## 4.13 STYGOFAUNA

### 4.13.1 Sampling Program

*This section responds to the submissions from stakeholders regarding the adequacy of the sampling program, in particular why the survey was limited to a single bore survey and included only very few bores in alluvial and colluvial geological units and none in Tertiary volcanics or within the Breeza State Forest.*

*Submission reference: RA13 and SIG10*

*Summary response: The Stygofauna Impact Assessment for the Project included sampling from 20 bores within the alluvium and colluvium (six bores), interburden (five bores), weathered Permian (five bores) and target coal seams (four bores). Sampling within the Tertiary volcanics was carried out and found no Stygofauna present. Water quality analysis in the bores in the Breeza State Forest identified conditions unfavourable for hosting stygofauna.*

A Stygofauna Impact Assessment was completed for the Project (see Appendix U of the EIS). As part of this assessment, an initial desktop study was undertaken to determine the likelihood of stygofauna occurring within the Project Boundary and immediate surrounds. This involved a review of available hydrogeological, geological and water quality monitoring data and previous stygofauna studies. The Narrabri and Gunnedah Formations within the Upper Namoi alluvium were identified as the most potentially suitable aquifers in the vicinity of the Project Boundary to host stygofauna.

As NSW has no designated or preferred stygofauna sampling protocol/guideline, the sampling protocol for the Project was designed to comply with the Western Australian (WA) Environmental Protection Authority *Guidance Statements for Sampling Subterranean Fauna* (WA EPA 2003, 2007). These guidelines have become the standard guidelines for stygofauna sampling in NSW, WA and Queensland. In addition, the sampling protocol designed for the Project complemented the WA protocol by undertaking additional sampling with a pump to increase the efficiency and accuracy of collection.

Following the desktop study, samples were collected from 20 bores (not one bore as suggested in a submission), screened within a range of strata present within the Project Boundary and the immediate vicinity, focusing on aquifers in the Narrabri and Gunnedah Formations and the weathered part of the Permian aquifers, as these were identified as the aquifers most suitable for stygofauna. EC was also considered during bore selection, with preference given to bores with favourable EC values for stygofauna occupation (i.e. EC <5,000 µS/cm).

For all cased bores with an internal diameter of 50 mm to 150 mm, samples were collected using the combined net and pump method, where suitable (Hancock and Boulton, 2009). For wells and unlined bores, samples were collected with a net only.

The water level at each bore was recorded prior to sampling followed by the measurement of pH, EC, temperature and dissolved oxygen concentration after pumping 10 L, 50 L and then every 50 L thereafter. Samples collected were sorted, counted and identified to a species level, where possible.

The bores sampled targeted the geological strata to be impacted by the Project and those identified as potential stygofauna habitat within the alluvium and colluvium (six bores), interburden (five bores), weathered Permian (five bores) and target coal seams (four bores).

No stygofauna were identified within the Project Boundary and its surrounds during the sampling program.

Extensive exploration by Shenhua Watermark throughout EL 7223 has confirmed that a capping of Tertiary basalts occurs in the eastern area of EL 7223 between the Eastern Mining Area and the village of Breeza, however is of limited extent and is unsaturated. The Groundwater Impact Assessment (Appendix T of the EIS) further confirms that the isolated occurrence of tertiary volcanics is not an interconnected aquifer and thus, unlikely to host stygofauna. Sample site WM0062 is located within the area of Tertiary volcanics within EL 7223 and did not identify any stygofauna to be present (see **Figure 71**).

The Breeza State Forest is predominately comprised of the Digby Formation geological unit. Monitoring data from 2010 to 2012 within groundwater monitoring bore WM0067A, located on the edge of Breeza State Forest in the Digby Formation, demonstrated EC levels ranging from 10,370 µS/cm to 11,830 µS/cm. This range of EC is beyond the favourable EC values for stygofauna occupation (i.e. EC <5,000 µS/cm) and thus, sampling within the Digby Formation was discounted as it was considered unlikely to host stygofauna.

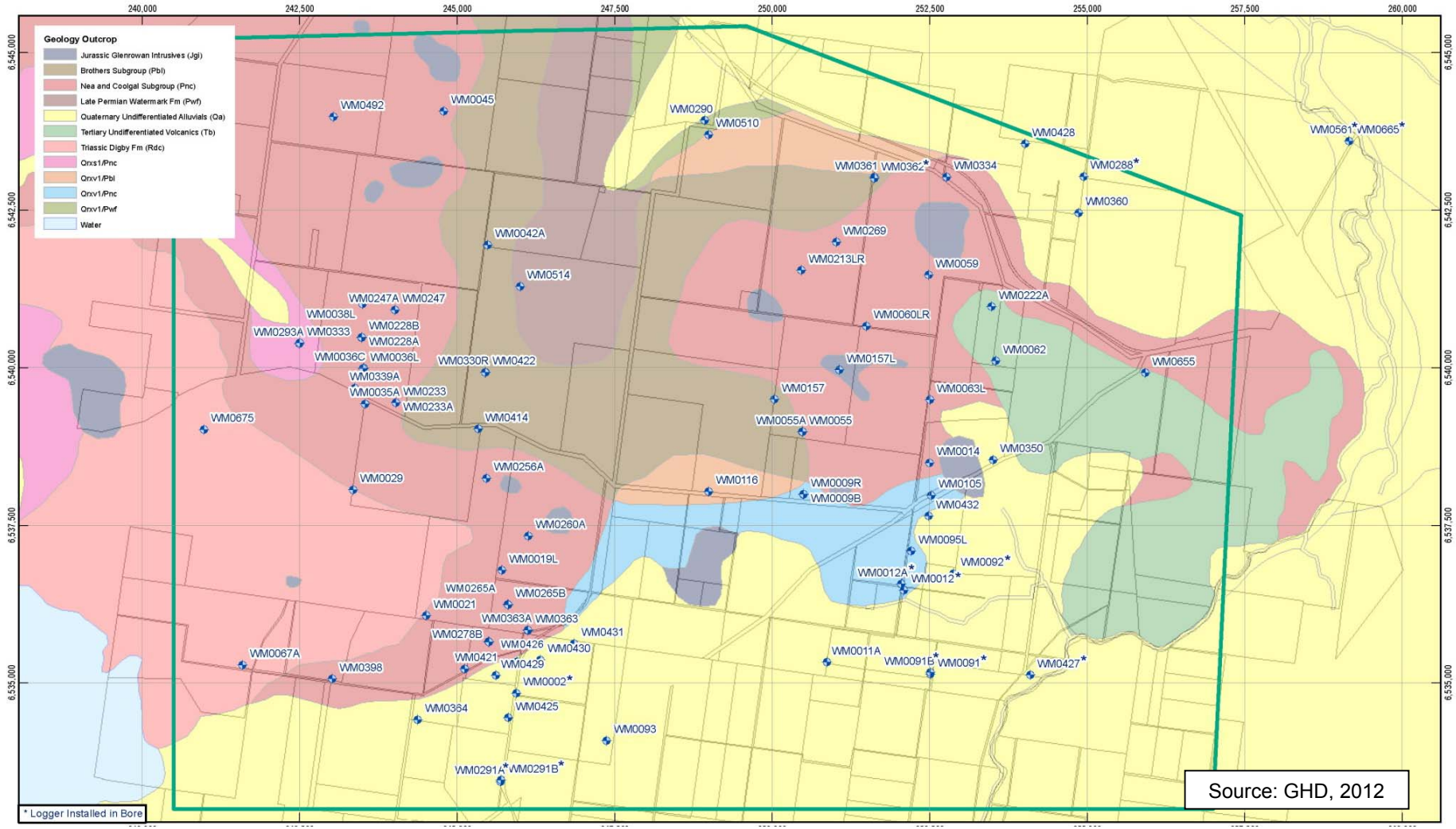


**Figure 71**

**Permian Formation Monitoring Bores and Geology**

### 4.13.2 Sampling Depths

*This section responds to submissions from stakeholders in regard to the relevance of sampling sites in the stygofauna survey, as sampling depths were not provided.*

*Submission reference: RA13 and SIG10*

*Summary response: Stygofauna sampling sites for the Project were selected based on an assessment of the aquifer monitored, water levels and other physiochemical properties. The sampling stratum (i.e. Gunnedah formation, Permian etc.) was considered to be a more relevant consideration for sampling site selection, as opposed to sampling depths, which are provided below.*

The Stygofauna Impact Assessment (Appendix U of the EIS) specified the bores selected for sampling, the relevant strata sampled (as correlated to a stratigraphic column), water levels and other physiochemical properties of the sample sites. Whilst the Stygofauna Impact Assessment did not specifically provide sample depths of the bores, the sampling strata was described which is more relevant in consideration of suitable sampling sites, as opposed to sampling depths. Nonetheless, **Table 54** provides the sampling depths of each bore and **Figure 72** illustrates the considerable range of the sample size to detect stygofauna within the Project Boundary and surrounds. The screen depth is the depth range of slotted screen within each groundwater monitoring bore which is the equivalent to the sampling depth.

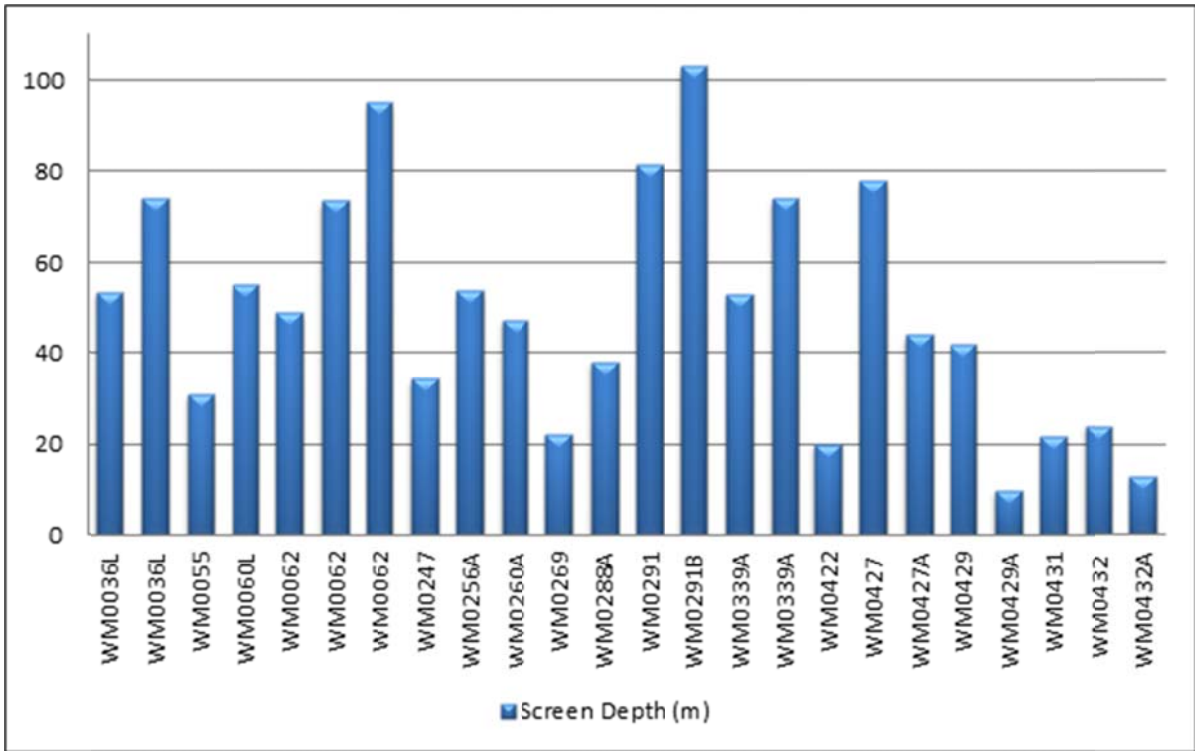


**Figure 72**
**Stygofauna Bore Sampling Depths**

**Table 54**
**Stygofauna Sample Sites and Depths**

| Sample Bore | Strata | Screen Depth (m) (Sampling Depth) |
|---|---|---|
| WM0036L | Fractured Interburden | 50.5 - 53.5<br>68 - 74 |
| WM0055 | Melvilles Seam | 28 - 31 |
| WM0060L | Interburden | 40-55 |
| WM0062 | Interburden inc. F Coal seam<br>Interburden<br>Melvilles Seam | 46.8 - 48.8<br>73.5<br>95 |
| WM0247 | Hoskisson Seam | 31.4 - 34.4 |
| WM0256A | Melvilles Seam | 50.8 - 53.8 |
| WM0260A | Interburden fault zone | 44.4 - 47.4 |
| WM0269 | Pamboola Formation | 17.6 - 22.1 |
| WM0288A | Narrabri Formation (alluvial) | 35 – 38 |
| WM0291 | Gunnedah Formation (alluvial) | 75.7 – 81.7 |
| WM0291B | Weathered Permian | 88 – 103 |
| WM0339A | Fractured interburden | 50 – 53<br>68 - 74 |
| WM0422 | Colluvium | 15 - 20 |
| WM0427 | Weathered Perm | 72 - 78 |
| WM0427A | Gunnedah Formation (alluvial) | 38 – 44 |
| WM0429 | Weathered Permian | 39 - 42 |
| WM0429A | Narrabri Formation (alluvial) | 7-10 |
| WM0431 | Weathered Permian | 18.5 – 21.5 |
| WM0432 | Weathered Permian | 21 - 24 |
| WM0432A | Narrabri Formation (alluvial) | 10 – 13 |

It is important to reiterate that stygofauna sampling was conducted using combined net and pump methods across all geological units/aquifers potentially impacted by the Project to enhance the likelihood of identifying stygofauna. The sampling program did not solely rely on collecting stygofauna samples with a pump from the bores.

### 4.13.3 Insitu Measurement Accuracy

*This section responds to submissions from stakeholders regarding the accuracy of the stygofauna sampling program due to concern the sampling methods did not allow for certainty in the accurate measurement of in-situ field water-chemical parameters.*

*Submission reference: RA13 and SIG10*

*Summary response: Water-chemical parameters were measured in the field and further verified by laboratory results as part of the groundwater monitoring program. This process is consistent with accepted guidelines for the sampling of stygofauna.*

As outlined in Section 1.2 of the Stygofauna Impact Assessment, the depth of the water table, salinity and dissolved oxygen are key factors influencing stygofauna presence in aquifers.

As such, the water level was measured at each bore using a water interface dip meter prior to sampling. Groundwater pH, EC, temperature, and dissolved oxygen were all measured during sampling using the pumping methods at 10 L, 50 L, and then every subsequent 50 L. In order to determine in-situ parameters in bores where pumping was not possible, water was collected using a groundwater bailer and the parameters were measured after 5 L was bailed from the bore.

Although the bailed water parameters were representative of the bore cavity rather than the aquifer water, these parameters were measured because it is the water from which net sampling collected stygofauna. Parameters were measured using a calibrated YSI-556 multi-parameter meter.

In addition, groundwater pH, EC, temperature and dissolved oxygen were measured both in the field and in the laboratory each month as part of the groundwater monitoring program. This data was used for validation purposes.

The method applied to measure insitu water-chemical parameters is consistent with the Western Australian Environmental Protection Authority *Guidance Statements for Sampling Subterranean Fauna* (WA EPA 2003, 2007), which were used in the absence of a NSW guideline.

### 4.13.4 Demonstration of Absence of Stygofauna

*This section responds to submissions from stakeholders that the absence of stygofauna has not been demonstrated; only inferred.*

*Submission reference: RA13 and SIG10*

*Summary response: Stygofauna sampling for the Project was conducted in 20 bores within groundwater aquifers identified as most likely to host stygofauna within the Project Boundary and its surrounds. No stygofauna were recorded during the survey. The absence of stygofauna has therefore been demonstrated consistent with the accepted guidelines.*

The sampling program for the Stygofauna Impact Assessment was designed to cover all geological units and aquifers potentially impacted by the Project. A comprehensive desktop analysis prior to field survey identified the Narrabri and Gunnedah formations (Upper Namoi Alluvium) as the aquifers most likely and suitable to host stygofauna.

Following the desktop study, samples were collected from 20 bores within the alluvium and colluvium (six bores), interburden (five bores), weathered Permian (five bores) and target coal seams (four bores). The sampling program used the combined net and pump method to enhance stygofauna identification. However, no stygofauna were recorded within the Project Boundary and its surrounds during the sampling program.

Further, an assessment of the existing groundwater regime and potential impacts that may occur to the system as a result of the Project, confirmed it is unlikely stygofauna communities will be affected should they occur within the Project Boundary or immediate surrounds.

As it is unlikely that there are significant stygofauna communities within or immediately surrounding the Project Boundary, and as operations are unlikely to cause major changes to the groundwater conditions in the Gunnedah Formation, no further sampling is necessary. The absence of stygofauna has been demonstrated consistent with the WA Environmental Protection Authority *Guidance Statements for Sampling Subterranean Fauna* (WA EPA 2003, 2007), which were used in the absence of a NSW guideline and demonstrate with certainty minimal impact to stygofauna due to the Project.

### 4.13.5 Depressurisation of the Gunnedah Formation and Impact to Stygofauna

*This section responds to the submissions from stakeholders regarding a perceived discrepancy in the predicted depressurisation values for the Gunnedah Formation.*

*Submission reference: P30 and SIG10*

*Summary response: The groundwater impacts as reported in the Stygofauna Impact Assessment are consistent with the EIS and Groundwater Impact Assessment. The predicted drawdown in the Gunnedah Formation is less than the 2 m maximum minimal harm criteria specified in the AIP.*

The Stygofauna Impact Assessment (see Appendix U of the EIS) provided the following from the Groundwater Impact Assessment (Appendix T of the EIS):

> *"As there will be no mining directly on the floodplain, the main impacts to the alluvial aquifers are likely to be through potential lowering of the water table from seepage from the Permian aquifers into the mine voids. Groundwater modelling indicates that small parts of the Gunnedah Formation could experience a decline in water table of up to 3.5 m during the life of the Project."*
>
> *The majority of this drawdown is less than 2 m and extends to a maximum radial extent of less than 4 km from the Project. Drawdown in the Gunnedah Formation commences towards the latter stage of mining activities (year 21). Groundwater impacts within the Gunnedah Formation recover close to detectable limits (less than 1 m) at the end of mining in year 30 (AGE, 2012). This is within the current range of fluctuations in the Gunnedah Formation, and would be unlikely to impact significantly on stygofauna communities if they occurred in the Project Boundary or in the immediate vicinity."*

Stakeholders expressed concern that the above stated maximum drawdown in the Gunnedah Formation (3.5 m) is different to the EIS and Groundwater Impact Assessment which reports drawdown in the Gunnedah Formation to be 1 to 2 m in Year 21. They further expressed concern that the predicted drawdown in the Gunnedah Formation may breach the AIP *"minimal impact considerations"*.

The maximum drawdown in the Gunnedah Formation (3.5 m) is measured at the very edge of the unit, closest to the mining activity and with the most potential impact. At this modelled point, there is a total available head of 31.6 m prior to mining. The groundwater model demonstrates that when the impacts are at their greatest in the Gunnedah Formation there is still 28.7 m of available water at Year 25.

**Figure 72** illustrates that in reality; any stygofauna present in the Gunnedah Formation at the very edge of the alluvium will remain in confined aquifer conditions and not be impacted. The only difference is that the pressure of the water surrounding them will decrease slightly, however this is predicted to recover rapidly at the end of mining.

Therefore, the groundwater impacts as reported in the Stygofauna Impact Assessment are consistent with the EIS and Groundwater Impact Assessment. Furthermore, the drawdown of the Gunnedah Formation is predicted to a maximum of 1.4 m in the closest private bore to the Project, which is less than the 2 m maximum minimal harm criteria specified in the AIP.