4 MODEL PREDICTIONS

4.1 Predictions Overview

The predictive scenarios considered groundwater response to existing mining (life of mine to closure) and Proposed mining (life of mine to closure) conditions. The duration of predictive simulations was from 2023 to 2052, as specified by the life of mine plan for Dawson South. The duration of stress periods was refined to assess wet and dry seasonal groundwater changes. For the mining periods, drain cells were activated to coincide with the mine plan (location and depth of mining) and turned off to allow recovery to correspond with the pit backfill and rehabilitation plan.

The post-closure simulations were modelled for a duration of 1,000 years to allow groundwater level to recover to a state of equilibrium. A conservative case was modelled for the Pit 25 and Pit 28 voids, maintaining the void water elevation at a minimum elevation as estimated through previous post-mining void scenarios (reported by WRM, 2019 and KCB 2023).

The associated estimated groundwater elevation and groundwater drawdown figures are provided in Model Appendix I.

4.2 Predictions for Remaining Operating Period

The predicted groundwater drawdown is the difference in the groundwater level between the pre-mining water level and the water level at each mined interval (the end of the initial calibration period in 1963 was used as representative of the pre-mining groundwater level for consistency). The maximum observed drawdown occurs in 2052 (toward the end of the mining operational period).

The estimated dewatering flow patterns for the existing Dawson South mining scenario are represented in Figure 4.1.

Groundwater predictions indicate that during operation there is negligible difference between the current and proposed mine scenarios. The reason for this similarity is the result of relatively low hydraulic conductivity of the overlying units, influencing the early stages of slower groundwater level recovery and the fact that both mining scenarios target the same coal seam, at the same depth and extent.

The groundwater elevation for the Proposed landform, 5 years before end of operations (Model Appendix I - Figure 1) and at the end of operations (Model Appendix I - Figure 2) decreased from 50 mAHD to -30 mAHD in the northern section of the mining area. This reflects the mining progression of the lower coal seam(s) in the north. Similarly, in the vicinity of Pit 25 to Pit 28 there is a decrease in the groundwater level from 0 mAHD to -40m AHD. A snapshot of the predicted head variation in the observation bores from 2024 to 2052 is represented in Figure 4.2 showing the expected ongoing decline in water levels from the Existing Case.

The comparative groundwater drawdown at the end of operations for the Proposed mine closure design (Model Appendix I - Figure 3) and the current mine closure design (Model Appendix I - Figure 4) are not significantly different.

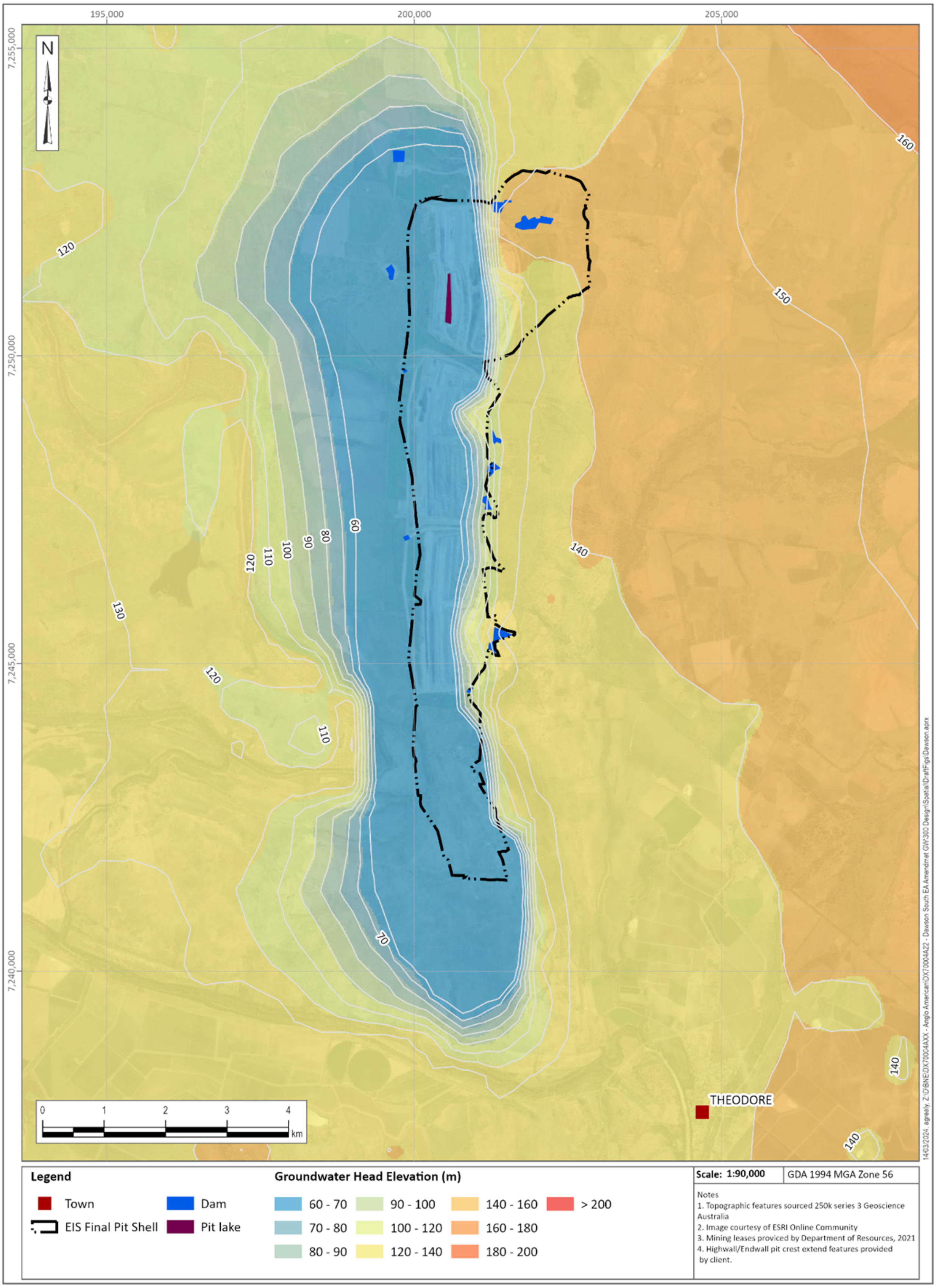

Figure 4.1 Water Table (Layer 2) at End of Mining (2052)

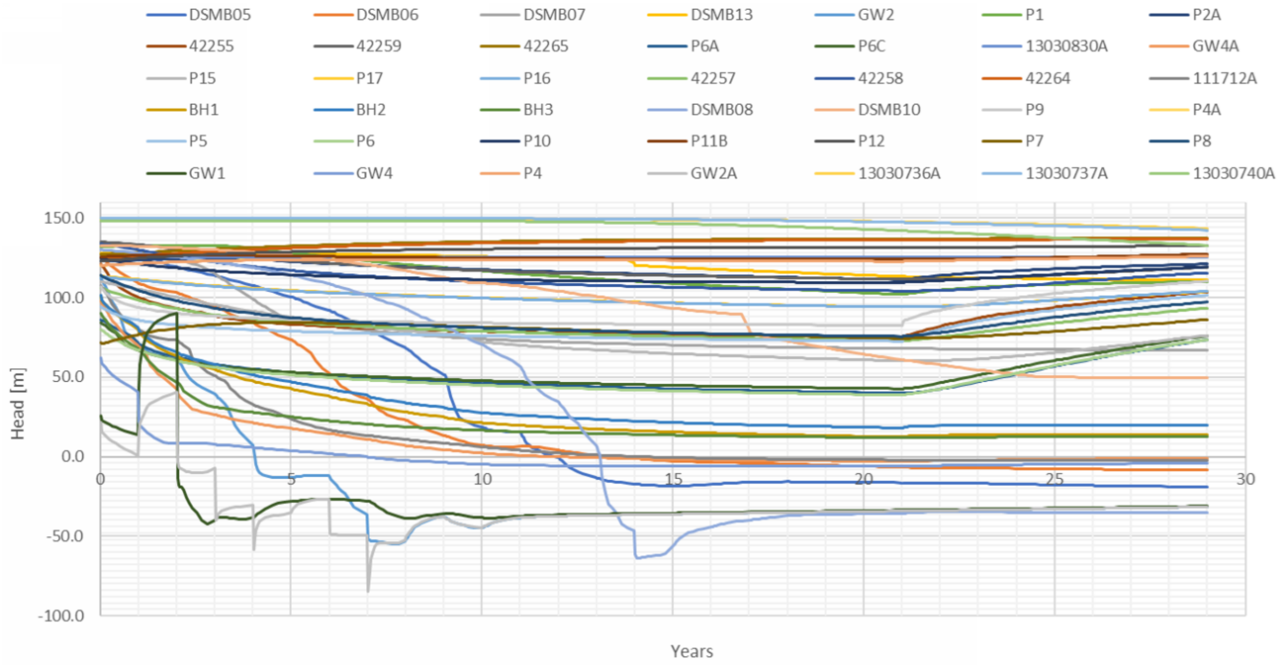

Figure 4.2 Predicted Head Variation between 2024 and 2052

4.3 Post Closure

An assessment of post-closure recovery of groundwater levels was performed to evaluate the response of the groundwater system following cessation of mining operations. The post-closure figures for groundwater elevations and drawdown are included in Model Appendix I. The model considered 1,000-year post-closure period, where all drain cells in Dawson South voids were deactivated/removed and recharge applied, in accordance with the long-term historical average. The other drain cells that represent mining in Dawson Central and North and for CSG were de-activated according to the mining/gas production schedules.

Predicted Post-Closure Groundwater Inflow and Void Elevation Estimates

The post-closure groundwater inflow flux was estimated for a range of void lake elevations, from the maximum inflow rate when groundwater levels are at the base of the pit (lowest), to the pre-mining groundwater level elevation where no groundwater inflow is observed (representing steady-state or equilibrium conditions). These fluxes (as a function of void head) were provided to ERM as inputs for the water balance model.

Final void elevations were simulated using the current Dawson water balance model (in GoldSIM), as part of ERMs the surface water assessment. This water balance incorporated all contributing fluxes to the voids, including the estimated groundwater inflow from this numerical model assessment.

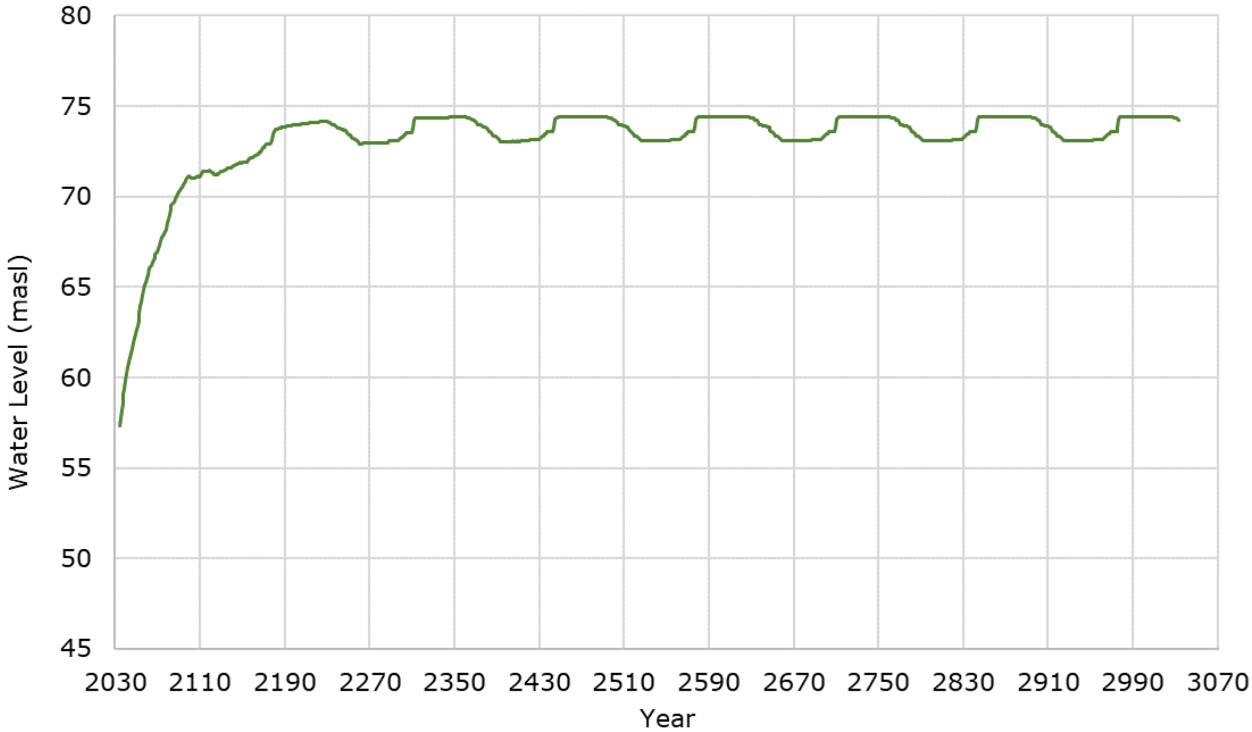

Figure 4.3 Pit 25 Predicted Void Water Levels

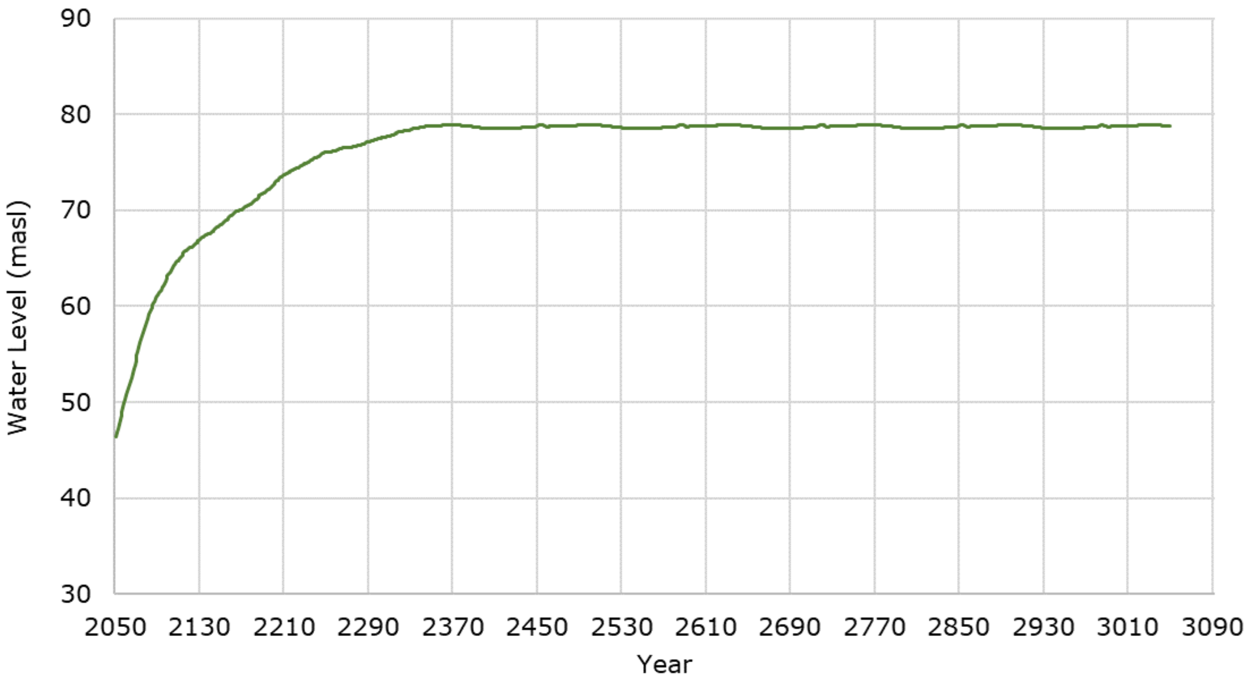

Figure 4.4 Pit 28 Predicted Void Water Levels

Predicted Post-Closure Groundwater Elevation

The post-closure predicted void rebounding water levels, as estimated by ERM for Pit 25 and Pit 28 (Figure 4.3 and Figure 4.4 respectively), were re-applied to the groundwater model, using a time-variable General Head Boundary (GHB) to assess the post-closure groundwater conditions.

There is minimal difference in the groundwater elevation between the 5-year current (Model Appendix I - Figure 5) post-mine closure design and the 5-year Proposed (Model Appendix I - Figure 6) post mine closure design.

1,000 Year Post Mine Closure Elevation

Since the greatest difference in groundwater response is in the long-term at the cessation of mining, two cases were compared: a case where water levels in the pit lakes are allowed to recover and a second (conservative case) where the pit lake water levels are kept at a minimum.

The current 1,000-year post-closure design (Figure 4.5, Model Appendix I - Figure 7) shows there is a remaining lake in Pit 28 and the groundwater elevation has recovered to 55 mAHD.

The Proposed 1,000-year post-closure design shows there are two remaining pit lakes, including one in the north of the project area around Pit 25 (Figure 4.6, Model Appendix I - Figure 8).

Several important observations follow from these comparisons, where the presence of the Pit 25 void in the Proposed case results in a continued flow of groundwater toward the void in the north. Around Pit 28, the difference between current and proposed is noteworthy since the Proposed landform allows a final void water level to equilibrate to a higher elevation than in the Existing mine plan. In the current landform, the equilibrated final void water elevation was around 50 m RL while the Proposed landform suggests that a final void water elevation of around 78 mRL is more likely.

The conservative case alternative (worst case scenario) for the Proposed maintained the previously assessed 50 m water level elevation (from the existing landform), to allow potential impacts to be identified for a system that provides significantly more stress to the groundwater system over the post-closure period. For this scenario (Model Appendix I - Figure 8) the groundwater has recovered to ~55 mAHD after 1,000 years post mining.

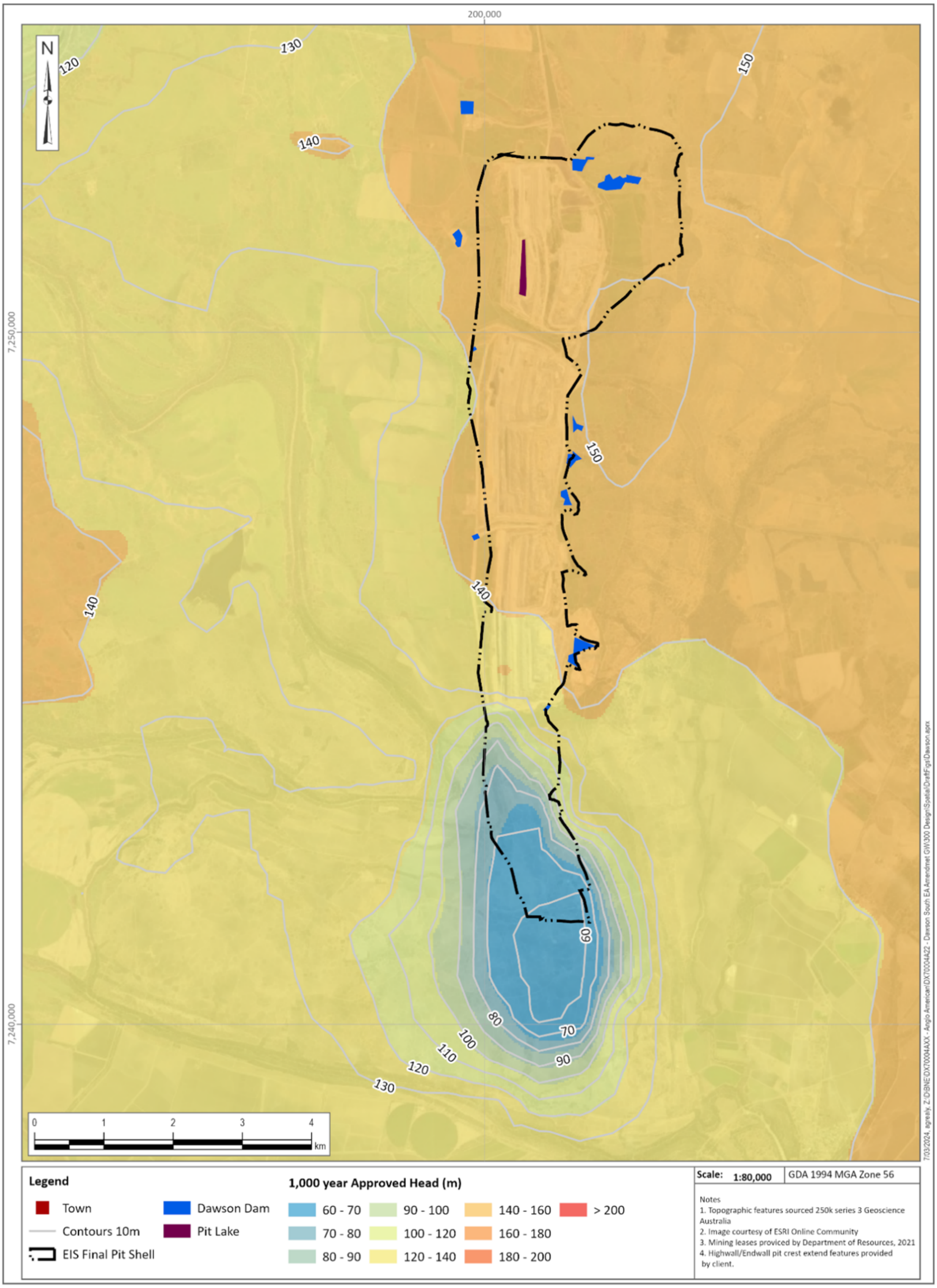

Figure 4.5 Groundwater Elevation – 1000 Years Post-Closure (Current)

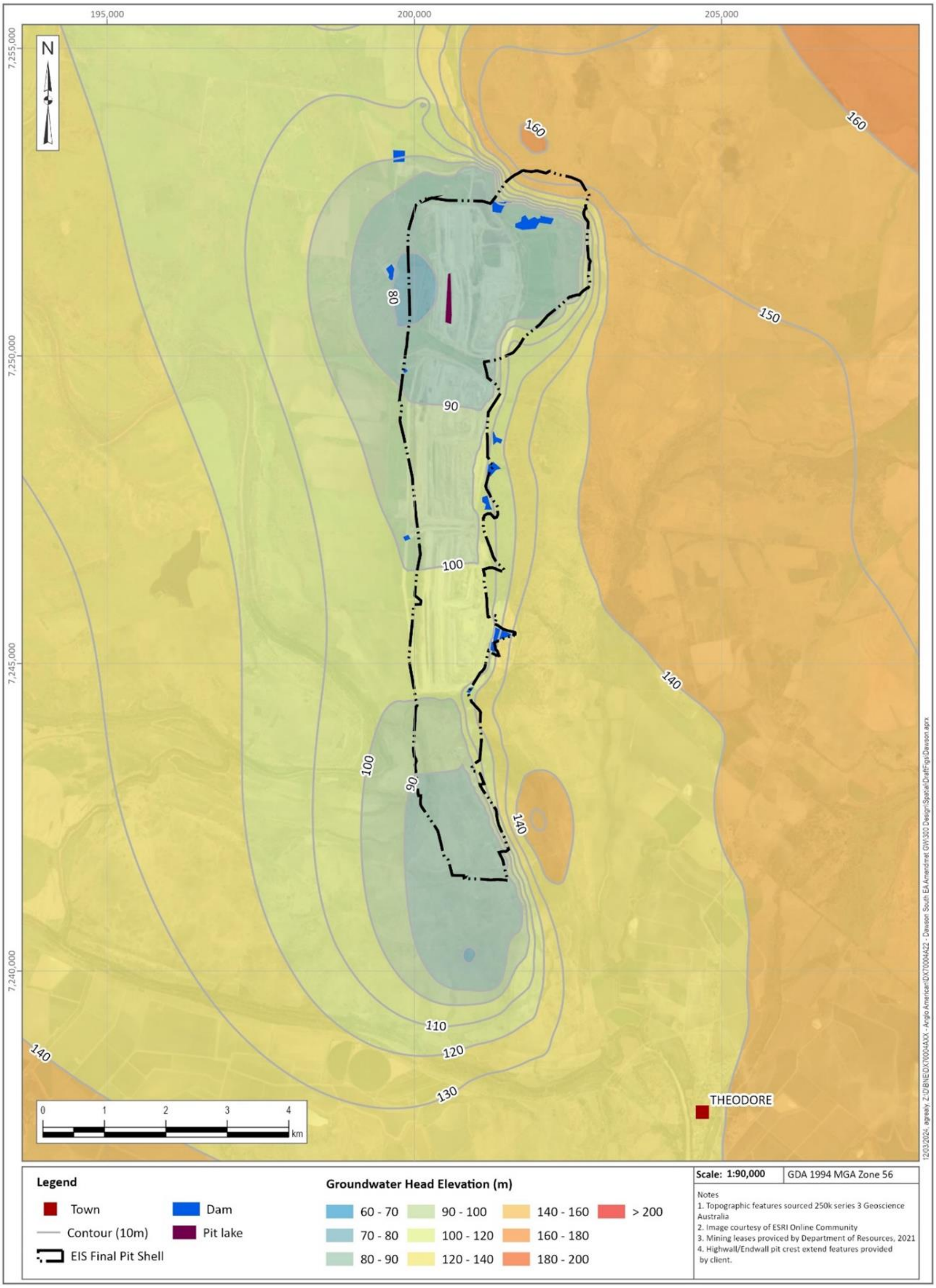

Figure 4.6 Groundwater Elevation – 1000 Years Post-Closure (Proposed Project)

Change in Groundwater Head

A groundwater level difference between the current and proposed mine closure designs, 1,000 years post mine closure is approximately 75 mAHD (around Pit 25) and 65 mAHD in the vicinity of Pit 25 (Model Appendix I - Figure 15). The large difference in the elevations between the current mine closure design and the Proposed mine closure design is attributed to the Proposed design having two voids (one at Pit 25 and one at Pit 28).

Predicted Drawdown Observations

The groundwater drawdown for the Proposed, 5-year post mine closure design (Model Appendix I - Figure 9) shows a maximum drawdown of 170 m. The current, five years post mine closure design (Model Appendix I - Figure 10) has a maximum groundwater drawdown of 165 m. There is a difference of 5 m drawdown between the current and proposed 5-year post mine closure designs.

The groundwater drawdown for the current, 50-year post mine closure design (Model Appendix I – Figure 11) shows a maximum drawdown of 140 m. The Proposed, 50 years post mine closure design (Model Appendix I Figure 12) has a maximum groundwater drawdown of 135 m.

The current 1,000-year post-closure design (Model Appendix I - Figure 13) shows a residual groundwater drawdown of 60 m across the project site. The Proposed 1,000 year post-closure design (Model Appendix I - Figure 14) shows a similar groundwater drawdown across the south of the site, but greater drawdown around the Pit 25 void. The drawdown remains higher in the Proposed closure design in the north due to the Pit 25 voids but due to the higher recovery level in Pit 28 drawdown is reduced in the south. These results have been simplified to show the potential maximum drawdown extent, represented by the 1 m and 0.2 m contours in Figure 4.9 and Figure 4.10.

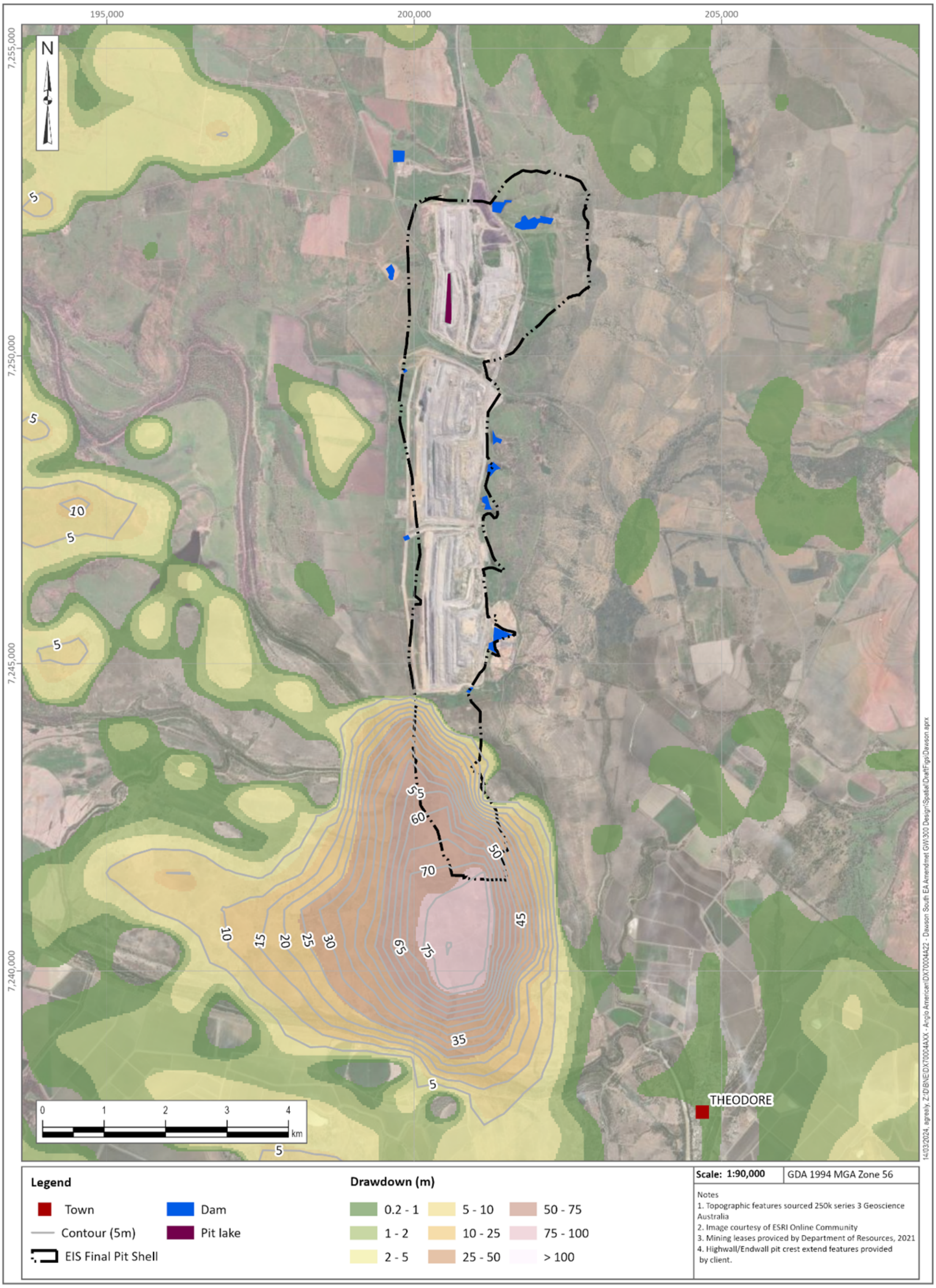

Figure 4.7 Existing mine plan Drawdown – 1,000 Years after Closure

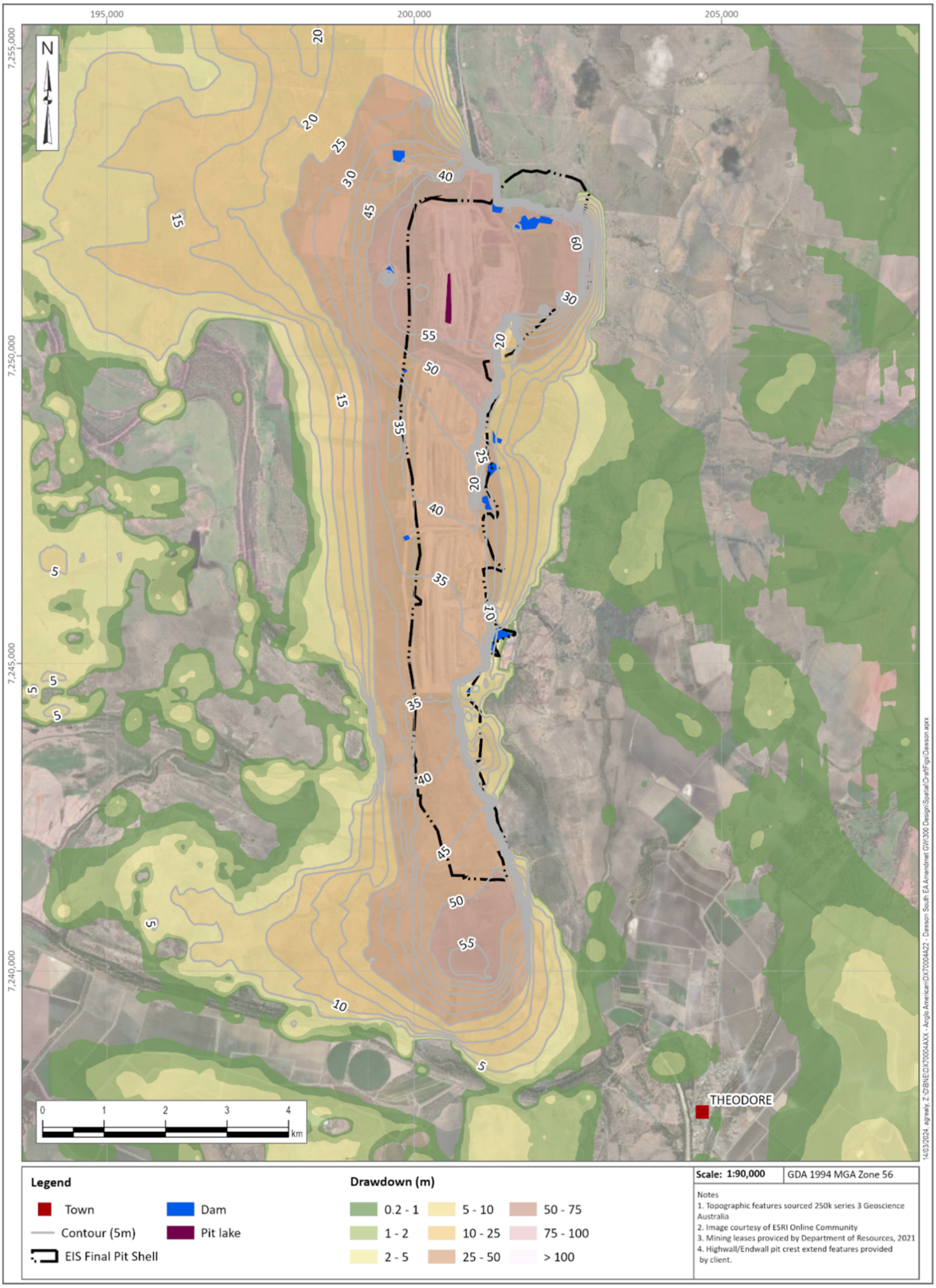

Figure 4.8 Proposed Project Case Drawdown – 1,000 Years after Closure

4.4 Potential Impacts to the Dawson River

During operations, the current and proposed cases have very similar impacts on groundwater and consequently, there is a negligible difference in associated Dawson River interaction. A comparison was obtained from the 1,000-year post-closure scenario, where the difference between the two cases is stable and at a maximum duration (i.e. the greatest incremental impact).

The River Boundary water balance across the entire extent of the Dawson South was extracted as comparison (Table 4-1). The results indicate that an additional water take of ~46 m^3/day could result from the Proposed scenario (i.e. ~ 0.5 L/s), across the entire length of the Dawson River.

Table 4.1 Comparison of the River Boundary Condition Flux across the Dawson South Mine Lease (1,000-Year Post-Closure)

		Influx (m^3/d)	Outflux (m^3/d)
Exiting (Approved Mine Plan)	River	1416.7	-700.8
Proposed	River	1470.0	-654.6

4.5 Sensitivity Analysis for Predicted Project Impacts

A sensitivity analysis was performed for the entire model using PEST to assess the response of the model to varying hydraulic properties. This analysis provides a comparison of the influence of these properties on the outcomes of predictions made by the model. Impacts on predictions of mine groundwater inflows and maximum drawdown due to hydraulic parameters have been examined.

Parameters that were assessed during the predictive sensitivity analysis were grouped and varied by an order of magnitude in the following manner (Table 4.2):

- Horizontal (Kh) and vertical (Kv) hydraulic conductivity of select layers were varied above and below their calibrated values;
- Specific storage (Ss) and specific yield (Sy) values for select layers were varied above and below their calibrated value; and
- Rainfall recharge rates were varied.

Table 4.2 presents the scenarios assessed in the sensitivity analysis. This shows that the model is sensitive to changes in hydraulic conductivity and increasing recharge. Overall, the sensitivity of the model indicates that the groundwater levels increase with effective recharge and river conductance, and vice versa suggesting that the cause-and-effect relationships in the model are consistently represented in the results. Overall the sensitivity analysis indicates that within the plausible ranges of the model, reasonable calibrations can be obtained.

Table 4.2 Summary of Sensitivity Analysis

Sensitivity Scenario	Parameter adjustment	Scaled RMS (%)	Correlation Coefficient
1	Baseline	4.9%	0.86
2	Increase the hydraulic conductivity – multiply by 10	6.6%	0.79
3	Decrease the hydraulic conductivity – divide by 10	6.0%	0.81
4	Increase the recharge – multiply by 10	6.6%	0.78
5	Decrease the recharge – divide by 10	4.9%	0.86
6	Increase the storativity – multiply by 10	5.7%	0.84
7	Decrease the storativity – divide by 10	5.4%	0.81

4.5.1 Prediction Sensitivity Cases

The approach to assess the range of potential impacts is consistent with the 2023 IESC guidance (Peters and Middlemiss, 2023) in that both the impact of different ranges of parameters as well as an alternate final void water level (conservatively assumed to be at a significantly lower water level of ~ 55m RL compared to the Project which is projected to equilibrate to around 78m RL) was used to assess the potential groundwater impact. These figures are contrasted to the Existing mine plan in Model Appendix Figures 4, 10, 14 and 16.

To assess the potential impact of these ranges on inflows and drawdown, a further set of sensitivity cases was undertaken (in addition to the alternative conservative post-closure water elevation case).

Table 4.3 Sensitivity Assessment on Predictions

ID	Predictive Sensitivity Model	Parameter adjustment
0	Base	Calibrated Parameters
1	S1	Decrease Allluvial k /10
2	S2	Increase Alluvial k x10
3	S3	Recharge (50%)
4	S4	Recharge (150%)
5	S5	River Boundary Conductance (10x lower)
6	S6	River Boundary Conductance (10x higher)
7	S7	Spoil sy /2
8	S8	Spoil sy x2

A summary of the results is provided on Model Appendix I - Figure 17, with specific comparisons to the base case provided as model snapshots Model Appendix I - Figure 20 to Model Appendix I - Figure 29.

4.5.2 Sensitivity Classification

The Murray Darling Basin Modelling Guidelines (MDBC, 2000) provide a framework for classification of a predictive model parameters in terms of their impacts on the model. These can be summarised as follows:

- Type I: Insignificant changes to calibration and predictions;
- Type II: Significant changes to calibration with insignificant changes to predictions;
- Type III: Significant changes to calibration with significant changes to predictions; and
- Type IV: Insignificant changes to calibration and significant changes to prediction.

Types I to III present no concern where management decisions are to be based on the model, provided the model is calibrated and encapsulates sufficient complexity to replicate the system. However, Type IV classification may be of concern as calibration may have done little to reduce potential for predictive error.

With consideration to the results of the sensitivity analysis, parameters employed in this model can be considered Type II to I classification and are suitable for the purpose of supporting a groundwater assessment for the Project.

5 CLOSING

We thank you for the opportunity to work on this assignment. Should you have any queries please do not hesitate to contact the undersigned.

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Lead Groundwater Modeller

REFERENCES

Anderson and Woessner. 1991. "Applied Groundwater Modeling. Sydney: Academic Press."

Barnett et al. 2012. "Australian Groundwater Modelling Guidelines." Waterlines Report. Canberra: National Water Commission.

CSIRO. 2002. "Bowen Basin Supermodel 2000."

———. 2012. "New Insights to the Chemical and Isotopic Composition of Rainfall across Australia."

———. 2021. "Climate Change in Australia. Climate Information, Projections, Tools and Data. Accessed November 2021. Www.Climatechangeinaustralia.Gov.Au."

Edraki et al. 2019. Prediction of long-term salt generation from coal spoils. ACARP PROJECT C25039.

Fityus, S, Buzzi, O. 2022. Groundwater pressures and flows within spoil dumps. ACARP Project C28038.

IESC. 2018. "Information Guidelines Explanatory Note Uncertainty Analysis—Guidance for Groundwater Modelling within a Risk Management Framework," 76.

JBT. 2018. "Groundwater Interaction with Dawson Final Voids." Prepared for Dawson Mining Complex JBT01-064–006. JBT Consulting Pty Ltd for Hatch Pty Ltd.

KCB. 2019. "Dawson Mining Complex TSF Seepage Review. Anglo American Metallurgical Coal."

KCB. 2021. "Mungi West / Mungi North Underground Water Impact Report. Westside Corporation Ltd."

MDBC. 2000. "Groundwater Flow Modelling Guideline. Murray-Darling Basin Commission. Aquaterra Consulting Pty Ltd."

Queensland Government. 2021. "Request Point Climate Data from 1889 to Yesterday." SILOAustralian Climate Data from 1889 to Yesterday. 2021. https://www.longpaddock.qld.gov.au/silo/point-data/.

State of Queensland. 2021. "Queensland Registered Bore Database."

WRM. 2019. "Dawson Mining Complex Final void study. Anglo Coal (Dawson Management) Pty Ltd."

MODEL APPENDIX I

Selected Model Outputs

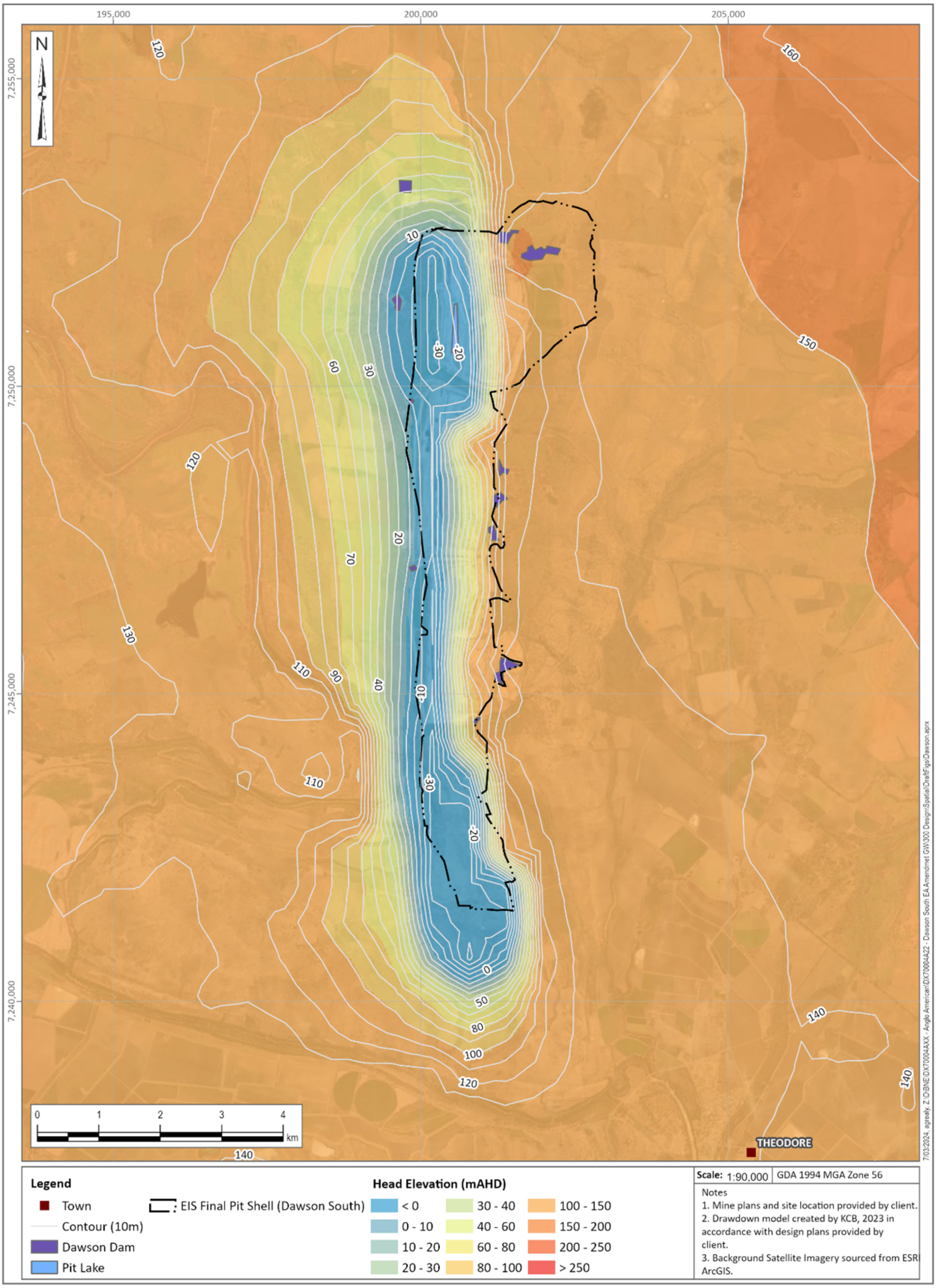

Figure I-1 Groundwater Elevation 5 years before End of Operations (Layer 2)

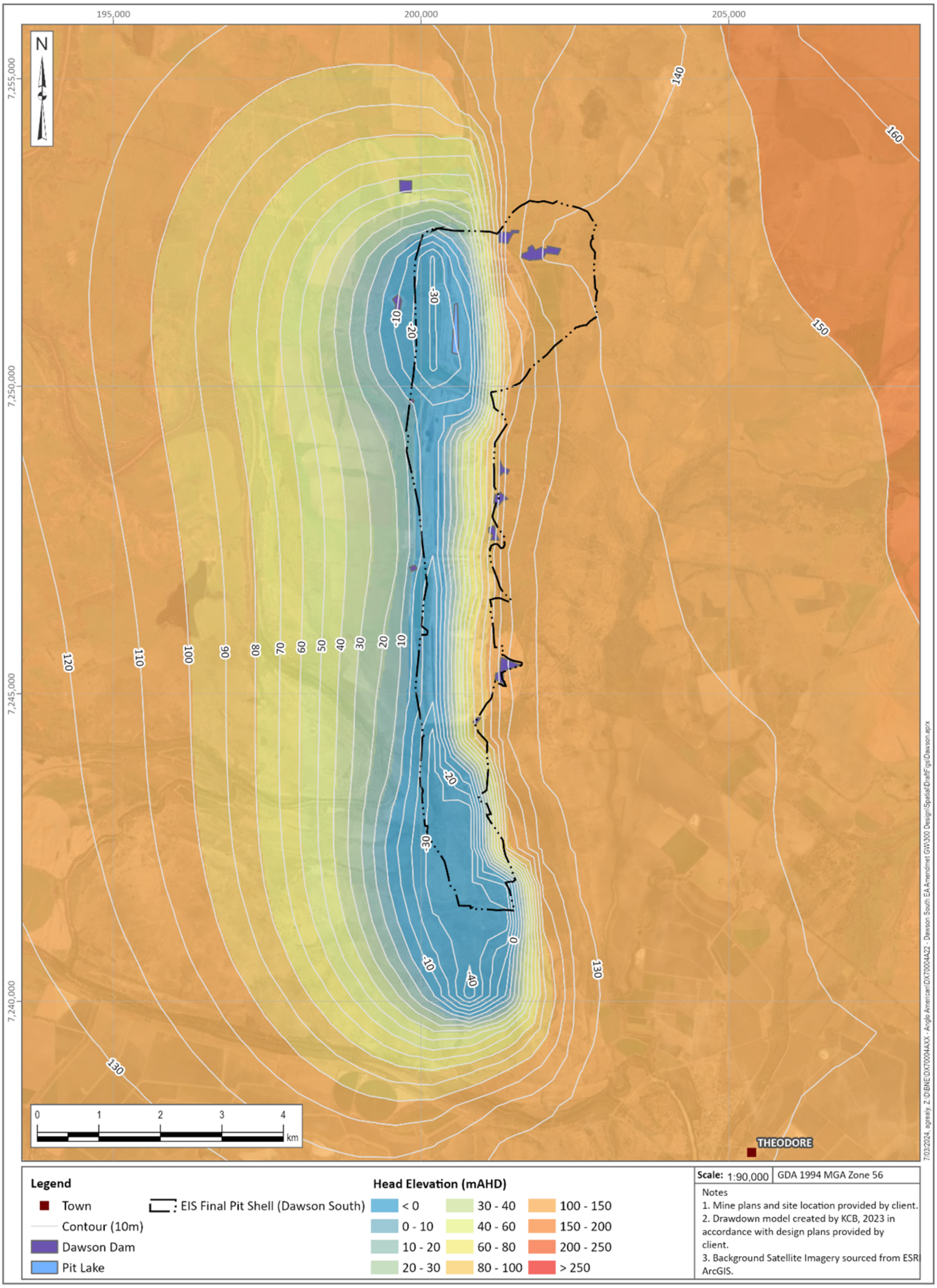

Figure I-2 Groundwater Elevation at the end of Operations (Layer 2)

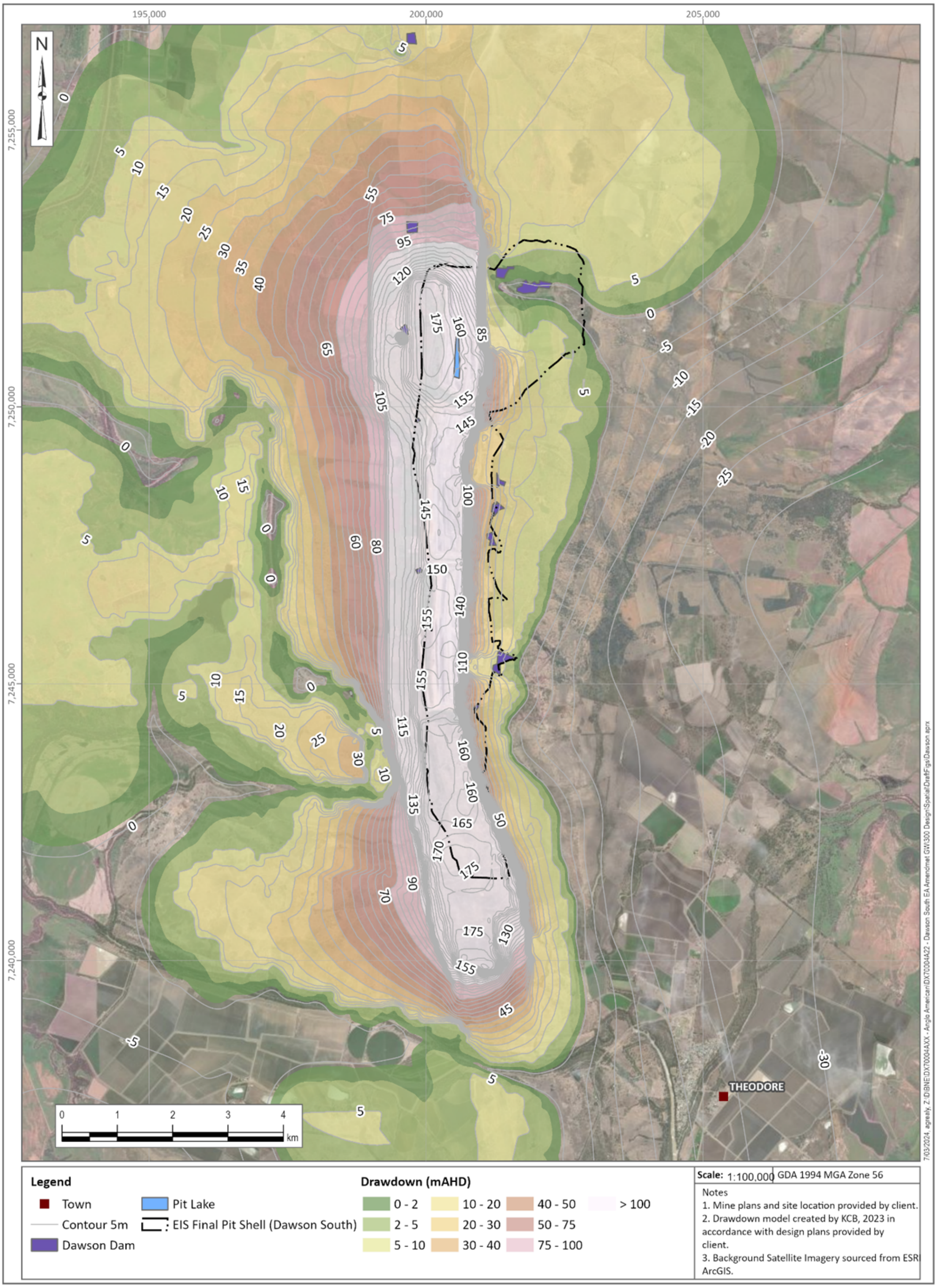

Figure I-3 Groundwater Drawdown at End of Operations – Existing mine plan (Layer 2)

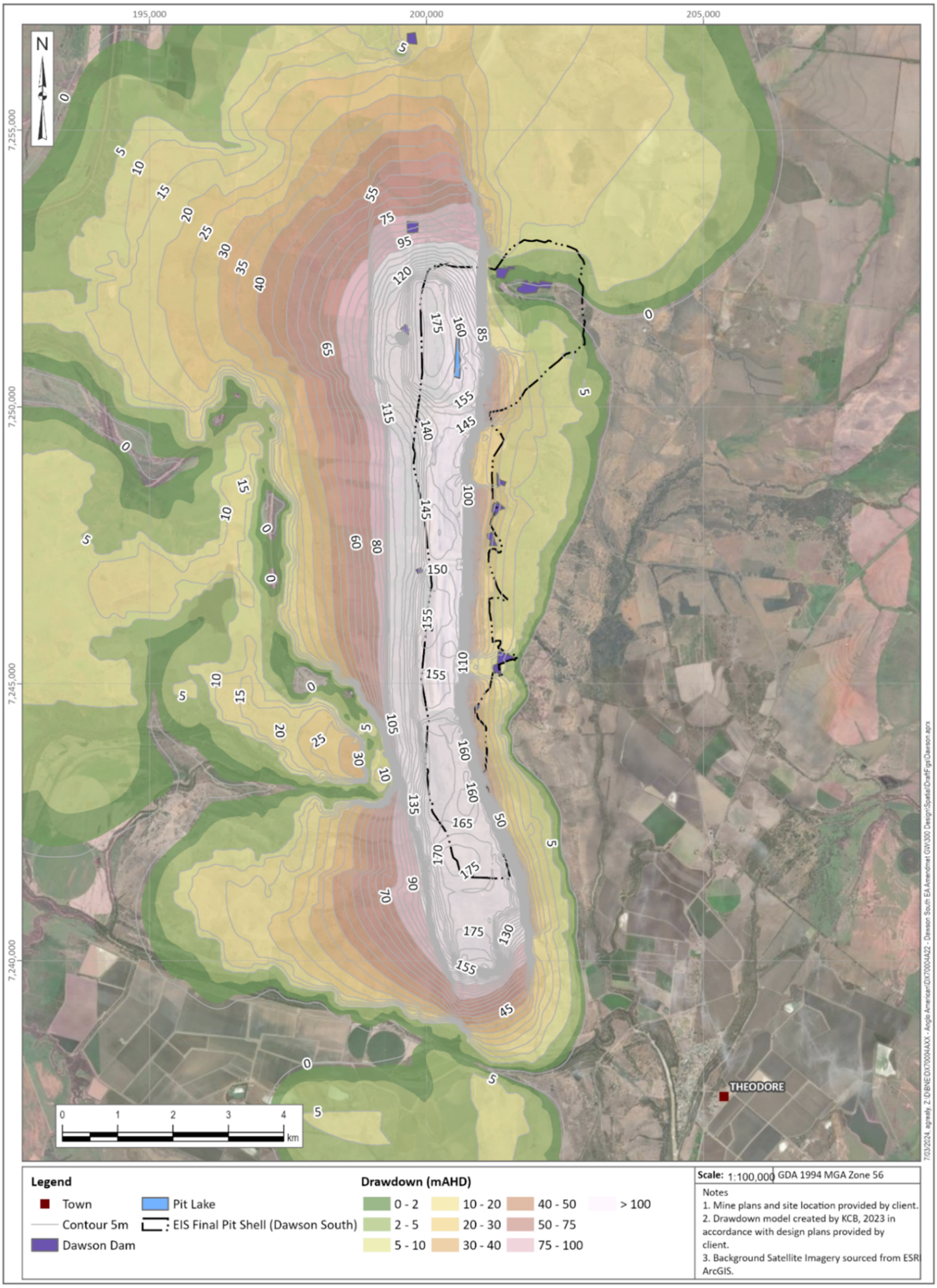

Figure I-4 **Groundwater Drawdown at End of Operations – Proposed Design Conservative Case (Layer 2)**