ESKOM EAST COAST CCGT PROJECT

HYDROLOGICAL AND FLOOD LINE REPORT

15 FEBRUARY 2017

EMPLOYER:	ENGINEER:
Andrew Batho 76 Valley View Road DURBAN 4001 Tel: 031 3032835 andrew@afzelia.co.za	Flip Krugel CONSULTING ENGINEERS CC TEL: 034 9823425 Bianca Muhl 119 Deputation Street VRYHEID 3100 Tel: 034 9823425 fkrugel@raws.co.za

ESKOM EAST COAST CCGT PROJECT
HYDROLOGICAL AND FLOOD LINE REPORT
15 FEBRUARY 2017

CONTENTS

ESKOM EAST COAST CCGT PROJECT

HYDROLOGICAL AND FLOOD LINE REPORT

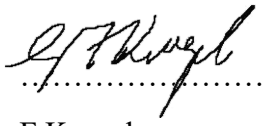
15 FEBRUARY 2017

1. QUALITY MANAGEMENT AND APPROVALS

STATUS OF REPORT: FINAL DESK TOP STUDY

FIRST DRAFT: 15 DECEMBER 2016

Approved by RAWS Consulting Engineers cc



……. 15 Feb 2017 ……

F.Krugel Date

Recommended by the Environmentalist

…….. ……..

Environmentalist Date

……..…... (Print name)

Accepted and Approved by the Employer

…….. ……..

Employer Date

……..…... (Print name)

2. EXECUTIVE SUMMARY

The following floods were determined using the TR137 method with a K value of 5.6.

River/Place	Catchment Area (km²)	Flood (m³/s)				
		RMF	1:200	1:100	1:50	1:20
Nseleni River	811	5754	4621	3844	3090	1151
uMthlatuze River	2946	10156	8338	7059	5789	2031
Estuary	3877	11454	9598	8293	6952	2334

RMF (Regional Maximum Flood)

The areas most severely affected are the low lying plains adjacent to the uMthlatuze River on which sugarcane is grown. Data used for this desk top study does not clearly indicate the correct and accurate levels of the roads and railway line embankments. It is assumed that the road embankments are constructed high enough to prevent flood water from the all the above floods except the RMF to flow over the roads. It is assumed that the railway line is constructed high enough to also prevent the RMF to flow over the railway line and into the harbour. It is assumed at this stage that culverts under the railway line is of insignificant size to raise water levels in the harbour area significantly from floods emanating from the Mhlatuze And Mseleni Rivers.

Topographical surveys are required to ensure an accurate final model.

The proposed sites (4A,5,6 and 7) lie high enough to prevent flooding of any of the 1:20, 1:50, 1:100, 1:200, and Regional Maximum Flood (RMF).The PMF (Probable Maximum flood was not analysed).

However, gas lines towards the harbour will most likely be flooded depending on the pipeline route. Some access roads may be flooded and power distribution line support structures may be partially under flood waters, depending on the routes. It is for this infrastructure that we need to refine the flood line assessment. This can only be done upon completion of an on-site topographical survey of roads, railway lines, bridges, weirs, culverts and cross sections through the Mhlatuze river at selected locations. Refer to detail in the report.

In terms of a site flooding hazard, any of the sites 4A, 5, 6 and 7 is suitable and one site cannot be regarded more suitable than the other at this preliminary stage. However, it can be cautiously speculated at this stage that site numbers 6 and 7 would be the best sites in terms of a flooding hazard of access roads and gas line routes.

For on-site storm water management plans the following figures should be used:

Applicable rainfall intensities (WRC K5/1060) for return periods 2 to 20 years.

Peroid		Rainfall (mm) for return peroid in years											
Duration		2	2l	2u	5	5L	5U	10	10L	10U	20	20L	20U
5	min	12	7	17	18	10	26	24	13	34	30	17	44
10	min	16	10	21	24	16	33	32	20	44	41	26	56
15	min	19	13	25	29	20	38	38	26	50	49	33	65
30	min	25	18	32	40	29	51	52	37	66	66	47	85
45	min	30	23	38	47	35	59	62	46	78	79	58	100
1	hour	34	26	43	54	41	67	70	53	87	89	67	112
1	day	107	94	119	167	147	186	218	191	244	277	241	314

L- Lower estimate

U- Upper estimate

2,5..- Average

Applicable rainfall intensities (WRC K5/1060) for return periods 50 to 200 years.

Peroid		Rainfall (mm) for return peroid in years								
		50	50L	50U	100	100L	100U	200	200L	200U
5	min	41	22	60	50	27	76	62	33	95
10	min	55	34	77	68	42	97	84	50	122
15	min	66	44	88	82	54	112	101	65	141
30	min	89	62	116	111	76	147	137	92	186
45	min	106	77	137	132	94	173	163	113	218
1	hour	121	89	153	150	108	194	185	131	245
1	day	375	321	430	466	392	543	575	474	685

Effect of waves, tides, tsunamis, etc. were not analysed as it was not included in the scope of works. It is recommended that at least 1.5 m additional height above mean sea level should be allowed for all flood lines for at least the tides and sea-level rise.

It is further recommended that the final designs of structures are based on accurate topographical surveys, using the actual flood heights above mean sea level (+at least 1.5 m) at the specific points and not the flood lines as indicated on the attached map.

3. INTRODUCTION

The Eskom Proposed Combined Cycle Gas Turbine (CCGT) Project has identified various sites where the CCGT could be constructed. The final location will depend on different factors, one of which is the risk of damage due to flooding. The area upstream of the uMhlatuze Estuary is relatively flat, hence floods can cover large areas.

RAWS Consulting Engineers were appointed by Afzelia Environmentalists to undertake a hydrological assessment in order to determine the flood lines along the uMhlathuze and Nseleni Rivers up to the Estuary. The impact on the harbour due to floods was not included per implication in the scope of works for this study as no sites were identified on the harbour side (lake Mzingazi catchment).

It should be noted that the flood-lines were determined purely by a desktop study at this stage. Various assumptions had to be made regarding the bridge heights, pier spacing and culverts as this information is not available as yet. It is necessary that the roads, railway lines, bridges and culverts are surveyed to ensure an accurate final model.

4. GENERAL HYDROLOGY

4.1. WATER RESOURCES

There are three main sources of fresh water for the Richards Bay/Empangeni/Esikaweni area. Esikaweni's raw water is from lake Cubhu, Richards Bay's water from lake Mzingazi, lake Nsezi and from the Mhlatuze River from the weir abstraction point. Empangeni's water is from lake Nsezi and from the Mhlatuze River from the weir abstraction point.

The Goedertrouw dam in the Mhlatuze River is a source of some stability in the domestic water supply to the Richards Bay area, but a major irrigation scheme is also dependant on the water from this dam. The area is presently in a situation where water supply is under severe pressure and doubling up of the Tugela-Goedertrouw dam transfer scheme is under consideration. There are also investigations completed to transfer water from the Umfolozi River to the area. It is not certain at this stage whether a recent projected water balance study has been done for the area or is underway, but it is definitely required. At this stage surety of domestic water supply cannot be quantified.

4.2. RAINFALL

The climate at the area where the proposed sites occur can be described as generally "humid and wet" in comparison to other regions in South Africa. Rainfall is fairly consistent but extreme rainfall does occur when tropical cyclones move over the area in their seasonal migrations from the equatorial zone toward the subtropics, during the later part of summer (Kelbe and Germishuyse, 1999).

At the location of the potential sites the mean annual rainfall can best be estimated by the Lynch isohyets as follows:

Average monthly rainfall (Lynch isohyets):

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Rain (mm)	103	130	128	146	174	151	110	82	57	56	60	84	1281

Applicable rainfall stations (WRC K5/1060):

Station Name	SAWS	Record	Lat		Long		MAP	Altitude
	Number	(Years)	(°)	(')	(°)	(')	(mm)	(m)
RICHARDS BAY (MUN)	0305167W	53	28	47	32	5	1255	16
ENSELENI	0305043W	48	28	43	32	2	1124	55
KULU HALT	0304823S	69	28	43	31	58	1080	76
KULU HALT	0304822W	72	28	42	31	58	1109	91
FELIXTON	0304680S	50	28	50	31	53	1321	47
EMPANGENI(MILL	0304705S	28	28	45	31	54	1099	107

Applicable 24 hour rainfall intensities (WRC K5/1060) for return periods 2 to 20 years.

Station Name	Rainfall (mm) for return peroid in years											
	2	2L	2U	5	5L	5U	10	10L	10U	20	20L	20U
RICHARDS BAY (MUN)	91	91	92	142	142	143	186	184	187	237	233	241
ENSELENI	100	99	100	155	155	156	203	201	205	259	254	263
KULU HALT	80	80	81	125	125	126	164	162	165	208	205	212
KULU HALT	96	95	96	149	149	150	195	193	197	249	244	253
FELIXTON	98	97	98	153	152	153	199	198	201	254	249	258
EMPANGENI(MILL	95	95	96	148	148	149	194	192	196	247	243	251

L- Lower estimate

U- Upper estimate

Applicable 24 hour rainfall intensities (WRC K5/1060) for return periods 50 to 200 years.

Station Name	Rainfall (mm) for return peroid in years								
	50	50L	50U	100	100L	100U	200	200L	200U
RICHARDS BAY (MUN)	320	309	329	398	378	416	491	457	525
ENSELENI	350	338	360	434	413	455	537	499	574
KULU HALT	282	272	290	350	332	366	432	402	462
KULU HALT	336	325	346	418	397	437	516	480	552
FELIXTON	343	332	353	426	405	447	527	490	563
EMPANGENI(MILL	334	323	344	415	394	435	513	477	548

Applicable rainfall intensities (WRC K5/1060) for return periods 2 to 20 years.

Peroid		Rainfall (mm) for return peroid in years											
Duration		2	2l	2u	5	5L	5U	10	10L	10U	20	20L	20U
5	min	12	7	17	18	10	26	24	13	34	30	17	44
10	min	16	10	21	24	16	33	32	20	44	41	26	56
15	min	19	13	25	29	20	38	38	26	50	49	33	65
30	min	25	18	32	40	29	51	52	37	66	66	47	85
45	min	30	23	38	47	35	59	62	46	78	79	58	100
1	hour	34	26	43	54	41	67	70	53	87	89	67	112
1	day	107	94	119	167	147	186	218	191	244	277	241	314

Applicable rainfall intensities (WRC K5/1060) for return periods 50 to 200 years.

Peroid		Rainfall (mm) for return peroid in years								
Duration		50	50L	50U	100	100L	100U	200	200L	200U
5	min	41	22	60	50	27	76	62	33	95
10	min	55	34	77	68	42	97	84	50	122
15	min	66	44	88	82	54	112	101	65	141
30	min	89	62	116	111	76	147	137	92	186
45	min	106	77	137	132	94	173	163	113	218
1	hour	121	89	153	150	108	194	185	131	245
1	day	375	321	430	466	392	543	575	474	685

Monthly Rainfall - DWA Station WE1009													
Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975/76	117	117	95	391	73	392	184	173	41	96	95	49	1822
1976/77	148	93	137	90	539	313	24	22	16	48	94	93	1617
1977/78	86	81	88	544	96	72	231	77	73	120	92	56	1616
1978/79	117	117	95	168	162	141	107	76	81	81	74	135	1355
1979/80	83	141	133	175	36	65	77	76	49	19	18	128	998
1980/81	54	101	33	174	108	85	132	260	105	29	102	183	1366
1981/82	114	126	61	140	115	195	202	93	12	64	21	86	1228
1982/83	123	48	50	72	105	58	28	21	89	179	133	51	956
1983/84	116	159	108	670	322	90	155	47	152	121	72	23	2034
1984/85	103	110	113	318	376	28	11	61	241	135	42	124	1661
1985/86	240	51	47	73	114	108	188	43	103	11	54	94	1124
1986/87	85	85	190	235	29	222	101	138	208	36	303	782	2415
1987/88	98	78	43	55	253	258	50	44	123	61	58	69	1189
1988/89	131	138	168	66	375	29	107	68	153	76	10	132	1453
1989/90	97	312	163	68	138	329	96	54	14	7	158	45	1480
1990/91	160	97	115	215	413	295	66	226	84	81	95	43	1888
1991/92	94	67	98	33	7	142	26	0	7	39	81	35	629
1992/93	29	119	86	118	137	111	39	23	27	32	80	96	895
1993/94	213	102	130	144	37	120	41	33	43	47	126	50	1085
1994/95	211	89	51	13	98	322	212	82	132	64	28	15	1316
1995/96	121	144	156	261	302	157	102	113	24	304	35	21	1738
1996/97	146	85	57	395	131	107	80	176	136	134	64	102	1613
1997/98	104	309	44	78	115	56	159	26	4	129	17	133	1173
1998/99	101	61	58	166	178	59	69	25	25	77	71	96	985
1999/00	86	26	97	159	246	233	235	114	15	50	10	120	1390
2000/01	111	151	99	221	145	81	80	55	12	63	21	143	1181
2001/02	124	176	162	131	111	56	63	8	156	277	120	71	1454
2002/03	53	127	79	50	82	56	103	40	189	66	43	94	981
2003/04	17	123	16	248	265	247	89	50	17	160	13	191	1435
2004/05	67	166	92	181	157	290	74	109	165	37	13	37	1389
2005/06	83	108	71	73	69	280	211	236	58	12	160	100	1460
2006/07	128	209	131	168	35	45	224	0	320	44	57	29	1389
2007/08	217	190	50	72	218	127	221	54	104	5	77	195	1529
2008/09	32	53	100	149	267	58	51	115	51	23	150	49	1098
2009/10	140	145	103	137	108	30	75	41	38	35	51	56	959
2010/11	156	117	140	184	162	0	171	33	43	175	53	103	1338
2011/12	117	117	95	51	131	174	63	15	67	16	22	147	1016
2012/13	167	79	128	301	114	119	58	168	47	33	50	81	1344
2013/14	142	75	127	27	72	130	62	39	9	14	16	21	733
2014/15	247	23	39	20	162	18	46	4	25	169	13	45	811
2015/16	30	91	37	51	52	92	77	78	78	157	70	103	914
Average	**117**	**117**	**95**	**168**	**162**	**141**	**107**	**76**	**81**	**81**	**70**	**103**	**1318**

4.3. EVAPORATION

Symons pan evaporation:

Monthly Evaporation - DWA Station WE1009													
Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975/76	128	148	109	114	130	122	131	96	68	82	92	119	1338
1976/77	140	175	155	157	170	143	100	75	74	80	108	104	1480
1977/78	115	162	186	157	119	127	132	67	74	66	71	112	1387
1978/79	128	148	169	172	149	143	109	81	67	1	67	77	1312
1979/80	122	132	166	178	154	145	123	1	58	64	93	85	1320
1980/81	142	135	198	177	126	158	145	79	52	63	87	87	1447
1981/82	140	152	188	181	174	180	105	75	69	81	90	112	1547
1982/83	141	155	202	200	160	146	106	105	66	78	76	110	1546
1983/84	115	131	186	173	155	128	121	96	57	53	80	119	1412
1984/85	129	165	225	200	129	165	146	95	57	82	118	106	1617
1985/86	185	191	189	228	182	168	128	95	79	82	99	126	1750
1986/87	163	159	201	193	185	166	137	102	82	71	89	95	1644
1987/88	123	131	193	200	169	153	121	83	68	83	90	110	1523
1988/89	124	169	172	178	132	171	2	79	50	75	117	114	1384
1989/90	129	148	188	177	143	141	111	81	79	74	89	101	1459
1990/91	122	169	161	172	136	135	126	88	55	62	97	109	1432
1991/92	119	167	190	194	202	181	140	124	98	100	98	104	1716
1992/93	170	168	186	230	150	159	139	101	76	87	101	106	1670
1993/94	111	163	168	211	193	165	125	97	83	83	87	138	1625
1994/95	137	164	211	237	177	150	93	81	55	72	102	110	1589
1995/96	124	126	155	169	149	134	102	70	64	58	76	131	1359
1996/97	136	147	213	168	160	121	110	70	58	55	86	99	1424
1997/98	130	151	149	170	153	140	127	94	72	76	96	121	1478
1998/99	136	154	173	204	161	160	131	87	63	83	96	106	1553
1999/00	104	131	141	127	129	131	76	58	48	55	85	88	1173
2000/01	82	127	162	159	127	147	90	79	62	72	87	112	1306
2001/02	112	122	160	185	113	145	112	83	59	59	73	109	1330
2002/03	132	145	151	170	152	157	94	76	53	63	80	94	1366
2003/04	127	149	187	152	122	107	101	80	57	77	78	97	1333
2004/05	127	154	173	197	134	140	110	95	69	76	84	111	1469
2005/06	117	144	153	122	111	117	96	81	56	59	92	110	1256
2006/07	137	146	165	183	147	139	92	86	93	74	98	106	1464
2007/08	119	119	173	161	149	123	113	77	72	64	93	118	1380
2008/09	116	124	178	145	135	129	101	75	61	69	89	80	1302
2009/10	120	140	146	150	150	170	115	87	67	81	93	120	1439
2010/11	131	148	135	130	149	143	110	76	60	51	78	106	1317
2011/12	128	148	169	188	152	126	103	72	79	66	79	97	1409
2012/13	104	110	154	114	142	121	84	61	62	59	101	90	1201
2013/14	127	184	124	163	139	113	97	70	74	69	78	113	1351
2014/15	103	116	152	155	149	140	86	74	87	68	85	102	1315
2015/16	135	161	87	105	144	129	101	93	68	63	89	106	1282
Average	**128**	**148**	**169**	**172**	**149**	**143**	**109**	**81**	**67**	**69**	**89**	**106**	**1432**

Patched data

4.4. RAINFALL-EVAPORATION BALANCE FOR LARGE OPEN RESERVOIRS

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Pan factor	0.81	0.8	0.8	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	
1976/77	35	-47	13	-42	390	187	-64	-43	-47	-19	7	9	378
1977/78	-8	-49	-61	413	-9	-39	114	19	11	65	35	-35	457
1978/79	14	-1	-41	24	31	15	11	5	24	80	20	73	254
1979/80	-16	36	0	25	-99	-63	-32	75	0	-34	-57	59	-107
1980/81	-62	-7	-125	26	-3	-54	4	192	61	-23	32	113	154
1981/82	0	4	-90	-12	-38	36	109	27	-46	-3	-52	-5	-69
1982/83	9	-76	-112	-96	-36	-70	-66	-70	33	114	71	-38	-338
1983/84	23	54	-41	525	185	-23	48	-37	103	77	7	-73	850
1984/85	-2	-22	-67	150	262	-118	-118	-22	193	67	-54	38	309
1985/86	91	-102	-105	-118	-46	-40	75	-40	36	-57	-26	-8	-340
1986/87	-47	-42	30	73	-134	76	-20	49	138	-22	231	705	1036
1987/88	-2	-27	-111	-113	104	123	-57	-28	65	-7	-15	-20	-88
1988/89	30	3	30	-84	258	-121	106	-1	110	13	-85	40	300
1989/90	-8	193	13	-81	12	205	-2	-16	-53	-54	86	-37	259
1990/91	61	-39	-14	70	293	176	-45	150	38	30	16	-45	689
1991/92	-3	-67	-54	-130	-171	-17	-97	-107	-77	-44	2	-49	-813
1992/93	-108	-15	-62	-75	5	-29	-83	-65	-38	-40	-2	10	-503
1993/94	123	-28	-5	-33	-133	-26	-70	-52	-28	-21	56	-62	-278
1994/95	100	-42	-117	-186	-58	190	130	11	85	4	-54	-74	-12
1995/96	20	43	32	119	171	39	12	52	-31	256	-27	-85	600
1996/97	36	-33	-114	254	-9	1	-17	115	87	88	-6	21	423
1997/98	-1	188	-75	-65	-20	-67	47	-56	-57	66	-61	36	-65
1998/99	-10	-62	-81	-5	37	-81	-46	-51	-29	8	-7	10	-317
1999/00	2	-79	-16	53	132	117	168	63	-26	4	-58	49	409
2000/01	44	49	-30	87	33	-48	1	-14	-40	4	-49	53	88
2001/02	33	79	34	-25	12	-72	-35	-64	106	228	61	-18	339
2002/03	-54	11	-42	-93	-52	-82	21	-26	143	14	-22	18	-164
2003/04	-86	3	-134	121	158	153	0	-19	-32	96	-50	112	322
2004/05	-36	42	-46	15	39	167	-22	26	107	-26	-55	-53	159
2005/06	-12	-7	-51	-29	-29	177	127	166	10	-37	86	11	410
2006/07	17	92	-1	14	-94	-77	143	-75	242	-17	-22	-57	164
2007/08	121	95	-88	-63	87	18	122	-13	42	-48	2	99	374
2008/09	-62	-46	-43	27	148	-56	-37	50	-1	-35	78	-16	9
2009/10	43	33	-13	11	-24	-120	-25	-35	-19	-32	-24	-41	-248
2010/11	50	-1	32	75	31	-126	74	-33	-7	132	-10	17	234
2011/12	14	-1	-41	-107	-3	63	-28	-47	0	-39	-42	68	-163
2012/13	83	-9	5	206	-12	13	-16	115	-6	-16	-32	9	339
2013/14	40	-73	28	-111	-51	30	-23	-21	-54	-43	-47	-70	-396
2014/15	163	-69	-83	-110	31	-105	-30	-60	-49	113	-56	-37	-292
2015/16	-79	-38	-32	-38	-75	-22	-12	-4	20	104	-3	17	-161
Average	14	-1	-41	16	32	8	9	3	25	23	-3	18	105

Negative values indicate more evaporation from reservoir than direct rainfall into the reservoir.

5. ASSUMPTIONS FOR FLOOD LINE ANALYSIS

- Francou-Rodier K-value of 5.6 applies to all catchments as calibrated using the Domoina Floods.
- The railway embankment along the uMhaltuze River, which separates the Estuary and the Harbour is high enough to accommodate all the investigated floods magnitudes and will not spill over the railway line into the harbour. It is also assumed that the culverts under the railway line are of insignificant size in terms of the flood volumes emanating from the Mhlatuze and Mseleni Rivers (A survey of the railway line is necessary or detail needs to be obtained from Transnet).
- The bridge decks on the R34 are at a level of minimum 13m above mean sea level. This was estimated from existing 25 m x 25 m aerial survey points. (A survey of the road levels is necessary or road invert levels to be obtained from DOT).
- The road branching off from the R34 which passes through the low lying sugarcane fields has a high enough embankment to prevent the 1:20, 1:50, 1:100 year floods from flowing over it (A survey for this road embankment is necessary or road invert levels to be obtained from DOT). Available aerial survey points indicate that this road should prevent the 1:20 and 1:50 year flood from flowing over, but the 1:100 year flood could possibly flow over.
- Bridge openings, pier spacing and culverts were obtained from Google Earth and photos taken from the road side and it is therefore necessary to obtain accurate detail to refine the model.

6. EXCLUSIONS

This study excludes the effect of high sea water levels due to tides, wind set-up, hydrostatic set-up, wave set-up and, in future, sea-level rise (SLR), the latter due to climate change. Sea water levels most significant to the Southern African context are the tides (South African spring tides are approximately 1 m above mean sea level) according to a recent study "Recent Extreme Events along the Coast of South Africa, by Andrew Mather and Andre Theron".

Sea-level rise can be as much as 3.3 mm per year (Rahmstorf et al, 2007). If this present trend continues, the rise can reach 330 mm in 100 years' time. This and all the above factors have not been included in the determination of the flood lines and it is recommended that at least 1.5 m additional height above mean sea level should be allowed for each flood magnitude as the sea level will affect the "backing up" of flood waters.

According to the same study, wave heights can reach 8 m annually. Wave run-up depends on the beach conditions and can cause damage significantly further/higher up than expected. This should be studied into much more detail for potential sites 5 and 6.

The potential effect which possible tsunamis may have on the flood levels is also not investigated.

7. FLOOD HYDROLOGY

The TR137 method (Francou-Rodier method) was used as the catchments areas are very large, which out-rules methods such as the Rational and Alternative Rational method.

A K-value of 5.6 was used for the uMhlatuze, Nseleni and Estuary catchments. Quaternary catchments W12A, W12B, W12C, W12D, W12E, W12F contribute to the uMhlatuze River run-off and W12G and W12H contribute to the Nseleni River. Quaternary catchments W12A to W12H contribute to the Estuary run-off.

Table 1 below indicates the catchment areas as well as the predicted floods.

Table 1: Predicted Flood magnitudes

River/Place	Catchment Area (km^2)	Flood (m^3/s)				
		RMF	1:200	1:100	1:50	1:20
Nseleni River	811	5754	4621	3844	3090	1151
uMthlatuze River	2946	10156	8338	7059	5789	2031
Estuary	3877	11454	9598	8293	6952	2334

Hec-Ras software was used to simulate the effect of the above floods along the rivers and adjacent flood plains. Cross-sections were obtained from existing 25m x 25m aerial survey points. Although these points are fairly accurate, there may be inaccuracies depending on vegetation and structures in the survey area. This will however not affect the flood heights significantly since the areas where inaccuracies are expected are very wide and will therefore not influence the flood depth. It is recommended that the final designs of structures are based on accurate topographical surveys, using the actual flood heights above mean sea level at the specific points and not the flood lines as indicated on the attached map. This will increase the accuracy of the predicted flood line significantly.

All proposed sites lie outside the Regional Maximum Flood (RMF) and obviously all the lessor floods. The PMF (Probable Maximum flood) was not analysed.

Although potential site number 6 is not indicated on the attached plan, there is absolutely no change of any of the above flood possibilities to have an effect on this site.

Note that this study excludes local storm water management plans for the sites. There may be small natural local storm water gullies etc. that will have to be accommodated in a storm water plan.

8. TOPOGRAPHICAL SURVEY REQUIRED.

At this stage aerial survey points in a 25 x 25 m grid has been used for the desktop floodline analysis. Aerial surveys are as accurate as vegetation allows and important levels such as road, railway and river bed levels are often "missed" by 25 x 25 m grid points. From the desktop study is it already clear that the probability of flooding of the sites is negligible. However access to the sites, gas line routes, transmission lines will be affected by the floods. It is specifically for these reasons that the actual flood heights be determined more accurately and that the probability of flooding of access roads be determined more accurately. On site surveying/measuring of bridge and culvert openings, weir height for the structures as indicated on the following plan:

10. ANNEXURE

10.1. FLOOD DETERMINATION USING THE TR137 METHOD

10.2. LAYOUT PLAN INDICATING FLOOD LINES

uMhlatuze River Floods

CALCULATION OF (RMF) REGIONAL MAXIMUM FLOOD AND THE RECOMMENDED (SEF) SAFETY EVALUATION FLOOD

(TR 137 "DWAF" - WITH THE FRANCOU-RODIER K-value's)

Size of dam (S/M/L)	S	Small / Medium / Large
Hazard rating (L/S/H)	L	Low / Significant / High
Ke - determined value if applicable	0	Ke - value where spesific determine otherwise "0"
Ke - envelope value	5.6	2.8 / 3.4 / 4 / 4.6 / 5 / 5.2 / 5.4 / 5.6
Watersurface at FSL (ha.)	9.0	In hectare
Areal catchment area (sq. km.)	2950.0	Smaller than 10 use other methods
Is the dam in the Southwest-Cape (Y/N) ?	N	Important for region 5

Zone	Flood zone
RMF	**10156.1**
Q200	8338.2
Q100	7058.5
Q50	5789.0
Q20*	2031.2
RDF	**5789.0**
** RMF - <>	8246.4
** RMF + <>	10156.1

PMF	**52249.6**
Spillway width (m)	800.0
Total freeboard (m)	9.0
Max. discharge	**46126.44**
Storage above FSL	810000
Sec. before O/T	**N/A**
Min. before O/T	**N/A**

	Recommended SEF
PMF based	42424.7
RMF based	8246.4
Average SEF	**25335.6**
SEF (Cat I) < 10km²	N/A

Nseleni River Floods

CALCULATION OF (RMF) REGIONAL MAXIMUM FLOOD AND THE RECOMMENDED (SEF) SAFETY EVALUATION FLOOD

(TR 137 "DWAF" - WITH THE FRANCOU-RODIER K-value's)

Size of dam (S/M/L)	S	Small / Medium / Large
Hazard rating (L/S/H)	L	Low / Significant / High
Ke - determined value if applicable	0	Ke - value where spesific determine otherwise "0"
Ke - envelope value	5.6	2.8 / 3.4 / 4 / 4.6 / 5 / 5.2 / 5.4 / 5.6
Watersurface at FSL (ha.)	9.0	In hectare
Areal catchment area (sq. km.)	811.0	Smaller than 10 use other methods
Is the dam in the Southwest-Cape (Y/N) ?	N	Important for region 5

Zone	Flood zone
RMF	**5754.1**
Q200	4620.5
Q100	3843.7
Q50	3089.9
Q20*	1150.8
RDF	**3089.9**
** RMF - <>	4553.0
** RMF + <>	5754.1

PMF	**27744.3**
Spillway width (m)	6.2
Total freeboard (m)	0.8
Max. discharge	**8.36**
Storage above FSL	72000
Sec. before O/T	**16**
Min. before O/T	**0**

	Recommended SEF
PMF based	21953.0
RMF based	4553.0
Average SEF	**13253.0**
SEF (Cat I) < 10km²	N/A

Estuary Floods

CALCULATION OF (RMF) REGIONAL MAXIMUM FLOOD AND THE RECOMMENDED (SEF) SAFETY EVALUATION FLOOD

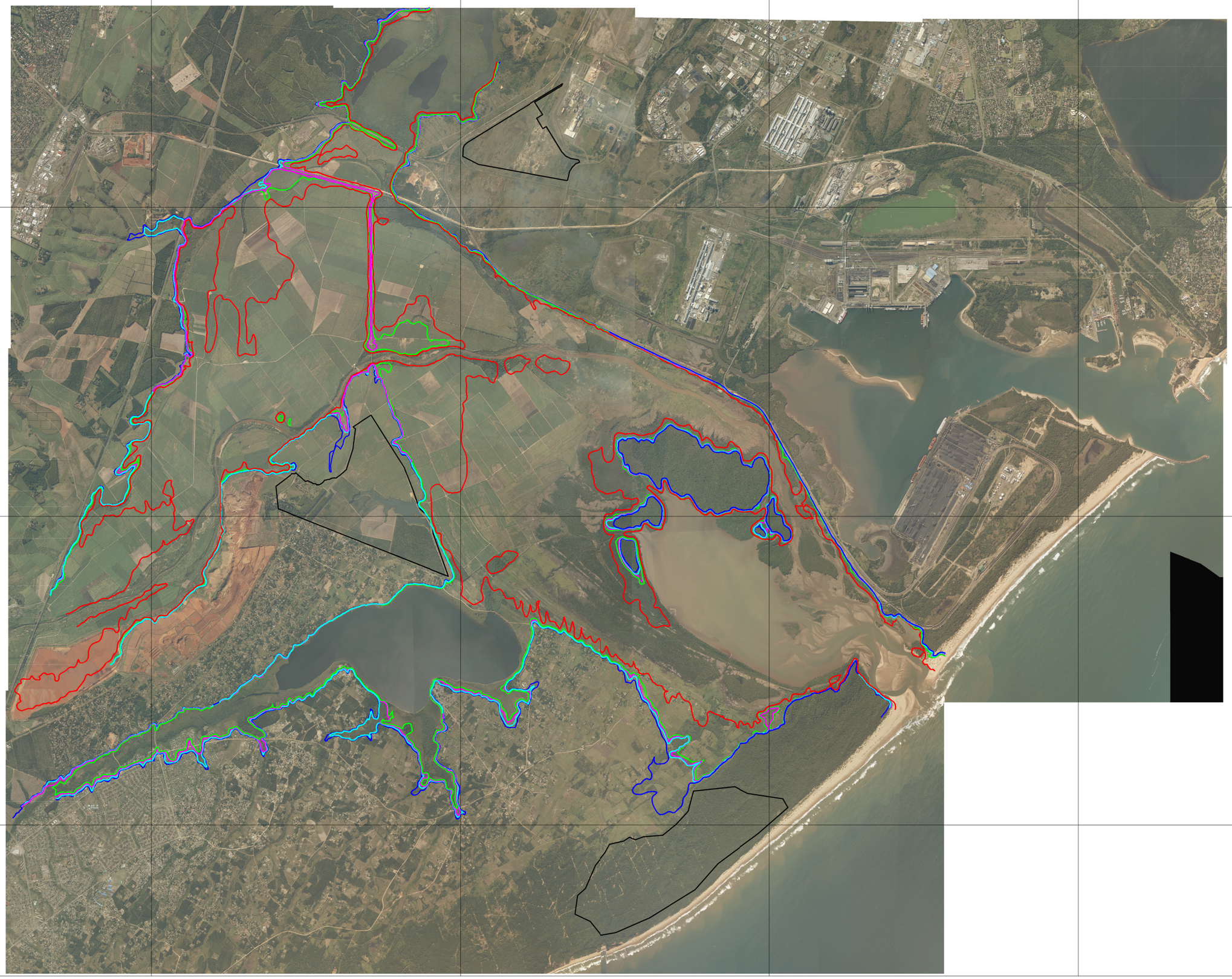
(TR 137 "DWAF" - WITH THE FRANCOU-RODIER K-value's)

Size of dam (S/M/L)	S	Small / Medium / Large
Hazard rating (L/S/H)	L	Low / Significant / High
Ke - determined value if applicable	0	Ke - value where spesific determine otherwise "0"
Ke - envelope value	5.6	2.8 / 3.4 / 4 / 4.6 / 5 / 5.2 / 5.4 / 5.6
Watersurface at FSL (ha.)	9.0	In hectare
Areal catchment area (sq. km.)	3877.0	Smaller than 10 use other methods
Is the dam in the Southwest-Cape (Y/N) ?	N	Important for region 5

Zone	Flood zone
RMF	**11453.7**
Q200	9598.2
Q100	8292.5
Q50	6952.4
Q20*	2290.7
RDF	**6952.4**
** RMF - <>	9350.9
** RMF + <>	11453.7

PMF	**62753.2**
Spillway width (m)	6.2
Total freeboard (m)	0.8
Max. discharge	**8.36**
Storage above FSL	72000
Sec. before O/T	**8**
Min. before O/T	**0**

	Recommended SEF
PMF based	51232.4
RMF based	9350.9
Average SEF	**30291.7**
SEF (Cat I) < 10km²	N/A



LEGEND

- RMF FLOODLINE
- 1:200 YEAR FLOODLINE
- 1:100 YEAR FLOODLINE
- 1:50 YEAR FLOODLINE
- 1:20 YEAR FLOODLINE
- PROPOSED SITES
- 1m CONTOUR
- 5m CONTOUR

Amendments

No.	Date	Checked	Done by	Description

CESA CESA

RAW

CONSULTING ENGINEERS CC

19 Deputasie Street
P O Box 2266 VRYHEID 3100
Tel / Fax: 034 982 3428

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

Approvals:

Engineer (G F KRUGEL, Pr Eng, ECSA Reg N° 910142): _____ Date _____

Client:

Eskom

Approvals:

Client: _____ _____ Date _____

Project Name:

ESKOM
EAST COAST CCGT PROJECT

Drawing Description:

MHLATUZE, NSELENI RIVER AND ESTUARY FLOODLINES

Cad Folder:

Z:\ESKOM\LAYOUT1.dt4

Scale:	Plot Date:
1:20000	2016/12/5
Project N°:	**Drawing Sequence N°:**
R 2016/11/01	R 2016/11/01/01