Lake Way Groundwater Modelling: 50ktpa Scoping

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Contents

Objective

A numerical groundwater model was developed to predict water level drawdown due brine production from trenches in the superficial lake sediments at Lake Way. The model simulates brine abstraction of 8Gl/a from a 38km trench network to meet the proposed production target of 50,000tpa for the demonstration plant at lake Way. The model development and prediction are summarized below.

Model Setup

Modelling Software and Interface

The numerical groundwater modelling code MODFLOW-USG TRANSPORT using the Upstream Weighting Package (UPW) was used to develop the groundwater flow model. The Groundwater Vistas graphical user interface (Version 7.20) was used to develop the model input files and process the model output.

Model Extent and Grid

The model domain has dimensions of 14km (north to south) by 16km (east to west), with corner coordinates specified in Table 1. The model covers the entire area of Lake Way.

Table 1 Model Domain

Model Corner	Easting(m)	Northing(m)
North-East	244815	7043422
North-West	228368	7043422
South-West	228368	7029371
South-East	244815	7029371

The model grid is structured like a standard finite difference grid and consists of 2 layers, 281 rows, 328 columns and has a uniform cell size of 50 by 50m. The model and all associated data have been plotted using the GDA 1994 zone 51 coordinate system.

Model Layer Geometry and Timing

The elevation of the top of the uppermost layer, Layer 1, represents the ground surface. The bottom of the lower layer, Layer 2, represents the top of weathered bedrock or paleovalley sediments underlying the lake sediments. A summary of model layers is presented in Table 2.

Table 2 Model Layer Geometry

Model Layer	Thickness (m)	Description
1	1.0	Top represents ground surface, bottom represents maximum depth of water level in trenches
2	0.5 to 10.3	Thickness of lake sediments below bottom of Layer 1

The simulation period is 5 years, divided into 60 monthly stress periods.

Initial Conditions

Initial water levels are set everywhere to 0.4m below the top of layer 1.

Figure 1 Model Area

Groundwater Inflow and Outflow

Groundwater Throughflow

No groundwater throughflow occurs into or out of the model. The model is bounded on all sides with no-flow boundaries. The south-eastern no-flow boundary passes through the Lake. This boundary is located far enough from the trench network such that drawdown impacts from trench abstraction do not reach the boundary. The bottom of the model represents the contact between lake sediments and the basement.

Recharge

Groundwater recharge occurs through infiltration of surface flows into the lake and direct rainfall recharge. There is no other source of inflow into the model.

There are three zones of recharge in the model: one for the area of the Lake with a ground surface elevation below 492mHD, one covering the area of the Lake between 492 and 494mAHD, and one for the remainder of the Lake. Elevations were based on 1 arcsecond SRTM elevation data.

Recharge calculations were based on monthly precipitation and estimated surface inflows into the lake for the 5-year period from 1971 to 1975.

Recharge rates were calculated monthly in the following manner:

1. If monthly surface inflow fills the lake to a level equal to or below 492mAHD then the recharge rate for this area = (inflow volume-evaporation)/ (area of lake below 492). Recharge to area above 492 = 0.
2. If monthly surface inflow fills the lake to a level above 492 then the recharge rate for this area = (inflow volume-(vol to fill lake to 492)-evaporation)/ (area of lake below 494).
3. For area of Lake above 492mAHD zero recharge from surface inflows is assumed.
4. Recharge from precipitation directly onto the Lake is set to 50% of daily rainfall above 4mm. This recharge is added to each zone.

Direct rainfall recharge was based on the estimated recharge at Lake Wells (Groundwater Science, 2017). Evaporation from water ponded in the Lake was 0.7 x (pan evaporation).

Drains were placed across the top of Layer 1 to prevent high levels of recharge from raising water levels above the ground surface. Drain elevations were set equal to the model top elevation of 492mAHD and conductance was set to 1000m^2/d.

Evapotranspiration

Evapotranspiration (ET) is simulated everywhere in the model with a maximum ET rate of 0.7 x pan evaporation and an extinction depth of 0.4m. The ET surface was set equal to the top of Layer 1. The ET rate was varied monthly based on evaporation data from the Meekatharra Airport BOM station for the 5-year period from 2009 to 2013. Data from the Wiluna BOM station was not used because it appears to be anomalously low compared to other gauges.

Williamson Pit

The Williamson Pit is represented in the model by drains in Layers 1 and 2. Drain elevations are set equal to the layer bottom elevation so that the model cells within the pit are completely dewatered at all times.

Aquifer Parameters

Aquifer parameters are homogeneous within each model layers. The hydraulic conductivity (K) was set at 4.0 m/d in both layers. Specific yield (Sy) was set to 0.10 in Layer 1 and 0.08 in Layer 2. The ratio of vertical to horizontal hydraulic conductivity was set to 0.1.

The hydraulic conductivity was based on the average K value from 4 trench pumping tests (average K = 5 m/d) on the Blackham tenements area on Lake Way and from lab analysis on 27 samples (average K = 4.4 m/d).

Specific Yield was based on two trench pumping tests and lab measurements of 18 samples from test pits at Lake Way (Salt Lake Potash, 2018). Trench pump testing gave estimates for Sy of 0.13 and 0.15. Lab measurements of Sy average 0.106 with values below the top 1m decreasing to 0.82.

Prediction

Prediction Setup

The prediction modelled a 38km trench network with trenches up to 9.6m deep. The prediction assumed a constant maximum abstraction rate of 8 Gl/a (254 l/sec) from the trench network. The modelled trench network occurs entirely within the Blackham tenement. The trench network is shown on Figure 1. The trenches were simulated using the MODFLOW-USG Connected Linear Network (CLN) package.
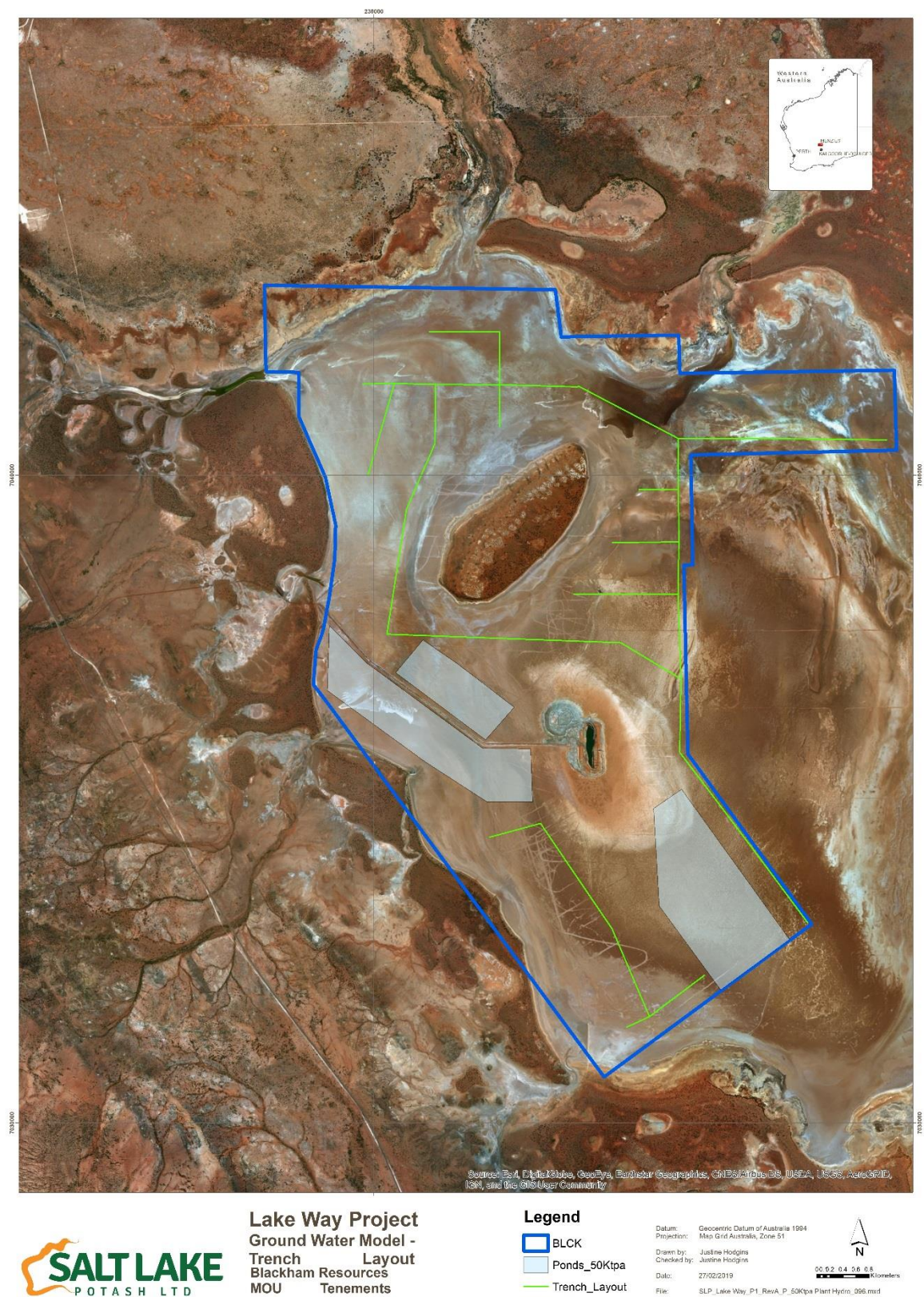
Figure 2 38 km Trench Network

Prediction Results

### Drawdown Due to Brine Abstraction from Trenches

Drawdown varies as a function of recharge, with maximum predicted drawdown occurring at the end of extended dry periods. Maximum predicted drawdown occured after 2 years of simulated brine production. Contours of maximum predicted drawdown are presented on Figure 3.

The minimum drawdown contour presented on Figure 3 is 0.5m. The 0.5m contour is the outermost contour surrounding the trenches. Inside the 0.5m contour, the contour interval is 0.1m up to a drawdown of 3m. Drawdown contours for greater then 3m are not shown.

The larger extent of drawdown on eastern side of trench network is due to greater trench depths and larger drawdowns at the trenches. Trench depths vary from 2m on the western side to 9.6m for the easternmost trench.

The 0.5m drawdown extends 47m away from the trenches at the shallowest eastern trenches to 660m at the deepest and easternmost trench.
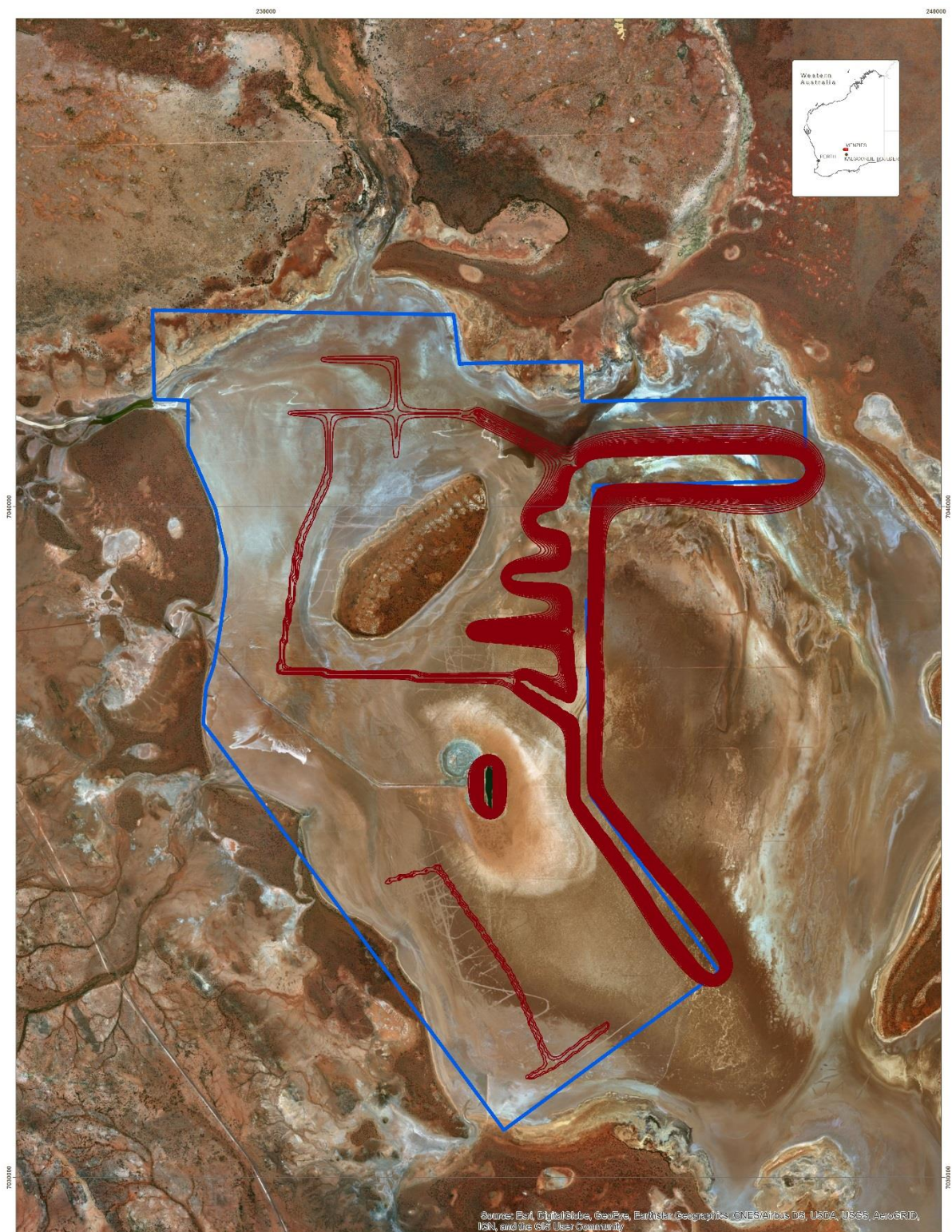
Figure 3 Contours of Maximum Drawdown

Prediction Sensitivity

A sensitivity analysis tested the effect of varying the specific yield (Sy) and hydraulic conductivity (K) on the predicted drawdown. Sensitivity predictions were run for K values of 2 and 6 m/d, representing upper and lower limits of the expected range of K values in the lacustrine sediments at Lake Way. Sy values were increased by 0.02 and decreased by 0.02, representing upper and lower limits of the expected range of Sy values.

The predicted 0.5 m drawdown contour for K values of 2 and 6 m/d are presented with the original (base) prediction (K = 4) on Figure 4**Error! Reference source not found.**. For the K = 6m/d case, predicted drawdown extent increased by a maximum of an additional 50m from the trenches. For the K = 2m/d case, predicted drawdown extent decreased by a maximum of 150m from the trenches.

The predicted 0.5 m drawdown contour for Sy values increased by 0.02 and decreased by 0.02 are presented with the original (base) prediction (Sy = 0.1 layer 1, Sy = 0.08 layer 2) on Figure 5**Error! Reference source not found.**. For the Sy + 0.02 case, predicted 0.5m drawdown extent decreased by a maximum of 54m from the trenches. For the Sy - 0.02 case, predicted 0.5m drawdown extent increased by a maximum of 60m from the trenches.
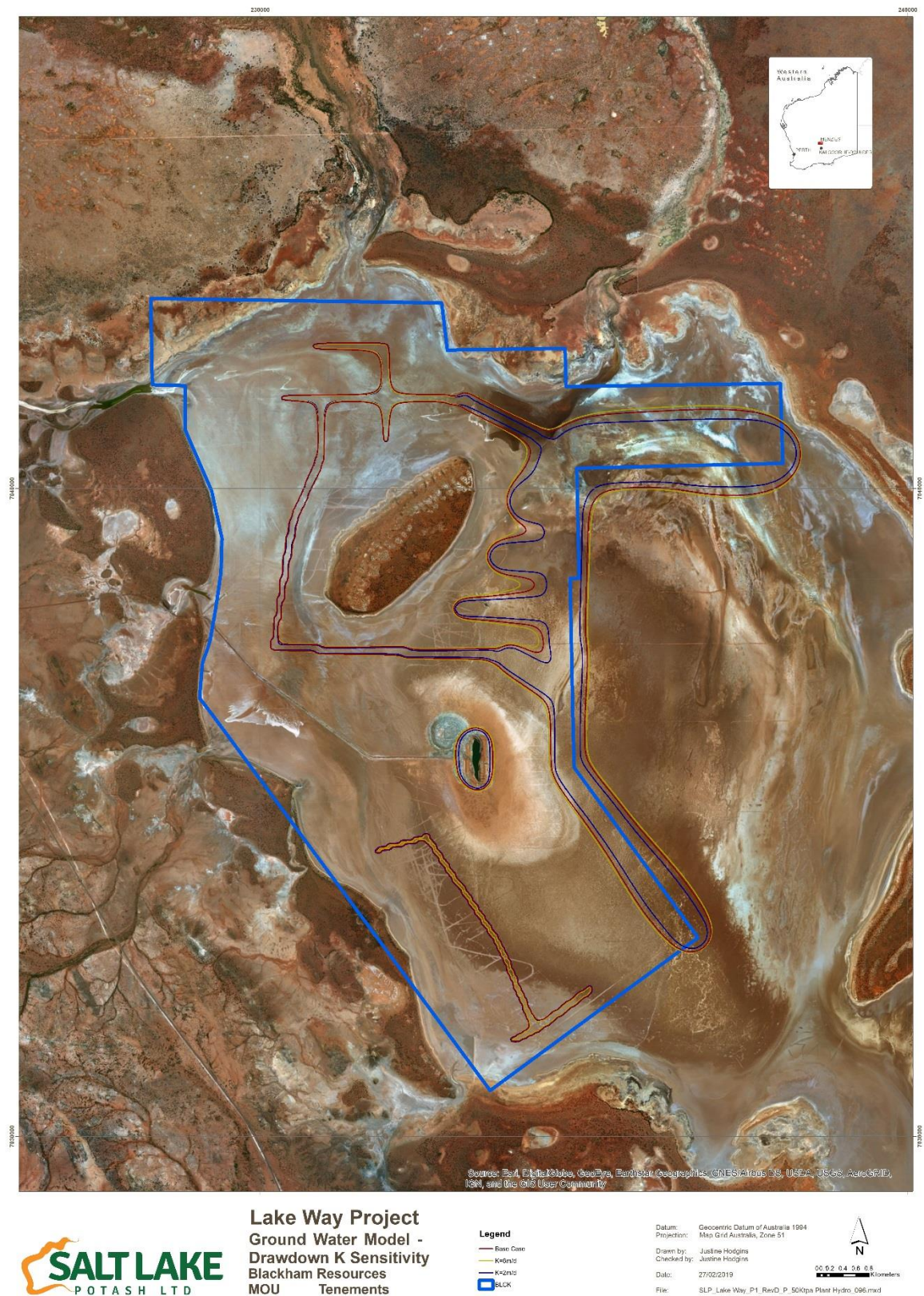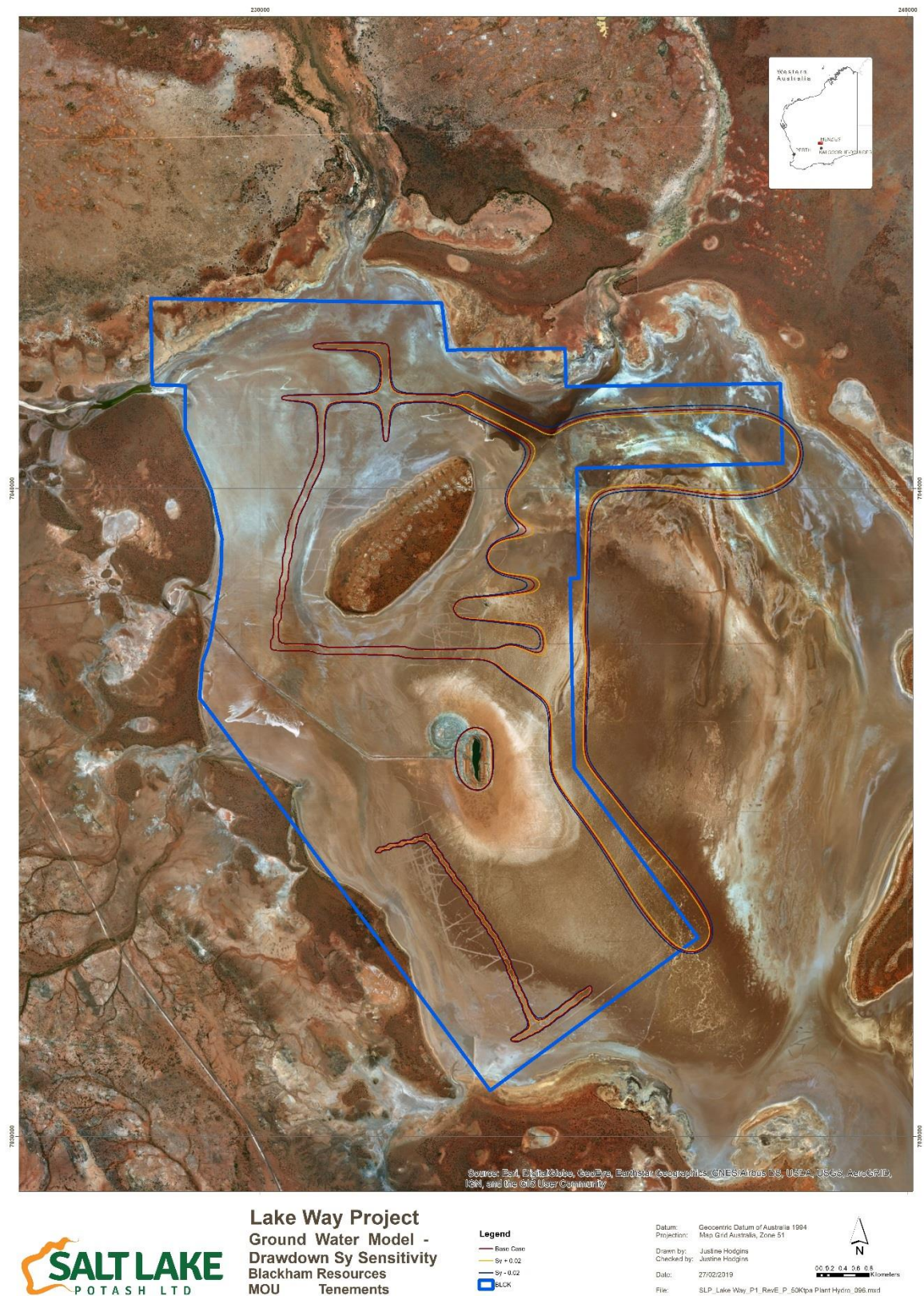
Figure 4 Drawdown Sensitivity to Hydraulic Conductivity

Figure 5 Drawdown Sensitivity to Specific Yield

References

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Salt Lake Potash LTD, 2018, Blackham Resources Tenements SOP Resource Estimate, July 2018.

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