Appendix 3-C

Ajax Project Open Pit Geotechnical Slope Design Parameters

KGHM
INTERNATIONAL

ADDENDUM

Original: **Ajax Project Open Pit Geotechnical Slope Design Parameters**

By: SRK Consulting, dated June 2014, final provided November 2014

Digital: KGH001_Ajax Geotechnical Design Report_Rev1.pdf

Addendum: Sheila Kluck (KGHM) Date: December 3, 2014

Introduction

In the open pit slope design report by SRK, select geotechnical data and symbols need correcting. Those corrections and clarifications are provided here. This information was gathered through email questions and discussions with William Gibson.

Geotechnical Corrections and Clarifications

Section	**Corrections**
Appendix E Tables E-1 to E-8	Rock unit SLD the UCS value for intact rock should have been σ_c of 91 MPa, not 99 MPa. The resulting friction angle, cohesion, and tensile strength would be reduced slightly, but not enough to effect the results or recommendations.
Table 5-3	Has the correct intact rock UCS of 91 MPa for SLD

	sc =99 [MPa] σ_{ci}	sc=91 [MPa] σ_{ci}
Fric	42.3	41.7
Cohe [MPa]	0.883	0.841
Tension [MPa]	0.236	0.217

Clarifications
For Ei, v, and density of SVHYB, there wasn't enough data so the values for SLD were used.
Data for PXPP are from the MAFV unit.
Data for MONZ and LAT are from the IMH unit
Fault strength values, as found in Section 5.5, are cohesion = 100kPa, friction angle = 26°, tensile strength = 2 kPa

Tension = tensile strength, is for rock mass.
UTS = unconfined tensile strength, is for intact rock.
All stress units are in MPa.
No residual strengths were calculated for the project

Symbol Clarifications
UCS for intact rock: sc = Sigma ci = σ_{ci}
UCS for rock mass: Sigma c = σ_c
Young's Modulus of intact rock is "E" in Table 5-3 and "Ei" in Table 5-5
Young's Modulus of rock mass is "Erm" in Table 5-5

Ajax Project Open Pit Geotechnical Slope Design Parameters

Report Prepared for

KGHM Ajax Mining Inc.

Report Prepared by

SRK Consulting (Australasia) Pty Ltd

Project Number

June 2014

Ajax Project Open Pit

Geotechnical Slope Design Parameters

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Executive Summary

Summary of principal objectives

The scope of work for this study was to produce open pit geotechnical slope design parameters to a Feasibility level of study for the final pit and five interim pits at the Ajax Project. The geotechnical evaluations were specified to include stability analysis carried out using 2D and 3D nonlinear models. The compilation and processing of previously-existing and recently-collected geotechnical information gathered from drillholes and laboratory testing was performed in order to complete the geotechnical evaluations.

Work programme

The detailed scope of work for the study was broken down into four phases, as described below:

Phase 1: Preliminary Data Review

This included a review of data required for model construction that was available at the commencement of the project (the Ajax logging database and geotechnical reports; and the pit design shells, topography, geology and faults models).

Phase 2: Rock Mass Characterisation

This incorporated the recent logging and sample testing data from the recent drilling campaign, and included:

- Collation of geotechnical data and calculation of rock mass classification values according to RMR and GSI systems.
- Identification of geotechnical domains (pit design sectors).
- Preliminary data analysis, with provision of statistical distribution of rock properties per pit design sector and rock type.
- Identification of rock mass strength properties and properties of joints for each sector and rock type. These were utilised as input for geotechnical models and stability analyses.

Phase 3: Geotechnical Analysis and Design Inputs for Interim Pits and Final Pit

This included:

- Kinematic analysis at bench scale to identify structural failure mechanisms and controls on bench/berm design.
- 2D stability analysis using deformation criteria at inter-ramp and overall slope scale to assess pit wall stability and optimise pit geometry for each of the pit stages. This was done using the FoS design criteria and/or Probability of Failure (PoF) criteria identified.
- FLAC 3D modelling of the pits to check the overall performance of the preliminary designs and adjust these to match the design criteria where necessary.

Phase 4: Reporting

Formal reporting for the project included:

- A memorandum summarising the pits slope design recommendations by the end of March.
- A complete technical report at the end of the project including: a description of all the work carried out; a list of all assumptions; an explanation of the evaluations and analyses conducted and the results thereof; all required recommendations for design and construction; and recommendations for further work.

Recommendations

Optimum slope geometries have been identified for the rock types within each of eight pit sectors identified. The slope geometry terminology is shown in Figure ES-1. The pit sectors are illustrated in Figure ES-2. Wireframe solids delineating the pit sectors have been produced by SRK to facilitate incorporating the slope design parameters into the shell designs for the final and interim pits.

In order to optimise the pit slope angles, the design recommendations vary from one part of the pit to another, changing according the changes in rock type and conditions. The variability of the rock type in space is defined by a geological model provided by KGHM. If future information indicates that these models are no longer valid, then the slope design should be reviewed accordingly.

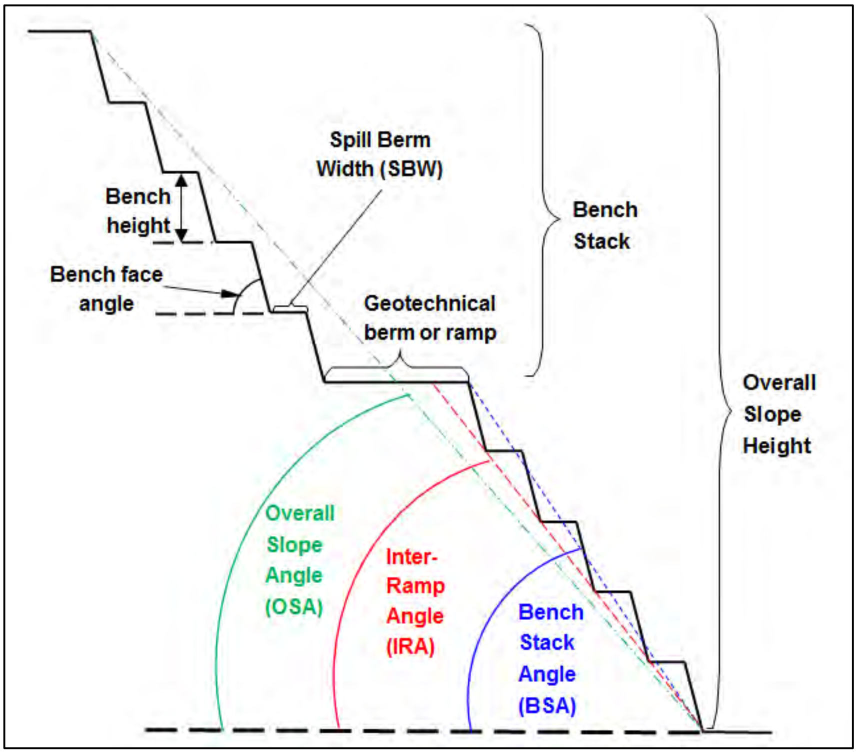

Figure ES-1: Sectional illustration of slope design geometries

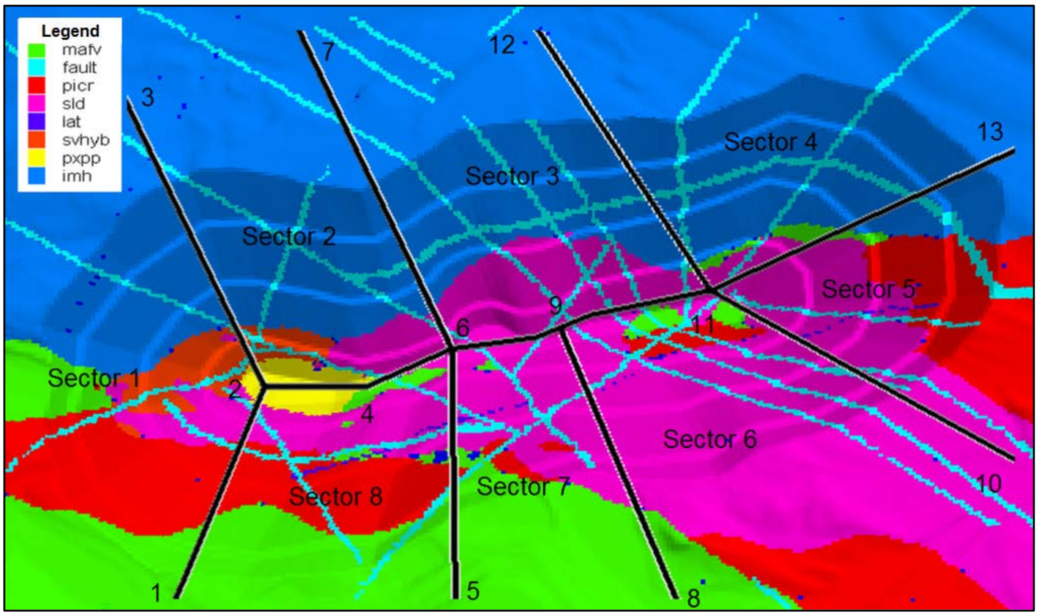

Figure ES-2: Plan view of pit sectors

Table ES-2 presents the simplified slope design recommendations, which have been selected to allow for slopes to be designed to the agreed acceptance criteria at the individual bench, inter-ramp and overall slope scale. These acceptance criteria are summarised in Table ES-1.

The bench stacks for the Ajax open pit are recommended to not exceed 150 m in height (and would therefore consist of five double benches of 30 m height each), and the geotechnical berms are recommended to be 25 m in width. In some cases the geotechnical berms must be adjusted to reduce the overall slope angle to a values less or equal the maximum value indicated in Table ES-2.

SRK has performed the design evaluations including geotechnical berms at fixed 150 m vertical intervals, the heights of which have been selected to: a) ensure that the 150 m limiting stack height is not significantly exceeded in any part of the pit, and b) to locate the geotechnical berms at practical positions within the final pit walls and walls of the various interim pit stages. The recommended heights (above mean sea level) of the geotechnical berms are as follows:

- 875 m
- 725 m
- 575 m.

The berm at 875 m will not be required through Sectors 6, 7 and 8, due to the lower height of the south wall of the pit. These heights can be changed to accommodate pit design constrains if necessary.

Using the individual bench/spill berm geometries recommended, individual bench stacks of 150 m in height will produce the bench stack angles and inter-ramp angles recommended in Table 8-1. It is important to note that for stacks of lesser height (fewer double benches) than the 150 m limiting height, the bench stack angles generated can be steeper. However the inter-ramp angle will remain constant.

The inter-ramp and overall slope angles recommended within Table ES-2 for each rock type within each sector of the pit should not be exceeded. Geotechnical berms and access ramps should be included in the design as necessary and an overall slope angle (OSA) of less than or equal to the limiting OSA value indicated in Table ES-2 should be created.

Table ES-1: Acceptance criteria for design slope stability

Slope Element	FoS criteria	PoF criteria
Bench face	1.10	The full volume of at least 95% of all failures should be retained upon the berms; and Not more than 10% of the volume of any wedge should be allowed to spill from the berm in the remaining 5% of cases.
Inter-ramp	1.20	- -
Overall Slope	1.30 (1.35 for the slopes adjacent to Jacko Lake in Sector 1)	- -

Table ES-2: Slope design parameters by pit sector and rock type

Sector	Unit	Bench Height h [m]	BFA [°]	Berm B [m]	BSA [°]	IRA [°]	Geotech Berm [m]	Maximum OSA [°]
1	IMH / PXPP – LAT	30	75	17	54.2	50.2	25	46
	SLD	30	75	18	53.2	49.0	25	
	PICR (NVP)	30	65	16	48.2	45.0	25	
	MAFV (NVV)	30	65	16	48.2	45.0	25	
2	IMH / PXPP – LAT	30	75	17	54.2	50.2	25	46
	SLD	30	75	18	53.2	49.0	25	
3	IMH	30	75	17	54.2	50.2	25	50
	SLD	30	75	18	53.2	49.0	25	
4	IMH	30	75	17	54.2	50.2	25	53
	SLD	30	75	18	53.2	49.0	25	
5	IMH	30	75	17	54.2	50.2	25	53
	SLD	30	75	17	54.2	50.2	25	
	PICR (NVP)	30	65	16	48.2	45.0	25	
6	SLD (*)	30	70 (75)	20 (17)	48.1 (54.2)	44.1 (50.2)	40 (30)	42
	PICR (NVP) (*)	30	65	16.5	47.8	44.5	40 (30)	
7-8	SLD	30	75	17	54.2	50.2	25	52
	PICR (NVP)	30	65	16	48.2	45.0	25	
	MAFV (NVV)	30	65	16	48.2	45.0	25	
	SLD / PXPP – LAT	30	75	17	54.2	50.2	25	

(*) The slope design recommended has been adjusted to produce the overall slope angle (OSA), which cannot be exceeded; this applies only for the final pit wall. The numbers in brackets are the recommendations for any interim pit walls.

The interim (6 stages) and final pit shell designs were provided by KGHM in late 2013. The various pit stages are referred to as Pit 0, Pit 1 etc. through to Pit 5 and the Final Pit It can be seen that, except for Pit 0, Pit 2 and part of Pit 1, large parts of the interim pit stages form sections of the final pit walls, therefore the recommendations given in Table ES-2 apply to these pit stages also. For the walls of Pits 0, 1 and 2 that are not part of the final wall, the recommendation given in Table ES-2 also apply, but without the restrictions recommended for the overall slope angle (because the pits are of lesser depth).

The design recommendations provided in Table ES-2 should be coded into the block model for creation of the final mine design pit shells, using the pit sector wirefame solids provided by SRK and the existing latest geology model solids of KGHM.

SRK has not identified any specific areas of the pit where pit ramps cannot be included from a geotechnical stability/risk point of view. Pit ramps will serve to further decrease the overall slope angle slightly as they will be somewhat wider than the 25 m geotechnical berms. The intent is that the slope design angles in Table ES-2 should not be exceeded; however, the pit slope angles in certain places may be less due to practical considerations (such as the inclusion of ramps).

Rock of moderate quality or better is generally encountered at shallow depth across the site, within approximately 10 m or less of the surface. Highly weathered or soil-like materials would generally constitute only a portion of the first bench mined from surface and therefore slope design within such materials has not been the focus of this study. The depth to bedrock may locally be as much as 30 m, however. Without a good understanding of the detailed properties of the soil and/or highly weathered materials, it is recommended in general that soil-like or highly weathered materials are battered back to a bench face angle of 45°, and benches within these materials are limited to a height of 15 m. It is however recommended that the validity of these design assumptions are assessed in more detail in the future to ensure the optimum design is identified.

Action points

1 It is strongly recommended that SRK be of assistance to the KGHM mining engineers in the incorporation of the geotechnical design parameters into the construction of the new design shells in order to:

- provide any clarifications if necessary;
- assist with the elimination of sections of geotechnical berms in places where the insertion of ramps have made these redundant; and
- perform a final check of the new KGHM pit shell designs for compliance to the geotechnical recommendations.

2 Before implementation of the slope design, it is very important that the assumptions made in this study concerning the groundwater levels and pit slope depressurisation achievable should be confirmed as part of the current hydrogeological study updates.

If the drainage measures will not be able to achieve a groundwater pushback of at least 125 m behind the slope face (as assumed in this report), the pit wall angles will need to be re-assessed taking into account the expected groundwater conditions.

3 There currently is not a good understanding of the detailed properties of the soil and/or highly weathered materials near surface. It may be advantageous that these materials are evaluated in more detail in the future to ensure that optimum slope design within them is identified.

Recommended activities during mining

It is considered that the slope design recommendations presented in this report provide a fairly robust but not conservative solution to slope design within the Ajax Pits. The recommendations are intended to be suitable for pit walls that will need to remain stable for long periods of time. It is therefore imperative that the integrity of the pit walls is maintained over time through rigorous monitoring and management practices.

Such practices should include (but not be limited to):

- Prevention of surface water drainage into the pit during mining operations;
- Installation of vibrating wire piezometers around the pit perimeter for monitoring of groundwater levels and pore pressures;
- Implementation of slope stability monitoring systems consisting of prisms, radar systems (if necessary) and regular inspections; and
- Ongoing assessment of rock mass conditions encountered during pit excavation and comparison with the rock mass characteristics presented in this report. If the conditions change from what is expected, the slope design should be reviewed and adjusted accordingly.

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List of Abbreviations

Abbreviation	Meaning
AST	Australian Soils Testing
BFA	Bench Face Angle
BH	Borehole
B/H	Bench Height
BSA	Bench Stack Angle
BSH	Bench Stack Height
C	Cohesion
c / c′	cohesion / effective cohesion
CTD	Central Thickened Discharge
D	disturbance factor
DTM	digital terrain model
E	Young’s modulus
FoS	Factor of Safety
GBI	Geotechnical Blockiness Index
GDM	geotechnical domain model
GIS	geographic information system
GSBW	geotechnical safety berm width
GSI	geological strength index
Hr	hydraulic radius
IRA	inter-ramp angle
IRS	intact rock strength
LOSA	limiting overall slope angle
mE	metres east
mi	material constant
mN	metres North
MRMR	Mining Rock Mass Rating
mS	metres South
Nc (Jc)	RMR joint condition parameter
Nf (Js)	RMR discontinuity density parameter
NMC	Natural Moisture Content
OSA	Overall Slope Angle
Pf	Probability of failure
PMF	Probable Maximum Flood
PSD	Particle Size Distribution
Q	Barton Q value
Q’	modified Q value
RMR	Rock Mass Rating
RQD	Rock Quality Designation
SBW	Spill Berm Width
SRF	Strength Reduction Factor
SRK	SRK Consulting (Australasia) Pty Ltd

Abbreviation	Meaning
TSF	Tailings Storage Facility
TTD	Thickened Tailings Disposal
UCS	Unconfined Compressive Strength
UTS	Unconfined Tensile Strength
VW	Vibrating Wire
γ	unit weight
°	friction angle / effective friction angle

Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (Australasia) Pty Ltd (SRK) by KGHM Ajax Mining Inc. (KGHM). The opinions in this Report are provided in response to a specific request from KGHM to do so. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this Report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.

Statement of SRK independence

Neither SRK nor any of the authors of this Report have any material present or contingent interest in the outcome of this Report, nor do they have any pecuniary or other interest that could be reasonably regarded as being capable of affecting their independence or that of SRK.

SRK has no prior association with KGHM in regard to the mineral assets that are the subject of this Report. SRK has no beneficial interest in the outcome of the technical assessment being capable of affecting its independence.

SRK's fee for completing this Report is based on its normal professional daily rates plus reimbursement of incidental expenses. The payment of that professional fee is not contingent upon the outcome of the Report.

Consents

SRK consents to this Report being included, in full, in the KGHM prospectus, in the form and context in which the technical assessment is provided, and not for any other purpose.

SRK provides this consent on the basis that the technical assessments expressed in the Summary and in the individual sections of this Report are considered with, and not independently of, the information set out in the complete Report and the Cover Letter.

1 Introduction

Julian Watson, Senior Manager - Geotechnical Engineering & Hydrogeology at KGHM International Ltd (KGHM), approached SRK Consulting (Australasia) Pty Ltd (SRK) in September 2013 to conduct a study to provide updated geotechnical design inputs at Feasibility Study level for the Ajax Project open pit near Kamloops in British Columbia, Canada. The project is a joint venture by KGHM and Abacus Mining and Exploration Corp.

Additional geotechnical drilling investigations designed by KGHM subsequently commenced at the site in late 2013, and SRK began the geotechnical study in December 2013, with the aim of providing geotechnical design inputs for the open pit slopes by the end of March, 2014.

2 Background and Brief

BGC Engineering Inc. (BGC) completed a study in 2009 to provide slope design criteria for the proposed open pit at preliminary economic assessment level (detailed in the BGC report: "Abacus Mining and Exploration Corp. Ajax Preliminary Economic Assessment Open Pit Slope Design", document no. AJAX09-001, April 30, 2009). This was followed-up in 2011 with a Feasibility Study, as detailed in the BGC report: "Abacus Mining & Exploration Corporation, Ajax Project Feasibility Study, Open Pit Geotechnical and Hydrogeological Assessments, Final", document no. 0712-003-R03-2011, November 10, 2011.

The geotechnical information contained in these BGC reports and the Ajax logging database, as well as that data obtained from the additional geotechnical drilling campaign completed in early 2014, has been used by SRK in the current study (described in this report). The purpose of this study is to perform an updated geotechnical assessment in order to identify the most suitable design inputs for the various pit slope elements (shown in Figure 3-1 in Section 3.2). The study was conducted in accordance with recent industry-accepted guidelines (as set out by Read and Stacy, 2009), and included detailed 3D numerical modelling for evaluation of slope performance.

3 Programme Objectives and Scope of Work

3.1 Programme objectives

The scope of work was to produce open pit geotechnical slope design parameters to a Feasibility level of study (as defined in Table 3-1) for the final pit and five interim pits. The geotechnical evaluations were specified to include stability analysis carried out using 3D nonlinear models (FLAC 3D software). It was suggested by SRK that using a combination of 2D and 3D models would enhance the efficiency of the stability analysis, and this was agreed upon in discussion with KGHM.

As part of the original proposal submission, SRK performed a review of the geotechnical drilling investigation campaign designed by KGHM for the purpose of providing the additional data required to address gaps in the existing data for an updated Feasibility level study. Following this review, SRK recommended extending the length of one drillhole and including the two holes in the additional geotechnical drilling proposed by KGHM. The recommended revised design for the drillholes is presented in Table 3-2. It was also confirmed by SRK that the core from the recommended drillholes should be oriented and logged geotechnically and structurally, with samples to be taken for laboratory testing (UCS, UTS and triaxial strength testing, and direct shear testing of joints).

Table 3-1: Definition of study levels (after Read and Stacey, 2009)

Project Stage					
Project Level Status	Conceptual	Pre-feasibility	Feasibility	Design & Construction	Operations
Geotechnical Level Status	Level 1	Level 2	Level 3	Level 4	Level 5
Geological Model	Regional literature; advance exploration mapping and core logging; database established; initial country rock model	Mine-scale outcrop mapping and core logging, enhancement of geological database: initial 3D geological model	Infill drilling and mapping, further enhancement of geological database and 3D model	Target drilling and mapping; refinement of geological database and 3D model	Ongoing pit mapping and drilling; further refinement of geological database and 3D model
Structural Model (Major Features)	Aerial photos and initial ground proofing	Mine-scale outcrop mapping: targeted orientated drilling; initial structural model	Trench mapping; infill orientated drilling; 3D structural model	Refine interpretation of 3D structural model	Structural mapping on all pit benches; further refinement of 3D model
Structural Model (Fabric)	Regional outcrop mapping	Mine-scale outcrop mapping: targeted orientated drilling; database established; initial stereographic assessment of fabric data; initial structural domains established	Infill trench mapping ad orientated drilling; enhancement of database; advanced stenographic assessment of fabric data; confirmation of structural domains	Refined interpretation of fabric data and structural domains	Structure mapping on all pit benches; further refinement of fabric data and structural domains
Hydrological Models	Regional groundwater survey	Mine-scale airlift, pumping and packer testing to establish initial hydrological parameters; initial hydrogeological model database and model established	Targeted pumping and airlift testing; piezometer installation; enhancement of hydrogeological database and 3D model; initial assessment of depressurisation and dewatering requirements	Installation of piezometers and dewatering wells; refinement of hydrogeological database; 3D model. Depressurisation and dewatering requirements	Ongoing management of piezometer and dewatering well network; continues refinement of hydrogeological database and 3D model
Intact Rock Strength	Literature values supplemented by index tests on core from geological drilling	Index and laboratory testing in samples selected from targeted mine-scale drilling; database established' initial assessment of lithological domains	Targeted drilling and detailed sampling and laboratory testing; enhancement of database; detailed assessment and establishments of geotechnical units for 3D geotechnical model	Infill drilling, sampling and laboratory testing; refinement of database and 3D geotechnical model	Ongoing maintenance of database and 3D geotechnical model
Strength of Structural Defects	Literature values supplemented by index tests on core from geological drilling	Laboratory direct shear tests of saw cut and defect samples selected from targeted mine-scale drill holes and outcrops; database established; assessment of defect strength within initial structural domains	Targeted sampling and laboratory testing; enhancement of database; detailed assessment and establishment of defect strengths within structural domains	Selected sampling and laboratory testing and refinement of database	Ongoing maintenance of database
Geotechnical Characterisation	Pertinent regional information; geotechnical assessment of advanced exploration data	Assessment and compilation of initial mine-scale geotechnical data; preparation of initial geotechnical database and 3D model	Ongoing assessment and compilation of all new mine-scale geotechnical data; enhancement of geotechnical database and 3D model	Refinement of geotechnical database and 3D model	Ongoing maintenance of geotechnical database and 3D model

Table 3-2: Drillholes Proposed by KGHM and Recommended by SRK

Target	Status	BHID	Dip	Azi	mN	mE	mRL	Depth [m]
North Wall	Designed	GT-001	-65	350	5610111	684390	920	200(*)
	Designed	GT-002	-65	000	5610110	684840	920	450
South Wall	Designed	GT-003	-65	210	5609425	683720	920	450
	Designed	GT-004	-65	180	5609525	684095	920	450
	Designed	GT-005	-65	160	5609505	684710	920	450
East end Wall	Designed	GT-006	-65	025	5610220	685250	920	400
	Designed	GT-007	-65	135	5609950	685300	920	450
	Recommended	GT-008	-65	350	5610314	685046	942	400
		GT-009	-65	10	5609987	683809	943	400

(*) recommended increase depth to 450 m

3.2 Design criteria

The acceptance criteria used in this project for pit slope design are based on industry standards (Read, 2009) and SRK experience in open pit slope design. The stability analyses carried out were largely deterministic; presenting a Factor of Safety (FoS). However, at bench scale, both deterministic and probabilistic analyses were carried out. The latter presents a Probability of Failure (PoF). The FoS and PoF acceptance criteria for pit slope stability adopted for this study are presented in Table 3-3. The definition of the slope geometrical elements is shown in Figure 3-1

The pit slope design aims to avoid the different scale failures shown in Figure 3-2 in some sectors the controlling criteria could be the inter-ramp angle and for those cases the FoS for overall slope will be larger than the values indicated in Table 3-3 and vice versa for other sectors.

Table 3-3: Acceptance criteria for design slope stability

Slope Element	FoS criteria	PoF criteria
Bench face	1.10	The full volume of at least 95% of all failures should be retained upon the berms; and Not more than 10% of the volume of any wedge should be allowed to spill from the berm in the remaining 5% of cases.
Inter-ramp recommended (*) Inter-ramp value used	1.20 – 1.35 1.20	- -
Overall recommended(*) Overall value used	1.30 – 1.50 1.30**	- -

* Read (2009)

** A value of 1.35 is used for the slopes adjacent to Jacko Lake.

As can be seen in the table, the values of FoS adopted as the criteria for the analyses are the minimum values recommended in the literature. The reasons for this approach were to avoid an overly-conservative approach, and also to account for the apparent over-estimation in the number of joints in the historical logging data (which may have resulted in unrealistically low rock mass classification values, as described in Section 5.2).

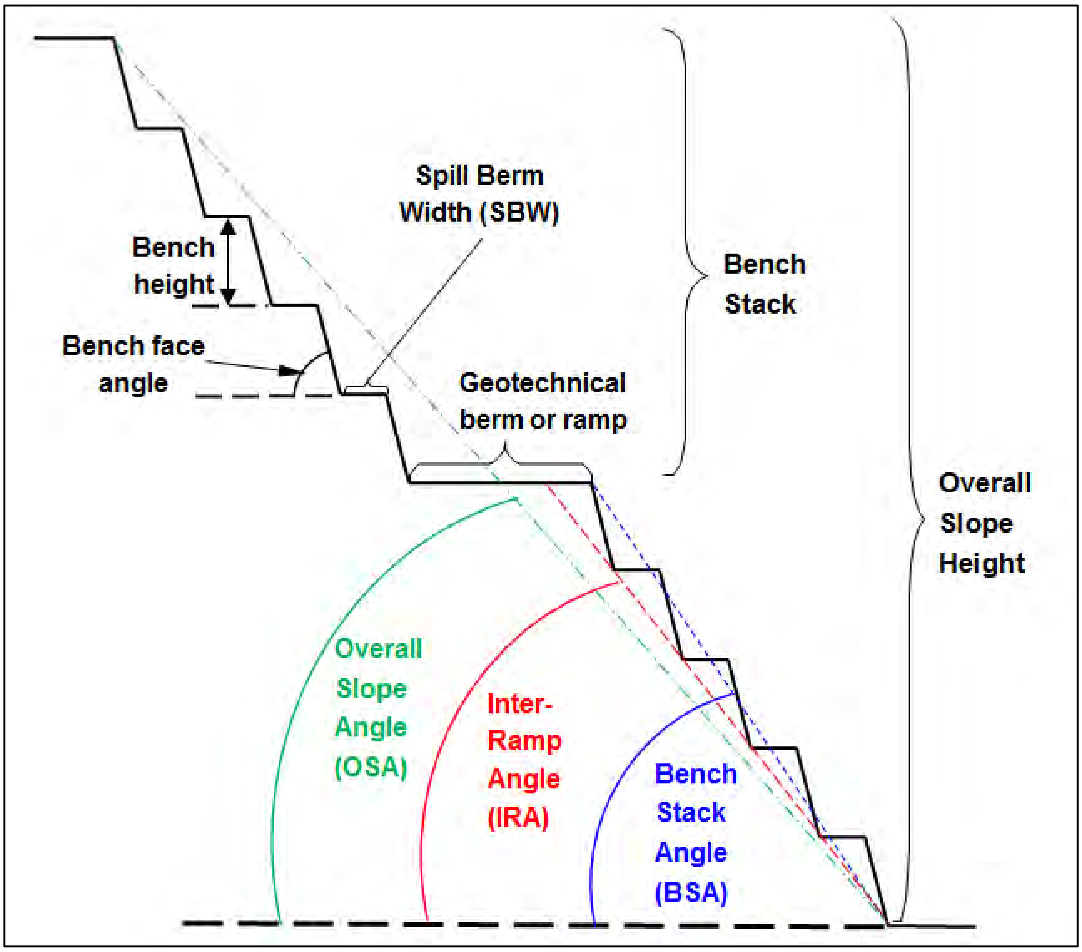

Figure 3-1: Pit slope geometrical elements

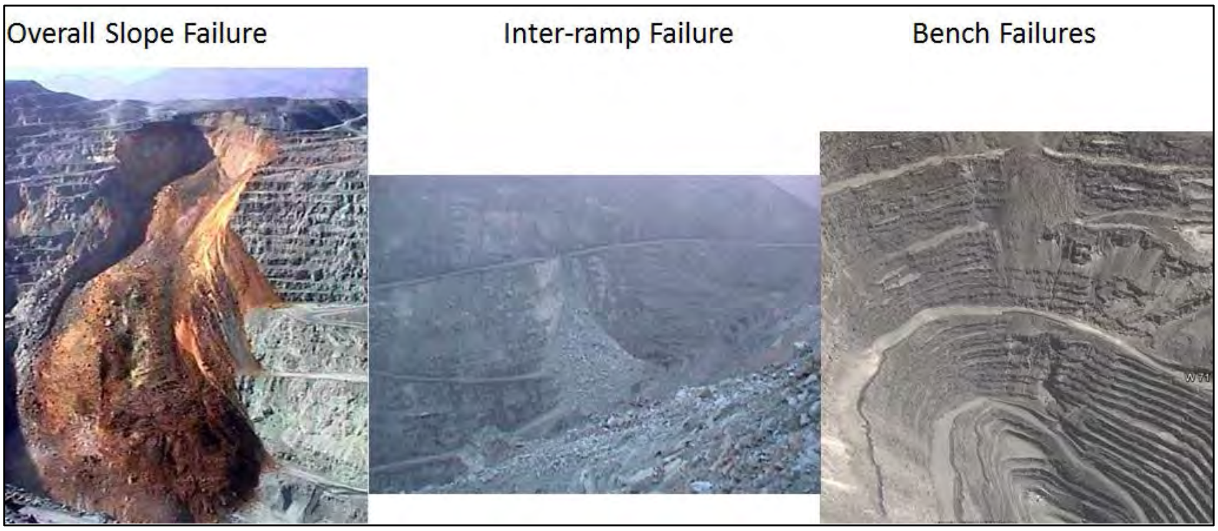

Figure 3-2: Slope failure at different scale

3.3 Scope of work

The detailed scope of work for the study was broken down into four phases, as described below:

Phase 1: Preliminary Data Review

This included a review of data required for model construction that was available at the commencement of the project (the Ajax logging database and geotechnical reports; and the pit design shells, topography, geology and faults models).

Phase 2: Rock Mass Characterisation

This incorporated the recent logging and sample testing data from the recent drilling campaign, and included:

- Collation of geotechnical data and calculation of rock mass classification values according to RMR_B (Bieniawski, 1989), RMR_L (Laubscher, 1990), and GSI (Hoek, 2002).
- Identification of geotechnical domains (pit design sectors).
- Preliminary data analysis, with provision of statistical distribution of rock properties per pit design sector and rock type.
- Identification of rock mass strength properties and properties of joints for each sector and rock type. These were utilised as input for geotechnical models and stability analyses.

Phase 3: Geotechnical Analysis and Design Inputs for Interim Pits and Final Pit

This included:

- Kinematic analysis at bench scale (30 m height) to identify structural failure mechanisms and controls on bench/berm design.
- 2D stability analysis using deformation criteria at inter-ramp and overall slope scale to assess pit wall stability and optimise pit geometry for each of the pit stages. This was done using the FoS design criteria and/or Probability of Failure (PoF) criteria identified in Section 3.2.
- FLAC 3D modelling of the pits to check the overall performance of the preliminary designs and adjust these to match the design criteria where necessary.

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Formal reporting for the project included:

- A memorandum summarising the pits slope design recommendations by the end of March 2014.
- A complete technical report at the end of the project including: a description of all the work carried out; a list of all assumptions; an explanation of the evaluations and analyses conducted and the results thereof; all required recommendations for design and construction; and recommendations for further work.
- Peer review of the geotechnical evaluations and reporting.

3.4 Work programme

The SRK project work was carried out from December 2013 to mid-April 2014 as follows:

- Phase 1 – Data Review: December 2013 and January 2014
- Phase 2 – Rock Mass Characterisation: January and February 2014
- Phase 3 – Geotechnical Analysis: February and March 2014
- Phase 4 – Reporting: March and April 2014.

The additional on-site geotechnical drilling investigations conducted by KGHM were completed in January 2014, with all the logging results available by the end of that month. The laboratory testing was carried out at Queen's University in Ontario in January and February 2014, with the full suite of test results available by the end of February.

3.5 Project team

The SRK project team included the consultants listed in Table 3-4.

Table 3-4: Project team

Consultant	Level	Project role
William Gibson	Principal Consultant	Project direction, design evaluations, reporting
Daniel Prado	Senior Consultant	Kinematic analyses and 2D numerical stability analyses
Jaya Mylvaganam	Senior Consultant	3D numerical stability analyses, design evaluations
Ian de Bruyn	Principal Consultant	Peer review, geotechnical domaining, reporting
Diane Walker	Principal Consultant	Rock mass characterisation
Ben Ogden	Senior Consultant	Structural characterisation and kinematic failure analysis
Alice Jack	Senior Consultant	Data collation and rock mass characterisation

4 General Site Information

4.1 Geological information

4.1.1 Rock types

The geological model was provided by KGHM to SRK in a wireframe format (as wireframe solids). The main lithological units (rock types) in the immediate pit vicinity are summarised in Table 4-1.

Table 4-1: Summary of major rock types

Unit	Rock Type Description	Wireframe Code	Rock Type Code(s)
Nicola Group Volcanics	Mafic volcanics and volcaniclastics	MAFV	NVV
Picrite	Serpentinised picritic basalts	PICR	NVP
Sugar Loaf Diorite	Diorite	SLD	SLD
Iron Mask Hybrid	Mixed volcanics and diorite (variable)	IMH	IMH

Other minor rock types for which wireframe solids were provided include PPXP, SVHYB, LAT and MONZO_ISO.

The distribution of rock types within the final pit walls is shown in Figure 6-1 in Section 6. The north pit wall will consist mainly of IMH, whilst the south pit wall will consist mainly of SLD and NVP.

No weathering interpretation surfaces were provided by KGHM. Review of the bedrock depths provided as part of the geological/geotechnical database indicates that rock of moderate quality or better is generally encountered at shallow depth across the site, within approximately 10 m or less of the surface. Highly weathered or soil like materials would therefore constitute only a portion of the first bench mined from surface. The depth to bedrock may locally be as much as 30 m, however.

4.1.2 Structural Information

Major faults

The major structural model was provided by KGHM, and consists of wireframe surface interpretations of major fault (as illustrated in Figure 4-1). Most of the faults are sub-vertical, and the few low-angle faults dip into the pit walls. Both conditions are favourable for pit wall stability, although it is possible that major structures can locally form boundaries of and thus potentially contribute to large scale rock mass instability mechanisms.

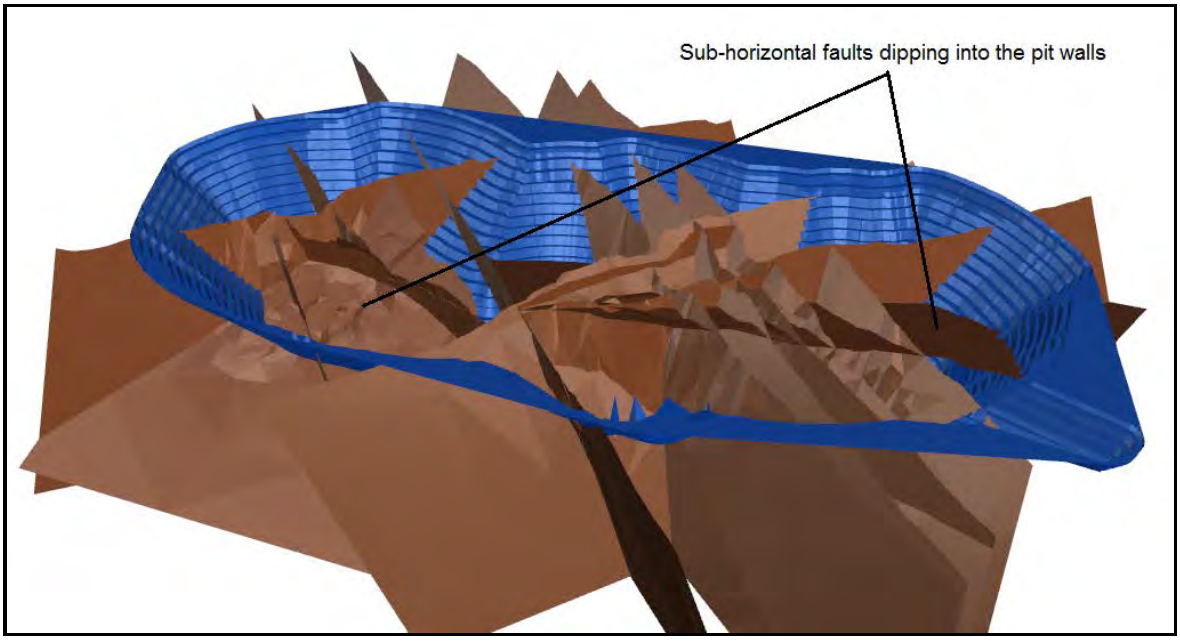

Figure 4-1: Isometric view from the south of the KGHM wireframe fault model shown relative to the final pit shell

Rock mass structural fabric

The structural data obtained from core logging, ATV surveys and mapping during previous investigations campaigns has been complemented with additional logging data collected during the recent drilling campaign. A detailed structural characterisation by pit sector and rock type has been included in Appendix B.

4.2 Hydrogeology

A revised hydrogeological study is currently being carried out, but was not yet available for input into this geotechnical study. The data provided by the BGC (2009) study indicates that the groundwater level is generally located 100 m below surface. The presence of Jacko Lake presumably modifies the water level to the west of the pit, increasing its elevation to close to the surface immediately adjacent to the lake. Assumptions concerning dewatering / depressurisation in the immediate vicinity of the pit walls is discussed in Section7.1.

4.3 Seismicity

The seismicity of a location can be defined by the Peak Ground Acceleration (PGA) likely to happen within a defined period of time. It is common to adopt the PGA with a 10% of probability of exceedance in 50 years.

The Government of Canada has a web page (www.earthquakescanada.nrcan.gc.ca) that provides the PGA for a given site. Using the coordinates of the site (N50° 36' 36"; W120° 24' 00"), a PGA=0.072g has been identified as characteristic for the site.

5 Geotechnical Characterisation

Geotechnical core logging was obtained from two sources:

- Historical data, collected and used by BCG for the preliminary geotechnical assessment (holes drilled between ~2006 and 2011); and
- Nine recently-drilled geotechnical holes (drilled in 2013), logged according to KGHM protocol.

Both sets of geotechnical holes were logged per core run, and the drill runs were not subdivided further to account for different geotechnical characteristics within a run.

Before the data from the two sources were combined into one data set, a comparison was undertaken to assess differences or similarities between the data sets.

5.1 Comparison of logging – fracture frequency

The BCG logging includes a count of discontinuities and mechanical breaks. The recent logging includes a count of “Total Fractures”.

Discontinuities/ fractures refer to natural, open, geological structure (banding, veins, faults, joints etc.). Mechanical breaks include recent breaks formed during handling of the core (for example driller’s breaks to release the core from the core catcher or to fit the core into core trays). A code of “99” is used to describe an interval of totally fragmented rock. A fracture frequency of “0” implies there are no natural discontinuities in the core run (i.e. sound, intact core, although mechanical breaks are more often than not still present).

Some rock types are more prone to breakage than others, such as weak rock, rock with strong fabric; or rock with reactive minerals (e.g. smectite clays, serpentine). It is the job of the person doing the geotechnical logging to examine each and every break to decide if the break is a natural, open discontinuity, a recent break along a weak parting plane or a mechanical break caused during the drilling or core handling process. For geotechnical assessment, only the first of these should be considered in rock mass rating calculation.

Fracture per interval was converted to fracture per metre for comparison across all intervals. Data from the historical and recent data sets is plotted in Figure 5-1.

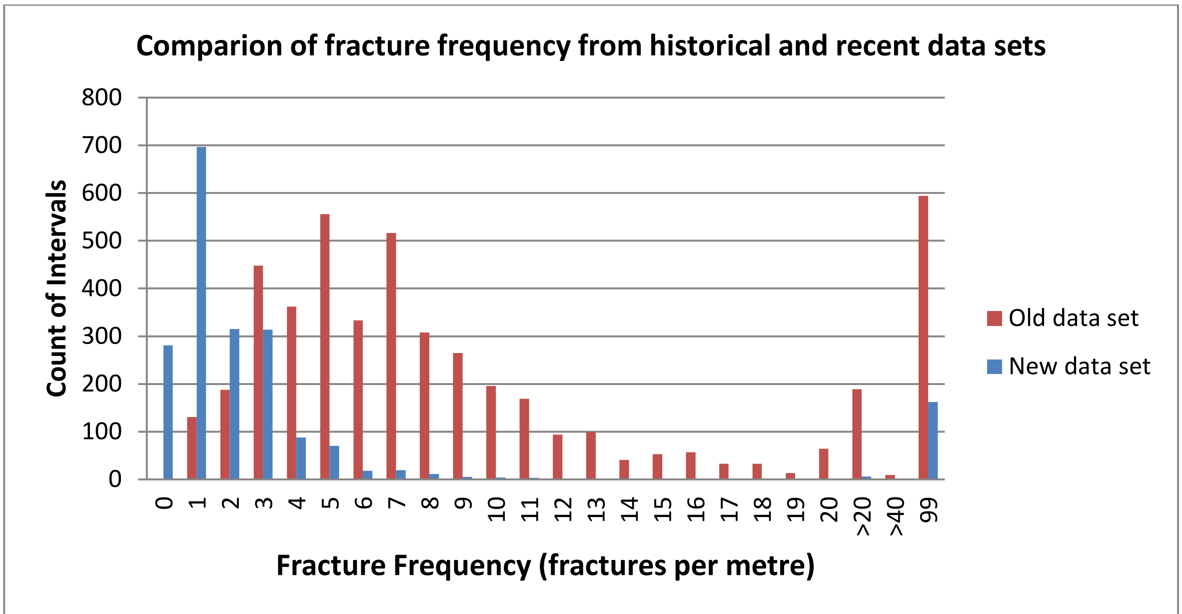

Figure 5-1: Comparison of fracture frequency from historical and recent data sets

This distribution shows that there is clearly a difference in the fracture frequency of the two data sets. In the recent data set, there are commonly between zero and three fractures per metre present. In the historical data sets, there are commonly between three and seven fractures per metre present.

Three drillholes were selected for the purposes of further comparison of the historical and recent data fracture frequency counts. This comparison is presented in Appendix D. Core photographs from the three drillholes and the recent and historical logging have been compared. In the historical logging, it appears that every structure has been counted (except obvious handling/ mechanical breaks), whereas only selected (natural) structures have been counted in the recent logging.

It must be noted that this observation is based on comparison of core photographs and logging data only, not on physical examination of the core. SRK cannot dismiss the previous logging, instead it has been combined with the recent information.

5.2 Comparison of joint condition and RMR (Bieniawski 1989)

Rock mass characterisation was made using the Bieniawski (1989) and Laubscher (1990) RMR rock mass classification systems (RMR_{B89} and RMR_L respectively). The parameters Nf and Nc (Gibson, 2006) have been used to characterise the fracture frequency (Nf) and joint condition (Nc) for each rock type.

Figure 5-2 shows the values calculated for each rock type, including the 25, 50 and 75 percentile values. Detailed histograms of RMR_{B89}, Nf, Nc and RQD for each rock type are included in Appendix E.

As mentioned in Section 5.1, it seems the historical logging has identified more joints than the recent logging. This can be observed in lower values of Nf (more joints) for each rock type in the historical logging when compared with the recent logging. No major difference is observed when joint condition (Nc) is compared.

The differences in logging of joint frequency in the historical and recent data are observed again in the calculated RMR values. The recent logging gives higher values of RMR for the main rock types when compared with the historical logging. This is illustrated in Figure 5-2.

It was decided to combine the two sets of data considering the fact that the historical logging presents the majority of data and because it was not possible to identify a systematic error that would then allow for easy and confident adjustment of the historical data set.

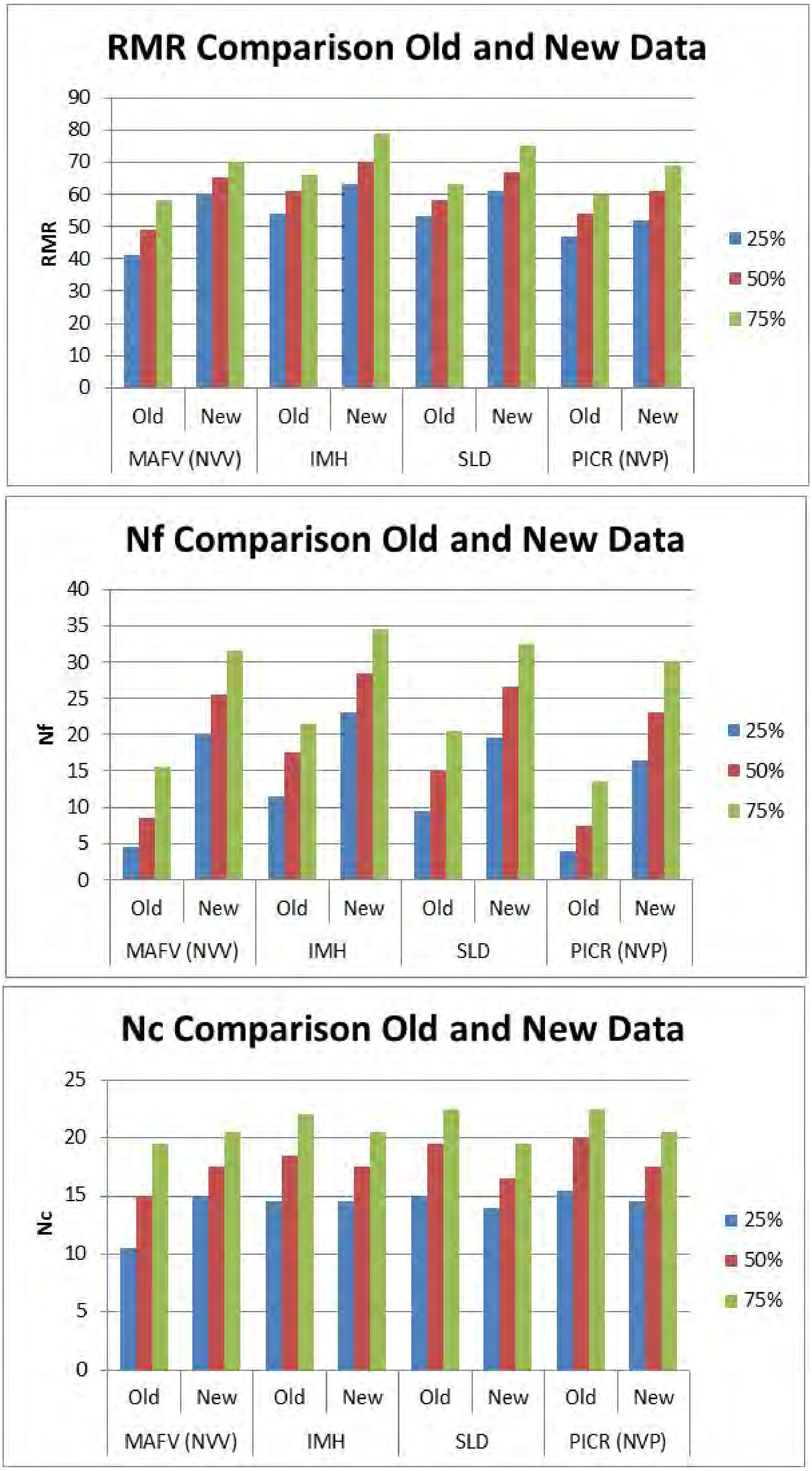

Figure 5-2: Comparison RMR, Nf and Nc parameters for historical and recent data

5.3 Comparison of field estimate strength (FES) and UCS

The assessment of the Unconfined Compressive Strength (UCS) was challenging in this project. Some rock types show a large variability in UCS, especially PICR (NVP). A bias towards stronger samples can occur during sampling, as weaker rock cannot easily be sampled. This may have accentuated the apparent large variability for intact strength for the PICR. A comparison of the field estimated strength (FES), the laboratory tested UCS, and the point load strength testing (PLT) data is shown in the rock strength column of the geotechnical drillhole logs provided in Appendix A. An example of this is shown in , using a section of the log (from 110 m to 350 m depth) for drillhole KAX13-106. A summary of the average strength for each of the major rock types obtained from each of the strength assessment methods is provided in Table 5-1. The full set of laboratory testing results is included in Appendix C.

It can be observed that the laboratory test results for PICR and MAFV (NVV) are higher than the FES. However the FES and PLT strength values present large volumes of data that is more consistently comparable in magnitude. It can be seen in the example in that the UCS samples have been taken from core that is indicated as relatively strong from the logging and PLT data. Therefore, the UCS values for PICR and MAFV used in the stability models were adjusted to consider the FES and PLT data because it was not considered appropriate to utilise the more limited laboratory testing data set only, which may present sampling bias and which may not capture the variability of the rock strength in these materials. The comments from the KGHM geotechnical logging personnel and the SRK staff member that visited site further confirm that there is large variability in the strength of the MAFV and PICR, with locally very poor, weak material.

Table 5-1: Comparison of UCS, PLT and FES results

Lithology	Laboratory Testing		Point Load Testing		Field Estimate Strength	
	Ave. UCS (MPa)	No. of tests	Ave. Calculated Strength (MPa)	No. of tests	Ave. Estimated Strength (MPa)	Metres logged
IMH	84	15	76	172	65	3615
SLD	91	13	71	57	49	3659
MAFV (NVV)	181	9	52	19	38	398
PICR (NVP)	106	6	44	74	56	3438

The average ratio between laboratory test results and PLT for IMH and SLD is 1.19. Using this factor, the UCS for MAFV and PICR was calculated from PLT test results, and values of 64MPa and 54MPa respectively were used for the stability analyses.

The procedure of using PLT test results is explained in Figure 5-4

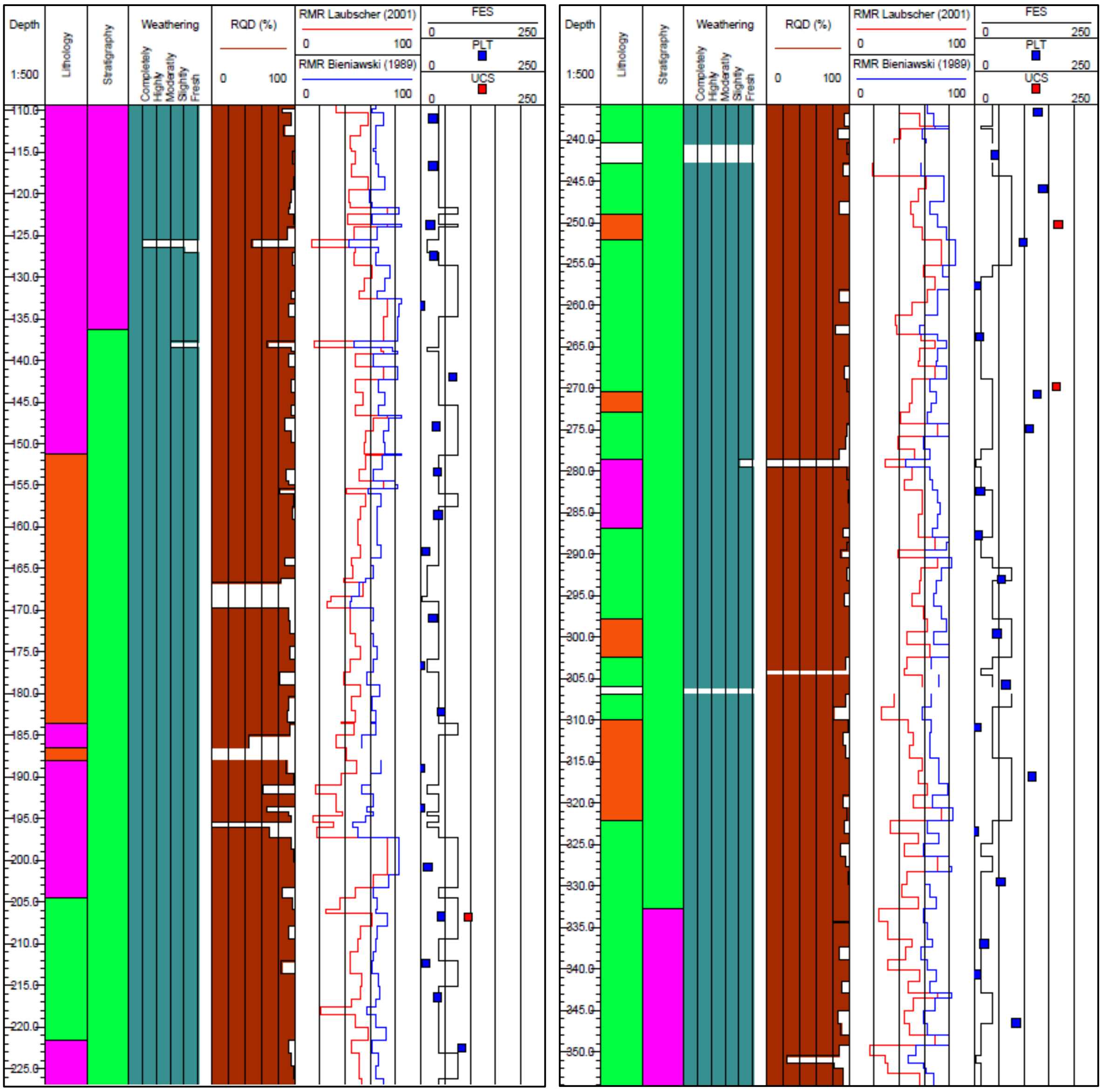

Figure 5-3: A section of the log for drillhole KAX13-106 illustrating logged FES, PLT and UCS for MAFV and PICR materials

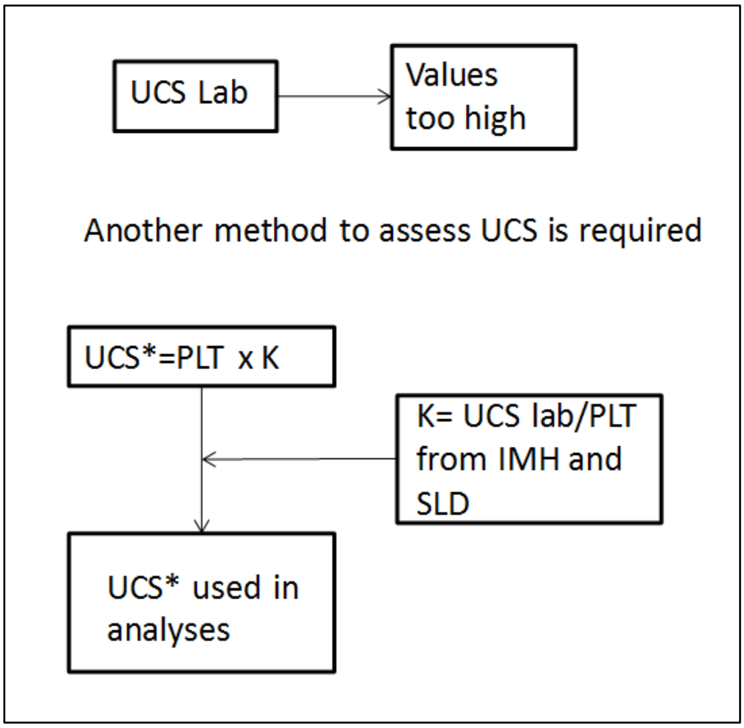

Figure 5-4: Procedure follow to assess UCS for MAFV and PICR using PLT results

5.4 Joint strength

The joint shear strength was assessed using the results from the direct shear tests (DSTs) conducted by Queen's University on samples taken during the recent drilling investigations, as well as using the previously-existing data reported in Appendix F of the BGC report: "Abacus Mining & Exploration Corporation, Ajax Project Feasibility Study, Open Pit Geotechnical and Hydrogeological Assessments, Final".

Based on the results of the multistage DSTs, the peak and the residual strength values were analysed and compared, considering normal stresses that are representative for a bench-scale assessment. A large part of the tests were performed at stresses that are considered inappropriately high for the bench-scale, and therefore it was considered appropriate that only the first points (stages) of each test, at lower confinement, be used to define the strength in each case. It is common practice for a cohesion of zero to be assumed for joints at bench-scale, as it is likely that the cohesion of joints near to the pit face is destroyed during blasting.

The joint strength assessment is provided in Appendix F, and Table 5-2 summarises the friction angles that were selected for each of the major rock types.

Table 5-2: Joint strength for units IMH, SLD and PICR

Unit	Selected Friction Angle (°)	Approximate Range (°)
IMH	35	[30 – 40]
SLD	30	[25 – 35]
PICR	25	[20 – 30]

5.5 Geotechnical characterisation of faults

The major fault model provided by KGHM was included in the FLAC 3D model for numerical stability analyses described in Section 7.4. These faults have therefore been modelled explicitly. Figure 6-1 in Section 6.3 shows a FLAC 3D model with the faults included.

An attempt has been made to locate the faults presented in the structural model within the drillcore of the geotechnical drilling campaigns, using the available core photographs. The anticipated depth of intersection of the various faults within the drillholes is listed in Table F-2 in Appendix F. Selected core photographs showing evidence of fault characteristics are provided in Figure F-4 through Figure F-10 in this appendix.

It must be noted that not all of the modelled faults are clearly identifiable within the geotechnical drillcore, and the characteristics of the fault intersections within the core are variable. No specific sampling and testing of material from within the fault zones was conducted, partly as a result of the variability, but also because the orientations of the faults indicated that they would likely not play a major role in slope instability mechanisms. It has therefore not been possible or practical to characterise the fault properties (either individual or overall) by means of definitive testing. Considering the information that has been collected, it has been necessary to use past experience and best engineering judgement in order to attempt to provide suitable identification of the fault shear strengths. It was decided that the faults should be included in the 3D stability modelling as narrow zones rather than as discrete planes, with rock mass properties assigned according to the Mohr Coulomb constitutive model. Based on assessments of similar fault types/conditions on other sites, SRK has estimated that the appropriate strength properties for the faults should be: cohesion 100 KPa, friction 26° and tension 2 KPa.

Special attention was placed on the SLD-PICR contact. Review of the core photos indicates that this contact is open and weak. It was decided not to represent this contact as a discrete plane of weakness in the stability models as the PICR is much weaker rock than the SLD, and the weak rock will control potential slope failure in the southern walls of the pit. Detailed analysis is provided in Appendix F.

5.6 Rock mass strength

The pit rock mass has been divided into eight sectors as described in Section 6.3. The rock mass strength for each rock type in each pit sector was assessed using the method recommended by Hoek (2002); the strength is calculated based on laboratory test results and rock mass characterisation. A disturbance factor D (used to account for reduction in the rock mass strength by blasting and rebound/relaxation upon excavation) of 0.7 was assumed for the assessments. This assumes that good quality blasting is achieved, which results in modest disturbance of the rock mass.

The non-linear Hoek-Brown strength envelope was used to achieve a linear (Mohr-Coulomb) envelope for identifying a representative cohesion (c) and friction angle (ϕ) for each rock type. The maximum confinement utilised for this process was $\sigma_{3\ max}$=2 MPa.

All the information pertaining to laboratory testing results and rock mass characterisation is included in Appendix A and Appendix C.

A discussion of the information is provided in the following Sections 5.6.1 and 5.6.2.

5.6.1 Laboratory test results

There are two sources of laboratory testing results. In addition to the results of the tests carried out on the samples collected from the recent drilling program, historical testing results have been provided by KGHM as detailed in the BGC report: “Abacus Mining & Exploration Corporation, Ajax Project Feasibility Study, Open Pit Geotechnical and Hydrogeological Assessments, Final”, document no. 0712-003-R03-2011, November 10, 2011. Table C-2 in Appendix C presents a summary of both set of results, whilst the Queen’s University laboratory testing report for samples from the recent drilling programme is also included in this appendix.

Both set of results compare fairly well. The average strengths for SLD are lower in the recent set of results but still in the range of the values obtained in the previous set of results.

It is important to note that for the MAFV and PICR the UCS values obtained from laboratory testing are much higher than both the FES values and those values calculated from PLT. It is also important to note that, when compared with previous investigations on which previous design studies were based, the UCS values obtained from laboratory testing of samples from the recent drilling investigations are significantly lower with a lower standard deviation (SD) for both the MAFV and SLD and are similar for the IMH. No testing was performed on the PICR in previous investigations.

As described in Section 5.3, the values used for UCS in the rock mass strength assessment for PICR and MAFV have been adjusted to incorporate the low strength measured with the PLT and FES. Details of the adjustment can be found in Appendix C. The values used in the analysis are shown in brackets in Table 5-3.

Table 5-3: Average Values of Laboratory test Results

Rock Type	Density [t/m^3]	UCS [MPa]	UTS [MPa]	Young's Modulus E [GPa]	Poisson's Ratio ν
MAFV (NVV)	2.90	181 (64)	13.3	70	0.24
IMH	3.20	84	10.5	102	0.26
SLD	2.84	91	11.9	75	0.24
PICR (NVP)	2.86	106 (54)	13.2	22	0.15

5.6.2 Rock mass characterisation

The rock mass characterisation was undertaken using all the information collected from the historical (historical) and recent drilling investigations. Detailed graphs and statistics for the rock mass characterisation are presented in Appendix A. Table 5-4 presents a summary of the rock mass characterisation for each rock type by pit sector. This summary includes GSI classification values in addition to the RMR_{B89}, Nc and Nf values discussed in Section 5.2.

The rock mass strengths derived for each rock type by pit sector is presented in Table 5-5.

Table 5-4: Summary rock mass characterisation by pit sector and rock type

		MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Sectors	Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
1	RMR	41	47	56	55	60	66	52	55	59	43	53	59	53	55	60
	GSI	36	42	51	50	55	61	47	50	54	38	48	54	48	50	55
	Nf	4	8	15	16.5	19.5	22.5	9.3	15	19.5	3	6.5	11.5	10	14	18
	Nc	10	14.5	18.5	14	17	21	14	17	20.5	14.5	19	22.5	19	20.5	22.5
2	RMR				55	62	68							62	68	74
	GSI				50	57	63							57	63	69
	Nf				13.5	19.5	24							13	18	21.5
	Nc				14.5	17.5	21.5							19.5	21	22.5
3	RMR				62	68	78	53	59	66				56	62	67
	GSI				57	63	73	48	54	61				51	57	62
	Nf				14.5	24	30	12.5	18	22.5				7	11	14.5
	Nc				15.5	18.5	21.5	14.5	18	22				19.5	21.5	23
4	RMR				66	73	81									
	GSI				61	68	76									
	Nf				26.5	31.5	37.5									
	Nc				15	18.5	21.5									
5	RMR	62	66	71	50	57	63	59	66	73	48	56	63			
	GSI	57	61	66	45	52	58	54	61	68	43	51	58			
	Nf	18	21.5	25.5	8	13.5	19.5	17.5	23	31	6.5	15.5	22.5			
	Nc	18.5	20.5	22.5	13.5	18	21.5	15	18	21.5	13	16	19			
6	RMR							53	59	63	51	56	60			
	GSI							48	54	58	46	51	55			
	Nf							10	15.5	22	5	10.5	15.5			
	Nc							15.5	19	21.5	18.6	20.5	22.5			
7	RMR							57	63	71	44	54	61			
	GSI							52	58	66	39	49	56			
	Nf							14.5	23	30.5	6.5	13.5	22.5			
	Nc							14	17	21	12.5	15.5	18.5			
8	RMR	55	63	69				62	67	80	50	59	68			
	GSI	50	58	64				57	62	75	45	54	63			
	Nf	19	25	31				9	14	21	7	17.5	26			
	Nc	15	18	21				20.5	25.5	28	15	19	23			

Table 5-5: Rock mass strength by pit sector and rock type

Sector	MAFV (NVV)			IMH			SLD			PICR (NVP)			SYHYB		
	Fric [°]	Coh [MPa]	Ten [MPa]	Fric [°]	Coh [MPa]	Ten [MPa]	Fric [°]	Coh [MPa]	Ten [MPa]	Fric [°]	Coh [MPa]	Ten [MPa]	Fric [°]	Coh [MPa]	Ten [MPa]
All	38	0.552	0.039	44	0.916	0.223	42	0.883	0.236	32	0.506	0.118	39	0.624	0.080
1	37	0.510	0.030	43	0.811	0.170	40	0.719	0.151	31	0.472	0.098	37	0.556	0.056
2				43	0.879	0.204							43	0.847	0.179
3				46	1.155	0.350	42	0.845	0.216				41	0.685	0.104
4				47	1.514	0.549									
5	46	0.902	0.166	41	0.725	0.130	45	1.182	0.406	33	0.525	0.129			
6							42	0.845	0.216	33	0.525	0.129			
7							44	1.015	0.310	32	0.488	0.108			
8	44	0.810	0.127				45	1.248	0.444	34	0.589	0.169			

	MAFV (NVV)	IMH	SLD	PICR (NVP)	SYHYB
Density [t/m^3]	2.90	3.20	2.84	2.86	
Ei [GPa]	70	102	75	22	
ν	0.24	0.26	0.24	0.15	
GSI	45	58	55	50	
Erm [GPa]	3.52	10.32	8.12	5.36	
K [GPa]	2.26	7.17	5.21	2.55	
G [GPa]	1.42	4.10	3.27	2.33	

6 Geotechnical Evaluations for Slope Design

6.1 Slope design methodology

SRK have developed a robust design methodology that follows a combination of empirical, structural and numerical analyses for derivation of slope design parameters within rock and soil materials.

The design methodology is described in Chapters 6 and 7, and comprises the following stages:

- Identification of acceptable design criteria for the various slope elements, in terms of Factors of Safety (FoS).
- Identification of geotechnical domains or pit sectors for rock mass characterisation, analysis and design purposes.
- Definition of bench heights, often based on mining equipment specification or mine planning advice.
- Evaluation and optimisation of bench face angle and spill berm width (SBW) by analysis of the structural data collected during the field investigations.
- Selection of limiting bench stack heights and position and width of geotechnical (inter-ramp) berms based on geotechnical rock mass classification and characterisation.
- Identification of appropriate bench stack angles (BSAs) and inter-ramp angles (IRAs) for each of the main material types following structural and empirical analyses.
- Compilation of a preliminary set of geotechnical design parameters and generation of preliminary slope designs within identified geotechnical domains or pit sectors.
- Evaluation of stability of overall slope geometries using numerical analysis. Empirical data and laboratory test data are used to provide rock mass strength input parameters for development of analytical models to calculate the overall slope Factor of Safety (FoS) and/or Probability of Failure (PoF).

6.2 The use of bench stacks in pit wall design

The limiting bench stack height defines the slope height that should not be exceeded without the slope angle being broken, and is dependent on the quality of the rock mass (and sometimes the potential slope failure mechanisms). If no ramp is present to provide this break in slope, a geotechnical berm (sometimes referred to as an “inter-ramp” berm) will need to be incorporated in the design. These ramps or geotechnical berms break the slope into individual bench stacks. Geotechnical berms are significantly wider than the spill berms that separate individual benches or double benches. The advantages of including geotechnical berms are as follows:

- The geotechnical berms serve to break the slope angle, allowing for bench stacks to be created of steepness suitable for the quality of the rock mass materials, whilst reducing the overall slope angles such that the walls are stable to an acceptable factor of safety.
- The limited height of the bench stack may help to limit the size of failures that may develop within the pit walls.
- The additional width of the geotechnical berm will serve to arrest the movement of falling rocks and multiple bench-size failures that cannot be arrested by the smaller spill berms.
- The geotechnical berms allow access to the wall to inspect or install additional drainage if required.

The bench stacks for the Ajax open pit are recommended to not exceed 150 m in height (and would consist of five double benches of 30 m height each), and the geotechnical berms are recommended to be 25 m in width. However, this width could locally be increased to adjust the overall slope angle (OSA) so that it does not exceed the recommended maximum OSA for each sector recommended in this report.

The limiting bench stack height of 150 m was selected as appropriate for the open pit at Ajax in order to accommodate the variability in strength/quality of the material types that will be exposed in the pit walls. For poor or weak materials (as can be locally encountered in the MAFV and PICR) stack heights limited to 100m may be more appropriate, however for good or very good quality materials such as the SLD and IMH bench stack heights of 180 m or greater may be possible. Because the quality of materials within the pit walls is indicated to have a strong lateral (rather than vertical) variability, it is more practical to adopt a single recommendation for bench stack heights – a suitable compromise that is not overly conservative in this case. In addition, stack heights of 150 m present a practical configuration when taking into account the placement of geotechnical berms within the pit walls of varying height (allowing for 3 stacks in the south and 4 stacks in the north in the final pit walls) and when taking into account the configurations and depths of the successive pit shell designs.

SRK has performed the design evaluations including geotechnical berms at fixed 150 m vertical intervals, the heights of which have been selected to: a) ensure that the 150 m limiting stack height is not significantly exceeded in any part of the pit, and b) to locate the geotechnical berms at practical positions within the final pit walls and walls of the various interim pit stages. The recommended heights (above mean sea level) of the geotechnical berms are as follows:

- 875 m
- 725 m
- 575 m.

The berm at 875 m will not be required through Sectors 6, 7 and 8, due to the lower height of the south wall of the pit. The pit shell design should be adjusted so that geotechnical berms are locally not included in slope sections where the access ramp provides the required break in slope.

6.3 Identification of geotechnical domains

The aim of geotechnical domain modelling is to identify regions of the ground (rock or soil) mass in which geotechnical conditions are expected to be similar, and to define the boundaries between these regions as accurately as possible. This is done in order to facilitate the analyses for derivation of pit wall design parameters.

As mentioned in Section 4.1, review of the bedrock depths provided as part of the geological/geotechnical database indicates that rock or moderate quality or better is generally encountered at shallow depth across the site, within approximately 10 m or less of the surface. Highly weathered or soil like materials would therefore constitute only a portion of the first bench mined from surface. The depth to bedrock may locally be as much as 30 m, however.

The rock strength, rock mass classification and structural (rock mass fabric) data for the Ajax pit was studied for 3D variations in spatial distribution in order to try and identify and delineate geotechnical domains. It was evident that below the bedrock interface there was little clearly discernible *pattern* or *obvious zonation* of variations in rock hardness or rock mass strength laterally or with depth (this does not mean that there is not considerable variation in hardness or strength, just that it is not easy to neatly delineate). It was decided that the rock mass in which the pit is situated should be divided into 8 sectors. The geotechnical 'domains' are then represented by the individual rock types within each sector, and the available data has been used to characterise them accordingly. Slope design parameters have then been evaluated for each rock type within each sector.

The delineation of pit sectors was made based on a number of factors to achieve the following aims:

- Optimisation of pit slope design across the pit, taking into account the laterally varying geology and rock mass conditions;
- Optimisation of slope design for pit walls of different orientations (this has particular relevance for risk of kinematic failure controlling bench and berm design); and
- Allowance for the recommended slope design parameters to be practically applicable for each interim pit and the final pit during the pit shell construction process.
- Orientation of the pit wall, same rock mass performs differently for a different pit wall orientation.

The individual pit sectors are shown in Figure 6-1, with reference to the final pit shape and geology model. Wireframe solids delineating the pit sectors have been produced by SRK (and are included with this report) to facilitate incorporating the slope design parameters into the shell designs for the final and interim pits. The co-ordinates delineating the pit sectors at the surface, for the points labelled on Figure 6-1, are listed in Table 6-1. The latest geology (rock type) wireframe solids produced by KGHM (as supplied to SRK) will also be required in the pit shell design process.

It is important to take into consideration that this process of defining sectors is done a priori before the stability analysis are carried out. If as a result of the analysis the pit slope parameters are the same for two adjacent sector the can be combined in one.

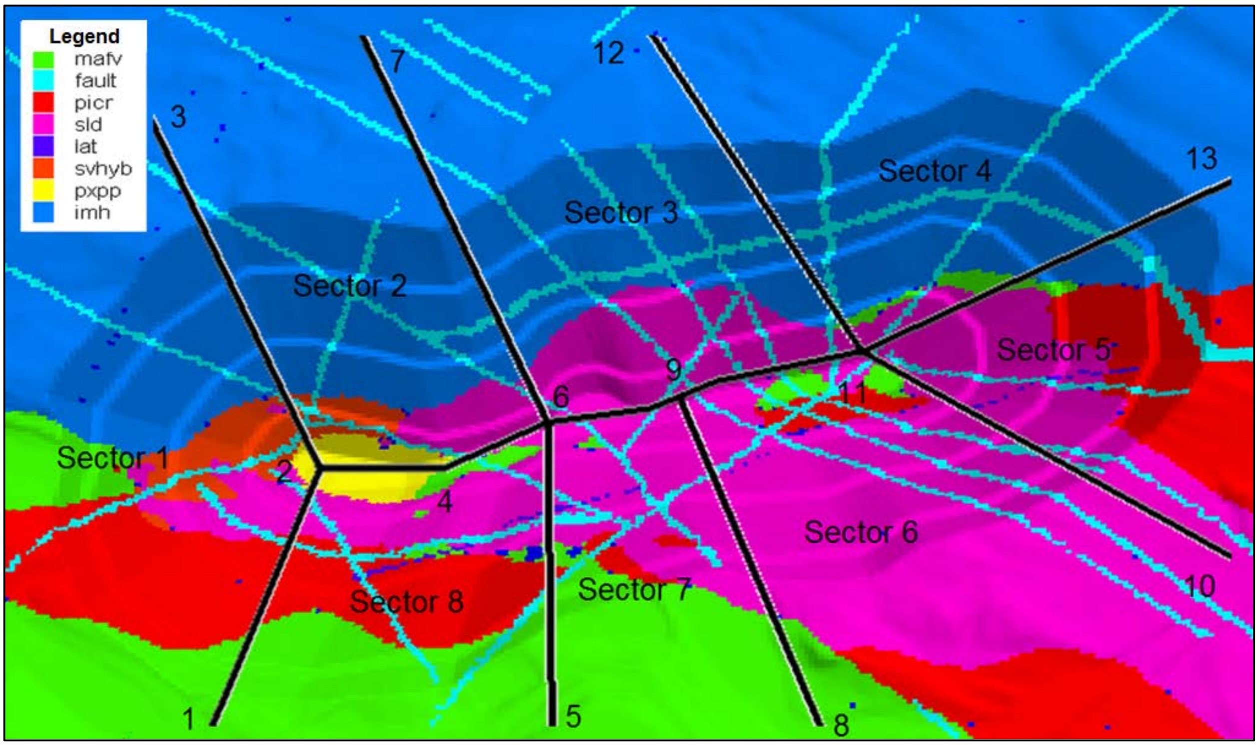

Figure 6-1: Pit design sectors (1 through 8) shown relative to approximate final pit shape, and lithology model

Table 6-1: Coordinates delineating sectors at surface

Point	East	North
1	683,500	5,609,070
2	683,650	5,609,610
3	683,350	5,610,330
4	683,970	5,609,590
5	684,280	5,609,120
6	684,190	5,609,690
7	683,960	5,610,360
8	684,770	5,609,130
9	684,485	5,609,770
10	685,550	5,609,519
11	684,930	5,609,890
12	684,630	5,610,440
13	685,610	5,610,080

6.4 Structural analyses

Structural analyses are conducted to assess the potential for structurally-controlled failure within the pit walls. An assessment of the potential for large-scale failure along major structures such as faults constitutes a major structural analysis. This involves an assessment of mechanisms that may result in large scale, large volume failures at specific localities within the pit(s) as defined by the known positions or intersections of major structures. For the Ajax pits, a basic assessment of the potential for such failures was made using the large structures identified in the structural model provided by KGHM. It was evident that the risk for the development of such failures is low. These structures were included in the 2D and 3D models for numerical stability analyses, however, and therefore the potential contributions of these structures to large-scale / complex instability mechanisms has been effectively taken into account.

Minor structural analyses are conducted in order to assess failure size and failure potential as a result of the interaction of the minor structures (joints, bedding, and foliation) that constitute the structural fabric with the various material types exposed within the walls of a pit. The interaction of major structures with minor structures is included in this.

Failures of this type are generally of small scale and may be ubiquitous through a material type or domain. The aim of minor structural analysis is therefore not to identify the actual positions of these failures, but to identify the likely failure mechanisms, the potential for failure (as defined by the FoS), and the maximum volumes of failed material generated. This allows for suitable design of the bench-scale slope geometrical elements in order to minimise failure potential and to safely arrest volumes of failed material. These slope elements are:

- Bench face (batter) angle
- Bench height
- Spill berm width.

Commonly-investigated ‘minor-structure’ driven modes of failure include wedge failure, planar (sliding or slab) failure and toppling failure. For this study, kinematic wedge failure analysis was conducted in detail. Planar failure is in practice mimicked by highly asymmetric failure wedges where one joint surface is at a very oblique angle to the bench face and sliding occurs mainly on this surface.

Toppling failure is a mechanism expected to be encountered where there are steeply-dipping discontinuity sets that are perpendicular to the pit walls. Flexural toppling occurs in bedded/foliated rock masses when bedding/foliation dips steeply into the slope and the centre of gravity of the bedding/foliation lies beyond the point of rotation. This type of failure is not expected to occur in the types of rock present at Ajax. Whilst there are steeply dipping joints present, few of the steep joint sets are parallel to the slope faces. Block toppling occurs when there are steeply dipping joints dipping into the slope combined with a low angled joint set (< joint friction) which acts as a release plane on which a block topples. In this case, the significance of toppling is expected to be a function of the spacing and dip of the low angled joints. In general low angled joint sets present are not combined with steep joint sets in a way which can lead to significant block toppling. The joint set patterns identified suggests that any toppling failures at Ajax are expected to be of low volume and localised in extent.

6.4.1 Input structural characteristics

Structural data was obtained from three sources:

4 Historical data, collected and used by BCG for the preliminary geotechnical assessment (holes drilled between ~2006 and 2011).

5 Recently drilled geotechnical holes (drilled in 2013), logged according to KGHM protocol.

6 ATV logging of selected drillholes from both drilling campaigns.

The full details of the structural assessment are provided in Appendix B, which describes the approach to identifying the structural sets and includes the individual stereonets.

For the purpose of the structural assessment, the structural data from the drillholes was divided according to the eight (8) sectors identified by the initial geotechnical domaining as shown in Figure 6-2. All structural assessment and subsequent kinematic analysis were based on these sectors. After the structural analyses were completed, and following preliminary 2D numerical modelling, the boundaries between Sectors 1 and 8 and Sectors 6 and 7 were changed to those shown in Figure 6-1 (compare with the original boundaries shown in Figure 6-2). This was due to the impact of the location of Jacko Lake on the slope design for Sector 1 and the overall slope failure mechanism identified in Sector 6. The joint sets identified in Sectors 1 and 8 and Sectors 6 and 7 are broadly similar and the slope face directions have not changed for the sectors as a result of moving the boundaries, therefore it was considered that the structural characterisations did not need revision for the modified sectors. Table 6-2 shows the drillholes used for characterisation of each Sector.

Once the structural data was separated by drillhole per sector, the structural data was split into the individual geological units, which were combined where suitable to do so.

Figure 6-2 details the combinations of rock types characterised per sector.

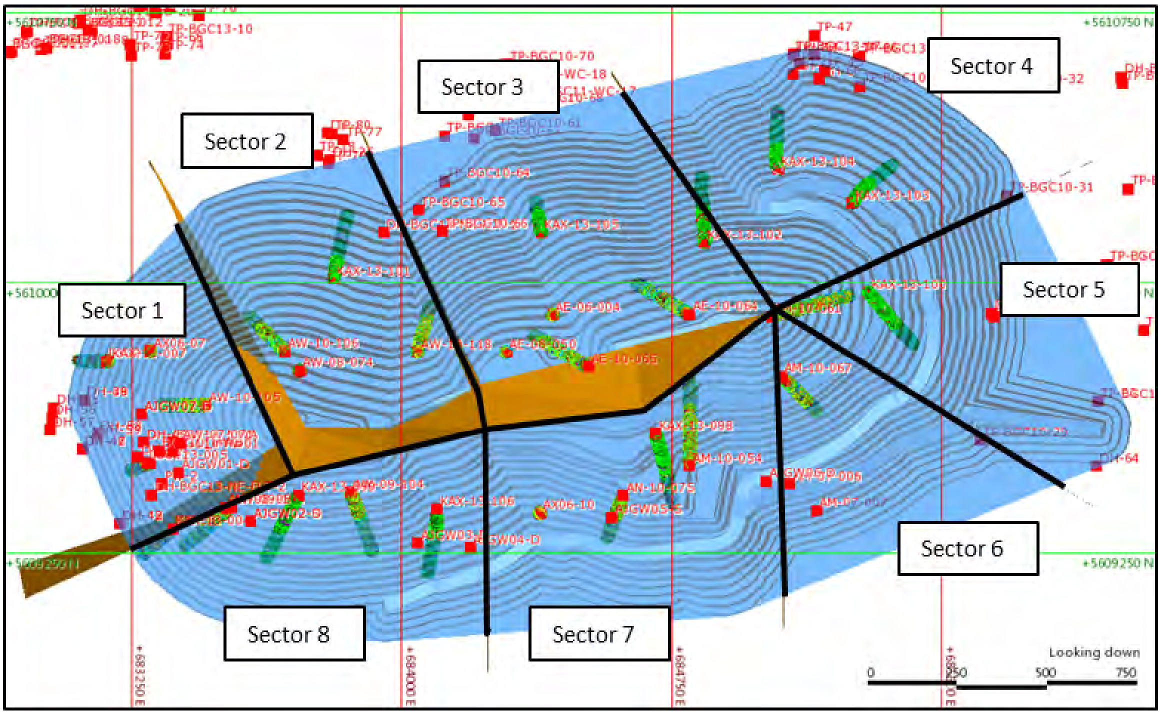

Figure 6-2: Final pit shell with location of original Sectors

Table 6-2: Drillholes in each pit sector

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8
BHID	AX06-07	AW-08-074	AE-06-004	KAX-13-103	AM-10-061	AM-10-067	AX06-10	AW-09-103
	AW-10-105	AW-10-106	AE-08-050	KAX-13-104	KAX-13-100		AM-10-054	AW-09-104
	KAX-13-005	AW-10-118	AE-10-064				AM-10-075	KAX-13-004
	KAX-13-007	KAX-13-101	AE-10-065				KAX-13-098	KAX-13-099
			KAX-13-102					KAX-13-106
			KAX-13-105					

Table 6-3: Rock types characterised per pit sector

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8
Rock Types	IMH	IMH	IMH	IMH	IMH	SLD-SVHYB	SLD	NVP-NVV
	NVP-NVV	SVHYB	SLD-SVHYB		NVP-NVV	IMH	NVP	SLD
	SLD-SVHYB				SLD			

Stereonet plots have been generated per rock type(s) per pit sector, and in each case the main structural ('joint') sets have been identified. The dip and dip direction of each set has then been identified. The origin of the structural data is displayed on the stereonet along with the set strength and main structure type in the set. This helps with interpretations during the kinematic analysis and to determine the likelihood of the failures occurring. In a number of older drillholes, structure types have not been identified and this data is therefore missing. When this is the case a “?” has been placed next to the likely structure type.

The structural data was compared, where possible, to that collected from photogrammetry as part of the BGC (2011) report. It must be noted that the photogrammetry was undertaken within the smaller existing pits well away from the final pit shell for which this new assessment has been undertaken. The BGC report identified a number of steeper joint sets which were less apparent in the drillhole data stereonet plots. This is due the excavations making identification of sub-vertical structures easier, whilst there is often a drilling directional bias that lessens the chance of recording such structures in steeply-dipping drillholes. Therefore, where weak sets or a small number of steeply dipping poles were identified in the drillhole data, steeply dipping sets were interpreted (where appropriate) to account for this.

6.4.2 Deterministic / probabilistic analysis of wedge failures

Wedge failure analysis is the primary means by which optimisation of pit slope geometries from a structural perspective is carried out. Wedges are only free to slide when combined with specific slope geometry, and the possibility of wedge failure will thus depend on the orientation and face angle of individual benches. Variation in the geometry and orientation of the pit slope design may result in changes in the potential for, and characteristics of, wedge failures and thus an analysis of the potential wedge failures within every material type within each pit wall were carried out.

For this structural pit slope optimisation process, the following factors are taken into account:

- The structural characteristics of the rock mass, which include:
  - Orientation of dominant structural sets
  - Persistence of discontinuities
  - Nature (friction and cohesion) of discontinuity surfaces
- Geometric considerations:
  - Orientation of pit walls
  - Bench face (batter) angle
  - Bench height
  - Spill berm width (SBW)

SRK in-house software MWedge was used to determine the SBWs required for each slope configuration analysed. MWedge can analyse multiple combinations of wedges generated by large numbers of discontinuity sets. It identifies all possible wedge geometries, their factors of safety, and the volumes and shapes of failed materials generated, and then calculate the SBWs required containing these failure materials. In addition to this deterministic analysis methodology, probabilistic analyses were carried out in order to identify the numbers of failure wedges, the number of failure wedges that result in overspill for an analysed SBW, and the percentages of overspill for each bench/berm geometry; for both the entire structural fabric within each sector and for just the key failure wedges of greatest size and overspill potential. The results of both the deterministic and probabilistic analyses were used in the identification of the optimal bench/berm geometries for each rock types within each sector.

The design criteria used for the design of the berm widths are:

- That the berms should be wide enough so that the full volume of at least 95% of all failures should be retained upon the berms; and
- That in the remaining 5% of cases (where there is spillage), not more than 10% of the volume of any wedge should be allowed to spill from the berm.

Wedge stability was analysed using the joint set data for each sector (provided in Appendix B), and the calculated joint strengths (presented in Appendix F). Table 6-4 presents the final results of the analyses, listing the berm widths required according to the criteria listed above.

For the analyses it was assumed that joints have a general persistence of 25 m (a significant portion the height of double benches). Where sets also have numerous faults within their orientation, the persistence of the set has been increased to 40 m. For each joint set a weighting value was assigned (between 0 and 1) to take into consideration how “strongly developed” that set is. This weighting is based on the relative number of joints measured within the set, and is intended to provide a weighting of the effect of this set on overall wedge failure development within the sector.

Table 6-4: Spill berm width required by sector and rock type

Sector	IMH		SLD		PICR (NVP)		MAFV (NVV)	
	$B_{95\%}$	Spill %	$B_{95\%}$	Spill %	$B_{95\%}$	Spill %	$B_{95\%}$	Spill %
1	16.5	1.2	18.0	2.3	16	0.3	16.0	0.4
2	17.5	1.8	17.5	1.0	- -	- -	- -	- -
3	18.5	3.4	20.5	1.9	- -	- -	- -	- -
4	16.5	1.5	18.0	2.3	- -	- -	- -	- -
5	14.0	2.9	21.5	0.9	16.0	1.1	16.0	0.7
6	- -	- -	17.0	1.4	15.0	0.7	- -	- -
7	- -	- -	17.0	2.1	- -	- -	- -	- -
8	- -	- -	17.0	2.0	15.0	2.0	15.0	1.4

Where: $B_{95\%}$ is the berm width [m] required to contain the failed material for 95% of all failures; and Spill % is the percentage of the material failed that will overspill the berm, falling onto the berm below.

The complete results of the wedge failure analyses are presented in Appendix G.

6.4.3 Freeze-thaw action on benches

In the climatic environment experienced at Ajax, it can be expected that cyclical freeze-thaw action will serve to loosen blocks of rock in close proximity to the pit walls. Whilst this is expected to result in an increase in rill material reporting to spill berms, this has not been identified as a problem that will influence slope design requirements at Ajax because:

- The significantly loosened material will be confined to a zone of limited extent behind the pit wall (several metres only), which will have no effect on overall slope stability;
- The volumes of rill generated at any time will be relatively low and should easily be accommodated on the spill berms of 15 m+ in width that have been recommended at Ajax. Although rill reduces the future catch-capacity of the spill berms, it also progressively reduces the volume of potential failure material from the bench faces above;and
- Although the freeze-thaw action may result in eventual reduction in the factor of safety of potential failure wedges, the exact reduction is very difficult to quantify and the proposed bench/berm design configuration is expected to be able to minimise overspill and rock fall without presenting overall slope angles that are too conservative in the larger context.

6.5 Empirical evaluations

Geotechnical core logging data forms the basis for empirical rock mass characterisation. Although the classification system of Bieniawski (1989) has been used as the primary system for rock mass characterisation for Ajax, the Mining Rock mass Rating (MRMR) classification system of Laubscher (1990) was also used, as it has been augmented by SRK to allow for empirically-derived preliminary slope design. In the Laubscher system, the results of the rock mass characterisation are used to provide mining rock mass ratings, which are in turn used to evaluate indicative bench stack angles (IBSAs), and/or provide indicative overall slope angles (IOSA). The MRMR classification system is an extremely useful and robust method of utilising all of the relevant rock mass parameters to assist with preliminary mine design.

6.5.1 RMR properties

The in-situ rock mass of the various material types can be classified based on their range of RMR calculated from the logged data, as indicated in Table 6-5.

Table 6-5: Rock mass Rating Classes

Material Type	100 - 80	80 - 60	60 - 40	40 - 20	20 – 0
Description	Very Good	Good	Fair	Poor	Very Poor

The representative RMR values selected from the data as being characteristic for each material type are listed in Table 5-4. Table 6-6 indicates that the rock mass at Ajax can be described as follows: IMH and SLD are fair and NVP and NVV poor. The rock in Domain 1 is generally weaker than the other domains.

6.5.2 Calculation of MRMR

In order to simulate the response of the rock mass in a mining environment, percentage adjustments are applied to Laubscher RMR values to obtain mining rock mass rating (MRMR) values. These adjustments are made to account for the potential time-dependent deterioration of the rock mass upon exposure, the unfavourable orientation of discontinuities with respect to excavation stability, the stress environment, and damage induced by blasting. MRMR values, as derived for design materials, can be related to an IBSA. The adjustments chosen are listed in Table 6-6.

Table 6-6: MRMR adjustments

Sector	Rock Type	RMR (Laubscher 1990)	Adjustments				Total Adjustment	MRMR (Laubscher 1990)
			W	O	S	B		
1	IMH	45	100%	100%	100%	97%	97%	44
	SLD	40	100%	100%	100%	97%	97%	39
	NVP	31	82%	100%	100%	97%	80%	25
	NVV	35	90%	100%	100%	97%	87%	30
2	IMH	48	100%	100%	100%	97%	97%	47
	SLD	52	100%	100%	100%	97%	97%	50
3	IMH	53	100%	100%	100%	97%	97%	51
	SLD	46	100%	100%	100%	97%	97%	45
4	IMH	60	100%	100%	100%	97%	97%	58
	SLD	No data	100%	100%	100%	97%	97%	
5	IMH	44	100%	100%	100%	97%	97%	43
	SLD	54	100%	100%	100%	97%	97%	52
	NVP	40	82%	100%	100%	97%	80%	32
6	SLD	44	100%	100%	100%	97%	97%	43
	NVP	44	82%	100%	100%	97%	80%	35
7	SLD	46	100%	100%	100%	97%	97%	45
	NVP	38	82%	100%	100%	97%	80%	30
	NVV	No data	90%	100%	100%	97%	87%	
8	SLD	54	100%	100%	100%	97%	97%	52
	NVP	43	82%	100%	100%	97%	80%	34
	NVV	36	90%	100%	100%	97%	87%	31

Where: W = Weathering adjustment; O = Orientation adjustment; S= Stress adjustment; B = Blasting adjustment

The weathering adjustment chosen was based on expected long term deterioration of the rock mass on exposure during mining. The MAFV and PICR had weathering adjustments applied.

The structural fabric within the rock mass at both deposits is not expected to present problematic conditions, with moderate to wide spacing and limited continuity of jointing. A joint orientation adjustment of 100% has therefore been used for all materials. The effects of joint fabrics have been taken into account in the structural analyses for bench/berm design.

No adjustments were made for the effects of in situ stress, as the stress field is considered to be benign given the relatively shallow depth the majority of the pit walls.

The weathered and fresh rock will require blasting for excavation. A blasting adjustment of 97% was assigned to these materials, which assumes that good quality, conventional blasting with pre-split will be achieved.

The MRMR value is calculated by multiplying the individual adjustment factors together to get the total adjustment and then multiplying the RMR value by this total adjustment. The calculated MRMR values for each material type are presented in Table 6-7.

6.5.3 Preliminary slope angle determination

The IBSA for each sector is selected from the chart presented in Figure 6-3 (Haines & Terbrugge, 1991). This chart utilises the relationship between MRMR and bench stack height to determine design bench stack angle for a range of FoS. The methodology is empirically derived, and relates to average

MRMR versus stack height and stack angle. Experience has proven that the use of this methodology is appropriate for initial assessments.

An example of slope angle determination for bench stacks using this method is shown on Figure 6-3, where a bench stack height of 150 m (red dashed line) is plotted for material of MRMR 45 (blue dashed line). The intersection point A is then used to read the appropriate slope angle from a series of parallel curves, depending on the selected target FoS. In this example, the appropriate slope angle (interpolated yellow curve) for an FoS of 1,2 is around 53° degrees, and the slope angle for an FoS of 1.5 is around 43°. An appropriate slope angle for an FoS of 1.35 would be proportionally interpolated as 48°.

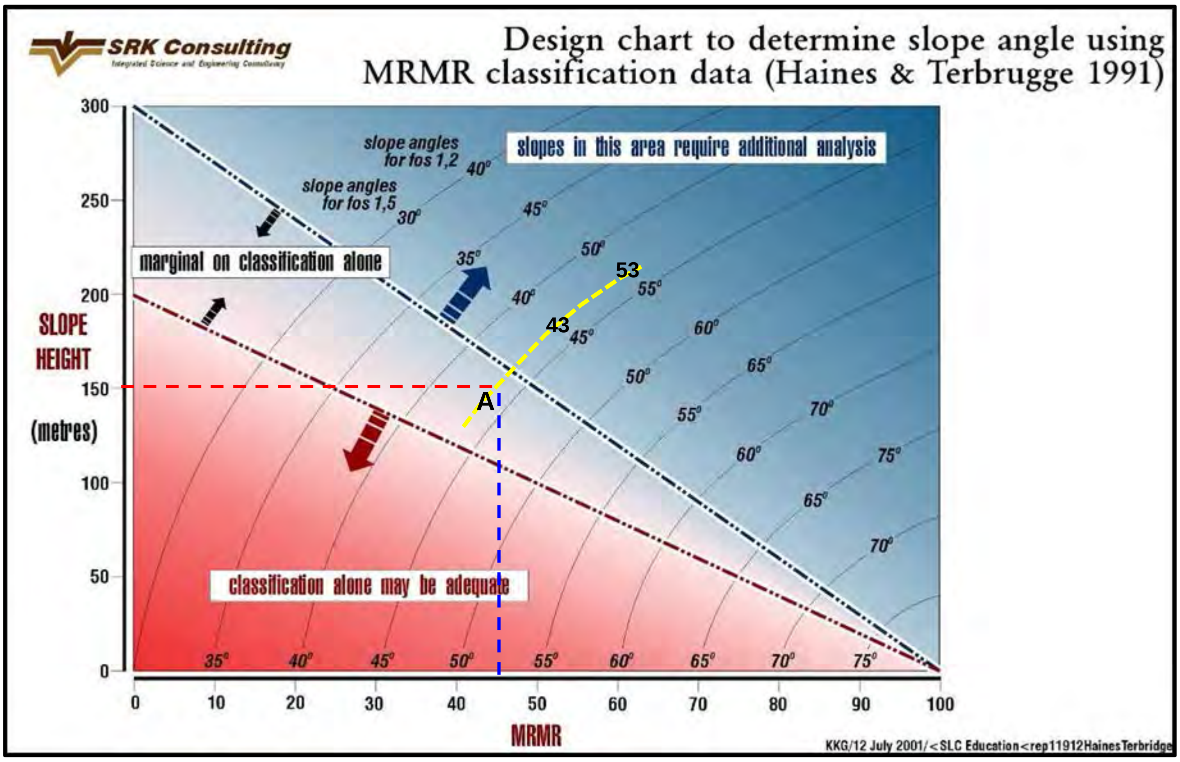

Figure 6-3: MRMR versus Bench Stack Angle Relationship

It is important to note that the bench stack angle represents the actual slope angle of the bench stack (crest to toe), and is used for stability analysis (refer to Figure 3-1). This angle will vary depending on the number of benches within the stack (i.e. changes in stack height). The inter-ramp angle (crest to crest or toe to toe) is a useful alternative for describing the slope angle of a bench stack because it is not dependent on the number of benches within the stack and thus remains constant with changes in stack height.

The BSAs that are assessed as being suitable for the various material types are presented in. These have been assessed for a FoS of 1.2, using the RMR for the material type and a bench stack height of 150 m which is deemed suitable for the type and quality of the material (based on engineering experience).

The empirically-derived BSAs listed in Table 6-7 are specified as indicative and do not represent the final design recommendations, which are presented in Chapter 8.

6.6 Discussion of structural and empirical evaluation results

The results of the structural and empirical evaluations and observations are discussed in this section. Their implications with regards to the design of the various elements of pit slope geometry are also explained.

The overall slope geometry for each sector is defined by the geometrical combination of the bench stack angles and the height of bench stacks. The positions of ramps have not been explicitly allowed for in the geotechnical design recommendations although inter-ramp berms of minimum 25 m width have been assumed to exist between bench stacks. These elements have been combined to result in the stable limiting overall slope angles identified as input for the numerical analyses in Section 7.

6.6.1 Bench height, bench face angle and bench stack height

As stated in Section 6.5.3, bench stack heights of 150 m are deemed suitable for the type and quality of the materials present within the Ajax rock mass. KGHM has confirmed that benches within all pits will effectively constitute double benches of 30 m height. Therefore stacks will consist of 5 double benches of 30 m height. However for the poorer quality materials (MAFV and PICR) in certain sectors, the performance of an alternative single 15 m bench height was assessed.

Kinematic (structural) failure analyses were carried out assessing the performance of the following bench face angles:

- For MAFV and PICR: 60°, 65°, 70° and 75°
- For all other rock types: 65°, 70°, 75° and 80°

From these analyses and from an understanding of rock mass quality, it was considered that bench face angles of 65° for the MAFV and PICR materials and 75° for all other rock types are most suitable.

Bench Stack Angle, Inter-ramp Angle and Spill Berm Width

From the structural analysis, the required spill berm widths for a variety of pit wall orientations and bench face angles have been identified. The resulting bench / berm configurations which provide for the steepest appropriate bench stack angles within each of the material types within each pit sector have been identified. These are compared in Table 6-7 with the bench stack angles determined from the empirical analysis. From the comparison presented in this table, a suitable bench stack angle has been selected for each rock type within each pit sector, and the spill berm widths needed to create the selected bench stack angles for each slope configuration within each material have been calculated. These are presented as part of the preliminary pit slope design parameters on the right in Table 6-7. The spill berm widths will be sufficient to contain the volumes of failure debris expected, with an allowance for a small amount of spillage volume in certain cases if expedient. Note that a minimum width of 8 m for spill berms is mandated according to regulations in British Columbia. Inter-ramp angles for the selected bench stack designs have been calculated and are also presented in the table.

6.7 Preliminary pit slope design parameters

Engineering judgement has been used to select the most appropriate preliminary slope angles for each sector using a combination of the structural and empirical analysis results presented in Table 6-7. The analyses have indicated that, compared with potential inter-ramp rock mass failure, structural failure at bench-scale is not the controlling factor for inter-ramp (bench stack) slope design. In most cases, the bench/berm configuration is therefore controlled primarily by limitations of bench stack / inter-ramp angle which is dependent on rock mass strength. It is important to note that these are preliminary recommendations upon which more detailed analysis has subsequently been done (as described in subsequent chapters) to derive the final geotechnical slope design recommendations.

Table 6-7: Summary results of structural and empirical analyses and resulting preliminary pit slope design parameters

Sector	Rock Type	RMR (Laubscher 1990)	Bench Face Angle (°)	Bench Stack Angles (BSA) (°)		Preliminary Design Recommendations		Resulting Approx. OSA (°)
				Kinematic Analysis	Empirical Analysis	BSA	SBW	
1	IMH	45	75	60	53	53	18	49
	SLD	40	75	64	51			
	PICR	31	65	55	47	45	20	42
	MAFV	35	65	55	45			
2	IMH	48	75	62	54	57	14	53
	SLD	52	75	63	56			
3	IMH	53	75	57	56	57	14	53
	SLD	46	75	57	53	55	16	51
4	IMH	60	75	62	59	60	12	56
	SLD	No data	75	64	53*	55	16	51
5	IMH	44	75	62	53	60	12	56
	SLD	54	75	64	57	55	16	51
	PICR	40	65	55	48	48	16	45
6	SLD	44	75	64	53	55	16	51
	PICR	44	65	57	49	48	16	45
7	SLD	46	75	61	53	55	16	51
	PICR	38	65	56	46	48	16	45
	MAFV	No data	65	56	47*		16	45
8	SLD	54	75	63	57	55	16	51
	PICR	43	65	55	49	48	16	45
	MAFV	36	65	55	47		16	45

Note: * Result from adjacent sector applied where there is no data

7 Numerical Stability Analyses

Stability analyses have been carried out at different scales (bench, inter-ramp and overall slope), using different methods that best take into account the mode of failure and modelling requirements. At bench-scale, the primary mode of failure is likely to be discrete structural failure (kinematic failure), as described in Section 6.4. However in a pit of large size in the conditions encountered at Ajax, slope failure at larger scale (bench stack / inter-ramp or overall slope scale) is likely to occur as rock mass failure. In this situation, the rock mass behaves approximately as a continuum. Appropriate 2D and 3D numerical methods are selected to calculate the changes in stresses and deformations within the slopes in order to assess slope stability and calculate Factors of Safety (FoS). These analyses are detailed in Section 7.3 and Section7.4. Key inputs into numerical stability analyses include the groundwater regime and the potential for seismic loading. These inputs with respect to Ajax are discussed in Section 7.1 and Section 7.2 respectively.

7.1 Groundwater

A revised hydrogeological study is currently being carried out, but was not yet available for input into this geotechnical study. The data provided by the BGC (2009) study indicates that the groundwater level is generally located 100 m below surface. The presence of Jacko Lake presumably modifies the water level to the west of the pit, increasing its elevation to close to the surface immediately adjacent to the lake.

SRK understands that 150 m long horizontal drainholes at 100m lateral spacing have been considered as a preliminary option to provide pit wall depressurisation, and the design can be changed based on the results of the current hydrogeological study.

It has been assumed by SRK based on experience that an effective groundwater pushback (depressurisation) to approximately 125 m behind the pit walls will be achieved by the drainholes of 150 m length and 100 m lateral spacing. For all the pit sectors (except Sector 1) the groundwater has been modelled as 100 m below the surface and 125 m behind the pit wall. This is illustrated in Figure 7-1. For Sector 1, adjacent to Jacko Lake, it was assumed that the groundwater level will be near the surface at the Lake but that the pit wall drainage measures will maintain a groundwater pushback of 125 m behind the pit wall (as illustrated in Figure 7-2)

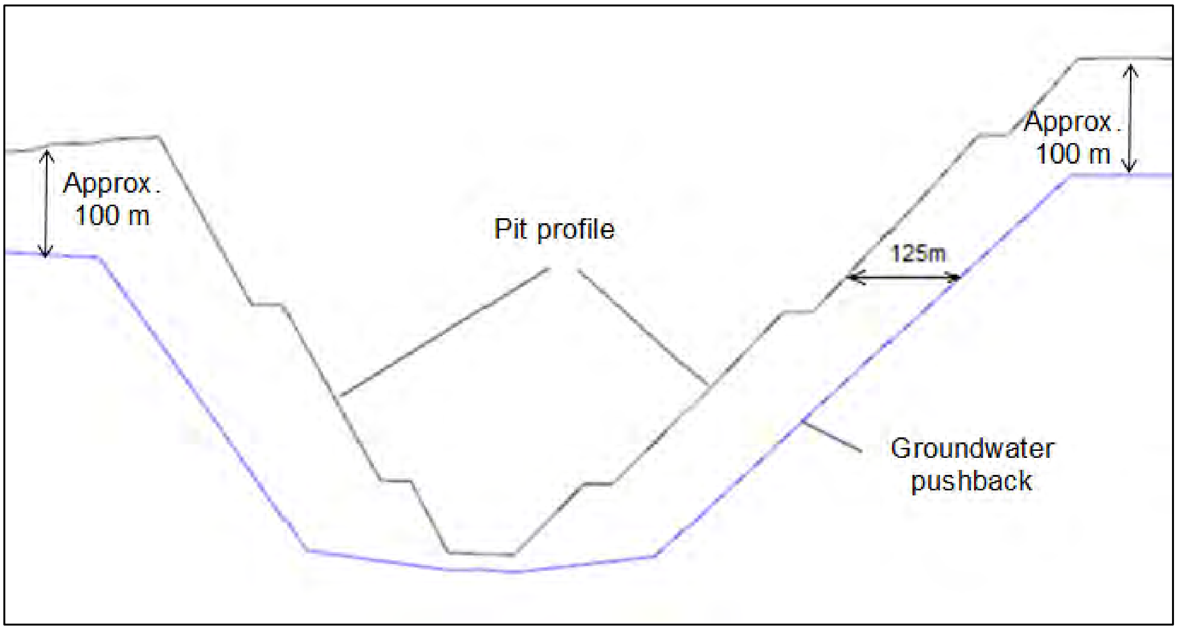

Figure 7-1: Sectional illustration of assumed groundwater level for all sectors (except 1)

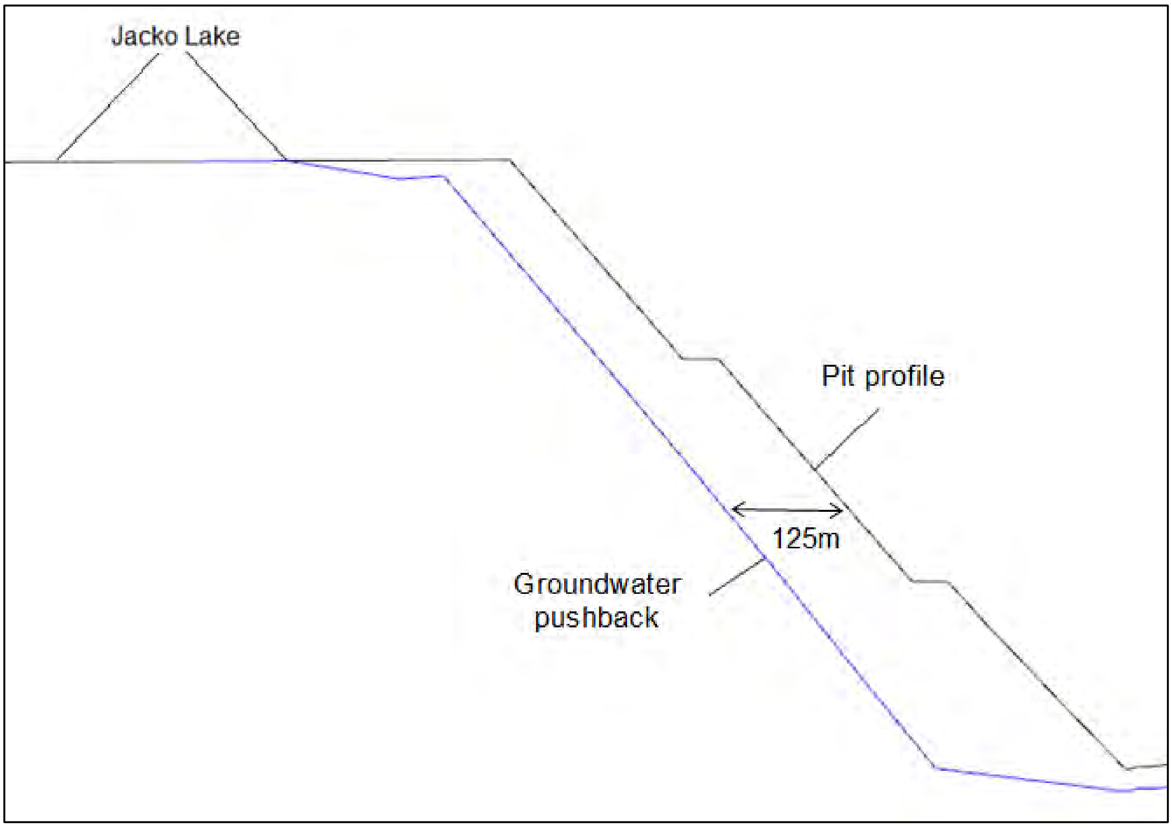

Figure 7-2: Sectional illustration of assumed groundwater level for Sector 1

7.2 Seismic loading

As explained earlier (in Section 4.3), a PGA=0.072g has been identified for the site.

It must be noted that there are few, if any, recorded instances in which earthquakes have been conclusively shown to produce significant slope instabilities in hard rock conditions (Read, 2009). Considering this, and because the recommended horizontal acceleration for seismic load is ½ of the PGA (0.036g in this case), the impact of potential seismic loading at Ajax was considered to be very low and it was not incorporated into the analyses.

7.3 Two dimensional stability analyses

Two dimensional stability analyses were performed to assess the performance of pit slope profiles generated using the preliminary design parameters. These analyses allowed for modification of the designs within each pit sector to best meet the design criteria and the modified designs were then further assessed using three dimensional analyses for the entire pit. The finite difference method (FLAC software) was used for the 2D analyses.

Eight sections were selected to best represent each sector as shown in Figure 7-3. Sector 8 was represented by two sections to take into account the variability of the lithology that could affect the Factor of Safety (FoS) of slopes within the sector.

The material properties used for each rock type in each pit sector have been listed in Section 5.6.

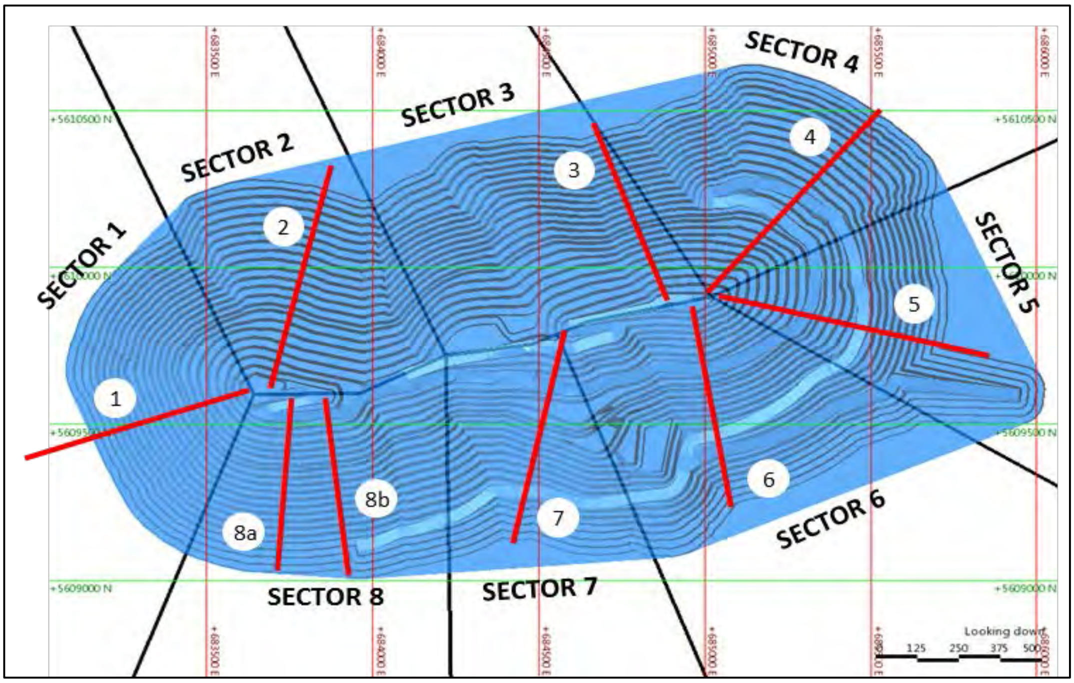

Figure 7-3: Plan view showing the positions of the 2D sections selected (red lines)

The main aim of the analyses was to identify the Overall Slope Angle (OSA) required to achieve a FoS of 1.3 for the slopes within each sector. The methodology required increase or reduction of the OSA generated by the preliminary design parameters until the approximate target FoS was achieved.

Appendix H presents the results of the 2D stability analyses for each sector. Table 7-1 presents a summary of the required OSAs identified for each sector. These angles were used as a reference for the construction of the 3D models. The final angles recommended are based largely on the 3D analyses results.

Section	1	2	3	4	5	6	7	8a	8b
OSA	43°	46°	53°	55°	57°	37°	56°	50°	54°

Table 7-1: Required OSAs for each pit sector determined by 2D stability analyses

7.4 Three dimensional stability analyses

Three dimensional numerical analyses were considered appropriate for the stability modelling of these Ajax pits because of the complex 3D nature of the geology, faults model and pit shapes (including convex sections of pit walls). The advanced modelling software FLAC 3D (Itasca Version 5.0) was chosen for this purpose. FLAC 3D is a three-dimensional explicit finite-difference program which simulates the behaviour of three-dimensional structures built of soil, rock or other materials that undergo plastic deformation when their yield limits are reached. The analyses were conducted mainly for the various sectors of the final pit as well as the stage 1 and stage 2 pits (Pit 1 and Pit 2). Individual 3D stability analyses of the stage 0, 3, 4 and 5 pits was considered less important as the majority the walls of these interim pits are common to the final pit except for the eastern wall which is progressively cut back. However, this pit wall is generally located in relatively good material compared with final pit limits overall.

7.4.1 Model geometry and properties

The geometry of the FLAC 3D model is created using finite different numerical zones of various standard shapes (e.g. Hexahedron and tetrahedron). In this case, the model was created using numerous hexahedron zones of mostly 10 m in edge length for the region of main focus and relatively larger zones in the outer regions for model efficiency. Initially, some preliminary models with smaller zone size of less than 10 m (the smaller the zone size the greater the accuracy) were created to assess the viability of such models in terms of model size and run time. However it was found that zones of less than 10 m were too small to maintain a viable model.

Utilising an internally developed program by William Gibson (FLAC 3D_Groups_10_MP), the hexahedron zones were adjusted to honour the pit surface, and then the rock mass material regions including faults (faults were modelled as a thin regions) were incorporated within the model by the use of DXF solids or surfaces. Figure 7-4 shows an example of pit geometry with various material regions.

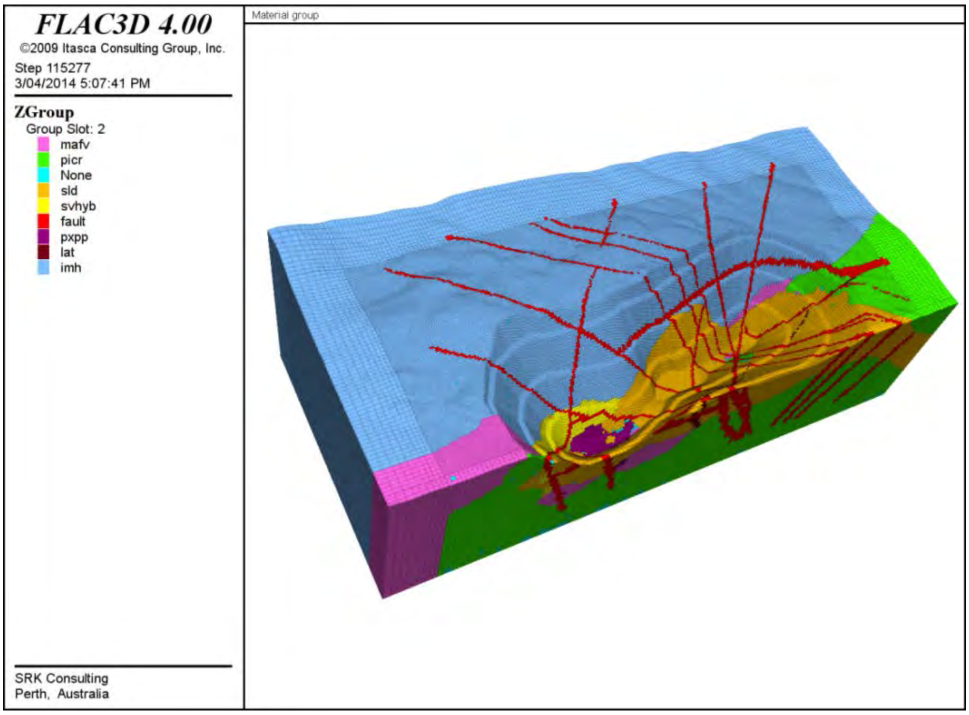

Figure 7-4: Cutaway isometric view from the southwest showing the pit Geometry and rock types in the FLAC 3D model

All the materials (rock types) were assigned with the Mohr Coulomb constitutive model except the outer region (the region where the effect of excavation is none or minimal) which utilised an elastic model to increase the efficiency of the model runs. Based on available data (field and laboratory), the relevant rock mass properties were assessed for each rock type incorporating engineering judgements (e.g. selection of disturbance factor). This has been explained in Section 5.6.

7.4.2 Initial and boundary conditions

Initial pre-mining vertical stresses were assigned by setting vertical stress according to rock density and depth below the initial ground surface. The E-W and N-S horizontal stresses were assumed to be equal to the vertical stress in all the analyses.

Boundaries were extended far enough out from the regions of interest for boundary effects on the analysis to be avoided. The East and West boundaries were restrained only in the X (E-W) direction, the North and South Boundaries were restrained only in the Y (N-S) direction, and the bottom boundary was restrained in all directions.

7.4.3 Groundwater

A groundwater surface at approximately 125 m behind the pit wall around the pit was incorporated in this modelling. The pre-mining water depth and the lake in the western side of the pit were taken into account while creating the 3D groundwater surface, as described in Section 7.1.

7.4.4 Analyses

Initial FLAC 3D analyses were carried out on new a final pit shell created using the outcomes of the 2D FLAC analyses. However, an iterative process (including slope flattening and/or steepening) during the 3D modelling was required to adjust the pit slopes to satisfy the design criteria. The following regions were modelled separately in the analyses.

1 Northern wall-Final pit
2 Southern Wall-Final pit
3 Eastern Wall-Final pit
4 Western Wall-Final pit
5 Stage 1 Pit
6 Stage 2 Pit

In all the analyses, the model representing the pre-mining stage was initially stepped to equilibrium, and the induced displacements were reset to zero. This is because they do not represent physically real deformations, but rather only the adjustments that must occur within the model to produce a self-consistent stress state.

The excavation of the pits was then simulated in four stages to better simulate the stress path balancing the efficiency of the model run. A number of monitoring history points was assigned along critical vertical sections (an example is shown in Figure 7-5) around the slopes to monitor the slope performance. The performance of the final slope excavation was analysed to assess the indicative FoS using an internally developed strength reduction routine. In this process, the shear strength of the rock mass (friction, cohesion and tensile strength) is reduced in progressive steps until it is interpreted that slope failure has occurred. This failure interpretation is made largely based on the contour and history plots of slope deformation and velocity. The strength reduction factor (SRF) at failure can be considered equivalent to the FoS.

Figure 7-5: Cross section showing an example of history point locations within the pit wall

Indicative FoS values, taken as the SRFs at failure (critical SRFs) of the last analysis in the iteration process of the modelling, are presented in Table 7-2 for various wall sectors of the final pit as well as the stage 1 and stage 2 pits. Figure 7-6 and Figure 7-7 illustrate the indicative instability (velocity contours) at the critical SRF for the northern walls of the pit. These velocity contours shows the distribution of velocity magnitude at the last numerical calculation step. It must be noted that these velocities cannot be related to reality, and they are only used for interpreting the instability. The detailed plots for each analysis are provided in Appendix I.

Table 7-2: Model results of critical SRF

Modelled region	Indicative critical SRF (~FoS)
Northern wall-Final pit	1.39
Southern Wall-Final pit	1.42
South-East Wall-Final pit	1.33
Eastern Wall-Final pit	1.75
Western Wall-Final pit	1.6
Stage 1 Pit	1.43
Stage 2 Pit	>1.80

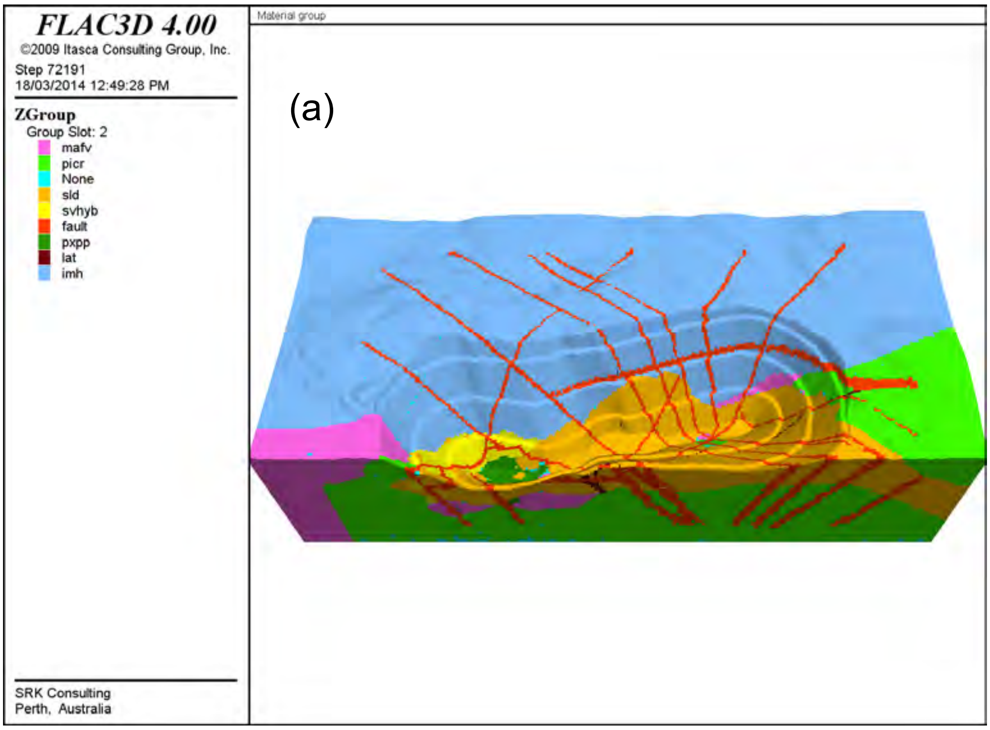

Figure 7-6: FLAC 3D model

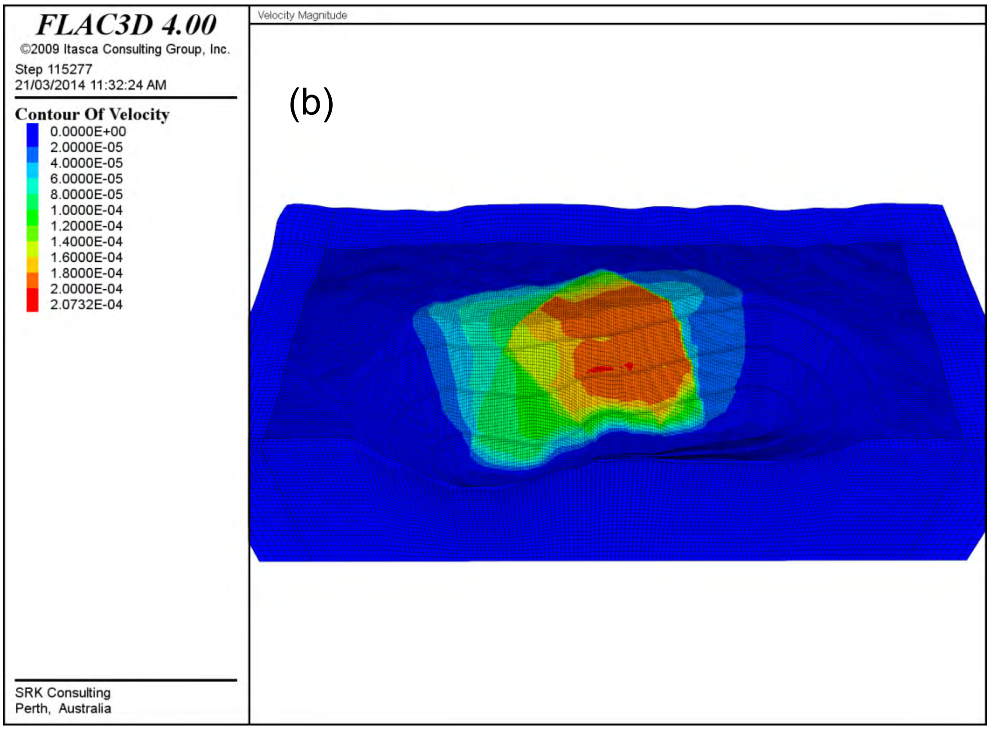

Figure 7-7: Northern pit wall: a) Material groups; b) velocity contours at critical SRF

8 Conclusions and Recommendations

8.1 Recommended slope design geometries and slope generation

The results of the kinematic, empirical and numerical stability analyses carried out at different scales have all been taken into consideration in the identification of the optimum slope geometries for each of the pit sectors. These pit sectors are illustrated in Figure 6-1 in Section 6.3, with reference to the final pit shape and geology model. Wireframe solids delineating the pit sectors have been produced by SRK to facilitate incorporating the slope design parameters into the shell designs for the final and interim pits.

In order to optimise the pit slope angles, the design recommendations vary from one part of the pit to another, changing according the changes in rock type and conditions. The variability of the rock type in space is defined by a geological model provided by KGHM. If future information indicates that these models are no longer valid, then the slope design should be reviewed accordingly.

Table 8-1 presents the simplified slope design recommendations, and the pit design should incorporate all the parameters indicated in the table. These parameters are considered to be the most optimal and practical for each sector, and have been selected taking into consideration all the analyses carried out to allow for slopes to be designed to the agreed acceptance criteria at the individual bench, inter-ramp and overall slope scale. To avoid abrupt changes in design between adjacent sectors small changes have been incorporated to make the design practical to apply. The slope geometry terminology is illustrated in Figure 3-1 in Section 3.2

The ‘building blocks’ of the slope are the bench height, bench face angle (BFA) and spill berm width (SBW). Bench stacks are created where consecutive benches form a stack, the slope angle of which is determined by the geometry of these smaller ‘building blocks’. The limiting bench stack height defines the slope height that should not be exceeded without the slope angle being broken, and is dependent on the quality of the rock mass. If no ramp is present to provide this break in slope, a geotechnical berm will need to be incorporated in the design.

The bench stacks for the Ajax open pit are recommended to not exceed 150 m in height (and would therefore consist of five double benches of 30 m height each), and the geotechnical berms are recommended to be 25 m in width. Using the individual bench/spill berm geometries recommended, individual bench stacks of 150 m in height will produce the bench stack angles and inter-ramp angles recommended in Table 8-1. It is important to note that for stacks of lesser height (fewer benches) than the 150 m limiting height, the bench stack angles generated can be steeper. However the inter-ramp angle (IRA) will remain constant.

The inter-ramp and overall slope angles recommended within Table 8-1 for each rock type within each sector of the pit should not be exceeded. If amendments need to be made to bench stack angles (and, by extension, overall slope angles), this should be done by increasing the berm widths. BFAs have been selected to be appropriate for the rock type and local structural fabric and the angles recommended should be adhered to.

Geotechnical berms and access ramps should be included in the design as necessary and an overall slope angle (OSA) of less than or equal to the limiting OSA value indicated in Table 8-1 should be created.

So for each pit sector, the process of bench stack generation is thus repeated upwards from the toe of the slope until the surface is reached, using the recommended bench/spill berm configurations that will generate bench stack / inter-ramp angles recommended for each rock type that forms part of the pit wall. The OSA achieved in this process must then be checked to make sure that it does not exceed the limiting OSA indicated in Table 8-1.

Sector 6 presents a special case where the OSA is controlled by the poor quality picrite (PICR) material *behind* the pit wall, which forces the slope angle design to be shallower when compared with other parts of the pit. The actual pit face in this sector will consist of SLD, a much stronger material, allowing the BFA and BSA / IRA to be theoretically steeper. However, these design elements need to be compatible with creating the overall slope angle (OSA) recommended. This was achieved by decreasing the BSA and increasing the geotechnical berm widths or locating the access ramp in this sector.

SRK has performed the design evaluations including geotechnical berms at fixed 150 m vertical intervals, the heights of which have been selected to: a) ensure that the 150 m limiting stack height is not significantly exceeded in any part of the pit, and b) to locate the geotechnical berms at practical positions within the final pit walls and walls of the various interim pit stages. The recommended heights (above mean sea level) of the geotechnical berms are as follows:

- 875 m
- 725 m
- 575 m.

The berm at 875 m will not be required through Sectors 6, 7 and 8, due to the lower height of the south wall of the pit. These heights can be changed to accommodate pit design constrains if necessary.

It can be seen from Table 8-1 that the slope design recommendations achieved for Sectors 7 and 8 have turned out to be identical, and therefore these two sectors can be combined into a single sector for the purposes of pit design shell creation. This has been done for the SRK wireframe solids delineating the pit sectors (there are now only 7).

Table 8-1: Slope design parameters by pit sector and rock type

Sector	Unit	Bench Height h [m]	BFA [°]	Berm B [m]	BSA [°]	IRA [°]	Geotech Berm [m]	Maximum OSA [°]
1	IMH / PXPP – LAT	30	75	17	54.2	50.2	25	46
	SLD	30	75	18	53.2	49.0	25	
	PICR (NVP)	30	65	16	48.2	45.0	25	
	MAFV (NVV)	30	65	16	48.2	45.0	25	
2	IMH / PXPP – LAT	30	75	17	54.2	50.2	25	46
	SLD	30	75	18	53.2	49.0	25	
3	IMH	30	75	17	54.2	50.2	25	50
	SLD	30	75	18	53.2	49.0	25	
4	IMH	30	75	17	54.2	50.2	25	53
	SLD	30	75	18	53.2	49.0	25	
5	IMH	30	75	17	54.2	50.2	25	53
	SLD	30	75	17	54.2	50.2	25	
	PICR (NVP)	30	65	16	48.2	45.0	25	
6	SLD (*)	30	70 (75)	20 (17)	48.1 (54.2)	44.1 (50.2)	40 (30)	42
	PICR (NVP) (*)	30	65	16.5	47.8	44.5	40 (30)	
7-8	SLD	30	75	17	54.2	50.2	25	52
	PICR (NVP)	30	65	16	48.2	45.0	25	
	MAFV (NVV)	30	65	16	48.2	45.0	25	
	SLD / PXPP – LAT	30	75	17	54.2	50.2	25	

(*) The slope design recommended has been adjusted to produce the overall slope angle (OSA), which cannot be exceeded as explained in the text; this applies only for the final pit wall. The numbers in brackets are the recommendations for any interim pit walls.

8.2 Applicability of slope design parameters to interim pits

Figure 8-1 shows the interim and final pit shell designs as provided by KGHM in late 2013. The various pit stages are referred to as Pit 0, Pit 1 etc. through to Pit 5 and the Final Pit It can be seen that, except for Pit 0, Pit 2 and part of Pit 1, large parts of the interim pit stages form sections of the final pit walls, therefore the recommendations given in Table 8-1 apply to these pit stages also. For the walls of Pits 0, 1 and 2 that are not part of the final wall, the recommendation given in Table 8-1 also apply, but without the restrictions recommended for the overall slope angle (because the pits are of lesser depth).

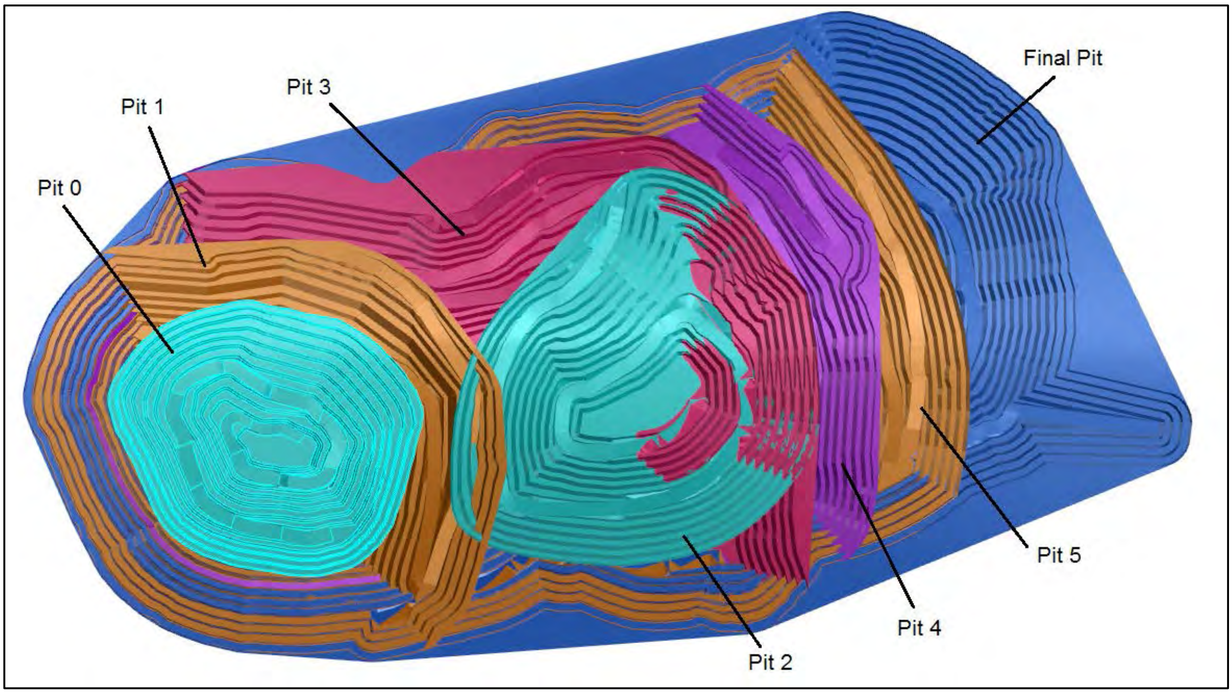

Figure 8-1: Planview showing interim pits and final Pit designs as provided by KGHM in late 2013

8.3 Construction of final pit design shells

The design recommendations provided in Table 8-1 should be coded into the block model for creation of the final mine design pit shells, using the pit sector wirefame solids provided by SRK and the existing latest geology model solids of KGHM.

SRK has not identified any specific areas of the pit where pit ramps cannot be included from a geotechnical stability/risk point of view. As the exact location of the pit ramps in the new designs is not currently known, the geotechnical evaluations have been carried out without the inclusion of ramps, but with the inclusion of geotechnical berms as described in Section 6.6.1. Pit ramps will serve to further decrease the overall slope angle slightly as they will be somewhat wider than the 25 m geotechnical berms. The intent is that the slope design angles in Table 8-1 should not be exceeded; however, the pit slope angles in certain places may be less due to practical consideration (such as the inclusion of ramps).

As mentioned in Section 4.1.1, rock of moderate quality or better is generally encountered at shallow depth across the site, within approximately 10 m or less of the surface. Highly weathered or soil-like materials would generally constitute only a portion of the first bench mined from surface and therefore slope design within such materials has not been the focus of this study. The depth to bedrock may locally be as much as 30 m, however. Without a good understanding of the detailed properties of the soil and/or highly weathered materials, it is recommended in general that soil-like or highly weathered materials are battered back to a bench face angle of 45°, and benches within these materials are limited to a height of 15 m. It is however recommended that the validity of these design assumptions are assessed in more detail in the future to ensure the optimum design is identified.

It is strongly recommended that SRK be of assistance to the KGHM mining engineers in the incorporation of the geotechnical design parameters into the construction of the new design shells in order to:

- provide any clarifications if necessary;
- assist with the elimination of sections of geotechnical berms in places where the insertion of ramps have made these redundant; and
- perform a final check of the new KGHM pit shell designs for compliance to the geotechnical recommendations.

8.4 Groundwater

Before implementation of the slope design, it is very important that the assumptions made in this study concerning the groundwater levels and pit slope depressurisation achievable should be confirmed as part of the current hydrogeological study updates.

If the drainage measures will not be able to achieve a groundwater pushback of at least 125 m behind the slope face (as assumed in this report), the pit wall angles will need to be re-assessed taking into account the expected groundwater conditions.

8.5 General recommendations for slope management

It is considered that the slope design recommendations presented in this report provide a fairly robust but not conservative solution to slope design within the Ajax Pits. The recommendations are intended to be suitable for pit walls that will need to remain stable for long periods of time.

It is therefore imperative that the integrity of the pit walls is maintained over time through rigorous monitoring and management practices.

Measures should be put in place to prevent drainage of surface water into the pit during mining operations, and to prevent pore pressure build-up in pit walls due to long term recharge or localised recharge from surface water. The measures may need to be modified as mining progresses, and must ensure that all surface water is efficiently drained away from the pit surrounds. Ponding of water on berms within the pit must be prevented. To facilitate berm drainage, consideration should be given to constructing berms with a cross-fall of 1-2%.

Vibrating wire piezometers should be installed at regular intervals around the pit perimeter for monitoring of groundwater levels and pore pressures. Piezometers should be installed at varying depths, down to the pit floor level.

During mining, the slopes should be managed and their performance monitored with regard to the expected design conditions, deformation rates, strains, blast conditions and slope depressurisation. Duties to be carried out as part of an open pit slope management programme should include the following:

Field Data Collection and Monitoring:

- Geotechnical mapping and inspection along benches.
- Geological and major structure mapping within the pit (possibly using photogrammetrical techniques).
- Creation and maintenance of lithology and major structures interpretations.

- Laboratory strength testing of rock materials and discontinuities.
- Developing and maintaining a monitoring system to provide early warning of instabilities (e.g. prisms, berm inspections, radar).
- The installation of piezometers for monitoring of groundwater with respect to geotechnical conditions and recommending appropriate control measures.
- Reporting back to mine management on stability and safety issues.
- Compilation of a rock mass failure register.
- Crack monitoring adjacent to failed areas or within areas of relaxation.
- Assisting in the review of drill and blast performance in the fresh rock.
- Ongoing training and implementation with external QA/QC.

Evaluation of Field Data:

- Developing a comprehensive structural model for slope design and dewatering.
- Review of monitoring data (from prisms and terrestrial laser scanning techniques, monitoring of tension cracks, berm inspections, piezometer information).
- Analysis of rock mass characterisation data.
- Analysis of structural data and evaluation of potential kinematic failure mechanisms.
- Conducting risk assessment of failures to determine likely effects on operations.
- Recommending changes to operating practices and design in light of encountered geotechnical conditions.
- Management of a geotechnical database.
- The overall objective and benefits of a geotechnical slope management programme is to provide input into mine design and mine safety issues.

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Principal Consultant

Peer Reviewed by

Ian de Bruyn

Principal Consultant

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ORIGINAL SIGNED [redacted]

Mr. Matthew Clark, P.Eng
APEGBC Membership ID#: 148133

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Appendices

Appendix A: Logging and Rock Mass Characterisation

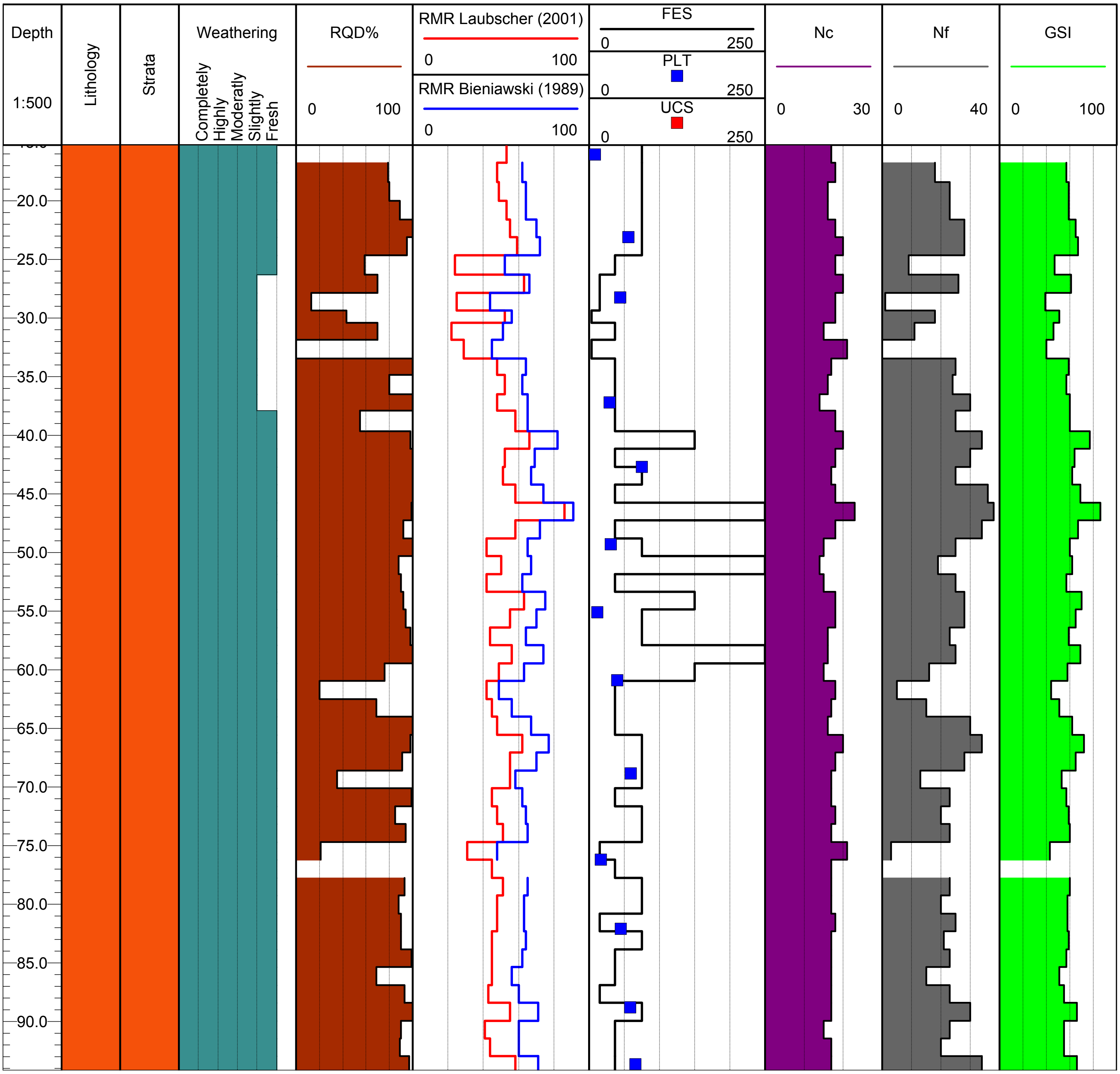
srk consulting

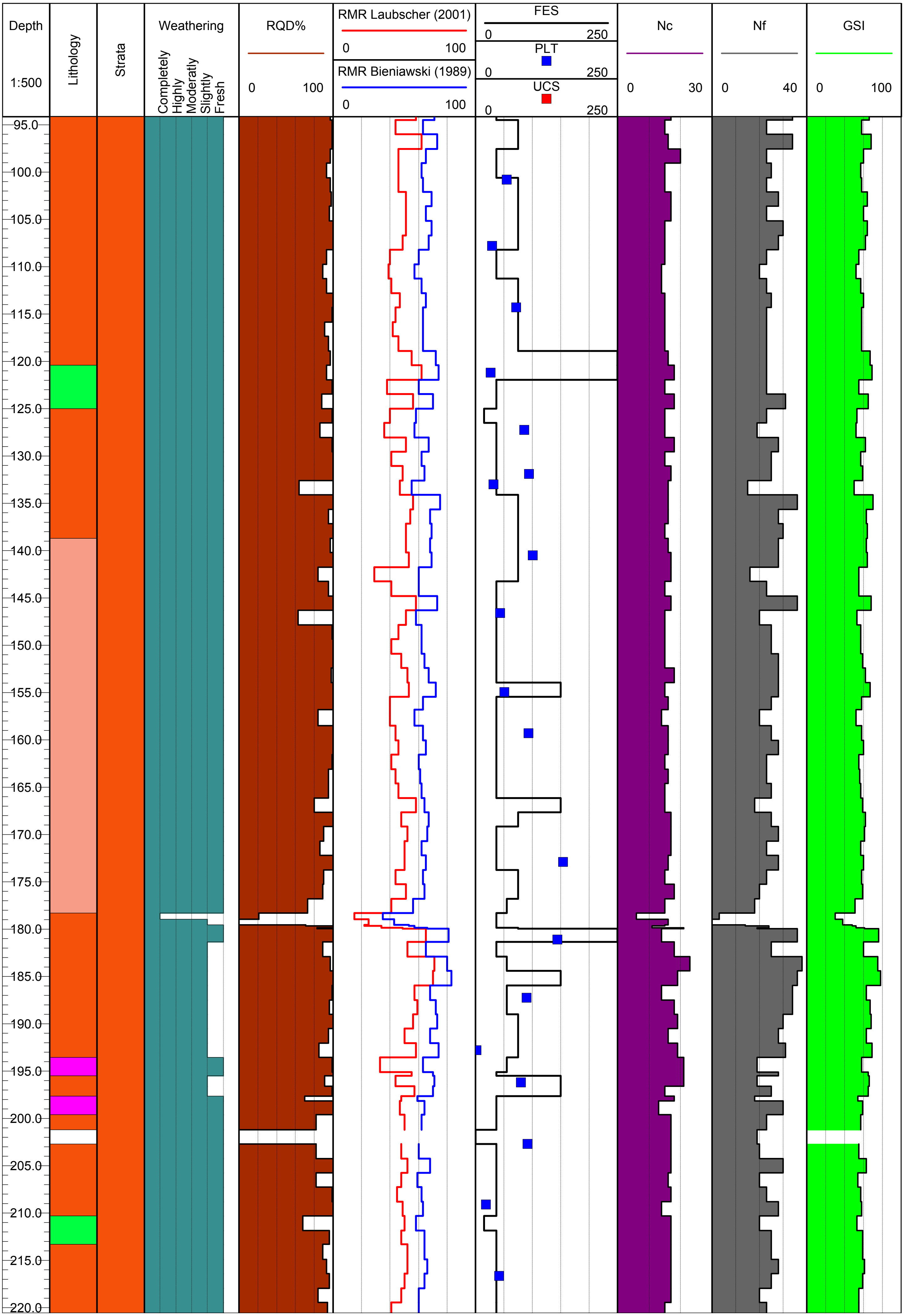
Geotechnical Borehole Log

Hole ID:	KAX-13-098	Project:	Ajax	SRK Project No:	KGH001
Easting:	684388	Northing:	5610139	RL:	920
Dip:	64	Azimuth:	165	Depth:	411.48m
Log From:	15.24m	Log To:	449.88m		

Lithology and Stratigraphy

- DYKE - Dyke
- MAFV - Mafic Volcanic
- PICR - Picrite
- N/L - Not Logged
- IMH - Iron Mask Hybrid
- MONZ - Monzonite
- PXPP - Pyroxene Plagioclase Porphyry
- LAT - Laterite
- SLD - Sugarloaf Diorite
- SVHYB - Sugarloaf/Volcanic Hybrid

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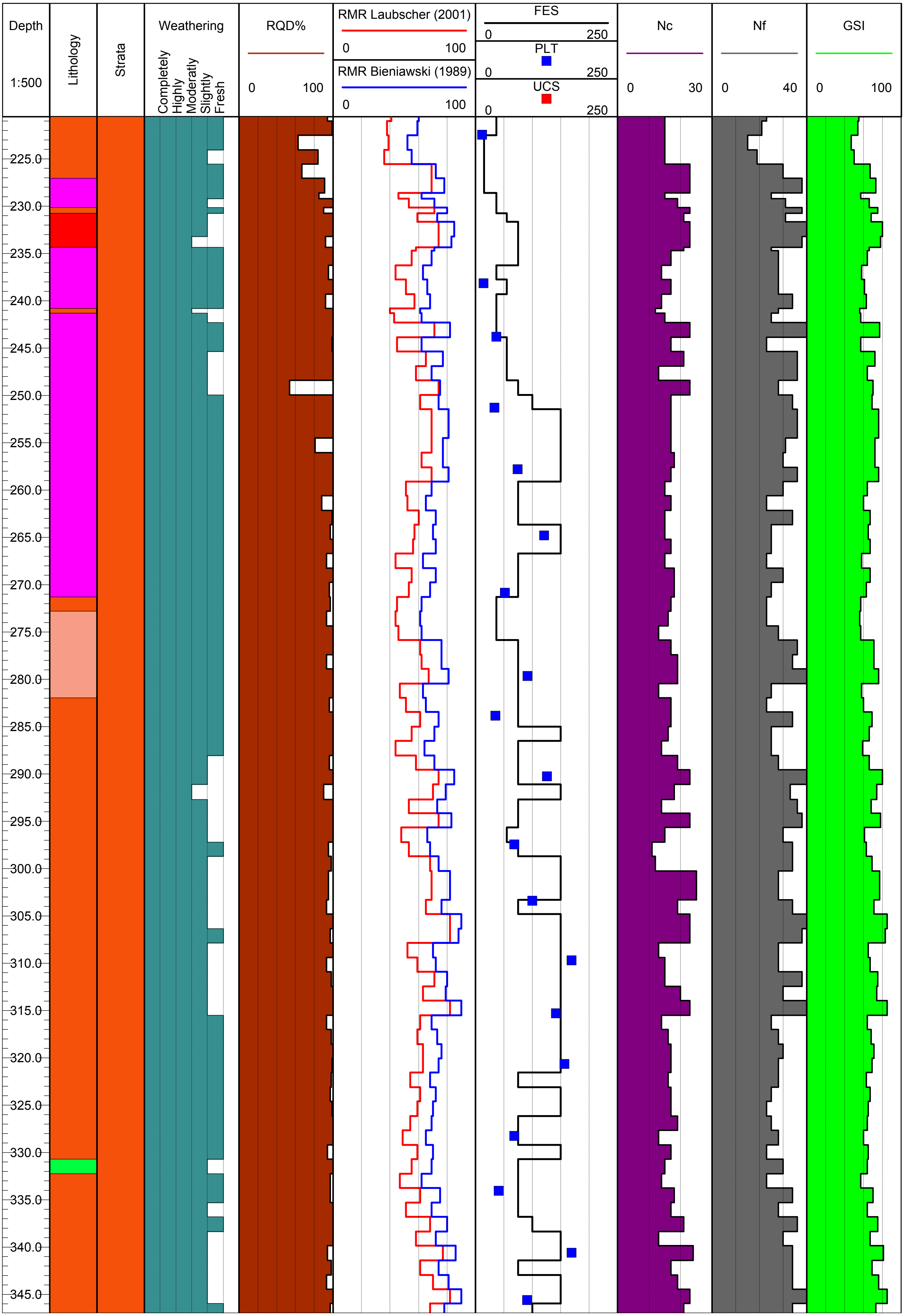

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RMR Bieniawski (1989)
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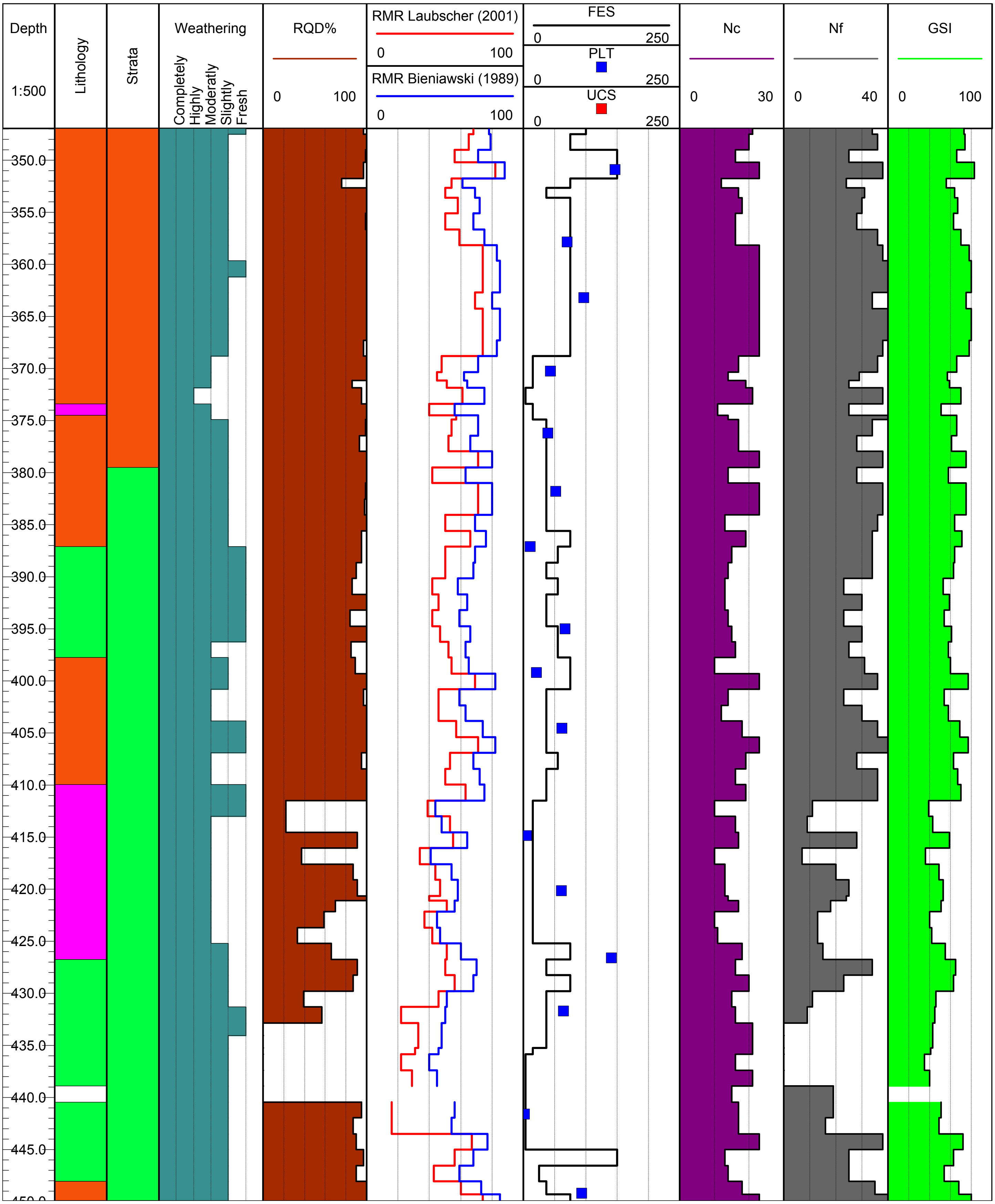
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Geotechnical Borehole Log

Hole ID:	KAX-13-099	Project:	Ajax	SRK Project No:	KGH001
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Dip:	63	Azimuth:	208	Depth:	449.88m
Log From:	21.95m	Log To:	449.89m		

Lithology and Stratigraphy

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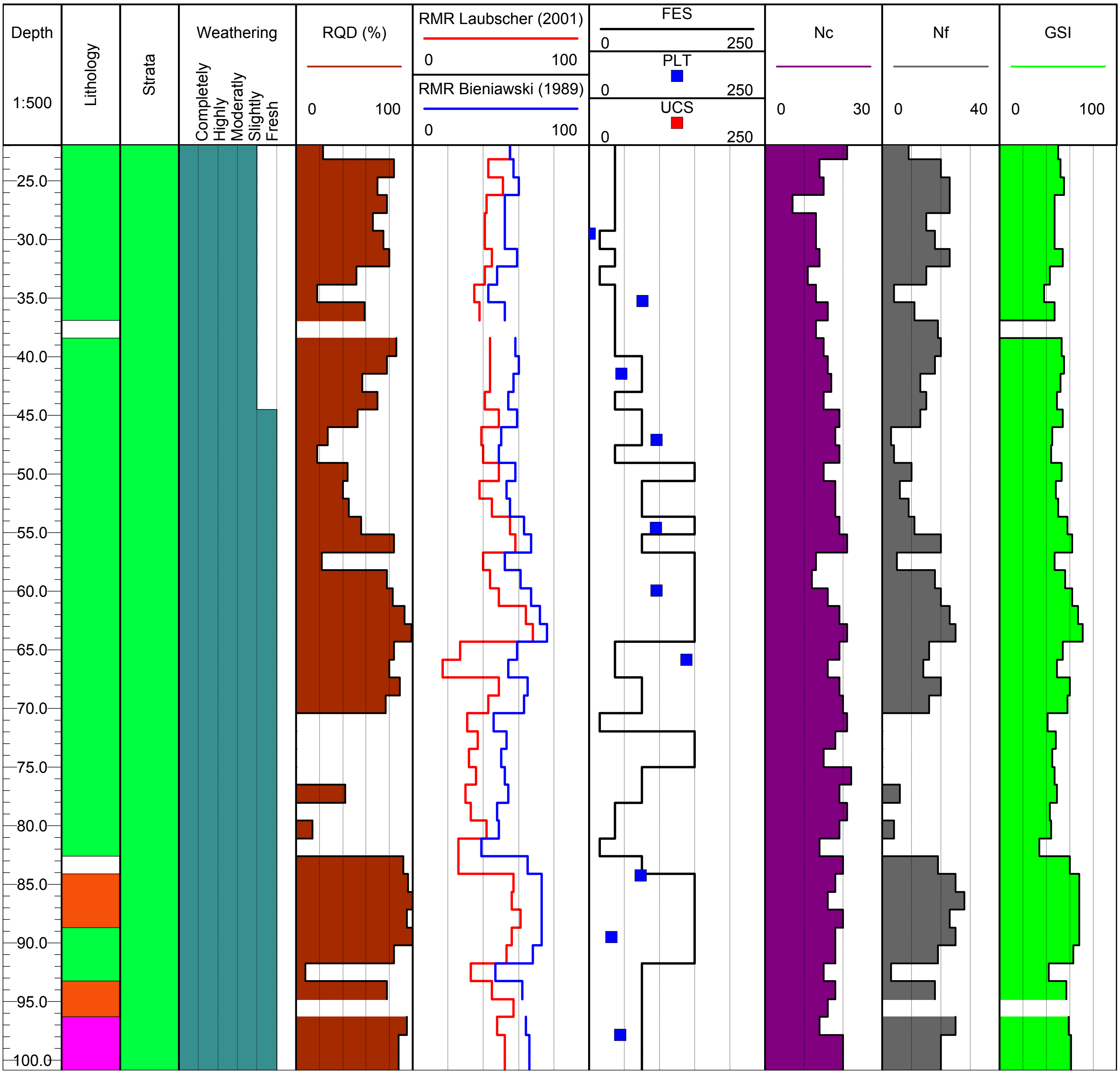

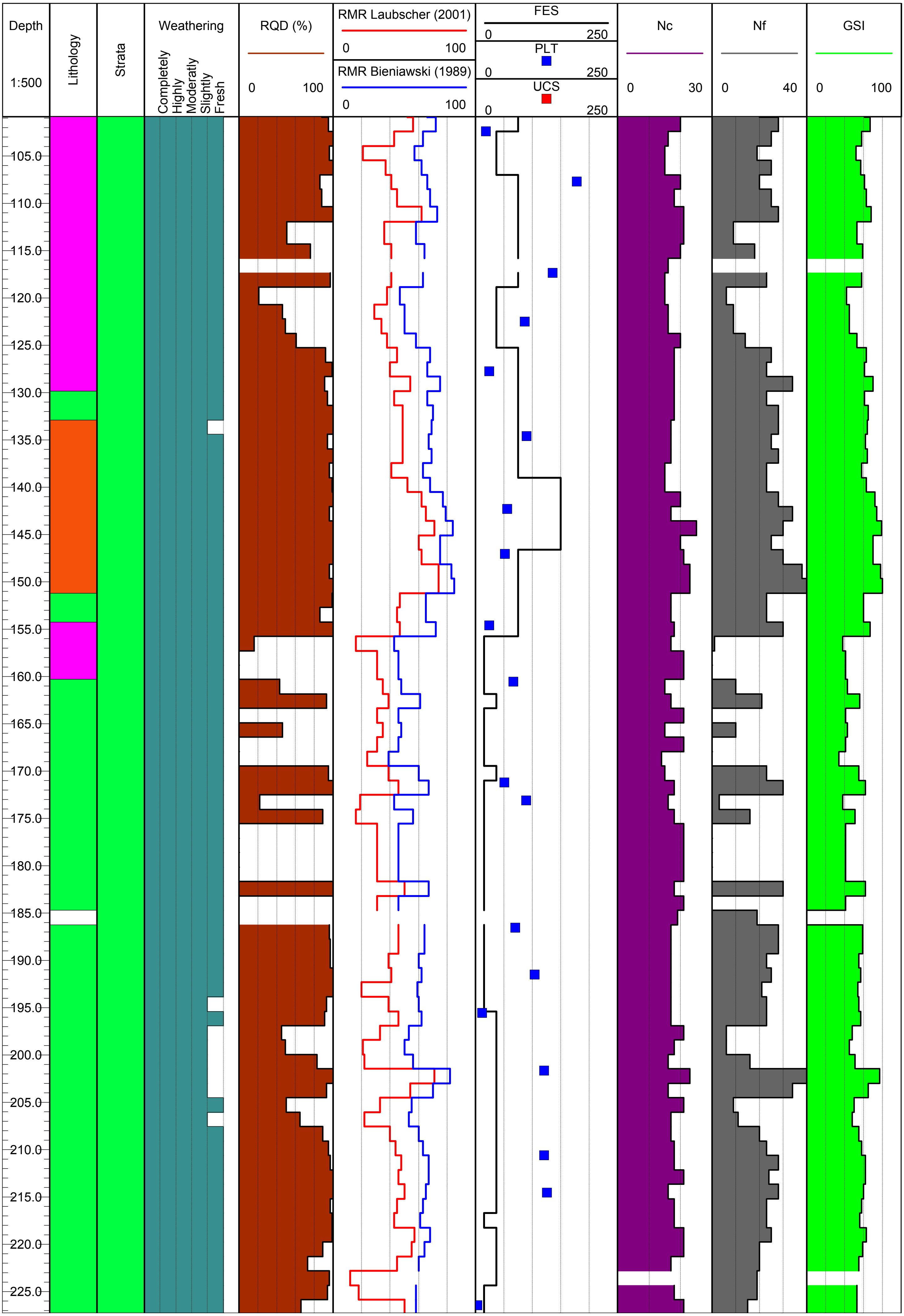

Depth
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RQD (%)
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0 100
FES
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PLT
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UCS
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Nf
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GSI
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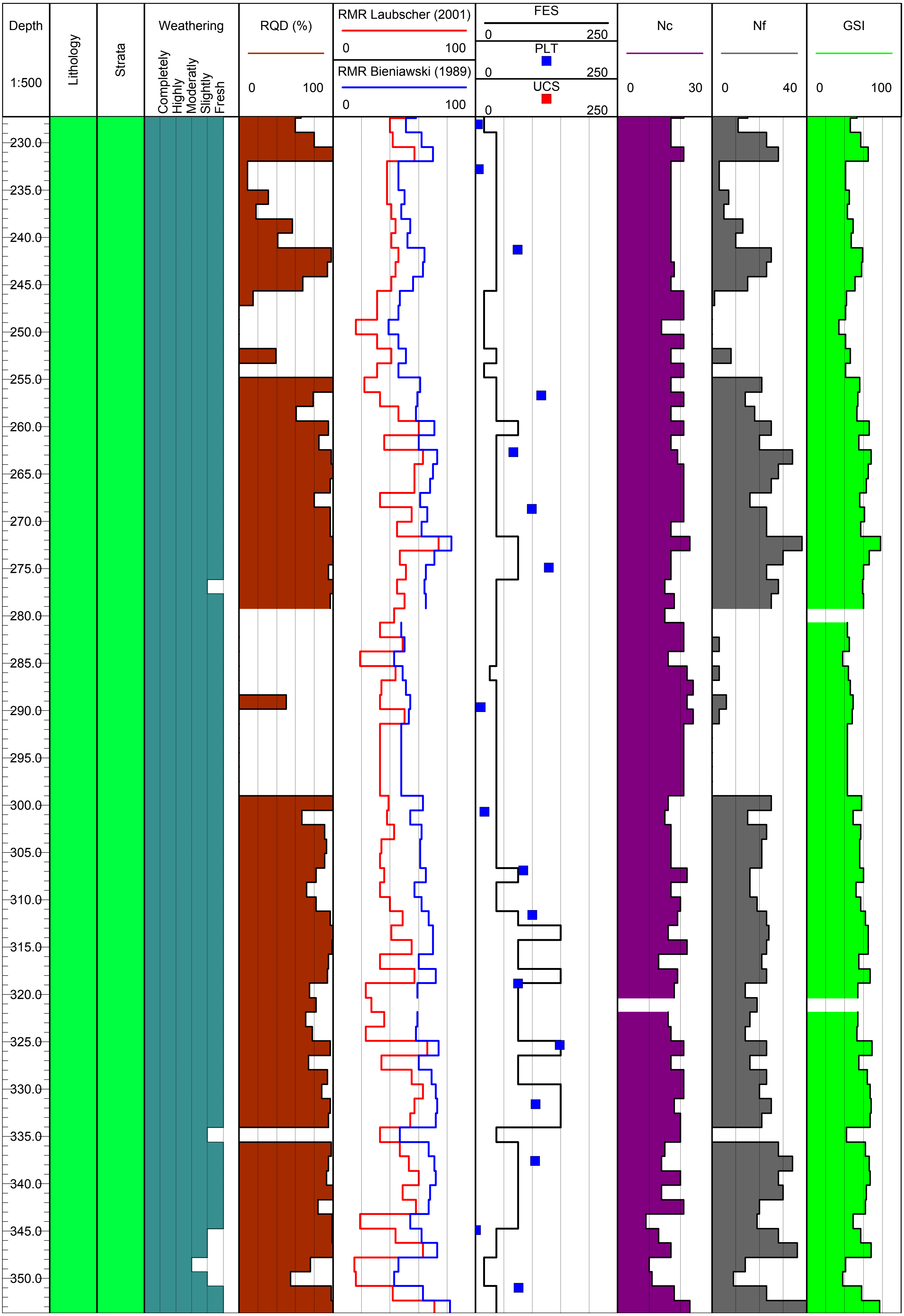

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Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
FES
0
250
PLT
0
250
UCS
0
250
Nc
0
30
Nf
0
40
GSI
0
100
230.0
235.0
240.0
245.0
250.0
255.0
260.0
265.0
270.0
275.0
280.0
285.0
290.0
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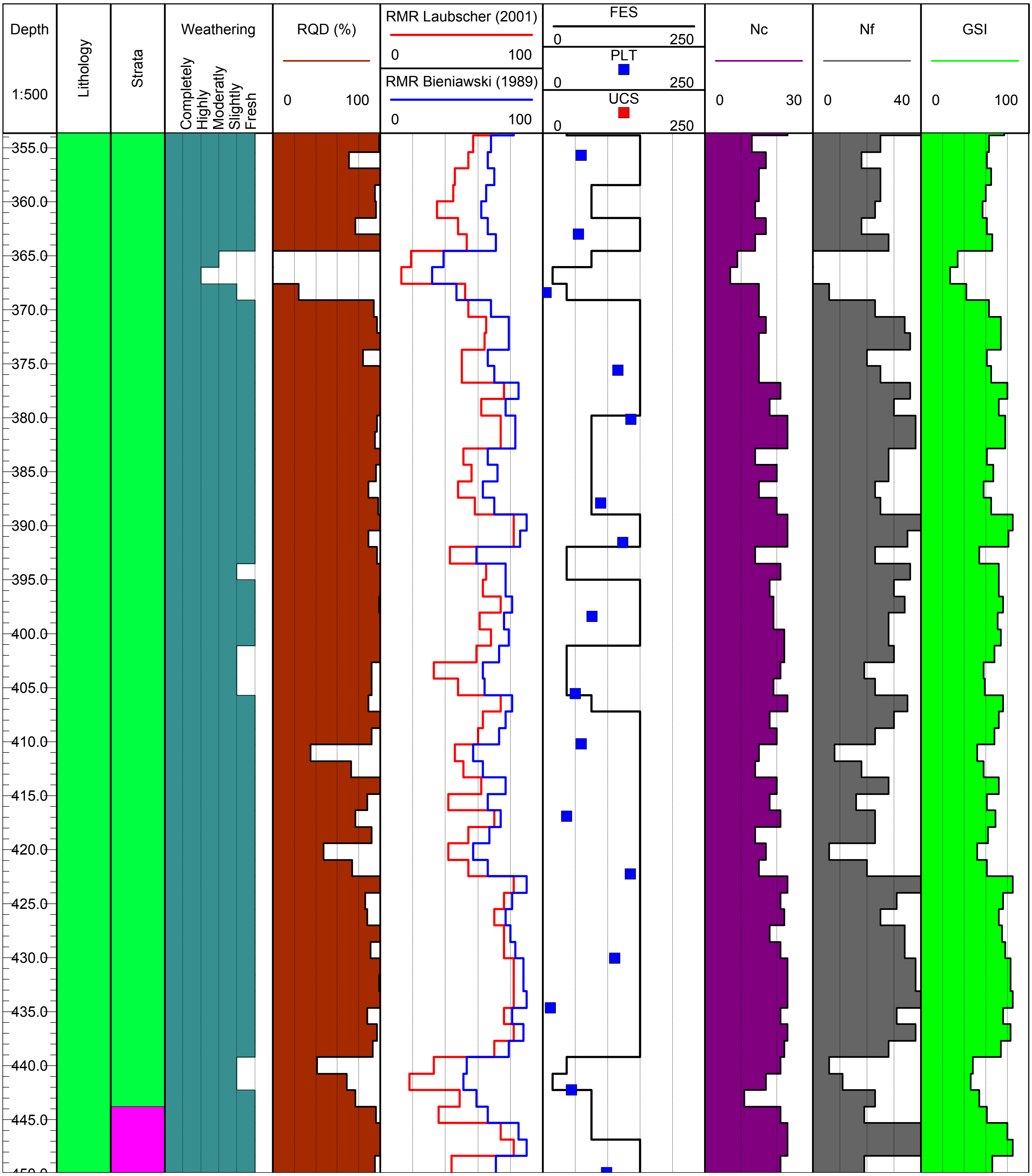
350.0

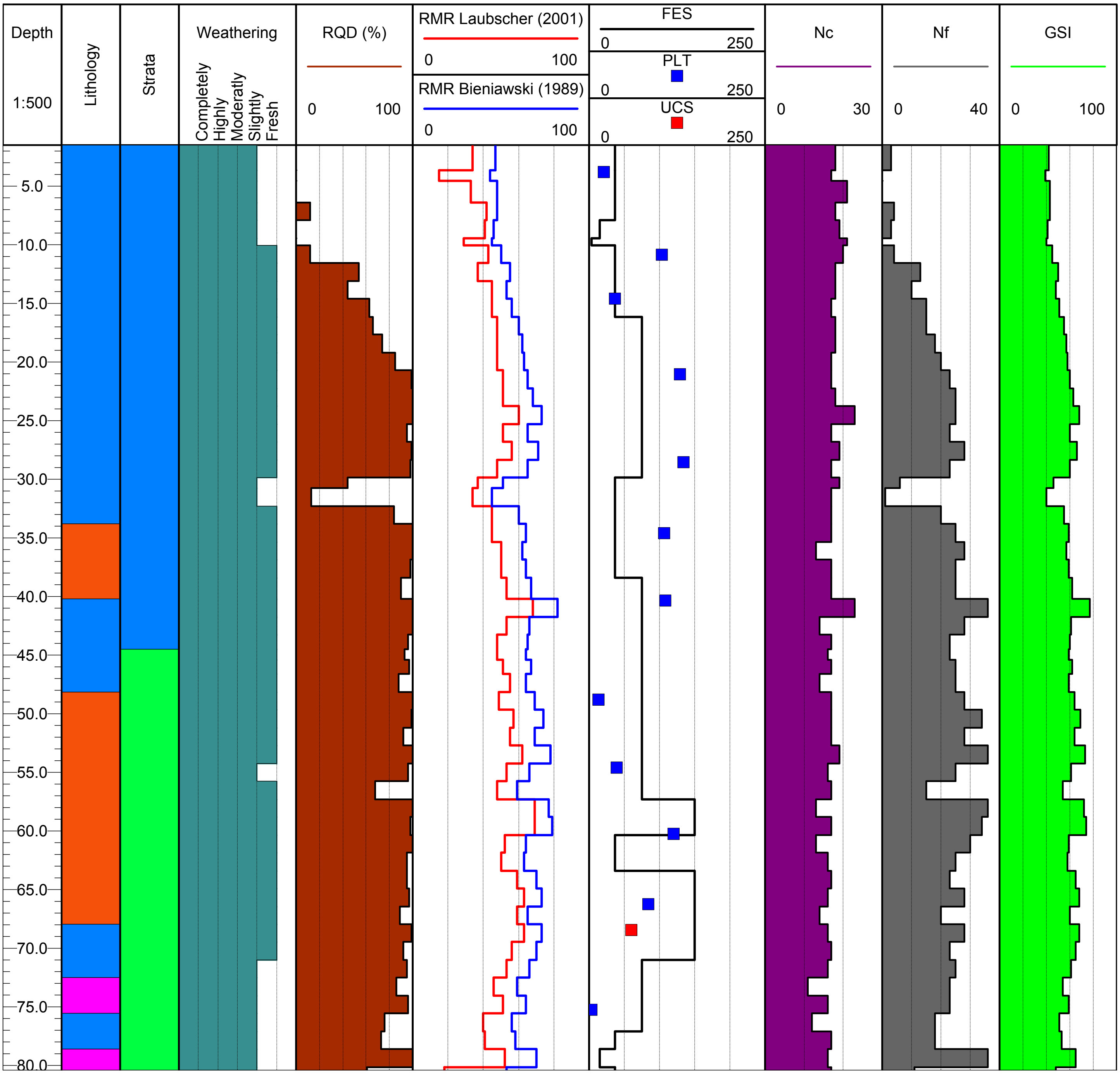

Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
FES
0 250
PLT
0 250
UCS
0 250
Nc
0 30
Nf
0 40
GSI
0 100
355.0
360.0
365.0
370.0
375.0
380.0
385.0
390.0
395.0
400.0
405.0
410.0
415.0
420.0
425.0
430.0
435.0
440.0
445.0

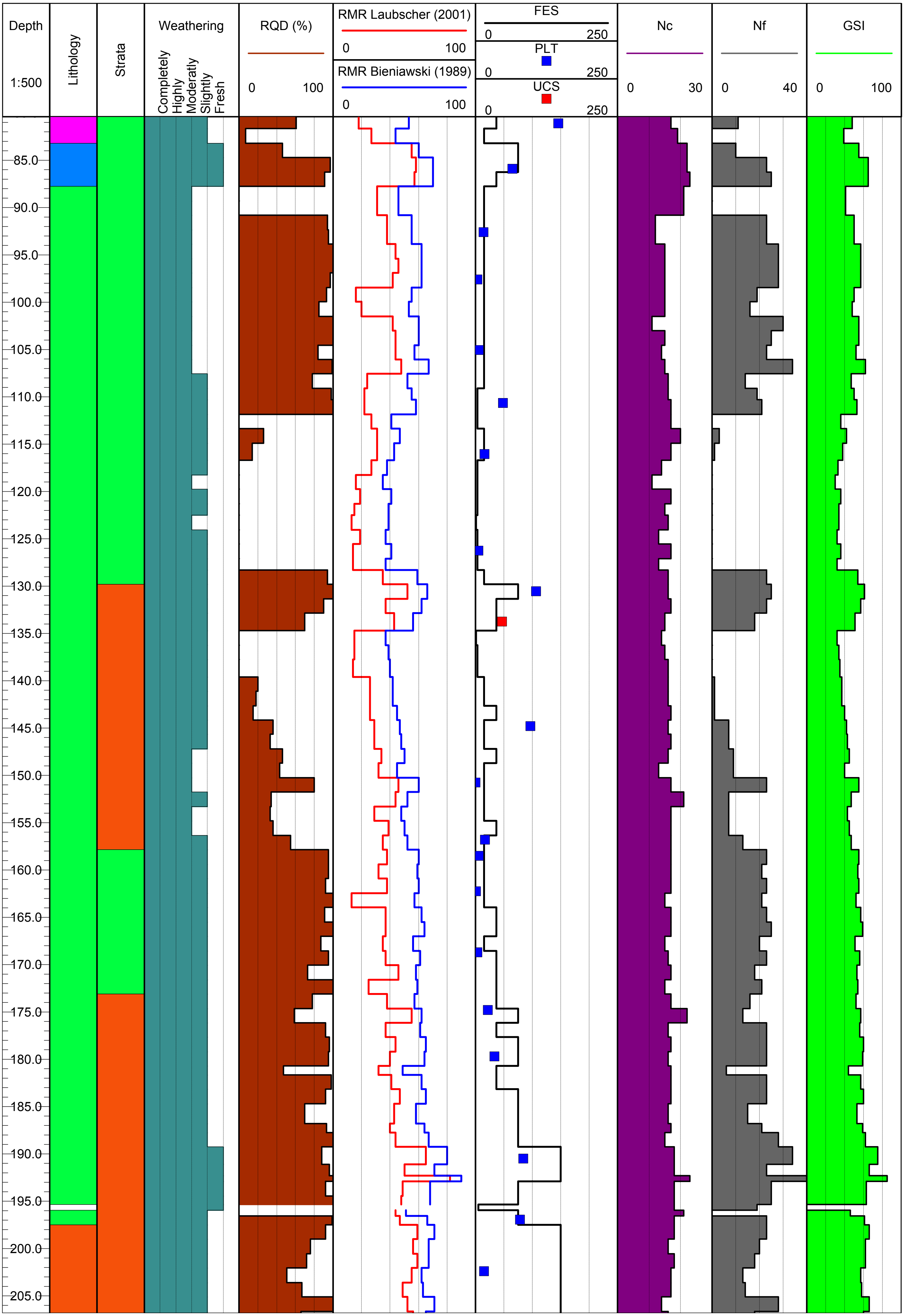
Geotechnical Borehole Log

Hole ID:	KAX-13-100	Project:	Ajax	SRK Project No:	KGH001
Easting:	5609410	Northing:	683714	RL:	920
Dip:	65	Azimuth:	140	Depth:	450.49m
Log From:	1.52m	Log To:	449.88m		

Lithology and Stratigraphy

- DYKE - Dyke
- IMH - Iron Mask Hybrid
- LAT - Laterite
- MAFV - Mafic Volcanic
- MONZ - Monzonite
- SLD - Sugarloaf Diorite
- PICR - Picrite
- PXPP - Pyroxene Plagioclase Porphyry
- SVHYB - Sugarloaf/Volcanic Hybrid
- N/L - Not Logged





Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
FES
0 250
PLT
0 250
UCS
0 250
Nc
0 30
Nf
0 40
GSI
0 100
85.0
90.0
95.0
100.0
105.0
110.0
115.0
120.0
125.0
130.0
135.0
140.0
145.0
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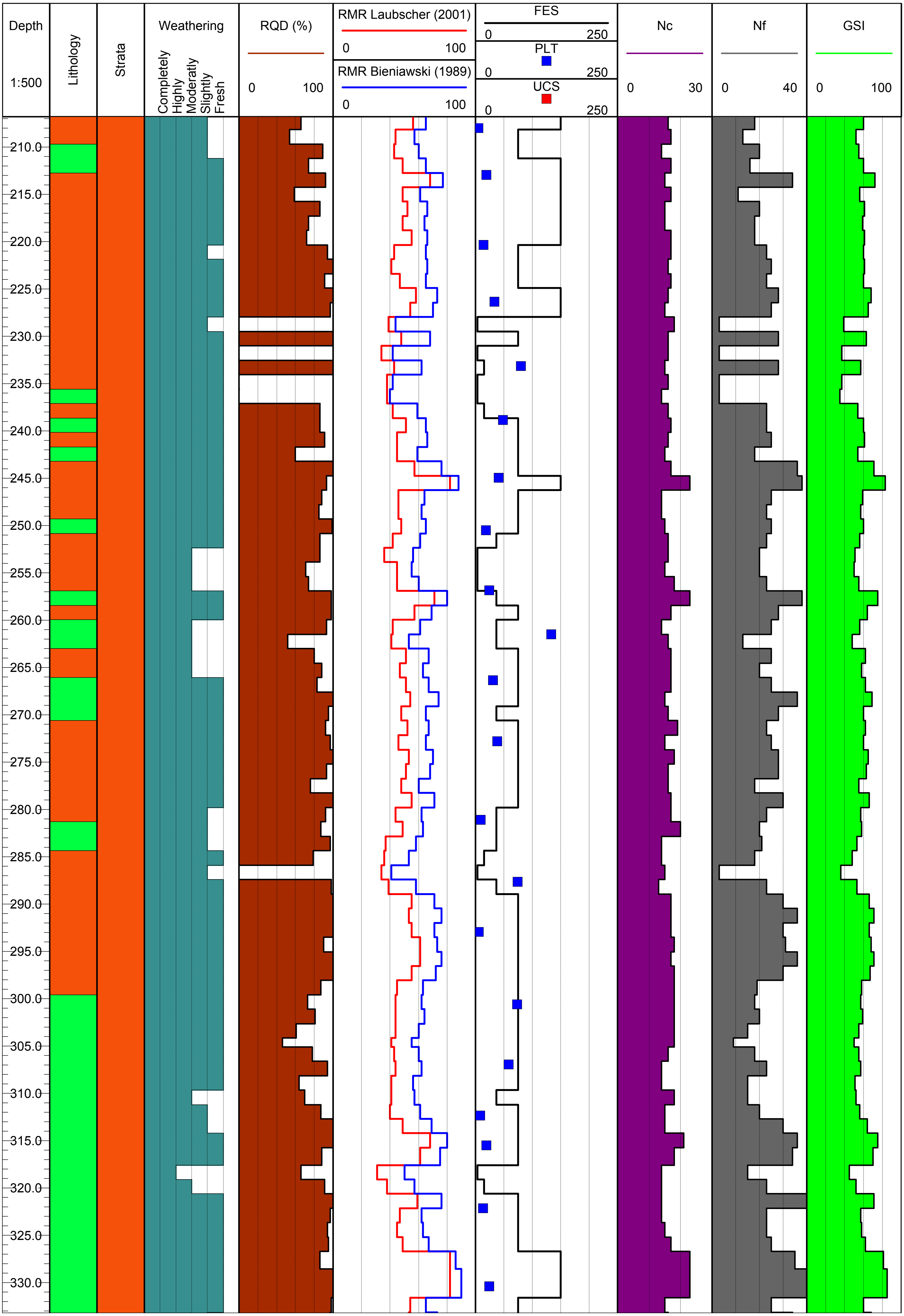
200.0
205.0



Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
FES
0 250
PLT
0 250
UCS
0 250
Nc
0 30
Nf
0 40
GSI
0 100
210.0
215.0
220.0
225.0
230.0
235.0
240.0
245.0
250.0
255.0
260.0
265.0
270.0
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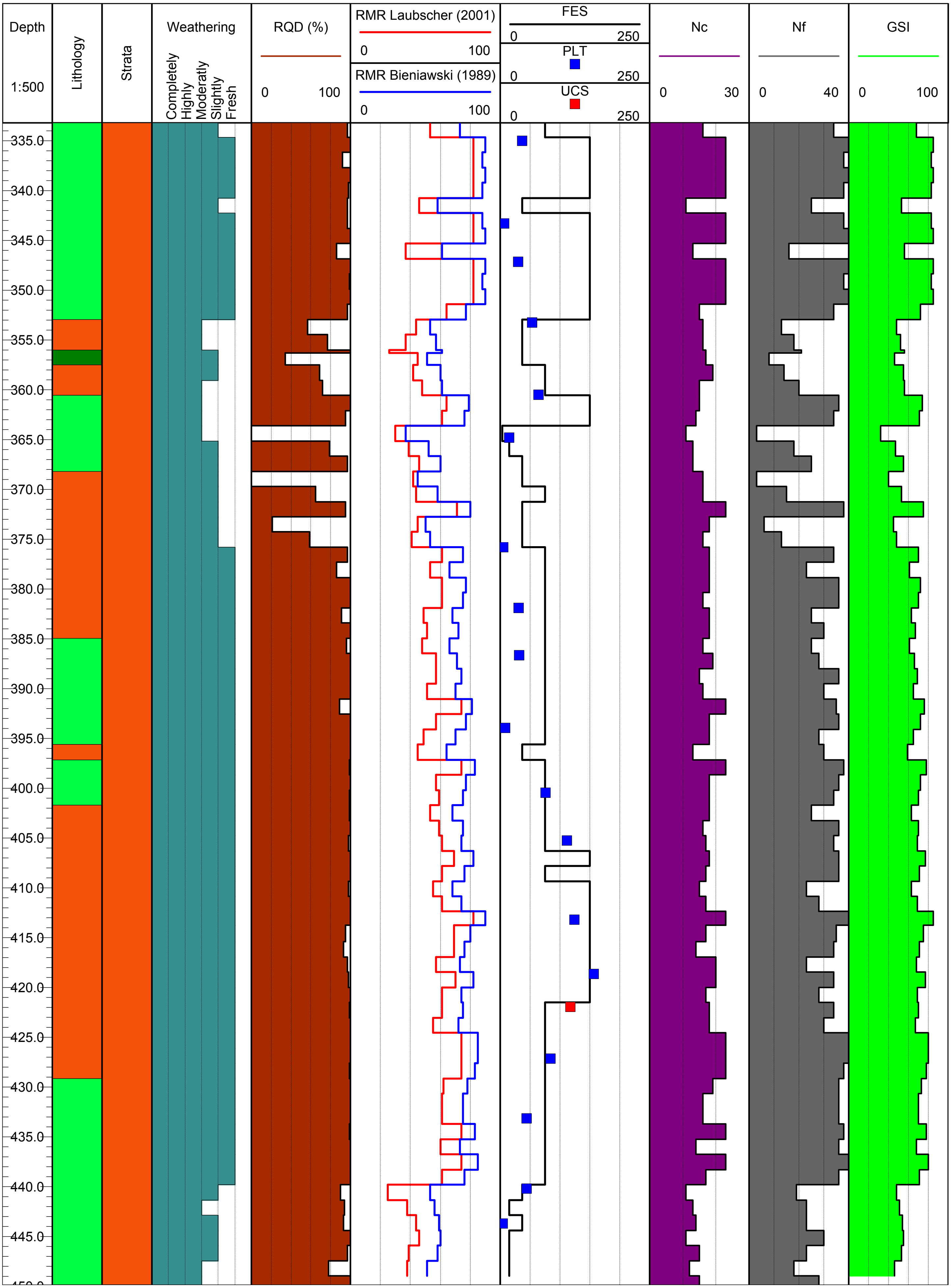
330.0



Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
FES
0
250
PLT
0
250
UCS
0
250
Nc
0
30
Nf
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GSI
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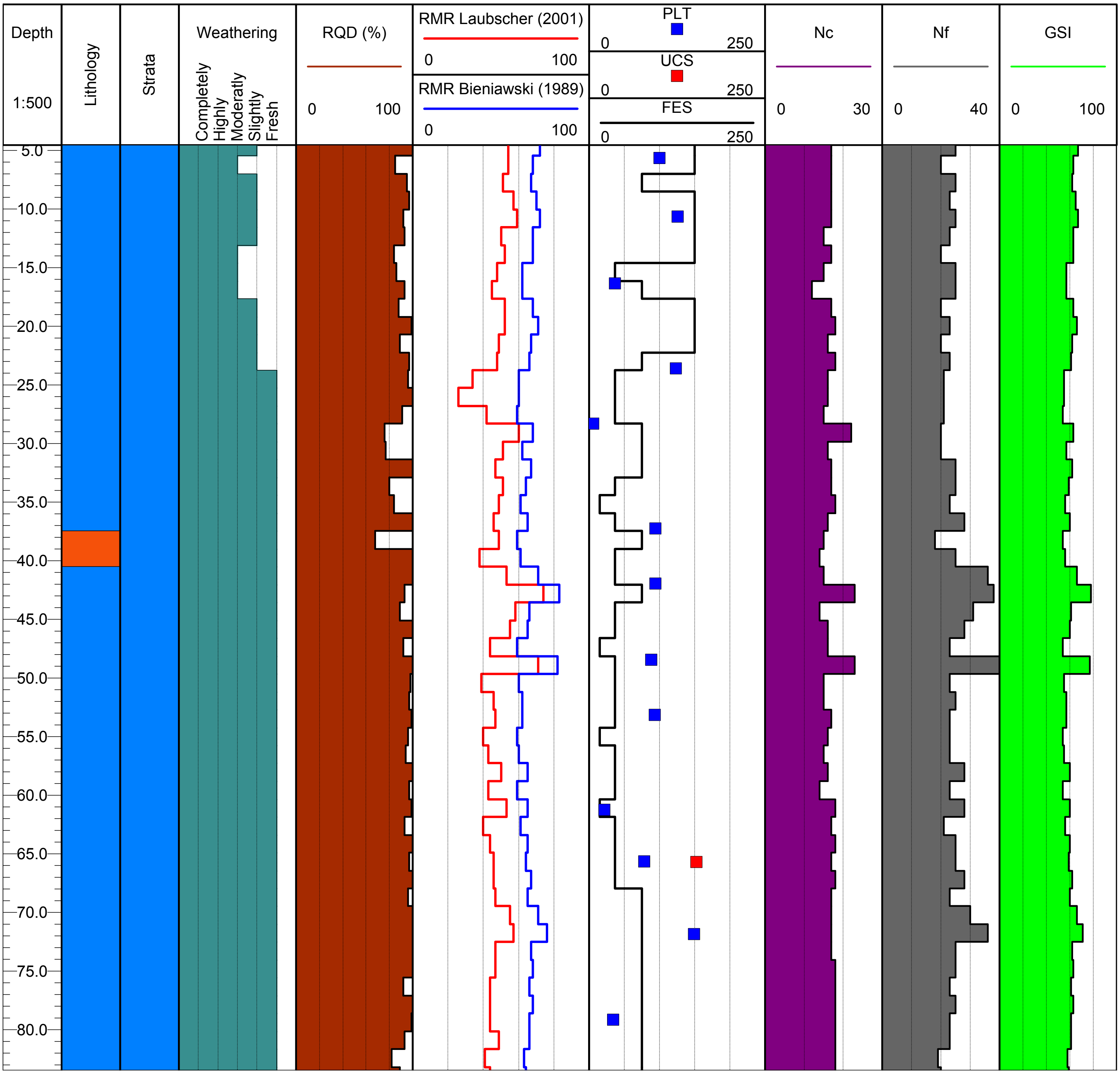
355.0
360.0
365.0
370.0
375.0
380.0
385.0
390.0
395.0
400.0
405.0
410.0
415.0
420.0
425.0
430.0
435.0
440.0
445.0

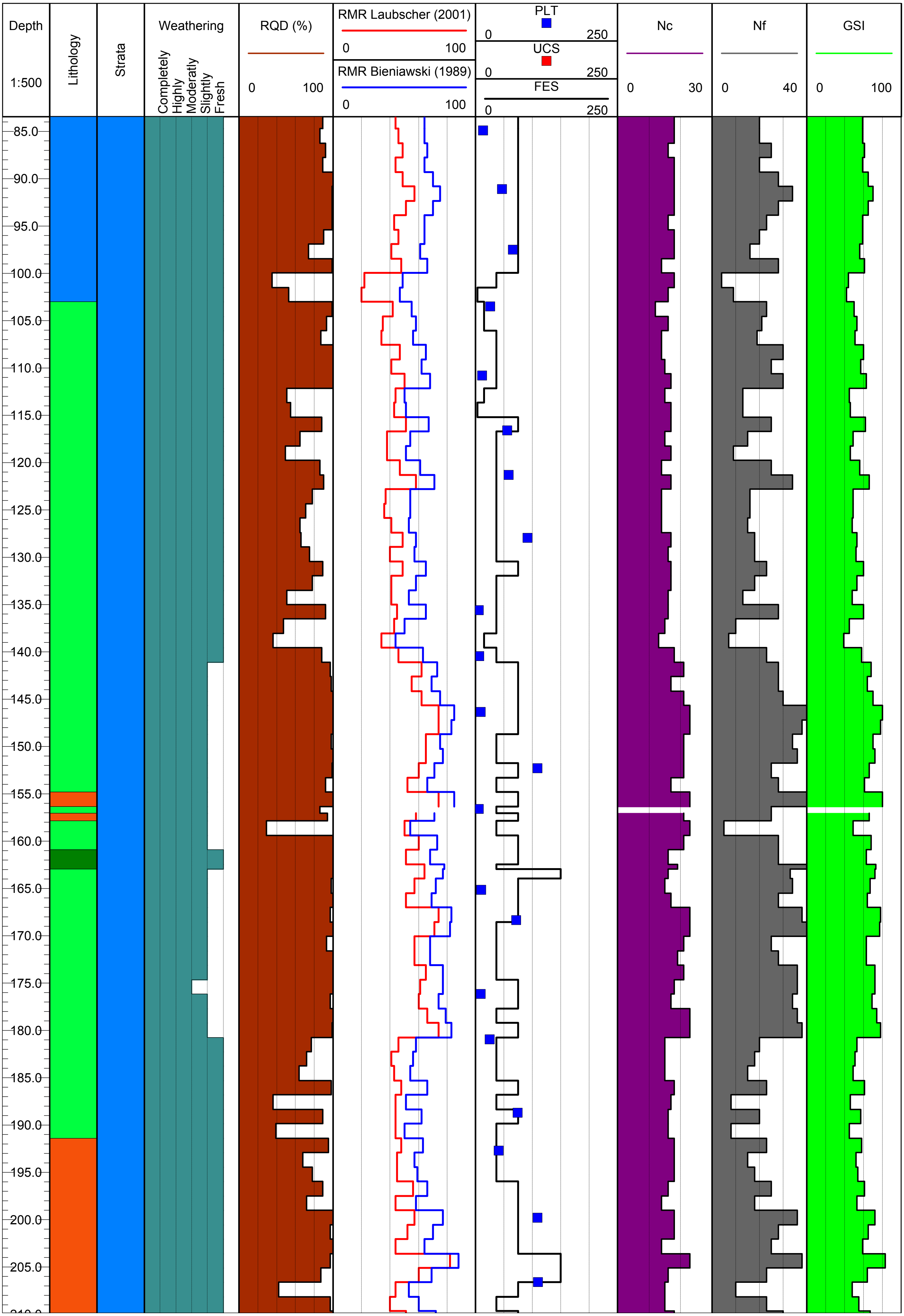
Geotechnical Borehole Log

Hole ID:	KAX-13-101	Project:	Ajax	SRK Project No:	KGH001
Easting:	684098	Northing:	5609371	RL:	920
Dip:	63	Azimuth:	012	Depth:	400.20m
Log From:	4.57m	Log To:	400.20m		

Lithology and Stratigraphy

DYKE - Dyke	MAFV - Mafic Volcanic	PICR - Picrite	N/L - Not Logged
IMH - Iron Mask Hybrid	MONZ - Monzonite	PXPP - Pyroxene Plagioclase Porphyry	
LAT - Laterite	SLD - Sugarloaf Diorite	SVHYB - Sugarloaf/Volcanic Hybrid	




Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
PLT
0
250
UCS
0
250
FES
0
250
Nc
0
30
Nf
0
40
GSI
0
100
85.0
90.0
95.0
100.0
105.0
110.0
115.0
120.0
125.0
130.0
135.0
140.0
145.0
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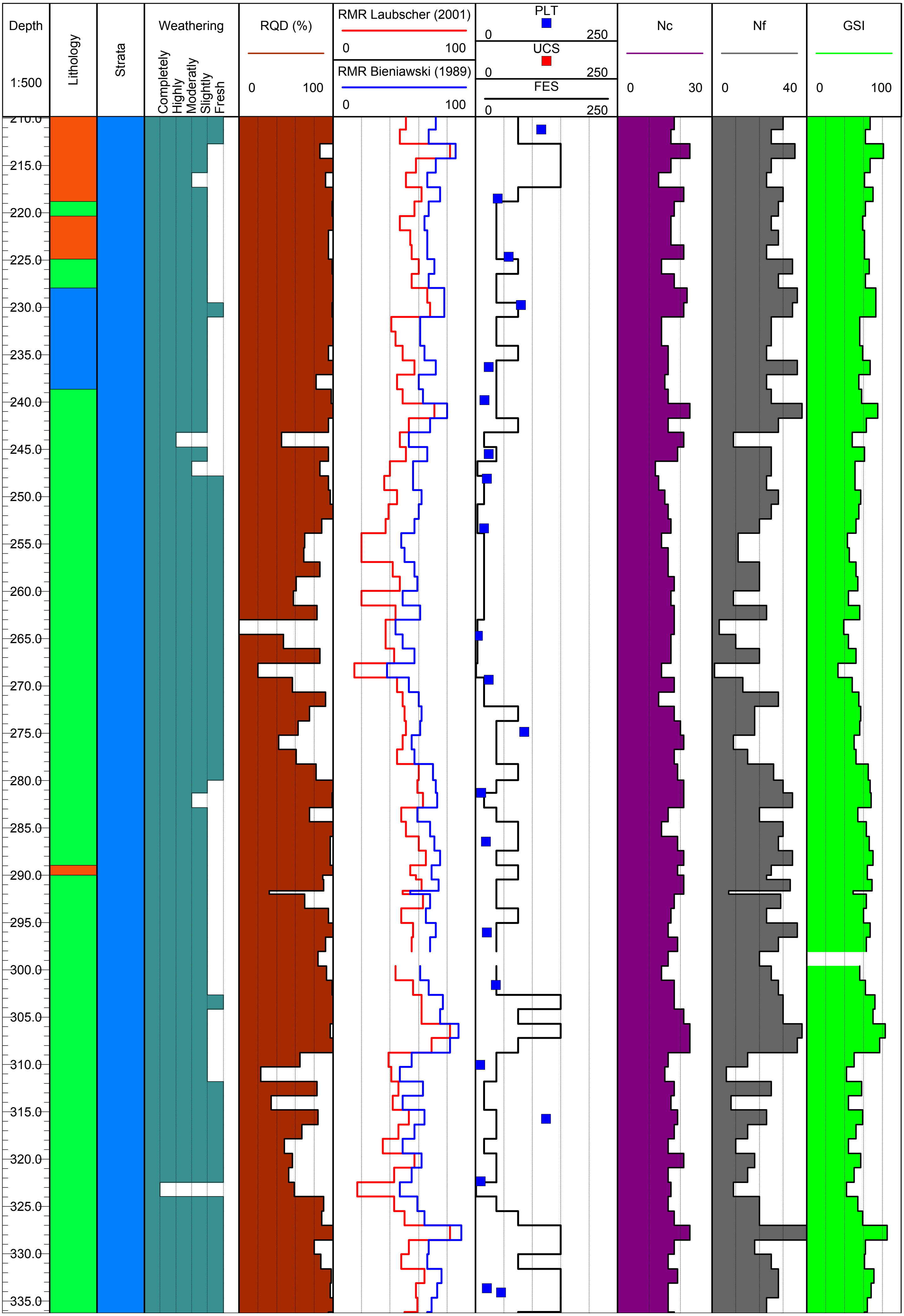
205.0


Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
PLT
0
250
UCS
0
250
FES
0
250
Nc
0
30
Nf
0
40
GSI
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210.0
215.0
220.0
225.0
230.0
235.0
240.0
245.0
250.0
255.0
260.0
265.0
270.0
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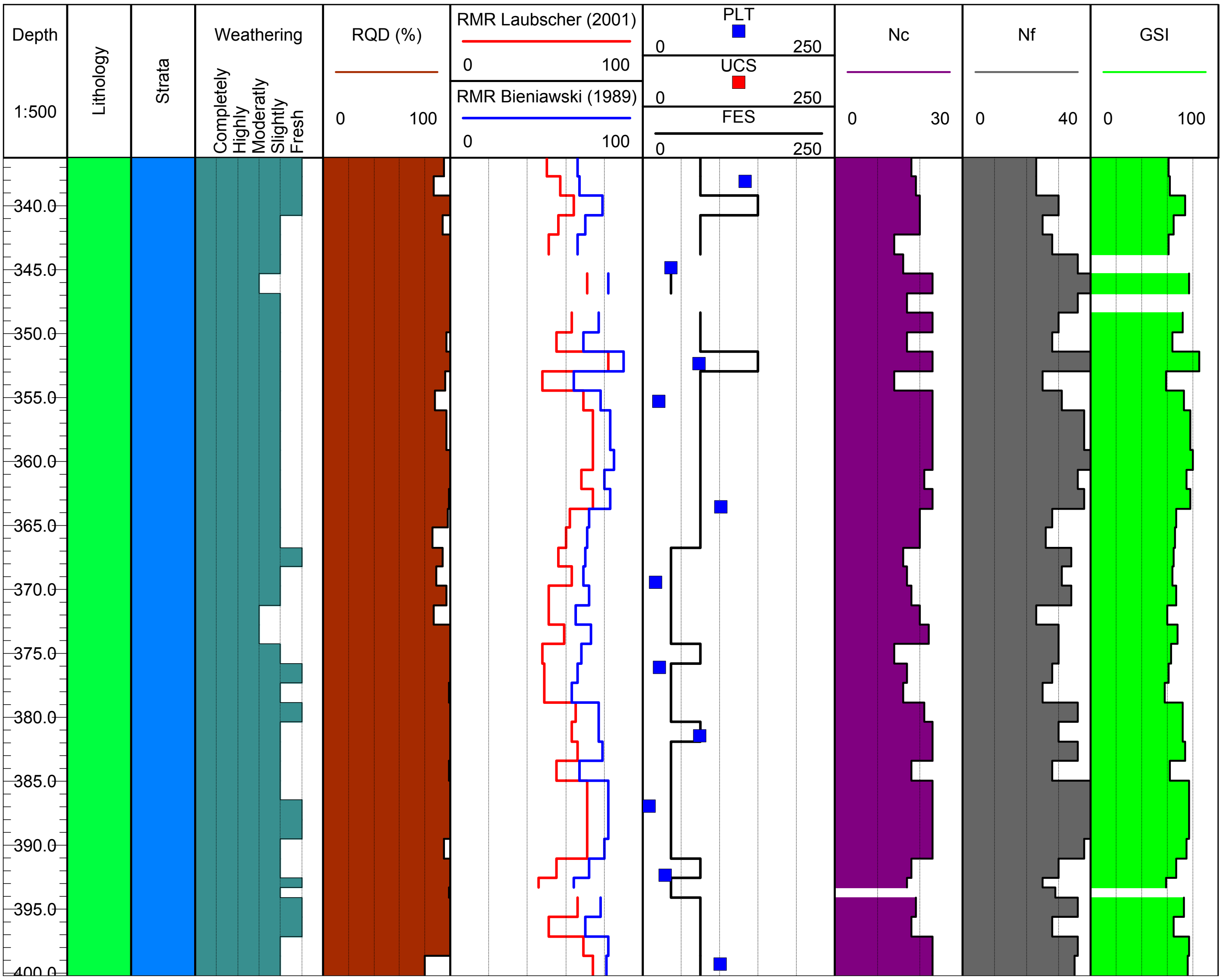
330.0
335.0

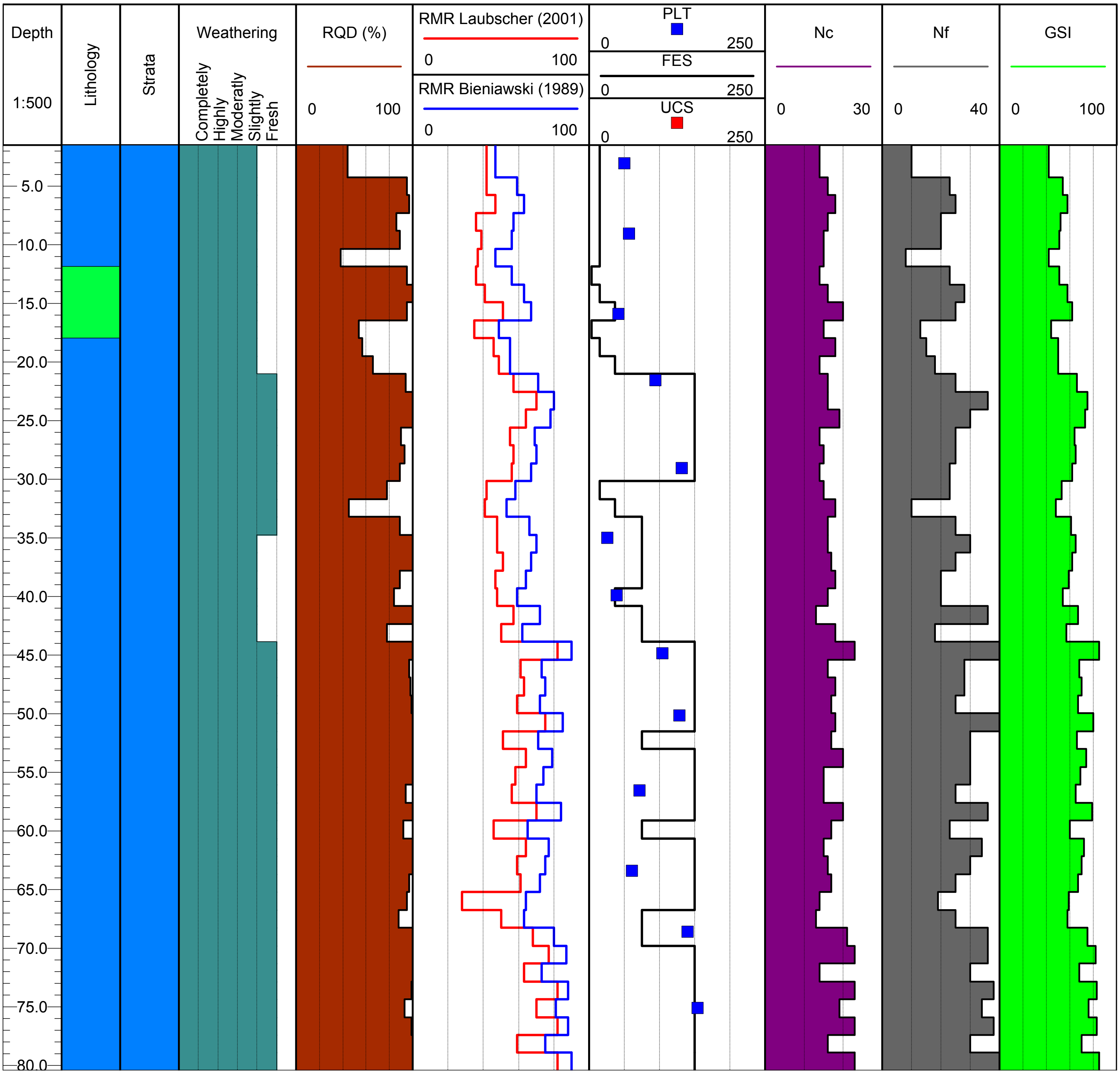

Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
PLT
0 250
UCS
0 250
FES
0 250
Nc
0 30
Nf
0 40
GSI
0 100
340.0
345.0
350.0
355.0
360.0
365.0
370.0
375.0
380.0
385.0
390.0
395.0
400.0

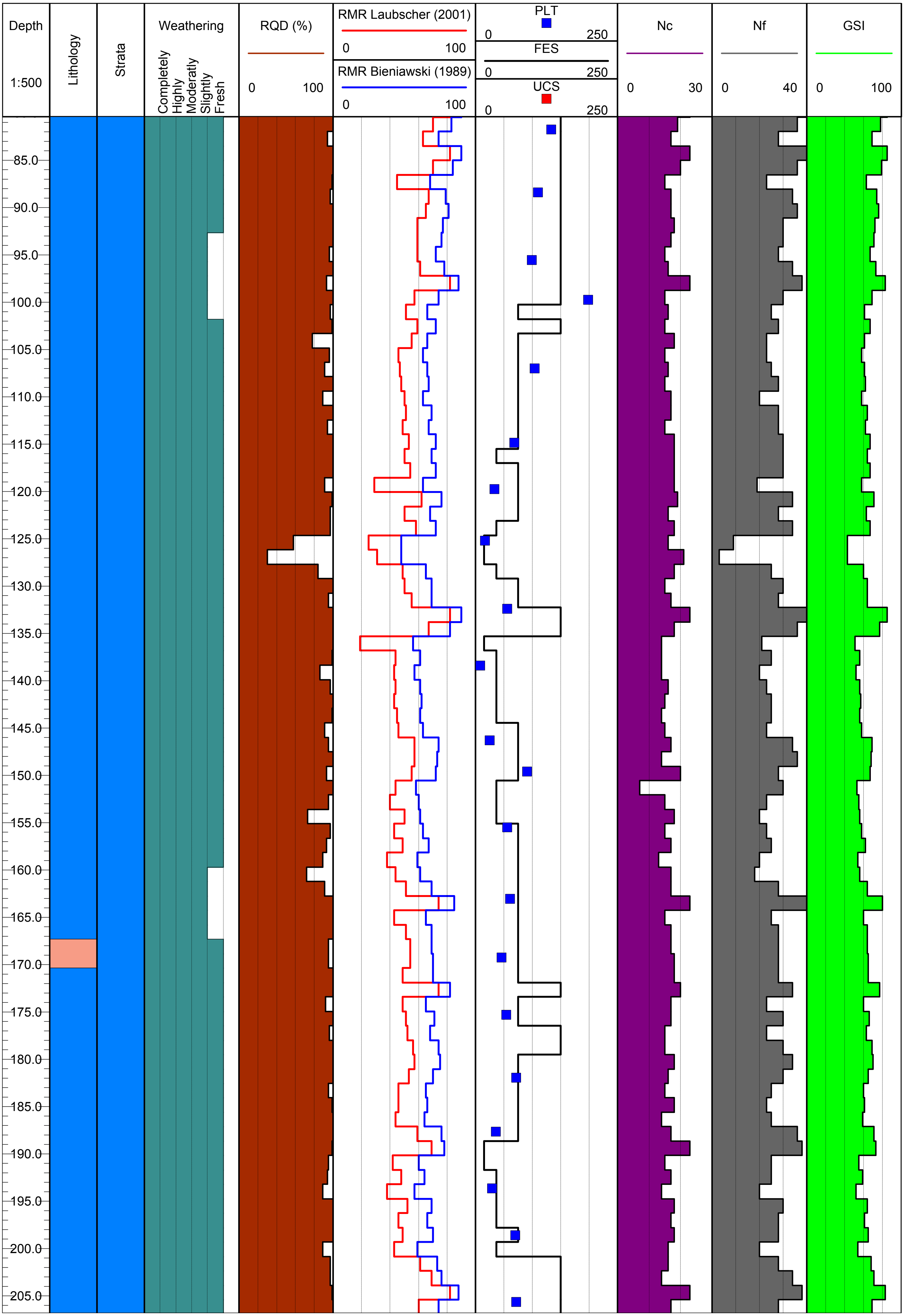
Geotechnical Borehole Log

Hole ID:	KAX-13-102	Project:	Ajax	SRK Project No:	KGH001
Easting:	684705	Northing:	5609581	RL:	920
Dip:	66	Azimuth:	264	Depth:	449.28
Log From:	1.52m	Log To:	449.25m		

Lithology and Stratigraphy

DYKE - Dyke
IMH - Iron Mask Hybrid
LAT - Laterite
MAFV - Mafic Volcanic
MONZ - Monzonite
SLD - Sugarloaf Diorite
PICR - Picrite
PXPP - Pyroxene Plagioclase Porphyry
SVHYB - Sugarloaf/Volcanic Hybrid
N/L - Not Logged





Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
PLT
0 250
FES
0 250
UCS
0 250
Nc
0 30
Nf
0 40
GSI
0 100
85.0
90.0
95.0
100.0
105.0
110.0
115.0
120.0
125.0
130.0
135.0
140.0
145.0
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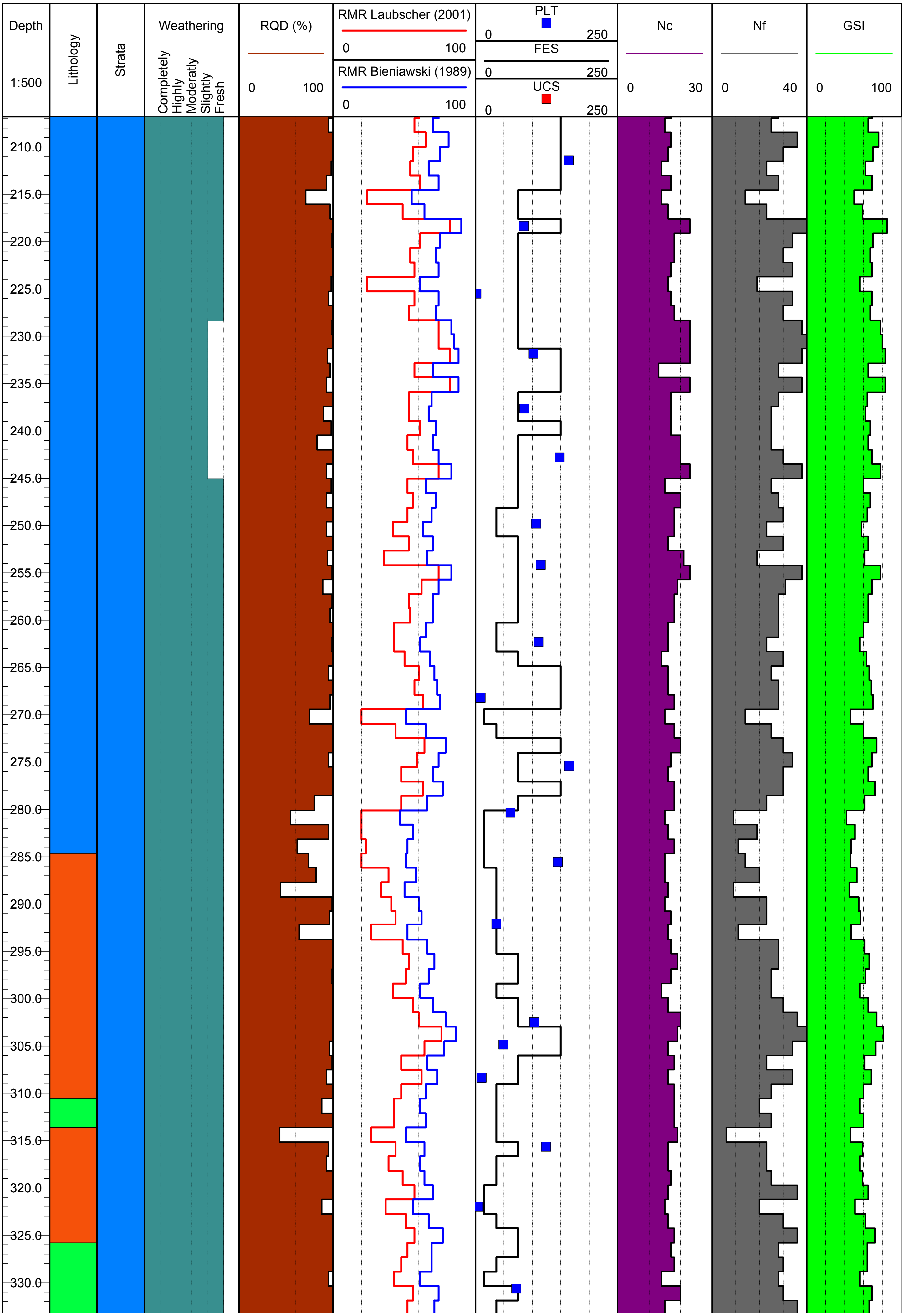
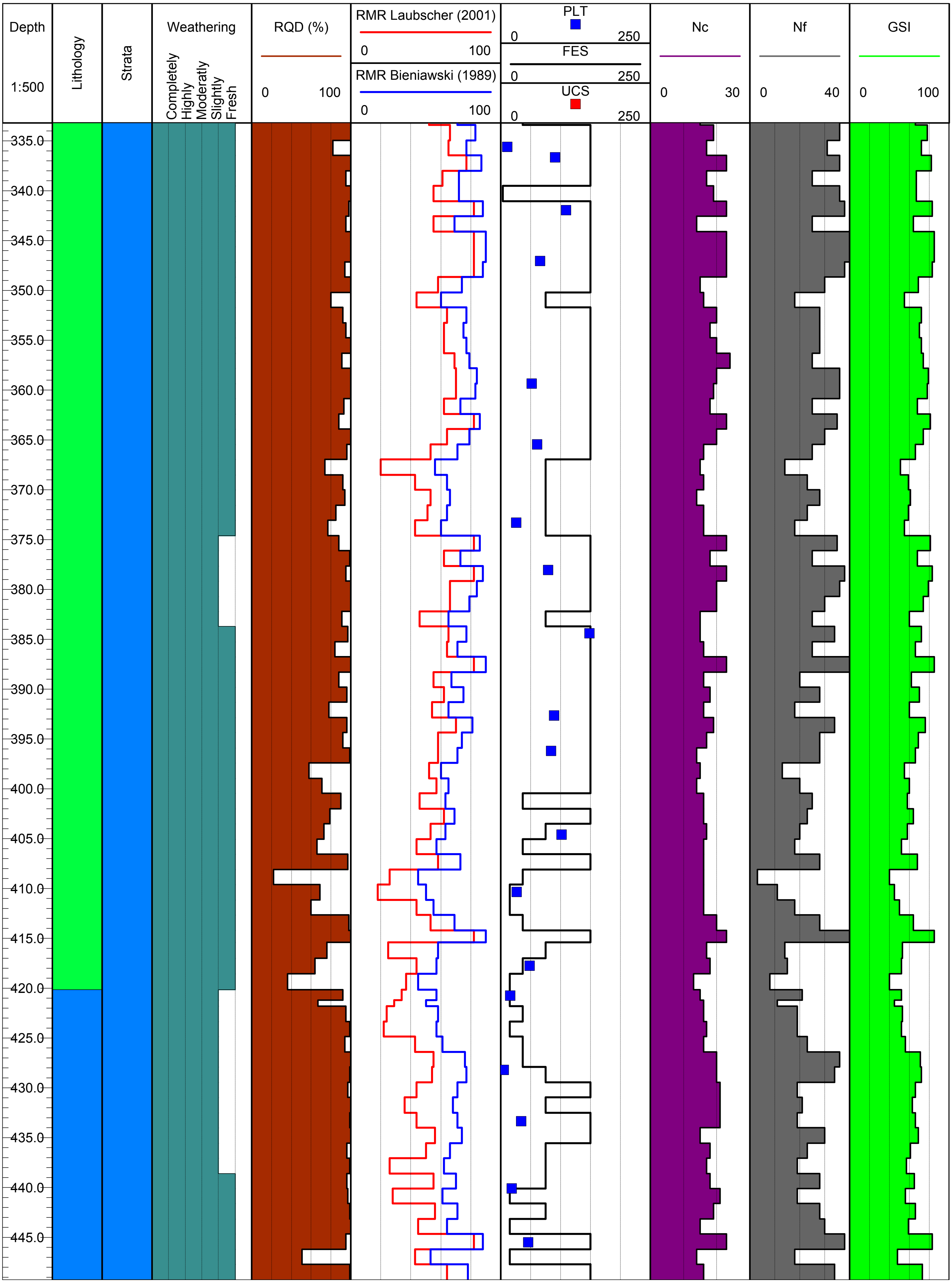
195.0
200.0
205.0



Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
PLT
0 250
FES
0 250
UCS
0 250
Nc
0 30
Nf
0 40
GSI
0 100
210.0
215.0
220.0
225.0
230.0
235.0
240.0
245.0
250.0
255.0
260.0
265.0
270.0
275.0
280.0
285.0
290.0
295.0
300.0
305.0
310.0
315.0
320.0
325.0
330.0

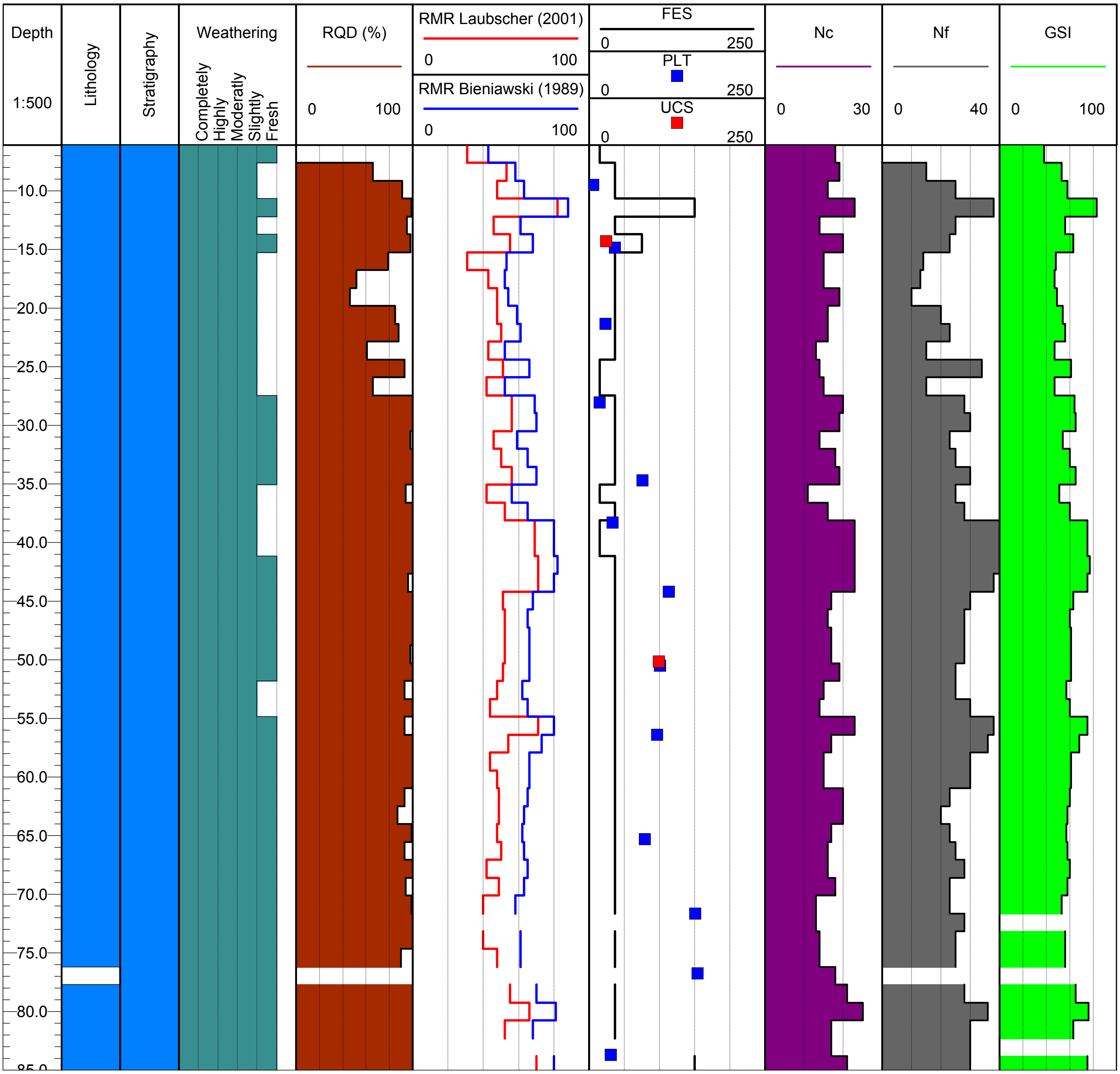

Depth
1:500
Lithology
Strata
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
PLT
0
250
FES
0
250
UCS
0
250
Nc
0
30
Nf
0
40
GSI
0
100
335.0
340.0
345.0
350.0
355.0
360.0
365.0
370.0
375.0
380.0
385.0
390.0
395.0
400.0
405.0
410.0
415.0
420.0
425.0
430.0
435.0
440.0
445.0

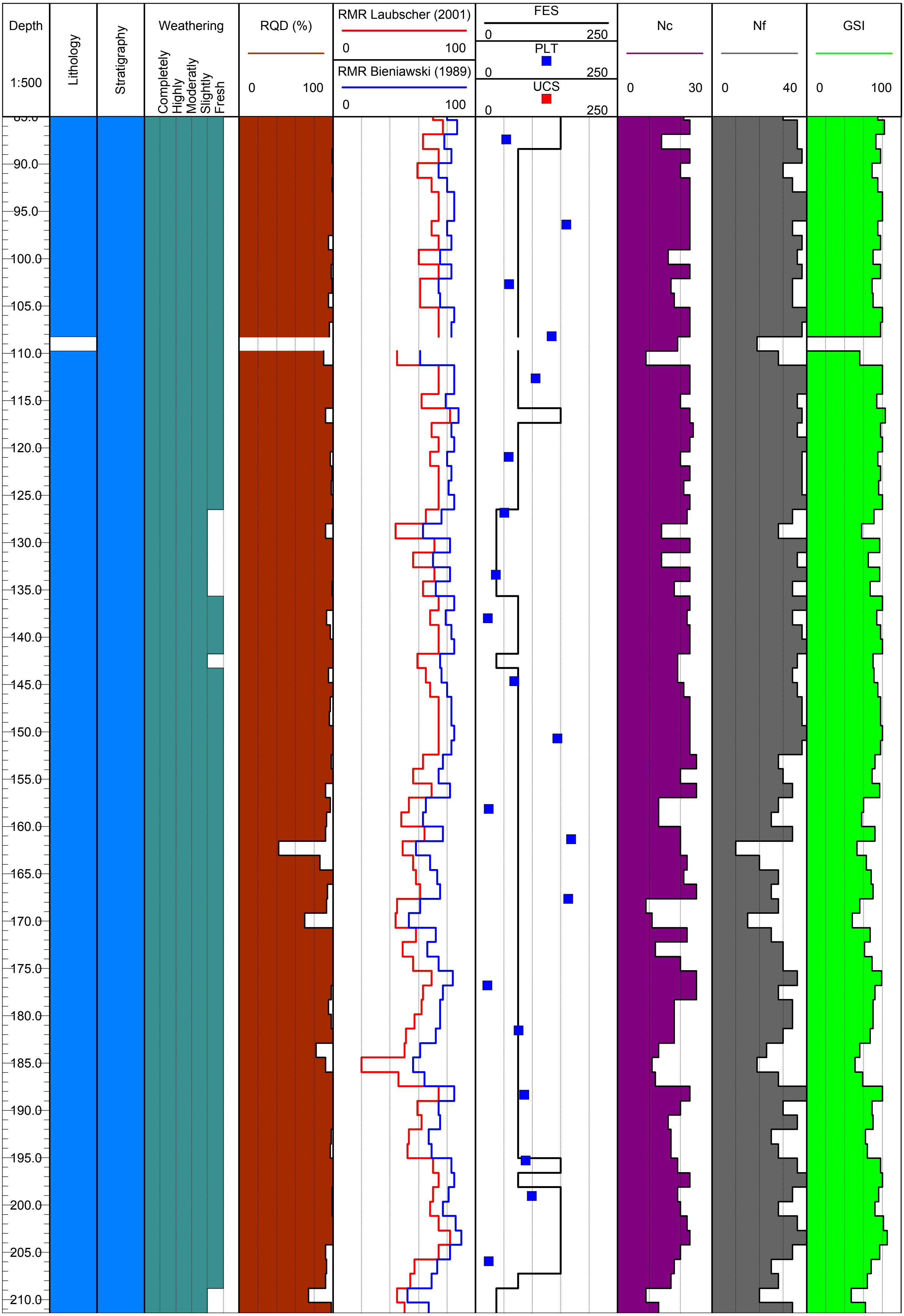
Geotechnical Borehole Log

Hole ID:	KAX-13-103	Project:	Ajax	SRK Project No:	KGH001
Easting:	685250	Northing:	5610220	RL:	920
Dip:	67	Azimuth:	037	Depth:	121.92
Log From:	6.10m	Log To:	399.29m		

Lithology and Stratigraphy

- DYKE - Dyke
- IMH - Iron Mask Hybrid
- LAT - Laterite
- MAFV - Mafic Volcanic
- MONZ - Monzonite
- SLD - Sugarloaf Diorite
- PICR - Picrite
- PXPP - Pyroxene Plagioclase Porphyry
- SVHYB - Sugarloaf/Volcanic Hybrid
- N/L - Not Logged





Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
FES
0
250
PLT
0
250
UCS
0
250
Nc
0
30
Nf
0
40
GSI
0
100
90.0
95.0
100.0
105.0
110.0
115.0
120.0
125.0
130.0
135.0
140.0
145.0
150.0
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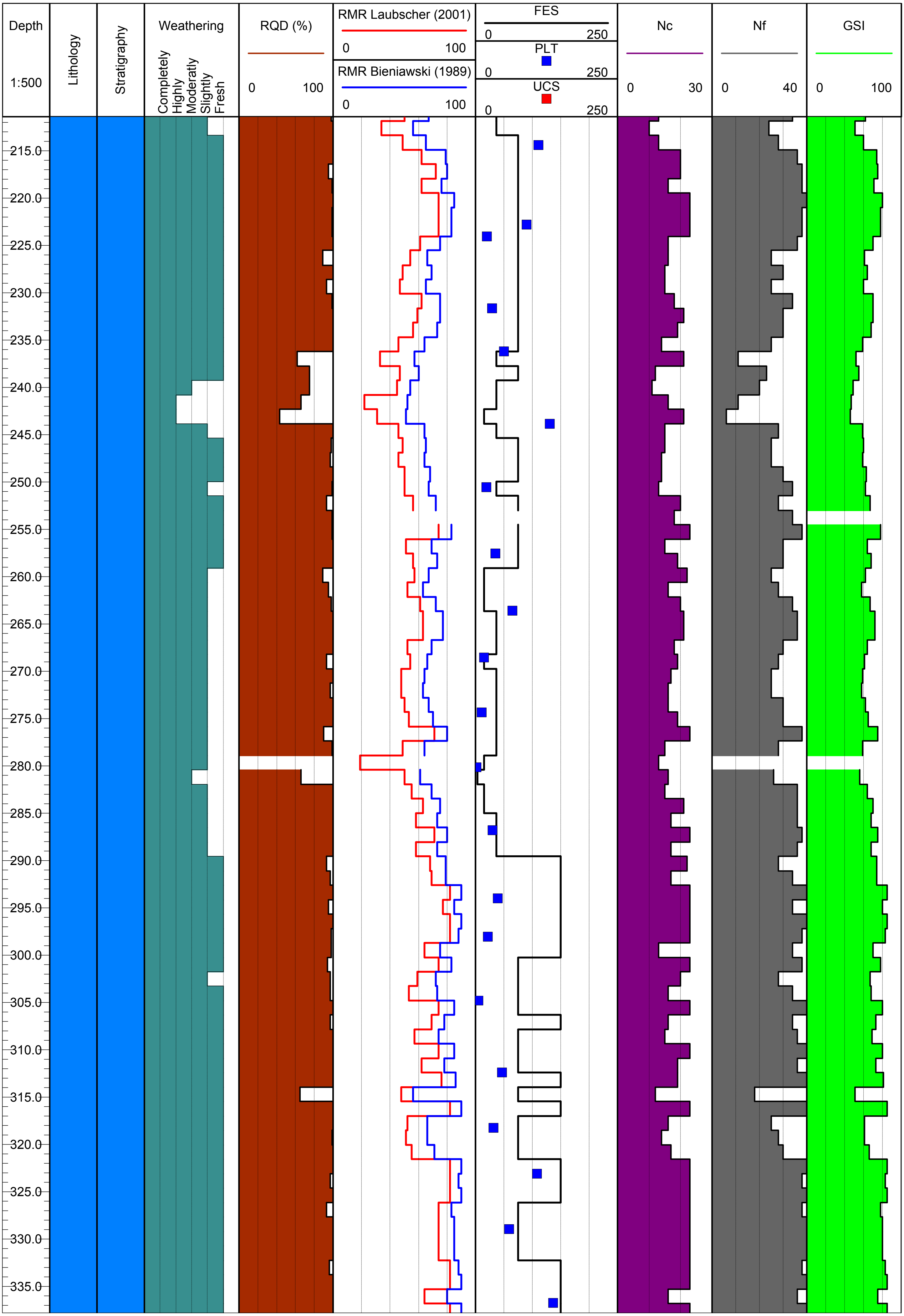
210.0



Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
FES
0 250
PLT
0 250
UCS
0 250
Nc
0 30
Nf
0 40
GSI
0 100
215.0
220.0
225.0
230.0
235.0
240.0
245.0
250.0
255.0
260.0
265.0
270.0
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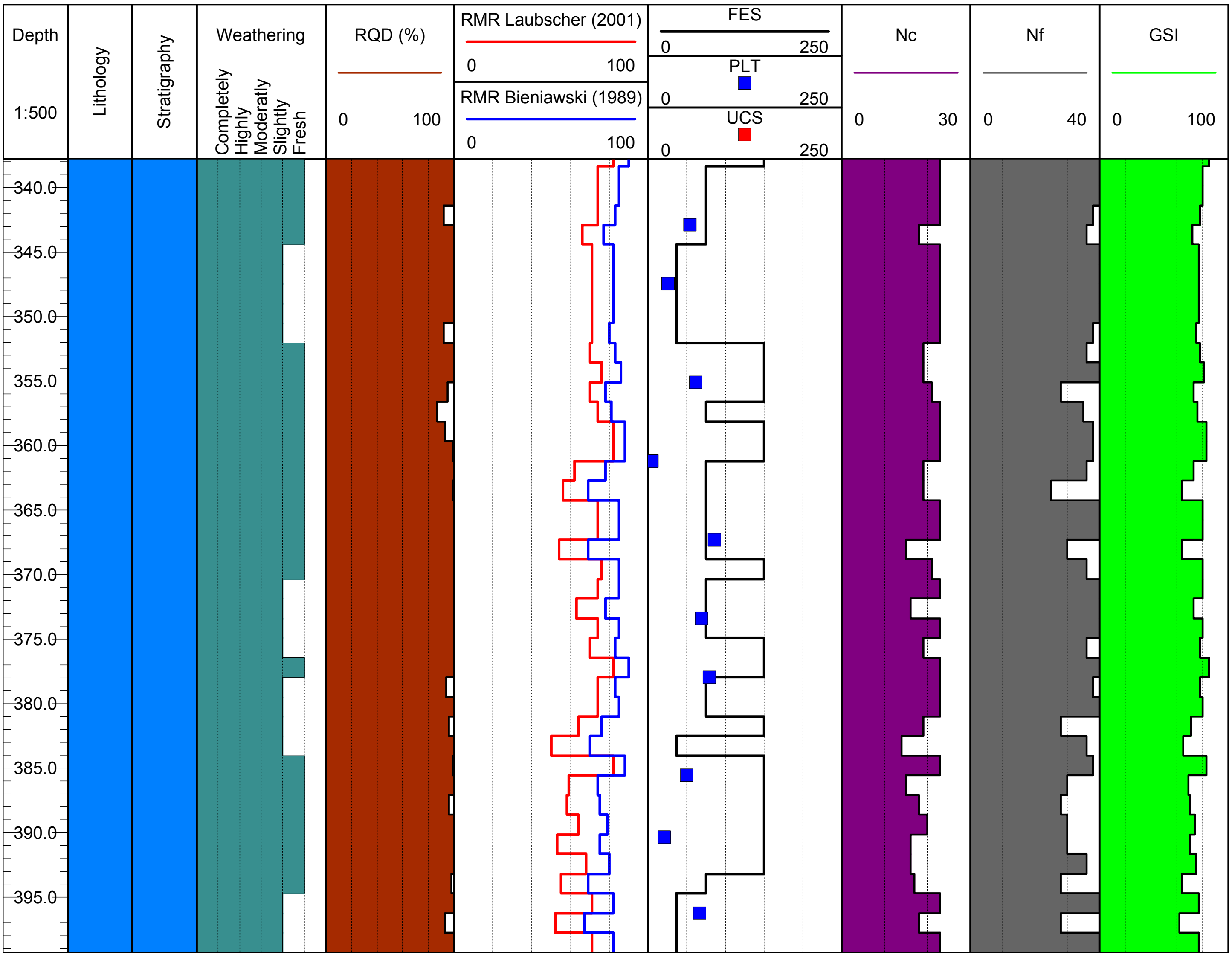
335.0



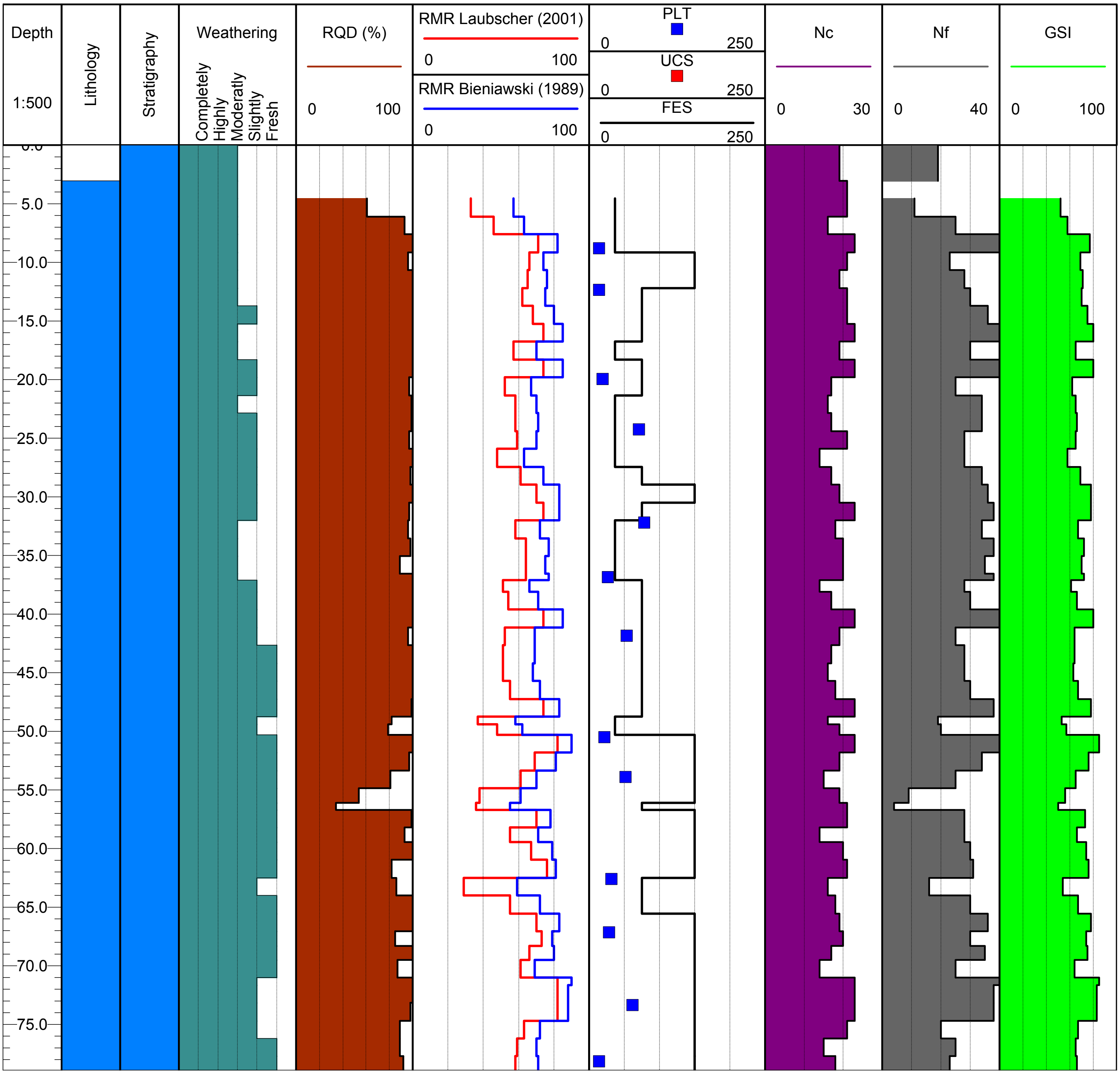
Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
FES
0 250
PLT
0 250
UCS
0 250
Nc
0 30
Nf
0 40
GSI
0 100
340.0
345.0
350.0
355.0
360.0
365.0
370.0
375.0
380.0
385.0
390.0
395.0

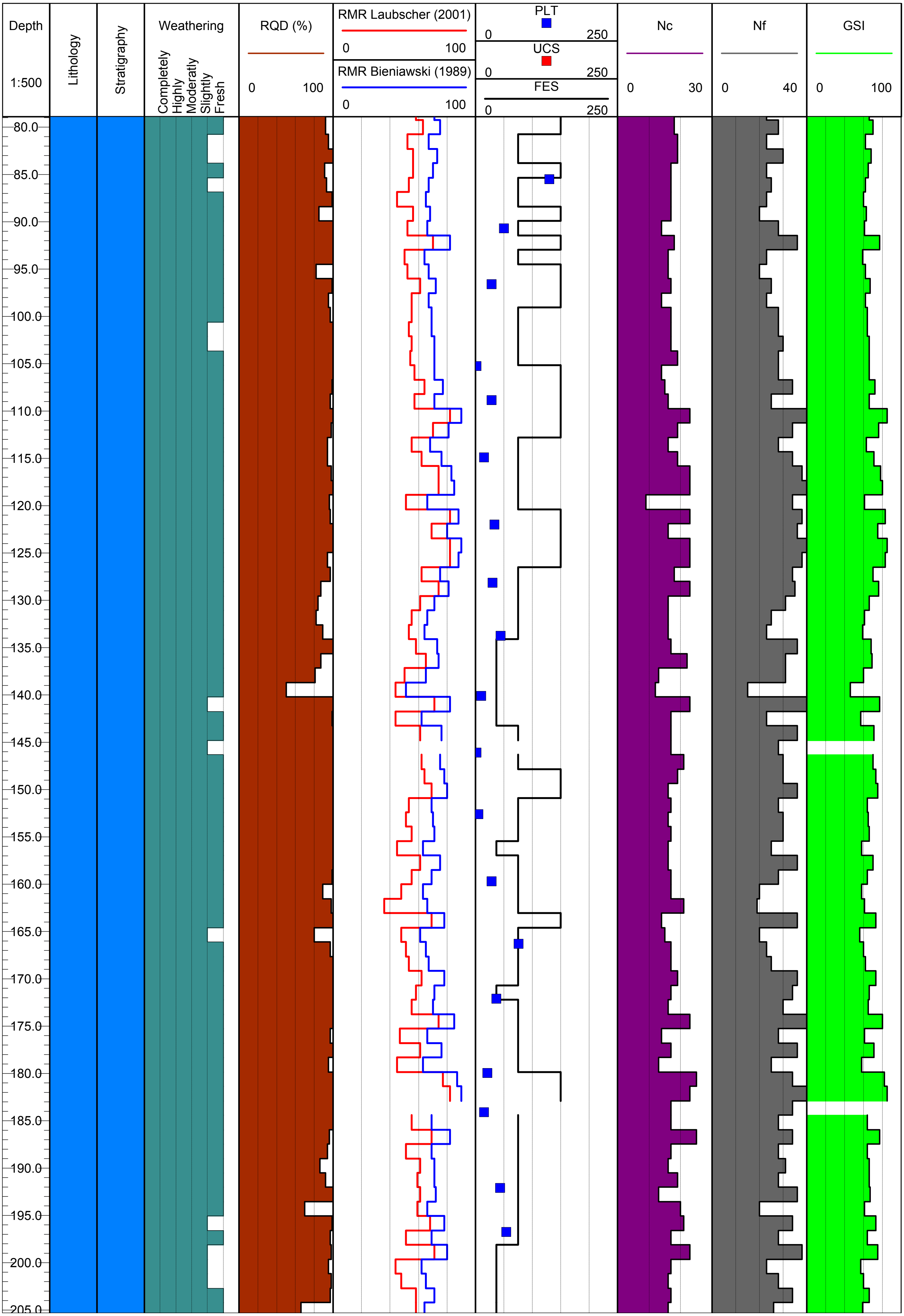
Geotechnical Borehole Log

Hole ID:	KAX-13-104	Project:	Ajax	SRK Project No:	KGH001
Easting:	685297	Northing:	5609973	RL:	920
Dip:	66	Azimuth:	245	Depth:	122.22m
Log From:	0.00m	Log To:	400.81m		

Lithology and Stratigraphy

- DYKE - Dyke
- IMH - Iron Mask Hybrid
- LAT - Laterite
- MAFV - Mafic Volcanic
- MONZ - Monzonite
- SLD - Sugarloaf Diorite
- PICR - Picrite
- PXPP - Pyroxene Plagioclase Porphyry
- SVHYB - Sugarloaf/Volcanic Hybrid
- N/L - Not Logged




Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
PLT
0
250
UCS
0
250
FES
0
250
Nc
0
30
Nf
0
40
GSI
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105.0
110.0
115.0
120.0
125.0
130.0
135.0
140.0
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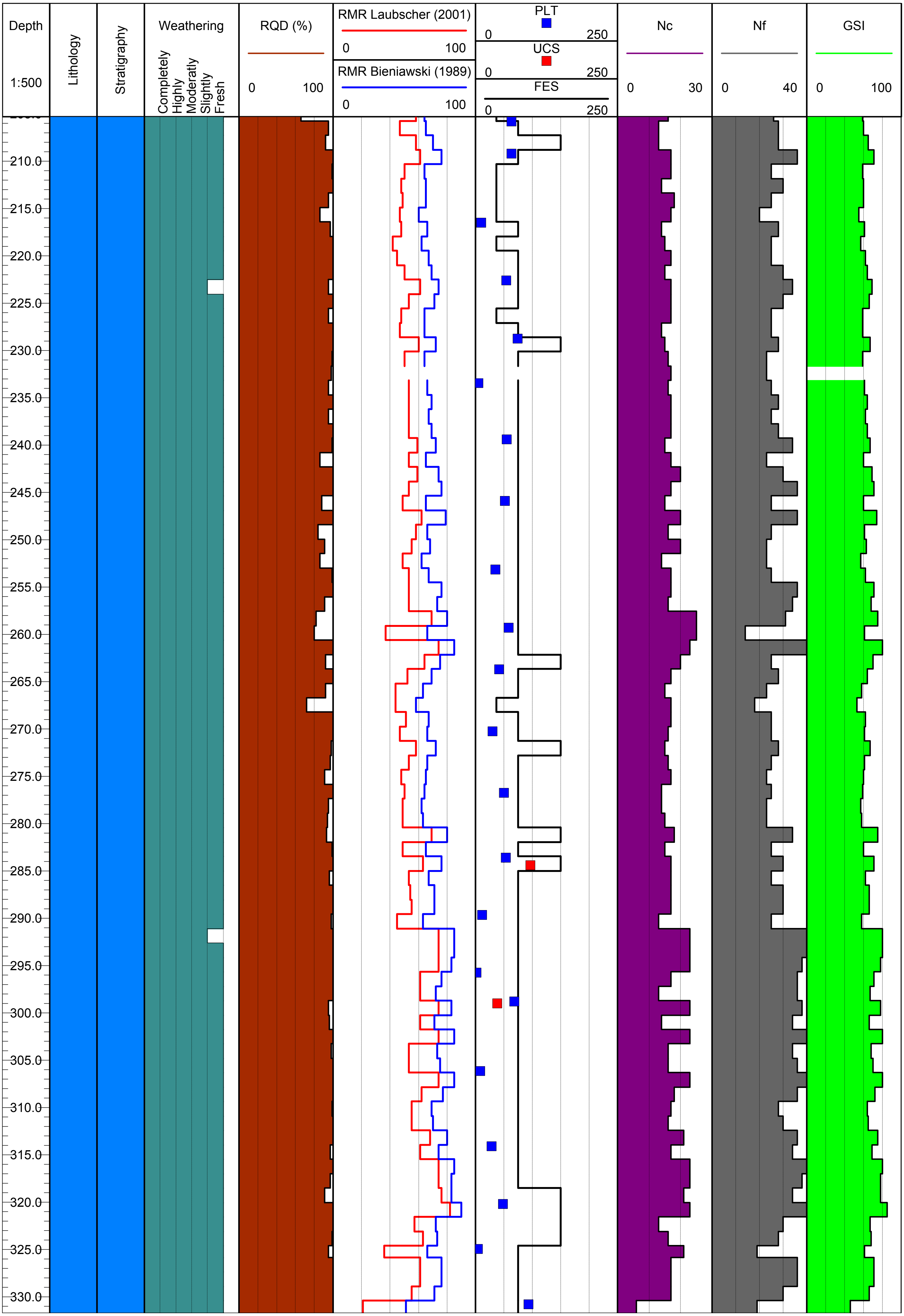
195.0
200.0
205.0



Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
PLT
0 250
UCS
0 250
FES
0 250
Nc
0 30
Nf
0 40
GSI
0 100
210.0
215.0
220.0
225.0
230.0
235.0
240.0
245.0
250.0
255.0
260.0
265.0
270.0
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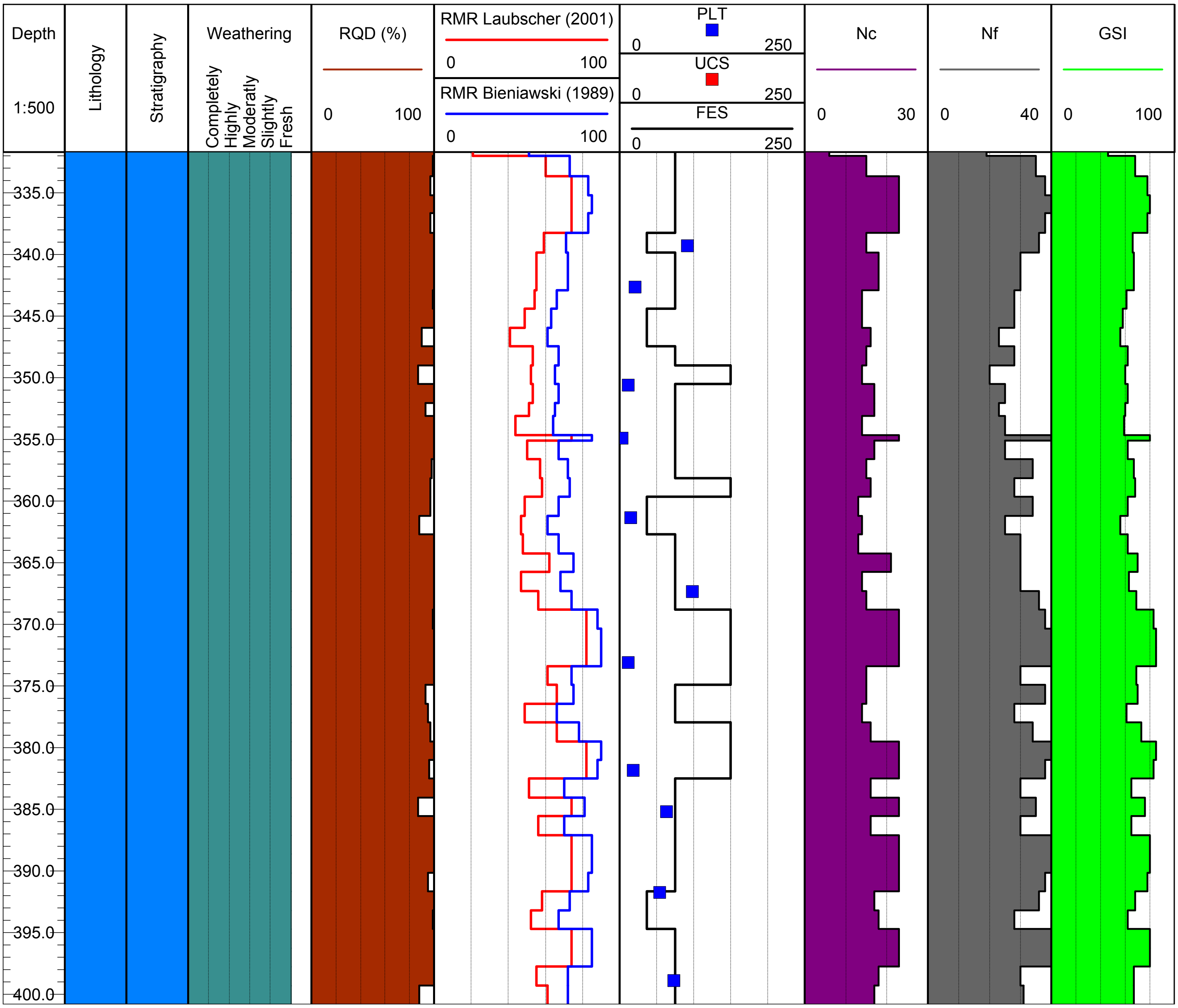
330.0



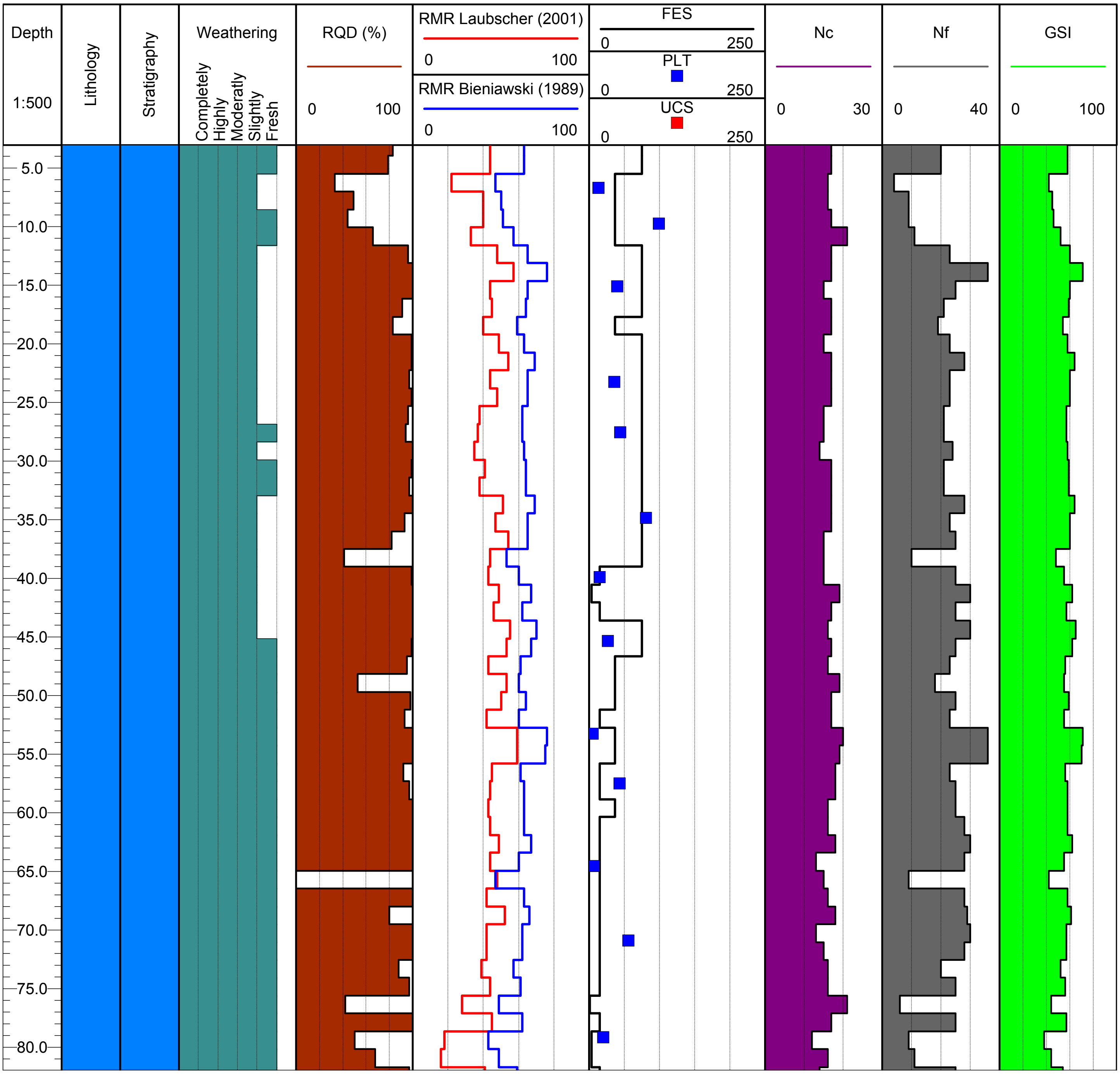
Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
PLT
0
250
UCS
0
250
FES
0
250
Nc
0
30
Nf
0
40
GSI
0
100
335.0
340.0
345.0
350.0
355.0
360.0
365.0
370.0
375.0
380.0
385.0
390.0
395.0
400.0

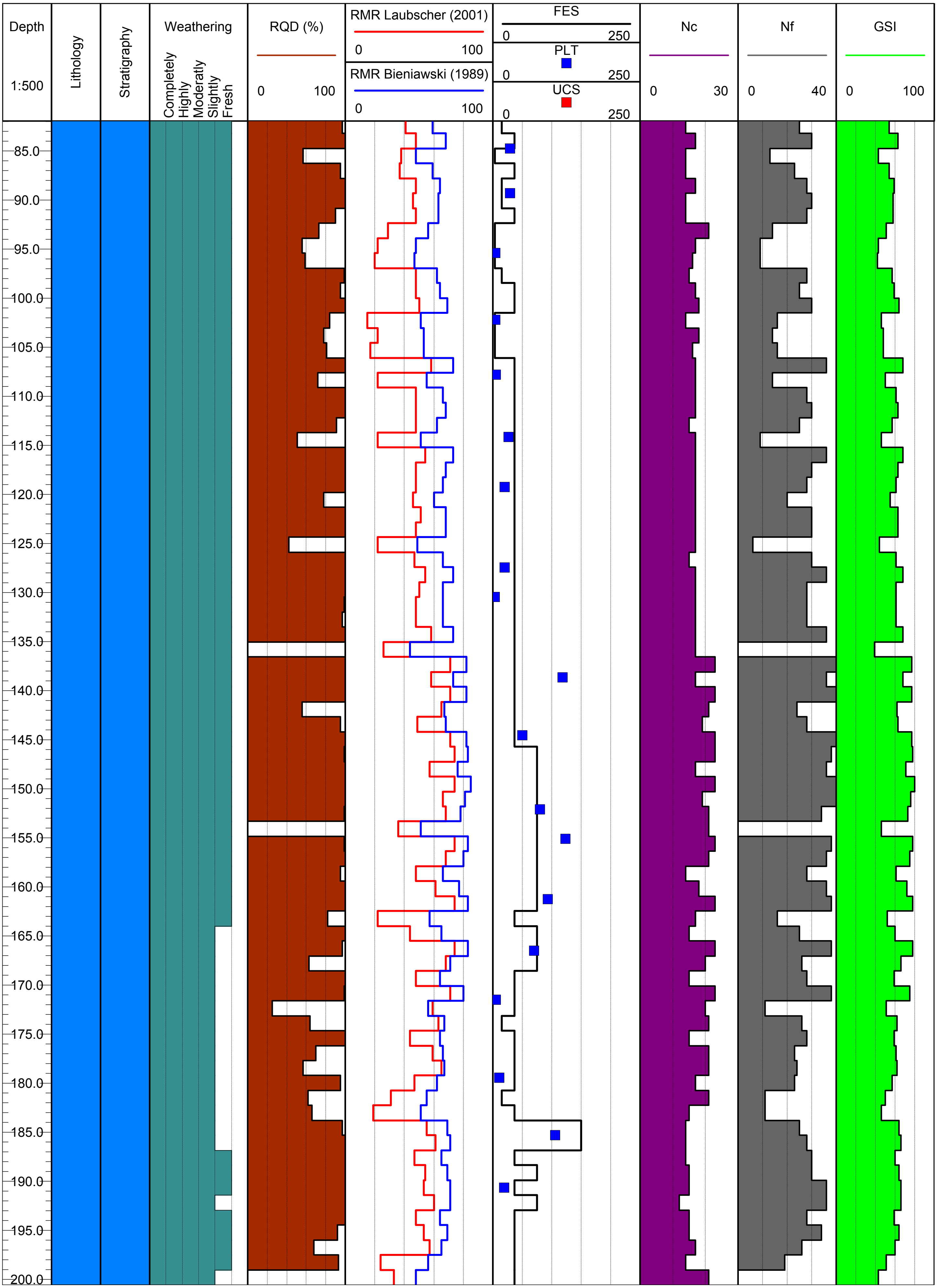
Geotechnical Borehole Log

Hole ID:	KAX-13-105	Project:	Ajax	SRK Project No:	KGH001
Easting:	685046	Northing:	5610314	RL:	942
Dip:	65	Azimuth:	350	Depth:	200.56m
Log From:	3.04m	Log To:	200.55m		

Lithology and Stratigraphy

DYKE - Dyke
IMH - Iron Mask Hybrid
LAT - Laterite
MAFV - Mafic Volcanic
MONZ - Monzonite
SLD - Sugarloaf Diorite
PICR - Picrite
PXPP - Pyroxene Plagioclase Porphyry
SVHYB - Sugarloaf/Volcanic Hybrid
N/L - Not Logged




Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
FES
0
250
PLT
0
250
UCS
0
250
Nc
0
30
Nf
0
40
GSI
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100
85.0
90.0
95.0
100.0
105.0
110.0
115.0
120.0
125.0
130.0
135.0
140.0
145.0
150.0
155.0
160.0
165.0
170.0
175.0
180.0
185.0
190.0
195.0
200.0

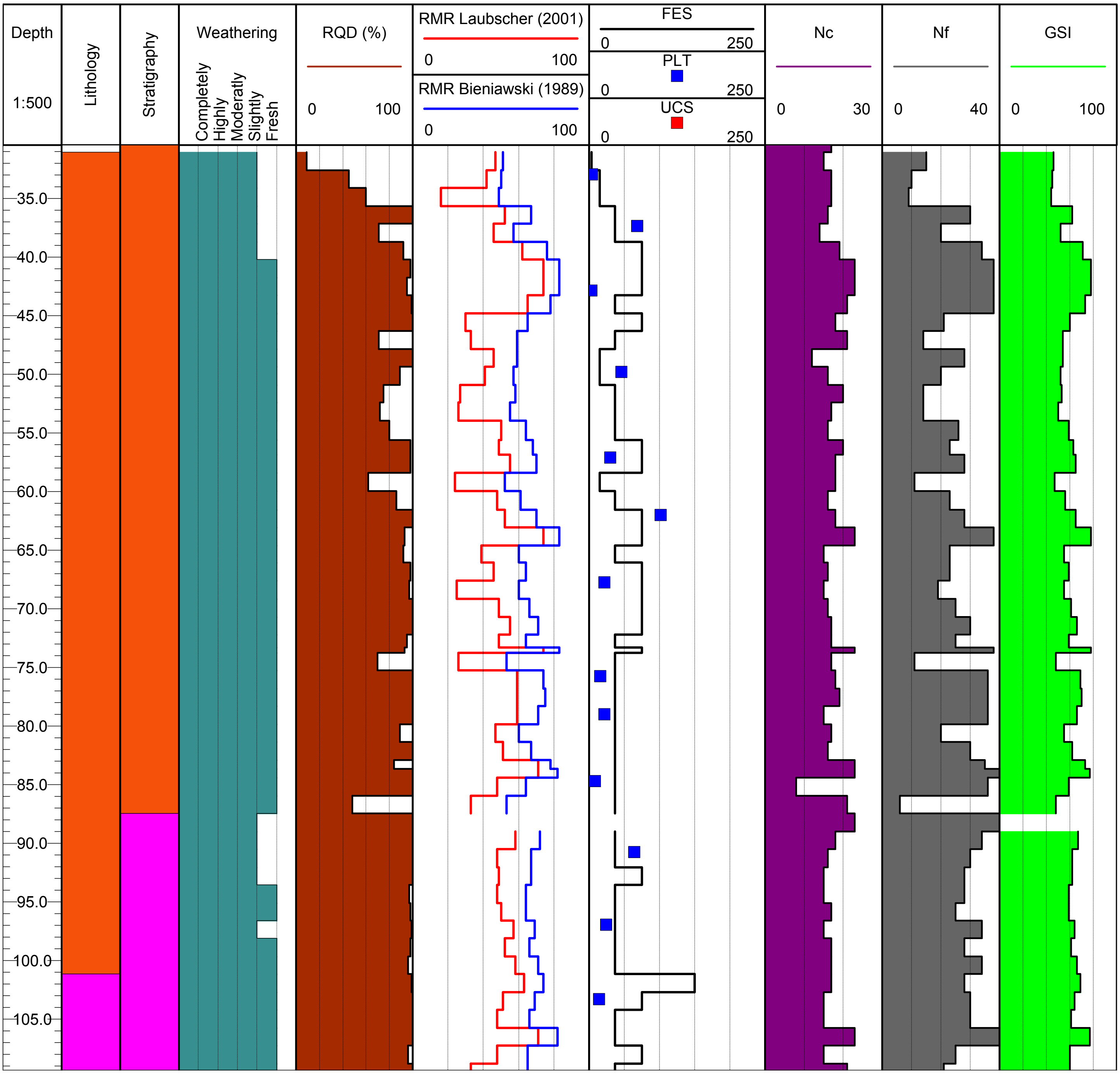
srk consulting

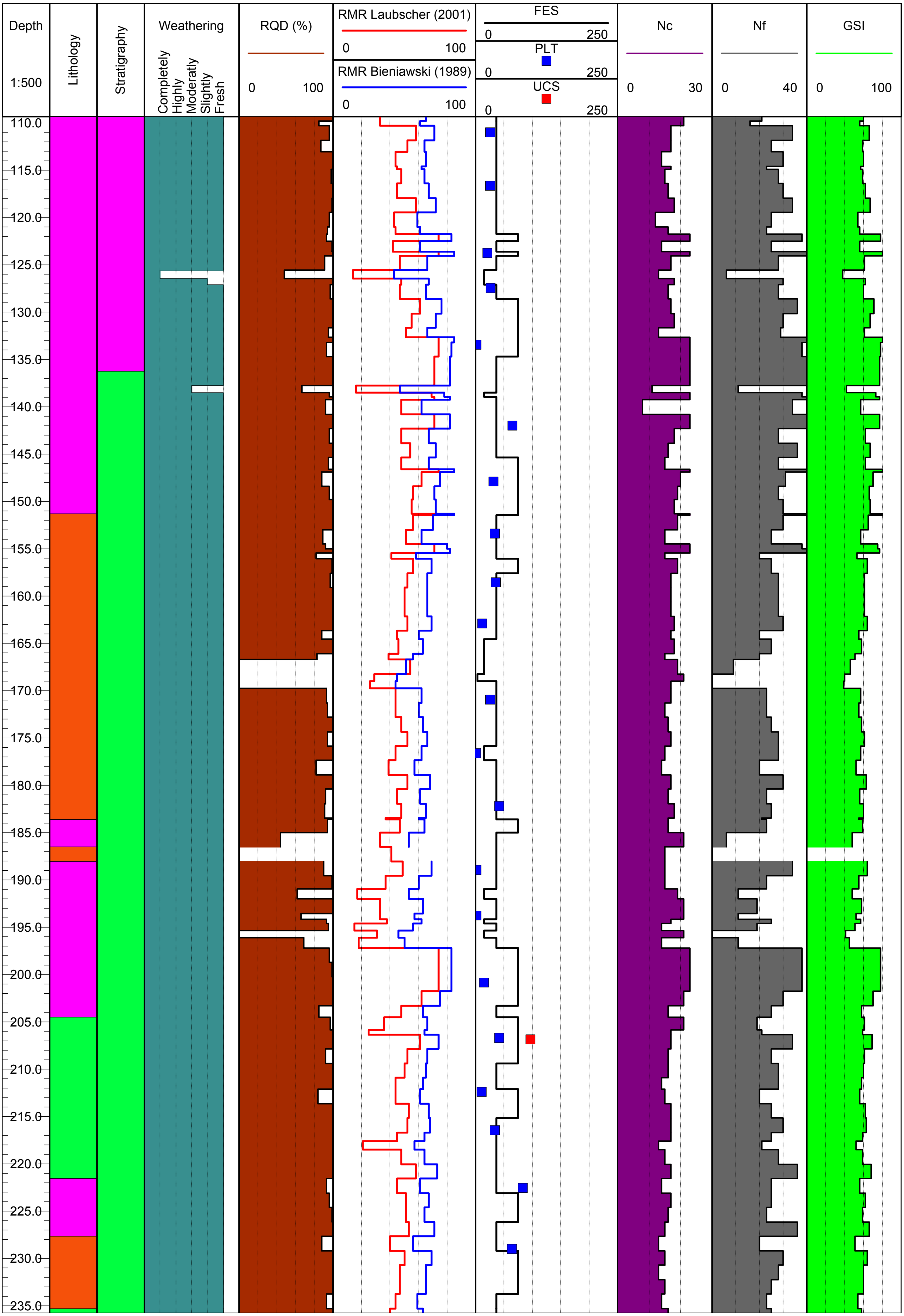
Geotechnical Borehole Log

Hole ID:	KAX-13-106	Project:	Ajax	SRK Project No:	KGH001
Easting:	683811	Northing:	5610011	RL:	943
Dip:	65	Azimuth:	184	Depth:	121.92m
Log From:	30.47m	Log To:	400.00m		

Lithology and Stratigraphy

DYKE - Dyke
IMH - Iron Mask Hybrid
LAT - Laterite
MAFV - Mafic Volcanic
MONZ - Monzonite
SLD - Sugarloaf Diorite
PICR - Picrite
PXPP - Pyroxene Plagioclase Porphyry
SVHYB - Sugarloaf/Volcanic Hybrid
N/L - Not Logged





Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
FES
0 250
PLT
0 250
UCS
0 250
Nc
0 30
Nf
0 40
GSI
0 100
110.0
115.0
120.0
125.0
130.0
135.0
140.0
145.0
150.0
155.0
160.0
165.0
170.0
175.0
180.0
185.0
190.0
195.0
200.0
205.0
210.0
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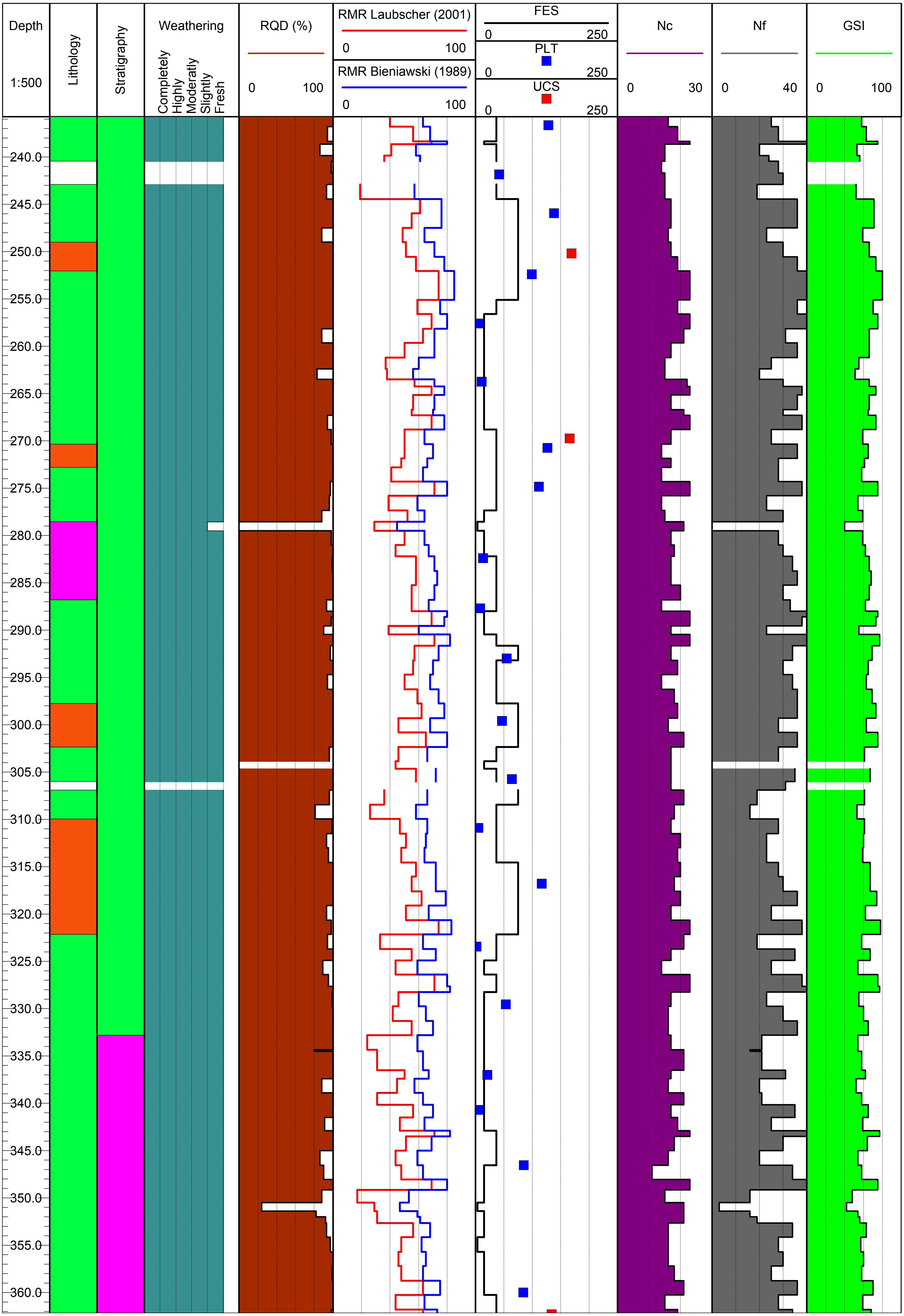
225.0
230.0
235.0



Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0
100
RMR Laubscher (2001)
0
100
RMR Bieniawski (1989)
0
100
FES
0
250
PLT
0
250
UCS
0
250
Nc
0
30
Nf
0
40
GSI
0
100
240.0
245.0
250.0
255.0
260.0
265.0
270.0
275.0
280.0
285.0
290.0
295.0
300.0
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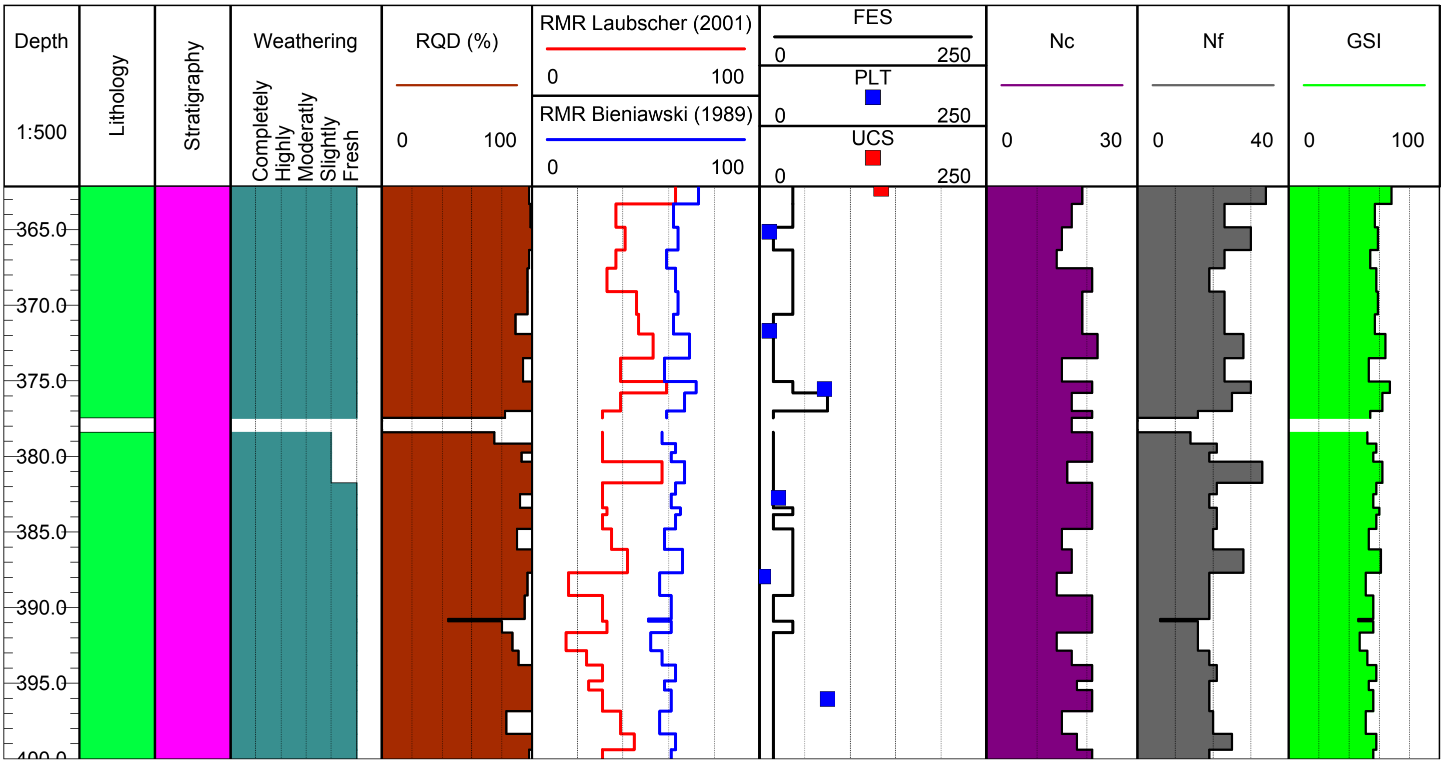
360.0



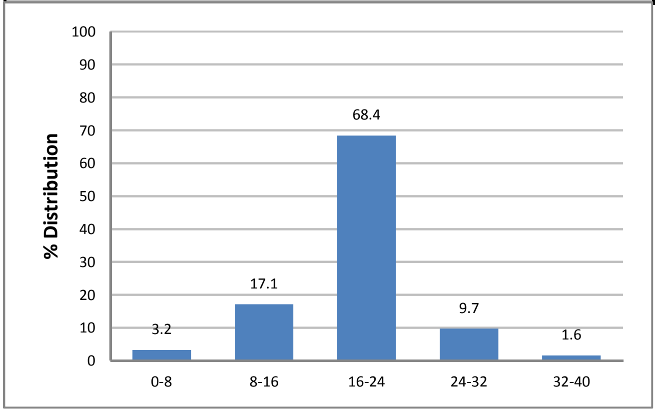
Depth
1:500
Lithology
Stratigraphy
Weathering
Completely
Highly
Moderatly
Slightly
Fresh
RQD (%)
0 100
RMR Laubscher (2001)
0 100
RMR Bieniawski (1989)
0 100
FES
0 250
PLT
0 250
UCS
0 250
Nc
0 30
Nf
0 40
GSI
0 100
365.0
370.0
375.0
380.0
385.0
390.0
395.0

RMR MASS DATA - RMR PARAMETERS

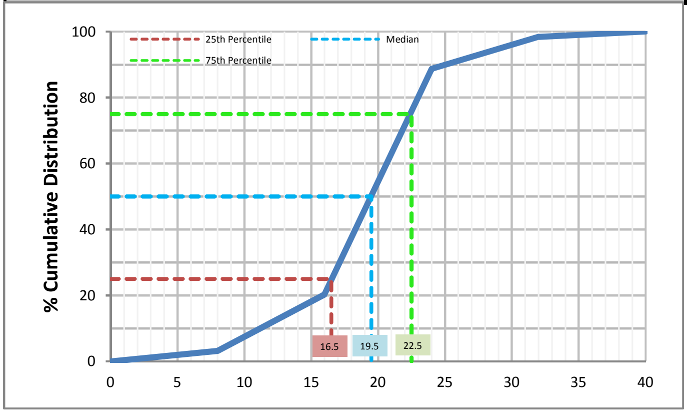
KGH001 - Ajax | Combined Data | Sector 1

Domain: IMH | Meters Logged: 475.56 m

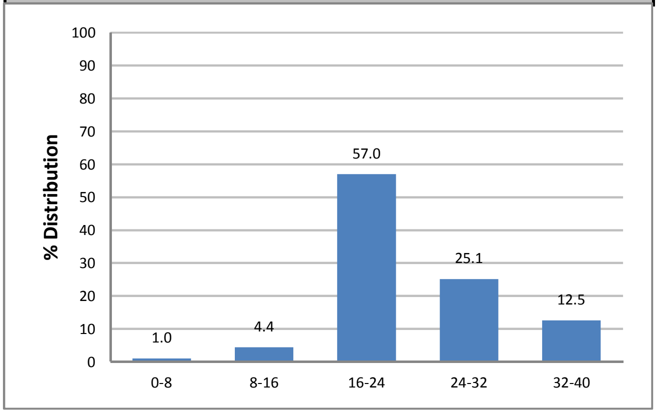
Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



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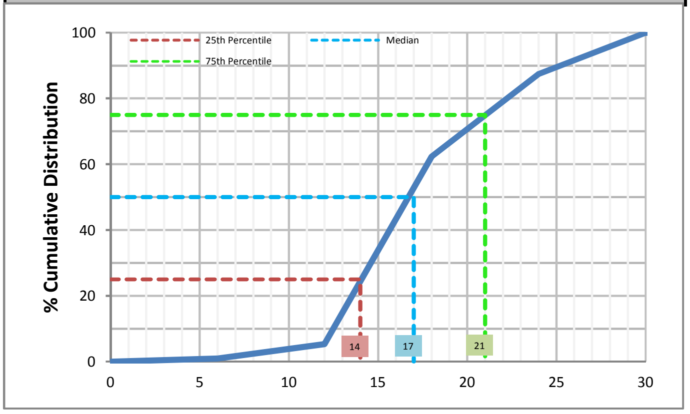

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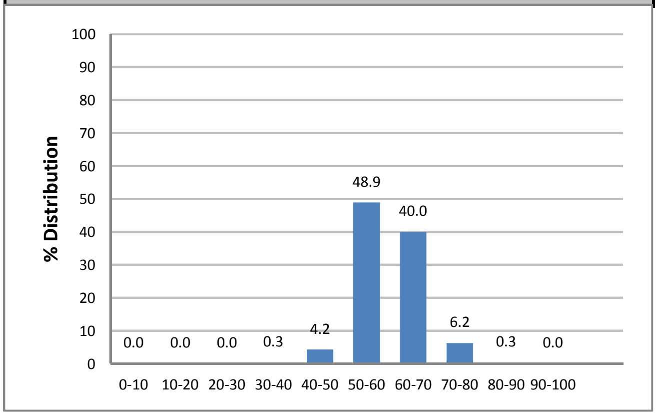

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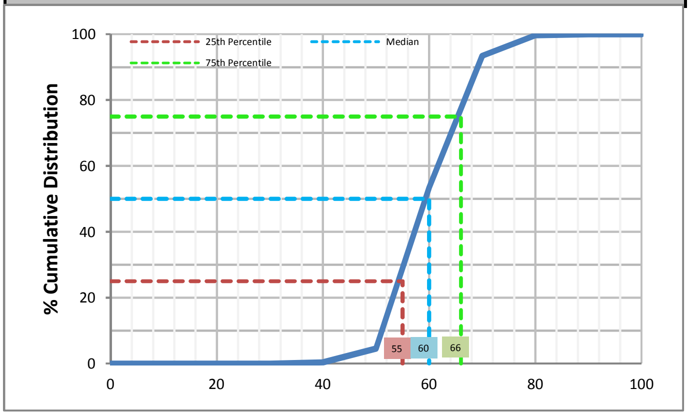
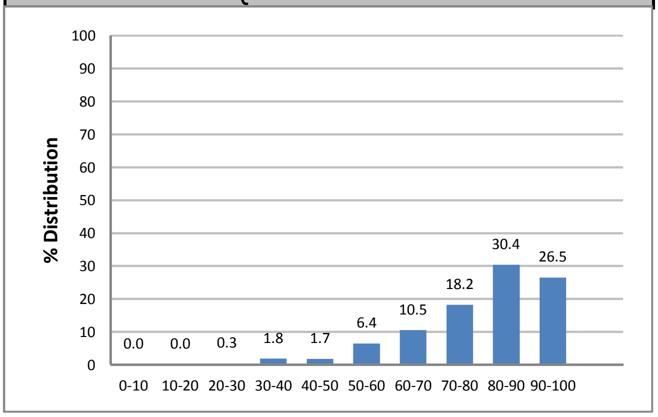
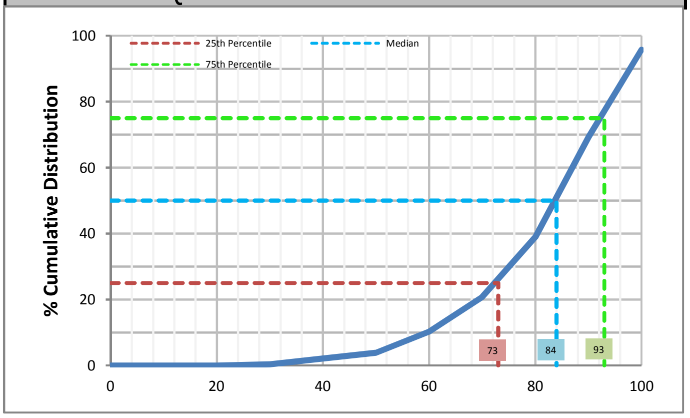


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

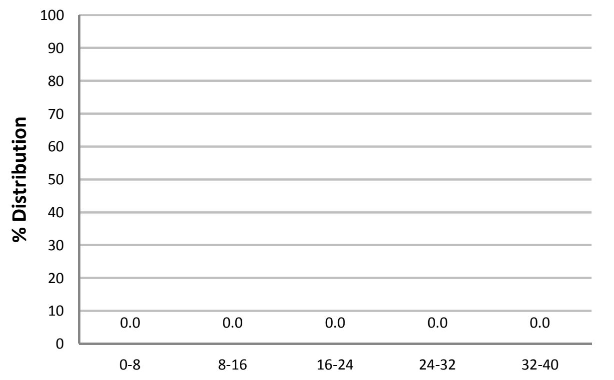


RMR MASS DATA - RMR PARAMETERS

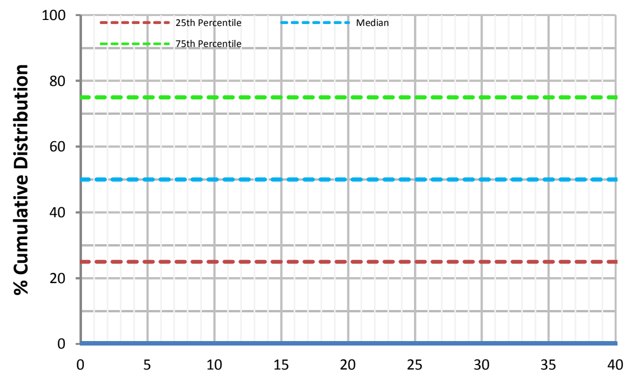
KGH001 - Ajax | Combined Data | Sector 1

Domain: LAT | Meters Logged: 0 m

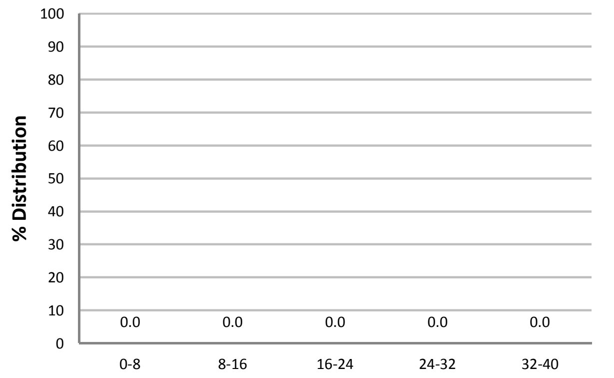
Nf DISTRIBUTION



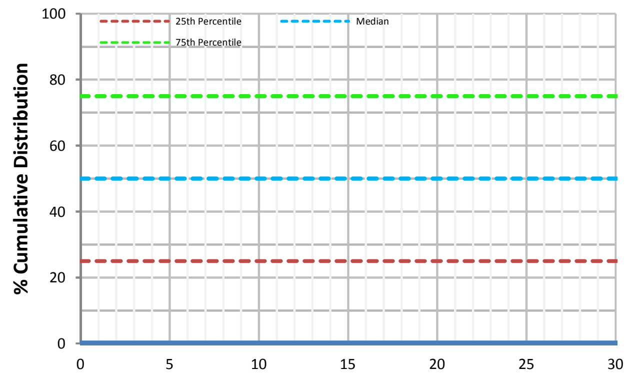
Nf CUMULATIVE DISTRIBUTION



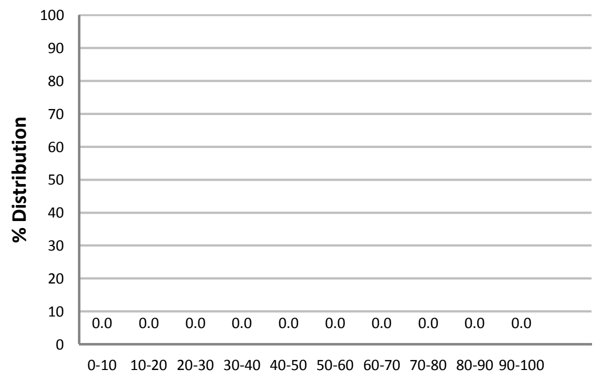
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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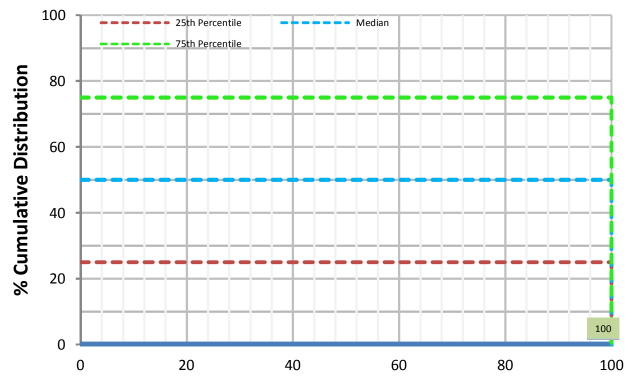

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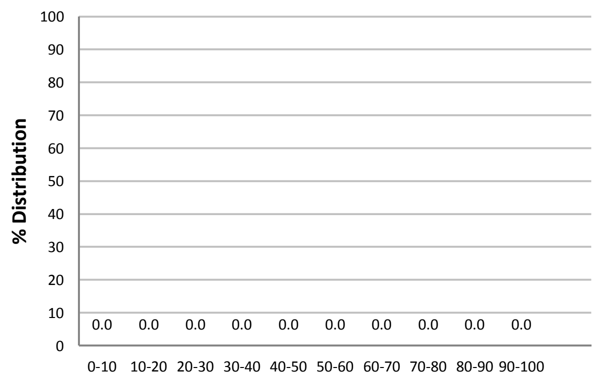

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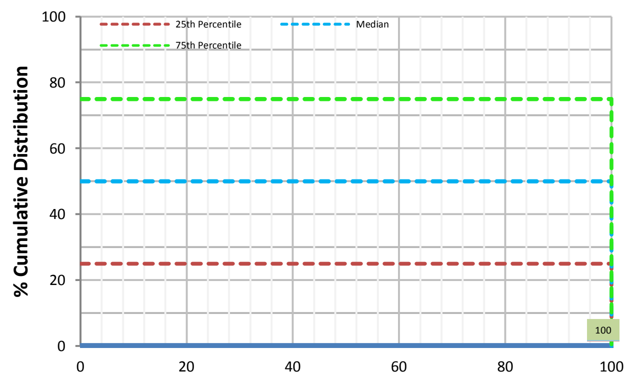
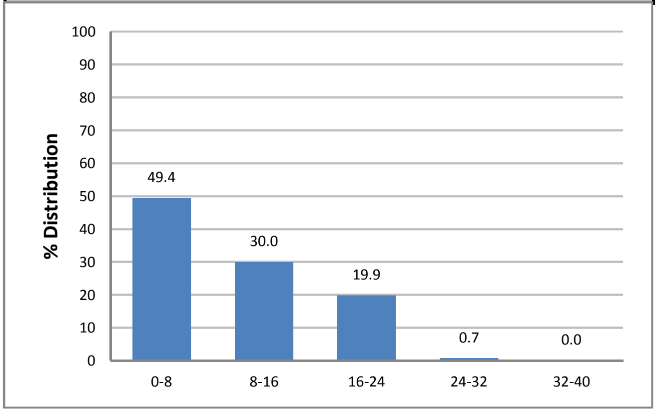


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 1

Domain: MAFV | Meters Logged: 269.72 m

Nf DISTRIBUTION



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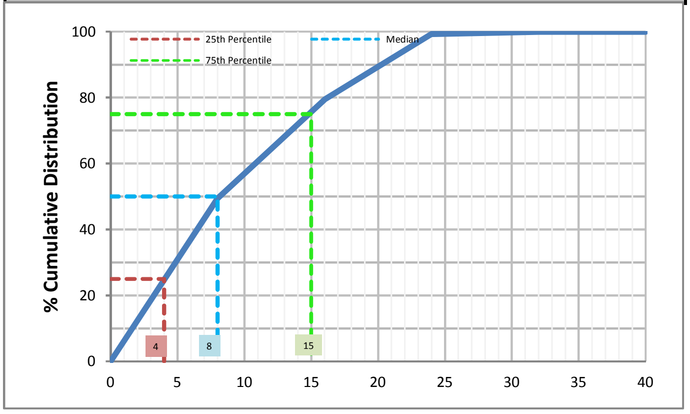
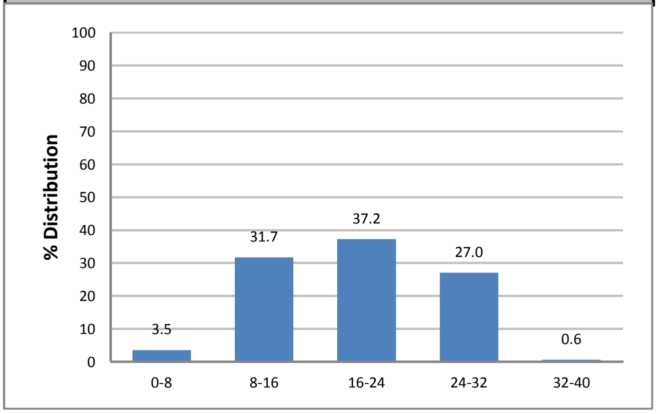
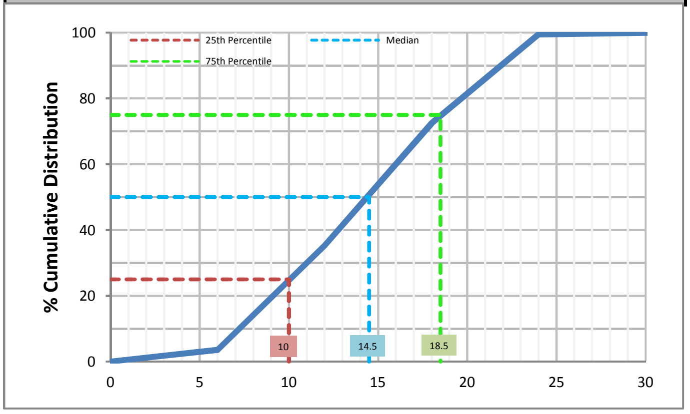


Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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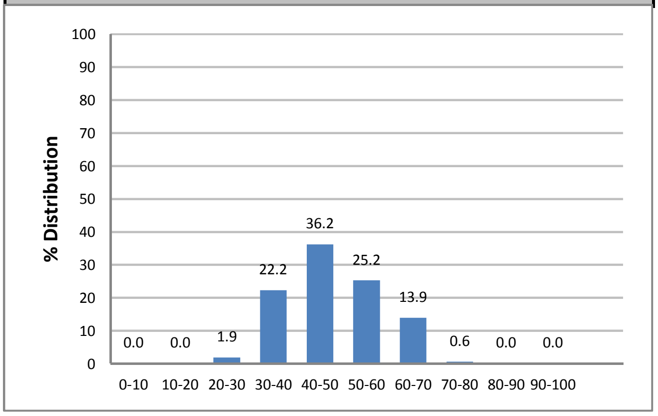

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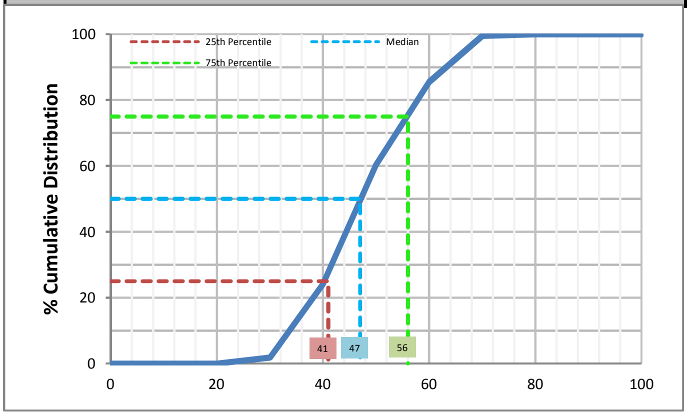

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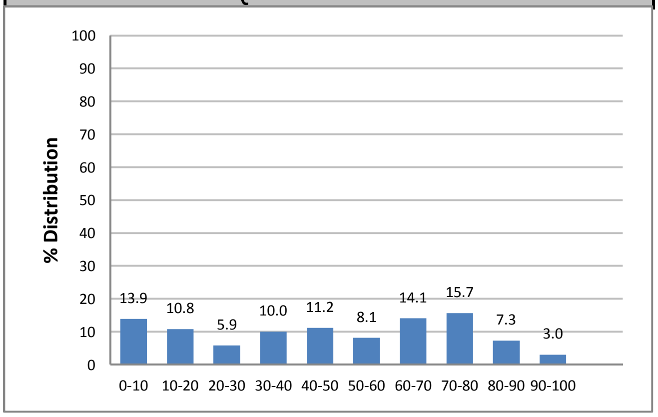
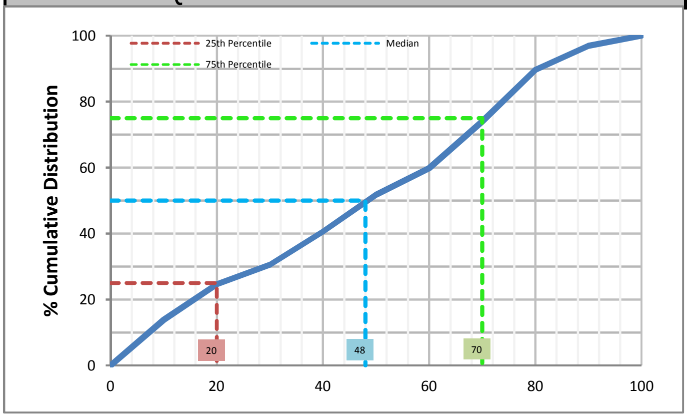


RQD CUMULATIVE DISTRIBUTION

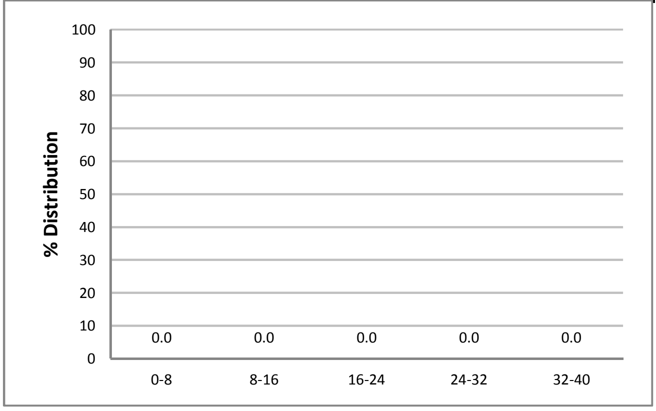


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 1

Domain: MONZ | Meters Logged: 0 m

Nf DISTRIBUTION



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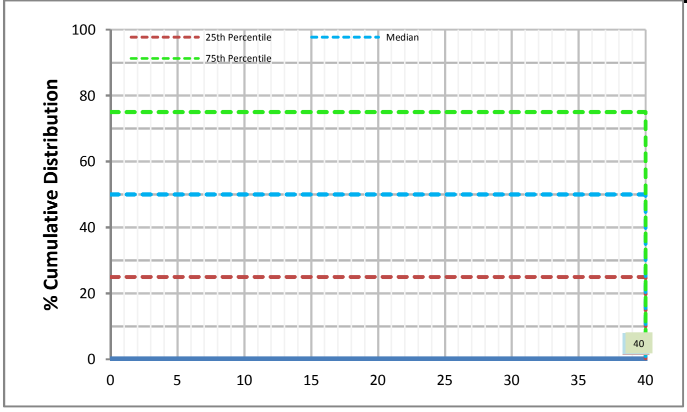
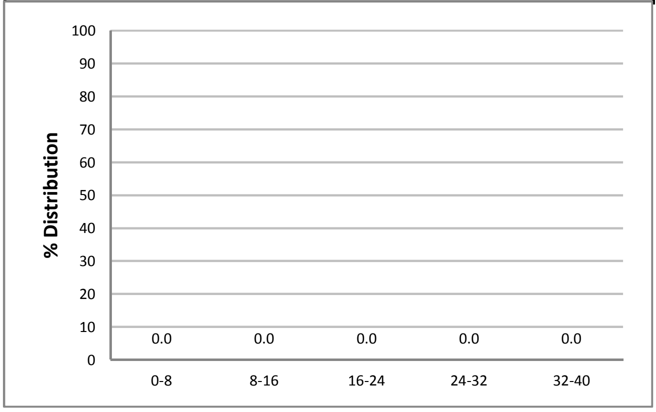
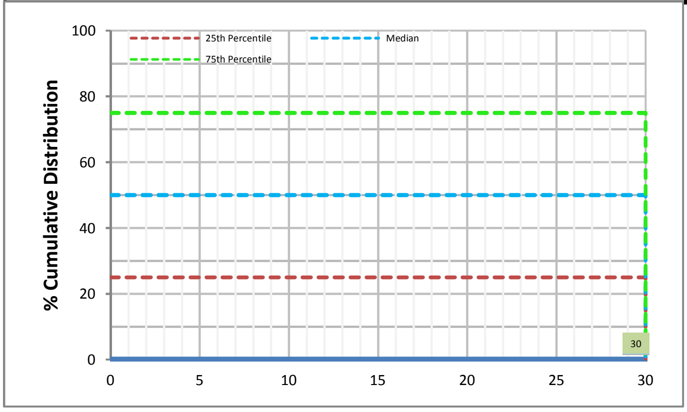


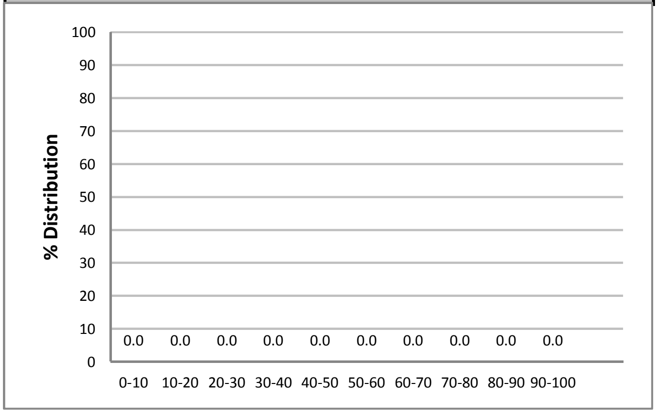
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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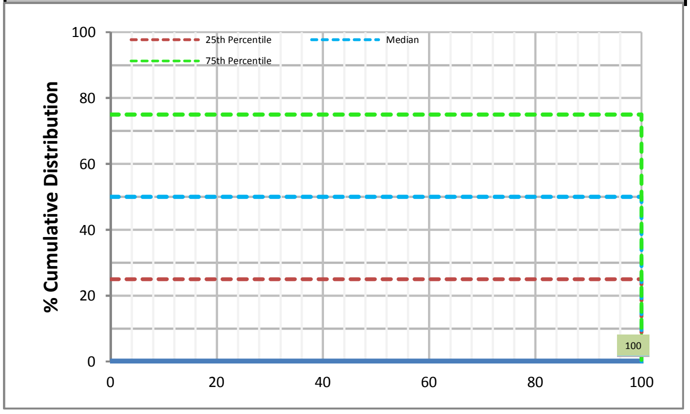
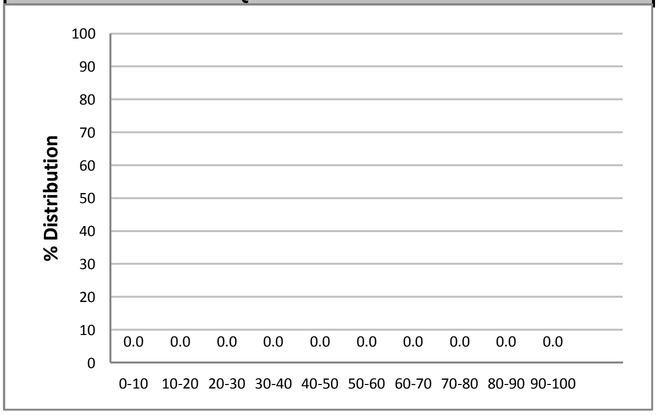


RQD DISTRIBUTION



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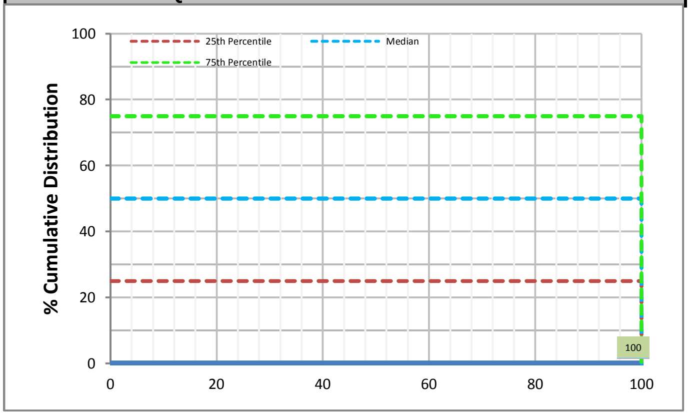


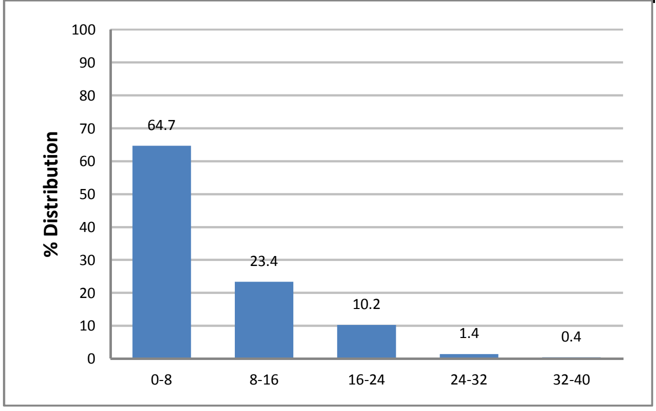
RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 1

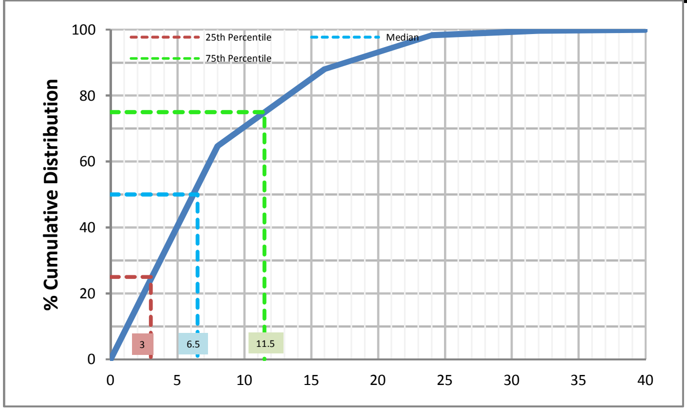
Domain: PICR

Meters Logged: 1282.81 m

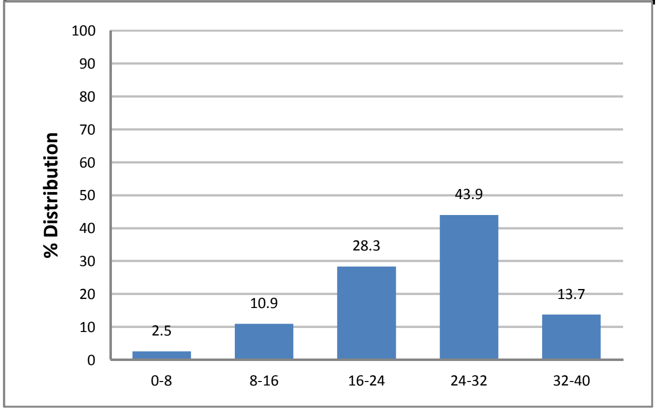
Nf DISTRIBUTION



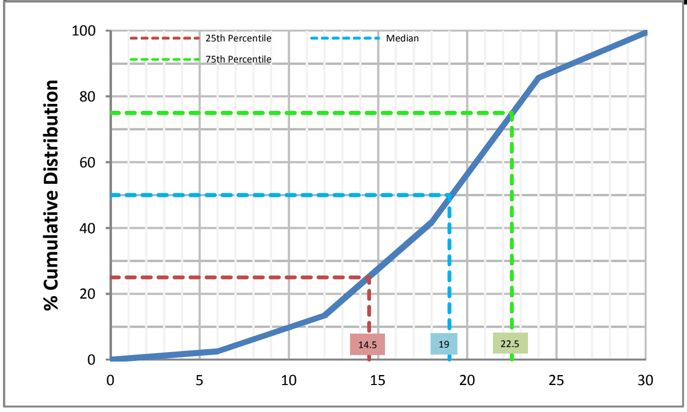
Nf CUMULATIVE DISTRIBUTION



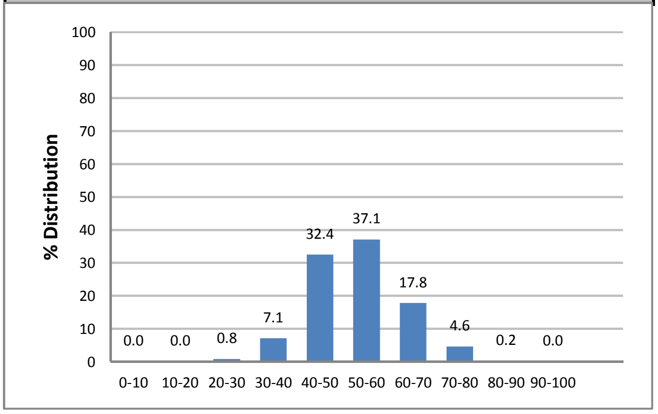
Nc DISTRIBUTION



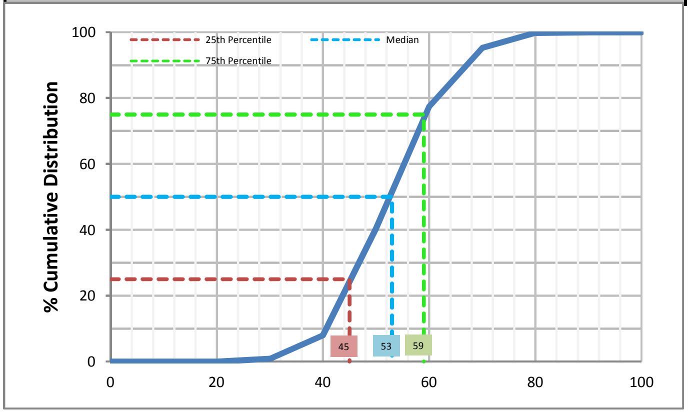
Nc CUMULATIVE DISTRIBUTION



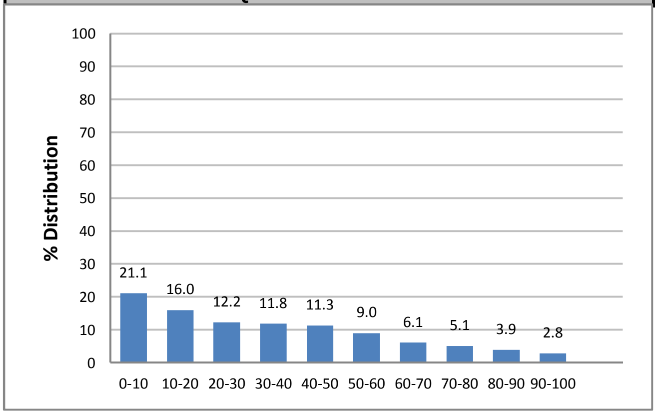
RMR DISTRIBUTION



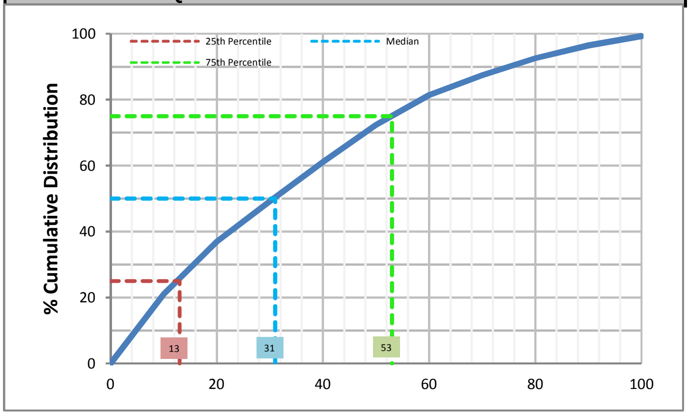
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



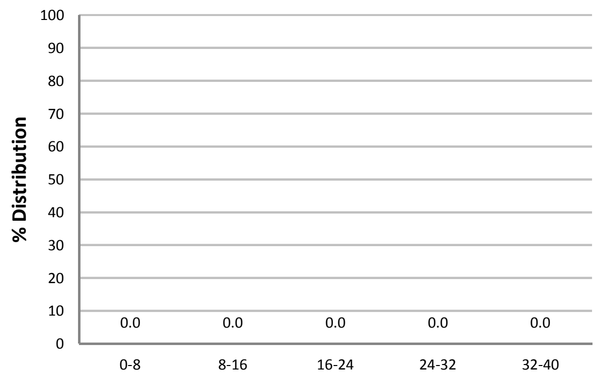
RQD CUMULATIVE DISTRIBUTION



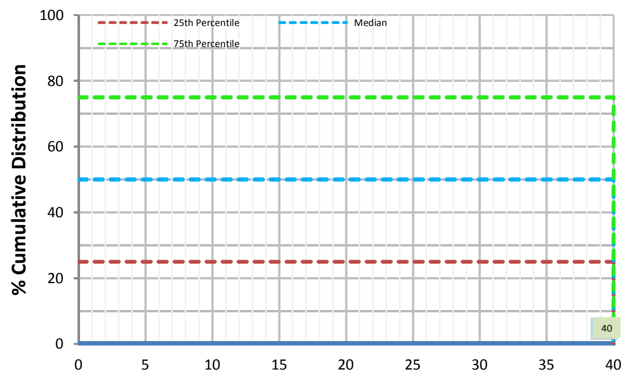
KGH001 - Ajax | Combined Data | Sector 1

Domain: PXPP | Meters Logged: 0 m

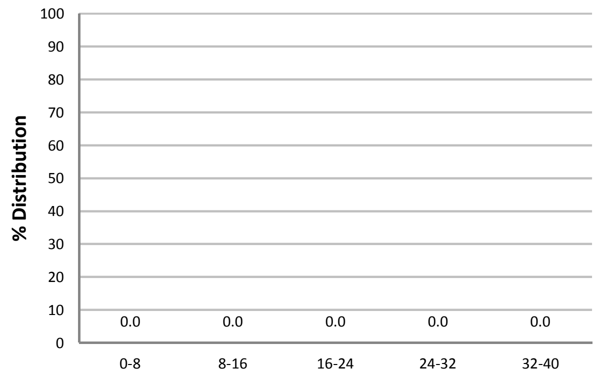
Nf DISTRIBUTION



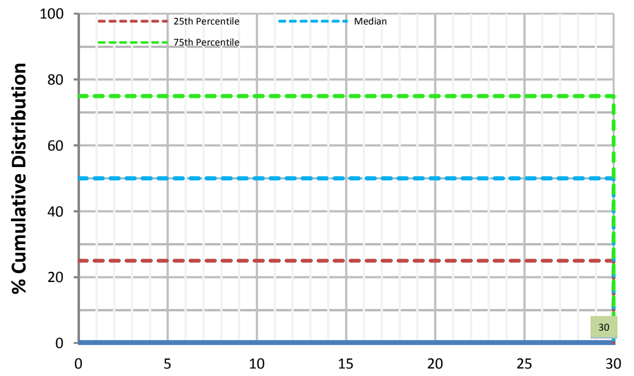
Nf CUMULATIVE DISTRIBUTION



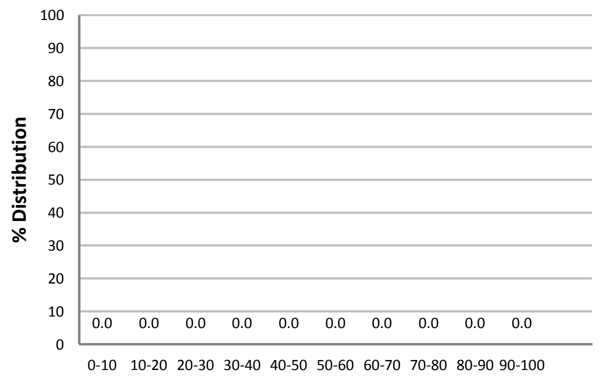
Nc DISTRIBUTION



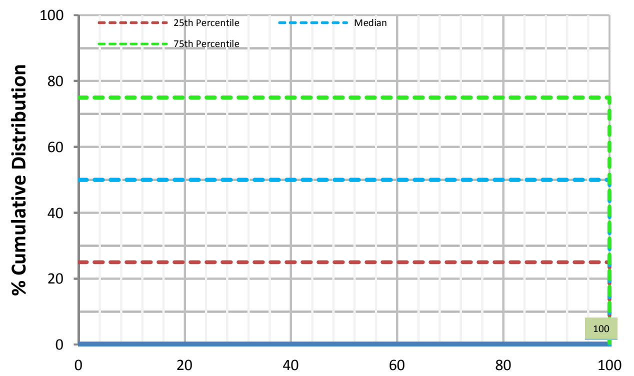
Nc CUMULATIVE DISTRIBUTION



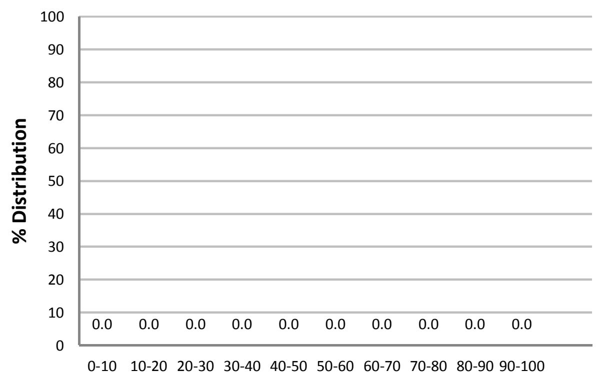
RMR DISTRIBUTION



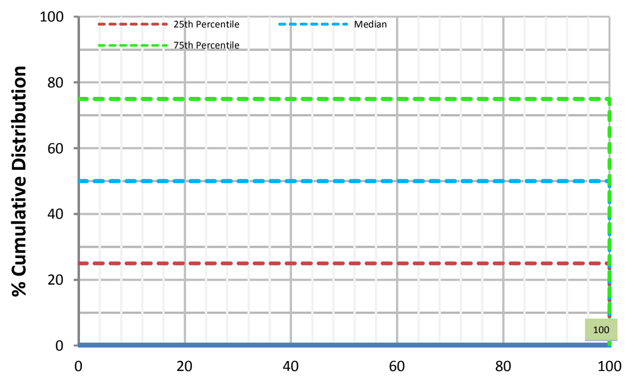
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

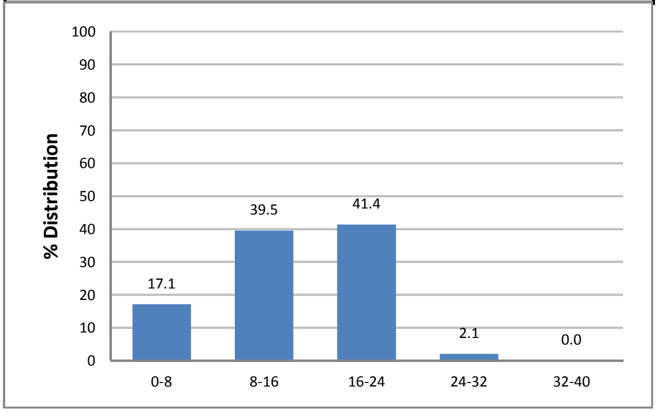


RMR MASS DATA - RMR PARAMETERS

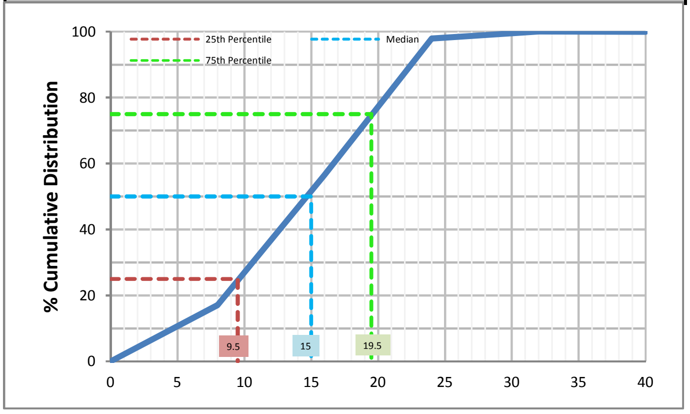
KGH001 - Ajax | Combined Data | Sector 1

Domain: SLD | Meters Logged: 203.03 m

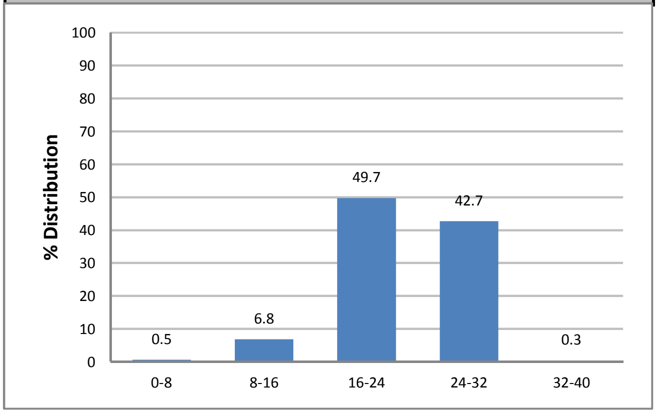
Nf DISTRIBUTION



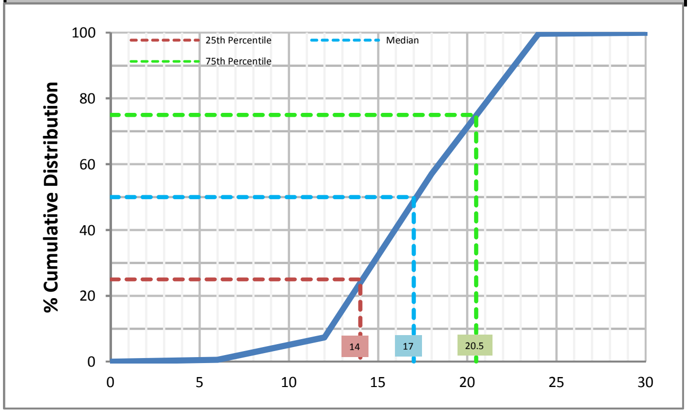
Nf CUMULATIVE DISTRIBUTION



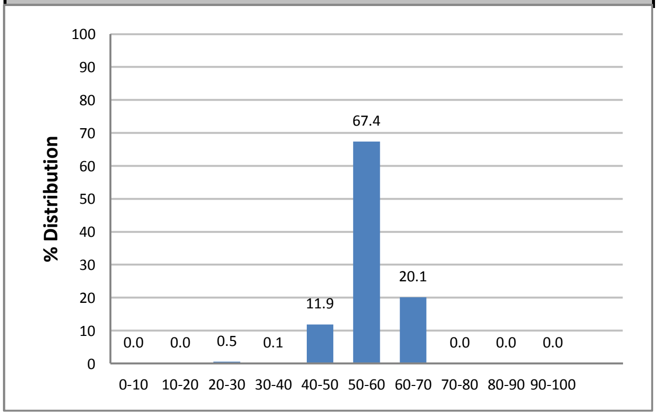
Nc DISTRIBUTION



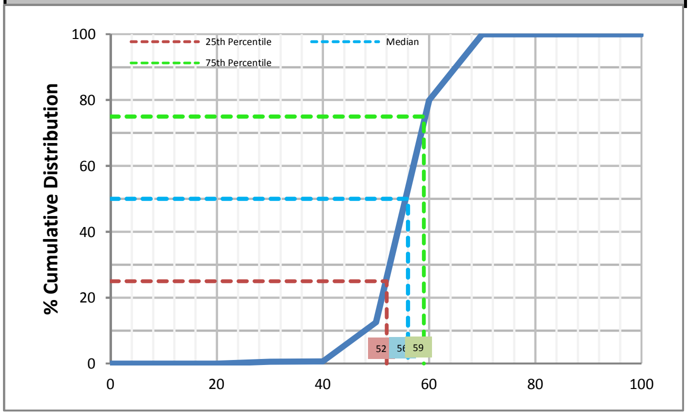
Nc CUMULATIVE DISTRIBUTION



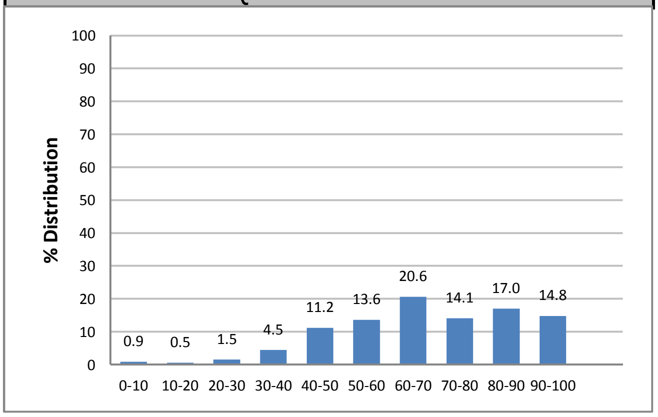
RMR DISTRIBUTION



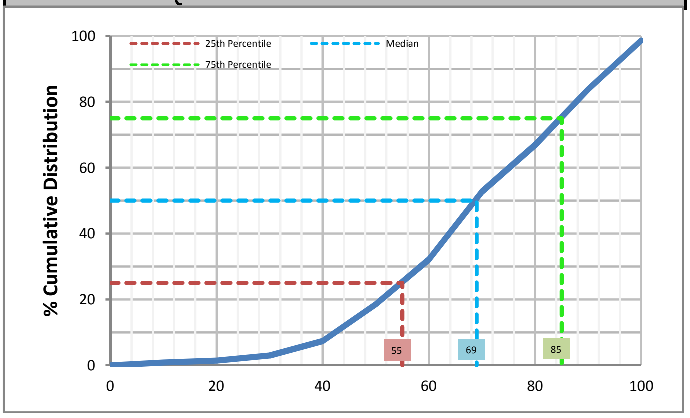
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

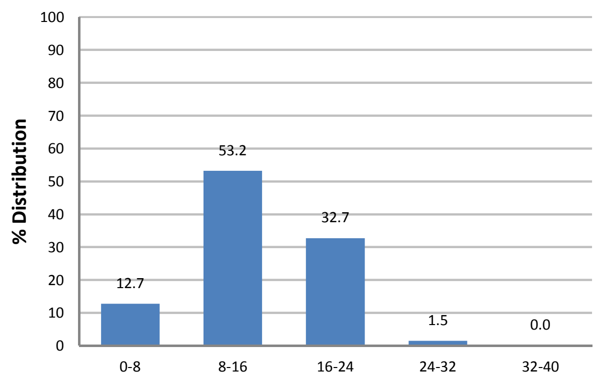


RMR MASS DATA - RMR PARAMETERS

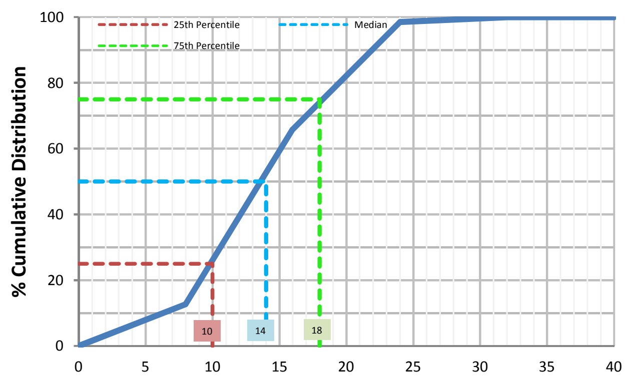
KGH001 - Ajax | Combined Data | Sector 1

Domain: SVHYB | Meters Logged: 384.65 m

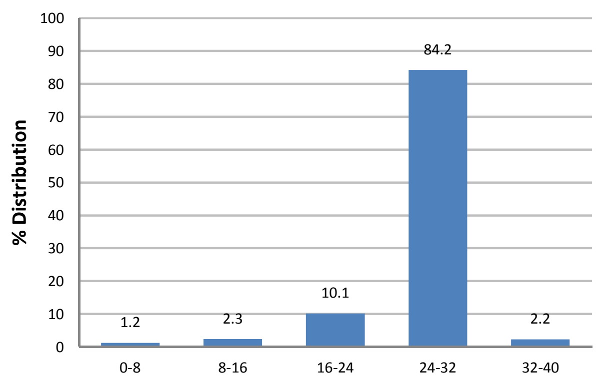
Nf DISTRIBUTION



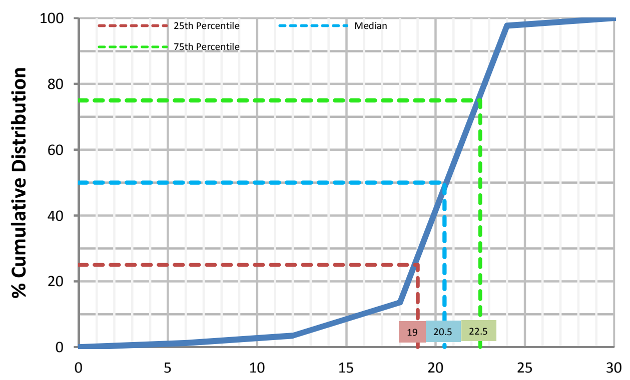
Nf CUMULATIVE DISTRIBUTION



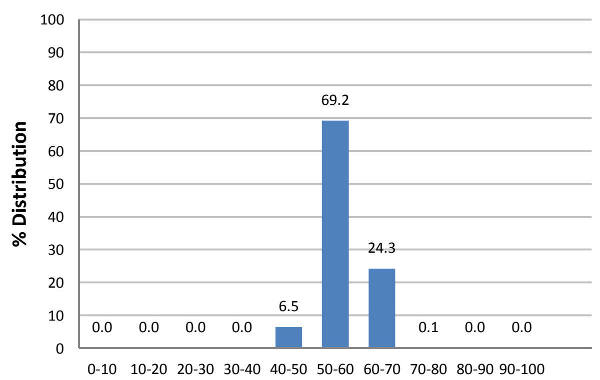
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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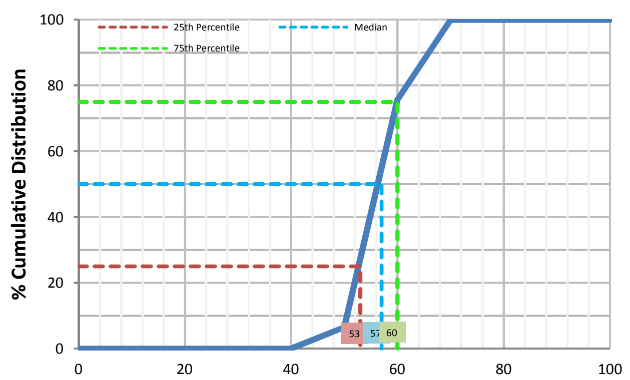
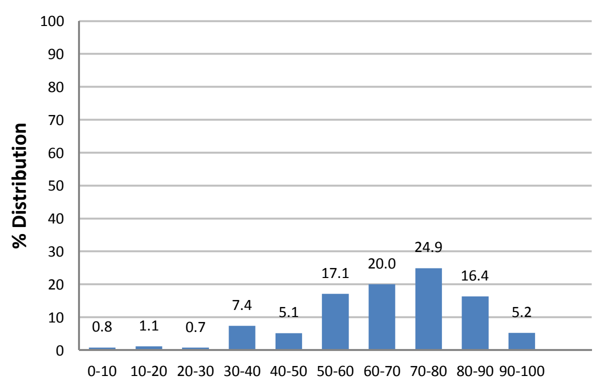
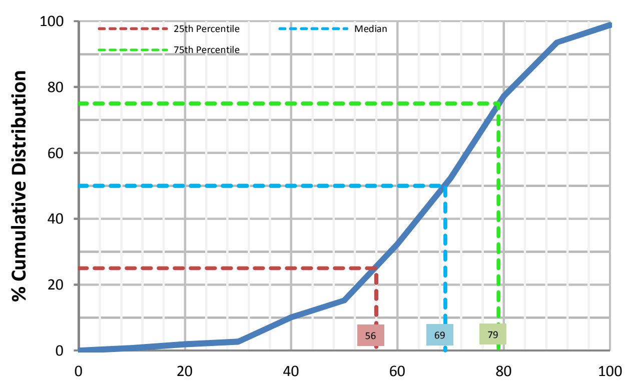


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

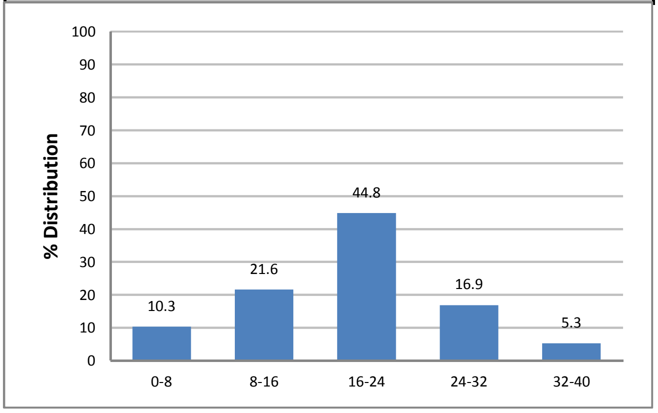


RMR MASS DATA - RMR PARAMETERS

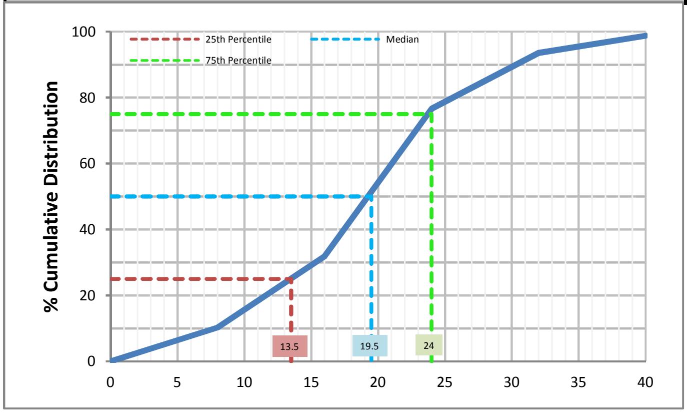
KGH001 - Ajax | Combined Data | Sector 2

Domain: IMH | Meters Logged: 1405.44 m

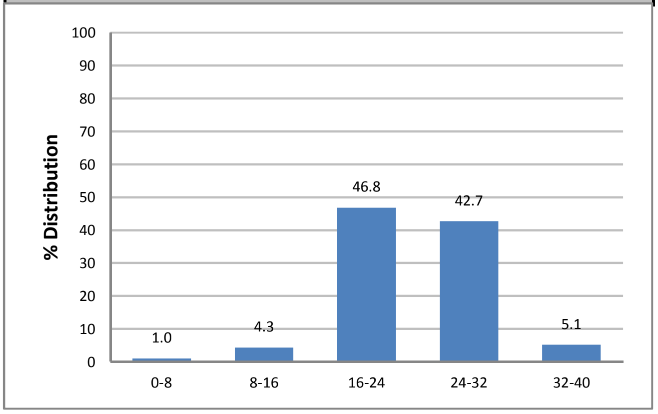
Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



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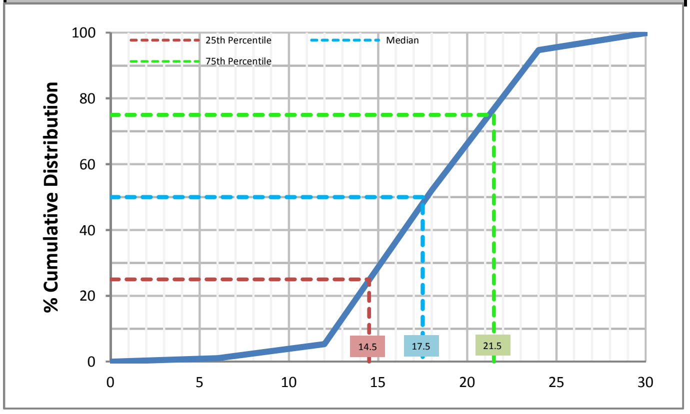

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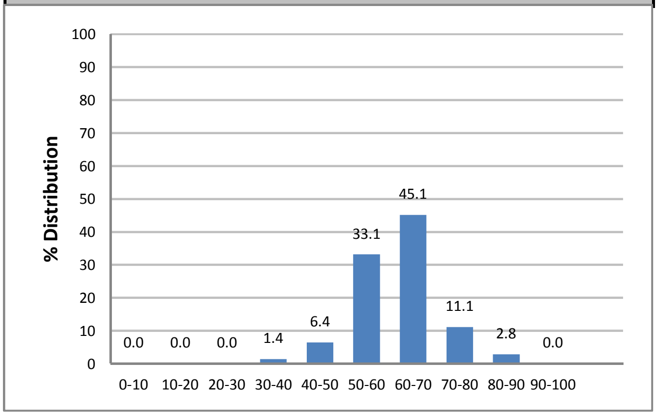

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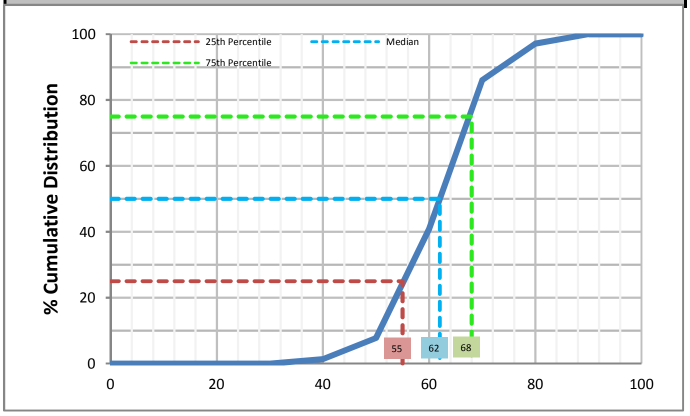
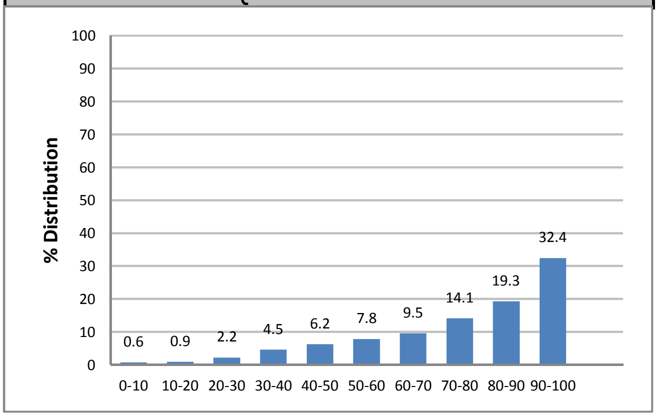
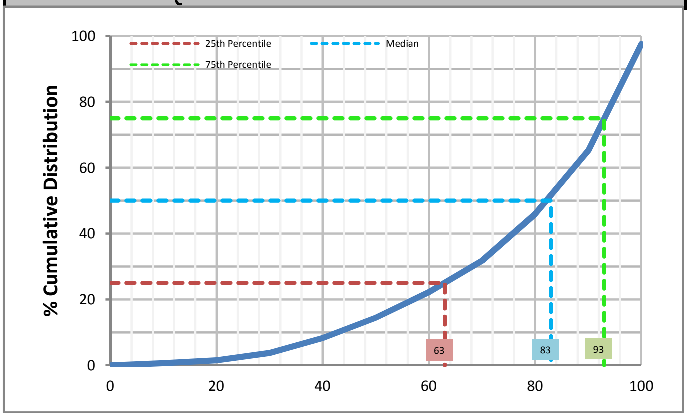


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

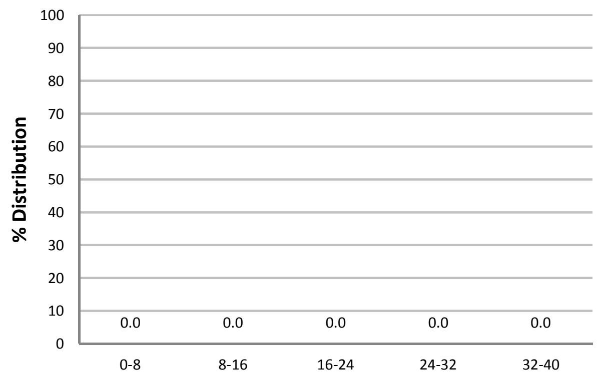


RMR MASS DATA - RMR PARAMETERS

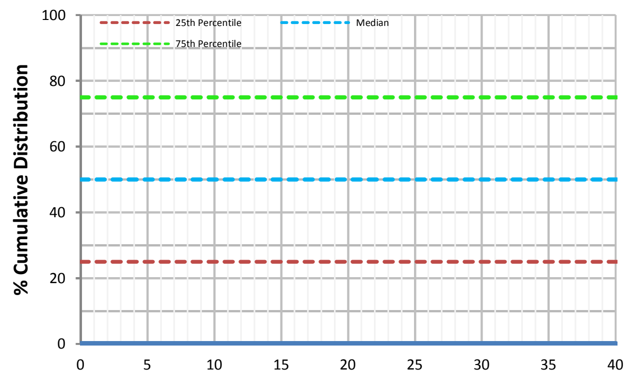
KGH001 - Ajax | Combined Data | Sector 2

Domain: LAT | Meters Logged: 0 m

Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



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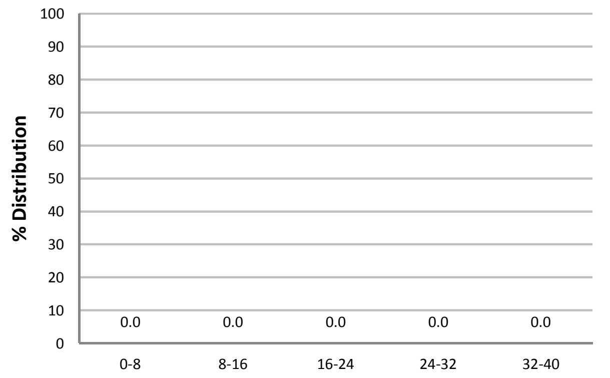

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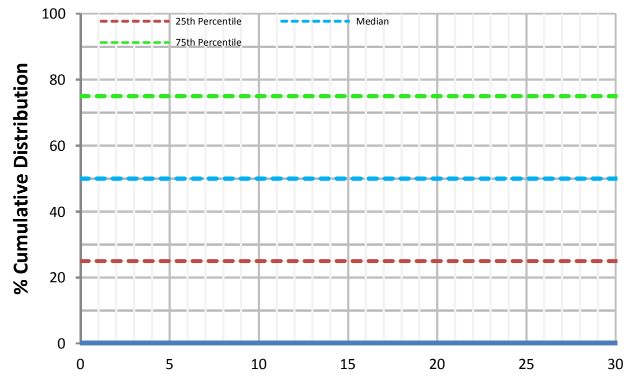

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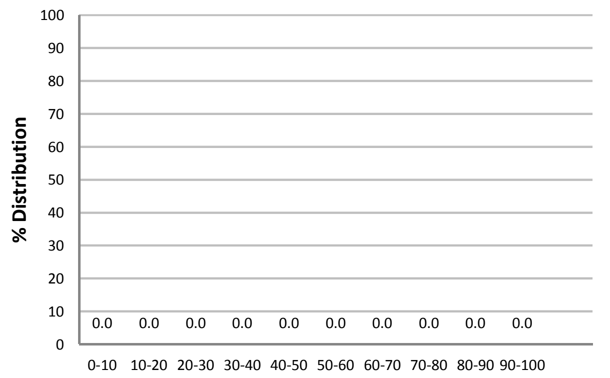

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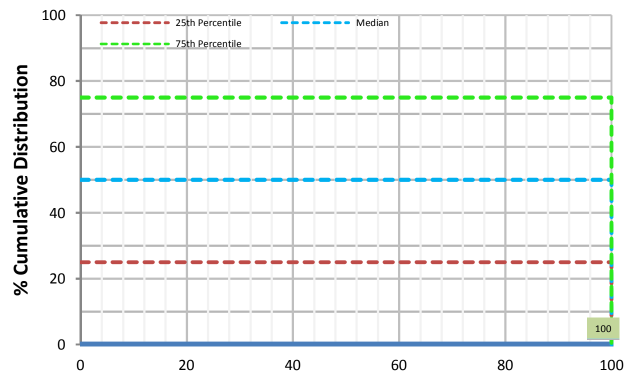

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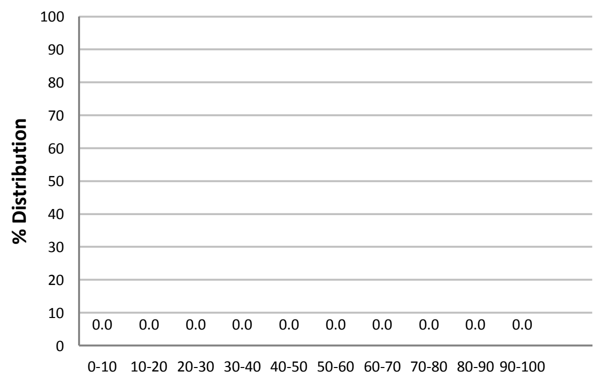

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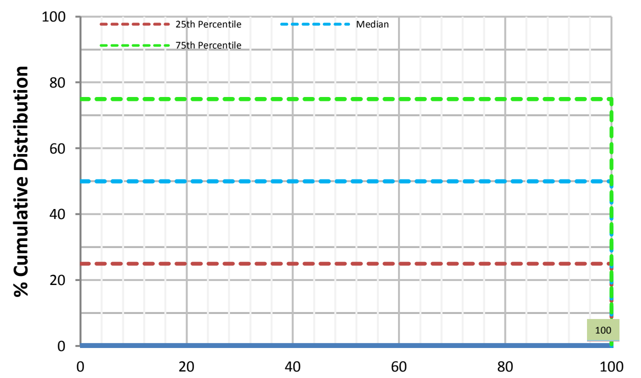
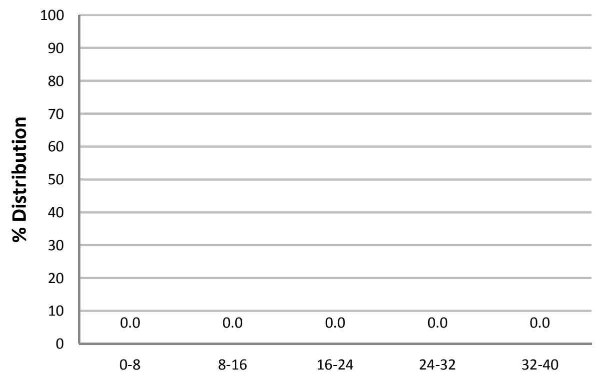


RMR MASS DATA - RMR PARAMETERS

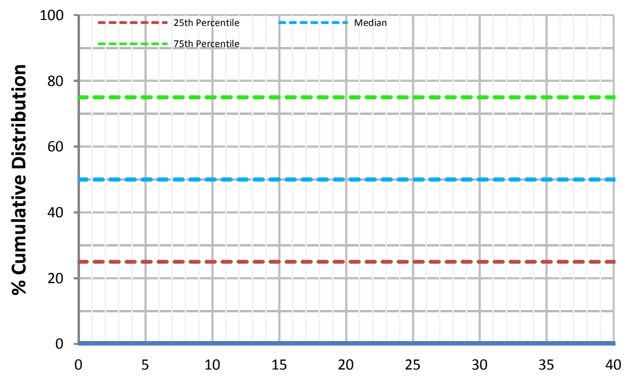
KGH001 - Ajax | Combined Data | Sector 2

Domain: MAFV | Meters Logged: 0 m

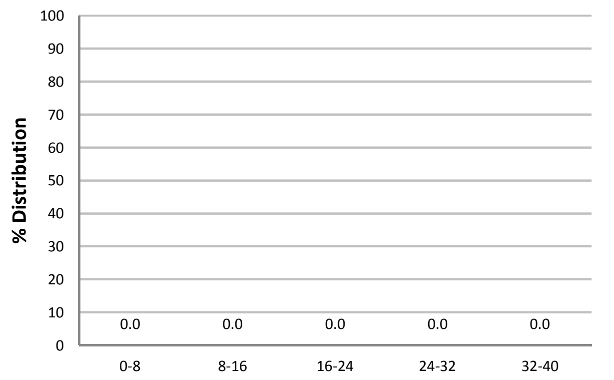
Nf DISTRIBUTION



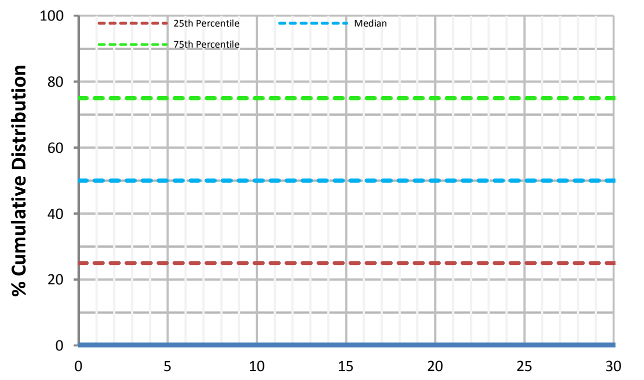
Nf CUMULATIVE DISTRIBUTION



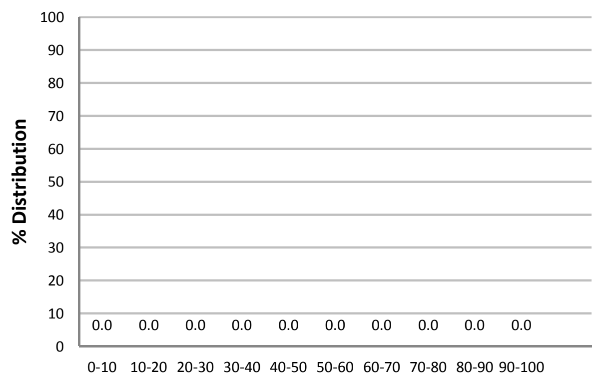
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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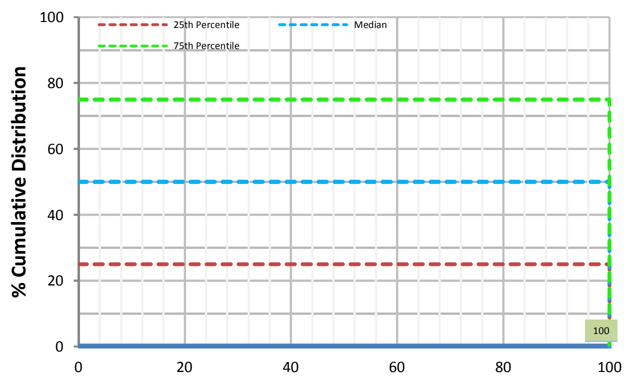

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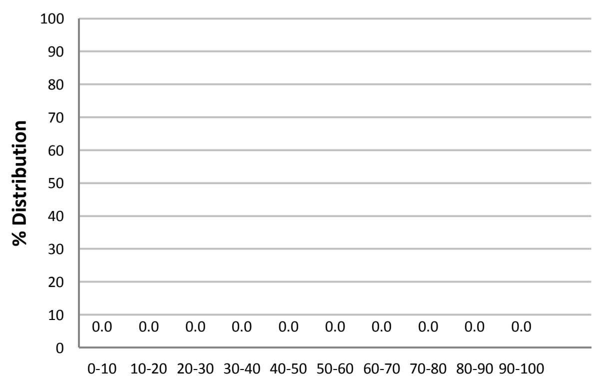

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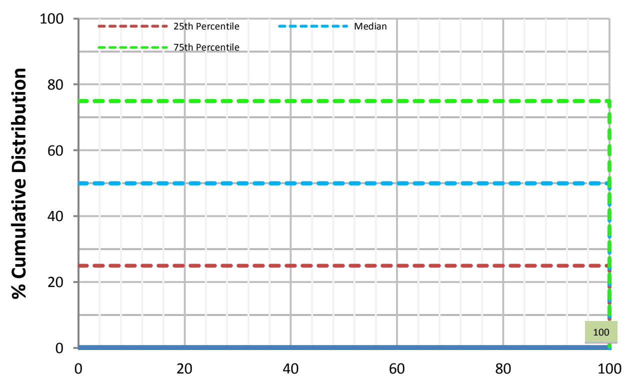
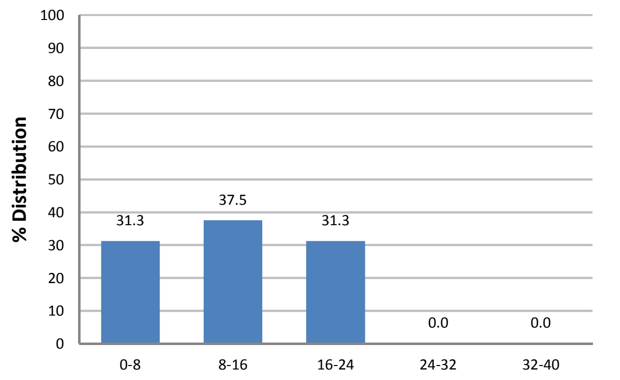


RMR MASS DATA - RMR PARAMETERS

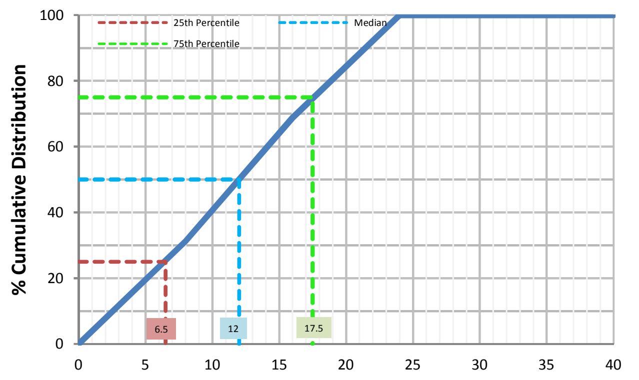
KGH001 - Ajax | Combined Data | Sector 2

Domain: MONZ | Meters Logged: 24.38 m

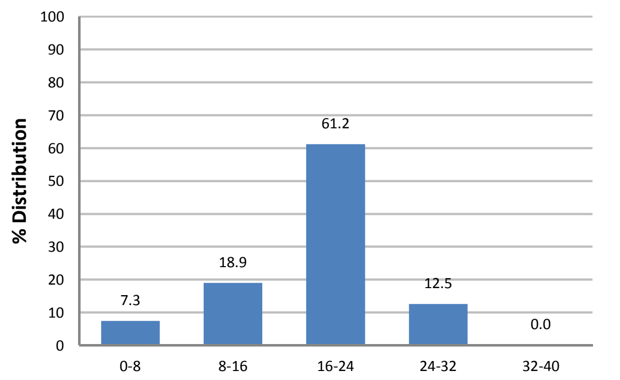
Nf DISTRIBUTION



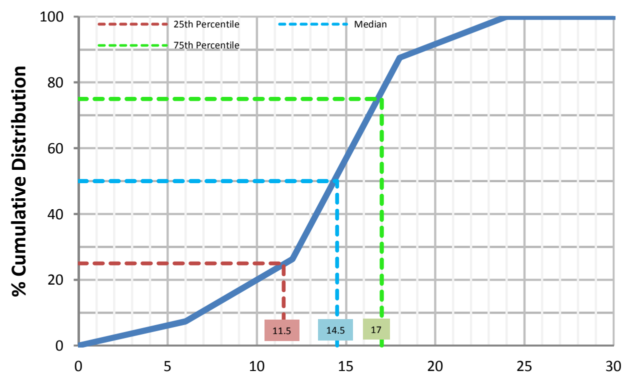
Nf CUMULATIVE DISTRIBUTION



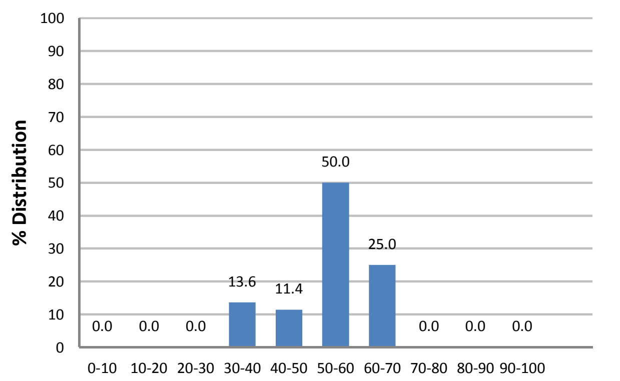
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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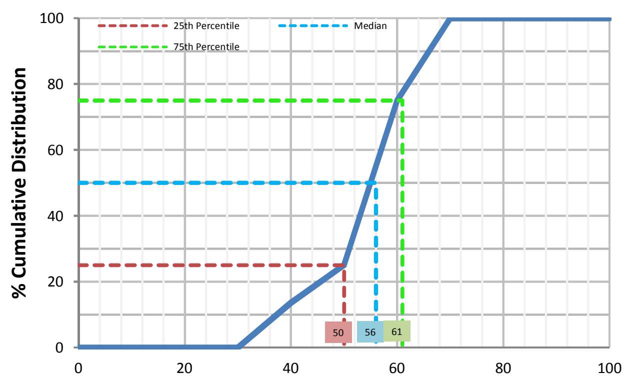
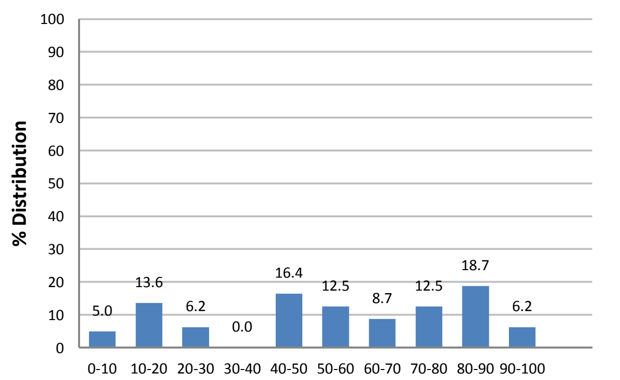


RQD DISTRIBUTION



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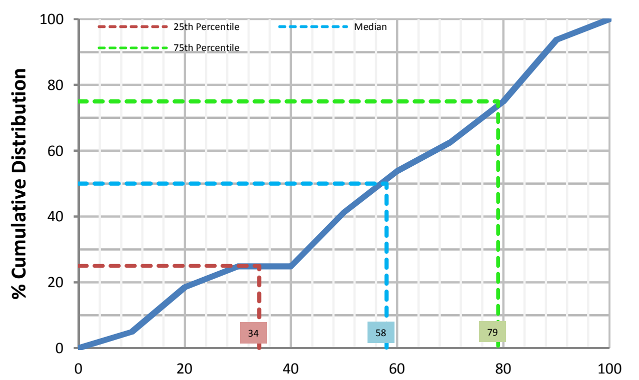
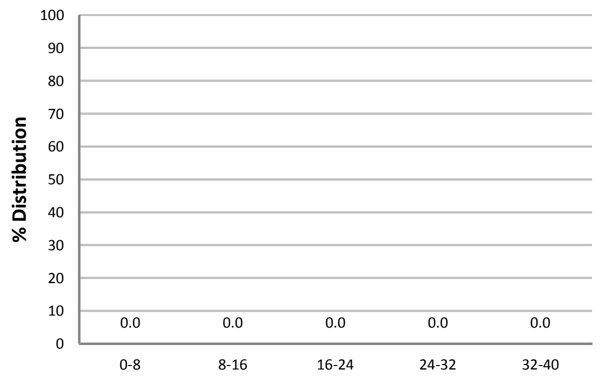


RMR MASS DATA - RMR PARAMETERS

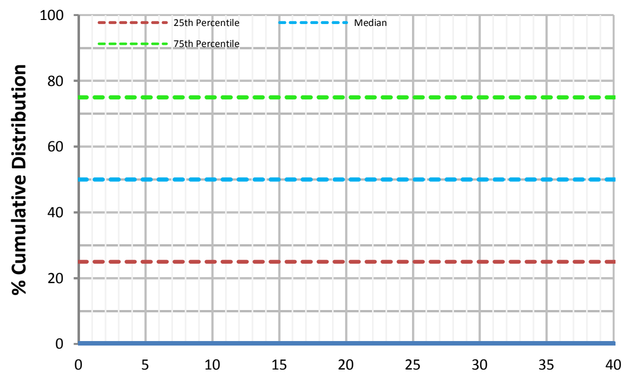
KGH001 - Ajax | Combined Data | Sector 2

Domain: PICR | Meters Logged: 0 m

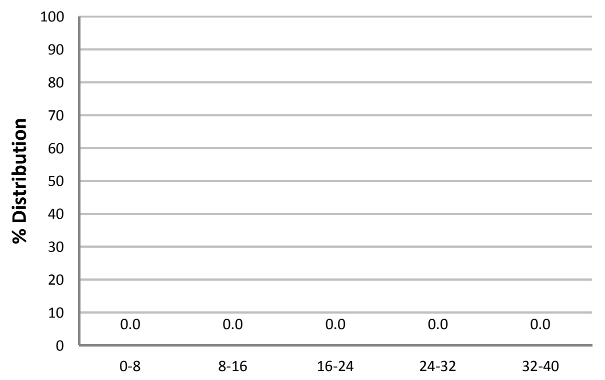
Nf DISTRIBUTION



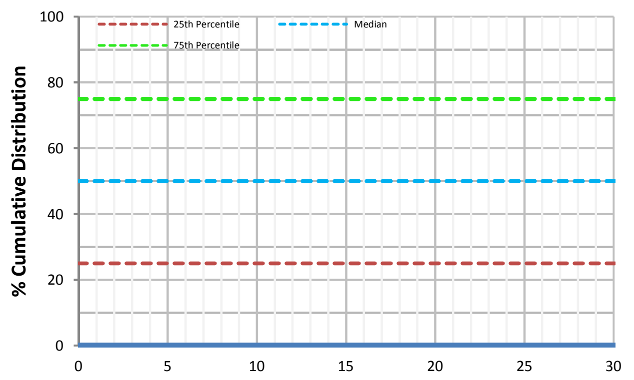
Nf CUMULATIVE DISTRIBUTION



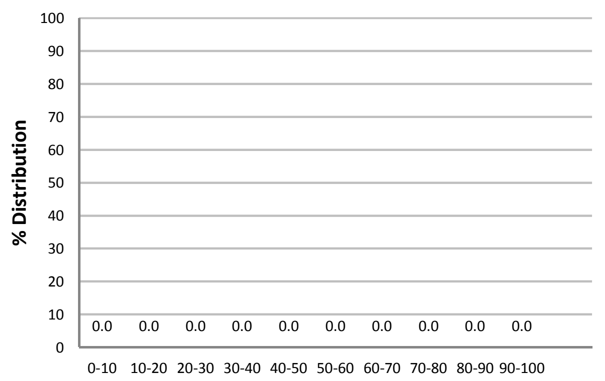
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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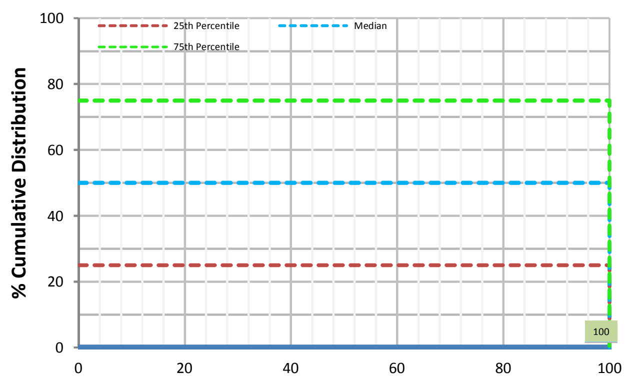
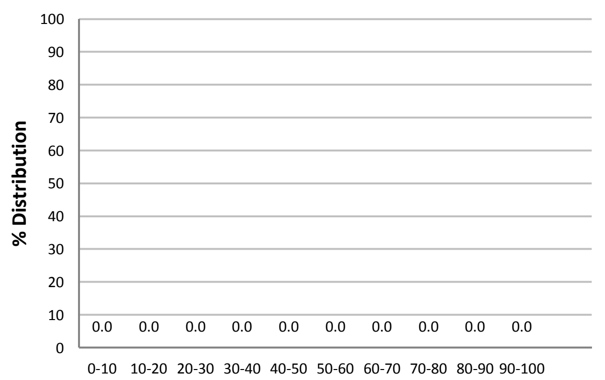


RQD DISTRIBUTION



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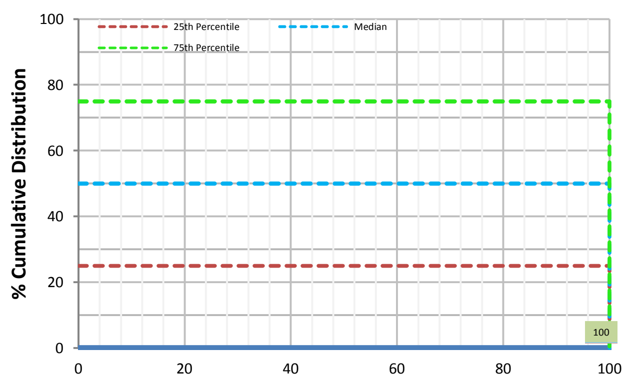
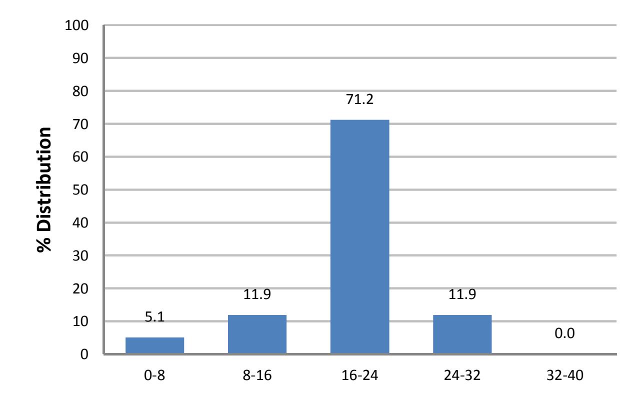


RMR MASS DATA - RMR PARAMETERS

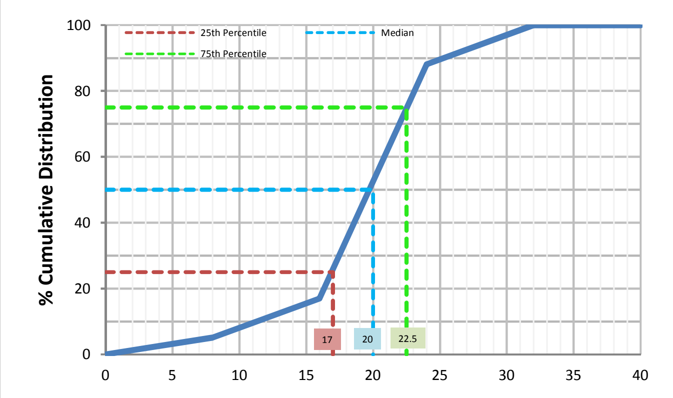
KGH001 - Ajax | Combined Data | Sector 2

Domain: PXPP | Meters Logged: 179.83 m

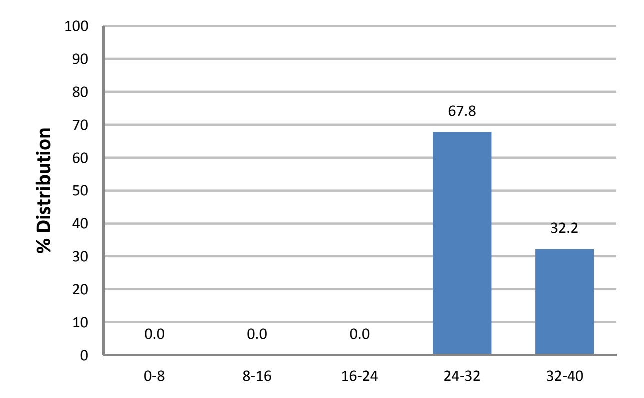
Nf DISTRIBUTION



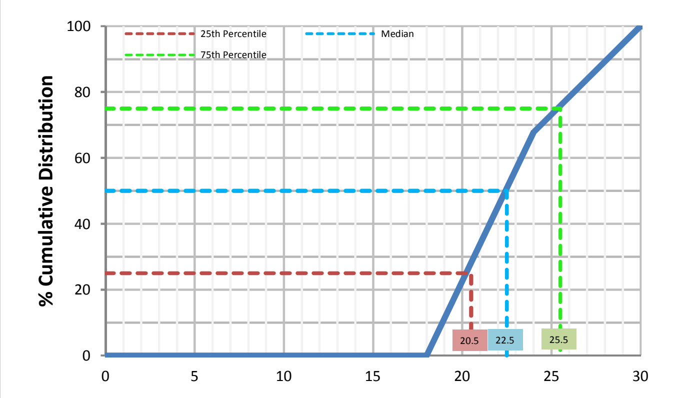
Nf CUMULATIVE DISTRIBUTION



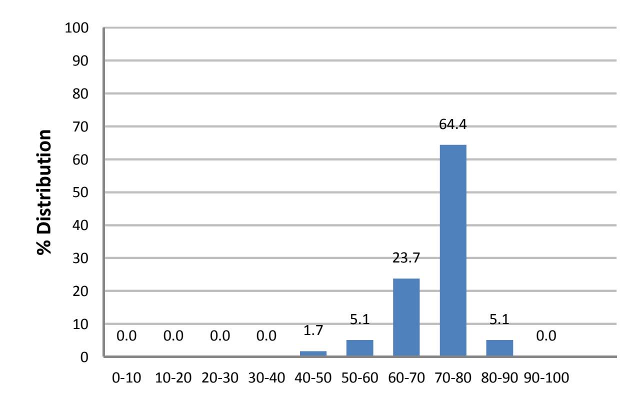
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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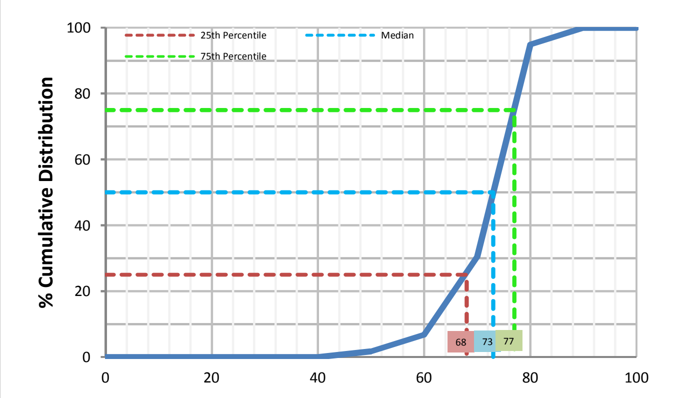
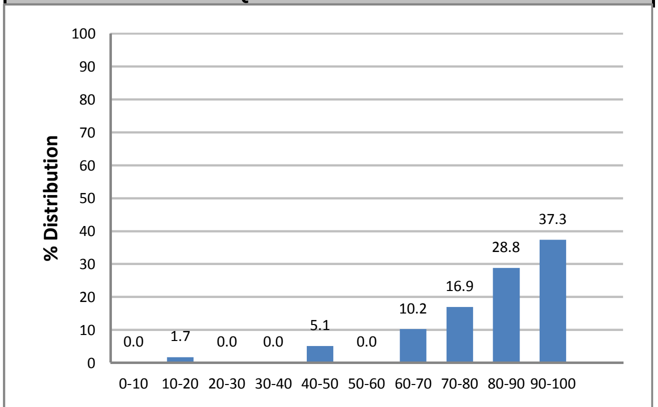


RQD DISTRIBUTION



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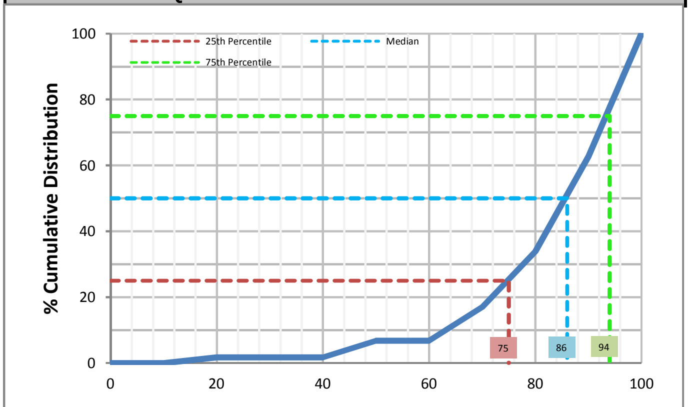


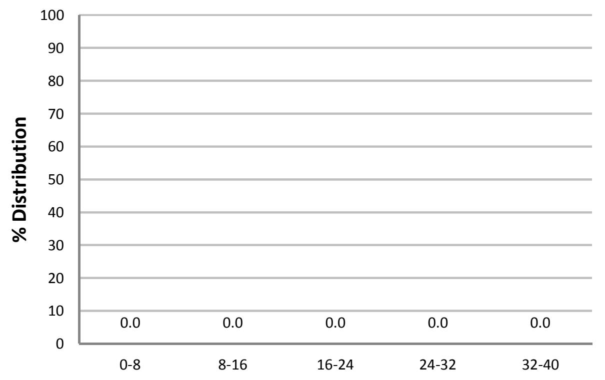
RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 2

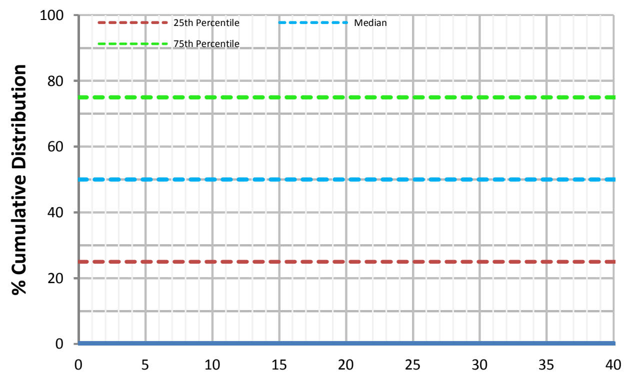
Domain: SLD

Meters Logged: 0 m

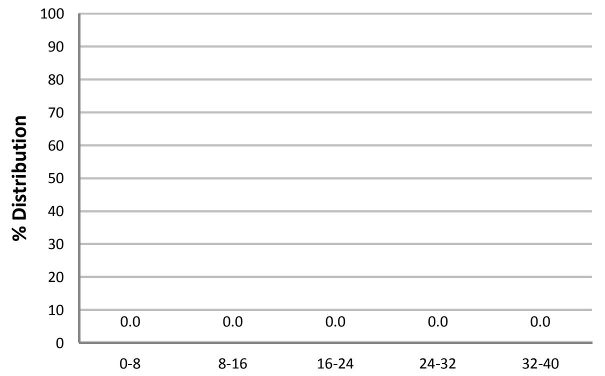
Nf DISTRIBUTION



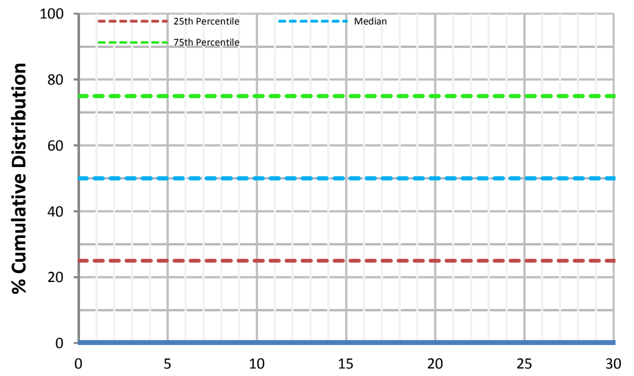
Nf CUMULATIVE DISTRIBUTION



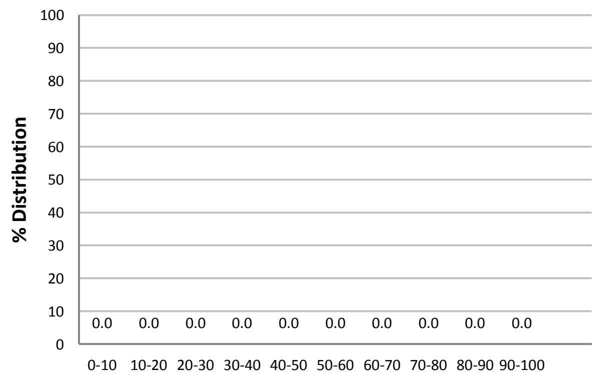
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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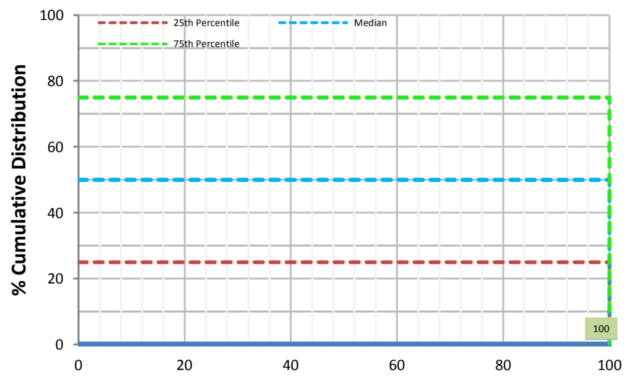
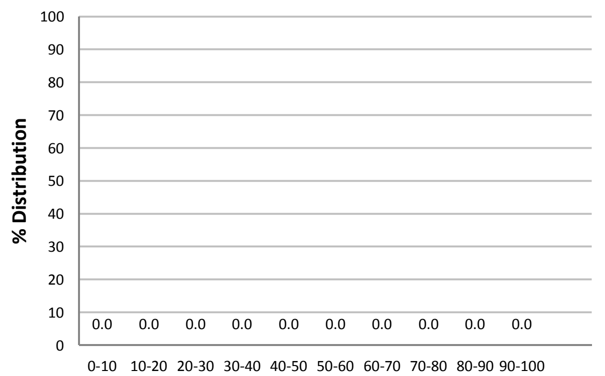
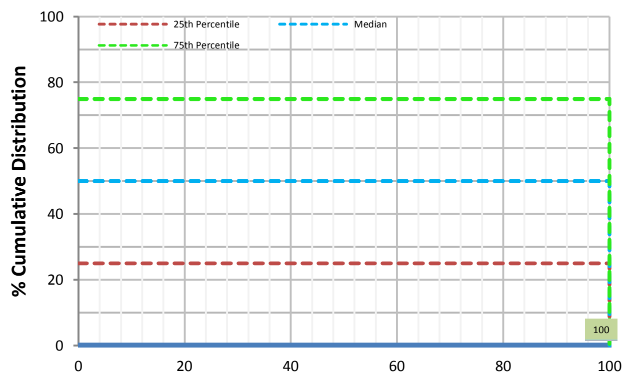


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

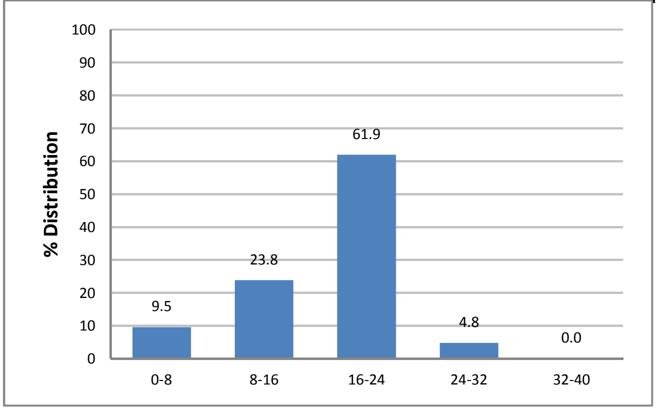


RMR MASS DATA - RMR PARAMETERS

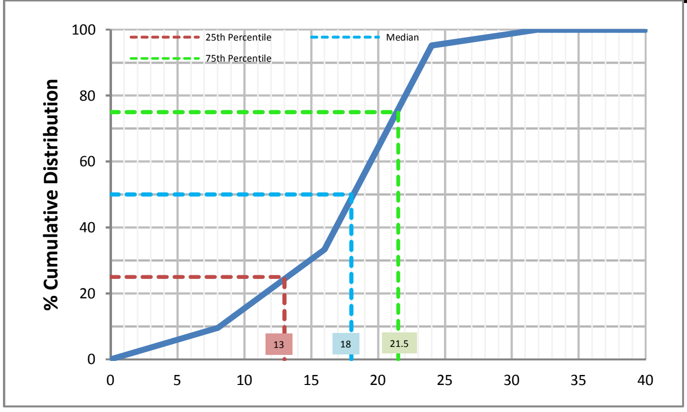
KGH001 - Ajax | Combined Data | Sector 2

Domain: SVHYB | Meters Logged: 192.03 m

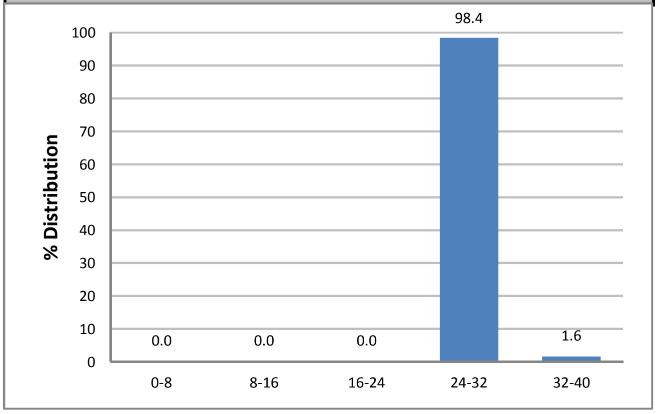
Nf DISTRIBUTION



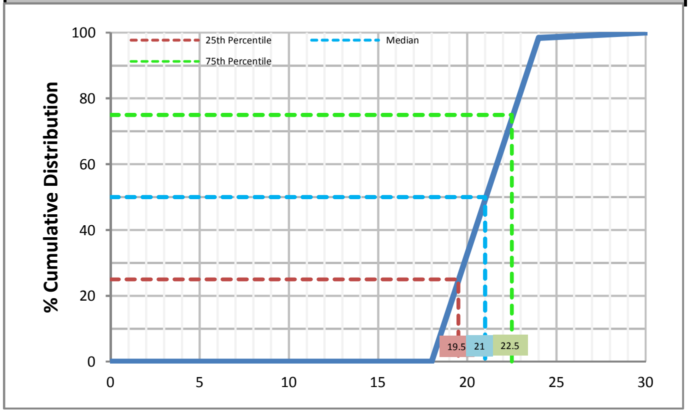
Nf CUMULATIVE DISTRIBUTION



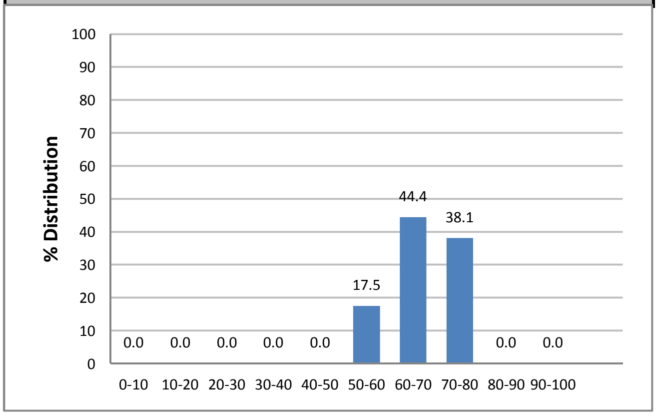
Nc DISTRIBUTION



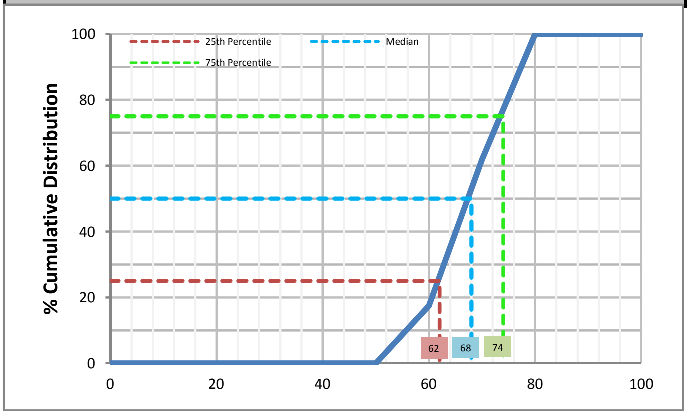
Nc CUMULATIVE DISTRIBUTION



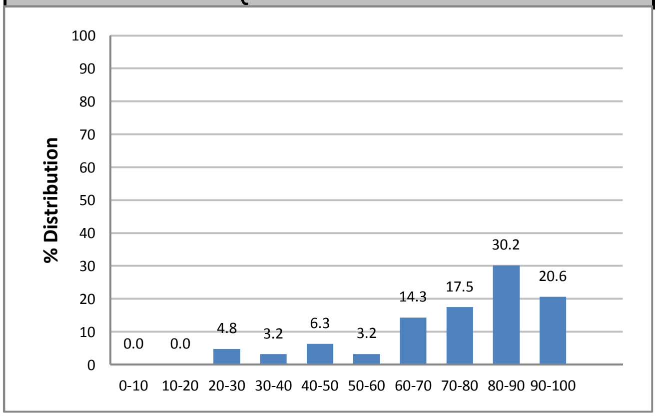
RMR DISTRIBUTION



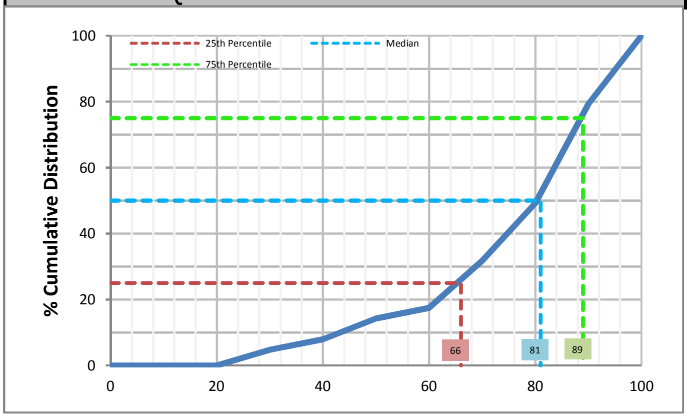
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

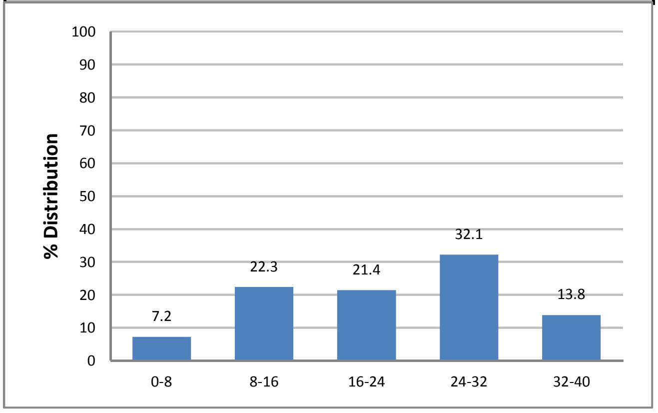


RMR MASS DATA - RMR PARAMETERS

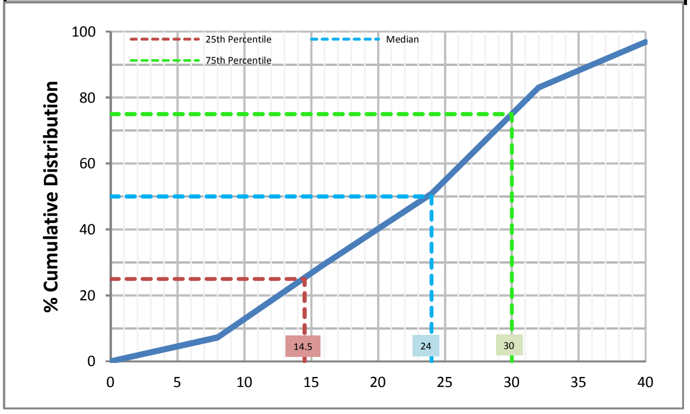
KGH001 - Ajax | Combined Data | Sector 3

Domain: IMH | Meters Logged: 870.63 m

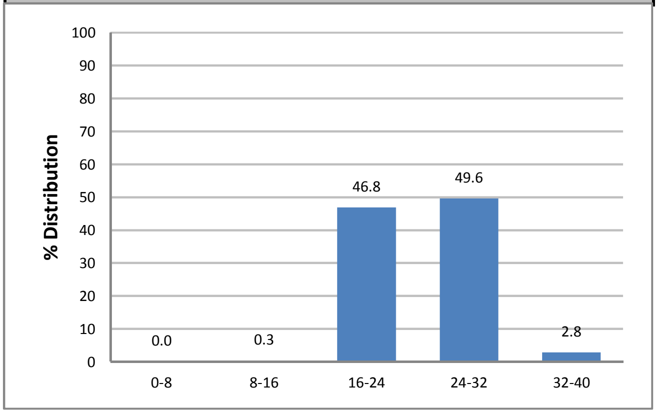
Nf DISTRIBUTION



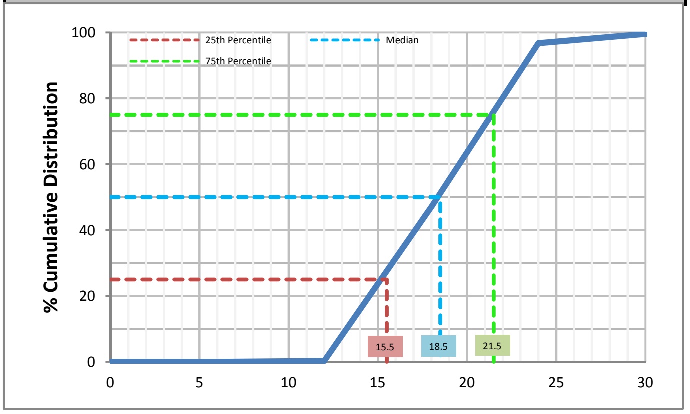
Nf CUMULATIVE DISTRIBUTION



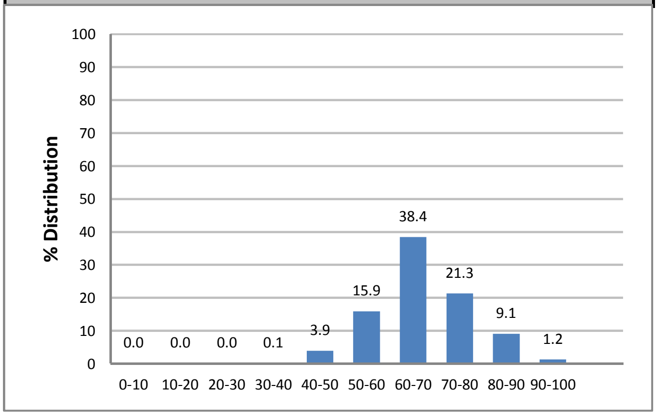
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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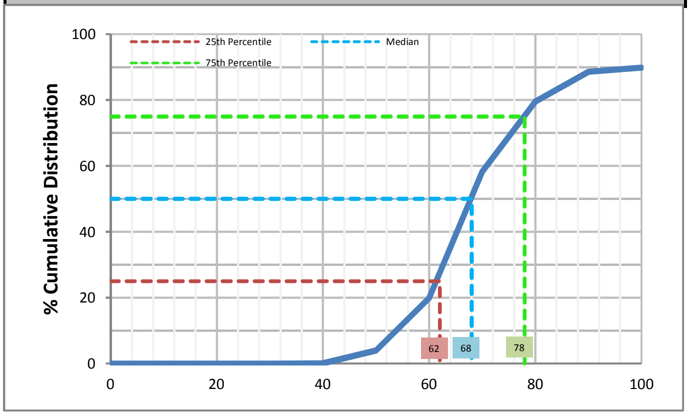
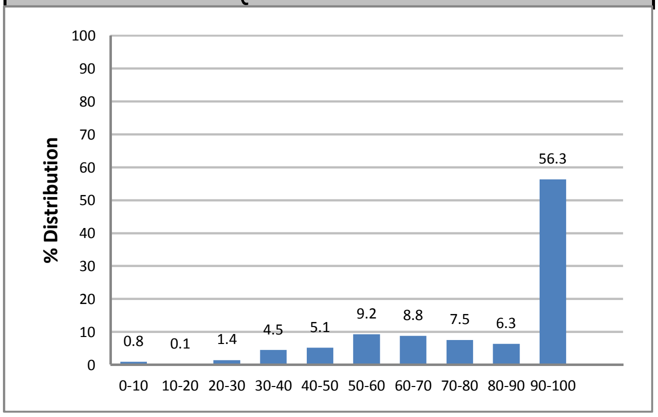
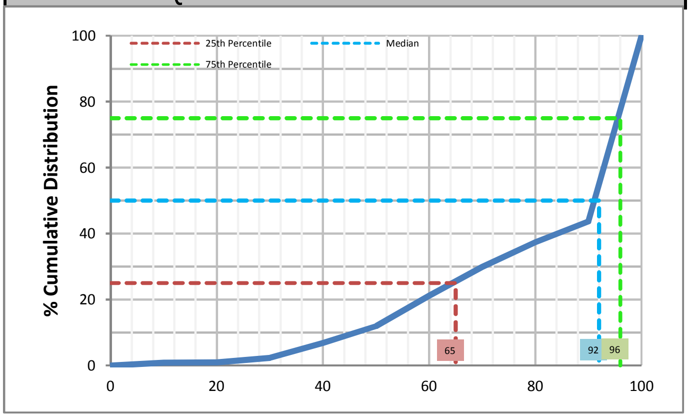


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

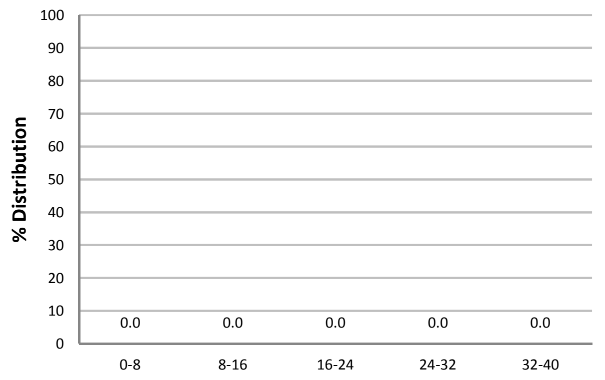


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 3

Domain: LAT | Meters Logged: 0 m

Nf DISTRIBUTION



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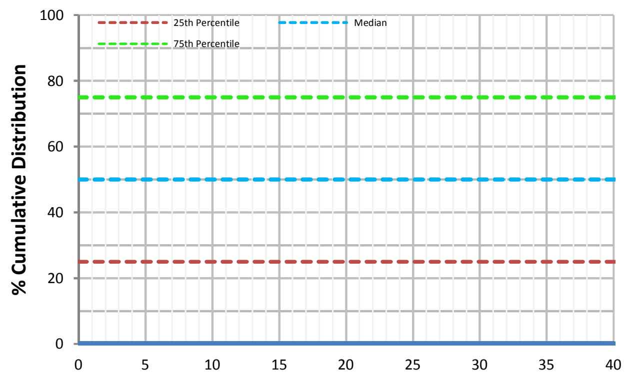
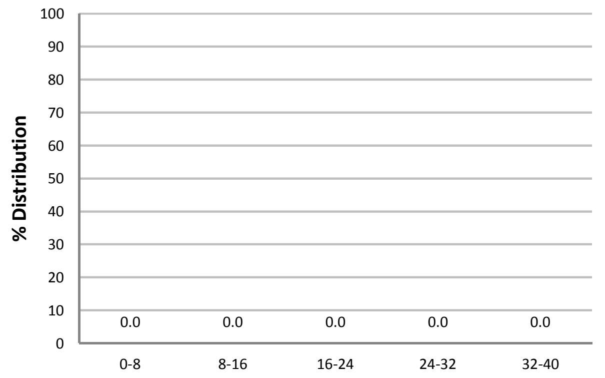


Nc DISTRIBUTION



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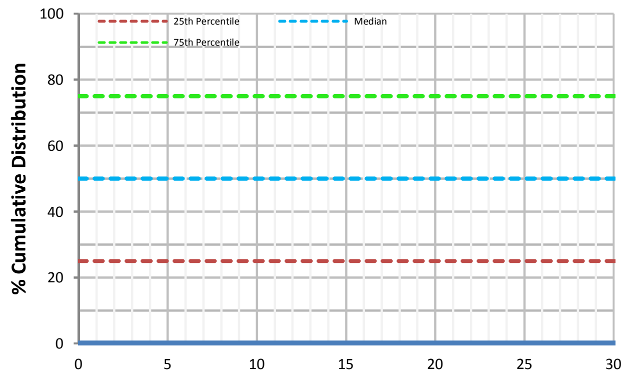

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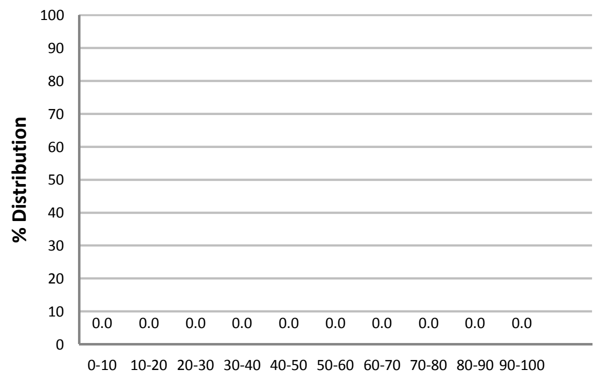

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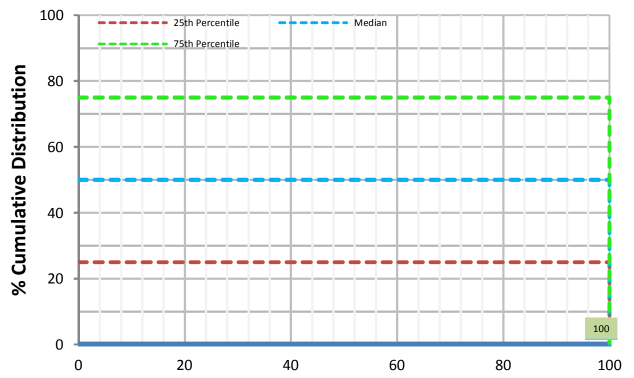

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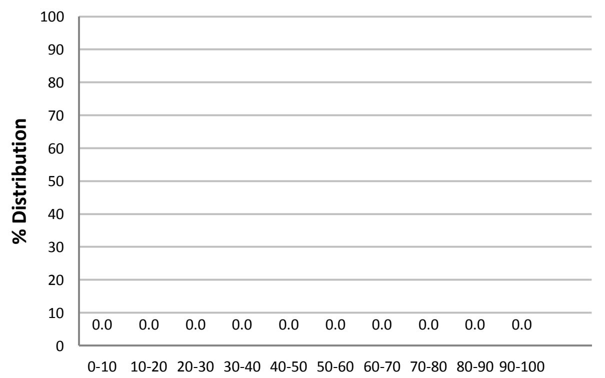

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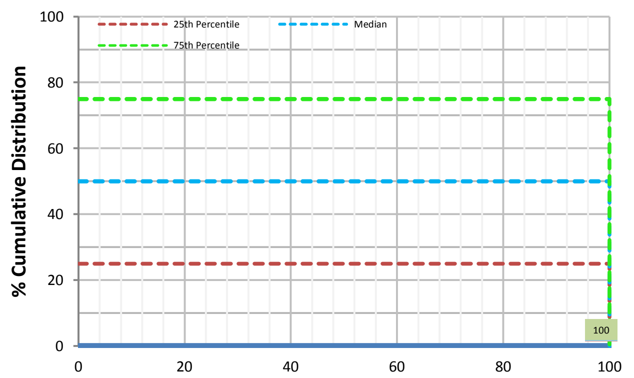
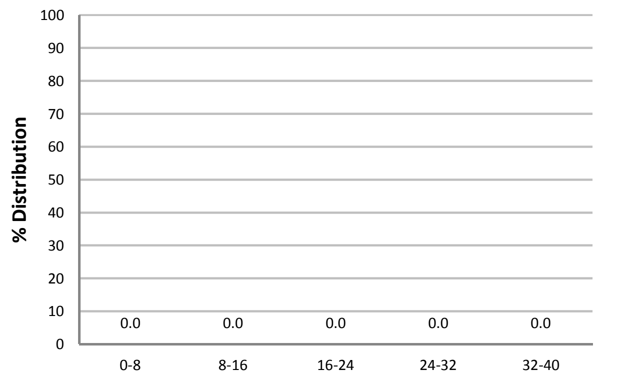


RMR MASS DATA - RMR PARAMETERS

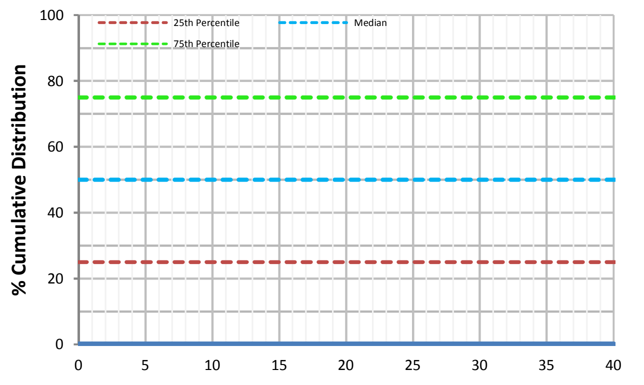
KGH001 - Ajax | Combined Data | Sector 3

Domain: MAFV | Meters Logged: 0 m

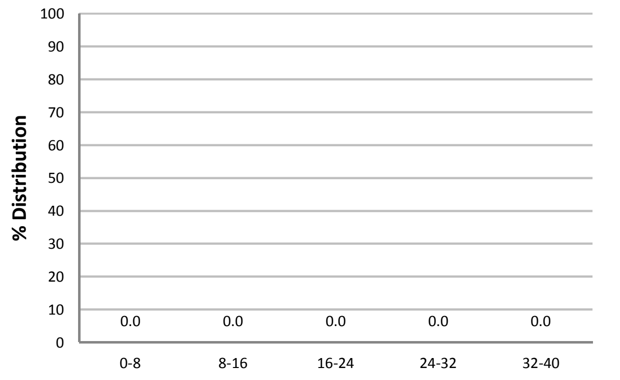
Nf DISTRIBUTION



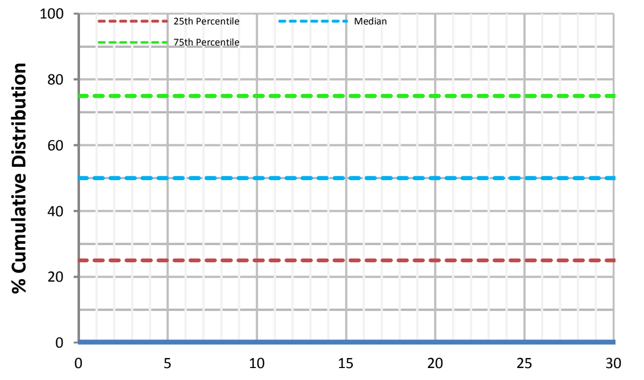
Nf CUMULATIVE DISTRIBUTION



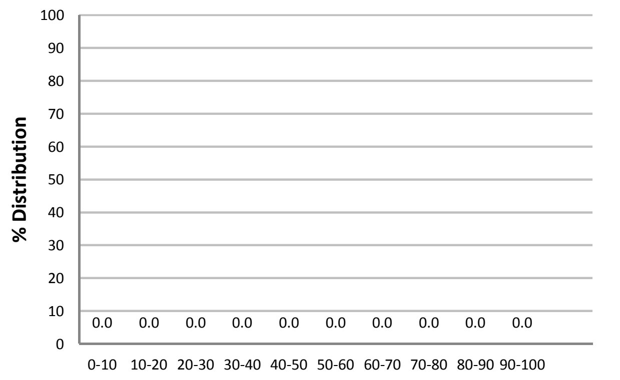
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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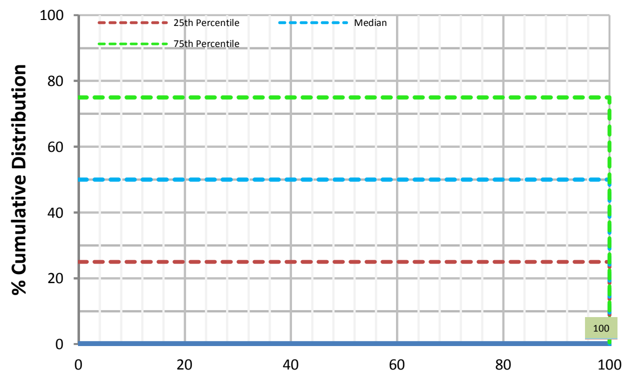
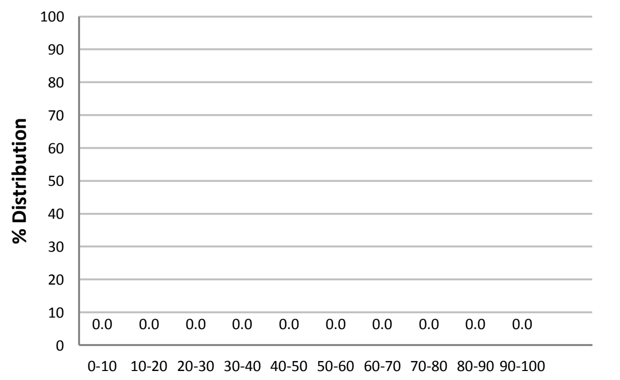


RQD DISTRIBUTION



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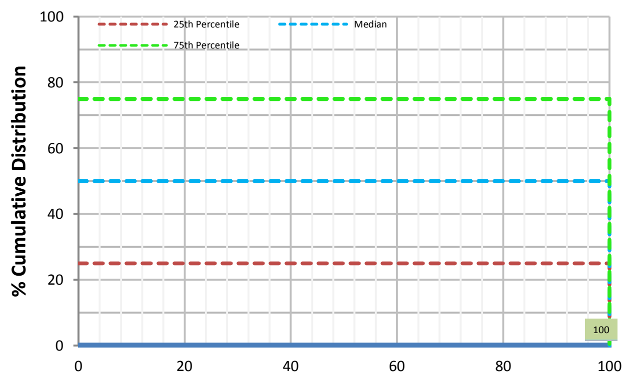
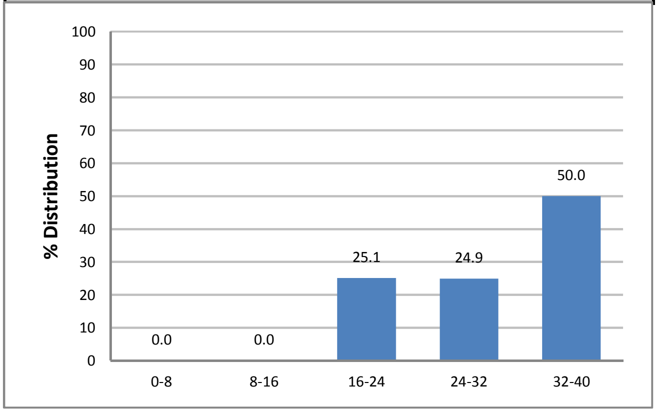


RMR MASS DATA - RMR PARAMETERS

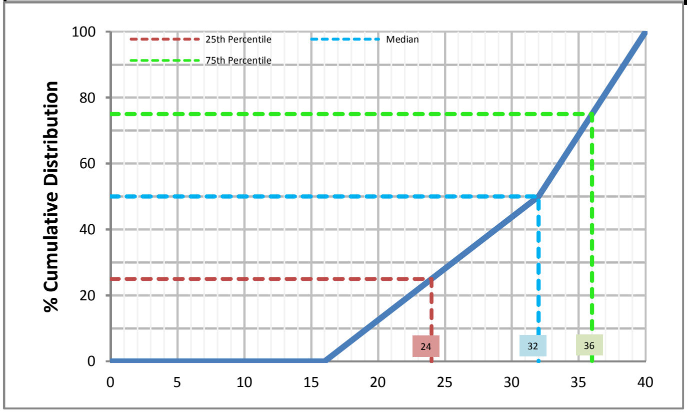
KGH001 - Ajax | Combined Data | Sector 3

Domain: MONZ | Meters Logged: 6.1 m

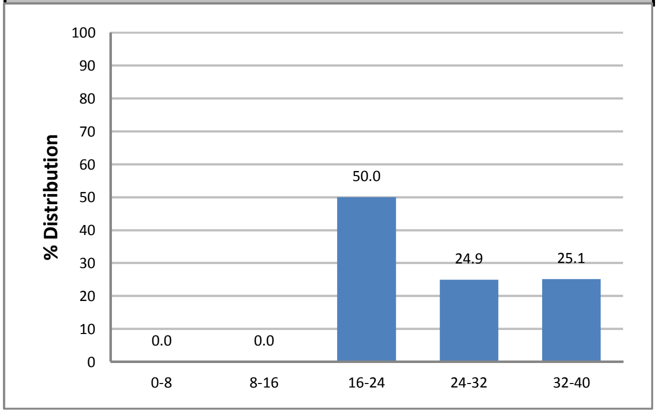
Nf DISTRIBUTION



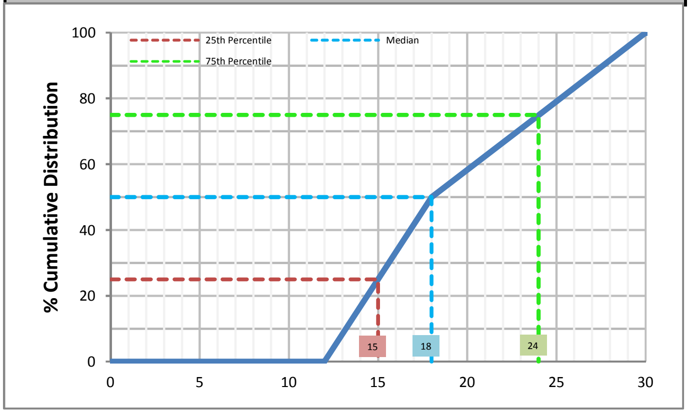
Nf CUMULATIVE DISTRIBUTION



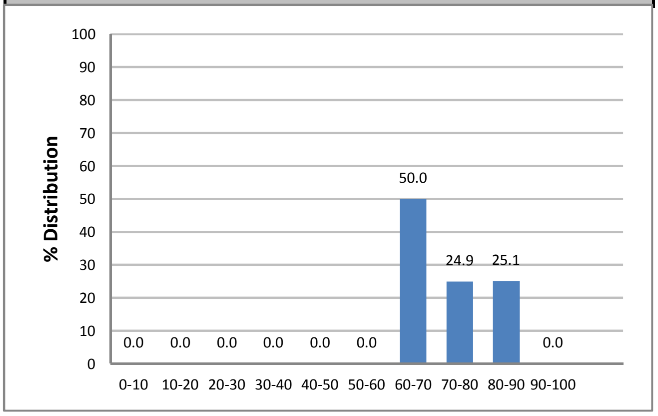
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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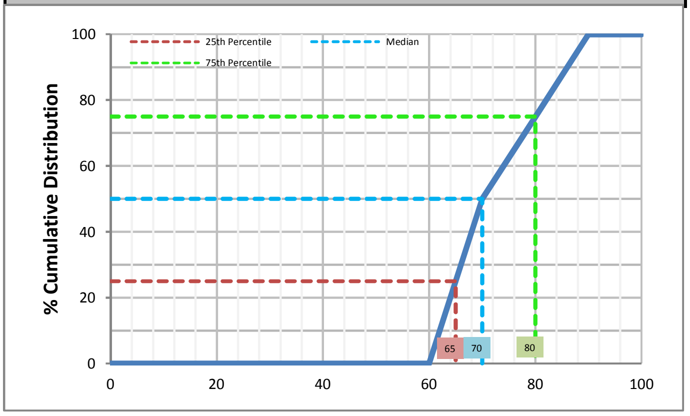
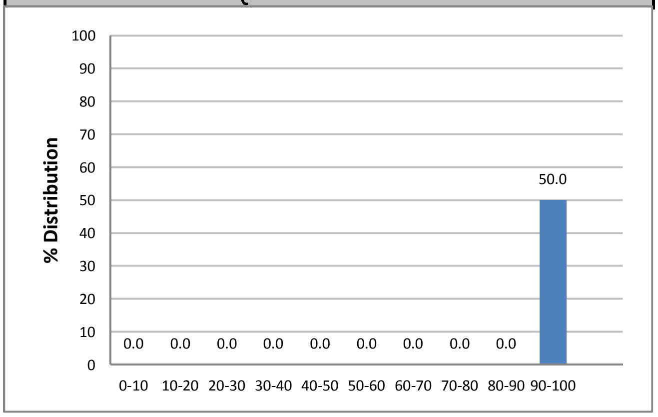
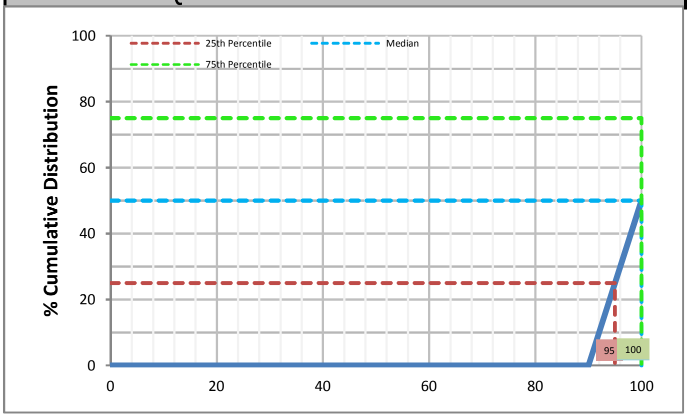


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

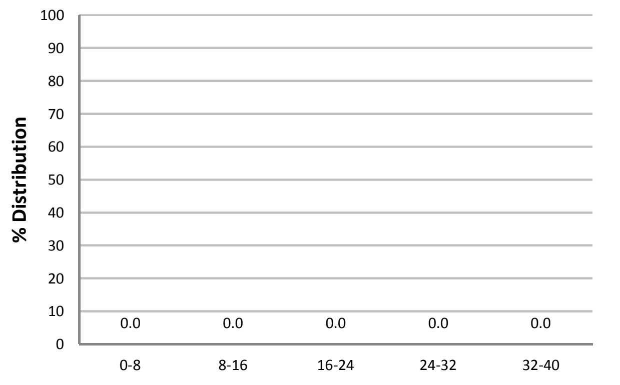


RMR MASS DATA - RMR PARAMETERS

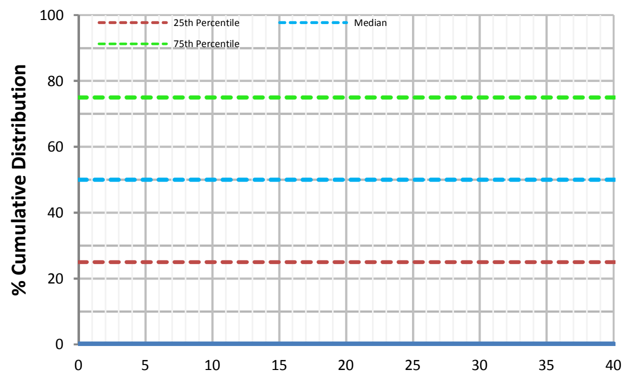
KGH001 - Ajax | Combined Data | Sector 3

Domain: PICR | Meters Logged: 0 m

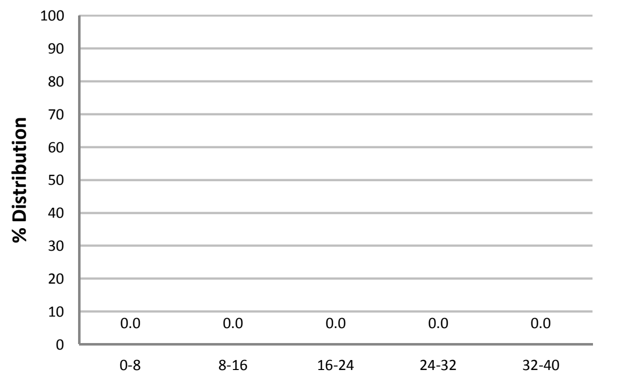
Nf DISTRIBUTION



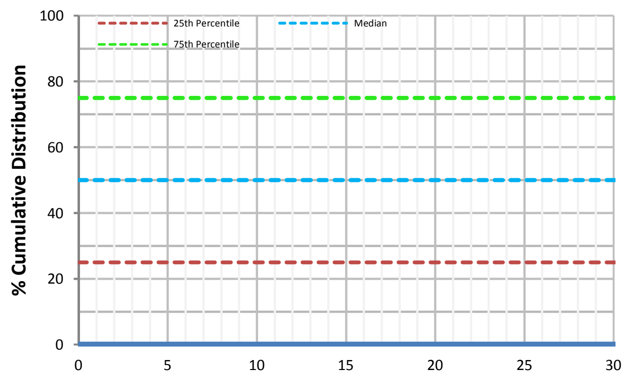
Nf CUMULATIVE DISTRIBUTION



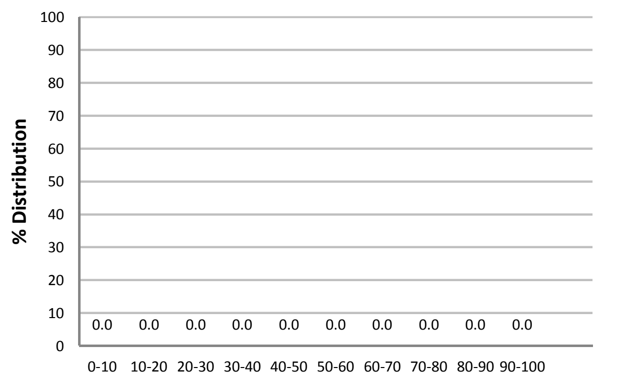
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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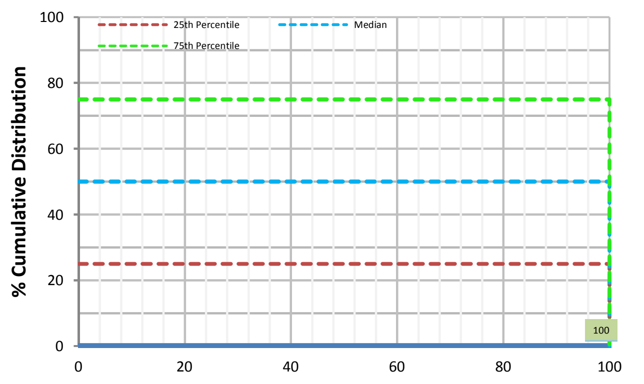
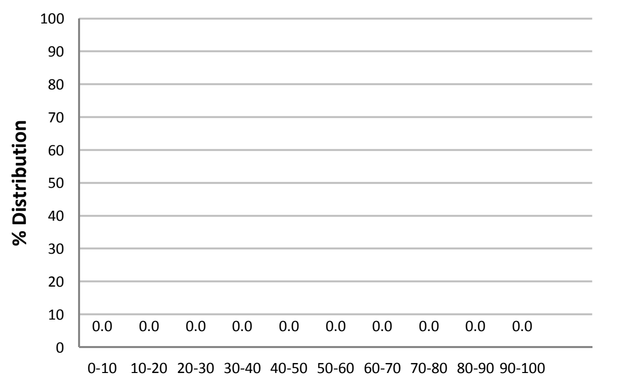


RQD DISTRIBUTION



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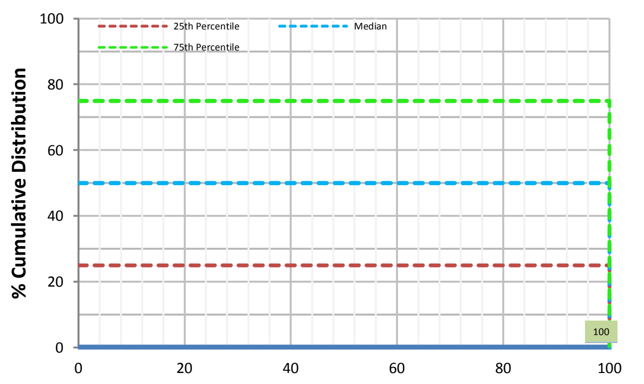
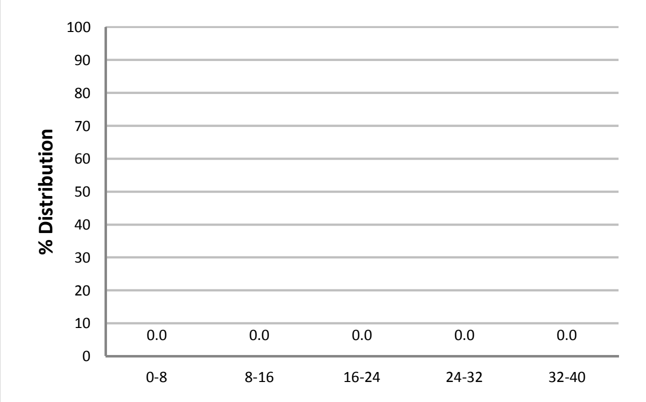


RMR MASS DATA - RMR PARAMETERS

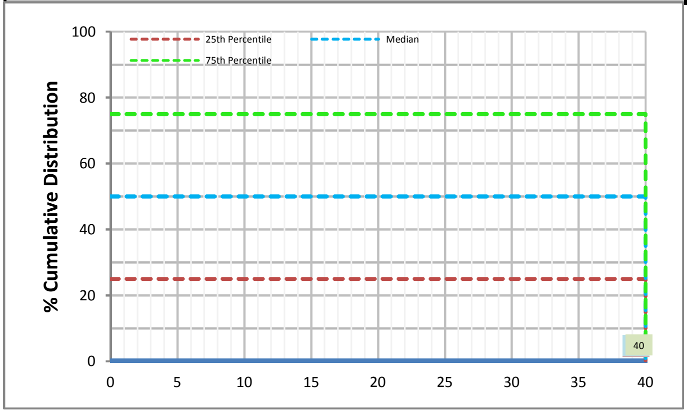
KGH001 - Ajax | Combined Data | Sector 3

Domain: PXPP | Meters Logged: 0 m

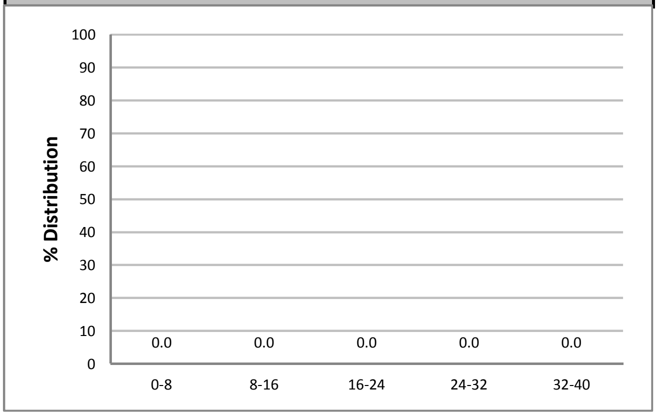
Nf DISTRIBUTION



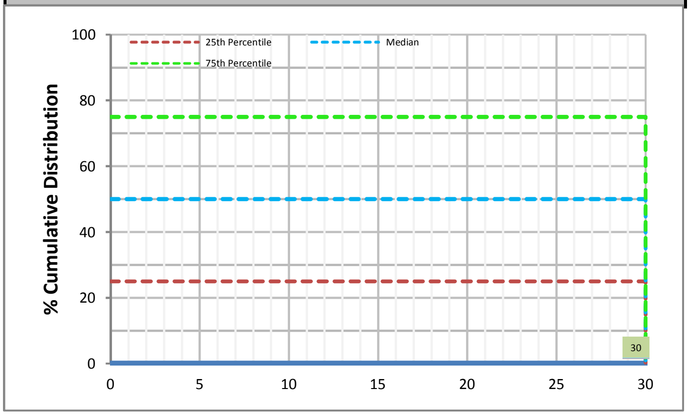
Nf CUMULATIVE DISTRIBUTION



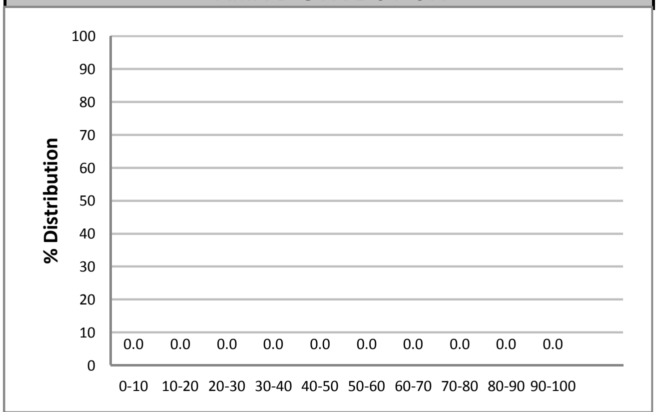
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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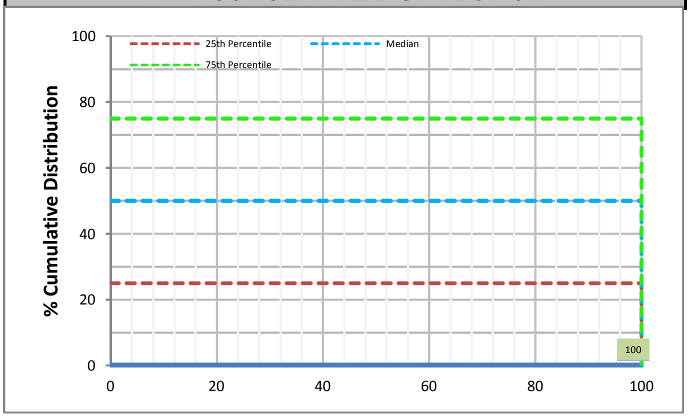
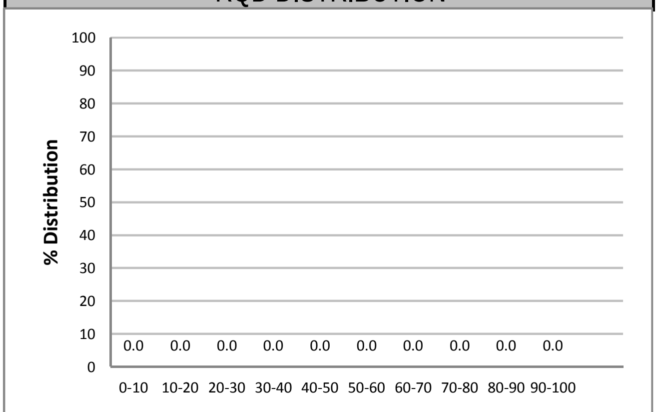


RQD DISTRIBUTION



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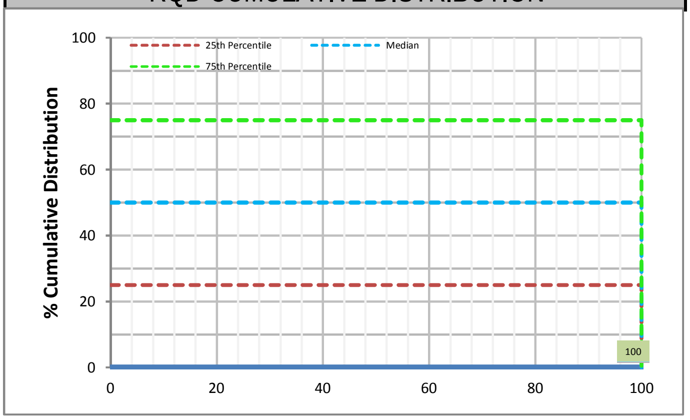
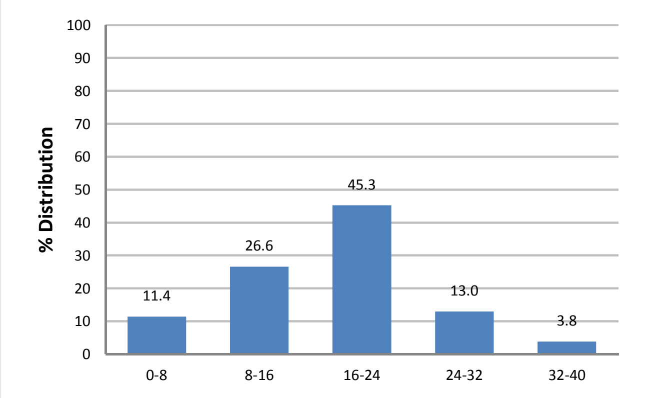


RMR MASS DATA - RMR PARAMETERS

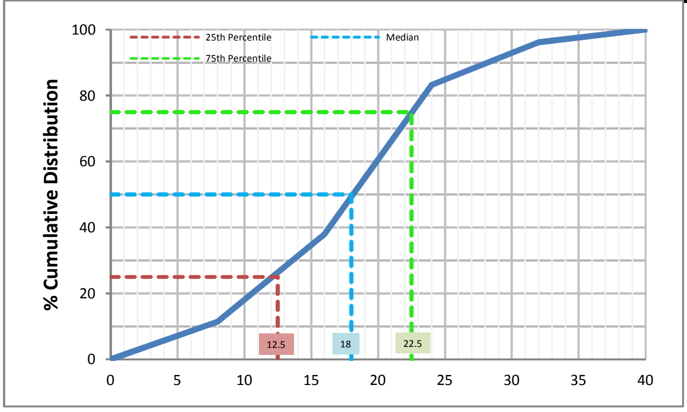
KGH001 - Ajax | Combined Data | Sector 3

Domain: SLD | Meters Logged: 1019.52 m

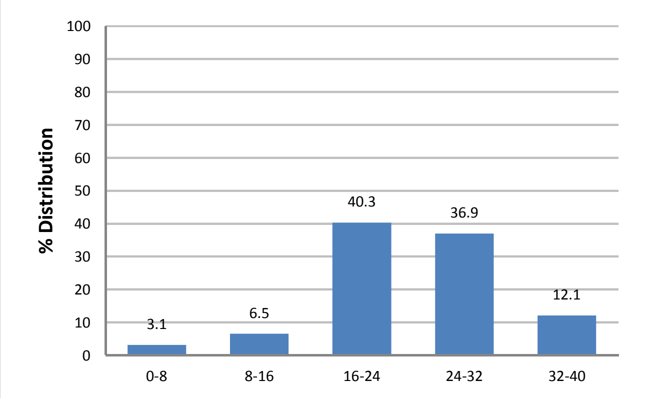
Nf DISTRIBUTION



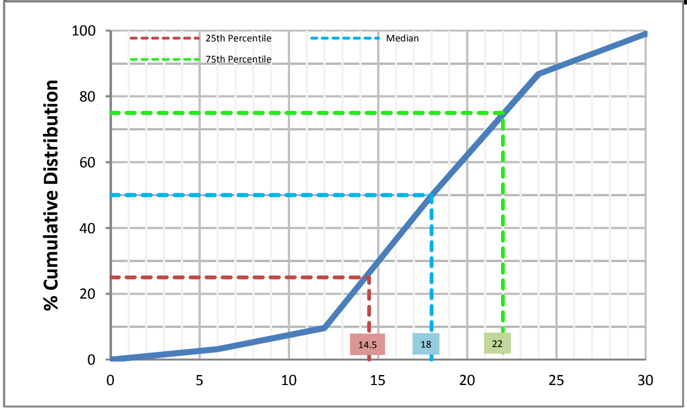
Nf CUMULATIVE DISTRIBUTION



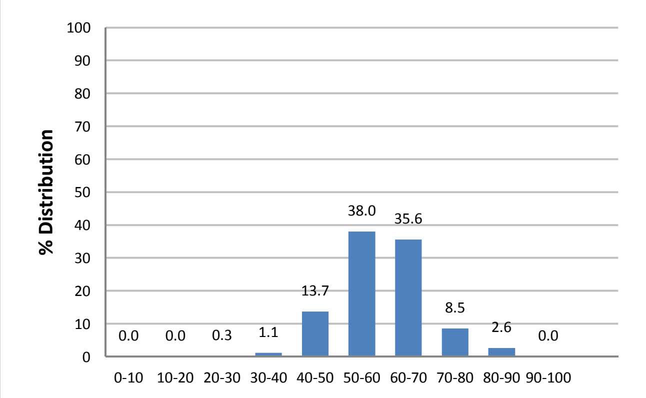
Nc DISTRIBUTION



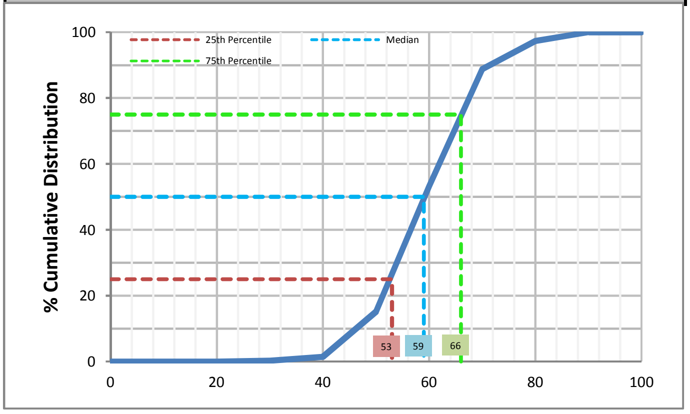
Nc CUMULATIVE DISTRIBUTION



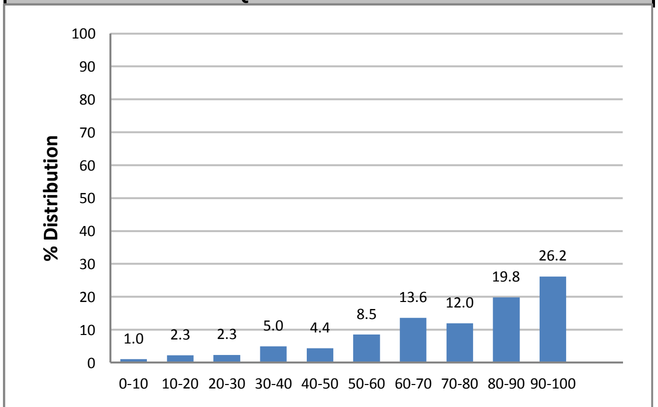
RMR DISTRIBUTION



RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



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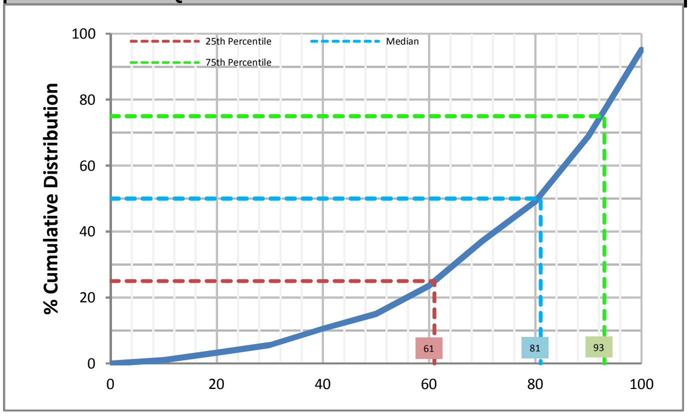
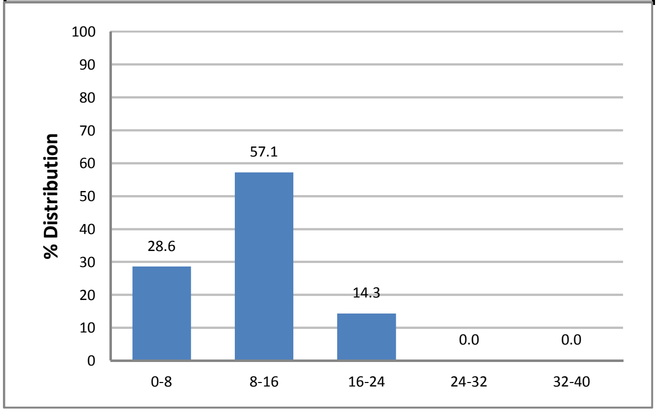


RMR MASS DATA - RMR PARAMETERS

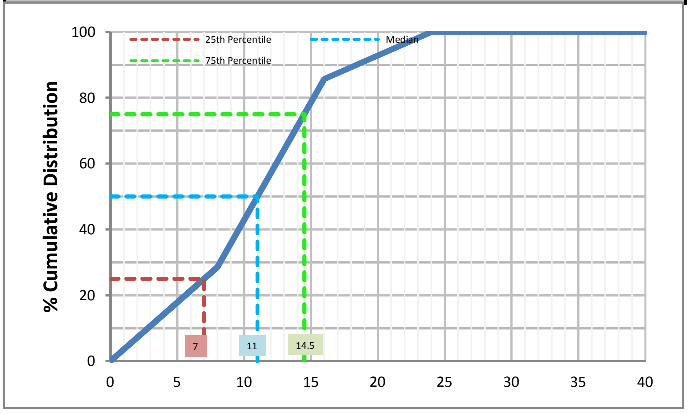
KGH001 - Ajax | Combined Data | Sector 3

Domain: SVHYB | Meters Logged: 42.67 m

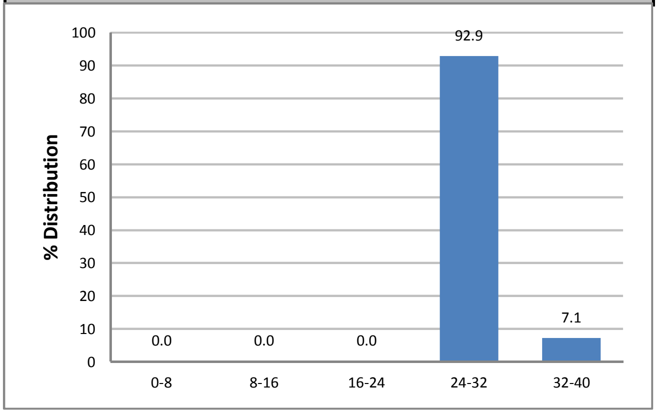
Nf DISTRIBUTION



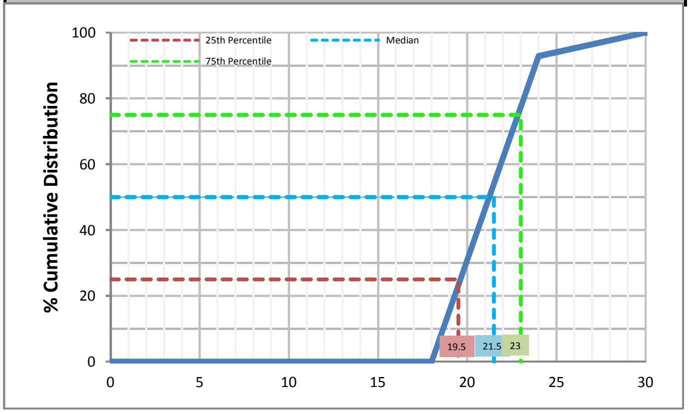
Nf CUMULATIVE DISTRIBUTION



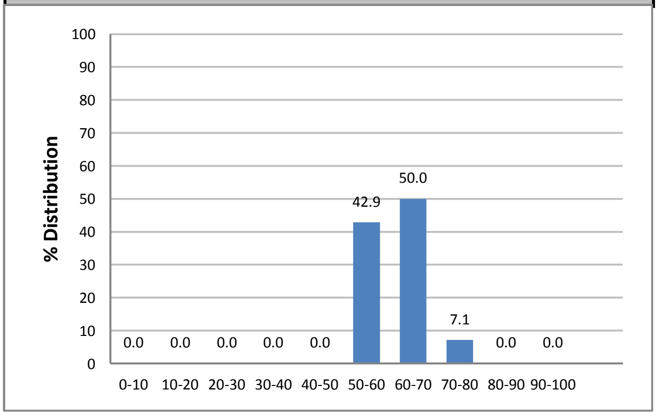
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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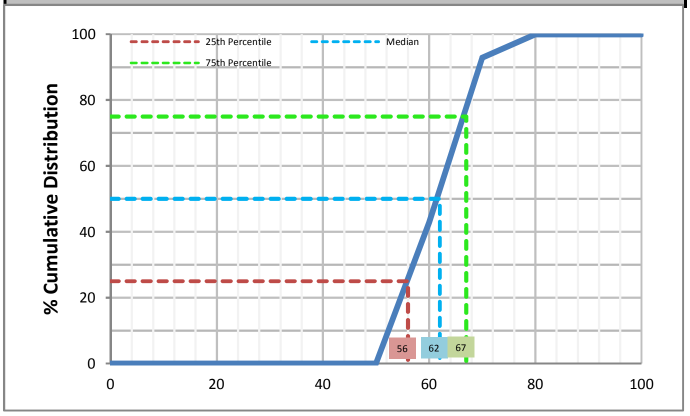
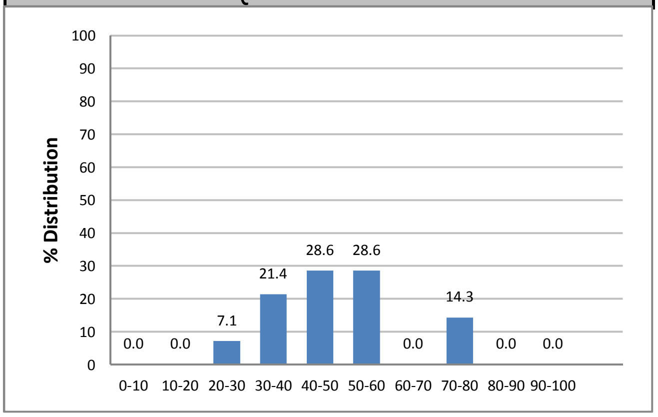
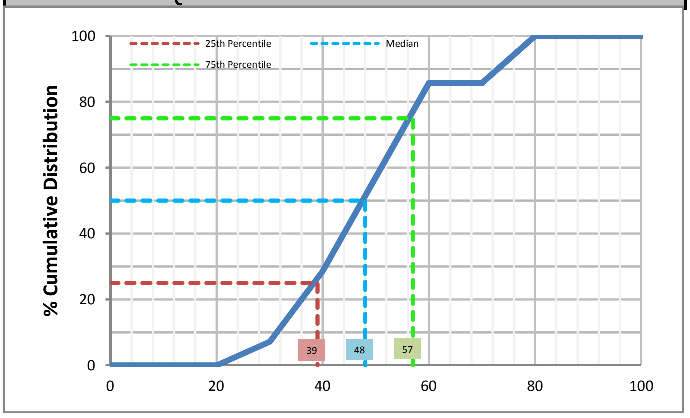


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

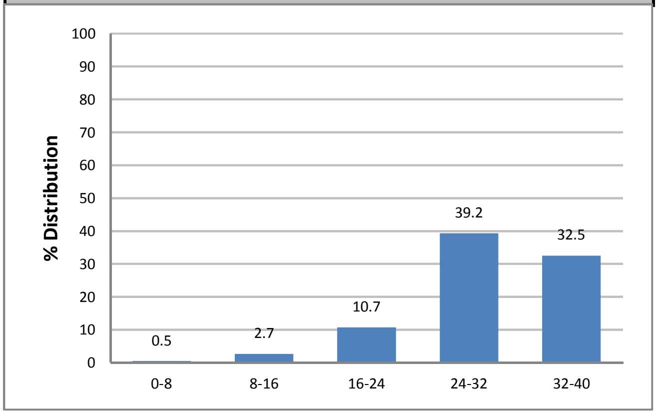


RMR MASS DATA - RMR PARAMETERS

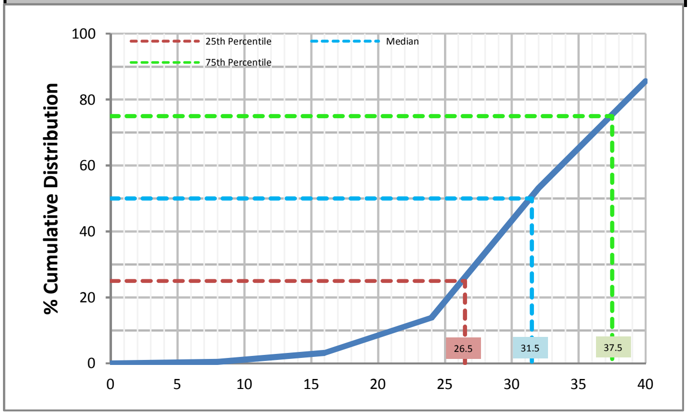
KGH001 - Ajax | Combined Data | Sector 4

Domain: IMH | Meters Logged: 794 m

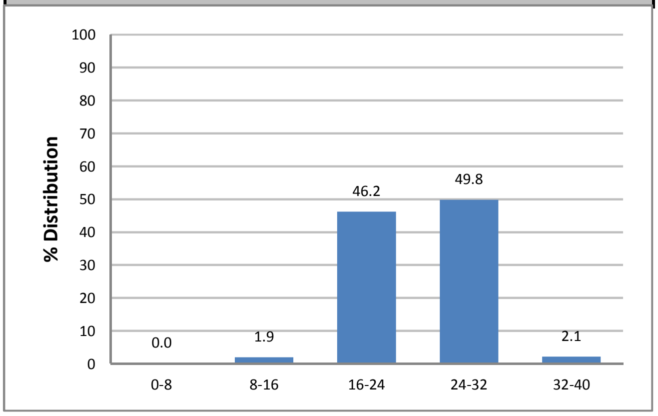
Nf DISTRIBUTION



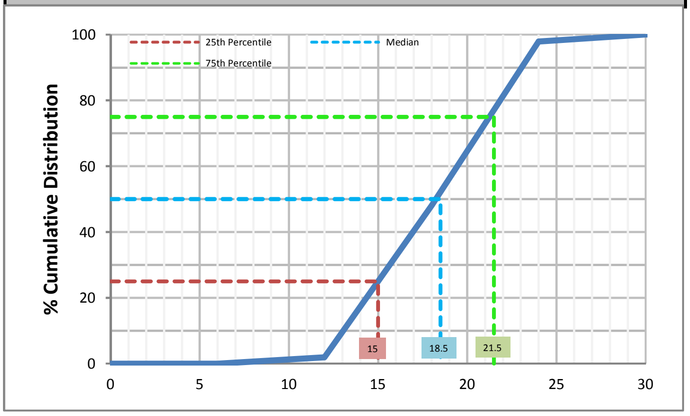
Nf CUMULATIVE DISTRIBUTION



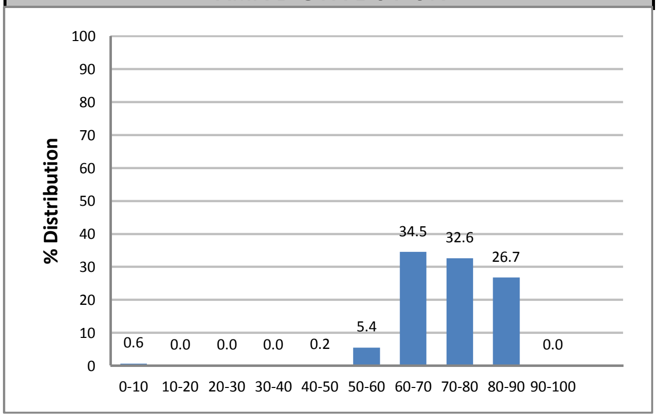
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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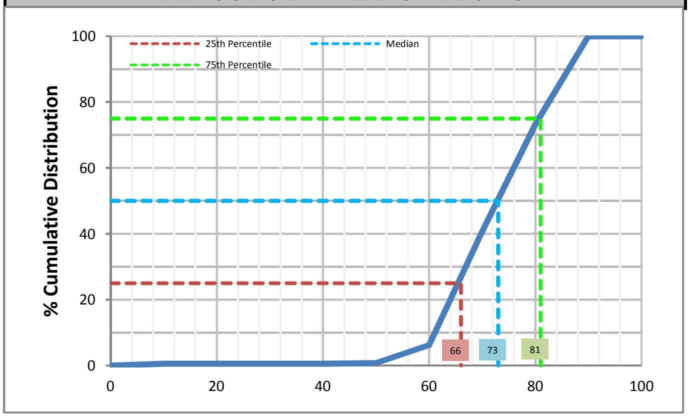
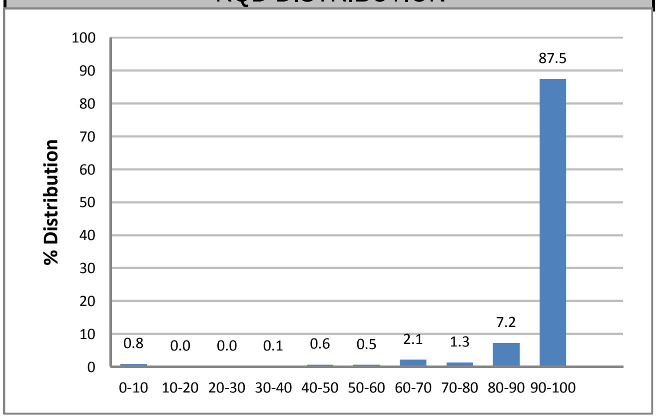
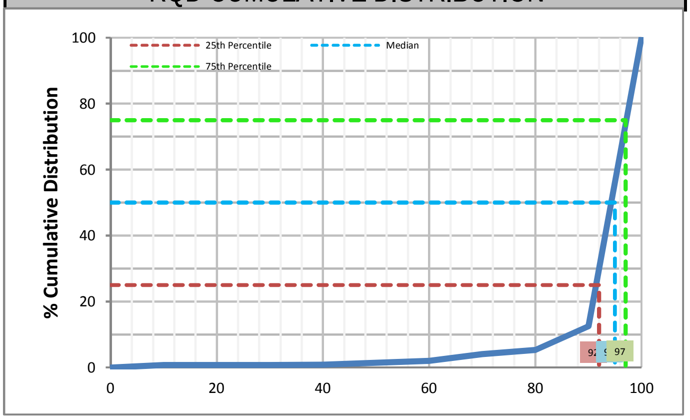


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

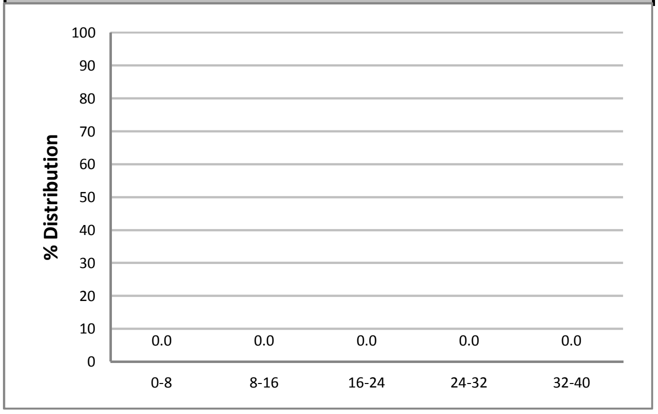


RMR MASS DATA - RMR PARAMETERS

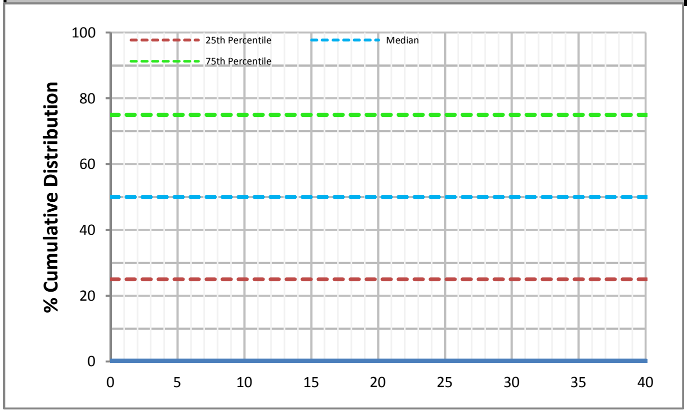
KGH001 - Ajax | Combined Data | Sector 4

Domain: LAT | Meters Logged: 0 m

Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



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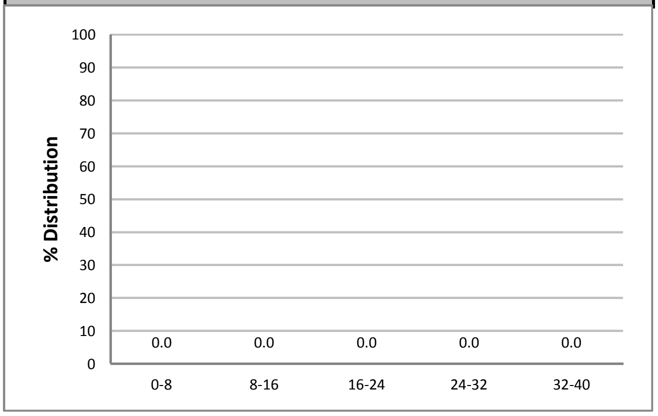

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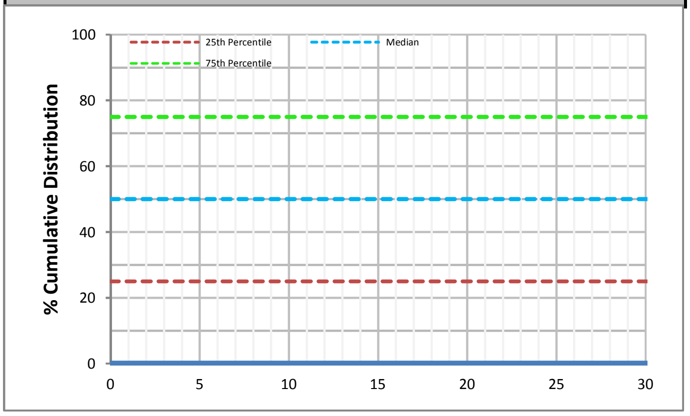
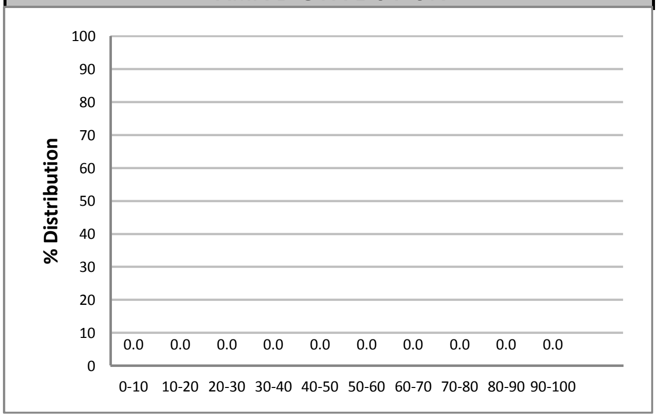


RMR DISTRIBUTION



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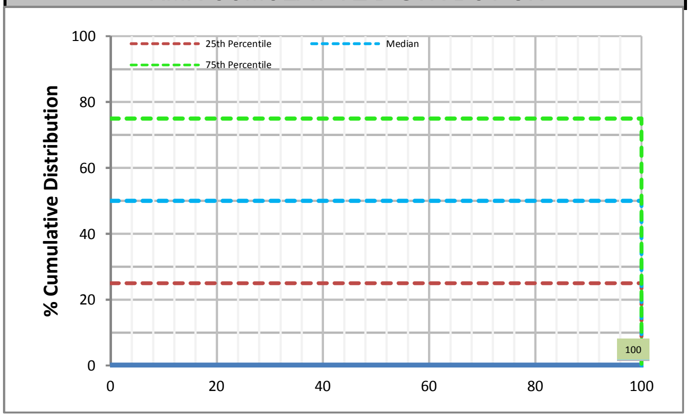

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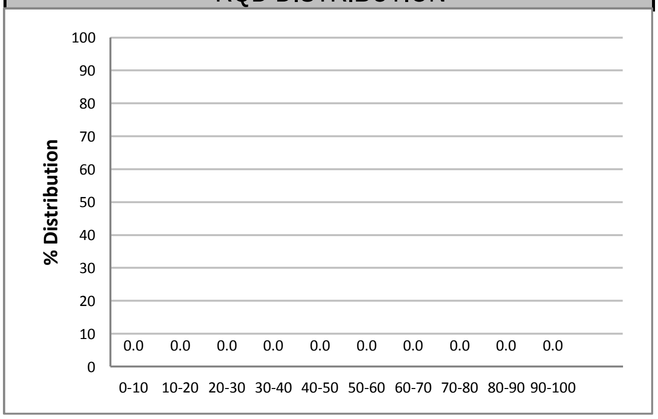

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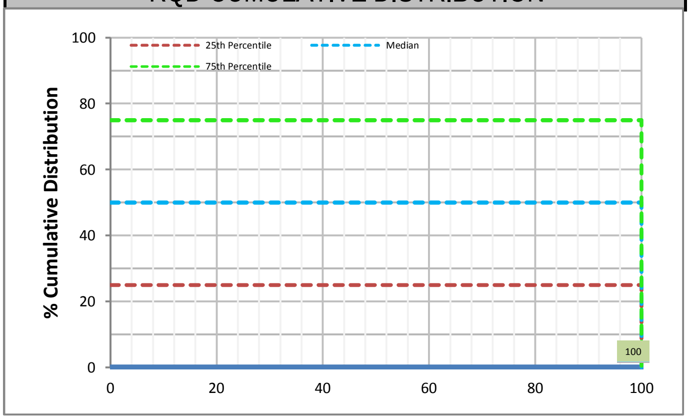
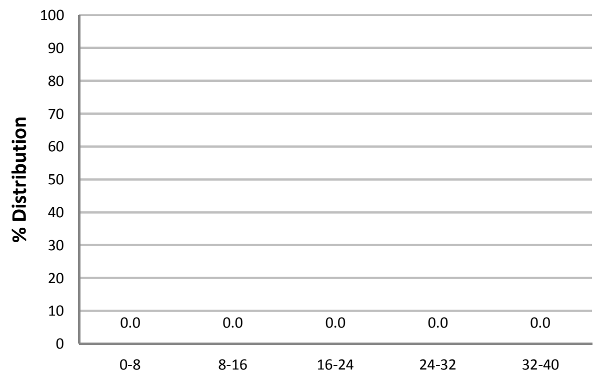


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 4

Domain: MAFV | Meters Logged: 0 m

Nf DISTRIBUTION



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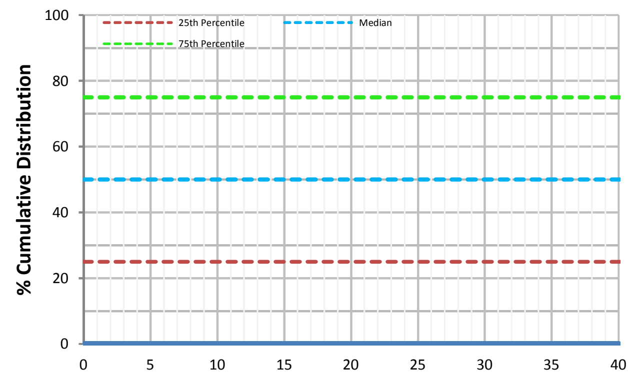
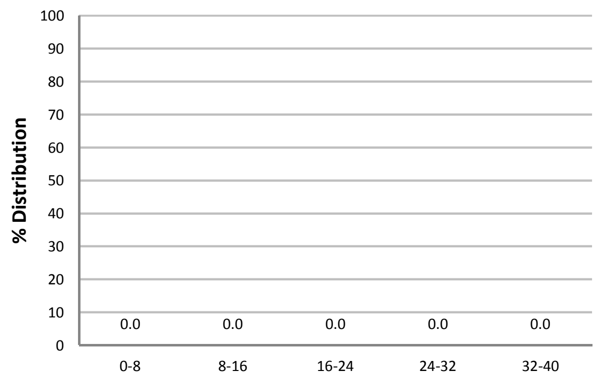
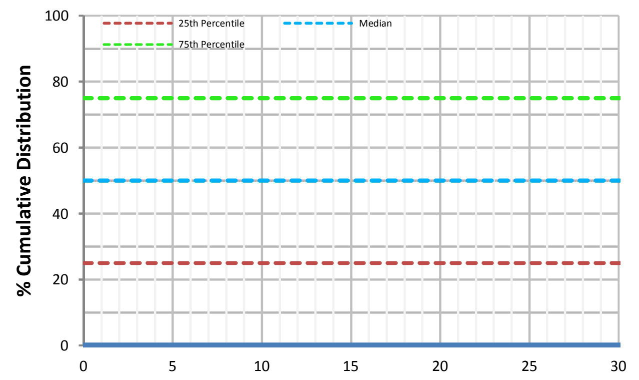


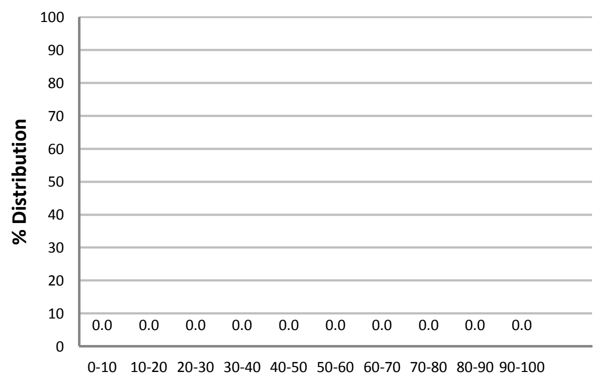
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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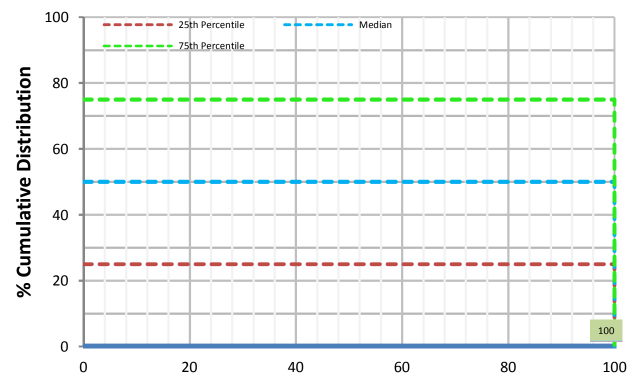

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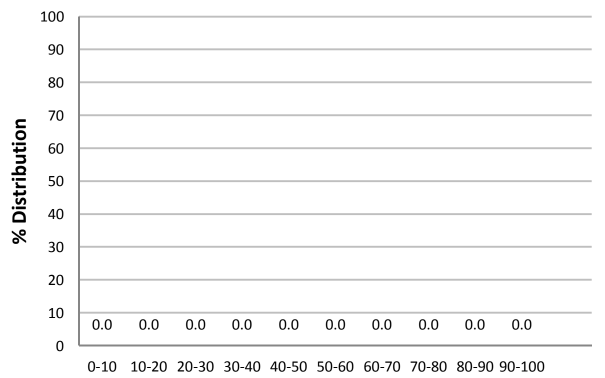

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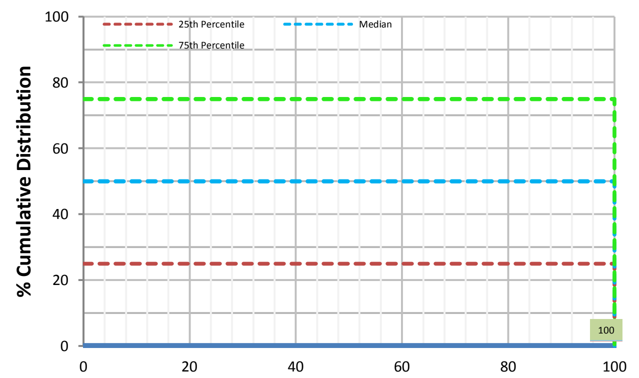
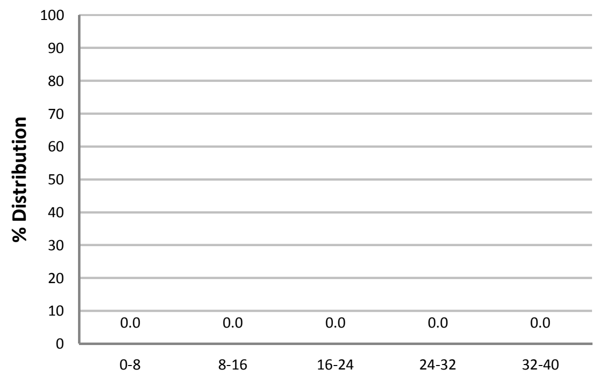


RMR MASS DATA - RMR PARAMETERS

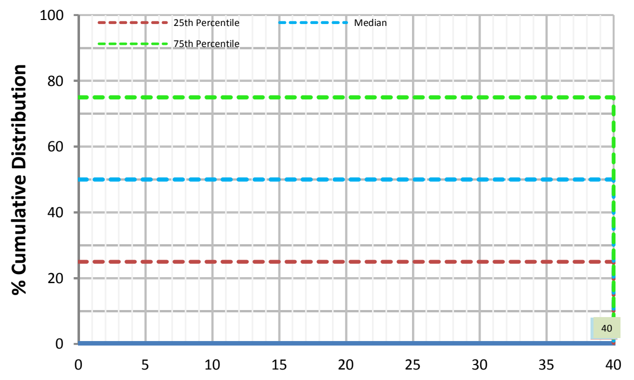
KGH001 - Ajax | Combined Data | Sector 4

Domain: MONZ | Meters Logged: 0 m

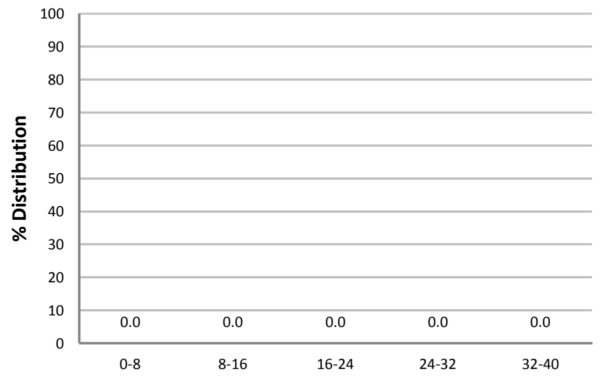
Nf DISTRIBUTION



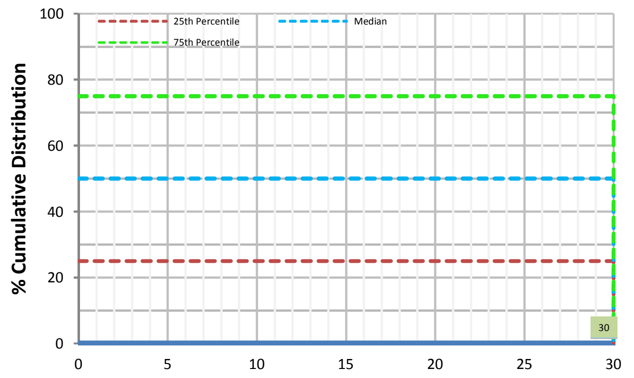
Nf CUMULATIVE DISTRIBUTION



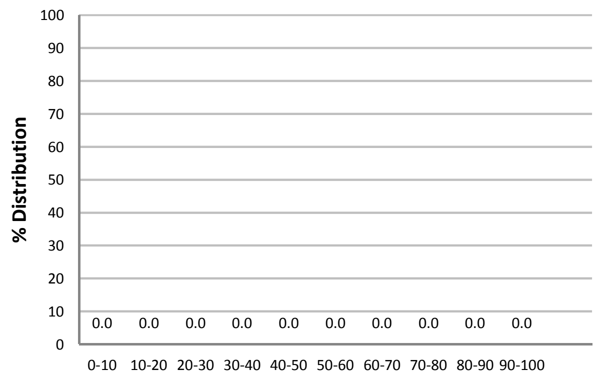
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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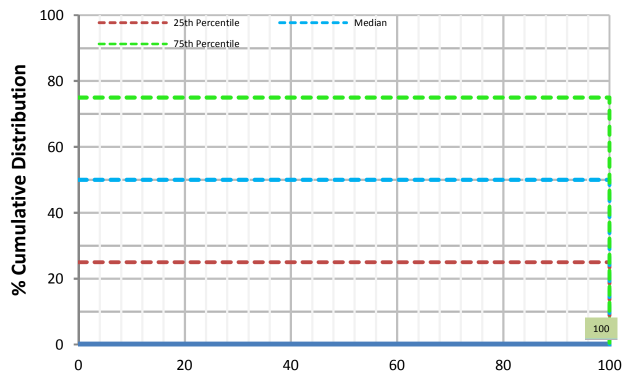

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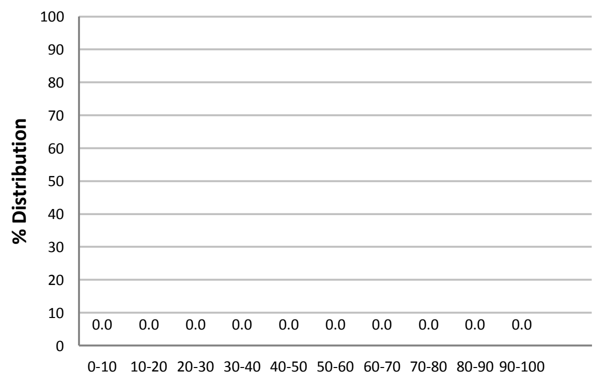

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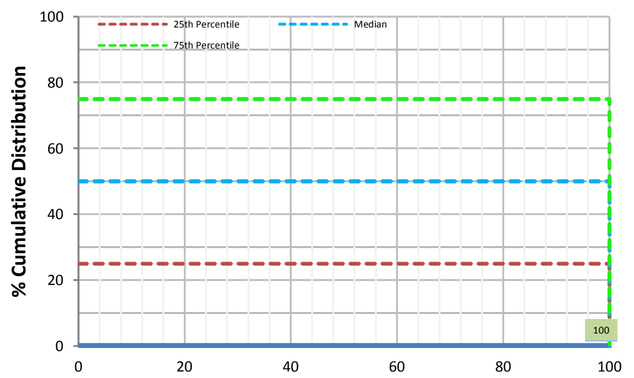


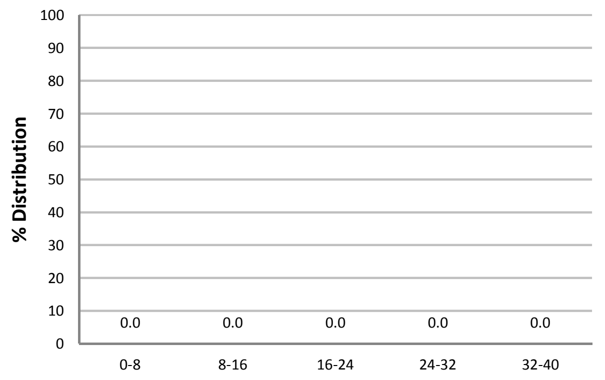
RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 4

Domain: PICR

Meters Logged: 0 m

Nf DISTRIBUTION



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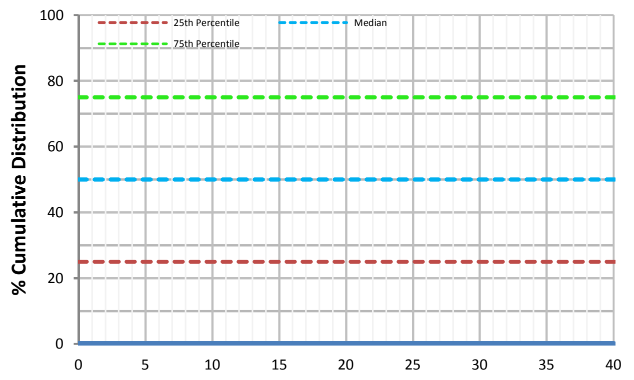
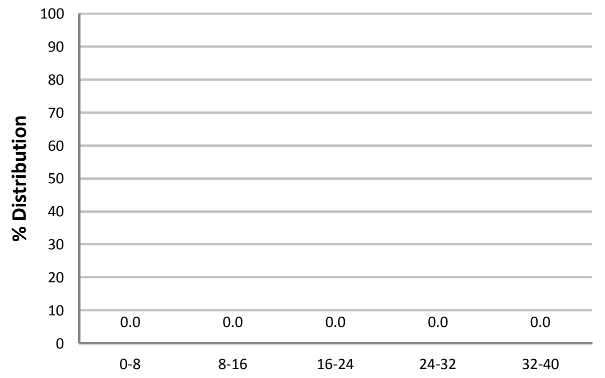
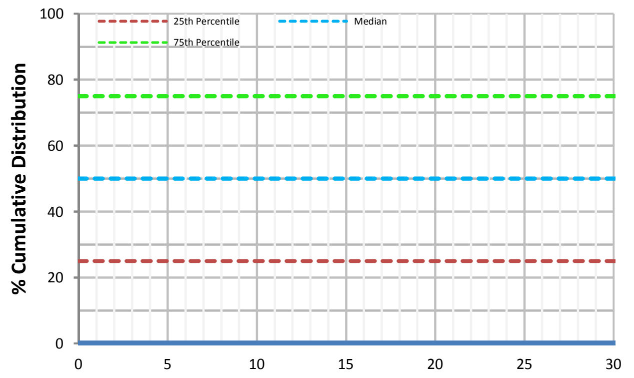


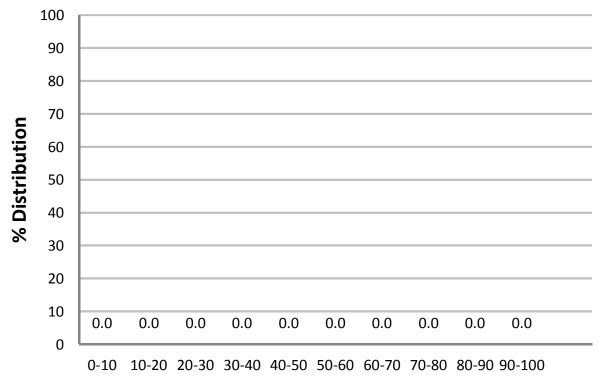
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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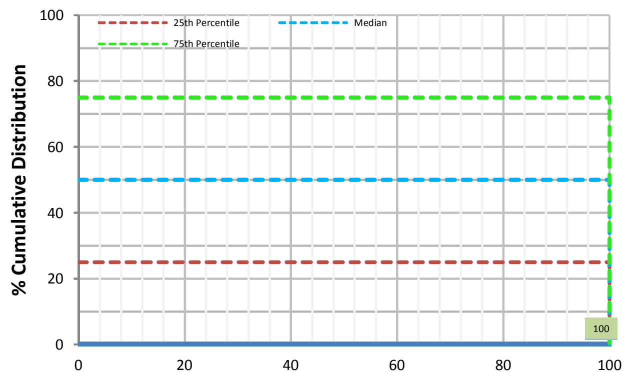

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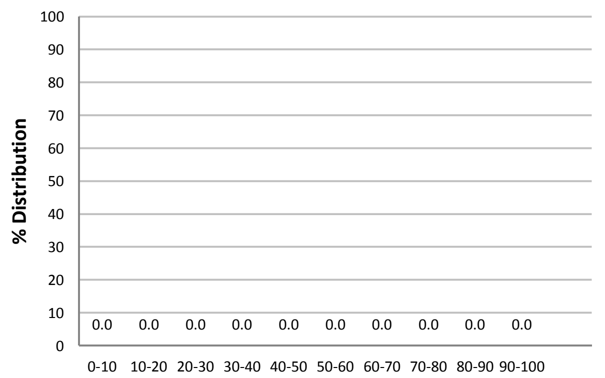

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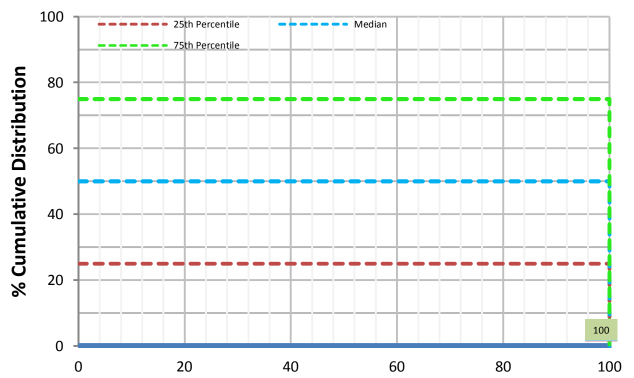
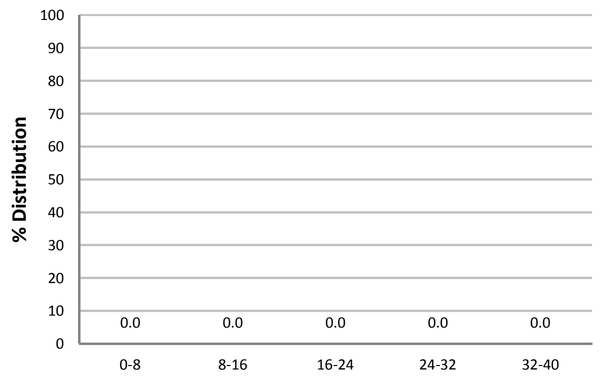


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 4

Domain: PXPP | Meters Logged: 0 m

Nf DISTRIBUTION



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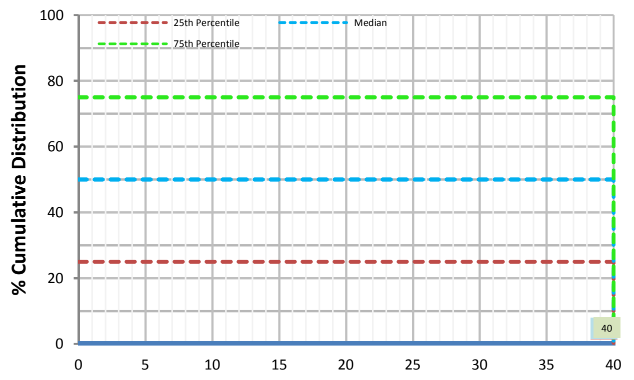
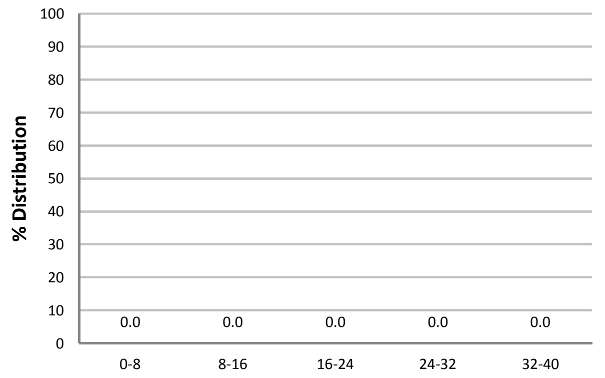
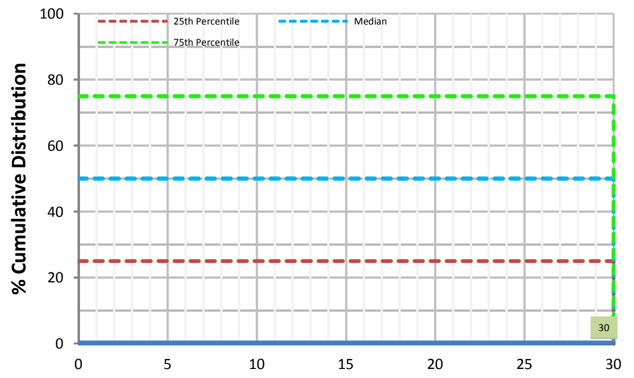


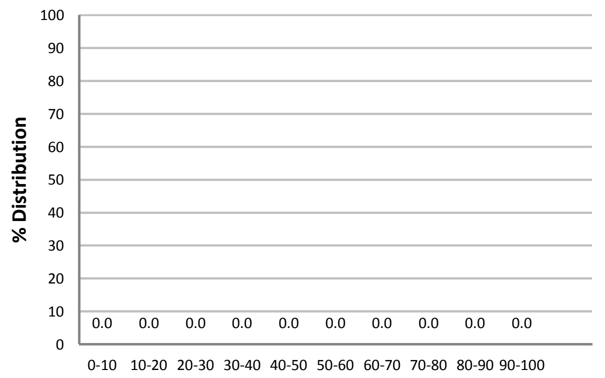
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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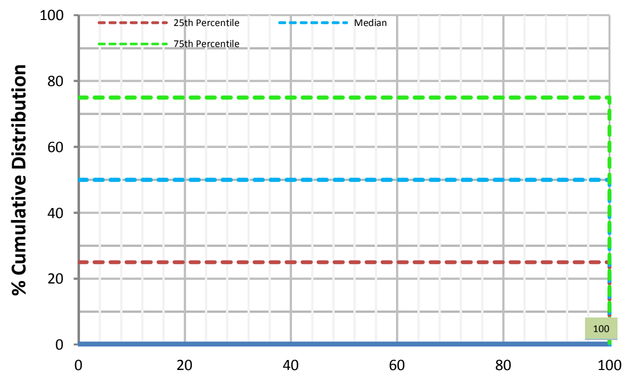
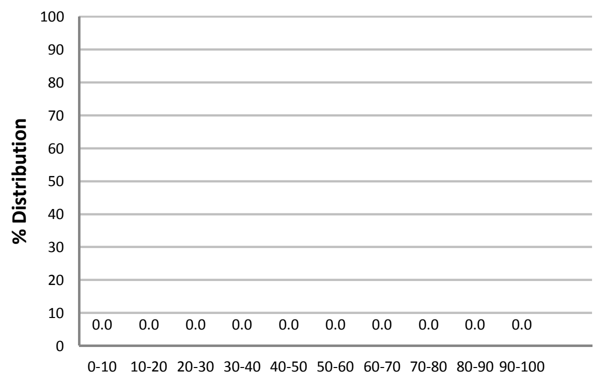


RQD DISTRIBUTION



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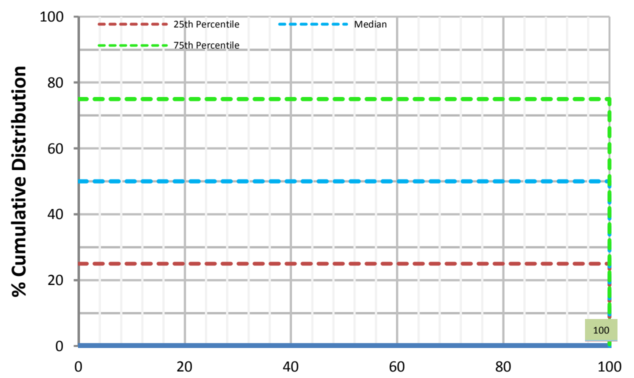


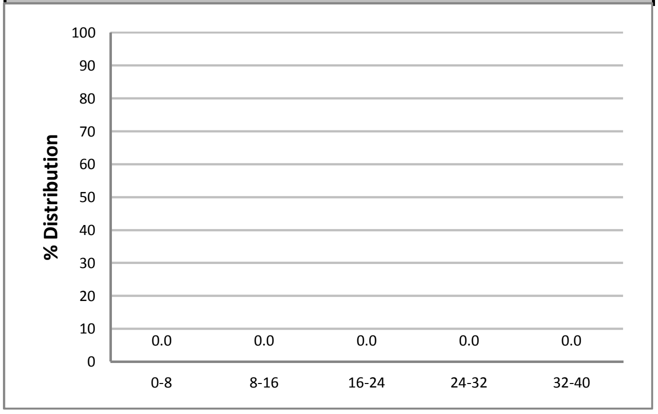
RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 4

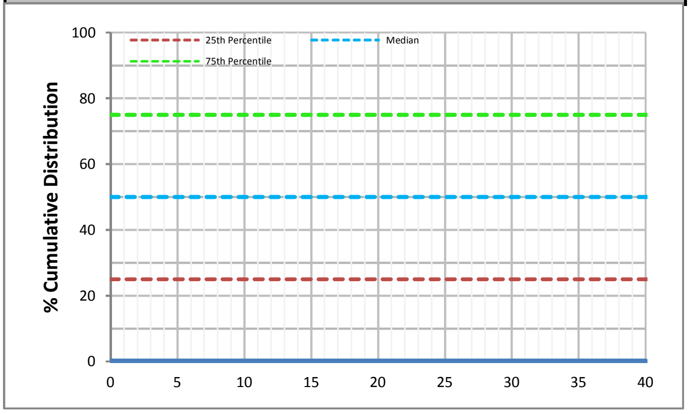
Domain: SLD

Meters Logged: 0 m

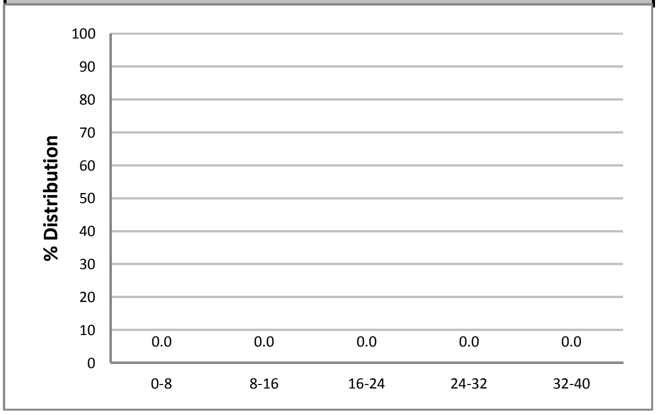
Nf DISTRIBUTION



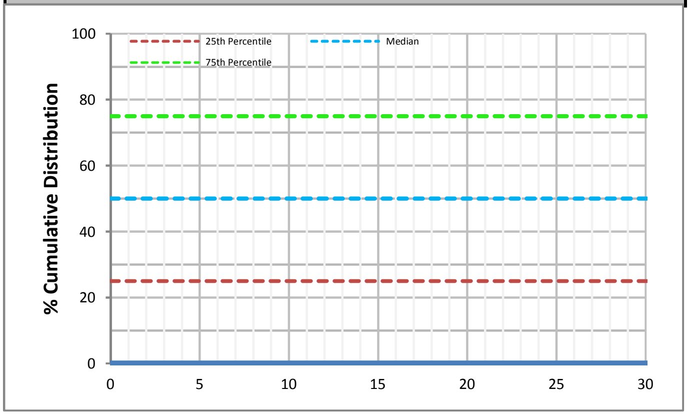
Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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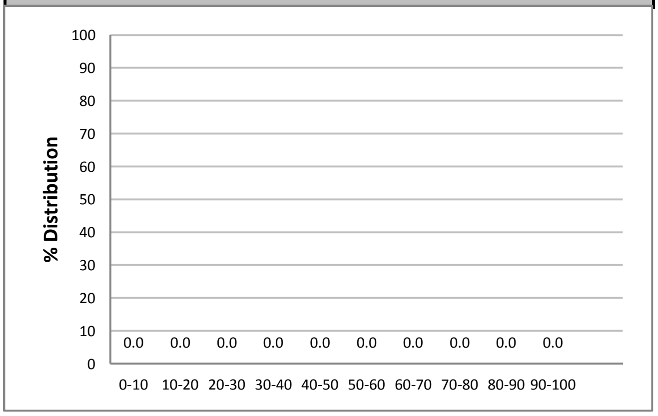
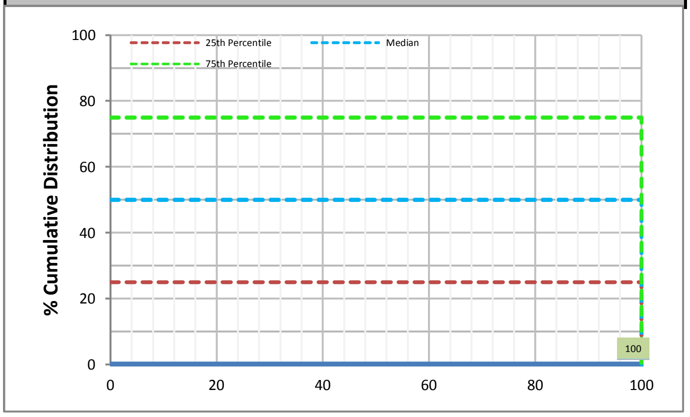
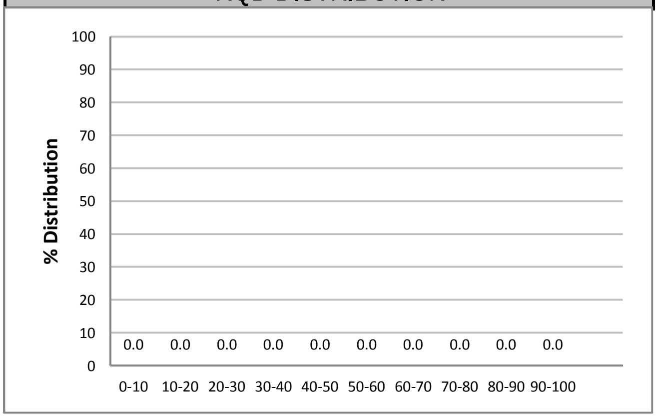


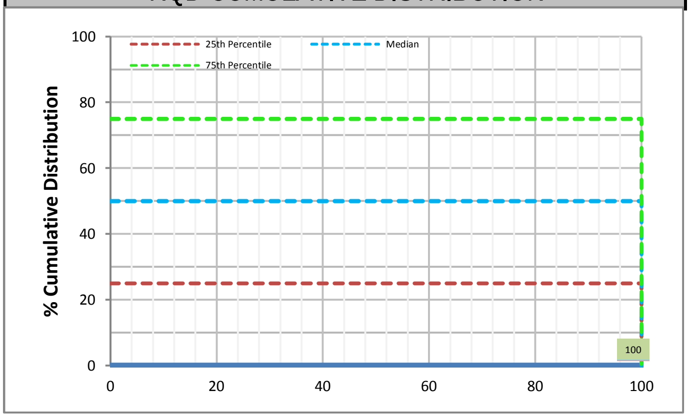
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

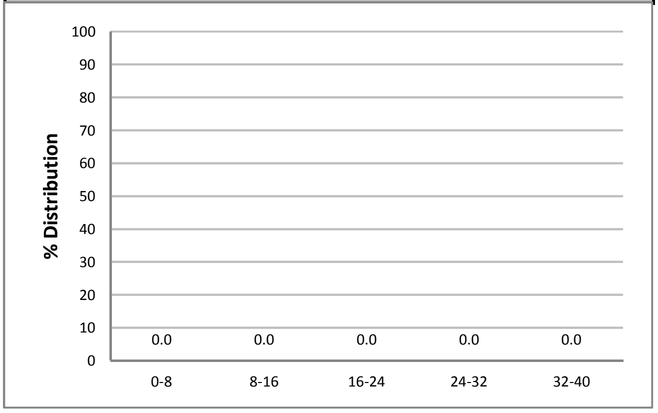


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 4

Domain: SVHYB | Meters Logged: 0 m

Nf DISTRIBUTION



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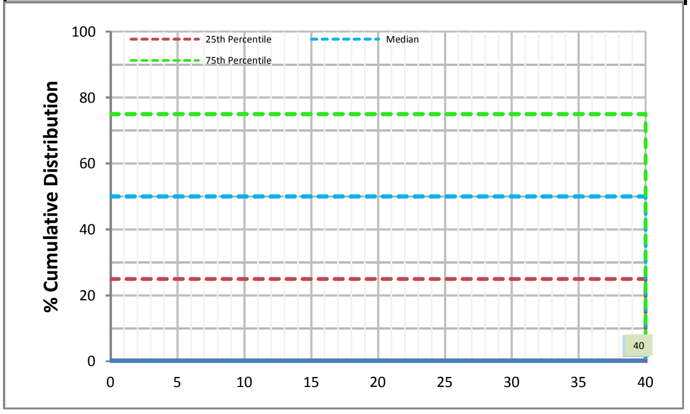
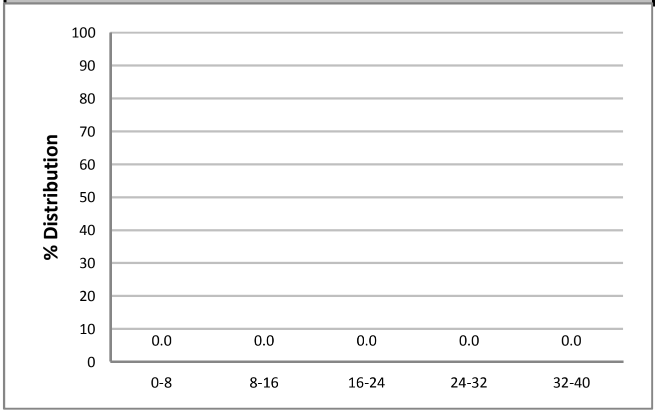
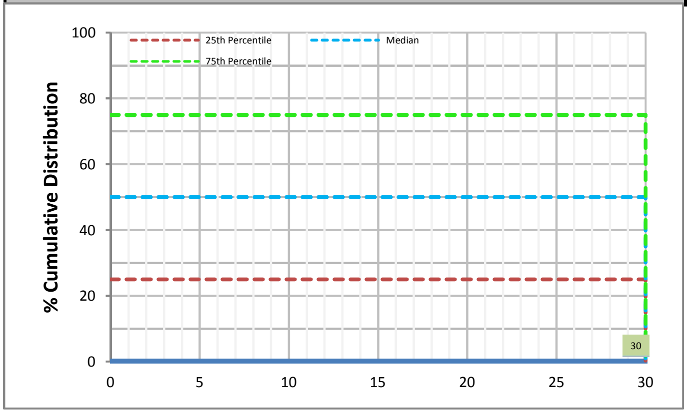


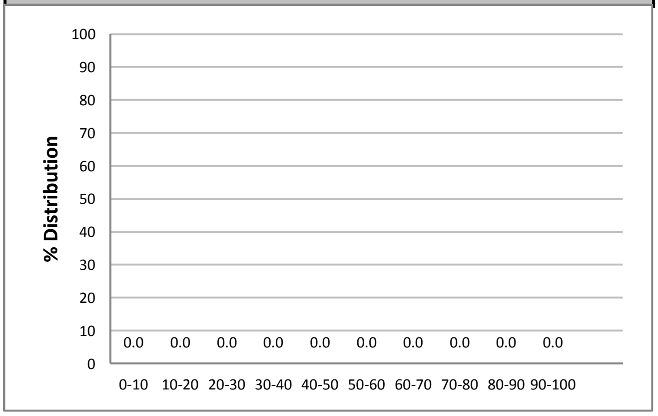
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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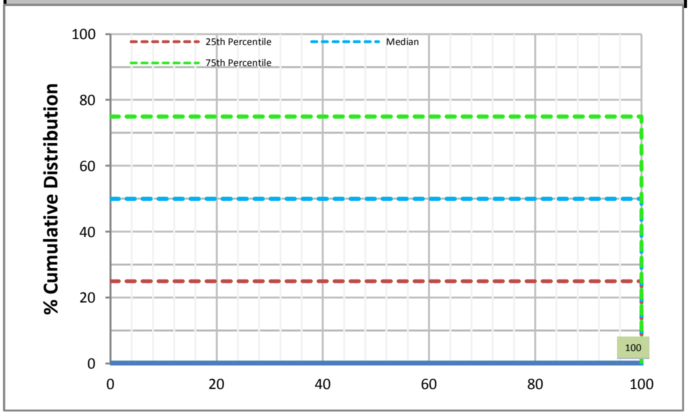
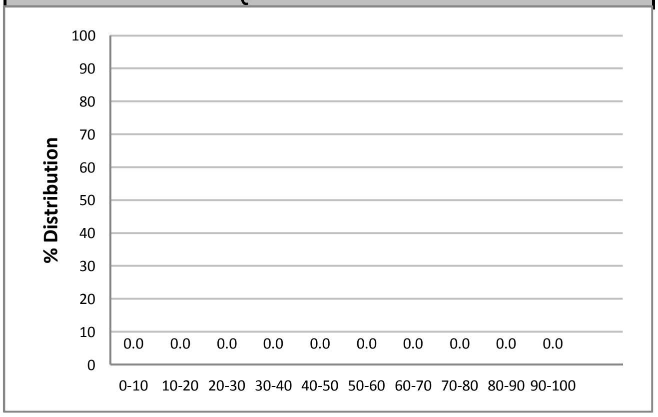


RQD DISTRIBUTION



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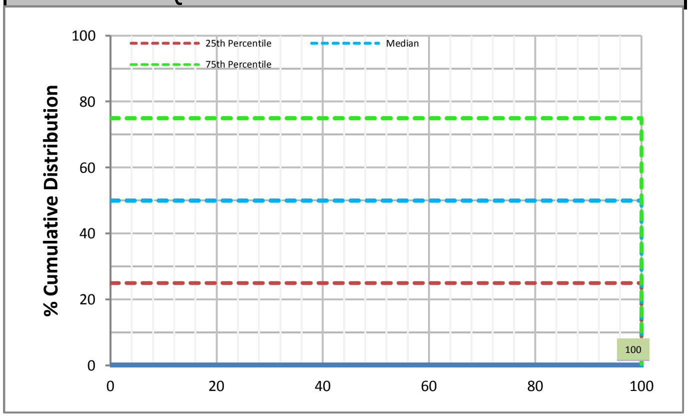
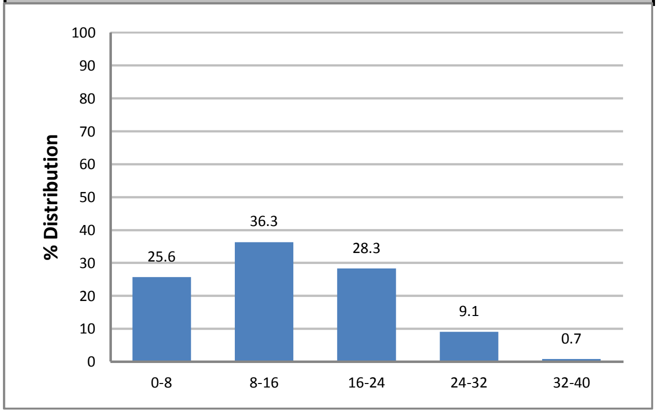


RMR MASS DATA - RMR PARAMETERS

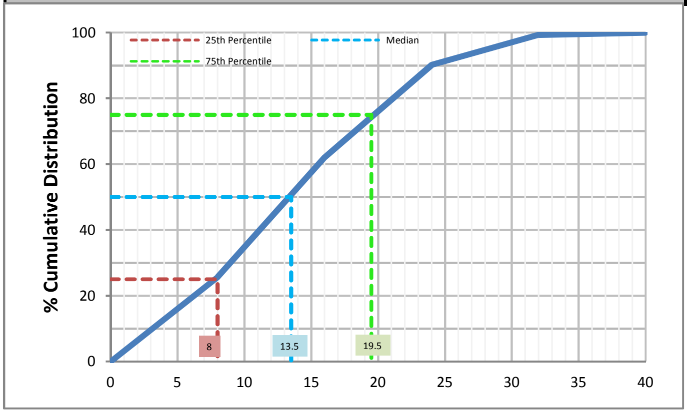
KGH001 - Ajax | Combined Data | Sector 5

Domain: IMH | Meters Logged: 208.48 m

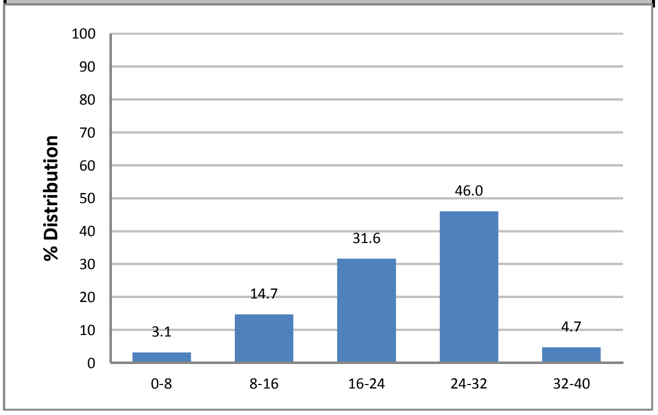
Nf DISTRIBUTION



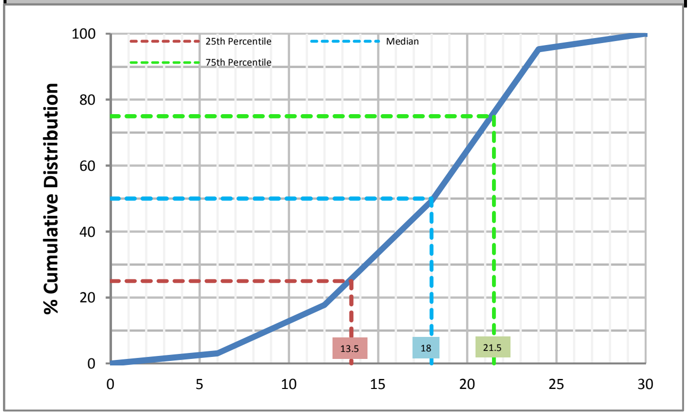
Nf CUMULATIVE DISTRIBUTION



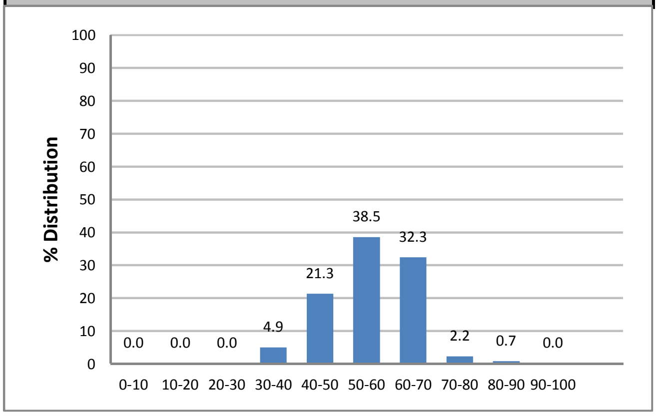
Nc DISTRIBUTION



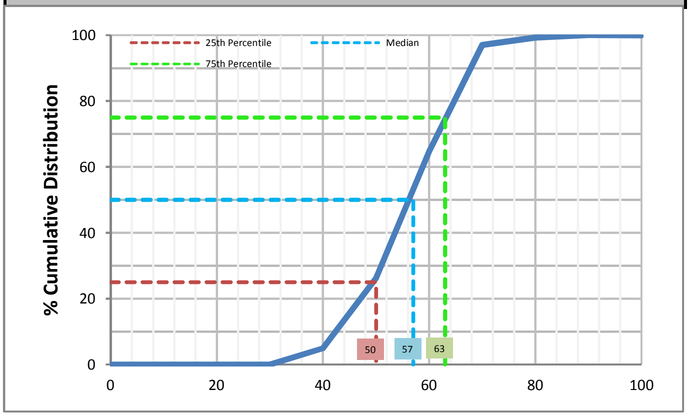
Nc CUMULATIVE DISTRIBUTION



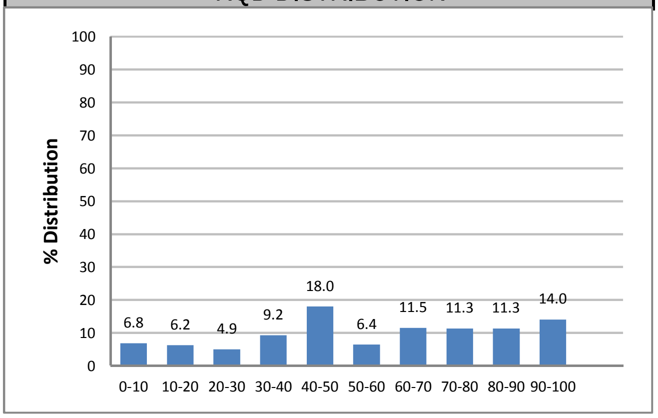
RMR DISTRIBUTION



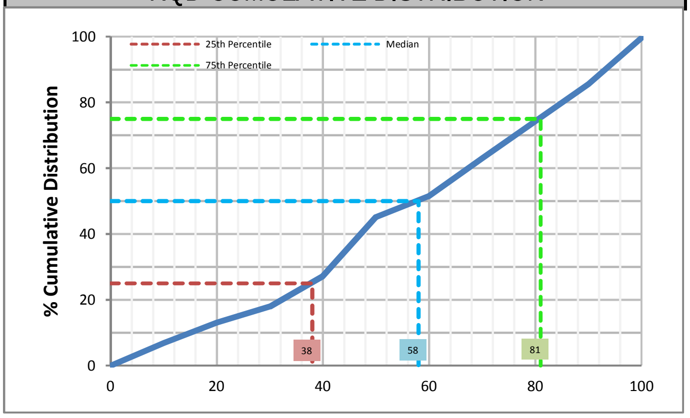
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

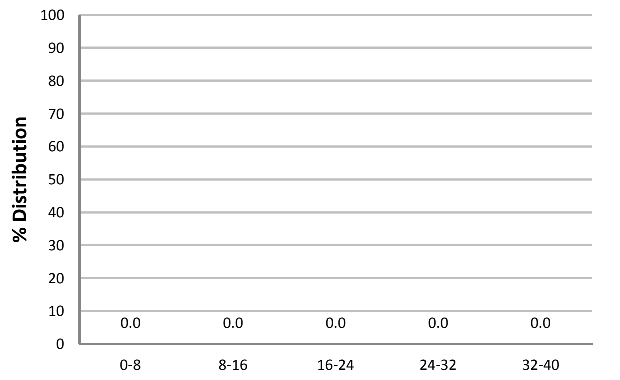


RMR MASS DATA - RMR PARAMETERS

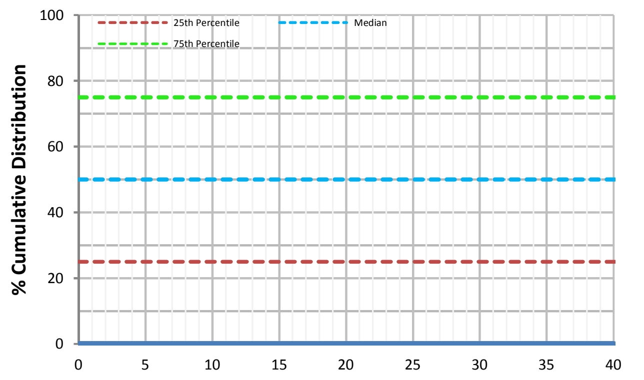
KGH001 - Ajax | Combined Data | Sector 5

Domain: LAT | Meters Logged: 0 m

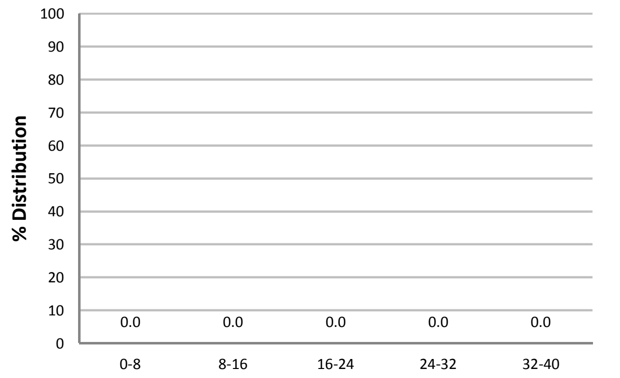
Nf DISTRIBUTION



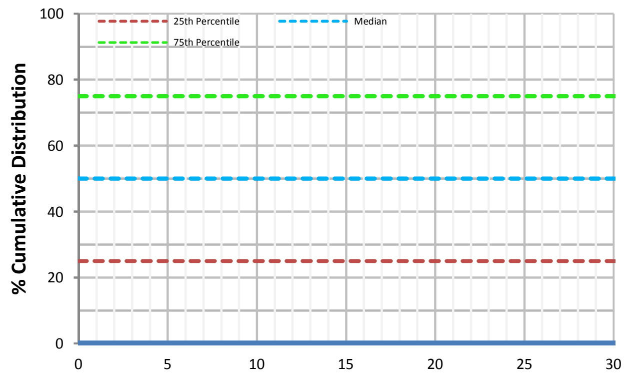
Nf CUMULATIVE DISTRIBUTION



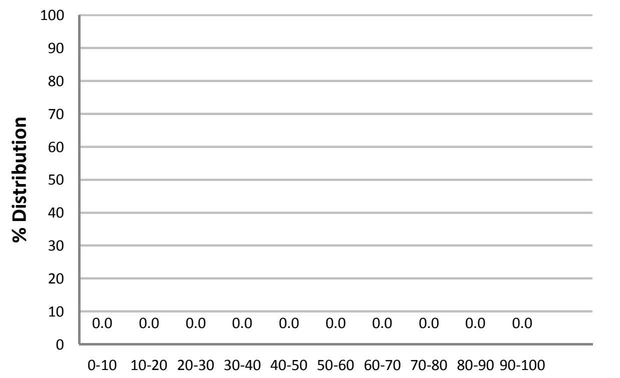
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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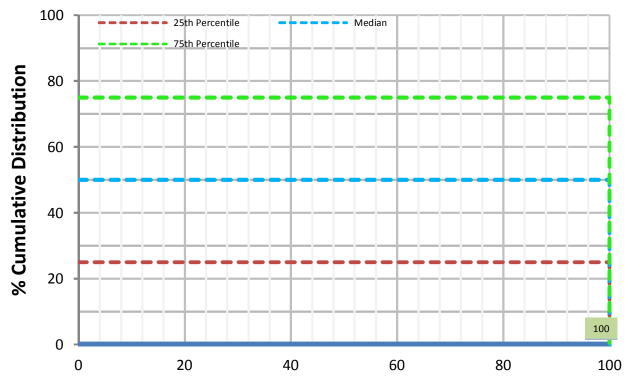

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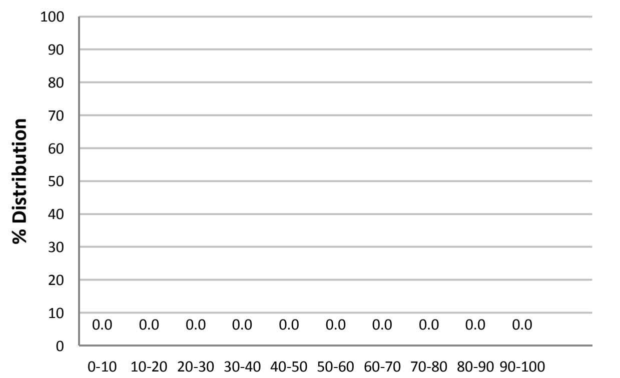
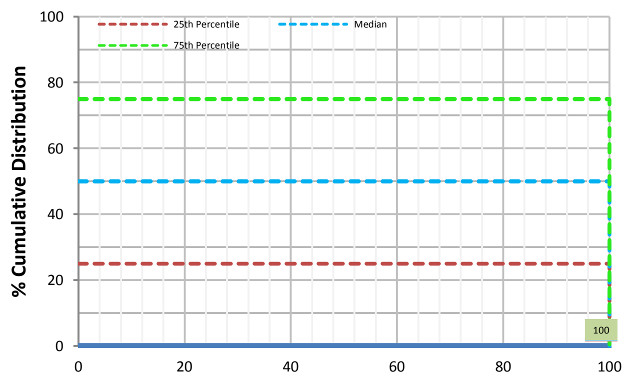


RQD CUMULATIVE DISTRIBUTION

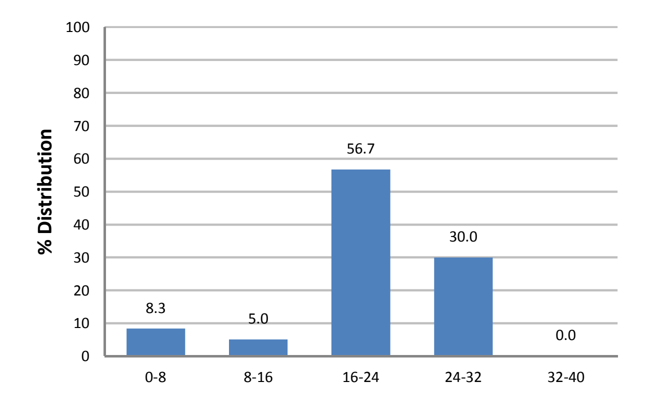


RMR MASS DATA - RMR PARAMETERS

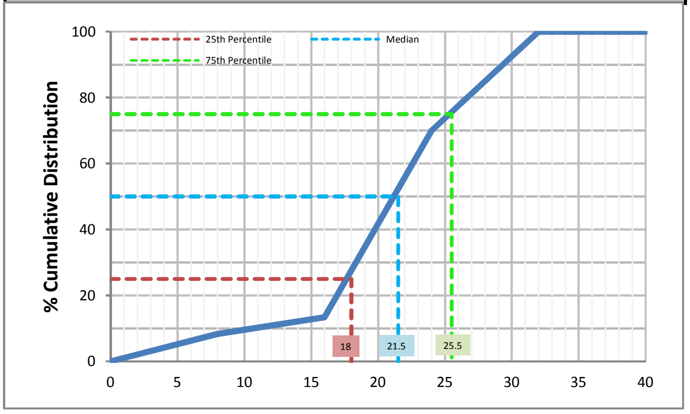
KGH001 - Ajax | Combined Data | Sector 5

Domain: MAFV | Meters Logged: 18.29 m

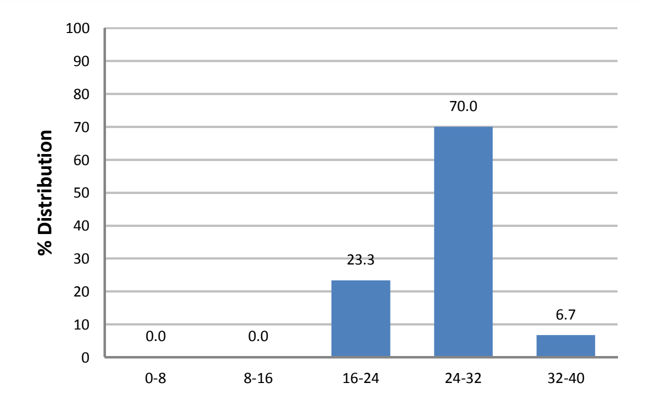
Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



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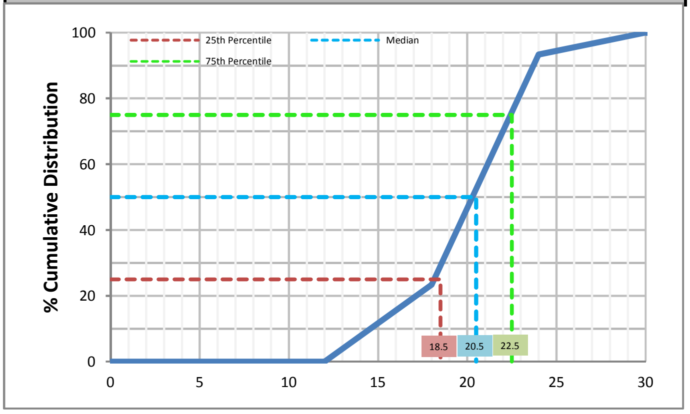
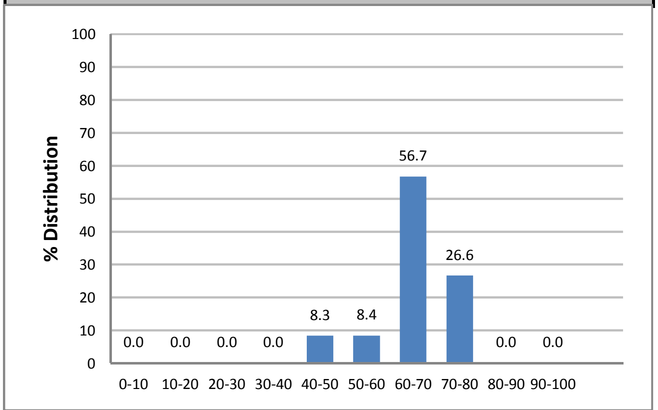


RMR DISTRIBUTION



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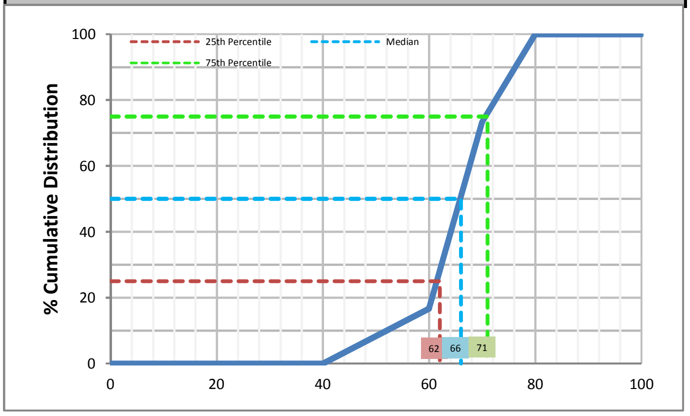
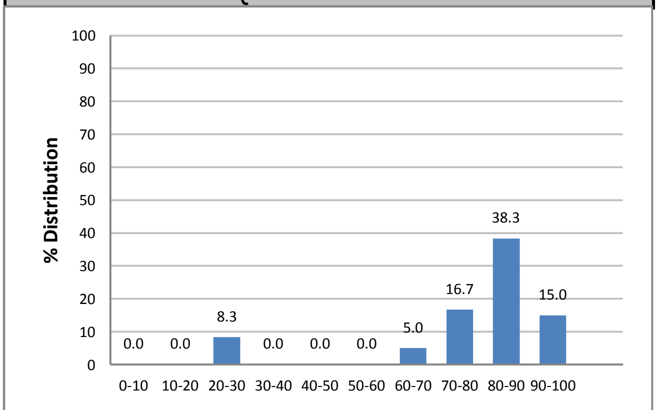
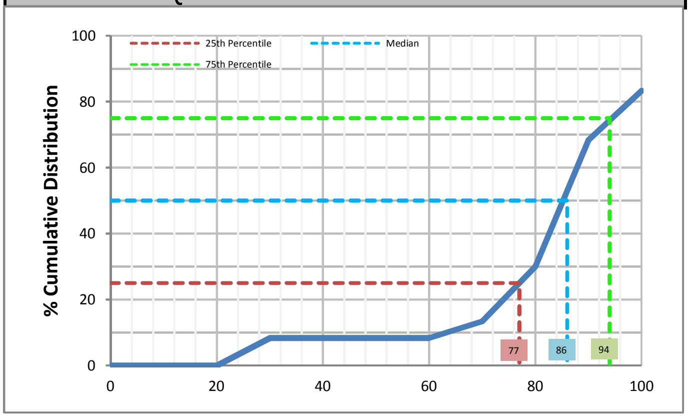


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

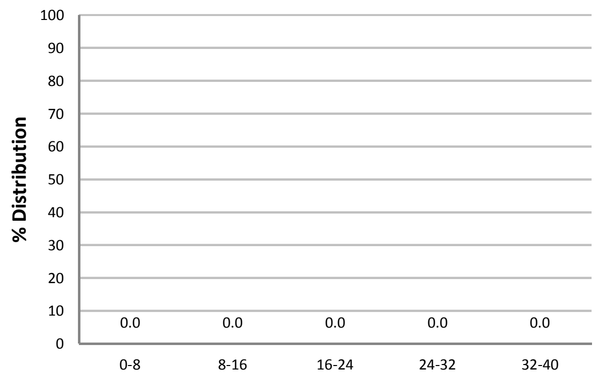


RMR MASS DATA - RMR PARAMETERS

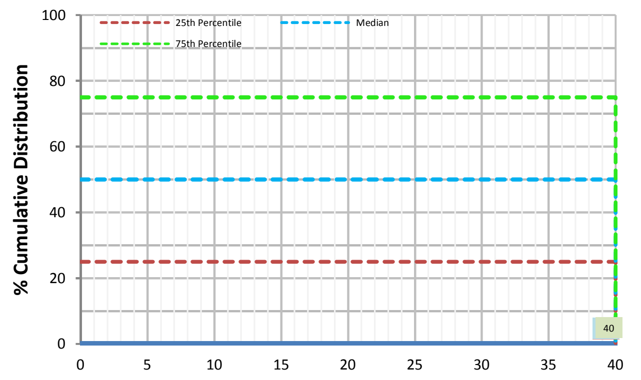
KGH001 - Ajax | Combined Data | Sector 5

Domain: MONZ | Meters Logged: 0 m

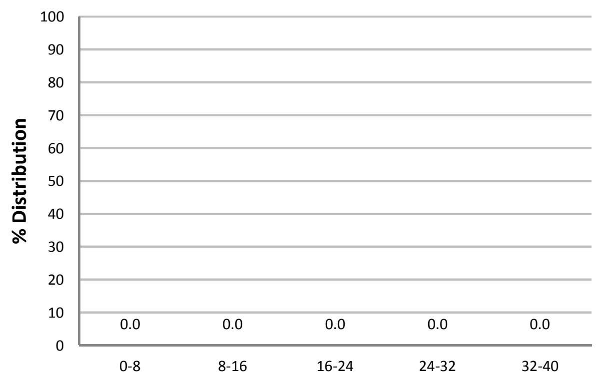
Nf DISTRIBUTION



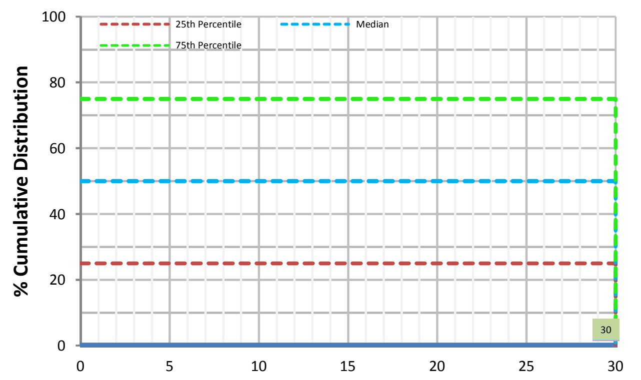
Nf CUMULATIVE DISTRIBUTION



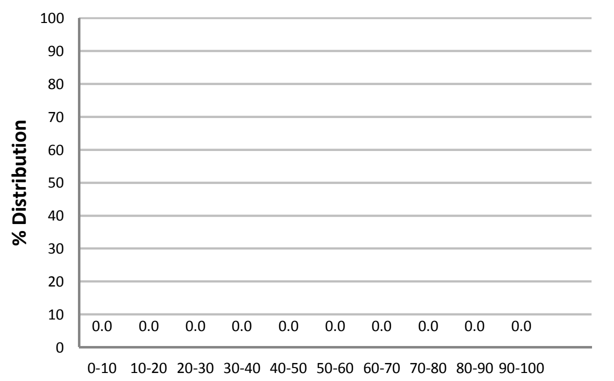
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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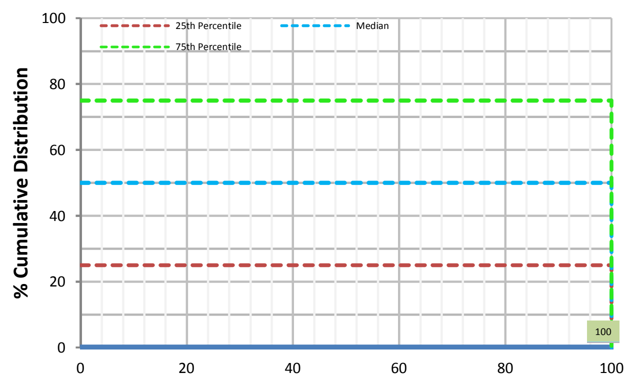

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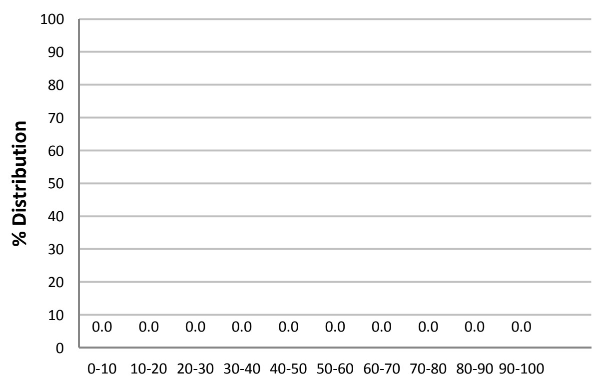

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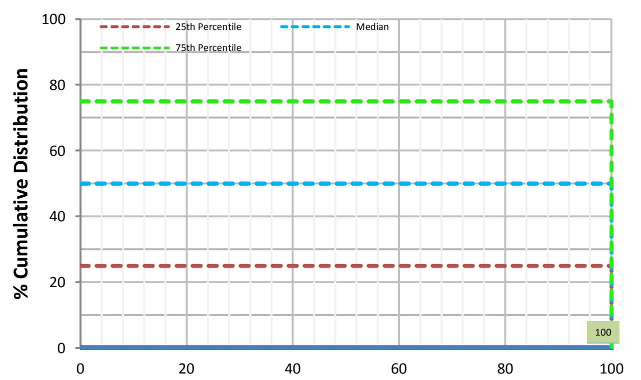
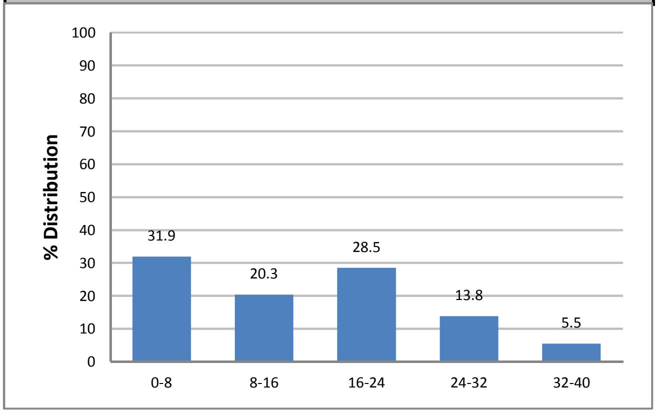


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 5

Domain: PICR | Meters Logged: 222 m

Nf DISTRIBUTION



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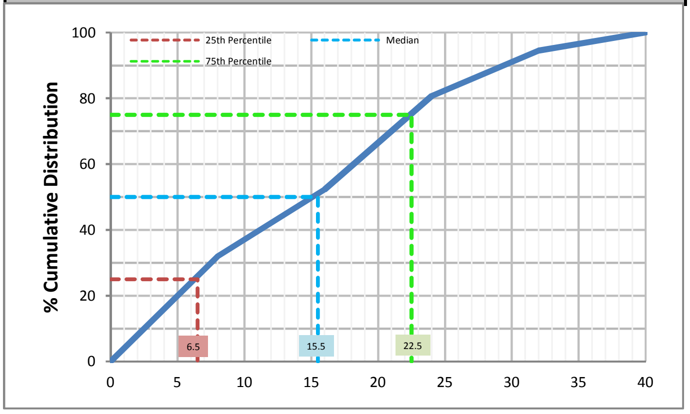
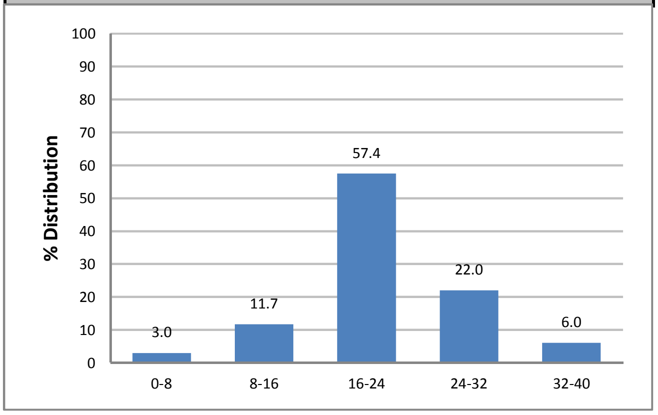
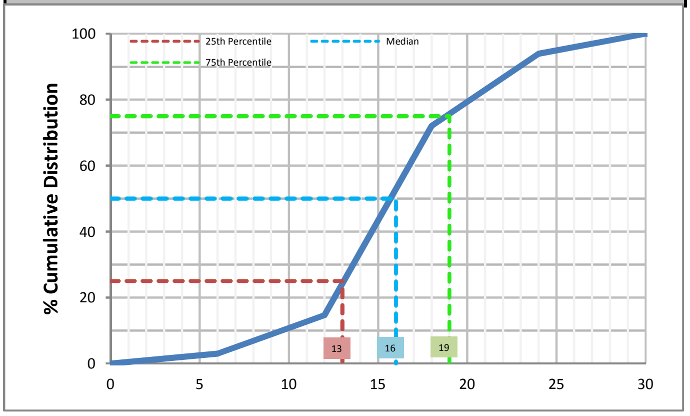


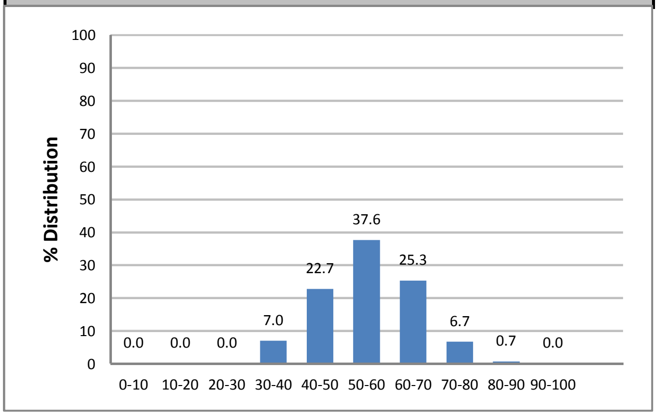
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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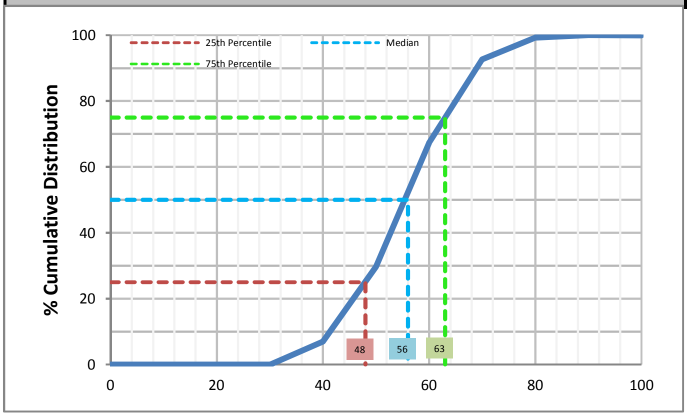
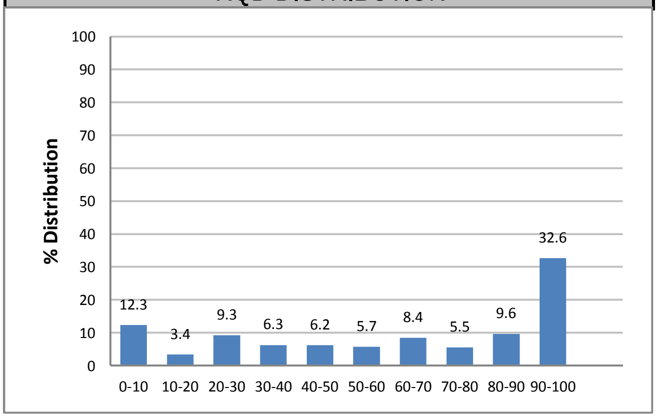


RQD DISTRIBUTION



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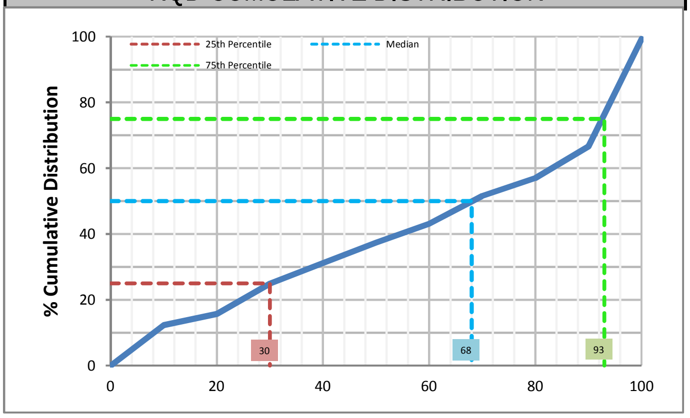
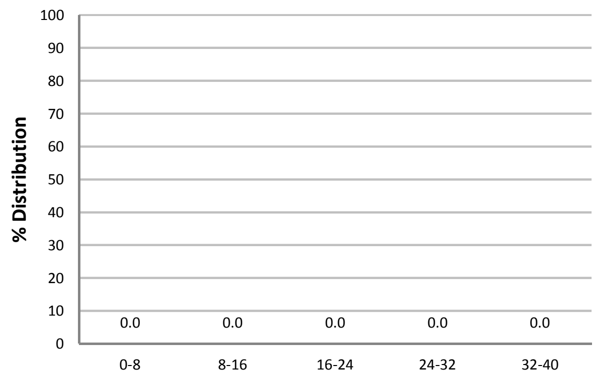


RMR MASS DATA - RMR PARAMETERS

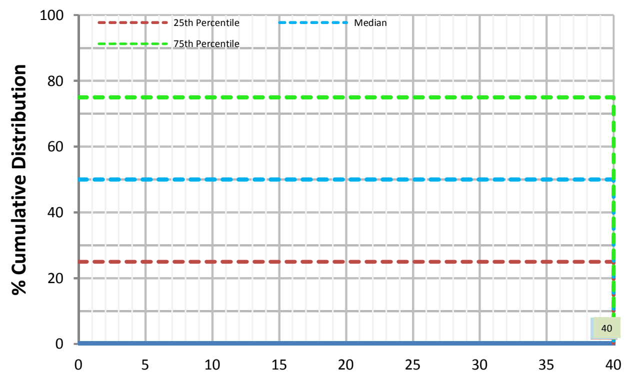
KGH001 - Ajax | Combined Data | Sector 5

Domain: PXPP | Meters Logged: 0 m

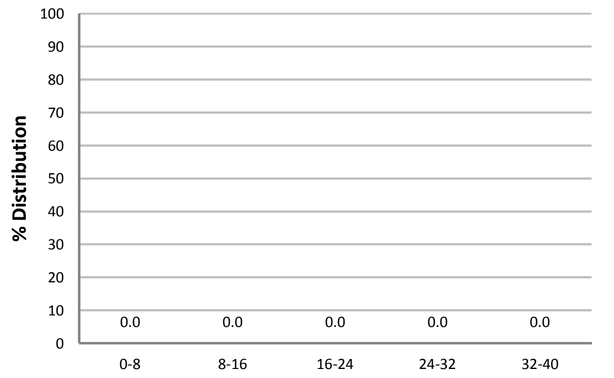
Nf DISTRIBUTION



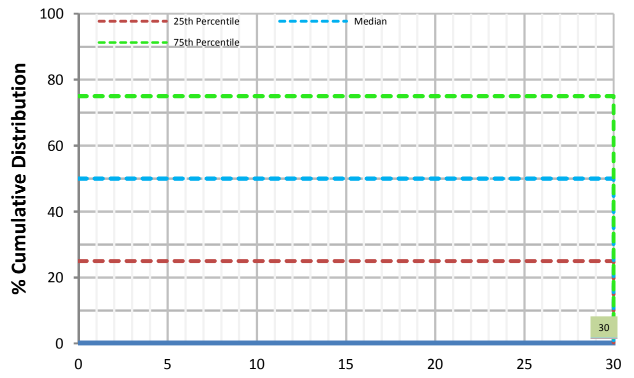
Nf CUMULATIVE DISTRIBUTION



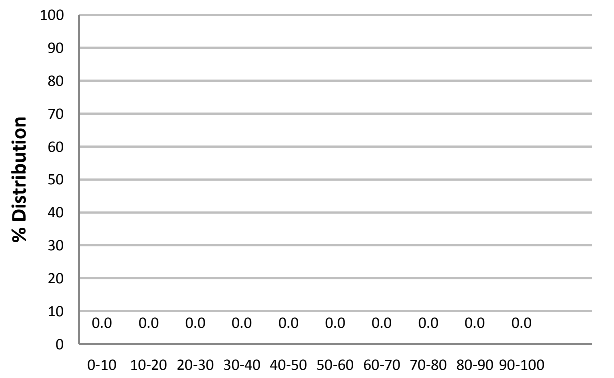
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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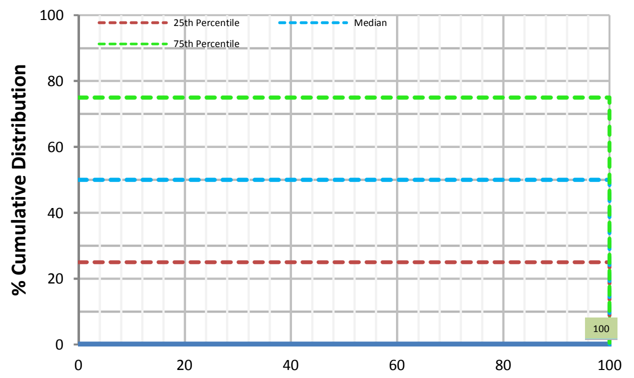

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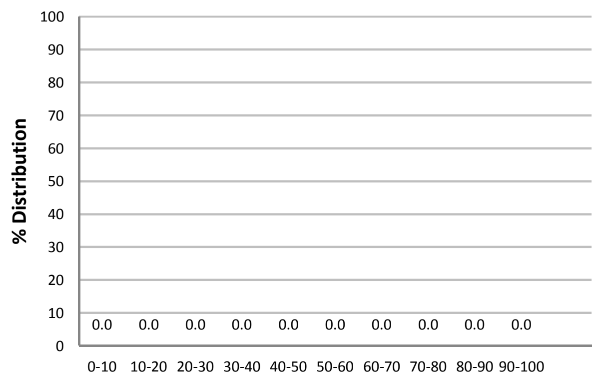

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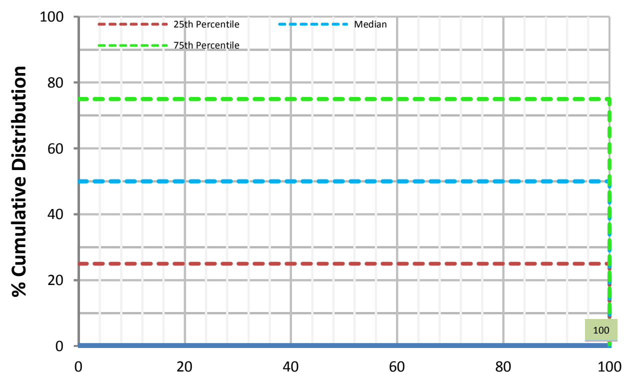
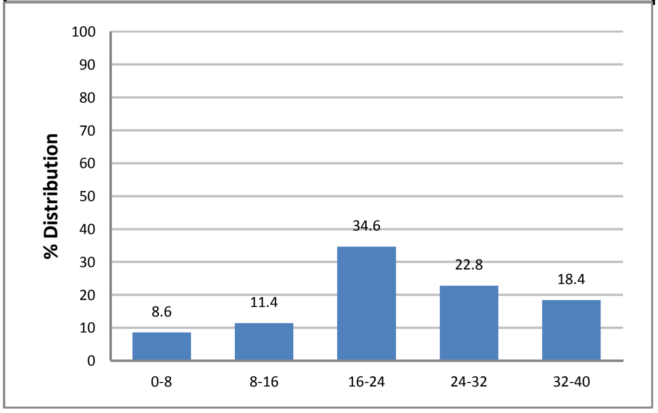


RMR MASS DATA - RMR PARAMETERS

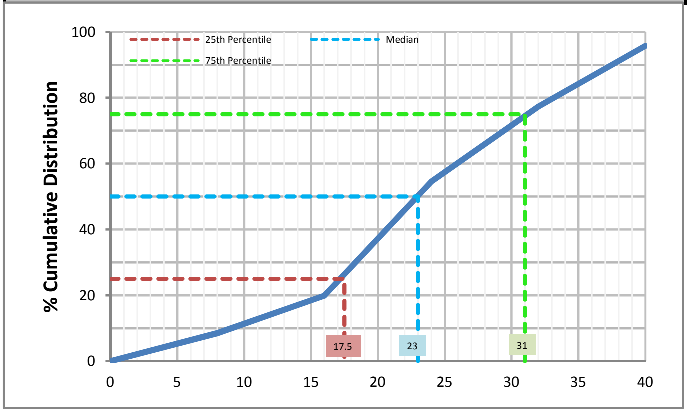
KGH001 - Ajax | Combined Data | Sector 5

Domain: SLD | Meters Logged: 435.88 m

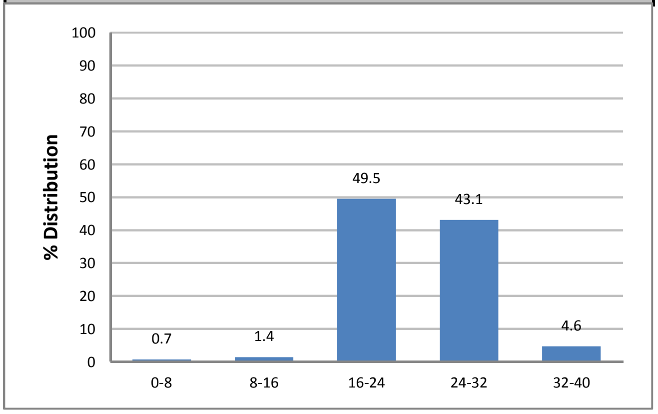
Nf DISTRIBUTION



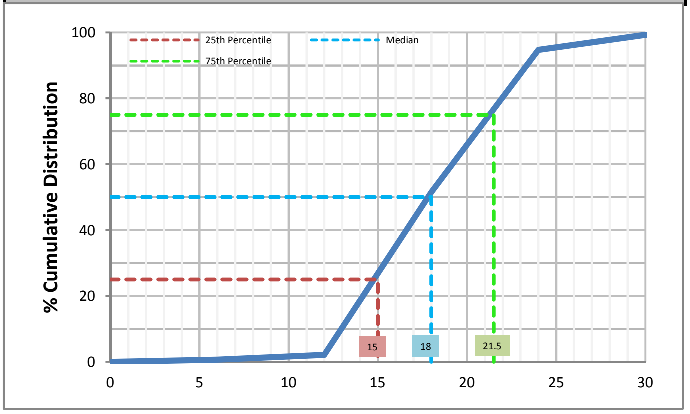
Nf CUMULATIVE DISTRIBUTION



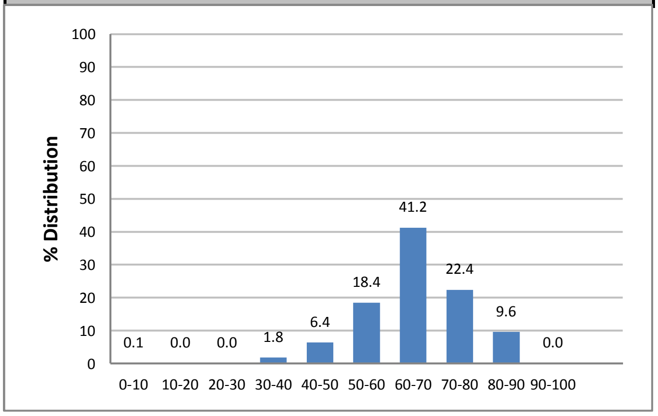
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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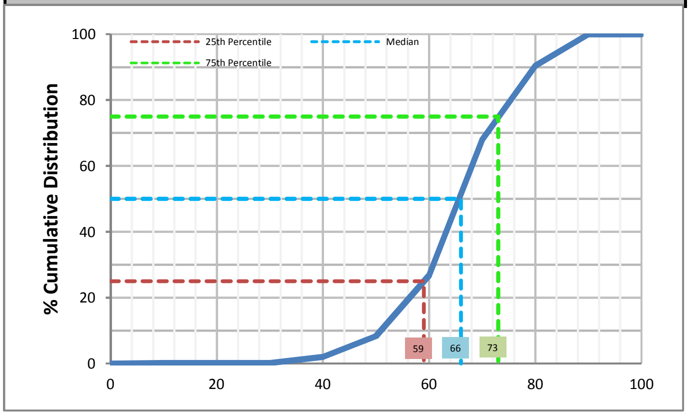
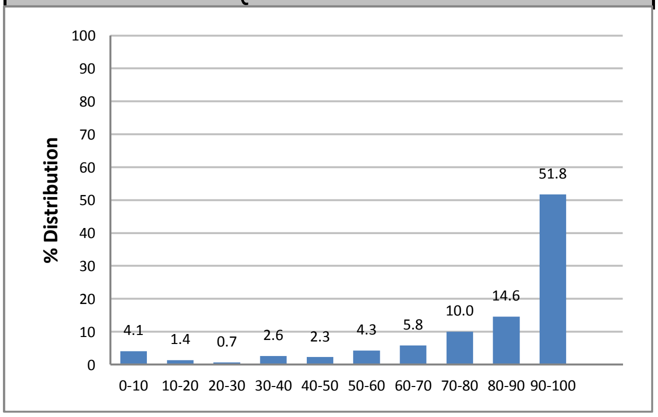


RQD DISTRIBUTION



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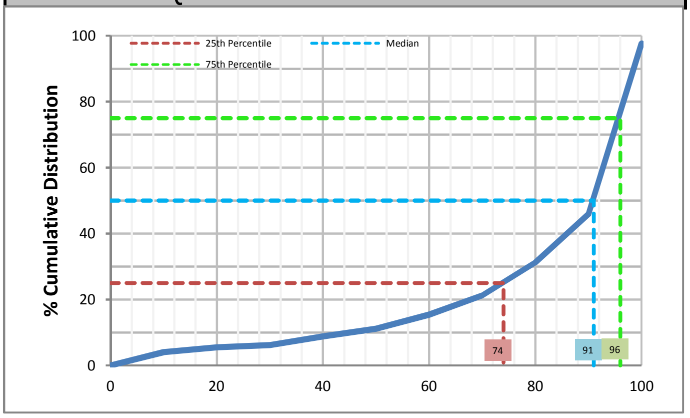
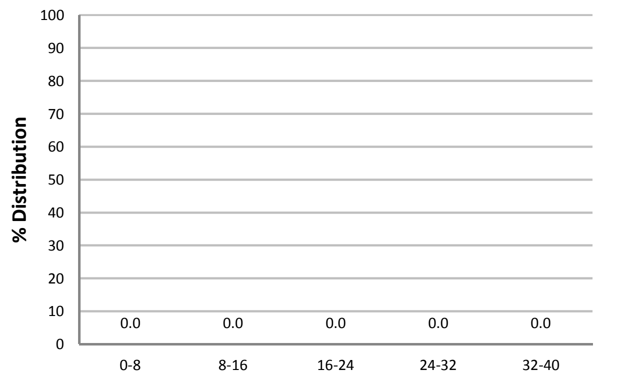


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 5

Domain: SVHYB | Meters Logged: 0 m

Nf DISTRIBUTION



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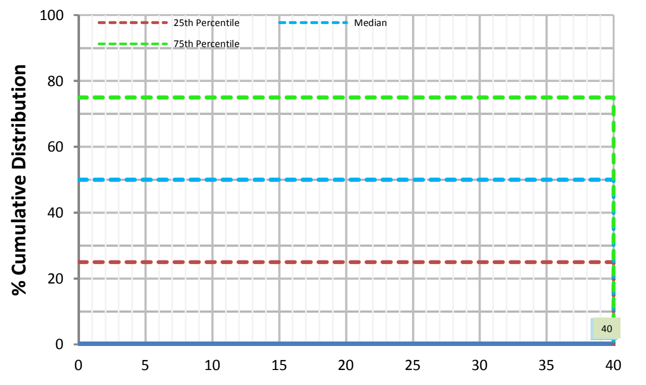
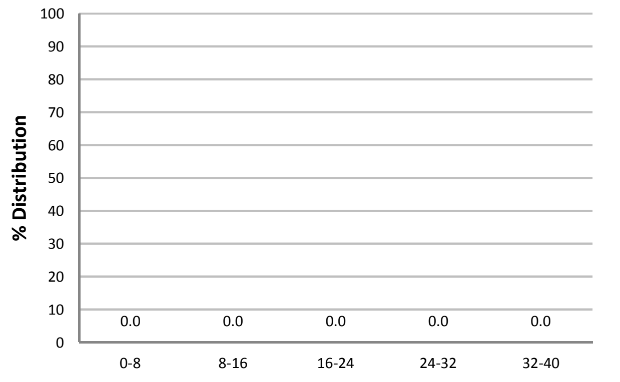
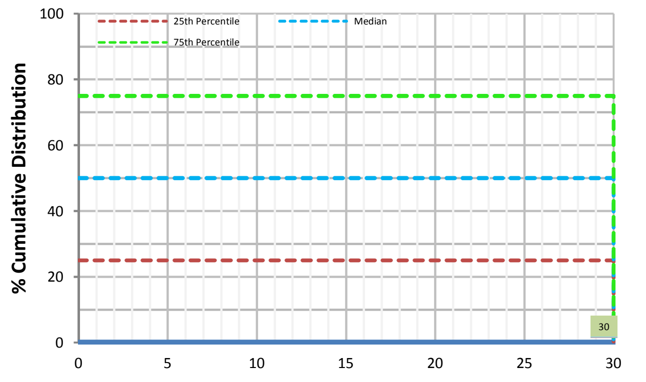


Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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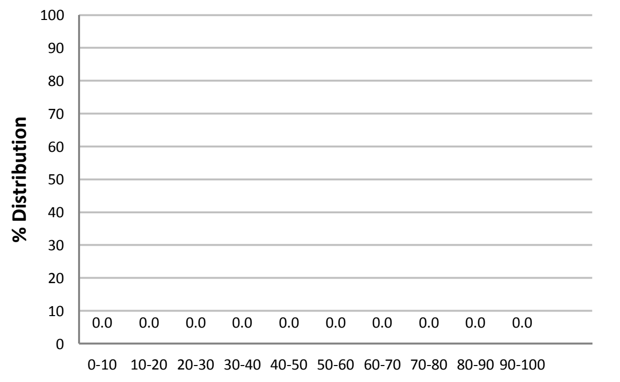
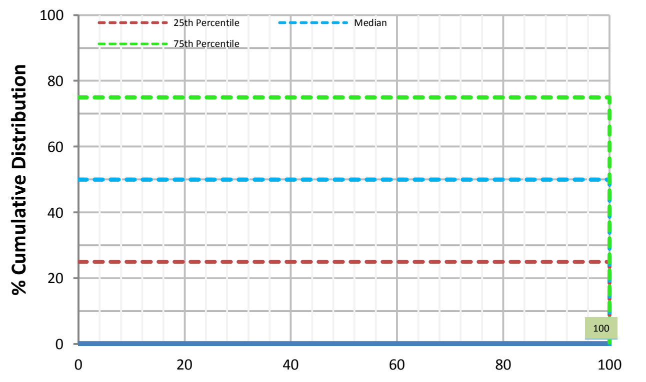
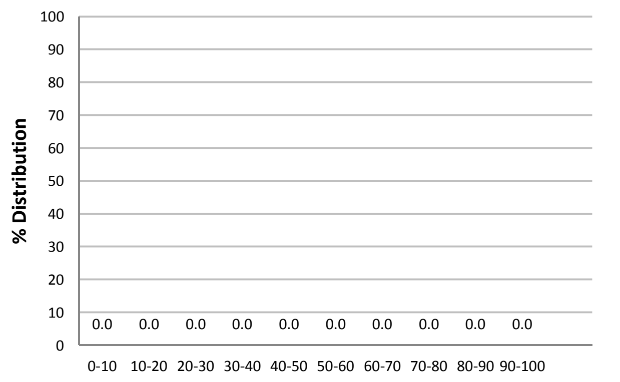


RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



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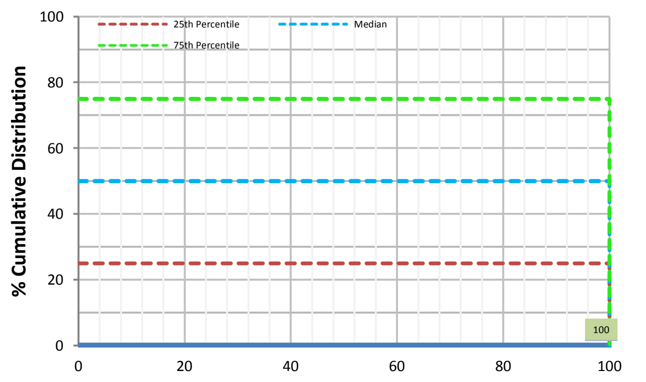
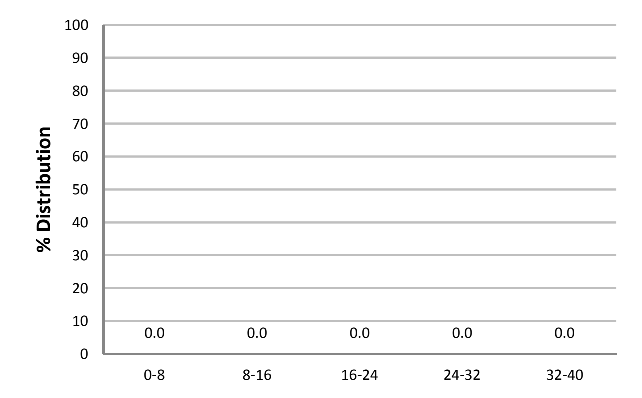


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 6

Domain: IMH | Meters Logged: 0 m

Nf DISTRIBUTION



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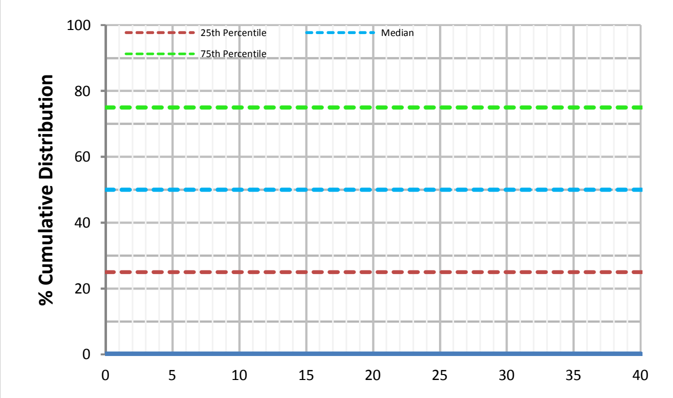
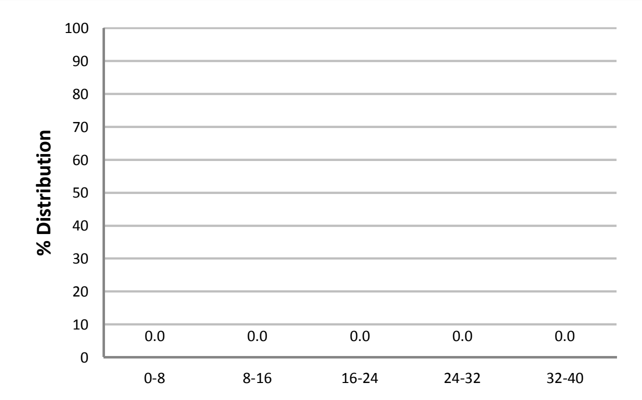
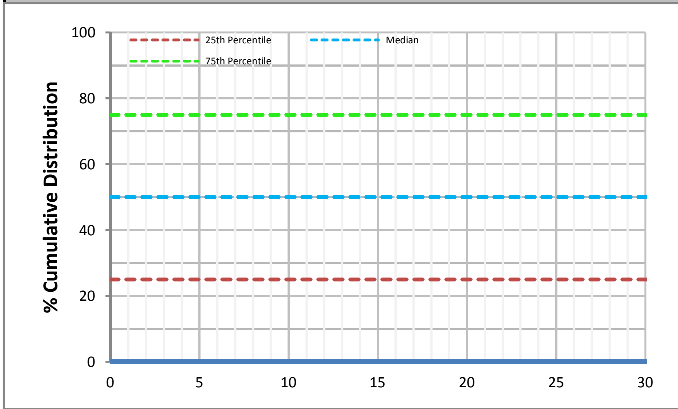


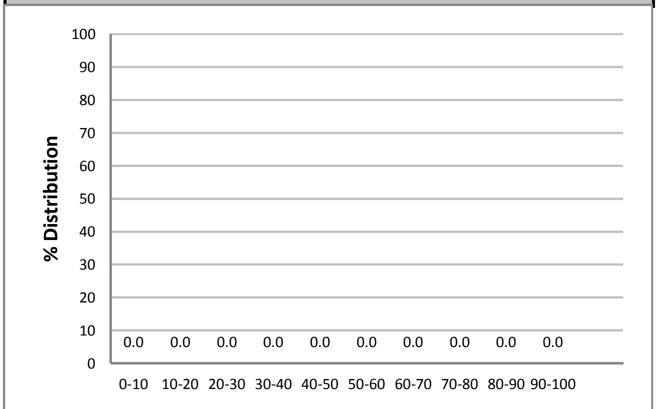
Nc DISTRIBUTION



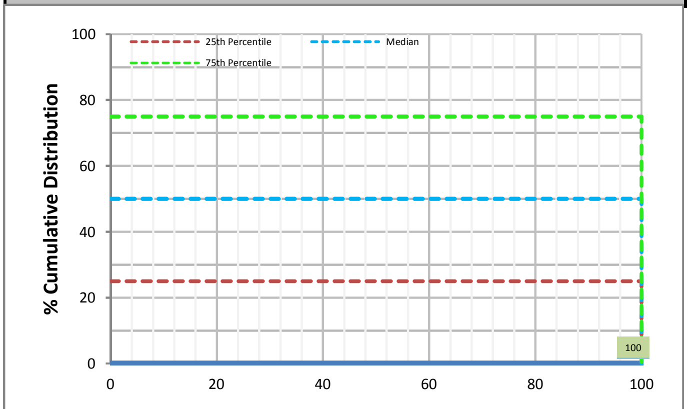
Nc CUMULATIVE DISTRIBUTION



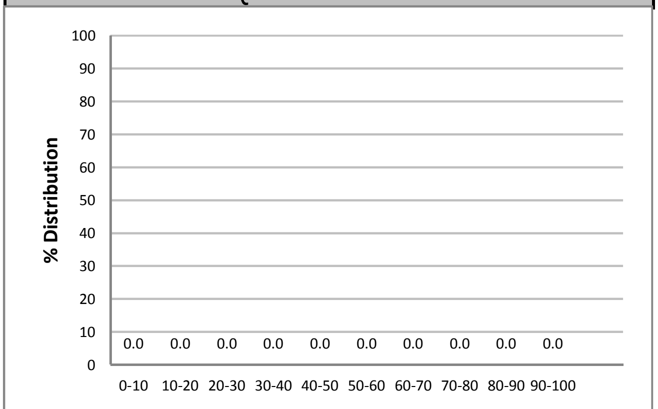
RMR DISTRIBUTION



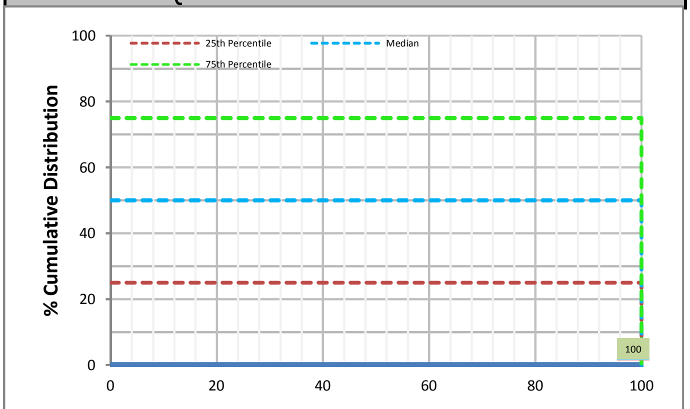
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

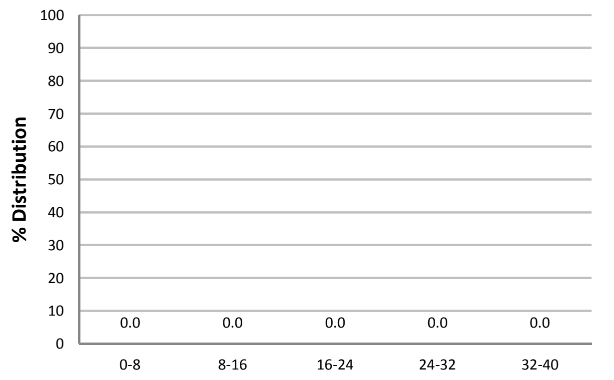


RMR MASS DATA - RMR PARAMETERS

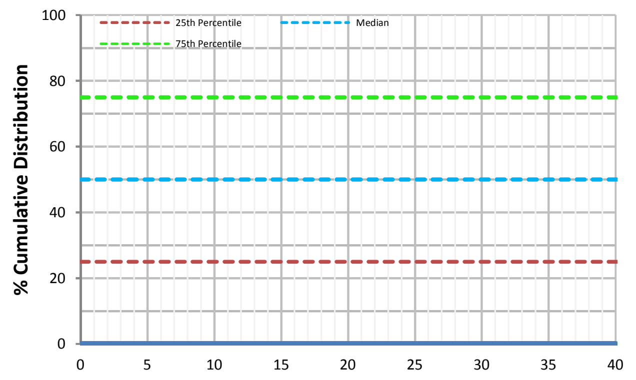
KGH001 - Ajax | Combined Data | Sector 6

Domain: LAT | Meters Logged: 0 m

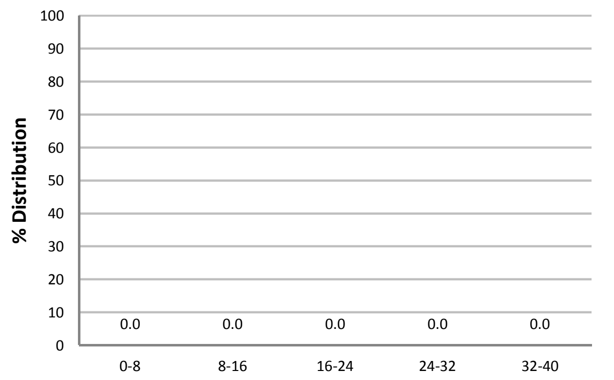
Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



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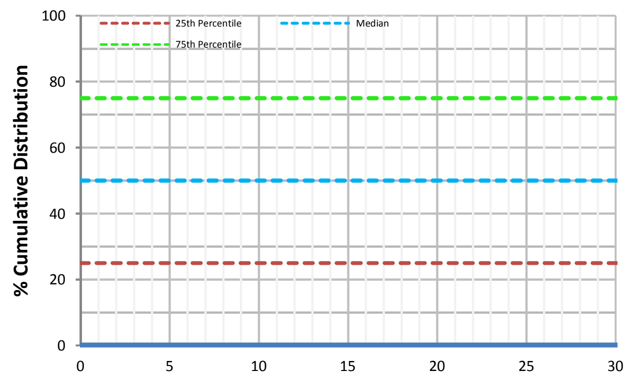

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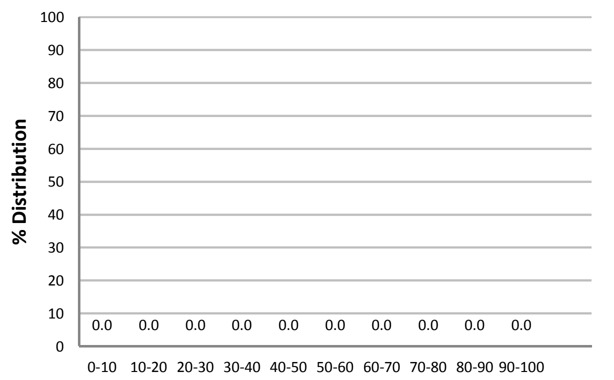

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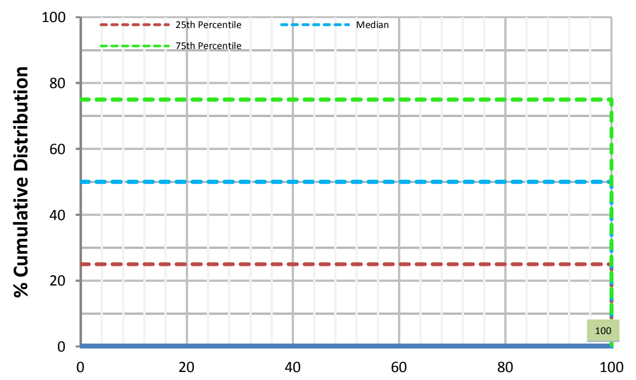

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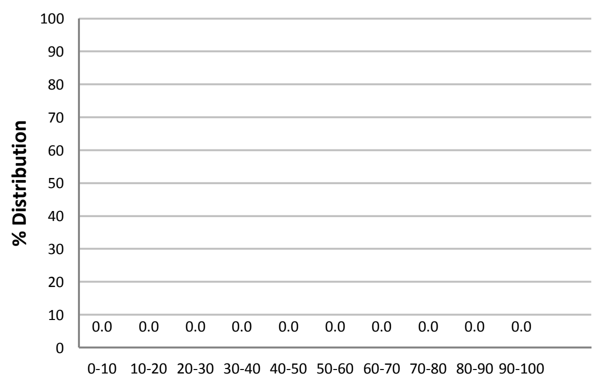
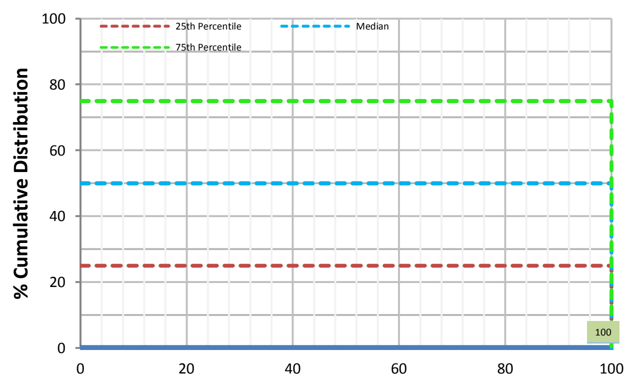


RQD CUMULATIVE DISTRIBUTION

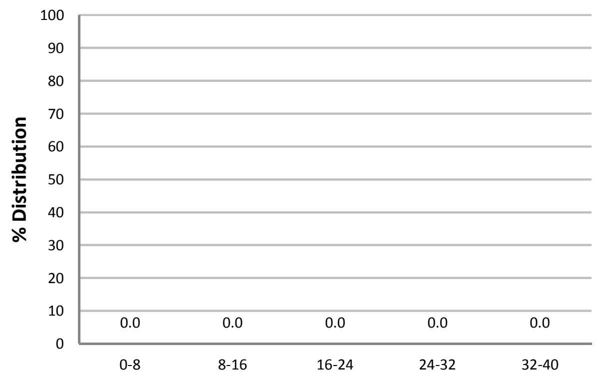


RMR MASS DATA - RMR PARAMETERS

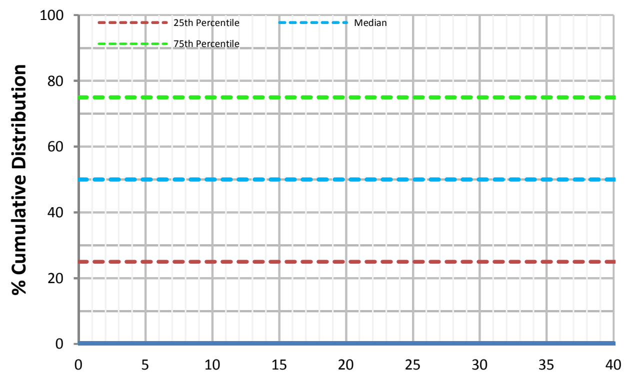
KGH001 - Ajax | Combined Data | Sector 6

Domain: MAFV | Meters Logged: 0 m

Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



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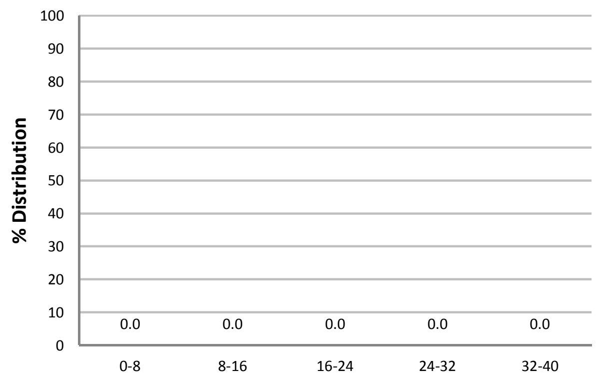

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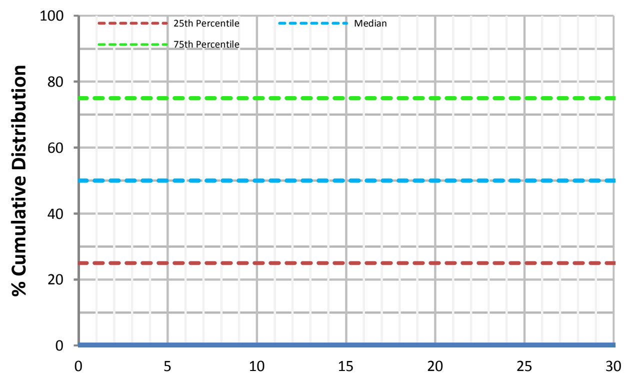

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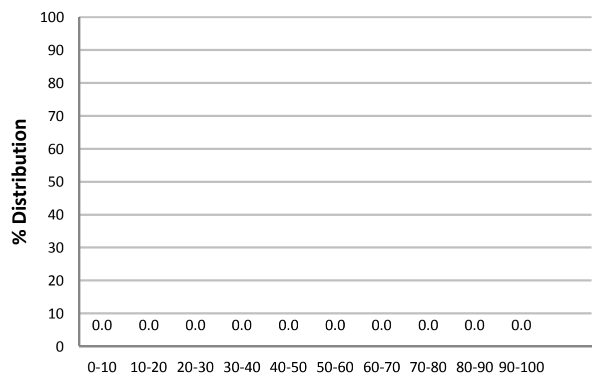

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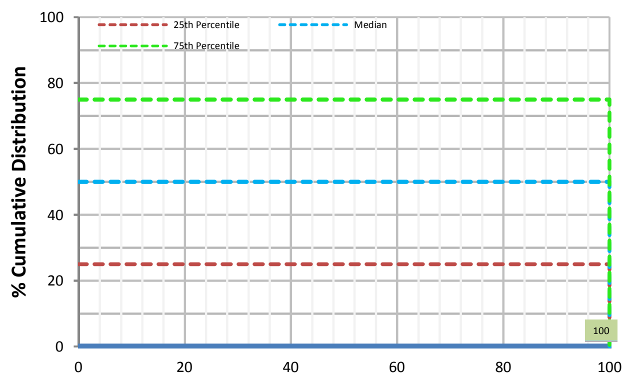

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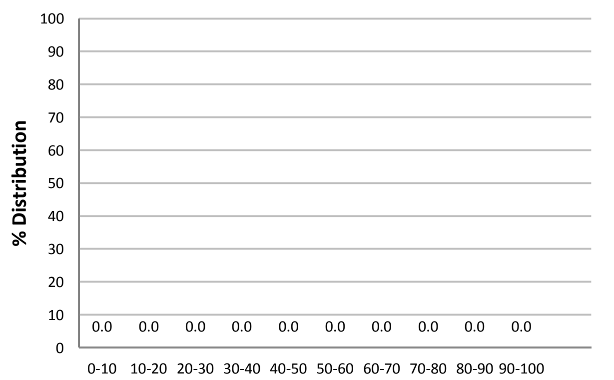
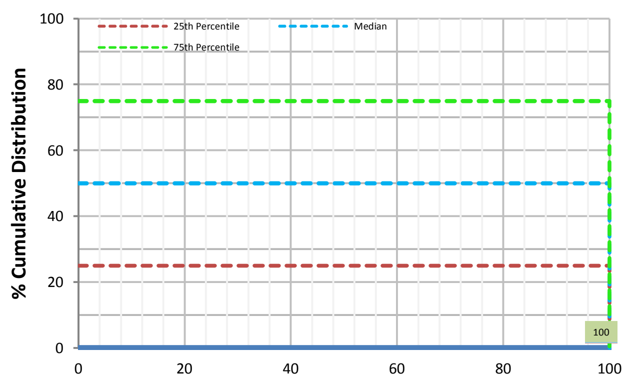


RQD CUMULATIVE DISTRIBUTION



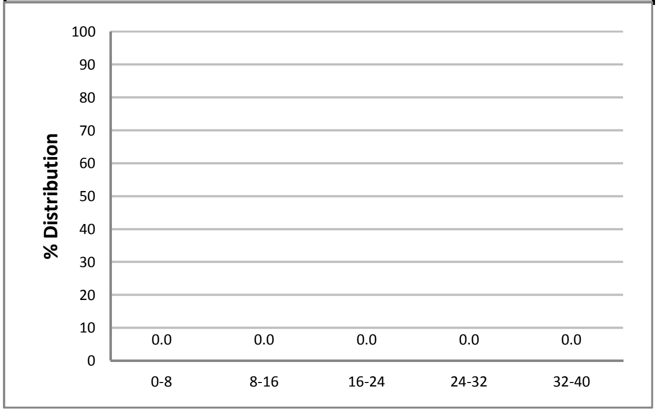
RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 6

Domain: MONZ

Meters Logged: 0 m

Nf DISTRIBUTION



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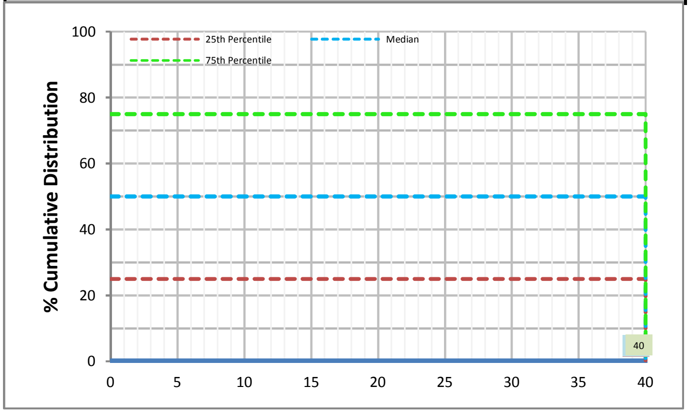
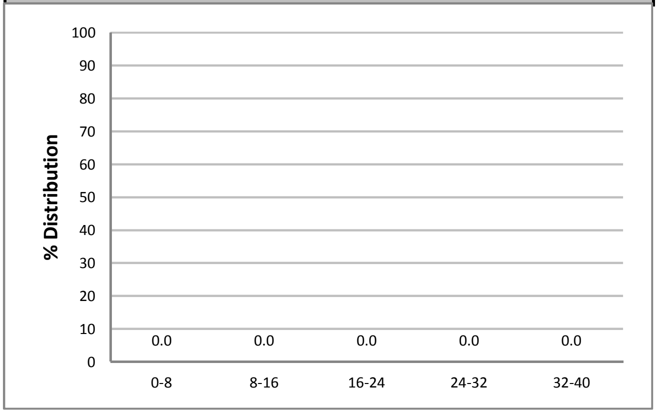


Nc DISTRIBUTION



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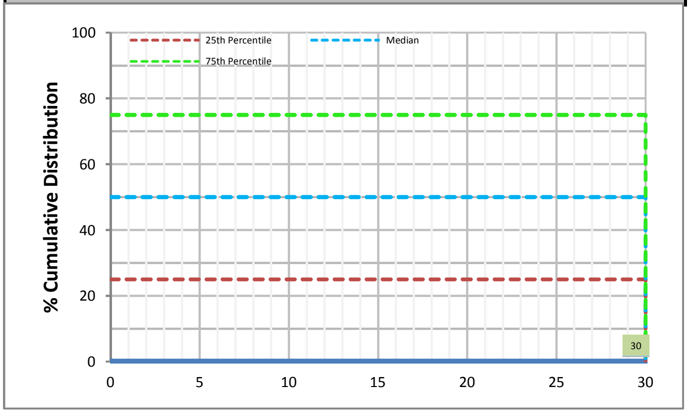

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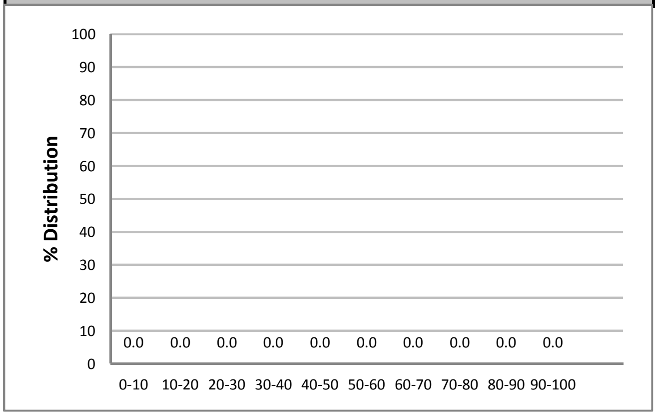

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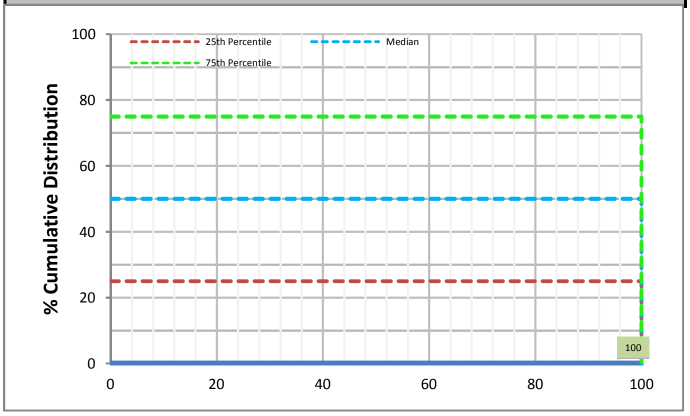

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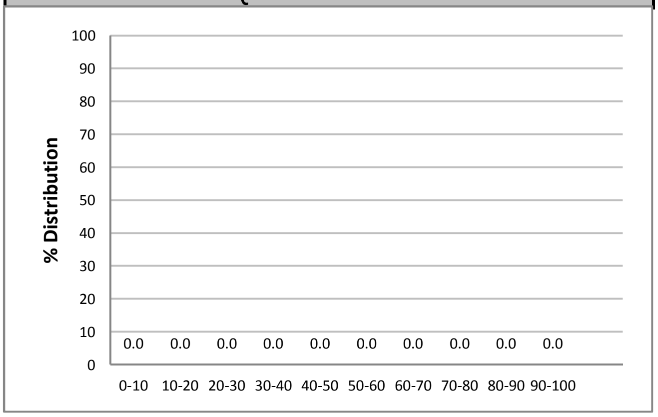

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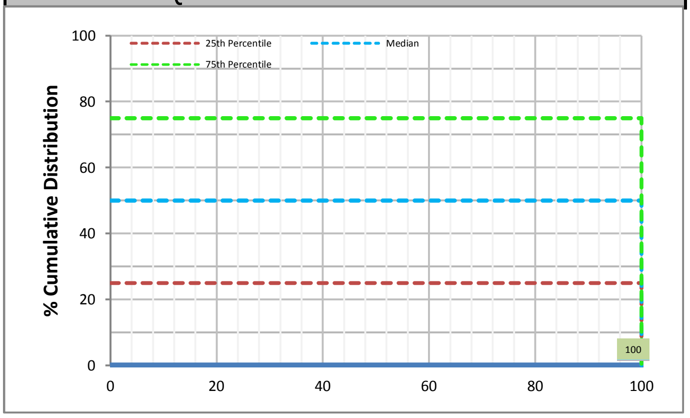
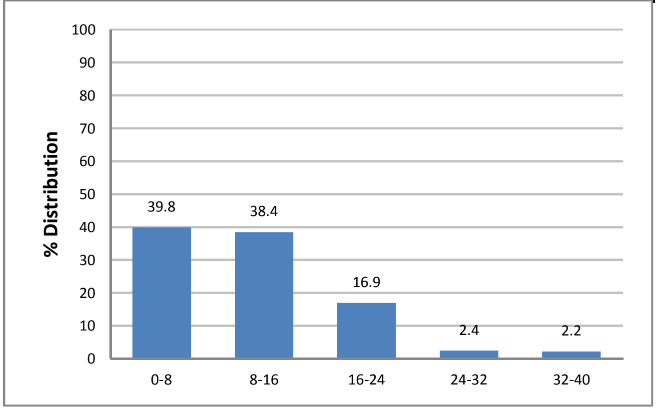


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 6

Domain: PICR | Meters Logged: 897.48 m

Nf DISTRIBUTION



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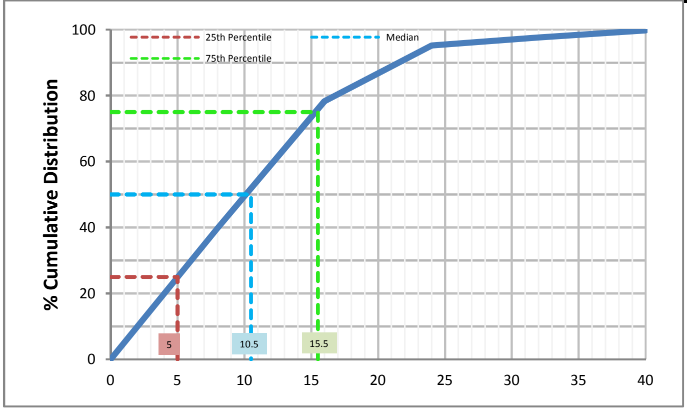
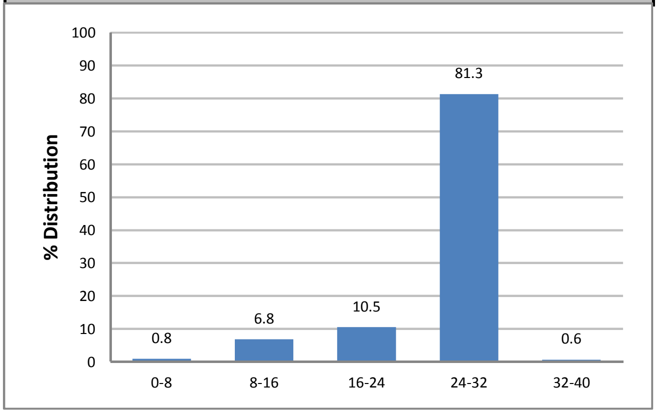


Nc DISTRIBUTION



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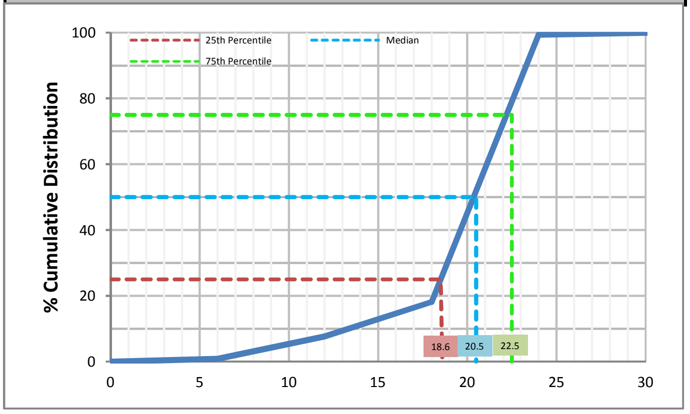
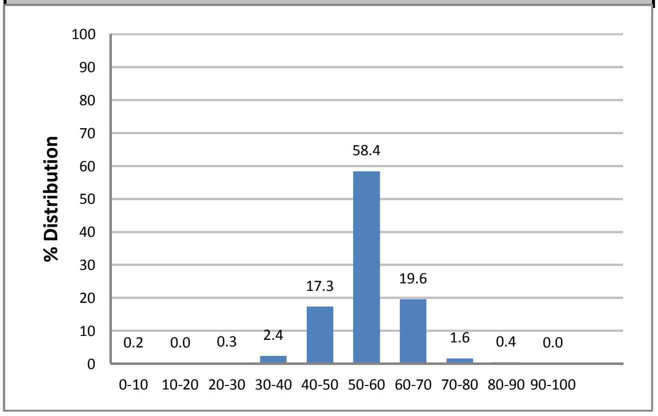


RMR DISTRIBUTION



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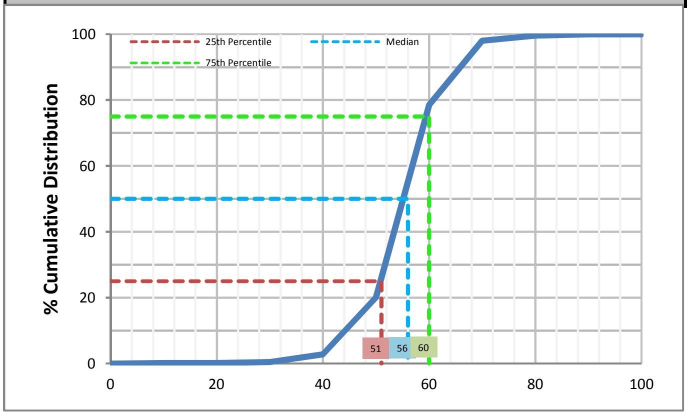
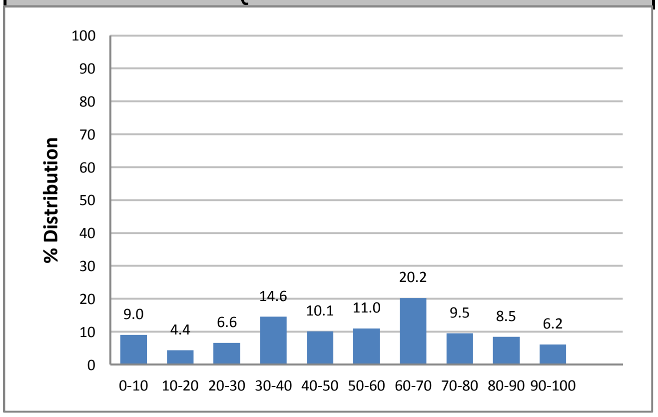


RQD DISTRIBUTION



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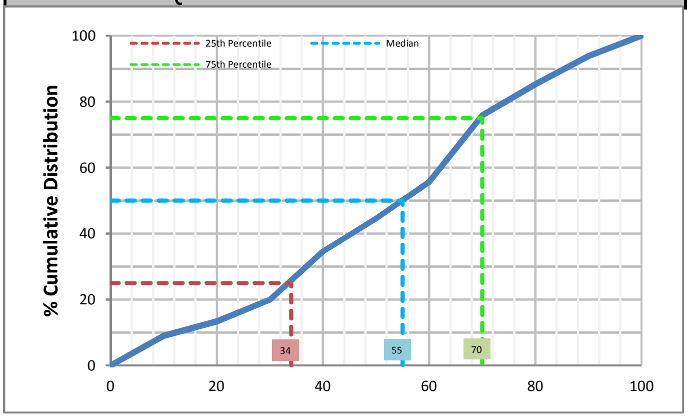


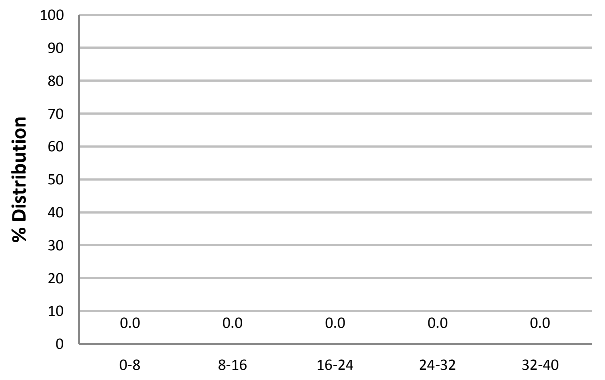
RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 6

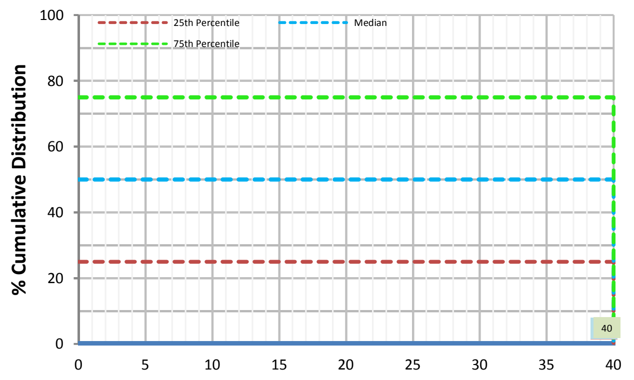
Domain: PXPP

Meters Logged: 0 m

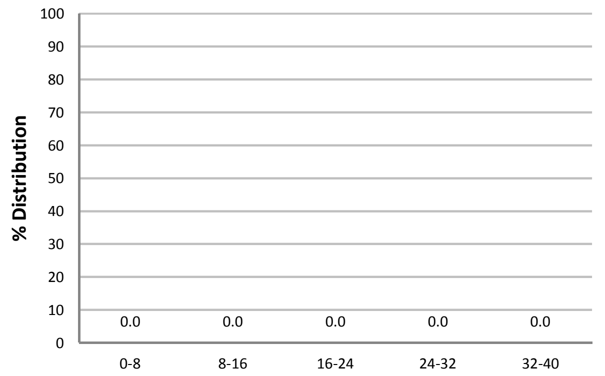
Nf DISTRIBUTION



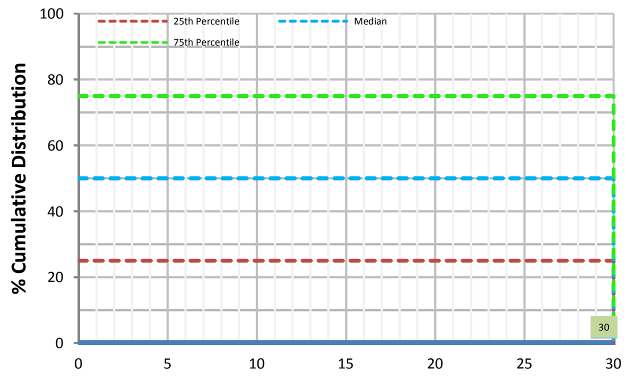
Nf CUMULATIVE DISTRIBUTION



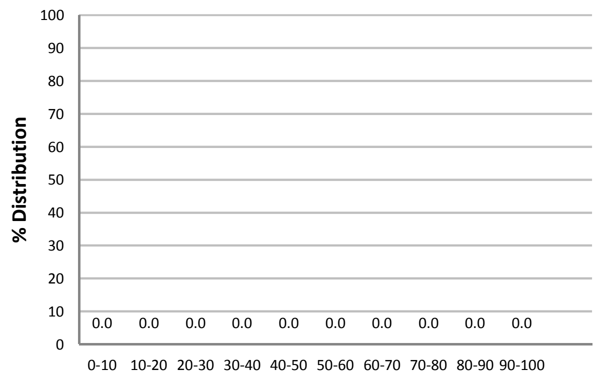
Nc DISTRIBUTION



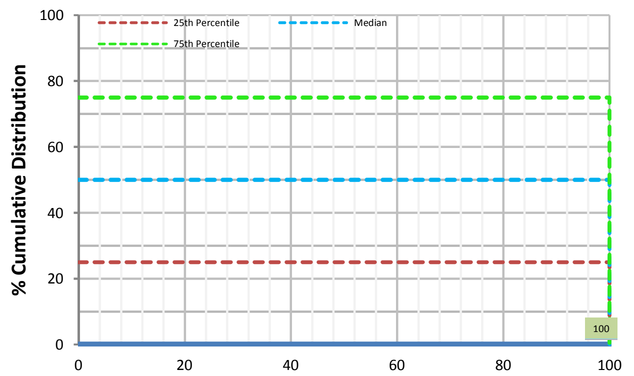
Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



RMR CUMULATIVE DISTRIBUTION



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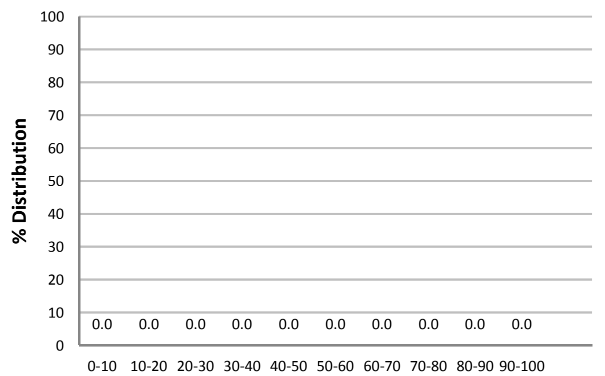

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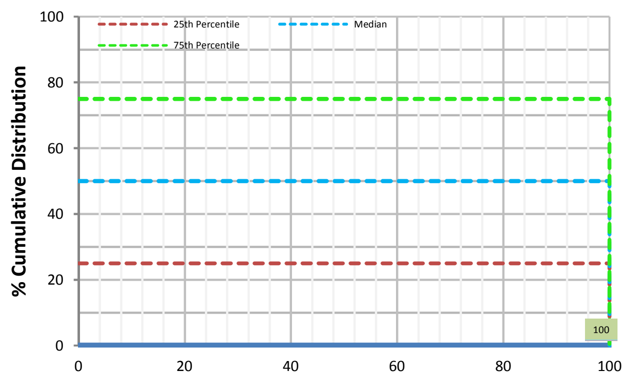
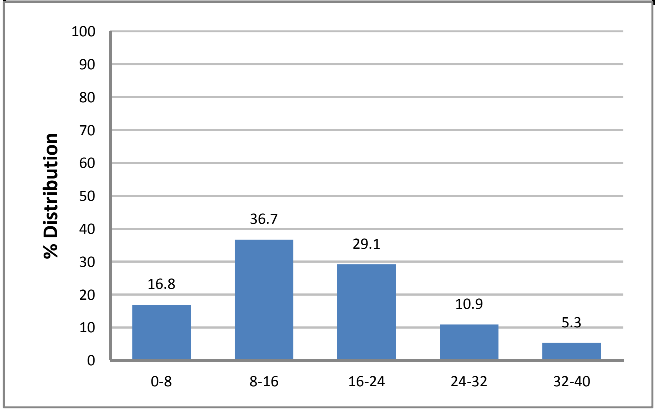


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 6

Domain: SLD | Meters Logged: 1500.69 m

Nf DISTRIBUTION



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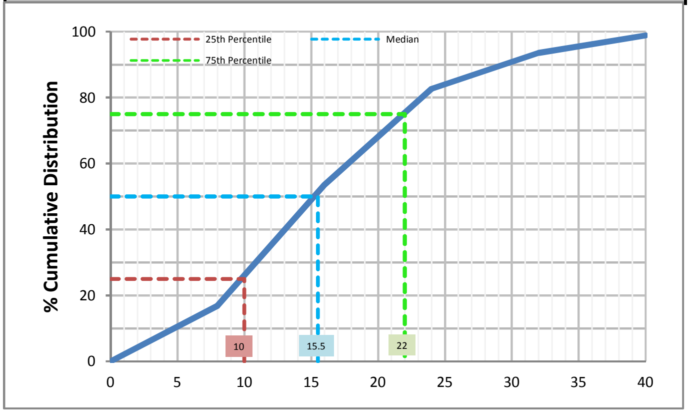
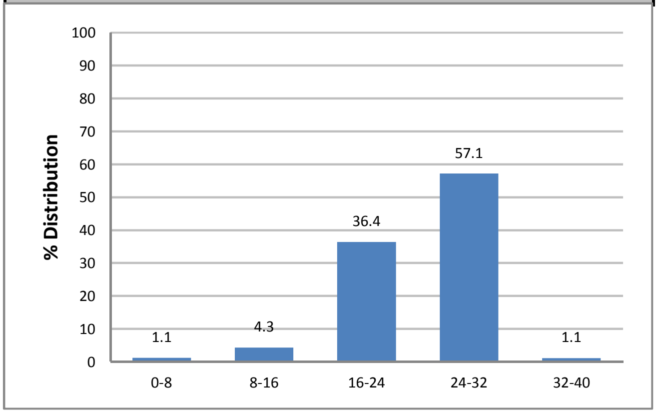
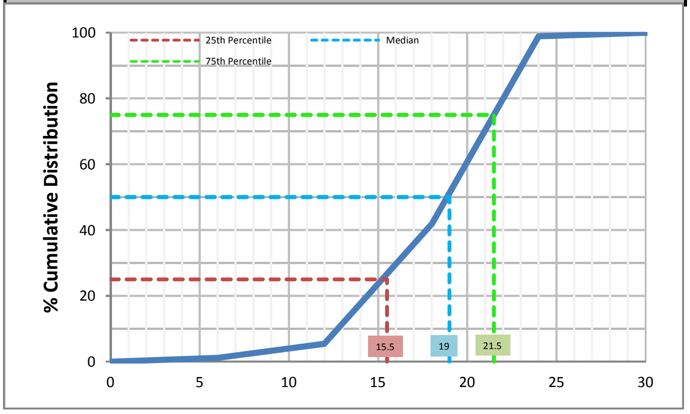


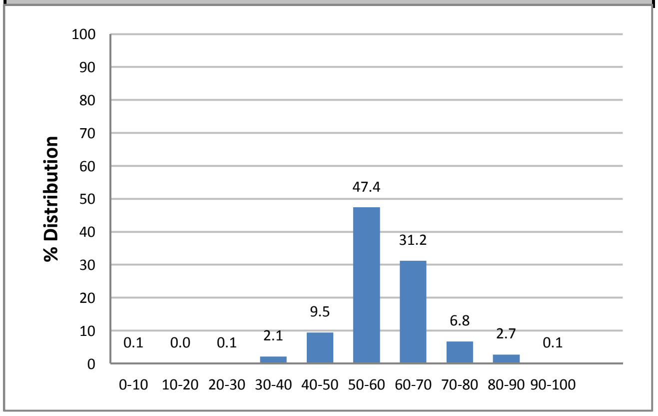
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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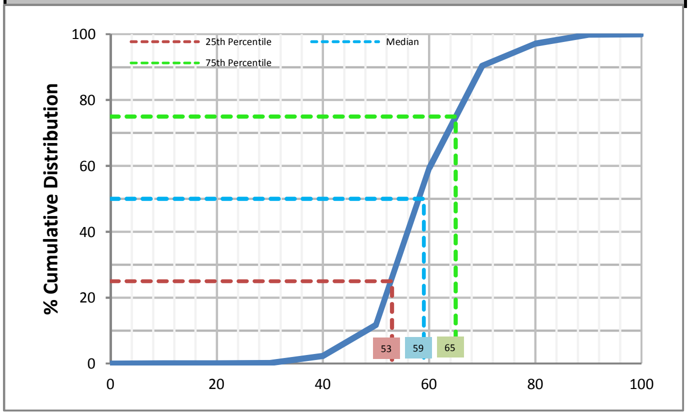
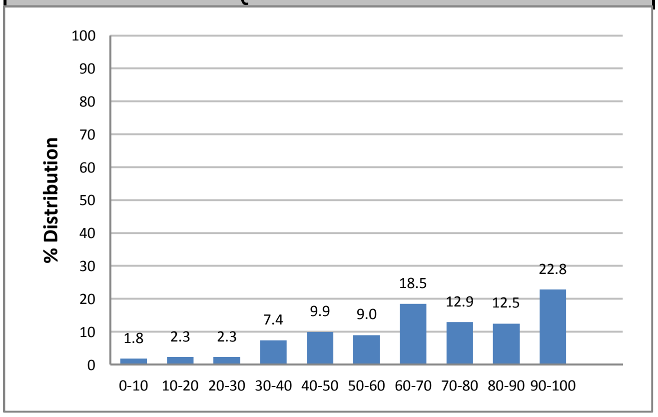


RQD DISTRIBUTION



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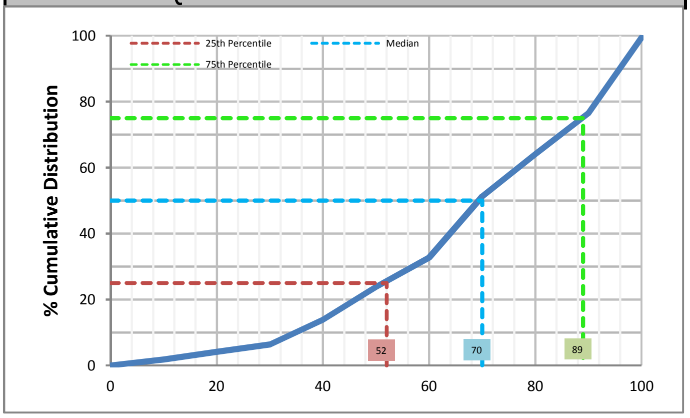
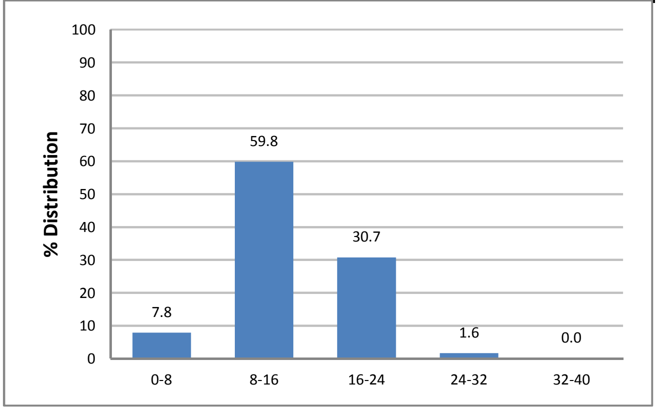


RMR MASS DATA - RMR PARAMETERS

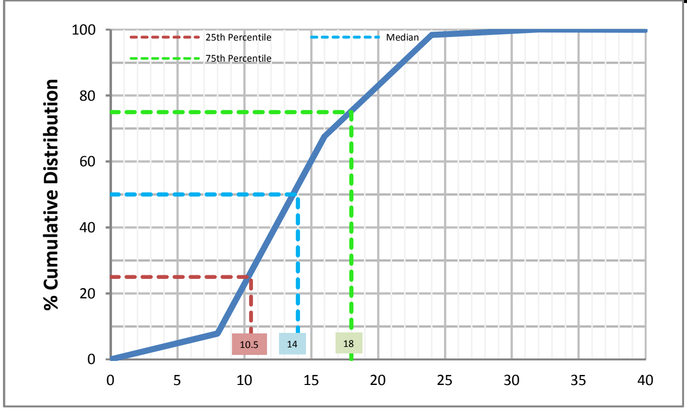
KGH001 - Ajax | Combined Data | Sector 6

Domain: SVHYB | Meters Logged: 56.39 m

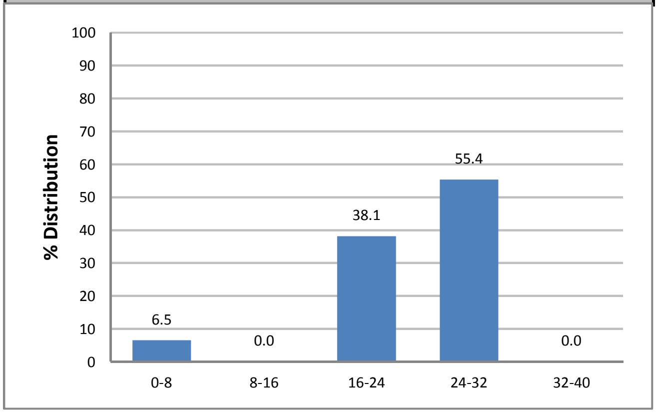
Nf DISTRIBUTION



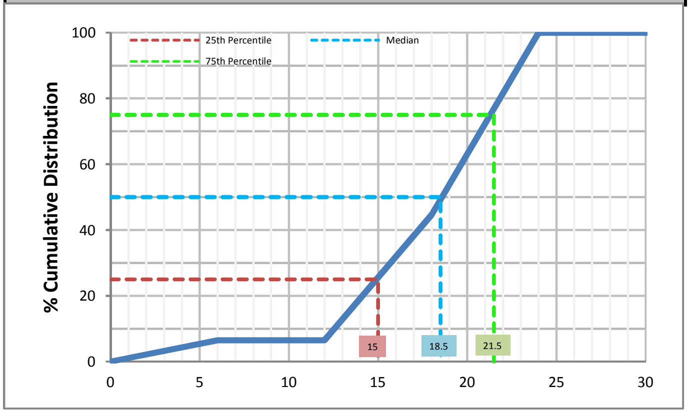
Nf CUMULATIVE DISTRIBUTION



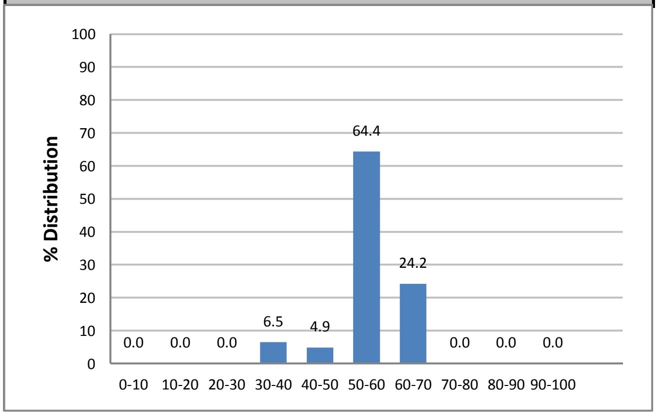
Nc DISTRIBUTION



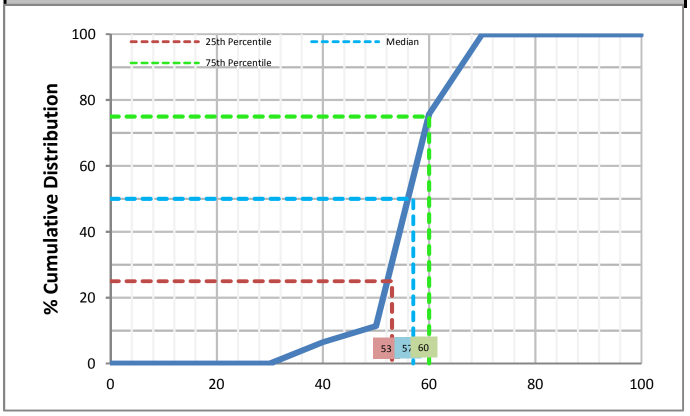
Nc CUMULATIVE DISTRIBUTION



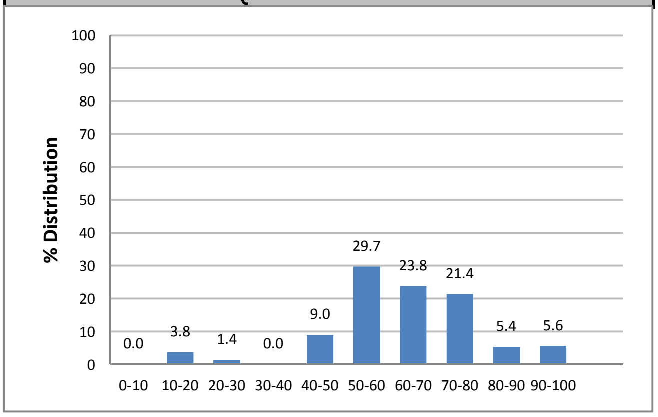
RMR DISTRIBUTION



RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



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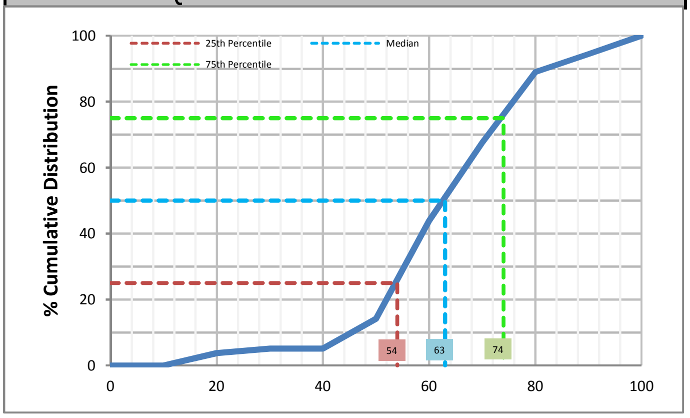
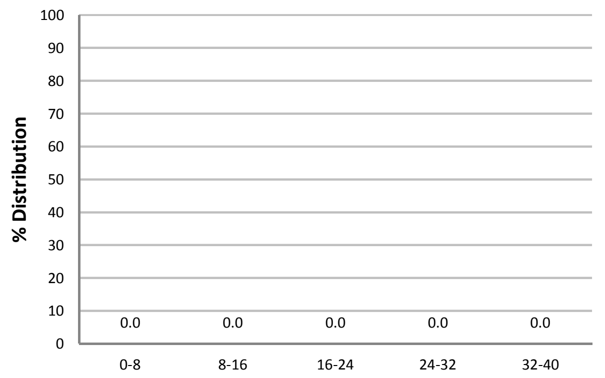


RMR MASS DATA - RMR PARAMETERS

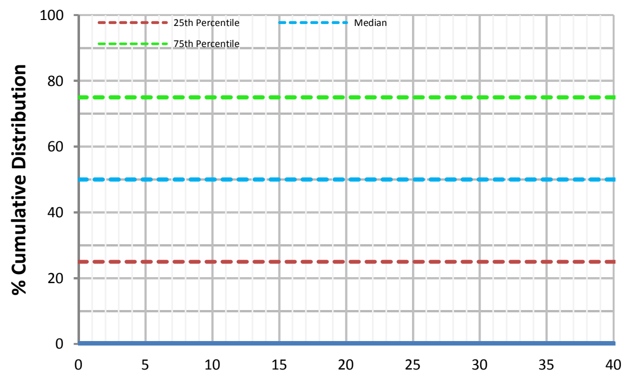
KGH001 - Ajax | Combined Data | Sector 7

Domain: IMH | Meters Logged: 0 m

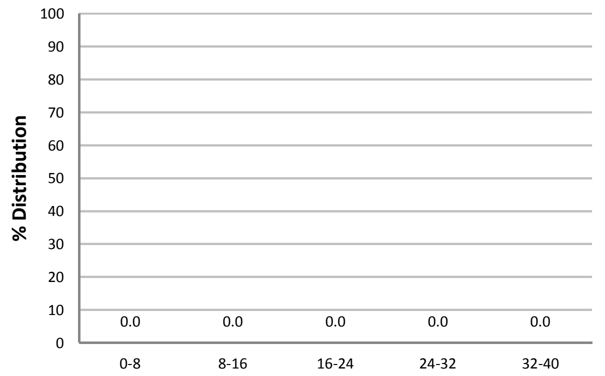
Nf DISTRIBUTION



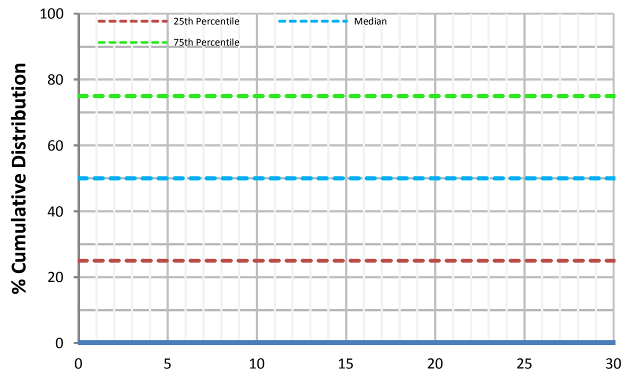
Nf CUMULATIVE DISTRIBUTION



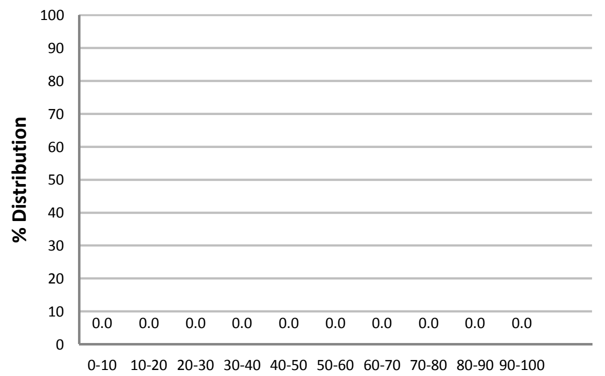
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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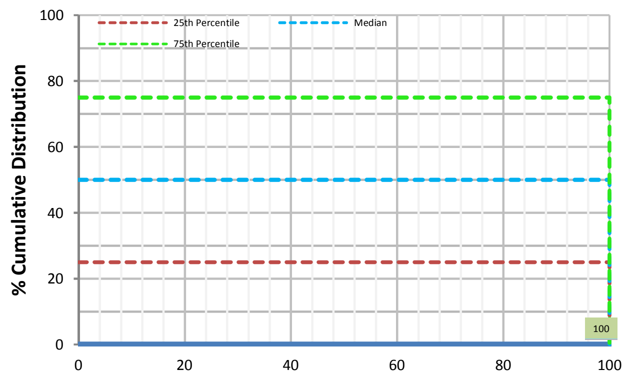
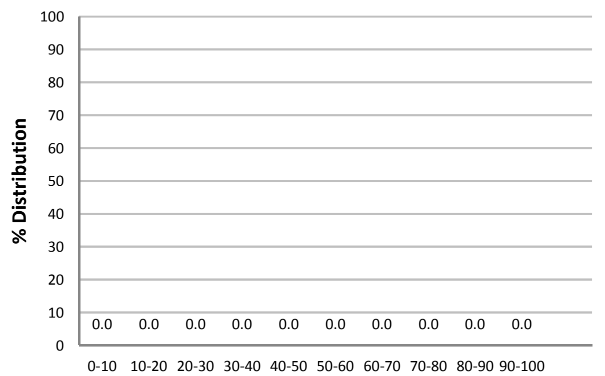


RQD DISTRIBUTION



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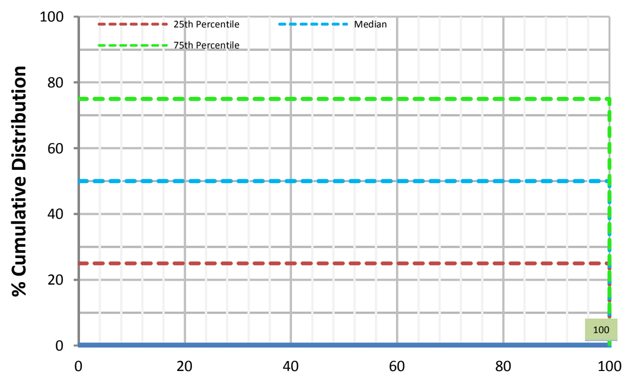
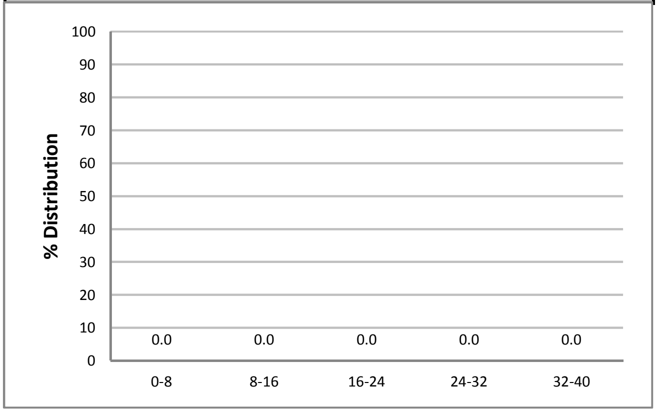


RMR MASS DATA - RMR PARAMETERS

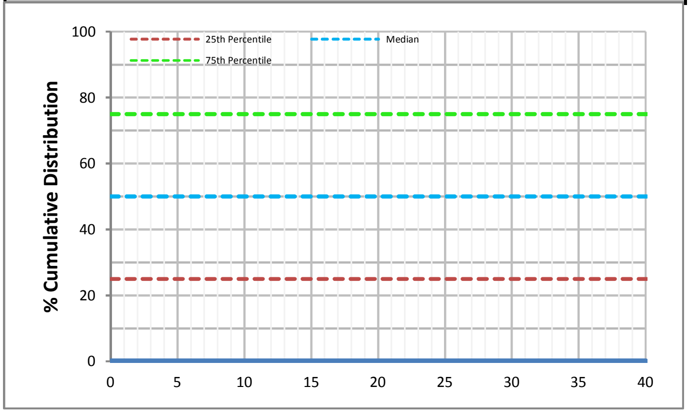
KGH001 - Ajax | Combined Data | Sector 7

Domain: LAT | Meters Logged: 0 m

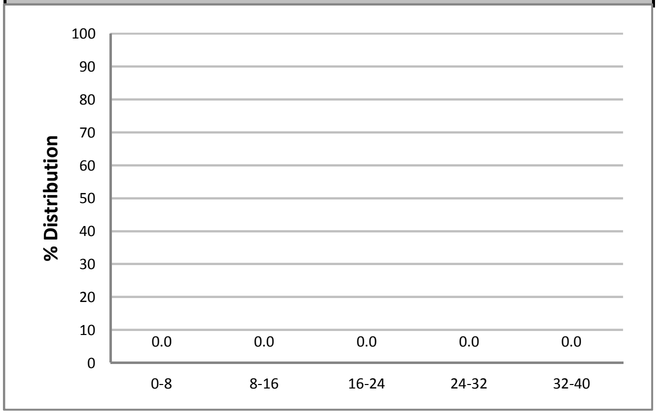
Nf DISTRIBUTION



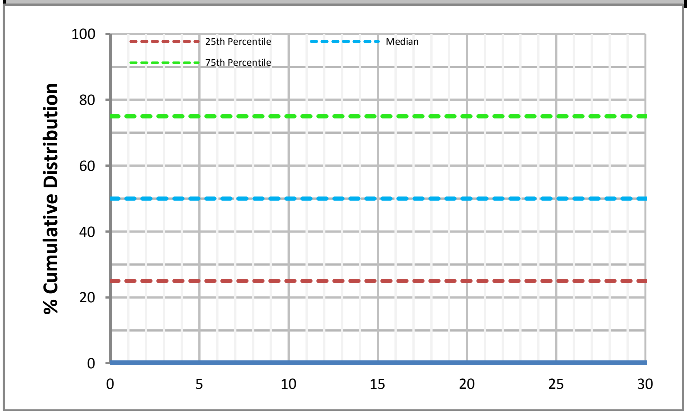
Nf CUMULATIVE DISTRIBUTION



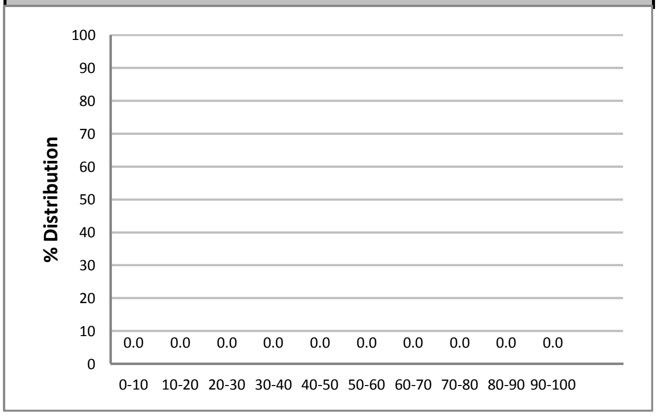
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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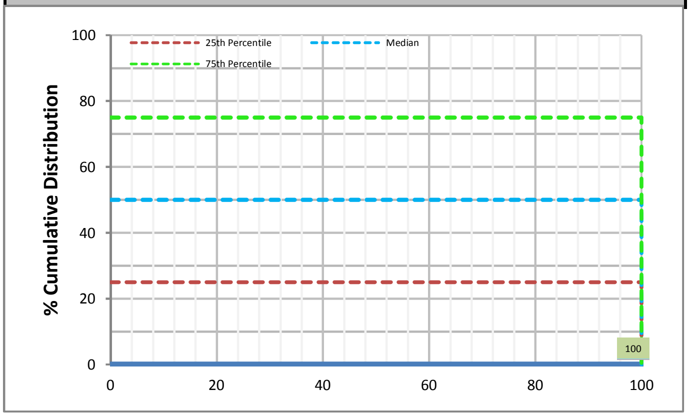
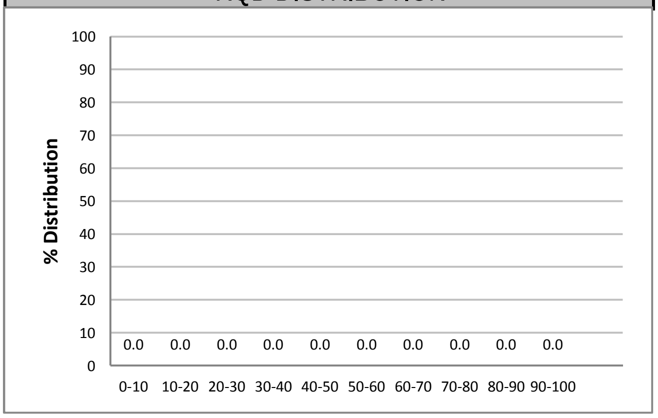
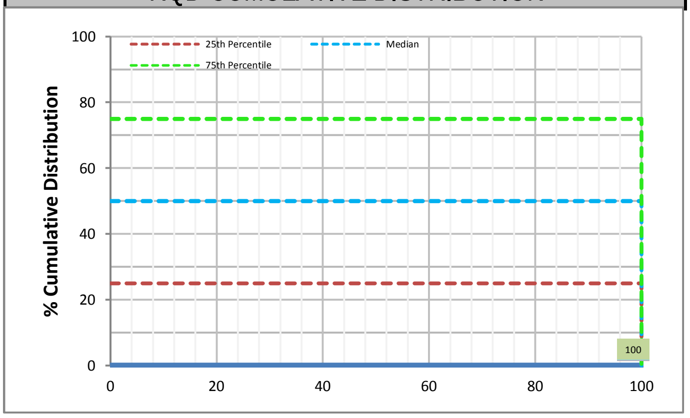


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

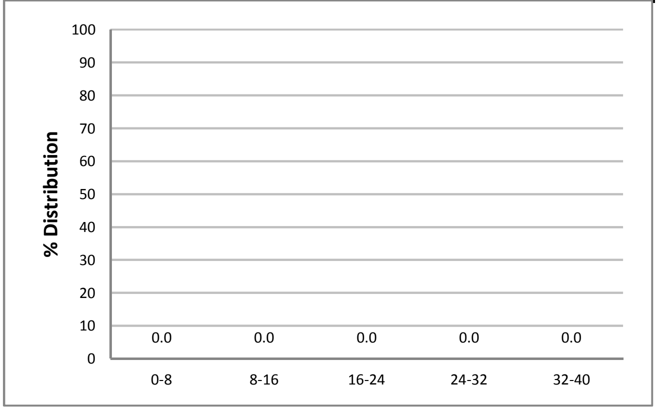


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 7

Domain: MAFV | Meters Logged: 0 m

Nf DISTRIBUTION



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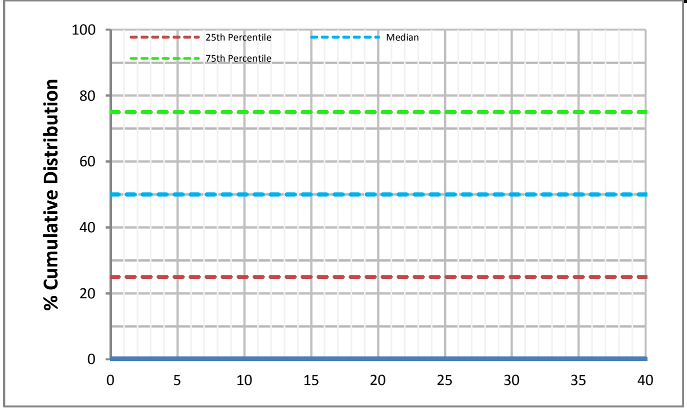
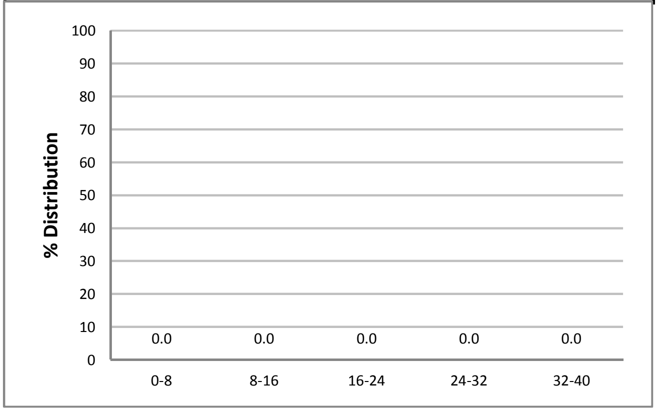


Nc DISTRIBUTION



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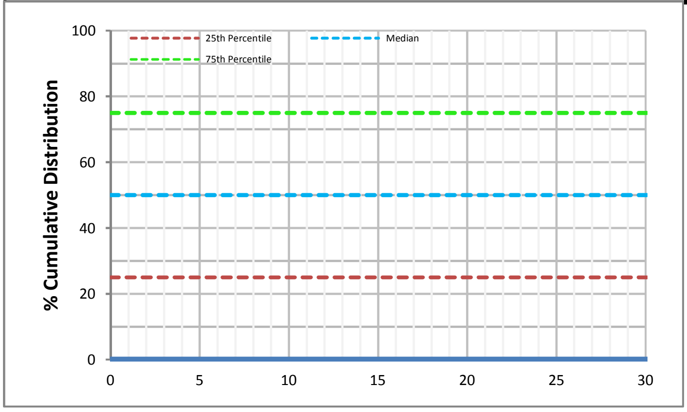

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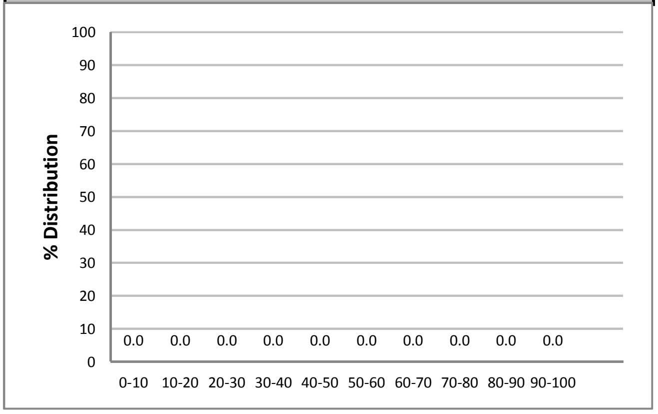

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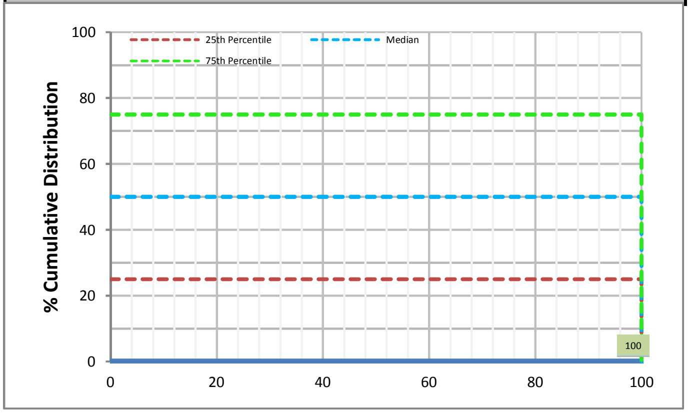
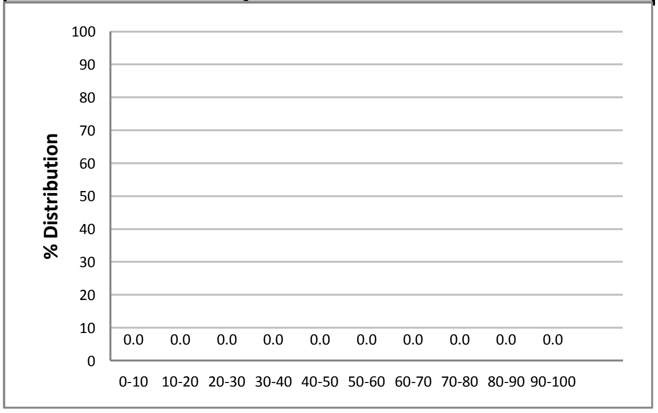
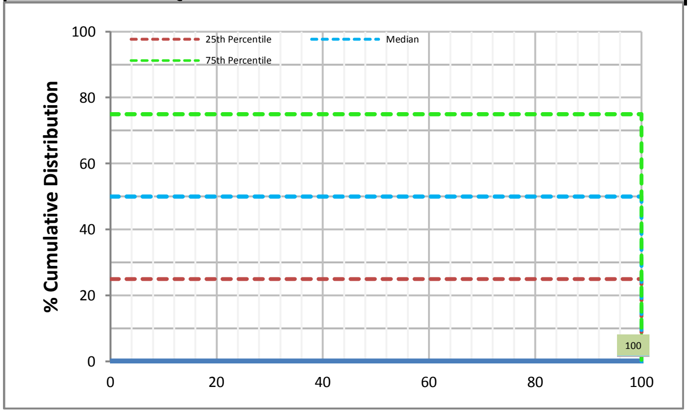


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

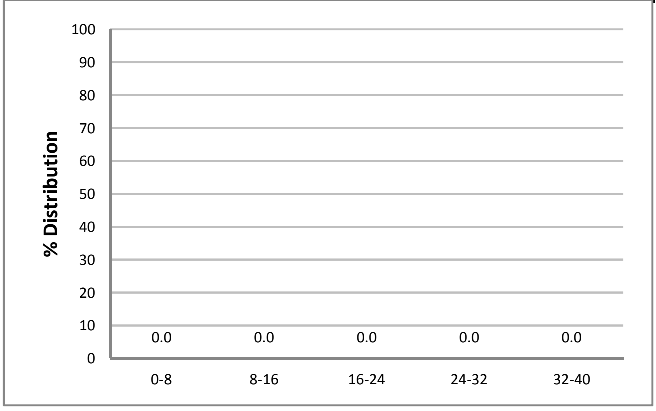


RMR MASS DATA - RMR PARAMETERS

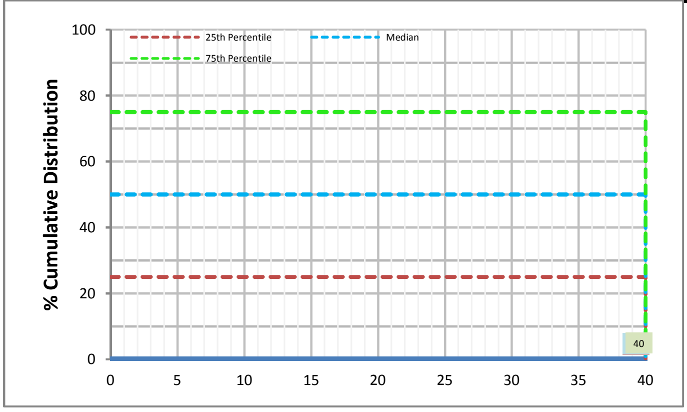
KGH001 - Ajax | Combined Data | Sector 7

Domain: MONZ | Meters Logged: 0 m

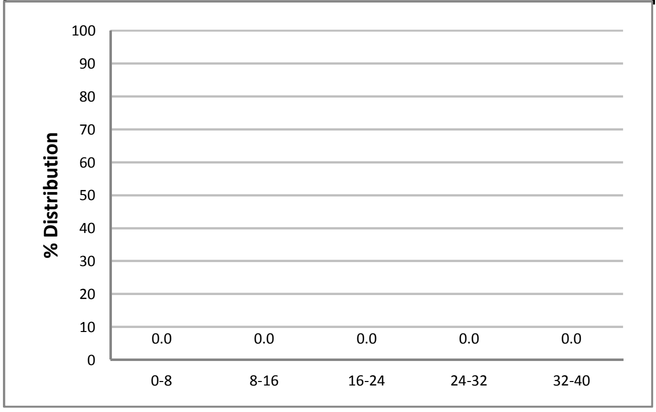
Nf DISTRIBUTION



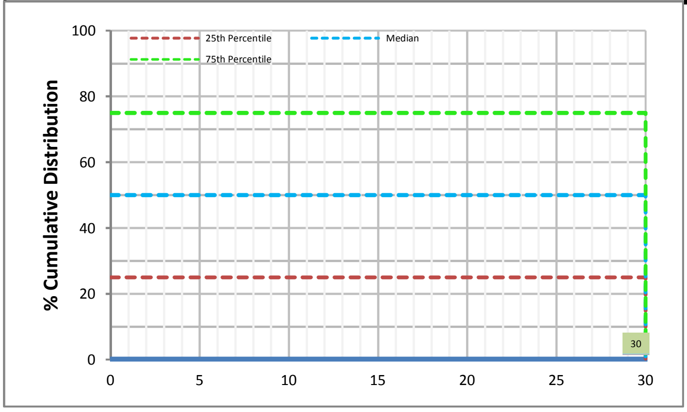
Nf CUMULATIVE DISTRIBUTION



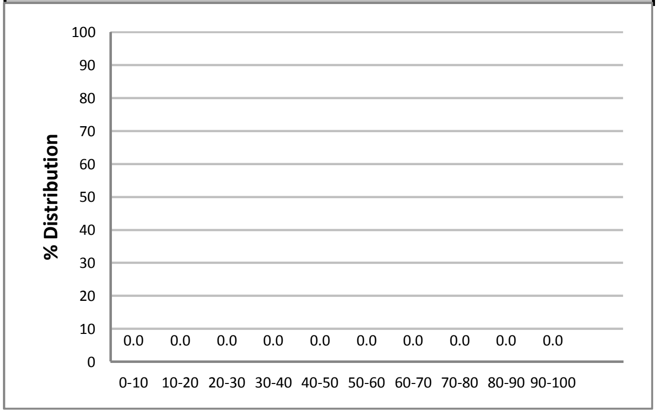
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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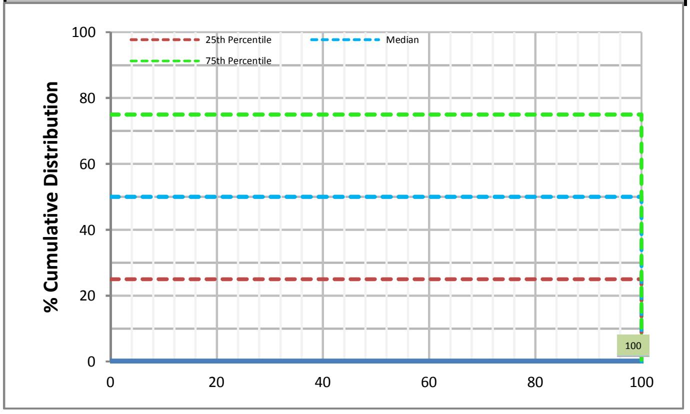
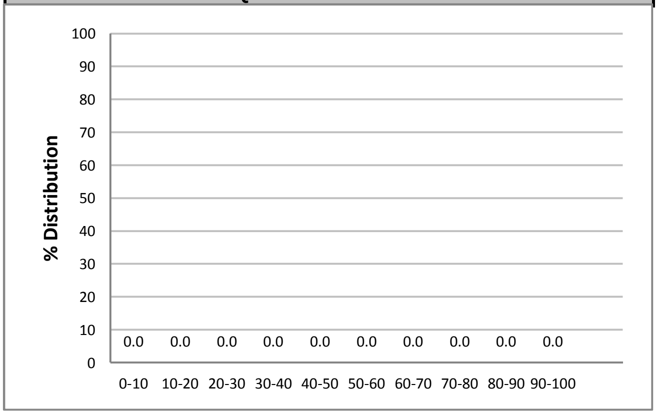


RQD DISTRIBUTION



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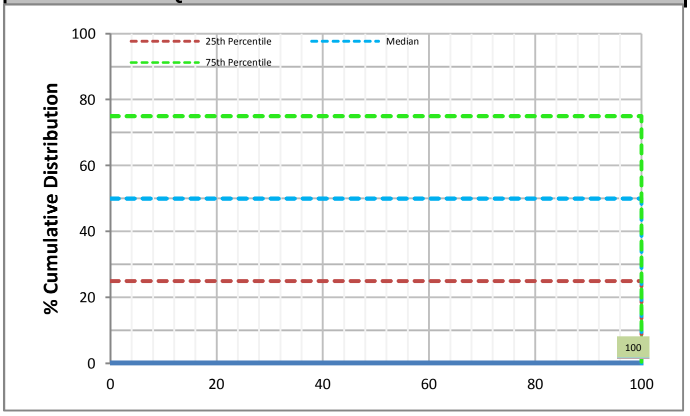
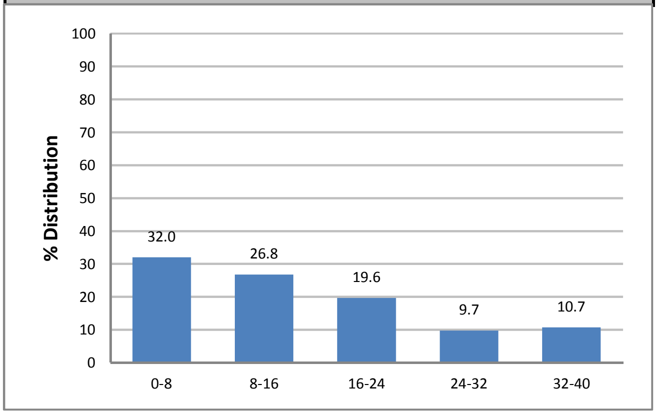


RMR MASS DATA - RMR PARAMETERS

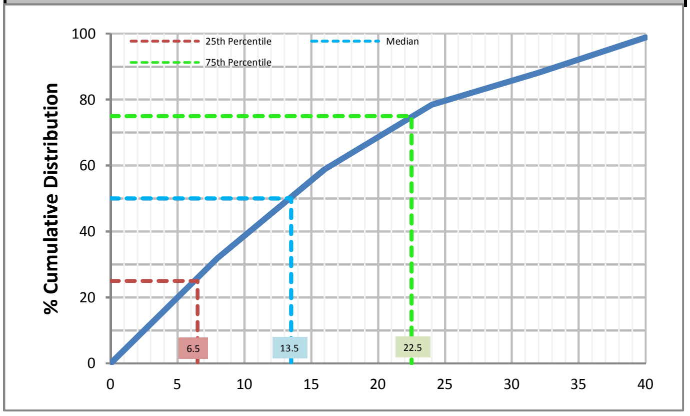
KGH001 - Ajax | Combined Data | Sector 7

Domain: PICR | Meters Logged: 181.65 m

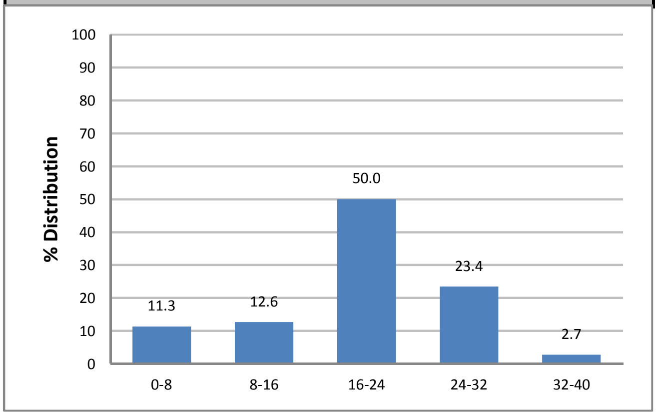
Nf DISTRIBUTION



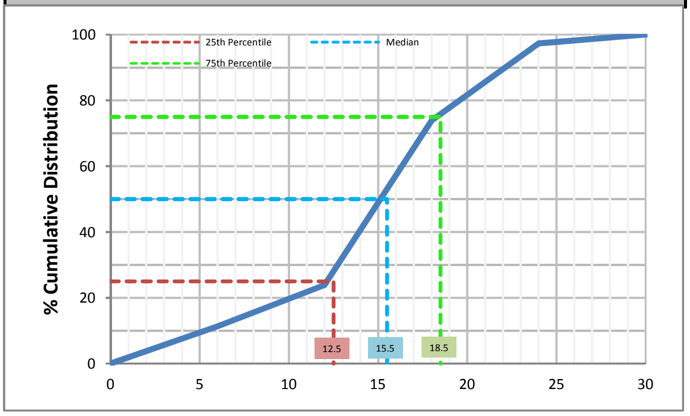
Nf CUMULATIVE DISTRIBUTION



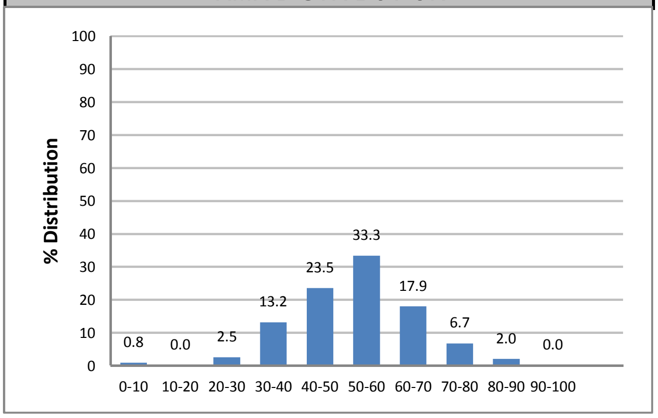
Nc DISTRIBUTION



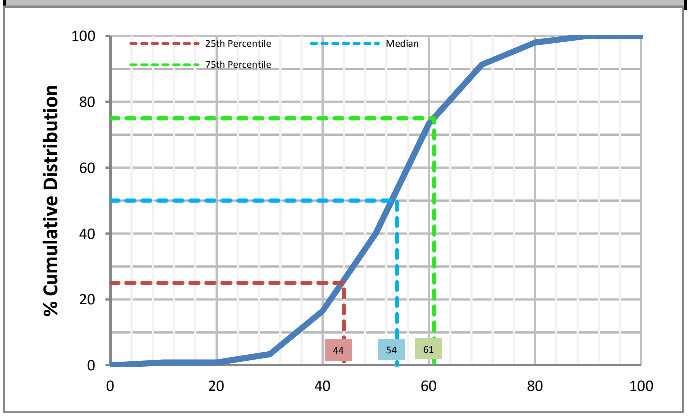
Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



RMR CUMULATIVE DISTRIBUTION



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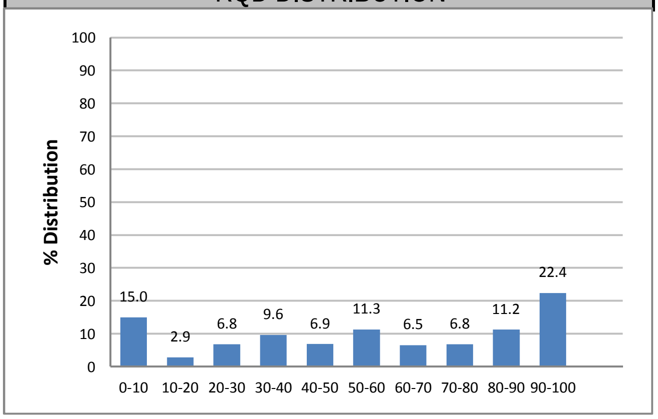

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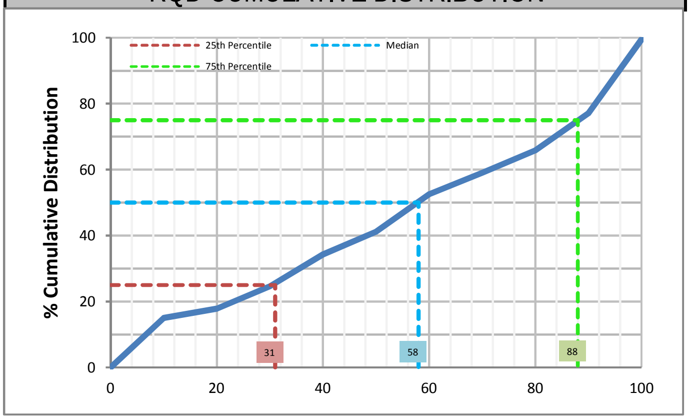
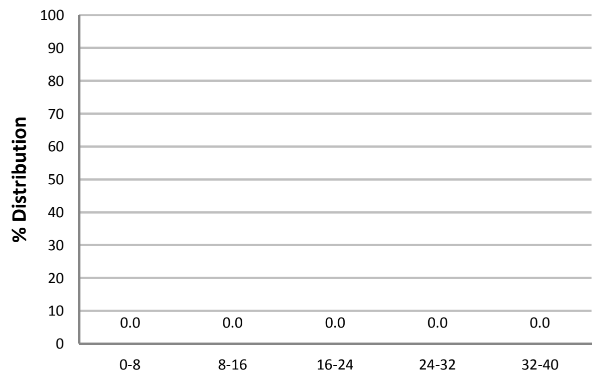


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 7

Domain: PXPP | Meters Logged: 0 m

Nf DISTRIBUTION



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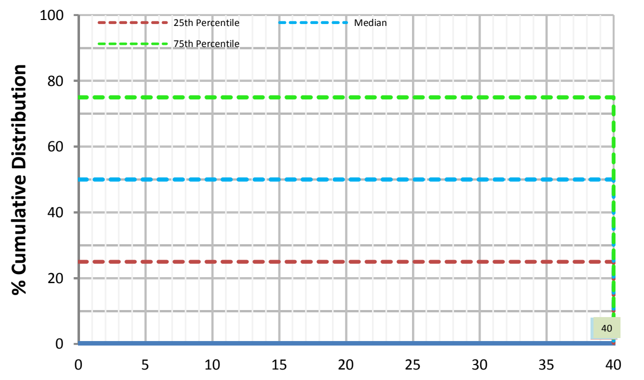
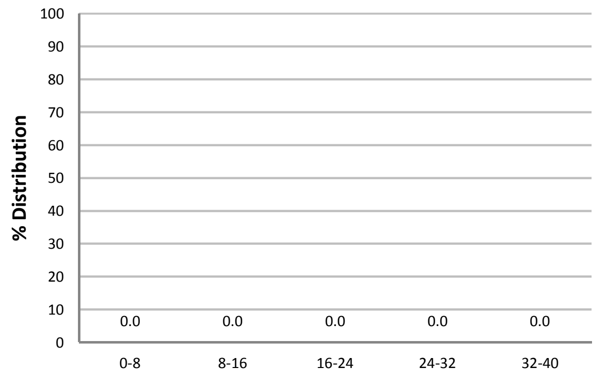
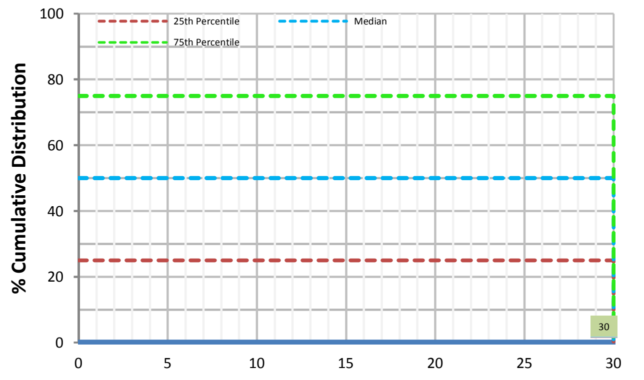


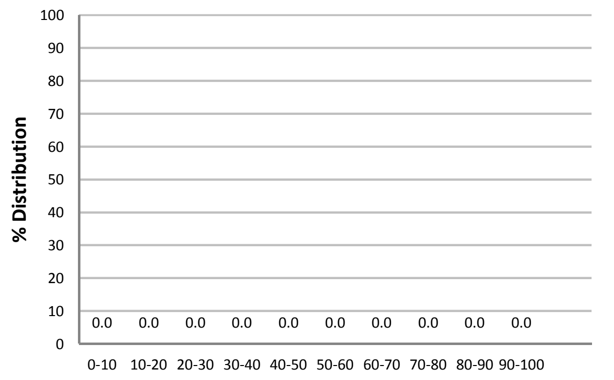
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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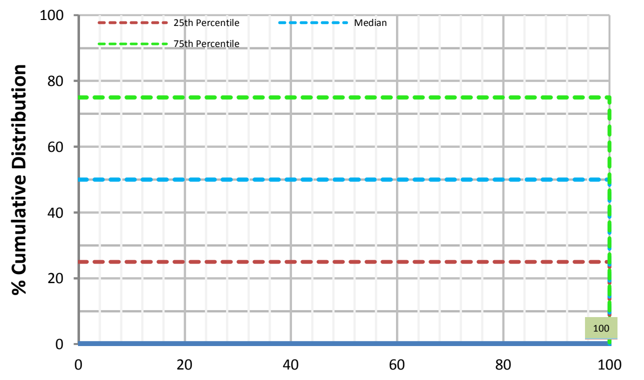

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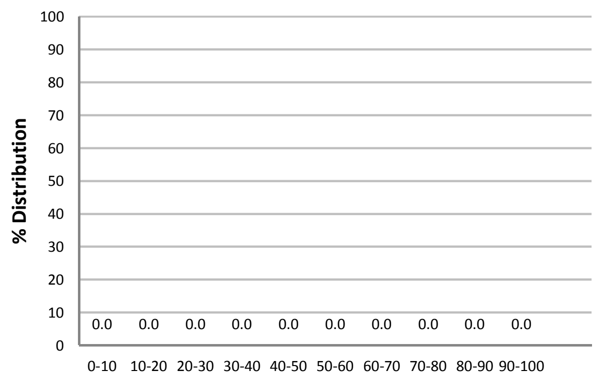

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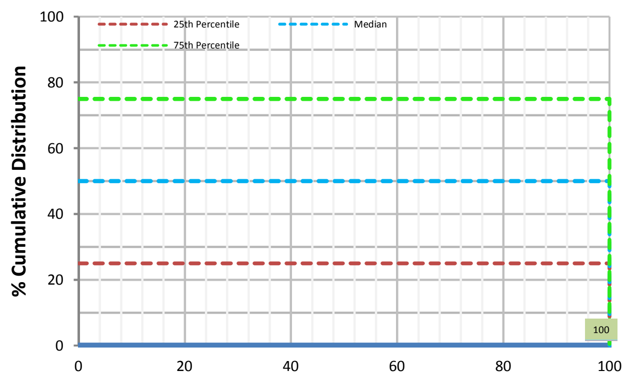
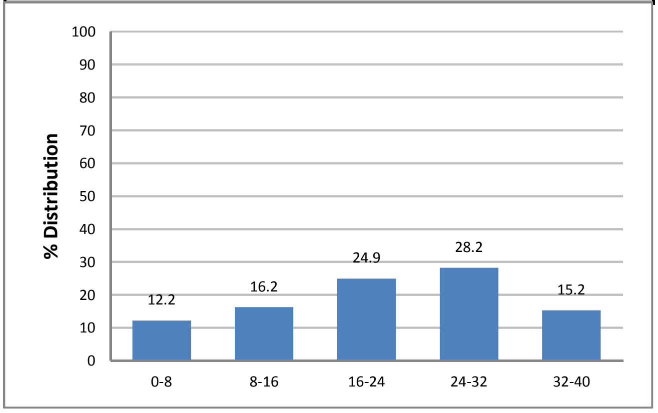


RMR MASS DATA - RMR PARAMETERS

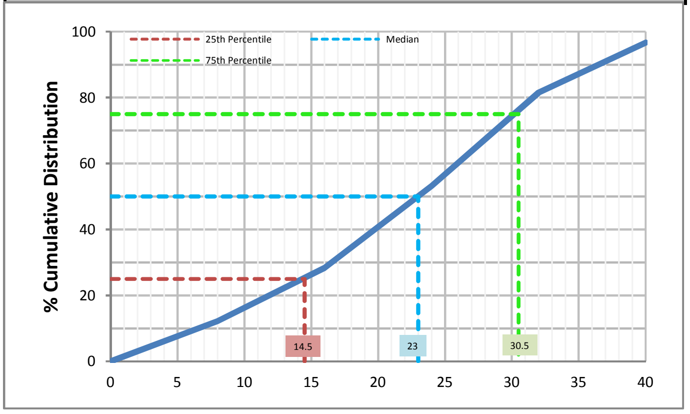
KGH001 - Ajax | Combined Data | Sector 7

Domain: SLD | Meters Logged: 525.43 m

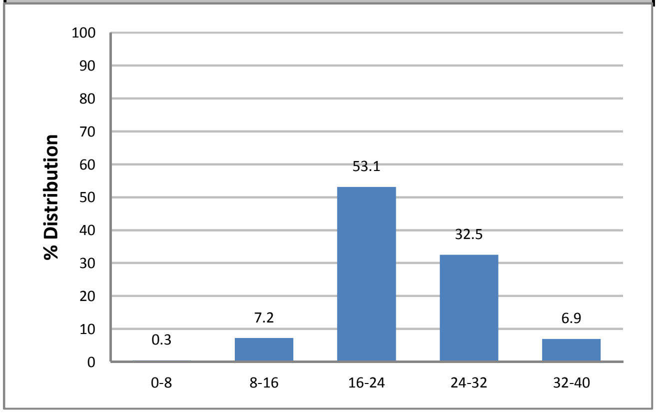
Nf DISTRIBUTION



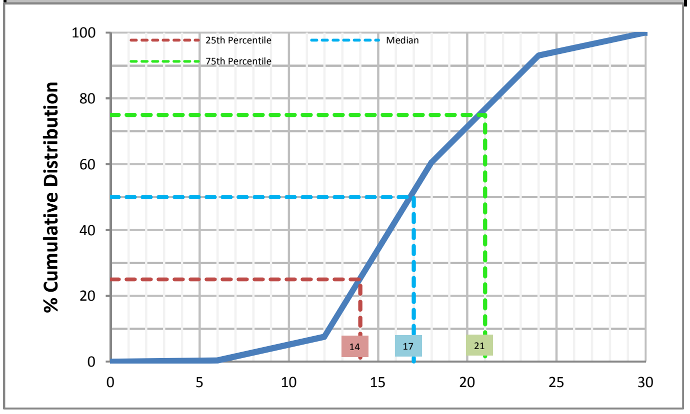
Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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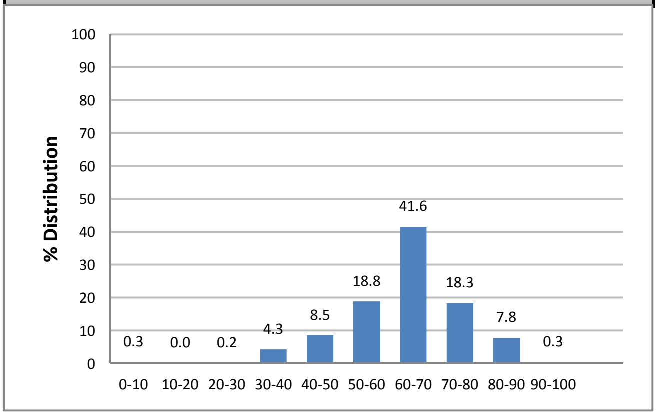

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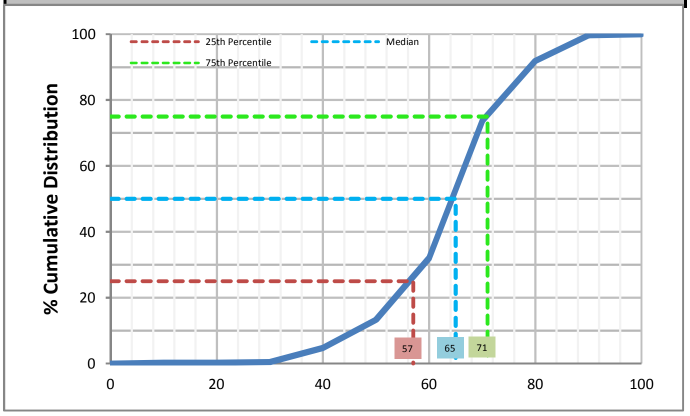
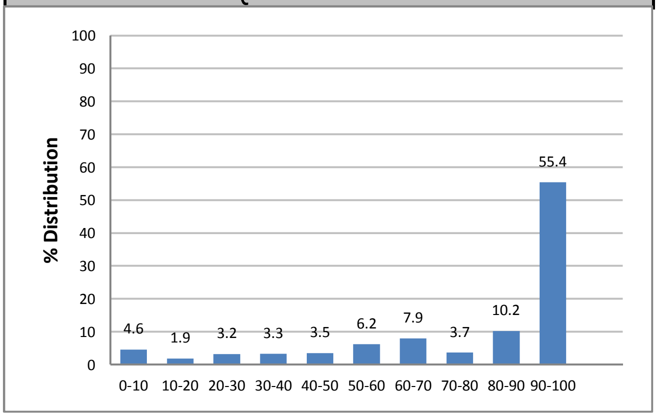


RQD DISTRIBUTION



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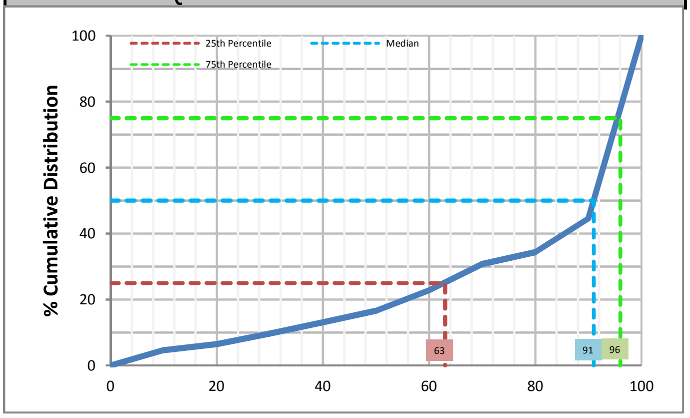
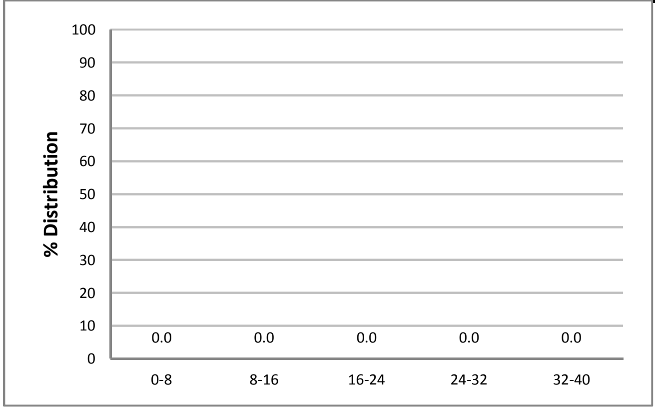


RMR MASS DATA - RMR PARAMETERS

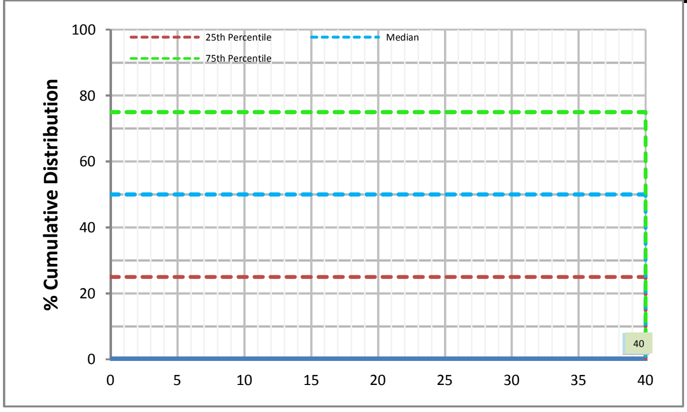
KGH001 - Ajax | Combined Data | Sector 7

Domain: SVHYB | Meters Logged: 0 m

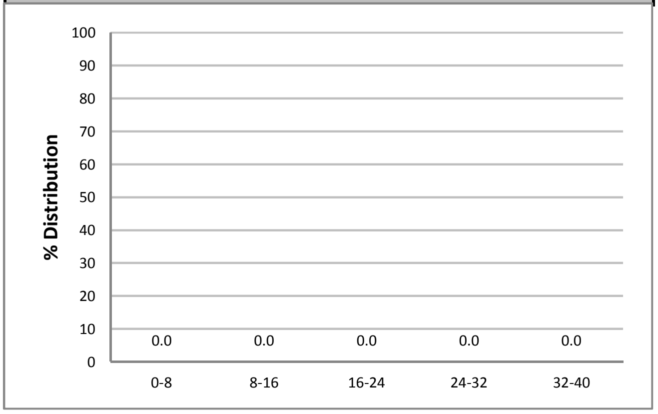
Nf DISTRIBUTION



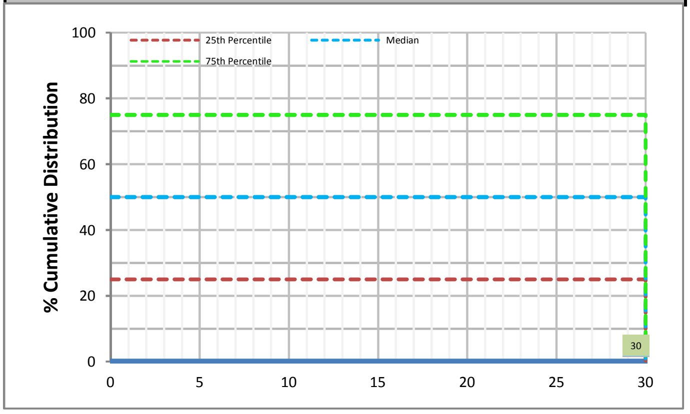
Nf CUMULATIVE DISTRIBUTION



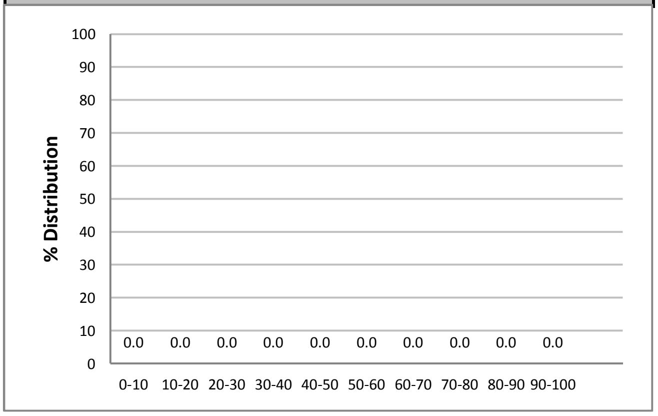
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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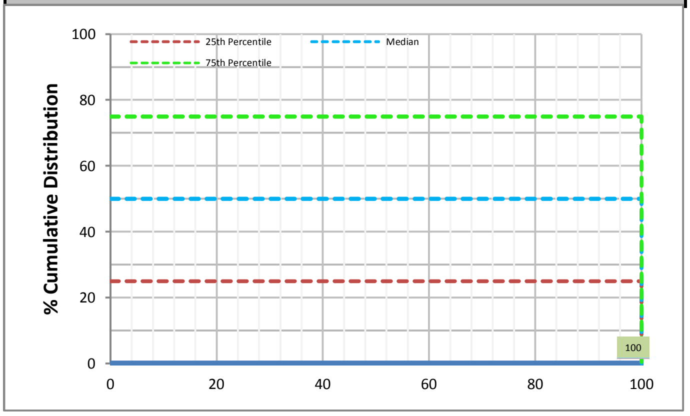

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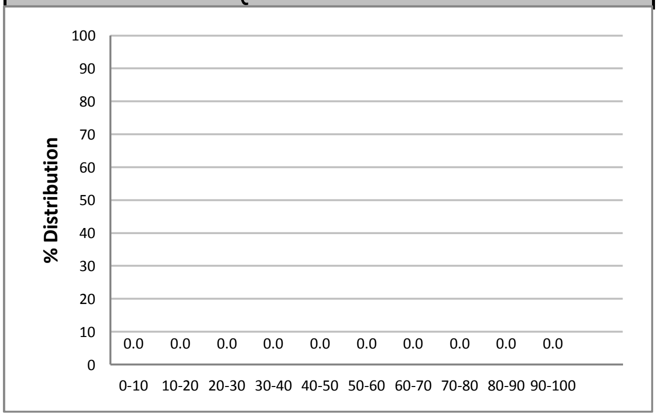
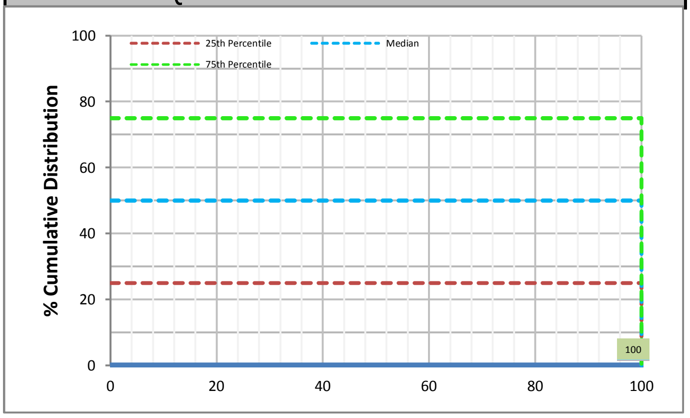


RQD CUMULATIVE DISTRIBUTION

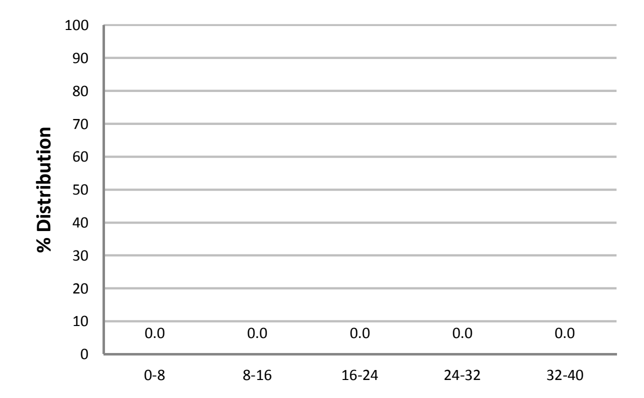


RMR MASS DATA - RMR PARAMETERS

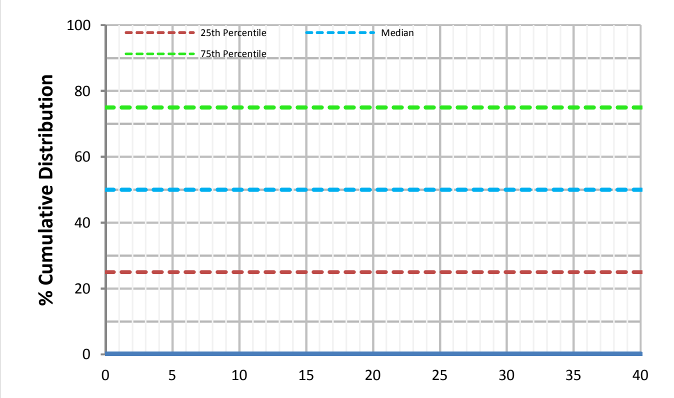
KGH001 - Ajax | Combined Data | Sector 8

Domain: IMH | Meters Logged: 0 m

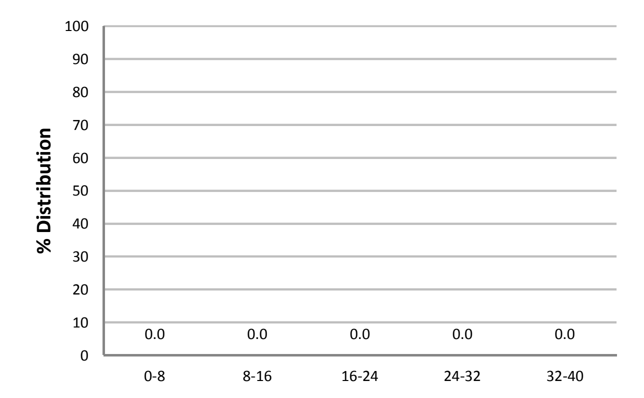
Nf DISTRIBUTION



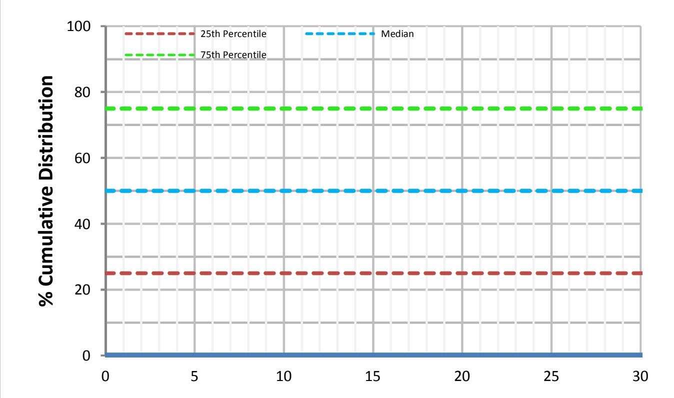
Nf CUMULATIVE DISTRIBUTION



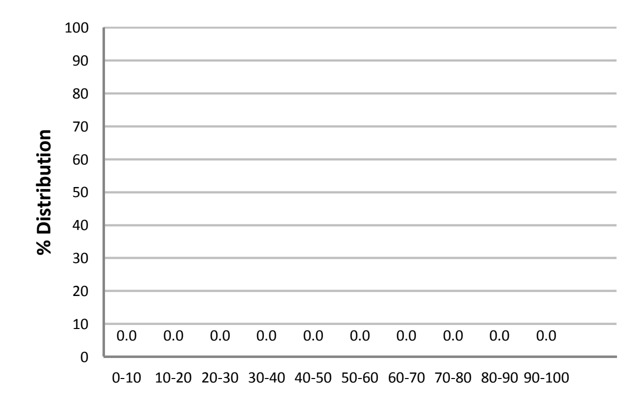
Nc DISTRIBUTION



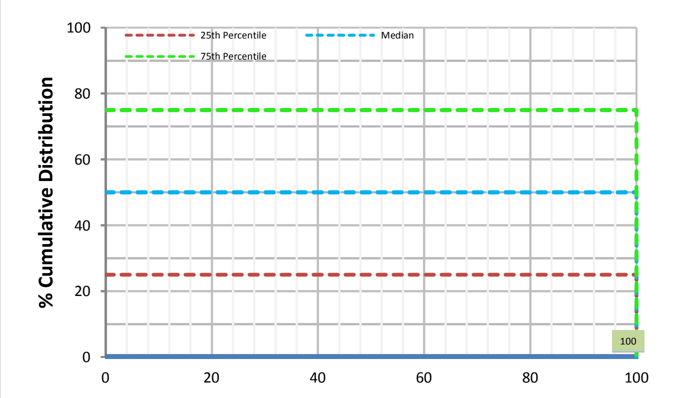
Nc CUMULATIVE DISTRIBUTION



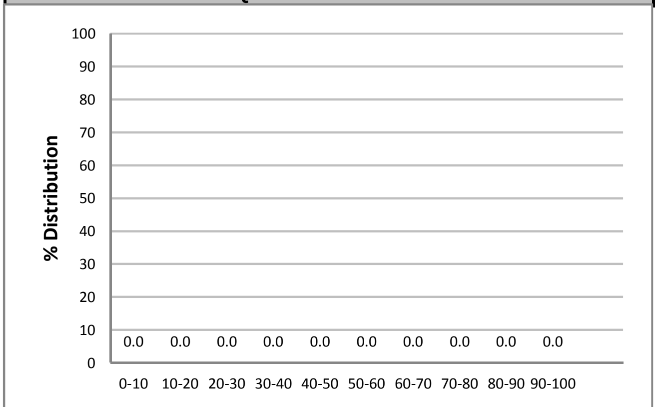
RMR DISTRIBUTION



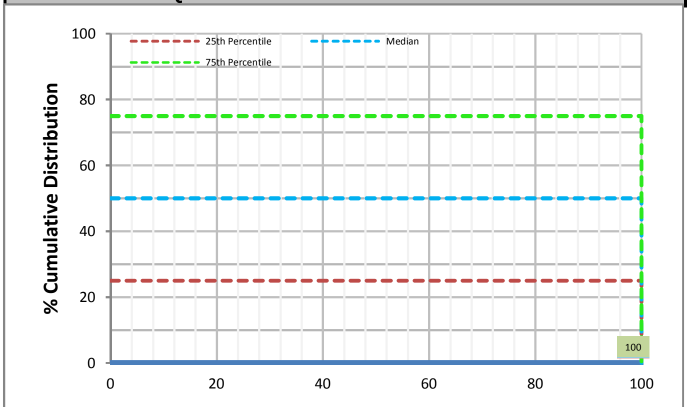
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

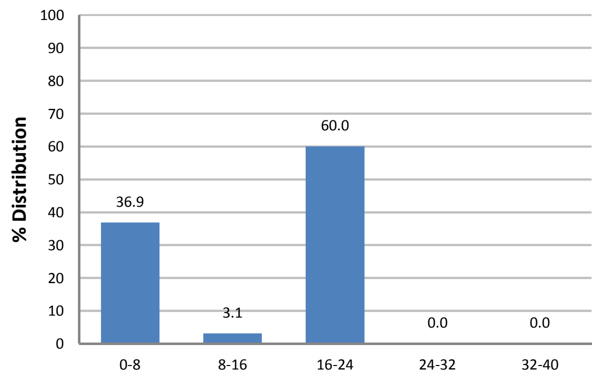


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector 8

Domain: LAT | Meters Logged: 15.24 m

Nf DISTRIBUTION



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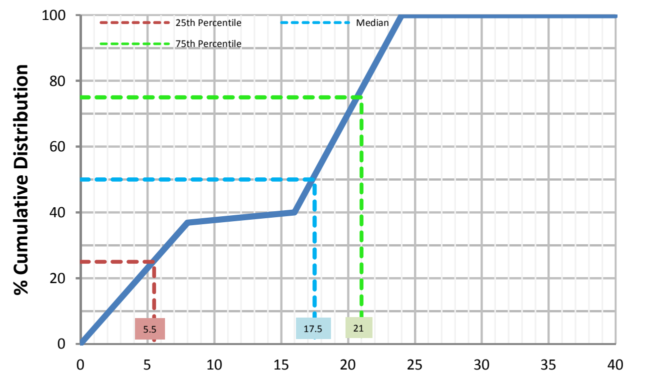
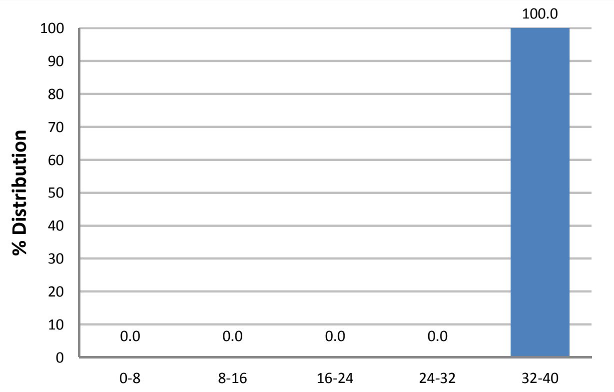
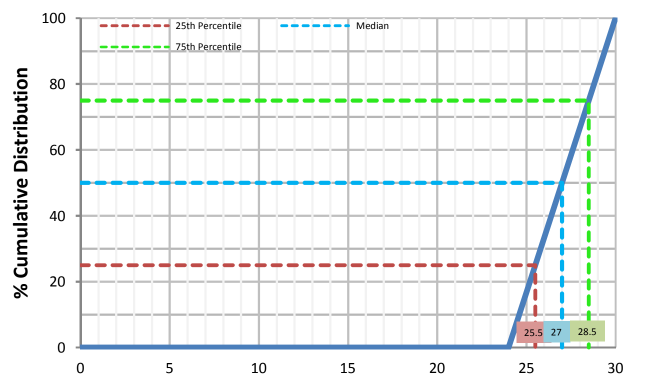


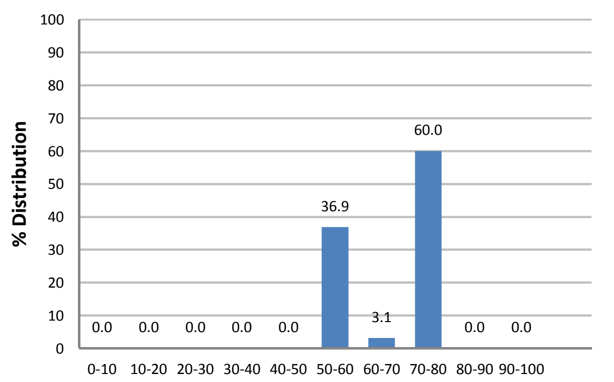
Nc DISTRIBUTION



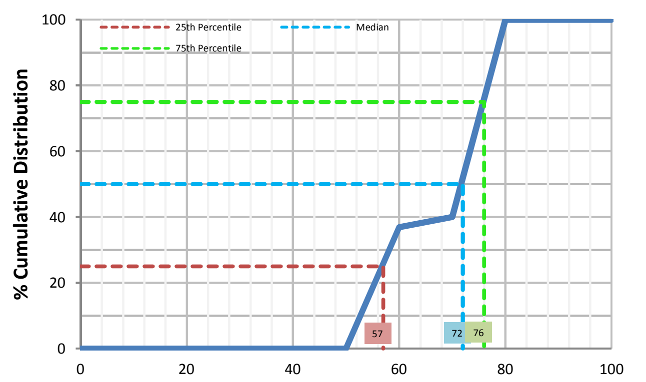
Nc CUMULATIVE DISTRIBUTION



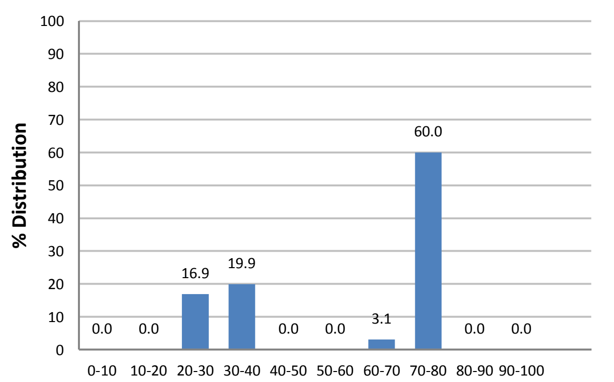
RMR DISTRIBUTION



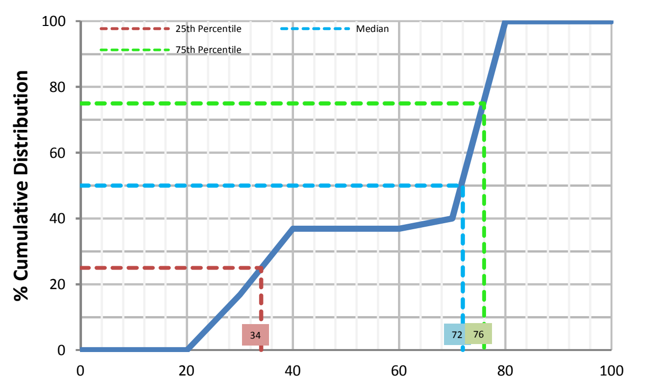
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

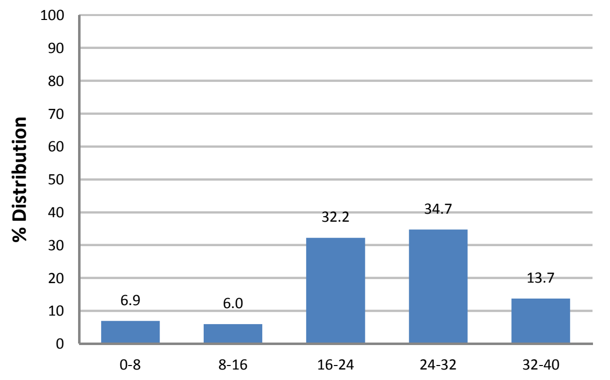


RMR MASS DATA - RMR PARAMETERS

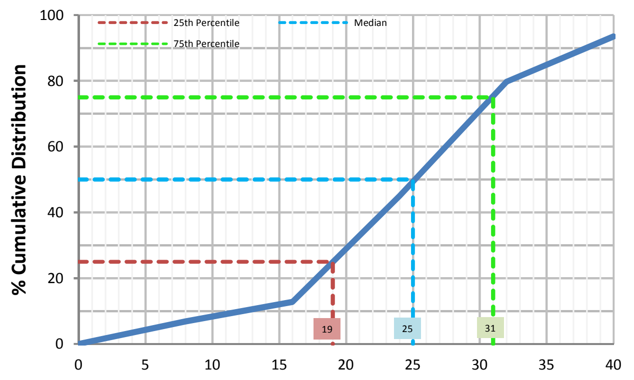
KGH001 - Ajax | Combined Data | Sector 8

Domain: MAFV | Meters Logged: 160.13 m

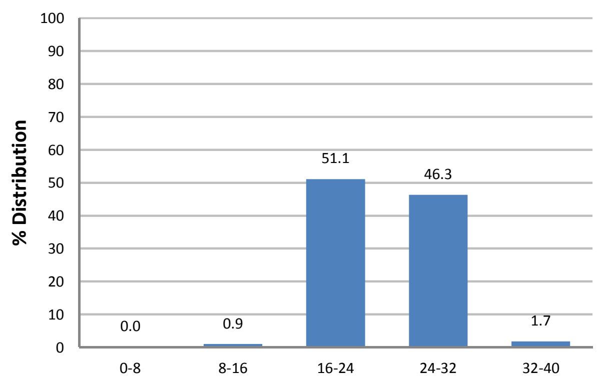
Nf DISTRIBUTION



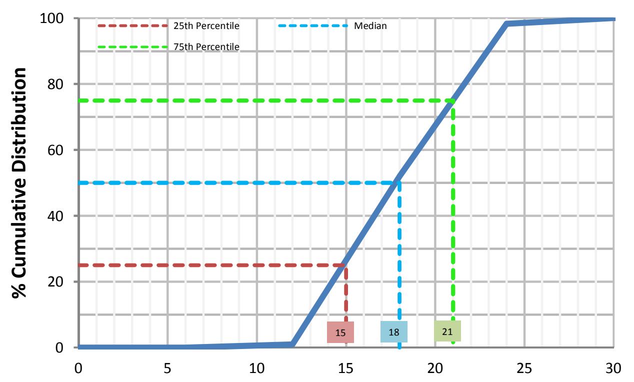
Nf CUMULATIVE DISTRIBUTION



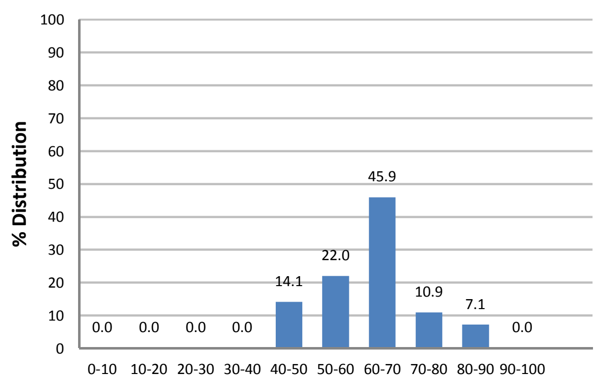
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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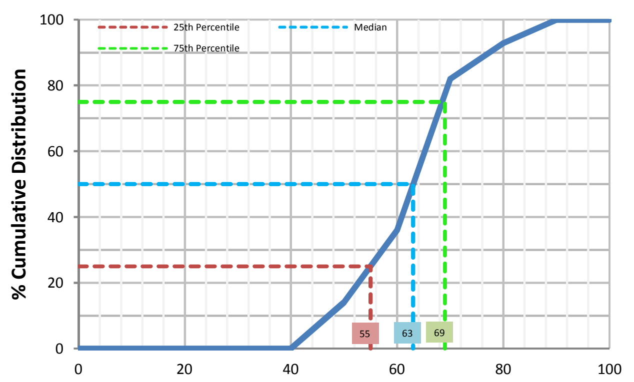
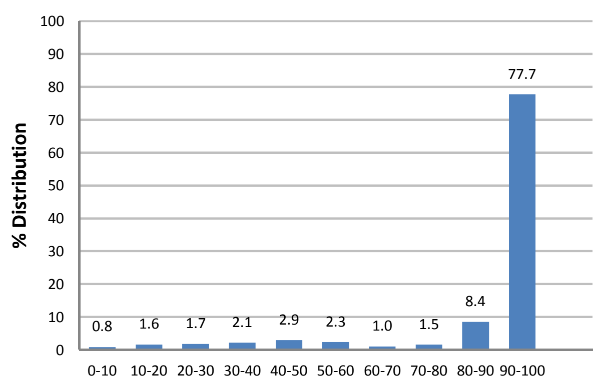
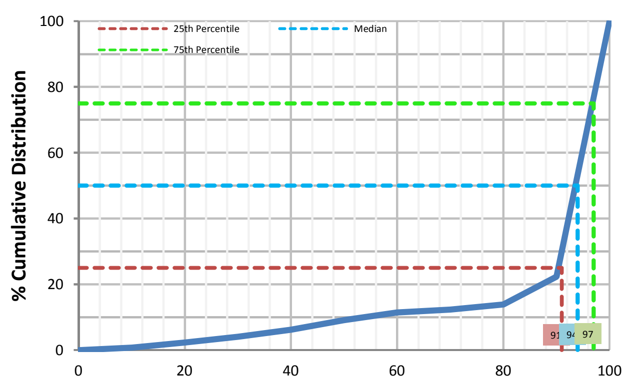


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

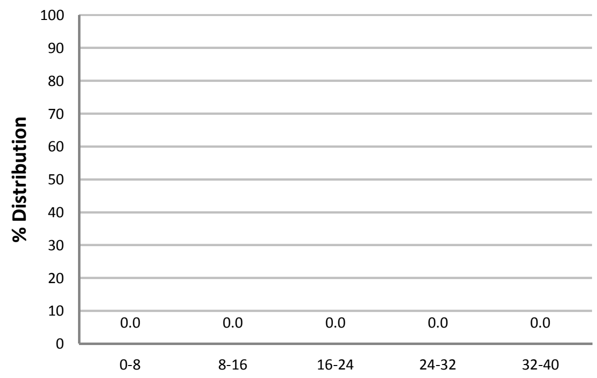


RMR MASS DATA - RMR PARAMETERS

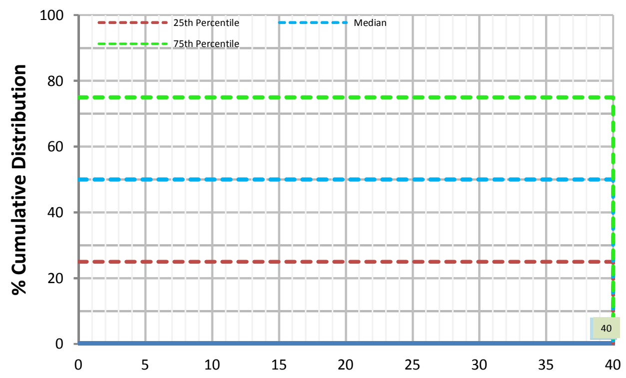
KGH001 - Ajax | Combined Data | Sector 8

Domain: MONZ | Meters Logged: 0 m

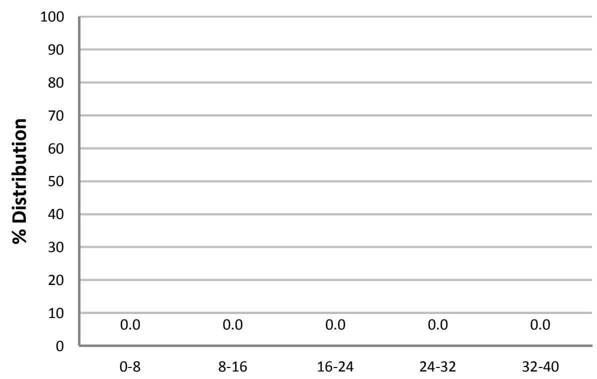
Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



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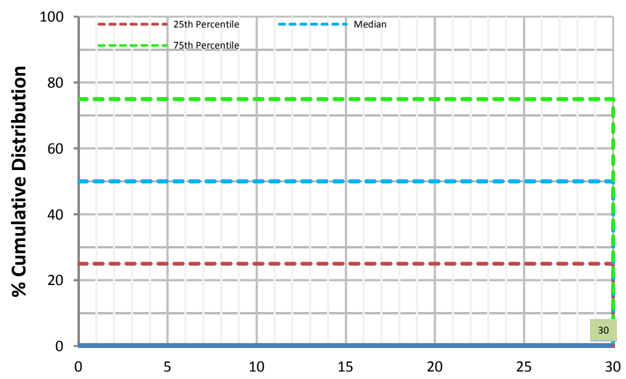

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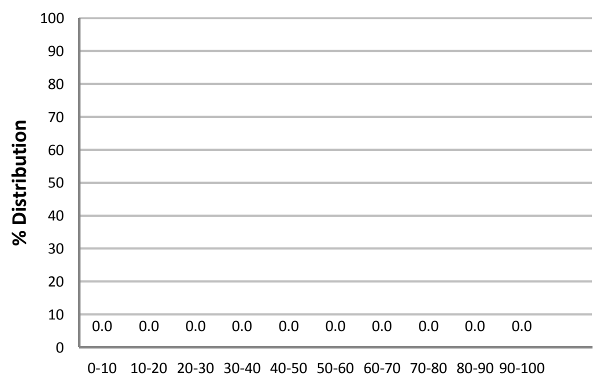

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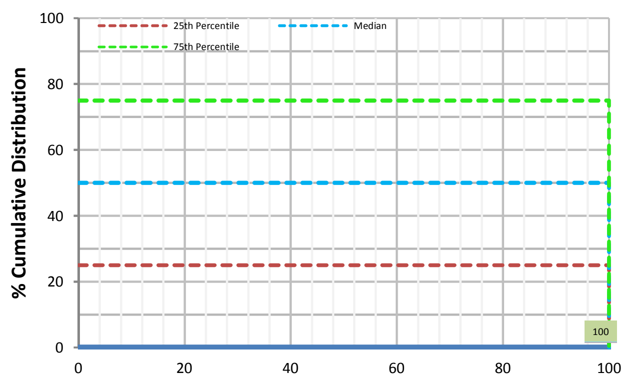
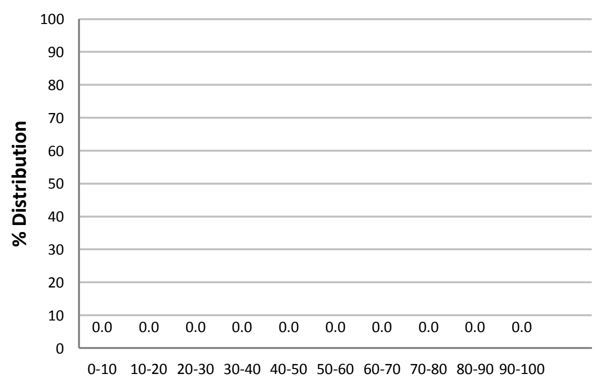
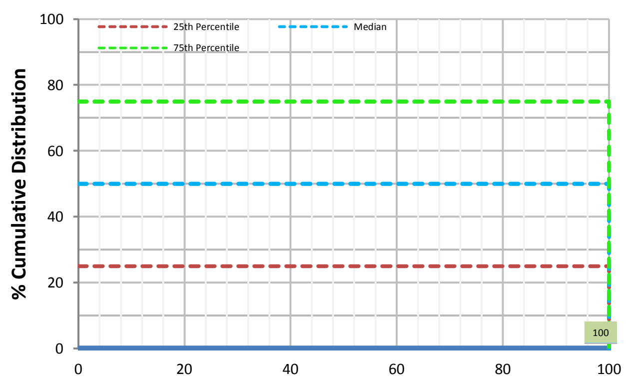


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

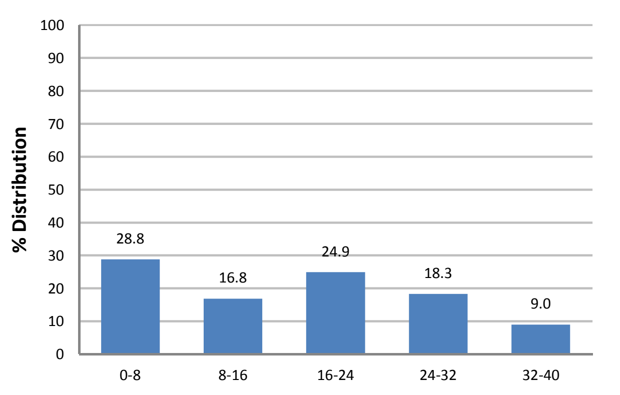


RMR MASS DATA - RMR PARAMETERS

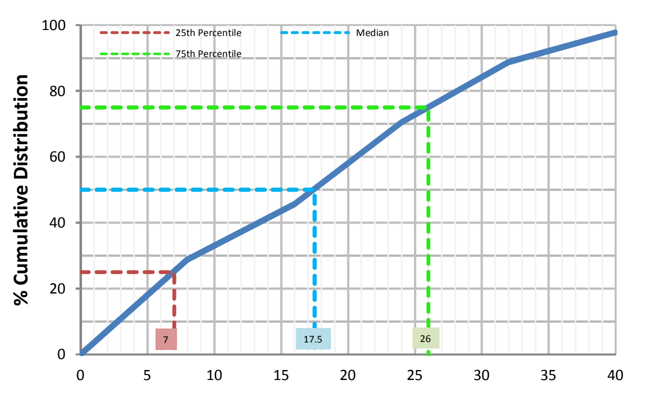
KGH001 - Ajax | Combined Data | Sector 8

Domain: PICR | Meters Logged: 922.74 m

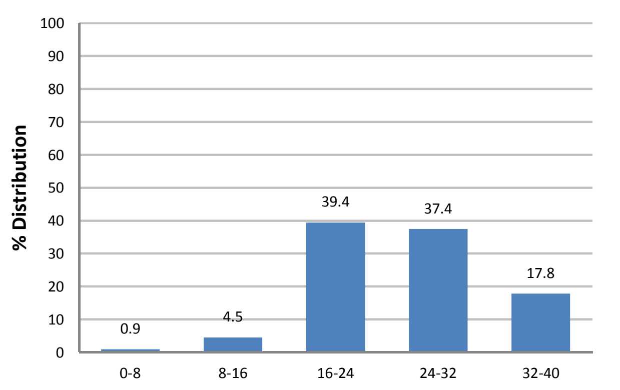
Nf DISTRIBUTION



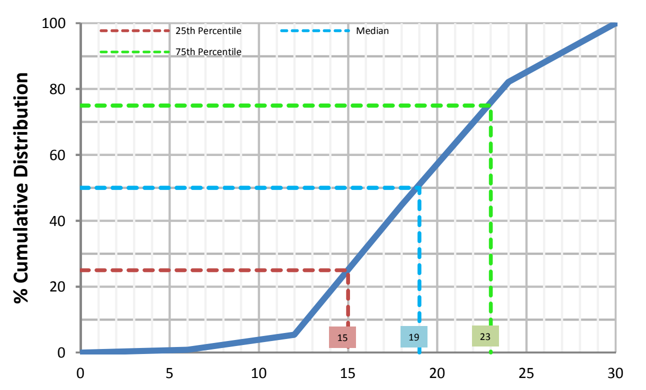
Nf CUMULATIVE DISTRIBUTION



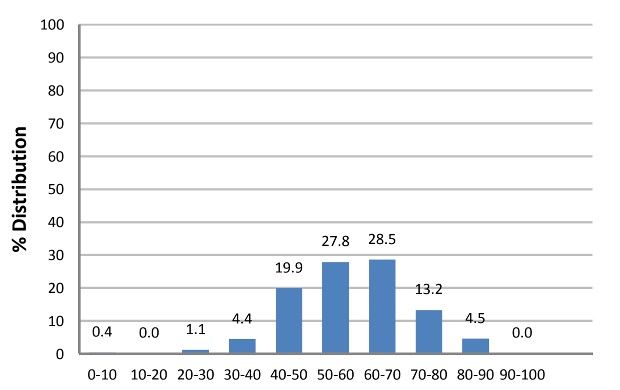
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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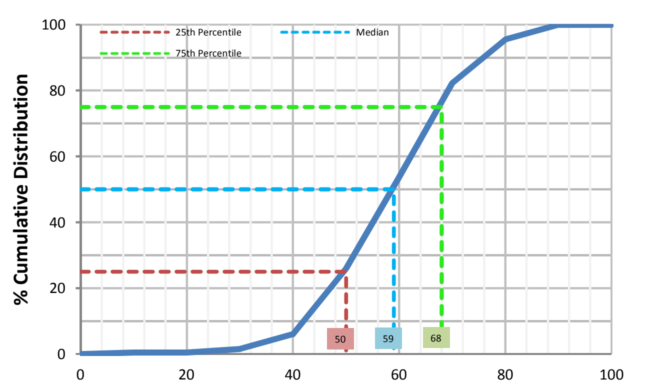
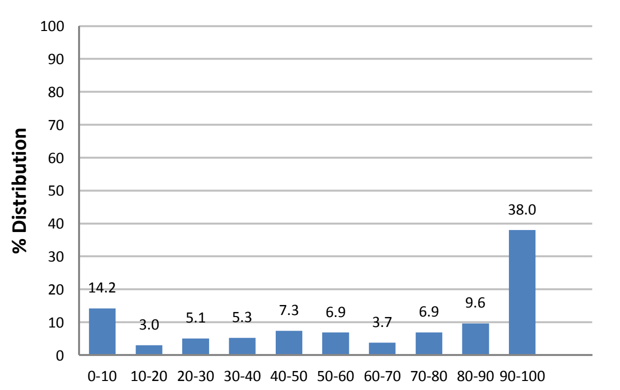


RQD DISTRIBUTION



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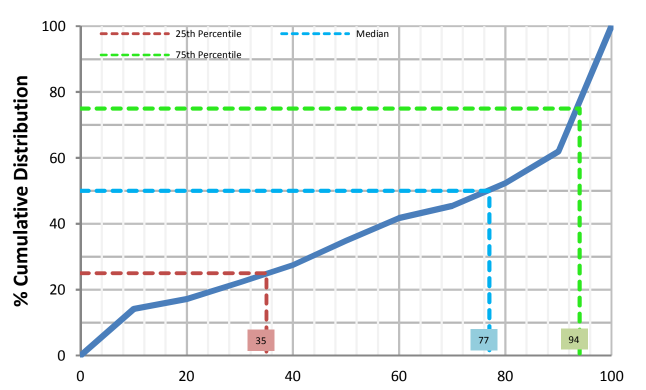
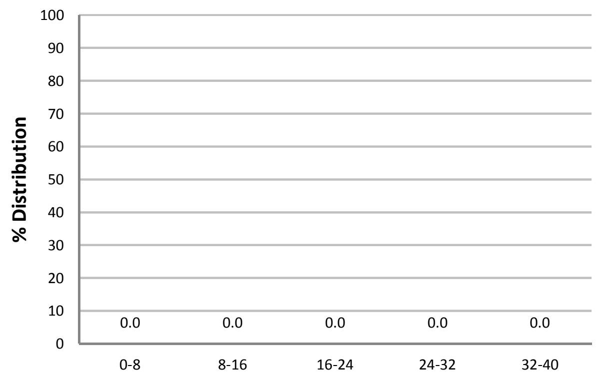


RMR MASS DATA - RMR PARAMETERS

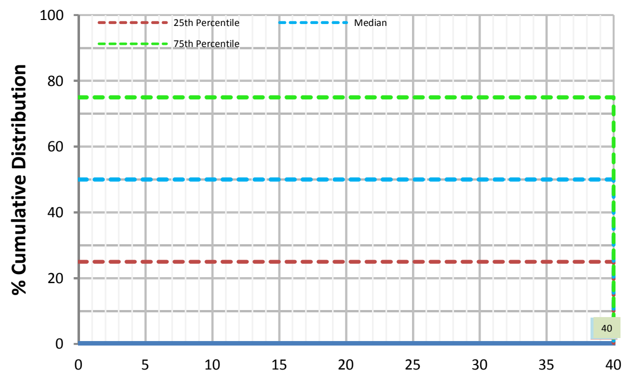
KGH001 - Ajax | Combined Data | Sector 8

Domain: PXPP | Meters Logged: 0 m

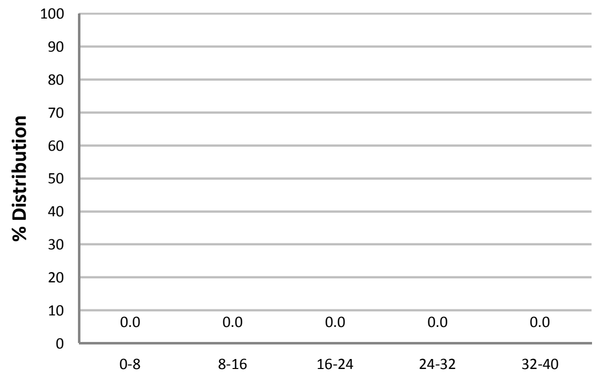
Nf DISTRIBUTION



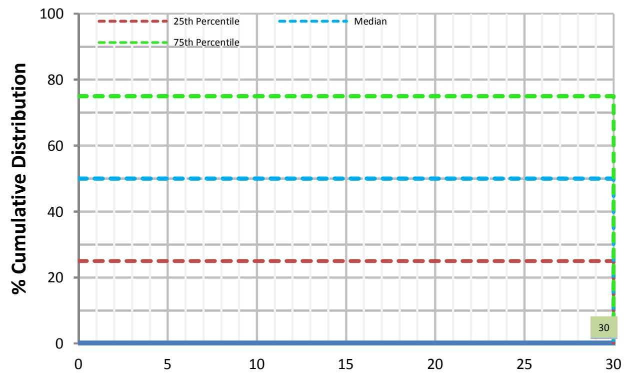
Nf CUMULATIVE DISTRIBUTION



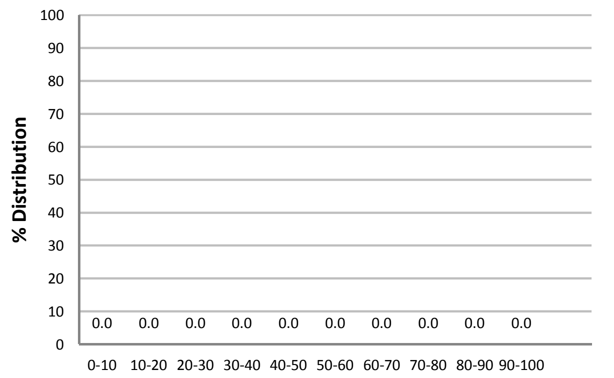
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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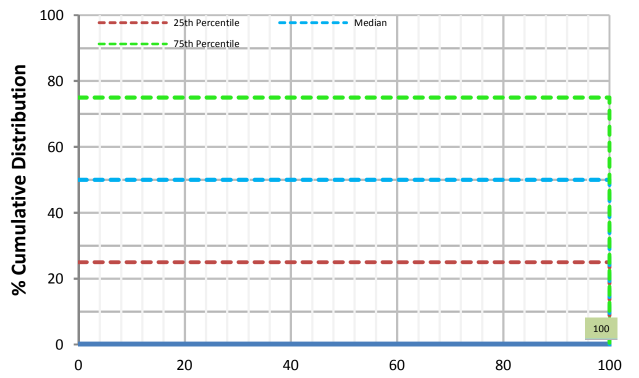
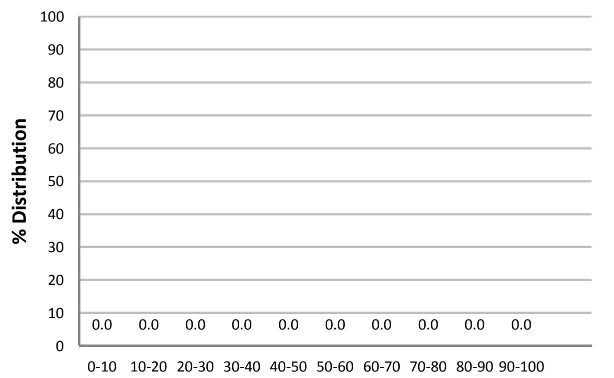


RQD DISTRIBUTION



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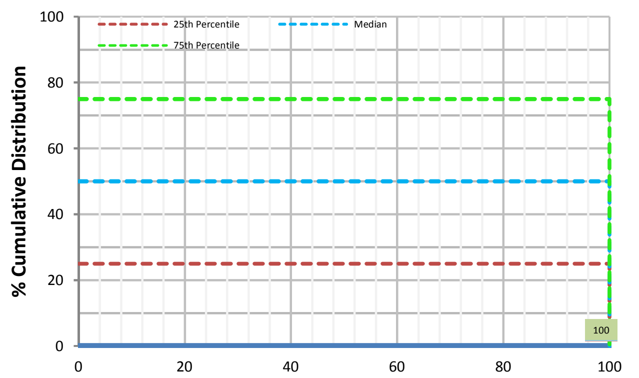
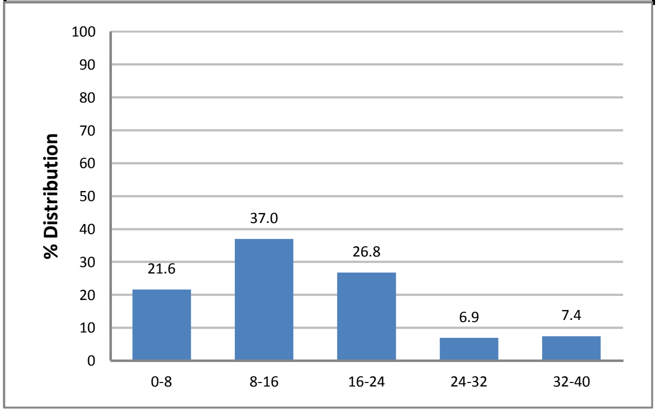


RMR MASS DATA - RMR PARAMETERS

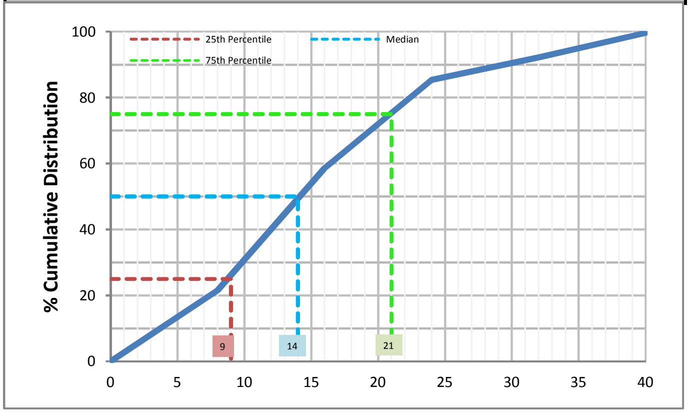
KGH001 - Ajax | Combined Data | Sector 8

Domain: SLD | Meters Logged: 202.4 m

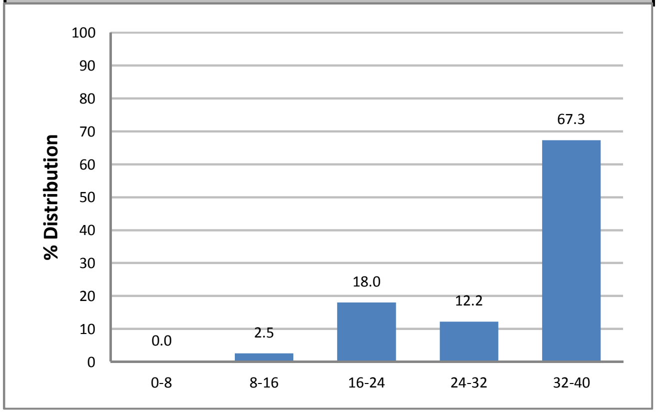
Nf DISTRIBUTION



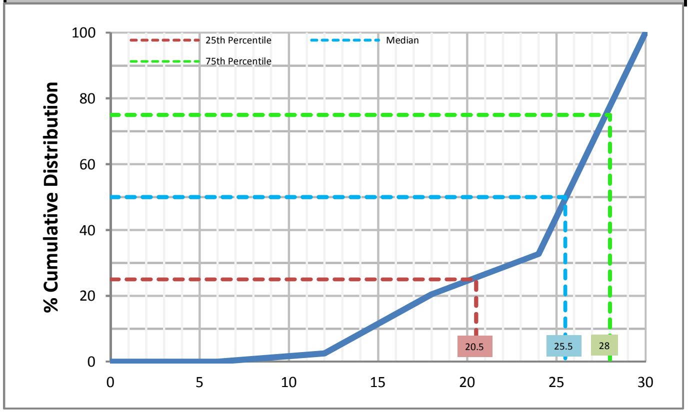
Nf CUMULATIVE DISTRIBUTION



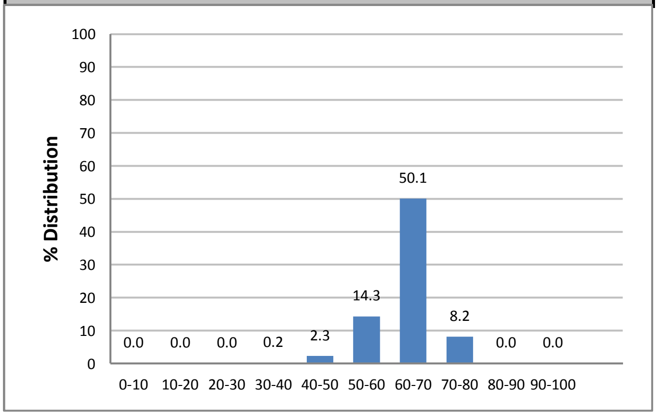
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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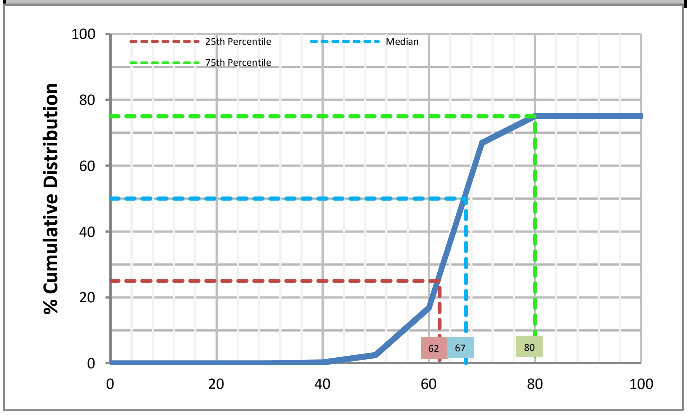
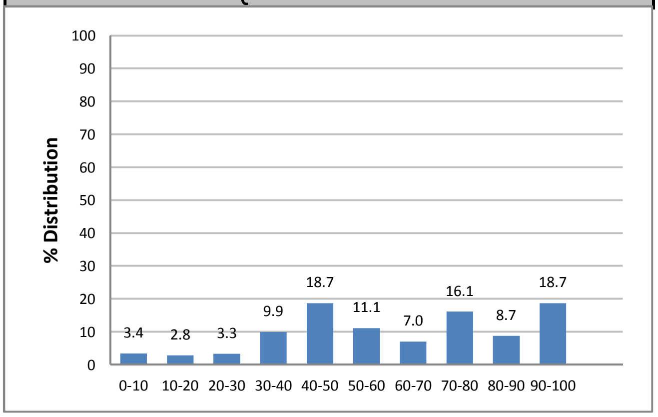


RQD DISTRIBUTION



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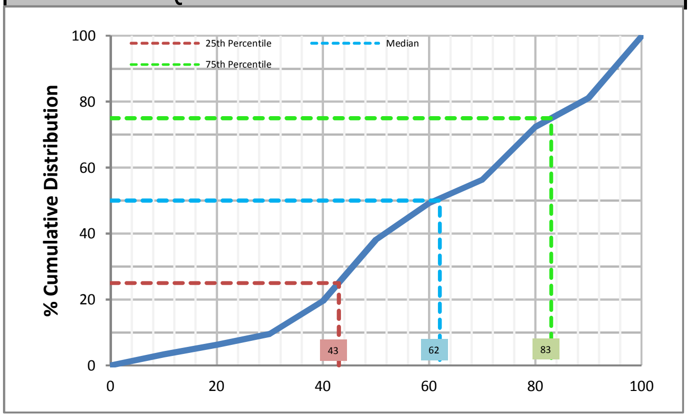
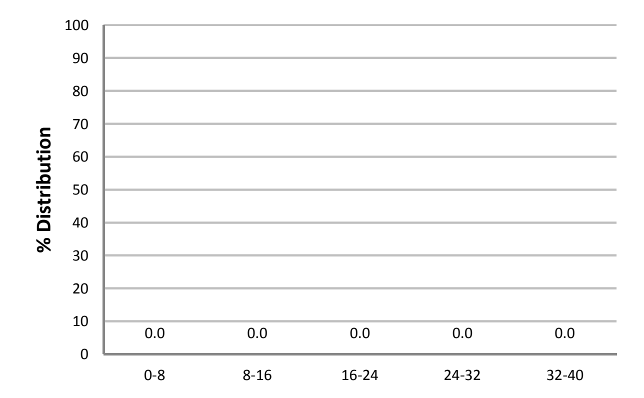


RMR MASS DATA - RMR PARAMETERS

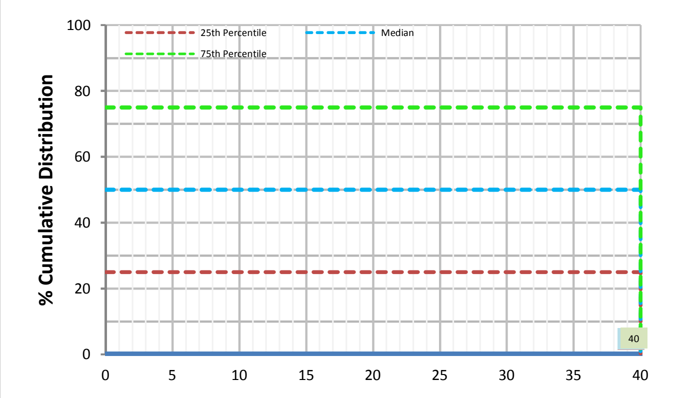
KGH001 - Ajax | Combined Data | Sector 8

Domain: SVHYB | Meters Logged: 0 m

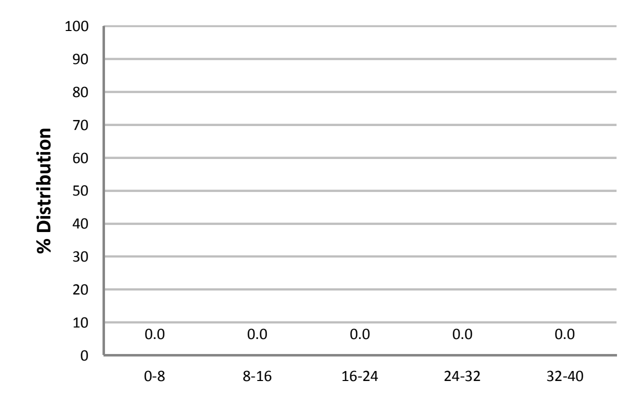
Nf DISTRIBUTION



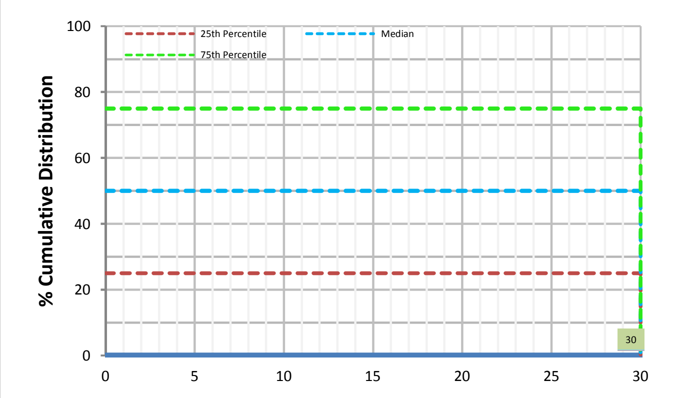
Nf CUMULATIVE DISTRIBUTION



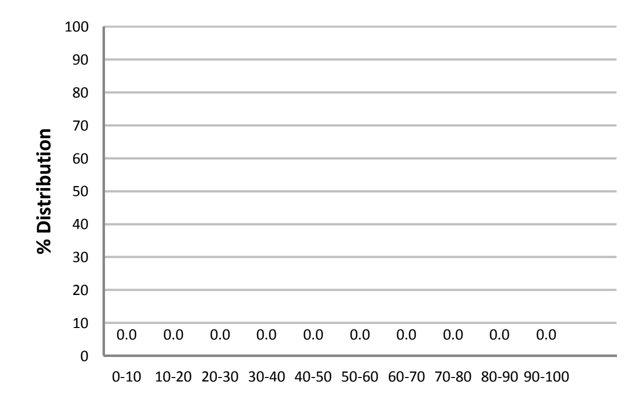
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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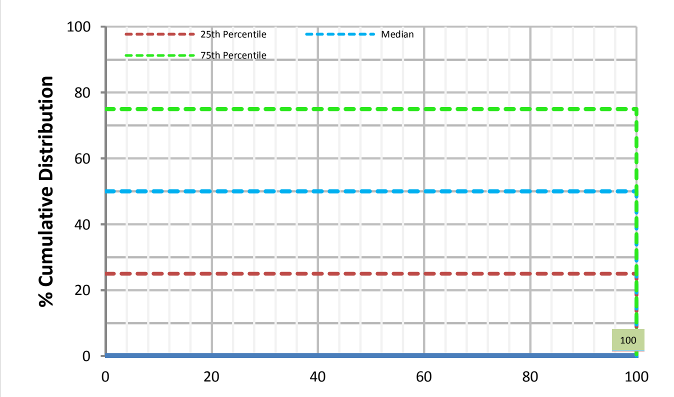
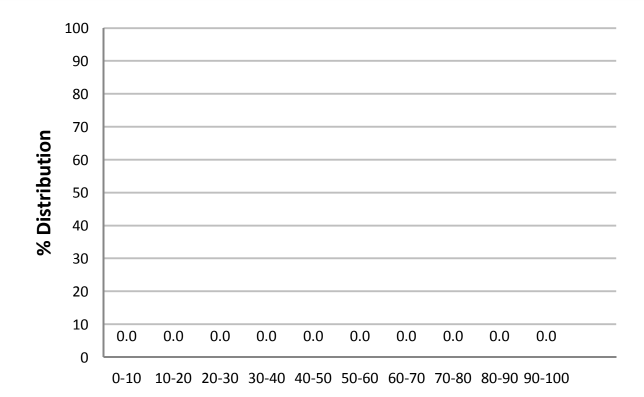


RQD DISTRIBUTION



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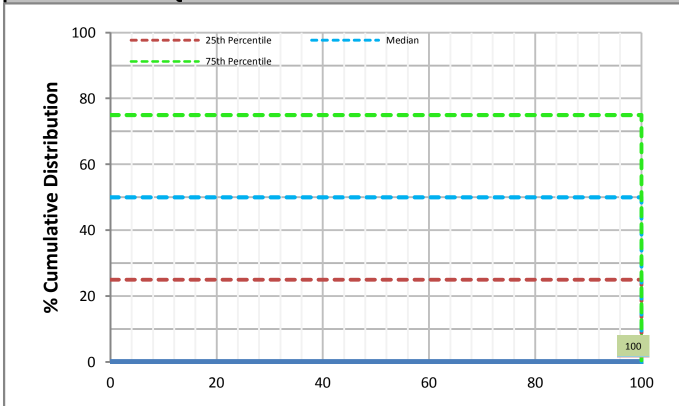
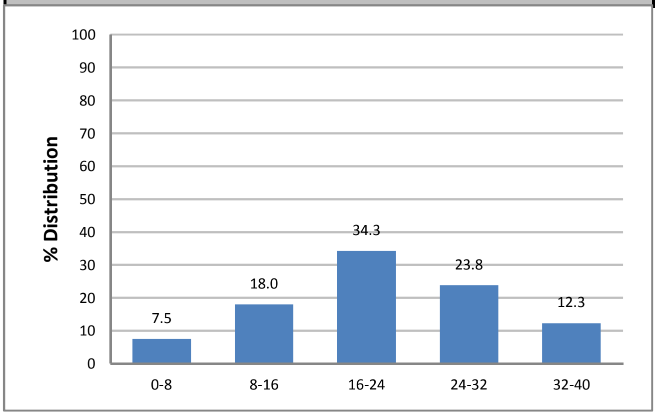


RMR MASS DATA - RMR PARAMETERS

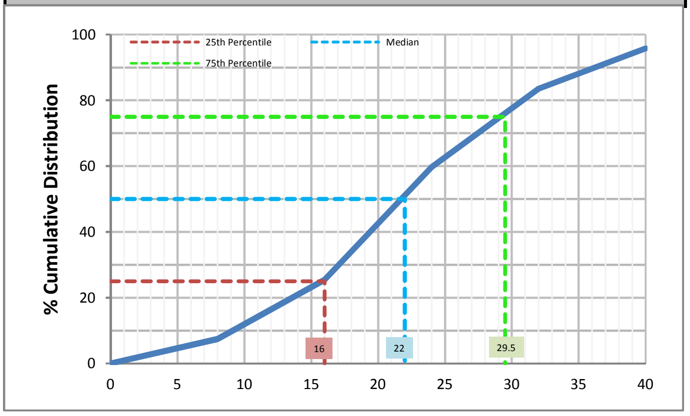
KGH001 - Ajax | Combined Data | Sector: ALL

Domain: IMH | Meters Logged: 3754.11 m

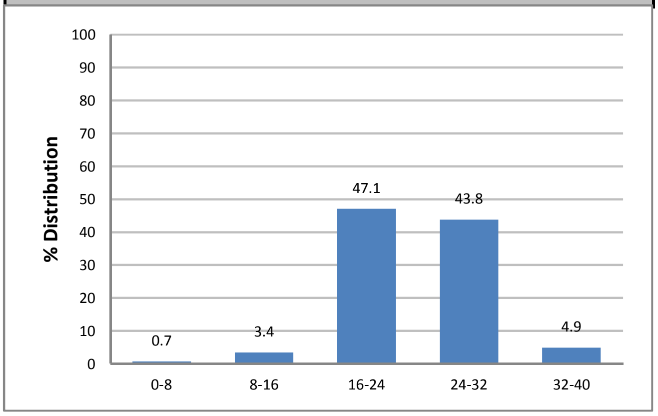
Nf DISTRIBUTION



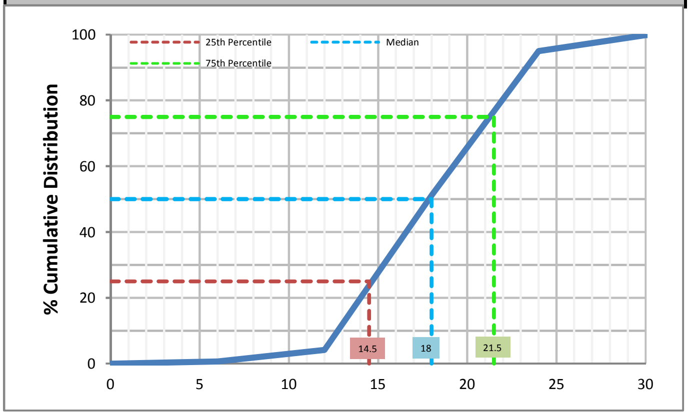
Nf CUMULATIVE DISTRIBUTION



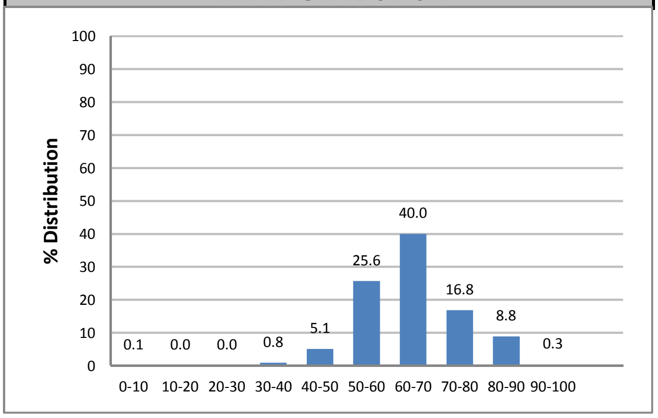
Nc DISTRIBUTION



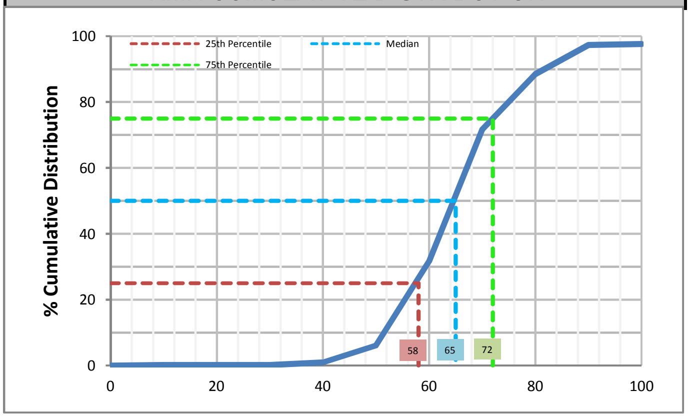
Nc CUMULATIVE DISTRIBUTION



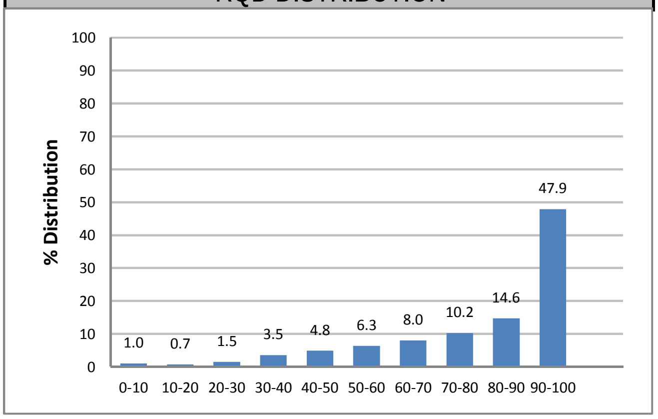
RMR DISTRIBUTION



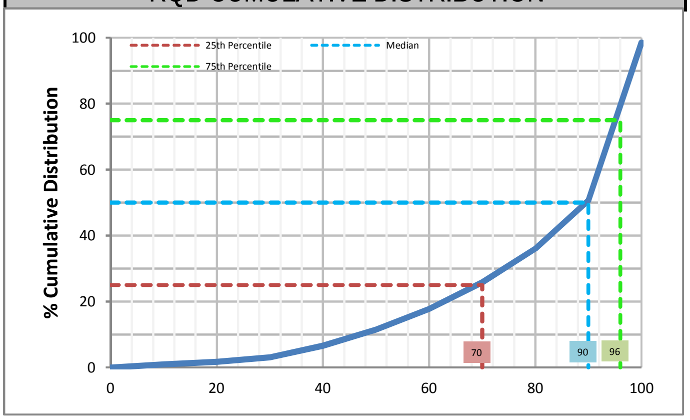
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

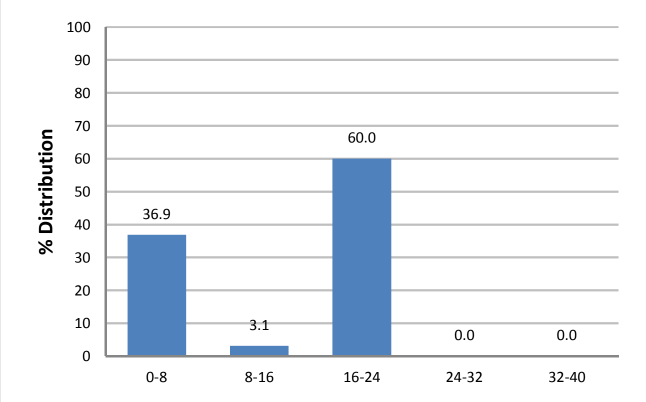


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector: ALL

Domain: LAT | Meters Logged: 15.24 m

Nf DISTRIBUTION



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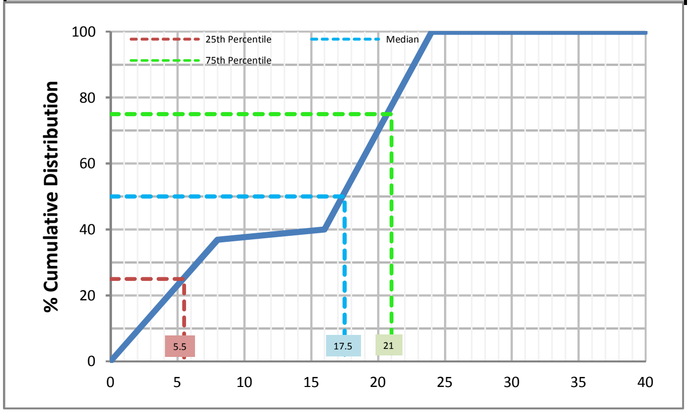
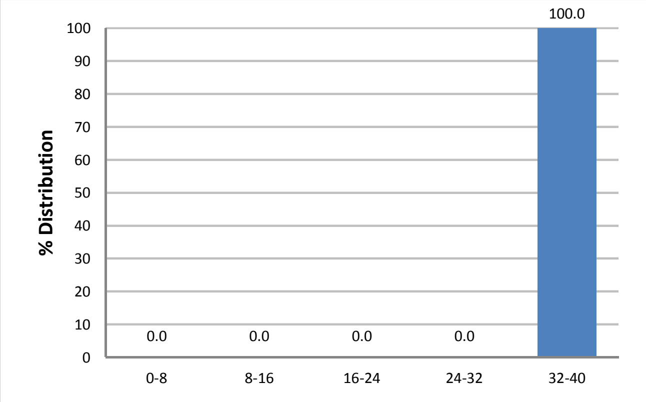
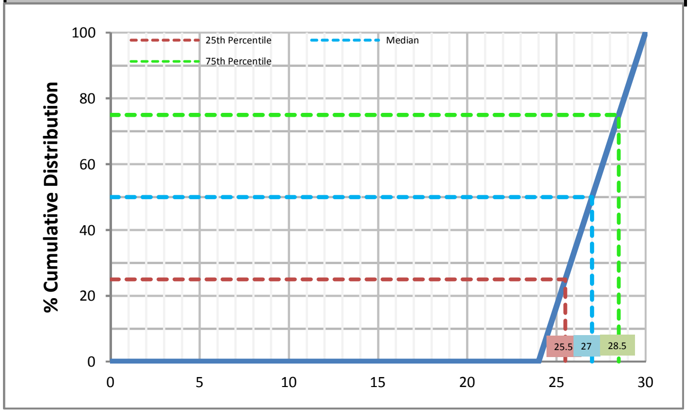


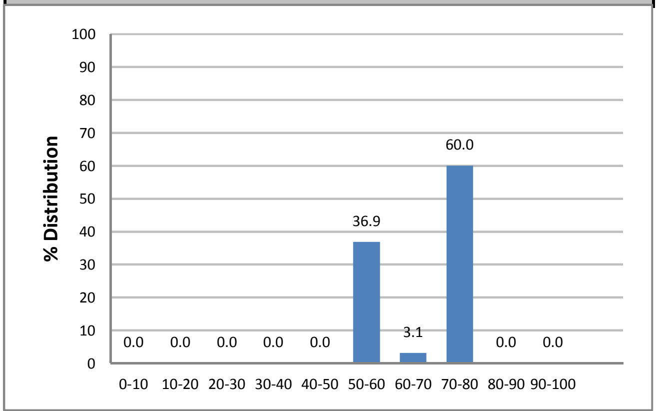
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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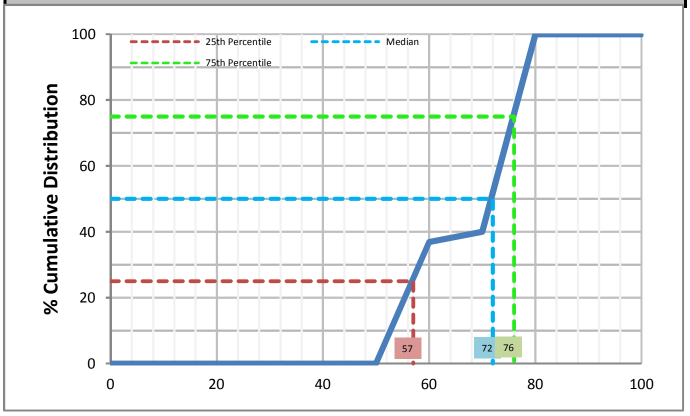
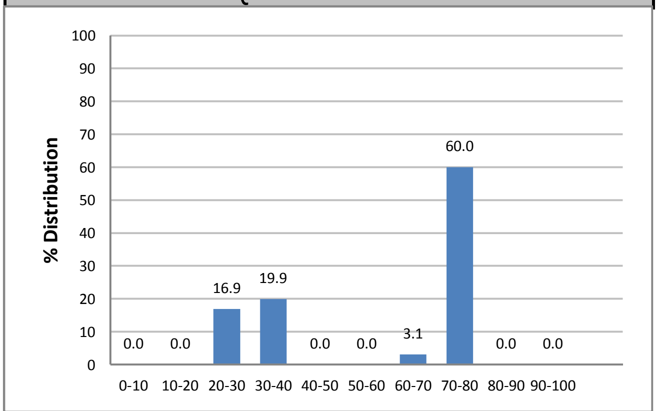
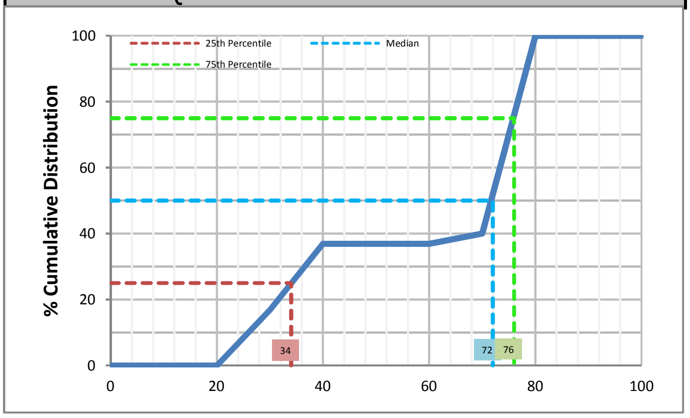


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

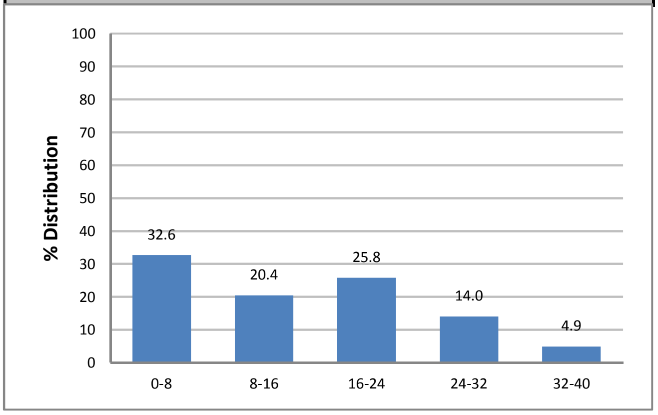


RMR MASS DATA - RMR PARAMETERS

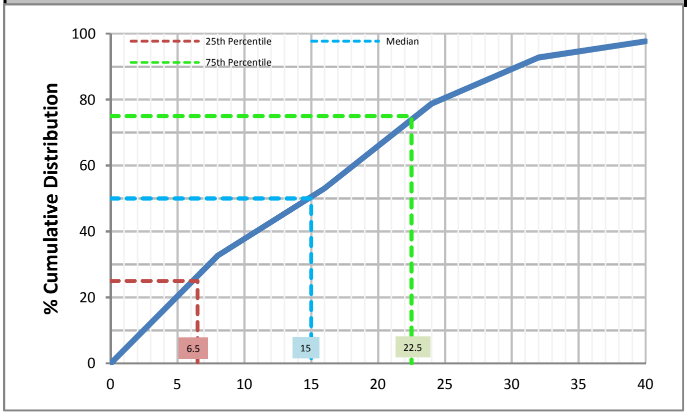
KGH001 - Ajax | Combined Data | Sector: ALL

Domain: MAFV | Meters Logged: 448.14 m

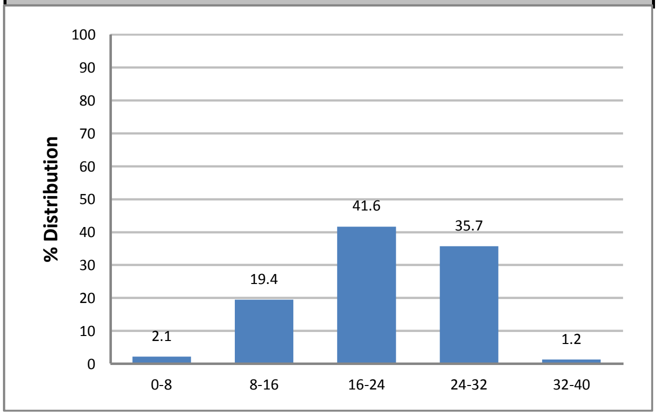
Nf DISTRIBUTION



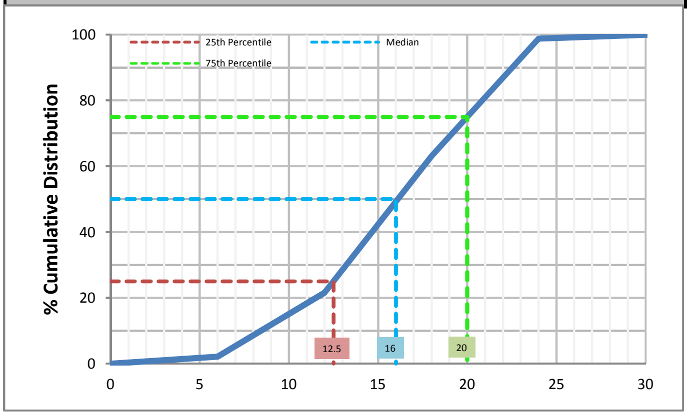
Nf CUMULATIVE DISTRIBUTION



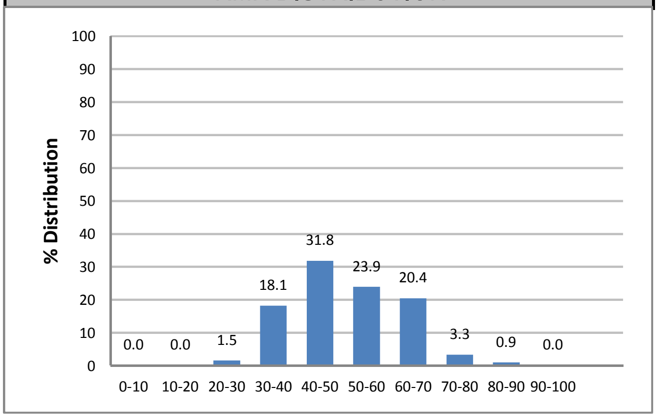
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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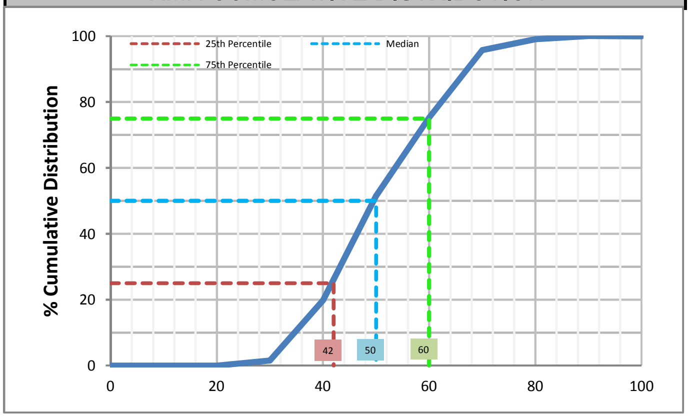
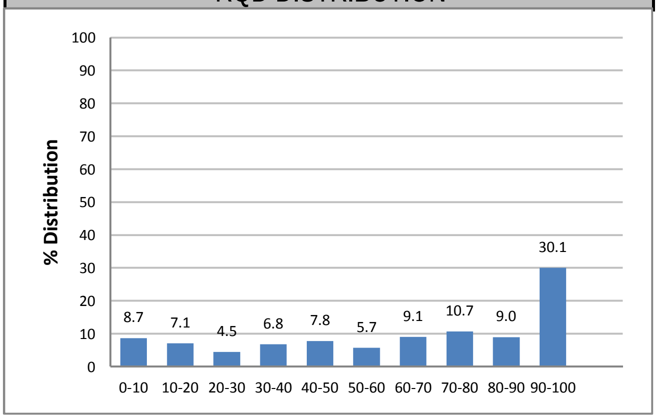
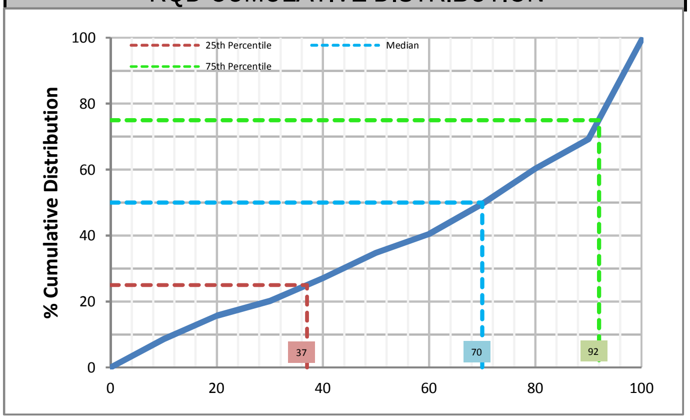


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

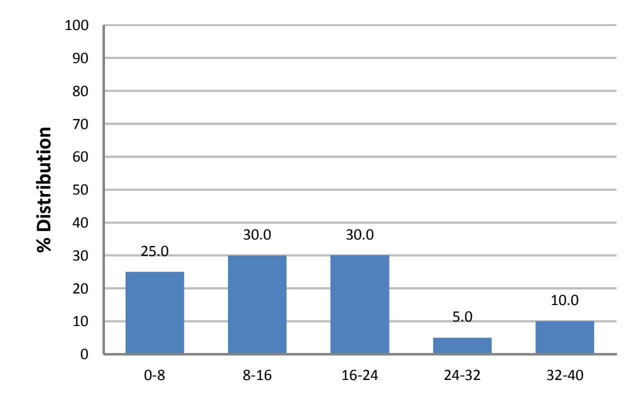


RMR MASS DATA - RMR PARAMETERS

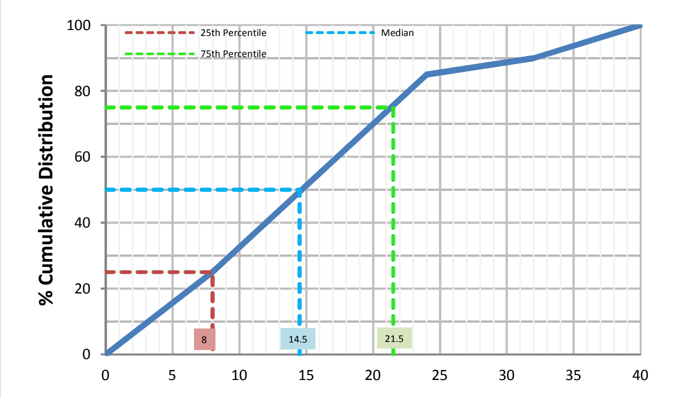
KGH001 - Ajax | Combined Data | Sector: ALL

Domain: MONZ | Meters Logged: 30.48 m

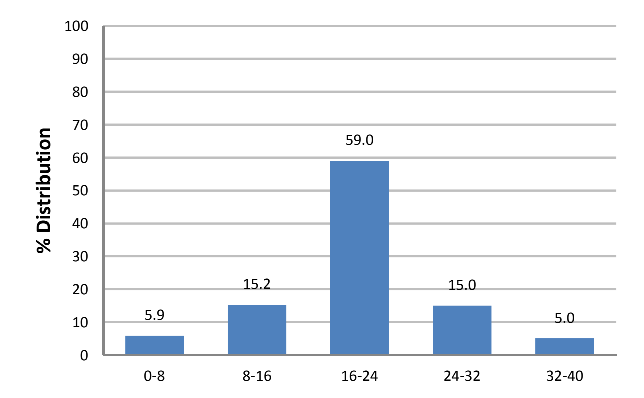
Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



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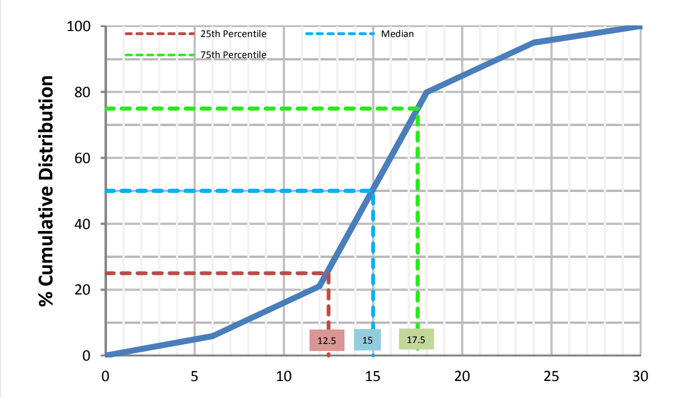
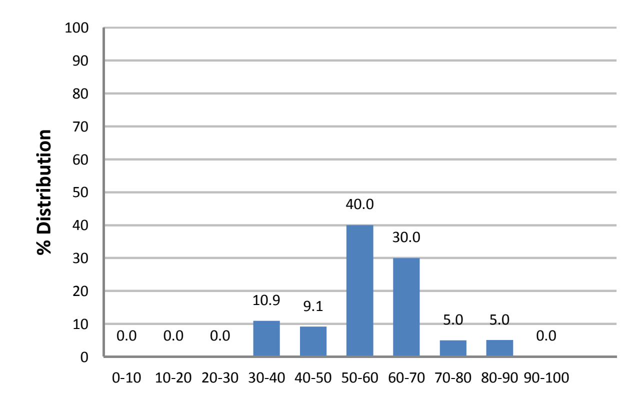


RMR DISTRIBUTION



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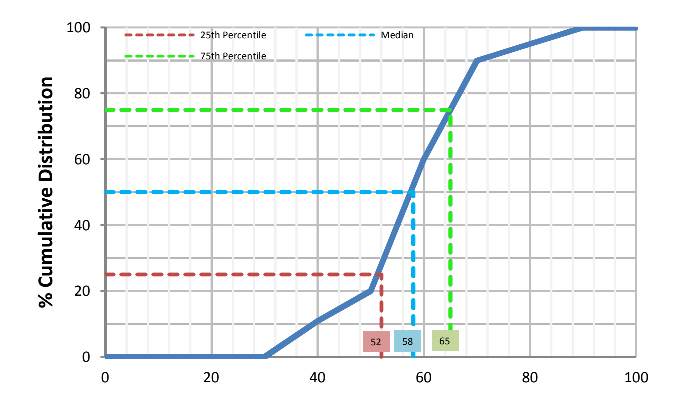

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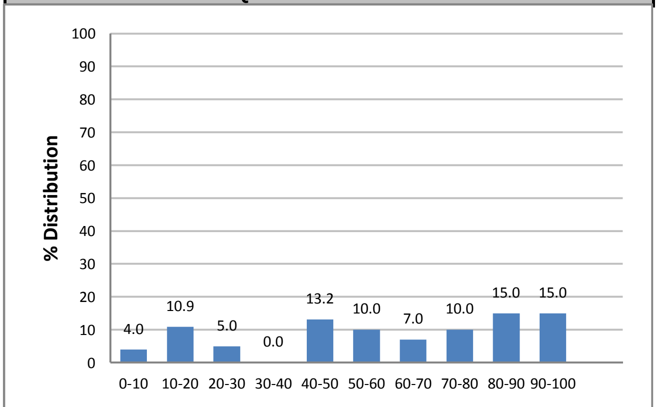
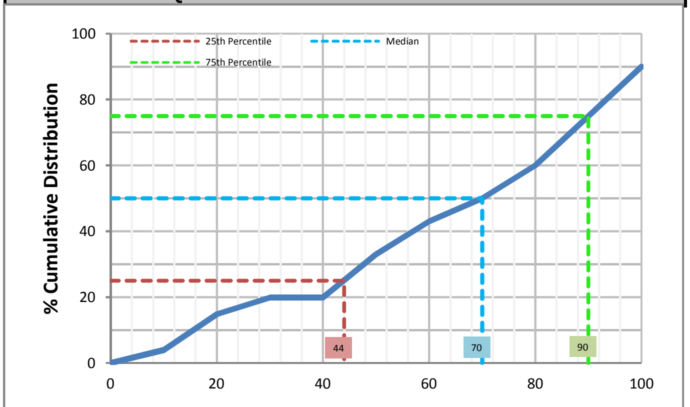


RQD CUMULATIVE DISTRIBUTION

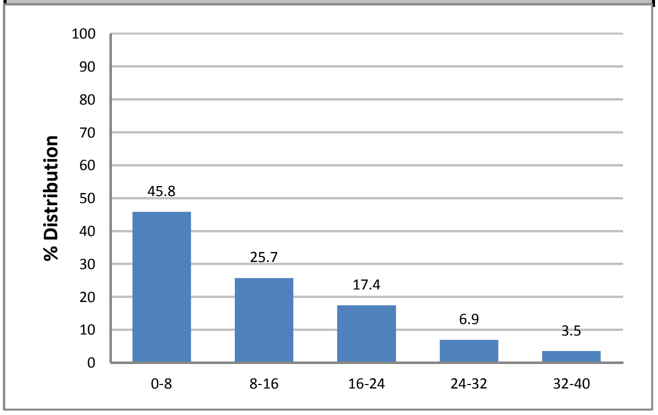


RMR MASS DATA - RMR PARAMETERS

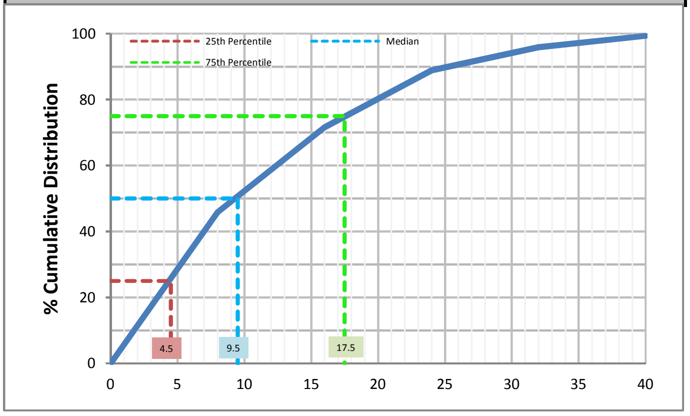
KGH001 - Ajax | Combined Data | Sector: ALL

Domain: PICR | Meters Logged: 3436.28 m

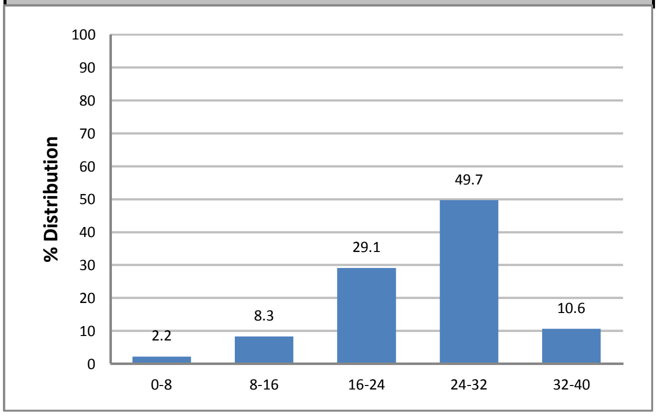
Nf DISTRIBUTION



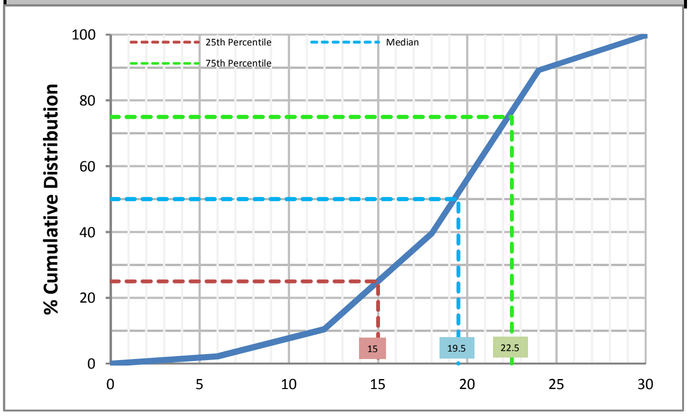
Nf CUMULATIVE DISTRIBUTION



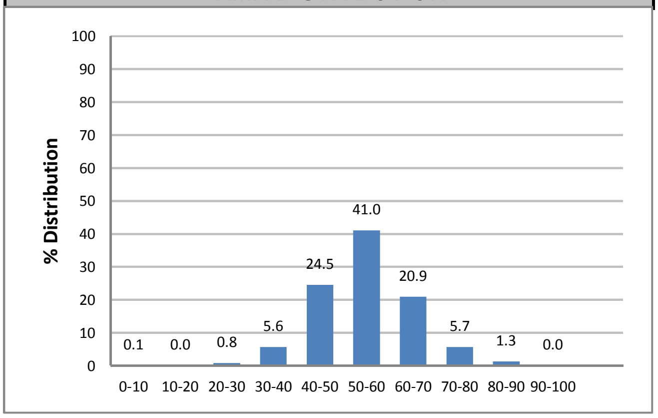
Nc DISTRIBUTION



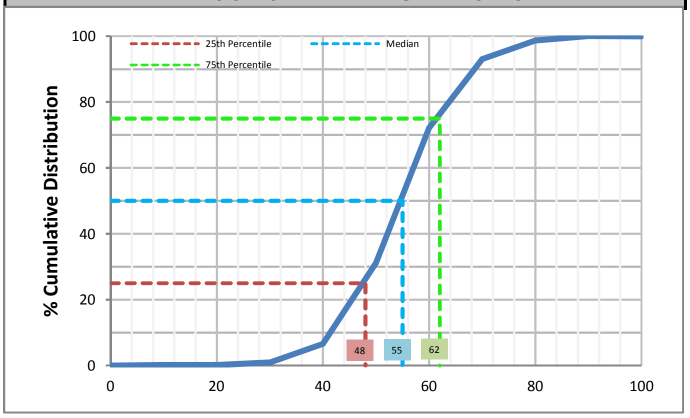
Nc CUMULATIVE DISTRIBUTION



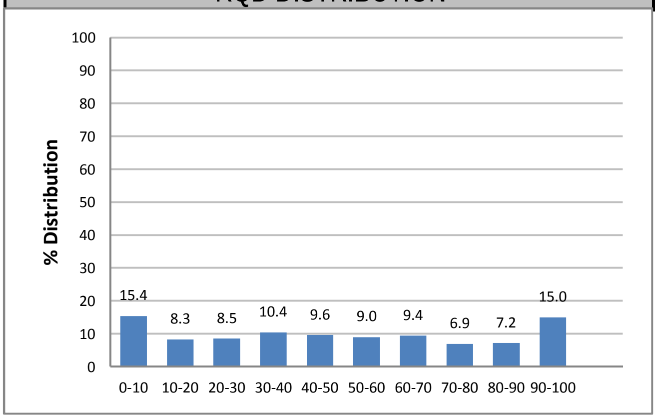
RMR DISTRIBUTION



RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



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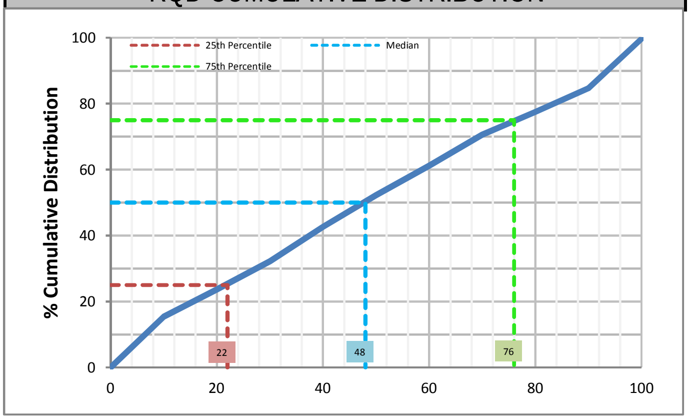
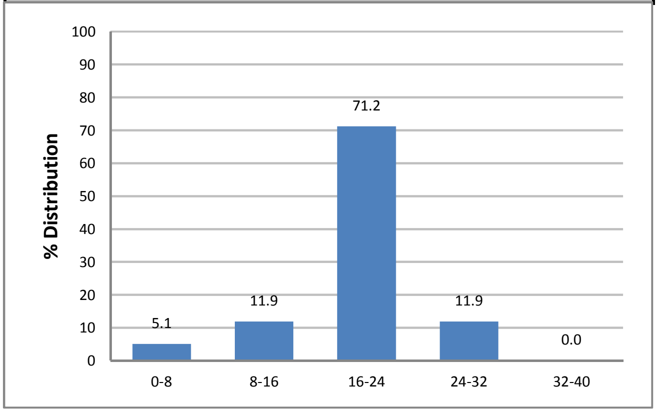


RMR MASS DATA - RMR PARAMETERS

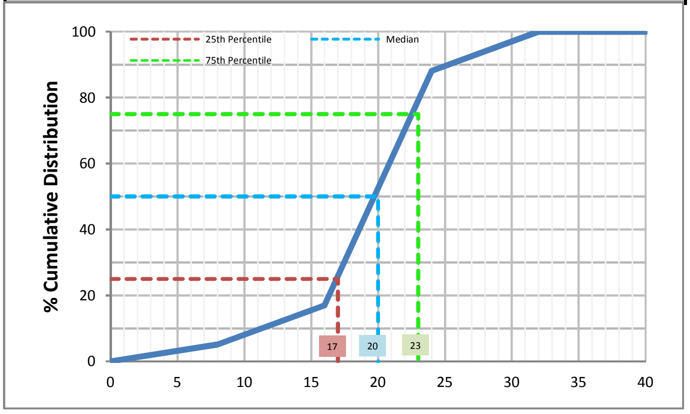
KGH001 - Ajax | Combined Data | Sector: ALL

Domain: PXPP | Meters Logged: 179.83 m

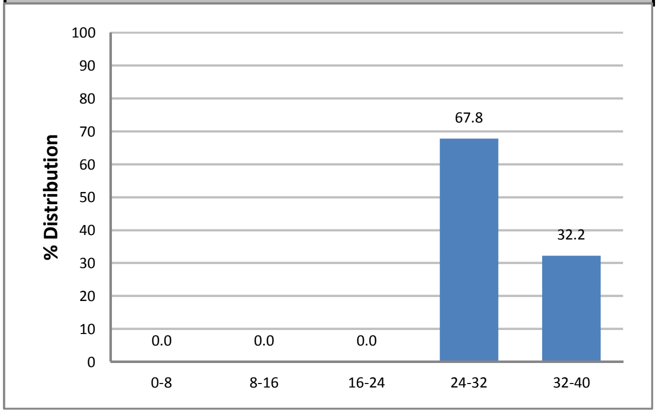
Nf DISTRIBUTION



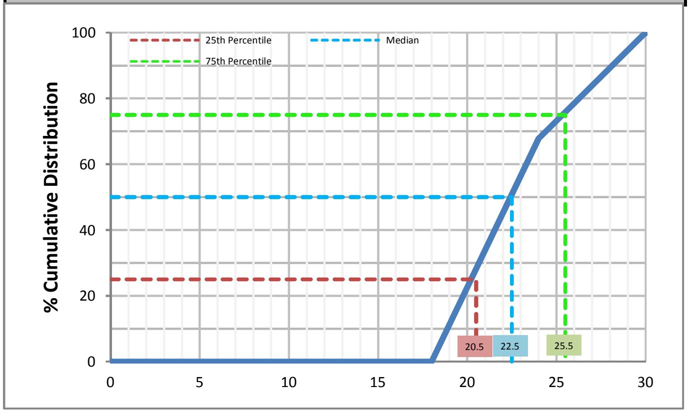
Nf CUMULATIVE DISTRIBUTION



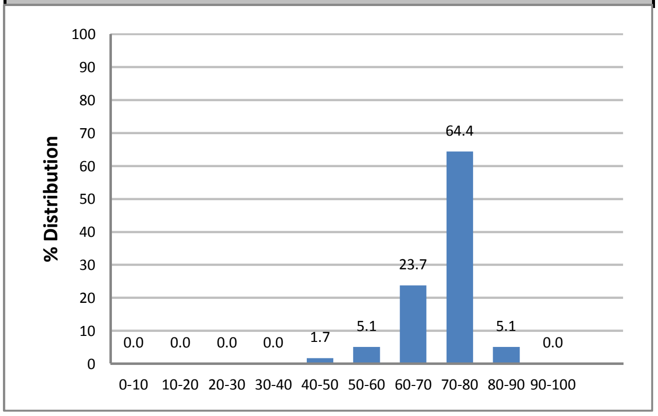
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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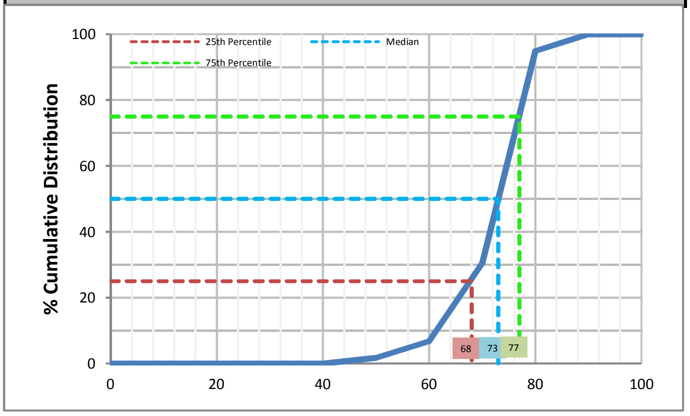

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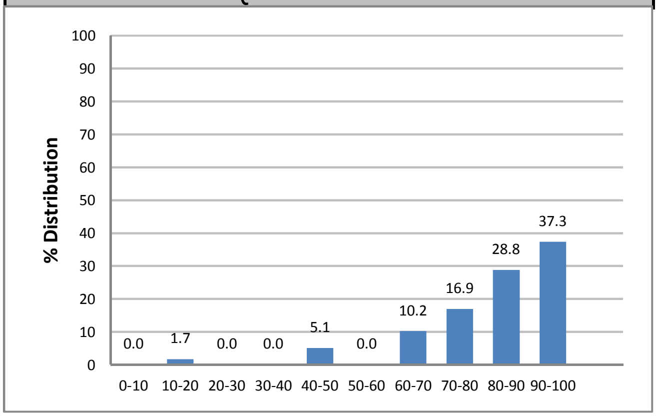
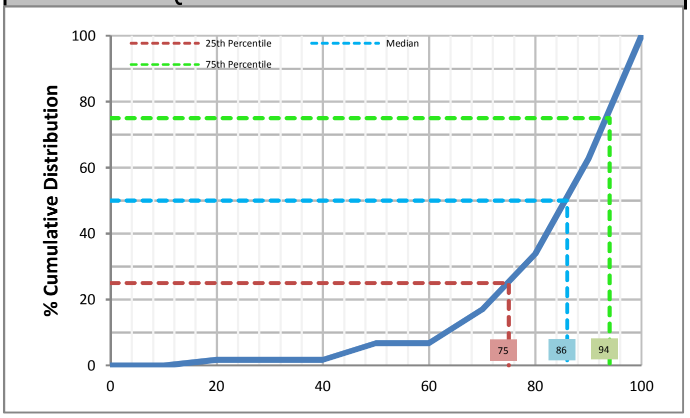


RQD CUMULATIVE DISTRIBUTION

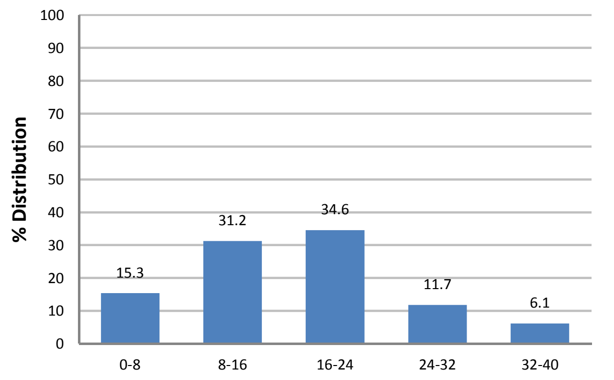


RMR MASS DATA - RMR PARAMETERS

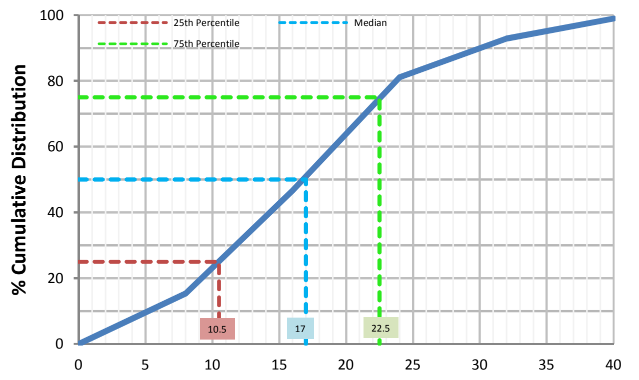
KGH001 - Ajax | Combined Data | Sector: ALL

Domain: SLD | Meters Logged: 3522.71 m

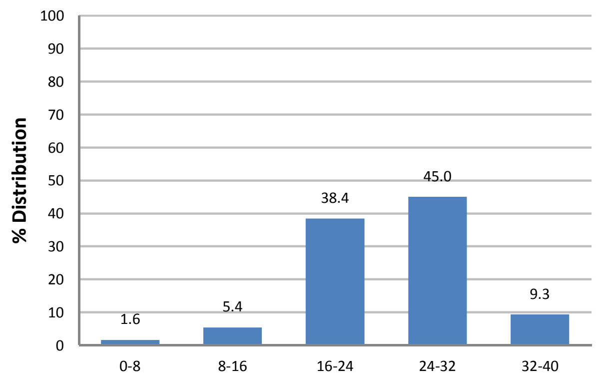
Nf DISTRIBUTION



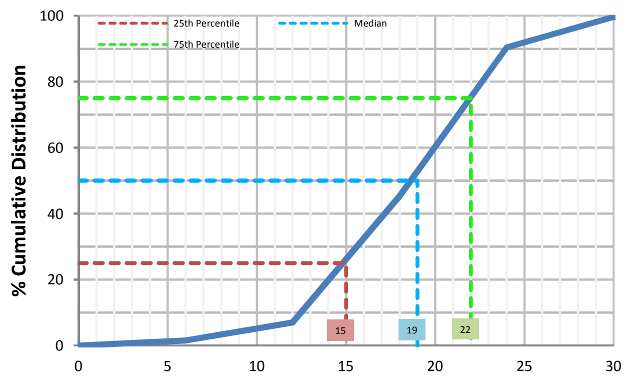
Nf CUMULATIVE DISTRIBUTION



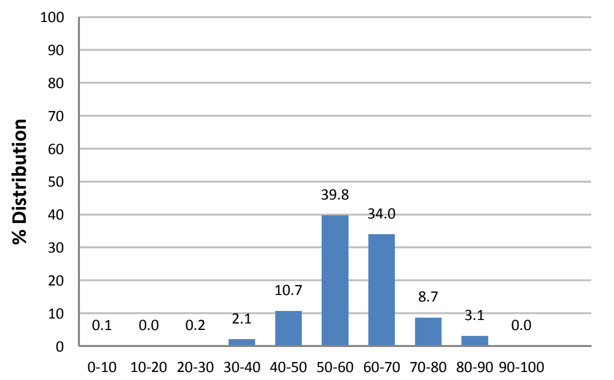
Nc DISTRIBUTION



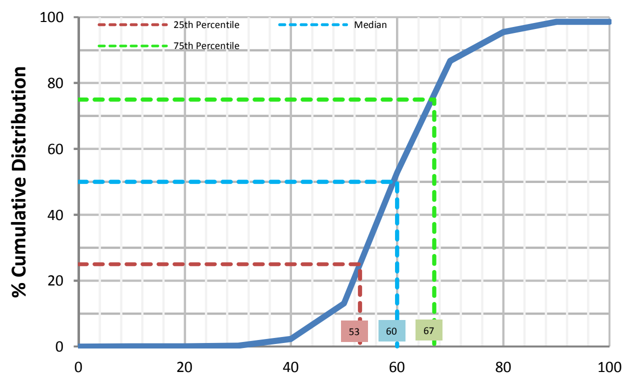
Nc CUMULATIVE DISTRIBUTION



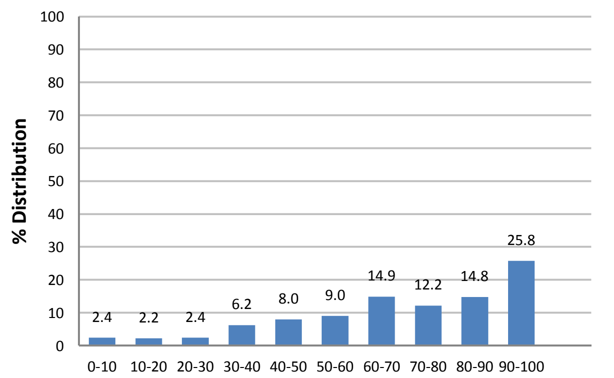
RMR DISTRIBUTION



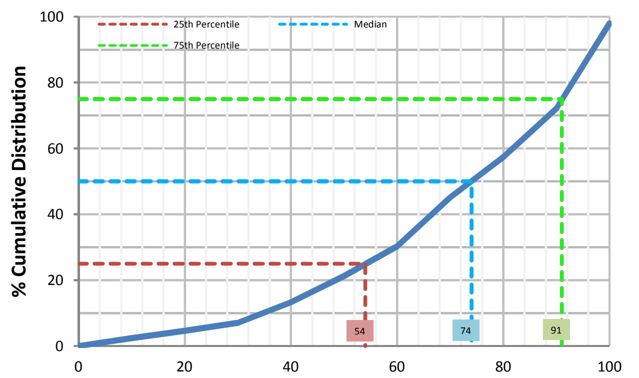
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

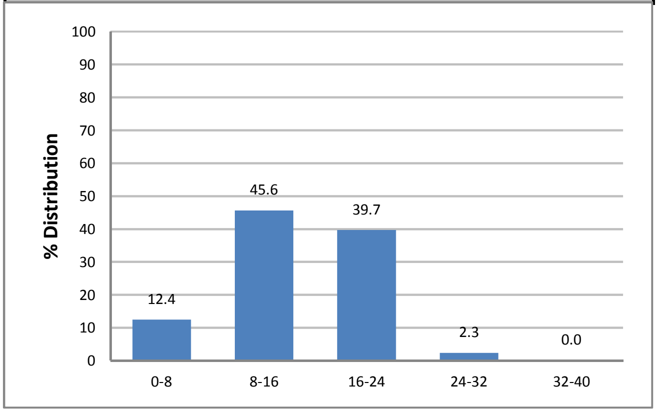


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | Combined Data | Sector: ALL

Domain: SVHYB | Meters Logged: 675.74 m

Nf DISTRIBUTION



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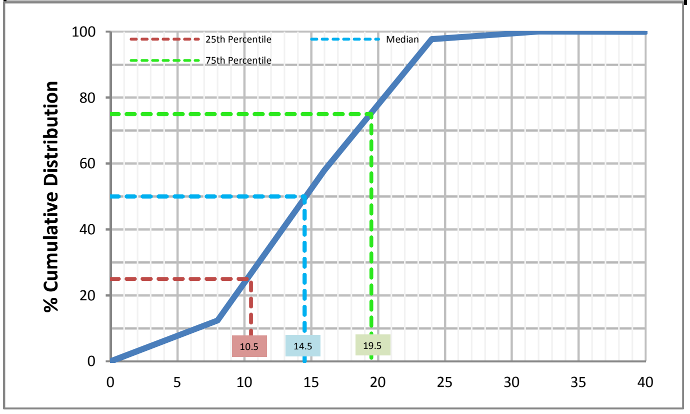
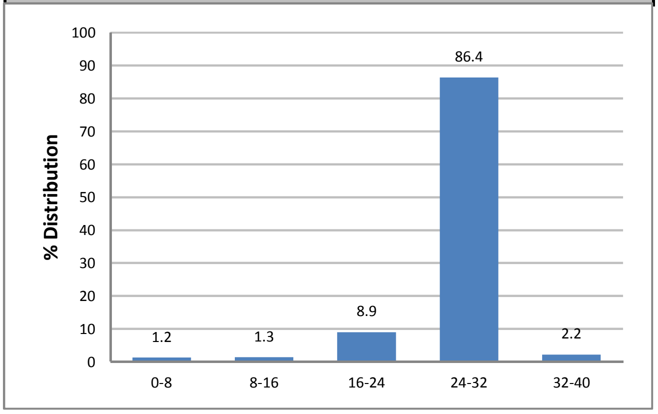
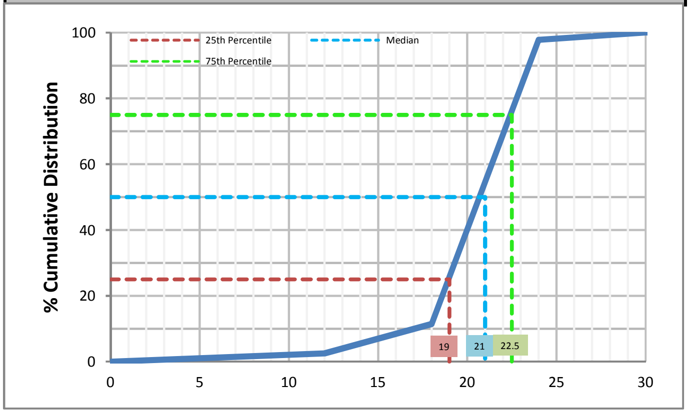


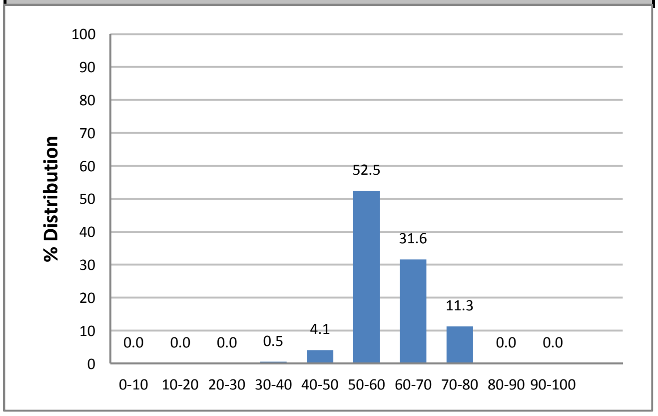
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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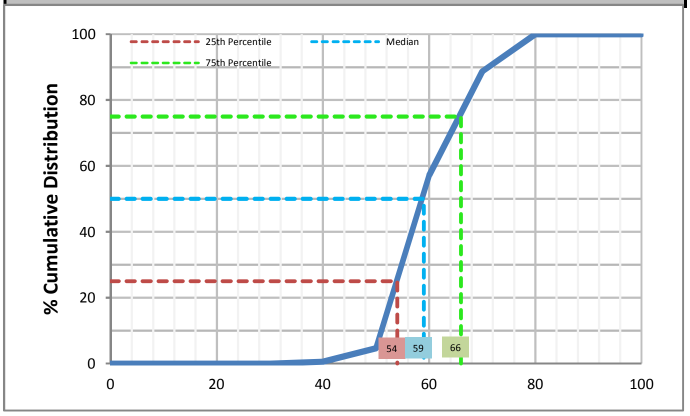
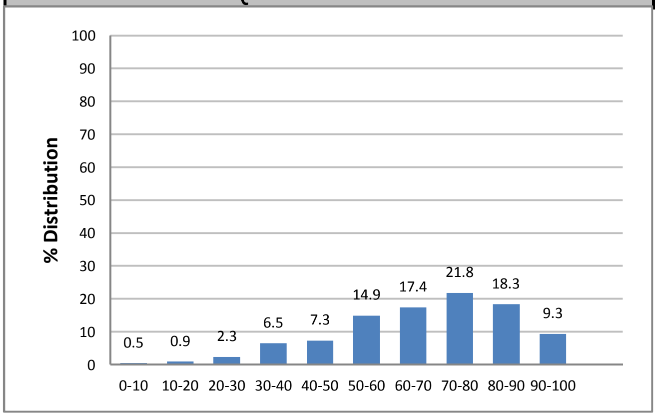
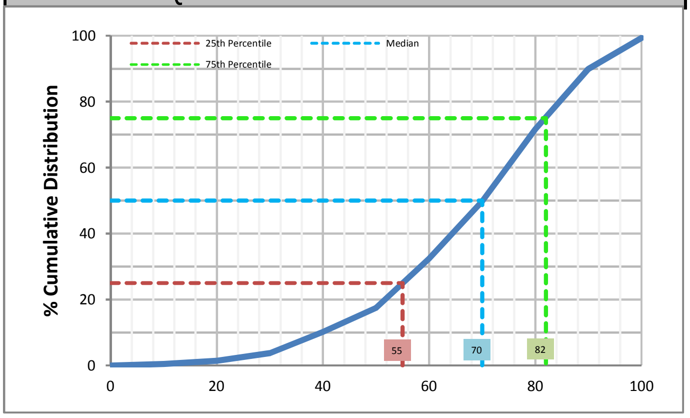


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION



RMR MASS DATA - RMR PARAMETERS

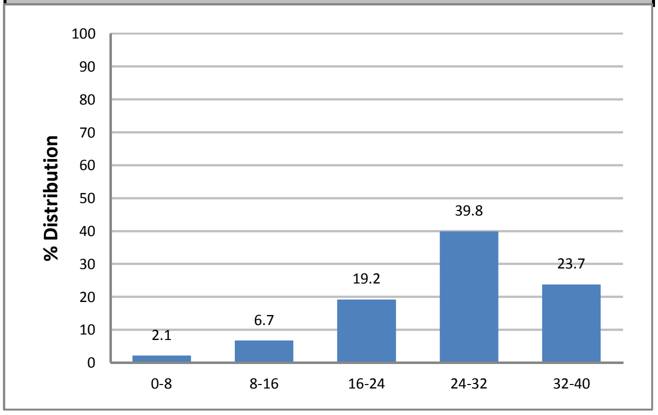
KGH001 - Ajax

New Data

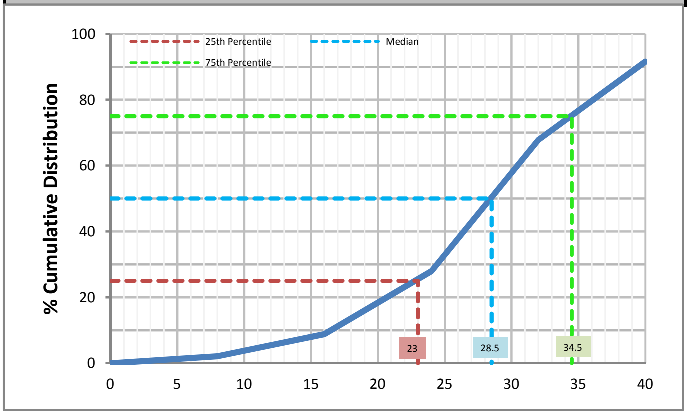
Domain: IMH

Meters Logged: 1877.85 m

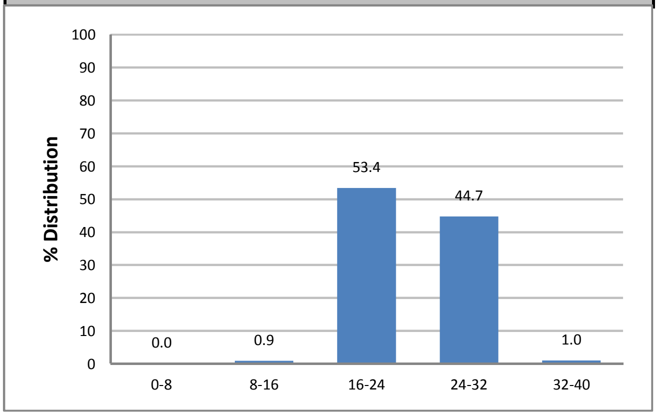
Nf DISTRIBUTION



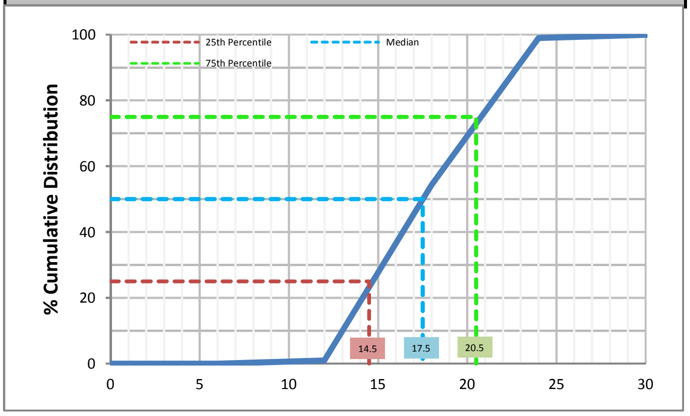
Nf CUMULATIVE DISTRIBUTION



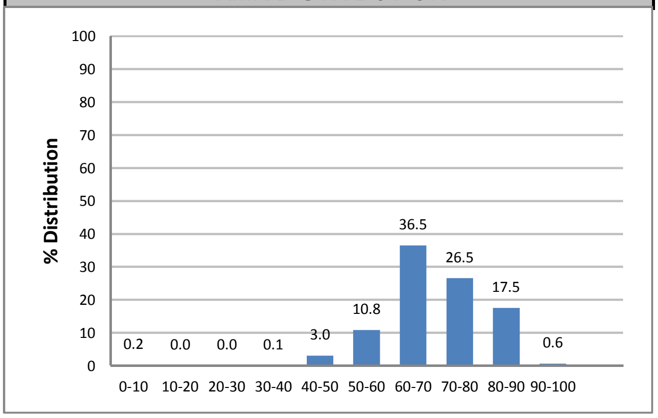
Nc DISTRIBUTION



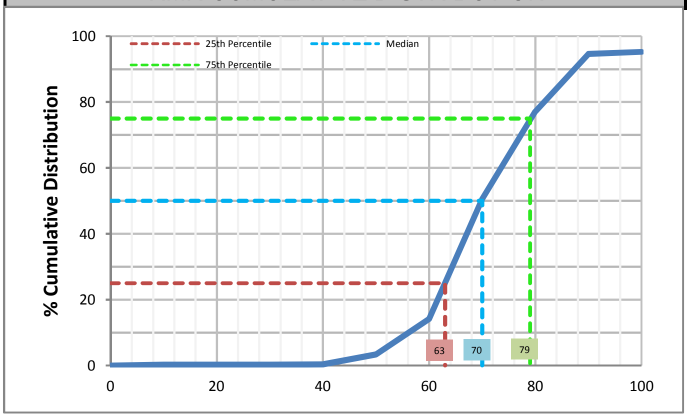
Nc CUMULATIVE DISTRIBUTION



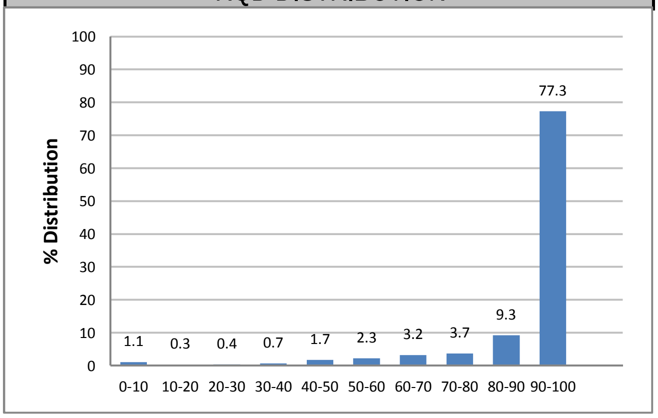
RMR DISTRIBUTION



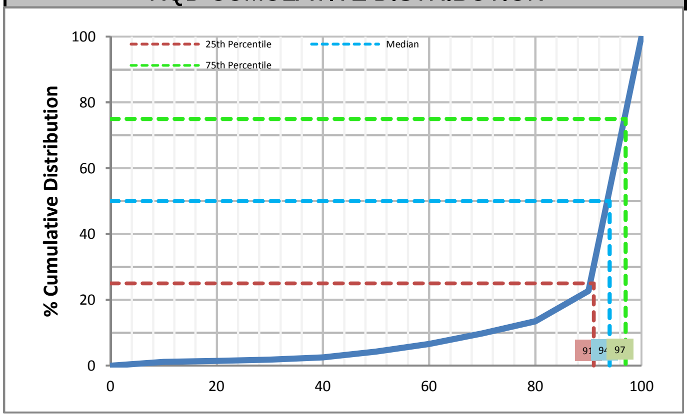
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION



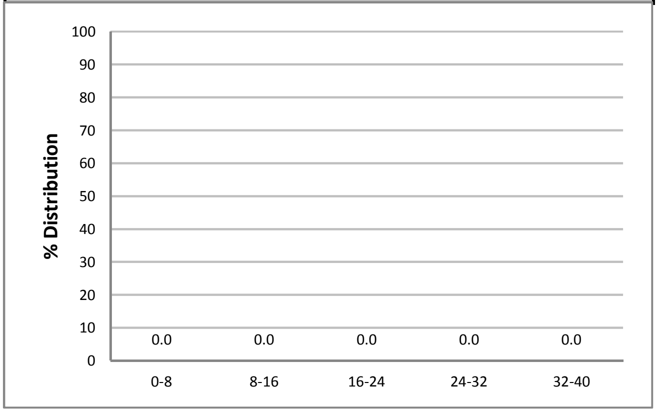
RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax

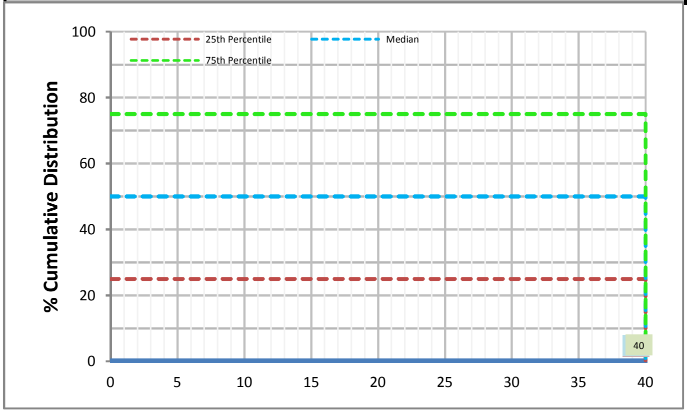
New Data

Domain	LAT	Meters Logged:	0 m

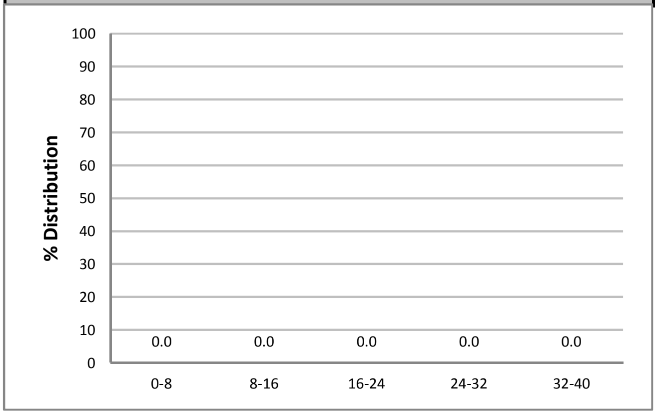
Nf DISTRIBUTION



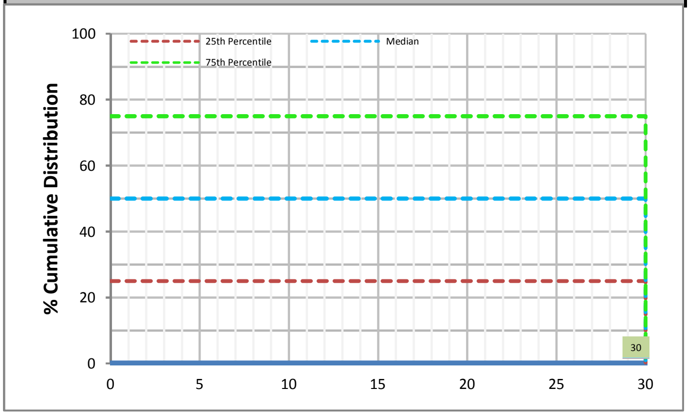
Nf CUMULATIVE DISTRIBUTION



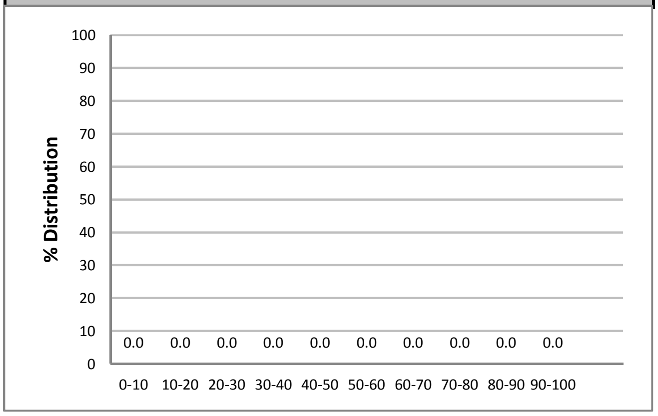
Nc DISTRIBUTION



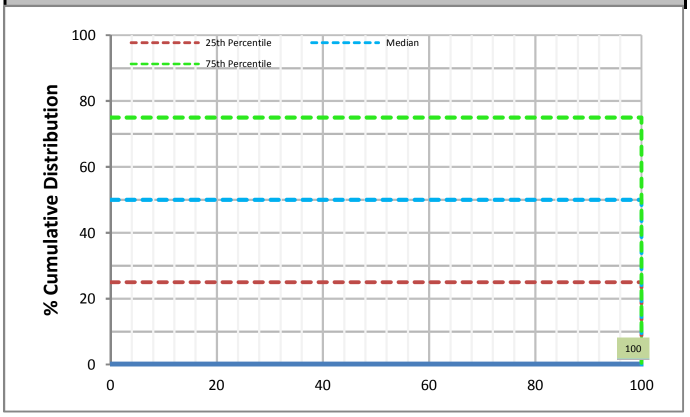
Nc CUMULATIVE DISTRIBUTION



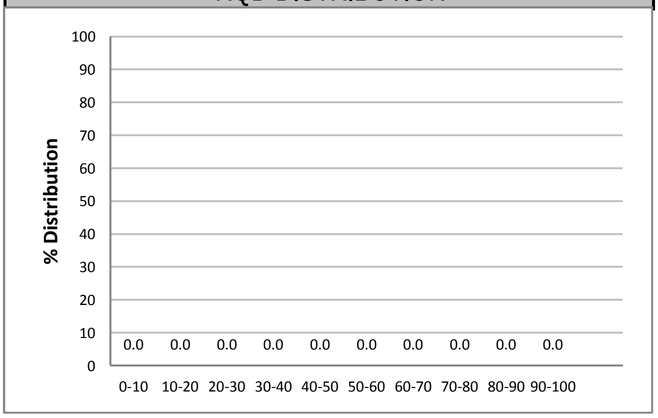
RMR DISTRIBUTION



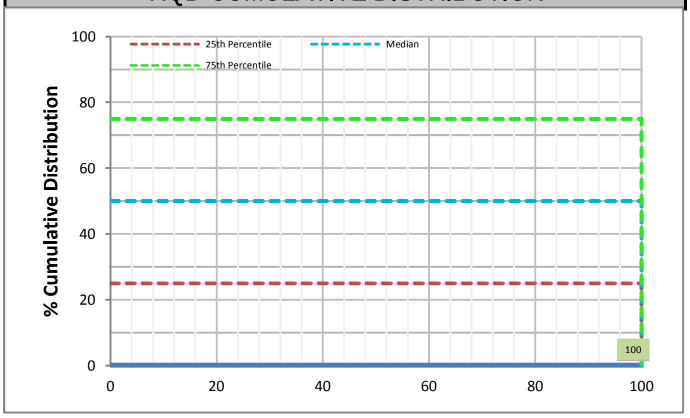
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION



RMR MASS DATA - RMR PARAMETERS

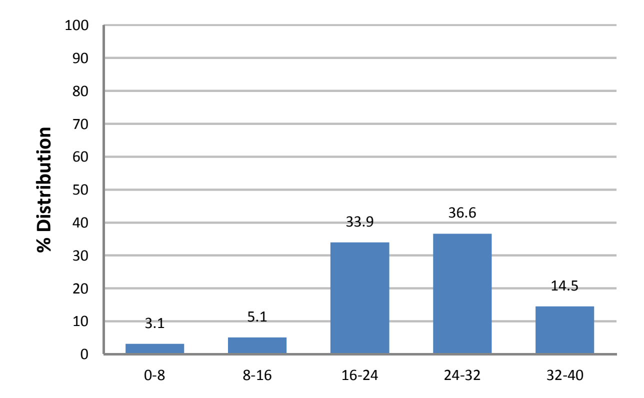
KGH001 - Ajax

New Data

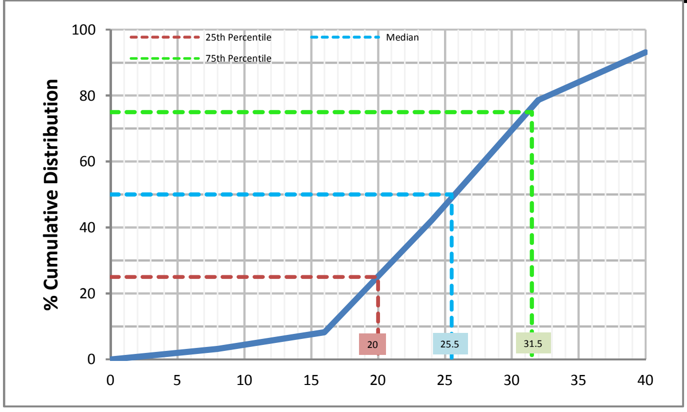
Domain: MAFV

Meters Logged: 152.18 m

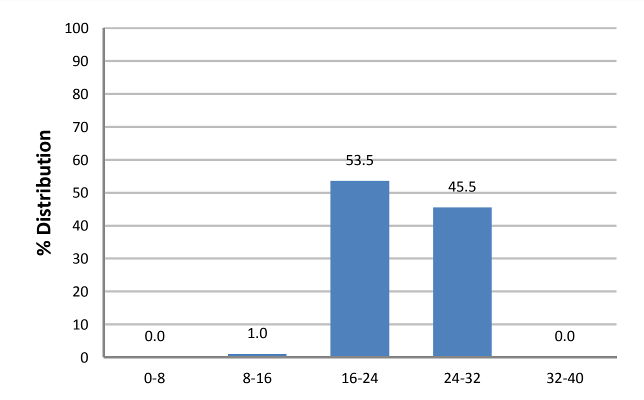
Nf DISTRIBUTION



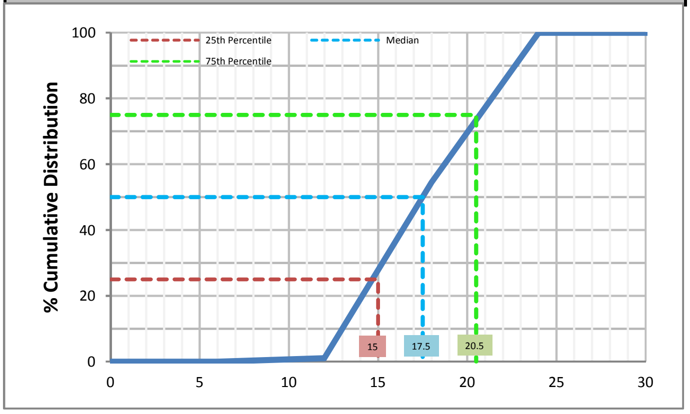
Nf CUMULATIVE DISTRIBUTION



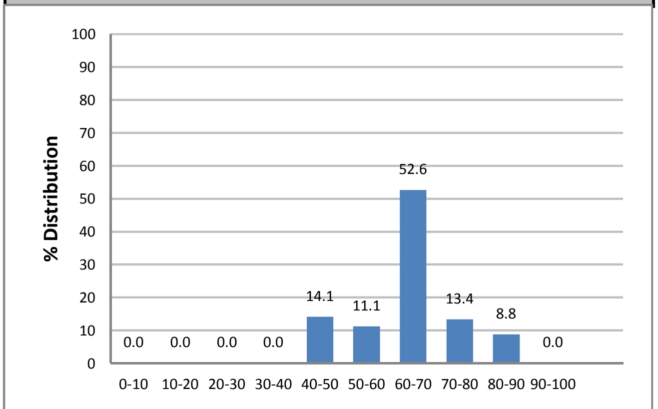
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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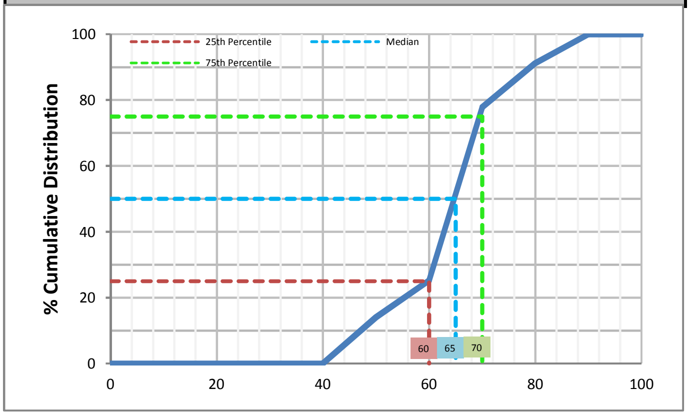
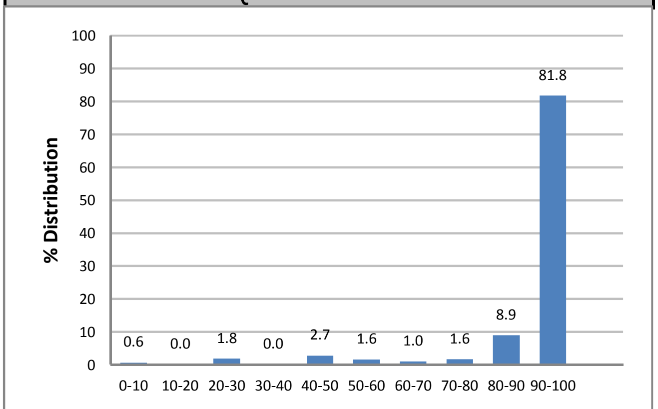
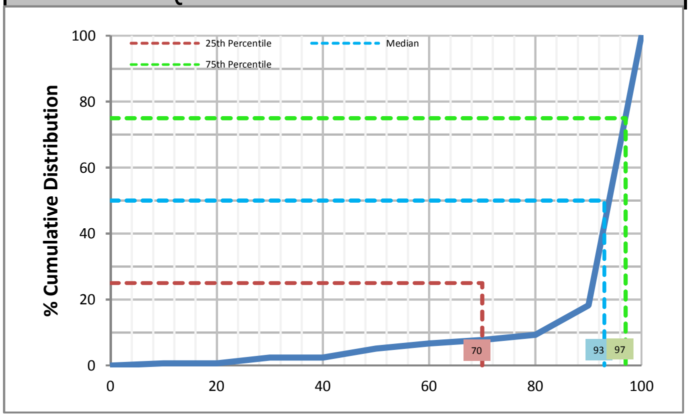


RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION



RMR MASS DATA - RMR PARAMETERS

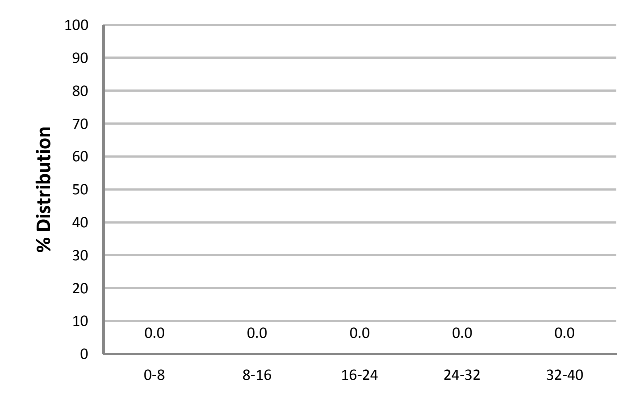
KGH001 - Ajax

New Data

Domain: MONZ

Meters Logged: 0 m

Nf DISTRIBUTION



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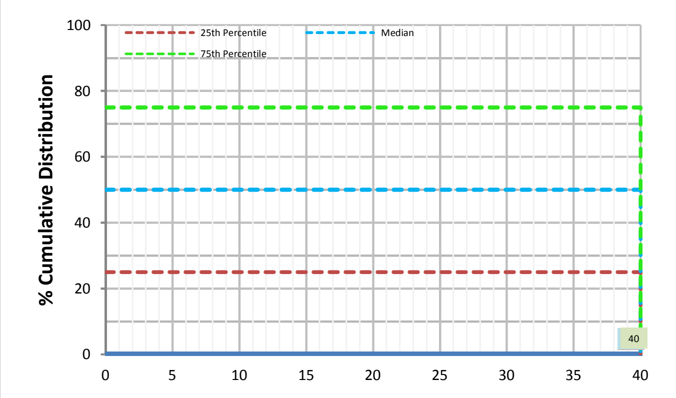
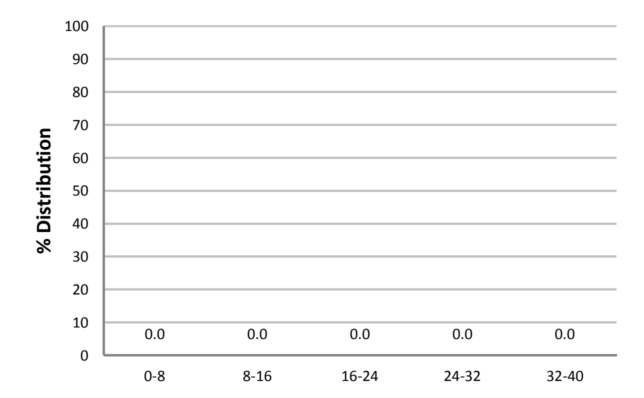
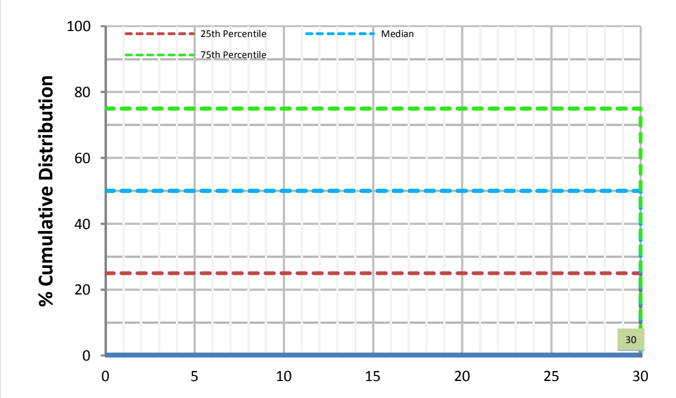


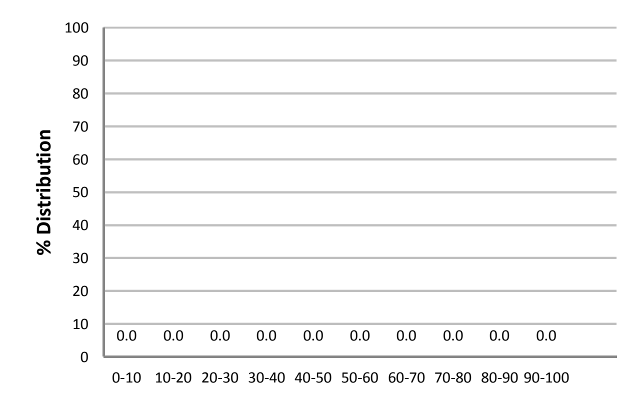
Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



RMR DISTRIBUTION



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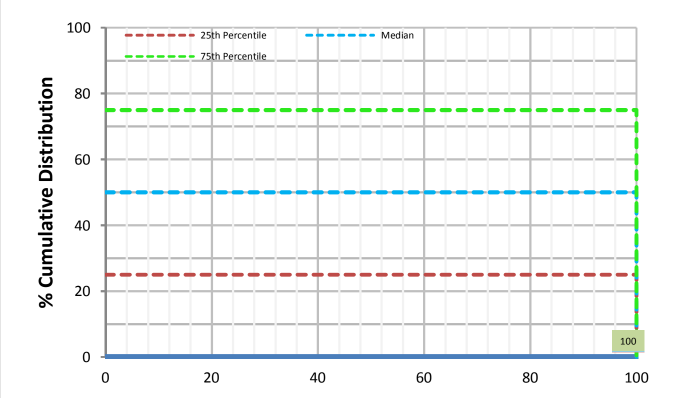

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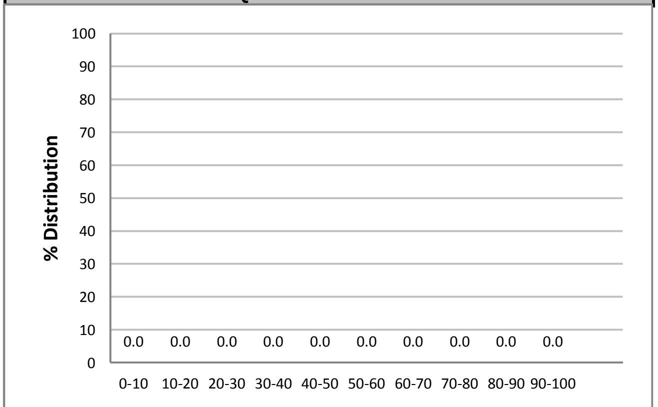

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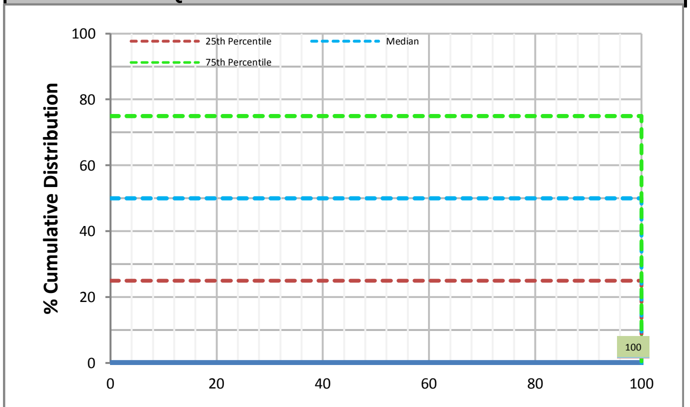
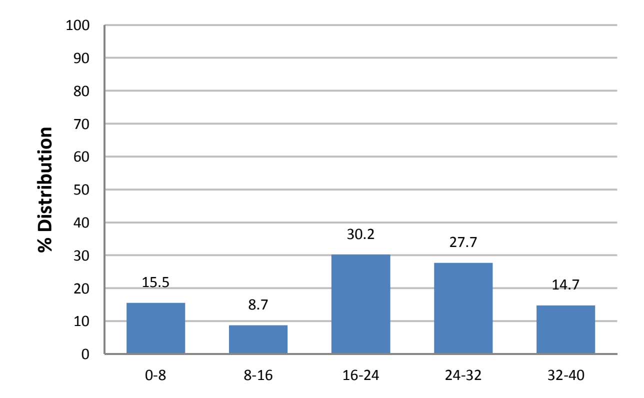


RMR MASS DATA - RMR PARAMETERS

KGH001 - Ajax | New Data

Domain	PICR	Meters Logged:	759.25	m

Nf DISTRIBUTION



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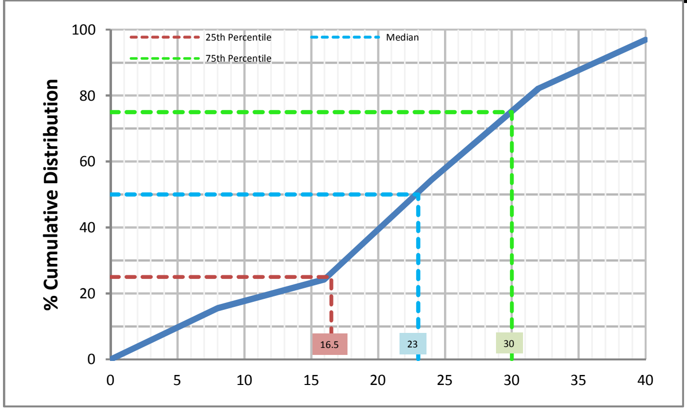

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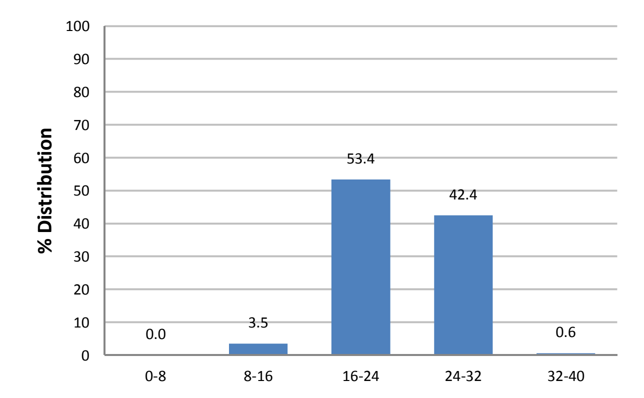

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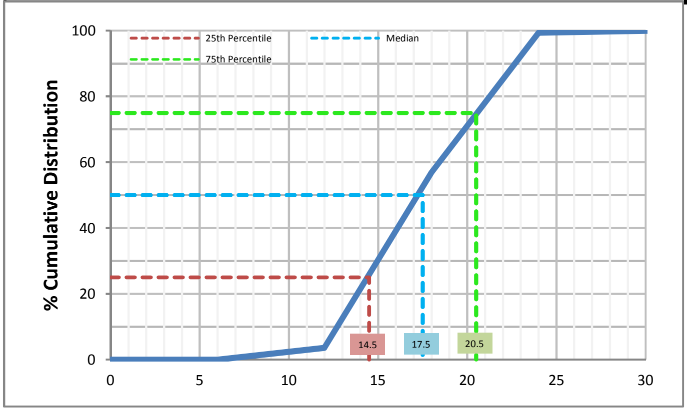

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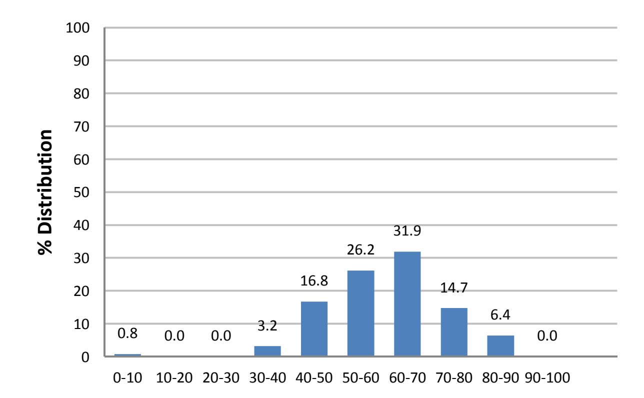

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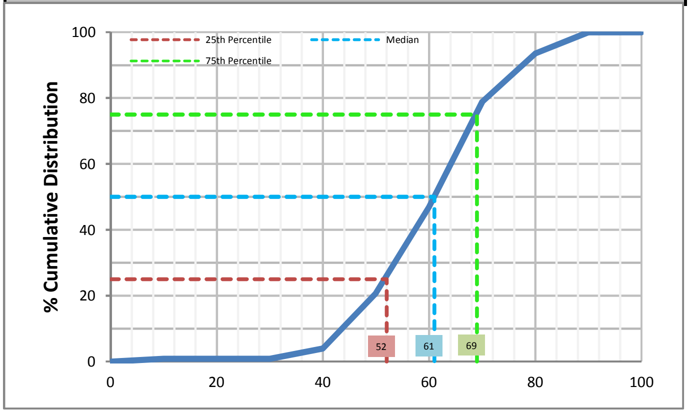

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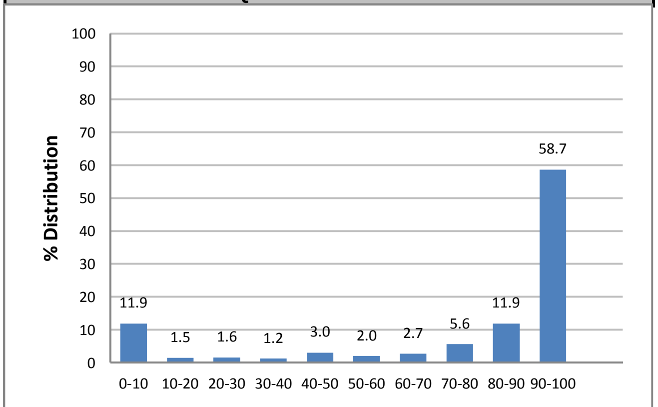
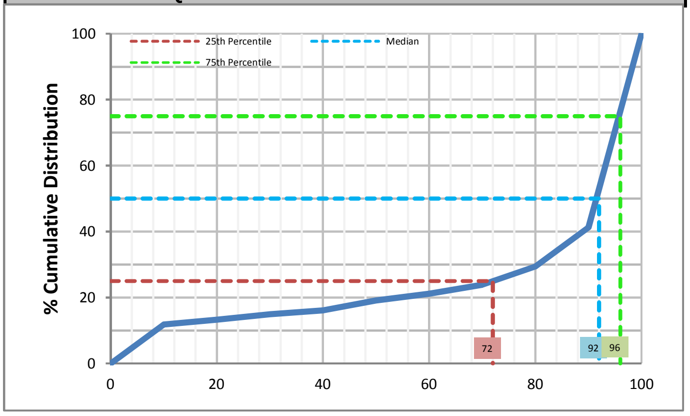


RQD CUMULATIVE DISTRIBUTION



RMR MASS DATA - RMR PARAMETERS

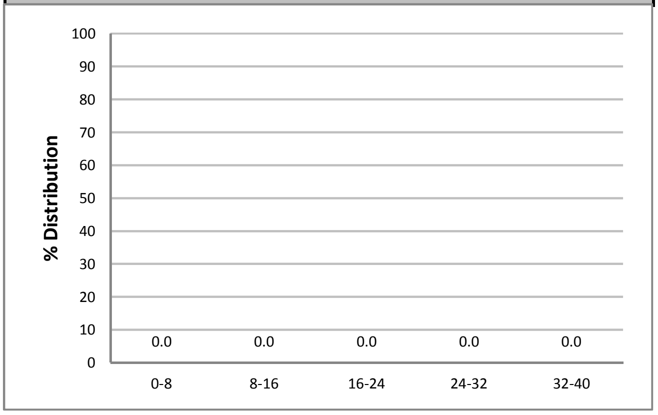
KGH001 - Ajax

New Data

Domain: PXPP

Meters Logged: 0 m

Nf DISTRIBUTION



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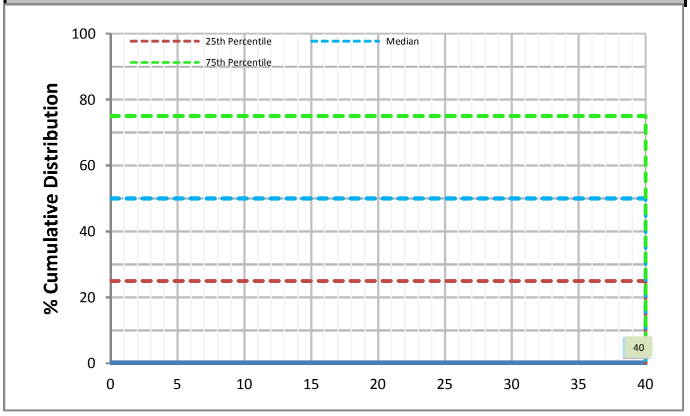
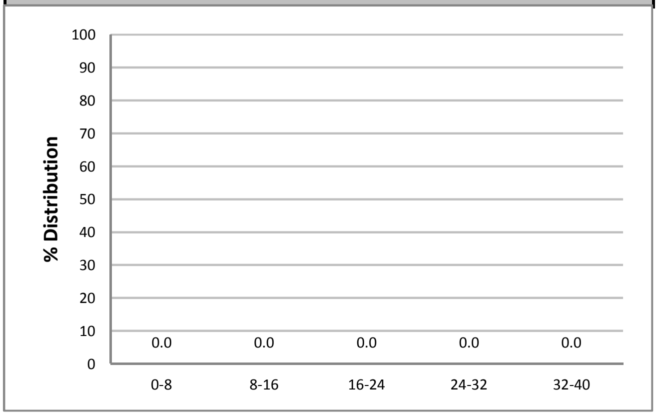


Nc DISTRIBUTION



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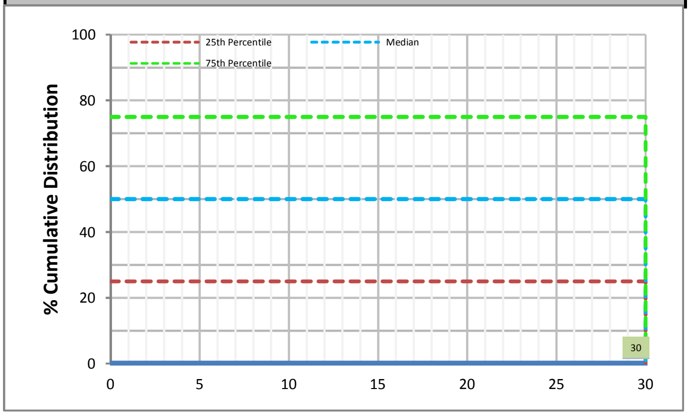

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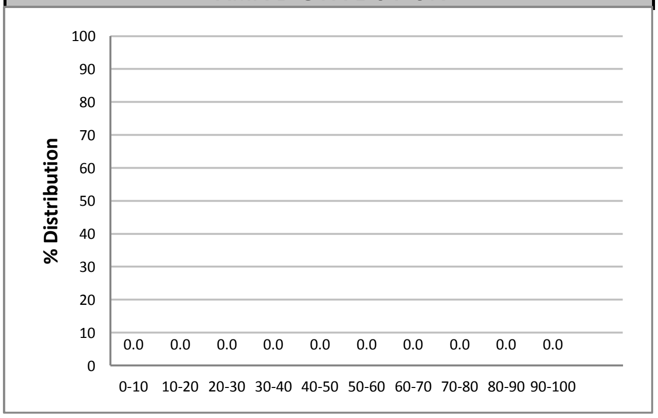

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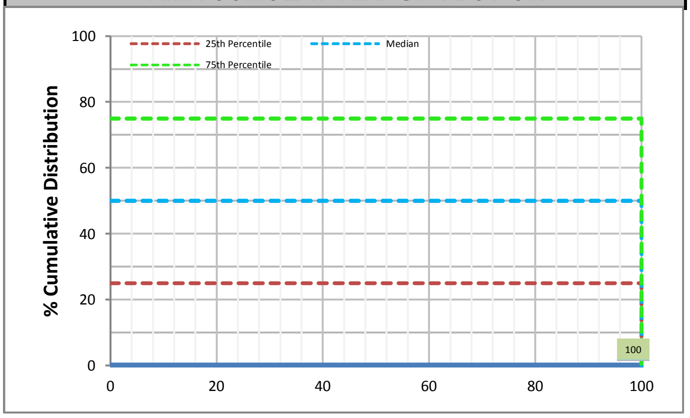

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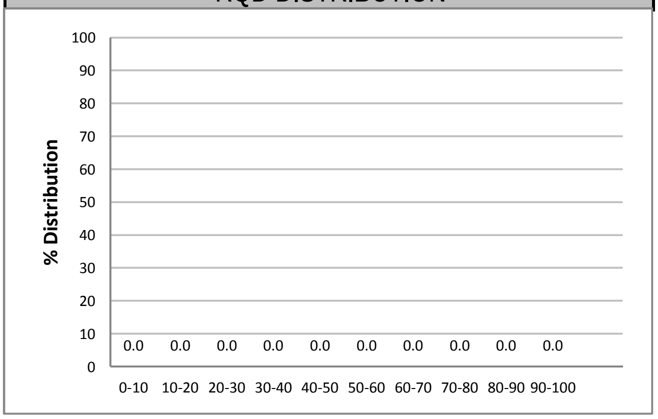

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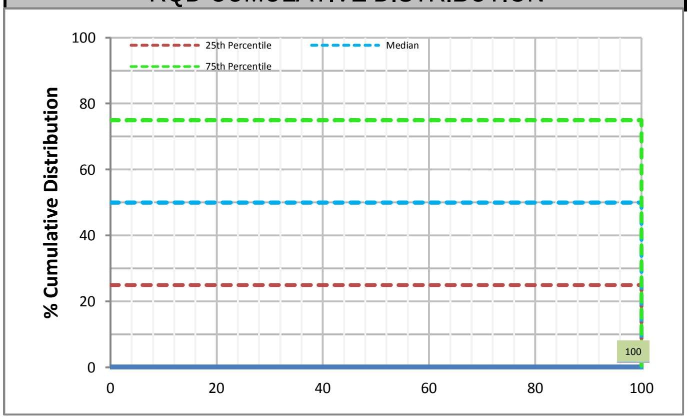


RMR MASS DATA - RMR PARAMETERS

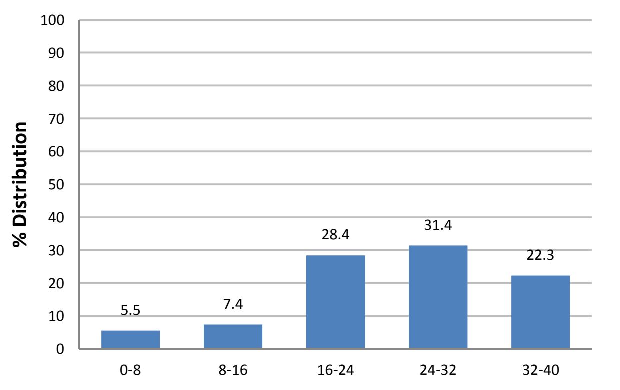
KGH001 - Ajax

New Data

Domain SLD

Meters Logged: 726.06 m

Nf DISTRIBUTION



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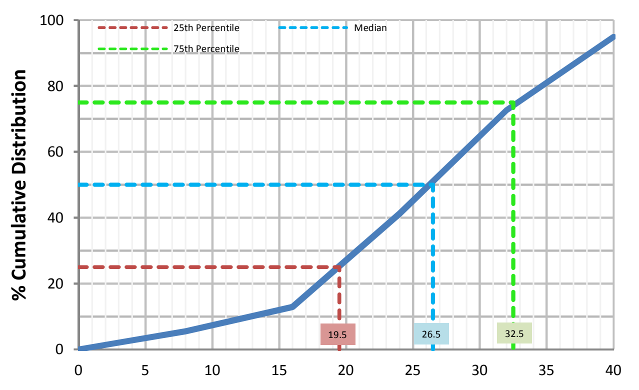
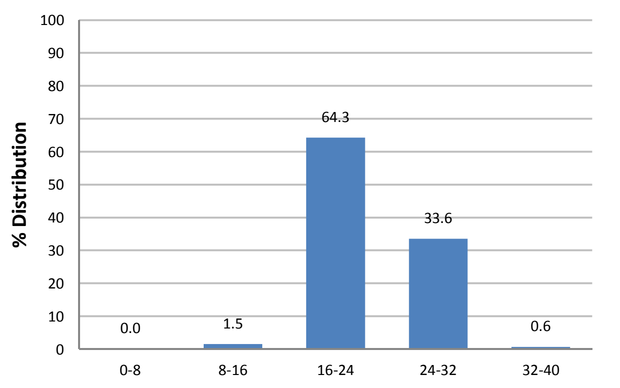
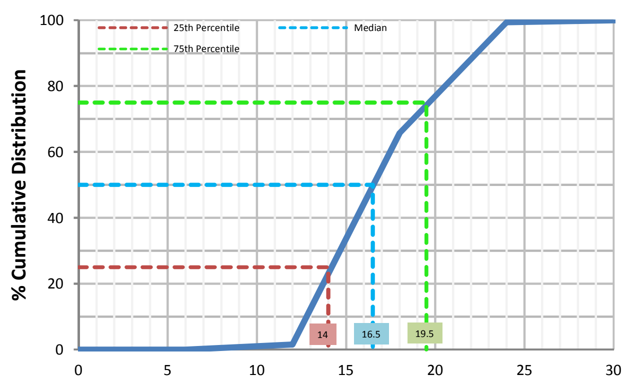


Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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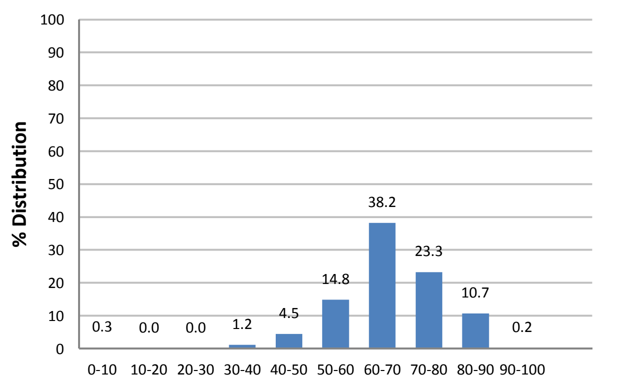

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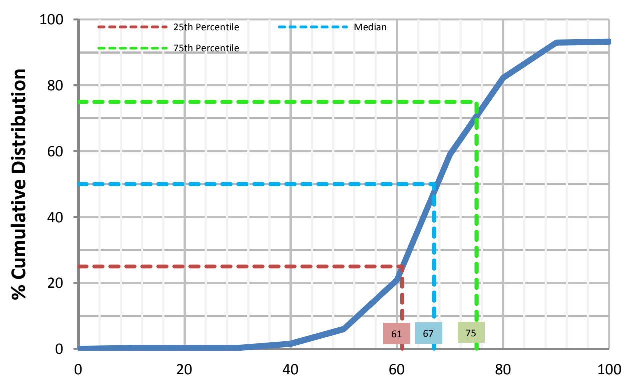

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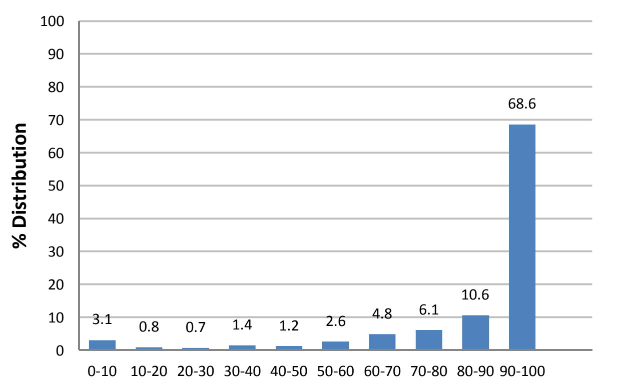

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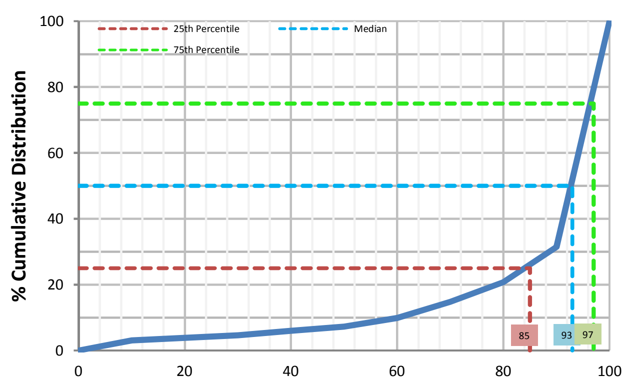


RMR MASS DATA - RMR PARAMETERS

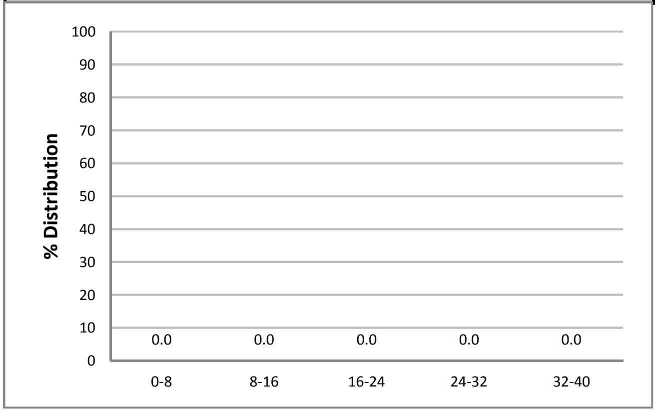
KGH001 - Ajax

New Data

Domain: SVHYB

Meters Logged: 0 m

Nf DISTRIBUTION



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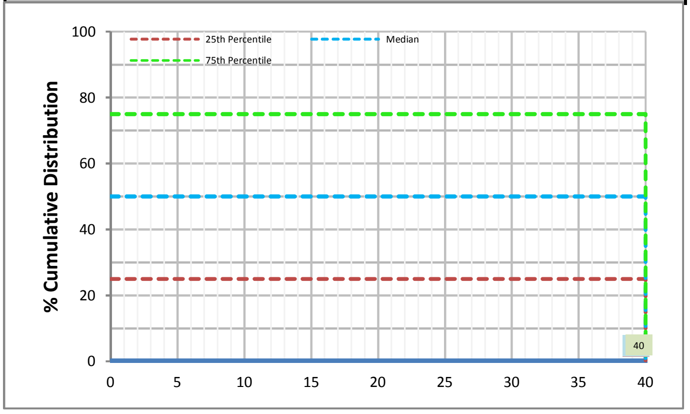
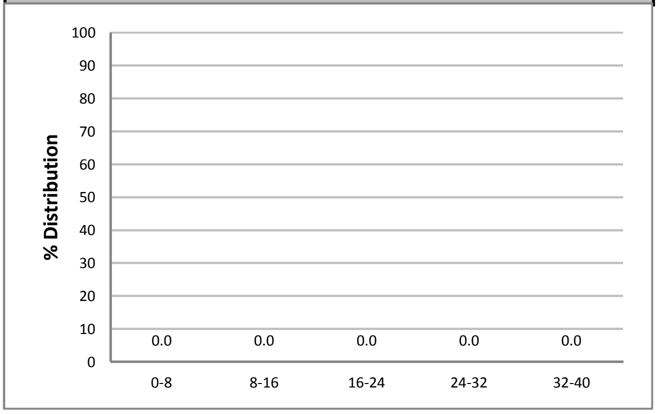
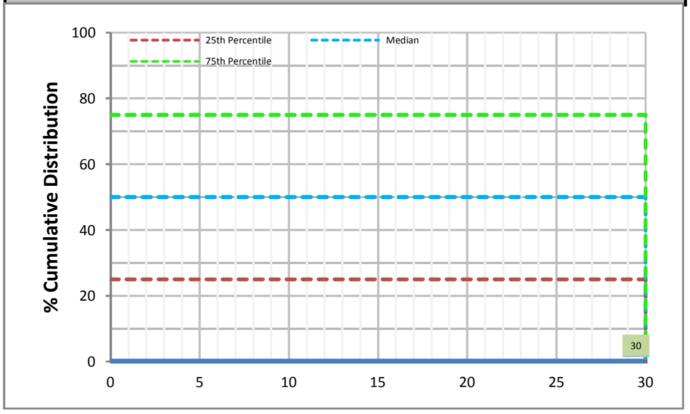


Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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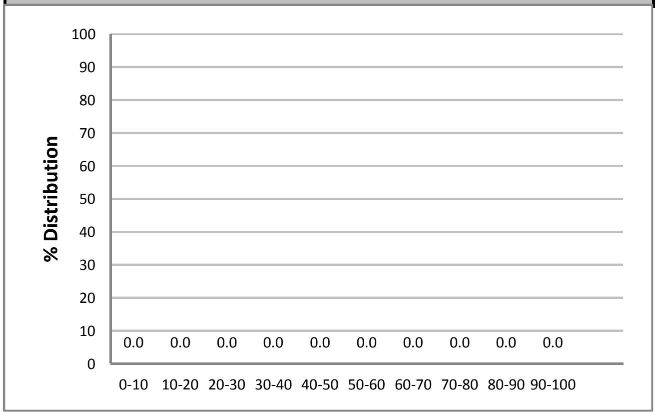

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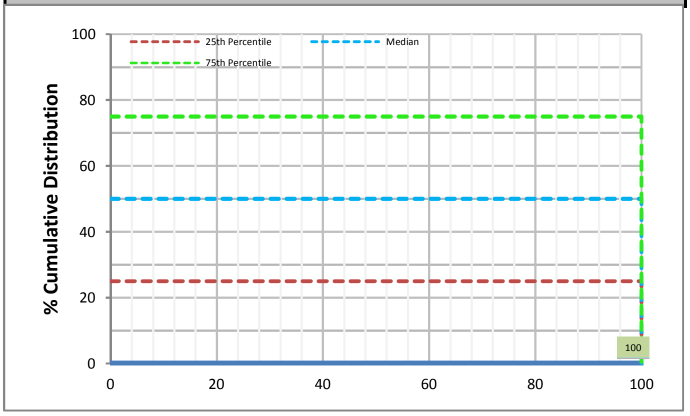
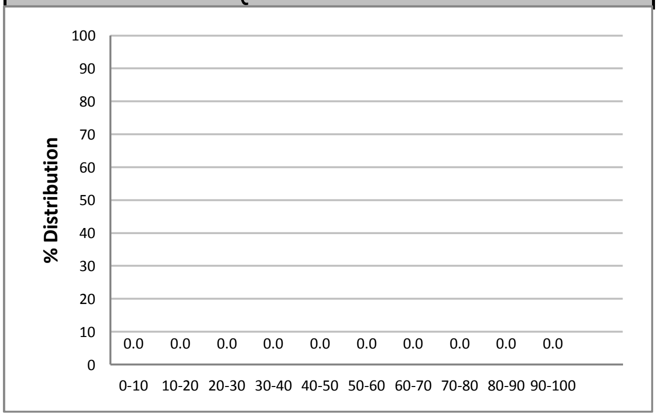


RQD DISTRIBUTION



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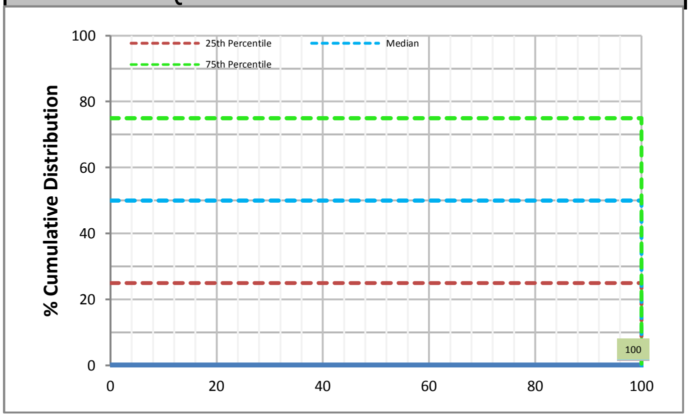
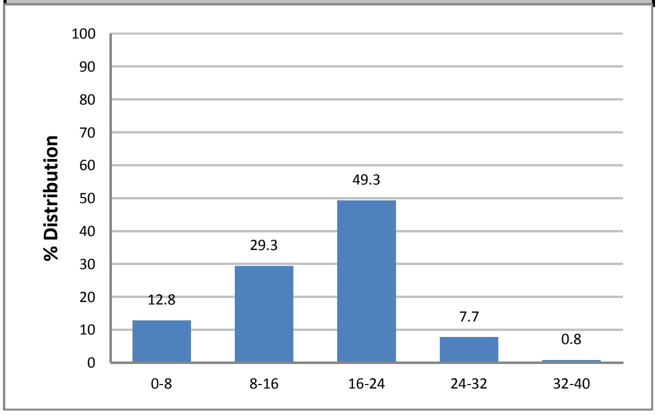


RMR MASS DATA - RMR PARAMETERS

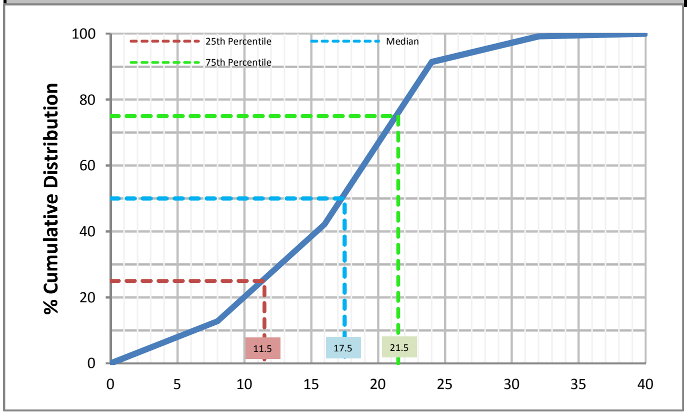
KGH001 - Ajax | Old Data

Domain: IMH | Meters Logged: 1876.26 m

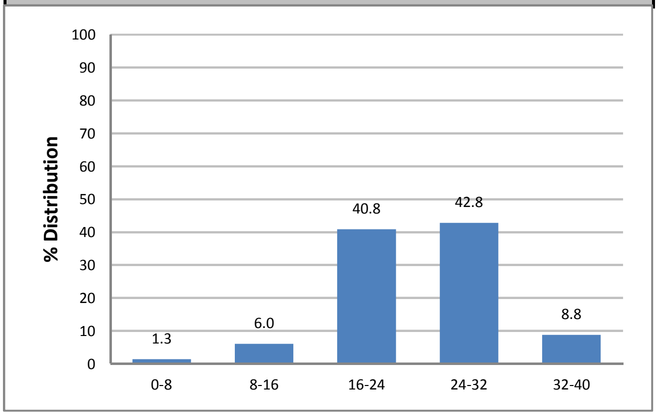
Nf DISTRIBUTION



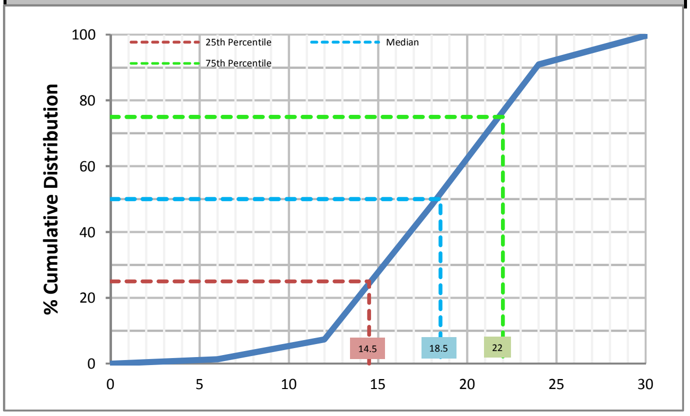
Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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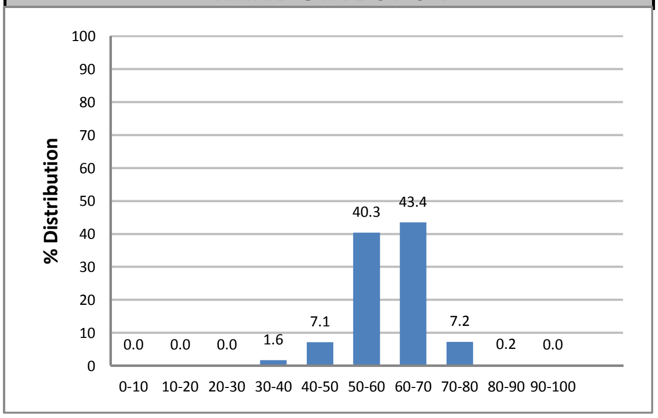

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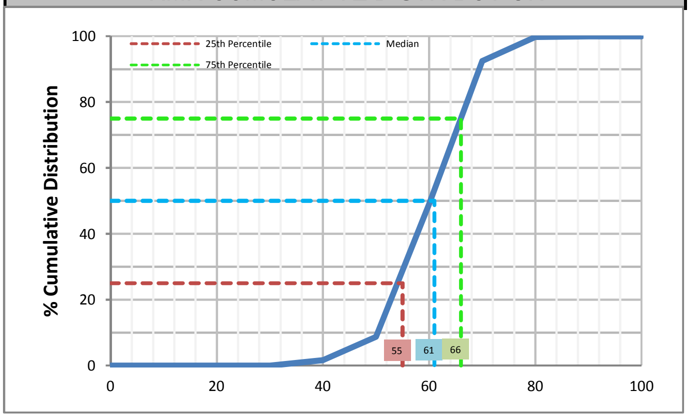

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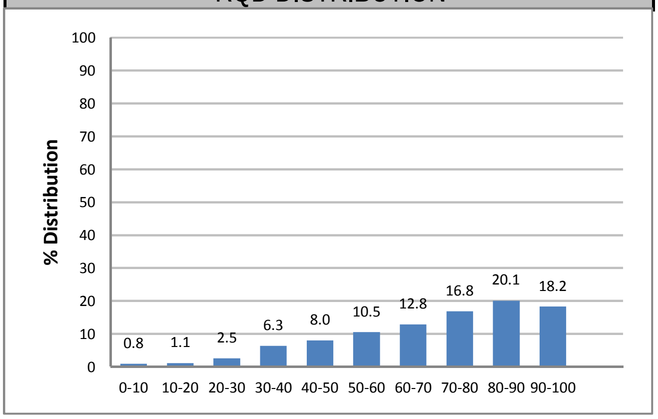

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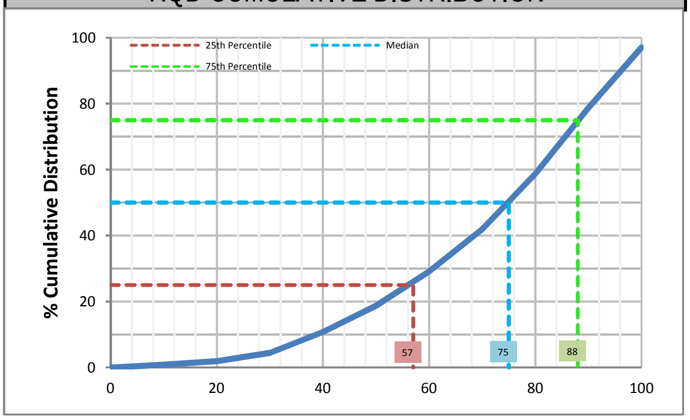


RMR MASS DATA - RMR PARAMETERS

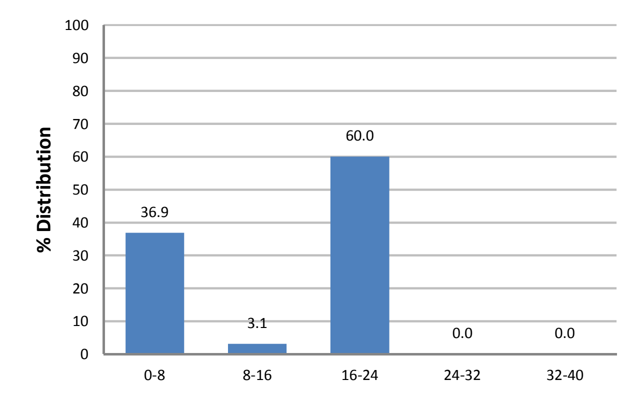
KGH001 - Ajax

Old Data

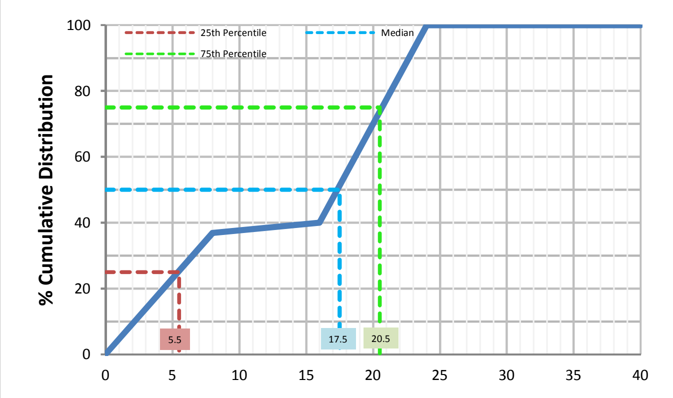
Domain: LAT

Meters Logged: 15.24 m

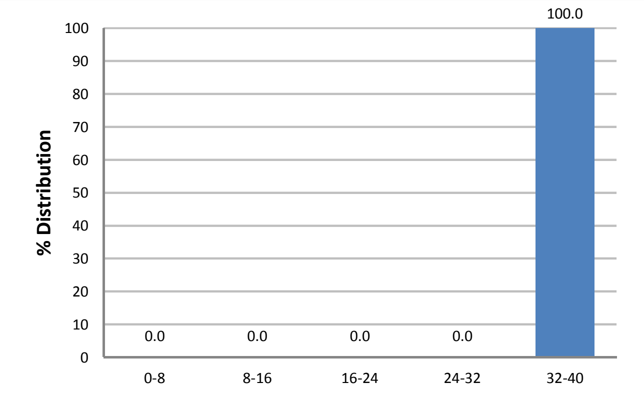
Nf DISTRIBUTION



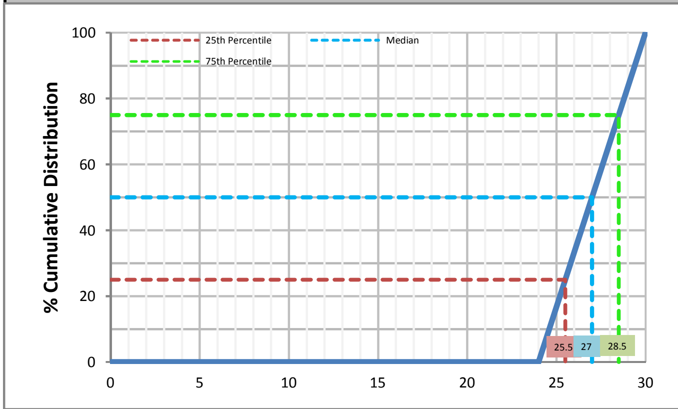
Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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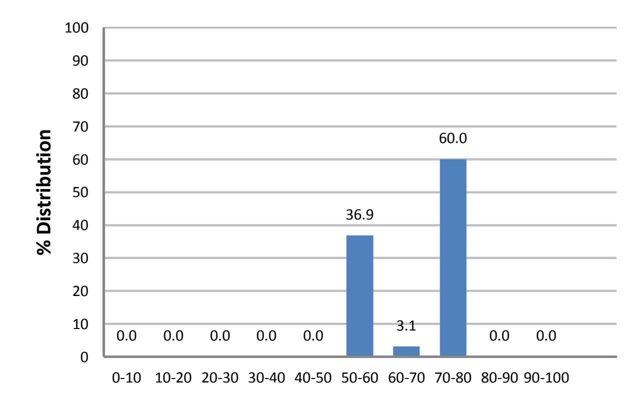

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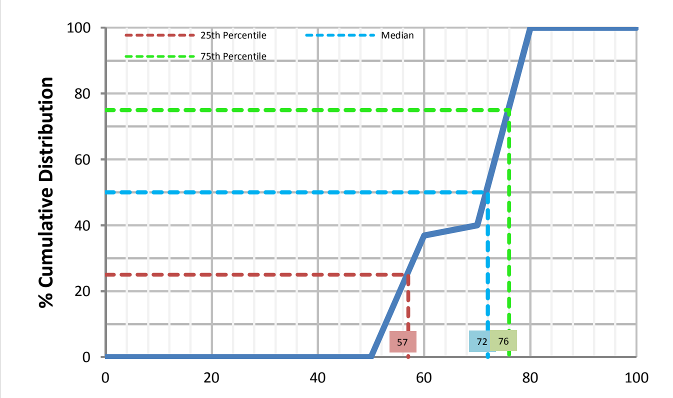

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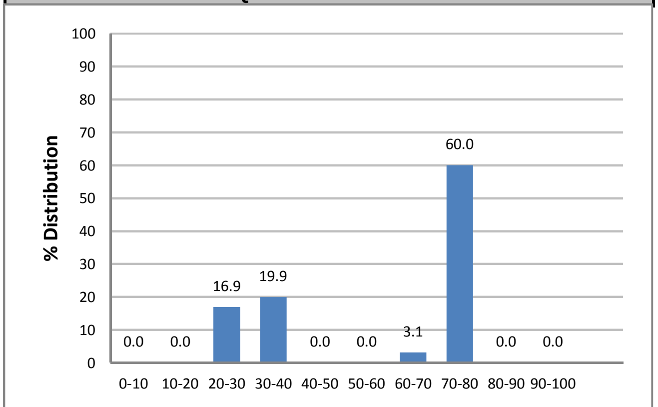
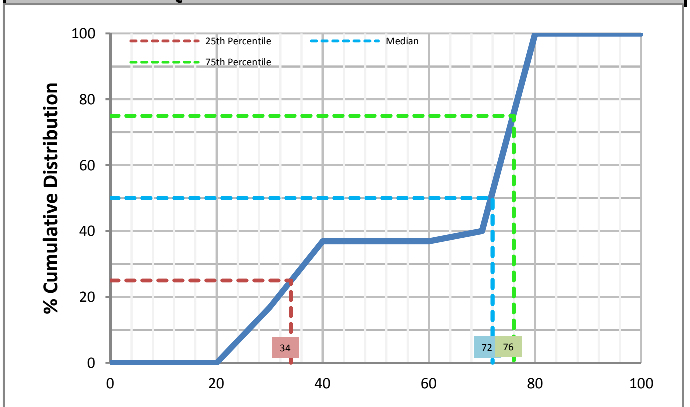


RQD CUMULATIVE DISTRIBUTION

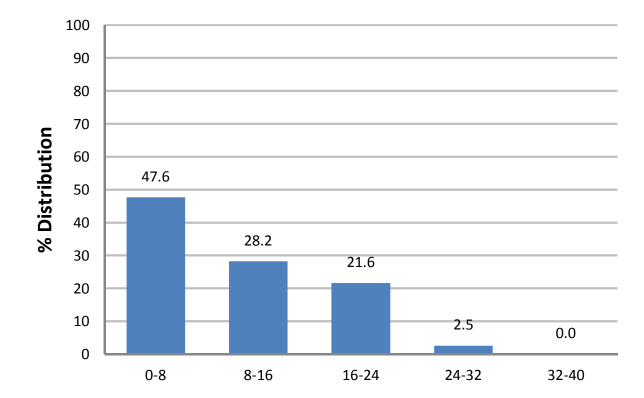


RMR MASS DATA - RMR PARAMETERS

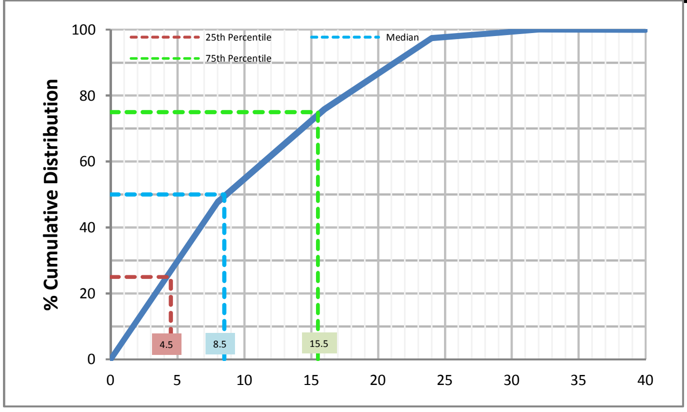
KGH001 - Ajax | Old Data

Domain: MAFV | Meters Logged: 295.96 m

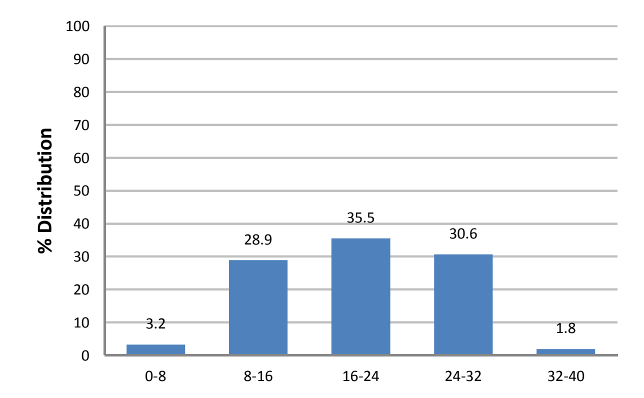
Nf DISTRIBUTION



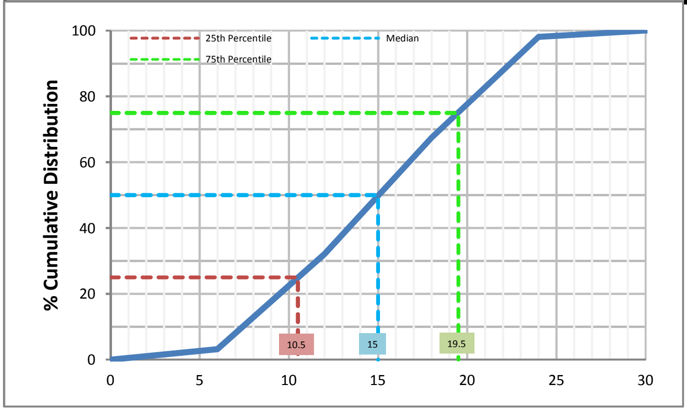
Nf CUMULATIVE DISTRIBUTION



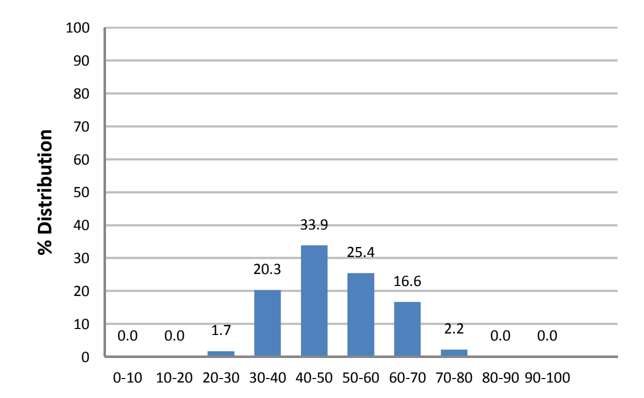
Nc DISTRIBUTION



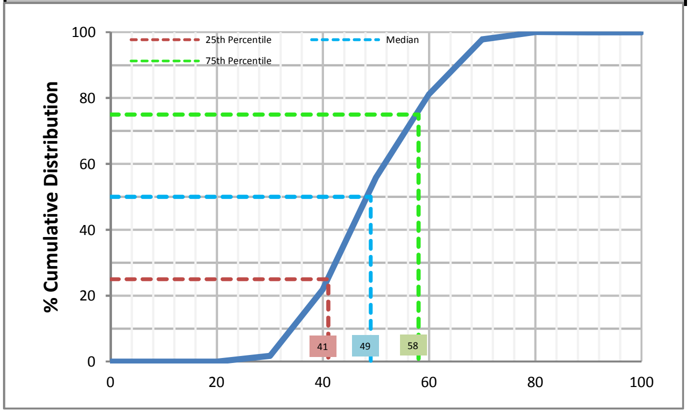
Nc CUMULATIVE DISTRIBUTION



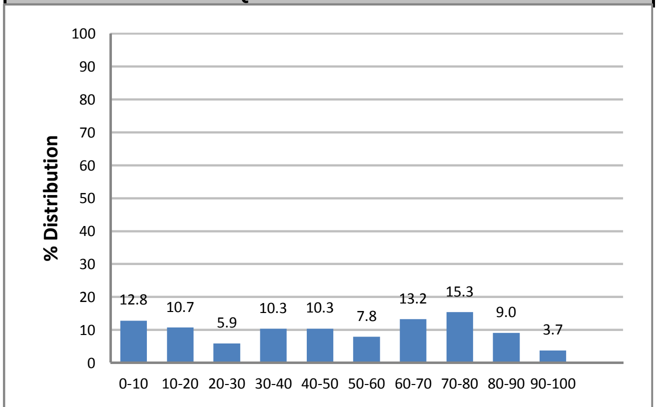
RMR DISTRIBUTION



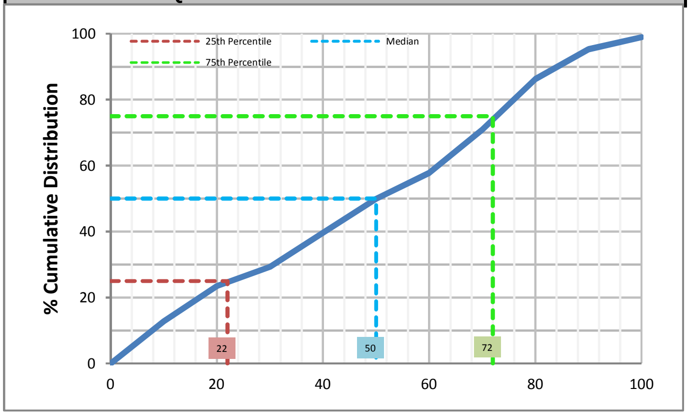
RMR CUMULATIVE DISTRIBUTION



RQD DISTRIBUTION



RQD CUMULATIVE DISTRIBUTION

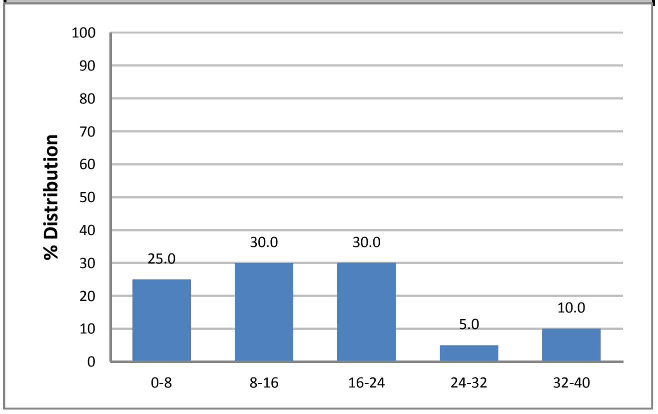


RMR MASS DATA - RMR PARAMETERS

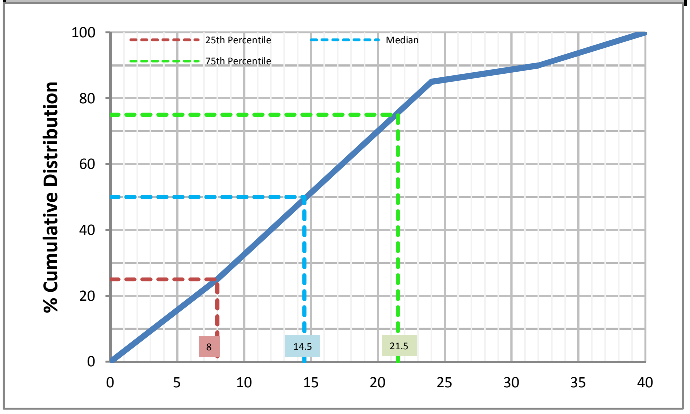
KGH001 - Ajax | Old Data

Domain: MONZ | Meters Logged: 30.48 m

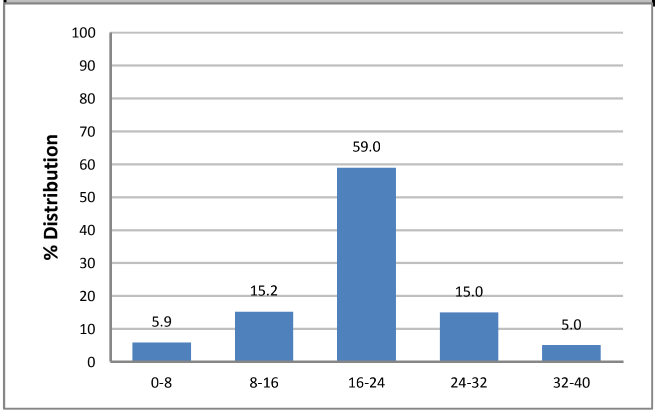
Nf DISTRIBUTION



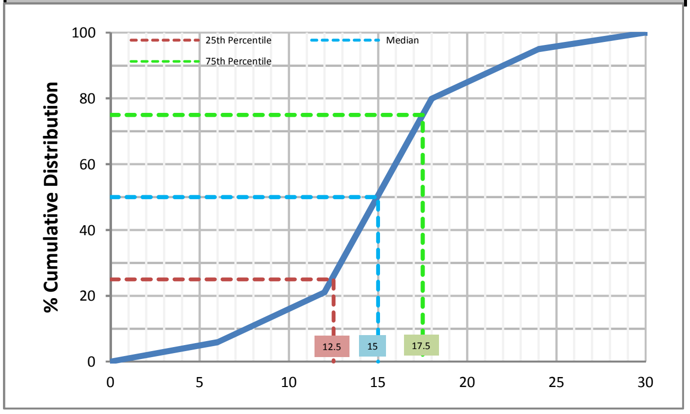
Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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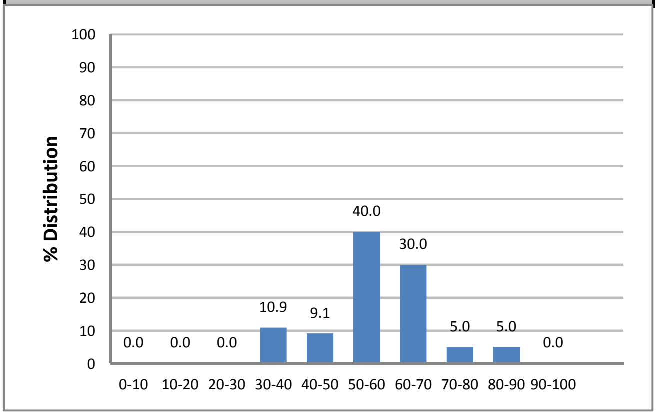

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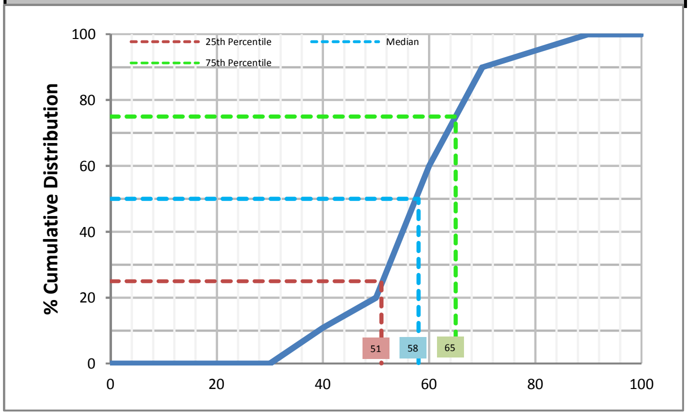

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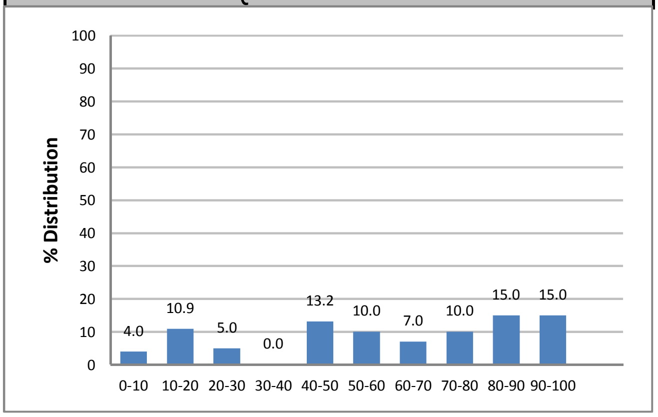

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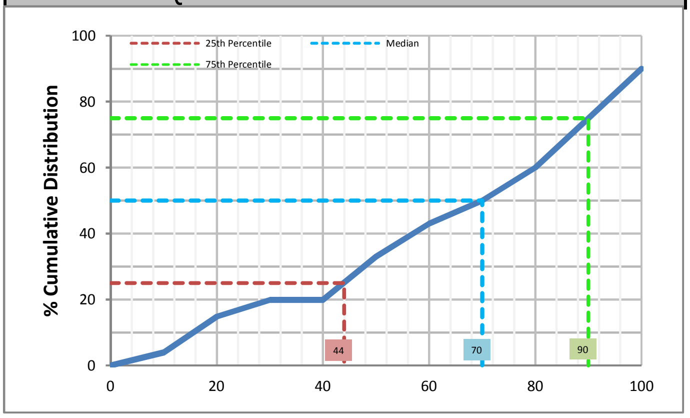


RMR MASS DATA - RMR PARAMETERS

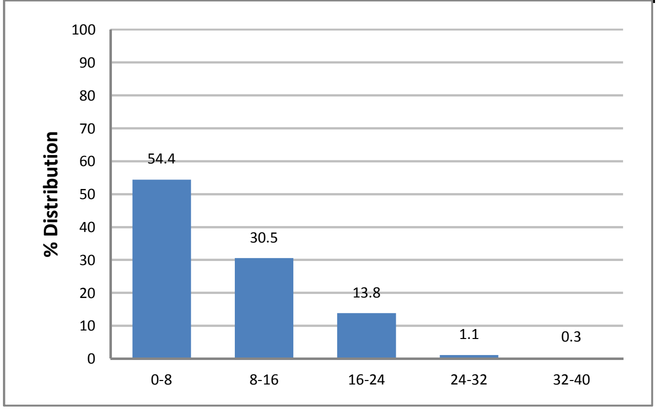
KGH001 - Ajax

Old Data

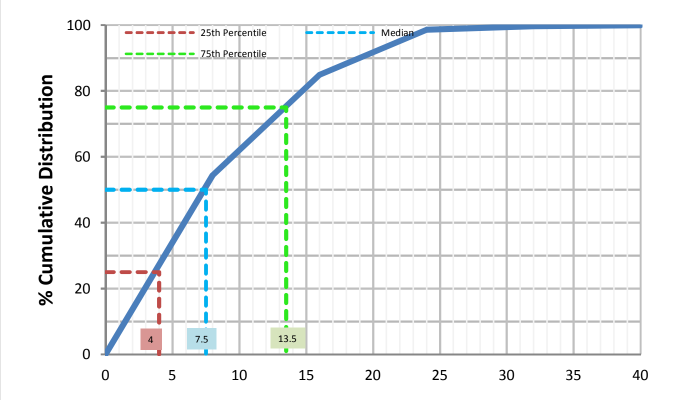
Domain: PICR

Meters Logged: 2677.03 m

Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



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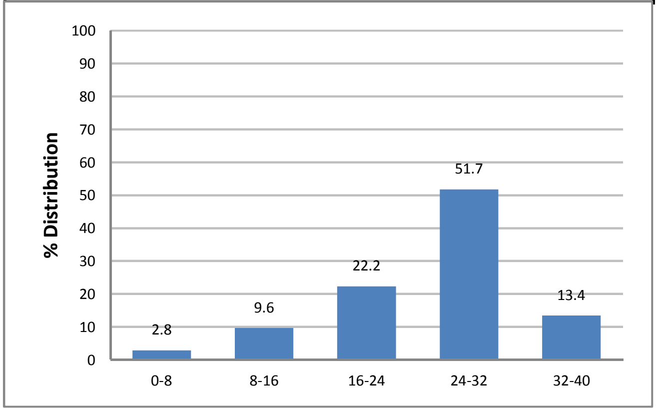
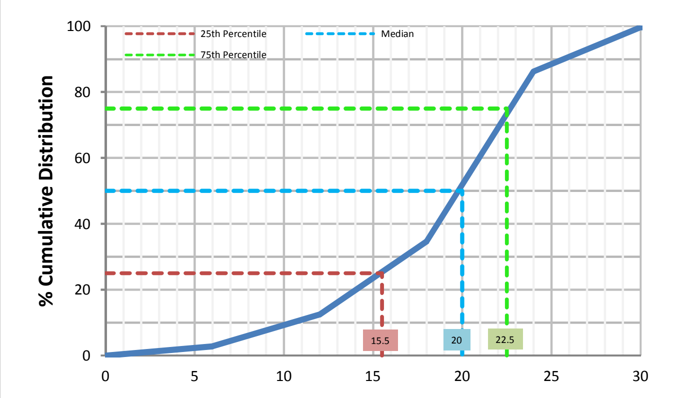


Nc CUMULATIVE DISTRIBUTION



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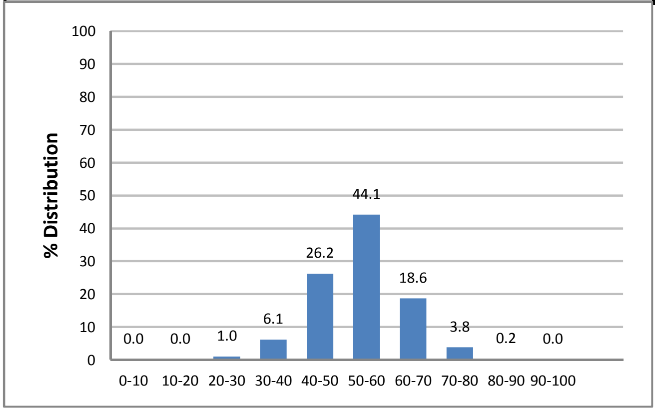

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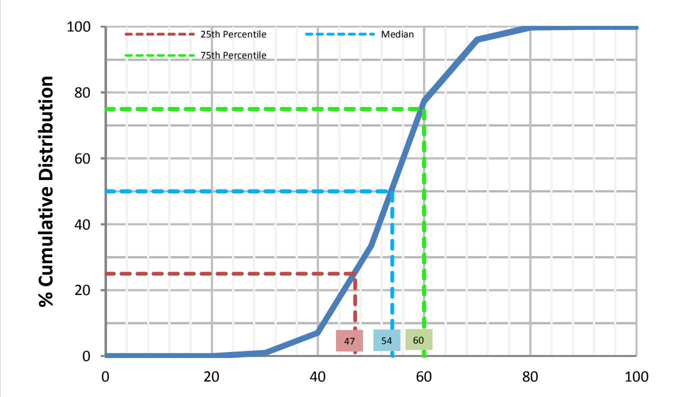

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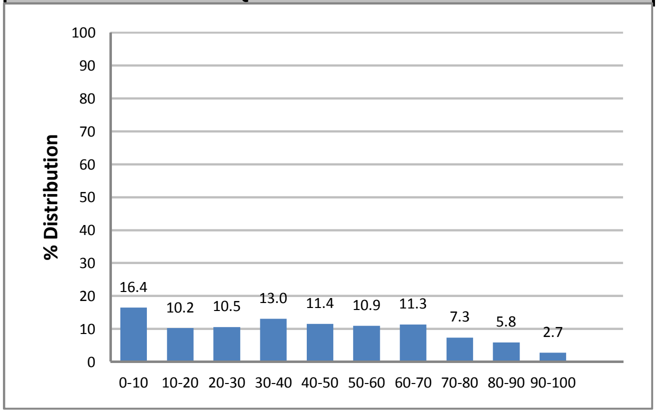

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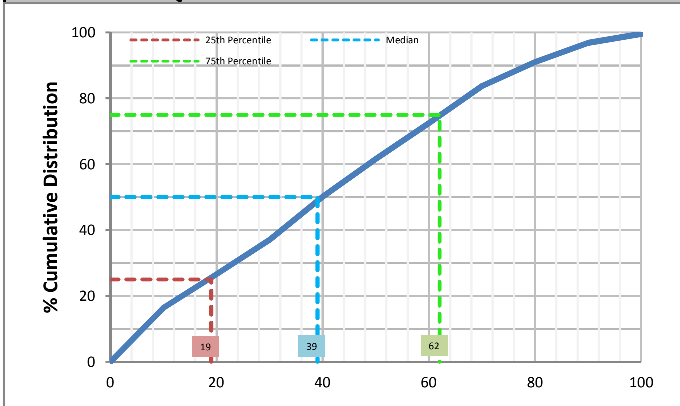


RMR MASS DATA - RMR PARAMETERS

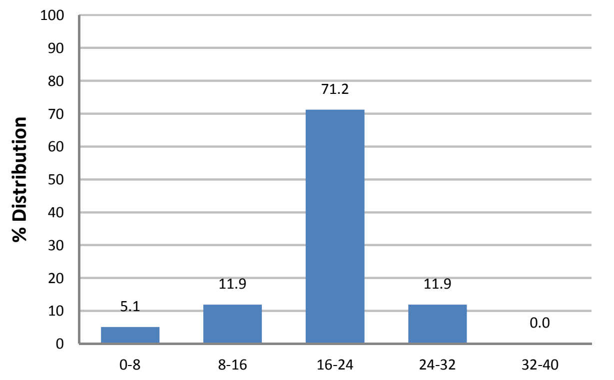
KGH001 - Ajax

Old Data

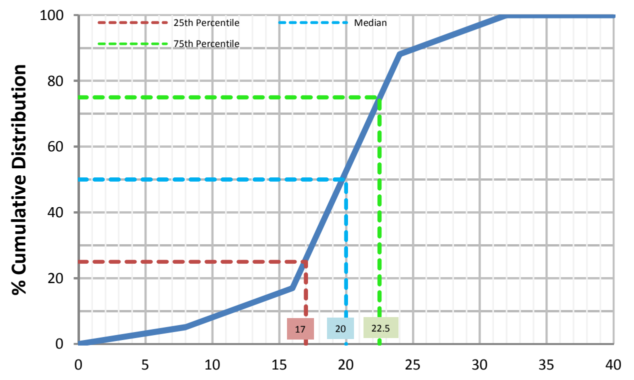
Domain: PXPP

Meters Logged: 179.83 m

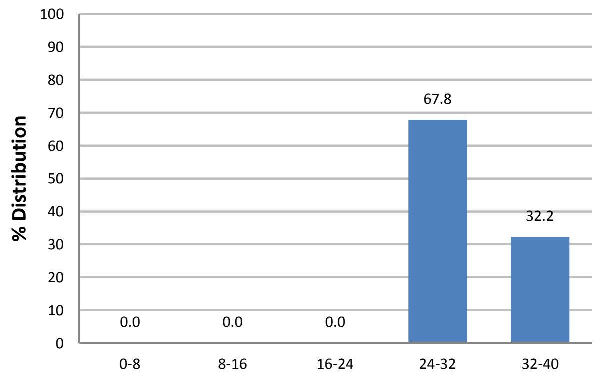
Nf DISTRIBUTION



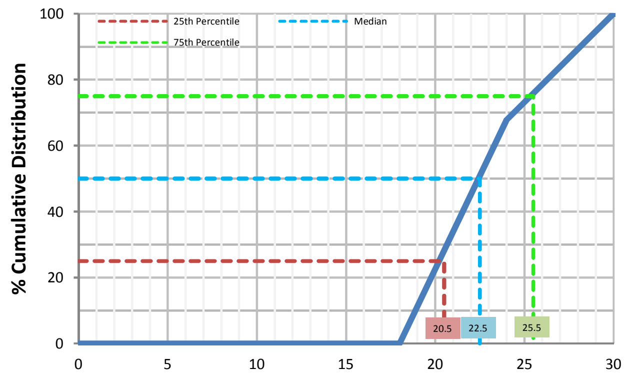
Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



Nc CUMULATIVE DISTRIBUTION



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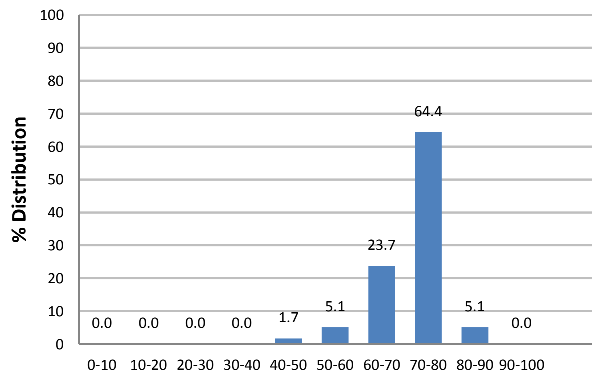

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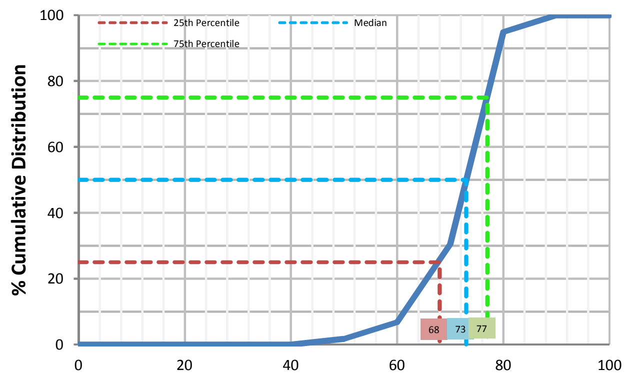

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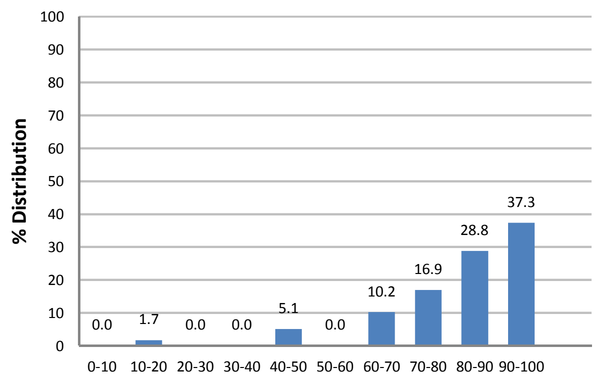

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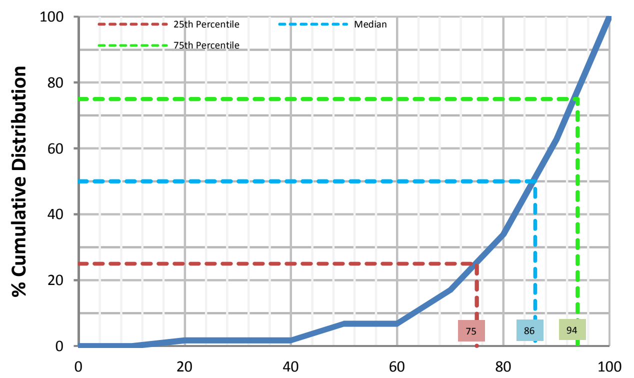


RMR MASS DATA - RMR PARAMETERS

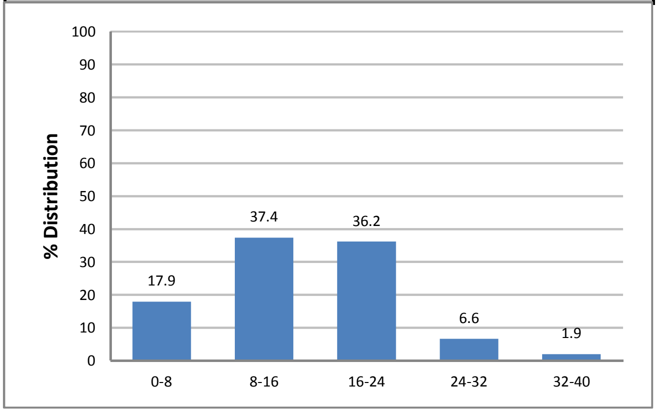
KGH001 - Ajax

Old Data

Domain: SLD

Meters Logged: 2796.65 m

Nf DISTRIBUTION



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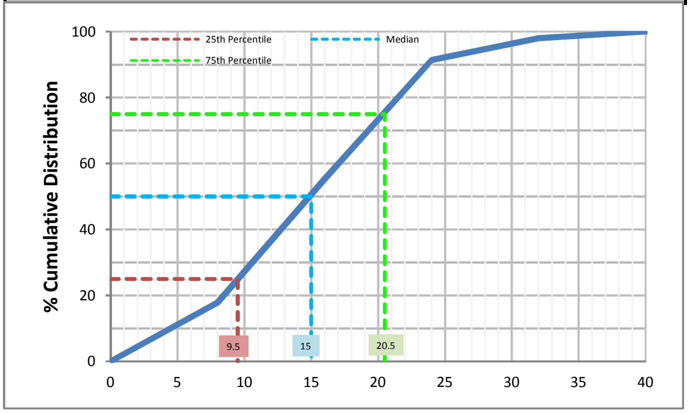
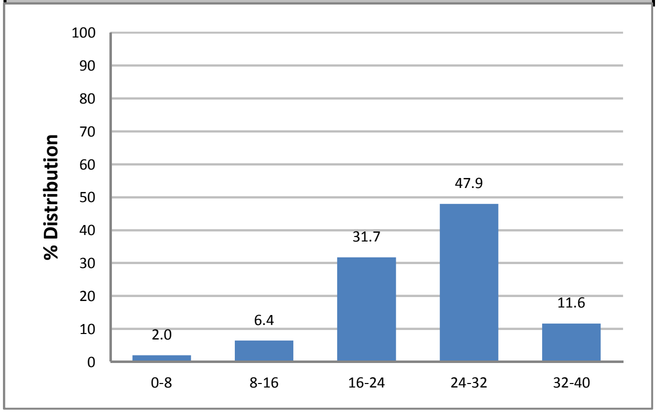


Nc DISTRIBUTION



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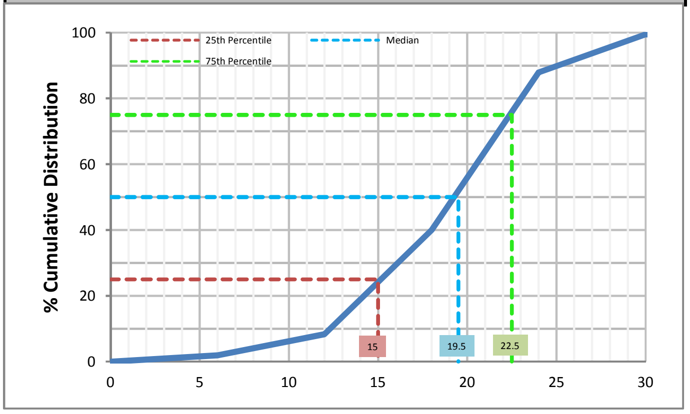

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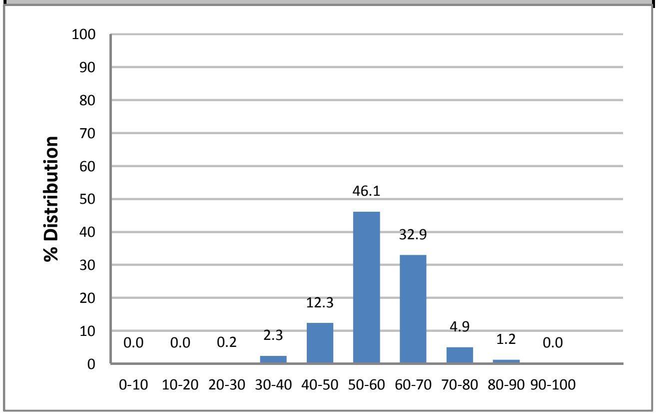

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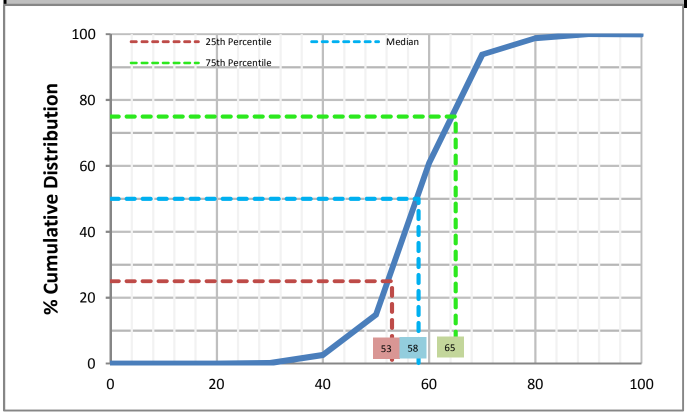

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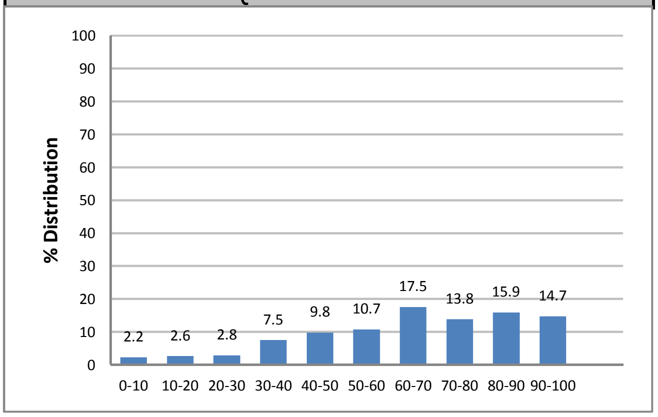
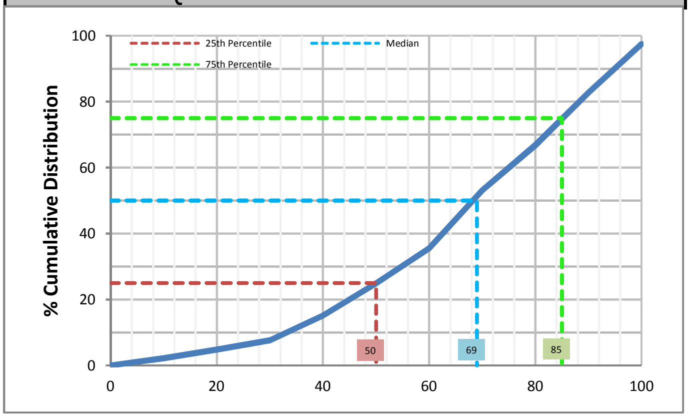


RQD CUMULATIVE DISTRIBUTION



RMR MASS DATA - RMR PARAMETERS

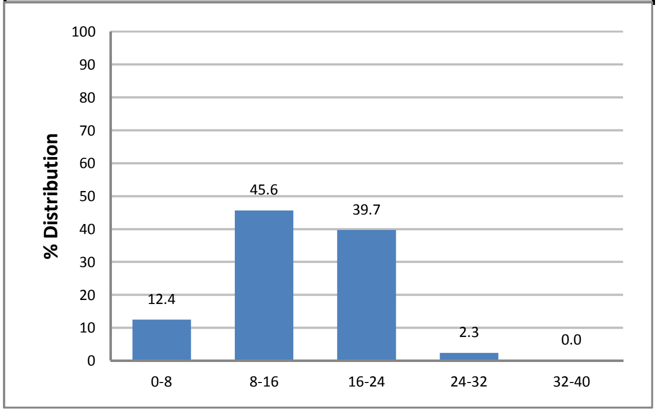
KGH001 - Ajax

Old Data

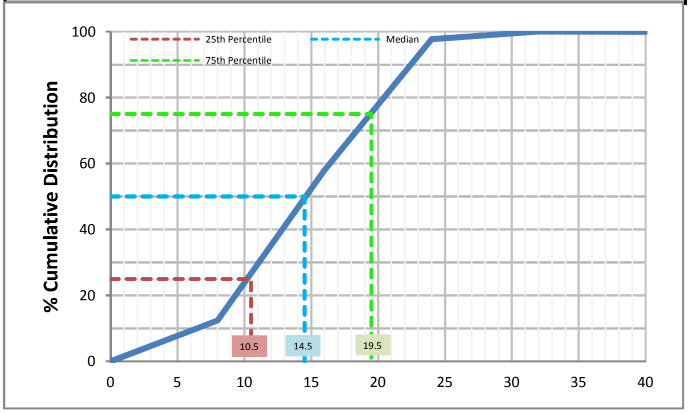
Domain: SVHYB

Meters Logged: 675.74 m

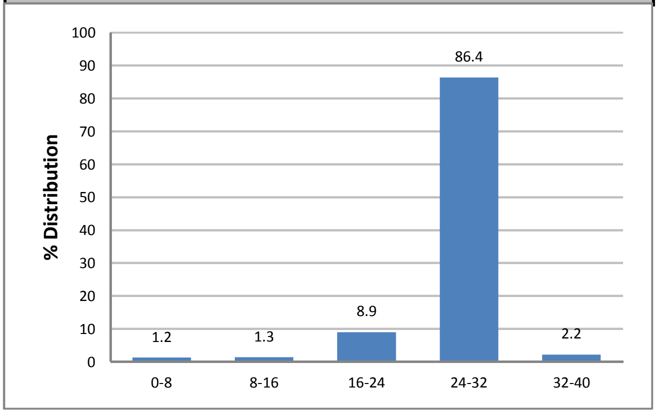
Nf DISTRIBUTION



Nf CUMULATIVE DISTRIBUTION



Nc DISTRIBUTION



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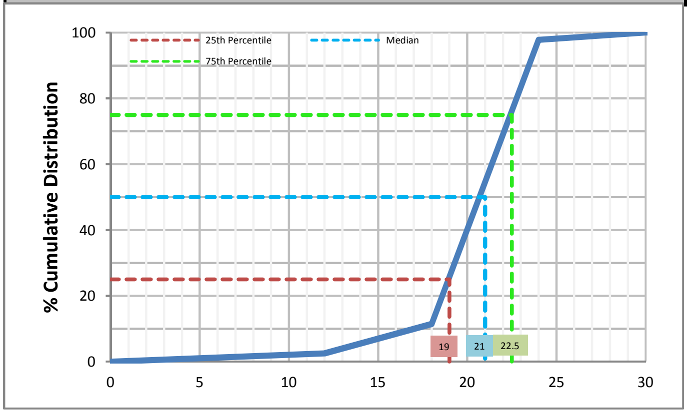

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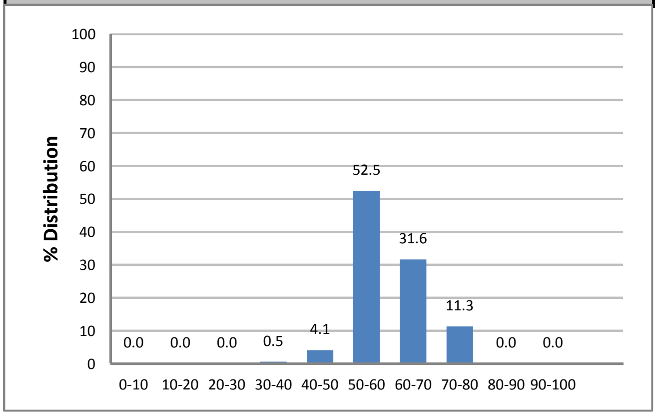

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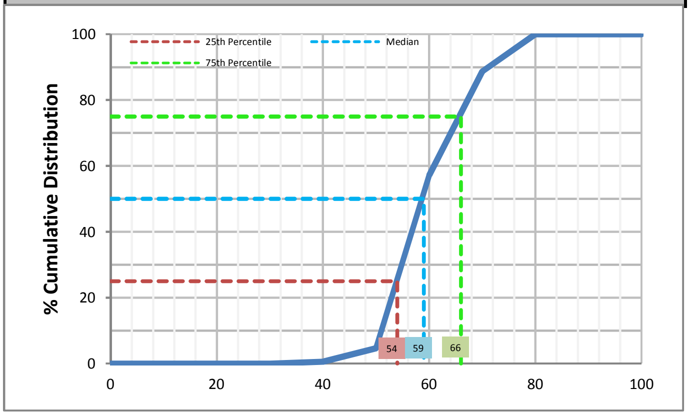
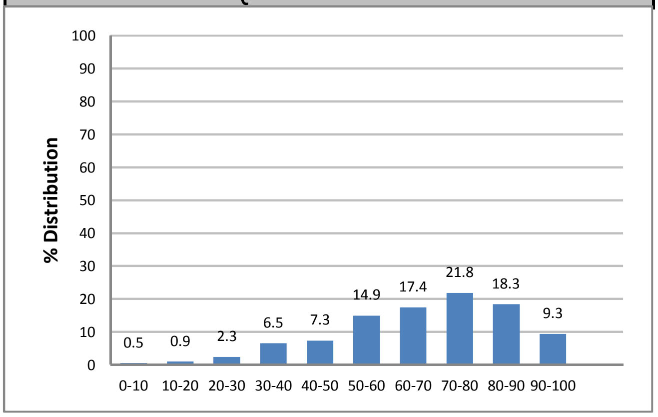


RQD DISTRIBUTION



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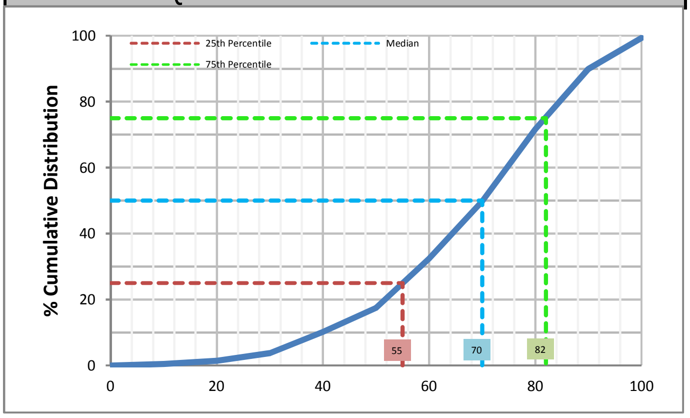

Appendix B: Structural Data

1 Introduction

This appendix summarises the structural data used for subsequent kinematic assessment as part of the Ajax project.

Structural data was obtained from three sources:

- Historical data, collected and used by BCG Engineering Inc for the preliminary geotechnical assessment (holes drilled between ~2006 and 2011).
- Recently drilled geotechnical holes (drilled in 2013), logged according to KGHM protocol.
- ATV logging of selected drillholes from both drilling campaigns.

The ATV logging is particularly useful when low reliability of the orientation line is expected, especially in less competent rock masses where obtaining accurate joint orientation from structural logging can be difficult. In addition it helps to eliminate structural bias down the drillhole as physical logging can miss important structures sub-parallel to the drillhole axis, leading to blind zones where important structural sets are poorly defined or missed. The ATV logging has been especially useful for this investigation as the structural logging frequently missed steeply dipping joints.

For the purpose of the structural assessment, the structural data from the drillholes was split into the eight sectors identified by the initial Geotechnical Domaining as detailed in Figure B-1. All structural assessment and subsequent kinematic analysis were based on these sectors. Following initial 2D numerical modelling, the boundaries between Sectors 1 and 8 and Sectors 6 and 7 were changed as shown in Figure B-2. This was due to the impact of the location of Jacko Lake on the slope design for Sector 1 and the overall slope failure mechanism identified in Sector 6. The joint sets identified in Sectors 1 and 8 and Sectors 6 and 7 are broadly similar and the slope face directions have not changed for the sectors as a result of moving the boundaries, therefore, the structural Sectors were left as per the original boundaries.

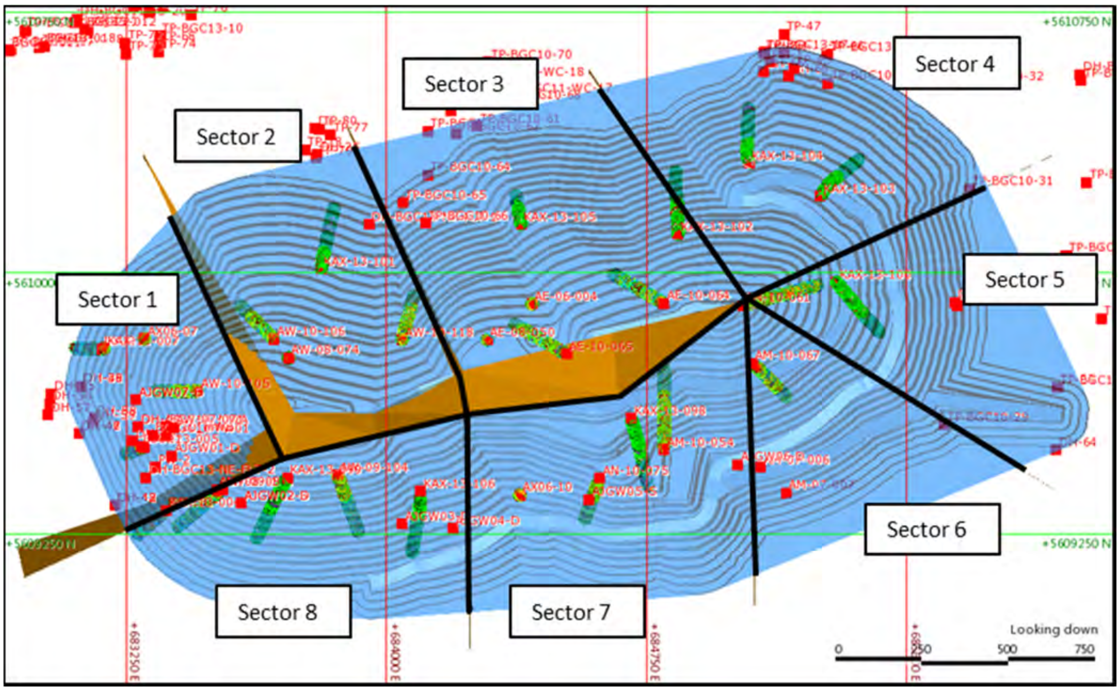

Figure B-1: Final pit with location of original Sectors

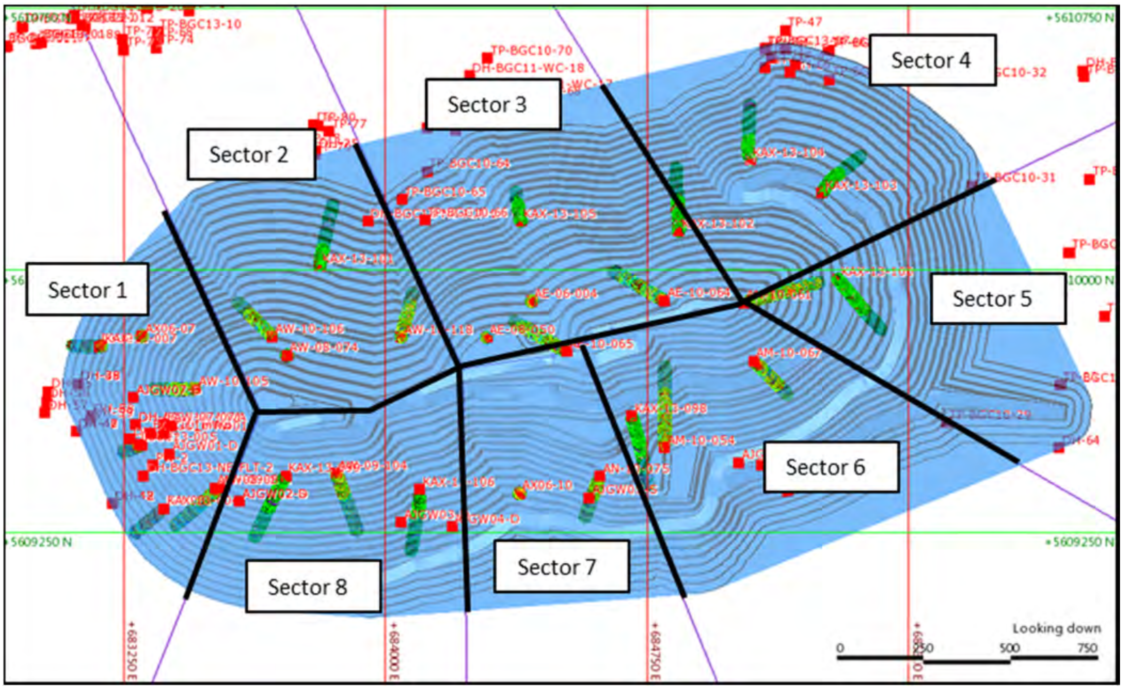

Figure B-2: Final pit shell with location of final Sectors

2 Structural assessment

Structural assessments were undertaken using Rocscience™ *Dips* software. The structural data was initially sorted by drillhole in each of the eight Sectors.

Table B-1 shows the drillholes used in each Sector. Structurally logged structures and ATV logged structures were kept separate throughout for comparison purposes and to ensure that weaker joint sets identified by the ATV logging were not overlooked. In some cases either structurally logged or ATV logged data is not present for a particular rock type.

Once the structural data was separated by drillhole per sector, the structural data was split into the individual geological units combined per geological domain. Table B-2 details the geological domains per sector. The geological unit “Monzo” (Monzodiorite) is present as a narrow intrusion. Therefore, the structural data from the Monzo unit was combined with the larger surrounding unit for completeness. The structures in the Monzo were similar to the surrounding materials and due to the limited extent of the unit, would not significantly impact on slope stability.

Table B-1: Drillholes in each Sector

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8
BHID	AX06-07	AW-08-074	AE-06-004	KAX-13-103	AM-10-061	AM-10-067	AX06-10	AW-09-103
	AW-10-105	AW-10-106	AE-08-050	KAX-13-104	KAX-13-100		AM-10-054	AW-09-104
	KAX-13-005	AW-10-118	AE-10-064				AN-10-075	KAX-13-004
	KAX-13-007	KAX-13-101	AE-10-065				KAX-13-098	KAX-13-099
			KAX-13-102					KAX-13-106
			KAX-13-105					

Table B-2: Domains per sector

	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8
Domains	IMH	IMH	IMH	IMH	IMH	SLD-SVHYB	SLD	NVP-NVV
	NVP-NVV	SVHYB	SLD-SVHYB		NVP-NVV	IMH	NVP	SLD
	SLD-SVHYB				SLD			

Once the structural data was arranged per domain, structural sets were identified from both the structurally logged and ATV logged stereonets. Between six and ten sets were identified per rock type. This is likely to be excessive in terms of the actual number of sets present in the rock mass however, it is difficult to determine the true number of sets from core logging as it results in a large scatter of data. For the purpose of this FS level study the high number of sets are considered appropriate for kinematic analysis.

2.1 Comparison with Photogrammetry

The structural data was compared, where possible, to that collected by photogrammetry as part of the BGC (2011) report. The photogrammetry was undertaken within the existing pits well away from the final pit shell for which this new assessment has been undertaken. Figure B-3 shows zones were photogrammetry was undertaken as part of the BGC (2011) report that have identified sets similar to those in Sector 2 (M6) and Sector 6 (M2). Although the M6 photogrammetry zone is closer to Sectors 3 and 7, the data does not compare well with sets in these Sectors. The BGC report identified a number of steeper joint sets which were less apparent in the drillhole data. This is because sub-vertical structures are easier to identify in the exposed benches of the open pit, but not frequently intersected by the orientation of the drillholes. Therefore, where weak sets or a small number of steeply dipping poles were identified in the drillhole data, steeply dipping sets were created, where appropriate, to account for this. Figure B-4 and Figure B-5 show the similar sets identified in Sectors and photogrammetry.

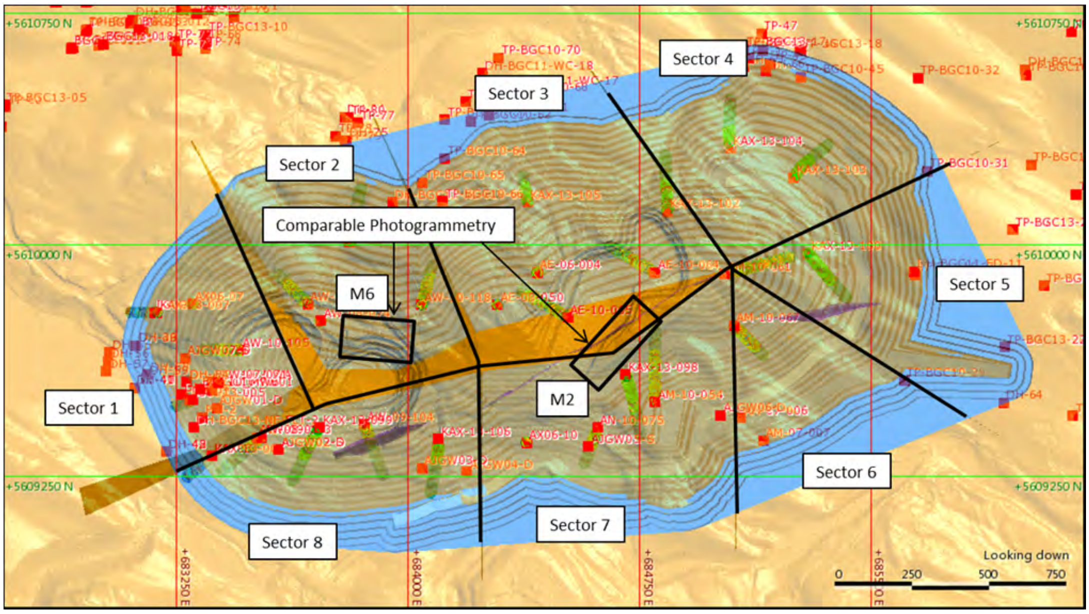

Figure B-3: Sectors and zones of comparable photogrammetry

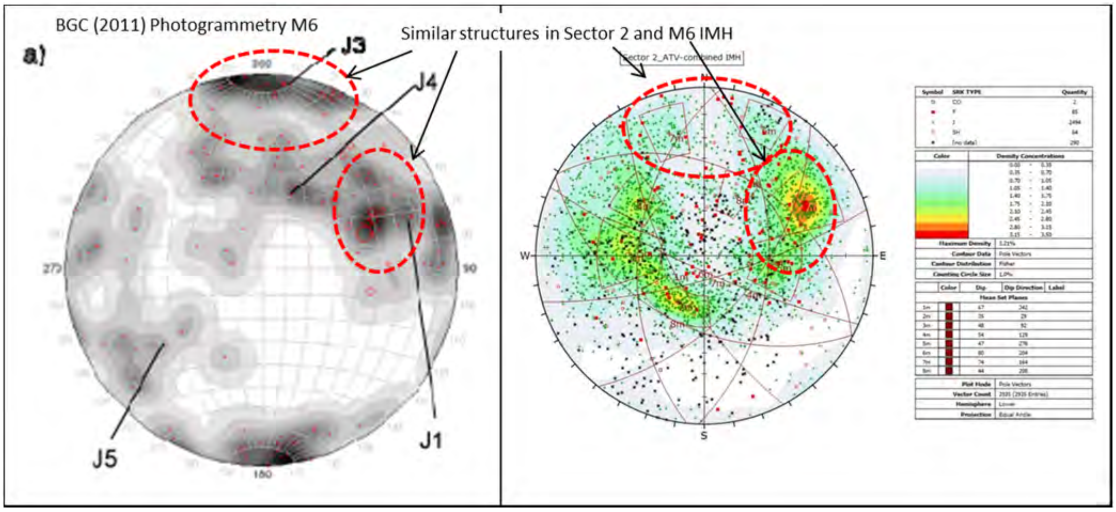

Figure B-4: Sets identified by both photogrammetry and logging (Sector 2 and M6)

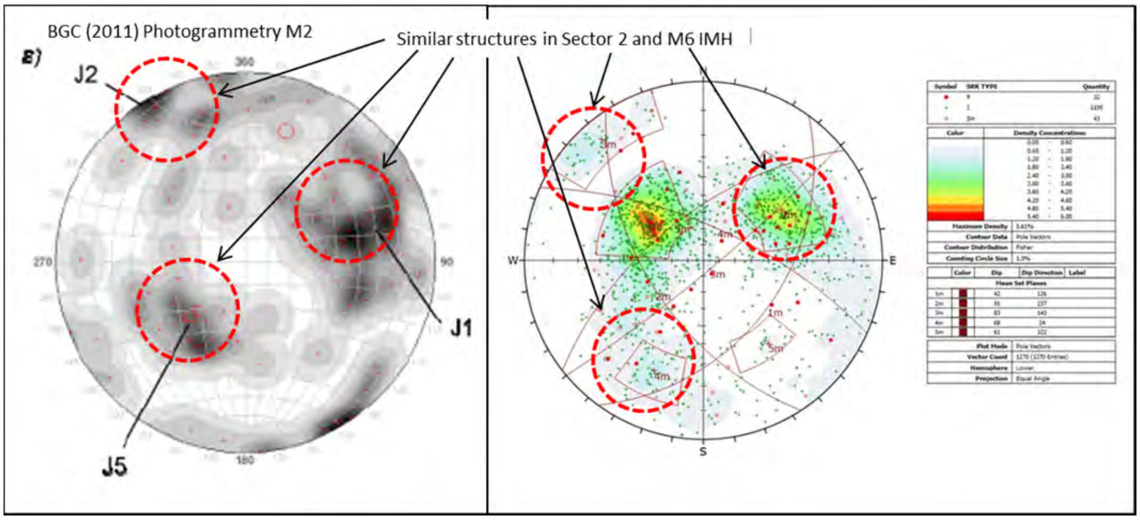

Figure B-5: Sets identified by both photogrammetry and logging (Sector 6 and M2)

2.2 Sets per Sector

The structural sets identified per rock type per Sector are presented in Table B-3 to Table B-10 and show the dip and dip direction of the sets. In addition the origin (Structural logging or ATV logging) of the structural data is displayed along with the set strength and main structure type in the set. This helps with interpretation of the kinematic analysis and to determine the likelihood of the failures occurring as an unfavourably orientated but poorly defined joint set may theoretically result in large failure however, in reality due to the limited number of structures the likelihood of such failures occurring is low. In a number of older drillholes, structure types have not been identified. When this is the case a "?" has been placed next to the likely structure type Figure B-6 to Figure B-32 show the individual stereonets for either structurally logged or ATV logged structures for each rock type along with the set windows.

Sector 1

Table B-3: Sector 1 set information

Sector	Rock Type	Set	Dip	Dip Direction	Ori/ATV	Set Strength	Main Structure Type
1	IMH	1	36	321	ATV	High	JT/FT
		2	34	152	ATV/ORI	Medium	JT/FT
		3	16	93	ATV/ORI	Low	JT/SH
		4	51	210	ATV	Low	JT/FT
		5	58	135	ATV	Low	JT
		6	71	102	ATV	Medium	JT
		7	86	249	ATV	Medium	JT
		8	70	162	ATV	Low	JT
		9	64	79	ATV	Low	JT
		10	87	296	Ori	Low	JT
	NVP-NVV	1	41	166	ATV	High	SH/FT
		2	60	349	ATV	Medium	JT/FT
		3	60	287	ATV	Low	JT
		4	34	18	ATV	Low	JT/SH
		5	21	199	ATV	Medium	JT
		6	27	289	ATV	Low	JT
		7	72	108	ATV	Low	JT
	SLD-SVHYB	1	32	109	ORI	High	JT/SH
		2	46	155	ATV	High	JT
		3	84	96	ATV/ORI	High	JT
		4	45	74	ATV	Medium	JT/SH
		5	49	9	ATV	Low	JT
		6	73	66	ATV	Low	JT
		7	27	218	ATV	Low	JT/SH
		8	26	282	ATV	Low	JT

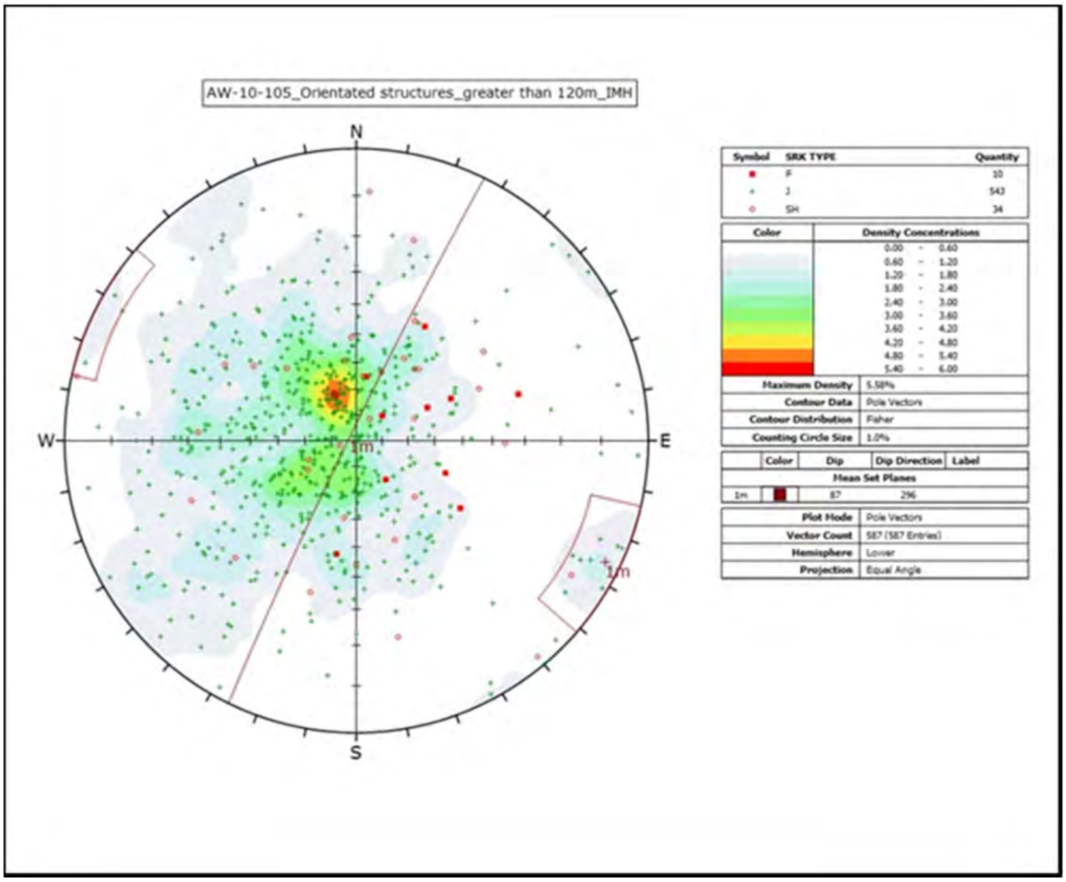

Figure B-6: Sector 1 structurally logged (orientated) structures in IMH

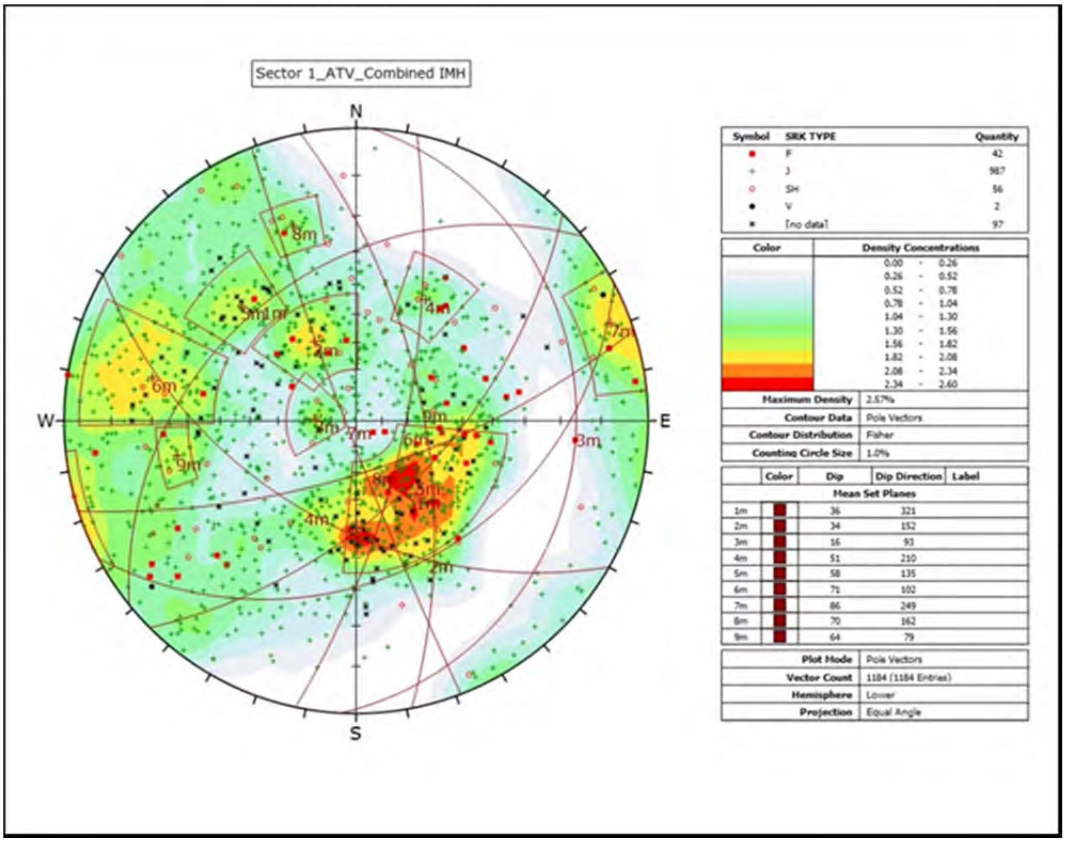

Figure B-7: Sector 1 ATV logged structures in IMH

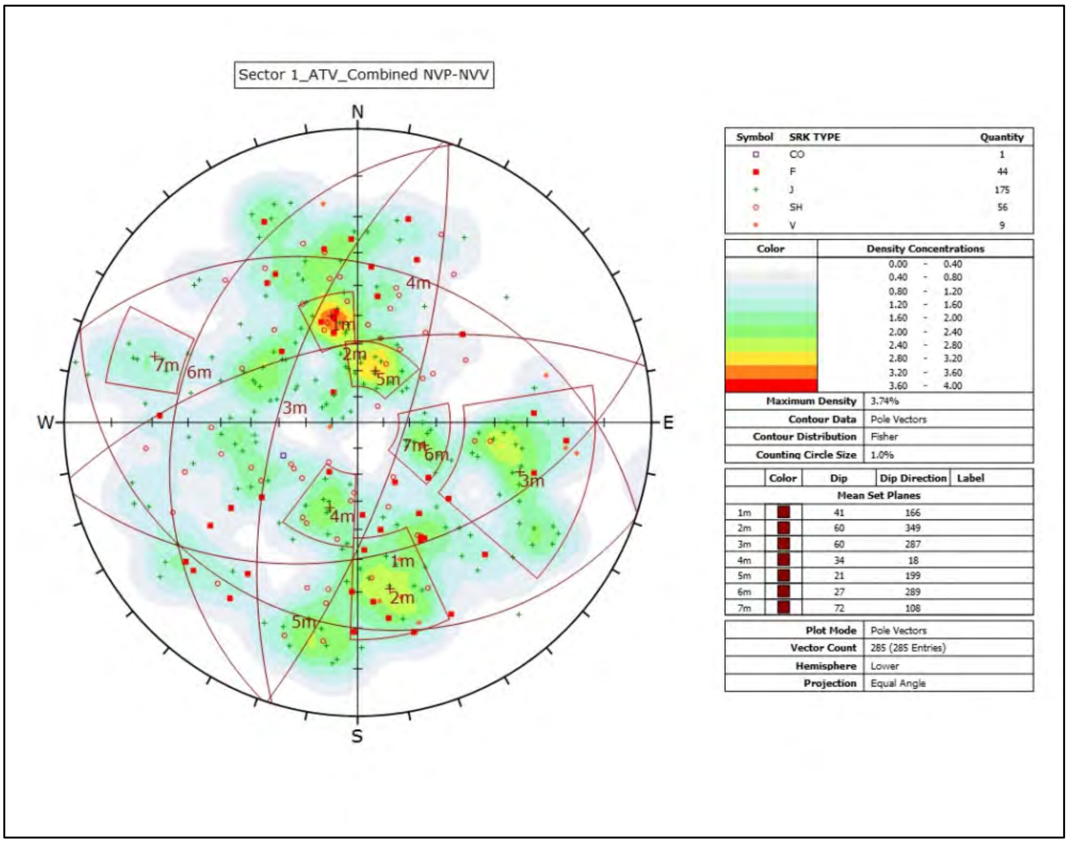

Figure B-8: Sector 1 ATV structures in NVP-NVV

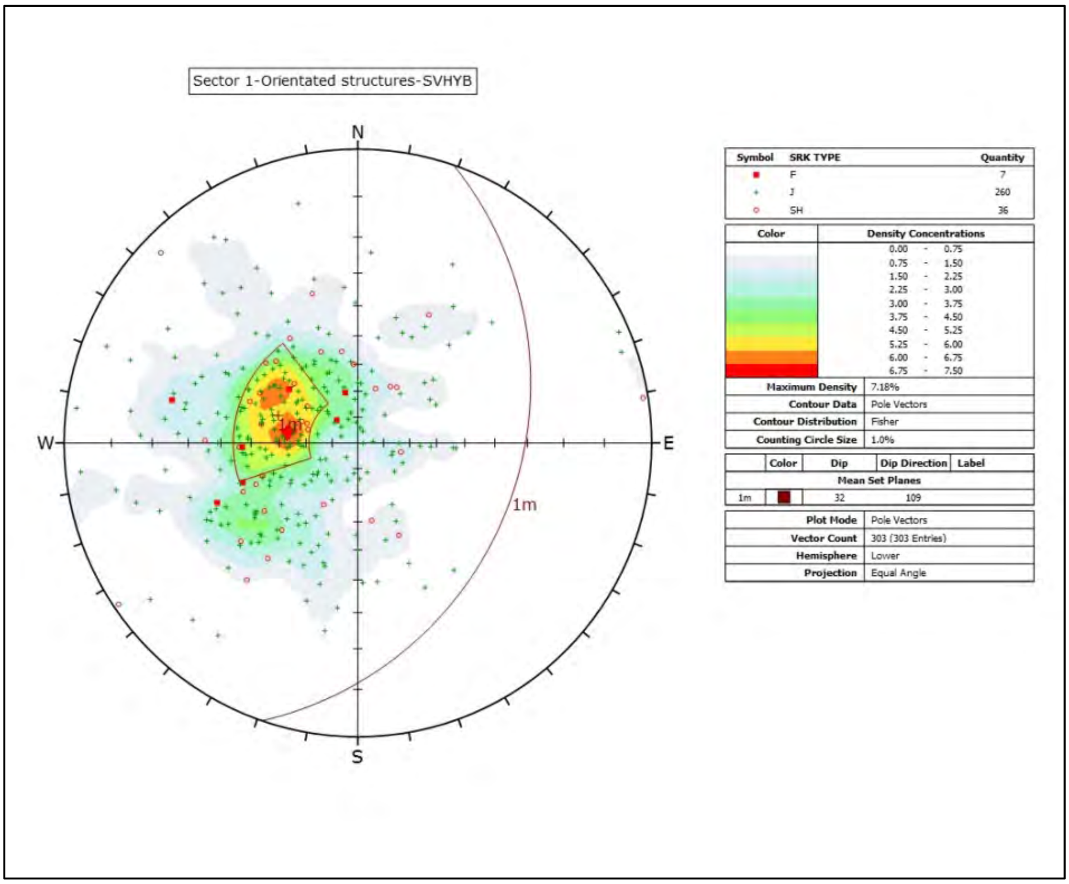

Figure B-9: Sector 1 structurally logged (orientated) structures in SVHYB

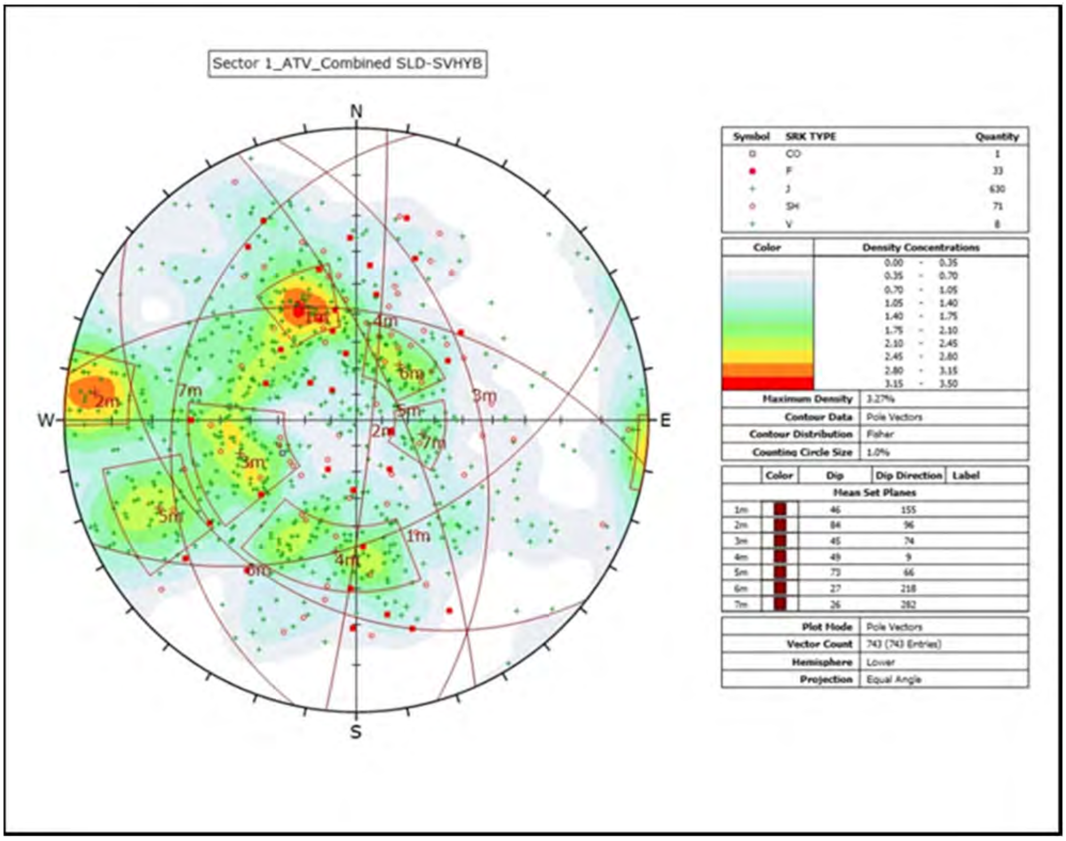

Figure B-10: Sector 1 ATV structures in SLD-SVHYB

Sector 2

Table B-4: Sector 2 set information

Sector	Rock Type	Set	Dip	Dip Direction	Ori/ATV	Set Strength	Main Structure Type
2	IMH	1	67	242	ATV/ORI	High	JT/FT
		2	35	29	ATV/ORI	High	JT/FT/SH
		3	48	92	ATV/ORI	High	JT
		4	54	129	ATV	Medium	JT/SH
		5	47	276	ATV	Medium	JT/SH
		6	80	204	ATV/ORI	Low	JT
		7	74	164	ATV/ORI	Low	JT
		8	44	208	ORI	Low	JT
	SVHYB	1	33	183	ATV	High	?
		2	48	342	ATV	Low	?
		3	79	35	ATV	Low	?
		4	85	68	ATV	Low	?
		5	52	81	ATV	Medium	?
		6	49	125	ATV	Medium	?
		7	15	133	ATV	Low	?

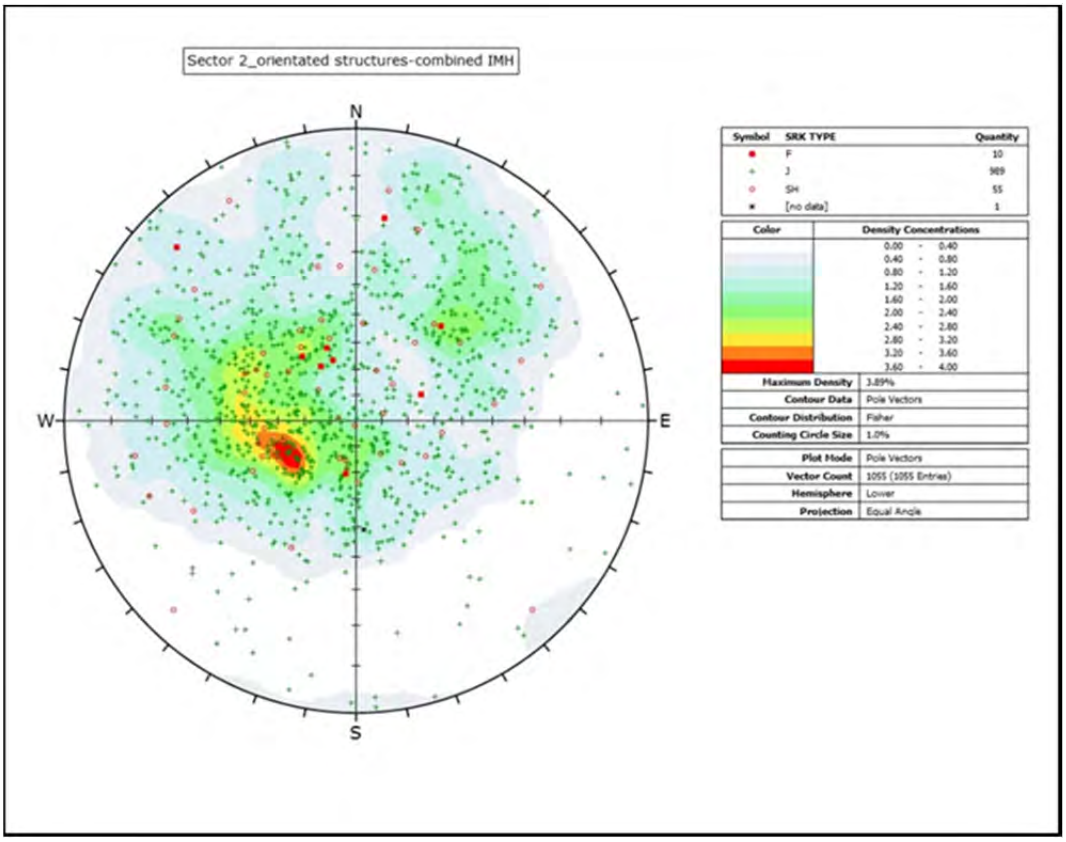

Figure B-11: Sector 2 structurally logged (orientated) structures in IMH

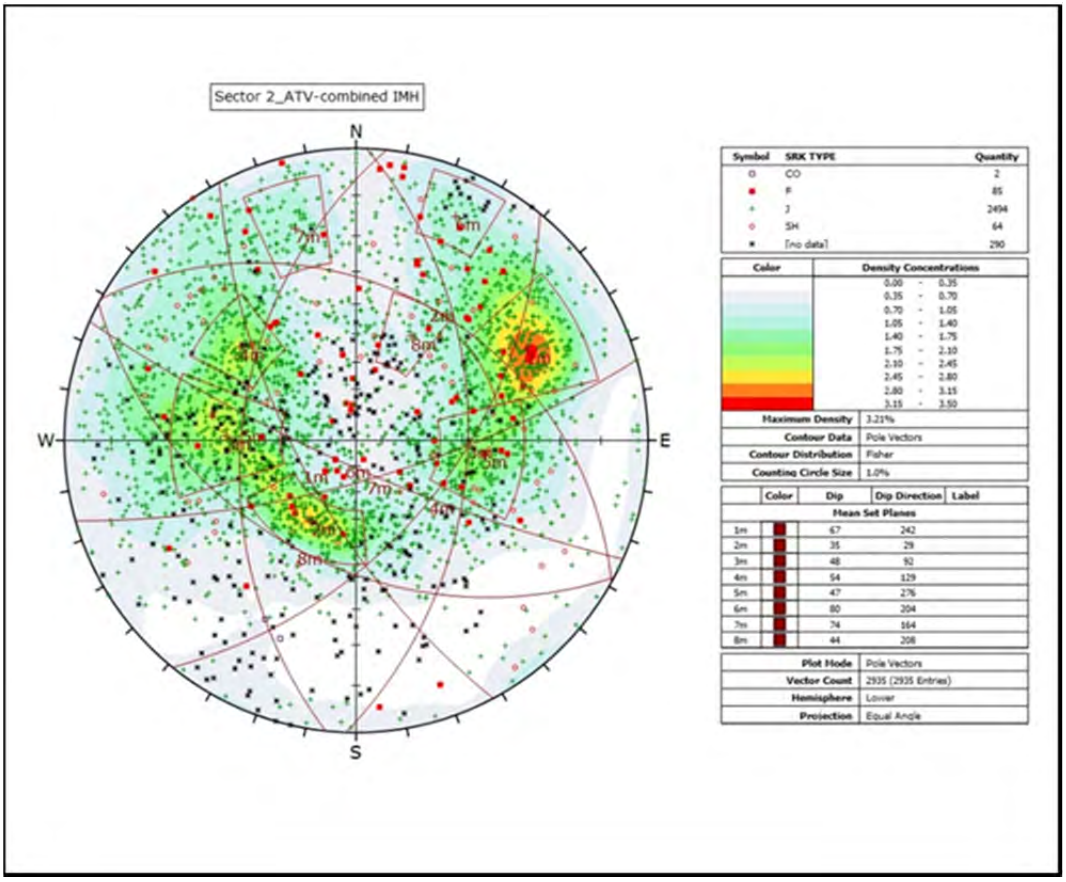

Figure B-12: Sector 2 ATV structures in IMH

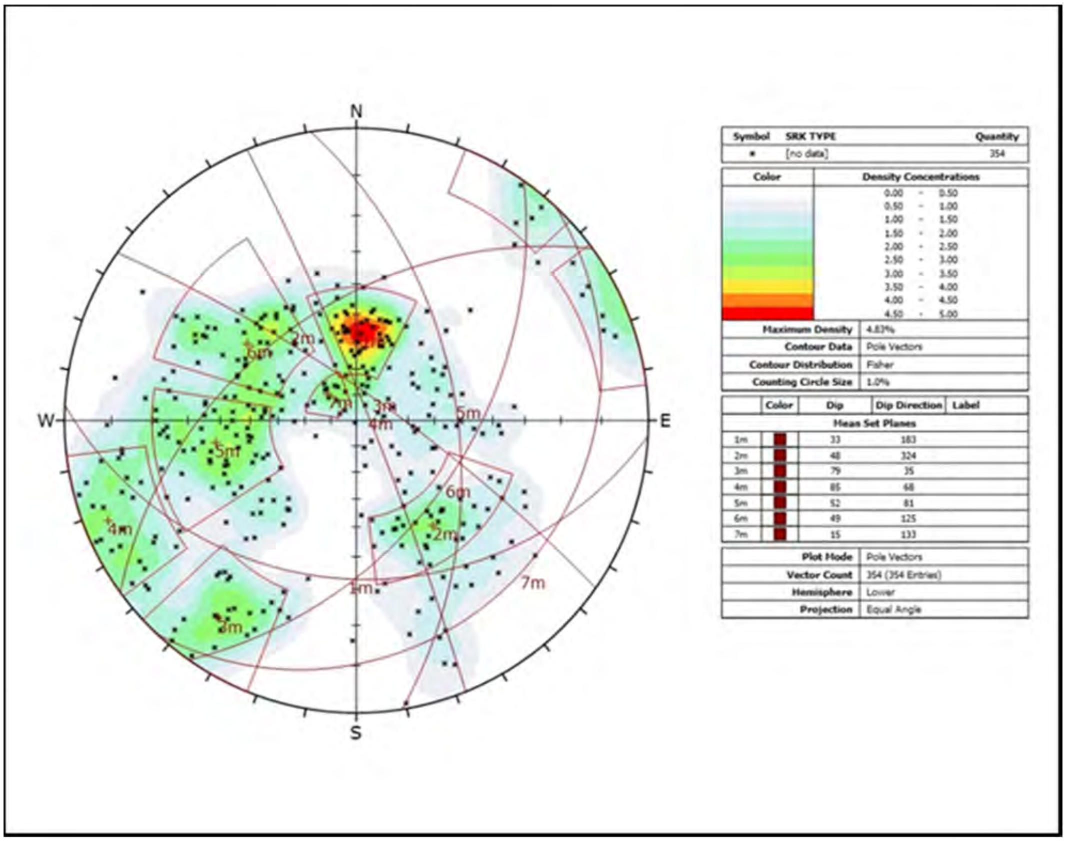

Figure B-13: Sector 2 ATV structures in SVHYB

Sector 3

Table B-5: Sector 3 set information

Sector	Rock Type	Set	Dip	Dip Direction	Ori/ATV	Set Strength	Main Structure Type
3	IMH	1	80	36	ATV	High	?
		2	43	97	ATV/ORI	High	JT
		3	43	287	ATV	High	JT
		4	29	588	ATV/ORI	High	JT
		5	70	359	ATV	Low	?
		6	34	199	ATV/ORI	Medium	JT/FT
		7	51	167	ORI	Low	JT
		8	54	218	ORI	Low	JT
		9	10	185	ORI	Medium	JT
		10	14	3	ORI	Low	JT
	SLD-SVHYB	1	56	103	ATV	High	JT/SH
		2	52	160	ATV	High	JT/SH
		3	46	274	ATV	High	JT/FT
		4	38	198	ATV/ORI	High	JT/SH
		5	71	240	ATV/ORI	Medium	JT
		6	19	54	ATV/ORI	Low	JT/FT
		7	80	160	ATV	Low	JT

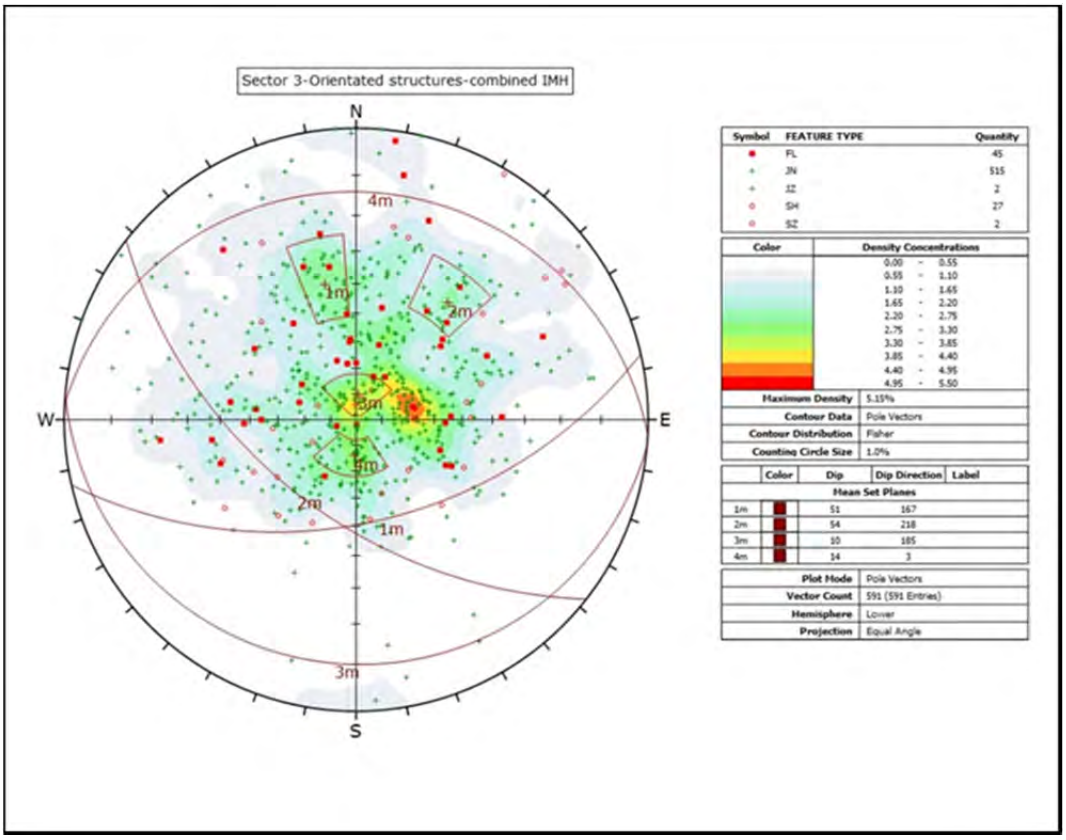

Figure B-14: Sector 3 structurally logged (orientated) structures in IMH

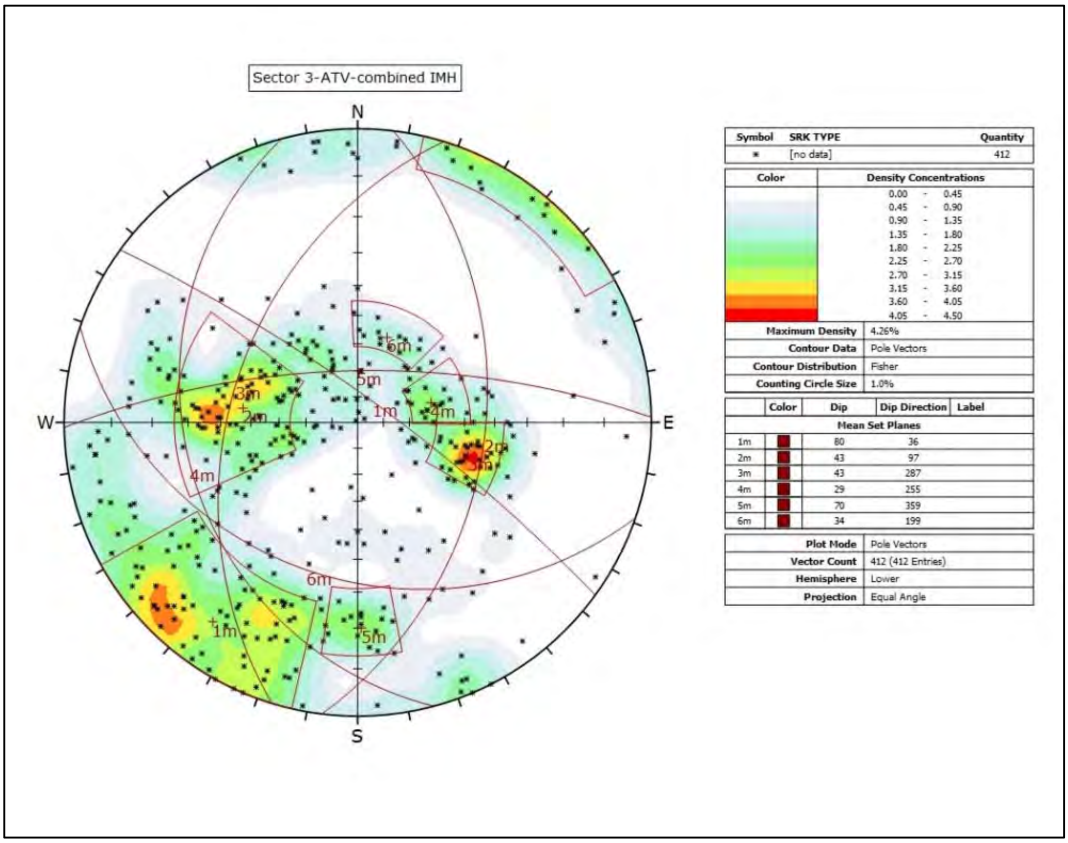

Figure B-15: Sector 3 ATV structures in IMH

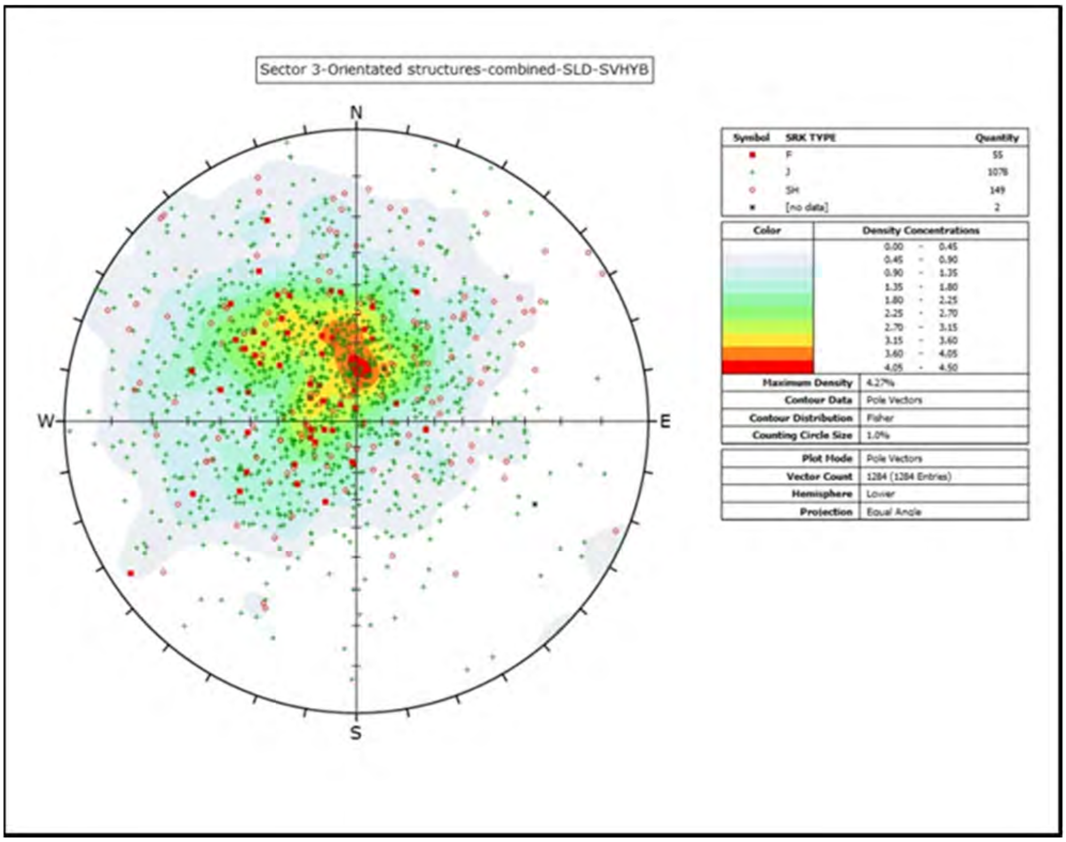

Figure B-16: Sector 3 structurally logged (orientated) structures in SLD-SVHYB

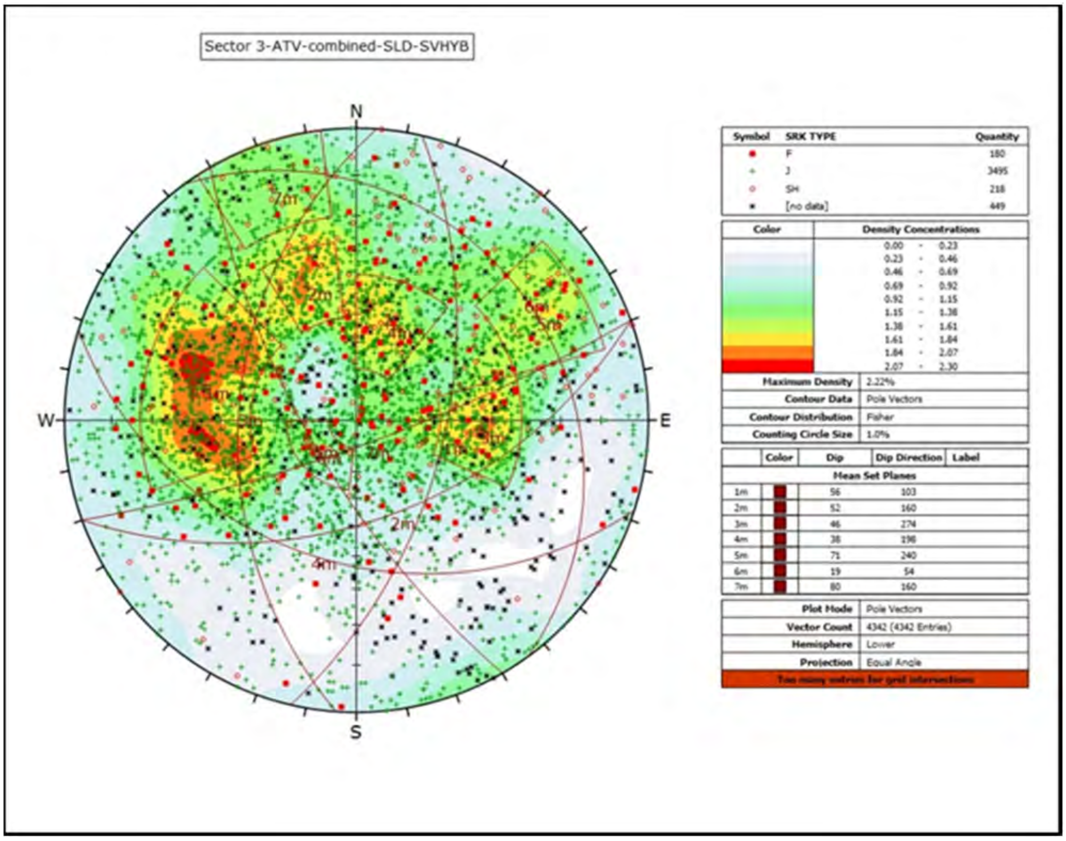

Figure B-17: Sector 3 ATV structures in SLD-SVHYB

Sector 4

Table B-6: Sector 4 set information

Sector	Rock Type	Set	Dip	Dip Direction	Ori/ATV	Set Strength	Main Structure Type
4	IMH	2	24	106	Ori	High	JT
		3	19	208	Ori	Medium	JT
		4	46	222	Ori	Medium	JT
		5	52	300	Ori	Low	JT
		6	69	182	Ori	Low	JT
		7	77	145	Ori	Low	JT/SH

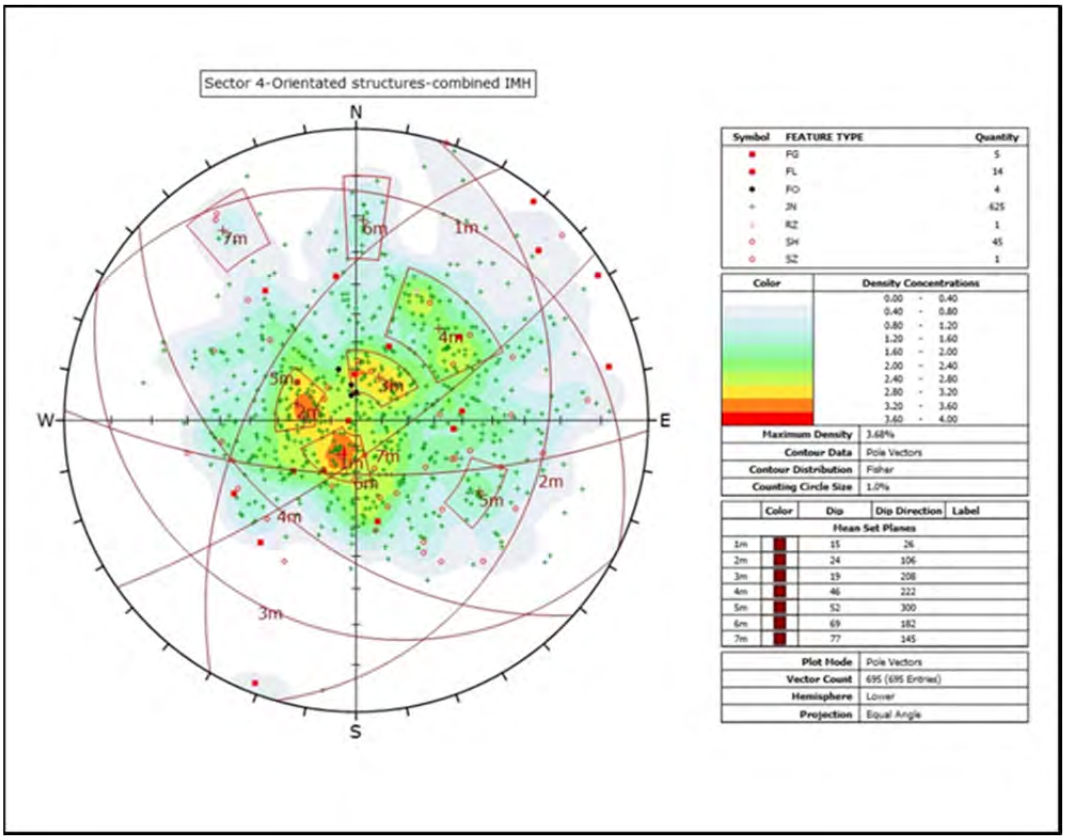

Figure B-18: Sector 4 structurally logged (orientated) structures in IMH

Sector 5

Table B-7: Sector 5 set information

Sector	Rock Type	Set	Dip	Dip Direction	Ori/ATV	Set Strength	Main Structure Type
5	IMH	1	21	321	Ori	High	JT
		2	19	68	Ori	High	JT
		3	9	177	Ori	High	JT
		4	58	315	Ori	Medium	JT
		5	45	25	Ori	Medium	JT
		6	45	241	Ori	Low	JT
		7	69	282	Ori	Low	JT/SH
		8	37	159	Ori	Low	JT
		9	78	41	ATV	Low	JT
	NVP/NVV	1	2	2	Ori	High	JT
		2	36	317	Ori	Medium	JT
		3	57	293	Ori/ATV	Low	JT
		4	57	260	Ori/ATV	Low	JT/FT
		5	81	101	Ori	Low	JT
		6	27	25	ATV	High	JT/FT
		7	52	186	ATV	Low	JT
		8	89	64	ATV	Low	JT
	SLD	1	57	332	Ori	High	JT
		2	29	243	Ori/ATV	High	JT
		3	43	34	Ori/ATV	High	JT
		4	53	229	Ori	Medium	JT
		5	18	103	Ori/ATV	Medium	JT
		6	86	358	Ori	Low	JT
		7	76	253	ATV	Medium	JT
		8	87	84	ATV	Low	JT
		9	48	167	ATV	Low	JT

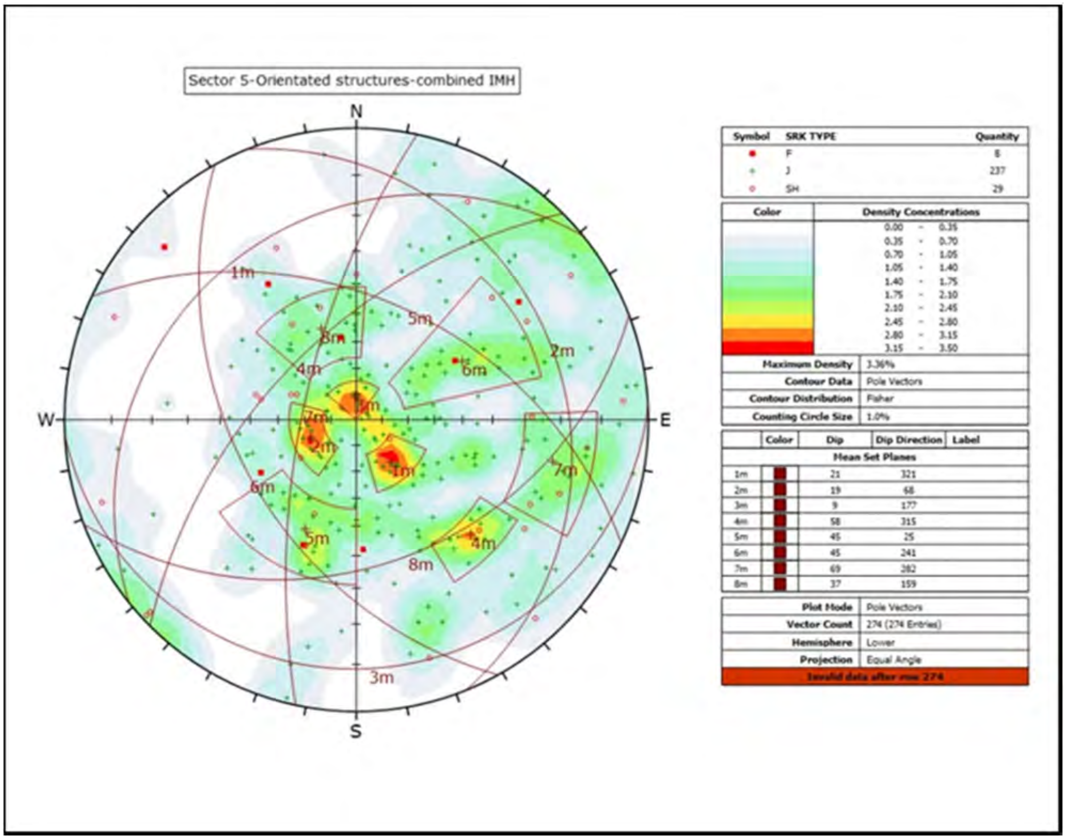

Figure B-19: Sector 5 structurally logged (orientated) structures in IMH

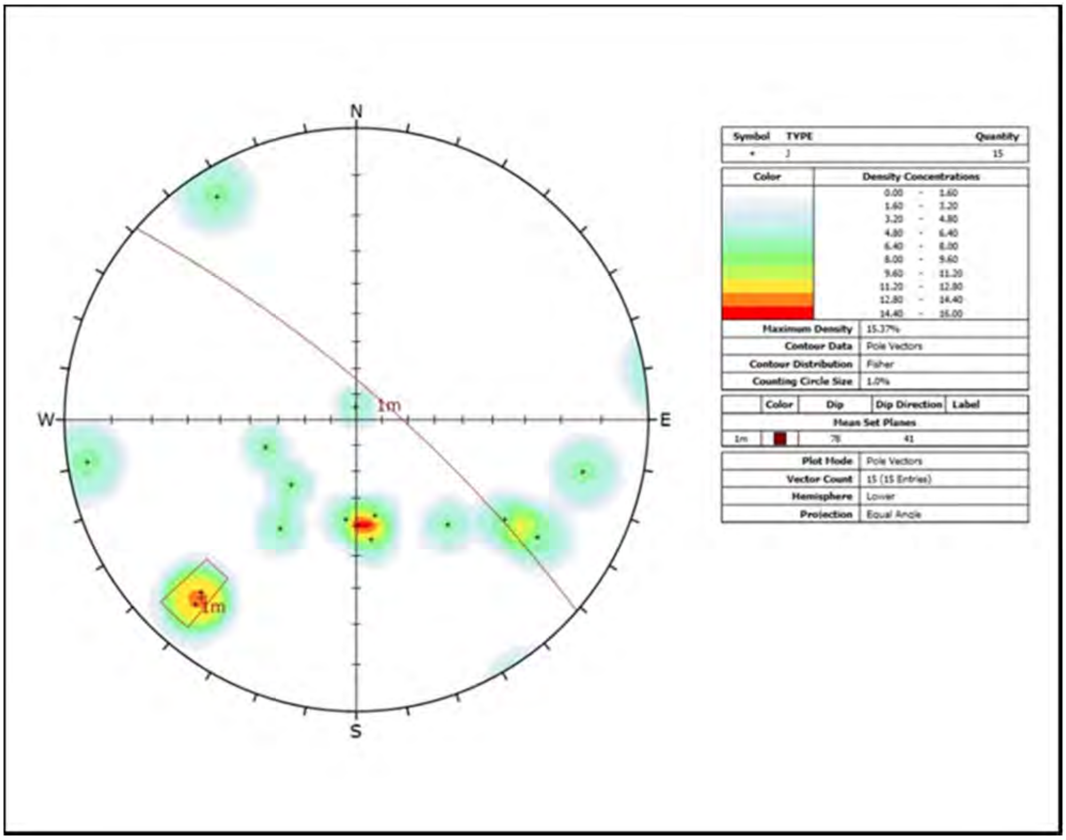

Figure B-20: Sector 5 ATV structures in IMH

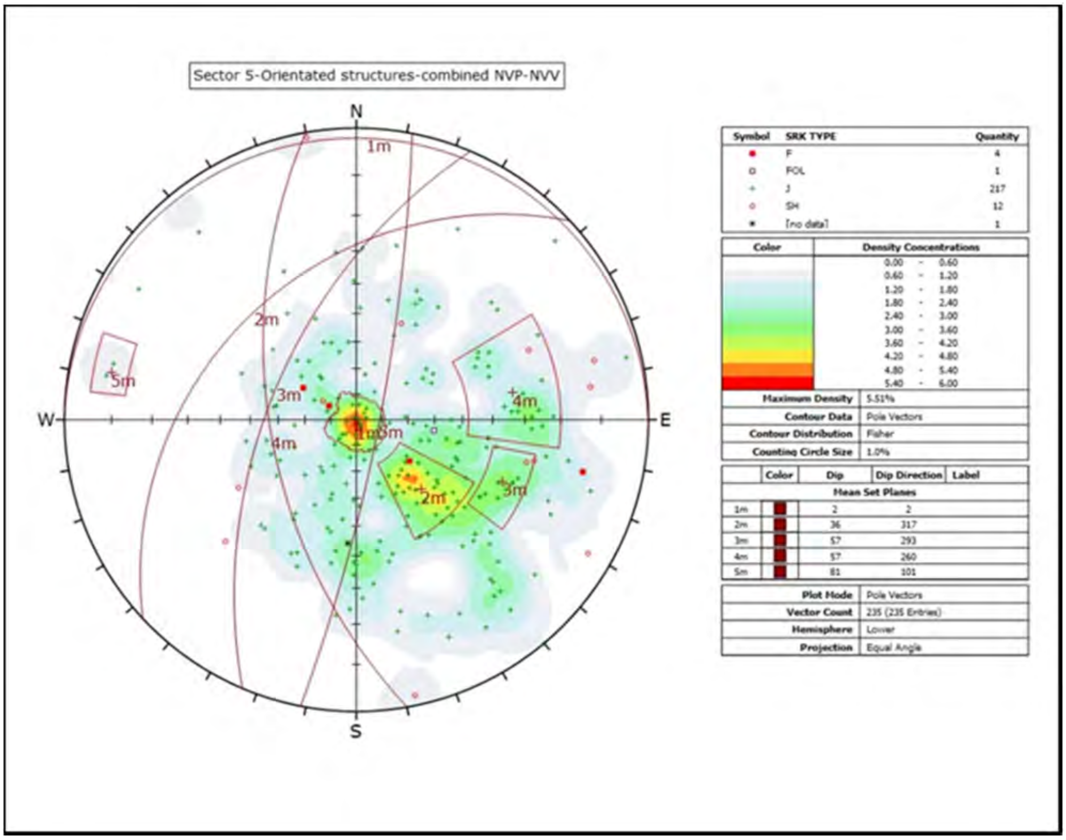

Figure B-21: Sector 5 structurally logged (orientated) structures in NVP-NVV

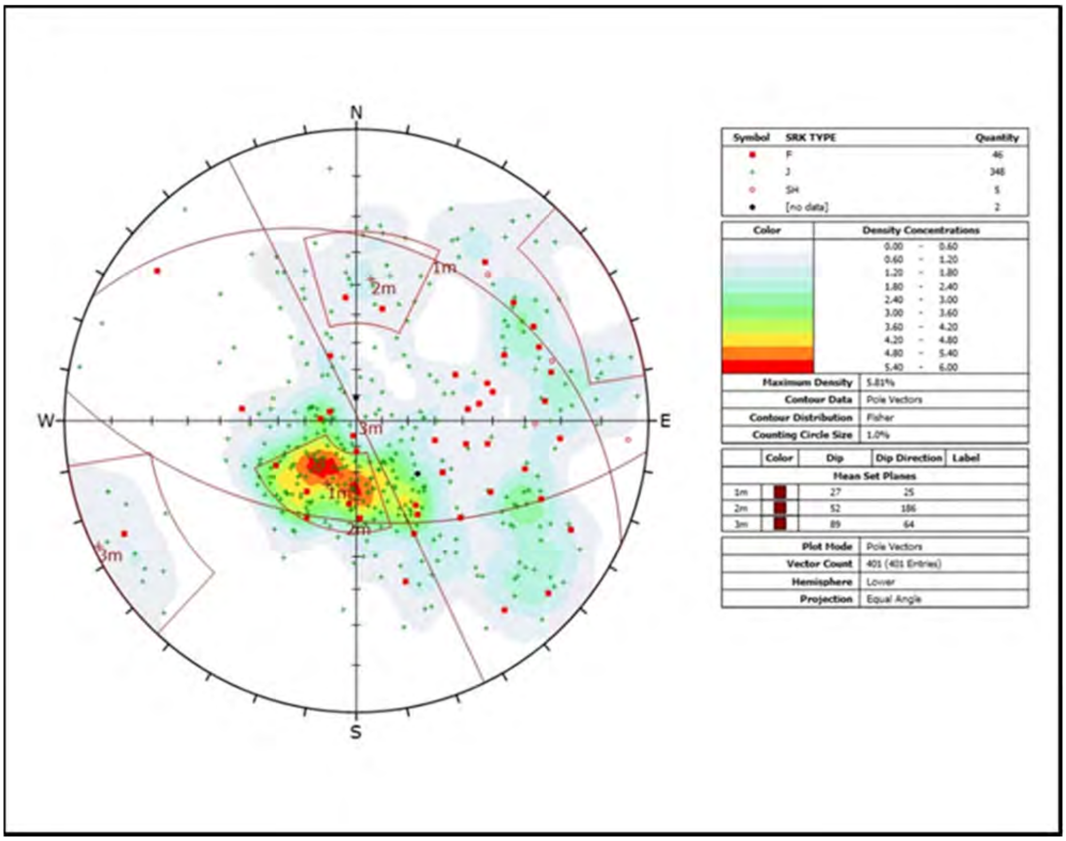

Figure B-22: Sector 5 ATV structures in NVP

Sector 6

Table B-8: Sector 6 set information

Sector	Rock Type	Set	Dip	Dip Direction	Ori/ATV	Set Strength	Main Structure Type
6	SLD-SVHYB	1	42	126	ATV	High	JT
		2	55	237	ATV/Ori	High	JT/FT
		3	83	140	ATV	Low	JT
		4	68	24	ATV/Ori	Low	JT
		5	61	322	ATV/Ori	Low	JT
		6	35	57	ORI	High	JT
		7	34	323	ORI	Low	JT/SH

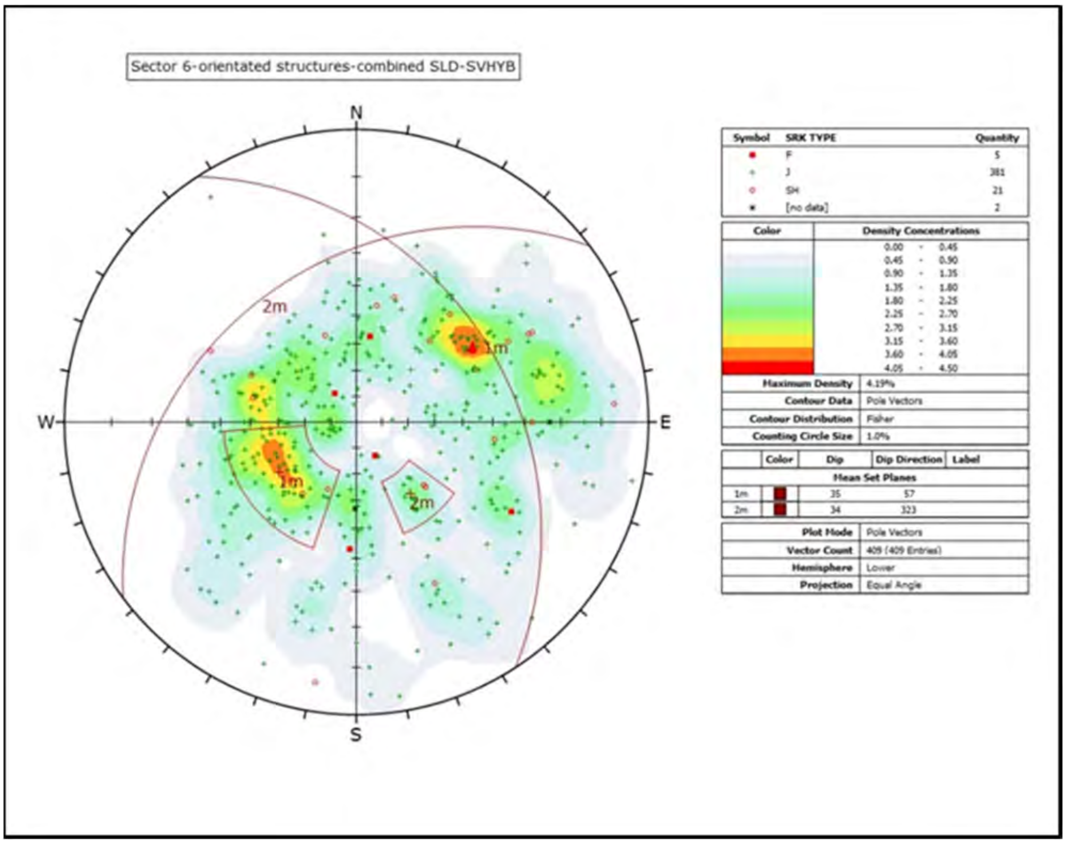

Figure B-23: Sector 6 structurally logged (orientated) structures in SLD-SVHYB

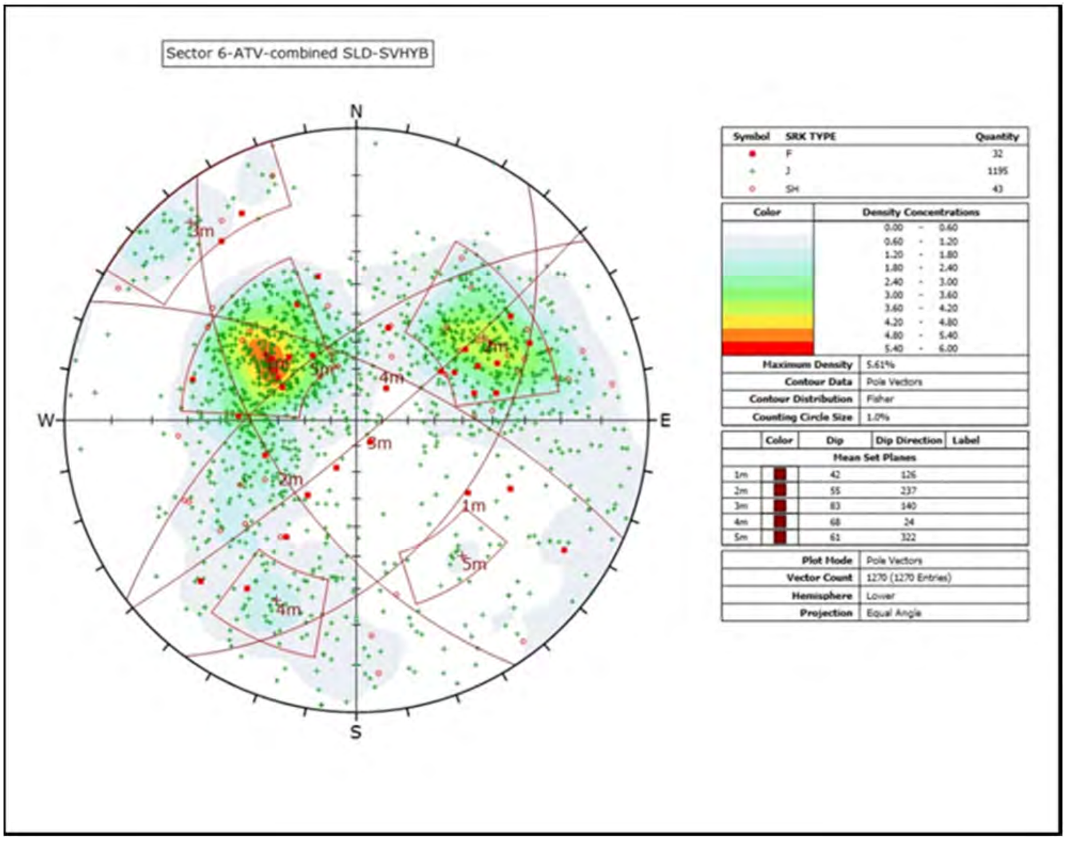

Figure B-24: Sector 6 ATV structures in SLD-SVHYB

Sector 7

Table B-9: Sector 7 set information

Sector	Rock Type	Set	Dip	Dip Direction	Ori/ATV	Set Strength	Main Structure Type
7	SLD	1	57	129	ATV	High	JT/FT
		2	83	9	ATV/ORI	Low	JT
		3	72	236	ATV	Low	JT
		4	39	46	ATV/ORI	Low	JT
		5	7	98	ORI	High	JT
		6	54	353	ORI	Medium	JT
		7	36	212	ORI	Low	JT
		8	27	360	ORI	Low	JT
	NVP	1	50	131	ATV/ORI	High	JT
		2	74	238	ATV/ORI	Low	JT
		3	81	146	ATV/ORI	Low	JT
		4	90	10	ATV/ORI	Low	JT/SH
		5	39	258	ATV/ORI	Low	JT/SJ
		6	45	318	ATV/ORI	Low	JT/SH
		7	58	183	Ori	Low	JT/SH
		8	81	66	Ori	Low	JT

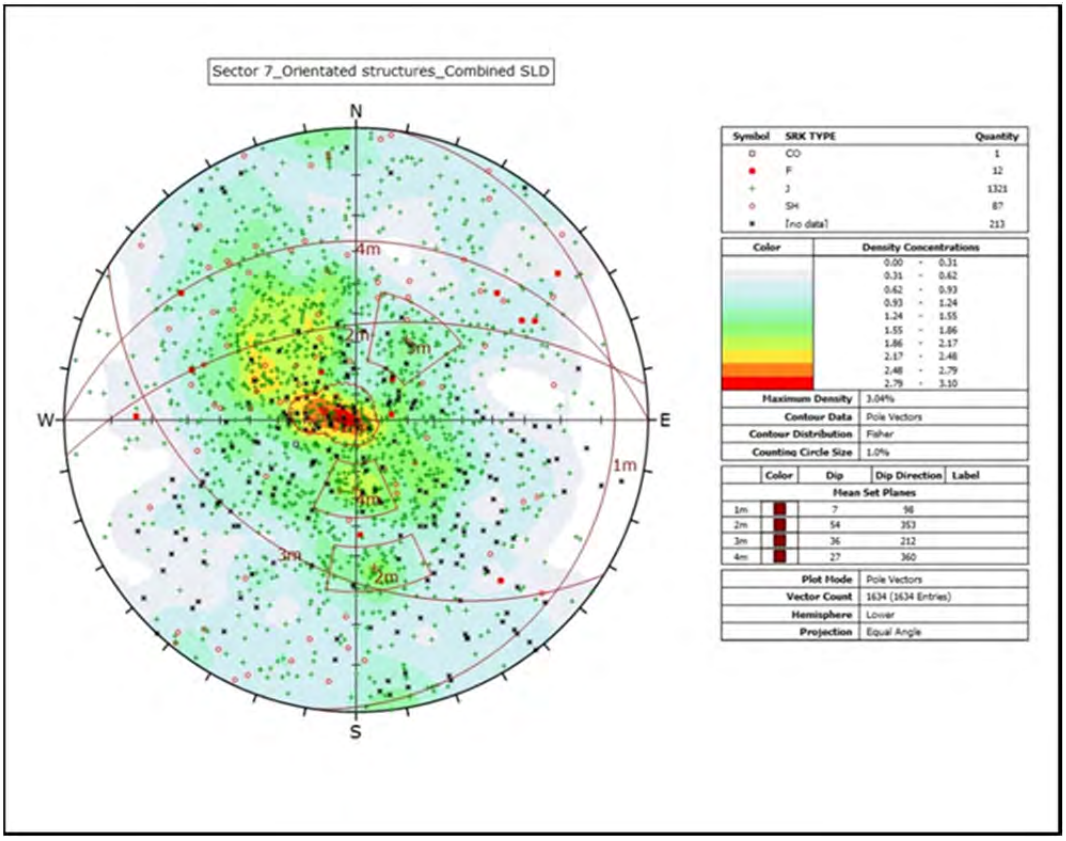

Figure B-25: Sector 7 structurally logged (orientated) structures in SLD

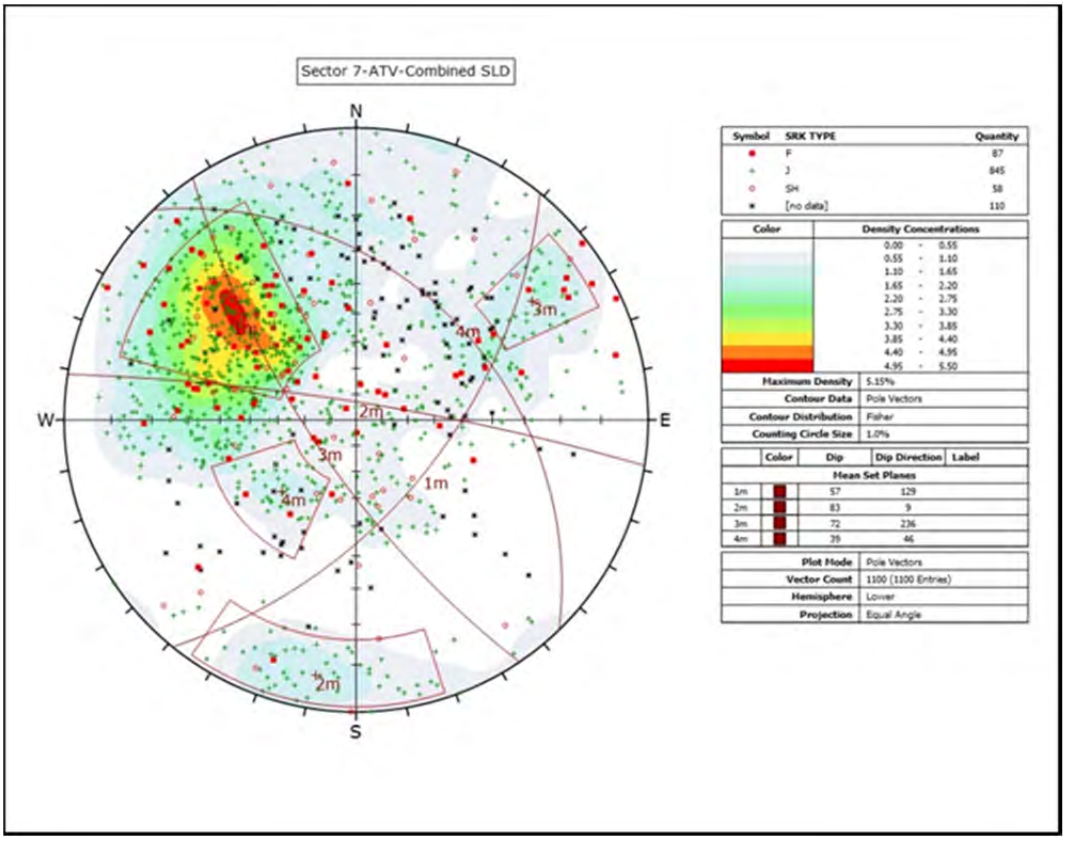

Figure B-26: Sector 7 ATV structures in SLD

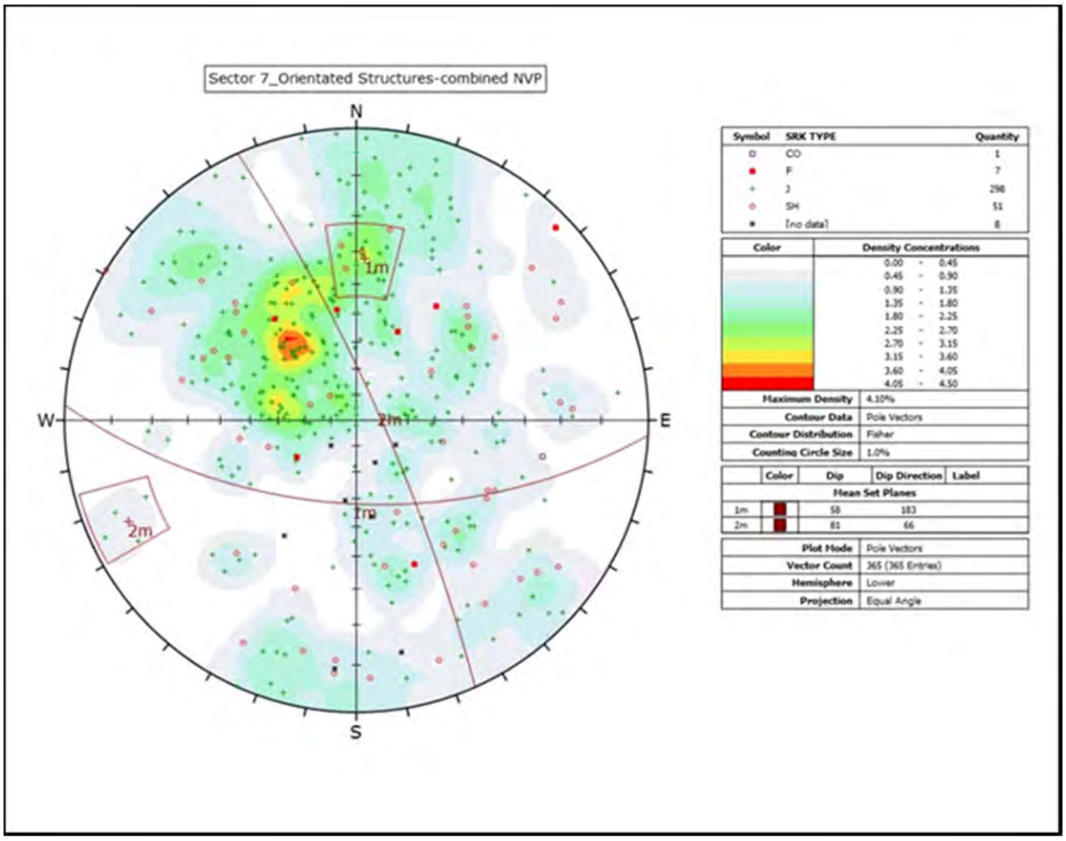

Figure B-27: Sector 7 structurally logged (orientated) structures in NVP

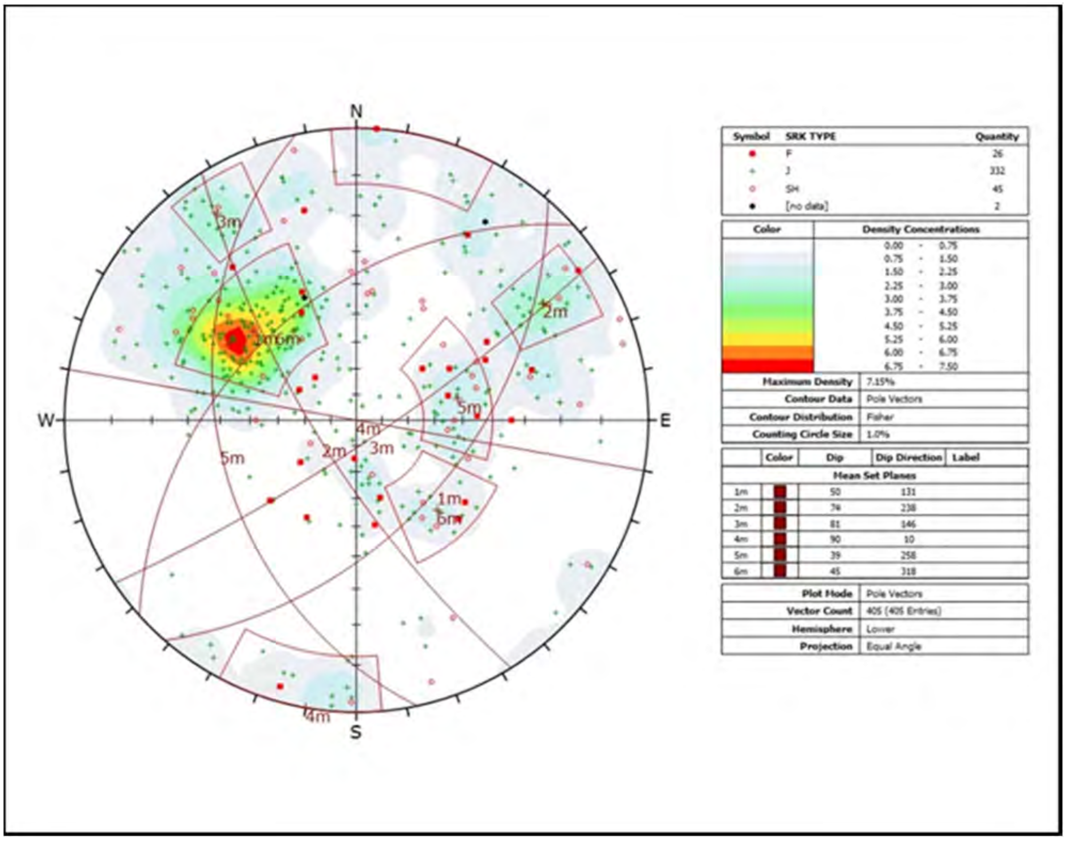

Figure B-28: Sector 7 ATV structures in NVP

Sector 8

Table B-10: Sector 8 set information

Sector	Rock Type	Set	Dip	Dip Direction	Ori/ATV	Set Strength	Main Structure Type
8	NVP/NVV	1	29	347	Ori	High	JT
		2	65	13	ORI/ATV	High	JT
		3	18	194	ORI/ATV	High	JT
		4	42	102	ORI/ATV	Medium	JT
		5	83	206	ORI/ATV	Low	JT
		6	50	290	ATV	Low	JT?
		7	90	86	ATV	Low	JT?
		8	35	41	ATV/ORI	Medium	JT
	SLD	1	57	331	ATV/Ori	High	JT?
		2	30	151	ATV/ORI	High	JT?
		3	86	137	ATV	Low	JT?
		4	32	46	ATV/ORI	Low	JT?
		5	42	283	ATV/ORI	Medium	JT?
		6	80	13	ATV	Low	JT?

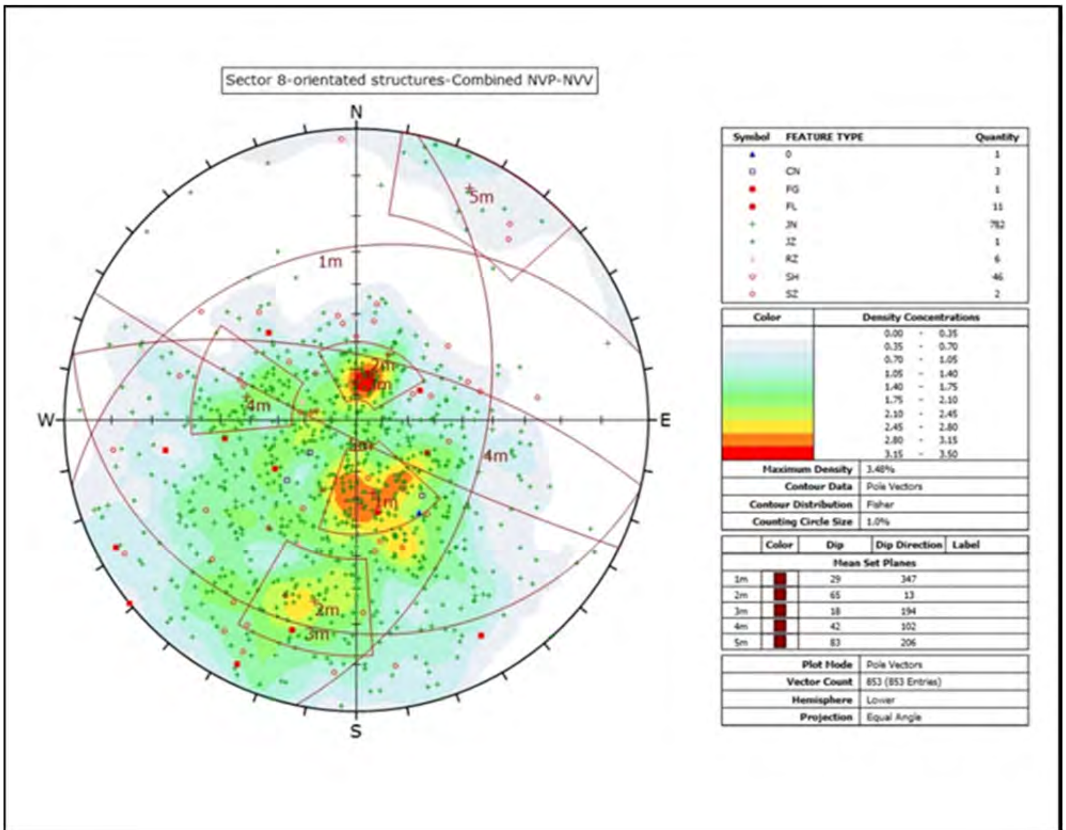

Figure B-29: Sector 8 structurally logged (orientated) structures in NVP-NVV

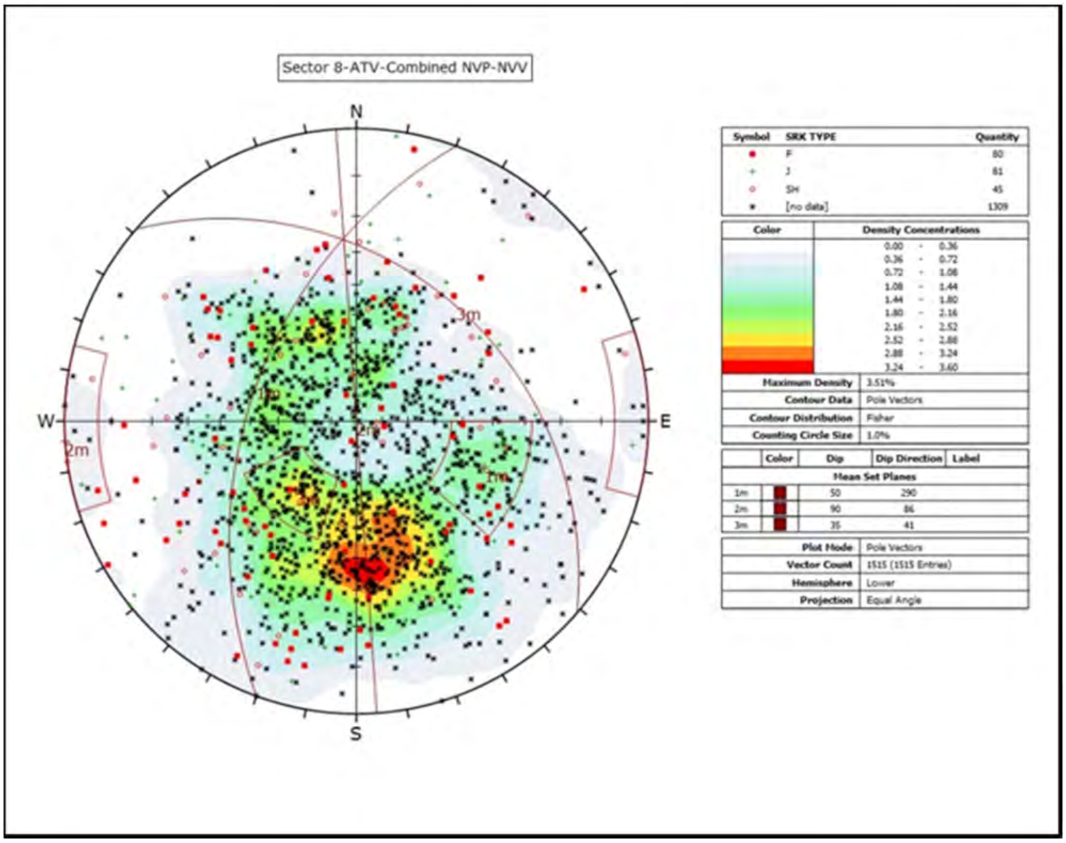

Figure B-30: Sector 8 ATV structures in NVP-NVV

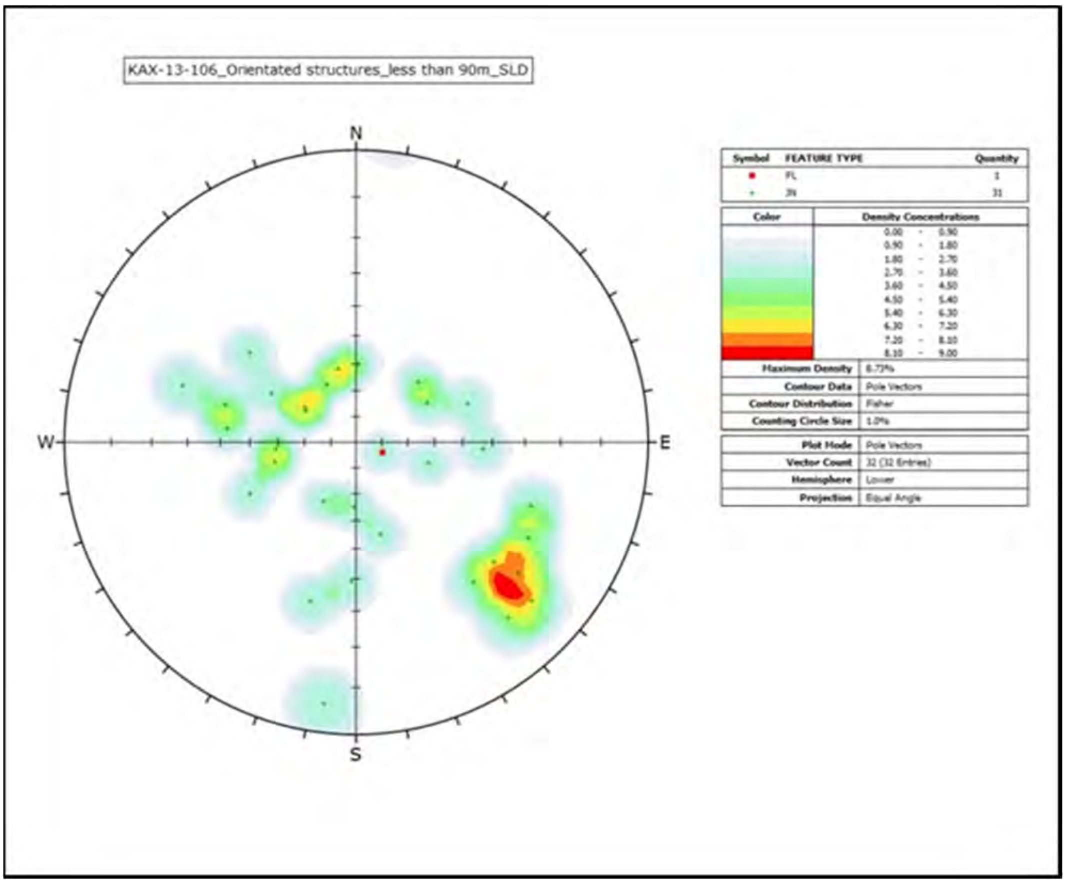

Figure B-31: Sector 8 structurally logged (orientated) structures in SLD

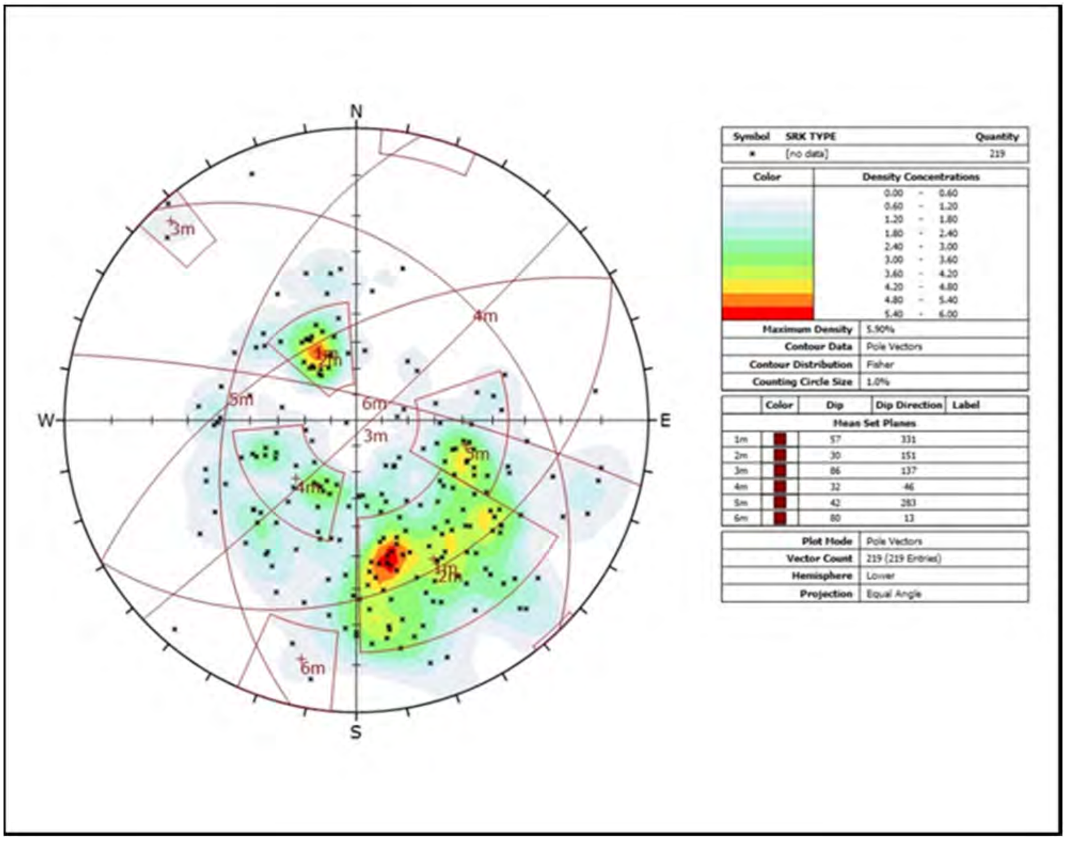

Figure B-32: Sector 8 ATV structures in SLD

Appendix C: Laboratory Test Results

Summary of laboratory test results

There are two sources of laboratory testing results. In addition to the results of the tests carried out on the samples collected from the recent drilling program, historical testing results have been provided by KGHM as detailed in the BGC report: “Abacus Mining & Exploration Corporation, Ajax Project Feasibility Study, Open Pit Geotechnical and Hydrogeological Assessments, Final”, document no. 0712-003-R03-2011, November 10, 2011. Table C-1 shows both set of results.

Both set of results compare fairly well. The average strengths for SLD are lower in the new set of results but still in the range of the values obtained in the previous set of results.

Table C-1: Laboratory Test Results Comparison.

		Previous results				New results			
Rock Type	**Value**	**UCS [MPa]**	**UTS [MPa]**	**E [GPa]**	**ν**	**UCS [MPa]**	**UTS [MPa]**	**E [GPa]**	**ν**
MAFV (NVV)	Average	192	13	87	0.28	142	15	36	0.13
	SD	46	5	27	0.04	7.7	4.4	12	0.02
	Min	99	5	38	0.22	134	11.1	16	0.11
	Max	241	20	107	0.33	150	19.9	48	0.15
	# tests	7	10	8	8	2	2	4	3
PICR (NVP)	Average	NA	NA	NA	NA	106	13	24	0.14
	SD					50	4	17	0.3
	Min					53	10.6	2.5	0.12
	Max					169	15.8	51	0.19
	# tests					6	2	12	6
IMH	Average	82	11	102	0.26	86	9.9	38	0.11
	SD	29	3	23	0.04	38	4.2	0	0
	Min	45	5	58	0.21	38	4.8	20	0.1
	Max	131	16	128	0.32	162	17.1	51	0.11
	# tests	8	16	8	8	7	6	5	3
SLD	Average	129	12	84	0.26	64	7.8	25	0.19
	SD	94	4	25	0.05	40	0	14	0.12
	Min	37	6	49	0.18	24	7.8	4.6	0.10
	Max	361	19	139	0.35	117	7.8	47	0.39
	# tests	10	17	9	9	4	1	8	5

NA: not available

The UCS for PICR and MAFV were adjusted to consider the rock strength measured by point load testing (PLT), and field estimated strengths (FES) are much lower than the values obtained in the laboratory (Table C-2).

Table C-1: Comparison UCS, PLT and FES results

Lithology	**Lab UCS (MPa)**	**# Tests**	**PLT (MPa)**	**# Tests**	**FES (MPa)**	**Meters (m)**
IMH	84	15	76	172	65	3615
SLD	91	13	71	57	49	3659
MAFV (NVV)	181	9	52	19	38	398
PICR (NVP)	106	6	44	74	56	3438

The average ratio between laboratory test results and PLT for IMH and SLD is 1.19. Using this factor, the UCS for MAFV and PICR was calculated from PLT test results, and values of 64MPa and 54MPa respectively were used for the analyses.

THE ROBERT M. BUCHAN
DEPARTMENT OF MINING

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February 28, 2014

Ms. Sheila Kluck
Robinson Holdings (USA) Ltd.
(Subsidiary of KGHM International Ltd.)
8105 Birch Bay Square St. Suite 202
Blaine, WA 98230
USA

Re: Core Testing (Ajax Project)

Ms. Kluck:

A total of eighty-three rock core specimens, including two soil specimens, all of which were identified as being Ajax Project materials, were received and tested to failure (where sufficient material was available) under a series of different test protocols within the Rock Mechanics Laboratory of the Robert M. Buchan Department of Mining, Queen's University at Kingston. Core specimens were received in multiple batches and were requested for testing to your specifications, with some samples being subjected to multiple test types. In several cases, as noted in the summary data table, an insuffficent quantity of sample was received to permit testing. In several other cases, and due to excessive as-received foliation damage, samples were unable to be prepared adequately for testing. Rock core tests that were successfully completed included twenty-three unconfined compression (UCS), twenty-one single stage confined compression, three multi-stage confined compression, thirteen Brazilian tensile, and thirty-three direct shear strength tests.

A summary of failure strength test results for all UCS, triaxial confined and Brazilian test samples is included as is the summary of results for direct shear tests in a separate table. Photo images of specimens pre- and post-failure are appended to the written report for your information (only post-test photos of direct shear specimens are included).

Should you also require any additional information concerning work that has been performed, please do not hesitate to contact me by telephone at (613)-533-2198 or by FAX at (613)-533-6597.

Please note that this Department assumes no liability for any test information that has been generated due to the selection of sample materials at source or for testing procedures requested. Additionally, we assume no responsibility for design application of any information that is transmitted.

Yours sincerely,

J. F. Archibald, Ph.D., P. Eng., FCIM

Summary of Failure Test Results
(Ajax Project) – February, 2014

Hole/Sample (depth, m)	Density (g/cm^3)	Young's Modulus E (GPa)	Poisson's ratio (μ)	UCS S_C (MPa)	Sigma 1 (MPa)	Sigma 3 (MPa)	Brazilian Tensile Strength (and range) (MPa)
KAX-13-103 (18.91-19.10) *	---	---	---	---	---	---	---
KAX-13-104 (240.79-241.05) *	---	---	---	---	---	---	---
KAX-13-103 (23.61-23.97) *	---	---	---	---	---	---	---
KAX-13-103 (32.69-33.09) *	---	---	---	---	---	---	---
KAX-13-104 (349.22-349.47) *	---	---	---	---	---	---	---
KAX-13-103 (30.68-31.00)	3.38	30.112	---	---	77.2	0.5	---
KAX-13-104 (100.78-101.09)	3.21	47.039	---	---	195.0	0.5	---
KAX-13-104 (52.52-52.78)	3.04	23.204	---	---	52.3	1.0	---
KAX-13-104 (166.63-166.84)	3.09	43.602	---	---	150.6	1.0	---
KAX-13-103 (60.09-60.46)	3.39	38.676	---	---	129.8	2.0	---
KAX-13-104 (337.13-337.41)	3.30	13.925	---	---	60.6	2.0	---
KAX-13-103 (14.17-14.43)	3.34	20.229	---	24.1 (pf)	---	---	---
KAX-13-103 (50.02-50.29)	3.42	51.266	0.10	99.5	---	---	6.6 (4.3-10.5)
KAX-13-104 (284.27-284.50)	3.09	43.388	---	96.5 (f)	---	---	---
KAX-13-104 (63.45-63.64)	No test	insufficient	sample	quantity			
KAX-13-104 (245.00-245.25)*	---	---	---	---	---	---	---
KAX-13-104 (298.89-299.15)	2.74	26.809	0.10	38.3	---	---	4.8 (3.8-6.6)
KAX-13-104 (337.13-337.41)	3.30	13.925	---	---	60.6	2.0	---
KAX-13-101 (82.73-82.98)*	---	---	---	---	---	---	---
KAX-13-106 (395.10-395.39)*	---	---	---	---	---	---	---
KAX-13-106 (225.38-225.78)*	---	---	---	---	---	---	---
KAX-13-106 (235.33-235.56)*	---	---	---	---	---	---	---
KAX-13-100 (169.28-169.52)	2.63	2.561	---	---	16.9	2.0	---
KAX-13-106 (206.87-207.22)	2.83	42.095	0.19	96.7	---	---	15.8 (12.5-18.4)
KAX-13-101 (65.71-66.01)	3.21	50.551	0.11	152.8	---	---	17.1 (15.1-18.4)
KAX-13-106 (362.30-362.59)	2.96	39.101	0.11	134.4	---	---	
KAX-13-100 (133.63-133.91)	2.79	16.872	0.12	46.7	---	---	7.8 (5.9-10.9)
KAX-13-106 (347.51-347.72)	No test	insufficient	sample	quantity			
KAX-13-100 (38.43-38.71)*	---	---	---	---	---	---	---
KAX-13-100 (213.09-213.44)*	---	---	---	---	---	---	---
KAX-13-100 (284.80-285.02)*	---	---	---	---	---	---	---
KAX-13-100 (403.35-403.86)*	---	---	---	---	---	---	---
KAX-13-100 (421.87-422.08)	2.93	46.786	0.21	117.1	---	---	---
KAX-13-106 (269.76-270.01)	2.80	43.148	0.15	166.2	---	---	---
KAX-13-106 (250.20-250.47)	2.83	51.322	0.16	168.9	---	---	---
KAX-13-100 (68.33-68.57)	2.89	37.268	0.12	59.7 (pf)	---	---	10.6 (4.4-17.2)
KAX-13-101 (110.87-111.19)*	---	---	---	---	---	---	---
KAX-13-101 (165.73-166.03)*	---	---	---	---	---	---	---
KAX-13-103 (227.60-227.93)*	---	---	---	---	---	---	---
KAX-13-101 (350.72-351.11)	2.98	31.525	---	---	97.2	1.0	---
KAX-13-101 (399.34-399.90)	3.03	23.234	---	---	70.6	1.0	---
KAX-13-103 (327.66-328.02)	3.40	20.095	0.12	46.1	---	---	9.0 (4.5-12.0)
KAX-13-098 (153.59-153.92)*	---	---	---	---	---	---	---
KAX-13-098 (154.28-154.38)*	---	---	---	---	---	---	---
KAX-13-098 (258.22-258.48)*	---	---	---	---	---	---	---

(pf) – sample failure occurred partially along pre-existing foliation surface

(*) - sample tested in direct shear with strength data reported in separate table

Hole/Sample (depth, m)	Density (g/cm^3)	Young's Modulus E (GPa)	Poisson's ratio (μ)	UCS S_C (MPa)	Sigma 1 (MPa)	Sigma 3 (MPa)	Brazilian Tensile Strength (and range) (MPa)
KAX-13-098 (264.96-265.18)	2.95	37.752	---	---	134.1	0.5	---
KAX-13-098 (311.82-312.13)	2.75	35.662	---	---	149.3	2.0	---
KAX-13-098 (386.60-386.82)*	---	---	---	---	---	---	---
KAX-13-099 (139.87-140.18)	2.77	42.676	---	---	164.0	1.0	---
KAX-13-099 (218.97-219.26)*	---	---	---	---	---	---	---
KAX-13-0-99 (209.50-209.87)*	---	---	---	---	---	---	---
KAX-13-099 (252.32-252.79)*	---	---	---	---	---	---	---
KAX-13-099 (316.46-316.72)	2.96	18.814	---	---	91.8	2.0	---
KAX-13-099 (449.31-449.64)	2.87	15.968	0.12	41.6 (pf)	---	---	11.1 (8.0-14.0)
KAX-13-105 (156.75-156.98)	3.30	46.918	0.10	93.1	---	---	11.2 (10.1-12.1)
KAX-13-105 (3.77-3.96) (multi)	3.16	27.362	---	---	20.9	0.5	---
KAX-13-105 (3.77-3.96) (multi)	3.16	27.362	---	---	32.1	1.0	---
KAX-13-105 (3.77-3.96) (multi)	3.16	27.362	---	---	89.9	2.0	---
KAX-13-105 (28.91-29.24)*	---	---	---	---	---	---	---
KAX-13-105 (47.88-48.16)	3.44	56.962	0.13	162.2	---	---	-insufficient sample
KAX-13-105 (140.48-140.84)*	---	---	---	---	---	---	---
KAX-13-105 (160.18-160.40)*	---	---	---	---	---	---	---
KAX-13-102 (21.64-22.02)*	---	---	---	---	---	---	---
KAX-13-102 (44.87-45.09)	3.17	34.896	---	---	108.1	0.5	
KAX-13-102 (62.30-62.55)*	---	---	---	---	---	---	---
KAX-13-102 (118.56-118.88)	3.10	51.782	---	---	227.7	1.0	---
KAX-13-102 (168.24-168.63)	2.76	30.384	0.10	66.8 (pf)	---	---	10.8 (5.4-21.9)
KAX-13-102 (213.60-213.92)	3.16	41.289	---	---	147.4	3.0	---
KAX-13-102 (221.15-221.47)*	---	---	---	---	---	---	---
KAX-13-098 (42.12-42.49)*	---	---	---	---	---	---	---
KAX-13-098 (68.21-68.48)	2.78	4.2425	0.12	6.4 (f)	---	---	18.7 (15.0-21.6)
KAX-13-098 (99.42-99.63)*	---	---	---	---	---	---	---
KAX-13-098 (132.98-133.21)	2.80	9.804	0.39	24.5	---	---	-insufficient sample
KAX-13-098 (150.88-151.09)	2.79	22.912	0.10	67.9 (pf)	---	---	-insufficient sample
KAX-13-098 (185.81-185.81?) (multi)	2.84	24.932	---	---	103.8	0.5	---
KAX-13-098 (185.81-185.81?) (multi)	2.84	24.932	---	---	107.7	1.0	---
KAX-13-098 (185.81-185.81?) (multi)	2.84	24.932	---	---	106.4	2.0	---
KAX-13-098 (207.25-207.48)	---	unable to	be tested	- excessive	foliation	---	---
KAX-13-098 (214.32-214.50)	2.96	4.671	---	---	17.2	2.0	
KAX-13-099 (33.56-33.80)	---	unable to	be tested	- excessive	foliation	---	---
KAX-13-099 (51.06-51.26)	2.58	2.475	---	---	14.1	0.5	---
KAX-13-099 (54.19-54.44) (multi)	3.00	27.027	---	---	38.9	0.5	---
KAX-13-099 (54.19-54.44) (multi)	3.00	27.027	---	---	105.7	1.0	---
KAX-13-099 (54.19-54.44) (multi)	3.00	27.027	---	---	115.5	2.0	---
KAX-13-099 (60.26-60.50)	2.77	3.837	---	---	16.3	1.0	---
KAX-13-099 (62.13-62.28)	2.72	8.439	---	---	26.8	2.0	---
KAX-13-099 (118.18-118.50)	3.00	48.523	0.15	149.8	---	---	19.9 (16.0-25.0)
KAX-13-099 (339.47-339.74)	3.37	21.742	0.12	96.4	---	---	22.7 (20.0-25.4)
KAX-13-099 (345.08-345.37)*	---	---	---	---	---	---	---
KAX-13-099 (243.05-243.32)	2.94	24.943	0.13	52.8 (pf)	---	---	-insufficient sample

(f) – sample failure occurred along pre-existing foliation surface
(pf) – sample failure occurred partially along pre-existing foliation surface
(*) - sample tested in direct shear with strength data reported in separate table

DIRECT SHEAR SAMPLE TEST RESULTS

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-106 (235.33-235.56)	0.217	0.238
	0.773	0.559
Residual Shear Strength	1.485	0.893
	1.949	1.060
	2.258	1.188
Cohesion = 243 kPa	2.506	1.304
Int. Friction Angle = 21.0º	2.815	1.368
	3.187	1.419
r^2 = 0.970	3.403	1.509
	3.743	1.535
	0.217	0.238

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-100 (38.43-38.71)	0.413	0.166
	0.637	0.166
Residual Shear Strength	0.951	0.314
	1.579	0.443
	1.983	0.591
Cohesion = 0 kPa	2.296	0.702
Int. Friction Angle = 18.1º	2.610	0.721
	3.370	0.997
r^2 = 0.964	3.776	1.349

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-101 (82.73-82.98)	0.442	0.702
	0.774	0.702
Residual Shear Strength	0.884	0.838
	1.047	1.014
	1.209	1.150
Cohesion = 217 kPa	1.419	1.423
Int. Friction Angle = 38.6º	1.628	1.558
	1.861	1.755
r^2 = 0.986	2.047	1.852
	2.280	2.067
	2.466	2.164
	2.629	2.281

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-106 (225.38-225.78)	0.169	0.128
	0.535	0.285
Residual Shear Strength	1.182	0.719
	1.379	0.817
Cohesion = 0 kPa	1.604	0.837
Int. Friction Angle = 32.6º	1.801	0.935
	2.195	1.172
	2.645	1.487
r^2 = 0.972	3.180	2.215
	3.490	2.314
	3.630	2.196
	0.197	0.167

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-103 (32.69-33.09)	0.553	0.354
	0.918	0.470
Residual Shear Strength	1.284	0.704
	1.558	0.937
Cohesion = 3 kPa	1.832	1.229
Int. Friction Angle = 31.7º	2.015	1.375
	2.350	1.608
	3.020	1.812
r^2 = 0.971	3.477	2.045

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-100 (213.09-213.44)	0.014	0.158
	0.716	0.536
Residual Shear Strength	1.139	0.715
	1.791	1.171
Cohesion = 58 kPa	2.212	1.475
Int. Friction Angle = 31.8º	2.673	1.753
	3.018	2.083
	3.439	2.362
r^2 = 0.994	3.785	2.412
	4.130	2.564
	4.475	2.716
	4.897	2.966
	0.257	0.158

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-100 (284.80-285.02)	0.139	0.182
	0.667	0.333
Residual Shear Strength	1.724	0.800
	2.211	1.104
Cohesion = 63 kPa	2.616	1.402
Int. Friction Angle = 25.6º	2.983	1.569
	3.473	1.720
r^2 = 0.989	3.676	1.853
	3.914	1.853

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-100 (403.35-403.86)	0.514	0.237
	0.799	0.381
Residual Shear Strength	1.013	0.381
	1.262	0.509
Cohesion = 0 kPa	1.547	0.509
Int. Friction Angle = 22.4º	1.690	0.526
	2.972	1.118
r^2 = 0.983	3.293	1.343
	3.765	1.583
	4.006	1.711
	4.397	1.807
	0.194	0.157

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-103 (18.91-19.10)	0.176	0.165
	0.586	0.428
Residual Shear Strength	0.803	0.558
	1.187	0.745
Cohesion = 184 kPa	1.434	0.839
Int. Friction Angle = 23.6º	1.681	0.952
	1.900	1.046
r^2 = 0.991	2.145	1.141
	2.392	1.253
	2.610	1.347
	2.829	1.384
	3.159	1.496
	3.459	1.687

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-103 (23.61-23.97)	0.274	0.364
	0.454	0.260
Residual Shear Strength	0.912	0.459
	1.459	0.509
Cohesion = 95 kPa	2.052	0.882
Int. Friction Angle = 20.6º	2.463	0.882
	2.873	1.106
r^2 = 0.978	3.284	1.355
	3.968	1.579
	4.331	1.778
	4.880	2.002

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-104 (240.79-241.05)	0.109	0.029
	0.568	0.288
Residual Shear Strength	1.062	0.402
	1.627	0.660
Cohesion = 11 kPa	1.874	0.718
Int. Friction Angle = 19.3º	2.0561	0.660
	2.369	0.747
r^2 = 0.984	2.581	0.919
	2.687	0.918
	2.934	1.033
	3.252	1.162
	3.641	1.334

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-104 (245.00-245.25)	0.236	0.172
	0.469	0.202
Residual Shear Strength	2.956	1.470
	3.331	1.923
Cohesion = 0 kPa	3.659	1.953
Int. Friction Angle = 29.8º	3.941	2.165
	4.363	2.497
r^2 = 0.996	4.691	2.678
	4.926	2.830
	5.395	3.011
	5.677	3.192
	0.235	0.051

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-104 (349.22-349.47)	0.115	0.030
	0.324	0.154
Residual Shear Strength	0.773	0.273
	1.072	0.381
Cohesion = 0 kPa	1.281	0.381
Int. Friction Angle = 25.3º	1.521	0.638
	1.790	0.868
r^2 = 0.982	2.058	0.974
	2.269	1.003
	2.508	1.124
	2.837	1.287
	3.168	1.462
	3.585	1.692

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-106 (395.10-395.39)	0.284	0.170
	0.523	0.368
Residual Shear Strength	1.241	0.500
	1.623	0.862
Cohesion = 0 kPa	2.342	1.225
Int. Friction Angle = 31.6º	2.676	1.324
	3.010	1.620
r^2 = 0.992	3.348	1.986
	3.682	2.148
	4.016	2.282
	4.353	2.511
	4.688	2.842

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-102 (221.15-221.47)	0.455	0.215
	0.756	0.294
Residual Shear Strength	1.170	0.390
	1.618	0.513
Cohesion = 0 kPa	2.035	0.741
Int. Friction Angle = 24.9º	2.295	0.952
	3.010	1.233
r^2 = 0.983	3.412	1.444
	4.029	1.795
	4.466	1.988
	5.147	2.322
	5.237	2.489

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-102 (21.64-22.02)	0.363	0.322
	0.671	0.322
Residual Shear Strength	1.022	0.902
	1.528	1.337
Cohesion = 93 kPa	2.211	1.772
Int. Friction Angle = 35.8º	2.727	2.207
	3.038	2.373
	3.578	2.518
r^2 = 0.987	4.069	2.924
	4.426	3.221

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-102 (62.30-62.55)	0.451	0.474
	0.694	0.666
Residual Shear Strength	1.094	0.833
	1.836	1.153
Cohesion = 241 kPa	3.081	1.783
Int. Friction Angle = 26.0º	3.817	2.158
	4.990	2.589
	5.509	2.908
r^2 = 0.995		

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-099 (209.50-209.87)	0.313	0.304
	0.316	0.318
Residual Shear Strength	0.497	0.447
	0.913	0.733
Cohesion = 150 kPa	1.159	0.861
Int. Friction Angle = 28.6º	1.729	1.176
	2.188	1.212
	2.798	1.605
r^2 = 0.993	3.491	2.077

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-105 (140.48-140.84)	0.343	0.345
	0.359	0.345
Residual Shear Strength	0.386	0.337
	0.829	0.570
Cohesion = 83 kPa	2.909	1.145
Int. Friction Angle = 22.7º	3.737	1.347
	4.426	1.751
	4.998	2.054
r^2 = 0.958	5.271	2.077
	5.458	2.519
	5.651	2.784
	5.820	2.985

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-105 (28.91-29.24)	0.351	0.209
	0.642	0.387
Residual Shear Strength	1.493	0.913
	2.998	1.599
Cohesion = 141 kPa	3.746	2.000
Int. Friction Angle = 25.4º	4.292	2.392
	4.968	2.704
	5.835	2.891
r^2 = 0.982	6.354	3.061
	7.038	3.426

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-099 (252.32-252.79)	0.315	0.065
	0.748	0.187
Residual Shear Strength	1.316	0.340
	2.228	0.647
Cohesion = 0 kPa	2.874	0.800
Int. Friction Angle = 17.7º	3.028	0.953
	3.406	1.106
	4.337	1.305
r^2 = 0.990	5.030	1.565

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-101 (110.87-111.19)	0.223	0.137
Residual Shear Strength	0.288	0.159
	0.557	0.361
	1.314	0.809
Cohesion = 0 kPa	1.998	1.258
Int. Friction Angle = 32.9º	2.644	1.706
	3.300	2.048
r^2 = 0.995		

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-101 (165.73-166.03)	0.191	0.116
Residual Shear Strength	0.272	0.210
	0.290	0.210
	0.404	0.305
Cohesion = 34 kPa	0.556	0.400
Int. Friction Angle = 32.8º	0.868	0.589
	1.112	0.684
r^2 = 0.997	1.189	0.821
	1.374	0.949
	1.550	1.063
	1.802	1.181

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-098 (154.28-154.38)	0.201	0.138
Residual Shear Strength	0.582	0.425
	1.292	0.833
	1.723	1.150
Cohesion = 50 kPa	1.999	1.296
Int. Friction Angle = 31.9º	2.468	1.608
	2.728	1.698
r^2 = 0.995	3.143	1.975
	3.391	2.177

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-098 (153.59-153.92)	0.265	0.214
	0.934	0.465
Residual Shear Strength	1.117	0.626
	1.337	0.828
Cohesion = 228 kPa	1.646	0.928
Int. Friction Angle = 20.0º	2.062	0.933
	2.293	1.049
	2.448	1.175
r^2 = 0.940	2.638	1.286
	2.785	1.215
	3.130	1.225
	3.516	1.452

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-098 (258.22-258.48)	0.202	0.094
	0.317	0.151
Residual Shear Strength	0.629	0.291
	0.891	0.406
Cohesion = 50 kPa	1.136	0.493
Int. Friction Angle = 20.9º	1.385	0.599
	1.544	0.671
	1.769	0.733
r^2 = 0.984	2.008	0.791
	2.214	0.887
	2.381	0.887
	2.527	0.983

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-105 (160.18-160.40)	0.370	0.218
	0.424	0.218
Residual Shear Strength	1.444	0.752
	1.856	0.931
Cohesion = 48 kPa	2.765	1.465
Int. Friction Angle = 26.9º	3.429	1.644
	4.117	2.178
	4.842	2.526
r^2 = 0.989	5.018	2.579

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-098 (386.60-386.82)	0.413	0.269
	0.560	0.381
Residual Shear Strength	0.605	0.410
	0.798	0.499
Cohesion = 228 kPa	1.046	0.546
Int. Friction Angle = 15.9º	1.451	0.676
	1.846	0.741
	2.373	0.960
r^2 = 0.978	2.669	0.972
	2.904	1.013

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-099 (218.97-219.26)	0.297	0.271
	0.983	0.331
Residual Shear Strength	1.851	0.554
	2.154	0.927
Cohesion = 0 kPa	2.830	1.225
Int. Friction Angle = 25.7º	3.181	1.522
	3.533	1.820
	3.979	1.746
r^2 = 0.967	4.557	2.081
	5.042	2.267
	5.323	2.386

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-098 (42.12-42.49)	0.667	0.522
	0.731	0.706
Residual Shear Strength	1.122	0.873
	1.559	1.292
	2.036	1.768
Cohesion = 339 kPa	2.591	1.827
Int. Friction Angle = 31.2º	3.014	2.262
	3.512	2.671
	3.982	2.705
r^2 = 0.963	4.501	3.207
	5.064	3.215

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-098 (99.42-99.63)	0.609	0.190
	0.998	0.34
Residual Shear Strength	1.504	0.446
	2.010	0.656
	2.503	0.811
Cohesion = 0 kPa	3.002	1.277
Int. Friction Angle = 27.6º	3.501	1.595
	3.917	1.890
	4.057	2.054
r^2 = 0.967	4.283	2.209

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-099 (345.08-345.37)	0.458	0.221
	0.982	0.575
Residual Shear Strength	1.530	0.584
	1.976	0.765
	2.481	1.127
Cohesion = 91 kPa	3.024	1.254
Int. Friction Angle = 20.4º	3.490	1.354
	3.836	1.481
	4.162	1.508
r^2 = 0.980	4.174	1.617

Sample	Normal Stress (MPa)	Shear Stress (MPa)
KAX-13-103 (227.60-227.93)	0.596	0.312
	0.809	0.369
Residual Shear Strength	1.003	0.483
	1.381	0.609
	1.422	0.643
Cohesion = 71 kPa	1.466	0.706
Int. Friction Angle = 22.2º	1.560	0.712
	1.783	0.827
	1.957	0.878
r^2 = 0.993	2.001	0.941
	2.337	1.055

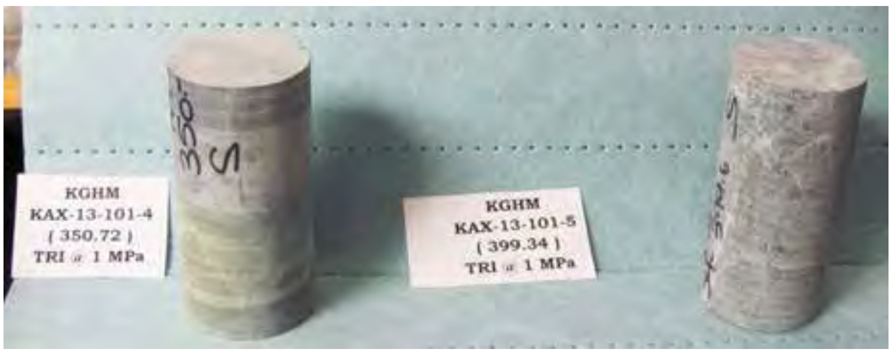
Pre-Test Specimen Photographs

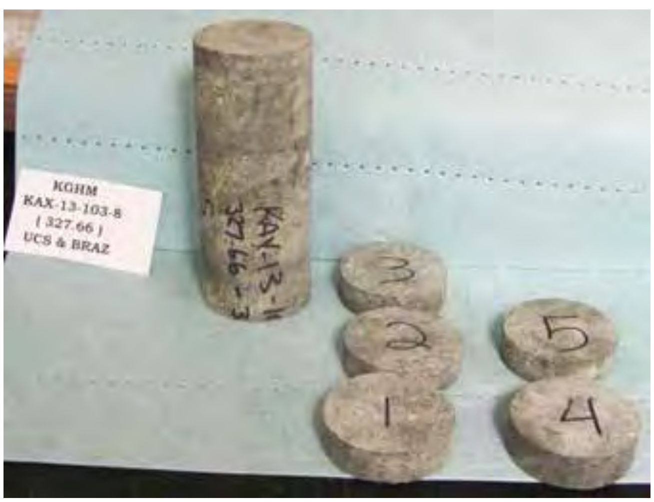

KGHM
KAX-13-104
(298.89)
UCS & BRAZ
KGHM
KAX-13-100
(133.63)
UCS & BRAZ


KGHM
KGHM
KAX-13-106
(362.3)
UCS & BRAZ


KGHM
KAX-13-100
(68.33)
UCS & BRAZ
KGHM
KAX-13-106
(250.2)
UCS & BRAZ


KGHM
KAX-13-106
(269.76)
UCS & BRAZ
KGHM
KAX-13-100
(421.87)
UCS & BRAZ


KGHM
KAX-13-101-4
(350.72)
TRI @ 1 MPa
KGHM
KAX-13-101-5
(399.34)
TRI @ 1 MPa


KGHM
KAX-13-103-8
(327.66)
UCS & BRAZ


KGHM
KAX-13-098-3
(264.96)
TRI @ .5 MPa
KGHM
KAX-13-098-4
(311.82)
TRI @ 2 MPa


KGHM
KAX-13-099
(316.46)
TRI @ 2 MPa
KGHM
KAX-13-09
(449.31
UCS & BR


KGHM
KAX-13-10
(156.75
UCS & BRA
KGHM
KAX-13-105
(3.77)
MST
KGHM
X-13-105-2
(47.88)
UCS & BRAZ


KGHM
KAX-13-102-1
(44.87)
TRI @ .5 MPa
KGHM
KAX-13-102-3
(118.56)
TRI @ 1 MPa


KGHM
KAX-13-102-4
(168.24)
UCS & BRAZ
KGHM
UCS & BRAZ


KGHM
KAX-13-098-7
(68.21)
UCS & BRAZ
KGHM


KGH
KAX-13-0
(132.98
UCS & BR
KGHM
KAX-13-098-10
(150.88)
UCS & BRAZ


KGHM
KAX-13-098-11
(185.81)
MST .5,1,2
KGHM
KAX-13-098-12
(207.25)
TRI @ 1 MPa

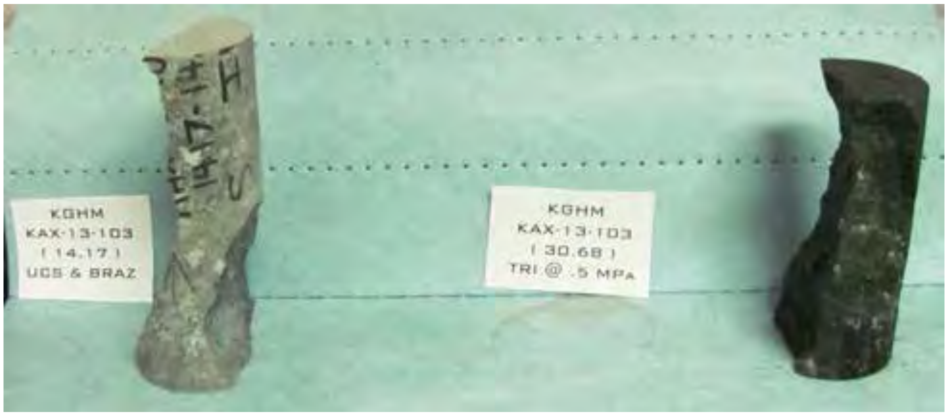

KGHM
KAX-13-098-13
(214.32)
TRI @ 2 MPa
KGHM
KAX-13-099-6
(33.56)
TRI @ .5 MPa
KGHM
KAX-13-099-7
(51.06)
TRI @ .5 MPa


KGHM
KAX-13-099-8
(54.19)
MST .5,1,2
KGHM
KAX-13-099-9
(60.26)
TRI @ 1 MPa
KGHM
KAX-13-099-10
(62.13)
TRI @ 2 MPa

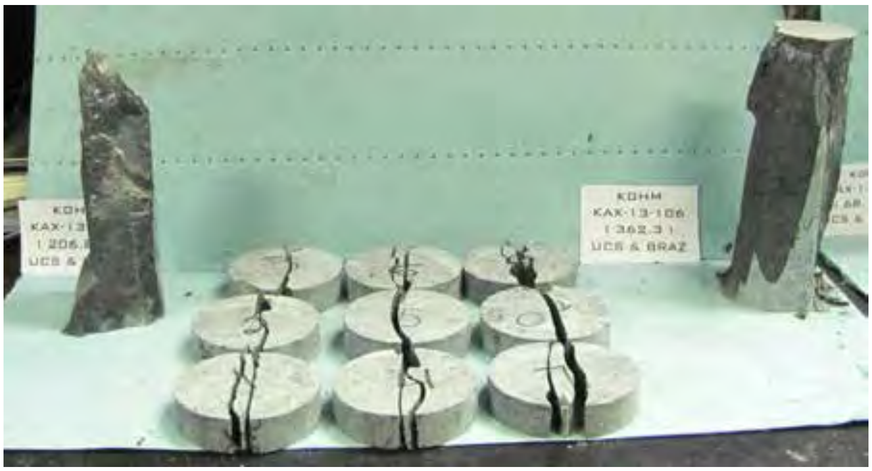

KGHM
KAX-13-099-12
(339.47)
UCS & BRAZ

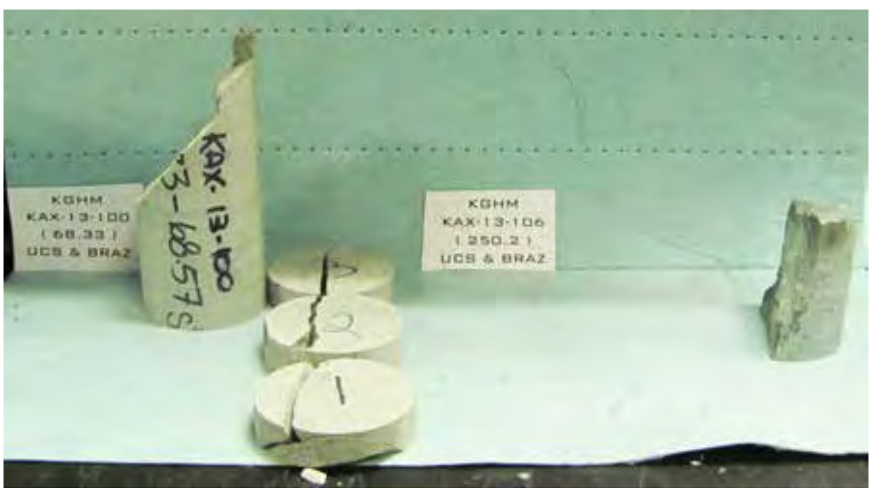

KGHM
(243.05)
KAX-13-099
KGHM
KAX-13-100
(169.28)
TRI @ 2MPa

Post-Test Specimen Photographs




KGHM
KAX-13-104
(298.89)
UCS & BRAZ
KGHM
KAX-13-100
(133.63)
UCS & BRAZ


KGHM
KAX-13-106
(362.3)
UCS & BRAZ


KGHM
KAX-13-100
(68.33)
UCS & BRAZ
KAX-13-100
KGHM
KAX-13-106
(250.2)
UCS & BRAZ


KGHM
KAX-13-106
(269.76)
UCS & BRAZ
KGHM
KAX-13-100
(421.87)
UCS & BRAZ


KGHM
KAX-13-10
(65.71)
UCS & BRA


KGHM
KAX-13-101-4
(350.72)
TRI @ 1 MPa
KGHM
KAX-13-101-5
(399.34)
TRI @ 1 MPa


KGHM
KAX-13-103-8
(327.66)
UCS & BRAZ


KGHM
KGHM
KAX-13-098-4
KGHM


KGHM
KAX-13-099-5
(449.31)
UCS & BRAZ


KGHM
KAX-13-105-4
(156.75)
UCS & BRAZ
KGHM
KAX-13-105
(3.77)
MBT
KGHM
KAX-13-105-2
(47.88)
UCS & BRAZ


KGHM
KAX-13-102-1
(44.87)
TRI @ .5 MPa
KGHM
KAX-13-102-3
(118.56)
TRI @ 1 MPa


KGHM
KAX-13-102-4
(168.24)
UCS & BRAZ


KGHM
KAX-13-098-7
(68.21)
UCS & BRAZ
KGHM
KAX-13-102-5


KGHM
KAX-13-098-9
(132.98)
UCS & BRAZ
KGHM
KAX-13-098-10
(150.88)
UCS & BRAZ


KGHM
KAX-13-098-11
(185.81)
MST .5,1,2
KGHM
KAX-13-098-12
(207.25)
TRI @ 1 MPa


KGHM
KAX-13-098-1
(214.32)
TRI @ 2 MPa
KGHM
KAX-13-099-6
(33.56)
TRI @ .5 MPa
KGHM
KAX-13-099-7
(51.06)
TRI @ .5 MPa


KGHM
KAX-13-099-8
(54.19)
MST .5,1,2
KGHM
KAX-13-099-9
(60.26)
TRI = 1 MPa
KGHM
KAX-13-099-10
(62.13)
TRI = 2 MPa


KGHM
KAX-13-099-12
(339.47)
UCS & BRAZ


KGHM
KAX-13-099-14
(243.05)
USC & BRAZ
KGHM
KAX-13-100
(169.28)
TRI @ 2 MPa

Post-Test Direct Shear Specimen Photographs

KAX-13-098 (153.59–153.92)

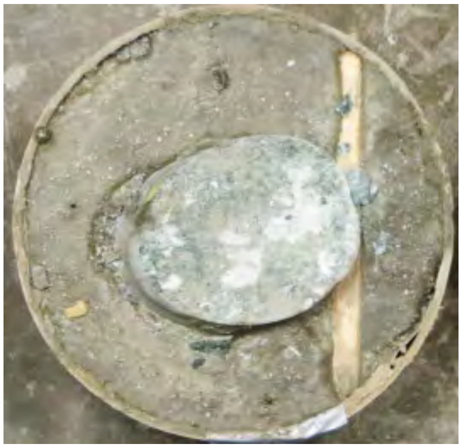
KAX-13-098 (154.28-154.38)

KAX-13-098 (258.22-258.48)

KAX-13-098 (386.60-386.82)

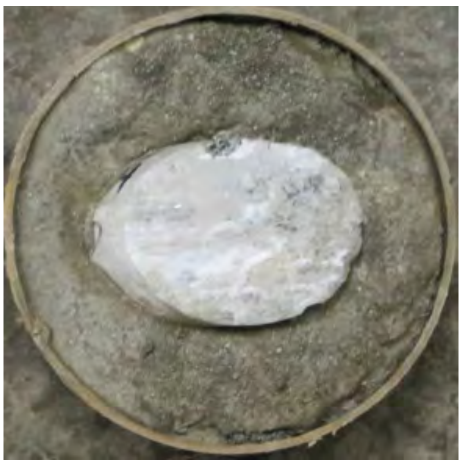
KAX-13-099 (209.50-209.87)

KAX-13-099 (218.97-219.26)



KAX-13-099 (252.32-252.79)

KAX-13-100 (38.43-38.71)



KAX-13-100 (213.09-213.44)

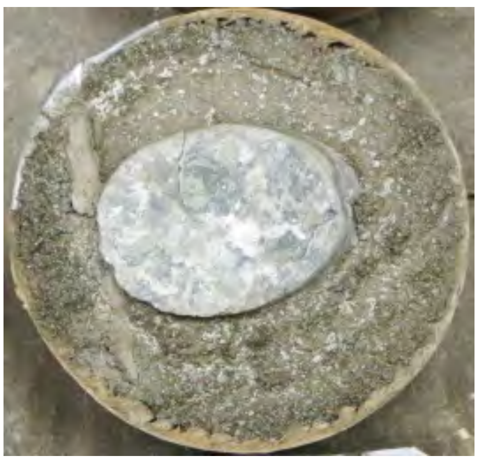
KAX-13-100 (284.80-285.02)

KAX-13-100 (403.35-403.86)

KAX-13-101 (82.73-82.98)

KAX-13-101 (110.87-111.19)

KAX-13-101 (165.73-166.03)



KAX-13-102 (21.64-22.02)

KAX-13-102 (62.30-62.55)

KAX-13-102 (221.15-221.47)

KAX-13-103 (18.91-19.10)

KAX-13-103 (23.61-23.97)

KAX-13-103 (32.69-33.09)

KAX-13-104 (240.79-241.05)

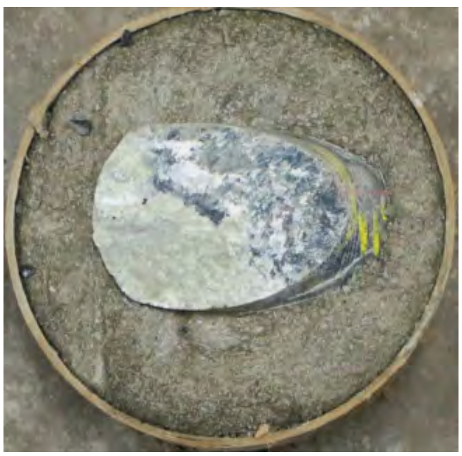
KAX-13-104 (245.00-245.25)

KAX-13-104 (349.22-349.47)

KAX-13-105 (28.91-29.24)

KAX-13-105 (140.48-140.84)

KAX013-105 (160.18-160.40)



KAX-13-106 (225.38-225.78)

KAX-13-106 (235.33-235.56)

KAX-13-106 (395.10-395.39)

Appendix D: Comparison Historical and Recent Data

Comparison of fracture count from recent and historical logs

A comparison was made of the fracture count from the historical and recent geotechnical logging. This appendix presents illustrative examples, using selected core box photographs (Figures D-1 through D-4) and the joint count recorded in the geotechnical logs for those intervals. Table D-1 shows the difference in recorded fractures, and it can be seen that this number is significantly higher in the historical logs than the recent logs.

The core photographs of the SLD from a recent hole (Figure D-2) and an historical hole (Figure D-3) showed similar conditions visually, although the historical hole showed a slightly higher number of fractures of the drillcore. An average of 2 fractures per interval were recorded for the recent hole, but 10 per interval were recorded for the historical logging.

In the historical logging, it appears that every structure has been counted (except obvious handling/ mechanical breaks), whereas only selected (natural) structures have been counted in the recent logging.

Table D-1: Fracture count directly from geotechnical logs

Data set	Drillhole	Photograph	Interval	Fractures Recorded	Rock Type
Recent	KAX-13-098	Figure D-1	254.51 - 256.03	1	MAFV
			256.03 - 257.57	2	MAFV
			257.57 - 259.08	1	MAFV
			259.08 - 260.6	2	MAFV
			260.6 - 262.13	3	MAFV
		Figure D-2	309.37 - 310.9	2	SLD
			310.9 - 312.42	0	SLD
			312.42 - 313.94	2	SLD
			313.94 - 315.47	0	SLD
			315.47 - 316.99	3	SLD
Historical	AE-10-064	Figure D-3	131.06 - 132.59	11	SLD
			132.59 - 134.11	9	SLD
			134.11 - 135.64	11	SLD
			135.64 - 137.16	8	SLD
			137.16 - 138.68	12	SLD
			138.68 - 140.21	12	SLD
	AE-10-064	Figure D-4	475.49 - 477.01	73	PICR
			477.01 - 477.93	12	PICR
			477.93 - 479.15	9	PICR
			479.15 - 480.67	16	PICR
			480.67 - 482.19	37	PICR

Data set	Drillhole	Photograph	Interval	Fractures Recorded	Rock Type
Historical	AE-10-064	Figure D-4	482.19 - 483.72	30	PICR
			483.72 - 485.24	29	PICR

Figure D-1: KAX-13-098 – MAFV – 254.26-263.65 m

Figure D-2: KAX-13-098 – SLD – 310.23-319.68 m

Figure D-3: AE-10-064 – SLD – 131.06-143.26 m

Figure D-4: AM-10-064 – PICR – 477.65-485.72 m

Appendix E: Rock Mass Strength

Rock Strength

The procedure for assessing rock mass strength is shown in Figure E-1. The procedure recommended by Hoek (2002) is used to calculate the Hoek-Brown (HB) strength parameters using laboratory test results and rock mass classification. For the slope stability analysis, the non-linear HB envelope has been converted to a linear envelope (Mohr–Coulomb, MC).

Rock Mass Strength Assessment Procedure

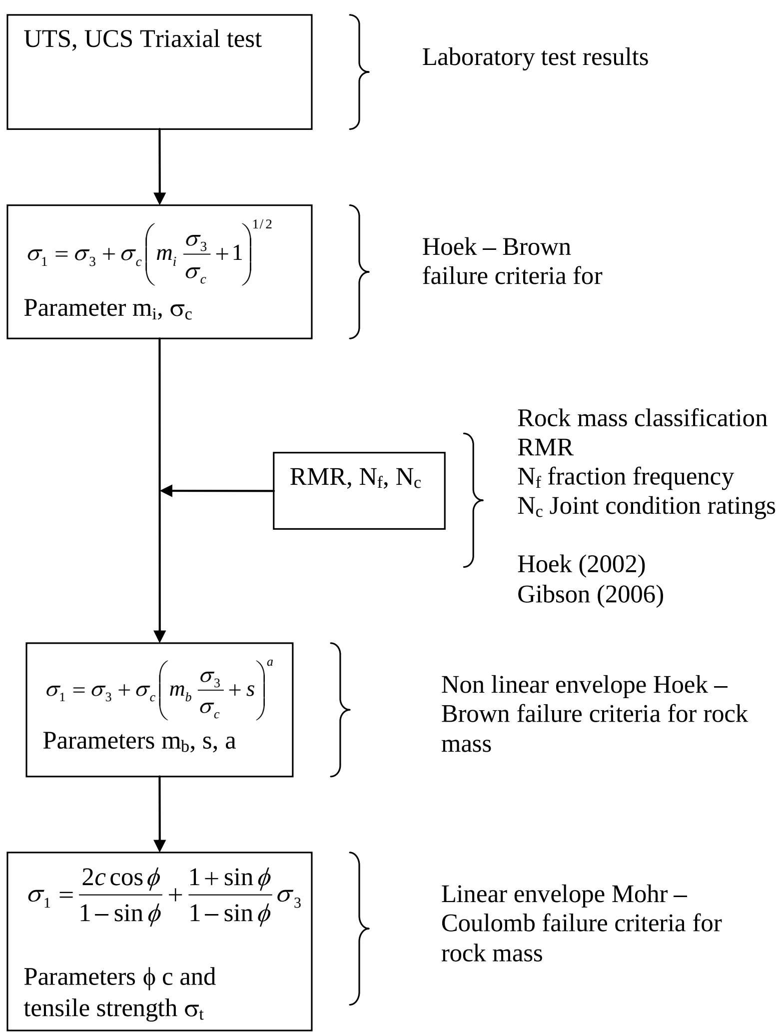


Figure E-1: Rock Mass Strength Assessment Procedure

Table E-1 through Table E-9 presents the rock mass strength parameters by sector and lithology (defined by wireframe) for the combined historical and recent data.

Table E- 1: Rockmass parameters for all sectors combined

	MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
RMR	42	50	60	58	63	72	53	60	67	48	55	62	54	59	66
GSI	37	45	55	53	58	67	48	55	62	43	50	57	49	54	61
Nf	6.3	15	22.5	16	22	29.5	10.5	17	22.5	4.3	9.5	17.5	10.5	14.5	19.5
Nc	12.5	16	20	14.5	18	21.5	15	19	22	15	19.5	22.5	19	21	22.5
sc	54	64	74	73	84	99	86	99	131	44	54	64	50	50	50
D	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
s3max	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
mi	11.5	11.5	11.5	8.6	8.6	8.6	7.3	7.3	7.3	5.1	5.1	5.1	10	10	10
mb	0.3609	0.5601	0.9703	0.6501	0.8556	1.4029	0.4193	0.6159	0.9048	0.2225	0.3269	0.4803	0.6068	0.7986	1.1732
s	0.0001	0.0003	0.0015	0.0011	0.0023	0.0084	0.0005	0.0015	0.0041	0.0003	0.0007	0.0020	0.0006	0.0013	0.0035
a	0.514	0.508	0.504	0.505	0.503	0.502	0.507	0.504	0.502	0.509	0.506	0.504	0.506	0.504	0.503
Fric	33	38	44	41	44	48	38	42	47	27	32	36	37	39	42
Cohesion	0.421	0.552	0.784	0.702	0.916	1.616	0.624	0.883	1.534	0.366	0.506	0.741	0.541	0.624	0.786
Tension	0.016	0.039	0.112	0.124	0.223	0.591	0.109	0.236	0.587	0.051	0.118	0.262	0.051	0.080	0.150
length		448			3754			3523			3436			676	

Table E- 2: Rockmass parameters for Sector 1

	MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
RMR	41	47	56	55	60	66	52	55	59	43	53	59	53	55	60
GSI	36	42	51	50	55	61	47	50	54	38	48	54	48	50	55
Nf	4	8	15	16.5	19.5	22.5	9.3	15	19.5	3	6.5	11.5	10	14	18
Nc	10	14.5	18.5	14	17	21	14	17	20.5	14.5	19	22.5	19	20.5	22.5
sc	54	64	74	73	84	99	86	99	131	44	54	64	50	50	50
D	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
s3max	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
mi	11.5	11.5	11.5	8.6	8.6	8.6	7.3	7.3	7.3	5.1	5.1	5.1	10	10	10
mb	0.3416	0.4750	0.7788	0.5513	0.7256	1.0089	0.3968	0.4680	0.5830	0.1691	0.2929	0.4073	0.5743	0.6410	0.8437
s	0.0001	0.0002	0.0008	0.0007	0.0015	0.0035	0.0005	0.0007	0.0013	0.0001	0.0005	0.0013	0.0005	0.0007	0.0015
a	0.515	0.510	0.505	0.506	0.504	0.503	0.507	0.506	0.504	0.513	0.507	0.504	0.507	0.506	0.504
Fric	32	37	42	39	43	46	38	40	44	25	31	35	37	37	40
Cohesion	0.410	0.510	0.691	0.634	0.811	1.165	0.602	0.719	0.999	0.314	0.472	0.648	0.527	0.556	0.643
Tension	0.015	0.030	0.078	0.094	0.170	0.344	0.100	0.151	0.286	0.033	0.098	0.200	0.046	0.056	0.087
Length [m]		270			476			203			1283			385	

Table E- 3: Rockmass parameters for Sector 2

	MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
RMR				55	62	68							62	68	74
GSI				50	57	63							57	63	69
Nf				13.5	19.5	24							13	18	21.5
Nc				14.5	17.5	21.5							19.5	21	22.5
sc				73	84	99							50	50	50
D				0.7	0.7	0.7							0.7	0.7	0.7
s3max				2	2	2							2	2	2
mi				8.6	8.6	8.6							10	10	10
mb				0.5513	0.8099	1.1261							0.9417	1.3095	1.8208
s				0.0007	0.0020	0.0047							0.0020	0.0047	0.0112
a				0.506	0.504	0.502							0.504	0.502	0.501
Fric				39	43	47							41	43	46
Cohesion				0.634	0.879	1.291							0.685	0.847	1.096
Tension				0.094	0.204	0.412							0.104	0.179	0.307
Length [m]					1405									192	

Table E- 4: Rockmass parameters for Sector 3

	MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
RMR				62	68	78	53	59	66				56	62	67
GSI				57	63	73	48	54	61				51	57	62
Nf				14.5	24	30	12.5	18	22.5				7	11	14.5
Nc				15.5	18.5	21.5	14.5	18	22				19.5	21.5	23
sc				73	84	99	86	99	131				50	50	50
D				0.7	0.7	0.7	0.7	0.7	0.7				0.7	0.7	0.7
s3max				2	2	2	2	2	2				2	2	2
mi				8.6	8.6	8.6	7.3	7.3	7.3				10	10	10
mb				0.8099	1.1261	1.9508	0.4193	0.5830	0.8564				0.6772	0.9417	1.2395
s				0.0020	0.0047	0.0200	0.0005	0.0013	0.0035				0.0008	0.0020	0.0041
a				0.504	0.502	0.501	0.507	0.504	0.503				0.505	0.504	0.502
Fric				42	46	50	38	42	46				38	41	43
Cohesion				0.814	1.155	2.368	0.624	0.845	1.446				0.572	0.685	0.815
Tension				0.177	0.350	1.014	0.109	0.216	0.537				0.061	0.104	0.164
Length [m]					871			1020						43	

Table E- 5: Rockmass parameters for Sector 4

	MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
RMR				66	73	81									
GSI				61	68	76									
Nf				26.5	31.5	37.5									
Nc				15	18.5	21.5									
sc				73	84	99									
D				0.7	0.7	0.7									
s3max				2	2	2									
mi				8.6	8.6	8.6									
mb				1.0089	1.4822	2.3004									
s				0.0035	0.0097	0.0309									
a				0.503	0.502	0.501									
Fric				44	47	50									
Cohesion				0.962	1.514	2.916									
Tension				0.254	0.549	1.328									
Length [m]					794										

Table E- 6: Rockmass parameters for Sector 5

	MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
RMR	62	66	71	50	57	63	59	66	73	48	56	63			
GSI	57	61	66	45	52	58	54	61	68	43	51	58			
Nf	18	21.5	25.5	8	13.5	19.5	17.5	23	31	6.5	15.5	22.5			
Nc	18.5	20.5	22.5	13.5	18	21.5	15	18	21.5	13	16	19			
sc	54	64	74	73	84	99	86	99	131	44	54	64			
D	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7			
s3max	2	2	2	2	2	2	2	2	2	2	2	2			
mi	11.5	11.5	11.5	8.6	8.6	8.6	7.3	7.3	7.3	5.1	5.1	5.1			
mb	1.0830	1.3492	1.7757	0.4189	0.6153	0.8556	0.5830	0.8564	1.2581	0.2225	0.3454	0.5074			
s	0.0020	0.0035	0.0072	0.0003	0.0010	0.0023	0.0013	0.0035	0.0097	0.0003	0.0008	0.0023			
a	0.504	0.503	0.502	0.508	0.505	0.503	0.504	0.503	0.502	0.509	0.505	0.503			
Fric	43	46	49	37	41	45	41	45	48	27	33	37			
Cohesion	0.724	0.902	1.209	0.543	0.725	1.010	0.781	1.182	2.250	0.366	0.525	0.777			
Tension	0.098	0.166	0.302	0.060	0.130	0.263	0.188	0.406	1.008	0.051	0.129	0.287			
Length [m]		18			208			436			222				

Table E- 7: Rockmass parameters for Sector 6

	MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
RMR							53	59	63	51	56	60			
GSI							48	54	58	46	51	55			
Nf							10	15.5	22	5	10.5	15.5			
Nc							15.5	19	21.5	18.6	20.5	22.5			
sc							86	99	131	44	54	64			
D							0.7	0.7	0.7	0.7	0.7	0.7			
s3max							2	2	2	2	2	2			
mi							7.3	7.3	7.3	5.1	5.1	5.1			
mb							0.4193	0.5830	0.7263	0.2624	0.3454	0.4303			
s							0.0005	0.0013	0.0023	0.0004	0.0008	0.0015			
a							0.507	0.504	0.503	0.508	0.505	0.504			
Fric							38	42	45	29	33	36			
Cohesion							0.624	0.845	1.223	0.402	0.525	0.677			
Tension							0.109	0.216	0.410	0.067	0.129	0.219			
Length [m]								1501			897				

Table E- 8: Rockmass parameters for Sector 7

	MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
RMR							57	63	71	44	54	61			
GSI							52	58	66	39	49	56			
Nf							14.5	23	30.5	6.5	13.5	22.5			
Nc							14	17	21	12.5	15.5	18.5			
sc							86	99	131	44	54	64			
D							0.7	0.7	0.7	0.7	0.7	0.7			
s3max							2	2	2	2	2	2			
mi							7.3	7.3	7.3	5.1	5.1	5.1			
mb							0.5223	0.7263	1.1272	0.1786	0.3095	0.4546			
s							0.0010	0.0023	0.0072	0.0001	0.0006	0.0017			
a							0.505	0.503	0.502	0.512	0.506	0.504			
Fric							40	44	48	25	32	36			
Cohesion							0.722	1.015	1.970	0.323	0.488	0.708			
Tension							0.157	0.310	0.842	0.036	0.108	0.239			
Length [m]								525			182				

Table E- 9: Rockmass parameters for Sector 8

	MAFV (NVV)			IMH			SLD			PICR (NVP)			SVHYB		
Property	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%	25%	50%	75%
RMR	55	63	69				62	67	80	50	59	68			
GSI	50	58	64				57	62	75	45	54	63			
Nf	19	25	31				9	14	21	7	17.5	26			
Nc	15	18	21				20.5	25.5	28	15	19	23			
sc	54	64	74				86	99	131	44	54	64			
D	0.7	0.7	0.7				0.7	0.7	0.7	0.7	0.7	0.7			
s3max	2	2	2				2	2	2	2	2	2			
mi	11.5	11.5	11.5				7.3	7.3	7.3	5.1	5.1	5.1			
mb	0.7372	1.1441	1.5909				0.6875	0.9048	1.8483	0.2484	0.4073	0.6678			
s	0.0007	0.0023	0.0054				0.0020	0.0041	0.0267	0.0003	0.0013	0.0047			
a	0.506	0.503	0.502				0.504	0.502	0.501	0.508	0.504	0.502			
Fric	39	44	48				42	45	49	28	34	39			
Cohesion	0.592	0.810	1.104				0.888	1.248	3.713	0.389	0.589	1.005			
Tension	0.052	0.127	0.252				0.246	0.444	1.892	0.061	0.169	0.449			
Length [m]		160						202			923				

Appendix F: Joint Strength

1 Joint Strength

The joint strength was calculated based on laboratory test results of direct shear on joints. Several sources of information were available; these are included in the information summaries for each of the major rock types presented in Figure F-1 through Figure F-3.

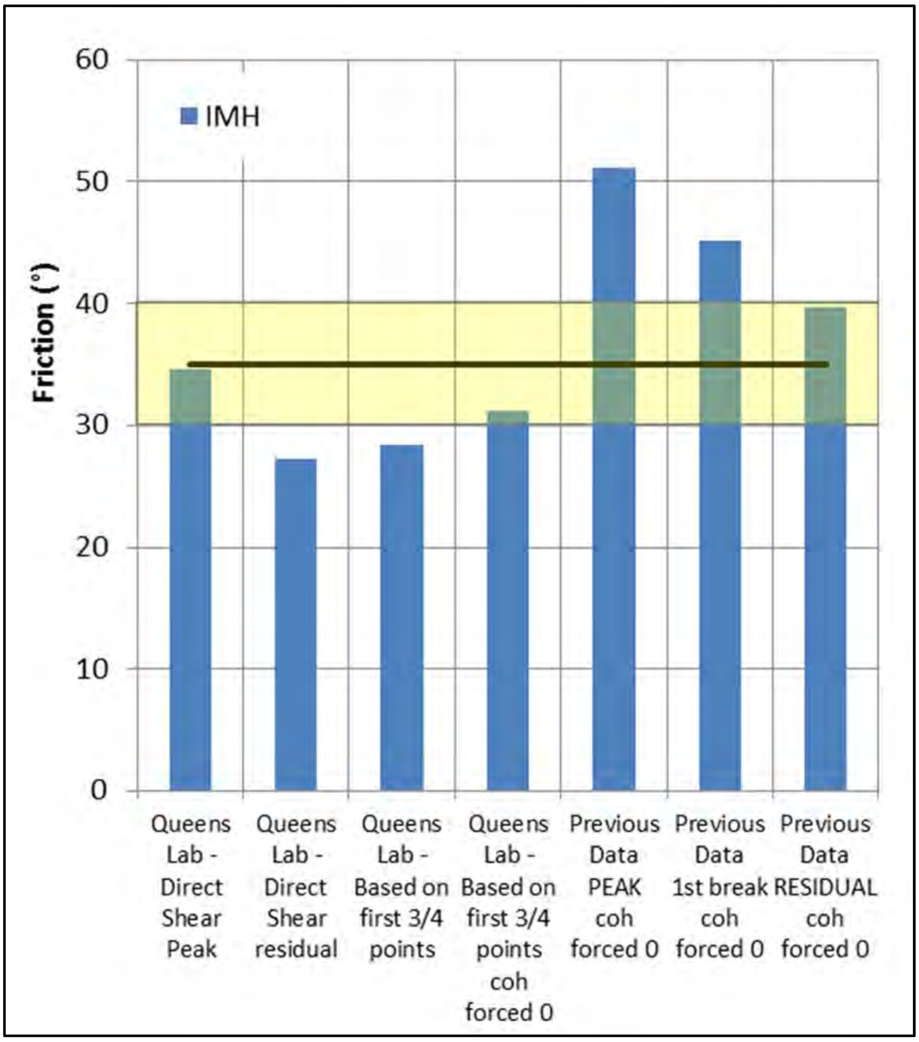


Figure F-1: Summary of joints strength for IMH

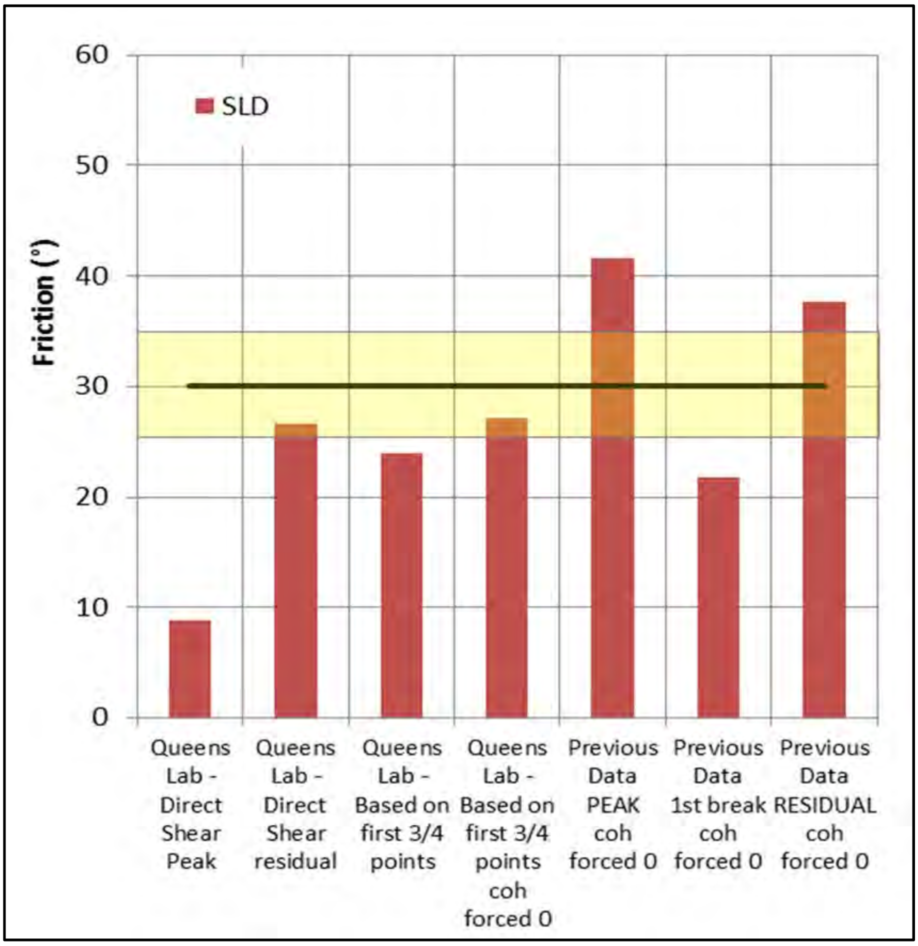


Figure F-2: Summary of joint strength for SLD

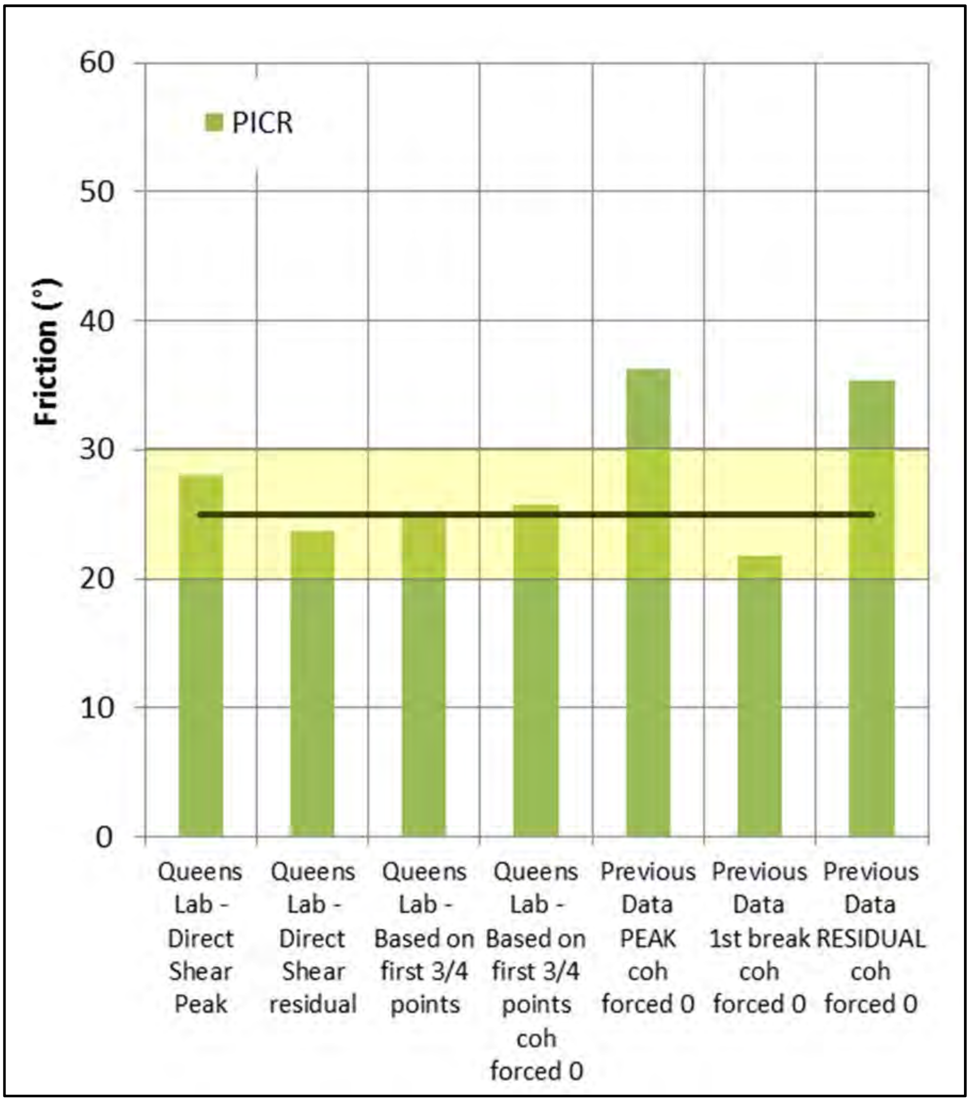


Figure F-3: Summary of joints strength for PICR

Table F-1 lists the representative friction angles selected for each of the major rock types.

Table F-1: Joint friction angles selected for units IMH, SLD and NVP

UNIT	Selected Friction Angle (°)	Approximate Range (°)
IMH	35	[30 – 40]
SLD	30	[25 – 35]
PICR	25	[20 – 30]

2 Fault characterisation

An attempt has been made to locate the faults presented in the KGHM structural model within the drillcore of the geotechnical drilling campaigns, using the available core photographs. The anticipated depth of intersection of the various faults within the drillholes is listed in Table F-2. Selected core photographs showing evidence of fault characteristics are provided in Figure F-4 through Figure F-10.

Table F-2: Logged faults

Drillhole	Wireframe	Comment - wireframes	Photo
AE-08-050	IMH	Fault at 168 (low angle)	
AE-10-064	SLD	Faults at 22 (subvert), 60 (low angle), 182 (low angle), 206 (60°) and 367 m (low angle)	
AE-10-065	SLD	Faults at 22 (60°), 56 (low angle) and 80 m (subvert)	
AM-07-006	NVP (Picrite)	Fault at 367 (subvert)	
AM-07-007	NVP (Picrite)	Fault at 450 (subvert)	
AM-10-054	SLD	Fault at 343 (subvert)	Figure F-4
AM-10-054	NVP (Picrite)	Fault at 520 (subvert)	Figure F-5
AM-10-061	IMH	Fault at 96 (low angle).	No photo
AM-10-067	SLD	Faults at 4 and 300 (both low angle)	Figure F-6
AN-10-075	SLD	Fault at 75 m (subvert)	Figure F-7
AW-07-071	NVP (Picrite)	Fault at 101 m (subvert)	No photo
AW-08-074	IMH	Fault at 108 m (low angle)	No photo
AW-08-074	PXPP	Fault at 496 m (subvert), possible intersection (subvert) at 592 m	No photo
AW-08-089	NVP (Picrite)	Fault at 280 m (low angle)	No photo
AW-09-103	NVP (Picrite)	Fault at 338 m (low angle)	No photo
AW-09-104	NVP (Picrite)	Fault at 249 m (low angle)	No photo
AW-10-061	NVP (Picrite)	Fault at 233 (60°)	Figure F-8
AW-10-106	IMH	Faults at 82 m (low angle) and 119 m (subvert)	82 m - No photo of core trays 16-18 119 m - Figure F-9
AW-10-118	IMH	Fault at 205 (low angle)	Figure F-10

Figure F-4: AM-10-054 fault in SLD at ~339-343 m – zone of weak, broken rock

Figure F-5: AM-10-054 fault in PICR at ~520 m – zone of broken rock, fault gouge

Figure F-6: AM-10-067 fault in SLD at ~300 m – fault gouge filled structure; rock appears more altered in immediate vicinity of fault

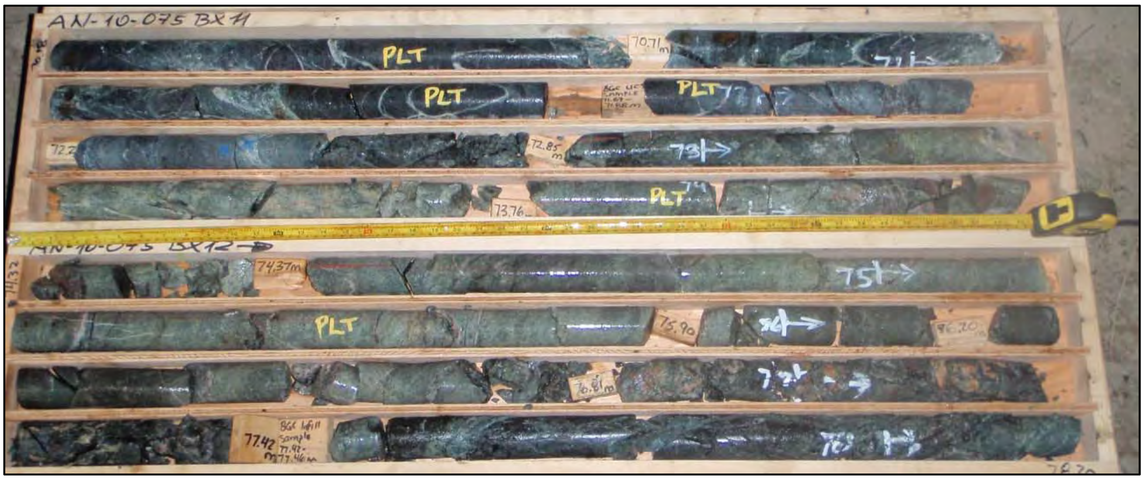


Figure F-7: AM-10-075 fault in SLD at ~77-78 m – fault gouge filled structure, rock appears more altered, weaker in immediate vicinity of fault

Figure F-8: AM-10-061 fault in PICR at ~233 m according to wireframe model. Core shows structures at 229.5 m and zone 241-245 m which could be the fault/ fault zone

Figure F-9: AW-10-106 fault in IMH at ~119 m according to wireframe model. No obvious structure visible in core photos at 119 m, possible broken, weak, altered zone at 122-125. Rock is generally more broken, altered, and weaker than surrounding IMH.

Figure F-10: AW-10-118 fault in IMH at ~205 m. Fault not obvious in photos- but structure with red iron staining (203.7 m) may indicate water bearing structure, which may be fault related

Based on the information collected, and on SRK experience, it has been estimated that the appropriate strength properties for the faults are: cohesion 100 KPa, friction 26° and tension 2 KPa.

3 SLD – PICR Contact

The SLD- PICR (NVP) contact in Sectors 6 and 7 is unfavourably-oriented. This is illustrated in Figure F-11. Core photos were examined to determine the geotechnical characteristics of this contact. This was done to ascertain if the contact needs to be considered as an open "structure", or if the contact is closed/ cemented, and thus not a control on stability in these sectors.

Core photos of the SLD-PICR contact from Sectors 6 and 7 are presented in Figures F-12 through F-15.

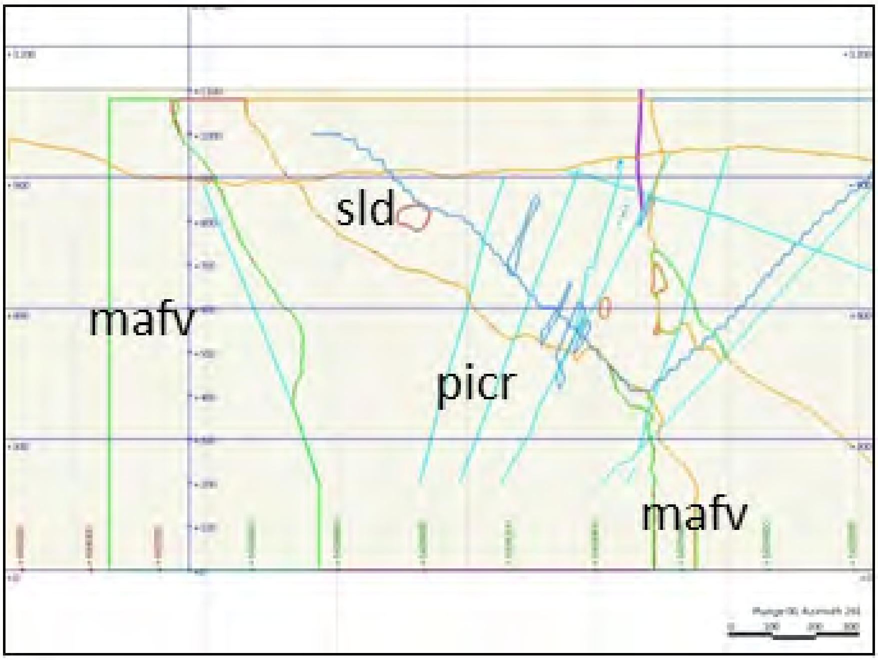


Figure F-11: Section 6 from Sector 6 showing potentially unfavourable orientation of SLD/PICR contact

Figure F-12: AM-10-054 Contact SLD-PICR at 454.76 m

Contact appears open. PICR appears less strong, more altered than SLD.

Figure F-13: AN-10-075 Contact PICR-SLD at 63.09 m

Contact appears open, rock near contact friable. Both PICR and SLD are highly altered and weak.

Figure F-14: AN-10-075 Contact SLD-PICR at 268.83 m

Contact appears open, rock near contact friable. PICR appears less strong, more altered than SLD.

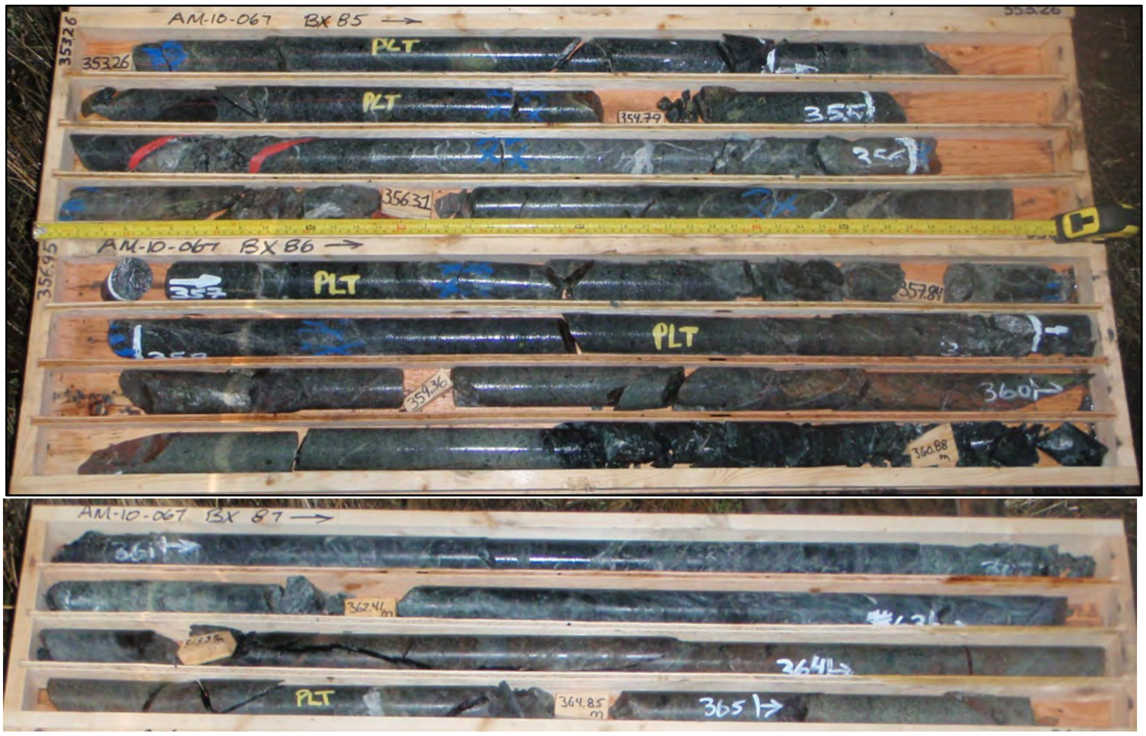


Figure F-15: AM-10-067 Contact SLD-PICR at ~360.5 m

PICR at contact appears friable; however 50 cm from contact the PICR is competent.

Comments on the geotechnical condition at the SLD-PICR contact have been summarised from the geotechnical logs in Table F-3.

Table F-3: SLD-PICR contact description from geotech logs

Drillhole – contact depth	Comment on geotech conditions at contact
AM-10-054 Contact SLD-PICR at 454.76 m	No reduction in logged FES or joint spacing near contact
AN-10-075 Contact PICR-SLD at 63.09 m	No change in rock strength near contact, PICR shows lower RQD at contact (5 core runs)
AN-10-075 Contact SLD-PICR at 268.83 m	Three runs of PICR at contact: very low FES, low RQD
AM-10-067 Contact SLD-PICR at ~360.5 m	No change in rock strength near contact, PICR shows lower RQD at contact (~0.5 m)
AW-09-104 Contact SLD-PICR at 145.39 m	No change in strength at contact. RQD in PICR generally lower than in SLD, but throughout all rock, not just at contact.
AM-07-006 Contact SLD-PICR at 252.06 m	No change in strength at contact. RQD in PICR generally lower than in SLD, but throughout all rock, not just at contact. PICR very low RDD (sometimes 0%) with “99” fractures per interval.
AM-07-007 Contact SLD-PICR at 185.01 m	No change in strength or RQD near contact. PICR does not appear weaker.
KAX-13-098 Contact SLD-PICR at 387.1 m	No change in strength at contact. RQD in PICR generally lower than in SLD, but throughout all rock, not just at contact.

In conclusion, the review of the core photographs seems to indicate that the contact is open. Description of geotechnical conditions indicated variable conditions, commonly with PICR uniformly weaker than the SLD. It was decided not to model the contact as a discrete plane of weakness, because the PICR is generally a much weaker rock than SLD, and the weak rock will thus control the potential failure in Section 6 and 7.

Appendix G: Wedge Stability Analysis

1 Introduction

A deterministic kinematic failure analysis was performed to determine the berm width required to contain wedge failure resulting from the structures identified as present in each sector and rock type. This information was used as a first geometric approach for the overall stability of the pit.

2 Procedure for Deterministic Analysis

For selected bench face angles, bench heights and slope face orientations in each rock type (with identified structural sets), all possible combination of joints that can form wedge failure are identified, and the factor of safety of the wedges is calculated. This is performed using SRK in-house MWedge software For any wedges with a Factor of Safety less than 1.1, the volume of the failed material (assuming a swelling factor of 40%) is calculated.

The analysis is iterative: if the berm does not retain the volume of failed material the berm width is increased until the full volume is retained. The required berm width identified in this way is rounded to the nearest 0.5 m.

The analysis inputs are summarised in Table G-1.

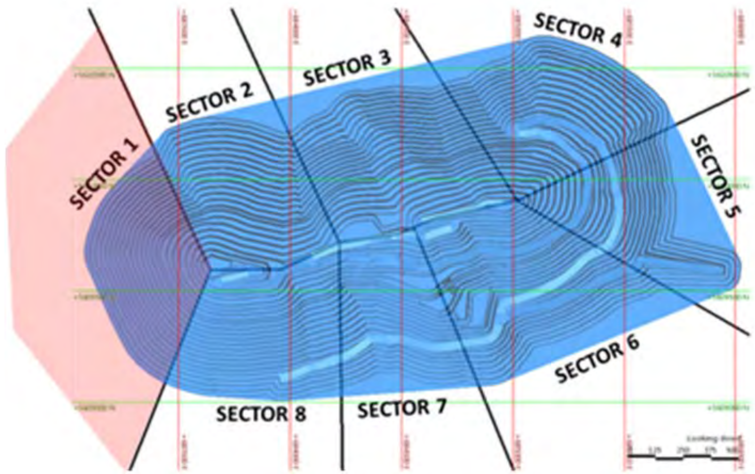
Table G-1 Summary of wedge failure kinematic analysis inputs

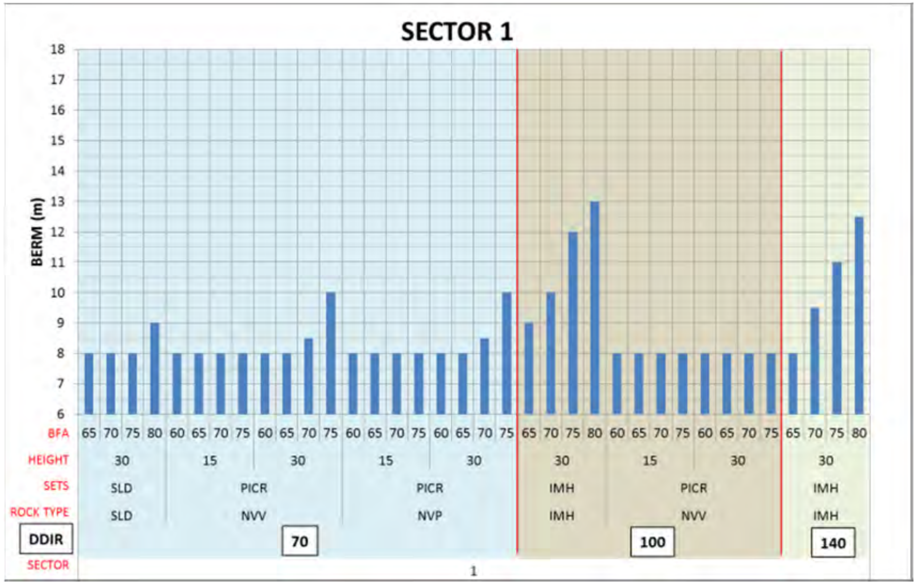
SECTOR	ORIENTATION DDIR (°)	ROCK TYPE JOINT STRENGTH [see Appendix F]	SETS [see Appendix B]	BENCH HEIGHT (m)	BENCH FACE ANGLE (°)
1 to 8	Dip direction of the slope at each sector	IMH	Structural sets of each rock type at each domain.	30	65° to 80°
		SLD			
		NVV		15 & 30	60° to 75°
		NVP			

3 Results

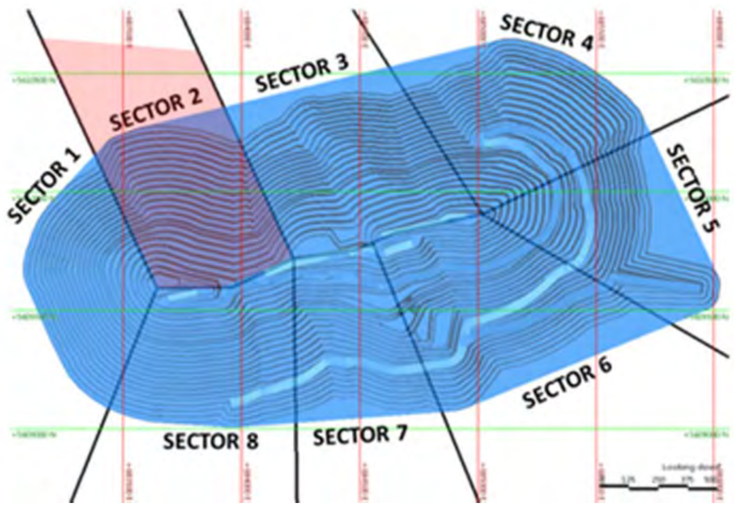
Figure G-1 through Figure G-4 present the results of the deterministic analysis for all pit sectors.

SECTOR 1





SECTOR 2



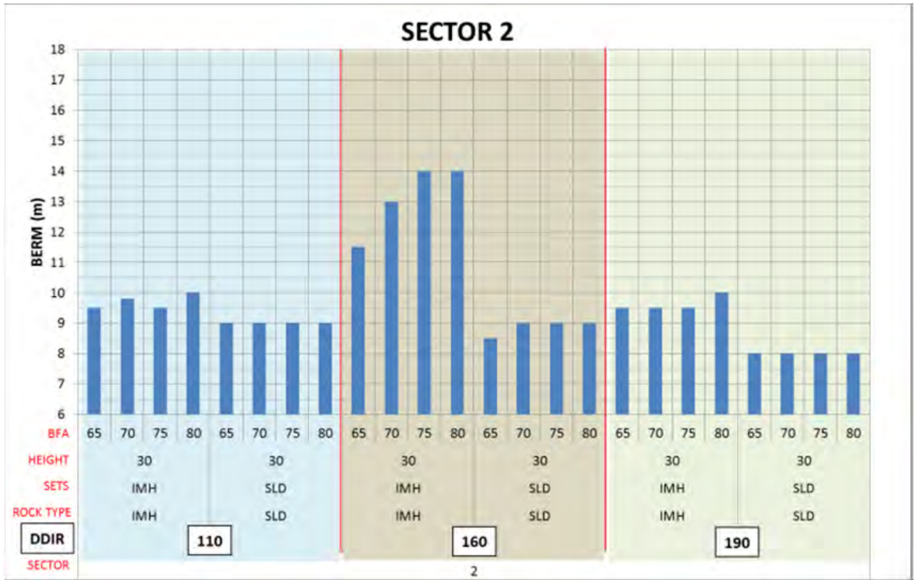


Figure G-1 Kinematic analysis: spill berm width required for Sectors 1 and 2

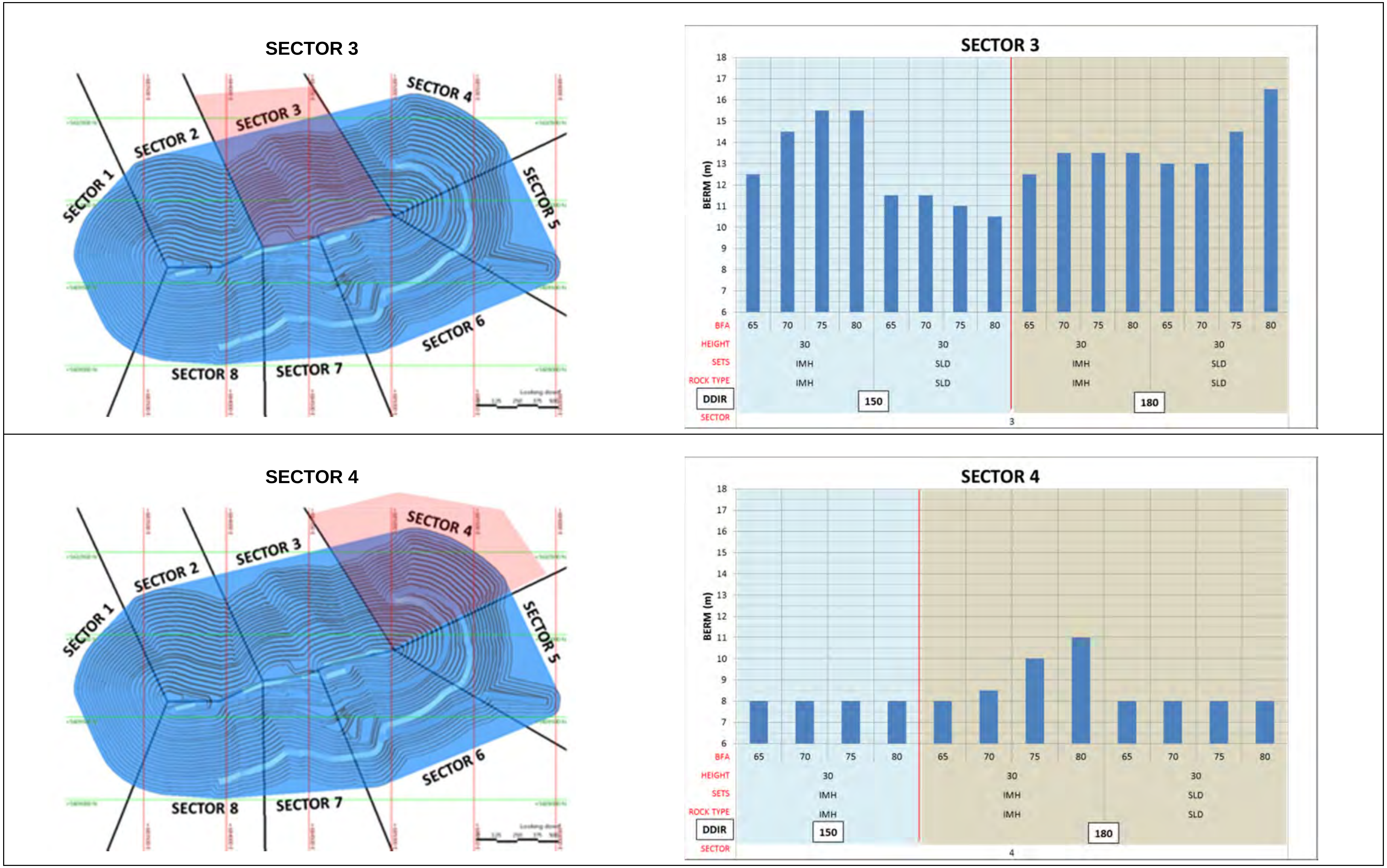
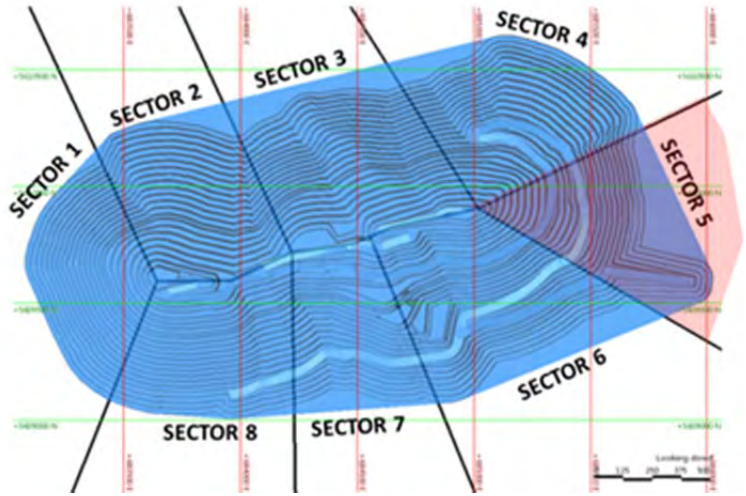
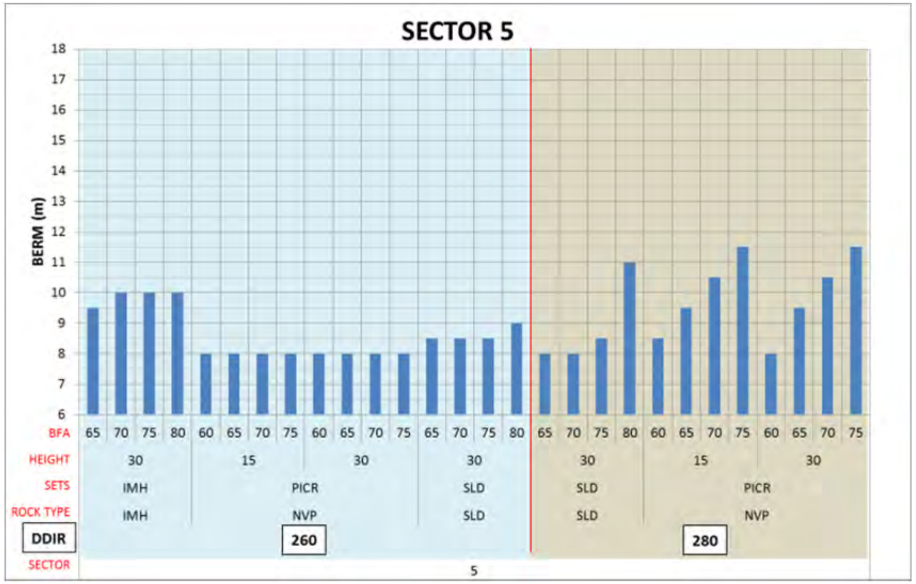


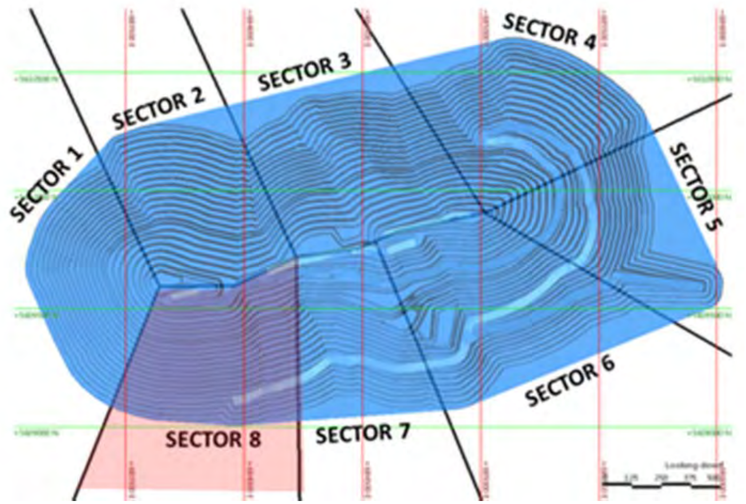
Figure G-2 Kinematic analysis: spill berm width required for Sectors 3 and 4

SECTOR 5





SECTOR 8



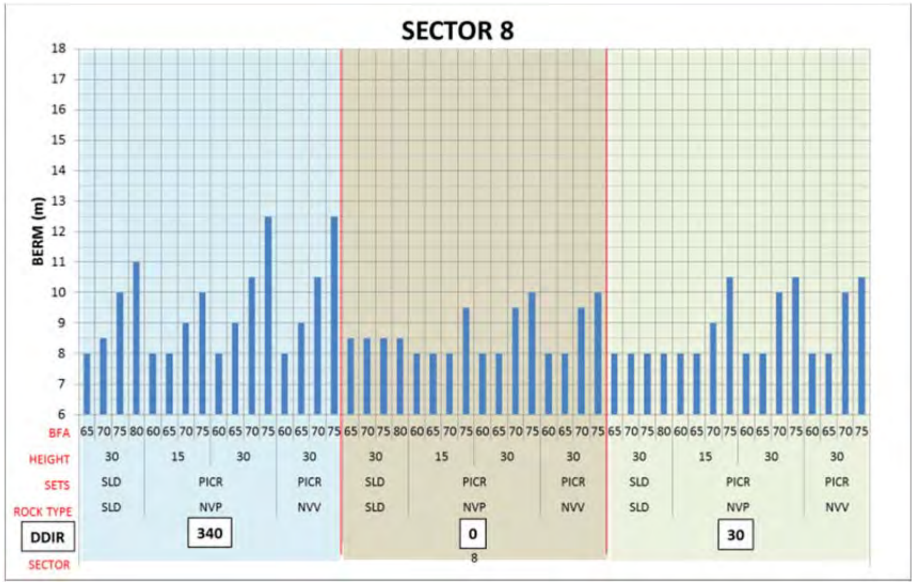
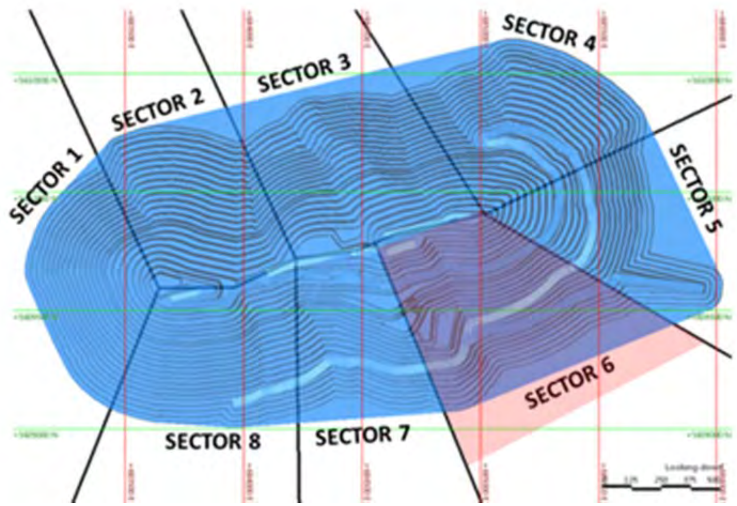
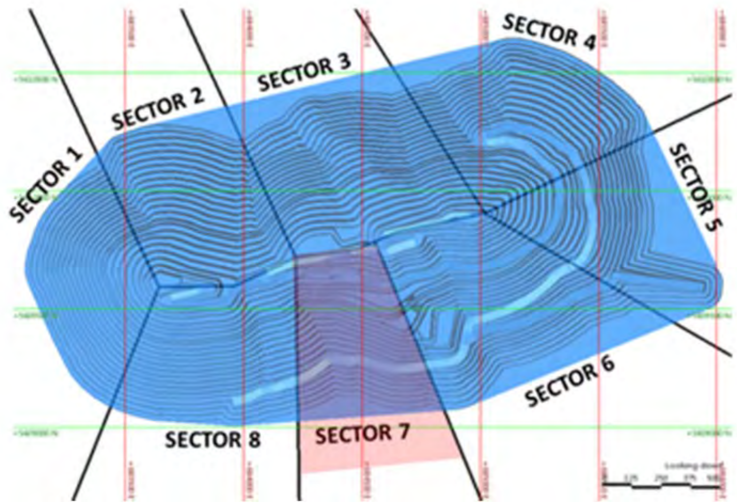


Figure G-3 Kinematic analysis: spill berm width required for Sectors 5 and 6

SECTOR 6



SECTOR 7



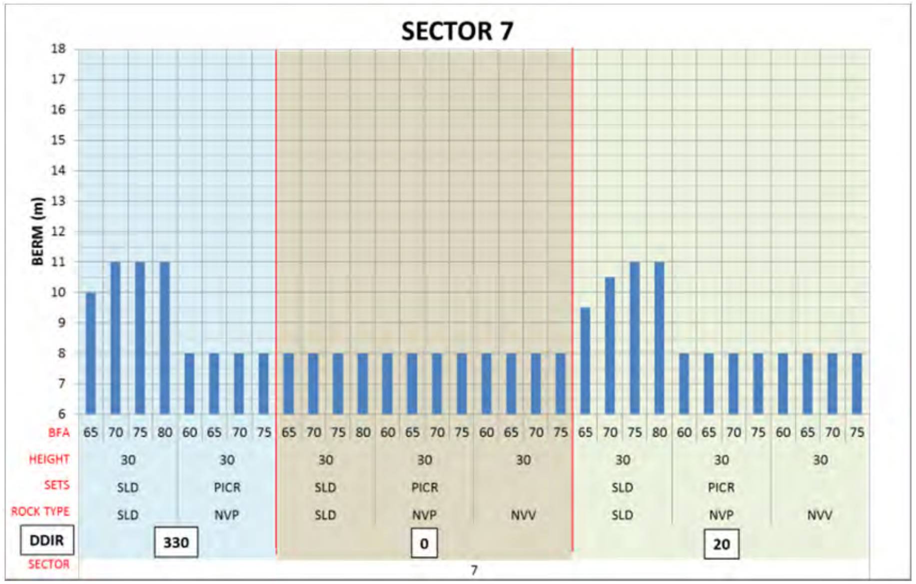


Figure G-4 Kinematic analysis: spill berm width required for Sectors 7 and 8

4 Probabilistic Analysis

The probabilistic analysis was carried out using the Monte Carlo method, in which 25,000 combinations are analysed for each material in each sector to calculate the distribution of the failed material and the capacity of the berm to contain the failed material.

The design criteria used for the design of the berm widths are:

- That the berms should be wide enough so that the full volume of at least 95% of all failures should be retained upon the berms; and
- That in the remaining 5% or cases (where there is spillage), not more than 10% of the volume of and wedge should be allowed to spill from the berm.

The analysis is iterative, and the berm with is changed until it satisfies the design criteria. Table 4-1 show the final results.

Table G-2: Spill berm width required by sector and rock type

Sector	IMH		SLD		NVP		NVV	
	$B_{95\%}$	Spill %	$B_{95\%}$	Spill %	$B_{95\%}$	Spill %	$B_{95\%}$	Spill %
1	16.5	1.2	18.0	2.3	16	0.3	16.0	0.4
2	17.5	1.8	17.5	1.0	- -	- -	- -	- -
3	18.5	3.4	20.5	1.9	- -	- -	- -	- -
4	16.5	1.5	18.0	2.3	- -	- -	- -	- -
5	14.0	2.9	21.5	0.9	16.0	1.1	16.0	0.7
6	- -	- -	17.0	1.4	15.0	0.7	- -	- -
7	- -	- -	17.0	2.1	- -	- -	- -	- -
8	- -	- -	17.0	2.0	15.0	2.0	15.0	1.4

Where: **$B_{95\%}$** is the berm width [m] required to contain the failed material for 95% of all failures; and

Spill % is the percentage of the material failed that will overspill the berm, falling onto the berm below.

Appendix H: FLAC 2D Analysis

1 Introduction

Two dimensional numerical stability analyses were performed to assess the performance of pit slope profiles generated using the preliminary design parameters.

Eight sections were selected to best represent each pit sector. Sector 8 was represented by two sections to take into account the variability of the lithologies within this sector.

2 Numerical Modelling approach

The finite difference method (FLAC software) was used for the 2D analyses. SRK developed routines to modify the overall slope angle of the cross section until a desired FoS was achieved.

The design criteria adopted consider a minimum Factor of Safety (FoS) of 1.3

3 Results

Figure H-1, H-2 and H-3 show:

- The location of the 2D sections selected and the Overall Slope Angle (OSA) obtained;
- A cross section profile with the rock types presented; and
- The mode of failure, based on its total displacement, obtained for each assessment.

The outcomes of the analysis were used as a starting point for the 3D modelling assessment.

<table>
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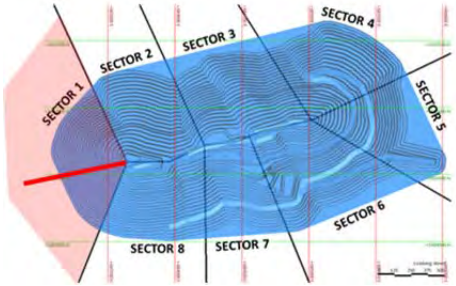

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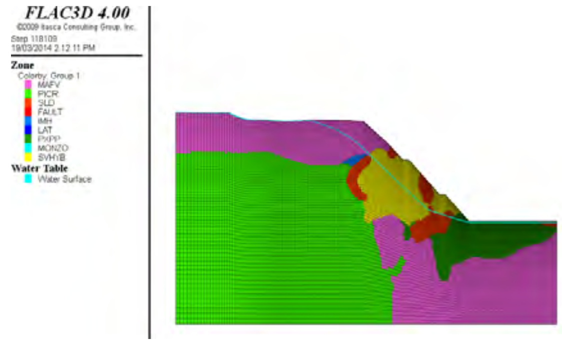

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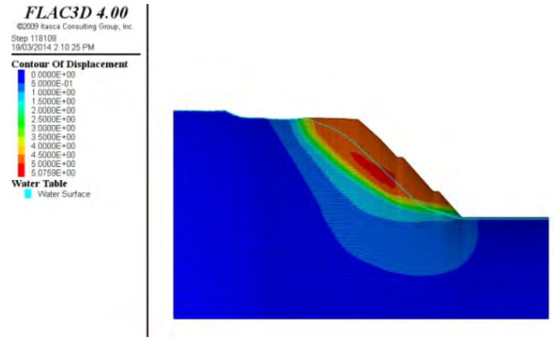

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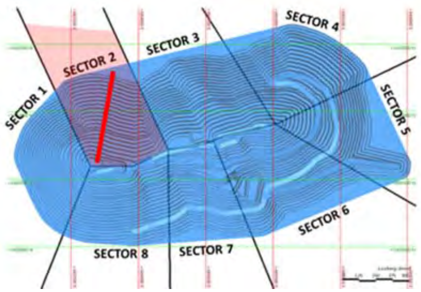

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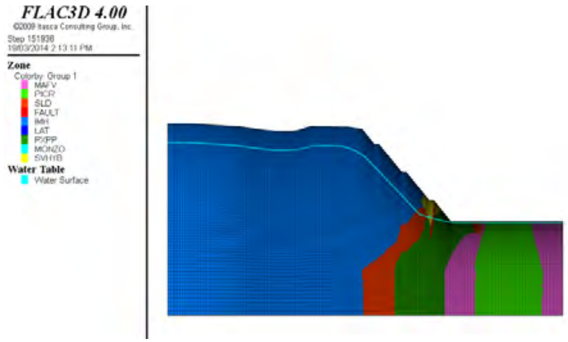

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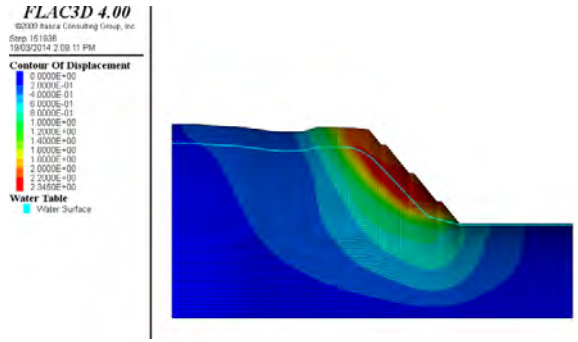

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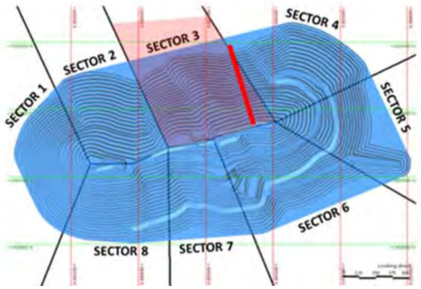

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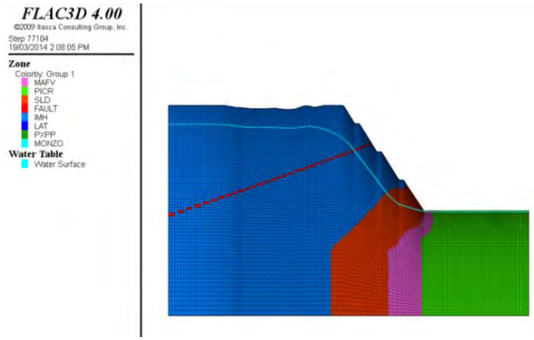

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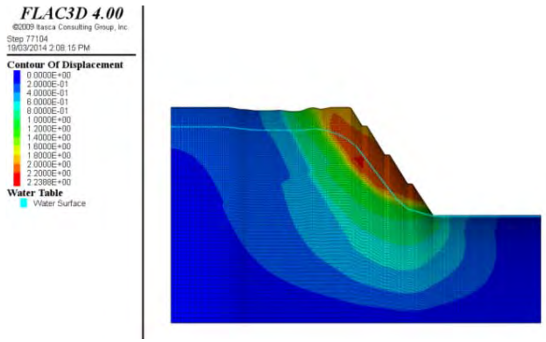

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Figure H-1 Results of 2D analyses for Sections 1, 2 and 3

<table>
<tr><th>PLAN VIEW</th><th>UNITS</th><th>TOTAL DISPLACEMENT (Displacement contour is indicative of the mode of failure)</th></tr>
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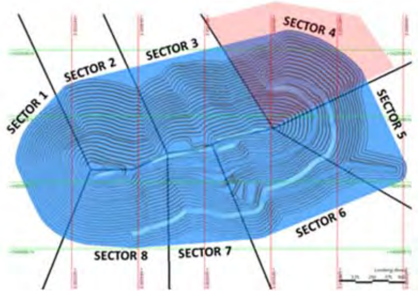
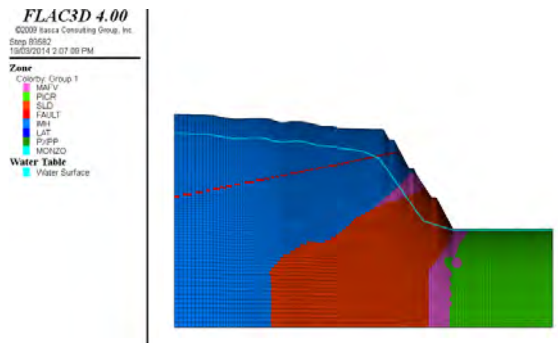
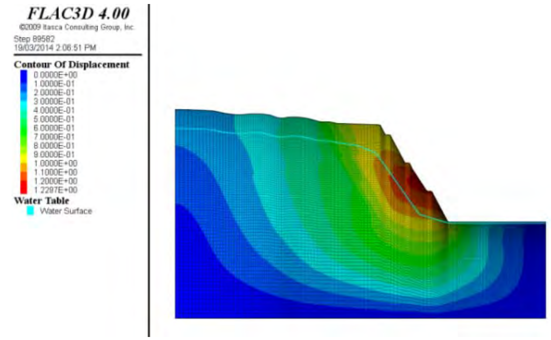
<td>SECTION 4 – OSA 55°
</td>
<td></td>
<td></td>
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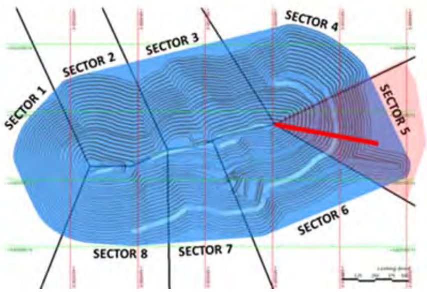
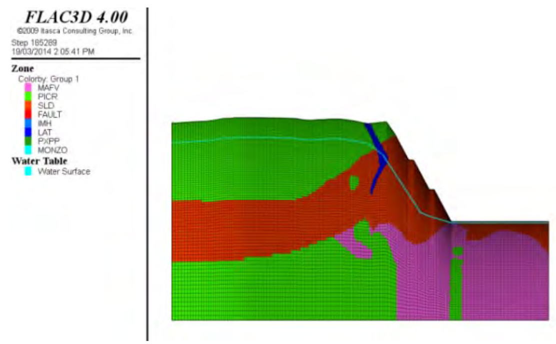
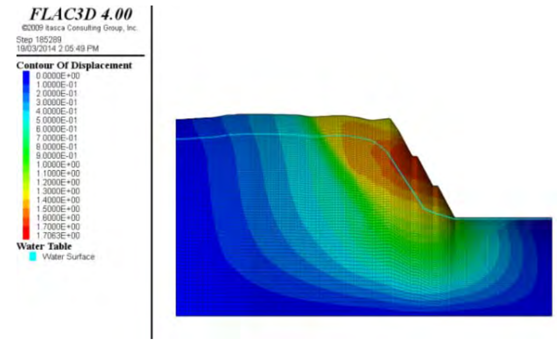
</td>
<td></td>
<td></td>
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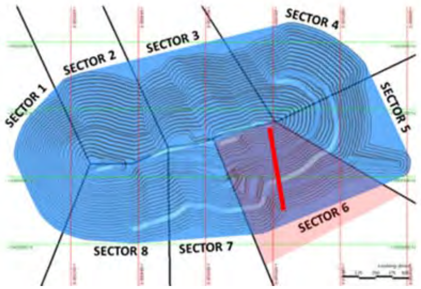
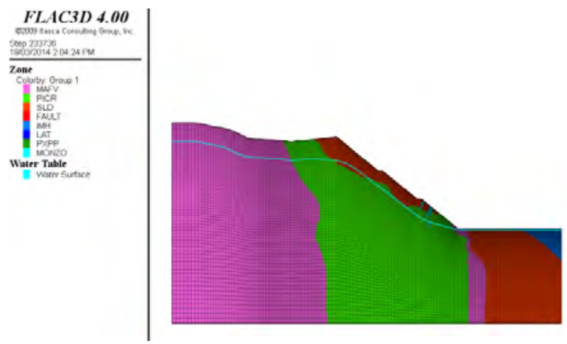
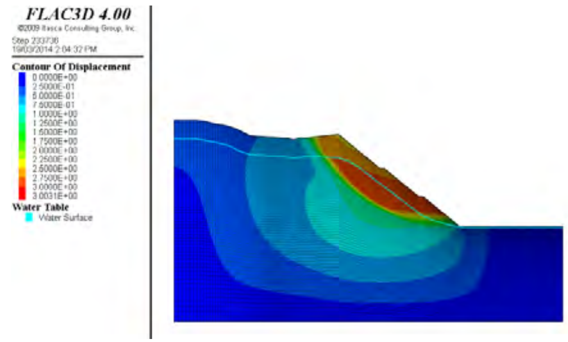
<tr>
<td>SECTION 6 – OSA 37°
</td>
<td></td>
<td></td>
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Figure H-2 Results of 2D analyses for Sections 4, 5 and 6

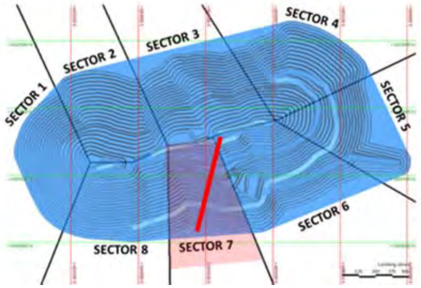
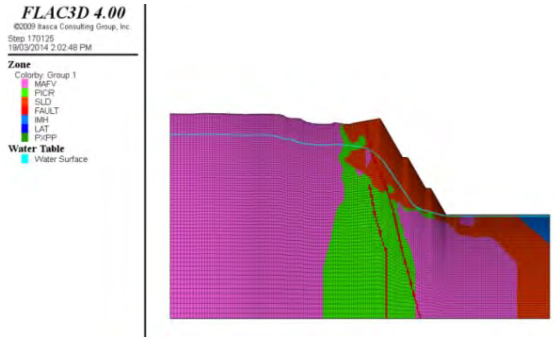
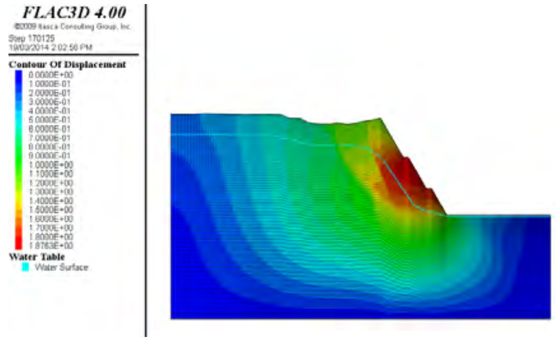
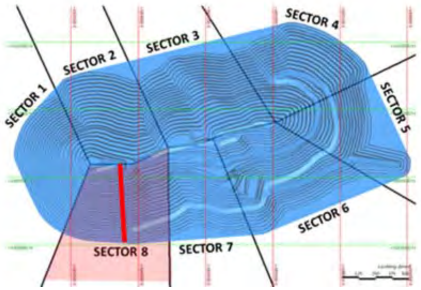
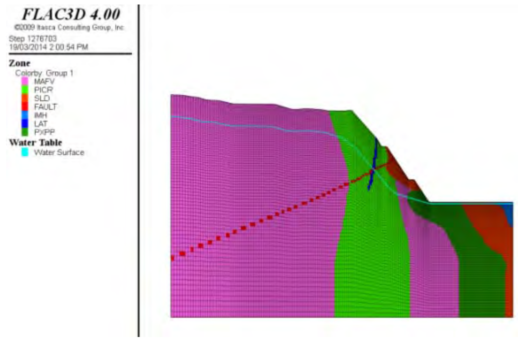
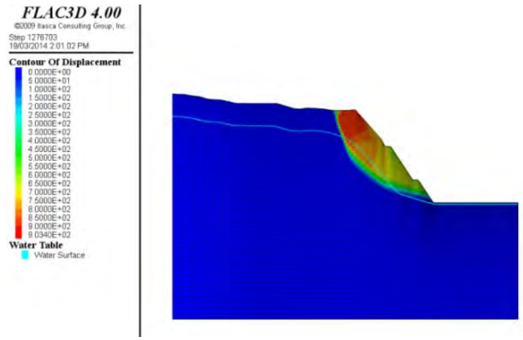
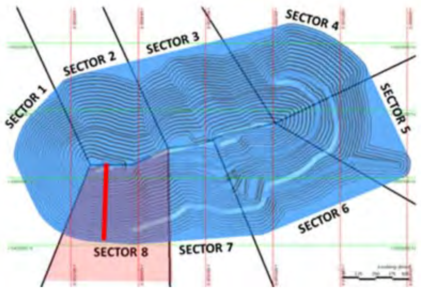
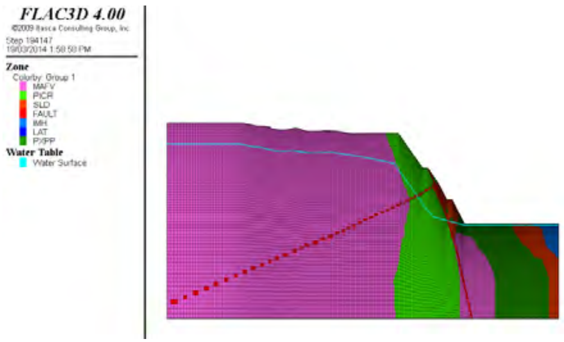
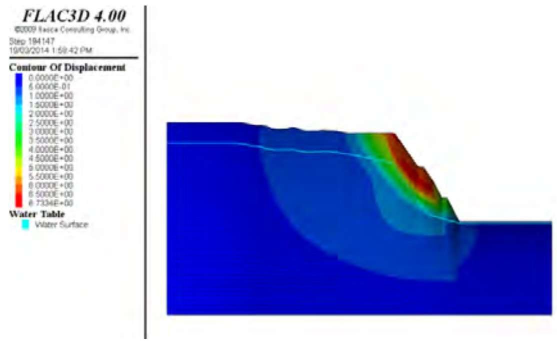
PLAN VIEW	UNITS	TOTAL DISPLACEMENT (Displacement contour is indicative of the mode of failure)
SECTION 7 – OSA 56° 		
SECTION 8a – OSA 50° 		
SECTION 8b – OSA 54° 		

Figure H-3 Results of 2D analyses for Sections 7, 8a and 8b

Appendix I: FLAC 3D Analysis

FLAC 3D Analysis

This appendix summarises the detailed results of the FLAC 3D analyses. For expediency, only the results of the last analysis in the modelling iteration are presented in this appendix. Table I-1 presents the indicative Factor of Safety values, which have been taken as the critical strength reduction factor (SRF) values for the various wall sectors of the final pit as well as the stage 1 and stage 2 pits.

Table I-1: Model results of critical SRF

Modelled region	Indicative critical SRF (~FoS)
Northern wall-Final pit	1.39
Southern Wall-Final pit	1.42
Eastern Wall-Final pit	1.75
Western Wall-Final pit	1.6
Stage 1 Pit	1.43
Stage 2 Pit	>1.80

The following plots are presented for each analysis to illustrate the indicative instability of the model corresponding to the FoS shown in Table I-1. These sets of plots are presented from Figure I-2 tnrough Figure I-67.

1. **History location plot:** This shows the locations of the vertical history planes in plan view (an example is provided in Figure I-1).
2. **Material group plot:** This illustrates various material regions within the modelled rockmass.
3. **Displacement contour plot:** This shows the contour of cumulative displacement magnitude during the SRF Analyses (i.e. displacements were reset before starting the SRF analyses) in 3-Dimensions. These displacements are only used for interpreting instability, and shall not be related to reality.
4. **Velocity Contour plot:** This shows the contour of velocity magnitude at the last numerical calculation step of the SRF analyses. These velocities shall not be related to the reality, and are only used for interpreting the instability.
5. **Velocity history plot for given history locations:** This plot shows the histories of velocity magnitude during SRF analyses for the given history points. As mentioned at (4) , these velocities shall not be related to the reality, and are only used for interpreting the instability.
6. **Velocity contour plot of vertical plane:** These plots shows the contour of velocity magnitude in 2D vertical sections cut along the history location planes. As mentioned at (4) , these velocities shall not be related to the reality, and are only used for interpreting the instability.

Figure I-1 An example of history point locations for a vertical section

Northern model-Final Pit

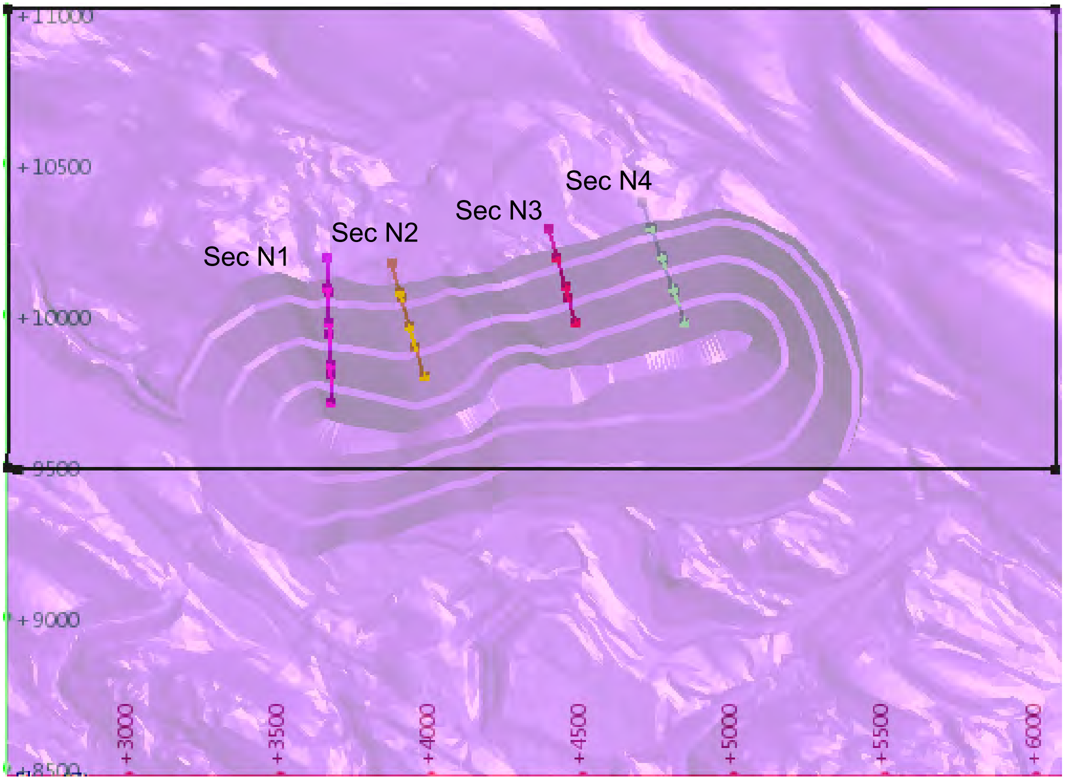


Figure I-2: History locations-Northern wall of final pit

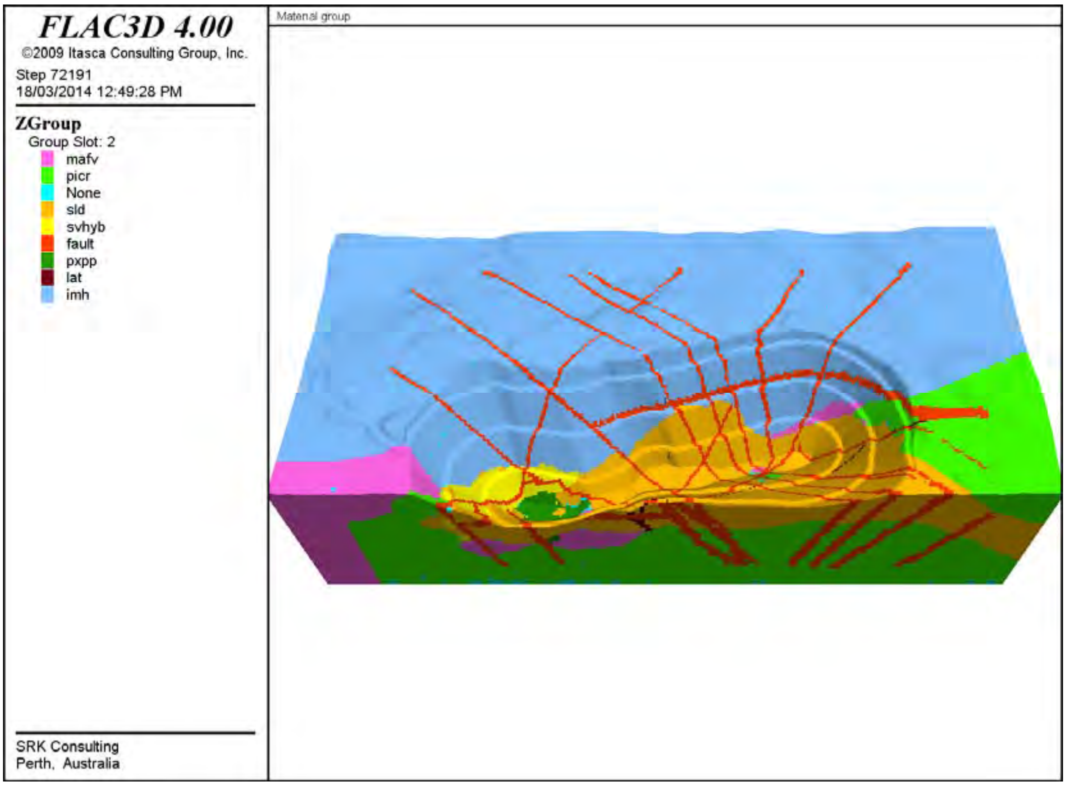


Figure I-3: Material groups-Northern wall of final pit

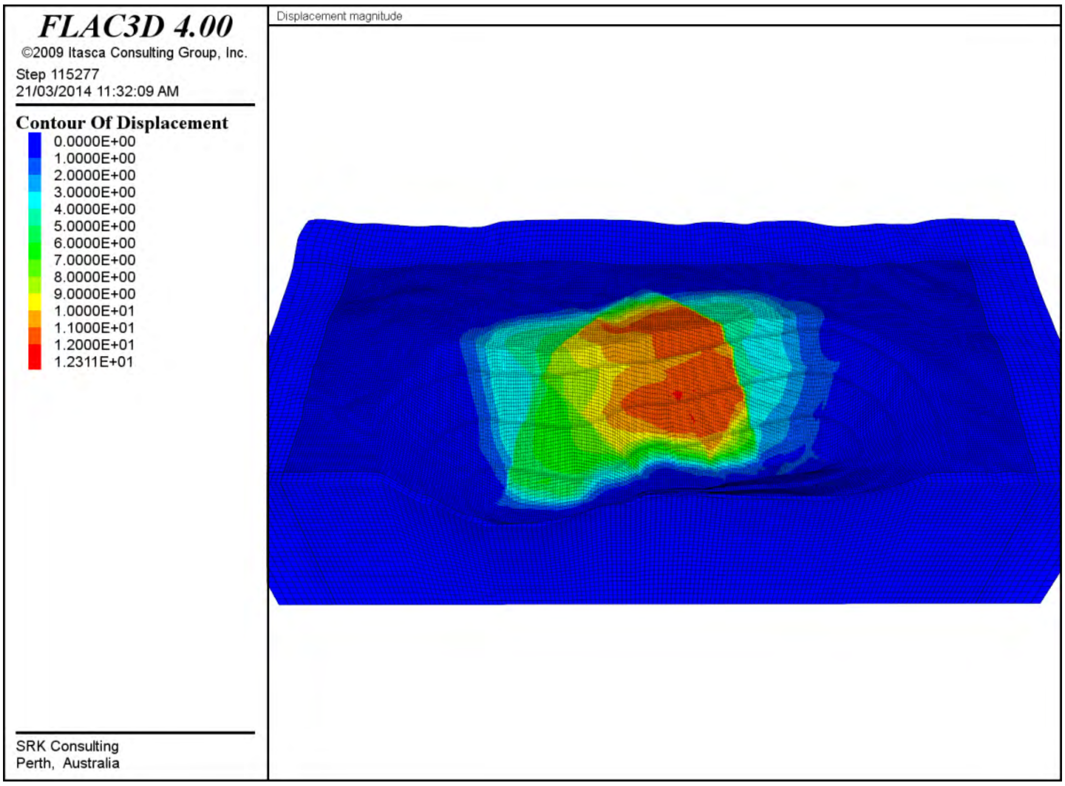


Figure I-4: Displacement contours--Northern wall of final pit

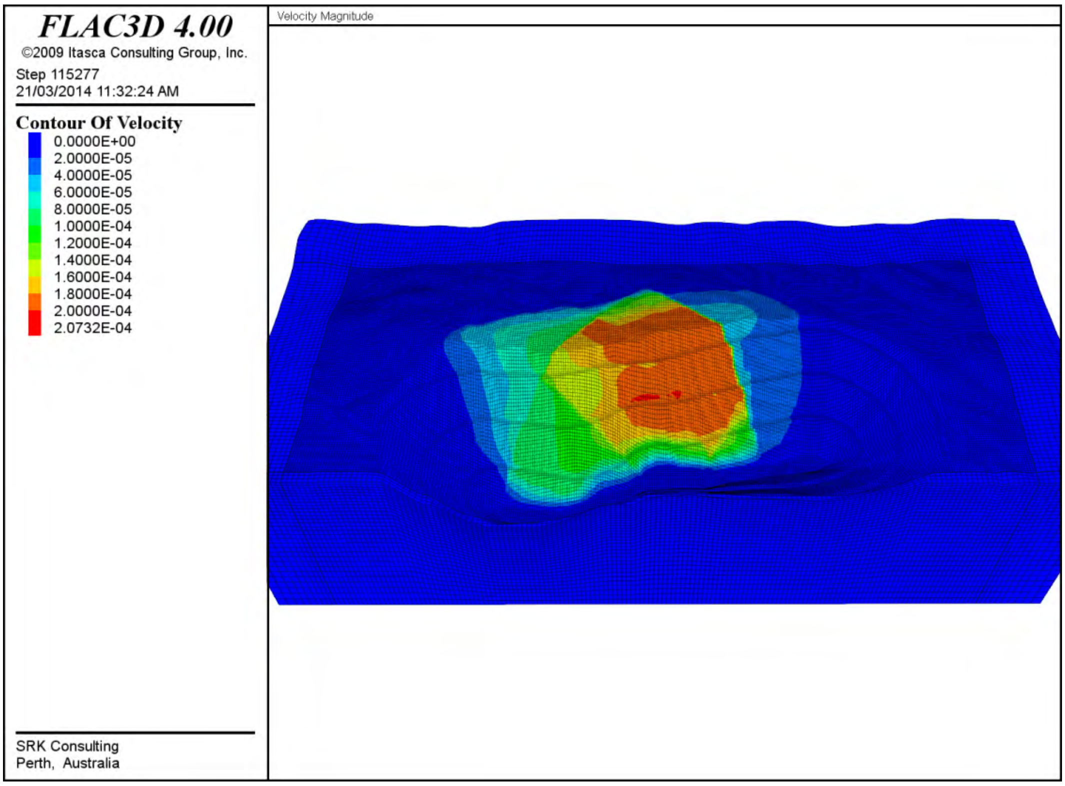


Figure I-5: Velocity Contours-Northern wall of final pit

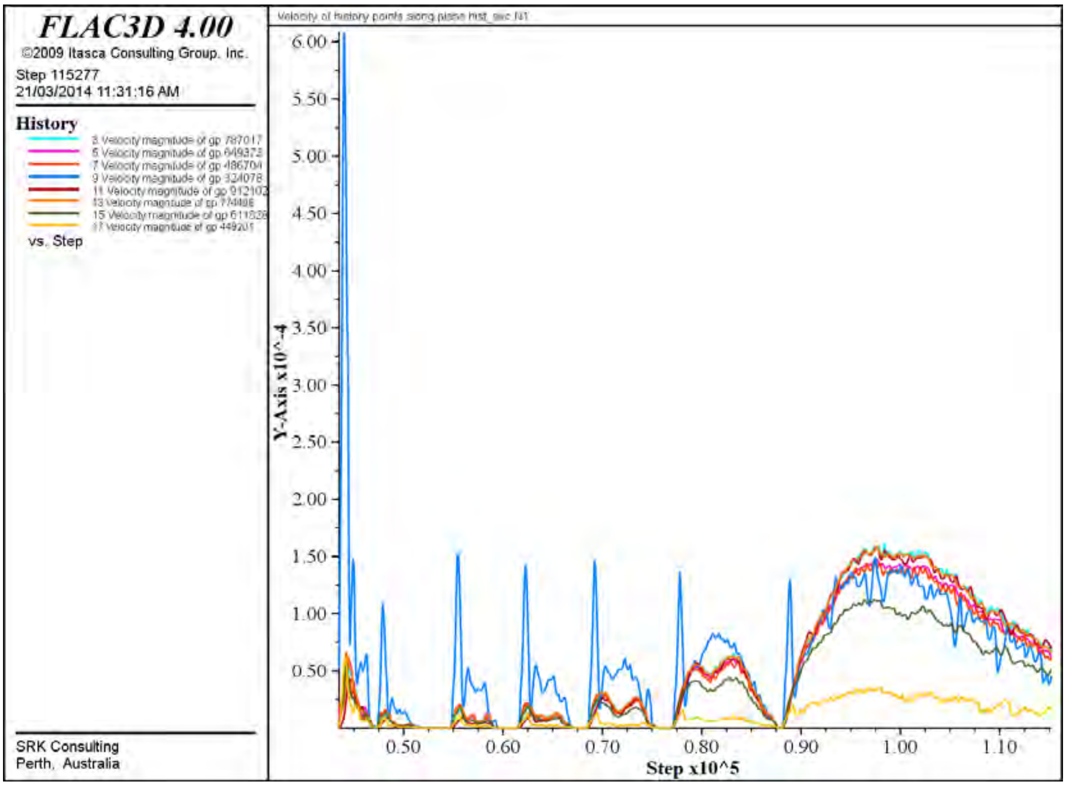


Figure I-6: Velocity histories for history locations at Sec-N1

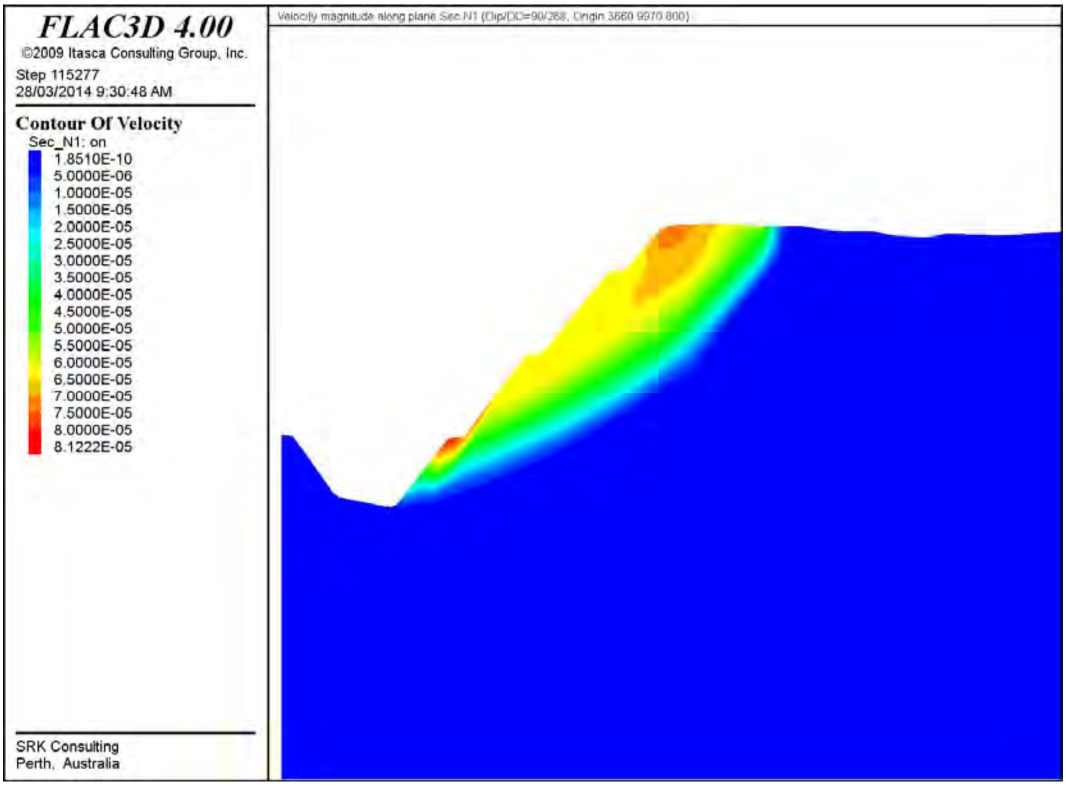


Figure I-7: Velocity contour of vertical plane at Sec-N1

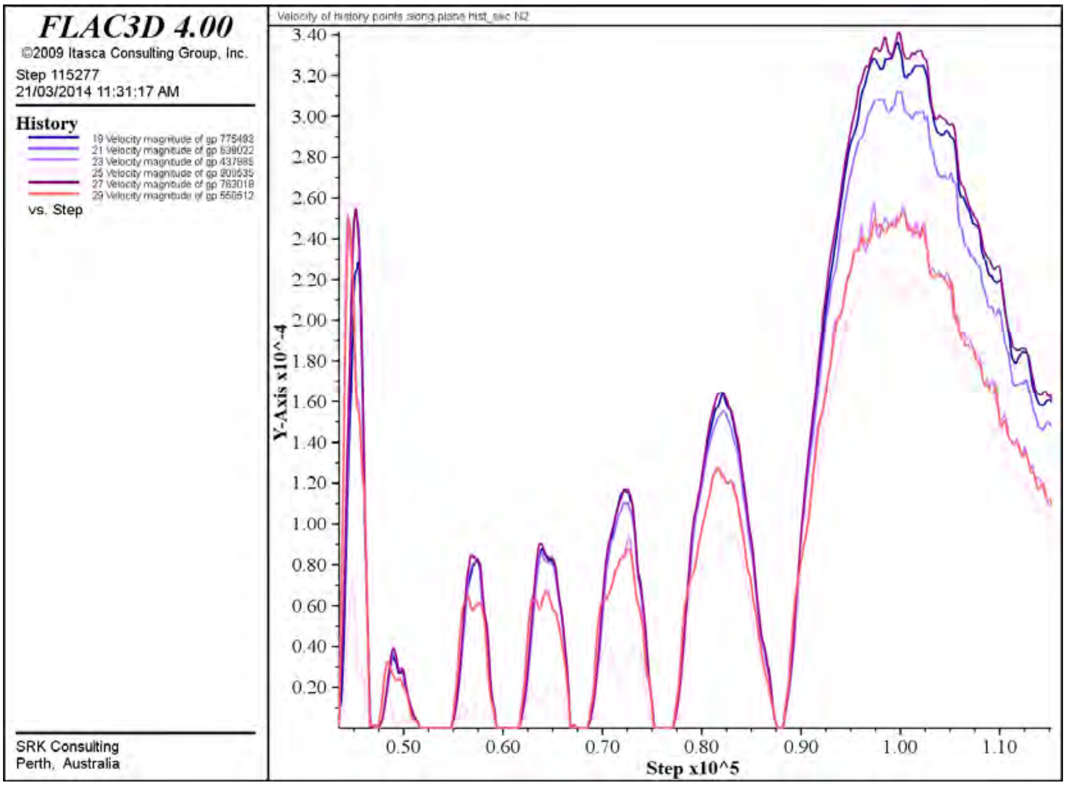


Figure I-8: Velocity histories for history locations at Sec-N2

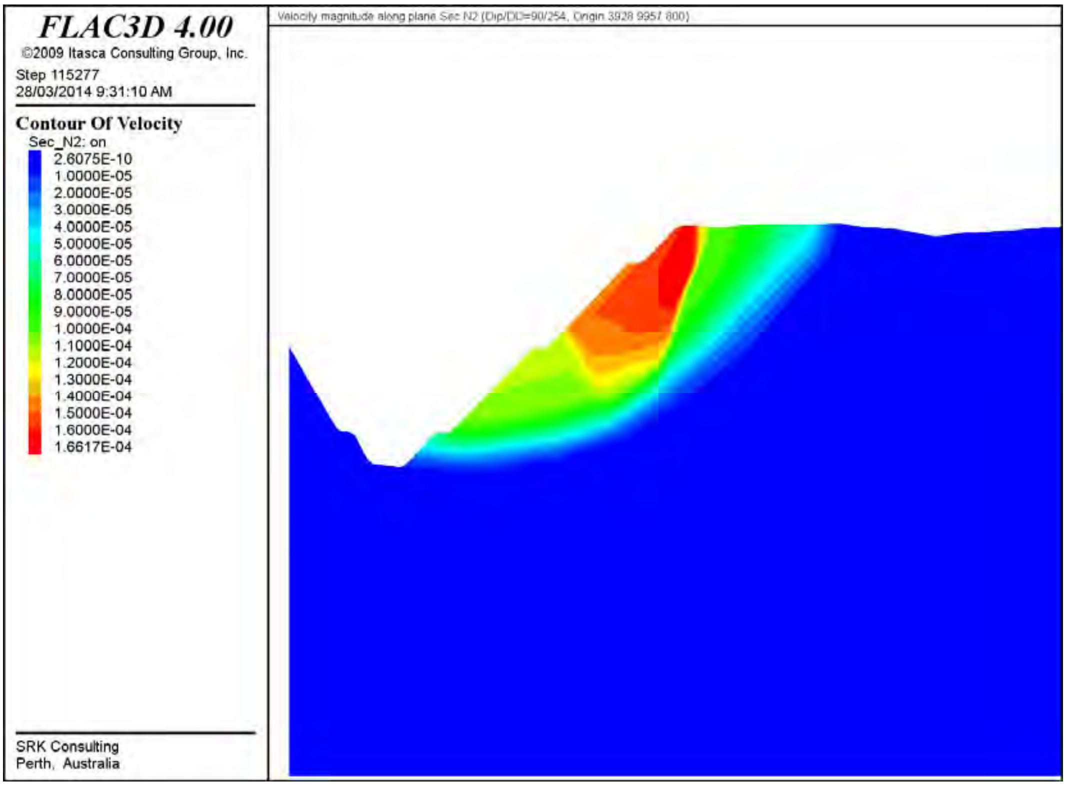


Figure I-9: Velocity contour of vertical plane at Sec-N2

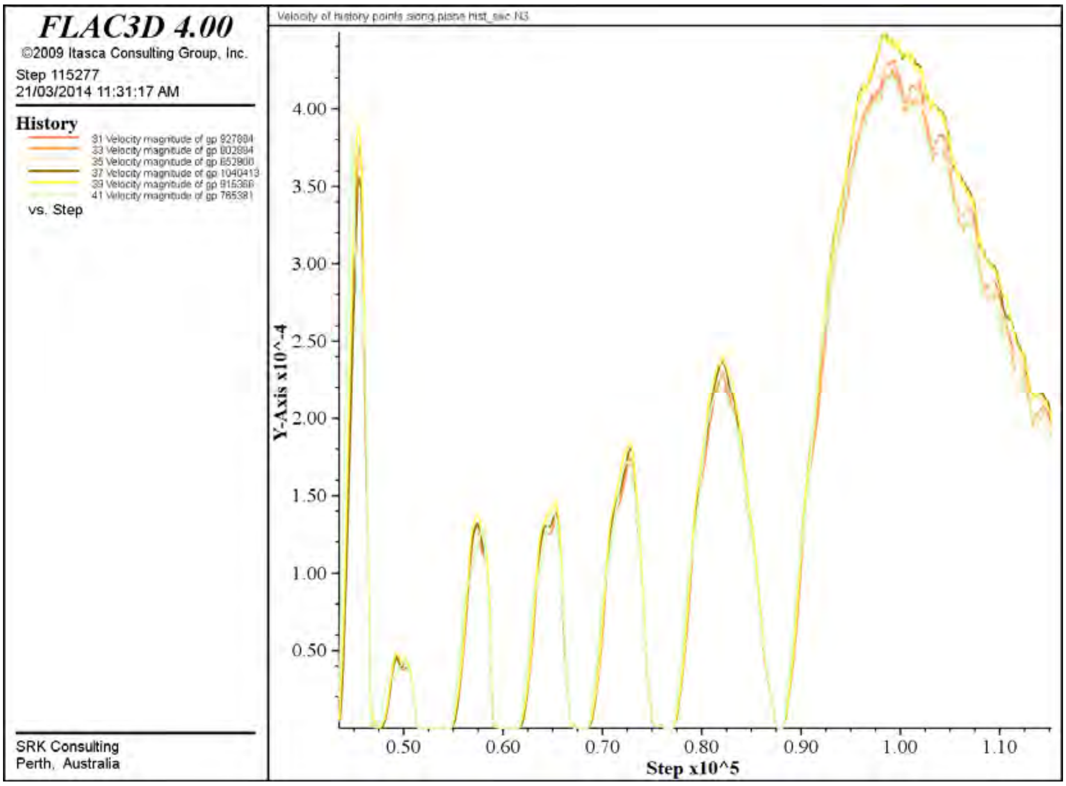


Figure I-10: Velocity histories for history locations at Sec-N3

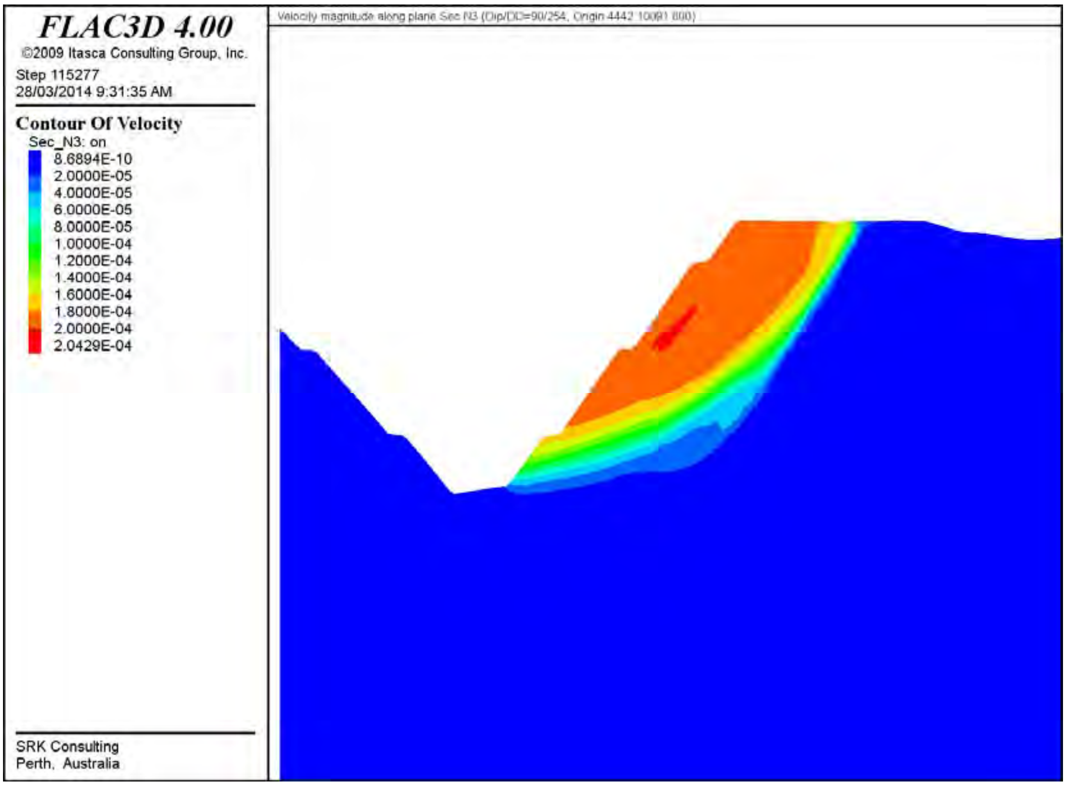


Figure I-11: Velocity contour of vertical plane at Sec-N3

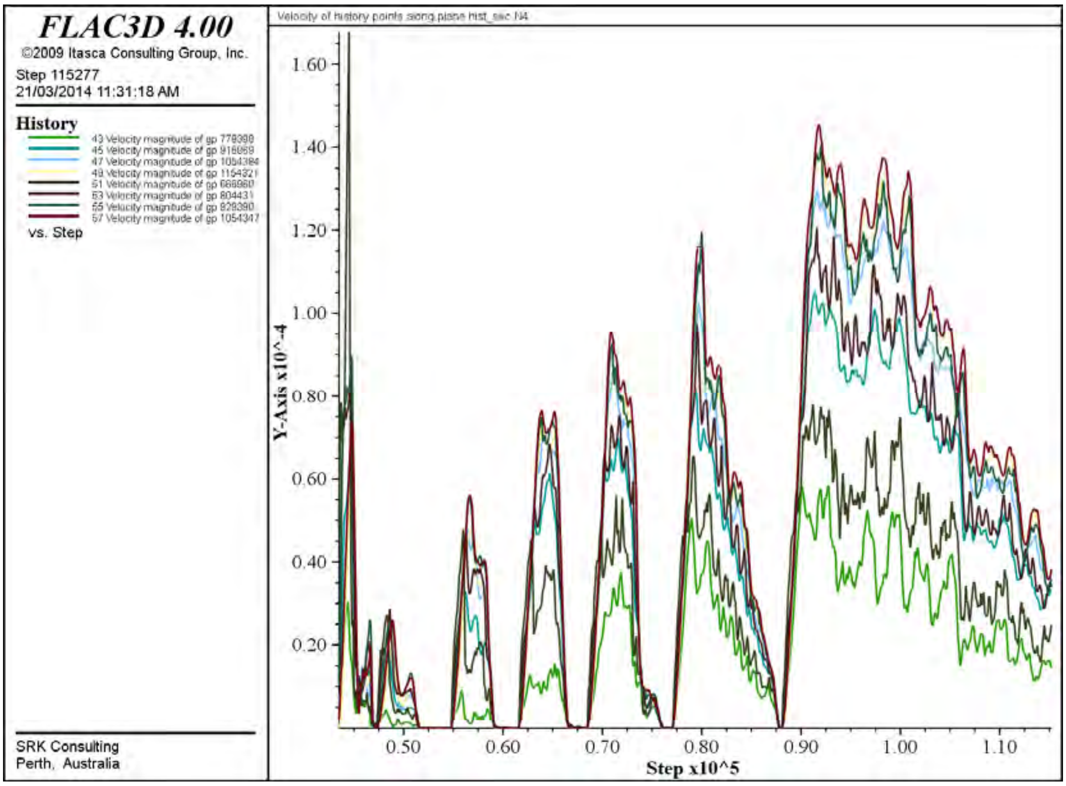


Figure I-12: Velocity histories for history locations at Sec-N4

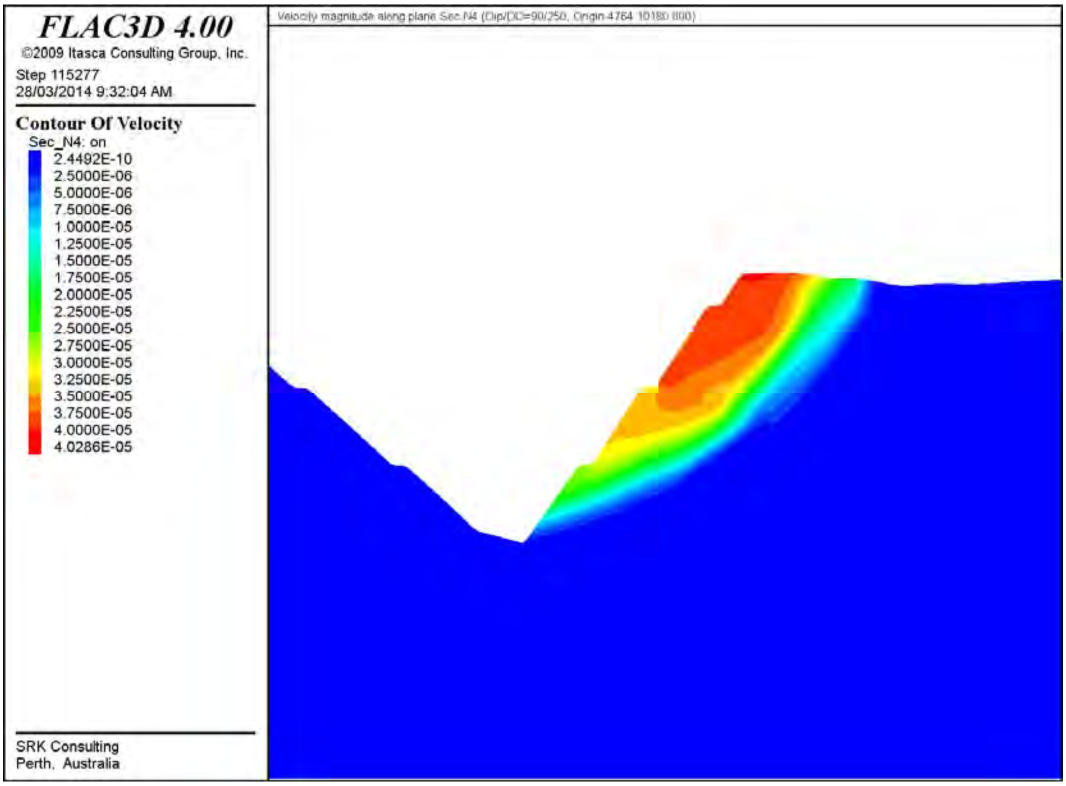


Figure I-13: Velocity contour of vertical plane at Sec-N4

Southern model-Final Pit

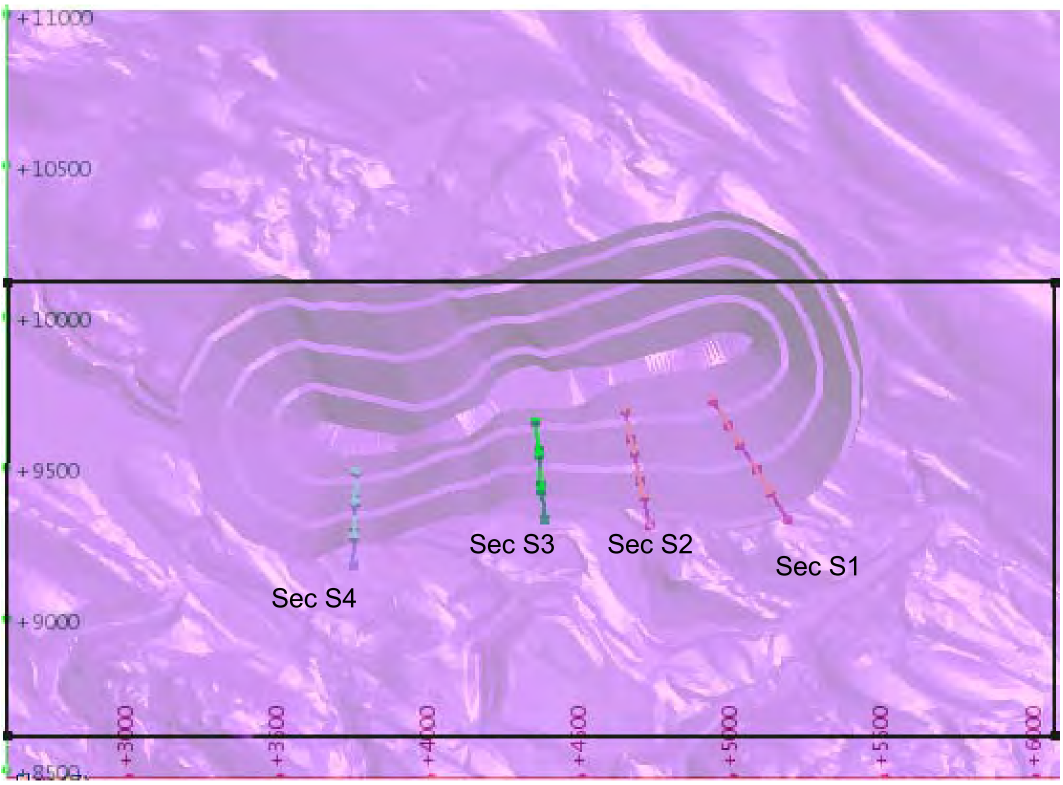


Figure I-14: History locations-Southern wall of final pit

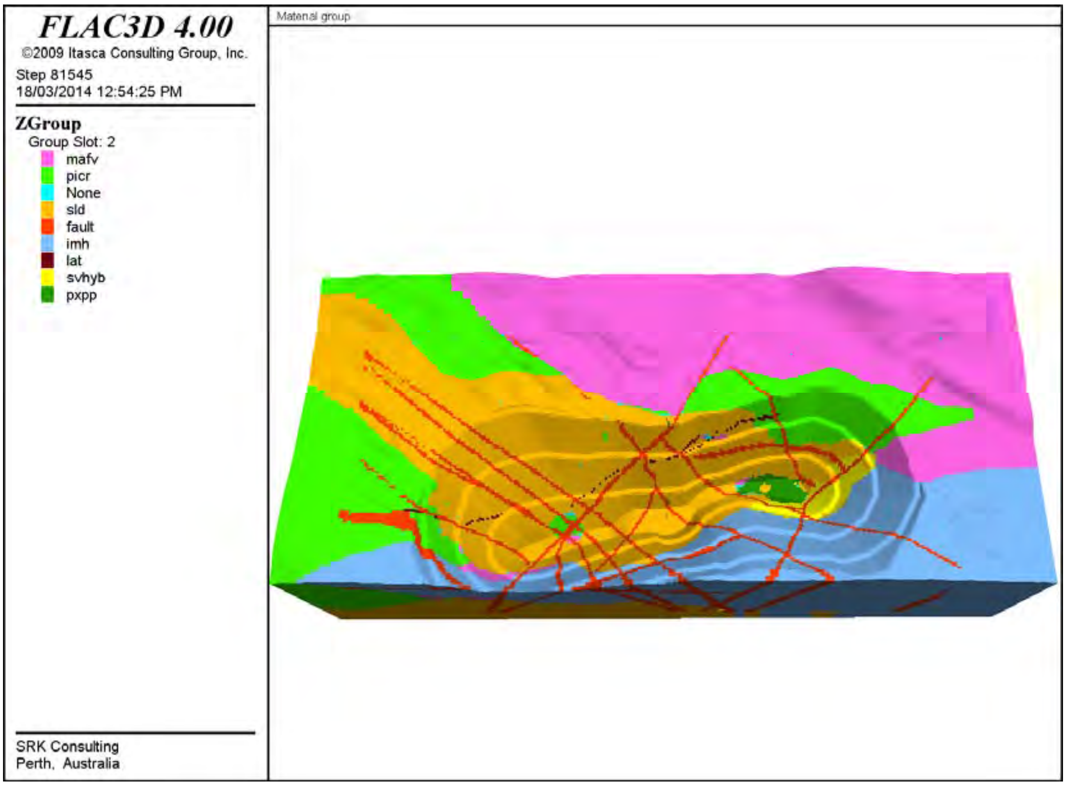


Figure I-15: Material groups-Southern wall of final pit

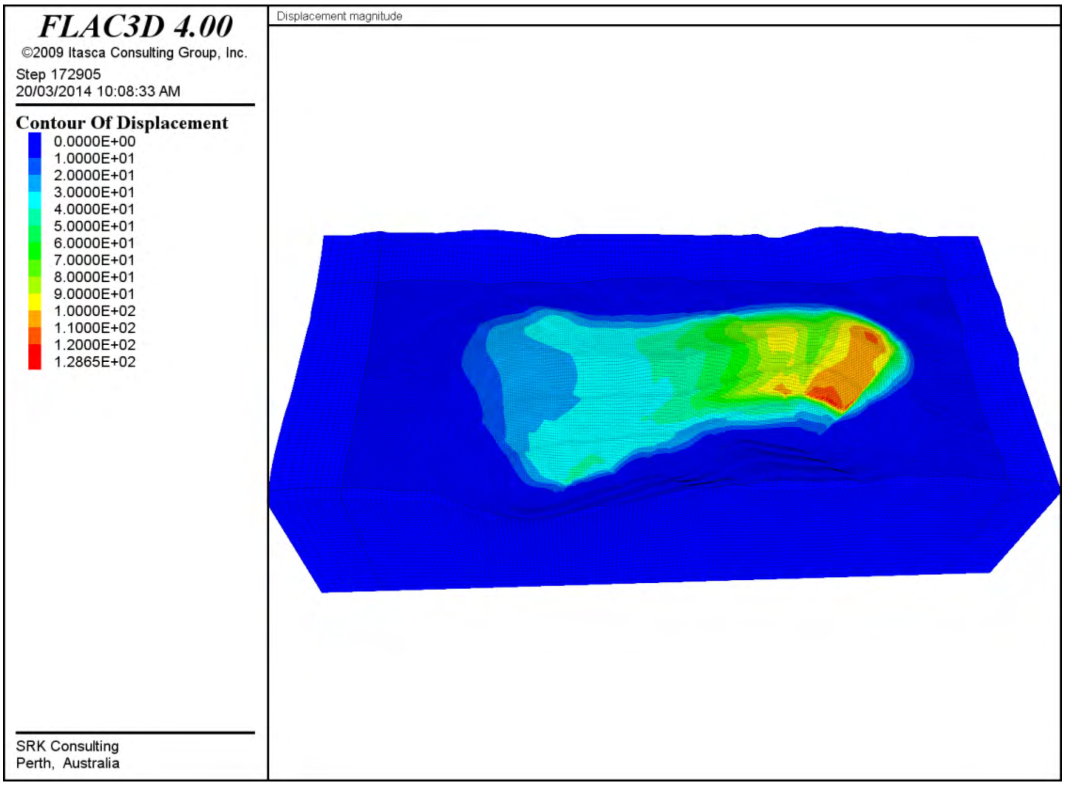


Figure I-16: Displacement contours-Southern wall of final pit

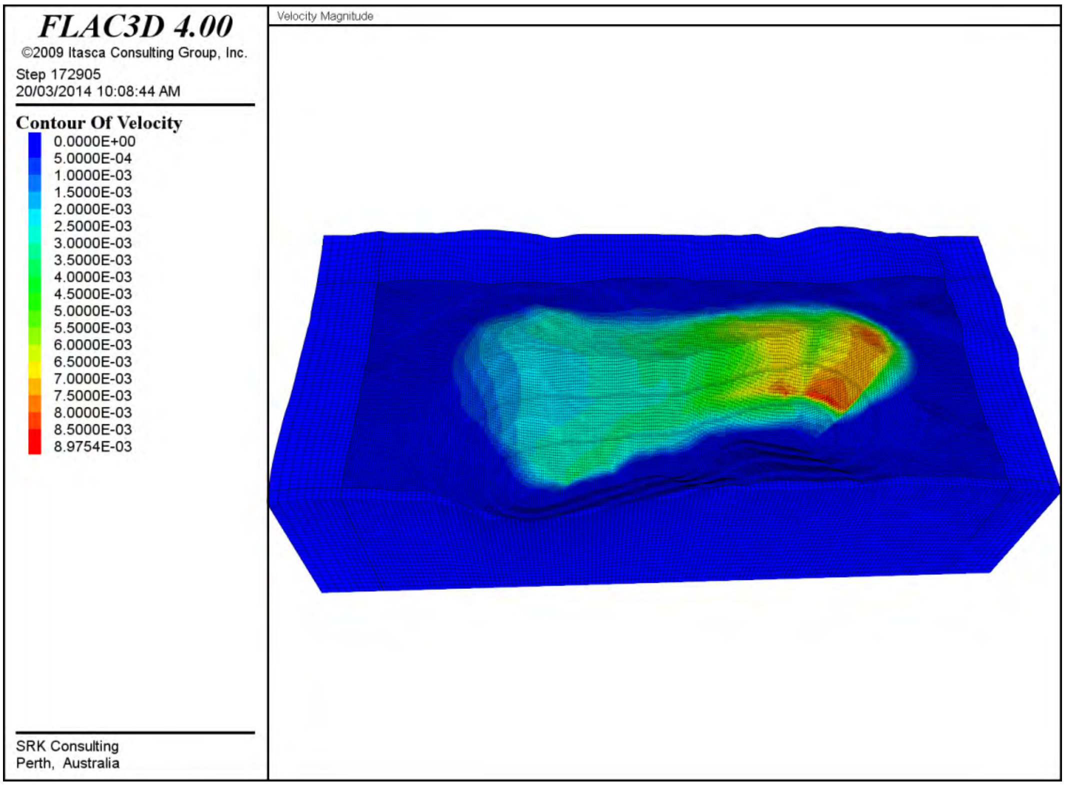


Figure I-17: Velocity Contours-Southern wall of final pit

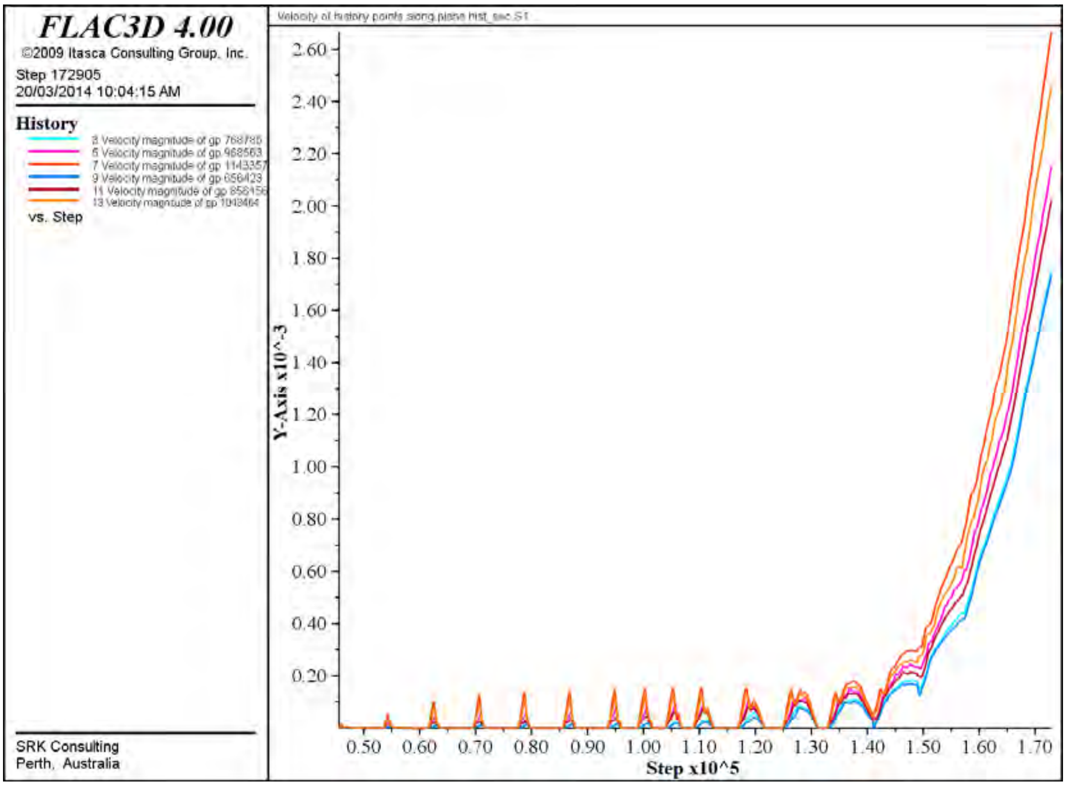


Figure I-18: Velocity histories for history locations at Sec-S1

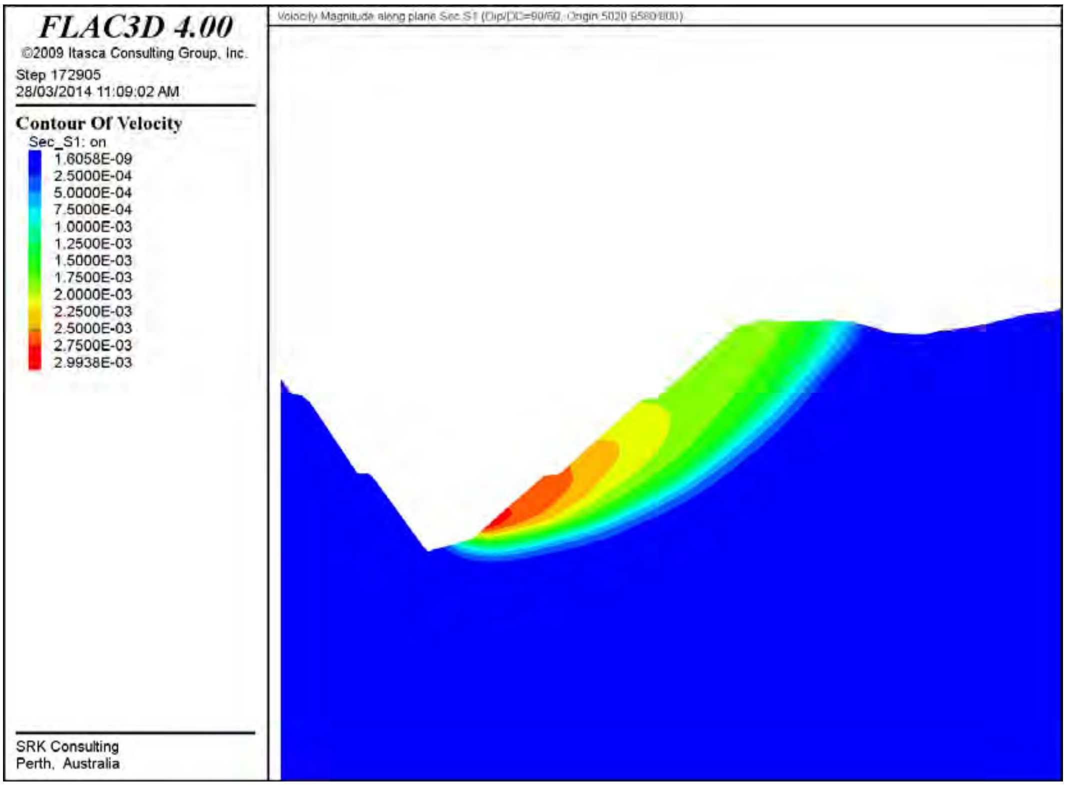


Figure I-19: Velocity contour of vertical plane at Sec-S1

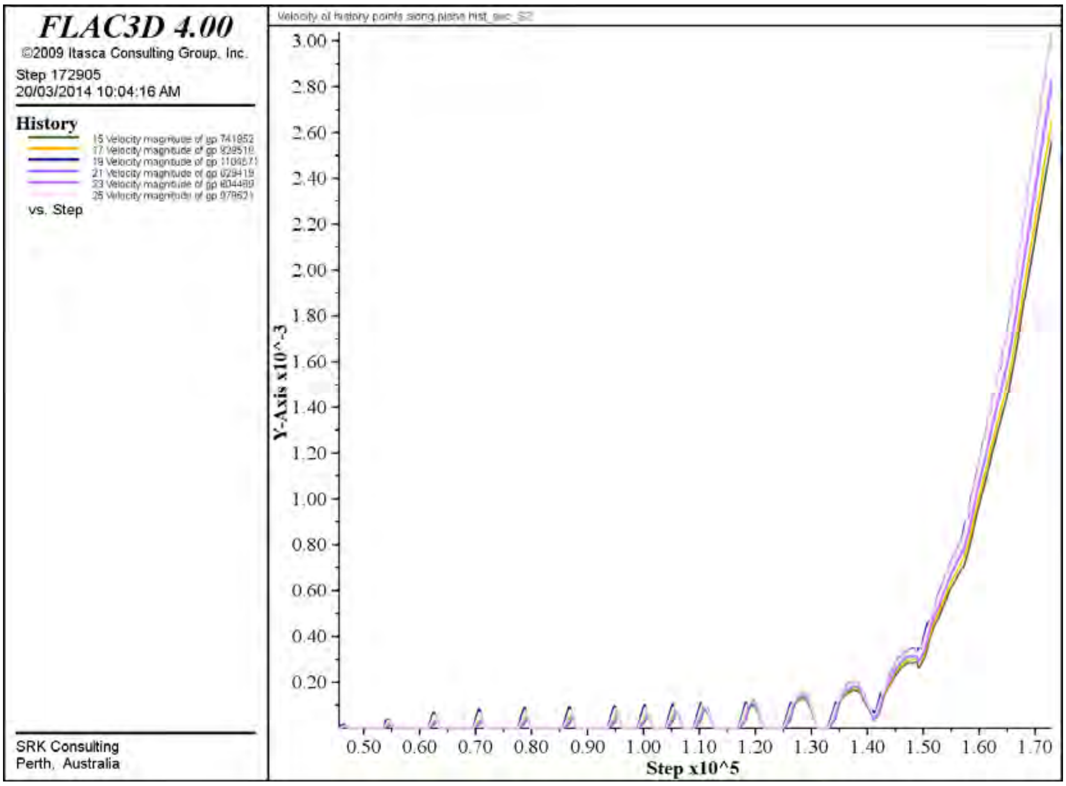


Figure I-20: Velocity histories for history locations at Sec-S2

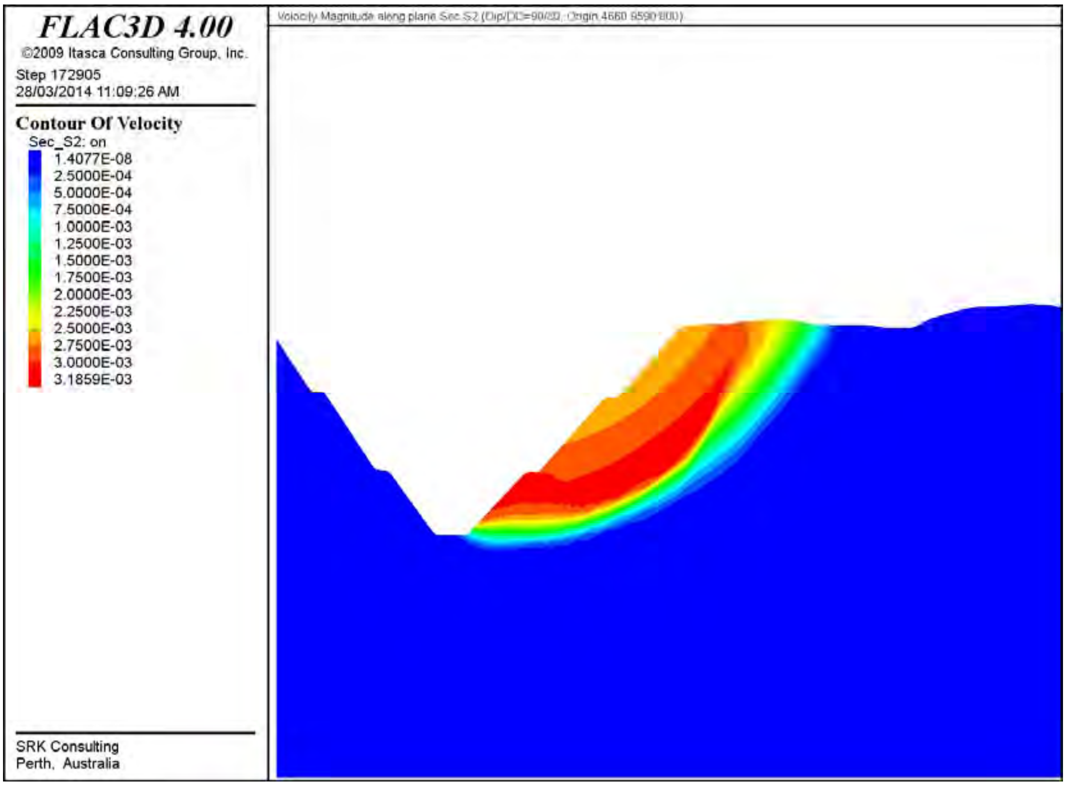


Figure I-21: Velocity contour of vertical plane at Sec-S2

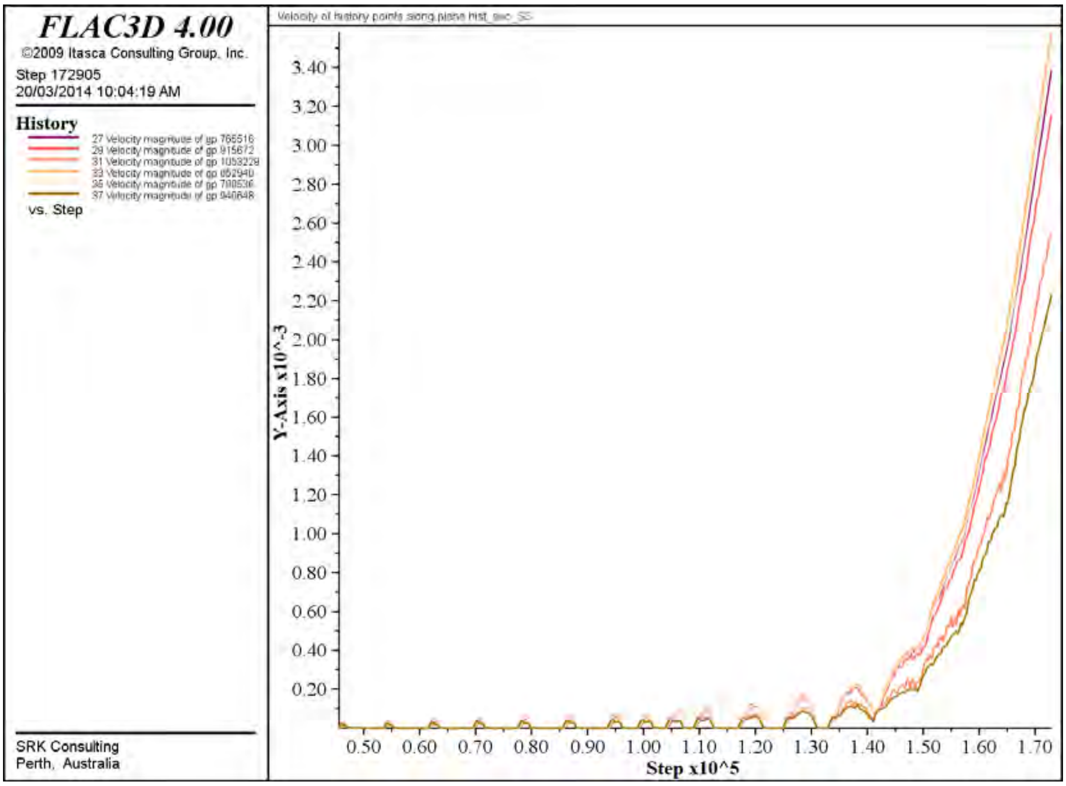


Figure I-22: Velocity histories for history locations at Sec-S3

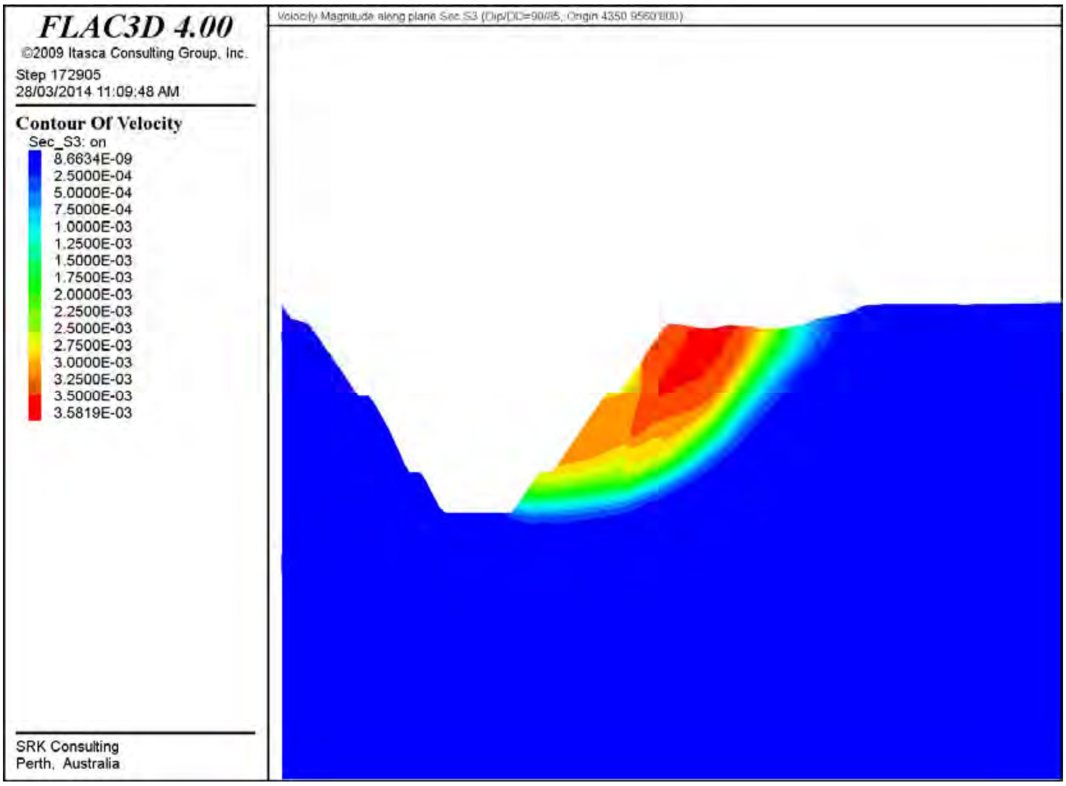


Figure I-23: Velocity contour of vertical plane at Sec-S3

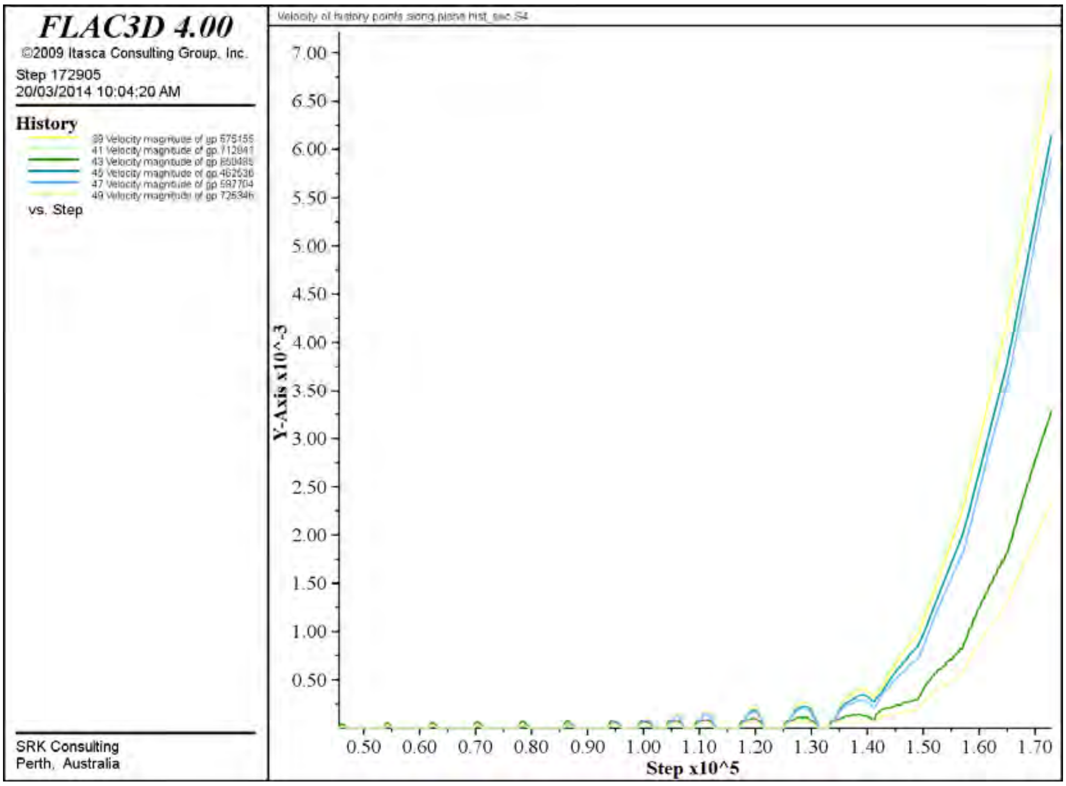


Figure I-24: Velocity histories for history locations at Sec- S4

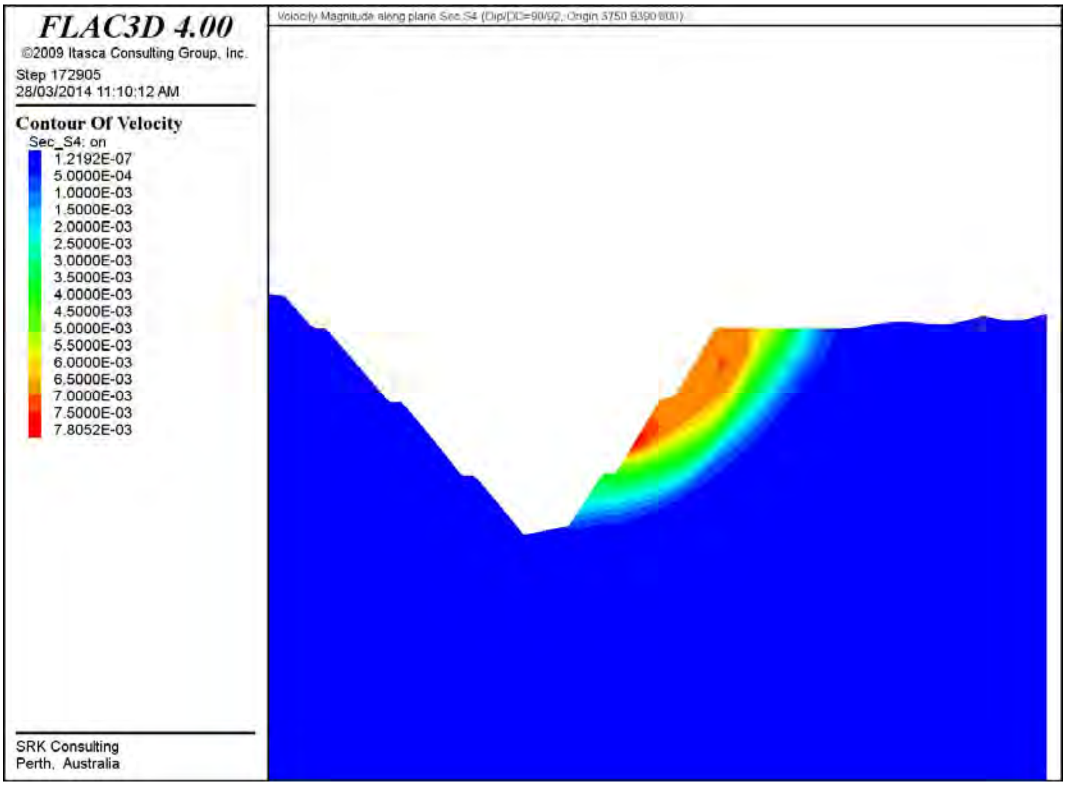


Figure I-25: Velocity contour of vertical plane at Sec- S4

Eastern model-Final Pit

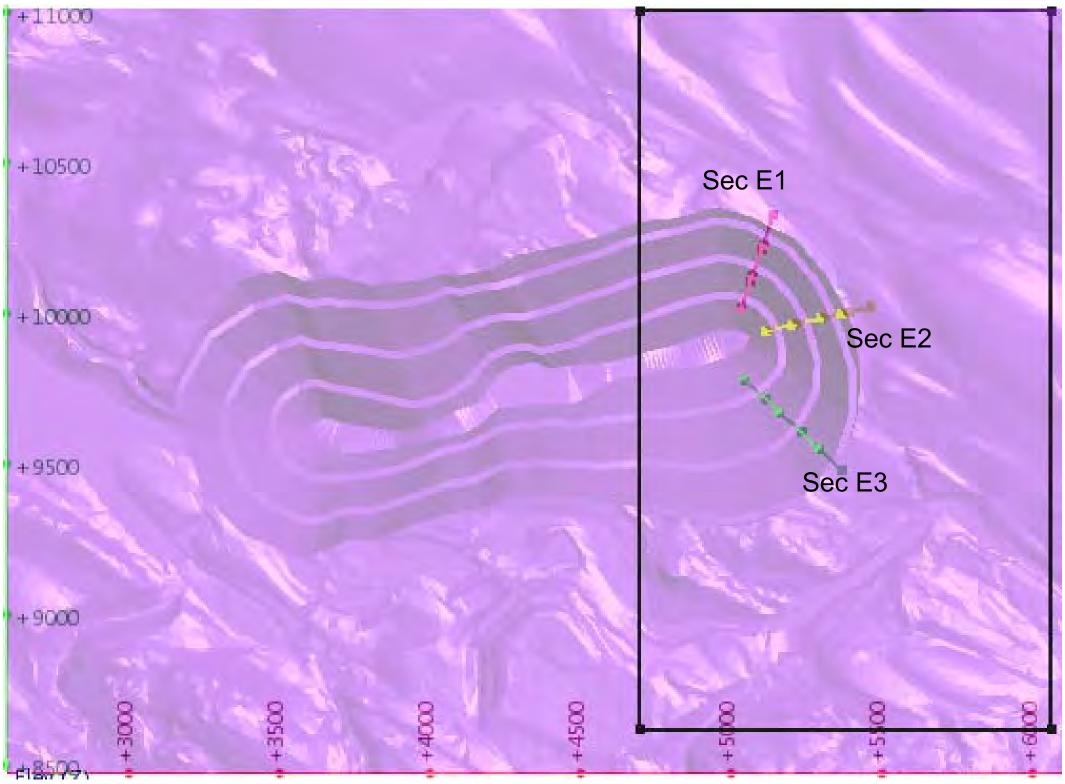


Figure I-26: History locations-Eastern wall of final pit

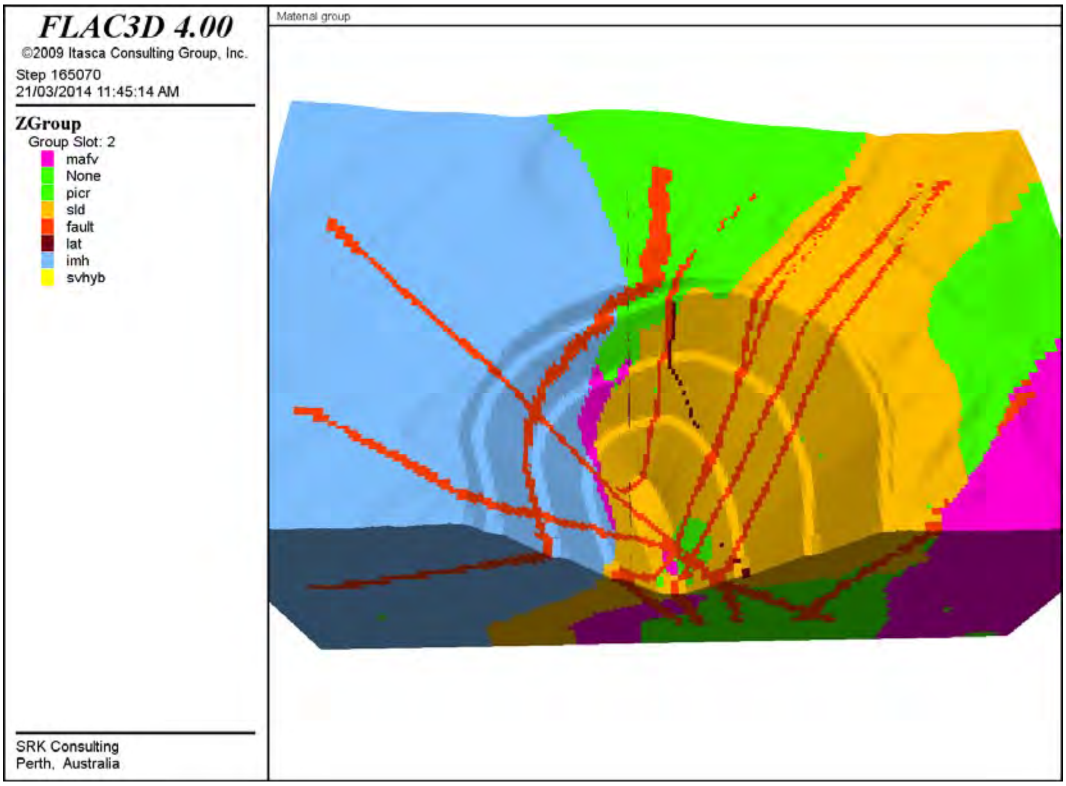


Figure I-27: Material groups-Eastern wall of final pit

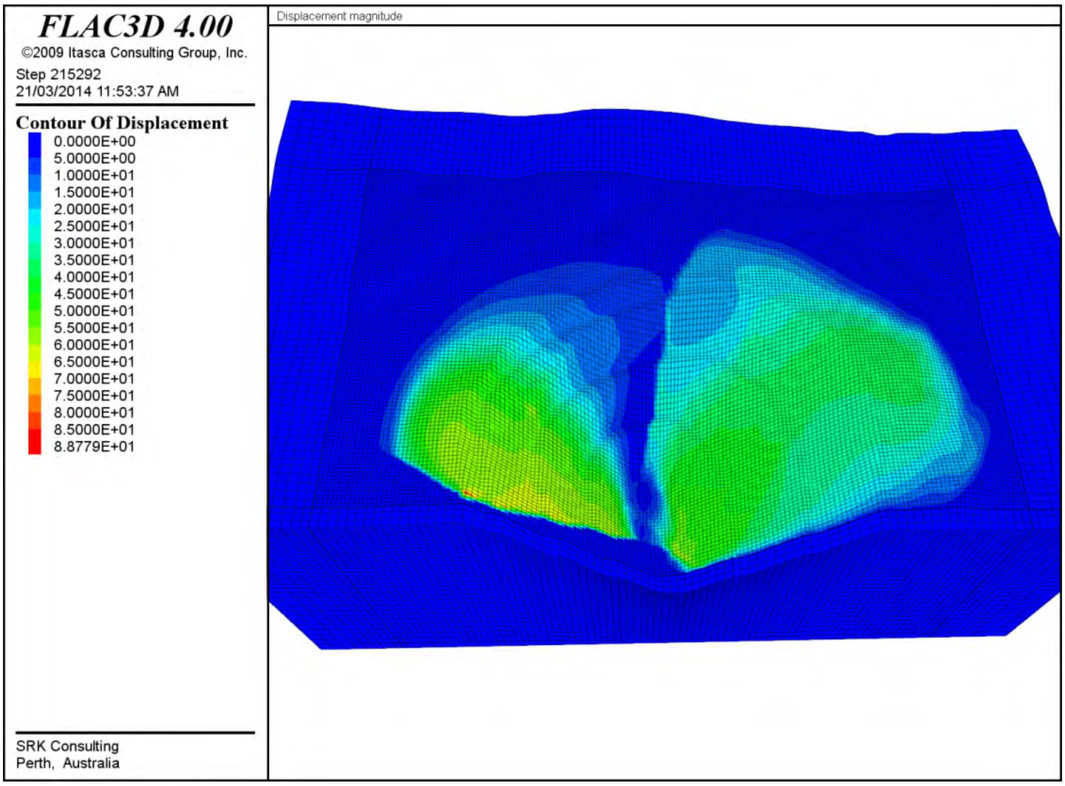


Figure I-28: Displacement contours-Eastern wall of final pit

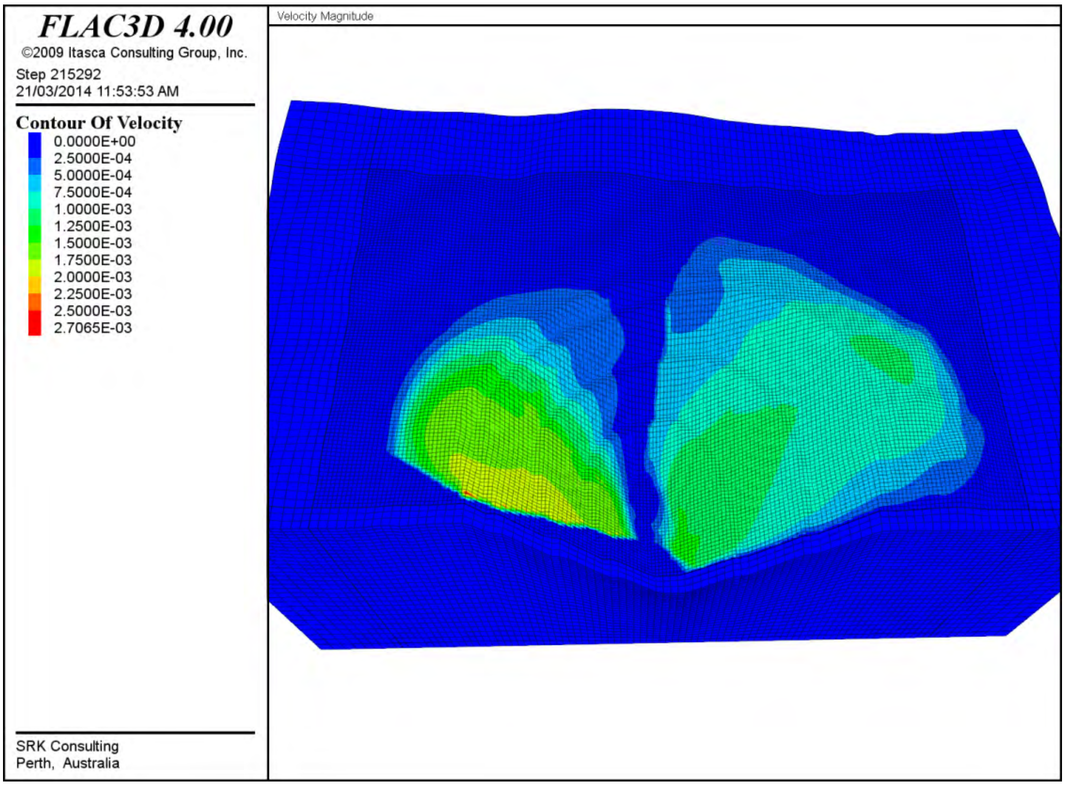


Figure I-29: Velocity Contours-Eastern wall of final pit

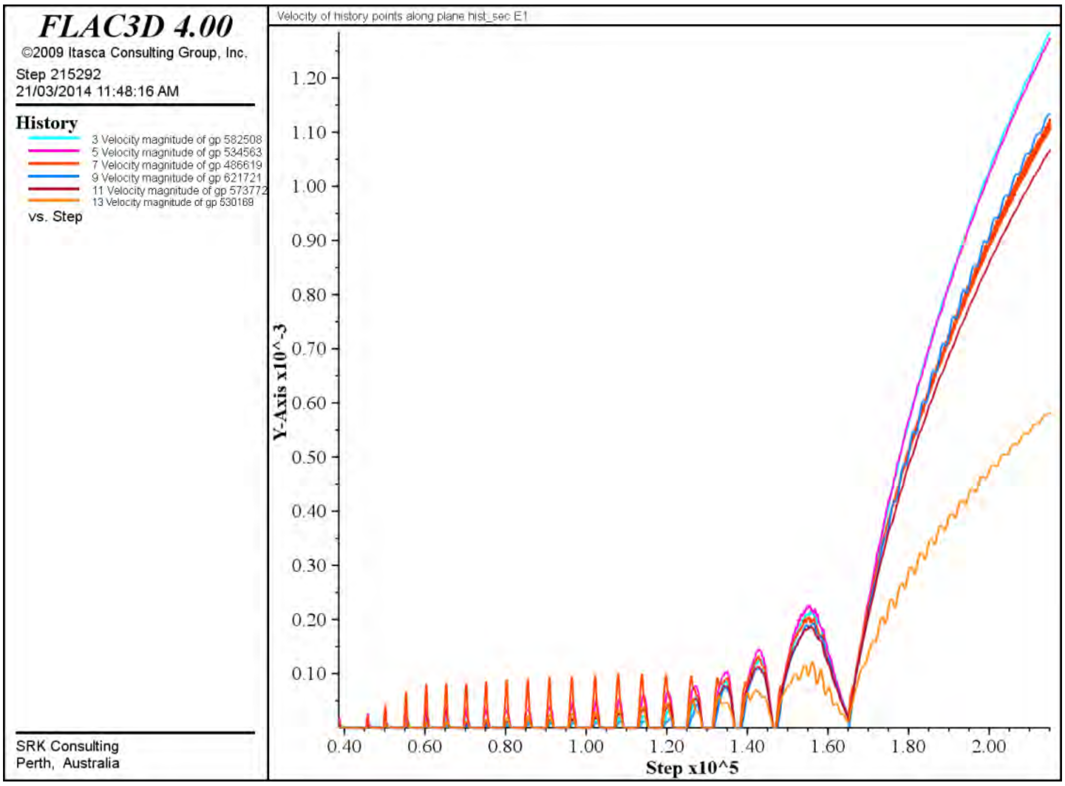


Figure I-30: Velocity histories for history locations at Sec-E1

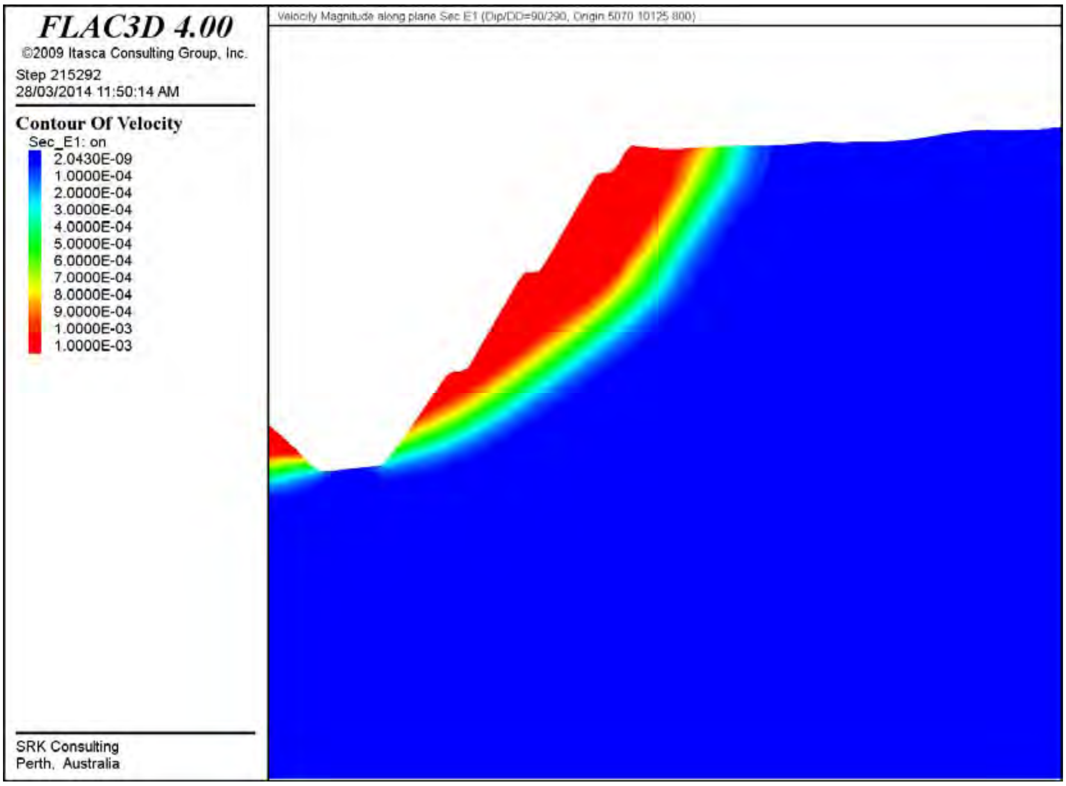


Figure I-31: Velocity contour of vertical plane at Sec-E1

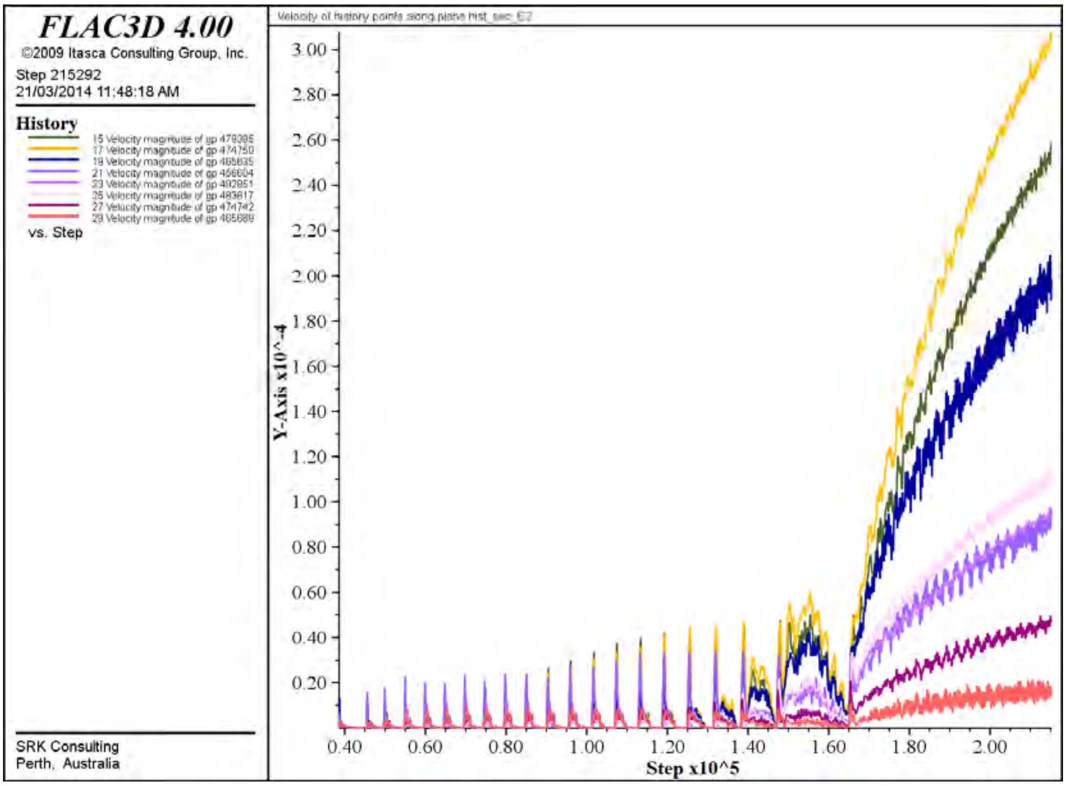


Figure I-32: Velocity histories for history locations at Sec-E2

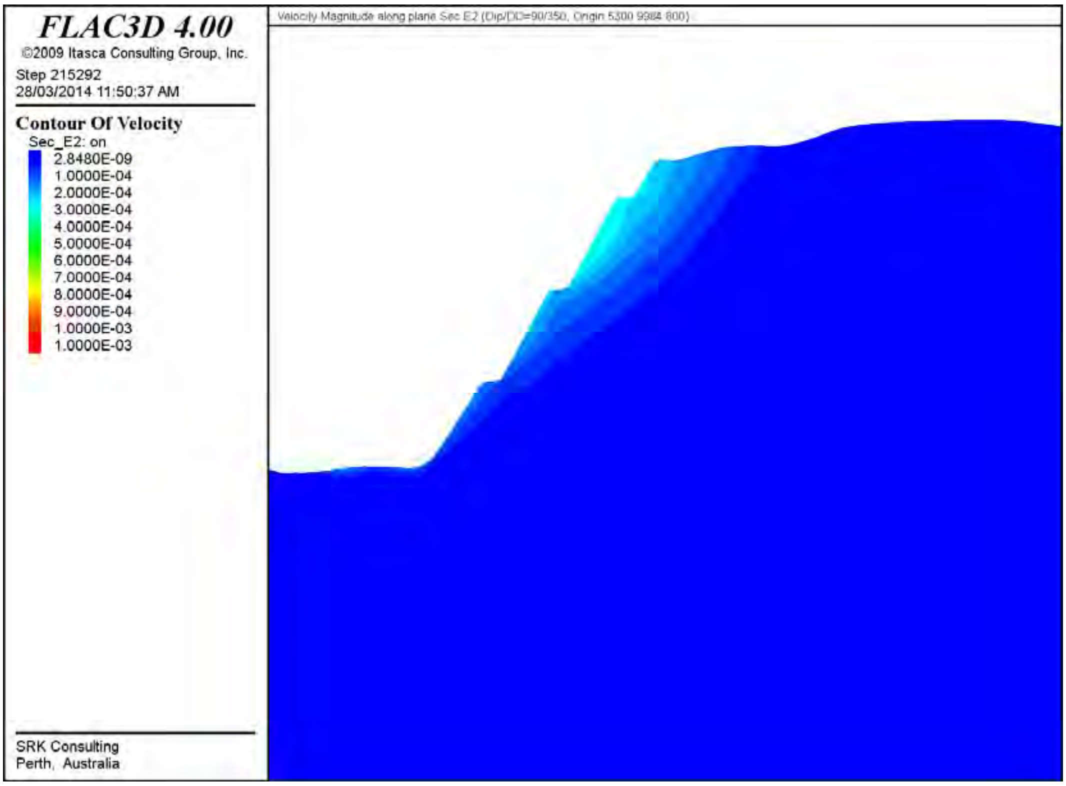


Figure I-33: Velocity contour of vertical plane at Sec-E2

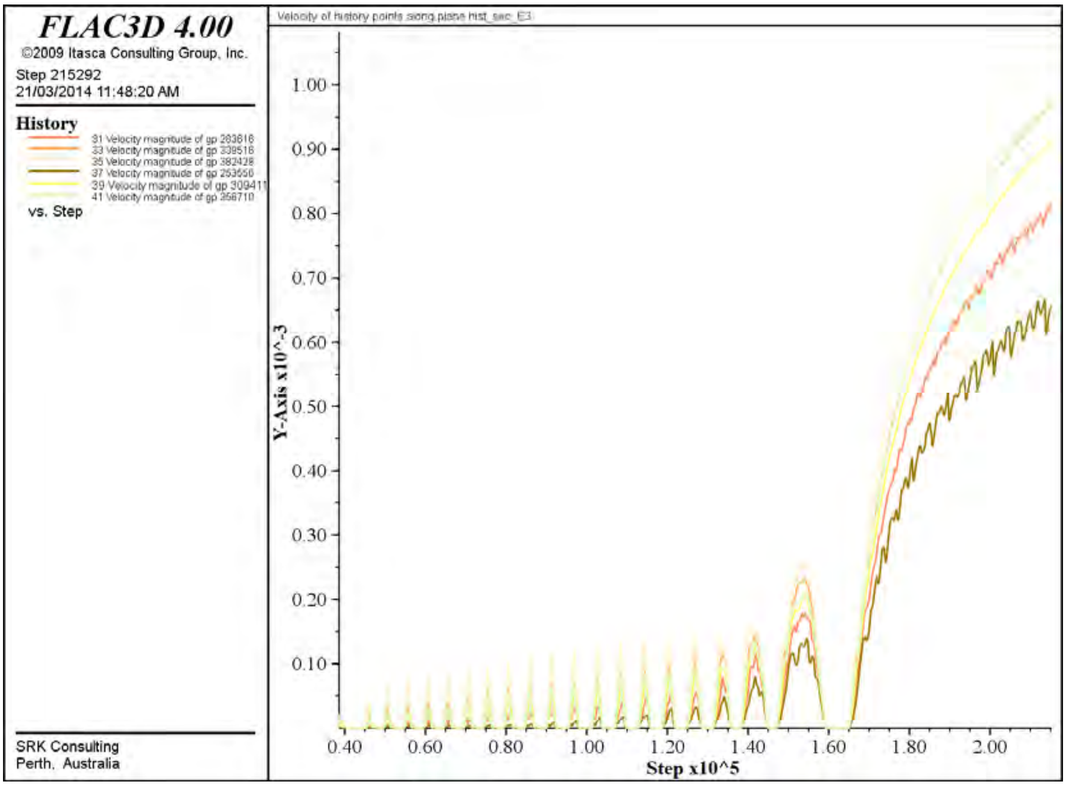


Figure I-34: Velocity histories for history locations at Sec-E3

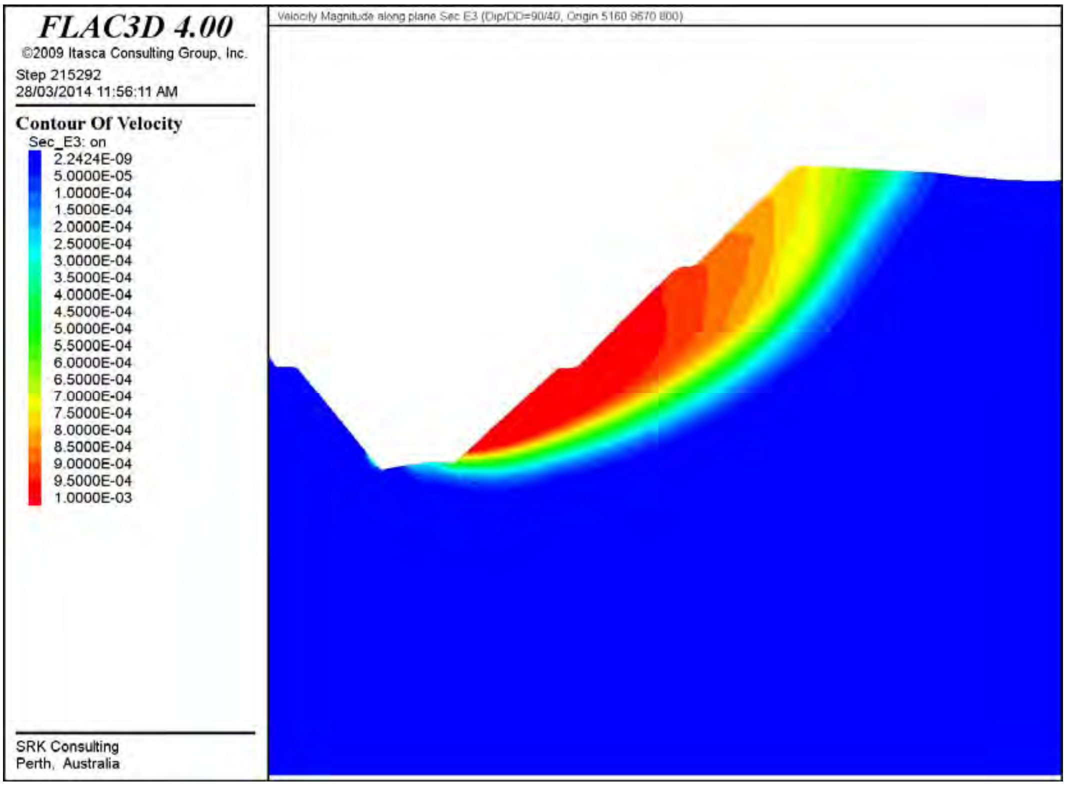


Figure I-35: Velocity contour of vertical plane at Sec-E3

Western model-Final Pit

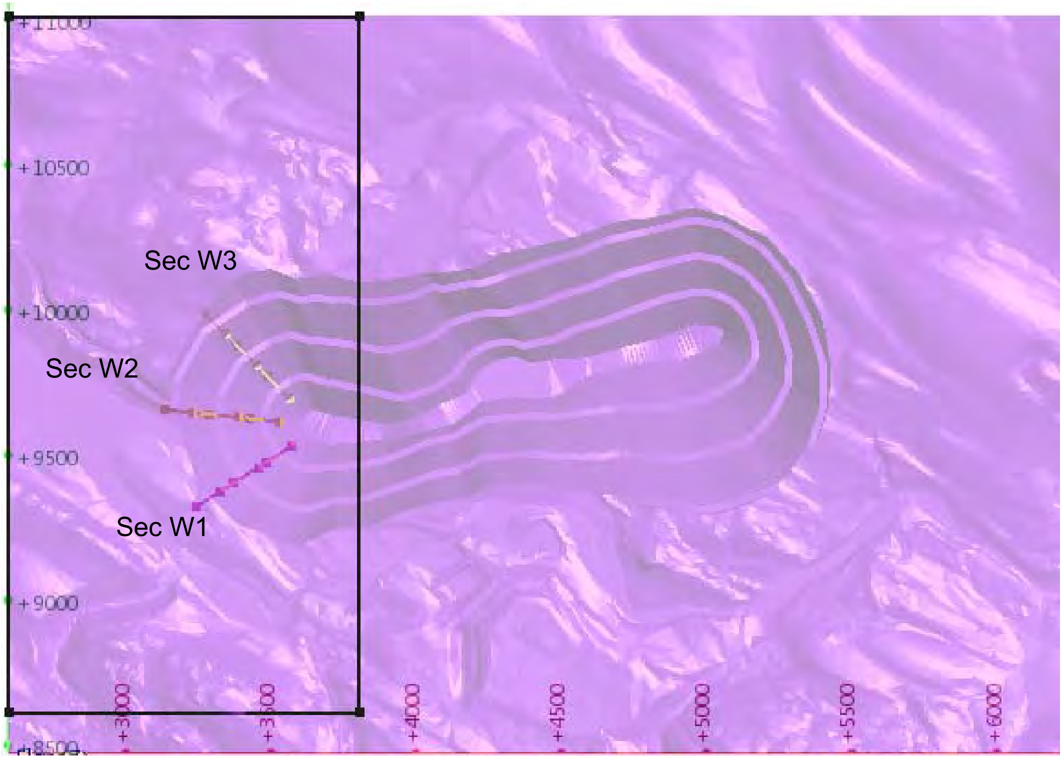


Figure I-36: History locations-Western wall of final pit

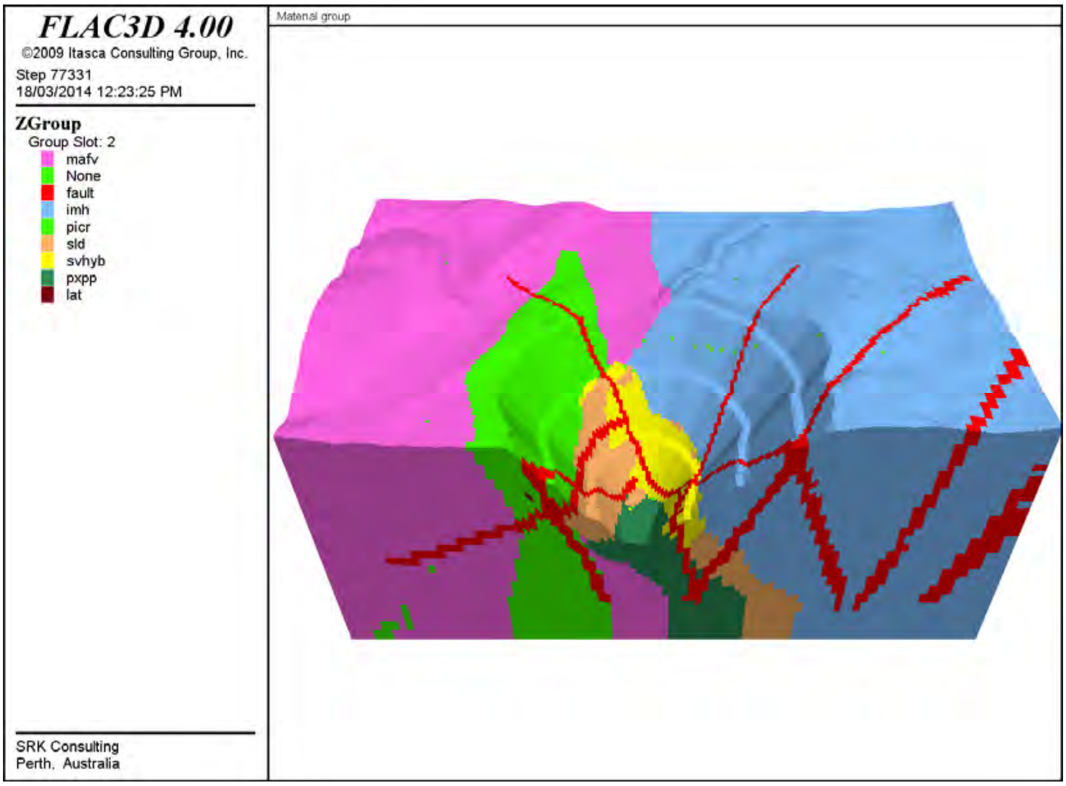


Figure I-37: Material groups-Western wall of final pit

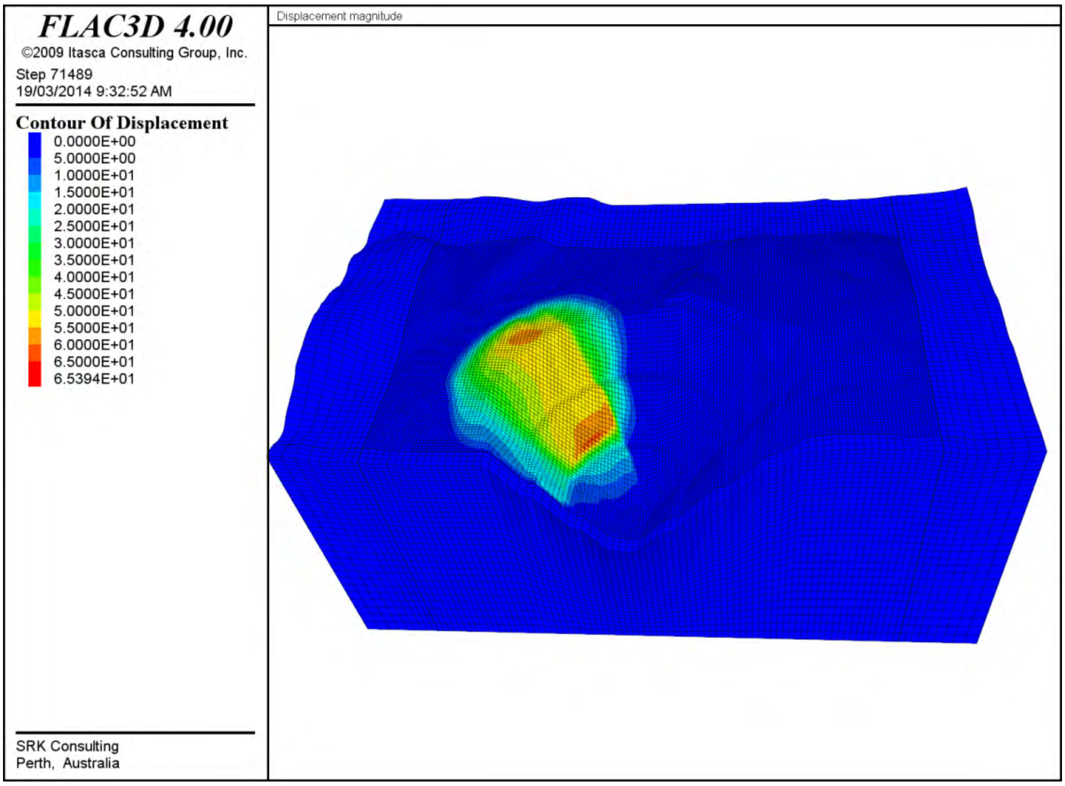


Figure I-38: Displacement contours-Western wall of final pit

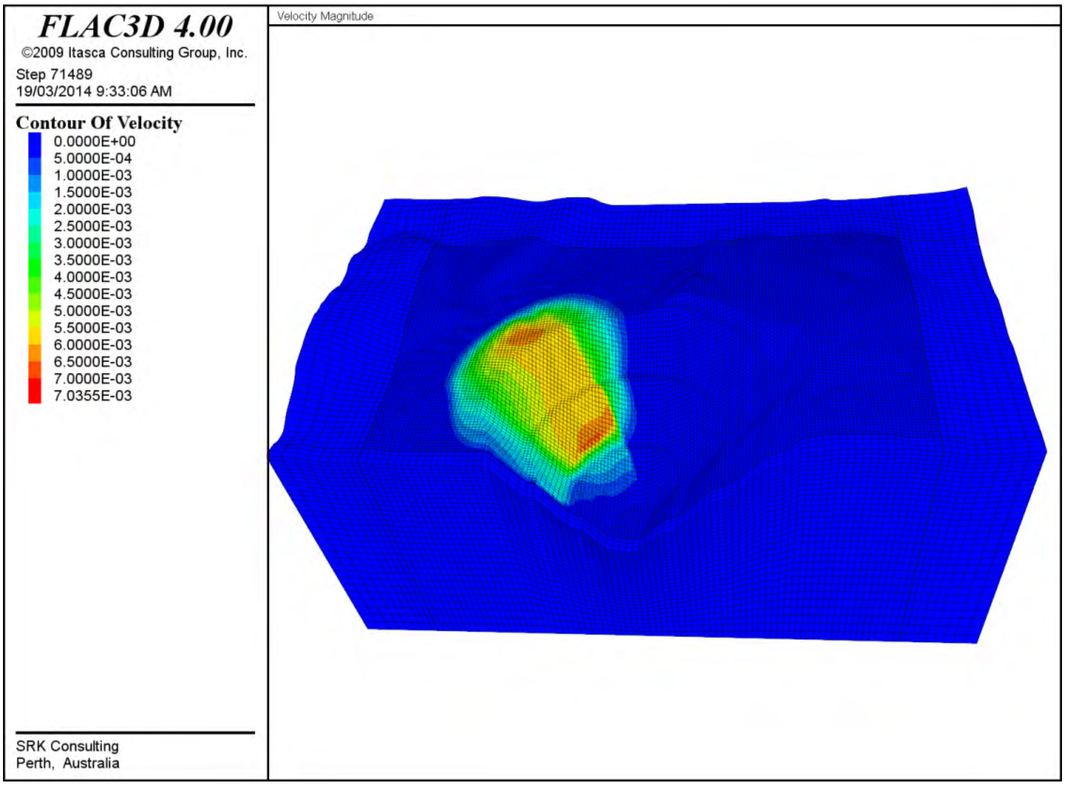


Figure I-39: Velocity Contours-Western wall of final pit

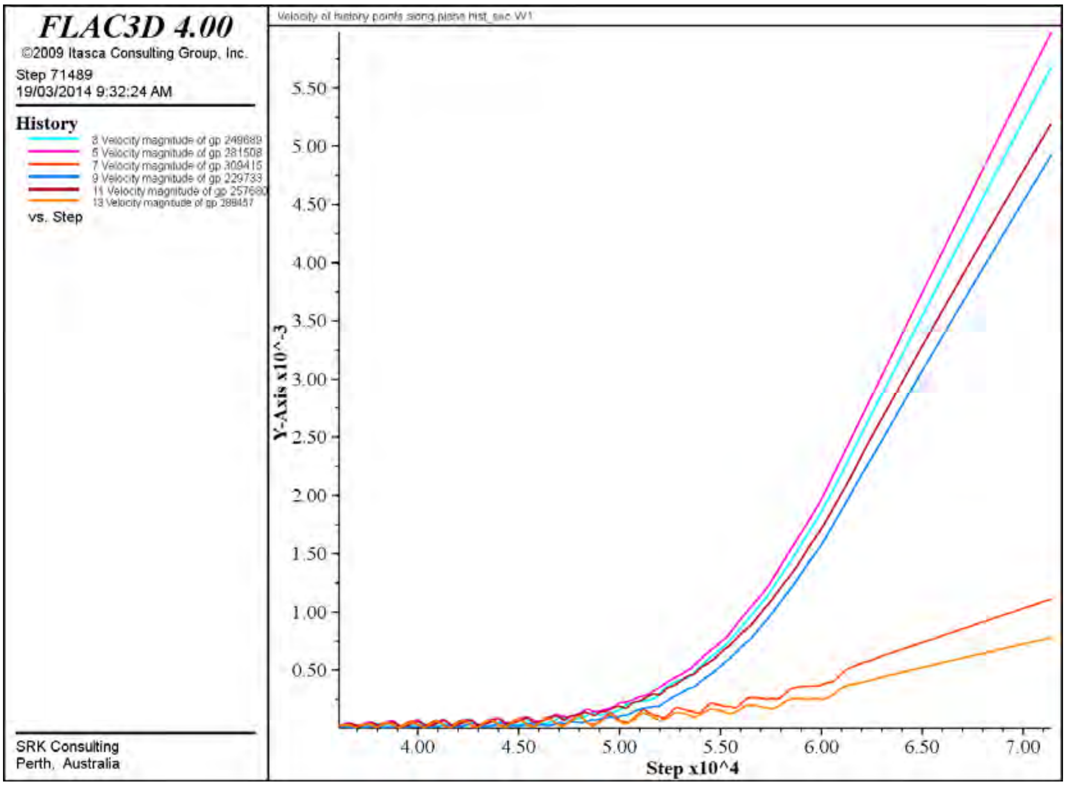


Figure I-40: Velocity histories for history locations at Sec-W1

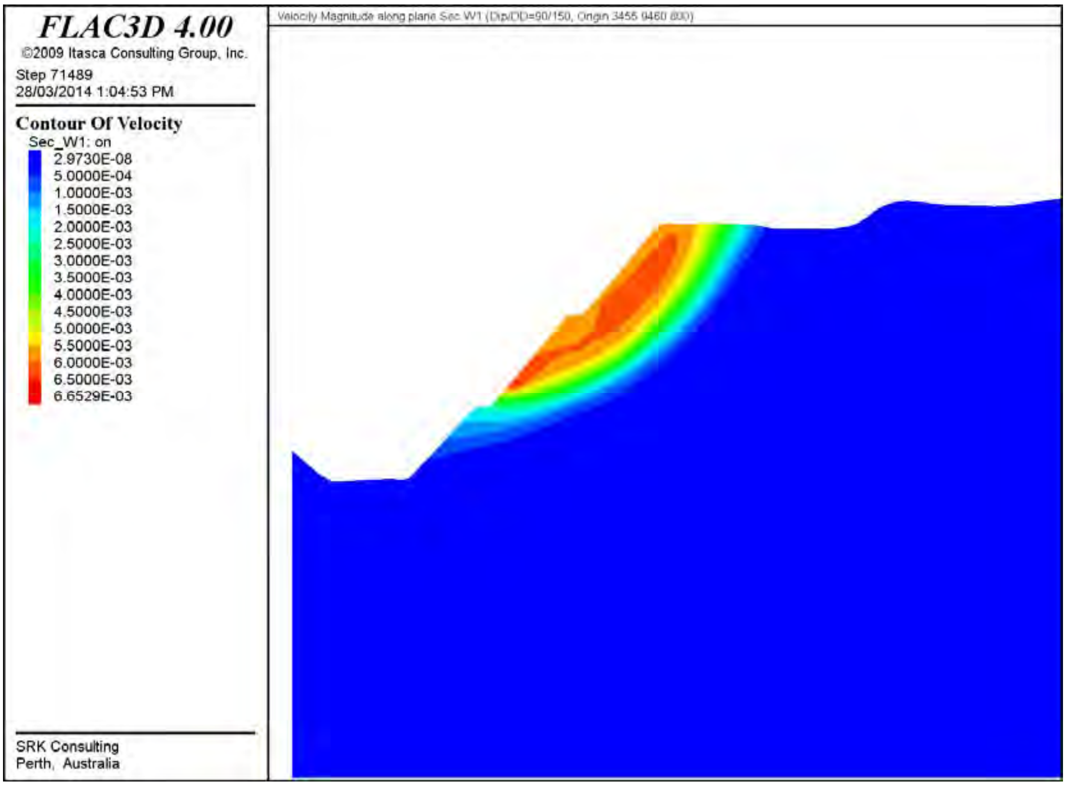


Figure I-41: Velocity contour of vertical plane at Sec-W1

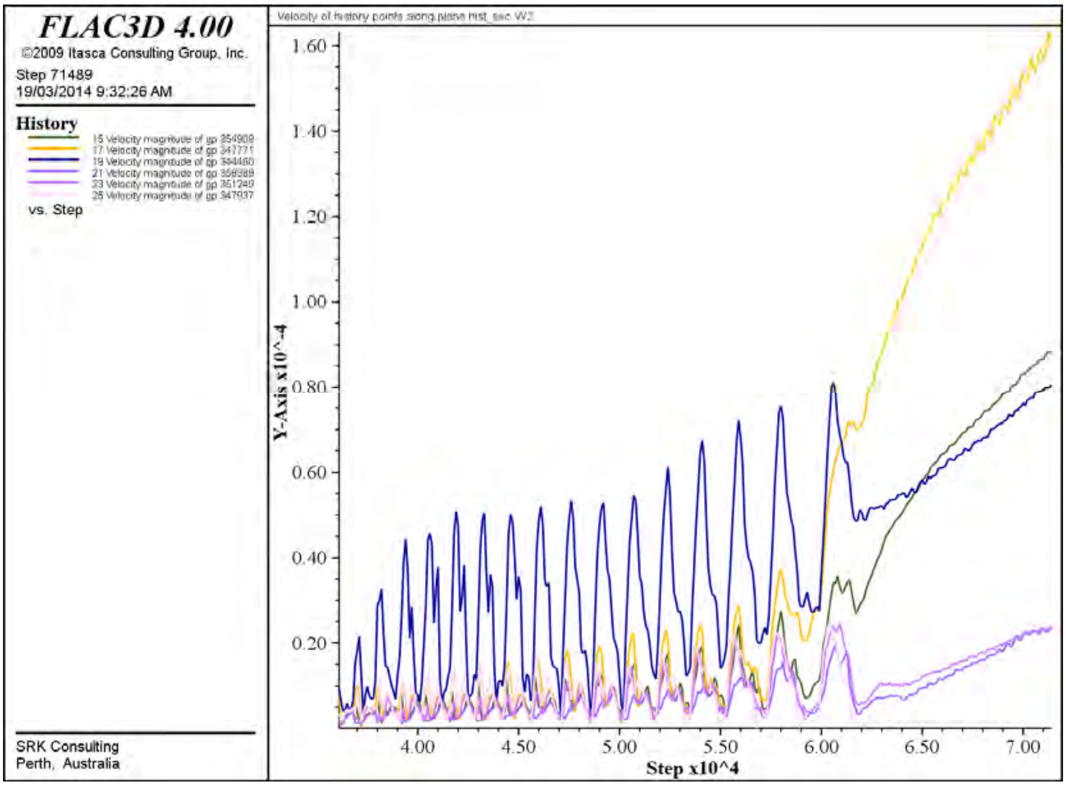


Figure I-42: Velocity histories for history locations at Sec-W2

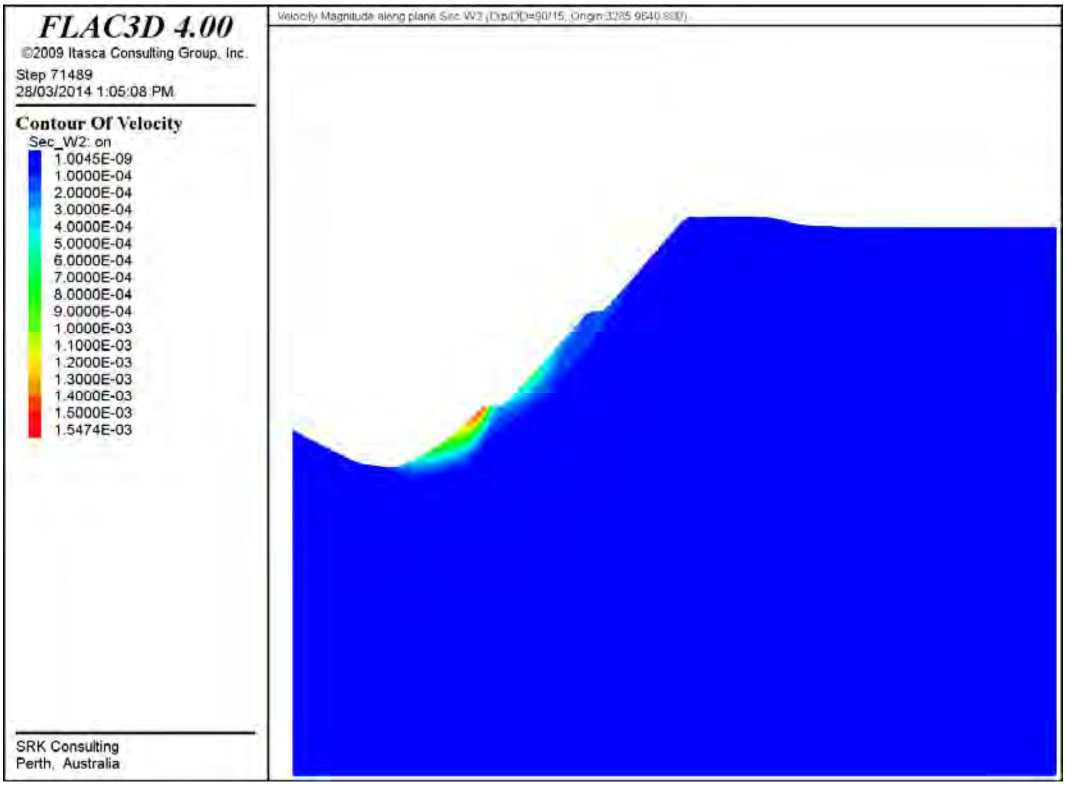


Figure I-43: Velocity contour of vertical plane at Sec-W2

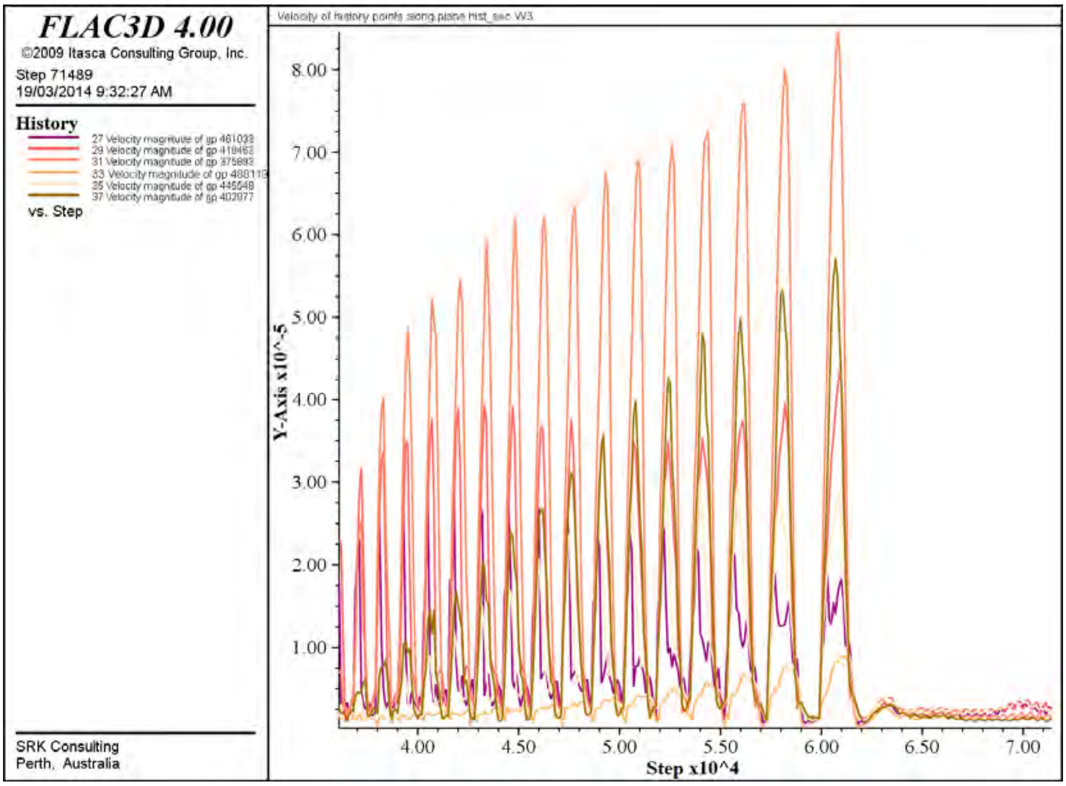


Figure I-44: Velocity histories for history locations at Sec-W3

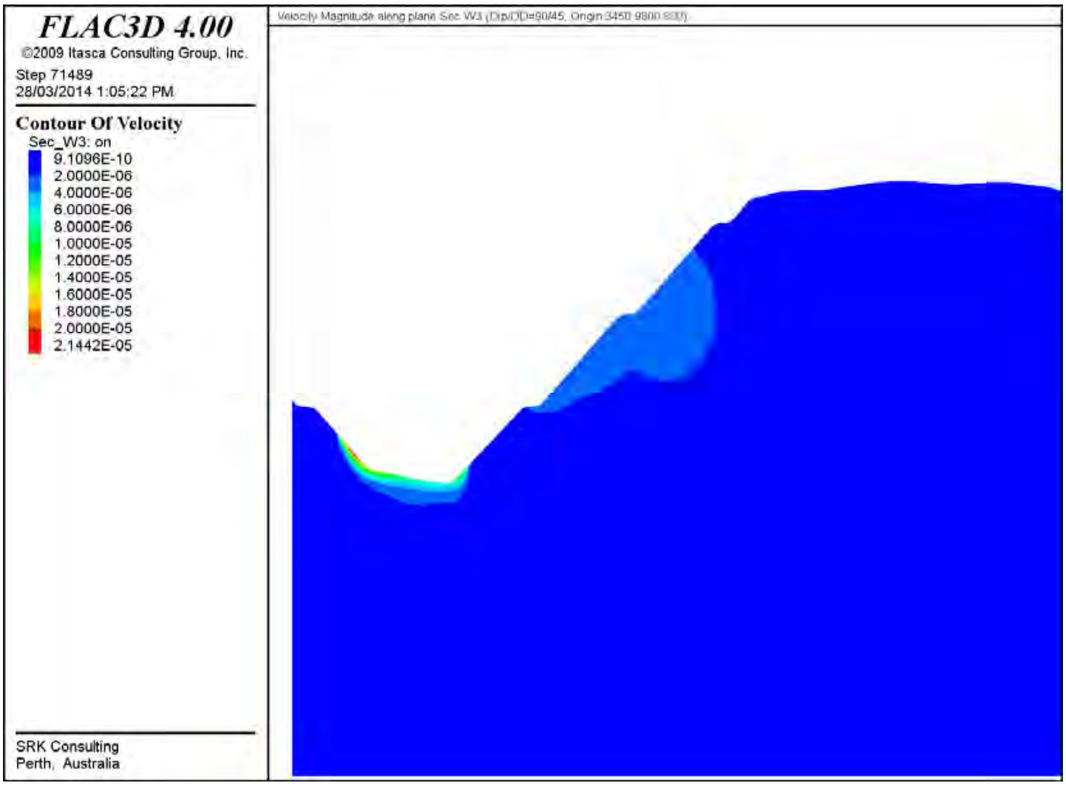


Figure I-45: Velocity contour of vertical plane at Sec-W3

Stage 1 Pit

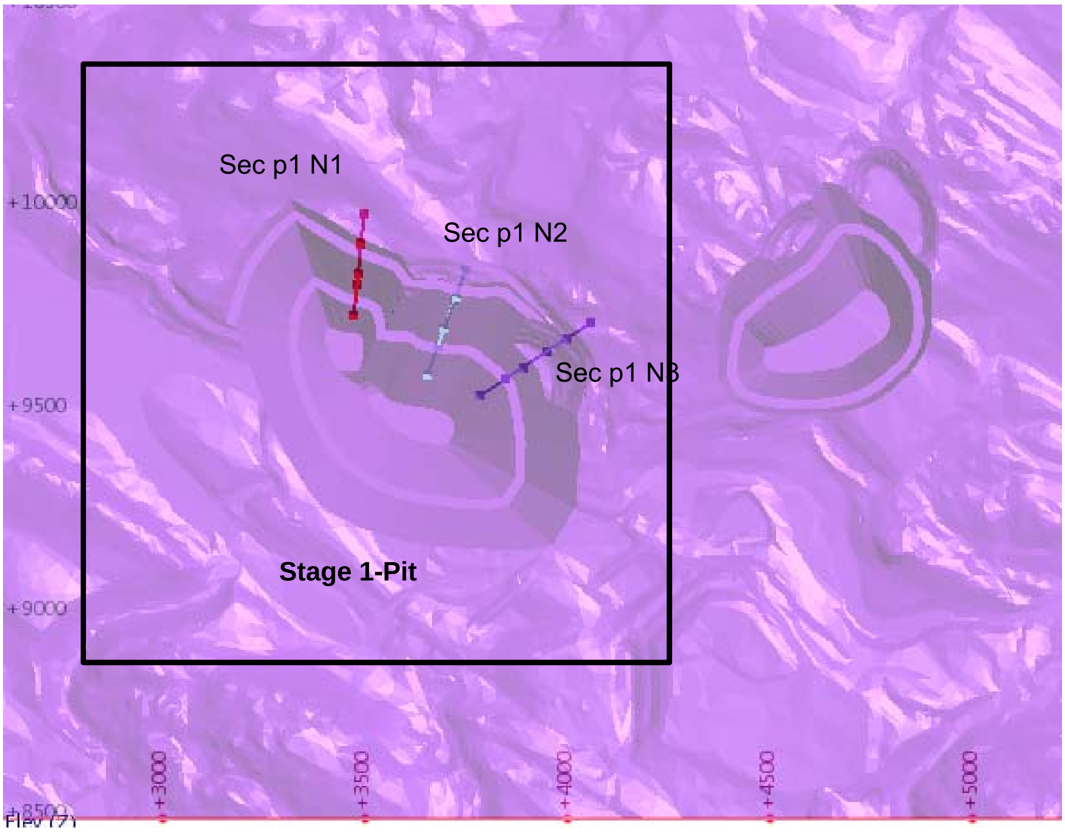


Figure I-46: History locations-Stage 1 pit

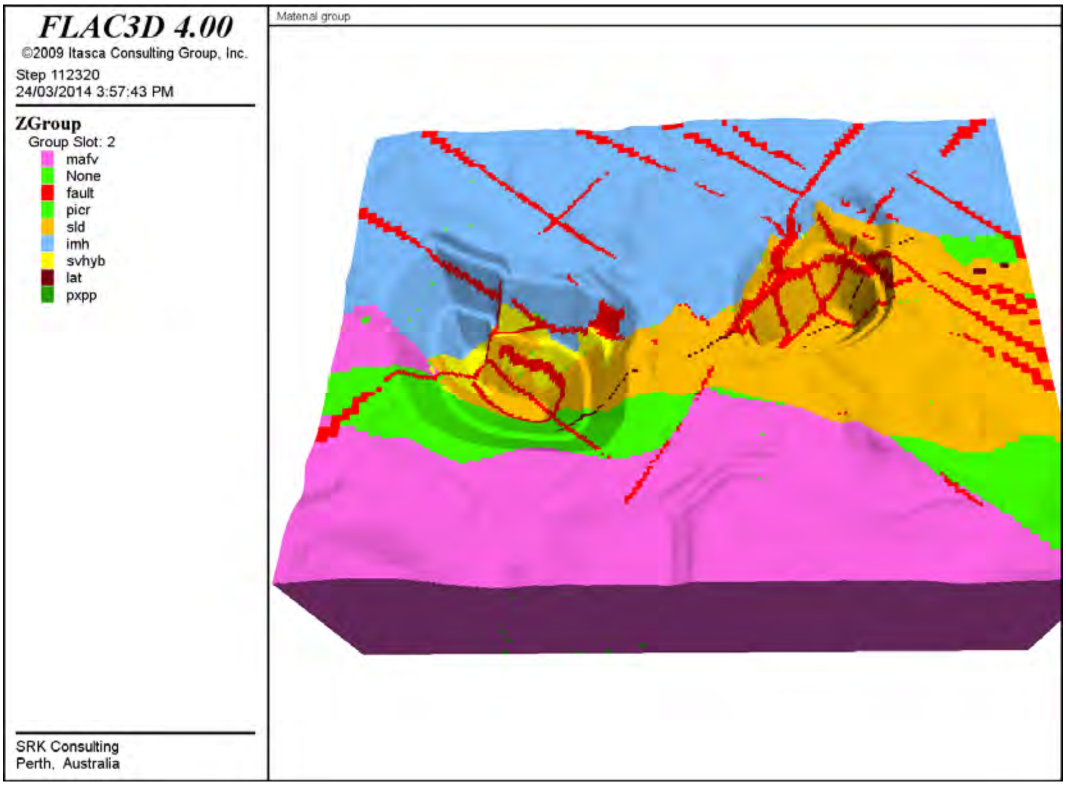


Figure I-47: Material groups-Stage 1 pit

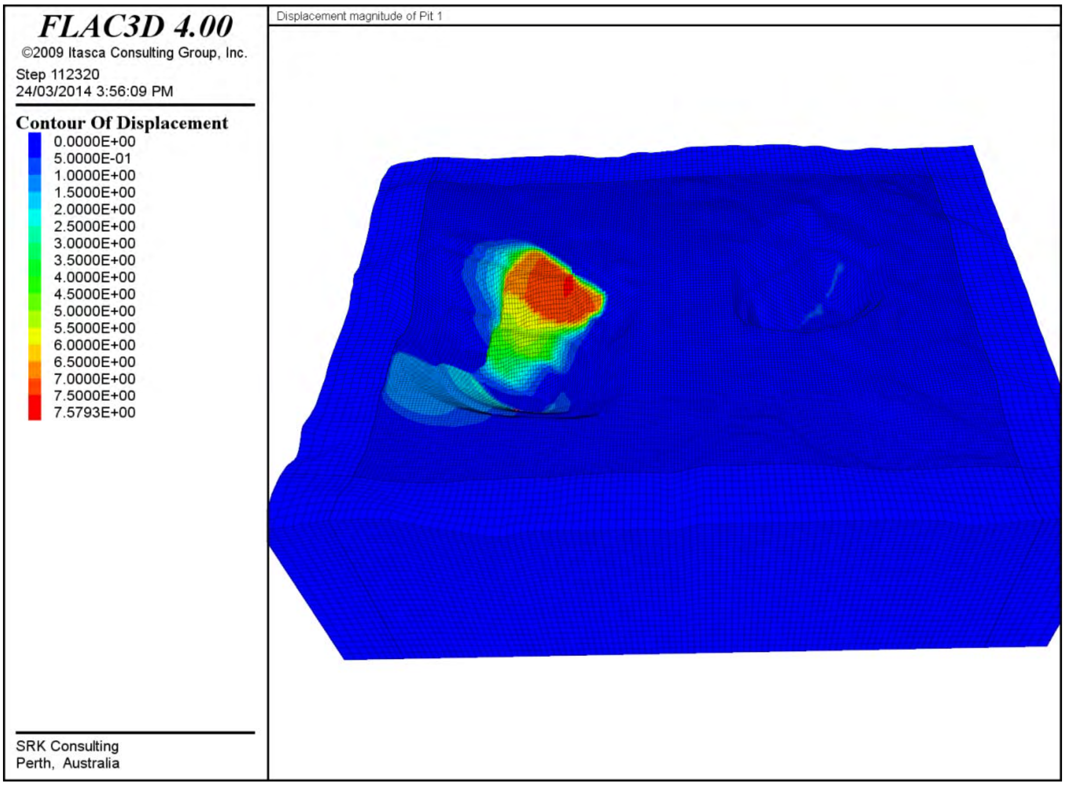


Figure I-48: Displacement contours-Stage 1 pit

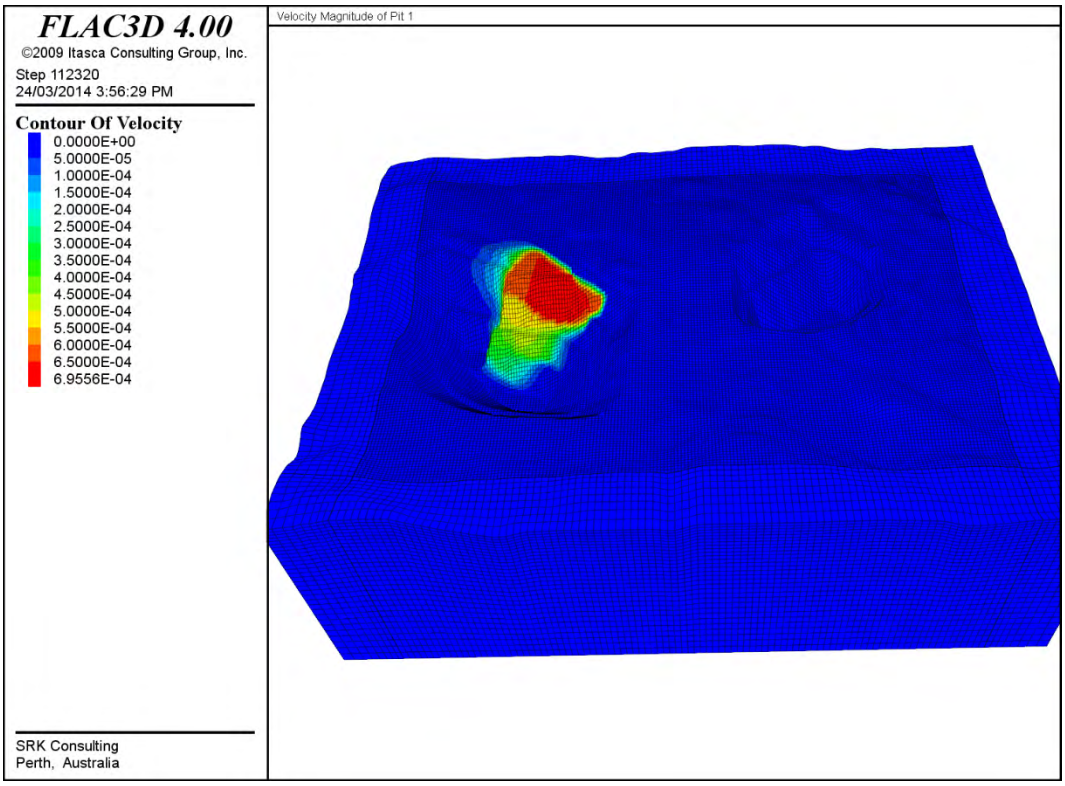


Figure I-49: Velocity Contours-Stage 1 pit

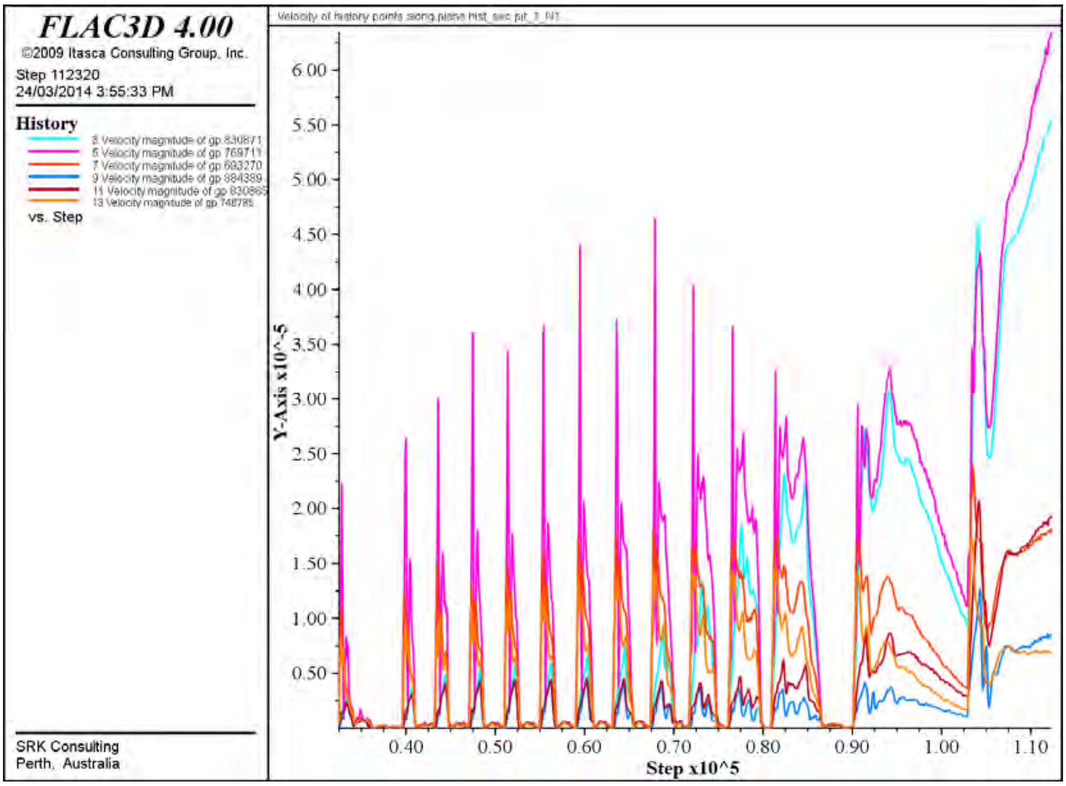


Figure I-50: Velocity histories for history locations at Sec- P1_N1

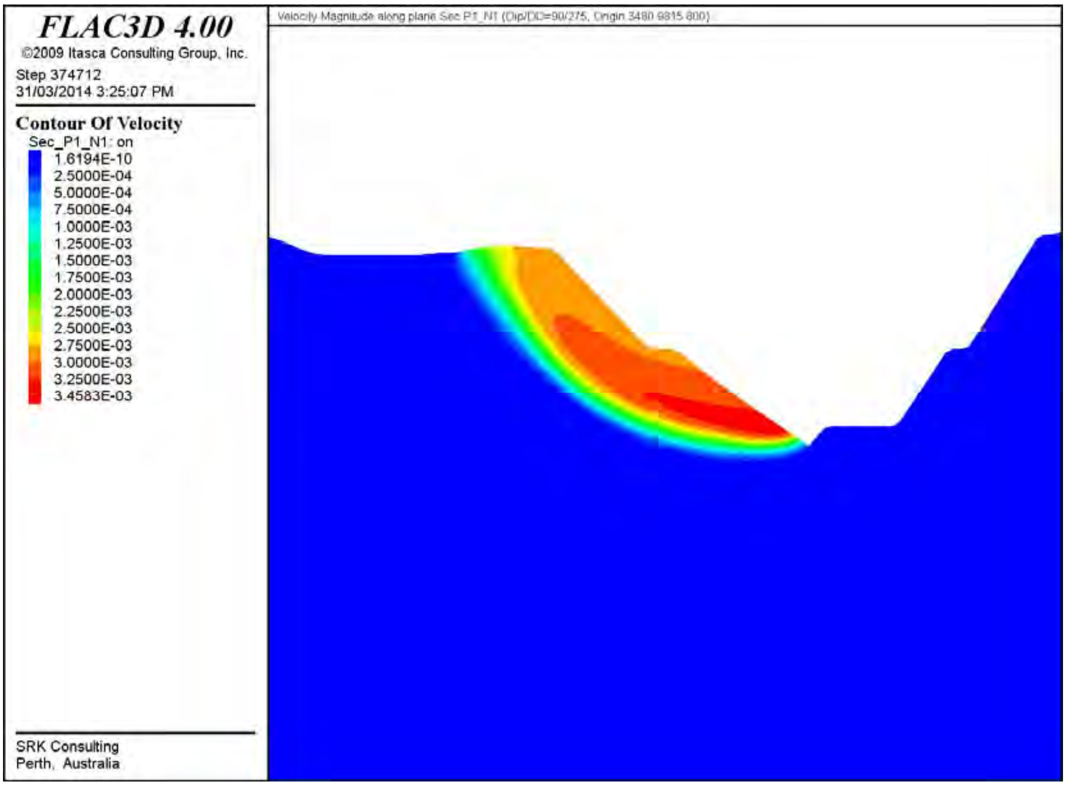


Figure I-51: Velocity contour of vertical plane at Sec- P1_N1

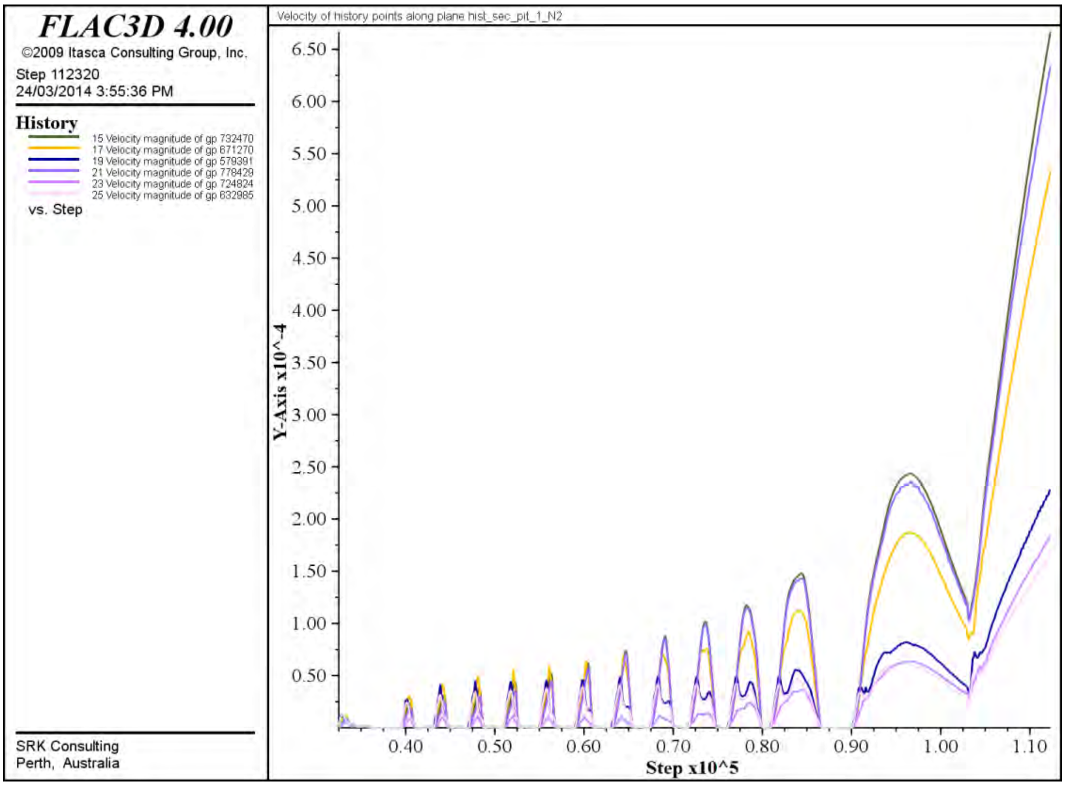


Figure I-52: Velocity histories for history locations at Sec- P1_N2

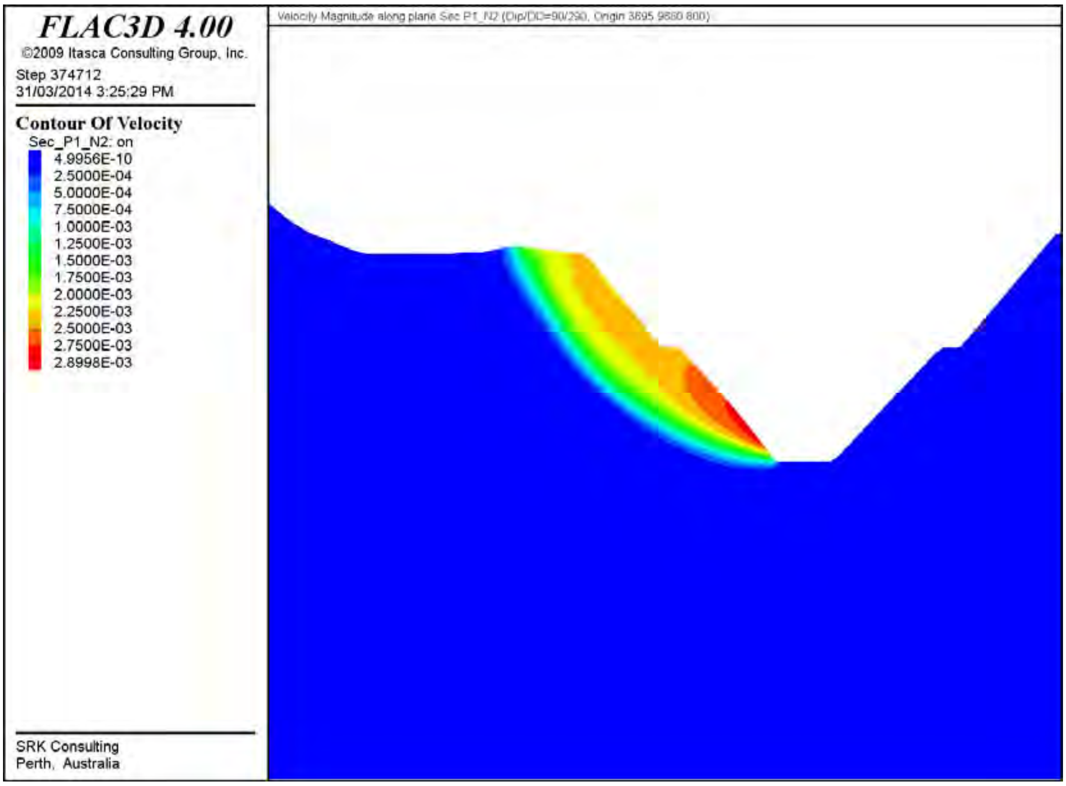


Figure I-53: Velocity contour of vertical plane at Sec- P1_N2

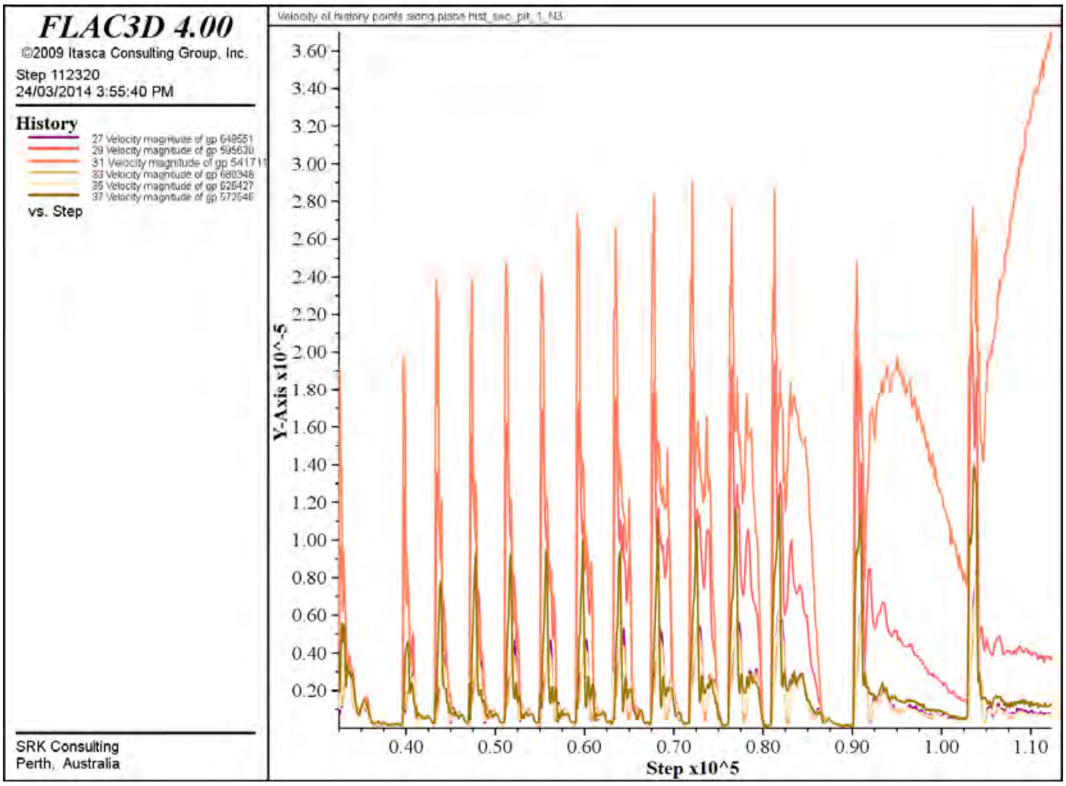


Figure I-54: Velocity histories for history locations at Sec- P1_N3

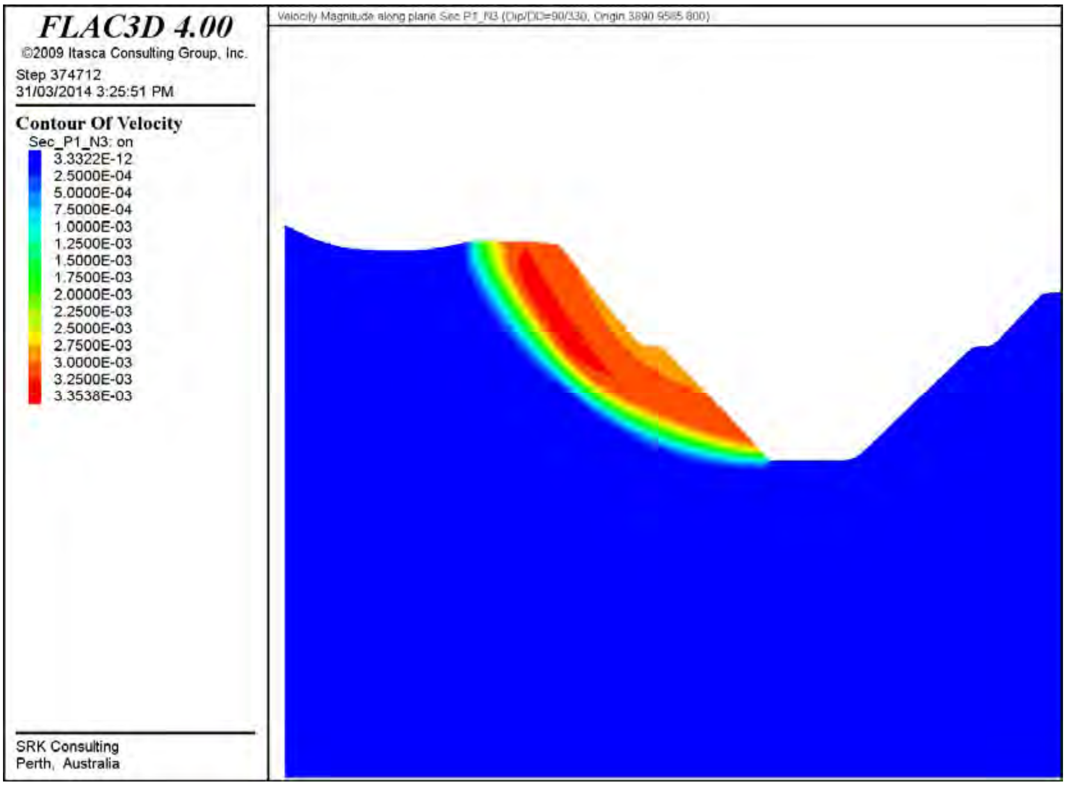


Figure I-55: Velocity contour of vertical plane at Sec- P1_N3

Stage 2 Pit

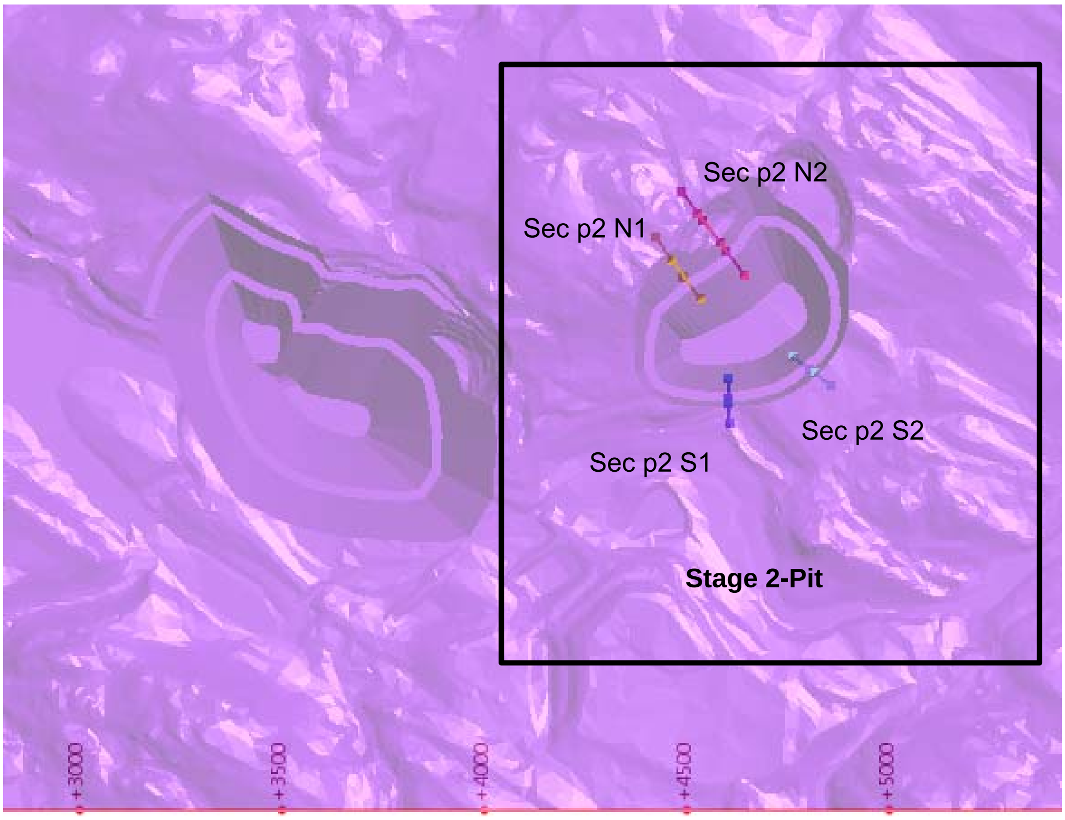


Figure I-56: History locations-Stage 2 pit

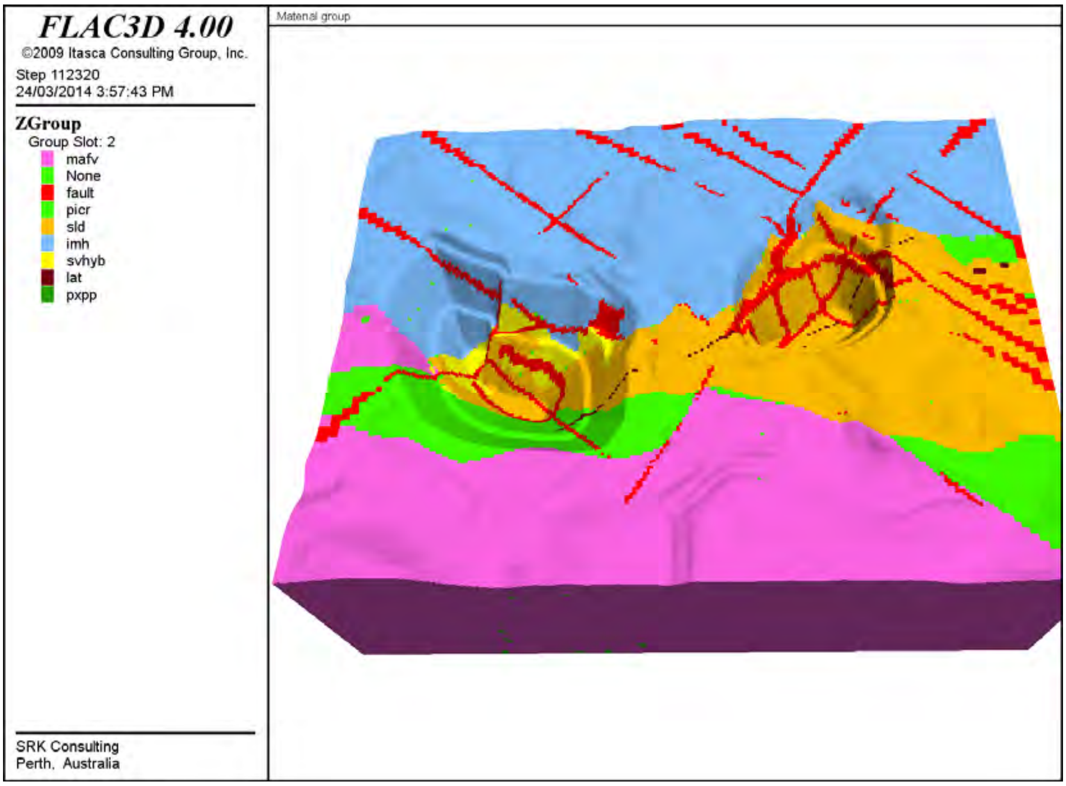


Figure I-57: Material groups-Stage 2 pit

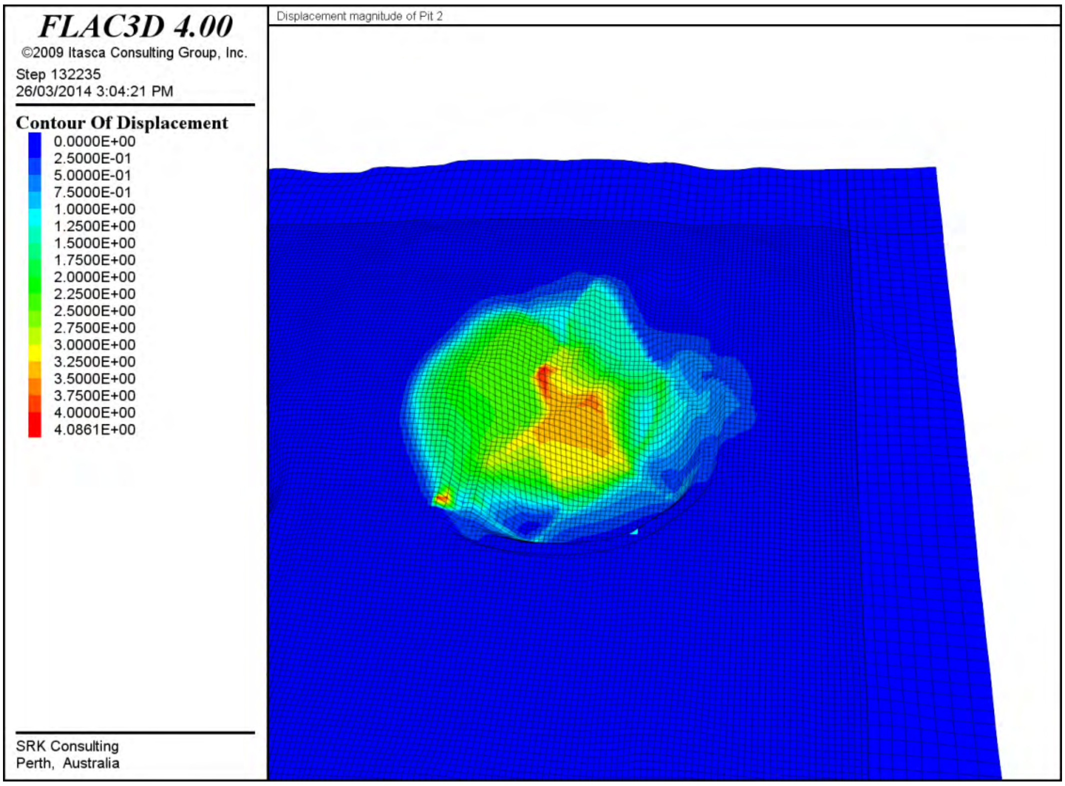


Figure I-58: Displacement contours-Stage 2 pit

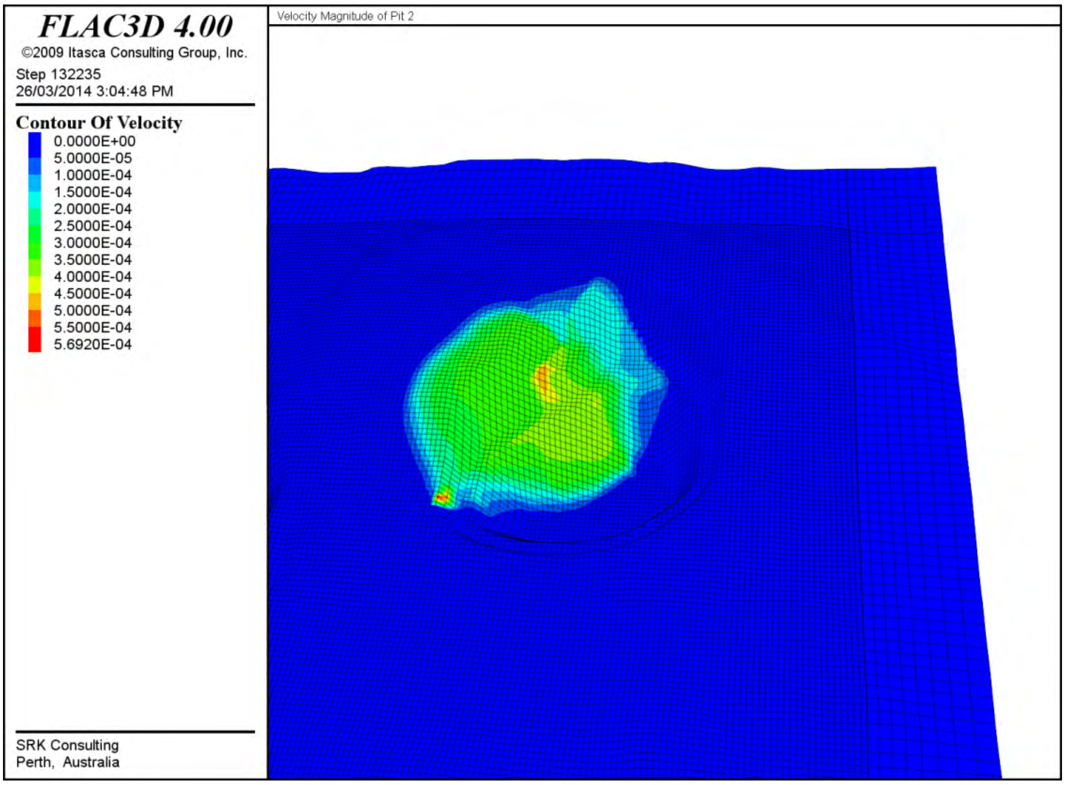


Figure I-59: Velocity Contours-Stage 2 pit

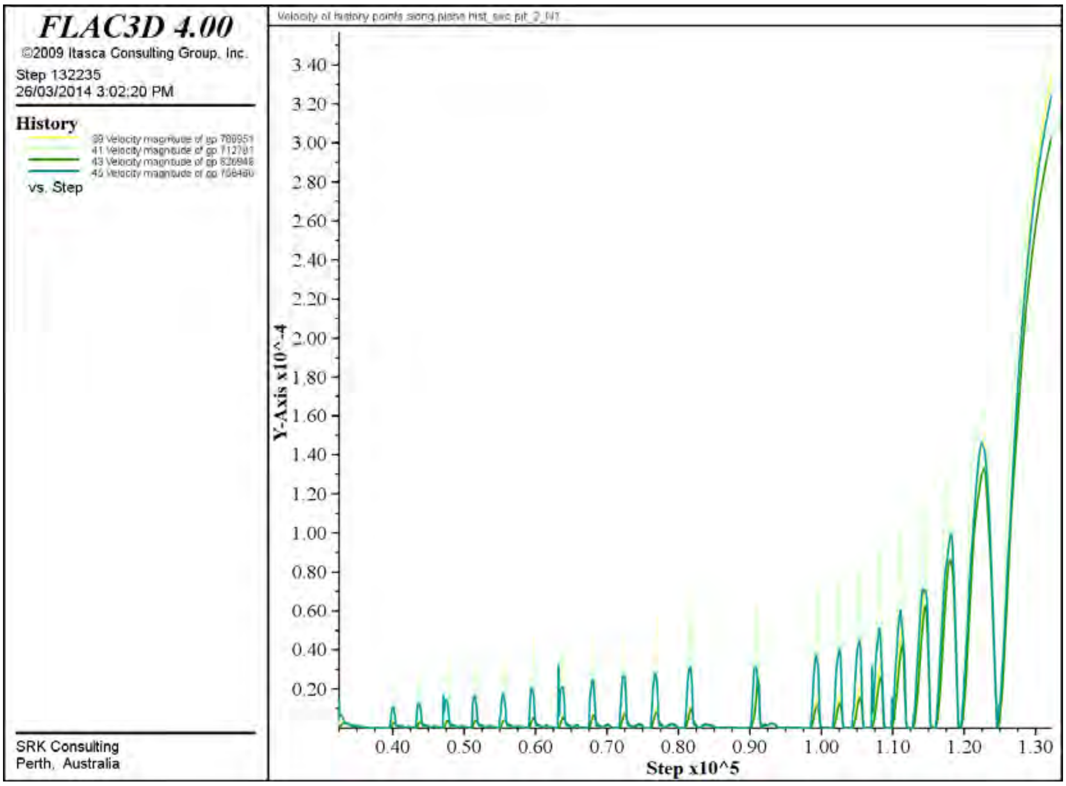


Figure I-60: Velocity histories for history locations at Sec- P2_N1

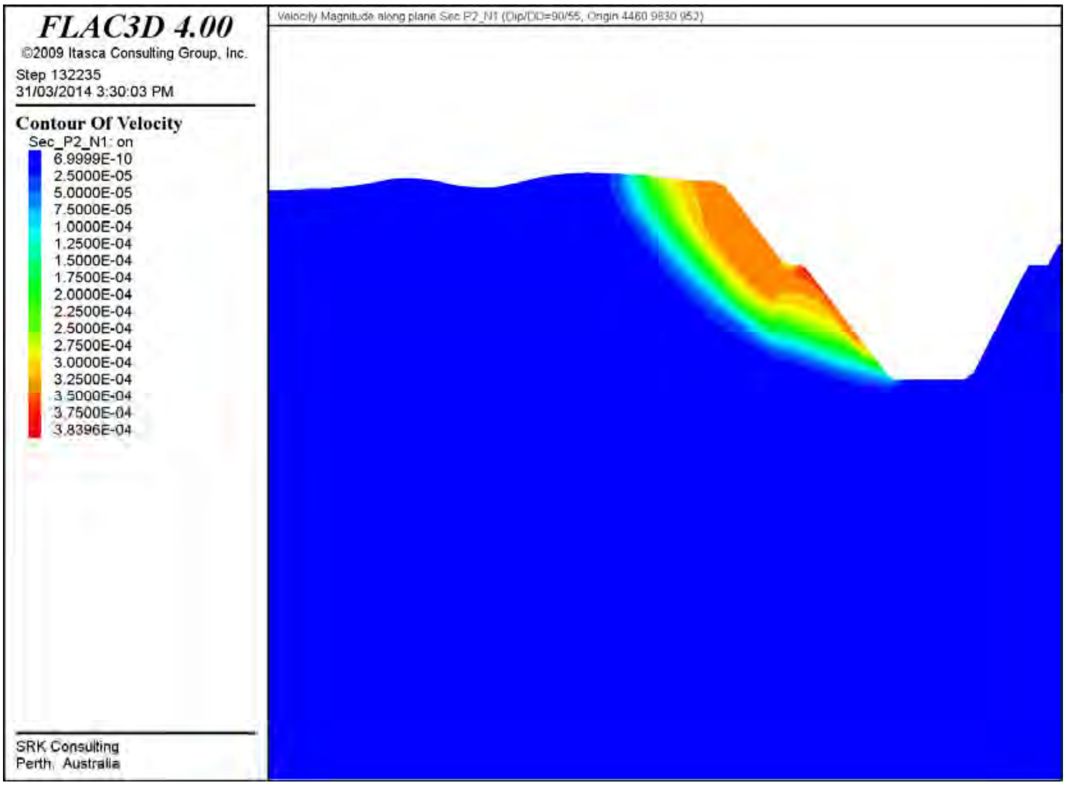


Figure I-61: Velocity contour of vertical plane at Sec- P2_N1

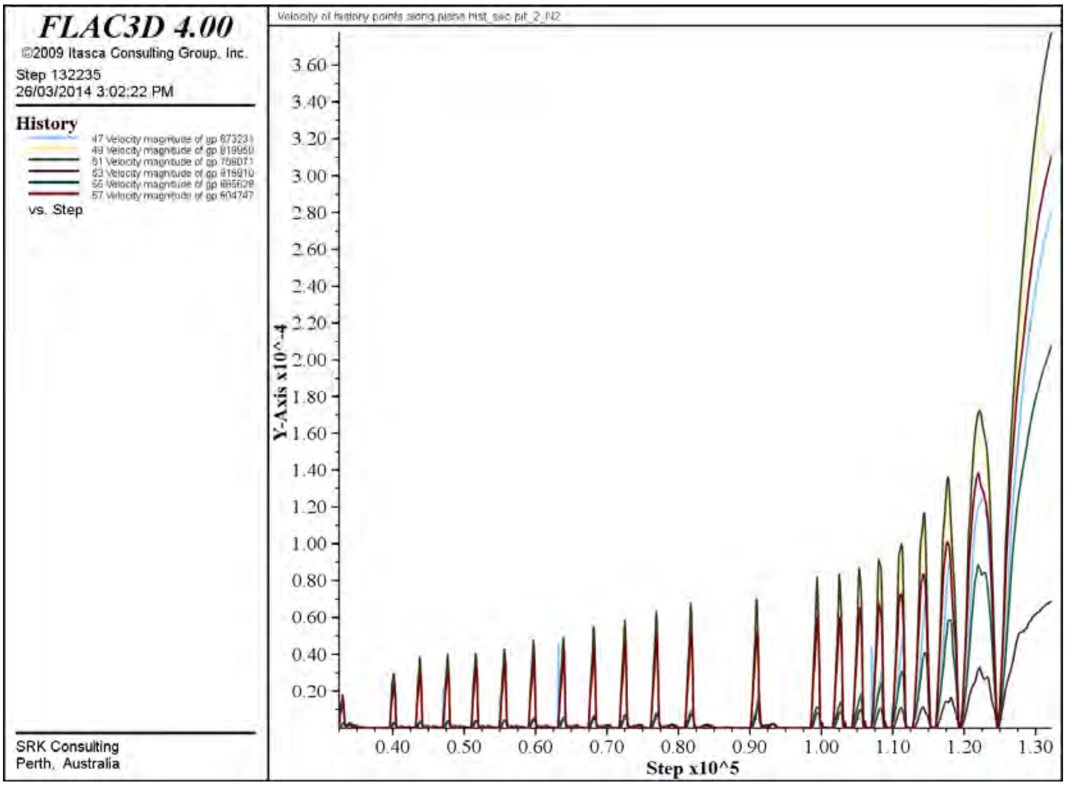


Figure I-62: Velocity histories for history locations at Sec- P2_N2

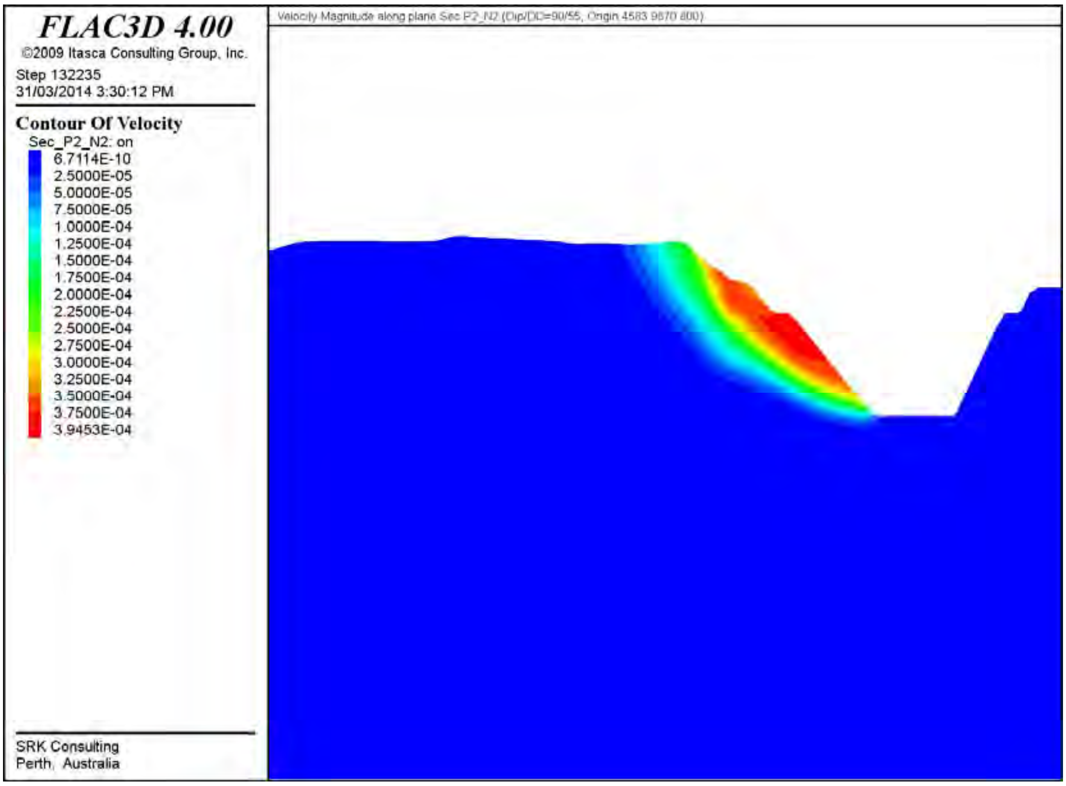


Figure I-63: Velocity contour of vertical plane at Sec- P2_N2

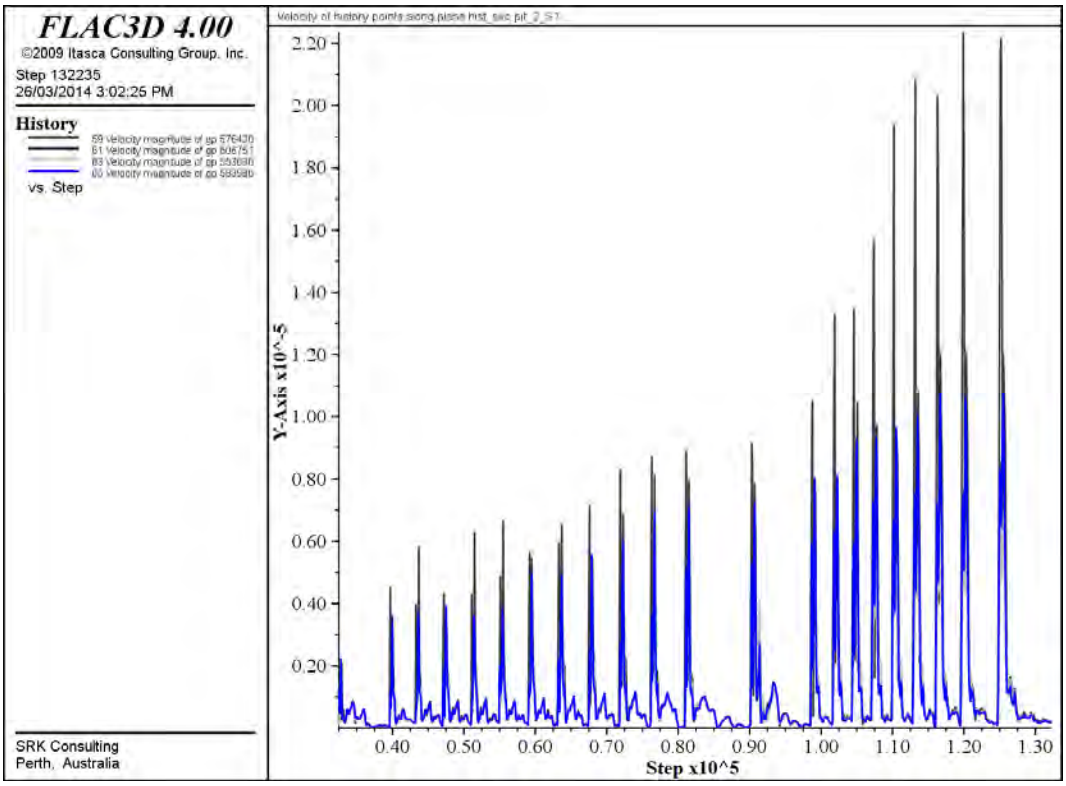


Figure I-64: Velocity histories for history locations at Sec- P2_S1

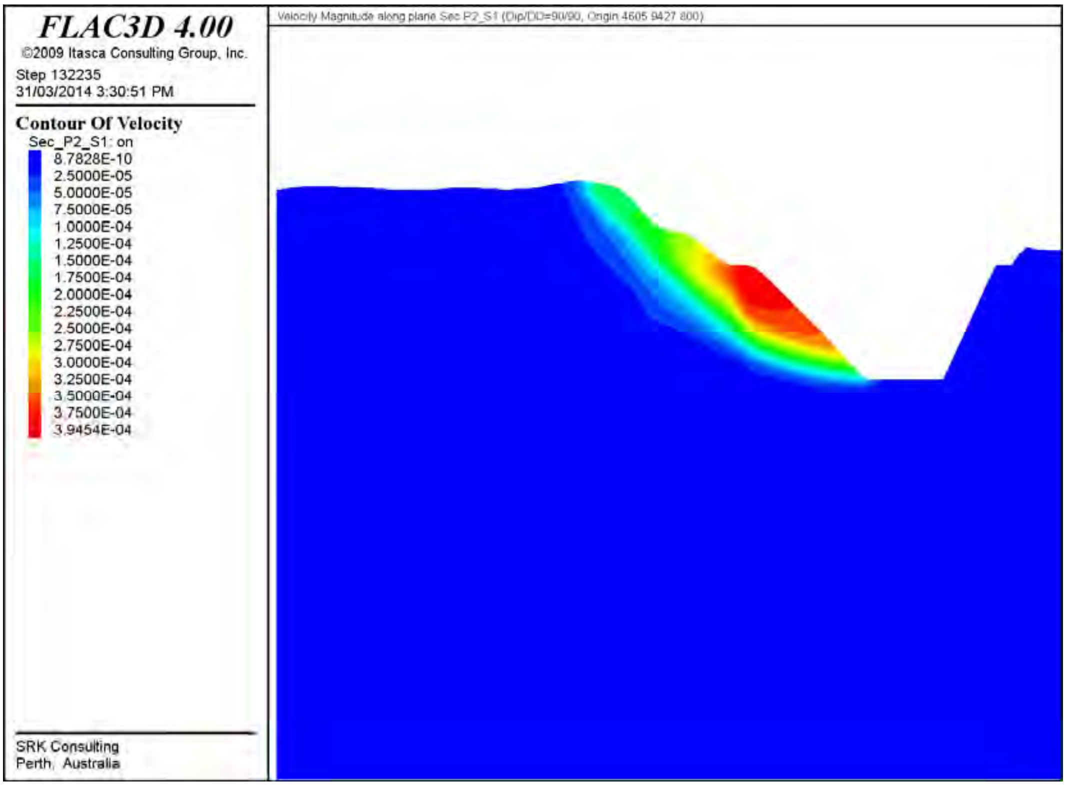


Figure I-65: Velocity contour of vertical plane at Sec- P2_S1

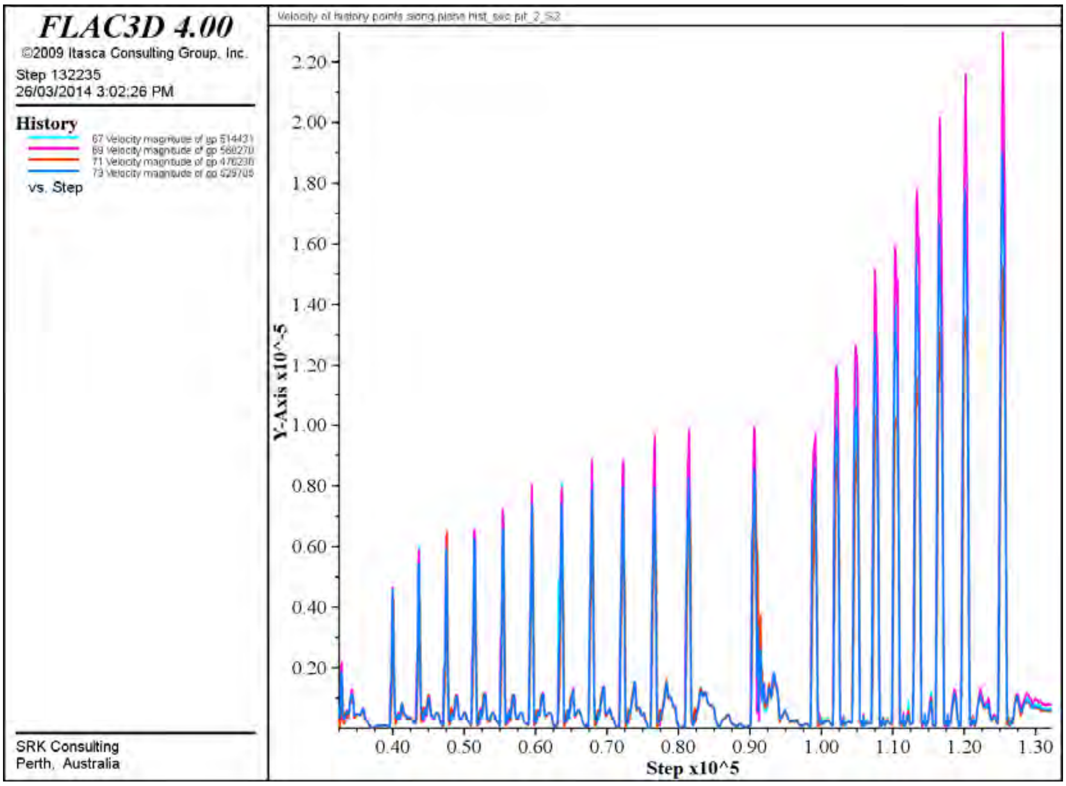


Figure I-66: Velocity histories for history locations at Sec- P2_ S2

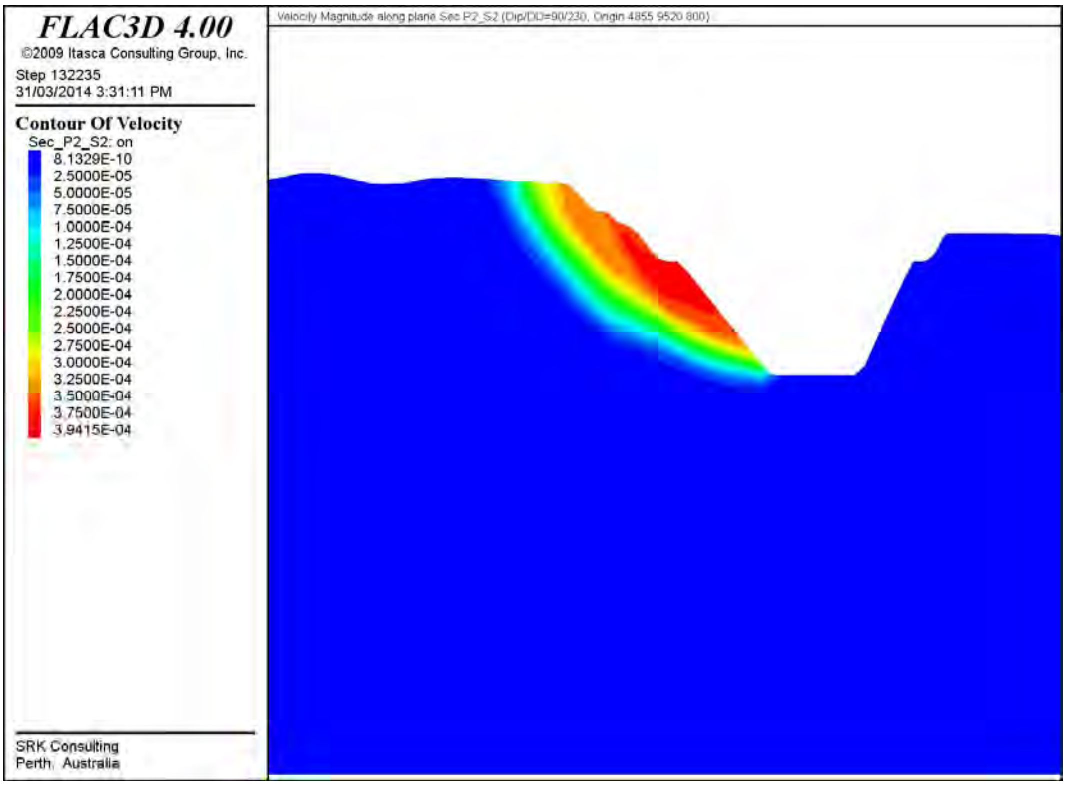


Figure I-67: Velocity contour of vertical plane at Sec- P2_ S2

SRK Report Client Distribution Record

Project Number: KGH001

Report Title: Ajax Project Open Pit Geotechnical Slope Design Parameters

Date Issued: 25 June 2014

Name/Title	Company
Julian Watson	KGHM

Rev No.	Date	Revised By	Revision Details
Rev0	16/04/2014	William Gibson	Draft report sent to client
Rev1	25/06/2014	Ian de Bruyn	First revision incorporating client’s feedback