5. Methodology

Methodology

1. Basic Datum for Surveying

The following basic datum for surveying was adopted for the topographic survey works:

1) Spheroid	:	Clarke 1880
2) Map projection	:	Universal Transverse Mercator
3) Datum	:	1960 Arc
4) Vertical datum	:	Mean Sea Level
5) Grid	:	UTM Zone 36 N
6) Unit of measurement	:	Metric system

2. Scope Survey Work

The survey works included the following activities:

1) Ground Control Survey for Photogrammetric Mapping
2) Installation of New Permanent Bench Marks and Pre-marking Points
3) Aerial Photography at a scale of 1:20,000
4) Photogrammetric mapping at a Scale of 1:10,000
5) Aerial Photography at a scale of 1:6,000
6) Photogrammetric mapping of Structure Sites at a Scale of 1:1,000
7) River Cross Section Survey
8) Ground Control Survey for Photogrammetric Mapping

3. Horizontal Control

(1) Method

A traverse was carried out from the controls used for the survey of Karuma Power Dam site. Location Map of Karuma Control Point is shown in the following figure.

Location Map of Karuma Control Point

Point	Easting	Northing	Elevation
K18	416661.235	248662.521	1058.332
K5	417525.205	248093.915	1070.706

The traversing to determine the horizontal coordinates was performed by using the Global Positioning System (GPS) equipments, with the following specifications:

a) Type of GPS receiver : Magellan ProMark 3 RTK
b) Accuracy of GPS receiver : ±(5 mm+1ppm×D)
(where, D = Distance of baseline)

4. Vertical Control

The elevation of new benchmarks that were used as the permanent base points were obtained by the 1st order leveling referred to the Fundamental Benchmark at Karuma.

KARUMA FBM	Easting	Northing	Elevation
FBM	415370.161	248312.822	1006.895
CMN	416106.831	247656.876	1039.704

(1) 1st Order Leveling

Leveling was started from the existing benchmarks and loops of approximately 500 m were taken. The accuracy of the leveling is within allowable limits.

AUTOMATIC Level ND 03 was used

5. Installation of New Bench Marks and Pre-marking points

We installed a total of 8 Bench marks (4 inlet south, 2 inlet north, and 2 outlet north).

Bench Marks

POINT	EASTING	NORTHING	ELEVATION
BM03	381032.005	259334.703	883.793
BM04	381236.300	258864.211	886.061
BM06	374255.504	260538.351	833.654
BM01	382249.591	260107.025	878.815
TBM1	380816.104	259436.918	886.417
TBM2	381016.536	258614.444	896.596
TBM 3	374368.293	260832.876	794.181
TBM4	382118.031	260079.174	874.400

6. Aerial Photography

The Aerial Photography was conducted on the 8th September, 2010 by Imao/Aerophoto Flight from France. The Aerial photography was carried out at a scale of 1:20,000 for aerial mapping at a scale of 1:10,000. A total of twenty six photos were taken at a scale of 1:6,000 for aerial mapping at a scale of 1:1,000. A total of seventeen photos were taken.

A total of fourty three (43) pre marking points were observed and their coordinates are as shown below;

Pre-Marking Points

	PREMARKING POINTS			
NO.	POINT NAME	Easting	Northing	Vert. Height
1	A	385723.577	256452.441	913.770
2	A1	385777.149	256431.880	911.326
3	B	385854.848	263424.767	892.728
4	B2	386333.563	263566.018	886.892
5	C	372332.593	263163.919	811.067
6	C2	372092.481	263445.029	805.718
7	D	372117.536	256524.050	895.845
8	D2	372005.252	256505.970	898.540
9	E	379208.969	256395.728	925.774
10	E2	379235.953	256407.574	926.451
11	F	380167.110	263445.001	887.322
12	F2	380134.676	263388.405	884.563
13	G	386096.158	259995.461	947.319
14	G2	386258.244	259957.873	950.855
15	H	371877.753	260668.434	786.341
16	H2	371814.295	260303.433	839.163
17	I	379283.948	260026.196	881.156
18	I2	379268.759	260079.680	881.410
19	IN1	382881.739	260013.466	884.280
20	IN1A	382897.240	260064.072	889.785
21	IN2	381090.507	258789.432	883.919
22	IN2A	381273.651	258763.765	883.405
23	IN3	380619.605	259471.081	899.315
24	IN3A	380646.029	259461.533	901.024
25	IN4	382020.507	260564.459	884.394
26	IN4A	382453.558	261118.496	911.448
27	OUT1	374319.873	260422.877	840.572
28	OUT1A	374726.322	260400.605	840.265
29	OUT2	373734.634	260612.912	784.139
30	OUT2A	373714.436	260516.870	837.462

31	OUT3	374052.673	262160.459	792.949
32	OUT3A	372714.178	262685.342	793.795
33	OUT4	374745.281	262039.567	798.010
34	OUT4A	373052.804	263506.791	812.028
35	B1	381888.757	259898.326	866.648
36	B3	381294.839	259412.349	862.117
37	B4	381585.167	259186.943	866.216
38	B5	381183.964	259365.727	869.797
39	B6	381506.220	259121.071	870.003
40	B7	374078.159	260757.248	795.664
41	B8	374300.282	260812.859	796.535
42	TBM 5	374162.902	261216.993	765.708
43	TBM6	374129.790	261214.096	767.295

7 Cross Section Survey

(1) River Cross Section Survey

JICA Study team, MEMD and the contractor had joint site inspections to identify actual survey lines of Nile River on the 1st -5thJune, 2010. Based on the results of the site inspection, a total of 5 river cross sections were made, three (3) at the inlet site and two (2) at the outlet site. River cross sections were done using an echo sounder mounted on a boat.

However, other area between inlet and outlet was not accessible by vehicle due to cliffs along the Nile River. Considering difficulties of transportation of a boat and importance of inlet and outlet site, land cross section areas both of inlet and outlet were increased in total length instead of river cross area.

(2) Land Cross Section Survey

Detailed topographic surveys were also carried out both at the inlet and outlet sections. Inland cross sections were done from the drill points to the river at various points.

The total length of cross sections is 11 km as shown below.

River/Land Cross Section

No	Section			Length (m)
1	Intake	Land Section	B-1	299
2	Intake	Land Section	B-1A	267
3	Intake	Land Section	B-2	463
4	Intake	Land Section	B3-1	368
5	Intake	Land Section	B3-2	383
6	Intake	Land Section	B3-3	420
7	Intake	Land Section	B3-4	425
8	Intake	Land Section	B4-1	500
9	Intake	Land Section	B4-2	500
10	Intake	Land Section	B4-3	500
11	Intake	Land Section	B4-4	580
12	Intake	Land Section	1	868
13	Intake	Land Section	1-1	864
14	Intake	Land Section	2	747
15	Intake	River cross section	1	346
16	Intake	River cross section	2	260
17	Intake	River cross section	3	840
18	Outlet	Land Section	1	456
19	Outlet	Land Section	2	503
20	Outlet	Land Section	3	360
21	Outlet	River cross section	1	617
22	Outlet	River cross section	2	442
	Total			11,008

6. Photographs

Photographs of Control Point

CMN

FBM2

FBM

Photographs of Control Points

BM1

E: 382249.5909

N: 260107.0253

ht: 878.8147

Photographs of Bench Mark

TBM4

E: 382118.031

N: 260079.1741

ht: 874.3997

Photographs of Bench Mark

BM3

E: 381032.0055

N: 259334.7034

ht: 883.7929

Photographs of Bench Marks

TBM1

E: 380816.1038

N: 259436.9178

ht: 886.4167

Photographs of Bench Marks

BM4

E: 381236.3001

N: 258864.2114

ht: 886.0613

Photographs of Bench Mark

TBM2

E: 381016.5364

N: 258614.4438

ht: 896.5964

Photographs of Bench Marks

BM6

E: 374255.5037

N: 260538.3506

ht: 833.6544

Photographs of Bench Mark

TBM3

E: 374368.2929

N: 260832.8759

ht: 794.1814

Photographs of Bench Mark

Appendix C

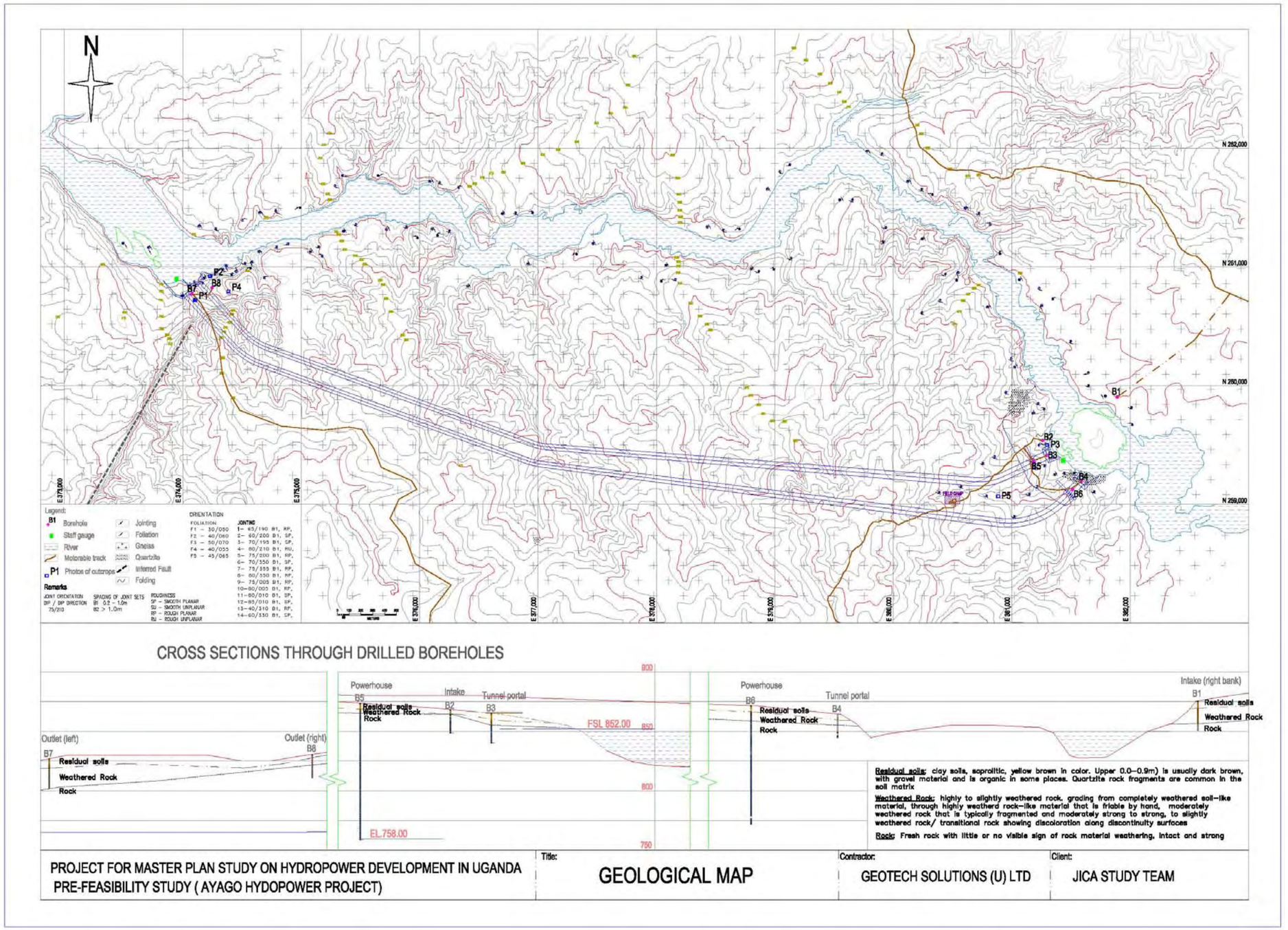
Geological Investigation

LIST OF CONTENTS

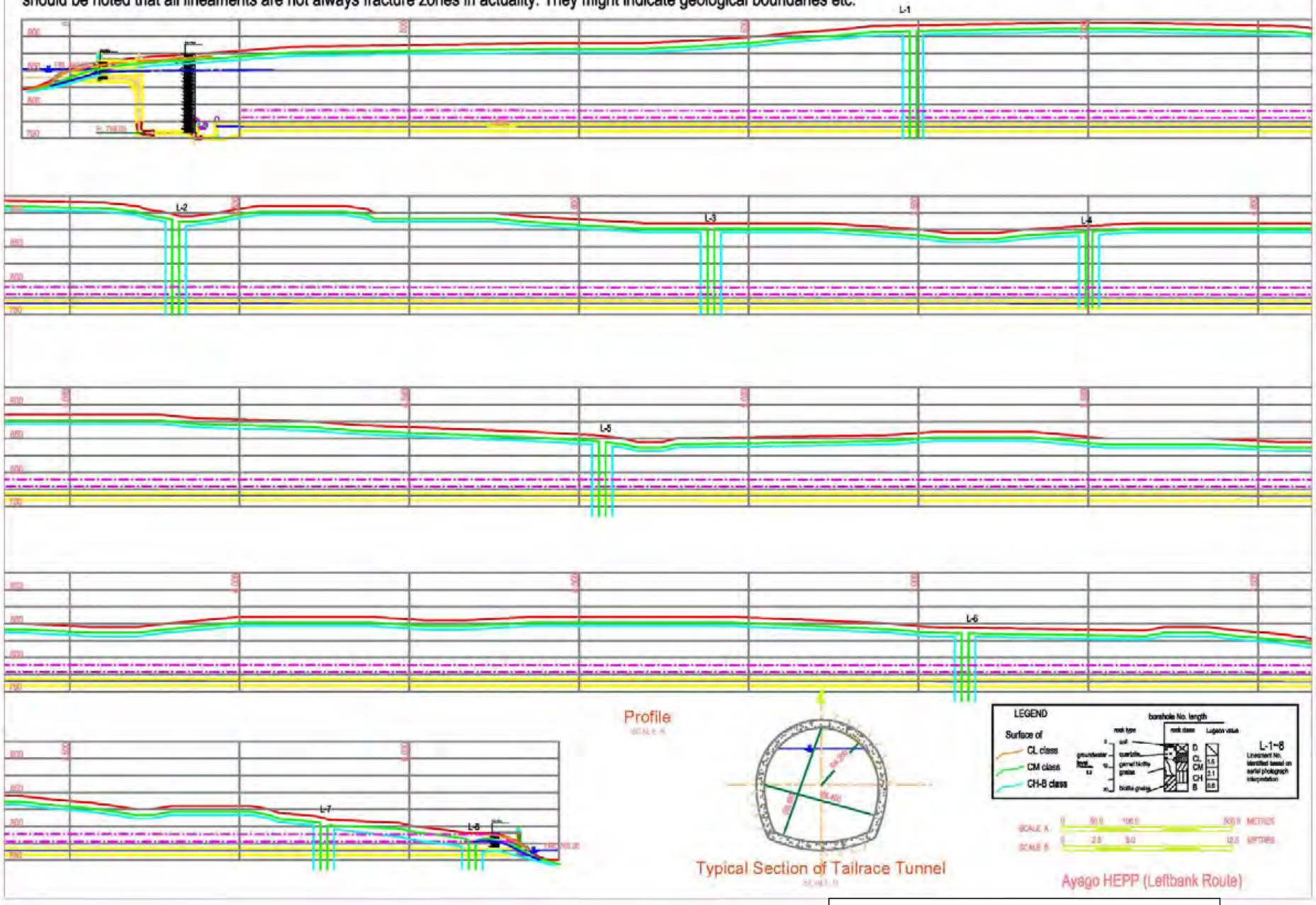
Note: Geodetic Information

1) Spheroid	:	Clarke 1880 (Modified)
2) Map projection	:	Transverse Mercator
3) Datum	:	New (1960) Arc
4) Vertical datum	:	New Khartoum
5) Grid	:	UTM Zone 36 N
6) Unit of measurement	:	Metric system

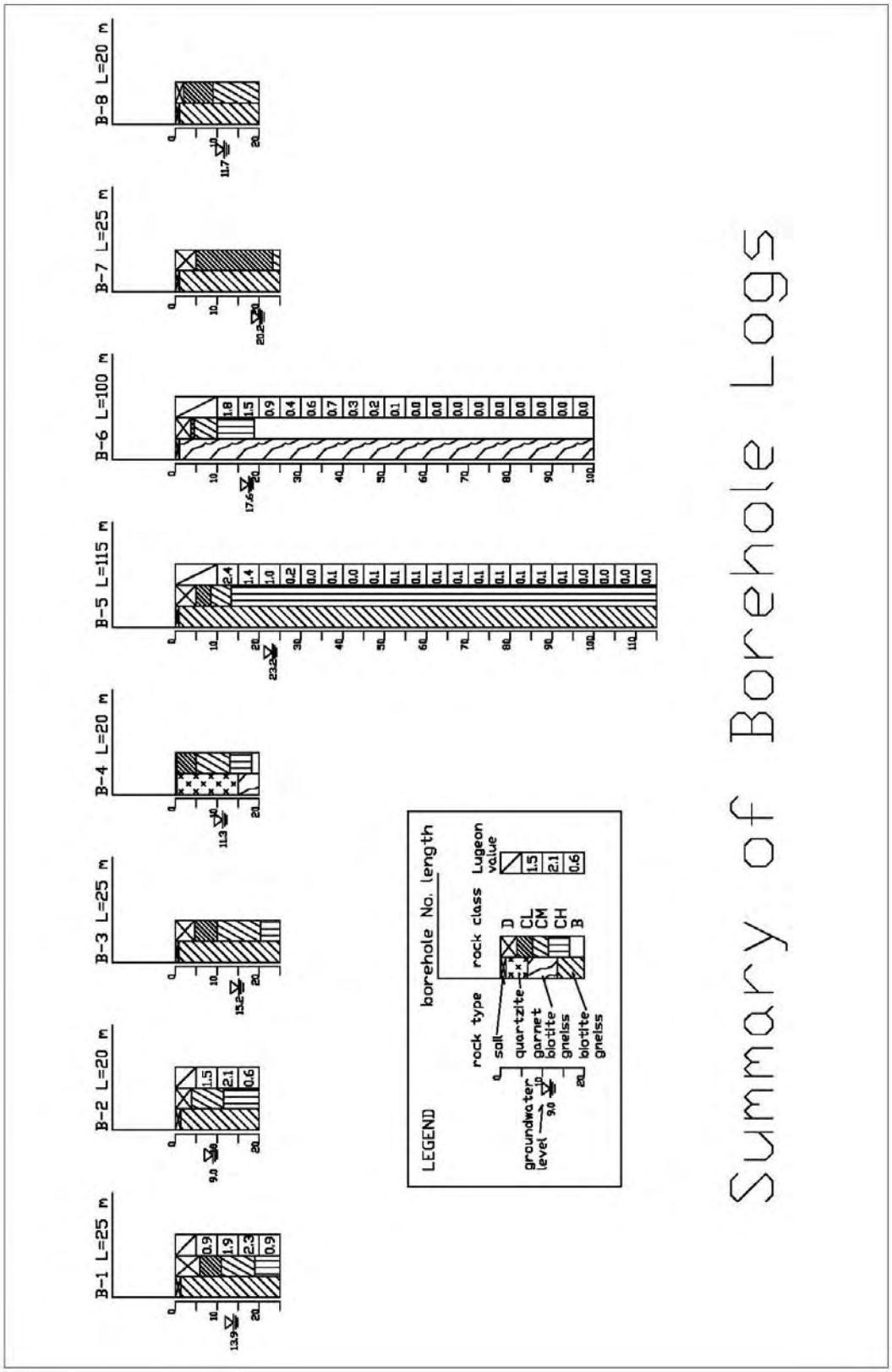
1. Geological Map/Geological Profile of Left Bank Route/Summary of Borehole Logs



Note: Lineaments (L-1~L-8) identified based on aerial photograph interpretation have been regarded as fracture zones to estimate rock condition along tunnel for safety reasons. However, it should be noted that all lineaments are not always fracture zones in actuality. They might indicate geological boundaries etc.



Geological Profile of Left Bank Route


Summary of Borehole Logs
B-1 L=25 m
B-2 L=20 m
B-3 L=25 m
B-4 L=20 m
B-5 L=115 m
B-6 L=100 m
B-7 L=25 m
B-8 L=20 m
LEGEND
borehole No. length
rock class
Lugeon value
rock type
soil
quartzite
garnet biotite gneiss
biotite gneiss
groundwater level

2. Borehole Logs

Project for Master Plan Study on Hydropower Development in Uganda

Geological Investications for Ayago HEPP Pre-feasibility Study

BOREHOLE LOG Borehole number: **B1**

Date of start for drilling: **25-Sep-10**
Date of completing drilling: **26-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **25m** Inclination: **90°**
Interval of Screen PVC pipe: **25.5m**

Easting co-ordinate: **381890.352**
Northing co-ordinate: **259900.428**
Ground Elevation: **866.647**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
0														
	3	3	3	100	0	0				***Residual soil*** clay soils, saprolitic, yellow brown in color. Upper 0.6m is dark and gravelly				
5	5	2	2	100	0	0								
									6.0					
	8	3	2.9	96.7	0	0				***Weathered rock*** Highly weathered weak rock-like material, friable by hand, yellow brown in color, with relic fractures	1.11			
10	10	2	1.9	95	0	0								
									11.0					
	13	3	2.9	96.7	0	0				***Moderately weathered rock*** moderately weathered rock, brown grayish in color with quartz veins, fragmented with dark stains along joint surfaces. Contains zones of highly weathered material	2.34			
15	15	2	1.8	90	0	0								
	18	3	2.8	93.3	0	0					2.79			
									19.0					
20	20	2	1.8	90	0.7	70				***Slightly weathered rock*** Slightly weathered gnessic rock. grayish in color with quartz veins, strong rock fragments, with brown stained joint surfaces			B1-U2	
	23	3	2.8	93.3	2	66.7					3.26		B1-W1 B1-U1	
25	25	2	1.8	90	1.7	85				**End of Hole: 25m**			B1-W2	

Client: **JICA Study Team**

1/2

Contractor: **GeoTech Solutions (U) Ltd**

BOREHOLE LOG

Borehole number: **B1**

Date of start for drilling: **25-Sep-10**
Date of completing drilling: **26-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **25m** Inclination: **90°**
Interval of Screen PVC pipe: **25.5m**

Easting co-ordinate: **381890.352**
Northing co-ordinate: **259900.428**
Ground Elevation: **866.647**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Legend:

- Water absorption and bulk specific gravity
- Unconfined compressive strength
- Soundness test
- Abrasion test
- Chemical reactivity test

BOREHOLE LOG

Borehole number: **B2**

Date of start for drilling: **12-Sep-10**
Date of completing drilling: **19-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael and Amon**
Final Hole Depth: **20m** Inclination: **90°**
Interval of Screen PVC pipe: **20.5m**

Easting co-ordinate: **381260.110**
Northing co-ordinate: **259538.086**
Ground Elevation: **856.536**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
0	3	3	2.8	93.3	0	0				***Residual soil*** clay soils, saprolitic, yellow brown to grayish in color. Upper 0.6m is dark and gravelly				
5	5	2		0		0			3.8					
	8	3	3	100	2.8	93.3				***Rock*** Slightly weathered to fresh sound rock. Gray to dark gray in color with while quartz veins, very strong with wide joint spacing (1 - 2m) fine to medium grained.	1.72			
10	10	2	2	100	2	100							B2-U2 B2-U1	
	13	3	3	100	2.8	93.3					2.12		B2-W1	
15	15	2	2	100	2	100								
	18	3	3	100	2.9	96.7					0.81		B2-W2 B2-U3	
20	20	2	2	100	1.8	90				**End of Hole: 20m**				

Legend:

- Water absorption and bulk specific gravity
- Unconfined compressive strength
- Soundness test
- Abrasion test
- Chemical reactivity test

Client: JICA Study Team

1/1

Contractor: GeoTech Solutions (U) Ltd

BOREHOLE LOG

Borehole number: **B3**

Date of start for drilling: **21-Aug-10**
Date of completing drilling: **23-Aug-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **25m** Inclination: **90°**
Interval of Screen PVC pipe: **25.5m**

Easting co-ordinate: **381294.839**
Northing co-ordinate: **259412.349**
Ground Elevation: **862.146**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
0	3	3	3	100	0	0				***Residual soil*** clay soils, saprolitic, yellow brown in color, upper 0.6m tends to dark brown and is gravelly				
5	6	3	2.5	83.3	0	0			5.0					
	9	3	2.9	96.7	0	0				***Moderately weathered rock*** moderately weathered rock, brown grayish in color with quartz veins, fragmented with dark stains along				
10	12	3	2.4	80	2.4	80			10.0	joint surfaces				
15	15	3	2.9	96.7	2.3	76.7				***Rock*** Slightly weathered to fresh sound rock. Gray to dark gray in color with white quartz veins, very strong			B3-U1	
	18	3	3	100	2.6	86.7				with joint spacing of (0.2 - 1m), fine to medium grained. Most joint surfaces have a brown staining,				
20	21	3	3	100	2.8	93.3				and the joints are open in most instances			B3-W1	
	24	3	3	100	2.5	83.3							B3-U2	
25	25	1	1	100	0.95	95				**End of Hole: 25m**			B3-W3 B3-W2	

Client: **JICA Study Team**

1/2

Contractor: **GeoTech Solutions (U) Ltd**

BOREHOLE LOG

Borehole number: **B3**

Date of start for drilling: **21-Aug-10**
Date of completing drilling: **23-Aug-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **25m** Inclination: **90°**
Interval of Screen PVC pipe: **25.5m**

Easting co-ordinate: **381294.839**
Northing co-ordinate: **259412.349**
Ground Elevation: **862.146**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Legend:

- Water absorption and bulk specific gravity
- Unconfined comprensive strength
- Soundness test
- Abrasion test
- Chemical reactivity test

BOREHOLE LOG

Borehole number: **B4**

Date of start for drilling: **8-Sep-10**
Date of completing drilling: **10-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael and Amon**
Final Hole Depth: **20m** Inclination: **90°**
Interval of Screen PVC pipe: **20.5m**

Easting co-ordinate: **381591.382**
Northing co-ordinate: **259190.542**
Ground Elevation: **864.924**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Sample Location	Sample Number	Remarks
0	3	3	3	100	0	0				***Quartzite boulders with soil*** **Gravelly soils in upper 0.5m, white** quartzite boulders in thin soil matrix. Band of clay at 4m to 5m			
5	6	3	3	100	0	0			5.0	***Quartzite rock (Weathered)*** Moderately weathered quartzite rock. Whitish in color. Highly fractured with clayey inclusions			
	9	3	3	100	0	0			9.0				
10	12	3	2.9	96.7	2.1	70				***Quartzite rock*** slightly weathered to fresh quartzite rock. Moderately fractured from 11m to 13m. Zone of dark colored rock at 15m to 16.2m and at 18.2m to 20m. The rocks are strong to very strong.		B4-U2	
15	15	3	2.6	93.3	2.4	80							
	18	3	3	100	2.7	90							
20	20	2	2	100	1.7	85				**End of Hole: 20m**		B4-W2 B4-W1	

Legend:

- Water absorption and bulk specific gravity
- Unconfined compressive strength
- Soundness test
- Abrasion test
- Chemical reactivity test

Client: JICA Study Team

1/1

Contractor: GeoTech Solutions (U) Ltd

BOREHOLE LOG

Borehole number: **B5**

Date of start for drilling: **27-Jul-10**
Date of completing drilling: **20-Aug-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **115m** Inclination: **90°**
Interval of Screen PVC pipe: **115.5m**

Easting co-ordinate: **381183.963**
Northing co-ordinate: **259365.727**
Ground Elevation: **875.125**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
0	3	3	3	100	0	0				***Residual soil*** clay soils, saprolitic, yellow brown in color, upper 0.7m tends to dark brown and somewhat organic				
5	5	2	2	100	0	0			5.0					
	8	3	3	100	0	0				***Weathered rock*** Highly weathered weak rock-like material, friable by hand, yellowish brown in color with relic fractures				
10	10	2	2	100	1.3	86.7			8.5	***Rock*** Slightly weathered to fresh sound rock. Gray to dark gray in color with white quartz veins, very strong with joint spacing of (0.2 - 1m), fine to medium grained. Most joint surfaces have no staining, and the joints are tight in most instances. Pyrite mineralization observed in the core.				
	13	3	2.6	86.7	2.5	83.3					2.73			
15	15	2	2	100	1.9	95								
	18	3	3	100	2.6	86.7					1.65			
20	20	2	1.8	90	1.7	85								
	23	3	3	100	3	100					1.11	O	BS U3	
25	25	2	1.8	90	1.8	90								

Client: JICA Study Team

Contractor: GeoTech Solutions (U) Ltd

BOREHOLE LOG

Borehole number: **B5**

Date of start for drilling: **27-Jul-10**
Date of completing drilling: **20-Aug-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **115m** Inclination: **90°**
Interval of Screen PVC pipe: **115.5m**

Easting co-ordinate: **381183.963**
Northing co-ordinate: **259365.727**
Ground Elevation: **875.125**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
	28	3	3	100	3	100				***Rock*** fresh sound rock, gray in color with white quartz veins, very strong with wide joint spacing (0.5 - 2m), fine to medium grained. Most joint surfaces have no staining, and the joints are generally tight	0.23		B5-W1	
30	30	2	2	100	1.9	95								
	33	3	3	100	3	100					0.06			
35	35	2	2	100	2	100							B5-A1	
	38	3	2.8	93.3	2.8	93.3					0.07			
40	40	2	1.8	90	1.8	90							B5-C1	
	43	3	2.9	96.7	2.9	96.7					0.06		B5-W2 B5-U5	
45	45	2	2	100	2	100								
	48	3	2.9	96.7	2.9	96.7					0.10			
50	50	2	2	100	2	100							B5-U1	

Client: **JICA Study Team**

2/5

Contractor: **GeoTech Solutions (U) Ltd**

BOREHOLE LOG

Borehole number: **B5**

Date of start for drilling: **27-Jul-10**
Date of completing drilling: **20-Aug-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **115m** Inclination: **90°**
Interval of Screen PVC pipe: **115.5m**

Easting co-ordinate: **381183.963**
Northing co-ordinate: **259365.727**
Ground Elevation: **875.125**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
	53	3	3	100	3	100					0.10			
55	55	2	2	100	2	100								
	58	3	2.8	93.3	2.7	90				***Rock***	0.14			
60	60	2	1.9	95	1.8	90				fresh sound rock, gray in color with white quartz veins, very strong with wide joint spacing (0.5 - 2m), fine to medium grained. Jointing is generally tight				
	63	3	3	100	3	100					0.11			
65	65	2	2	100	2	100								
	68	3	3	100	3	100					0.17			
70	70	2	2	100	2	100								
	73	3	3	100	3	100					0.11			
75	75	2	2	100	2	100								

Client: JICA Study Team

Contractor: GeoTech Solutions (U) Ltd

BOREHOLE LOG

Borehole number: **B5**

Date of start for drilling: **27-Jul-10**
Date of completing drilling: **20-Aug-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael and Amon**
Final Hole Depth: **115m** Inclination: **90°**
Interval of Screen PVC pipe: **115.5m**

Easting co-ordinate: **381183.963**
Northing co-ordinate: **259365.727**
Ground Elevation: **875.125**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
	78	3	2.9	96.7	2.9	96.7					0.08			
80	80	2	2	100	2	100							B5-U2	
	83	3	2.9	96.7	2.9	96.7					0.11			
85	85	2	2	100	2	100								
	88	3	3	100	2.8	93.3				***Rock***				
90	90	2	2	100	1.8	90				fresh sound rock, gray in color with white quartz veins, very strong with wide joint spacing (0.5 - 2m), fine to medium grained. Jointing is generally tight	0.07		B5-W3	
	93	3	3	100	2.5	83.3								
95	95	2	2	100	2	100					0.04			
	98	3	3	100	2.7	90					0.04			
100	100	2	2	100	2	100							B5-U4 B5-S1	

Client: JICA Study Team

Contractor: GeoTech Solutions (U) Ltd

BOREHOLE LOG

Borehole number: **B5**

Date of start for drilling: **27-Jul-10**
Date of completing drilling: **20-Aug-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **115m** Inclination: **90°**
Interval of Screen PVC pipe: **115.5m**

Easting co-ordinate: **381183.963**
Northing co-ordinate: **259365.727**
Ground Elevation: **875.125**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
	103	3	3	100	1.6	53.3				locally fractured zone at 102m to 104m, with mono quartz	0.05			
105	105	2	2	100	1.3	75								
	108	3	2.8	93.3	2.7	90					0.04			
110	110	2	2	100	1.8	90							B5-W4	
	113	3	3	100	3	100					0.05			
115	115	2	1.9	95	1.9	95				End of Hole: 115m				

Legend:

- Water absorption and bulk specific gravity
- Unconfined compressive strength
- Soundness test
- Abrasion test
- Chemical reactivity test

BOREHOLE LOG

Borehole number: **B6**

Date of start for drilling: **25-Aug-10**
Date of completing drilling: **8-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **100m** Inclination: **90°**
Interval of Screen PVC pipe: **100.5m**

Easting co-ordinate: **381512.473**
Northing co-ordinate: **259123.827**
Ground Elevation: **868.827**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
0	3	3	3	100	0	0				***Residual soil*** clay soils, saprolitic, yellow brown in color, upper 0.8m tends to dark brown and somewhat organic,				
5	5	2	2	100	0	0			5.0	quartzitic boulder at 4m to 5m				
	8	3	3	100	2.4	80				***Transitional Rock*** Moderate to slightly weathered rock with zones of preferential weathering at 9.4m to 10.0m and 10.8m to 11.0m.				
10	10	2	1.8	90	0.9	45								
	13	3	2.8	93.3	2.4	80				The rock is gray in color, strong, with moderate fragmentation. Most joints have a brown coating	2.17			
									13.0					
15	15	2	1.9	95	1.7	85								
	18	3	3	100	2.9	96.7				***Rock*** fresh sound rock, gray in color with afew quartz stringers/ veins very strong, joint spacing (0.2 - 2m), fine to medium grained. Most joint surfaces have no staining, and the joints are generally tight	1.85			
20	20	2	2	100	2	100								
	33	3	3	100	2.9	96.7					1.07			
25	25	2	2	100	2	100						B6-W1		

Client: JICA Study Team

Contractor: GeoTech Solutions (U) Ltd

BOREHOLE LOG

Borehole number: **B6**

Date of start for drilling: **25-Aug-10**
Date of completing drilling: **8-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **100m** Inclination: **90°**
Interval of Screen PVC pipe: **100.5m**

Easting co-ordinate: **381512.473**
Northing co-ordinate: **259123.827**
Ground Elevation: **868.827**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
	28	3	3	100	2.9	96.7					0.54			
30	30	2	2	100	2	100				***Rock*** fresh sound rock, gray in color with many quartz stringers/ veins in the zone between 35m and 45m, very strong, joint spacing (0.2 - 2m), fine to medium grained. Most joint surfaces have no staining, and the joints are generally tight				
	33	3	2.9	96.7	2.7	90					0.88			
35	35	2	2	100	1.8	90								
	38	3	3	100	3	100					1.03			
40	40	2	2	100	1.8	90							B6-U1 B6-U3	
	43	3	3	100	3	100					0.44			
45	45	2	2	100	2	100								
	48	3	2.9	96.7	2.9	96.7					0.24			
50	50	2	2	100	2	100								

Client: JICA Study Team

Contractor: GeoTech Solutions (U) Ltd

BOREHOLE LOG

Borehole number: **B6**

Date of start for drilling: **25-Aug-10**
Date of completing drilling: **8-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael and Amon**
Final Hole Depth: **100m** Inclination: **90°**
Interval of Screen PVC pipe: **100.5m**

Easting co-ordinate: **381512.473**
Northing co-ordinate: **259123.827**
Ground Elevation: **868.827**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
	53	3	3	100	3	100					0.16			
55	55	2	1.9	95	1.9	95							B6-W2	
	58	3	2.9	96.7	2.9	96.7					0.07			
60	60	2	2	100	2	100				***Rock***				
	63	3	2.9	96.7	2.85	95				fresh sound rock, gray in color with afew quartz stringers/ veins very strong, joint spacing (0.2 - 2m), fine to medium grained. Jointing is generally tight	0.05			
65	65	2	2	100	2	100								
	68	3	3	100	2.9	96.7					0.07			
70	70	2	2	100	2	100								
	73	3	3	100	2.6	86.7					0.10			
75	75	2	1.9	95	1.9	95							B6-U1	

BOREHOLE LOG

Borehole number: **B6**

Date of start for drilling: **25-Aug-10**
Date of completing drilling: **8-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **100m** Inclination: **90°**
Interval of Screen PVC pipe: **100.5m**

Easting co-ordinate: **381512.473**
Northing co-ordinate: **259123.827**
Ground Elevation: **868.827**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks
	78	3	2.9	96.7	2.8	93.3					0.05			
80	80	2	2	100	2	100								
	83	3	3	100	2.7	90					0.06			
85	85	2	2	100	1.95	97.5								
	88	3	3	100	3	100					0.04			
90	90	2	2	100	2	100				***Rock*** fresh sound rock, gray in color with afew quartz stringers/ veins. zone of mono quartz at 93m to 95m, very strong, joint spacing (0.2 - 2m), fine to medium grained. Jointing is generally tight				
	93	3	2.9	96.7	2.9	96.7					0.02			
95	95	2	2	100	2	100								
	98	3	3	100	3	100					0.03			
100	100	2	2	100	2	100				**End of Hole: 100m**		B6-U2 B6-W3		

Client: JICA Study Team

Contractor: GeoTech Solutions (U) Ltd

BOREHOLE LOG

Borehole number: **B6**

Date of start for drilling: **25-Aug-10**
Date of completing drilling: **8-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **100m** Inclination: **90°**
Interval of Screen PVC pipe: **100.5m**

Easting co-ordinate: **381512.473**
Northing co-ordinate: **259123.827**
Ground Elevation: **868.827**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Lugeon value	Sample Location	Sample Number	Remarks

Legend:

- Water absorption and bulk specific gravity
- Unconfined compressive strength
- Soundness test
- Abrasion test
- Chemical reactivity test

BOREHOLE LOG

Borehole number: **B7**

Date of start for drilling: **17-Sep-10**
Date of completing drilling: **19-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **25m** Inclination: **90°**
Interval of Screen PVC pipe: **15.5m**

Easting co-ordinate: **374078.159**
Northing co-ordinate: **260757.248**
Ground Elevation: **795.664**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Sample Location	Sample Number	Remarks
0										***Residual soil*** clay soils, saprolitic, yellow brown in color, upper 0.6m tends to dark brown and is gravelly			Obstruction at about 14m due possibly to hole caving in, as a result of poor rock conditions. PVC screen pipe installed to 15m approximately.
	3	3	3	100	0	0							
5		3	2.3	76.7	0	0			5.0				
	6									***Highly weathered rock:*** Highly weathered rock-like material, friable by hand, yellowish brown in color with relic rock structure and afew strong corestones			
		3	2.9	96.7	0	0			8.0				
	9												
10										***Moderately weathered rock*** Weathered rock, moderately strong to strong, slightly weathered core-stones, typically fragmented and/or broken. Yellowish to gray in color. zones of very weak soil-like material at between 17m to 19m, and 21m to 23.5m, with large core losses.			
	12	3	2.8	93.3	0	0							
		3	2.7	90	0	0							
15	15												
	18	3	2.1	70	0	0							no sampling due to absence of fresh rock
20		3	2.3	76.7	0	0							
	21												
		3	1.3	43.3	0	0							
	24												
25	25	1	0.9	90	0	0				End of Hole: 25m			

Client:
JICA Study Team

Consultant:
GeoTech Solutions (U) Ltd

BOREHOLE LOG

Borehole number: **B7**

Date of start for drilling: **17-Sep-10**
Date of completing drilling: **19-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael** and **Amon**
Final Hole Depth: **25m** Inclination: **90°**
Interval of Screen PVC pipe: **15.5m**

Easting co-ordinate: **374078.159**
Northing co-ordinate: **260757.248**
Ground Elevation: **795.664**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Legend:

- Water absorption and bulk specific gravity
- Unconfined compressive strength
- Soundness test
- Abrasion test
- Chemical reactivity test

BOREHOLE LOG

Borehole number: **B8**

Date of start for drilling: **20-Sep-10**
Date of completing drilling: **21-Sep-10**
Drilling Equipment: **Kamaz Russian Made Rig**
Driller: **Raphael and Amon**
Final Hole Depth: **20m** Inclination: **90°**
Interval of Screen PVC pipe: **20.5m**

Easting co-ordinate: **374252.443**
Northing co-ordinate: **260823.751**
Ground Elevation: **796.535**
Logged by: **John Bosco Lubega**
Drilling Method: **Coring**
Core diameter: **64mm**

Depth (m)	Run Boundary (m)	Run length (m)	Core recovery (m)	Core recovery (%)	RQD (m)	RQD (%)	Graphic Log	Water Table	Lithological Boundary depth (m)	Description	Sample Location	Sample Number	Remarks
0	3	3	3	100	0	0			2.0	**Residual soils:** clayey material, brown in color, micaceous at 1.2m to 1.8m.			
5	6	3	3	100	0	0				***Moderately weathered rock:*** moderately strong to strong, typically fragmented and/or broken, pinkish to gray in color, with brown coated joint surfaces. Quartz vein at 6.5m and 8.3m to 8.7m.			
	9	3	2.8	93.3	0	0							
10	12	3	3	100	1.9	63.3			10.0	***Slightly weathered gneissic rock*** strong to very strong, highly fragmented with close spaced jointing (50mm – 350mm). Joint surfaces have brown coating. gentle dip angle for joint planes (10-20°). Quartz vein at 14.3m gray to pinkish in color. Fine to medium grained			
15	15	3	2.9	96.7	1.4	46.7							
	18	3	2.8	93.3	2	66.7							
20	20	2	2	100	1.4	70				**End of Hole: 20m**		B8-U1 B8-W3 B8-W2 B8-U2	

Legend:

- Water absorption and bulk specific gravity
- Unconfined compressive strength
- Soundness test
- Abrasion test
- Chemical reactivity test

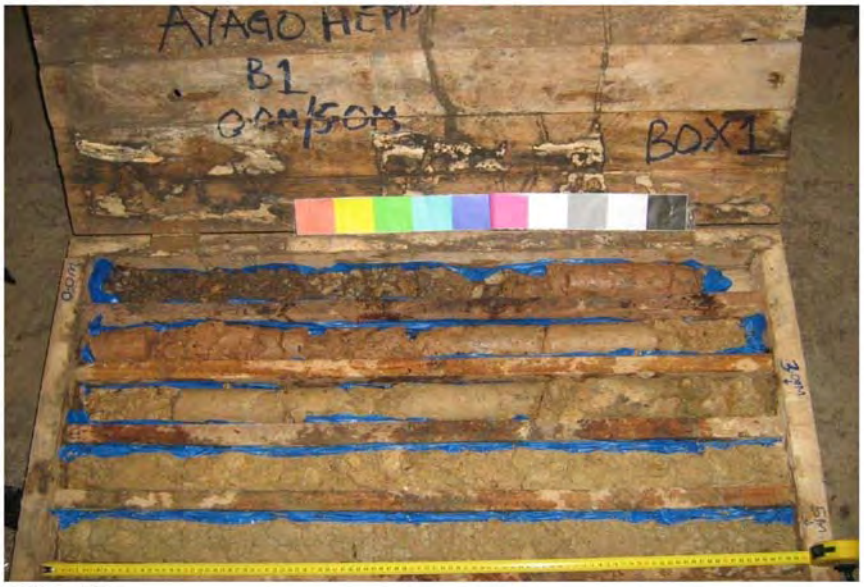
Client: JICA Study Team

1/1

Contractor: GeoTech Solutions (U) Ltd

3. Core Photographs

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor:	Client:	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Intake dam	B1



0.0m - 5.0m

5.0m - 10.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor:	Client:	Area	Borehole number:
GeoTech Solutions (U) Ltd	JICA Study Team	Intake dam	B1

10.0m - 15.0m

15.0m - 19.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Intake dam	B1

19.0m - 25.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Intake dam	B2

0.0m - 5.0m

5.0m - 10.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Intake dam	B2

10.0m - 15.0m

15.0m - 20.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Tunnel Portal	B3

0.0m - 5.0m

5.0m - 10.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Tunnel Portal	B3

10.0m - 15.0m

15.0m - 20.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Tunnel Portal	B3

20.0m - 25.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Tunnel Portal	B4

0.0m - 5.0m

5.0m - 10.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Tunnel Portal	B4

10.0m - 15.0m

15.0m - 20.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	BS

0.0m - 5.0m

5.0m - 10.0m

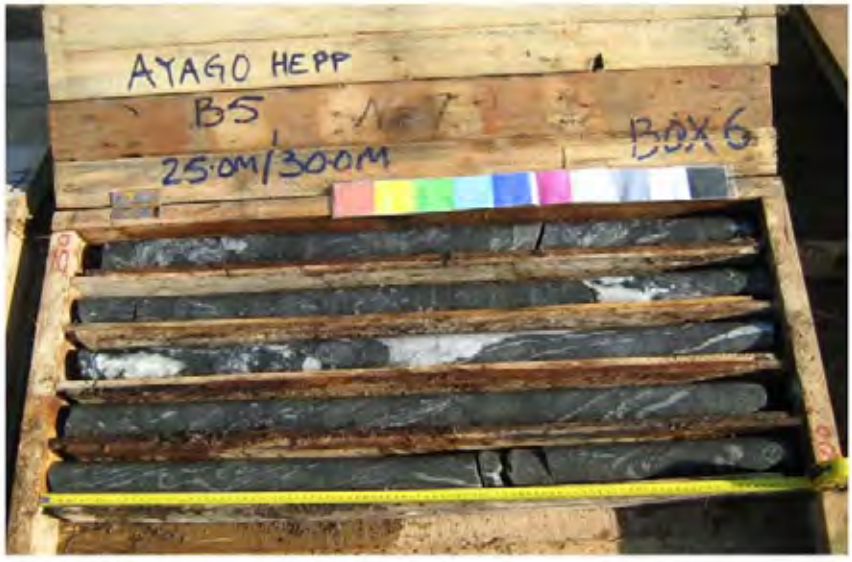
Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5

10.0m - 15.0m

15.0m - 20.0m

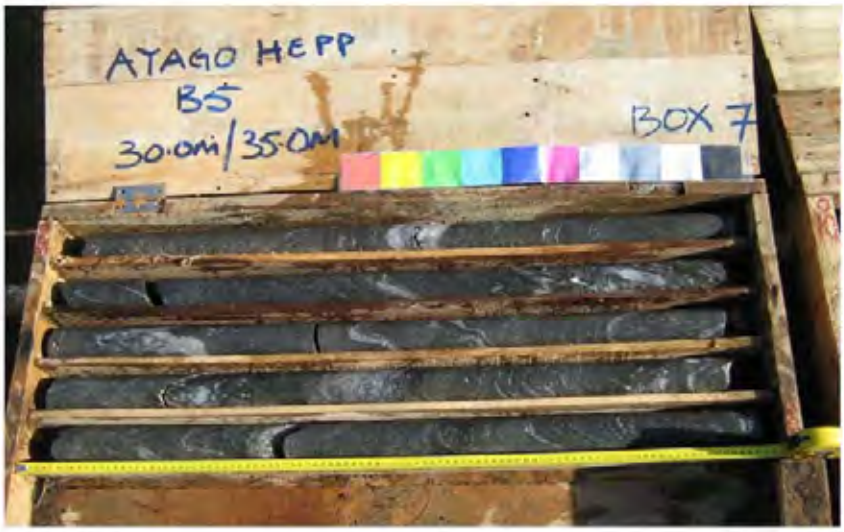
Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5

20.0m - 25.0m



25.0m - 30.0m

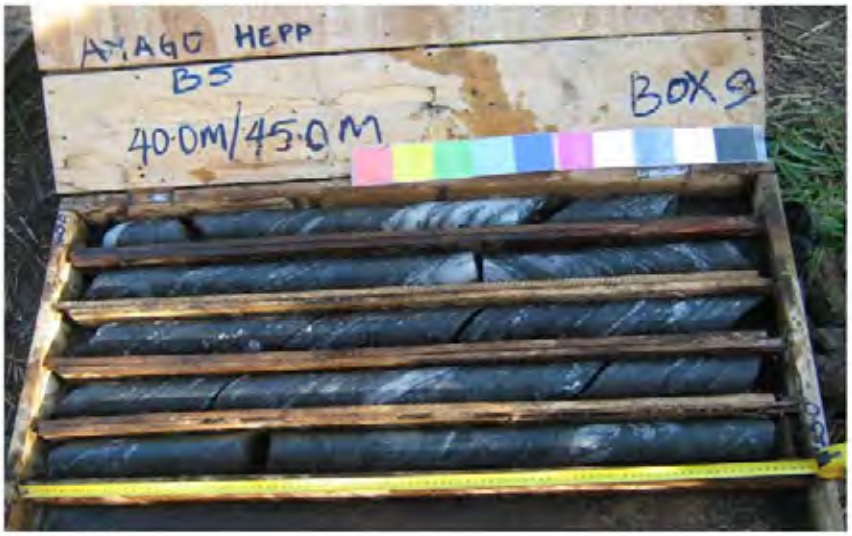
Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5



30.0m - 35.0m

35.0m - 40.0m

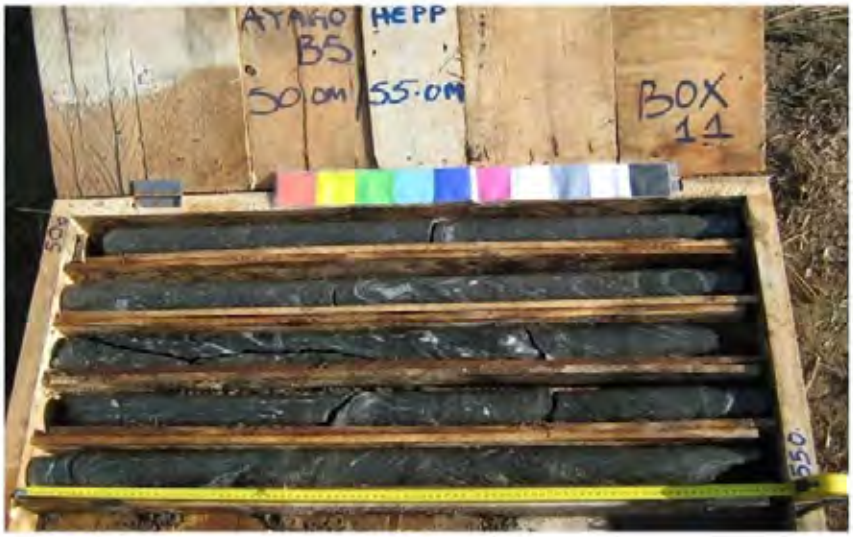
Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5



40.0m - 45.0m

45.0m - 50.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5



50.0m - 55.0m

55.0m - 60.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5

60.0m - 65.0m

65.0m - 70.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5

70.0m - 75.0m

75.0m - 80.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5

80.0m - 85.0m

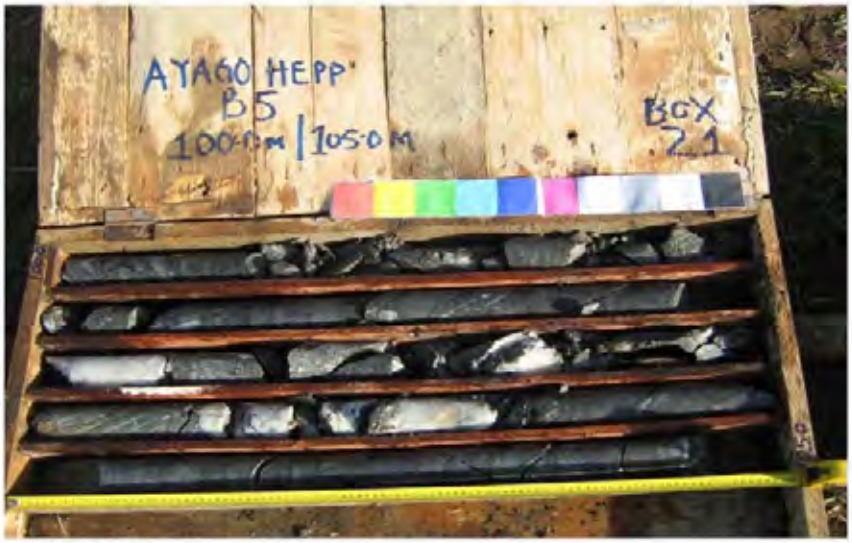
85.0m - 90.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5

90.0m - 95.0m

95.0m - 100.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5



100.0m - 105.0m

105.0m - 110.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B5

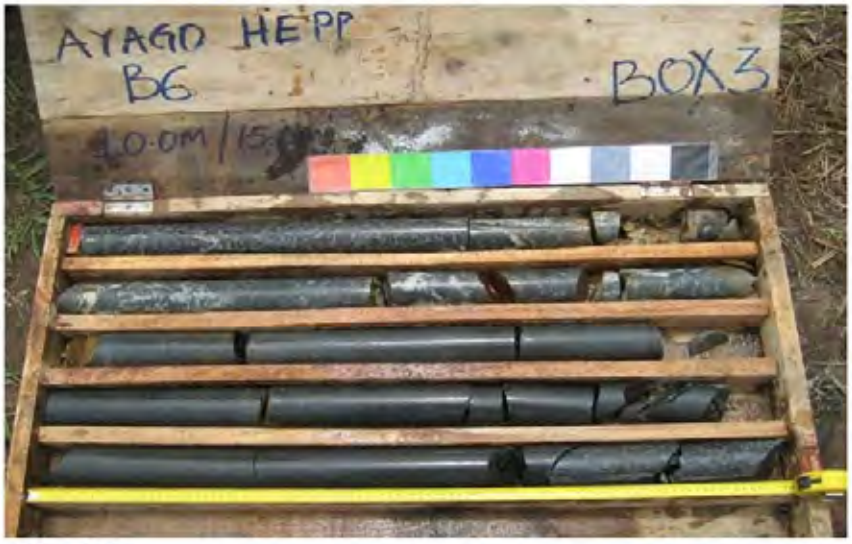
110.0m - 115.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6

0.0m - 5.0m

5.0m - 10.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6



10.0m - 15.0m

15.0m - 20.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6

20.0m - 25.0m

25.0m - 30.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6

30.0m - 35.0m

35.0m - 40.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6

40.0m - 45.0m

45.0m - 50.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6

50.0m - 55.0m

55.0m - 60.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6

60.0m - 65.0m

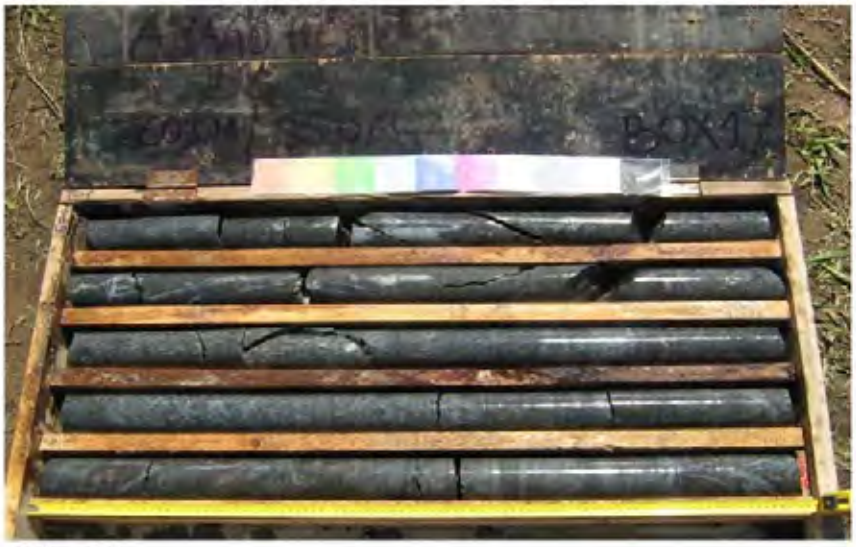
65.0m - 70.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6

70.0m - 75.0m

75.0m - 80.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6



80.0m - 85.0m

85.0m - 90.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Powerhouse	B6

90.0m - 95.0m

95.0m - 100.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Outlet (Left)	B7

0.0m - 5.0m

5.0m - 10.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Outlet (Left)	B7

10.0m - 15.0m

15.0m - 20.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Outlet (Left)	B7

20.0m - 25.0m

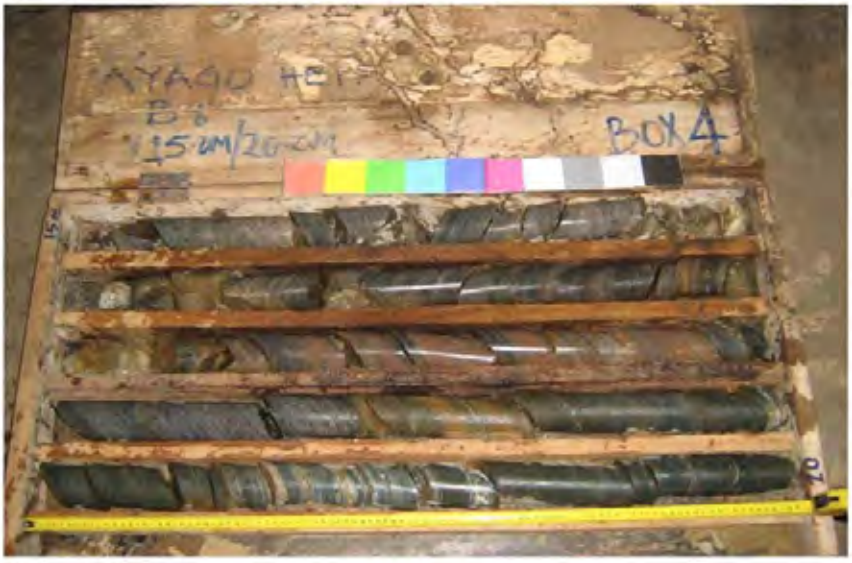
Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Outlet (Right)	B8

0.0m - 5.0m

5.0m - 10.0m

Ayago Hydro Electric Power Project Pre-feasibility Study		Investigation Boreholes Core Photos	
Contractor	Client	Area	Borehole number
GeoTech Solutions (U) Ltd	JICA Study Team	Outlet (Right)	B8

10.0m - 15.0m



15.0m - 20.0m