Eskom	Scope of Work	Group Technology

Title:	**Kriel Power Station Stability Assessment for Existing Ash Dam Complex**	Unique Identifier:	**377-KRL-AABZ4-AS0000-4**
		Alternative Reference Number:	**NA**
		Area of Applicability:	**Eskom Group Technology**
		Documentation Type:	**Scope**
		Revision:	**1.0**
		Total Pages:	**14**
		Next Review Date:	**NA**
		Disclosure Classification:	**CONTROLLED DISCLOSURE**

Compiled by	Functional Responsibility	Authorized by
……..	……..	……..
A Simbudayal	**A Kreuiter**	**ST Mavunda**
Senior Engineering Geologist	**Chief Engineer**	**CoE Manager**
Geotechnical Engineering CoE	**Geotechnical Engineering CoE**	**Geotechnical Engineering CoE**
Date: 13/06/2019	Date: 13/06/2019	Date: 14/06/2019

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1. INTRODUCTION

Kriel Power Station requires a geotechnical stability assessment of the existing ash dam complex. The geotechnical investigation will aim to determine the current and future stability of the existing ash facilities and advise on mitigative measures to allow the power station to continue ashing in an environmentally responsible manner for the duration of its operating life.

2. SUPPORTING CLAUSES

2.1 SCOPE

The scope comprises of a detailed, statistically reliable geotechnical investigation of the ash and foundation soils around the existing ash dam complex at Kriel Power Station, as well as an assessment of the ash stiffness and prevalent water table condition in the existing ash dam itself.

A volumetric evaluation of the Rate of Rise of the existing ash dam complex must also be done together with the stability analysis to determine the maximum allowable safe height of the existing ash dam complex and thus its remaining operating life. This information must be used to assess the risk of stability failure of the ash facilities.

2.1.1 Purpose

- Determine the risk of stability failure of the existing wet ash dam complex at Kriel Power Station, and provide mitigation measures.

2.1.2 Applicability

This document shall apply throughout Eskom Group Technology Engineering and Kriel Power Station

2.2 NORMATIVE/INFORMATIVE REFERENCES

2.2.1 Normative

[1] All drilling is conducted in accordance with CSRA: Standard Specification for Sub-surface Investigations, 2010

[2] All laboratory testing are conducted in accordance with the latest standard methods and procedures as outlined by the appropriate authorities (S.A.N.S, B.S/ EuroCode equivalent, A.S.T.M, A.A.S.H.T.O, I.S.R.M, S.A.B.S)

[3] All Soil profiling is conducted in accordance with guidelines outlined in: Jennings, J.E, Brink, A.B.A, & Williams, A.A.B, (1973) “Revised Guide to Soil Profiling for Civil Engineering purposes in Southern Africa” Trans. S.A.I.C.E, Vol. 15, No. 1, pp 3 – 12.

[4] All work is conducted in accordance with the requirements of the Occupational Health and Safety Act (Act 85 of 1993) as amended

[5] The successful tenderer is required to conform to all relevant legislation, whether natural, social, cultural or technical, and shall liaise with the appropriate authorities if required.

2.2.2 Informative

[6] JW129/15/F015 – (April 2016): Kriel Ash Dam Step-In & Go Higher Geotechnical Investigation And Stability Assessment – Final Report

[7] TN061/16/F912-01 - (January 2017): Kriel Power Station: Ash Dam Complex Geotechnical Stability Review

[8] 1789563-319669-1 (November 2018): Kriel Ash Dam Complex Stability Evaluation

[9] 1792940-321732-1 (October 2018): Kriel Power Station Ash Dam Operations and Maintenance Manual

2.3 DEFINITIONS

2.3.1 Classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.3.2 Abbreviations

Abbreviation	Description
A.A.S.H.T.O.	American Association of State Highway and Transport Officials
A.S.T.M.	American Society for Testing and Materials
B.S.	British Standard (Euro code equivalent)
CoE	Centre of Excellence
CPTu	Cone Penetration Tests
C.S.R.A.	Committee of State Road Authorities
D.E.M.	Digital Elevation Model
D.P.S.H.	Dynamic Probe Super Heavy
D.S.O.	Dam Safety Office
D.T.M.	Digital Terrain Model
F.o.S.	Factor of Safety
G.S.D.	Ground Sample Distance
I.S.R.M.	International Society of Rock Mechanics
O.S.H.	Occupational Health & Safety
S.A.B.S	South African Bureau of Standards
S.A.I.C.E.	South African Institute of Civil Engineers

Abbreviation	Description
S.A.N.S.	South African National Standards
S.P.T.	Standard Penetration Tests
W.G.S.	World Geodetic System

2.3.3 Roles and Responsibilities

The *Consultant* is required to:

I. review all relevant existing site information inclusive of existing geological and geotechnical data;

II. For the stability investigations, the *Consultant* will:

a. undertake additional Geotechnical Investigation (GI), as required, to establish the required geotechnical parameters for the stability analysis,

b. review the historical and current piezometer levels of all current operational piezometer lines on the existing ash dam complex and install additional piezometers at critical stability sections,

c. carry out Piezocone testing through the ash dam sideslopes and install vibrating wire piezometer installation positions at critical stability sections for future monitoring,

d. drill geotechnical boreholes with SPT [Standard Penetration Tests], and implement tube sampling, at the crest of each section,

e. conduct DPSH [Dynamic Probe Super Heavy] tests around the perimeter of the existing ash dam complex to identify areas of poor founding conditions,

f. excavate test pits around the perimeter of the existing ash dam complex to confirm founding conditions,

g. perform laboratory testing on representative samples to establish geotechnical stability parameters for the ash and foundation soils,

h. provide analysis of buttressing of critical slopes to achieve the minimum Factor of Safety (FoS) of 1.3 during construction and 1.5 post closure.

i. prepare a comprehensive report, which will summarize the stability conditions of the existing ash dam complex and recommend a revised maximum height and side slope geometry,

j. assist with engagement to relevant authorities (where needed),

III. provide adequate resources including provision of equipment for required works,

IV. manage cost and a scheduled time frame of work,

V. ensure that the scope is carried out in full,

VI. provide regular feedback on the status of each phase,

VII. ensure that all site work is conducted by a competent person,

VIII. ensure that prior to any fieldwork, all parties working on site have familiarized themselves with the Employers safety requirements and the Occupational Health and Safety (OSH)Regulations act (85 of 1993) and,

IX. apply his/her discretion in conducting tests in as close an area to the desired location as possible, should access to testing areas be restricted and/or obstructed.

2.4 PROCESS FOR MONITORING

Not Applicable

2.5 RELATED/SUPPORTING DOCUMENTS

Not Applicable

3. SCOPE OF WORKS FOR STABILITY ASSESSEMENT OF EXISTING ASH DAM COMPLEX

The scope of work includes all field and laboratory testing, stability and Rate of Rise analysis including report writing, as outlined below. The *Consultant* makes written recommendation to the *Employer* should he be of the opinion further or additional tests may be necessary in order to fulfil the requirements of the scope.

The *Consultant* must review and familiarise himself with known literature, existing geotechnical information and regional information available for the existing ash facilities and associated foundation soils in the area.

The latest aerial LIDAR survey with orthophoto (issued by Eskom) can be used for planning the geotechnical investigation and analyses.

The *Works* includes but is not limited to:

3.1 LIDAR SURVEY OF KRIEL EXISTING ASH DAM

I. High resolution digital geo-referenced orthophoto imagery in .ecw format
    a. Non image background area to be white
    b. Split into 1000 m square tiles and as a single composite image
II. Original photography image pixel size 10cm.
III. Point horizontal accuracy 5.0 cm, Vertical accuracy 10.0 cm.
IV. Classification of laser points to ground and above ground classes.
V. LIDAR points to be supplied in ASCII format and Microstation V8 CAD Format (-Y, -X, -Z) North upwards.
VI. DEM, DTM Extraction.
VII. Lidar points to be supplied as completed area in single file and split into 1000m blocks to coincide with image tiles
VIII. 0.5m smoothed contouring of ground model to be supplied in Microstation V8 .dgn format.
IX. CAD file to include image, tile grid and file names.
X. GSD imagery 2.5 cm.
XI. Approximate raw point density per m^2: 1-3
XII. Survey co-ordinate system: WGS 84 Lo 29

3.2 CORE LOGGING

I. Drill and supervise N-size boreholes on the existing dams.

II. Selected boreholes will contain Standard Penetration Tests (SPT) to determine ash and foundation soil stiffness profiles

III. Based on previous geotechnical investigations, the ash column is known to be of variable stiffness's. It is therefore recommended that the drilling as far possible be conducted to suit the stiffness of the ash to allow for representative ash recoveries.

IV. All water strikes encountered during drilling activities are recorded.

V. All boreholes are required to drill beyond the ash columns into founding soils.

VI. Boreholes must terminate a minimum of three (3) meters into founding soils.

VII. Shelby and Piston Tube Sampling is implemented for boring through fine materials. The *Consultant* is to ensure that all samples are adequately labelled and sealed prior to transport to the laboratory for testing.

VIII. Representative samples are extracted and placed into plastic sheaths and stored in labelled core boxes within an adequate covering to be logged to the standardised procedure.

IX. All samples retrieved from the boreholes are submitted to accredited soil, rock and water laboratories for testing.

X. All boreholes are adequately backfilled.

XI. The proposed borehole layout; inclusive of the boreholes which will contain SPT; shall be provided by the *Consultant,* and reviewed by the *Employe*r prior to excavation. Proposed borehole depths are communicated to the *Employer* prior to excavation. All boreholes to be indicated in a Microstation V8 CAD dgn file.

XII. Evaluation and interpretation of test results.

3.3 PIEZOMETER CLUSTERS

The *Consultant* is required to:

I. Obtain all historical and current piezometer readings for the existing piezometer lines.

II. Evaluate and interpret recorded results.

III. Instruct upset tests for piezometers indicating blockages.

IV. Drill and supervise the installation of standpipe and internet linked vibrating wire piezometers at critical cross sections (as required).

3.4 CONE PENETROMETER TESTS (C.P.T.U)

I. CPTu (piezocone) tests are conducted to supplement water table data derived from the piezometer clusters.

II. CPTu tests are required to assess the changes in pore pressures regime and dissipation measurements.

III. <u>It must be noted that, due to the hardness of the ash there may be a requirement to conduct pre-drilling to allow for the placement of CPTu probes at required line sections.</u>

IV. Analysis of CPTu data.

V. CPTu positions to be indicated in a Microstation V8 CAD dgn file.

3.5 TEST PITTING

I. Excavation and supervision of test pits around the perimeter of the existing ash dam complex.

II. Test pits are excavated to a maximum depth of three (3) meters.

III. All the test pits are profiled by an engineering geologist/ geotechnical engineer according to 'Guidelines for Soil and Rock Logging in SA, 2nd Impression' (Brink and Bruin, 2002).

IV. The number of test pits and samples for testing should allow statistically reliable strength parameters for the ash and founding soils to be achieved.

V. The number of test pits shall be advised upon by the *Consultant* and reviewed by the *Employer* prior to excavation.

VI. Evaluation and interpretation of results.

VII. The *Employer* may request additional sampling.

VIII. All test pits are reinstated using the soil removed from pits following completion of soil profiling and sampling.

IX. Reinstated soils are adequately compacted to minimize differential settlements.

X. The *Consultant* must (a) take reasonable and sufficient steps in order to prevent, as far as is reasonably practicable, any person from being buried or trapped by a fall or dislodgement of material in an excavation; (b) may not require or permit any person to work in an excavation which has not been adequately shored or braced as stipulated in Section 13 of Reference [4].

XI. Test pit positions to be indicated in a Microstation V8 CAD dgn file.

3.6 DYNAMIC PROBE SUPER - HEAVY (D.P.S.H)

I. The *Consultant* is required to select for the number of D.P.S.H tests which will be required to aid in predicting foundation performance around the perimeter of the existing ash dam complex.

II. The number of D.P.S.H tests shall be advised upon by the *Consultant*, and reviewed by the *Employer* prior to commencement of testing.

III. DPSH positions to be indicated in a Microstation V8 CAD dgn file.

3.7 ASSESSMENT OF OUTLET DRAINS

I. Assess outlet drains by means of remote sensing equipment.

II. Determine and produce drawings of blocked and unblocked outlet drains.

III. Provide recommendations on methods for unblocking outlet drains.

IV. Outlet drain positions to be indicated in a Microstation V8 CAD dgn file with outlet ID number and colour differentiation to indicate whether the drains are working or blocked.

3.8 TESTS ON SOIL SAMPLES

3.8.1 Identification Tests

- Atterberg Limits
- Sieve analysis including hydrometer

3.8.2 State Tests

- In-situ Moisture content
- Undisturbed Bulk Density

3.8.3 Strength Tests

- Triaxial tests – with measure for pore water pressure
- Shear Box tests

3.8.4 Deformability Tests

- Collapse Potential (modified single Oedometer)
- Double Oedometer

3.8.5 Permeability Tests

- Laboratory permeability tests on soil samples

3.8.6 Chemical Tests

- Organic Content

3.9 TESTS ON ASH SAMPLES FOR RATE OF RISE VERIFICATION

3.9.1 Air Dry Evaporation Tests

- Dry out tests on ash

3.9.2 Critical State Line

3.9.3 Consolidometer

- Consolidometer tests on ash slurry

3.10 SAMPLING AND METHODOLOGIES

I. Sampling is conducted on representative disturbed and undisturbed samples.

II. Samples are collected, stored and labelled as per the relevant S.A.I.C.E standards.

III. The Consultant ensures that all samples are transported carefully to the laboratory, such that the samples retain their sample integrity.

IV. No samples are to be misplaced, damaged or lost during transportation and testing.

V. The test layouts and proposed sampling plan with rationalised methodology is submitted for review and acceptance by the *Employer* prior to commencement on site.

3.11 ANALYSIS

I. Determine the maximum ash dam height based on the maximum allowable Rate of Rise of 3.5 m/y (unless otherwise calculated by ash tests), for the ash material deposition rate and ash dam geometry.

II. A statistically reliable stability analysis is to be carried out along all existing and new (where applicable) piezometer lines, as well as any other critical positions the *Consultant* deems necessary, for the existing and remaining height of the existing ash dam complex.

III. A minimum Factor of Safety of 1.3 for operational slopes and 1.5 for post closure slopes must be used. The probability of failure as a percentage for the current and final ash dump geometry must be determined to allow the risk of failure to be quantified. (Risk of Failure = Probability of Failure x Consequence of Failure).

IV. The Probability of Slope Failure, the Hazard Classification, the Adequacy of Real Time Information, the Adequacy of Controls, the Risk to Ongoing Operation of the power station, the Environmental Pollution Risk, the Risk to Loss of Life and Legal Liability must be assessed to arrive at the final overall Risk of Ash Dam Failure as a weighted percentage.

V. If the minimum sideslope stability assessment FoS of 1.3 or 1.5 is not achieved with the current and projected ash dam sideslope geometry, the provision of buttresses and/or other possible remedial measures must be evaluated to bring the sideslope stability FoS (and Probability of Failure) to acceptable levels. The location, dimensions, material and construction specification for the buttresses and/or other remedial measures must be determined and indicated in a Microstation V8 CAD dgn file. The Risk of Ash Dam Failure without and with remedial measures must be evaluated. The acting as a buttress of the Dam 4 ash compartments must be evaluated to determine whether this will allow the existing ash dam to be raised safely.

VI. The ash dam side slope and final height geometry must be reassessed to determine whether on going ashing operations will create stability concerns or constraints on the existing ash dam complex. Both the Rate of Rise and the Stability of the existing ash dam complex must be considered to determine the maximum allowable remaining ash dam height.

VII. Verify whether the existing penstocks and ash deposition methods are sufficient for pool control on the existing and final height of the ash dams.

3.12 LIQUEFACTION ASSESSMENT

I. A narrative and tabular summary of the findings of the liquefaction evaluation and analysis.

II. A detailed discussion of the liquefaction evaluation.

III. Scope, extent and findings of the sub-surface investigations as related to the liquefaction potential evaluation conducted.

a. All reference documentation used during the assessment must be marked showing clearly their relation to the ash dam complex and the surrounding environment.

3.13 DAM BREACH ANALYSIS

I. Detailed simulation of breach hydrography and subsequent downstream inundation.

3.14 REPORTING

I. After completion of fieldworks and laboratory testing, the professional engineering geologist or geotechnical engineer is required to prepare and submit a consolidated geotechnical report based on the fieldworks conducted.

II. Factual information and interpretive results are to be clearly distinguished.

III. The geotechnical, stability and risk analysis report includes:

- Site Location.
- Site Description (this shall include: observed relief, vegetation, drainage, manmade features).
- Geological Setting;
    - Regional Geology,
    - Local Geology and Geo-hydrology;
        - All geo-hydrological information is to be sourced from the local municipality, adjacent mines and mining areas and through accepted published literary works,
    - Regional Geological Hazards,
- After completion of the LIDAR survey, the Professional Land Surveyor shall prepare and submit a consolidated Survey Report, which must include.
    - Microstation V8 CAD Drawings
    - 0.5m smoothed contours
    - Image and co-ordinate tile grid with file names
    - Survey area shape
    - Co-ordinate points in ASCII text files separated into ground and above ground files, for the total area in one file and also split into 1000m tiles.
    - All images.
- Surface and sub-surface conditions as determined by intrusive ground testing. This includes:
    - classification and description of all pertinent geotechnical properties

- any and all groundwater and process water intersection, quantification and source thereof,
- Mitigations of excess water and/or water management measures
- All DWS engagement related to water mitigation measures and/or contraventions
- All seepage areas present on the ash dam side slopes to be surveyed and indicated in a Microstation V8 CAD dgn file.

- Detailed results and discussions of all *in situ* and laboratory tests, classifications and stability of the existing structure
- Recommendations of maximum heights based on the stability of the existing ash facilities
- Recommendations of maximum ash dam heights and geometry, as well as other remedial and consequential works required, based on the Stability and Risk Assessment results.
- Recommendations for additional monitoring and controls in both the short term (before remedial works) and long term (after remedial works) must be proposed.
- All field data and laboratory results are to be included in the appendices

IV. The *Consultant's* design reviews will be supplemented with the Eskom Engineering governance procedures (240-53113685).

V. Formal progress reports shall be submitted in the form of:

- Weekly progress reports (electronic copies); 2 weekly progress meetings

VI. The priced proposal will include:

- Resource(s), rate and price for *Works* highlighted above including the provision of an updated schedule to be issued monthly to the *Employer*. This schedule identifies milestones outlining drilling progress and accompanying core logging, excavation of test pits and logging of soil profile, the execution of DPSH testing, As well as samples acquisition and testing.

4. AUTHORIZATION

This document has been seen and accepted by the development team and the Geotechnical Engineering CoE [Centre of Excellence] Manager.

- Alicia Simbudayal – Senior Engineering Geologist – Geotechnical Engineering CoE
- Andre Kreuiter – Chief Engineer – Geotechnical Engineering CoE
- Terrance Mavunda – CoE Manager, Geotechnical Engineering CoE

5. REVISIONS

Date	Rev.	Compiler	Remarks
February 2019	0.1	A Simbudayal	Draft document for review
February 2019	1.0	A Simbudayal	Final document for signature
June 2019	1.0	A Simbudayal	New document for only Stability assessment works as required by Kriel PS

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

- Alicia Simbudayal – Senior Engineering Geologist, Geotechnical Engineering
- Andre Kreuiter – Chief Engineer, Geotechnical Engineering

7. ACKNOWLEDGEMENTS

- Terrance Mavunda – CoE Manager, Geotechnical Engineering