Memo

To: James McMahon

From: Karen Crews and Anna Jacks

Date: 13 December 2022

Subject: Subterranean fauna desktop assessment – Napier Downs Irrigation Project

1 INTRODUCTION

Australian Capital Equity Pty Ltd (ACE) is seeking to develop the Napier Downs Irrigation Project (the Project) located on Napier Downs Station, approximately 77 km east of Derby, Western Australia (WA; Figure 1). The Project will entail the development of centre irrigation pivots which will be used to produce fodder crops for cattle stocked on Napier Downs and nearby stations, with water to be sourced from the Grant Group aquifer.

1.1 BACKGROUND

An application was submitted on 4 December 2018 for a licence to abstract 6.0 gigalitres per annum of groundwater under section 5C of the *Rights in Water and Irrigation Act 1914* from the Canning-Kimberley, Canning-Grant aquifer (IGS 2021). Groundwater in this area is known to have strong potential for use in agricultural, industrial, commercial and domestic applications; however, has been poorly studied in terms of biological values (DOW 2010).

Phoenix (2019) was engaged by ACE in March 2019 to conduct a desktop assessment of subterranean invertebrate fauna in accordance with relevant EPA (2016b) guidance. In December 2021, the EPA released updated guidance for undertaking subterranean fauna assessments for EIA (EPA 2021).

The original desktop review Phoenix (2019) was undertaken for two previous options for the proposed irrigation area (Options 1 and 2). Due to environmental constraints of the first two options, Option 3, located in Scrubby Paddock (Figure 1) was subsequently adopted. A desktop addendum was later prepared specifically for Option 3 (Phoenix 2020). The current Project area (Figure 1) falls partly outside the study area for the Option 3 desktop addendum; however, the desktop is still considered valid for the current Project area.

The desktop review identified 12 troglofauna and one stygofauna species from the desktop search area, a 100 km radius of the Project area, all of which are associated with a single cave within the Napier Range. The literature review however, revealed stygofauna have been recorded from wells bores, cave pools and springs in the wider West Kimberley region (Humphreys 1995; Karanovic 2005a; Karanovic 2005b).

Based on geology and hydrogeology data for the Option 3 study area, the desktop review determined that there is potential for subterranean fauna to occur in underlying habitats. The addendum did not provide comment on habitat suitability for subterranean fauna in the wider area of potential groundwater drawdown from the Project as the H3 hydrogeological assessment had not been conducted at the time reporting. However, the desktop addendum recommended that, as a minimum, a risk assessment for subterranean fauna be conducted based on the findings of the H3 hydrological report for the Project. The Department of Water and Environment Regulation (DWER) subsequently confirmed further investigation into stygofauna at the Project area and area of predicted drawdown is required to inform the groundwater licence application

Phoenix Environmental Sciences Pty Ltd (Phoenix) was therefore commissioned by ACE to conduct a preliminary assessment for subterranean fauna for the Project, in particular if stygofauna were likely to be present and to clarify potential impacts by the Project.

The groundwater drawdown is modelled to be 5 m at the point of extraction over 10 years, with the drawdown decreasing with further distance from the Project area (IGS 2021).

Subterranean fauna are animals, predominantly invertebrates, which have evolved to live underground to escape harsh environmental conditions such as extreme heat and dryness of exposed environments. They are classified into two types:

- troglofauna – animals that live in air-filled subterranean networks
- stygofauna – animals that live in water-filled subterranean networks.

1.2 SCOPE OF WORKS

The scope of work was as follows:

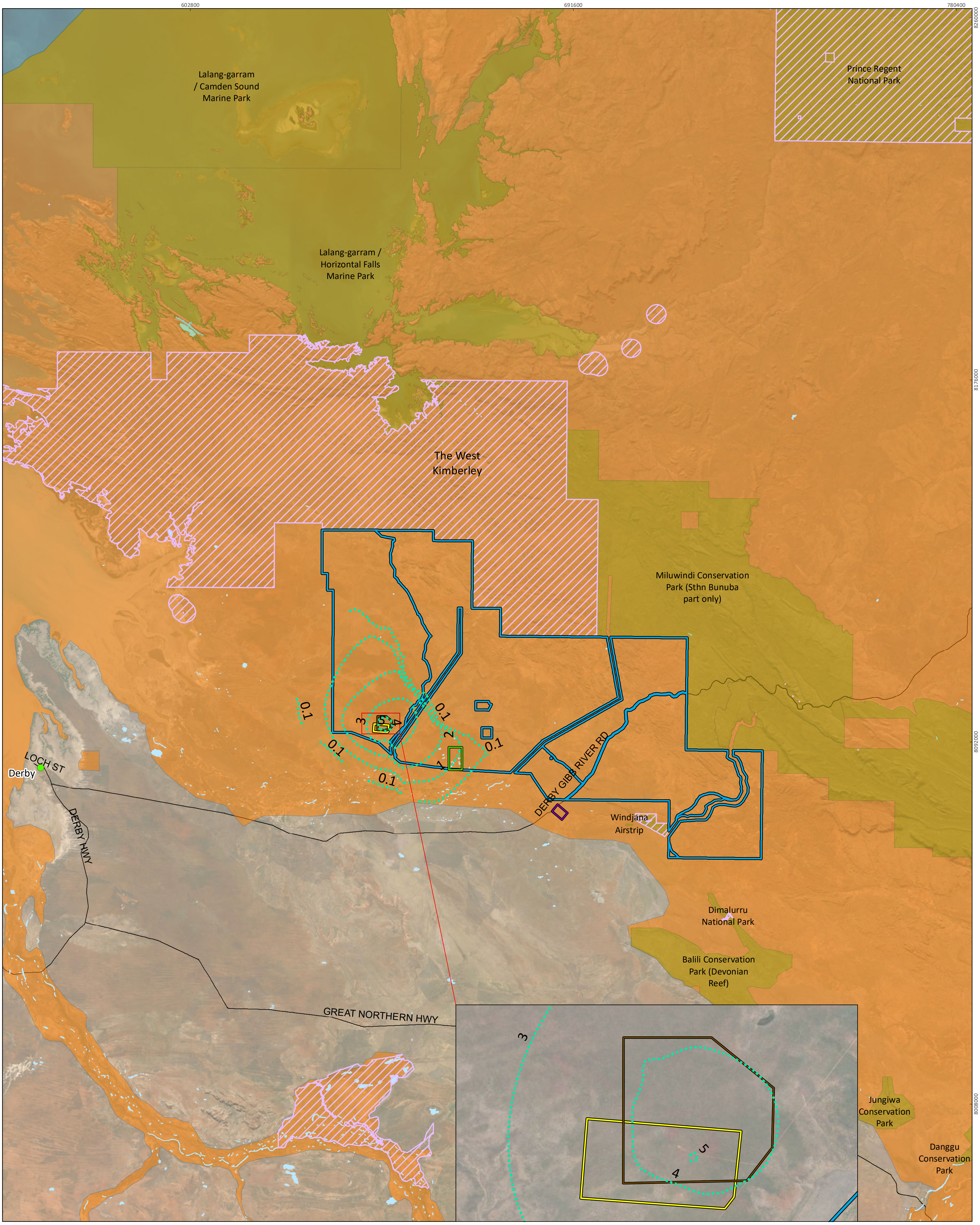
- Review geological and hydrogeological information for the study area to determine if suitable habitat is present for stygofauna.
- Conduct a desktop and risk assessment for subterranean fauna for the Project.

2 STUDY AREA

Napier Downs is a 387,317 ha pastoral station, located 77 km east of Derby, WA. The Project area is located in the south-west corner of the station and at present contains single monitoring and production bores (Figure 1). The study area for this report was the extent of the potential impact area, defined in this report as the modelled extent of drawdown (at the 50^{th} percentile) to < 0.1 m over a 10-year period (Figure 1).

3 METHODS

The presence of subterranean fauna is large determined by geological conditions, including 'vugginess' (presence of cavities) and hydrology, i.e. the presence and quality of groundwater. Therefore, the preliminary assessment reviewed publicly available datasets and publications on geological and hydrogeological conditions at Napier Down Station.



Australian Capital Equity
Napier Downes Irrigation Project

Project No	1545-NAP-ACE-ADV
Date	13/12/2022
Drawn by	BK
Map author	AJ

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Kilometers

1:800,000 (at A3) GDA 1994 MGA Zone 51

Current project area
Napier Downs Station
Previous study areas
Option 1
Option 2
Option 3
Environmentally sensitive areas
DBCA managed land
Lakes
National Heritage places
Drawdown contours at 10 years (50th percentile), Study area at 0.1 m

Figure 1

Project location and study area

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4 RESULTS

4.1 GEOLOGY AND HYDROGEOLOGY

The surface geology of the Project area is comprised of the Czs unit (Figure 2), a cenozoic sandplain comprised of sand or gravel plains; quartz sand sheets commonly with ferruginous pisoliths or pebbles, minor clay; local calcrete, laterite, silcrete, silt, clay, alluvium, colluvium, aeolian sand (Stewart *et al.* 2008). This unit is a reasonably widespread geological type throughout the region, with most of the underlying geology of the Canning Basin covered by cenozoic colluvium and alluvium. There has been little structural movement of the Canning Basin since the Jurassic.

Within the wider study area, six surface geology types ranging in habitat suitability for subterranean fauna are present (Table 1; Figure 2).

Table 1 Surface geology of the study area

Symbol	Unit name	Lithology description	Habitat suitability
Czs	Sand plain	Sand or gravel plains; quartz sand sheets commonly with ferruginous pisoliths or pebbles, minor clay; local calcrete, laterite, silcrete, silt, clay, alluvium, colluvium, aeolian sand	Low to High – depending on level of porosity
Qa	Alluvium	Channel and flood plain alluvium; gravel, sand, silt, clay, locally calcreted	Moderate to High – depending on level of porosity
Qrlb	Black soil plain	Residual black, dark grey or brown clayey soil	Low
Qd	Dunes	Dunes, sandplain with dunes and swales; may include numerous interdune claypans; residual and aeolian sand with minor silt and clay; aeolian red quartz sand, clay and silt, in places gypsiferous; yellow hummocky sand	Low
DClf	Fairfield group	Limestone, shale, siltstone, sandstone, dolomite	High – depending on level of porosity
Czl	Ferruginous duricrust	Pisolitic, nodular or vuggy ferruginous laterite; some lateritic soils; ferricrete; magnesite; ferruginous and siliceous duricrusts and reworked products, calcrete, kaolinised rock, gossan; residual ferruginous saprolite	Moderate to High – depending on level of porosity

The hydrogeology of the study area comprises of primarily of Sedimentary Rocks – extensive and deep aquifers, comprised of the Poole Sandstone which overlies the Canning – Grant Group geology. Both Poole Sandstone and Grant Group are lithologically very similar and are considered a single aquifer system (Taylor *et al.* 2018). The Grant Group is geologically described as: sandstone; minor shale and siltstone. It is a very thick sedimentary sequence consisting mainly of Carboniferous and Permian sandstones, with minor Devonian sandstone on the northeast margin included with the aquifer (DWER 2020). The Grant Group-Poole sandstone aquifer extends dozens of kilometres north-west and south-east of the Project area (IGS 2021). The potentiometric groundwater level and interpolated aquifer base elevation within the Project area is approximately 41.23 m and 250 m AHD respectively, giving a total aquifer depth of approximately 209 m (IGS 2021). Within the study area, groundwater levels generally become increasingly shallower towards the south-west, and deeper towards the north-west, while the interpolated aquifer base elevation becomes increasingly deeper in the south-west and shallower in the north-east (IGS 2021), resulting in an increased total aquifer depth in the south-west of the study area and a decreased aquifer depth in the north-east of the study area (Figure 4).

Aquifers in this group are unconfined and recharged directly by rainfall and possibly by river flow. Groundwater flow is to the southwest, possibly into Permian sediments (Grant Group) (Smith 1992). Hawkstone Creek is located approximately 3.3 km east of the Project area and flowing in a north-south direction. Lennard River is a larger river located approximately 13 km south of the Project area and flows in an east-west direction. Ngooderoodyne Spring is located approximately 13 km west of the Project area. It is a surface expression of the underground aquifer system.

The hydrogeology of the south and south-westerns portion of the study area, respectively comprises of Surficial Sediments - Shallow Aquifers, and Rocks of Low Permeability, Fractured and Weathered Rocks - Local Aquifers.

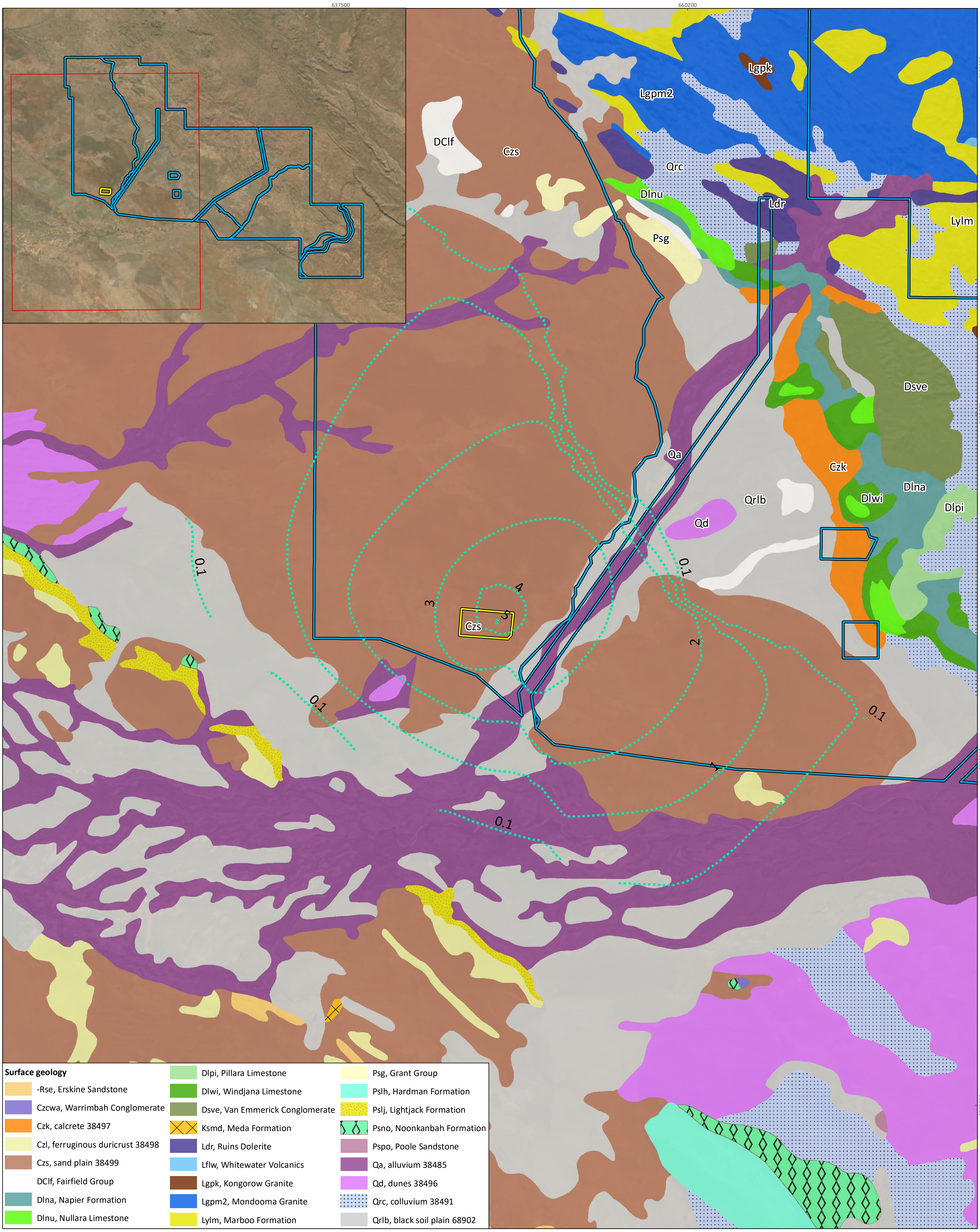
The Napier Ranges lie outside of the study area to the north-east. The hydrogeology of the Napier Ranges comprises of much older, igneous and metamorphic rocks including the Paperbark Supersuite (granites), Marboo Formation (metasandstone and phyllite), Whitewater Volcanics, and Ruins Dolerite; and Devonian-age sedimentary rocks including the Fairfield Group (limestone, shale and siltstone) and various reef limestone complexes to the north-west of the study area (IGS 2021).

Drill logs of the monitoring and production bore at Scrubby (NDSMB01; Figure 5 and Figure 6), the bore within the Project area, indicate Pindan soils – deep red, silty or clayey earthy sands that are well to rapidly drained (Smolinski *et al.* 2016) – and fine deep red soils occupy the top 6 – 12 m. These are underlain by weathered or fine to medium grain sandstone. Below the water table is predominately comprised of white fine, or fine to medium grained sandstone to the depth of the bores (102 m and 115 m respectively). The water table begins at approximately 30 m bgl (below ground level).

Salinity (TDS) in the region generally ranges from 250 – 500 mg/L (DWER 2009); however, records from NDSMB01 at Scrubby recorded a TDS of 74 mg/L, with surrounding bores recording between 49 – 290 mg/L (IGS 2021).

Table 2 Aquifers of the study area

Aquifer	Habitat suitability
Sedimentary Rocks - Extensive and Deep Aquifers	Suitable habitat depending on level of porosity of rocks. This aquifer type is generally unconfined and is the most widespread within the study area.
Rocks of Low Permeability, Fractured and Weathered Rocks - Local Aquifers	Suitable habitat depending on level of porosity. Where Rocks of Low Permeability (aquicludes) are present in association with fractured or weathered rocks, this may produce highly isolated habitats.
Surficial Sediments - Shallow Aquifers	Suitable. This habitat type is generally shallow and unconfined.



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Kilometers

1:227,000 (at A3) GDA 1994 MGA Zone 51

Current project area
Napier Downs Station
Drawdown contours at 10 years (50th percentile), Study area at 0.1 m

Figure 2

Surface geology of the study area

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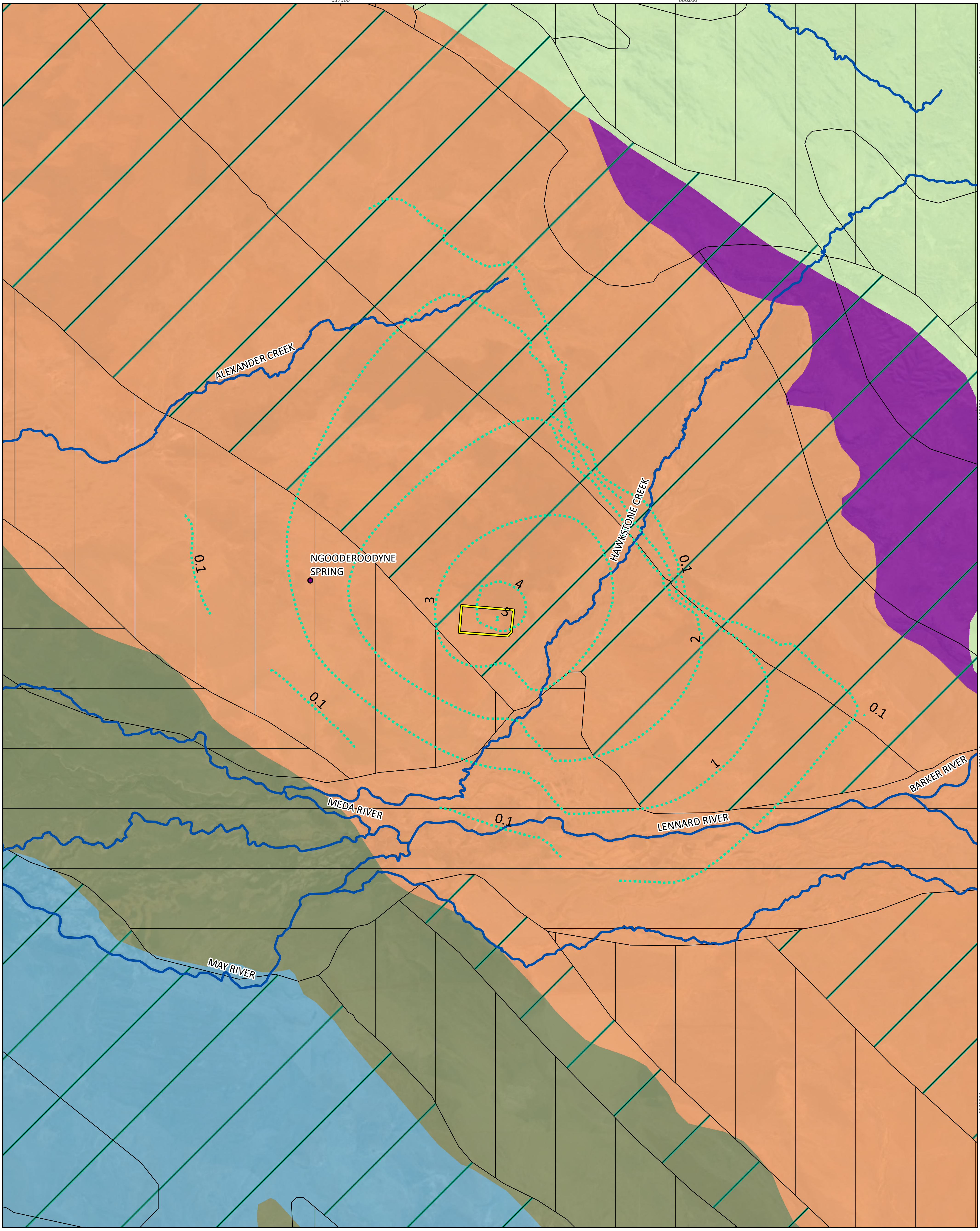

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Map author	AJ

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Study area (Option 4)

Aquifer name (WRIMS)

- Canning - Erskine, Unconfined
- Canning - Grant, Unconfined
- Canning - Limestone, Unconfined
- Canning - Liveringa, Unconfined
- Combined - Fractured Rock Central, Unconfined

Aquifer type

- Rocks of Low Permeability, Fractured and Weathered Rocks - Local Aquifers
- Sedimentary Rocks - Extensive And Deep Aquifers
- Surficial Sediments - Shallow Aquifers
- P50 10 years

Figure 3

Hydrogeology of the study area

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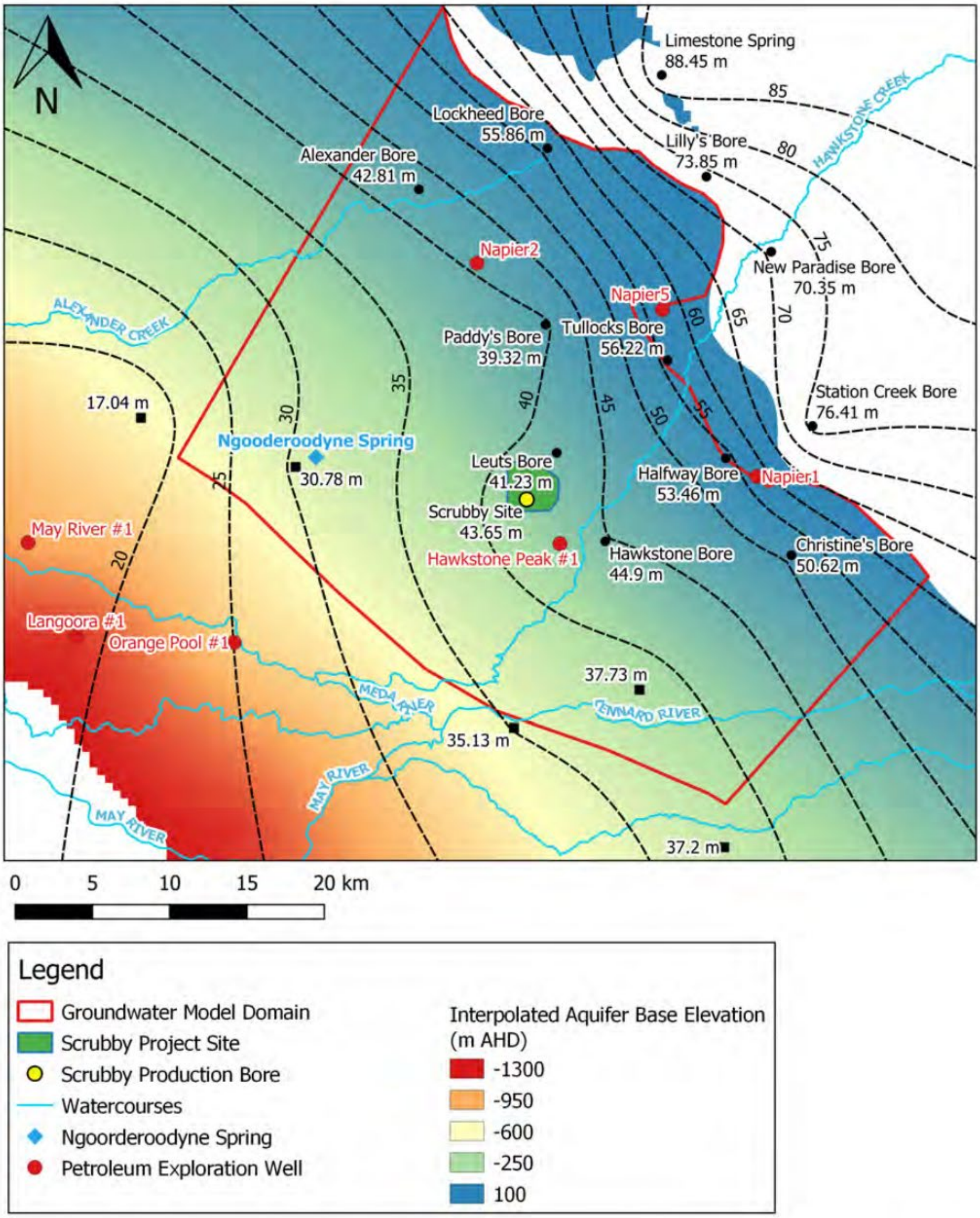


Figure 4 **Hydrogeology map showing combined Grant Group/Poole Sandstone aquifer extent, interpolated aquifer base elevations and potentiometric groundwater levels (IGS 2021)**

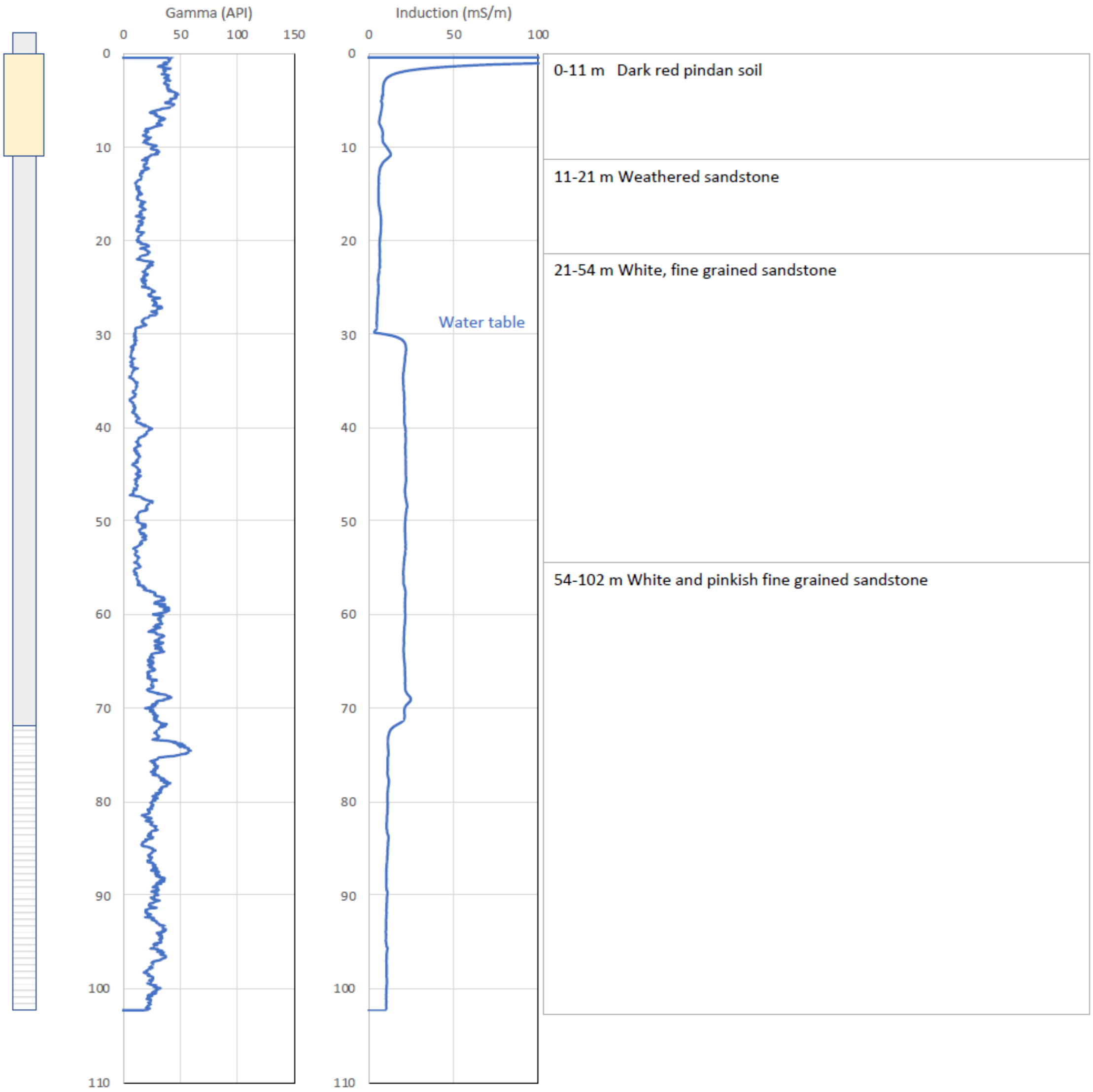


Figure 5 Scrubby monitoring bore NDSMB01 construction, downhole geophysics and lithology log (IGS 2021)

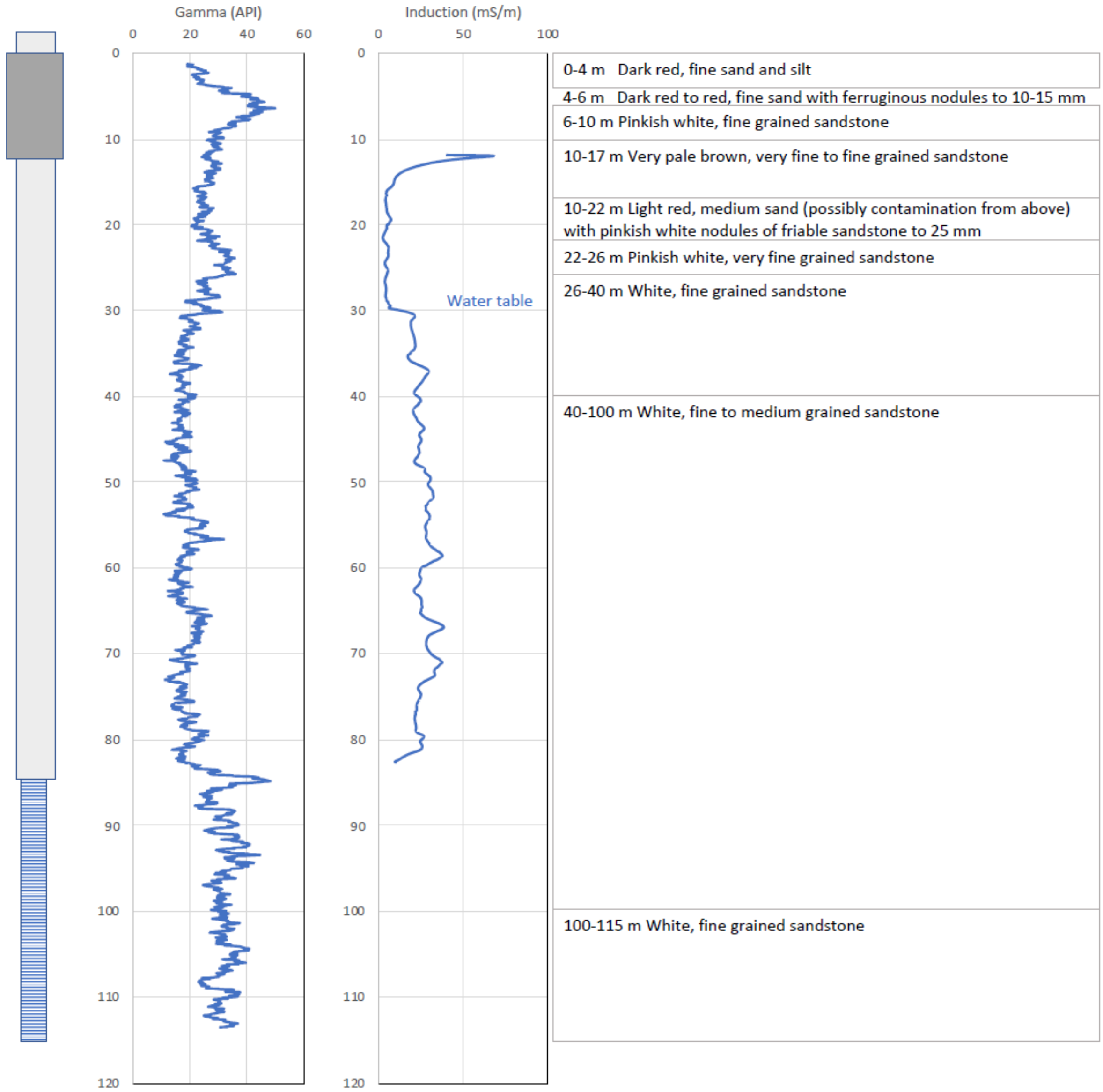


Figure 6 Scrubby production bore NDSMB01 construction, downhole geophysics and lithology log (IGS 2021)

4.2 SUBTERRANEAN FAUNA

There is little information on subterranean fauna of the Kimberley; however, stygofauna have been documented from a range of geologies within the region and troglofauna have been recorded from cave systems. Within the desktop review area, one species of stygofauna and 12 species of troglofauna have been recorded (Phoenix 2019) (Figure 7).

4.2.1 Stygofauna

The single stygofauna species, *Candonopsis kimberleyi* (Karanovic 2002) is a stygobitic ostracod recorded from 25 km east of the study area. The location of these specimens lies within the Canning

– Limestone aquifer where Devonian limestones outcrop and form the Windjana and Geike Gorges. The limestone is a distinct aquifer in the Canning Basin and exhibits karst features (DWER 2020) and extends down the north-east margin of the Canning Basin.

Regionally, several other records of stygofauna are known to occur:

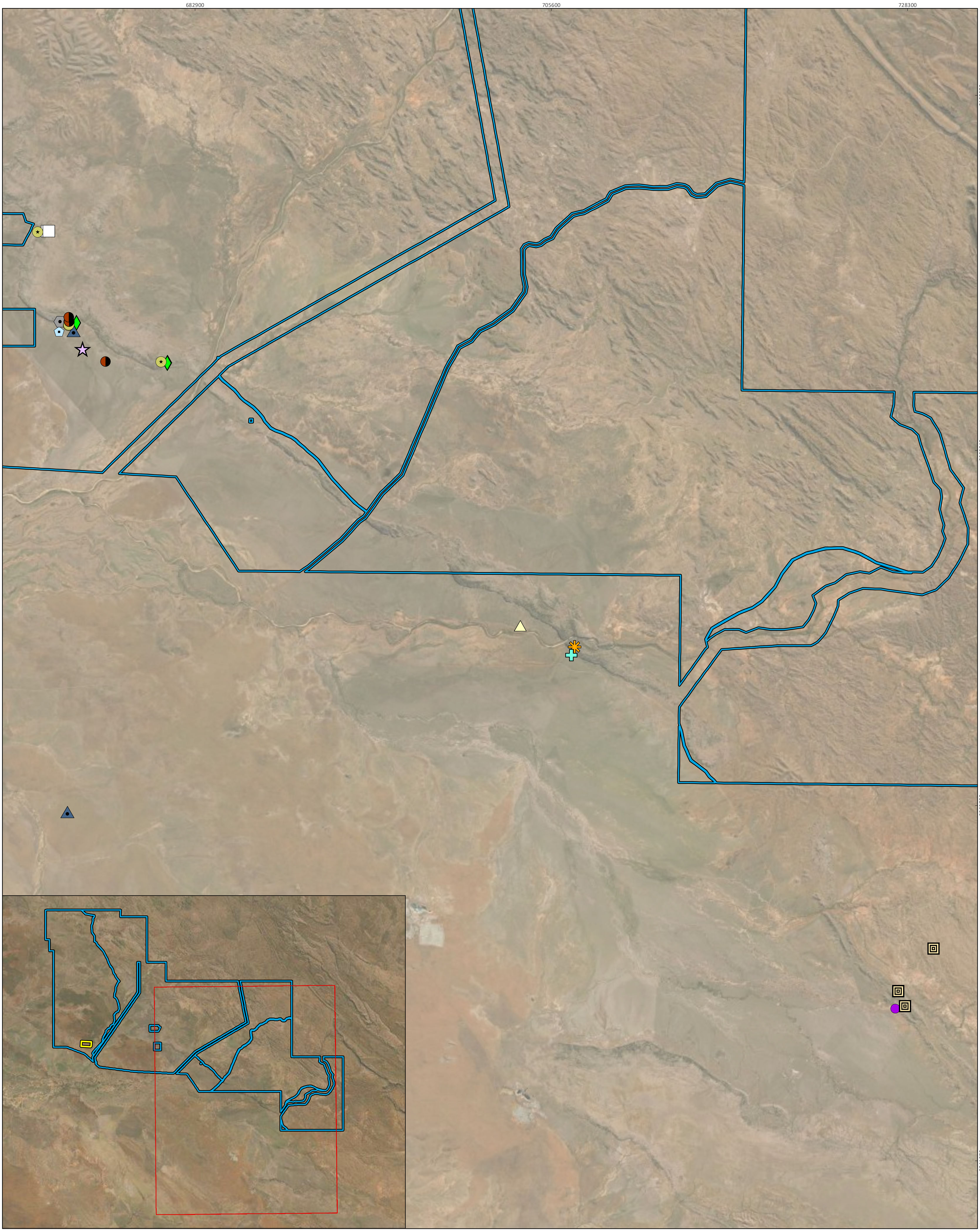
- Karst aquifers of the Ord River Irrigation Area (ca. 480 km east of the study area) are known to contain stygofauna communities in the north-east of the Kimberley, including syncarids, copepods, ostracods, oligochaetes and oribatid mites from alluvial sediments (Cho *et al.* 2005; Humphreys 1999).
- Stygofauna sampling for the Argyle Diamond Mine (ca. 400 km east of the study area) in the northeast Kimberley identified at least 15 species of stygofauna (EPA 2005 in Rockwater 2012) including four stygobitic copepods, two stygobitic ostracods, and at least two stygobitic syncarids (Humphreys 2003). These records were retrieved from fractured rock aquifers in granites.
- Subterranean fauna surveys in the Broome Sandstone aquifer as part of an industrial development near Broome and reference sites at Nita Station (ca. 230 km east of the Project) recovered a total of at least 18 stygofauna species in in six higher taxa (Copepoda, Nematoda, Oligochaeta, Syncarida, Gastropoda, Ostracoda and Rotifera) (Rockwater 2012).

4.2.2 Troglofauna

All 12 taxa of troglofauna from the desktop review area come from known cave systems and have been collected by speleologists by hand (i.e. not surveying boreholes) from caves in the Napier Ranges.

- *Apozomus eberhardi* – a schizomid (whip-tail scorpion)
- Assamiidae sp. – a harvest spider
- *Bamazomus hunti* – a schizomid (whip-tail scorpion)
- Cheierididae sp. – a pseudoscorpion
- *Cheieridium* 'sp. nov.' – a pseudoscorpion
- Eukoeneniidae sp. – a mite, also known from 42 km SE. of the study area; however these two records are not likely not be synonymous
- Hubbardiidae `SCHAAC` `SCH093` – a schizomid (whip-tail scorpion)
- *Indohya napierensis* – a pseudoscorpion
- Paradoxosomatidae sp. – a millipede, possibly *Stygiochiropus*
- *Stygiochiropus* 'sp. Napier Range' – a millipede
- *Tainisops napierensis* – an isopod
- *Wandella infernalis* – a spider.

Regionally, very few other records of troglofauna are known to occur. A single troglofauna species, an isopod *Troglarmadillo* sp. B25, was collected near Broome at Nita Station (Rockwater 2012) approximately 235 km west of the Project area. Little more is known about this record.



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Kilometers

1:221,000 (at A3) GDA 1994 MGA Zone 51

Study area (Option 4)
Napier Downs Station

Troglofauna (cave)
Apozomus eberhardi
Assamiidae sp.
Bamazomus hunti
Cheiridiidae sp.
Cheiridium `sp. nov.`
Eukoeneniidae sp.
Hubbardiidae `SCHAAC` `SCH093`
Indohya napierensis
Paradoxosomatidae sp.
Stygiochiropus `sp. Napier Range`
Tainisopus napierensis
Wandella infernalis

Stygofauna
Candonopsis kimberleyi

Figure 7

Desktop records of subterranean fauna

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5 DISCUSSION

The EPA's objective for subterranean fauna is its protection so that biological diversity and ecological integrity are maintained (EPA 2021). Subterranean communities are often restricted to very small areas based on the limited dispersal capabilities of the fauna, with short-range endemism interpreted at a much smaller scales than in terrestrial systems (Eberhard *et al.* 2009). Therefore, activities that may impact on subterranean assemblages require attention at a much smaller scale.

A number of factors contribute to the likelihood of subterranean fauna to occur, including sediment texture, hydraulic conductivity (controlling food and oxygen supply), depth from surface, water regime (timing, frequency, duration, extent and depth, and variability), energy (food) flow (in the form of dissolved organic matter, salinity, dissolved oxygen (DO) and redox status of the groundwater (Subterranean Ecology 2010). Independent of all other factors, salinity appears to be the main limiting factor for the occurrence of stygofauna. The majority of non-marine stygofauna are intolerant to salinity. Most are found in freshwater (<3,000 mg/L TDS) but some will tolerate water with salinities above this level. Stygofauna have been collected in saline waters (3,000-70,000 mg/L TDS) in calcrete formations in the Yilgarn and Nullarbor regions of WA (Cooper *et al.* 2008; Humphreys *et al.* 2004).

Based on the geology and hydrogeology present, the Grant Group aquifer, may provide the conditions for stygofauna to occur in study area. Stygofauna are likely where there are groundwater voids present, for example in karst limestone, calcretes, alluvial formations and fractured rock (EPA 2016a). Troglofauna are not likely to occur in the study area. Habitats likely to support troglofauna are karstic limestone, channel iron deposits (in particular pisolite in inverted landscape geomorphology), groundwater calcretes above the water table, alluvium/colluvium in valley-fill settings, banded iron formations and weathered and fractured sandstone.

5.1 IMPACT ASSESSMENT

This impact assessment is conducted under the assumption that stygofauna fauna communities are present at Napier Downs Station.

Impacts to subterranean fauna can be classed as either:

- **primary impacts** – impacts that physically destroy the subterranean void networks
- **secondary impacts** – impacts that change the subterranean habitat without physically destroying the void networks.

Primary impacts are obvious, whereas secondary impacts tend to be cumulative and may affect a far greater area than that being developed (Hamilton-Smith & Eberhard 2000). There are commonly two key threatening processes from development activities that impact subterranean fauna through the direct loss of habitat:

- **Removal of habitat** – the most obvious primary impact to subterranean habitats occurs as a result of their physical removal, for example during mining. Troglofauna require air-filled void networks and most of this habitat exists in the overburden, which is typically destroyed during pit construction/excavation. Similarly, direct loss of stygofauna habitat may be caused by the removal of geological formations if any aquifers are associated with these formations.
- **Depletion of an aquifer leading to loss of stygofauna habitat** – depletion of an aquifer that is identified as suitable for stygofauna represents a direct loss of stygofauna habitat. The significance of the impact is dependent on the depth of drawdown, the size and extent of the aquifer and the connectivity of the aquifer with adjacent habitat for stygofauna.

Secondary impacts are those that affect the physicochemical properties of subterranean habitats. The nature of these changes can be difficult to measure and there is limited empirical evidence to support or refute these putative impacts. There are two secondary impacts that may be relevant to the Project:

- **Depletion of an aquifer leading to altered relative humidity** – troglofauna are dependent on high relative humidity. Dewatering may impact troglofauna habitat in unsaturated strata above the water table by lowering relative humidity.
- **Contamination** – contamination of subterranean habitats from spills, such as diesel fuel, or excessive nutrient run-off may degrade the quality of subterranean habitats. Such impacts would generally be highly localised and minor in scale; however, major contamination of subterranean habitats may have significant impacts.

5.1.1 Stygofauna

The loss of stygofauna habitat due to a drawdown of the aquifer is considered the main potential impact by the Project.

Groundwater changes based on modelled (P50) water abstraction for the Project are predicted to be about 5 m at the extraction site over 10 years, which must be considered very small, in relation to its saturated thickness, which extends approximately 200 m bgl within the Project area (IGS 2021). Further to this, the depth of drawdown is expected to decrease rapidly moving away from the site (Figure 8).

Optimal stygofauna habitat is likely to occur with increasing depth, as the substrate is getting coarser with depth, in particular 40 – 70 m bgl range, where the substrate is the most coarse, and access to nutrients high. Given the water table begins at 30 m bgl a top drawdown of 5 m will not affect stygofauna.

Use of farming equipment (organic spills) and fertilizer has the potential to contaminate the groundwater, although taking the depth to groundwater into account, the risk is considered very low if properly managed and potential scale of impact very small considering the nature of the Project.

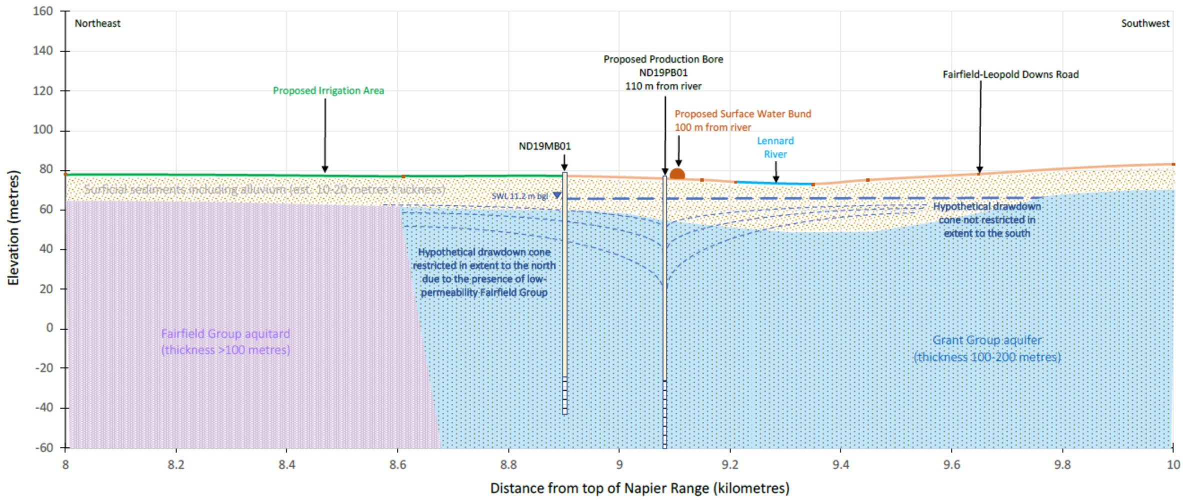

Figure 2B. Conceptual hydrogeological cross-section focussing on the proposed irrigation area adjacent Lennard River. Hypothetical drawdown cones are shown for illustrative purposes to demonstrate how drawdown in water level/pressure will be limited to the north, thereby circumventing impacts to ecologically and culturally sensitive sites within the Napier Range (see Figure 2A for location).

Figure 8 Conceptual hydrological cross-section showing hypothetical drawdown contours (IGS 2021)

5.1.2 Troglofauna

The troglofauna recorded from the desktop review are from cave systems of Devonian reef origin within the Napier Ranges. A previous survey in Broome Sandstone approximately 230 km west of the Project area provided limited evidence of significant troglofauna assemblages to occur, with only a single specimen of a subterranean isopod (*Trogloarmadillo* sp.) collected in a total of 118 samples, although it has to be considered that sampling techniques mainly targeted stygofauna (Rockwater 2012).

Potential impacts of the proposed Project on troglofauna are considered negligible. There will be no direct removal of troglofauna habitat and the small extent of groundwater drawdown relative to saturated thickness of the aquifer is considered highly unlikely to significantly alter relative humidity of troglofauna habitat.

6 CONCLUSION

It is possible the underlying aquifer supports a community of stygofauna given suitable habitat and water quality. Water abstraction will result in the loss of possible stygofauna habitat by approximately 5 m of the aquifer at the point of abstraction within 10 years. This is less pronounced moving further away from the Project area. This predicted loss of habitat within an aquifer depth of 200 m, which has no obvious geological barriers for dispersal should be considered negligible for stygofauna. Consequently, subterranean fauna should not be considered a key environmental factor for the development of the Project.

Anna Jacks

Invertebrate Section Manager

Phoenix Environmental Sciences

anna.jacks @phoenixenv.com.au

6323 5410

2/3 King Edward Road, Osborne Park WA

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