Uncertainty Analysis

Uncertainty analysis is an assessment of the impact that uncertainty in the assumed values of the input hydraulic parameters has on model predictions and model reliability. While the sensitivity analyses conducted by Aquaterra (2009) suggests that the model is not sensitive to changes in hydraulic parameter values, in the absence of prior experience with longwall mining in the Gunnedah Basin, Aquaterra (2009) undertook the following uncertainty analyses.

1. Accounting for the possibility that continuous fracturing could extend higher into the Garrawilla Volcanics.
2. Assuming higher and lower vertical hydraulic conductivities for the portions of Layers 5 to 8 within the longwall footprint.
3. Assuming the changed hydraulic parameters (of uncertainty analyses 2) within the fracture zone may reduce over time (lag factor of 1 to 2 years) to model the settling and/or redistribution of fines within the affected strata.

Detail on the parameter values incorporated into each uncertainty analysis model run are provided by Aquaterra (2009 – see *Table 6.14*).

4B.2.5.3 Predicted Impacts on Mine In-flows

Figure 4B.12 presents the predicted groundwater in-flow to the underground workings, for the base case and three uncertainty analyses of Aquaterra (2009), over the life of the Longwall Project. It is predicted that groundwater would initially in-flow at a moderate rate of 0.21ML/day (78ML/year), steadily increase to a peak rate of 3.89ML/day (1419ML/year) in about Year 18 before declining as water is allowed to recover into the goaf areas of completed longwall panels in areas down dip of the active mining.

When considering the uncertainty analyses, the modelling of Aquaterra (2009) indicates the following.

- If connected fracturing extends up into the Garrawilla Volcanics, a slight increase in the peak inflow rate to 3.85ML/day (1 409ML/year) may occur.
- In the unlikely event that vertical permeabilities are increased by a significantly greater amount than anticipated in the subsidence zones above the longwall goafs, inflow rates peaking at up to 5.23ML/day (1 914ML/year) may occur.

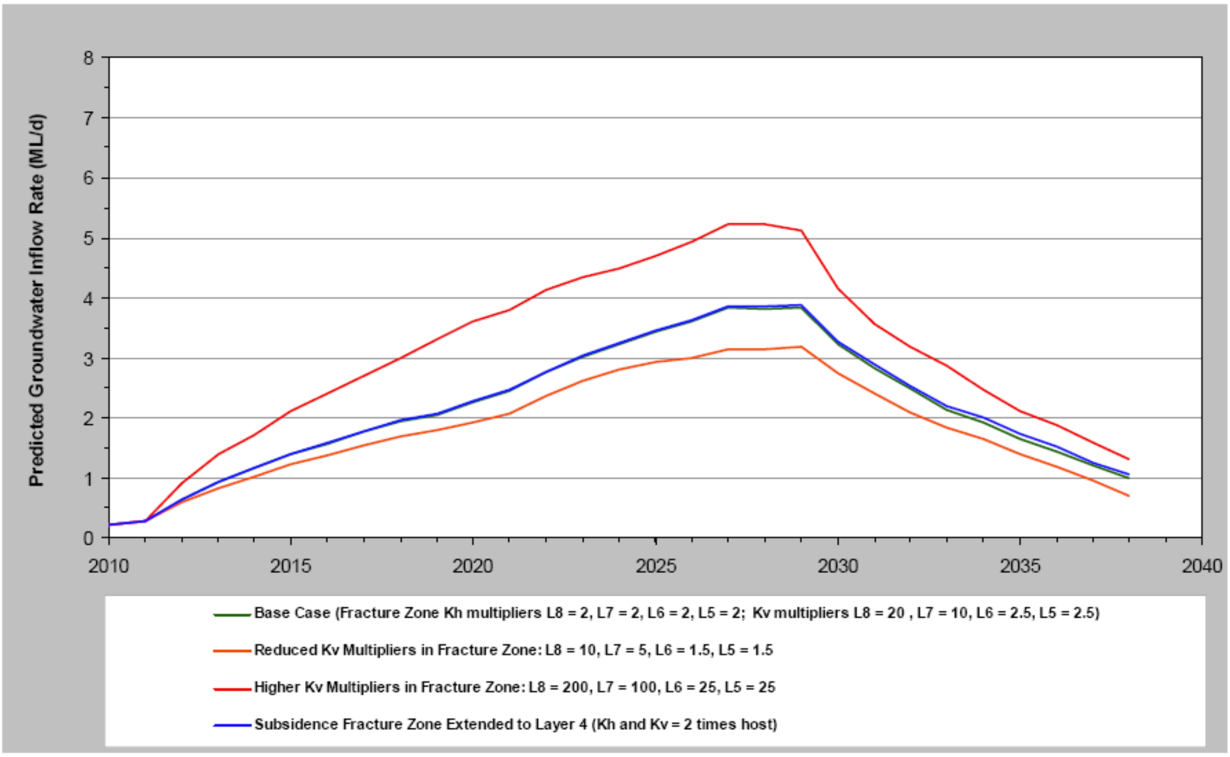

FIGURE 4B.12
PREDICTED MINE IN-FLOWS

Source: Modified after Aquaterra (2009) – Figure 6.27

Acknowledging the lack of prior experience of longwall mining in the Gunnedah Basin, the base case and uncertainty analyses 1 and 2 represent a conservative approach to parameter estimation, and therefore the prediction of possible in-flow rates. Elements of conservatism that have been built into the assessment of mine in-flows (and subsequently groundwater drawdown – see Section 4B.2.5.5) for the base case and uncertainty analyses 1 and 2 are as follows.

- The representative hydraulic properties assumed for each model layer may be too high. The values used have been influenced principally by the results of hydraulic testing, which is carried out preferentially on bores that intersected measurable groundwater inflows, ie. those bore holes which have no or very low in-flows are not included in the calculation of average hydraulic properties. Hence the dataset is skewed towards the more permeable locations, and ignores the numerous locations that are essentially impermeable.
- All model layers have been assumed to be regionally hydraulically continuous. It is likely that hydraulic barrier boundaries would be found to exist within the vicinity of the mine that would at least partly reduce the regional extent of drawdown and therefore groundwater in-flow. Aquaterra (2009) report that these hydraulic barriers are common in practice, but can only be identified under extended pumping or dewatering conditions. It is likely that some partial hydraulic barriers would be found to exist in the area of predicted impact that would lead to a reduction in actual in-flow rates.

- No allowance has been made for reduction in permeability or lateral flows of the subsidence affected strata over time. Aquaterra (2009) reports that some locations in the central Hunter Valley have shown signs of apparent “healing” or in-filling of subsidence fractures reasonably soon after subsidence occurs which leads to a reduction in ongoing drawdown and mine in-flow.

Based on the above, it is assessed that the predicted mine in-flows presented for the base case and uncertainty analyses 1 and 2 in **Figure 4B.12** (in particular that representing the higher vertical permeabilities in Layers 5, 6, 7 and 8 of uncertainty analysis 2 - see **Table 4B.10**), are likely to over-estimate actual mine in-flows. The third uncertainty analysis, which accounts for some reduction in vertical conductivity and lateral flows, provides for a reduction in the predicted mine in-flow rate, peaking at up to 3.17ML/day (1 157ML/year) may occur. This may be the more likely of the four scenarios modelled, however, in the interest of conservatism, the Proponent has provided for water management of groundwater up to and exceeding that predicted by uncertainty analysis 2.

The Proponent has committed to monitoring mine in-flows throughout the life of the Longwall Project, to obtain the necessary operational experience such that the groundwater model can be refined and recalibrated to allow for greater confidence to be placed on forward predictions of inflow rates (and other impacts).

4B.2.5.4 Predicted Impacts on Groundwater Levels

Figures 4B.13 to **4B.15** present the groundwater drawdown predicted by Aquaterra (2009) in the Alluvium (Layer 1), Garawilla Volcanics (Layer 4) and Hoskissons Coal Seam (Layer 9) after Year 15, the completion of mining (Year 29) and at the end of the recovery period (Year 129).

The most significant impacts on groundwater levels are predicted to occur within the Hoskissons Coal Seam (Layer 9). Groundwater in-flows would be induced laterally and from adjacent hydrogeological units, and subsidence fracturing above the goaf would allow increased drainage from the units above the longwall panels, extending up to the Napperby Formation, and possibly above into the Garrawilla Volcanics. Although the mine is not overlain by any significant aquifer, potential impacts on the aquifers that do exist are as follows:

- A cone of depression centred on the Mining Area is evident in the Hoskissons Coal Seam, with a less pronounced cone of depression in the units above. A review of **Figures 4B.13** to **4B.15** indicates the following.
  - Within the Hoskissons Coal Seam, drawdowns of 5m or more extend to 15km from the Mine Site at the end of mining. Drawdowns of 1m or more are predicted to extend to a maximum of approximately 20km from the Mine Site to the southwest and northwest and 10km from the mined areas to the south. Drawdown to the east is limited by the truncation of the Hoskissons Coal Seam in sub-crop.

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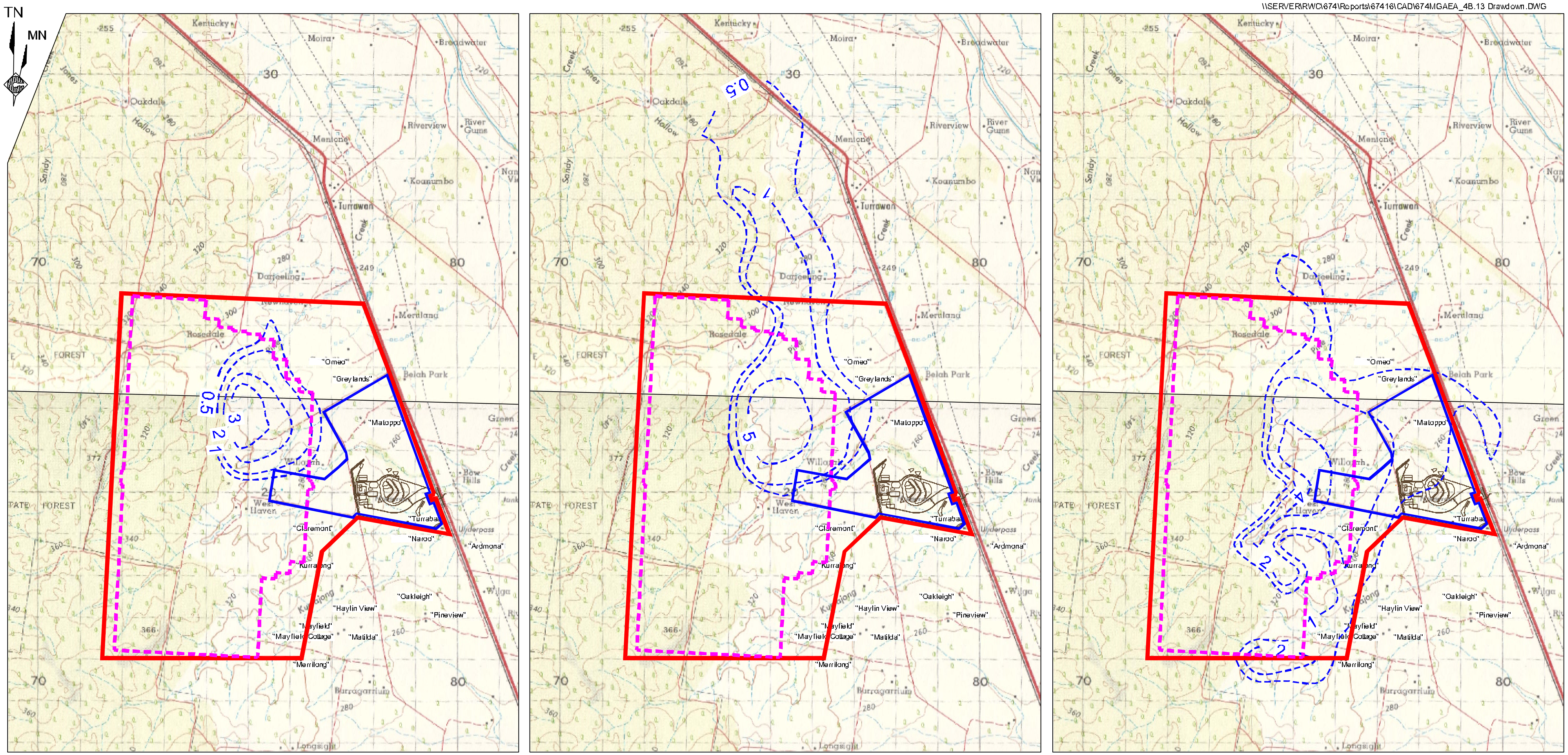

Year 15   Year 29   Year 130

REFERENCE
- Mine Site Boundary
- Indicative Limit of Underground Workings
- Pit Top Area Boundary
- 3 Groundwater Drawdown Contour (m AHD)

SCALE 1:100 000

1 0 1 2 3 4 5 km

Source: Aquaterra (2009) - Figures 6.13, 6.14 & 6.21

Figure 4B.13
PREDICTED GROUNDWATER DRAWDOWN IN ALLUVIUM, COLLUVIUM AND REGOLITH

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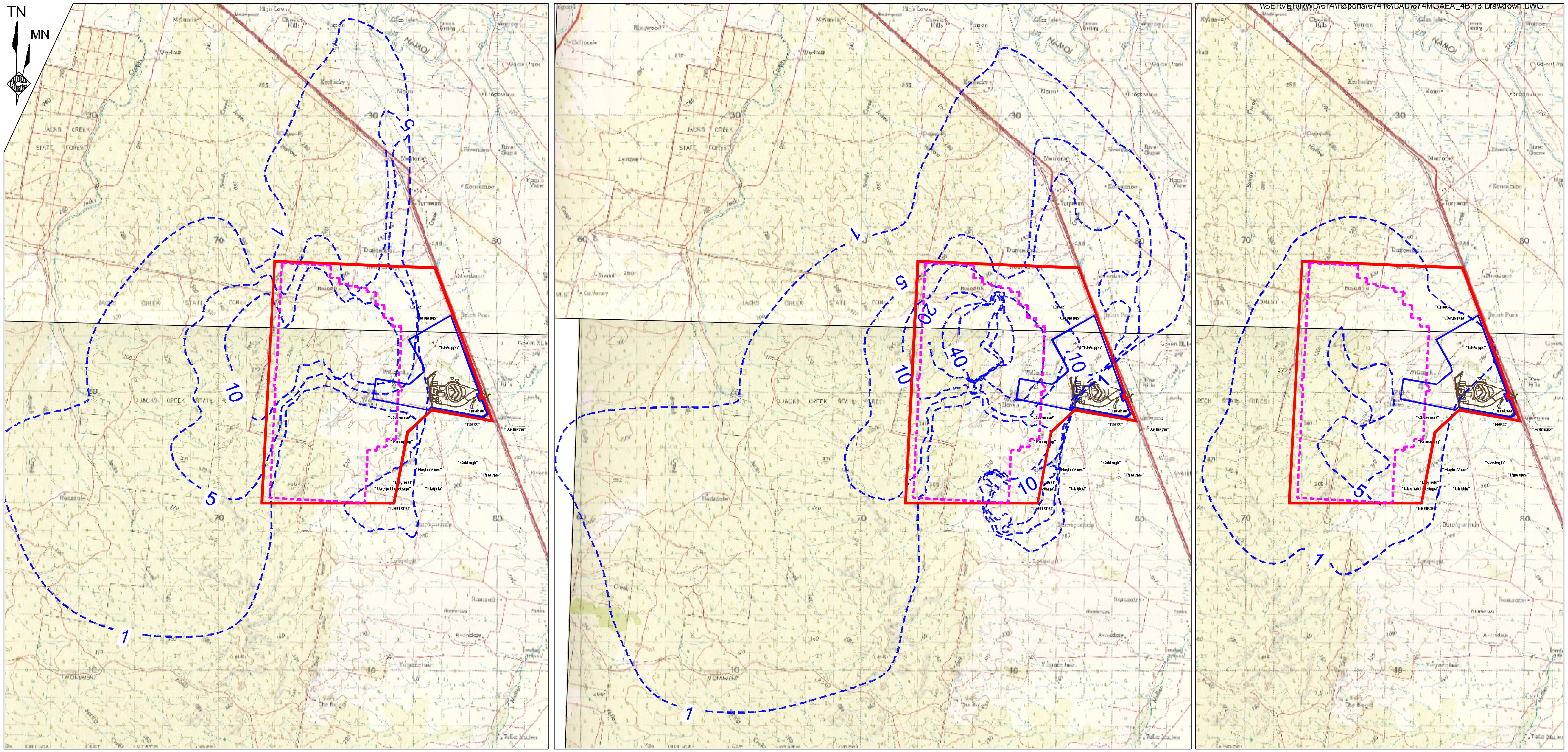

Year 15 | Year 29 | Year 130

REFERENCE
- Mine Site Boundary
- Indicative Limit of Underground Workings
- Pit Top Area Boundary
- 3 Groundwater Drawdown Contour (m AHD)

SCALE 1:150 000
2.5 0 2.5 5.0 7.5 km

Source: Aquaterra (2009) - Figures 6.15, 6.16 & 6.22

Figure 4B.14
PREDICTED GROUNDWATER DRAWDOWN IN GARRAWILLA VOLCANICS