



REPUBLIC OF RWANDA



MINISTRY OF INFRASTRUCTURE



Japan International Cooperation Agency

Consultant:

yec CONSULTING ENGINEERS & ARCHITECTS
YACHIYO ENGINEERING CO., LTD.

Project:

**PROJECT FOR IMPROVEMENT OF SUBSTATIONS
AND DISTRIBUTION NETWORK**
JICA PROJECT PHASE II

Content:

SURVEY FINAL REPORT

Date :

May 18, 2015

PROJECT FOR IMPROVEMENT OF SUBSTATIONS AND DISTRIBUTION NETWORK IN RWANDA

JICA PROJECT PHASE II

PRESENTATION OF SURVEY FINAL REPORT REFERENCE MADE TO THE CONTRACT BETWEEN YACHIYO ENGINEERING Co.Ltd AND PITRAD IBAMBA LTD SIGNED ON 24th March 2015

The present document is aimed to present briefly the content of survey report of the project **for Improvement of Substations and distribution network in Rwanda referenced as**

JICA PROJECT PHASE II

The present report is composed by 5 main components and important observation as follows:

1. Choice & materialization of the line route
2. Line survey and execution of the line profile
3. Result of the study containing the list of equipment (Tower lists)
4. Connection points of the electrical lines of the project
5. Different illustration photos
6. Important observation

1. Choice & materialization of the line routes

Based on the requirements of RWANDA ENERGY GROUP (**REG**) it has been done a deep site investigation to crosscheck the obstacles to be crossed by the project at site in order to minimize the social and environmental impact choosing the line routes based on the current situation at site.

In general, the corridors of the line routes have been selected in order to avoid damages as much as possible while it is not so easy because the project site is in the vicinity of the city Kigali Capital of the republic of Rwanda.

Furthermore, the selection of line routes has taken into consideration as well the solution which may be economical as much as possible for the construction cost purpose.

For more details concerning the line lengths, the crossed areas and obstacles, refer to the project General layout at page 5/32 of this report file.

2. Line routes survey and execution of the line profile

The line profile and tower spotting have been executed following the general technical requirements/standard in this regard, the survey data have been taken at site using theodolite total stations with enough accuracy in order to ensure the tolerances of +/- 5cm/km in line length and +/- 5cm in altitude at each surveyed point.

Doing tower/pole spotting, it has been respected the electrical clearances in mid spans to meet the required values and at the same time considering enough ground clearance all along the life of the lines as well as to the crossed objects.

The tower spotting has been executed in way to keep everywhere the ground clearance of 7m minimum at the conductor temperature of 50°C. The sag has been drawn taking into consideration the temperature of 50°C as well. However, the stringing shall be done according to time temperature of the operation. Therefore, the ground clearance at real time (day & night) shall be always in all conditions higher than 7 m depending on respective spans. For more details of the line profile and tower spotting, refer to the drawings contained in this report.

3. Result of the study containing the list of equipment (Tower lists)

After realization of the line route and line profile, the summary of line equipment has been done under a document called "Tower lists"

This document is a table showing the numbering and type of towers, the line, wind and weight spans at the first columns, the following columns show the insulators sets at each tower, the angle of the line, the cumulative distance of the line at each tower/pole location and the altitude of the lowest conductor attachment point at each tower/pole.

4. Connection points of the electrical lines of the project at the existing network

As the installations of the current project shall be inserted in the existing network both at 110 kV and 15 kV sides, the current survey study has also proposed how the connections to the existing network shall be realized, for more details, refer to the pages 17/32 & 18/32 for 110 kV double circuit line, 27/32 & 28/32 for 15 kV double circuit line, 29/32, 30/32 & 31/32 for 15 kV rerouted line, refer to the Table of Content of the documents composing this survey study for easy reference.

5. Different illustration photos

In order to have the idea of the site of the project, different photos have taken for illustration purpose, these photos show all tower/pole locations where they will be materialized at site.

The marking points with numbers of towers/poles using concretes stones have been installed at site as shown at the photos. These photos are integral part of this report.

6. Important observation

It is very important to note that the land of line corridor and tower/locations must be purchased by REG as soon as possible in order to make it available and to be secured as the project is in the vicinity of the city of Kigali where many constructions are taking place at higher speed. If this measure is not taken within following two months, the risk of new houses or villages construction may hinder the realization of the project and can even make it impossible in very short term.

End of the presentation.

Kigali 18th May 2015

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TOWERS & POLES LIST OF THE 15 KV M.V. LINE GASOGI - KABUGA CONSIDERED AT 0 DEGREE CELCIUS TEMPERATURE

Angle Point	SIP	Tower n° & Pole n°	Coordinates			Tower type	Span (m)			Insulator sets				Angle of the line in grade ⁸⁷	Length of the line (km)	Altitude of lower cond. cond. atmt point	Remarks
			East	North	Altitude		line	wind	weight	SS	SD	ST	DT				
							1.00										Gasogi Substation
AP1	SIP-12	1	188792.00	9787104.00	1498.39	110-E1		61.62	61.74			3	3	0	0.000	1510.89	Soil investig. point
							122.23										
		2	188807.00	9786984.00	1484.53	15-PB1		123.62	123.87	3				200.00	0.122	1497.03	
							125.00										
		3	188820.00	9786860.00	1471.62	15-PB1		127.50	127.76	3				200.00	0.247	1484.12	
							130.00										
		4	188836.00	9786730.00	1458.19	15-PB1		124.78	125.03	3				200.00	0.377	1470.69	
							119.56										
		5	188847.00	9786614.00	1443.86	15-TB1		174.55	174.90	3				200.00	0.497	1457.36	
							229.53										
AP2	SIP-13	6	188870.00	9786384.00	1450.00	15-TD1		179.77	180.13			6		176.48	0.726	1463.5	Soil investig. point
							130.00										
		7	188837.00	9786258.00	1458.48	15-PB1		119.58	119.82	3				200.00	0.856	1470.98	
							109.16										
		8	188809.00	9786152.00	1462.05	15-PB1		101.76	101.96	3				200.00	0.965	1474.74	
							94.35										
AP3		9	188785.00	9786060.00	1460.29	15-PA1		111.98	112.21			3	3	172.80	1.060	1472.79	
							129.61										
		10	188808.00	9785932.00	1455.96	15-PB1		129.81	130.07	3				200.00	1.189	1468.46	
							130.00										
		11	188828.00	9785804.00	1460.20	15-PB1		126.02	126.28	3				200.00	1.319	1472.7	
							122.04										
		12	188850.00	9785684.00	1459.09	15-PB1		116.15	116.39	3				200.00	1.441	1471.79	
							110.26										
AP4	SIP-14	13	188868.00	9785574.00	1459.67	15-TD1+2		143.50	143.79			6		179.43	1.552	1475.17	Soil investig. point
							176.74										
		14	188949.00	9785418.00	1467.67	15-TB1+2		198.96	199.36	3				200.00	1.728	1483.17	
							221.17										
		15	189053.00	9785224.00	1483.64	15-TB1		221.93	222.38	3				200.00	1.950	1497.14	
							222.69										
AP5	SIP-15	16	189160.00	9785028.00	1500.40	15-TD1+2		231.26	231.73			3	3	200.00	2.172	1515.9	Soil investig. point
							239.83										
AP6		17	189160.00	9785028.00	1496.11	15-TD1+2		219.40	219.84			3	3	200.00	2.412	1511.61	
							198.96										
		18	189316.00	9784620.00	1488.10	15-TB1		188.02	188.40	3				200.00	2.611	1501.6	
							177.08										
		19	189398.00	9784464.00	1475.21	15-TB1		202.67	203.08	3				200.00	2.788	1488.71	
							228.26										
AP7	SIP-16	20	189506.00	9784260.00	1457.71	15-TD1		179.56	179.92			6		182.19	3.016	1471.21	Soil investig. point
							130.86										
		21	189533.00	9784134.00	1458.80	15-PB1		130.42	130.68	3				200.00	3.147	1471.3	
							129.97										
		22	189558.00	9784004.00	1454.90	15-PB1		129.99	130.25	3				200.00	3.277	1467.4	
							130.00										
		23	189586.00	9783878.00	1455.13	15-PB1		129.22	129.48	3				200.00	3.407	1467.63	

Angle Point	SIP	Tower n° & Pole n°	Coordinates			Tower type	Span (m)			Insulator sets				Angle of the line in grade °'	Length of the line (km)	Altitude of lower cond. cond. atmt point	Remarks
			East	North	Altitude		line	wind	weight	SS	SD	ST	DT				
		23	189586.00	9783878.00	1455.13	15-PB1		129.22	129.48	3				200.00	3.407	1467.63	
							128.43										
		24	189610.00	9783752.00	1455.06	15-PB1		129.22	129.48	3				200.00	3.536	1467.56	
							130.00										
		25	189637.00	9783626.00	1456.48	15-PB1		120.02	120.26	3				200.00	3.666	1468.98	
							110.03										
AP8	SIP-17	26	189659.00	9783516.00	1451.87	15-PA1		117.62	117.85			6		188.54	3.776	1464.37	Soil investig. point
							125.20										
		27	189705.00	9783400.00	1442.83	15-PB1		127.60	127.86	3				200.00	3.901	1455.33	
							130.00										
		28	189755.00	9783278.00	1427.46	15-PB1		129.94	130.20	3				200.00	4.031	1439.96	
							129.88										
		29	189803.00	9783160.00	1409.86	15-PB1		125.35	125.60	3				200.00	4.161	1422.36	
							120.82										
		30	189851.00	9783050.00	1383.98	15-PB1		117.55	117.78	3				200.00	4.282	1396.48	
							114.27										
		31	189889.00	9782942.00	1356.66	15-PB1		112.14	112.36	3				200.00	4.396	1369.16	
							110.00										
		32	189933.00	9782840.00	1329.46	15-PB1		107.59	107.80	3				200.00	4.506	1341.96	
							105.17										
AP9	SIP-18	33	189973.00	9782742.00	1308.32	15-PA1		108.86	109.08			6		195.67	4.611	1320.82	Soil investig. point
							112.55										
		34	190023.00	9782642.00	1289.99	15-PB1		111.00	111.22	3				200.00	4.724	1302.49	
							109.44										
		35	190071.00	9782546.00	1272.29	15-PB1		127.17	127.43	3				200.00	4.833	1284.79	
							144.90										
	SIP-19	36	190134.00	9782412.00	1249.46	15-TD1		200.45	200.86			6		200.00	4.978	1262.96	Soil investig. point
							256.00										
		37	190244.00	9782182.00	1251.23	15-TB1		190.98	191.36	3				200.00	5.234	1264.73	
							125.95										
		38	190300.00	9782068.00	1259.34	15-PB1		119.94	120.18	3				200.00	5.360	1271.84	
							113.93										
		39	190350.00	9781966.00	1276.12	15-PB1		116.97	117.20	3				200.00	5.474	1288.62	
							120.00										
		40	190402.00	9781858.00	1297.46	15-PB1		110.63	110.85	3				200.00	5.594	1309.96	
							101.26										
		41	190449.00	9781766.00	1316.00	15-PB1		103.79	104.00	3				200.00	5.695	1328.5	
							106.32										
AP10		42	190493.00	9781672.00	1324.90	15-TD1		168.83	169.17			6		169.15	5.801	1338.4	
							231.33										
AP11	SIP-20	43	190484.00	9781440.00	1337.36	15-TD1+2		116.17	116.40			3			6.033	1352.86	Soil investig. point
							1										Kabuga RMU

TOWERS LIST OF THE 110 KV H.V. LINE FROM BIREMBO - GASOGI LINE TO NDERA SUBSTATION

Angle Point	SIP	Tower n°	Coordinates			Tower type	Span (m)			Insulator sets				Angle of the line in grade ^{gr}	Length of the line (km)	Altitude of lower cond. at atmt point	Remarks
			East	North	Altitude		line	wind	weight	SS	SD	ST	DT				
EXISTING LINE REROUTED																	
							1.00									Existing tension tower	
		211	183893.00	9787801.00	1651.98	TENSION							189.94	0.000	1669.43		
							229.74	115.37									
AP1	SIP-1	1	184120.00	9787770.00	1613.04	110-E1				97.75			200.00	0.230	1626.24	Connection to the existing line	
							376.52	303.13									
		213	184496.00	9787720.00	1573.44	SUSPENSION							200.00	0.606	1585.94	Existing susp. tower	
NEW LINE																	
							1.00								1626.24		
AP1	SIP-1	1	184120.00	9787770.00	1613.04	110-E1			15.79			6	6	0	0.000	1626.24	Connection to the existing line
							73.43	36.715									
AP2		2	184086.21	9787707.51	1611.86	110-B2				316.47			12	191.66	0.073	1626.86	
							302.23	187.83									
	SIP-2	3	184021.24	9787407.55	1596.04	110-A2			201.68	6			200.00	0.376	1614.04	Soil investigation point	
							301.14	301.685									
	SIP-3	4	183942.36	9787116.93	1595.12	110-A2			195.90	6			200.00	0.677	1613.12	Soil investigation point	
							179.45	240.295									
AP3	SIP-4	5	183890.00	9786940.00	1597.70	110-D2			158.71			12	186.43	0.856	1615.7	Soil investigation point	
							205.82	192.635									
AP4	SIP-5	6	183709.00	9786836.00	1603.40	110-B2			396.60			12	194.79	1.062	1621.4	Soil investigation point	
							372.96	289.39									
AP5	SIP-6	7	183428.55	9786574.26	1597.90	110-B2			449.33			12	157.70	1.435	1615.9	Soil investigation point	
							184.55	278.755									
	SIP-7	8	183266.29	9786451.30	1585.73	110-A2			211.85	6			200.00	1.620	1600.73	Soil investigation point	
							205.02	194.785									
AP6	SIP-8	9	183091.00	9786401.00	1567.48	110-B2			59.59			12	172.80	1.825	1582.48	Soil investigation point	
							172.24	188.63									
AP7	SIP-9	10	182938.00	9786331.00	1557.91	110-D2			652.86			12	157.70	1.997	1575.91	Soil investigation point	
							78.69	125.465									
GANTRY	SIP-21	11	182886.39	9786206.93	1548.52	GANTRY			-584.33		6			2.076	1556.52	Soil investigation point	
							1									Ndera Substation	
															1556.52		

TOWERS LIST OF THE 15 KV DOUBLE CIRCUIT LINE & 15kV RUBUNGO- GISHAKA SINGLE LINE REROUTED

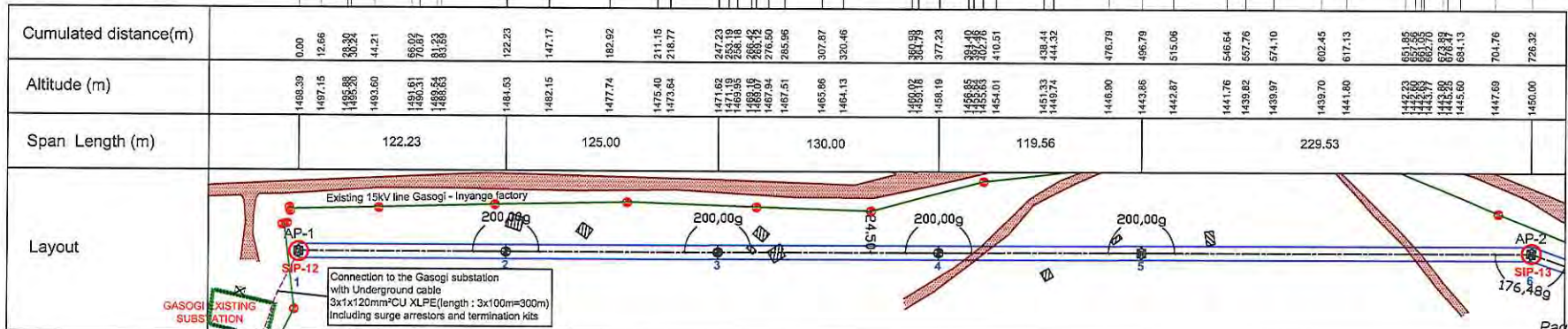
Angle Point	SIP	Tower n°	Coordinates			Tower type	Span (m)			Insulator sets				Angle of the line in grade [°]	Length of the line (km)	Altitude of lower cond. at atmt point	Remarks
			East	North	Elevation		line	wind	weight	SS	SD	ST	DT				
15 KV DOUBLE CIRCUIT DISTRIBUTION LINE																	
															1557.68		
							1.00										
A1	SIP-27	1	182841.47	9786199.73	1542.68	15-TD2		81.32	81.48			6			0.000	1557.68	Connection to the existing line
							161.63										
A2		2	182744.00	9786070.00	1534.52	15-TB2		172.29	172.64			6	6	199.70	0.162	1549.52	
							182.95										
A3	SIP-10	3	182637.00	9785922.00	1506.00	15-TB2		210.68	211.11				12	169.21	0.345	1524	
							238.41										
A4	SIP-11	4	182605.38	9785685.75	1485.50	15-TD2		119.71	119.95				6		0.583	1503.5	Connection to the existing line
							1.00										
															1503.5		
15 KV SINGLE CIRCUIT LINE RUBUNGO - GISHAKA REROUTED																	
															1554.96		
							1.00										
Ex. Tower	Ex. Tower		182748.07	9786105.90	1539.46	TENSION		103.84	104.05					141.87	0.000	1554.96	Existing tower
							206.67										
	1R		182873.31	9786267.73	1552.32	15-TD1		143.24	143.53				6	187.40	0.207	1565.82	
							79.81										
	2R		182908.29	9786347.31	1561.22	15-PA1		118.43	118.67				6	156.35	0.286	1573.72	
							157.05										
Ex. Tower	Ex. Tower		183050.01	9786409.74	1570.84	TENSION		79.03	79.19					197.02	0.444	1582.34	Existing tower
							1										
															1582.34		

LEGEND	
	Ground level in the line axis
	Approx. ground level at 7m right from the axis
	Approx. Ground level at 7m left from the axis
	Electrical line in project
	Road
	House

1	2	3	4	5	6
Pole type: 110-E1 3DT/3ST 0.000Km	Pole type: 15-PB1 3SS 0.122Km	Pole type: 15-PB1 3SS 0.247Km	Pole type: 15-PB1 3SS 0.377Km	Tower type: 15-TB1 3SS 0.497Km	Tower type: 15-TD1 3ST/3ST 0.726Km

Connection to the Gasogi substation with Underground cable
3x1x120mm²CU XLPE(length : 3x100m=300m)
Including surge arrestors and termination kits

15kV TRANSMISSION LINE
GASOGI - KABUGA
Scale of length : 1/3000
Scale of height : 1/750
Reference height(Rh) : 1433.00



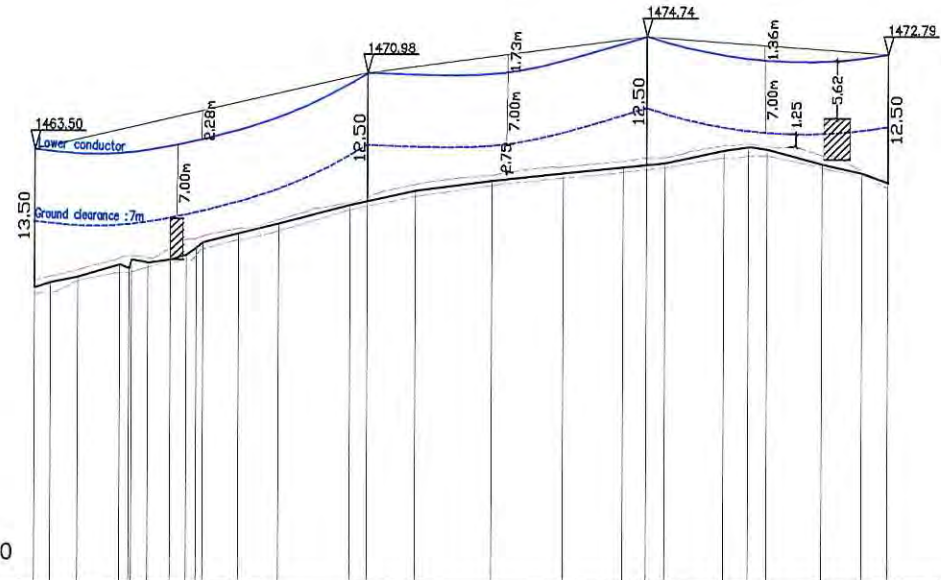
LEGEND	
	Ground level in the line axis
	Approx. ground level at 7m right from the axis
	Approx. Ground level at 7m left from the axis
	Electrical line in project
	Road
	House

6
Tower type:
15-TD1
3ST/3ST
0.726Km

7
Pole type:
15-PB1
3SS
0.856Km

8
Pole type:
15-PB1
3SS
0.965Km

9
Pole type:
15-PA1
3ST/3ST
1.059Km



15kv TRANSMISSION LINE
GASOGI - KABUGA

Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1421.00

Cumulated distance(m)	0.00	6.31	16.92	33.30	37.94	44.29	53.11	59.31	63.18	65.85	79.72	95.34	123.31	130.00	148.75	178.67	206.65	230.03	239.16	246.35	269.43	279.12	286.36	307.88	323.41	333.51		
Altitude (m)	1450.00	1450.51	1451.03	1452.27	1452.72	1452.46	1452.75	1453.20	1453.91	1454.46	1455.32	1456.28	1458.11	1458.48	1459.51	1460.48	1461.22	1461.81	1462.05	1462.24	1463.45	1463.81	1463.55	1462.11	1461.22	1460.29		
Span Length (m)				130.00											109.16								94.35					
Layout																												

LEGEND

- Ground level in the line axis
- - - - - Approx. ground level at 7m right from the axis
- - - - - Approx. ground level at 7m left from the axis
- — — — — Electrical line in project
- Road
- House

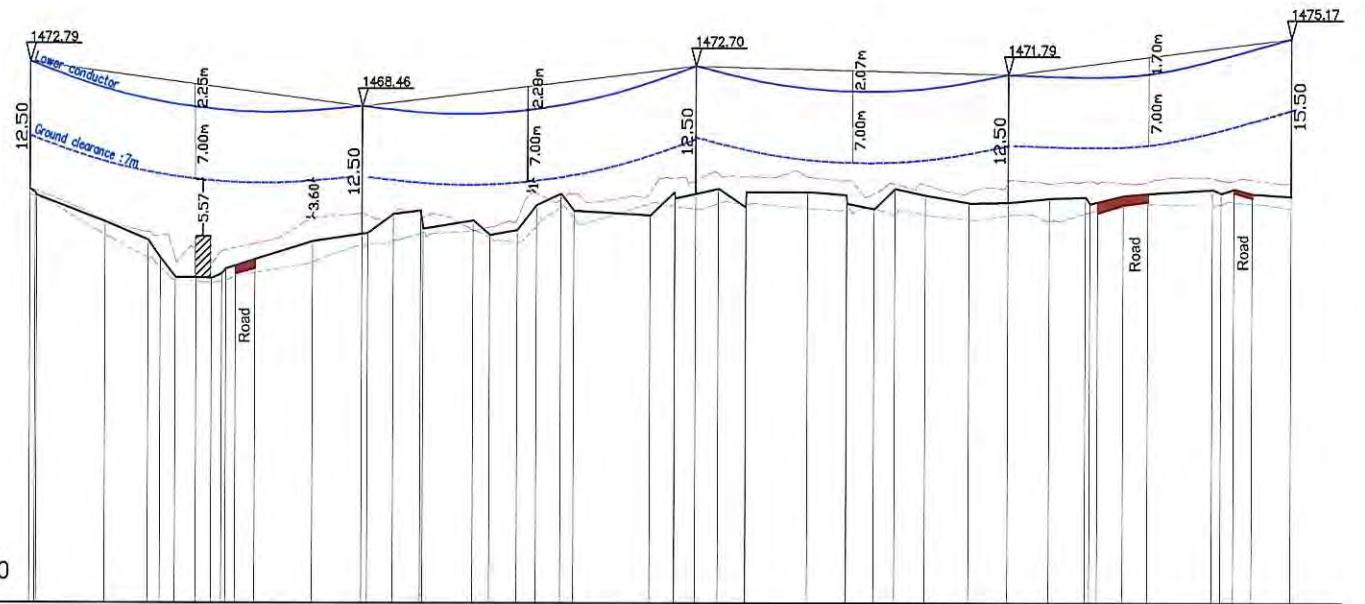
9	10	11	12	13
Pole type: 15-PA1 3ST/3ST 1.059Km	Pole type: 15-PB1 3SS 1.189Km	Pole type: 15-PB1 3SS 1.319Km	Pole type: 15-PB1 3SS 1.441Km	Tower type: 15-TD1+2 3ST/3ST 1.551Km

15kV TRANSMISSION LINE
GASOGI - KABUGA

Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1420.00



Cumulated distance(m)	0.00 1.95	29.23	46.25 50.61 56.78	64.88 70.82 74.83 76.51	110.41	129.61 131.78	141.81 152.41 153.43	172.99 179.41 190.18	197.58 207.04 212.20	241.94 251.38 259.61	268.51 279.15	303.43	318.41	329.39	337.53	349.32	366.51	381.65	397.75	411.84 413.81	426.65 436.19	461.35 464.75 469.68	476.71	491.91
Altitude (m)	1460.29 1459.95	1457.10	1455.30 1453.84 1451.69	1451.66 1451.60 1452.06 1452.53	1455.21	1455.96 1456.04	1457.92 1458.25 1456.48	1457.30 1455.85 1456.34	1458.78 1459.89 1458.22	1457.77 1460.06 1460.20	1460.43 1458.55	1460.11	1459.80	1458.40	1460.43	1459.75	1458.99	1459.09	1459.47	1458.61 1458.85	1459.75 1460.42	1460.32 1459.90	1459.87	1459.67
Span Length (m)			129.61				130.00						122.04							110.26				
Layout																								

LEGEND

- Ground level in the line axis
- Approx. ground level at 7m right from the axis
- Approx. Ground level at 7m left from the axis
- Electrical line in project
- Road
- House

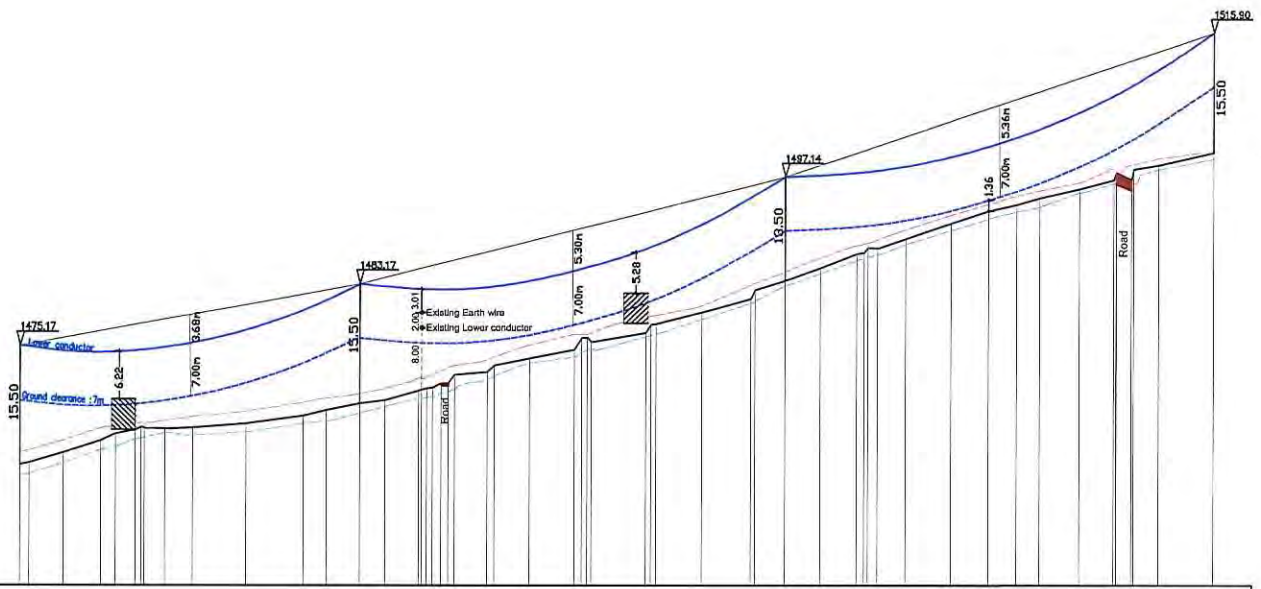
13 Tower type: 15-TD1+2 3ST/3ST 1.551Km	14 Tower type: 15-TB1+2 3SD 1.728Km	15 Tower type: 15-TB1 3SD 1.949Km	16 Tower type: 15-TD1+2 3ST/3DT 2.172Km
-----------------------------------------------------	-------------------------------------------------	-----------------------------------------------	-----------------------------------------------------

15Kv TRANSMISSION LINE
GASOGI - KABUGA

Scale of length : 1/3000

Scale of height : 1/750

Reference height(Rh) : 1444.00



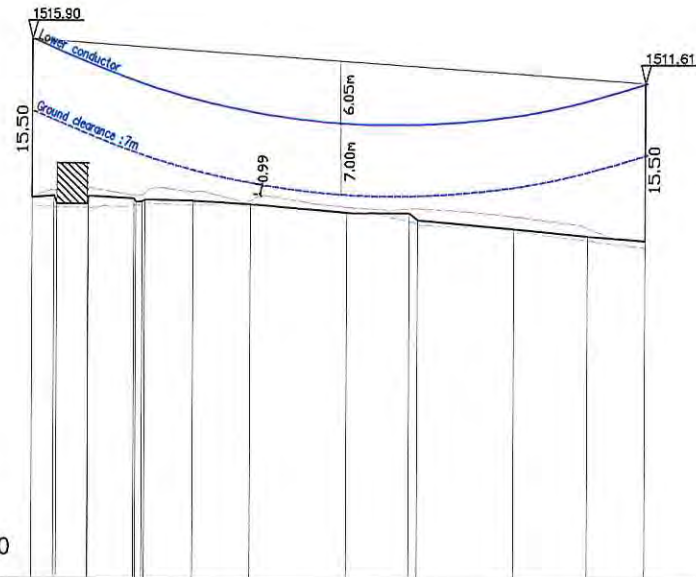
Cumulated distance(m)	Altitude (m)	Span Length (m)	Layout
0,00 4,73	1459,87 1459,80		
22,63	1461,25		
42,13	1462,95	176,74	
49,81	1463,72		
60,03	1464,17		
64,68	1464,30		
75,30	1464,30		
89,91	1464,48		
117,74	1465,01		
147,53	1466,05		
159,47	1466,80		
176,74	1467,67		
189,84	1468,07		
207,29	1468,74		
215,00	1468,97		
226,63	1470,33		
242,94	1472,61	221,17	
264,98	1473,51		
283,73	1476,99		
297,16	1475,66		
335,43	1476,88		
354,58	1479,52		
383,25	1482,42		
397,91	1483,64		
416,16	1485,28		
435,14	1487,16		
441,02	1487,94		
446,05	1487,85		
460,55	1489,09		
484,29	1491,13		
503,78	1492,78		
518,44	1493,51		
530,31	1494,42		
551,10	1495,65		
566,90	1497,29		
576,92	1498,91		
592,21	1498,72		
620,60	1500,40		

LEGEND

- Ground level in the line axis
- Approx. ground level at 7m right from the axis
- Approx. Ground level at 7m left from the axis
- Electrical line in project
- Road
- House

16
Tower type:
15-TD1+2
3ST/3DT
2.172Km

17
Tower type:
15-TD1+2
3DT/3ST
2.412Km



**15Kv TRANSMISSION LINE
GASOGI - KABUGA**

Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1463.00

Cumulated distance(m)	0.00 15.53 31.06 46.59 62.12 77.65 93.18 108.71 124.24 139.77 155.30 170.83 186.36 201.89 217.42 232.95 248.48 264.01 279.54 295.07
Altitude (m)	1500.40 1500.61 1499.80 1499.78 1500.28 1500.26 1500.26 1500.06 1499.71 1498.86 1498.81 1498.18 1497.32 1496.60 1496.11
Span Length (m)	239.83
Layout	

LEGEND

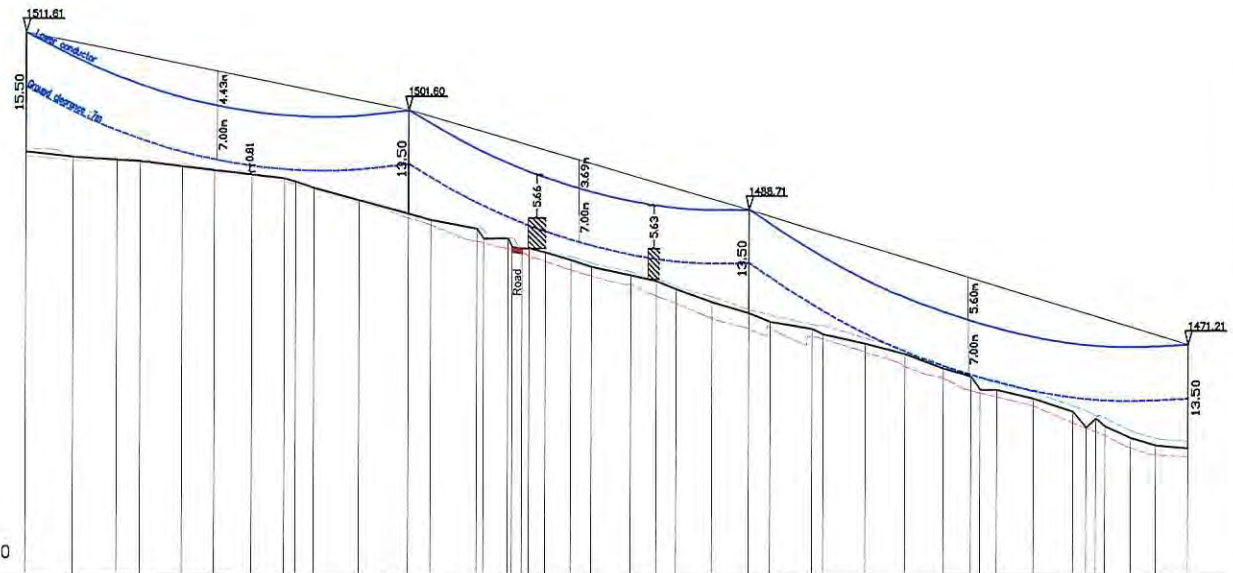
- Ground level in the line axis
- - - - - Approx. ground level at 7m right from the axis
- - - - - Approx. Ground level at 7m left from the axis
- — — — — Electrical line in project
- — — — — Road
- House

17
Tower type:
15-TD1+2
3DT/3ST
2.412Km

18
Tower type:
15-TB1
3SD
2.611Km

19
Tower type:
15-TB1
3SD
2.788Km

20
Tower type:
15-TD1
3ST/3ST
3.016Km



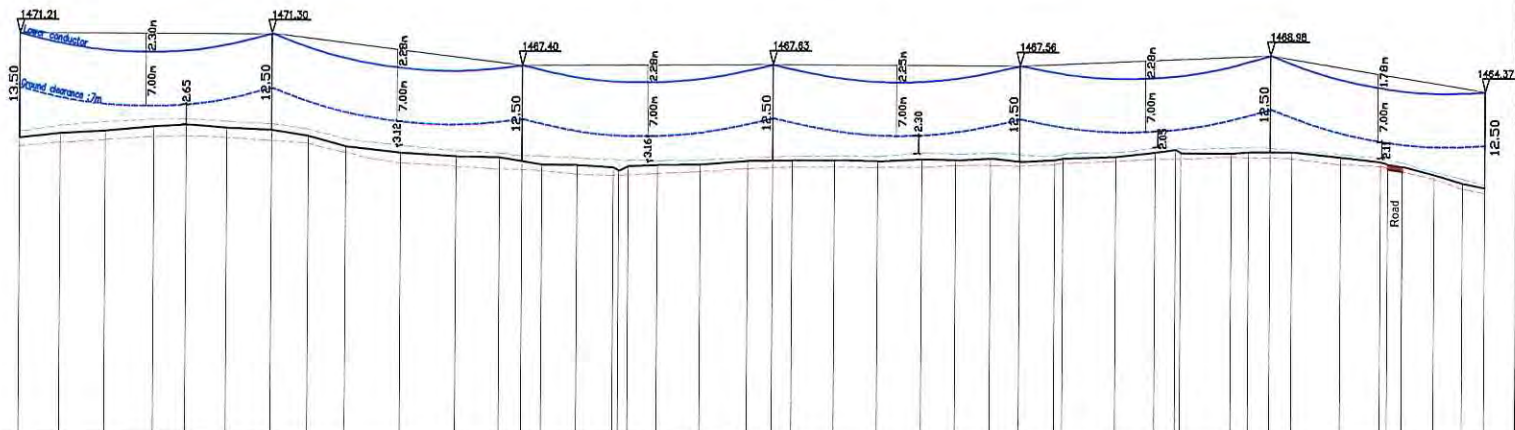
15kV TRANSMISSION LINE
GASOGI - KABUGA
Scale of length : 1/3000
Scale of height : 1/750
Reference height(Rh) : 1441.00

Cumulated distance(m)	0.00	24.73	47.39	59.57	81.34	98.10	117.55	134.63	140.39	149.91	173.90	189.96	210.66	234.61	250.74	267.08	270.15	283.61	284.17	314.72	327.83	338.22	356.93	376.04	387.27	409.07	414.85	436.82	457.37	477.40	494.63	505.92	524.34	544.74	551.63	567.20	574.73	587.67	604.30
Altitude (m)	1486.11	1495.44	1495.07	1484.92	1494.21	1493.73	1493.18	1492.69	1492.25	1491.49	1489.85	1488.10	1487.33	1486.20	1485.00	1483.08	1482.06	1481.23	1480.15	1478.39	1476.35	1476.64	1475.21	1474.09	1473.18	1472.47	1471.26	1469.92	1468.06	1467.01	1465.28	1464.16	1462.47	1460.36	1458.59	1459.04	1458.07	1457.71	
Span Length (m)					198.96									177.08														228.26											
Layout	<p>The layout view shows the horizontal alignment of the transmission line. It includes tower locations (AP-6, AP-7), sag values (186,53g, 200,00g), and a structure labeled SIP-16. The line is shown as a solid line with sag curves, and the terrain is indicated by a shaded area.</p>																																						

LEGEND

- Ground level in the line axis
- - - - - Approx. ground level at 7m right from the axis
- - - - - Approx. Ground level at 7m left from the axis
- — — — — Electrical line in project
- Road
- House

20	21	22	23	24	25	26
Tower type: 15-TD1 3ST/3ST 3.016Km	Pole type: 15-PB1 3SS 3.147Km	Pole type: 15-PB1 3SS 3.277Km	Pole type: 15-PB1 3SS 3.407Km	Pole type: 15-PB1 3SS 3.536Km	Pole type: 15-PB1 3SS 3.666Km	Pole type: 15-PA1 3ST/3ST 3.776Km



15kV TRANSMISSION LINE
GASOGI - KABUGA

Scale of length : 1/3000

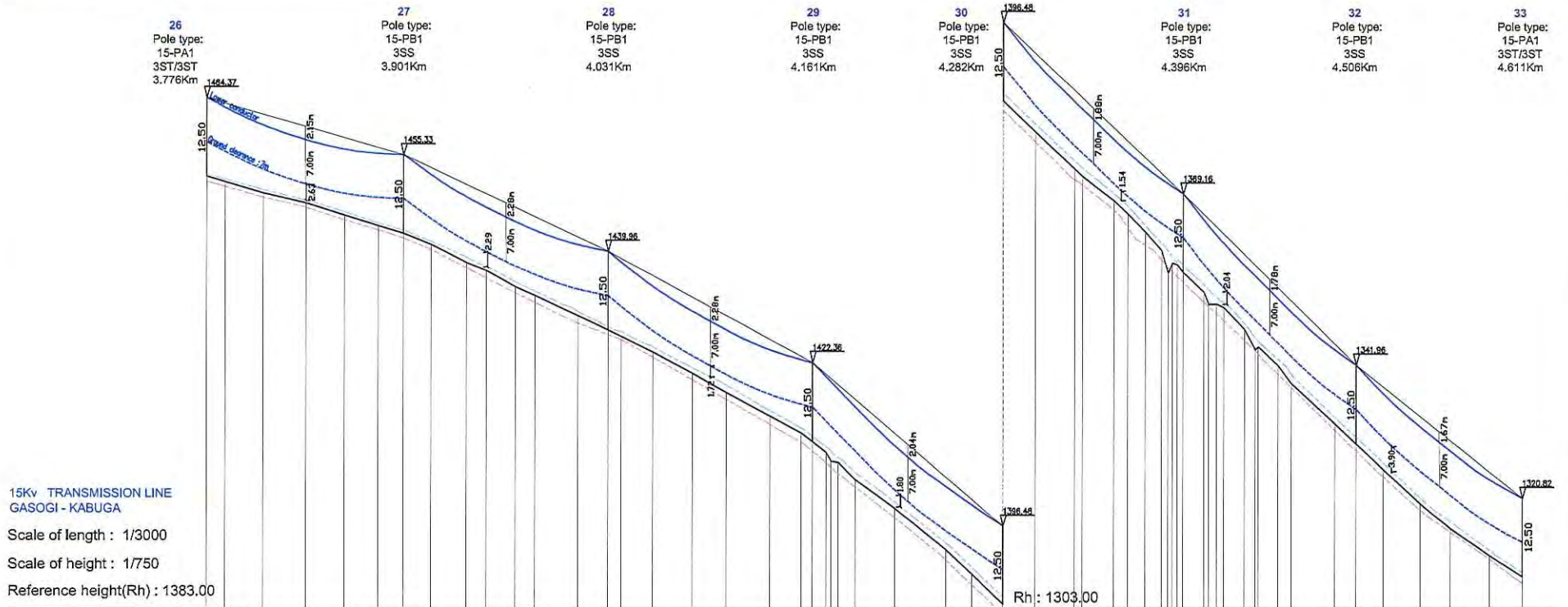
Scale of height : 1/750

Reference height(Rh) : 1419.00

Cumulated distance(m)	0.00	1489.29	1490.03	1489.17	1489.47	1489.03	1488.80	1489.02	1486.70	1485.92	1455.53	1455.38	1454.90	1454.47	1454.41	1454.11	1453.73	1454.48	1454.58	1455.10	1455.13	1455.15	1455.21	1455.08	1455.39	1455.28	1455.51	1455.06	1455.33	1455.61	1456.36	1456.75	1466.30	1466.47	1466.48	1455.76	1455.00	1454.61	1453.50	1452.45	1451.87			
Altitude (m)	1457.71	1489.29	1490.03	1489.17	1489.47	1489.03	1488.80	1489.02	1486.70	1485.92	1455.53	1455.38	1454.90	1454.47	1454.41	1454.11	1453.73	1454.48	1454.58	1455.10	1455.13	1455.15	1455.21	1455.08	1455.39	1455.28	1455.51	1455.06	1455.33	1455.61	1456.36	1456.75	1466.30	1466.47	1466.48	1455.76	1455.00	1454.61	1453.50	1452.45	1451.87			
Span Length (m)		130.86							129.97					130.00						128.43							130.00																110.03	
Layout																																												

LEGEND








- Ground level in the line axis
- — — — Approx. ground level at 7m right from the axis
- — — — Approx. Ground level at 7m left from the axis
- Electrical line in project
- Road
- House
- ▨ Forestation



15kV TRANSMISSION LINE
GASOGI - KABUGA
Scale of length : 1/3000
Scale of height : 1/750
Reference height(Rh) : 1383.00

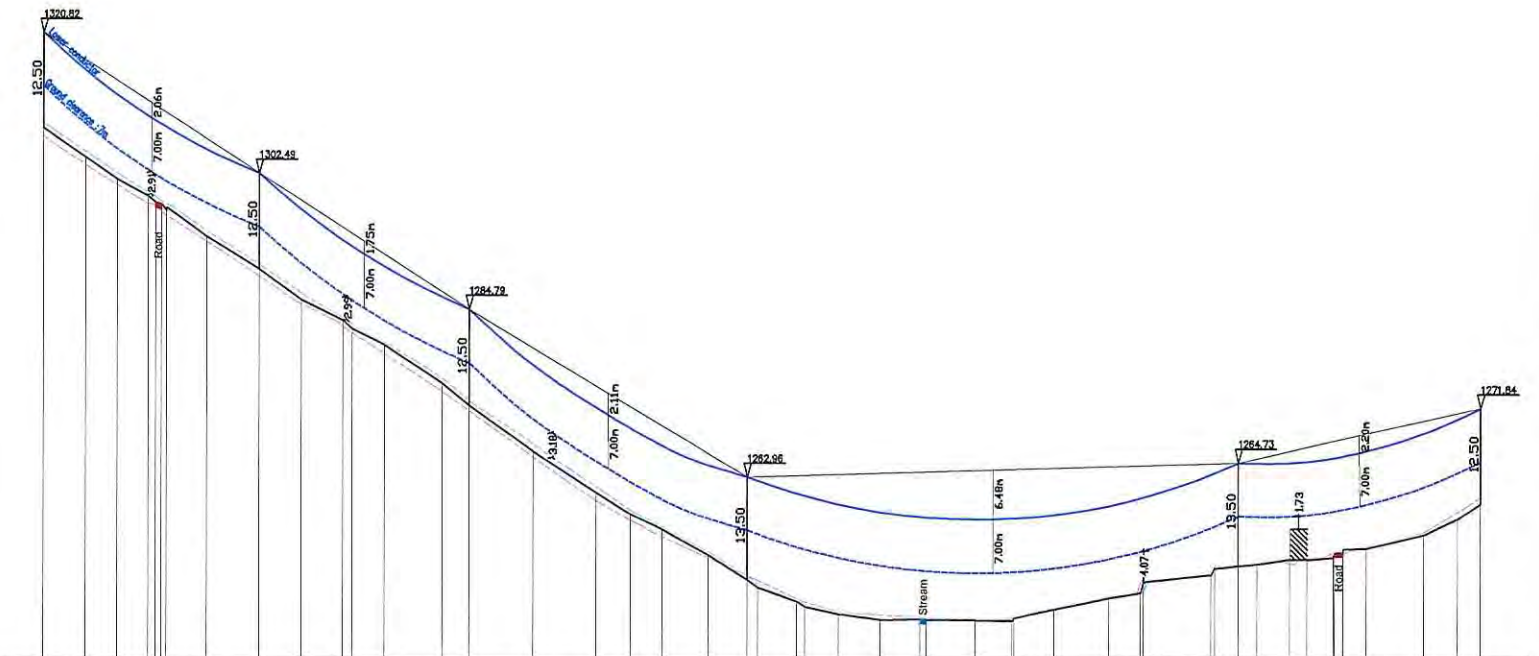
Cumulated distance(m)	0.00	11.69	36.90	63.11	87.69	108.12	126.20	142.85	165.21	177.90	196.32	208.81	236.23	255.20	263.49	263.67	308.89	330.36	358.07	377.88	395.08	408.10	412.20	437.24	469.70	486.28	505.90	526.39	551.27	556.34	576.21	585.14	596.15	608.67	618.17	633.46	641.25	646.06	659.27	669.35	680.56	689.12	716.69	730.17	747.49	770.82	789.82	814.42	835.24								
Altitude (m)	1451.87	1450.98	1449.21	1447.62	1445.67	1444.02	1442.83	1441.03	1438.22	1436.82	1434.33	1432.95	1429.73	1427.46	1426.47	1424.02	1420.69	1417.65	1413.91	1411.22	1409.66	1408.10	1406.58	1403.86	1399.30	1392.68	1388.79	1383.98	1378.69	1373.06	1371.91	1367.09	1365.04	1363.06	1360.42	1357.91	1356.86	1353.81	1351.25	1351.07	1347.60	1344.89	1341.87	1339.05	1332.64	1329.46	1325.37	1319.98	1316.01	1311.73	1308.32						
Span Length (m)		125.20																																																							
Layout																																																									

LEGEND

-  Ground level in the line axis
-  Approx. ground level at 7m right from the axis
-  Approx. Ground level at 7m left from the axis
-  Electrical line in project
-  Road
-  House
-  Forestation

33 Pole type: 15-PA1 3ST/3ST 4.611Km	34 Pole type: 15-PB1 3SS 4.724Km	35 Pole type: 15-PB1 3SS 4.833Km	36 Tower type: 15-TD1 3ST/3ST 4.978Km	37 Tower type: 15-TB1 3SS 5.234Km	38 Pole type: 15-PB1 3SS 5.360Km
--------------------------------------------------	----------------------------------------------	----------------------------------------------	---------------------------------------------------	-----------------------------------------------	----------------------------------------------

15kV TRANSMISSION LINE
GASOGI - KABUGA
Scale of length : 1/3000
Scale of height : 1/750
Reference height(Rh) : 1239.00



Cumulated distance(m)																																							
Altitude (m)	1308.32	1304.53	1301.71	1299.46	1297.55	1294.20	1289.09	1285.99	1283.37	1282.26	1280.16	1275.16	1272.29	1266.27	1260.81	1258.04	1255.04	1252.71	1249.46	1248.49	1246.50	1244.29	1244.29	1244.18	1244.08	1245.89	1247.09	1246.74	1250.02	1251.23	1251.45	1252.09	1252.06	1252.30	1252.94	1253.62	1255.27	1257.34	1259.34
Span Length (m)		112.55		109.44			144.90					256.00					125.95																						
Layout																																							

LEGEND

- Ground level in the line axis
- Approx. ground level at 7m right from the axis
- Approx. Ground level at 7m left from the axis
- Electrical line in project
- Road
- House
- Forestation

38
Pole type:
15-PB1
3SS
5.360Km

39
Pole type:
15-PB1
3SS
5.474Km

40
Pole type:
15-PB1
3SS
5.594Km

41
Pole type:
15-PB1
3SS
5.695Km

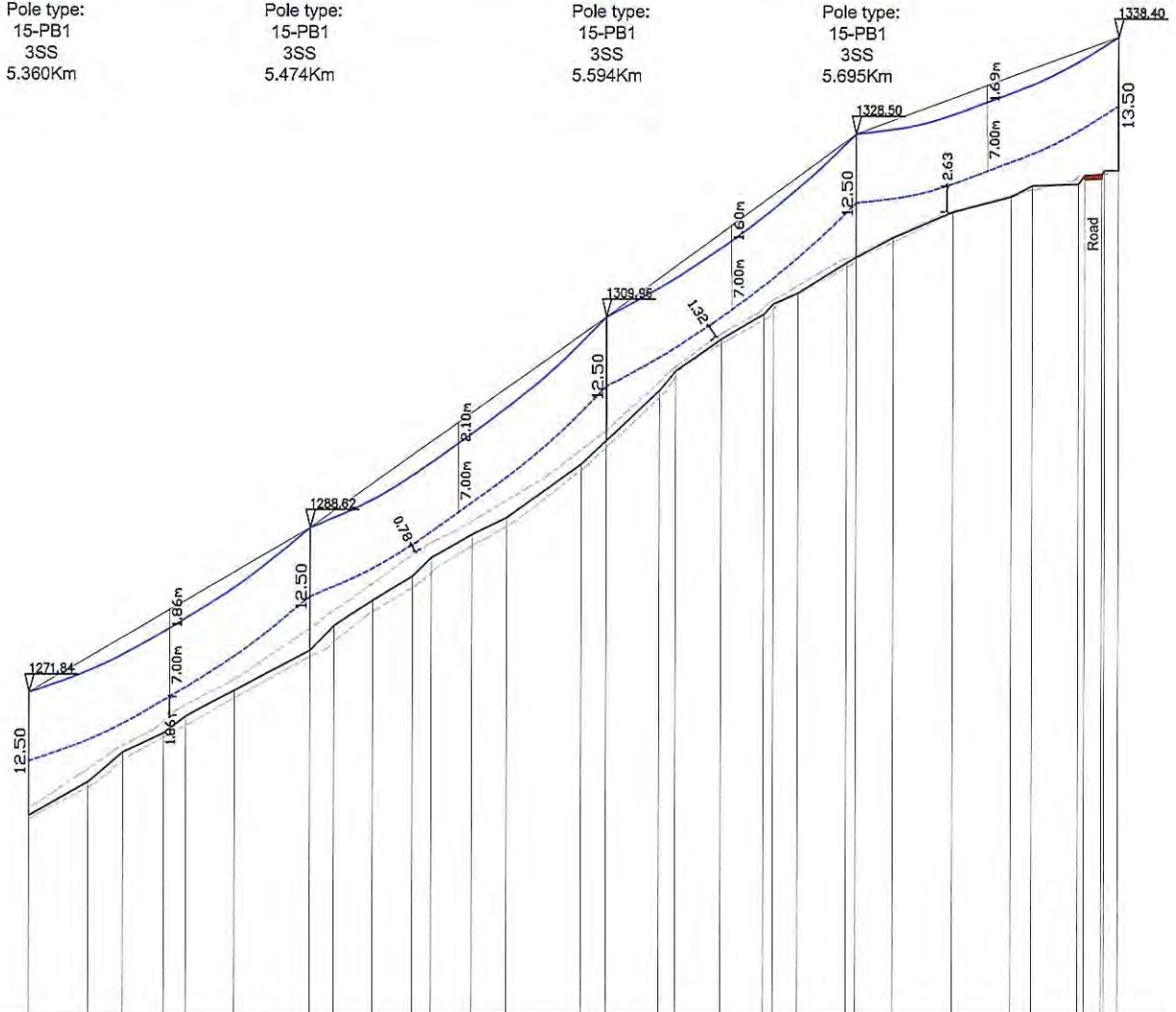
42
Tower type:
15-TD1
3DT/3DT
5.801Km

15kV TRANSMISSION LINE
GASOGI - KABUGA

Scale of length : 1/2000








Scale of height : 1/500

Reference height(Rh) : 1239.00



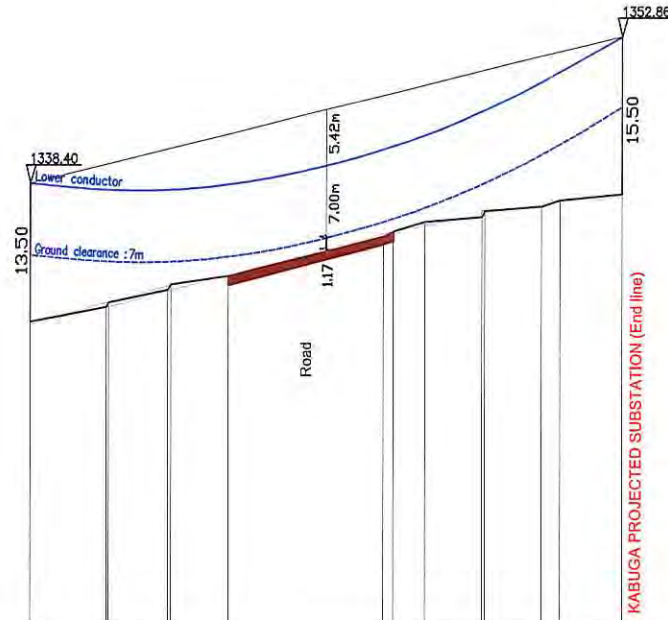
Cumulated distance(m)	748.84	772.90	786.92	803.59	812.53	832.27	862.77	872.54	888.32	904.32	911.97	928.47	942.47	972.72	982.77	1004.23	1010.82	1029.27	1046.56	1050.82	1060.55	1088.03	1099.17	1123.34	1147.12	1155.46	1174.16	1183.97	1184.91	1186.35	
Altitude (m)	1259.34	1262.74	1265.74	1267.72	1269.40	1272.05	1276.12	1278.65	1281.24	1283.72	1285.58	1287.95	1289.64	1295.07	1297.46	1302.45	1304.49	1307.68	1310.27	1311.27	1312.38	1315.43	1318.04	1320.62	1322.18	1323.30	1323.50	1323.79	1324.86	1324.91	1324.96
Span Length (m)		113.93					120.00					101.26					106.32														
Layout																															

LEGEND

-  Ground level in the line axis
-  Approx. ground level at 7m right from the axis
-  Approx. Ground level at 7m left from the axis
-  Electrical line in project
-  Road
-  House
-  Forestation

42
Tower type:
15-TD1
3DT/3DT
5.801Km

43
Tower type:
15-TD1+2
3DT/—
6.033Km



15Kv TRANSMISSION LINE
GASOGI - KABUGA

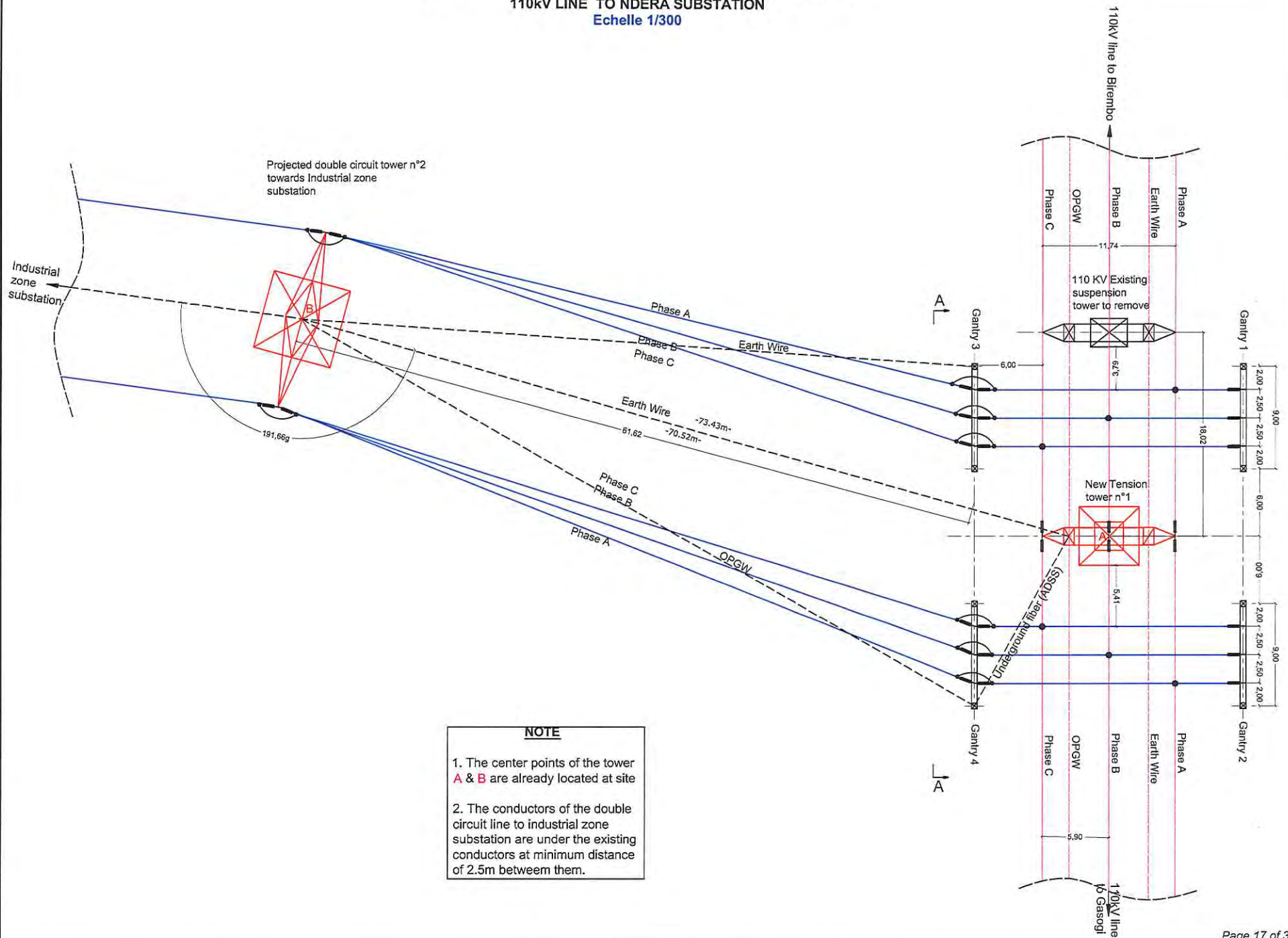
Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1295.00

Cumulated distance(m)	0.00	29.77	58.56	77.43	135.02	141.90	154.29	176.83	198.84	207.09	231.33
Altitude (m)	1324.90	1326.40	1328.03	1329.41	1333.25	1333.86	1334.65	1335.76	1336.17	1336.76	1337.36
Span Length (m)	231.33										
Layout											

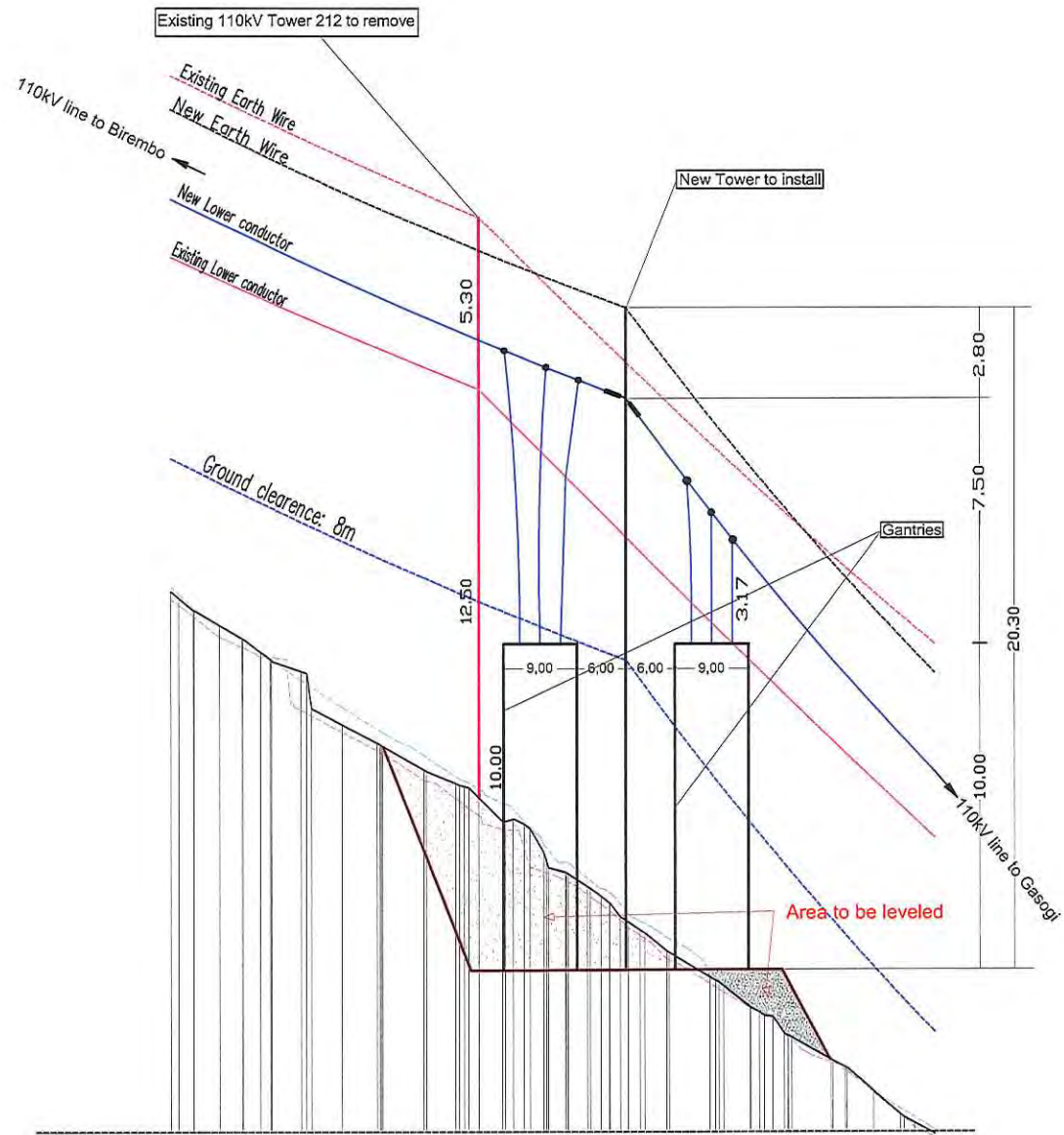
**CONNECTION OF 110kV DOUBLE CIRCUIT LINE FROM EXISTING
110kV LINE TO NDERA SUBSTATION**
Echelle 1/300



NOTE

1. The center points of the tower **A** & **B** are already located at site
2. The conductors of the double circuit line to industrial zone substation are under the existing conductors at minimum distance of 2.5m between them.

CONNECTION OF 110kV DOUBLE CIRCUIT LINE FROM EXISTING
 110kV LINE TO NDERA SUBSTATION
 Scale : 1/300

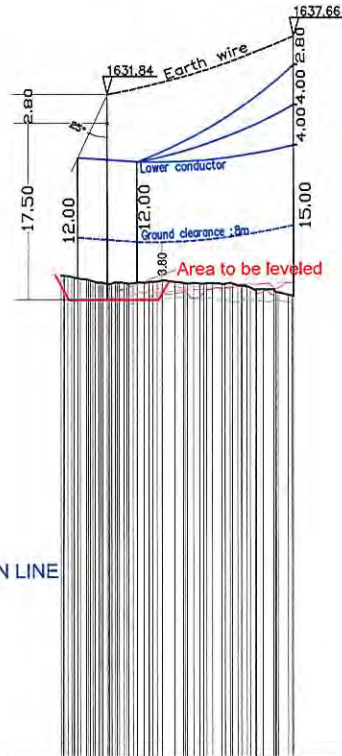


SECTION A-A

LEGEND

- Right ground level at 10m from axis
- Right ground level at 5m from axis
- Axis ground level
- Left ground level at 10m from axis
- Left ground level at 5m from axis
- Soil Investigation Point

Tower n°1	Tower n°2
Type : 110-E1	Type : 110-B2
6DT/6ST	6ST/6ST
0.00Km	0.073Km



110kV DOUBLE CIRCUIT TRANSMISSION LINE TO NDERA SUBSTATION

Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1566.00

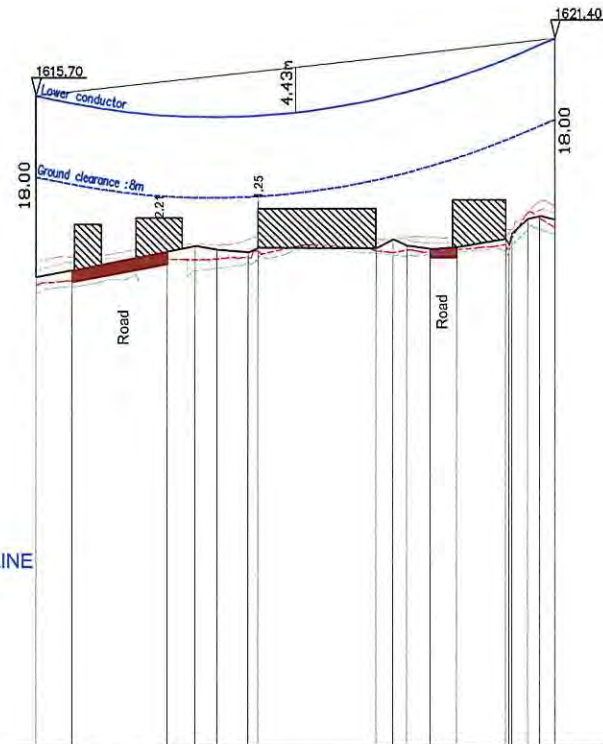
Cumulated distance(m)	0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00 40.00 45.00 50.00 55.00 60.00 65.00 70.00 75.00 80.00 85.00 90.00
Altitude (m)	1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66 1637.66
Span Length (m)	73.43
Layout	

LEGEND

- Right ground level at 10m from axis
- Right ground level at 5m from axis
- Axis ground level
- Left ground level at 10m from axis
- Left ground level at 5m from axis
- SIP
Soil Investigation Point

Tower n°5
Type : 110-D2
6DT/6DT
0.856Km

Tower n°6
Type : 110-B2
6DT/6DT
1.062Km



110Kv DOUBLE CIRCUIT TRANSMISSION LINE TO NDERA SUBSTATION

Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1551.00

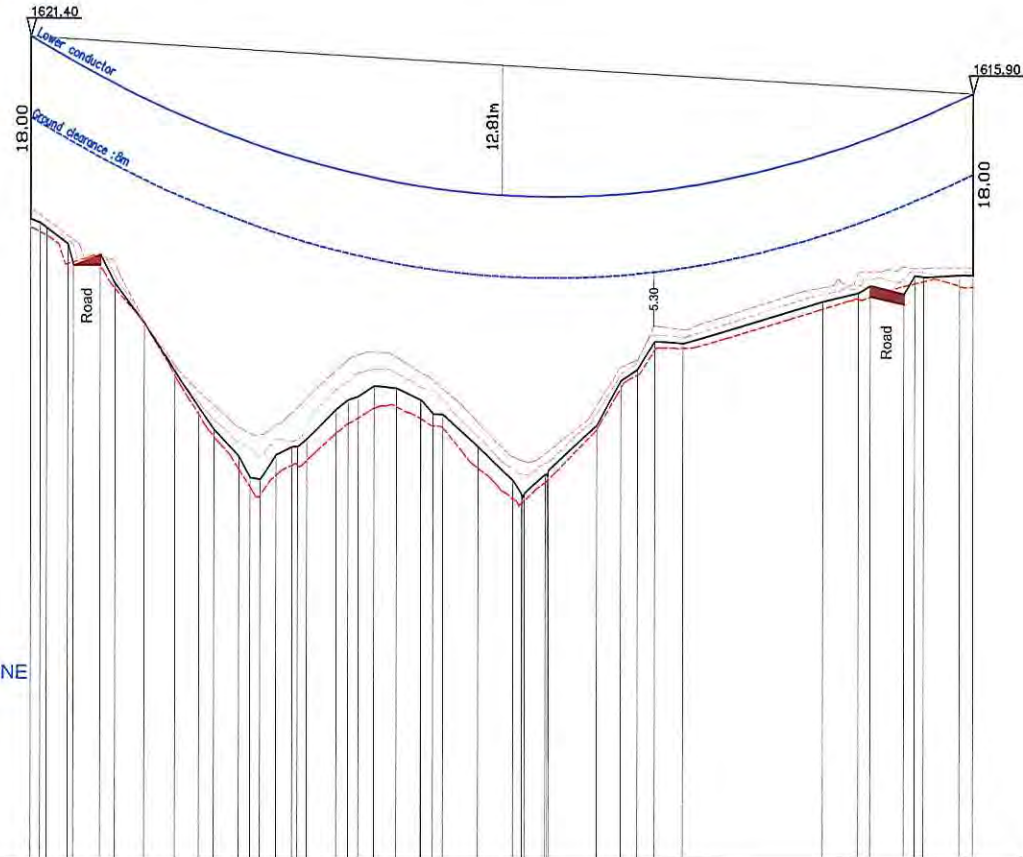
Cumulated distance(m)	0.000	63.156	71.795	84.871	88.068	134.888	141.488	147.085	156.300	166.839	186.468	188.768	196.737	205.817
Altitude (m)	1597.70	1600.76	1600.37	1600.16	1600.56	1600.50	1601.41	1600.77	1600.47	1600.65	1601.43	1602.92	1603.80	1603.40
Span Length (m)		205.82												
Layout														

LEGEND

- Right ground level at 10m from axis
- - - Right ground level at 5m from axis
- Axis ground level
- - - Left ground level at 10m from axis
- Left ground level at 5m from axis
- Soil Investigation Point

Tower n°6
Type : 110-B2
6DT/6DT
1.062Km

Tower n°7
Type : 110-B2
6DT/6DT
1.435Km



110Kv DOUBLE CIRCUIT TRANSMISSION LINE TO NDERA SUBSTATION

Scale of length : 1/2000
Scale of height : 1/500
Reference height(Rh) : 1540.00

Cumulated distance(m)	0,000 2,358 16,774 27,514 33,442 44,973 57,195 66,605 72,515 82,403 86,819 87,135 103,308 108,385 109,340 120,897 125,625 135,667 144,802 154,199 159,196 163,045 177,024 190,824 185,325 204,882 223,976 233,502 240,188 246,924 258,065 313,616 327,597 332,256 345,651 350,816 353,449 367,629 372,956
Altitude (m)	1603.49 1603.56 1601.00 1601.98 1599.99 1597.08 1593.25 1588.39 1584.86 1582.68 1580.03 1577.92 1580.19 1580.89 1581.00 1581.79 1584.72 1582.64 1582.00 1587.02 1585.62 1584.24 1584.19 1580.96 1577.80 1576.38 1576.69 1583.16 1587.53 1588.63 1591.41 1591.18 1595.36 1586.19 1586.92 1586.05 1587.90 1587.75 1597.97 1597.90
Span Length (m)	372.96
Layout	

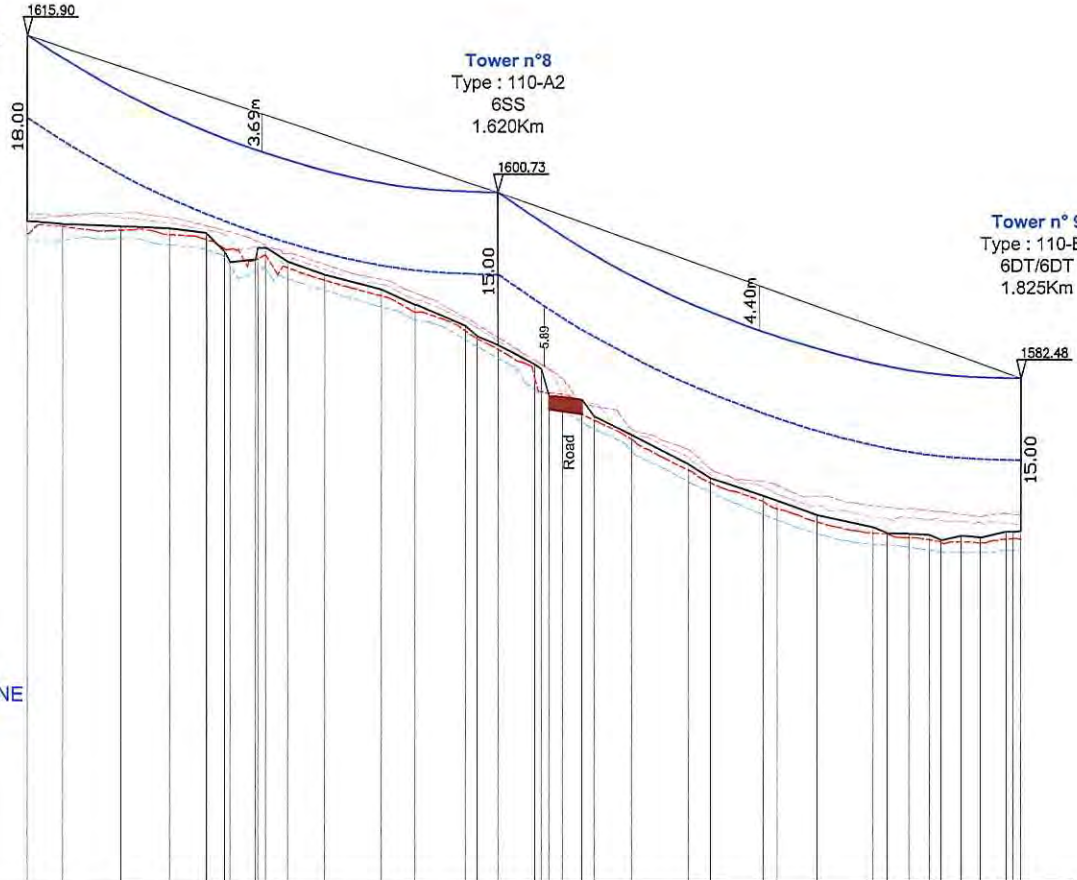
LEGEND

- Right ground level at 10m from axis
- Right ground level at 5m from axis
- Axis ground level
- Left ground level at 10m from axis
- Left ground level at 5m from axis
- Soil Investigation Point

Tower n°7
Type : 110-B2
6DT/6DT
1.435Km

Tower n°8
Type : 110-A2
6SS
1.620Km

Tower n°9
Type : 110-B2
6DT/6DT
1.825Km



110kV DOUBLE CIRCUIT TRANSMISSION LINE TO NDERA SUBSTATION

Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1533.00

Cumulated distance(m)	0.000	13.949	36.751	55.845	70.192	77.428	79.569	89.645	93.433	102.129	116.723	138.835	152.013	171.753	176.381	184.546	198.884	201.481	206.876	217.366	222.111	236.882	259.251	267.719	288.613	294.036	309.673	331.601	337.150	345.676	353.830	368.254	366.086	373.636	388.837	389.568			
Altitude (m)	1597.90	1597.63	1597.40	1597.21	1596.78	1594.98	1593.96	1594.23	1595.38	1593.99	1592.69	1591.28	1589.78	1587.71	1586.67	1585.73	1583.85	1583.45	1580.92	1580.41	1578.75	1576.97	1574.08	1572.67	1570.94	1570.49	1569.06	1567.83	1567.23	1567.18	1567.08	1566.55	1566.98	1566.82	1567.47	1567.48			
Span Length (m)					184.55												205.02																						
Layout																																							

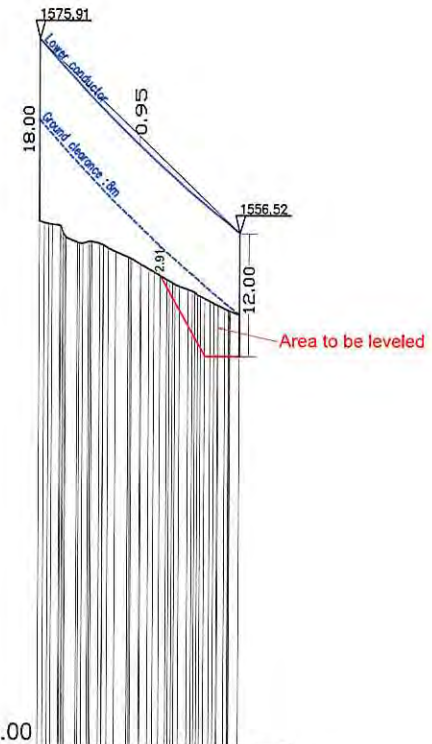
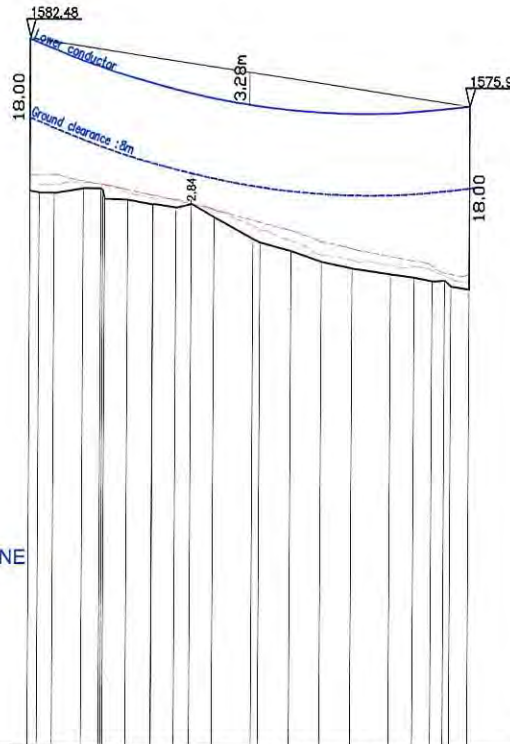
LEGEND

- Right ground level at 10m from axis
- Right ground level at 5m from axis
- Axis ground level
- Left ground level at 10m from axis
- Left ground level at 5m from axis
- SIP
Soil Investigation Point

Tower n° 9
Type : 110-B2
6DT/6DT
1.825Km

Tower n° 10
Type : 110-D2
6DT/6DT
1.997Km

11
Type : GANTRY
6ST
2.076Km



110kV DOUBLE CIRCUIT TRANSMISSION LINE
TO NDERA SUBSTATION

Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1513.00

Rh : 1506.00

Cumulated distance(m)	0,000 3,530 3,512 20,859 27,763 29,252 38,273 48,134 57,280 63,216 72,209 87,417 86,417 102,402 114,366 126,316 141,386 150,620 157,672 162,374 168,318 172,238
Altitude (m)	1567,48 1567,32 1567,30 1567,76 1567,76 1566,72 1566,62 1566,16 1565,88 1566,24 1564,91 1562,75 1562,47 1561,64 1560,57 1559,91 1559,34 1559,03 1558,70 1558,18 1557,74 1557,91
Span Length (m)	172.24
Layout	

Cumulated distance(m)	0,00 5,00 10,00 15,00 20,00 23,00 30,00 35,00 43,00 50,00 55,00 60,00 70,00 78,69
Altitude (m)	1575,91 1575,41 1575,15 1575,12 1575,32 1574,76 1574,71 1572,73 1571,99 1571,34 1570,98 1570,98 1570,90 1570,62
Span Length (m)	78.69
Layout	

LEGEND

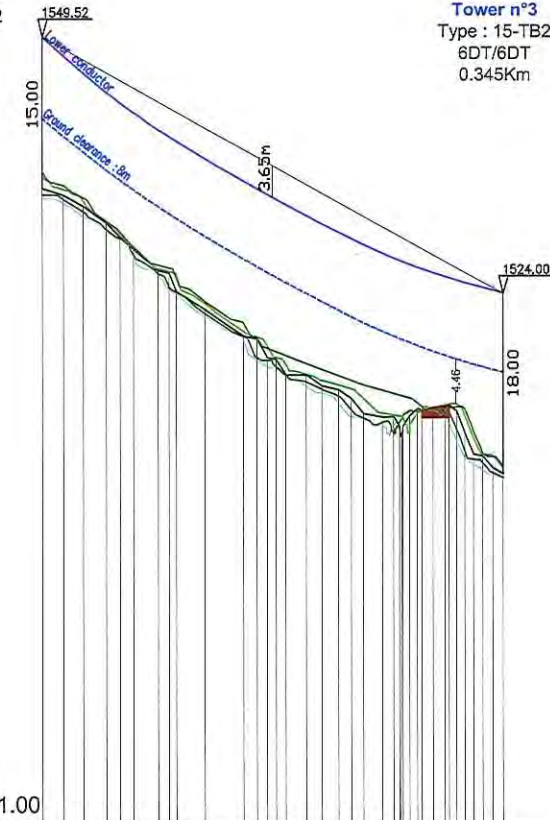
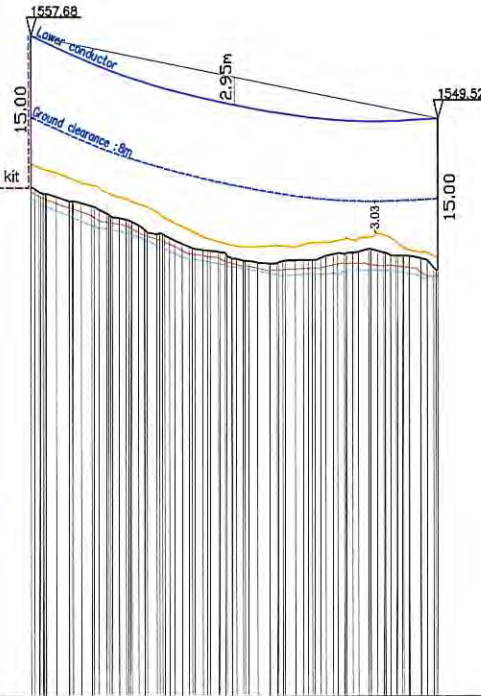
- Right ground level at 10m from axis
- Right ground level at 5m from axis
- Axis ground level
- Left ground level at 10m from axis
- Left ground level at 5m from axis
- SIP
Soil Investigation Point

Connection to the substation
with Underground cable
Circuit 1 : 3x1x240mm²CU XLPE
Circuit 1 : 3x1x240mm²CU XLPE
Including surge arrestors and termination kit

Tower n°1
Type : 15-TD2
6ST
0.000Km

Tower n°2
Type : 15-TB2
6ST/6DT
0.162Km

Tower n°3
Type : 15-TB2
6DT/6DT
0.345Km



15kV DOUBLE CIRCUIT DISTRIBUTION LINE

Scale of length : 1/2000

Scale of height : 1/500






Reference height(Rh) : 1492.00


Rh: 1471.00

Cumulated distance(m)	0.00 5.00 15.00 20.00 26.00 30.00 40.00 50.00 60.00 66.00 70.00 80.00 85.00 90.00 96.00 100.00 110.00 115.00 120.00 130.00 140.00 145.00 150.00 161.63
Altitude (m)	1542.68 1542.97 1541.26 1540.78 1540.65 1539.22 1538.50 1538.03 1537.01 1536.53 1536.36 1536.23 1535.33 1535.15 1535.08 1534.32 1535.41 1535.64 1536.00 1536.25 1536.53 1536.13 1535.92 1535.68 1534.62
Span Length (m)	161.63
Layout	

Cumulated distance(m)	0.000 8.519 16.322 25.465 30.947 36.236 45.987 50.318 64.657 80.021 85.363 89.718 96.823 104.984 111.118 117.741 122.833 127.663 135.107 136.661 146.032 151.832 151.832 160.014 174.305 174.305 182.950
Altitude (m)	1534.52 1533.84 1532.76 1531.11 1528.85 1528.51 1526.38 1526.20 1524.20 1522.40 1519.77 1518.54 1517.94 1515.92 1515.89 1514.77 1514.42 1513.56 1512.01 1511.68 1511.74 1511.83 1512.82 1512.80 1506.00 1507.76 1506.00
Span Length (m)	182.95
Layout	

LEGEND

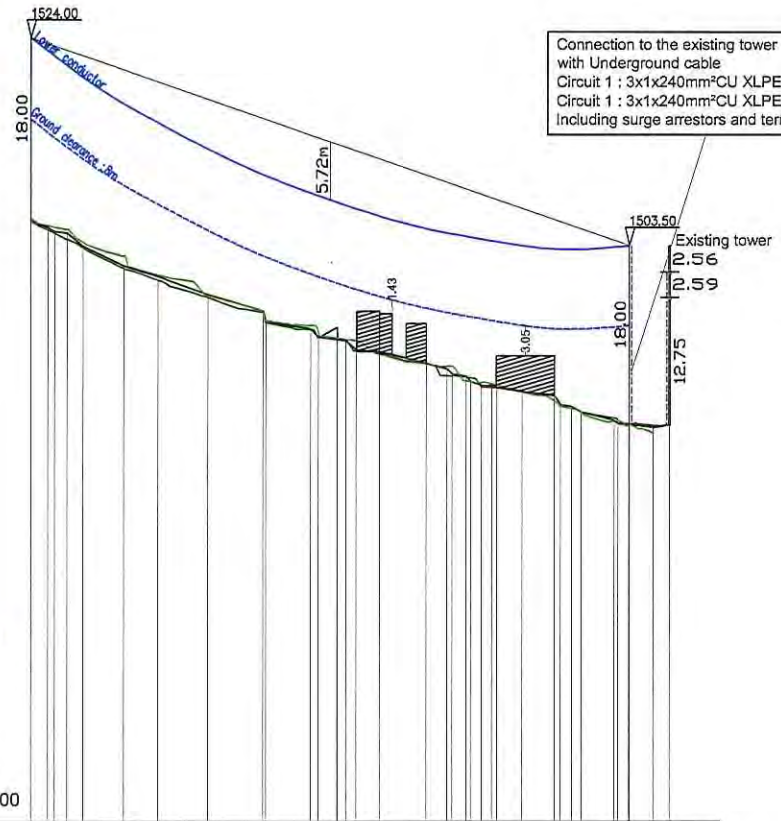
-  Right ground level at 10m from axis
-  Right ground level at 5m from axis
-  Axis ground level
-  Left ground level at 10m from axis
-  Left ground level at 5m from axis

 Soil Investigation Point

Tower n°3
Type : 15-TB2
6DT/6DT
0.345Km

Connection to the existing tower
with Underground cable
Circuit 1 : 3x1x240mm²CU XLPE
Circuit 2 : 3x1x240mm²CU XLPE
Including surge arrestors and termination kit

Tower n°4
Type : 15-TD2
6DT
0.583Km



15kV DOUBLE CIRCUIT DISTRIBUTION LINE

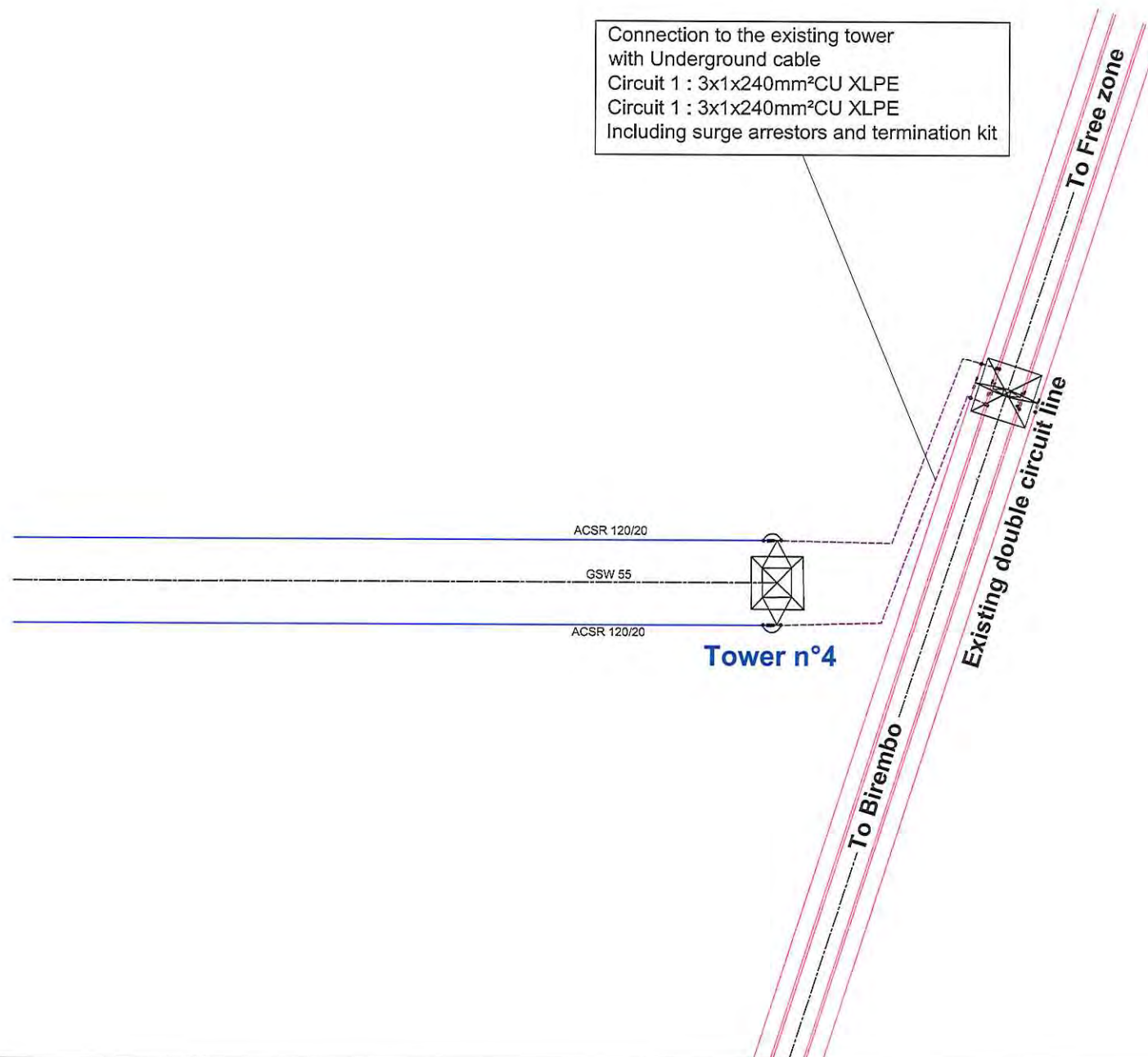
Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1492.00

Cumulated distance(m)	0.000	6.651	14.383	20.700	36.941	50.605	70.486	92.438	93.479	111.378	145.325	149.174	167.304	169.911	173.364	179.438	183.492	185.632	195.690	208.435	210.947	218.178	233.863	247.912	254.410	
Altitude (m)	1506.00	1505.32	1504.79	1503.45	1501.53	1500.48	1498.61	1496.96	1495.85	1495.22	1495.38	1495.68	1495.98	1496.28	1496.58	1496.88	1497.18	1497.48	1497.78	1498.08	1498.38	1498.68	1498.98	1499.28	1499.58	1499.88
Span Length (m)																										
Layout																										

CONNECTION OF 15KV DOUBLE CIRCUIT LINE TO THE EXISTING LINE
Echelle 1/400



LEGEND

- Left ground level at 5m from axis
- Axis ground level
- Right ground level at 5m from axis
- SIP
Soil Investigation Point
- Road
- House

Tower n°1R is direct connected to the substation with underground cable
 Circuit 1 : 3x1x120mm²CU with termination kits and arrestors.
 Length: 3x150m=450m

Existing Tower n°3
0.000km

1R
 Tower type:
 15-TD1
 3DT/3DT
 0.207Km

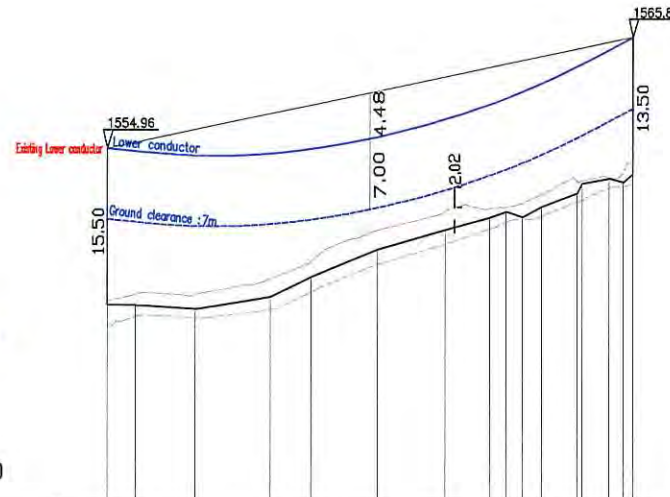
2R
 Pole type:
 15-PA1
 3DT/3DT
 0.286Km

**15kV TRANSMISSION LINE
 RUBUNGO - GISHAKA REROUTED**

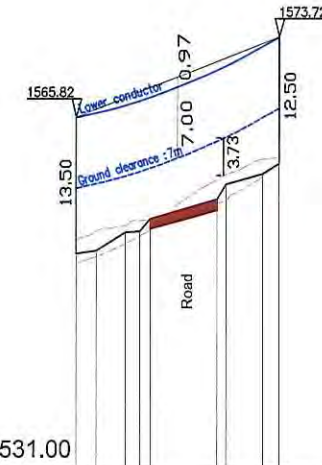
Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1520.00



Rh : 1531.00



Cumulated distance(m)	0.00	11.04	34.60	64.09	80.11	106.34	132.88	150.40	156.75	163.23	170.72	184.94	188.75	197.25	202.79	206.67
Altitude (m)	1539.46	1539.42	1539.04	1540.23	1542.19	1544.90	1546.83	1548.05	156.75	1548.09	1549.11	1550.46	1551.43	1551.87	1551.92	1552.32
Span Length (m)	206.67															
Layout																

Cumulated distance(m)	0.00	7.92	19.29	24.92	29.22	55.56	73.52	79.81
Altitude (m)	1552.32	1552.61	1554.39	1554.50	1555.77	1557.68	1560.19	1561.22
Span Length (m)	79.81							
Layout								

LEGEND

- Left ground level at 5m from axis
- Axis ground level
- Right ground level at 5m from axis
- SIP
- Road
- House

2R
 Pole type:
 15-PA1
 3DT/3DT
 0.286Km

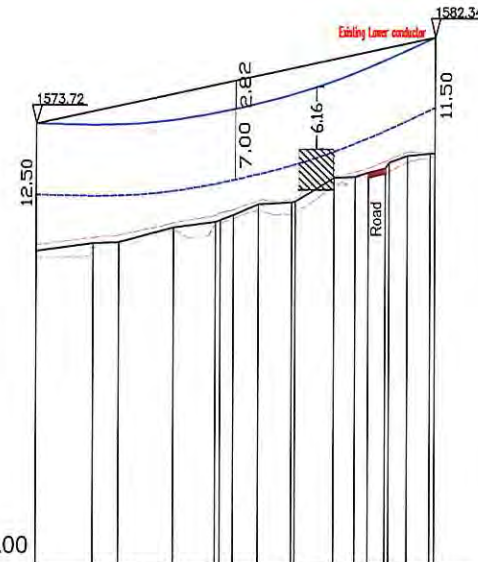
Existing Tower n°5
 0.444km

**15kV TRANSMISSION LINE
 RUBUNGO - GISHAKA REROUTED**

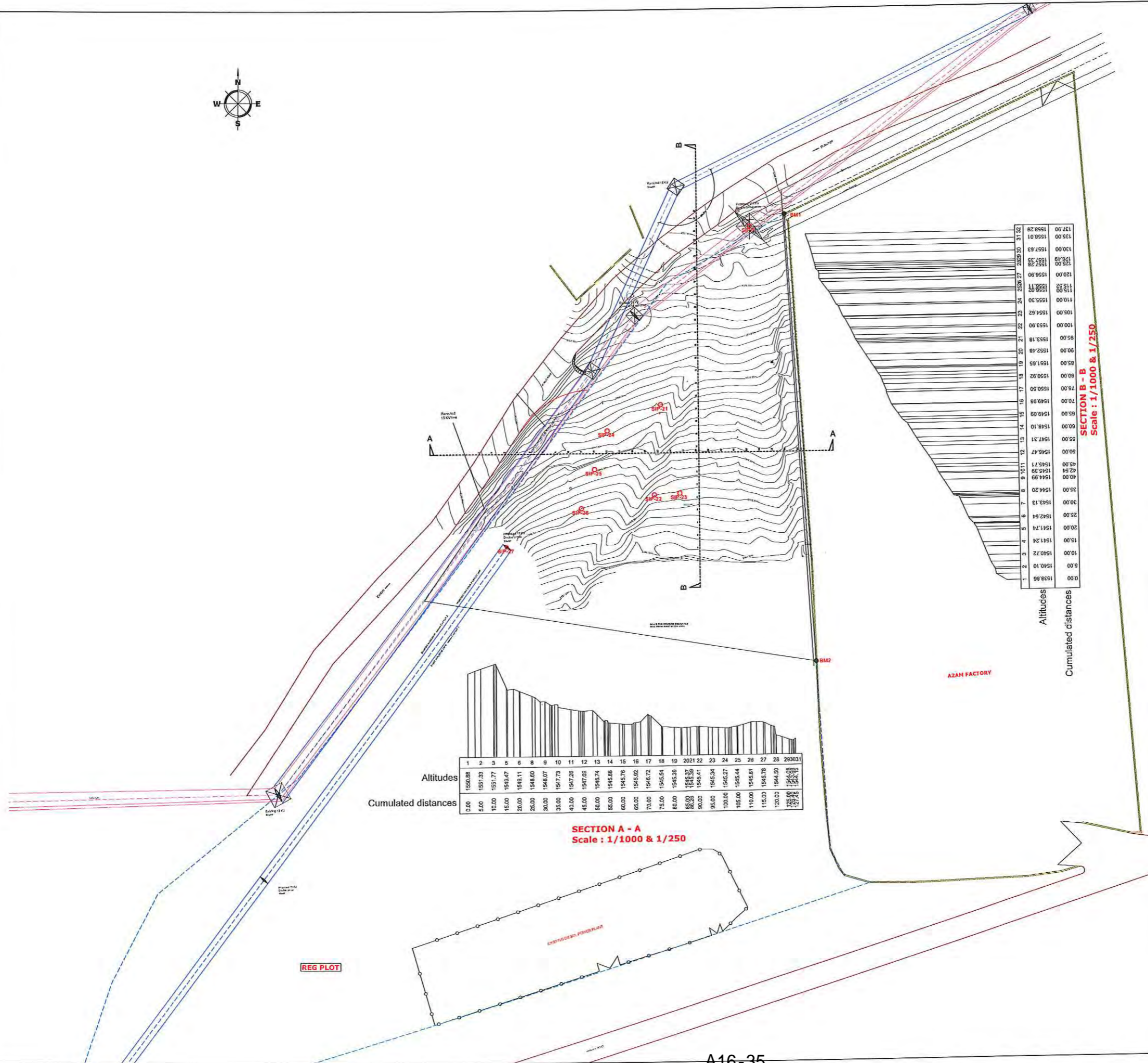
Scale of length : 1/2000

Scale of height : 1/500

Reference height(Rh) : 1520.00
 RHP: 1530.00



Cumulated distance(m)	0.00	22.36	32.46	54.02	70.65	72.47	77.67	87.55	100.59	101.99	117.25	125.56	130.78	137.46	138.36	146.19	157.00
Altitude (m)	1561.22	1562.00	1562.09	1563.51	1564.05	1564.26	1564.76	1565.80	1565.97	1566.08	1566.39	1568.48	1568.91	1569.32	1569.32	1570.61	1570.84
Span Length (m)					157.05												
Layout	<p>The layout view shows the horizontal alignment of the transmission line. It includes the pole type '2R' and 'Existing Tower n°5', the projected 110kV double circuit line, and the terrain features like a road and a house. The ground level is shown as a dashed line, and the terrain is shown as a solid line. The layout is labeled 'AZAM' and '197,02g'.</p>																



POINTS COORDINATES			
BM1	36M	182949.67	9786332.31
BM2	36M	182959.89	9786155.62
SIP-9	36M	182938.00	9786331
SIP-21	36M	182903.85	9786260.08
SIP-22	36M	182902.01	9786224.28
SIP-23	36M	182911.96	9786225.27
SIP-24	36M	182883.13	9786249.49
SIP-25	36M	182878.45	9786234.04
SIP-26	36M	182873.57	9786218.62
SIP-27	36M	182839.59	9786201.98

Altitudes	Cumulated distances
15888.88	0.00
15889.00	1.00
15889.12	2.00
15889.24	3.00
15889.36	4.00
15889.48	5.00
15889.60	6.00
15889.72	7.00
15889.84	8.00
15889.96	9.00
15890.08	10.00
15890.20	11.00
15890.32	12.00
15890.44	13.00
15890.56	14.00
15890.68	15.00
15890.80	16.00
15890.92	17.00
15891.04	18.00
15891.16	19.00
15891.28	20.00
15891.40	21.00
15891.52	22.00
15891.64	23.00
15891.76	24.00
15891.88	25.00
15892.00	26.00
15892.12	27.00
15892.24	28.00
15892.36	29.00
15892.48	30.00
15892.60	31.00
15892.72	32.00

Altitudes	Cumulated distances
1550.88	0.00
1551.23	5.00
1551.77	10.00
1552.47	15.00
1553.31	20.00
1554.60	25.00
1556.07	30.00
1557.73	35.00
1559.03	40.00
1560.74	45.00
1562.88	50.00
1565.32	55.00
1568.07	60.00
1571.13	65.00
1574.51	70.00
1578.21	75.00
1582.23	80.00
1586.57	85.00
1591.23	90.00
1596.21	95.00
1601.51	100.00
1607.13	105.00
1613.07	110.00
1619.23	115.00
1625.61	120.00
1632.21	125.00
1639.03	130.00
1646.07	135.00
1653.33	140.00
1660.81	145.00
1668.51	150.00
1676.43	155.00
1684.57	160.00
1692.93	165.00
1701.51	170.00
1710.31	175.00
1719.33	180.00
1728.57	185.00
1738.03	190.00
1747.71	195.00
1757.61	200.00
1767.73	205.00
1778.07	210.00
1788.63	215.00
1799.41	220.00
1810.41	225.00
1821.63	230.00
1833.07	235.00
1844.73	240.00
1856.61	245.00
1868.71	250.00
1881.03	255.00
1893.57	260.00
1906.33	265.00
1919.31	270.00
1932.51	275.00
1945.93	280.00
1959.57	285.00
1973.43	290.00
1987.51	295.00
2001.81	300.00
2016.33	305.00
2031.07	310.00
2046.03	315.00
2061.21	320.00
2076.61	325.00
2092.23	330.00
2108.07	335.00
2124.13	340.00
2140.41	345.00
2156.91	350.00
2173.63	355.00
2190.57	360.00
2207.73	365.00
2225.11	370.00
2242.71	375.00
2260.53	380.00
2278.57	385.00
2296.83	390.00
2315.31	395.00
2334.01	400.00
2352.93	405.00
2372.07	410.00
2391.43	415.00
2411.01	420.00
2430.81	425.00
2450.83	430.00
2471.07	435.00
2491.53	440.00
2512.21	445.00
2533.11	450.00
2554.23	455.00
2575.57	460.00
2597.13	465.00
2618.91	470.00
2640.91	475.00
2663.13	480.00
2685.57	485.00
2708.23	490.00
2731.11	495.00
2754.21	500.00
2777.53	505.00
2801.07	510.00
2824.83	515.00
2848.81	520.00
2873.01	525.00
2897.43	530.00
2922.07	535.00
2946.93	540.00
2972.01	545.00
2997.31	550.00
3022.83	555.00
3048.57	560.00
3074.53	565.00
3100.71	570.00
3127.11	575.00
3153.73	580.00
3180.57	585.00
3207.63	590.00
3234.91	595.00
3262.41	600.00
3290.13	605.00
3318.07	610.00
3346.23	615.00
3374.61	620.00
3403.21	625.00
3432.03	630.00
3461.07	635.00
3490.33	640.00
3519.81	645.00
3549.51	650.00
3579.43	655.00
3609.57	660.00
3639.93	665.00
3670.51	670.00
3701.31	675.00
3732.33	680.00
3763.57	685.00
3795.03	690.00
3826.71	695.00
3858.61	700.00
3890.73	705.00
3923.07	710.00
3955.63	715.00
3988.41	720.00
4021.41	725.00
4054.63	730.00
4088.07	735.00
4121.73	740.00
4155.61	745.00
4189.71	750.00
4224.03	755.00
4258.57	760.00
4293.33	765.00
4328.31	770.00
4363.51	775.00
4398.93	780.00
4434.57	785.00
4470.43	790.00
4506.51	795.00
4542.81	800.00
4579.33	805.00
4616.07	810.00
4653.03	815.00
4690.21	820.00
4727.61	825.00
4765.23	830.00
4803.07	835.00
4841.13	840.00
4879.41	845.00
4917.91	850.00
4956.63	855.00
4995.57	860.00
5034.73	865.00
5074.11	870.00
5113.71	875.00
5153.53	880.00
5193.57	885.00
5233.83	890.00
5274.31	895.00
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5355.63	905.00
5396.57	910.00
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5479.11	920.00
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5562.53	930.00
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5689.31	945.00
5731.91	950.00
5774.63	955.00
5817.57	960.00
5860.73	965.00
5904.11	970.00
5947.71	975.00
5991.53	980.00
6035.57	985.00
6079.83	990.00
6124.31	995.00
6168.91	1000.00

SECTION A - A
Scale : 1/1000 & 1/250

SECTION B - B
Scale : 1/1000 & 1/250

LEGEND

- Proposed 110 kV double circuit line
- Existing 15kV OHL
- 15kV OHL rerouted
- Soil investigation point

REV.	DATE	DESCRIPTION	ISSUED	CHECKED
2	April 2015	Ndera Substation Layout	REG LTD	REG LTD
1	March 2015	Ndera Substation Layout	REG LTD	REG LTD



REPUBLIC OF RWANDA



RWANDA ENERGY GROUP

Project : **JICA PROJECT PHASE II**

Title : **NDERA SUBSTATION LAYOUT**

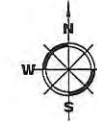
Name	Fonction	Appova by Client	Date	Signature & stamp

PAPER SIZE	SCALE	DOCUMENT NO.	DATE	DRAWING STATUS
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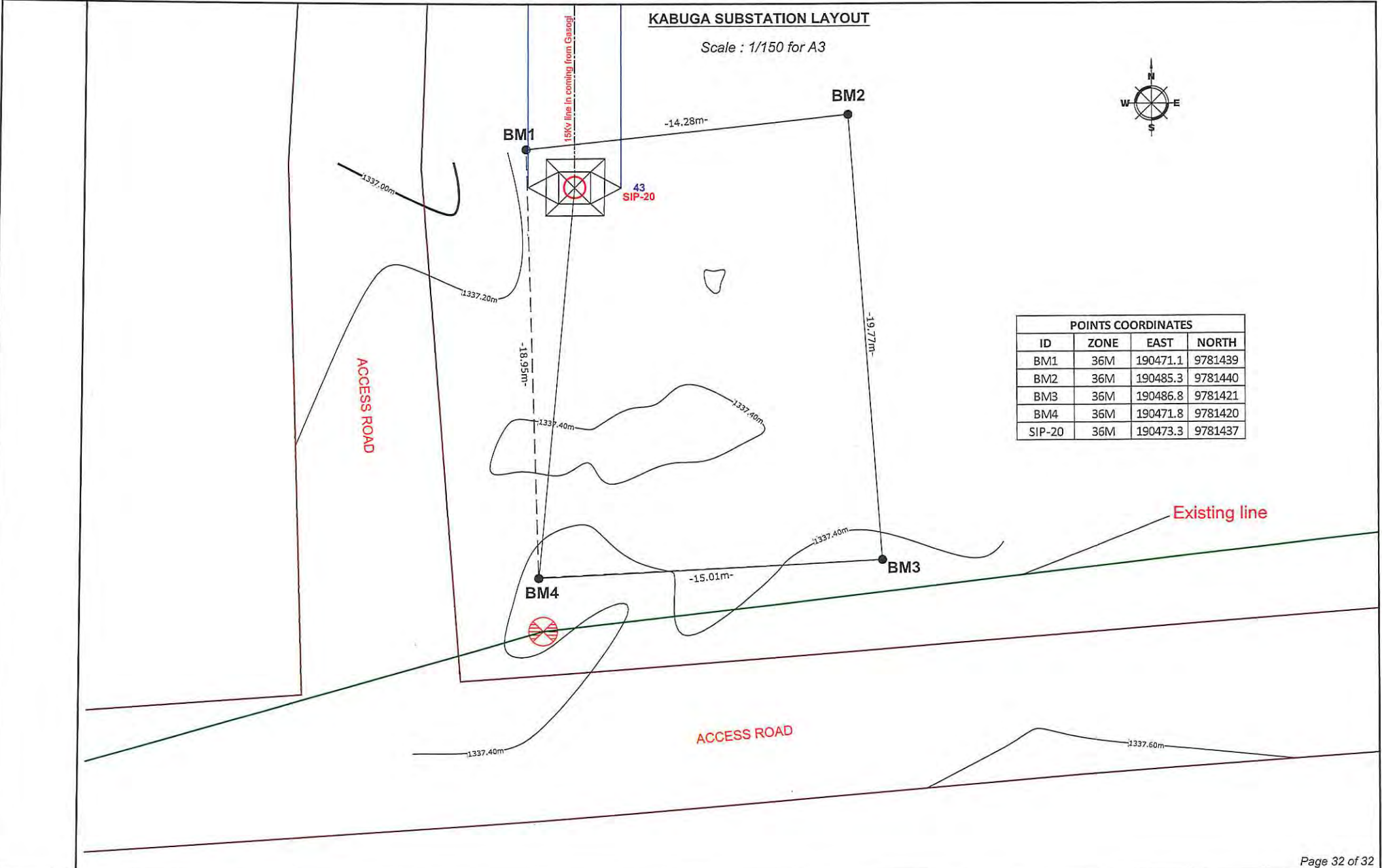
Drawing n°4/JPPH

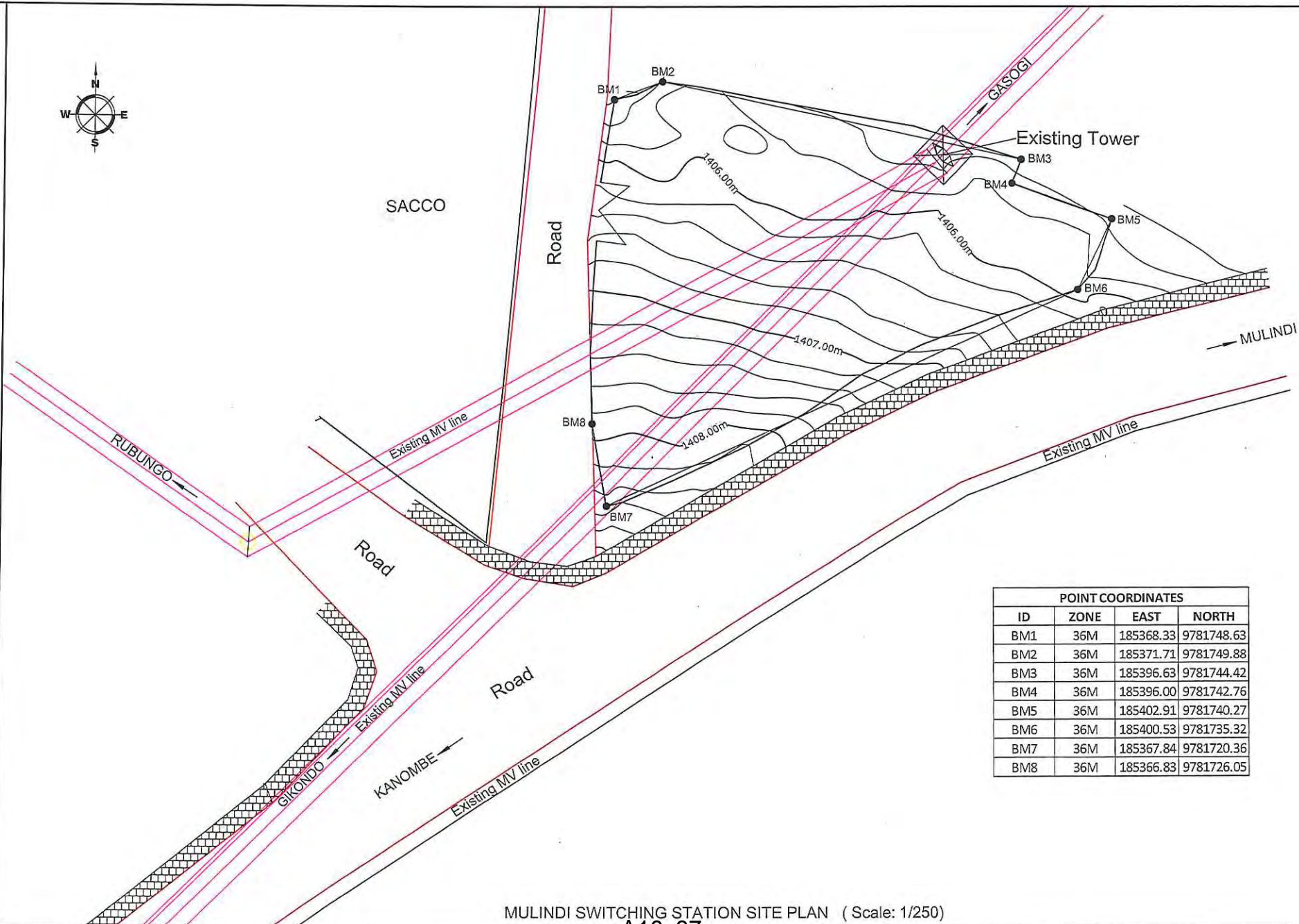
KABUGA SUBSTATION LAYOUT

Scale : 1/150 for A3



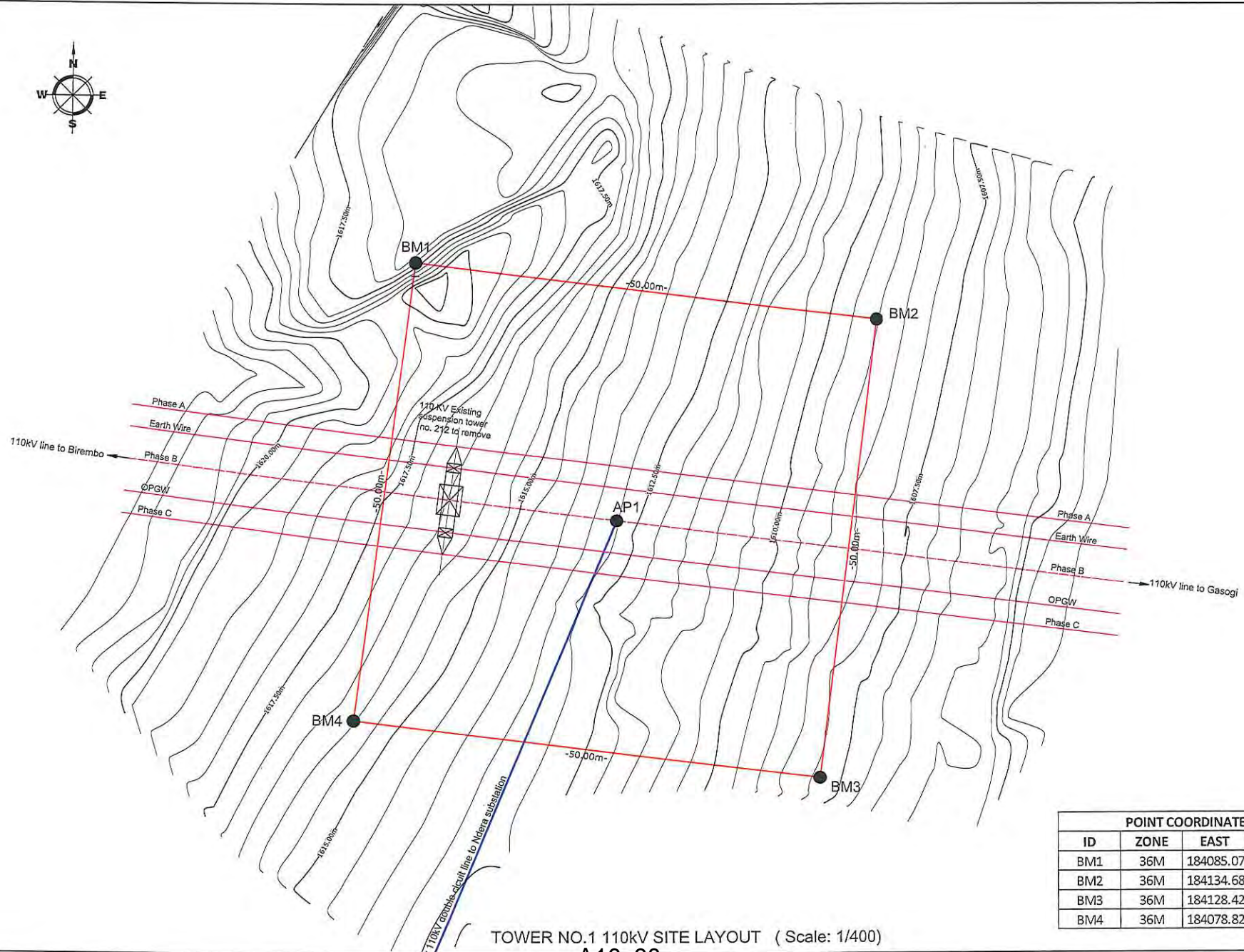
POINTS COORDINATES			
ID	ZONE	EAST	NORTH
BM1	36M	190471.1	9781439
BM2	36M	190485.3	9781440
BM3	36M	190486.8	9781421
BM4	36M	190471.8	9781420
SIP-20	36M	190473.3	9781437





POINT COORDINATES			
ID	ZONE	EAST	NORTH
BM1	36M	185368.33	9781748.63
BM2	36M	185371.71	9781749.88
BM3	36M	185396.63	9781744.42
BM4	36M	185396.00	9781742.76
BM5	36M	185402.91	9781740.27
BM6	36M	185400.53	9781735.32
BM7	36M	185367.84	9781720.36
BM8	36M	185366.83	9781726.05

MULINDI SWITCHING STATION SITE PLAN (Scale: 1/250)



POINT COORDINATES			
ID	ZONE	EAST	NORTH
BM1	36M	184085.07	9787809.52
BM2	36M	184134.68	9787803.27
BM3	36M	184128.42	9787753.66
BM4	36M	184078.82	9787759.92

TOWER NO.1 110kV SITE LAYOUT (Scale: 1/400)

























REPUBLIC OF RWANDA
MINISTRY OF INFRASTRUCTURE



Japan International Cooperation Agency



CONTRACTOR

yec CONSULTING ENGINEERS & ARCHITECTS
YACHIYO ENGINEERING CO., LTD.

IMPROVEMENT OF SUBSTATIONS AND DISTRIBUTION NETWORK, PHASE 2, IN THE REPUBLIC OF RWANDA

SOIL INVESTIGATIONS FOR :

. 110 / 15 kV NDERA SUBSTATION

. 110 kV & 15 kV POWER LINES

FILE 1 / 2



KIGALI, May 2015

CONTENT

I. METHODOLOGY

II. STANDARD REFERENCES

III. ILLUSTRATIONS OF STUDIES ON DIFFERENT PHASES

IV. EXPOSED OBSERVATIONS ON EACH TEST PIT

V. GENERAL CONCLUSION

VI. TABLE OF TEST RESULTS & RECOMMENDATIONS FOR THE FOUNDATION

I. METHODOLOGY

For this project, the soil investigations were done on 27 points defined on the drawing in the survey report :

- page no.5 : General overview project for 15 kV & 110 kV lines.
- page no.31 : Ndera substation layout.

These points, for soil investigations, are :

- SIP1-SIP2-SIP3-SIP4-SIP5-SIP6-SIP7-SIP8-SIP9-SIP10-SIP11-SIP12-SIP13-SIP14-SIP15-SIP16-SIP17-SIP18-SIP19- SIP20-SIP21-SIP22-SIP23-SIP24-SIP25-SIP26-SIP27.

In the immediate vicinity of each point, approximately 3m around, the soil was examined in situ and the levy of samples was performed at required depth.

After having dug a 4m deep hole for a section of 1.30 m x 1.30 m ; had followed the following operations that are the essential phases of these geotechnical studies.

1) Field tests and levy of samples (on each point)

This phase comprises :

- Observations and analysis of soils texture on the walls of the test pits ;
- Levy of undisturbed samples ;
- Levy of samples overhauled ;
- Backfilling of the test pits ;
- Penetration test in natural ground, performed with a static penetrometer 50 kN, up to more than 10 m deep.

2) Laboratory tests (for each point)

On the selected samples from test pits, physical, mechanical and chemical tests analysis were performed by the following tests :

- Physical tests : Natural water content, Specific gravity, Sieve analysis, Liquid limit, Plastic limit.
- Mechanical tests : Modified proctor, Shear test, unconfined compression test.
- Chemical tests : the degree of alkalinity in soil expressed as a pH, the concentration of sulphate (as SO_4^{2-}) and chlorites (as Cl^-)

3) Results and recommendations for foundation

Bringing together the results of field tests and laboratory tests, soil represented by each point is identified, in its form and in its quality.

This identification, facilitating the rational use of these soils, allows the expert to give recommendations for better land use, such as materials and support.

All the work of geotechnical studies, as described above, is presented in two volumes :

- volume 1/2 : own report of the expert ;
- volume 2/2 : test report.

For reasons of speed and ease, separate laboratories were used simultaneously :

- Rincent BTP Rwanda Ltd,
- Geotechnical laboratory and laboratory of agronomy, University of Rwanda, Huye campus.

II. STANDARDS REFERENCES

In large part, we use the French standardization (NF) and, in lesser extent, British Standards (BSCS) and American Standards (AASHTO) & ASTM.

- Sampling - Standard NF P94-202
 - Moisture content - Standard NF P94-050
 - Specific gravity - Standard NF P94-053
 - Sieve analysis - Standard NF P94-056
 - Atterberg limits- Standard NF P94-051
 - Modified proctor- Standard NF P94-093
 - Direct shear box- Standard NF P94-071-2
 - Unconfined compression strength- Standard AASHTO T134
 - British Soil Classification System- BSCS
 - Chemical analysis (sulfate & chloride) - Standard : ASTM D 4327
 - Chemical analysis (pH) - Standard : ASTM D 4972
- In-Situ static penetration tests performed using a GeoMIL 50 kN SPT.

III. ILLUSTRATION OF THESE STUDIES ON DIFFERENT PHASES

1) Excavation of test pit



2) Levy of undisturbed sample



3) Levy of sample overhauled



4) Penetration tests:



Setting ink needles for the base of the penetrometer



Installation of the base



Loading sounding tubes



Penetrometer in action



Penetrometer in action : measuring applied forces

5) Laboratory work

a. Liquid limit



b. Sieve analysis



c. Modified Proctor



Drying oven



d. Shear frame



e. Unconfined compression test



Molded specimens,
immersed in a
treatment basin

f. Chemical analysis



IV. EXPOSED OBSERVATIONS ON EACH TEST PIT

Legend :

- ALT : height above sea level for the natural ground - V_s : depth of vegetable soil
- G_w : presence of groundwater - S_E : the extraction depth of the sample

SIP 1



Excavation



Extraction of sample



Earth excavation encountered scattered pebbles from 3.40 m deep



Backfilling of the borehole

Designation	Value
ALT	1 613.04 m
V_s	0.80 m
S_E	1.00 - 2.00 m
W_G	Not
After 0.80 m of vegetable earth, a reddish silt occupies practically all the depth and the background becomes stony.	

SIP 2



Excavations



Excavated soils

Designation	Value
ALT.....	1 596.04 m
Vs.....	0.50 m
SE.....	0.80 - 1.20 m
WG.....	Not
It is a pure lateritic area, extends 50.0 m radius.	

Legend :

- ALT: height above sea level for the natural ground
- Vs: depth of vegetable soil
- Gw: presence of groundwater
- SE: the extraction depth of the sample

SIP 3



Excavations



Excavated soils

Designation	Value
ALT.....	1 595.12 m
Vs.....	1.00 m
SE.....	3.30 - 4.00 m
WG.....	Not
Beyond the topsoil, this soil consists of lateritic silt	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- GW : presence of groundwater
- SE : the extraction depth of the sample



Excavations



Excavated soils

Designation	Value
ALT.....	1 597.70 m
VS.....	1.00 m
SE.....	2.50 - 3.00 m
WG.....	Not
Beyond the topsoil, this soil consists of lateritic silt	

Legend :

- ALT: height above sea level for the natural ground
- VS: depth of vegetable soil
- GW: presence of groundwater
- SE: the extraction depth of the sample

SIP 5



Excavated soils

Designation	Value
ALT	1 603.40 m
Vs	0.50 m
SE	2.00 - 2.40 m
WG	Not

Completely lateritic hill, with a very hard laterite from 1.00 m deep.



Excavations



Excavated soils

Designation	Value
ALT	1 597.90 m
Vs	0.60 m
SE	2.00 - 2.50 m
WG	Not
After earth vegetable, soil consists of silty clay.	

Legend :

- ALT: height above sea level for the natural ground
- Vs: depth of vegetable soil
- Gw: presence of groundwater
- SE: the extraction depth of the sample

SIP 7



Excavations



Excavated soils

Designation	Value
ALT	1 585.73 m
Vs	0.50 m
SE	2.00 - 2.50 m
WG	Not
After earth vegetable, soil consists of silty clay.	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- GW : presence of groundwater
- SE : the extraction depth of the sample

SIP 8



Excavations



Excavated soils

Designation	Value
ALT.....	1 567.48 m
Vs.....	0.50 m
SE.....	3.50 - 3.70 m
WG.....	Not
Full deph, the topsoil is based on a layer of silt soil laterite.	

Legend :

- ALT: height above sea level for the natural ground
- Vs: depth of vegetable soil
- GW: presence of groundwater
- SE: the extraction depth of the sample

SIP 9



Excavations



Excavated soils

Designation	Value
ALT.....	1 557.91 m
Vs.....	0.70 m
SE.....	3.60 - 3.90 m
WG.....	Not
The layer of soil vegetable overlooks a lateritic soil silt.	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- SE : the extraction depth of the sample

SIP 10



Excavations



Excavated soils

Designation	Value
ALT.....	1 506.00 m
Vs.....	0.70 m
SE.....	1.60 - 2.00 m
WG.....	Not
This soil is totally lateritic	

Legend :

- ALT: height above sea level for the natural ground
- Vs: depth of vegetable soil
- GW: presence of groundwater
- SE: the extraction depth of the sample

SIP 11



Excavation



Excavated soils

Designation	Value
ALT	1 485.50 m
Vs	0.70 m
SE	2.00 - 2.50 m
WG	Not

A layer of silty clay (1.50 m) on lateritic silt comes just after the topsoil.

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- GW : presence of groundwater
- SE : the extraction depth of the sample

SIP 12



Excavations



Excavated soils

Designation	Value
ALT.....	1 484.53 m
Vs.....	0.30 m
SE.....	1.00 - 3.00 m
WG.....	Not
Under the topsoil, comes a layer of soil laterite (3.00 m) on silt.	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- GW : presence of groundwater
- SE : the extraction depth of the sample

SIP 13



Excavation



Earth excavation

Designation	Value
ALT	1 450.00 m
Vs	0.70 m
SE	3.00 - 3.30 m
WG	Not

The topsoil rests on stony ground semi hard sedimentary formation.

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- GW : presence of groundwater
- SE : the extraction depth of the sample

SIP 14



Excavations



Excavated soils

Designation	Value
ALT.....	1 459.67 m
Vs.....	0.70 m
SE.....	3.00 - 3.40 m
Wg.....	Not
Soil consists of silty land based on sedimentary rocks loose.	

Legend :

- ALT: height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- SE: the extraction depth of the sample

SIP 15



Excavations



Excavated soils

Designation	Value
ALT.....	1 500.00 m
V _s	0.70 m
S _E	2.20 - 2.50 m
W _G	Not
Lateritic soil under topsoil	

Legend :

- ALT : height above sea level for the natural ground
- V_s : depth of vegetable soil
- G_w : presence of groundwater
- S_E : the extraction depth of the sample

SIP 16



Excavation



Excavated soils

Designation	Value
ALT.....	1 457.71 m
Vs.....	1.40 m
Se.....	1.20 - 1.50 m
WG.....	Not
Under a large vegetable layer, brown and whitish soil is rocky.	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- Se : the extraction depth of the sample

SIP 17



Excavation



The immediate vicinity of the point

Designation	Value
ALT	1 451.87 m
Vs	0.70 m
SE	0.70 - 1.00 m
WG	Not
Silty soil whitish and hard sedimentary rocks.	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- GW : presence of groundwater
- SE : the extraction depth of the sample

SIP 18



Excavation



Excavated soils

Designation	Value
ALT.....	1 308.32 m
Vs.....	0.20 m
SE.....	2.00 - 2.30 m
WG.....	Not
Hard ground made of quartz gravel	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- SE : the extraction depth of the sample

SIP 19



Excavation



Excavated soils

Designation	Value
ALT	1 249.46 m
Vs	1.00 m
SE	1.00 - 1.50 m
WG	Not
After earth vegetable, a silty clay layer (0.50 m) rests on a rocky ground	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- SE : the extraction depth of the sample



Excavation



Excavated soils

Designation	Value
ALT	1 337.36 m
Vs	1.30 m
SE	1.60 - 2.00 m
WG	Not
Under a thick layer of topsoil, the soil is lateritic silt	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- SE : the extraction depth of the sample

SIP 21



Excavation



Excavated soils

Designation	Value
ALT.....	1 548.52 m
Vs.....	0.50 m
SE.....	3.50 - 3.80 m
WG.....	Not
A layer of pure clay (2.30 m) draws on hard lateritic soil.	

Legend :

- ALT: height above sea level for the natural ground
- Vs: depth of vegetable soil
- Gw: presence of groundwater
- SE: the extraction depth of the sample



Excavation



Excavated soils

Designation	Value
ALT.....	1 543.00 m
Vs.....	0.50 m
SE.....	2.00 - 2.50 m
WG.....	Not
A silty clay layer (3.00 m) on whitish sedimentary rocks.	

Legend :

- ALT: height above sea level for the natural ground
- Vs: depth of vegetable soil
- GW: presence of groundwater
- SE: the extraction depth of the sample

SIP 23



Excavations



Designation	Value
ALT.....	1 542.70 m
Vs.....	0.50 m
SE.....	2.00 - 2.60 m
WG.....	Not
Land of hard stones with lateritic ground.	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- GW : presence of groundwater
- SE : the extraction depth of the sample

SIP 24



Excavation



Excavated soils

Designation	Value
ALT	1 548.25 m
Vs	0.50 m
SE	3.60 - 4.00 m
WG	Not

The ground is entirely composed of silty clay, the color changes from black to brown.

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- SE : the extraction depth of the sample

SIP 25



Excavation



Excavated soils

Designation	Value
ALT	1 545.00 m
Vs.....	0.60 m
SE.....	3.50 - 3.90 m
WG.....	Not

The soil is red clay full depth.

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- SE : the extraction depth of the sample

SIP 26



Excavation



Excavated soils

Designation	Value
ALT	1 543.00 m
Vs	0.55 m
SE	3.00 - 3.20 m
WG	Not
The soil is red clay full depth.	

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- SE : the extraction depth of the sample

SIP 27



Excavation



Excavated soils

Designation	Value
ALT	1 542.68 m
Vs	0.70 m
SE	2.20 - 2.50 m
WG	Not

The soil is rocky mid hard sediment.

Legend :

- ALT : height above sea level for the natural ground
- Vs : depth of vegetable soil
- Gw : presence of groundwater
- SE : the extraction depth of the sample

V. GENERAL CONCLUSION

The geotechnical studies of this project show soils in the following manner :

1) Soil as support structure.

From 2.40 m deep, all the soils encountered are of good quality and present no risk of destabilization by groundwater or flooding; although, we are at the end of the rainy season.

Indeed, the bearing capacity, consistency and density of these soils can allow no punching, no shifting, no swelling, under load.

- The plasticity is intermediat : $12 \% \leq IP \leq 18 \%$;
- The cohesion is also intermediat because the internal friction angle varies from 20° to 30° .
- The minimum bearing capacity is greater than 0.2 Mpa.

(Nota / penetration test sheet :

Rt : total resistance, Rp : resistance to the tip and Qadm : bearing capacity).

2) Soil as building material.

Set up by backfill, soils must protect the works of all lifting and overturn.

The characteristics data from these studies attribute those qualities to examined soils ; indeed :

- The dry density $\gamma_{d\text{OPM}} \geq 1.60 \text{ t/m}^3$
- The internal friction angle is greater than 20° for the majority of points (the shear strength is proportional to soil consolidation).
- The unconfined compressive strength gives good resistances ($\geq 0.2 \text{ Mpa}$) to the compression pressure.
- No soil presents no aggression against cement ($SO_4^{2-} \leq 0.06 \%$; $pH = \pm 7.0$ and $Cl \leq 61$ parts per million).

General observation of all the results of the tests imposed on soils allows us to classify them into two categories :

1) Good soil, including :

- the Clay of Intermediate plasticity (CI),
- very Silty Sand (SF),
- very Clayey Sand (SCI).

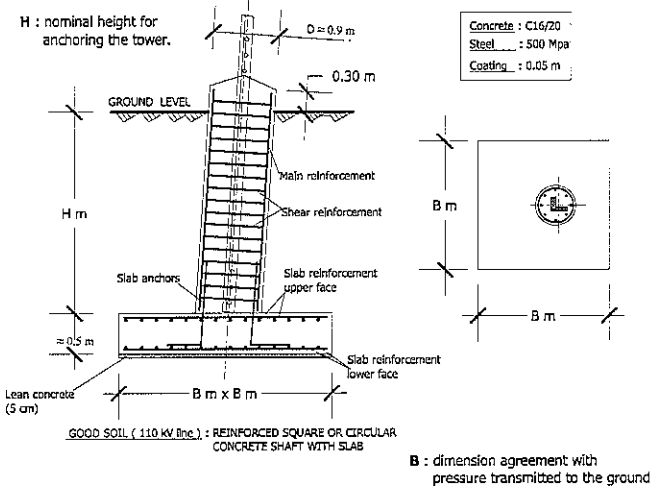
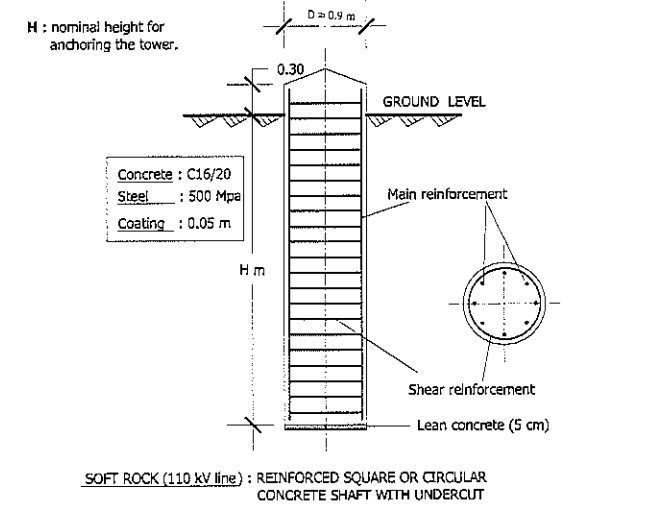
2) Soft rock including : - weathered rock, - well-graded silty gravel, - well-graded clayey gravel (G C)

VI. TABLE OF TEST RESULTS & RECOMMENDATIONS FOR FOUNDATION SYSTEM

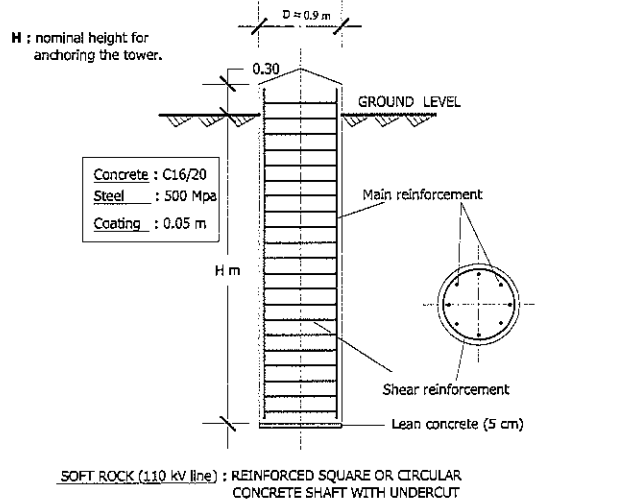
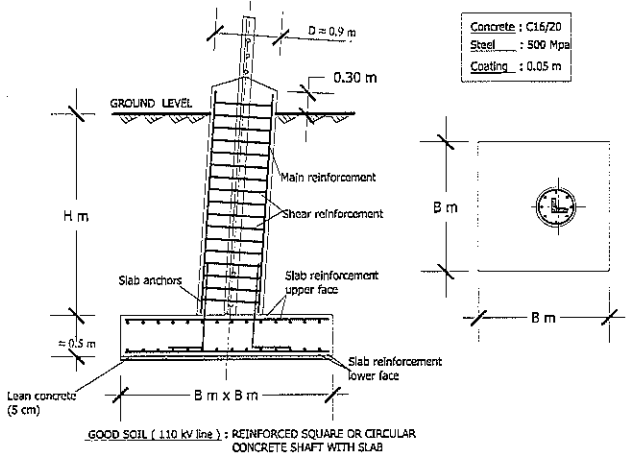
TO REFER TO COMPLEMENTARY ELUCIDATIONS, FROM PAGE 49 TO PAGE 74

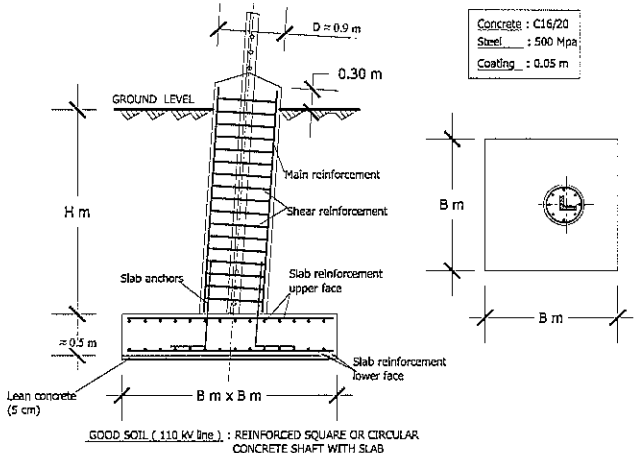
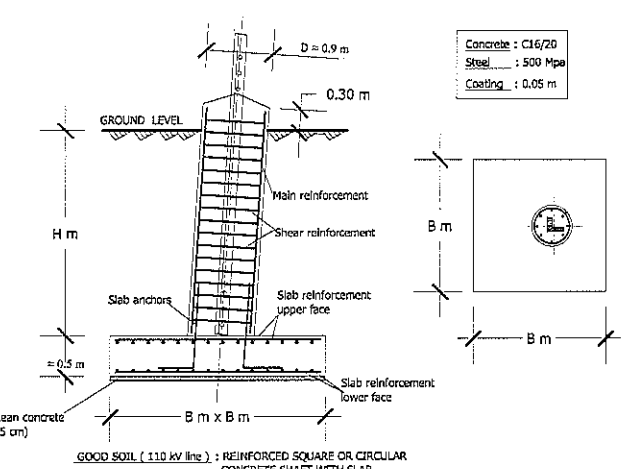
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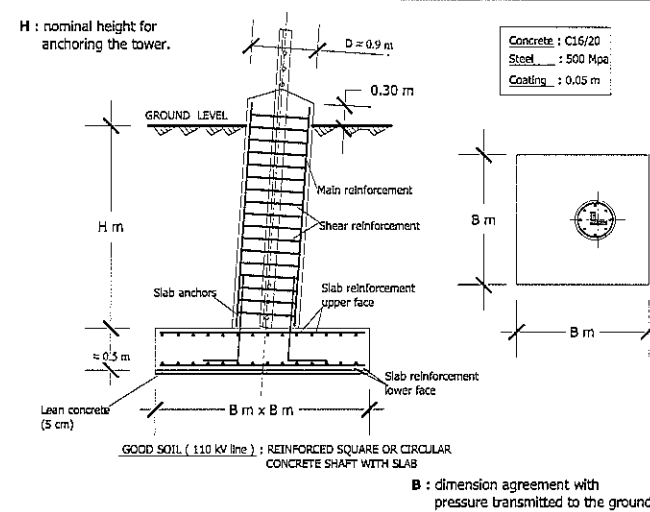
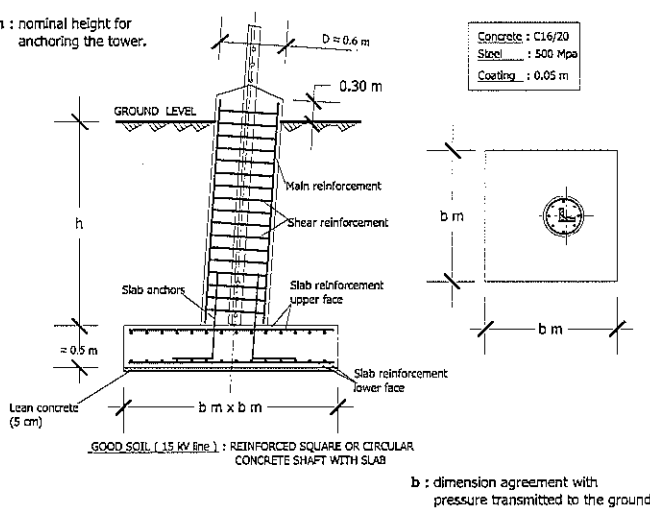
- I_P : Plasticity Index - I_c : Consistency Index - $W_{opm} (\%)$: Optimum water content
- $\gamma_{d\text{opm}}$: Optimum dry specific gravity - γ_h : Natural specific gravity - $w_{(N)}$: Natural Moisture content
- C_{uu} : Cohesion unconsolidated - undrained - ψ_{uu} : Angle of internal friction

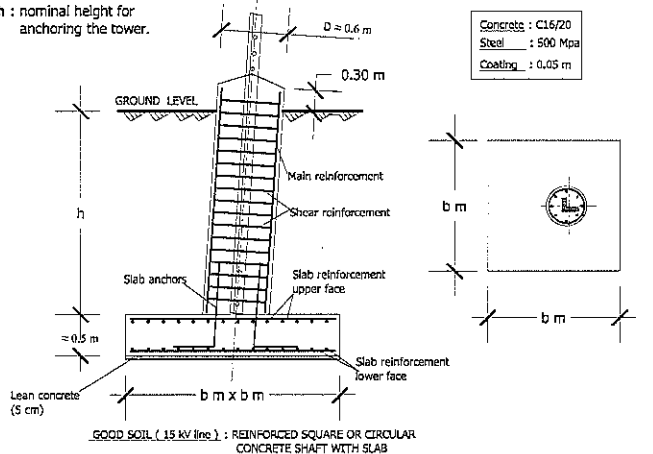
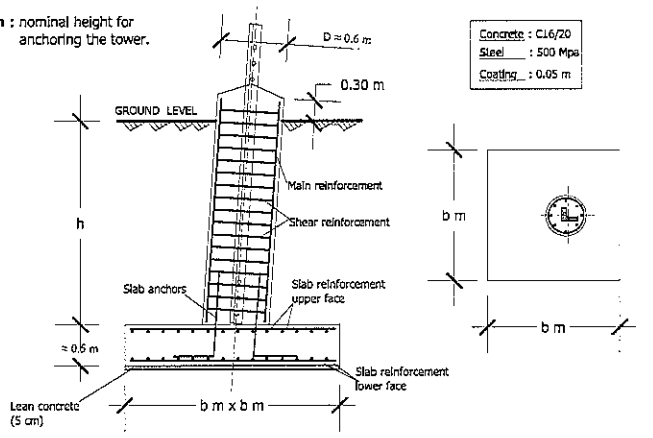
SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
<p>SIP 1 (ON 110 kV line)</p>	<p>CI (clay of intermediate plasticity)</p>	<p>- IP : 16.8 % - Consistency $I_c = 1.39 > 1$: very consistent ground</p> <p>- Compaction Backfill : $\gamma_{OPM} = 1.92 \text{ t/m}^3$ $W_{OPM} = 13.28 \%$</p> <p>- Natural soil : $\gamma_h = 1.61 \text{ t/m}$ $W_{(N)} = 14.90 \%$ $\gamma_s = 2.68 \text{ t/m}$</p>	<p>- Permissible bearing pressure (from 2.40 m deep) = 2167 kPa</p> <p>- Shear test : $C_{uu} = 35 \text{ kN/m}^2$ $\psi_{uu} = 25.41^\circ$</p> <p>- Chemical analysis : $pH = 6.03$ $SO_4^{2-} = 0.021 \%$ $Cl^- = 22 \text{ ppm}$</p>	<p>Picks and shovels can be used.</p>	 <p>GOOD SOIL (110 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p> <p>B : dimension agreement with pressure transmitted to the ground .</p>
<p>SIP 2 (ON 110 kV line)</p>	<p>SF (very silty sand)</p>	<p>- IP : 13.8 % - Consistency $I_c = 1.42 > 1$: very consistent ground</p> <p>- Compaction Backfill : $\gamma_{OPM} = 1.92 \text{ t/m}^3$ $W_{OPM} = 12.42 \%$</p> <p>- Natural soil : $\gamma_h = 1.60 \text{ t/m}$ $W_{(N)} = 15.10 \%$ $\gamma_s = 2.68 \text{ t/m}$</p>	<p>- Permissible bearing pressure (from 2.40 m deep) = 9167 kPa</p> <p>- Shear test : $C_{uu} = 1 \text{ kN/m}^2$ $\psi_{uu} = 39.18^\circ$</p> <p>- Chemical analysis : $pH = 5.99$ $SO_4^{2-} = 0.02 \%$ $Cl^- = 26 \text{ ppm}$</p>	<p>pneumatic hammer</p>	 <p>SOFT ROCK (110 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH UNDERCLUT</p>

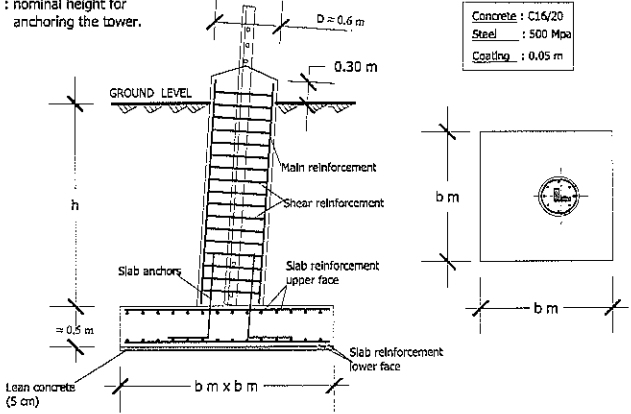
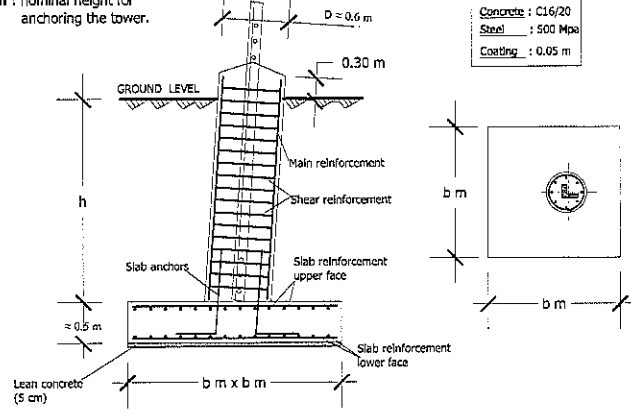
SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a log)
SIP 3 (ON 110 kV line)	SCI (very clayey sand)	<ul style="list-style-type: none"> - IP : 18.3 % - Consistency $I_c = 1.77 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 2.00 \text{ t/m}^3$. $W_{OPM} = 11.25 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.81 \text{ t/m}^3$. $W_{(N)} = 8.7 \%$. $\gamma_s = 2.68 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 9333 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 25 \text{ kN/m}^2$. $\psi_{un} = 31.38^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.84 . $SO_4^2 = 0.018 \%$. $Cl^- = 23 \text{ ppm}$ 	Picks and shovels can be used.	<p>H : nominal height for anchoring the tower.</p> <p>Concrete : C16/20 Steel : 500 Mpa Coating : 0.05 m</p> <p>B : dimension agreement with pressure transmitted to the ground .</p> <p>GOOD SOIL (110 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p>
SIP 4 (ON 110 kV line)	SF (very silty sand)	<ul style="list-style-type: none"> - IP : 21.0 % - Consistency $I_c = 1.30 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.81 \text{ t/m}^3$. $W_{OPM} = 16.21 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.58 \text{ t/m}^3$. $W_{(N)} = 16.0 \%$. $\gamma_s = 2.66 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 9333 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 25 \text{ kN/m}^2$. $\psi_{un} = 31.38^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.85 . $SO_4^2 = 0.018 \%$. $Cl^- = 23 \text{ ppm}$ 	Picks and shovels can be used.	<p>Concrete : C16/20 Steel : 500 Mpa Coating : 0.05 m</p> <p>GOOD SOIL (110 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p>

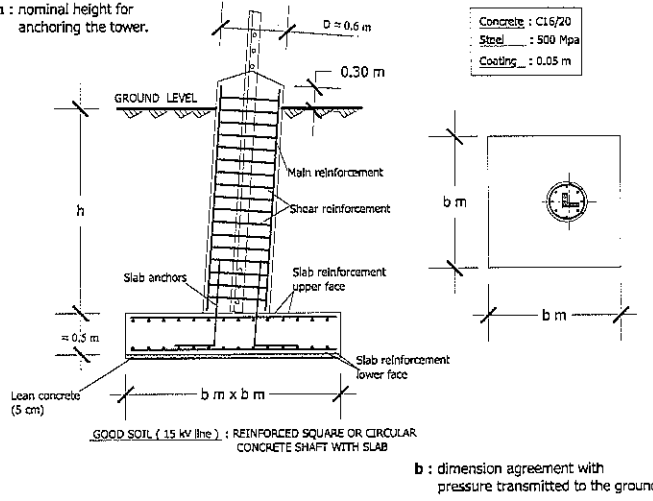
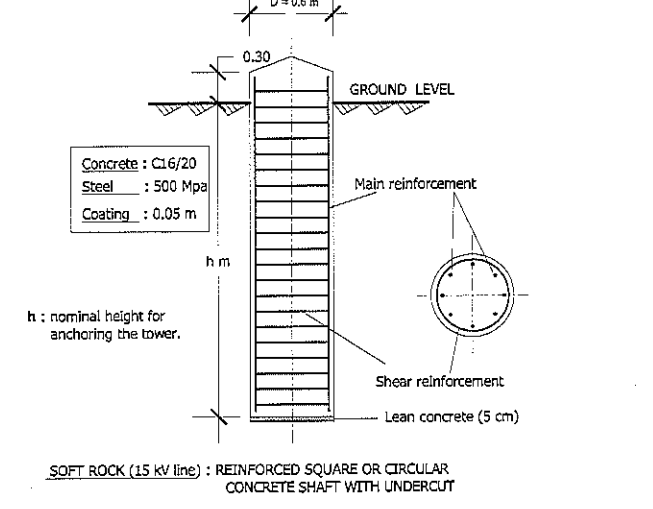
SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 5 (ON 110 kV line)	S F	<ul style="list-style-type: none"> - IP : 12.4 % - Consistency $I_c = 1.95 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 2.02 \text{ t/m}^3$. $W_{OPM} = 11.87 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.64 \text{ t/m}^3$. $W(n) = 10 \%$. $\gamma_s = 2.75 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 8000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 5 \text{ kN/m}^2$. $\psi_{uu} = 30.54^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 6.40 . $SO_4^2 = 0.017 \%$. $Cl^- = 37 \text{ ppm}$ 	Pneumatique hammer	 <p>SOFT ROCK (110 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH UNDERCUT</p>
SIP 6 (ON 110 kV line)	C I	<ul style="list-style-type: none"> - IP : 21.9 % - Consistency $I_c = 1.22 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.72 \text{ t/m}^3$. $W_{OPM} = 17.20 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.62 \text{ t/m}^3$. $W(n) = 18.9 \%$. $\gamma_s = 2.63 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 2000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 62 \text{ kN/m}^2$. $\psi_{uu} = 10.48^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.71 . $SO_4^2 = 0.015 \%$. $Cl^- = 11 \text{ ppm}$ 	Picks and shovels can be used.	 <p>GOOD SOIL (110 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p>

SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 7 (ON 110 kV line)	C I	<ul style="list-style-type: none"> - IP : 21.1 % - Consistency $I_c = 1.20 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.71 \text{ t/m}^3$. $W_{OPM} = 19.48 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.59 \text{ t/m}^3$. $W_{(N)} = 19.0 \%$. $\gamma_s = 2.63 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 1333 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 55 \text{ kN/m}^2$. $\psi_{uu} = 28.37^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 6.56 . $SO_4 = 0.021 \%$. $Cl^- = 16 \text{ ppm}$ 	Picks and shovels can be used.	
SIP 8 (ON 110 kV line)	C I	<ul style="list-style-type: none"> - IP : 18.8 % - Consistency $I_c = 1.04 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.76 \text{ t/m}^3$. $W_{OPM} = 17.32 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.65 \text{ t/m}^3$. $W_{(N)} = 19.6 \%$. $\gamma_s = 2.63 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 2500 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 27 \text{ kN/m}^2$. $\psi_{uu} = 26.57^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 7.31 . $SO_4 = 0.023 \%$. $Cl^- = 23 \text{ ppm}$ 	Picks and shovels can be used.	

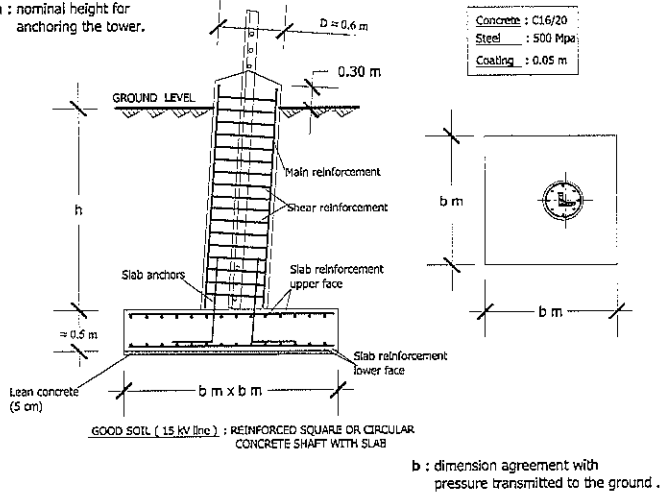
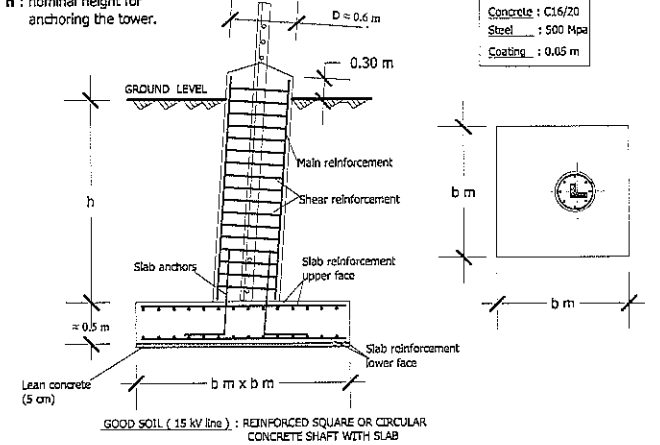
SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 9 (ON 110 kV line)	C I	<ul style="list-style-type: none"> - IP : 17.4 % - Consistency $I_c = 1.28 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.68 \text{ t/m}^3$. $W_{OPM} = 20.90 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.53 \text{ t/m}^3$. $W_{(N)} = 18.0 \%$. $\gamma_s = 2.67 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 2000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 44 \text{ kN/m}^2$. $\psi_{uu} = 25.87^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.67 . $SO_4^2 = 0.010 \%$. $Cl^- = 9 \text{ ppm}$ 	Picks and shovels can be used.	
SIP 10 (ON 15 kV line)	S F	<ul style="list-style-type: none"> - IP : 14.1 % - Consistency $I_c = 1.39 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 2.04 \text{ t/m}^3$. $W_{OPM} = 11.20 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.94 \text{ t/m}^3$. $W_{(N)} = 13.0 \%$. $\gamma_s = 2.79 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 7000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 1.0 \text{ kN/m}^2$. $\psi_{uu} = 33.42^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 7.00 . $SO_4^2 = 0.037 \%$. $Cl^- = 46 \text{ ppm}$ 	Picks and shovels can be used.	

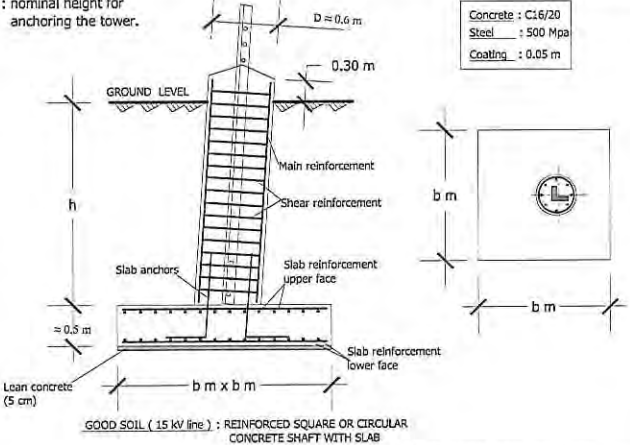
SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 11 (ON 15 kV line)	C I	<ul style="list-style-type: none"> - IP : 18.3 % - Consistency $I_c = 1.29 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.83 \text{ t/m}^3$. $W_{OPM} = 15.6 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.76 \text{ t/m}^3$. $W_{(N)} = 12.3 \%$. $\gamma_s = 2.66 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 8833 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 39 \text{ kN/m}^2$. $\psi_{uu} = 11.31^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 7.35 . $SO_4^2 = 0.014 \%$. $Cl^- = 14 \text{ ppm}$ 	Picks and shovels can be used.	<p>h : nominal height for anchoring the tower.</p>  <p>GOOD SOIL (15 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p> <p>b : dimension agreement with pressure transmitted to the ground .</p>
SIP 12 (ON 15 kV line)	C G	<ul style="list-style-type: none"> - IP : / - Consistency $I_c > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.91 \text{ t/m}^3$. $W_{OPM} = 13.21 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.82 \text{ t/m}^3$. $W_{(N)} = 10.2 \%$. $\gamma_s = 2.66 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 800 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = /$. $\psi_{uu} = /$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 7.68 . $SO_4^2 = 0.034 \%$. $Cl^- = 46 \text{ ppm}$ 	Picks and shovels can be used.	<p>h : nominal height for anchoring the tower.</p>  <p>GOOD SOIL (15 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p> <p>b : dimension agreement with pressure transmitted to the ground .</p>

SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 13 (ON 15 kV line)	C G	<ul style="list-style-type: none"> - IP : / - Consistency $I_c = > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.82 \text{ t/m}^3$. $W_{OPM} = 12.4 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.78 \text{ t/m}^3$. $W_{(N)} = 9.9 \%$. $\gamma_s = 2.45 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 9000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = /$. $\psi_{uu} = /$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.81 . $SO_4^{2-} = 0.021 \%$. $Cl^- = 26 \text{ ppm}$ 	Picks and shovels can be used.	<p>h : nominal height for anchoring the tower.</p>  <p>Concrete : C16/20 Steel : 500 Mpa Coating : 0.05 m</p> <p>GOOD SOIL (15 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p> <p>b : dimension agreement with pressure transmitted to the ground .</p>
SIP 14 (ON 15 kV line)	S F	<ul style="list-style-type: none"> - IP : / - Consistency $I_c > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 2.07 \text{ t/m}^3$. $W_{OPM} = 7.90 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.98 \text{ t/m}^3$. $W_{(N)} = 10.0 \%$. $\gamma_s = 2.61 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 9000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = /$. $\psi_{uu} = /$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.81 . $SO_4^{2-} = 0.021 \%$. $Cl^- = 26 \text{ ppm}$ 	Picks and shovels can be used.	<p>h : nominal height for anchoring the tower.</p>  <p>Concrete : C16/20 Steel : 500 Mpa Coating : 0.05 m</p> <p>GOOD SOIL (15 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p> <p>b : dimension agreement with pressure transmitted to the ground .</p>

SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 15 (ON 15 kV line)	C I	<ul style="list-style-type: none"> - IP : 15 % - Consistency $I_c = 1.61 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.97 \text{ t/m}^3$. $W_{OPM} = 11.48 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.82 \text{ t/m}^3$. $W_{(n)} = 7.0 \%$. $\gamma_s = 2.62 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 9000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 44 \text{ kN/m}^2$. $\psi_{uu} = 25.87^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.81 . $SO_4^2 = 0.050 \%$. $Cl^- = 28 \text{ ppm}$ 	Picks and shovels can be used.	
SIP 16 (ON 15 kV line)	S F	<ul style="list-style-type: none"> - IP : / - Consistency $I_c > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 2.00 \text{ t/m}^3$. $W_{OPM} = 11.5 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.71 \text{ t/m}^3$. $W_{(n)} = 2.6 \%$. $\gamma_s = 2.7 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 9000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = /$. $\psi_{uu} = /$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.82 . $SO_4^2 = 0.060 \%$. $Cl^- = 55 \text{ ppm}$ 	Pneumatique hammer	

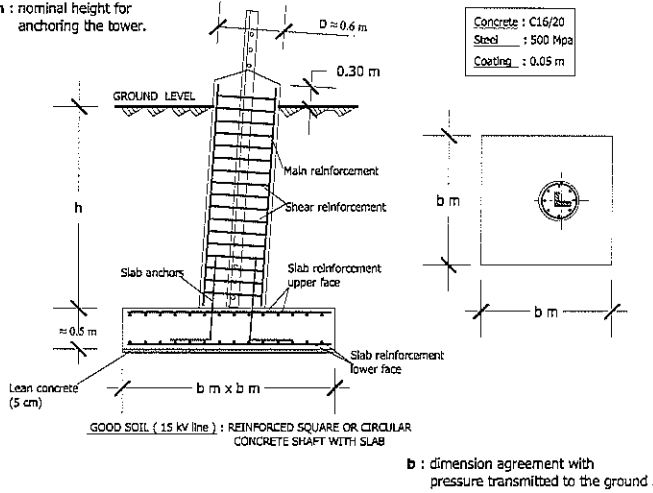
SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 17 (ON 15 kV line)	S F	<ul style="list-style-type: none"> - IP : / - Consistency $I_c > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{OPM} = 2.02 \text{ t/m}^3$. $W_{OPM} = 6.82 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.88 \text{ t/m}^3$. $W_{(N)} = 5.4 \%$. $\gamma_s = 2.43 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 9000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = /$. $\psi_{uu} = /$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 6.02 . $SO_4^2 = 0.010 \%$. $Cl^- = 10 \text{ ppm}$ 	Pneumatique hammer	<p>SOFT ROCK (15 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH UNDERCUT</p>
SIP 18 (ON 15 kV line)	C G	<ul style="list-style-type: none"> - IP : / - Consistency $I_c > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{OPM} = 2.09 \text{ t/m}^3$. $W_{OPM} = 6.0 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.97 \text{ t/m}^3$. $W_{(N)} = 6.0 \%$. $\gamma_s = 2.45 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 9000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = /$. $\psi_{uu} = /$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.88 . $SO_4^2 = 0.038 \%$. $Cl^- = 61 \text{ ppm}$ 	Pneumatique hammer	<p>SOFT ROCK (15 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH UNDERCUT</p>

SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a log)
SIP 19 (ON 15 kV line)	S F	<ul style="list-style-type: none"> - IP : 17.5 % - Consistency $I_c = 1.54 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 2.06 \text{ t/m}^3$. $W_{OPM} = 5.1 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.92 \text{ t/m}^3$. $W_{(N)} = 7.0 \%$. $\gamma_s = 2.60 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 1000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 60 \text{ kN/m}^2$. $\psi_{uu} = 26.79^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 6.18 . $SO_4^2 = 0.022 \%$. $Cl^- = 36 \text{ ppm}$ 	Picks and shovels can be used.	<p>h : nominal height for anchoring the tower.</p>  <p>Concrete : C16/20 Steel : 500 Mpa Coating : 0.05 m</p> <p>GOOD SOIL (15 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p> <p>b : dimension agreement with pressure transmitted to the ground .</p>
SIP 20 (ON 15 kV line)	C I	<ul style="list-style-type: none"> - IP : 17.9 % - Consistency $I_c = 1.31 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.80 \text{ t/m}^3$. $W_{OPM} = 18.42 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.68 \text{ t/m}^3$. $W_{(N)} = 13.5 \%$. $\gamma_s = 2.77 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 6000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 51 \text{ kN/m}^2$. $\psi_{uu} = 29.25^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 7.36 . $SO_4^2 = 0.025 \%$. $Cl^- = 45 \text{ ppm}$ 	Picks and shovels can be used.	<p>h : nominal height for anchoring the tower.</p>  <p>Concrete : C16/20 Steel : 500 Mpa Coating : 0.05 m</p> <p>GOOD SOIL (15 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p> <p>b : dimension agreement with pressure transmitted to the ground .</p>

SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 21 (gantry in REG Plot)	C I	<ul style="list-style-type: none"> - IP : 15.1 % - Consistency $I_c = 1.06 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{d,OPM} = 1.97 \text{ t/m}^3$. $W_{OPM} = 10.0 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.58 \text{ t/m}^3$. $W_{(N)} = 16.8 \%$. $\gamma_s = 2.61 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 3000 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 33 \text{ kN/m}^2$. $\psi_{uu} = 25.64^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 7.34 . $SO_4^2 = 0.013 \%$. $Cl^- = 12 \text{ ppm}$ 	Picks and shovels can be used.	<p>h : nominal height for anchoring the tower.</p>  <p>Concrete : C16/20 Steel : 500 Mpa Coating : 0.05 m</p> <p>GOOD SOIL (15 kV line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p> <p>b : dimension agreement with pressure transmitted to the ground .</p>
SIP 22 (in REG Plot)	C I (loose sedimentary rocks)	<ul style="list-style-type: none"> - IP : 19.0 % - Consistency $I_c = 1.27 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{d,OPM} = 1.77 \text{ t/m}^3$. $W_{OPM} = 17.91 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.66 \text{ t/m}^3$. $W_{(N)} = 17.2 \%$. $\gamma_s = 2.66 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 2333 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 44 \text{ kN/m}^2$. $\psi_{uu} = 25.87^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 6.75 . $SO_4^2 = 0.015 \%$. $Cl^- = 19 \text{ ppm}$ 	Picks and shovels can be used.	<p style="text-align: center;">IMPORTANT NOTES</p> <p>The area marked by the points SIP22, SIP23, SIP24, SIP25 and SIP26 is a land with a surface silty clay layer ($\pm 3.80 \text{ m}$) whose depth decreases towards the east and west, while it increases to the north. Below this layer, it generally falls on a hard sedimentary metamorphic layer.</p> <p>For any foundation constructed within 2.50 m of depth; the bearing capacity of the soil must be limited to 0.2 Mpa for current civil engineering works (buildings, various works), whereas for foundations going beyond this depth; the case of towers, take one of the types of foundation proposed above.</p>

SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 23 (in REG Plot)	S F (metamorphic sedimentary rocks)	<ul style="list-style-type: none"> - IP : / - Consistency $I_c > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 2.0 \text{ t/m}^3$. $W_{OPM} = 10.02 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.86 \text{ t/m}^3$. $W_{(N)} = 8.0 \%$. $\gamma_s = 2.62 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 8333 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = /$. $\psi_{uu} = /$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 6.89 . $SO_4^2 = 0.017 \%$. $Cl^- = 18 \text{ ppm}$ 	Picks and shovels can be used; preferably use pneumatic hammer.	See " IMPORTANT NOTES " (SIP 22)
SIP 24 (in REG Plot)	C I (clay hard)	<ul style="list-style-type: none"> - IP : 19.3 % - Consistency $I_c = 0.69$ and $0.5 < I_c < 0.75$: semi - consistence ground. - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{dOPM} = 1.76 \text{ t/m}^3$. $W_{OPM} = 19.60 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.65 \text{ t/m}^3$. $W_{(N)} = 18.0 \%$. $\gamma_s = 2.75 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 1333 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 45 \text{ kN/m}^2$. $\psi_{uu} = 18.78^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 6.88 . $SO_4^2 = 0.016 \%$. $Cl^- = 13 \text{ ppm}$ 	Picks and shovels can be used.	See " IMPORTANT NOTES " (SIP 22)

SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
SIP 25 (in REG Plot)	C I (clay hard)	<ul style="list-style-type: none"> - IP : 19.1 % - Consistency $I_c = 1.20 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{d,OPM} = 1.73 \text{ t/m}^3$. $W_{OPM} = 18.4 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.64 \text{ t/m}^3$. $W_{(N)} = 17.9 \%$. $\gamma_s = 2.65 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 1500 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 44 \text{ kN/m}^2$. $\psi_{su} = 25.87^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.52 . $SO_4^2 = 0.013 \%$. $Cl^- = 6 \text{ ppm}$ 	Picks and shovels can be used .	<u>See " IMPORTANT NOTES " (SIP 22)</u>
SIP 26 (in REG Plot)	C I (clay hard)	<ul style="list-style-type: none"> - IP : 18.5 % - Consistency $I_c = 1.15 > 1$: very consistent ground - Compaction Backfill : <ul style="list-style-type: none"> . $\gamma_{d,OPM} = 1.78 \text{ t/m}^3$. $W_{OPM} = 17.75 \%$ - Natural soil : <ul style="list-style-type: none"> . $\gamma_h = 1.62 \text{ t/m}^3$. $W_{(N)} = 16.3 \%$. $\gamma_s = 2.65 \text{ t/m}^3$ 	<ul style="list-style-type: none"> - Permissible bearing pressure (from 2.40 m deep) = 1500 kPa - Shear test : <ul style="list-style-type: none"> . $C_{uu} = 50 \text{ kN/m}^2$. $\psi_{su} = 29.25^\circ$ - Chemical analysis : <ul style="list-style-type: none"> . pH = 5.56 . $SO_4^2 = 0.009 \%$. $Cl^- = 7 \text{ ppm}$ 	Picks and shovels can be used.	<u>See " IMPORTANT NOTES " (SIP 22)</u>

SOIL INVESTIGATION POINTS	CLASSIFICATION ACCORDING BSCS	ENGINEERING PROPERTIES		EXCAVATION CONDITION	FOUNDATION TYPE (a leg)
<p>SIP 27 (on 15 kV line in REG Plot)</p>	<p>S F</p>	<p>- IP : /</p> <p>- Consistency $I_c > 1$: very consistent ground</p> <p>- Compaction Backfill :</p> <p> $\gamma_{d\text{PRM}} = 2.09 \text{ t/m}^3$</p> <p> $W_{\text{opt}} = 8.20 \%$</p> <p>- Natural soil :</p> <p> $\gamma_h = 1.98 \text{ t/m}^3$</p> <p> $W_{(N)} = 6.0 \%$</p> <p> $\gamma_s = 2.65 \text{ t/m}^3$</p>	<p>- Permissible bearing pressure (from 2.40 m deep) = 8667 kPa</p> <p>- Shear test :</p> <p> $C_{uu} = /$</p> <p> $\psi_{uu} = /$</p> <p>- Chemical analysis :</p> <p> pH = 5.94</p> <p> $\text{SO}_4^2 = 0.020 \%$</p> <p> $\text{Cl}^- = 16 \text{ ppm}$</p>	<p>Picks and shovels can be used ; preferably, use pneumatic hammer.</p>	 <p>h : nominal height for anchoring the tower.</p> <p>Concrete : C16/20 Steel : 500 Mpa Coating : 0.05 m</p> <p>GROUND LEVEL</p> <p>$D = 0.6 \text{ m}$</p> <p>0.30 m</p> <p>Main reinforcement</p> <p>Shear reinforcement</p> <p>Slab anchors</p> <p>Slab reinforcement upper face</p> <p>Slab reinforcement lower face</p> <p>h</p> <p>$b \text{ m}$</p> <p>$b \text{ m}$</p> <p>$b \text{ m} \times b \text{ m}$</p> <p>Lean concrete (5 cm)</p> <p>GOOD SOIL (15 kv line) : REINFORCED SQUARE OR CIRCULAR CONCRETE SHAFT WITH SLAB</p> <p>b : dimension agreement with pressure transmitted to the ground .</p>

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GEOLOGICAL UNIT SIP 1


Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES				
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)		
	0		0	0	0		
Organic Clay with rootlets, dark brownish, soft, moist, low plasticity. 0.00 - 0.80 m	20	[Red shaded area]	167	500	600		
	40		333	1000	1600		
	60		400	1200	2800		
	80		333	1000	4300		
	100		400	1200	6300		
Clay, yellowish beige, consistent & hard, intermediate plasticity. 0.80 - 3.40 m	120	[Orange shaded area]	267	800	7500		
	140		467	1400	8000		
	160		1400	4200	9000		
	180		3167	9500	13500		
	200		3500	10500	16500		
	220		2167	6500	20000		
	240		4000	12000	24500		
	260		4667	14000	31500		
	280		3333	10000	31000		
	300		3167	9500	30500		
	320		2667	8000	29500		
	340		2167	6500	27000		
	Clay with pebbels, yellowish beige, consistent & hard, low plasticity.		360	[Patterned area]	3667	11000	29500
			380		8667	26000	50000
			400				
	420						
	440						
	460						
	480						
	500						
	520						
	540						
	560						
	580						
	620						
	640						
	660						
	680						
	700						
	720						
	740						
	760						
	780						
	800						
	820						
	840						
	860						
	880						
	900						
	920						
	940						
	960						
	980						
	1000						

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 2

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES			
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)	
Lateritic soil with rootlets, dark red, hard, dry, without plasticity. 0.00 - 0.50 m	0		0	0	0	
	20		233	700	800	
	40		1167	3500	4000	
	60		2333	7000	7500	
80	2500		7500	8000		
100	2667		8000	8500		
120	4333		13000	13500		
140	7500		22500	34500		
160	8667		26000	46500		
180	9167		27500	50000		
Lateritic soil, dark red, very hard, dry, without plasticity. 0.50 - 4.00 m	200					
	220					
	240					
	260					
	280					
	300					
	320					
	340					
	360					
	380					
	400					
	420					
	440					
	460					
	480					
	500					
	520					
	540					
	560					
	580					
620						
640						
660						
680						
700						
720						
740						
760						
780						
800						
820						
840						
860						
880						
900						
920						
940						
960						
980						
1000						

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 3

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Organic Clay with rootlets, dark brownish, soft, moist, low plasticity. 0.00 - 1.00 m	20		567	1700	1800
	40		700	2100	3000
	60		533	1600	4000
	80		467	1400	4500
	100		833	2500	6000
Lateritic Clay, yellowish beige, consistent & hard, low plasticity. 1.00 - 4.00 m	120		1833	5500	7500
	140		4000	12000	13000
	160		8500	25500	34000
	180		8667	26000	43000
	200		9333	28000	50000
	220				
	240				
	260				
	280				
	300				
	320				
	340				
	360				
	380				
	400				
420					
440					
460					
480					
500					
520					
540					
560					
580					
620					
640					
660					
680					
700					
720					
740					
760					
780					
800					
820					
840					
860					
880					
900					
920					
940					
960					
980					
1000					
* ULS : Ultimate Limit State					

GEOLOGICAL UNIT SIP 4 (identical to SIP 3)

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Organic Clay with rootlets, dark brownish, soft, moist, low plasticity. 0.00 - 1.00 m	20		567	1700	1800
	40		700	2100	3000
	60		533	1600	4000
	80		467	1400	4500
	100		833	2500	6000
	120		1833	5500	7500
Lateritic Clay, yellowish beige, consistent & hard, low plasticity. 1.00 - 4.00 m	140		4000	12000	13000
	160		8500	25500	34000
	180		8667	26000	43000
	200		9333	28000	50000
	220				
	240				
	260				
	280				
	300				
	320				
	340				
	360				
	380				
	400				
	420				
	440				
	460				
	480				
500					
520					
540					
560					
580					
620					
640					
660					
680					
700					
720					
740					
760					
780					
800					
820					
840					
860					
880					
900					
920					
940					
960					
980					
1000					

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 5

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
Lateritic soil with rootlets, dark red, hard, dry, without plasticity. 0.00 - 0.50 m	0		0	0	0
	20		1167	3500	4000
	40		2167	6500	7000
	60		2333	7000	8000
	80		2167	6500	7500
Lateritic soil, dark red, very hard, dry, without plasticity. 0.50 - 4.00 m	100		2833	8500	9000
	120		4000	12000	13500
	140		4667	14000	14500
	160		5167	15500	18500
	180		6167	18500	24500
	200		6833	20500	27000
	220		7333	22000	36000
	240		8000	24000	44500
	260		9000	27000	50000
	280				
	300				
	320				
	340				
	360				
	380				
	400				
	420				
440					
460					
480					
500					
520					
540					
560					
580					
620					
640					
660					
680					
700					
720					
740					
760					
780					
800					
820					
840					
860					
880					
900					
920					
940					
960					
980					
1000					

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 6

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Clay soil with rootlets, yellowish red, soft, moist, intermediat plasticity. 0.00 - 0.50 m	20		133	400	600
	40		367	1100	1300
	60		800	2400	2700
	80		667	2000	4500
	100		767	2300	6500
Clay soil, yellowish red, consistent hard, dry, intermediat plasticity. 0.50 - 4.00 m	120		600	1800	7000
	140		2000	6000	11500
	160		2167	6500	14000
	180		1833	5500	13500
	200		2333	7000	15000
	220		2167	6500	17000
	240		2500	7500	19500
	260		3167	9500	23500
	280		3333	10000	27500
	300		3500	10500	28500
	320		3000	9000	27000
	340		2833	8500	26500
	360		2500	7500	27000
	380		2333	7000	24500
	400		2167	6500	24000
420		2000	6000	23500	
440		3000	9000	26500	
460		2333	7000	24500	
480		2167	6500	24000	
500		6333	19000	36000	
520		7000	21000	50000	
540					
560					
580					
620					
640					
660					
680					
700					
720					
740					
760					
780					
800					
820					
840					
860					
880					
900					
920					
940					
960					
980					
1000					

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 7

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
Clay soil with rootlets, dark brown, soft, moist, intermediat plasticity. 0.00 - 0.50 m	0		0	0	0
	20		100	300	400
	40		267	800	1000
	60		667	2000	2400
	80		833	2500	4500
Clay soil, brown,consistent hard, dry, intermediat plasticity. 0.50 - 4.00 m	100		933	2800	6000
	120		767	2300	7000
	140		867	2600	7500
	160		933	2800	8000
	180		1000	3000	10000
	200		1167	3500	12500
	220		1500	4500	15500
	240		1400	4200	14500
	260		1333	4000	14000
	280		1400	4200	15000
	300		1600	4800	15500
	320		1667	5000	14000
	340		2000	6000	14500
	360		2167	6500	15500
	380		2267	6800	17000
	400		2333	7000	19500
	420		2167	6500	16500
	440		1733	5200	14500
	460		1667	5000	13000
	480		1833	5500	13500
	500		1667	5000	13000
	520		1733	5200	13500
540		1333	4000	13000	
560		1833	5500	11500	
580		1667	5000	13500	
620		2000	6000	14500	
640		1833	5500	15500	
660		2000	6000	15000	
680		1733	5200	16000	
700		1833	5500	17000	
720		2167	6500	20000	
740		1833	5500	19000	
760		2167	6500	18500	
780		1833	5500	19500	
800		2000	6000	18500	
820		1833	5500	19500	
840		1833	5500	19000	
860		2000	6000	20500	
880		2167	6500	20000	
900		1833	5500	20500	
920		3000	9000	26500	
940		4833	14500	34500	
960		5667	17000	41500	
980		6833	20500	50000	
1000					

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 8

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Clay soil with rootlets, ligh brown, soft, moist, intermediat plasticity. 0.00 - 0.50 m	20		667	2000	2200
	40		1167	3500	3600
	60		1667	5000	5500
	80		2167	6500	7000
	100		2067	6200	6500
Clay soil, dark brown,consistent hard, dry, intermediat plasticity. 0.50 - 4.00 m	120		2333	7000	7500
	140		2500	7500	8000
	160		2333	7000	8500
	180		3500	10500	11000
	200		3667	11000	11500
	220		4333	13000	13500
	240		5167	15500	16500
	260		5333	16000	19500
	280		5000	15000	22500
	300		3667	11000	26500
	320		3833	11500	24500
	340		3500	10500	23500
	360		3667	11000	22500
	380		2667	8000	20500
	400		2500	7500	20000
	420		2667	8000	17500
	440		2500	7500	16500
	460		2333	7000	17000
	480		3500	10500	18000
	500		3167	9500	19500
520		2667	8000	22500	
540		3000	9000	22000	
560		3500	10500	24500	
580		5167	15500	28000	
620		6667	20000	40500	
640		6833	20500	45500	
660		7500	22500	50000	
680					
700					
720					
740					
760					
780					
800					
820					
840					
860					
880					
900					
920					
940					
960					
980					
1000					

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 9

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES			
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)	
	0		0	0	0	
Clay soil with rootlets, reddish brown, soft, moist, intermediat plasticity. 0.00 - 0.70 m	20		133	400	600	
	40		533	1600	2000	
	60		867	2600	2800	
	80		1567	4700	5000	
Clay soil, reddish brown,consistent hard, dry, intermediat plasticity. 0.70 - 4.00 m	100		1800	5400	5700	
	120		1333	4000	7500	
	140		2333	7000	8000	
	160		2500	7500	9500	
	180		2000	6000	11500	
	200		2167	6500	14500	
	220		2333	7000	18500	
	240		2167	6500	19000	
	260		2333	7000	19500	
	280		2167	6500	20500	
	300		2333	7000	21000	
	320		2000	6000	22500	
	340		2167	6500	24000	
	360		2333	7000	26000	
	380		2500	7500	26500	
	400		2167	6500	25500	
	420		2000	6000	24500	
	* ULS : Ultimate Limit State		440	1833	5500	22500
			460	1667	5000	21500
			480	2167	6500	21000
500			2333	7000	20500	
520			2167	6500	16500	
540			2333	7000	15500	
560			2500	7500	19000	
580			2667	8000	18000	
620			2833	8500	20500	
640			3167	9500	22500	
660			3000	9000	24000	
680			3167	9500	24500	
700			2833	8500	22500	
720			2333	7000	23500	
740			2167	6500	21500	
760			2667	8000	20500	
780			2500	7500	19500	
800			2833	8500	21500	
820			3000	9000	20500	
840		3167	9500	21000		
860	3500	10500	23500			
880	6833	20500	44500			
900	8667	26000	50000			
920						
940						
960						
980						
1000						

GEOLOGICAL UNIT SIP 10

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Clay soil with rootlets, reddish brown, soft, moist, intermediat plasticity. 0.00 - 0.70 m	20		400	1200	1500
	40		1167	3500	3700
	60		1067	3200	4200
	80		733	2200	5500
	100		1333	4000	7500
Clay soil, reddish brown,consistent hard, dry, intermediat plasticity. 0.70 - 4.00 m	120		1567	4700	9000
	140		1667	5000	14500
	160		4833	14500	25000
	180		5500	16500	34000
	200		6333	19000	42000
	220		7000	21000	50000
	240				
	260				
	280				
	300				
	320				
	340				
	360				
	380				
	400				
420					
* ULS : Ultimate Limit State	440				
	460				
	480				
	500				
	520				
	540				
	560				
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
820					
840					
860					
880					
900					
920					
940					
960					
980					
1000					

GEOLOGICAL UNIT SIP 11

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Blackish gray clay, soft, dry, intermediat plasticity. 0.00 - 1.50 m	20		233	700	800
	40		500	1500	1700
	60		633	1900	2200
	80		500	1500	2800
	100		533	1600	3700
	120		733	2200	6700
	140		5500	16500	23500
	160		6500	19500	44500
	180		8833	26500	50000
Blackish brown lateritic soil, consistent hard, dry, intermediat plasticity. 1.50 - 4.00 m	200				
	220				
	240				
	260				
	280				
	300				
	320				
	340				
	360				
	380				
	400				
	420				
	440				
	460				
480					
500					
520					
540					
560					
580					
620					
640					
660					
680					
700					
720					
740					
760					
780					
800					
820					
840					
860					
880					
900					
920					
940					
960					
980					
1000					

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 13

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES			
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)	
Silt with rootlets, dark brownish, soft, dry, low plasticity. 0.00 - 0.70 m	0		0	0	0	
	20					
	40					
	60					
	80					
Friable sedimentary rock, consistent hard, dry. 0.70 - 4.00 m	100		Metamorphic rock from 20 cm not allowing penetration We consider the minimum value under 2.40 m from SIP 15 area.			
	120					
	140					
	160					
	180					
	200		9000	27000	50000	
	220					
	240					
	260					
	280					
	300					
	320					
	340					
	360					
	380					
	390					
	400					
	* ULS : Ultimate Limit State	420				
		440				
		460				
480						
500						
520						
540						
560						
580						
620						
640						
660						
680						
700						
720						
740						
760						
780						
800						
820						
840						
860						
880						
900						
920						
940						
960						
980						
1000						

GEOLOGICAL UNIT SIP 14

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES			
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)	
Silt with rootlets, dark brownish, soft, dry, low plasticity. 0.00 - 0.70 m	0		0	0	0	
	20	Metamorphic rock from 20 cm not allowing penetration	We consider the minimum value under 2.40 m from SIP 15 area.			
	40					
	60					
	80					
100						
Friable sedimentary rock, consistent hard, dry. 0.70 - 4.00 m	120					
	140					
	160					
	180					
	200		9000	27000	50000	
	220					
	240					
	260					
	280					
	300					
	320					
	340					
	360					
	380					
	390					
	400					
	* ULS : Ultimate Limit State	420				
		440				
		460				
		480				
500						
520						
540						
560						
580						
620						
640						
660						
680						
700						
720						
740						
760						
780						
800						
820						
840						
860						
880						
900						
920						
940						
960						
980						
1000						

GEOLOGICAL UNIT SIP 15

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
Reddish clay with rootlets, soft, dry, low plasticity. 0.00 - 0.70 m	0		0	0	0
	20		333	1000	1400
	40		267	800	1000
	60		333	1000	1600
	80		400	1200	2000
Reddish clay with very hard gravel, hard, dry, low plasticity. 0.70 - 4.00 m	100		1500	4500	5000
	120		5167	15500	16000
	140		6833	20500	26000
	160		8500	25500	30500
	180		8667	26000	41500
	200		9000	27000	50000
	220				
	240				
	260				
	280				
	300				
	320				
	340				
	360				
	380				
	390				
	400				
	420				
	440				
	460				
480					
500					
520					
540					
560					
580					
620					
640					
660					
680					
700					
720					
740					
760					
780					
800					
820					
840					
860					
880					
900					
920					
* ULS : Ultimate Limit State	940				
	960				
	980				
	1000				

GEOLOGICAL UNIT SIP 16

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Rocky ground, whitish brown, moyenement hard sedimentary rock	20		Metamorphhic rock from 20 cm not allowing penetration We consider the minimum value under 2.40 m from SIP 15 area.		
	40				
	60				
	80				
	100				
	120				
	140				
	160				
	180				
	200		9000	27000	50000
	220				
	240				
	260				
	280				
	300				
	320				
	340				
	360				
	380				
	390				
400					
* ULS : Ultimate Limit State	420				
	440				
	460				
	480				
	500				
	520				
	540				
	560				
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
	820				
840					
860					
880					
900					
920					
940					
960					
980					
1000					

GEOLOGICAL UNIT SIP 17

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES			
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)	
	0		0	0	0	
	20	Metamorphic rock from 20 cm not allowing penetration We consider the minimum value under 2.40 m from SIP 15 area.				
	40					
	60					
	80					
	100					
	120					
	140					
	160					
	180					
	200			9000	27000	50000
	220					
	240					
	260					
	280					
	300					
	320					
	340					
	360					
	380					
	390					
	400					
	420					
	440					
	460					
	480					
	500					
	520					
	540					
	560					
	580					
	620					
	640					
	660					
	680					
	700					
	720					
	740					
	760					
	780					
	800					
	820					
	840					
	860					
	880					
	900					
	920					
	940					
	960					
	980					
	1000					

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 18

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES					
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)			
	0		0	0	0			
Rocky ground, whitish brown, moyement hard sedimentary rock and quartz gravel.	20		Metamorohic rock from 20 cm not allowing penetration We consider the minimum value under 2.40 m from SIP 15 area.					
	40							
	60							
	80							
	100							
	120							
	140							
	160							
	180							
	200					9000	27000	50000
	220							
	240							
	260							
	280							
	300							
	320							
	340							
	360							
	380							
	390							
400								
	420							
	440							
	460							
	480							
	500							
	520							
	540							
	560							
	580							
	620							
	640							
	660							
	680							
	700							
	720							
	740							
	760							
	780							
	800							
	820							
	840							
	860							
	880							
	900							
	920							
	940							
	960							
	980							
	1000							

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 19

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Clay soil with rootlets, reddish brown, soft, moist, intermediat plasticity. 0.00 - 1.50 m	20		500	1500	1800
	40		533	1600	2700
	60		900	2700	4500
	80		2000	6000	7000
	100		2333	7000	8500
	120		1500	4500	9500
	140		1333	4000	13500
	160		1667	5000	16500
	180		1500	4500	19000
	200		2000	6000	23000
Sedimentary rock soil, reddish brown, consistent but friable and dry. 1.50 - 4.00 m	220		1500	4500	29500
	240		1333	4000	25500
	260		1500	4500	26500
	280		2333	7000	30500
	300		3333	10000	34500
	320		3500	10500	36500
	340		3333	10000	39500
	360		2000	6000	40500
	380		1500	4500	38000
	400		1000	3000	37500
* ULS : Ultimate Limit State	420		3667	11000	36500
	440		5000	15000	44000
	460		5500	16500	50000
	480				
	500				
	520				
	540				
	560				
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
	820				
840					
860					
880					
900					
920					
940					
960					
980					
1000					

GEOLOGICAL UNIT SIP 20

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Clay soil with rootlets, reddish brown, soft, moist, intermediat plasticity. 0.00 - 1.30 m	20		400	1200	1500
	40		333	1000	1600
	60		267	800	2800
	80		600	1800	3200
	100		1667	5000	6500
	120		3667	11000	14000
	140		4167	12500	18500
Lateritic soil, reddish brown, consistent ,hard, dry. 1.30 - 4.00 m	160		4667	14000	23000
	180		4833	14500	29500
	200		5167	15500	33500
	220		5833	17500	41500
	240		6000	18000	46500
	260		6167	18500	50000
	280				
	300				
	320				
	340				
	360				
	380				
	400				
* ULS : Ultimate Limit State	420				
	440				
	460				
	480				
	500				
	520				
	540				
	560				
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
	820				
840					
860					
880					
900					
920					
940					
960					
980					
1000					

GEOLOGICAL UNIT SIP 21

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Clay soil with rootlets, reddish brown, soft, moist, intermediat plasticity. 0.00 - 2.30 m	20		500	1500	2100
	40		1533	4600	5000
	60		2233	6700	7000
	80		2167	6500	6500
	100		2167	6500	7000
	120		2233	6700	7500
	140		2500	7500	8000
	160		2000	6000	10500
	180		1667	5000	13500
	200		1833	5500	19500
	220		2000	6000	18000
	240		1833	5500	17500
	Lateritic soil, reddish brown, consistent ,hard, dry. 2.30 - 4.00 m		260		3000
280		4667	14000		30500
300		6833	20500		43500
320		8667	26000		50000
340					
360					
380					
400					
* ULS : Ultimate Limit State	420				
	440				
	460				
	480				
	500				
	520				
	540				
	560				
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
	820				
840					
860					
880					
900					
920					
940					
960					
980					
1000					

GEOLOGICAL UNIT SIP 22

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Clay soil with rootlets in topsoil (0.50 cm thick), reddish brown, hard, intermediat plasticity. 0.00 - 3.60 m	20		100	300	400
	40		167	500	500
	60		567	1700	2000
	80		600	1800	2200
	100		1167	3500	3700
	120		900	2700	5000
	140		833	2500	7500
	160		2000	6000	10500
	180		2167	6500	12500
	200		333	1000	9500
	220		1667	5000	12000
	240		2333	7000	15500
	260		6667	20000	30500
	280		7333	22000	40500
	300		5667	17000	42000
	320		8667	26000	46500
	340		8833	26500	50000
360					
Lateritic soil, reddish brown, consistent, hard, dry. 3.6 - 4.00 m	380				
	400				
	420				
	440				
	460				
	480				
	500				
	520				
	540				
	560				
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
	820				
	840				
	860				
	880				
	900				
	920				
	940				
	960				
	980				
	1000				

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 23

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Lateritic soil with pebbles over the height, reddish brown, consistent, hard, dry.	20		67	200	500
	40		333	1000	1200
	60		600	1800	2200
	80		900	2700	3000
	100		1167	3500	5500
	120		2000	6000	7000
	140		3167	9500	14500
	160		2667	8000	16500
	180		5333	16000	25500
	200		8333	25000	31500
	220		8500	25500	40500
	240		8333	25000	46000
	260		8833	26500	50000
	280				
	300				
	320				
	340				
360					
380					
400					
* ULS : Ultimate Limit State	420				
	440				
	460				
	480				
	500				
	520				
	540				
	560				
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
	820				
840					
860					
880					
900					
920					
940					
960					
980					
1000					

GEOLOGICAL UNIT SIP 24

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Lateritic soil, reddish gray, consistent, hard. 0.00 - 3.20 m	20		133	400	1700
	40		500	1500	2200
	60		667	2000	4000
	80		1200	3600	5600
	100		1667	5000	7500
	120		2000	6000	8500
	140		1500	4500	11000
	160		1667	5000	14500
	180		2000	6000	16500
	200		2167	6500	18500
	220		2333	7000	19500
	240		2500	7500	22000
	260		2667	8000	20500
	280		2333	7000	19500
	300		2167	6500	18500
320	2000	6000	18000		
Lateritic soil, reddish brown, consistent, hard. 3.20 - 4.00 m	340		1867	5600	18500
	360		2000	6000	17000
	380		1833	5500	15500
	400		1500	4500	13500
	420		1333	4000	20500
	440		3167	9500	26500
	460		3667	11000	39500
	480		4833	14500	32500
	500		4000	12000	42500
	520		5500	16500	44500
	540		5667	17000	50000
	560				
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
	820				
840					
860					
880					
900					
920					
940					
* ULS : Ultimate Limit State	960				
	980				
	1000				

GEOLOGICAL UNIT SIP 25

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Lateritic soil, reddish gray, consistent, hard. 0.00 - 3.20 m	20		167	500	800
	40		400	1200	1400
	60		733	2200	2500
	80		1333	4000	4500
	100		1833	5500	6000
	120		2167	6500	7500
	140		2333	7000	10500
	160		2167	6500	16500
	180		2500	7500	24000
	200		2667	8000	26500
	220		2333	7000	25500
	240		2000	6000	24000
	260		1833	5500	25500
	280		2000	6000	25000
	300		1833	5500	27500
320	1667	5000	26000		
Lateritic soil, reddish brown, consistent, hard. 3.20 - 4.00 m	340		1500	4500	24500
	360		1667	5000	25500
	380		2000	6000	26500
	400		2167	6500	24500
	420		1833	5500	21000
	440		2167	6500	21500
	460		2000	6000	24500
	480		2167	6500	27500
	500		2333	7000	38000
	520		4833	14500	41500
	540		5333	16000	44500
	560		5833	17500	50000
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
	820				
840					
860					
880					
900					
920					
940					
* ULS : Ultimate Limit State	960				
	980				
	1000				

GEOLOGICAL UNIT SIP 26

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

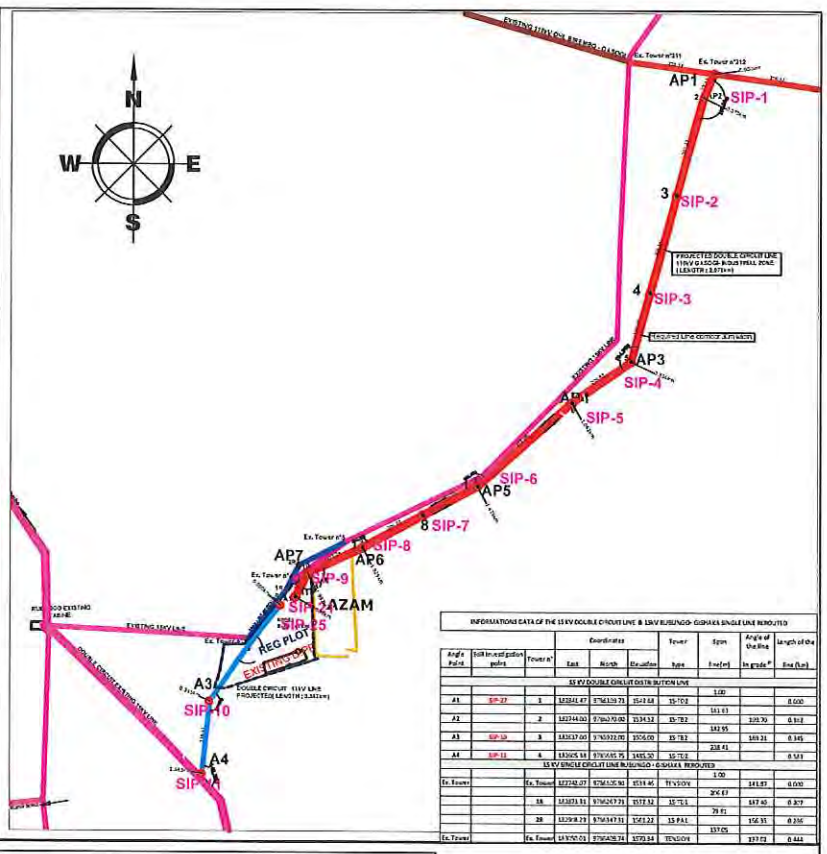
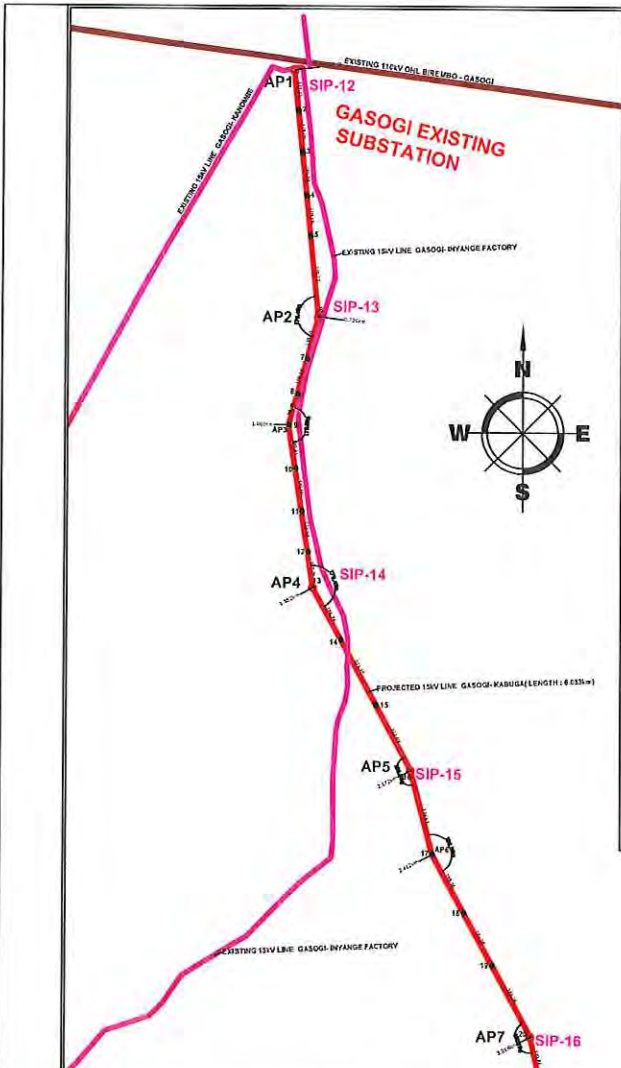
DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Clay soil, dark red, consistent, hard.	20		33	100	200
	40		400	1200	1500
	60		667	2000	2500
	80		567	1700	4500
	100		933	2800	6500
	120		2333	7000	10500
	140		2500	7500	17000
	160		2167	6500	21000
	180		2333	7000	24500
	200		2167	6500	28500
	220		3000	9000	31500
	240		3333	10000	32500
	260		3500	10500	36500
	280		3167	9500	38000
	300		3667	11000	39500
	320		3833	11500	41500
	340		4000	12000	42500
	360		2167	6500	44500
	380		2000	6000	43000
	400		1833	5500	42000
	420		1667	5000	41500
	440		1500	4500	39500
	460		1667	5000	37500
	480		1333	4000	36500
	500		1667	5000	37000
	520		2167	6500	39500
	540		4833	14500	42000
	560		6833	20500	50000
	580				
	620				
	640				
	660				
	680				
	700				
	720				
	740				
	760				
	780				
	800				
	820				
840					
860					
880					
900					
920					
940					
960					
980					
1000					

* ULS : Ultimate Limit State

GEOLOGICAL UNIT SIP 27

Light penetrometer (GeoMIL 50 kN SPT) test without soil coring for sample taking

DESCRIPTION OF THE PIT	Depth (below existing ground level) cm	Soil Stratigraphy (observed in the well)	GEOTECHNICAL BEARING CAPACITIES		
			Allowable (kPa)	ULS * (kPa)	Ultimate (kPa)
	0		0	0	0
Organic Clay with rootlets, dark brownish, soft, moist, low plasticity. 0.00 - 0.70 m	20		267	800	1000
	40		500	1500	1700
	60		533	1600	2800
	80		400	1200	3500
	100		667	2000	6000
Brownish gray stony soil, hard, low plasticity. 0.70 - 4.0 m	120		2333	7000	9500
	140		5333	16000	25500
	160		6833	20500	31500
	180		6500	19500	36500
	200		6833	20500	46000
	220		7333	22000	47500
	240		8667	26000	50000
	260				
	280				
	300				
	320				
	340				
	360				
	380				
	400				
* ULS : Ultimate Limit State	420				
	440				
	460				
	480				
	500				
	520				
	540				
	560				
	580				
	620				
	640				
	660				
	680				
	700				
	720				
740					
760					
780					
800					
820					
840					
860					
880					
900					
920					
940					
960					
980					
1000					



Angle Point	SP Tower n°	Coordinates		Tower Type	Span (m)	Angle of the line (grade)	Length of the line (m)
		East	North				
AP1 SIP-12	1	142731.00	277726.00	15-F.1	110.0	0	0.00
		142731.00	277726.00	15-F.1	110.0	0	0.00
		142731.00	277726.00	15-F.1	110.0	0	0.00
		142731.00	277726.00	15-F.1	110.0	0	0.00
		142731.00	277726.00	15-F.1	110.0	0	0.00

Angle Point	SP Tower n°	Coordinates			Tower Type	Span (m)	Angle of the line (grade)	Length of the line (m)
		East	North	Division				
EXISTING LINE REDROUTED								
AP1	SIP-12	142731.00	277726.00	15-F.1	110.0			0.00

Angle Point	SP Tower n°	Coordinates			Tower Type	Span (m)	Angle of the line (grade)	Length of the line (m)
		East	North	Division				
EXISTING LINE REDROUTED								
NEW LINE								
AP1	SIP-3	124120.00	979770.00	15-F.1	110.0			0.00

LEGEND

- 15 kV existing line
- Projected 15kV line Gasogi - Kibuga
- 110kV existing line
- SIP Soil Investigation Point

2	Apr 2015	General Overview project	YES	JCA
1	Apr 2015	General Overview project	YES	JCA
REV.	DATE	DESCRIPTION	ISSUED	CHECKED

REPUBLIC OF RWANDA

Yeco YACHIO ENGINEERING CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY

PROJECT

JICA PROJECT PHASE II

TITLE

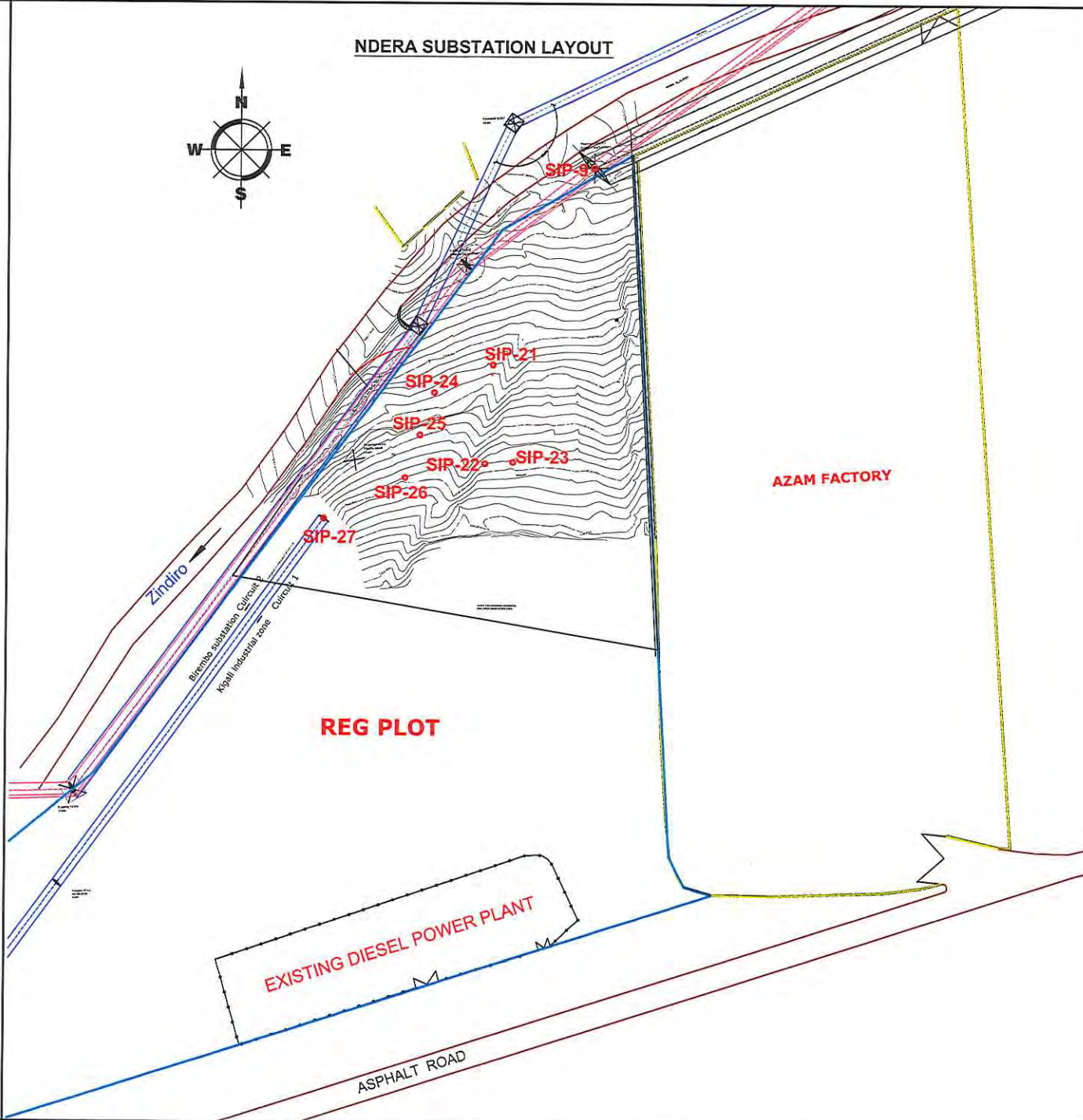
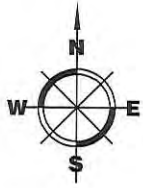
GENERAL OVERVIEW PROJECT FOR 15 & 110kV LINES

Revised by: [Signature]

+110kV & 15kV double circuit line drawing of 15-F.1 & 2
+15kV single circuit line drawing of 15-F.1 & 2
+15kV proposed line drawing of 15-F.1

Name	Position	Approval by Client	Date	Signature & stamp

NDERA SUBSTATION LAYOUT



CONNECTION OF 110KV DOUBLE CIRCUIT LINE TO EXISTING 15KV
LINE FROM BIRAMBA TO GASOGI SUBSTATIONS
Scale: 1:200

SIP	WGS 84	UTM	Easting	Northing
SIP-21	WGS 84	UTM	128740.00	9786111.78
SIP-22	WGS 84	UTM	128740.00	9786111.78
SIP-23	WGS 84	UTM	128740.00	9786111.78
SIP-24	WGS 84	UTM	128740.00	9786111.78
SIP-25	WGS 84	UTM	128740.00	9786111.78
SIP-26	WGS 84	UTM	128740.00	9786111.78
SIP-27	WGS 84	UTM	128740.00	9786111.78

LEGEND

- Proposed 110 kV double circuit line
- Existing 15 kV line
- 15 kV line to be replaced
- Soil investigation point

REPUBLIC OF RWANDA			
RWANDA ENERGY GROUP			
Project: JICA PROJECT PHASE II			
Title: NDERA SUBSTATION LAYOUT			
Drawn	Checked	Approved by Client	Date
Author	Scale	Contract No.	Date
Drawing No: 1000-1-001			