Ministry of Power and Energy
Ceylon Electricity Board
Democratic Socialist Republic of Sri Lanka

Feasibility Study
for
Expansion of Victoria Hydropower Station
in
Sri Lanka

Final Report
(Appendix II: Supplementary Data)

June 2009

Japan International Cooperation Agency

Electric Power Development Co., Ltd.
Nippon Koei Co., Ltd.

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Chapter 5

Meteorology and Hydrology

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Table 1 Monthly Rainfall Record at Wattegama (Galphele) (M146)

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1943	80	69	35	149	542	276	201	74	165	313	371	223	2,496
1944	146	240	152	127	133	131	84	19	138	454	589	189	2,401
1945	9	6	74	195	62	128	71	108	34	472	366	229	1,753
1946	75	95	156	248	84	142	106	194	213	225	297	638	2,473
1947	347	19	255	143	94	101	91	580	165	363	47	181	2,383
1948	101	15	97	143	122	270	217	84	57	216	127	343	1,791
1949	97	40	53	274	110	175	301	196	111	184	227	365	2,132
1950	97	82	86	64	231	158	187	160	176	230	141	88	1,699
1951	492	129	45	137	89	288	149	20	247	180	281	179	2,236
1952	210	174	178	232	379	119	47	158	41	340	177	75	2,130
1953	95	81	86	350	-	76	306	85	89	312	169	168	-
1954	94	155	71	179	119	75	122	212	25	429	142	393	2,017
1955	235	121	185	170	154	292	133	99	234	192	193	60	2,067
1956	63	6	80	155	109	321	60	95	79	275	497	138	1,876
1957	138	153	9	174	180	198	243	69	59	287	532	855	2,898
1958	84	37	167	255	114	84	44	213	19	306	301	172	1,796
1959	41	38	6	157	194	300	284	90	194	349	267	169	2,090
1960	267	332	18	217	173	124	240	54	313	329	409	43	2,518
1961	148	104	53	204	203	87	123	151	102	222	273	302	1,972
1962	133	76	68	193	332	68	125	170	297	322	198	190	2,173
1963	207	79	23	164	26	119	132	76	120	209	326	307	1,787
1964	185	196	76	85	125	92	184	94	140	194	278	186	1,833
1965	49	207	23	238	195	110	47	248	57	136	281	224	1,815
1966	86	16	114	136	8	86	46	80	374	215	236	223	1,621
1967	94	148	67	71	30	167	126	72	98	278	338	382	1,870
1968	87	40	152	83	50	168	236	109	211	248	215	208	1,806
1969	144	72	27	257	166	115	33	135	149	425	122	320	1,964
1970	76	369	68	274	108	94	96	107	144	216	369	270	2,189
1971	112	55	75	282	102	206	124	186	492	192	205	384	2,414
1972	29	-	52	171	331	76	164	79	96	405	297	-	-
1973	-	19	36	98	52	60	114	146	41	118	279	303	-
1974	-	111	18	122	201	135	281	191	265	93	90	190	-
1975	33	42	135	85	130	190	106	306	162	289	419	223	2,118
1976	144	1	32	163	-	27	105	78	32	343	392	127	
1977	10	33	137	146	198	111	129	92	64	413	269	115	1,717
1978	23	86	52	28	299	73	176	170	163	369	641	239	2,317
1979	-	17	16	72	33	38	29	14	236	405	343	204	-
1980	-	-	43	261	64	118	157	137	139	165	298	150	-
1981	111	29	62	149	123	253	434	27	426	151	238	129	2,129
1982	-	-	117	131	272	281	195	74	99	366	361	482	-
1983	26	9	-	52	231	149	177	192	127	209	303	409	-
1984	298	304	303	282	34	200	248	82	617	172	233	169	2,941
1985	127	74	176	56	174	552	237	110	170	221	317	250	2,465
1986	532	170	102	196	60	79	168	195	247	447	153	99	2,447
1987	119	7	119	197	191	182	-	187	482	477	321	157	-
1988	10	98	132	320	123	119	204	358	203	65	463	305	2,400
1989	294	17	97	90	121	208	418	121	269	247	356	25	2,261
1990	339	68	142	92	466	142	122	161	118	428	231	346	2,654
1991	275	12	90	171	150	324	176	167	89	405	244	351	2,454
1992	33	-	-	165	200	164	313	140	177	258	448	134	-
1993	28	140	58	57	331	427	215	95	65	656	347	503	2,921
1994	231	261	72	226	133	111	160	102	284	509	403	220	2,711
1995	209	107	41	359	220	200	83	105	208	521	349	50	2,450
1996	123	93	39	205	15	121	170	132	286	335	211	141	1,871
1997	10	52	100	241	165	72	133	93	427	629	426	327	2,676
1998	123	39	18	2	147	161	194	-	269	149	167	-	-
1999	-	150	40	175	221	207	39	50	93	414	-	154	-
2000	179	203	108	97	76	139	197	116	116	179	228	303	1,941
2001	290	53	26	291	35	-	180	23	195	277	139	396	-
2002	36	62	42	309	88	79	86	178	17	285	437	130	1,749
2003	196	74	220	124	53	90	127	115	81	90	219	27	1,416
2004	64	40	134	102	165	137	205	87	266	232	318	199	1,948
2005	86	75	77	180	132	279	217	114	231	304	447	262	2,404
2006	324	115	190	141	126	133	110	112	113	474	503	184	2,525
2007	139	15	26	338	69	228	206	48	307	317	87	282	2,060
Average	143	94	88	173	153	163	163	130	180	300	296	239	2,124

"-": Data not available

Data souce: Meteorological Dept.

Table 2 Monthly Rainfall Record at Hope Estate (M191)

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1943	141	176	94	143	648	322	259	52	120	336	232	427	2,949
1944	352	449	257	261	159	126	119	7	163	311	301	336	2,841
1945	35	14	208	246	61	244	92	50	29	493	436	157	2,065
1946	143	306	196	318	41	172	113	143	165	241	290	508	2,636
1947	638	25	234	151	131	118	74	682	123	262	139	231	2,807
1948	234	22	103	178	94	309	169	64	22	212	230	473	2,109
1949	398	70	110	240	110	158	196	107	151	182	387	605	2,716
1950	214	105	268	85	260	135	224	95	305	99	231	182	2,201
1951	750	122	120	209	161	509	165	39	386	273	380	629	3,743
1952	612	198	123	341	507	119	55	111	83	317	200	252	2,918
1953	326	132	67	263	-	78	407	33	60	268	346	433	-
1954	229	152	122	150	38	34	109	243	20	434	227	462	2,220
1955	548	328	131	292	197	265	44	54	309	114	203	235	2,718
1956	139	47	110	105	86	387	73	56	40	200	589	459	2,291
1957	289	354	44	89	237	252	227	64	71	219	565	1,273	3,682
1958	349	82	243	287	165	177	61	143	21	256	305	345	2,434
1959	174	103	11	365	220	295	251	168	158	412	307	211	2,676
1960	315	529	22	295	160	90	300	83	263	358	351	185	2,950
1961	251	239	124	235	335	172	175	234	71	249	457	430	2,973
1962	252	149	80	262	331	81	250	160	214	314	314	307	2,713
1963	352	230	114	241	96	184	176	82	137	254	451	446	2,763
1964	458	435	134	79	96	131	231	123	205	140	264	349	2,644
1965	220	352	146	399	320	131	59	169	83	193	386	363	2,819
1966	286	66	267	189	10	123	71	38	425	262	366	373	2,474
1967	248	361	183	183	62	179	66	102	65	433	670	369	2,921
1968	233	72	184	117	126	260	329	122	165	394	245	500	2,747
1969	310	124	103	354	226	110	86	126	123	441	179	569	2,751
1970	220	394	131	289	92	111	98	140	114	203	544	537	2,872
1971	354	156	121	278	60	204	168	280	541	232	247	533	3,174
1972	252	2	5	262	278	83	171	84	191	452	427	517	2,724
1973	37	101	204	93	13	75	102	158	55	-	278	574	-
1974	-	198	83	340	226	180	273	165	215	158	119	619	-
1975	231	137	152	178	158	476	57	283	184	143	238	353	2,588
1976	373	47	64	201	5	32	108	116	48	260	387	214	1,855
1977	23	47	147	197	168	171	193	109	53	524	358	355	2,344
1978	198	146	119	97	360	82	245	219	160	256	717	390	2,990
1979	207	76	21	158	210	235	184	39	344	364	558	363	2,758
1980	124	-	150	172	74	76	81	164	59	223	312	169	-
1981	106	224	58	149	138	371	165	57	226	103	306	342	2,244
1982	55	-	170	127	255	282	139	80	42	101	463	730	-
1983	219	1	-	28	175	63	54	148	76	260	300	421	-
1984	356	340	163	360	165	221	246	106	435	271	429	218	3,309
1985	311	181	216	139	207	598	109	212	180	427	379	425	3,384
1986	641	260	243	282	100	235	109	307	169	448	216	345	3,354
1987	322	44	119	338	344	168	-	170	106	533	301	235	-
1988	128	103	196	447	112	77	233	132	216	111	522	565	2,840
1989	680	43	77	158	177	244	602	137	123	247	419	207	3,112
1990	422	249	161	69	292	218	138	152	40	289	389	781	3,200
1991	647	46	143	64	90	547	215	100	67	417	402	557	3,293
1992	294	-	-	142	160	138	253	136	112	183	455	384	-
1993	126	61	23	43	304	244	253	31	60	547	310	618	2,619
1994	265	276	65	135	101	66	183	156	78	601	500	419	2,845
1995	202	140	185	182	272	149	45	267	121	291	114	287	2,256
1996	292	223	20	243	65	134	138	106	159	365	263	282	2,289
1997	5	-	57	437	282	162	347	195	299	623	566	474	-
1998	223	72	-	22	171	280	255	209	219	129	187	305	-
1999	677	227	101	83	226	399	36	85	134	279	249	232	2,727
2000	319	415	107	182	4	391	108	500	96	166	346	-	-
2001	354	109	32	669	46	126	66	54	220	122	129	233	2,159
2002	127	102	164	212	85	24	55	127	6	155	235	334	1,625
2003	307	81	141	218	23	43	88	53	38	71	274	134	1,473
2004	276	158	87	207	141	110	68	49	130	454	527	932	3,137
2005	256	143	77	231	194	84	200	66	202	242	549	199	2,443
2006	757	189	272	230	418	262	264	3	212	459	848	974	4,888
2007	844	26	62	310	12	232	196	165	327	-	294	546	3,014
Average	308	168	128	216	173	196	166	137	154	292	357	420	2,716

"-": Data not available

Data souce: Meteorological Dept.

Table 3 Monthly Rainfall Record at Kandaketiya (M238)

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1943	176	76	26	39	89		146	159	288	161	46	46	-
1944	96	9		39		17	267	269	510	555	151	86	-
1945	98	6		32	257			358	670	377	158	187	-
1946	15	87		8	24		100	24	161	895	352	90	-
1947	133	146	10	33	71	92	125	386	666	616	197	130	-
1948	143	97		29		87	97	311	318	449	243	153	-
1949	99	13	14	74	17	57	170	148	514	436	270	61	1,872
1950	157	34		33	50	23	292	234	451	1,024	368	138	-
1951	63	7		8	145	173	79	130	275	242	97	106	-
1952	228		192		59		237	452	237	247	130	25	-
1953	46	43				32	105	517	1,253	404	182	171	-
1954	145	39			25	48	152	132	530	291	171	8	-
1955	174	46	30	12	28	47	342	342	298	671	708	100	2,798
1956	129	126	2	101	26	20	150	255	135	302	255	198	1,697
1957	96	11				24	108	741	435	419	168	82	-
1958	119	66	10	34	121		182	211		400	314	54	-
1959	52	42	23	17	2	42	141	276	514	583	544	184	2,421
1960	60	41	2	40	54	54	106	186	423	291	480	34	1,768
1961	196	102		23	141	10	150	466	472	435	156	144	-
1962	82				32	34	205	174		249	241	85	-
1963	7	11	9	1	2	44	196	671	330	268	6	181	1,724
1964	59	19	7	3	1	71	167	246	531	365	165	19	1,653
1965	128	25	1	2	110	54	301		627		381	85	-
1966	90	90		5	28	24	45		231				-
1967	45					114	117	253	737	271	0	20	-
1968	73	75	14			158	457	428	459	71	33	111	-
1969	30	12	16	55	1	125	103	246	534		97	74	-
1970	20				51	60	42	140	569	194	64	96	-
1971	49	39								591	37		-
1972						76	54						-
1973												93	-
1974	47	85		33			120	197	383	164	34		-
1975		4					207	326					-
1976		40					24		155	111	109	5	-
1977	70	39	3	273	38	49	204	237	317	52		13	-
1978	43	76	5	14	31	23	212	259	658	193	8		-
1979	26	34		33	9	8	202	260	470	353	397	155	-
1980	105			80		135	106	209	185	248	146	227	-
1981	37	19	10	13	3	140	199	153	412	852	69	190	-
1982	91	54		30	87		403	207	388	338	139	153	-
1983	213	129			4	73	263	114	300	73	65	152	-
1984	220	13		50	37	27	145	281	564	492	13	26	-
1985	27	15		57	15	100	304	286	94	372	137	158	-
1986	83	101			40	13	196	185	620	346	49	101	-
1987	146	109	32		6	38	99	303	578	195			-
1988	31	24	3	32	22	74	178	754	424	201	96	99	1,937
1989	87	67	7	55		14	215	499	497	439	232	166	-
1990	37	22			0	152	265	522	638	187	140	27	-
1991	153	122			10	22	122	92	381	373	236	1	-
1992	196		31		60	38	99	269	287	19	44	10	-
1993	36	134	29	7		64	255	416	476	357	93	6	-
1994	11	80	6	103	32	33	72	263	419	834	368	9	2,229
1995	21	4	14		1	46	248	332	272	531	408	39	-
1996	51	96		10	140	16		394	226	413	163		-
1997	174		24			6	136	206	455				-
Average	92	55	21	40	48	58	175	296	436	374	187	93	1,875

"-": Data not available

Data souce: Meteorological Dept.

Table 4 Monthly Rainfall Record at Kobonella-Hunnasgiriya (M283)

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1943	309	306	111	236	512	232	187	100	195	431	314	673	3,606
1944	490	636	352	280	250	110	78	42	185	515	656	481	4,075
1945	39	37	467	249	57	270	109	118	27	616	814	333	3,136
1946	369	357	474	490	67	121	199	236	253	351	558	911	4,385
1947	1,002	76	399	379	136	90	52	370	88	372	308	633	3,902
1948	482	54	196	324	193	143	222	68	17	265	441	856	3,259
1949	429	122	91	461	113	-	245	224	98	140	554	857	-
1950	452	228	176	111	297	85	96	72	282	157	258	306	2,520
1951	1,235	202	188	225	135	273	93	76	437	320	530	696	4,410
1952	759	355	206	367	459	75	54	88	172	169	234	310	3,247
1953	410	194	109	326	2	77	298	78	83	468	324	498	2,865
1954	393	363	512	285	110	23	61	254	14	365	268	754	3,401
1955	862	381	277	267	177	201	72	83	130	177	307	333	3,267
1956	269	95	142	118	59	328	30	107	28	267	943	541	2,926
1957	489	571	129	186	177	157	190	44	60	176	947	1,880	5,007
1958	654	147	239	293	104	56	28	368	142	445	528	567	3,571
1959	356	110	71	243	123	229	320	174	225	-	-	-	-
1960	-	-	75	472	137	82	257	89	210	347	378	303	-
1961	449	222	214	-	220	77	124	156	94	385	780	807	-
1962	484	328	201	585	494	31	161	253	274	410	588	557	4,364
1963	638	540	198	461	151	160	213	84	237	454	592	808	4,535
1964	773	592	274	149	175	74	195	90	202	242	306	577	3,649
1965	407	623	153	495	224	61	70	346	44	505	604	510	4,042
1966	466	122	276	387	5	109	40	169	396	482	583	408	3,444
1967	294	394	154	402	44	152	95	68	123	404	961	607	3,696
1968	444	312	473	163	137	184	261	146	240	368	309	510	3,546
1969	478	295	76	397	201	114	49	185	217	652	295	959	3,917
1970	441	885	113	484	97	91	78	208	208	305	446	593	3,949
1971	540	264	230	249	136	188	175	240	604	242	448	1,050	4,366
1972	366	29	24	186	272	65	184	63	149	688	605	814	3,444
1973	206	264	202	196	84	61	105	173	212	234	558	876	3,169
1974	-	234	183	278	276	77	220	200	257	188	127	736	-
1975	329	221	289	346	190	387	192	433	288	208	453	821	4,155
1976	702	85	133	268	-	34	245	158	19	207	655	722	-
1977	77	181	199	368	181	118	107	121	76	655	432	524	3,038
1978	196	51	298	194	605	113	268	193	64	620	573	852	4,026
1979	351	101	147	305	145	185	129	164	301	526	365	529	3,247
1980	146	-	93	409	87	95	98	180	164	237	603	247	-
1981	232	215	134	145	126	200	233	145	209	204	284	437	2,563
1982	42	5	167	137	237	168	115	85	111	410	556	893	2,924
1983	453	-	32	12	331	-	84	120	71	364	317	963	-
1984	530	456	227	341	52	170	231	144	547	324	665	285	3,972
1985	376	316	424	70	285	489	219	131	141	328	503	776	4,057
1986	622	410	357	250	117	174	176	316	131	352	334	703	3,942
1987	463	57	187	317	109	37	3	136	195	560	267	333	2,663
1988	102	128	309	421	72	28	182	133	207	254	278	524	2,637
1989	313	19	61	99	125	125	394	104	206	256	184	191	2,077
1990	389	284	213	76	237	192	110	141	169	435	369	884	3,499
1991	700	79	364	69	99	263	87	62	239	338	475	941	3,714
1992	284	-	-	92	96	185	325	142	312	269	940	622	-
1993	188	114	84	76	170	305	226	41	33	472	554	843	3,106
1994	752	353	165	175	142	28	206	152	236	617	711	531	4,069
1995	493	318	76	411	290	155	38	56	124	377	280	323	2,940
1996	437	390	24	428	-	165	230	134	174	290	223	166	-
1997	31	151	101	296	117	115	78	381	381	1,066	529	646	3,890
1998	642	375	38	455	92	109	168	138	204	157	233	535	3,146
1999	904	441	210	148	150	258	7	37	57	432	408	368	3,420
2000	606	342	164	135	104	184	66	248	118	109	570	342	2,988
2001	582	95	-	287	78	120	64	21	263	277	182	476	-
Average	455	264	201	277	173	147	150	154	185	370	474	624	3,476

"-": Data not available

Data souce: Meteorological Dept.

Table 5　Monthly Rainfall Record at Deltota

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1943	143	164	50	211	564	364	269	105	172	351	374	315	3,082
1944	289	508	340	269	164	139	97	14	147	362	353	178	2,861
1945	10	14	148	209	19	175	85	128	49	393	347	157	1,733
1946	84	211	138	297	54	225	116	214	146	248	375	501	2,608
1947	438	17	273	193	127	110	93	639	220	474	60	201	2,847
1948	162	31	155	218	98	320	188	78	41	218	164	373	2,045
1949	204	114	99	245	174	288	304	170	138	218	271	497	2,723
1950	163	129	143	164	260	168	356	186	292	200	200	184	2,442
1951	603	104	182	292	205	572	204	37	417	320	328	490	3,753
1952	372	105	109	318	553	246	77	214	81	425	230	112	2,844
1953	167	180	56	311	-	120	446	100	100	327	205	236	-
1954	229	179	207	208	148	96	187	390	69	493	143	476	2,825
1955	345	259	105	205	316	412	155	160	346	169	253	162	2,887
1956	93	10	100	202	186	511	96	311	169	314	484	345	2,821
1957	224	252	-	106	283	299	337	158	108	268	561	1,054	-
1958	246	60	362	257	499	157	33	221	57	391	442	167	2,892
1959	114	56	23	352	182	374	297	185	165	382	267	149	2,544
1960	306	392	-	343	228	118	292	148	348	310	438	90	-
1961	148	127	98	183	244	111	251	252	151	272	372	371	2,580
1962	150	72	62	207	435	88	212	137	254	339	179	305	2,438
1963	273	134	78	185	67	179	228	140	186	314	326	448	2,557
1964	327	294	67	150	95	154	257	112	198	186	438	266	2,545
1965	119	253	113	248	346	132	49	217	93	326	317	280	2,493
1966	172	26	227	116	21	136	73	54	452	205	308	292	2,081
1967	145	-	147	248	74	248	127	104	41	561	460	370	-
1968	91	59	143	175	159	293	350	121	251	323	276	270	2,509
1969	172	73	117	258	286	131	89	216	116	556	283	367	2,664
1970	122	339	101	288	119	141	145	187	124	269	642	361	2,837
1971	164	157	53	-	136	253	168	218	572	277	256	477	-
1972	119	-	2	229	392	77	161	109	201	494	297	406	-
1973	18	52	81	96	16	67	123	167	71	145	241	415	1,492
1974	-	197	31	278	175	168	347	200	222	125	181	321	-
1975	99	102	87	178	173	346	94	375	182	205	324	246	2,408
1976	284	16	54	296	7	36	205	87	50	249	418	176	1,878
1977	12	28	164	211	258	197	164	112	69	480	506	239	2,439
1978	92	141	84	82	348	76	223	200	212	299	762	287	2,806
1979	94	86	29	262	259	-	-	-	-	273	492	186	-
1980	74	-	55	123	98	79	128	126	178	232	331	-	-
1981	-	91	107	176	87	298	223	117	313	155	336	179	2,080
1982	26	-	178	183	250	264	131	108	81	271	329	511	-
1983	123	48	1	50	182	103	97	208	88	226	343	492	1,960
1984	334	421	128	271	172	200	249	169	381	134	280	130	2,868
1985	231	139	153	52	254	509	358	310	119	341	361	273	3,100
1986	439	156	144	205	26	162	119	268	145	269	112	142	2,185
1987	116	6	99	326	216	114	-	205	125	609	204	230	-
1988	26	32	112	543	111	119	248	146	202	94	460	268	2,361
1989	262	13	46	89	166	159	366	238	157	288	257	122	2,164
1990	282	198	176	105	243	192	121	99	31	233	249	477	2,405
1991	393	33	130	131	106	351	147	98	79	304	209	360	2,340
1992	98	-	-	179	93	153	269	-	65	280	379	185	-
1993	120	18	67	83	209	367	219	59	58	432	290	387	2,310
1994	276	148	45	136	121	97	229	147	228	582	365	276	2,649
1995	153	100	179	237	442	146	108	-	-	-	-	-	-
Average	191	132	117	211	201	208	194	175	172	312	328	310	2,552

"-": Data not available

Data souce: Meteorological Dept.

Table 6 Monthly Rainfall Record at Woodside Estate

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1943	213	251	118	368	375	133	95	36	98	266	258	394	2,606
1944	412	372	273	246	180	61	24	16	234	287	460	285	2,850
1945	21	11	198	165	67	96	57	69	4	306	495	296	1,785
1946	179	265	321	219	13	84	66	87	185	359	407	533	2,716
1947	568	49	199	151	285	60	33	358	42	210	164	325	2,444
1948	250	7	121	161	91	75	106	8	31	283	277	776	2,185
1949	374	70	67	224	60	90	185	132	44	94	343	534	2,215
1950	296	133	196	143	187	63	121	43	137	172	78	214	1,783
1951	970	173	116	195	105	277	111	36	259	172	344	701	3,461
1952	686	236	202	302	328	30	27	29	96	178	221	308	2,643
1953	279	217	137	307	-	61	187	8	75	270	332	458	-
1954	398	298	228	212	33	9	39	192	21	487	218	799	2,935
1955	682	298	154	187	106	114	40	66	159	161	174	178	2,317
1956	150	26	45	100	50	229	14	25	47	284	626	494	2,089
1957	271	357	66	151	243	104	176	15	84	220	796	1,298	3,780
1958	337	111	236	217	219	92	23	113	44	416	439	315	2,562
1959	158	53	25	191	74	296	157	89	126	481	443	336	2,427
1960	431	694	45	182	115	49	206	52	202	251	456	185	2,867
1961	274	220	151	143	139	35	86	105	74	240	457	512	2,435
1962	316	197	167	289	232	18	90	113	114	264	338	330	2,467
1963	348	237	53	248	193	74	105	33	207	305	484	470	2,757
1964	429	513	190	78	90	32	136	80	79	160	294	363	2,443
1965	216	452	104	296	229	32	27	241	32	291	474	404	2,797
1966	261	79	159	296	5	61	16	62	280	244	406	256	2,125
1967	134	251	86	303	3	80	53	26	125	336	659	431	2,488
1968	167	-	213	70	42	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	338	-	233	933	-
1972	122	35	22	256	518	38	117	35	138	709	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	-	-	98	-	-	-	-	-
1976	343	18	46	130	-	9	85	85	15	263	461	175	1,630
1977	-	63	68	176	188	34	85	35	65	507	320	221	1,760
1978	-	85	81	62	148	6	111	40	60	386	415	426	1,820
1979	109	48	45	83	101	100	55	35	219	307	307	201	1,609
1980	43	-	51	233	93	37	32	50	91	274	484	180	1,568
1981	157	61	118	236	126	32	157	24	265	222	362	154	1,914
1982	-	-	126	143	193	-	98	41	56	335	495	475	-
1983	-	-	10	10	206	14	11	53	42	206	181	348	-
1984	275	256	123	181	50	27	146	39	285	60	281	252	1,974
1985	257	115	209	74	102	156	72	93	230	251	197	322	2,077
1986	-	186	309	140	63	116	35	54	56	699	110	243	-
1987	65	29	36	67	135	10	22	21	252	303	75	75	1,089
1988	29	14	60	234	14	1	59	40	125	165	291	119	1,150
1989	337	38	82	204	82	63	105	4	108	390	227	135	1,774
1990	326	150	168	75	145	38	23	41	132	245	227	661	2,230
1991	388	26	109	119	125	69	47	31	81	269	303	479	2,044
1992	118	-	-	49	129	60	183	36	368	115	673	197	-
1993	84	50	120	51	183	180	94	13	10	411	434	578	2,208
1994	424	295	92	210	32	16	25	9	239	415	634	241	2,631
1995	236	244	17	446	259	27	23	48	32	337	168	202	2,039
1996	230	215	8	270	3	90	86	69	78	263	198	129	1,639
1997	-	91	114	516	208	227	47	4	169	716	684	484	-
1998	320	62	43	40	97	47	157	109	125	67	156	437	1,660
1999	594	249	61	116	63	74	14	36	226	462	257	226	2,376
2000	243	301	80	122	43	29	53	193	109	102	466	367	2,108
2001	398	123	-	451	10	51	50	-	295	262	188	232	-
Average	296	173	119	191	133	75	80	65	132	298	355	379	2,295

"-": Data not available

Data souce: Meteorological Dept.

Table7 Monthly Rainfall Record at Kundasale

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	36	35	116	116	112	162	175	149	126	127	302	191	1,646
1976	135	3	36	159	3	13	90	70	32	219	237	89	1,085
1977	3	44	109	129	131	53	60	55	88	195	252	79	1,198
1978	47	42	87	65	173	70	83	61	98	111	391	145	1,372
1979	25	-	-	186	136	185	-	-	-	-	-	-	-
1980	8	-	64	-	101	63	62	47	118	209	235	96	1,001
1981	86	23	57	166	49	89	219	48	218	61	202	68	1,285
1982	-	-	120	104	95	109	67	35	22	187	274	371	1,383
1983	24	-	49	20	106	33	35	104	60	112	157	156	855
1984	94	209	138	276	57	99	172	57	180	112	197	102	1,692
1985	91	35	121	35	113	279	151	80	99	183	181	122	1,489
1986	305	134	109	120	34	92	82	144	50	257	56	38	1,419
1987	47	0	20	103	139	77	-	50	107	263	155	101	1,062
1988	3	41	80	315	-	-	-	-	-	-	-	-	-
1989	33	10	-	97	123	97	259	74	-	-	-	-	-
1990	163	14	62	86	250	129	27	56	48	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	234	221	23	110	42	35	80	24	163	373	224	61	1,590
1995	184	82	71	215	258	65	32	-	-	247	283	58	1,493
1996	66	82	7	157	1	100	103	53	126	200	335	81	1,311
1997	1	35	27	257	151	54	61	45	255	522	298	189	1,894
1998	87	4	64	55	162	92	201	70	113	99	95	206	1,247
1999	307	136	7	116	111	123	26	39	52	216	157	108	1,399
2000	77	186	81	190	63	92	38	216	61	163	228	154	1,549
2001	186	67	44	289	17	89	100	16	124	176	97	321	1,527
2002	18	55	64	254	98	62	62	143	34	187	364	154	1,496
2003	138	56	195	201	92	80	57	49	55	98	196	10	1,225
2004	66	35	197	107	81	99	41	60	122	166	114	295	1,382
2005	43	76	43	154	86	74	53	14	63	126	331	109	1,171
2006	173	94	126	75	92	97	76	68	91	321	391	146	1,749
2007	93	9	104	209	45	125	90	33	144	172	128	233	1,384
Average	96	66	79	150	101	94	93	69	102	196	226	142	1,414

"-": Data not available

Data souce: Meteorological Dept.

Table 8 Monthly Rainfall at Mahaberiyatenna-Digana

(unit: mm)

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1989	199	18	30	83	84	29	222	21	102	102	232	46	1,168
1990	337	125	143	29	155	66	14	32	60	213	98	383	1,655
1991	187	23	70	122	55	127	43	45	45	197	185	216	1,314
1992	22	-	-	110	108	44	117	52	74	31	546	105	1,206
1993	7	52	90	64	101	180	60	6	68	340	307	345	1,618
1994	274	98	69	61	83	-	-	-	-	-	-	-	-
1995	-	-	58	215	170	17	6	38	31	192	173	75	-
1996	124	88	7	333	2	68	73	33	48	302	173	107	1,356
1997	2	25	38	267	154	57	42	20	140	399	334	229	1,708
1998	125	23	12	46	97	38	91	105	80	48	86	251	1,003
Average	142	56	57	133	101	70	74	39	72	203	237	195	1,379

"-": Data not available

Data souce: Meteorological Dept.

Table 9 Monthly Rainfall Record at Victoria Powerstation

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1989	250	25	-	118	102	4	136	18	115	235	206	132	1,340
1990	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	195	190	366	-
1992	67	115	42	147	99	21	29	9	39	112	450	170	1,299
1993	110	83	39	61	73	83	36	-	77	369	320	439	-
1994	315	155	100	219	11	15	17	38	179	275	416	268	2,006
1995	202	129	13	162	195	16	7	43	18	132	133	173	1,221
1996	142	132	4	160	-	67	16	69	31	225	178	130	-
1997	0	42	71	49	188	109	13	4	150	301	353	198	1,479
1998	244	34	51	76	136	28	46	52	55	14	96	321	1,151
1999	417	253	51	85	7	8	-	5	30	70	221	269	-
2000	237	187	28	120	13	20	3	102	76	38	415	147	1,387
2001	234	60	33	98	4	9	18	0	52	179	125	254	1,065
2002	234	60	33	98	4	9	18	0	52	179	125	254	1,065
2003	298	92	122	80	24	8	31	2	58	118	278	46	1,156
2004	104	65	62	196	22	17	12	9	35	186	192	532	1,431
2005	77	90	25	99	35	13	38	-	16	46	155	62	655
2006	290	134	128	248	31	28	16	38	67	324	499	372	2,176
2007	378	8	11	195	3	55	27	-	-	-	-	-	-
Average	212	98	51	130	59	30	29	28	66	176	256	243	1,377

"-": Data not available

Data souce: Victoria Hydropower Office

Table 10 Monthly Rainfall at Randenigala Powerstation

(unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2000	495	301	84	50	-	1	44	63	28	-	556	-	-
2001	414	131	3	128	-	19	-	-	21	-	167	555	-
2002	265	135	95	190	65	1	-	20	13	120	357	526	1,787
2003	533	-	148	55	16	39	16	47	98	103	370	112	-
2004	71	152	37	85	14	3	2	2	102	255	502	780	2,004
2005	42	65	96	133	29	6	16	12	4	89	679	98	1,267
2006	517	244	74	95	52	9	1	13	78	230	363	558	2,234
2007	547	-	6	208	3	12	12	15	40	105	186	413	-
Average	360	171	68	118	30	11	15	25	48	150	398	435	1,829

"-": Data not available

Data souce: Randenigala Dam Office

Table 11 Monthly Minimum Temperature Measured at Kundasale

(unit: Celsius)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1975	27.4	30.0	31.0	30.7	29.8	27.4	29.2	27.6	28.5	27.6	28.1	27.6	28.7
1976	26.8	29.6	32.0	31.3	31.3	31.4	31.3	29.4	30.8	29.5	29.3	28.1	30.1
1977	28.6	30.1	31.2	32.6	28.5	28.9	29.0	29.9	30.5	29.5	28.9	28.1	29.7
1978	29.0	30.6	31.5	31.5	30.6	29.2	28.7	28.0	30.2	30.0	29.7	28.5	29.8
1979	29.2	-	-	32.8	30.9	30.4	-	-	-	-	-	-	-
1980	29.9	31.9	33.1	29.7	31.8	29.8	28.8	29.5	30.0	29.0	28.9	28.3	30.1
1981	28.8	29.9	32.0	29.9	-	-	-	-	29.0	30.9	30.7	30.6	-
1982	30.2	32.5	33.0	34.0	32.2	28.0	28.3	28.9	29.9				-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	28.8	29.0	30.4	30.1	29.9	-
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	28.2		32.2	32.4	30.7	27.9	28.6	28.4	-	-	-	-	-
1990	28.3	28.9	30.8	32.0	30.5	28.5	28.9	29.5	31.1	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	27.3	29.0	30.0	31.7	31.8	29.0	28.9	-	-	29.2	-	27.4	-
1995	-	29.3	31.7	32.3	30.2	29.4	29.1	-	-	29.8	29.3	28.0	-
1996	28.1	30.3	32.5	31.6	32.4	29.5	28.4	29.0	28.5	29.4	29.4	29.0	29.8
1997	29.7	30.8	33.4	32.2	31.2	31.4	29.6	30.5	30.4	30.7	30.1	27.4	30.6
1998	29.4	31.7	33.5	34.4	32.1	29.9	29.3	29.5	29.3	29.3	29.7	29.3	30.6
1999	28.5	30.0	32.1	30.1	30.0	28.9	29.3	30.2	31.0	28.8	29.4	28.4	29.7
2000	28.5	29.9	31.0	31.7	32.1	29.1	29.9	29.3	30.1	29.7	29.5	28.3	29.9
2001	28.7	30.8	33.0	31.9	31.6	29.6	29.5	29.8	31.0	29.7	29.9	29.6	30.4
2002	29.4	30.0	32.6	32.5	30.8	29.9	29.1	29.7	31.5	30.4	29.9	28.4	30.4
2003	28.4	30.2	31.7	32.5	30.9	30.6	30.0	29.6	30.7	30.4	28.7	29.9	30.3
2004	29.9	30.8	32.3	32.1	30.2	29.1	29.0	29.8	30.2	29.8	28.9	28.0	30.0
2005	28.7	30.7	32.7	31.8	31.6	29.3	29.1	30.9	29.6	30.3	28.9	28.7	30.2
2006	28.2	29.8	31.5	31.8	31.0	30.4	28.8	29.9	30.5	30.6	29.7	27.5	30.0
2007	27.7	30.2	32.6	31.2	31.1	29.8	28.9	29.7	29.1	28.7	29.5	27.8	29.7
Average	28.6	30.3	32.1	31.9	31.0	29.5	29.2	29.4	30.0	29.7	29.4	28.5	30.0

"-": Data not available

Table 12 Monthly Minimum Temperature Measured at Kundasale

(unit: Celsius)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1975	19.0	17.3	18.3	20.7	21.6	22.0	19.8	24.5	20.2	20.5	20.0	17.7	20.1
1976	17.1	15.9	16.2	20.2	21.4	21.1	21.4	18.0	18.1	20.0	20.2	18.2	19.0
1977	14.3	17.6	20.4	20.4	21.0	21.8	21.2	20.6	20.8	20.2	19.9	19.8	19.8
1978	17.8	19.0	19.9	20.3	21.8	21.8	21.3	21.4	20.3	20.1	18.7	19.5	20.2
1979	19.2	-	-	20.5	20.7	-	-	-	-	-	-	-	-
1980	18.1	17.2	18.3	21.2	22.1	22.5	-	-	21.2	21.1	20.1	19.7	-
1981	18.1	18.2	20.9	22.8	22.8	22.7	22.2	22.9	20.6	20.2	19.9	18.5	20.8
1982	16.7	15.4	18.9	21.2	21.2	24.4	23.6	21.6	21.5	20.7	21.3	20.5	20.6
1983	19.5	17.8	19.3	20.9	22.7	22.9	22.3	22.7	22.5	21.2	20.2	20.8	21.1
1984	20.1	20.7	20.9	21.6	22.8	22.6	21.9		21.6	20.0	19.6	19.2	21.0
1985	20.0	19.4	21.3	21.2	22.1	22.0	21.3	21.5	21.6	20.7	20.1	20.4	21.0
1986	19.9	18.7	20.1	-	21.9	24.1	22.0	20.6	21.4	21.8	20.0	21.1	21.1
1987	-	-	-	-	-	-	-	-	-	-	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	20.4	15.4	18.3	21.0	22.0	21.9	21.9	22.9	-	-	-	-	-
1990	16.4	19.9	20.6	21.6	22.4		21.1	22.1	21.3	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	19.6	18.7	18.6	21.1	22.2	22.4	23.2	-	-	19.4	20.7	20.4	20.6
1995	18.2	17.8	18.2	21.1	21.9	-	22.0	-	-	20.8	20.7	19.4	20.0
1996	18.3	19.6	18.7	21.5	22.0	20.9	21.9	21.6	21.4	19.9	19.7	18.5	20.3
1997	17.1	16.5	18.7	20.7	21.6	20.9	22.1	22.1	21.0	20.8	21.2	20.8	20.3
1998	21.0	20.4	20.6	21.8	23.2	22.9	22.1	21.4	21.5	21.0	19.9	19.4	21.3
1999	18.3	20.1	18.7	21.4	21.9	20.4	21.9	21.3	21.1	20.9	19.9	18.9	20.4
2000	19.6	19.4	19.4	21.1	22.0	21.7	18.3	18.9	20.5	15.6	15.3	19.1	19.2
2001	19.2	16.4	18.0	21.0	22.4	22.2	21.4	21.5	20.8	21.5	19.7	19.3	20.3
2002	18.4	20.7	19.3	21.1	22.3	22.0	21.9	21.6	21.1	21.0	20.6	-	-
2003	-	-	-	-	-	-	-	-	-	-	-	-	-
2004	-	-	19.6	21.2	21.9	21.7	21.6	21.4	21.1	20.6	20.7	19.1	-
2005	19.0	18.4	19.9	21.4	21.4	22.2	21.7	21.3	21.0	21.2	20.3	19.3	20.6
2006	17.5	19.2	19.5	20.7	21.2	21.4	21.6	20.4	20.4	20.3	20.2	25.1	20.6
2007	18.6	18.4	16.8	20.9	21.8	21.6	21.5	20.9	21.1	20.4	18.5	19.2	20.0
Average	18.5	18.3	19.2	21.1	21.9	22.1	21.6	21.4	21.0	20.4	19.9	19.7	20.4

"-": Data not available

Table 13 Diversion to the Sudu River at Polgolla Weir

(unit: MCM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	138	121	125	132	116	145	146	91	75	140	131	75	1,435
1985	75	24	16	50	80	115	140	131	120	124	118	107	1,099
1986	64	53	40	27	87	119	124	106	73	63	64	91	911
1987	60	52	24	47	53	84	51	58	0	0	80	125	634
1988	98	74	51	32	100	121	81	50	0	14	66	121	808
1989	99	79	57	38	58	63	85	110	114	113	80	82	978
1990	38	104	102	61	92	134	129	130	113	64	104	85	1,157
1991	53	92	61	42	43	117	123	129	104	92	125	68	1,050
1992	47	69	32	8	13	87	110	116	111	145	124	61	924
1993	73	60	17	24	60	105	148	138	140	114	76	13	969
1994	13	19	54	59	110	120	89	122	95	85	18	7	790
1995	61	34	60	44	33	83	133	118	98	124	69	99	956
1996	84	57	19	37	25	21	67	82	92	124	133	103	845
1997	75	57	13	38	53	66	104	91	43	116	73	28	758
1998	31	55	64	26	66	102	120	127	133	114	135	121	1,094
1999	23	50	28	51	120	111	131	120	60	129	123	77	1,023
2000	52	26	14	8	47	68	122	92	70	106	93	80	778
2001	22	9	45	12	39	88	101	108	28	105	120	84	761
2002	49	35	14	15	60	84	115	123	9	63	72	23	663
2003	20	14	9	33	40	89	89	51	59	112	86	63	664
2004	44	18	18	39	71	86	82	110	60	83	85	12	707
2005	22	40	57	66	65	81	121	113	80	113	70	63	890
2006	37	53	18	44	81	114	131	130	36	64	48	91	846
Average	52	49	37	37	63	94	109	107	74	94	89	73	877

Data souce: MASL

Table 14 Downstream Release at Polgolla Weir

(unit: MCM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	64	47	41	108	18	149	476	79	121	171	42	27	1,344
1985	41	8	5	21	95	721	419	137	23	180	286	65	2,000
1986	303	93	112	173	102	42	34	150	204	356	211	3	1,783
1987	2	4	2	2	26	54	52	62	228	327	208	44	1,011
1988	4	5	23	77	48	67	229	294	366	179	194	24	1,509
1989	21	0	4	5	57	319	574	277	217	181	360	85	2,100
1990	149	12	17	0	76	95	101	90	36	60	99	21	757
1991	42	2	0	5	0	83	27	23	26	87	53	70	419
1992	40	5	0	17	33	83	171	217	121	156	135	92	1,070
1993	5	0	0	0	84	297	239	79	6	151	214	223	1,298
1994	131	90	10	6	19	17	13	82	59	214	306	155	1,102
1995	22	31	10	69	275	208	57	75	136	229	215	29	1,354
1996	3	4	4	60	5	71	81	95	203	252	65	46	889
1997	4	0	3	35	99	13	56	40	187	159	260	165	1,022
1998	45	4	13	0	12	36	90	96	122	173	67	44	701
1999	148	20	47	71	77	289	45	19	37	49	34	41	878
2000	36	93	68	67	14	47	28	132	67	101	44	42	739
2001	57	61	16	46	27	19	81	53	66	146	74	72	720
2002	32	11	7	112	77	66	22	62	77	60	125	89	740
2003	80	39	86	83	110	8	47	106	95	23	2	0	679
2004	0	0	6	44	69	116	113	80	83	109	81	123	825
2005	22	39	16	13	18	15	21	18	137	82	215	106	702
2006	78	30	76	53	44	63	107	36	66	87	508	119	1,268
Average	57	25	24	44	62	124	119	101	117	153	171	75	1,071

Data souce: MASL

Table 15 Water Supply for Irrigation of Minipe Left Bank

(unit: MCM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	17	8	22	38	40	36	36	0	0	17	38	36	287
1985	26	27	13	15	46	37	40	39	0	20	38	13	312
1986	17	31	7	3	34	40	43	39	19	7	28	17	286
1987	8	21	19	5	27	18	29	36	0	11	37	33	245
1988	29	36	14	7	40	42	41	42	6	0	35	31	325
1989	22	36	38	15	43	42	44	44	22	0	29	34	369
1990	27	31	35	1	28	38	40	40	21	7	35	30	334
1991	30	35	35	18	40	39	40	40	14	4	35	25	355
1992	36	36	38	0	0	13	26	27	26	10	18	36	267
1993	35	33	36	0	0	35	40	40	37	37	22	20	334
1994	18	25	32	18	0	0	0	0	0	12	21	28	154
1995	25	9	25	0	6	38	42	44	40	0	32	38	299
1996	32	25	15	0	23	36	39	37	27	0	37	28	300
1997	38	31	22	0	15	30	32	32	25	11	24	19	278
1998	16	20	34	36	53	48	49	33	0	40	53	27	409
1999	9	11	3	36	48	52	53	41	3	20	40	33	349
2000	17	16	2	17	41	44	47	40	6	18	37	31	315
2001	26	17	20	23	41	43	42	36	9	3	30	17	307
2002	13	26	8	0	27	41	44	38	0	34	31	10	273
2003	8	19	13	19	47	48	51	39	0	25	45	30	344
2004	27	26	19	8	33	32	32	30	8	7	17	12	252
2005	20	24	10	20	39	36	40	31	3	11	22	29	285
2006	14	22	21	12	43	44	48	46	17	1	22	32	322
Average	22	25	21	12	31	36	39	36	13	13	31	26	305

Data souce: MASL

Table 16 Water Supply for Irrigation of Minipe Right Bank

(unit: MCM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	-	-	-	-	30	-	-	-	-	2	26	15	-
1985	6	0	0	1	36	38	79	83	55	66	38	76	477
1986	0	0	0	0	4	41	135	37	34	24	52	34	360
1987	19	21	21	0	22	43	68	59	30	16	31	38	368
1988	43	106	92	50	85	133	108	121	60	92	65	124	1,080
1989	43	116	68	121	117	130	129	103	83	146	80	69	1,204
1990	55	84	105	104	126	102	126	109	-	55	79	18	-
1991	16	66	64	39	140	141	139	130	4	44	82	90	953
1992	93	107	157	81	91	90	78	52	4	119	128	88	1,087
1993	90	108	39	104	170	140	125	128	43	143	109	57	1,256
1994	37	62	48	141	169	168	190	154	50	143	63	10	1,235
1995	67	51	57	149	146	135	160	133	79	139	157	148	1,423
1996	140	131	11	60	154	127	119	91	9	123	153	119	1,239
1997	158	139	93	112	166	135	123	85	0	134	121	85	1,351
1998	115	138	171	155	159	144	121	95	54	138	141	102	1,533
1999	32	43	53	105	130	168	179	138	106	80	114	87	1,234
2000	79	104	44	56	76	160	118	86	36	89	104	70	1,022
2001	88	78	40	49	136	130	108	68	14	74	147	129	1,062
2002	58	90	123	70	77	121	135	95	5	129	112	52	1,069
2003	62	97	44	112	103	154	143	73	0	66	142	49	1,044
2004	95	112	78	0	115	111	117	115	43	54	57	46	944
2005	63	92	37	53	128	138	130	65	9	99	52	94	961
2006	64	87	43	131	150	144	160	122	0	115	111	47	1,175
Average	79	94	69	89	132	138	134	102	29	106	112	80	1,162

"-": Data not available

Data souce: MASL

Table 17 Power Release at Victoria Dam

(unit: MCM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	-	-	-	-	-	-	0	1	13	0	59	111	-
1985	12	113	150	94	79	34	82	97	122	125	108	127	1,141
1986	165	142	153	147	154	156	180	123	93	93	191	157	1,756
1987	145	163	149	41	34	59	44	28	98	153	117	72	1,104
1988	45	102	120	93	85	47	80	98	145	176	98	52	1,142
1989	136	70	231	132	127	133	51	63	67	80	83	136	1,310
1990	154	126	129	162	177	81	17	67	130	150	54	77	1,324
1991	108	47	136	192	171	91	91	66	52	69	81	58	1,164
1992	99	125	134	56	69	59	138	142	151	120	79	177	1,350
1993	139	98	210	198	142	44	39	123	197	167	106	101	1,564
1994	170	146	264	191	144	142	91	52	106	89	163	204	1,762
1995	172	132	180	162	173	178	183	242	156	178	231	230	2,216
1996	182	142	159	108	105	26	106	141	89	124	139	128	1,448
1997	136	87	149	106	42	89	105	144	94	111	125	199	1,386
1998	195	128	190	148	101	79	80	87	130	96	110	105	1,450
1999	153	130	179	170	152	151	193	197	172	150	64	88	1,799
2000	38	106	169	138	111	83	61	80	164	107	104	138	1,300
2001	138	103	112	79	66	55	104	94	59	107	119	115	1,152
2002	95	99	83	48	46	38	94	106	74	123	132	103	1,041
2003	54	62	110	122	184	155	91	58	66	57	76	52	1,086
2004	66	75	55	28	14	148	130	113	62	34	67	50	843
2005	67	27	85	72	78	50	23	98	62	67	84	56	768
2006	197	86	119	139	65	70	190	121	112	80	216	290	1,686
Average	121	105	148	119	105	89	99	106	109	112	116	123	1,354

"-": Data not available

Data souce: MASL

Table 18 Non-Power Release at Victoria Dam

(unit: MCM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	-	-	-	79	30	55	184	7	104	118	7	0	584
1985	0	0	0	0	0	292	244	51	23	0	291	0	901
1986	334	0	0	1	0	0	1	1	1	0	0	2	340
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	75	29	103
1989	31	0	0	0	0	0	133	209	154	99	273	23	923
1990	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	49	58	0	0	192	335	635
1994	120	49	0	0	0	0	0	0	0	0	139	99	408
1995	0	0	0	0	0	0	0	0	0	8	162	0	170
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	5	134	139
1998	4	0	0	0	0	0	0	0	0	0	0	0	4
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	244	45	289
Average	22	2	0	0	0	13	19	15	8	5	63	30	178

"-": Data not available

Data souce: MASL

Table 19 Power Release at Randenigala Dam

(unit: MCM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1986	-	-	-	-	-	-	-	127	205	167	141	338	-
1987	312	292	305	77	67	62	96	5	5	23	64	90	1,398
1988	122	201	166	77	114	173	126	120	43	73	140	134	1,490
1989	41	257	71	258	302	178	188	131	104	43	139	215	1,928
1990	259	204	219	208	198	158	156	183	113	71	149	82	1,999
1991	70	124	182	174	415	237	159	142	44	53	94	72	1,765
1992	72	143	299	94	91	115	142	95	53	125	116	73	1,416
1993	101	140	217	297	291	163	171	179	102	143	114	207	2,124
1994	354	299	302	229	192	207	282	165	120	113	57	311	2,630
1995	317	266	190	210	234	241	210	209	233	217	284	289	2,898
1996	309	263	245	139	265	185	133	112	25	125	173	114	2,087
1997	196	179	120	89	142	161	161	127	25	89	45	291	1,626
1998	327	150	230	184	196	196	182	133	95	195	187	112	2,188
1999	11	186	275	231	189	225	274	239	146	144	175	92	2,188
2000	86	197	307	146	179	218	167	66	75	127	121	92	1,781
2001	176	139	167	136	187	196	146	95	53	81	166	133	1,674
2002	32	90	154	57	79	159	171	128	30	148	98	41	1,186
2003	87	167	157	299	160	221	200	133	36	105	147	54	1,769
2004	78	123	90	16	141	135	143	143	41	15	14	23	962
2005	111	140	128	97	146	188	178	108	35	104	54	113	1,401
2006	62	153	98	197	182	187	229	178	132	122	205	444	2,190
Average	156	186	196	161	188	180	176	134	82	109	128	158	1,835

"-": Data not available

Data souce: MASL

Table 20 Power Release at Randenigala Dam

(unit: MCM)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1986	-	-	-	-	15	79	173	56	0	0	0	0	323
1987	0	0	0	0	0	0	0	92	17	8	0	0	117
1988	0	0	0	0	0	0	0	12	2	0	0	11	25
1989	89	16	46	0	0	0	0	2	7	26	287	59	531
1990	86	0	0	0	0	0	0	0	0	0	0	0	86
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	61	323	384
1994	98	36	0	0	0	0	0	0	0	0	0	163	297
1995	0	0	0	0	0	0	0	0	0	0	112	0	112
1996	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	67	67
1998	2	0	0	0	0	0	0	0	0	0	0	0	2
1999	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	50	0	0	0	0	50
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	67	117	183
Average	14	3	2	0	0	0	0	10	1	2	25	35	93

"-": Data not available

Data souce: MASL

Table 21 Monthly Water Level of the Randenigala Reservoir

(EL.m)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	225.8	226.7	224.9	223.6	-	218.6	212.5	208.7	211.2	-	216.4	-
2001	223.3	225.6	225.6	224.2	-	214.4	-	-	207.6	-	210.0	210.8
2002	216.0	220.8	220.6	219.7	220.1	217.0	211.8	209.2	210.0	211.0	212.9	219.4
2003	226.5	228.2	227.5	224.1	222.5	222.8	219.5	215.4	214.4	214.5	212.7	212.8
2004	214.8	215.2	214.0	214.2	211.6	208.8	209.1	208.1	207.9	209.9	214.5	223.1
2005	224.7	229.2	227.4	227.2	226.4	222.2	214.7	210.3	211.1	211.2	212.6	214.1
2006	220.1	227.2	228.7	230.0	227.9	223.7	221.0	219.5	218.5	218.1	224.9	231.8
2007	231.5	-	227.2	227.7	226.9	221.3	213.9	208.9	208.5	210.0	211.0	214.0
Average	222.8	224.7	224.5	223.8	222.5	218.6	214.6	211.4	211.1	212.4	214.4	218.0

"-": Data not available

Table 22 Monthly Mean Water Level of the Victoria Reservoir

(EL.m)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	428.4	425.3	418.8	411.8	406.2	425.2	437.6	437.8	435.7	435.6	437.9	437.6
1986	437.8	436.5	435.0	433.8	433.5	427.9	419.4	414.7	414.7	426.9	434.7	429.2
1987	423.5	414.7	395.0	378.6	376.2	376.7	377.4	381.0	391.9	400.1	414.2	422.1
1988	421.3	416.3	406.9	403.0	403.6	404.8	413.2	424.9	432.4	436.6	437.6	438.0
1989	437.5	435.1	428.3	417.1	408.1	415.4	426.9	438.0	437.5	438.0	438.0	437.3
1990	437.1	433.7	430.2	423.3	414.7	411.7	418.9	423.2	420.6	413.8	420.3	424.0
1991	428.2	428.9	425.8	415.1	393.6	391.6	383.8	380.1	379.2	381.9	398.8	409.0
1992	418.4	413.4	398.5	381.2	380.2	387.4	393.6	416.4	419.8	424.5	430.8	437.0
1993	435.2	432.7	426.3	412.0	389.7	417.8	434.6	437.4	433.1	430.7	437.9	438.0
1994	438.0	437.9	433.7	423.9	413.1	405.0	394.0	408.6	410.0	419.6	436.5	437.9
1995	436.0	434.2	430.3	424.3	431.1	435.5	437.3	431.6	431.7	436.2	437.5	433.4
1996	425.7	419.4	408.2	397.6	390.0	386.1	394.8	396.3	405.4	424.9	428.7	429.3
1997	425.1	419.0	410.7	396.7	409.0	409.8	404.1	398.9	397.7	417.1	432.4	437.9
1998	437.4	433.9	426.8	416.7	406.7	400.3	402.5	410.3	413.6	425.1	428.6	429.0
1999	434.3	436.1	432.7	427.5	421.9	432.0	433.5	426.2	415.9	407.3	407.7	411.1
2000	414.6	419.0	417.9	412.0	403.9	398.5	396.7	403.4	406.4	410.0	410.5	407.0
2001	405.4	410.3	403.6	397.8	396.8	394.5	392.9	395.3	388.0	402.3	406.7	406.5
2002	405.4	410.3	403.6	397.8	396.8	394.5	392.9	395.3	388.0	402.3	406.7	406.5
2003	423.8	429.8	429.3	429.4	428.1	420.2	412.1	410.6	417.9	417.5	415.0	413.4
2004	410.8	405.0	396.1	392.3	398.4	403.1	401.0	392.9	387.8	399.5	409.8	418.6
2005	425.4	428.1	426.2	421.6	419.7	415.3	415.5	412.9	414.5	417.1	424.0	434.4
2006	437.1	436.5	435.8	434.2	432.3	433.3	434.1	429.9	427.1	426.8	435.9	437.4
2007	435.7	433.0	426.8	419.6	415.9	413.4	415.5	-	-	-	-	-
Average	427.0	425.6	419.4	411.6	407.4	408.7	410.1	412.1	412.2	417.9	424.1	426.1

"-": Data not available

Appendix II-5-2

Estimation of the Inflow from the Residual Basin between the Polgolla Weir and the Victoria Dam

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Estimation of the Inflow from the Residual Basin between the Polgolla Weir and the Victoria Dam

1. General

According to the operation record of Polgolla weir and the Victoria dam, inflow between the Polgolla weir and the Victoria dam is estimated approximately to 461 MCM/year. However, flow regime and monthly inflow are unknown because any discharge measurement of the tributaries has not been undertaken. The rainfall pattern in the upstream of the Polgolla weir and in the residual basin between the Polgolla weir and at the Victoria dam are different, because upstream area is subject to Southwest monsoon while the residual basin is under Northeast monsoon as described in Chapter 5.

Since the flow regime of the Victoria dam affects to the Victoria reservoir operation, it is important to estimate the inflow corresponding to the rainfall pattern in the basin.

This appendix aims to present the hydrological method to estimate inflow into the Victoria reservoir between the Polgolla weir and Victoria dam.

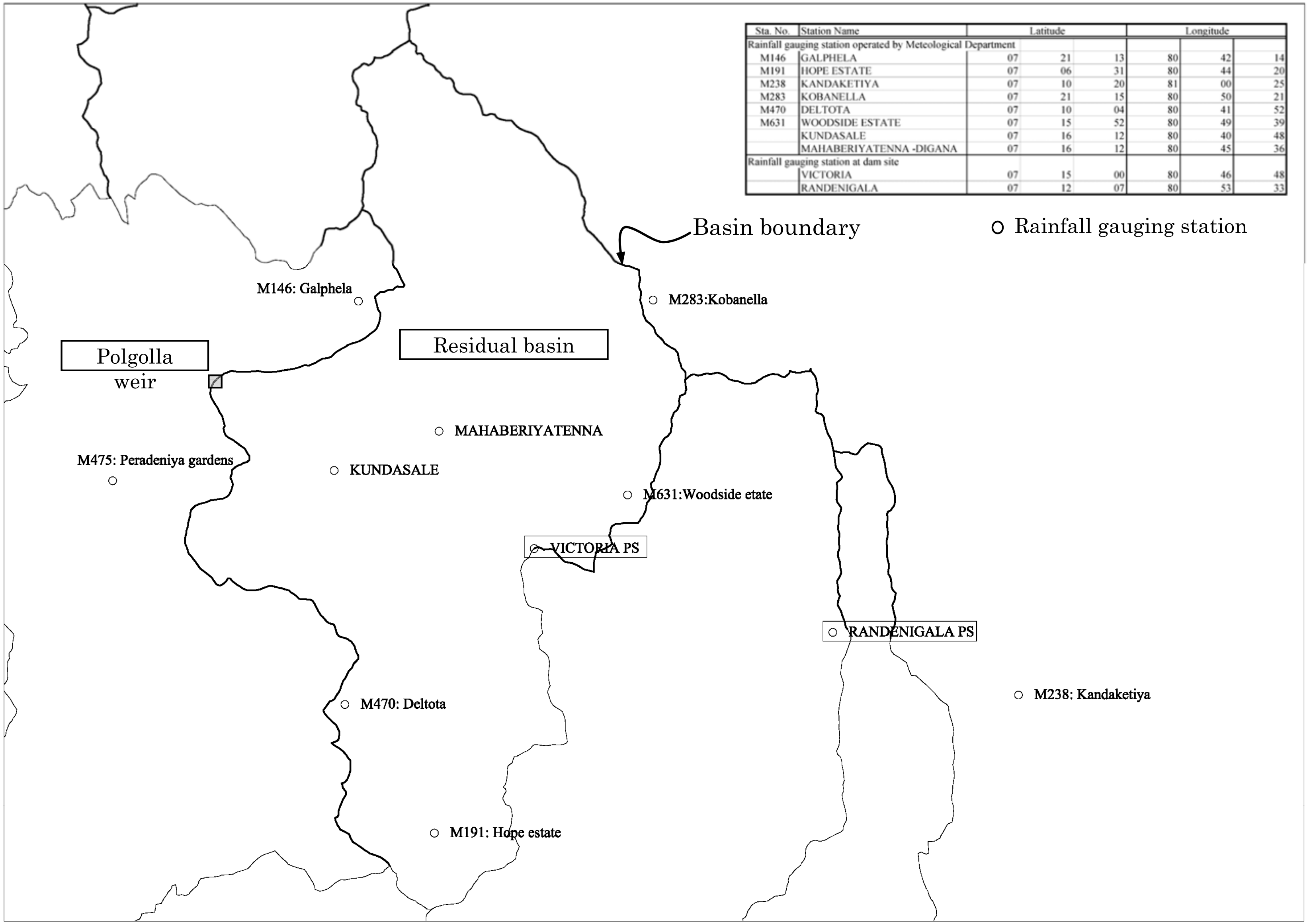
2. Rainfall Data

There are 11 rainfall gauging stations located vicinity of the Victoria hydropower station. The list of the rainfall gauging stations is shown below.

Table 1 Discharge Record at Bottom Outlet and Spillway Release

Sta. No.	Station Name	Latitude			Longitude		
Rainfall gauging station operated by Meteological Department							
M146	GALPHELA	07	21	13	80	42	14
M191	HOPE ESTATE	07	06	31	80	44	20
M238	KANDAKETIYA	07	10	20	81	00	25
M283	KOBANELLA	07	21	15	80	50	21
M470	DELTOTA	07	10	04	80	41	52
M631	WOODSIDE ESTATE	07	15	52	80	49	39
	KUNDASALE	07	16	12	80	40	48
	MAHABERIYATENNA -DIGANA	07	16	12	80	45	36
Rainfall gauging station at dam site							
	VICTORIA	07	15	00	80	46	48
	RANDENIGALA	07	12	07	80	53	33

The location of the rainfall gauging station is shown in **Figure 1**.



Sta. No.	Station Name	Latitude			Longitude		
Rainfall gauging station operated by Meteological Department							
M146	GALPHELA	07	21	13	80	42	14
M191	HOPE ESTATE	07	06	31	80	44	20
M238	KANDAKETIYA	07	10	20	81	00	25
M283	KOBANELLA	07	21	15	80	50	21
M470	DELTOTA	07	10	04	80	41	52
M631	WOODSIDE ESTATE	07	15	52	80	49	39
	KUNDASALE	07	16	12	80	40	48
	MAHABERIYATENNA -DIGANA	07	16	12	80	45	36
Rainfall gauging station at dam site							
	VICTORIA	07	15	00	80	46	48
	RANDENIGALA	07	12	07	80	53	33

Figure 1 Basin Boundary and Location of Rainfall Gauging Station

(1) Correlation coefficient

The correlation coefficient of the data measured at each station is shown in **Table 2**.

Table 2 Correlation Coefficient of the Rainfall Data between Each Station

	Kundasale	M191: Hope Esate	M238: Kandaketiya	M283: Kobanella	M146: Galphela	M470: Deltota	M631: WoodSide	Randenigala	Victotia	Mahawel	M 475: P.Gardens
Kundasale		0.655	0.15	0.60	0.79	0.82	0.71	0.57	0.61	0.77	0.69
M191: Hope Esate	0.65		−0.08	0.80	0.71	0.71	0.84	0.78	0.71	0.73	0.74
M238: Kandaketiya	0.15	−0.08		−0.12	0.15	0.03	−0.04	#DIV/0!	0.06	−0.10	0.13
M283: Kobanella	0.60	0.80	−0.12		0.62	0.67	0.86	0.90	0.81	0.76	0.43
M146: Galphela	0.79	0.71	0.15	0.62		0.82	0.66	0.46	0.55	0.76	0.76
M470: Deltota	0.82	0.71	0.03	0.67	0.82		0.70	#DIV/0!	0.66	0.76	0.76
M631: WoodSide	0.71	0.84	−0.04	0.86	0.66	0.70		0.62	0.82	0.87	0.48
Randenigala	0.57	0.78	#DIV/0!	0.90	0.46	#DIV/0!	0.62		0.85	#DIV/0!	0.08
Victoria	0.61	0.71	0.06	0.81	0.55	0.66	0.82	0.85		0.82	0.38
Mahawel	0.77	0.73	−0.10	0.76	0.76	0.87	0.87	#DIV/0!	0.82		0.57
M 475: P.Gardens	0.69	0.74	0.13	0.43	0.76	0.48	0.48	0.08	0.38	0.57	

‘#DIV/0!’ in the table indicates that there is no data matched in the same duration. According to the table above, most of the gauging station has some correlation to others except gauging station M238.

(2) Generating missing rainfall data

Missing data is generated from the most correlated gauging station data. Data is generated by using linear regression line.

(3) Verification of data by double mass curve

After generating missing data by regression analysis, the validity of the data is checked by double mass curve analysis. The rainfall data of measured at M238 and the Randenigala hydropower station is not omitted because these data are not used in the further study.

Double mass curve is a graph showing aggregated data in both ‘x’ and ‘y’ axis. Double mass curve of each the rainfall gauging station data and average of all rainfall data is plotted as shown in **Figure 2**. In **Figure 2**, ‘x’ axis is aggregated average rainfall monthly data of all rainfall station, and ‘y’ axis is aggregated rainfall monthly data of the targeted rainfall data.

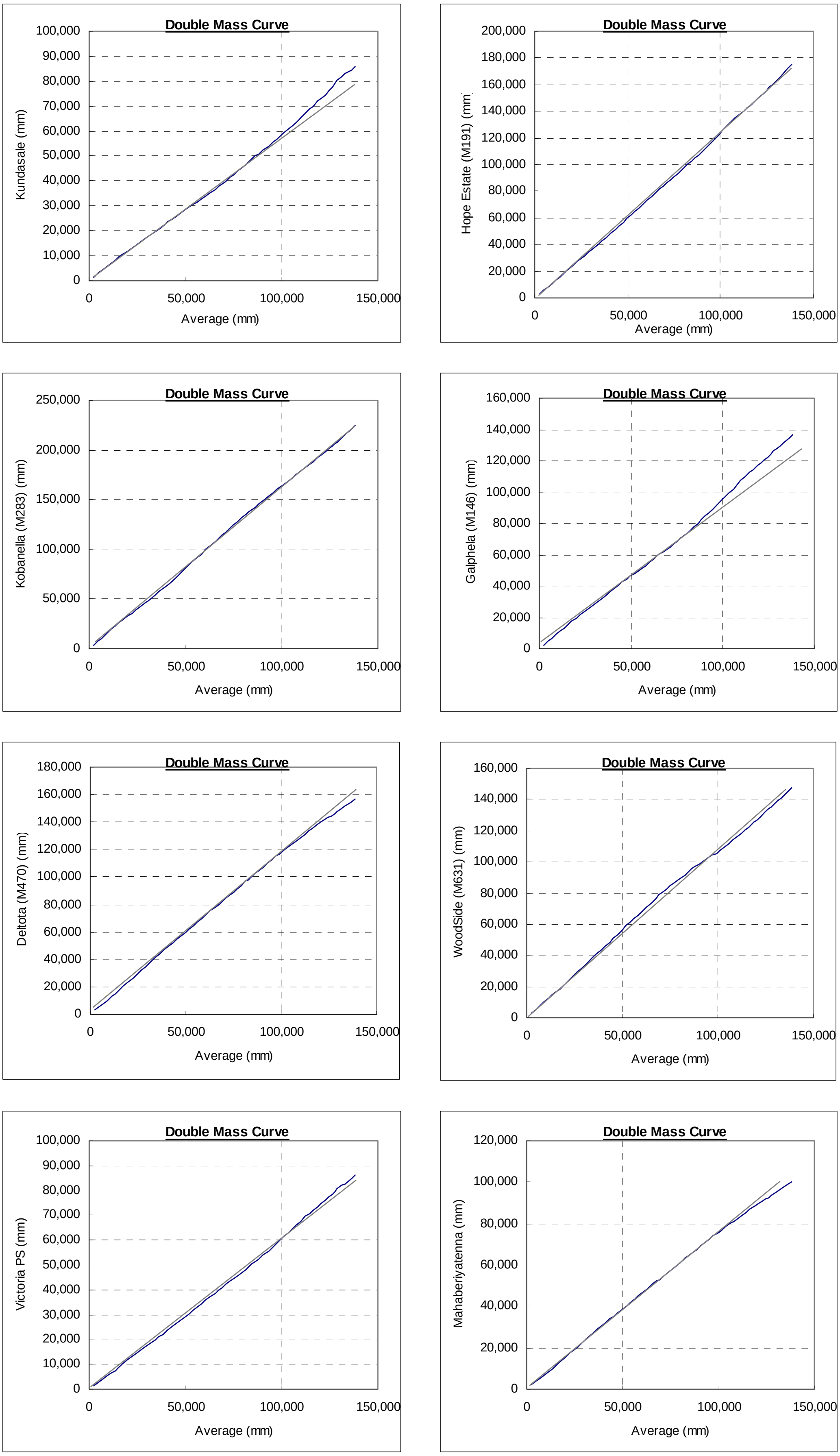


Figure 2 Double Mass Curve Analysis of Rainfall Data (1/2)

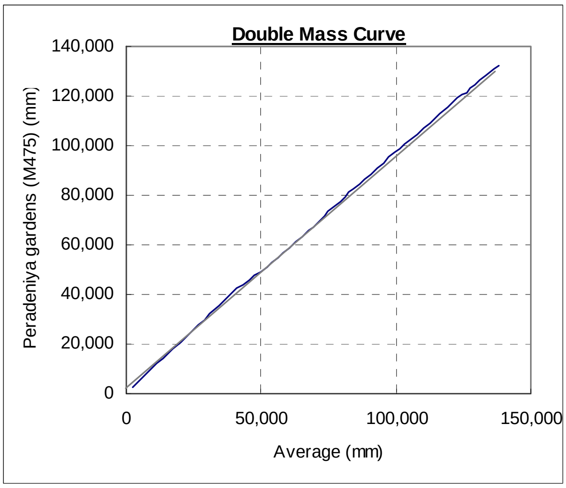


Figure 2 Double Mass Curve Analysis of Rainfall Data (2/2)

According to the above mass curve, Kundasale and Galphela has showing clear bent during the observation. Therefore, the data may have error and should be corrected.
The rainfall data of Kundasale and Galphela is corrected by the following equation.

$R_{cx} = R_x * Sc / Sa$

Where,

R_{cx} : corrected rainfall values at any time period at station X

R_x : original recorded rainfall values at any time period at station X

Sc : corrected slope of the double-mass curve

Sa : original slope of the mass curve

By applying above equation, double mass curve for the both station are shows almost on the straight line as shown in **Figure 3**.

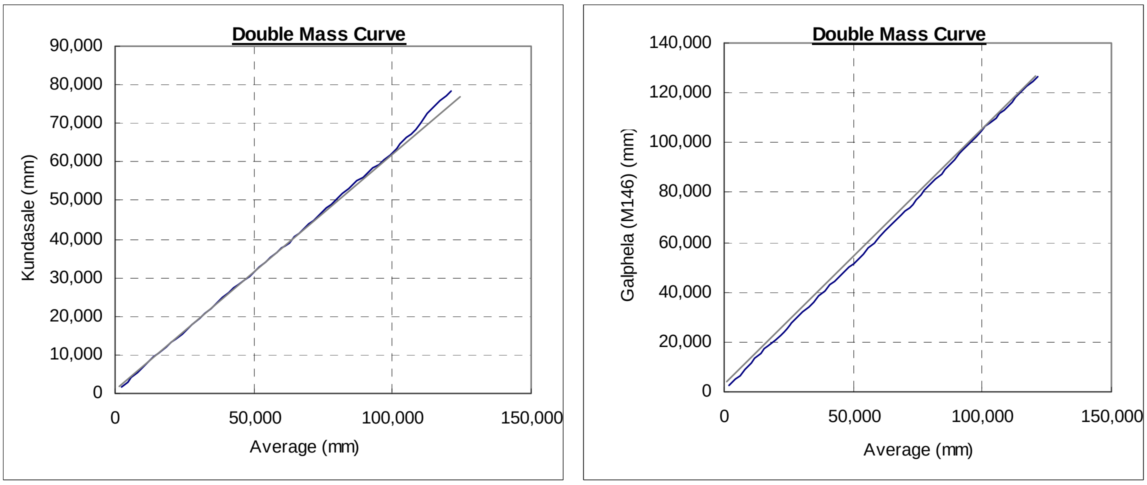


Figure 3 Double Mass Curve Analysis of Kundasale and Galphela after Corrected

(4) Thiessen Polygon

Thiessen Polygon for the residual basin is shown in below.

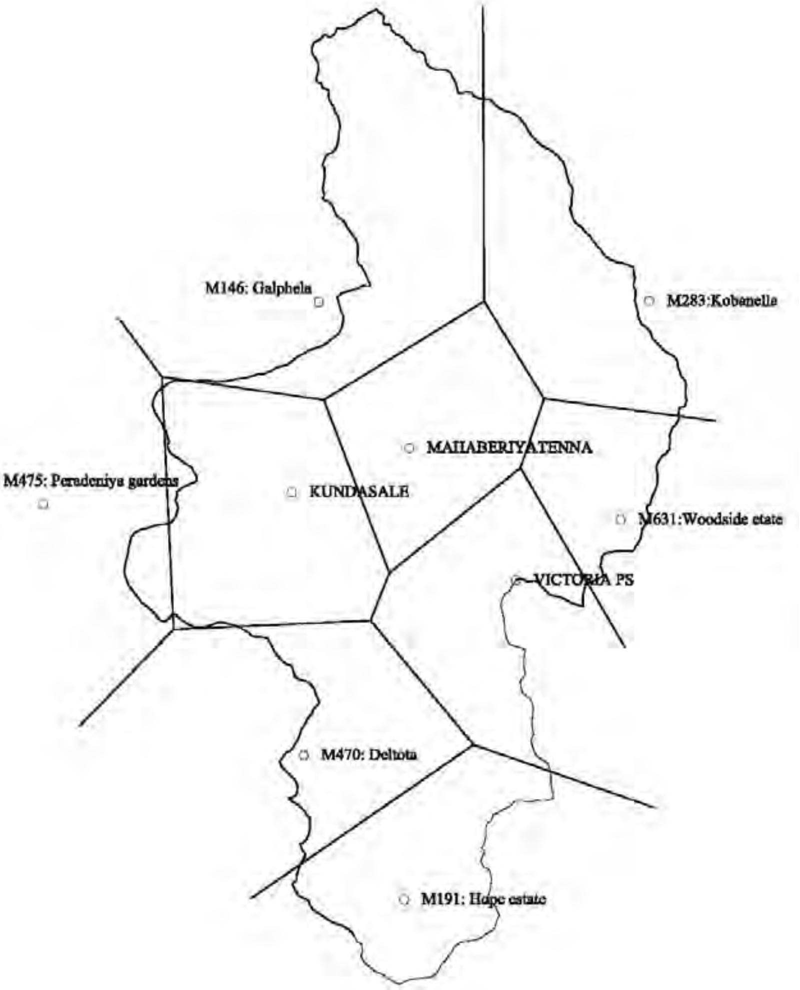


Figure 4 Thiessen Polygon for the Residual Basin

Area of each Thiessen polygon is tabulated below.

Table 3 Thiessen Polygon Area for Each Rainfall Gauging Station

Rainfall Gauging Sta.	Area (km^2)
Kundasale	90.0
M191: Hope Esate	63.8
M283: Kobanella	69.6
M146: Galphela	96.6
M470: Deltota	54.5
M631: WoodSide	36.5
Victoria	63.0
Mahawel	67.9
M 475: P.Gardens	7.6
Total	**459.5**

Average rainfall of the basin is obtained by the weighted average on the polygon area. The average rainfall in the basin is calculated as below.

Table 4 Average Rainfall in the Basin

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1985	193	121	178	62	170	394	175	143	126	256	283	298	2,398
1986	421	184	165	176	56	125	102	196	121	323	138	210	2,216
1987	169	19	86	209	172	94	2	121	170	406	201	168	1,819
1988	44	61	129	339	78	66	159	151	155	94	334	290	1,900
1989	269	20	49	106	117	117	308	86	150	214	247	96	1,779
1990	289	138	134	66	238	133	76	94	73	270	220	463	2,196
1991	350	28	120	95	88	257	112	81	81	280	249	401	2,143
1992	106	117	43	118	119	105	200	90	137	168	476	218	1,895
1993	76	74	57	56	188	246	148	40	50	431	318	463	2,146
1994	320	213	73	149	83	54	129	88	183	447	399	254	2,394
1995	212	134	77	260	247	98	42	86	101	303	220	138	1,919
1996	169	148	23	239	30	91	108	85	131	270	248	153	1,694
1997	8	62	60	274	178	95	105	103	271	559	413	325	2,454
1998	214	76	31	86	124	109	153	120	156	118	131	289	1,607
1999	399	196	74	145	154	202	35	48	70	282	212	172	1,989
2000	211	222	85	121	55	135	68	196	94	127	272	209	1,794
2001	262	65	35	266	31	68	95	15	143	174	105	258	1,520
2002	82	67	79	211	69	42	55	116	18	185	276	200	1,399
2003	214	68	155	147	39	54	79	60	51	78	216	59	1,220
2004	131	76	104	136	110	94	91	52	145	264	307	469	1,981
2005	125	91	58	164	120	124	143	58	147	195	380	167	1,773
2006	404	126	179	157	192	143	133	49	125	377	544	438	2,867
Average	212	105	91	163	121	129	115	94	123	265	281	261	1,959

3. Estimation of Inflow by Tank Model

The inflow of the residual basin is estimated by 4 × 1 tank model. The parameters of the tank model are decided so as to that the annual average coincides the actual records, and minimize the deviation of annual average for each year.

The parameters are determined by the try-and-error process to fulfill the aforesaid condition.
The inflow from the residual basin is estimated by tank model. The result of the estimated inflow is tabulated in **Table 5** and hydrograph is shown in **Figure 5**.

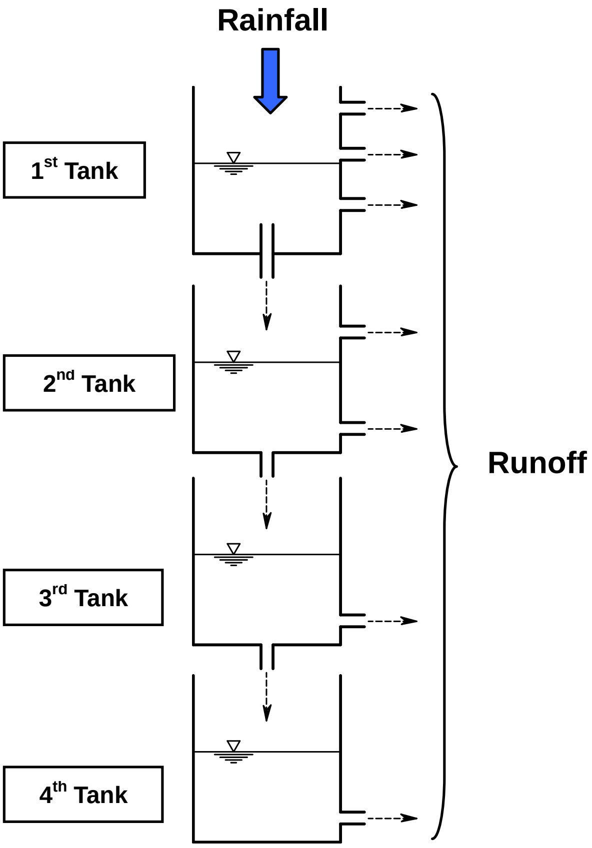


Figure 5　Conceptual Structure of the Tank Model

Table 5
Monthly Inflow from the Residual Basin between Polgolla Div. and the Victoria Dam

（MCM）

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1985	31.9	22.0	26.5	10.4	21.5	69.3	45.1	31.3	23.3	47.3	62.2	69.3	460.1
1986	93.3	56.6	38.7	37.2	15.6	19.0	17.6	34.1	25.2	62.6	42.5	48.6	491.1
1987	41.5	12.6	12.1	31.0	32.9	20.5	11.7	14.6	27.7	78.5	59.4	46.4	388.9
1988	18.7	12.4	14.3	59.4	25.1	15.3	26.3	29.2	30.6	22.3	66.1	71.4	391.1
1989	68.2	21.7	13.8	14.9	17.5	20.4	57.5	28.0	30.1	45.1	58.3	33.6	409.2
1990	60.0	39.6	29.6	18.0	41.9	32.8	20.1	18.6	15.7	49.9	55.4	101.8	483.4
1991	94.8	32.3	26.2	21.8	19.1	48.6	32.5	21.6	18.8	54.4	63.4	94.2	527.9
1992	48.0	34.2	17.8	19.7	22.9	22.7	40.6	25.6	29.2	38.5	100.7	72.7	472.6
1993	36.0	23.6	18.0	17.4	31.5	51.6	40.5	20.0	16.9	79.5	84.6	112.9	532.4
1994	94.6	68.2	30.9	35.1	23.8	19.0	23.8	21.1	36.6	93.8	105.8	82.5	635.1
1995	65.8	45.0	26.0	53.7	60.3	36.3	20.5	20.4	21.4	62.0	62.6	46.9	520.9
1996	45.8	40.6	20.1	44.5	19.4	19.7	21.8	20.6	26.5	57.5	65.5	49.8	431.8
1997	18.8	18.2	17.6	48.7	43.5	27.9	25.0	23.2	53.5	119.6	116.7	99.3	612.0
1998	71.7	36.2	20.1	19.9	22.9	24.8	34.0	30.3	35.6	32.7	36.1	65.4	429.5
1999	94.2	65.2	30.6	34.8	36.6	47.4	23.2	20.0	19.3	54.3	58.0	51.0	534.7
2000	54.5	56.9	29.4	29.5	19.6	25.1	20.1	38.4	26.4	31.1	61.4	58.8	451.0
2001	66.5	31.6	19.3	48.9	21.0	18.6	19.3	17.8	24.5	38.2	31.7	57.2	394.7
2002	31.2	20.9	17.4	36.6	20.1	16.7	16.1	18.0	15.4	32.2	60.0	54.1	338.6
2003	53.6	25.3	29.5	31.6	15.8	15.2	15.1	14.5	13.9	14.1	39.8	20.0	288.5
2004	25.4	16.9	16.0	22.7	19.9	17.3	16.7	13.2	20.2	50.5	70.6	106.7	396.1
2005	53.6	29.2	14.6	25.1	22.8	24.3	28.8	16.3	24.5	40.1	81.7	55.1	416.1
2006	89.3	47.9	41.8	38.0	42.3	36.0	32.4	18.7	22.0	74.8	125.2	122.0	690.3
Average	57.2	34.4	23.2	31.8	27.1	28.6	26.8	22.5	25.3	53.6	68.5	69.1	468.0

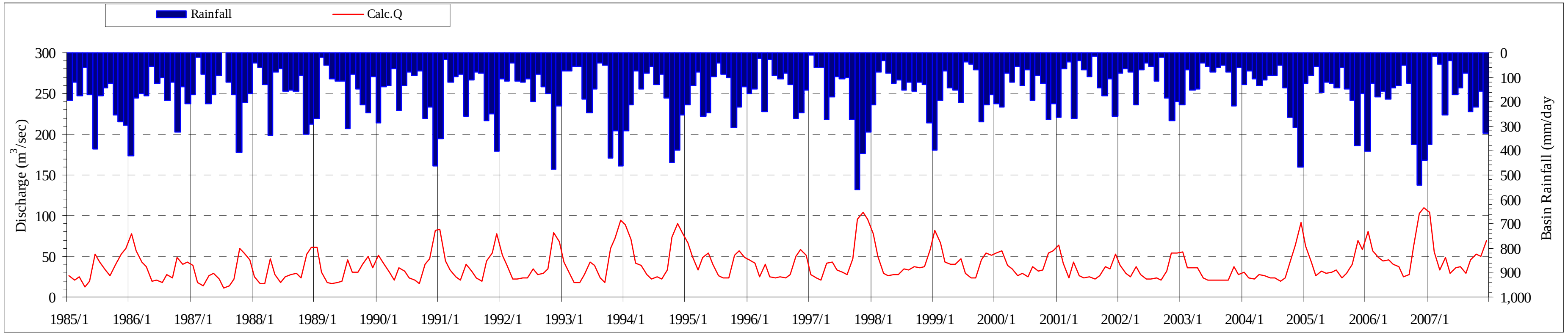


Figure 6 Monthly Inflow from the Residual Basin between Polgolla Div. and the Victoria Dam

The estimated inflow has annual average of 461 MCM/year same as the operation records given by MASL.

Chapter 6

Optimization of Development Plan

Appendix II-6-1

Optimal Layout of Downstream Option for Comparative Study of Alternative Options

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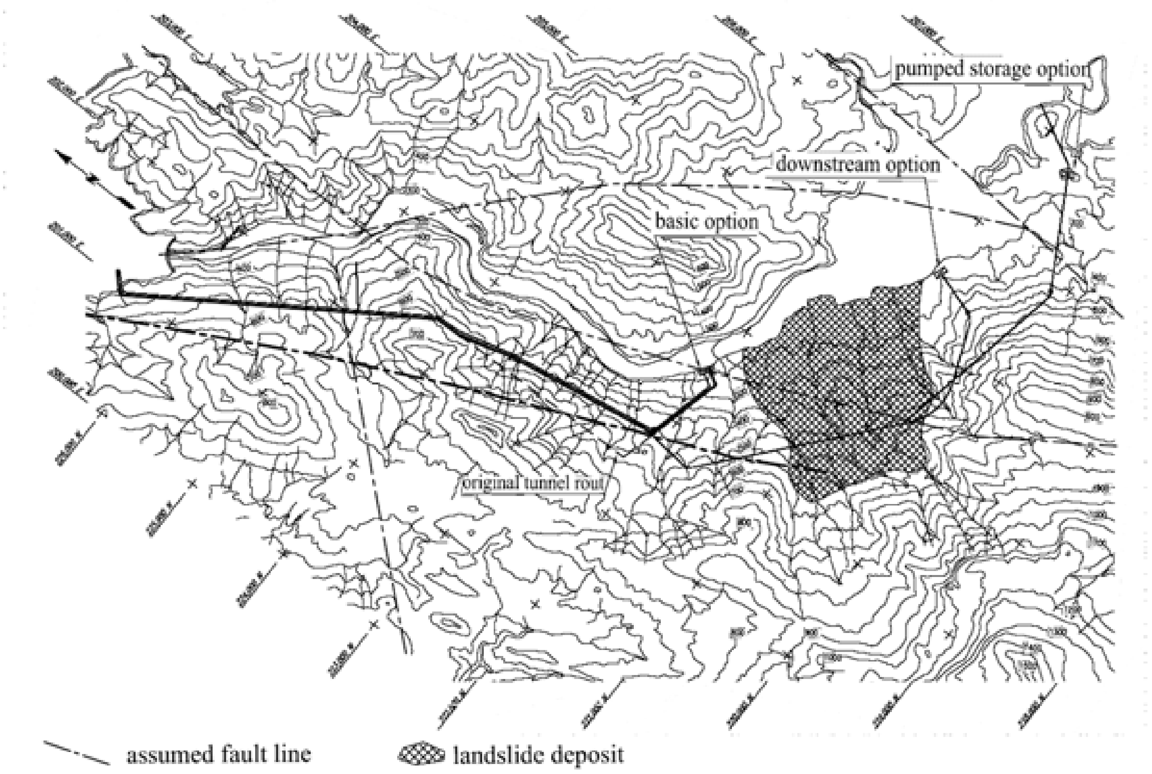
Optimal Layout of Downstream Option for Comparative Study of Alternative Options

1. General

The Study Team conducted the comparative study of the alternative options on a preliminary feasibility study level as specified in the inception report. During the comparative study, the following layouts are examined for the downstream option in consideration of the landslide deposit area shown in **Figure 1**.



Note: Layout A is shown in this Figure.

Figure 1 Main Geological Structures

(1) Layout A

To avoid any open-air structures located on landslide deposits area, an open-air powerhouse and outlet are installed downstream of the landslide area. The Layout A has longer tunnel length than the Layout B mentioned below.

It is noted that any open-air type structure could not be installed upstream of the landslide deposits area, because there are small valleys on which do not deems suitable to install open-air structures.

(2) Layout B

Turbine center elevation is EL. 218 m which is 10 m lower than that of the existing facilities to prevent the Randenigla reservoir water level from being lowered during construction of the outlet structure. . A powerhouse is of underground type to avoid the adverse geological condition, but the outlet is located in the landslide area and its sill elevation is EL. 220 m.

2. Scale of Expansion

(1) General Layout

The general plan and profile of “Layout A” and “Layout B” are shown in **Figure 2** and **Figure 3**, respectively.

(2) Number of Units and Discharge for Generation

The number of generation units is considered as three, and the maximum discharge for generation is 140 m^3/s for both layouts in this comparative study.

(3) Tunnel Length

In order to confine the internal pressure of the water conveyance tunnel, it is required to have enough rock cover above the tunnel roof. For determining alignment of the headrace tunnel, the tunnel alignment is laid on where ground surface elevation is EL. 450 m or higher on the topographic map.

The tunnel length of each layout is shown in **Table 1**;

Table 1 Tunnel Length of Layouts A and B

Layout A	Layout B
9.1 km	7.0 km

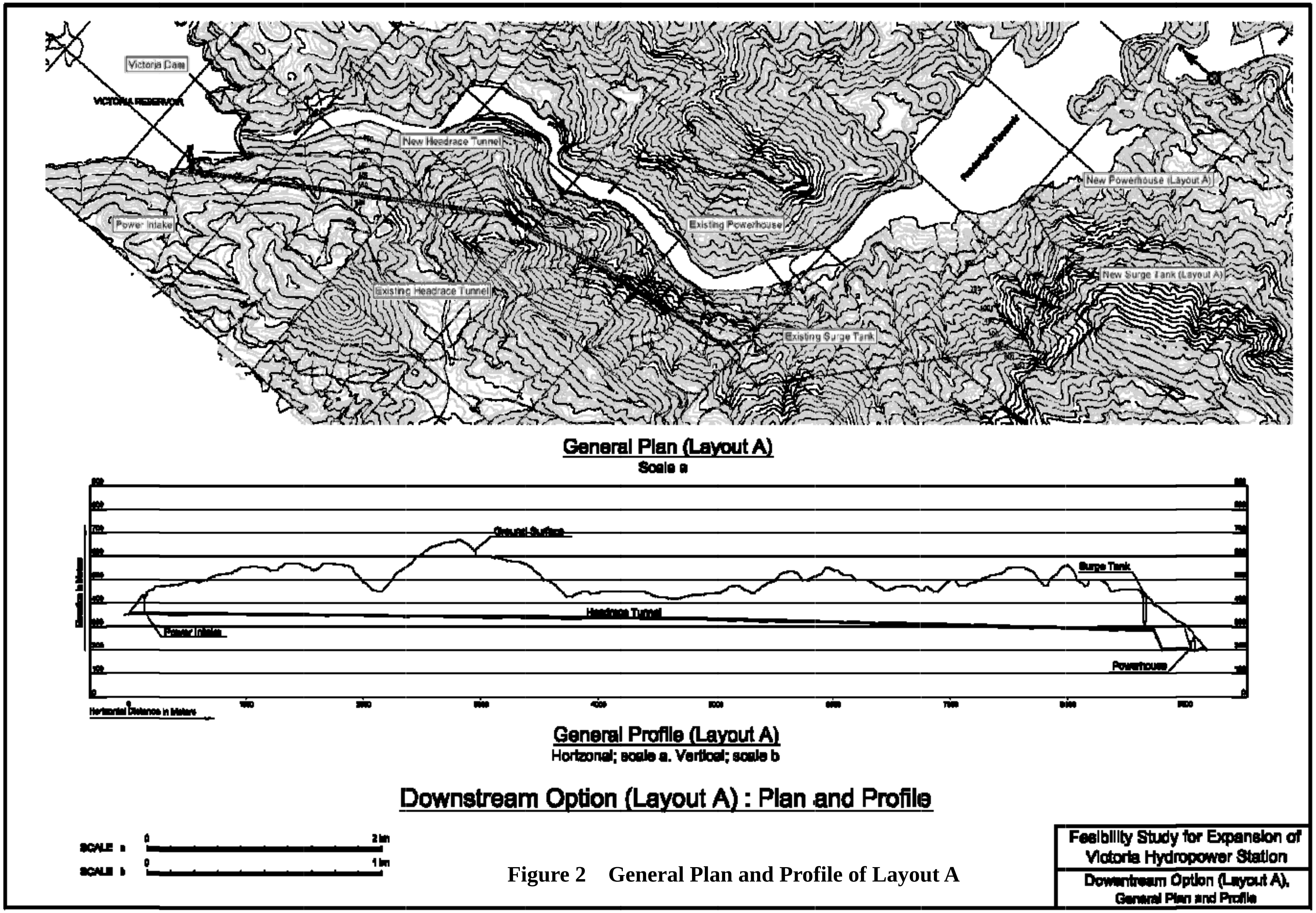


Figure 2 General Plan and Profile of Layout A

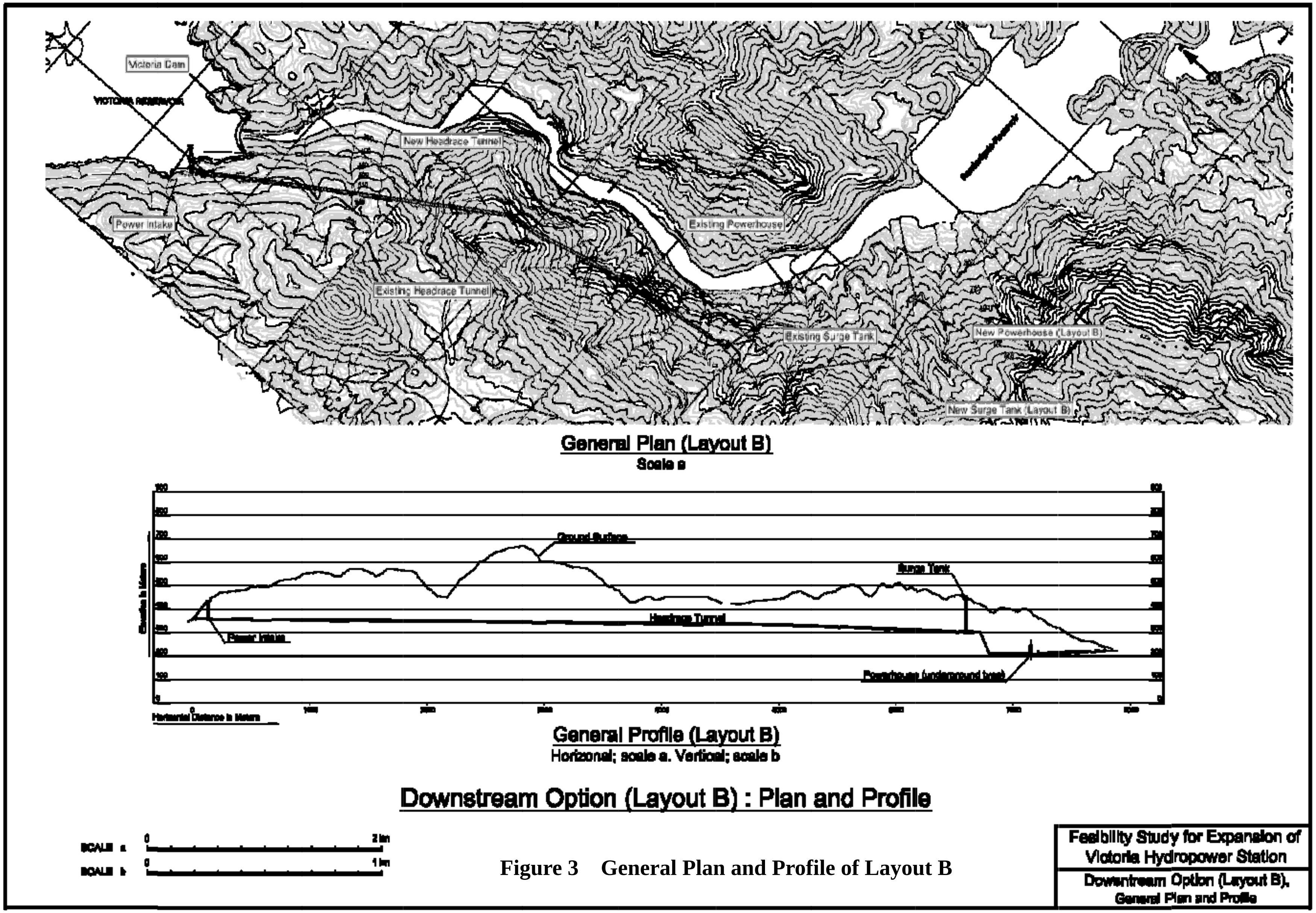


Figure 3 General Plan and Profile of Layout B

3. Annual Energy

Annual energy for “Layout A” is calculated as 652 GWh/year by the simulation on power generation using monthly inflow data into the Victoria reservoir. The detail of the calculation is given in the **Chapter 6**.

The annual energy for “Layout B” is calculated by using the same data for “Layout A”. The duration of the inflow data used in the power generation simulation is from 1985 to 2006.

The result of the power generation simulation of “Layout B” is shown with that of “Layout A” in **Table 2**.

Table 2 Annual Energy and Dependable Capacity of Layouts A and B

Option	# of units	Installed Capacity (MW)	Annual Energy (GWh)	Firm Energy (GWh)	Secondary Energy (GWh)	95% Dependable Capacity (MW)
Downstream Option: Layout A	3	219	652	449	203	361
Downstream Option: Layout B	3	225	658	460	198	359

4. Construction Cost

The construction cost of “Layout A” is described as the 3-unit expansion of the downstream option in the **Chapter 6**. For “Layout B”, the cost due to lowering the reservoir water level of Randenigala reservoir may not be necessary during the construction, because the sill elevation is EL. 220 m with temporary coffer dam. However, the underground power house necessitates more construction cost than surface type powerhouse. The estimated cost of “Layout A” and “Layout B” is summarized in **Table 3**.

Table 3 Project Cost of Layouts A and B

Item	Unit	Layout A	Layout B
		peak duration = 3 hrs	peak duration = 3 hrs
		3 unit	3 unit
Preparatory Works	Mill. US$	1.96	1.96
Civil works	Mill. US$	90	109
Equipment & Transmission Line	Mill. US$	83	81
Environmental Cost	Mill. US$	3	3
Administration & Engineering Fee	Mill. US$	17	19
Contingency	Mill. US$	20	21
Reduction of Energy	GWh/year	108	0
Period of reduction	years	1	0
kWh value by coal	US$/kWh	0.053	0.053
Cost of reduction of energy covered by Coal power	Mill. US$	5.8	0.0
Total construction cost	Mill. US$	215	236
Total construction cost incl. cost of reduction of energy	Mill. US$	220	236

It is noted that the total construction cost of “Layout B” is larger than that of “Layout A”. This is mainly due to the increment of construction cost of the underground powerhouse.

5. Benefit and Cost Analysis

(1) Cost

The benefit and cost analysis is to comparing the ratio of annualized benefit and cost (B/C). The method of the B/C analysis is given in **Chapter 6**. The annualized cost of “Layout A” and “Layout B” is given in **Table 4**.

Table 4 Annualized Cost of Layouts A and B

Item	Unit	Layout A peak duration = 3 hrs 3 unit	Layout B peak duration = 3 hrs 3 unit
1) Additional capacity	MW	219	225
2) Installed capacity including existing units of 210 MW	MW	429	435
3) Depandable capacity	MW	361	359
4) Annual Energy	GWh	652	658
Firm Energy	GWh	449	460
Secondary Energy	GWh	203	198
5) Total Construction cost	Mill. US$	215	236
Construction cost: civil works	Mill. US$	90	109
Equipment & Transmission Line	Mill. US$	83	81
Construction cost: others	Mill. US$	42	45
6) Construction period	years	5.5	5.5
7) Economic life of hydropower	years	50	50
8) Interest rate	%	10.0	10.0
9) Capital recovery factor	%	10.1	10.1
10) O & M rate for civil works	%	0.50	0.50
11) O & M rate for Equipment & Transmission Line	%	1.50	1.50
12) Annual O & M Cost	Mill. US$/year	2	2
13) Interest during construction(IDC)	Mill. US$	47	52
14) Annualized cost: Construction, IDC and O&M: [5) + 13)] × 9) + 12)	Mill. US$/year	28	31
15) Cost of reduction of energy during construction	Mill. US$	6	0
16) Annualized Cost of 15)	Mill. US$/year	1	0
17) Pump-up cost (using coal kWh value)	Mill. US$/year	-	
Annualized cost: 14) + 16) + 17)	Mill. US$/year	29	31

(2) Benefit

The benefit of “Layout A” and “Layout B” is calculated by the increment of the benefit to the existing generation facilities. The detail of the method of benefit calculation is given in **Chapter 6**. The annualized benefit of the both “Layout A” and “Layout B” is shown in **Table 5**.

Table 5 Benefit of Layouts A and B

Description	Unit	Existing	Downstream Layout A	Downstream Layout B
1. Annual Energy	GWh	632	652	658
Firm Energy	GWh	230	449	460
Secondary Energy	GWh	402	203	198
2. Dependable Peak Capacity	MW	210	361	359
3. Power to be Generated (Gas)	MW	248	427	425
4. Energy to be Generaged (Gas)	GWh/yr	235	459	470
5. Energy to be Generaged (Coal)	GWh/yr	435	220	214
6. kWh-Value (Gas)	US$/MWh	177	177	177
7. kWh-Value (Coal)	US$/MWh	53	53	53
8. kW-Value (Gas)	US$/kW	70	70	70
9. Annual Benefit (Gas) for capacity	Mill.US$/yr	17	30	30
10. Annual Benefit (Gas) for firm energy	Mill.US$/yr	42	81	83
11. Annual Benefit (Coal) for secondary energy	Mill.US$/yr	23	12	11
12. Annual Benefit (Gas&Coal)	Mill.US$/yr	82	123	124
Increment of Benefit	Mill.US$/yr	0	41	42

As shown in the table, the benefit of “Layout B” is slightly larger than that of “Layout A”.

(3) B/C

The ratio of the benefit to the cost for “Layout A” and “Layout B” is calculated as tabulated in **Table 6**.

Table 6 B/C Analysis of Layouts A and B

Item	Unit	Layout A	Layout B
Installed capacity	MW	219	225
Benefit	Mill. US$/year	41	42
Cost	Mill. US$/year	29	31
B / C		1.42	1.37

As shown in the table, the B/C of “Layout A” is larger than that of “Layout B”. Therefore, “Layout A” is the better to be the downstream option from the economic point of view and compared with the other two options in the Study.

Appendix II-6-2

Peak Duration Required by Power Demand and That from Viewpoint of Hydropower Planning

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Peak Duration Required by Power Demand and That from Viewpoint of Hydropower Planning

1. General

In **Section 6.1.3**, the peak duration for the existing and expansion plants was examined only in consideration of power demand in the gird by using daily load curve, daily load duration curve, and annual load duration curve. In some similar studies on hydropower projects, comparison study on the peak duration of a hydropower plant is examined by varying peak duration hours, in addition to the examination on the peak duration required by power demand in the system grid. In this appendix, explanation why Study Team examined it only from the viewpoint of power demand is mentioned.

2. Examination Conducted in Section 6.1.4 of Final Report

In **6.1.4 (2)** of the final report, water available for the expansion plant was calculated as mentioned below;

a. 95% dependable discharge which is the available discharge for hydropower generation for 24 hours. was calculated to 35 m^3/s.

b. The relation among the maximum plant discharge, the firm discharge and peak hours is;

$$Q_{max} = Q_{firm} \times \frac{24}{T} \ (m^3/s) \text{ ....(1)}$$

Where,

Q_{max} : Maximum plant discharge (m^3/s)
Q_{firm} : Firm discharge = 95% dependable discharge (m^3/s)
T : Peak duration for Victoria Hydropower Station (hours)

c. As mentioned in **Section 6.1.3**, the peak duration appropriate for the Victoria Hydropower Station is 3 hours. In this case, the maximum plant discharge is as follows;

$$Q_{max} = 35 \times \frac{24}{3} = 280 \ (m^3/s)$$

The maximum plant discharge for the existing hydropower generators is 140 m^3/s. Therefore, the residual of 140 m^3/s is the available discharge for the expansion units.

Relations among the 95% dependable discharge, maximum plant discharge and peak duration are shown in **Figure 1**. The development plan with 3-hour peak duration is referred to as Plan 1 in this appendix.

It is noted that the maximum plant discharge of the existing plant is set at 140 m^3/s in any case, to be able to generate power at the installed capacity (210 MW).

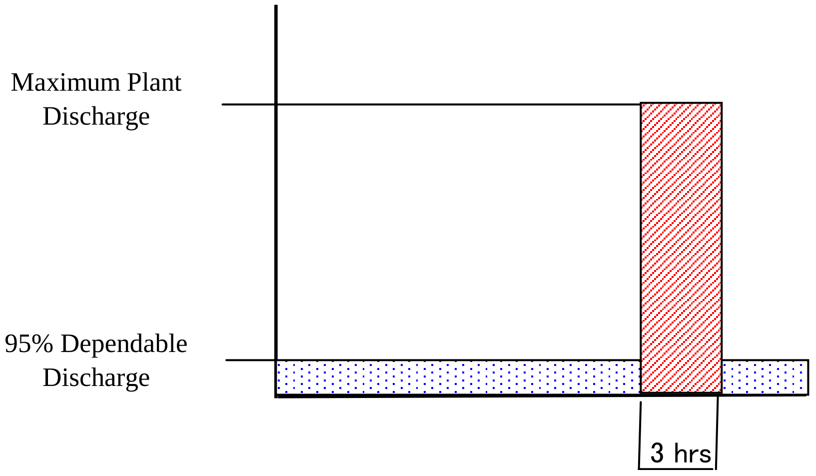

Figure 1
Firm Discharge and Maximum Plant Discharge with 3-Hour Peak Duration

To select optimal peak duration time of the plant, the benefit and cost method is used for an economic evaluation in the same way of the optimization study in **Chapter 6** of the final report.

The cost for economic evaluation corresponds to annualized construction cost and annual operation and maintenance (O&M) cost for the Project, and the benefit consists of the following costs of the alternative thermal power plant;

a. Capacity benefit (US$/kW) : Capital cost (construction cost) and fixed O&M cost
b. Energy benefit (US$/kWh) : Variable O&M cost and fuel cost

The benefit of the firm energy which is obtained during peak demand hours is calculated by using variable O & M cost and fuel cost of the alternative gas turbine, and the benefit of secondary energy obtained during off-peak hours was calculated by using those costs of coal-fired thermal plant. It is noted that kWh value of the firm energy is higher than that of the secondary energy.

3. Case of Longer Peak Duration than Peak Demand Duration

This case means the peak duration of the plant is longer than peak demand duration of 3 hours.

In the case, the maximum plant discharge for the existing and expansion is less than 280 m^3/s, because the peak duration (T) in the equation (1) is longer than 3 hours. Hence, the maximum plant discharge for the expansion plant is less than 140 m^3/s, and the installed capacity of the expansion plant is smaller than that of Plan 1.

Relations among the 95% dependable discharge, maximum plant discharge, peak duration required by demand (3 hours), and peak duration of the plant (longer than 3 hours) are shown in **Figure 2**.

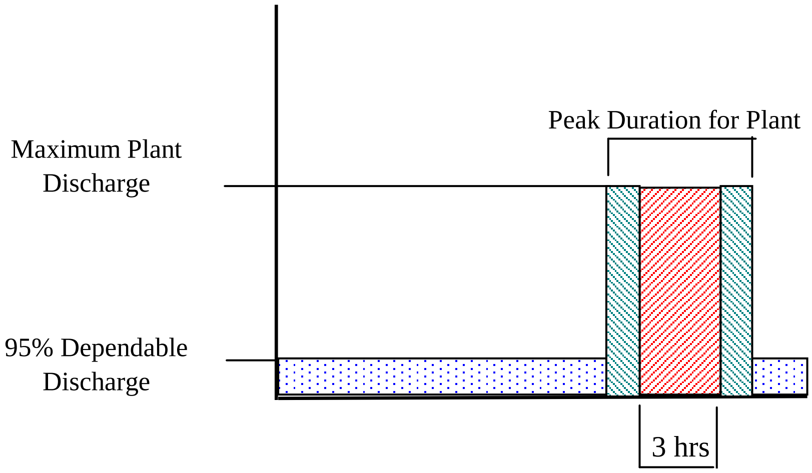

Figure 2
Firm Discharge and Maximum Plant Discharge with Longer Peak Duration than 3 Hours

Because the demand requires 3-hour peak operation, the firm energy corresponds to only the red colored portion in **Figure 2**, and the green colored portion is regarded as secondary energy. Hence, less firm energy is obtained in comparison with Plan 1 in Section 2 because of smaller installed capacity than that of Plan 1.

In comparison with Plan 1, less kW benefit and less kWh benefit are obtained because of smaller installed capacity and less firm energy, although lower construction cost is required due to smaller capacity. Consequently the benefit cost ratio (B/C) is smaller than that of Plan 1.

4. Case of Shorter Peak Duration than Peak Demand Duration

This case means the peak duration of the plant is shorter than 3-hour peak demand duration.

In the case, the maximum plant discharge for the existing and expansion is more than 280 m^3/s, because the peak duration (T) in the equation (1) is shorter than 3 hours. Hence, the maximum plant discharge for the expansion plant is more than 140 m^3/s, and the installed capacity of the expansion plant is larger than that of Plan 1.

Relations among the 95% dependable discharge, maximum plant discharge, peak duration required by demand (3 hours), and peak duration of the plant (shorter than 3 hours) are shown in **Figure 3**.

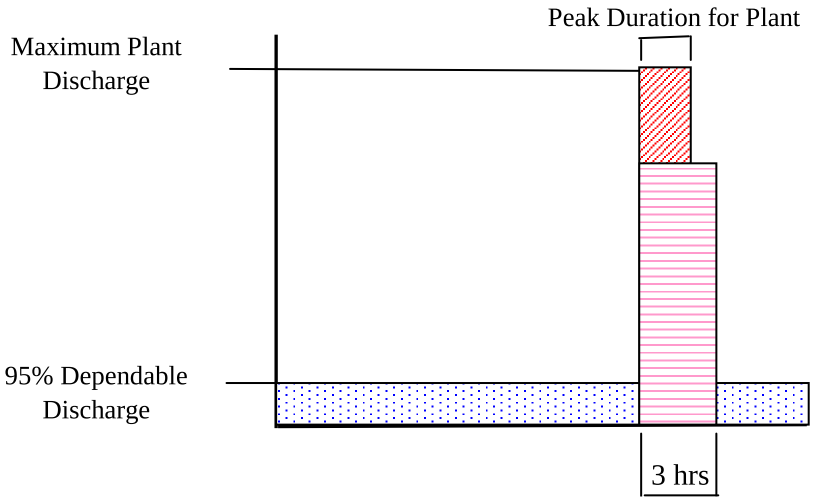

Figure 3
Firm Discharge and Maximum Plant Discharge with Shorter Peak Duration than 3 Hours

Because the demand in the grid requires longer peak operation than peak duration of the plant, the plant is obliged to be operated with less output than the installed capacity because longer duration (3 hours) than peak duration of the plant is required. Energy obtained corresponds to pink colored portion.

In comparison with Plan 1, kW value and kWh value are not larger than Plan 1 due to longer operation with less output than the installed capacity, but construction cost is higher than that of Plan 1 due to larger installed capacity. Consequently B/C is smaller than that of Plan 1

5. Conclusion

Although the above explanation is qualitative, it is definite in accordance with the consultant’s experience in the field of hydropower planning. Therefore, the peak duration for the expansion plant is examined only from the viewpoint of power demand.

Appendix II-6-3

Affects on Randenigala Reservoir Water Level due to Expansion of Victoria Hydropower Station

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Affects on Randenigala Reservoir Water Level due to Expansion of Victoria Hydropower Station

Study Team calculated water levels of the Randenigala reservoir after the Victoria expansion to grasp affects on water level of the reservoir. In this appendix, the method used and result of calculation are described.

1. Data Used for Water Balance of Randenigala Reservoir

The following data are used for the water balance of the Randenigala reservoir:

(1) Inflow to Randenigala Reservoir

Inflow to the Rendemigala reservoir is calculated with the following equation;

$$\text{Inflow} = \overset{\text{Release from Victoria reservoir}}{\begin{pmatrix} \text{release from power generation} \\ \text{+ spill out from spillway} \\ \text{+ release from bottom outlet} \end{pmatrix}} + \begin{matrix} \text{Residual flow between Victoria} \\ \text{and Randenigala reservoirs} \end{matrix}$$

The release of Victoria reservoir, which was calculated in the energy calculation of the Victoria hydropower station, is used as “Release from Victoria reservoir” in the above equation. The data of residual flow between Victoria and Randenigala reservoirs is estimated with catchment area and monthly rainfall pattern.

(2) Release from Randenigara reservoir

Release records provided by MASL are used for release from Randenigala reservoir for both power generation and non-power generation.

(3) Randenigala reservoir water level

The water level record of the Randenigala reservoir was provided to Study Team by the Randenigala Hydropower Station. The duration of the data is available from year 2000 to 2006. The water level records are used for the comparison of the Randenigala reservoir water level simulation.

2. Calculation Results

(1) Calculation Cases

Monthly water level before and after expansion with 3-hour peak operation are calculated from 2000 to 2006 when records on monthly water levels of Randenigala reservoir are available.

(2) Water Balance

Water balance of the both cases are shown in **Table 1** and **Table 2**;

Table 1 Water Balance of Randenigala Reservoir before Expansion

Case 1: Use Victoria Simulation Release (Before Expansion)						
	(1)	(2)	(3) = (1) + (2)	(4)	(5)	(6) = (3) − (4) − (5)
Year	Victoria Release	Inflow from residual basin	Inflow to Radenigala	Randenigala release	Randenigala Spill	Delta V (Inflow − Release)
2000	1,219,268	461,314	1,680,582	1,780,572	0	−99,990
2001	1,141,194	405,874	1,547,068	1,673,511	0	−126,443
2002	1,128,772	369,966	1,498,738	1,186,419	0	312,319
2003	1,045,413	342,886	1,388,299	1,768,828	50,364	−430,893
2004	1,238,029	405,059	1,643,089	962,112	202,270	478,707
2005	1,177,119	457,856	1,634,975	1,400,998	233,977	0
2006	1,605,232	654,211	2,259,442	2,190,248	464,350	−395,156
Total	8,555,027	3,097,166	11,652,193	10,962,688	950,961	−261,456

Table 2 Water Balance of Randenigala Reservoir after Expansion

Case 2: Use Victoria Simulation Release (After Expansion)						
	(1)	(2)	(3) = (1) + (2)	(4)	(5)	(6) = (3) − (4) − (5)
Year	Victoria Release	Inflow from residual basin	Inflow to Radenigala	Randenigala release	Randenigala Spill	Delta V (Inflow − Release)
2000	1,197,795	461,314	1,659,109	1,780,572	0	−121,463
2001	1,132,563	405,874	1,538,437	1,673,511	0	−135,074
2002	1,153,454	369,966	1,523,421	1,186,419	0	337,002
2003	1,181,665	342,886	1,524,551	1,768,828	43,889	−288,167
2004	1,086,131	405,059	1,491,191	962,112	187,676	341,402
2005	1,152,217	457,856	1,610,073	1,400,998	209,075	−0
2006	1,634,051	654,211	2,288,261	2,190,248	494,642	−396,629
Total	8,537,876	3,097,166	11,635,042	10,962,688	935,283	−262,929

(3) Water Level of Randenigala Reservoir

Calculation results of the water level before and after expansion are shown in **Table 3** and **Table 4**, and those with actual reservoir water level records are shown in **Figure 1**.

Table 3 Water Level of Randenigala Reservoir before Expansion

Case 1: Use Victoria Simulation Release (Before Expansion)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	228.2	228.4	221.6	221.0	214.8	208.5	203.3	211.6	214.4	216.8	218.4	221.5
2001	221.8	221.9	216.5	216.5	210.1	202.5	201.5	201.8	205.8	213.8	212.6	214.8
2002	219.3	217.8	212.6	219.7	221.9	219.8	213.7	212.6	217.6	216.1	222.9	229.5
2003	232.0	229.0	229.1	223.0	222.8	214.4	207.4	208.4	213.8	211.4	207.2	208.0
2004	207.5	203.9	202.2	206.5	204.5	205.0	205.8	204.2	209.5	219.9	228.1	232.0
2005	232.0	231.0	228.3	227.3	224.5	219.3	214.1	211.5	220.5	222.8	232.0	232.0
2006	232.0	231.3	232.0	229.2	227.1	225.1	223.1	218.9	218.1	222.3	232.0	227.0

Table 4 Water Level of Randenigala Reservoir after Expansion

Case 2: Use Victoria Simulation Release (After Expansion)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	228.1	228.0	221.0	220.4	216.7	210.7	207.5	210.8	213.7	215.9	217.4	220.6
2001	220.7	220.8	217.8	217.2	212.9	207.8	205.8	206.6	209.9	212.3	210.9	213.1
2002	218.3	219.2	216.7	220.2	222.4	220.2	216.7	215.6	219.9	218.2	222.8	229.2
2003	232.0	229.2	229.0	222.7	222.5	216.6	211.3	209.8	214.2	214.3	212.7	215.9
2004	218.0	216.7	217.6	222.1	220.7	219.3	217.2	215.0	218.7	223.9	229.5	232.0
2005	232.0	230.9	230.0	231.0	229.5	226.3	223.7	223.7	227.0	227.7	232.0	232.0
2006	232.0	231.1	232.0	228.9	226.6	224.6	222.3	219.1	218.2	222.2	232.0	226.9

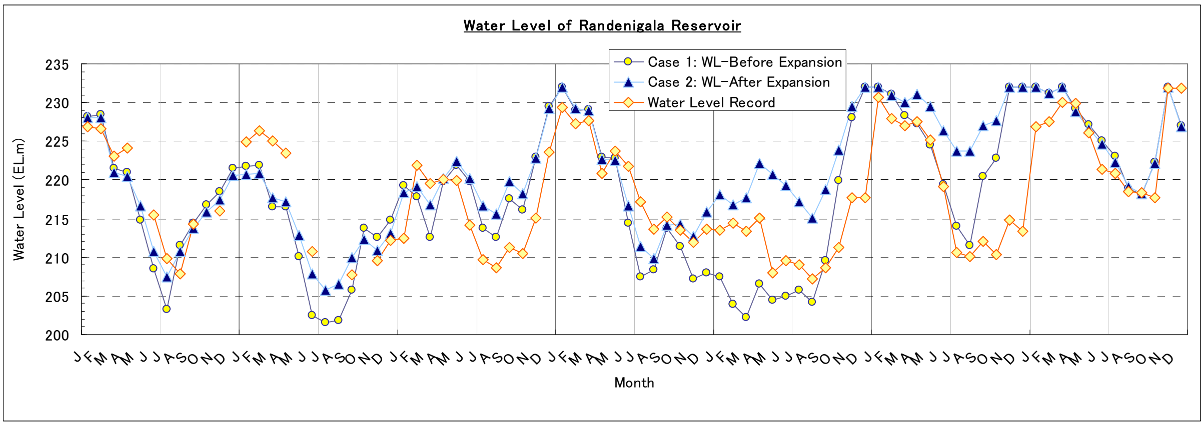

Figure 1 Water Level of Randenigala Reservoir

According to the above results, water levels of the Randenigara reservoir after expansion are fluctuated less largely than actual recorded water levels. Water levels below 207 m after expansion are calculated less frequently than those actually recorded.

Chapter 9

Basic Design

Appendix II-9-1

Depth of Tunnel Cover

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Appendix II-9-1
Depth of Tunnel Cover

In this appendix, the results of checking of depth of tunnel cover described in **9.3.1** are shown with figures.

The tunnel consists of the concrete lined headrace tunnel approximately 5,000m long and the penstock tunnel approximately 600m in length. The tunnel cover was examined in the headrace tunnel section.

The checked sections were Section1 (Ch.2,022~2,122m), Section2 (Ch.3,717~3,867m) and Section3 (Ch.4,440~4,590m) where the depths are relatively shallow. The investigated sections are shown in **Figure 1**.

Necessary depth of cover (red dot line) and actual depth of cover (blue line) is shown in **Figure 2** to **Figure 21**.

The actual depth of cover satisfies necessary depth of cover in the headrace tunnel section.

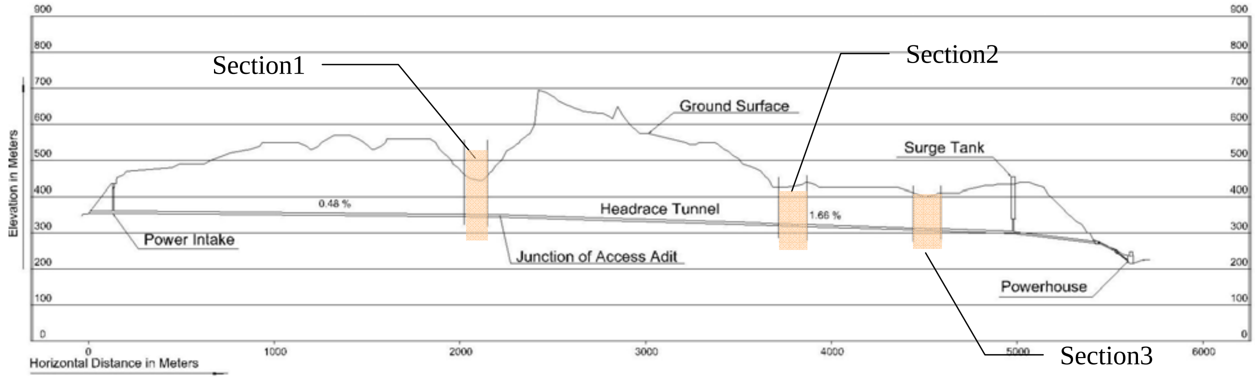

Figure 1　Investigated Section

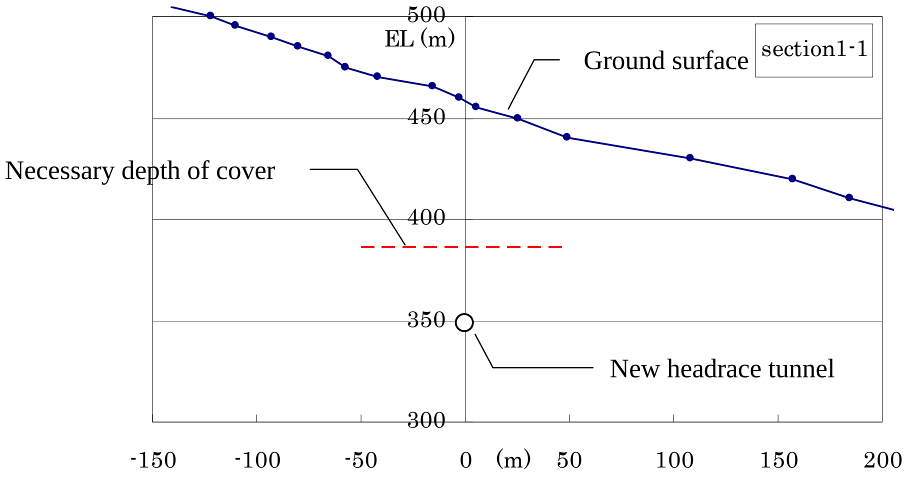

Figure 2　Section 1-1 Ch. 2,022 m

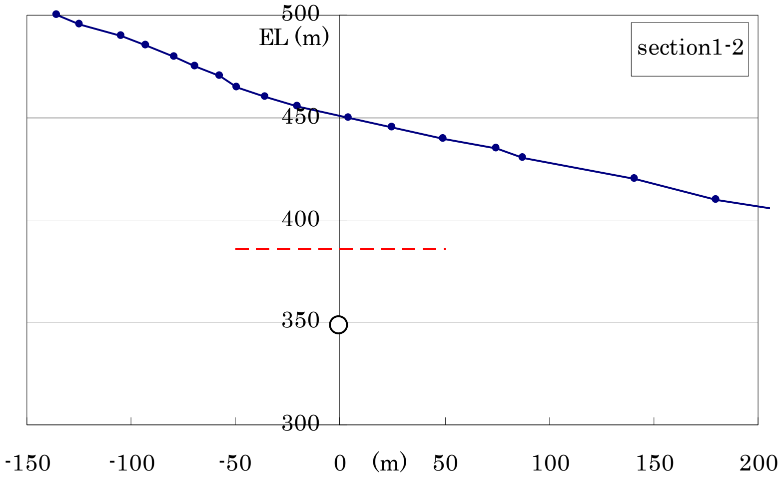

Figure 3 Section 1-2 Ch. 2,047 m

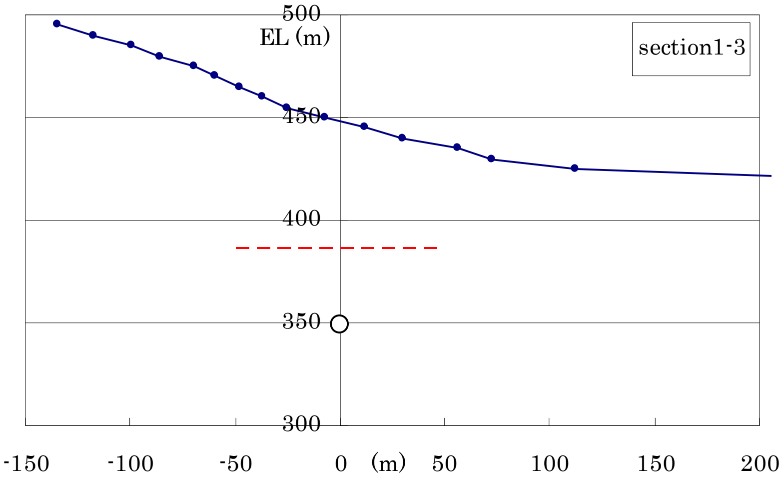

Figure 4 Section 1-3 Ch. 2,072 m

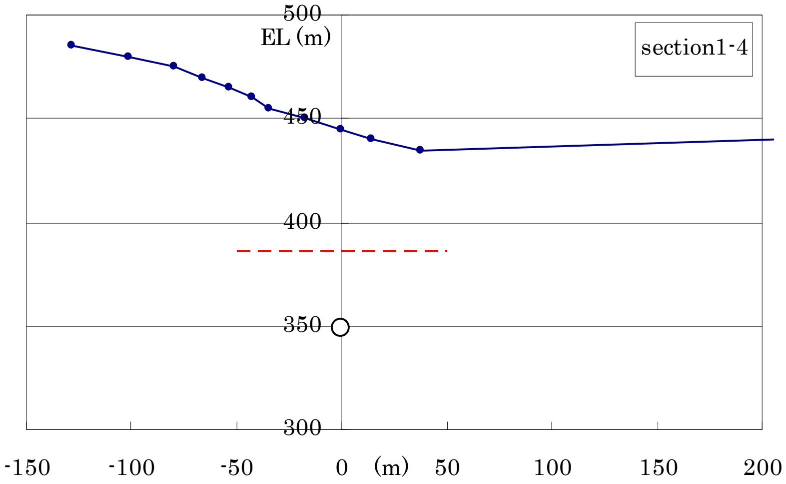

Figure 5 Section 1-4 Ch. 2,097 m

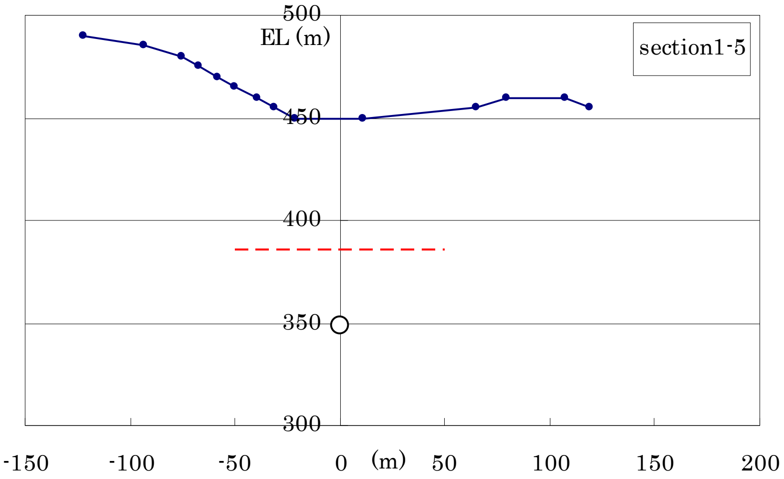

Figure 6 Section 1-5 Ch. 3,817 m

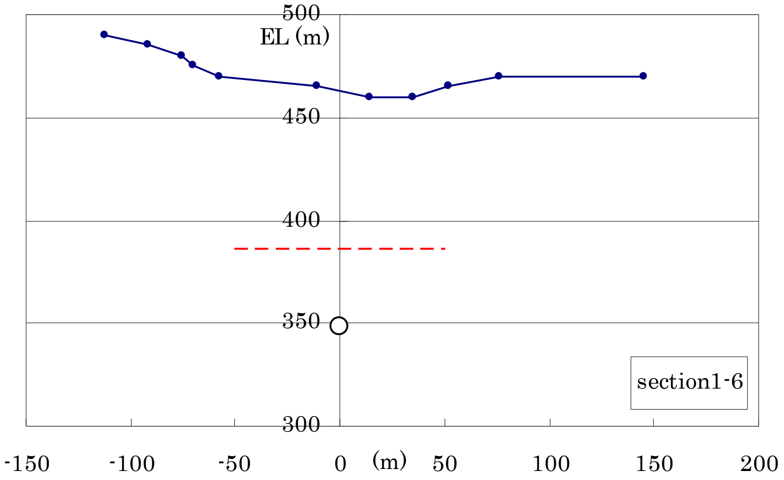

Figure 7 Section 1-6 Ch. 2,122 m

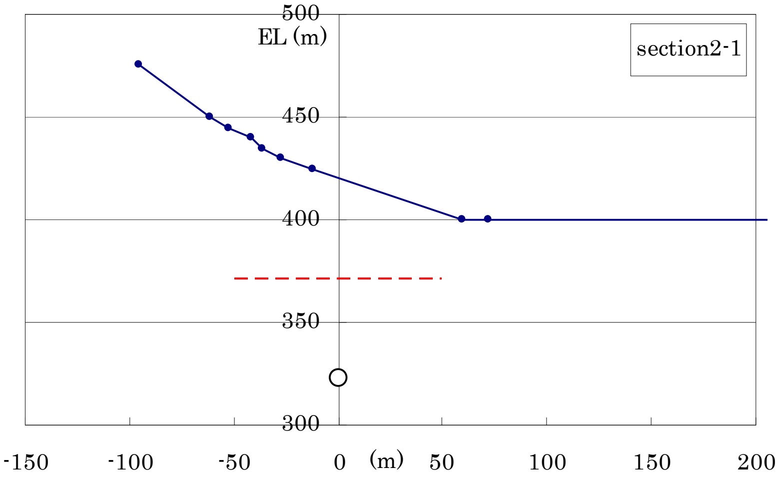

Figure 8 Section 2-1 Ch. 3,717 m

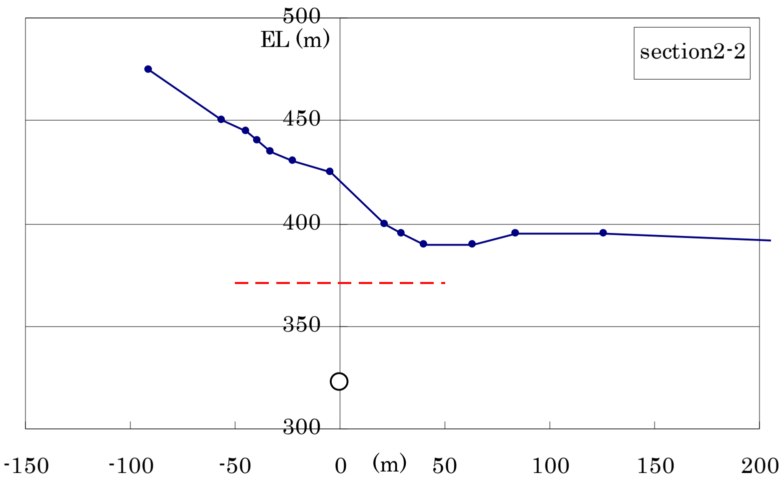

Figure 9 Section 2-2 Ch. 3,742 m

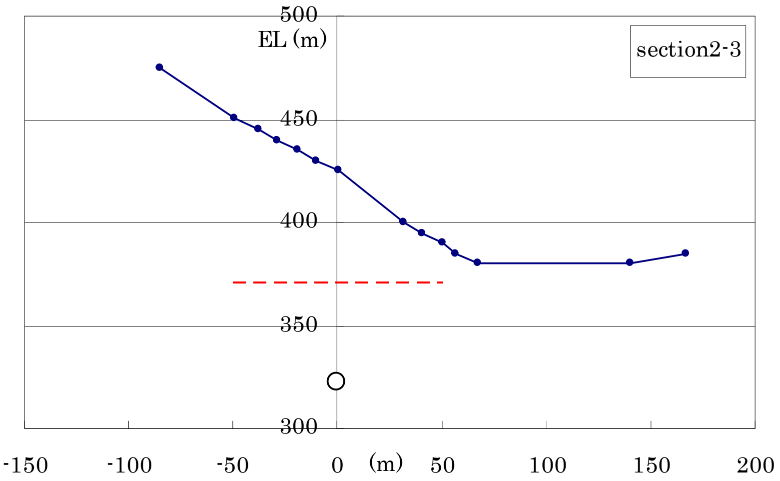

Figure 10 Section 2-3 Ch. 3,767 m

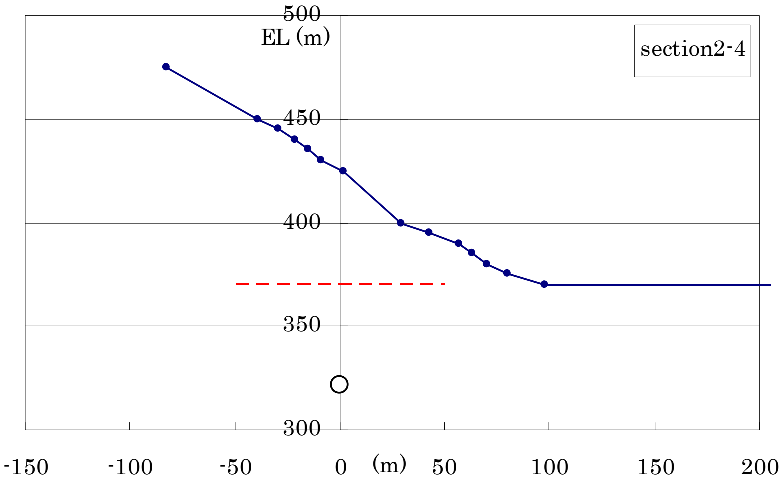

Figure 11 Section 2-4 Ch. 3,792 m

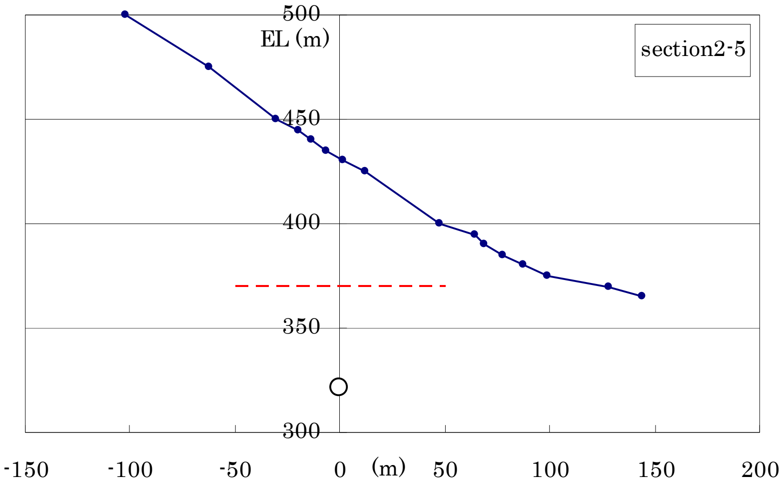

Figure 12 Section 2-5 Ch. 3,817 m

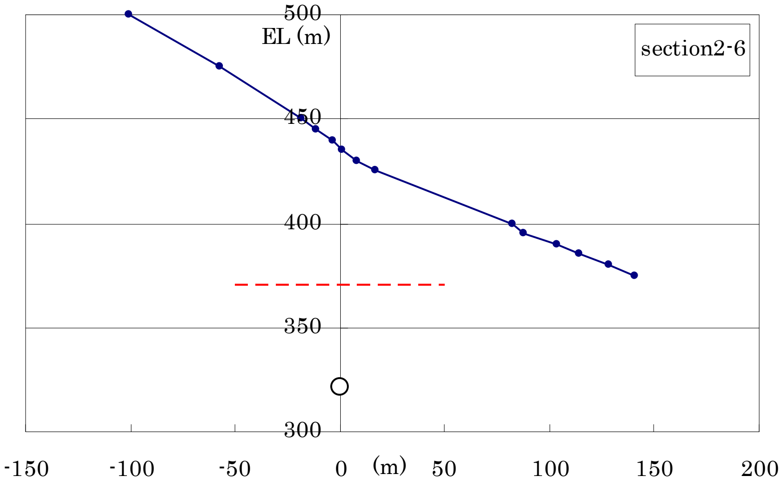

Figure 13 Section 2-6 Ch. 3,842 m

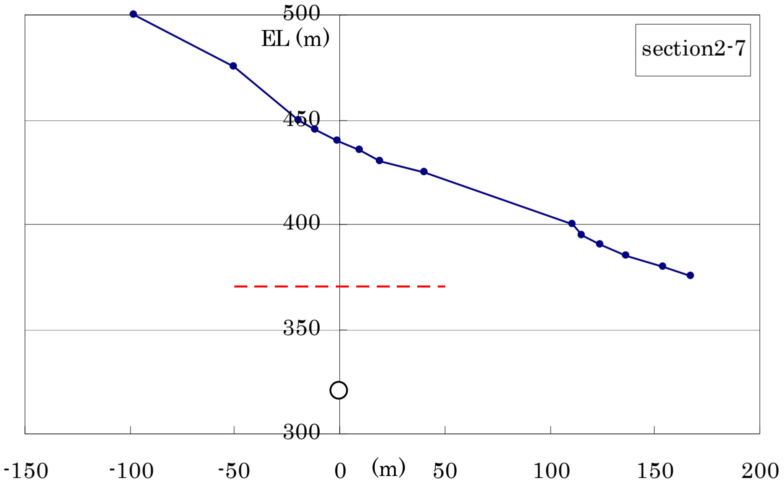

Figure 14 Section 2-7 Ch. 3,867 m

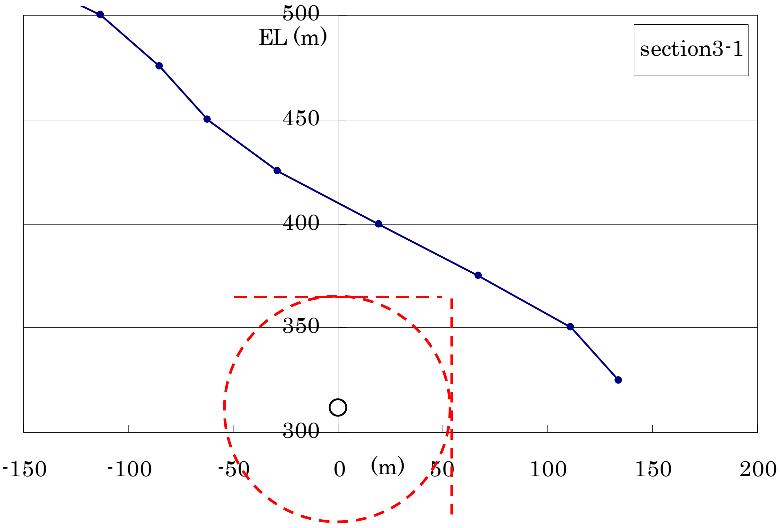

Figure 15 Section 3-1 Ch. 4,440 m

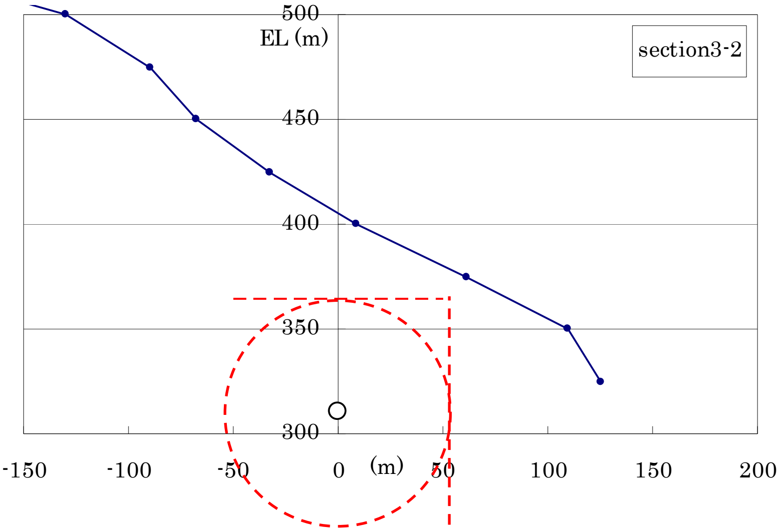

Figure 16 Section 3-2 Ch. 4,465 m

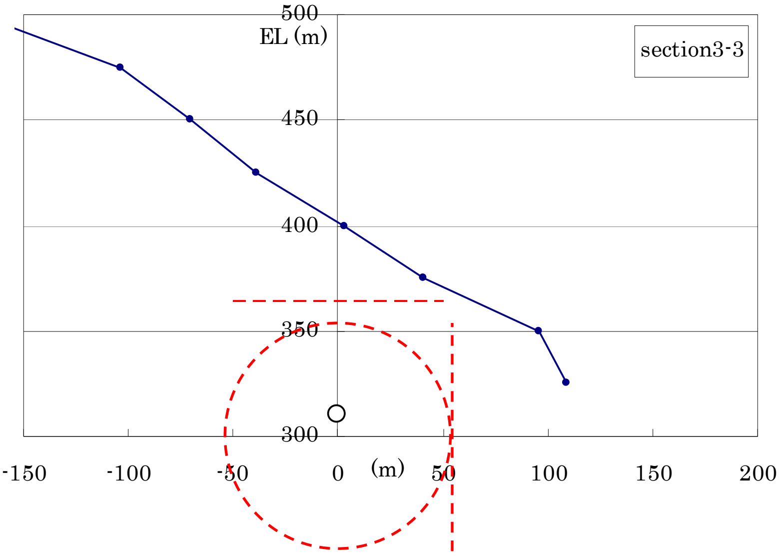

Figure 17 Section 3-3 Ch. 4,490 m

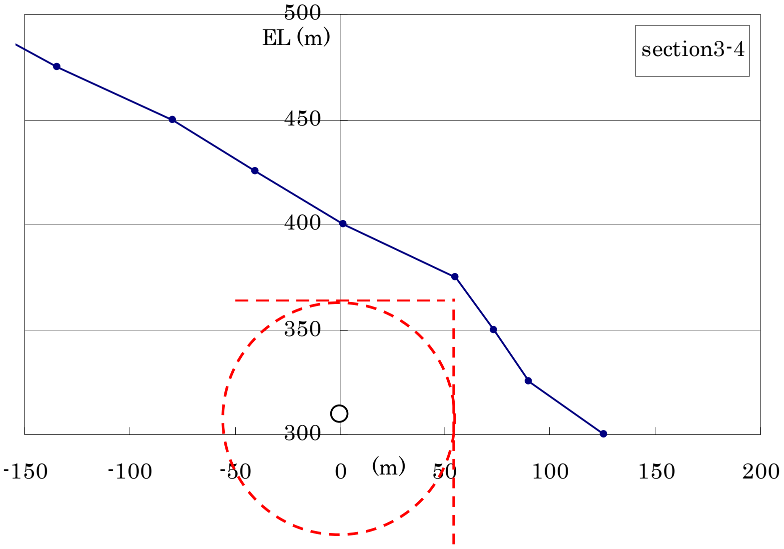

Figure 18 Section 3-4 Ch. 4,515 m

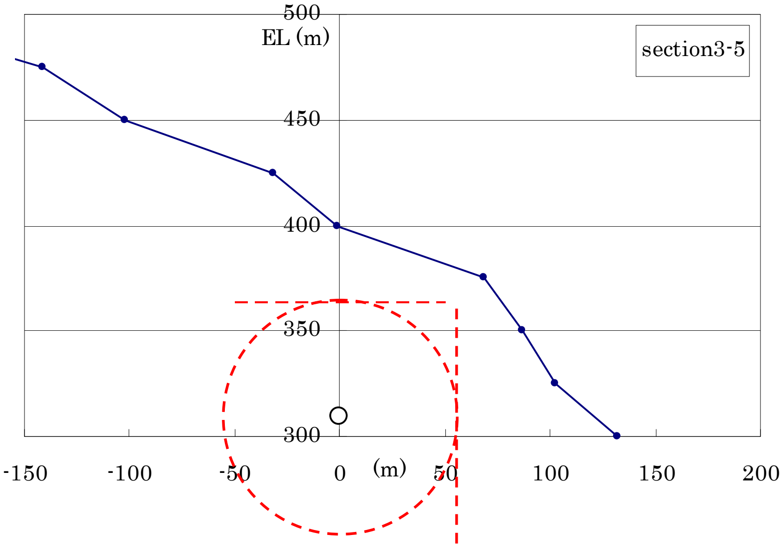

Figure 19 Section 3-5 Ch. 4,540 m

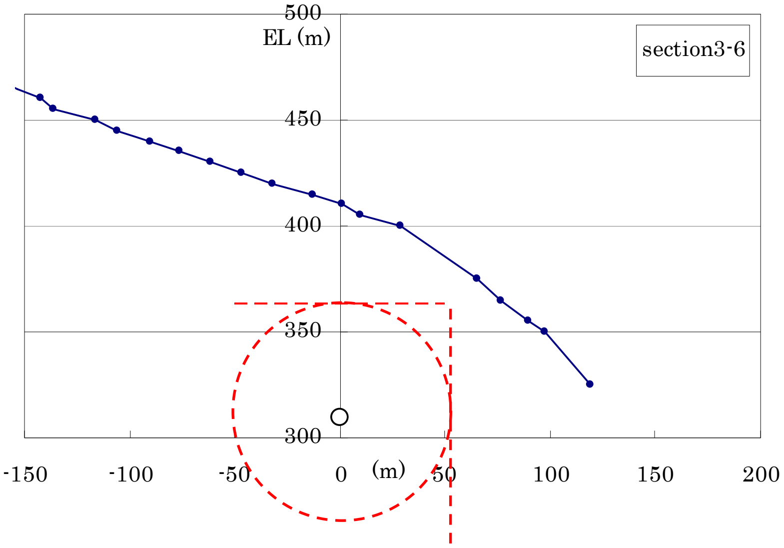

Figure 20 Section 3-6 Ch. 4,565 m

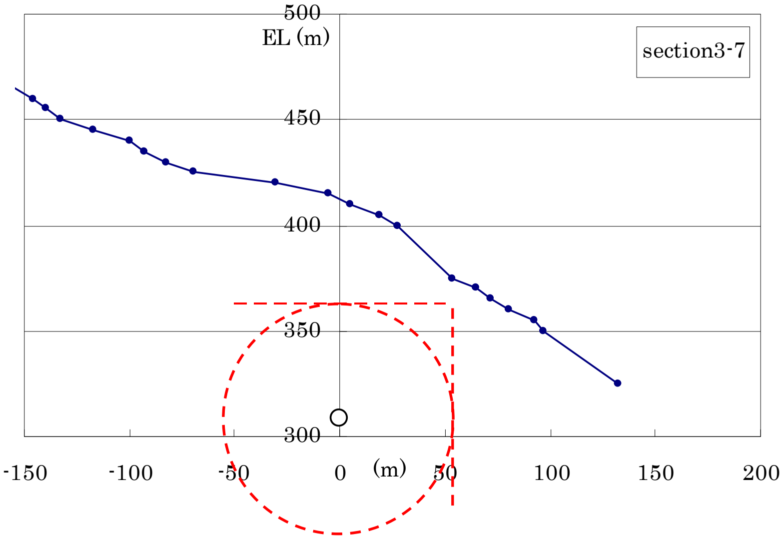

Figure 21 Section 3-7 Ch. 4,590 m

Appendix II-9-2

Water Level of Mahaweli River

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Water Level of Mahaweli River

1. Investigation Section of Mahaweli River

Investigation section of Mahaweli River is from the outlet of the new power station to Randenigala reservoir (1,614 m) as shown in **Figure 1**.

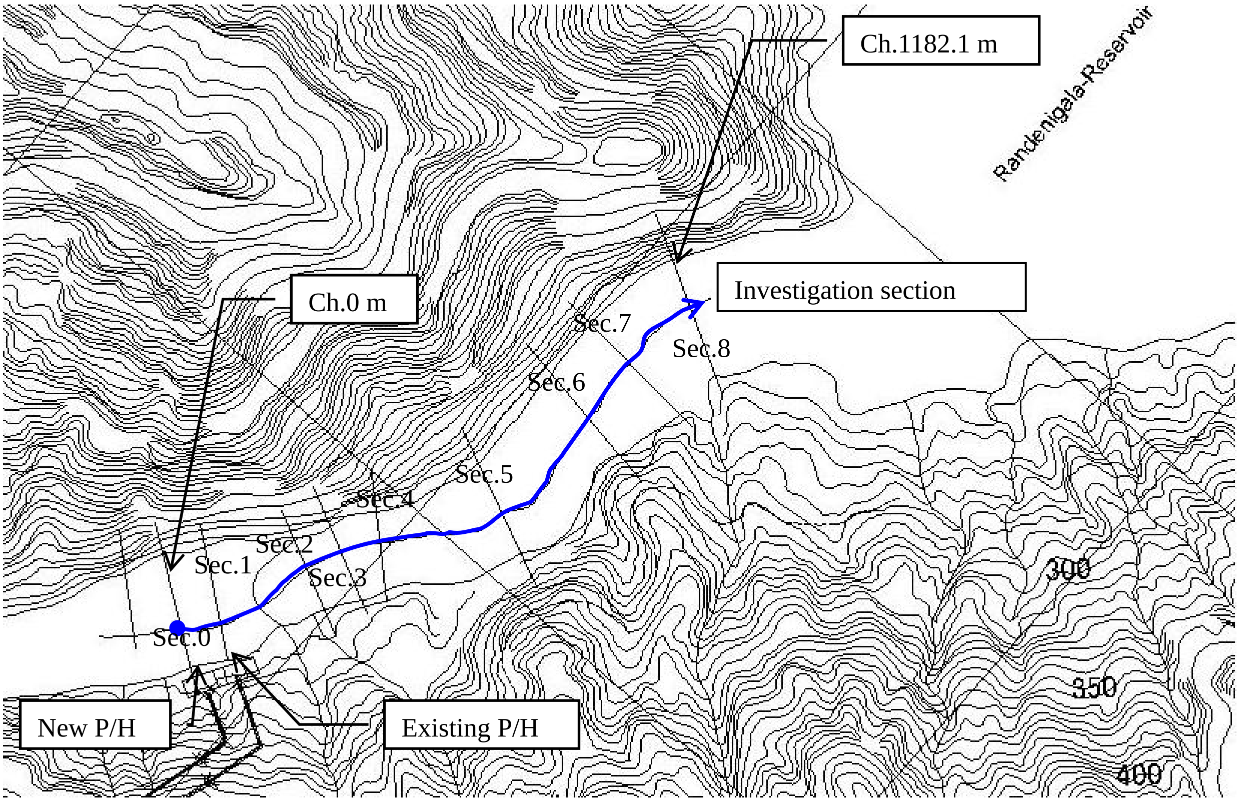


Figure 1 Investigation section

2. Discharge of Victoria Power Station

Base Operation : $35 m^3/s$ for 24 hours
Peak Operation 1 (Only Existing) : 140 m^3/s for 3 hours in the evening
Peak Operation 2 (Existing and Expansion) : 280 m^3/s for 3 hours in the evening

3. Fluctuation of Water Level at Randenigala Reservoir

Fluctuation of water level at Randenigala Reservoir is shown in **Figure 2**.

Maximum water level appears in March and minimum water level appears in September. This tendency is shown in past 8 years.

From this, Low Water Level (L.W.L.), Mean Water Level (M.W.L.) and High Water Level (H.W.L.) is set as below.

L.W.L.	209 m.
M.W.L.	218.3 m.
H.W.L.	232 m.

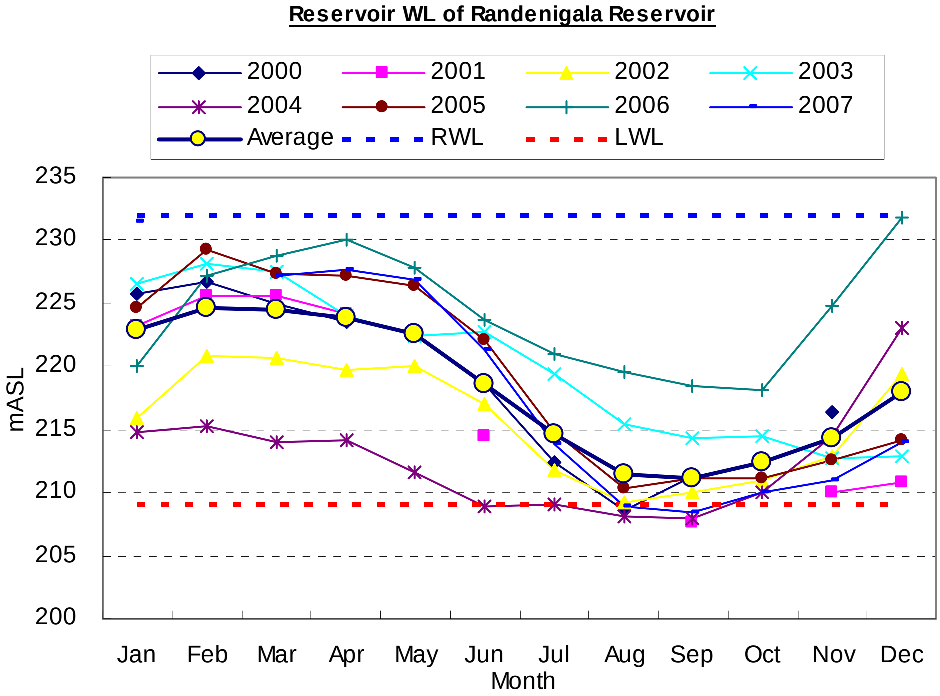


Figure 2 Water level in Randenigala Reservoir

4. Investigation Case

Flow investigation is carried out to compare the water levels between Base Operation discharge and Peak Operation discharge.

Cases of the flow investigation are shown in **Table 1**.

Table 1 Investigation case

WL at Randenigala Reservoir EL (m)	Discharge (m^3/s)
209 (L.W.L)	35 (Base Operation)
	140 (Peak Operation 1)
	280 (Peak Operation 2)
218.3 (M.W.L.)	35
	140
	280
232 (H.W.L.)	35
	140
	280

5. Condition for Calculation

Calculation is carried out by using following equations;

$$\frac{dH}{dx} + \alpha \frac{Q}{2g} \frac{d}{dx}\left(\frac{1}{A^2}\right) + \frac{n^2Q^2}{R^{4/3}A^2} = 0$$

Where,

H : Water Level (EL m)

Q : Discharge (m^3/s)

A : Area of Cross Section (m^2)

α : Energy correction coefficient 1.1

R : Hydraulic mean depth (m)

I : Gradient of water level

n : Manning's coefficient of roughness 0.045

6. Investigation result

Water level of Mahaveli River is investigated.

The differences of water level are shown in **Figure 3~Figure 32** and **Table 2**.

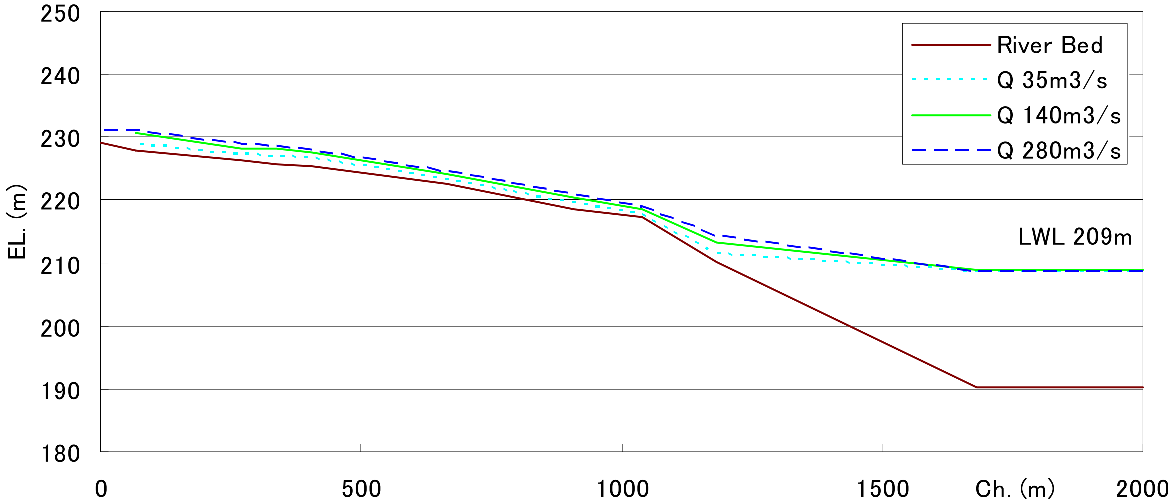


Figure 3 Difference of Water Level (LWL)

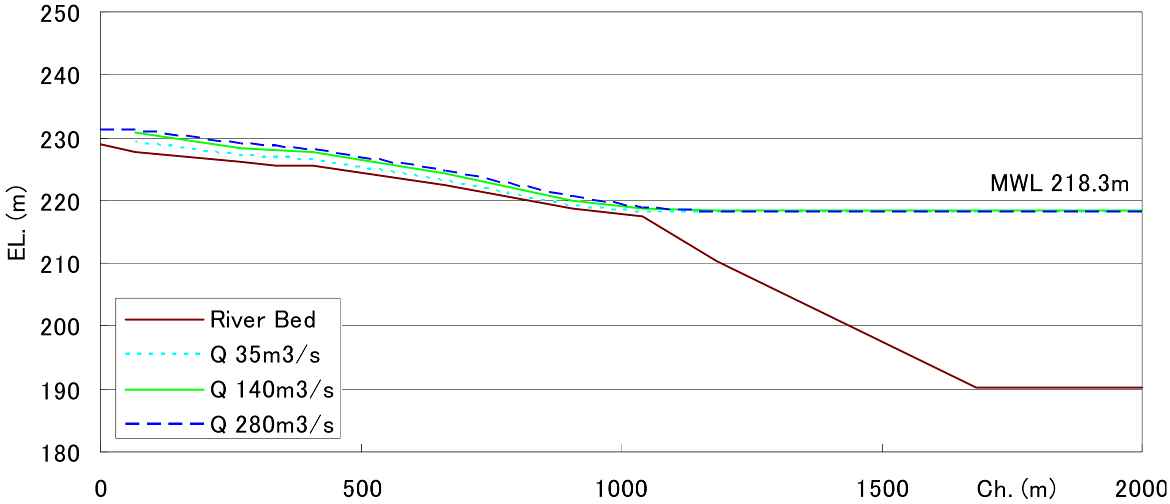


Figure 4 Difference of Water Level (MWL)

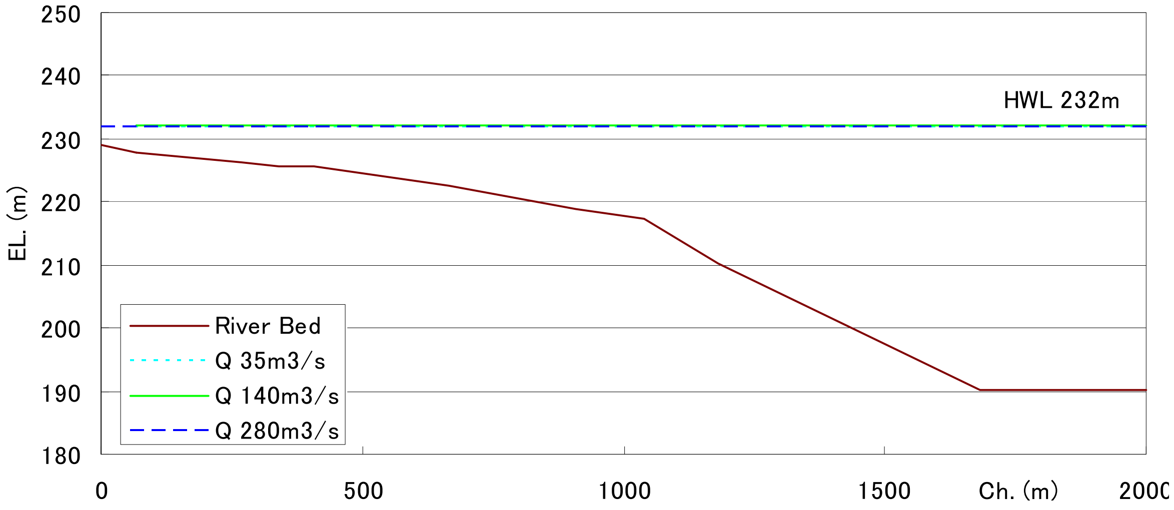


Figure 5 Difference of water level (HWL)

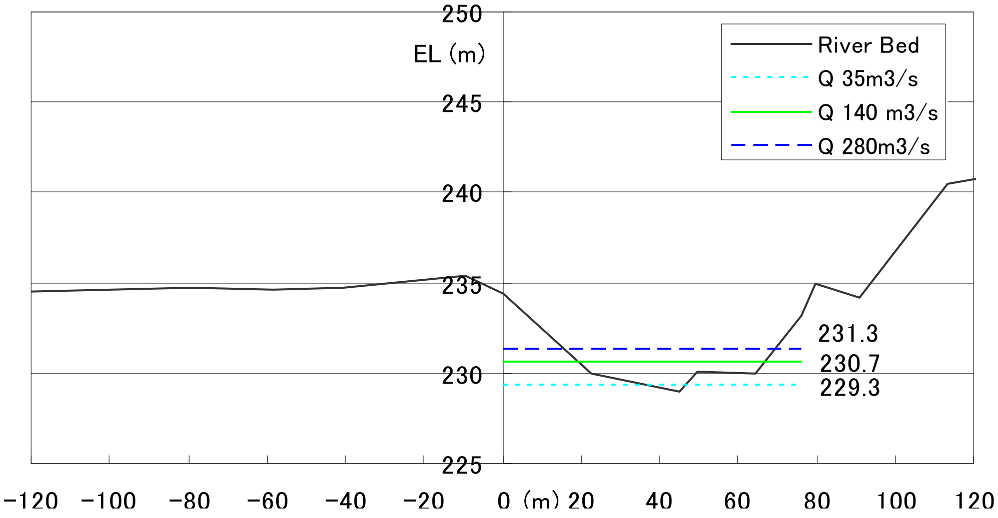


Figure 6 Water level at Sec.0 (Ch.0) LWL

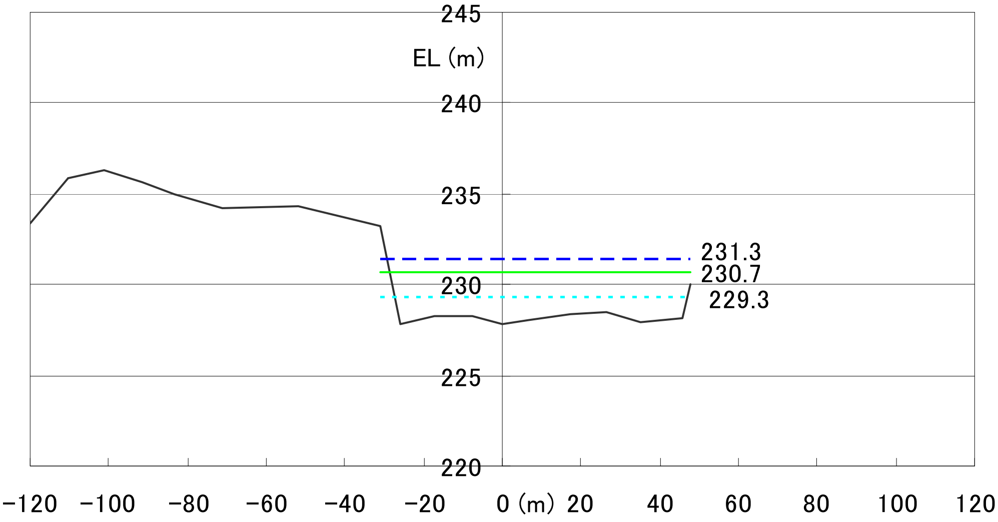


Figure 7 Water level at Sec.1 (Ch.67.7) LWL

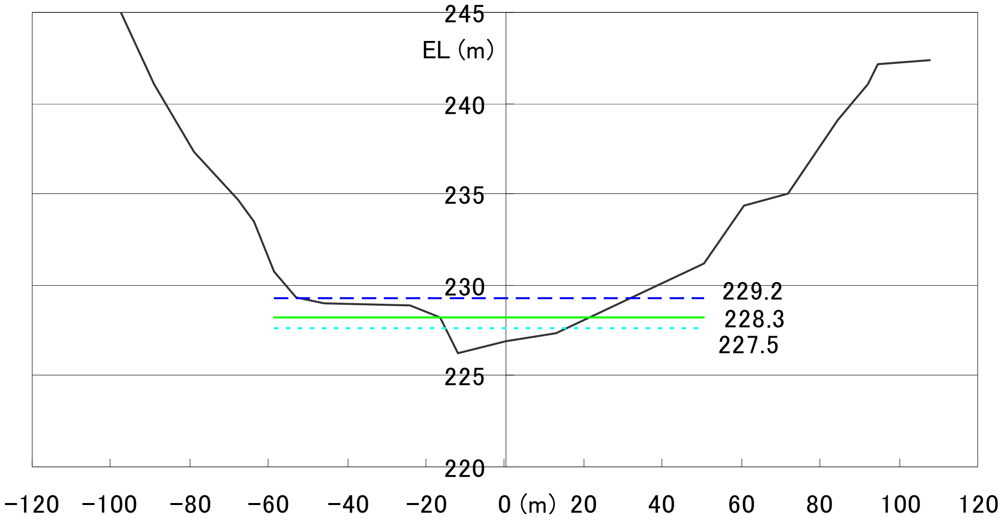


Figure 8 Water level at Sec.2 (Ch.271.0) LWL

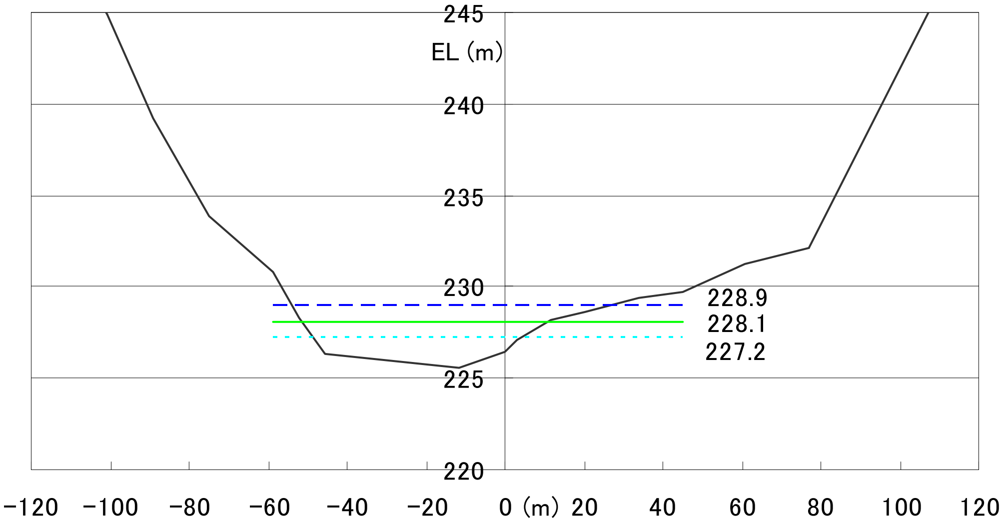


Figure 9 Water level at Sec.3 (Ch.338.6) LWL

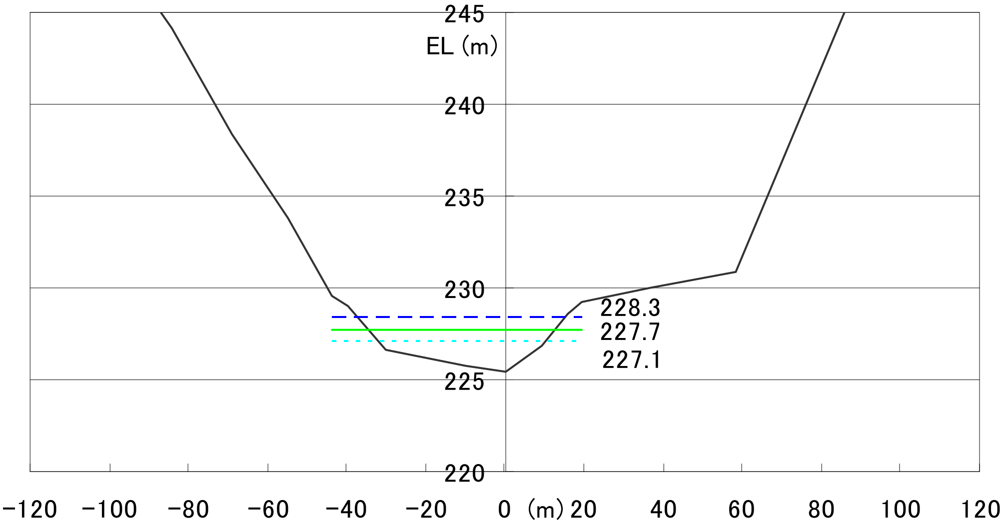


Figure 10 Water level at Sec.4 (Ch.407.1) LWL

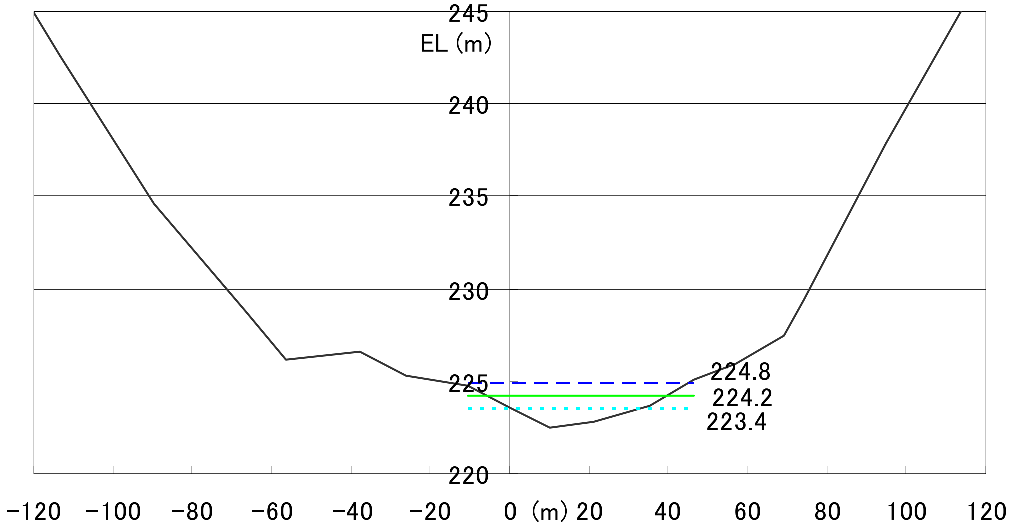


Figure 11 Water level at Sec.5 (Ch.664.1) LWL

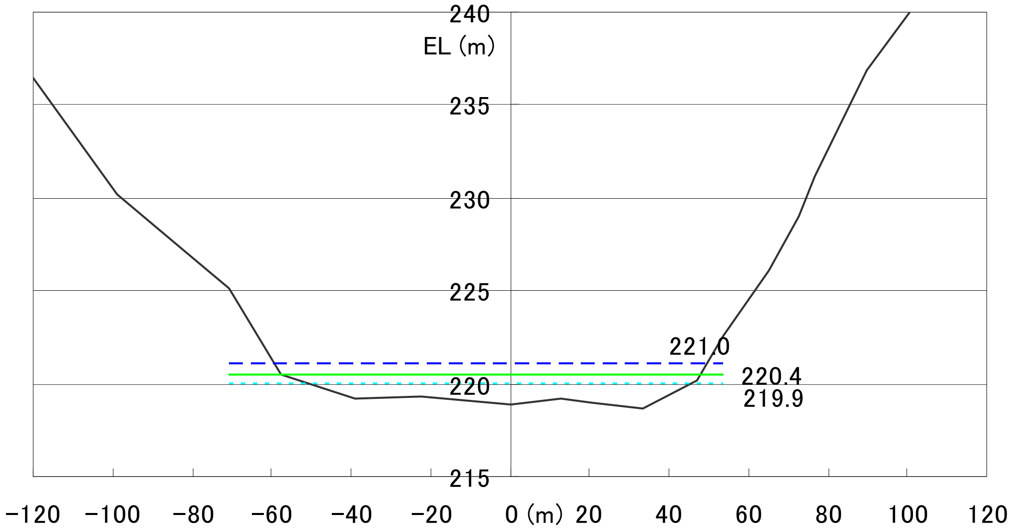


Figure 12 Water level at Sec.6 (Ch.907.8) LWL

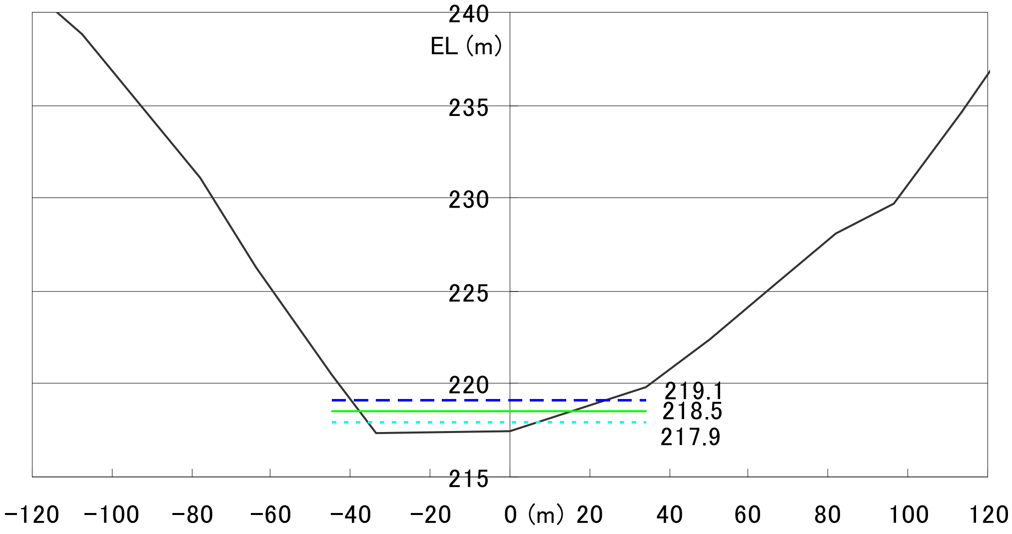


Figure 13 Water level at Sec.7 (Ch. 1039.8) LWL

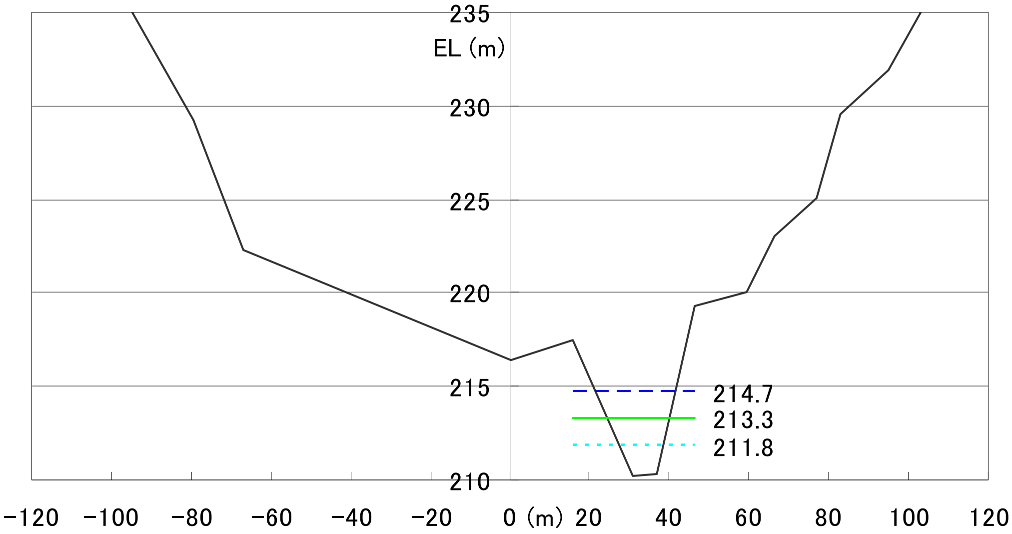


Figure 14 Water level at Sec.8 (Ch.1182.1) LWL

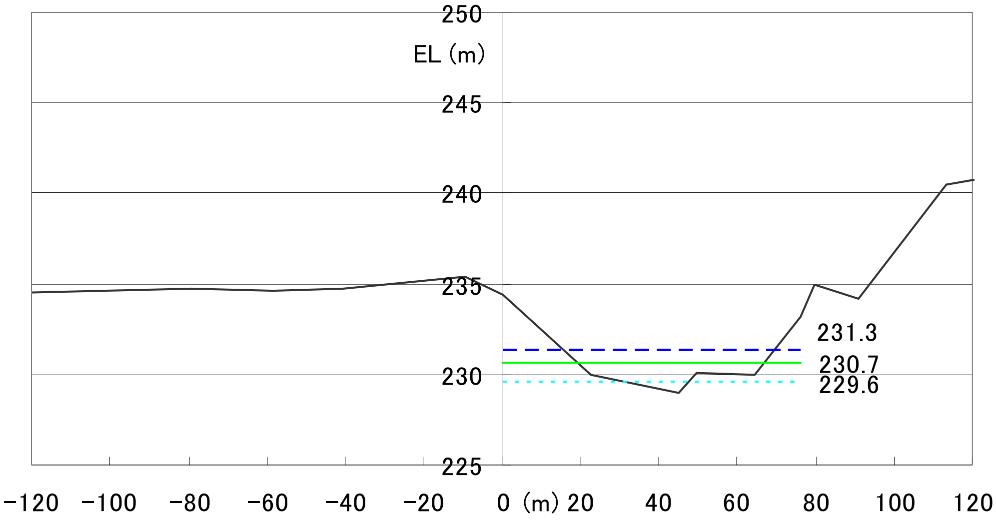


Figure 15 Water level at Sec.0 (Ch.0) MWL

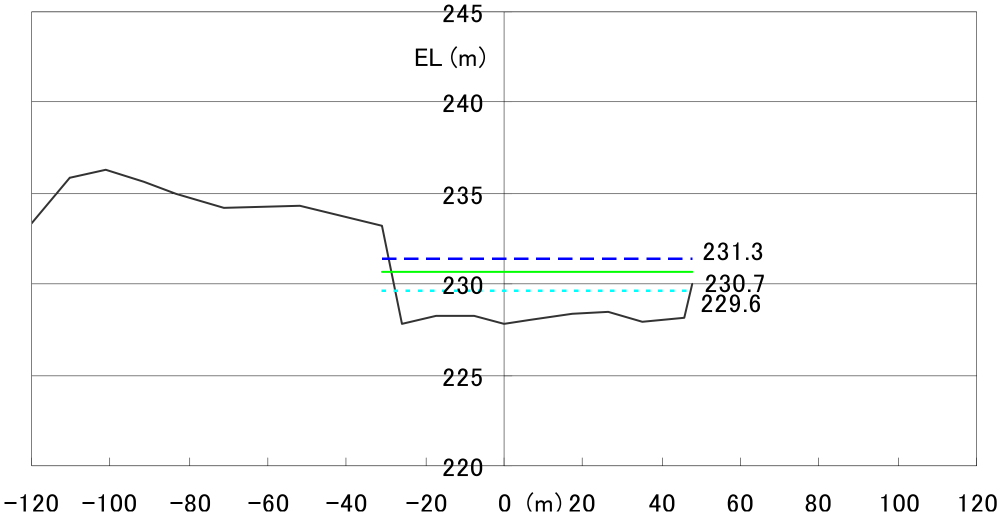


Figure 16 Water level at Sec.1 (Ch.67.7) MWL

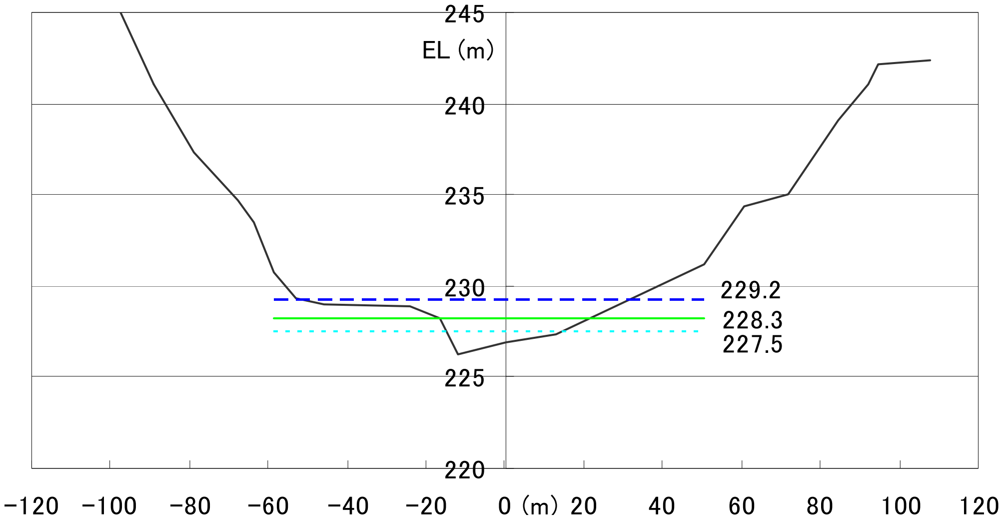


Figure 17 Water level at Sec.2 (Ch.271.0) MWL

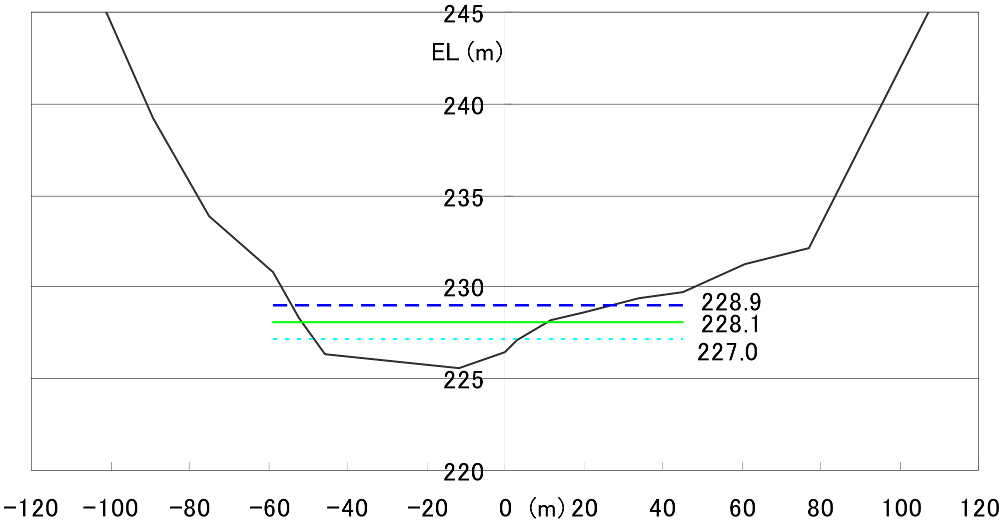


Figure 18 Water level at Sec.3 (Ch.338.6) MWL

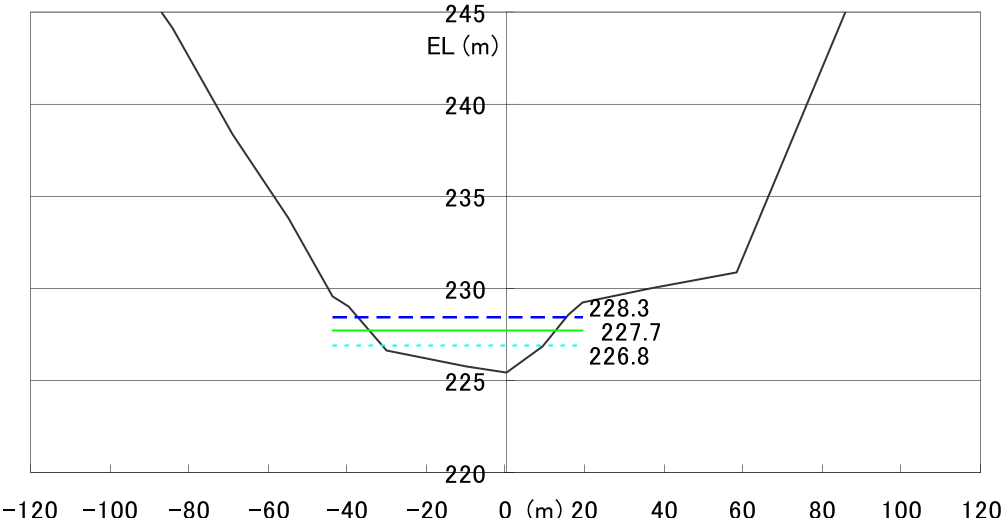


Figure 19 Water level at Sec.4 (Ch.407.1) MWL

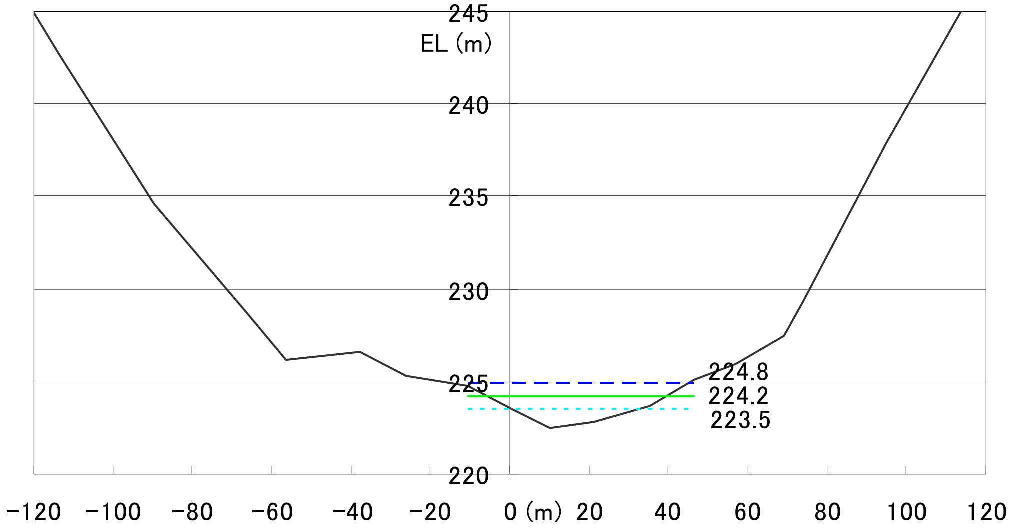


Figure 20 Water level at Sec.5 (Ch.664.1) MWL

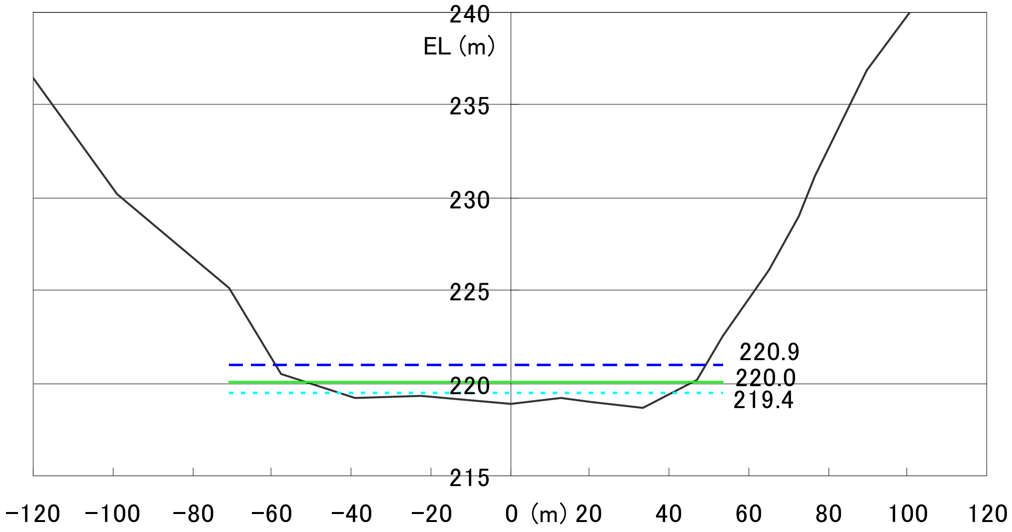


Figure 21 Water level at Sec.6 (Ch.907.8) MWL

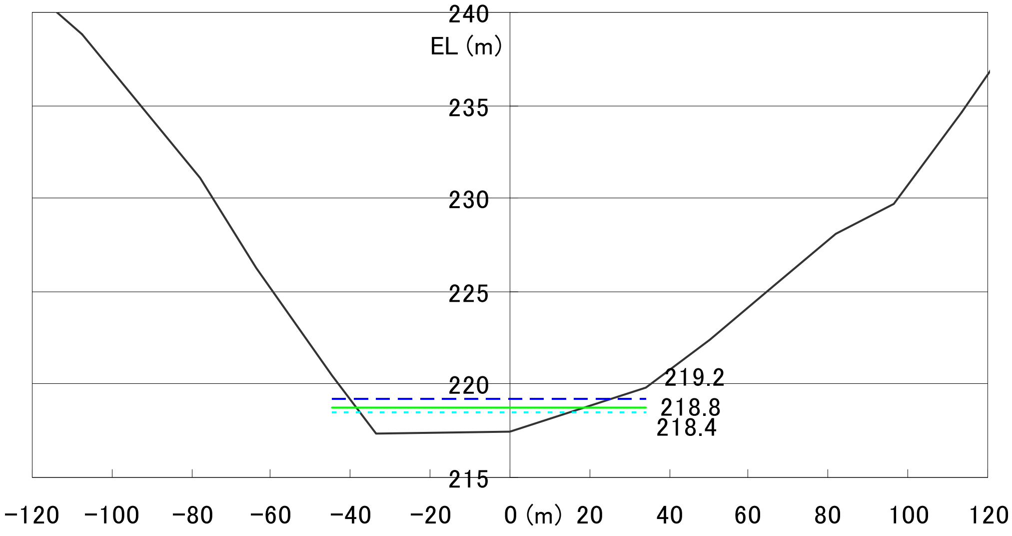


Figure 22 Water level at Sec.7 (Ch. 1039.8) MWL

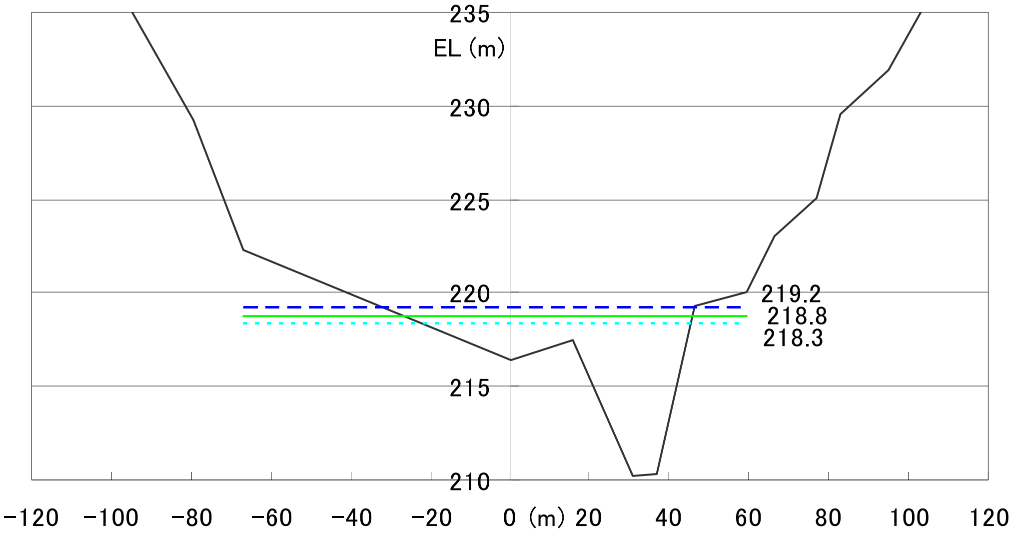


Figure 23 Water level at Sec.8 (Ch.1182.1) MWL

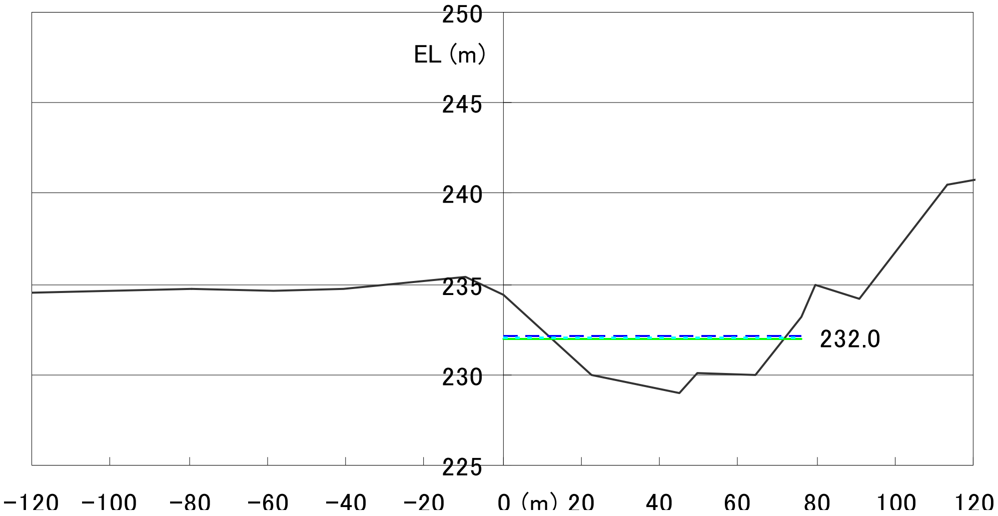


Figure 24 Water level at Sec.0 (Ch.0) HWL

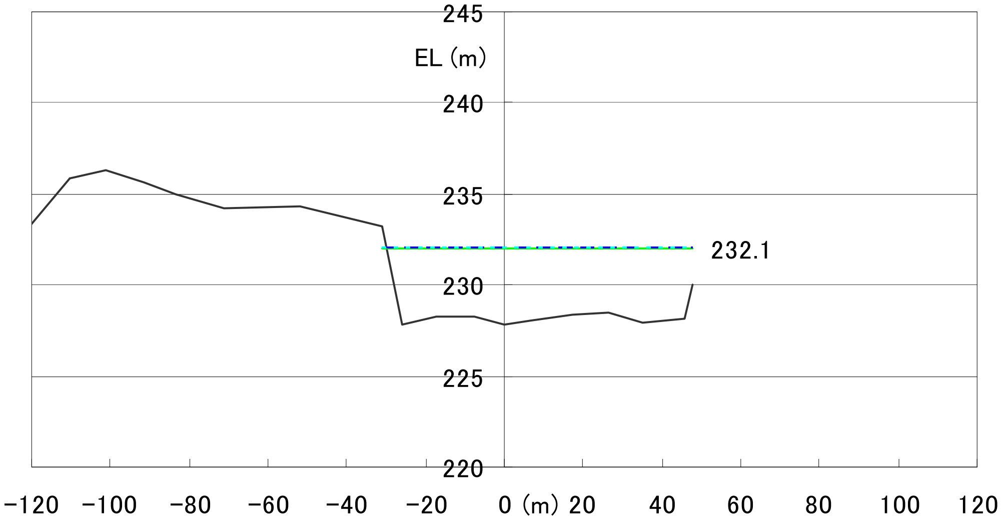


Figure 25 Water level at Sec.1 (Ch.67.7) HWL

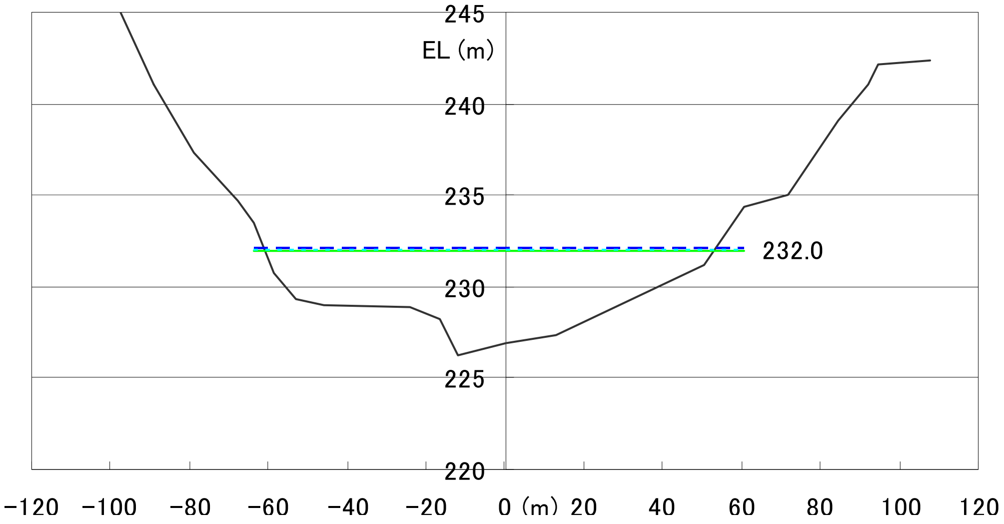


Figure 26 Water level at Sec.2 (Ch.271.0) HWL

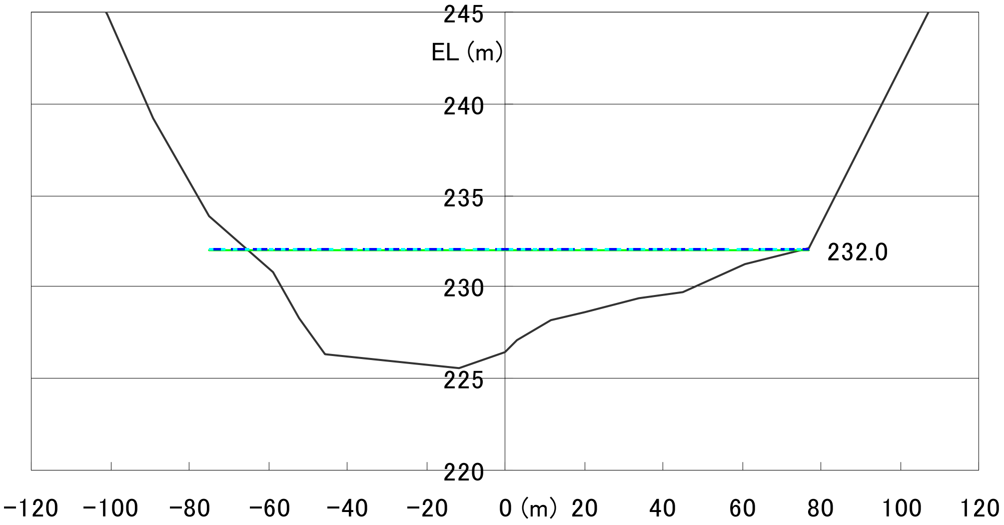


Figure 27 Water level at Sec.3 (Ch.338.6) HWL

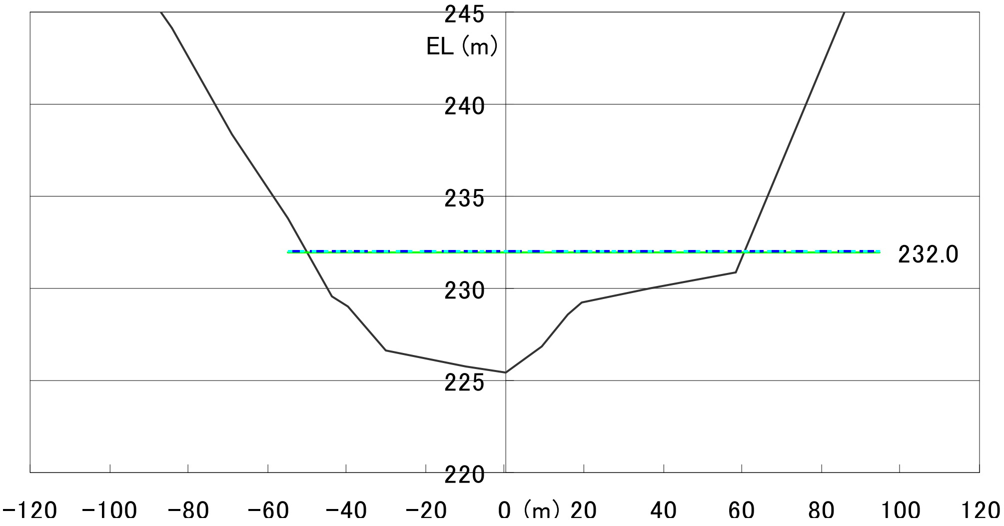


Figure 28 Water level at Sec.4 (Ch.407.1) HWL

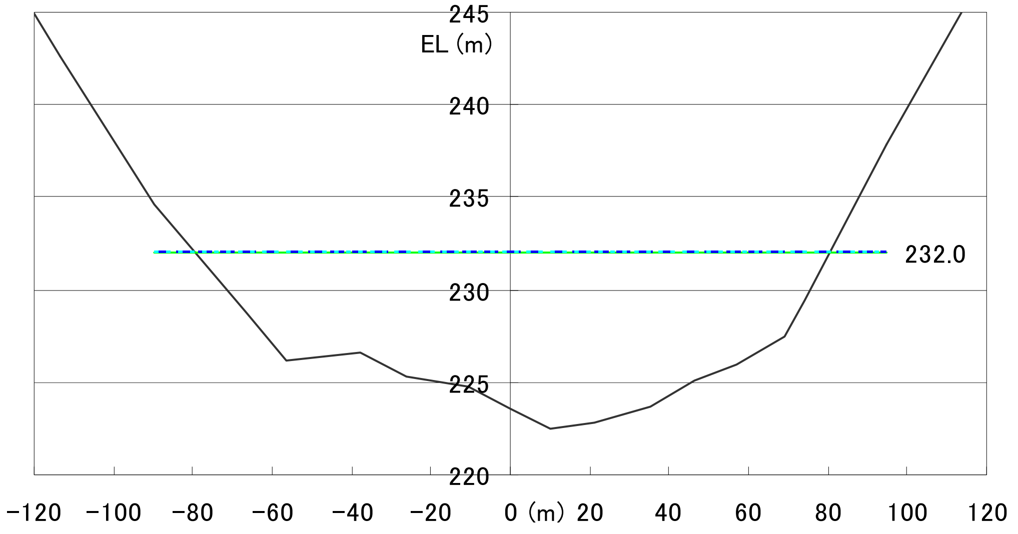


Figure 29 Water level at Sec.5 (Ch.664.1) HWL

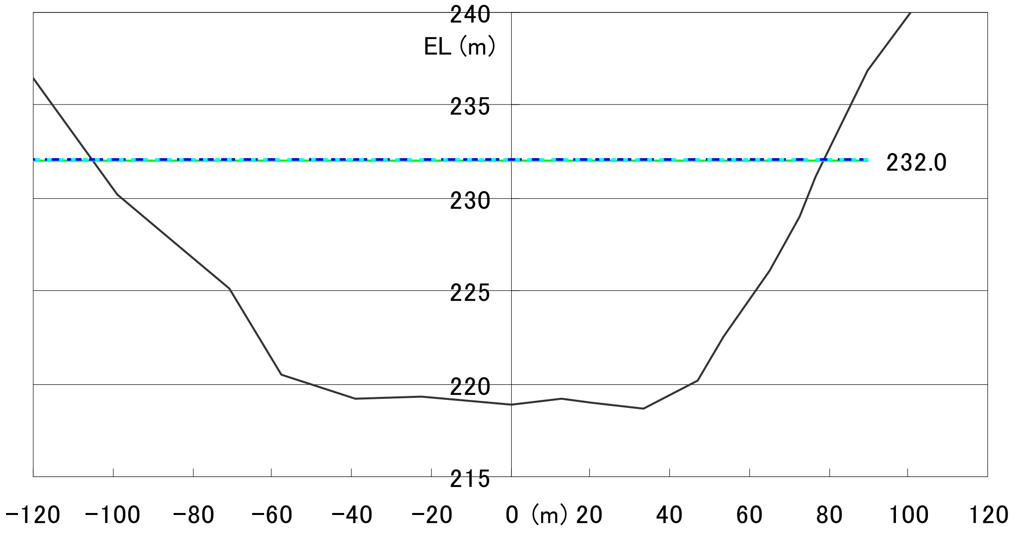


Figure 30 Water level at Sec.6 (Ch.907.8) HWL

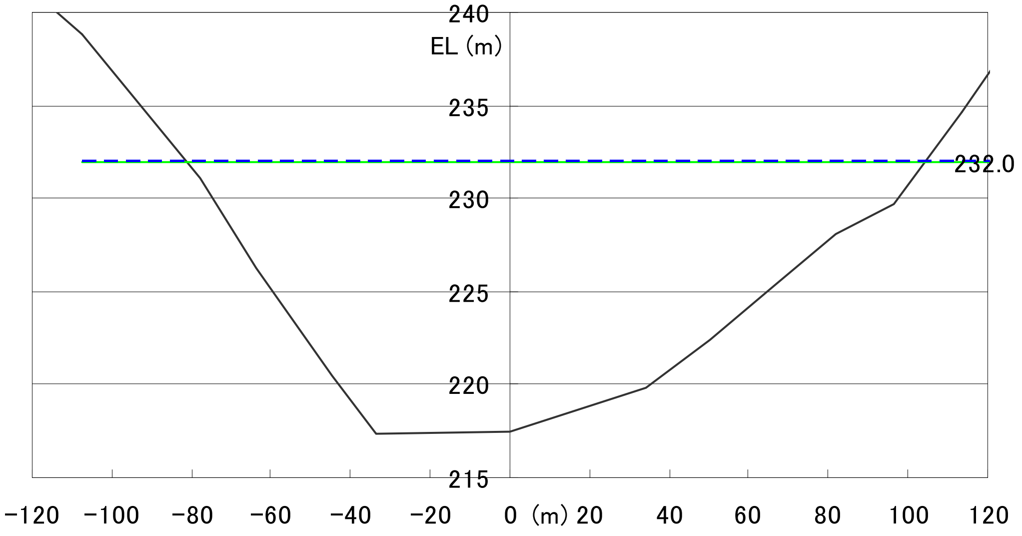


Figure 31 Water level at Sec.7 (Ch. 1039.8) HWL

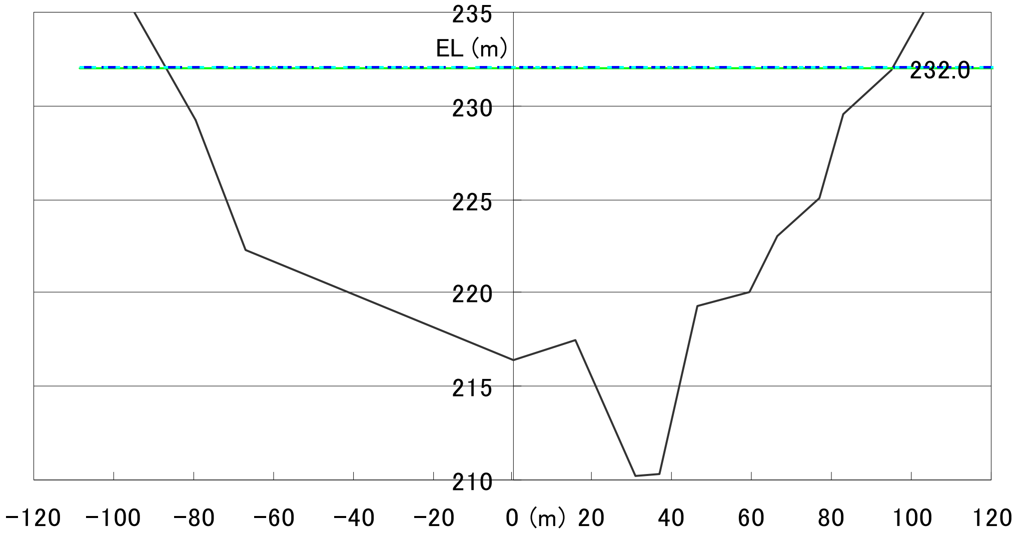


Figure 32 Water level at Sec.8 (Ch.1182.1) HWL

Table 2 Difference of Water level

		Ch. (m)								
		0	**67.7**	**271**	**338.5**	**407**	**664.1**	**907.7**	**1,039.8**	**1,182.1**
Case1	WL1 (m)	-	229.3	227.5	227.2	227.2	223.4	219.9	217.9	211.8
	$H1_{max}$ (m)	-	1.5	1.3	1.6	1.6	0.9	1.2	0.5	1.6
	WL2 (m)	-	230.7	228.3	228.1	227.7	224.2	220.4	218.5	213.3
	$H2_{max}$ (m)	-	2.9	2.0	2.5	2.2	1.7	1.7	1.2	3.1
	WL3 (m)	231.3	231.3	229.2	228.9	228.3	224.8	221.0	219.1	214.7
	$H3_{max}$ (m)	2.3	3.5	2.9	3.3	2.8	2.3	2.3	1.7	4.4
	$\Delta h1$ (m)	-	1.4	0.8	0.9	0.6	0.8	0.5	0.6	1.5
	$\Delta h2$ (m)	-	0.6	0.9	0.8	0.6	0.6	0.6	0.6	1.4
Case2	WL1 (m)	-	229.6	227.5	227.0	226.8	223.5	219.4	218.4	218.3
	$H1_{max}$ (m)	-	1.8	1.2	1.4	1.3	0.9	0.7	1.0	8.1
	WL2 (m)	-	230.7	228.3	228.1	227.7	224.2	220.0	218.8	218.3
	$H2_{max}$ (m)	-	2.9	2.0	2.5	2.2	1.7	1.3	1.4	8.1
	WL3 (m)	231.3	230.7	228.3	228.1	227.7	224.2	220.0	218.8	218.3
	$H3_{max}$ (m)	2.3	3.5	2.9	3.3	2.8	2.3	2.2	1.8	8.2
	$\Delta h1$ (m)	-	1.1	0.8	1.1	0.9	0.7	0.6	0.4	0.0
	$\Delta h2$ (m)	-	0.6	0.9	0.8	0.6	0.6	0.8	0.4	0.1
Case3	WL1 (m)	-	232.0	232.0	232.0	232.0	232.0	232.0	232.0	232.0
	$H1_{max}$ (m)	-	4.2	5.7	6.4	6.5	9.5	13.3	14.6	21.8
	WL2 (m)	-	232.0	232.0	232.0	232.0	232.0	232.0	232.0	232.0
	$H2_{max}$ (m)	-	4.2	5.7	6.4	6.5	9.5	13.3	14.6	21.8
	WL3 (m)	232.0	232.1	232.0	232.0	232.0	232.0	232.0	232.0	232.0
	$H3_{max}$ (m)	3.0	4.3	5.8	6.4	6.5	9.5	13.3	14.6	21.8
	$\Delta h1$ (m)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	$\Delta h2$ (m)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Here, WL1 : Water level at Base Operation (Q=35m^3/s)
WL2 : Water level at Peak Operation1 (Q=140m^3/s)
WL3 : Water level at Peak Operation2 (Q=280m^3/s)

$H1_{max}$: Maximum water depth (Q=35m^3/s)
$H2_{max}$: Maximum water depth (Q=140m^3/s)
$H3_{max}$: Maximum water depth (Q=280m^3/s)

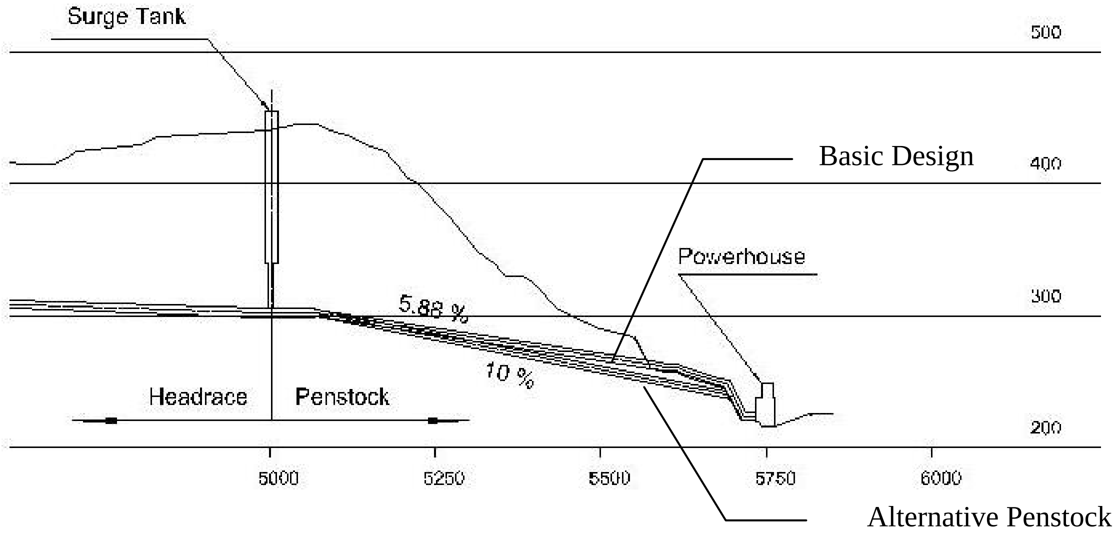
$\Delta h1$: Difference of water level (WL2-WL1)
$\Delta h2$: Difference of water level (WL3-WL2)

Appendix II-9-3

Alternative Penstock Route

Appendix II-9-3
Alternative Penstock Route

An alternative penstock route which has shorter than that adopted in the basic design as shown in **Figure 1** is examined to compare economic validity with the basic design penstock route. The gradient of the alternative penstock tunnel is determined as 10 % which is the maximum gradient for tired heavy equipment passage.



** 10% is the maximum gradient for rubber tired heavy equipment.*

Figure 1 The Main Difference of Penstock Routes

The penstock length of the alternative is 35 m shorter than that of the basic design in total, and a head loss decreases by 0.13 m. The main differences of penstock routes between the basic design and alternative penstock route are as follows;

Table 1 Length and Head Loss of Both Routes

	Basic Design	Alternative	Difference
Tunnel Length: m	500	580	+80
Open-air Length: m	170	55	-115
Total Length m	670	635	35
Head Loss: m	6.24	6.11	-0.13

In the same way in **9.3.3**, construction cost, annualized cost (C) and power revenue loss (L) of the alternative route are calculated as shown in **Table 2** below;

Table 2 Comparison of Economic Validity

	Basic Design	Alternative	Difference
C: 10^3 USD	4,121	4,471	+350
L: 10^3 USD	1,998	1,955	-43
C + L: 10^3 USD	6,119	6,426	+307

As above, difference in annualized cost (ΔC) and that in power revenue loss (ΔL) are 350×10^3 USD and -43×10^3 USD, respectively.

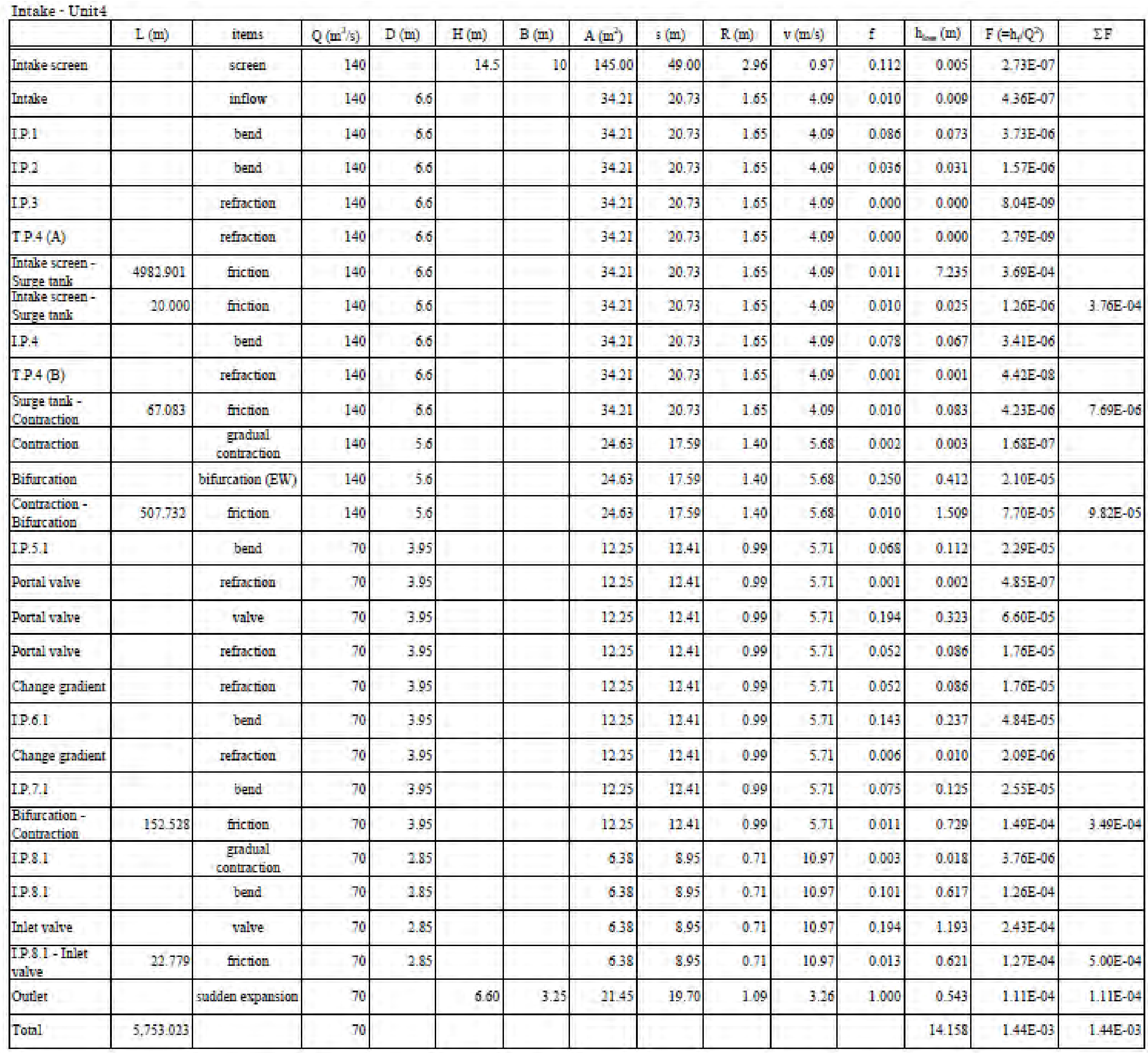
The sum of ΔC and ΔL is 307×10^3 USD (>0), therefore, the alternative penstock route is less practical than the basic design penstock route for the Expansion Project.

Appendix II-9-4

Head Loss Calculation of Waterway

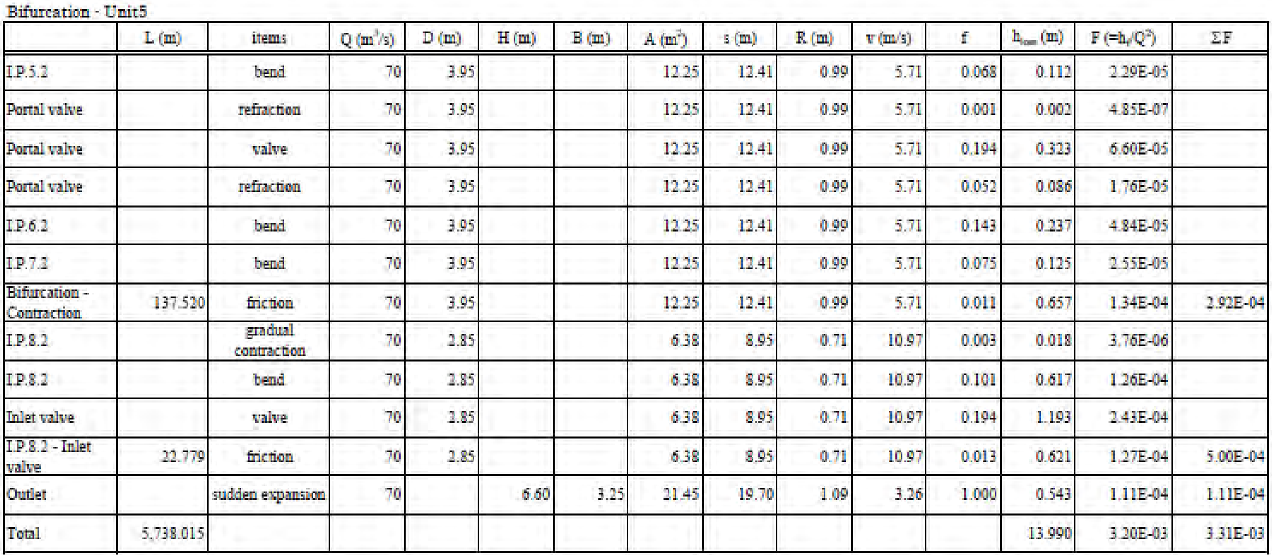
Appendix II-9-4

Head Loss Calculation of Waterway



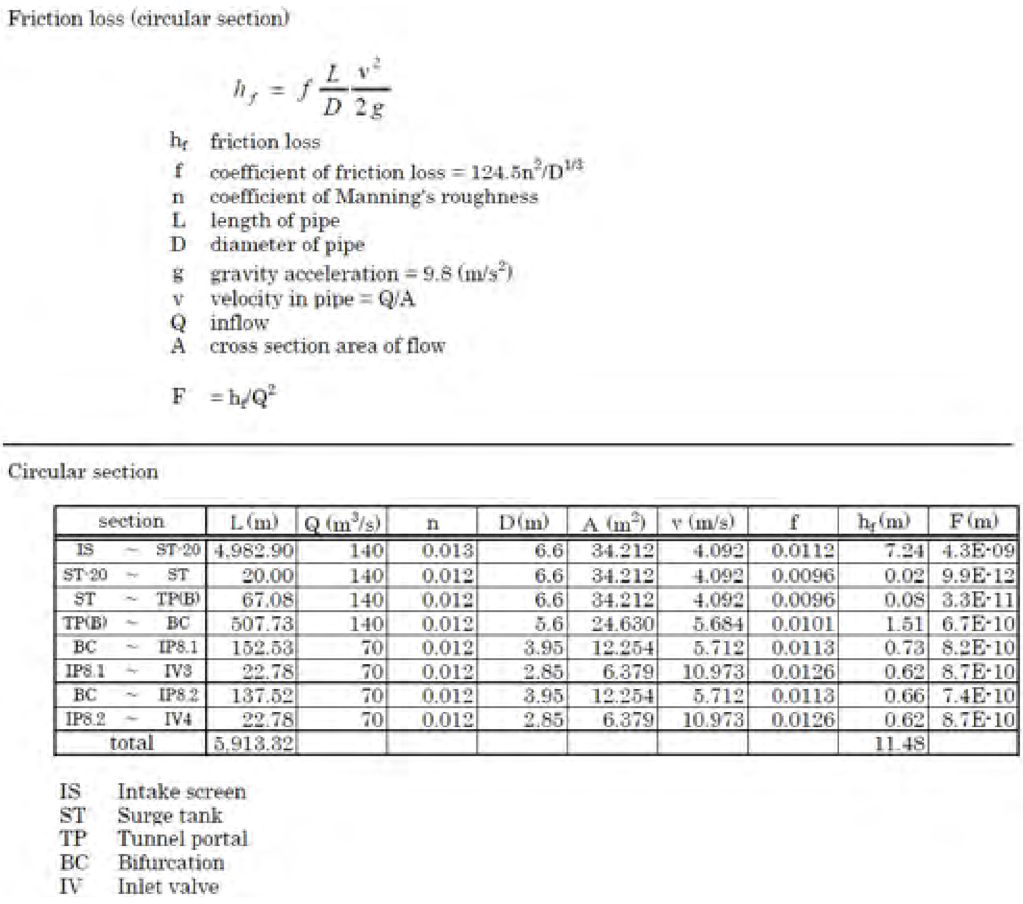
Intake - Unit4

	L (m)	items	Q (m^3/s)	D (m)	H (m)	B (m)	A (m^2)	s (m)	R (m)	v (m/s)	f	h_{loss} (m)	F ($=h_f/Q^2$)	ΣF
Intake screen		screen	140		14.5	10	145.00	49.00	2.96	0.97	0.112	0.005	2.73E-07	
Intake		inflow	140	6.6			34.21	20.73	1.65	4.09	0.010	0.009	4.36E-07	
I.P.1		bend	140	6.6			34.21	20.73	1.65	4.09	0.086	0.073	3.73E-06	
I.P.2		bend	140	6.6			34.21	20.73	1.65	4.09	0.036	0.031	1.57E-06	
I.P.3		refraction	140	6.6			34.21	20.73	1.65	4.09	0.000	0.000	8.04E-09	
T.P.4 (A)		refraction	140	6.6			34.21	20.73	1.65	4.09	0.000	0.000	2.79E-09	
Intake screen - Surge tank	4982.901	friction	140	6.6			34.21	20.73	1.65	4.09	0.011	7.235	3.69E-04	
Intake screen - Surge tank	20.000	friction	140	6.6			34.21	20.73	1.65	4.09	0.010	0.025	1.26E-06	3.76E-04
I.P.4		bend	140	6.6			34.21	20.73	1.65	4.09	0.078	0.067	3.41E-06	
T.P.4 (B)		refraction	140	6.6			34.21	20.73	1.65	4.09	0.001	0.001	4.42E-08	
Surge tank - Contraction	67.083	friction	140	6.6			34.21	20.73	1.65	4.09	0.010	0.083	4.23E-06	7.69E-06
Contraction		gradual contraction	140	5.6			24.63	17.59	1.40	5.68	0.002	0.003	1.68E-07	
Bifurcation		bifurcation (EW)	140	5.6			24.63	17.59	1.40	5.68	0.250	0.412	2.10E-05	
Contraction - Bifurcation	507.732	friction	140	5.6			24.63	17.59	1.40	5.68	0.010	1.509	7.70E-05	9.82E-05
I.P.5.1		bend	70	3.95			12.25	12.41	0.99	5.71	0.068	0.112	2.29E-05	
Portal valve		refraction	70	3.95			12.25	12.41	0.99	5.71	0.001	0.002	4.85E-07	
Portal valve		valve	70	3.95			12.25	12.41	0.99	5.71	0.194	0.323	6.60E-05	
Portal valve		refraction	70	3.95			12.25	12.41	0.99	5.71	0.052	0.086	1.76E-05	
Change gradient		refraction	70	3.95			12.25	12.41	0.99	5.71	0.052	0.086	1.76E-05	
I.P.6.1		bend	70	3.95			12.25	12.41	0.99	5.71	0.143	0.237	4.84E-05	
Change gradient		refraction	70	3.95			12.25	12.41	0.99	5.71	0.006	0.010	2.09E-06	
I.P.7.1		bend	70	3.95			12.25	12.41	0.99	5.71	0.075	0.125	2.55E-05	
Bifurcation - Contraction	152.528	friction	70	3.95			12.25	12.41	0.99	5.71	0.011	0.729	1.49E-04	3.49E-04
I.P.8.1		gradual contraction	70	2.85			6.38	8.95	0.71	10.97	0.003	0.018	3.76E-06	
I.P.8.1		bend	70	2.85			6.38	8.95	0.71	10.97	0.101	0.617	1.26E-04	
Inlet valve		valve	70	2.85			6.38	8.95	0.71	10.97	0.194	1.193	2.43E-04	
I.P.8.1 - Inlet valve	22.779	friction	70	2.85			6.38	8.95	0.71	10.97	0.013	0.621	1.27E-04	5.00E-04
Outlet		sudden expansion	70		6.60	3.25	21.45	19.70	1.09	3.26	1.000	0.543	1.11E-04	1.11E-04
Total	5,753.023		70									14.158	1.44E-03	1.44E-03



Bifurcation - Unit5

	L (m)	items	Q (m^3/s)	D (m)	H (m)	B (m)	A (m^2)	s (m)	R (m)	v (m/s)	f	h_{loss} (m)	F (=h_l/Q^2)	ΣF
I.P.5.2		bend	70	3.95			12.25	12.41	0.99	5.71	0.068	0.112	2.29E-05	
Portal valve		refraction	70	3.95			12.25	12.41	0.99	5.71	0.001	0.002	4.85E-07	
Portal valve		valve	70	3.95			12.25	12.41	0.99	5.71	0.194	0.323	6.60E-05	
Portal valve		refraction	70	3.95			12.25	12.41	0.99	5.71	0.052	0.086	1.76E-05	
I.P.6.2		bend	70	3.95			12.25	12.41	0.99	5.71	0.143	0.237	4.84E-05	
I.P.7.2		bend	70	3.95			12.25	12.41	0.99	5.71	0.075	0.125	2.55E-05	
Bifurcation - Contraction	137.520	friction	70	3.95			12.25	12.41	0.99	5.71	0.011	0.657	1.34E-04	2.92E-04
I.P.8.2		gradual contraction	70	2.85			6.38	8.95	0.71	10.97	0.003	0.018	3.76E-06	
I.P.8.2		bend	70	2.85			6.38	8.95	0.71	10.97	0.101	0.617	1.26E-04	
Inlet valve		valve	70	2.85			6.38	8.95	0.71	10.97	0.194	1.193	2.43E-04	
I.P.8.2 - Inlet valve	22.779	friction	70	2.85			6.38	8.95	0.71	10.97	0.013	0.621	1.27E-04	5.00E-04
Outlet		sudden expansion	70		6.60	3.25	21.45	19.70	1.09	3.26	1.000	0.543	1.11E-04	1.11E-04
Total	5,738.015											13.990	3.20E-03	3.31E-03



Friction loss (circular section)

$$h_f = f \frac{L}{D} \frac{v^2}{2g}$$

h_f	friction loss
f	coefficient of friction loss = $124.5n^2/D^{1/3}$
n	coefficient of Manning's roughness
L	length of pipe
D	diameter of pipe
g	gravity acceleration = 9.8 (m/s^2)
v	velocity in pipe = Q/A
Q	inflow
A	cross section area of flow

F $= h_f/Q^2$

Circular section

section	L (m)	Q (m^3/s)	n	D (m)	A (m^2)	v (m/s)	f	h_f (m)	F (m)
IS ~ ST-20	4,982.90	140	0.013	6.6	34.212	4.092	0.0112	7.24	4.3E-09
ST-20 ~ ST	20.00	140	0.012	6.6	34.212	4.092	0.0096	0.02	9.9E-12
ST ~ TP(B)	67.08	140	0.012	6.6	34.212	4.092	0.0096	0.08	3.3E-11
TP(B) ~ BC	507.73	140	0.012	5.6	24.630	5.684	0.0101	1.51	6.7E-10
BC ~ IP8.1	152.53	70	0.012	3.95	12.254	5.712	0.0113	0.73	8.2E-10
IP8.1 ~ IV3	22.78	70	0.012	2.85	6.379	10.973	0.0126	0.62	8.7E-10
BC ~ IP8.2	137.52	70	0.012	3.95	12.254	5.712	0.0113	0.66	7.4E-10
IP8.2 ~ IV4	22.78	70	0.012	2.85	6.379	10.973	0.0126	0.62	8.7E-10
total	5,913.32							11.48	

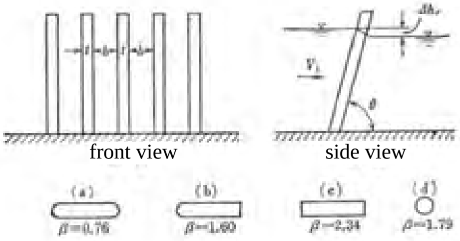
IS	Intake screen
ST	Surge tank
TP	Tunnel portal
BC	Bifurcation
IV	Inlet valve

Loss of head by screen

$$h_r = f_r \frac{v_1^2}{2g}$$

$$f_r = \beta \sin\theta \left(\frac{t}{b}\right)^{\frac{4}{3}}$$

h_r	loss of head by screen
f_r	coefficient of loss by screen
g	gravity acceleration = 9.8 (m/s^2)
v_1	velocity in front of screen = Q/A
Q	inflow
A	cross section area of flow
β	Kirschmer's coefficient
θ	gradient of screen (deg)
t	gauge of screen bar
b	gap between bars



Intake screen

Q = 140 (m^3/s)
A = 145 (m^2)
β = 2.34
θ = 40 (deg)
t = 0.02 (m)
b = 0.14 (m)

width 14.5 (m)
height 10 (m)

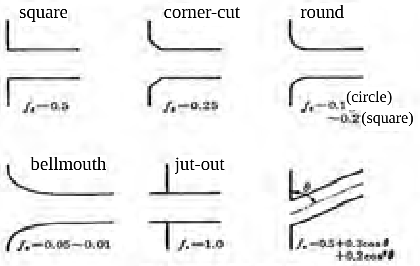
f_r = 0.112
v_1 = 0.966 (m/s)
h_r = 0.005 (m)

F = 2.73E-07 =h_r/Q^2

Entrance loss

$$h_e = f_e \frac{v_2^2}{2g}$$

h_e entrance loss
f_e Weisbach's coefficietn of entrance loss
g gravity acceleration = 9.8 (m/s^2)
v_2 velocity at backside of entrance = Q/A
Q inflow
A cross section area of flow



type of entrance and loss coefficient

Intake

Q = 140 (m^3/s)
D = 6.6 (m)
A = 34.21 (m^2)
f_e = 0.01 (bell mouth)

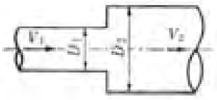
v_2 = 4.092 (m/s)
h_e = 0.0085 (m)

F = 4.36E-07 $=h_e/Q^2$

sudden expansion (Borda's formula)

$$h_{se} = f_{se} \frac{v_1^2}{2g}$$

h_{se} loss of head by sudden expansion
f_{se} coefficient of loss by sudden expansion = $\{1-(A_1/A_2)\}^2$
A_1 cross section area of flow in front of sudden expansion
A_2 cross section area of flow back side of sudden expansion
g gravity acceleration = 9.8 (m/s^2)
v_1 velocity in front of sudden expansion = Q/A_1
Q inflow



$A_1=1/4D_1^2\pi$
$A_2=1/4D_2^2\pi$

Outlet

Q = 70 (m^3/s) ref.
A_1 = 19.50 (m^2) 78350/R3/4, 78350/R width 6.00 (m)
A_2 = 1,000,000 (m^2) height 3.25 (m)

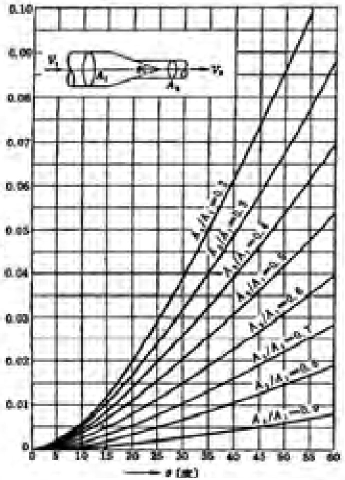
f_{se} = 1.00
v_1 = 3.5897 (m/s)
h_{se} = 0.6574 (m)

F = 1.34E-04 $=h_{se}/Q^2$

gradual contraction

$$h_{gc} = f_{gc} \frac{v_2^2}{2g}$$

h_{gc}	loss of head by gradual contraction
f_{gc}	Gardel's coefficient of loss by gradual contraction
g	gravity acceleration = 9.8 (m/s^2)
v_2	velocity at back side of gradual contraction = Q/A_2
A_2	cross section area of flow at back side of sudden expansion
Q	inflow



gradual contraction coefficient

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penstock after surge tank

Q = 140 (m^3/s)

D_1 = 6.600 (m^2)

D_2 = 5.600 (m^2)

A_1 = 34.212 (m^2)

A_2 = 24.630 (m^2)

θ = 10.00 °

L = 5.70 (m)

$$\theta = 2\tan^{-1}\left(\frac{D_1 - D_2}{2L}\right)$$

A_2/A_1 = 0.72

f_{gc} = 0.002

v_2 = 5.6841 (m/s)

h_{ge} = 0.0033 (m)

F = 1.68E-07 $=h_{gc}/Q^2$

I.P.8.1 & 8.2

Q = 70 (m^3/s)

D_1 = 3.950 (m^2)

D_2 = 2.850 (m^2)

A_1 = 12.254 (m^2)

A_2 = 6.379 (m^2)

θ = 10.00 °

L = 6.30 (m)

A_2/A_1 = 0.52

f_{gc} = 0.003

v_2 = 10.9728 (m/s)

h_{ge} = 0.0184 (m)

F = 3.76E-06 $=h_{gc}/Q^2$

I.P.2

Q = 140 (m^3/s)
D = 6.6 (m)
A = 34.21 (m^2)
ρ = 70.00 (m)
θ = 22.57 °
ρ/D = 10.6
f_{b1} = 0.09
f_{b2} = 0.4
v = 4.0921 (m/s)
h_b = 0.0308 (m)

F = 1.57E-06 $=h_b/Q^2$

I.P.4

Q = 140 (m^3/s)
D = 5.6 (m)
A = 24.63 (m^2)
ρ = 70.00 (m)
θ = 66.79 °
ρ/D = 12.5
f_{b1} = 0.09
f_{b2} = 0.87
v = 5.6841 (m/s)
h_b = 0.1291 (m)

F = 6.59E-06 $=h_b/Q^2$

I.P.5.1 & 5.2

Q = 70 (m^3/s)
D = 3.95 (m)
A = 12.25 (m^2)
ρ = 7.90 (m)
θ = 24.88 °
ρ/D = 2.0
f_{b1} = 0.15
f_{b2} = 0.45
v = 5.7123 (m/s)
h_b = 0.1124 (m)

F = 2.29E-05 $=h_b/Q^2$

I.P.6.1

Q = 70 (m^3/s)
D = 3.95 (m)
A = 12.25 (m^2)
ρ = 7.90 (m)
θ = 74.24 °
ρ/D = 2.0
f_{b1} = 0.15
f_{b2} = 0.95
v = 5.7123 (m/s)
h_b = 0.2372 (m)

F = 4.84E-05 $=h_b/Q^2$

I.P 7.1 & 7.2

Q = 70 (m^3/s)
D = 2.85 (m)
A = 6.38 (m^2)
ρ = 5.70 (m)
θ = 31.25 °
ρ/D = 2.0
f_{b1} = 0.15
f_{b2} = 0.5
v = 10.9728 (m/s)
h_b = 0.4607 (m)

F = 9.40E-05 $=h_b/Q^2$

I.P 8.1 & 8.2

Q = 70 (m^3/s)
D = 2.85 (m)
A = 6.38 (m^2)
ρ = 5.70 (m)
θ = 42.72 °
ρ/D = 2.0
f_{b1} = 0.15
f_{b2} = 0.67
v = 10.9728 (m/s)
h_b = 0.6174 (m)

F = 1.26E-04 $=h_b/Q^2$

I.P.6.2

Q = 70 (m^3/s)
D = 3.95 (m)
A = 12.25 (m^2)
ρ = 7.90 (m)
θ = 74.24 °
ρ/D = 2.0
f_{b1} = 0.15
f_{b2} = 0.95
v = 5.7123 (m/s)
h_b = 0.2372 (m)

F = 4.84E-05 $=h_b/Q^2$

Surge tank (B)

Q = 140 (m^3/s)
D = 6.6 (m)
A = 34.21 (m^2)
θ = 3.748567 °

f_{be} = 0.0010
v = 4.0921 (m/s)
h_{be} = 0.0009 (m)

F = 4.42E-08 $=h_{be}/Q^2$

Portal valve up

Q = 140 (m^3/s)
D = 3.95 (m)
A = 12.25 (m^2)
θ = 4.4438 °

f_{be} = 0.0014
v = 11.4247 (m/s)
h_{be} = 0.0095 (m)

F = 4.85E-07 $=h_{be}/Q^2$

Portal valve down

Q = 140 (m^3/s)
D = 5.6 (m)
A = 24.63 (m^2)
θ = 25.7121 °

f_{be} = 0.0519
v = 5.6841 (m/s)
h_{be} = 0.0855 (m)

F = 4.36E-06 $=h_{be}/Q^2$

Change gradient (I.P.6.1)

Q = 140 (m^3/s)
D = 5.6 (m)
A = 24.63 (m^2)
θ = 25.7121 °

f_{be} = 0.0519
v = 5.6841 (m/s)
h_{be} = 0.0855 (m)

F = 4.36E-06 $=h_{be}/Q^2$

refraction

$$h_{be} = f_{be} \frac{v^2}{2g}$$

$$f_{be} = 0.946 \sin^2 \frac{\vartheta}{2} + 2.05 \sin^4 \frac{\vartheta}{2}$$

h_{be} loss of head by refraction
f_{be} coefficient of loss by refraction
θ refraction angle
g gravity acceleration = 9.8 (m/s^2)
v velocity in pipe = Q/A
A cross section area of pipe
Q inflow

I.P.3

Q = 140 (m^3/s)
D = 6.6 (m)
A = 34.21 (m^2)
θ = 1.6 °

f_{be} = 0.0002
v = 4.0921 (m/s)
h_{be} = 0.0002 (m)

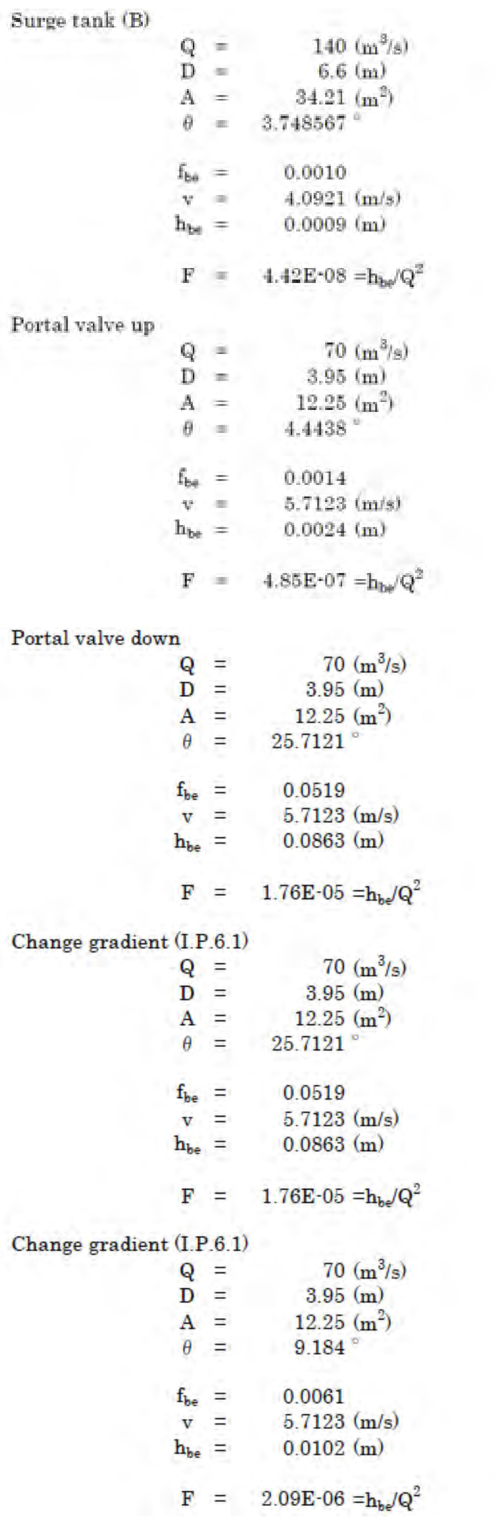
F = 8.04E-09 $=h_{be}/Q^2$

Surge tank (A)

Q = 140 (m^3/s)
D = 6.6 (m)
A = 34.21 (m^2)
θ = 0.94234 °

f_{be} = 0.0001
v = 4.0921 (m/s)
h_{be} = 0.0001 (m)

F = 2.79E-09 $=h_{be}/Q^2$



Surge tank (B)

Q = 140 (m^3/s)
D = 6.6 (m)
A = 34.21 (m^2)
θ = 3.748567 °

f_{be} = 0.0010
v = 4.0921 (m/s)
h_{be} = 0.0009 (m)

F = 4.42E-08 $=h_{be}/Q^2$

Portal valve up

Q = 70 (m^3/s)
D = 3.95 (m)
A = 12.25 (m^2)
θ = 4.4438 °

f_{be} = 0.0014
v = 5.7123 (m/s)
h_{be} = 0.0024 (m)

F = 4.85E-07 $=h_{be}/Q^2$

Portal valve down

Q = 70 (m^3/s)
D = 3.95 (m)
A = 12.25 (m^2)
θ = 25.7121 °

f_{be} = 0.0519
v = 5.7123 (m/s)
h_{be} = 0.0863 (m)

F = 1.76E-05 $=h_{be}/Q^2$

Change gradient (I.P.6.1)

Q = 70 (m^3/s)
D = 3.95 (m)
A = 12.25 (m^2)
θ = 25.7121 °

f_{be} = 0.0519
v = 5.7123 (m/s)
h_{be} = 0.0863 (m)

F = 1.76E-05 $=h_{be}/Q^2$

Change gradient (I.P.6.1)

Q = 70 (m^3/s)
D = 3.95 (m)
A = 12.25 (m^2)
θ = 9.184 °

f_{be} = 0.0061
v = 5.7123 (m/s)
h_{be} = 0.0102 (m)

F = 2.09E-06 $=h_{be}/Q^2$