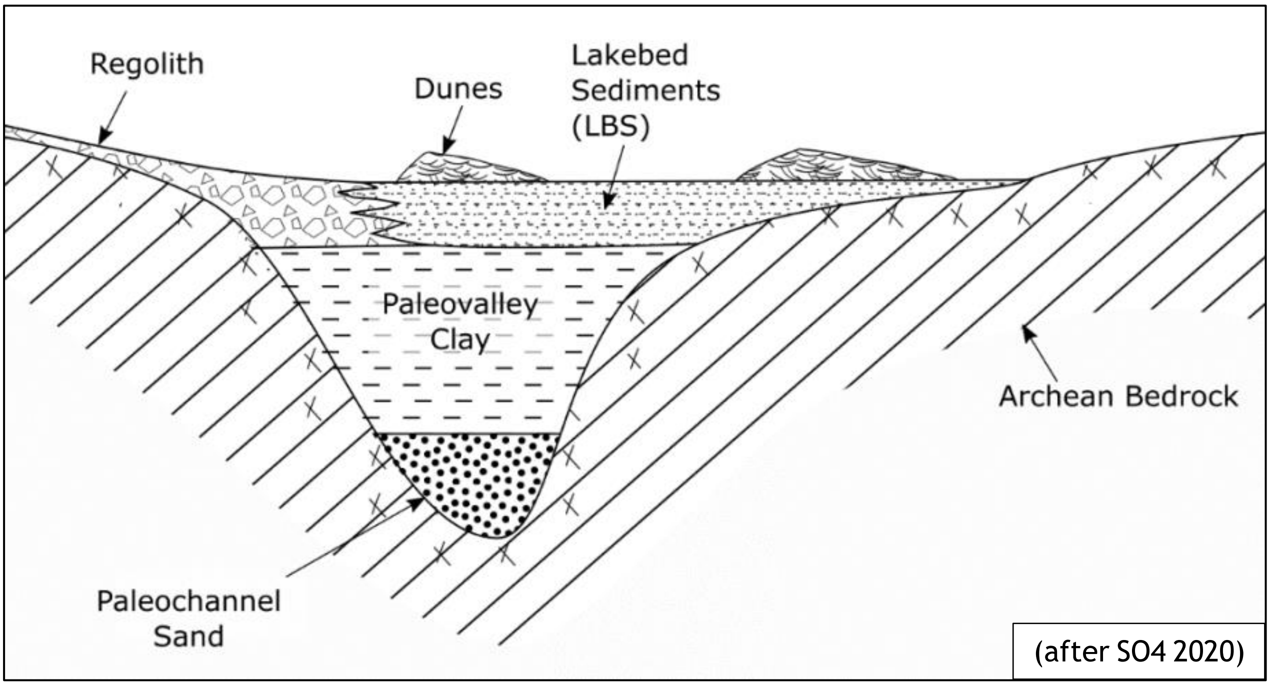
Lake Way Potash Project
Groundwater Modelling Review

Prepared for:	Salt Lake Potash Ltd	26 May 2020



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1. Introduction

1.1 Lake Way Potash Project

Salt Lake Potash Limited ('SO4') propose to develop the Lake Way sulphate of potash project about 25 km south of Wiluna in the northern Goldfields of Western Australia. The project involves pumping brine from trenches in shallow lake bed sediments (LBS) and from bores in the underlying palaeochannel sediments (front cover and Figure 1), to meet the production target. Salt Lake Potash have conducted a range of hydrogeological and groundwater modelling investigations to provide information for feasibility and for impact assessment and management purposes. Numerical groundwater flow and solute transport models of the Lake Way system have been developed for several purposes, including a) estimating the resource reserve (SO4, October 2019), and b) assessing the groundwater-related effects of the project (SO4, May 2020), building on the 2019 work as part of the project referral process.

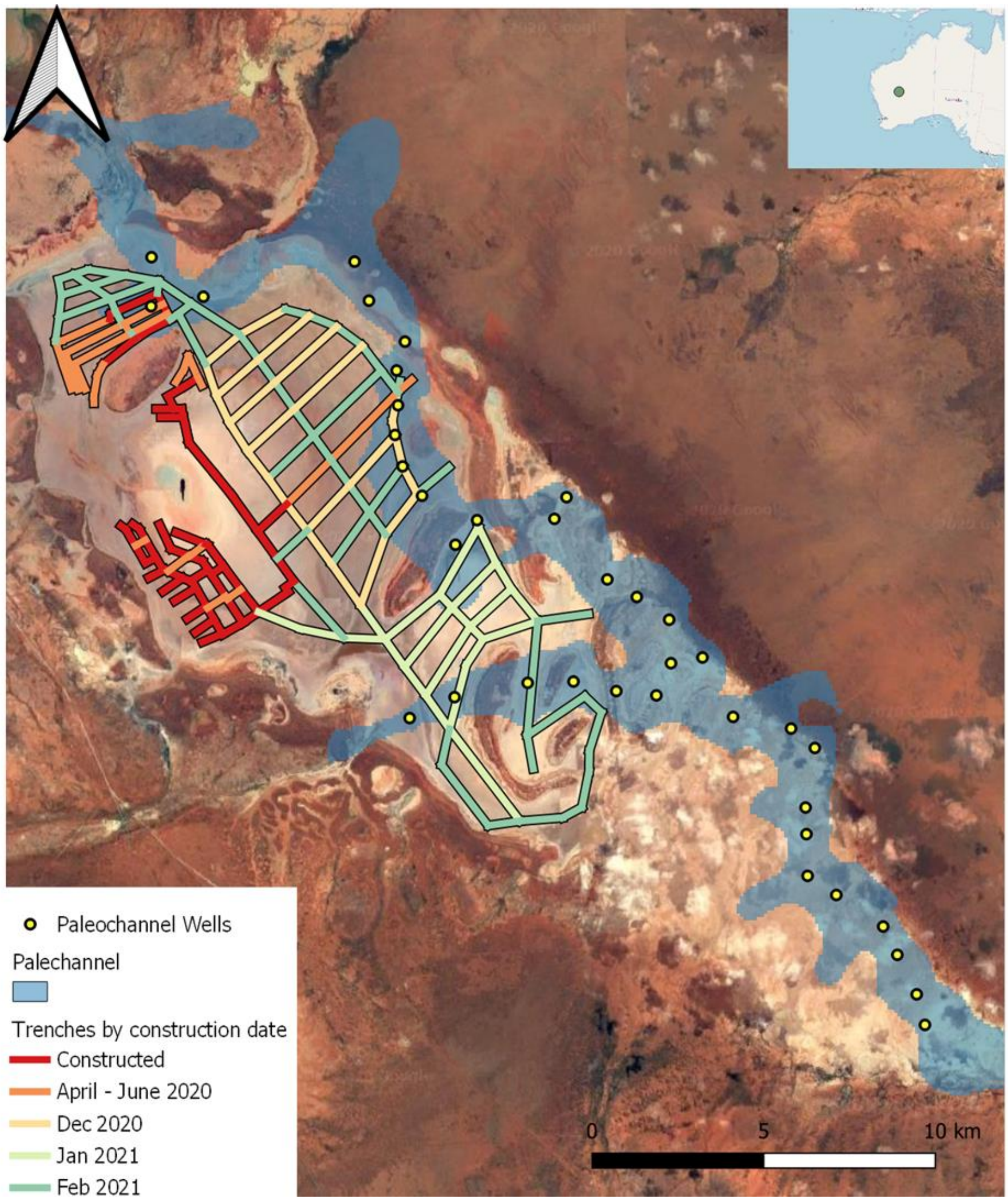

Figure 1 - Lake Way brine trench network and palaeochannel borefield (after SO4 2020)

1.2 Peer Review

This brief report documents the findings of an independent peer review of the groundwater modelling investigations that form the quantitative basis for the groundwater assessment of the Lake Way Sulphate of Potash Project that supports the project referral process (SO4, 2020).

This review was conducted by Hugh Middlemis (HydroGeoLogic), in accordance with the best practice principles and procedures of the Australian Groundwater Modelling Guideline (Barnett et al. 2012), and with consideration of recent guidance on uncertainty analysis (Middlemis and Peeters, 2018; Middlemis et al. 2019).

The review process was conducted as the modelling program progressed through the latter half of 2019 and the first half of 2020. It involved desktop reviews of draft technical notes and reports, and telephone and video conference discussions with SO4 hydrogeologists (David Van Brocklin and Pawel Rakowski).

The main evidentiary basis for this peer review was the groundwater modelling report (SO4, 2020), supplemented by the BFS modelling report (SO4, 2019). The review outcomes are summarised in section 2, including the modelling guideline compliance summary checklist (Table 1).

2. Review Outcome Summary

Table 1 - Groundwater Model Compliance: 10-point essential summary - Lake Way So4

Question	Y/N	Comments re Lake Way SO4 groundwater model
1. Are the model objectives and model confidence level classification clearly stated?	Yes	Model confidence level not specifically discussed. The report provides details on the proposed mining project, the hydrogeological setting and groundwater modelling, the impact assessment with its focus on priority groundwater dependent ecosystems, and related monitoring and management planning. This warrants a Class 1-2 model confidence level, and this review independently assessed that Class 1-2 has been achieved.
2. Are the objectives satisfied?	Yes	Competent model design and execution consistent with best practice. 3D modelling in steady state and transient modes, with calibration to good quality datasets available from 2019, including aquifer responses to major rainfall and flooding events and 17-day pumping test at 18 L/s. All with sensitivity and predictive uncertainty analyses.
3. Is the conceptual model consistent with objectives and confidence level?	Yes	Conceptualisation is sound, consistent with data, objectives and Class 1-2 confidence level for mining project impact assessment. Onerous data requirements means that Class 3 model is not achievable at approval stage for most mining projects (eg. no long term metered extraction; prediction duration more than 3x history match calibration period with good quality data).
4. Is the conceptual model based on all available data, presented clearly and reviewed by an appropriate reviewer?	Yes	Reasonable knowledge base outlined in section 2.1. Carefully considered to develop a sound conceptual model. Competent hydrogeologists and modellers have evaluated the data, conceptualisation, model design, execution & outcomes.

Question	Y/N	Comments re Lake Way SO4 groundwater model
5. Does the model design conform to best practice?	Yes	The model software, design, extent, layers, grid, boundaries, parameters and modelling methodology are consistent with best practice design and execution. Model grid comprises 6 layers, cell sizes vary from about 30m to 1000m. Main inputs and outputs are spatially and temporally variable; recharge from rainfall, creek bed leakage and lake flood inundation (Sentinel imagery used), and depth-dependent evapotranspiration plus brine pumping. Appropriate methods and parameters applied and tested for sensitivity. The 2019 and 2020 modelling programs tested: • multiple numerical methods (MODFLOW-USG-Transport, MODFLOW-2000; SEAWAT; FEFLOW) • multiple conceptual models (eg. with/without boundary inflow/outflow; various recharge/discharge features) • optimum solver settings and model performance • density and viscosity effects; low sensitivity demonstrated.
6. Is the model calibration satisfactory?	Yes	3D model calibration in steady state and transient, with focus on groundwater levels since 2019, major rainfall and flooding events in early 2020. BFS 2019 modelling assessed 17-day pumping test and 2D modelling of trench mining and brine grades. Conducted with appropriate sensitivity-uncertainty analyses. Calibration performance (SRMS 11%) acceptable for fairly low environmental risk context of brine lake and palaeochannel mining context (eg. saline groundwater, no nearby users, existing sparse vegetation dependent on soil moisture in the zone above the water table). Limitations and uncertainties addressed via targeted sensitivity and uncertainty analyses to explore project risks, identifying key factors of low Kv for clay, Sy for LBS, and recharge/dry climate (but not sensitive to Kh).
7. Are the calibrated parameter values and estimated fluxes plausible?	Yes	Model parameter values are consistent with the drilling and testing information across one 17-day bore pumping test at 18 L/s, four trench pumping tests, 27 test pits and laboratory analysis of total porosity and drainable porosity. Fluxes plausible and benchmarked to measurements (eg. brine trench pumping tests) and/or realistic constrained estimates. Calibration tested for sensitivity in 2019 and 2020 modelling programs (key parameters of Kv, Sy and recharge, plus less sensitive Kh, Ss, porosity. palaeochannel bore configurations).
8. Do the model predictions conform to best practice?	Yes	Overall methodology is consistent with best practice and suitable for guiding mining project groundwater assessments.
9. Is the uncertainty associated with the simulations/predictions reported?	Yes	Qualitative uncertainty assessment commentary has appropriate focus on project risk factors. Selected sensitivity scenarios explore potential effects of key uncertainties (e.g. 'undrainable' porosity, Sy, Ss, climate/recharge, palaeovalley clay properties). Can be characterised as a basic uncertainty assessment, consistent with best practice guidance for the fairly low environmental risk context, suitable for mining project groundwater assessment.
10. Is the model fit for purpose?	Yes	My professional opinion is that the Lake Way potash groundwater modelling assessment has been conducted consistent with best practice. It is fit for the purpose of guiding mining project groundwater assessments. Ongoing monitoring and other investigations will provide additional data for future model refinements and improvements in performance and for comprehensive uncertainty analysis. Such progressive updates should, in turn, be used to guide future monitoring and management programs.

3. Discussion

The modelling report (SO4 2020) provides adequate explanations of the hydrogeological setting, the conceptual model, the numerical model design and execution, the mining project stresses and simulations, and the sensitivity and uncertainty analyses.

We note that the project context suggests a relatively low risk setting for potential groundwater-related impacts, in that the lake bed and groundwater is hypersaline, there are no nearby consumptive users, and the existing sparse vegetation is dependent on soil moisture in the zone above the water table, where disturbances will be avoided (except for mined areas, of course). The impact assessment has an appropriate focus on drawdown predictions at the Priority Ecological Community (PEC) mapped areas.

The hydrogeological conceptualisation appears to be sound, and has been implemented aptly in the models. The model domains, layer setup, grid designs, boundary conditions and parameters applied are consistent with the available information. The model design and parameterisation is also consistent with the best practice modelling principle of parsimony (Barnett et al. 2012; Guiding Principle 3.1 and related commentary):

- 'The level of detail within the conceptual model should be chosen, based on the modelling objectives, the availability of quality data, knowledge of the groundwater system of interest, and its complexity.'
- 'In regional problems where the focus is on predicting flow, predictions depend on large scale spatial averages of hydraulic conductivity rather than on local variability. Moreover, in large regions there may be insufficient data to resolve or support a more variable representation of hydraulic conductivity. A parsimonious approach may be reasonable, using constant properties over large zones, or throughout a hydrostratigraphic unit.'
- 'Model predictions that integrate larger areas are often less uncertain because characterisation methods are well-suited to discern bulk properties, and field observations directly reflect bulk system properties.'

The modelling guidelines (Barnett et al. 2012) recommend a calibration statistical metric of 10% scaled RMS, which is slightly exceeded by the regional 3D model calibration performance of 11% sRMS. This is considered acceptable given the project context, and there is acceptable justification given for excluding three outlier bores from the RMS statistic.

Other model calibration/prediction performance issues have been acknowledged in the model limitations statement, including there being no long term time series bore data for a 20-year transient calibration (ie. consistent with the roughly 20-year mine life). Similarly, there have been no pumping stresses on the aquifer of a scale similar to the proposed mining project. These issues are common to mining project developments at the approval stage, and are usually addressed via sensitivity and uncertainty analyses, as has occurred in this case.

Despite the data available not meeting ideal requirements for model calibration, the Lake Way model has been well-designed and its performance has been demonstrated to be suitable for the groundwater assessment and management purpose. For example:

a) the calibrated model groundwater flow patterns reflect the hydrogeological conceptualisation and the measured groundwater levels generally; more importantly, the modelled groundwater levels are well-matched in the key area of the lake bed, and a reasonable match was obtained to the dynamic responses to the major rainfall and flooding events of early 2020;

b) data from a 17-day pumping test at 18 L/s was evaluated by a local scale 3D model to derive aquifer parameters for application to the regional model (SO4 2019); the test bore was screened across the paleochannel sand, and observation bores nearby in the paleochannel sand and clay units were also monitored; excellent model performance was achieved, which can be partly attributed to the careful local scale model design, notably including multiple layers for the thick clay and sand sequences, applying the CLN package to represent the pumping from the sand unit, and applying PEST parameter estimation software; the pumping test analysis had a focus on the key parameter values for the paleochannel sand horizontal hydraulic conductivity (Kh), paleochannel clay vertical hydraulic conductivity (Kv), and the specific storage (Ss) for those units; the calibrated pumping test parameter were applied to the regional model, which helps address the pumping stress limitation issue discussed above, and provides further confirmation of the model fitness for purpose.

The somewhat limited data available for long term history match calibration means that uncertainties apply regarding the model predictive capability for the large pumping stresses proposed to be applied to the full scale project. This is a common occurrence for mining projects at the approval stage, in that there is often limited data available to benchmark the modelled system response to the scale of the proposed pumping and thus establish confidence in the model results. The uncertainties are adequately addressed via the sensitivity and predictive uncertainty scenarios. The qualitative uncertainty analysis commentary in the modelling reports are consistent with recent guidance (Middlemis and Peeters 2018; Middlemis et al. 2019).

The information presented is suitable for the purposes of mining project impact assessment and to develop environmental monitoring and management plans. For example, the sensitivity/uncertainty runs have a focus on the mining project risks in terms of the effects of parameter uncertainties on brine production volumes and grades, as well as potential environmental impacts, notably the spatial and temporal variability in the predicted drawdowns at the key GDEs of mapped *Tecticornia* and PEC areas.

4. Conclusions and Recommendations

My professional opinion is that the Lake Way potash groundwater modelling assessment has been conducted consistent with best practice, including the predictive scenarios and selected sensitivity/uncertainty assessments. It is fit for the purpose of guiding mining project groundwater assessments.

Ongoing monitoring and other investigations will provide additional data for future model refinements and improvements in performance and for comprehensive uncertainty analysis. Such progressive updates should, in turn, be used to guide future monitoring and management programs.

5. Declarations

For the record, the peer reviewer, Hugh Middlemis, is an independent consultant specialising in groundwater modelling. He has a degree in civil engineering and a master's degree in hydrology and hydrogeology, and about 40 years' experience, including on brine solution mining projects in Chile, Argentina and California. Hugh was principal author of the first Australian groundwater modelling guidelines (Middlemis et al. 2001) that formed the basis for the latest guidelines (Barnett et al. 2012) and was awarded a Churchill Fellowship in 2004 to benchmark groundwater modelling best practice. He is principal author on two recent guidance reports on modelling uncertainty (Middlemis and Peeters 2018; and Middlemis et al. 2019).

We assert no conflict of interest issues in relation to this work. Hugh Middlemis has not worked directly on the Lake Way Project or for Salt Lake Potash. Hugh has previously worked with David van Brocklin and Pawel Rakowski (Salt Lake Potash hydrogeologists) during their employment at Aquaterra Consulting. Hugh ceased employment at Aquaterra in 2013 and established the HydroGeoLogic independent consultancy in 2014. Hugh has completed independent reviews of models developed by Pawel Rakowski for Hawkes Bay Regional Council (NZ) from 2015 to 2018.

6. References

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