APPENDIX 7

POWER FLOW ANALYSIS

Demand distribution of Uganda

		Bus No.	2013		2014		2015		2016		2017 (Before)		2017 (After)		2018		2019		2020		2021		2022		2023		2024		2025		2026		2027	
			PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL	PL	QL
Country			**483**	**158**	**516**	**170**	**551**	**177**	**588**	**193**	**627**	**206**	**627**	**206**	**670**	**220**	**715**	**235**	**763**	**251**	**814**	**268**	**869**	**286**	**928**	**305**	**991**	**326**	**1058**	**348**	**1129**	**371**	**1205**	**396**
1.Central area			**353**	**116**	**377**	**124**	**401**	**132**	**430**	**141**	**458**	**151**	**458**	**151**	**490**	**161**	**522**	**172**	**557**	**183**	**594**	**195**	**635**	**209**	**677**	**223**	**723**	**238**	**773**	**254**	**824**	**271**	**880**	**289**
(1)Metropolitan area			**317**	**104**	**338**	**111**	**358**	**118**	**384**	**126**	**408**	**134**	**408**	**134**	**435**	**143**	**462**	**152**	**492**	**162**	**524**	**172**	**559**	**184**	**594**	**195**	**633**	**208**	**675**	**222**	**718**	**236**	**765**	**251**
①	Lugogo Substation	3125	56	18	60	20	63	21	68	22	72	24	56	18	60	20	53	17	56	18	81	27	86	28	85	28	90	30	92	30	98	32	104	34
②		3325	41	13	44	14	47	15	51	17	55	18	56	18	60	20	53	17	57	19	81	27	86	28	85	28	91	30	92	30	98	32	104	34
③	Kampala North Substatio	3124	56	18	60	20	63	21	68	22	72	24	56	18	60	20	53	17	56	18	53	17	57	19	57	19	60	20	62	20	65	21	70	23
④		3324	41	13	44	14	48	16	51	17	55	18	56	18	60	20	53	17	57	19	53	17	58	19	57	19	61	20	92	30	98	32	104	34
⑤	Mutundwe Substation	3129	29	10	30	10	32	11	34	11	36	12	29	10	30	10	79	26	84	28	81	27	86	28	85	28	90	30	92	30	98	32	104	34
⑥		3329	55	18	59	19	62	20	67	22	71	23	57	19	60	20	79	26	84	28	81	27	86	28	85	28	91	30	92	30	98	32	104	34
⑦	Kawaala Substation	3120	11	4	12	4	13	4	14	5	15	5	14	5	15	5	13	4	14	5	13	4	14	5	55	18	60	20	61	20	65	21	71	23
⑧	Queensway Substation	3301	28	9	29	10	30	10	31	10	32	11	84	28	90	30	79	26	84	28	81	27	86	28	85	28	90	30	92	30	98	32	104	34
(2)Outbound of metropolitan area			**36**	**12**	**39**	**13**	**43**	**14**	**46**	**15**	**50**	**16**	**50**	**16**	**55**	**18**	**60**	**20**	**65**	**21**	**70**	**23**	**76**	**25**	**83**	**27**	**90**	**30**	**98**	**32**	**106**	**35**	**115**	**38**
①	Kawanda	3321	17	6	17	6	18	6	18	6	19	6	19	6	19	6	20	7	20	7	21	7	21	7	22	7	23	8	23	8	24	8	24	8
②	Namanve	3333	19	6	22	7	25	8	8	3	3	1	3	1	5	2	6	2	8	3	9	3	12	4	13	4	14	5	17	6	19	6	21	7
③	Namanve Sounth	3427							8	3	9	3	9	3	10	3	11	4	12	4	13	4	14	5	16	5	18	6	20	7	22	7	25	8
④	Luzira	3428							4	1	5	2	5	2	6	2	7	2	8	3	9	3	10	3	11	4	12	4	13	4	14	5	15	5
⑤	Mukono	3426							8	3	9	3	9	3	10	3	11	4	12	4	13	4	14	5	16	5	18	6	20	7	22	7	25	8
⑥	Entebbe	3312									5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2	5	2
2.Western area			**43**	**14**	**46**	**15**	**50**	**15**	**53**	**17**	**56**	**18**	**56**	**18**	**60**	**20**	**64**	**21**	**69**	**23**	**73**	**24**	**78**	**26**	**84**	**28**	**89**	**29**	**95**	**31**	**102**	**34**	**108**	**35**
①	Masaka	3387	13	4	14	5	14	5	13	4	11	4	11	4	9	3	10	3	10	3	11	4	10	3	12	4	12	4	15	5	18	6	21	7
②	Nkonge	3351	4	1	4	1	5	2	4	1	4	1	4	1	5	2	5	2	5	2	5	2	5	2	6	2	6	2	6	2	6	2	6	2
③	Nkenda	3389	13	4	14	5	15	5	15	5	15	5	15	5	16	5	16	5	17	6	17	6	18	6	18	6	19	6	19	6	20	7	20	7
④	Mbarara	1301	13	4	14	5	13	4	12	4	11	4	11	4	13	4	14	5	15	5	16	5	17	6	18	6	19	6	20	7	21	7	22	7
⑤	Fort Portal	3313							3	1	4	1	4	1	5	2	6	2	7	2	8	3	9	3	10	3	11	4	12	4	13	4	14	5
⑥	Hoima	3314							3	1	4	1	4	1	5	2	6	2	7	2	8	3	9	3	10	3	11	4	12	4	13	4	14	5
⑦	Kiboga	3409									2	1	2	1	2	1	2	1	2	1	2	1	3	1	3	1	3	1	3	1	3	1	3	1
⑧	Mirama	3414					3		3	1	3	1	3	1	3	1	3	1	4	1	4	1	4	1	4	1	5	2	5	2	5	2	5	2
⑨	Kabale	3317									2	1	2	1	2	1	2	1	2	1	2	1	3	1	3	1	3	1	3	1	3	1	3	1
3.Eastern area			**63**	**21**	**67**	**22**	**72**	**21**	**76**	**25**	**82**	**27**	**82**	**27**	**87**	**29**	**93**	**31**	**99**	**33**	**106**	**35**	**113**	**37**	**121**	**40**	**129**	**42**	**137**	**45**	**147**	**48**	**157**	**52**
①	Nalubaale	3357	35	12	39	13	34	11	28	9	23	8	23	8	23	8	24	8	25	8	26	9	28	9	30	10	32	11	34	11	38	12	42	14
②	Lugazi	3156	8	3	8	3	9	3	9	3	15	5	15	5	16	5	17	6	18	6	19	6	20	7	21	7	22	7	23	8	24	8	25	8
③	Tororo	3362	20	7	20	7	21	7	21	7	25	8	25	8	28	9	31	10	34	11	37	12	40	13	43	14	46	15	49	16	52	17	55	18
④	Iganga	3429							10	3	10	3	10	3	11	4	11	4	12	4	12	4	13	4	14	5	15	5	16	5	17	6	18	6
⑤	Mbale	3399					8		8	3	9	3	9	3	9	3	10	3	10	3	12	4	12	4	13	4	14	5	15	5	16	5	17	6
4.Northern area			**24**	**8**	**26**	**9**	**28**	**9**	**29**	**10**	**31**	**10**	**31**	**10**	**33**	**11**	**36**	**12**	**38**	**12**	**41**	**13**	**43**	**14**	**46**	**15**	**50**	**16**	**53**	**17**	**56**	**18**	**60**	**20**
①	Opuyo	3361	7	2	8	3	9	3	9	3	9	3	9	3	8	3	9	3	9	3	8	3	10	3	11	4	11	4	12	4	12	4	12	4
②	Lira	3364	17	6	18	6	19	6	20	7	16	5	16	5	10	3	12	4	14	5	14	5	14	5	16	5	16	5	18	6	20	7	20	7
③	Moroto	3365									6	2	6	2	6	2	6	2	6	2	7	2	7	2	7	2	8	3	8	3	9	3	10	3
④	Gulu	3394													5	2	5	2	5	2	6	2	6	2	6	2	7	2	7	2	7	2	8	3
⑤	Olwiyo	3366													2	1	2	1	2	1	3	1	3	1	3	1	4	1	4	1	4	1	5	2
⑥	Arua	3396													2	1	2	1	2	1	3	1	3	1	3	1	4	1	4	1	4	1	5	2
5.Regional interconnection			**12**	**4**	**13**	**4**	**50**	**16**	**60**	**20**	**70**	**23**	**70**	**23**	**150**	**49**	**230**	**76**	**260**	**85**	**280**	**92**	**300**	**99**	**320**	**105**	**340**	**112**	**340**	**112**	**315**	**104**	**315**	**104**
①	Kenya (Lessos)	2199					20	7	20	7	30	10	30	10	50	16	100	33	100	33	100	33	100	33	100	33	100	33	100	33	100	33	100	33
②	Tanzania (MTKU)	6199	12	4	13	4	20	7	20	7	20	7	20	7	50	16	50	16	70	23	80	26	100	33	120	39	120	39	120	39	120	39	120	39
③	Rwanda	3293					10	3	20	7	20	7	20	7	50	16	50	16	50	16	50	16	50	16	50	16	50	16	50	16	25	8	25	8
④	Kongo (Mpondwe)	3290					0	0	0	0	0	0	0	0	30	10	30	10	40	13	40	13	50	16	50	16	50	16	50	16	50	16	50	16
⑤	South Sudan (Nimule)	3486															0	0	20	7	20	7	20	7	20	7	20	7	20	7	20	7	20	7
Total demand			**495**	**162**	**529**	**174**	**601**	**194**	**648**	**213**	**697**	**229**	**697**	**229**	**820**	**270**	**945**	**311**	**1023**	**336**	**1094**	**360**	**1169**	**384**	**1248**	**410**	**1331**	**437**	**1398**	**460**	**1444**	**475**	**1520**	**500**

PL: Active power load[MW]
QL: Reactive power load[Mvar]

Supply-Demand Balance of Uganda

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Kiira－Nalubaale	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Bujagali	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Karuma						200	300	400	400	450	500	600	600	600	600
Ishinba					50	150	150	150	150	150	180	180	180	180	180
Ayago								100	100	100	100	300	300	500	500
KarumaB															
Oriang															
Murchison															
Achwa					40	80	80	80	80	80	80	80	80	80	80
Large hydro total	450	450	450	450	540	880	980	1180	1180	1230	1310	1610	1610	1810	1810
Mini hydro total	39	39	56	80	131	133	133	133	133	133	133	133	133	134	134
Hydro total	489	489	506	530	671	1013	1113	1313	1313	1363	1443	1743	1743	1944	1944
Thermal total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Others	24	37	37	37	37	37	37	37	37	37	37	37	37	37	37
Total generation capacity	513	526	543	567	708	1050	1150	1350	1350	1400	1480	1780	1780	1981	1981
Domestic demand	483	516	551	588	627	670	715	763	814	869	928	991	1058	1129	1205
Reserve margin	48	52	55	59	63	67	72	76	81	87	93	99	106	113	121
Domestic demand	531	568	606	647	690	737	787	839	895	956	1021	1090	1164	1242	1326
Kenya			20	20	30	50	100	100	100	100	100	100	100	100	100
Tanzania	12	13	20	20	20	20	50	50	70	80	100	120	120	120	120
Rwanda			10	20	20	50	50	50	50	50	50	50	50	25	25
Kongo			0	0	0	30	30	40	40	50	50	50	50	50	50
South Sudan						0	0	20	20	20	20	20	20	20	20
Total exports	12	13	50	60	70	150	230	260	280	300	320	340	340	315	315
Total demand	543	581	656	707	760	887	1017	1099	1175	1256	1341	1430	1504	1557	1641
Power Excess/Deficit (Domestic)	-18	-41	-64	-80	18	313	363	511	454	444	459	690	616	739	655
Power Excess/Deficit (Domestic+Export)	-30	-54	-114	-140	-52	163	133	251	174	144	139	350	276	424	340
Dependancy on large hydro total	88%	85%	83%	79%	76%	84%	85%	87%	87%	88%	89%	90%	90%	91%	91%
Domestic-Export Ratio	2%	2%	8%	9%	10%	20%	29%	31%	31%	31%	31%	31%	29%	25%	24%
	6.7%														
		516	551	588	628	669	715	763	814	869	928	991	1058	1129	1205

Power Generation Facility Plan

		Rated capacity MVA	Rated output MW	2013			2014			2015			2016			2017			2018			2019			2020			2021			2022			2023			2024			2025			2026			2027		
				Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW	Output MW	Unit	Total output MW
	Kiira－Nalubaale		380.0	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95	11.88	8	95
				35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105	35	3	105
	Bujagali		250.0	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250	50	5	250
	Karuma		600.0																100	2	200	100	3	300	100	4	400	100	4	400	100	4.5	450	100	5	500	100	6	600	100	6	600	100	6	600	100	6	600
	Ishimba		200.0													50	1	50	50	3	150	50	3	150	50	3	150	50	3	150	50	3	150			180			180			180			180			180
	Ayago		600.0																						100	1	100	100	1	100	100	1	100	100	1	100	100	3	300	100	3	300	125	4	500	125	4	500
	KarumaB		250.0																																												
	Orianiz		400.0																																												
	Murchison		600.0																																												
	Achwa		80.0													40	1	40	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80	40	2	80
Large hydro total:						450			450			450			450			540			880			980			1180			1180			1230			1310			1610			1610			1810			1810
	KML	2.8	2.5	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0	1.5	2	3.0
	KCCL	3.6	3.2	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0	0.0	3	0.0
	Maziba	1.0	1.0																																												
	ISHSHA	3.6	3.2	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0
	Nyagak 3	4.0	3.6							2.1	0	0.0	2.1	0	0.0	2.1	0	0.0	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1	2.1	1	2.1
	Kikagati	17.9	16.0							11.0	0	0.0	11.0	0	0.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0	11.0	1	11.0
	BUGY0	14.8	13.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0	9.0	1	9.0
	Waaki	5.6	5.0							2.0	0	0.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0	2.0	1	2.0
	MUZZ	30.2	27.0							16.0	0	0.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0	16.0	1	16.0
	MPANGA	6.7	6.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0	4.0	3	12.0
	Kyambura	9.3	8.3	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	7.0	1	7.0	8.0	1	8.0
	Buseruka(HMAX)	10.1	9.0	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4	5.4	1	5.4
	Nyamambwa	15.7	14.0							8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4	8.4	1	8.4
	Muyembe	11.2	10.0							6.0	0	0.0	6.0	0	0.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0	6.0	1	6.0
	Siti1	5.6	5.0							4.0	0	0.0	4.0	0	0.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0	4.0	1	4.0
	Siti 2	18.4	16.5							8.9	0	0.0	8.9	0	0.0	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9	8.9	1	8.9
	Lubilia	6.0	5.5							3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2	3.2	1	3.2
	Rwimi	6.2	5.5							3.3	0	0.0	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3	3.3	1	3.3
	NENGO Bridge	11.2	10.0							4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5	4.5	1	4.5
	Nsongezi	39.0	35.0													21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0	21.0	1	21.0
	KAKA	8.0	7.2							3.0	0	0.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0	3.0	1	3.0
Mini hydro total:						39.4			39.4			55.5			79.8			130.7			132.8			132.8			132.8			132.8			132.8			132.8			132.8			132.8			133.8			133.8
Hydro total:						489.4			489.4			505.5			529.8			670.7			1012.8			1112.8			1312.8			1312.8			1362.8			1442.8			1742.8			1742.8			1943.8			1943.8
	Namanve	－	50.0																																												
	Invespro,Nalubaale	－	50.0																																												
	Electromaxx	－	50.0																																											
	Mputa-Kabale(Test crude)	－	57.0																																												
	Mputa-Kabale(Gas&Oil)	－	250.0																																												
	Albatros	－	230.0																																												
	Kabaale Peat	－	33.0																																												
	Sesame	－	33.0																																												
	Geothemal	－	100.0																																												
	Namugoga Solar	－	50.0																																												
Thermal total:						0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0			0.0
	Kinyara Sugar Works	－	5.0	1.5	1	1.5	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0	5.0	1	5.0
	Kakira Sugar Works	－	40.0	22.0	1	22.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0	32.0	1	32.0
	SCOUL,Lugazi	－	6.0																																												
Cogeneration total:						23.5			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0			37.0
Generation capacity total						512.9			526.4			542.5			566.8			707.7			1049.8			1149.8			1349.8			1349.8			1399.8			1479.8			1779.8			1779.8			1980.8			1980.8

Transmissin facility plan

No.	Transmission line	kV	cct	Condition	2013	2014	2015	2016	2017 (Before)	2017 (After)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
2013Year Existing transmission facility	Kabulasoke-MasakaWest	132	1	Existing	●															
	Kabulasoke-Nkonge	132	1	Existing	●															
	Lugogo-Kampala North	132	2	Existing	●															
	Lugogo-Mutundwe	132	2	Existing	●															
	MasakaWest-MTKU(Tanzania)	132	1	Existing	●															
	MasakaWest-Mbarara North	132	1	Existing	●															
	Nkonge-(Kafungye)-Nkenda	132	1	Existing	●															
	Nalubaale-(T-MUKONO)-(T-NMVE STH)-Namanve	132	1	Existing	●															
	Namanve-Kampala North	132	1	Existing	●															
	Nalubaale-Lugazi	66	1	Existing	●															
	Nalubaale-Lugogo	132	2	Existing	●															
	Opuyo-Lira	132	1	Existing	●															
	Tororo-Lessos(Kenya)	132	2	Existing	●															
	Tororo-Opuyo	132	1	Existing	●															
	Bujagali-Tororo	132	2	Existing	●			Middle (Iganga Construction)												
	Bujagali-Kawanda	132	2	Existing→Upgrading	●(132kV)		●(220kV)													
	Nalubaale-Bujagali	132	2	Existing	●															
	Mutundwe-Kawanda	132	2	Existing	●															
	Kampala North-(Kawaala)-Mutundwe	132	2	Existing	●															
	Mutundwe-Kabulasoke	132	1	Existing→Upgrading	●	●														
Metropolitan area, Outbound of metropolitan area					2013	2014	2015	2016	2017 (Before)	2017 (After)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	NamanveSounth-Luzira	132	1	Construction				●												
	Mukono(Nalubaale-Namanve)T-off	132	1	Construction				●												
	Namanve-NamanveSounth	132	1	Construction				●												
	Nalubaale-Bujagali	132	2	Upgrading					●											
	Owen falls(Nalubaale)-Namanve-Kampala North	132	1	Upgrading					●											
	Bujagali-Ishinba	132	2	Construction					●											
	Nalubaale-Lugazi	132	2	Construction					●											
	Mutundwe-Entebbe	132	2	Construction					●											
	Kawanda-Bombo	132	2	Construction							●									
	Kampala North-Mutundwe	132	1	Upgrading							●									
Metropolitan area ⇔Western area					2013	2014	2015	2016	2017 (Before)	2017 (After)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Kawanda-Masaka	220	2	Construction					●											
	Mutundwe-Kabulasoke-Nkenda	220	2	Construction									●							
Metropolitan area ⇔Northern area					2013	2014	2015	2016	2017 (Before)	2017 (After)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Karuma-Kawanda	400	2	Construction							●									
Western area					2013	2014	2015	2016	2017 (Before)	2017 (After)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Nkenda-Fort Portal-Kabale-Hoima	220	2	Construction				●												
	Mbarara-Nkenda	132	2	Construction					●											
	Mirama-Kabale	132	2	Construction					●											
	Kabulasoke-Kiganda-Kiboga	132	1	Construction					●											
	Mirama-Kikagati-Nsongezi	132	2	Construction					●											
	Masaka-Mbarara	220	2	Construction							●									
	Mbarara-Nkenda	220	2	2027																●
Eastern area					2013	2014	2015	2016	2017 (Before)	2017 (After)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Iganga(Bujagali-Tororo)	132	2	Construction				●												
	Opuyo-Moroto	132	2	Construction					●											
	Mbale-Buranburi	132	2	Construction					●											
Northern area					2013	2014	2015	2016	2017 (Before)	2017 (After)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Hoima-Kafu	220	2	Construction					●											
	Gulu-Achwa(Agago)	132	1	Construction					●											
	Karuma-Lira	132	2	Construction					●											
	Lira-Gulu	132	1	Construction					●											
	Gulu-Kitugum	132	2	Construction							●									
	Gulu-Olwiyo-Nebi-Arua	132	2	Construction							●									
	Karuma-Olwiyo	400	2	Construction									●							
	Ayago-Olwiyo	400	2	Construction									●							
Northern area⇔ Eastern area					2013	2014	2015	2016	2017 (Before)	2017 (After)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Tororo-Mbale-Opuyo-Lira	132	2	Construction			●													
	Karuma-Tororo	400	2	Construction										●						
Regional interconnection					2013	2014	2015	2016	2017 (Before)	2017 (After)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
	Bujagali-Tororo-Lessos(Kenya)	220	2	Construction			●													
	Mbarara-Mirama-Birenbo(Rwanda)	220	2	Construction			●													
	Nkenda-Mpondwe(Kongo)	220	2	Construction							●									
	Masaka-Mwanza(Tanzania)	220	2	Construction							●									
	Olwiyo-Nimule(SounthSouth Sudan)	400	2	Construction									●							

Substation facility plan

		Voltage	Existing	2013		2014		2015		2016		2017 (Before)		2017 (After)		2018		2019		2020		2021		2022		2023		2014		2025		2026		2027	
1.Central area(1)Metropolitan																																	
	Lugogo	132/11	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	Abolition											
		132/11	Upgrading																			2	120	2	120	2	120	2	120	2	120	2	120	2	120
		132/33	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	Abolition											
		132/33	Upgrading																			2	120	2	120	2	120	2	120	2	120	2	120	2	120
	Kampala North	132/11	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		132/33	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		132/33	Upgrading																											1	40	1	40	1	40
	Mutundwe	132/11	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	Abolition																	
		132/11	Upgrading															2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
		132/33	●	2	80	2	80	2	80	2	80	2	80	2	80	2	80	Abolition																	
		132/33	Upgrading															2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
		220/132	Construction																	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250
	Kawaala	132/11	●	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	Abolition									
		132/11	Upgrading							1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	Abolition									
		132/11	Upgrading																							2	80	2	80	2	80	2	80	2	80
	Queensway	132/33	Upgrading											3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120
1.Central area(2)Outbound of																																	
	Kawanda	132/33	●	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40
		132/33	Upgrading							1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40
		220/132	Construction					2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500
		400/220	Construction													2	1200	2	1200	2	1200	2	1200	2	1200	2	1200	2	1200	2	1200	2	1200	2	1200
	Namanve	132/33	●	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120	3	120
	NamanveSounth	132/33	Construction							3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180
	Luzira	132/33	Construction							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	Mukono	132/33	Construction							3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180	3	180
	Entebbe	132/33	Construction									2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140	2	140
	Bombo	132/33	Construction													2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
2.Western area																																	
	MasakaWest	132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		220/132	Construction									2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250
	Nkonge	132/33	●	1	7.5	1	7.5	1	7.5	1	7.5	Abolition																							
		132/33	Upgrading									1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
	Nkenda	132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		132/33	Upgrading									1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
		220/132	Construction							2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
	Mbarara North	132/33	●	1	20	1	20	1	20	1	20	Abolition																							
		132/33	●	1	15	1	15	1	15	1	15	Abolition																							
		132/33	Upgrading									2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		220/132/33	Construction					1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60
	Fort Portal	132/33	Construction							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		220/132	Construction							2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
	Hoima	132/33	Construction							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
		220/132	Construction							2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
	Kiboga	132/22	Construction									2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	Mirama	220/132/33	Construction					1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60	1	60
	Kabale	132/33	Construction									2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	Kafungye	132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	Kabulasoke	220/132	Construction																	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250
	Kinyara	220/132	Construction									1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45	1	45
	Kabale	220/33	Construction							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
3.Eastern area																																	
	Nalubaale	66/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	Lugazi	66/11	●	2	28	2	28	2	28	2	28	Abolition																							
		132/11	Construction									2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	Tororo	132/33	●	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
		132/33	●	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40
		132/33	Upgrading									1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40	1	40
		220/132	Construction					2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300	2	300
		400/220	Construction																			2	400	2	400	2	400	2	400	2	400	2	400	2	400
	Iganga	132/33	Construction							2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	Mbale	132/33	Construction					2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	Bujagali	220/132/33	Construction					2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500
4.Northern area																																	
	Opuyo	132/33	●	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10	1	10
		132/33	Upgrading					1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
	Lira	132/33	●	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		132/33	Upgrading									1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
	Moroto	132/33	Construction									2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80	2	80
	Gulu	132/33	Construction									2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	Olwiyo	132/33	Construction													2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
		400/132	Construction																	2	250	2	250	2	250	2	250	2	250	2	250	2	250	2	250
	Arua	132/33	Construction													1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20	1	20
	Karuma	400/132	Construction													1	273	1	273	1	273	1	273	1	273	1	273	1	273	1	273	1	273	1	273
	Nebbi	132/33	Construction													2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40	2	40
	Kafu	220/132	Construction									2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120	2	120
		400/220	Construction													2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500	2	500

Switch Shunt

	Area	Voltage [kV]	Unit	Capacity [Mvar]	2013 Input [Mvar]	2014 Input [Mvar]	2015 Input [Mvar]	2016 Input [Mvar]	2017B Input [Mvar]	2017A Input [Mvar]	2018 Input [Mvar]	2019 Input [Mvar]	2020 Input [Mvar]	2021 Input [Mvar]	2022 Input [Mvar]	2023 Input [Mvar]	2024 Input [Mvar]	2025 Input [Mvar]	2026 Input [Mvar]	2027 Input [Mvar]
1.Central area (1)Metropolitan area	Lugogo	33	1	10			10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Kampala North	33	1	10					10	10	10	10	10	10	10	10	10	10	10	10
	Mutundwe	33	1	10																
	Kampala North	132	5	40												40	120	160	200	200
	Lugogo	132	1	40																40
1.Central area (2)Outbound of metropolitan area	Namanve	33	3	16		48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
	NamanveSounth	33	3	10				30	30	30	30	30	30	30	30	30	30	30	30	30
	Luzira	33	3	10																
	Mukono	33	3	15																
	Entebbe	33	1	20																
	Namanve	132	1	40																
	Entebbe	132	2	10																
	Kawanda	400	2	−35							−70	−70	−70	−70	−70	−70	−70	−70	−70	−70
2.Western area	MasakaWest	33	1	10	10	10	10	10												
	Nkenda	33	1	10	0	10	10	10												
	Nkenda	132	2	20																
	Mbarara	33	3	4	4	4	4	4												
	New Mbarara	33	2	−10					−10	−10	−10	−10	−10	−10	−10	−10	−10	−10	−10	−10
	Mirama	33	1	−10					−10	−10	−10	−10	−10	−10	−10	−10	−10	−10	−10	−10
3.Eastern area	Nalubaale	33	2	10																
	Lugazi	132	3	10																
	Tororo	33	4	−10																
	Tororo	132	1	20																
	Iganga	33	2	10																
4.Northern area	Opuyo	33	1	−10							−10	−10	−10	−10	−10	−10	−10	−10	−10	−10
	Lira	33	1	−10							−10	−10	−10	−10	−10	−10	−10	−10	−10	−10
5.Regional interconnection	Lessos	132	3	20																
	Tanzania (MTKU)	132	1	10								10	10	10	10	10	10	10	10	10

APPENDIX 8

TOPOGRAPHIC SURVEY REPORT

QUEENSWAY SUBSTATION IMPROVEMENT: TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

A-8-1

VOLUME I: TOPOGRAPHIC SURVEY REPORT

MAY 2014

Prepared by Consultant : NEWPLAN Limited

For : Yachiyo Engineering Company Ltd

Prepared:	AA
Checked:	RK
Approved:	EK

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Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume I: Topographic Survey Report

1. INTRODUCTION

1.1 General

The surveys are required to facilitate the design of the various components of the expansion and upgrading of Queensway substation. The resultant data and maps can also be used for preparation of the Resettlement Action Plan (RAP) for the project.

1.2 Location and access to the site

The project is located along Queensway on Entebbe road, in the Central Business District of Kampala. The project site is located adjacent to the existing Queensway substation, opposite USAFI market in the Pan-African Freedom square as shown in the image below.

1.3 Project Description, Duration, Staffing and Equipment

The Consultant subcontracted NEWPLAN to carry out a topographic survey of the site covering the existing substation site, the proposed extension site, T-off tower sites, and the cable alignment for the proposed connection into the Substation.

The main product of the survey would be a topographic map covering the entire area to facilitate the design of the Substation. The survey has to be supported by a set of control points, well measured to enable the topographic survey to be as accurate as possible. The control points will also be used for setting out the scheme during construction.

Part of NEWPLAN's survey team together with the representatives of Yachiyo Engineering Company Ltd carried out a reconnaissance site visit on 22nd April 2014, to get a clear understanding of the client's requirements for the survey.

In general, fieldwork for the topographic survey was carried out in the first two days after the reconnaissance visit. On 5th May 2014, a final site visit was carried out to measure the elevations of the six cables on the Transmission line at the point where the T-off connection to the substation will be made.

The survey team comprised of: two Field Surveyors, each with two Chainmen.

The Equipment used included; GPS (CHC X90), and a Leica TCR 700 Series Total station, and their accessories.

The computations and drawings were processed using a computer and relevant software.

2. TOPOGRAPHIC SURVEYS

2.1 General

A reconnaissance site visit was carried out with the client for the purpose of understanding the site requirements for the survey and enable making decisions on a way to approach the exercise.

During the entire exercise, the consultant carried out the following activities:

1. Extended control to the site in order to be able to carry out the topographic survey.
2. Measured coordinate (XYZ) details of feature points for preparation of a topographic map for the site.

2.2 Extension of Control

National grid control had to be extended from known point(s) 71Y125, an RTS close to the site at the Mukwano Round about. Details of this control point are as follows.

Point	Descr.	East	North	Height
71Y125	RTS	454808.454	35074.665	1150.081

(RTS: Rigorous Traverse Station)

Connection to the National Grid

The control point RTS 71Y125 is a reliable control point used in the Kampala area and is already connected to the national grid.

The National Grid is based on the following:

Reference Ellipsoid: Clarke 1880 with the following parameters

- Semi-major axis: 6378249.145m
- Inverse flattening: 293.465

Datum: Arc 1960

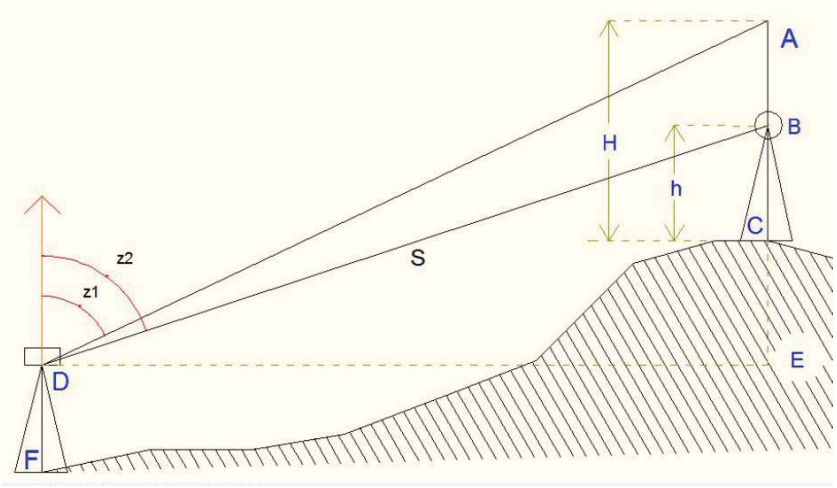
Projection Type: Transverse Mercator Zone: UTM Zone 36N (the project was in the northern hemisphere) Zone parameters: Central Meridian (CM): 33^{o}E Scale factor at CM: 0.9996 Longitude of Grid Origin: 0.0^{o}E Latitude of Grid Origin: 0.0^{o}N False Northing: 0.0m False Easting: 500000.0m Scale Factor: 0.9996 Uses orthometric heights.

2.3 Topographic Detail Points Measurement/ Field Observations

After extension of control to the site, all other topographic detail points were measured; with 'Change Points' made at convenient points in and around the site to enable faster measurement. Point spot heights were measured using Total station and RTK GPS. More details about staffing and equipment for this exercise can be found in section 1.3 above.

2.4 Measurement of Elevations of Transmission Line Wires

The REM method (Wei and Cheng, 2006) was used to find the height above ground of the wires of the transmission at the location of the proposed T-off tower. It is best explained in the figure below.



And the height of the wires above the ground was calculated using the formula;

$$H = S \sin Z_2 \cot Z_1 - S \cos Z_2 + h$$

Where: H is the height of the inaccessible point above the ground

S is the slope distance to a measured target of known height

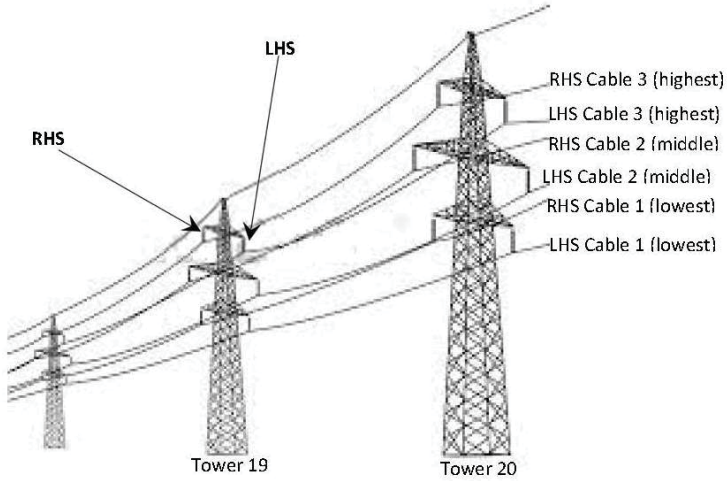
h is the height of the target

Z_1 is the vertical angle to the inaccessible point

Z_2 is the vertical angle to the measured target of known height

The measured target of known height above the ground has to be placed directly below the inaccessible point (electric wire) in the plumb position.

The above parameters were measured and recorded for all the six wires on either side of the towers 19 and 20, with the LHS (Left hand side) and RHS (Right hand side) defined moving from Tower 19 towards Tower 20, as illustrated in the drawing below:



The measurement results are summarized in the table below:

	Cables	Elevation	Height above ground
LHS	Cable1 (Lowest)	1174.264m	13.103m
	Cable2 (Middle)	1178.341m	17.180m
	Cable3 (Highest)	1182.537m	21.376m
RHS	Cable1 (Lowest)	1174.060m	13.557m
	Cable2 (Middle)	1178.031m	17.528m
	Cable3 (Highest)	1182.367m	21.864m

2.5 Computations and Topographic Mapping

Spread sheets were used to reorganise the Total Station measured detail points. These were saved as excel files in comma separated values (csv) format with the following descriptions.

- 're' road edge
- 'hse' for house/structure corner
- 'sh' spot height
- 'fe' fence
- 'tree' tree
- 'drain' drain
- 'c top' for channel top
- 'c bottom' channel bottom
- 'mh' man hole

Etc.

The points were imported into CAD software in which the drawing was processed.

Topographical Maps

The maps were formatted to A1 and A3 paper print size in AutoCAD layouts and in pdf and are submitted as attachments to this report. A softcopy file in AutoCAD format will be submitted as well.

Autodesk Civil 3D 2012 was used to prepare the topographic map drawing with the following details.

Area Covered

2D surface area = 15588.02 sq.m

3D surface area = 16337.82 sq.m

Scale

The scale of the drawing in the model is 1:1000 m

The scale of the drawing on the ready for print layouts is 1:5000 m on A3 paper size.

Contour Intervals

Major Contour Interval (Brown colour) = 2m

Minor Contour Interval (Grey colour) = 0.5m

Grid Interval

The grid interval in the map is 50m

3. CHALLENGES

Some artificial features especially underground ones like electric cables, sewer lines, water pipes were not easy to identify and therefore difficult to accurately measure and show on the map.

On-going construction works on the site made it difficult to measure and show all the existing features on ground as ground conditions were changing on a daily basis.

Sewerage flowing in the drainage channel made the measurements therein very unpleasant.

During the measurement of Transmission wire elevations above the ground, it difficult to get the plumb position of the wires on the ground.

4. RECOMMENDATIONS AND CONCLUSION

The survey was done within acceptable limits of accuracy and connected to the National Grid and therefore sufficient to be used for execution of the project for the design as well as for the Resettlement Action Plan (RAP) surveys.

APPENDIX 1: SELECTED PHOTOGRAPHS OF PROJECT AREA

Drainage Channel

Pan-African Freedom Square

Existing Substation

33kV line to Existing Substation

LHS: Existing Queensway Substation
CENTRE: Sidewalk with drainage channel
RHS: Queensway

FOREGROUND: Queensway
BACKGROUND: Pan-African Freedom Square

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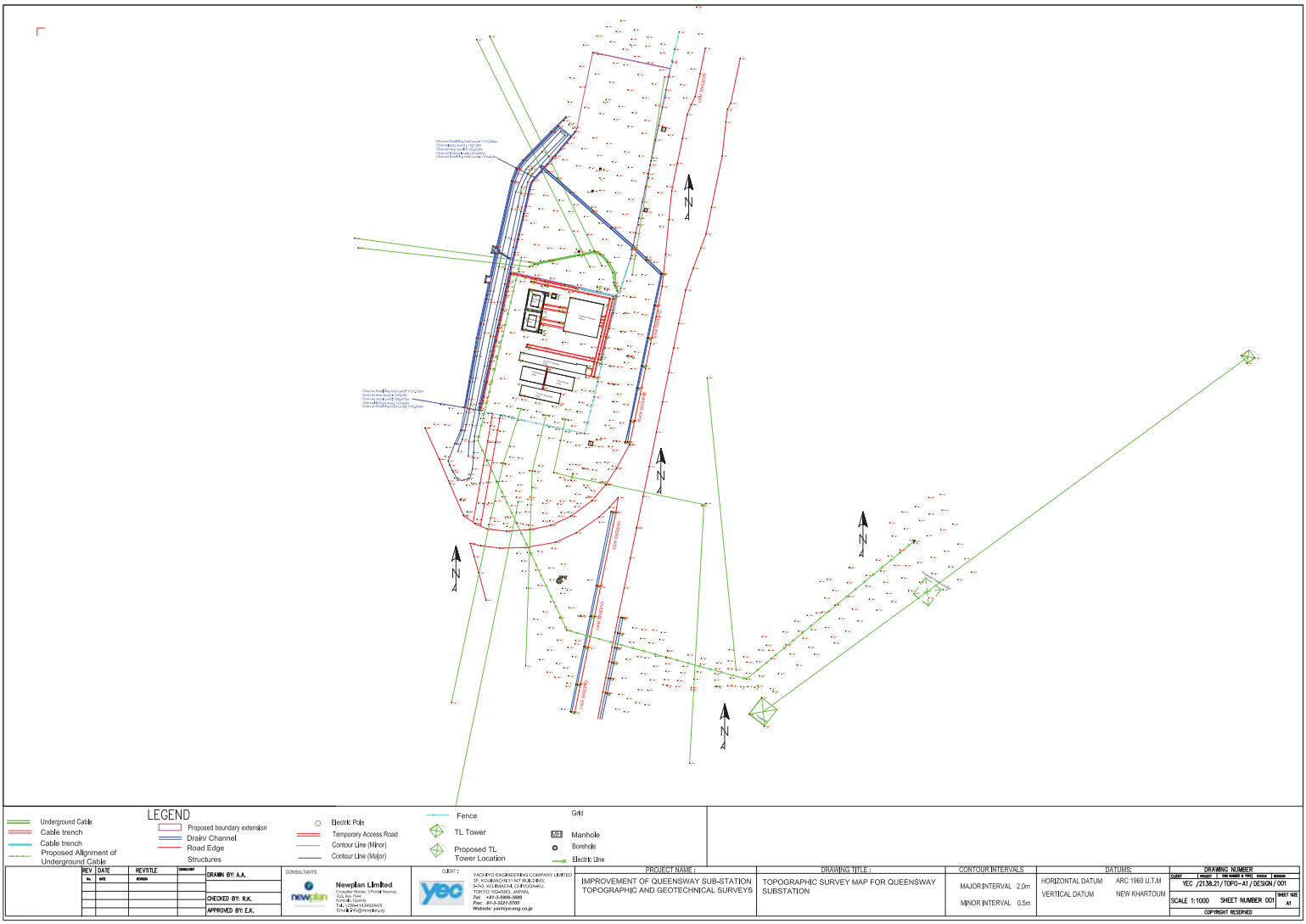
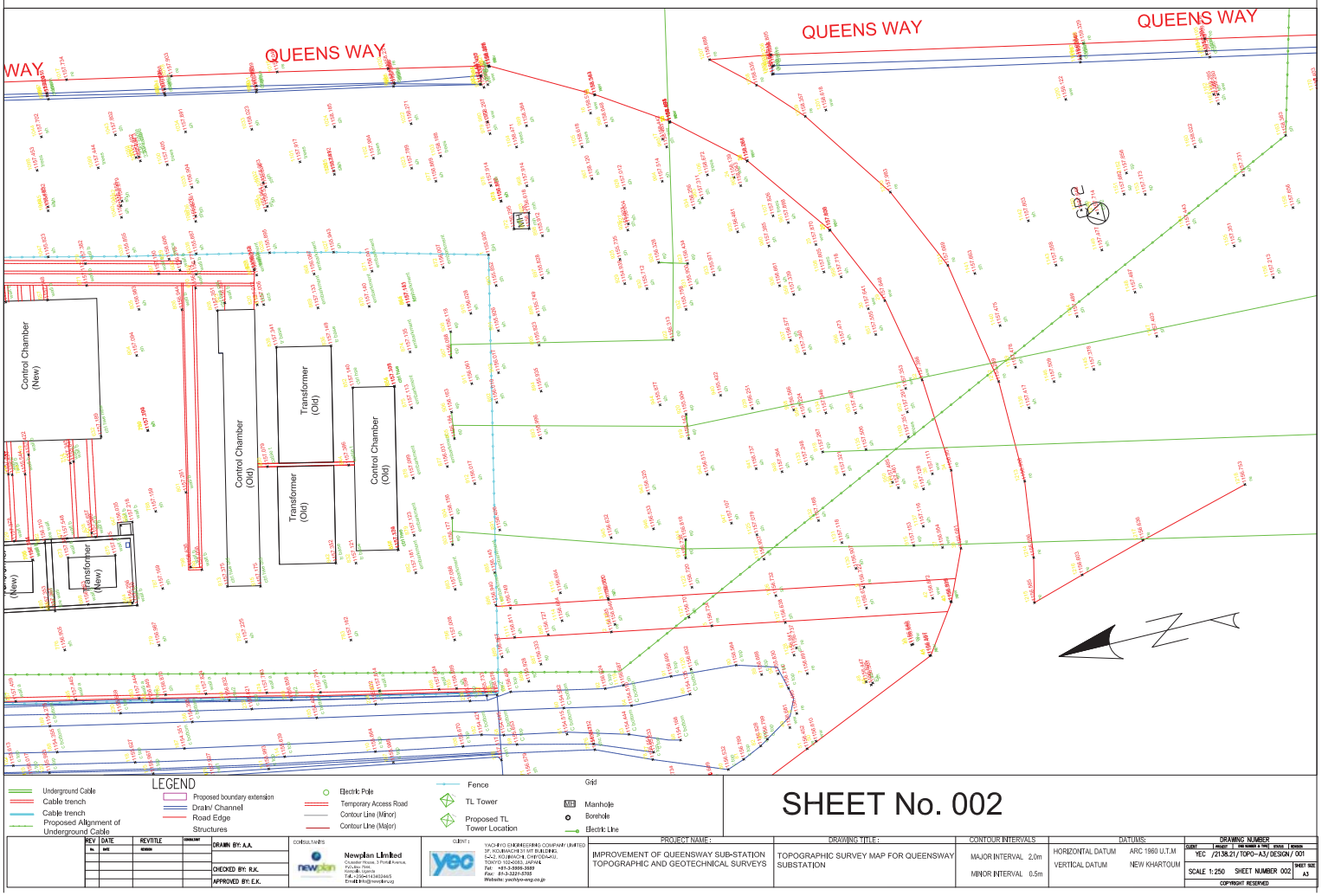
Drainage channel over-grown with weeds at the planned site of the substation extension



APPENDIX 2: TOPOGRAPHIC SURVEY MAP

[See subsequent pages]



LEGEND

Underground Cable
Cable trench
Cable trench
Proposed Alignment of Underground Cable
Proposed boundary extension
Drain/ Channel
Road Edge
Structures
Electric Pole
Temporary Access Road
Contour Line (Minor)
Contour Line (Major)
Fence
TL Tower
Proposed TL Tower Location
Grid
MH Manhole
Borehole
Electric Line

SHEET No. 002

REV	DATE	REVISTILE	CONSULTANT

DRAWN BY: A.A.
CHECKED BY: R.K.
APPROVED BY: E.K.

CONSULTANTS: Newplan Limited, Crusader House, 3 Portal Avenue, P.O.Box 7644, Kampala Uganda, Tel: +256-414-343444/5, E-mail: info@newplan.ug

CLIENT: YACHIYO ENGINEERING COMPANY LIMITED, 5F, KOJIMACHI D1 MT BUILDING, 5-4-2, KOJIMACHI, CHIYODA-KU, TOKYO 102-0083, JAPAN, Tel: +81-3-3556-3585, Fax: +81-3-3221-5765, Website: yachiyo-eng.co.jp

PROJECT NAME: IMPROVEMENT OF QUEENSWAY SUB-STATION TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

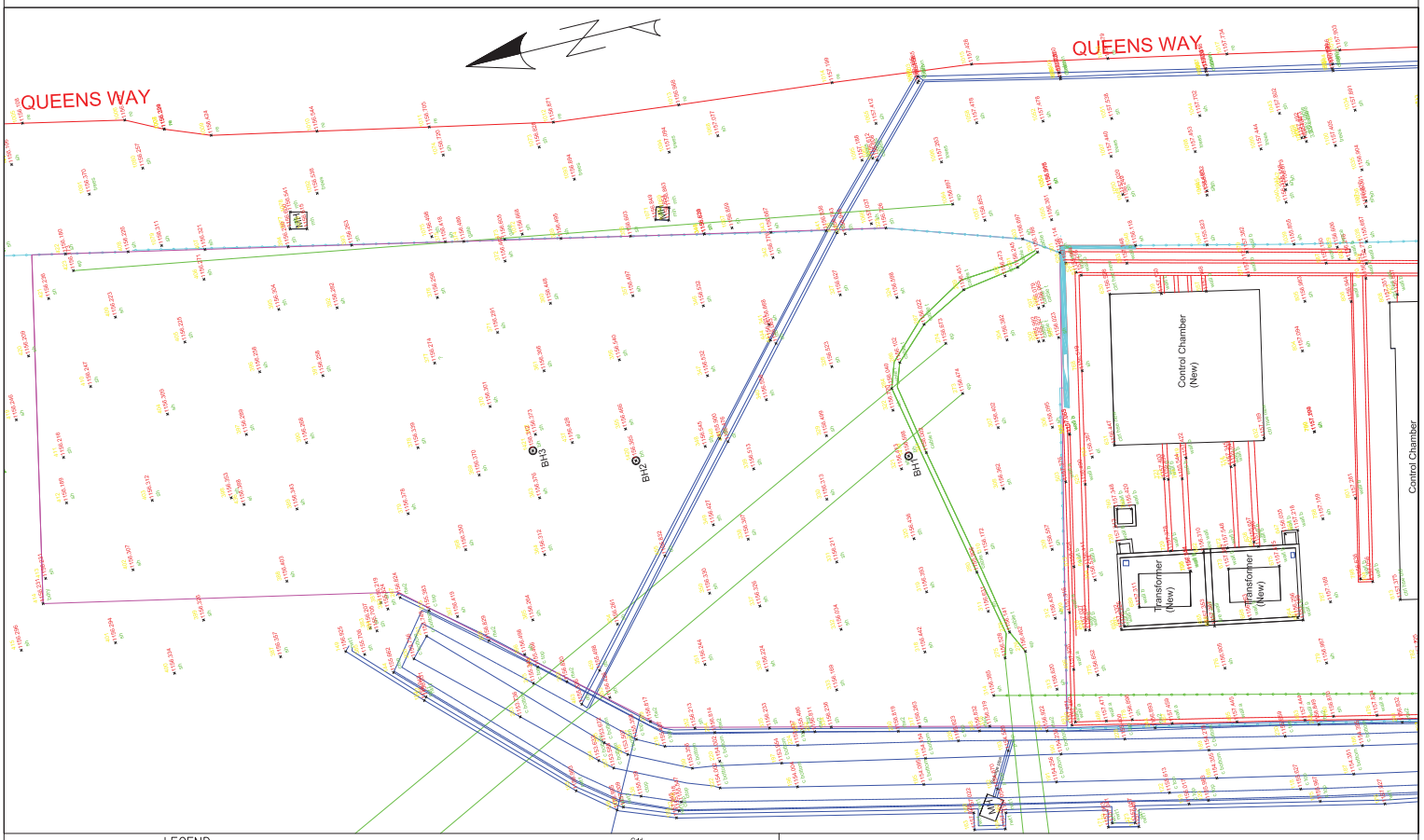
DRAWING TITLE: TOPOGRAPHIC SURVEY MAP FOR QUEENSWAY SUBSTATION

CONTOUR INTERVALS: MAJOR INTERVAL 2.0m; MINOR INTERVAL 0.5m

DATUMS: HORIZONTAL DATUM ARC 1960 U.T.M; VERTICAL DATUM NEW KHARTOUM

DRAWING NUMBER: CLIENT | PROJECT | SUB NUMBER & TYPE | STATUS | REVISION: YEC /2138.21/ TOPO–A3/ DESIGN/ 001

SCALE 1:250 SHEET NUMBER 002 SHEET SIZE A3



LEGEND

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Proposed Alignment of Underground Cable
Proposed boundary extension
Drain/ Channel
Road Edge
Structures
Electric Pole
Temporary Access Road
Contour Line (Minor)
Contour Line (Major)
Fence
TL Tower
Proposed TL Tower Location
Grid
MH Manhole
Borehole
Electric Line

SHEET No. 001

REV	DATE	REVISTILE	CONSULTANT

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PROJECT NAME: IMPROVEMENT OF QUEENSWAY SUB-STATION TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

DRAWING TITLE: TOPOGRAPHIC SURVEY MAP FOR QUEENSWAY SUBSTATION

CONTOUR INTERVALS: MAJOR INTERVAL 2.0m; MINOR INTERVAL 0.5m

DATUMS: HORIZONTAL DATUM ARC 1960 U.T.M; VERTICAL DATUM NEW KHARTOUM

DRAWING NUMBER: CLIENT | PROJECT | SUB NUMBER & TYPE | STATUS | REVISION: YEC /2138.21/ TOPO–A3/ DESIGN/ 001

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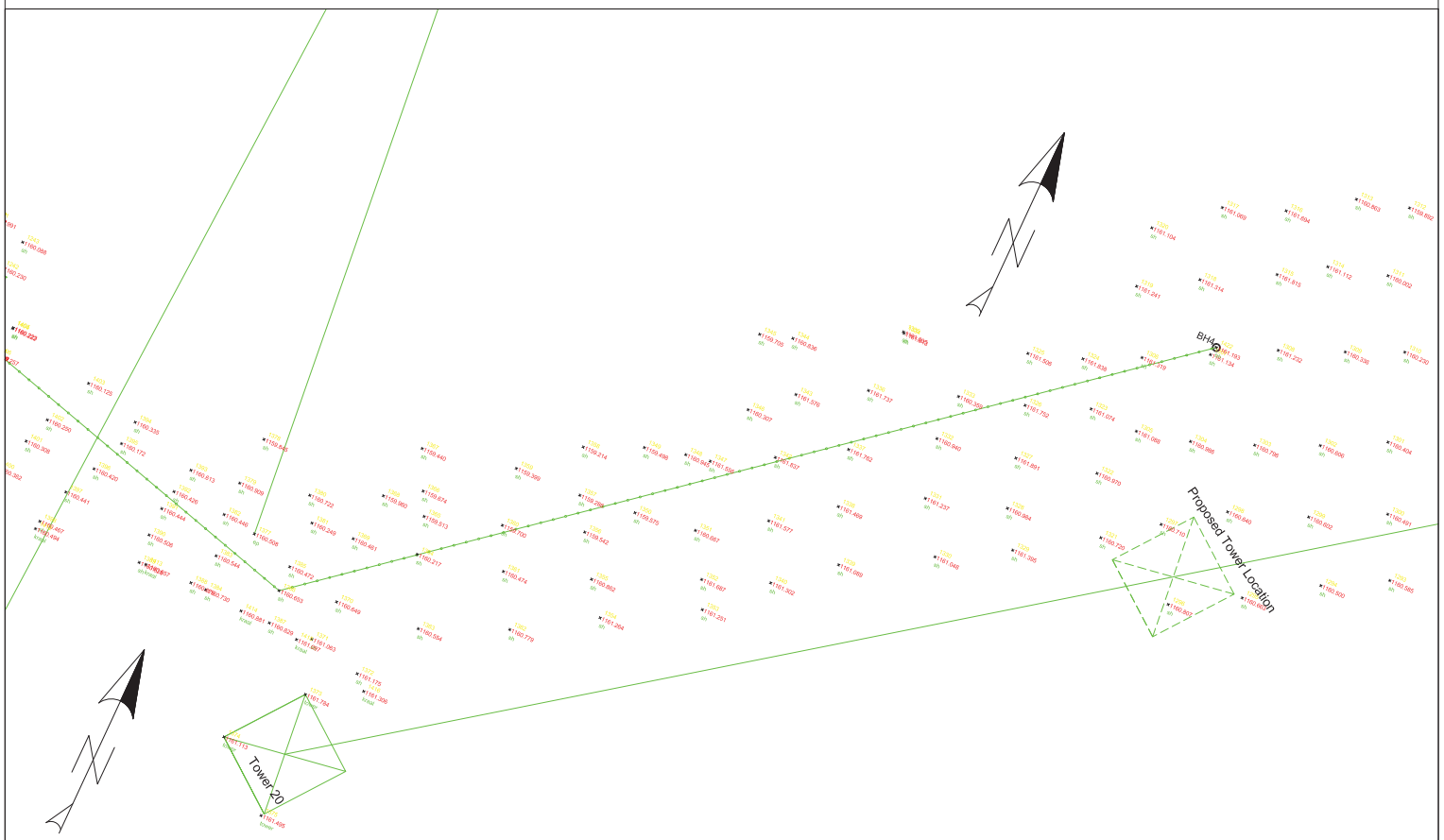

LEGEND

Underground Cable
Cable trench
Cable trench
Proposed Alignment of Underground Cable
Proposed boundary extension
Drain/ Channel
Road Edge
Structures
Electric Pole
Temporary Access Road
Contour Line (Minor)
Contour Line (Major)
Fence
TL Tower
Proposed TL Tower Location
Grid
MH Manhole
Borehole
Electric Line

SHEET No. 004

REV	DATE	REVISTILE	CONSULT
No.	DATE	REMARK	

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PROJECT NAME:
IMPROVEMENT OF QUEENSWAY SUB-STATION TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

DRAWING TITLE:
TOPOGRAPHIC SURVEY MAP FOR QUEENSWAY SUBSTATION

CONTOUR INTERVALS
MAJOR INTERVAL 2.0m
MINOR INTERVAL 0.5m

DATUMS:
HORIZONTAL DATUM ARC 1960 U.T.M
VERTICAL DATUM NEW KHARTOUM

DRAWING NUMBER
CLIENT | PROJECT | SUB NUMBER & TYPE | STATUS | REVISION
YEC /21.38.21/ TOPO–A3/ DESIGN/ 001
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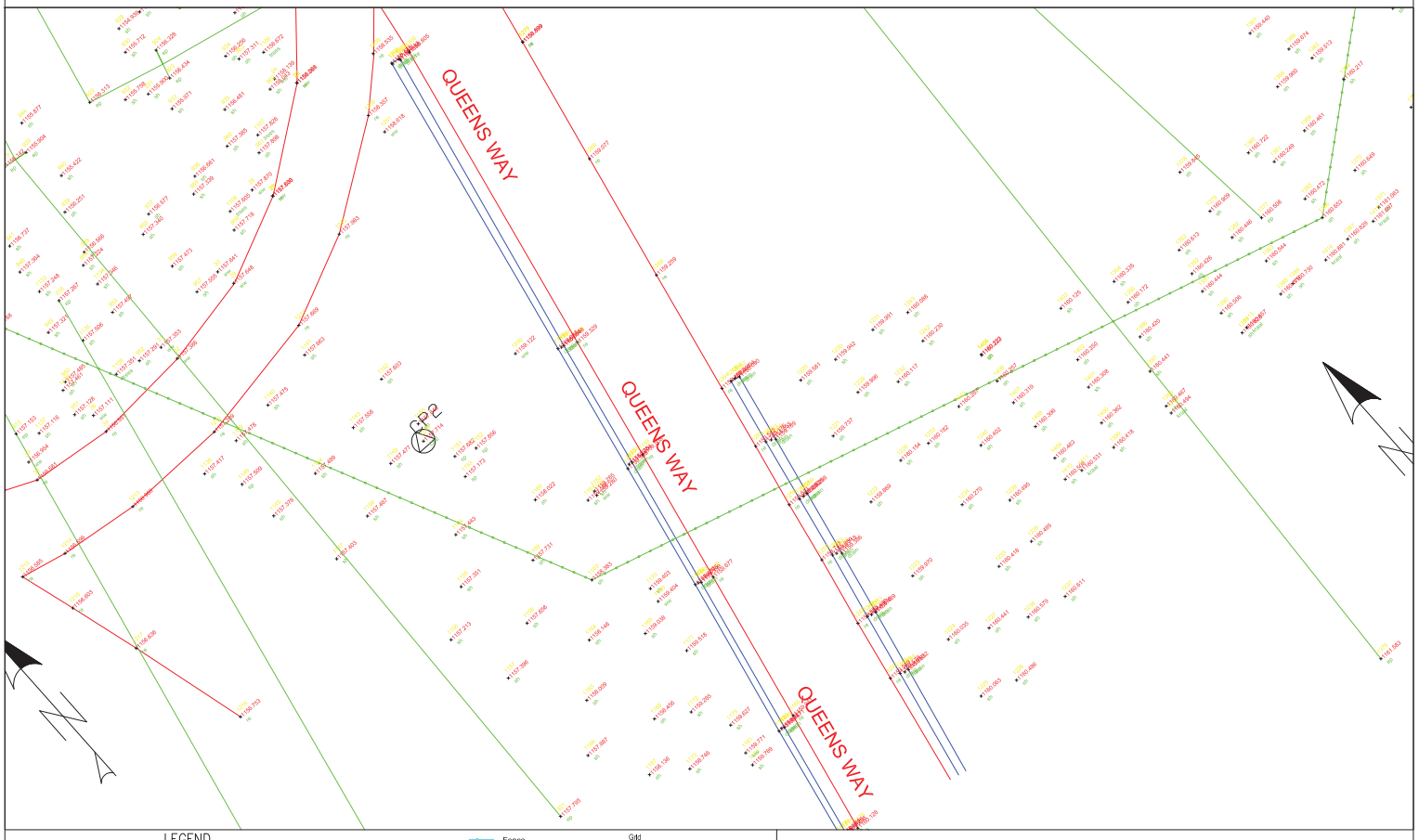

LEGEND

Underground Cable
Cable trench
Cable trench
Proposed Alignment of Underground Cable
Proposed boundary extension
Drain/ Channel
Road Edge
Structures
Electric Pole
Temporary Access Road
Contour Line (Minor)
Contour Line (Major)
Fence
TL Tower
Proposed TL Tower Location
Grid
MH Manhole
Borehole
Electric Line

SHEET No. 003

REV	DATE	REVISTILE	CONSULT
No.	DATE	REMARK	

DRAWN BY: A.A.
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PROJECT NAME:
IMPROVEMENT OF QUEENSWAY SUB-STATION TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

DRAWING TITLE:
TOPOGRAPHIC SURVEY MAP FOR QUEENSWAY SUBSTATION

CONTOUR INTERVALS
MAJOR INTERVAL 2.0m
MINOR INTERVAL 0.5m

DATUMS:
HORIZONTAL DATUM ARC 1960 U.T.M
VERTICAL DATUM NEW KHARTOUM

DRAWING NUMBER
CLIENT | PROJECT | SUB NUMBER & TYPE | STATUS | REVISION
YEC /21.38.21/ TOPO–A3/ DESIGN/ 001
SCALE 1:250 SHEET NUMBER 003 SHEET SIZE A3

APPENDIX 9

GEOTECHNICAL SURVEY REPORT

QUEENSWAY SUBSTATION IMPROVEMENT: TOPOGRAPHIC AND GEOTECHNICAL SURVEYS

VOLUME II: GEOTECHNICAL SURVEY REPORT

MAY 2014

Prepared by Consultant : NEWPLAN Limited

For : Yachiyo Engineering Company Ltd

A-9-1

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Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

LIST OF SYMBOLS

BS	-	British Standard
C	-	Cohesion
CL	-	Sandy lean clay
CL^-	-	Chlorides
D	-	Depth
kN/m^3	-	Kilo Newton per cubic meter
LL	-	Liquid Limit
m	-	Linear meters
mm	-	Millimeters
ML	-	Sandy silt
NMC	-	Natural Moisture Content
NP	-	Non-plastic
PI	-	Plasticity Index
PL	-	Plastic Limit
SM	-	Clayey sand with gravel
SO^{3-}	-	Sulphates
TP	-	Test Pit
U	-	Position of Undisturbed sample
USCS	-	Unified Soil Classification System
Φ	-	Internal angle of friction
%	-	Percentage

1 BACKGROUND

NEWPLAN Limited was contracted by Yachiyo Engineering Company Limited to carry out a geotechnical survey involving soil investigations at the construction site for the planned improvements for the substation and electrical transmission lines area at Queensway substation.

Following drilling, the soil samples were transferred to the Central Materials Laboratory for testing.

2 METHODOLOGY

2.1 Drilling

Drilling was carried out in line with BS 4049-4: 1993 standard using the HGY 200 series drilling machine. In order to ensure maximum sample recovery rotary drilling without water circulation was implemented using the NX casings with a drilling bit, up to such a depth where cores failed to be recovered in the casing. After the failure a triple core tube with a smaller diameter was also used without water circulation to further recover cores as much as possible. Water was then circulated with a standard NXW drilling bit since at this level the ground consisted of cobbles and boulders making highly weathered rock before fresh bedrock.

2.2 SPT tests

SPT tests were done in line with BS 1377-9: 1990. The standard penetration test (SPT) is an in-situ dynamic penetration test designed to provide information on the geotechnical engineering properties of soil. The test uses a thick-walled sample tube, with an outside diameter of 50 mm and an inside diameter of 35 mm, and a length of around 650 mm. This was driven into the ground at the bottom of a borehole by blows from a slide hammer with a weight of 63.5 kg falling through a distance of 760 mm. The blow count (n-value) provides an indication of the density of the ground.

Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

3 FIELD ACTIVITIES

The consultancy implementation activities were to be in line with the terms of reference and are described as follows.

a) Preparation of work implementation schedule

b) No confirmation of location was done since this would have required to dig a pit up to the maximum depth of 20 meters.

c) Transportation, assembling, and disassembling of all the drilling equipment

d) Installation of a ladder and other safety measures during the execution of the works

e) Implementation of miscellaneous work related to penetrating and sampling, field test and laboratory test

f) Execution of field test

g) Sampling and transportation of sampled soil

h) Report on geological aspect based on laboratory tests and field tests

i) Submission of geological samples for inspection

j) Presentation of test results and necessary calculations in report form

k) Backfilling of borehole

Coordinates of for each drilling site were collected using a GPS set to ellipsoid WGS 84

3.1 Borehole BH1

This borehole was drilled at coordinates 36N 452901E, 34116N to 13.1 meter depth. Drilling was stopped in bedrock. The borehole drilling included a 0.7m rock core extraction at the bottom of borehole. Groundwater was intercepted at 0.8 meter depth. The following pictures show the core boxes into which samples were collected.

Figure 3-1: Core box for borehole BH1 box 1 of 3

Figure 3-2: Core box for borehole BH1 box 2 of 3

Figure 3-3: Core box for borehole BH1 box 3 of 3

The log for borehole 1 was prepared as presented in Appendix 6.

SPT tests were done at one meter intervals during drilling of the soil sections. The following table shows the n-number for SPT tests done for BH1.

Table 3-1: N-number for SPT Tests at BH1

Depth (m)	Number of hammers (N-value)
1.0 to 1.5	25
2.0 to 2.5	3
3.0 to 3.5	11 (no sample recovered)
3.5 to 4.0	23
5.0 to 5.5	48
6.5 to 7.0	56
7.5 to 8.0	55
9.0 to 9.5	24
10.0 to 10.5	102
11.5 to 12.0	78
12.5 to 13.0	Refusal

The photograph below shows the SPT cores collected from borehole BH1:

Figure 3-4: SPT cores from BH1

3.2 Borehole BH2

This borehole was drilled at 18.5m north of BH1 coordinates 36N 452906E, 34133N to 9.0 meter depth. Drilling was stopped in bedrock. The borehole drilling included a 0.6m rock core extraction at the bottom of borehole. Groundwater was intercepted at 0.7 meter depth. The following pictures show the core boxes where samples were collected into.

Figure 3-5: Core box for borehole BH2 box 1 of 2

Figure 3-6: Core box for borehole BH2 box 2 of 2

The log for borehole 2 was prepared as presented in Appendix 6.

SPT tests were done at one meter intervals during drilling of the soil sections. The following table shows the n-number for SPT tests done for BH2.

Table 3-2: N-number for SPT Tests at BH2

Depth (m)	Number of hammers (N-value)
1.0 to 1.5	12
2.0 to 2.5	5
3.0 to 3.5	12
4.0 to 4.5	24
5.0 to 5.5	18
6.0 to 6.5	123
7.0 to 7.5	>102
8.0 to 8.5	26

The photograph below shows the SPT cores collected from borehole BH2:

Figure 3-7: SPT cores from BH2

Attempts to collect SPT samples resulted into unsuccessful hammering giving empty core barrels beyond 8.5 meters

3.3 Borehole BH3

This borehole was drilled at coordinates 36N 452905E, 34140N to 10.0 meter depth. Drilling was stopped before encountering fresh bedrock. Groundwater was intercepted at 0.8 meter depth. The following pictures show the core boxes where samples were collected into.

Figure 3-8: Core box for borehole BH3 box 1 of 2

Figure 3-9: Core box for borehole BH3 box 2 of 2

The log for borehole 3 was prepared by the sub consultant as presented in Appendix 6.

SPT tests were done at one meter intervals during drilling of the soil sections. The following table shows the n-number for SPT tests done for BH3.

Table 3-3: N-number for SPT Tests at BH3

Depth (m)	Number of hammers (N-value)
1.0 to 1.5	7
2.0 to 2.5	7
3.0 to 3.5	15
4.0 to 4.5	19
5.0 to 5.5	47
6.0 to 6.5	>100
7.0 to 7.5	48
8.0 to 8.5	42

The photograph below shows the SPT cores collected from borehole BH3

Figure 3-10: SPT cores from BH3

3.4 Borehole BH4

This borehole was drilled at coordinates 36N 452906E, 34133N to 12.0 meter depth. Drilling was stopped before reaching bedrock. Groundwater was intercepted at 5.2 meter depth. The following pictures show the core boxes where samples were collected into.

Figure 3-11: Core box for borehole BH4 box 1 of 3

Figure 3-12: Core box for borehole BH4 box 2 of 3

Figure 3-13: Core box for borehole BH4 box 3 of 3

The log for borehole 4 was prepared by the sub consultant as presented in Appendix 6.

SPT tests were done at one meter intervals during drilling of the soil sections. The following table shows the n-number for SPT tests done for BH4.

Table 3-4: N-number for SPT Tests at BH4

Depth (m)	Number of hammers (N-value)
1.0 to 1.5	52
2.0 to 2.5	15
3.0 to 3.5	25
4.0 to 4.5	29
5.0 to 5.5	42
6.0 to 6.5	33
7.0 to 7.5	56
8.0 to 8.5	27
9.0 to 9.5	29
10.0 to 10.5	25
11.0 to 11.5	45
12.0 to 12.5	44

The photograph below shows the SPT cores collected from borehole BH 4

Figure 3-14: SPT cores from BH4

4 LABORATORY REPORT

4.1 Scope of Work

The scope of work involved conducting tests on disturbed and undisturbed soil samples as in the Table 4-1 below:

Table 4-1: Tests carried out

Test	Standard
Sieve Analysis	BS1377 or equivalent International Standard
Liquid Limits	
Plastic Limits	
Water Natural Content	
Specific Gravity	
Unconfined compression Test	
Triaxial Compression Test (UU) *Test machine was faulty so Shear box test was instead carried out on all samples.* *	
Consolidation Test (One sample was tested)	

* The materials engineer who was assigned to implement the analysis for the project at the lab informed the lead investigator that the test machine for the triaxial compression test was faulty, however, this information was not relayed on time to the consultant as an omission. It was discussed at the time that shear box tests be carried out instead of the triaxial compression test in order to obtain some results on the bearing capacity.

4.2 Laboratory Testing Procedure

Laboratory testing was carried out on disturbed and undisturbed samples to identify the physical properties of the soils and establish parameters for predicting their strength characteristics. The tests were conducted according to the standard methods.

4.2.1 Classification tests

- **Natural Moisture Content**

This test was carried out in accordance with BS 1377: Part 2: 1990. Representative specimens were obtained from the samples and their net weights taken. The specimens were oven dried at temperatures between 105°C and 110°C for 24 hours and their dry weights were taken. The ratio of moisture loss (wet mass – dry mass) to the mass of the dried soil expressed as a percentage was taken as the moisture content of the respective specimen. See results in Appendix 1

- **Sieve Analysis**

The standard method of wet sieving which conforms to BS 1377: Part 2: 1990 was adopted. Representative specimens were taken from the samples and oven dried at temperatures between 105ºC and 110ºC for 24 hours. The dried soils were washed through a 0.075mm BS test sieve in accordance with the test method. The retained fractions were again oven-dried for 24 hours at the same temperature and then sieved through a nest of sieves in a descending order of aperture sizes, using a mechanical shaker. The fractions retained on each sieve were weighed and the proportions of the original sample passing given sieves were determined. See results in Appendix 1

- **Liquid Limit (LL)**

Liquid limit test was carried out using the British Standard (BS) cone penetrometer in accordance with BS 1377: Part 2: 1990. A British Standard (BS) cone penetrometer fitted with an automatic timing device that ensures 5 second penetration under an 80gm load was used. Oven-dried representative samples were pounded and sieved through a 0.425mm BS test sieve. 200gm of each sample passing the 0.425 mm BS test sieve was mixed thoroughly with distilled water and the water allowed to permeate it overnight in an air tight container. Each of the dried soils samples were then remixed the following day with sufficient water to achieve two penetrations in the range between 15mm and 25mm. After each penetration the soils paste moisture content were taken. The results are attached in Appendix 1.

- **Plastic Limit**

Plastic limit test was carried out in accordance with BS 1377: Part 2: 1990. The samples used for the tests were prepared in the same manner as those for the liquid limit tests. The test consisted of rolling a ball of soil paste between the hands and then into threads between the palm and a glass plate. The plastic limit was the moisture content at which the threads develop transverse cracks when they were about 3mm diameter. The results are attached in Appendix 1.

- **Plasticity Index**

The plasticity Index was determined in conformity with BS 1377: Part 2: 1990. The plasticity index (PI) is the numerical difference between the Liquid Limit (LL) and Plastic Limit (PL).

$$PI = LL - PL$$

A summary of the results of the soil index properties is attached in Appendix 1.

4.2.2 Strength

- **Direct Shear test**

This was performed on the undisturbed samples in conformity with BS: 1377: Part 7: 1990. For each of the samples, three specimens of sizes 60x60x20mm were prepared. The first specimen was given a fixed normal stress close to the respective overburden pressure and was sheared along its horizontal plane through its mid-depth to failure.

Thereafter the same was done on the other two specimens but this time the fixed normal stresses were successively increased. The failure points were noted. A plot was made between the normal stress of the absicca and the shear stress as the ordinate. The slope of the graph was the angle of internal friction Ø and the intercept was the cohesion C_u. Detailed results are as indicated in Appendix 2.

4.2.3 Consolidation test

This was performed in accordance with BS 1377: Part 5:1990. A specimen of **76mm** diameter and **20mm** height was cut from the undisturbed sample and placed in the floating ring of the odometer cell. Soaking of the sample was done after which the sample was loaded. Readings of compression were noted at regular time intervals of **0 min, 1/2, 1, 2, 4, 8, 15, 30 1hr.....24hr**. Successively higher loads were applied each after 24hours until 7 cycles were completed. In the meantime the specific gravity of the same sample was determined. A plot was made between the cell pressure and the void ratio from which the coefficient of volume compressibility (**mv**) and the pre-consolidation pressure (**Pc)** were determined. Results are presented in Appendix 3.

4.2.4 Unconfined compression strength test (UCS) on soils samples

This test was conducted in conformity with test requirements and methods in BS 1377: Part 7 1992. The test specimens were trimmed with a spatula from the intact portions of SPT samples that were properly preserved at natural moisture content. The lengths of each specimen was twice the diameter. The mass of the prepared specimen was determined and likewise the bulk density calculated. The specimen was vertically put on to the loading machine and compressed to failure as prescribed in the above mentioned standard. The maximum load at failure was recorded and the compressive strength calculated in N/mm2 (Mpa). The results are showed in Appendix 4.

4.2.5 Unconfined compression strength test (UCS) on soils samples

This test was conducted in conformity with test requirements and methods in BS 1377: Part 7 1992.The surfaces of the two bearing discs were cleaned and the test specimen. Alignment was done carefully with the axis of specimen with the center of thrust of the spherical seat. A load was continuously applied at a constant stress rate within the limits of 0.5 MPa/s to 1.0 MPa/s. The maximum load on the specimen at failure in N within 1% accuracy was recorded. The water absorption of the specimens were determined. Two specimens were used for each section of rock core in the two boreholes. The results are showed in Appendix 5

5 CONCLUSIONS AND RECOMMENDATIONS

i. The soils generally comprised fat clay, lean clay, sandy fat clay and silty sand;

ii. Shear strength parameters for the samples indicate mixed soils that derive their strength more from friction than cohesion at the substation. At the 132Kv line the inter-particle friction is more important than the cohesion. The computed allowable bearing capacity values due to local shear failure ranged from 71kPa to 668kPa at all the four drilling points;

iii. The key index properties of the soil samples varied as follows: LL = 31 to 60%, PL = NP to 29% and PI = 0 to 38%.

iv. The specific gravity ranged from 2.38 to 2.60 g/cm^3.

v. The Natural Moisture Content ranged from 1 to 49%.

vi. The groundwater table was between 0.7 and 0.8 meters below ground level at the substation and 5.2 meter under the 132Kv line. The groundwater level under the 132kv was made deeper by the over three meters of material dumped at this site.

vii. The volume compressibility from the consolidation test ranged from 0.26 to 0.04 m^2/MN for the sample that was collected between 3 to 3.5m depth in borehole 2.

viii. The unconfined compressive strength varied from 0.024 to 0.948. It is noteworthy to observe that the highest unconfined compressive strengths were obtained between 7.5 and 7.8 m depth borehole 1, 4.5 to 4.7 m depth in borehole 2, 4.8 to 5.2 m depth in borehole 3 and the values were generally much higher for borehole 4 compared to the rest of the boreholes drilled at the substation.

ix. The rock samples for boreholes 1 and 2 were tested for their compressive strength and water absorption. The tests yielded unconfined compressive strength of 10.6 to 43.1 Mpa and water absorption of 0.3 to 1.5.

x. Based on all the observations and results above a recommended excavation depth of 6 meters is desired at the substation and for the 132 Kv line, the depth should be 8 meters for stable founding conditions. This implies the need for deep foundations, piles would be suitable. The optimum size and depth could not be determined at this stage due to lack of design loadings from the structures

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APPENDICES: DETAILS OF LABORATORY RESULTS AND BOREHOLE LOGS

Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

APPENDIX 1: CLASSIFICATION TEST RESULTS

CENTRAL MATERIALS LABORATORY

PROJECT : IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT : M/S CaCL CONSULTING LTD.
DATE : MAY 2014

SUMMARY OF SOIL CLASSIFICATION RESULTS TESTED IN ACCORDANCE WITH BS 1377: 1990

SAMPLE IDENTIFICATION		GRADING % PASSING											ATTEBERG LIMITS			NMC	GS	USCS	REMARKS
BH No.	DEPTH m	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.150 mm	0.075 mm	LL %	PL %	PI %	%			
1	1.0 – 1.5		100	96	95	91	88	87	86	86	85	83	52	14	38	38	2.59	CH	Fat Clay
	3.5 – 4.0					100	98	84	80	79	78	76	46	17	29	26	2.57	CL	Lean Clay
	6.5 – 7.0				100	97	81	74	70	66	63	58	45	12	33	49	2.54	CL	Lean Clay
	9.0 – 9.5					100	78	52	37	21	14	10	31	NP	-	22	2.37	SW-SM	Well graded sand with silt
	11.5 – 12.0				100	98	63	51	44	36	30	24	32	NP	-	13	2.40	SM	Silty Sand
2	1.0 – 1.5				100	95	89	86	85	83	80	74	51	21	30	28	2.58	CH	Fat Clay with sand
	3.0 – 3.5				100	99	96	95	94	94	93	91	58	22	36	24	2.60	CH	Fat Clay
	5.0 – 5.5				100	97	80	75	72	69	67	63	52	16	36	21	2.55	CH	Sandy Fat Clay
	7.0 – 7.5		100	97	95	84	51	41	37	32	29	27	28	NP	-	8	2.41	SM	Silty Sand

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CENTRAL MATERIALS LABORATORY

PROJECT : IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT : M/S CaCL CONSULTING LTD.
DATE : MAY 2014

SUMMARY OF SOIL CLASSIFICATION RESULTS TESTED IN ACCORDANCE WITH BS 1377: 1990

SAMPLE IDENTIFICATION		GRADING % PASSING											ATTEBERG LIMITS			NMC	GS	USCS	REMARKS
BH No.	DEPTH m	20.0 mm	10.0 mm	6.3 mm	5.0 mm	2.0 mm	0.600 mm	0.425 mm	0.300 mm	0.212 mm	0.150 mm	0.075 mm	LL %	PL %	PI %	%			
3	1.0 – 1.5	100	98	97	95	89	84	83	82	82	81	80	48	19	29	4	2.59	CL	Lean Clay with sand
	3.0 – 3.5					100	93	88	86	83	80	78	49	17	32	22	2.59	CL	Lean Clay with sand
	5.0 – 5.5		100	96	92	77	55	47	43	39	35	31	38	13	25	11	2.52	SC-SM	Clayey sand with silt
	7.0 – 7.5		100	97	96	89	76	70	66	60	57	50	30	9	21	8	2.50	CL	Sandy Lean Clay
	9.0 – 9.5					100	74	53	46	33	25	16	29	NP	-	1	2.38	SM	Silty Sand
4	1.0 – 1.5	100	97	94	93	87	84	81	80	77	76	72	37	13	24	9	2.55	CL	Lean Clay with sand
	3.0 – 3.5		100	74	74	66	54	52	50	49	48	45	50	22	28	17	2.57	CH	Sandy Fat Clay
	5.0 – 5.5				100	99	93	91	90	88	85	82	45	16	29	23	2.60	CL	Lean Clay with sand
	7.0 – 7.5			100	98	96	88	83	81	76	71	66	45	17	28	23	2.54	CL	Sandy Fat Clay
	9.0 – 9.5				100	99	95	92	91	88	87	84	56	25	31	33	2.52	CH	Fat Clay with sand
	11.0 – 11.5				100	97	90	86	84	78	74	69	60	29	31	20	2.50	CH	Sandy Fat Clay

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APPENDIX 2: SHEAR BOX TEST RESULTS

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT : M/S CaCI CONSULTING LTD
DATE : MAY 2014

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

SAMPLE No.	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ kN/m³	COHESION C (KPa)	COHESION C' (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS Nc	Nq	N_γ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
BH 01	1.3	1.0	17.16	13	9	27	18	13.1	5.3	2.1	280	3	93
BH 01	3.3	1.0	17.16	16	11	27	18	13.1	5.3	2.1	491	3	164
BH 01	5.3	1.0	17.02	21	14	33	23	18.1	8.7	4.9	1139	3	380
BH 01	7.3	1.0	20.14	32	21	35	25	20.7	10.7	6.8	2194	3	731
BH 01	9.3	1.0	20.33	17	11	38	27	23.9	13.2	9.3	2912	3	971

$q_{ult} = C'N_c sc + q_o N_q + \frac{1}{2}\gamma B N_\gamma s\gamma$

Where: $q_o = \gamma D$

$\phi' = \tan^{-1}(0.67 \tan \phi)$

$C' = 0.67C$

$q_{all} = q_{ult}/F$

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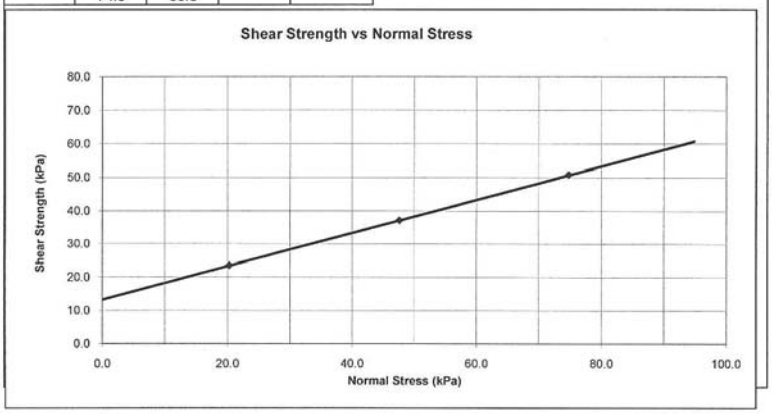
SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 01
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	1.25

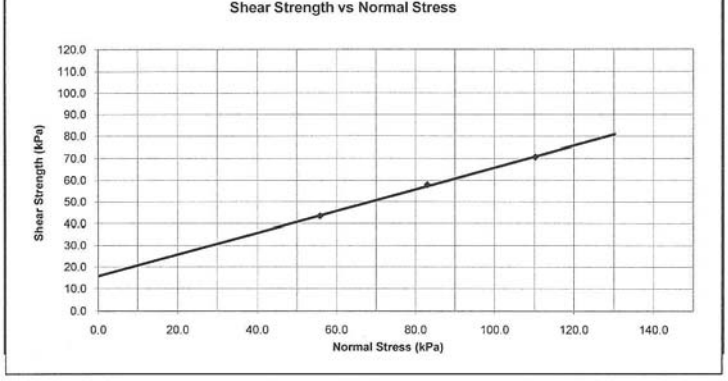
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.76	20.3	23.5	13	27
	47.6	37.1		
	74.8	50.8		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		LABEL	BH 01
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		DEPTH (m):	3.25

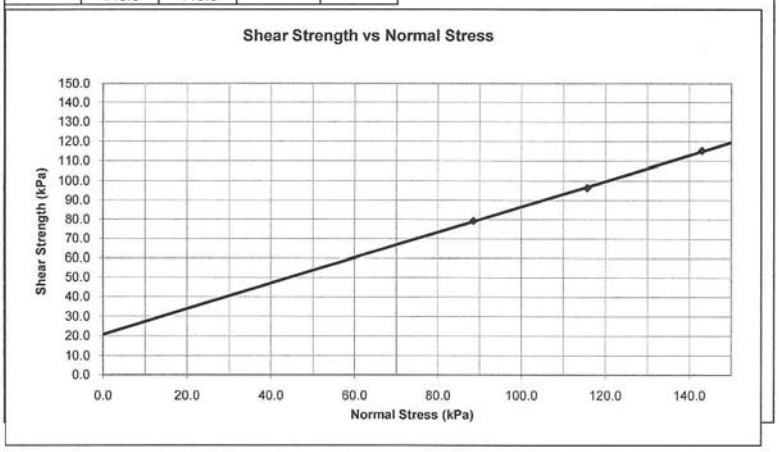
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.72	55.8	43.4	16	27
	83.0	57.9		
	110.3	70.6		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		**LABEL**	**BH 01**
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		**DEPTH (m):**	**5.25**

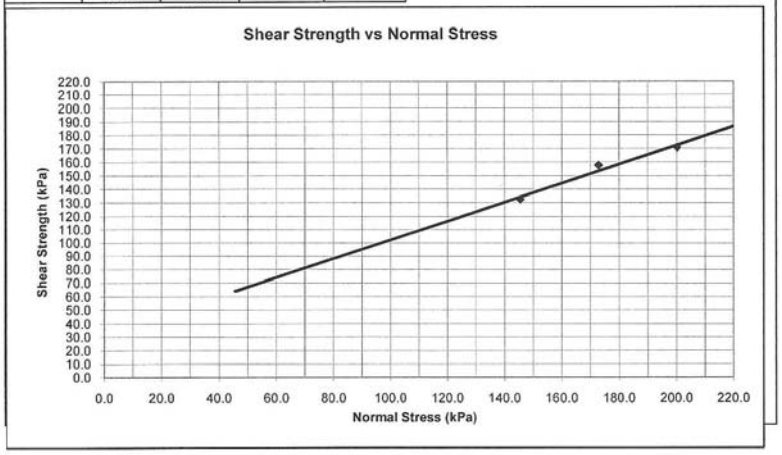
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.70	88.5	79.4	21	33
	115.7	96.4		
	143.0	115.3		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		**LABEL**	**BH 01**
Client : M/S CaCl CONSULTING LTD			
Date : MAY 2014		**DEPTH (m):**	**7.25**

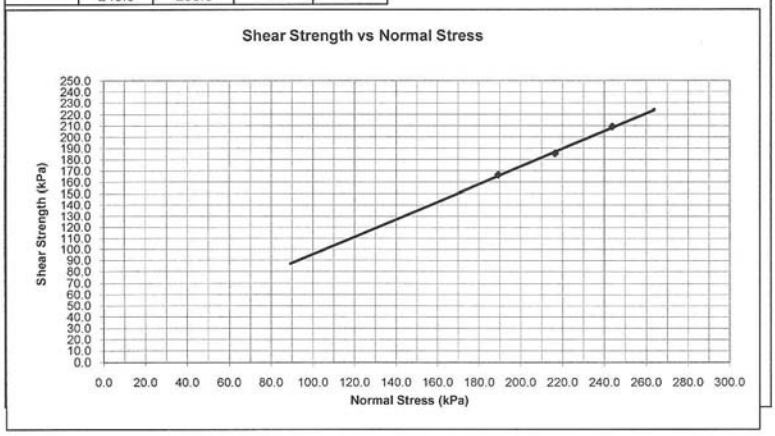
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.01	145.6	132.4	32	35
	172.9	157.6		
	200.2	170.8		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	**LABEL** BH 01
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	**DEPTH (m):** 9.25

Bulk Density γ_b Mg/m^3	Normal Stress $\bar{\sigma}_n$ kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.03	189.3	166.5	17	38
	216.5	185.4		
	243.8	209.3		



CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT : M/S CaCl CONSULTING LTD
DATE : MAY 2014

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

SAMPLE No.	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ kN/m^3	COHESION C (KPa)	COHESION C' (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS Nc	Nq	N_γ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
BH 02	1.25	1.0	20.63	11	7	23	15	11.0	3.9	1.2	212	3	71
BH 02	3.25	1.0	20.63	11	7	23	15	11.0	3.9	1.2	375	3	125
BH 02	5.25	1.0	18.63	16	11	28	19	13.9	5.8	2.5	779	3	260
BH 02	7.25	1.0	19.39	8	6	28	19	13.9	5.8	2.5	935	3	312

$q_{ult} = C'N_c sc + q_o N_q + \frac{1}{2}\gamma B N_\gamma s\gamma$

Where: $q_o = \gamma D$

$\phi' = \tan^{-1}(0.67 \tan \phi)$

$C' = 0.67C$

$q_{all} = q_{ult}/F$

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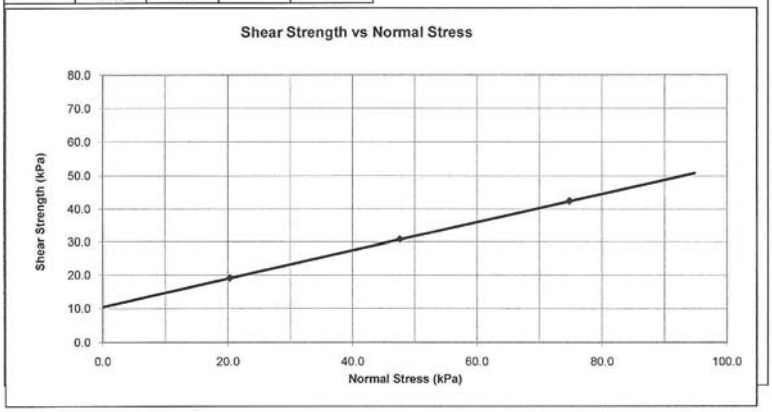
SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		**LABEL**	**BH 02**
Client : M/S CaCI CONSULTING LTD			
Date : MAY 2014		**DEPTH (m):**	**1.25**

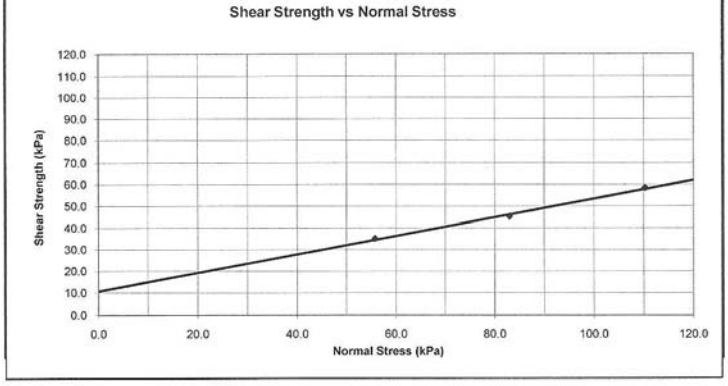
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.74	20.3	19.2	11	23
	47.6	30.8		
	74.8	42.4		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION		**LABEL**	**BH 02**
Client : M/S CaCI CONSULTING LTD			
Date : MAY 2014		**DEPTH (m):**	**3.25**

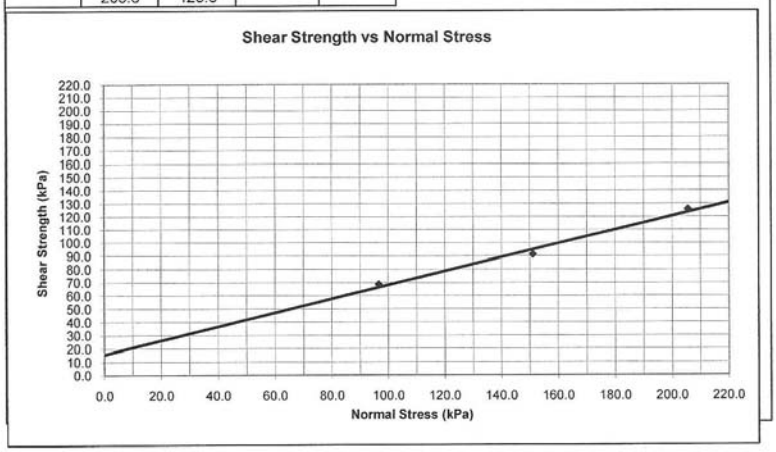
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.06	55.8	35.2	11	23
	83.0	45.2		
	110.3	58.5		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	**LABEL** BH 02
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	**DEPTH (m):** 5.25

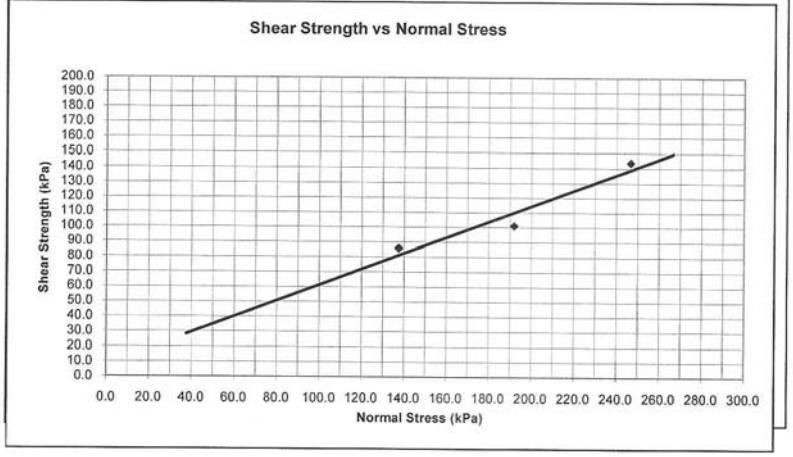
Bulk Density γ_b Mg/m^3	Normal Stress $\bar{\sigma}_n$ kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.86	96.6	68.5	16	28
	151.1	91.1		
	205.6	125.6		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	**LABEL** BH 02
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	**DEPTH (m):** 7.25

Bulk Density γ_b Mg/m^3	Normal Stress $\bar{\sigma}_n$ kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.94	137.5	85.7	8	28
	192.0	101.2		
	246.5	143.5		



CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT : M/S CaCl CONSULTING LTD
DATE : MAY 2014

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

SAMPLE No.	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ kN/m³	COHESION C (KPa)	COHESION C' (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS Nc	Nq	N_γ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
BH 03	1.25	1.0	17.03	23	15	15	10	8.4	2.5	0.4	223	3	74
BH 03	3.25	1.0	17.03	14	10	25	17	12.3	4.8	1.7	430	3	143
BH 03	5.25	1.0	19.47	28	19	25	17	12.3	4.8	1.7	804	3	268
BH 03	7.25	1.0	20.35	56	38	26	18	13.1	5.3	2.1	1439	3	480
BH 03	9.25	1.0	20.61	33	22	32	22	16.9	7.8	4.1	2003	3	668

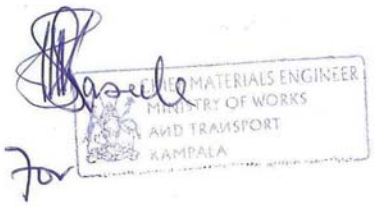
$q_{ult} = C'N_C sc + q_o N_q + \frac{1}{2}\gamma B N_\gamma s\gamma$

Where: $q_o = \gamma D$

$\phi' = \tan^{-1}(0.67 \tan \phi)$

$C' = 0.67C$

$q_{all} = q_{ult}/F$

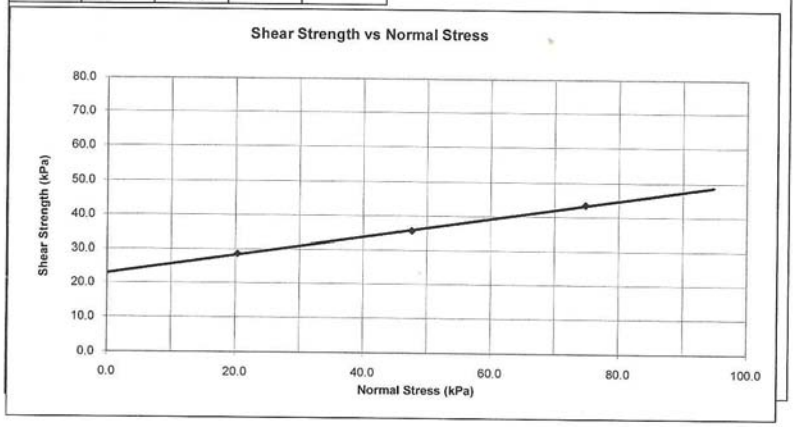


for

SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 03
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 1.25

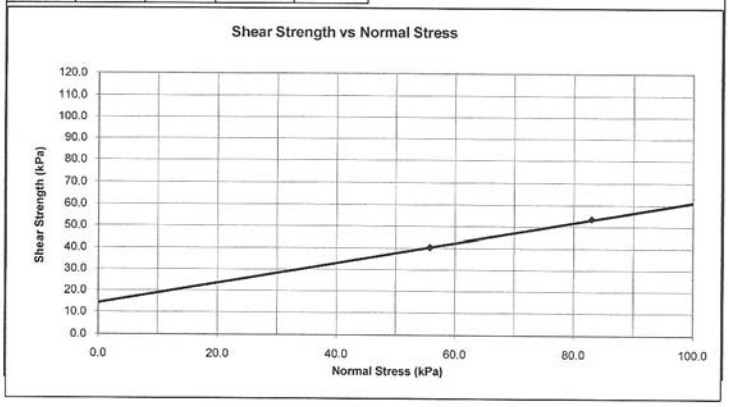
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.69	20.3	28.6	23	15
	47.6	35.6		
	74.8	43.5		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 03
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 3.25

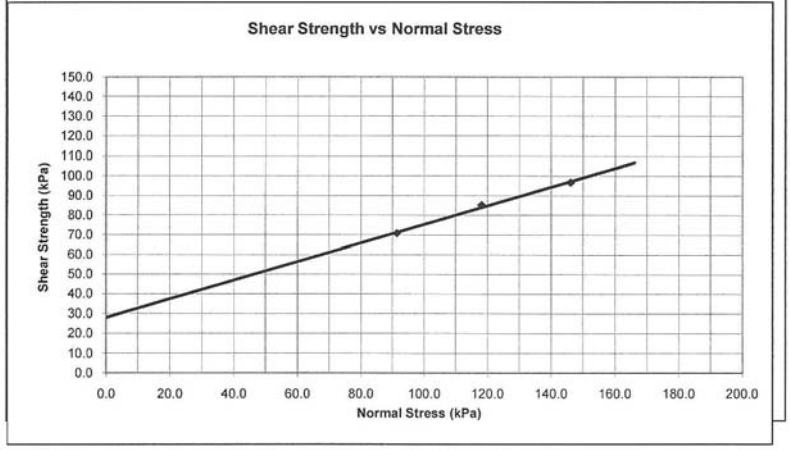
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.70	55.8	40.3	14	25
	83.0	53.6		
	110.3	65.9		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 03
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 5.25

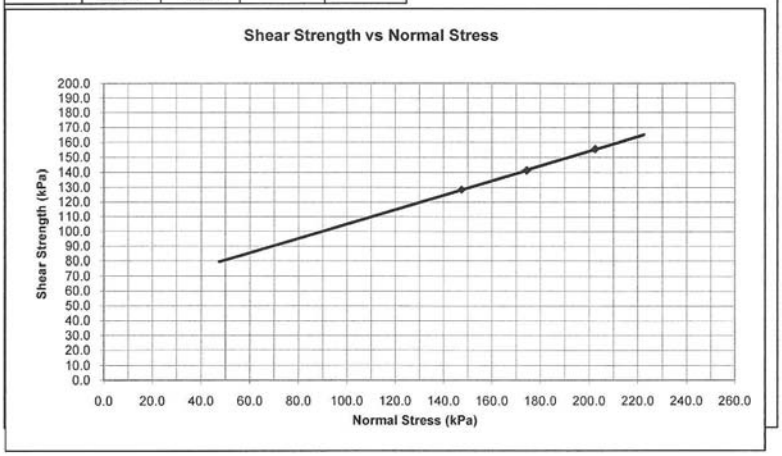
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.95	91.4	70.8	28	25
	118.2	85.3		
	146.1	96.8		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 03
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 7.25

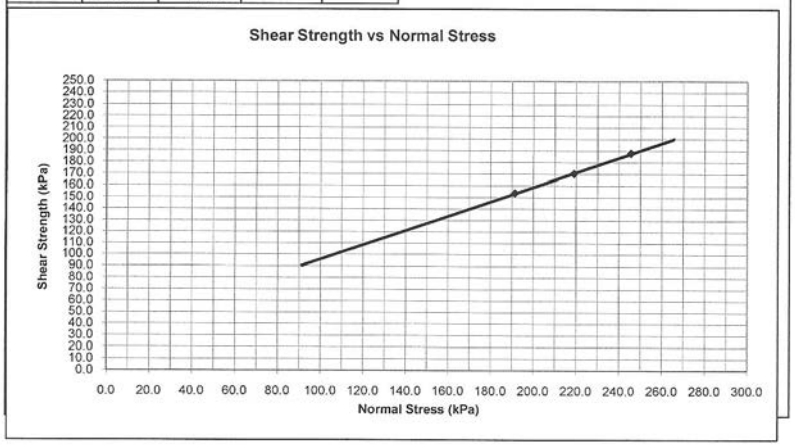
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.04	147.4	128.4	56	26
	174.3	141.3		
	202.5	155.4		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	LABEL BH 03
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	DEPTH (m): 9.25

Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
2.06	191.3	153.7	33	32
	219.0	170.3		
	245.5	187.9		



CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
CLIENT : M/S CaCl CONSULTING LTD
DATE : MAY 2014

EVALUATION OF BEARING CAPACITY BASED ON TERZAGHI'S MODEL (LOCAL SHEAR FAILURE)

SAMPLE No.	DEPTH, D (m)	WIDTH, B (m)	BULK DENSITY, γ kN/m³	COHESION C (KPa)	COHESION C' (KPa)	ANGLE OF FRICTION ϕ (Degrees)	MODIFIED ANGLE OF FRICTION ϕ' (Degrees)	BEARING CAPACITY FACTORS Nc	Nq	N_γ	ULTIMATE BEARING CAPACITY q_{ult} (KPa)	SAFETY FACTOR (F)	ALLOWABLE BEARING CAPACITY q_{all} (KPa)
BH 04	1.25	1.0	18.78	19	13	18	12	9.3	3.0	0.6	229	3	76
BH 04	3.25	1.0	18.78	26	18	24	16	11.6	4.3	1.4	538	3	179
BH 04	5.25	1.0	19.53	57	38	21	14	10.4	3.6	1.0	892	3	297
BH 04	7.25	1.0	19.18	65	44	24	16	11.6	4.3	1.4	1269	3	423
BH 04	9.25	1.0	19.53	55	37	26	18	13.1	5.3	2.1	1607	3	536

$q_{ult} = C'N_c sc + q_o N_q + \frac{1}{2}\gamma B N_\gamma s\gamma$

Where: $q_o = \gamma D$

$\phi' = \tan^{-1}(0.67 \tan \phi)$

$C' = 0.67C$

$q_{all} = q_{ult}/F$

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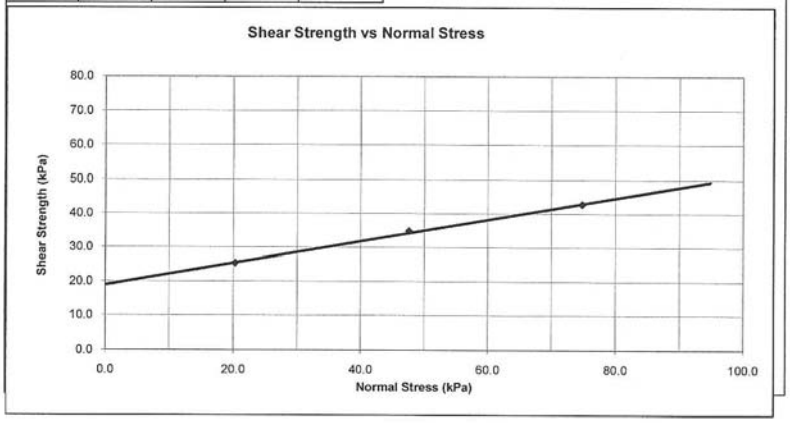
SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	**LABEL** BH 04
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	**DEPTH (m):** 1.25

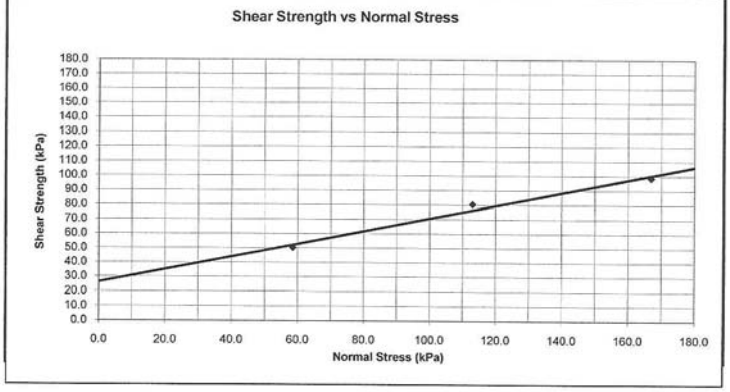
Bulk Density γ_b Mg/m³	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.88	20.3	25.3	19	18
	47.6	34.8		
	74.8	42.8		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	**LABEL**	**BH 04**
Client : M/S CaCl CONSULTING LTD		
Date : MAY 2014	**DEPTH (m):**	**3.25**

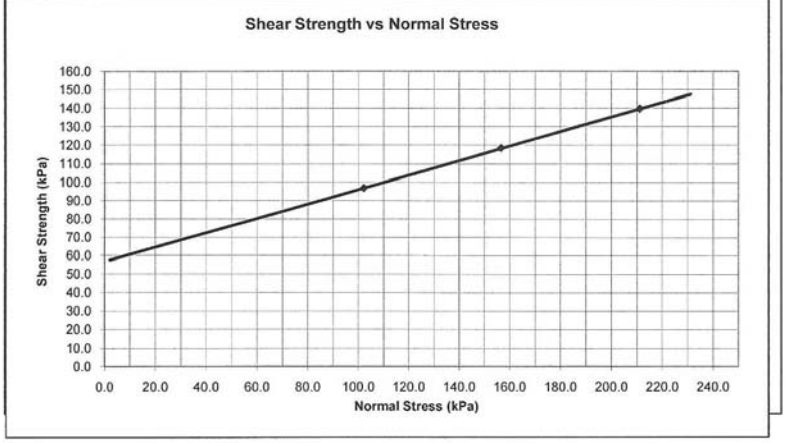
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.88	58.5	50.3	26	24
	113.0	80.4		
	167.0	98.5		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	**LABEL**	**BH 04**
Client : M/S CaCl CONSULTING LTD		
Date : MAY 2014	**DEPTH (m):**	**5.25**

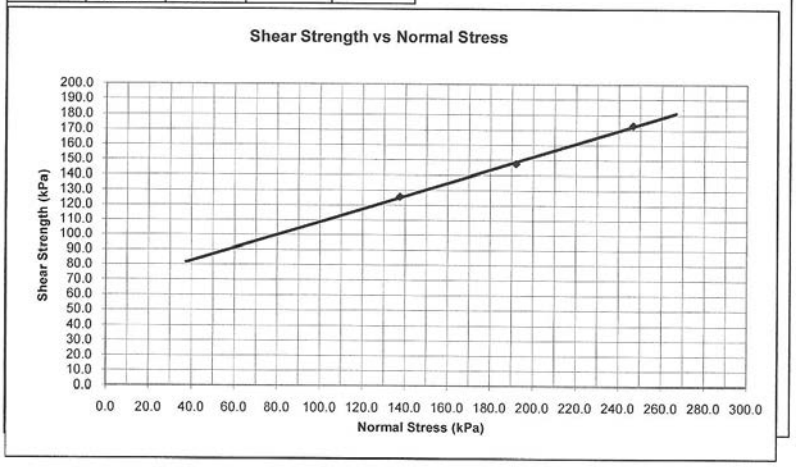
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.95	102.1	96.9	57	21
	156.6	118.4		
	211.1	139.7		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	**LABEL** BH 04
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	**DEPTH (m):** 7.25

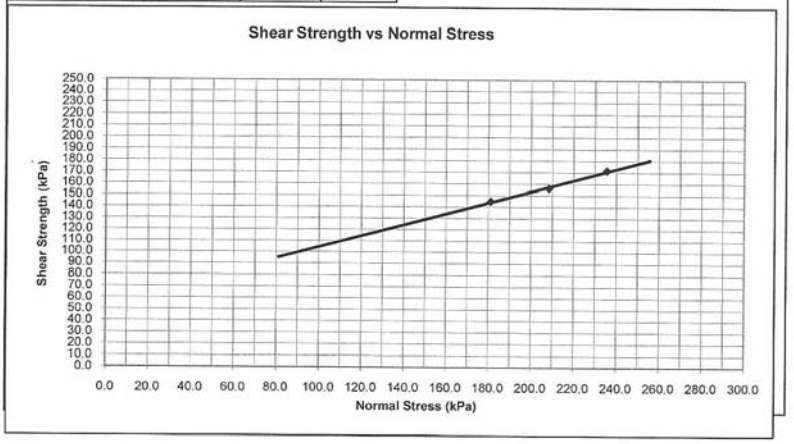
Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.92	137.5	125.7	65	24
	192.0	147.6		
	246.5	173.1		



SHEAR BOX TEST OF SOILS

Project : IMPROVEMENT OF QUEEN'S ELECTRICITY SUBSTATION	**LABEL** BH 04
Client : M/S CaCl CONSULTING LTD	
Date : MAY 2014	**DEPTH (m):** 9.25

Bulk Density γ_b Mg/m^3	Normal Stress δ_n kPa	Shear Strength τ_s kPa	Cohesion C kPa	Angle of Internal Friction ϕ (Degree)
1.95	181.1	144.8	55	26
	208.4	156.3		
	235.6	171.5		



APPENDIX 3: CONSOLIDATION TEST RESULTS

CENTRAL MATERIALS LABORATORY

PROJECT: IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION

CLIENT: M/S CaCl CONSULTING LTD

DATE: MAY 2014

THE CONSOLIDATION TEST DATA SHEET

SAMPLE No	REF: BH 02		DEPTH 3.00 - 3.50m	
DIAMETER OF SPECIMEN	0.075 m		THICKNESS ($2H_1$)	0.02 m
VOLUME OF SPECIMEN	0.0000884 m^3			
MC BEFORE TEST	24.3 %		BULK DENSITY	2.093 Mg/m^3
WT OF SAMPLE $ RING	270.08 g		DRY DENSITY (γ_D)	1.684 Mg/m^3
WT OF EMPTY RING	85.07 g		SPECIFIC GRAVITY	2.61
WT OF WET SOIL	185.01 g		e_o	0.550
WT OF DRY SOIL	148.84 g			
			VOID RATIO FACTOR (F)	0.0775
RING CALIBRATION FACTOR	0.01			

APPLIED PRESSURE Kpa	INITIAL GAUGE READING Dev	FINAL GAUGE READING Dev	CHANGE IN HEIGHT (2H) mm	CHANGE IN VOID RATIO (F*change in 2H)	e (e_o-Change in void ratio)	VOLUME COMPRESSIBILITY Incremental Changes Viod ratio	Pressure	$1+e_1$	m_v m^2/MN
0	0.0				0.549881	0	0		
40	0.0	20.50	0.2050	0.015886	0.533995	0.01589	40.0	1.550	0.26
80	0.0	45.00	0.4500	0.034872	0.515009	0.01899	40.0	1.534	0.31
160	0.0	75.00	0.7500	0.058121	0.491761	0.02325	80.0	1.515	0.19
320	0.0	108.00	1.0800	0.083694	0.466188	0.02557	160.0	1.492	0.11
640	0.0	150.00	1.5000	0.116241	0.433640	0.03255	320.0	1.466	0.07
1280	0.0	193.00	1.9300	0.149564	0.400318	0.03332	640.0	1.434	0.04
Average									0.162

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APPENDIX 4: UNCONFINED COMPRESSION STRENGTH TEST ON SOIL SAMPLES.

CENTRAL MATERIALS LABORATORY

CLIENT : M/S CaCl CONSULTING LTD.
PROJECT : IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
DATE : MAY 2014

SUMMARY OF UNCONFINED COMPRESSIVE STRENGTH RESULTS FOR SPT SOIL SAMPLES

Sample Identification		Dimensions		Mass	Bulk Density	Natural Moisture Content	Load	Un Unconfined Compressive Strength
BH No.	Depth (m)	Diameter (mm)	Length (mm)	(Kg)	(Kg/m^3)	(%)	(kN)	(Mpa)
1	1.0 – 1.5	75	150	1.206	1820	26	0.194	0.044
	1.5 – 1.8	70	140	1.133	2103	26	0.370	0.096
	2.5 – 2.7	70	140	1.138	2112	26	0.387	0.101
	7.5 – 7.8	60	120	0.767	2261	12	0.869	0.307
	8.5 – 90	55	110	0.585	2238	12	0.520	0.219
2	3.1 – 3.4	75	150	1.216	1835	23	0.275	0.062
	3.5 – 4.0	75	150	1.158	1747	23	0.108	0.024
	4.5 – 4.7	75	150	1.369	2066	20	2.193	0.496
	7.0 – 7.3	55	110	0.445	1703	17	0.062	0.026

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CENTRAL MATERIALS LABORATORY

CLIENT : M/S CaCl CONSULTING LTD.
PROJECT : IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
DATE : MAY 2014

SUMMARY OF UNCONFINED COMPRESSIVE STRENGTH RESULTS FOR SPT SOIL SAMPLES

Sample Identification		Dimensions		Mass	Bulk Density	Natural Moisture Content	Load	Un Unconfined Compressive Strength
BH No.	Depth (m)	Diameter (mm)	Length (mm)	(Kg)	(Kg/m^3)	(%)	(kN)	(Mpa)
3	1.6 – 2.0	75	150	1.183	1785	26	0.516	0.117
	2.5 – 2.8	75	150	1.245	1879	26	0.512	0.116
	4.8 – 5.0	75	150	1.368	2064	26	2.098	0.475
	6.5 – 6.7	75	150	1.402	2116	14	0.735	0.166
4	3.0 – 3.2	75	150	1.376	2076	20	4.188	0.948
	3.5 – 3.8	75	150	1.394	2104	20	1.634	0.370
	5.5 – 5 7	75	150	1.284	1938	15	1.359	0.308
	7.1 – 7.3	75	150	1.383	2087	15	1.183	0.268

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Queensway Substation Improvement: Topographic and Geotechnical Surveys
Volume II: Geotechnical Survey Report

APPENDIX 5: UNCONFINED COMPRESSION STRENGTH TEST ON ROCK CORES

CENTRAL MATERIALS LABORATORY

CLIENT : M/S CaCl CONSULTING LTD.
PROJECT : IMPROVEMENT OF QUEEN'S WAY ELECTRICITY SUBSTATION
DATE : MAY 2014

SUMMARY OF ROCK CORES TEST RESULTS:

Sample Identification			Dimensions		Mass	Density	Load	Unconfined Compressive Strength	Water Absorption
BH No.	Depth (m)	Specimen (No.)	Diameter (mm)	Length (mm)	(Kg)	(Kg/m^3)	(kN)	(Mpa)	(%)
1	12.0-13.1	1	60	120	0.931	2744	112	39.6	0.3
		2	60	120	0.938	2765	122	43.1	0.3
2	8.0-9.0	1	60	120	0.855	2520	32	11.3	1.5
		2	60	120	0.851	2508	30	10.6	1.2

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APPENDIX 6: BOREHOLE LOGS

BOREHOLE No. 1

Equipment/Method: HGY 200 borehole drilling rig. Uses casing with drilling diameter of 75mm cores in soft material and 58mm cores in hard rock. Uses convetional drilling system.

Location No. 1

Location: Queens Way substation

Carried out for NewPlan Ltd

Ground Level

Coordinates 36N 452901E, 34116N

Date: 25th to 27th April 2014

Description	Reduced Level	Legend	Depth (thick)	Sample/Tests: Depth	Sample: Type	Sample: No.	Test	No. of hammers (n-value)
Firm black CLAY with roots			0.1					
Firm black CLAY with COBBLES			0.37					
Very strong, light grey, fine grained fresh massive GRANITE			0.51	1-1.5	U D			25
				2-2.5	U			25
Loose grey brown CLAY				3-3.5	D			11 (no sample recovered)
				3.5-4	U			23
			5.5	5-5.5	U			48
Loose brown CLAY with SILT				6.5-7	D U			56
				7.5-8	U			55
			9.4	9-9.5	D U			24
Loose, brown, Coarse grained, completely weathered GRANITE (COBBLES and SILT)				10-10.5	U			102
				11.5-12	D U			78
Very strong, light grey brown, fresh GRANITE			12.2	12.5-13				Refusal

Remarks: Hard rock intercepted at the bottom of the borehole was tested for compressive strength and water absoption

Logged by CaCl Consulting Ltd

Scale NTS

Fig.

BOREHOLE No. 2

Equipment/Method: HGY 200 borehole drilling rig. Uses casing with drilling diameter of 75mm cores in soft material and 58mm cores in hard rock. Uses convetional drilling system.

Location No.2

Location: Queens Way substation

Carried out for NewPlan Ltd

Ground Level

Coordinates 36N 452906E, 34133N

Date: 28th April 2014

Description	Reduced Level	Legend	Depth (thick)	Sample/Tests: Depth	Sample: Type	Sample: No.	Test	No. of hammers (n-value)
Firm black CLAY with COBBLES			0.1					
Firm brown CLAY			1.2	1-1.5	U D			12
				2-2.5	U			5
Loose grey CLAY				3-3.5	U D			12
				4-4.5	U			24
			4.9	5-5.5	U D			18
				6-6.5	U			123
Loose, brown, Coarse grained, completely weathered GRANITE (COBBLES and SILT)				7-7.5	U D			>102
				8-8.5	U			26
Very strong, light grey brown, fresh GRANITE			8.4					

Remarks: Hard rock intercepted at the bottom of the borehole was tested for compressive strength and water absoption

Logged by CaCl Consulting Ltd

Scale NTS

Fig.

BOREHOLE No. 3

Equipment/Method: HGY 200 borehole drilling rig. Uses casing with drilling diameter of 75mm cores in soft material and 58mm cores in hard rock. Uses convetional drilling system.

Location No. 3

Location: Queens Way substation

Carried out for: NewPlan Ltd

Ground Level | Coordinates: 36N 452905E, 34140N | Date: 29th April 2014

Description	Reduced Level	Legend	Depth (thick)	Sample/Tests: Depth	Sample: Type	Sample: No.	Test	No. of hammers (n-value)
Firm black CLAY			0.2					
Firm brown CLAY with SILT			0.5					
Loose grey CLAY with SILT			4.7	1-1.5	U D			7
				2-2.5	U			7
				3-3.5	U D			15
				4-4.5	U			19
Loose brown SILT with CLAY and COBBLES			7.1	5-5.5	U D			47
				6-6.5	U			>100
Loose, brown, Coarse grained, completely weathered GRANITE (COBBLES and SILT)				7-7.5	U D			48
				8-8.5	U			42
					D			

Remarks: No bed rock was intercepted

Logged by: CaCl Consulting Ltd

Scale: NTS

Fig.

BOREHOLE No. 4

Equipment/Method: HGY 200 borehole drilling rig. Uses casing with drilling diameter of 75mm cores in soft material and 58mm cores in hard rock. Uses convetional drilling system.

Location No. 4

Location: Under 132kv Line

Carried out for: NewPlan Ltd

Ground Level | Coordinates: 36N 452906E, 34133N | Date: 25th to 27th April 2014

Description	Reduced Level	Legend	Depth (thick)	Sample/Tests: Depth	Sample: Type	Sample: No.	Test	No. of hammers (n-value)
Firm brown grey CLAY, SILT and COBBLES. Transported material			3	1-1.5	U D			52
				2-2.5	U			15
Firm brown CLAY with SILT			3.5	3-3.5	U D			25
Loose grey CLAY with SILT and COBBLES			3.6	4-4.5	U			29
				5-5.5	U D			42
				6-6.5	U			33
				7-7.5	U D			56
				8-8.5	U			27
Loose, brown grey, Coarse grained, moderately weathered GRANITE			8.4	9-9.5	U D			29
				10-10.5	U			25
				11-11.5	U D			45
				12-12.5	U			44

Remarks: No bed rock was intercepted

Logged by: CaCl Consulting Ltd

Scale: NTS

Fig.