APPENDIX H7

GROUNDWATER MODELLING AND DISCHARGE PREDICTIONS
2011

ANGAS PROCESSING FACILITY

MISCELLANEOUS PURPOSES LICENSE APPLICATION
2019/0826

TERRAMIN

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Our Ref: 261-11-TAB

15 August,2011

Mr. Matt Daniel
Environment & Community Superintendent
Terramin Angas Zinc Mine
P.O. Box 125 Strathalbyn
SA 5255

Dear Matt,

ANGAS MINE MODELLING AND DISCHARGE PREDICTIONS

The initial groundwater model of the Angas Mine site was a very simple, single-layer model prepared by Australian Water Environments (AWE) and reported in the Mining and Rehabilitation Program (MARP). The MARP also contained, as an annotation to Figures 82 and 83, an estimated value of 6 L/s for summer and winter discharge from the underground workings together with a statement "Groundwater inflow progressive- modeled for mine as developed".

The initial model was reported in the AWE letter report of 20/7/2006, which estimated flows from the mine workings to range from 30 L/s at start-up to 5 L/s in the long term.

This model was revised (AWE report, 27/9/2006) taking into account the lithology of rock units as derived from over 100 exploration drillholes at the site and the results of pumping tests on 3 water wells. This exercise resulted in a three-layer model with a thin upper aquifer to a depth of approximately 100m, a fractured rock layer extending the a depth of 380m and a less permeable layer to 600m depth. An anisotropy ratio of 3 to 1 (NS Permeability = 3xEW permeability) was applied to the two lower layers to reflect the geological structure of the fractured rock systems. The mine workings were simulated by drains, which were added to the model, at the appropriate times, positions and depths taken from the proposed mining schedule thus representing the development of the underground workings in time. The following conclusions were presented.

"The model has been run with both relatively thick and thin layer 1 configurations. It is likely that these two scenarios represent the two probable extremes as far as can be predicted based on the available data. With the initial geometry of Layer 1, the maximum predicted instantaneous mine discharge is in excess of 40 L/s whilst at later time, the (combined Layer 1 and Layer 2) flow rate is about 7.5 L/s (Figure 3). The revised Layer 1 model has an instantaneous maximum extraction rate of just over 12 L/s and a late time value of 4.5 L/s (Figure 12). Dewatering in neither scenario was shown to impact the Angas River to any significant extent. Owing to the natural variability inherent in the site geology it would be prudent to have in place contingency plans to cope with surplus discharge water (such as re-injection) in the event that conditions prove to be more like those in the initial model version, or to obtain additional plant water requirements from water bores should the underground workings fail to produce sufficient water to satisfy process requirements. Additional hydraulic testing would be beneficial in refining hydraulic parameters, leading to the better definition of water disposal or procurement requirements."

The model was revised again in 2007 as part of the Australian Groundwater Technologies (AGT) study into injection as a disposal method. More pumping test data was incorporated but there was no information available regarding discharge from underground to use as a calibration tool for the model discharge predictions.

An additional model layer was added resulting in the following vertical discretisation of the model domain:

- ground level to 35m – shallow aquifer ; 35m to 65m – weathered clayey zone ; 65m to 355m – fractured rock aquifer containing mine workings ; 355m to 570m – deeper, lower permeability fractured rocks.

The *Pre-injectionTrial report* (AGT report, 2007/19) investigated 4 possible fracture scenarios, possibly linking the injection sites to the mine workings, which were thought could influence the behaviour of injected fluids.

Model predicted discharges for these scenarios are presented in Figure D.

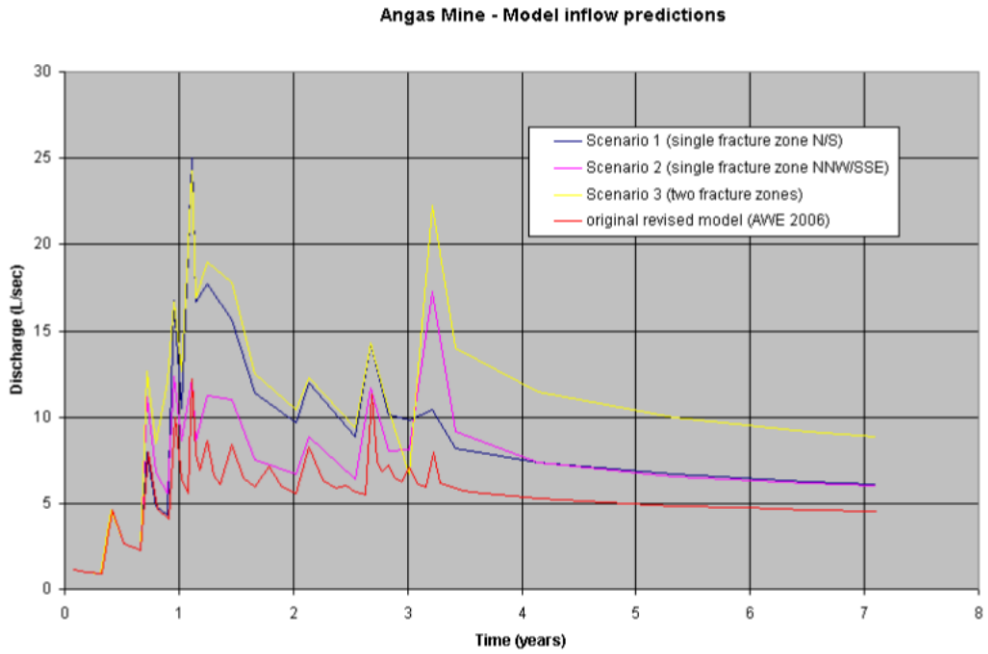

Figure D

Scenarios 1 and 2 in Figure D were considered to be the most likely scenarios with mid-term discharges of around 7.5 L/s falling to ~ 6 L/s after 7 years. This selection is supported by the observation that there has been no evidence of mine workings intersecting major water-bearing fracture zones to date and the full depth range of the workings has now been excavated.

The current round of model revision has had the benefit of a set of measured groundwater discharge rates included in *Angas flowmetertotalisergraphs.xls* covering the period 5/01/2010 to end July 2011.

Model hydraulic properties have been adjusted to reflect the measured mean flow rates and it can be seen from **Figure 1** that the model predicted flows are very similar to the statistical mean of the measured rates (which are highly variable due to influences such as rainfall events, pump or power outages which are not simulated in the model). The model discharges exhibit a slight falling trend and the 14 day moving average of the measured values shows evidence of a overall downward trend overlying the non-systematic fluctuations.

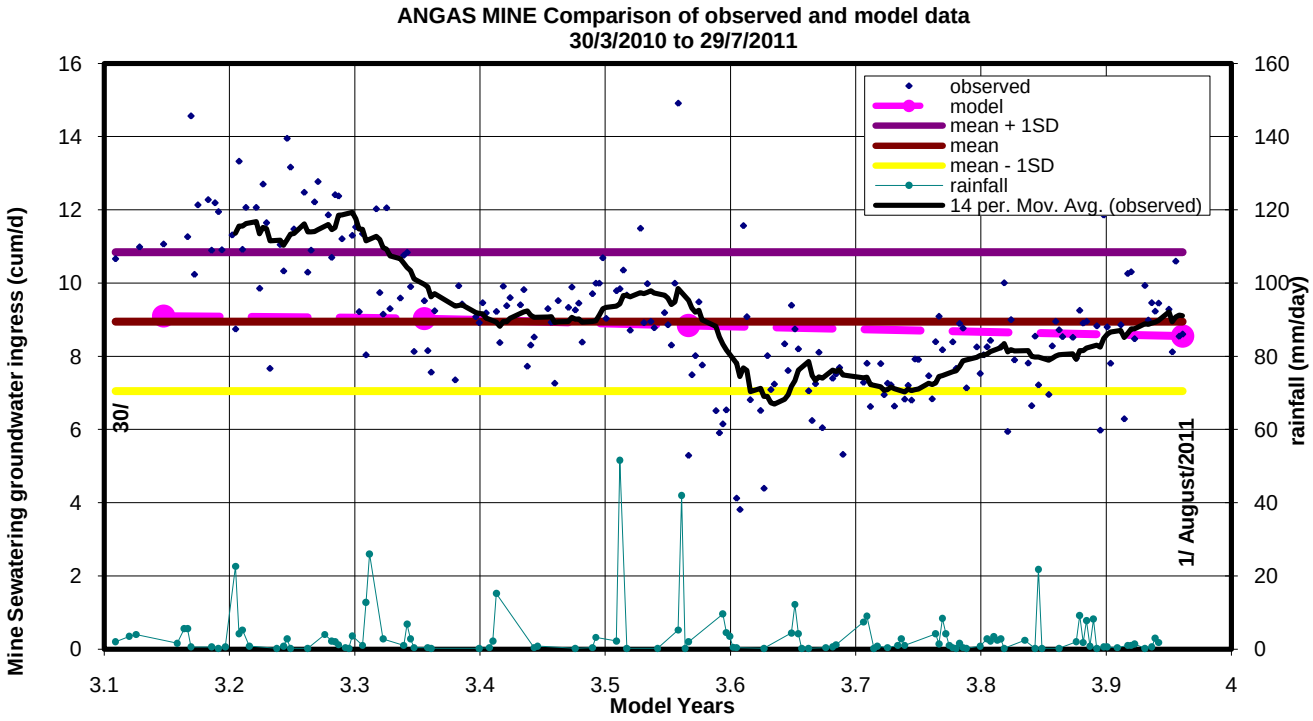

Figure 1 Comparison of Measured and Model predicted Minewater Discharge

The great majority of measured points lie within +/- 1 standard deviation of the mean value (a confidence interval of 95%) and the mean of the measured population 9.076L/s is only marginally greater than the average model predicted rate of 8.88L/sec for the period under consideration (an error of ~ 2%).

The current revised model was used to simulate injection into 4 wells at total rates of 6, 8 and 12 L/s in order to evaluate the impact on water pressures at the injection sites and also to determine whether the injection process has any impact on the predicted minewater discharges.

The resulting model-predicted discharges are shown in **Figure 2** and expressed as % increase over the non-injection scenario values for each time step in **Figure 3**.

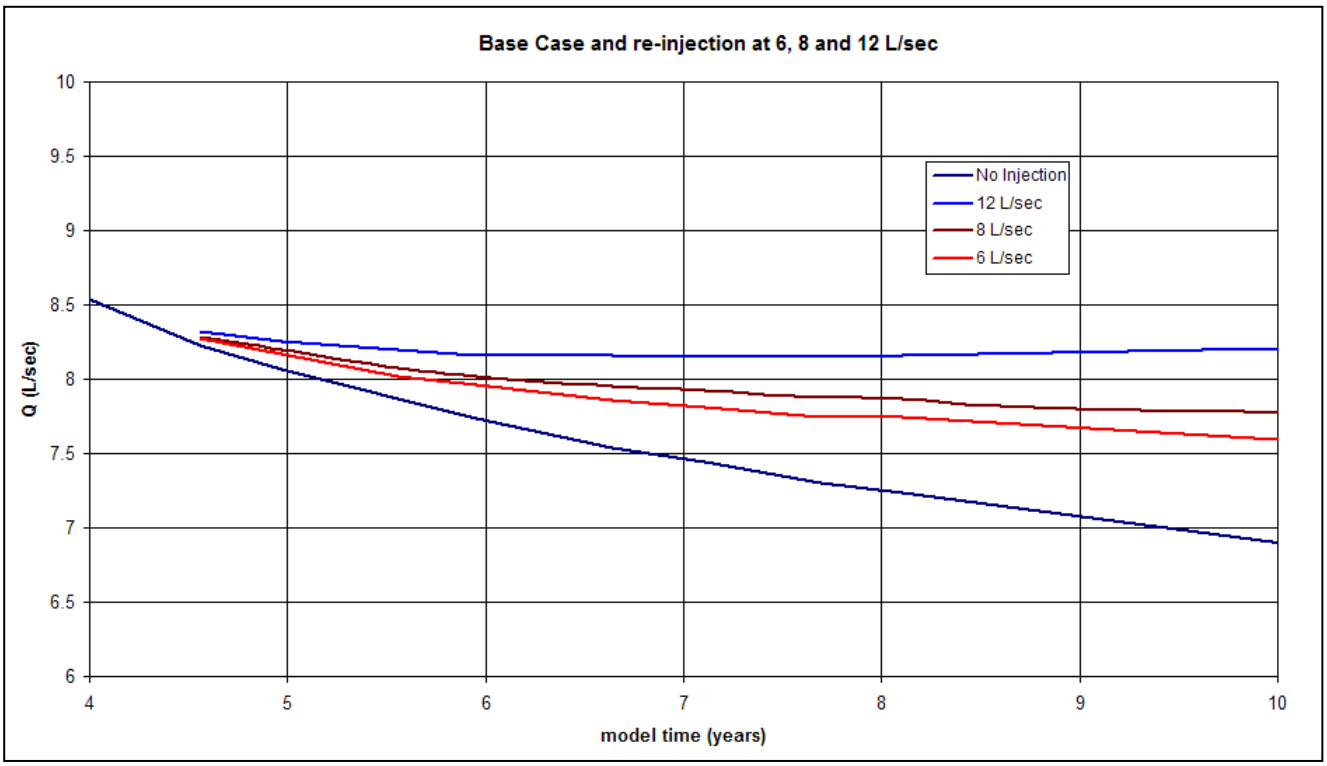

Figure 2 Model-predicted minewater flows in response to injection

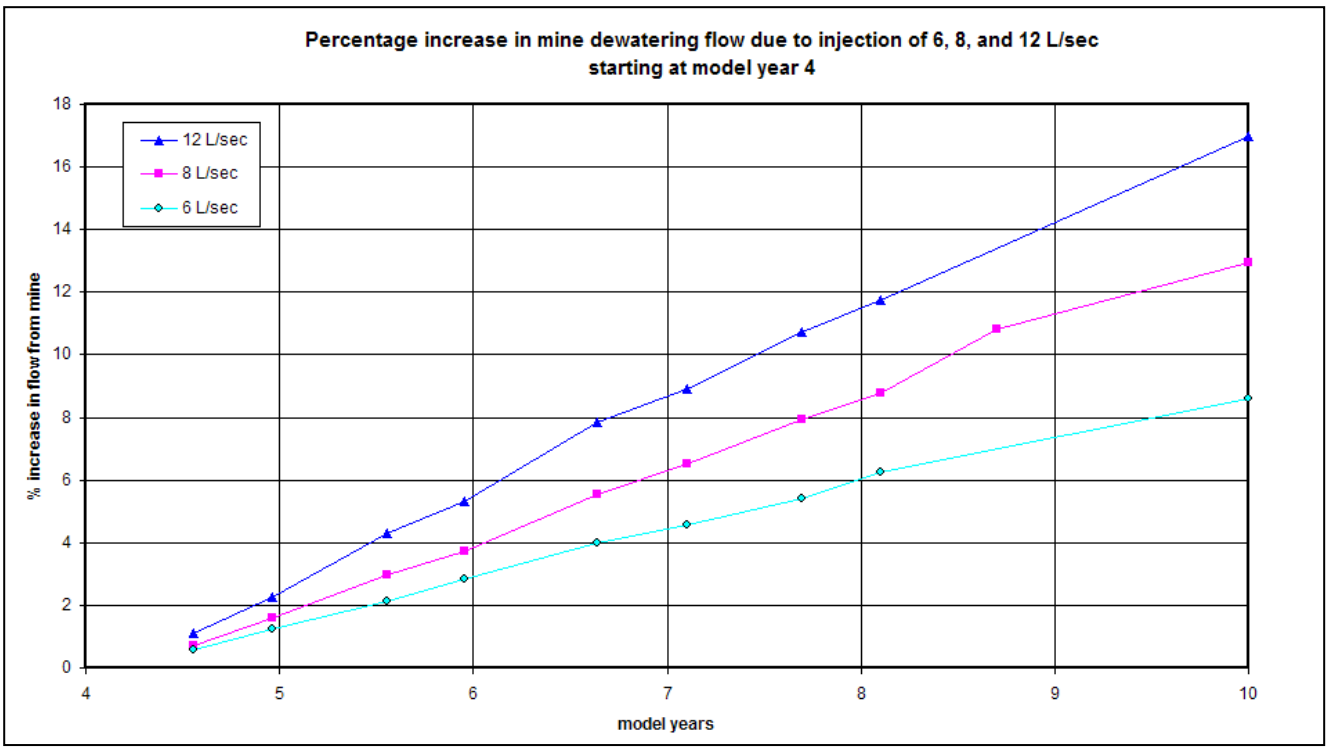

Figure 3 Percent increase in predicted minewater flow due to injection

The base case 10 year predicted flow of under 7 L/s is potentially increased by 8.5% when injecting at 6 L/s, 13% when injection is 8 L/s and 17% when injecting at 12 L/s.

Whilst these predicted increases in dewatering flow are not considered to be a major problem, the development of aquifer pressure at the disposal well sites is of major concern. In general a rise in head equal to the twice the depth of the aquifer below surface is considered to be a limiting factor.

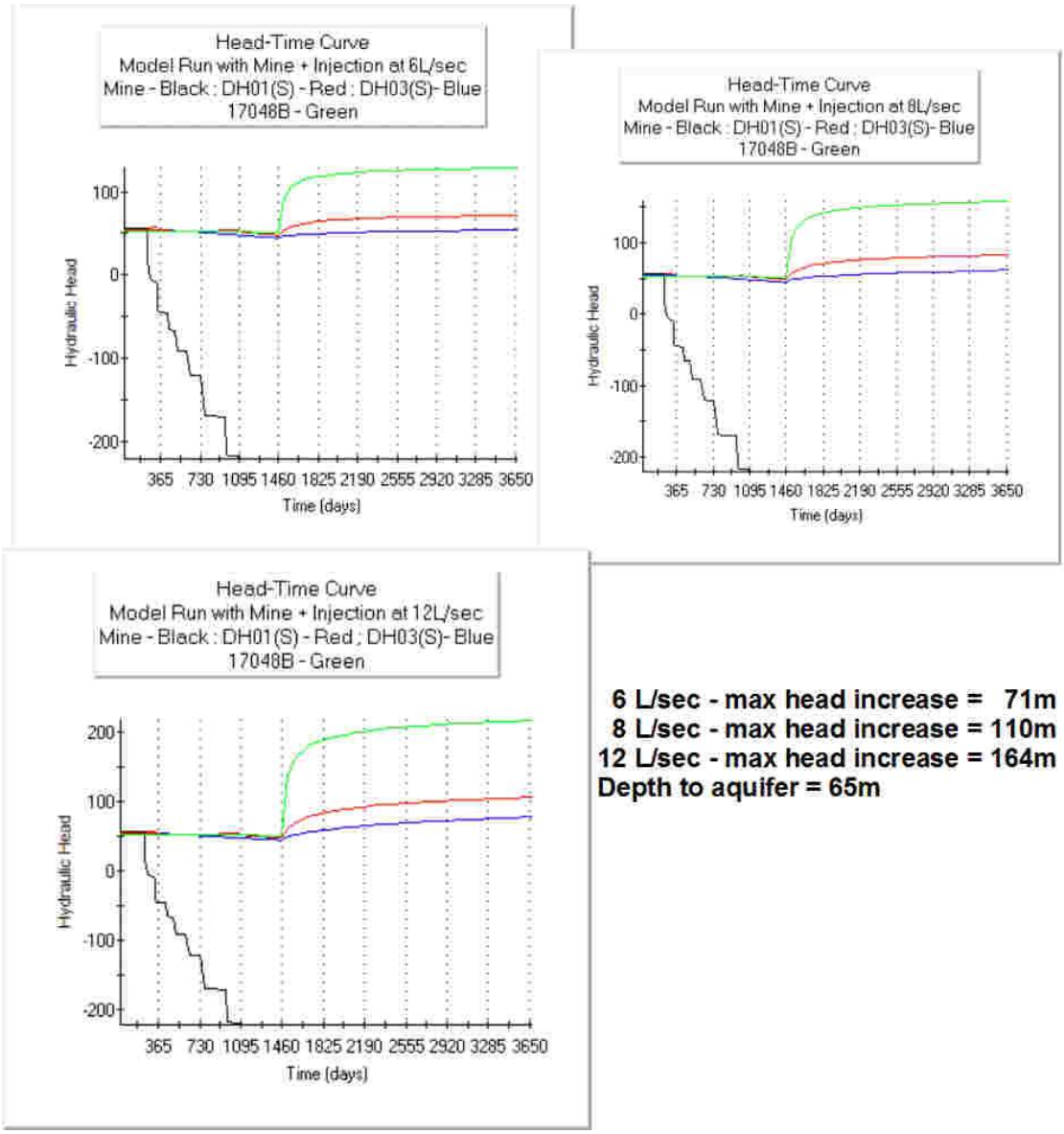

Figure 4 Heads vs time for injection at 6, 8 and 12 L/s

Based on the model depth to aquifer of 65m, the heads developed at well 17048B would be considered unacceptable and potentially capable of inducing hydrofracturing in the aquifer. The model heads therefore indicate that 12 L/s would not be a sustainable injection rate.

Since the actual development of injection heads is well-specific, the actual performance of the injection wells during the testing phase must be taken into account. It is possible that the 8 L/s injection rate may not be sustainable in the medium to long term when well performance is considered.

In summary,

- The comparison of measured discharges with discharges predicted by the current revised model has shown that the average of predicted values over the period of available relevant measured data is within 2% of the statistical median value for the measured data set.
- Model predicted rates of increase in minewater flow in response to injection rates of 6, 8 and 12 L/s are 8.5%, 13% and 17% respectively.
- Heads developed at the injection well sites have maximum values at well 17048B of 71m, 110m and 164m for injection rates of 6, 8 and 12 L/s, respectively. The heads developed at 8L/s suggest that individual well performance must be evaluated and at 12L/s injection heads are expected to be beyond the acceptable range of 2xdepth to aquifer. Monitoring of injection rate/per well and resulting head build up at the current total injection rate of ~6 L/s should provide data to more reliably evaluate well performance.

Yours Sincerely,

Don Armstrong

For and on behalf of AGT Pty Ltd

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