Agrimin Limited

Water Supply Assessment for Mackay SOP Project

Groundwater Modelling Report

19 May 2020

CDM Smith

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Executive Summary

A numerical groundwater model has been developed in support of the water supply assessment for the proposed Lake Mackay Sulphate of Potash (SOP) project.

The development of the groundwater model follows the recommendations of the Australian Groundwater Modelling Guidelines (modelling guidelines). The numerical model is a groundwater flow model developed with Feflow and Modflow-Surfact modelling codes. It is assessed to be Class 2 flow model with respect to the confidence-level classification criteria in the modelling guidelines.

Results of calibrated model parameters (recharge, hydraulic conductivity, specific yield) were consistent with background ranges determined mainly from the literature and available field studies. Model convergence and the model water balance were within guideline target criteria. The model had acceptable qualitative performance with modelled groundwater levels in reasonable agreement with observed values. Unfortunately, due to lack of data longer term groundwater model calibration could not be performed where predicted and measured long term trends could be compared. This represent a major limitation of this model.

The model reports a final standard error (RMS) of 2.2 m, the scale root mean squared (SRMS) is 8.1% and slightly below the guideline target of 10%. The SRMS value is considered reasonable given the dependence of groundwater levels on SRTM ground elevations, which can have considerable error.

Seven predictive scenarios were modelled to investigate water supply options for the project that meet a lower demand of 0.7GL/a for a SOPM production case and 3.5GL/a for a SOP production case. In conjunction with target water demands various borefield setups have been trialled, ranging from seven to twenty-eight bores, placed in one or two tenement lines, with spacing between the bores ranging between 1 and 2 km. Water supply was tested for the life of mine of 20 years.

For the adopted base case model parameters all seven prediction runs assessed that the projected water demand could be met over the life of mine.

Sensitivity analysis mainly assessed lower ranges of horizontal and vertical hydraulic conductivity and unconfined aquifer storage. These parameters were provided as part of the NMR assessments which have been completed outside of this scope. Lower hydraulic conductivity for the Surficial Deposits result in estimated model abstraction not being able to meet the target water demand. It is recommended that horizontal and vertical hydraulic conductivity are assessed further, and test pumping can provide quantitative information on the aquifer parameters, hydraulic efficiency of the production bores and the hydraulic relationship between the shallow and deep paleochannel aquifers and the adjacent boundary conditions.

The test should separately assess shallow and deep aquifers and their connections. The results of the pumping test along with the long-term water level and water quality monitoring data would complete the requirements for transient model calibration, improve model reliability and reduce uncertainties in the model.

This report is a full record of the model development and predictive simulations. It includes descriptions of the hydrogeological conceptualisation, model construction and calibration, predictive simulations and results, and predictive sensitivity analysis.

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Section 1 Introduction

Agrimin Limited (Agrimin) is proposing to develop the Mackay SOP Project (the project) which is the world's largest undeveloped SOP-bearing salt lake. The Project is situated on Lake Mackay just north of the Tropic of Capricorn approximately 785 kilometres (km) south of Wyndham (ref Figure 1-5). The project is based on the extraction SOP mineralisation which is dissolved in the brine (hypersaline groundwater) within Lake Mackay.

The main focus of this study is to simulate water supply options for the project that meet a lower demand of 0.7GL/a for a SOPM production case and 3.5GL/a for a SOP production case. The PFS assessed the economics of an initial 20 year Life of Mine (LoM) operation. Excellent potential exists for Agrimin to increase planned production rates and/or extend the operational life of the project potentially to a 40 year LoM when additional production data becomes available.

Raw water is planned to be abstracted from a borefield located approximately 38km south-east of the proposed process plant site. Based on the Agrimin's water exploration drilling completed in 2017, the borefield will target an extensive palaeovalley sand aquifer with brackish to saline water quality. The proposed borefield design consists of approximately 28 bores with the capacity to allow for downtime of 4 bores at any one time. Agrimin is currently investigating two other areas with the potential to provide a source of fresher water.

1.1 Hydrogeological Conceptualisation

The hydrogeological conceptualisation was completed by Agrimin. Initial investigations in 2017 identified the area 38km SE of the proposed Process Plant as a potential water source for the project's process water requirements. Following these investigations, the 2019 "Southern Borefield Process Water Supply Investigation" drilling program was designed to gather geological information on potential aquifer units and obtain water quality samples.

The 2019 drilling program commenced on the 16th of September and was completed by the 21st of September. A total of 8 drill locations were planned and 4 were drilled (ref Bore Completion Report, Agrimin, 3 March 2020). The results of the 2019 drilling program were also assessed as part of this study.

Sections 1.1.1 to 1.1.6 are taken from Agrimin's conceptual report.

1.1.1 Regional Geology

Lake Mackay is located in the Great Sandy Desert on the border between Western Australia and the Northern Territory. The geology of the Lake Mackay area is summarised in the Webb 1:250,000 geological series map. The lake overlies the western margin of the Paleoproterozoic Arunta Complex and Neoproterozoic Amadeus and Ngalia Basins. The Amadeus Basin occupies much of the southern quarter of the northern territory and extends 150km into Western Australia. The sediments of the western extent of the Amadeus Basin have been identified as a potential source of groundwater for the Projects process water requirements and has been the focal point of several geophysical and hydrogeological investigations.

1.1.2 Historical Exploration

Initial exploration of the area south of Lake Mackay was undertaken by Toro Energy targeting hard rock Iron Oxide Copper Gold (IOCG) mineralisation and uranium in palaeochannels. The company completed airborne magnetic and electromagnetic (EM) surveys over the area and drilled over 100 aircore holes and one diamond hole into basement (Figure 1-1). The drilling identified clay and sand sequences overlain by a laterally extensive silcrete layer at 40m and a similarly extensive calcrete layer at surface (Brooker and Fulton, 2016). Quaternary aeolian deposits often overlie these calcrete deposits. Extensive calcrete formations are known to be a reliable source of near surface (10-20m deep) groundwater resources.

Following a review of the Toro Energy data, a groundwater exploration target area was defined based on the distribution of a 40m thick sand sequence identified in the drill logs and EM survey data (Brooker and Fulton, 2016). This target area was investigated for its groundwater potential in 2017. Three test production bores and five monitoring bores were installed using mud rotary techniques (Figure 1)**Error! Reference source not found.**. A review of the results of the 2017 drilling investigation and extensive desktop study in 2019 further refined the target area and identified the sediments of the Amadeus Basin as a source of potential groundwater. An exploration drilling and monitoring bore installation program was completed in September 2019 with the aim of obtaining lithological and water quality samples from the Amadeus sediments.

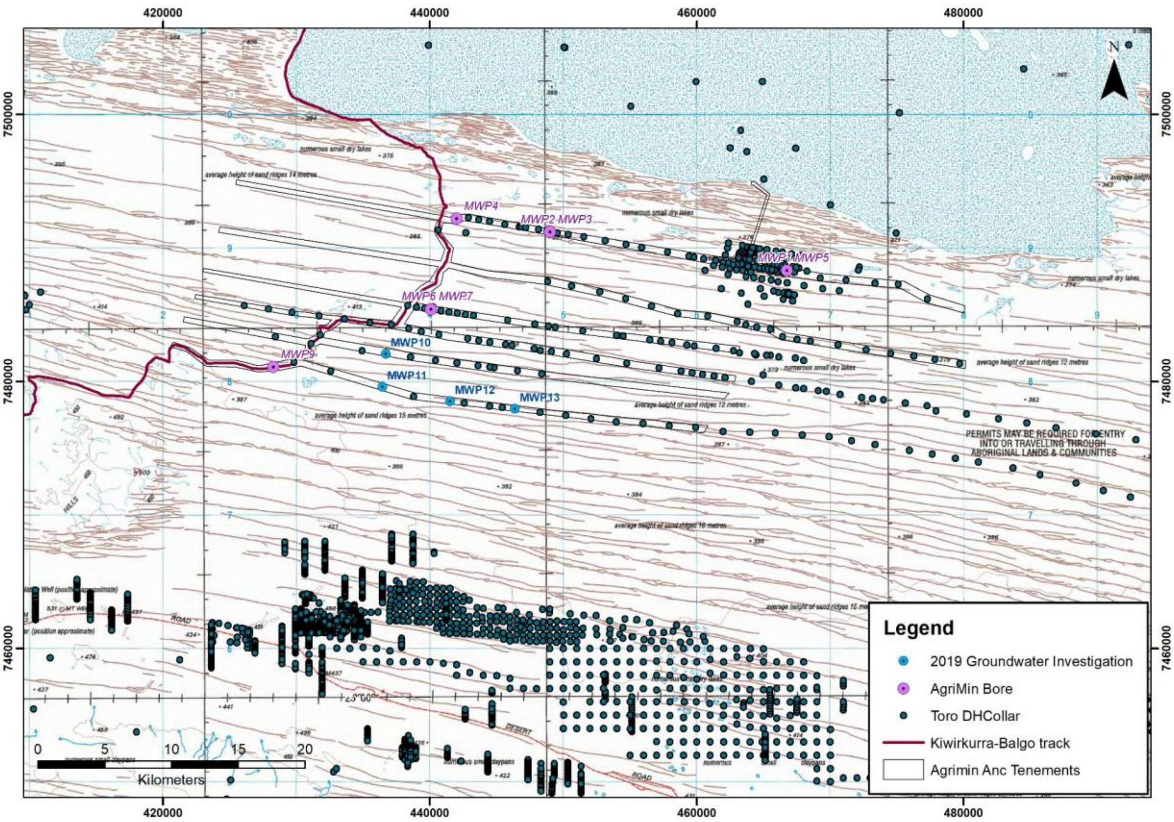

Figure 1-1 Locality of Agrimin Miscellaneous tenements and Toro Energy drill holes south of Lake MacKay

A summary of the hydrogeological field programmes completed prior to the development of a groundwater model included the following:

- Toro Energy (2009-10): Airborne magnetic and electromagnetic surveys, exploration drilling.
- Agrimin (2017): Passive seismic surveys, Time Domain Electromagnetic and Magnetics, exploration and production bore drilling and pump testing.
- Agrimin (2019): Exploration drilling and monitor bore installation, airlift investigations and groundwater sampling.
- Agrimin (2020): Down hole Nuclear Magnetic Resonance (NMR) profiling and groundwater sampling.

1.1.3 Hydrogeological Conceptualisation

A review of the geology and hydrogeology south of Lake Mackay was completed to assess the area as a potential source of suitable process water for the project. Geological data from previous exploration programs described above have been incorporated into the hydrogeological assessment. The area of assessment focuses on the Miscellaneous Tenements shown in Figure 1-1, with emphasis on the southern two lines, and extends southward to include other potential water resource areas.

1.1.4 Geological Interpretation

Bedrock geology of the investigation area is shown by Figure 1-2, which mostly comprises Neoproterozoic - Early Cambrian rocks being part of an outlier of the Amadeus Basin, which is part of the Petermann Orogeny (580–520 Ma) (Joly et al., 2013; Spaggiari et al., 2016). Sediments in the western portion of the review area are dominated by the Angas Hills Formation, which comprises predominantly of interbedded pebble and cobble conglomerate, sandstone, pebbly sandstone and siltstone with a matrix of clayey sandstone and minor mudstone. The eastern section, a sequence of sandstone, siltstone and shale are consistent with the older Pertatataka Formation. The remainder of the area is made up of undifferentiated Amadeus siliciclastic sediments and is shown in the Total magnetic Image (TMI) in Figure 1-3 as an area of partially obscured magnetics.

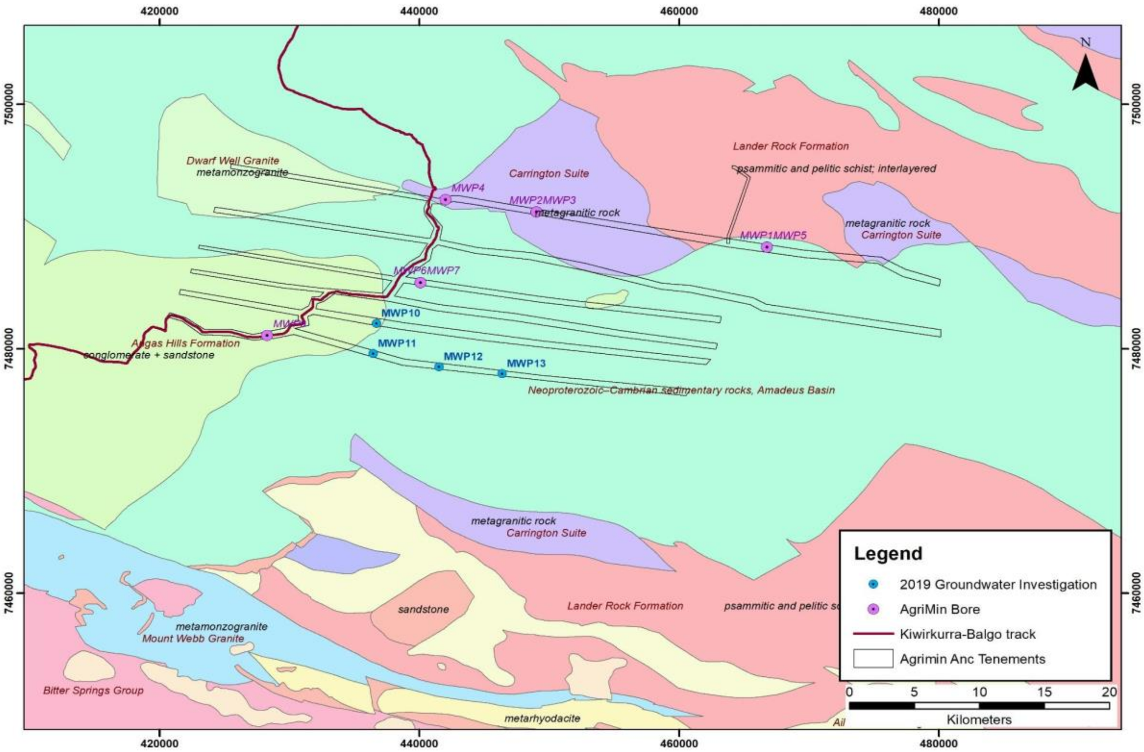

Figure 1-2 Bedrock Geology and Groundwater Investigation Holes South of Lake Mackay

The investigation area is bound to the north and south by Paleoproterozoic rocks of the Lander Rock Formation, which are part of the Arunta Complex. These areas are made up of granitic and metasedimentary rocks which are clearly visible on magnetic imagery (Figure 1-3).

The Neoproterozoic deposits are largely overlain by Tertiary paleochannel deposits and broad alluvial cover of Neogene age. The stratigraphy of the investigation area is summarised in Table 1 and a geological section through the western portion of the southern tenement line is shown in Figure 1-4.

Table 1-1 Stratigraphy of the southern borefield area

Formation	Age	Lithology	Max Intersected thickness (m)
Surficial	Quaternary	Sand	10
Unnamed Neogene deposits	Neogene	Clayey sandstone, with calcrete, silcrete and ferricrete	49
Paleochannel	Paleogene	Silty clay and clay, over sand	107
Angas Hills Formation	?Cambrian	Silty fine-grained sand, conglomeritic clayey sand	57
Carnegie Formation / Pertatataka Formation	Cryogenian – Ediacaran	Fine to medium-grained sandstone / siltstone and claystone	81

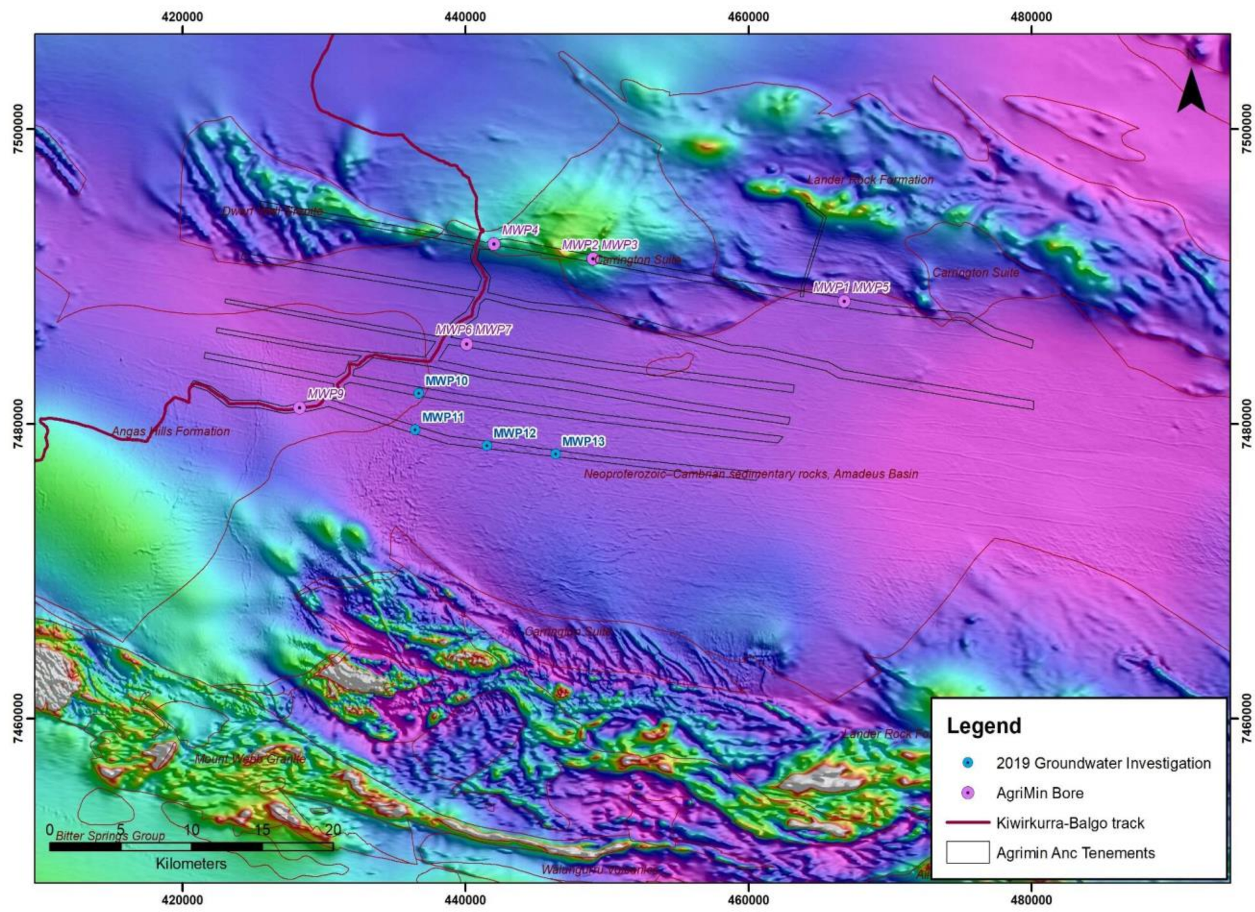

Figure 1-3 Magnetic Imagery of the Investigation Area

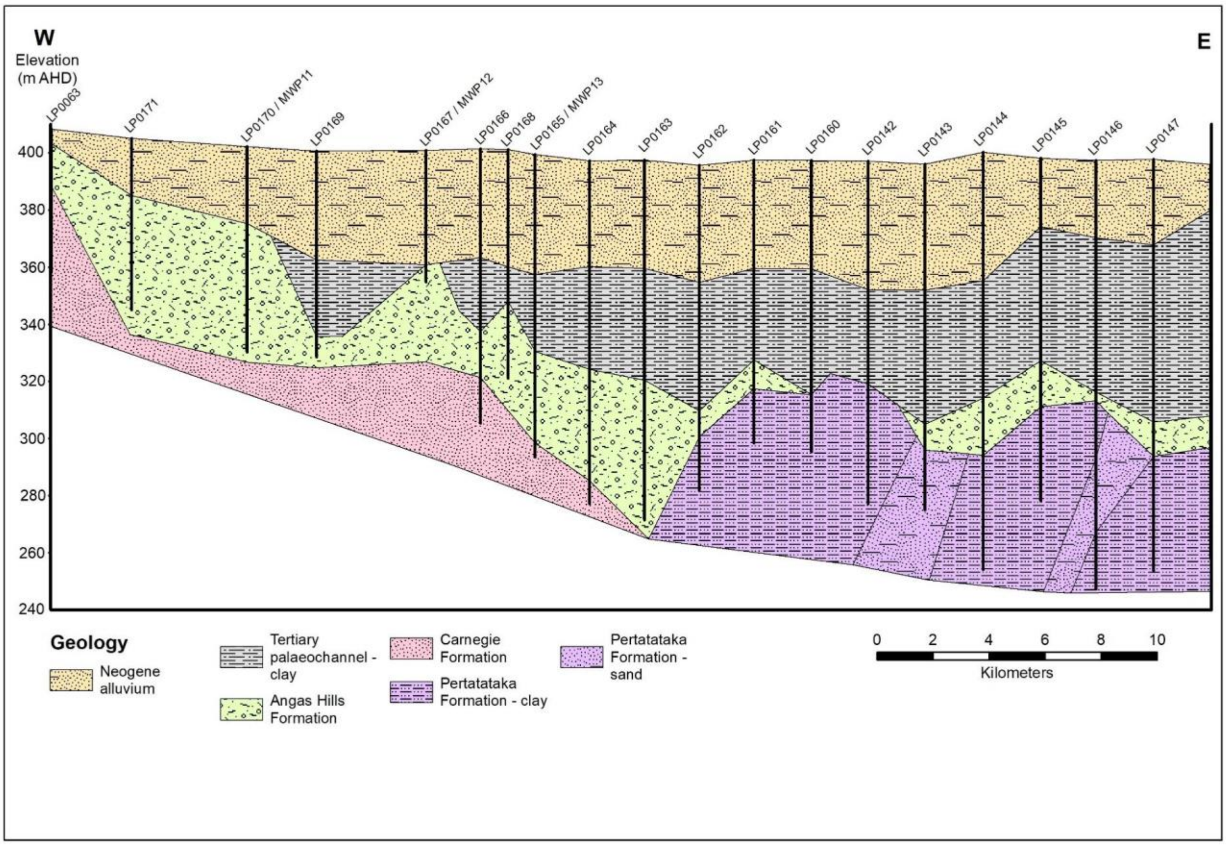

Figure 1-4 West to East Geologic Section Along Southern Tenement Line (Toro Energy)

1.1.5 Hydrogeology

The aquifers in the area south of Lake Mackay are formed by Neogene deposits, Angas Hills Formation and Carnegie Formation. Tertiary paleochannel sand forms a localised aquifer near the lake. Tertiary paleochannel clay forms an aquitard, and where present separates aquifers within the Neogene Deposits and Angas Hills Formation. The Pertatataka Formation is an aquitard forming a basement to the overlying effective aquifers. Paleoproterozoic bedrock and its associated overlying weathered profile form hydraulic barriers to groundwater flow south of Lake Mackay.

Airlifting while drilling and a pump test of MWP7 confirmed that water can be extracted from the aquifers in the investigation area. In the Northern Territory, water bores in Late Proterozoic to Early Cambrian age deposits equivalent to the Amadeus Basin produced yields averaging around 2 L/s (about 173 kL/day) (Jacobson et al., 1989).

Neogene deposits form a productive aquifer through intergranular permeability and cavities associated with calcrete, silcrete and ferricrete zones and is referred to as the shallow aquifer in this report. Reverse circulation airlifting flows of 4-8 L/s were obtained from this unit in MWP12 and MWP13 (25 m and 32 m depths respectively). Fractures within a laterally extensive silcrete layer approximately 40 m depth at the top of the Angas Hills Formation was identified as an aquifer suitable for water supplies (Brooker and Fulton, 2016).

The distribution of conglomeritic sand and gravel of the Angas Hills Formation form a palaeovalley infill deposit and is referred to as the deep aquifer in this report. Airlifting from this unit yielded 2.5 – 4 L/s from MWP10 over 43 – 49m, while between 4 and 7 L/s was obtained from fine-grained sands in MWP12 and MWP13, although some of this flow may have included water from the overlying Neogene Deposits.

The Carnegie Formation is thought to have some intergranular permeability associated with decomposed sandstone in its upper portion and is likely to be dominantly a fractured rock aquifer that becomes less permeable with increasing depth. Reverse Circulation water flows of up to 7 L/s were obtained from the sandstone in MWP11 and MWP13, however this flow likely includes contribution from overlying aquifers. Drilling water loss in sandstone over 92-95 m reported in Toro hole LM0003 (toward eastern end of 3rd tenement line from north) is likely due to a fractured high permeability zone.

1.1.6 Groundwater Quality

Groundwater samples taken from the 2017 and 2019 monitoring bores have been used to characterise the salinity gradient moving southward from the lake. Salinity levels in the bores adjacent to the lake (MWP1-5) range from 7400mg/L to 47000mg/L TDS and were found to increase with depth. The salinity decreases to between 8000mg/L and 17000mg/L TDS 13km south of the lake (MWP6-7). Salinity levels in the monitoring bores 20km south of the lake along the southern tenement line decrease further to between 1200ml/L and 6300mg/L TSD (MWP9-13).

1.2 This Report

This report describes the preliminary groundwater modelling being undertaken by CDM Smith Australia Pty Ltd (CDM Smith) for the Mackay SOP Project. The purpose of the modelling is to assess the feasibility of meeting the project's water supply from a proposed borefield to be located south of Lake Mackay within Agrimin's tenements (Figure 1-5) and to assess potential drawdown impacts from operation of the borefield.

The report presents the following information:

- Model design and construction;
- Model calibration and adopted hydrogeological properties; and
- Results from preliminary predictive scenarios.
- Recommendations.

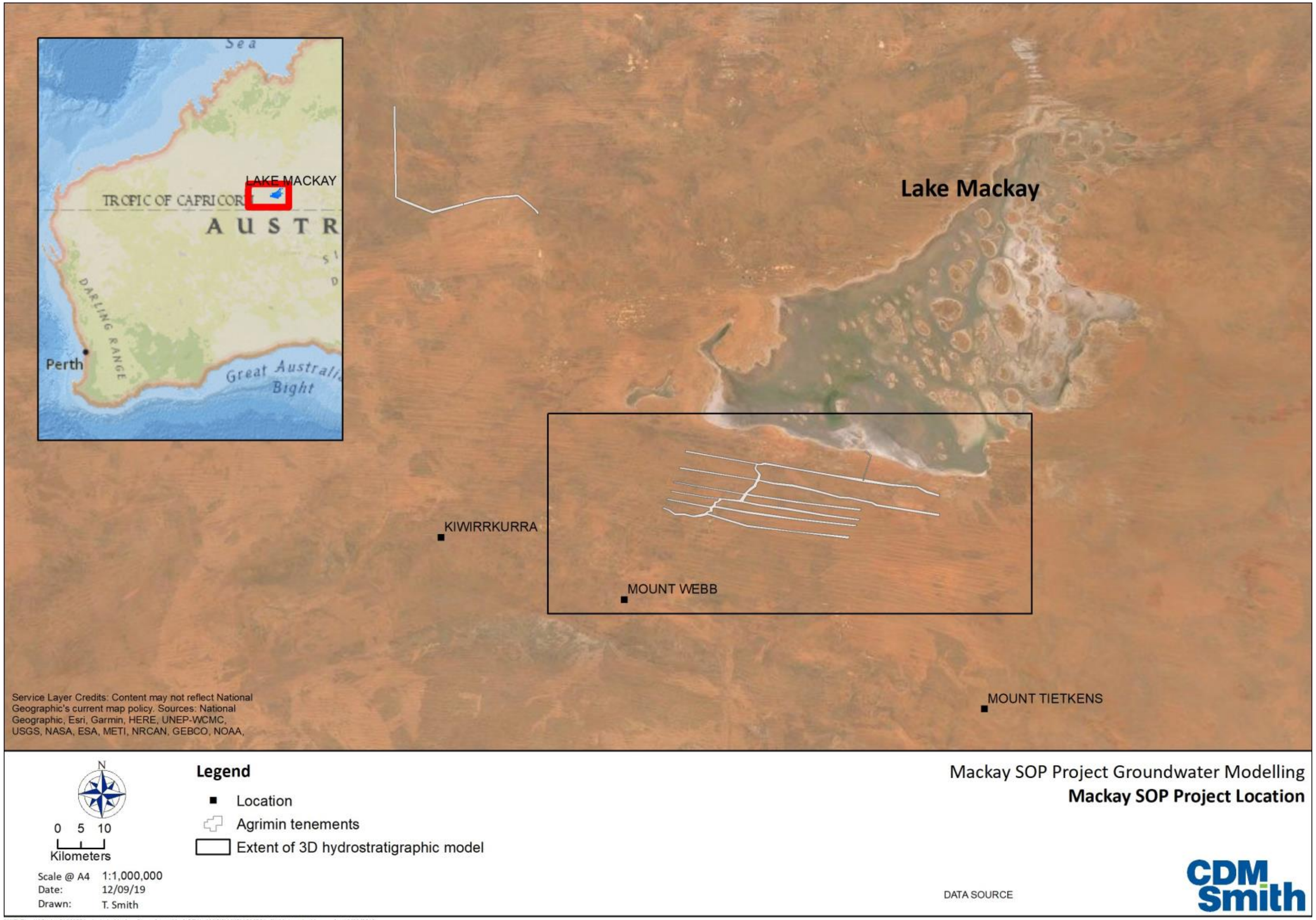

Figure 1-5 Mackay SOP Project location

Section 2 Model Design and Construction

2.1 Background

In terms of numerical groundwater modelling, this study has been done in two parts. Revision A of the report, completed in November 2019, which comprised model building, calibration and some of the prediction and uncertainty runs, was completed using FEFLOW which is a finite-element modelling approach. All additional work (Revision B scope of work) was completed using Modflow-Surfact which is a finite-difference approach, due to unnecessary large model run times of FEFLOW models. Conversion from FEFLOW to Modflow-Surfact captured all setups of the original FEFLOW model and no additional changes were made to any of the FEFLOW models (Revision A models) in Modflow-Surfact.

2.2 Model Design

The boundary of the groundwater model is adopted from the 3D hydrostratigraphic model (see Figure 1-5 and Figure 2-1). The boundary spans 104 km from east to west and 43 km from north to south.

The top surface of the groundwater model uses the Webb 1:250k map sheet DEM (digital elevation model) from Geoscience Australia, which is available for download through the Geophysical Archive Data Delivery System.

The model is comprised of 5 layers as presented in Table 2-1. FEFLOW model mesh consists of 131,800 elements as shown in Figure 2-2. The Modflow-Surfact model is comprised of 70,685 active cells as shown in Figure 2-3.

Layer thicknesses and top and bottom elevations are adopted directly from the 3D hydrostratigraphic model (Leapfrog Model). The model incorporates key geometric features that are represented in the modelling, including the lateral boundaries of each hydrostratigraphic unit and the shoreline of Lake Mackay.

The bottom elevation of the model is set equal to 20 m below the top surface of the basal units represented by layer 5.

Table 2-1 Groundwater model layers

Model layer	Formation	Age	Lithology
1	Surficial	Quaternary	Sand
	Unnamed	Neogene	Clayey sandstone, with calcrete, silcrete and ferricrete
2	Palaeochannel clay	Paleogene	Silty clay and clay
3	Palaeochannel sand	Paleogene	Sand
4	Angas Hills Formation	?Cambrian	Silty fine-grained sand, conglomeritic clayey sand
5	Carnegie Formation	Cryogenian to Ediacaran	Fine to medium-grained sandstone
	Pertatataka Formation		Siltstone and claystone
	Basement		Weathered bedrock and granitic basement

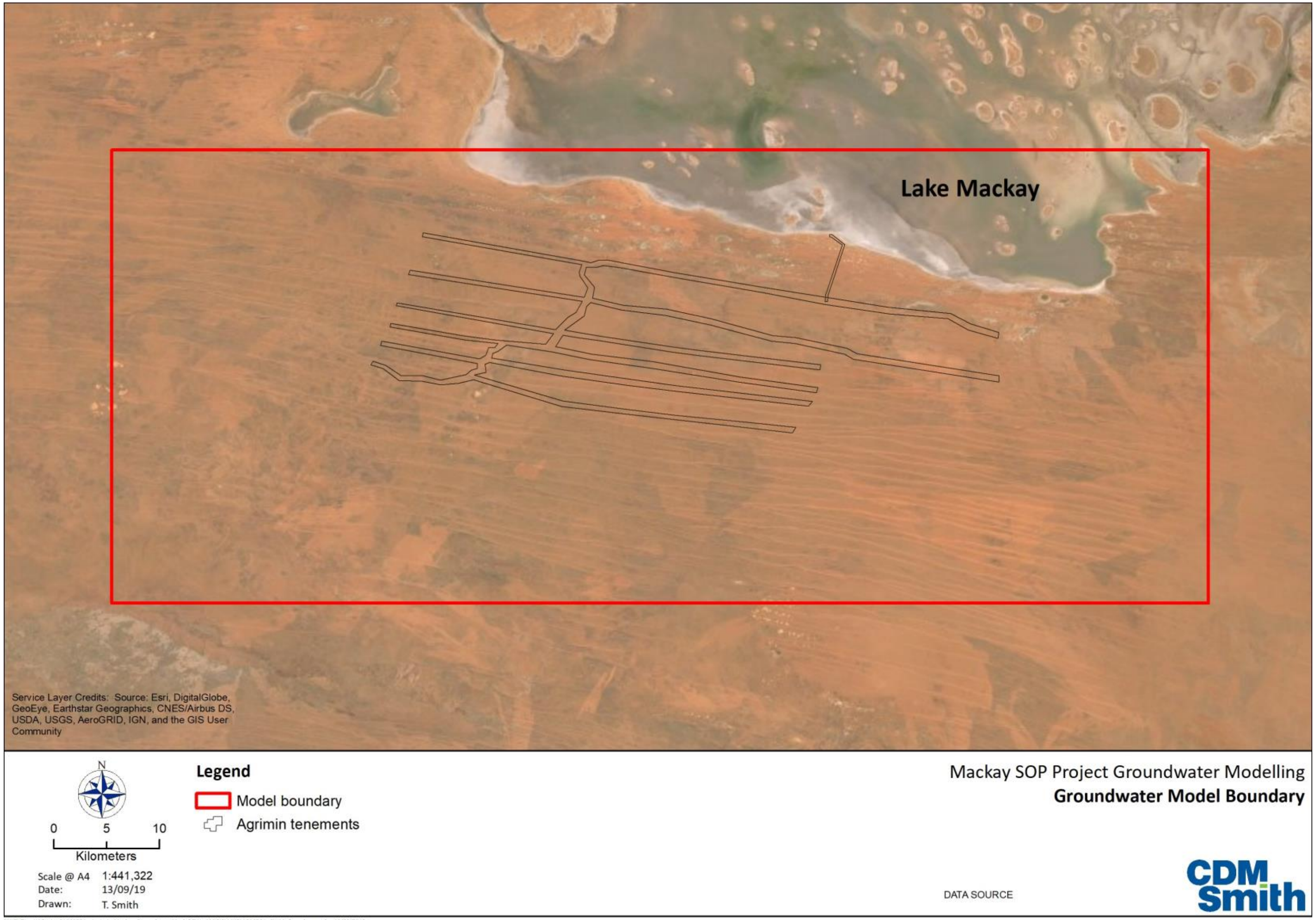

Figure 2-1 Groundwater model boundary

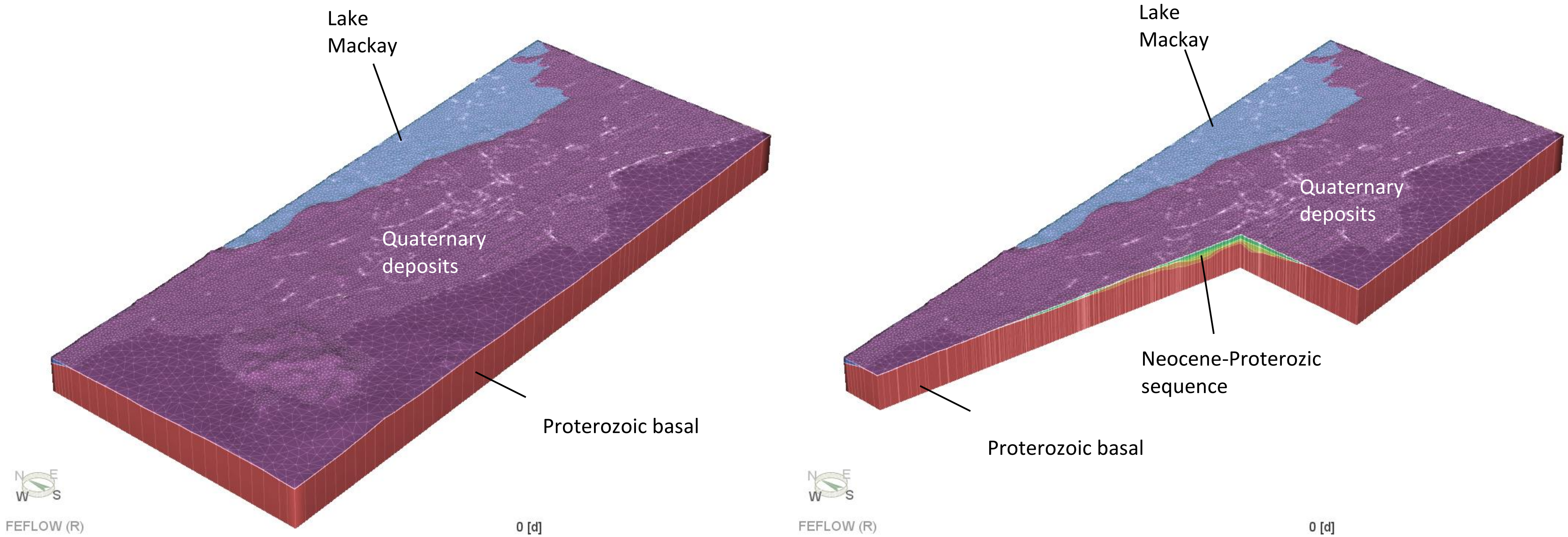

Figure 2-2 FEFLOW model mesh and layering (×25 vertical exaggeration)

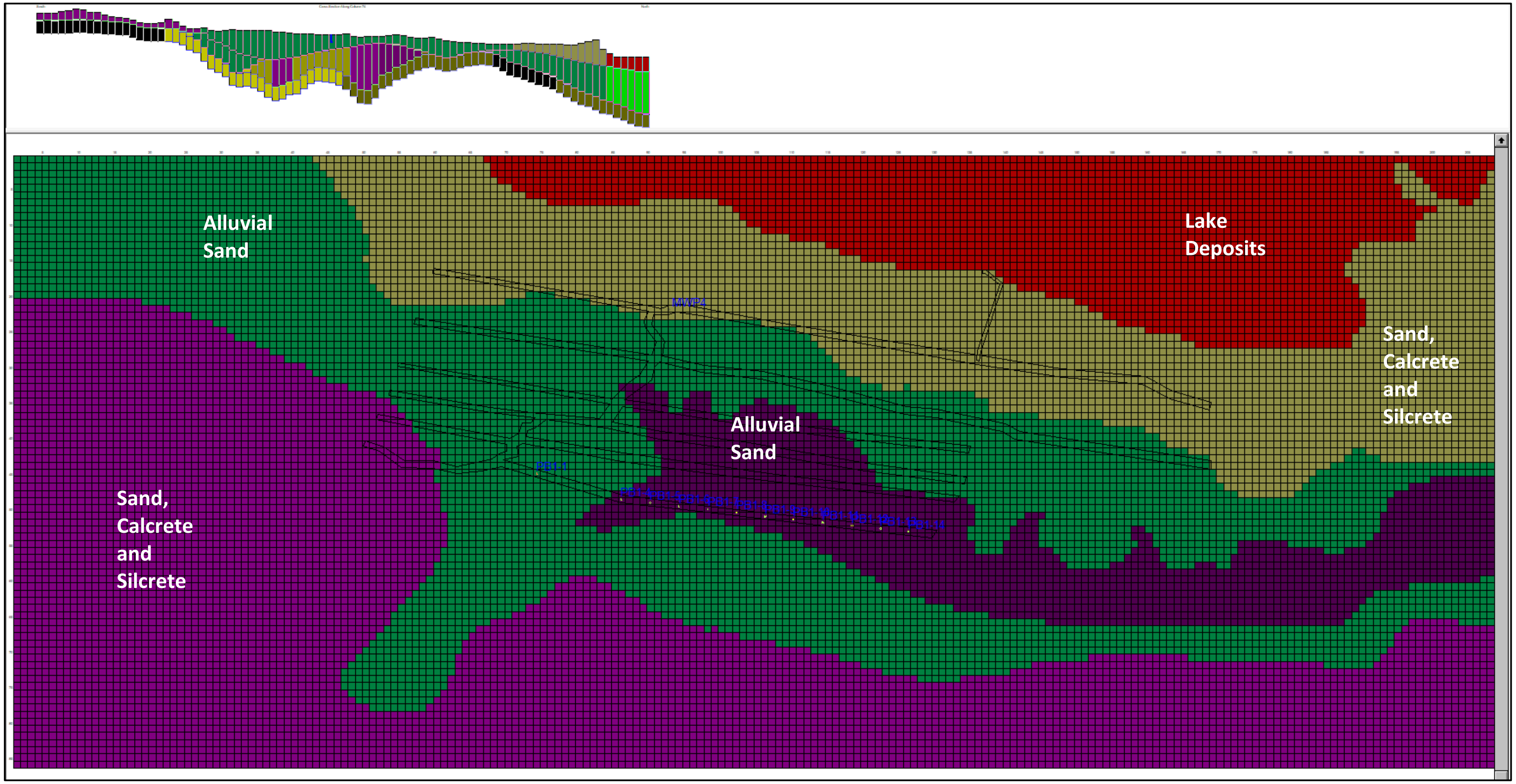

Figure 2-3 Modflow-Surfact model grid

2.3 Boundary Conditions

2.3.1 Lake Mackay

Lake Mackay is the low point of a vast catchment that extends hundreds of kilometres east from the lake. As such it conceptually represents a draining feature where groundwater drains toward the lake and discharges at the lakebed by evaporation to the atmosphere.

For the numerical representation of the lake a constant head boundary (CHB) condition was used set to a value of 370 mAHD. This choice is based on the frequency distribution of lakebed elevation (within the model domain) presented in Figure 2-4.

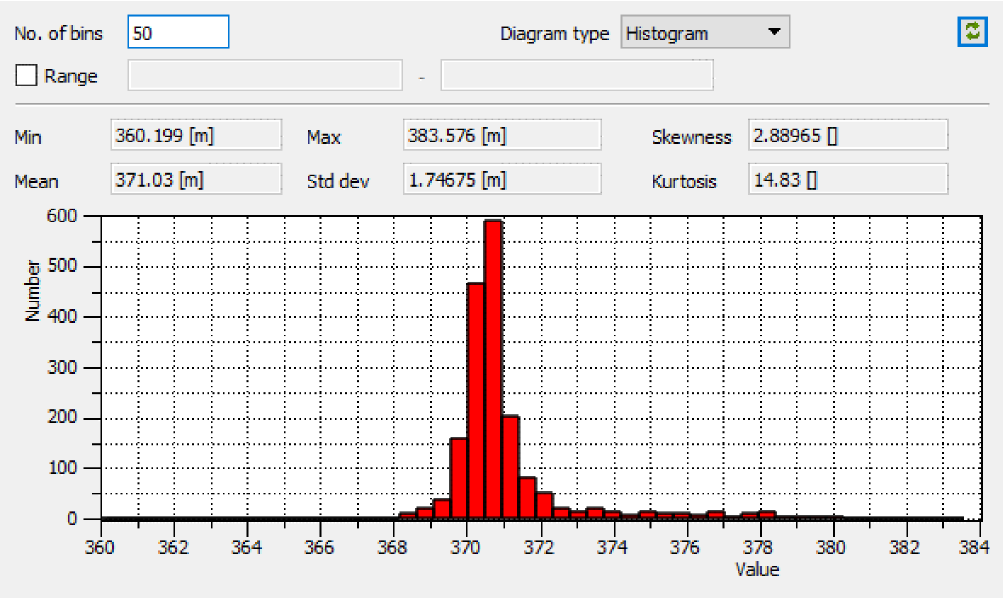

Figure 2-4 Distribution of the model nodal elevations within Lake Mackay

2.3.2 Recharge and Evapotranspiration

FEFLOW Model

Groundwater recharge and evapotranspiration (ET) are implemented as part of the same boundary condition, referred to in FEFLOW as the "In/outflow on top/bottom" boundary condition. Recharge and ET are implemented using FEFLOW's Expression Editor, which allows the use of a user-defined mathematical expression to control the inflow and outflow rates of recharge and ET at the top surface of the model.

The following expression is implemented using the Expression Editor:

$$Q = \begin{cases} -ET_{rate} : \text{if } DWT \leq 0 \\ R - \left(ET_{rate} \times \dfrac{ET_{depth} - DWT}{ET_{depth}} \right) : \text{if } 0 < DWT \leq ET_{depth} \\ R : \text{if } DWT > ET_{depth} \end{cases}$$

where Q is the net flux applied at the water table (with recharge positive and discharge negative) [L/T]; ET_{rate} is the maximum potential rate of evaporation from the water table [L/T]; ET_{depth} is the extinction depth for ET, below which the water table is too deep for ET to occur [L]; DWT is the depth of water table below ground surface [L]; and R is the recharge rate [L/T].

Put into words, the above expression means the following:

- If water table elevation is at, or above the ground surface elevation (i.e., the area is inundated) then the maximum ET rate is applied at that location and there is no net recharge;
- If the water table elevation is below ground surface but above the elevation of the ET extinction depth, then a net recharge flux is applied at that location equal to the difference between *R* and the ET rate at that water-table depth.; and
- If water table elevation is below the ET Extinction depth, then the recharge rate is set equal to *R* and applied at the water table at that location.

The recharge rate is calculated as average annual rainfall multiplied by a rainfall recharge factor, which represents the fraction of rainfall that infiltrates ground surface and percolates to the water table. The value of the rainfall recharge factor is adjusted during model calibration. Average annual rainfall of 300 mm/a is adopted in the modelling based on the Bureau of Meteorology rainfall data presented in Figure 2-5.

A maximum evapotranspiration rate of 1490 mm/a is adopted in the modelling based on the Bureau of Meteorology areal potential evapotranspiration data presented in Figure 2-6.

The net recharge flux *Q* at the water table calculated by the model is 1.2 mm/a. The calibrated value of the rainfall recharge factor is 0.004, which is equivalent to a maximum recharge rate of 1.2 mm/a. Thus, the model estimates of net recharge at the water table are relatively small, varying from zero up to the above maximum value. Areas with recharge rate less than 1.2 mm/a occur where the water table is within the ET extinction depth of 3m and there is partial loss of groundwater recharge by ET.

Modflow-Surfact Model

Consistent with the FEFLOW model, 1.2 mm/a of rainfall recharge, or 0.4% of the long-term average rainfall, was applied in the Modflow-Surfact model. Also, a maximum evapotranspiration rate of 1,490 mm/a was adopted in the model with an extinction depth of 3m consistent with the FEFLOW model.

2.3.3 Lateral Boundary

All other model boundaries are simulated as no-flow boundaries in the model, representing conservatism in the modelling approach. Thus, in predictive simulations, the borefield cannot draw in groundwater from outside the model boundary.

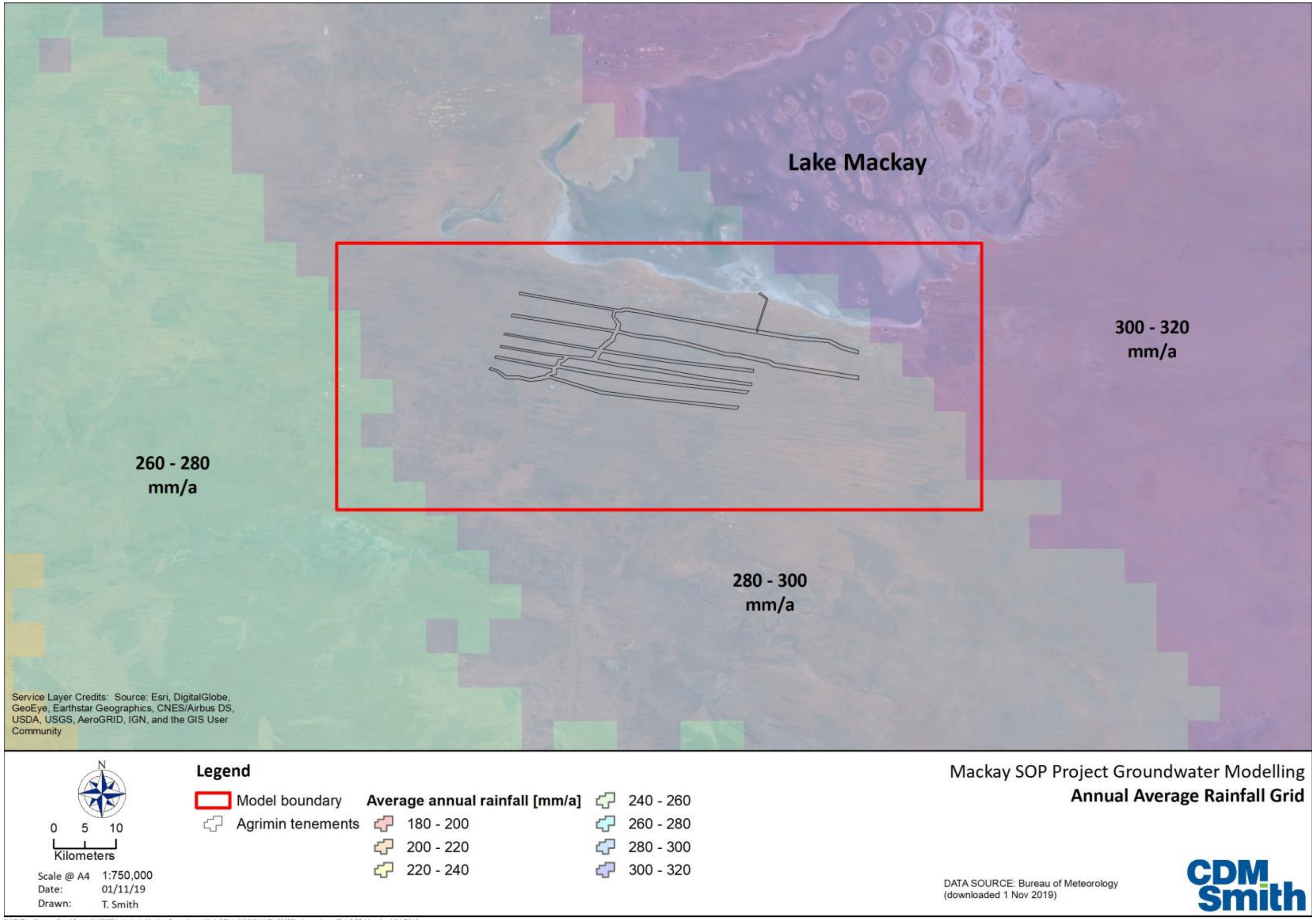

Figure 2-5 Bureau of Meteorology average annual rainfall grid

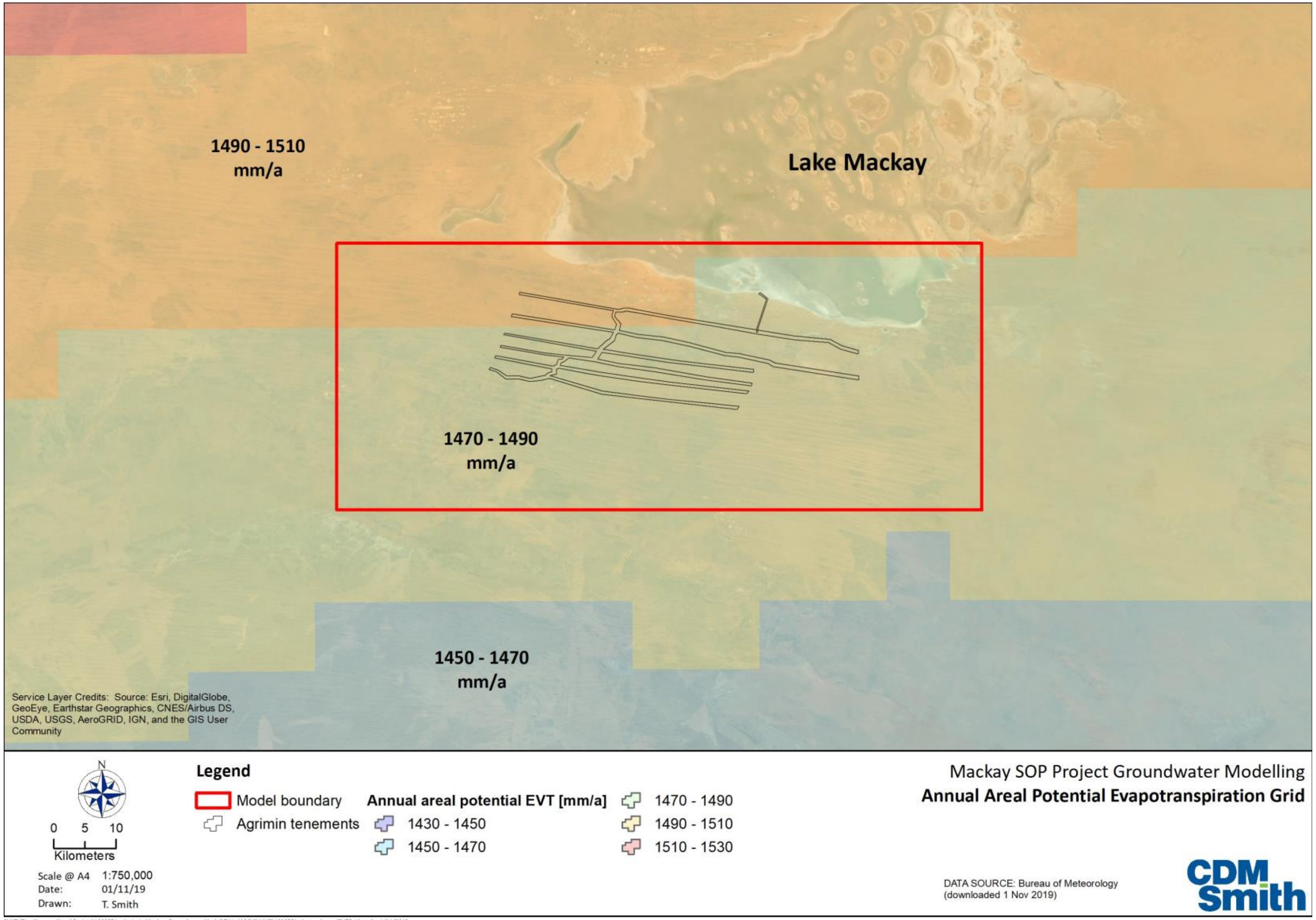

Figure 2-6 Bureau of Meteorology average of annual areal potential evapotranspiration grid

Section 3 Model Calibration

FEFLOW model was used for calibration. The model calibration is performed in steady state by advancing a transient simulation to a pseudo steady state, such that hydraulic head values no longer change with increasing simulation time.

3.1 Calibration Targets

Calibration targets for the steady state solution are derived from depth to water table measurements collected in August and October 2019. These data are presented in Table 3-1 and Figure 3-2.

Measurements of depth to water table were made in one or two monitoring bores at five drill pad locations (MWP1-9) in late August 2019 and in four additional monitoring bores (MWP10-13) in October 2019. Topographic elevation at the drill pad locations is estimated from the Webb 1:250k map sheet DEM (Table 3-1).

The estimates of water table elevations are calculated by subtracting the depth to water table measurements from the estimated topographic elevations.

Model calibration is assessed by comparing the model predicted water table elevations at the monitoring bore locations to the estimates in Table 3-1 (see Section 3.3).

Figure 3-1 is a graph comparing the measured water table elevations at monitoring bores to their shortest distances from the shoreline of Lake Mackay. A hydraulic gradient of around 0.0014 (0.14%) is evident, extending from the shoreline of the lake to approximately 20 km south.

Table 3-1 Water table calibration targets

Location	Monitoring bore hole ID	Easting [m] MGA zone 52	Northing [m] MGA zone 52	Depth to water table[1] [m BGL]	Estimated topographic elevation[1] [m AHD]	Estimated water table elevation [m AHD]
Drill pad 1	MWP1	466737	7488337	10.38	387.3	376.9
Drill pad 3	MWP2	449026	7491202	7.14	387.0	379.8
Drill pad 4	MWP4	442075	7492210	3.47	388.2	384.7
Drill pad 5	MWP6, MWP7	440098	7485542	5.25	393.7	388.5
Drill pad 6	MWP9	428274	7481083	5.17	408.8	403.6
NA	MWP10	436670	7482101	8.26	401.9	393.7
NA	MWP11	436419	7479586	5.81	402.2	396.4
NA	MWP12	441482	7478530	6.27	402.1	395.8
NA	MWP13	446377	7477943	7.42	399.5	392.1

[1]Webb 1:250k map sheet DEM

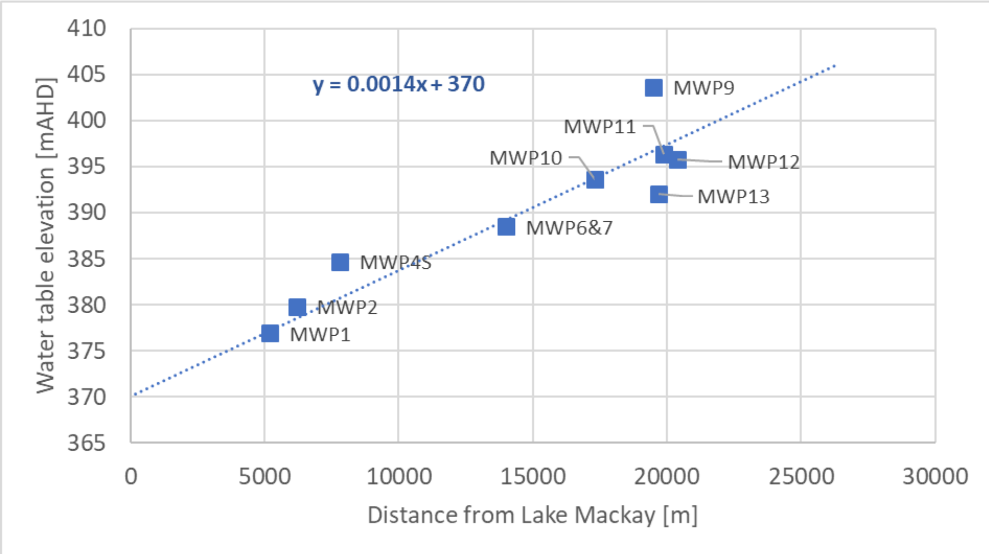

Figure 3-1 Observed hydraulic gradient from Agrimin's tenement to Lake Mackay

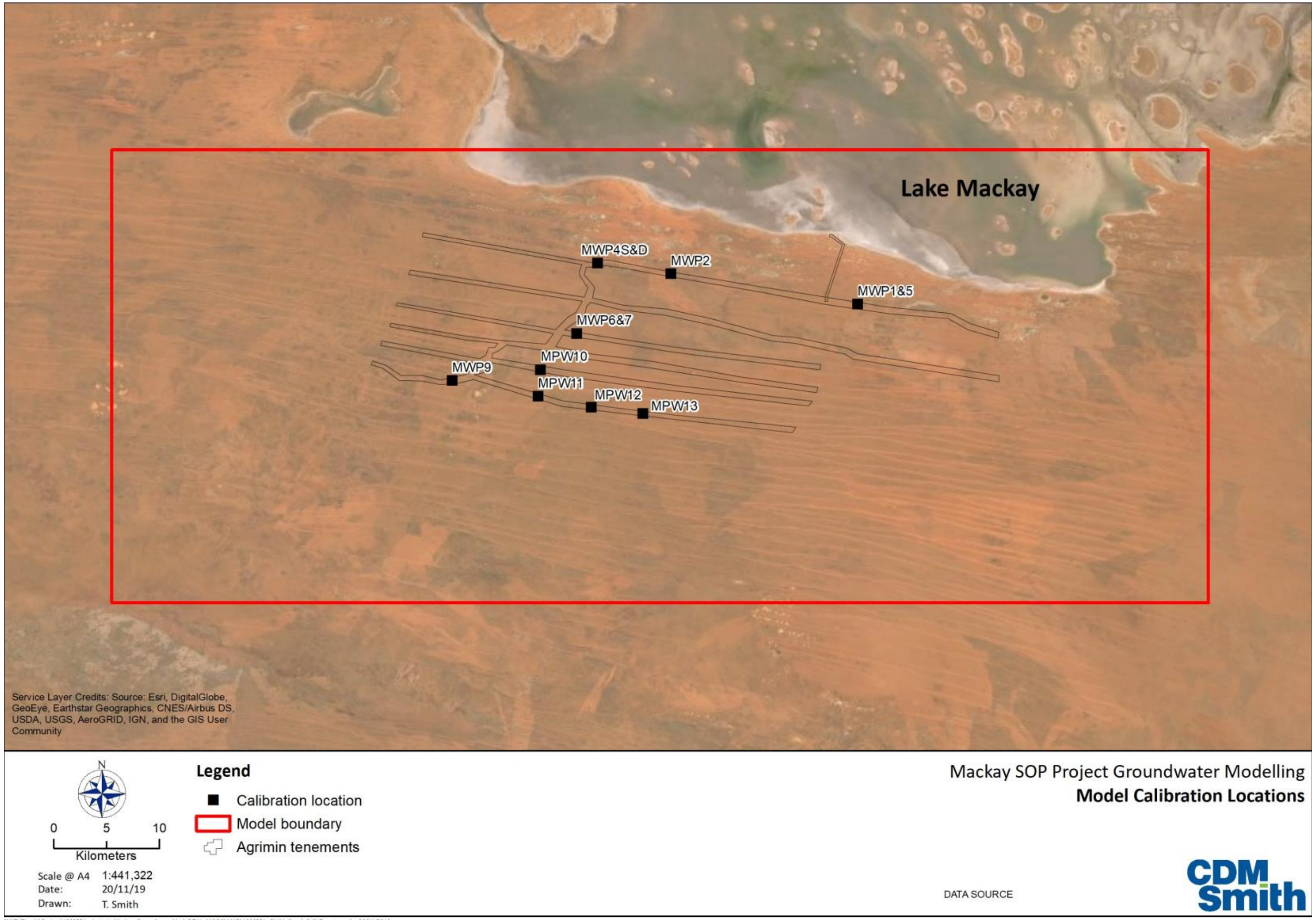

Figure 3-2 Model calibration locations

3.2 Hydrogeological Properties

The steady state model calibration yields estimates of hydraulic conductivity for the sixteen hydrostratigraphic zones presented in Table 3-2 and in Figure 3-3 and Figure 3-4. The basal units shown in part c of Figure 3-4 are assumed to have negligible permeability within the context of the resource assessment and are set as inactive zones in the modelling; noting that setting a zone to inactive status in FEFLOW is equivalent to treating it as impermeable.

A steady state calibration does not yield estimates of the aquifer storage coefficients.

Table 3-2 Adopted hydraulic conductivity values for the calibration model

Model layer	Zone	Kh [m/d]	Kv [m/d]
1 – Surficial deposits	Zone 1 – lake deposits	5	0.5
	Zone 2 – sand, calcrete and silcrete	4	0.4
	Zone 3 – sand, calcrete and silcrete	1	0.1
	Zone 4 – alluvial sand	1	0.1
	Zone 5 – alluvial sand	2	0.2
2 – Palaeochannel clay	Zone 6 – clay	0.001	0.0001
	Zone 7 – clay, mudstone and lower fine sand	0.01	0.0001
3 – Palaeochannel sand	Zone 8 – fine to medium sand with clay	3	0.01
4 – Angas Hills Formation	Zone 9 – fluvial sand	1	0.1
	Zone 10 – fluvial sand, gravel and conglomerate, mostly clayey	1	0.1
	Zone 11 – fluvial sand, mostly fine	0.1	0.01
5 – Carnegie Formation, Pertatataka Formation and basement	Zone 12 – clay, siltstone and some sandstone	0.01	0.0001
	Zone 13 – sand, sandstone and clay	0.1	0.001
	Zone 14 – sand and sandstone	0.05	0.001
	Zone 15 – sandstone	0.05	0.01
	Zone 16 – possibly sand and sandstone	0.2	0.001
	Zone 17 – weathered bedrock and granitic basement	inactive	inactive

Kh – horizontal hydraulic conductivity; Kv – vertical hydraulic conductivity

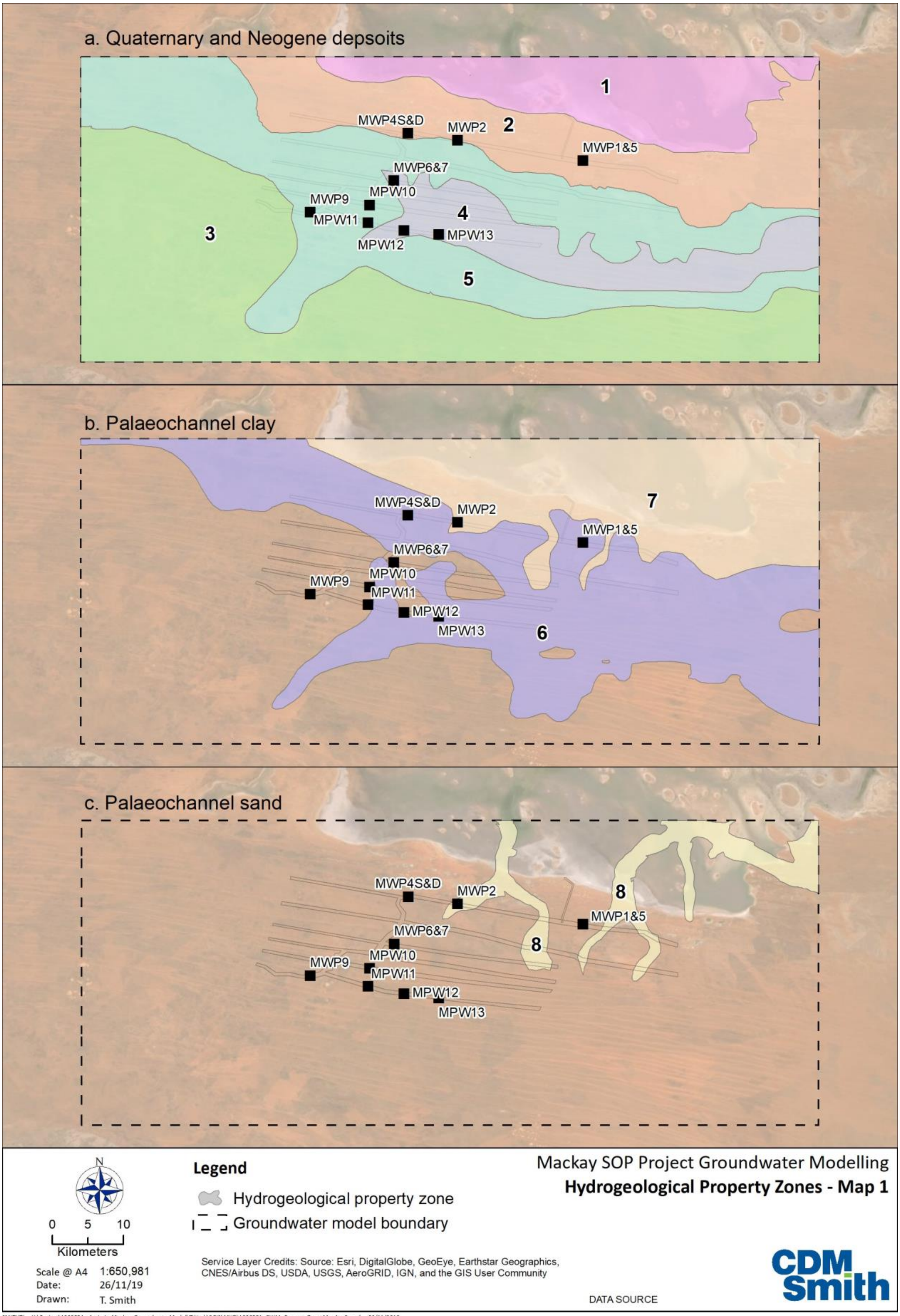

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Figure 3-3 Hydrogeological property zones – Map 1

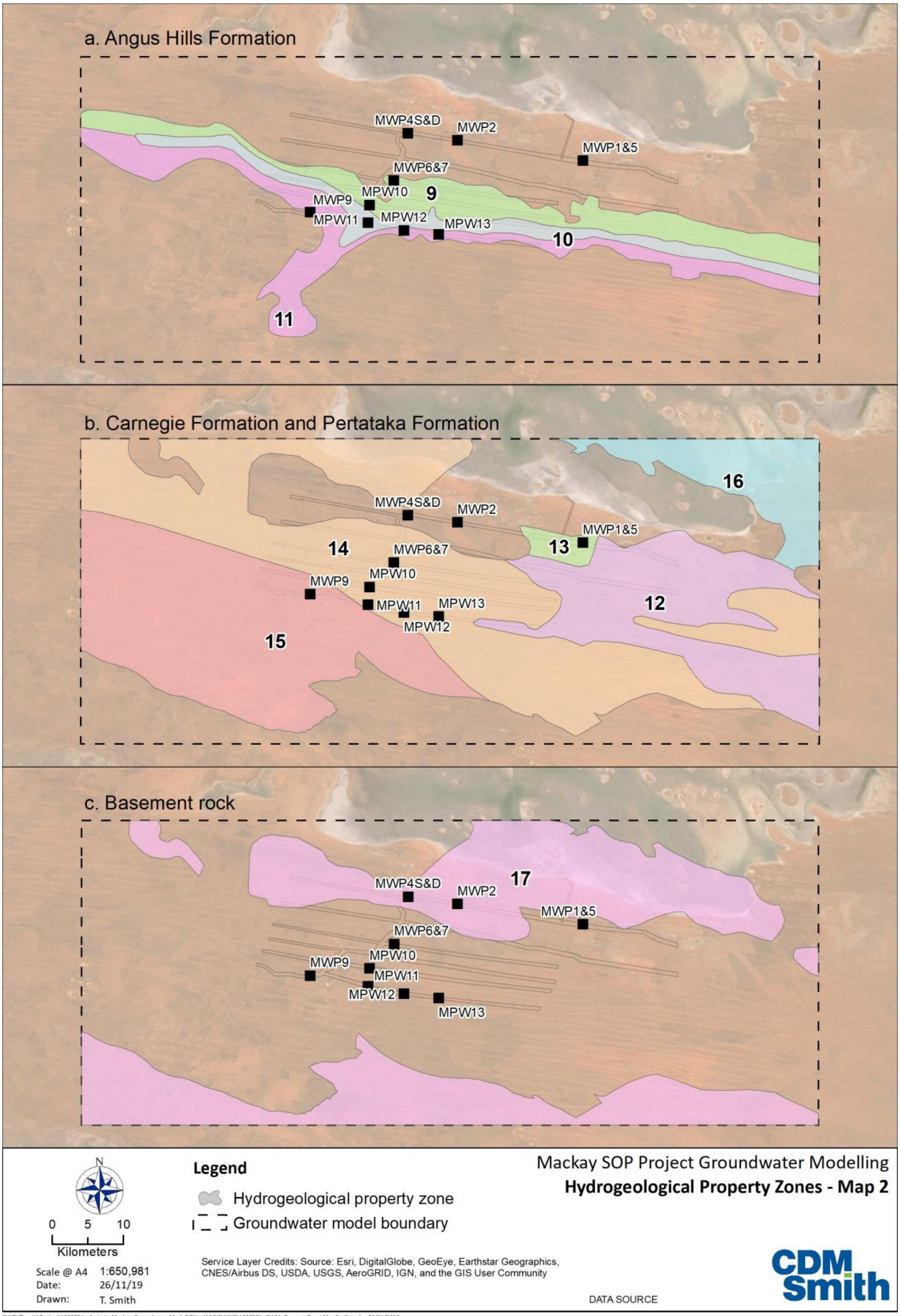

Figure 3-4 Hydrogeological property zones – Map 2

3.3 Calibration Performance

The model calibration performance is presented as a scatter plot in Figure 3-5, for which the root mean square (RMS) and the scaled-RMS statistics are 2.2 and 8.1%, respectively. Reasonable matches between observed and modelled water table elevations are achieved at all monitoring bores using the adopted hydrogeological model and anticipated order-of-magnitude values for the formation hydraulic conductivities.

Groundwater recharge is discussed in the following section.

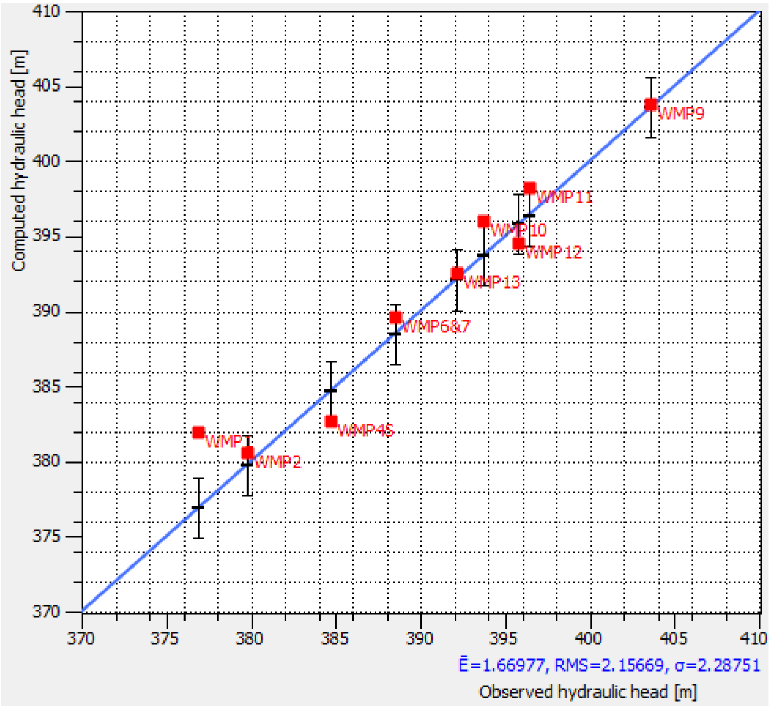

Figure 3-5 Scatter plot – calibration model

3.4 Net Flux to Water Table

The model calculates a value of net flux to the water table within each model cell as presented in Figure 3-6. Blue-coloured areas of the figure indicate a net recharge (positive) flux at the water table and red-coloured areas indicate a net discharge (negative) flux at the water table. The recharge and evapotranspiration (ET) processes leading to these flux estimates are presented earlier in Section 2.3.2.

The adopted recharge and ET parameters for the calibration model are presented in Table 3-3, wherein the average annual rainfall and ET rates are based on the Bureau of Meteorology data in Section 2.3.2.

The calibrated value of the rainfall recharge factor is 0.004, which is equivalent to a maximum recharge rate of 1.2 mm/a. Thus, the model estimates of net recharge at the water table are relatively small, varying from zero up to the above maximum value. Areas with recharge rate less than 1.2 mm/a occur where the water table is within the ET extinction depth and there is partial loss of groundwater recharge by ET.

The adopted ET extinction depth is 3 m, meaning no ET occurs if the water table is greater than 3 m below ground surface. Evapotranspiration from the water table can occur due to capillary rise (wicking) of water from the water table toward ground surface, and through uptake of soil water and groundwater by plants within their rooting depths. The review of extinction depths for ET by Shah et al. (2007) found extinction depths for grass cover on different soil types varied from 1.45 m for sand up to 7.15 m for clay, with values between 1.7 m and 5.5 m for various combinations of sand, silt and clay. The adopted extinction depth of 3 m used in the modelling is generally consistent with these values.

Figure 3-6 shows that net groundwater recharge in the modelling is balance by net ET in areas of shallower water table within local topographic depressions, as well as groundwater ET at Lake Mackay.

Table 3-3 Model recharge and evapotranspiration parameters – calibration model

Parameter	Value
Average annual maximum potential ET rate	1490 mm/a (see Figure 2-6)
ET extinction depth	3 m
Average annual rainfall	300 mm/a (see Figure 2-5)
Rainfall recharge factor	0.004 (1.2 mm/a)

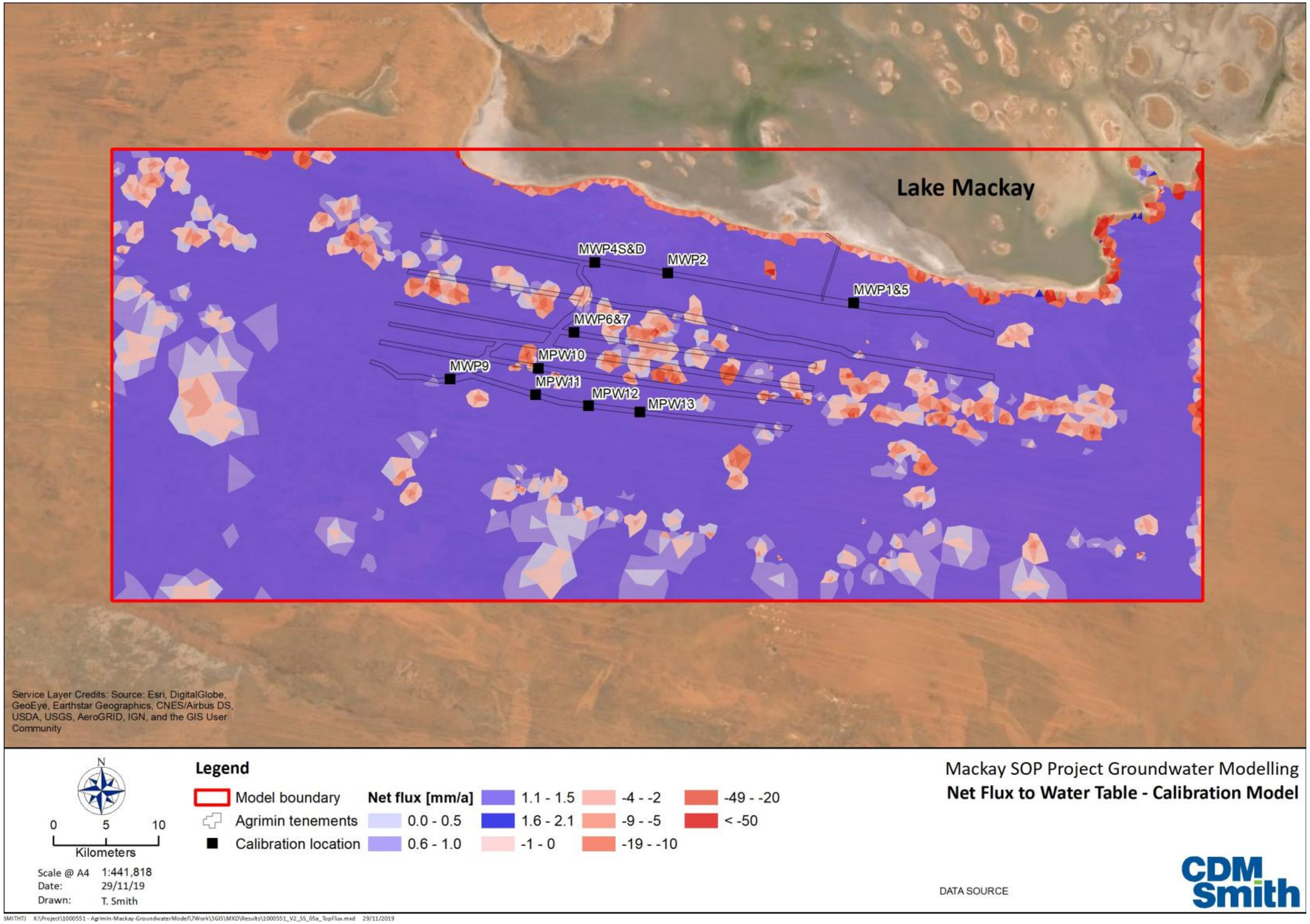

Figure 3-6 Net flux to the water table – calibration model

3.5 Model Steady State Head

Simulated water table elevation from the calibration model is presented as contours with 5-m intervals in Figure 3-7. Beneath most of the southern tenement area the simulated water table evaluation is around 395 to 400 mAHD and reduces to 370 mAHD at Lake Mackay.

Simulated depth to water table is presented in Figure 3-8. Groundwater is shallowest (0 to 3 m depth) within Lake Mackay and in local topographic depressions away from the lake. Modelled depth to water table generally varies between 3 and 10 m within Agimin's tenement area and increases up to around 65 m to the southwest due to topographic rise.

3.6 Steady State Water Balance

The steady state water balance is presented in Table 3-4 below:

Table 3-4 Steady State Water Balance

Parameter	Inflow (kL/d)	Outflow (kL/d)
Lake Mackay (Constant Head Boundary)	0	1,140
Rainfall Recharge	12,980	0
Evapotranspiration	0	11,840
TOTAL	**12,980**	**12,980**

The only source of inflow to the simulated aquifers within the model domain is rainfall recharge. 0.4% of the long term measured rainfall of 300 mm/a equates to 1.2 mm/a or 3.29E-6 m/d. When simulated recharge (3.29E-6 m/d) is applied in the model over an area of 3,950 km^2, which excludes the lake (recharge hasn't been applied to the lake as the lake is represented using the constant head boundary) the result is 12,980 kL/d of inflow from the rainfall recharge in the model. Majority of the simulated inflow (92%) is taken out by evapotranspiration processes in the model where groundwater levels are less or equal to 3 m below the ground. The constant head boundary associated with Lake Mackay is predicted to take out 8% or 1,140 kL/d of the overall inflow.

3.7 Limitations of the Model Calibration

The presented model calibration is informed by preliminary estimates of the hydraulic conductivities for the conceptual model and HSUs presented in Section 2. The calibration is constrained by a small number of hydraulic head observations and no groundwater fluxes. In this situation, it is expected alternate model calibrations of similar quality are possible for larger estimates of the hydraulic conductivities combined with larger estimates of groundwater recharge rates, and similarly, for smaller estimates of the hydraulic conductivities combined with smaller estimates of recharge rates. The certainty of the current estimates could be better assessed with the benefit of other independent estimates of groundwater recharge and long term groundwater level monitoring.

Because the calibration is steady state, it does not yield estimates of the aquifer storage coefficients, which will be important in determining the capacity of the target aquifer to supply the project water supply. A transient model calibration to yield estimates of the aquifer storage coefficients is not currently possible due to lack of transient data. The model predictive simulations should consider a realistic range of values for the aquifer storage coefficients to help assess this uncertainty.

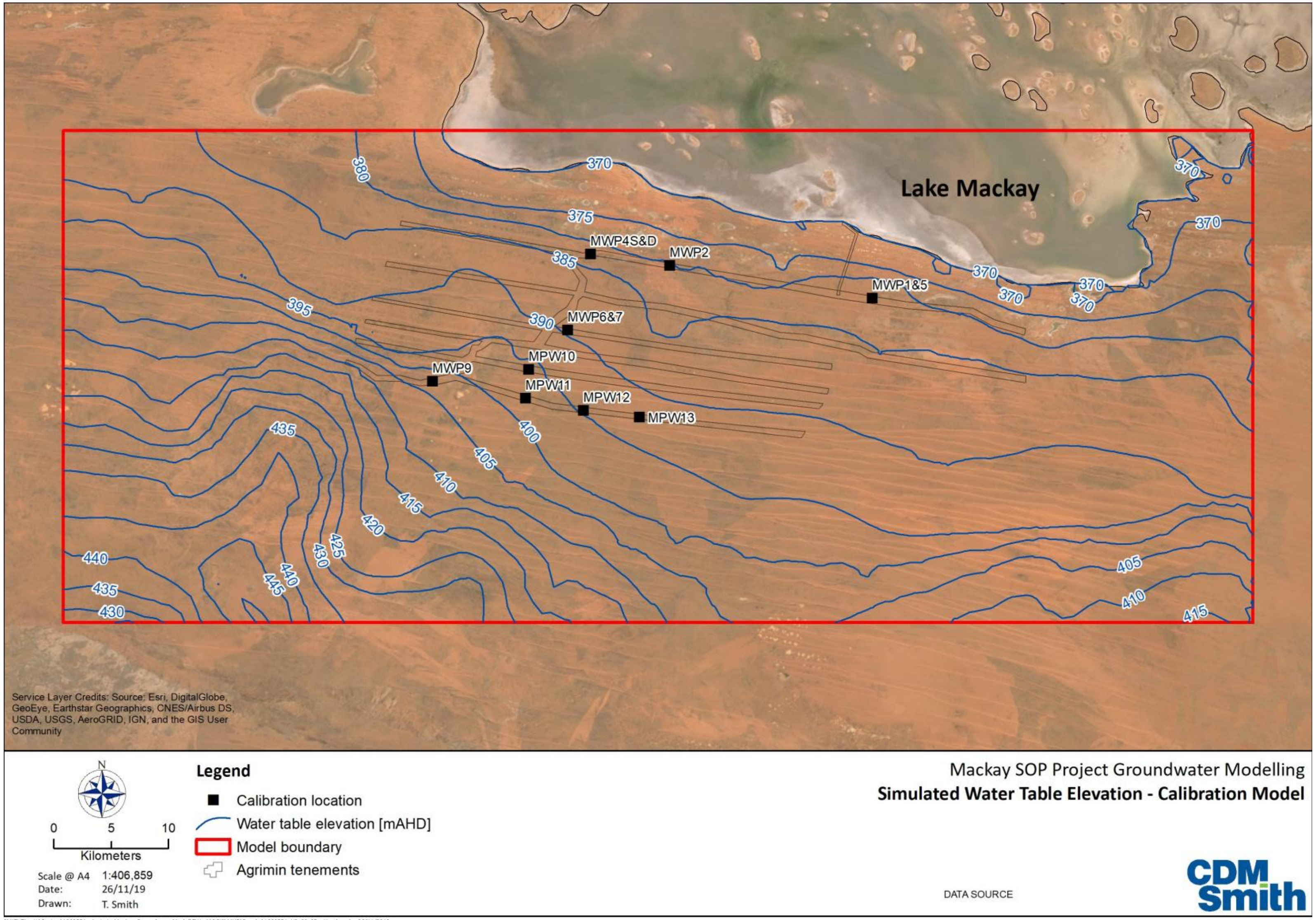

Figure 3-7 Simulated water table elevation – calibration model

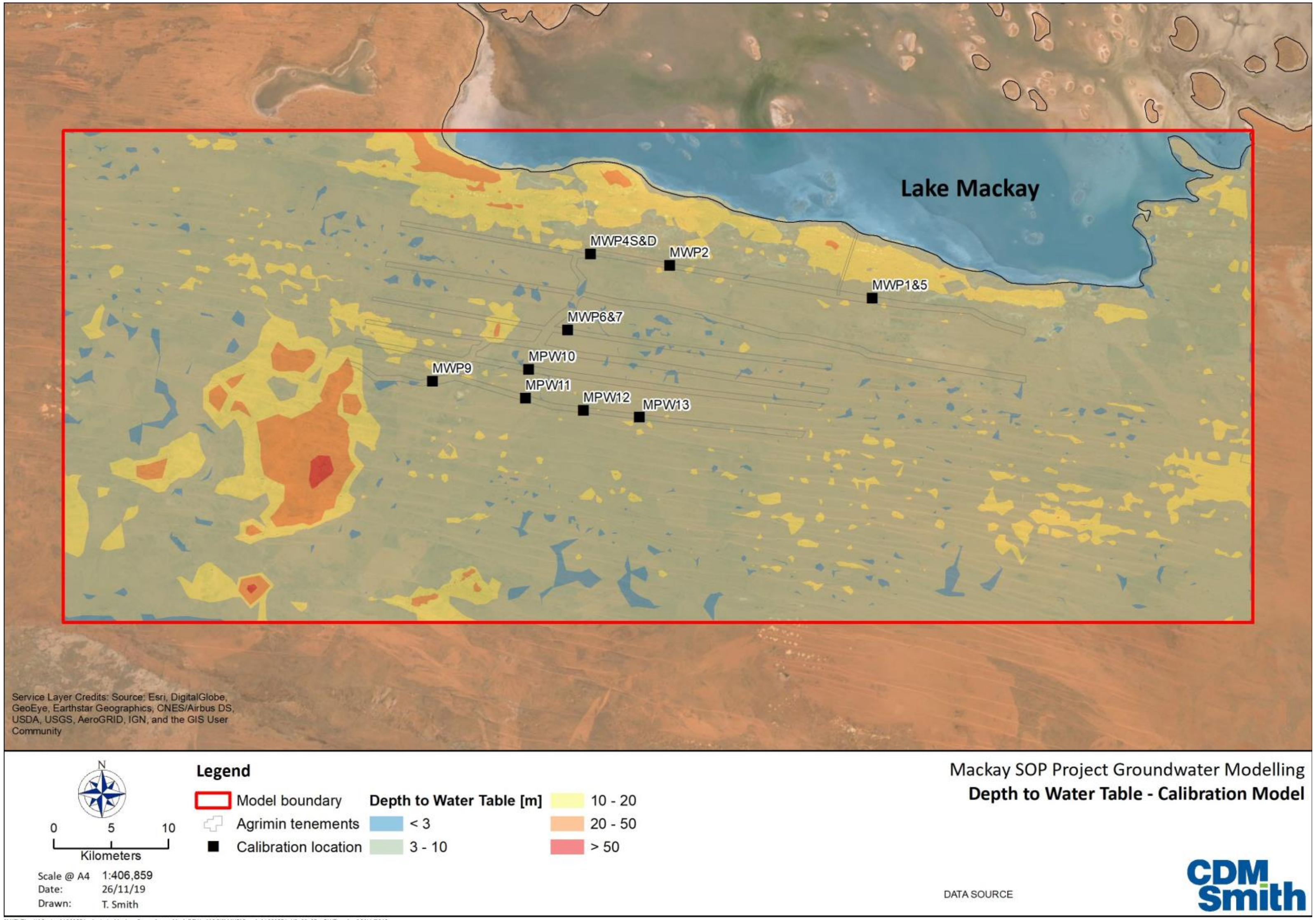

Figure 3-8 Simulated depth to water table – calibration model

Section 4 Preliminary Predictive Simulations

4.1 Adopted Storage Coefficients

Steady state model was used for model predictions. Table 4-1 presents the formation storage coefficients adopted for the preliminary predictive simulations. These values of specific yield (Sy) and specific storativity (Ss) are estimates based on the available information from the project hydrogeological investigations and typical values from textbook reviews.

Table 4-1 Adopted values of the formation storage coefficients

Model layer	Zone	Sy [1]	Ss [1/m]
1 – Quaternary and Neogene deposits	All zones	0.15	1×10^{-4}
2 – Palaeochannel clay	All zones	0.03	1×10^{-3}
3 – Palaeochannel sand	All zones	0.1	1×10^{-4}
4 – Angas Hills Formation	All zones	0.1	1×10^{-4}
5 – Carnegie Formation and Pertatataka Formation	All zones	0.1	5×10^{-5}

Sy – specific yield; Ss – specific storativity

4.2 Southern Borefield Scenarios

Seven borefield scenarios have been simulated in the model. Table 4-2 summarises all seven borefield scenarios:

Table 4-2 Summary of borefield scenarios

Scenario	Target water demand [GL/a]	No. of production bores	Production Lines [southern, northern or both	Spacing Between Production Bores [km]	Model Used for Simulation [FEFLOW or Modflow-Surfact]	Simulated Life of Mine [years]
PRED01	0.7	7	Southern	2	FEFLOW	20
PRED02	1.0	10	Southern	2	FEFLOW	20
PRED03	2.0	19	Both	2	FEFLOW	20
PRED04	3.0	28	Both	2	FEFLOW	20
PRED05	3.5	28	Both	2	FEFLOW	20
PRED06	3.5	28	Both	1	Modflow-Surfact	20
PRED07	3.5	28	Southern	1	Modflow-Surfact	20

Maps of the simulated borefield layouts are presented in Figure 4-1 to Figure 4-5.

Proposed production bores are arranged along one or two southern-most lines of Agrimin's tenements starting at the west end of the tenement lines and extending eastward at either 1 or 2 km spacing between bores. The southern tenement line is developed first and can accommodate fourteen production bores of up to at 2 km spacing. The northern tenement line is developed second and can accommodate fifteen production bores of up to 2 km spacing between them.

4.2.1 Pumping Targets

The pumping scenarios explore total borefield production varying from 0.7 GL/a up to 3.5 GL/a.

Table 4-2 lists the borefield scenarios, including the target production rate for the borefield and proposed number of production bores.

All production bores within the borefield are assigned the same target yield; however, the target values vary slightly between scenarios to achieve each of the target production rates with the given number of production bores. More generally, the target bore yields are based on realising an average bore yield of around 3.5 L/s, representing a potential range in bore yields of 2 to 5 L/s.

4.2.2 Abstraction Bore Setup

The borefield production bores are represented in the modelling as FEFLOW multilayer wells that are screened from the saturated surficial sediments to the top of the basal units (i.e., from model layer 1 to 4). A multilayer well is defined by a pumping rate to be achieved by the well. The portion of the total pumping drawn from each formation screened by the bore is calculated dynamically by the model based on the hydraulic conductivities of the formations and the head differences that develop between the formations and the production bore. The target pumping rates for the predictive simulations are presented in the preceding section. Borefield setup was represented using the Fractured Well (FWL4) package in Modflow-Surfact. It is an equivalent package that uses the same concept as the multilayer well package of FEFLOW.

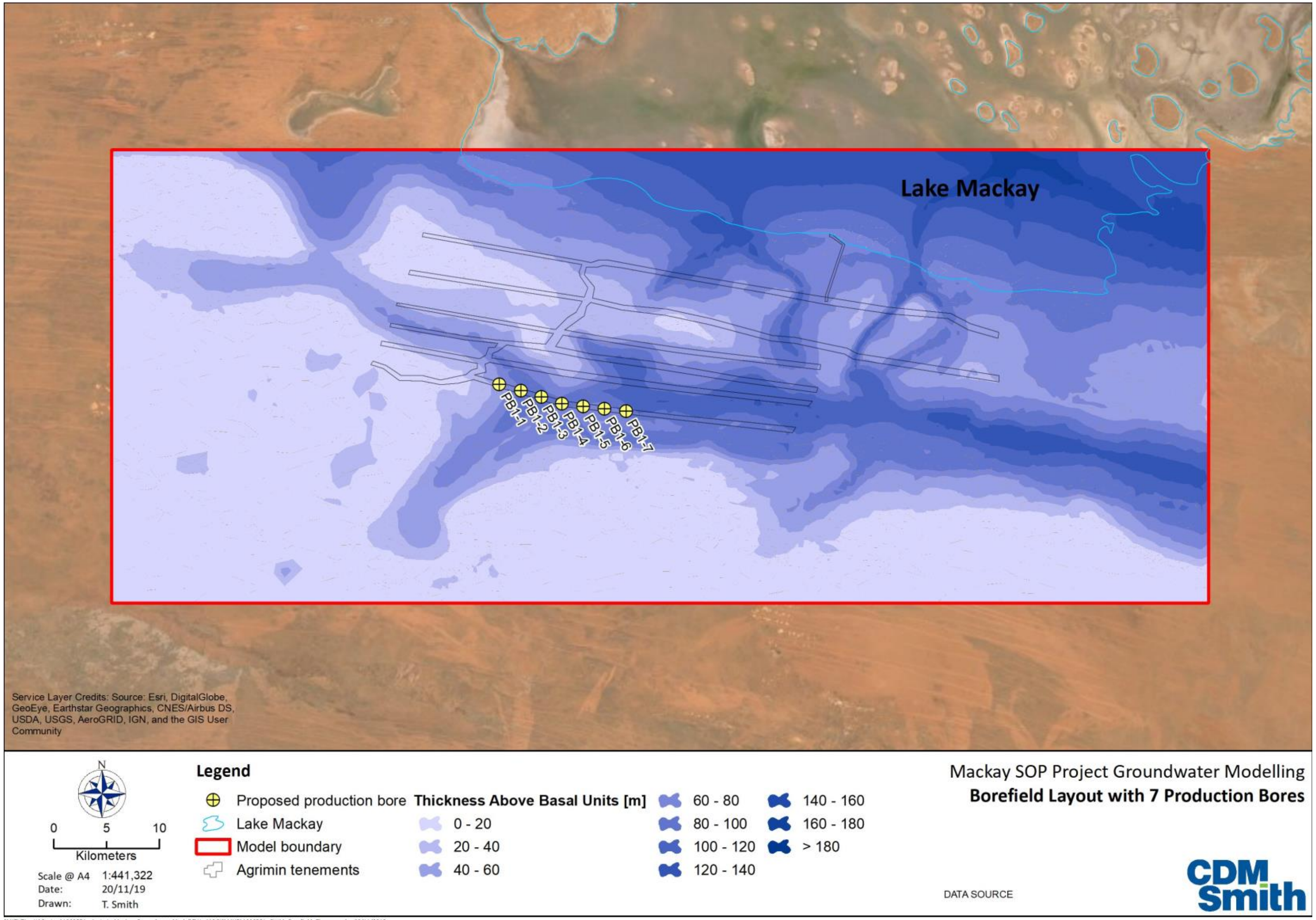

Figure 4-1 Borefield layout with 7 production bores (PRED01)

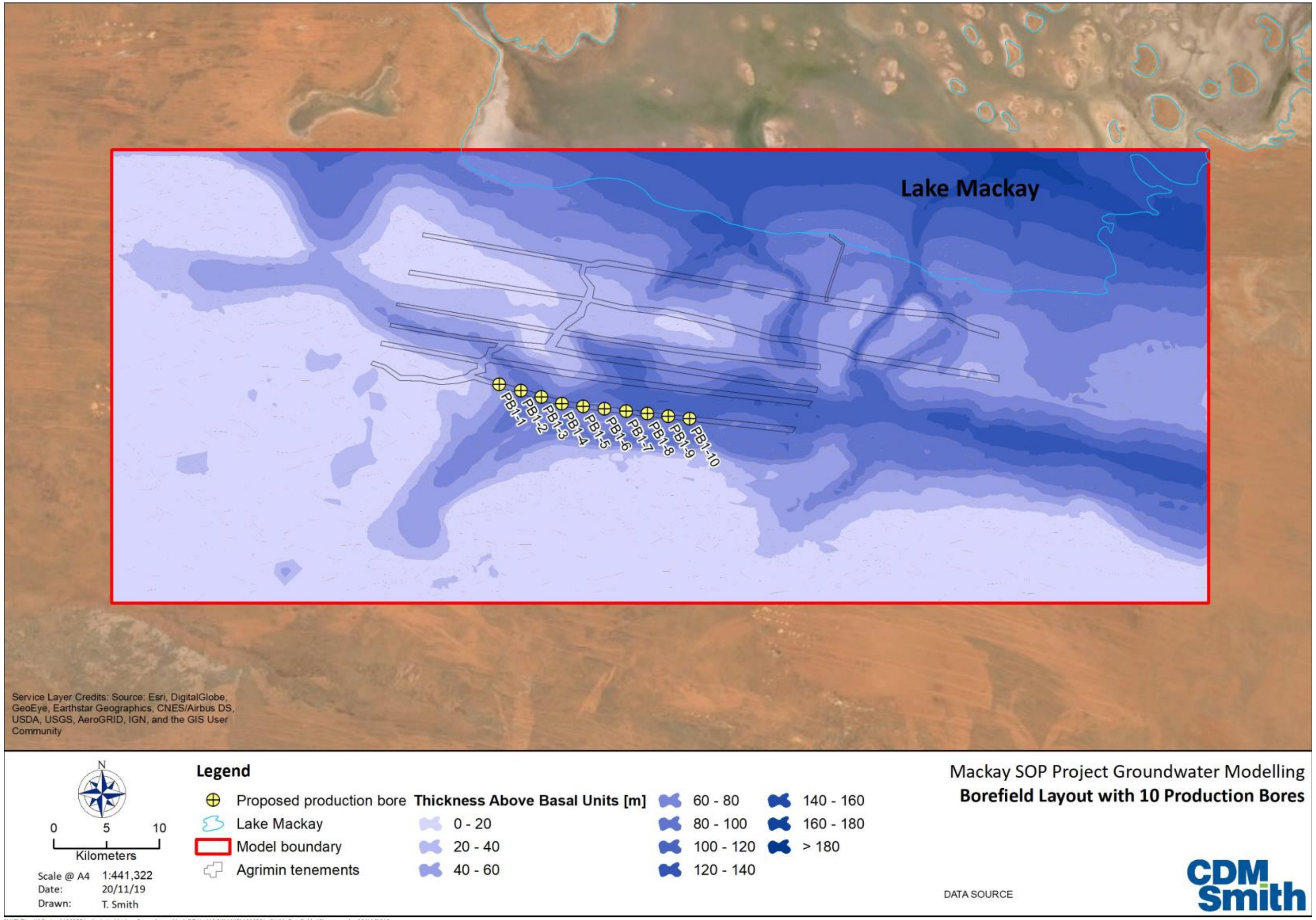

Figure 4-2 Borefield layout with 10 production bores (PRED02)

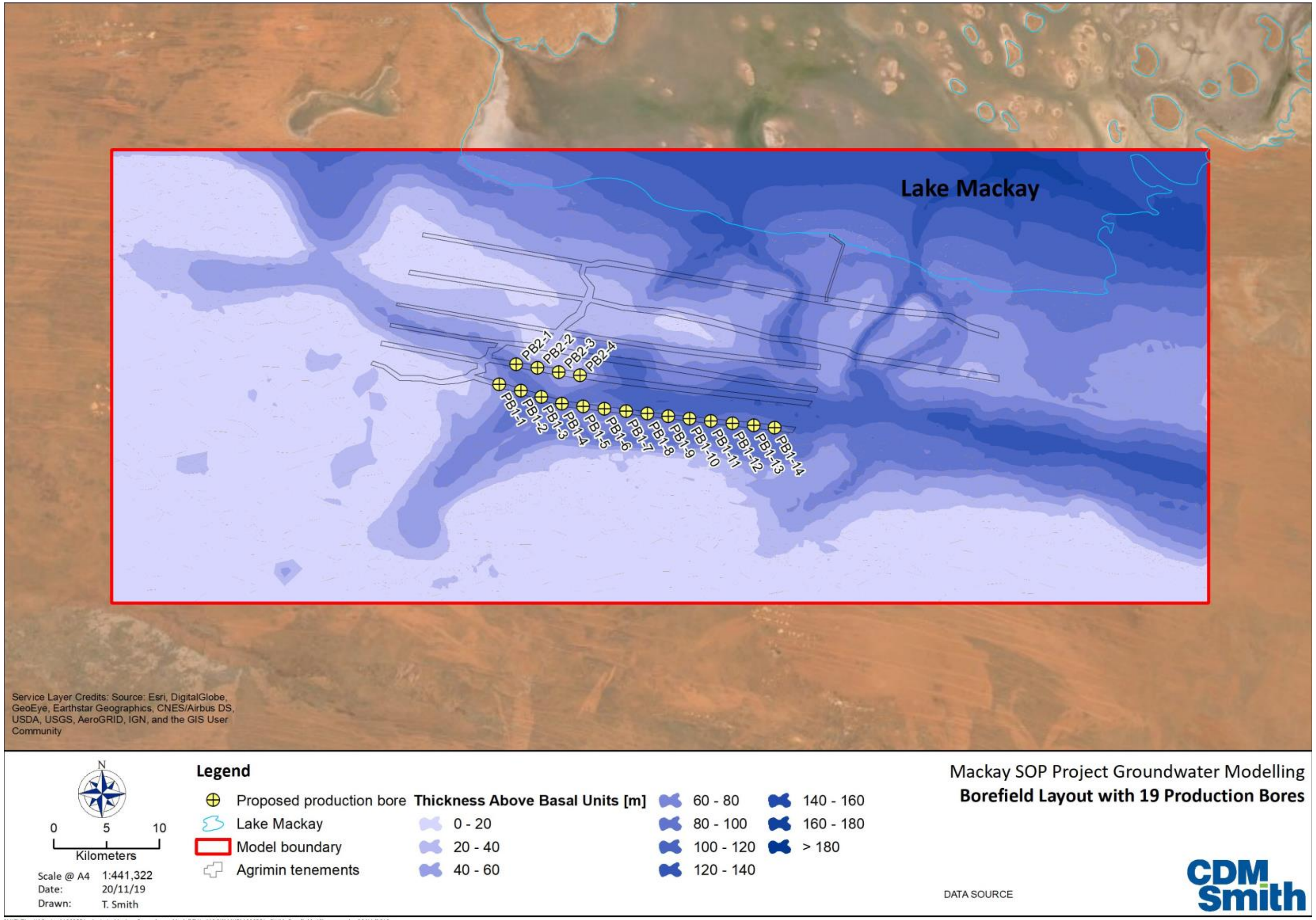

Figure 4-3 Borefield layout with 19 production bores (PRED03)

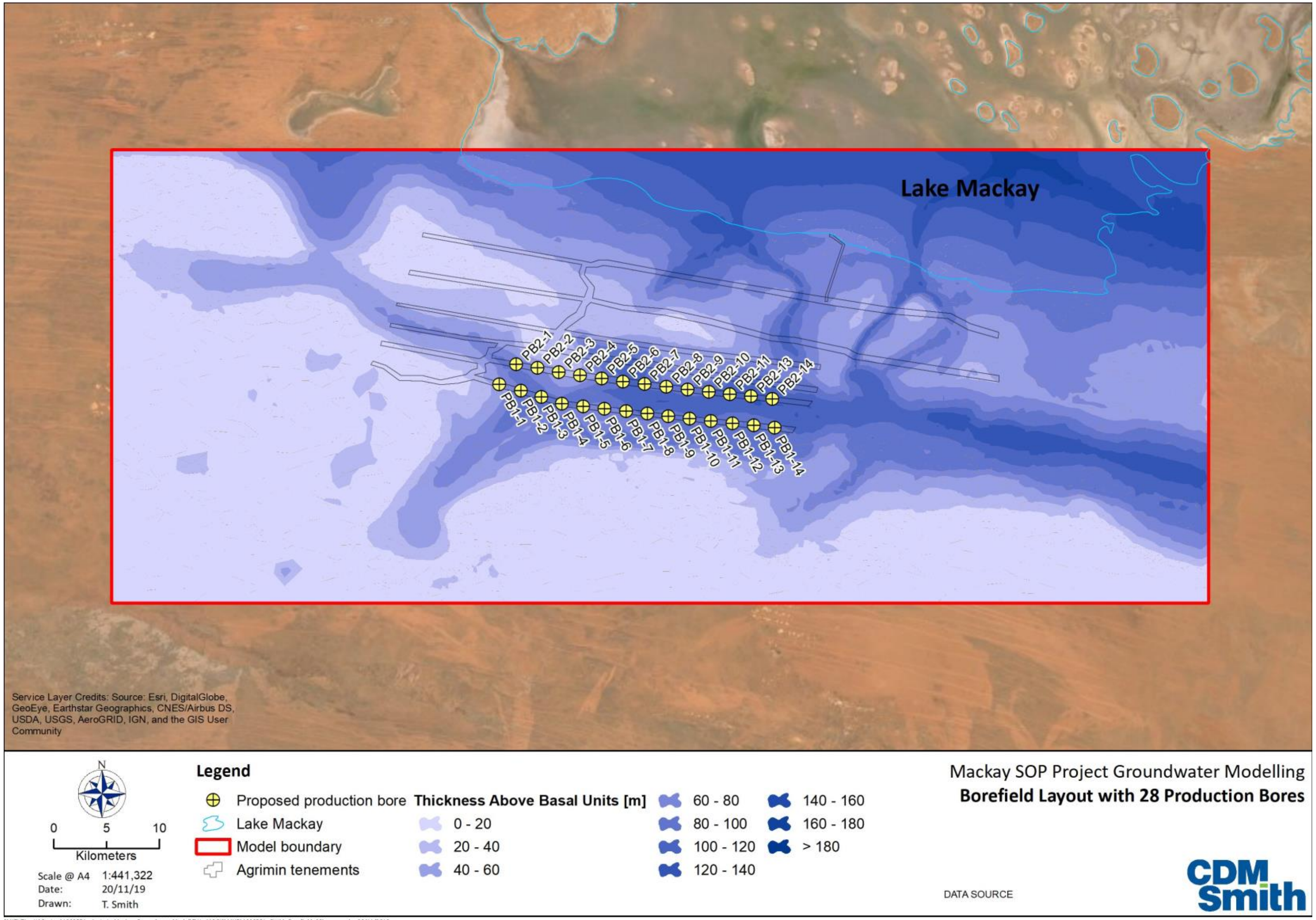

Figure 4-4 Borefield layout with 28 production bores (PRED04-06)

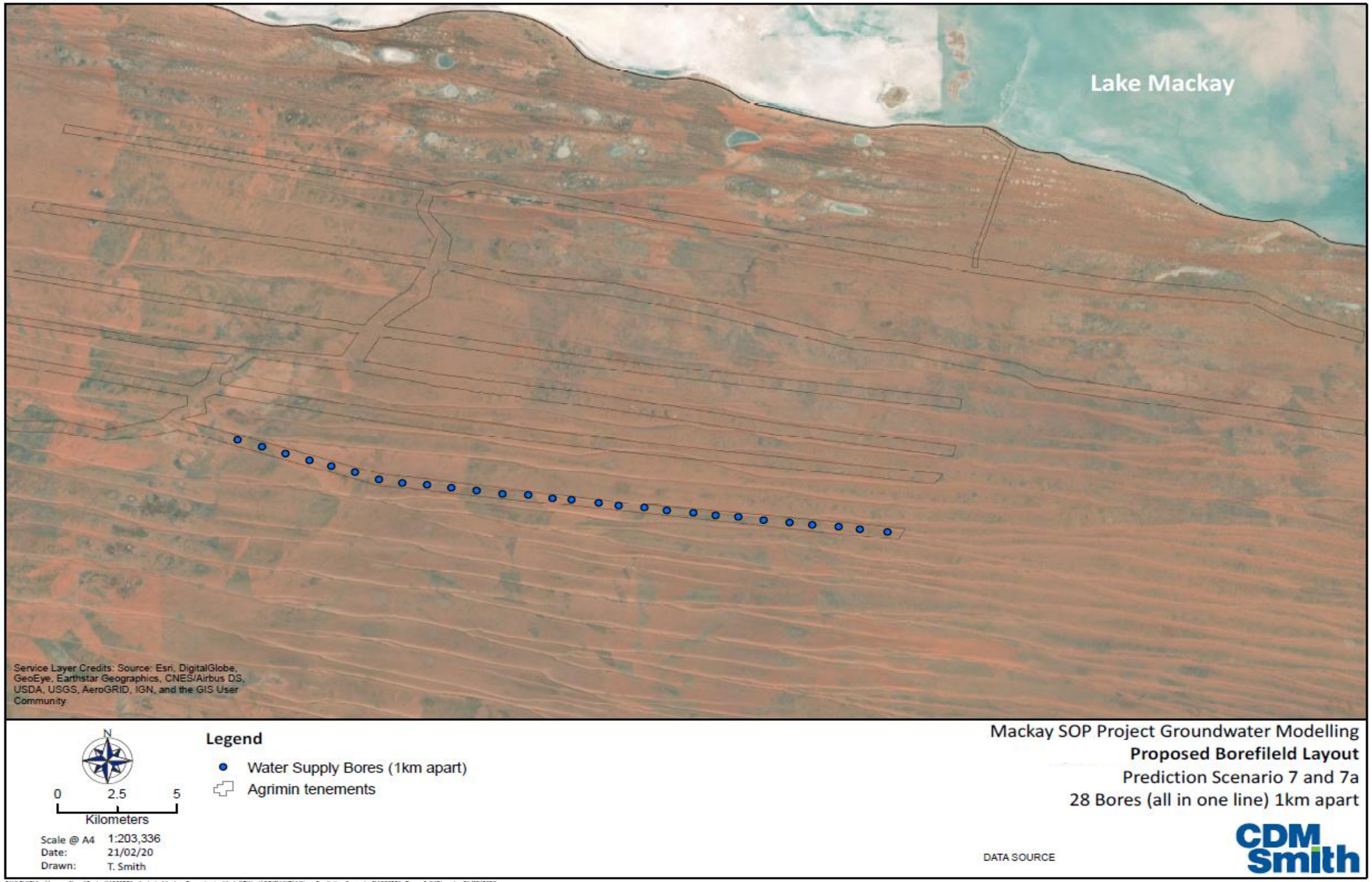

Figure 4-5 Borefield layout with 28 production bores (PRED07)

4.3 Results

The following sections present the modelling results for the seven predictive simulations described in Table 4-2.

The objective of this groundwater modelling study was to estimate if the projected water demand of up to 3.5 GL/a could be met from the two proposed southern-most lines.

For all simulated water supply scenarios with the adopted model parameters, it was estimated that the projected water demand could be met with the proposed borefield setups under the assumption that the capacity of each bore is sufficient to provide a continuous yield of up to 342.47 kL/d (Table 4-3).

Table 4-3 Results of simulated borefield scenarios

Scenario	Target water demand [GL/a]	No. of production bores	Production Lines [southern, northern or both	Spacing Between Production Bores [km]	Model Used for Simulation [FEFLOW or Modflow-Surfact]	Simulated Life of Mine [years]	Target water demand achieved [Yes/No]
PRED01	0.7	7	Southern	2	FEFLOW	20	Yes
PRED02	1.0	10	Southern	2	FEFLOW	20	Yes
PRED03	2.0	19	Both	2	FEFLOW	20	Yes
PRED04	3.0	28	Both	2	FEFLOW	20	Yes
PRED05	3.5	28	Both	2	FEFLOW	20	Yes
PRED06	3.5	28	Both	1	Modflow-Surfact	20	Yes
PRED07	3.5	28	Southern	1	Modflow-Surfact	20	Yes

The simulation results suggest that the majority of water supply would be sourced from the deep aquifer of the Angas Hills Formation which comprises fluvial sands, gravel and conglomerates. Assigned aquifer parameters for this formation are presented in Tables 3-2 and 4-1 above. Adopted hydraulic conductivity of this formation was 1 m/d (horizontal) and 0.1 m/d (vertical); specific storage (Ss) of 0.0001/m and specific yield (Sy) of 10%. It should be noted that these values of Sy and Ss are mostly typical values from textbook reviews. Due to the configuration of the deep aquifer (Figure 4-14) prediction scenarios PRED04-06, where 28 abstraction bores were simulated in the model, all 14 bores modelled along the northern line and 5 bores of the southern line were predicted to source the water mostly from the deep aquifer. The other 9 bores of the southern line were predicted to source the water mostly from the Alluvial Sands represented as Surficial Deposits in the model because deep aquifer is not present at the proposed bore locations (Figure 4-15).

In addition, with the proposed borefield setup in PRED07 model run results suggest that the majority of water supply would be sourced from the shallow aquifer. Only 5 out of 28 bores were estimated to source the water from the deep aquifer (Figure 4-16) and other 23 bores in the model were mostly taking the water out from the shallow aquifer (Figure 4-17) due to absence of the deep aquifer at those locations.

4.3.1 Predictive Drawdown Estimates

Drawdown estimates for the seven predictive simulations described in Table 4-2 are presented in Figure 4-6 to Figure 4-13.

The information shown on the figures includes the proposed production bore locations, the computed contours of water-table drawdown and the residual saturated depth of aquifer at the end of 20 years of extraction. The drawdown contours shown on the maps are 0.1, 0.2, 0.5, 1, 2, 3, 5 and 10 m. As an example, Figure 4-11 presents the predicted development of water table drawdown over time for scenario PRED05 (3.5 GL/a). For the adopted base case parameters maximum extent of drawdown was estimated to extend approximately 6 km away from the borefield towards the lake.

At the proposal stage of this study, groundwater particle tracking was proposed as a method to explore potential movement of saline groundwater toward the borefield. Now that the modelling results have been produced, it is apparent that the predicted movement of groundwater toward the borefield over the simulated 20-year extraction period is small, and therefore particle tracking is not necessary. In fact, the length of groundwater path lines are too small to show practically on a map figure at the scale of the borefield.

Table 4-4 Summary of residual saturated depth and drawdown for the southern borefield scenarios

Scenario	Target water demand [GL/a]	No. of production bores	Production Lines [southern, northern or both	Spacing Between Production Bores [km]	Simulated Life of Mine [years]	Maximum Distance of Drawdown Away from the Borefield [km]
PRED01	0.7	7	Southern	2	20	4
PRED02	1.0	10	Southern	2	20	4
PRED03	2.0	19	Both	2	20	4.5
PRED04	3.0	28	Both	2	20	5
PRED05	3.5	28	Both	2	20	6
PRED06	3.5	28	Both	1	20	6
PRED07	3.5	28	Southern	1	20	6

With the adopted model setups this model is the storage depletion model. Although recharge is estimated to provide ~13ML/d of inflow, ET is also estimated to take ~11ML/d out, leaving the proposed borefield to source the water out from the storage. One of the sensitivity runs described below (SENS03 – Run PT14) had recharge completely removed from the model. The model (PT14) still managed to sustain the assigned abstraction of 3.5GL/y over the life of mine even with no recharge.

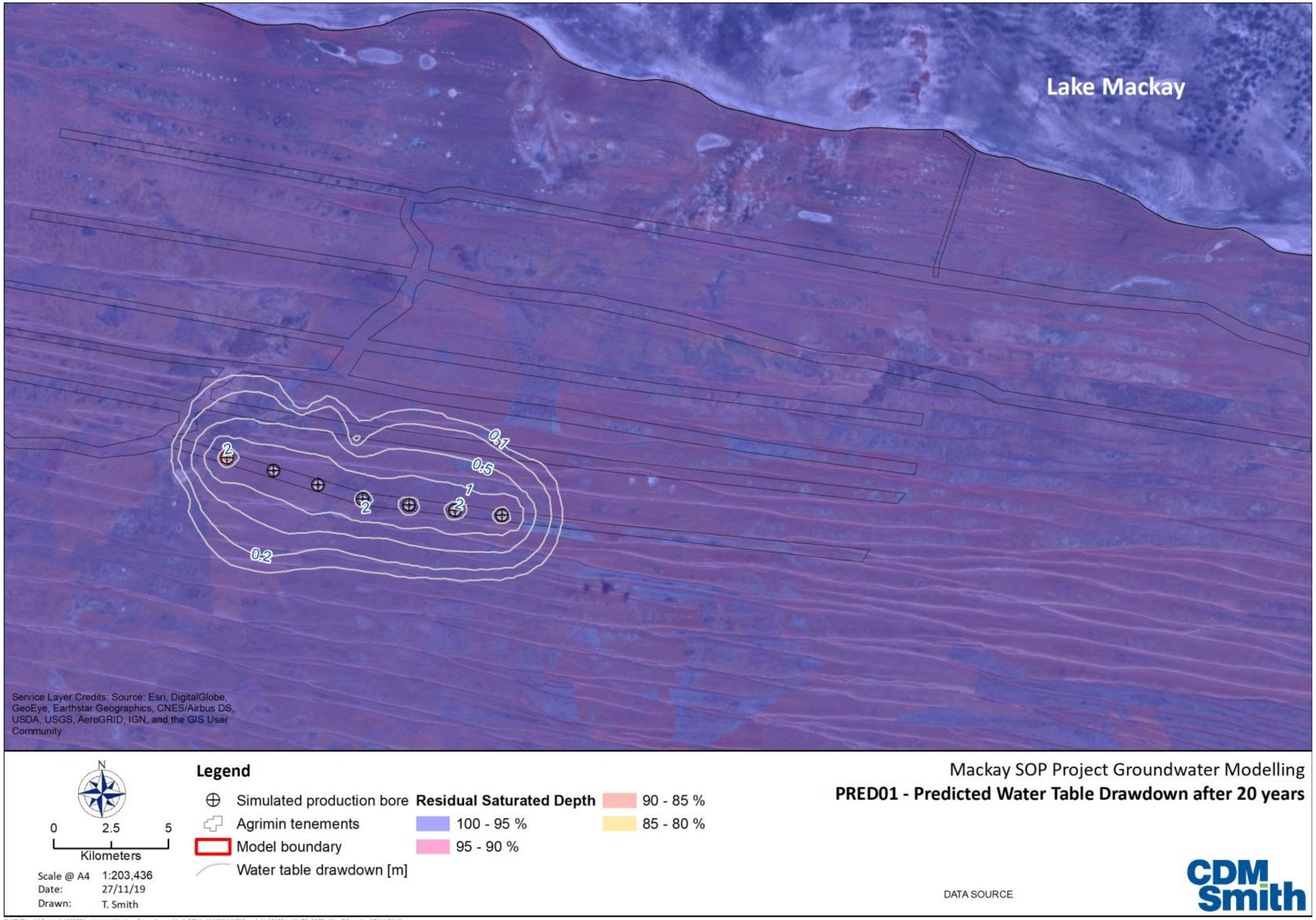

Figure 4-6 **PRED01 – Predicted water table drawdown after 20 years (0.7 GL/a)**

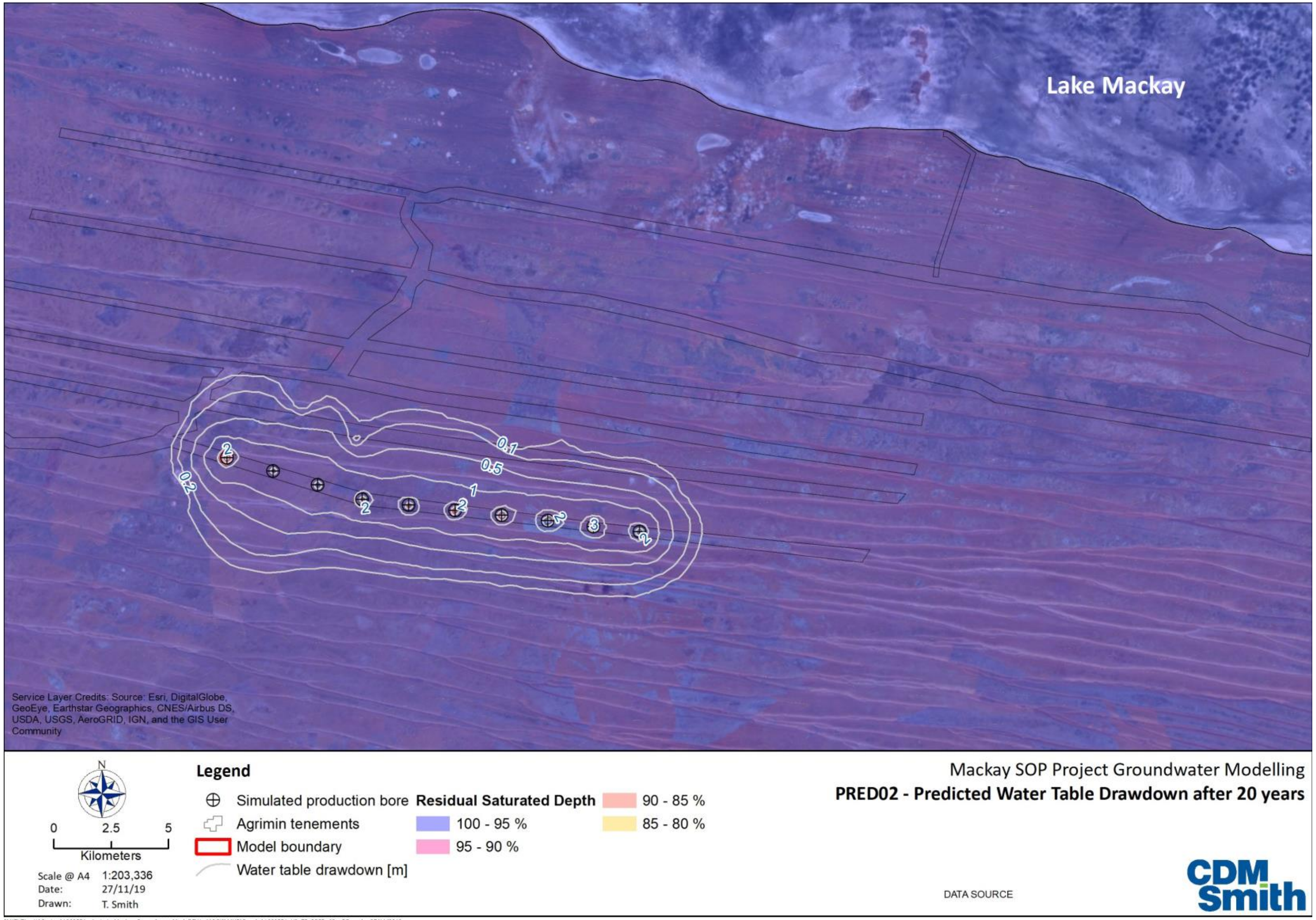

Figure 4-7 PRED02 – Predicted water table drawdown after 20 years (1 GL/a)

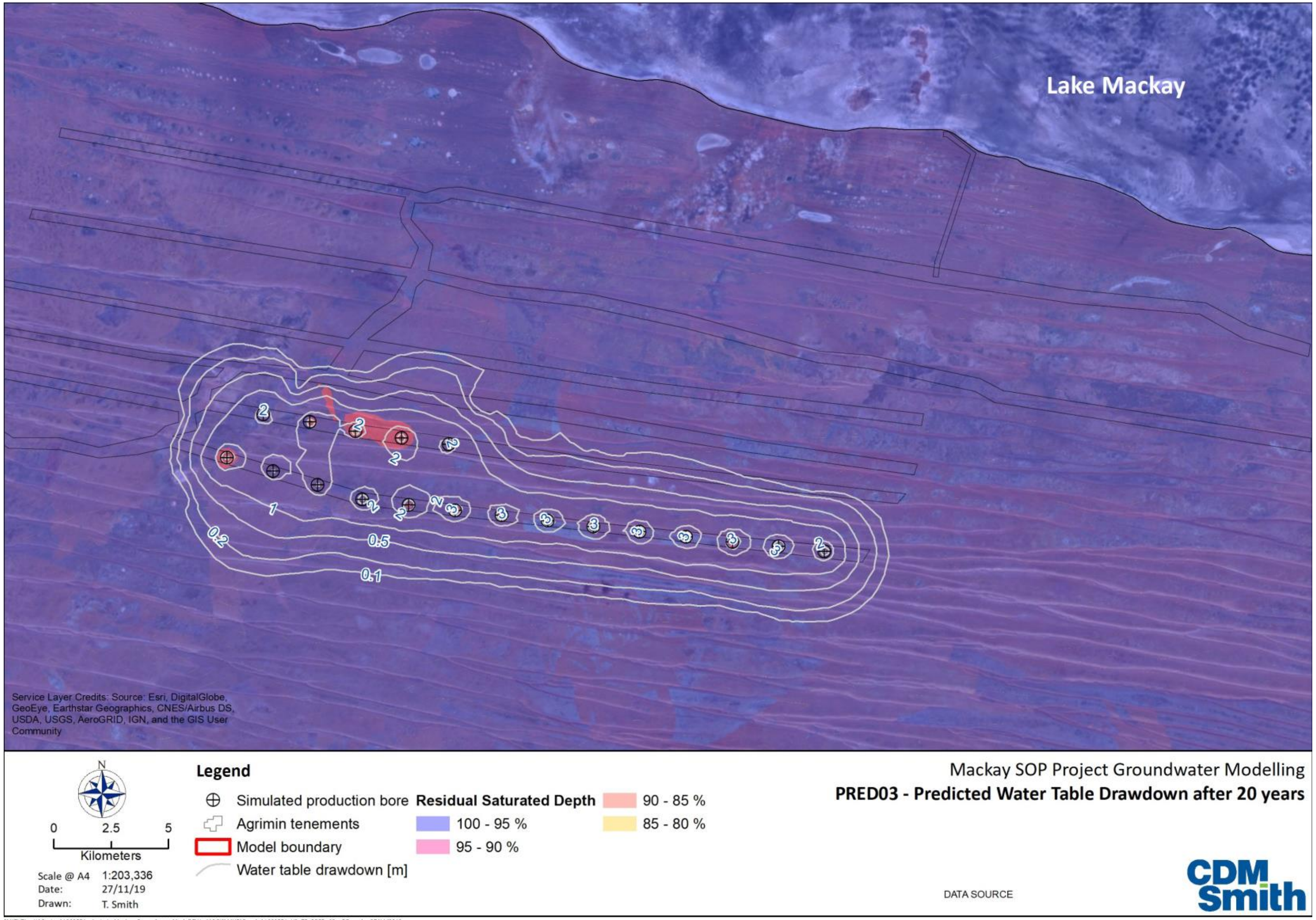

Figure 4-8 PRED03 – Predicted water table drawdown after 20 years (2 GL/a)

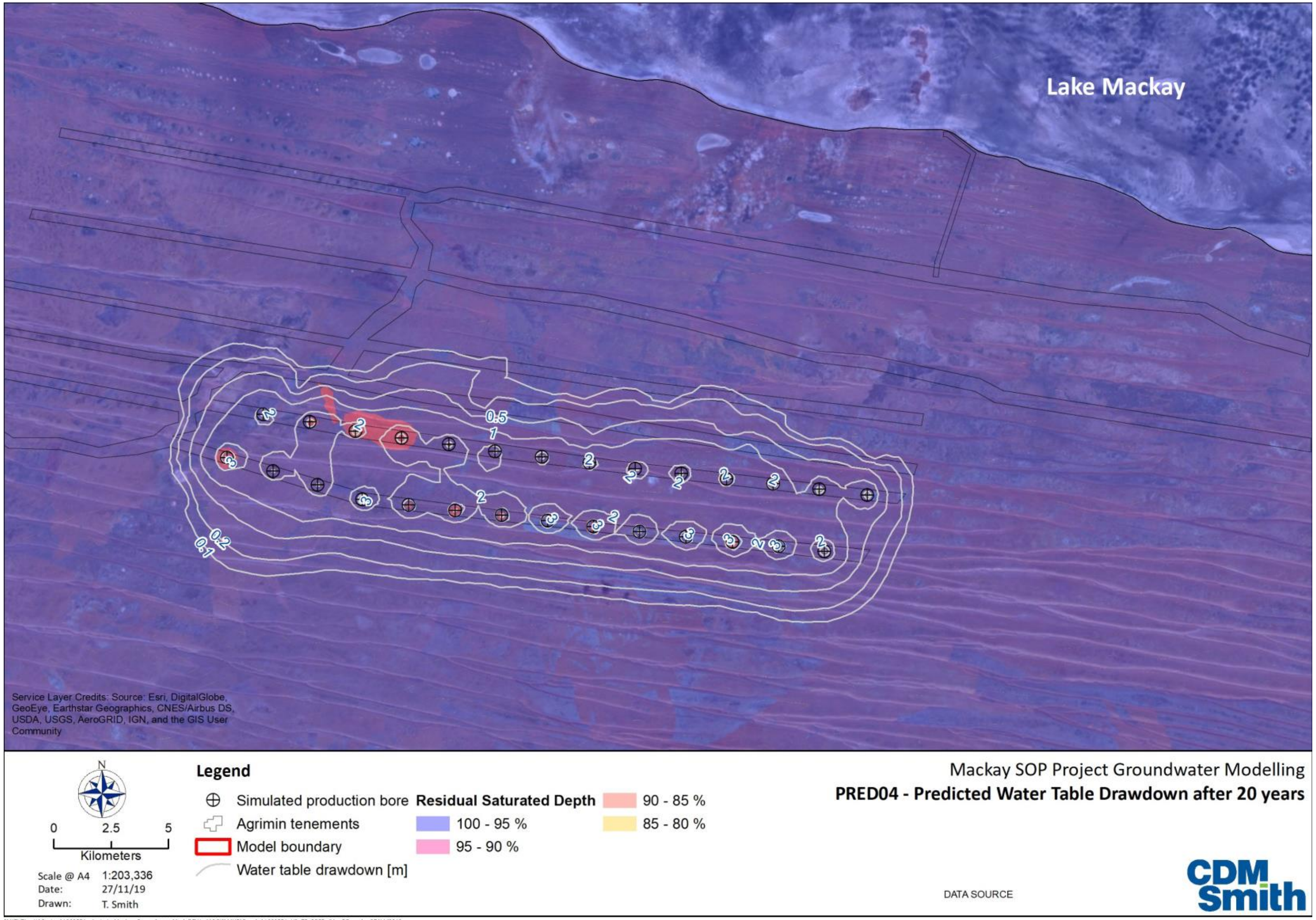

Figure 4-9 **PRED04 – Predicted water table drawdown after 20 years (3 GL/a)**

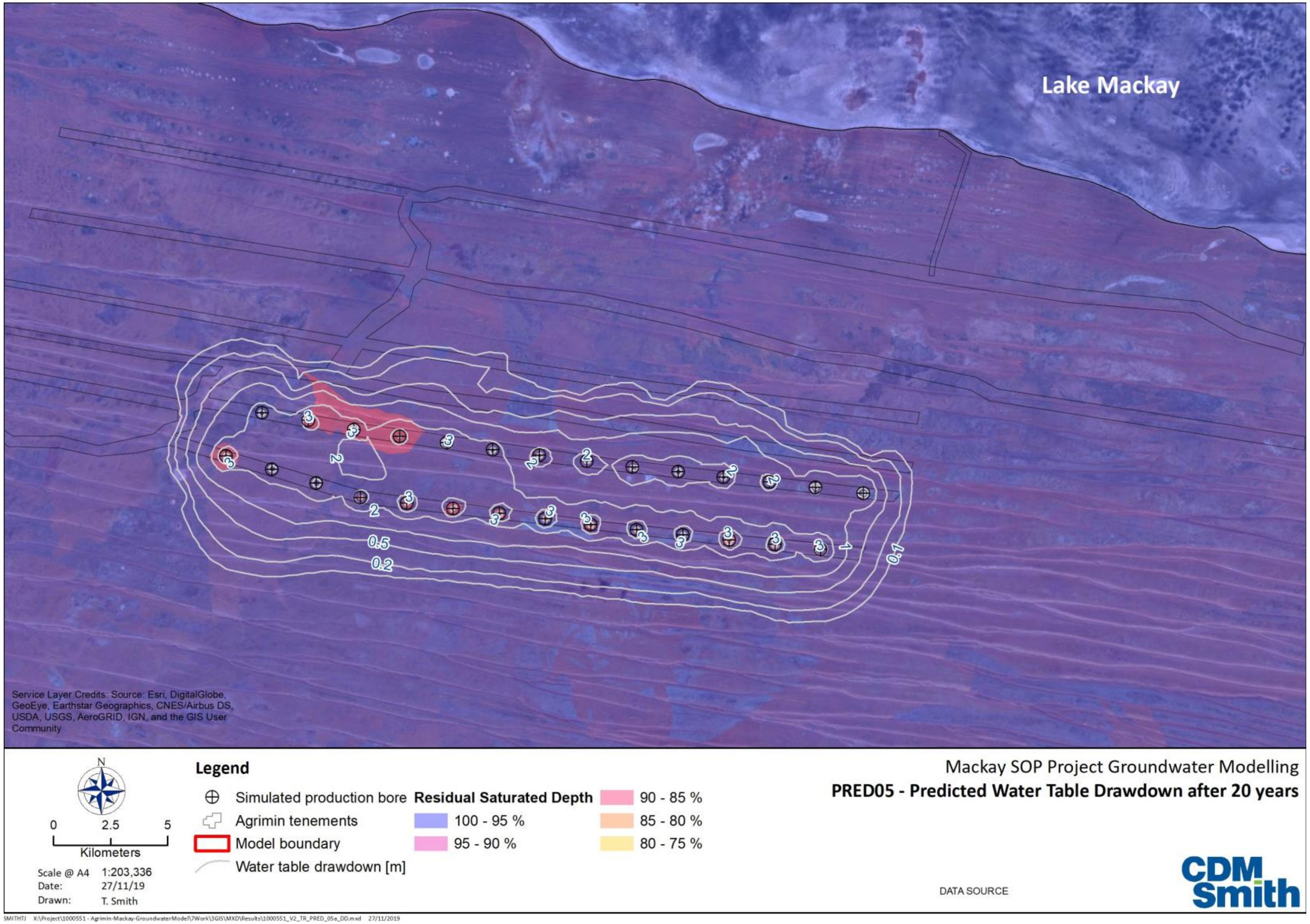

Figure 4-10 PRED05 – Predicted water table drawdown after 20 years (3.5 GL/a)

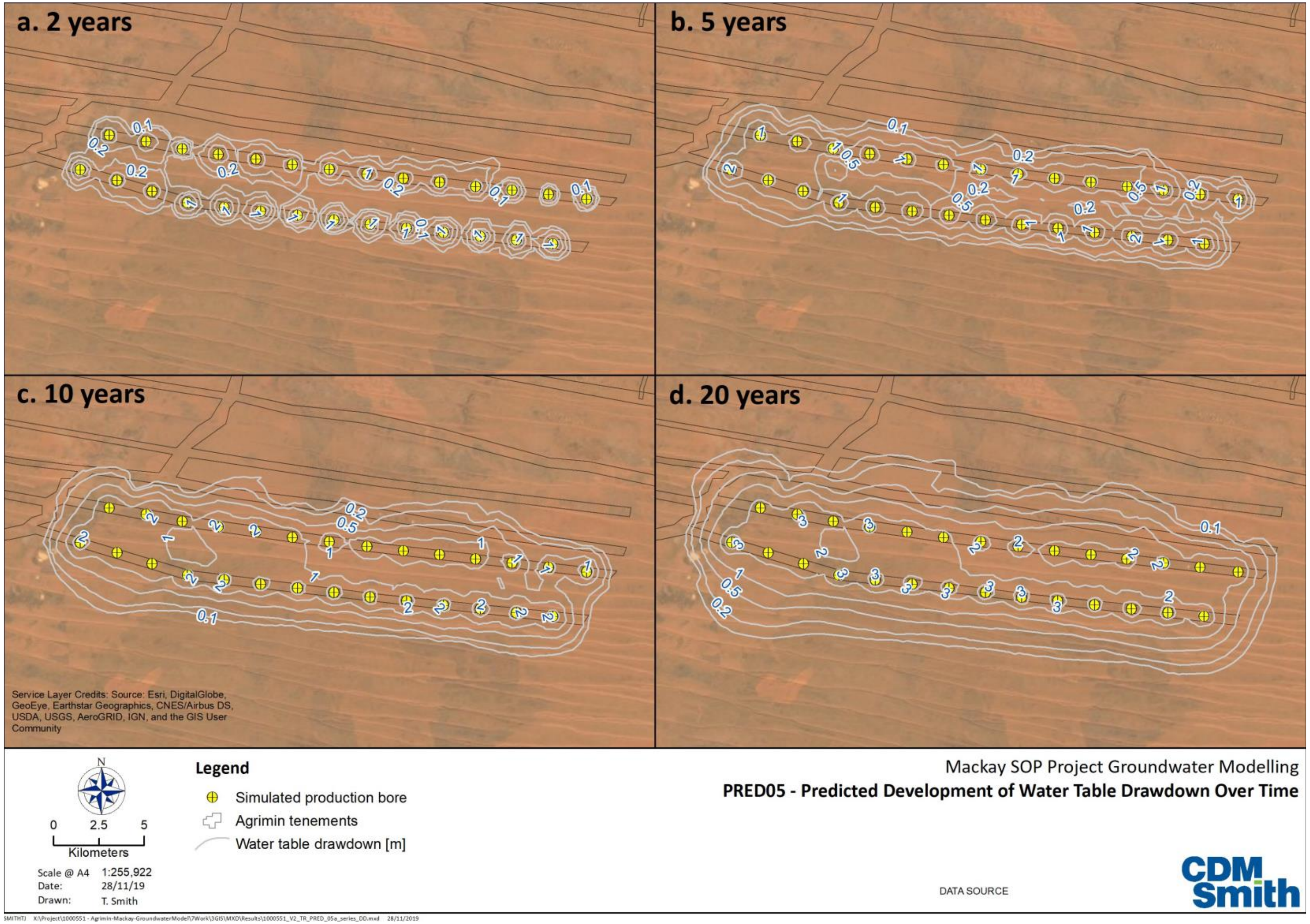

Figure 4-11 PRED05 – Predicted development of water table drawdown over time

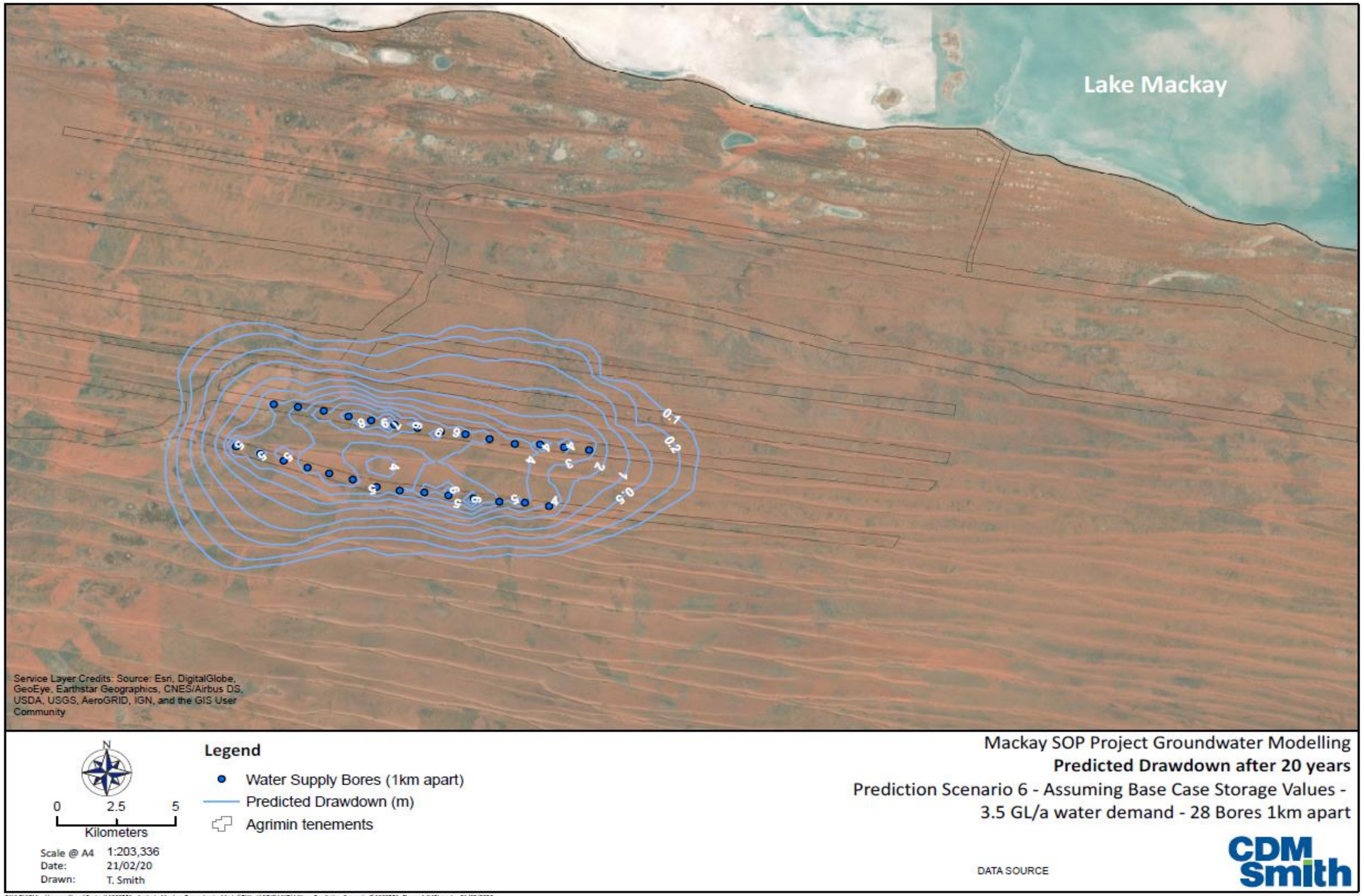

Figure 4-12 PRED06 – Predicted water table drawdown after 20 years (3.5 GL/a)

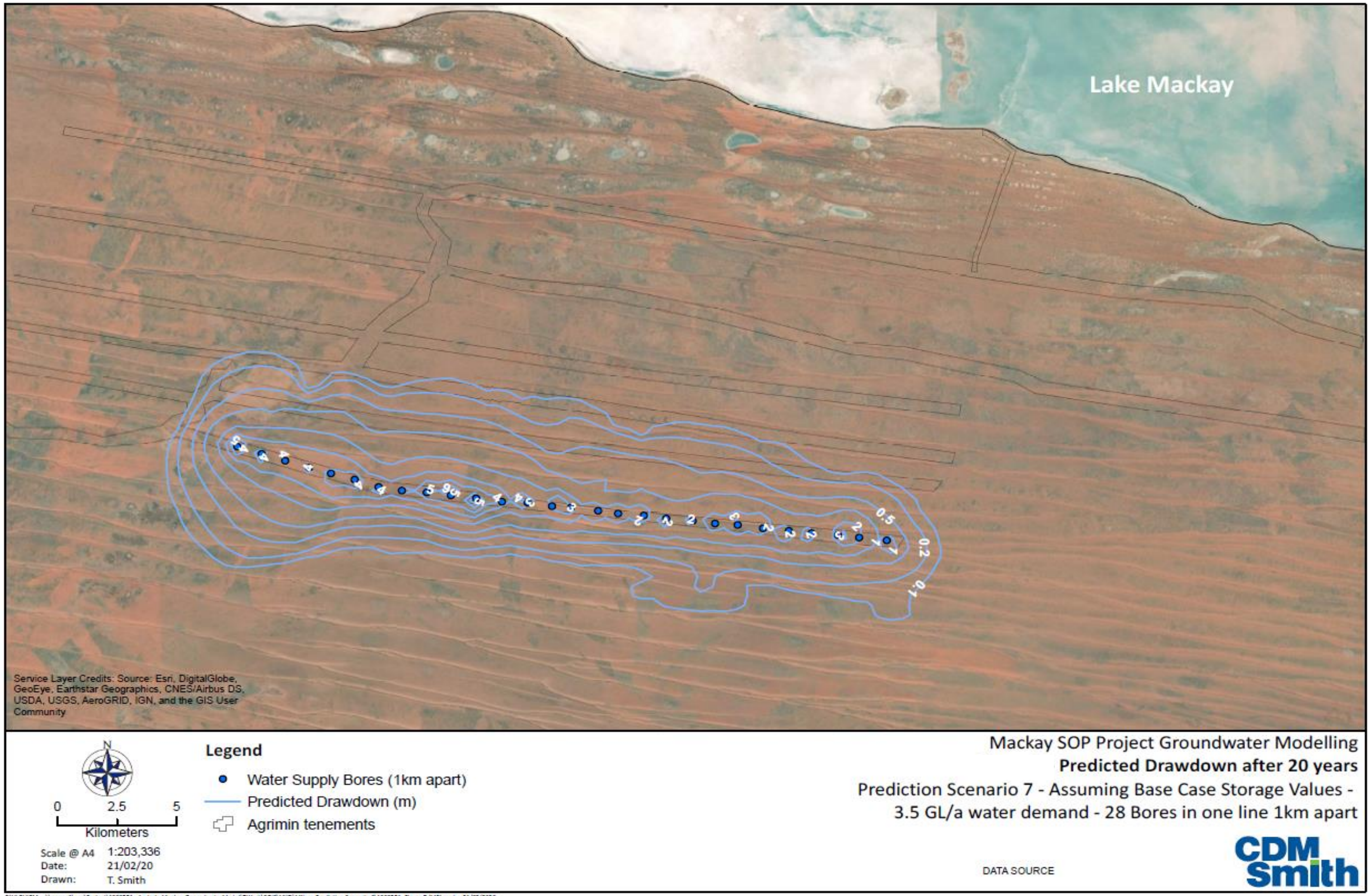

Figure 4-13 PRED07 – Predicted water table drawdown after 20 years (3.5 GL/a)

Figure 4-14 PRED04-06 – Deep Aquifer Borefield Setup

Figure 4-15 PRED04-06 – Shallow Aquifer Borefield Setup

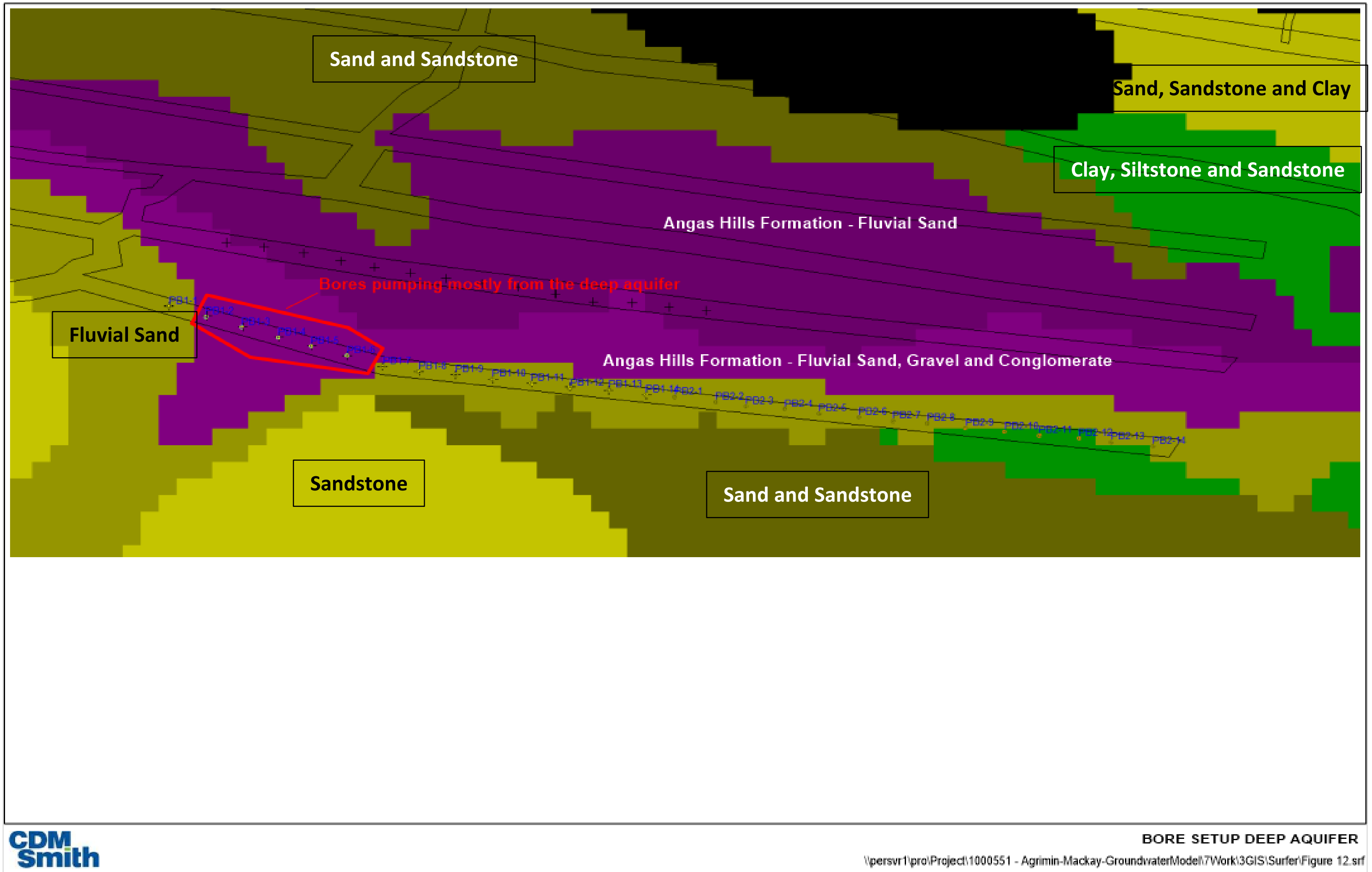

Figure 4-16 PRED07 – Deep Aquifer Borefield Setup

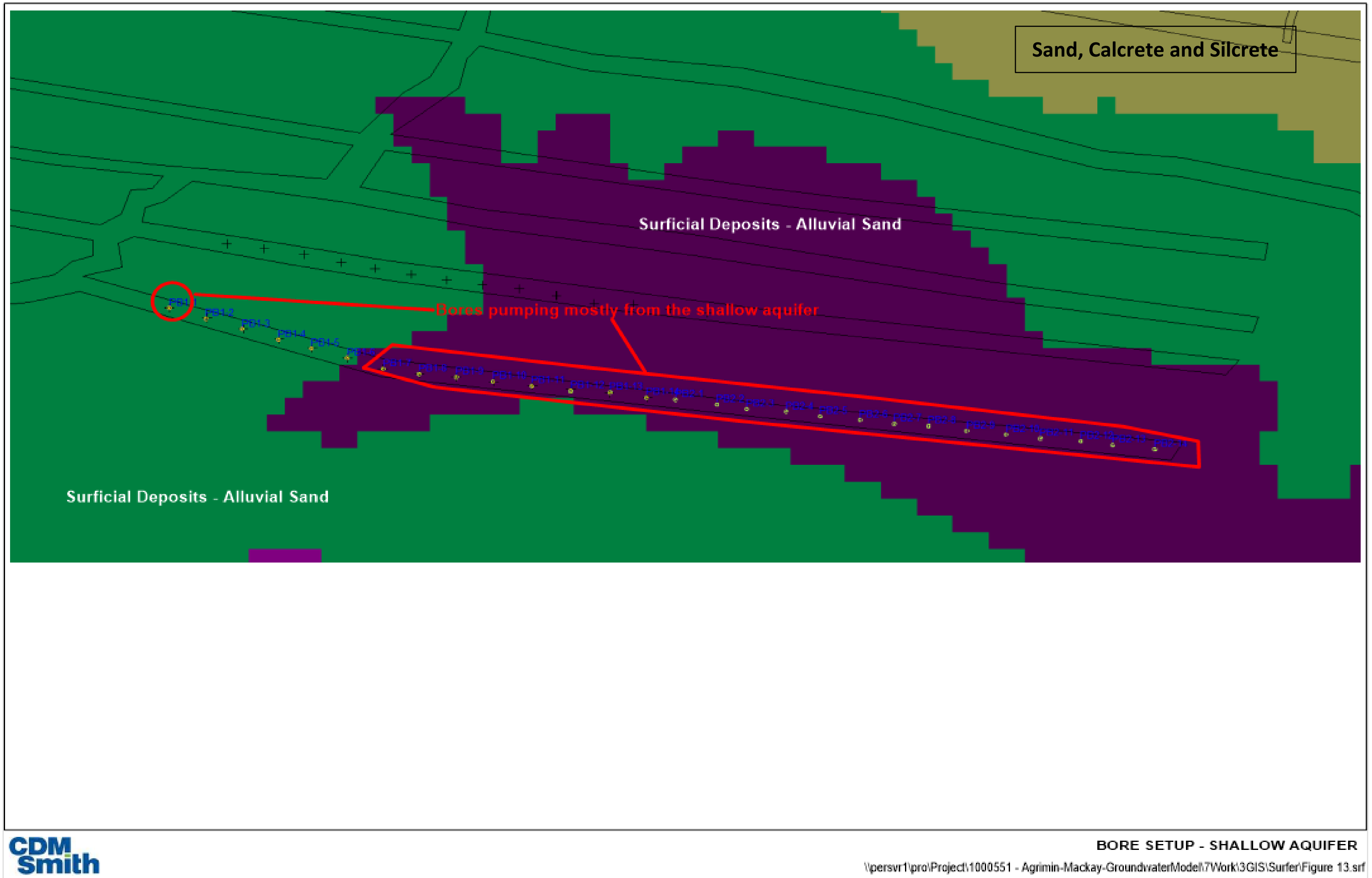

Figure 4-17 PRED07 – Shallow Aquifer Borefield Setup

Section 5 Sensitivity Analysis

Since all seven base case prediction runs have achieved target abstraction regardless of number of bores, spacing between them and the overall borefield setup, sensitivity analyses have been designed to produce an undesirable outcome. In other words, sensitivity analyses are aimed to test parameter values and conceptual features in the model in order to cause the model to 'fail', or not being able to achieve target abstraction. The results of the sensitivity analysis will inform future hydrogeological investigations on site and analysis to improve conceptual hydrogeological understanding and reduce uncertainty in borefield assessments subject of this study. Sensitivity runs are summarised in Table 5-1 and the following sections of the report.

Table 5-1 Summary of sensitivity runs

Approach	Description	Source of data	Parameter or feature tested
SENS01	Low storage simulation	U.S. Geological Survey	Unconfined Storage
SENS02	NMR parameters	NMR	Unconfined Storage
			Hydraulic Conductivity
SENS03	Conceptual features in the model	-	Lake setup (CHB)
			Recharge

5.1 SENS01 - Low-Storage Simulations

Selected predictive scenarios are re-run with lower estimates of specific yield to explore potential uncertainty in the modelling results from potential over-estimation of the formation storage coefficients. Low storage sensitivity scenarios were only testing high target water demand scenarios PRED05, PRED06 and PRED07 with a provision to test other base case borefield cases if high cases fail to achieve target water demand.

Table 5-2 compares reference values for specific yield against the adopted values in Table 4-1. In general, the adopted values are already reasonably conservative and tend to be closer to the lower end of the reference ranges.

The reference values in Table 4-1 are taken from reviews of specific yield published by the U.S. Geological Survey (Johnson 1966, Morris & Johnson 1967). Figure 5-1, sourced from Johnson (1966), is a graphical representation of how specific yield typically varies with the texture classes of unconsolidated sediments.

Based on the comparison in Table 5-2, the specific yield of the surficial units for the low-storage simulation is reduced from 0.15 to 0.1, the specific yield of the palaeochannel clay is reduced from 0.03 to 0.02 and specific yield of the palaeochannel sand is unchanged; noting it is already at the lower end of the reference range.

Table 5-2 Choice of formation storage coefficients for the low storage scenarios

Model layer	[1]Reference values		Adopted value	Low storage case
1 – Quaternary and Neogene deposits	Sand	0.15 – 0.35	0.15	0.1
	Fine-grained sandstone	0.02 – 0.4 0.21 (mean)		
2 – Palaeochannel clay	Silty clay	0.02 – 0.05	0.03	0.02

Model layer	[1]Reference values		Adopted value	Low storage case
3 – Palaeochannel sand	Fine	0.1 – 0.28	0.1	0.1
	Medium	0.15 – 0.32		
	Coarse	0.2 – 0.35		
4 – Angas Formation	Silty sand	0.1 – 0.3	0.1	0.05
	Clayey sand	0.05 – 0.1		

[1]Johnson (1966) and Morris and Johnson (1967)

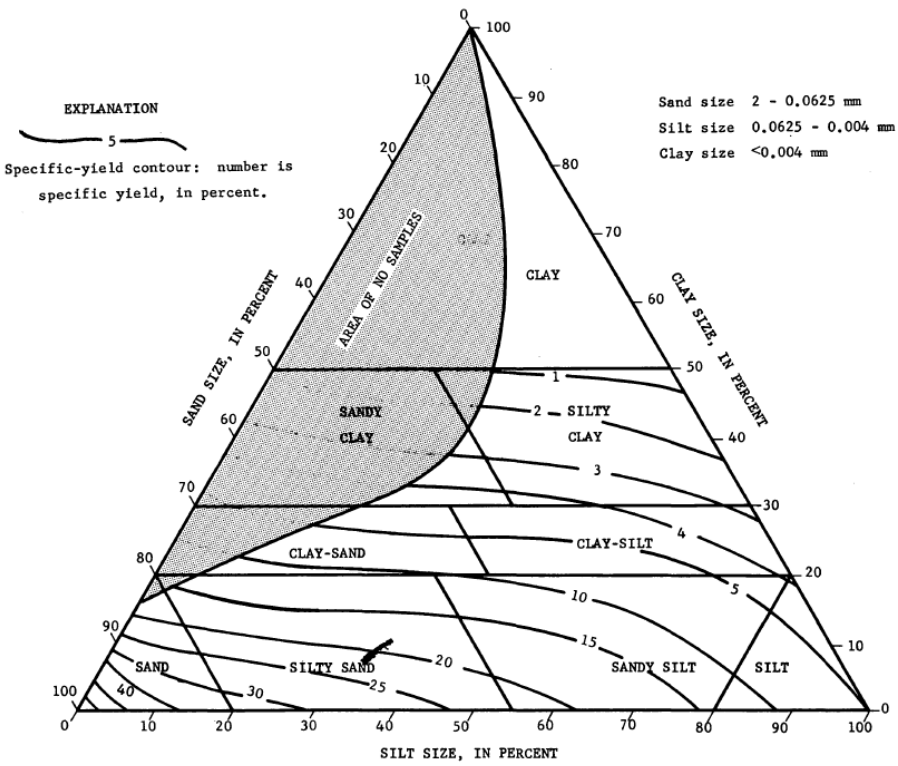

Figure 5-1 Soil classification triangle showing specific yield as contours (Johnson 1966)

5.1.1 SENS01 Results

The results of the low-storage sensitivity runs are summarised in **Error! Reference source not found.** below:

Table 5-3 Results of low-storage sensitivity runs

Scenario	Target water demand [GL/a]	No. of production bores	Production Lines [southern, northern or both	Spacing Between Production Bores [km]	Model Used for Simulation [FEFLOW or Modflow-Surfact]	Simulated Life of Mine [years]	Target water demand achieved [Yes/No]	
							Base case setup	SENS01 setup
PRED05	3.5	28	Both	2	FEFLOW	20	Yes	Yes
PRED06	3.5	28	Both	1	Modflow-Surfact	20	Yes	Yes
PRED07	3.5	28	Southern	1	Modflow-Surfact	20	Yes	Yes

For all three high water demand cases (PRED05, PRED06 and PRED07) results suggests that target water demand, even with the reduced aquifer storage, could be achieved. The results suggest that the even with the reduced aquifer storage the sheer volume of the aquifer units combined with inflow from the rainfall recharge would enable the proposed borefield to meet the target water demand.

As presented Figure 5-2 to Figure 5-6 below, drawdown results for all three cases are not excessive, and the modelling indicates the borefield can operate successfully for 20 years. Since these three prediction cases are the worst-cases in terms of water demand and drawdown result for the southern borefield scenarios considered in this report, the other borefield scenarios with lower extraction rates (PRED01 to PRED04) have not been rerun as low-storage simulation at this time.

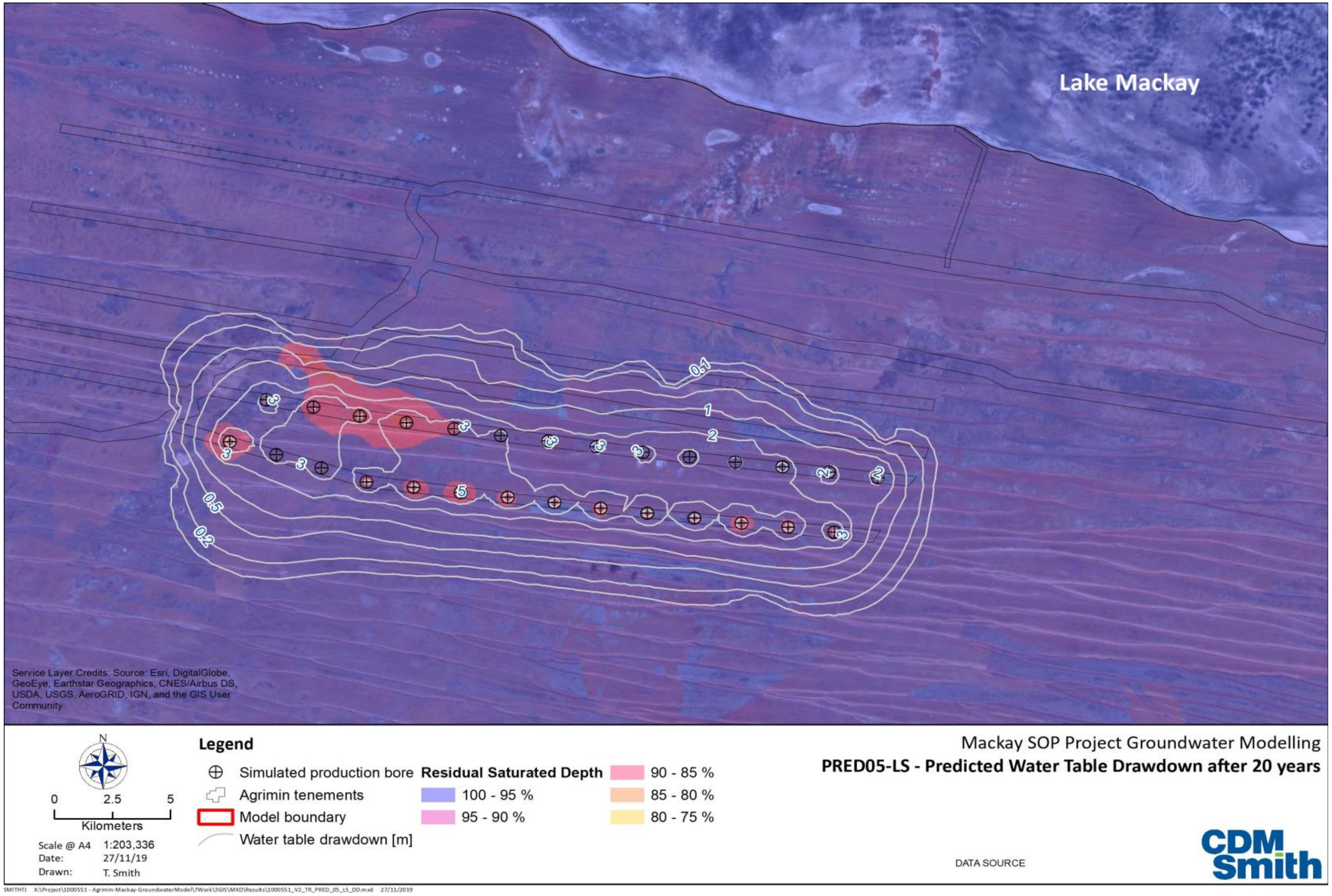

Figure 5-2 **PRED05 – Low-Storage Case SENS01- Predicted water table drawdown after 20 years (3.5 GL/a)**

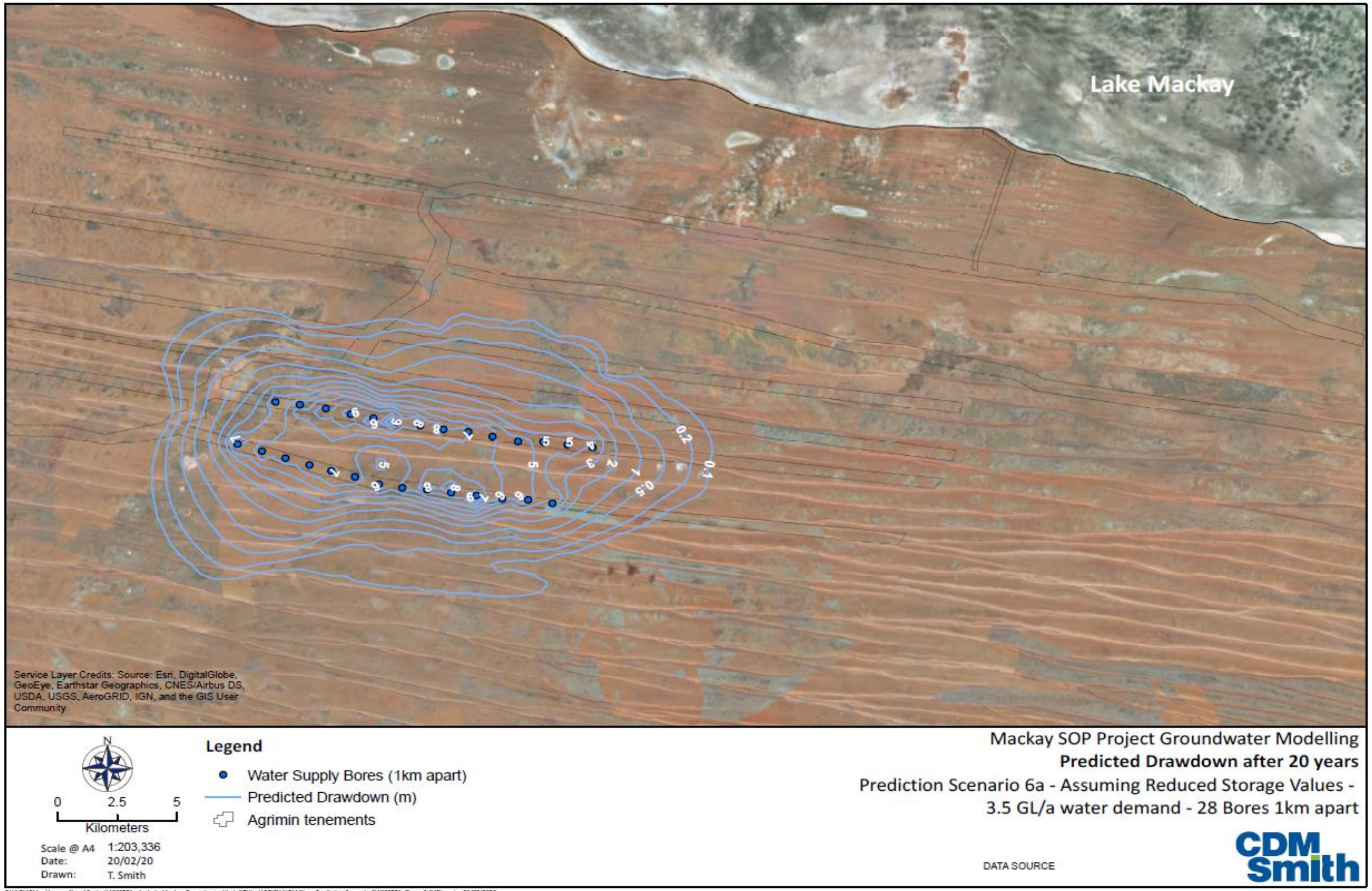

Figure 5-3 PRED06 – Low-Storage Case SENS01- Predicted water table drawdown after 20 years (3.5 GL/a)

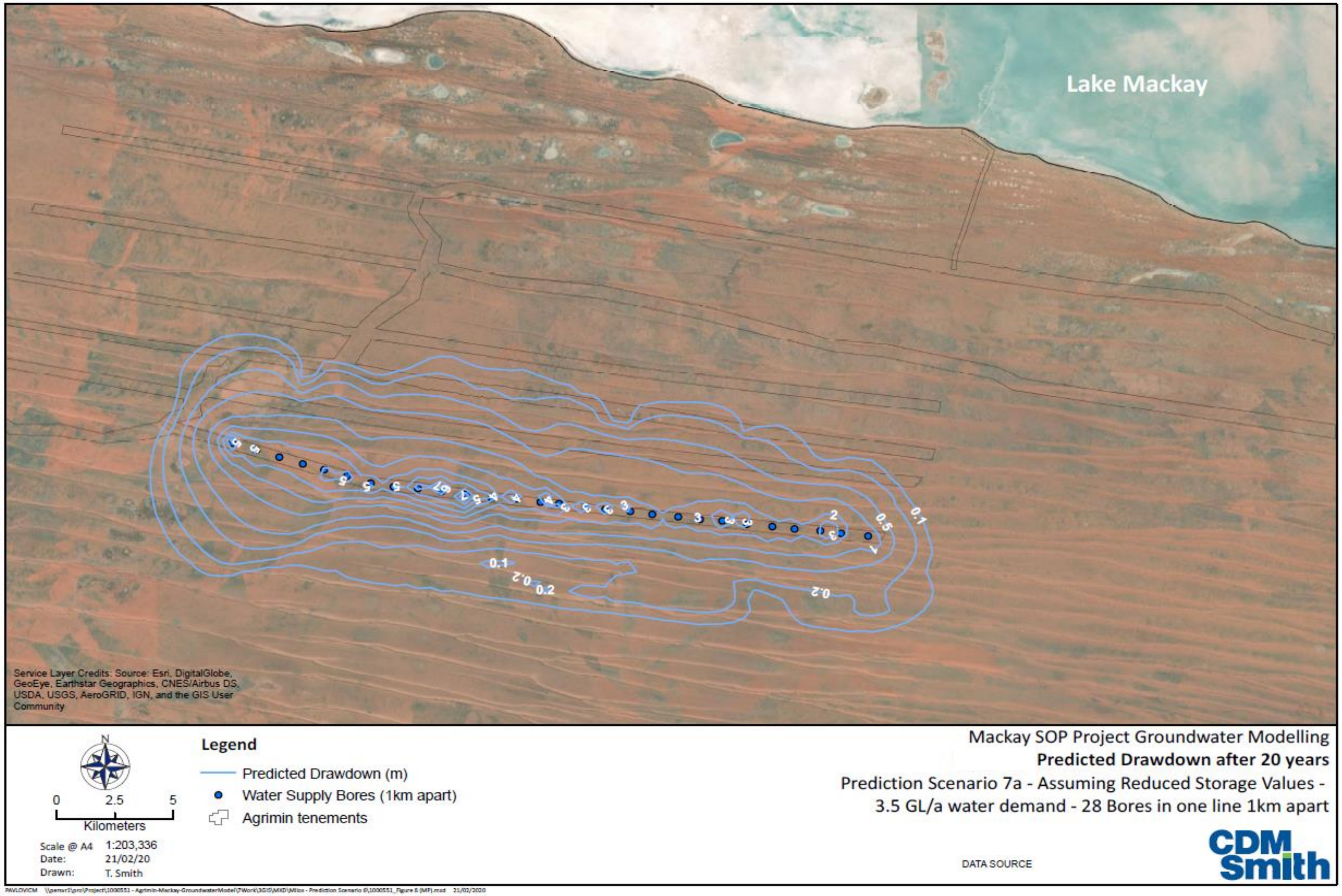

Figure 5-4 PRED07 – Low-Storage Case SENS01- Predicted water table drawdown after 20 years (3.5 GL/a)

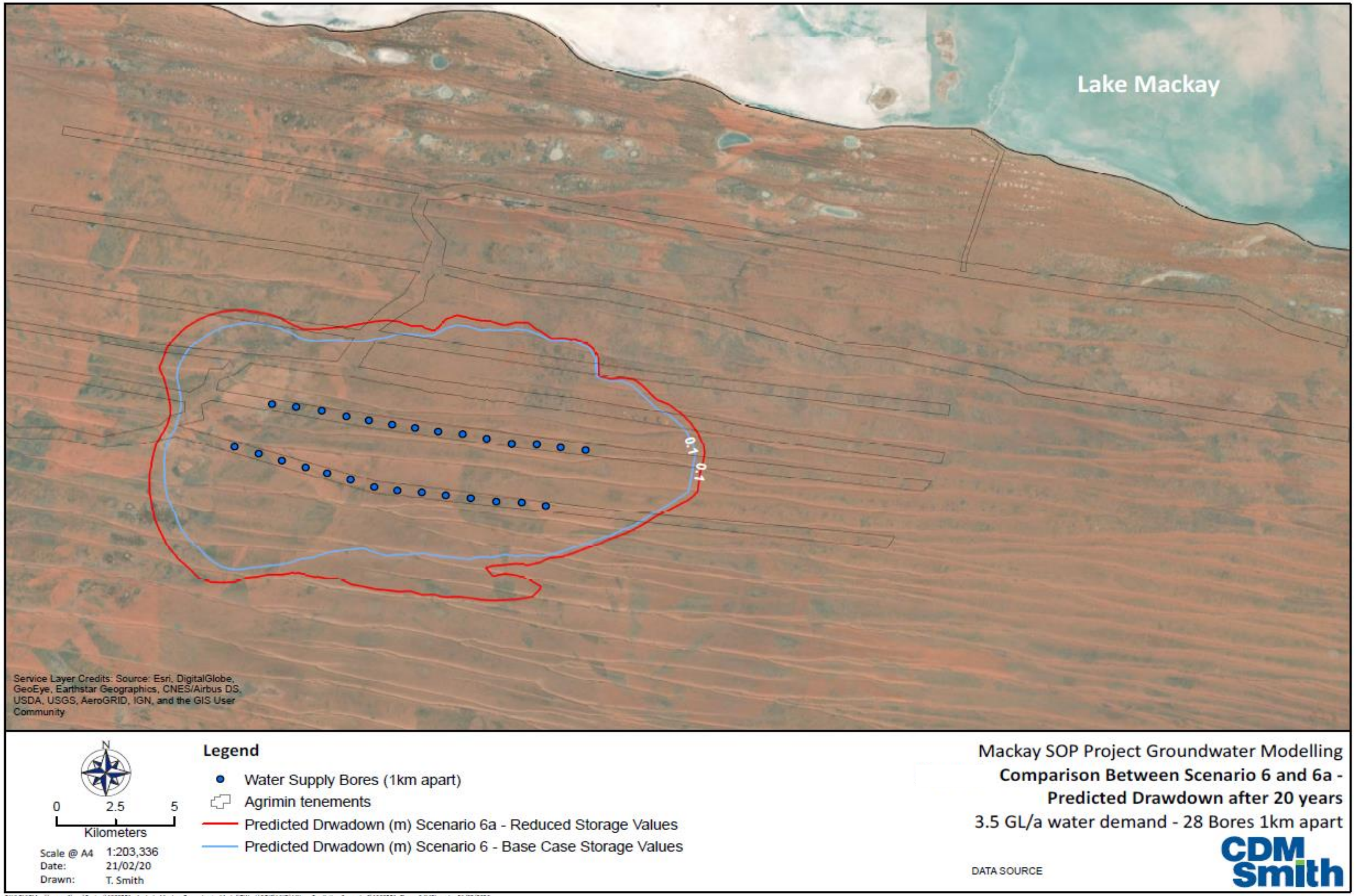

Figure 5-5 PRED06 – Drawdown comparison between Base Case and Low-Storage Case after 20 years (3.5 GL/a)

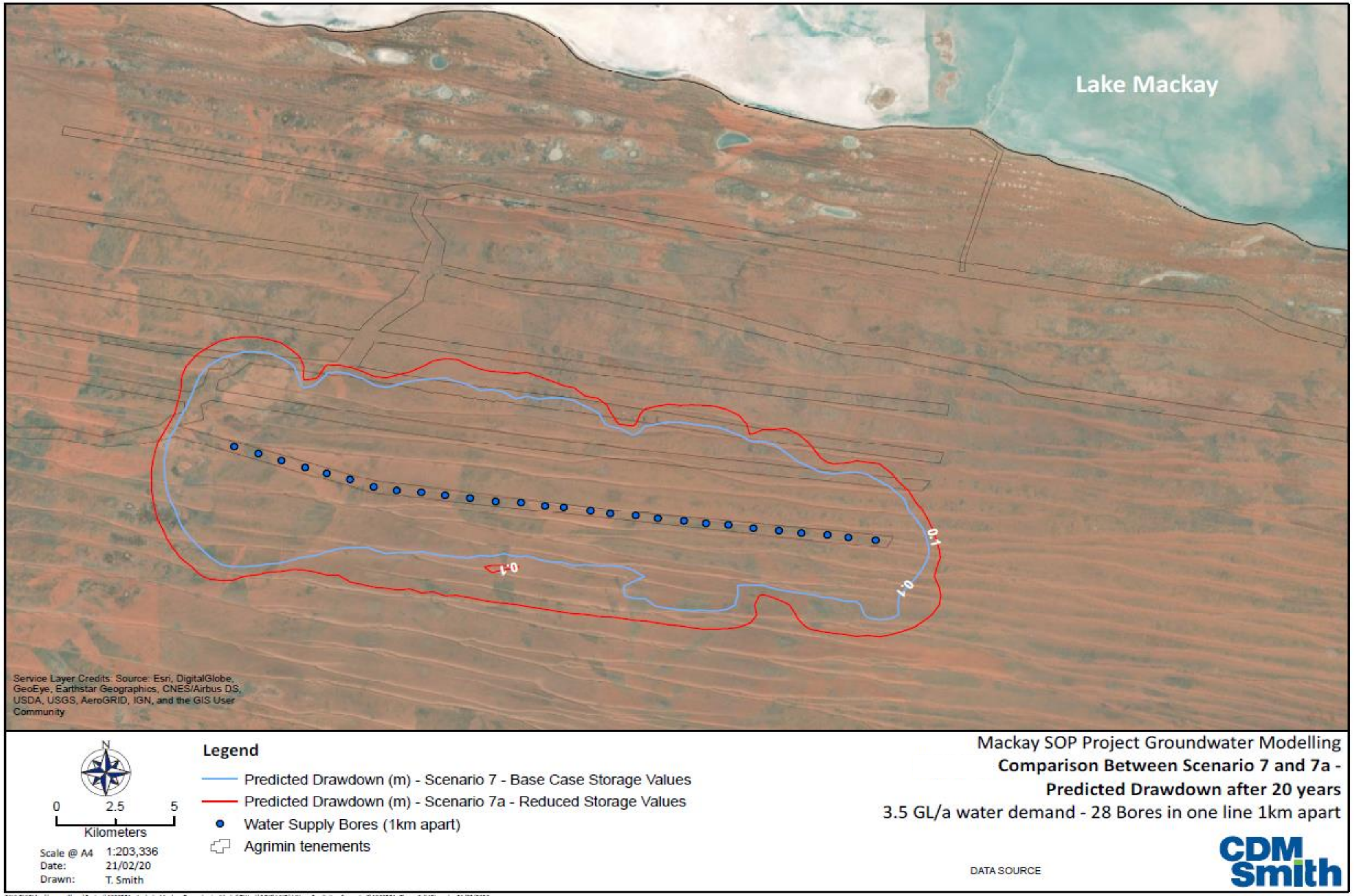

Figure 5-6 PRED07 – Drawdown comparison between Base Case and Low-Storage Case after 20 years (3.5 GL/a)

5.2 SENS02 – Sensitivity of Modelling of NMR Material Parameter Changes

As mentioned in the previous sections of this report, initial investigations in 2017 identified the area as a potential water source for the project's process water requirements. Agrimin in cooperation with the CSIRO commenced the "Southern Borefield Process Water Supply Investigation" in 2019 with the objective to gather geological information on potential aquifer units and obtain water quality samples.

The 2019 drilling program commenced on the 16th of September and was completed by the 21st of September. A total of 8 drill locations were planned (Figure 3), of the 8 planned holes, 4 were drilled (Table 1).

Borehole logging was completed by CSIRO using the Vista Clara Javelin NMR tool on five MWP bores, including two holes drilled in 2017, from the 24th to the 28th of February 2020. Logging was completed using a Javelin NMR system at 0.5 m stepped intervals with a recording time of 2 minutes. The probe had a coil length of 1 m and a total length of 2.2 m. Raw data was sent to Vista Clara PTY (USA) for processing and log generation. NMR results are presented in Table 5-4 below.

Comparison between modelled aquifer parameters and NMR results could be summarised as follows:

- Adopted horizontal hydraulic conductivity of the Surficial Deposits in the model was much higher compared to the NMR. Horizontal hydraulic conductivity in the model was between 1 to 5 m/d versus estimated 0.12 to 0.31 m/d (NMR).
- Adopted horizontal hydraulic conductivity of the Paleochannel Clay in the model was much lower compared to the NMR. Horizontal hydraulic conductivity in the model was between 0.001 to 0.01 m/d versus estimated 0.31 to 3.42 m/d (NMR).
- Adopted horizontal hydraulic conductivity of the Angas Hills Formation in the model was slightly higher compared to the NMR. Horizontal hydraulic conductivity in the model was between 0.1 and 1 m/d versus estimated 0.01 and 0.56 m/d (NMR).
- Adopted horizontal hydraulic conductivity of the Carnegie Formation and Pertatatka Formation in the model was relatively consistent to the NMR estimates. Horizontal hydraulic conductivity in the model was between 0.01 and 0.2 m/d versus estimated 0.01 and 0.03 m/d (NMR).
- Adopted unconfined storage of the Surficial Deposits in the model was higher compared to the NMR. Unconfined storage in the model was 15% versus estimated 9% (NMR).
- Adopted unconfined storage of the Paleochannel Clay in the model was much lower compared to the NMR. Unconfined storage in the model was 3% versus estimated 20% (NMR).
- Adopted unconfined storage of the Angas Hills Formation in the model was consistent compared to the NMR. Unconfined storage in the model was 10% versus estimated 7 to 11% (NMR).
- Adopted unconfined storage of the Carnegie Formation and Pertatatka Formation in the model was higher compared to the NMR estimates. Unconfined storage in the model was 10% versus estimated 3-4% (NMR).

Table 5-4 NMR Results

Model Layer	Zone	Estimated		NMR Derived Values																	
				MWP11						MWP12						MWP13					
		Kh [m/day]	Kv [m/day]	Kh [m/day] (SOE)			Sy (freef)			Kh [m/day] (SOE)			Sy (freef)			Kh [m/day] (SOE)			Sy (freef)		
				min	max	Ave	min	max	Ave	min	max	Ave	min	max	Ave	min	max	Ave	min	max	Ave
1 - Surficial Deposits	Zone 1 - Lake deposits	5	0.5																		
	Zone 2 - Sand, calcrete and silcrete	2	0.2																		
	Zone 3 - Sand, calcrete and silcrete	1	0.1	0.00	0.72	0.19	0.00	0.19	0.09	0.00	0.39	0.12	0.00	0.20	0.09	0.00	2.62	0.31	0.00	0.25	0.09
	Zone 4 - Alluvial sand	1	0.1																		
	Zone 5 - Alluvial sand	2	0.2																		
2 - Paleochannel Clay	Zone 6 - Clay	0.001	0.0001													0.73 0.31	3.42 3.42	2.52 1.69	0.14 0.09	0.30 0.30	0.25 0.19
	Zone 7 - Clay, mudstone and lower fine sand	0.01	0.0001													0.31	3.27	1.28	0.09	0.27	0.16
3 - Paleochannel Sand	Zone 8 - Fine to medium sand	3	0.01																		
4 - Angus Hills Formation	Zone 9 - Fluvial sand	1	0.1							0.08	0.50	0.33	0.08	0.17	0.15						
	Zone 10 - Fluvial sand, gravel and conglomerate, mostley c	1	0.1	0.02	0.22	0.10	0.03	0.10	0.07	0.01 0.01	0.26 0.56	0.08 0.17	0.01 0.01	0.22 0.22	0.09 0.11						
	Zone 11 - Fluvial sand, mostly fine	0.1	0.01							0.04	0.56	0.20	0.06	0.22	0.12						
5 - Carnegie Formation, Pertatatka Formation and basement	Zone 12 - Clay, siltstone and some sandstone	0.01	0.0001																		
	Zone 13 - Sand, sandstone and clay	0.1	0.001																		
	Zone 14 - Sand and sandstone	0.05	0.001	0.00	0.07	0.01	0.00	0.09	0.04	0.00	0.04	0.01	0.00	0.06	0.03						
	Zone 15 - Sandstone	0.05	0.01																		
	Zone 16 - Possibly sand and sandstone	0.2	0.001																		
	Zone 17 - Weathered bedrock and granitic basement	Inactive	Inactive																		

Based on the results of the NMR the following sensitivity model runs have been tested:

Table 5-5 Summary of SENS02 runs

		Surficial Aquifer		Lower Aquifer		Number of bores	Bore spacing [km]	Production Lines [southern, northern or both	Target water demand achieved [Yes/No]
Run no.*	Derived Run*	Adopted K values	Adopted Sy values	Adopted K values	Adopted Sy values				
PT06		Base Case	NMR	Base Case	NMR	28	1	southern	Yes
PT07	PT07	NMR	Base Case	NMR	Base Case	28	1	southern	No
	PT09	NMR	Base Case	NMR	Base Case	28	1	both	No
	PT10	NMR	Base Case	NMR	Base Case	28	2	both	No
	PT11	Base Case	Base Case	NMR	Base Case	28	1	southern	3% reduction
	PT12	NMR	Base Case	Base Case	Base Case	28	1	southern	No
PT08		NMR	NMR	NMR	NMR	28	1	southern	No

* *Numbering references of the SENS02 runs are internal CDM Smith's references which are linked to the actual model runs*

Based on discussions with Agrimin, NMR parameters were only tested on the PRED07 base case model setup which involves 28 production bores, 1 km apart installed in one line (southern-most line).

Detailed model setups and results of model runs PT06 – PT012 are presented in the following sections but it was evident that whenever estimated NMR values of hydraulic conductivity were adopted for the Surficial Aquifer units the model failed to achieve target water demand. Estimated K and Sy NMR values are lower compared to the values adopted in the base case model. Also, in order to produce the "worst case" scenario, where K or Sy values in the base case model were lower compared to the NMR values, lower values were used.

In summary, when vertical hydraulic conductivity (Kv) of the Surficial Aquifer is reduced the interconnection between the deep and shallow aquifers 'ceases' and groundwater stored in the shallow aquifer cannot contribute to the water supply pumping in the deep aquifer. Simulated aquifers in model runs PT07 – PT12 were struggling to exchange water vertically. Also, potential of the applied rainfall recharge to reach the deep aquifer units was significantly reduced and combined with the lower Kv was causing parts of the deep aquifer to become unsaturated or even become dry (as shown in Figure 5-8). For that reason vertical hydraulic conductivity of the Surficial Aquifer could be designated as the most sensitive parameter in the model and future hydrogeological investigations must be designed to look into this parameter in more detail.

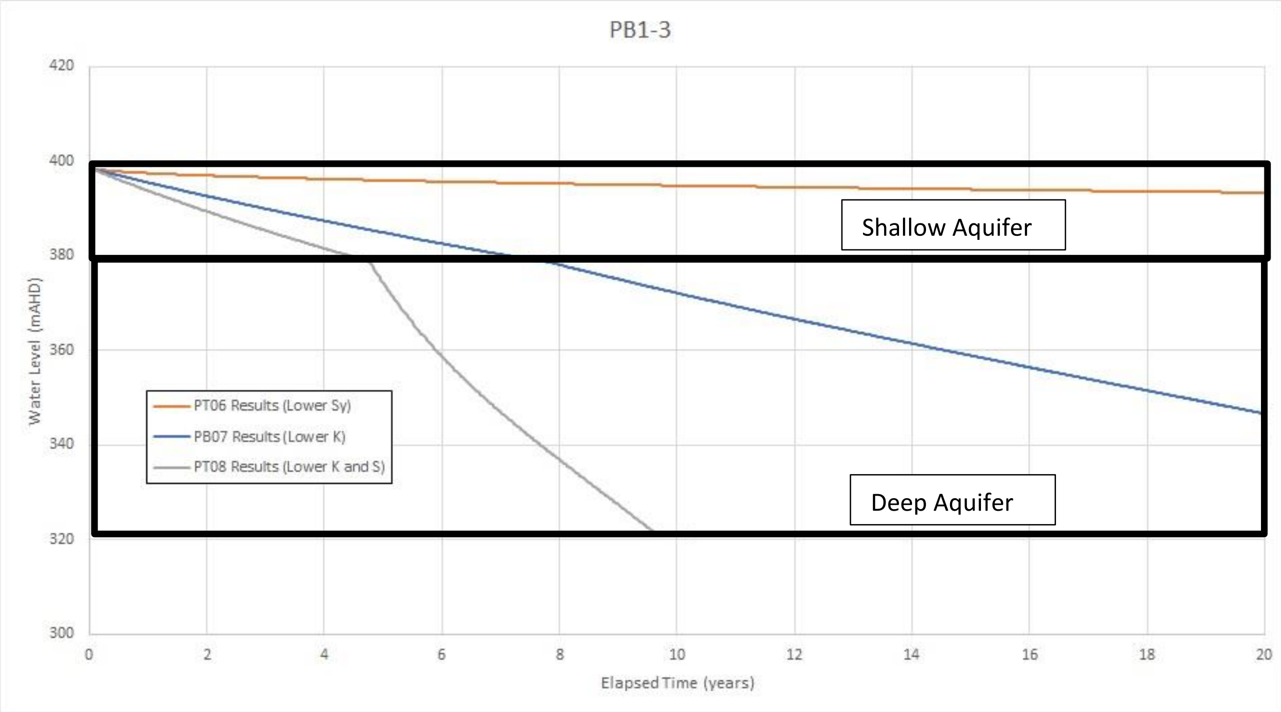

Figure 5-7 Estimate of groundwater level drawdown PT06, PT07 and PT08 modelling results

5.2.1 SENS02 – PT06 Model Setup and Results

Summary of the adopted parameter values in the PT06 model are shown in

Table 5-6. Unconfined aquifer storage of the Surficial Deposits was reduced from 15% to 9%, unconfined aquifer storage of the Angas Hills Formation was reduced from 10% to 1% and unconfined aquifer storage of the Carnegie and Pertatatka Formations was reduced from 10% to 3%.

Table 5-6 PT06 Model Parameters

		Base Case Model			PT06 Model		
Model Layer	**Zone**	**Kh [m/day]**	**Kv [m/day]**	**Sy**	**Kh [m/day]**	**Kv [m/day]**	**Sy**
1 - Surficial Deposits	Zone 1 - Lake deposits	5	0.5	0.15	5	0.5	0.09
	Zone 2 - Sand, calcrete and silcrete	2	0.2	0.15	2	0.2	0.09
	Zone 3 - Sand, calcrete and silcrete	1	0.1	0.15	1	0.1	0.09
	Zone 4 - Alluvial sand	1	0.1	0.15	1	0.1	0.09
	Zone 5 - Alluvial sand	2	0.2	0.15	2	0.2	0.09
2 - Paleochannel Clay	Zone 6 - Clay	0.001	0.0001	0.03	0.001	0.0001	0.03
	Zone 7 - Clay, mudstone and lower fine sand	0.01	0.0001	0.03	0.01	0.0001	0.03
3 - Paleochannel Sand	Zone 8 - Fine to medium sand	3	0.01	0.1	3	0.01	0.1
4 - Angus Hills Formation	Zone 9 - Fluvial sand	1	0.1	0.1	1	0.1	0.01
	Zone 10 - Fluvial sand, gravel and conglomerate, mostley c	1	0.1	0.1	1	0.1	0.01
	Zone 11 - Fluvial sand, mostly fine	0.1	0.01	0.1	0.1	0.01	0.01
5 - Carnegie Formation, Pertatatka Formation and basement	Zone 12 - Clay, siltstone and some sandstone	0.01	0.0001	0.1	0.01	0.0001	0.03
	Zone 13 - Sand, sandstone and clay	0.1	0.001	0.1	0.1	0.001	0.03
	Zone 14 - Sand and sandstone	0.05	0.001	0.1	0.05	0.001	0.03
	Zone 15 - Sandstone	0.05	0.01	0.1	0.05	0.01	0.03
	Zone 16 - Possibly sand and sandstone	0.2	0.001	0.1	0.2	0.001	0.03
	Zone 17 - Weathered bedrock and granitic basement	Inactive			Inactive		

The results suggest that even with the reduced aquifer storage, the target water demand of 3.5 GL/a could be achieved. The results suggest that even with the reduced aquifer storage the sheer volume of the aquifer units combined with inflow from the rainfall recharge would enable the proposed borefield to meet the target water demand.

5.2.2 SENS02 – PT07 Model Setup and Results

Table 5-7 lists the adopted parameter values for the PT07 model. Horizontal hydraulic conductivity of the Surficial Deposits was reduced to 0.12 m/d, hydraulic conductivity of the Angas Hills Formation was reduced to 0.01 m/d and hydraulic conductivity of the Carnegie and Pertatatka Formations was reduced to 0.01 m/d.

Table 5-7 PT07 Model Parameters

		Base Case Model			PT07 Model		
Model Layer	**Zone**	**Kh [m/day]**	**Kv [m/day]**	**Sy**	**Kh [m/day]**	**Kv [m/day]**	**Sy**
1 - Surficial Deposits	Zone 1 - Lake deposits	5	0.5	0.15	0.12	0.012	0.15
	Zone 2 - Sand, calcrete and silcrete	4	0.4	0.15	0.12	0.012	0.15
	Zone 3 - Sand, calcrete and silcrete	1	0.1	0.15	0.12	0.012	0.15
	Zone 4 - Alluvial sand	1	0.1	0.15	0.12	0.012	0.15
	Zone 5 - Alluvial sand	2	0.2	0.15	0.12	0.012	0.15
2 - Paleochannel Clay	Zone 6 - Clay	0.001	0.0001	0.03	0.001	0.0001	0.03
	Zone 7 - Clay, mudstone and lower fine sand	0.01	0.0001	0.03	0.01	0.0001	0.03
3 - Paleochannel Sand	Zone 8 - Fine to medium sand	3	0.01	0.1	3	0.01	0.1
4 - Angus Hills Formation	Zone 9 - Fluvial sand	1	0.1	0.1	0.01	0.001	0.10
	Zone 10 - Fluvial sand, gravel and conglomerate, mostley c	1	0.1	0.1	0.01	0.001	0.10
	Zone 11 - Fluvial sand, mostly fine	0.1	0.01	0.1	0.01	0.001	0.10
5 - Carnegie Formation, Pertatatka Formation and basement	Zone 12 - Clay, siltstone and some sandstone	0.01	0.0001	0.1	0.01	0.0001	0.10
	Zone 13 - Sand, sandstone and clay	0.1	0.001	0.1	0.01	0.0001	0.10
	Zone 14 - Sand and sandstone	0.05	0.001	0.1	0.01	0.001	0.10
	Zone 15 - Sandstone	0.05	0.01	0.1	0.01	0.001	0.10
	Zone 16 - Possibly sand and sandstone	0.2	0.001	0.1	0.01	0.001	0.10
	Zone 17 - Weathered bedrock and granitic basement	Inactive			Inactive		

When estimated NMR values of hydraulic conductivity were adopted the model failed to achieve the target water demand of 3.5 GL/year (Figure 5-8). Total predicted borefield abstraction reduced to approximately 2.1 GL/year (Figure 5-8).

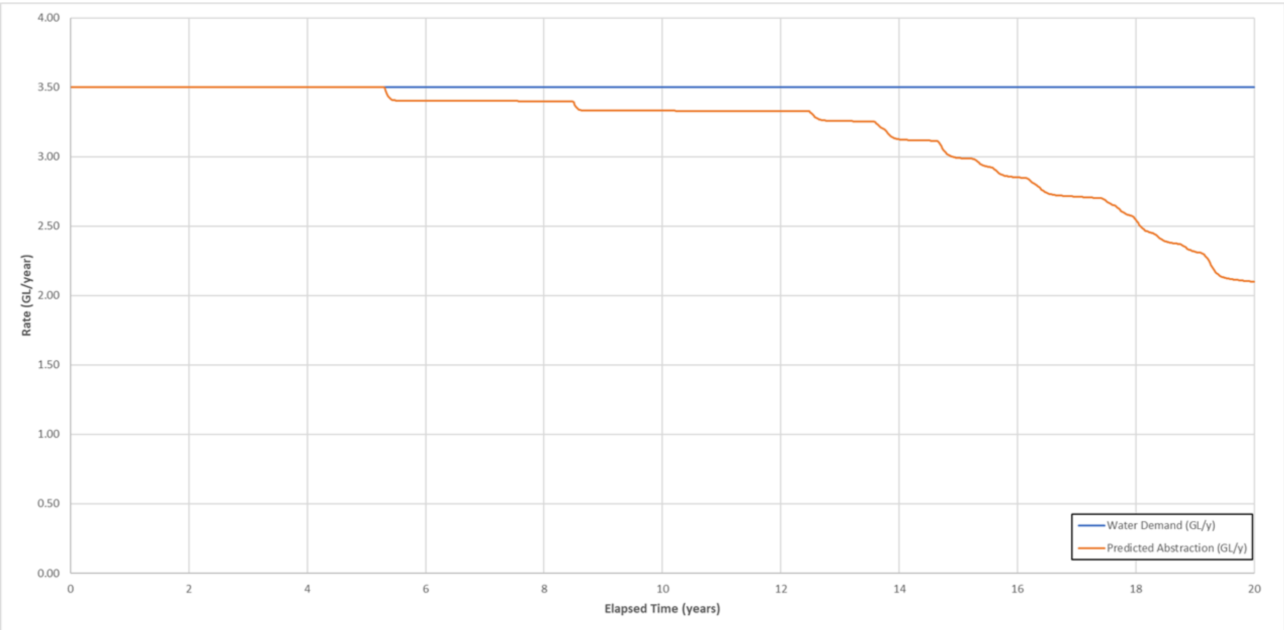

Figure 5-8 Estimated abstraction over life-of-mine - SENS02 – PT07 run

Following the PT07 model run, runs PT09 and PT10 investigated if the target water demand could be achieved if bores were placed in two lines or if the spacing between bores was increased from 1 to 2 km. Setup of model runs PT09 and PT10 is summarised below:

- PT09 model parameters are consistent with the PT07 run (Table 5-7). Difference between PT07 and PT09 model runs is that water supply bores in PT09 run were placed in two lines (southern and northern line), 1 km apart.
- In the PT10 run bore spacing was further increased from 1 to 2 km. PT10 model parameters are consistent with the PT07 run (Table 5-7). Difference between PT07 and PT10 model runs is that water supply bores in PT10 run were placed in two lines (southern and northern line), 2 km apart.

Both runs, PT09 and PT10 failed to achieve the target water demand of 3.5 GL/a over the life of mine. In run PT09 total predicted borefield abstraction reduced to below 3.5 GL/a after 3.5 years of pumping down to 2.3 GL/year after 20 years (Figure 5-9. In run PT10 total predicted borefield abstraction falls below the target water demand after 5 years of pumping and reduces further to 2.7 GL/year after 20 years (Figure 5-9).

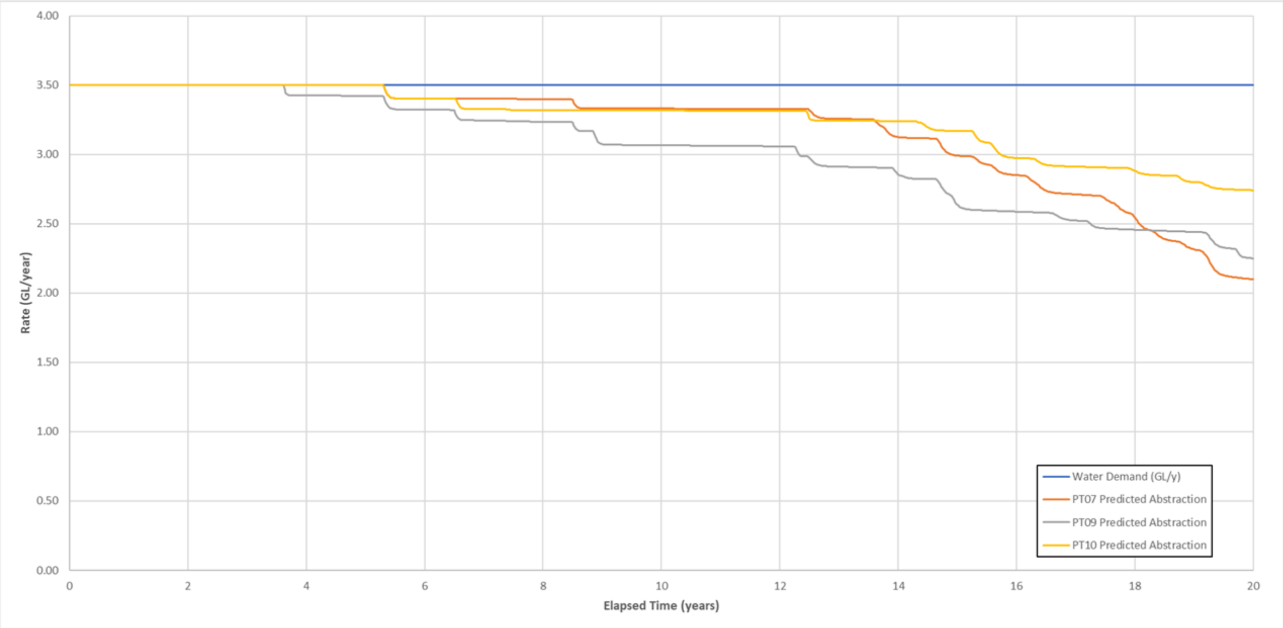

Figure 5-9 Estimated abstraction over life-of-mine - SENS02 – PT09 and PT10 runs

5.2.3 SENS02 – PT11 and PT12 Model Setup and Results

Following the PT07 model run, PT11 and PT12 model run were designed to test which aquifer units (shallow or deep) were most sensitive to the adopted lower hydraulic conductivity values. In run PT11 lower (NMR) hydraulic conductivity values were only adopted for Angas Hills, Carnegie and Pertatatka Formations (Table 5-8), whereas for model run PT12 the deep aquifer units were set to base case values and lower hydraulic conductivity values (NMR values) were applied to the shallow aquifer units (Table 5-9).

Table 5-8 PT11 Model Parameters

Model Layer	Zone	Base Case Model Kh [m/day]	Base Case Model Kv [m/day]	Base Case Model Sy	PT11 Model Kh [m/day]	PT11 Model Kv [m/day]	PT11 Model Sy
1 - Surficial Deposits	Zone 1 - Lake deposits	5	0.5	0.15	5.00	0.5	0.15
	Zone 2 - Sand, calcrete and silcrete	4	0.4	0.15	4.00	0.4	0.15
	Zone 3 - Sand, calcrete and silcrete	1	0.1	0.15	1.00	0.1	0.15
	Zone 4 - Alluvial sand	1	0.1	0.15	1.00	0.1	0.15
	Zone 5 - Alluvial sand	2	0.2	0.15	2.00	0.2	0.15
2 - Paleochannel Clay	Zone 6 - Clay	0.001	0.0001	0.03	0.001	0.0001	0.03
	Zone 7 - Clay, mudstone and lower fine sand	0.01	0.0001	0.03	0.01	0.0001	0.03
3 - Paleochannel Sand	Zone 8 - Fine to medium sand	3	0.01	0.1	3	0.01	0.1
4 - Angus Hills Formation	Zone 9 - Fluvial sand	1	0.1	0.1	0.01	0.001	0.10
	Zone 10 - Fluvial sand, gravel and conglomerate, mostley c	1	0.1	0.1	0.01	0.001	0.10
	Zone 11 - Fluvial sand, mostly fine	0.1	0.01	0.1	0.01	0.001	0.10
5 - Carnegie Formation, Pertatatka Formation and basement	Zone 12 - Clay, siltstone and some sandstone	0.01	0.0001	0.1	0.01	0.0001	0.10
	Zone 13 - Sand, sandstone and clay	0.1	0.001	0.1	0.01	0.0001	0.10
	Zone 14 - Sand and sandstone	0.05	0.001	0.1	0.01	0.001	0.10
	Zone 15 - Sandstone	0.05	0.01	0.1	0.01	0.001	0.10
	Zone 16 - Possibly sand and sandstone	0.2	0.001	0.1	0.01	0.001	0.10
	Zone 17 - Weathered bedrock and granitic basement	Inactive			Inactive		

Table 5-9 PT12 Model Parameters

Model Layer	Zone	Base Case Model Kh [m/day]	Base Case Model Kv [m/day]	Base Case Model Sy	PT12 Model Kh [m/day]	PT12 Model Kv [m/day]	PT12 Model Sy
1 - Surficial Deposits	Zone 1 - Lake deposits	5	0.5	0.15	0.12	0.012	0.15
	Zone 2 - Sand, calcrete and silcrete	4	0.4	0.15	0.12	0.012	0.15
	Zone 3 - Sand, calcrete and silcrete	1	0.1	0.15	0.12	0.012	0.15
	Zone 4 - Alluvial sand	1	0.1	0.15	0.12	0.012	0.15
	Zone 5 - Alluvial sand	2	0.2	0.15	0.12	0.012	0.15
2 - Paleochannel Clay	Zone 6 - Clay	0.001	0.0001	0.03	0.001	0.0001	0.03
	Zone 7 - Clay, mudstone and lower fine sand	0.01	0.0001	0.03	0.01	0.0001	0.03
3 - Paleochannel Sand	Zone 8 - Fine to medium sand	3	0.01	0.1	3	0.01	0.1
4 - Angus Hills Formation	Zone 9 - Fluvial sand	1	0.1	0.1	1.00	0.10	0.10
	Zone 10 - Fluvial sand, gravel and conglomerate, mostley c	1	0.1	0.1	1.00	0.10	0.10
	Zone 11 - Fluvial sand, mostly fine	0.1	0.01	0.1	0.10	0.01	0.10
5 - Carnegie Formation, Pertatatka Formation and basement	Zone 12 - Clay, siltstone and some sandstone	0.01	0.0001	0.1	0.01	0.0001	0.10
	Zone 13 - Sand, sandstone and clay	0.1	0.001	0.1	0.1	0.001	0.10
	Zone 14 - Sand and sandstone	0.05	0.001	0.1	0.05	0.001	0.10
	Zone 15 - Sandstone	0.05	0.01	0.1	0.05	0.01	0.10
	Zone 16 - Possibly sand and sandstone	0.2	0.001	0.1	0.2	0.001	0.10
	Zone 17 - Weathered bedrock and granitic basement	Inactive			Inactive		

The borefield setup for both, PT11 and PT12, was consistent with the PT07 model and comprise 28 bores in southern-most line (one line) 1 km apart.

The impact of reduced hydraulic conductivity of deep aquifers on borefield pumping was minimal. Although modelling suggest that the water demand of 3.5 GL/year cannot fully be achieved with the proposed borefield setup, the abstraction was estimated to drop by less than 3% (Figure 5-10) over the life-of-mine.

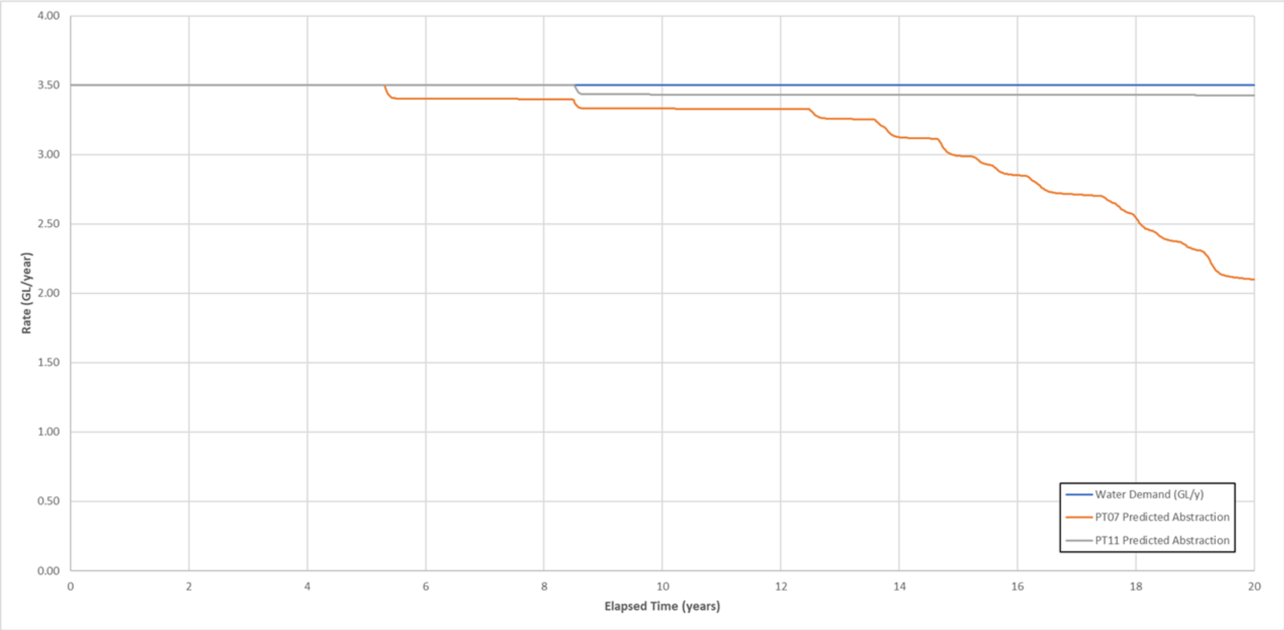

Figure 5-10 Estimated abstraction over life-of-mine - SENS02 – PT11 run

Model SENS02 – PT12 results suggest that the target water demand of 3.5 GL/year can't be achieved with the hydraulic conductivity values and the proposed borefield setup adopted for this model. Production rates reduce to below the target water demand after 8 years of pumping with rates continuously decreasing to 2.3 GL/year after 20 years of pumping (Figure 5-11).

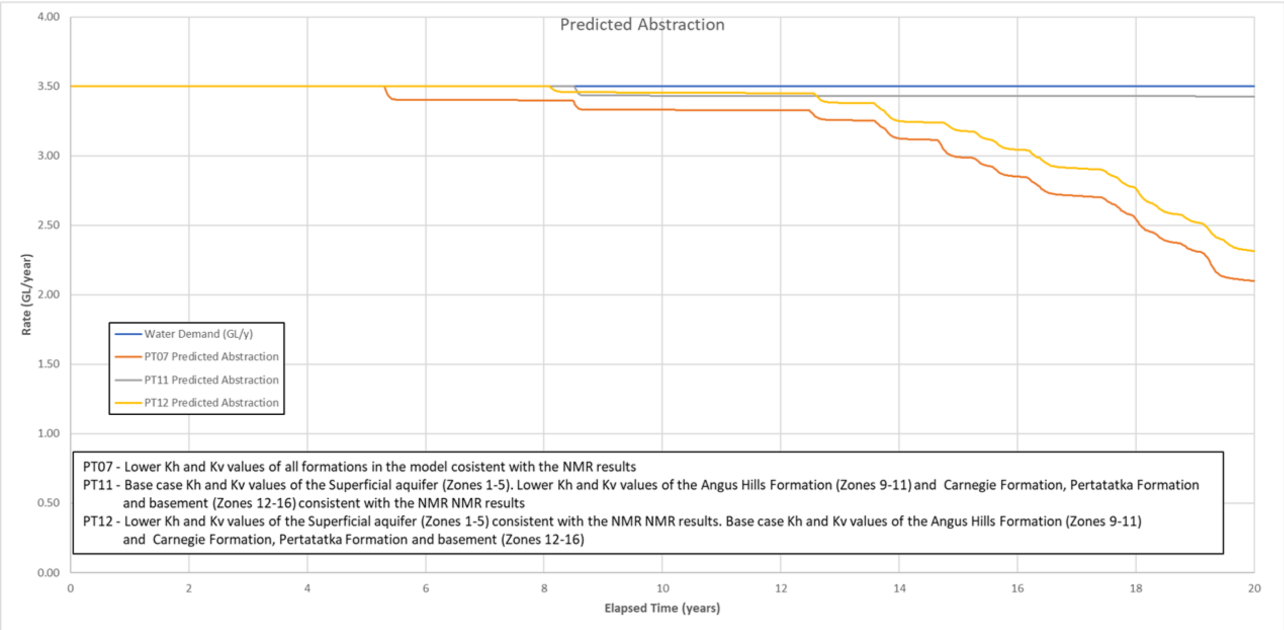

Figure 5-11 Estimated abstraction over life-of-mine - SENS02 – PT12 run

Results of the PT11 and PT12 runs clearly show that the model is most sensitive to changes in hydraulic conductivity values (namely vertical hydraulic conductivity) of the Surficial Deposits.

The Surficial Deposits comprise five hydrostratigraphic units:

Zone 1 - Lake deposits
Zone 2 - Sand, calcrete and silcrete
Zone 3 - Sand, calcrete and silcrete
Zone 4 - Alluvial sand and
Zone 5 - Alluvial sand

Further testing aims to identify the Surficial Aquifer zones having the most effect of bore production rates when lowering its hydraulic conductivity. Although all five zones being less conductive provides the "worst case" scenario, results show that reducing the hydraulic conductivity of the Alluvial sands (Zones 4 and 5) in the immediate borefield area is producing the largest impact (Figure 5-12) on production rates over time. Reducing the hydraulic conductivity of the Zone 3 - Sand, calcrete and silcrete to the south has a notable although less significant impact on production rates. Since throughflow is coming from the south towards the lake, reducing hydraulic conductivity of this zone results in less water available in the immediate borefield area. Zone 1 - Lake deposits and Zone 2 - Sand, calcrete and silcrete on the downgradient side of the proposed borefield to the north have very little impact on the borefield production rates.

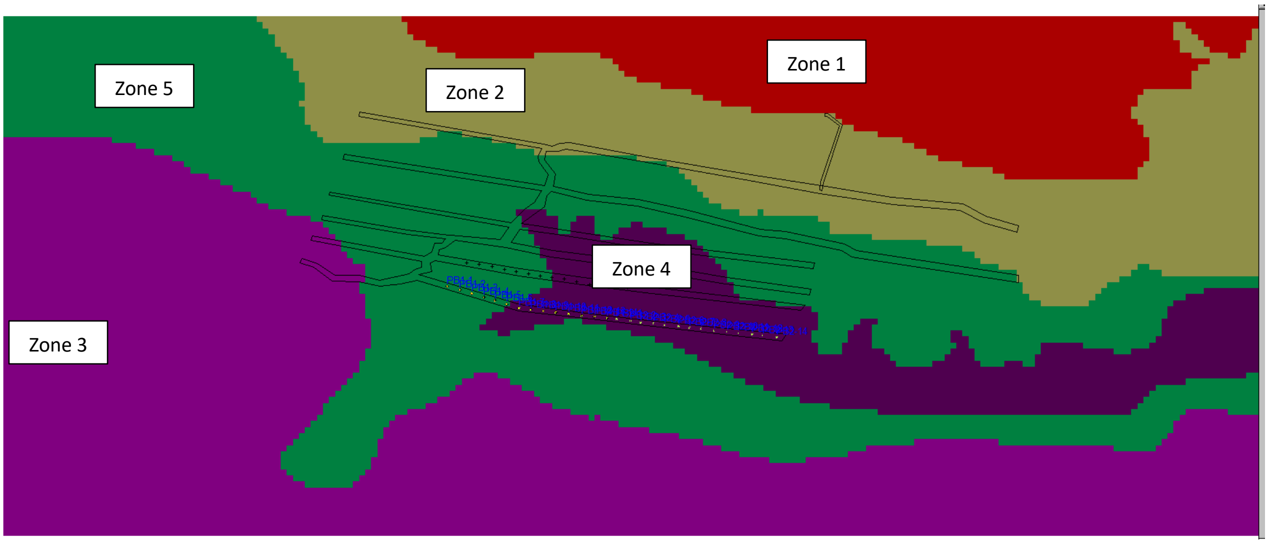

Figure 5-12 Shallow aquifer units

5.2.4 SENS02 – PT08 Model Setup and Results

PT08 combines lower NMR estimates of hydraulic conductivity and unconfined aquifer storage. It could be described as the "worst case" scenario. Adopted parameters for the PT08 model run are presented in Table 5-10.

Table 5-10 PT08 Model Parameters

Model Layer	Zone	Base Case Model			PT08 Model		
		Kh [m/day]	Kv [m/day]	Sy	Kh [m/day]	Kv [m/day]	Sy
1 - Surficial Deposits	Zone 1 - Lake deposits	5	0.5	0.15	0.12	0.012	0.09
	Zone 2 - Sand, calcrete and silcrete	2	0.2	0.15	0.12	0.012	0.09
	Zone 3 - Sand, calcrete and silcrete	1	0.1	0.15	0.12	0.012	0.09
	Zone 4 - Alluvial sand	1	0.1	0.15	0.12	0.012	0.09
	Zone 5 - Alluvial sand	2	0.2	0.15	0.12	0.012	0.09
2 - Paleochannel Clay	Zone 6 - Clay	0.001	0.0001	0.03	0.001	0.0001	0.03
	Zone 7 - Clay, mudstone and lower fine sand	0.01	0.0001	0.03	0.01	0.0001	0.03
3 - Paleochannel Sand	Zone 8 - Fine to medium sand	3	0.01	0.1	3	0.01	0.1
4 - Angus Hills Formation	Zone 9 - Fluvial sand	1	0.1	0.1	0.01	0.001	0.01
	Zone 10 - Fluvial sand, gravel and conglomerate, mostley c	1	0.1	0.1	0.01	0.001	0.01
	Zone 11 - Fluvial sand, mostly fine	0.1	0.01	0.1	0.01	0.001	0.01
5 - Carnegie Formation, Pertatatka Formation and basement	Zone 12 - Clay, siltstone and some sandstone	0.01	0.0001	0.1	0.01	0.0001	0.03
	Zone 13 - Sand, sandstone and clay	0.1	0.001	0.1	0.01	0.0001	0.03
	Zone 14 - Sand and sandstone	0.05	0.001	0.1	0.01	0.001	0.03
	Zone 15 - Sandstone	0.05	0.01	0.1	0.01	0.001	0.03
	Zone 16 - Possibly sand and sandstone	0.2	0.001	0.1	0.01	0.001	0.03
	Zone 17 - Weathered bedrock and granitic basement	Inactive			Inactive		

Results of the PT08 model run are presented in Figure 5-13. Water demand of 3.5 GL/year could not be achieved with the proposed borefield setup. Borefield yield was estimated to reduce below the water demand after 1.5 years of production and continues to decline to 1.3 GL/year after 20 years of pumping (Figure 5-13)

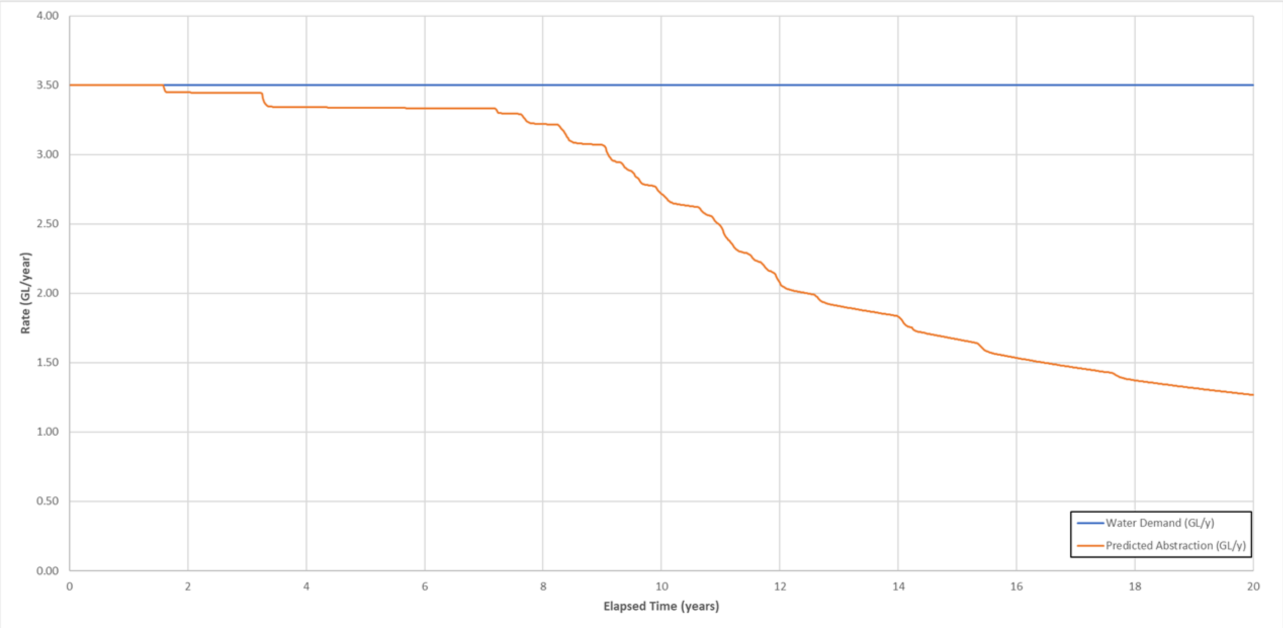

Figure 5-13 Estimated abstraction over life-of-mine - SENS02 – PT08 run

5.3 SENS03 – Sensitivity of the Conceptual Features in the Model

Following the results of the SENS02 – PT06 model, where hydraulic conductivity of modelled deep and shallow aquifer units was set to base case values but lower (NMR) values of the unconfined storage Sy was adopted, and which despite that managed to achieve the target water demand of 3.5 GL/a, conceptual features in the model were tested in an attempt to estimate if the target water demand in the PT06 run was partially sourced from the lake, simulated as the constant head boundary in the model. When borefield pumping is in full swing and gradients are reversed, the constant head boundary associated with the lake could potentially switch from being an outflow mechanism in the model to providing inflow to the Surficial Aquifer units (run PT13).

In the PT13 model run the constant head boundary (CHB) associated with Lake Mackay was replaced with the boundary of the Modflow Drain (DRN) package. The drain boundary (DRN) can only provide outflow from the model and if the groundwater levels drop below the drain elevation it cannot provide inflow, unlike the CHB which would become an inflow mechanism in that case. Drain elevations were set consistent with the CHB set to 370 mAHD. Drain conductances were set sufficiently high (1,000 m^2/d) so the only resistance to flow between the drain and the aquifer is related to the adopted hydraulic conductivity of the lake deposits.

Results of the PT13 run show no impact on predicted pumping. The results suggest that target water demand of 3.5 GL/year could be fully achieved with this setup and that the CHB associated with the lake had no impact on estimated water supply in run PT06 even with the reduced storage. Either the volume of water stored in the aquifer units enabled the proposed borefield to meet the target water demand or inflow from the rainfall recharge was providing (too much) inflow substituting for the reduction in storage.

Next sensitivity run (PT14 model run) was designed to test if the target water demand was partially sourced from the rainfall recharge and if the applied rainfall recharge was too high substituting for the reduced storage values. In the PT14 run rainfall recharge was removed from the model (recharge set to zero).

Results of the PT14 run show no impact on predicted pumping. Water demand of 3.5 GL/year was fully met even with no recharge in the model. The conclusion is that even with the reduced aquifer storage the volume of water stored in the aquifer units would enable the proposed borefield setup to meet the target water demand of 3.5 GL/a over the life of mine (20 years).

Both PT13 and PT14 models are having the same aquifer parameters (hydraulic conductivity and aquifer storage) as the PT06 run presented in

Table 5-6.

Section 6 Summary and Recommendations

A numerical groundwater model has been developed in support of the water supply assessment for the Mackay SOP Project. The model development follows the recommendations of the Australian Groundwater Modelling Guidelines (modelling guidelines) (Barnett et al. 2012).

This report presents a full record of the model development and predictive simulations conducted using the model, including descriptions of the model construction and calibration, predictive simulations and results, and predictive sensitivity analysis.

The purpose of the modelling is to simulate water supply options for the project that meet a lower demand of 0.7GL/a for a SOPM production case and 3.5GL/a for a SOP production case.

The groundwater model is developed in the FEFLOW™ finite element simulation system and Modflow-Surfact, finite difference approach, to represent the hydrogeological conceptualisation developed outside of this study. From shallowest to deepest geological units, the model represents the hydrostratigraphy of the Surficial Deposits, Paleochannel Clay, Paleochannel Sand, Angas Hills Formation, Carnegie Formation, Pertatatka Formation and basement to a depth of 20m below the top surface of the basal units.

Model boundary conditions are assigned to represent groundwater recharge, evapotranspiration, groundwater extraction from selected production bores and groundwater interactions with surface drainage such as Lake Mackay.

The major limitation of this model is that the model is only calibrated to available groundwater level records from groundwater monitoring bores within in the steady state mode. Due to lack of long-term monitoring and abstraction records robust transient model calibration could not be granted at this stage.

The steady state calibration represents average conditions in around August and October 2019 and provides high level estimates of the aquifer hydraulic conductivities and the initial condition for the predictive simulations.

The modelling is fully conservative with respect to adopted boundary conditions and assumes no flow boundary conditions on the perimeter of the model domain.

The results of the modelling are presented as maps and charts of predicted abstraction versus water demand. The model estimated that even if the proposed borefield is installed in one line (28 bores in southern-most line), 1km apart, the water demand of 3.5GL/y would be achieved over the life of mine.

The predictive sensitivity analysis for the modelling explores the possibility of predicting an undesirable outcome in terms of potential to supply target water demand. An undesirable outcome is defined as estimated abstraction being less than the projected water demand.

Key conclusions of the sensitivity analysis include:

- The largest introduced uncertainty in the assessment is the estimated or adopted horizontal and vertical conductivity of the Surficial Deposits, which are assessed outside of the groundwater modelling as part of the NMR;
- Built-in conservatism of the groundwater modelling includes no other sources of inflow outside of the model domain (all boundaries were considered as no-flow boundaries).

To address one of the major limitations of this model the following recommendations could be made:

- On-going groundwater level and quality monitoring is recommended. It should continue for a longer duration to understand seasonal fluctuations, if any. This will provide further baseline data for ongoing environmental and aquifer monitoring, as well as allow a more robust validation and update of the numerical model. Monitoring bores have to be equipped with water level loggers. Long term groundwater level and groundwater quality data would be used to support transient model calibration. Long term measured water level fluctuations would provide a database for assessment of the rainfall recharge to shallow and deep aquifer units within the proposed borefield area.

- Test pumping is required to adequately assess safe bore yield, sustainable borefield yields and potential long-term impacts of the proposed abstraction to the aquifer and environment. It will also allow assessment of water availability for the proposed development. The aquifer testing program should take place within the proposed borefield area. The test should comprise a step-rate test (comprising nominally five 100-minute steps), followed by a constant-rate test of 1 to 10 days duration or until equilibrium is reached, and a recovery test. The purpose of test pumping is to provide quantitative information on the hydraulic efficiency of the production bores, aquifer parameters and the hydraulic relationship between the shallow and deep paleochannel aquifers and the adjacent boundary conditions. The test should separately assess shallow and deep aquifers and their connections. The results of the pumping test along with the long-term water level and water quality data would complete the requirements for transient model calibration, improve model reliability and reduce uncertainties in the model.

  Pumping test design is subject to further discussion but in general should comprise four abstraction and six monitoring bores. Two proposed paleochannel bores should be designed to test the deep paleochannel aquifer (Angas Hills Formation) in isolation from the overlying sediments. For that assessment we are proposing bores PB1-5 and PB1-6 (refer Figure 4-16). Proposed bore designs are subject to further discussion but in general paleochannel bores should be installed by mud rotary and drilled to a diameter of 310mm. The bores should be then then constructed with 155mm, Class 12 uPVC and 316 Stainless Steel wire wrap casing with a 0.5mm aperture. Fine gravel pack is to be installed into the borehole across the screen section. A bentonite/grout seal is to be installed as an annular seal below the base of the overlying permeable sediments to prevent any potential vertical leakage. Bores have to be sealed at the surface to prevent any ponded water at the surface of vertical seepage along the bore casing.

  Same principal applies to the shallow aquifer bores. Other two bores should be designed to test the shallow aquifer (Surficial Deposits) in isolation from the deep aquifer. For that assessment we are proposing bores PB1-7 and PB1-8 (refer Figure 4-16 and Figure 4-17).

  Four production bores should be accompanied by nested piezometers separately monitoring deep and shallow aquifers. We are proposing six locations in total, two locations to the north, two locations to the south, one to the east and one to the west of the proposed abstraction bores. Two nested piezometers should be installed at each location, one monitoring deep and the other monitoring in the shallow aquifer.

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