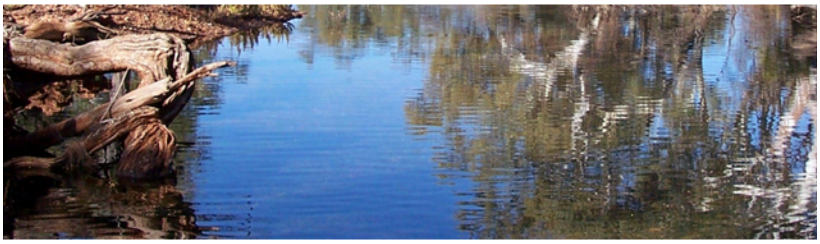
Biota Environmental Sciences

Yandi Pocket and Billiards South Supplementary Stygofauna Review



Prepared for Rio Tinto

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Yandi PBS Supplementary Stygofauna Review

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1.0 Introduction

1.1 Project Background

Rio Tinto currently operates the Yandicoogina (Yandi) iron ore mine, located approximately 90 km northwest of Newman in the Pilbara region of Western Australia.

Rio Tinto plans to sustain the operations at the existing Yandi mine. The proposed sustaining operations include the development of the Pocket and Billiard South (PBS) deposits within the existing Yandi operations Development Envelope. All the deposits at Yandi are Channel Iron Deposits (CID) located in close proximity to the Marillana and Weeli Wolli creek systems. In order to access the ore within the deposits, advance dewatering and groundwater management will be required, as the deposits are almost entirely below the water table. Such activity has the potential to impact stygofauna communities (obligate, groundwater-dwelling fauna) and extensive sampling for stygofauna has been undertaken in the locality as part of the assessment of similar previous projects since 2003.

1.2 Role and Scope of this Document

Environmental Protection Authority (EPA) policy requires Rio Tinto to determine the potential impacts of proposed mining operations on subterranean fauna prior to formal approval and operations commencing (EPA 2013). The proposed development of the Yandi PBS deposits is currently being assessed by the EPA at the level of Public Environmental Review (PER) under the terms of the *Environmental Protection Act 1986*.

Public and government regulator submissions on the PER have recently been received, and this document is intended as a brief technical review to provide supplementary supporting information addressing matters raised in the submissions relating to stygofauna.

1.3 Matters Raised in Submissions

The submissions received on the Yandi PBS PER regarding stygofauna may be categorised as relating to the following items:

1. the continuity of stygofauna habitat within the Proposal area, including vertical connectivity between potential habitat strata;
2. the distribution of the stygofauna community present in the Proposal groundwater impact areas in relation to identified habitat;
3. the identification of the extent of refugial habitats for stygofauna species with limited distributions during the implementation of the Proposal, including consideration of other groundwater impacts in the wider locality where possible; and
4. a broad risk assessment of the cumulative impacts on the stygofauna habitat and communities represented in the Proposal Area.

1.4 Terminology used in this Document

The following definitions apply to key spatial and impact assessment terms used in this document:

Conceptual design:	The current conceptual design for proposed pit locations and boundaries, and proposed waste dumps, for the Yandi PBS Proposal.
Development Envelope:	The predicted maximum ground disturbance area for the integrated Yandi operations (comprising the existing approved operations and the proposed PBS expansion).
Proposal Area:	The area within which the proposed Yandi PBS development will occur.

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2.0 Stygofauna Habitat and Distribution

2.1 Stygofauna Habitat

The suitability of any geological formation as habitat for subterranean fauna is predominantly determined by the availability of space within the rock type and potential for nutrient infiltration. In the case of stygofauna, this can be further refined to where such rock formations occur below the water table. Several geological units are recognised as being core habitat for subterranean fauna as they characteristically form fractures, caverns and vugs, which facilitate fauna dispersal and infiltration of nutrients and organic material. These units include limestone karstic systems, calcrete, alluvium, gravels, limonite and dolomite (Marmonier et al. 1993, Humphreys 1999).

The superficial geology of the Yandi PBS Proposal Area includes several units that represent suitable habitat for stygofauna. These include alluvium (Qa), colluvium (Qw) and calcrete (Czk), all of which occur as valley fill formations broadly associated with contemporary drainages in the locality, and have been well sampled during past subterranean fauna surveys (Biota 2015). A relatively small proportion of these valley fill units are saturated, representing the superficial floodplain aquifer, and baseline depth to water table varies across the Proposal Area (Rio Tinto 2010). Prolonged discharge of dewatering outputs has, however, caused sections of both Marillana and Weeli Wolli Creek downstream from existing Rio Tinto and BHP Billiton Iron Ore operations to retain water for much longer than during typical seasonal cycles. This has resulted in superficial formations remaining saturated for extended periods compared to past conditions. The geology and hydrology of the superficial aquifer of the Proposal Area is therefore well suited to utilisation by stygobitic fauna, with a high percentage of the shallow stratigraphy comprised of saturated units with interconnected habitat space (Biota 2015).

The underlying CID in the Proposal Area is imbedded into a bedrock of shale, dolerite and banded iron formation (BIF) of the deeper Weeli Wolli Formation (Figure 2.1). The CID in this area is almost entirely below the water table and is overlain with varying depths of unconsolidated alluvium and colluvium. During the public submissions process, a public comment was received which queried the underlying geology, suggesting that the Weeli Wolli Formation may form a barrier for dispersion between the CID and the alluvial aquifer in the Proposal Area. However this is not the case, as the CID is imbedded in the underlying Weeli Wolli Formation, and the Weeli Wolli Formation does not occur between the CID and the superficial alluvium (see Figure 2.1). The CID aquifer is in fact hydrologically connected to the overlying superficial floodplain aquifer for the entire length of the Proposal Area (Rio Tinto 2010), with no suggestion of physical barriers to potential fauna movement between the two groundwater systems.

The CID itself is divided into three main units based on mineralogy and chemistry: the upper ore zone (GVU), the lower ore zone (GVL), and deeper material that represents the waste zone of the deposit (LGC) (Figure 2.1). The latter two units form the major aquifer within the CID due to the development of secondary fractures and cavities (Rio Tinto 2010).

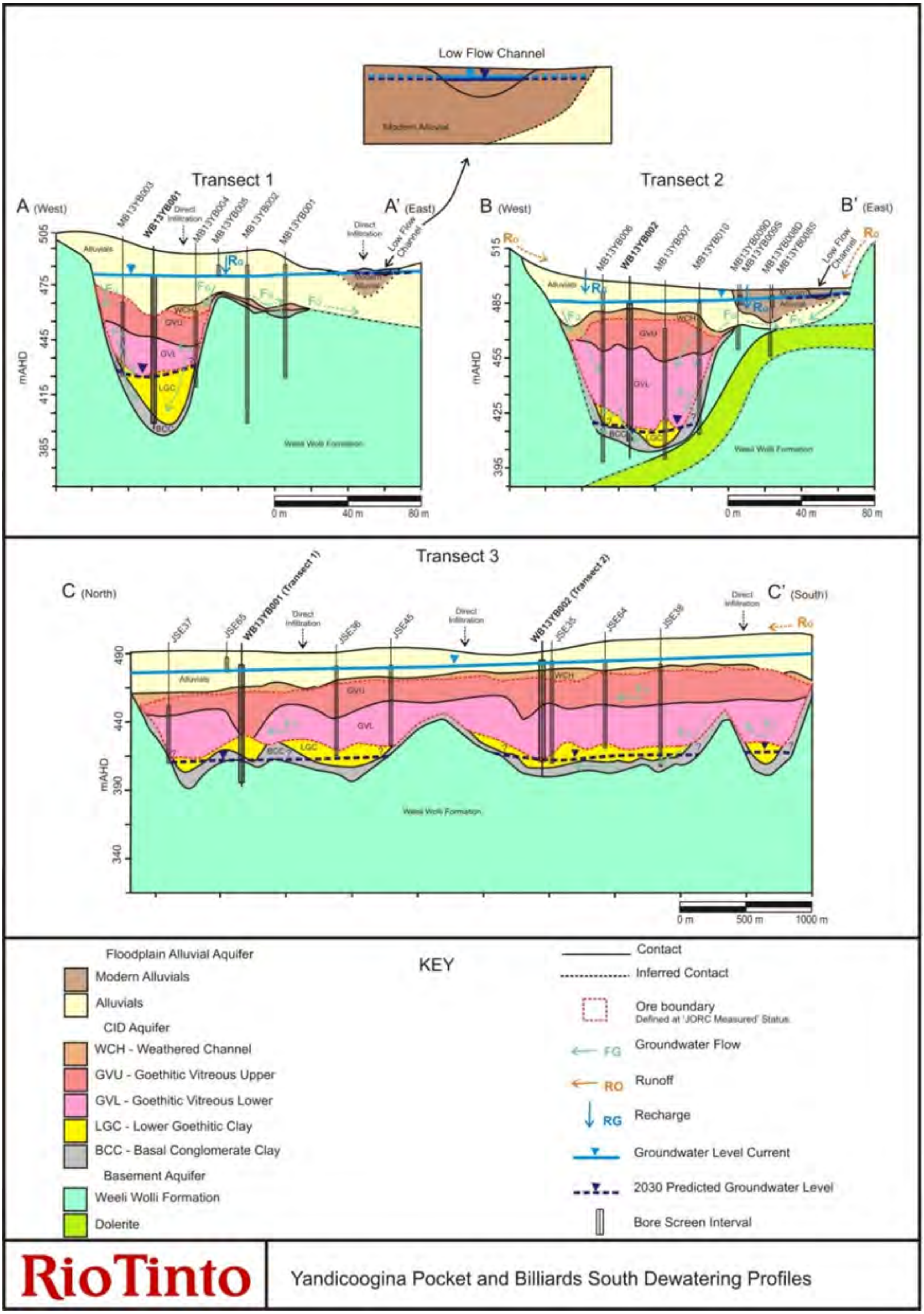

Figure 2.1: Cross-section of the PBS Proposal Area showing stratigraphic arrangement and dewatering profiles (figure supplied by Rio Tinto).

2.2 Relationship Between Stygofauna Records and Habitats

2.2.1 Overview

Extensive sampling for stygofauna has been completed in the Yandi Development Envelope over more than a decade, and the fauna of the locality is now one of the best documented in the Pilbara region (Biota 2015). A total of at least 88 taxa are known from the nearly 10,000 specimens that have been collected to date (Biota 2015), representing one of the more abundant and diverse stygal communities known compared to similar-sized areas in the region. The stygofauna itself is generally well recognised as being of conservation significance at both individual species and ecological community levels (EPA 2003, 2013).

2.2.2 Habitat Delineation

Identification of the extent of the habitat used by stygofauna requires consideration of both spatial coverage (i.e. mapped geological units) and how habitats are arranged vertically (i.e. the relationship with depth between stratigraphy and aquifer systems in the locality) to properly consider habitat in three dimensions.

Reviews of drillhole data from past sampling have shown that most specimens have been recorded from saturated superficial alluvium, colluvium and calcrete habitats, within or immediately adjacent to either Marillana or Weeli Wolli Creek (Biota 2015). The spatial extent of stygofauna habitat in the locality was therefore mapped primarily on the basis of these low-lying valley fill units, which are associated with the superficial floodplain aquifer of the Yandi Development Envelope (using the 1:250,000 scale mapping of Geological Survey of Western Australia (2001)).

While some records came from drillholes dominated by CID geology, the great majority of the stygofauna records are associated with sites that primarily or entirely intersect the more superficial floodplain aquifer (Biota 2015). This is consistent with regional data from the wider Pilbara, which indicate that the diversity and abundance of stygofauna significantly declines once depth exceeds approximately 40 m below ground level in most settings (Biota (unpublished data) and Halse et al. (2014)). This is likely to be a function of the attenuation of nutrient and primary production energy inputs from surface sources that occurs with increasing depth below ground. This inverse relationship of stygal abundance with depth below ground suggests that the lower units, which form the primary aquifer (Section 2.1) are unlikely to represent core habitat for stygofauna, given that they occur deeper than 40 m below ground level (Figure 2.1).

Pre-mining depth to water table was therefore also considered using data supplied by Rio Tinto, and a joint approach to mapping habitat was adopted by combining the most prospective geological units with areas where the depth to water table was less than 40 m below ground level (the latter criterion based on Biota (unpublished data) and Halse et al. (2014)). The output of this is shown in Figure 2.2, along with the distribution of all past stygofauna records from the Development Envelope, which demonstrate that habitat mapping on this basis provides a good fit for the known occurrence of the fauna.

2.2.3 Habitat Continuity

The floodplain alluvium occurs virtually continuously along the length of Weeli Wolli Creek. Within the Proposal Area it varies between 6 and 24 m in thickness, with the greatest thickness occurring adjacent to Weeli Wolli Creek (Rio Tinto 2010). In general, the superficial creek alluvium is comprised of inter-bedded layers of clays, sands and gravels to cobbles, and is highly conductive resulting in rapid recharge to the underlying deeper alluvium during creek flows.

Both the superficial floodplain aquifer and the CID aquifer are recharged by rainfall, groundwater and surface water flow. The CID is primarily recharged by seepage in areas where the creek overlays the CID (Rio Tinto 2010). The shallow water table and seasonally variable influx of water from storm events are also ecologically important in stygofauna dispersal and the maintenance of general hydraulic connectivity of subterranean habitats across the Proposal Area and wider catchment scale. The low flow channel of the Weeli Wolli Creek is an important hydrological feature in this respect, being the primary mechanism by which the core stygofauna habitat of the superficial floodplain aquifer is recharged and kept saturated (URS Australia 2015).

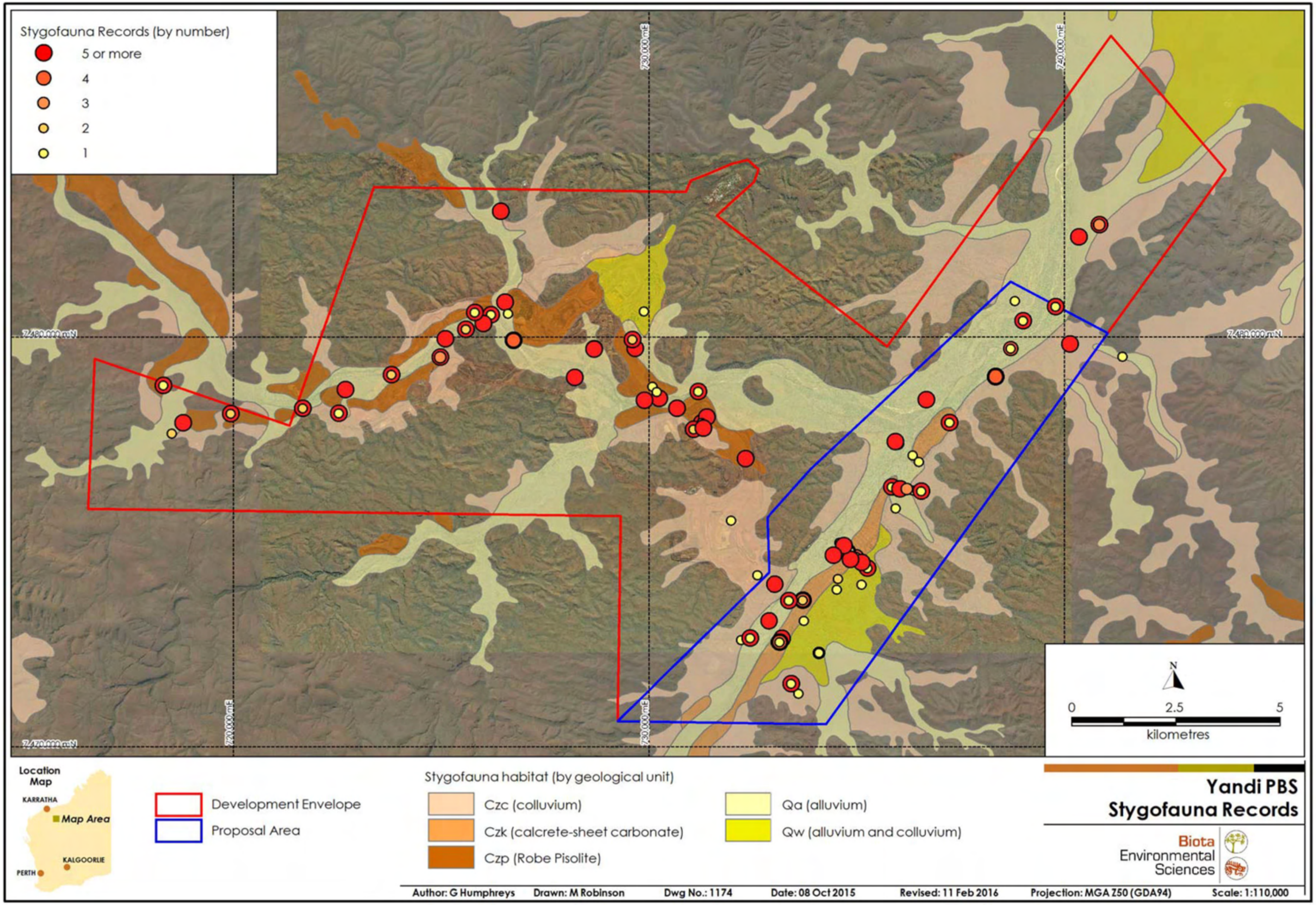

Figure 2.2: **Stygofauna records and mapped habitat associated with the Yandi Development Envelope.**

This level of continuity and connectivity of habitat from geological and hydrological perspectives is also reflected in stygofauna distribution in the system. The distributions of three species representative of the stygofauna of the Proposal Area are shown in Figure 2.3, along with the wider extent of the stygofauna habitat mapping (using the same methods followed at the local scale; see Section 2.2.2). These three taxa represent a cross-section of the stygal community in regards to taxonomic composition, body-size and ecology: a copepod (*Diacyclops humphreysi humphreysi*), an amphipod (Paramelitidae DEC sp. B02) and an isopod (*Pygolabis weeliwolli*).

The records of all three species show catchment-wide distributions extending beyond the Proposal Area into the upper reaches of Marillana and Weeli Wolli Creeks (see Figure 2.3). In the case of *Pygolabis weeliwolli*, this locally widespread distribution extends even to the genotype level, with the same DNA haplotypes having been recorded within both Marillana and Weeli Wolli Creeks during past genetic studies (Finston et al. 2009). This pattern of connectivity, and distribution of the same stygal species within local drainage catchments, has also been observed elsewhere in the Pilbara bioregion (Finston and Johnson 2004).

These observations suggest that there are interbreeding stygal populations occurring along the extent of the habitat associated with Marillana and Weeli Wolli Creeks beyond the Development Envelope and out to the broader catchment scale. There is no evidence from past hydrogeological or stygofauna studies of any major discontinuities in groundwater habitats within these alluvial aquifers, suggesting a low risk of barriers to gene flow or small-scale restrictions in species distributions within the catchment.

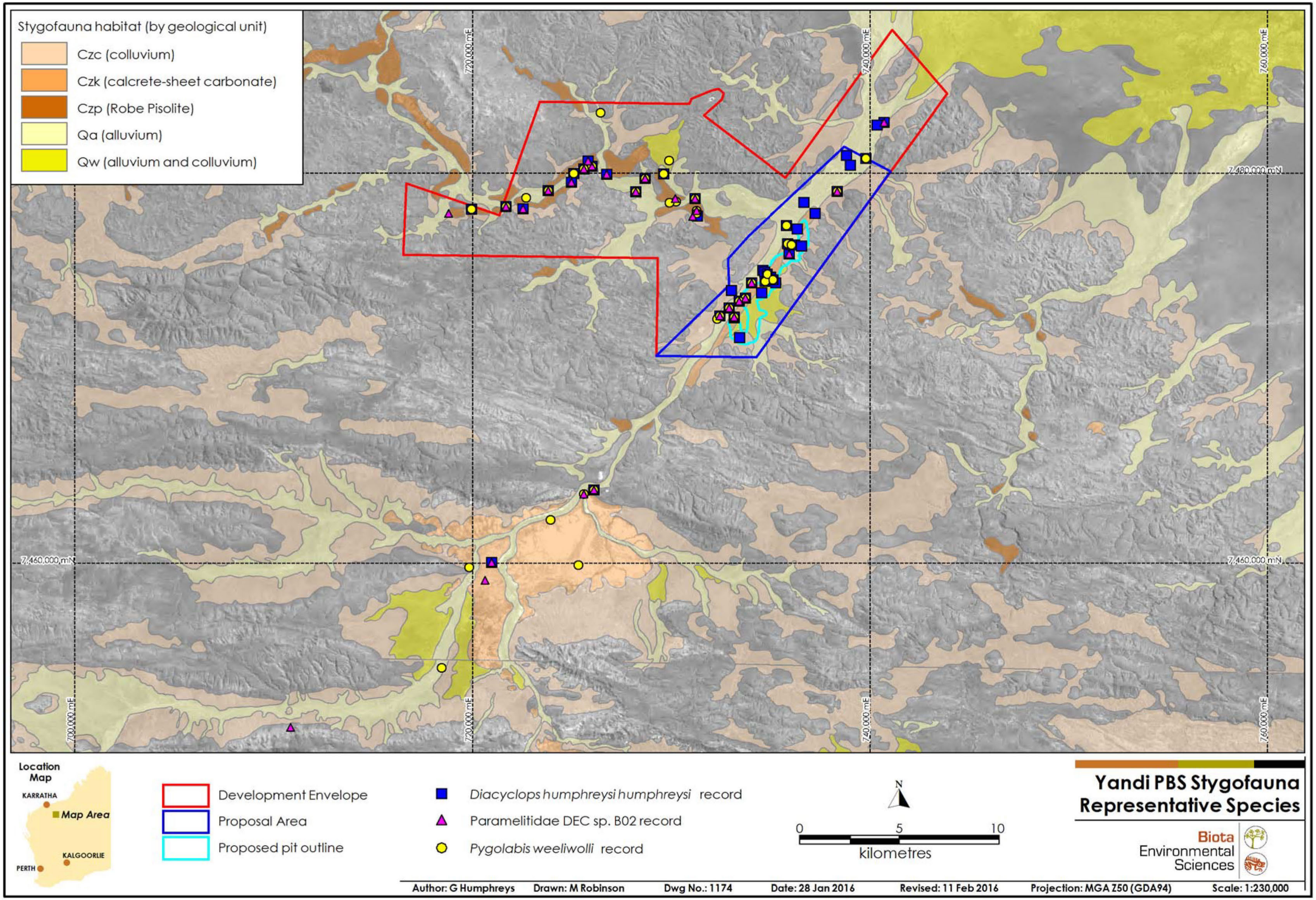

Figure 2.3: **Stygofauna records and mapped habitat associated with the Yandi Development Envelope.**

3.0 Cumulative Impacts

One of the matters raised in public submissions was the extent of habitat that would remain for stygofauna species with limited distributions during the implementation of the Proposal (see Section 1.3). It was suggested in submissions received that this should be assessed using a risk-based approach, and also take account of the influence of other operations in the catchment.

The data from both surveys of the Yandi PBS Proposal Area (Biota 2014) and the wider Development Envelope (Biota 2015) all suggest that the risk of any stygofauna species actually having a distribution limited to the Proposal Area is low. Geological, hydrological and biological data all indicate that stygofauna habitats and populations are effectively connected to at least the local catchment scale within Marillana and Weeli Wolli Creeks (Section 2.2.3). Of the 26 stygal taxa recorded from Yandi PBS, only two of those determined to species level are currently known only from the Proposal Area. The remaining species all have distributions that extend to the wider catchment scale or further afield in the Pilbara bioregion (Biota 2014). The same biogeographic pattern is evident at the somewhat wider scale of the Yandi Development Envelope: of the 88 taxa known, 39 of the morphologically-identified species (accounting for 6,183 specimens; or 64% of total records) have been recorded from elsewhere in Australia or globally (Biota 2015). The majority of the remaining taxa have records from across the Marillana-Weeli Wolli catchment (Biota 2015). These data, especially when considered in context with the overall level of habitat connectivity, suggest that it is, in fact, unlikely that there will be any stygofauna species that are limited in distribution to the Proposal Area. Repeat phases of sampling in Marillana Creek support this view, even for species that initially appeared potentially restricted. As an example, the ostracod *Gomphodella alexanderi* was initially thought to be a species with a potentially very small distribution at the time of the Yandi Junction South East assessment (Biota 2005). Subsequent sampling has now proven that this species, like most others in the Proposal Area, is in fact more widely distributed, with a total of 123 records from seven sites now known from later compliance sampling phases (Biota 2015).

The extent of refugial habitat remaining during Proposal implementation can still be usefully considered more widely, as a habitat-based assessment of groundwater impacts at the local catchment scale. Figure 3.1 shows the maximum predicted aquifer drawdown arising from the Proposal, along with stygofauna habitat in the Marillana-Weeli Wolli catchment. This shows that substantial areas of stygofauna habitat in Weeli Wolli Creek, particularly in the reach between the Proposal Area and Hope Downs 1, will remain unaffected by the dewatering and will therefore represent refugia (Figure 3.1). Some upper reach areas of Marillana Creek will be similarly unaffected by the Proposal. The locations of the three other operations that may influence stygofauna habitat in the catchment, BHP Billiton's Yandi and Mining Area C, and Rio Tinto's Hope Downs 1 operations, are also shown in Figure 3.1. The extent of dewatering influence from these operations is not quantified sufficiently to be able to map this, and only the direct impact of pit extents are shown and could be used for cumulative habitat loss calculations at catchment scale (see Table 3.1). The approximated local catchment extent shown in Figure 3.1 contained an overall total of 117,213 ha of stygofauna habitat prior to the commencement of development and represents the baseline case for this assessment. Existing operating and approved pits account for the removal of 3.6% of the stygofauna habitat in the catchment, with the Proposal representing an incremental impact of 0.5% loss (Table 3.1; Figure 3.1). An estimated 112,378 ha of habitat would remain unaffected by mine pits in the catchment (95.9% of the baseline extent).

Table 3.1: Estimated cumulative impact of the Proposal on stygofauna habitat at catchment scale.

Source of Impact	Area of Habitat Affected [1]	Proportion of Catchment Habitat [2]
Existing Operations		
BHPB Yandi	2,565 ha	2.2%
Mining Area C	40 ha	<0.1%
Rio Tinto Yandi	1,238 ha	1.1%
Hope Downs 1	387 ha	0.3%
Total existing impact:	**4,230 ha**	**3.6%**
Proposal		
PBS Proposal Pit	605 ha	0.5%
Total cumulative impact	**4,835 ha**	**4.1%**

1 Based on direct pit extent impact only (dewatering information not available for most operations).

2 As a percentage of the total mapped extent of stygofauna habitat of 117,213 ha (as presented in Figure 3.1).

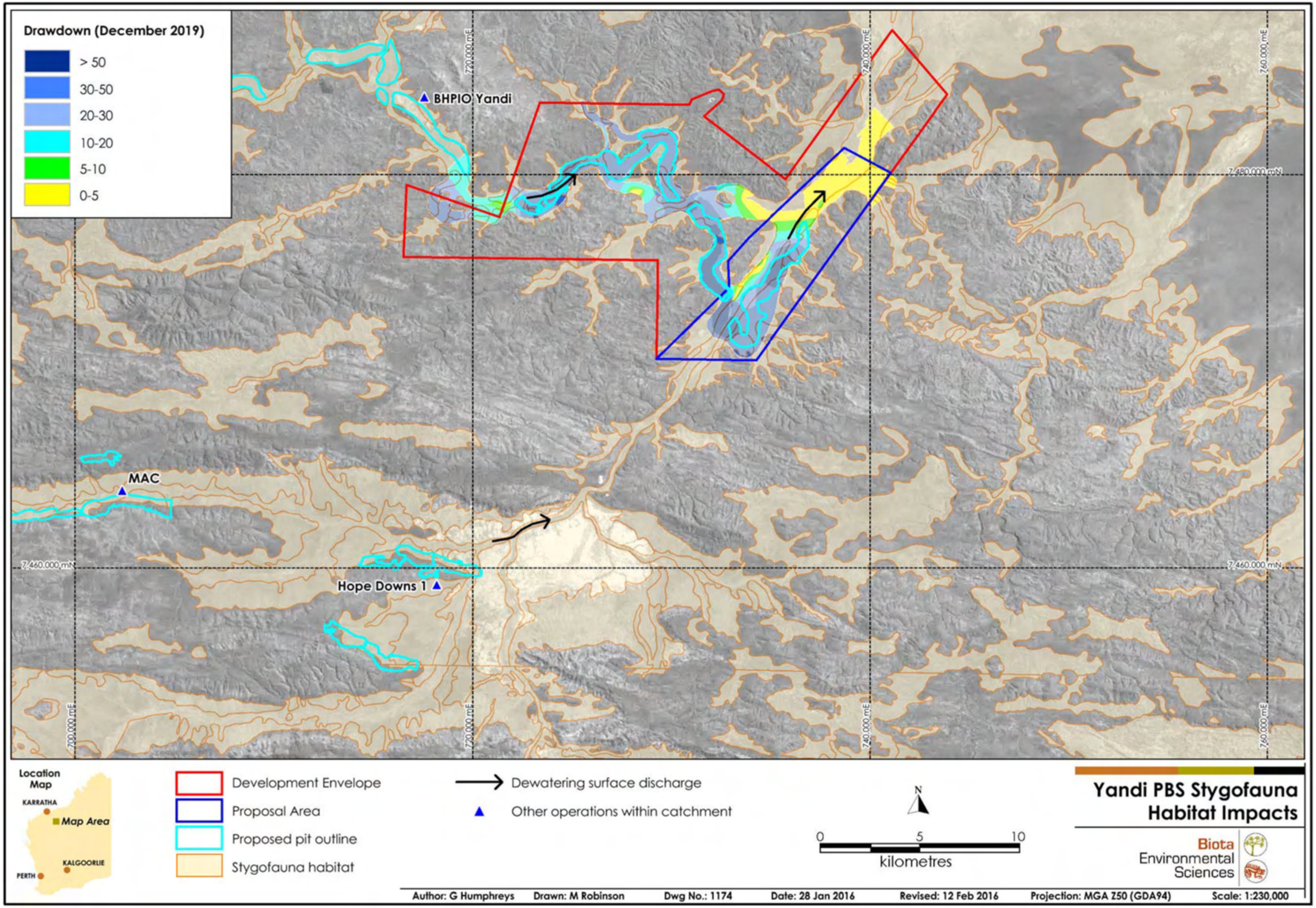

Figure 3.1: Catchment-scale stygofauna habitat, modelled dewatering influence for the Proposal and other developments within the catchment.

Additional localised reductions in stygofauna habitat will also occur in the areas immediately adjacent to the other existing operations in the catchment. However, those other operations also discharge groundwater into the superficial floodplain aquifers of Marillana and Weeli Wolli Creeks, both currently and during the implementation of the Proposal, saturating some habitat areas that would otherwise be seasonally dry or potentially dewatered. This surface discharge of abstracted groundwater into Marillana and Weeli Wolli Creeks has expanded the spatial and vertical extent of stygofauna habitat to date, with the continuous recharge of surface water resulting in maintenance of higher water table levels in the floodplain aquifer compared with baseline conditions (URS Australia 2015). Current predictions are that this will continue to result in surface water flow in at least the low flow channel of Weeli Wolli Creek during implementation of the Proposal (URS Australia 2015). While not originally designed for this purpose, this will provide a level of mitigation to some of the impacts on stygofauna arising from the dewatering required for the current Proposal. Superficial stygofauna habitat in areas downstream of Hope Downs 1 and the current Proposal Area in particular are likely to remain saturated as a result of this process, and again may act as a refuge during the course of the Proposal implementation.

The evidence from compliance sampling for stygofauna at the existing Yandi operations also supports this overall assessment of a low risk of significant change to the stygal community at catchment scale. While dewatering, subsequent surface discharge, and habitat removal at Yandi over the past decade have undoubtedly affected the distribution and local abundance of stygofauna species, the compositon of the overall ecological community has remained stable across the sites during compliance monitoring phases (Biota 2005, 2008, 2009, 2011a, 2011b, 2013).

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