




# SUBTERRANEAN FAUNA HABITAT ASSESSMENT

## HEMI GOLD PROJECT

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## 1. INTRODUCTION

De Grey Mining Limited (De Grey) is proposing to develop the Hemi Gold Project (Hemi) located in the Pilbara Region of Western Australia, approximately 60 km south of Port Hedland in the Town of Port Hedland (Figure 1-1).

Sampling for subterranean fauna conducted by Bennelongia (2023) consisted of three rounds of sampling for stygofauna and a single round of sampling for troglifauna. Sampling occurred between October 2021 and October 2022 with a total of 20 troglifauna and 120 stygofauna samples collected during the survey.

Forty bores and drill holes were sampled three times for stygofauna, with 19 of these being in the proposed mine pits or nearby in areas expected to be affected by dewatering. The other 21 were outside the area of groundwater drawdown and are treated as 'reference' sites. They were mostly pastoral bores.

Twenty drill holes were sampled once for troglifauna with 13 of the holes being inside the proposed mine pits and seven being outside and treated as 'reference' sites.

A targeted survey for stygofauna was also completed in early 2024, which sampled 33 sites (Bennelongia 2024)

The surveys collected at least 52 stygofauna species. The major groups of stygofauna collected were amphipods, isopods, syncarids, ostracods, copepods, oligochaete worms along with nematode worms and rotifers. Twenty-six species were collected from within the Project impact area (defined as the area of  $\geq 1$  m of Project associated groundwater drawdown), with five species known only from within the area of  $\geq 1$  m groundwater drawdown associated with mine pit dewatering. It is probable, based upon extent of habitat availability with limited barriers to dispersal, that all five species have local occurrence outside the Project.

One species of troglifauna was collected during the survey. This species is currently only known from the Project area, where two specimens were collected from within the proposed Hemi mine pit. The low number of troglifauna species collected is likely due to the shallow water table in the Project area, which limits the available habitat for troglifauna.

Multiple sampling campaigns for stygofauna at Hemi resulted in a significant reduction in the number of potentially restricted species. This trend in reducing the numbers of potentially restricted species in successive sampling campaigns is evidence that species do not appear to be inherently restricted at a regional scale, and more so reflects the challenges of characterising the subterranean assemblage.

A full characterisation of the distribution and abundance of subterranean fauna is not practicable, and as such other deterministic steps to confirm the likelihood of occurrence more regionally have been accepted by the EPA historically, and widely employed by industry. EPA have recognised through their Technical Guidance (EPA, 2021) that the assessment of subterranean fauna is often more complex than for other biodiversity factors due to limited knowledge of species distributions and habitat requirements and due to the inherent challenge of characterising assemblages using available survey techniques.

In recognition of the challenges of fully characterising the distribution and abundance of subterranean fauna through sampling alone, this study focusses on the availability and extent of relevant habitat to demonstrate landscape and/or genetic connectivity. This work was done to confirm the availability of habitats in the region, and the potential for subterranean fauna to move between them.

Assessing and modelling subterranean habitats in three dimensions (3D) facilitates the visualisation and quantitative estimation of suitable subterranean habitats within specific modelled boundaries. Rather than representing planar, two dimensional (2D) potential areas of occupancy for subterranean species, 3D estimates include representation of the likely depth or thickness of suitable geological/hydrogeological strata (i.e., the 3D extent of subterranean habitat) throughout the modelling area. Volumetric calculations can quantify the proportion of suitable habitat subjected to loss or reduction by the proposed impacts, relative to the wider extent of potential habitat remaining unaffected.

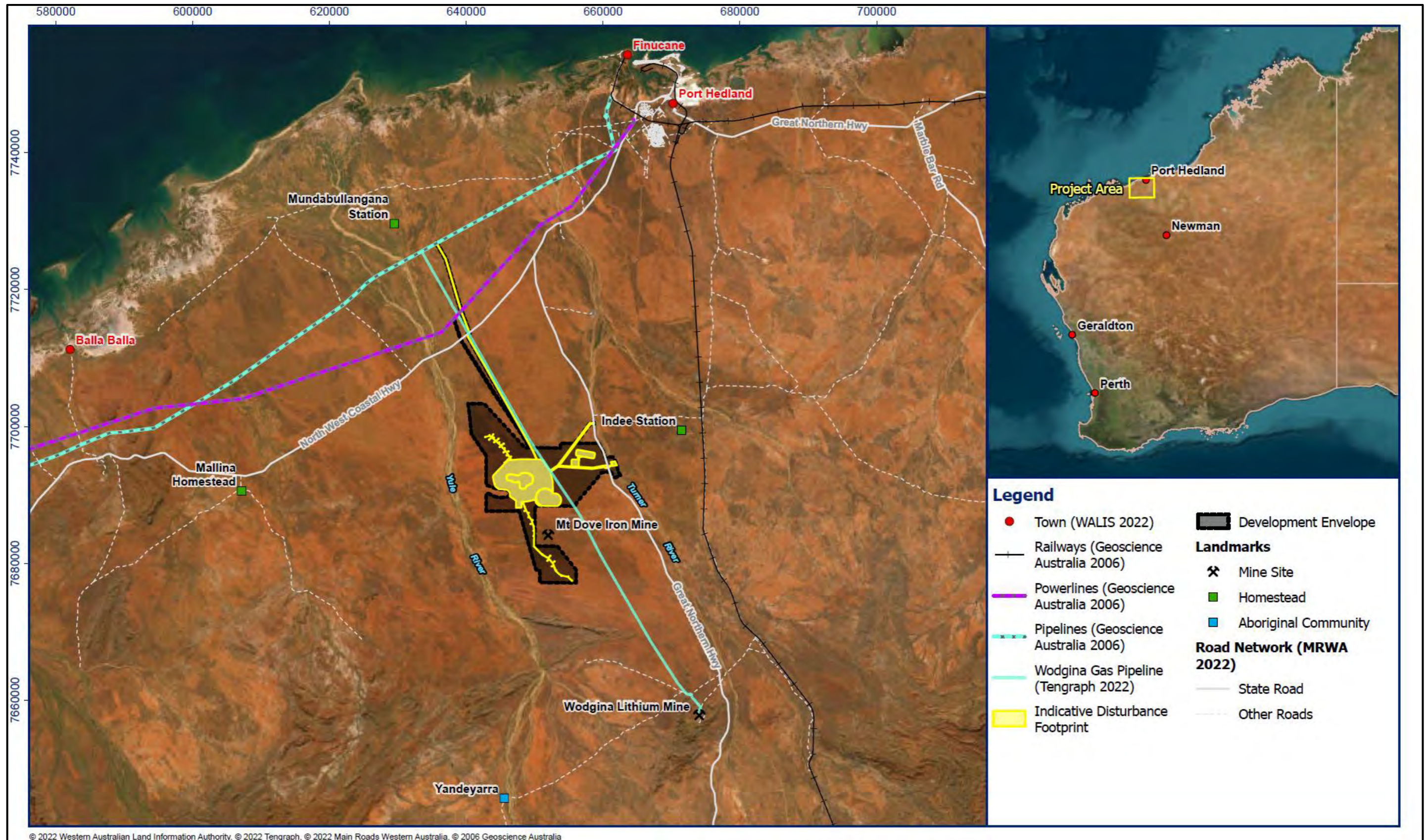


Figure 1-1: Location Plan

## 2. SCOPE

Based on the recognition of the challenges of fully characterising the distribution and abundance of subterranean fauna, and considerations for alternate strategic and risk-based approaches focusing on the extent of relevant habitat to demonstrate landscape and/or genetic connectivity, the purpose of this study was to:

- Investigate and confirm the geological parameters that support subterranean fauna which can be assigned as habitat. This work was done to determine whether there were:
  - Any geological parameters that controlled the presence or absence of subterranean fauna within the landscape.
  - Any geological parameters that controlled the presence of potentially restricted subterranean fauna species within the landscape.
- Investigate regional geological datasets in 3D to confirm the likely presence, and continuity of habitat inside and outside of areas that may be impacted by the proposed project. This work was done to confirm the availability of habitats in the region, and the potential for subterranean fauna to move between them.

## 3. BACKGROUND

### 3.1 Exploration History

Hemi lies within the Pilbara Craton of Western Australia. The Pilbara district is the site of some of the earliest recorded gold discoveries in Western Australia. Several of these early discoveries lie on De Grey's current tenements, and with recent drilling now forming part of De Grey's overall gold resource base for the Mallina Gold Project (MGP). One of the earliest reported Pilbara gold discoveries was 40 km west of the Hemi Gold Project, at the Mallina deposit in 1888.

De Grey held the tenement hosting Hemi for almost 20 years before the discovery. Previous phases of exploration by the company included aircore drilling and soil sampling. During 2018/2019, De Grey completed 48.6km of aircore drilling at various prospects across the tenement package. The Hemi discovery, in late 2019, resulted from the broad-spaced, regional Mt Berghaus West drilling program, with 19.7km of aircore completed in this program to the end of 2019.

Subsequent drilling has now defined the current JORC 2012 Mineral Resource Estimate (MRE) 2023 of 255 million tonnes grading at 1.3 g/t gold for 10.5 million ounces at Hemi. The MRE underpins the Hemi reserves of 121 million tonnes grading at 1.5 g/t gold for 6 million ounces of gold.

All available drill holes have been drilled from surface and have been used to develop a detailed geological understanding of the project area (Section 3.4). The available drilling data provides an unprecedented scale of advanced geoscientific datasets. These critical datasets significantly add to the accuracy of the models.

Detailed studies of the main mineral deposits in the terrane have been carried out by De Grey for the Definitive Feasibility Study. These collective efforts have resulted in a well-documented geological and hydrogeological understanding of the region, including regolith style, regolith lateral and vertical extents, alluvial and paleochannel distribution and the nature and age relations of the underlying basement rocks.

### 3.2 Regional Geology

Hemi is located on the western side of the Archean aged Pilbara Craton in Western Australia. The project area is dominated by a broadly east northeast to west southwest trending Archaean greenstone and meta-sediment sequences that have been complexly folded and structurally deformed by regional deformation and the emplacement of granitic batholiths and smaller localised intrusions as shown in Figure 3-1.

The Pilbara Craton is subdivided into three main terranes, the West Pilbara Superterrane ("WPS"), the East Pilbara Terrane ("EPT") and the Kurrana Terrane ("KT") as shown in Figure 3-2. The De Grey

Superbasin occurs around the margins of the EPT and contains the Central Pilbara Tectonic Zone (“CPTZ”) to the west and the Mosquito Creek Basin (“MCB”) to the east.

Hemi occurs within the CPTZ of the De Grey Superbasin. The western De Grey Supergroup, of the supracrustal De Grey Superbasin, is comprised of the Mallina Basin rift-basin depository. This basin is interpreted to be a continental rift basin and is divided into the underlying Constantine Formation and the overlying Mallina Formation. The Warrawoona Group and Cleaverville Formation form the basement rocks to the De Grey Supergroup.

The basal Constantine Formation comprises conglomerate, arkose sandstone and shale and the Mallina Formation is comprised of shales, siltstones, wackestones and turbiditic sedimentary rocks sequences. The Constantine Formation can form topographic highs whereas the Mallina Formation typically outcrops very poorly and is predominantly covered by Phanerozoic aeolian, alluvium, colluvium and other chemical pedolith.

The Mallina Basin was intruded by mafic-ultramafic sills of the Indee and Langenbeck Suites during basin development through to proto-inversion. These intrusions are present as extensive, thin sills in the lower half of the basin and as intermediate to felsic granitoid bodies that intruded the basin and its margins. The fractionated suite, in the Mallina Basin, are interpreted to be syn-deformational to post-deformational in the timing of their emplacement and it is interpreted that the location and emplacement of the intrusions is associated with major, trans-lithospheric structures.

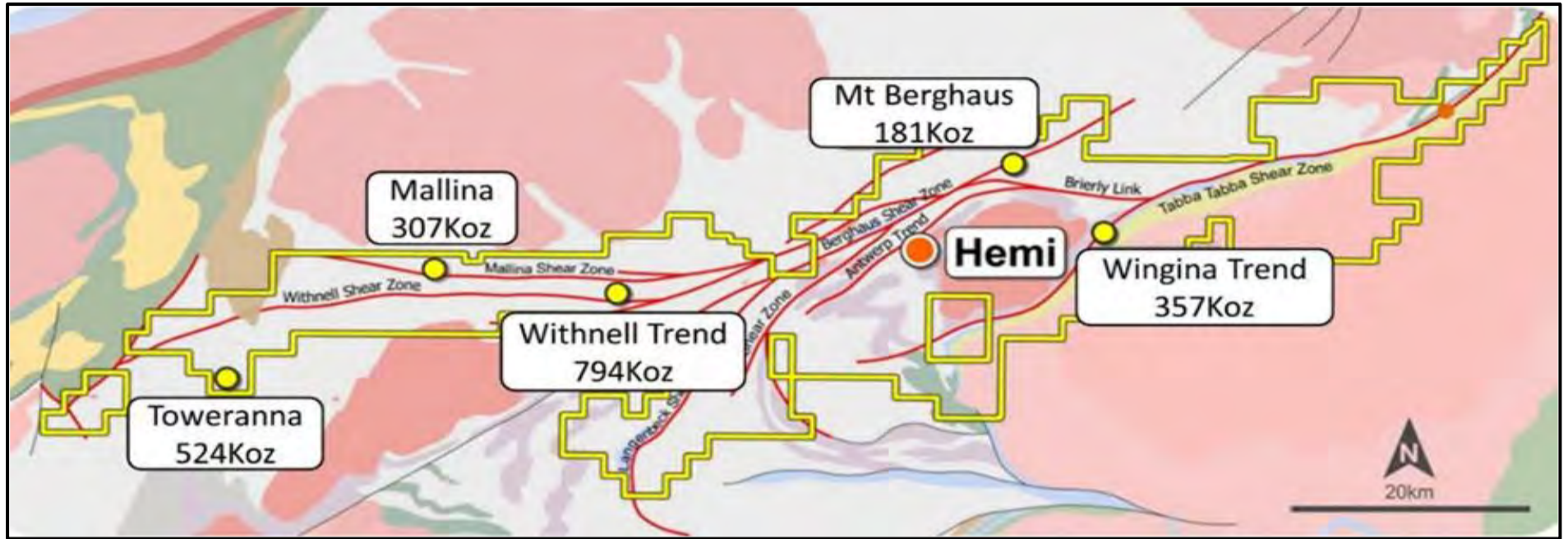
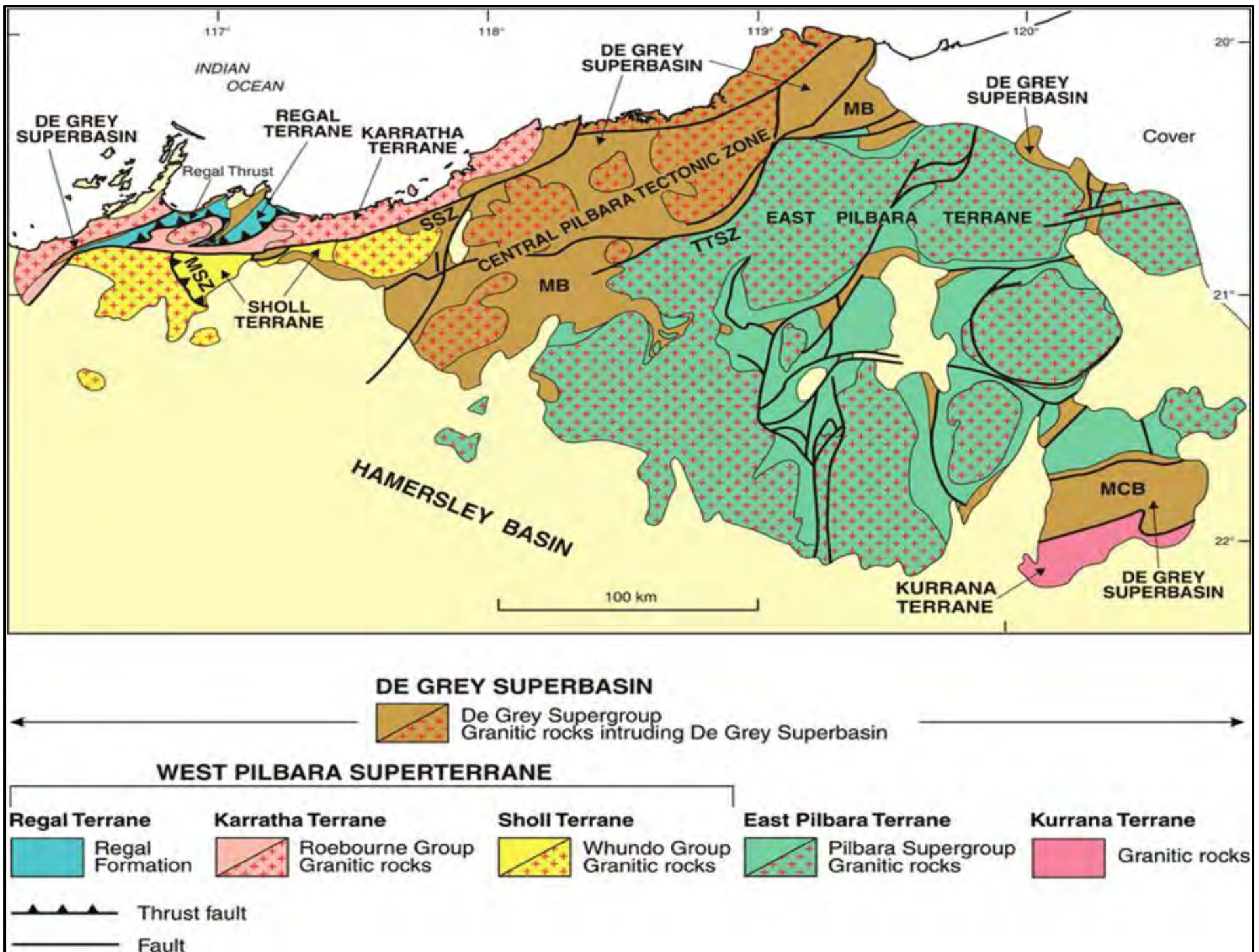


Figure 3-1: Pilbara Gold Province Geological Setting



(Van Kranendonk et al., 2007)

Figure 3-2: Simplified Geology Map of the Pilbara Craton, showing Terranes and Major Structures

## 3.3 Local Geology

Hemi comprises a series of gold deposits hosted within predominately diorite to quartz diorite intrusions and sills that have been emplaced within the Mallina Basin. The gold deposits comprise of Aquila, Brolga, Crow, Falcon, Diucon and Eagle, with the latter two straddling the locally important Diucon Thrust and the former four being situated to the south of the Diucon Thrust.

The intrusions in the Hemi area were emplaced into a sequence of sedimentary rocks that form part of the Mallina Formation and locally comprise greywacke, siltstones, sandstones, shale and black shale. Mafic-ultramafic sills occur within the area, which help to map the interpreted folding and faulting within the region around the Hemi discovery amongst the otherwise poorly outcropping and non-magnetic sediments of the Mallina Formation. The sediments immediately enclosing the intrusions have largely been strongly sheared but in limited instances the contact is hornfelsed, expressed by locally developed hardening and biotitic alteration related to emplacement of the intrusions (Figure 3-3).

The rock sequence at Hemi has undergone a complex deformation history commencing in extension during basin development, basin inversion during a compression event that resulted in northwest-southeast striking folding and brittle-ductile shear zone development. The area was then subject to a locally more significant compression event that has resulted in northeast-southwest striking folding and typically local scale faulting. The northeast-southwest striking folding and brittle-ductile shear zone development has resulted in dislocation, truncation and repetition of the lithostratigraphy. The shear zones occur as fold hinge parallel shears and as imbricate thrust fault fans/stacks that are important constraints on the lithostratigraphy and mineralisation.

The Archean rock sequence across the northwest Pilbara is generally overlain by unconsolidated Phanerozoic regolith products such as aeolian sand, colluvium, alluvium, pisolithic iron deposits, lateritic duricrust and other chemical pedolith (e.g. calcrete). The outcrop and shallow sub-crop relative to later regolith cover is generally high across the Pilbara. However, this trend is reversed at Hemi and the local region around it, where the younger, Phanerozoic regolith, dominates the current landform (~12% outcrop/shallow sub-crop in the current Hemi Regional Regolith model). The current Hemi Regional Regolith model is displayed in Figure 3-4.

The in-situ regolith environment is well understood in and around Hemi (see Section 3.4 for further discussion). Relative age relationships are also well understood. Unlike the Yilgarn craton, regolith absolute age dates are not well understood across the Pilbara.

There are several sub-domains of interpreted Tertiary and Quaternary regolith that occur at Hemi. With the exception of the Pisolithic Limonite Gravel and the Gregory landform Aeolian Dunes, the division and modelling of the other sub-domains in the Tertiary and Quaternary cover are not currently considered useful for the Hemi Regional Regolith model nor are they considered

# Subterranean Fauna Habitat Assessment Hemi Gold Project



important to differentiate for subterranean fauna. This is in large part due to the thickness of the mostly colluvium domains (~1-3m thick). As such, the sub-divisions are amalgamated in the current Hemi Alluvium and Colluvium model. The MGP Regional Regolith Model, including shallow outcrop and subcrop are outlined in Section 3.4.

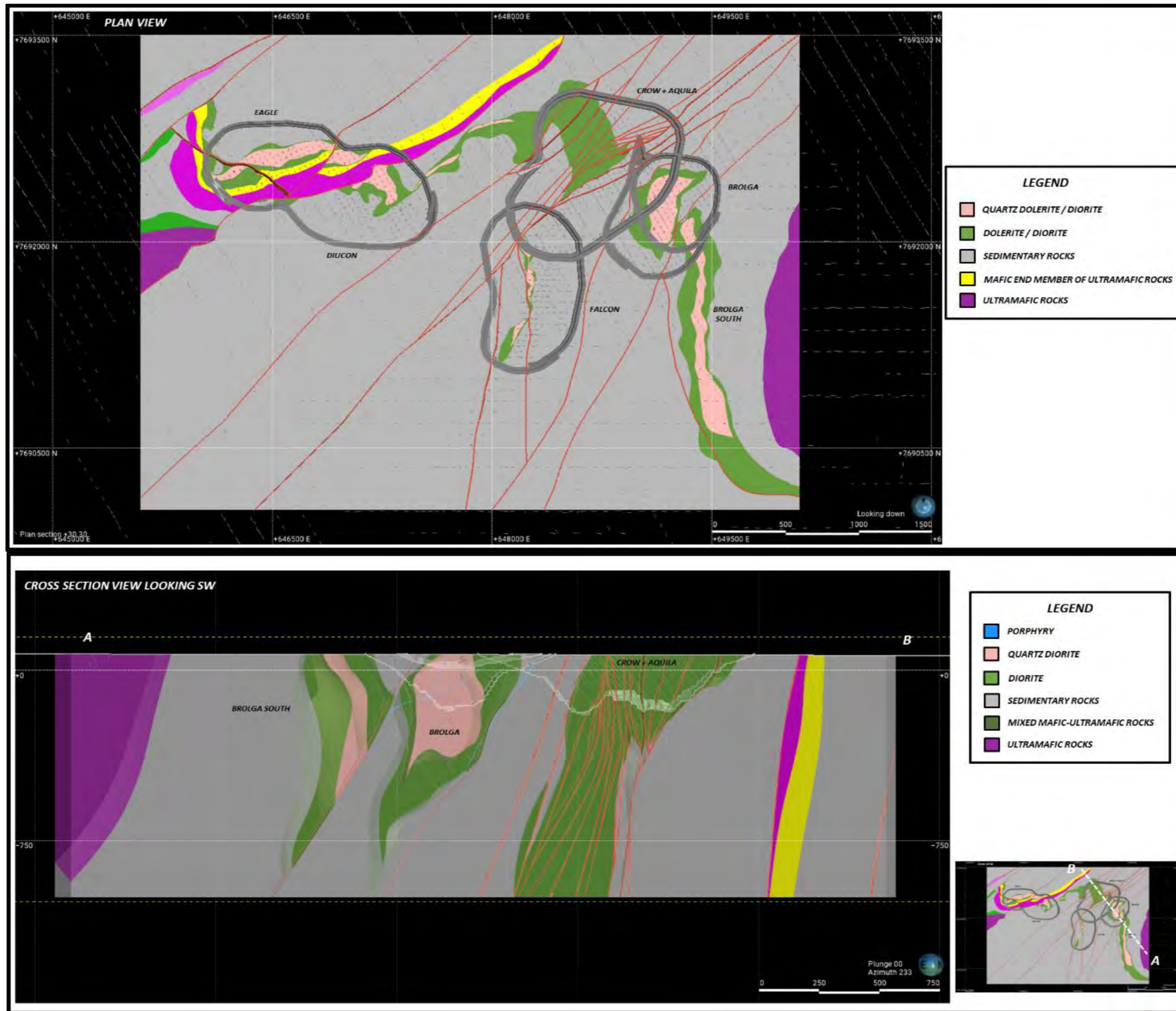


Figure 3-3: Example Flitch View and Cross-section of the Lithostratigraphy and the Brittle-ductile Shear Zone Architecture (red) Interaction at the Hemi area.

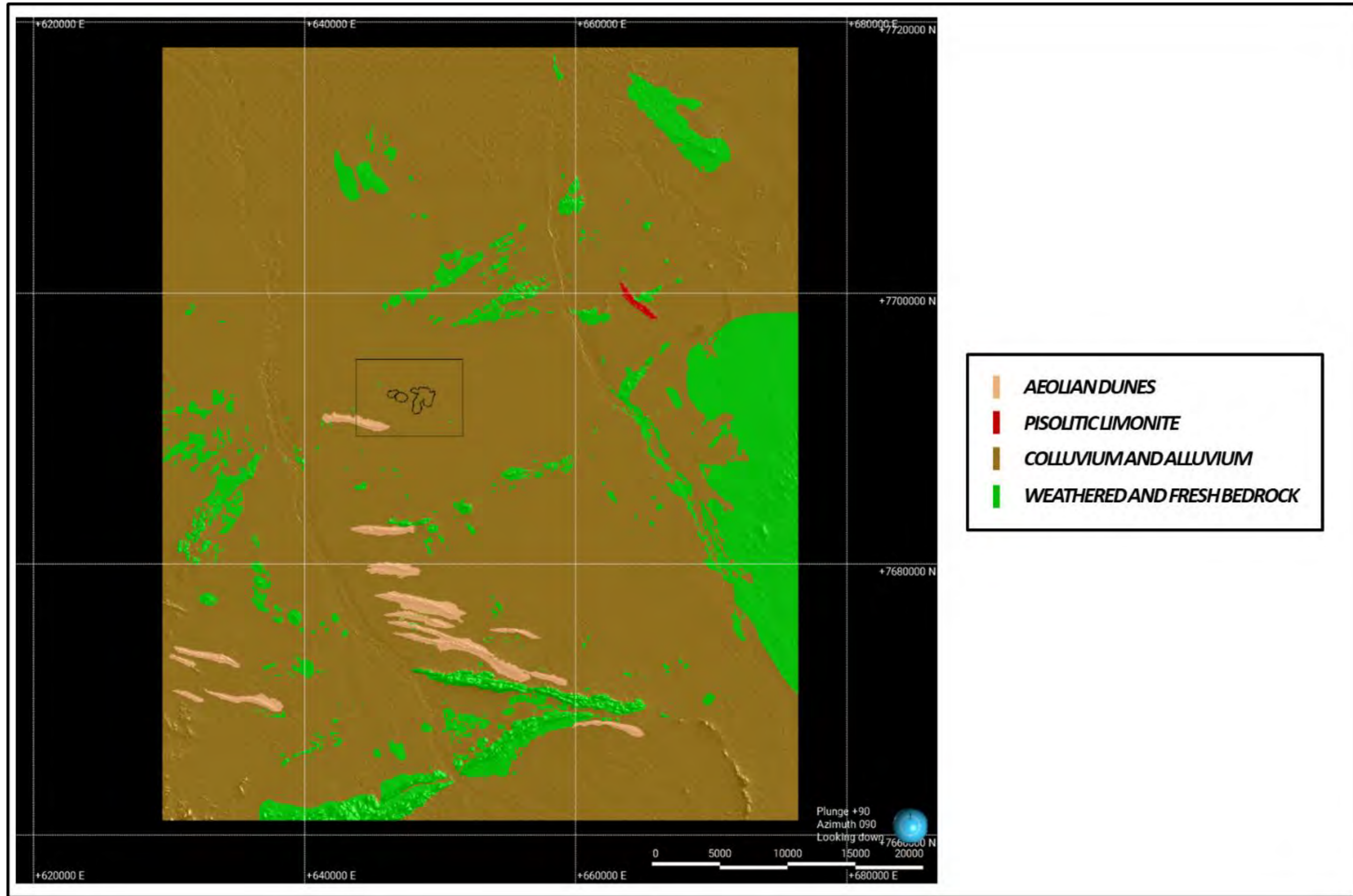


Figure 3-4: The Hemi Regional Regolith Model 2024. Black Box indicates the Hemi Mine Regolith model area. The DFS 2023 Mine Designs are also Displayed

## 3.4 3D Geological Model in Leapfrog Geo™ v 2023.2.3

### 3.4.1 Introduction

Two models have been created to understand the regolith geology at Hemi. The first, was completed for the Definitive Feasibility Study (DFS) (De Grey 2023). The second, a larger regional model, was completed for this study. The two models have different model resolutions that reflect the density of input data, available computational power and end-user requirements.

The first higher resolution DFS regolith model details are provided as it forms a key input to the basement geology of the conceptual groundwater model used in the DFS. The second, larger regional model, uses the same data inputs to the DFS regolith model. It also uses additional data sources distal to the DFS regolith model. The basement regolith domains are amalgamated into one domain as the primary focus of the regional model is on the alluvial sequences. Further details of the models are outlined Section 3.4.2.

The regolith models were created by generating points snapped to drill holes on the base of the contact between model domain and domain below. Some of the ensemble models are run as offset surface models, generated using these points in conjunction with the Digital Elevation Model (DEM). Additional polylines were used to control some trends in the model. The basal sand / gravel paleochannel unit - base of transported cover interface was created as an offset model from the base of the transported cover model. The offset model methodology ensures that the base of the models is offset from the DEM or base of transported cover model in areas of no drilling data or surface regolith mapping.

The saprock – strongly joint weathered fresh rock, strongly joint weathered fresh rock – weakly joint weathered fresh rock and weakly joint weathered fresh rock – fresh rock interfaces were created using the same methodology, but the surfaces were ‘normal’ Radial Basis Function (RBF) interpolant surfaces and not offset from the Digital Terrain Model (DTM). 3D volumes were generated as output volumes from these surfaces. This methodology in Leapfrog Geo™ v 2023.2.3 is used to handle areas where there is no residual and transported cover (outcrop).

Only surveyed (collar and downhole) diamond and Reverse Circulation (RC) drill holes were used immediately in and around the optimised pit shells. Air Core (AC) and Rotary Air Blast (RAB) drill holes were used outside of this area, particularly where no other drilling is available. The cut-off on drill type was typically >100 m from the first diamond or RC drill hole outside of the pit surface. If a diamond or RC drill hole occurs in the vicinity of a RAB or AC drill hole, the RAB or AC drill hole was removed and replaced by the superior drilling and downhole survey method.

### 3.4.2 Hemi Regolith Model

Modelling of the regolith and fresh rock profiles was completed for the DFS and included a base of aeolian and colluvial cover model, base of calcrete – silcrete (duricrust) model, a transported

(alluvial) cover model (alluvium model herein), a basal sand and gravel paleochannel model that occurs internal to the transported cover model, a base of upper saprolite model, a base of lower saprolite model, a base of saprock model, a base of strongly joint weathered fresh rock model, and base of weakly joint weathered fresh rock model.

All of models were constructed in Leapfrog Geo™ v 2023.2.3. The wireframe resolution was 10 m for all regolith models except for the base of the Transported (alluvium) cover model to assist in density allocation in the resource estimate and waste block processing time.

The regolith models range in thickness as follows (Figure 3-5):

- Aeolian and Colluvial Cover – 0 m – 4 m
- Calcrete – Silcrete Cover – 0 m – 3 m
- Alluvium Cover – 0.5 m to 55 m
- Basal Transported Sand and Gravel Unit - 0 m to 25 m
- Upper saprolite – 0 m to 75 m
- Lower saprolite – 0 m to 80 m
- Saprock – 0 m to 100 m
- Strongly Joint Weathered Fresh Rock – 0 m to 80 m
- Weakly Joint Weathered Fresh Rock – 0 m to 120 m
- Fresh Rock – 450 m to >700 m

The surface names consist of:

- Base of Aeolian and Colluvial Cover: TRCover\_Aeolian\_Colluvium
- Base of Calcrete – Silcrete Cover: TRCover\_Calcrete-Silcrete
- Base of Alluvium Cover: TRCover
- Basal Transported Sand and Gravel Unit: TRCover\_Palaochannel CG Siliciclastic Unit
- Base of Upper Saprolite: RSU
- Base of Lower Saprolite: RSL
- Base of Saprock: RSR
- Base of Strongly Joint Weathered Fresh Rock: FRJS
- Base of Weakly Joint Weathered Fresh Rock: FRJW
- Fresh Rock: FR

The regolith model construction is derived from multiple geoscientific datasets that consist of:

- Logging of diamond drill core and percussion drill chips and spoils.
- Downhole in-situ bulk density measurements by water immersion.
- Geotechnical parameters: Field Geotechnical Logging, RQD, GSI and RMR89.
- Geochemistry: multi-element and element ratio workflow and a Scott Halley derived calculated mineralogy that is available in most drill holes.
- Hyperspectral dataset: Short-wave Infrared (SWIR) measurements that are available in most drill holes.

- 3D lithostratigraphy and structural geology impacts on the weathering regime.
- Potential field datasets (airborne aeromagnetics and ground gravity grids).

Typical logging of these profiles is displayed in Figure 3-6. An example of the data input into the model is given in Figure 3-7.

While all datasets are integrated into the modelling, the data is treated in a hierarchy in order of the above bullet points outlining model dataset inputs (highest priority = top; lowest priority = bottom).

A critical component to the models is that the modelling is designed to capture the in-ground regolith regime at Hemi but also the end-user requirements such as geotechnical studies or hydrogeological studies. As such, the domain boundaries mark key changes required for the end-users and can also easily be combined to be directly applicable to end-user study. An example cross-section and end user outputs of the regolith models is displayed in Figure 3-8.

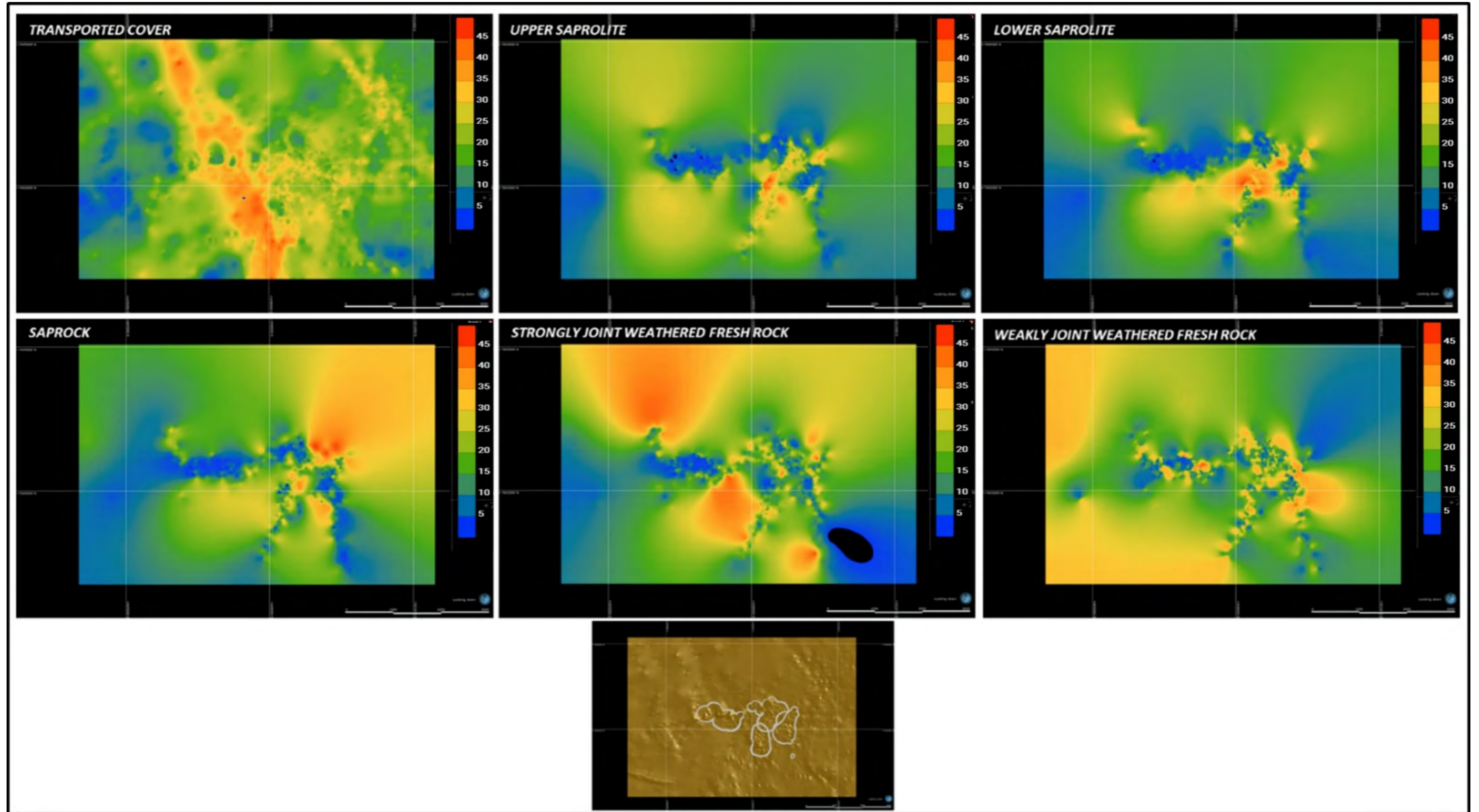


Figure 3-5: Thickness Grids of the Regolith Model Above Fresh Rock



Figure 3-6: Typical Regolith Domain Divisions at Hemi

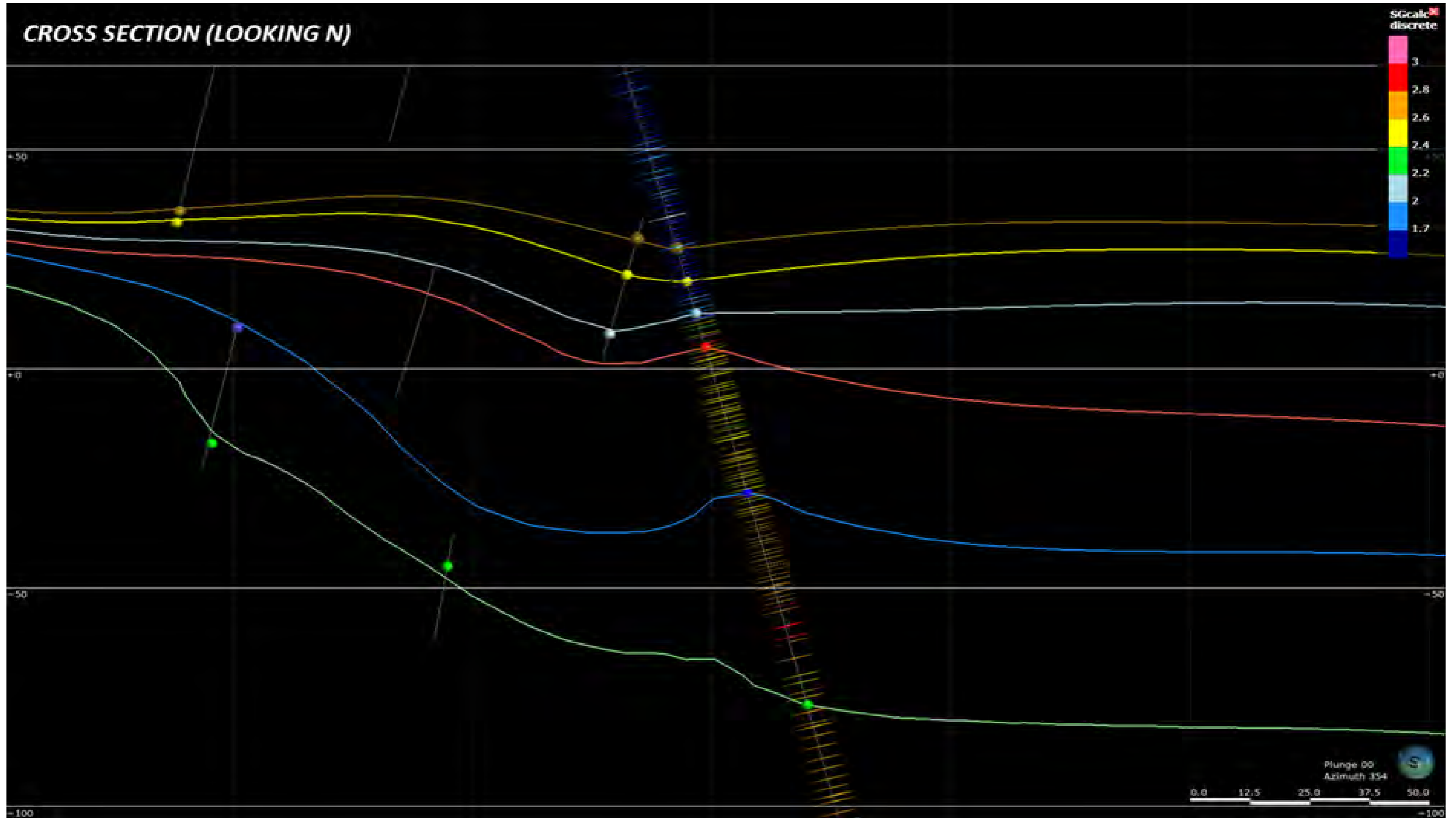


Figure 3-7: Example Cross Section of the Integration of Density into the Regolith Modelling

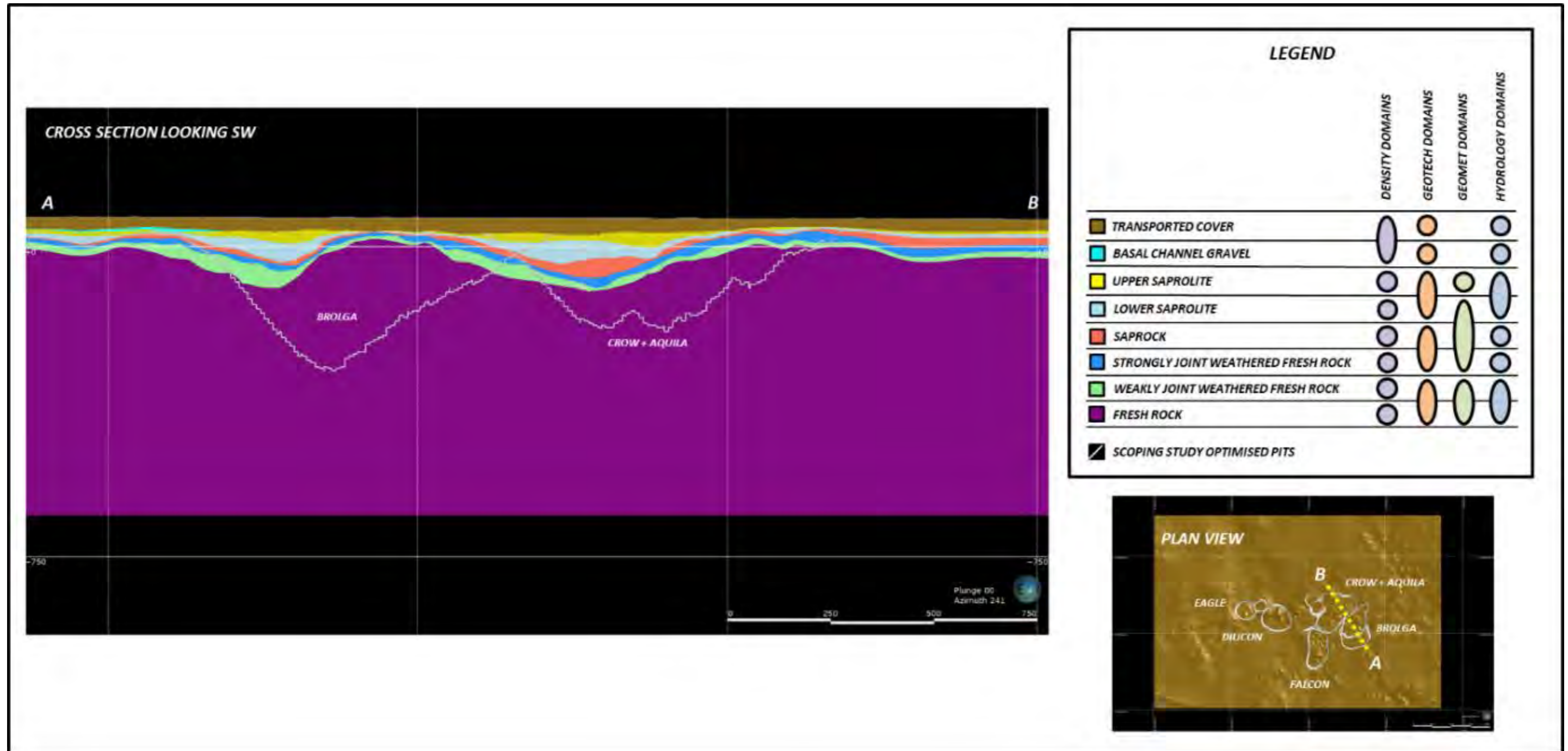


Figure 3-8: Cross-section to Display the Different Regolith Models at Hemi

### 3.4.3 Regional Regolith Model

The Hemi regional regolith model is primarily focussed on understanding the regional context and extent of the alluvium aquifer. As the in-situ geology is modelled, it can be directly used for this study as the major regolith domains form the basis and extents of the troglofaunal and stygofaunal habitats. The modelling includes a base of aeolian sand dune cover model, base of pisolitic - limonite model, a base of transported cover model (Alluvium model herein), a basal sand and gravel paleochannel unit model that occurs internal and to the base of the alluvium cover model (where present). Archean basement occurs beneath the alluvium cover model.

This model was constructed in Leapfrog Geo™ v 2023.2.3. The wireframe resolution is 17.5 m for all the Hemi regional regolith.

The regolith models range in thickness as follows (Figure 3-9):

- Aeolian Dune Cover – 0 m – 27 m
- Pisolitic - Limonite Cover – 0 m – 19 m
- Colluvium and Alluvium Cover – 0 m to 55 m
- Basal Transported Sand and Gravel Unit -- 0 m to 37 m
- Weathered and Fresh Rock (Bedrock) – 200 m to >500 m
- The combined Colluvium and Alluvium Cover and Basal Sand and Gravel model is subdivided into a:
  - Unsaturated Domain – 0 m to 20 m
  - Saturated Domain – 6 m to 55 m

The base of surface names consists of:

- Base of Aeolian Dune Cover: TRCover\_Aeolian\_Dune
- Base of Pisolitic - Limonite Cover: TRCover\_PisoliticLimonite
- Base of Alluvium Cover: TRCover\_HydrogeologyModelArea
- Basal Transported Sand and Gravel Unit: Palaochannel\_HydrogeologyModelArea
- Unsaturated Domain: HGP\_SGWL

The regolith model construction is derived from collating and interrogating multiple geoscientific datasets. These consist of:

- Geological logging of diamond drill core and percussion drill chips and spoils of over 20,000 drill holes for over 1.4 million metres of drilling (acquired over >30 years). The drill database is sourced from:
  - De Grey drilling (includes all drill holes drilled for water purposes)
  - Texas Gulf (public)
  - Atlas Iron bores (public)
  - DWER / Water Corporation bores (public)
  - Other publicly available drill holes available on the DMIRS servers
- Downhole in-situ density measurements by water immersion
- Geotechnical parameters such as: Rockmass Logging (RQD, GSI and RMR89)

- Geochemistry: multi-element and element ratio workflow and a Scott Halley derived calculated mineralogy that is available in most drill holes
- Hyperspectral dataset: SWIR measurements that are available in most drill holes
- 3D lithostratigraphy and structural geology impacts on the weathering regime
- Airbourne DEM
- Geological Survey of Western Australia (GSWA) datasets that primarily include surface mapping of outcrop, sub-crop and other regolith features such as calcrete. The 1:100k GSWA mapping sheets included in this study consist of:
  - Yule
  - Wallaringa
  - Wodgina
  - Satirist
- Geophysical Surveys including:
  - Potential field datasets (airborne aeromagnetism and ground gravity grids)
  - Unconstrained airborne electromagnetic AarhusGeo a-priori spatially constrained inversions (AEM) consisting of:
    - AusAEM2 Tempest EM Survey
    - VTEM Surveys
    - ADTEM Surveys
  - Remote Sensing data that includes data from the Copernicus Sentinel II satellite
  - Waterborne drone Deeper Sonar PROTM sonar survey to map the profile of the semi-permanent water pools located within the Yule River system

The data inputs into the Hemi Regional Regolith Model are displayed in Figure 3-9. Data inputs such as the potential field geophysics datasets are not listed as they cover the whole model area. The thickness of selected models in the Hemi Regional Model are displayed in Figure 3-10, Figure 3-11 and Figure 3-12.

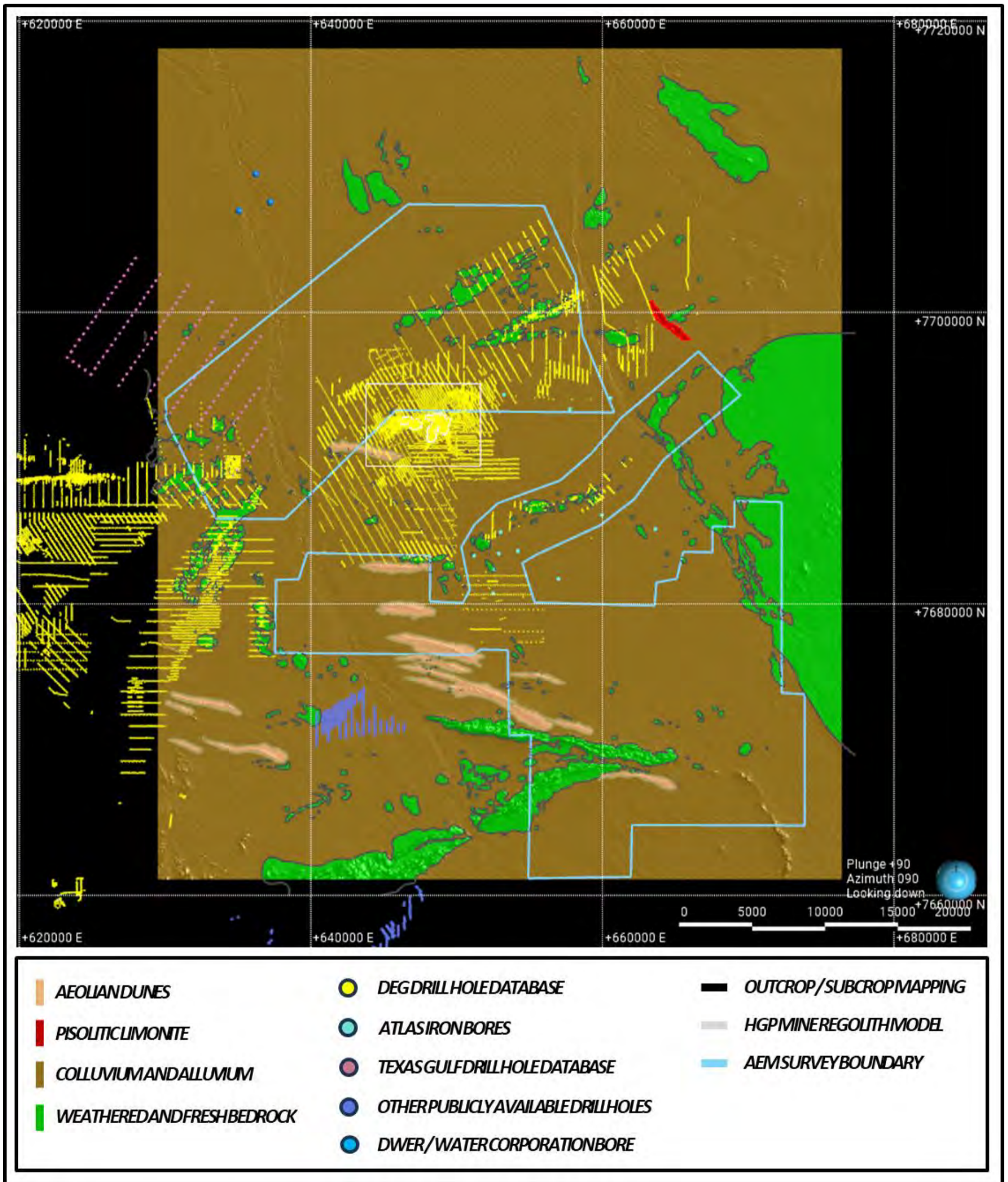


Figure 3-9: Data Inputs into the Hemi Regional Regolith Model. The Hemi Mine Designs, and Outline of the Hemi Mine Regolith Model are Displayed in White

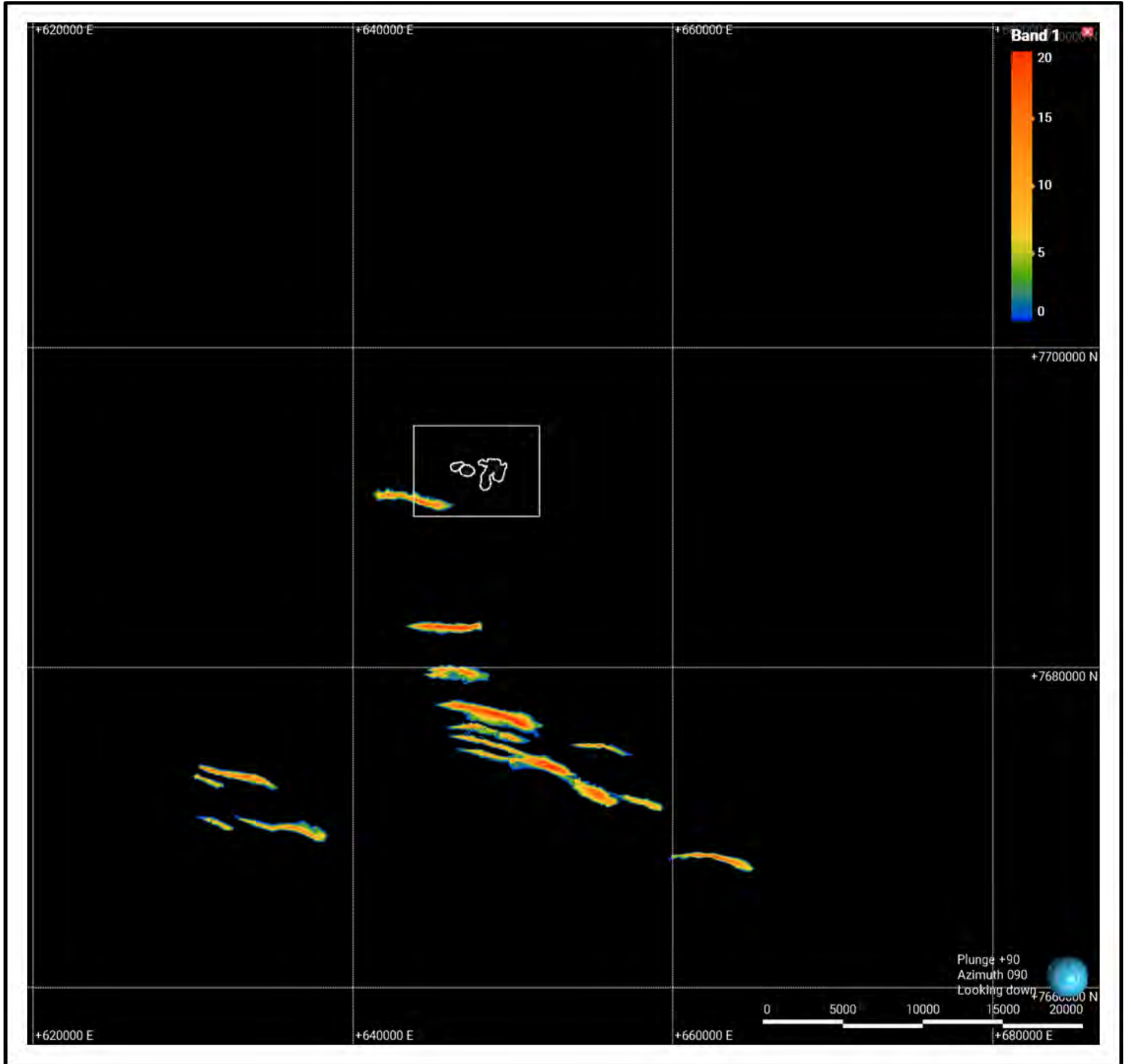


Figure 3-10: Thickness of the Aeolian Dunes Across the Hemi Regional Regolith Model. The Hemi Mine Designs, and Outline of the Hemi Mine Regolith Model are Displayed in White

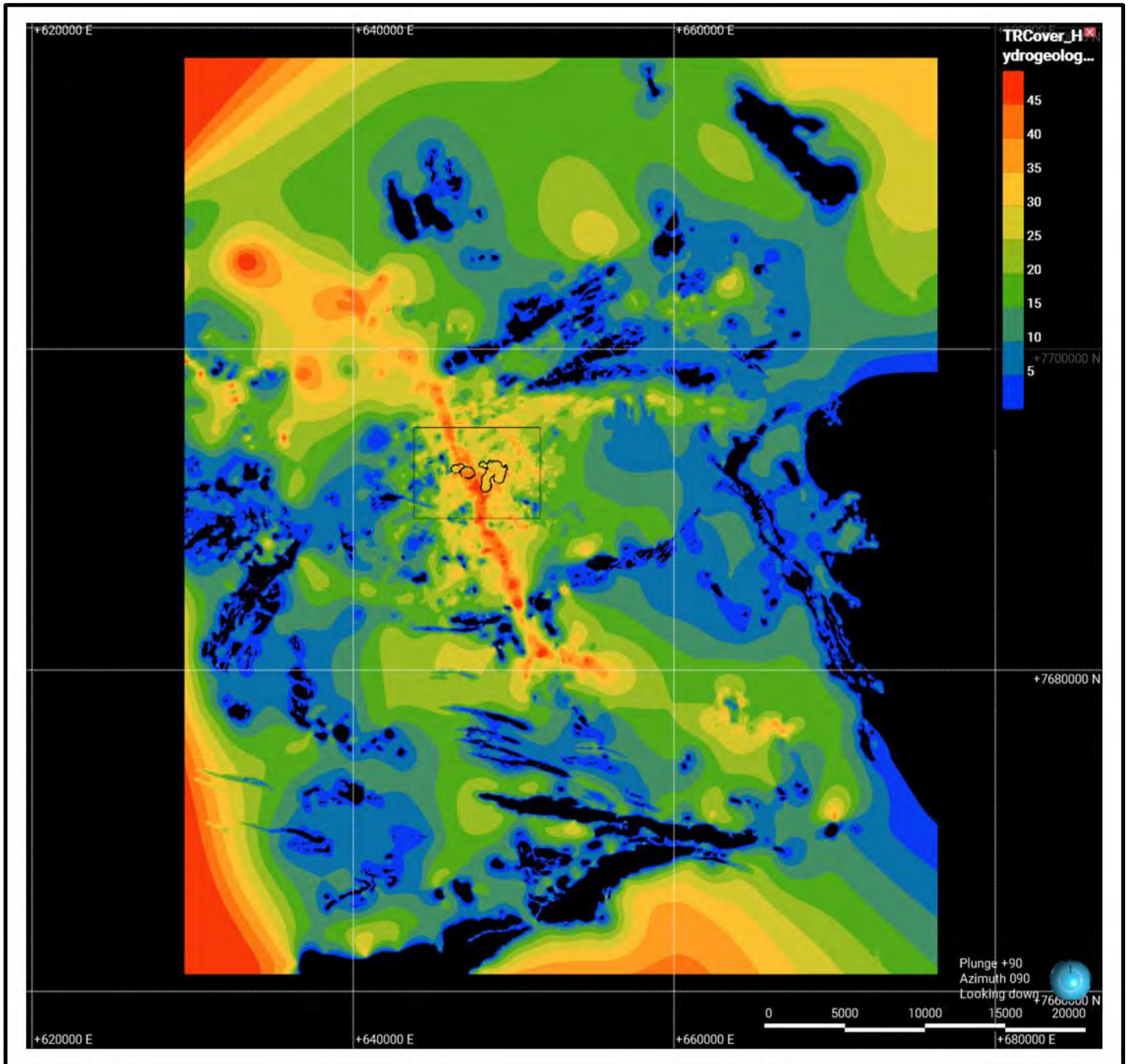


Figure 3-11: Thickness of the Alluvium Domains Across the Hemi Regional Regolith Model. The Hemi Mine Designs, and outline of the Hemi Mine Regolith Model are Displayed in Black

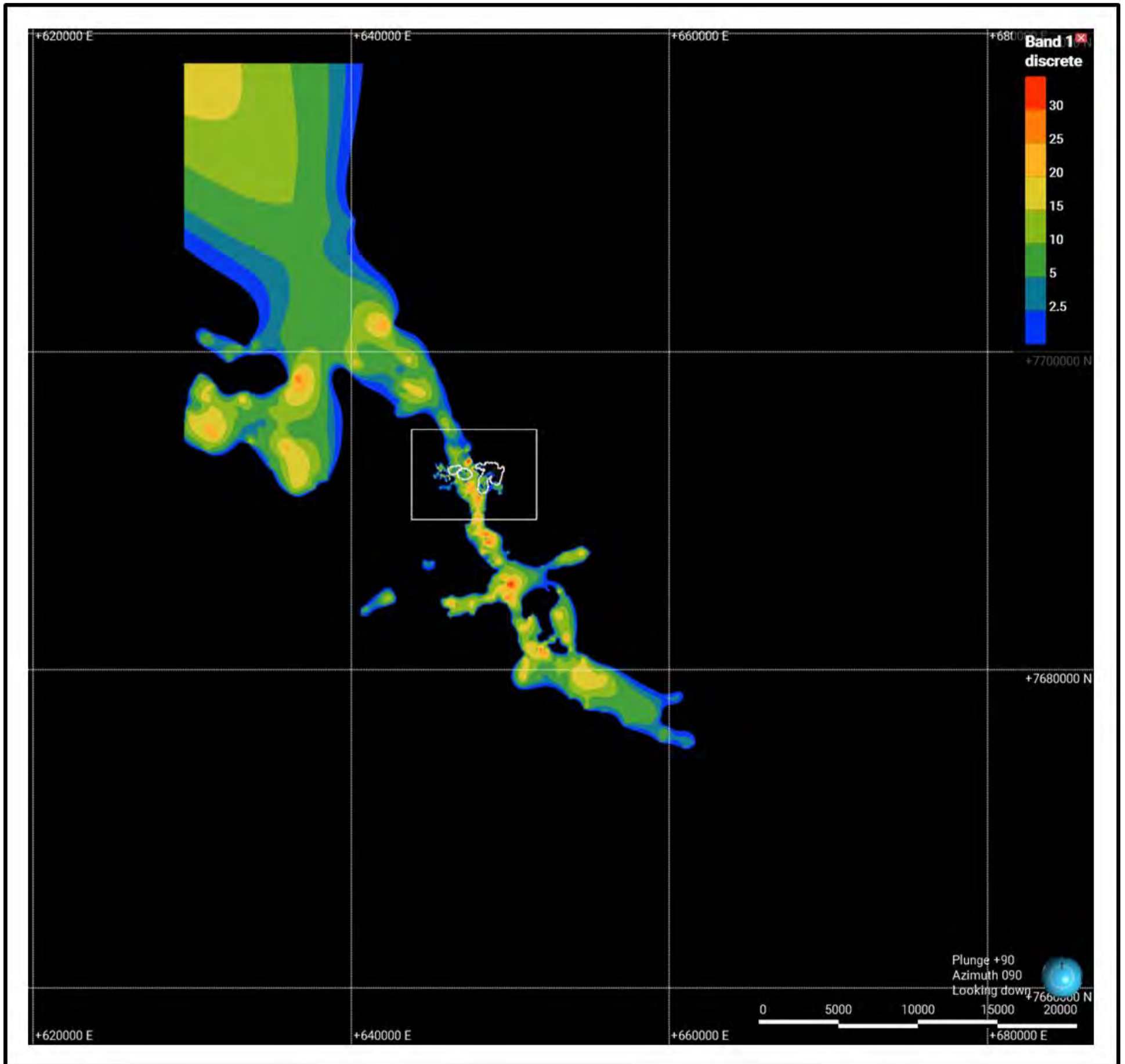


Figure 3-12: Thickness of the Basal Transported Sand and Gravel Unit to the Alluvium Model Across the Hemi Regional Regolith Model. The Hemi Mine Designs, and Outline of the Hemi Mine Regolith Model are Displayed in White

## 3.5 Hydrogeology

### 3.5.1 Aquifer setting

A schematic section through the Hemi Deposit is displayed as Figure 3-13 to highlight the hydrostratigraphy that has been resolved by the mineral resource drilling and groundwater bores installed to date. The different aquifer zones are based on their fundamental lithology type and comprise, from shallowest to deepest:

- Upper alluvium – a laterally extensive aquifer system having low to moderate permeability and saturated thickness.
- Lower alluvium – a similar system to the upper alluvium, but which notably includes a palaeochannel facies containing relatively unconsolidated sands and gravels, which form a major aquifer system with high permeability and storage values. The palaeochannel has significant continuity in the north-south direction and is of the order of 1 – 2 km in the transverse east-west direction near Hemi.
- Saprolite zone – the uppermost sections of weathered bedrock that commonly weathers to a clay-rich assemblage with a resultant inherent limited permeability, notably within the sedimentary and ultramafic lithologies. This zone encompasses both the upper and lower saprolite regolith profiles modelled by De Grey.
- Saprock zone – this covers the lower part of the weathering profile and comprises moderately to slightly weathered rock. At Hemi, the intermediate igneous intrusives have developed a relatively higher permeability than the surrounding sedimentary and ultramafic units in the saprock profile. Diamond drill core and water bore testing indicate low – moderate fractured rock permeability in the intrusives. This zone encompasses both the saprock and ‘strongly joint weathered fresh rock’ regolith profiles modelled by De Grey.
- Fresh bedrock – The bedrock lithologies present at and near Hemi do not form aquifer zones when they are unweathered, including the arkosic wackes and sandstones. Extensive reviews of diamond drill core logs and photos indicates that minor amounts of discrete fracture zones within fresh rock may form narrow flow paths with elevated permeability. There is a general trend for these discrete fractures to close and tighten with depth, such that permeable fractures in core were rarely observed below about 150 m (vertically) below ground. It is interpreted that the greatest occurrence of fracture permeability in fresh bedrock occurs within the felsic, intermediate and mafic intrusive lithologies near their contact with the meta-sedimentary units, shear zones and fold hinges.

The upper and lower alluvium aquifers can be classified as a High Hydraulic Conductivity Aquifer (HHCA) whilst the saprolite, saprock and fresh bedrock can be classified as a Low Hydraulic Conductivity Aquifer (LHCA).

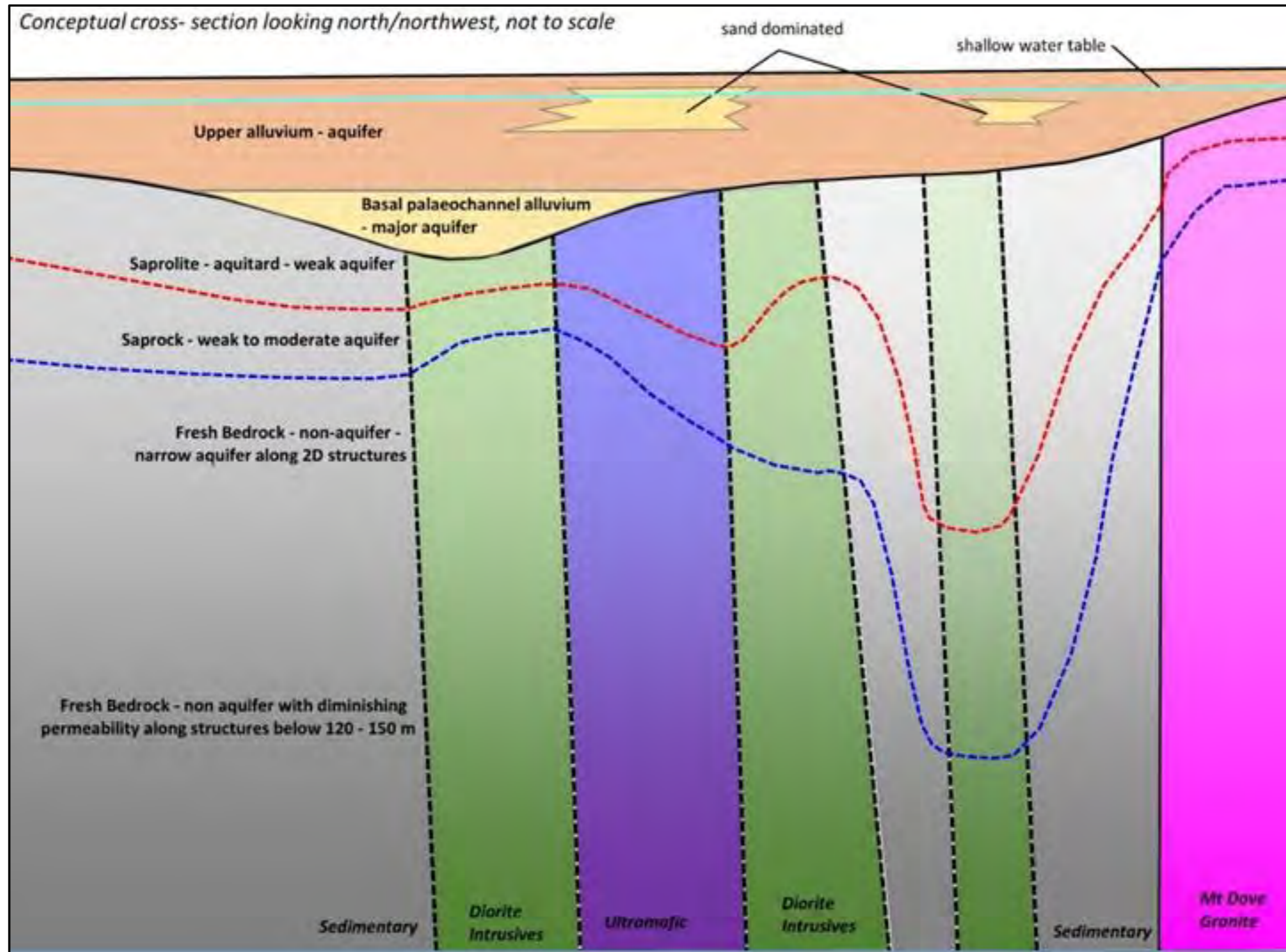


Figure 3-13: Conceptual Cross Section of the Hemi Aquifer

## 3.5.2 Groundwater Levels

The regional water table has been interpolated using Surfer v16 software to produce the contours shown on Figure 3-14 which also shows the location of water bores and wells with groundwater level data (water observation points).

The water table in the project region is a broad reflection of the overlying ground surface and shows that regional groundwater flow in the shallow aquifer system is north-north-westerly under low hydraulic gradients of between 1-in-800 to 1-in-1600. These are similar to the average riverbed gradients of the nearby Yule River (1 in 900) and Turner River (1 in 650).

The depth to the water table below ground was calculated in Surfer v16 by subtracting the water table surface from a ground surface DTM generated on a 20 m grid size from finer resolution Lidar data. As shown on Figure 3-15, the water table in the immediate Hemi area occurs between five (5) to seven (7) m below surface, with a broad trend of slowly increasing depth to the south and slightly decreasing to the north in areas of low relief. The greatest depths to the water table (> 20 m) occur below outcropping bedrock and sand dune areas, which are more prominent to the south of Hemi.

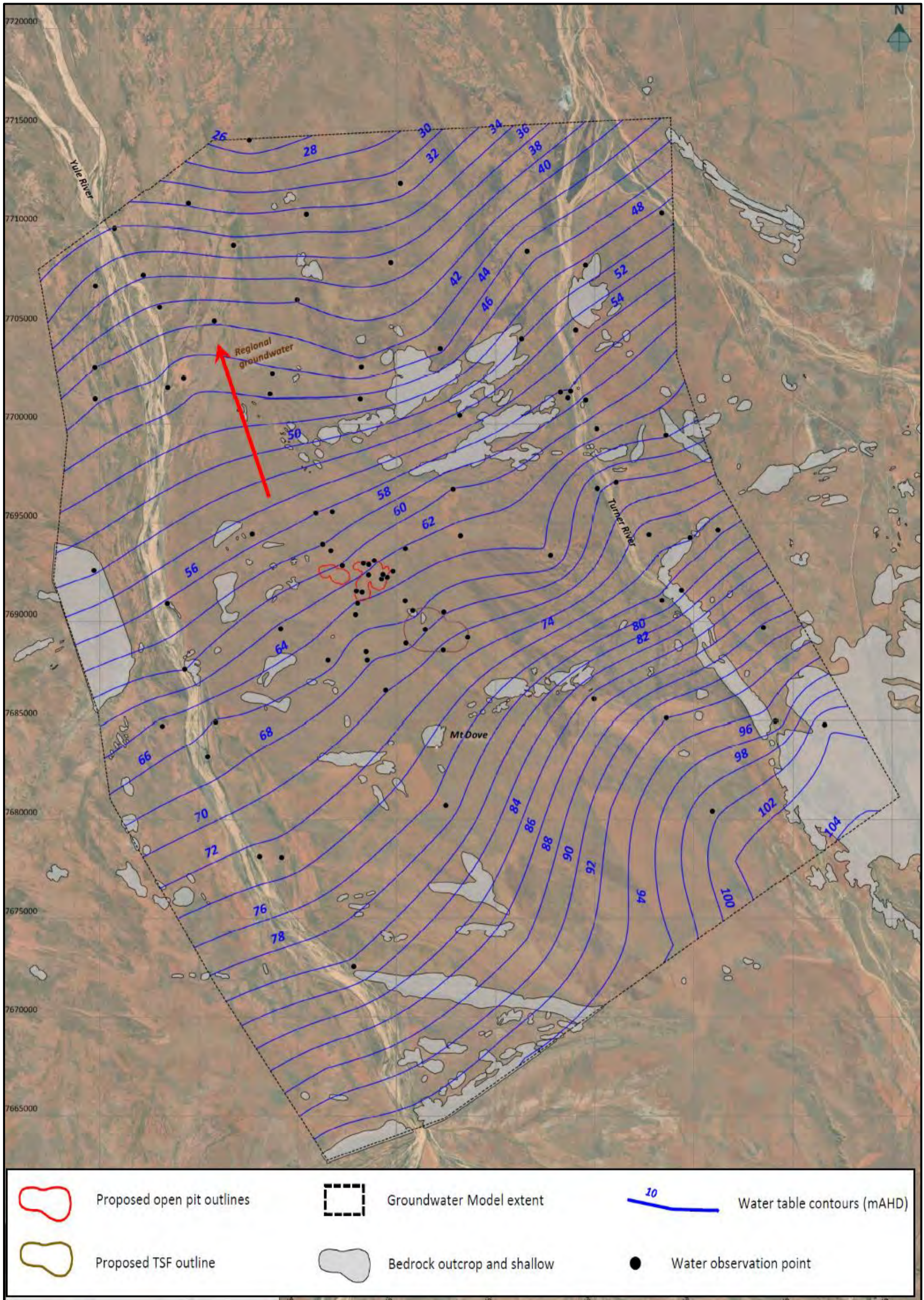


Figure 3-14: Regional Water Table Contours

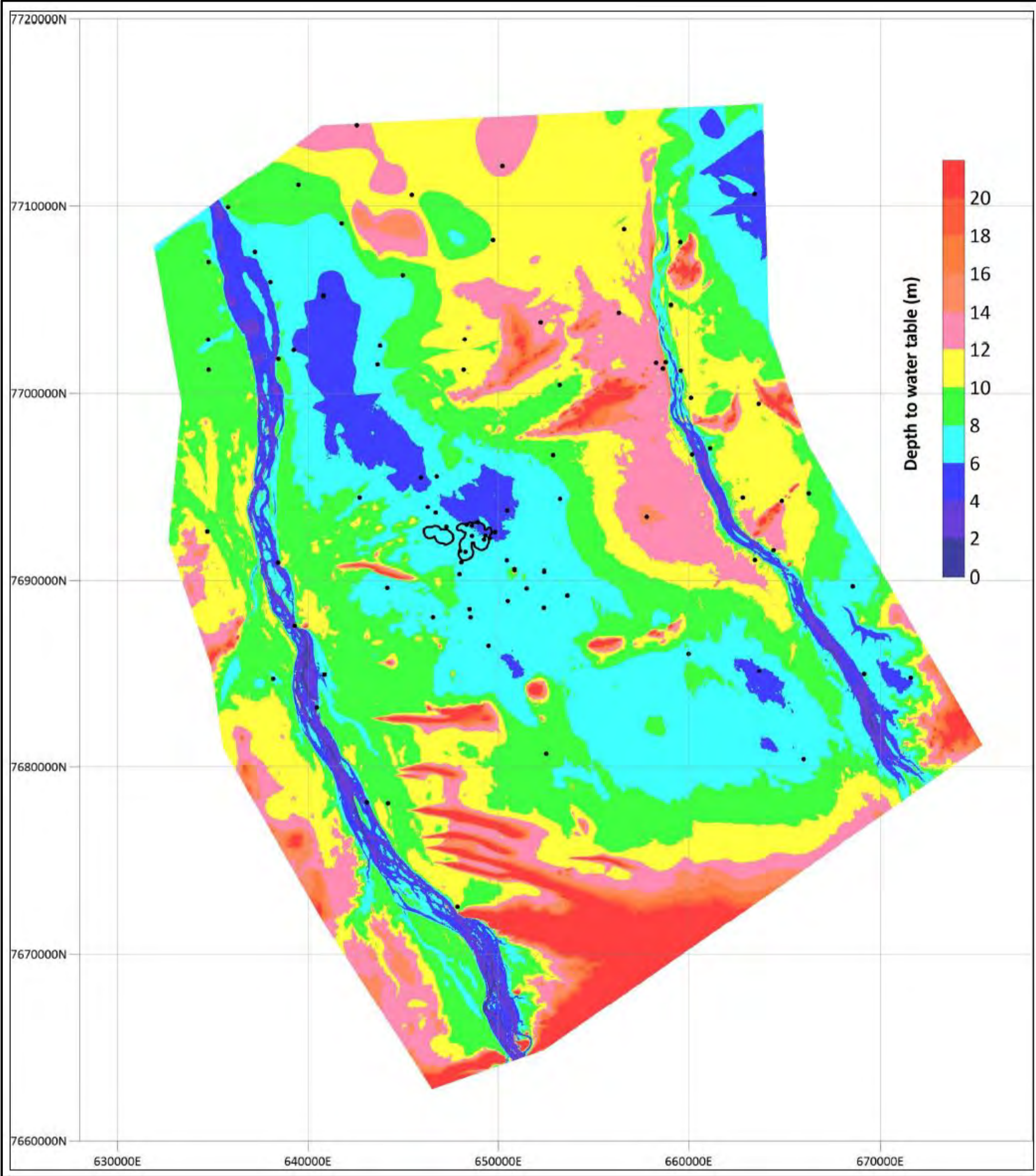


Figure 3-15: Depth to Water Table

### 3.5.3 Saturated Alluvium

Estimation of the alluvial aquifer thickness has been achieved by subtracting the base of alluvium from the water table grid in Surfer v16. Contours of the aquifer thickness are shown for the regional area on Figure 3-16 and on Figure 3-17 for the local Hemi area. These figures highlight the following:

The alluvial aquifer is not continuous throughout the entire model area, notably to the east of Hemi, and along much of the Turner River. Between Hemi and the Yule River there are some 'islands' where the alluvium is unsaturated, and the water table would be present within the bedrock profile.

In the Hemi Deposit area, there are large areas of alluvial aquifer between 20 – 36 m thickness that will require dewatering ahead of open-pit mining. On the south-east side of the proposed TSF, the water table is present just below the base of alluvium.

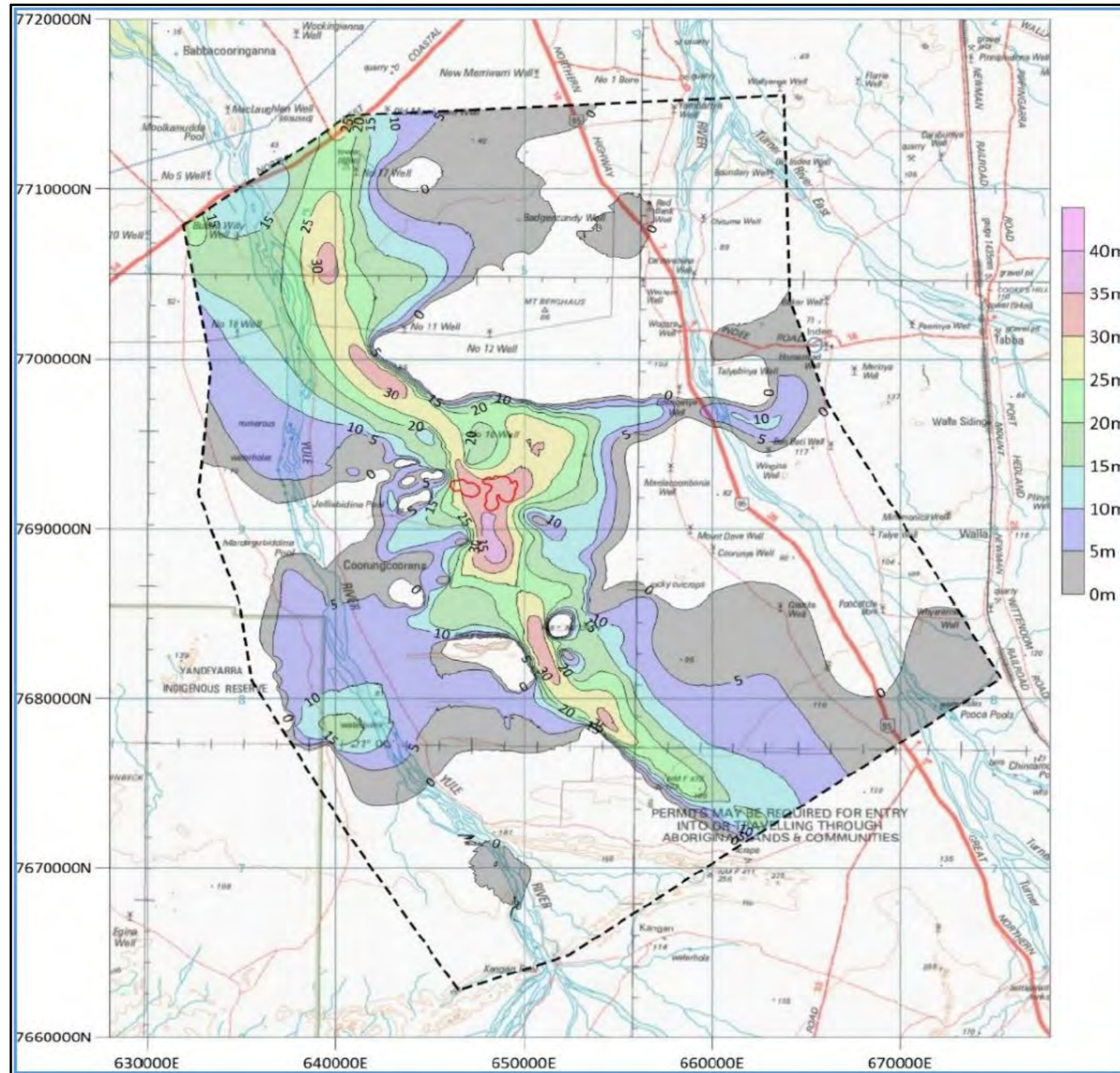


Figure 3-16: Alluvial Aquifer Thickness (m) – Regional

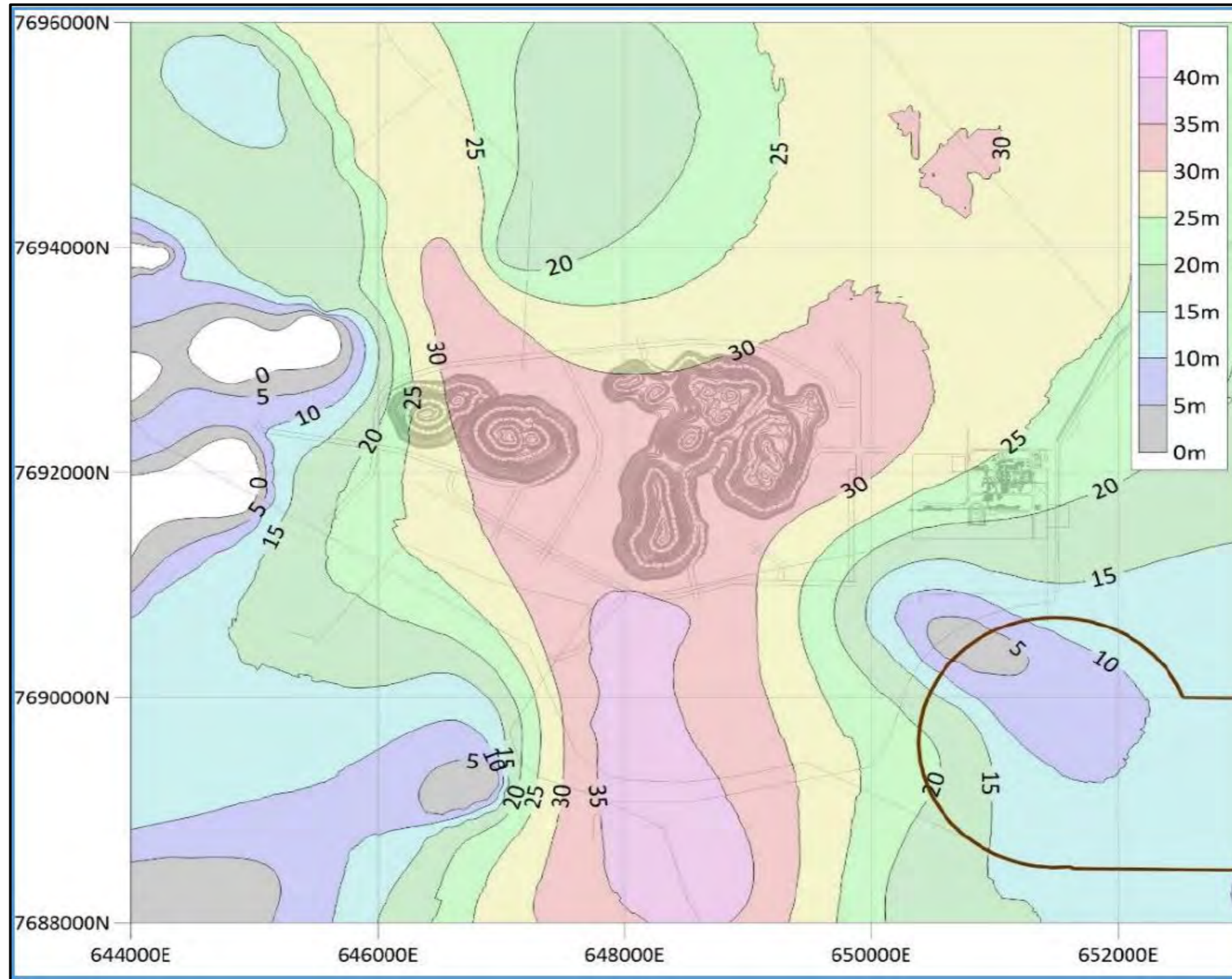


Figure 3-17: Alluvial Aquifer Thickness (m) - Hemi

## 3.6 Impact Assessment Extents

### 3.6.1 *Stygofauna*

The spatial context of this assessment includes both those areas where stygofauna habitat may be directly removed through the development of open pit mines below the water table, and indirect removal as a result of groundwater drawdown from mine pit dewatering and borefield abstraction.

To determine the full extent of impacts resulting from development of an open pit mine, mine dewatering and borefield abstraction a numerical groundwater model was developed by Geowater (2023). A high degree of emphasis was placed on the accuracy of this model to ensure that it could be used to make accurate predictions about impacts. The model has been subject to a peer review by Jurassic Groundwater (2023) and range of sensitivity analysis to ensure that the model was conservative for the purpose of impact assessment.

The numerical groundwater model makes projections of groundwater drawdown for mine dewatering and for borefield abstraction. The numerical model outputs included the extent of groundwater contours at end of mine life (15 years) (Figure 3-18). Further details relating to the numerical groundwater model can be found in Geowater (2023).

### 3.6.2 *Troglofauna*

The spatial context of this assessment includes both those areas where troglofauna habitat may be directly removed through the development of open pit mines, above water table, and indirect impacts as a result of groundwater reinjection that would occur from mine pit dewatering and reinjection into the borefield (Figure 3-19).

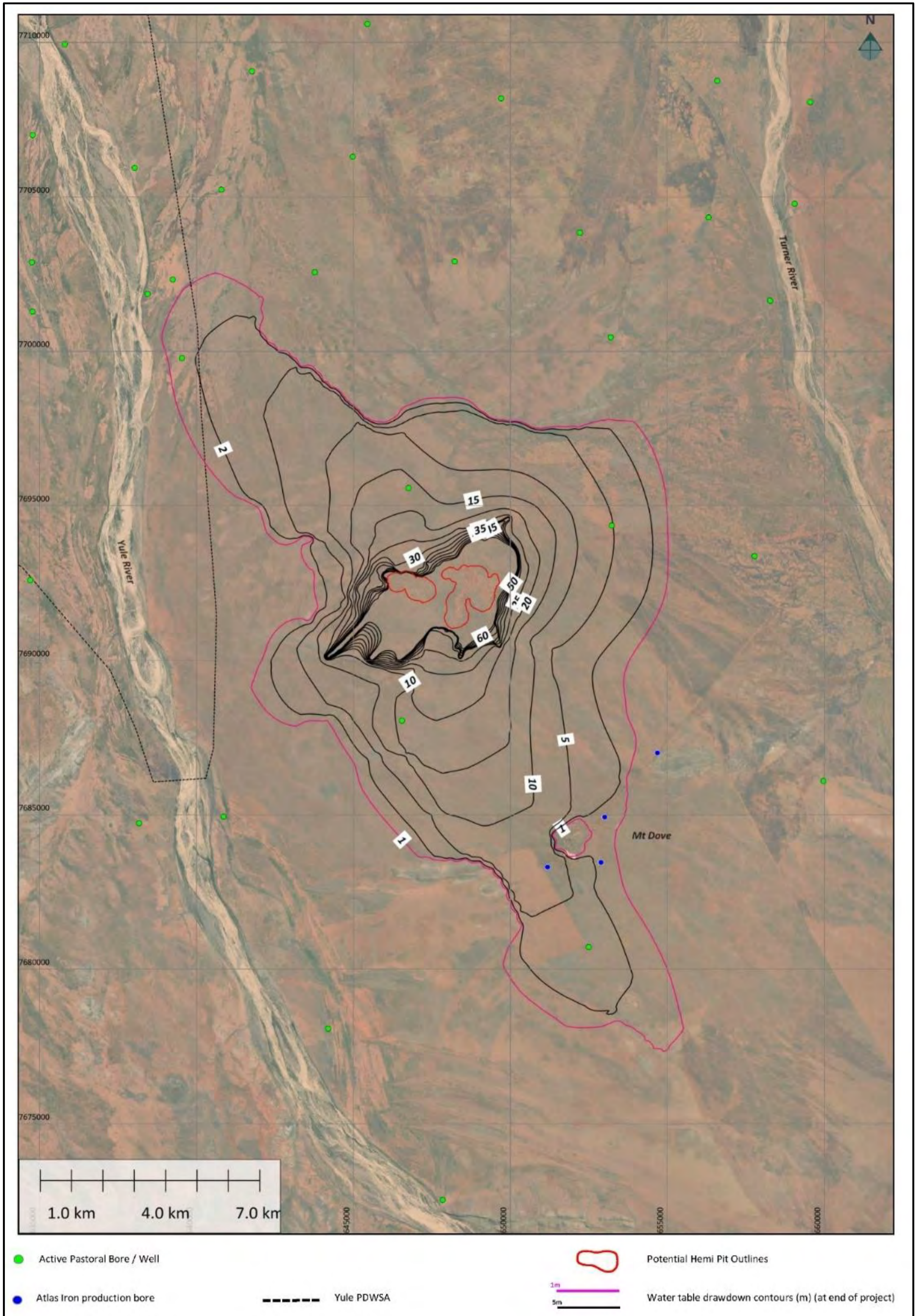


Figure 3-18: Worst Case 5 m Drawdown Contour at End of Mine Life (15 Years)

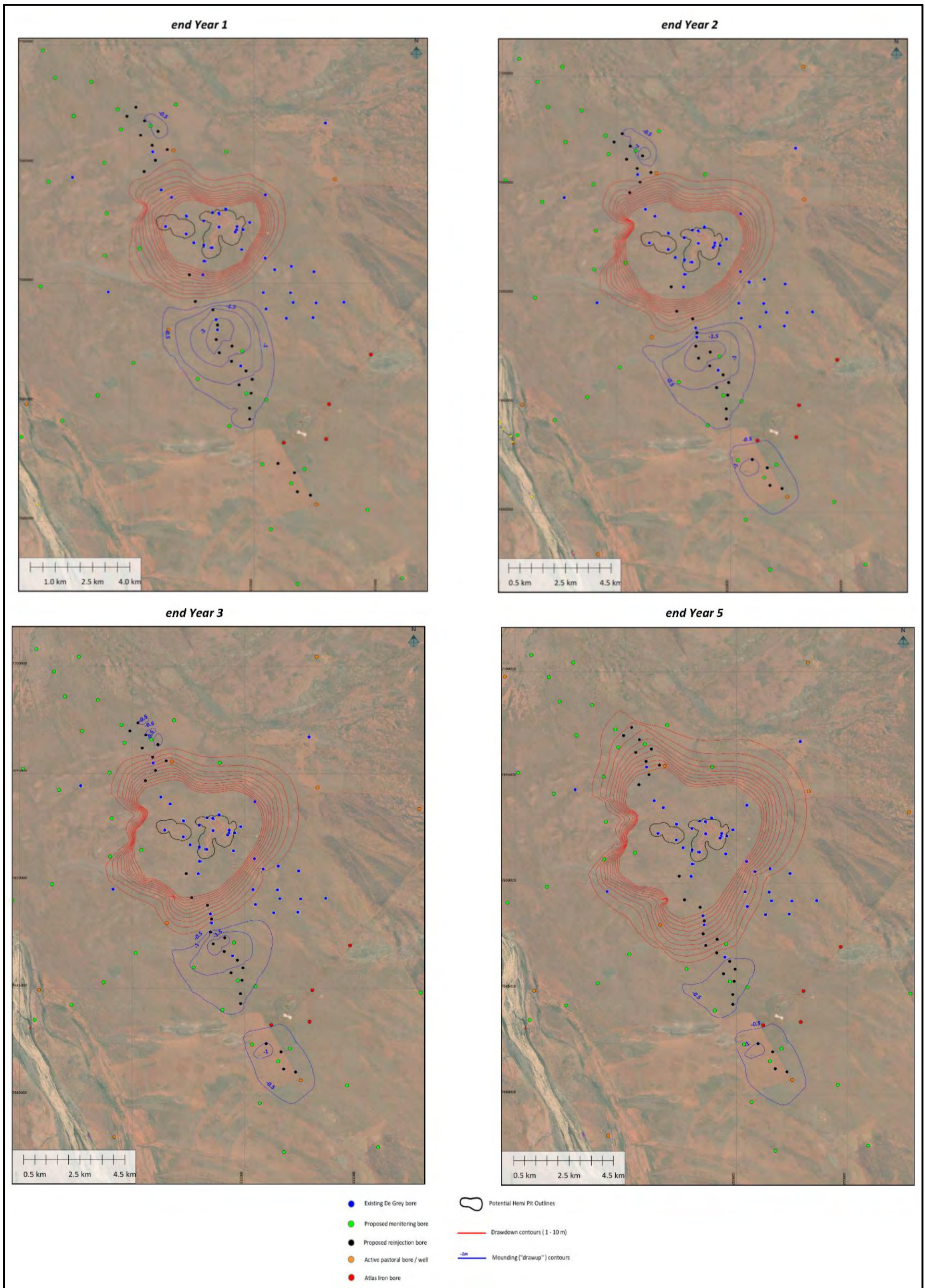


Figure 3-19: Open Pit Dimensions and Modelled Mounding Drawdown and Draw Up Contours for the First Five Years of Mining

## 3.7 Basis of Habitat Assessment

The Hemi regional regolith model dataset inputs are outlined in Section 3.4.2. This section outlines how the data inputs were used to generate the various domains in the model and therefore the extent of the habitat.

The mapping of subterranean fauna habitat was undertaken by collating and interrogating multiple geoscientific datasets. The primary data included but was not limited to:

- Geological logging of the study was sourced from 20,000 drill holes for >1.4 million metres of drilling (acquired over >30 years) which was used to accurately map the regolith environment and by proxy the subterranean fauna habitat across the Hemi regional regolith model, where drilling activities have been completed. A largely uniform interpretation of the logging data has been completed using the advanced drill hole dataset available to De Grey by using quantitative analysis of the datasets where possible. This contrasts to historical regolith modelling, where a more qualitative approach was typically used. The drill hole data types and sources are listed below:
  - Downhole in-situ bulk density measurements by water immersion. In-situ bulk density changes due to the degree of weathering are well established, particularly in the field of mineral resource estimation.
  - Geotechnical parameters such as Rockmass Logging (RQD, GSI and RMR89) were used to map the regolith domains. The domain boundaries capture the degree of weathering of the basement rock and the joint / fracture percentage of a domain. The amount of fracturing can be an important constraint on subterranean fauna habitat extent.
  - Geochemistry: multi-element and element ratio workflow and a Scott Halley derived calculated mineralogy that was available in most drill holes enabled consistent interpretation of the domains, as key elements or compounds change with the degree of weathering changes.
  - Hyperspectral dataset: SWIR measurements were available in most drill holes. SWIR measurements were particularly useful in identifying clay minerals and therefore the transition from the alluvial sequence to the saprolite and then onto fresh rock.
  - Hydrogeological bore logging of all available bores at Hemi.
- Geological Survey of Western Australia (GSWA) datasets, primarily include surface mapping of outcrop, sub-crop and other regolith features such as calcrete. The major regolith features are important inputs into the habitat extent available to subterranean fauna. The 1:100k GSWA mapping sheets included in this study consisted of:
  - Yule
  - Wallaringa
  - Wedging
  - Satirist
- Geophysical surveys including:
  - Potential field datasets (airborne aeromagnetic and ground gravity grids) are used to assist the interpretation of the lateral extents of the alluvial sequence.

- Airbourne electromagnetic (AEM) surveying data that has been processed with an unconstrained AarhusGeo a-priori spatially constrained inversions. AEM surveys consisting of:
  - AusAEM2 Tempest EM Survey.
  - Versatile Time Domain Electromagnetic (VTEM) surveys.
  - ADTEM Surveys.
- AEM data can detect variations in the electrical conductivity of the ground to a depth of several hundred metres. In-ground conductivity responses can be caused by several sources. Common sources in fresh rock are graphite and the presence of sulphides. Common sources in regolith profiles are clay and groundwater. The inversion of the AEM data has been used to detect the position of the unconformity between the alluvial sequence and the underlying weathered bedrock and the presence of thicker portions of the alluvial aquifer at Hemi.
- Remote Sensing data that includes data from the Copernicus Sentinel II satellite. False colour images of the project area, utilising the multi-spectral sensors on the satellite were used to map areas of outcrop or subcrop.
- Waterborne drone Deeper Sonar PROTM sonar survey was used to map the profile of three of the semi-permanent water pools located within the Yule River system.
- 3D lithostratigraphy and structural geology impacts on the weathering regime are typical too deeply weathered rock environments. Different rock types weather more readily when compared to others. Likewise structures typically weather more readily as they are zones of alteration, deformation fabric and/or reduced rock mass quality. Palaeovalley highs and lows form due to their higher or lower basement resistance to weathering and contribute to the local thickening or thinning of the alluvial sequence and/or the underlying basement regolith regime.
- Hydrological and hydrogeological data and numerical models including aquifer information and water quality data are used to delineate the standing groundwater level across the model area as this is key habitat boundary for troglofauna and stygofauna (Geowater 2023).

## 4. GROUNDWATER PHYSICOCHEMICAL PROPERTIES

### 4.1 Groundwater Quality

Groundwater quality in the Hemi region (based on ~350 samples collected from Hemi Project bores) is typically fresh to brackish (800 – 1,100 mg/L TDS), slightly alkaline (pH mostly in the range from 7.5 – 8.5), and with elevated hardness (average of 270 mg/L as calcium carbonate). Since December 2020, ~350 groundwater samples from the Hemi and Turner River areas have been analysed for detailed water quality by ALS at their Wangara laboratory in Perth. Results are summarised in Section 4.1.1 to 4.1.3.

#### 4.1.1 *Water Type*

Groundwater in the alluvial aquifers of the Hemi region can be characterised as a mixed water type, with sodium and potassium the dominant cations, with lesser magnesium and only minor calcium. Chloride and bicarbonate are the dominant anions with only minor sulphate. The bedrock intervals sampled to date are relatively shallow but show a trend towards increasing sodium and potassium levels at the expense of magnesium. This may be a result of cation exchange within the clay mineralogies of the saprolite and saprock intervals that the bedrock bores are screened within.

In a vertical context, the salinity of groundwater within alluvium and weathered bedrock at Hemi is very similar, with no obvious changes between shallow and deeper intervals (excluding the finer-scaled observation of fresher water at or very close to the water table surface in some bores). Water samples collected from multi-piezometer bores on the same dates have salinity values within 10% of each other between shallow and deep intervals.

The alluvial aquifer in the Hemi region shows a trend of increasing salinity from west to east. The major ion water chemistry of this trend shows that, from west to east, cation ratios remain similar whilst chloride increases notably at the expense of bicarbonate. Given the similar geochemistry of the alluvium, the increasing salinity and chloride to the east is interpreted to reflect relatively lower rates of groundwater recharge.

Out of a suite of 29 dissolved minor and trace metal concentrations, only arsenic, boron, uranium, vanadium and strontium are characterised by high concentrations. The elevated concentration of these trace metals may reflect the combined effect of high alkalinity and high dissolved oxygen concentrations and evapo-concentration processes occurring within the aquifer. Weathering of the basement geology rich in these trace metals may provide a precursor to relatively high concentrations, followed by further enrichment by these conditions within the alluvium aquifer.

The concentration of dissolved arsenic in the Hemi region is highly variable (over three orders of magnitude) and ranges from 0.6 to 797 µg/L (median = 9.4 µg/L). There is a spatial tendency for the observed higher concentrations to occur within bedrock bores located in relative proximity to

orebodies, which contain elevated levels of arsenopyrite. The concentration of the other elevated metals (B, U, V, Sr) show a poor correlation with vertical depth and distance to gold mineralisation, suggesting that the increase in these trace metals is related to the geochemical characteristics of the host alluvium aquifer and/or other bedrock types.

The main sources of boron and uranium are the underlying basement granitic rocks and pegmatites. They are also associated with biotite and amphibolite. Uranium concentrations range from 2 to 114 µg/L. Similar to uranium, vanadium concentrations vary over a large range between 0.3 to 44.3 µg/L (Median = 28.4 µg/L). Vanadium, U and B show a good correlation with As and are likely to be derived from similar sources under alkaline groundwater conditions. The general trends observed between U and As in the groundwaters may also suggest their control by similar geochemical processes.

### 4.1.2 Salinity Trends

The alluvial aquifer in the Hemi region shows a trend of increasing salinity from west to east. The major ion water chemistry of this trend is highlighted on the Durov plot (Figure 4-1) which shows that, from west to east, cation ratios remain similar whilst chloride increases notably at the expense of bicarbonate. Given the similar geochemistry of the alluvium, the increasing salinity and chloride to the east is interpreted to reflect relatively lower rates of groundwater recharge.

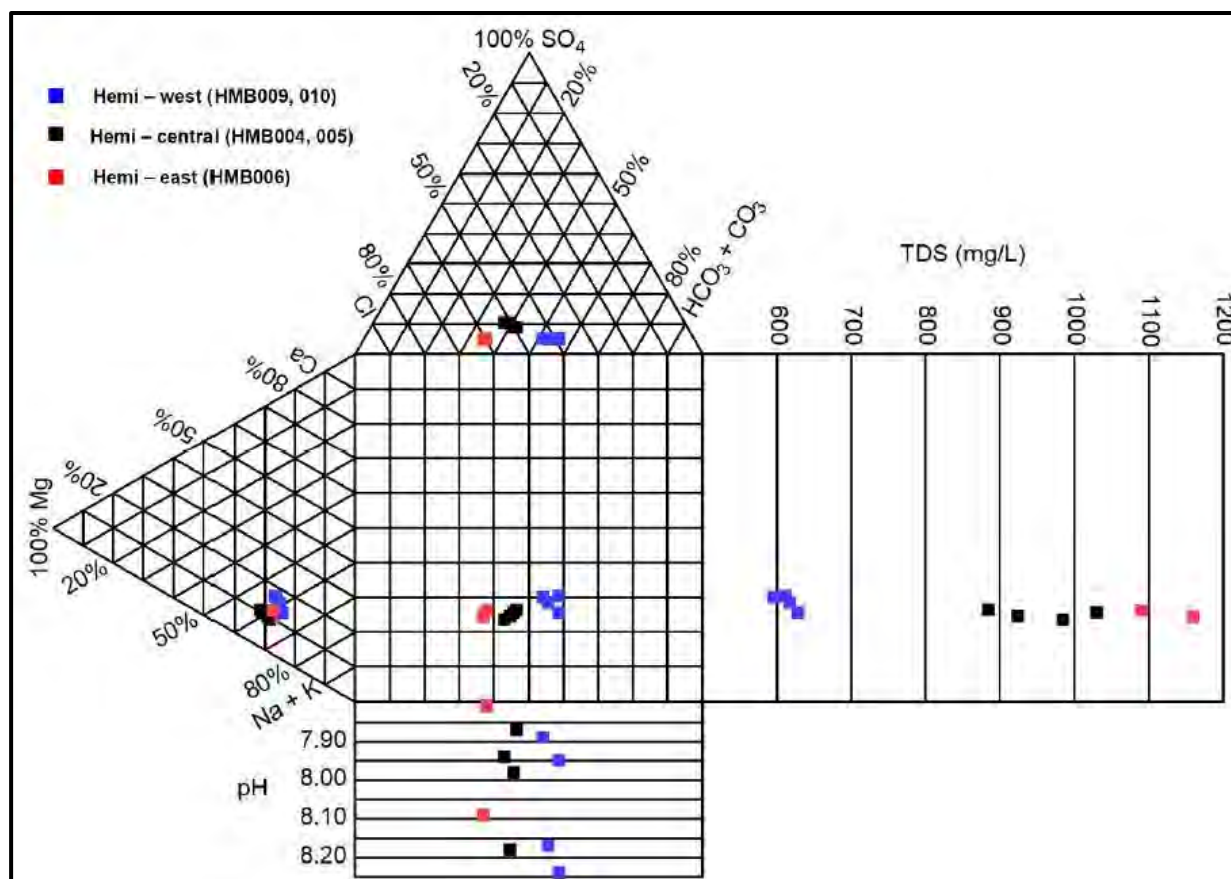


Figure 4-1: Durov Plot – Hemi Alluvial Aquifer

## 4.1.3 Trace Metals

A comprehensive suite of trace metals has been analysed on all groundwater samples, to the lowest detection limits available across the project region. Total metals analyses have also been undertaken since October 2021 on groundwater samples that exhibit a cloudy or turbid nature.

Groundwater quality analysis indicates that:

- Dissolved arsenic, chromium, uranium, and vanadium levels in some bores at Hemi can be significantly higher than the levels in bores more distant from Hemi and/or in baseline surface water samples collected in the Turner River to date.
- Groundwater samples in bedrock are only available for bores located within ore zones and show the highest arsenic levels (up to almost 1 mg/L).
- There is a tendency for arsenic values in alluvium in bores located directly downgradient of ore zones to be higher than alluvium bores located upgradient of the Hemi ore zones.
- Chromium values are typically higher in alluvium bores located upgradient and laterally distant from the Hemi ore zones, which suggest that elevated chromium levels are not related to the Hemi gold mineralisation system.
- Groundwater near the Turner River bores typically have the lowest arsenic, chromium, and uranium levels relative to the Hemi region.
- Uranium and vanadium levels are similar in concentration between upgradient, downgradient and Hemi bedrock zones, which suggest their distribution in the groundwater system is not closely related to the Hemi gold system. It may be more in relation to all the Hemi sites being broadly downgradient of a large granodiorite dome present to the south-east of Hemi.

## 5. SUBTERRANEAN FAUNA

### 5.1 Sampling Effort

Sampling for subterranean fauna consisted of three rounds of sampling for stygofauna and a single round of sampling for troglofauna. Sampling occurred between October 2021 and May 2022 with a total of 20 troglofauna and 120 stygofauna samples collected during all surveys.

Forty bores and drill holes were sampled three times for stygofauna, with 19 of these being in the proposed mine pits or nearby in areas expected to be affected by dewatering. The other 21 were outside the area of groundwater disturbance and are treated as 'reference' sites (Figure 5-1).

Twenty drill holes were sampled once for troglofauna with 13 of the holes being inside the proposed mine pits and seven being outside and treated as 'reference' sites (Figure 5-1).

### 5.2 Subterranean Fauna Sampling Method

#### 5.2.1 *Stygofauna*

Methodology used for sampling for stygofauna adhered to the methods recommended by the EPA (2021), whereby stygofauna were sampled at each monitoring bore using weighted plankton nets. Six hauls were taken at each site, three using a 50 µm mesh net and three with a 150 µm mesh net. The net was lowered to the bottom of the hole and jerked up and down briefly to agitate benthos (increasing the likelihood of collecting benthic species) and then slowly retrieved. Contents of the net were transferred to a 125 ml polycarbonate vial after each haul, flushed with bore water to reduce fine sediment content, preserved in 100% ethanol and refrigerated at a constant 4°C. Nets were washed between holes to control site-to-site contamination.

#### 5.2.2 *Troglofauna*

Sampling for troglofauna was conducted in adherence to methods recommended in EPA (2021) whereby each troglofauna sample from a borehole consisted of results from two separate collection techniques, scraping and trapping:

- Scraping was completed using a weighted net of 150 µm mesh that had an upper diameter approximately 60% of the drill hole diameter. The net was lowered to the bottom of the hole or to the water table, and subsequently scraped back to the surface at least four times. In each of these scrapes a different section of the wall of the hole was targeted (e.g., north, south) to maximize the number of animals retrieved. After each haul, net contents were transferred to a 125 ml vial with refrigerated 100% ethanol until return to the laboratory.
- Trapping was completed using traps of cylindrical PVC (170 x 65 mm) with holes on the sides and top to function as entrances and a bait of microwaved leaf litter. Traps are lowered on nylon cord to the end of the hole or to a few metres above the water table. For most holes, one trap was set near the bottom of the hole; at a quarter of holes a second trap was set approximately halfway between the surface and the first trap. Traps were then left in place for approximately

eight weeks for troglofauna to colonize them. During that period, the bores were sealed off at the surface to minimise entry of surface animals into the traps. After retrieval the contents of traps were transferred to a zip-lock bag and animals transported alive to the laboratory in Perth.

### 5.2.3 Laboratory Processing

All samples were processed by Bennelongia laboratory staff in Perth. Leaf litter retrieved from troglofauna traps was processed in Berlese funnels under halogen lamps for 72 hours, during which time the light and heat drives animals downwards, towards a vial containing 100% ethanol as a preservative. Litter was quickly checked after removal from the funnels to ensure no invertebrates remained. Samples in ethanol from the Berlese funnels were carefully screened under a dissecting microscope to pick out troglofaunal animals.

Stygofauna net and troglofauna scrape samples were elutriated to separate animals from sediment and put through sieves to fractionate the contents according to size (250, 90 and 53  $\mu\text{m}$ ) to improve searching efficiency. All potential stygofauna and troglofauna animals were removed from these samples for species or morphospecies level identification. Surface animals were identified to Order level and classified as by-catch.

Species identification of stygofauna and troglofauna was conducted using published, unpublished and informal taxonomic keys, as well as species descriptions in the scientific literature. Morphospecies were established using the characters of existing species keys, and the lowest level of identification possible was reached given the constraints of sex, maturity of the specimens (juveniles and females often cannot be identified to species level) and possible damage to body parts. Dissecting and compound microscopes were used during the sorting and identification processes, with specimens dissected as required.

DNA sequencing was completed on seven specimens (from at least five different species) from the study area. Depending on the size of the specimens, legs or whole animals were used for DNA extractions using a Qiagen DNeasy Blood & Tissue kit (Qiagen 2006). Elute volumes were 25 to 40  $\mu\text{L}$  determined by the age, condition and quantity of material. Primers combinations used for PCR amplifications were LCO1490:HCO2198, C1J1718:HCO2198, and LCO1490:HCOoutout for the MT-CO1 gene (Folmer et al. 1994; Schwendinger and Giribet 2005) and SRJ14197:SRN1474S for 12S. Next, dual-direction sanger sequencing was undertaken for PCR products by the Australian Genome Research Facility (AGRF). The sequences returned were edited and aligned in Geneious (Kearse et al. 2012), where neighbour-joining phylogenetic trees were then calculated using 1000 bootstraps. Genetic distances (using the Tamura-Nei method) between unique sequences were measured as uncorrected p-distances (total percentage of nucleotide differences between sequences). Sequences on GenBank and in grey literature were included in phylogenetic analysis to provide a framework for assessing intra and interspecific variation, as well as to examine levels of differentiation among individuals within described species across their geographic ranges.

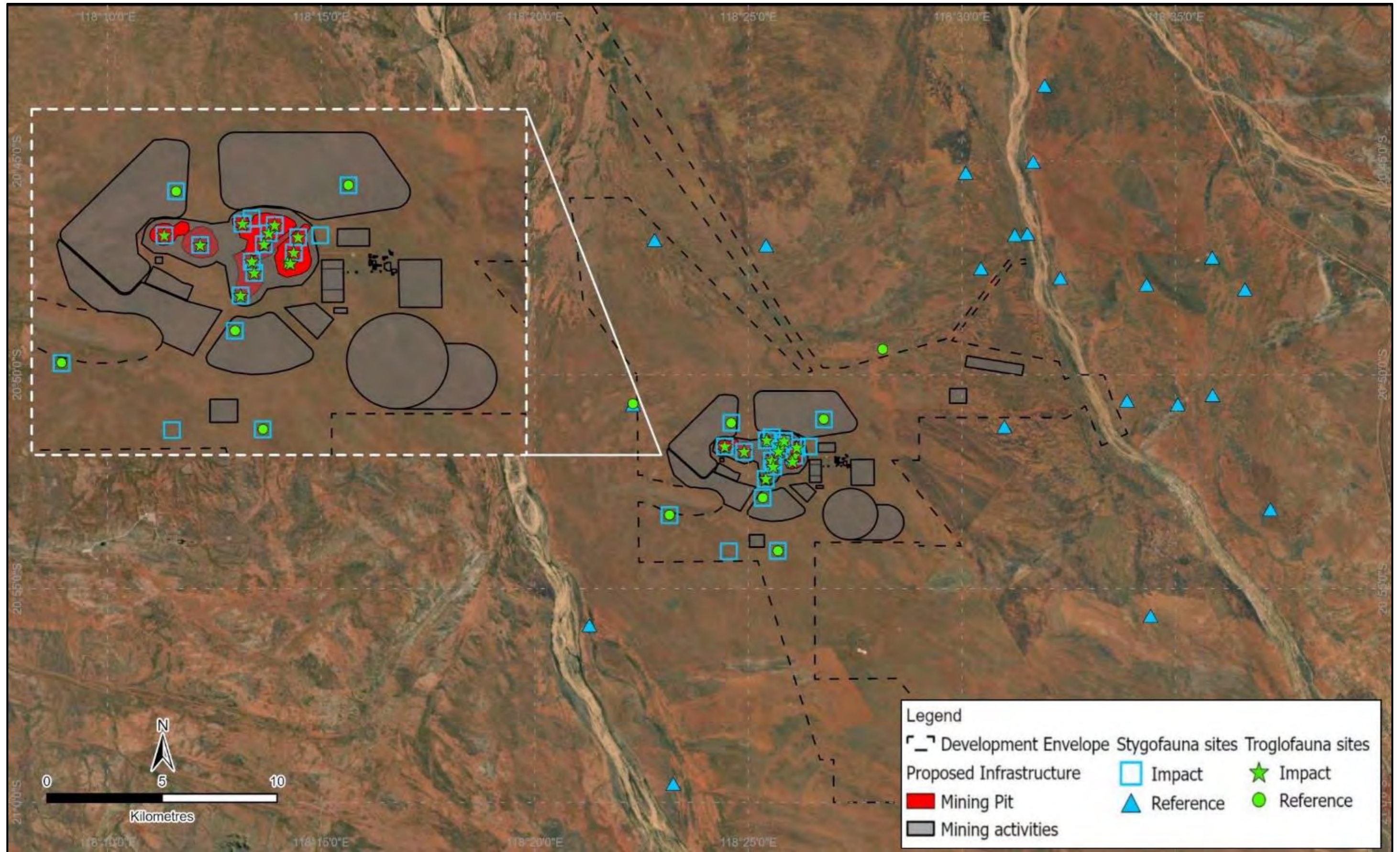


Figure 5-1: Sites Sampled for Subterranean Fauna

## 5.3 Subterranean Fauna Sampling Results

Bennelongia (2023) have undertaken an extensive sampling, analyses and genetic testing program for subterranean fauna at Hemi. The complete report is provided as the Subterranean Fauna Assessment Appendix of the De Grey EPA Section 38 Referral Supporting Document.

### 5.3.1 *Stygofauna*

Across the three rounds of sampling, 3,967 stygofauna specimens were collected representing at least 52 species. This included ostracods (14 species), copepods (11 species), annelid worms (eight species), amphipods (four species), syncarids (two species), isopods (one species), rotifers (one species) and nematodes.

Of the 52 species, 27 were collected from the impact area, with 14 being considered widespread species (i.e. occurring within the region or wider area) and eight occurring beyond the impact area (i.e. occurring beyond the 1m drawdown contour). The remaining five species (Parastenocaris 'BHA392', Brevisomabathynella 'BSY226', Paramelitidae 'BAM210', Microcerberidae 'BIS464' and Microcerberidae 'BIS544') have only been identified from within the impact area, however, are expected to occur outside based on habitat availability and connectivity.

### 5.3.2 *Troglofauna*

A single species of troglofauna, the dipluran Parajapygidae 'BDP208', was collected within the proposed mine pits. Diplurans are primitive insects. The species was only recorded from the area of direct impact, where habitat will be removed for mining.

The low yield of troglofauna species from the Project is attributed to lack of available habitat because of the shallow water table (Bennelongia 2023).

The average linear range of troglofauna species in the Pilbara has been estimated as 5 km (Halse and Pearson 2014).

## 6. SUBTERRANEAN FAUNA HABITAT

### 6.1 Stygofauna and Troglafauna Habitat Domain Control

Stygofauna are defined as aquatic animals that live in groundwater environments. The best-known examples occur in cave lakes but other examples include alluvial, karstic or fractured-rock aquifers. Troglafauna are defined as air breathing subterranean animals and typically found 1-2 metres below the ground surface to the water table.

In groundwater aquifers, establishing the standing ground water level below the topographic surface is a fundamental constraint on defining the upper and lower habitat boundary for stygofauna and troglafauna respectively. De Grey has established an extensive network of hydrological monitoring bores across the project (Figure 6-1 and Figure 6-2) for hydrogeological and environmental baseline and impact studies. Monthly bore monitoring data has established the standing ground water level across the wider project area and this surface level has been used as a control to determine the habitat available for the categories of subterranean fauna.

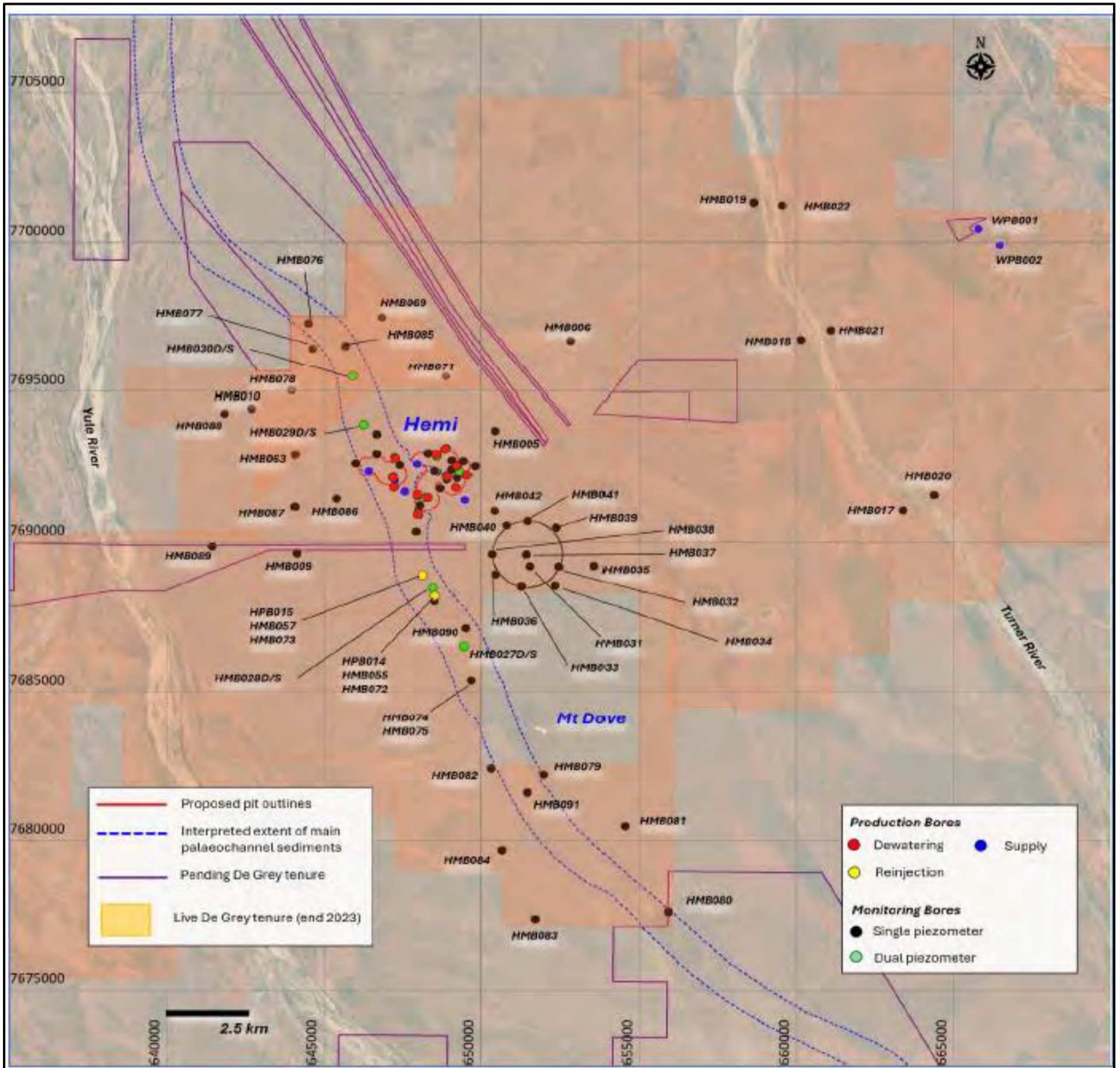


Figure 6-1: De Grey Bore Locations – Regional



Figure 6-2: De Grey Bore Locations - Hemi

## 6.2 Stygofauna

To better characterise stygofauna assemblages, it was recognised that a detailed understanding of stygofauna habit was required. The following program of investigation was developed to facilitate improved habitat understanding:

- Geological logging interpretation of drill hole data.
- Hydrogeological logging of bore data.
- Measurements taken in the standing water level below the current topographic surface.
- Estimation of the depth and spatial extent of habitat within the landscape.

The results of these investigations are discussed in the following subsections.

### 6.2.1 *Geological Interpretation of Data*

Accuracy of the geological interpretation of drill hole data is of critical importance when considering geology as potential subterranean fauna habitat. The following provides an overview of the methods used for completing the analysis.

A multi-geoscientific dataset approach to geological interpretation is applied at De Grey. This approach results in more accurate interpretations as it relies on quantitative datasets such as multi-element assays as well as qualitative to semi-quantitative datasets such as geological logging. The inputs to the models are outlined in section 3.4.

Geological logging of AC and RC rock chips and spoils and diamond drill core includes systematic recording and measurement for determination of the lithology (rock types), mineralogy, grain size, potential geological history, structure, alteration zones and all other relevant observations.

Experienced field geologists conducted geological logging for all drill holes in the project. These geologists were well-versed in the area's lithologies, regolith types, and variations within the broader project. The geological logs underwent regular quality checks by geology supervisors to ensure accuracy and detail (i.e., QAQC). Primary data collection occurred using standard templates on laptop computers with lookup codes. Subsequently, the information was validated and compiled into an SQL database in Perth.

Multi-element geochemical assaying is routinely undertaken across all drill holes and most water bore holes. Chemical fractionation that results from the weathering of fresh rock types is a well understood process globally. The systematic approach to geochemical data acquisition on the Project has enabled a detailed understanding of chemical signature of the different regolith domains across the project. Geochemical analysis is completed by ALS Global laboratory in Perth. All assay data is subject to rigorous QAQC protocols to ensure the assay data is of sufficient quality to meet Company standards.

Geotechnical logging parameters such as RQD and RMR89 are used as one of the geoscientific data inputs into the regolith models. These parameters provide quantitative measures on the in-ground geological conditions. This includes the quality of the soil-like medium through to the quality of the rock mass. Rock mass is defined as an inhomogeneous material built up of smaller and larger blocks/pieces composed of rock material. The blocks/pieces result from discontinuities at a scale

of joints, fractures, faults and schistosity. The inclusion of these parameters are therefore a measure of potential habitat for subterranean fauna external to the alluvial sequence.

3D geological modelling has been undertaken by a Principal Geologist with sufficient experience in the 3D geological modelling of regolith regimes to ensure the models and therefore available subterranean habitat extents are accurately modelled to the available input data.

The colluvium and alluvium 3D geological model comprise two distinct geological domains available as core habitat for Stygofauna:

- **Type S1 Saturated Upper Aeolian, Colluvium and Alluvium** – A laterally extensive facies consisting of unconsolidated clay, mud, silt and lesser sand. This domain of the groundwater aquifer is considered to have low to high permeability (clay/mud content dependent) and is largely saturated. This domain is considered stratigraphically equivalent to the DWER Yule River Aquifer Upper Sand – Silt – Clay Alluvium hydrogeological domain (Plate 6).
- **Type S2 Saturated Lower Colluvium and Alluvium** – A similar system to the upper alluvium, but which notably is defined as the palaeochannel facies and contains unconsolidated sands and gravels and lesser silt. This is the main host to the groundwater aquifer system and has high permeability and storage values. The palaeochannel has significant continuity in the north-south direction and is of the order of 0.5 – 2 km in the transverse east-west direction near Hemi. This domain is considered stratigraphically equivalent to the DWER Yule River Aquifer Lower Sand - Gravel Alluvium hydrogeological domain (Plate 6).

The basement 3D geological model comprises three distinct geological domains the first two (T3 and T4) of which have some potential to support stygofauna and the last one, bedrock (T5), which is considered to be limited in its ability to support stygofauna:

- **Type S3 Saprolite and Saprock** – A compact clay dominant domain with lesser silt, sand and clasts of highly weathered rock. This domain contains minor volumes voids or fractures that occur in association with shear zones and faults but also part of the natural development of the profile during a deep tropical weathering event. The saprolite can be split on a visual basis between upper and lower saprolite, with the upper saprolite typically bearing a yellow-red and mottled colour and the lower saprolite bearing a grey colour. This domain is spatially located below the Type S1 and Type S2 domains (Plate 6).
- **Type S4 Joint Weathered Bedrock Basement** – A weathered fractured bedrock (incipiently weathered rock) domain with minor clays/oxides on the joint surfaces. The joints increase in spacing as a result of the incipient weathering. The domain is largely located below and above Type S3 and Type S4 domains respectively except where subcrop and outcrop areas are located, where Type S3 has been mechanically removed by erosion processes (Plate 6).
- **Type S5 Fresh Bedrock Basement** – Fresh bedrock with no signs of incipient weathering of the rock mass. Generally low joint/fracture frequency spacing. Local areas of increased fracturing present where faults are present. This domain is considered to limited habitat potential given the lack of open voids and connection to the regolith environment spatially above the domain (Plate 6).

The major river systems, geological domains/available potential stygofauna habitat, recorded stygofauna locations at family level and the Development Envelope are displayed in Figure 6-3.

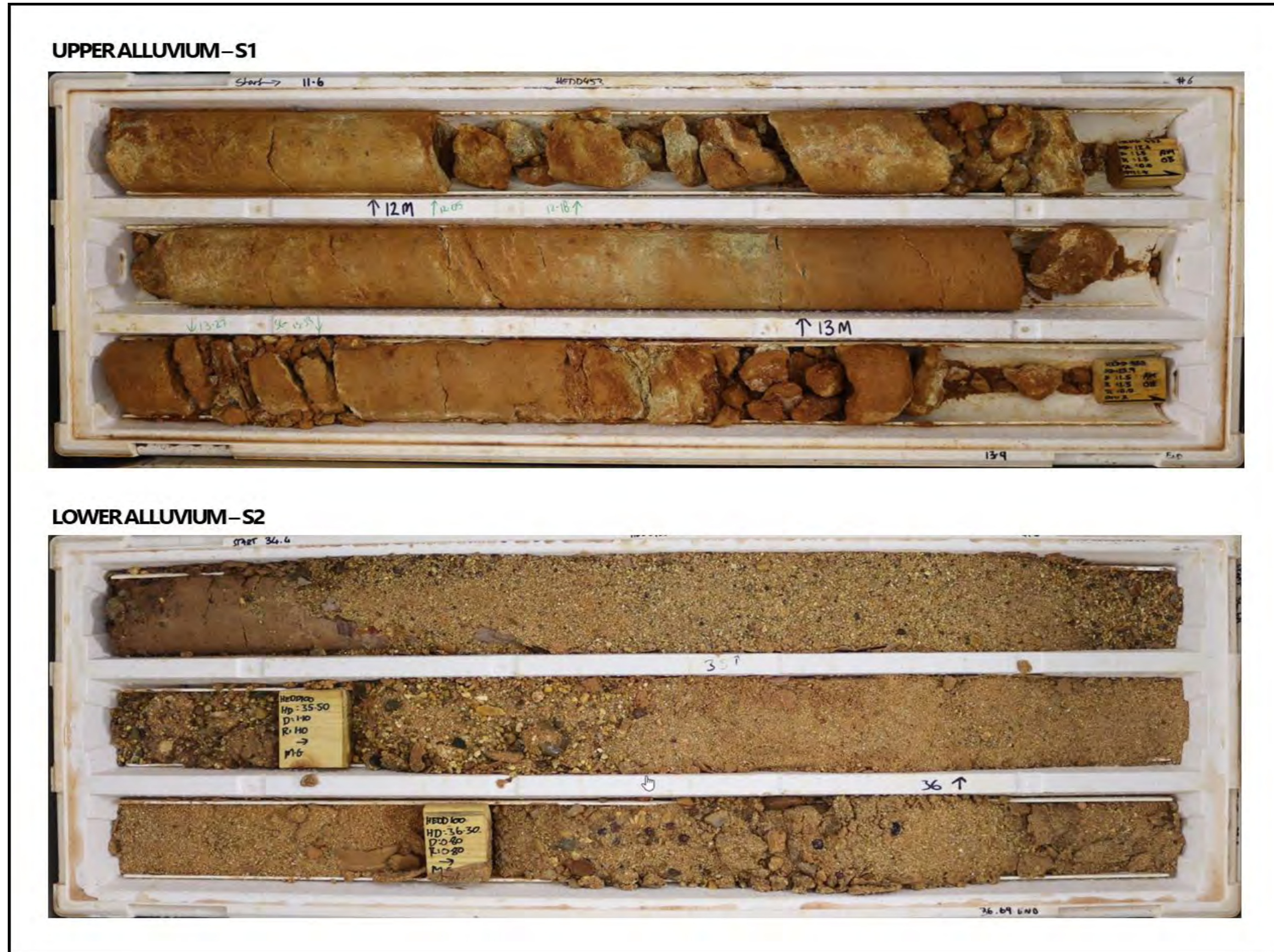


Plate 6-1: Diamond Drill Core Examples of the Upper Alluvium (S1) and the Lower Alluvium (S2) Geological Domains



Plate 6-2: Diamond Drill Core Examples of the Saprolite – Saprock (S3), Fractured Bedrock (S4) and Bedrock (S5) Geological Domains

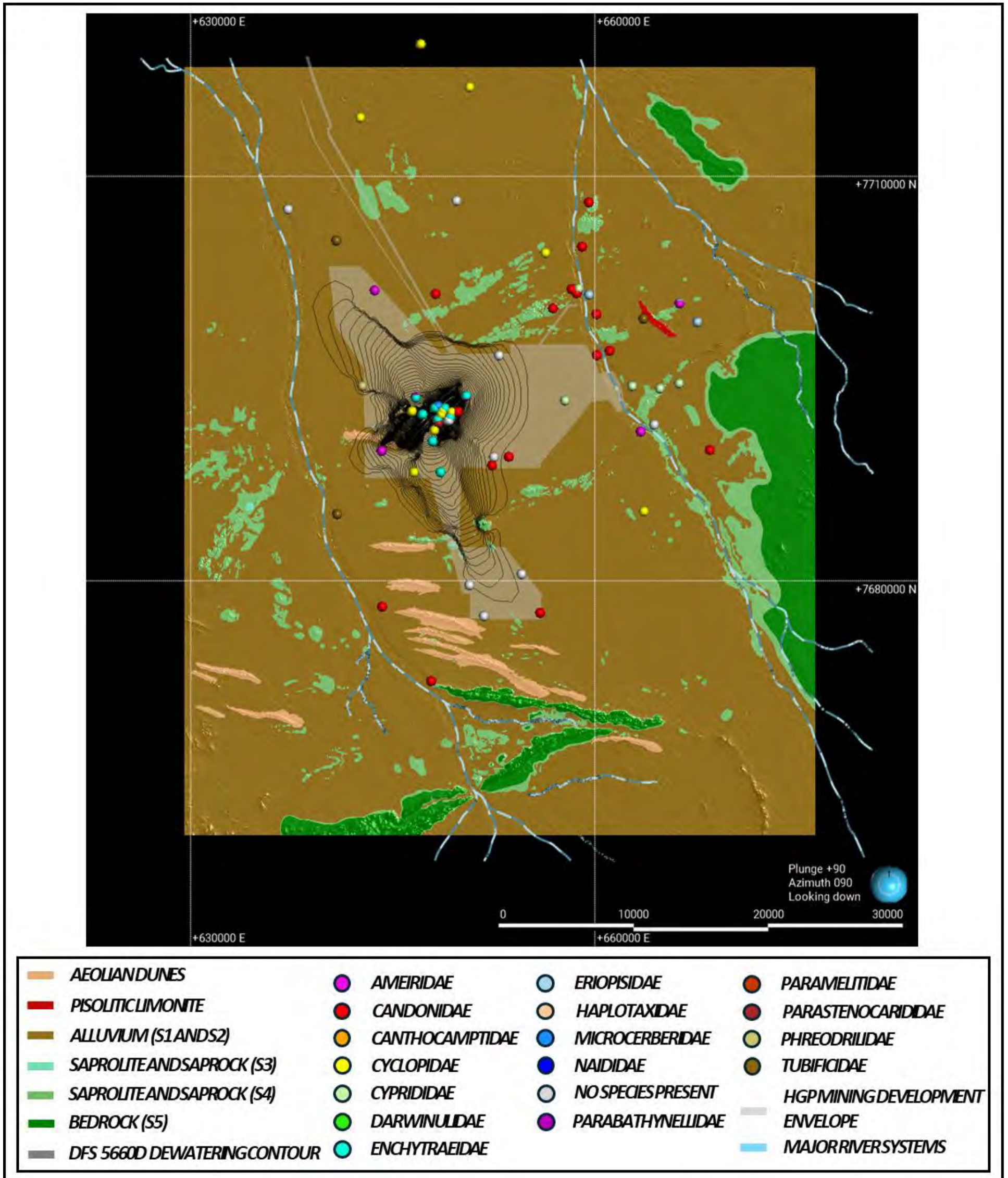


Figure 6-3: Major River Systems, Geological Domains Representing Available Potential Stygofauna Habitat, Recorded Stygofauna Locations and Development Envelope

## 6.2.2 Comparative Analysis of Geological Stygofauna Habitat

Detailed geological analysis has been completed to assess the geological domains and their influence on the subterranean fauna across the study area. The analysis consisted of assessments of productive and unproductive bores to establish if:

- Local geological changes within and between drillholes that form a controlling factor in the establishment of a stygofauna habitat in a given geological domain.
- Geochemical changes form a controlling factor in the establishment of a stygofauna habitat in a given geological domain.
- Geological domains variations (e.g. thickness) form a controlling factor in the establishment of a stygofauna habitat in a given geological domain.

The following provides a summary of key findings of the comparative geological habitat assessment:

- 69 boreholes were sampled for stygofauna over four sampling periods.
- Geological variations and differences within the productive stygofauna monitoring bores were negligible across the project.
- 9 boreholes (13%) sampled during the study period were unproductive.
- 59 boreholes (85%) sampled during the study period were productive during the sampling period, of which 9 boreholes (13%) yielded potentially restricted species.
- 52 stygofauna species were reported over the sampling periods.
- There were no statistical differences in geology between boreholes that yielded potentially restricted species, compared to all other productive bore holes.
- 57 species (97%) were recorded in the Types S1 and S2 geological profiles.
- 3 species (3%) were not recorded in the Types S1 and S2 domains. The species include Candonidae `BOS1657` and Mesocyclops sp. and were recorded in the Type S4 and S5 and S3, S4 and S5 domains respectively. Despite this potential restriction on the habitat for these species, multiple family and genus taxonomic orders for Candonidae `BOS1657` and Mesocyclops sp. were recorded and are widespread across the study area and geological profiles e.g. the Candonidae family or the genus Mesocyclops.
- Most genus and all family taxonomic ranks were recorded in all geological domains indicating the stygofauna can move freely between the geological domains. This is consistent with the fundamental geological and hydrogeological characteristics of the region, where:
  - Alluvium is unconsolidated and when the river channel was active, it behaved as a largely erosional system that prevented the deposition of impermeable clay layers.
  - The aquifer occurs throughout all regolith domains.
- The low number of unproductive bores (9) indicates that the stygofauna are likely to be transient across the different domains. This suggests that unproductive bores are an artifact of sampling. The thickness of the regolith / stygofauna domains were assessed to determine if regional changes in domain thickness related to outcrop distribution (vertical extent habitat) are responsible for species or genus distribution. This analysis demonstrates no correlation is present and that the stygofauna species are likely to be able to freely move laterally and vertically across the region. An example of this is displayed in Figure 6-5.

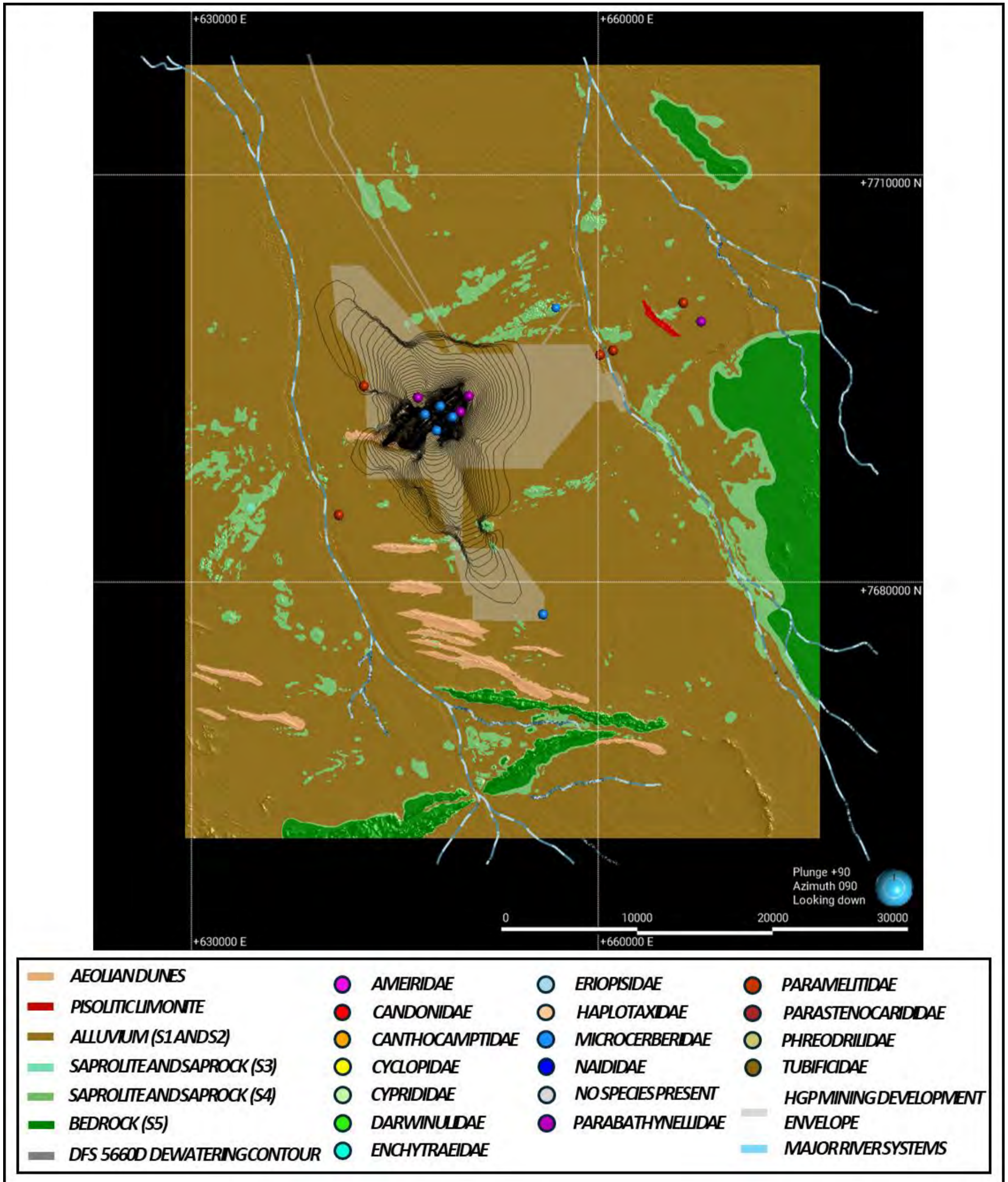


Figure 6-4: Spatial distribution of potentially restricted species displayed at a family taxonomic rank across Type S1 – S5 Domains

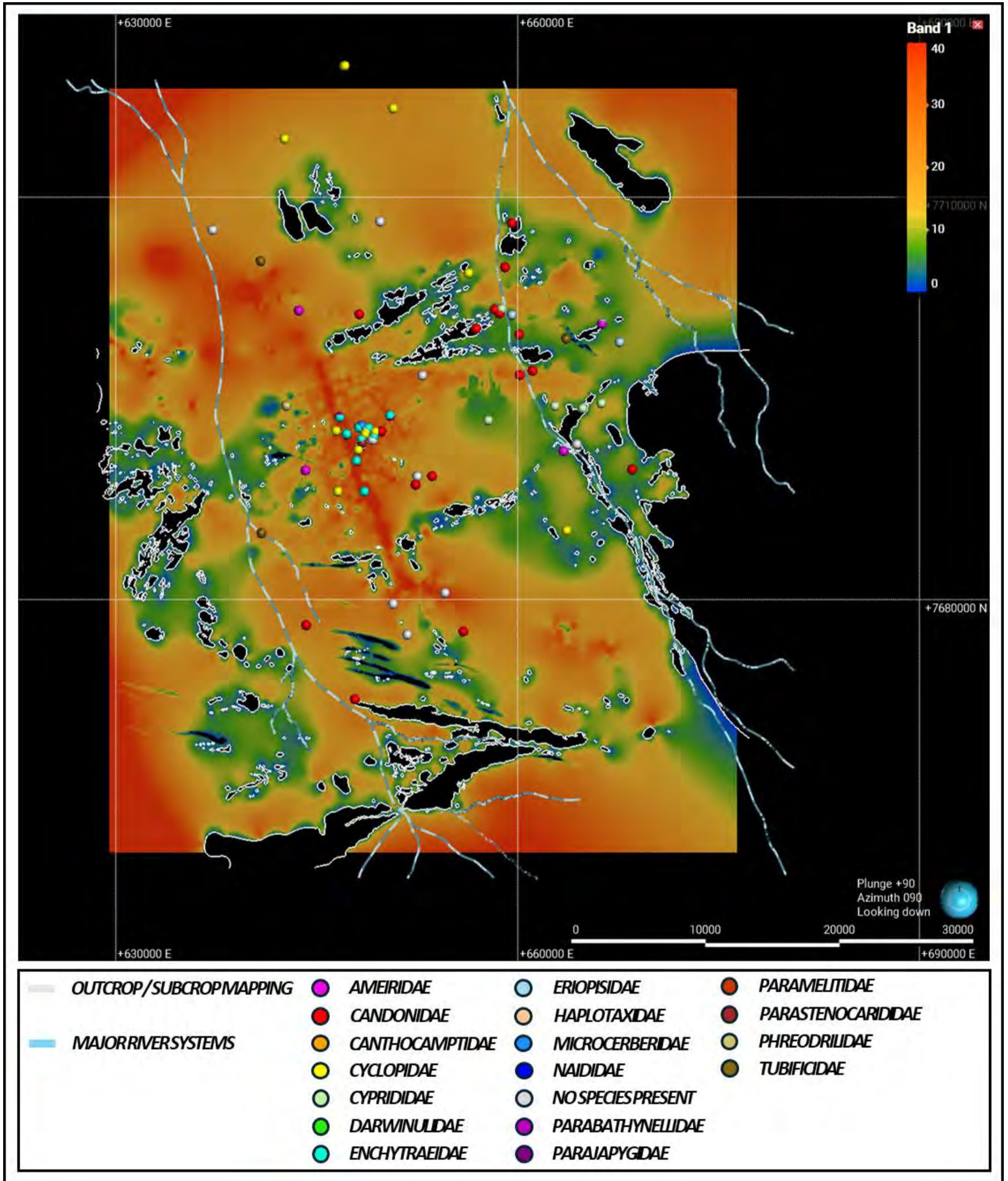


Figure 6-5: Example of a Lack or Correlation between Stygofauna Distribution and Thickness of Geological/Stygofauna Domains. The Thickness (Band 1) of the Total Alluvium (Type S1 and S2) is Displayed

## Estimation of the Alluvium Domain (Type S1 and S2) and Volume of Available Habitat

Geological modelling of the available geological domains and habitat volumes reflects the detailed understanding of the regolith and bedrock geology at Hemi. This understanding has developed through the integration in 3D of multiple geoscientific datasets and has enabled accurate relative age relationships of the domains to be established but also enables the accurate spatial definition of the 3D spatial extent of the domains.

Type S1 and S2 comprise unconsolidated alluvium. The extensive drill hole database and water bore network at the Project has demonstrated no evidence to date to support an impermeable unit within the alluvium. Evidence is present in the alluvium of a highly active palaeo-drainage system and this energy environment is not geologically conducive for the deposition of large and spatially extensive accumulations of impermeable clay. As such, all the available alluvium below the standing groundwater table below the current topographic surface (S1 and S2 domains) are considered as available stygofauna habitat (Table 6.1).

The extensive water bore network (Figure 6-1) is monitored routinely for standing groundwater table level below the current topographic surface. This data is also routinely modelled in 3D and this was used to derive the habitat volume estimates for stygofauna. S1 and S2 form the High Hydraulic Conductivity Aquifer domain of the total Hemi Regional area, as described in Section 3.5.

Table 6.1: Estimated Geological Volumes for Type S1 and S2 Domains/Habitats. High Hydraulic Conductivity Aquifer

Aquifer Domain	Habitat Classification	Volume of Geological Domain (m <sup>3</sup> )	Estimated Percentage of Geological Domain Suitable for Stygofauna of Habitat (m <sup>3</sup> )	Area of Habitat (ha)	Inferred Volume of Habitat (m <sup>3</sup> )
HHCA	<b>Type S1</b>	17,635,700,000	100%	1,496,180,000	17,635,700,000
	<b>Type S2</b>	2,851,300,000	100%	335,620,000	2,851,300,000

### 6.2.3 Estimation of the Weathered Bedrock Geological Domains and the Volume of the Available Habitat

The 3D geological regolith models integrate fundamental concepts for geotechnical characterisation of soil-like and rock materials and this enables a statistical approach to be taken to establishing the degree of voids present within the soil-like weathered rock material and rock mass. Detailed geotechnical logging has been undertaken to support mine design studies and this enables a statistical approach to be derived on the joint/fracture frequency (spacing in a metre) and width of the joints logged as a proxy to voids presents within the domains.

The frequency and joint width were integrated assuming they are applicable to a cubic metre of geological material within a given domain to establish the likely proportion of a geological volume that is available for habitat suitable for stygofauna species. The statistics are derived from diamond drill core that has been geotechnically assessed.

Joint / fracture frequency and apertures are assumed in the geological domains where no diamond core is present. This approach is valid given the robust multi-geoscientific data inputs on the

regolith geological models and improves the robustness of the volume estimate for the Type S3, S4 and S5 domains by providing an estimate on the available voids within the soil-like weathered rock material and the rock mass. Table 6.2 outlines the analysis undertaken to understand the available voids in the Type S3, S4 and S5 domains. Table 6.2 outlines the estimated total available geological and corresponding habitat volume for the Type S3, S4 and S5 domains.

Table 6.2 Joint / Fracture analysis to estimate the available void volumes within the geological domains

Habitat Classification	No. Joint/Fractures (per m)	Joint/Fracture Aperture (per m)	Estimated Void Volume (m <sup>3</sup> )	Estimated Void Volume Percent (%)	Volume of Geological Domain (m <sup>3</sup> )	Inferred Volume of Habitat (m <sup>3</sup> )
<b>Type S3</b>	3.45	0.03	0.10	10.34%	82,361,000,000	8,520,103,448
<b>Type S4</b>	3.03	0.02	0.06	6.06%	135,490,000,000	8,211,515,152
<b>Type S5</b>	1.19	0.01	0.01	1.19%	625,110,000,000	7,441,785,714

Evidence of the presence of groundwater in the Saprolite-Saprock (Type S3) and Fractured Bedrock (Type S4) domains is present for the total of these domains. A precautionary approach has however been taken on the extent of the available voids in the Saprolite-Saprock, Fractured bedrock and Bedrock domains (Type S3, S4 and S5) to host stygofauna as it has been assumed that stygofauna habitat becomes less suitable at ~100m below the topographic surface. The current Digital Elevation Model (DEM; topography) was offset 100m below the current position. This was applied to the stygofauna domains to ensure that nutrient supply is sufficient to maintain a habitat within these domains. This process acts to reduce the Inferred Volume of Habitat (Table 6.3).

Table 6.3: Estimated geological volumes, habitat area and inferred habitat volumes for the Type S3 and S4 (Low Hydraulic Conductivity Aquifer) Domains within 100 m of Surface

Aquifer Domain	Habitat Classification	Area of Habitat (ha)	Inferred Void Volume of Habitat (m <sup>3</sup> )	Inferred Volume of Habitat (m <sup>3</sup> )
LHCH	<b>Type S3</b>	2,303,750,000	8,520,103,448	8,369,896,552
	<b>Type S4</b>	2,510,900,000	8,211,515,152	6,046,909,091
N/A	<b>Type S5</b>	2,699,800,000	7,441,785,714	535,761,905

## 6.2.4 Additional Controls on Available Stygofauna Habitat

### 6.2.5.1 Influence of Mineralisation

The mineralogy and lithogeochemistry of the basement rock (siliciclastic sedimentary rock sequence and pyroxenite to tonalite sills) hosting the deposits are the same across the region surrounding the Project (50km radius) except for small volumes of iron and arsenic sulphides.

While the presence of sulphides could theoretically provide the basis of a distinct (restrictive) habitat for stygofauna to have evolved into occupying, there is no evidence in drill hole logging, lithogeochemistry, regolith development or water chemistry that this has occurred.

The mineralisation is therefore not likely to be a controlling factor on the presence or absence of stygofauna across the Project nor is it likely to have provided a restrictive habitat location for stygofauna to occupy.

### 6.2.5.2 Radiological Influences on Subterranean Fauna Evolution

At other sites in Western Australia, the presence of radioactive minerals in geological units have resulted in a subterranean fauna that is highly unique. This is also believed to increase the likelihood of restricted stygofauna species.

Sampling of rock materials was undertaken and shows that uranium concentration are in the range of 0.3 to 37 mg/kg with lower concentrations in ore (1 to 2.2 mg/kg) and thorium concentration in rock and ore averaging 9.1 mg/kg and 5.7mg/kg respectively.

Total uranium and thorium concentrations were used to calculate head-of-chain activity concentrations of naturally occurring uranium and thorium series radionuclides in materials within the proposed project. Based on maximum total uranium and thorium concentrations, maximum head-of-chain activity concentrations for  $^{238}\text{U}$  and  $^{232}\text{Th}$  are between 0.0031 to 0.46 Bq/g (waste rock) and 0.012 to 0.028 Bq/g (ore) and 0.041 to 0.11 Bq/g (waste rock) and 0.014 to 0.033 Bq/g (ore). The above values are below the definition of a radioactive material.

Given extremely low levels of radioactive minerals and concentrations present in the proposed project area, these are not considered to present a controlling factor or influence the presence, absence or species richness of stygofauna at Hemi.

### 6.2.5.3 Total Dissolved Solids (TDS), River Systems and the Alluvium Palaeochannel

Given that the geological variations and differences within the productive stygofauna monitoring bores were negligible across the study area and that there is no statistical difference in geology between boreholes that yielded potentially restricted species, compared to all other productive bore holes, total dissolved solids and by proxy salinity were investigated as possible mechanisms that control stygofauna evolution and occupation of a particular habitat / domain (Appendix 1).

The extensive De Grey owned, and accessible 3<sup>rd</sup> party bore network is routinely monitored for various industry standard protocols. One of which is electrical conductivity ( $\mu\text{S}/\text{cm}$ ; EC wherein). EC and Total Dissolved Solids (TDS) are indicators of salinity level within a water sample. The determination of EC in the field by a conductivity metre is well established. Further test work using external accredited laboratories, has shown that EC determined in the field is statistically equivalent to laboratory measurements. EC can be used to derive total dissolved solids (TDS) in a hydrological sample via the following equation:

$$TDS_{(mg/l)} = K \times EC_{(\mu S/cm)} \quad (1)$$

Where: TDS = Total dissolved solids, K = dimensionless conversion factor and EC = Electrical Conductivity

Analysis of external accredited laboratory data acquired by De Grey has established that a K of 0.65 is appropriate for use across the Project area. Derived TDS across the bore network was then used to assess if stygofauna family, genus and species variations are driven by salinity.

The following provides a summary of key findings of the comparative salinity-river system habitat assessment within the broader geology / stygofauna domains:

- The salinity of the high hydraulic conductivity domain of the groundwater aquifer broadly changes from high to lower salinity from the east to the west of the Project area.
- The salinity of the high hydraulic conductivity domain of the groundwater aquifer is controlled by the proximity of the domain to bedrock, outcrop and outcrop controlled shallow pools in the major river systems (primarily in the Turner River).
- The salinity of the groundwater aquifer is likely to be influenced by the Yule River system, the Turner River system and the Palaeochannel regolith domain (Type S2). Low salinity bores are recorded in proximity to the Yule River system and the Palaeochannel regolith domain while high and low salinity measurements are recorded along the length of the Turner River system. The variation along the Turner River is most likely related to the presence and/or the thickness of alluvium and the proximity of outcrop controlled shallow pools that promote local increased evaporation and therefore salinity. Figure 6-6 displays family ranks, total alluvium (low and high hydraulic conductivity) aquifer TDS and distance buffers from the river and Palaeochannel systems.
- While there is some spatial clustering of the bores, the subterranean fauna data shows indications of associations with either the Yule River system, the Palaeochannel domain or the Turner River system. A small central corridor between the Palaeochannel domain and the Turner River system (Central River Corridor) may be less favourable for some species of stygofauna to occupy. This clustering is likely due to subterranean fauna adapting to flood related recharge of water into the river systems and the salinity of the groundwater (Yule River system association is typically lower salinity against higher salinity in the Turner River system aquifer association).
- Family and genus taxonomic level assessments demonstrate some family ranks have a clear correlation between regolith / stygofauna habitat, TDS (salinity) and major river system – Palaeochannel domain analysis (Table 6.4 and Figure 6-3). Other family or genus ranks are widespread and show occupation and by proxy, adaption to a range of salinity values. The following summary can be observed:
  - Stygofauna genus rank that classifies in association with the Yule River and / or the Palaeochannel correlate with lower TDS results. This suggests the adaption to lower aquifer salinity results but critically that the genus ranks are capable of moving across the geological and hydrogeological domains below the peak salinity range.
  - Stygofauna genus rank that classifies into a mixed Turner River – Palaeochannel domain show a wide range in TDS. This range is typically bimodal, with the lower end of the range reflecting a population that is located in the Palaeochannel domain and the higher end reflecting a population that is located in the Turner River domain (Table 6.4). The area of higher salinity in Central River Corridor may provide a limited barrier between the two populations. It also

suggests that the Palaeochannel and Turner River populations were either connected in the past and have adapted to different salinity conditions or that they are able to move across the region.

- Stygofauna genus rank that classifies across most or all the hydrogeological domains show a large range in salinity indicating both adaption to all salinity ranges in the region but also the ability to move across all geological and salinity domains.

Table 6.4: Stygofauna genus ranks' dominant hydrogeological domain and the TDS model contour range at the sample locations (bore)

Stygofauna Genus Rank	Dominant Hydrogeological Domain	TDS Range
Apocyclops	Central River Corridor	1000 - 2000
Areacandona	All	400 - 4000
Atopobathynella	Turner River - Palaeochannel	600 - 2000
Bdelloidea	Turner River	600 - 700
Brevisomabathynella	Alluvium Palaeochannel	1000 - 1500
Candonidae	Yule River	600 - 700
Copepoda	Yule River - Palaeochannel	800 - 1000
Cyclopidae Unk Gen	Palaeochannel	1000 - 2000
Cypretta	Yule River – Palaeochannel – Turner River	500 - 4000
Cyprinotus	Turner River	500 - 3000
Dero	Yule River – Palaeochannel – Turner River	800 - 1500
Diacyclops	All	500 - >8000
Dussartcyclops	Turner River - Palaeochannel	1000 - 2000
Elaphoidella	Turner River - Palaeochannel	500 - 3000
Enchytraeidae	Yule River – Palaeochannel – Turner River	600 - 2000
Eriopisidae	Turner River	900 - 1000
Haplotoxidae	Turner River	800 - 900
Megastygonitocrella	Yule River – Palaeochannel – Turner River	500 - >8000
Mesocyclops	Yule River – Palaeochannel – Turner River	800 – 2000
Microcerberidae	Turner River - Palaeochannel	500 – 1500
Microcyclops	Yule River – Palaeochannel – Turner River	500 – 3000
Monopylephorus	Yule River – Palaeochannel – Turner River	600 - >8000
Naididae	Turner River	2000- 3000
Nedsia	Turner River - Palaeochannel	500 - >8000
Orbuscyclops	Palaeochannel	600 - 1000
Ostracoda	Turner River - Palaeochannel	900 - 1000
Parajapygidae	Palaeochannel	1000 - 1500
Paramelitidae	Yule River – Palaeochannel – Turner River	600 - 2000
Parastenocaris	Turner River - Palaeochannel	700 - 2000
Phreodrilidae	Yule River – Palaeochannel – Turner River	600 - 4000

Stygofauna Genus Rank	Dominant Hydrogeological Domain	TDS Range
Pilbarana	Turner River	1500 - 2000
Pristina	Turner River	500 - 600
Riocypris	Turner River - Palaeochannel	500 - 3000
Sarscypridopsis	Yule River – Palaeochannel – Turner River	600 - 2000
Stenocypris	Turner River - Palaeochannel	500 - 2000
Tubificidae	Turner River - Palaeochannel	600 - 4000
Vestalenula	Yule River - Palaeochannel	600 - 900

## 6.2.5 Final Estimation of Stygofauna Habitat

The saprolite – saprock (Type S3) and fractured bedrock (Type S4) domains habitat estimates are outlined in detail in Section 6.2.3.

Given the likely influence by the major river systems, the salinity of the groundwater and the geological domains (outlined in Section 6.2.4) on presence and the ability of stygofauna species to migrate over the Regional area, a precautionary approach has been applied to the habitat available for the species in the Type S1 and S2 habitat types (rather than using the whole Type S1 and S2 domains). The habitat volumes for each genus have been reduced using the TDS model contours for the Type S1 and S2 domains (Table 6.5).

Table 6.5 Inferred Volumes for the Type S1 and S2 Habitats using the TDS Contour

Habitat Classification	Area of Habitat (ha)	Inferred Volume of Habitat (m <sup>3</sup> )
<b>Type S1</b>	129,546	15,269,725,414
<b>Type S2</b>	29,059	2,468,774,592

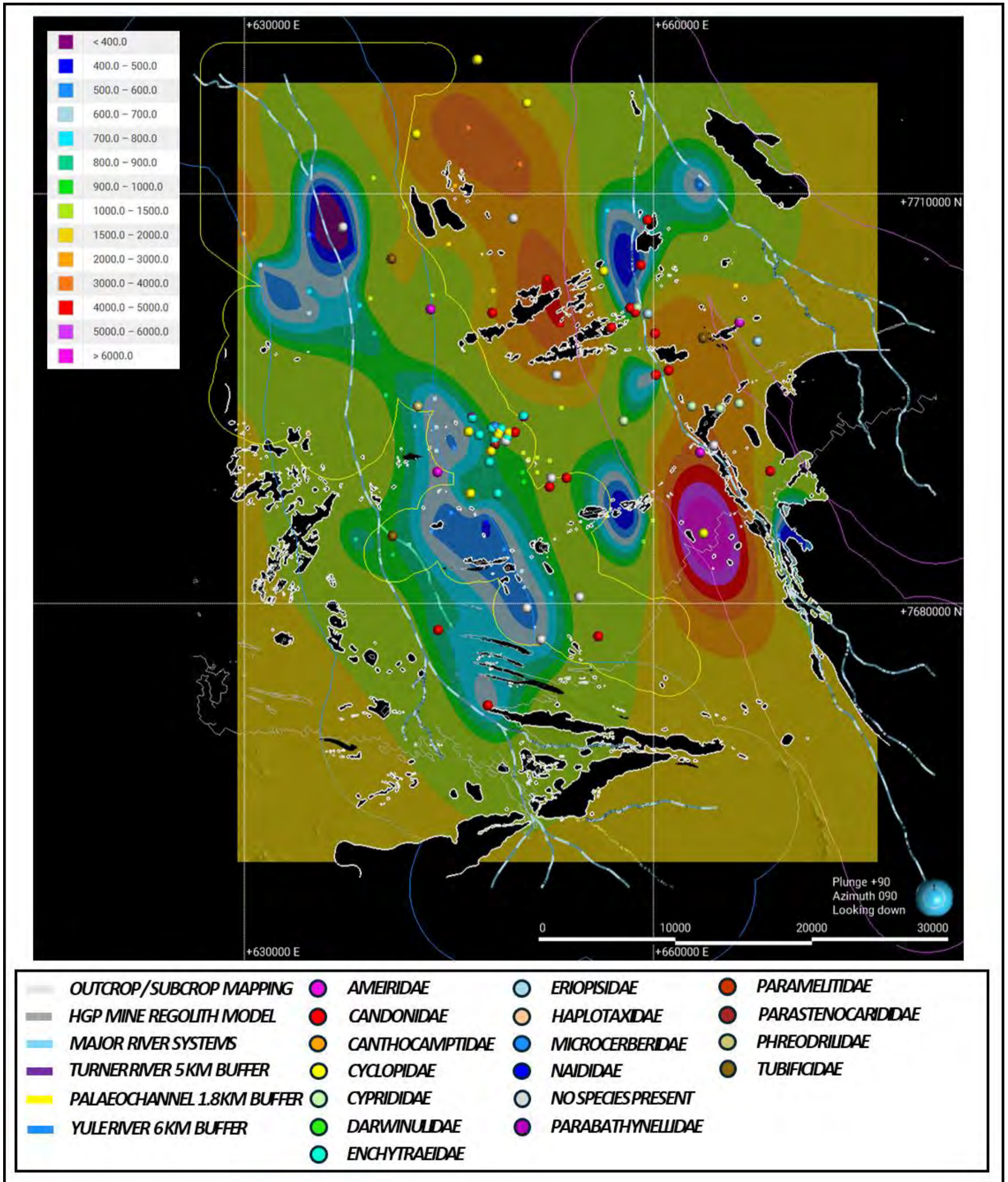


Figure 6-6: Stygofauna family locations, outcrop, total alluvium (low and high hydraulic conductivity) aquifer TDS and distance buffers from the river and Palaeochannel systems across the Hemi Regional model area

## 6.3 Troglifauna

### 6.3.1 Geological Interpretation of Drill Hole Data

Accuracy of geological logging was of critical importance in the interpretation of the subterranean fauna habitats at Hemi. The geological logging for troglifauna monitoring bores was done in the same manner as it was for stygofauna. A description of the geological logging technique and associated quality control and quality assurance is provided in Section 6.2.1.

The unsaturated portion of the regolith model domains is determined by wireframing the standing ground water below surface measurements. This wireframe is then used to remove the saturated portion of the regolith domains.

The colluvium and alluvium 3D geological model comprise of:

- **Type T1 Unsaturated Aeolian, Colluvium and Alluvium** – A laterally extensive facies consisting largely of unconsolidated clay, mud, silt and lesser sand alluvium. The unit also contains a veneer of recent aeolian and colluvium sand and silt and duricrusts. This domain is the same as the S1 Saturated Aeolian, Colluvium and Alluvium domain but occurs only above the standing groundwater level. The T1 domain is considered as the unsaturated component of the DWER Yule River Aquifer Upper Sand – Silt – Clay Alluvium hydrogeological domain and an example is displayed in Plate 6-3.
- **Type T2 Saturated Lower Colluvium and Alluvium** – A similar system to the upper alluvium, but which notably is defined as the palaeochannel facies and contains unconsolidated sands and gravels and lesser silt. The T2 domain is very limited in volume as the majority of the Palaeochannel unit is saturated (below standing groundwater level). Geospatially, the palaeochannel has significant continuity in the north-south direction and is of the order of 0.5 – 2 km in the transverse east-west direction near Hemi. It however is highly constrained above the water table, resulting in limited volumetric scale. This domain is considered the unsaturated portion of the DWER Yule River Aquifer Lower Sand - Gravel Alluvium hydrogeological domain and an example is displayed in Plate 6-3.46

The basement 3D geological model comprises three distinct geological domains. All three of which are considered to have limited potential to support troglifauna.

The basement domains consist of:

- **Type T3 Saprolite and Saprock** – A compact clay dominant domain with lesser silt, sand and clasts of highly weathered rock. This domain contains minor volumes voids or fractures that occur in association with shear zones and faults but also part of the natural development of the profile during a deep tropical weathering event. The saprolite can be split on a visual basis between upper and lower saprolite, with the upper saprolite typically bearing a yellow-red and mottled colour and the lower saprolite bearing a grey colour. This domain is generally spatially located below Type T1 and Type T2 domains and an example is displayed in Plate 6-4.
- **Type T4 Joint Weathered Bedrock Basement** – A weathered fractured bedrock (incipiently weathered rock) domain with minor clays/oxides on the joint surfaces. The joints increase in spacing as a result of the incipient weathering. The domain is largely located below and above Type S3 and Type S4 domains respectively except where subcrop and outcrop areas are located, where Type S3 has been mechanically removed by erosion processes. An example is displayed in Plate 6-4.

- **Type T5 Fresh Bedrock Basement** – Fresh bedrock with no signs of incipient weathering of the rock mass. Generally low joint/fracture frequency spacing. Local areas of increased fracturing present where faults are present. This domain is considered to provide limited habitat potential given the lack of open voids and connection to the regolith environment spatially above the domain. An example is displayed in Plate 6-4.

The major river systems, geological domains/available potential troglofauna habitat, recorded troglofauna locations and the Development Envelope are displayed in Figure 6-7. This shows that Type T1 and T2 habitats are widespread and well represented in the region with no barriers to dispersal.

**T1 – AEOLIAN / COLLUVIUM - UPPERALLUVIUM**



**T1 – DURICRUST WITHIN THE UPPERALLUVIUM**



**T1 - UPPERALLUVIUM**



**T2 – LOWERALLUVIUM**

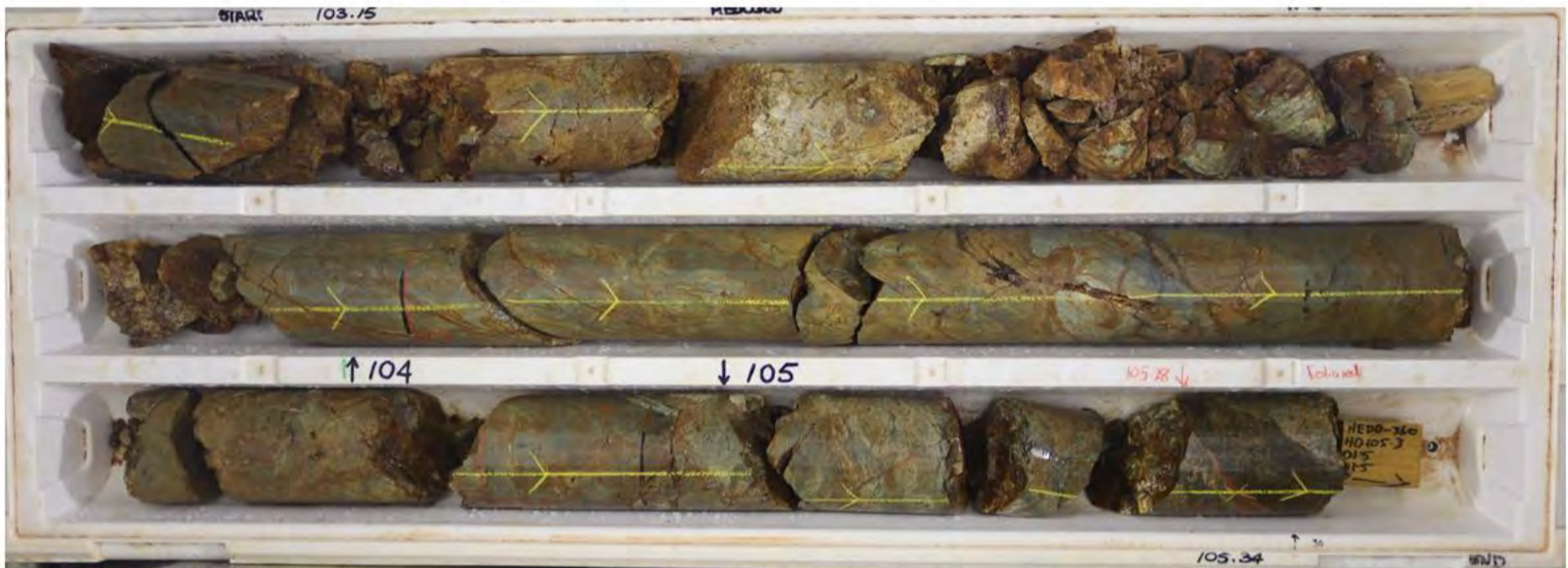


Plate 6-3: Diamond Drill Core Examples of the Facies changes in the Upper Alluvium (T1) and the Lower Alluvium (T2) Geological Domains

**SAPROLITE-SAPROCK-T3**



**FRACTURED BEDROCK-T4**



**BEDROCK-T5**

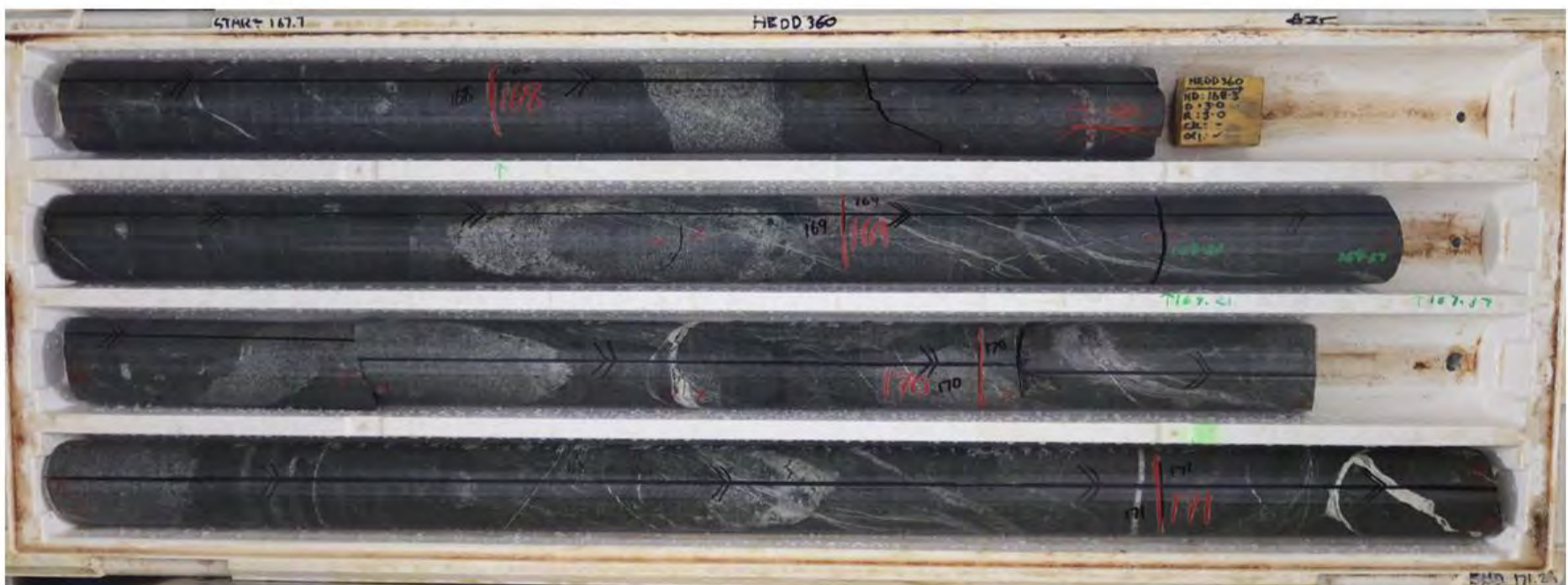


Plate 6-4: Diamond Drill Core Examples of the Saprolite – Saprock (T3), Fractured Bedrock (T4) and Bedrock (T5) Geological Domains

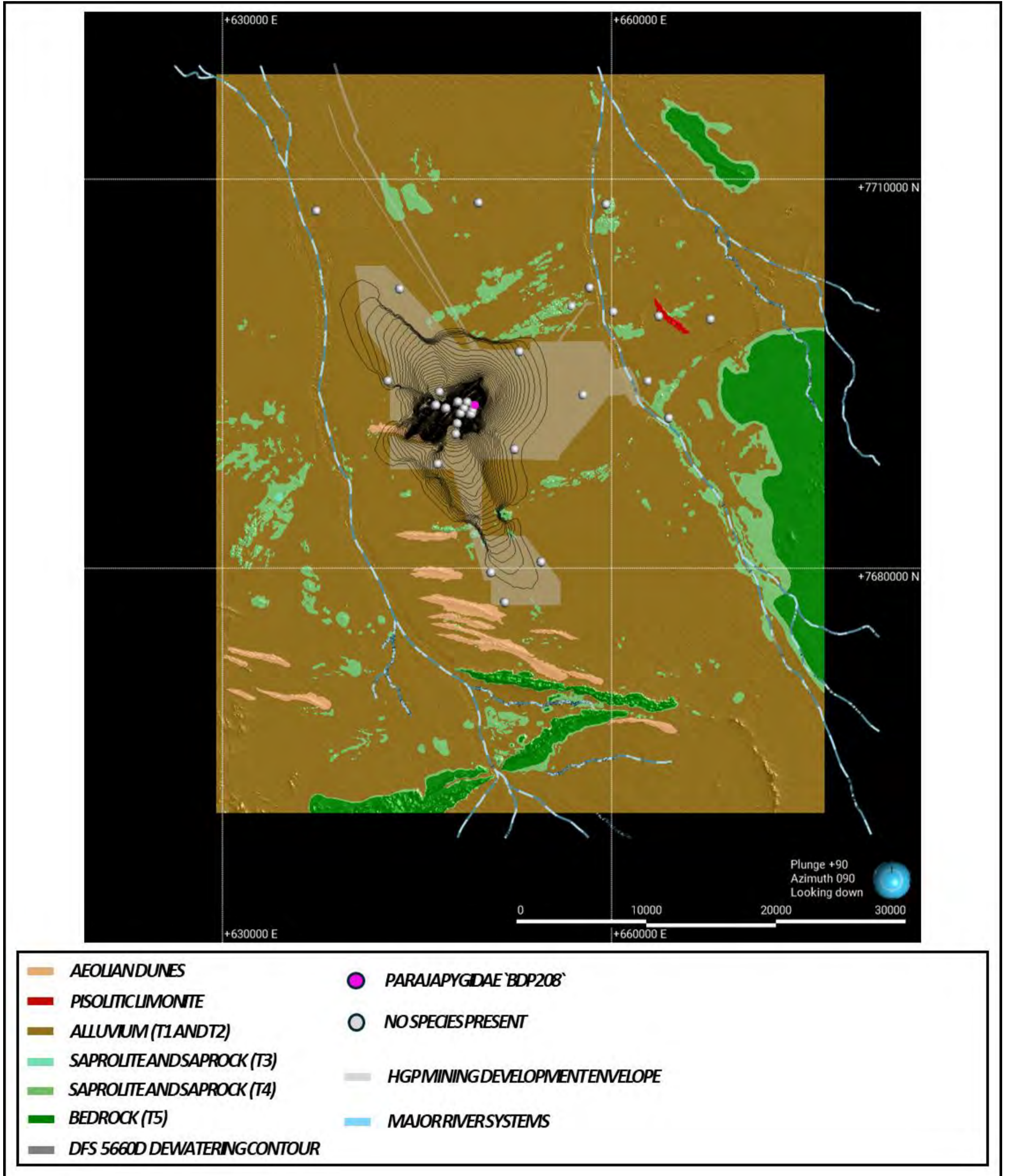


Figure 6-7: Major River Systems, Geological Domains Representing Available Potential Troglifauna Habitat, Recorded Troglifauna Location and Development Envelope

### 6.3.2 Comparative Analysis of Geological Troglofauna Habitat

Detailed geological analysis has been completed to assess the geological domains and their influence on the subterranean fauna across the study area. The analysis consisted of assessments of productive and unproductive bores to establish if:

- Local geological changes within and between drillholes that form a controlling factor in the establishment of a troglofauna habitat in a given geological domain.
- Geochemical changes form a controlling factor in the establishment of a troglofauna habitat in a given geological domain.
- Geological domains variations (e.g. thickness) form a controlling factor in the establishment of a troglofauna habitat in a given geological domain.

The following provides a summary of key findings of the comparative geological habitat assessment:

- 20 boreholes were sampled for troglofauna over one sampling period. No troglofauna were found and Bennelongia (2023) considered the troglofauna community to be depauperate such that additional sampling was not required.
- One species of troglofauna was however collected as bycatch during stygofauna sampling in December 2021 and May 2022.
- Geological variations and differences within the productive and non-productive stygofauna monitoring bores were negligible across the project.
- 20 (100%) of the boreholes sampled in October 2021 were unproductive.
- 1 (0.7%) of the boreholes sampled for stygofauna during the entire study period were productive for troglofauna, as bycatch.
- 1 troglofauna species was reported over the troglofauna and stygofauna sampling periods.
- There were no statistical differences in geology between boreholes that yielded the troglofauna species.

### 6.3.3 Estimation of the Alluvium Domain (Type T1 and T2) and Volume of Available Habitat

Geological modelling of the available geological domains and habitat volumes reflects the detailed understanding of the regolith and bedrock geology at the Proposal and surrounding region. This understanding has developed through the integration in 3D of multiple geoscientific datasets and has enabled accurate relative age relationships of the domains to be established but also enables the accurate spatial definition of the 3D spatial extent of the domains.

Type T1 and T2 comprise unconsolidated aeolian, colluvium, limited duricrust and alluvium. The extensive drill hole database and water bore network at the Project has demonstrated no evidence to date to support an impermeable unit within the units that might act as a geological barrier to the movement of troglofauna species across the domains. Evidence is present in the alluvium of a highly active palaeo-drainage system and this energy environment is not geologically conducive for the deposition of large and spatially extensive accumulations of impermeable clay. As such, all the available alluvium above the standing groundwater table below the current topographic surface (T1 and T2 domains) are considered as available troglofauna habitat as presented in Table 6.6.

The extensive water bore network (De Grey or accessible 3<sup>rd</sup> party owned) is monitored routinely for standing groundwater table level below the current topographic surface. This data is also routinely modelled in 3D and this was used to derive the habitat volume estimates for the troglotauna. See Section 3.5 for further details.

Table 6.6: Estimated Geological Volumes for Type T1 and T2 Domains/Habitats

Habitat Classification	Volume of Geological Domain (m <sup>3</sup> )	Estimated Percentage of Geological Domain Suitable for Stygofauna of Habitat (m <sup>3</sup> )	Area of Habitat (ha)	Inferred Volume of Habitat (m <sup>3</sup> )
<b>Type T1</b>	20,774,000,000	100%	233,915	20,774,000,000
<b>Type T2</b>	164,490	100%	9.8	164,490

#### 6.3.4 Estimation of the Weathered Bedrock Geological Domains and the Volume of the Available Habitat

The 3D geological regolith models integrate fundamental concepts for geotechnical characterisation of soil-like and rock materials and this enables a statistical approach to be taken to establishing the degree of voids present within the soil-like weathered rock material and rock mass. Detailed geotechnical logging has been undertaken to support mine design studies and this enables a statistical approach to be derived on the joint/fracture frequency (spacing in a metre) and width of the joints logged as a proxy to voids present within the domains.

The frequency and joint width were integrated assuming they are applicable to a cubic metre of geological material within a given domain to establish the likely proportion of a geological volume that is available for habitat suitable for stygofauna species. The statistics are derived from diamond drill core that has been geotechnically assessed.

Joint / fracture frequency and apertures are assumed in the geological domains where no diamond core is present. This approach is valid given the robust multi-geoscientific data inputs on the regolith geological models and improves the robustness of the volume estimate for the Type T3, T4 and T5 domains by providing an estimate on the available voids within the soil-like weathered rock material and the rock mass. Table 6.7 outlines the analysis undertaken to understand the available voids in the Type T3, T4 and T5 domains. Table 6.7 outlines the estimated total available geological and corresponding habitat volume for the Type T3, T4 and T5 domains.

Table 6.7 Joint / Fracture analysis to estimate the available void volumes within the geological domains

Habitat Classification	No. Joint/Fractures (per m)	Joint/Fracture Aperture (per m)	Estimated Void Volume (m <sup>3</sup> )	Estimated Void Volume Percent (%)	Volume of Geological Domain (m <sup>3</sup> )	Inferred Volume of Habitat (m <sup>3</sup> )
<b>Type T3</b>	3.45	0.03	0.10	10.34%	1,447,500,000	149,671,500
<b>Type T4</b>	3.03	0.02	0.06	6.06%	1,898,900,000	115,073,340
<b>Type T5</b>	1.19	0.01	0.01	1.19%	1,895,500,000	22,565,476

### 6.3.5 Additional Controls on Available Troglifauna Habitat

#### 6.3.5.1 Influence of Mineralisation

A description of the influence of mineralisation is provided in Section 6.2.5.1. Findings detailed in Section 6.2.5.1 are consistent for the above water table geology where troglifauna are present, and as such provides evidence that mineralisation is not a controlling feature on the presence of potentially restricted troglifauna.

#### 6.3.5.2 Radiological Influences on Subterranean Evolution

A description on the influence of radiological materials is provided in Section 6.2.5.2. Findings detailed in Section 6.2.5.2 are consistent for the above water table geology and as such provides evidence that radiological influences are not a controlling feature on the presence of potentially restricted troglifauna.

#### 6.3.5.3 Depth of Habitat

As detailed in Section 1.1.1, groundwater occurs throughout the landscape between 5 and 10 mbgl, averaging 6.5 mbgl over all geological habitats. Groundwater flow directions and hydraulic gradients are relatively uniform, with groundwater levels around 105 mAHD on the southern boundary and 26 mAHD on a section of the northern.

From this understanding the following conclusions were made relating to troglifauna habitat:

- The water table occurs throughout the Hemi project area with an average depth of 6.5 mbgl.
- The universally shallow water table across the region is expected to provide humid conditions in the alluvium to a limited extent above the water table and thus conditions required to support troglifauna.

The shallow groundwater however results in limited habitat across the region which is reflected by the depauperate troglifauna community found to occur at Hemi.

## 7. SUMMARY AND CONCLUSIONS

### 7.1 Summary of Findings

Subterranean fauna characterisation is inherently challenging owing to the site-specific nature, long timeframes and expense of these studies. De Grey has sampled 40 drill holes representing impact and reference sites to characterise the subterranean fauna within the proposed project area. Over a four-year period, sampling collecting approximately 140 sets of samples (including six sweeps in each sample) for stygofauna and approximately 20 traps, and 20 bore scrapes (consisting of 20 x four sets of scrapes) for troglifauna.

Sampling for subterranean fauna has resulted in a reduction over time of potentially restricted species, particularly for stygofauna between the first sampling event in 2021 to the most recent in 2024. This trend in reducing the numbers of potentially restricted species in successive sampling events provides evidence that species do not appear to be inherently restricted at a regional scale, and more so reflects the challenges of characterising the subterranean environment using currently available sampling methods.

A full characterisation of the distribution and abundance of subterranean fauna is not practicable, and as such other deterministic steps to confirm the likelihood of occurrence more regionally have been accepted by the EPA, and widely employed by industry. EPA have recognised that the assessment of subterranean fauna is often more complex than for other biodiversity factors due to limited knowledge of species distributions and habitat requirements and due to the inherent challenges of characterising assemblages using available survey techniques.

The use of habitat surrogates is an accepted method to augment existing information, particularly where a reasonable amount of sampling is unlikely to reveal the full range of a species. The use of habitat surrogates, together with the information gathered during baseline surveys, aims to raise the level of confidence in the predictions of impacts and provide sufficient confidence that the EPA's environmental objectives can be met.

The present study focussed on physical characteristics of habitat that support stygofauna and troglifauna in the region, specifically:

- The physicochemical parameters that may influence stygofauna presence or absence at Hemi.
- The geological profiles that provide habitat to support stygofauna and troglifauna presence or absence.
- The regional availability, and continuity of stygofauna and troglifauna habitat inside and outside of areas that may be impacted by the Proposal.

The key findings of this habitat assessment are discussed below.

Clear identification of the following prospective habitats and physical and/or chemical factors influencing the presence or absence of stygofauna and troglofauna within the region:

## Hydrogeology

- The presence of a consistent and shallow depth to water table (average 6.5 mbgl) across the landscape is evidence of a porous and interconnected geological environment below the water table with minimal annual fluctuation (ranging between 1.0 m to 2.0 m)
- Mineralisation and naturally occurring radiation were not found to be a controlling factor for the presence, absence or variability of stygofauna or troglofauna across the study area.

## Geology

- Geology was found to be the main controlling factor for the presence and absence of subterranean fauna across the project area.
- Stygofauna: Type S1 and Type S2 geological profiles below the water table were found to represent core habitats for stygofauna as they occur within a High Hydraulic Conductivity Aquifer, with Types S3 and S4 providing additional habitat as they occur within a Low Hydraulic Conductive Aquifer. Type S5 geological profiles were found to provide limited to no value as habitat for subterranean fauna, most likely due to the lack of interconnected pore spaces.
- Troglofauna: Type T1 and to a lesser extent T2 geological profiles above the water table were found to represent cores habitats for troglofauna. Type T3 and Type T4 geological profiles also represented troglofauna habitat although of lesser value.

## Hydrochemistry

- Water chemistry (salinity) appeared to have some influence on distribution of stygofauna, particularly at a family level. This was accounted for when considering habitat connectivity, area and volume in the study.

## Species Restriction

- There were no statistical differences in the habitat classifications between those habitats where potentially restricted subterranean fauna species, and all other species were recorded. This result indicates that these species are unlikely to be inherently 'restricted' and likely represent an artefact of using only sampling to characterise the faunal assemblage. Based on the homogeneity of habitat between those areas where potentially restricted and unrestricted subterranean fauna were present it is considered highly likely that these species would occur outside of the impacted area.
- Some individuals of the same species of stygofauna were found in both Type S1 and S2 habitats, indicating that movement across habitat types is probable to likely. This connectivity is also supported by the consistent water levels across the landscape.

## Subterranean Fauna Habitat Extent and Connectivity

The following conclusions were made from a comprehensive review of the geological database, which was then used to build a 3D model of Subterranean fauna habitats across the study area:

## Stygofauna habitat extent

- 15,269,725,414 and 2,468,744,592 m<sup>3</sup> of core stygofauna habitats Type S1 and S2 were mapped in the study area. These habitats are continuous and unbroken between the impact area and study area.
- 8,369,896,552 and 6,046,909,091 m<sup>3</sup> of additional stygofauna habitats Type S3 and S4 were mapped in the study area. These habitats are continuous and unbroken between the impact area and study area.
- Multiple data sets were analysed in Leapfrog Geo™ v 2023.2.3 to create a 3D habitat model. This was in turn used to calculate volumes of Type S1, S2, S3 and S4 habitats across the study and predict impacts to these habitat types.
- The 3D model provides a reasonable indication that significant volumes of interconnected core habitat for stygofauna (Type S1 and S2) are likely to occur across the region. A cross and long section of the habitat types extracted from the 3D model is shown in Figure 7-1 and Figure 7-2.
- Subterranean fauna habitats where potentially restricted species occur are widespread and continuous between the impacted and unimpacted areas. This continuity of habitat provides high likelihood of a wider occurrence of the fauna assemblages identified in the impact area (including potentially restricted species).

## Troglofauna habitat extent

- 20,744,000,000 and 164,490 m<sup>3</sup> of core troglofauna habitats Type T1 and T2 were mapped in the study area. These habitats are continuous and unbroken between the impact area and study area.
- 149,671,500 and 115,073,340 m<sup>3</sup> of additional troglofauna habitats Type T3 and T4 were mapped in the study area. These habitats are continuous and unbroken between the impact area and study area.
- Multiple data sets were analysed in Leapfrog Geo™ v 2023.2.3 to create a 3D habitat model. This was in turn used to calculate volumes of Type T1 habitats across the study and predict impacts to these habitat types.
- The 3D model provides a reasonable indication that significant volumes of interconnected core habitat for troglofauna (Type T1 and T2) are likely to occur across the region. A cross and long section of the habitat types extracted from the 3D model is shown in Figure 7-1 and Figure 7-2.
- Sampling results very strongly indicate that the troglofauna community of the Project area is depauperate and it may be inferred that in such circumstances any troglofauna species present will be a wide-ranging, rather than an endemic, species.

## 7.2 Study Limitations

The following limitations to the study are recognised:

- Unproductive boreholes occurred in all geological profiles even where the habitat was conducive to the presence of subterranean fauna. While it is not definitive as to why subterranean fauna were not found where suitable habitats are available, it may be due to:
  - Fauna were not present during the time of sampling. It is noted that at many of the productive boreholes animals were only sampled during one of multiple sampling events, and sometimes were not sampled until the third round of sampling nine months after the

commencement of sampling. This result indicates subterranean fauna are likely transient in the landscape.

- Inability of subterranean fauna to enter a borehole due to the level of development of a borehole. Physical factors may influence the ability of a borehole to yield animals, including cementing and compaction of the borehole walls and fractures during drilling, or the silting of holes and fractures during or after the drilling. The collapsing of pore spaces during the drilling process is likely to be more prevalent in bores above the water table where hydrostatic pressures are not present to keep those pore spaces open.
- Lateral connectivity of fractures is not apparent. The consistency of fracture mapping results and the consistent water table throughout the landscape supports that high degrees of connectivity are present.
- Drill hole locations are often biased to the mineralised area of a project, and Hemi is no exception. Regional interpretations of geology are often based on fewer drill holes, and as such variation between widely spaced drill holes may be apparent. This limitation has been lessened by using a number of geophysical interpretations, and by constraining the study to areas where a reasonable volume of drill hole data exists.
- Drill hole logging by geologists is often focused on the mineralised part of the core, or areas with potential mineralisation.

## 7.3 Conclusion

This study is based on a holistic approach which has integrated extensive and detailed geological, geochemical, geophysical, hydrogeological and ecological data at multiple scales ranging from millimetres to tens of kilometres. De Grey has high confidence in the findings and the results have allowed De Grey to clearly define stygofauna and troglofauna habitats across the study area.

Within the study area four viable stygofauna habitats (Type S1 and S2 which represent core habitat and Type S3 and S4 which represent additional habitat), and four viable troglofauna habitats (Type T1 and T2 which represent core habitat and Type T3 and T4 which represent additional habitat) were clearly defined.

These habitats dominate the study area and greater region and thus the bulk of the terrane has a high probability of containing extensive areas of viable and connected subterranean fauna habitat.

The non-viable habitat for subterranean fauna predominantly consisted of S5 and T5 geological profiles. These areas represent a minor portion of the regolith profiles within the study area compared to the viable habitat.

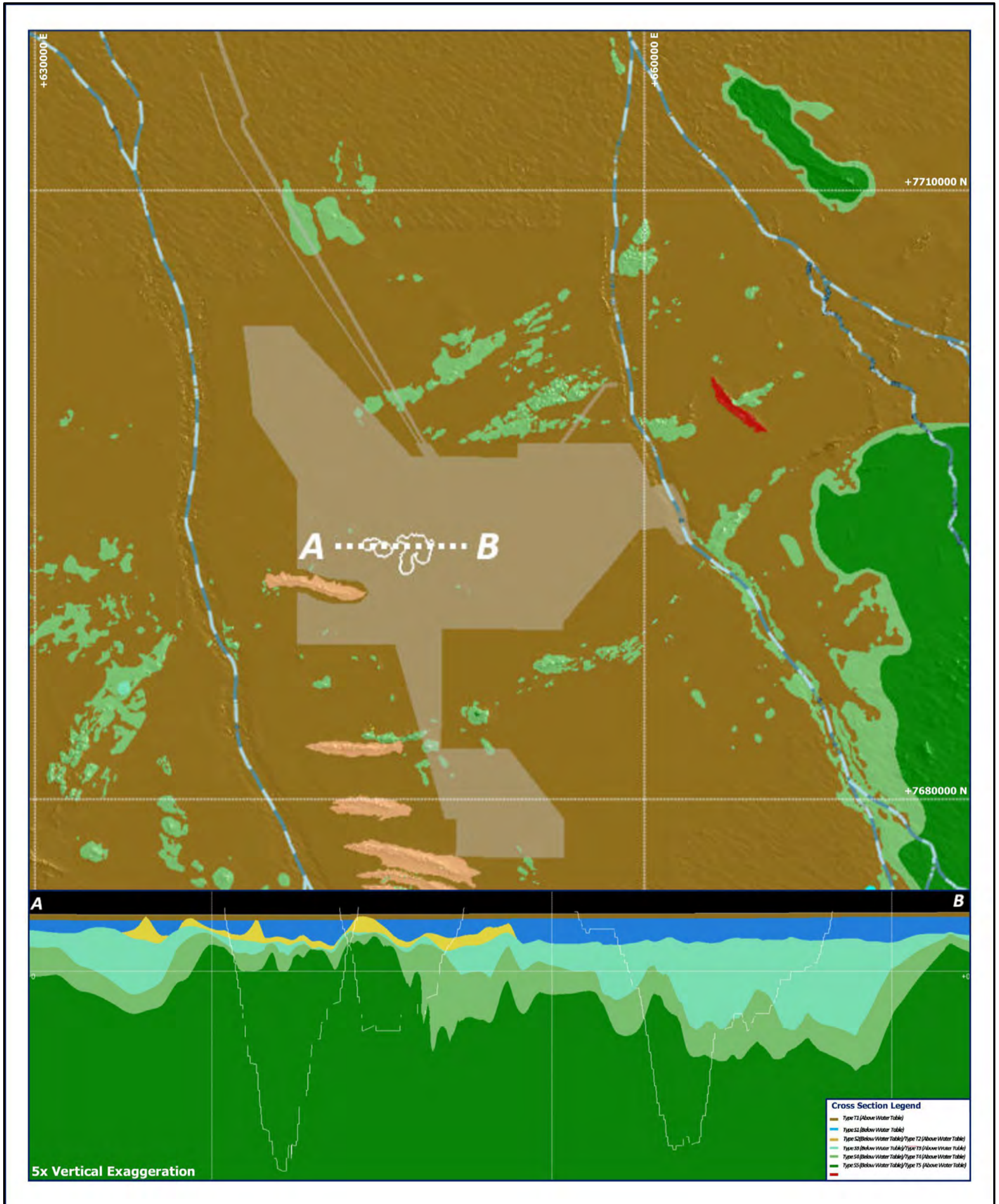


Figure 7-1: 3D Cross Section through the Development Envelope of Core (Type S1/T1 and S2/T2), Additional (Type S3/T3 and S4/T4) and Limited (Type S5/T5) Stygofauna and Troglifauna Habitat within the Study Area

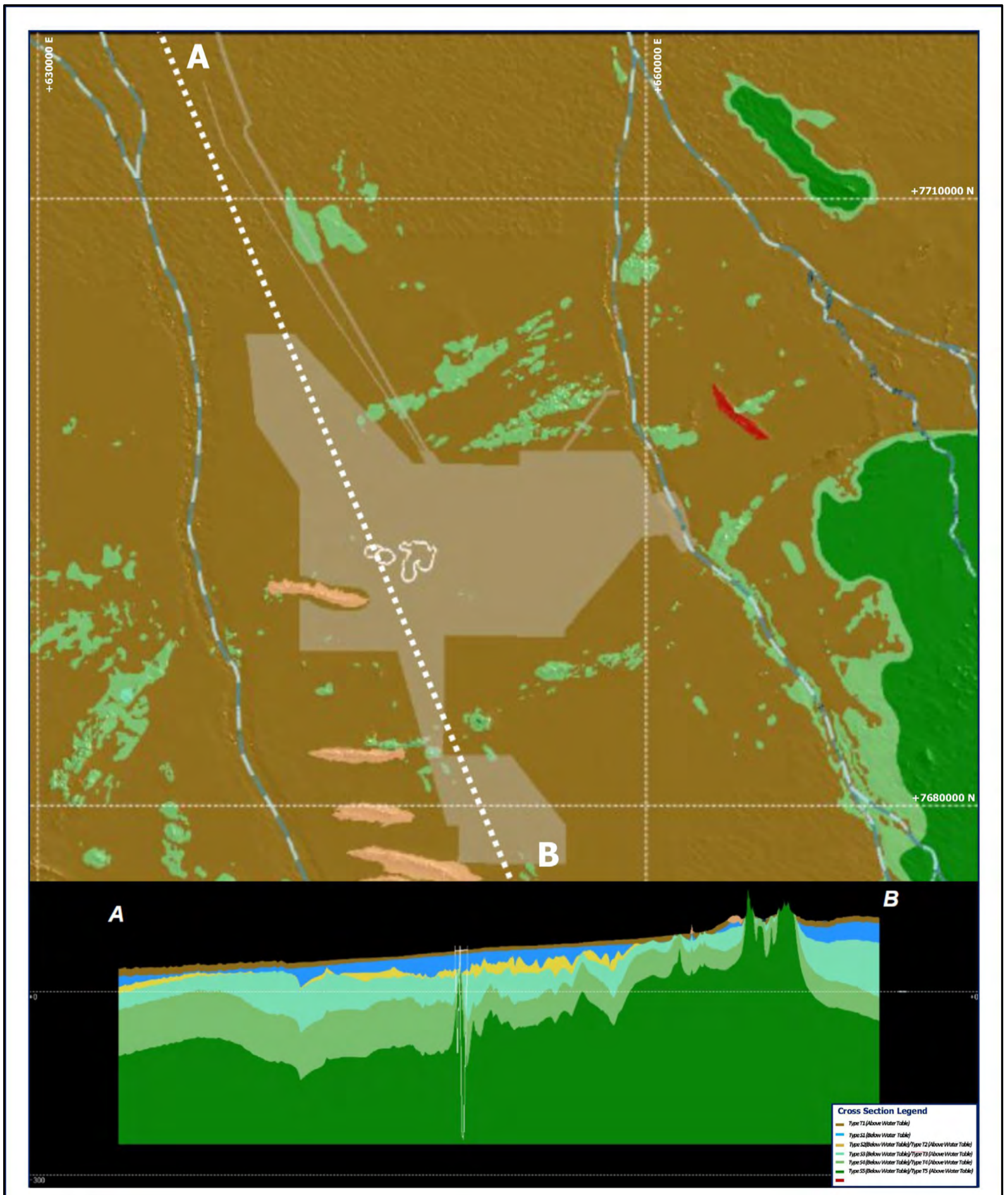


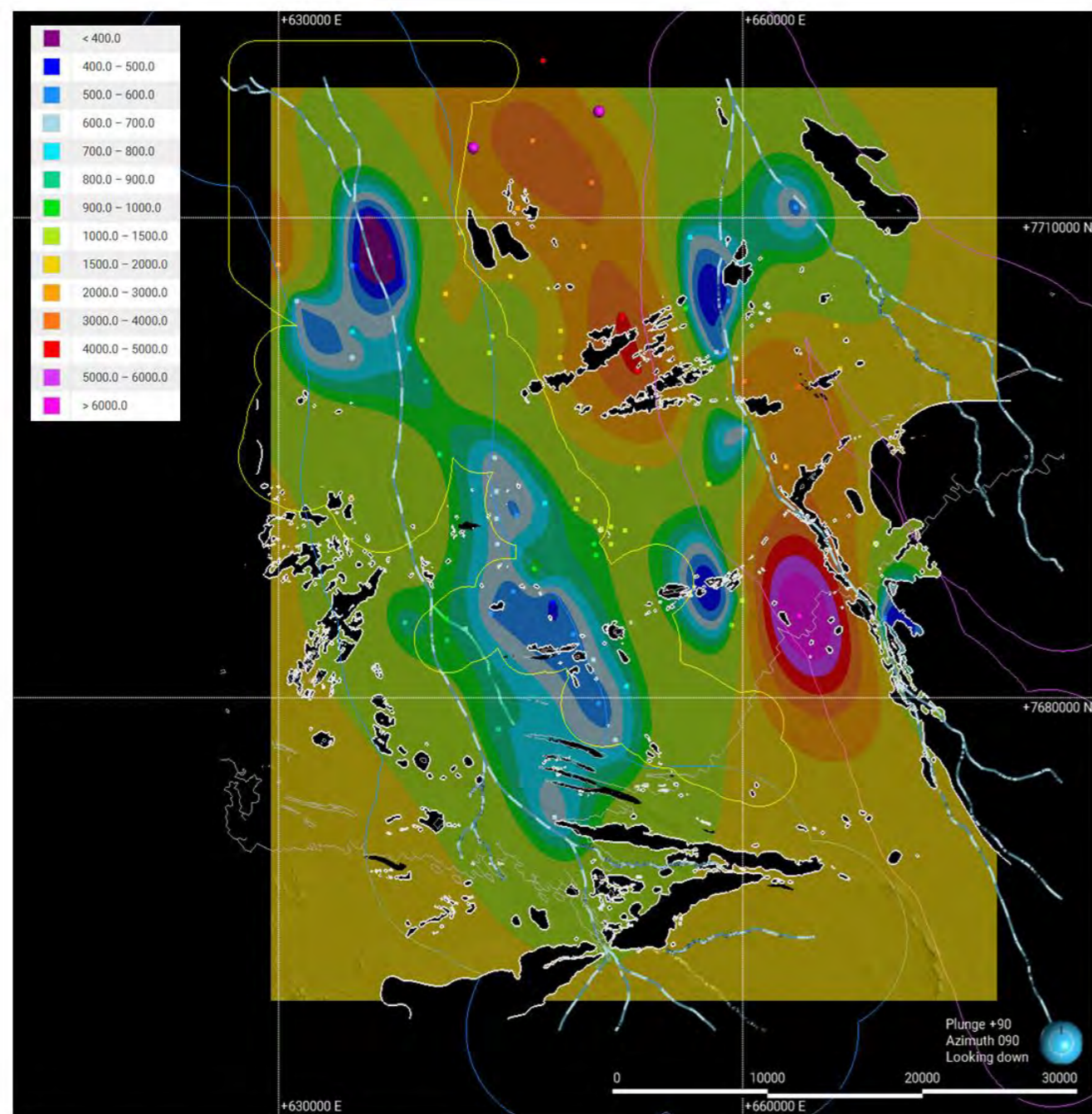
Figure 7-2: 3D Long Section through the Development Envelope of Cor (Type S1/T1 and S2/T2), Additional (Type S3/T3 and S4/T4) and Limited (Type S5/T5) Stygofauna and Troglifauna Habitat within the Study Area

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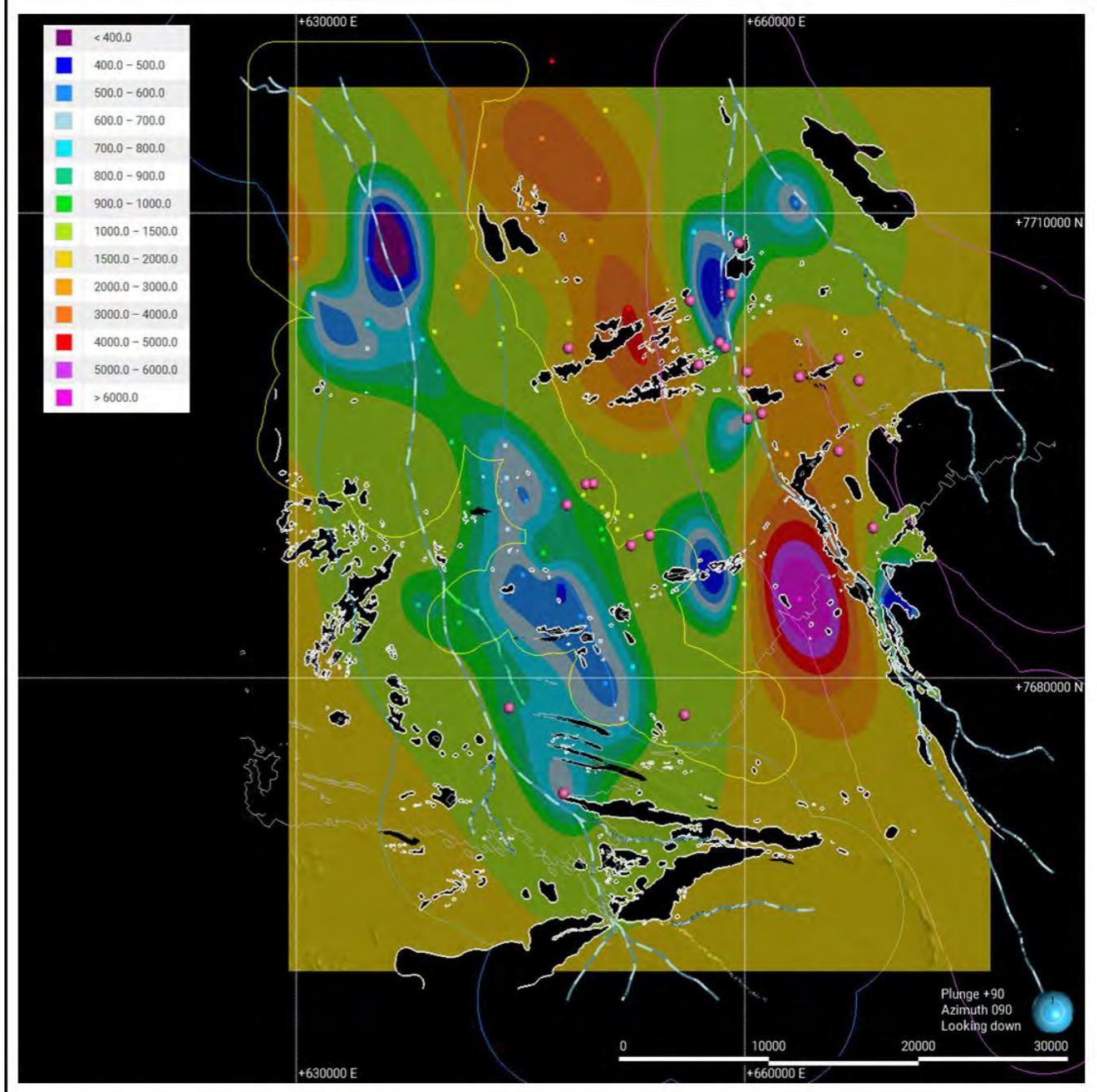
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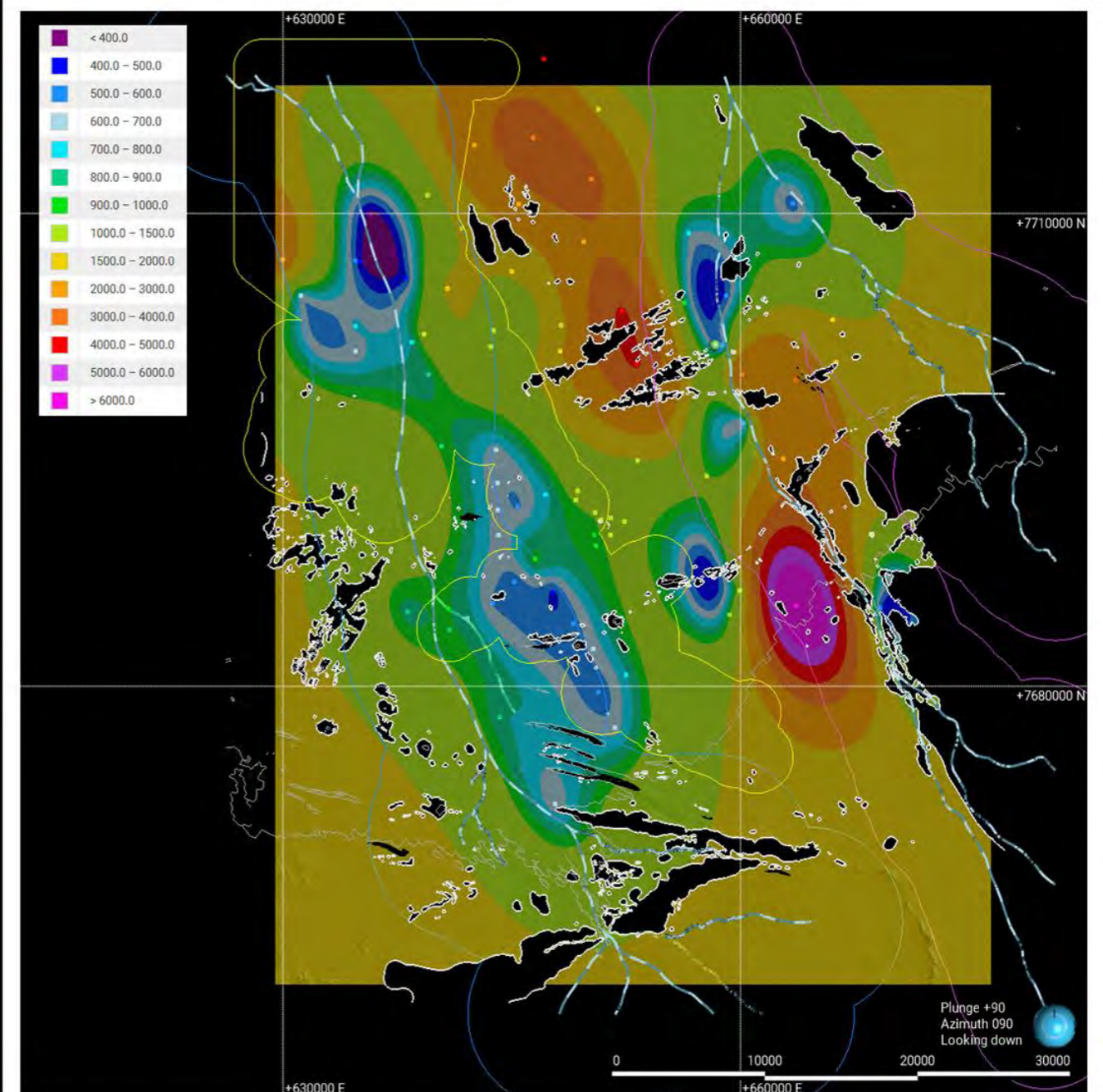
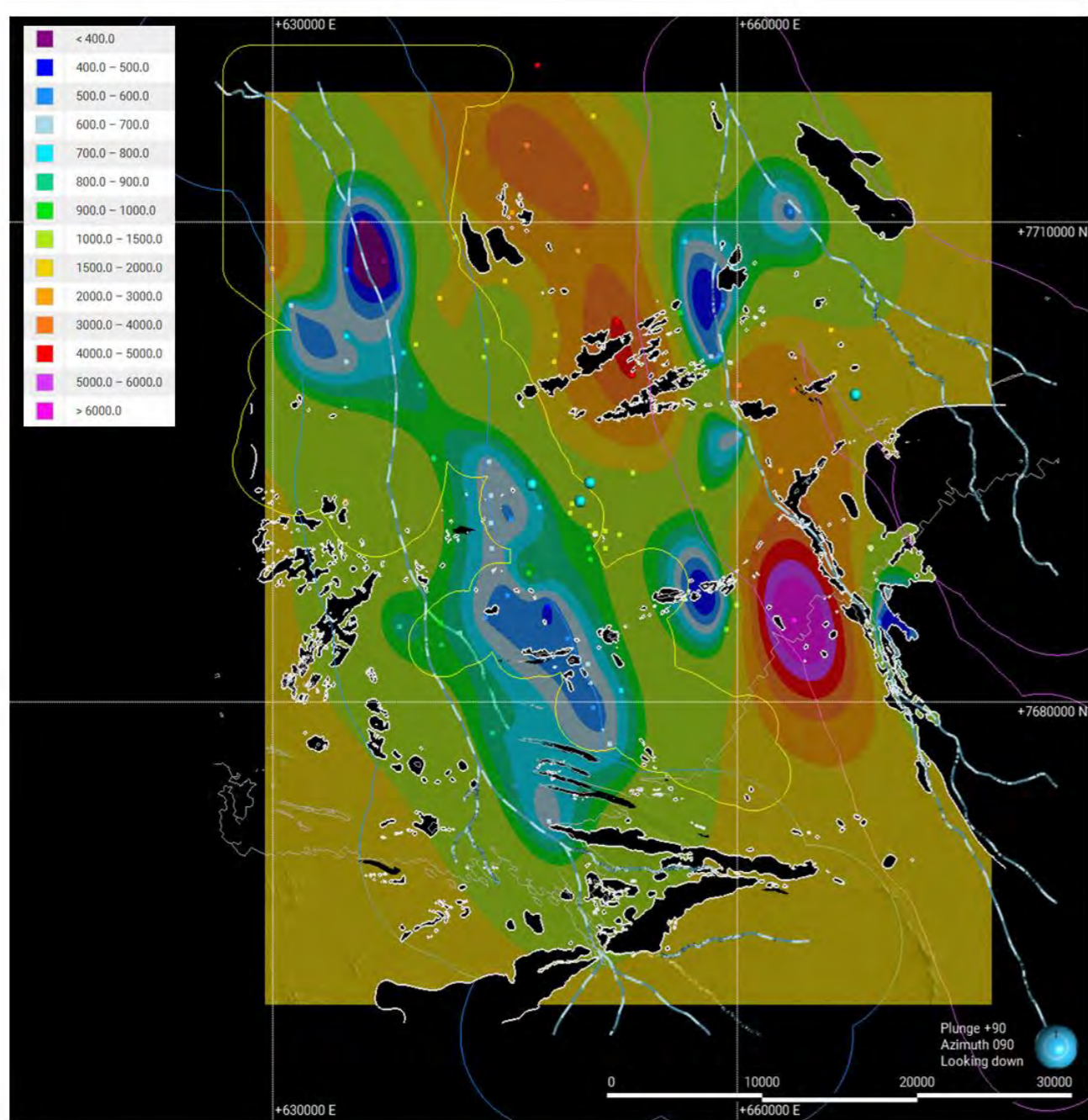
**APPENDIX 1: ANALYSIS OF SUBTERRANEAN FAUNA GENUS'  
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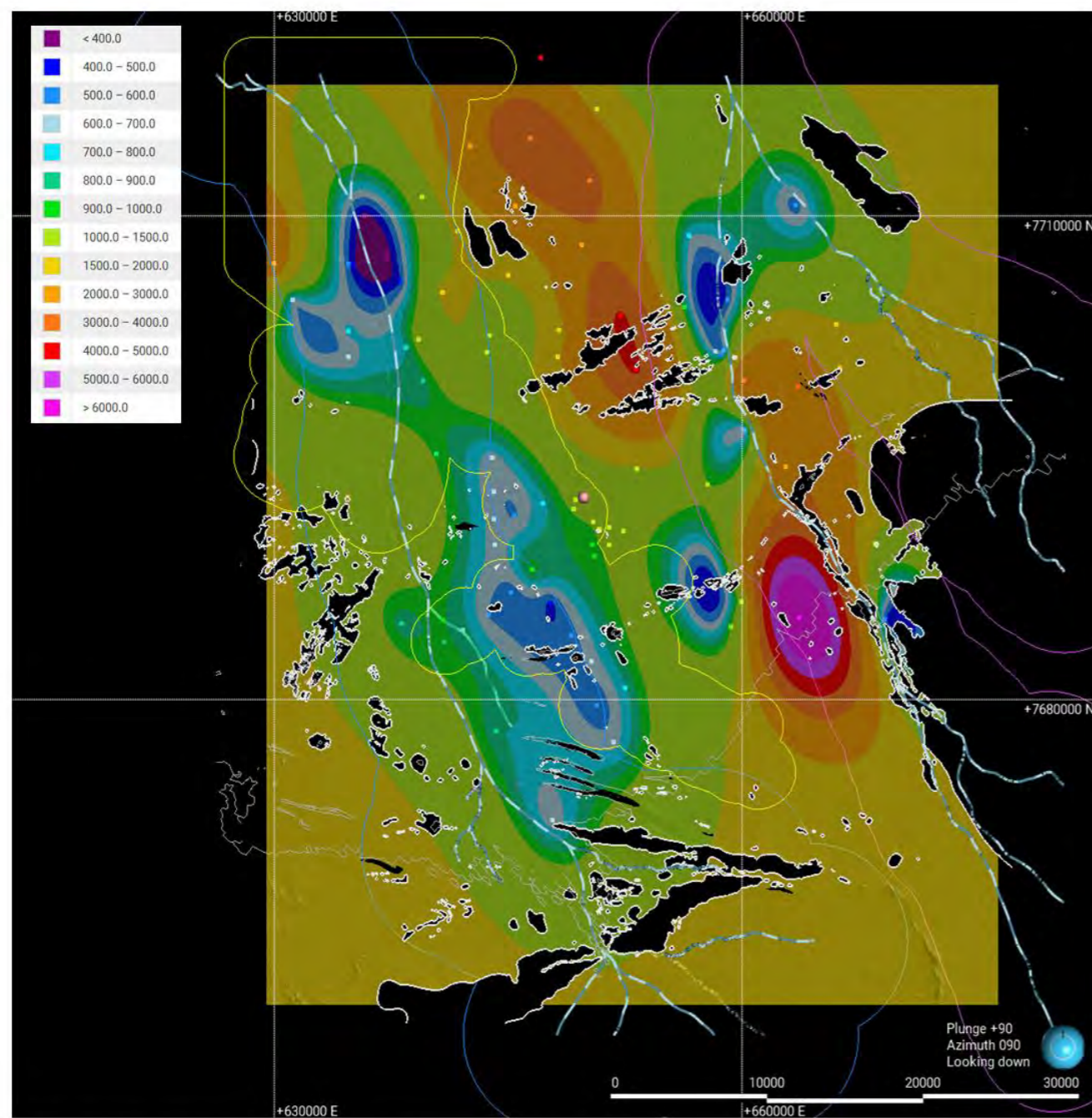


- OUTCROP/SUBCROP MAPPING**    **APOCYCLOPS**
- HGP MINE REGOLITH MODEL**
- MAJOR RIVER SYSTEMS**
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- PALAEOCHANNEL 1.8KM BUFFER**
- YULERRIVER 6KM BUFFER**

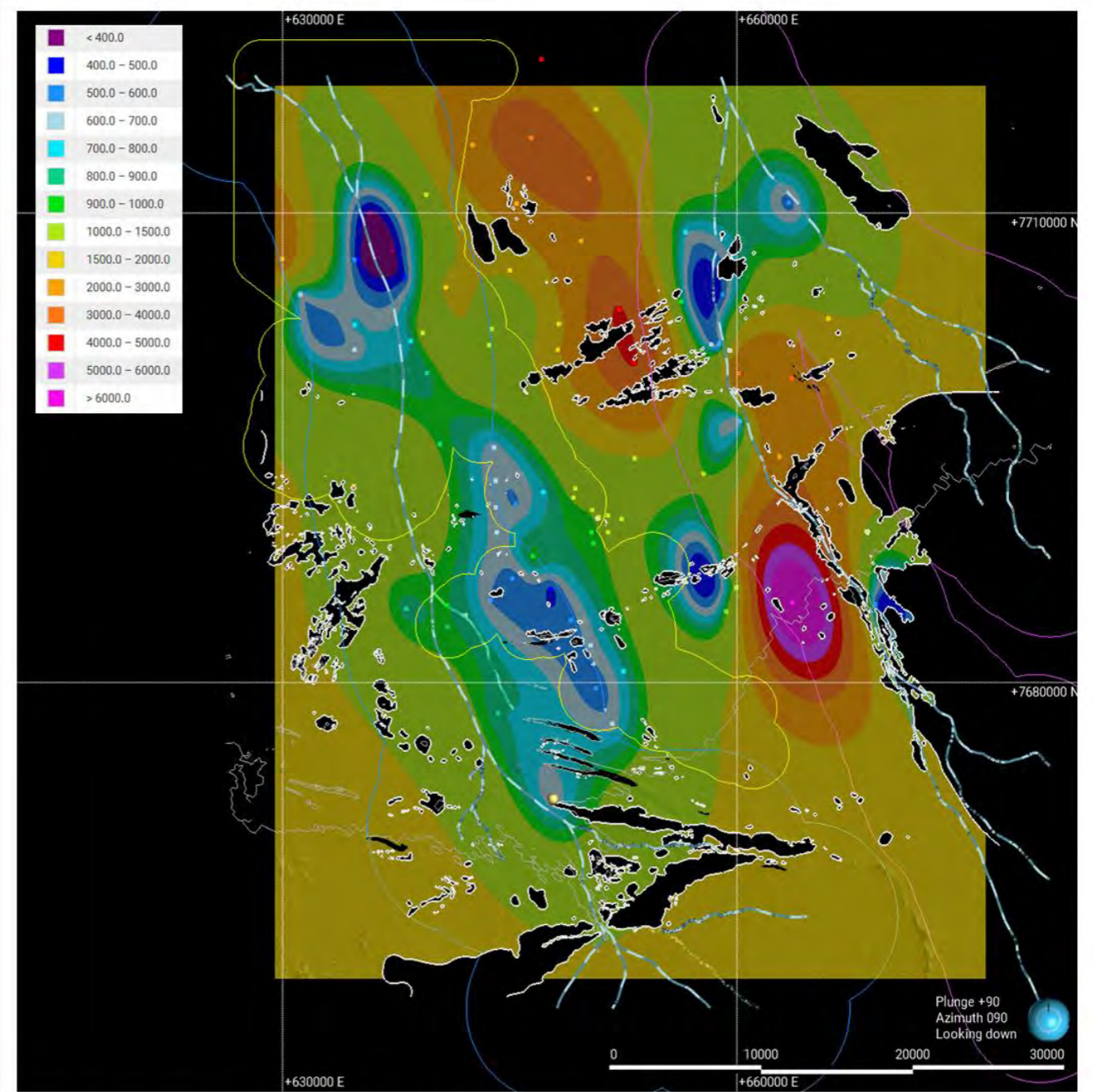


- OUTCROP/SUBCROP MAPPING**    **AREACANDONA**
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- MAJOR RIVER SYSTEMS**
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- YULERRIVER 6KM BUFFER**

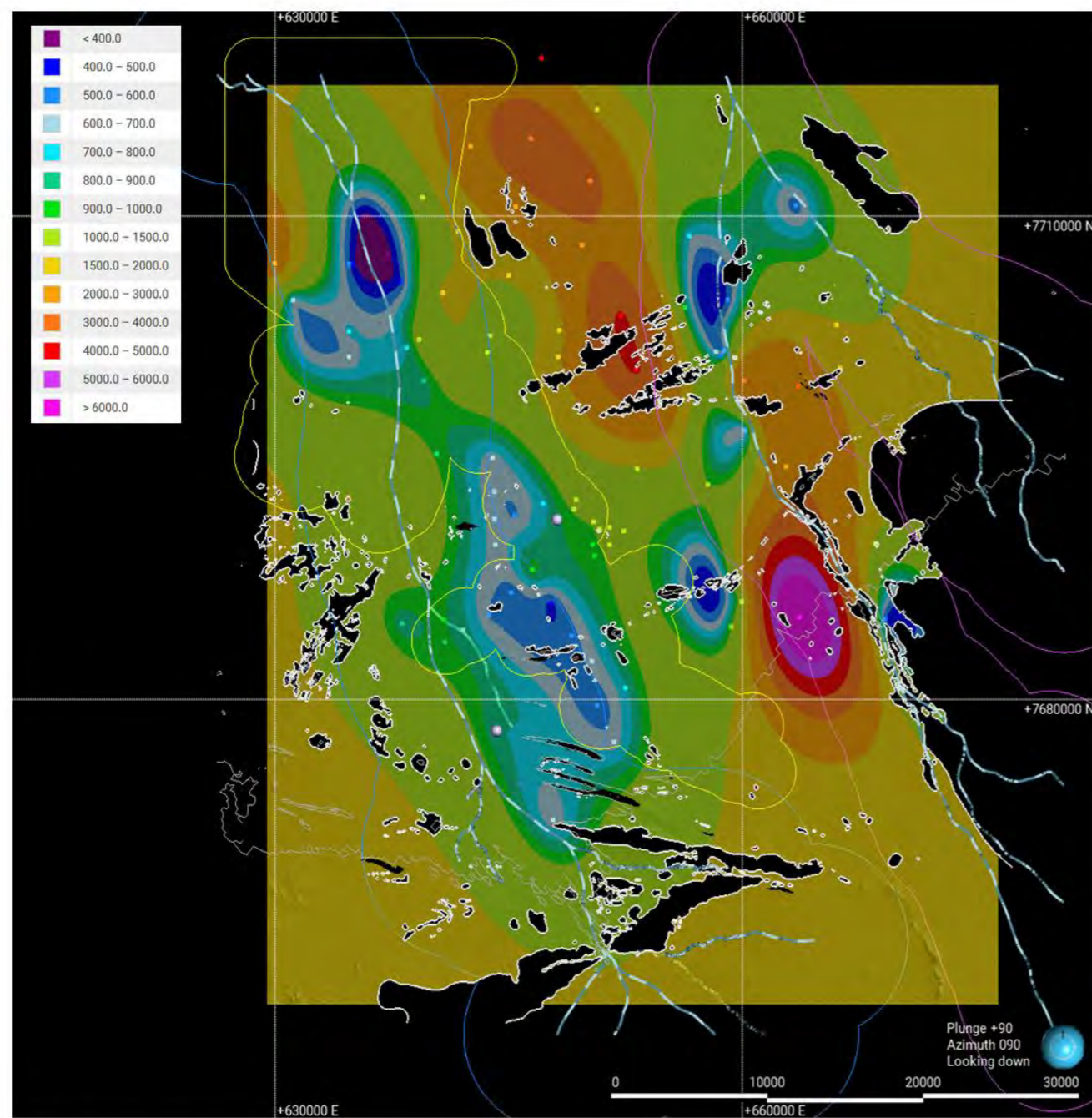




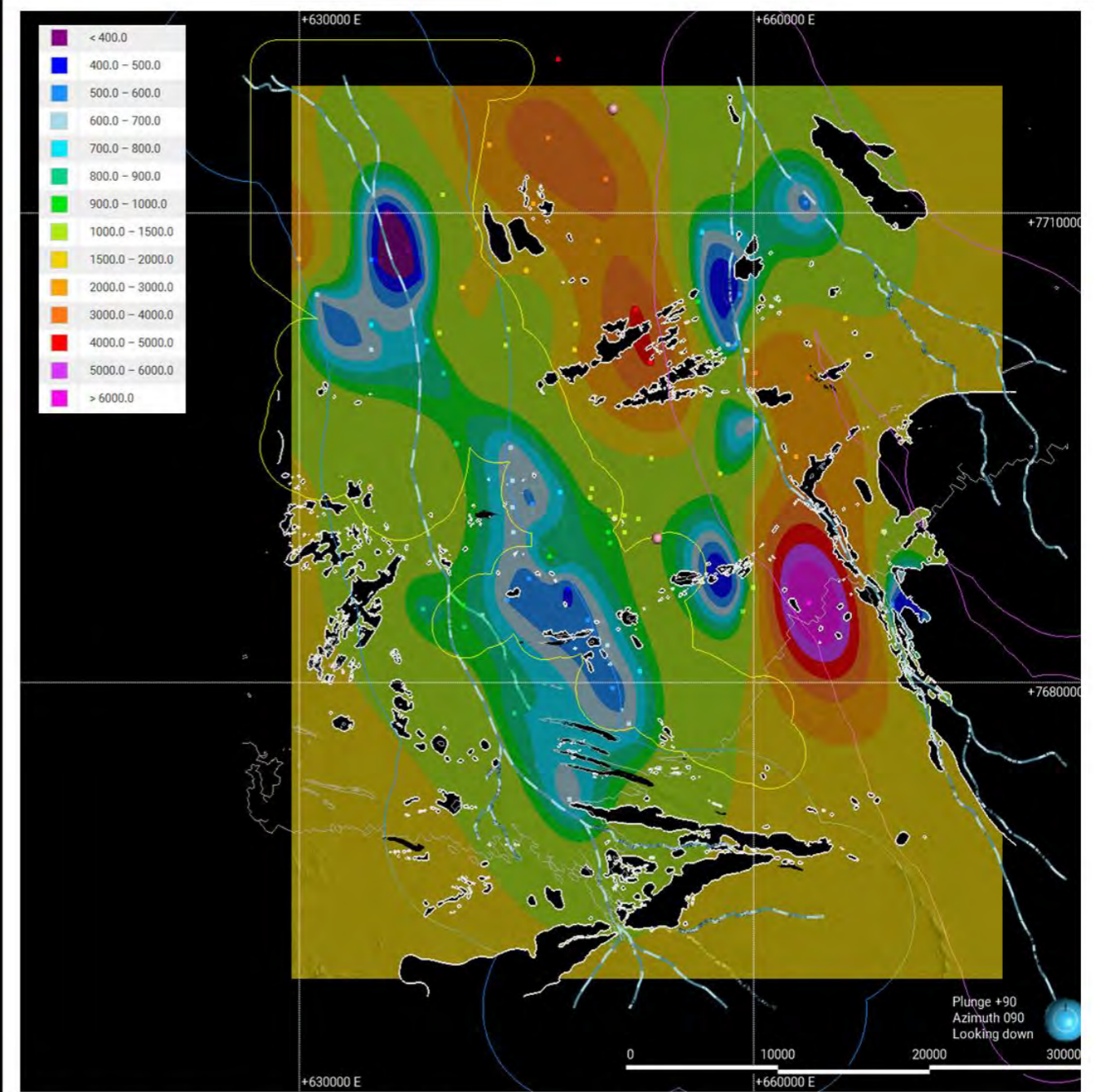
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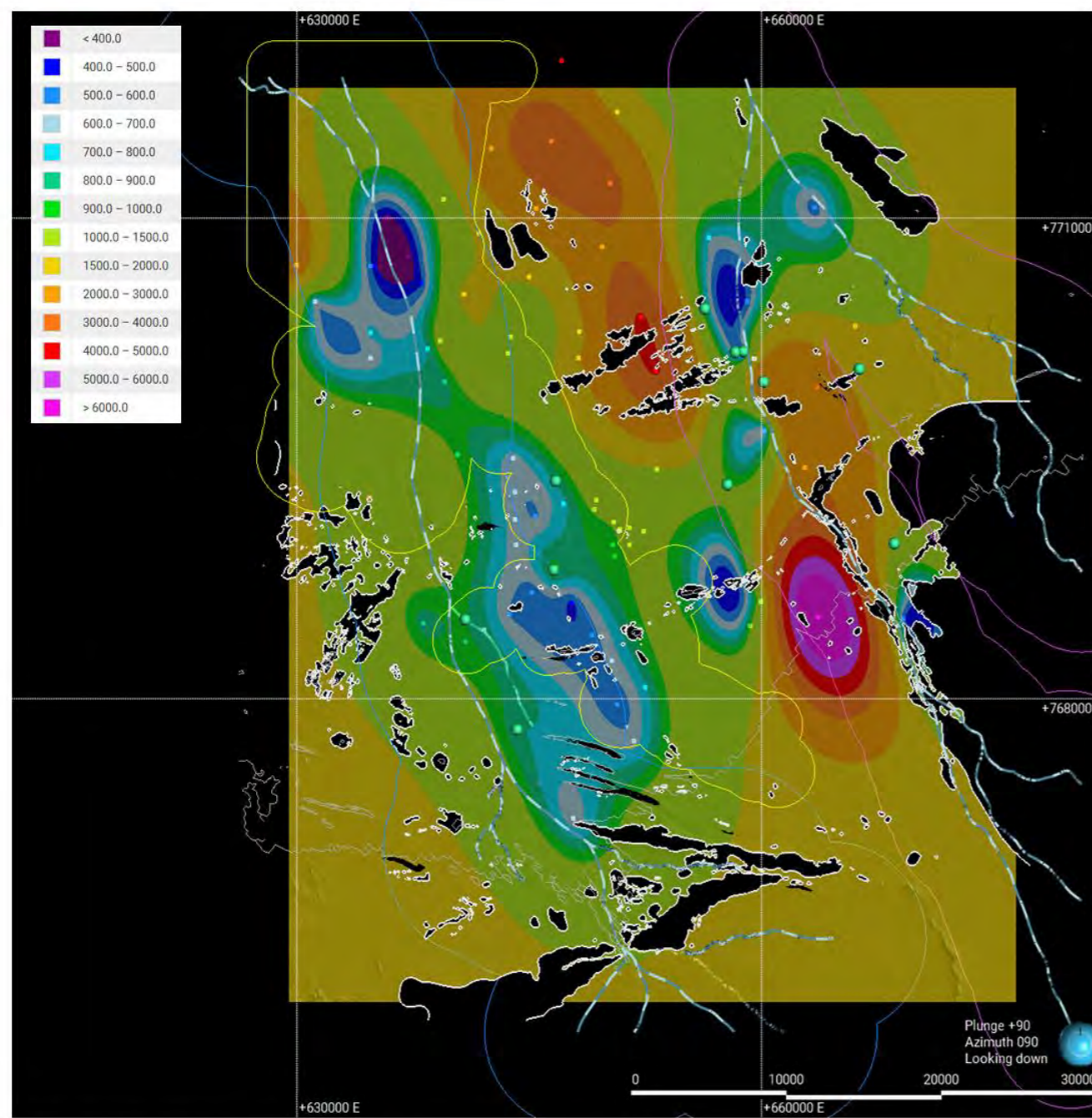
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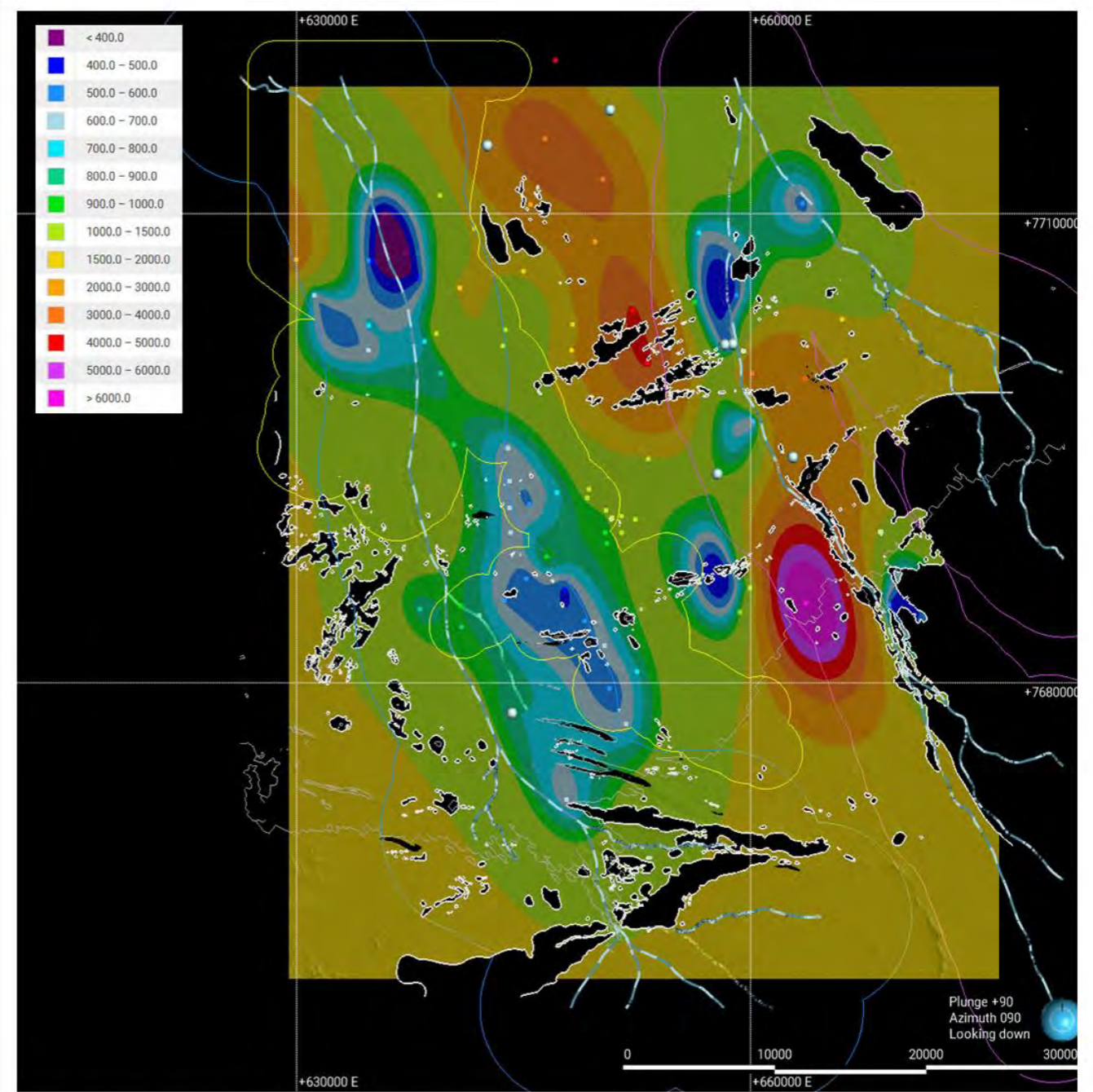
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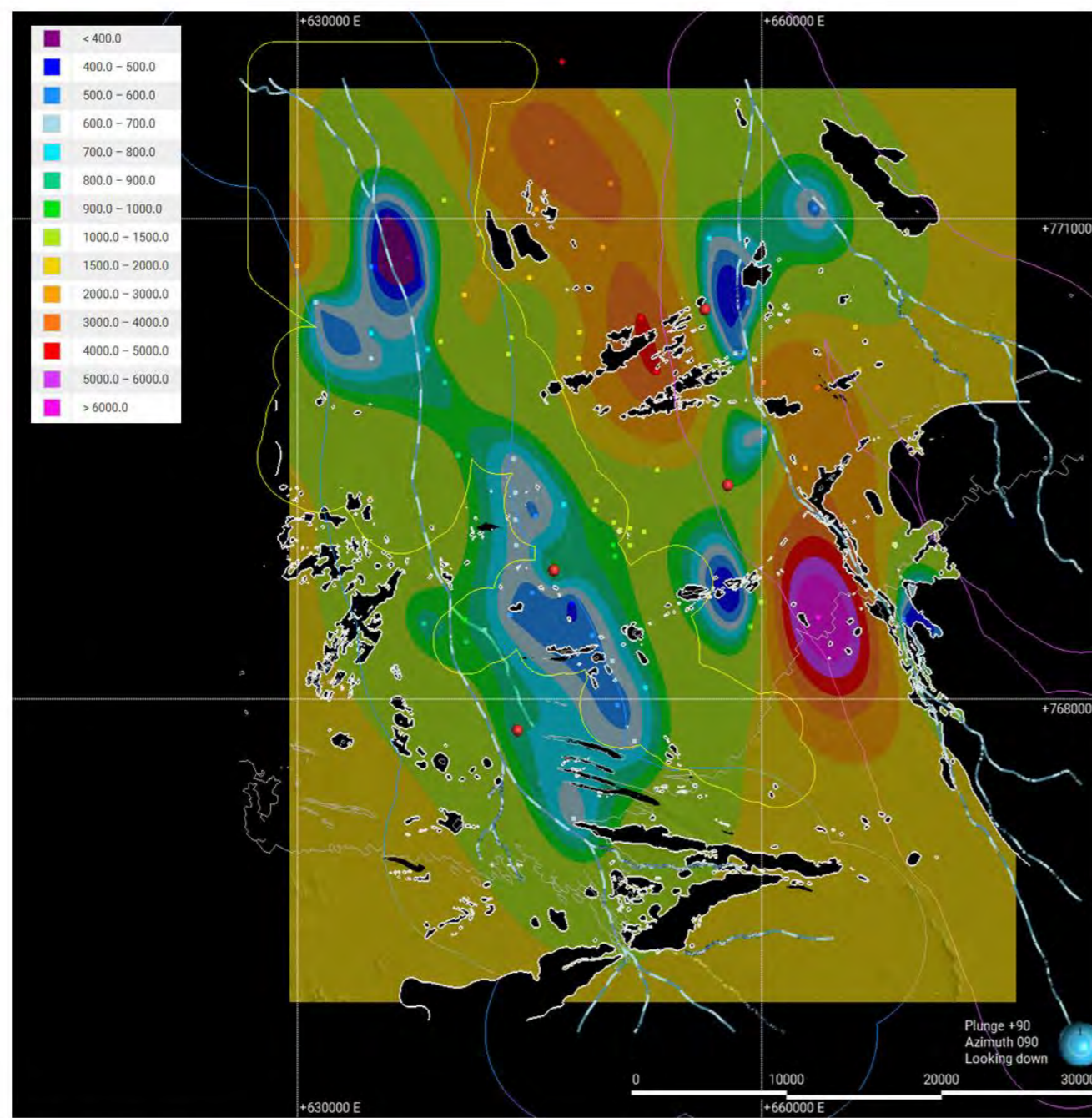
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- YULERIVER 6KM BUFFER



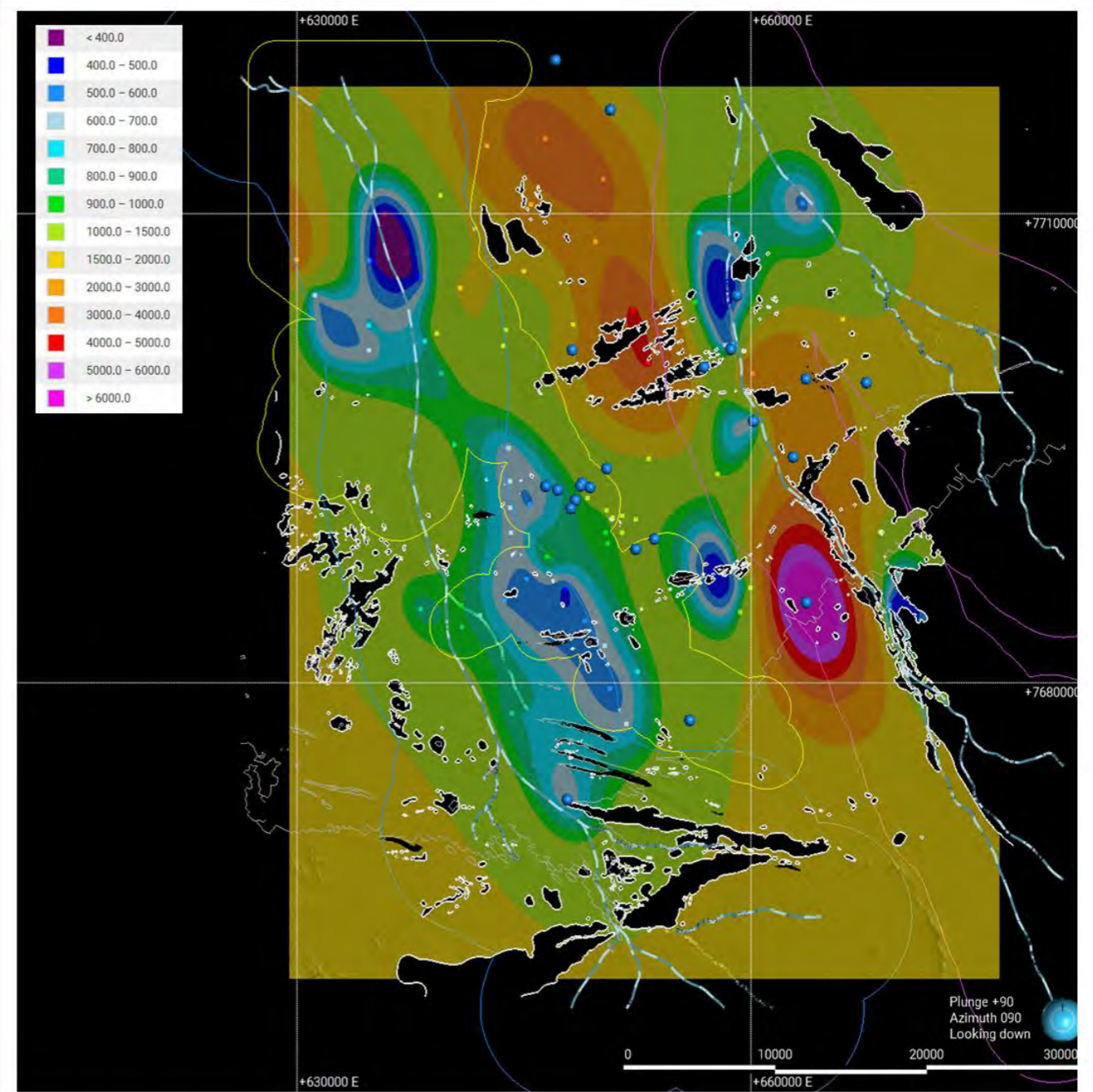
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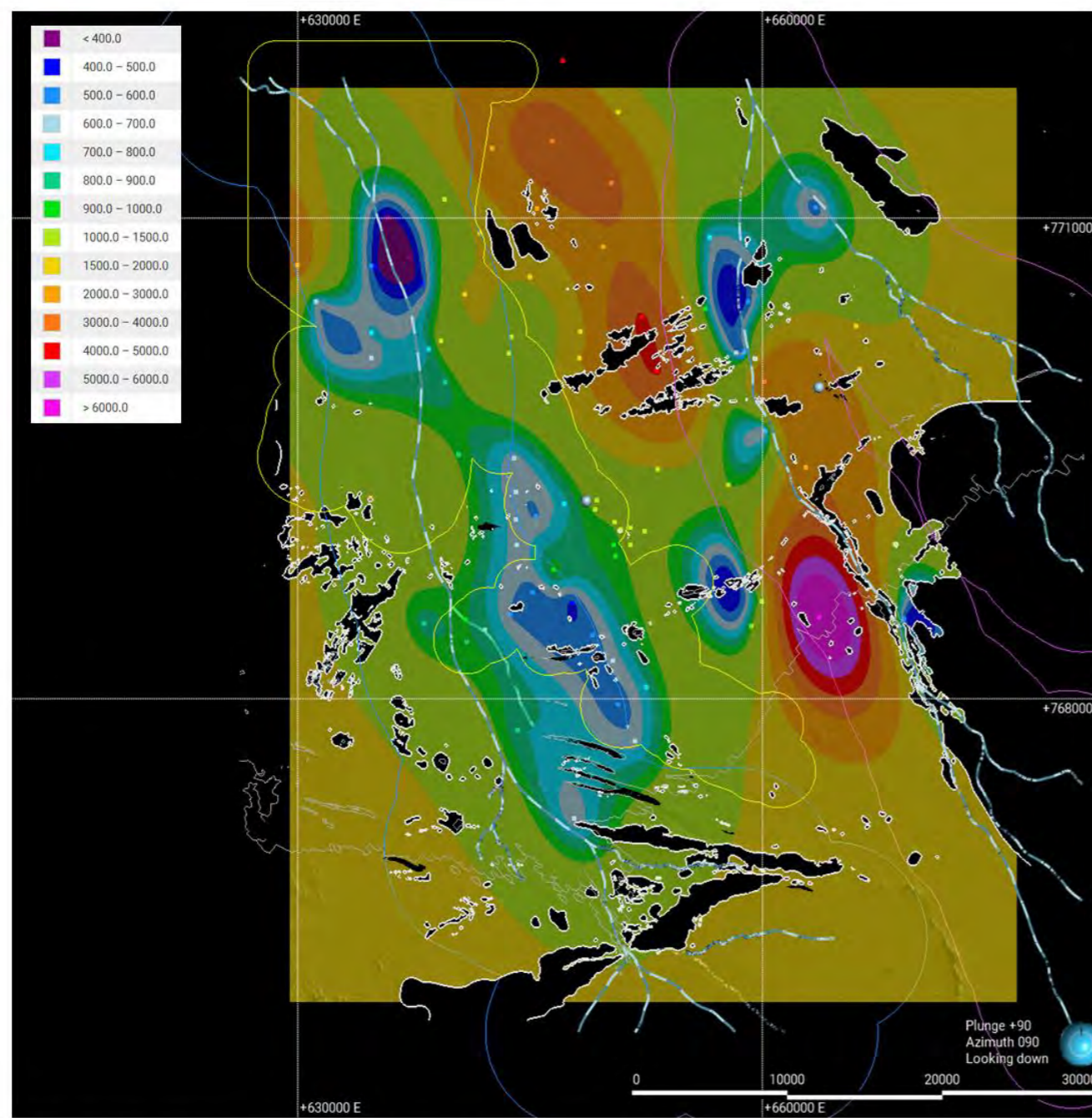
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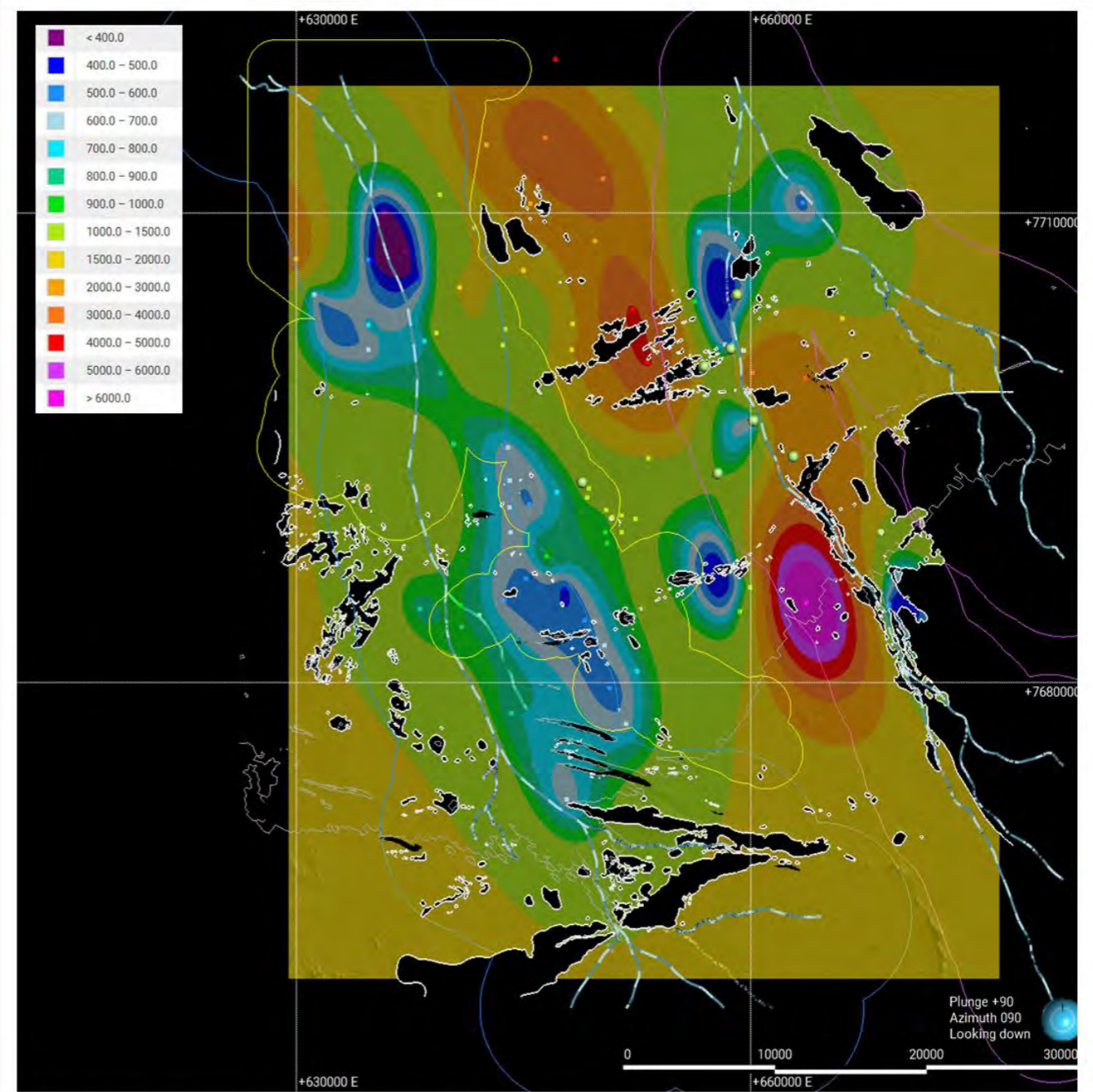
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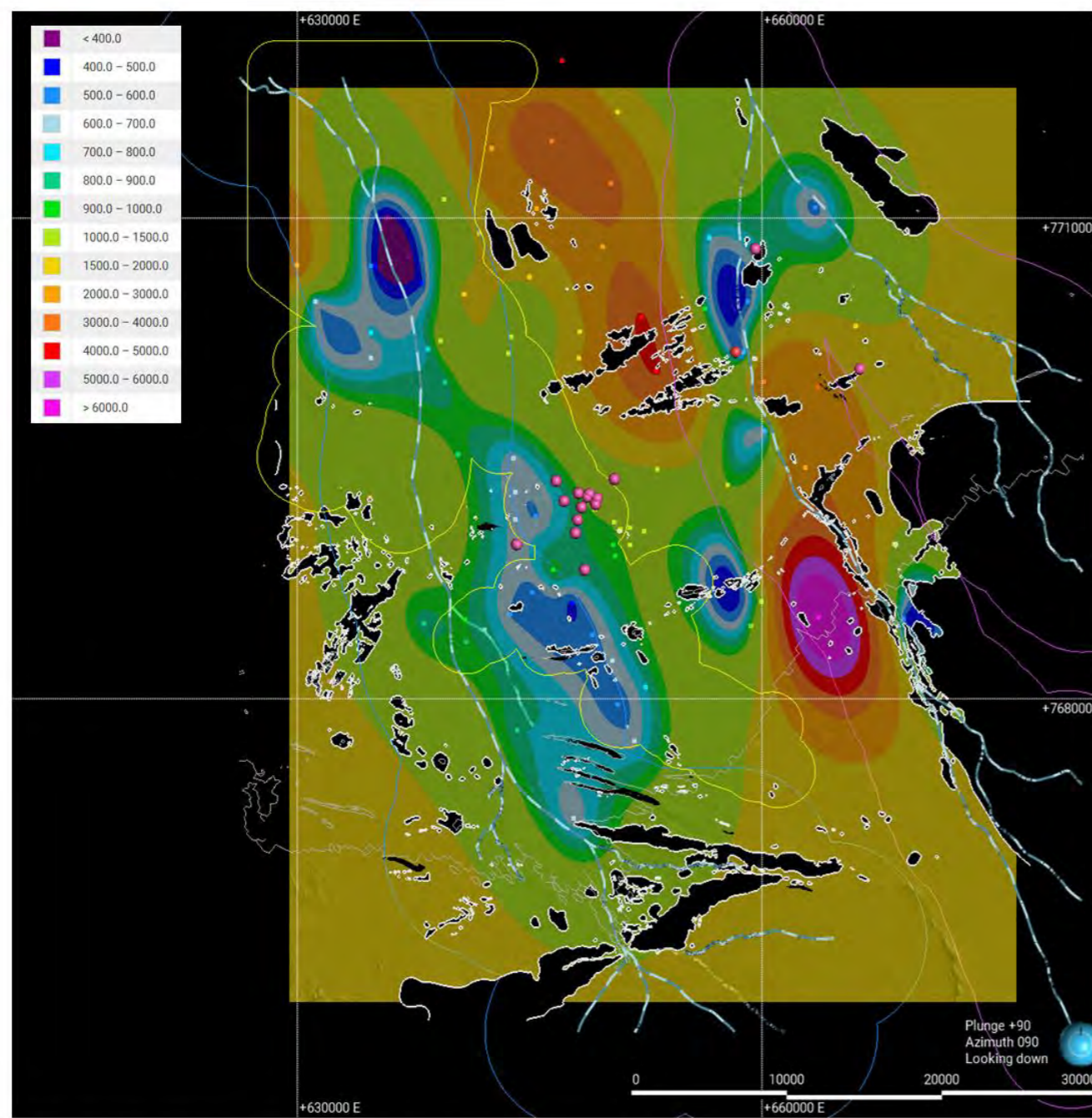
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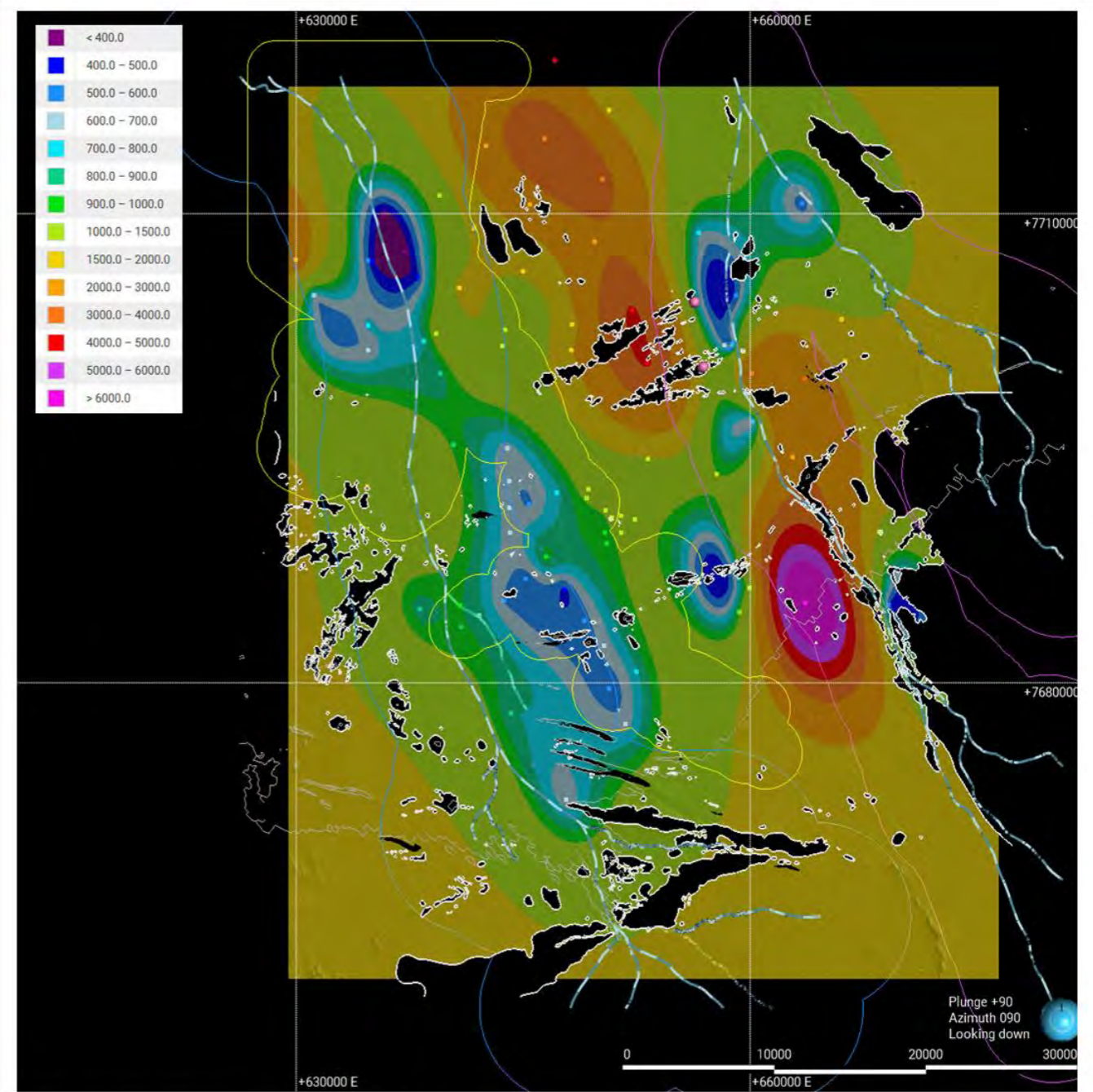
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- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



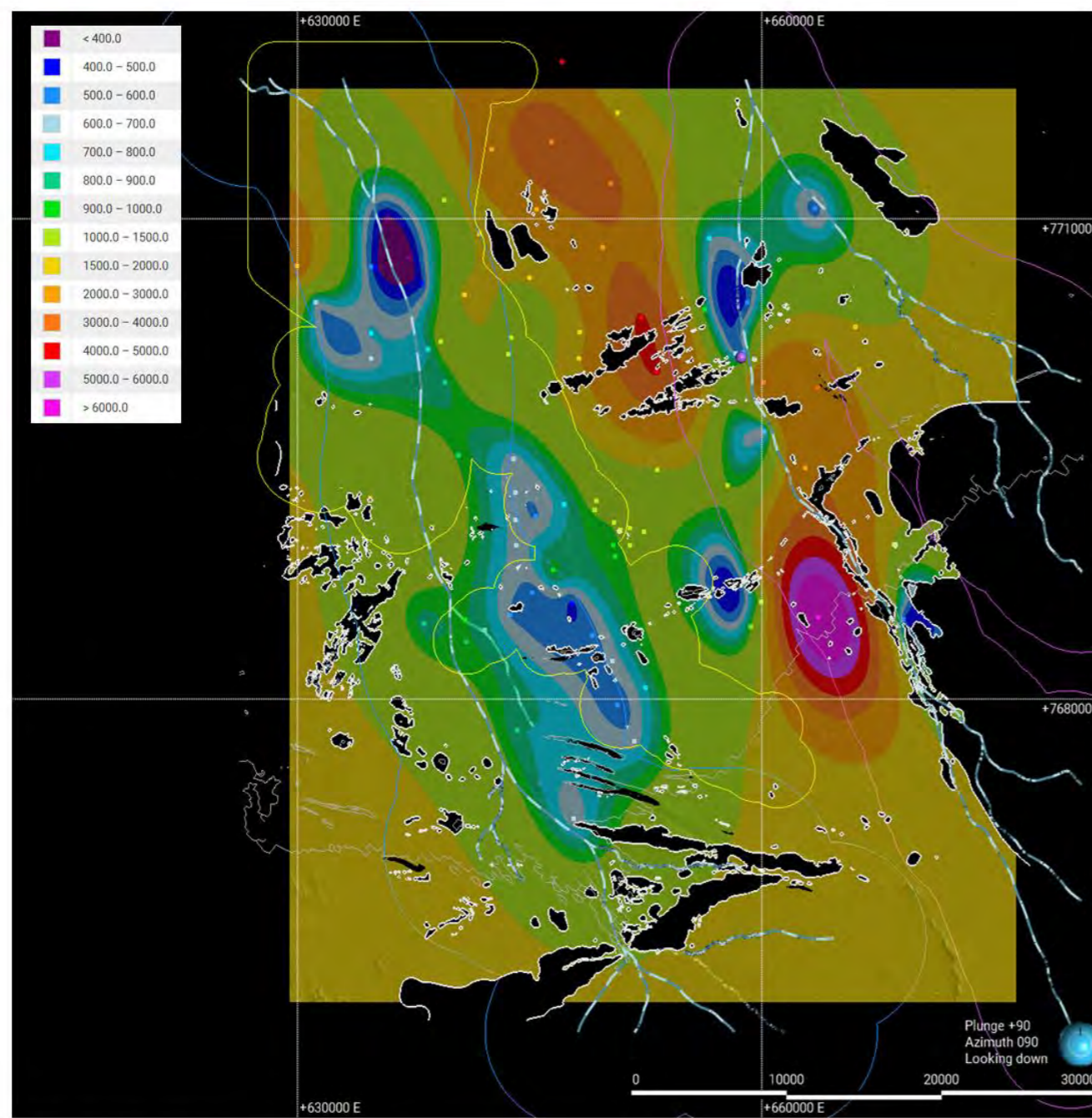
- OUTCROP/SUBCROP MAPPING    ● *ELAPHOIDELLA*
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



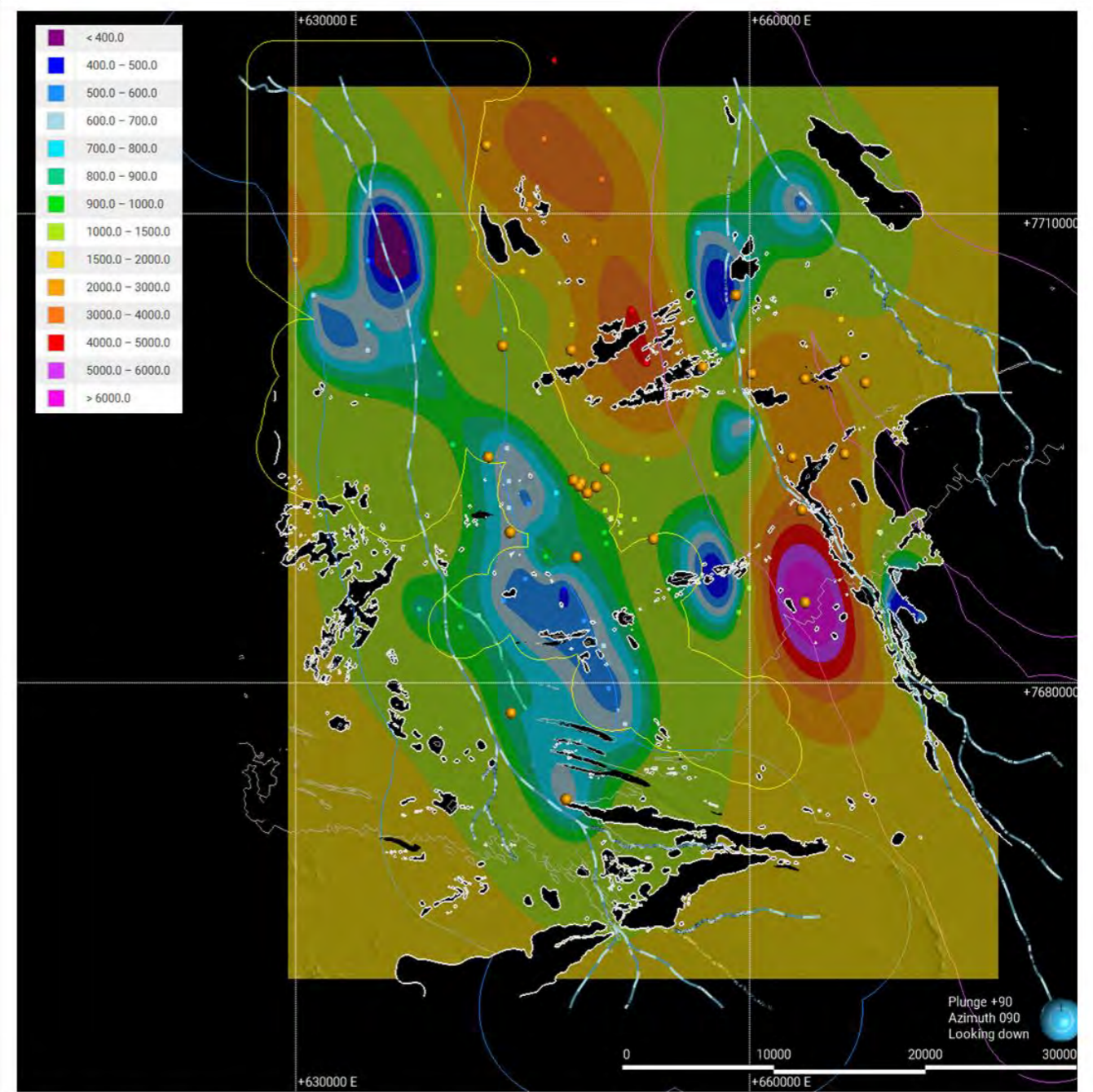
- OUTCROP/SUBCROP MAPPING    ● ENCHYTRAEIDAE
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



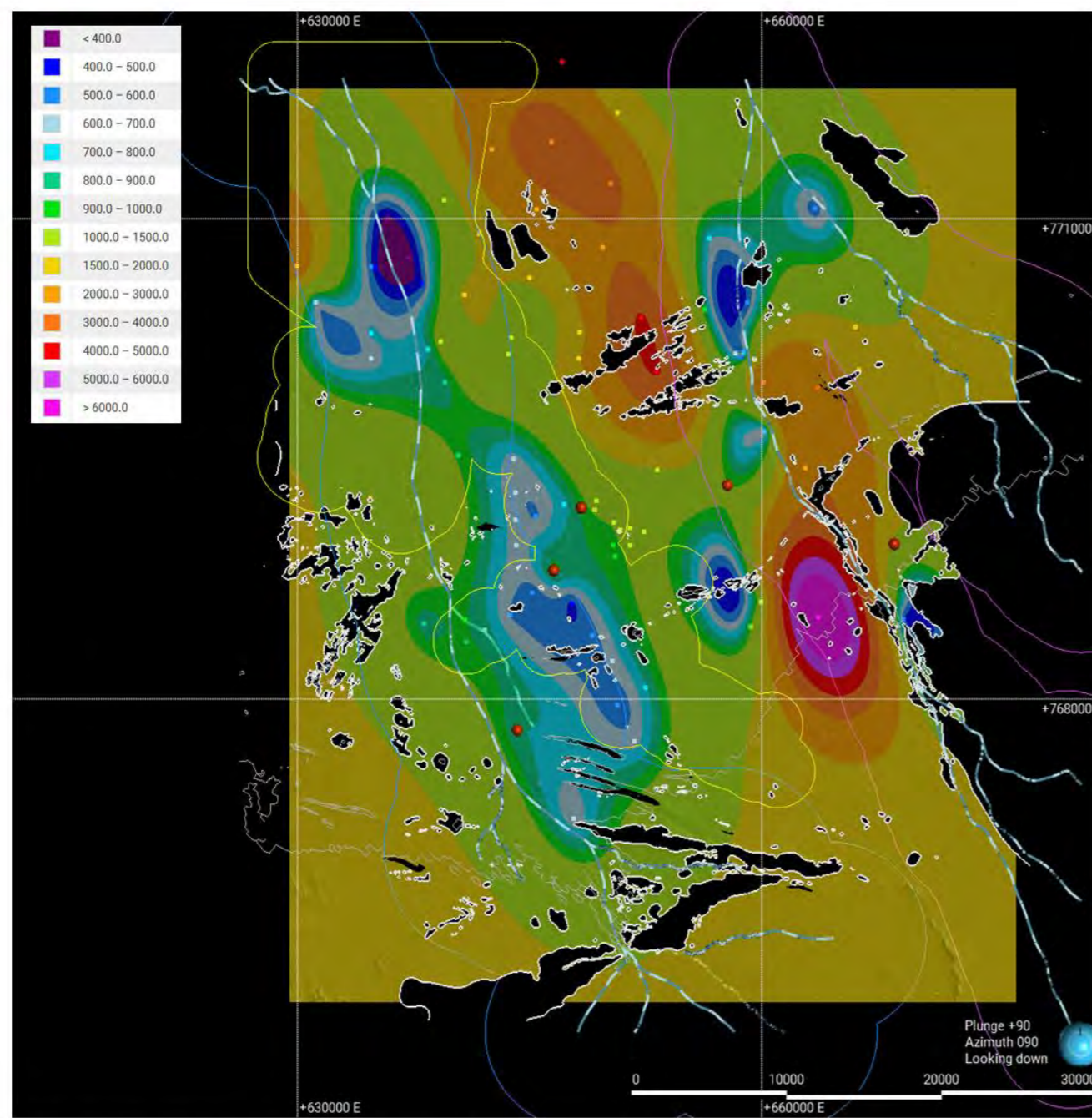
- OUTCROP/SUBCROP MAPPING    ● ERIOPSISIDAE
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



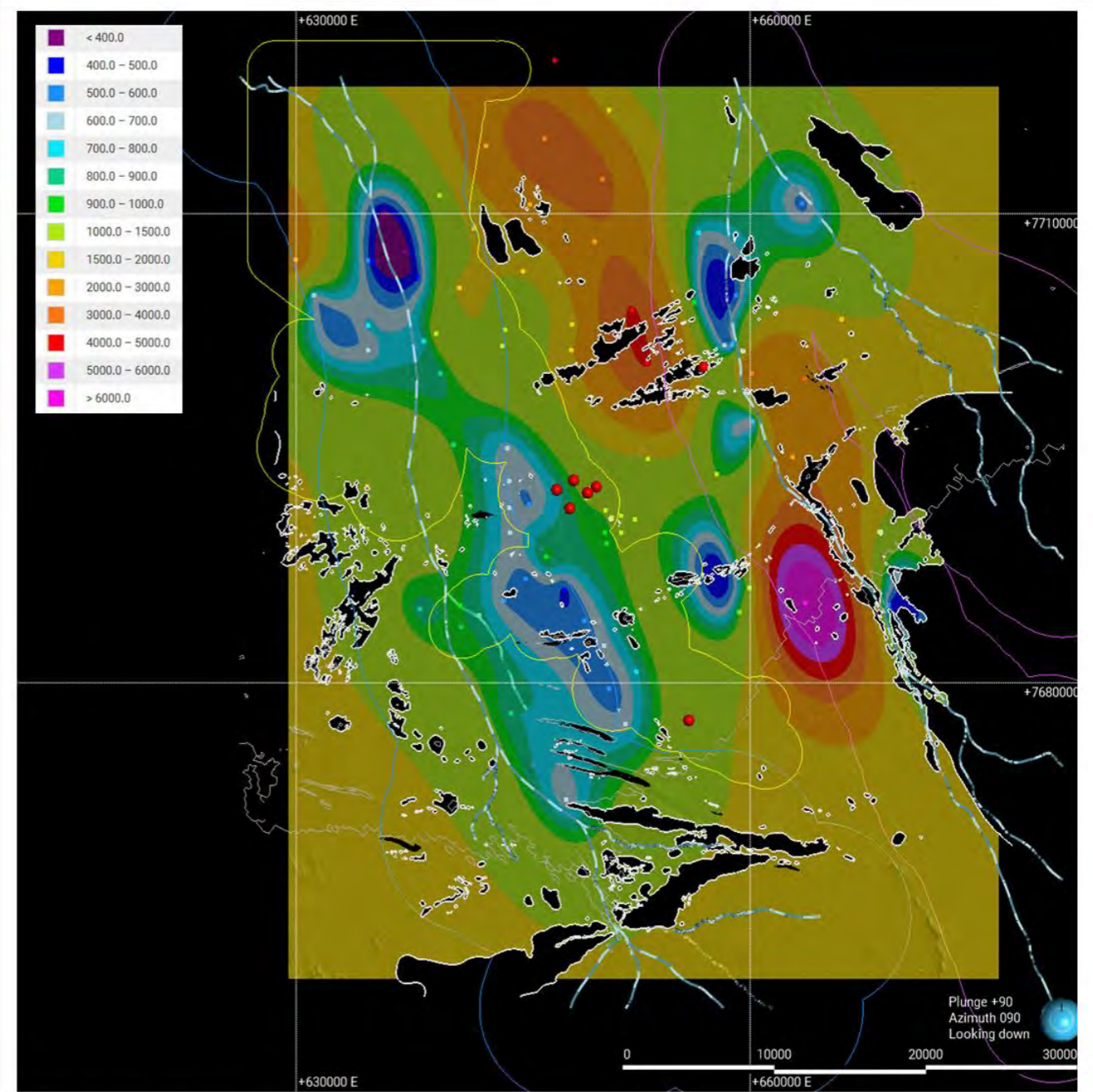
- OUTCROP/SUBCROP MAPPING    ● HAPLOTAXIS
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



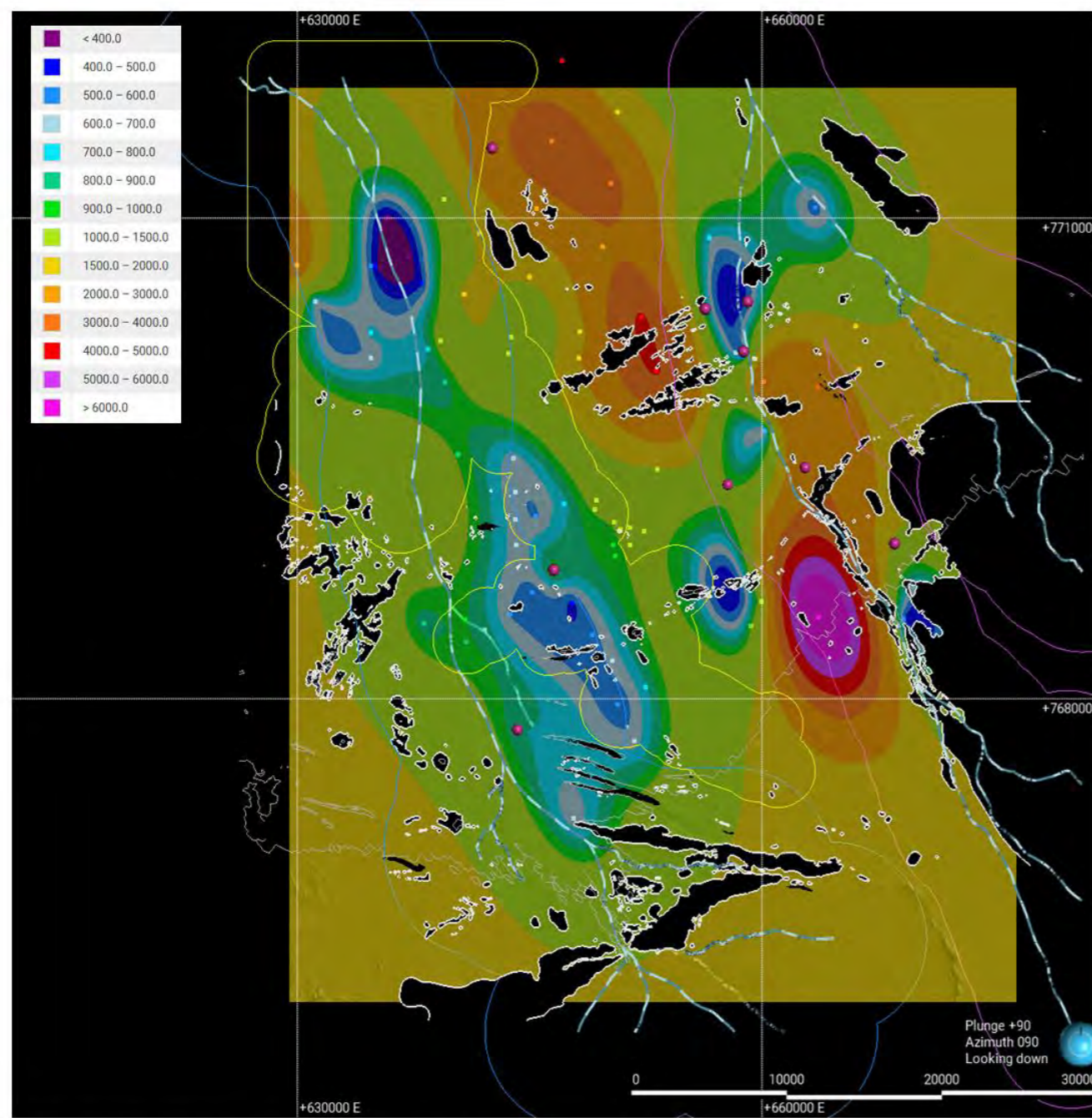
- OUTCROP/SUBCROP MAPPING    ● MEGASTYGONITOCRELLA
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



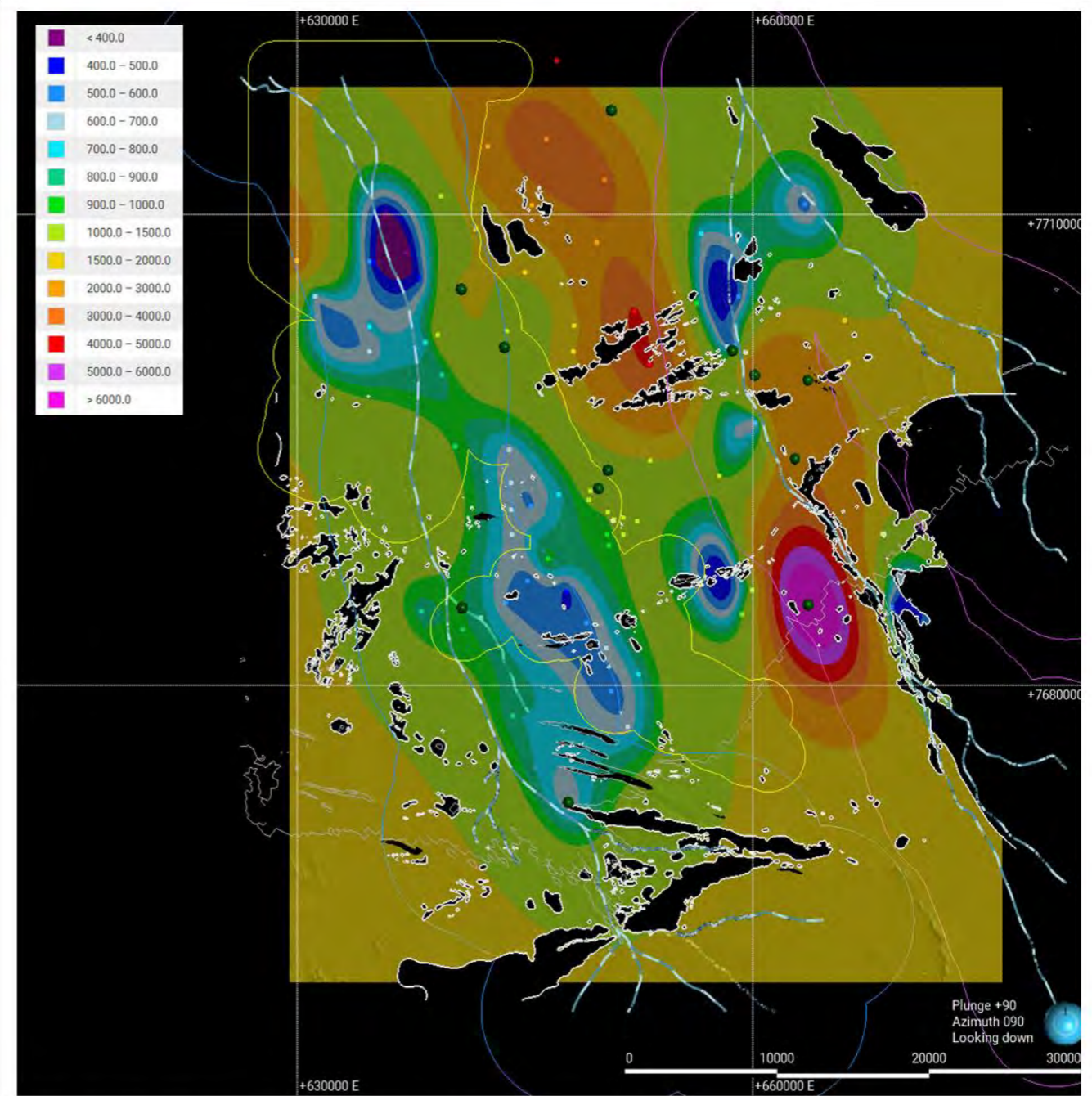
- OUTCROP/SUBCROP MAPPING
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER
- MESOCYCLOPS



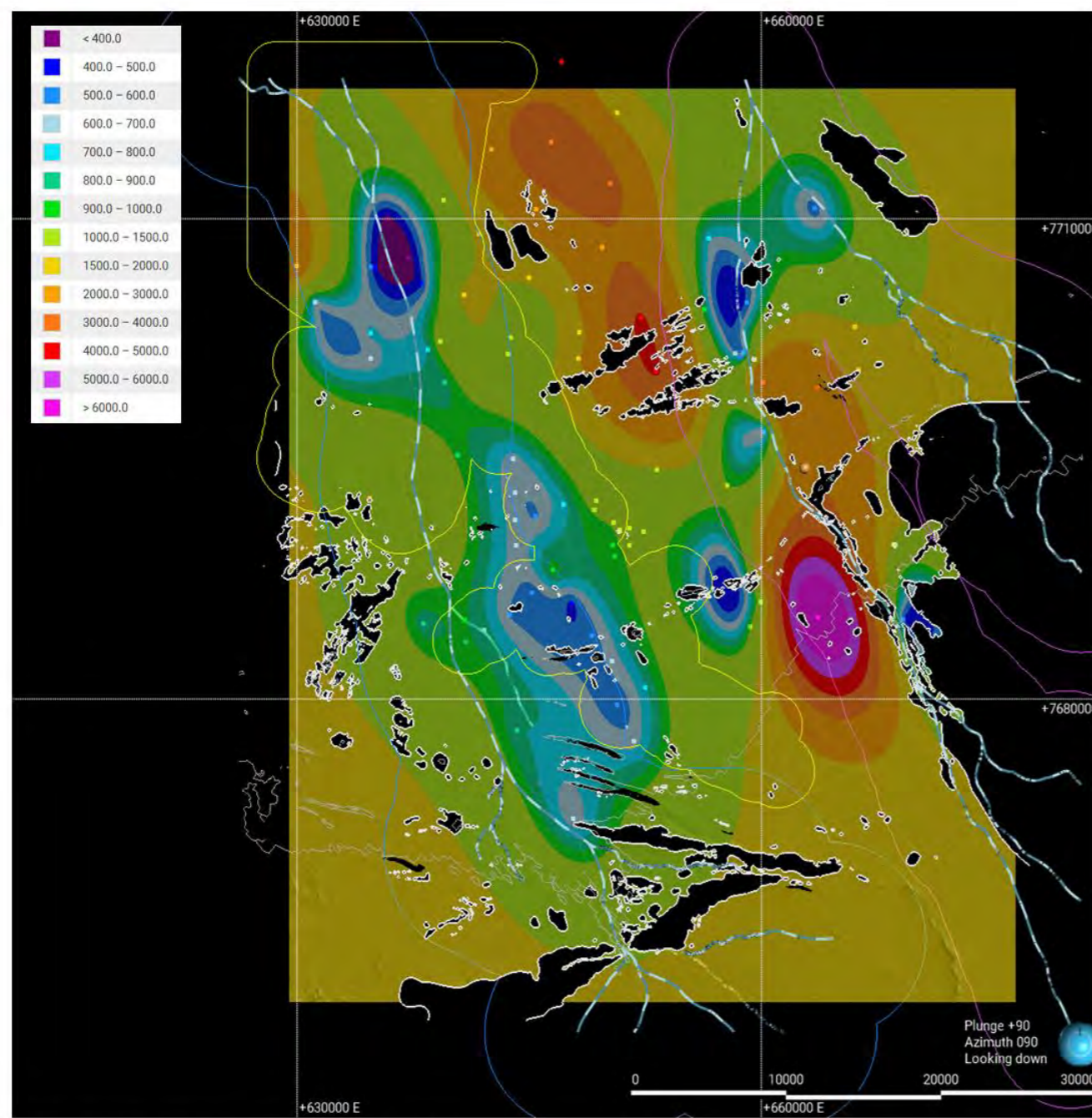
- OUTCROP/SUBCROP MAPPING
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER
- MICROCERBERIDAE



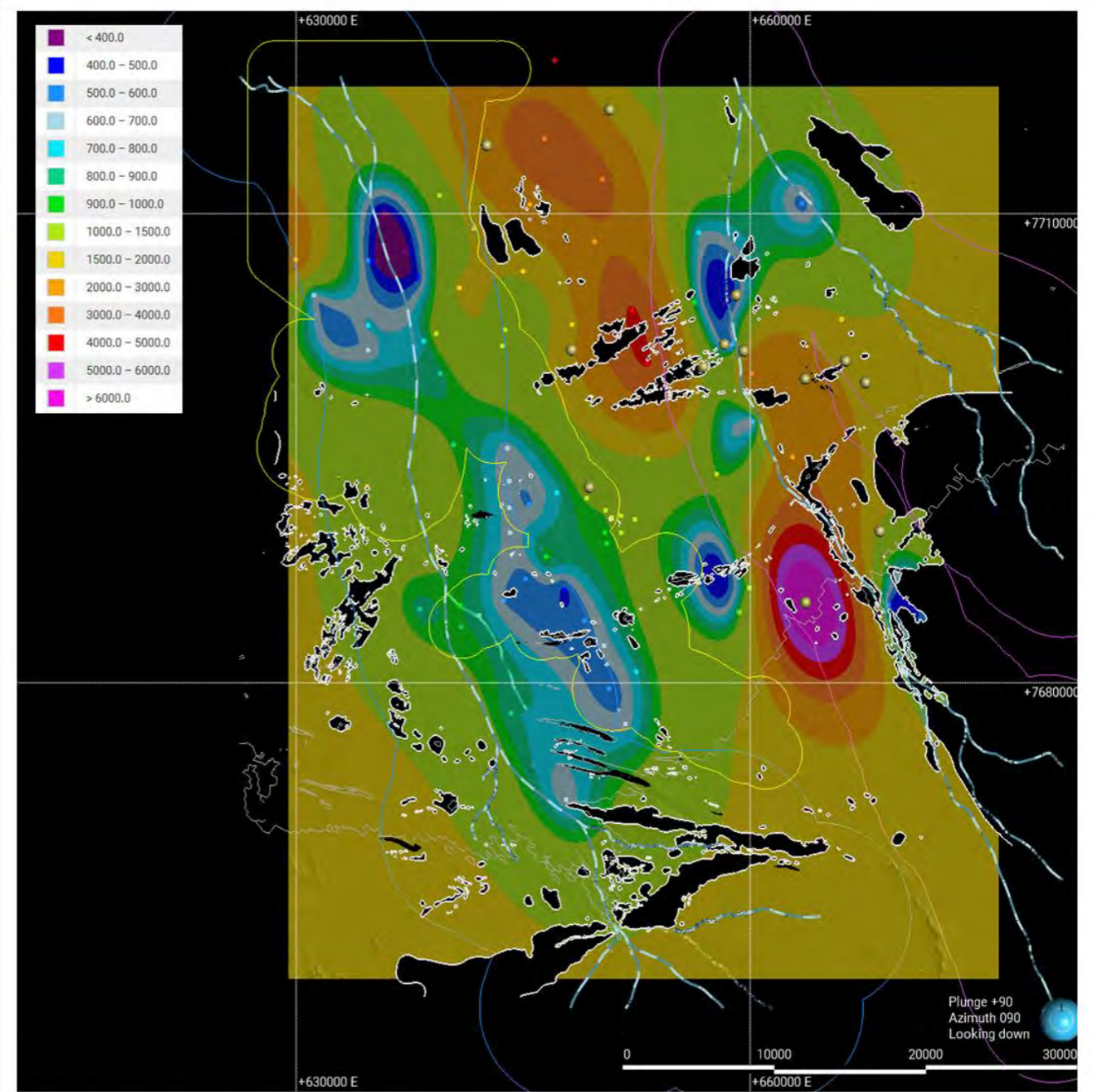
- OUTCROP/SUBCROP MAPPING
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER
- MICROCYCLOPS



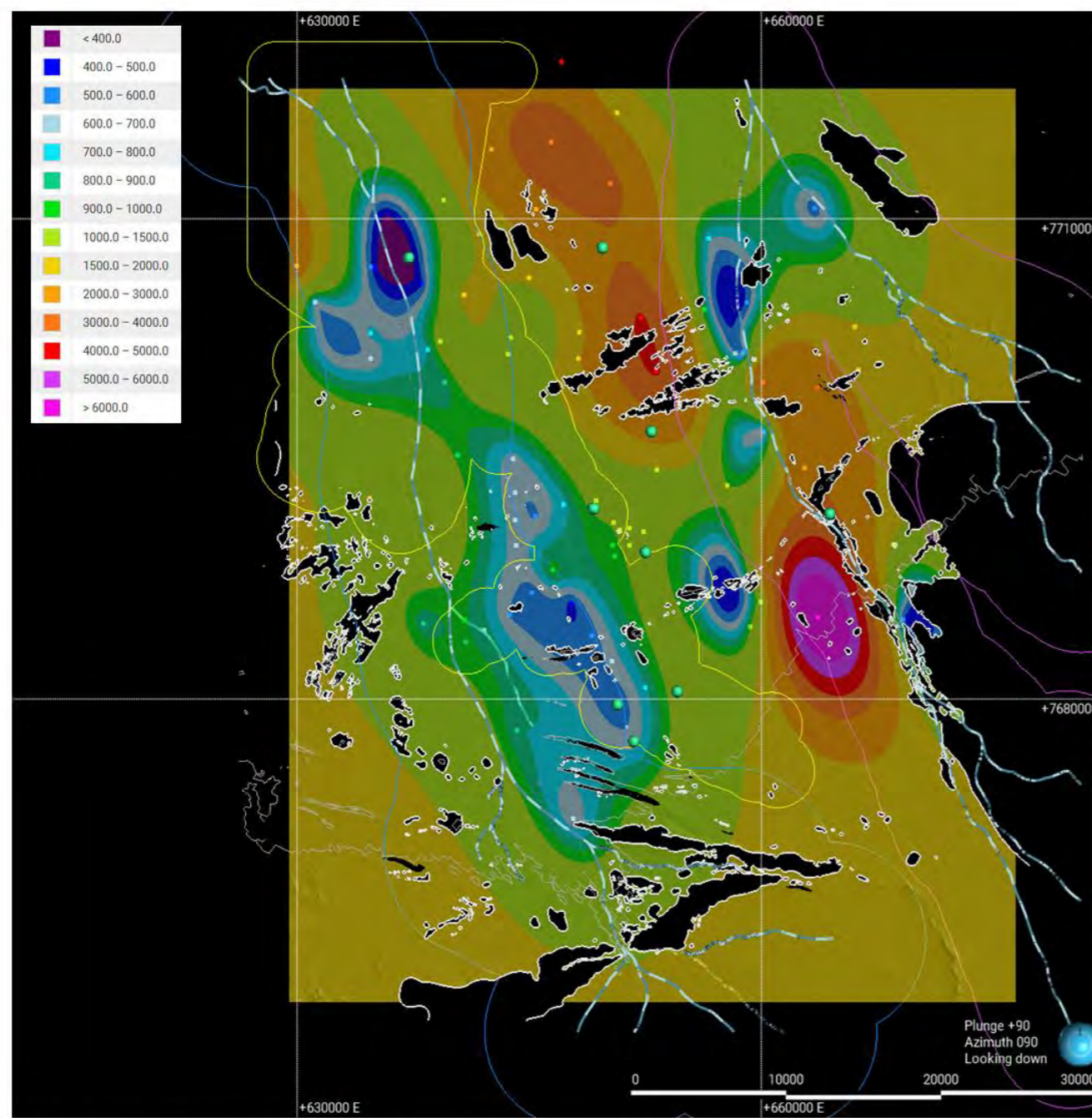
- OUTCROP/SUBCROP MAPPING
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER
- MONOPYLEPHORUS



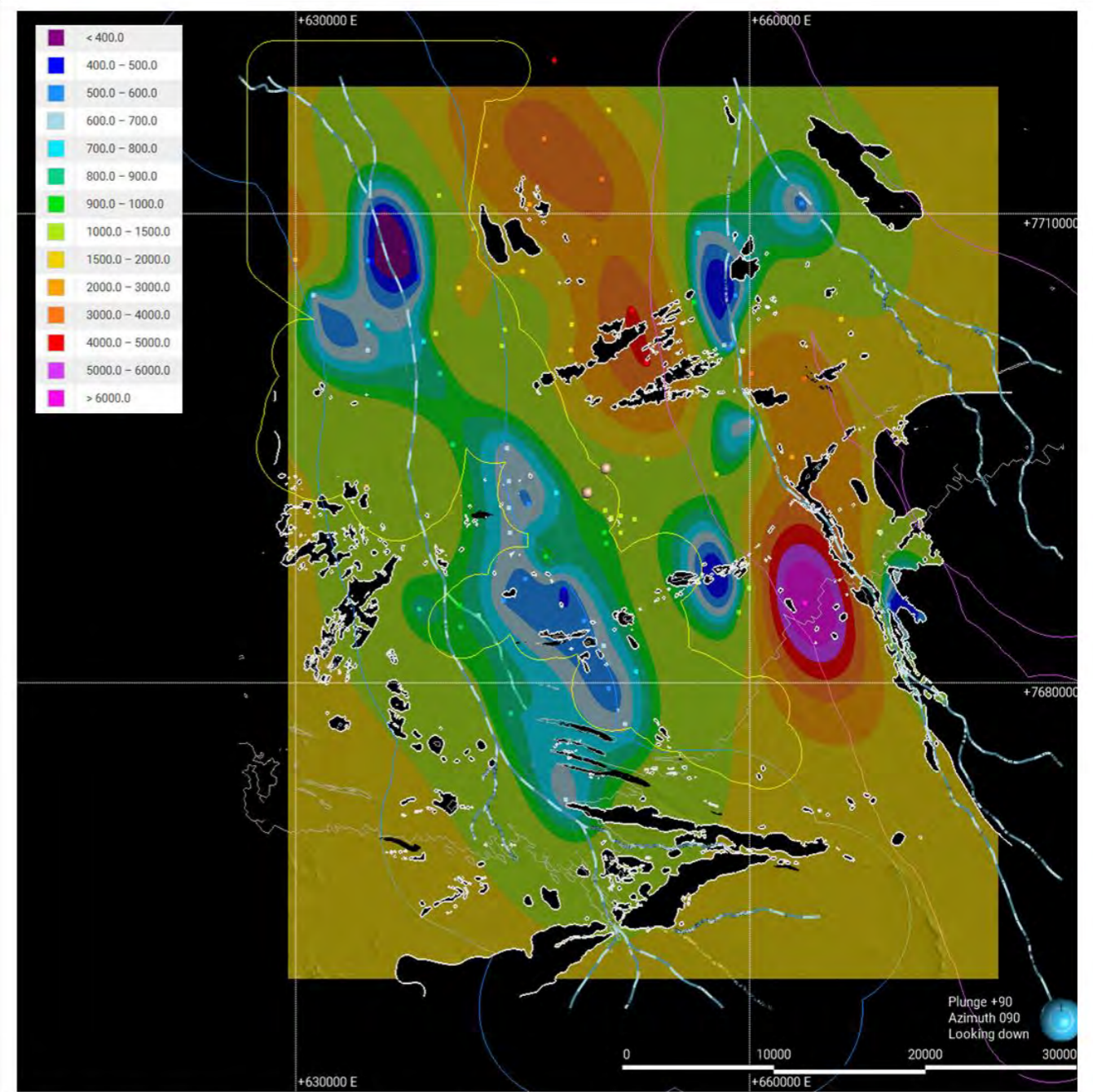
- OUTCROP/SUBCROP MAPPING
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERRIVER 6KM BUFFER
- NAIDIDAE



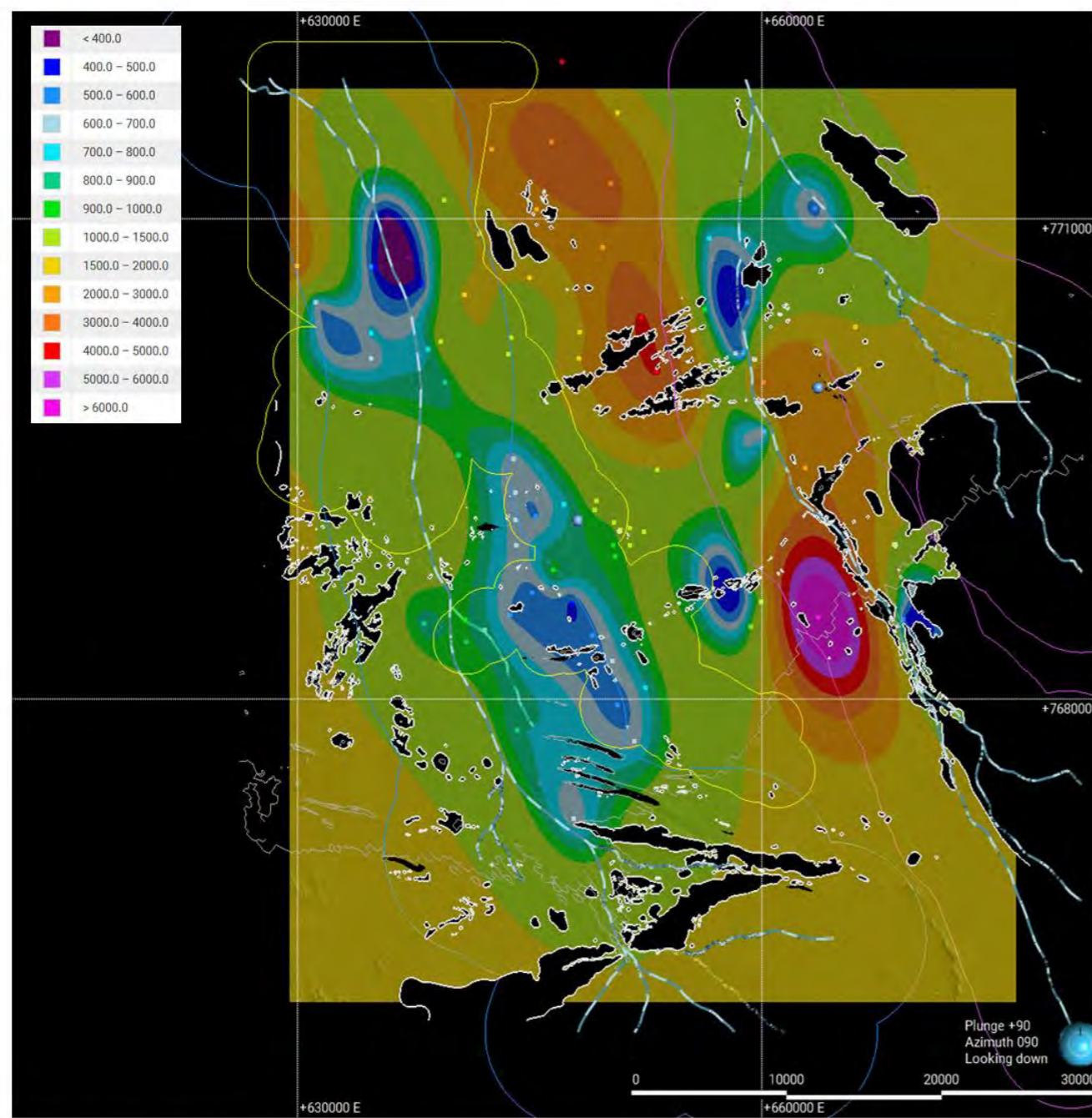
- OUTCROP/SUBCROP MAPPING
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERRIVER 6KM BUFFER
- NEDSIA



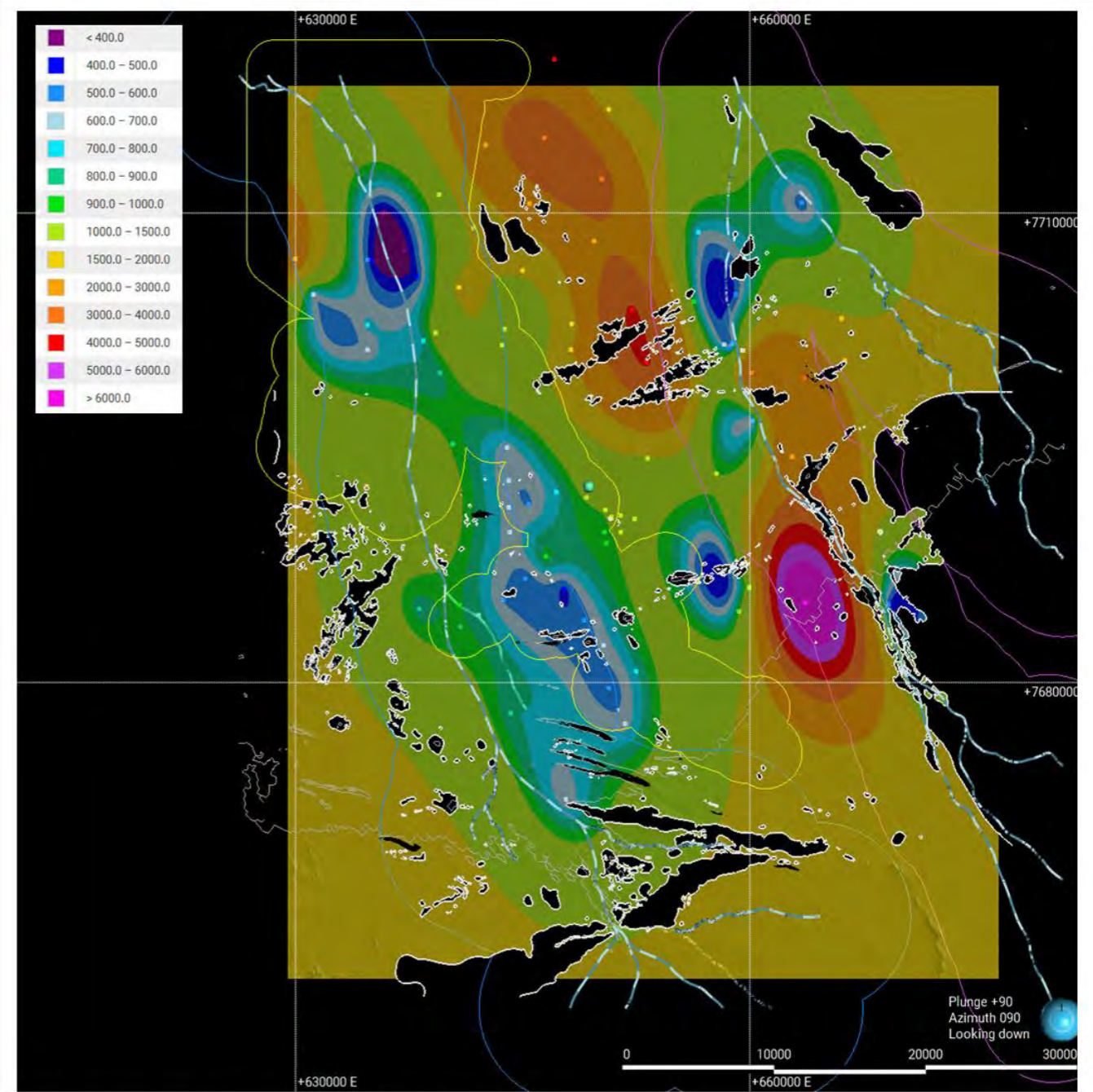
- OUTCROP/SUBCROP MAPPING    ● NO SPECIES
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



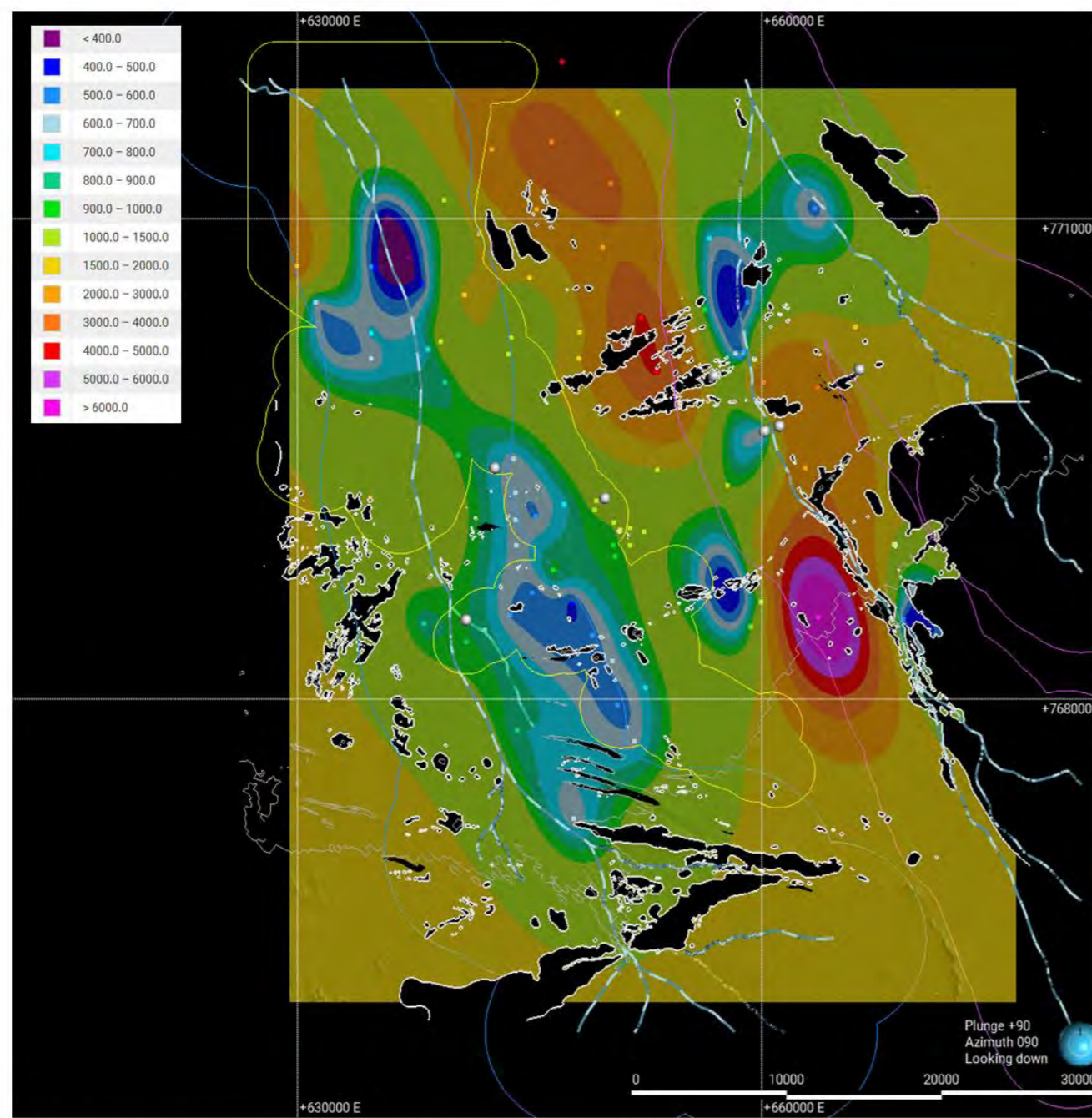
- OUTCROP/SUBCROP MAPPING    ● ORBUSCYCLOPS
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



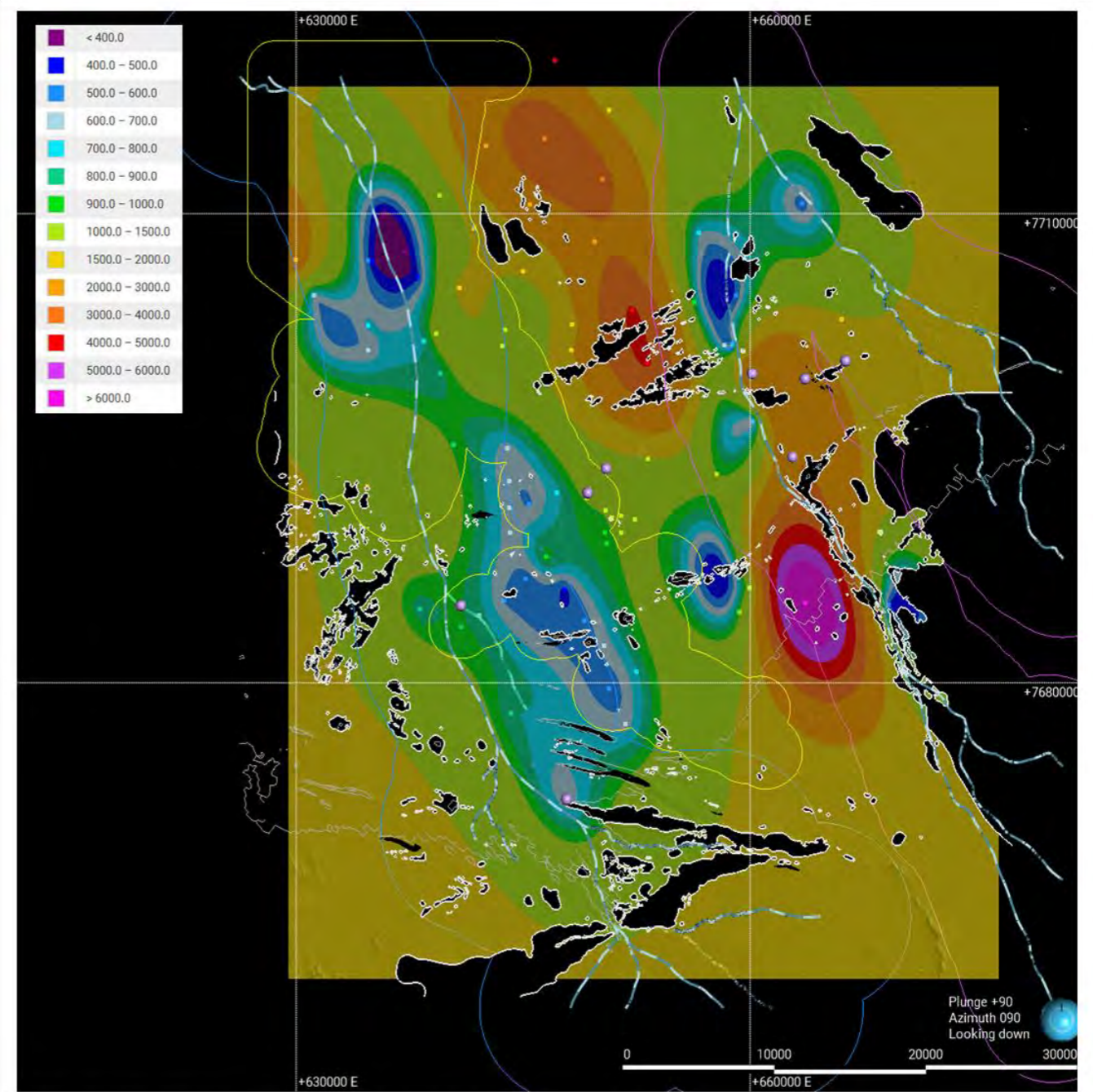
- OUTCROP/SUBCROP MAPPING
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER
- OSTRACODA



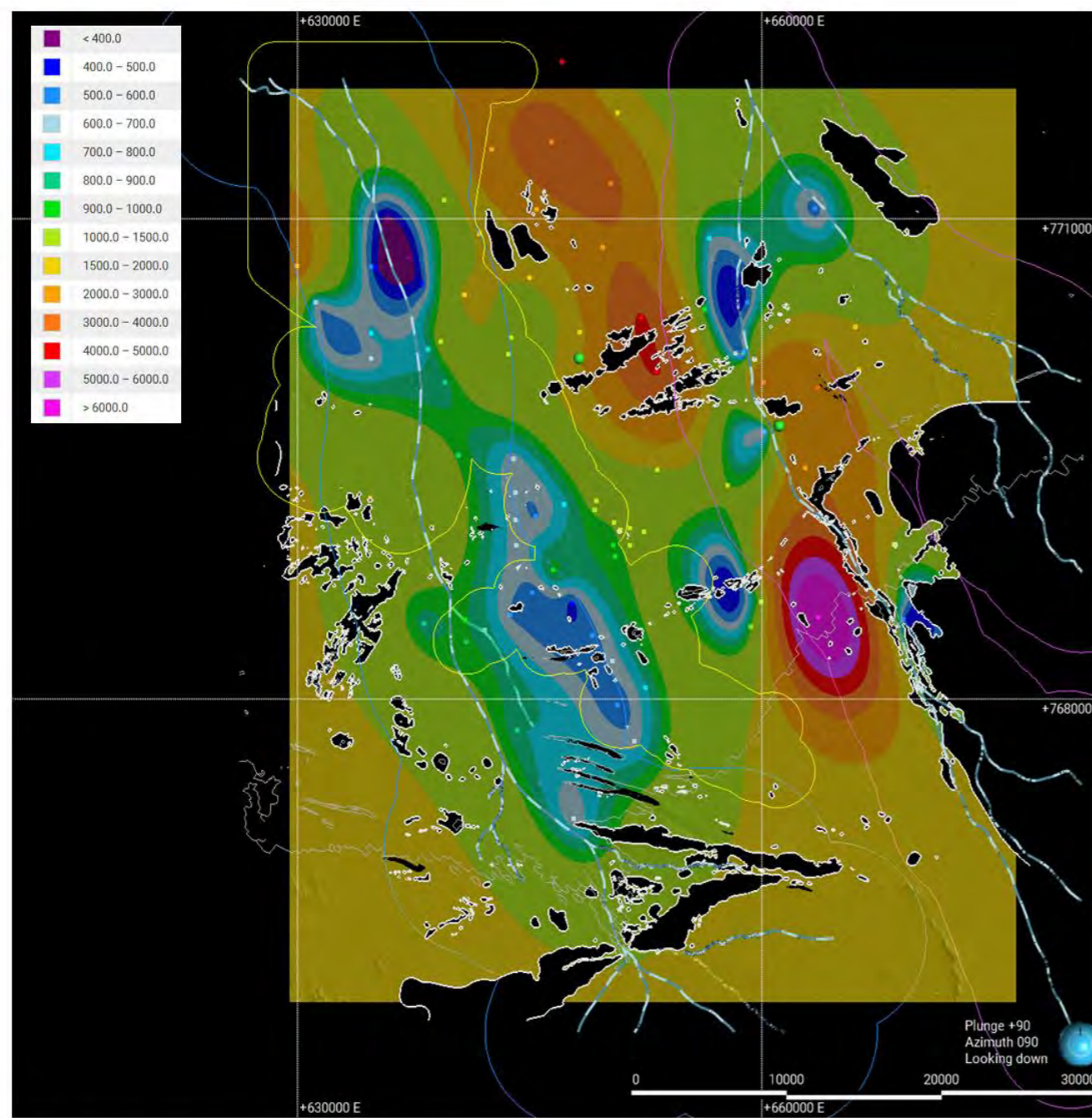
- OUTCROP/SUBCROP MAPPING
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER
- PARAJAPYGIDAE



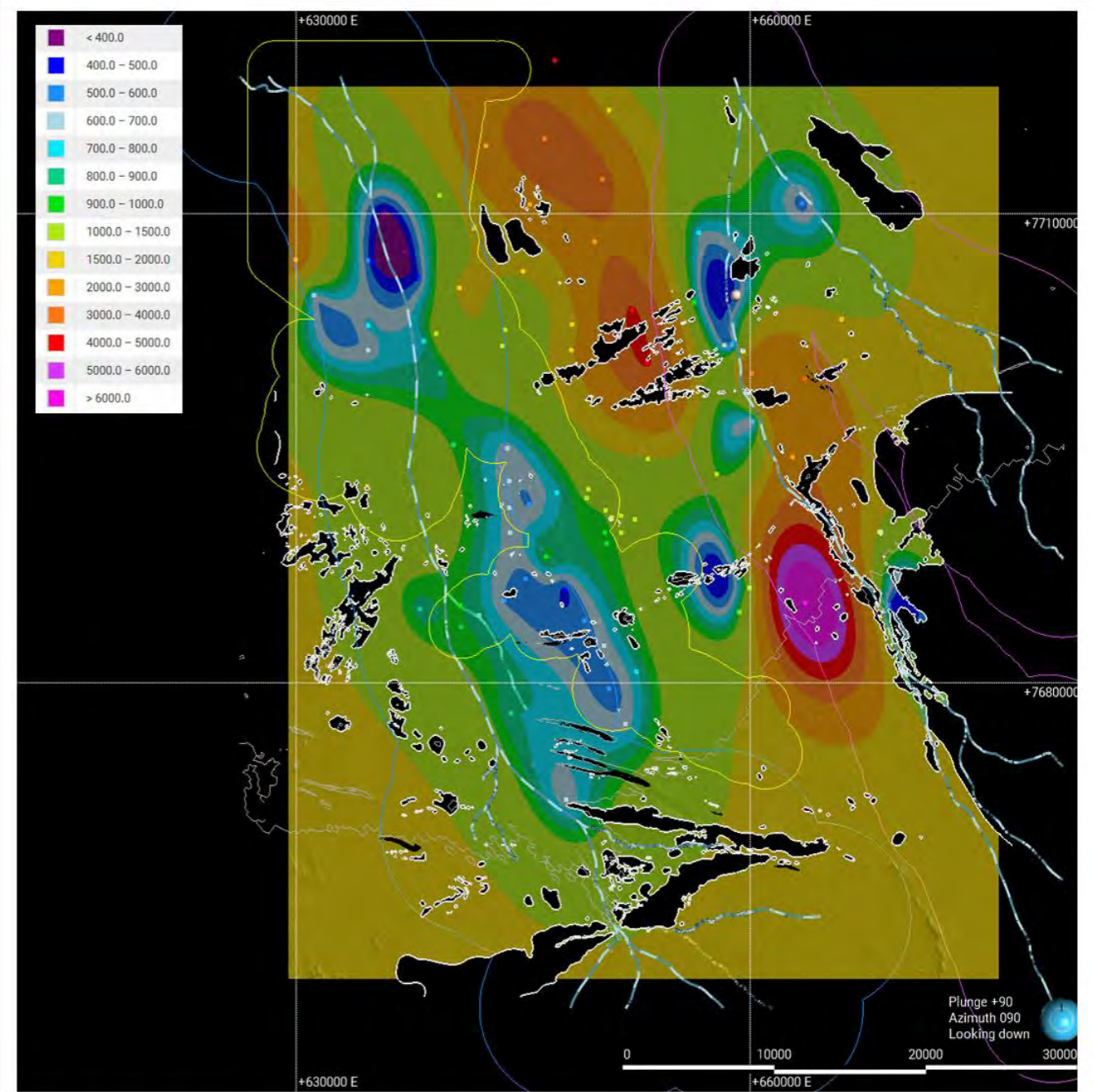
- OUTCROP/SUBCROP MAPPING    ● PARAMELITIDAE
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERRIVER 6KM BUFFER



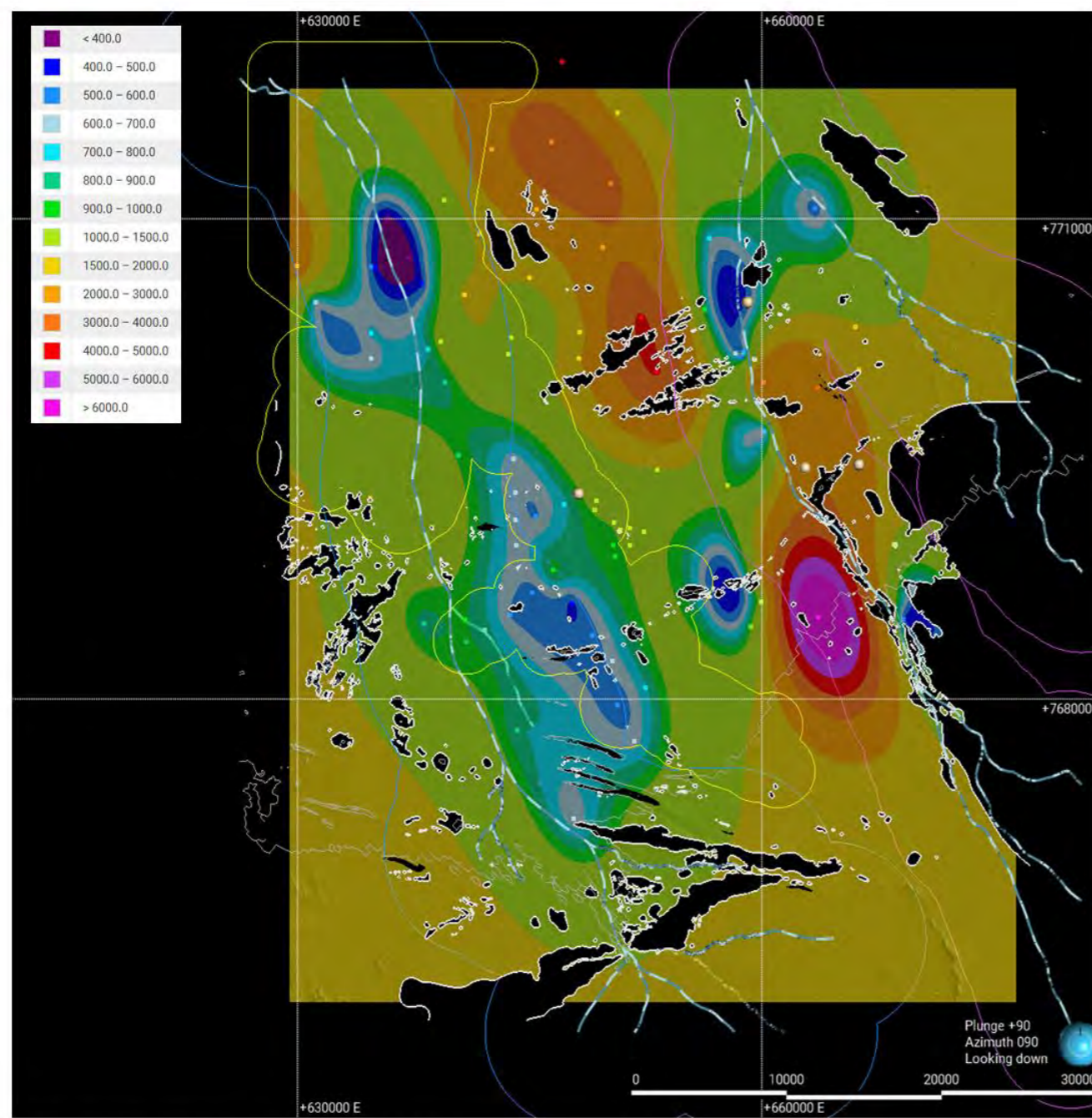
- OUTCROP/SUBCROP MAPPING    ● PHREODRILIDAE
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERRIVER 6KM BUFFER



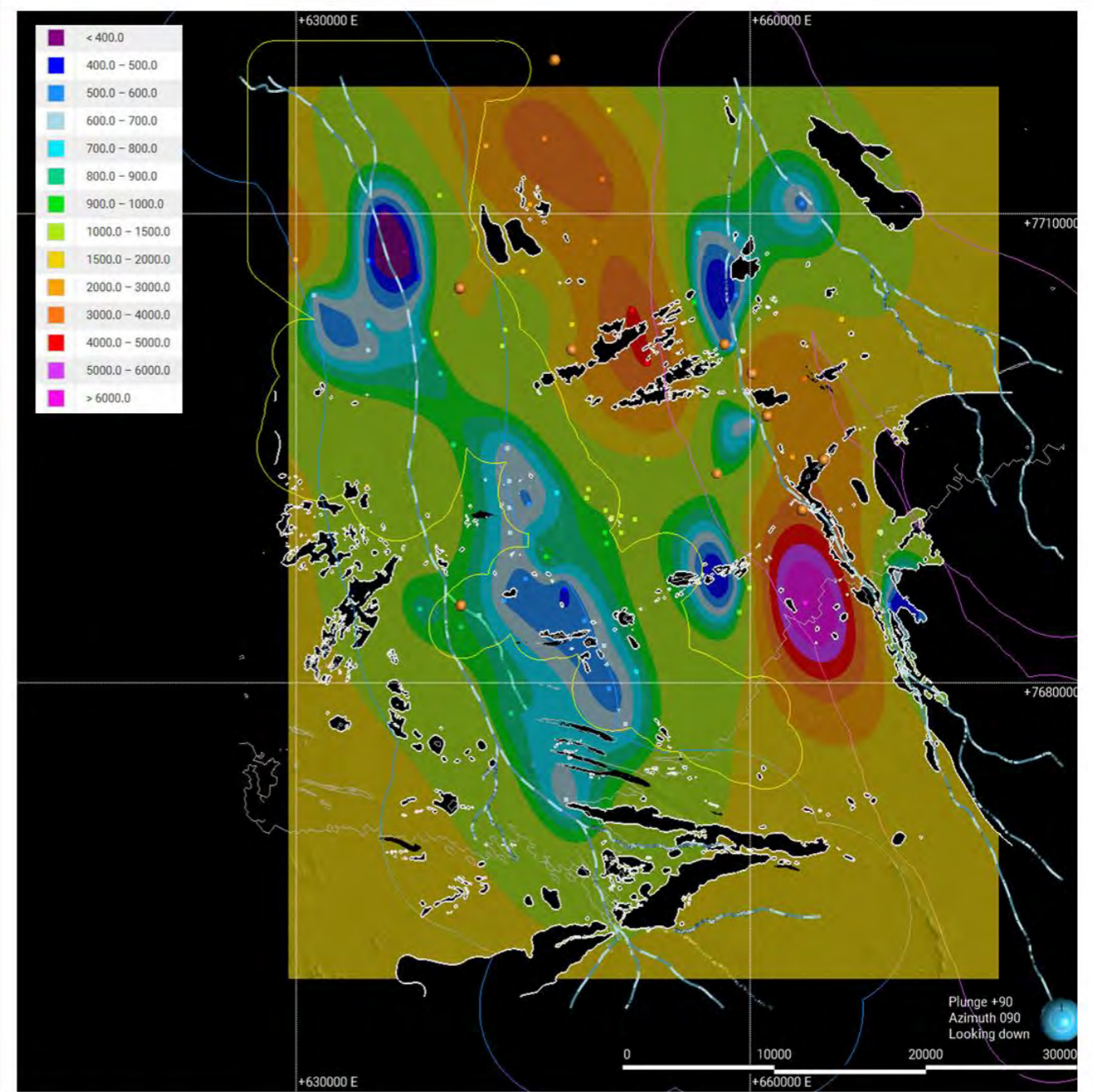
- OUTCROP/SUBCROP MAPPING ● PILBARANA
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



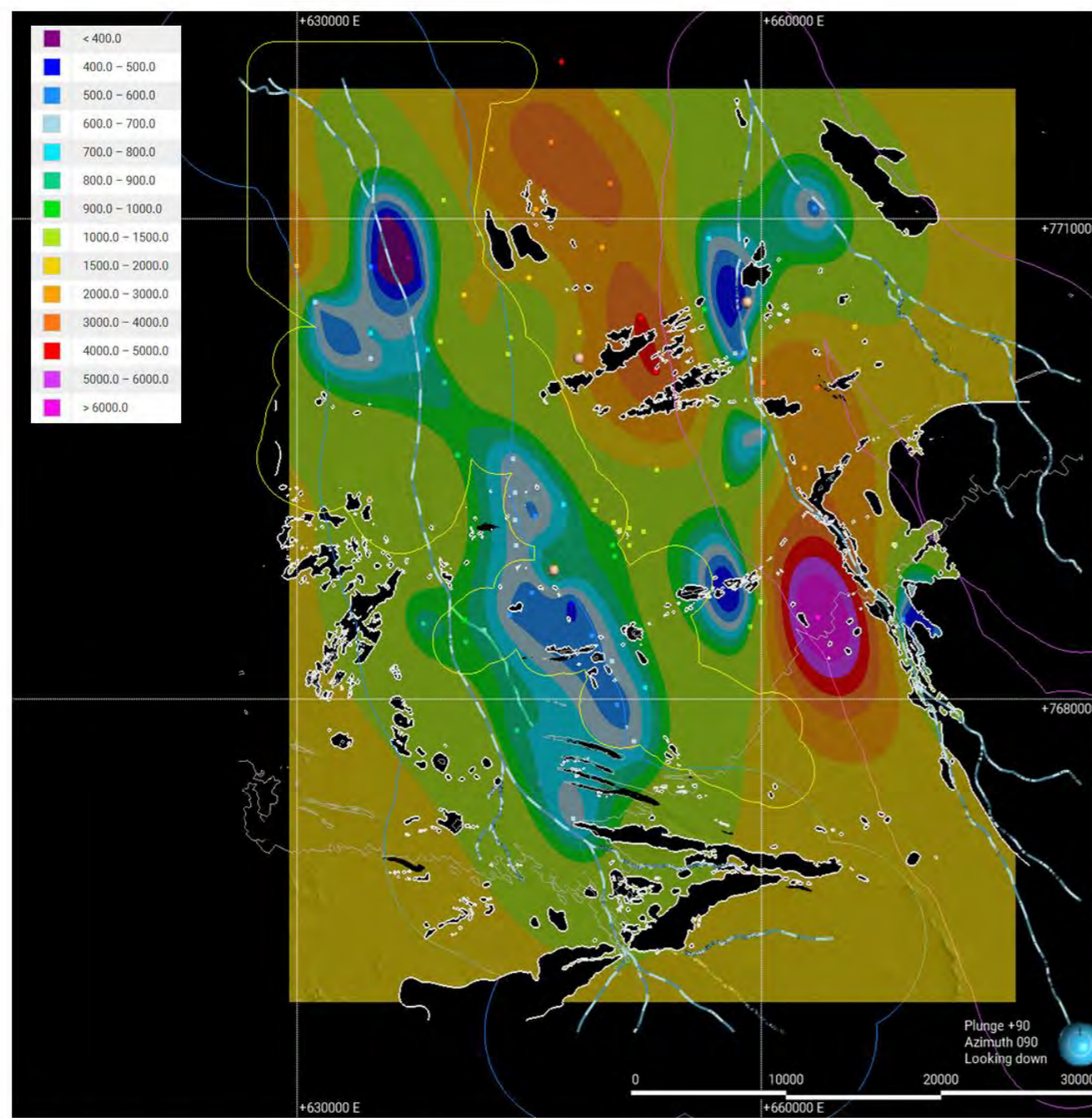
- OUTCROP/SUBCROP MAPPING ○ PRISTINA
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



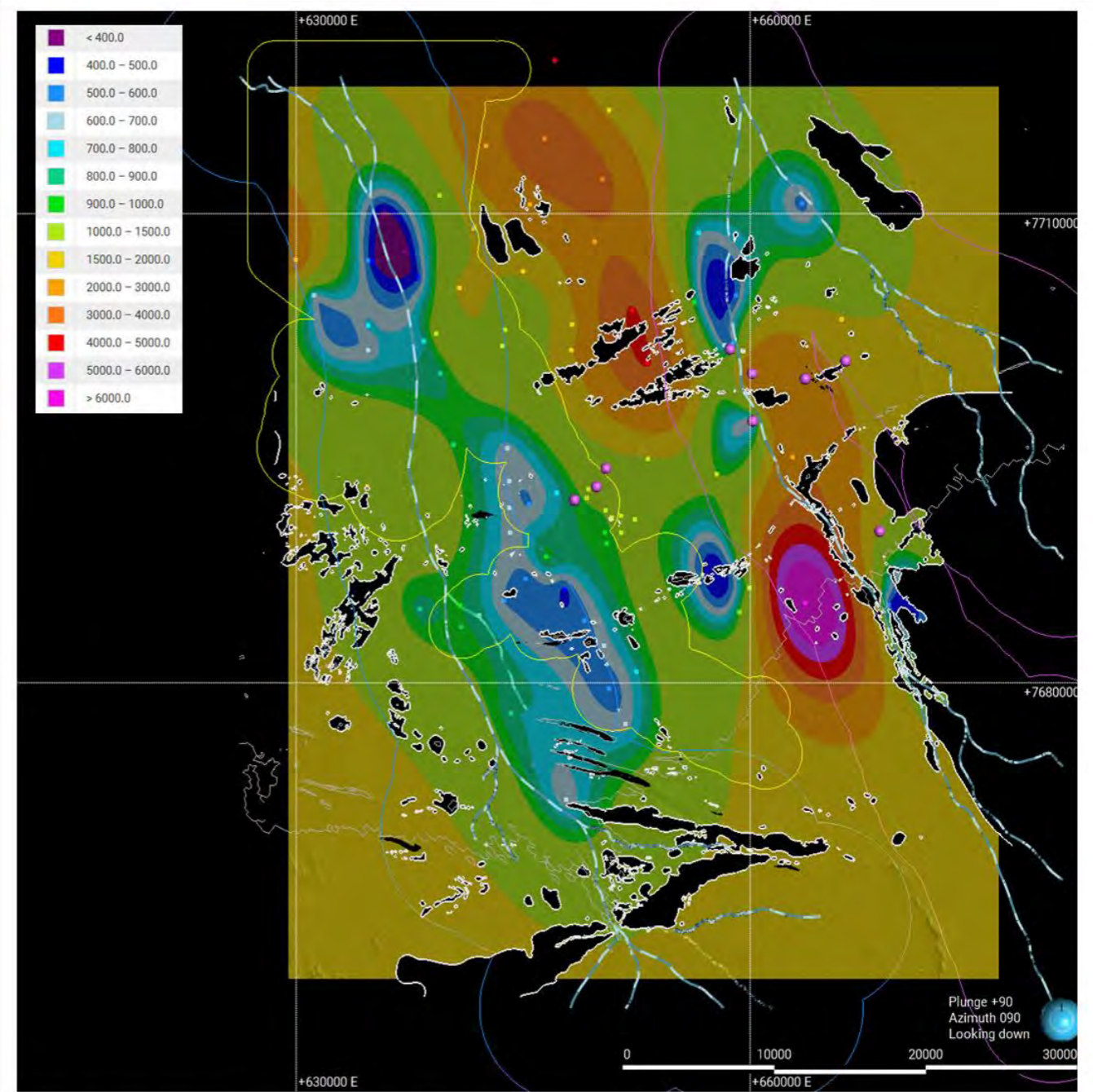
- OUTCROP/SUBCROP MAPPING    ○ RIOCYPRIS
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



- OUTCROP/SUBCROP MAPPING    ○ SARSCYPRIDOPSIS
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERIVER 6KM BUFFER



- OUTCROP/SUBCROP MAPPING    ○ STENOCYPRIS
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERRIVER 6KM BUFFER



- OUTCROP/SUBCROP MAPPING    ● TUBIFICIDAE
- HGP MINE REGOLITH MODEL
- MAJOR RIVER SYSTEMS
- TURNERRIVER 5KM BUFFER
- PALAEOCHANNEL 1.8KM BUFFER
- YULERRIVER 6KM BUFFER

