Peer Review of “Hope Down 2 Proposal: Targeted Riparian Survey of the Greater Hope Downs 1 Area”

Client: Rio Tinto

Peer Reviewer: Associate Professor Dr Eddie van Etten, ECU

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INTRODUCTION AND SCOPE OF PEER REVIEW

Rio Tinto is currently involved in an extensive EIA (Environmental Impact Assessment) process for a new mining development known as Hope Downs 2 (HD2), located in the Hamersley Ranges in the Pilbara regions of Western Australia some 80 km north-west of Newman. The proposal seeks to develop, operate and close (rehabilitate) two iron ore deposits within the HD2 area, with a projected development envelope of about 14,000 ha. All mining is proposed to occur above the water table, although there is likely to be some extraction of groundwater during construction and operation for purposes such as dust suppression and ore processing (up to 38 GL over 13 years of the project).

To support the EIA process, Rio Tinto has completed a study of the riparian vegetation of the HD2 area and surrounds and assessed the significance of various plant communities found. The findings and outcomes of this study area are outlined in their report titled ‘Targeted Riparian Values Assessment of the Greater Hope Downs 1 Area’, dated November 2023 (hereafter referred to as ‘the report’, or ‘the Rio Tinto report’ if required for clarity). Rio Tinto engaged A/Prof Eddie van Etten as an independent expert to undertake a peer review of the report in December 2023. This document provides the summary, outcomes and recommendations stemming from the peer review. Eddie’s experience and qualification are summarised in Appendix 1 of this document.

The scope of the peer-review as assigned by Rio Tino is described via the following Peer Review question:

> “Please assess and review how appropriate and effective the following tools in the ‘Targeted Riparian Values Assessment of the Greater Hope Downs 1 Area (Rio Tinto 2023)’ are at identifying, characterising and contextualising riparian ecosystems (and potential GDV) as per the EPA Environmental Factor Guidelines* for use in EIA.
>
> - Pilbara Riparian Ecohydrological Framework (PREF)
> - Pilbara Riparian Ecotype Classification (PREC)
>
> In addition, please review ‘pool classifications’ and ‘riparian definitions’ used in the report (Rio Tinto 2023).
>
> The outcomes of the peer review should be provided in a report and based on expert opinion and current academic understanding. “

*The two relevant EPA Environmental Factor Guidelines being ‘Flora and Vegetation’ and ‘Inland Waters’.

OVERALL CONCLUSIONS AND RECOMMENDATIONS OF PEER REVIEW

The main outcome and broader implication stemming from the report is that the riparian vegetation of the study area (and surrounds) covers a wide range of biological and hydrological features and hence values, which has been somewhat underappreciated in previous EIA processes. An underlying goal was to improve the systems and procedures to delineate and assess riparian vegetation (compared to previous works and approaches which tended to group and simplify riparian vegetation types and their significance). **Overall, I agree with the rationale and need for this study, and am broadly supportive of the methodological approach and assessment process put forward.**

The primary conclusion of the report is that most riparian communities within the development envelope of HD2 are relatively well represented in the broader region comprising generally common riparian vegetation with mostly ephemeral species. More specifically, the report concluded that one area in particular, the lower reaches of the Weeli Wooli Creek within the study area, known locally as Ben's Oasis, is exceptional having elevated significance by virtue of its biodiversity and ecological values, being distinct (from the other riparian vegetation units) in terms of its ecohydrology, floristics, and vegetation, as well as being relatively restricted in occurrence. The Ben's Oasis area was found to be unique being the only patch in the study area supporting a high likelihood of GDV (groundwater-dependent vegetation). **These conclusions are supported together with the methodological approach and systems used to classify and assess the range of riparian vegetation types.**

The study, and hence the report, is multi-factorial and thorough, but also complex in terms of design and implementation. This is a consequence of the many lines of evidence used to support its conclusions, which includes classifications and/or mapping of hydrological features, vegetation types (units), keystone species, plant traits and water-use strategies, vegetation and surface water persistence, ground-water dependency, catchment characteristics, and geomorphology. Although there is some attempt to integrate this wide-ranging information and data, and recognising this is a relatively new and novel methodology, future work could benefit from greater integration of the evidence and data, which could include an appraisal of the degree of spatial congruence of the various mapped layers.

The study introduces the Pilbara Regional Ecohydrological Framework (PREF) and associated Pilbara Regional Ecotype Classification (PREC). These represent an attempt by Rio Tinto to classify, evaluate and contextualise riparian vegetation/ecosystems of the region across known gradients in water availability, consistency and permanence, parameters which are inferred to be of increasing ecohydrological importance in riparian settings. It uses three key factors to classify riparian vegetation: 1) keystone species and their abundance and contribution to vegetation structure; 2) presence and diversity of species which are indicative of ecohydrological status; and 3) presence and persistence of aquatic habitat features. **The PREF in particular has demonstrated its utility in this study by providing an important link between the floristics of the various vegetation units determined and the water/moisture persistence classes (which then forms the basis for an assessment of representation and, thus, inferred significance)**. It is noted that the PREF is still in draft form and is currently undergoing improvement via internal research and, in time, external peer-review; however, it is clear it has strong potential to advance the classification and assessment of various types of riparian vegetation across the broader region, as well to improve assessment and contextualisation of riparian vegetation in dryland ecosystems more generally. **To this end, it would be advantageous and prudent to obtain further expert validation and support for both the methodology and utility of the PREF, such as via publication in a suitable peer-reviewed journal.**

The methodological approach adopted in the report, although seeking to improve and advance assessment processes, **maintains consistency with the EPA guidance statements on Flora & Vegetation (EPA 2016a), and Inland Waters (EPA 2018)**, albeit accepting the EPA guidance is broadly based. Further, **the approach adopted by Rio Tinto in this report attempts to integrate common elements of both guidance statements that are relevant to riparian vegetation. Lastly, the classification of pools in terms of water persistency, as well as the definitions of riparian vegetation/ecosystems and groundwater-dependent vegetation/ecosystems, employed in the report are appropriate and consistent with the international and national literature on the topic.**

SPECIFIC COMMENTS AND RECOMMENDATIONS ON EACH SECTION OF THE REPORT

SECTION 1: INTRODUCTION

This brief section of the report summarises the mining proposal and defines the study area and objectives.

The 'key objective' of the study is broadly stated as "to further study riparian ecosystems (beyond baseline flora and vegetation studies)". This is laudable given information required to satisfy EIA requirements can be rudimentary and simplistic, and so any attempt to improve assessment process and outcomes for riparian vegetation of the study area, and more broadly, is worthy. Specific aims of the study are further explained in terms of stated outcomes of study, which are namely to produce:

1) refined riparian vegetation mapping (of higher detail than previously)

2) Groundwater Dependent Vegetation (GDV) likelihood mapping,

3) relevant surface water mapping, and

4) a detailed significance assessment of the mapped riparian communities using representation and potential restriction as a proxy for significance

SECTION 2: BACKGROUND INFORMATION

Section 2 critically reviews relevant background on the study area, covering its hydrogeological features (including groundwater, surface water, climate, soils, and catchment characteristics), previous vegetation survey and mapping efforts, and other relevant data/maps.

Overall, this review of background information serves as a useful foundation for the study and is both relevant and comprehensive in its coverage. Previous vegetation classifications and mapping are of interest, but it is noteworthy that there is little agreement between these previous works, likely reflecting different methodology, scales, and/or interpretation employed by different consultants. This is noted in the more recent of the flora/vegetation surveys done explicitly for HD2 (Astron 2020). The Astron survey seems to be the most important of the previous surveys as it is used as the foundation for vegetation mapping presented in the Rio Tinto report. The methodology employed by Astron is outlined in the complete report done for the HD2 EIA (Astron 2019) and was found (to me) to be robust and thorough, employing an objective, quantitative and statistically tested classification of floristic data collected throughout the study area, although their techniques for vegetation mapping is somewhat obscurely covered. The general lack of consistency and standards in vegetation classification and mapping done for EIA in WA is beyond the scope of this peer review.

Vegetation persistence mapping is a method developed by CSIRO utilising NDVI data derived from remote sensing to detect riparian vegetation by comparing seasonal changes in vegetation reflectance (with riparian being differentiated by small levels of seasonal change reflecting more consistent access to moisture). It has demonstrable success in delineating and accurately mapping not only riparian vegetation but also occurrences of Groundwater Dependent Ecosystems (GDEs) within this broad vegetation group. The methodology has been tested (via reasonable amount of ground truthing) and peer reviewed (see references in Rio Tinto report, as well as others such as Alaisbakhsh et al. 2017). It is noteworthy that persistence mapping used later in the RT report uses Sentinel 2 data and hence is likely to be higher resolution than previous mapping done with Landsat. High persistence vegetation, which is inferred to be accessing stored moisture (either vadose or aquifer), is defined as areas with equal or greater to 70% persistence, with mapping provided at Fig 2-5 utilising NDVI persistence greater that 0.32 to presumably map riparian vegetation. These thresholds have been validated in other studies (e.g., Barron et al. 2017) and, to me, are acceptable for use in this study.

SECTION 3: RIPARIAN & GROUNDWATER DEPENDENT ECOSYSTEMS

This section gives more specific background on these ecosystems, including definition of key terms, description of underlying hydrological and ecological processes, identification of suitable indicator species, and a review of GDEs and GDVs, including a description of the developing framework for broader assessment of riparian ecosystems, the PREF (Pilbara Regional Eco-hydrological Framework). Fundamentally, this section provides a detailed explanation of and rationale for the methodological approach adopted in the study.

The first two sub-sections (3.1 & 3.2) outline how these ecosystems are assessed by the WA EPA including how they are relevant to EPA Environmental Factor Guidelines (EFGs) for Inland Water and Flora & Vegetation. Although not specifically stated in the EFGs, riparian vegetation can be considered under the Inland Waters EFG by virtue of the broad definitions of inland waters adopted (being ecosystems which experience flooding at least occasionally or are dependent on groundwater discharge and/or surface water flows, which applies to riparian vegetation). Guidance on assessing the significance of riparian ecosystems under the EFGs is quite broad (necessary given its State-wide applicability); despite this, of specific relevance to the study area are two PECs which incorporate permanent (or near-permanent) springs and pools (Weeli Wooli Spring PEC, and Springs and River Pools of the Pilbara PEC), although these are very restricted in the study area (to the Ben’s Oasis area). Also specified as significant ecosystems in the EFGs are those which are restricted in distribution and/or poorly represented in reserves, and those providing refuge for other species (which are applicable to certain types of riparian vegetation in the Pilbara, but not all types given some are widespread and common). Therefore, although the guidance provided by the EPA is broadly based and captures riparian vegetation, it needs to be appreciated that there are a range of riparian vegetation types within the study area and these should not be regarded as equally significant given they cover a wide range of ecological attributes (such as differing species composition, function and structure), hydrological features (range of flooding and moisture regimes, and degree of groundwater dependency), and levels of geographic restriction and representation. Hence the various types of riparian vegetation will likely possess substantially different conservation values and significance. GDEs can be defined and delineated as a subset of riparian vegetation, but even these vary substantially in terms of degree to which they are dependent on groundwater and, for some, surface water. **The underlying rationale of the Rio Tinto report, to provide a more nuanced and detailed classification of riparian vegetation to help assess ecosystem restriction and significance more accurately and appropriately, is therefore supported. Notwithstanding this, the**

assessment outlined in the report is consistent with the applicable EPA Environmental Factor Guidelines.

Rio Tinto (in the report) argue that riparian ecosystems in the Pilbara are generally under-appreciated in terms of their importance and vulnerability. This is because they are often occur in specific (wetter) habitats which typically only occur in localised patches generally lower in the landscape. Also, as they occur within an essentially harsh arid region, they vividly contrast with other ecosystems in terms of species (both flora and fauna), structure (being much denser, generally), and other ecosystem attributes, as well as in their cultural/aesthetic values (often being true oases). Despite this overall importance, riparian vegetation does vary widely across the region, from the more widespread and typical types characteristic of ephemeral streams and other broad drainage features to far more restricted, mesic, and specialised types of riparian vegetation associated with permanent pools. Therefore, a 'one size fits all' approach to delineating and assessing riparian vegetation is to be avoided.

A good example of such a simplistic approach is the use of dominant riparian tree species to define and identify riparian vegetation, such as *Eucalyptus camaldulensis* and *E. victrix*. Although these two species occur in most riparian vegetation of the Pilbara, they both tolerate a wide range of different ecohydrological conditions and are associated with a variety of other species which have more specific habitat requirements. Both are facultative phreatophytic species (FPCs), meaning their dependence of groundwater can vary from nothing to substantial (Eamus et al. 2006). Delineating riparian moisture regimes with minimal lines of evidence (e.g. two species) is fraught with problems given the variation and complexity in hydrology and species responses.

Therefore, a more integrated approach, as adopted in the report, to the determination and assessment of riparian vegetation types (primarily based on more detailed and targeted floristic data, but combined with various layers of ecohydrological information) is strongly supported. The presence and relative dominance of long-lived perennial species are particularly useful indicators of moisture regimes over the medium to longer term.

Available information on riparian plant species of the study area (both published and unpublished), combined with field observations and experience of the report authors, are reviewed and consolidated to derive a list of potential indicator species and a classification of these species into groundwater dependency (Table 3-1) and degree of moisture availability/permanence (Table 3-2). Only one consistently 'obligate' phreatophyte species (OPS) is recognised for the study area (*Melaleuca argentea*), with *Eucalyptus camaldulensis* and *E. victrix* identified as being facultative phreatophytic species (FPS), with the former recognised as having greater (i.e., moderate level) dependence on groundwater than the latter. This distinction in the degree of groundwater dependency between these two widespread and often dominant riparian trees of the region is of considerable importance as it means the absolute and/or relative dominance of each can be used to indicate the degree of water permanence and moisture availability at a site. This assumption is central to the methods developed and is well reasoned in the report, and is supported.

A thorough review of literature and robust rationale for the classifications is provided, although it is clear only the two dominant eucalypts have been thoroughly studied in terms of ecophysiology, although it is accepted that such studies are expensive, extensive, and logistically challenging. **Overall, I agree with the selection of plant species and their ecohydrological classification, with several of these species being suitable indicator species for the final classification of riparian vegetation types (see Results).**

The PREF is a hierarchical classification of defined guilds of indicator plant species to aid in the assessment of riparian and GDE values and their ecohydrology. It plays a key role in the report under review as it provides the main link between the riparian vegetation types determined and their assessment in terms of significance and ecological attributes. The description of the PREF given in the report was supplemented by: 1) a draft description of the PREF developed by Rio Tinto ("Assessing the Significance of Riparian Ecosystems in Arid Landscapes such as the Pilbara", draft dated March 2024; Rio Tinto 2024) and slides of a presentation given at the 2021 (WA) Biodiversity Conference by Jeremy Naaykens, Senior Advisor Ecohydrology, at Rio Tinto. A thorough peer review process is planned for the PREF (via WABSI), and so the review of PREF provided here is more focussed on its applicability and utility in assessing the various types of riparian vegetation established for the study area, rather than a detailed critique of the broader framework. It is also noted that the PREF is still a work in progress and is likely to be updated and improved based on ongoing review and testing. Some preliminary testing of the PREF has shown a strong association between plant guilds and regional vegetation (NDVI) persistence data (Rio Tino 2024), which is encouraging.

In essence, the (draft) PREF presented in the report is a table of indicator plant species grouped into categories of increasing degrees of moisture availability and permanence from Low to Very High (5 categories, running vertically across the table). It is further divided horizontally into mesophytes (terrestrial plants of at least moderate water requirements) and hydrophytes (plants adapted to aquatic environments).

Although understorey and less common plants play a role as indicators (where present), it is the presence and dominance of keystone overstorey mesophytes which are most important in a practical sense for classifying riparian vegetation into the PREF categories. It seems reasonably straightforward to place riparian vegetation into the appropriate PREF category, even though some tree species occur in more than one category. For example, *Eucalytpus camaldulensis*, a very common and widespread species of most riparian ecosystems of the Pilbara, occurs in both 'High' and 'Moderate-High' categories of moisture availability, but in the former it is 'dominant', whereas only 'present, abundant' in the other. This difference could be viewed as being relatively subtle from some perspectives, and hence may lead to practical difficulties in differentiation in the field; despite this, the framework also lists other species of trees and tall shrubs which can differentiate between these classes. For example, *Melaleuca bracteata*. *M. glomerata* and *M. linophylla* are typically abundant in "Moderate-High", whereas not so in 'High'.

The other most common riparian tree species of the study area (and broader region), *Eucalyptus victrix*, also occurs in two categories, but where abundant it indicates the presence of the 'Moderate' moisture category, and where only scattered (sparse), it is indicative of the 'Low' category. Again, other dominant and common species are included to help determine the appropriate class.

Overall, the choice of species, their descriptions, and their placement in categories is supported, although further review and field testing is recommended to further refine and improve the PREF. It is interesting to see a list of hydrophytes for the 'low' and 'moderate' categories despite the more ephemeral nature of moisture availability. It is accepted these are species more likely to be found in and adapted to ephemeral (rainfall-fed) aquatic environments – that is species which persist in highly variable flooding regimes typical of many Pilbara drainage lines and creeks, demonstrating greater tolerance of inter-flood dry periods compared to species found in the higher categories of moisture availability and permanence.

Section 3.5 reviews factors to be considered when assessing biological and conservation significance of ecosystems. It mainly uses factors outlined in the two EPA Factor Guidelines (for Flora &

Vegetation, and Inland Waters), although it should be remembered that these guidelines are broadly described given they are designed to apply across the whole of WA. More specific factors applicable to regional significance could perhaps be also outlined in this section, for example regionally restricted ecosystem types.

As a general note, the literature used in this and other sections to support the methodology employed in the study is mostly local or national in its perspective. Similar issues surrounding delineation, classification and assessment of riparian vegetation can be found in other regions of the world, including other drylands (e.g., Manning et al. 2020; McMahon et al. 2024) and perhaps references such as these could be added to provide further support for the approaches taken in the report.

SECTION 4: METHODS

The methods used to define, describe and assess riparian vegetation types are complex and multifaceted. In summary, my interpretation of the general methodological approach and workflow adopted is:

1. Desktop review and consolidation of previous surveys and mapping, particularly to identify gaps and areas for in-fill surveys and field work.
2. Vegetation (NDVI) persistence mapping, mainly using Sentinel sensor and validated image processing;
3. Mapping presence and relative dominance of key FPS (particularly *E. camaldulensis* and *E. victrix*) using high-resolution aerial photographs and other remotely sensed imagery;
4. Field work to obtain floristic data at selected sites (plots and relevés) and observational notes and field mapping of indicator species along streams (also to field validate the interim mapping);
5. Integration of above information with groundwater depth data to derive and refine maps of ecohydrological zones, GDV likelihood, and surface water (permanent or near permanent pools), within the major drainage lines and creeks of study area.
6. Assessment of derived riparian types based on classification using PREF and ecotypes, and then evaluation of their extent and distribution.

Specific comments, queries and suggestions related to the methodology:

- NDVI Persistence mapping – the use of this technique is supported given it has been thoroughly field tested and peer-reviewed. More specifically, I am reasonably satisfied that the thresholds used for various classes of GDV likelihood (e.g., >90% for increased reliance on GW; <60% = IDE riparian being dependent on surface flows, etc) have been independently verified for the study area (e.g., Barron et al. 2017).

- Mapping of dominant tree species using high-resolution aerial photographs – detailed description and examples were sufficient to be confident that species can be differentiated from each other (even though they are sometimes difficult to tell apart in the field). This approach provides a more detailed mapping of vegetation compared with persistence mapping, although lack of overstorey in some riparian vegetation can lead to problems. Ultimately, determining the dominant eucalypts from aerial photos are based on differences in color/hue, branching patterns and canopy density, which an experienced interpreter could do accurately. Ongoing opportunities to improve discrimination and accuracy should however be explored, including potential for incorporating the use of AI or other machine-learning methods.

- Altogether it seems floristic data from some 57 quadrats/releves were available across the riparian vegetation of the study area (including those collected by consultants previously). I am reasonably satisfied that floristic data has been collected by suitably experienced botanists using accepted field methods (as per EPA guidelines, eg EPA 2016b). In terms of vegetation classification, it appears a structural approach has been adopted (i.e., where sites are somewhat subjectively grouped based on vegetation structure and dominant/common species) and this is supported given the relatively small data set. However future studies, where larger data sets may be available, could explore more objective numerical (statistical) classification techniques.

- Vegetation mapping is typically a highly iterative process (of initial mapping, followed by field checking and subsequent refining) and has a certain element of subjectivity based on incorporating local field knowledge and adjusting boundaries between units/types as required. I am therefore broadly supportive of the process of map refinement employed, although the process could be more succinctly and clearly explained to the reader, and the inherent subjectivity made more explicit.

The process and steps in mapping of GDV likelihood classification and mapping are described in Section 4.5. From the description of methodology in this section, it seems classification is applied to the established vegetation units via several lines of evidence obtained from a range of different data and information, both collected in the field and via desktop review (including water use strategy of keystone trees, age structure of trees, vegetation cover/structure, depth to groundwater, vegetation persistence mapping, surface water presence, catchment size and geomorphology). This is lot of information to synthesise and so, ultimately, classification into categories of GDV (from 'Very Low' to 'Very High') is based on expert judgement and field knowledge. **It is noted, and agreed, that impacts on GDV associated with HD2 are likely to be minimal given limited planned water abstraction and/or discharge into streams.**

The last subsection is s4.6 which covers the rationale and methodology for mapping of riparian surface water (including permanent pools). This mapping is designed to 'add value and give context' to the other mapping and assessment of riparian and groundwater dependent vegetation. This makes sense as the riparian areas of highest value and significance are typically associated with permanent or near-permanent water (as distinct from ephemeral surface water typically associated with wet seasons or periods). The methodology involves measuring the degree of water persistence over several years as detected using remote sensing (specifically using certain spectral bands from Sentinel 2 satellite imagery), with supplementary evidence from high-resolution aerial photography. An index of water persistence (Sentinel Water Mask, or SWM) is calculated with values above 0.59/0.60 indicating surface water as opposed to hydrated tree canopy (generally having SWM values below this threshold). It seems this threshold has been derived for the Pilbara, although more detail on how this has been validated is warranted. Further, peer-reviewed scientific papers which support the use of SWM to detect surface water are not given (but yet are available, eg Nagaraj & Kumar 2024).

Based on presence of surface water, pools were detected and differentiated as being either Permanent Pools or Semi-Permanent Pools. It is reasoned that such pools are typically groundwater fed, particularly if monitored over many years. In contrast, persistent pools and ephemeral pools tend to be fed by surface streamflows during wetter periods, with the former being associated with sediment and/or near-surface basement rocks of low permeability. **Overall, the classification of**

pools (as either permanent, semi-permanent, persistent, or ephemeral) and their defining characteristics are broadly supported.

SECTION 5: RESULTS

5.1 Ecohydrological Zones

A classification of major drainage lines of the study area into ecohydrological types (4 main classes, divided into 12 subclasses) is presented at Table 5-1 and these are mapped as ecohydrological zones in Fig 5-1. These four main classes (Mesic, Ephemeral Plus, Broadly Ephemeral, and Highly Ephemeral) are generally sensible and supported, although the definitions/descriptions could be more precisely worded in places to better distinguish between the classes. This is particularly the case for the 3 classes of ephemeral zones. For example, the Broadly Ephemeral class is described as "….generally quite ephemeral in nature…" which can be widely interpreted. Nonetheless, it is noted that the classification and map of ecohydrological zones was done to provide important fundamental information on ecological and hydrological patterning as a foundation for the other mapping and assessments of the riparian vegetation, and in this regard provide useful and relevant information. Further, they highlight the distinctiveness of the mesic zone in terms of hydrological, ecological and floristic features, and emphasise the relatively restricted distribution of this zone (i.e., to the Ben's Oasis area).

5.2 Riparian Vegetation – Units and Mapping

Fifteen 'Vegetation Units' are defined and described in Table 5-2 and mapped at various scales in Figs 5-2 to 5-5 (including three 'floodplain and yes that w associated riparian' vegetation units, which are not true or core riparian vegetation). The vegetation units are generally clearly defined and distinguishable based on their dominant species of trees and shrubs. Most are also readily separable by their particular (physical) environmental setting in terms of catchment size and position in the creek profile, although perhaps more descriptive detail is possible here to distinguish between the various types, including detail of their geology, topography, soils etc.

Overall, the vegetation classification/mapping is important as it provides the basis for the assessment of riparian vegetation significance. The units defined are appropriate and generally supported in terms of their distinctiveness and key/indicator species (as per Appendix D in the report). **They provide a consistent, practical, and robust foundation for the assessment of significance.**

5.3 Riparian Flora

In total, some 418 plant species have been collected across the various studies and surveys of riparian vegetation of the study area. This demonstrates the high biodiversity value of this vegetation broadly, and reflects the thoroughness of the survey work. The collection includes four priority species, with relevant information on these taxa provided in this section.

5.4 Assessment of Riparian Vegetation Communities

Each of the 15 riparian vegetation units were successfully assessed in terms of their representation throughout the study area, being classed as either "restricted' or 'well represented". Although this is a relatively simple (binary) scheme, it is supported by quantitative data presented at Appendix B (which includes the areal extent of each unit in km^2).

To validly assess representation of vegetation units derived for a certain area (such as within a development envelope) requires an understanding of the distribution of these types at a regional or broader scale (for context). This is in line with IUCN methods for the assessment of the conservation status of ecosystems (Keith et al. 2015). Specifically, this requires spatial data on the extent of occurrence of each unit outside the study area. Such mapping is rarely available however at the required scale, resolution, and level of abstraction (as per the derived vegetation units), and indeed would often require a massive survey, analysis and mapping effort (which is likely to be prohibitive). Therefore, true assessment of restriction (or otherwise) of vegetation types as per EPA Guidance Statements is often not possible. Rio Tinto have faced similar difficulties in assessing whether vegetation types are restricted (or not) given their fine-scale classification and mapping in this study. However, they have done a commendable attempt at comparing each vegetation unit with similar riparian units in the Rio Tinto database (again presented at Appendix B), although they recognise the difficulties and problems in doing this given differences in scale, purpose etc. Further, the development of the PREF and associated PREC by Rio Tinto represent a serious attempt to classify and assess various types of riparian vegetation across the Pilbara region, and hence, when finalised, should assist in contextualising vegetation units defined at local scales and enable the degree of representation to be assessed in a superior fashion compared to what has been previously available.

Table 5-11 provides a high-level and fuller description of all 15 riparian vegetation units involving their indicator species (including any mesophytes or hydrophytes), hydrological/topographical setting, and GDV likelihood, and, as such, presents a worthy initial attempt at integrating the various information layers collected for the study area.

5.5 GDV Likelihood Mapping

Each vegetation unit is assigned a GDV likelihood rating from 'High-Very High' to 'Very Low'(outlined in Table 5-12) which is then used to map GDV likelihood at Figs 5-7 to 5-10. A range of evidence is used and integrated to derive these ratings (as outlined in s.4.5). I am generally supportive of the approach adopted, although some review and consolidation of the number of ranks could be undertaken (I counted 13 including sub- and intermediate ranks like 'Moderate-Low' and 'Low+'). A slightly more simplified hierarchical scheme could be just as effective, although this should not come at the expense of accuracy and utility.

SECTION 6: DISCUSSION

The discussion convincingly highlights the key findings of the study, principally the significance and uniqueness of Ben's Oasis, a permanent pool fed by a natural spring in the lower section of the Weeli Wooli Creek within the Study Area. The field data collected and various maps of ecohydrological and vegetation types all point to this area being distinct from the other riparian vegetation of the study area, comprising permanent (or near so) waterbodies typically fed by a shallow underlying aquifer and harbouring a range of mesophytic and hydrophytic species (including groundwater-dependent species) not typically found elsewhere in the study area, and being generally of restricted occurrence in the wider Hamersley Ranges region. The reasoning put forward to support its rich and unique biodiversity and ecological values is not disputed.

The broader argument being advanced by this study is that riparian vegetation varies substantially in terms of their inherent biological features and ecohydrological settings even within a relatively small study area, and hence there is a substantial range of significance associated with this vegetation. Assessments which tend to lump riparian vegetation into a single or small number of homogeneous types based on a few dominant tree species are likely to underappreciate the wide variation in their biodiversity, hydrological regimes (including water sources), and, therefore, ecosystem functions and values . As mentioned above, the Bens' Oasis area differs substantially from the other riparian vegetation in the Study Area (representing an area of high GDV likelihood as well as being restricted in extent). Despite this, a small number of other riparian vegetation units were flagged (in s6.1) as being more restricted and/or of higher significance than others (e.g., C3A), and it would be worthwhile to perhaps elaborate and assess these units more substantially.

The remaining vegetation types determined were assessed as being well represented both locally and in the broader region. Further, their floristic and eco-hydrological features were deemed to be typical of highly ephemeral broad floodplains and creekline systems of the region with low or very low likelihood of groundwater dependence and few to no permanent or highly persistent pools. This has led Rio Tinto to assess these as riparian vegetation types of lower significance (compared to the other riparian types described above). The reasoning and evidence used for this assessment is supported, and indeed subscribes to my local knowledge and experience in the region. Further the PREF and PREC have, in my opinion, provided an appropriate approach to provide the important regional and eco-hydrological context for the vegetation types determined and, although they are still in their development and testing phase, have considerable potential to improve assessments of riparian ecosystems across the region.

An appraisal of environmental impacts of proposed and current mining activities is included in the Discussion, concluding little to no impact on riparian vegetation of the Study Area due to: 1) minimal extraction of groundwater associated with proposed HD2 (with mining occurring above the watertable); and 2) groundwater drawdown associated with current HD1 mining only affects a small proportion of the Study Area where calcrete formations and relatively deep aquifers mean stored moisture is likely the most important source of water for the vegetation. I support these conclusions regarding minimal likelihood of environmental impact due to mining activities.

The report represents a substantial and, in places, complex study where various lines of evidence are used to highlight riparian vegetation types and zones with elevated conservation significance. These lines of evidence include the hydrological setting, vegetation units and key plant traits, vegetation persistence, relative water permanence, degree of groundwater dependency, and regional-based frameworks for riparian ecohydrology (PREF) and ecotypes (PREC). What is generally lacking in the Discussion and Conclusion sections is how these various elements are aligned, in other words an appraisal of the congruence of this evidence would help tie together the various elements of the study (although it is accepted that some attempt at this is made in the Table 5-11 and Appendices). It is noted that the PREF and PREC are designed to integrate this information and provide the regional context; they are subject to wider review and scrutiny beyond the scope of this specific peer-review.

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APPENDIX 1: BRIEF BIO OF PEER REVIEWER

Dr Eddie van Etten has some 30 years of research experience centring on arid zone ecology, including ecological studies and reviews of riparian systems in the Pilbara region. He completed his PhD on the classification and mapping of the major vegetation types of the Hamersley Ranges in the Pilbara (completed in 2000). Eddie has written many reports and reviews for mining companies and other clients on environmental matters and has delivered these in a timely and professional manner. The details of these report and his other publications, and experiences, are further outlined in his CV (available on request).

<u>END OF REPORT</u>