WOOLARD CONSULTING PTY LTD

Mulga Rock Uranium Project

Stygofauna Pilot Assessment

October 2015

Mulga Rock Uranium Project - Public Environmental Review - December 2015

Appendix C - Subterranean Fauna

C1

Authorship and Review

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V. Campagna	Peer Reviewer	Final Rev 1.2	09/04/2015
X. Moreau	Authorised for distribution	Final	08/06/2015
C. Woolard	Update with new mining parameters	Rev 1.3	09/10/2015
G. Bradley	Final edit and review	Rev 2.0	12/10/2015

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Mulga Rock Uranium Project Survey Team – Pilot Survey, 26 February 2013

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Executive Summary

Vimy Resources (Vimy), formerly Energy and Minerals Australia (EAMA), proposes to develop the Mulga Rock Uranium Project (MRUP) which is located 240km east-northeast of Kalgoorlie in the dune fields of the Shield Subregion of the Great Victorian Desert (GVD) Biogeographic region of Western Australia.

The MRUP will include open pit mining, ore processing, and establishment of associated infrastructure including water supply borefields, mine dewatering, excess groundwater reinjection and tailings storage areas within the Project area. These are activities which have the potential to impact on subterranean fauna communities, if present.

The Project covers approximately 102,000 hectares on granted mining tenure (primarily M39/1080 and M39/1081) within Unallocated Crown Land (UCL) of with proposed disturbance estimated at approximately 3,800ha within a proposed 10,000ha Development Envelope. It includes two distinct mining centres, Mulga Rock East (MRE) comprising the Princess and Ambassador resources and Mulga Rock West (MRW) comprising the Emperor and Shogun resources, which are approximately 20km apart (Figure 9).

Following discussions with the Department of Environment and Conservation (DEC) in 2011, Vimy was advised to undertake a Pilot Study for the presence of stygofauna at the MRUP. In February 2013, a Level 1 survey was undertaken in the Ambassador, Emperor, Shogun deposits and Kakarook borefield to determine if stygofauna were present in the groundwater associated with the Project. The samples were also analysed for the presence of troglofauna, often recorded as by-catch in stygofauna surveys.

Eleven bores were sampled; seven at Ambassador, two at Kakarook and one each in Emperor and Shogun. The groundwater quality, with the exception of Kakarook, was found to be mostly acidic and saline. No subterranean fauna were identified from the 104 arthropod specimens retrieved, all were epigean or edaphic taxa and did not display any troglomorphic features. Of the bores sampled, NND5030, NND5034, NND5040 and KB002 did not yield any specimens.

Based on the findings of this survey plus data collected from regional bores, the main MRUP Disturbance Footprint area does not support significant subterranean fauna habitat. This is supported by:

- the absence of alluvial aquifers in the mine and borefield development areas,
- the paleochannel aquifer in the MRUP area, which hosts the lignitic orebody has a clay aquitard which limits the transfer of resources,
- groundwater displays a range of geochemical characteristics not considered conducive to supporting biological habitats,
- desktop searches have not found any record of stygofauna associated with lignitic aquifers in Australia.

These findings are consistent with results from recent surveys of regional bores undertaken by others (*ecologia* 2009a & b) within 100km radius of the MRUP.

1. Introduction

1.1 Background

Vimy Resources Limited (Vimy), formerly Energy and Minerals Australia (EAMA), proposes to develop the Mulga Rock Uranium Project (MRUP or the Project), which is located 240km east-northeast of Kalgoorlie (Figure 1). The Project will involve the shallow open pit mining of four poly-metallic deposits with commercial grades of contained uranium hosted in carbonaceous material below the groundwater table. Processing will be undertaken onsite at a central mill.

The MRUP area, on the western flank of the Great Victoria Desert, is located in the Shire of Menzies, within granted mining tenure on Unallocated Crown Land. It consists of 102,000 hectares of dune fields and is remote, with access limited to four wheel drive vehicles. The nearest residential town is Laverton which is approximately 200km to the northwest. Other communities include Pinjin Station Homestead, located approximately 100km to the west; Coonana Aboriginal Community, approximately 130km to the south-southwest; Kanandah Station Homestead, approximately 150km to the southeast; and the Tropicana Gold Mine approximately 110km to the northeast.

The uranium mineralisation is located within the primary site aquifer. No records of stygofauna from previous surveys within a 100km radius of the MRUP site were located during the desktop search. In addition, a review of the drilling database, groundwater quality analyses and lithostratigraphic records of historic (Eocene) marine incursions indicated that suitable habitats were unlikely to be present.

Vimy undertook a Level 1 assessment in accordance with the key environmental factors outlined in the Environmental Scoping Document and the EPA Environmental Assessment Guideline 12 (EAG 12) (EPA 2013). This involves a desktop assessment and a reconnaissance survey.

This report documents the results from the Level 1 Pilot Survey undertaken in the Ambassador, Princess, Shogun deposits and Kakarook borefield between 26 February and 1 March 2013.

1.2 Project Description

Following dewatering of the ore zone aquifer, ore will be mined by traditional open cut techniques, crushed, beneficiated and then processed at an onsite leach and precipitation treatment plant to produce up to 1360 tonnes of uranium oxide concentrate per year over the life of the Project. The anticipated life of mine is up to 16 years, based on the currently identified resources. The drummed uranium oxide concentrate (UOC) will be transported by road from the mine site in sealed sea containers to a suitable port, approved to receive and ship Class 7 materials (expected to be Port Adelaide), for export.

The MRUP will require clearing of vegetation, mine dewatering, creation of overburden (un-mineralised) landforms, construction of onsite processing facilities and waste management systems. Major built infrastructure will include a processing plant, Run of Mine (ROM) ore stockpile area, construction of above-ground overburden landforms for un-mineralised mined materials, an above-ground tailings storage facility and water storage/evaporation facilities. Once sufficient voids are created, tailings will be deposited back into the pits, capped with un-mineralised waste rock and rehabilitated. Rehabilitation of disturbed areas will, where feasible, be undertaken in accordance with an approved Mine Closure Plan. The MRUP area is shown on Figure 1.

Required project infrastructure will include mine administration and workshop facilities, fuel and chemical storage, a diesel-fired power plant of up to 20 megawatt (MW) capacity, a saline water borefield, mine water reinjection borefield and associated pipelines. Service infrastructure will include a power supply, accommodation village for a fly-in fly-out workforce, airstrip, laydown areas and other supporting ancillary infrastructure such as communication systems, roads, waste water treatment plant and solid waste landfill facilities. Transport to site for consumables, bulk materials and general supply items will be via existing public road systems linked to dedicated project site roads.

For assessment purposes, potential impacts to any subterranean fauna communities within the MRUP could result from activities associated with mine dewatering, above-ground or in-pit tailings disposal, water reinjection and abstraction of groundwater from the supply borefields.

1.3 Purpose and Scope of Report

Purpose

Projects undertaken as part of the Environmental Impact Assessment (EIA) for both State and Federal processes require that subterranean fauna values within the proposed zones of impact be investigated so as to determine if the development proposal will place any subterranean fauna at risk.

The purpose of the MRUP Level 1 survey is to determine the presence of subterranean fauna in the area of impact associated with pit mining, tailings disposal, mine dewatering and borefield abstraction. From the findings, the significance of the area as habitat for subterranean fauna will be determined and the potential risk from the MRUP to any subterranean taxa assessed. Other project activities are unlikely to affect the aquifer.

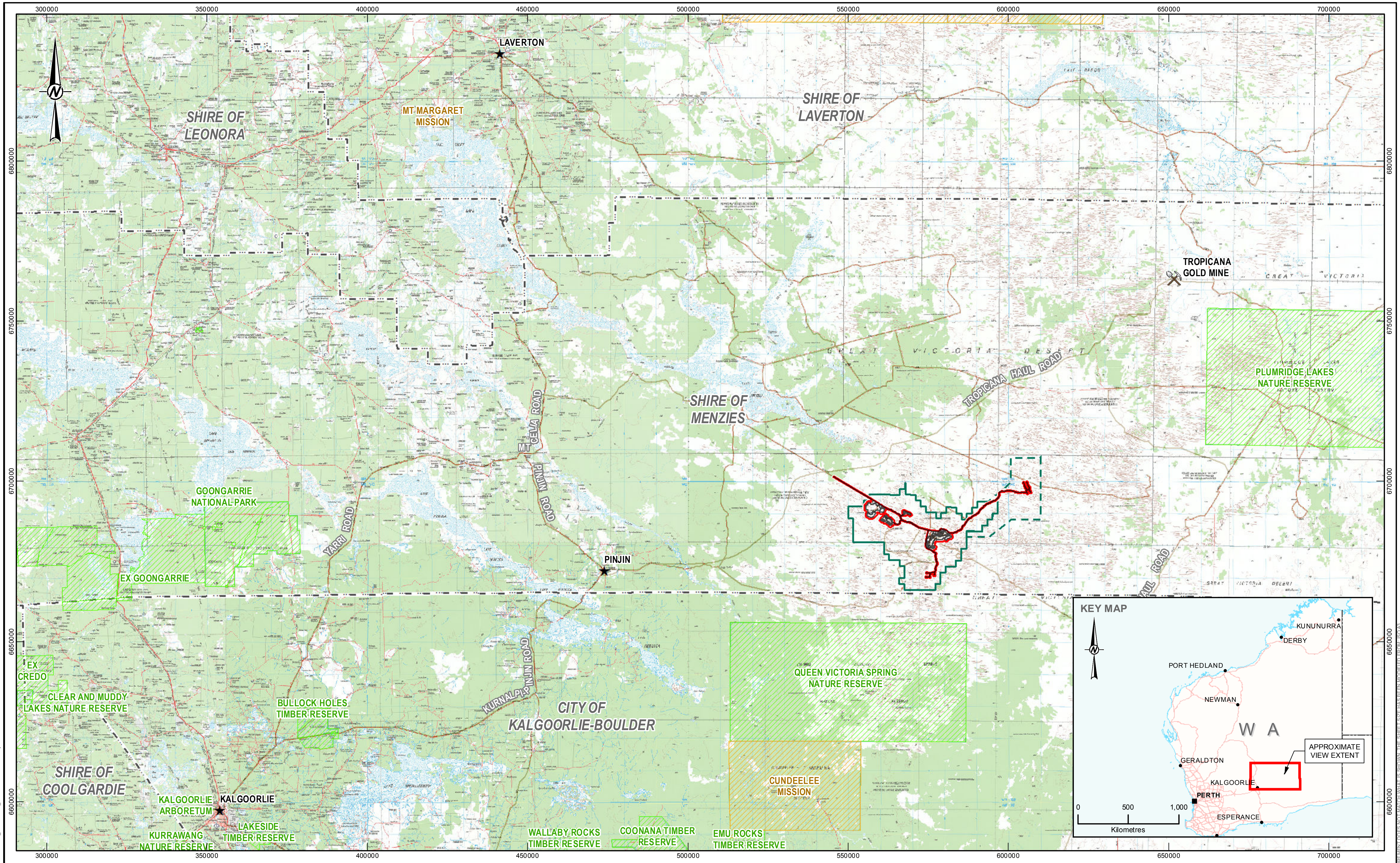
This report documents the findings of the Level 1 subterranean fauna survey (desktop review and reconnaissance survey) at the Ambassador, Shogun, Emperor deposits and Kakarook borefield of the MRUP.

Scope of Work

- Conduct a desktop review of the biophysical environment dataset to determine the potential for stygofauna and troglofauna to occur in the Project area and any records from surrounding areas,
- Undertake a Level 1 survey using phreatic haul nets of available bores in the Project area in accordance with EAG 12 (EPA 2013),
- Determine by measurement, appropriate physiochemical groundwater parameters to characterise the groundwater including pH, temperature, conductivity, total dissolved solids (TDS), dissolved oxygen (DO) and redox potential (ORP),
- Evaluate the sampling results and determine if there is a likelihood that subterranean fauna may occur in the Project development area and, if present,
  - identify if the area has significant habitat for subterranean fauna,
  - address the potential risk to any subterranean fauna from the findings and
  - make recommendations in respect to further monitoring and field studies.

The assessment was prepared in accordance with:

- *Environmental Assessment Guideline for Consideration of Subterranean Fauna in Environmental Impact Assessments in WA, EAG 12* (EPA, 2013),
- *Guidance Statement 54A: Sampling methods and survey considerations for subterranean fauna in Western Australia (Technical appendix to Guidance Statement 54)* (EPA, 2007).



LEGEND

- TROPICANA GOLD MINE
- TOWN
- ROAD
- INFRASTRUCTURE
- MRUP DEVELOPMENT ENVELOPE
- PROJECT BOUNDARY (MINING TENURE)
- PROJECT BOUNDARY (MISCELLANEOUS TENURE)
- CONSERVATION RESERVE
- ABORIGINAL LAND TRUST ESTATE
- LOCAL GOVERNMENT AUTHORITY (LGA) BOUNDARY

NOTES

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 51

REFERENCE

INFRASTRUCTURE DATA PROVIDED BY CLIENT
BASE DATA © WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2015)
IMAGE SOURCED FROM GEOSCIENCE AUSTRALIA 250K TOPO
INSET BASE DATA/ROADS SOURCED FROM STREET PRO DATA 2009

0 25 50
1:1,100,000 KILOMETRES

CLIENT
VIMY RESOURCES LIMITED

PROJECT
MULGA ROCK URANIUM PROJECT

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-21
DESIGNED	MS
PREPARED	MS
REVIEWED	GB
APPROVED	GB

TITLE
REGIONAL LOCATION

PROJECT NO.	CONTROL	REV.	FIGURE
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25mm

2. Relevant Guidelines and Legislation

2.1 WA EPA Guidance Statements 12 and 54a

WA EPA, Environmental Assessment Guideline 12 (EAG 12) and Guidance Statement 54a provide information that the WA EPA considers important when assessing proposals where subterranean fauna is considered a relevant environment factor.

EAG 12 allows for a pilot survey approach where it is considered that the likelihood of finding stygofauna is low (e.g. poor groundwater quality, unsuitable geology, historic sampling of the local area has not recovered stygofauna and lack of alluvial groundwater). A pilot survey approach in WA is considered acceptable to provide a 'background assessment' of stygofauna. Whilst pilot surveys allow for a reduced sampling effort (usually between six to ten samples) conducted in a single season, there is a requirement in the Guidelines that in the event of a pilot survey finding significant stygofauna communities, additional sampling effort is required to satisfy the full WA EPA Guideline requirements.

2.2 Environment Protection and Biodiversity Conservation Act 1999

Legislation relevant to the assessment of impacts on subterranean fauna in Western Australia includes the *Environmental Protection Act 1986* (EP Act), the *Wildlife Conservation Act 1950* (WC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Information which the EPA will consider when assessing proposals where subterranean fauna is a factor includes:

- protection of the environment as defined by the EP Act with a focus on the conservation and protection of biodiversity values of subterranean fauna,
- the conservation of subterranean fauna species as listed by the WC Act; and ecological communities endorsed by the WA Minister for Environment and
- the conservation of subterranean fauna species and ecological communities as listed by the EPBC Act.

The EPBC Act defines and regulates significant impacts on Matters of National Environmental Significance (MNES). The MRUP has been declared a controlled action under the EPBC Act due to the potential for significant impacts on MNES not related to subterranean fauna.

3. Desktop Review

3.1 Stygofauna Ecological Requirements

As part of the desktop study, various literature and data were reviewed, including previous subterranean fauna studies in the region, available hydrogeological reports and maps, government databases and project-specific data supplied by Vimy.

The probability that a site contains a diverse subterranean fauna is largely determined by the region in which the site occurs and local geology (EPA 2013). For the Gascoyne/Murchison and Yilgarn/Goldfields regions of Western Australia, the EPA considers that there is a high to very high probability that diverse stygofauna communities will occur in aquifers of calcrete, shallow alluvium or banded ironstone. There has been very little survey work for stygofauna in the inland deserts, unlike the central and northern parts of the Yilgarn, which are the next most studied regions of Western Australia after the Pilbara (EPA 2013).

Given the remoteness of the Mulga Rock Uranium Project and paucity of subterranean fauna data from the area, a wider buffer (100km) than normal was used for database searches and previous relevant studies in a literature search. These included studies for the Duketon Gold Project (Bennelongia 2007), Lake Way (*ecologia* 2005 & 2006, Outback Ecology 2011) the Tropicana Gold Project (*ecologia* 2009a) and Stage 2 of the MRUP (Rockwater 2015).

3.2 Database Searches

A database search request was submitted to WA Museum as part of the desktop study. Searches of various WA Museum databases were undertaken for an area of over 100km by 100km surrounding the MRUP, and the results screened for subterranean fauna records. Searches were conducted of the Crustacean, Arachnid and Mollusca databases, as well as the database maintained of research undertaken by Dr Bill Humphreys. The results of the search provided no records of stygofauna within the area (Rockwater 2015).

The project number for WA Museum database searches was WAMDB064 and the search area polygon was bounded by points:

NW: -29.531,123.252 ; SE: -30.534,124.357.

Many of the calcrete aquifers associated with paleodrainages in the Goldfields region contain unique stygofauna assemblages and have been listed by the Department of Parks and Wildlife (DPaW) as Priority Ecological Communities (PECs). However, there are no listed calcrete groundwater assemblages in the vicinity of the MRUP. The nearest PECs associated with calcretes occur significantly further west and northwest of the MRUP.

3.3 Previous Studies

The closest stygofauna study to the MRUP was for the Tropicana Gold Project, approximately 110km northeast. *Ecologia* (2009a) surveyed for stygofauna in the operations area and Subterranean Ecology (2009) tested the fine-grained sandstone aquifer at the Tropicana Gold Project water supply area to the north. Stygofauna was not detected in either the water supply area or the operational mining areas and it was concluded that the groundwater habitats of the area were devoid of stygofauna (*ecologia* 2009a and Subterranean Ecology 2009).

Most records of stygofauna in the Yilgarn and Murchison relate to paleovalley aquifers, particularly calcretes. Calcrete aquifers are known to contain significant stygofauna communities in the Yilgarn (Cooper *et al*. 2008, Humphreys 2008), with particular ‘hotspots’ of stygofauna diversity occurring in the eastern drainage at Paroo, Lake Violet, Lake Way and Hinkler Well (Humphreys 2001). These calcrete habitats are reported to contain an arid stygofauna assemblage, comprising a wide range of crustacean species and dytiscid diving beetles.

A study of the genetic structure of animals collected in calcrete aquifers in the Yilgarn by Guzik *et al.* (2011) found that individual aquifers vary in their faunal composition and the population genetic substructure of species. Stygofauna was sampled at three sites over a 15km distance in the Laverton Downs Groundwater Assemblage to explore the mechanisms of speciation in subterranean ecosystems. Multispecies population fragmentation was investigated using species that were recorded at multiple sites. Below species-level genetic divergence was identified in several species of groundwater isopods and diving beetles, and in a single amphipod species that occurred throughout the survey area.

A subterranean fauna study was conducted for the Duketon Gold Project, located 130km north of Laverton and (approximately 350km northwest of MRUP) by Bennelongia in 2007. The survey recorded 24 stygofauna species, with 88% of these being from reference sites in or near calcrete. The habitats of the Archaean greenstone in the mine area yielded nematodes, an oligochaete, a copepod and an ostracod. No species was restricted to the mine pits, but three harpacticoid copepods and a bathynellid syncarid were recorded in the water supply area, located in a nearby calcrete aquifer.

Stygofauna has previously been recorded in aquifers of the Abercromby and Lake Way paleovalleys; however, these are several hundred kilometres northwest of MRUP (*ecologia* 2005, 2006, Outback Ecology 2011). Several Priority Ecological Communities relating to stygofauna are known to occur from calcretes of the Lake Way area.

Toro Energy is developing a uranium project at Lake Way near Wiluna. Outback Ecology (2011) undertook sampling at the Lake Way, Centipede and West Creek Projects and showed that the distributions of many taxa were relatively widespread within the calcrete system of the survey area. Most of the species collected from a mining disturbance area were also found from sites outside the mining area. Of 13 species recorded from the Centipede mining area, only three species were not detected from reference sites. Similarly, in the Lake Way project area, 11 species were recorded from the mining area with only one not detected beyond it. At West Creek, seven of 21 species collected were restricted to the impact area. The EPA assessment of the project concluded that [on the basis of local hydrogeological conditions and the proponents Groundwater Drawdown Monitoring and Management Plan] “it is unlikely that any species of stygofauna will be threatened by extinction as a result of the mining or dewatering for the proposal” (EPA 2012).

Sampling for stygofauna was undertaken at the Magellan Lead Project, west of Wiluna (Biota Environmental Sciences 2005). Six of the seven taxa recorded from impact bores were shown to be distributed more widely; either in reference bores or elsewhere in the region. The results suggested there was population connectivity, at least at a local catchment level through the calcrete aquifer system, across a range of stygal groups.

3.4 Stygofauna in Lignite Aquifers

Stygofauna studies undertaken in Australia, since 2000, have recorded taxa from calcrete, limestone, fractured rock and alluvial aquifers (Humphreys 2008). The literature search could not find any record of stygofauna being found in carboniferous or coal aquifers similar to those identified at MRUP. The reasons for the non-utilisation of this habitat have been cited as adverse water quality and restriction on downward leakage from recharge events.

Regional weather data is available for Bureau of Meteorology (BOM) Stations of Laverton (182km to northwest), Kalgoorlie (260km southwest) and Balgair (204km to the southeast) on the trans line. Local data is provided by three automatic weather stations at Ambassador, Shogun and Emperor. These stations were established in late 2009. A weather summary is referenced in Appendix A.

4. Biophysical Environment

4.1 Background

The Great Victoria Desert Bioregion as defined in the Interim Biogeographic Regionalisation of Australia (IBRA) Version 7.0 (DSEWPaC 2012) extends from the Eastern Goldfields area in Western Australia across the southern parts of central Australia to the Stuart and Gawler Ranges in South Australia. It is divided into three subregions, with the western shield subregion – GVD1, covering 54,427 square kilometres – the only division relevant to the Mulga Rock Uranium Project.

The bioregion is reported by Barton and Cowan (2001) to contain special values in relation to landscape, ecosystems and species. These include yellow sand plain communities with diverse mammalian and reptile fauna and distinctive plant communities.

The vegetation consists predominantly of an open spinifex – eucalypt association. There are no permanent surface water bodies present, groundwater is of varying quality and, with the exception of the Kakarook Borefield, is associated with the carbonaceous mineralisation at depths of 25 to 50m below the natural ground surface. Uranium mineralisation in the MRUP deposits is contained entirely within the paleochannel sediments and has no surface expression. Depth to groundwater in the Kakarook Borefield varies and for this survey is recorded at 26 to 28m below the surface.

4.2 Climate Summary

The climate is arid, with mean annual rainfall ranging from below 150mm to over 250mm. Rainfall is aseasonal, but shows great variability between years with 70% falling between March and August. Mean daily maximum and minimum temperatures are about 34°C and 18°C, respectively, in January, and 16°C and 6°C in July when overnight minima can commonly fall below 0°C. Annual evaporation for the area, derived from Luke *et al.* (1987) is 3000mm. A Vimy site climate summary report for 2012 is referenced in Appendix A.

4.3 Geology

The terrain surrounding the MRUP is an undulating sandy plain at an elevation of ~300-400m, crossed by ESE-trending linear sand dunes that locally can reach a height of 10-15m. A schematic of a SW-NE cross-section profile of the MRUP is shown in Figure 2.

The Project covers a significant portion of the Narnoo Basin, a small late Eocene sub-basin within the larger Gunbarrel Basin (mostly filled with Late Carboniferous-Early Permian glacio-fluvial sediments), located at the contact between an Archaean basement of the Yilgarn craton (Burtville Terrane) and a Paleo-Proterozoic metamorphic basement (Northern Foreland, reworked Archean). The position and scale of the basin in respect to surrounding tectonic units is shown in Figure 3.

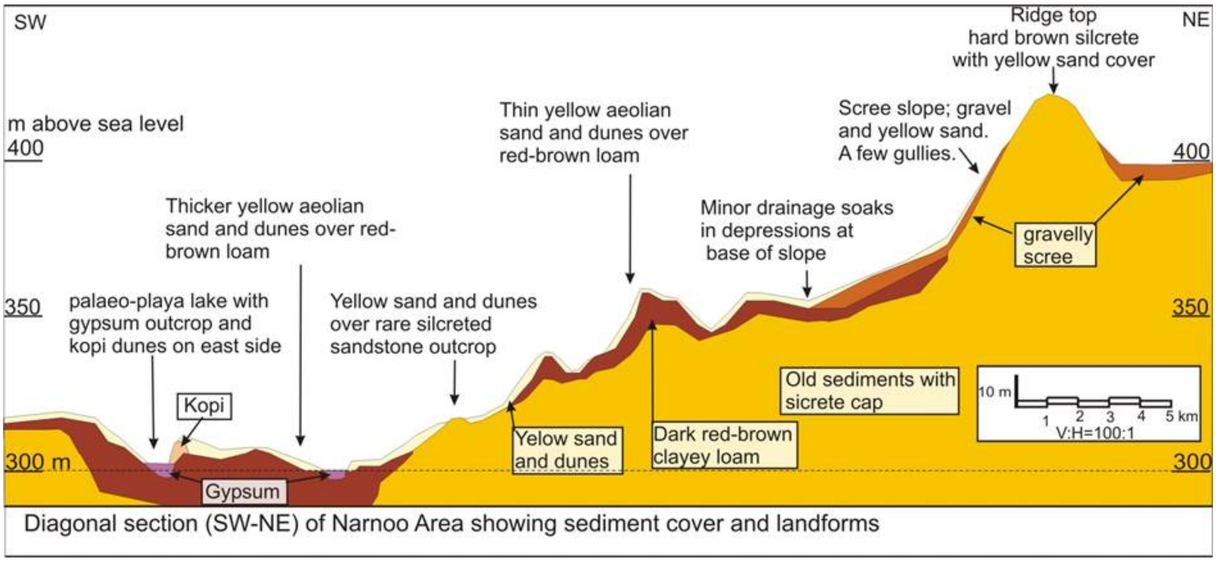


Figure 2 SW-NE cross-section of the Project area representative of landforms present over the Mulga Rock Uranium Project

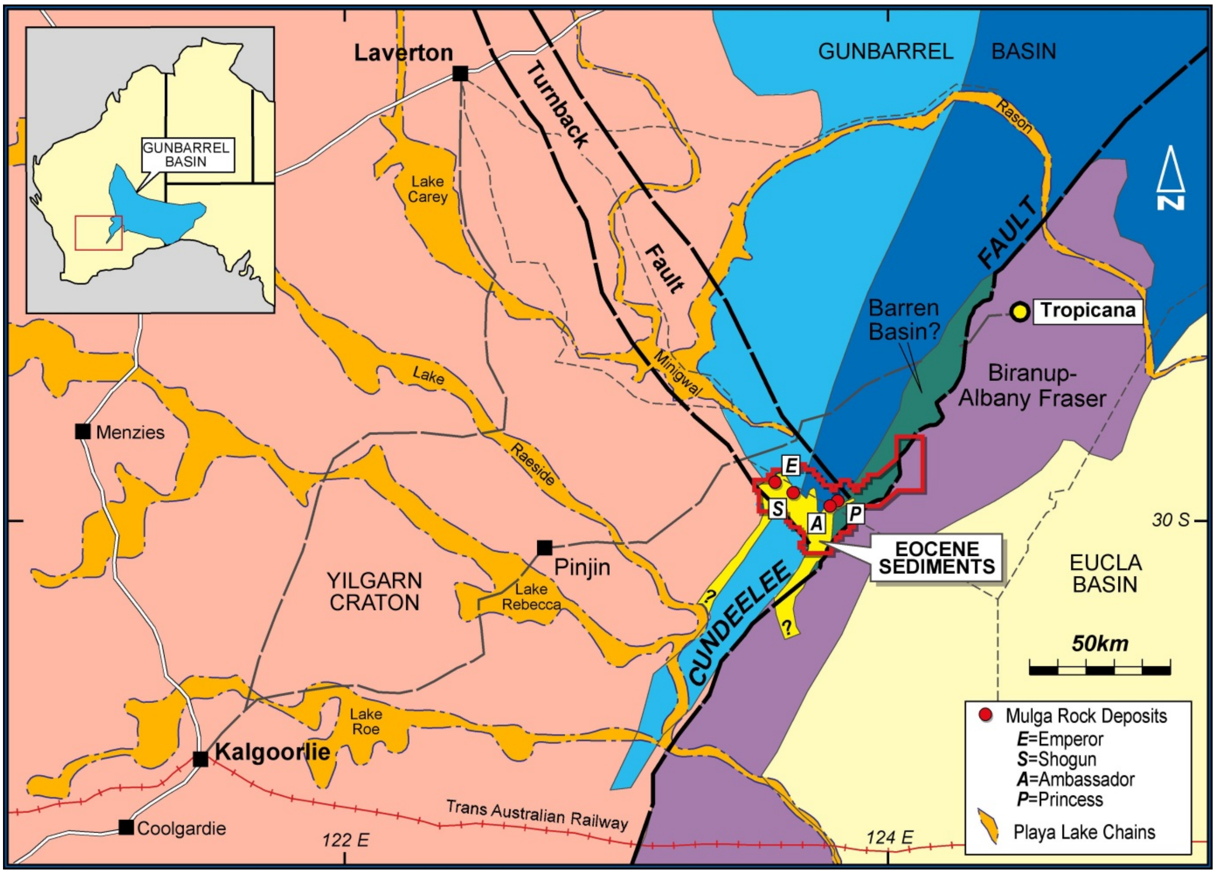


Figure 3 Regional geological setting of the MRUP deposits

A significant wedge of preserved meta-sediments enriched in various base metals (inferred to be PaleoProterozoic in age and correlated to the Mount Barren Group) marks the contact between the Burtville Terrane and the Northern Foreland. All these geological units are covered by a significant veneer of Quaternary alluvium and Aeolian sands, obscuring much of their diagnostic features and geophysical signatures. These units are cross-cut by a number of long-lived deep-seated shear zones, thrusts and more recent high angle brittle fault zones that have significantly constrained groundwater flows and metals migration.

The MRUP deposits are hosted by late Eocene variably carbonaceous lacustrine to estuarine sediments (including lignites), concentrated along various inset valleys feeding into a floodplain environment (Douglas *et. al* 1993). Those Eocene sediments are often incised within more indurated Cretaceous and Permo-carboniferous sediments (see Figure 5).

A falling water table associated with differential uplift of the Gunbarrel Basin to the north of the project has resulted in a significant weathering profile and metal mobilisation through processes common to acid-sulphate environments, often resulting in partial silicification of transported material.

Repeated episodic groundwater flow has focused large groundwater volumes into the paleovalley-fills, resulting in a complete oxidation of the top 25m to 55m, as well as deeper sediments along fault-bound valley edges. In the Project area, the top of the paleoaquifer is capped by a white clay unit 1m to 5m thick (Figure 4) which acts as an aquitard to the aquifer and is likely to limit the movement of resources necessary to sustain biological life in the underlying aquifer.

Importantly, this low hydraulic conductivity layer ensures the present vegetation and biologically active zone is not connected in any way to saline groundwaters associated with the mineralisation over and around the Project area (Figure 4).

Uranium and other base metals (Ni, Co, Cu, Zn, Sc, REE and Y) are enriched below the main redox front but also locally present at depth in reduced sandstones along lateral redox boundaries (see Figure 5 and Figure 6). Uranium mineralisation is mostly amorphous and absorbed on organic matter.

Figure 4 White clay aquitard layer at top of orebody aquifer in PNC trial slot

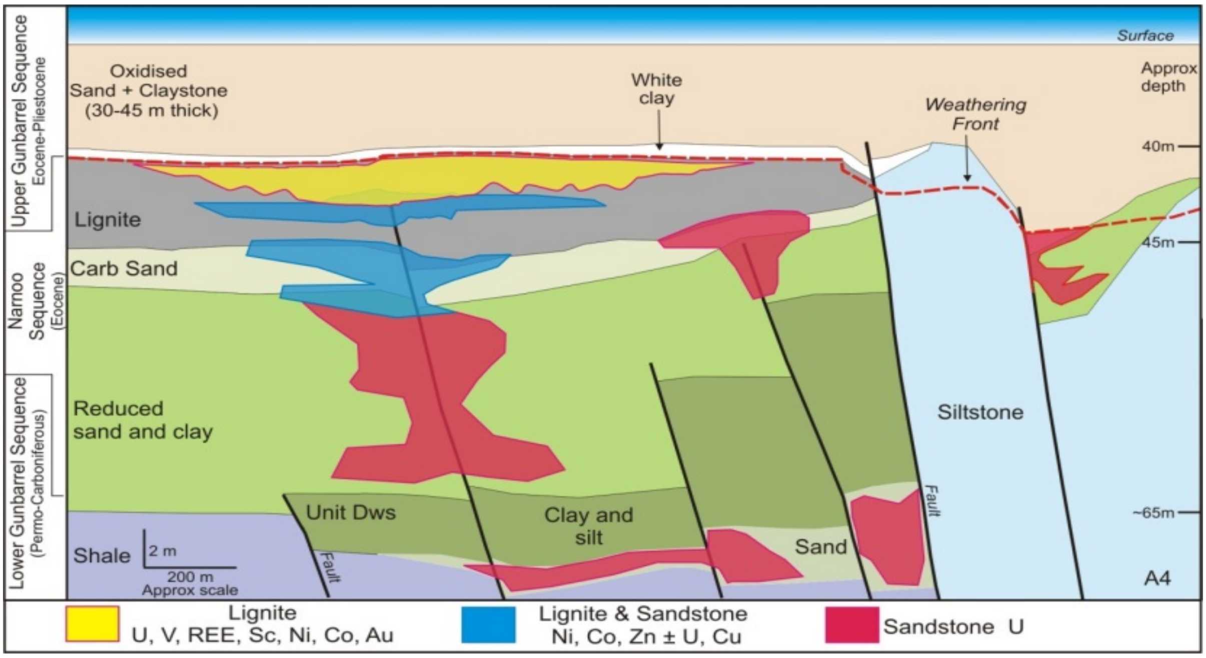


Figure 5 **Schematic of MRUP stratigraphy and mineralisation showing the white clay aquitard unit at the top of the aquifer**

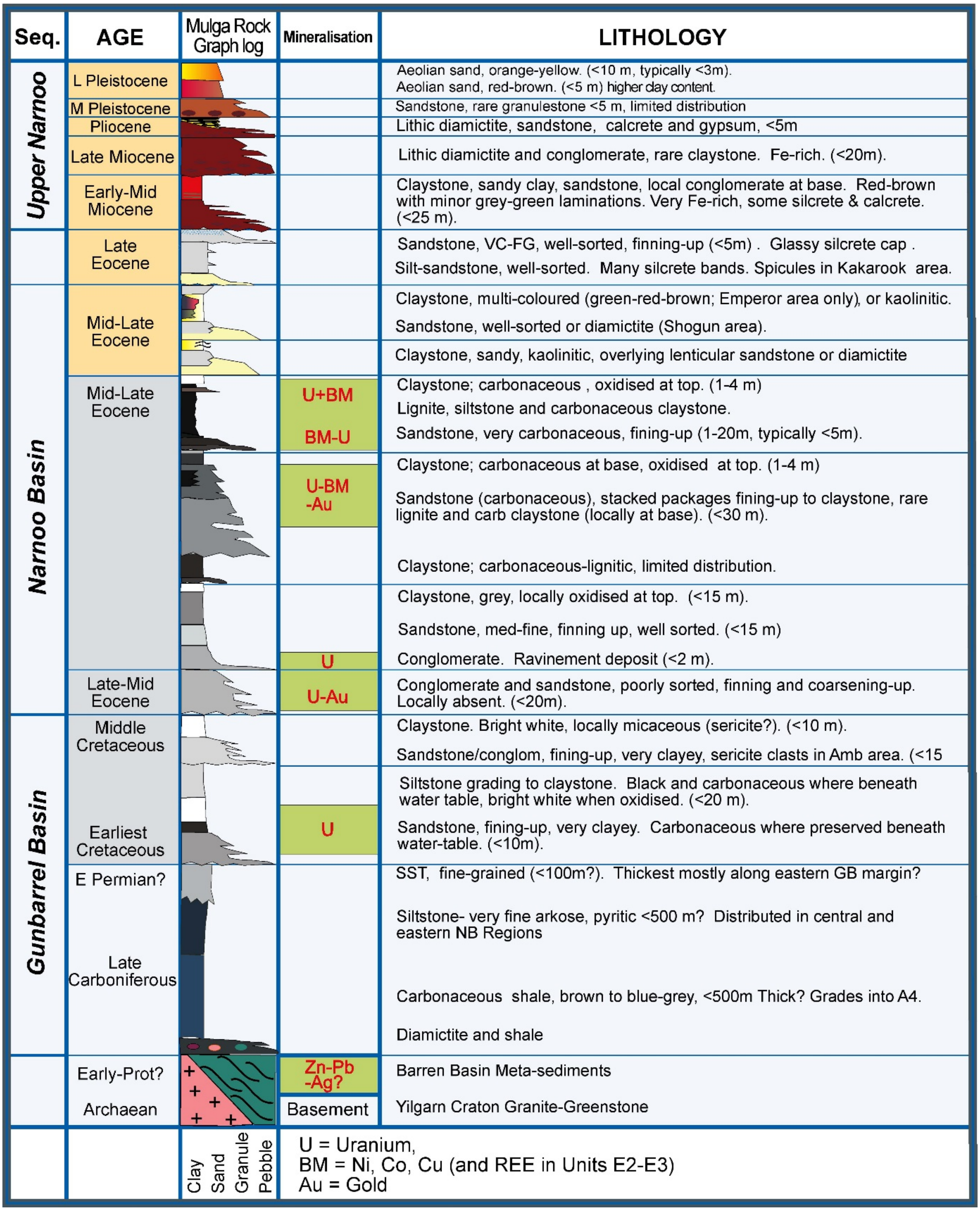


Figure 6 Mulga Rock Uranium Project - lithostratigraphic legend showing interface clay unit (F2) between ore zone (E3 - grey colour) and overlying alluvium

4.4 Hydrogeology

4.4.1 Regional Setting

The MRUP deposits lie in the Narnoo sub-basin (Fewster 2009), a structurally controlled paleovalley that was established during the Permian. Significant phases of fluvial sedimentation in Early and Mid-Cretaceous have been largely obliterated via major uplift pre-dating the mid-Eocene. A major phase of stream rejuvenation in the late Eocene, followed by marine transgressions led to the development of the paleodrainage which contains the mineralised sediments. The Narnoo sub-basin contains fluvial, lacustrine and marine sediments of Tertiary and Cretaceous age that include sandstone, claystone, lignite and minor conglomerate, which commonly occur in graded beds. Mineralisation typically occurs in the lignite and the underlying sandstone, with a minor fraction hosted by more clayey Cretaceous fluvial sediments.

The Tertiary Minigwal paleodrainage which includes Lake Minigwal might have flowed originally into the Narnoo sub-basin and then continued to the south along the western edge of crystalline rocks of the Albany-Fraser Orogen, before discharging into the Eucla Basin[1]. That paleodrainage might since have been captured by another drainage system (see Figure 3) and now flows further to the north towards Lake Rason. There may still be an outlet from the Narnoo sub-basin to the south: the southerly direction of flow can be seen by groundwater levels measured in the Ambassador deposit (Figure 8). Uranerz (1986) drilled a number of sections across the paleodrainage which they referred to as the Ponton Channel. The channel includes a West Arm which extends south from the Emperor and Shogun deposits, and an East Arm that extends south from near the Ambassador deposit. The nearest section to Ambassador was on Uranerz grid line 92500N, about 23km south of Ambassador. At that location, the paleodrainage is about 6km wide and contains Tertiary sand and clay to a maximum depth of about 95m (Uranerz 1986).

The Lake Raeside/Ponton Creek paleodrainage contains hypersaline groundwater with salinity in the range 150,000mg/L to 250,000mg/L TDS. In adjacent parts of the Narnoo sub-basin, the groundwater is commonly less saline (ranging from saline to hypersaline), probably due to mixing with low salinity water that is recharged by infiltration of rainfall to the north.

Salinities and conductivity factors increase in the flow directions towards the centre of the paleodrainage. Piper trilinear diagrams of major ion groundwater chemistry (Figure 7) indicate that the portions of sodium and chloride increase, and calcium, magnesium and sulphate decrease – from the Kakarook North and BP areas, to the Ambassador/Princess, Shogun and to the Emperor deposit. This corresponds with generally increasing salinity and presumably groundwater age, and reflects the reducing geochemical conditions.

Thirty kilometres northeast of the Ambassador deposit there are tertiary sediments that have been deposited within depressions in the Proterozoic bedrock and draining large Cretaceous and Permian plateaus. Mineral sand exploration holes drilled by Ramsgate Resources Ltd for the Kakarook mineral sand project intersected these sediments and where deep they extend below the water table. Water exploration holes have recently been drilled in the area by Vimy as part of their search for low salinity groundwater.

A recent in-house re-interpretation of the extent of the Cretaceous and Eocene sedimentary sequences at Kakarook -Kakarook North suggest a much greater lateral extent and overall volume of low salinity groundwater (originally estimated at 30GL, Rockwater 2013). The impact of that revision is currently being assessed under a separate detailed assessment (H3 survey, Rockwater 2015).

[1] Drilling conducted in the last 30 years between that inferred Eocene spill point between the Lake Minigwal and Mulga Rock paleodrainage have failed to identify it. However, airborne EM imagery suggests a potential continuity of saline to hypersaline brines at depth, likely in Carboniferous-Permian sediments.

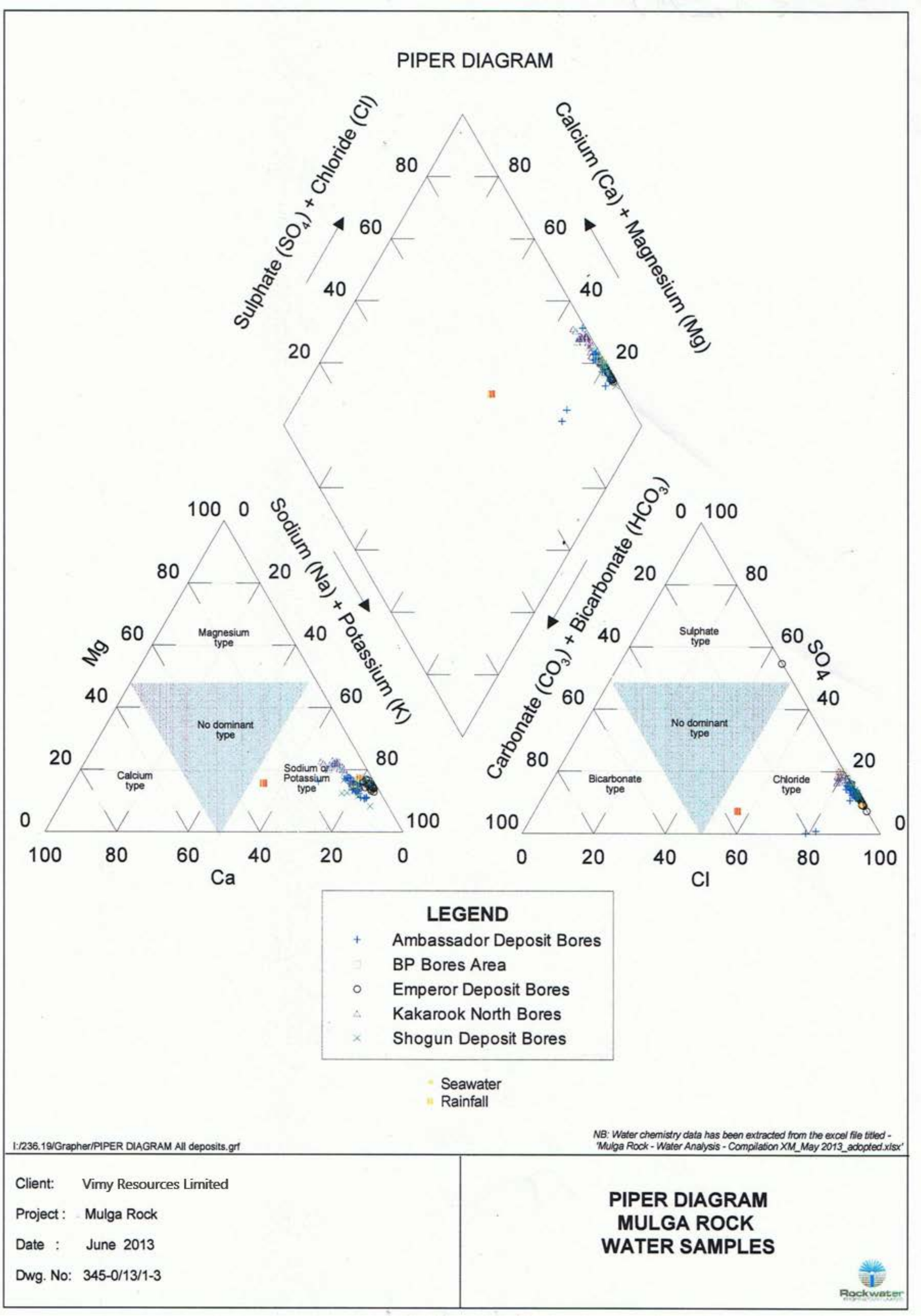


Figure 7 Piper plot of groundwaters from the MRUP mineralised zones and Kakarook Borefield

4.5 Site Hydrogeology

Water levels measured by Vimy at various times across the four deposits indicate an east to south-easterly direction of groundwater flow at Emperor and Shogun; a south-westerly flow at Princess and Ambassador (Figure 8) and southerly flow at Kakarook.

The water table at the Ambassador deposit is 27m to 48m deep. The water table slopes downwards to the southwest and south at an average gradient of 0.09-0.1% (with significant drops in the standing water levels inferred to mark faulted section of the post-Cretaceous stratigraphy), against a more regional gradient of 0.07% between Kakarook North and the south-western section of Ambassador. The local groundwater flow direction is almost at a right angle to the regional easterly or south-easterly flow towards the Eucla Basin. However, it is consistent with flow towards the east arm of the paleochannel mapped by Uranerz (1986) that extends south from Ambassador. A limited dataset available for that section of the paleochannel arm suggests that similar acidic (pH 4.5 to 5.5) reducing brines make up that aquifer, with a significant and variable amount of uranium in solution.

The water table at the Princess deposit ranges from 35.4m to 48.0m below ground level, with depths largely dependent on ground elevation. It slopes gently to the southwest, with reduced water levels between 296m and 298m AHD.

The stratigraphy at Emperor and Shogun is similar to that at Ambassador, with mostly clayey sand and clay overlying silcrete, carbonaceous clay and lignite; and with clayey sand and up to 10m or more of clean sand near the base of the Tertiary sequence. The thickness of the basal clean sand was contoured and shows that the sand extends along the section of the paleodrainage that has been drilled for the Mulga Rock Uranium Project, but that the thickness, is quite variable and in some locations most or all of the sand appears to be clayey. The thickest section of those basal sands on the north-western portion of the paleochannel at Emperor is now interpreted as alluvial fans draining a deeply weathered Yilgarn regolith.

Groundwater Chemistry

Ambassador – Princess

Water samples have been analysed at various times for different suites of parameters from 93 drill holes in total in the Ambassador and Princess deposits. The results from some of the separate sampling events for the Ambassador deposit are described below.

Water samples were airlifted from ten holes in the Ambassador deposit in March 2010 and analysed for major components and a range of other elements and metals (Table 1). Other holes in the area were sampled in 2012 and in 2013 during surveys. Salinity ranges from 10,000mg/L to 29,000mg/L TDS; pH 3.5 to 6.8 and Fe <0.2mg/L to 50.8mg/L. Salinities within the Princess and Ambassador deposits generally range from 20,000mg/L to 30,000mg/L TDS although some field measure measurements recorded higher values for salinity.

Minor elements and metals, other than iron, that were analysed were generally at low concentrations or below the limits of detection, including uranium. There were some elevated metal concentrations in holes that had low pH. Bromine concentrations ranged from 3mg/L to 23mg/L; and strontium 2mg/L to 12mg/L.

Water samples taken from the Princess deposit were measured in the field in 2012 and 2013 for salinity and pH. The water is acidic, with pH generally ranging from 5.0 to 6.5. Lower acidity, with pH of around 3, have been measured in one hole, NNA5623. Salinities are lower than most at Ambassador, ranging from 8,700mg/L to 21,400mg/L TDS, as the deposit is up-gradient of Ambassador.

Shogun – Emperor

Water samples have been collected and analysed from 155 drill holes in these deposits, mostly in 1984 and 2012. Groundwater salinity at Emperor and Shogun ranged from 32,500mg/L to 139,700mg/L TDS (GRC 1984) with the highest salinities in the south, and the lowest salinities towards the margins of the paleochannel to the north or west suggesting possible recharge in these areas of less saline water. The salinity increased with depth and is generally more saline than at the Ambassador deposit.

The water from the bores at Emperor and Shogun is more acidic than at Ambassador, with pH of 3.8 to 4.1 (Rockwater 2012). It is of sodium chloride type with moderately high magnesium and sulphate concentrations.

The Piper trilinear diagram indicates that the portions of the major ions are similar to seawater (Figure 7). Of the water samples collected from drill holes in 2012 and 2013, many had low pH in the range 3 to 4 (minimum 2.9 and maximum 6.2) and salinity ranging from 6,100mg/L to 95,500mg/L TDS. Most salinities are greater than 50,000mg/L TDS.

Iron concentrations range from <0.05mg/L to 55mg/L in recent samples and up to 190mg/L in the 1984 samples. Bromine (four analyses) ranged from 23mg/L to 71mg/L; and strontium 7.7mg/L and 8.8mg/L (two samples). Other elements and metals that were analysed were at low levels or below levels of detection. Uranium was above the level of detection in five samples, with one high value (0.35mg/L) from the Shogun costean in 1983.

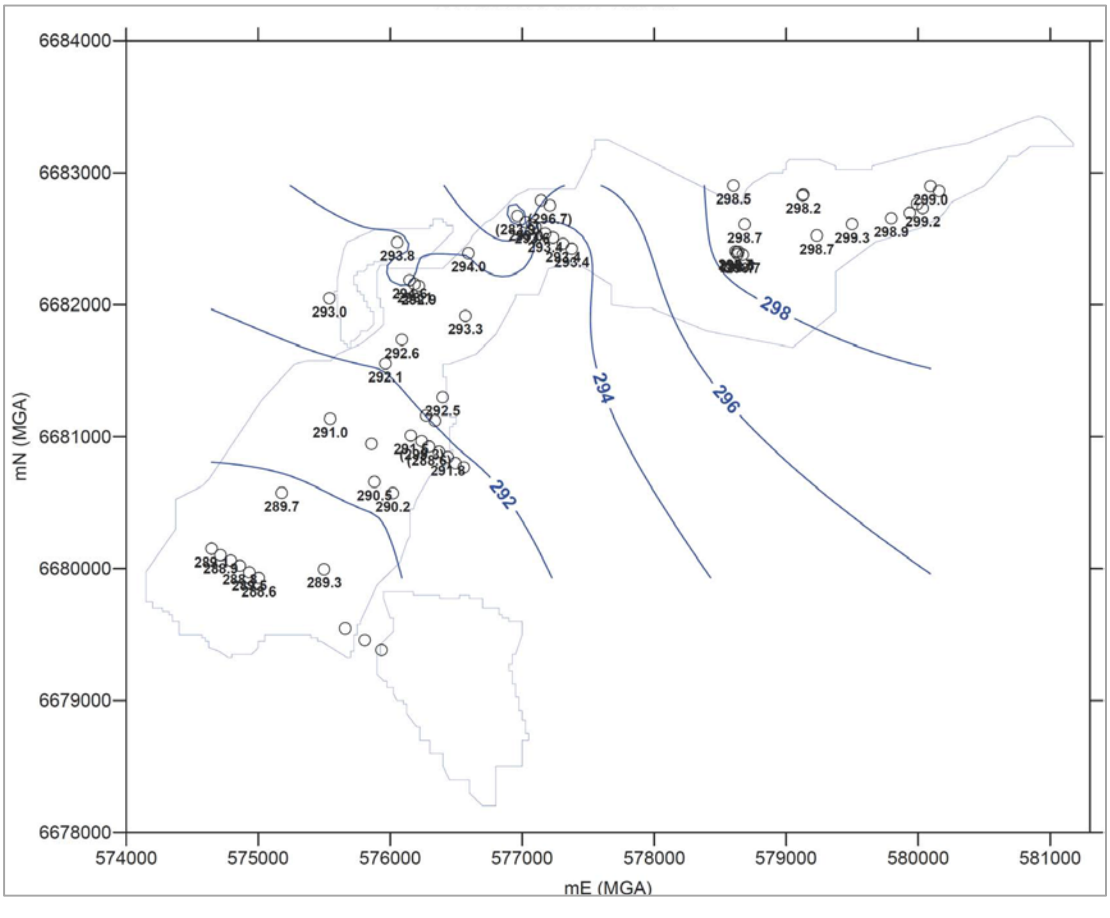


Figure 8 **Ambassador Deposit – borehole water levels showing southerly direction of flow in paleochannel**

Table 1 Ambassador Deposit bores - results of major component analyses and other elements and metals (Rockwater 2010)

Hole/Bore Hole/Sample Depth Date Analysed	Units	NA5027 82 26/03/2010	NA5198 64 26/03/2010	NA5393 73 26/03/2010	NA5127 65 26/03/2010	NA5140 51 26/03/2010	NA5086 75 26/03/2010	NA5103 66 26/03/2010	NA5199 55 26/03/2010	NA5155 51 26/03/2010	NA5107 69 26/03/2010
pH	pH Units	4.1	3.5	4.2	5.5	6.4	6.8	4.3	4.2	6.7	4.8
Conductivity @25 C	µS/cm	17780	23060	31200	31400	27420	47800	41700	45000	28390	44700
TDS (Calculated)	mg/L	10668	13836	18720	18840	16452	28680	25020	27000	17034	26820
Soluble Iron, Fe	mg/L	0.844	50.813	6.526	0.203	<0.2	<0.2	0.76	5.885	<0.2	<0.2
Sodium, Na	mg/L	3038	4116	5748	5710	4898	8651	7602	8197	5087	8130
Potassium, K	mg/L	101	128	185	187	171	349	257	316	180	292
Calcium, Ca	mg/L	197	274	416	463	357	604	580	614	362	620
Magnesium, Mg	mg/L	301	336	548	531	422	900	772	833	488	834
Chloride, Cl	mg/L	5311	7558	11235	10922	8689	17219	13693	16462	9677	15717
Carbonate, CO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate, HCO3	mg/L	<5	<5	<5	49	9	32	<5	<5	31	<5
Sulphate, SO4	mg/L	1355	1633	2237	2227	1751	3317	2875	3273	1827	3553
Nitrate, NO3	mg/L	0.35	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cation/Anion balance	%	-2.5	-5	-6.3	-5.2	-2.1	-6.3	-1.9	-6.9	-4.6	-5.8
Sum of Ions (calc.)	mg/L	10303	14045	20368	20089	16297	31071	25778	29695	17652	29147
Soluble Arsenic, As	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.01	<0.005	<0.01
Soluble Boron, B	mg/L	1.252	1.011	1.611	1.409	1.208	2.712	1.722	2.126	1.352	1.688
Soluble Barium, Ba	mg/L	0.038	0.052	0.035	0.055	0.07	0.051	0.066	0.094	0.053	0.067
Soluble Beryllium, Be	mg/L	<0.005	0.02	0.005	<0.005	<0.005	<0.01	<0.01	<0.01	<0.005	<0.01
Soluble Cadmium, Cd	mg/L	<0.0005	0.001	0.003	0.024	0.0009	0.007	0.013	<0.001	<0.0005	0.319
Soluble Chromium, Cr	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	0.013	<0.01	<0.005	<0.01
Soluble Copper, Cu	mg/L	0.032	0.021	0.018	0.013	0.024	0.018	0.628	0.016	0.005	1.904
Soluble Cobalt, Co	mg/L	0.075	0.719	1.052	0.625	0.148	0.199	3.958	0.653	0.026	2.292
Soluble Lead, Pb	mg/L	0.015	0.041	<0.005	<0.005	0.006	<0.01	0.345	<0.01	<0.005	3.077
Soluble Molybdenum, Mo	mg/L	<0.005	<0.005	<0.005	0.012	0.035	<0.01	<0.01	<0.01	0.008	<0.01
Soluble Manganese, Mn	mg/L	3.208	1.367	1.021	1.246	0.532	1.964	1.608	1.299	0.562	2.345
Soluble Nickel, Ni	mg/L	0.055	1.153	1.888	0.627	0.181	0.377	3.83	1.719	0.023	2.905
Antimony, Sb	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.01	<0.005	<0.01
Soluble Tin, Sn	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.01	<0.005	<0.01
Soluble Selenium, Se	mg/L	<0.005	0.007	<0.005	0.009	<0.005	<0.01	0.104	<0.01	<0.005	<0.01
Soluble Zinc, Zn	mg/L	0.08	6.647	3.252	0.266	0.162	0.918	5.256	7.779	0.074	12.888
Soluble Uranium	mg/L	<0.005	<0.005	0.028	0.032	<0.005	<0.01	0.019	<0.01	<0.005	0.068
Vanadium	mg/L	<0.005	<0.005	<0.005	<0.005	0.009	<0.01	<0.01	<0.01	<0.005	<0.01
Soluble Mercury, Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

5. Methodology

The desktop study did not identify any records of stygofauna in bores within the 100km buffer which had been sampled by *ecologia* (2009) as part of regional studies for the Tropicana Gold Project. Furthermore, water quality results from all four deposits, the clayey stratigraphy and direct association of the paleochannel aquifer with lignite mineralisation suggests the likelihood of encountering stygofauna in the development area aquifer is considered low. To assist in the assessment for the presence of subterranean fauna, a Level 1 survey was adopted for the MRUP. A desktop study found that data for the area was severely limited and a reconnaissance survey was undertaken as per the EAG 12 (EPA 2013).

5.1 Survey Design

Approximately 1600 exploration bores and seven water bores were drilled by PNC[2] from 1979 to 1989. Another 770 holes have been drilled by EAMA (Vimy) to 2013. The original exploration holes were subsurface capped, and being uncased, have largely collapsed, however, the project water bores were available with the exception of WB01 which was found to have been vandalised (blocked) above the water table. Fortunately, this southern bore had been sampled for stygofauna by consultants *(ecologia* 2009) working for the Tropicana Joint Venture and the bore survey data was publically available. Other regional bores sampled as part of the Tropicana Joint Venture studies included the BP Bore and WB 02, 06 and 07 located south of Ambassador. Three water bores with ages greater than 25 years since construction and six diamond holes drilled in the past five years were selected for testing. These bores were selected because of ease of access, their well construction history was documented and their stratigraphic and aquifer characteristics were recorded. These details are presented in Appendix C.

The location of the water bores selected for stygofauna sampling are shown superimposed on the MR Project Development Plan (10). The sampling effort and site details are shown in Table 1.

5.2 Bore Selection Criteria

Bores were selected for the Pilot Survey if they satisfied the following criteria:

- The bore construction was recorded, the lithographic details were available and the bores were of varying age and generally older than three years,
- The bores were vertical, accessible and covered the potential zones of impact associated with drawdown,
- The diameters of the bore casing were greater than 48mm and had not been pumped for at least three years and were screened through the water column.

5.3 Groundwater Sampling

Groundwater sampling preceded biological sampling to ensure the groundwater contained within the bore was undisturbed. Groundwater samples were collected initially using a low flow bladder pump, however this method was ineffective and all subsequent sampling was undertaken using a PVC bailer lowered by hand to approximately 3m below the water surface (Plate D-2).

Sampling for subterranean fauna was conducted according to the EPA Guidelines 54a (2007) as well as that described in Hose and Lategan (2012). Water was measured for pH (units), electrical conductivity (µS/cm), dissolved oxygen (mg/L) and oxidisation reduction potential (mV) using a multi-parameter water quality meter in order to provide a general estimate of standing groundwater quality. The meter was calibrated in the laboratory prior to its use in the field, with calibrations regularly cross-checked.. The meter was used in accordance with the manufacturer's specifications. Field and laboratory results are referenced in Table 1 and Appendix B. Voucher

[2] Power and Nuclear Company of Japan, the uranium exploration arm of the Japanese Government.

water samples were collected for analysis by SGS (Perth) to satisfy quality control. Temperature could not be measured *in situ*.

In addition to *in situ* water quality, measurements were also collected from each groundwater bore on depth to water table (using a Heron water level meter) (Plate D-1), depth to end of hole (where possible). All data was recorded manually on field sheets. A photographic record of each bore and surrounding habitat was also collected (Appendix D). Lithostratigraphic bore logs were prepared for each hole and form part of the dataset. These are referenced in Appendix C.

5.4 Stygofauna Sampling

Stygofauna samples were collected using phreatic haul nets, found to be the most efficient retrieval method (Allford *et al.* 2008). The phreatic nets were 150µm and a 50µm mesh size net and of varying diameter depending on the size of the borehole. Each net had an engineered stainless steel cod-end, fitted with a glass vial with a base mesh of 50µm. The first sample was collected using the 150µm net for three hauls and then three with the 50µm net. To increase the capture rate of any periphytic or benthic stygofauna, the net was used to gently agitate the base area of the shallow bore holes, resuspending the sediment. On the up-haul the net was scraped along the sides of the bore casing. This action was designed to dislodge any troglofauna that may be present.

On retrieval the collection vial was unscrewed from the net and the contents emptied into a 120ml polycarbonate vial, inspected with an X50 Hand Lens (Plate D-6), and preserved with 100% undenatured ethanol. Undenatured ethanol was used should allozyme electrophoresis and mitochondrial DNA sequencing be required.

All sampling equipment was washed thoroughly with Decon 90 (detergent) and then rinsed with distilled water after sampling each borehole as a measure of hygiene (Plate D-8).

5.5 Constraints and Limitations

With exception of vandalism restricting access to WB1, all other bores selected were fit for purpose and six hauls were completed for each site. The use of a low flow bladder pump was initially trialled (See Plate D-3) but discontinued due to difficulties in maintaining abstraction flow even though the depth to aquifer was within the pump specifications.

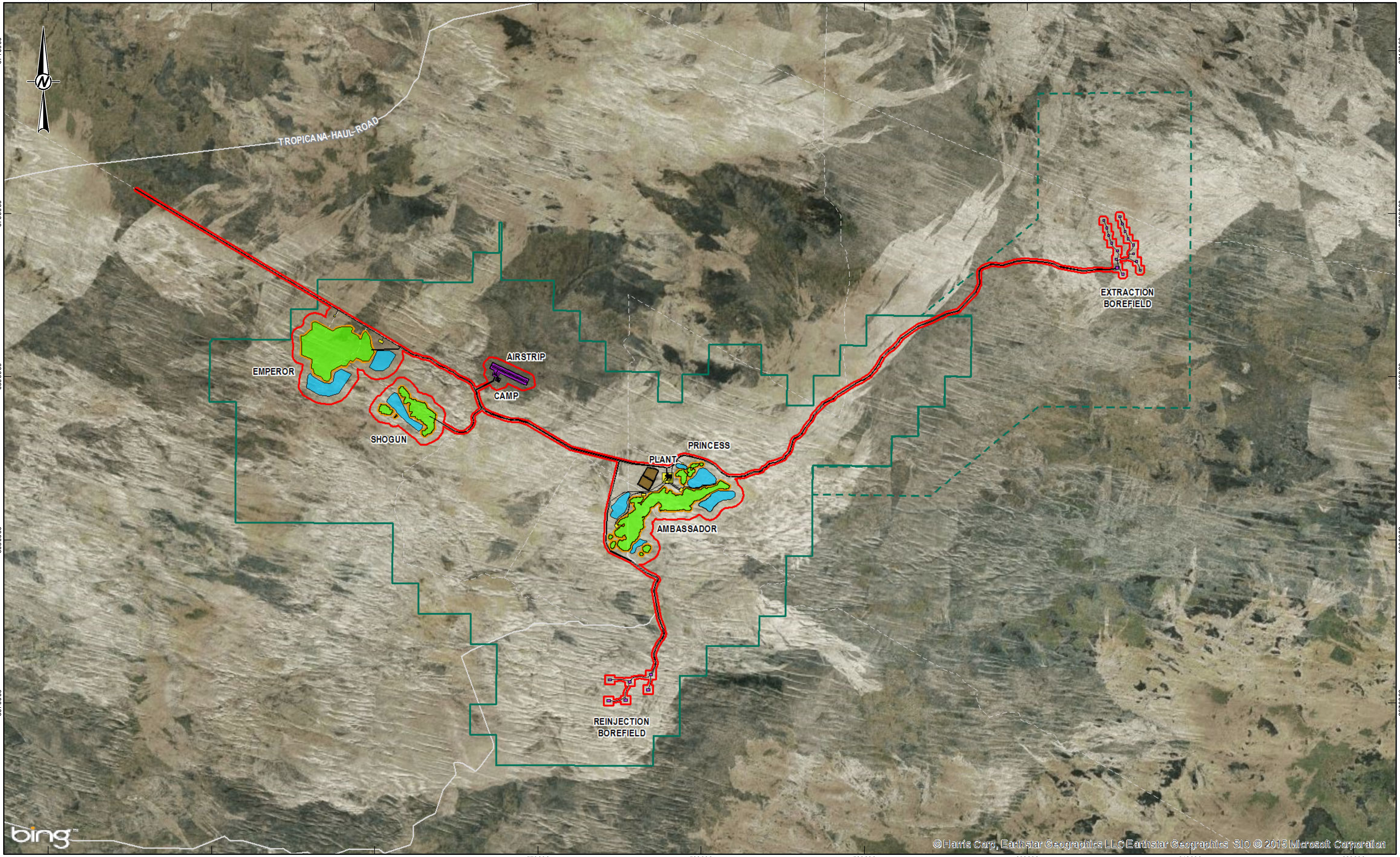
5.6 Survey Timing and Personnel

The survey was undertaken from 27 February to 3 March 2013. Monthly rainfall in the Project area from localised storms was above average for October, November and December 2012 (Vimy, 2013)Field sampling was undertaken by Mr Xavier Moreau and Mr Morris Wu from Vimy, and Mr Colin Woolard (Woolard Consulting Pty Ltd). A Regulation 17 Licence to take fauna for scientific purposes under the *Wildlife Conservation Act* (1950) was acquired prior to the surveys (Lic. No. SF009109 and SF009723). The report accompanying the licenses has been submitted online at www.dpaw.wa.gov.au/fauna_returns.

5.7 Laboratory Procedures and Identification

Preserved samples were manually sorted using a stereomicroscope to extract and identify any subterranean fauna specimens at Dalcon Environmental Pty Ltd (Dalcon) Laboratory in Malaga. Samples were first elutriated to separate the larger sediment particles, and then sieved into fractions using 212µm, 150µm and 45µm mesh sizes by Ms Sabrina Arklie (Senior Scientific Officer/Laboratory Manager, Dalcon). This technique was found to improve sorting efficiency (EPA 2007).

Invertebrate specimens were sorted and identified to their lowest possible taxonomic level by Mr Ross Gordon (Senior Scientific Officer, Dalcon). The data for this report was analysed by Dr Veronica Campagna (Limnologist).



LEGEND

- MINOR ROAD/TRACK
- ROAD
- MRUP DEVELOPMENT ENVELOPE
- PROJECT BOUNDARY (MINING TENURE)
- PROJECT BOUNDARY (MISCELLANEOUS TENURE)
- PIT
- OVERBURDEN LANDFORM
- PROCESSING INFRASTRUCTURE
- ABOVE GROUND TSF
- SUPPORTING INFRASTRUCTURE
- PIT CLEARING (50 m BUFFER)

NOTES

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 51

REFERENCE

INFRASTRUCTURE DATA PROVIDED BY CLIENT
AERIAL IMAGERY SOURCED FROM ESRI ONLINE
TOPOGRAPHY BASED ON NATIONAL DEM 1 S SOURCED FROM GEOSCIENCE AUSTRALIA

0 5 10
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CLIENT
VIMY RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-21
DESIGNED	MS
PREPARED	MS
REVIEWED	GB
APPROVED	GB

PROJECT
MULGA ROCK URANIUM PROJECT

TITLE
PROJECT TENURE AND DEVELOPMENT ENVELOPE

PROJECT NO.	CONTROL	REV.	FIGURE
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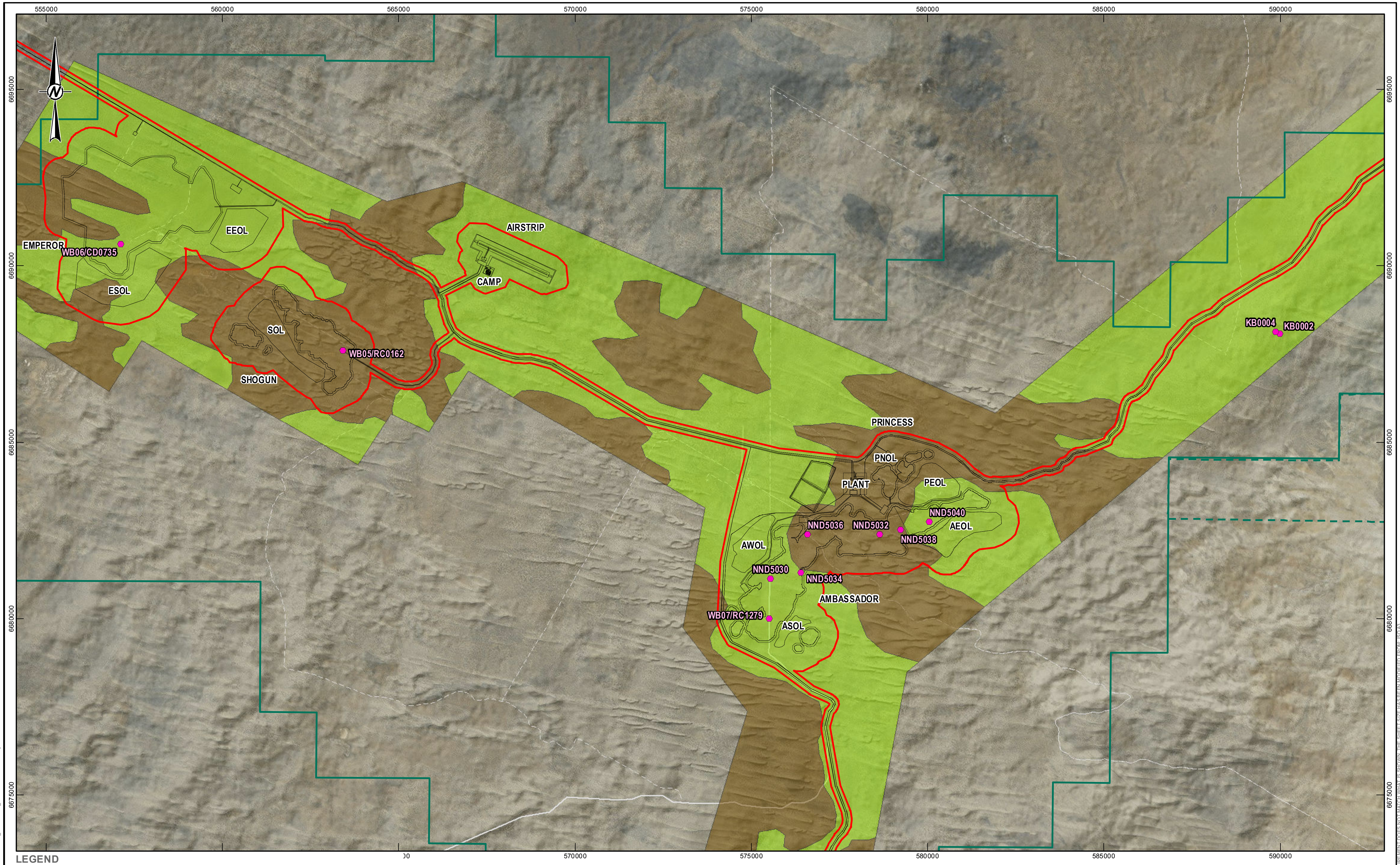

LEGEND

- 2013 STYGOFAUNA SURVEY SITE
- MINOR ROAD/TRACK
- ROAD
- INFRASTRUCTURE
- MRUP DEVELOPMENT ENVELOPE
- PROJECT BOUNDARY (MINING TENURE)
- PROJECT BOUNDARY (MISCELLANEOUS TENURE)

SOIL LANDFORM ASSOCIATIONS

- DUNES
- PLAIN

NOTES

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 51

REFERENCE

INFRASTRUCTURE DATA PROVIDED BY CLIENT
TOPOGRAPHY BASED ON NATIONAL DEM 1 S SOURCED FROM GEOSCIENCE AUSTRALIA
GEOLOGY MAP SOURCED FROM DEPARTMENT OF MINES AND PETROLEUM

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CLIENT
VIMY RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-23
DESIGNED	MS
PREPARED	MS
REVIEWED	GB
APPROVED	GB

PROJECT
MULGA ROCK URANIUM PROJECT

TITLE
STYGOFAUNA SURVEY SITES (2013 PILOT STUDY)

PROJECT NO.	CONTROL	REV.	FIGURE
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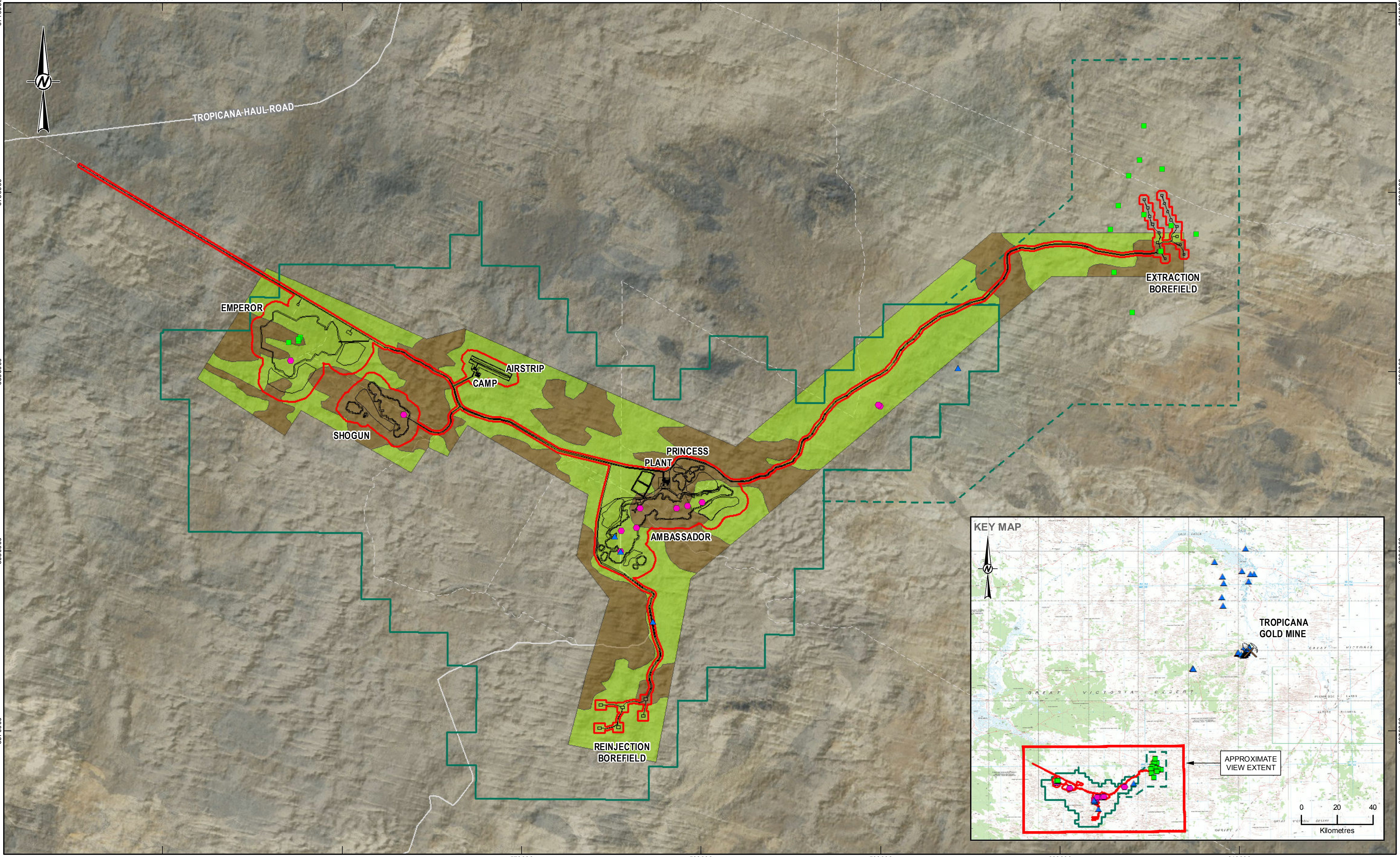

LEGEND

- 2013 STYGOFAUNA PILOT SITE
- 2014 ROCKWATER SURVEY SITE
- TGM STYGOFAUNA SAMPLE SITE
- MINOR ROAD/TRACK
- ROAD
- INFRASTRUCTURE
- MRUP DEVELOPMENT ENVELOPE
- PROJECT BOUNDARY (MINING TENURE)
- PROJECT BOUNDARY (MISCELLANEOUS TENURE)

SOIL LANDFORM ASSOCIATIONS

- DUNES
- PLAIN

NOTES

1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 51

REFERENCE

INFRASTRUCTURE DATA PROVIDED BY CLIENT
BASE DATA © WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2015)
IMAGE SOURCED FROM GEOSCIENCE AUSTRALIA 250K TOPO
INSET BASE DATA/ROADS SOURCED FROM STREET PRO DATA 2009

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CLIENT
VIMY RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-10-23
DESIGNED	MS
PREPARED	MS
REVIEWED	GB
APPROVED	GB

PROJECT
MULGA ROCK URANIUM PROJECT

TITLE
SUBTERRANEAN FAUNA SURVEY SITES FOR MRUP AND TROPICANA GOLD MINE

PROJECT NO.	CONTROL	REV.	FIGURE
1540340	C1	0	11

25mm
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3

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6. Survey Results

Eleven drill holes were sampled for stygofauna from 27 February to 3 March 2013 (Figure 10, Table 2). These sites included bores established by PNC for water production and groundwater test work and recently by Vimy for exploration use.

Bores were primarily located in the Ambassador (seven bores) area and one bore each in the Shogun and Emperor mineralised zone, as well as two bores at the Kakarook Borefield (Figure 10). The Tropicana Joint Venture undertook a stygofauna survey of the Tropicana development site in September 2007 (*ecologia* 2009) and included three PNC bores (WB01, 02 and 07-) and the BP Bore as regional test bores as part of their stygofauna assessment. No stygofauna was identified in the course of that survey.

6.1 Water Chemistry

The groundwater chemistry varied between sites with WB06 (at Emperor) having the highest salinity (102.20mS/cm EC and 66,900mg/L TDS) and the lowest pH (3.81). In nearby Shogun, site WB05, the salinity was also high, though half that of WB06. This site was also quite acidic (pH = 4.2). The groundwater at the Ambassador sites displayed the greatest variation in water quality with salinities ranging from 1.43mS/cm at NND5040 to 62.10mS/cm at RC1279. The other five sites displayed similar salinities of between 16.80mS/cm to 25.40mS/cm (Table 2). The pH at the Ambassador sites was mostly slightly acidic to circum-neutral (pH 5.62 to 7.14). The salinity at the two Kakarook sites was similar (11.50mS/cm and 15.40mS/cm). Both sites had low pH values.

The dissolved oxygen (DO) levels also varied throughout the MRUP. Site WB06 had the lowest reading (2.70mg/L). The DO levels at Ambassador were a little more consistent ranging from 4.10mg/L to 7.90mg/L (mostly around 7mg/L). The two sites at Kakarook had similar DO levels while WB05 had a DO of 5.90mg/L.

Overall, the groundwater chemistry recorded during the 2013 survey of the MRUP was not consistent with data which would indicate habitat that was suitable for stygofauna. This is based on data collected from areas in the Yilgarn of similar physiography to that of MRUP.

6.2 Biological Samples

From the eleven drill holes sampled using phreatic haul nets, 104 invertebrates were collected from seven boreholes, while four yielded no invertebrates (Table 3). None of the invertebrates collected in the 2013 survey were considered subterranean taxa displaying no features characteristic of stygofauna or troglofauna.

This report provides an assessment of the taxa collected, identifying stygal and non-stygal taxa. The risk of the proposal to the stygofauna is then assessed according to the status of the stygal taxa, as per the Environmental Guidance Statement 12 (EPA 2013). Non-stygal taxa are not considered to be at risk and therefore the descriptions are minimal.

The invertebrates consisted of three classes, dominated by the insects, then the arachnids (mites, spiders and pseudoscorpiones) and collembolan (springtails). The dominant taxa, numerically and spatially, were the ants (Formicidae) followed by the mites (Acarina). These findings are typical of surveys in arid regions where surface dwellers enter the boreholes that have a more humid environment. All the invertebrate taxa collected in the net haul samples were terrestrial and well known edaphobites (surface soil and litter dwellers).

The highest diversity was recorded at WB05 followed by WB05, both sites having vegetation close to the sampling bore (**Error! Reference source not found.**). Both sites also yielded spiders and a high diversity of insects. Pseudoscorpiones were collected from WB05, though they were not troglofauna, many pseudoscorpiones have been found in habitats associated with soil in Western Australia southwest (Harvey, 2010).

The only potentially aquatic inverts were the mites (Superorder Acarina). However, closer examination found they did not belong to the Hydracarina, the only group of mites listed in the EPA Guidance Statement 54A (EPA 2007) as requiring low-level identification. Like the other invertebrates the mites were terrestrial forms with pigmentation and eyes present.

Plate 1 Site WB05

Plate 2 Site KB004 showing the variation in vegetation communities near the drill holes

Table 2 Groundwater quality data (field measurements) and bore details of the stygofauna sample sites for the Ambassador, Emperor, Shogun and Kakarook South locations

Tenement		Drill hole ID	Sample Date	Easting	Northing	Slotting (m)	Drill Method	EoH (m)	SWL (mbgl)	DO (mg/L)	EC (mS/cm)	TDS (mg/L)	pH (+)	ORP (mV)
Lease	Prospect			UTM51J, WGS84										
E39/876	Emperor	WB06	28/02/2013	557121	6690615	58-70	DDH	38.00	27.90	2.70	102.20	66,900	3.81	181.00
E39/877	Shogun	WB05	28/02/2013	563414	6687607	44-46	RCD	77.00	30.20	5.90	50.10	26,600	4.24	157.00
	Ambassador	RC1279(WB7)	26/02/2013	575498	6679995	68-92	RCD	100.00	33.35	4.10	62.10	33,400	6.30	37.00
		NND5030	26/02/2013	575544	6681137	56-62	DDH	68.40	35.29	7.40	20.60	11,600	5.62	78.80
		NND5034	26/02/2013	576399	6681300	39-45	DDH	47.00	39.87	4.10	25.40	14,600	6.04	52.70
		NND5036	27/02/2013	576591	6682391	41-47	DDH	53.00	39.27	7.30	16.80	9,410	6.07	51.70
		NND5032	24/02/2013	578632	6682382	41-47	DDH	53.10	38.46	4.50	20.60	11,600	6.18	46.60
		NND5038	27/02/2013	579231	6682522	44-50	DDH	56.00	39.26	6.60	18.30	10,200	7.14	8.50
		NND5040	27/02/2013	580034	6682734	35-41	DDH	47.00	32.82	7.90	1.43	7,200	5.68	74.90
L39/193	Kakarook South	KB004	28/02/2013	589867	6688126	30-36	ACD	36.00	28.68	7.90	11.50	6,280	5.48	86.30
		KB002	27/02/2013	589978	6688075	29-35	ACD	40.00	26.48	7.60	15.40	8,600	4.65	133.00

EoH = end of hole, SWL = standing water level, DO = dissolved oxygen, EC = electrical conductivity, TDS = total dissolved solids, ORP = oxidation-reduction potential, DDH = Diamond Drill Hole, RCD= Reverse Circulation Drilling, ACD = Air Core Drilling.

Table 3 Record of invertebrate taxa collected during the February 2013 Level 1 Survey from drill holes in the MRUP. None displayed stygal or troglomorphic features.

Taxa		Emperor	Shogun	Ambassador							Kakarook		Total
Class	Lowest ID	WB06	WB05	RC1279	NND5030	NND5034	NND5036	NND5032	NND5038	NND5040	KB002	KB004	
Arachnida	Acarina	1	2	12									**15**
	Araneae	2	4										**6**
	Pseudoscorpiones		2										**2**
Collembola	Collembola	1	1										**2**
Insecta	Hymenoptera		2										**2**
	Formicidae	4	44	5			6	1	7			1	**68**
	Thysanura	1		1									**2**
	Hemiptera	1											**1**
	Psocoptera						1						**1**
	Orthoptera		1										**1**
	Coleoptera		4										**4**
Total		**10**	**60**	**18**	**0**	**0**	**7**	**1**	**7**	**0**	**0**	**1**	**104**

7. Discussion

The purpose of this report is to present sufficient information to inform the consideration and assessment of subterranean fauna for the MRUP. A desktop study identified the MRUP area as having very low potential as subterranean fauna habitat based on the geology of the area. Additionally an environmental impact assessment for the Tropicana JV, located 110km northeast of the MRUP found the area did not support stygofauna (*ecologia* 2009a). Because the level of information regarding subterranean fauna in the Great Victoria Desert was limited, a reconnaissance survey was undertaken. The survey was designed to confirm the presence of stygofauna in the groundwaters of the Ambassador, Shogun, Emperor and south Kakarook prospects of the MRUP and identify any potential subterranean fauna habitats. The presence of troglofauna was also assessed from the samples collected.

The majority of troglofauna specimens collected in Western Australian surveys are as by-catch from stygofauna haul samples and troglofauna surveys now include a technique similar to phreatic haul nets called scrapings. Yields from by-catch are usually higher than those of scrapings particularly when the sample hole intersects the water table, indicating the importance of a humid environment for troglofauna (pers. comm., V. Campagna). Based on this information, the 2013 Level 1 survey of MRUP was considered appropriate to address the considerations of stygofauna and troglofauna in the MRUP area.

Stygofauna, like surface water fauna, are influenced by their immediate environment with their distribution within the aquifer controlled by the physiochemical characteristics of the groundwater (Strayer 1994). The basic water quality parameters that have the greatest influence on aquatic organisms are pH, temperature, salinity, as well as EC, and DO. While DO levels below 2mg/L can restrict surface water invertebrates, stygobitic species are able to tolerate and recover from very low oxygen levels (Strayer 1994). Many Australian species are commonly associated with suboxic waters that have DO levels below 1mg/L (Humphreys 2008). Salinity affects stygofauna in the same way it does epigean fauna, the greater the salinity the lower the diversity (Humphreys 2009).

The water chemistry of the MRUP survey area was not consistent with subterranean environments in the Yilgarn. Several areas have recorded stygofauna in hypersaline environments (Lake Way, Lake Maitland), however not with low groundwater pH and high sulphate levels. A falling water table associated with differential uplift of the Gunbarrel Basin to the north of the project has resulted in a significant weathering profile and metal mobilisation through processes common to acid-sulphate environments.

Subterranean fauna can live in extreme environments as long as there is little fluctuation in conditions. Temperature, pH, humidity, salinity are usually constant and this allows them to survive in the absence of light. The groundwater in the MRUP area displayed quite a large variation within a small area. The soil temperature in the MRUP area also fluctuates throughout the year reflecting the seasonal variation (Appendix A, Figure A-7). Subterranean fauna prefer a more stable environment, particularly in regards to temperature (Howarth 1983).

Endemic stygofauna are not distributed randomly; rather they are concentrated in regions that support diverse communities such as surficial aquifers, with diversity decreasing with increasing depth. Generally, groundwaters have a more diverse community in areas of groundwater recharge compared to those of groundwater discharge, with the flux of organic carbon governing the presence of stygofauna (Humphreys 2009). The dissolved organic carbon (DOC) is either percolated down through the vadose zone or transported laterally within the groundwater flow. This transfer is dependent on the hydraulic conductivity, or the groundwater flow, of the aquifers. Repeated episodic groundwater flow has focused large groundwater volumes into the paleovalley-fills, resulting in a complete oxidation of the top 25m to 45m, as well as deeper sediments along fault-bound valley edges. The base of the biologically active zone (marked by deep tap roots) is well defined via drilling and past in the Shogun trial pit (1983 - 1995) and corresponds to the interface between Miocene and Eocene sediments, typically 15-20m above the aquifer. In the MRUP area, the top of the aquifer is capped by a white clay unit 1m to 5m thick which acts as an aquitard to the aquifer. This low hydraulic conductivity layer ensures the present vegetation and biologically active zone is not connected in any way to saline groundwaters associated with the mineralisation over and around the MRUP area. With the exception of one sample site, KB002, all other sites had large quantities of fine silt in the samples (Plate E-11). Sediment texture is highly influential on community structure and on hydraulic conductivity, with pore sizes determining the biota that use the space (Coineanu 2000; Strayer 1994).

A review of subterranean fauna assessments in the Pilbara showed there was a strong relationship between geology and the presence of troglofauna. No troglofauna were collected from holes that were dry or in clay, silt, or sand and confirmed the need for a humid environment. For assessments that included a range of geologies in the sampling program, troglofauna were generally collected only from drill holes that intercepted the water table (Biota Environmental Sciences, 2006; OES, 2009; OES, 2010 and Subterranean Ecology, 2007). By inhabiting environments that have close to 100% relative humidity, or by reducing surface area available for water loss, the problem of water loss faced by invertebrates can be overcome (Villani *et al*. 1999). The soil overlying the water table at MRUP is disconnected from the water table by the aquitard (the white clay layer).

The invertebrates collected during the MRUP Level 1 survey were edaphobitic (soil or litter dwellers), such as the springtails (Collembola) and mites (Acarina), or epigean such as ants (Formicidae). Surveys in other arid regions found high numbers of mites and springtails were collected from dry drill holes using baited traps while troglofauna were usually absent (Subterranean Ecology 2007).

8. Conclusion

The Level 1 survey of the MRUP resource area undertaken in February 2013 did not identify significant stygofauna communities in the Ambassador, Shogun, Emperor deposits or the Kakarook Borefield. No stygofauna were retrieved from the 11 drill holes sampled. The groundwater chemistry identified the aquifers sampled as having high salinities, low pH and high sulphate. The samples collected also had very high silt content and very fine black particles.

In the primary resource areas tested, the aquifer is overlaid by a white clay layer acting as an aquitard. This prevents recharge and limits the hydraulic conductivity. In terms of subterranean fauna this isolates invertebrates from surface resources, the only available source of energy.

Troglofauna require a humid environment and usually inhabit the area just above the water table that retains humidity. Site climatic conditions are arid and characterised by low precipitation and high evaporation, and the soil is sandy and with no connection to the water table. It is therefore, unlikely conditions would be suitable to retain moisture sufficiently to support a robust troglobitic community. From the 11 samples collected during the Pilot survey, some contained surface invertebrates, however no troglofauna were identified. The majority were collected from one site, WB05 (Plate 1), which had dense shrub vegetation around the drill hole.

The survey completed by Rockwater in their 2014 survey, identified subterranean fauna, though limited. The stygofauna were collected from the proposed Kakarook borefield north of the survey area, which has a less hostile water chemistry and is different geologically. The troglofauna were collected in small numbers and associated mostly where the water table was intersected. In terms of habitat, the troglofauna were recorded from habitat that is extensive and continues outside the MRUP area.

Based on survey results, the Ambassador, Emperor, Shogun and Kakarook areas surveyed for this assessment did not identify significant habitat for subterranean fauna. Consequently, no troglofauna or stygofauna are placed at risk by the MRUP.

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10. Glossary of Terms and Abbreviations

Alluvial — Alluvial deposits are sediments composed of gravel, sand, silt or clay deposited in river channels or on floodplains. Alluvial aquifers are generally shallower than sedimentary and fractured rock aquifers and water levels often fluctuate due to varying recharge and pumping rates. Due to their shallow and unconfined nature, alluvial aquifers are susceptible to contamination and pollution.

Aquitard — A bed of low permeability within an aquifer resulting in low hydraulic conductivity across the unit.

ANZECC — Australia and New Zealand Environment and Conservation Council.

Aquifer — A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economic quantities of water to wells and springs.

ARMCANZ — Agriculture and Resource Management Council of Australia and New Zealand.

Calcrete — Carbonate deposits that form in arid environments as a result of groundwater evaporation.

Confined Aquifer — An aquifer that lies below a low permeability material. The piezometric surface in confined aquifers is above the base of the confining material e.g. artesian aquifers.

Cosmopolitan Species — Species with very large distribution in many, or all, parts of the world and ecosystems.

Dewatering — The removal of groundwater from geological units by pumping or draining. This is often done during the development phase of mine construction and/or production due to a high water table. It usually involves the use of dewatering bores.

Dissolved Oxygen — A measure of the amount of gaseous oxygen dissolved in a solution.

Distribution Range — The overall geographic area that a species is known to occur in.

Drawdown — The distance between the static water level and the surface of the cone of depression caused by groundwater abstraction.

EPA — Environmental Protection Authority – Western Australia.

Ecosystem — A functional unit consisting of all the living organisms (plants, animals and microbes) in a given area, and all the non-living physical and chemical factors of their environment, linked together through nutrient cycling and energy flow.

Ecotone — A transitional zone between two communities containing the characteristic species of each.

Ecozone — A broad geographic area in which there are distinctive climate patterns, ocean conditions, types of landscapes and species of plants and animals.

Electrical Conductivity (EC) — The measure of a solutions ability to conduct electricity. EC units are used to express salinity levels in water. When salt is dissolved in water the conductivity increases, so the more salt, the higher the EC value. Usually expressed as micro Siemens per centimetre μS/cm at 25°C.

Endemic	Pertaining to organisms in a specific geographical region or ecological habitat; organisms native to a region and not introduced.
EPBC Act	Environment Protection and Biodiversity Conservation Act (1999).
Extinct	A taxon is extinct when there is no reasonable doubt that the last living individual has died.
Facultative Groundwater Dependent Ecosystem	A GDE is one that is not entirely dependent on groundwater but may rely on groundwater on a seasonal basis or only during extended drought periods. At other times water requirements may be met by soil or surface water.
Groundwater	The water contained within the joints, vesicles, fractures or interconnected pores of an aquifer.
Groundwater Dependent Ecosystem (GDE)	Is a broad overarching term encompassing all ecosystems that use groundwater either permanently or occasionally to survive. In this context the term covers a vast majority of terrestrial and aquatic ecosystems. See Facultative and Obligate GDE definitions.
Hydraulic Conductivity	A coefficient of proportionality describing the rate at which water can move through a permeable medium. Horizontal hydraulic conductivity (Kh) refers to the coefficient of proportionality in the horizontal direction, whereas vertical hydraulic conductivity (Kv) refers to the coefficient of proportionality in the vertical direction.
Hydrogeologic	Those factors that deal with subsurface waters and related geologic aspects of surface waters.
Hypogean	Located under the earth's surface often defined as the subterranean zone.
Hyporheic Zone	The ecotonal zone below and within the porous sand and gravel substrate of a river bed. This ecotonal zone often connects the surface running water system to that of the deep subterranean.
Hyporheos	The assemblage of organisms which inhabit the hyporheic zone.
Karst	Terrain with special landforms and drainage characteristics on account of greater solubility of certain rocks in natural waters than is common.
Lithology	The description of rocks on the basis of such characteristics as colour, mineralogy and grain size.
mbgl	metres below ground level.
mbtoc	metres below top of casing.
ML	Mining Lease.
Mtpa	Million Tonnes per Annum.
Obligate GDE	Describes a GDE that is entirely dependent on groundwater. Typically most karst, mound springs, wetland and hypogean/aquifers are classified as GDE's.
Paleochannel, Paleodrainage	A remnant of a stream or river channel cut in older rock and filled by the sediments of younger overlying rock.

Permeability	The property or capacity of a porous rock, sediment or soil for transmitting a fluid. It is a measure of the relative ease of fluid flow under unequal pressure.
Phreatic Water	Water below the level at which all voids in the rock are completely filled with water.
Phreatic Zone	Zone where voids in the rock are completely filled with water. Also refers to deep groundwater.
Phreatobite	Stygobites that are restricted to the deep groundwater substrata of alluvial aquifers (phreatic waters). All species within this classification have specialised morphological and physiological adaptations.
Piezometer	A narrow tube, pipe or borehole for measuring the moisture in a soil or water level in an aquifer.
Recharge Area	An area that allows water to enter the aquifer. The area is particularly vulnerable to any pollutants that could be in the water.
Saturated Zone	The zone in which the voids in the rock or soil are filled with water. Sometimes referred to as the phreatic zone.
Standing Water Level (SWL)	The depth from groundwater level (or other stated reference point) to the water level in a bore which is not influenced by pumping.
Stygobite/Stygobiont	Organisms that are specialised subterranean forms, obligatory hypogea. Some are ubiquitous, widely distributed in all types of groundwater systems (both karst and alluvia).
Stygofauna	An all-encompassing term for all animals that occur in subsurface waters.
Stygophile	Having greater affinities with the groundwater environment than stygoxenes because they appear to actively exploit resources in the groundwater system and/or actively seek protection from unfavourable situations in the surface environment resulting from biotic or stochastic processes. Stygophiles can be divided into (1) occasional or temporary hyporheos, and (2) permanent hyporheos. The occasional or temporary hyporheos include individuals of the same species that could either spend their lives in the surface environment or spend a part of their lives in the surface environment and a part in groundwater. The permanent hyporheos is present during all life stages in either groundwater or in benthic habitats and possess specialist adaptations for living in this environment.
Yilgarn	Pertaining to the Yilgarn Craton, a 65,000km^2 body of the earth's crust in south-western Australia that dates back to the Archaean period, 2.6 to 3.7 million years ago.

Abbreviations

%	-	percent
°C	-	degrees centigrade
bgl	-	below ground level
BOM	-	Bureau of Meteorology
D.E	-	Dalcon Environmental
DEC	-	Department of Environment and Conservation
D.O.	-	Dissolved Oxygen (measured in mg/L or ppm)
DPaW	-	Department of Parks and Wildlife
EAMA	-	Energy and Minerals Australia
EC	-	Electrical Conductivity
EIA	-	Environmental Impact Assessment
EIS	-	Environmental Impact Statement
EOH	-	End of Hole
EPA	-	Environmental Protection Authority
ESD	-	Environmental Scoping Document
GDE	-	Groundwater Dependant Ecosystem
GVD	-	Great Victoria Desert
IBRA	-	Interim Biogeographic Regionalisation of Australia
m	-	metres
mg/l	-	milligrams per litre

MNES	-	Matters of National Environmental Significance
MRE	-	Mulga Rock East
MRUP	-	Mulga Rock Uranium Project
MRW	-	Mulga Rock West
mS/cm	-	milli Siemens per centimetre
µm	-	Micrometres
PEC	-	Priority Ecological Community
PNC	-	Power Nuclear Corporation of Japan
Redox	-	Oxidisation Reduction Potential (Eh) measured in mV
ROM	-	Run of Mine
SWL	-	Standing Water Level
TDS	-	Total Dissolved Solids
UCL	-	Unallocated Crown Land
UOC	-	Uranium Oxide Concentrate
WA	-	Western Australia

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Appendix A

Mulga Rock Uranium Project Area Climate Report 2012

Annual Climate Summary for Mulga Rock

Year 2012

Rainfall:

- Annual rainfall at MRUP (245mm Project average) in 2012 was lower than for the three nearest regional weather stations, namely Kalgoorlie (460mm), Laverton (261mm), and Leonora (286mm).

- The wettest month was January with 63.6mm of rainfall recorded. Annual rainfall recorded at VMY_904* was 130mm at VMY_907 - 240mm and VMY_908 - 263mm. The site rainfall for 2012 was significantly lower than that recorded in 2011 (an exceptional year with close to three times the average recorded onsite).

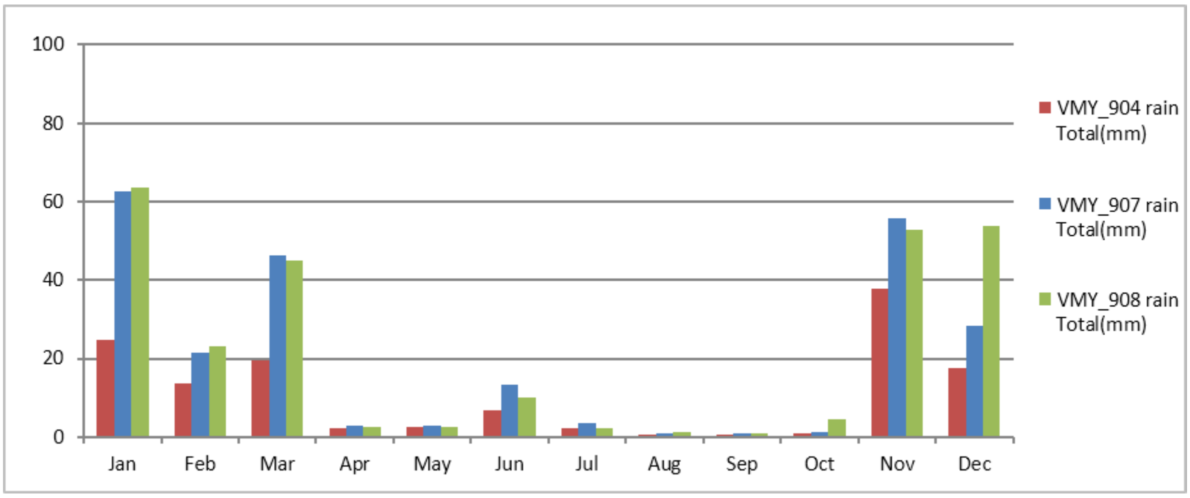

Figure A-1 Monthly rainfall (mm) recorded at Mulga Rock weather stations – VMY_904, VMY_907 and VMY_908

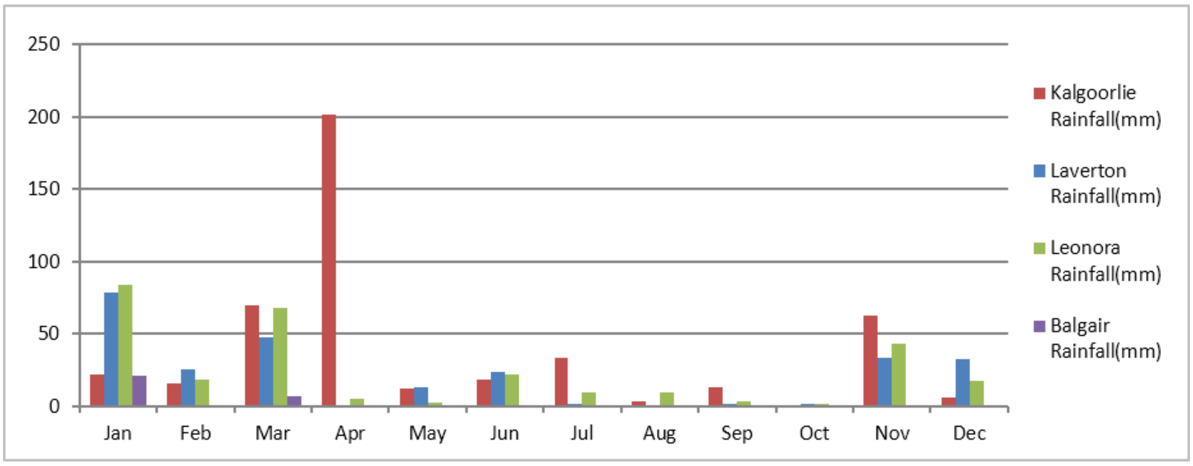

Figure A-2 Monthly rainfall (mm) recorded at regional weather stations – Kalgoorlie, Laverton, Leonora and Balgair

* VMY_904: Ambassador, VMY_907: Shogun, VMY_908: Emperor station

Table A-1 Mulga Rock Weather Stations - Monthly Rainfall - 2012 (mm)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
VMY_904	24.9	13.7	19.7	2.2	2.6	6.9	2.1	0.6	0.6	1	37.9	17.5	129.7
VMY_907	31.6	30.8	26.4	26.1	21.6	17.6	13.1	21.4	23	29.3	31	30.8	302.7
VMY_908	31.2	30.5	26.6	25.9	21.8	17.6	13.4	21.5	23.1	29.3	31.3	30.3	302.5

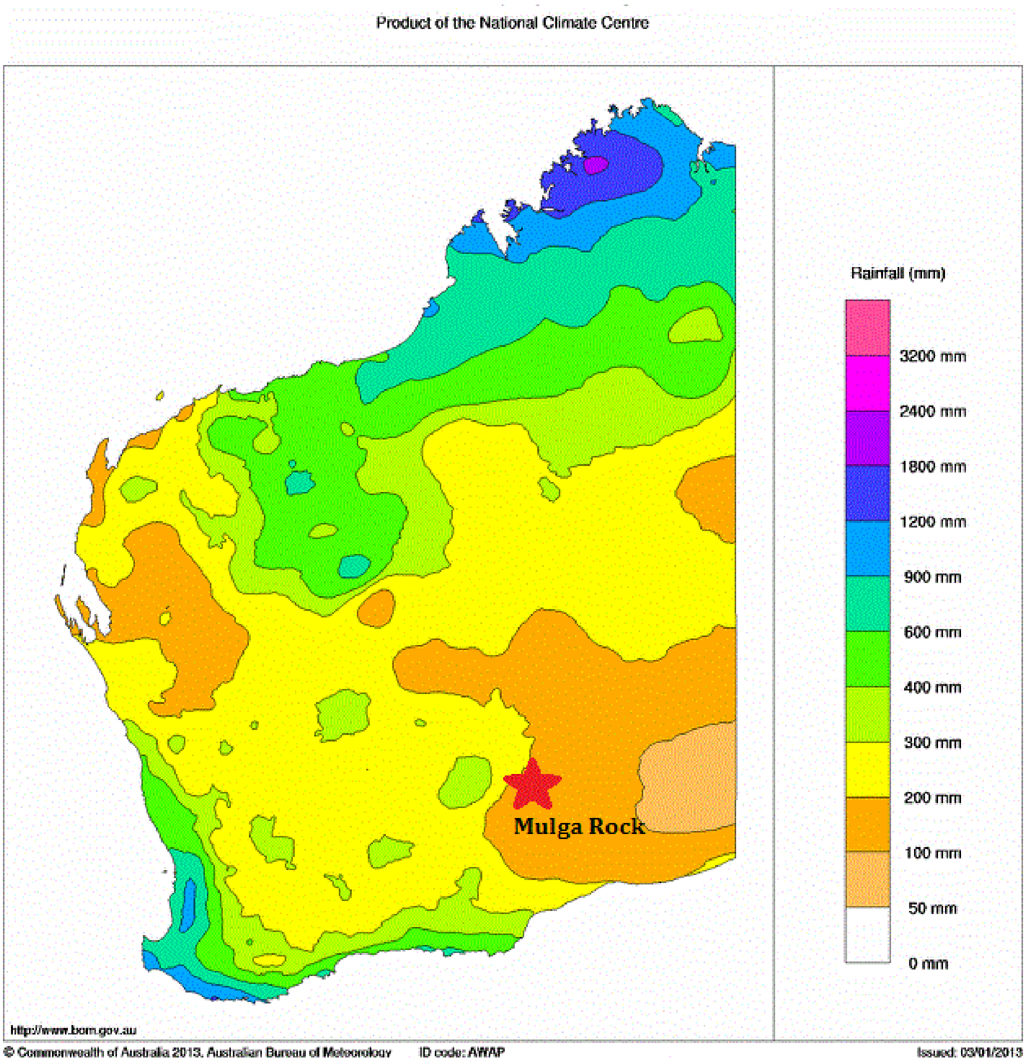

Figure A-3 Western Australian rainfall totals (mm) 1 January to 31 December 2012

Mulga Rock Weather Stations – Air Temperature – 2012:

Hottest Day on Hourly maximum temperature: 43.5 °C on VMY_904 at 4:22 PM on 22 December 2012.

Coldest Night on Hourly minimum temperature: -1.2 °C on VMY_907 at 7AM on 12 June 2012.

Warmest Daily Average was 31.8 °C at VMY_904 on 23 January 2012.

Coolest Daily Average was 4.1 °C at VMY_904 and VMY_907 on 27 July 2012.

The average annual temperature of 2012 in Mulga Rock Camp was close to that recorded in 2011, with only 0.1 degree of difference.

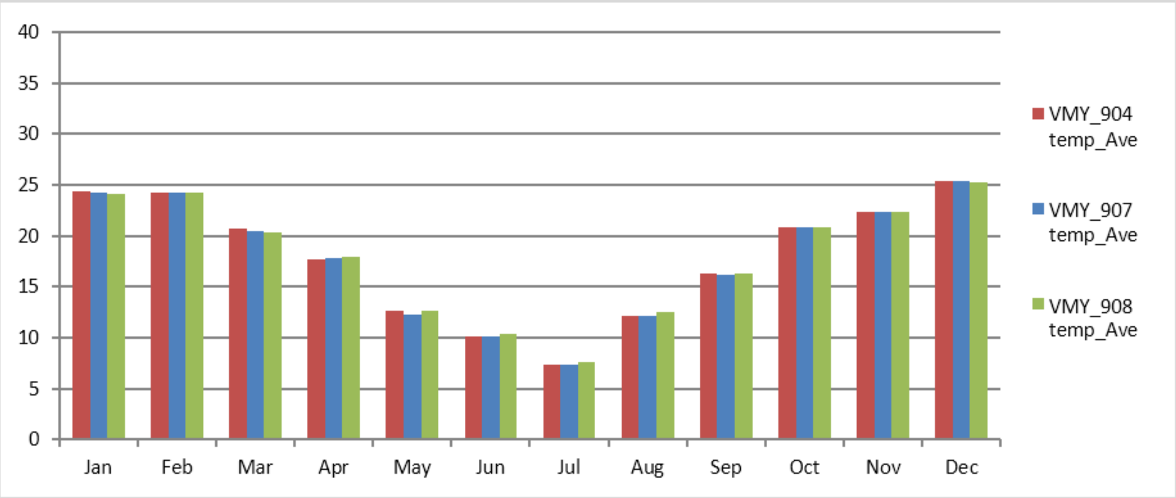

Figure A-4 **Monthly average temperature (•C) recorded at Mulga Rock weather stations – VMY_904, VMY_907 and VMY_908**

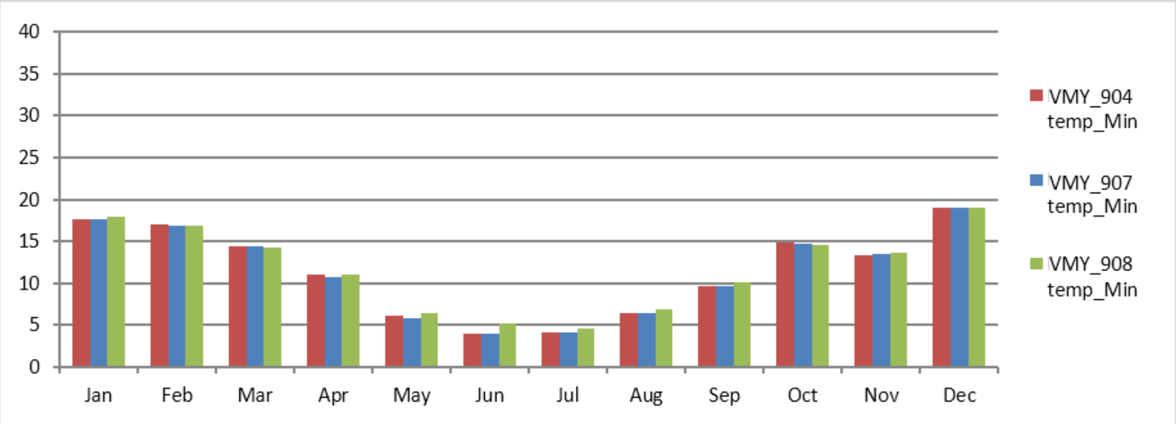

Figure A-5 **Monthly minimum temperature (•C) recorded at Mulga Rock weather stations – VMY_904, VMY_907 and VMY_908**

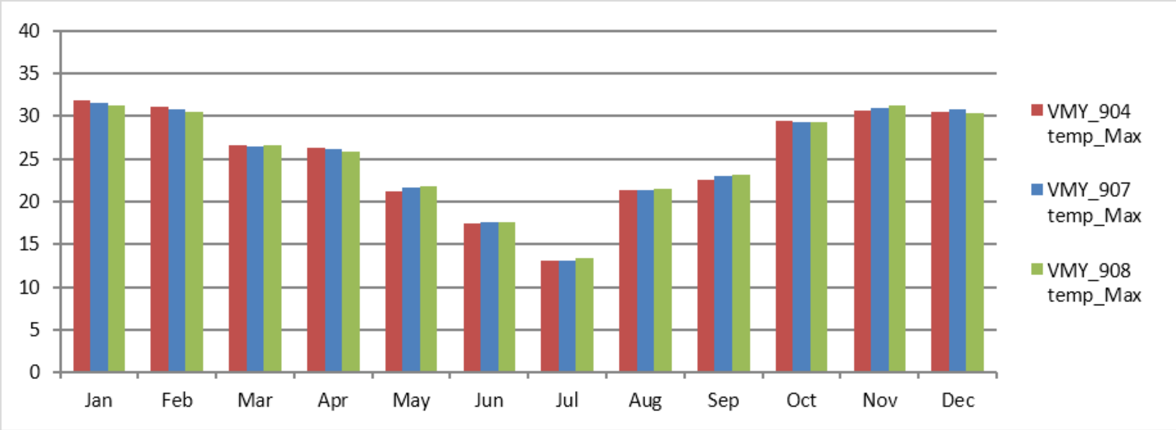

Figure A-6 **Monthly maximum temperature (•C) recorded at Mulga Rock weather stations – VMY_904, VMY_907 and VMY_908**

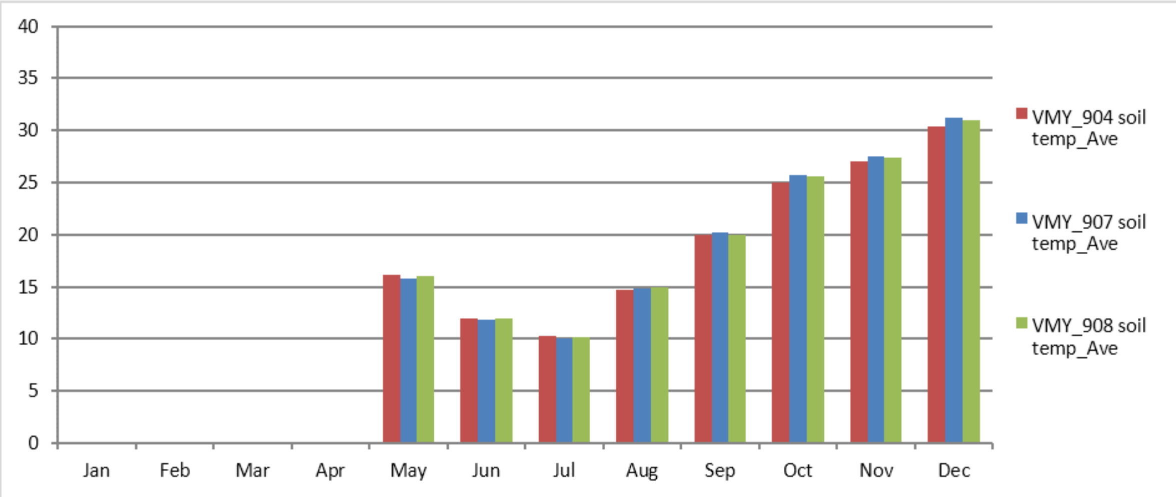

Figure A-7 **Monthly average soil temperature (•C) recorded at Mulga Rock weather stations – VMY_904, VMY_907 and VMY_908**

Table A-2 Mulga Rock Uranium Project: Monthly Average Air Temperature in 2012 (2m sensor height, based on mean daily data)

Air Temp Min	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
VMY_904	17.7	17.1	14.5	11.1	6.1	4	4.1	6.4	9.7	14.9	13.4	19.1
VMY_907	17.6	16.9	14.5	10.8	5.9	4	4.1	6.4	9.6	14.8	13.5	19
VMY_908	17.9	16.9	14.3	11.1	6.5	5.2	4.6	6.9	10.2	14.6	13.6	19.1
Air Temp Max	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
VMY_904	31.8	31.1	26.6	26.3	21.2	17.4	13.1	21.4	22.6	29.4	30.7	30.5
VMY_907	31.6	30.8	26.4	26.1	21.6	17.6	13.1	21.4	23	29.3	31	30.8
VMY_908	31.2	30.5	26.6	25.9	21.8	17.6	13.4	21.5	23.1	29.3	31.3	30.3
Air Average	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
VMY_904	24.4	24.3	20.7	17.7	12.7	10.1	7.4	12.1	16.3	20.8	22.3	25.4
VMY_907	24.2	24.2	20.5	17.8	12.3	10.1	7.4	12.2	16.2	20.8	22.3	25.4
VMY_908	24.1	24.2	20.4	17.9	12.6	10.4	7.6	12.5	16.3	20.8	22.3	25.3

Appendix B

Groundwater Quality Data

Groundwater Quality

Pilot Study Field Survey

Area/Prospect Unit	Hole_ID	Type	Hole Depth (m)	Easting	Northing	R.L. (m)	pH	TDS (ppm)	Conductivity µS/cm	Conductivity Factor	DO Raw mg/L	DO Factored mg/L	ORP mV
Water Bore	KB0002	AC	40	589978	6688075	344.5	4.65	8600	15400	0.56	8.3	7.6	171
Water Bore	KB0004	AC	36	589867	6688126	346.0	5.48	6280	11500	0.55	8.4	7.9	93
AMB_W	NNA5508	AC	126	575239	6680797	324.3	6.77	12900	22600	0.57	8.2	7.1	44
AMB_W	NND5030	DDH	68.4	575544	6681137	326.2	5.62	11600	20600	0.56	8.4	7.4	-135
AMB_E	NND5032	DDH	53.1	578632	6682382	337.6	6.18	11600	20600	0.56	5.1	4.5	-248
AMB_W	NND5034	DDH	47.0	576399	6681300	332.3	6.04	14600	25400	0.57	4.8	4.1	-205
AMB_W	NND5036	DDH	53.0	576591	6682391	332.9	6.07	9410	16800	0.56	8.1	7.3	-207
AMB_E	NND5038	DDH	56.0	579231	6682522	338.3	7.14	10200	18300	0.56	7.4	6.6	-364
AMB_E	NND5040	DDH	47.0	580034	6682734	332.1	5.68	720	1430	0.50	8.0	7.9	-119
AMB_S	RC0065[3]	RC	76	577282	6676116	323.0	3.81	66900	122000	0.55	8.1	2.7	251
SHO	RC0162[4]	RC	77	563414	6687607	319.1	4.24	26600	50100	0.53	8.0	5.9	151
AMB_W	RC1279[5]	RC	100	575499	6679995	322.2	6.30	33400	62100	0.54	6.1	4.1	46

The equipment and calibration solutions used in the field to sample and measure the groundwater samples were as follow:

- Alkalinity: HACH Digital Titrator Model 16900
- Dissolved Oxygen (DO): Lutron DO-5509
- Oxido-Reduction Potential (ORP): EZDO ORP5041
- Conductivity/Total Dissolved Salts (TDS): WP-81 with k=10/ATC/Temperature Sensor
- pH: WP-81 with Combination pH Sensor
- Groundwater pump:
  - Proactive Supernova 120
  - Pumping depth: ~37m
  - Dimensions of pump: 1.44”O.D. x 16”length
- Calibration solutions for pH/conductivity:
  - Enviroequip pH 4 buffer solution Lot.1K1136
  - Enviroequip pH 6.88 buffer solution Lot.1H1841
  - ROWE scientific 2.76mS/cm@25°C Batch: DB161014

[3] PNC’s water bore WB01
[4] PNC’s water bore WB05
[5] PNC’s water bore WB07

Groundwater Quality

Pilot Study – SGS Perth

SGS

ANALYTICAL REPORT

NATA
WORLD RECOGNISED ACCREDITATION

CLIENT DETAILS		LABORATORY DETAILS	
Contact	Xavier Moreau	Manager	Ros Ma
Client	Energy & Minerals Australia Pty Ltd	Laboratory	SGS Newburn Environmental
Address	PO Box 23 West Perth WA 6872	Address	10 Reid Rd Newburn WA 6105
Telephone	08 - 9389 2700	Telephone	(08) 9373 3500
Facsimile	(Not specified)	Facsimile	(08) 9373 3556
Email	xmoreau@eama.com.au	Email	au.environmental.perth@sgs.com
Project	**MULGA ROCKS**	SGS Reference	**PE075356 R0**
Order Number	(Not specified)	Report Number	0000056790
Samples	12	Date Reported	11 Mar 2013
		Date Received	06 Mar 2013

COMMENTS

Accredited for compliance with ISO/IEC 17025. NATA accredited laboratory 2562(898/20210).

Samples were diluted due to high conductivity for Metals. Hence, LORs were raised.

Chloride MS failed acceptance criteria due to presence of significant level of analyte in the sample.

SIGNATORIES

Hue Thanh Ly Metals Supervisor	Leanne Orsmond Inorganics Coordinator	Michael McKay Inorganic Team Leader - Waters
Ohmar David Metals Chemist	Ros Ma Laboratory Manager	

ANALYTICAL REPORT

PE075356 R0

Parameter	Units	LOR	PE075356.001	PE075356.002	PE075356.003	PE075356.004
Sample Number			PE075356.001	PE075356.002	PE075356.003	PE075356.004
Sample Matrix			Water	Water	Water	Water
Sample Date			26 Feb 2013	26 Feb 2013	26 Feb 2013	27 Feb 2013
Sample Name			MRP-NND5030	MRP-NND5034	MRP-RC1279	MRP-NND5040
pH in water Method: AN101						
pH	pH Units	0.1	6.9	6.6	6.4	6.0
Conductivity and TDS by Calculation - Water Method: AN106						
Conductivity @ 25 C	µS/cm	2	20000	24000	43000	1300
Total Dissolved Solids (TDS) in water Method: AN113						
Total Dissolved Solids Dried at 180°C	mg/L	10	12100	15400	31000	723
Alkalinity Method: AN135						
Total Alkalinity as CaCO3	mg/L	5	6	49	17	<5
Bicarbonate Alkalinity as HCO3	mg/L	5	8	60	21	5
Carbonate Alkalinity as CO3	mg/L	1	<1	<1	<1	<1
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5	<5
Chloride by Discrete Analyser in Water Method: AN274						
Chloride	mg/L	1	6600	8200	16000	330
Sulphate in water Method: AN275						
Sulphate	mg/L	1	1300	1800	3300	74
Metals in Water (Dissolved) by ICPOES Method: AN320/AN321						
Arsenic, As	mg/L	0.02	<0.02	<0.02	<0.10↑	<0.02
Cadmium, Cd	mg/L	0.001	0.002	<0.001	<0.005↑	<0.001
Calcium, Ca	mg/L	0.2	220	300	610	16
Chromium, Cr	mg/L	0.005	<0.005	<0.005	<0.025↑	<0.005
Copper, Cu	mg/L	0.005	<0.005	<0.005	<0.025↑	0.008
Lead, Pb	mg/L	0.02	<0.020	<0.020	<0.10↑	<0.020
Magnesium, Mg	mg/L	0.1	320	480	1000	19
Nickel, Ni	mg/L	0.005	0.008	0.029	0.073	0.013
Potassium, K	mg/L	0.1	190	230	260	8.3
Sodium, Na	mg/L	0.5	4600	4900	9400	190
Zinc, Zn	mg/L	0.01	0.40	0.36	0.47	0.12
Mercury (dissolved) in Water Method: AN311/AN312						
Mercury	mg/L	0.0001	<0.00010	<0.00010	<0.00010	<0.00010

ANALYTICAL REPORT

PE075356 R0

Parameter	Units	LOR	PE075356.001	PE075356.002	PE075356.003	PE075356.004
Sample Number			PE075356.001	PE075356.002	PE075356.003	PE075356.004
Sample Matrix			Water	Water	Water	Water
Sample Date			26 Feb 2013	26 Feb 2013	26 Feb 2013	27 Feb 2013
Sample Name			MRP-NND5030	MRP-NND5034	MRP-RC1279	MRP-NND5040
Calculation of Anion-Cation Balance (SAR Calc) Method: AN121						
Anion-Cation Balance	%	-100	5	1	1	0

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ANALYTICAL REPORT

PE075356 R0

Parameter	Units	LOR	PE075356.005	PE075356.006	PE075356.007	PE075356.008
Sample Matrix			Water	Water	Water	Water
Sample Date			27 Feb 2013	27 Feb 2013	27 Feb 2013	27 Feb 2013
Sample Name			MRP-NND5036	MRP-NND5038	MRP-NND5032	MRP-KB002
pH in water Method: AN101						
pH	pH Units	0.1	6.8	8.0	6.9	6.2
Conductivity and TDS by Calculation - Water Method: AN106						
Conductivity @ 25 C	µS/cm	2	16000	17000	20000	14000
Total Dissolved Solids (TDS) in water Method: AN113						
Total Dissolved Solids Dried at 180°C	mg/L	10	9660	10600	12700	8490
Alkalinity Method: AN135						
Total Alkalinity as CaCO3	mg/L	5	68	1700	120	<5
Bicarbonate Alkalinity as HCO3	mg/L	5	83	2100	150	<5
Carbonate Alkalinity as CO3	mg/L	1	<1	<1	<1	<1
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5	<5
Chloride by Discrete Analyser in Water Method: AN274						
Chloride	mg/L	1	5000	5700	6300	4300
Sulphate in water Method: AN275						
Sulphate	mg/L	1	900	8	1600	1300
Metals in Water (Dissolved) by ICPOES Method: AN320/AN321						
Arsenic, As	mg/L	0.02	<0.02	0.03	<0.02	<0.02
Cadmium, Cd	mg/L	0.001	<0.001	0.001	<0.001	<0.001
Calcium, Ca	mg/L	0.2	170	260	260	170
Chromium, Cr	mg/L	0.005	<0.005	0.011	0.010	0.020
Copper, Cu	mg/L	0.005	<0.005	<0.005	<0.005	0.016
Lead, Pb	mg/L	0.02	<0.020	<0.020	<0.020	<0.020
Magnesium, Mg	mg/L	0.1	230	390	450	300
Nickel, Ni	mg/L	0.005	0.008	0.046	0.067	0.22
Potassium, K	mg/L	0.1	130	200	240	160
Sodium, Na	mg/L	0.5	3300	3400	3700	2700
Zinc, Zn	mg/L	0.01	0.05	<0.01	0.27	0.79
Mercury (dissolved) in Water Method: AN311/AN312						
Mercury	mg/L	0.0001	<0.00010	<0.00010	<0.00010	0.00017

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ANALYTICAL REPORT

PE075356 R0

Parameter	Units	LOR	PE075356.005	PE075356.006	PE075356.007	PE075356.008
Sample Matrix			Water	Water	Water	Water
Sample Date			27 Feb 2013	27 Feb 2013	27 Feb 2013	27 Feb 2013
Sample Name			MRP-NND5036	MRP-NND5038	MRP-NND5032	MRP-KB002
Calculation of Anion-Cation Balance (SAR Calc) Method: AN121						
Anion-Cation Balance	%	-100	3	0	1	2

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ANALYTICAL REPORT

PE075356 R0

Parameter	Units	LOR	Sample Number: PE075356.009 Sample Matrix: Water Sample Date: 27 Feb 2013 Sample Name: MRP-KB004	PE075356.010 Water 28 Feb 2013 MRP-NNA5508	PE075356.011 Water 28 Feb 2013 MRP-WB01	PE075356.012 Water 28 Feb 2013 MRP-WB5
pH in water Method: AN101						
pH	pH Units	0.1	6.0	7.6	4.1	3.8
Conductivity and TDS by Calculation - Water Method: AN106						
Conductivity @ 25 C	µS/cm	2	11000	21000	91000	49000
Total Dissolved Solids (TDS) in water Method: AN113						
Total Dissolved Solids Dried at 180°C	mg/L	10	6480	13700	76200	37600
Alkalinity Method: AN135						
Total Alkalinity as CaCO3	mg/L	5	<5	280	<5	<5
Bicarbonate Alkalinity as HCO3	mg/L	5	5	340	<5	<5
Carbonate Alkalinity as CO3	mg/L	1	<1	<1	<1	<1
Hydroxide Alkalinity as OH	mg/L	5	<5	<5	<5	<5
Chloride by Discrete Analyser in Water Method: AN274						
Chloride	mg/L	1	3100	7100	38000	19000
Sulphate in water Method: AN275						
Sulphate	mg/L	1	860	1200	6600	3900
Metals in Water (Dissolved) by ICPOES Method: AN320/AN321						
Arsenic, As	mg/L	0.02	<0.02	<0.02	<0.10↑	<0.10↑
Cadmium, Cd	mg/L	0.001	<0.001	<0.001	<0.005↑	<0.005↑
Calcium, Ca	mg/L	0.2	140	260	400	690
Chromium, Cr	mg/L	0.005	0.016	0.006	<0.025↑	<0.025↑
Copper, Cu	mg/L	0.005	0.012	<0.005	<0.025↑	<0.025↑
Lead, Pb	mg/L	0.02	<0.020	<0.020	0.66	<0.10↑
Magnesium, Mg	mg/L	0.1	220	310	2400	840
Nickel, Ni	mg/L	0.005	0.21	0.020	0.070	0.060
Potassium, K	mg/L	0.1	110	180	740	280
Sodium, Na	mg/L	0.5	2000	4600	24000	9200
Zinc, Zn	mg/L	0.01	0.78	0.49	0.12	0.17
Mercury (dissolved) in Water Method: AN311/AN312						
Mercury	mg/L	0.0001	0.00028	<0.00010	<0.00010	<0.00010

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ANALYTICAL REPORT

PE075356 R0

Parameter	Units	LOR	Sample Number: PE075356.009 Sample Matrix: Water Sample Date: 27 Feb 2013 Sample Name: MRP-KB004	PE075356.010 Water 28 Feb 2013 MRP-NNA5508	PE075356.011 Water 28 Feb 2013 MRP-WB01	PE075356.012 Water 28 Feb 2013 MRP-WB5
Calculation of Anion-Cation Balance (SAR Calc) Method: AN121						
Anion-Cation Balance	%	-100	3	2	4	-10

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QC SUMMARY

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula: *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

Alkalinity Method: ME-(AU)-[ENV]AN135

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Total Alkalinity as CaCO3	LB060016	mg/L	5	<5	4%	99%
Bicarbonate Alkalinity as HCO3	LB060016	mg/L	5	<5		
Carbonate Alkalinity as CO3	LB060016	mg/L	1	<1		
Hydroxide Alkalinity as OH	LB060016	mg/L	5	<5		

Chloride by Discrete Analyser in Water Method: ME-(AU)-[ENV]AN274

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Chloride	LB059981	mg/L	1	<1	0 - 2%	102 - 103%	-249 - 83%

Conductivity and TDS by Calculation - Water Method: ME-(AU)-[ENV]AN106

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
Conductivity @ 25 C	LB060014	µS/cm	2	<2	1%	99%

Mercury (dissolved) in Water Method: ME-(AU)-[ENV]AN311/AN312

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Mercury	LB060041	mg/L	0.0001	<0.00010	0%	111%	115%

Metals in Water (Dissolved) by ICPOES Method: ME-(AU)-[ENV]AN320/AN321

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Arsenic, As	LB059969	mg/L	0.02	<0.02	1%	110%	
Cadmium, Cd	LB059969	mg/L	0.001	<0.001	37%	114%	
Calcium, Ca	LB059969	mg/L	0.2	<0.2	9%	100%	100%
Chromium, Cr	LB059969	mg/L	0.005	<0.005	2%	104%	
Copper, Cu	LB059969	mg/L	0.005	<0.005	0%	106%	
Lead, Pb	LB059969	mg/L	0.02	<0.020	0%	109%	
Magnesium, Mg	LB059969	mg/L	0.1	<0.1	2%	102%	102%
Nickel, Ni	LB059969	mg/L	0.005	<0.005	3%	111%	
Potassium, K	LB059969	mg/L	0.1	<0.1	6%	114%	117%
Sodium, Na	LB059969	mg/L	0.5	<0.5	4%	111%	104%
Zinc, Zn	LB059969	mg/L	0.01	<0.01	6%	108%	

MB blank results are compared to the Limit of Reporting
LCS and MS spike recoveries are measured as the percentage of analyte recovered from the sample compared the the amount of analyte spiked into the sample.
DUP and MSD relative percent differences are measured against their original counterpart samples according to the formula: *the absolute difference of the two results divided by the average of the two results as a percentage*. Where the DUP RPD is 'NA' , the results are less than the LOR and thus the RPD is not applicable.

pH in water   Method: ME-(AU)-[ENV]AN101

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery
pH	LB060014	pH Units	0.1	5.6 - 5.7	0 - 1%	100%

Sulphate in water   Method: ME-(AU)-[ENV]AN275

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery
Sulphate	LB059981	mg/L	1	<1	1 - 5%	102 - 103%	99 - 100%

Total Dissolved Solids (TDS) in water   Method: ME-(AU)-[ENV]AN113

Parameter	QC Reference	Units	LOR	MB	DUP %RPD	LCS %Recovery	MS %Recovery	MSD %RPD
Total Dissolved Solids Dried at 180°C	LB059995	mg/L	10	<10	1 - 2%	100 - 104%	107%	4%

METHOD	METHODOLOGY SUMMARY
AN020	Unpreserved water sample is filtered through a 0.45µm membrane filter and acidified with nitric acid similar to APHA3030B.
AN101	pH in Soil Sludge Sediment and Water: pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity and TDS by Calculation: Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Total Dissolved Salts can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. SGS use 0.6. Reference APHA 2520 B.
AN113	Total Dissolved Solids: A well-mixed filtered sample of known volume is evaporated to dryness at 180°C and the residue weighed. Approximate methods for correlating chemical analysis with dissolved solids are available. Reference APHA 2540 C.
AN121	This method is used to calculation the balance of major Anions and Cations in water samples and converts major ion concentration to milliequivalents and then summed. Anions sum and Cation sum is calculated as a difference and expressed as a percentage.
AN121	The sum of cations and anions in mg/L may also be reported. This sums Na, K, Ca, Mg, NH3, Fe, Cl, Total Alkalinity, SO4 and NO3.
AN135	Alkalinity (and forms of) by Titration: The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN135	Free and Total Carbon Dioxide may be calculated using alkalinity forms only when the samples TDS is <500mg/L. If TDS is >500mg/L free or total carbon dioxide cannot be reported. APHA4500CO2 D.
AN274	Chloride by Aquakem DA: Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	Sulphate by Aquakem DA: Sulphate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulphate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN311/AN312	Mercury by Cold Vapour AAS in Waters: Mercury ions are reduced by stannous chloride reagent in acidic solution to elemental mercury. This mercury vapour is purged by nitrogen into a cold cell in an atomic absorption spectrometer or mercury analyser. Quantification is made by comparing absorbances to those of the calibration standards. Reference APHA 3112/3500.
AN320/AN321	Metals by ICP-OES: Samples are preserved with 10% nitric acid for a wide range of metals and some non-metals. This solution is measured by Inductively Coupled Plasma. Solutions are aspirated into an argon plasma at 8000-10000K and emit characteristic energy or light as a result of electron transitions through unique energy levels. The emitted light is focused onto a diffraction grating where it is separated into components.
AN320/AN321	Photomultipliers or CCDs are used to measure the light intensity at specific wavelengths. This intensity is directly proportional to concentration. Corrections are required to compensate for spectral overlap between elements. Reference APHA 3120 B.

FOOTNOTES

IS	Insufficient sample for analysis.	QFH	QC result is above the upper tolerance
LNR	Sample listed, but not received.	QFL	QC result is below the lower tolerance
*	This analysis is not covered by the scope of accreditation.	-	The sample was not analysed for this analyte
^	Performed by outside laboratory.	NVL	Not Validated
LOR	Limit of Reporting		
↑↓	Raised or Lowered Limit of Reporting		

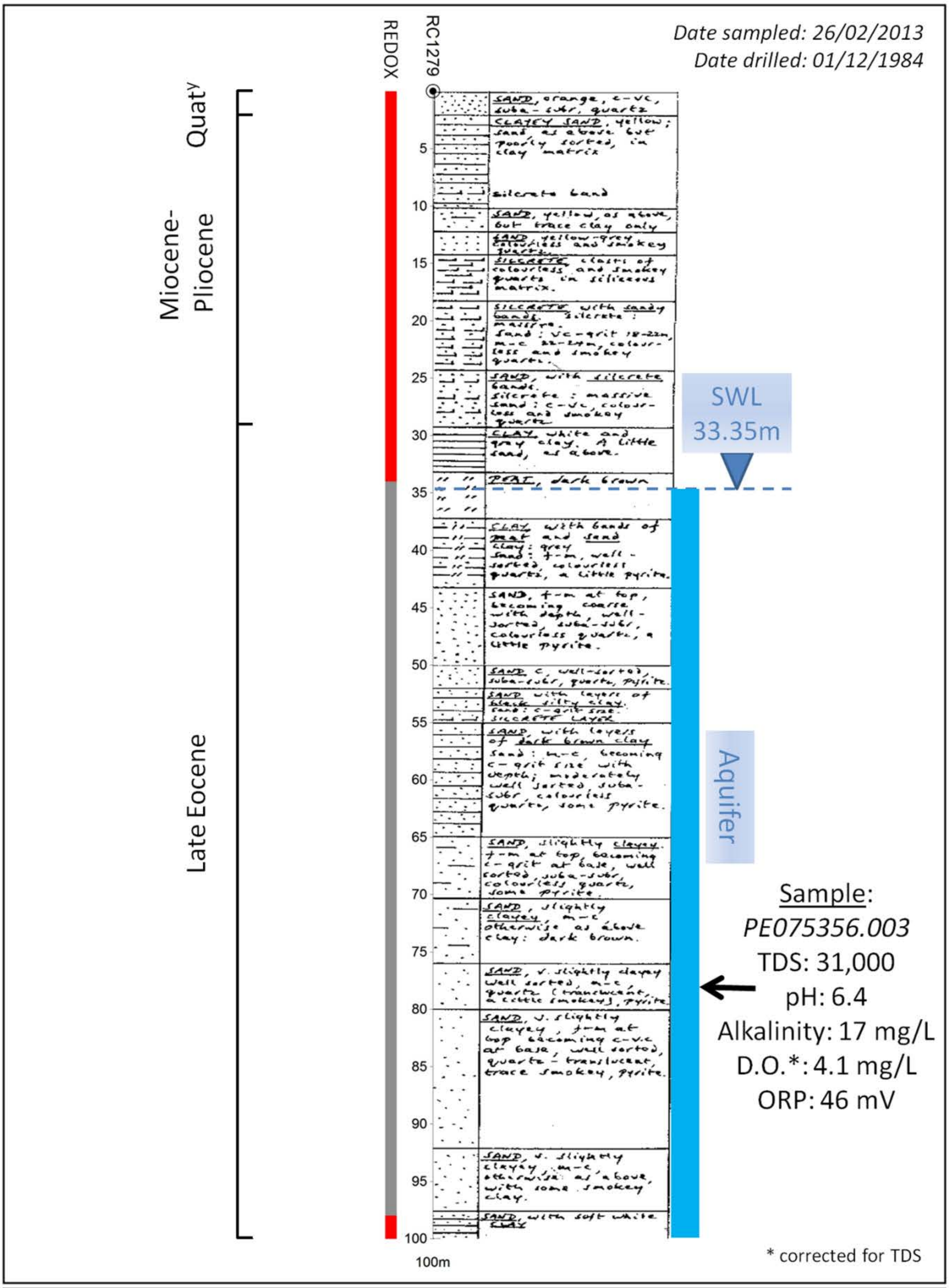
Samples analysed as received.
Solid samples expressed on a dry weight basis.

Some totals may not appear to add up because the total is rounded after adding up the raw values.

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: http://www.sgs.com.au.pv.sgsv3/~/media/Local/Australia/Documents/Technical%20Documents/MP-AU-ENV-QU-022%20QA%20QC%20Plan.pdf

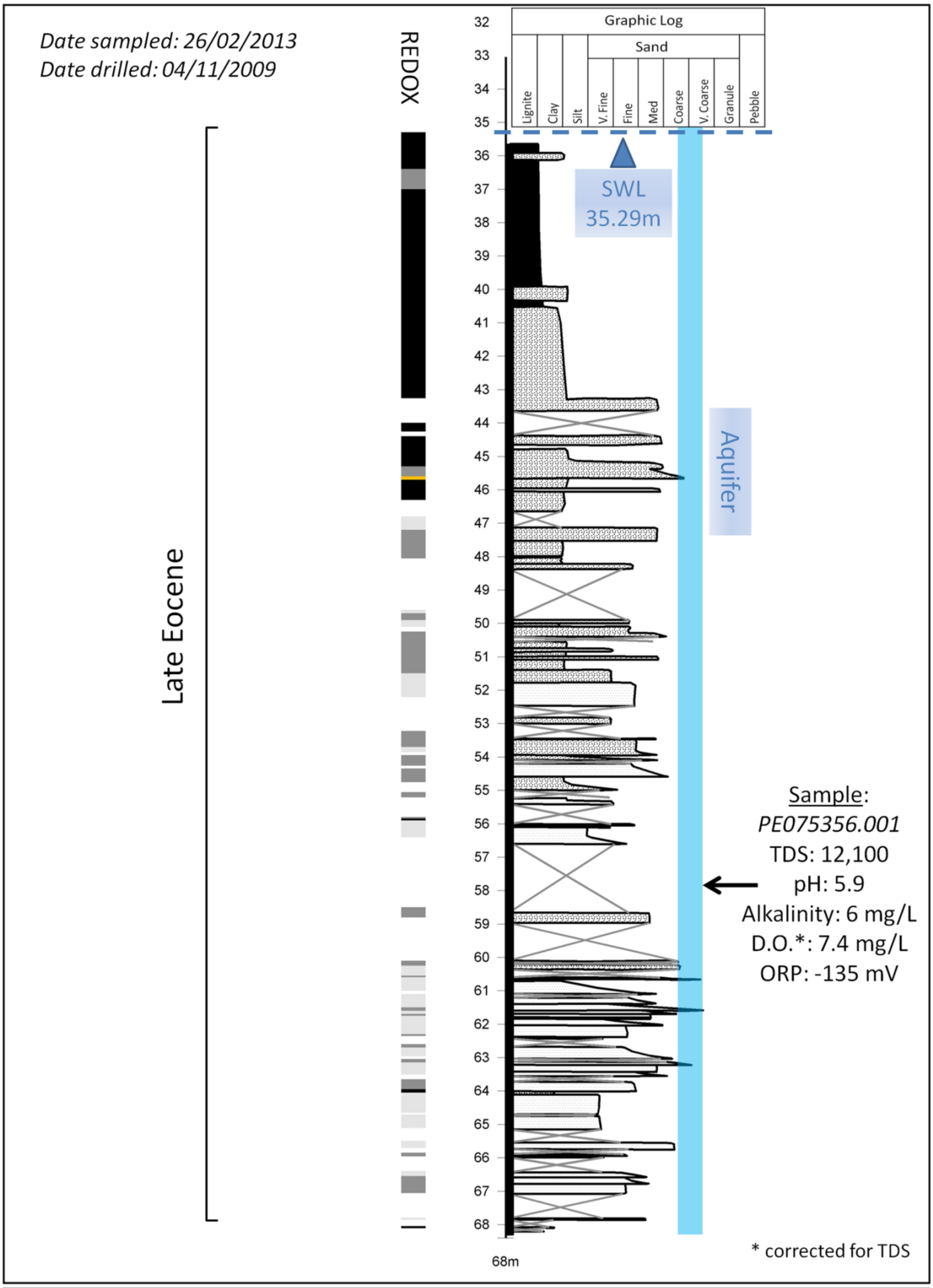
Appendix C

Data Sheets – Bore Hole Stratigraphic Logs



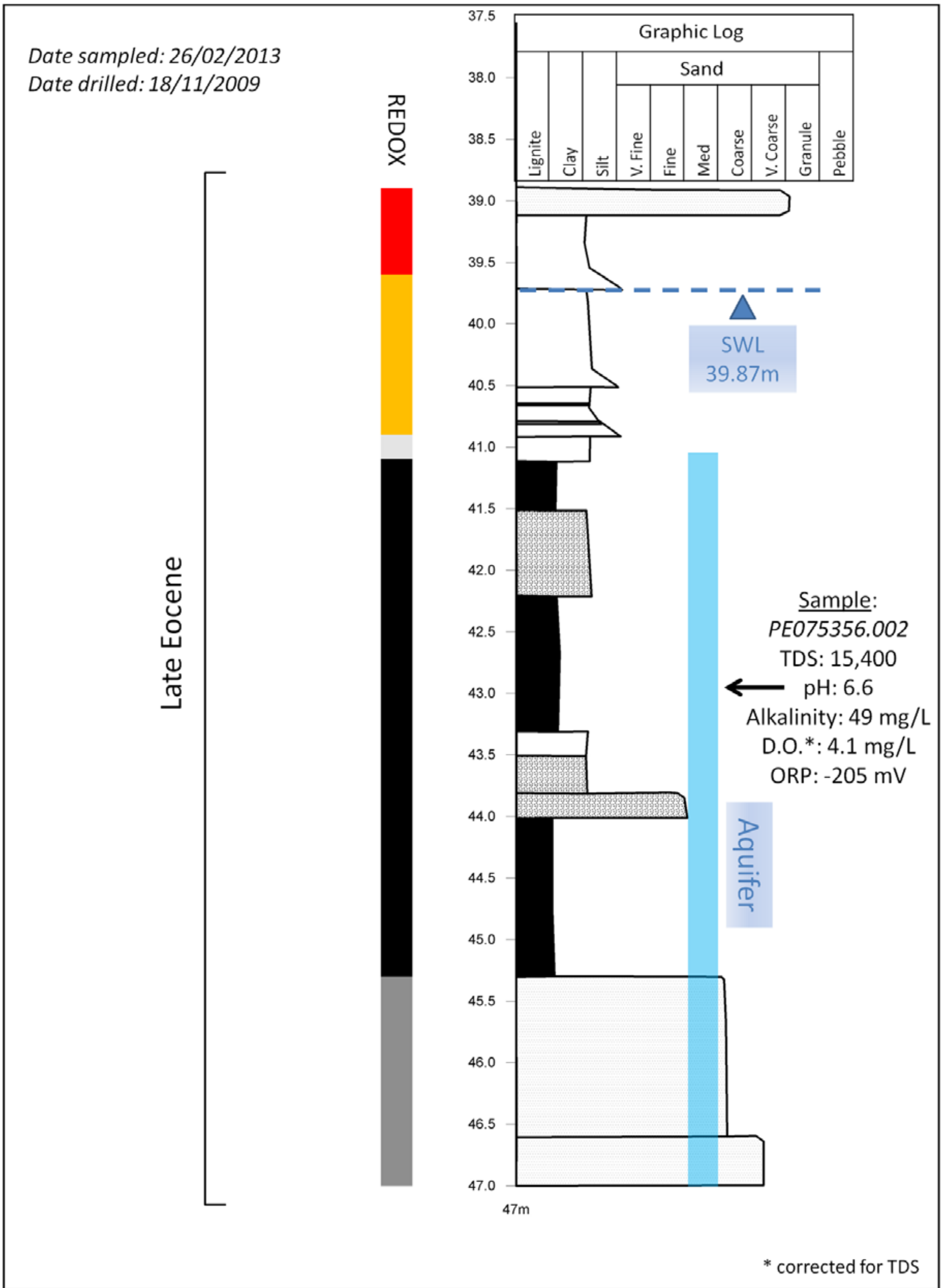
VIMY RESOURCES

Simplified geological profile: RC1279



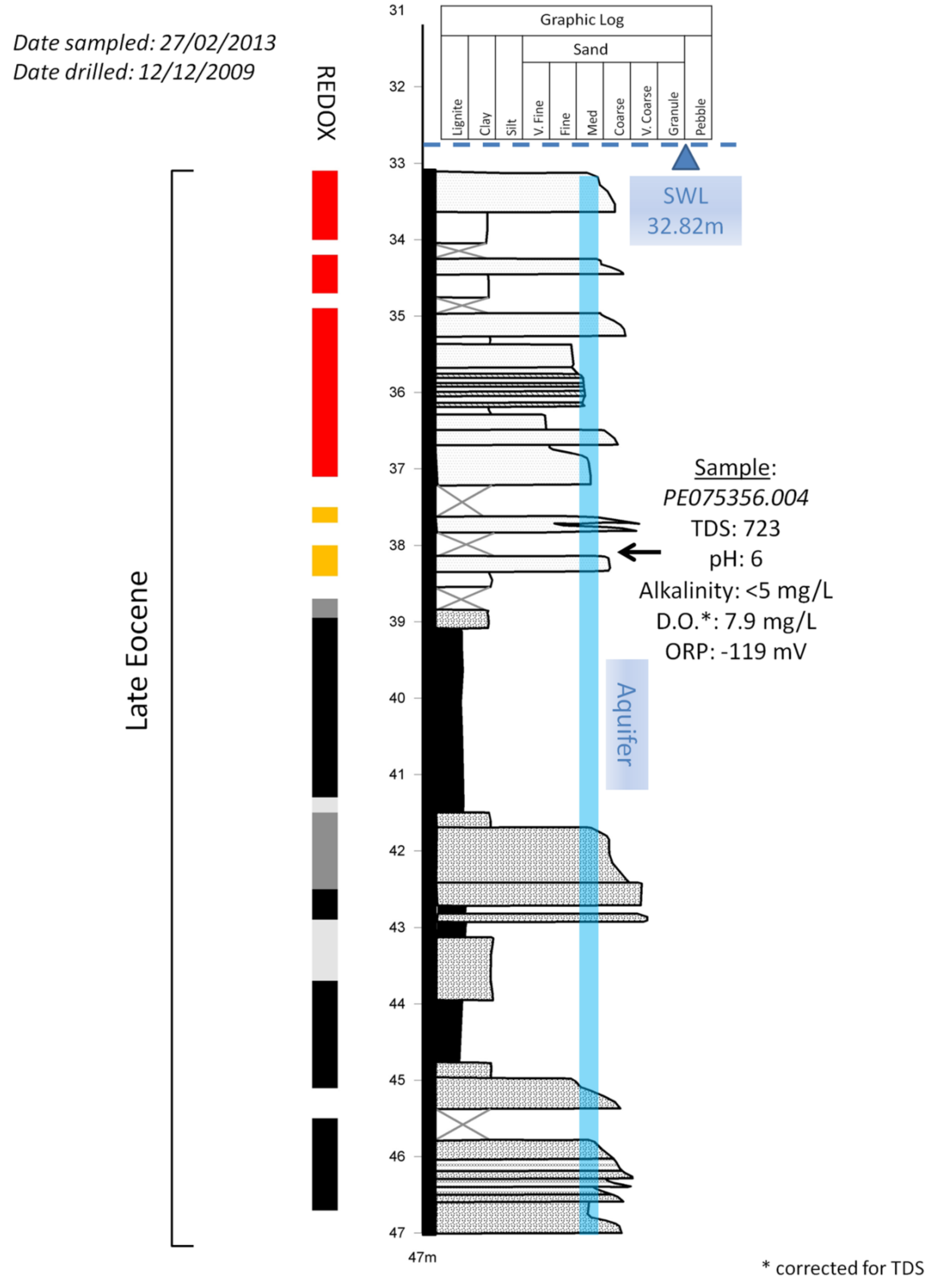
VIMY RESOURCES

Simplified geological profile: NND5030



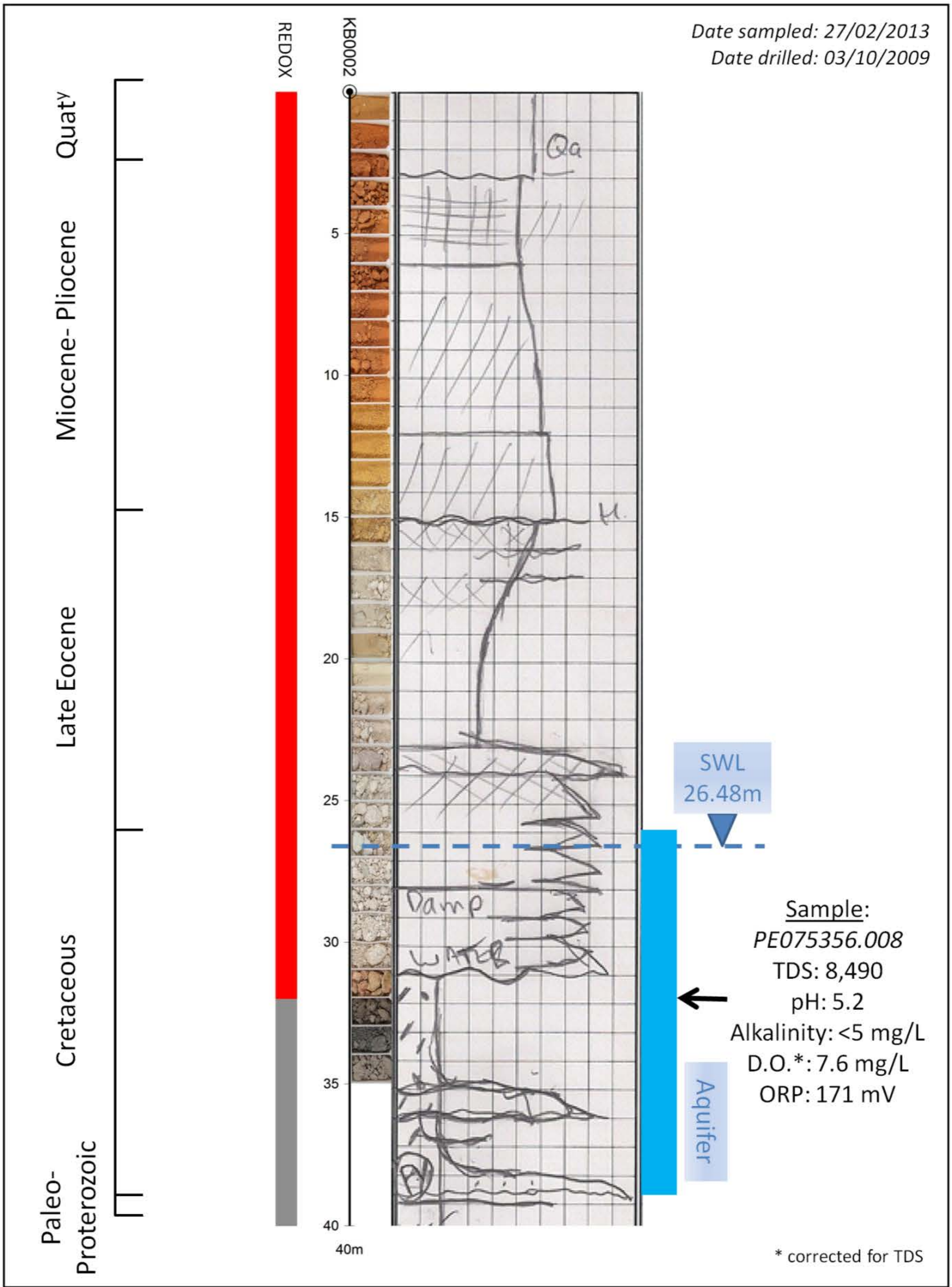
VIMY RESOURCES

Simplified geological profile: NND5034



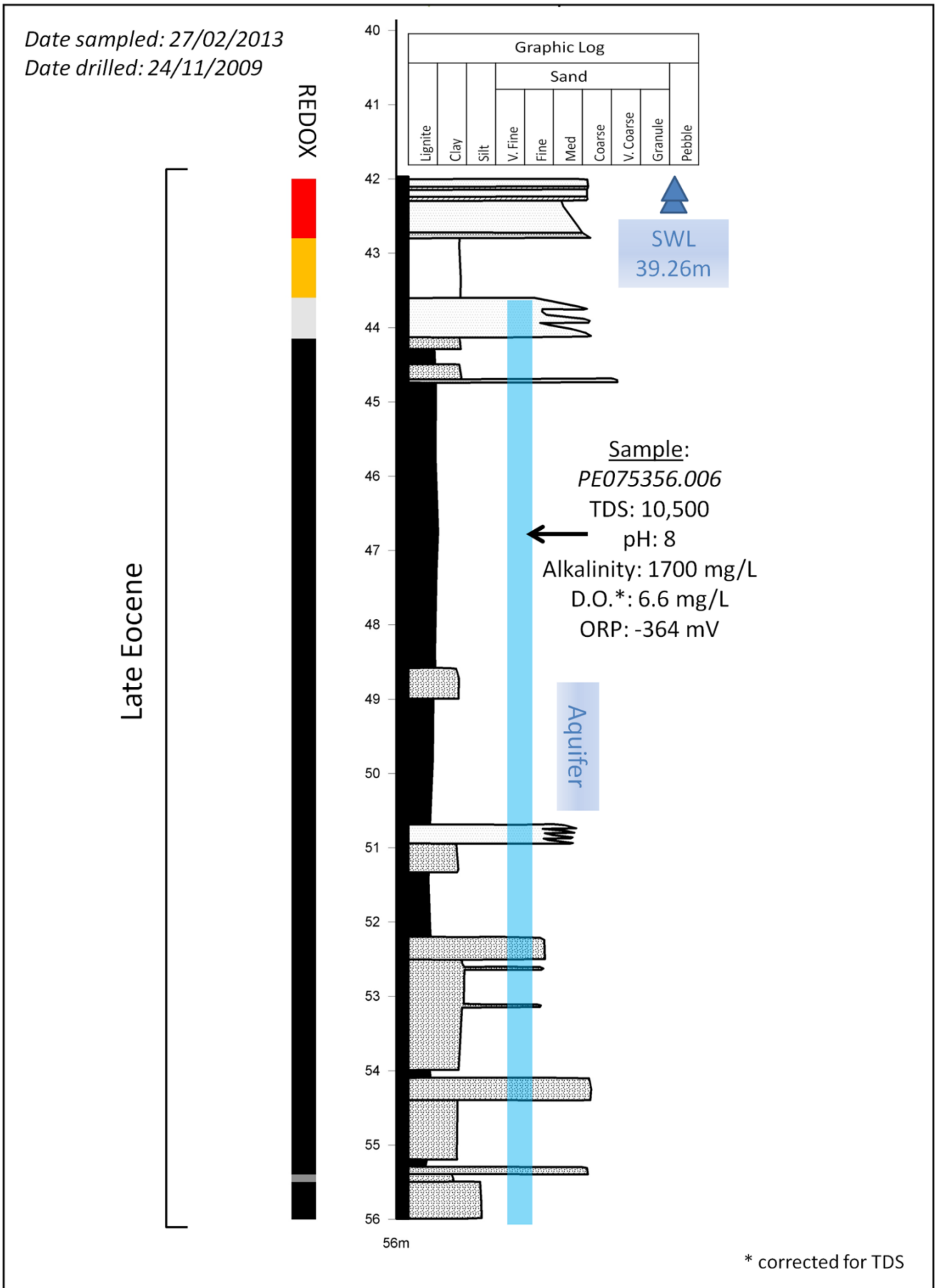
VIMY RESOURCES

Simplified geological profile: NND5040



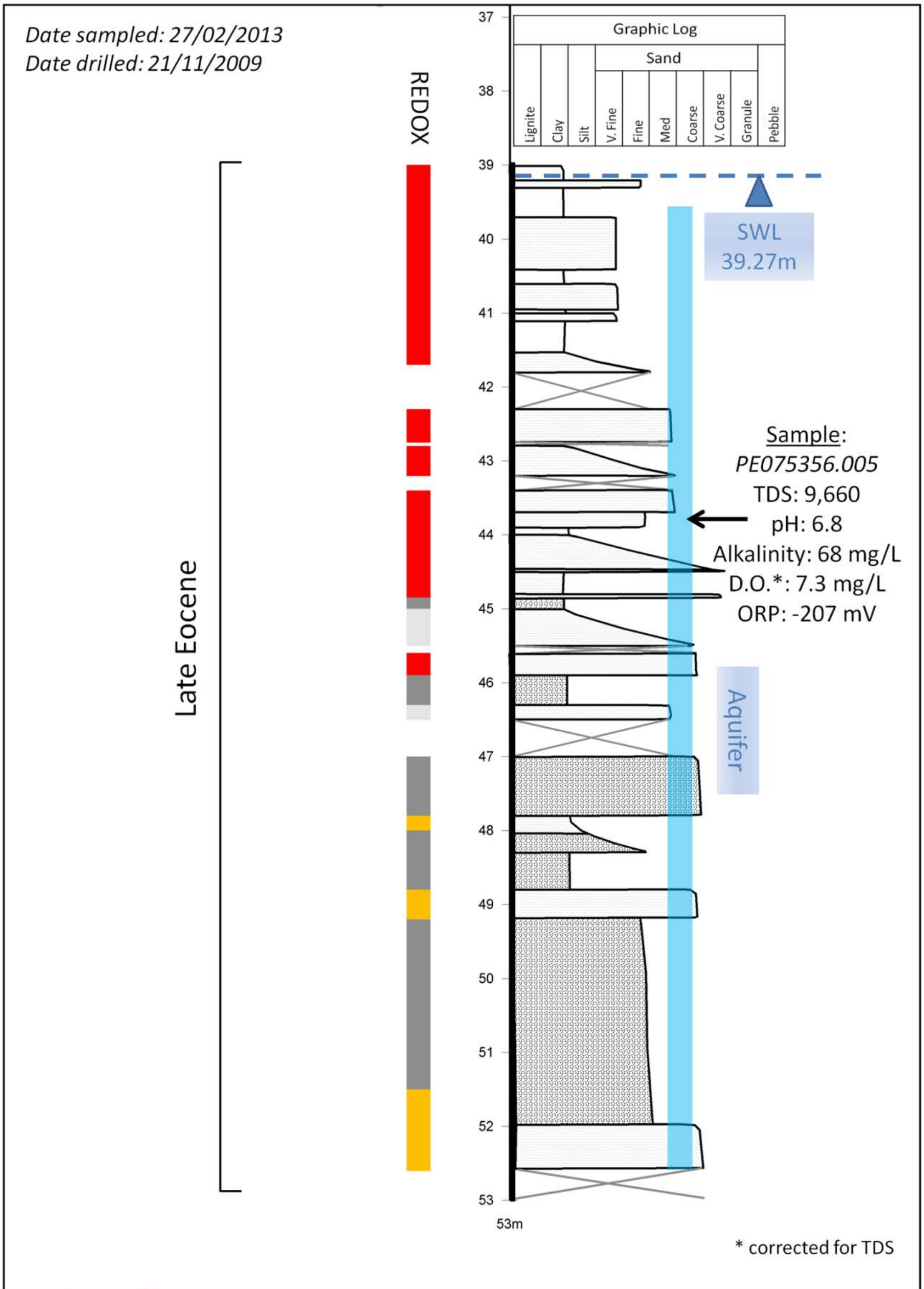
Simplified geological profile: KB02

VIMY RESOURCES

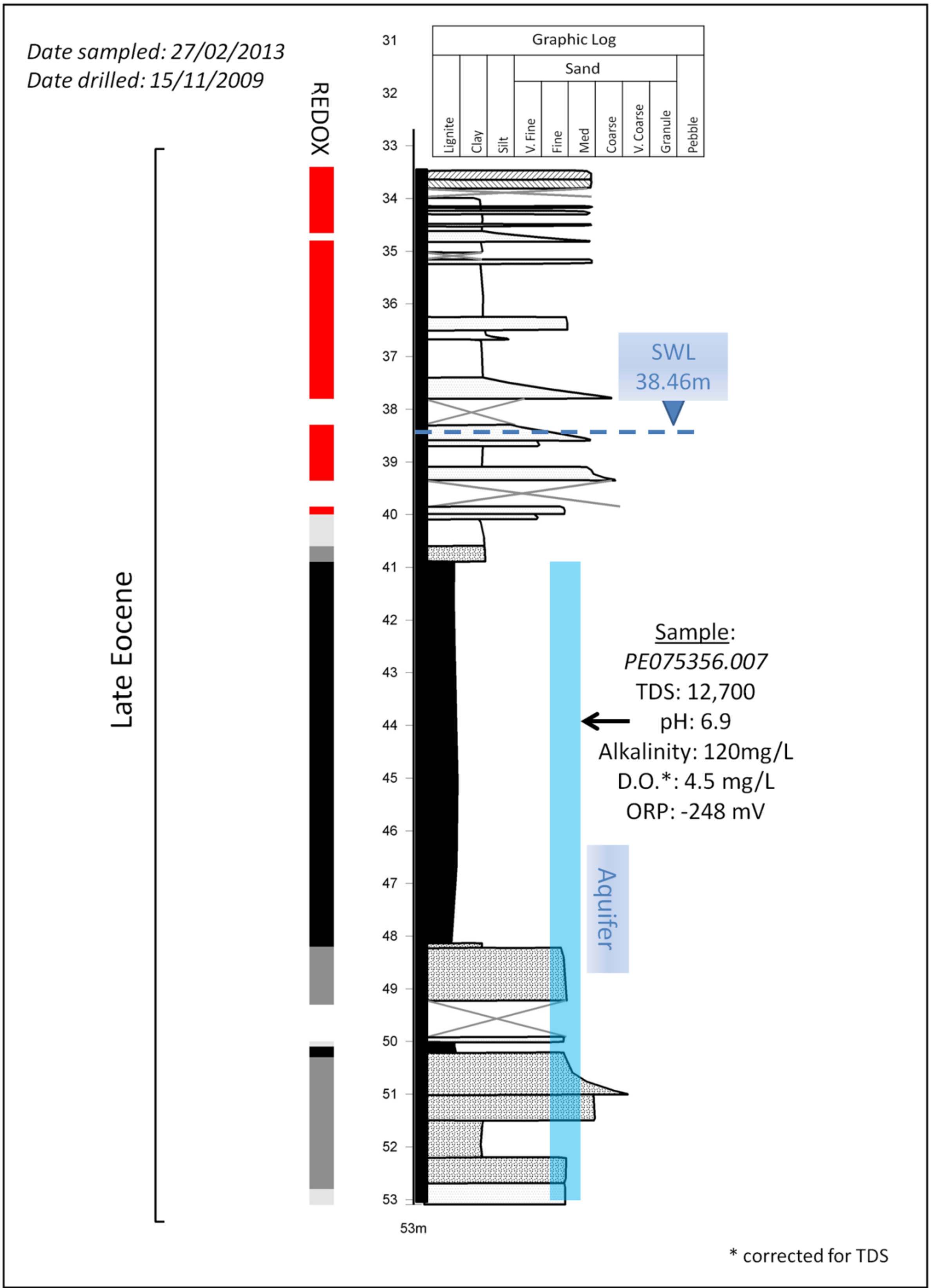


VIMY RESOURCES

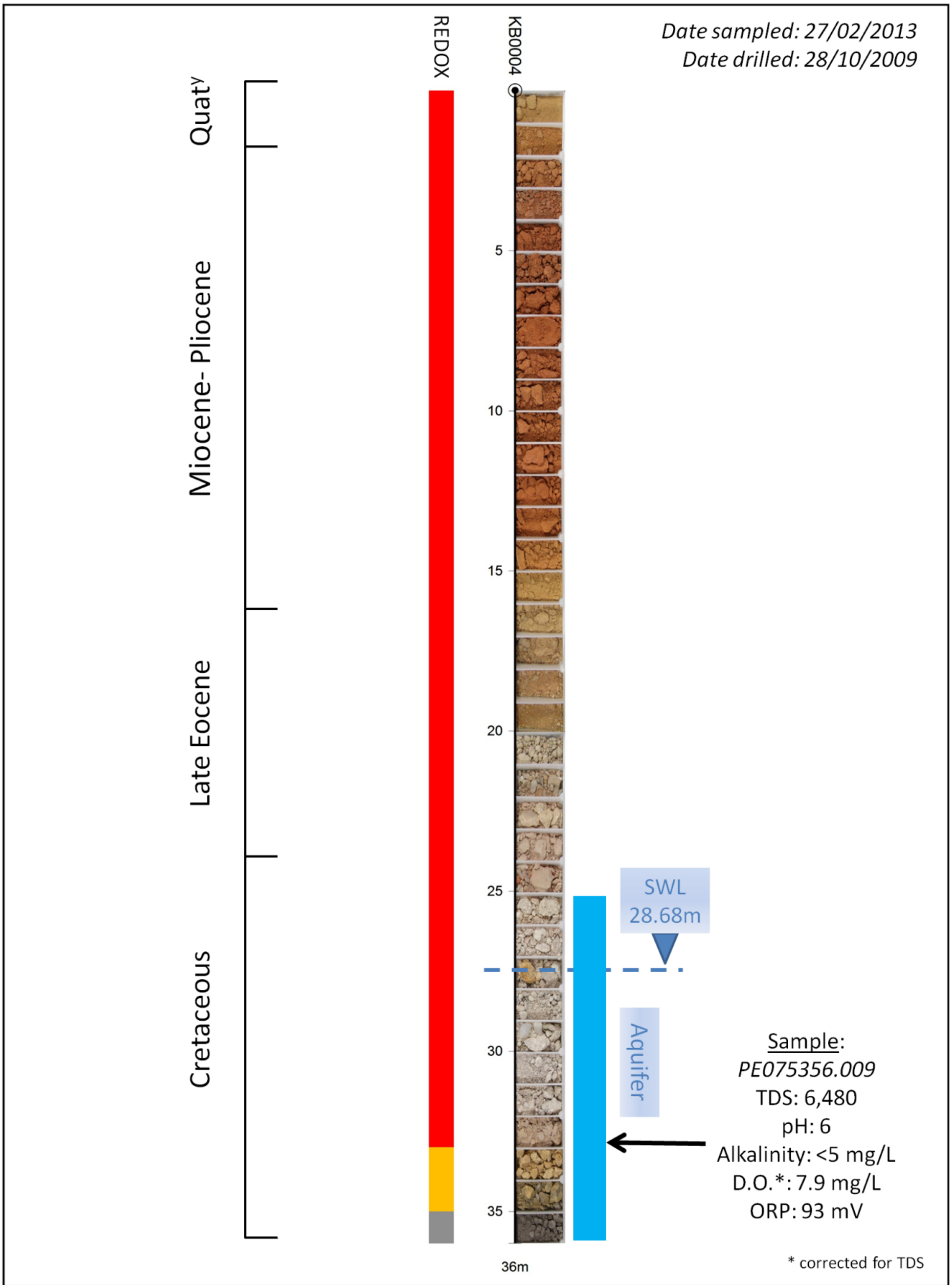
Simplified geological profile: NND5038



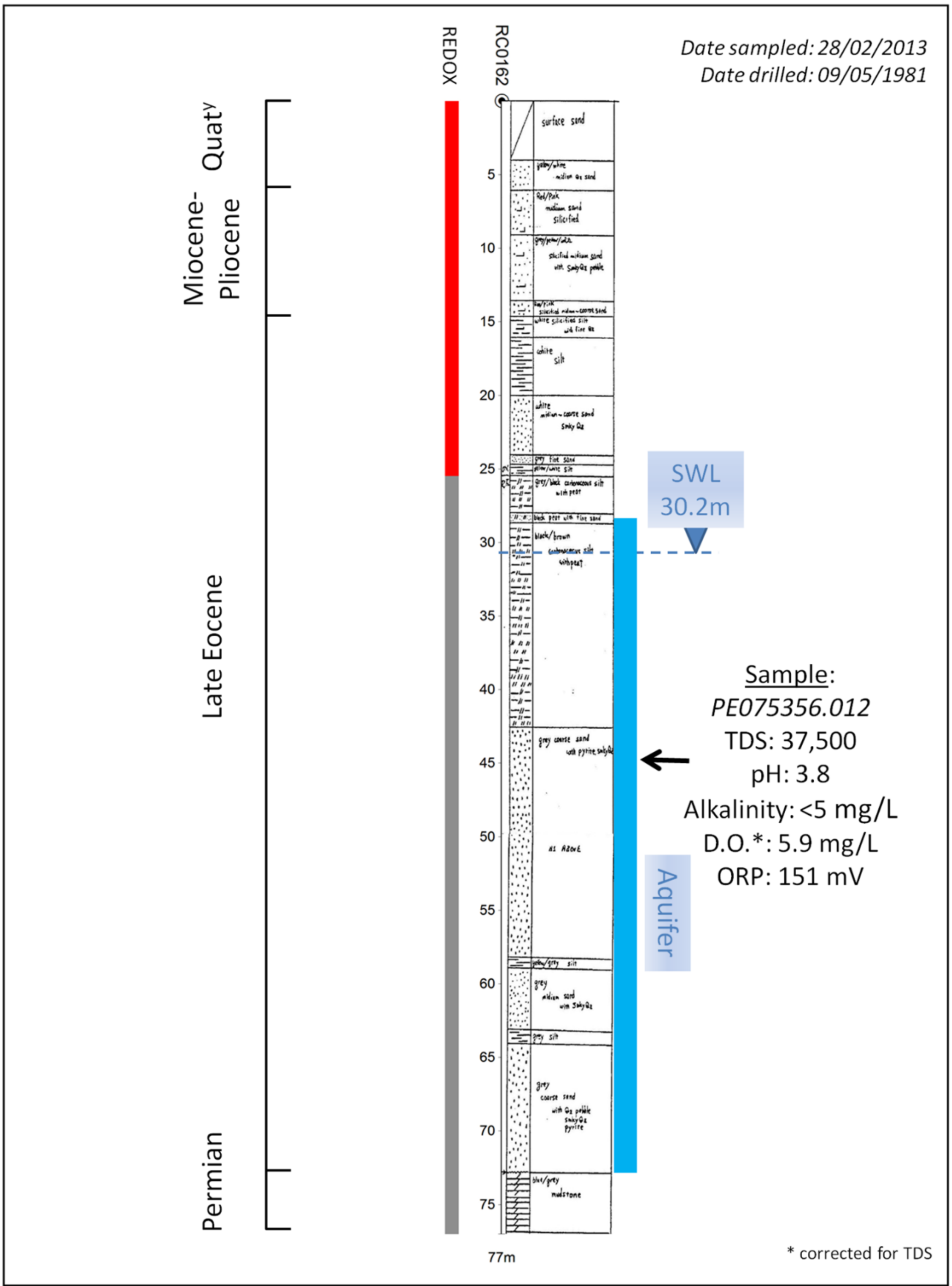
Simplified geological profile:
NND5036



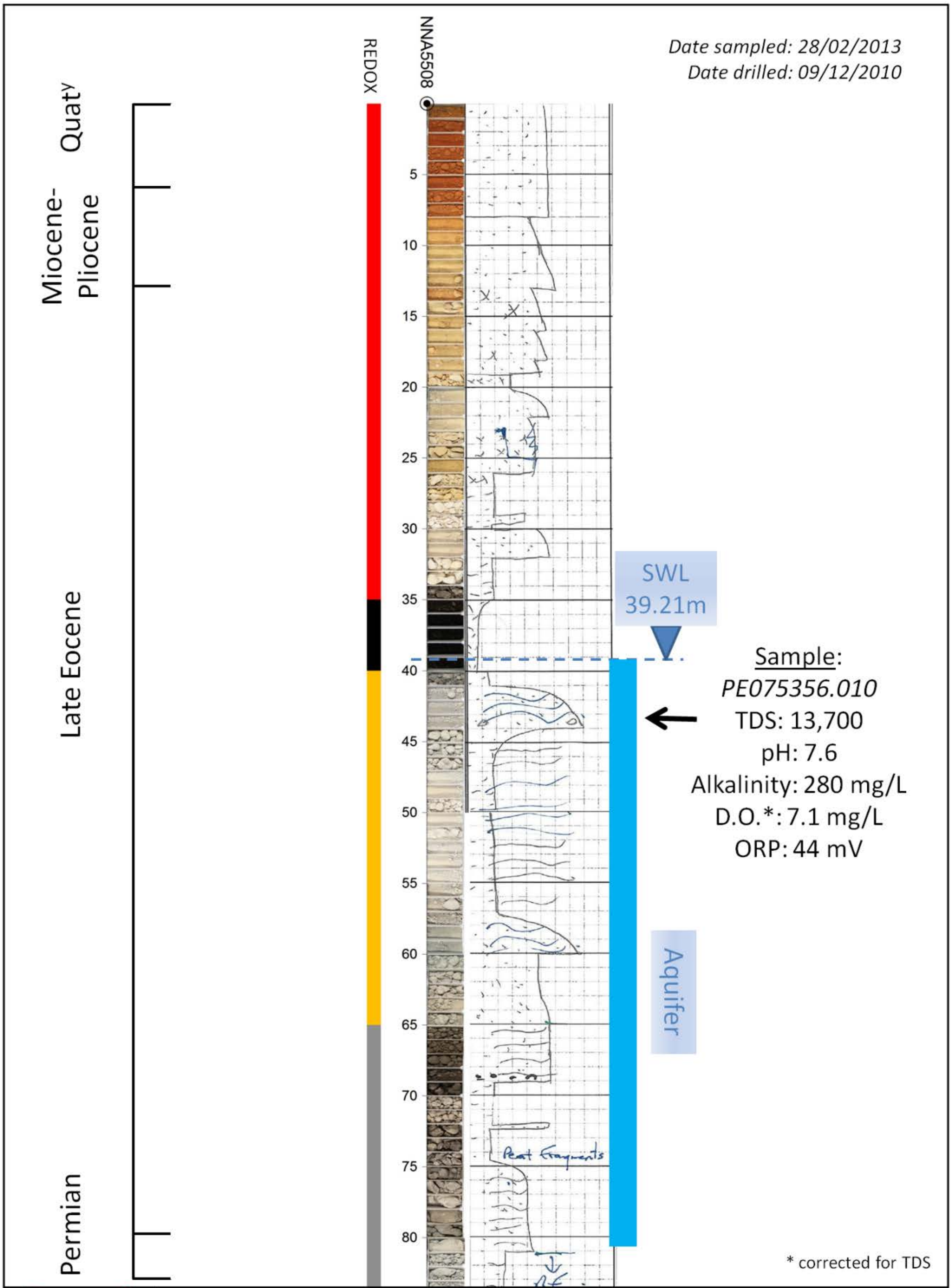
Simplified geological profile: NND5032



Simplified geological profile:
KB04



Simplified geological profile: RC0162 (WB5)



Simplified geological profile: NNA5508

Appendix D

Plates

Plate D - 1: Measuring SWL with Heron Water Level Meter

Plate D - 2: Bailing Groundwater Sample

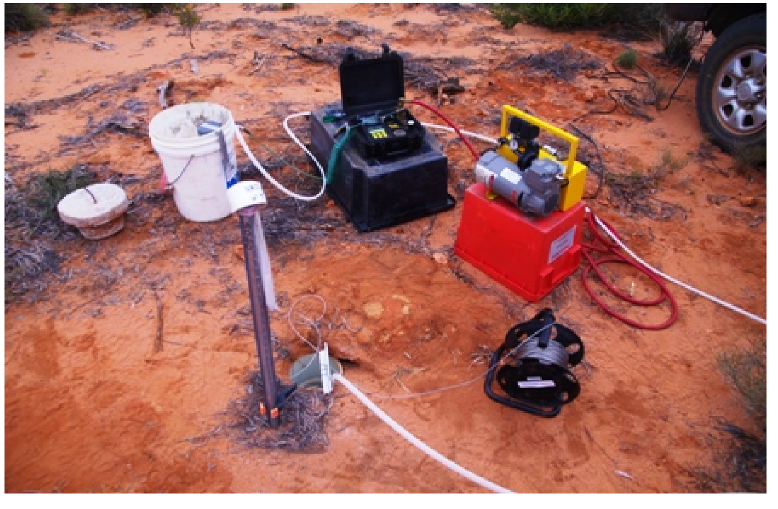


Plate D - 3: Trialling Bladder Pump System

Plate D - 4: Completing Trawl with 50µm Net

Plate D - 5: Rinsing Trawl Net

Plate D - 6: Checking Sample Flask Content with Hand Lens

Plate D - 7: Rinsing Netbottle Prior to Reuse

Plate D - 8: Decontaminating Nets Between Holes

Plate D - 9: WB05

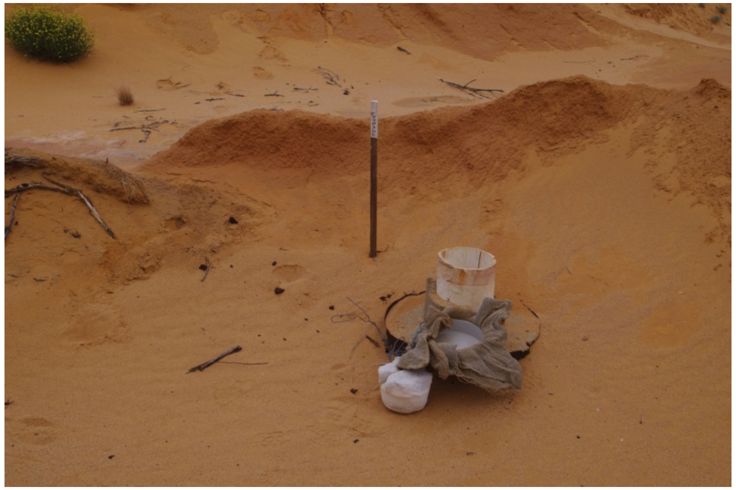


Plate D - 10: WB06

Plate D -11: KB004

Plate D - 12: KB002

Plate D - 13: RC1279 (WB7)

Plate D - 14: NND5030

Plate D - 15: NND5034

Plate D - 16: NND5036

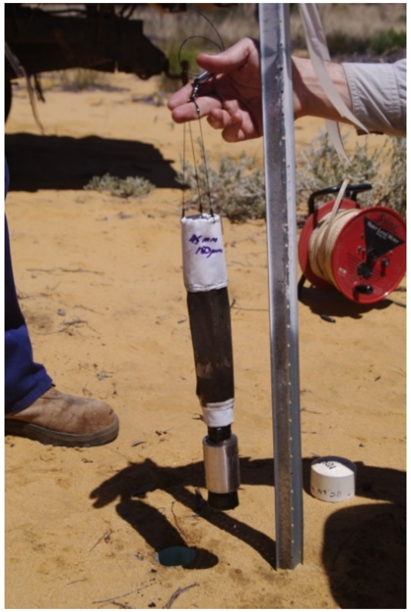


Plate D - 17: NND5032

Plate D - 18: NND5038

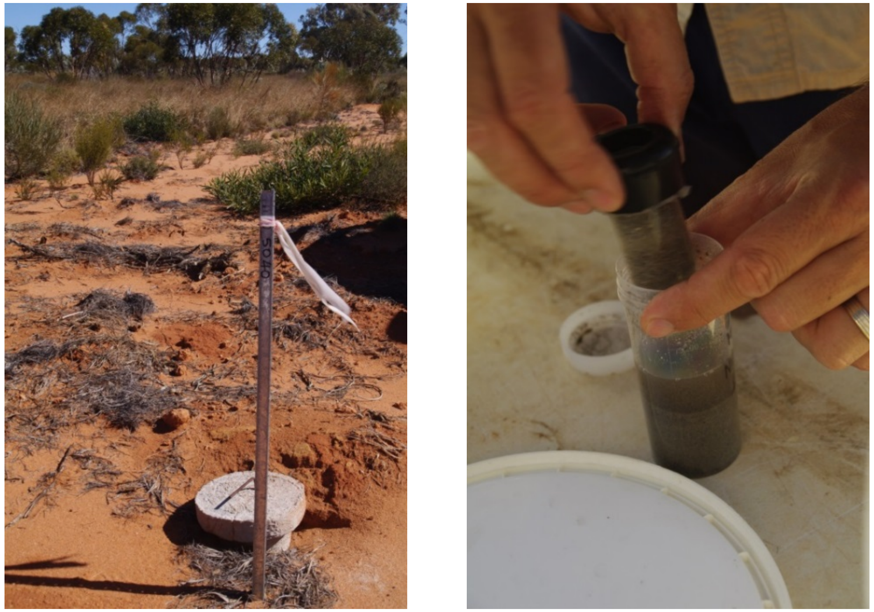


Plate D - 19: NND5040