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Nuclear 1 Seismic Hazard Peer Review

Report

Version – 2

11 February 2016

Gibb (Pty) Ltd.

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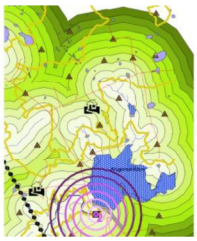


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EXECUTIVE SUMMARY

The CGS (2011) report is a competent compilation of data and current information from publications and other scientific reports, based on work carried out mainly by professionally capable personnel from the CGS. It is based mainly on sources other than those originating from the CGS. The Terms of Reference supplied for the Seismic Hazard Assessment provided by Arcus GIBB are very specific requirements of the specialist Seismic Hazard Assessment process. Competent descriptions of seismic hazard for the sites are provided and the cumulative risks are carefully considered.

GCS agree with the conclusions that the Seismic hazard assessment recommends each locality is suitable for the erection of a Nuclear Power Station. This is subject to a requirement for ongoing surveys to improve source characterisation; especially for offshore faults, where little or no geological information is available. More detailed surveys need to be carried out in these areas, because this additional information could alter the final conclusions reached in the report regarding the choice of site.

The overall evaluations of the CGS (2011) report in relation to the Terms of Reference for the specialist Geology Assessment are detailed in Table A. The assessment summary against the Terms of Reference as provided by GIBB is provided in Table B.

In summary: The CGS report (2011) represents a competent compilation. At the time of compilation, the product would have been improved through:

- The consideration and incorporation of relevant investigations and findings external to the CGS;
- The incorporation of inventories of activities performed, databases compiled and the synthesis thereof, which would have also facilitated enhanced review of the report versus the Terms of Reference;
- In order to position the sites for applications for ESP an update of the PSHA should be conducted in line with latest USNRC regulations such as NUREG 2115 during the NNR Nuclear Licensing Process; and
- Unambiguous and consistent characterisation of fault capability at the 3 site.

It is recommended that the above recommendations together with those made by the CGS (2011) should be pursued to substantiate the suitability of the proposed sites for the erection of Nuclear Power Stations.

In order to position the sites for applications for ESP, an update of the Probabilistic Seismic Hazard Analysis (PSHA) should be conducted in line with latest USNRC regulations such as NUREG 2115.

Table A: Terms of Reference provided to the CGS for the special Seismic Hazard Assessment on seismic hazards related to the construction of Nuclear Power Plants (CGS, 2011).

	Terms of Reference	Rating*	Comments
1	Describe the baseline conditions that exist in the study area and identify any sensitive areas that would need special consideration	3	Summary Provided. Authors refer to SRAFA, 2004.
2	Ensure that all issues and concerns and potential environmental impacts relevant to the specific specialist study are addressed and recommend the inclusion of any additional issues required in the Terms of Reference, based on professional expertise and experience. Also consider comments on the previous specialist studies undertaken for the NSIP undertaken during the 1980s-1990s	2	Site specific potential impacts are addressed but not those of the broader environment
3	Provide a brief outline of the approach used in the study. Assumptions, sources of information and the difficulties with predictive models must also be clearly stated	3	Done. Authors refer to SRAFA, 2004 where they are addressed.
4	Indicate the reliability of information used in the assessment, as well as any constraints/limitations applicable to the report (e.g. any areas of insufficient information or uncertainty);	2	No uncertainty results provided. The PSHA results are not provided.
5	Identify the potential sources of risk to the affected environment during construction, operational and decommissioning phases of the proposed project;	3	The risk is not explicitly quantified, but is stated as being the same throughout the project life.
6	Identify and list relevant legislative and permit requirements applicable to the potential impacts of the proposed project;	2	Local regulations and guidelines are not cited in the report while relevant international guidelines applicable at the time of writing are cited. To date these regulations have been extensively revised
7	Include an assessment of the "no go" alternative and identified feasible alternatives	2	Alternatives for the 'no go' option are not clearly stated
8	Assess and evaluate potential direct and indirect impacts during construction operational and decommissioning phases of the proposed project	3	Addressed adequately in Section 4 of the Report
9	Identify and assess any cumulative effects arising from the proposed project;	3	Addressed
10	Undertake field surveys, as appropriate to the requirements of the particular specialist study	2	It is not clear if this was done for this report. However, earlier field surveys and studies undertaken are cited
11	Identify areas where impacts could combine or interact with impacts likely to be covered by other specialists, resulting in aggravated or enhanced impacts and assess potential effects	2	Incomplete. There is no access to other specialist sections of the study
12	Apply the precautionary principle in the assessment of impacts, in particular where there is major uncertainty, low levels of confidence in predictions and poor data or information	3	This has been applied and current best practice and use of international standards where local information is lacking

13	Determine the significance of assessed impacts according to a Convention for Assigning Significance Ratings to Impacts;	2	It is done, but requires better justification in some cases
14	Recommend practicable mitigation measures to minimise or eliminate negative impacts, enhance potential project benefits or to protect public and individual rights to compensation and indicate how these can be implemented in the final design, construction, operation and decommissioning of the proposed project	2	Incomplete. It does not address public and private rights to compensation during the various stages of the proposed project
15	Provide a revised significance rating of assessed impacts after the implementation of mitigation measures	3	Done
16	Identify ways to ensure that recommended mitigation measures would be implemented, as appropriate	3	Done
17	Recommend an appropriate monitoring and review programme in order to track the effectiveness of proposed mitigation measures	3	Done
*	1 = low (not or hardly addressed), 2 = medium (partially addressed or information may be present but is not provided in the document), 3 = high (fulfilled)		

Table B: Assessment of "Terms of Reference" as provided by GIBB

	Terms of Reference	Rating*	Comments
1	Fulfilment of Terms of Reference	3	
2	Report Objectivity	2	Should state explicitly in sections where further investigation is required
3	Technical, Scientific and Professional credibility	2	Poor justification in some instances especially in the addressing of impacts inadequate
4	Defensibility of methodology and study approach	2	Should adapt to current methodologies/approach quantify uncertainties
5	Information gaps, omissions or errors	3	Clearly addressed
6	Sensibility of recommendations and presentation of best options	3	Could include more maps and figures or at least refer to the maps that would exist in other sections of the EIA
7	Alternative viewpoints, presentation and clarity of statement	2	
8	Accessibility of style of report to non-specialists	3	The reader would need some geological background
9	Meeting of normal standards of professional practice and competence	3	
*	1 = low, 2 = medium, 3 = high		

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1 INTRODUCTION

GCS Water and Environment (Pty) Ltd. (GCS) was appointed by Gibb (Pty) Ltd. to conduct a peer review of the Seismic Hazard Environmental Impact Report compiled by the Council for Geoscience (2011) based on the EIA for a proposed Nuclear Power Station project. The project sites are located at Thyspunt in the Eastern Cape Province and at Bantamsklip and Duynefontein in the Western Cape Province of South Africa.

The review of this particular report was sub-contracted by GCS to Dr Mulemwa Akombelwa, and this review report contains the findings of the expert review.

1.1 Background

This study provides a summary of findings of the Nuclear Siting Investigation Programme (NSIP) program as conducted by the CGS. It is accompanied by a reference list and an additional summary of the Probabilistic Seismic Hazard Analysis (PSHA) findings. The methodology for computation of PSHA parameters applied (Parametric-Historic procedure) is widely accepted and recommended in the USNRC guidelines of 2012 (NUREG 2115). The ground shaking hazard from earthquakes represents the most serious geological hazard impacting on the design of a new Nuclear Power Station site. Mitigation for this hazard requires use of a very low probability of exceedance when determining the ground motions for establishing the design basis of the power plant (CGS, 2011).

As in the case of other nuclear power plants around the world investigations, studies and seismic monitoring were conducted by the CGS to ensure regular updates to the seismic hazard. The methodologies used to perform PSHA are continually evolving and the most up to date, accepted methodology (according to USNRC and IAEA) needs to be used in each of the PSHA updates.

This study by GCS was concluded in March 2011 and at the time, the Nuclear guidelines provided many general statements and objectives and some case studies on how to conduct a PSHA analysis. In 2012, the USNRC published NUREG 2115 which provided detailed guidelines and case studies of seismic source characterisation. These guidelines replaced some older guidelines and is applicable for vendors applying for ESPs and COLAs. Of particular importance is that these guidelines are derived for the CEUS region and would be most applicable to South Africas' stable continental environment. In light of this, the authors of the EIA would need to check the consistency of the PSHA with these guide lines.

When considering the NUREG guidelines it is evident that the potential fault sources mentioned for the three sites can also be handled in other ways – by making assumptions on its fault capability, weighting according to importance etc. and then quantitatively incorporating these sources into the PSHA. In this study, in many cases, the fault capability has generally been assessed qualitatively and discarded. New evidence of fault sources should be incorporated into the PSHA.

The SHA undertaken to date has determined the PGAs on hard rock of 0.16g, 0.23g and 0.30g for the Thyspunt, Bantamsklip and Duynefontein sites, respectively. These are deterministically assessed values and no PSHA results are provided.

The report titled "Environmental Impact Assessment for a Proposed Nuclear Power Station (Nuclear-1) and Associated Infrastructure - Seismic Hazard Environmental Impact Report" is a specialist compilation of the geology, structural geology, tectonic data, geophysical input and environmental considerations, aimed at assessing the suitability of three potential sites along the southern African coastline for the erection of Nuclear Power Stations. This compilation required a sound understanding of the geology of the entire Cape Fold Belt, as well as offshore information gained from geophysical surveys. In its broadest context the report embraces palaeo-seismic investigations especially neotectonic activity associated with the Ceres-Kango-Baviaanskloof_Coega Fault system and coastal warping. The report not only includes information related to risk factors associated with fault activity (guided by Nuclear Regulatory Code and Regulations), but also incorporates other geological risk factors pertinent to surface/near surface deformation and the effect these could have on the assessment.

It is noted that the CGS (2011) report, based on the references cited therein, was compiled during 2009 and completed in 2010. Since then, significant developments have occurred which would have impacted on the report. Therefore, the assessment has been carried out considering only literature that was available up to the time of completion of the report. However, attention has been drawn to areas were further investigations are suggested in the light of more recent developments.

2 SCOPE OF WORK PROVIDED BY GIBB

The scope of work for the seismic hazard peer review study is as follows:

- Assess the document/ report in terms of its fulfilment of its Terms of Reference set;
- Consider whether the report is entirely objective;
- Consider whether the report is technically, scientifically and professionally credible;
- Consider whether the method and the study approach are defensible;
- Identify whether there are any information gaps, omissions or errors;

- Consider whether the recommendations presented are sensible and present the best options;
- Consider whether there are alternative viewpoints around issues presented in the report and if these are clearly stated;
- Consider whether the style of the report is written so as to make it accessible to non-specialists, technical jargon is explained and impacts are described using comparative analogies where necessary; and
- Report on whether normal standards of professional practice and competence have been met.

3 REVIEWED DOCUMENT

The reviewed document is a Seismic Hazard Environmental Impact Report compiled by the Council for Geoscience, March, 2011. The document is titled "Environmental Impact Assessment for the Proposed Nuclear Power Station ("Nuclear-1") and Associated Infrastructure".

3.1 Fulfilment of Terms of Reference

In the report the Terms of Reference, as set out on page 3 (CGS, 2011) include the description of baseline conditions for the study area, analysis and synthesis thereof, and the assessment of relevant seismic hazard for the three (3) potential sites. Information used in the report is reliable and documented from mostly published data, predominantly in-house reports of the CGS. In this respect, literature other than that originating from the CGS is underrepresented. Where information is lacking this has been pointed out in the report. Recommendations are made for future investigations in areas where information is lacking, or incomplete.

The authors of the report have opted for the more general approach in the presentation of the report. In the absence of an inventory of activities and data e.g. maps, air photos, satellite images, geophysical data, it is difficult to ascertain with certainty whether the specific terms related to data collection have been met.

The overall assessment of the report against the "Terms of Reference for the specialist Seismic Hazard Assessments" is detailed in Table 1.

Table 1: Terms of Reference provided to the CGS for the special Seismic Hazard Assessment on seismic hazards related to the construction of Nuclear Power Plants (CGS, 2011).

	Terms of Reference	Rating*	Comments

1	Describe the baseline conditions that exist in the study area and identify any sensitive areas that would need special consideration	3	Summary Provided. Authors refer to SRAFA, 2004
2	Ensure that all issues and concerns and potential environmental impacts relevant to the specific specialist study are addressed and recommend the inclusion of any additional issues required in the Terms of Reference, based on professional expertise and experience. Also consider comments on the previous specialist studies undertaken for the NSIP undertaken during the 1980s-1990s	2	Site specific potential impacts are addressed but not those of the broader environment
3	Provide a brief outline of the approach used in the study. Assumptions, sources of information and the difficulties with predictive models must also be clearly stated	3	Done. Authors refer to SRAFA, 2004 where they are addressed.
4	Indicate the reliability of information used in the assessment, as well as any constraints/limitations applicable to the report (e.g. any areas of insufficient information or uncertainty);	2	No uncertainty results and PSHA or SSHAC results are provided
5	Identify the potential sources of risk to the affected environment during construction, operational and decommissioning phases of the proposed project;	3	The risk is not explicitly quantified, but is stated as being the same throughout the project life.
6	Identify and list relevant legislative and permit requirements applicable to the potential impacts of the proposed project;	2	Local regulations and guidelines are not cited in the report
7	Include an assessment of the "no go" alternative and identified feasible alternatives	2	Alternatives for the 'no go' option are not clearly stated
8	Assess and evaluate potential direct and indirect impacts during construction operational and decommissioning phases of the proposed project	3	Addressed adequately in Section 4 of the Report
9	Identify and assess any cumulative effects arising from the proposed project;	3	Addressed
10	Undertake field surveys, as appropriate to the requirements of the particular specialist study	2	It is not clear if this was done for this report. However, earlier field surveys and studies undertaken are cited
11	Identify areas where impacts could combine or interact with impacts likely to be covered by other specialists, resulting in aggravated or enhanced impacts and assess potential effects	2	Incomplete. There is no access to other specialist sections of the study
12	Apply the precautionary principle in the assessment of impacts, in particular where there is major uncertainty, low levels of confidence in predictions and poor data or information	3	This has been applied and current best practice and use of international standards where local information is lacking
13	Determine the significance of assessed impacts according to a Convention for Assigning Significance Ratings to Impacts;	2	It is done, but requires better justification in some cases
14	Recommend practicable mitigation measures to minimise or eliminate negative impacts, enhance potential project benefits or to protect public and individual rights to compensation and indicate how these can be implemented in the final design, construction, operation and decommissioning of the proposed project	2	Incomplete. It does not address public and private rights to compensation during the various stages of the proposed project
15	Provide a revised significance rating of assessed impacts after the implementation of mitigation measures	3	Done
16	Identify ways to ensure that recommended mitigation measures would be	3	Done

	implemented, as appropriate		
17	Recommend an appropriate monitoring and review programme in order to track the effectiveness of proposed mitigation measures	3	Done
*	1 = low (not or hardly addressed), 2 = medium (partially addressed or information may be present but is not provided in the document), 3 = high (fulfilled)		

3.2 Report Objectivity

The CGS (2011) report is deemed as an objective assessment of facts, inferences and interpretations of data relating to the assessment of seismic hazard at each of the three potential sites which will ultimately influence the choice for the establishment of one or more Nuclear Power Stations.

The systematic collection of field data using conventional methods, adequate compilation of the results and conveyance of this information indicates that objectivity was adhered to in this report. It is assumed that this compiled information is available but has not been documented in the report.

It must be noted, however, that the seismic sources described have much uncertainty and require further investigation as stated in the report – *yet the authors in CGS (2011) then go on to state that there are NO disqualifiers for the sites. This is quite inconsistent*.

3.3 Technical, Scientific and Professional Credibility

The compilation, presentation and interpretation of the seismic hazard pertinent to the three proposed sites is assumed to have been done by experts associated with the CGS in the areas of geology and geophysics reliant on the most knowledgeable personnel in their various disciplines. The combined experience of the experts lends adequate scientific credibility to the report, and therefore allows the report to be deemed reliable and trustworthy.

The seismic hazard at each of the proposed sites i.e. Thyspunt, Bantamsklip and Duynefontein, was individually evaluated, taking into account various available information sources about the nearest capable major and lesser fault systems which could cause ground movement, with consequent damaging environmental impacts at the sites. However, for a study of this nature, it would have been better to quantify the uncertainties associated with the risk hazard.

3.4 Defensibility of Methodology and Study Approach

The CGS has decades of experience in regional and local mapping and geophysical investigations. It is therefore deduced that the methodologies employed by the investigating team, in carrying out this study, are reliable, tried and tested methods, involving relevant fieldwork techniques and appropriate interpretation of the results. The study approach, guided by the US Regulations for Seismic Hazard Analysis and the South African National Environmental Management Act, is therefore appropriately and adequately carried out.

The value cited for the PGA for each site is a deterministically assessed value. The methodology used for the PSHA calculation (Parametric- Historic Procedure) is acceptable as cited in the NUREG 2115 guidelines. The authors mention in the glossary that this methodology (Parametric- Historic Procedure) is no longer in use by the CGS. The Parametric-Historic Procedures relevant to assessing earthquake recurrence parameters can certainly be incorporated into the Cornell –McGuire framework (NUREG 2117).

3.5 Information Gaps, Omissions or Errors

Data collection from extensive fieldwork from previous studies and competent compilation of data has shown that gaps in information exist, notably the limited coverage of the wider literature. The authors of the report however draw attention to the fact that ongoing investigations are being conducted to assign ranges of slip rates to known faults. Further they add that the data in the instrumental and historical catalogues is also being reappraised, and these catalogues will subsequently be used to define activity rates in broad area sources of floating earthquakes that account for seismicity not directly linked to these faults. Advanced studies are being carried out to determine a set of appropriate GMPEs, using inversions of weak-motion data, stochastic simulations, and selection and ranking tools based on maximum-likelihood and information-theory approaches (CGS, 2011).

As is standard with other nuclear power plants around the world, continued investigations into the seismo-tectonic settings of the three sites is ongoing with the intent of reconfirming the hazard levels at regular intervals using the latest data and SHA methodologies. Such technical information and data is needed for better identification and assessment of the impact of seismic risk at the proposed sites. In this study, the fault capability has generally been assessed qualitatively and discarded. New evidence of fault sources should be incorporated into the SHA according to the updated regulatory guidelines.

Errors in the report are minor, typographic and grammatical in nature. These errors, however, do not detract from the essential content of the report.

3.6 Sensibility of Recommendations and Presentation of Best Options

The overall recommendation is that all three sites are suitable for the erection of a Nuclear Power Station. This recommendation is based on a thorough understanding of the geological impacts related to the proposed development and may involve site-specific hazards such as soil conditions, erosion, fault rupture and ground shaking during earthquakes.

Since the effects of the site-specific geology on the level of ground-motion are explicitly included in the seismic hazard calculations to assess vibratory ground motion levels used in the definition of the design parameters, no additional consideration of a cumulative impact is required, other than the consideration of secondary hazards such as fault rupture, liquefaction and slope stability which together play an important role in deciding the suitability of the establishment of Nuclear Power Stations. All three sites have a large number of faults transecting the local bedrock but they are classified as 'not capable' hence posing minimum risk to the construction and operation of a nuclear station.

The authors of the CGS (2011) report point out the scarcity of offshore geophysical data and suggest that ongoing data collection is required, especially from geophysical surveys. This is important to note as it will provide a clearer understanding of the seismic hazard with time.

The recommendations presented in the report are sensible with appropriate options.

3.7 Alternative Viewpoints, Presentation and Clarity of Statement

Alternative viewpoints are not many, because the geology of the three sites is relatively well understood. However, not all aspects of viewpoints in this report are clearly set out, and ambiguous statements need to be revised or removed altogether in the report. An example is the recommendation for the 'no-go' alternative in section 4 of the report which is rather ambiguous.

The statements for the qualification of the sites for construction of the nuclear stations in section 3 may need to be revisited after applying the latest USNSRC guidelines for SHA. For instance the qualifier statement for Duynefontein in Section 3.1.3 is based on a study carried out in 1976 by Dames and Moore. Ongoing research should provide better information for the site.

Since the authors have recognised and accepted the need to have ongoing geophysical surveys at the three sites, it would be useful to consider using latest best practice in line with the latest USNRC guidelines such as NUREG 2117 and other recent publications such as Midzi et al. (2013); Vilanova et al. (2014); Saunders et al. (2008); Singh et al. (2009, 2014).

3.8 Accessibility of Style of Report to Non-Specialists

The style of the report is biased towards people with a geological background. Whoever reads the report should have some fundamental knowledge of how geological processes work and the assessment of the seismic hazard is performed. This is because major decisions about suitability of Nuclear Power Station sites are decided largely on the understanding of what these aspects of the science are about.

The report is written in a style accessible to non-professionals, although they will need some assistance in getting to grips with the technical terms. Helpful to the reader, in this respect, are the “List of Abbreviations” and "Glossary of Terms” related to technical terms used in the text (provided on page (viii) of the report).

The report is set out in an easily readable style, with appropriate headings and sub-headings. The clarity and user friendliness of the report could be improved through professional editing.

3.9 Meeting of Normal Standards of Professional Practice and Competence

The CGS (2011) report meets the normal standards of professional practice. This suggests that since the norms have been met, the competence in carrying out fieldwork, compilation and presentation of data is sound - within the context of the lack of other literature sources and inventories referred to earlier. The report has been compiled taking into account the local regulatory guidelines as well as the US regulatory guidelines and is set out according to the norms and standards of professional best practice.

4 SUMMARY AND CONCLUSIONS

The CGS (2011) report is a competent compilation of data and current information from publications and other scientific reports, based on work carried out mainly by professionally capable personnel from the CGS. It is based mainly on sources other than those originating from the CGS. The Terms of Reference supplied for the Seismic Hazard Assessment provided by Arcus GIBB are very specific requirements of the specialist Seismic Hazard Assessment process. Competent descriptions of seismic hazard for the sites are provided and the cumulative risks are carefully considered.

GCS is in agreement with the conclusions reached that the Seismic hazard at each locality is suitable for the erection of a Nuclear Power Station. This is subject to the important recommendation to conduct ongoing surveys for improved source characterisation especially for offshore faults, where little or no geological information is available. More detailed surveys need to be carried out in these areas, because this new information could alter the conclusions reached in the report regarding the choice of site.

The overall evaluations of the CGS (2011) report against the Terms of Reference for the specialist Seismic Hazard Assessment are detailed in Table 1. The assessment summary against the "Terms of Reference" as provided by GIBB is provided in Table 2.

Table 2: Summary of peer review as provided by GIBB

	Terms of Reference	Rating*	Comments
1	Fulfilment of Terms of Reference	3	
2	Report Objectivity	2	Should state explicitly in sections where further investigation is required
3	Technical, Scientific and Professional credibility	2	Poor justifications - addressing of impacts inadequate
4	Defensibility of methodology and study approach	2	Should adapt to current methodologies/approach quantify uncertainties
5	Information gaps, omissions or errors	3	Clearly addressed
6	Sensibility of recommendations and presentation of best options	3	Could include more maps and figures
7	Alternative viewpoints, presentation and clarity of statement	2	
8	Accessibility of style of report to non-specialists	3	You need some geological background
9	Meeting of normal standards of professional practice and competence	3	
*	1 = low, 2 = medium, 3 = high		

In summary: The CGS report (2011) represents a competent compilation. At the time of compilation, the product would have been improved through:

- The consideration and incorporation of relevant investigations and findings external to the CGS;
- The incorporation of inventories of activities performed, databases compiled and the synthesis thereof, which would have also facilitated enhanced review of the report versus the Terms of Reference;
- In order to position the sites for applications for ESP an update of the PSHA should be conducted in line with latest USNRC regulations such as NUREG 2115 during the NNR Nuclear Licensing Process; and

- Unambiguous and consistent characterisation of fault capability at the 3 sites (See Section 3.2 above).

It is recommended that the above, and the recommendations made by the CGS (2011) should be pursued to substantiate the suitability of the proposed sites for the erection of Nuclear Power Stations.

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