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Attention: [redacted]
Specialist Zoologist, Biological Assessments
State Agreements and Approvals

Rio Tinto
Central Park
152-158 St George's Terrance
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Peer Review of Subterranean Fauna Habitat Assessment and Modelling Memorandum (Biologic Environmental Survey 2020)

Dear [redacted]

As discussed, the purpose of this letter is to provide a peer review of the Subterranean Fauna Habitat Assessment and Modelling Memorandum (Biologic 2020) (the Memorandum). This includes an evaluation of the Memorandum's appendices:

- Appendix A — Drill logging code combinations used for the 2019 Paraburdoo subterranean habitat modelling (categorisations updated 2020).
- Appendix B — Habitat Modelling Workflow Process (Seequent Expert Services).

The reason for the peer review came from the joint decision made by the Environmental Protection Authority (EPA), Department of Parks and Wildlife (DPAW), Rio Tinto Iron Ore (Rio Tinto), and Biologic Environmental Survey Pty Ltd (Biologic), that "if the subterranean fauna habitat modelling method proposed is intended to be used for future assessments, it should be peer-reviewed, and a report provided to the EPA detailing the methods and data used". The Memorandum constitutes the report detailing the methods and data used in the development of the three-dimensional (3D) subterranean fauna habitat model.

Yours sincerely

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1. Introduction

Rio Tinto and Biologic have developed an approach to create 3D subterranean fauna habitat models to better understand and quantify the potential and accumulated impacts to subterranean fauna values posed by proposed mining developments within Rio Tinto's Project Hubs.

The 3D habitat modelling approach was incorporated in the Greater Paraburdoo subterranean fauna assessment (Biologic 2019) as part of the environmental assessment of the Greater Paraburdoo Iron Ore Hub Proposal (Assessment No. 2189, EPBC 2018/8341). The initial advice received by Rio Tinto from the EPA was that "*the use of a habitat prospectivity model for subterranean fauna habitats should be considered experimental as it has not been tested against all the habitat categories or regional data*".

As a result of the advice received, the main objectives of this peer review of the Memorandum are to assess if the approach outlined provides a sound basis for:

1. A credible and reasonable geological / hydrogeological representation of the three-dimensional extent of the potential subterranean fauna habitat present within the limits of available data?
2. Development of subterranean fauna habitat models across different geological / hydrogeological settings throughout RTIO's project hub areas, based on the available local data?
3. Assessment of the suitability, extent, and connectivity of subterranean fauna habitats above and below the water table?
4. Understanding and visualising habitat extent and connectivity to make reasonable inferences regarding the distribution of collected subterranean species?
5. Making reasonable predictions of the potential wider distribution of subterranean fauna species recorded from a single individual or only known from a single location?
6. Assessment of the likely impacts or risks arising from proposed mining development scenarios on subterranean fauna species and habitats, within the limits of available data and information?"

2. Categorisation of Surface Geology (2D)

An important criteria of a robust subterranean fauna assessment is to ensure that survey results are presented and discussed in the context of the habitat (both above (AWT) and below (BWT) the water table) present within and surrounding the study area. The relationship of the subterranean fauna values to the geological, hydrological, and hydrogeological setting/s hosting the potential subterranean habitat, within and surrounding a study area constitutes the central narrative of an environmental impact assessment (EIA). In the absence of 3D modelling (as presented below in Section 4 and 5 of the memorandum), the lateral and vertical extents of AWT and BWT habitat/s present are inferred from an assessment of data available, including geological units present, groundwater parameters, and survey results. The inferred extent of AWT and BWT subterranean fauna habitat/s (inferred 3D habitat) is the standard approach used in stygofauna and troglofauna EIA. It is important that the inferred 3D habitat extends beyond the proposed impact area/s to provide a broader environmental context within in which a Project occurs.

The Memorandum clearly outlines a three-layered process to develop subterranean fauna habitat assessments and 3D models. The first layer of this framework, *Categorisation of Surface Geology (2D)* (Section 3 of the Memorandum), does not constitute the full approach required to provide a thorough enough context within which the merits of the 3D habitat modelling framework layers can be better realised. As well explained in the Memorandum, the modelled 3D habitats can be constrained to a relatively confined area that may not extend far beyond the main areas of the proposed development. The 3D models can provide a more accurate understanding of the extent of habitat present in and around the immediate development area/s where there is a greater density of drill hole data, but are constrained by limitations in drilling data that can be sparse or patchy outside of the main resource area/s. It is in the areas where drill hole data is too limited (greater than 300 m between drill holes) for 3D modelling to occur that inferred 3D habitat can be used. Therefore, it is fundamental that the approach of the first assessment layer is expanded to infer the 3D extent of habitat to establish a better understanding of the broader continuity of the subterranean habitat in association with and surrounding the more confined modelled areas; i.e. connect the 3D model to the surrounding environment.

In an expanded first layer of the framework, the inferred 3D extent of AWT and BWT habitat could be developed using 2D mapping of surface (regolith) (e.g. Section 3 of the Memorandum, Figures 1 to 3) and sub-surface (bedrock) geology, incorporating drainage lines and known geological structures (e.g. faults, fracture and shear zones, dykes), incorporated with figures of geological profiles depicting examples of stratigraphic interpretations present based on logged drill hole lithologies and diamond drill core assessments. Further assessment of an inferred 3D habitat concept should incorporate information on finer scale geological attributes (e.g. secondary porosity, or lack thereof) from a selection of relevant diamond drill cores and/or logged drill hole data, and groundwater parameters (e.g. standing water levels (SWL), groundwater quality, particularly salinity, pH and dissolved oxygen (DO)). It would be within this broader extent of inferred 3D habitat that the second and third modelled layers of the habitat assessment framework would be set.

In Section 3 of the Memorandum the discussion and Tables 3-1 and 3-2 provide a logical approach to an example of categorising habitat suitability based on the generalised physical characteristics of the geological/ hydrogeological units and evidence from subterranean fauna studies. However, the intermediate habitat suitability categories, *Low-Medium* and *Medium-High* should be amalgamated with *Low* and *Medium*, respectively, as determining between *Low* and *Low-Medium*, and between *Medium* and *Medium-High* is not considered to be reliably feasible.

3. 3D Stratigraphic/ Hydrostratigraphic Habitat Modelling

Section 4 of the Memorandum outlines well the process and considerations involved in the development of the 3D *Stratigraphic/ Hydrostratigraphic Habitat Modelling* (stratigraphic modelling), the second layer of the habitat assessment framework. The 3D stratigraphic habitat model is derived from the 3D Regional model that are constructed by Rio Tinto to provide a representation of the main stratigraphic units, hydrostratigraphic formations, and relevant geological structures (e.g. faults, dykes) throughout a development hub. The data used to develop the Regional models is derived from logged drilling data, surface intercepts, and geological/ hydrogeological studies.

The 3D stratigraphic modelling assigns a habitat suitability category (e.g. High, Medium, Low) to the stratigraphic units included in the Regional model. The assignment of habitat suitability categories follows the same principles and logic as applied for inferred 3D habitat extents with generalised suitability based on the physical characteristics of the geological/ hydrogeological units and evidence from subterranean fauna studies.

Similar stratigraphic 3D subterranean fauna habitat models have been used previously in EIA of resource developments. Models of habitat extent were developed for both the Lake Way and Lake Maitland calcrete systems as part of an EIA for a subsequently approved project (MWH 2016). The 3D model was developed using a similar approach to that described for the creation of 3D stratigraphic habitat models from Regional models. The recorded calcrete stratigraphy was interpolated among drill holes as well as extrapolated to varying degrees in combination with data derived from Geological Survey of Western Australia (GSWA) resources (**Figure 1**). The calcrete geological unit constituted the 'High' value habitat category, a designation that is the result of been well supported by many subterranean fauna research studies and EIA consulting projects. The stratigraphic units not considered to host viable subterranean fauna habitat were excluded from the model.

The 3D stratigraphic modelling is considered to provide a more reliable means to convey an effective visual understanding of the nature of potentially suitable subterranean fauna habitat present than is possible from inferred 3D habitat extents alone. The figured hypothetical example shown in Section 4 clearly demonstrates the useful potential of this.

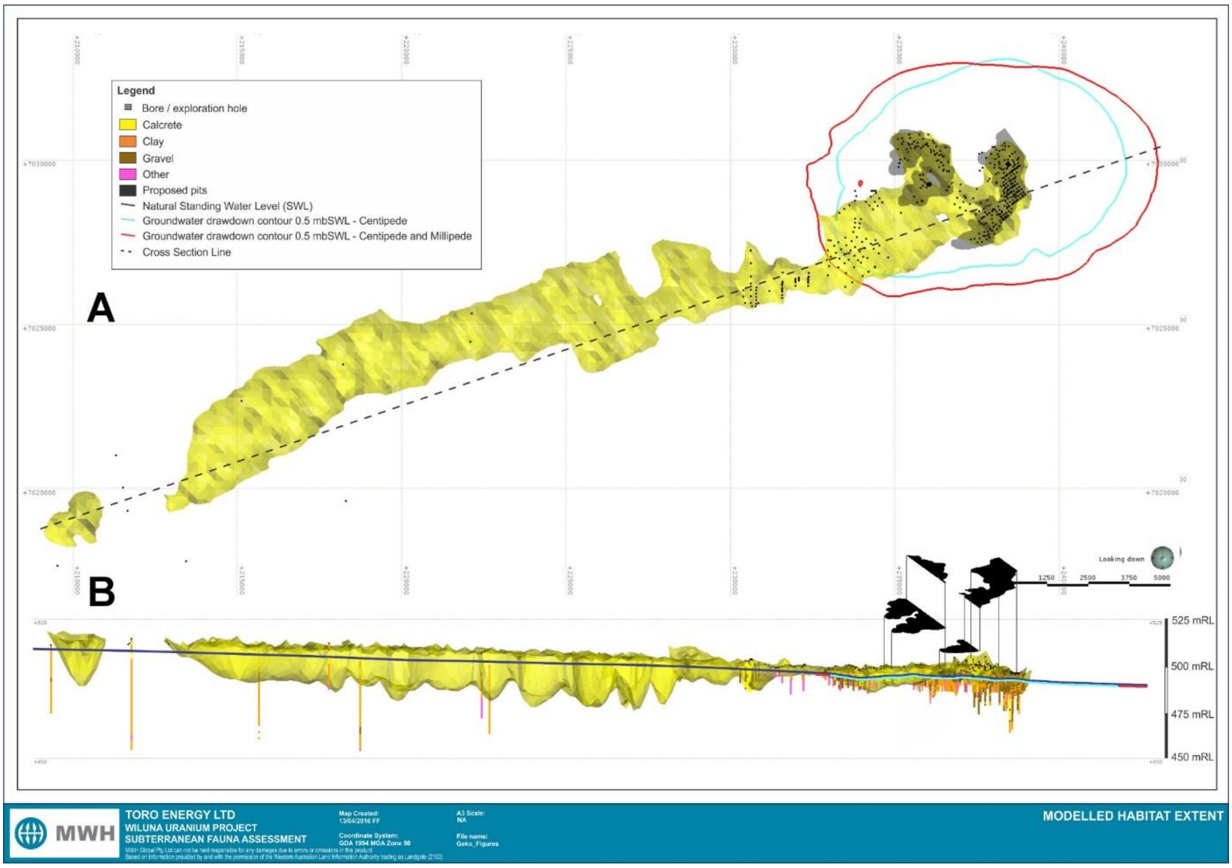

Figure 1: Example of stratigraphic 3D habitat modelling using a similar approach as outlined in Section 4 of the Memorandum. The figure shows the extent of modelled 'calcrete' habitat associated with the Hinkler Well calcrete system: A) Plan view; B) Lateral view, looking north (Figure A-3 from MWH 2016).

4. 3D Habitat Modelling From Drill Hole Information

Section 5 of the Memorandum outlines well the process and considerations involved in the development of the 3D *Habitat Modelling from Drill Hole Information* (detailed habitat modelling), the third and more innovative layer of the habitat assessment framework. The 3D detailed habitat modelling goes a step further than stratigraphic modelling. Instead of categorising an entire stratigraphic unit as 'High' or 'Low' habitat suitability, the individual logged drill hole data is assessed at a finer scale resulting in a more detailed assessment of the likely habitat present.

The logged lithological drill hole data codes the rock type to indicate the stratigraphic unit (strand) and the physical structure and mineralisation characteristics (tag) present. The 3D drill hole modelling uses both the strand and tag data to assess and categorise drill log codes for subterranean fauna habitat suitability. The logic and principles used in assessing the strand and tag data and ascribing a habitat suitability category (High, Medium, Low, or Uncertain) are similar as for inferred 3D habitat suitability, involving the degree of secondary porosity present as well as any relevant subterranean fauna records if available.

The figured results of the 3D detailed habitat modelling provided in the Memorandum do illustrate well the extent and nature of the habitat structure within the modelled area. It is agreed that the detailed modelling method does provide an accurate assessment of the extent, thickness, and connectivity of the Medium to High suitable habitats. It would be valuable to see at least one representation of the 3D detailed habitat with Low suitable habitats included. This may show if the more suitable habitats are bounded by less favourable habitat conditions and give an indication of how potentially isolated the modelled habitat extent is from the surrounding region.

The review of the drill logging strand and tag code combinations used for the 2019 Paraburdoo subterranean habitat modelling (Appendix A of the Memorandum) revealed the extensive and intensive work involved. There are 698 logging codes (Strand: Tag combinations) based on the strand and tag descriptions. The number of logging codes per habitat category were: High (120), Medium (256), Low (205), Uncertain (109), Ommitted (8). An assessment of the combinations used made logical sense except for one set, as per below.

Habitat category	Logging Code (S; T)	Strand Description	Tag Description
Medium	F; <F>	<F> - Fault	Fault
Uncertain	<F>; <F>	Fault	Fault

The methods as laid out in Section 5 and the Sequent Habitat Modelling Workflow Process Document (Appendix 2 of the Memorandum) appear to a modelling novice's eye to provide a thorough and consistently repeatable process to develop 3D habitat models.

5. Impact Assessment

Section 6 of the Memorandum outlines well the approach, considerations, and potential benefits that both stratigraphic and detailed modelled 3D habitats can bring to the impact assessment process. Benefits include the ability for direct impacts of habitat removal to be modelled and incorporated with the modelled habitat, along with taxon distributions. Additional benefits include the ability for multiple impact scenarios to be modelled to reflect the progressive staged development of a project from pre-mining through to post-mining.

The 3D habitat impact models incorporating the impact scenarios can provide a more accurate quantitative assessment of the volume of habitat removed and remaining in the modelled extent area. The remaining habitat can also be visually assessed to gain greater insight into the degree of fragmentation that may occur as the development progresses.

6. Validation of Habitat Assessment

The validation of habitat assessments with subterranean fauna records is important regardless of whether the 3D habitat is inferred or modelled. Subterranean fauna records from in and surrounding the area of assessment from current and previous studies as well as from the broader literature can provide further insight into habitat assessments. This can form an important iterative process whereby the recorded diversity may influence the designated habitat category, e.g. high diversity recorded from habitat categorised as Low or Uncertain prospectivity (Biologic 2018). This iterative process is inherent in the logic and principles used in categorising habitat suitability based on the characteristics of the geological/ hydrogeological units present and evidence from subterranean fauna studies.

7. Visual Clarity: Viewer Versus Reader

The use of three-dimensional (3D) modelling in studying ecological systems has increased with the advancement of accessible computing power and software packages. The enhancements to gaining a better understanding of ecosystems, whether marine, freshwater, or terrestrial using numerous combinations/inputs of field derived quantitative and qualitative data inputted into 3D modelling are significant compared to the more conventional use inferring the 3D environment through two dimension (2D) mapping and profile schematic diagrams.

One of the many benefits of developing a 3D model of an ecosystem is the creation of a highly visual interactive computer file product / video that enables viewers to 'fly' through the model to gain an enhanced appreciation of the system from many different angles and zoom extents. Interactive 3D models also allow a fourth dimension to be incorporated, time. Temporal data can be added that incorporates short or long term processes such as typical or atypical seasonal affects, anthropogenic influences (e.g. pastoral practices or resource development), and geological processes (e.g. Model faulted and deformed geology from drillhole data @ https://www.youtube.com/watch?v=DMkKWm8AidE).

Much of the effectiveness of the high visual clarity of 3D model videos or interactive files is unfortunately lost when presented on paper in a strictly 2D non-interactive medium. The loss in translation of the visual clarity is greatly compounded when dealing with complex and/or extensive systems, making it difficult for authors to present on paper, and for readers to interpret, information that was developed for viewers in an interactive 3D environment. The loss of visual clarity from an interactive 3D environment to a paper media may be limited by creating clearer schematic representations of the imported 3D habitat model images. It may be warranted to also provide a version of Leapfrog file or a 'fly through' video of the 3D modelled habitats along with the subterranean fauna reports as part of the EIA process.

8. Approach Assessment

Does the approach outlined in the Memorandum provide a sound basis for:

1. A credible and reasonable geological / hydrogeological representation of the three-dimensional extent of the potential subterranean fauna habitat present within the limits of available data?

The 3D modelling process does enable a reliable representation of the 3D habitat extent to be developed within the modelled extent.

2. Development of subterranean fauna habitat models across different geological / hydrogeological settings throughout RTIO's project hub areas, based on the available local data?

The approach used could be applied to any area as long as sufficient drill log data was available. The logging codes (Strand: Tag combinations) would need to be evaluated in the local context for which the 3D model was to be developed.

3. Assessment of the suitability, extent, and connectivity of subterranean fauna habitats above and below the water table?

The 3D modelled habitats can provide an accurate and precise visualisation of the AWT and BWT subterranean habitat extents, thickness, and connectivity. Geological structures and groundwater attributes can also be incorporated into the model to further enhance the understanding of the habitat.

4. Understanding and visualising habitat extent and connectivity to make reasonable inferences regarding the distribution of collected subterranean species?

The 3D modelled habitats can provide an accurate and precise visualisation of subterranean habitat extents, thickness, and connectivity. This would enable reasonable inferences to be made of the distributions of recorded subterranean fauna species. The use other lines of evidence can be considered to support distribution predictions such as distribution trends of other taxa recorded in the area/assemblage, and/or of closely related taxa.

5. Making reasonable predictions of the potential wider distribution of subterranean fauna species recorded from a single individual or only known from a single location?

The 3D modelled habitats can provide an accurate and precise visualisation of subterranean habitat extents, thickness, and connectivity. This would enable reasonable predictions to be made of the potential wider distributions of subterranean fauna species known only from limited locations. However, it is important to also use other lines of evidence to support possible broader distributions such as distribution trends of other taxa recorded in the area/assemblage, and/or of closely related taxa.

6. Assessment of the likely impacts or risks arising from proposed mining development scenarios on subterranean fauna species and habitats, within the limits of available data and information?

One of the main strengths of the 3D modelling is the ability for direct impacts of habitat removal to be modelled and incorporated with the modelled habitat, along with taxon distributions. The impact assessment can include multiple modelled impact scenarios that can reflect the progressive staged development of a project from pre-mining through to post-mining. The 3D habitat impact models can provide a more accurate quantitative and visual assessment of the degree of proposed impact.

9. Conclusion

The 3D modelling of subterranean fauna habitat does not 're-invent the wheel' in assessing the likely extent or quality of habitat present. The development of a 3D model should not be viewed as experimental as such, but more as an innovative extension that is guided by the same logic and principles outlined in regulatory guidelines and currently used in inferring the 3D subterranean habitat in EIA. The data used (e.g. stratigraphic unit habitat suitability) in the development of a 3D model is essentially the same from which an inferred 3D concept is derived. The assignment of habitat suitability categories follows the same principles and logic as applied for inferred 3D habitat extents with generalised suitability based on the physical characteristics of the geological/ hydrogeological units and evidence from subterranean fauna studies.

References

Biologic. (2018) *Mesa A Hub Subterranean Fauna Peer Review* Report prepared for Rio Tinto, Perth, Western Australia.

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MWH. (2016) *Wiluna Extension Uranium Project: MWH responses to OEPA's request for additional information regarding subterranean fauna* Report prepared for Toro Energy, Perth Western Australia.