１５．測量結果

PREPARATORY SURVEY ON THE PROJECT FOR REINFORCEMENT OF TRANSMISSION NETWORK IN NACALA CORRIDOR IN THE REPUBLIC OF MOZAMBIQUE

TOPOGRAPHIC SURVEY

FINAL REPORT

PREPARED FOR:

ORICONSUL

PREPARED By:

Address: Av. 25 de Setembro nº 2526, 1º floor
Maputo-Mozambique

September, 2014
Project No. P567/TEC/2014

FINAL REPORT

Document History and Status

Date of Submission	Semptember 20th 2014		**Sign and Date**
Project Description (Title)	PREPARATORY SURVEY ON THE PROJECT FOR REINFORCEMENT OF TRANSMISSION NETWORK IN NACALA CORRIDOR IN THE REPUBLIC OF MOZAMBIQUE TOPOGRAPHIC SURVEY		
Prepared By	José Walters Monteiro (Civil/Survey Eng.)		
Checked By	Sidney de Abreu (Civil/Geotechnical Eng.)		
Approved By	Carlos Quadros (Senior Geotechnical Eng)		

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1 Introduction

As part of The Preparatory Survey on The Project for Reinforcement of Transmission Network In Nacala Corridor in The Republic of Mozambique, Oriental Consultants Co., Ltd has contracted TÉCNICA – Engenheiros Consultores Lda, to do the topographic survey of the indicated site.

2 Methodology

The survey was done on the WGS 84 UTM Zone 37 System. Unfortunately the closest official beacon to the site, which was reported to be located in Meconta has been destroyed as a result of vandalism action. In the absence of an official beacon the survey was conducted on the basis of self-positioning a differential GPS Trimble make, model R4. The base was set for about four hours enabling to have accurate horizontal coordinates, which are tided to the Mozambique official network. The heights used in this survey were GPS heights, which are geoid ones. No transformation was done to get levels referenced to the mean sea level; therefore heights in this survey are geoid heights.

Concrete benchmarks have been established in the corners of the plot as well as some control points have been established along the corridor connecting the substation plot to the EN8 though a straight alignment. The Benchmarks were coordinated by GPS. Verification was done through orthometric survey with a level to check the accuracy of the GPS. The differences found were less than 5mm. The verification of GPS heights accuracy can be seen in Appendix A.

The ground survey was done using the differential GPS while the location of electrical towers, poles and trees was done by a Total station.

3 Coordinates of benchmarks and corners

The coordinates of the benchmarks and the control points along the corridor can be seen in Appendix B.

4 Deliverables

Pursuant to the terms of reference the following deliverables are included:

- Layout of the plot in hard copy and pdf format;
- Survey map in DWG format (Autocad 2007);
- Survey map in hard copy in 1:500 scale

5 Resources involved

Surveyors: Amós Mandlate Júnior; Remédio Francisco, qualified surveyors

Coordinator: José Walters Monteiro, Civil Engineer

Equipment: GPS Trimble R4; Total Station Topcon GPT 7500; Level

APPENDIX A

Verification of GPS Heights

NAMIALO SUBSTATION
APPENDIX A. VERIFICATION OF GPS HEIGHTS ACCURACY

Benchmark	Back Sight	Forward Sight	Height of Instrument	Real Level	corrected level	Level by GPS
C0	1,422		174,601	173,179		
Change Point	1,245	1,303	174,543			
C3	1,181	1,181	174,543	173,362	**173,357**	**173,379**
Change Point	1,319	1,225	174,637			
C0		1,453		173,184		
	closing error= 0.005m					

Benchmark	Back Sight	Forward Sight	Height of Instr	Real Level	corrected level	Level by GPS
C0	0,52		173,699	173,179		
Change Point	0,82	1,81	172,709			
C4	**2,371**	**2,37**	**172,71**	**170,339**	**170,336**	**170,36**
Change Point	1,801	0,951	173,56			
C0		0,378		173,182		
	Closing error= 0.003m					

Benchmark	Back Sight	Forward Sight	Height of Instr	Real Level	corrected level	Level by GPS
C0	1,44		174,619	173,179		
Change Point	1,685	1,631	174,673			
Change Point	1,33	1,575	174,428			
Change Point	0,76	3,718	171,47			
C2	**2,279**	**2,279**	**171,47**	**169,191**	**169,19**	**169,203**
Change Point	2,985	0,232	174,223			
Change Point	1,709	1,261	174,671			
C0		1,491		173,18		
	closing error= 0.001m					

Benchmark	Back Sight	Forward Sight	Height of Instr	Real Level	corrected level	Level by GPS
C0	1,251		174,43	173,179		
Change Point	0,779	1,099	174,11			
Change Point	0,225	1,99	172,345			
Change Point	0,475	3,72	169,1			
C1	**3,602**	**3,602**	**169,1**	**165,498**	**165,501**	**165,525**
Change Point	3,71	0,227	172,583			
Change Point	2,062	0,47	174,175			
Change Point	1,87	1,439	174,606			
C0		1,43		173,176		
	closing error=- 0.003m					

Benchmark	Back Sight	Forward Sight	Height of Instr	Real Level	corrected level	Level by GPS
C3	1,375		174,732	173,357		
Change Point	1,433	1,22	174,945			
E1	**1,314**	**1,314**	**174,945**	**173,631**	**173,632**	**173,65**
Change Point	1,269	1,478	174,736			
C3		1,38		173,356		
	closing error= -0.001m					

Benchmark	Back Sight	Forward Sight	Height of Instr	Real Level	corrected level	Level by GPS
E1	1,519		175,151	173,632		
Change Point	1,32	1,39	175,081			
E2	**1,361**	**1,361**	**175,081**	**173,72**	**173,717**	**173,714**
Change Point	1,36	1,27	175,171			
E1		1,536		173,635		
	closing error= 0.003m					

Benchmark	Back Sight	Forward Sight	Height of Instr	Real Level	corrected level	Level by GPS
E2	1,425		175,142	173,717		
Change Point	1,67	0,81	176,002			
Change Point	1,511	1,449	176,064			
E3	**1,229**	**1,229**	**176,064**	**174,835**	**174,839**	**174,825**
Change Point	1,143	1,481	175,726			
Change Point	1,21	1,82	175,116			
E2		1,403		173,713		
	Closing error =- 0.004					

APPENDIX B

Benchmarks Coordinates

APPENDIX B - BENCHMARKS COORDINATES

pt. Name	Northing	Easting	elevation
Substation Plot Corners			
C0	8347621,37	603400,713	173,179
C2	8347607,368	603045,39	169,203
C1	8347422,802	603107,924	165,525
C4	8347557,634	603505,945	170,36
C3	8347742,208	603443,349	173,379
C5	8349284,63	603632,859	176,052
Access Corridor Control Points			
E1	8347898,219	603468,166	173,65
E2	8348114,887	603409,816	173,714
E3	8348349,68	603514,236	174,825
E4	8348550,313	603465,635	175,557
E5	8348750,099	603470,98	175,679
E6	8348935,918	603592,936	174,608
E7	8349009,117	603527,86	174,965
E8	8349188,815	603534,788	175,448
E9	8349224,726	603645,302	175,181

APPENDIX C

Photographic Record

APPENDIX B - PHOTOGRAFIC RECORD

Corner C0

Corner C1

Corner C2

Corner C3

Corner C4

Corner C5

Removed beacon in Meconta

Railway crossing

EN8 crossing facing Namialo

Access corridor from EN8 to railway

Substation plot

Substation plot

APPENDIX D

Topographic Survey Maps

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REV	DATA	DESIGNAÇÃO

DATA	JULHO 2014
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CALCULADO	.....
APROVADO	.....

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PROJECTO PREPARATORY ON THE PROJECT FOR REINFORCEMENT OF TRANSMISSION NETWORK IN NACALA CORRIDOR

DESENHO N°	PTO-CP-TOP-000
PROJECTO N°	P 567
ASSUNTO	TOPOGRAPHIC SURVEY
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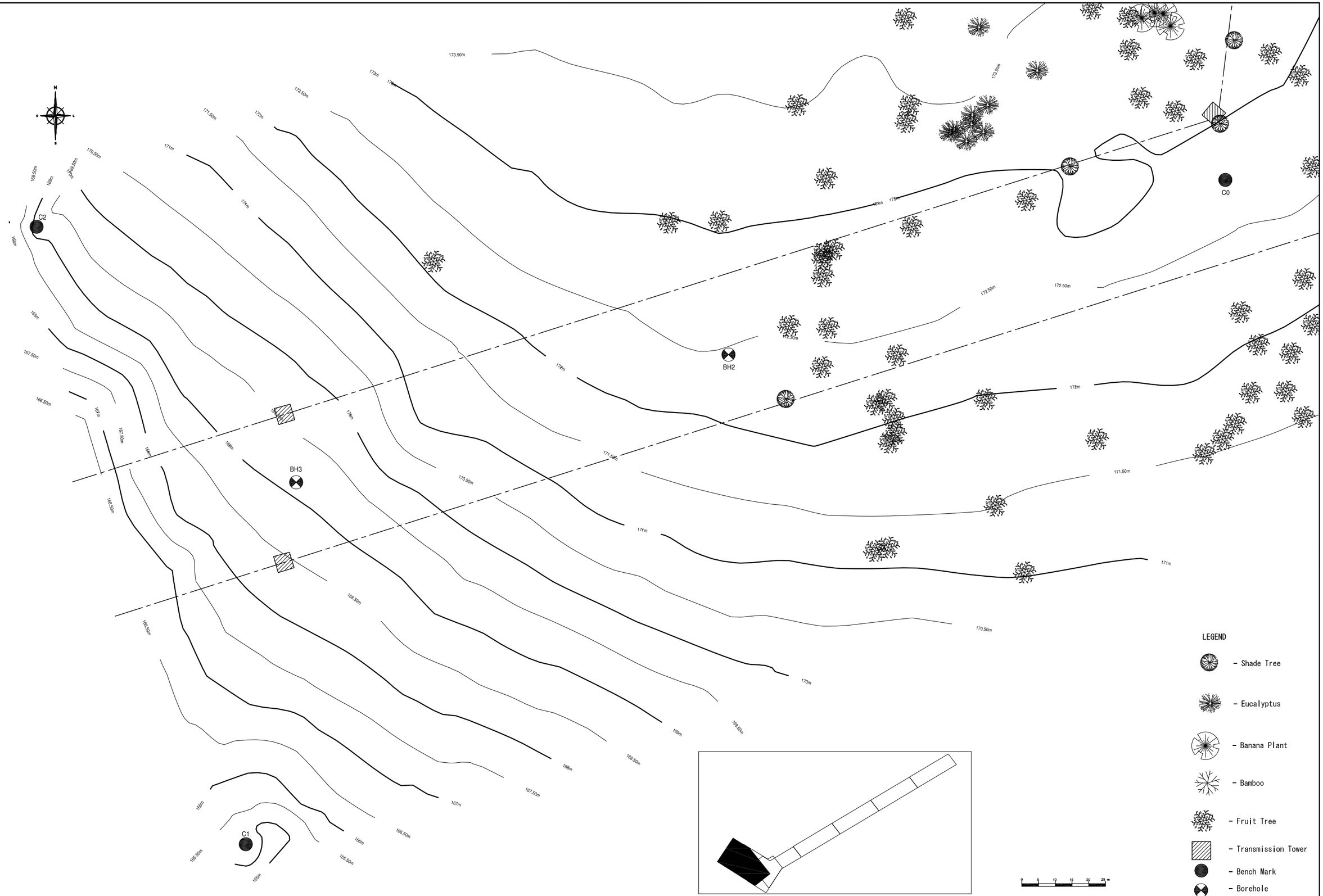

LEGEND

- Shade Tree
- Eucalyptus
- Banana Plant
- Bamboo
- Fruit Tree
- Transmission Tower
- Bench Mark
- Borehole

0 5 10 15 20 25 m

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DESENHO N° PTO-CP-TOP-001
PROJECTO N° P 567
ASSUNTO TOPOGRAPHIC SURVEY

ESCALA 1 : 500

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A15-16

LEGEND

- Shade Tree
- Eucalyptus
- Banana Plant
- Bamboo
- Fruit Tree
- Transmission Tower
- Bench Mark
- Borehole

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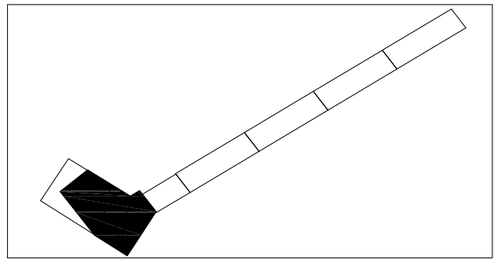

C3

C0

BH1

BH2

C4

N

O L

S

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DESENHO N° PTO-CP-TOP-002
PROJECTO N° P 567
ASSUNTO TOPOGRAPHIC SURVEY

ESCALA 1 : 500

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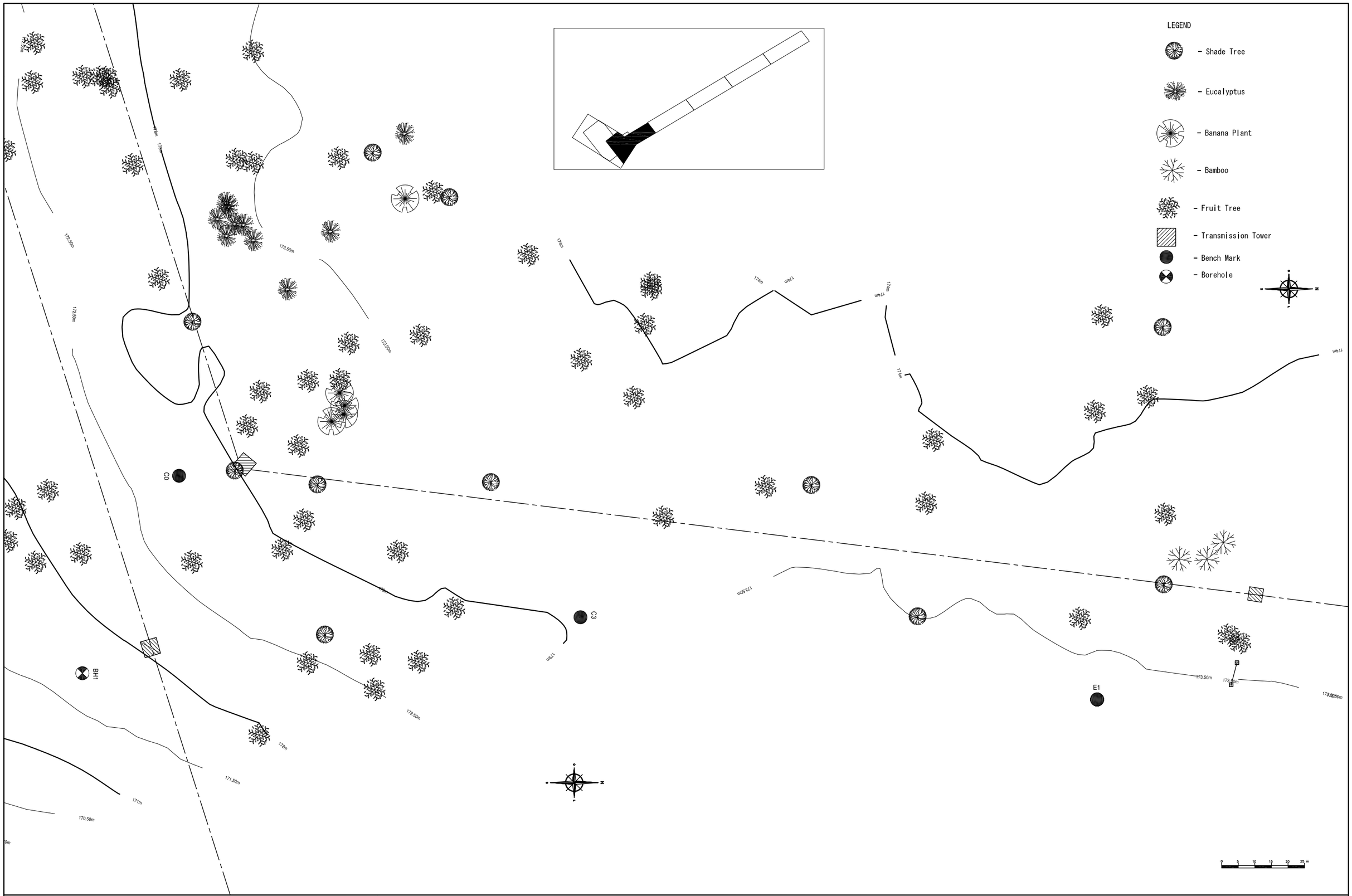

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PROJECTO PREPARATORY ON THE PROJECT FOR REINFORCEMENT OF TRANSMISSION NETWORK IN NACALA CORRIDOR

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PROJECTO N°	P 567
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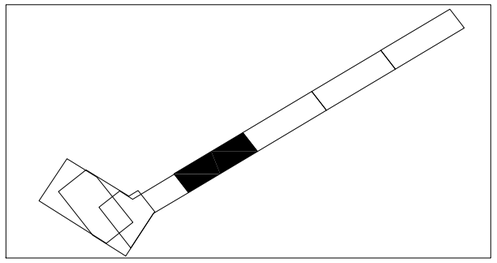

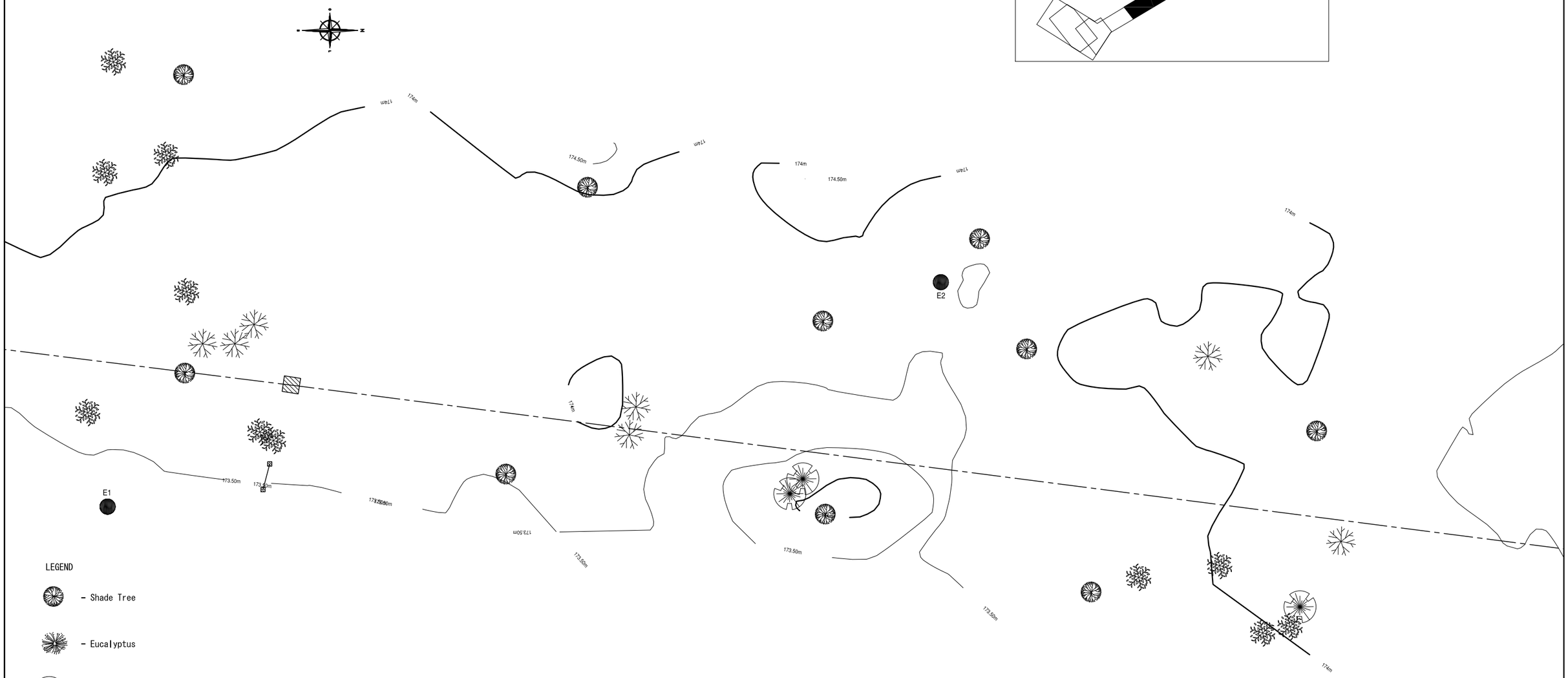

LEGEND

- Shade Tree
- Eucalyptus
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0 5 10 15 20 25 m

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PROJECTO N° P 567
ASSUNTO TOPOGRAPHIC SURVEY

ESCALA 1 : 500

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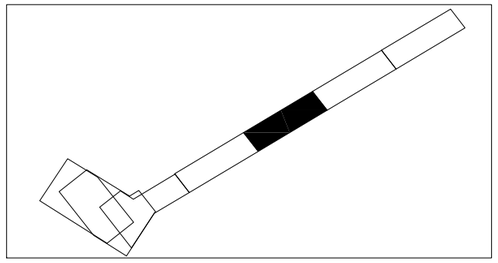

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PROJECTO N° P 567
ASSUNTO **TOPOGRAPHIC SURVEY**
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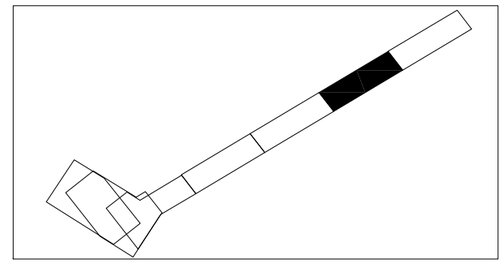

LEGEND

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PROJECTO N° P 567
ASSUNTO TOPOGRAPHIC SURVEY

ESCALA 1 : 500

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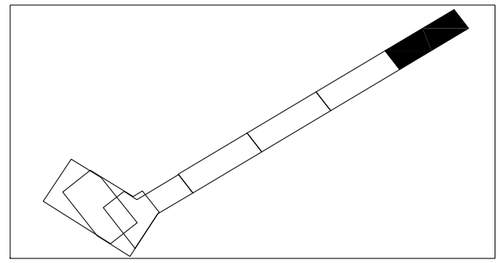

RAILWAY

EN6

E6
E7
E8
E9
C5

LEGEND

- Shade Tree
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0 5 10 15 20 25 m

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PROJECTO PREPARATORY ON THE PROJECT FOR REINFORCEMENT OF TRANSMISSION NETWORK IN NACALA CORRIDOR

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PROJECTO N° P 567
ASSUNTO TOPOGRAPHIC SURVEY
ESCALA 1 : 500

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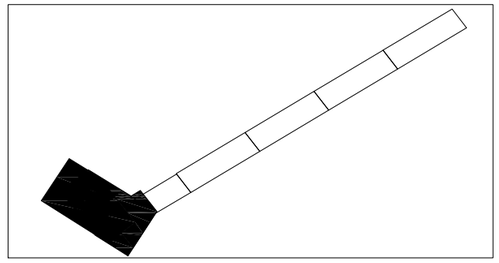

BENCH MARKS

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603107.92	8347422.80	165.53	C1
603505.95	8347557.63	170.36	C4
603443.35	8347742.21	173.38	C3
603632.86	8349284.63	176.05	C5
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603409.82	8348114.89	173.71	E2
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603465.64	8348550.31	175.56	E4
603470.98	8348750.10	175.68	E5
603592.94	8348935.92	174.61	E6
603527.86	8349009.12	174.97	E7
603534.79	8349188.82	175.45	E8

BOREHOLE

603460.24	8347592.21	171.60	BH1
603252.21	8347569.14	173.50	BH2
603122.99	8347530.98	169.10	BH3

LEGEND

- Shade Tree
- Eucalyptus
- Banana Plant
- Bamboo
- Fruit Tree
- Transmission Tower
- Bench Mark
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0 10 20 30 40 m

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APROVADO .....

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DESENHO N° PTO-CP-TOP-001
PROJECTO N° P 567
ASSUNTO PROPOSED NAMIALO SS SITE

ESCALA 1 : 750

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１６．土質調査報告書

GEOTECHNICAL INVESTIGATION AND TOPOGRAPHIC SURVEY FOR PREPARATORY SURVEY OF REIFORCEMENT PLAN FOR TRANSMISSION LINE AT NACALA CORRIDOR IN MOZAMBIQUE

FINAL REPORT

PREPARED FOR:

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FINAL REPORT

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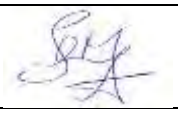
Checked By	Sidney de Abreu (Civil/Geotechnical Eng.)		
Approved By	Carlos Quadros (Senior Geotechnical Eng)		

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1 INTRODUCTION

TECNICA Lda was contracted by ORICONSUL to undertake a geophysical and geotechnical investigation for the "Preparatory Survey on the Project for Reinforcement of Transmission Network in Nacala Corridor".

The purpose of the Geotechnical and Geological investigations was to provide a geological description of the region and ascertain the nature of soil at the project area and determine the geotechnical properties of the subsoil. The other aim of the site investigation was to determine the position of the groundwater level and the soil resistivity. To define the soil properties laboratory tests were conducted. The knowledge of the engineering properties of the soil are very useful to design and propose a suitable and economical foundation for the structures.

TECNICA hereby presents the Final Report of the field work and laboratory tests carried out in the framework of this project.

This report is based on the field investigation carried between 14th and 31st July 2014 at the site project. The services were carried out in accordance with the scope of work proposed by the Client.

The objectives of investigation were to obtain:

- Subsurface profile detailing different strata and their variation with depth – this was done by core drilling investigation of 3 boreholes up to 15 meters depth;
- Position of the Groundwater surface;
- To determine the engineering properties of the strata and necessary soil data to help in deciding on soil bearing capacity and the suitable foundation structures;

2 SCOPE OF WORK

2.1 General

To prepare this report, TÉCNICA undertook the following work:

a) Physical site reconnaissance to review project limits, clearing drill rig access, mark out exploration boring locations;
b) Geological desktop study;
c) Borehole Drilling
d) Soil sampling
e) Laboratory soil testing;
f) Geotechnical soil characterization.
g) In Situ Soil resistivity testing

2.2 Project Location

The project site is located in Namialo, District of Nampula, approximately 78km to the East of Nampula City, near the Namialo Village (Figure 1).

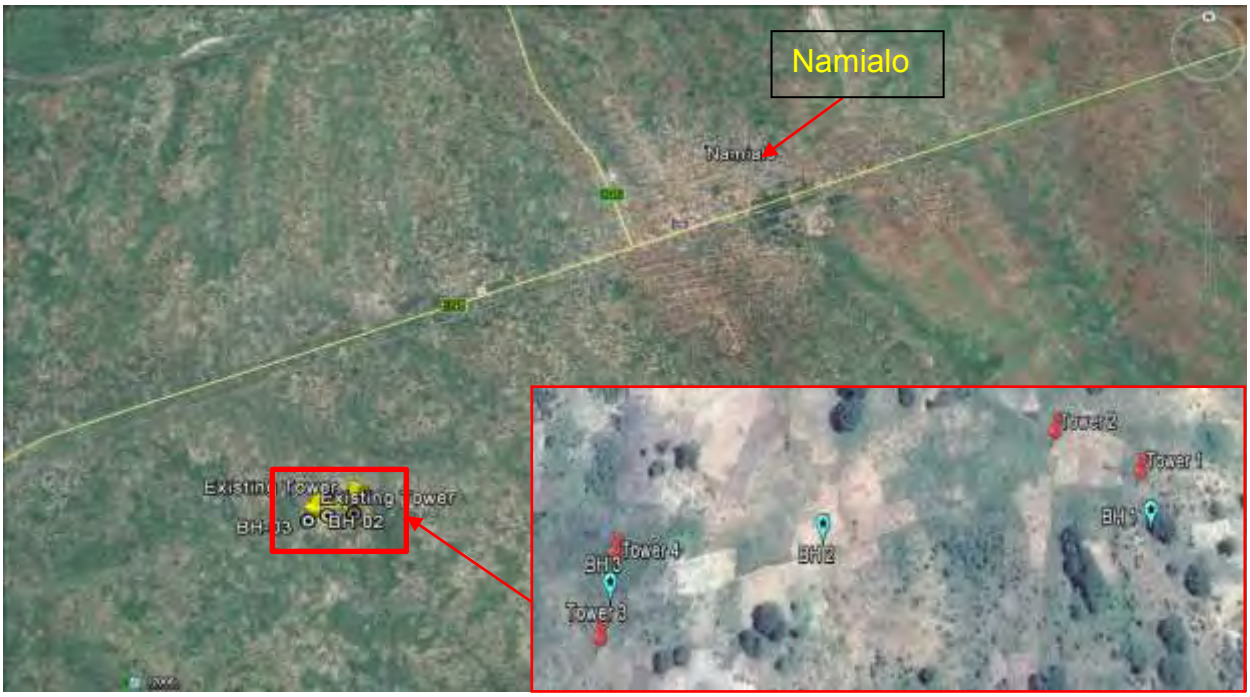

Figure 1 - Borehole site location

2.3 Scope of Works

The following works were executed, following the ToR and the main objectives of the investigation:

a) No. 3 Boreholes up to 15 m depth, with the execution of SPT test (Standard Penetration Test) at every 1.0 m depth;
b) Collection of disturbed soil samples to perform the following laboratory tests:
    - Moisture content
    - Sieve analysis
    - Atterberg Limits
c) No. 2 Soil Resistivity Tests using the Wenner method

The soil laboratory tests such as the triaxial compression test, unconfined compression test, and consolidation test, was not executed since the soil encountered on the boreholes was mostly composed by sand and silty sand.

3 GEOLOGICAL DESCRIPTION

The project area belongs to the Namialo pluton consisting mainly on granodioritic rocks and is closely associated with tonalitic gneisses.

In terms of Geomorphology, the project area is flattened land and downgraded as a result of changing existing rock that is predominantly granodiorite and gneissic quatzodiorites easily weathered rocks. The weathering process is made easier by the granular texture and composition rich in feldspar and biotite and the result is the formation of a residual soil (thin layers of sandy and clayey soils).

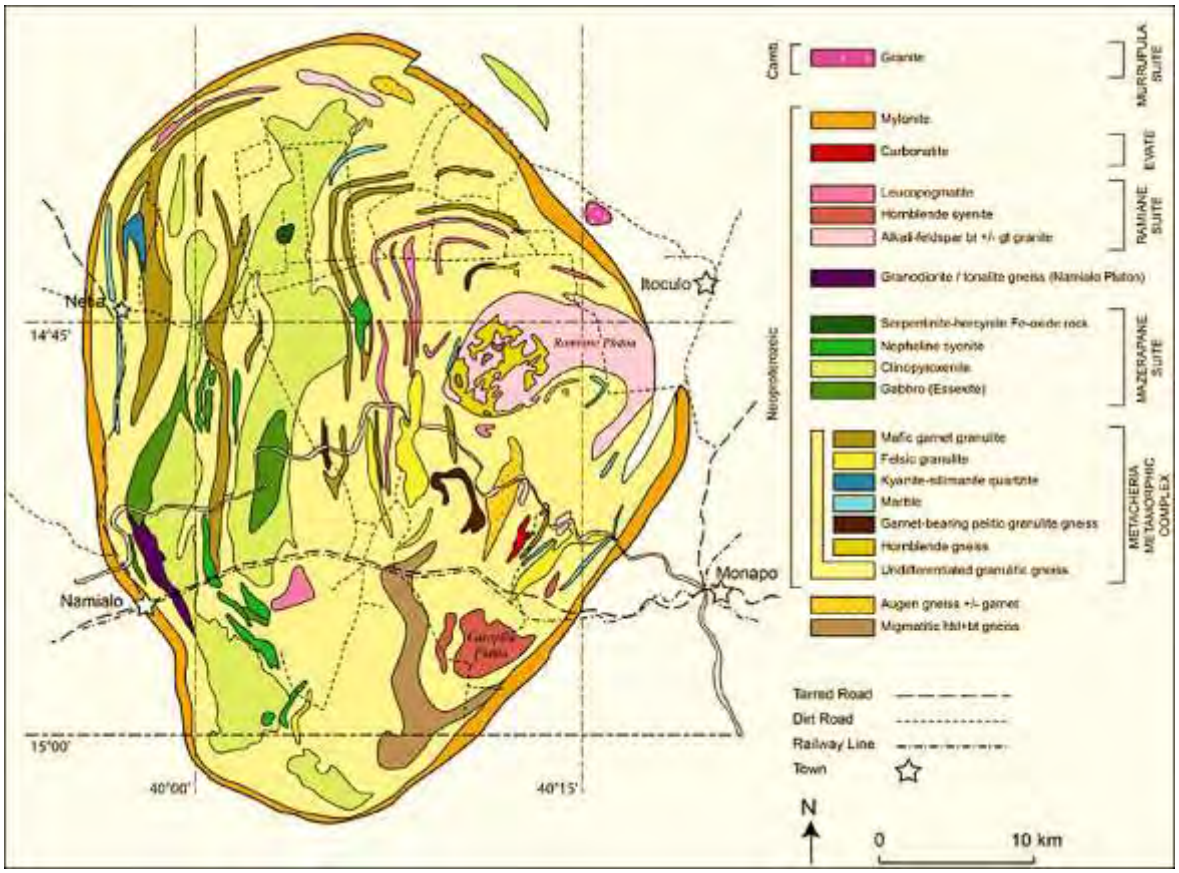

Figure 2 - Geological map of the Monapo Klippe.

The weathering leads to the formation of fine grained soils and the genesis of clay minerals that in turn favor the flattening of these areas due to the erosion process.

4 DRILLING INVESTIGATION

Between 14th and 31st July 2014 No.3 boreholes were drilled at the locations shown on the Site Plan, APPENDIX 1. Each borehole was drilled to a depth of 15 m. The soil found was visually examined during drilling, and logged according to the ASTM International Standards System. Standard Penetration Tests (SPT) was executed at every 1.0 m, and disturbed samples from the standard SPT- sampler were taken.

All samples were properly packed and taken to the laboratory of Soillab in Maputo, Mozambique. Groundwater levels were measured upon completion of drilling. The local ground

surface elevations of the borehole locations were surveyed using GPS equipment referenced to a geodetic datum. The elevations are shown on the table below.

Boreholes	Elevation (m)	Maximum depth drilled (m)	Coordinates (Latitude^{o})	Coordinates (Longitude^{o})	Date (dd/July/2014)	
					Start	End
BH1	171.6	15	-14.944467°	39.962067°	14	24
BH2	173.5	15	-14.944683°	39.960133°	25	27
BH3	169.1	15	-14.945033°	39.958933°	28	31

Table 1- Boreholes coordinates

4.1 Methodology

As specified, three boreholes were drilled by rotary core drilling method.
The objectives of the drilling investigation were to obtain the following:

a) Subsurface profile identifying different strata and their thickness ;
b) Obtain representative samples from the soil strata;
c) Carry out Standard Penetration Test (SPT) for bearing capacity estimation;
d) Determination of the position of the groundwater table;
e) Logging of the subsoil

Standard Penetration Test (SPT)

Standard Penetration Tests were performed on each hole at depths indicated in Table 1. The SPT tests were conducted in general compliance with applicable ASTM requirements. The test is basically a penetration test in which, a thick wall split tube sampler, is driven 300 mm into the undisturbed soil at the bottom of the hole under the blows of a 63.5 kg drive weight with 75 cm free fall.

4.2 Soil Condition

The general soil profile encountered at this site consists of superficial topsoil overlying mostly Silty Sands with some Clay layers. There is also the occurrence of beds of saprolite of

weathered gneiss rock along the 15m with variable thickness with more predominance on region where is located the borehole BH2. The soils generally increased in consistency and density with depth. It is found that up to 2.5 m depth the soil is less compacted but from there on the soil become dense to very dense with N_{SPT} greater than 60.

The detailed soil conditions found at the borehole locations are described on the borehole logs in APPENDIX 3. The following is a brief description of the soil types encountered

a) Topsoil

The layer of topsoil was encountered at all borehole locations with thickness ranging from 30 to 70 cm.

The topsoil was moderately organic, sandy silts with dark brown to reddish brown color and medium to fine grain size, very loose.

In general, this topsoil is considered to be weak and compressible under load.

b) Silty Sand

Silty sand is the kind of soil most abundant at the project site. It is a very dense and compact fine to medium grained material with mica minerals, interspread sometimes with some conglomerates, with N_{SPT} values ranging between 40 and greater than 50 blows per 300 mm of penetration, with exception of the first 2 meter in which the soil is less compacted with N_{SPT} ranging from 9 to 25 blows, as observed on borehole BH2 and BH3. The color of the silty sand varies from brown on the first meters, to light grey at higher depths. The fine component of this material shows a non-plastic behavior in accordance with the laboratory plasticity results (Atterberg Limits).

c) Clays,

Generally, there clay was found mixed with sand or silt. But there are some layers with thickness less than 1 m composed by sandy plastic clays, as could be observed in borehole BH1. The clays are in general light grey to reddish in color. In terms of consistency these clays can be classified as ”hard” (N_{SPT} > 35).

d) Saprolite

Saprolites (mixtures of residual soils and weathered rock) were found in borehole BH1 (8m and 10m) with thickness varying from 1 to 1.5 m, but it is more predominant in borehole BH2 being the layers thicker than 4 meter, starting from the depth 11.5m extending further than 15 m. These saprolites are the product of weathered gneiss with color varying from light brown to whitish grey.

4.3 Penetration Resistance, SPT-N

The sampler is first driven through 150 mm as a seating drive. It is further driven through 300 mm or until 50 blows have been applied. The number of blows required to drive the sampler 30 cm beyond the seating drive is termed as “Penetration Resistance N”. The tag of identification marks such as project, location, borehole number, sample number, penetration resistance with blows for each 15 cm and depth were attached to the sample.

Results of the SPT tests are shown on the individual boring log sheets in APPENDIX 3.

The degree of relative density of granular soils and the degree of consistency of cohesive soils are generally described on the boring logs according to the conventional correlation that can be visualized in Table 2 below:

Granular Soils		**Cohesive Soils**	
SPT Blow Count, N	**Description**	**SPT Blow Count, N**	**Description**
< 4	Very Loose	< 2	Very Soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium Dense	4 - 8	Medium Stiff
30 - 50	Dense	8 - 15	Stiff
> 50	Very Dense	15 - 30	Very Stiff
		> 30	Hard

Table 2- Conventional Correlation for Log Sheets

It is widely accepted that SPT blow count correlations, including those above, are overly simplistic and the blow counts should be adjusted for other factors, which may include, depending on the application, the effective vertical pressure at the sample depth and the details of the sampling system (such as hammer efficiency, rods, sampler details, and techniques used). The relative density and consistency descriptions on the logs are based on the unadjusted SPT blow count recorded in the field and reported on the logs.
In the present case, no correction of the blow count was introduced.

4.4 Sampling for laboratory tests

No. 13 disturbed samples were collected from each borehole. The soil samples collected were preserved in plastic bags, well packed and suitably labeled according with good practices. From each borehole No. 3 representative samples were selected for the laboratory tests.

4.5 Groundwater

The results of an investigation of the resistivity of the soil at the location of boreholes BH1 and boreholes BH2 indicate the existence of a partially saturated water layer. This layer has a thickness ranging from 5.0 to 7.0 meters. On the region of the borehole BH1 it has a thickness of about 7.0 meter and is located between the depth of 3.0 m and 11.0 m. At the zone of the borehole BH2 it has a thickness of about 5.0 meters and it is located between the depth of 3.5 m and 8.0 m.

Although groundwater was found at shallow depth, we are of the opinion that this water is due to localized effects, probably a result of the existence of a less pervious layer (perched groundwater level). The existence of the groundwater has, in our view, no detrimental effect in the bearing capacity of the soil.

5 LABORATORY TESTING

5.1 General

The soil samples were labeled and numbered in the field and taken to the materials laboratory of SOILLAB. The following tests were carried out:

- Particle size distribution
- Atterberg limits
- Moisture content

All laboratory tests were done in accordance with ASTM , "Standard Test Method" . The summary of the tests are presented on the Table 3 below.

Complete laboratory results can be found in the APPENDIX 2- summary of soil laboratory tests

Table 3 - Summary of laboratory tests

Sample No.	Depht (m)	Borehole No.	SPT No.	Moisture Content (%)	Sieve Analysis Percentage Passing Sieves (mm)					Atterberg Limits (%)		
					19	9.50	4.75	2.36	0.075	LL	PL	IP
61/SM/1	1.0 - 1.45	1	1	5.9	100	100	92	83	16	NP	NP	NP
61/SM/2	3.0 - 3.45	1	3	32.6	100	100	100	100	53	54.0	27.9	26.1
61/SM/3	13.5 - 14.0	1	13	14.7	100	98	98	97	33	31.8	17.9	13.9
61/SM/4	2.0 - 2.45	2	2	9.9	100	100	96	80	14	NP	NP	NP
61/SM/5	9.0 - 9.45	2	9	13.9	100	100	100	100	13	NP	NP	NP
61/SM/6	11.0 - 11.45	2	11	15.1	100	97	87	75	17	23.5	18.2	5.3
61/SM/7	4.0 - 4.75	3	4	4.3.6	100	99	98	96	19	NP	NP	NP
61/SM/8	9.0 - 9.45	3	9	12.2	100	100	100	100	11	NP	NP	NP
61/SM/9	13.0 - 13.45	3	13	11.7	100	100	100	99	16	NP	NP	NP

6 LOGGING OF SOILS

The logging of the boreholes was initiated in the field in which it was recorded the soil characteristics, observations, sample location, and other drilling information.

The soils were visually classified in general accordance with the Unified Soil Classification System (ASTM D 2488, “Standard Practice for Description and Identification of Soils). The final boring logs were prepared on the basis of visual observation of the samples and results of the laboratory tests. Groundwater observations are included in the logs. The logs also include our interpretation of the condition between sampling intervals.

7 GEOPHYSICAL INVESTIGATION

7.1 Methodology

The study involved measuring the resistivity in the form of vertical electrical soundings (VES) using the Ohmega resistivity (Fig 4).

The array of the electrodes, both current and potential was Schlumberger, in this case with a constant separation between both electrodes.

The VES intended to give an insight of the lithological differences with depth, and thickness of the layer.

Figure 3 - Image of Ohmega resistivity used in geophysical research.

7.2 Vertical Electrical Sounding (VES)

The vertical electrical soundings using the geoelectric method took place in the pre-selected sites according to the needs of the study.

The field work took place in August 2014 after a reconnaissance visit to the site involving the Client´s representative.

Two vertical electrical soundings to a depth of 45 m each were made in places where the borehole investigations were done.

Figure 4 - SEV set-up and geophysical technician during the field works near Borehole 01

7.3 Results

The results of the geophysical investigation are presented in tables and graphs (APPENDIX 4)

The table used to present the field data was provided by the Client and it contains the intervals separating the electrodes, both current and potential.

The arrangement of the electrodes was executed strictly in accordance with the instructions given in the table.

Table 4 - Values used for measuring the resistivity of the soil in the study area.

Earth Resistivity Measurement Sheet (Example)

				Musurement Company	ABC Co., Ltd.
Venue of site	Namialo SS	Date of measurement	25/06/2014		
Electrode Distance a[m]	Electrode moving distance P1and P2 (1/2a)	Electrode moving distanceC1and C2 (1.5a)	2πa [m]	R[Ω]=V/I Actual measurement value	ρ[Ωm]=2πa*R
0.6	0.3	0.9	3.77	61.0	230.0
1.0	0.5	1.5	6.28	38.2	240.0
1.5	0.75	2.25	9.42	28.5	269.6
2.0	1.0	3.0	12.57	23.9	300.3
3.0	1.5	4.5	18.85	20.7	390.2
5.0	2.5	7.5	31.42	15.6	490.1
7.0	3.5	10.5	43.98	12.3	541.0
10.0	5.0	15.0	62.8	8.4	527.8
15.0	7.5	22.5	94.2	5.5	480.0
30.0	15.0	45.0	188.5	2.5	471.3

It is noted that the values in the table above correspond to the distance between the current electrodes, the potential and the geoelectrical constant (2πa) was used.

More detailed results are presented in the APPENDIX 4.

8 CONCLUSIONS

The conclusions of the investigation are the following:

1. The project area is located at Namialo-Metochéria Formation consisting on a range of mafic, ultramafic and silica over saturated rocks (Fig. 3). The most important of these are the Evate Carbonatite, which is tentatively correlated with the Mezerepane Suite, and the Namialo Pluton, which has characteristics similar to the Ramiane.

2. On the geological/geotechnical formation: the whole area, with minor variations, is composed by silty sands with some clay and silty clay layers. There is also the occurrence of beds of Saprolite of weathered Gneiss rock and gneiss rock along the 15m with variable thickness, more predominant in region of borehole BH2. The soils generally increased in consistency and density with depth. It is found that up to 2.5 m depth the soil is relatively loose but from there on the soil becomes dense to very dense with N_{SPT} greater than 60. The silty sands show a small fraction of clay with low plasticity and in most of the cases non-plastic fines.

3. For engineering purposes:
    - In terms of bearing capacity, considering a shallow foundation, the results of STP test shows that the Allowable Bearing Capacity (with a Factor of Safety of 3) range from 200 to 250 kPa at 1.5m and it increases with depth. This is applicable to the locations of BH1 and BH3. The first layers of soil (up to 1m depth) are composed by less compacted silty sand and sandy silt with low bearing capacity. Founding structures in this layer should be avoided;
    - At location of BH2, the bearing capacity inferred directly from the SPT readings is apparently lower at 1.5m. However, in residual soils the spatial variation of the soils properties is a fact. It is noted that the formation is rather homogeneous and therefore the bearing capacity at say 1.5m can be taken as 200 kPa. There is no concern regarding soil failure. It is also noted that the thickness of the less compact soil is “small” and therefore no significant vertical movements are to be expected. Due to the nature of the soils, any vertical movements will be of the type “immediate settlements”.
    - The soil encountered on the project area has a poor drainage capacity (permeability estimated at 10^{-5} to10^{-6} cm/s) at the investigated depths. In this case a well-designed drainage system is important to protect the foundations of the structures and it should be implemented in the project area;
    - As per the results found from the STP test it is clear that there is no soft or very compressible material that could lead to critical settlement, after 1.5 m depth. Even the layers of clay found on the site, despite having no significant thickness, it has a very stiff to hard consistency (N_{SPT} greater than 60 blows), not constituting a major concern;
    - Excavations may stand stable with vertical walls for a reasonable time. If left exposed to the weather elements, walls of excavation may collapse, on the long term;

APPENDIX I

Site Plan


Existing Tower
Existing tower
BH-01
BH-02
Existing Tower
BH-03
Existing Tower
Image © 2014 CNES / Astrium
Google
2006
Data das imagens: 2/2/2014 lat. -14.944723° long. 39.960485° elev 189 m altitude de visualizaçã

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APPENDIX II

Laboratory Tests

- Summary of Test Results
- Sieve Analysis
- Atterberg Limits

SUMMARY OF SAMPLING & LABORATORY TEST RESULTS

Borehole Information					Moisture Content	Atterberg Limits			Particle Size Distribution (% Passing Sieve Size)					USCS Classification
Borehole Ref.	Sample Nr. Ref	SAMPLES TYPE	DEPTH (m)			Liquid Limit	Plastic Limit	Plasticity Index	19	9.5	4.75	2.36	0.075	
			From	To	%	%	%	%	mm	mm	mm	mm	mm	
BH1	1	Disturbed Samples	1	1.45	5.9	NP	NP	NP	100	100	92	83	16	SM
	2	Disturbed Samples	3	3.45	32.6	54	27.9	26.1	100	100	100	100	53	CH
	3	Disturbed Samples	13.5	14	14.7	31.8	17.9	13.9	100	98	98	97	33	SC-SM
BH2	1	Disturbed samples	2	2.45	9.9	NP	NP	NP	100	100	96	80	14	SM
	2	Disturbed Samples	9	9.45	13.9	NP	NP	NP	100	100	100	100	13	SM
	3	Disturbed Samples	11	11.45	15.1	23.5	18.2	5.3	100	97	87	75	17	SC-SM
BH3	1	Disturbed Samples	4	4.75	4.36	NP	NP	NP	100	99	98	96	19	SM
	2	Disturbed Samples	9	9.45	12.2	NP	NP	NP	100	100	100	100	11	SP-SM
	3	Disturbed Samples	13	13.45	11.7	NP	NP	NP	100	100	100	99	16	SM

Borehole BH1

SOILLAB
Moçambique

Gravel:	17.2	%
Coarse Sand:	27.1	%
Medium Sand:	31.4	%
Fine Sand:	8.1	%
Elem. < 0.075 mm	16.2	%

Weight of oven dry sample:	300.0	gr
Weight of washed oven dry:	251.4	gr
Weight of wash loss<0.075mm:	48.6	gr (P1)

REQUEST/ LAB. No.: 61/SM/GR/1
SPECIFICATION: ASTM C136 **DEPTH:** 1.0 - 1.45 m
SAMPLE No.: BH1-01 **CLIENT:** Oriconsul
SOIL DESCRIPTION: Silty Sand with Gravel
TESTED BY: Flora Cariório **DATE:** 05.08.14

Module Granulometric. G.M.= 0.68

Sieve mm	Retained (g)	Retained (%)	Passing (%)
			100
75.0			100.00
50.0			100.00
37.5			100.00
19.0			100.00
9.5			100.00
4.75	22.80	7.60	92.40
2.36	28.80	9.60	82.80
1.18	34.30	11.43	71.37
0.600	47.00	15.67	55.70
0.300	48.60	16.20	39.50
0.150	45.6	15.20	24.30
0.075	24.3	8.10	16.20
Base (P2)			
(P1)	48.6		
< 0.075	48.6	16.20	
W.Total	300.0		

Tot. Weight Pass. 0.075mm = (P1)+(P2)

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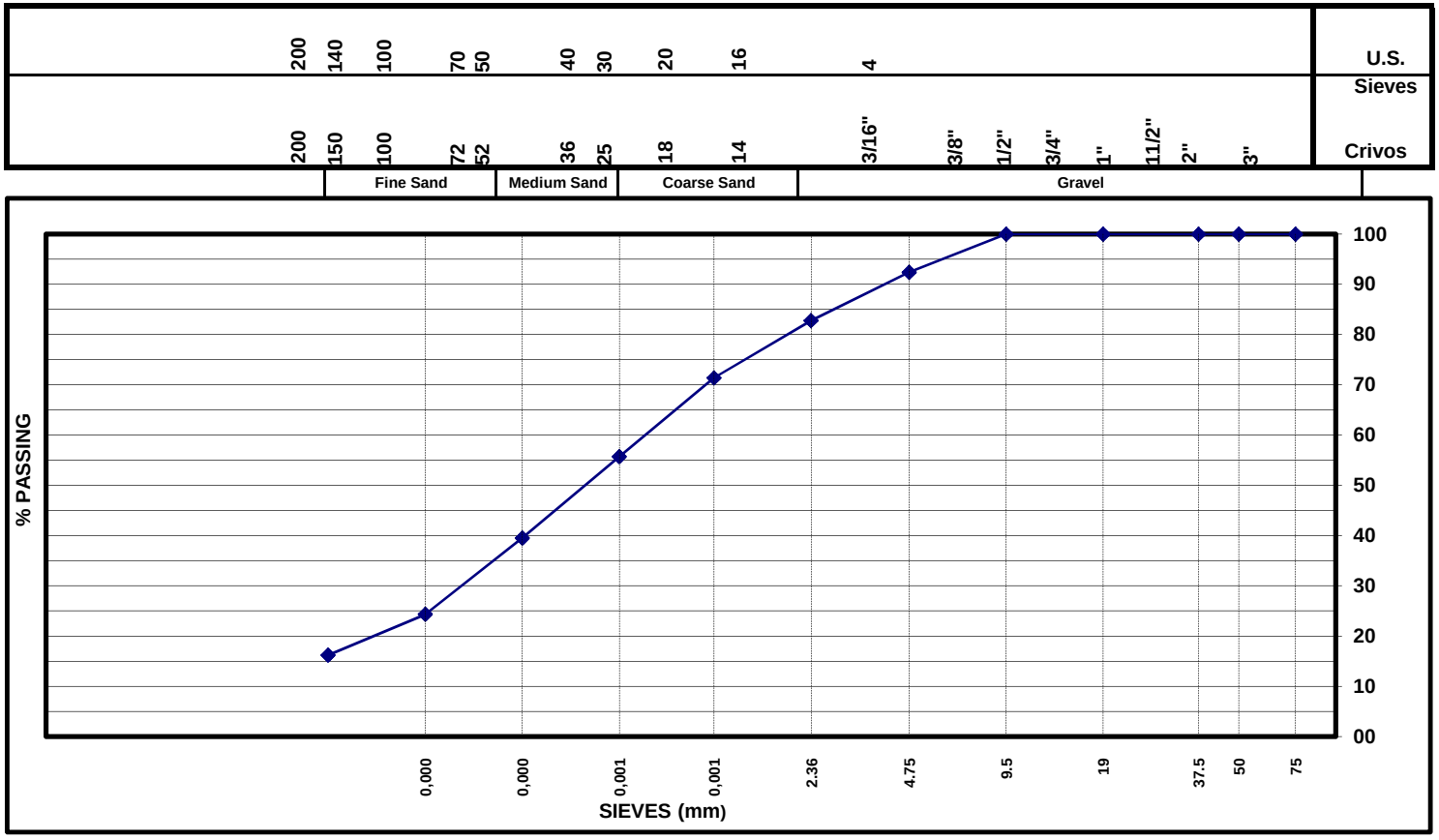

Checked By: Flora Cariório
Date: 06.08.14

Approved By: Vilma Manhique
Date: 06.08.14

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Gravel:		%
Coarse Sand:	6.6	%
Medium Sand:	31.2	%
Fine Sand:	9.4	%
Elem. < 0.075 mm	52.8	%

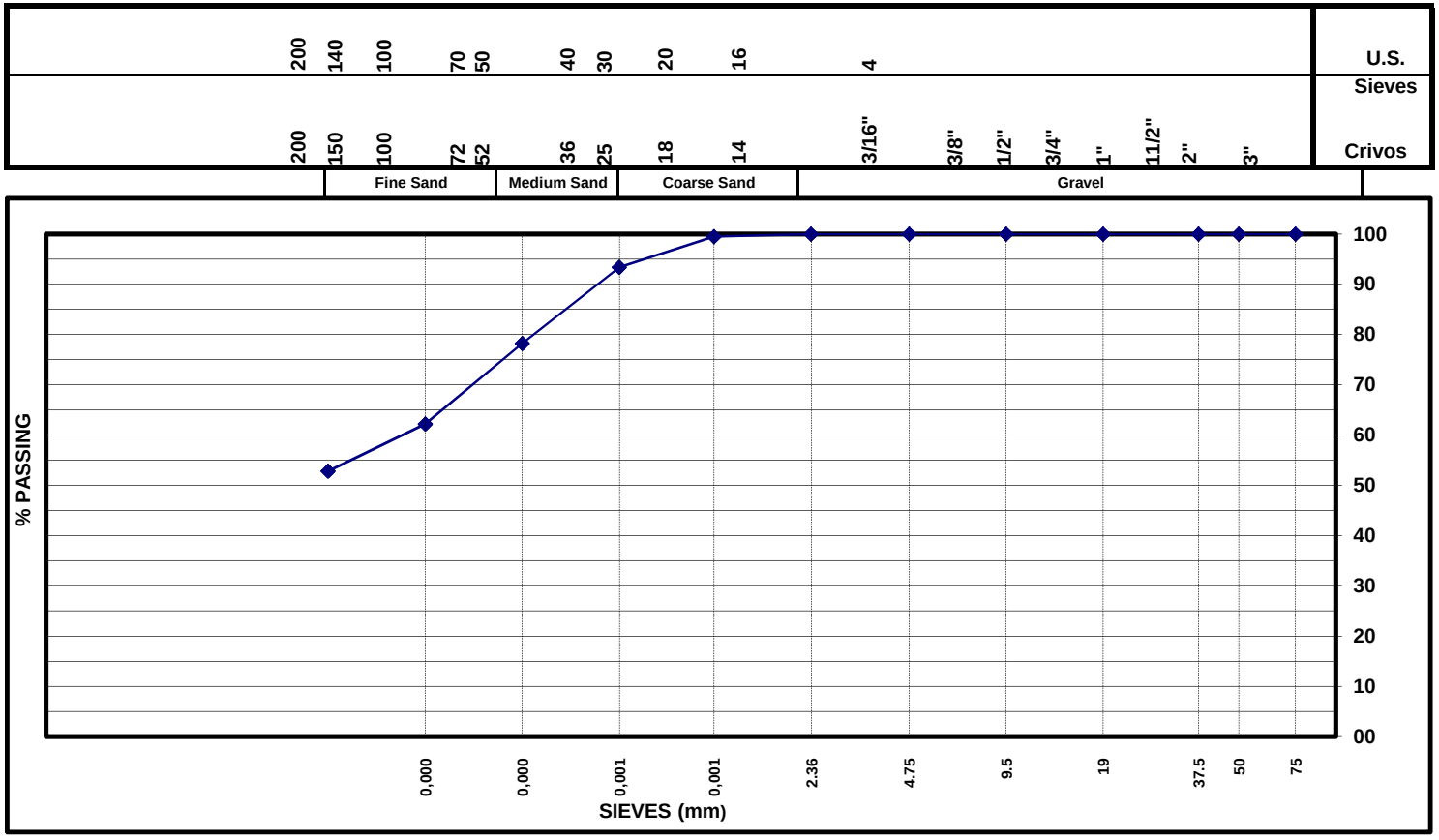
Weight of oven dry sample:	100.0	gr
Weight of washed oven dry:	47.2	gr
Weight of wash loss<0.075mm:	52.8	gr (P1)

REQUEST/ LAB. No.: 61/SM/GR/2
SPECIFICATION: ASTM C136 **DEPTH:** 3.0 - 3.45 m
SAMPLE No.: BH1-03 **CLIENT:** Oriconsul
SOIL DESCRIPTION: Sandy fat Clay
TESTED BY: Flora Cariório **DATE:** 05.08.14

Module Granulometric. G.M.= 0.38

Sieve mm	Retained (g)	Retained (%)	Passing (%)
			100
75.0			100.00
50.0			100.00
37.5			100.00
19.0			100.00
9.5			100.00
4.75			100.00
2.36			100.00
1.18	0.50	0.50	99.50
0.600	6.10	6.10	93.40
0.300	15.20	15.20	78.20
0.150	16.0	16.00	62.20
0.075	9.4	9.40	52.80
Base (P2)			
(P1)	52.8		
< 0.075	52.8	52.80	
W.Total	100.0		

Tot. Weight Pass. 0.075mm = (P1)+(P2)



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Checked By: Flora Cariório
Date: 06.08.14

Approved By: Vilma Manhique
Date: 06.08.14

SOILLAB
Moçambique

Gravel:	3.2	%
Coarse Sand:	13.8	%
Medium Sand:	38.0	%
Fine Sand:	11.8	%
Elem. < 0.075 mm	33.3	%

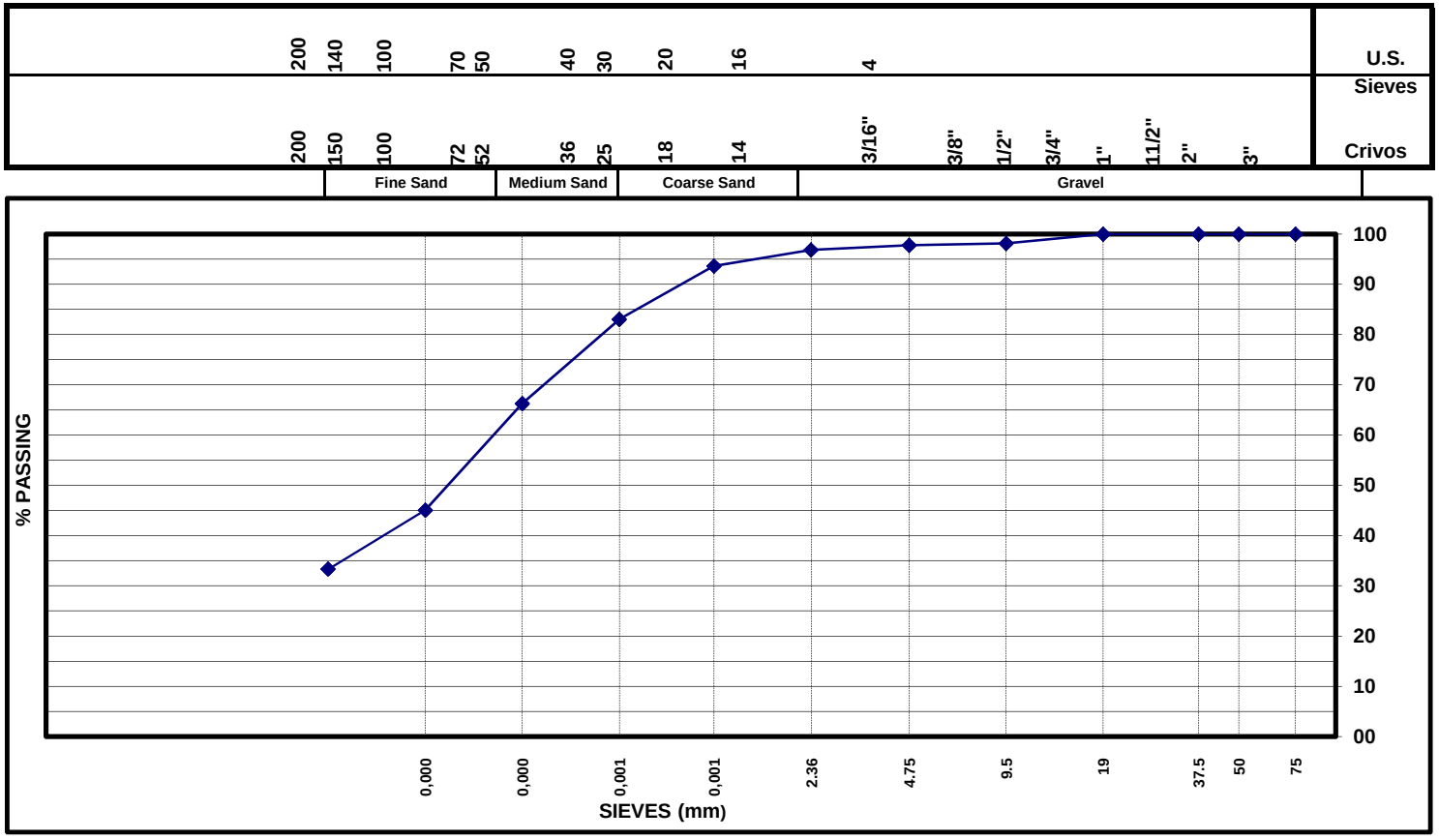
Weight of oven dry sample:	500.0	gr
Weight of washed oven dry:	333.5	gr
Weight of wash loss<0.075mm:	166.5	gr (P1)

REQUEST/ LAB. No.: 61/SM/GR/3
SPECIFICATION: ASTM C136 **DEPTH:** 13.5 - 14.0 m
SAMPLE No.: BH1-13 **CLIENT:** Oriconsul
SOIL DESCRIPTION: Clayey Silty Sand
TESTED BY: Flora Cariório **DATE:** 05.08.14

Module Granulometric. G.M.= 0.55

Sieve mm	Retained (g)	Retained (%)	Passing (%)
			100
75.0			100.00
50.0			100.00
37.5			100.00
19.0			100.00
9.5	9.40	1.88	98.12
4.75	1.70	0.34	97.78
2.36	4.70	0.94	96.84
1.18	16.10	3.22	93.62
0.600	53.00	10.60	83.02
0.300	83.80	16.76	66.26
0.150	106.0	21.20	45.06
0.075	58.8	11.76	33.30
Base (P2)			
(P1)	166.5		
< 0.075	166.5	33.30	
W.Total	500.0		

Tot. Weight Pass. 0.075mm = (P1)+(P2)



Checked By: Flora Cariório
Date: 06.08.14

Approved By: Vilma Manhique
Date: 06.08.14

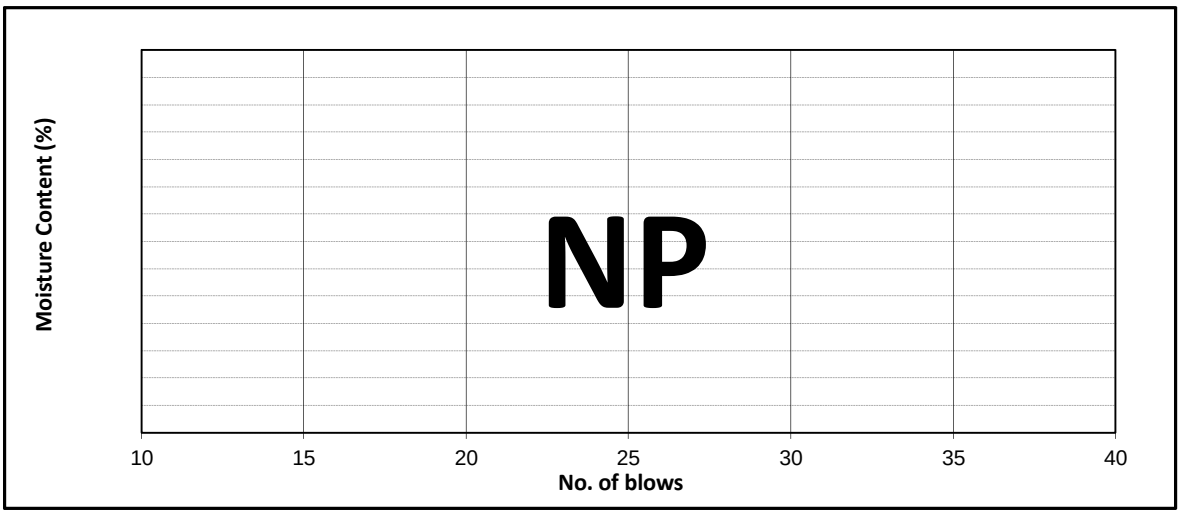
A16-25

SOILLAB Moçambique	***Determination of Atterberg Limits*** ***Air-Dried***	***Request/ Lab. No.*** ***61/SM/AL/01***

Contract:	P567	**Sample Location:**	Namialo
Project:	Reinforcement of Transmission Network in Nacala	**Depth:**	1.0 - 1.45 m
Client:	Oriconsul	**Specification:**	ASTM, D4318
Sample No.:	BH1-01	**Operator:**	Joaquina
Description:	SM	**Date:**	04.08.14

1. DETERMINATION OF LIQUID LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Number of Blows	**No.**							



2. DETERMINATION OF PLASTIC LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Average	**%**							

3. DETERMINATION OF LINEAR SHRINKAGE

Trough	**No.**	
No. of Blows	**No.**	
Length Before Drying	**mm**	
Length After Drying	**mm**	
Linear Shrinkage	**%**	

4. RESULTS

Liquid Limit	**%**	NP
Plastic Limit	**%**	NP
Plastic Index	**%**	NP
Linear Shrinkage	**%**	

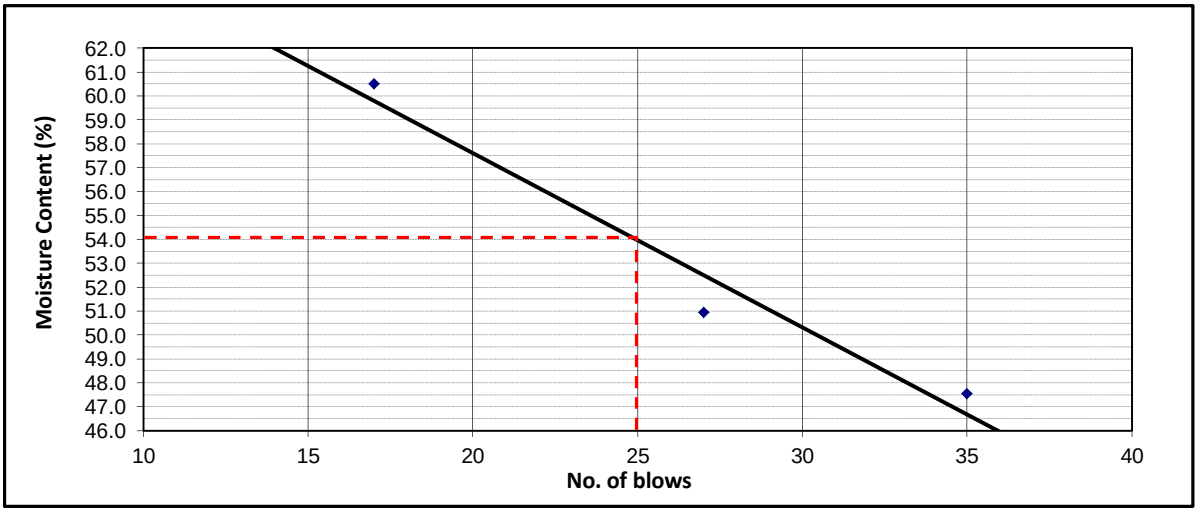
Checked By: Flora Cariório	**Approved By:** Vilma Manhique
Date: 05.08.14	**Date:** 06.08.14

SOILLAB Moçambique	***Determination of Atterberg Limits*** ***Air-Dried***	***Request/ Lab. No.*** ***61/SM/AL/02***

Contract:	P567	**Sample Location:**	Namialo
Project:	Reinforcement of Transmission Network in Nacala	**Depth:**	3.0 - 3.45 m
Client:	Oriconsul	**Specification:**	ASTM, D4318
Sample No.:	BH1-03	**Operator:**	Joaquina
Description:	CH	**Date:**	04.08.14

1. DETERMINATION OF LIQUID LIMIT

Container	**No.**	T	D	C				
Wgt of Wet Soil + Container	**g**	27.50	27.46	28.80				
Wgt of Dry Soil + Container	**g**	25.56	25.32	25.92				
Wgt of Moisture	**g**	1.94	2.14	2.88				
Wgt of Container	**g**	21.48	21.12	21.16				
Wgt of Dry Soil	**g**	4.08	4.2	4.76				
Moisture Content	**%**	47.55	50.95	60.50				
Number of Blows	**No.**	35	27	17				



2. DETERMINATION OF PLASTIC LIMIT

Container	**No.**	R	J					
Wgt of Wet Soil + Container	**g**	23.72	24.56					
Wgt of Dry Soil + Container	**g**	23.18	23.84					
Wgt of Moisture	**g**	0.54	0.7					
Wgt of Container	**g**	21.26	21.24					
Wgt of Dry Soil	**g**	1.92	2.6					
Moisture Content	**%**	28.13	27.69					
Average	**%**	27.9						

3. DETERMINATION OF LINEAR SHRINKAGE

Trough	**No.**	2
No. of Blows	**No.**	27
Length Before Drying	**mm**	150
Length After Drying	**mm**	123
Linear Shrinkage	**%**	18

4. RESULTS

Liquid Limit	**%**	54.0
Plastic Limit	**%**	27.9
Plastic Index	**%**	26.1
Linear Shrinkage	**%**	18

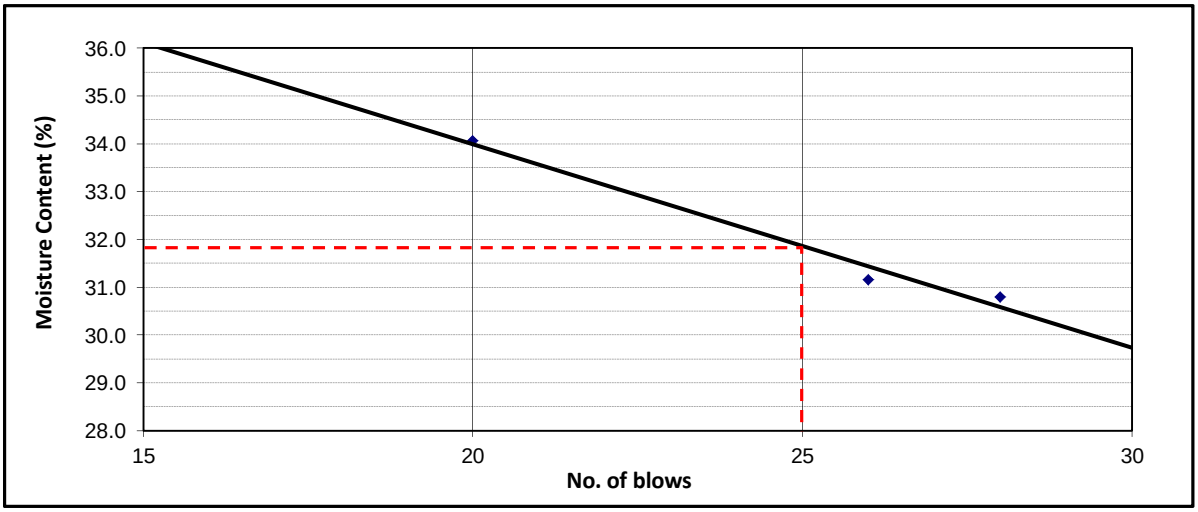
Checked By: Flora Cariório	**Approved By:** Vilma Manhique
Date: 05.06.14	**Date:** 06.06.14

SOILLAB Moçambique	***Determination of Atterberg Limits*** ***Air-Dried***	***Request/ Lab. No.*** ***61/SM/AL/03***

Contract:	P567	**Sample Location:**	Namialo
Project:	Reinforcement of Transmission Network in Nacala	**Depth:**	13.5 - 14.0 m
Client:	Oriconsul	**Specification:**	ASTM, D4318
Sample No.:	BH1-13	**Operator:**	Joaquina
Description:	SC-SM	**Date:**	04.08.14

1. DETERMINATION OF LIQUID LIMIT

Container	**No.**	A	B	E				
Wgt of Wet Soil + Container	**g**	28.60	28.60	27.52				
Wgt of Dry Soil + Container	**g**	26.90	26.88	25.96				
Wgt of Moisture	**g**	1.70	1.72	1.56				
Wgt of Container	**g**	21.38	21.36	21.38				
Wgt of Dry Soil	**g**	5.52	5.52	4.58				
Moisture Content	**%**	30.80	31.16	34.06				
Number of Blows	**No.**	28	26	20				



2. DETERMINATION OF PLASTIC LIMIT

Container	**No.**	F	S					
Wgt of Wet Soil + Container	**g**	28.16	28.74					
Wgt of Dry Soil + Container	**g**	27.1	27.62					
Wgt of Moisture	**g**	1.06	1.1					
Wgt of Container	**g**	21.28	21.28					
Wgt of Dry Soil	**g**	5.82	6.34					
Moisture Content	**%**	18.21	17.67					
Average	**%**	17.9						

3. DETERMINATION OF LINEAR SHRINKAGE

Trough	**No.**	11
No. of Blows	**No.**	26
Length Before Drying	**mm**	150
Length After Drying	**mm**	145
Linear Shrinkage	**%**	3

4. RESULTS

Liquid Limit	**%**	31.8
Plastic Limit	**%**	17.9
Plastic Index	**%**	13.9
Linear Shrinkage	**%**	3

Checked By: Flora Cariório	**Approved By:** Vilma Manhique
Date: 05.06.14	**Date:** 06.06.14

Borehole BH2

SOILLAB
Moçambique

Gravel:	20.4	%
Coarse Sand:	28.8	%
Medium Sand:	31.0	%
Fine Sand:	6.2	%
Elem. < 0.075 mm	13.5	%

Weight of oven dry sample:	300.0	gr
Weight of washed oven dry:	259.4	gr
Weight of wash loss<0.075mm:	40.6	gr (P1)

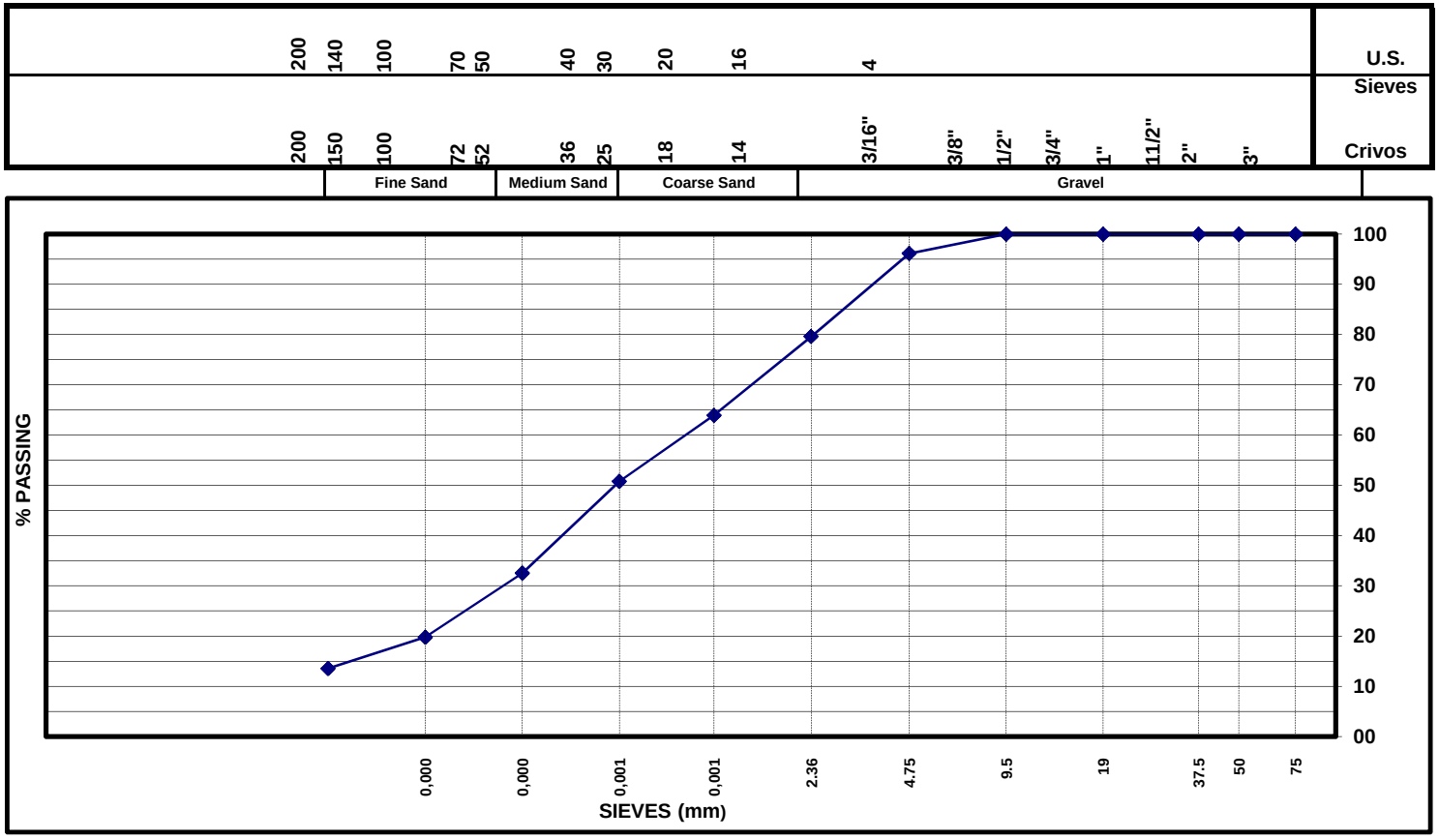
REQUEST/ LAB. No.: 61/SM/GR/4
SPECIFICATION: ASTM C136 **DEPTH:** 2.0 - 2.45 m
SAMPLE No.: BH2-02 **CLIENT:** Oriconsul
SOIL DESCRIPTION: Silty Sand with Gravel
TESTED BY: Flora Cariório **DATE:** 22.08.14

Module Granulometric. G.M.= 0.80

A16-30

Sieve mm	Retained (g)	Retained (%)	Passing (%)
			100
75.0			100.00
50.0			100.00
37.5			100.00
19.0			100.00
9.5			100.00
4.75	11.60	3.87	96.13
2.36	49.60	16.53	79.60
1.18	47.10	15.70	63.90
0.600	39.40	13.13	50.77
0.300	54.80	18.27	32.50
0.150	38.2	12.73	19.77
0.075	18.7	6.23	13.53
Base (P2)			
(P1)	40.6		
< 0.075	40.6	13.53	
W.Total	300.0		

Tot. Weight Pass. 0.075mm = (P1)+(P2)



Checked By: Flora Cariório
Date: 23.08.14

Approved By: Vilma Manhique
Date: 23.08.14

SOILLAB
Moçambique

Gravel:		%
Coarse Sand:	5.9	%
Medium Sand:	70.0	%
Fine Sand:	11.6	%
Elem. < 0.075 mm	12.5	%

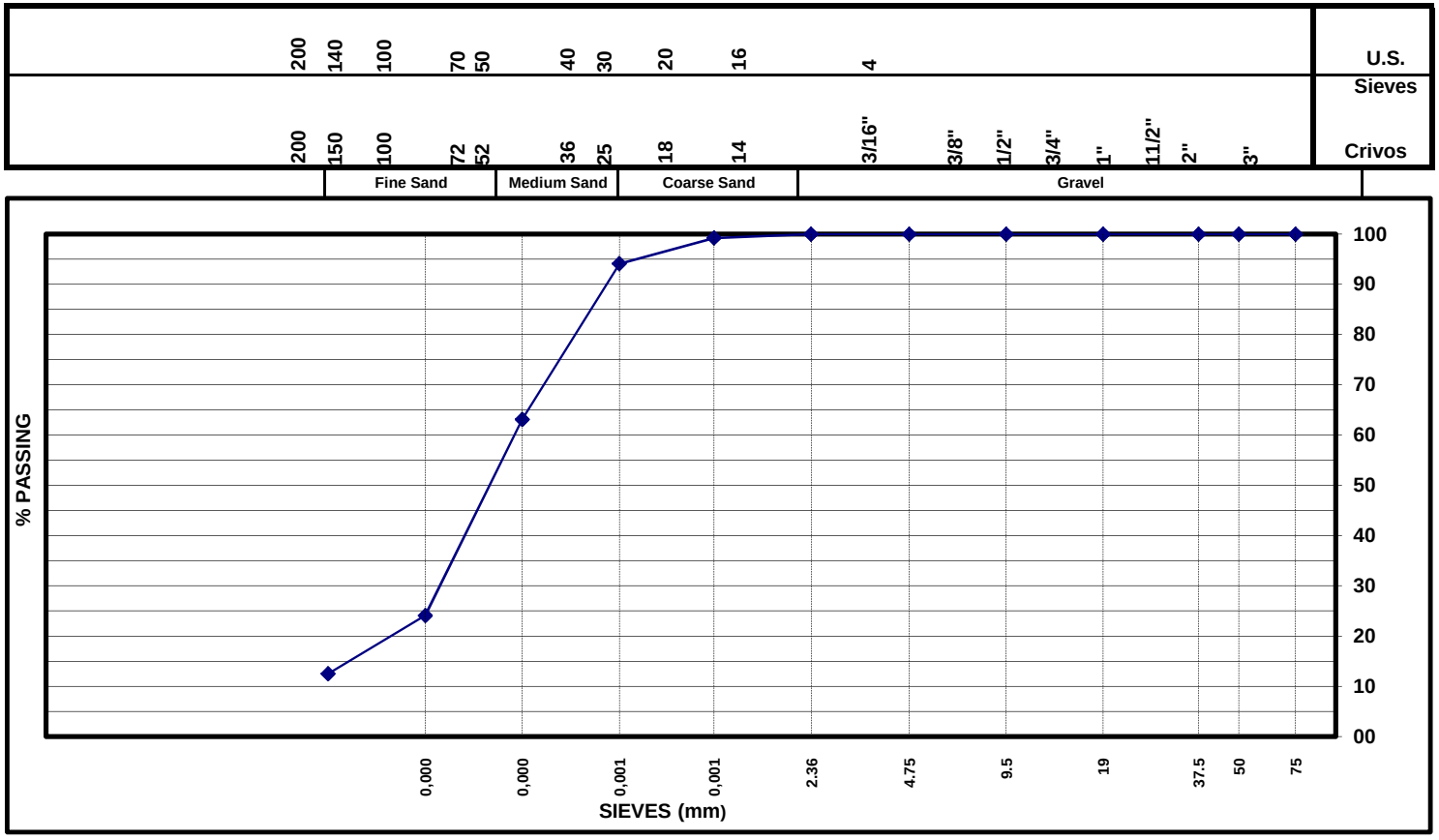
Weight of oven dry sample:	100.0	gr
Weight of washed oven dry:	87.5	gr
Weight of wash loss<0.075mm:	12.5	gr (P1)

REQUEST/ LAB. No.: 61/SM/GR/5
SPECIFICATION: ASTM C136 **DEPTH:** 9.0 - 9.45 m
SAMPLE No.: BH2-09 **CLIENT:** Oriconsul
SOIL DESCRIPTION: Silty Sand
TESTED BY: Flora Cariório **DATE:** 22.08.14

Module Granulometric. G.M.= 0.76

Sieve mm	Retained (g)	Retained (%)	Passing (%)
			100
75.0			100.00
50.0			100.00
37.5			100.00
19.0			100.00
9.5			100.00
4.75			100.00
2.36			100.00
1.18	0.80	0.80	99.20
0.600	5.10	5.10	94.10
0.300	31.00	31.00	63.10
0.150	39.0	39.00	24.10
0.075	11.6	11.60	12.50
Base (P2)			
(P1)	12.5		
< 0.075	12.5	12.50	
W.Total	100.0		

Tot. Weight Pass. 0.075mm = (P1)+(P2)



Checked By: Flora Cariório
Date: 23.08.14

Approved By: Vilma Manhique
Date: 23.08.14

A16-31

SOILLAB
Moçambique

Gravel:	24.8	%
Coarse Sand:	22.3	%
Medium Sand:	27.8	%
Fine Sand:	8.2	%
Elem. < 0.075 mm	16.9	%

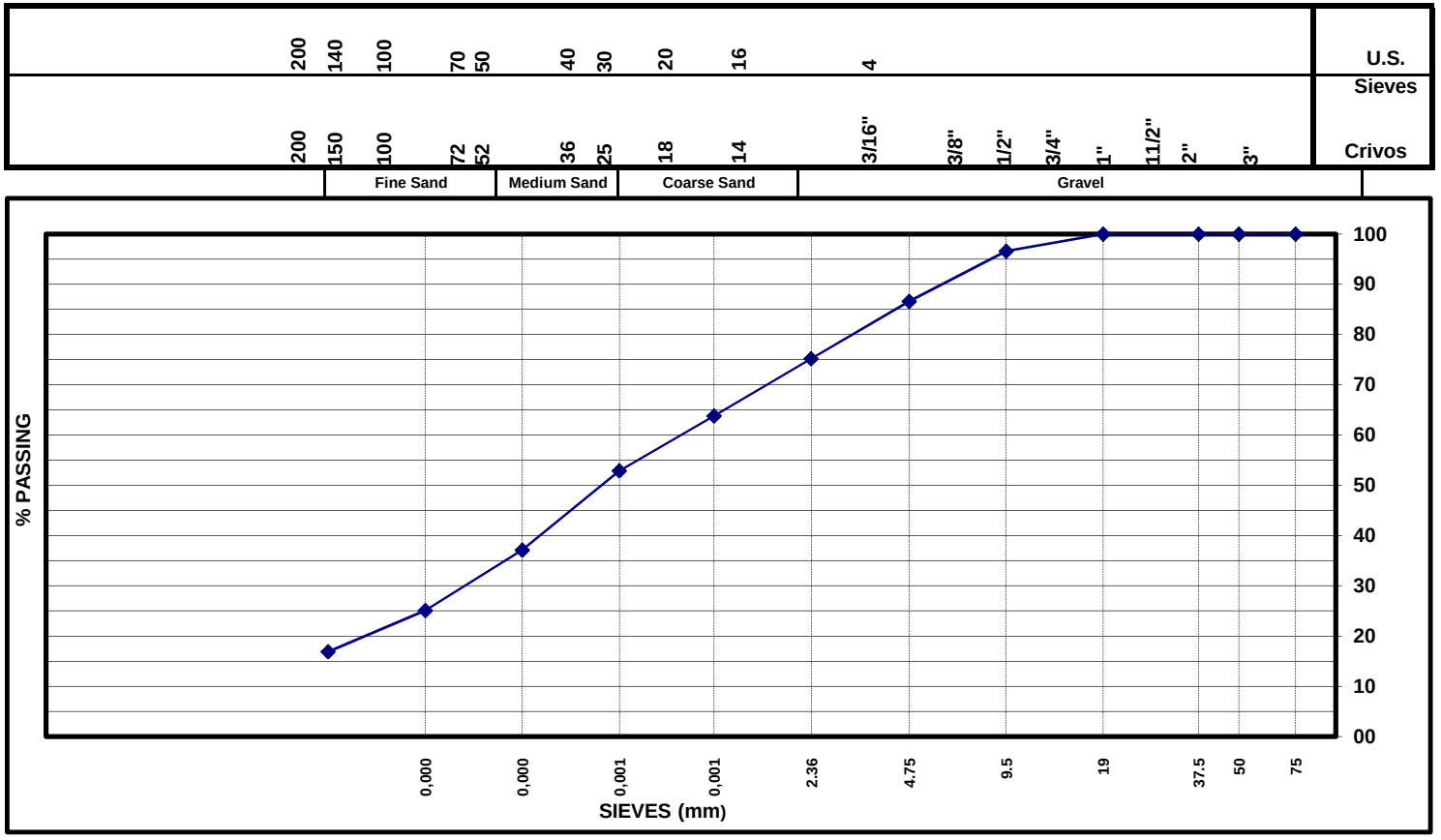
Weight of oven dry sample:	100.0	gr
Weight of washed oven dry:	83.1	gr
Weight of wash loss<0.075mm:	16.9	gr (P1)

REQUEST/ LAB. No.: 61/SM/GR/6
SPECIFICATION: ASTM C136 **DEPTH:** 11.0 - 11.45 m
SAMPLE No.: BH2-11 **CLIENT:** Oriconsul
SOIL DESCRIPTION: Silty Clayey Sand (SC-SM)
TESTED BY: Flora Cariório **DATE:** 22.08.14

Module Granulometric. G.M.= 0.75

Sieve mm	Retained (g)	Retained (%)	Passing (%)
			100
75.0			100.00
50.0			100.00
37.5			100.00
19.0			100.00
9.5	3.40	3.40	96.60
4.75	10.00	10.00	86.60
2.36	11.40	11.40	75.20
1.18	11.40	11.40	63.80
0.600	10.90	10.90	52.90
0.300	15.80	15.80	37.10
0.150	12.0	12.00	25.10
0.075	8.2	8.20	16.90
Base (P2)			
(P1)	16.9		
< 0.075	16.9	16.90	
W.Total	100.0		

Tot. Weight Pass. 0.075mm = (P1)+(P2)



A16-32

Checked By: Flora Cariório
Date: 23.08.14

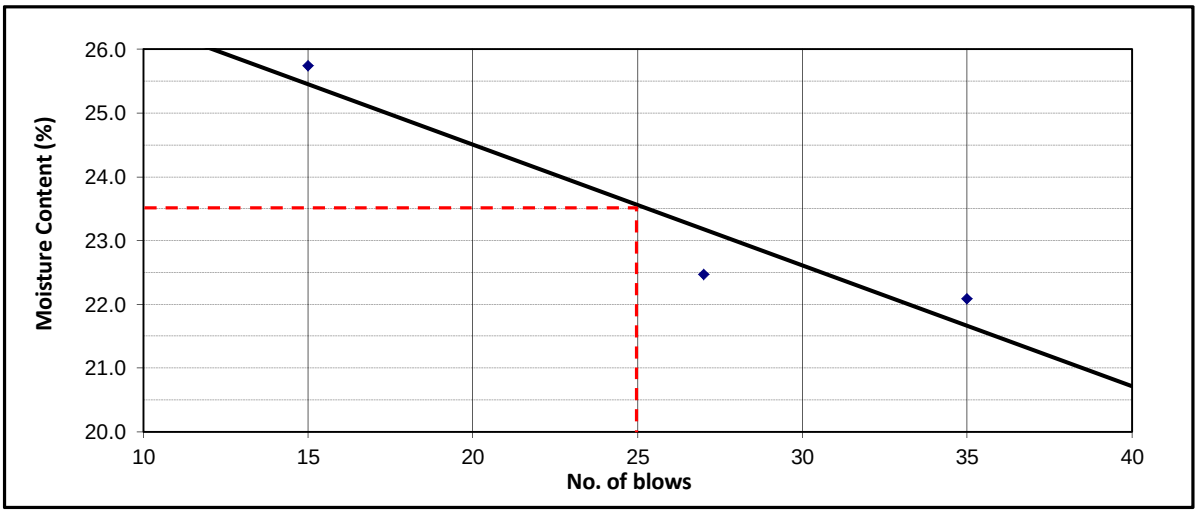
Approved By: Vilma Manhique
Date: 23.08.14

SOILLAB Moçambique	***Determination of Atterberg Limits*** ***Air-Dried***	***Request/ Lab. No.*** ***61/SM/AL/06***

Contract:	P567	**Sample Location:**	Namialo
Project:	Reinforcement of Transmission Network in Nacala	**Depth:**	11.0 - 11.45 m
Client:	Oriconsul	**Specification:**	ASTM, D4318
Sample No.:	BH2-11	**Operator:**	Joaquina
Description:	SC-SM	**Date:**	21.08.14

1. DETERMINATION OF LIQUID LIMIT

Container	No.	K	L	M				
Wgt of Wet Soil + Container	g	27.56	26.50	27.20				
Wgt of Dry Soil + Container	g	26.46	25.48	25.98				
Wgt of Moisture	g	1.10	1.02	1.22				
Wgt of Container	g	21.48	20.94	21.24				
Wgt of Dry Soil	g	4.98	4.54	4.74				
Moisture Content	%	22.09	22.47	25.74				
Number of Blows	No.	35	27	15				



2. DETERMINATION OF PLASTIC LIMIT

Container	No.	N	O					
Wgt of Wet Soil + Container	g	28.8	26.42					
Wgt of Dry Soil + Container	g	27.7	25.62					
Wgt of Moisture	g	1.1	0.8					
Wgt of Container	g	21.64	21.24					
Wgt of Dry Soil	g	6.06	4.38					
Moisture Content	%	18.15	18.26					
Average	%	18.2						

3. DETERMINATION OF LINEAR SHRINKAGE

Trough	No.	
No. of Blows	No.	
Length Before Drying	mm	
Length After Drying	mm	
Linear Shrinkage	%	

4. RESULTS

Liquid Limit	%	23.5
Plastic Limit	%	18.2
Plastic Index	%	5.3
Linear Shrinkage	%	0

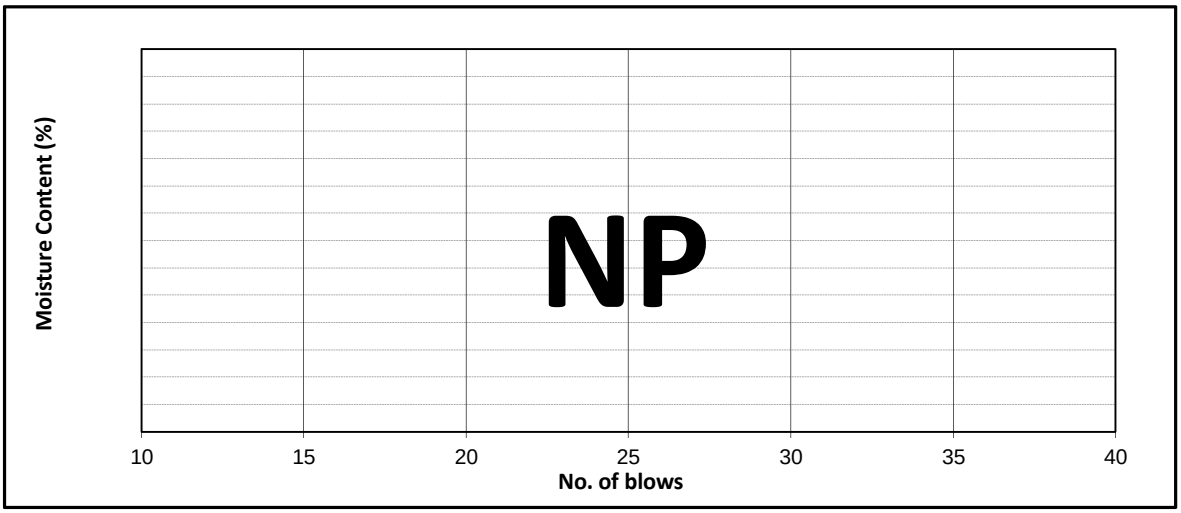
Checked By: Flora Cariório	**Approved By:** Vilma Manhique
Date: 22.08.14	**Date:** 22.08.14

SOILLAB Moçambique	***Determination of Atterberg Limits*** ***Air-Dried***	***Request/ Lab. No.*** ***61/SM/AL/04***

Contract:	P567	**Sample Location:**	Namialo
Project:	Reinforcement of Transmission Network in Nacala	**Depth:**	2.0 - 2.45 m
Client:	Oriconsul	**Specification:**	ASTM, D4318
Sample No.:	BH2-02	**Operator:**	Joaquina
Description:	SM	**Date:**	21.08.14

1. DETERMINATION OF LIQUID LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Number of Blows	**No.**							



2. DETERMINATION OF PLASTIC LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Average	**%**							

3. DETERMINATION OF LINEAR SHRINKAGE

Trough	**No.**	
No. of Blows	**No.**	
Length Before Drying	**mm**	
Length After Drying	**mm**	
Linear Shrinkage	**%**	

4. RESULTS

Liquid Limit	**%**	NP
Plastic Limit	**%**	NP
Plastic Index	**%**	NP
Linear Shrinkage	**%**	

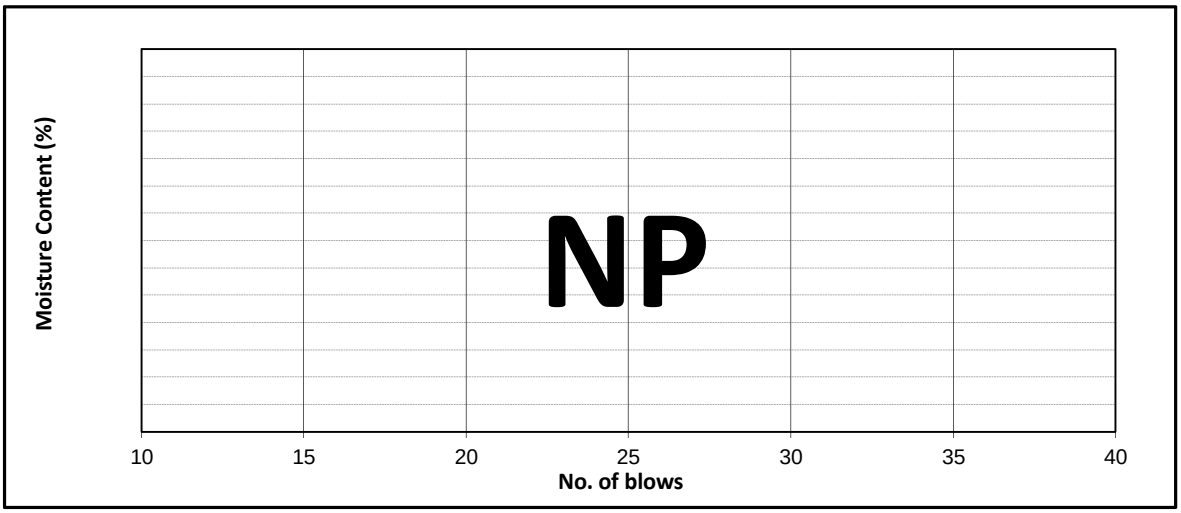
Checked By: Flora Cariório	**Approved By:** Vilma Manhique
Date: 22.08.14	**Date:** 22.08.14

SOILLAB Moçambique	***Determination of Atterberg Limits*** ***Air-Dried***	***Request/ Lab. No.*** ***61/SM/AL/05***

Contract:	P567	**Sample Location:**	Namialo
Project:	Reinforcement of Transmission Network in Nacala	**Depth:**	9.0 - 9.45 m
Client:	Oriconsul	**Specification:**	ASTM, D4318
Sample No.:	BH2-09	**Operator:**	Joaquina
Description:	SM	**Date:**	21.08.14

1. DETERMINATION OF LIQUID LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Number of Blows	**No.**							



2. DETERMINATION OF PLASTIC LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Average	**%**							

3. DETERMINATION OF LINEAR SHRINKAGE

Trough	**No.**	
No. of Blows	**No.**	
Length Before Drying	**mm**	
Length After Drying	**mm**	
Linear Shrinkage	**%**	

4. RESULTS

Liquid Limit	**%**	NP
Plastic Limit	**%**	NP
Plastic Index	**%**	NP
Linear Shrinkage	**%**	

Checked By: Flora Cariório	**Approved By:** Vilma Manhique
Date: 22.08.14	**Date:** 22.08.14

Borehole BH3

SOILLAB
Moçambique

Gravel:	**3.6**	%
Coarse Sand:	**11.9**	%
Medium Sand:	**51.3**	%
Fine Sand:	**14.6**	%
Elem. < 0.075 mm	**18.7**	%

Module Granulometric. G.M.= 0.67

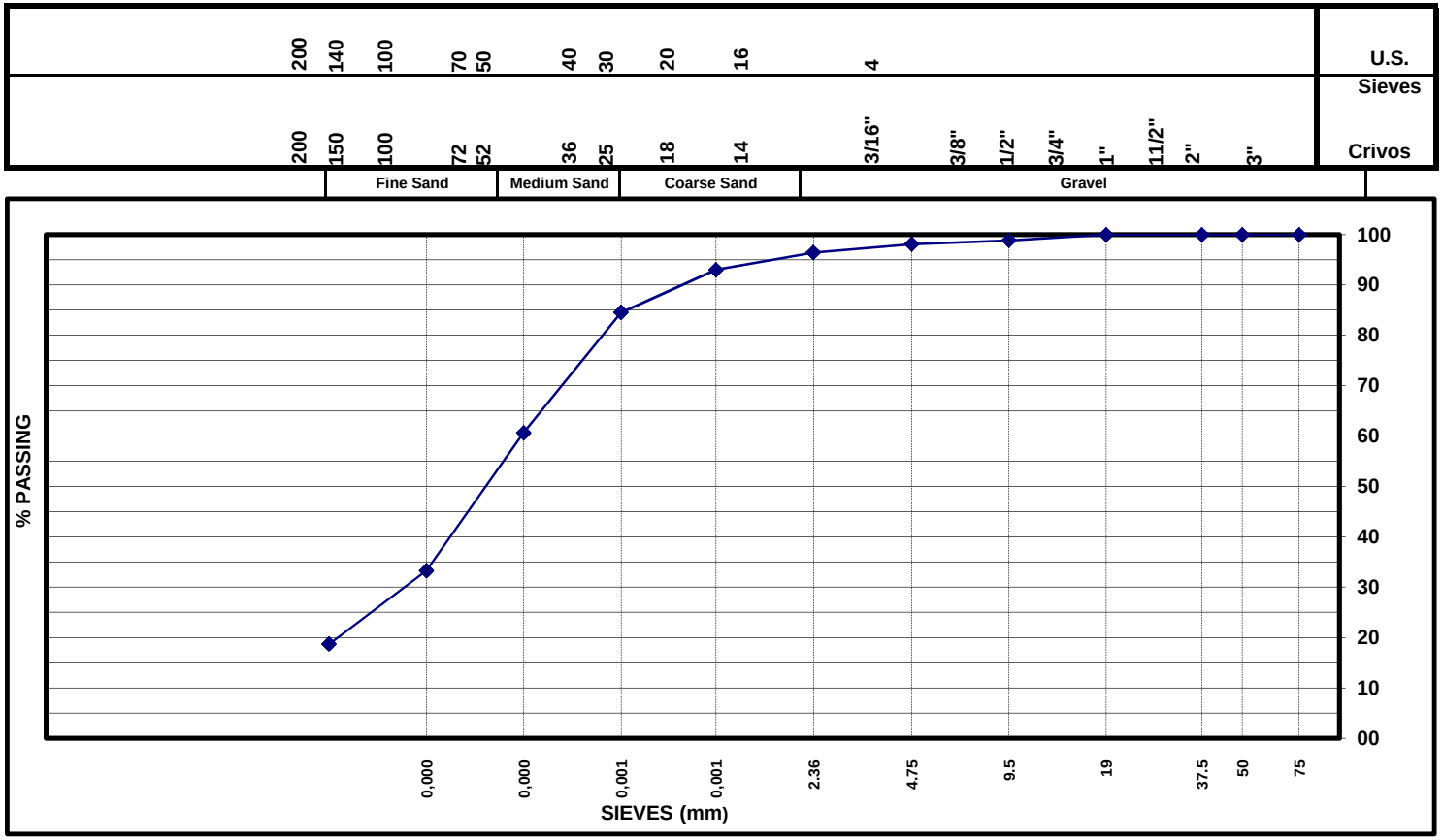
Weight of oven dry sample:	300.0	gr
Weight of washed oven dry:	244.0	gr
Weight of wash loss<0.075mm:	56.0	gr (P1)

REQUEST/ LAB. No.: 61/SM/GR/7
SPECIFICATION: ASTM C136 **DEPTH:** 4.0 - 4.45 m
SAMPLE No.: BH3-04 **CLIENT:** Oriconsul
SOIL DESCRIPTION: **Silty Sand (SM)**
TESTED BY: Flora Cariório **DATE:** 22.08.14

A16-37

Sieve mm	Retained (g)	Retained (%)	Passing (%)
			100
75.0			100.00
50.0			100.00
37.5			100.00
19.0			100.00
9.5	3.50	1.17	98.83
4.75	2.20	0.73	98.10
2.36	5.00	1.67	96.43
1.18	10.20	3.40	93.03
0.600	25.50	8.50	84.53
0.300	71.60	23.87	60.67
0.150	82.2	27.40	33.27
0.075	43.7	14.57	18.70
Base (P2)	0.1		
(P1)	**56.0**		
< 0.075	**56.1**	18.70	
W.Total	**300.0**		

Tot. Weight Pass. 0.075mm = (P1)+(P2)



Checked By: Flora Cariório **Approved By:** Vilma Manhique
Date: 23.08.14 **Date:** 23.08.14

SOILLAB
Moçambique

Gravel:		%
Coarse Sand:	2.8	%
Medium Sand:	79.8	%
Fine Sand:	6.7	%
Elem. < 0.075 mm	10.7	%

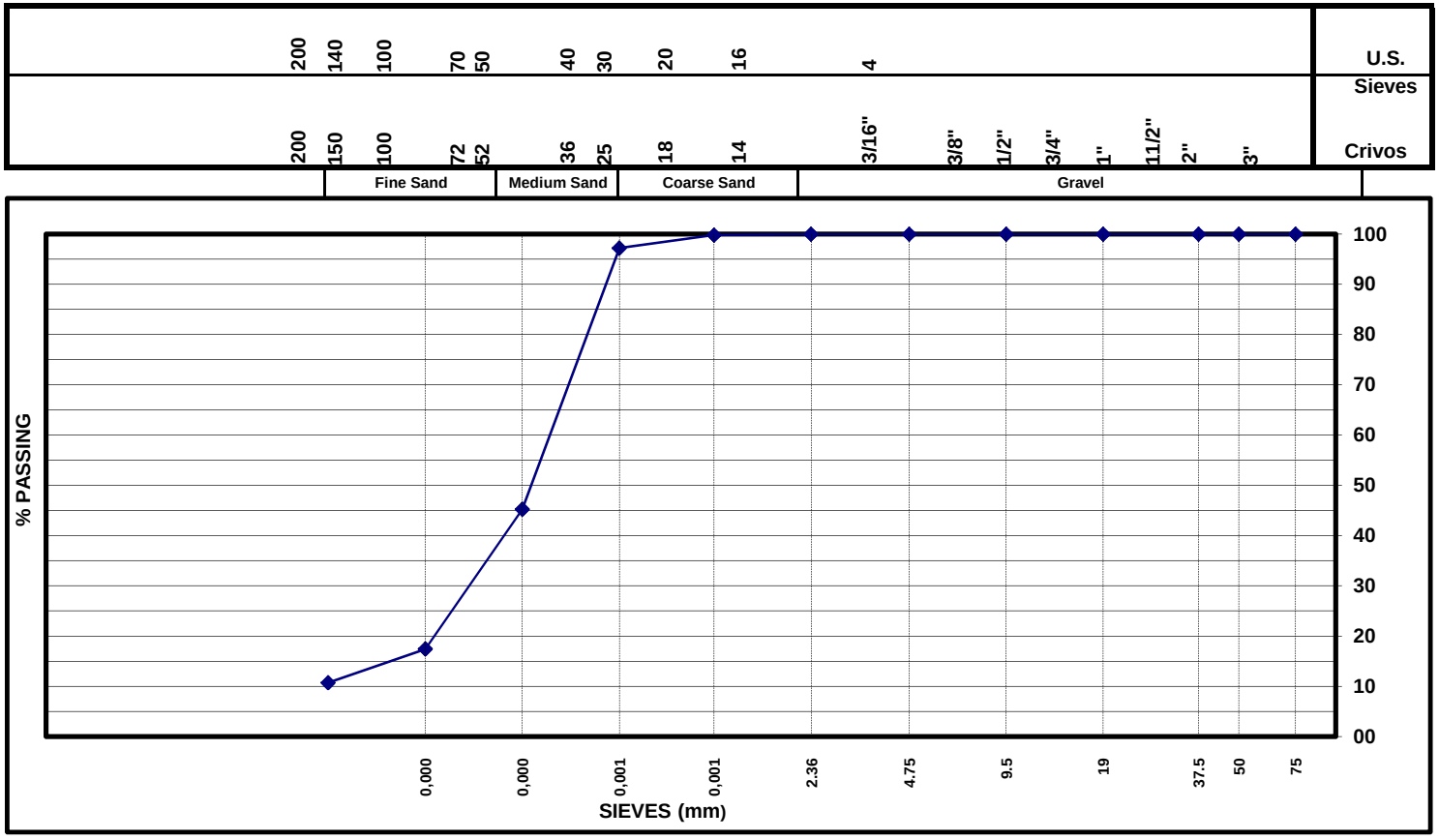
Weight of oven dry sample:	100.0	gr
Weight of washed oven dry:	89.3	gr
Weight of wash loss<0.075mm:	10.7	gr (P1)

REQUEST/ LAB. No.: 61/SM/GR/8
SPECIFICATION: ASTM C136 **DEPTH:** 9.0 - 9.45 m
SAMPLE No.: BH3-09 **CLIENT:** Oriconsul
SOIL DESCRIPTION: Poorly Graded Sand with Silt (SM)
TESTED BY: Flora Cariório **DATE:** 22.08.14

Module Granulometric. G.M.= 0.83

Sieve mm	Retained (g)	Retained (%)	Passing (%)
			100
75.0			100.00
50.0			100.00
37.5			100.00
19.0			100.00
9.5			100.00
4.75			100.00
2.36			100.00
1.18	0.20	0.20	99.80
0.600	2.60	2.60	97.20
0.300	52.00	52.00	45.20
0.150	27.8	27.80	17.40
0.075	6.7	6.70	10.70
Base (P2)			
(P1)	10.7		
< 0.075	10.7	10.70	
W.Total	100.0		

Tot. Weight Pass. 0.075mm = (P1)+(P2)



Checked By: Flora Cariório
Date: 23.08.14

Approved By: Vilma Manhique
Date: 23.08.14

A16-38

SOILLAB
Moçambique

Gravel:	0.6	%
Coarse Sand:	16.2	%
Medium Sand:	55.8	%
Fine Sand:	11.2	%
Elem. < 0.075 mm	16.2	%

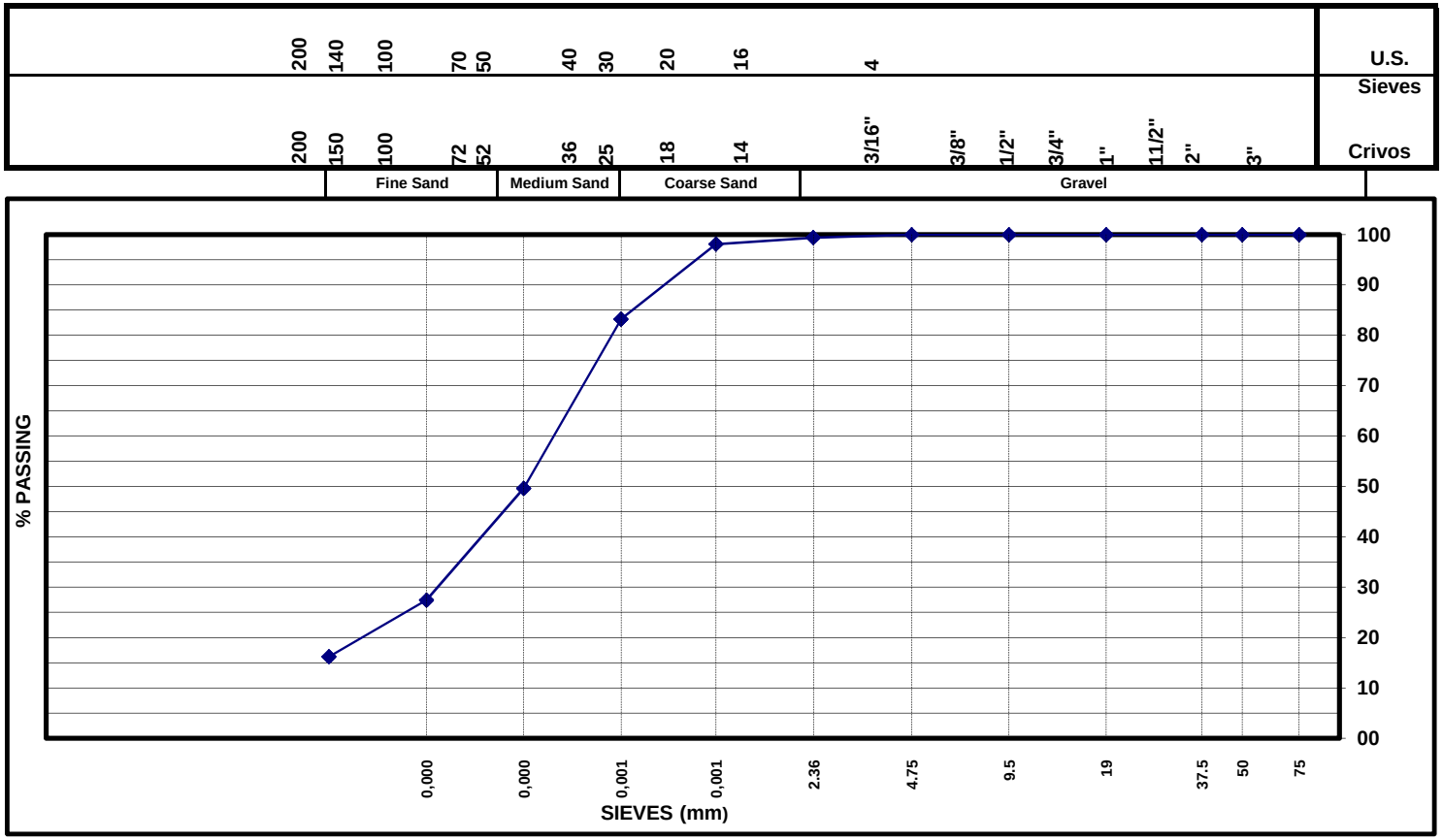
Weight of oven dry sample:	100.0	gr
Weight of washed oven dry:	83.8	gr
Weight of wash loss<0.075mm:	16.2	gr (P1)

REQUEST/ LAB. No.: 61/SM/GR/8
SPECIFICATION: ASTM C136 **DEPTH:** 13.0 - 13.45 m
SAMPLE No.: BH3-13 **CLIENT:** Oriconsul
SOIL DESCRIPTION: Silty Sand (SM)
TESTED BY: Flora Cariório **DATE:** 22.08.14

Module Granulometric. G.M.= 0.73

Sieve mm	Retained (g)	Retained (%)	Passing (%)
			100
75.0			100.00
50.0			100.00
37.5			100.00
19.0			100.00
9.5			100.00
4.75			100.00
2.36	0.60	0.60	99.40
1.18	1.30	1.30	98.10
0.600	14.90	14.90	83.20
0.300	33.60	33.60	49.60
0.150	22.2	22.20	27.40
0.075	11.2	11.20	16.20
Base (P2)			
(P1)	16.2		
< 0.075	16.2	16.20	
W.Total	100.0		

Tot. Weight Pass. 0.075mm = (P1)+(P2)



Checked By: Flora Cariório
Date: 23.08.14

Approved By: Vilma Manhique
Date: 23.08.14

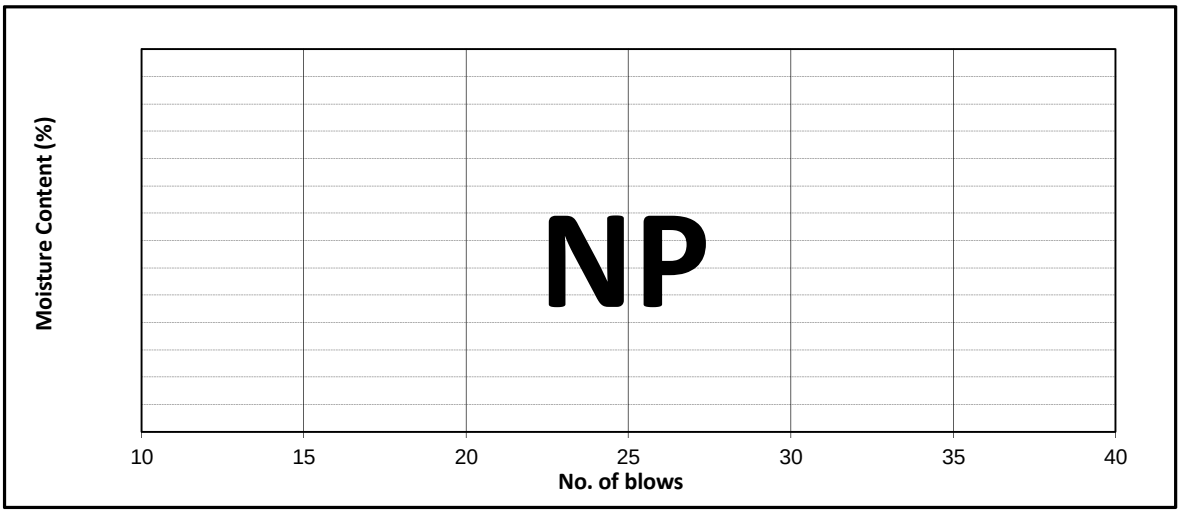
A16-39

SOILLAB Moçambique	***Determination of Atterberg Limits*** ***Air-Dried***	***Request/ Lab. No.*** ***61/SM/AL/07***

Contract:	P567	**Sample Location:**	Namialo
Project:	Reinforcement of Transmission Network in Nacala	**Depth:**	4.0 - 4.75 m
Client:	Oriconsul	**Specification:**	ASTM, D4318
Sample No.:	BH3-04	**Operator:**	Joaquina
Description:	SM	**Date:**	21.08.14

1. DETERMINATION OF LIQUID LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Number of Blows	**No.**							



2. DETERMINATION OF PLASTIC LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Average	**%**							

3. DETERMINATION OF LINEAR SHRINKAGE

Trough	**No.**	
No. of Blows	**No.**	
Length Before Drying	**mm**	
Length After Drying	**mm**	
Linear Shrinkage	**%**	

4. RESULTS

Liquid Limit	**%**	NP
Plastic Limit	**%**	NP
Plastic Index	**%**	NP
Linear Shrinkage	**%**	

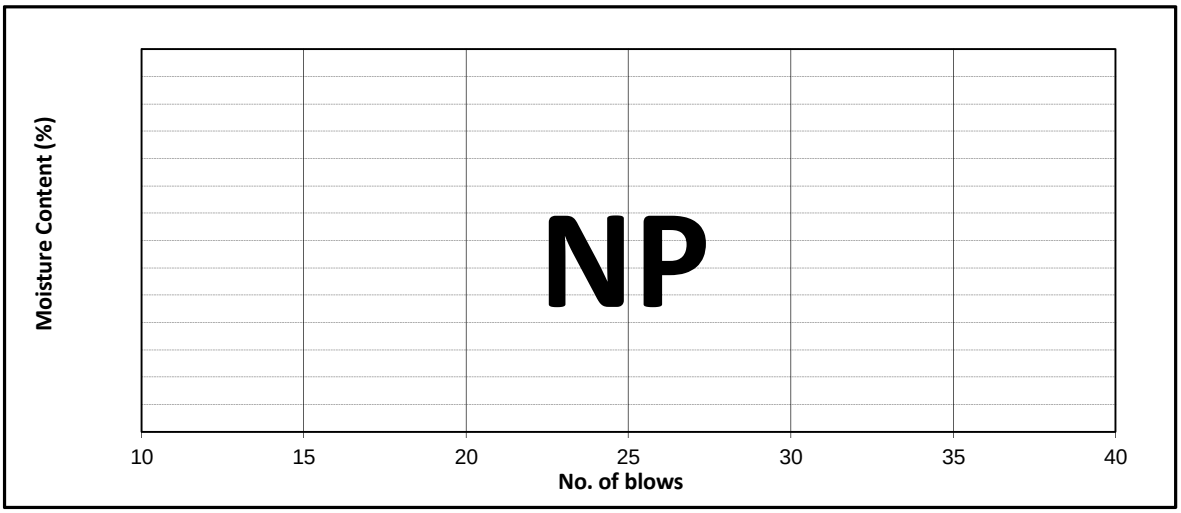
Checked By: Flora Cariório	**Approved By:** Vilma Manhique
Date: 22.08.14	**Date:** 22.08.14

SOILLAB Moçambique	***Determination of Atterberg Limits*** ***Air-Dried***	***Request/ Lab. No.*** ***61/SM/AL/09***

Contract:	P567	**Sample Location:**	Namialo
Project:	Reinforcement of Transmission Network in Nacala	**Depth:**	13.0 - 13.45 m
Client:	Oriconsul	**Specification:**	ASTM, D4318
Sample No.:	BH3-13	**Operator:**	Joaquina
Description:	SM	**Date:**	21.08.14

1. DETERMINATION OF LIQUID LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Number of Blows	**No.**							



2. DETERMINATION OF PLASTIC LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Average	**%**							

3. DETERMINATION OF LINEAR SHRINKAGE

Trough	**No.**	
No. of Blows	**No.**	
Length Before Drying	**mm**	
Length After Drying	**mm**	
Linear Shrinkage	**%**	

4. RESULTS

Liquid Limit	**%**	NP
Plastic Limit	**%**	NP
Plastic Index	**%**	NP
Linear Shrinkage	**%**	

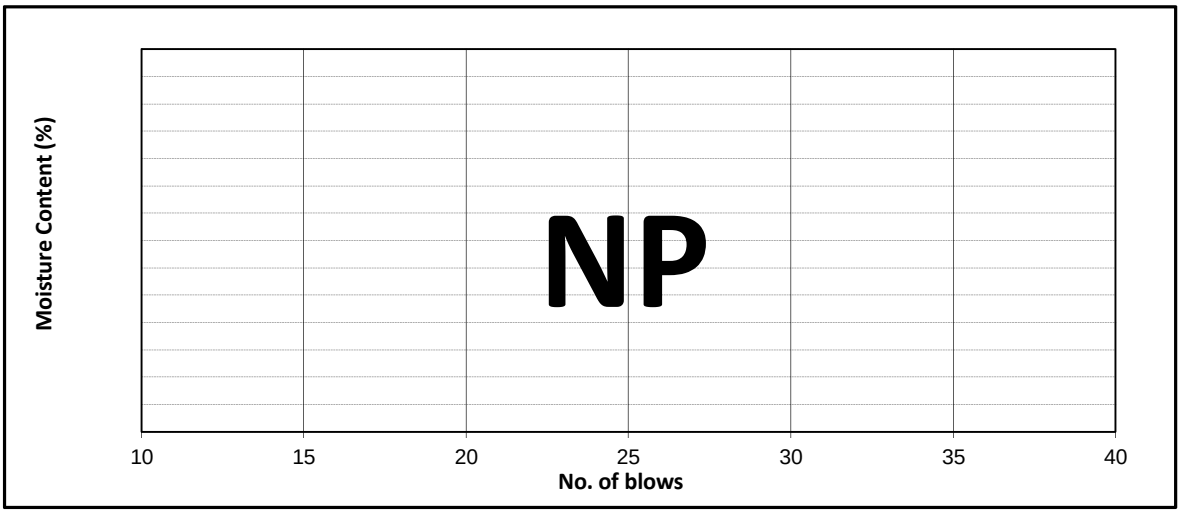
Checked By: Flora Cariório	**Approved By:** Vilma Manhique
Date: 22.08.14	**Date:** 22.08.14

SOILLAB Moçambique	***Determination of Atterberg Limits*** ***Air-Dried***	***Request/ Lab. No.*** ***61/SM/AL/08***

Contract:	P567	**Sample Location:**	Namialo
Project:	Reinforcement of Transmission Network in Nacala	**Depth:**	9.0 - 9.45 m
Client:	Oriconsul	**Specification:**	ASTM, D4318
Sample No.:	BH3-09	**Operator:**	Joaquina
Description:	SP-SM	**Date:**	21.08.14

1. DETERMINATION OF LIQUID LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Number of Blows	**No.**							



2. DETERMINATION OF PLASTIC LIMIT

Container	**No.**							
Wgt of Wet Soil + Container	**g**							
Wgt of Dry Soil + Container	**g**							
Wgt of Moisture	**g**							
Wgt of Container	**g**							
Wgt of Dry Soil	**g**							
Moisture Content	**%**							
Average	**%**							

3. DETERMINATION OF LINEAR SHRINKAGE

Trough	**No.**	
No. of Blows	**No.**	
Length Before Drying	**mm**	
Length After Drying	**mm**	
Linear Shrinkage	**%**	

4. RESULTS

Liquid Limit	**%**	NP
Plastic Limit	**%**	NP
Plastic Index	**%**	NP
Linear Shrinkage	**%**	

Checked By: Flora Cariório	**Approved By:** Vilma Manhique
Date: 22.08.14	**Date:** 22.08.14

APPENDIX III

Logging of Boreholes

Photography Report

Borehole BH1

LOG OF BORING BH1

Boring No:	BH 01	**Sheet**	1
Project Number:	P567	**Project Name:**	GEOTECHCANICAL INVESTIGATION AND TOPOGRAPHIC SURVEY FOR PREPARATORY SURVEY OF REIFORCEMENT PLAN FOR TRANSMISSION LINE AT NACALA CORRIDOR IN MOZAMBIQUE
Total depth:	15 m	**Location:**	Namialo - Nampula
Drill contractor:		**Sampling Method:**	Rotary Drilling
Date Started:	14-Jul-14		
Date Completed:	24-Jul-14	**Driller:**	Manuel Cardoso
Client:	ORICONSUL	**Drill Rig Type:**	Unimog, V100 – Bomag

Depth (m)	Water level	Samples Type	Samples Number	Blow counts (N) 30 cm	Graphic Log	MATERIAL DESCRIPTION	Classification Symbol	Water Content (%)	Dry Unit Weight kg/m3	REMARKS AND OTHER TESTS
0						Clayey silt, dark brown, fine grained, loose				
1						Sandy silt, reddish color, fine grained, medium	SM	5.9		LL=NP PL=NP IP=NP
		SPT disturbed	BH1-01	Refusal						
2						Silt and conglomerate botrioidal calcite and spherical. Phenocrysts and quartz crystals, reddish and brown color, very dense				
		SPT disturbed	BH1-02	Refusal						
3						Silty clay (calcite), white color and medium to fine grain size, hard				
		SPT disturbed	BH1-03	35		Sandy fat clay, white and red color, with fine to medium grain size sand, hard	CH	32.6		LL=54 PL=27.9 IP=26.1
4						Silty sand, gray color, with fine grain size, very dense				
				Refusal						
5						Silty clay (calcite), white color and medium to fine grain size, hard				
		SPT disturbed	BH1-05	Refusal						
6						Silty clay, grey color, medium to fine grain size, hard. Gneiss rock of medium to fine grain size, hard. (6.5m to 6.6m deep)				
		SPT disturbed	BH1-06	39						
7						Clayey sand, brownish green color, medium to fine grain size, hard				
		SPT disturbed	BH1-07	64		Silty clay of medium to fine grain size, hard				
8						Saprolite (weathered gneiss) brown color, medium to fine grain size, hard				
		SPT disturbed	BH1-08	Refusal						
9						Clayey sand, variegated, gray color, with medium to fine grain size, hard				
		SPT disturbed	BH1-09	Refusal		Clayey sand, gray color with medium to fine grain size, hard				
10						Fragmented saprolite, brownish yellow color, medium to fine grain size, hard				
		SPT disturbed	BH1-10	Refusal		Gneiss rock with brown to white color, fine to medium grain size, hard. Saprolite, gneissy and clayey micaceous intemperate, gray green color, fine to coarse grain size, hard (11.2m to 11.3m deep)				
11		SPT disturbed	BH1-11	Refusal						
12				Refusal		Silty clayey sand, mottled with gray color, medium to fine grain size, hard	SC-SM	14.7		LL=31.8 PL=17.9 IP=13.9
13				Refusal						
		SPT disturbed	BH1-13							
14				Refusal		Gneiss rock, gray to white color, very hard				
						Silty clay, graycolor, medium to fine grain size, very hard				
15						Granite, very hard				

Co-ordinates		Borehole diameter: 114 mm	Checked by: Sidney de Abreu
Lat. (°)	(-)14.944467°		Logged by: Ivan Manhiça
Long. (°)	39.962067°	Ground Water Observation: Existente of parcialy saturated layer between the depth 3,0m and 11,0 m	
Ground Elevation:	171.6 m		

Photo 1 - Logg 1, from 0.0m to 7.5m depth

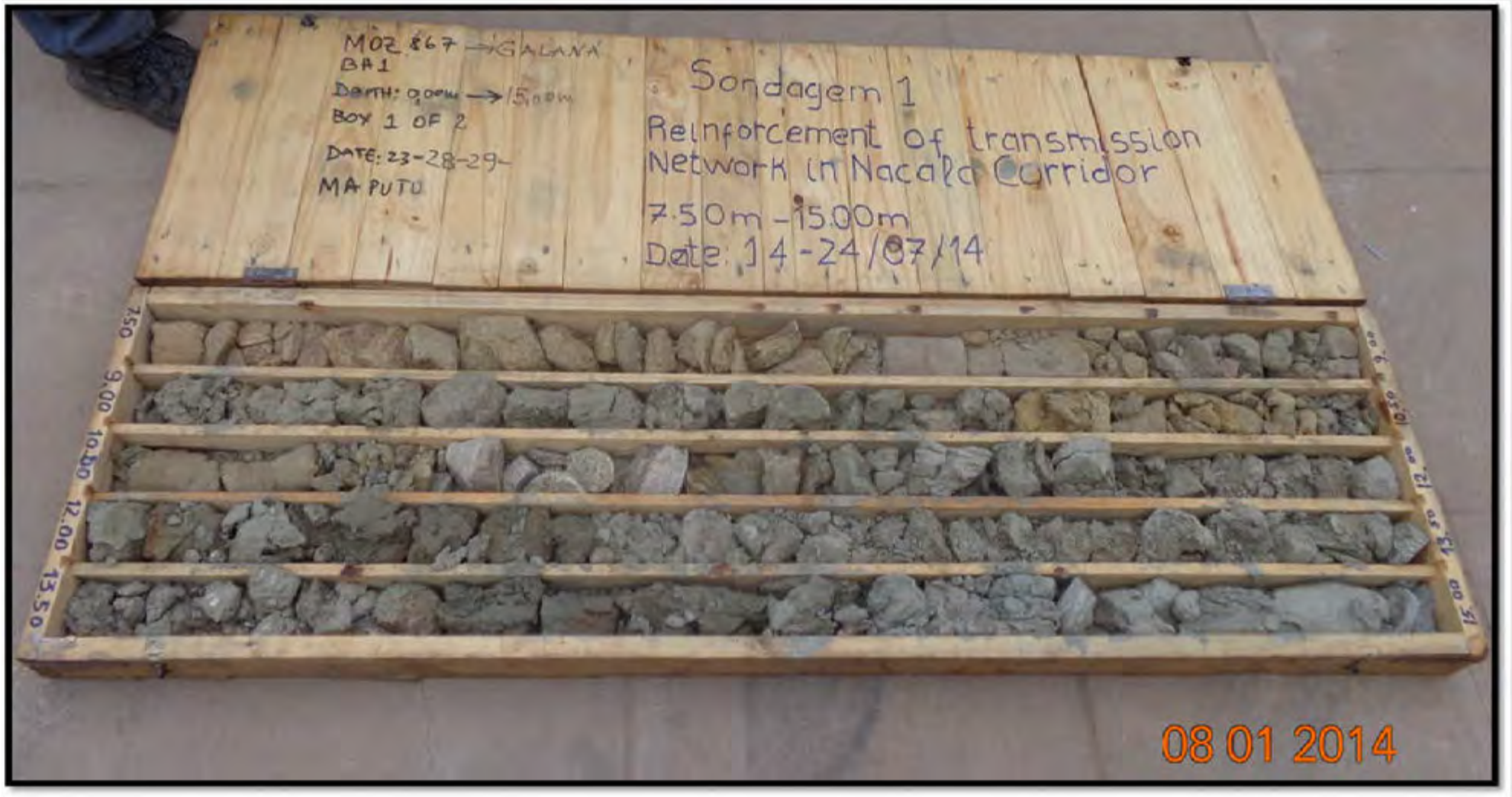


Photo 2 - Logg 1, from 7.5m to 15m depth

Borehole BH2

LOG OF BORING BH2

Boring No:	BH 02	**Sheet**	1
Project Number:	P567	**Project Name:**	GEOTECHCANICAL INVESTIGATION AND TOPOGRAPHIC SURVEY FOR PREPARATORY SURVEY OF REIFORCEMENT PLAN FOR TRANSMISSION LINE AT NACALA CORRIDOR IN MOZAMBIQUE
Total depth:	15 m	**Location:**	Namialo - Nampula
Drill contractor:		**Sampling Method:**	Rotary Drilling
Date Started:	25-Jul-14		
Date Completed:	27-Jul-14	**Driller:**	Manuel Cardoso
Client:	ORICONSUL	**Drill Rig Type:**	Unimog, V100 – Bomag

Depth (m)	Water level	Samples: Type	Samples: Number	Blow counts (N) 30 cm	Graphic Log	MATERIAL DESCRIPTION	Classification Symbol	Water Content (%)	Dry Unit Weight kg/m3	REMARKS AND OTHER TESTS
0						Sandy silt dark brown color, medium to fine grain size, very loose				
1				-		Silty Sand, reddish brown color, medium to fine grain size, very loose				
		SPT disturbed	BH2-01	9		Silty sand, brown color, medium to fine grain size, loose				
2		SPT disturbed	BH2-02	14		Micaceous silty sand, conglomerates (botrioidal calcite) and saprolite, fine grain size, medium	SM	9.9		LL=NP PL=NP IP=NP
						Silt (calcite and siltstone), white color, medium to fine grain size, medium dense				
3		SPT disturbed	BH2-03	46		Micaceous silty sand, brown color, variegated, medium to fine grain size, very dense				
4		SPT disturbed	BH2-04	Refusal		Fragmented saprolite preserving gneiss structure, brown color, very dense				
5		SPT disturbed	BH2-05	54		Saprolite, yellowish brown color, with medium to fine grain size, very dense				
						Very weathered quartzite, white color, medium to coarse grain size, very dense				
6				Refusal		Micaceous silty sand, brown color, very fine grain size, very dense	SM			LL=NP PL=NP IP=NP
7		SPT disturbed	BH2-07	Refusal						
8		SPT disturbed	BH2-08	Refusal						
9		SPT disturbed	BH2-09	Refusal		Silty sand, light brown color, with large insurgency of quartz crystals, very dense	SM	13.9		
10		SPT disturbed	BH2-10	Refusal		Fragmented saprolite (weathered gneiss), brown color, medium to fine grain size, very dense				
						Clay and variegated silty sand (loam), brown color, hard				
11		SPT disturbed	BH2-11	Refusal		Silty sand, brown to purple color, with medium to fine grain size, very dense	SC-SM	15.1		LL=23.5 PL=18.2 IP=5.3
						Varigated silty sand (loam) with clay, brown to purple color, hard				
12		SPT disturbed		Refusal		Fragmented saprolite (weathered gneiss), brown color, with medium to fine grain size, very dense				
13				Refusal		Fragmented saprolite (weathered gneiss), brown color, medium to fine grain size, very dense				
14				Refusal						
15										

Co-ordinates		Borehole diameter: 114 mm	Checked by: Sidney de Abreu
Lat. (°)	(-)14.944683°		Logged by: Ivan Manhiça
Long. (°)	39.960133°	Ground Water Observation: Existente of parcialy saturated layer between the depth 3,5m and 8,0 m	
Ground Elevation:	173.5m		

Photo 3 - Logg 2, from 0.0m to 7.5m depth

Photo 4 Logg 2, from 7.5m to 15.0m depth

Borehole BH3

LOG OF BORING BH3

Boring No:	BH 03	**Sheet**	1
Project Number:	P567	**Project Name:**	GEOTECHCANICAL INVESTIGATION AND TOPOGRAPHIC SURVEY FOR PREPARATORY SURVEY OF REIFORCEMENT PLAN FOR TRANSMISSION LINE AT NACALA CORRIDOR IN MOZAMBIQUE
Total depth:	15 m	**Location:**	Namialo - Nampula
Drill contractor:		**Sampling Method:**	Rotary Drilling
Date Started:	28-Jul-14		
Date Completed:	31-Jul-14	**Driller:**	Manuel Cardoso
Client:	ORICONSUL	**Drill Rig Type:**	Unimog, V100 – Bomag

Depth (m)	Water level	Samples Type	Samples Number	Blow counts (N) 30 cm	Graphic Log	MATERIAL DESCRIPTION	Classification Symbol	Water Content (%)	Dry Unit Weight kg/m3	REMARKS AND OTHER TESTS
0						Sandy silt (with organic material) dark brown to reddish color, medium to fine grain size, very loose				
				-		Mottled silty sand, reddish brown color, fine to medium, very lose				
1		SPT disturbed	BH3-01	11		Mottled sandy clay, brown color, fine to coarse grain size medium				
2		SPT disturbed	BH3-02	24		Mottled silty sand, white and brown banded color (calcita and siltstone), fine grain size, dense				
3		SPT disturbed	BH3-03	46			SM			LL=NP PL=NP IP=NP
4		SPT disturbed	BH3-04	79		Mottled micaceous silty sand, light gray green color, fine to medium grain size, very dense		4.36		
5		SPT disturbed	BH3-05	27		Silty clay, gray to green color, fine to medium grain size, very stiff				
6		SPT disturbed	BH3-06	Refusal		Mottled sandy clay, gray to brown color, fine grain size very dense				
7				Refusal						
8		SPT disturbed	BH3-08	Refusal		Micaceous clayey sand with evidence of gneiss (weathered) saprolite and large quartz crystals, with gray / green color, very dense				
9		SPT disturbed	BH3-09	Refusal		Mottled micaceous silty sand,Brown color, very fine to coarse grain size, very dense				
10		SPT disturbed	BH3-10	Refusal		Micaceous variegated silty sand, fine grain size, very dense	SP-SM	12.2		LL=NP PL=NP IP=NP
11				Refusal		Variegated loamy sand, Brown to gray color, fine to medium grain size, very dense Silty clay, gray color, fine grained, hard				
12		SPT disturbed	BH3-12	Refusal						
13		SPT disturbed	BH3-13	Refusal		Micaceous silty sand, gray color, fine grain size, very dense	SM	11.7		LL=NP PL=NP IP=NP
14				Refusal		Bent sandy clay, gray to green color, fine to medium grain size, hard Micaceous silty clay, gray and brown colors, fine to medium grain size, Bent silty sand, gray color, medium to fine grain size, very dense Silty clay, gray color, very fine grained, hard				
15										

Co-ordinates		Borehole diameter: 114 mm	Checked by: Sidney de Abreu
Lat. (°)	(-)14.945033°		Logged by: Ivan Manhiça
Long. (°)	39.958933°	Ground Water Observation: Existente of parcialy saturated layer between the depth 2,5m and 8.0m	
Ground Elevation:	169.1m		

Photo 5 - Logg 3, from 0.0m to 7.5m depth

Photo 6 - Logg 3, from 7.5m to 15.0m depth

APPENDIX IV

SOIL RESISTIVITY RESULTS

BH1 - Earth Resistivity Measurement Sheet

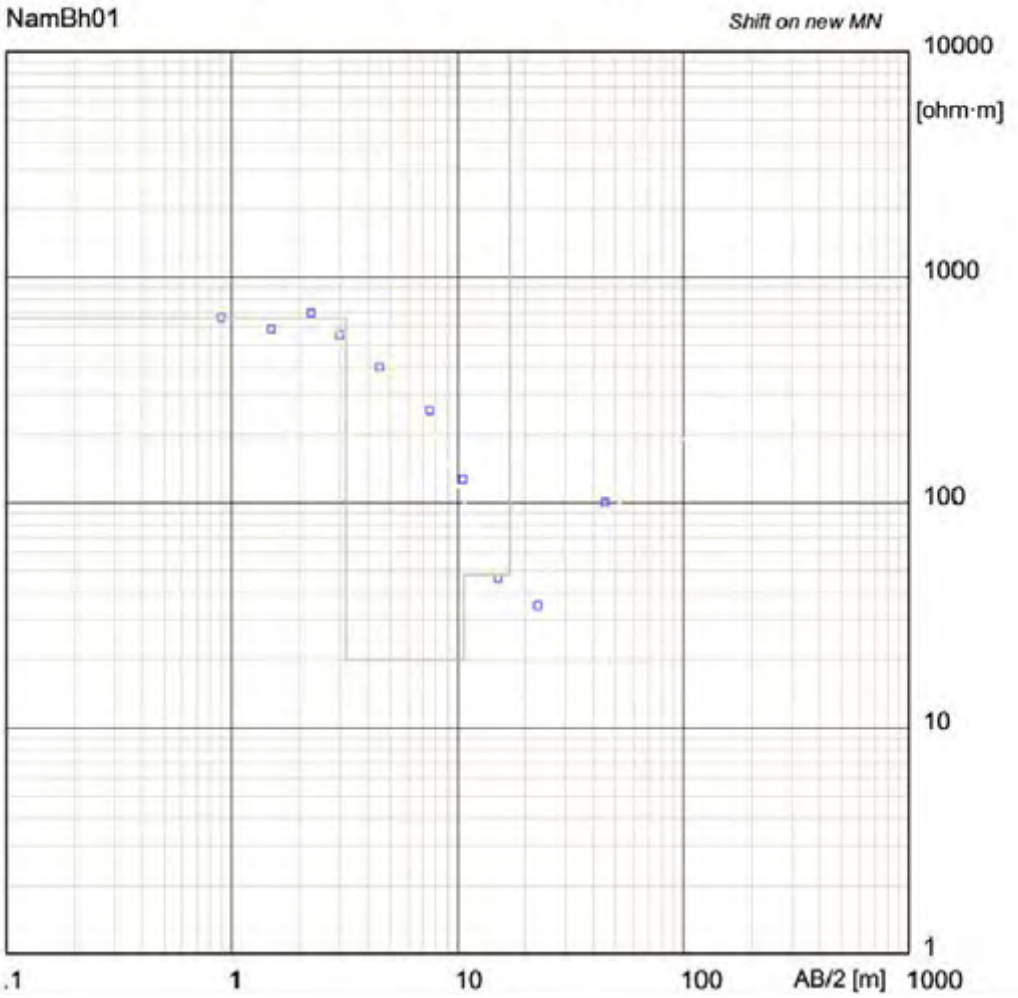
Project:	Reinforcement of Transmission Network in Nacala Corridor	**Client:**	Oriconsul	**Logged by**: Amilcar Amiacale **Revised by**: Sidney de Abreu	
Local:	Namialo-Nampula	**Data:**	12-08-2014		
Electrode Distance a[m]	**Electrode moving distance P1and P2 (1/2a)**	**Electrode moving distanceC1and C2 (1.5a)**	**2πa [m]**	**R[Ω]=V/I Actual measurement value**	**ρ[Ωm]=2πa*R**
0.6	0.3	0.9	3.77	165.2	230.0
1.0	0.5	1.5	6.28	94.0	240.0
1.5	0.75	2.25	9.42	75.8	269.6
2.0	1.0	3.0	12.57	44.3	300.3
3.0	1.5	4.5	18.85	21.3	390.2
5.0	2.5	7.5	31.42	8.2	490.1
7.0	3.5	10.5	43.98	2.9	541.0
10.0	5.0	15.0	62.8	0.7	527.8
15.0	7.5	22.5	94.2	0.4	480.0
30.0	15.0	45.0	188.5	0.5	471.3

BH2 - Earth Resistivity Measurement Sheet

Project:	Reinforcement of Transmission Network in Nacala Corridor	**Client:**	Oriconsul	**Logged by**: Amilcar Amiacale **Revised by**: Sidney de Abreu	
Local:	Namialo-Nampula	**Data:**	12-08-2014		
Electrode Distance a[m]	Electrode moving distance P1and P2 (1/2a)	Electrode moving distanceC1and C2 (1.5a)	2πa [m]	R[Ω]=V/I Actual measurement value	ρ[Ωm]=2πa*R
0.6	0.3	0.9	3.77	501.7	230.0
1.0	0.5	1.5	6.28	252.4	240.0
1.5	0.75	2.25	9.42	172.3	269.6
2.0	1.0	3.0	12.57	114.5	300.3
3.0	1.5	4.5	18.85	69.8	390.2
5.0	2.5	7.5	31.42	22.2	490.1
7.0	3.5	10.5	43.98	6.9	541.0
10.0	5.0	15.0	62.8	1.2	527.8
15.0	7.5	22.5	94.2	0.9	480.0
30.0	15.0	45.0	188.5	1.0	471.3

TECNICA - Engenheiros Consultores, Lda
Av. 25 de Setembro nº 2526, 1º Floor
Maputo- Mozambique
email: geral@tec.co.mz
www.tec.co.mz

Electrical sounding Schlumberger - NamBh01.WS3



Location X = 39.962067 Y = -14.944467 Z = 189 Azim = N-S

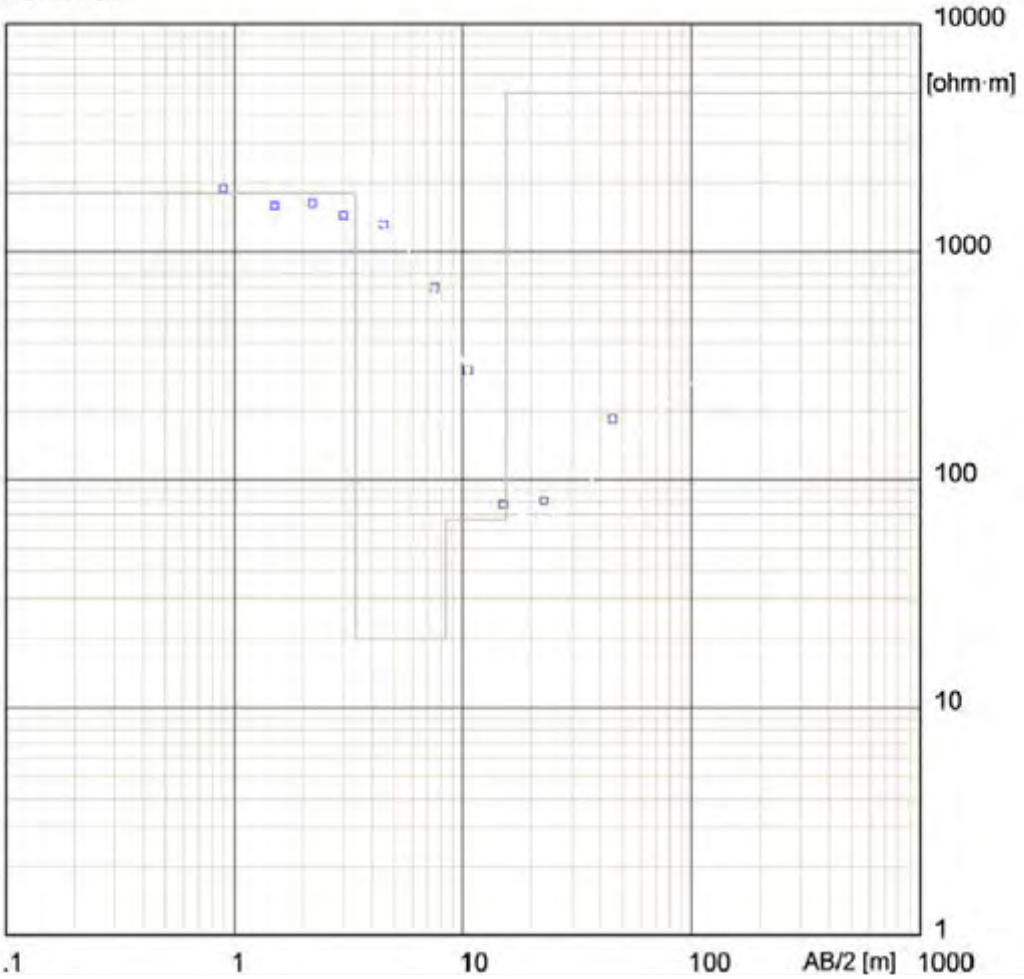
Model Resistivity	Thickness	Depth	Altitude
[ohm·m]	[m]	[m]	[m]
658	3.2		189
20	7.4	3.2	185.8
48	6.4	11	178
61358		17	172

The VES was made nearby the Borehole nº01.

W-GeoSoft / WinSev 6.3

Electrical sounding Schlumberger - NamBh02.WS3

NamBh02



Location X = 39.962067 Y = -14.944467 Z = 190 Azim = 060-240

Model Resistivity	Thickness	Depth	Altitude
[ohm·m]	[m]	[m]	[m]
1807	3.4		190
20	5	3.4	186.6
67	7	8.4	181.6
5000		15	175

The VES was made nearby the the Borehole nº02 between Bh nº 01 and Bh nº 03

W-GeoSoft / WinSev 6.3