest and sluice gate for desilting. The Cost of such a structure considering site and access difficulties could amount to $400,000.

5.2 Construction of a dam 24 chains upstream from lower tunnel entrance

The lower portion of the gorge race has a much flatter gradient than the upper portion near the silt trap, there being only 3.3 feet difference in invert level over the lower 24 chains; the river grade however is still relatively steep and this enables a dam to be built with most of the advantages of 5.1 above but with a height above river level of 25 feet and crest width of 100 feet. Concrete yardage of this upper dam would only amount to about one sixth of the previous alternative, but attention would have to be given to the 24 chains of raceline to the tunnel entrance. This could be replaced with R.C. pipe laid along the present formation and covered over for protection (100 cusecs would require a 54 inch diameter pipe). The cost of the smaller dam including sluicegate provision as previously, plus 24 chains of pipework and protection could total $215,000. All the work could be done without disrupting the irrigation supply, with only the pipes having to be placed outside the irrigation season.

5.3 Replacement of the race section with pipe and recasting the headworks

From the silt trap to the entrance of the lower tunnel the race invert falls 33 feet in 61 chains and it would be possible to pipe 100 cusecs through 42 inch diameter pipe down this length. The pipe could be laid along the race invert and be covered for protection against rockfall as in 5.2 above; rubber ring joints would accommodate any slight movement of the country and the system would be leak free. An access bench would need to be formed alongside the race which would involve some difficult rockwork, and the work would have to be done during the May-September period to maintain irrigation

supplies. Winter conditions in the gorge are relatively severe, it being frosty and sunless. Reinstatement of the race by piping would cost approximately $140,000.

With a piped race however the silt trap would have to remain in the system and would be even more necessary than it is now, as wear of the pipe invert by transported gravels could not be countenanced. As long as the unprotected, open to everything, intake tunnel mouth is persisted with, a silt trap of no lesser proportions than the present structure will be absolutely necessary. It is not possible to put a 'life' on the existing structure, but with the expenditure of say between 5,000-10,000 dollars it might be expected to last many years. Especially would this be so if it could be given an easier life by the provision of a protected intake for the tunnel, and the best method of doing this would be by an infiltration gallery in the gravels upstream of the present boulder weir. The riverflow however gets very low at times during the irrigation season and virtually all the water is diverted into the tunnel; to collect all the water by infiltration a concrete weir across the river would be necessary with the gallery along its upstream face. With a suitable filter bed against the weir, only sand sizes down need enter the system, and the silt trap would handle such grades with a minimum of wear. Construction of a weir and gallery could cost approximately $105,000. It would involve cutting an access road to the intake, but most of the work could be done without interrupting the supply.

Both phases of this alternative treatment of the problem thus amount to $245,000. If the weir and gallery were not proceeded with, wear and general deterioration of the silt trap would continue and accelerate, however it is not possible to put a figure on this and it is unlikely that complete replacement would be necessary for many years. A silt trap must form an essential part of the system though as transport of bedload through pipes must not occur.

5.4 Tunnel possibilities

(a) The first alternative would be to parallel the troublesome section of gorge race by tunnel in a similar manner to the old length of gorge race that was bypassed in 1937. This would still demand the presence of a silt trap or an amended intake as for 5.3, would be 60 chains in length and at current tunnelling costs would be about 40% more expensive than the equivalent length in covered pipe.

(b) A second alternative consists of tunnelling through a spur on the left bank of the river with the outlet opposite No.2 tunnel entrance and the intake approximately twenty chains upstream of the present silt trap. This tunnel would be over 10 chains shorter than that above, but would have to incorporate a new intake and silt trap, plus a siphon/bridge crossing of the river, and so is no more attractive than (a) above.

(c) It would also be possible to tunnel directly from the gorge at the present silt trap in a generally westerly direction and emerge in a gully not far from the Chinky Gully flume; this would be even less attractive as such a tunnel would be a mile and a quarter long and have the same intake and silt trap troubles to contend with as (a).

5.5 Pumping

An alternative to 5.2 consists of replacing the dam with pumps to gain the 25 feet head above the river. Work involved would include the provision of a pump pool which could be sluiced out periodically and after floods, a pump structure above flood level, a power supply to the installation and 24 chains of pipe replacing the race as in 5.2. A scheme of this nature could cost slightly less than 5.2, say $200,000, but would have the disadvantages of higher renewal costs and operating costs, as all power charges would be a direct charge on the farmer - at present water usage rates, power would amount to an extra $2 per acre. High operating costs for negligible capital cost reduction, put this proposal in a poor light when compared with the purely gravity supply alternatives.

6. Conclusions and Recommendation

It must be recognised that due generally to the standards of the original construction, the age of the installation and the rugged and unstable nature of the country, the physical condition of the scheme headworks is not good, but that it is impossible to put a 'life' on the works. The present state of affairs could pertain for another 10 to 20 years, with little or no more interruption to supply or relative cost of repairs than is now the case. However, it must also be emphasised that a critical eye must be kept on the headworks at all times, and that although renewal or replacement cannot now be classed as top priority, it could be in say 10 or 20 years. When that time does come it appears that the most attractive solution, from both the engineering and cost viewpoints, will be the provision of a low head dam (alternative 5.2) able to sluice through any accumulations of river bedload, serving to raise water levels to utilize No.2 tunnel, and functioning also as a settling pond/boulder trap.

While the repair bill continues to average below $1000 per annum compared with the cost of recasting the headworks at say $200,000, the only recommendation possible in todays circumstances is to continue maintenance as at present, but with the recognition that this will be ever increasing and that ultimate replacement is inevitable.

M.R. Bolt
I.I.E.

27.7.67

Attached - Some Notes on:

A. Headworks Maintenance Costs/Replacement Costs.

B. Water Usage - Manuherikia Scheme.

C. Estimate Figures - Alternative Headworks Proposals.

General layout of Scheme Headworks.

Graphs of Scheme Water Usage and Costs.

A. Headworks Maintenance Costs/Replacement Costs

As long as repair costs stay below $1000 p.a. it is probable that repair, as against renewal at $200,000, is comparatively economic. To date repair costs appear to have been below $500 p.a. although actual figures are not available. The stage at which repair becomes uneconomic is difficult to assess, and could depend on whether recasting the scheme is accepted as a renewal or a capital work, i.e., whether the money is found from the farmers water rates or from Government sources. At present, income from water rates covers approximately 30% of the scheme operation and maintenance costs, so the problem is somewhat hypothetical. Existing irrigation agreements and water rates do not expire until 1972 - renewal must be a major factor in the reassessment of these rates.

With the accumulated deficit now associated with this scheme, a renewal fund just does not exist - it would require $1000 invested annually at 4⅞% for 50 years to compound to $200,000.

B. Water Usage - Manuherikia Scheme

The capacity of the existing headworks system is approximately 100 cusecs, and all the replacement alternatives considered in the report are based on being able to supply this same quantity. The area under Agreement however is only 4,900 acres, and with a reasonable water duty of say 100 acres per cusec this area should be able to be supplied by a 50 cusec system. Providing for a 50 cusec system would naturally reduce the cost of several of the alternatives presented with respect to pipe sizes, intake capacities, pump and power requirements, etc., however this has not been done as it is considered that the demand for additional water/irrigable land exists although at present it tends to be hidden.

Attached is a table giving water diverted and sold figures for the last 12 seasons. The water quota for this scheme varies from 24" to 36" (rate 82 cents to $1.62 per acre) according to the land, with extra water available at 52 cents per acre foot. It can be seen that over recent years the usage has been very high - since 1961 the depth of application over the agreed irrigation area has averaged 4 feet with an all time high last season (66/67) of 56.2 inches. Add the irrigation seasons rainfall to this, usually about 9 inches, and a soil moisture content similar to the West Coast can readily be imagined.

These figures point to two main possibilities:

(i) That because water is cheap, irrigators are not worried about being efficient in its usage, and

(ii) That more land is being irrigated than is under Agreement.

It is probable that a combination of the two present the actual state of affairs. With respect to (i), this scheme has been operating now for 45 years and farmers have long accepted the water supply and its low cost, and unlike those of the later schemes, have not had to make full use of the water to cover high water rates. The present day rates are lower than those of 40 years ago when the Irrigation Investigation Committee report was produced in 1928. It is fair to comment however that much of the land under the scheme is sidling country and so is more difficult to irrigate efficiently, but it must also be stated that of the flatter land able to be border-dyked very little has been attempted. With respect to (ii) it is natural enough to expect a farmer who utilizes his quota to irrigate efficiently his agreed acreage and who recognizes his water supply as a real asset, to take extra water at approximately half the cost to irrigate further land outside his contract area. Judging by the quantity of water sold it appears probable that more land is being irrigated than is under Agreement, and if this is so, it is reasonable to allow for headworks with capacity greater than 50 cusecs. For the report 100 cusecs has been assumed, to be in keeping with the capacity of No.2 tunnel and downrace structures. This figure will allow for any increase to include land now irrigated out of Agreement and also possible further extensions of irrigation - the scheme main race commands about 12,000 acres. The demand for water is as high as ever - over the last season (during which 10 inches of rain were recorded) the main intake race operated for 218 days with an average flow of 67.2 cusecs.

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With the expiry of Agreements in 1972 new water rates will be fixed, and to do this a reassessment of both irrigated area and quotas is called for. The present quota figures between 24" and 36" are considered relatively generous for the region - it could be that up to 7000 acres are now being irrigated. To help justify future heavy expenditure that will be necessary on this scheme it may be appropriate to assess new rates on irrigable land.

C. Estimate Figures - Alternative Headworks Proposals

5.1.1	Site development, access road, establishment, etc.	$20,000
.2	Excavations, foundations	15,000
.3	Dam, concrete (5000 cyd), formwork incl.	300,000
.4	Sluice gate, steelwork, mechanism	30,000
.5	Misc. and contingency, 10% approx.	35,000
		$400,000
5.2.1	Site development, access, establishment, etc.	$25,000
.2	Excavations, foundations	10,000
.3	Dam, concrete (800cyd) formwork	80,000
.4	Sluicegate, steelwork, mechanism	30,000
.5	Pipework, protection (24 chains)	50,000
.6	Misc. and contingency, 10% approx.	20,000
		$215,000
5.3.1	Access to site, access bench, establishment etc.	$25,000
.2	Pipework and protection (61 chains)	100,000
.3	Contingency, Survey, Misc., 10% approx.	13,000
		$138,000
5.3.4	Access to intake, establishment, etc.	$20,000
.5	Excavations, foundations	15,000
.6	Concrete weir, gallery, control gates, filter.	60,000
.7	Survey, misc., 10%.	10,000
		$105,000
5.4 (a)	Access, etc., as for 5.3.1	$25,000
	Tunnelling allow part lined (61 chains)	160,000
	Survey, contingency	15,000
		$200,000
5.4 (b)	Intake etc., as 5.3.4-6	$95,000
	Tunnelling (50 chains)	130,000
	Bridge/siphon crossing	15,000
	Survey, contingency, etc.	25,000
		$265,000

N.B. 1967 COSTS