GALILEE BASIN HYDROGEOLOGICAL MODEL

Milestone 3 Report

FOR

Geoscience Australia

BY

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Heritage Computing Pty Ltd

trading as

HydroSimulations

Project number: GSA001

Report: HC2015/030

Date: November 2015

DOCUMENT REGISTER

Revision	Description	Date	Comments
A	Milestone 1 Report	09 June 2015	Submitted to Geoscience Australia
B	Milestone 2 Report_v1	30 June 2015	Submitted to Geoscience Australia
C	Milestone 3 Report_v2	30 July 2015	Submitted to Geoscience Australia
D	Milestone 3 Report_v3	16 November 2015	After review by Geoscience Australia

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EXECUTIVE SUMMARY

Background

A numerical groundwater flow model of the Galilee Basin of Queensland, Australia has been developed in order to assess the cumulative impacts to groundwater of seven proposed coal mines as part of the Lake Eyre Basin Bioregional Assessment (BA). The seven mines include, from north to south, Hyde Park, China Stone, Carmichael, Kevin's Corner, Alpha, China First and South Galilee.

The Galilee Basin is composed of fluviatile sediment of Permian age, in which many thermal coal seam layers exist. The Galilee basin dips to the west following the regional stratigraphy, with coal seam layers sub-cropping near the eastern margin of the basin where the proposed coal mines are located. Overlying the Galilee Basin units is the Eromanga Basin, part of the Great Artesian Basin (GAB), an aquifer system of great regional significance. The Rewan Formation is a key siltstone layer which is considered to be the regional aquitard separating the GAB units hydrogeologically from those of the underlying Galilee Basin where it is present, and is conceptually expected to minimise any impacts to the GAB from depressurisation of the coal seam layers. The reader is directed to other BA documentation for a more detailed description of the regional (hydro)geology.

Model Set-up

The groundwater model covers the entire Galilee Basin area (approximately 300,000km^2) and was constructed from an existing uncalibrated groundwater model and datasets created by Geoscience Australia (GA). The updated model was run both in steady-state and transient mode using the finite volume code MODFLOW-USG using an unstructured Voronoi mesh created using AlgoMesh software. The use of an unstructured grid allowed for model refinement around mines, rivers and springs (minimum cell size 150m diameter), while regional cells were able to be substantially larger (maximum 10km diameter) enabling adequate representation of important features while maintaining manageable computational demand. Square cell geometry was used to represent underground longwall panels, with two cells per panel width sized and aligned with mining orientation for each individual longwall.

The model consists of 13 layers, of which the upper 8 are alternating aquifer/aquitard layers of the GAB and upper Galilee Basin, the most important aquifers being the unconfined Winton Formation, and the confined Hooray, Hutton and Clematis Sandstones. The Rewan Formation is model layer 9. The following three layers include the coal seam and interburden layers, and were divided by GA based on observed hydraulic head gradients. The three coal measures sections have been labelled BC1 (Top of Bandanna Formation to Base B Seam), BC2 (Base B Seam to Top E Seam) and BC3 (Base E Seam to Base Colinlea Sandstone). The model basement includes the Joe Joe formation in the central/eastern portion of the model, the Drummond Basin to the far east and crystalline basement to the west.

The transient model ran with annual stress periods for the calibration period (1983 – 2012), and then in periods ranging from one to five year length depending on mine schedule data, such that model stress periods always coincided with the planned start or end of one of the seven mines.

Model Stresses

Steady-state recharge calculated by GA using chloride mass balance methodology was applied to the steady-state groundwater model. For the transient calibration simulation, a series of annual multipliers calculated by CSIRO were applied to derive a transient recharge distribution. For predictive modelling, recharge was applied as per the steady-state model, and represents average conditions. No variation in long term recharge due to potential climate change was applied in the model. Actual evapotranspiration was applied using the annual average distribution from the Bureau of Meteorology.

The following major water courses were assumed to have connection to the groundwater system: the Carmichael River, Belyando River, Native Companion Creek, Alpha Creek, Aramac Creek, Thomson River, Flinders River, Diamantina River, Barcoo River, Warrego River and Blackwater Creek. These rivers were modelled using the two-way flow MODFLOW River package, allowing leakage from the rivers to groundwater, as well as baseflow from groundwater into rivers, according to the local head differences computed by the model. For both steady-state and transient simulations, the model determined that most rivers act as *net* losing systems, meaning that for most of the river reaches the groundwater level was below the stream base and water was discharged from the streams to groundwater. However, due to the annual time-stepping of the model this only represents an average annual water balance, and does not represent any seasonal variation in flows.

Over 100 groundwater springs are simulated in the model, also using the MODFLOW River package, but constrained to act in one direction only (as groundwater discharge). Of these, 27 are considered by GA to be of significant value, determined by discharge volumes of over 100kL/day, and include such groups of springs as Doongmabulla, Mellaluka, Edgebaston, Correna and Corinda springs, among others. Springs are assigned to known aquifers where the information is available, or the nearest outcropping aquifer where information is not available. The Mellaluka Springs have been assigned to the Joe Joe formation based on the most recent drilling records of the Carmichael mine (previously thought to be sourced from the Colinlea Sandstone).

Groundwater abstractions for irrigation, industry and town water supply were compiled and provided by GA. There was significant difficulty in compiling these datasets resulting in several iterations of flow volumes provided. This indicates substantial uncertainty in well flow volumes, and a post-reporting review of the modelled data suggests that well stresses applied in the model are likely to be too high (although this has yet to be quantified), with almost 900ML/day of groundwater abstraction applied from 2012 onwards. This over-simulation of groundwater extraction noticeably impacted calibration results from earlier iterations with lower abstractions by forcing higher hydraulic conductivities and storativities in order to match observed heads and minimise drawdown due to pumping.

Mine workings are simulated in the model using the MODFLOW drain package. Due to limited detail on mine plans and exact coal seam elevations, the mining depth was assumed to be the base of the layer containing the target coal seams for all open cut and underground workings, meaning that it is likely that the model simulates mining activities to be deeper than they are in reality. Drain cells are added progressively in the transient model, however the timing of these activations has been guided by only very coarse resolution mine plan data (generally 5 year intervals or more) and has been interpolated between known dates by HydroSimulations.

Hydraulic parameters are changed with time in the goaf and overlying fracture zone during extraction of each longwall panel using the MODFLOW-USG Time-Variant Materials package (TVM) to simulate fracturing due to caving. The height of fracturing above the longwall is calculated using the Ditton model. Cracking to surface is predicted to occur at the eastern portions of Carmichael, South Galilee, China First and Kevin’s Corner, while at other locations cracking only extends to the Rewan Formation.

Model Calibration

Initial hydraulic conductivity and storage parameters were assigned as per GA recommended parameter ranges. Calibration was undertaken manually and using the automated calibration utility, PEST. The majority of calibrated parameters remained within the recommended bounds, however the horizontal hydraulic conductivity bounds of the alluvium, Hutton Sandstone, Moolayember Formation, Clematis Sandstone and BC3 (Base of E Seam to Base of Colinlea Sandstone) needed to be raised by half an order of magnitude to enhance calibration. Storage parameters for the GAB units were at the upper end of the acceptable bounds in order to prevent excessive drawdown due to the currently estimated level of pumping. Model calibration statistics for both the steady-state and transient model were within the acceptable 5-10% range as recommend in the Australian Groundwater Modelling Guidelines, with the scaled RMS error being 4.6% for steady-state, and 5.9% for transient. The total mass balance error was 0.0% for both model runs. Regional hydraulic gradient and flow direction were well replicated by the model. Calibration of water levels in the vicinity of the mines was generally good for all layers (within +-10m), except to the north of the Carmichael River where groundwater levels were simulated higher than observed levels by up to 36m within the coal seam layers.

Predictive Modelling

Two model scenarios were run for predictive modelling (2012 – 2200), the first being a baseline run with no mining stresses applied, and the second being identical to the baseline with the exception of the addition of drain boundary conditions and changing hydraulic parameters and recharge to reflect the seven mine operations. Model stresses were set as per the steady-state average conditions except for abstraction volumes, which were maintained at the same pumping rate as at 2012 (the most recently provided data).

Fracture deformation has been applied to the model where the layer containing the target seam has an enhanced horizontal permeability (that is, hydraulic conductivity) of 100m/day and vertical permeability of 5m/day. Fractured layers above the target seam have enhanced permeabilities calculated using a log-linear ramp function, where at the base of the layer directly above the coal seam layer hydraulic properties are enhanced by a factor of 1000, and at the top of the highest layer affected by fracturing the permeability is enhanced by a factor of 50 (vertical) and 333 (horizontal) except where fracturing extended to surface, in which case a factor of 2x was used (due to the properties of weathered material and the already high conductivity of these layers).

Predicted mine inflows range from 5ML/day at Hyde Park up to 78ML/day at China First, with an average total inflow of 176ML/day over the operational mine period and a cumulative total inflow of 2,822 GL. The individual mine inflows are notably higher than EIS model results for Alpha, Kevin's Corner and Carmichael, but are comparable for the other mines.

Predicted drawdowns show significant wide-spread depressurisation of the Permian coal seam layers, however in most locations this does not propagate vertically above the Rewan Formation. Some drawdown to the Clematis Sandstone is predicted to occur near Barcaldine where the Rewan Formation is absent. Significant localised drawdown also occurs within the Clematis Sandstone to the west of China Stone, however this is expected to be an artefact of simulated water levels being too high in this location, as well as a potential error in the assignment of geological extents.

Only five springs are predicted to have drawdowns greater than 1m, the only "significant" springs affected being the Mellaluka Springs which are predicted to be completely dried out. Most springs are predicted to have impacts of only a few centimetres of drawdown. Eighty-nine registered groundwater bores are predicted to have drawdowns greater than 1m, with 30 of these having greater than 5m drawdown. Severely affected bores (>5m drawdown) are restricted to the Permian layers, however there are several bores in the GAB units and Clematis Sandstone that have predicted drawdowns between 1m and 5m.

Sensitivity Analysis

Minimal sensitivity analysis was able to be completed in the time frame and agreed scope of the project. Two sensitivity runs were done. The first assessed the impact of the vertical hydraulic conductivity (K_Z) of the aquitard layers by increasing the K_Z by one order of magnitude for all aquitards. The result was a 15% increase in mine inflows, an increase in the number of wells and springs affected by >1m drawdown, but a decrease in the area affected by depressurisation (due to replenishment of water from above leaky aquifers).

The second sensitivity run was used to assess the impact of applied hydraulic fracture properties which was carried out by running the model without using the TVM package, that is with an assumption of no fracturing due to mining. This sensitivity run yielded almost identical results to the basecase scenario, with only a 2% reduction in inflows and no change in the number of affected springs and bores, or the distribution of the cone of depression.

Limitations

There are several limitations to the groundwater model. Of these, the most significant include:

1. The lumping together of coal seam and interburden layers affecting the resolution of application of mining activities and resulting deformation in the model, as well as limiting the assignment of hydraulic parameters to single bulk values and reducing in particular the vertical conductivity control on groundwater flow that would be observed with finer layering.

2. Possible significant errors in groundwater well flow volume data (overestimation of flow) impacting the model calibration and therefore affecting prediction results.

3. Limited information on mine scheduling and excavation depths, meaning the simulated timing and depths of mining have at best been approximated.

4. Minimal transient calibration data, resulting in heavy reliance on steady-state calibration to constrain hydraulic conductivity parameters and little information content on storage parameters during transient calibration.

5. Drawdown in Layer 1 of the model is poorly simulated due to a combination of inadequate detail for layer thickness (Layer 1 is likely to be too thin in the location of the mines) as well as an issue with the version of MODFLOW-USG used to run this model resulting in a small thickness of water being held at the base of each layer maintaining an artificial groundwater head instead of simulating dry conditions.

1 INTRODUCTION

HydroSimulations (HS) was contracted by Geoscience Australia (GA) on behalf of the Department of the Environment, Office of Water Science to develop a numerical groundwater flow model of the Galilee Basin of Queensland, Australia. The purpose of the model was to assess the cumulative impacts of new coal mining developments on water-dependent assets and receptors, with potential for inclusion of coal seam gas projects. This model is to help support the Bioregional Assessment (BA) programme being undertaken by the Commonwealth Department of the Environment for the Galilee subregion of the Lake Eyre Basin bioregion, one of six regions being assessed across Australia. Currently, limited information is available regarding the planned extraction of coal seam gas (CSG) from the basin; therefore the extraction of CSG is not included in the model. The model can be modified in future for this purpose.

This report addresses the scope of work specified for Milestones 1-3 in Commonwealth Contract - Goods and Services Reference No. 001237 (as amended by a Deed of Variation).

The scope of work for Milestone 1 was:

> *It is anticipated that the current model as developed by GA (the GA model) will be used as a basis for development of a calibrated and stress tested transient numerical groundwater flow model. Milestone 1 report should include an assessment of the GA model, available data and suitability for incorporation into the transient model, a workplan outlining modelling strategy and objectives, proposed work programme, calibration strategy and assessment criteria.*

The scope of work for Milestone 2 was:

> *Delivery of a progress report in an accessible digital format outlining the development of the model including details and characteristics of the model such as key assumptions, methods used, discretisation, boundary conditions and steady-state calibration.*

The scope of work for Milestone 3 was:

1. *Delivery of a calibrated and stress tested transient groundwater flow model constructed in accordance with currently accepted guidelines (NWC, 2012).*

2. *Delivery of a final report in an accessible digital format outlining the development of the model including details and characteristics of the model such as key assumptions, methods used, discretisation, boundary conditions, calibration performance, sensitivity analysis, data gaps and identification of limitations and uncertainties associated with the model.*

3. *Provision of a data package containing all digital files associated with the model in a suitable format. Provide a briefing at Geoscience Australia Canberra to hand over the model and ensure that the model code runs on Geoscience Australia hardware.*

Reports addressing Milestone 1 and Milestone 2 were issued on 9 June 2015 and 30 June 2015, respectively. This report addresses Milestone 3 and includes the results from the earlier Milestones.

The groundwater model comprises the entire Galilee Basin and part of the overlying Eromanga Basin. The model aims to assess the combined impacts of mine development at the following coal projects (ordered north to south):

1. Hyde Park
2. China Stone
3. Carmichael
4. Kevin's Corner
5. Alpha
6. China First
7. South Galilee

These coal mines were chosen due to being at the most advanced stages of approval at the time of project commencement (2014). However, at that time there were also an additional seven leases under application, six mineral development licences and a further three pending mineral application licences (Lewis et al., 2014).

The model will be used to make predictions of impacts due to cumulative impact of the above mining operations including maximum regional drawdown the Great Artesian Basin (GAB) aquifer units, drawdown at springs and wells, impacts on stream baseflow and annual mine inflow estimates. Impacts of individual mines were not required to be differentiated, however the model is easily modifiable to add or remove mines as further development applications are considered in the future.

2 REGIONAL SETTING

A brief summary of the regional setting and hydrogeological context of the model area is provided in this section taken from the GA Model Summary Report Addendum 3 (Jiang et al., 2015). Additional detail can be found in the Galilee subregion context statement and resource report (Evans et al., 2015). The reader is referred to these documents for further information.

2.1 GEOLOGY

The Galilee Basin is a large intra-cratonic basin of mostly fluviatile sediment of Permian age. It is located in central Queensland between the Surat basin to the east and the Great Artesian Basin to the west. The Galilee Basin units follow the regional westerly dip and are unconformably overlain by the Eromanga Basin units (a sub-region of the GAB). Regional stratigraphy is divided into three chronostratigraphic intervals:

1. Late Carboniferous to Early Permian (Galilee Basin);
2. Middle Jurassic to Early Cretaceous (Eromanga Basin – part of the GAB); and
3. Cenozoic (surficial cover sediments).

Subcropping geology and an associated regional cross section are shown in Figure 2-1 and Figure 2-2 respectively.

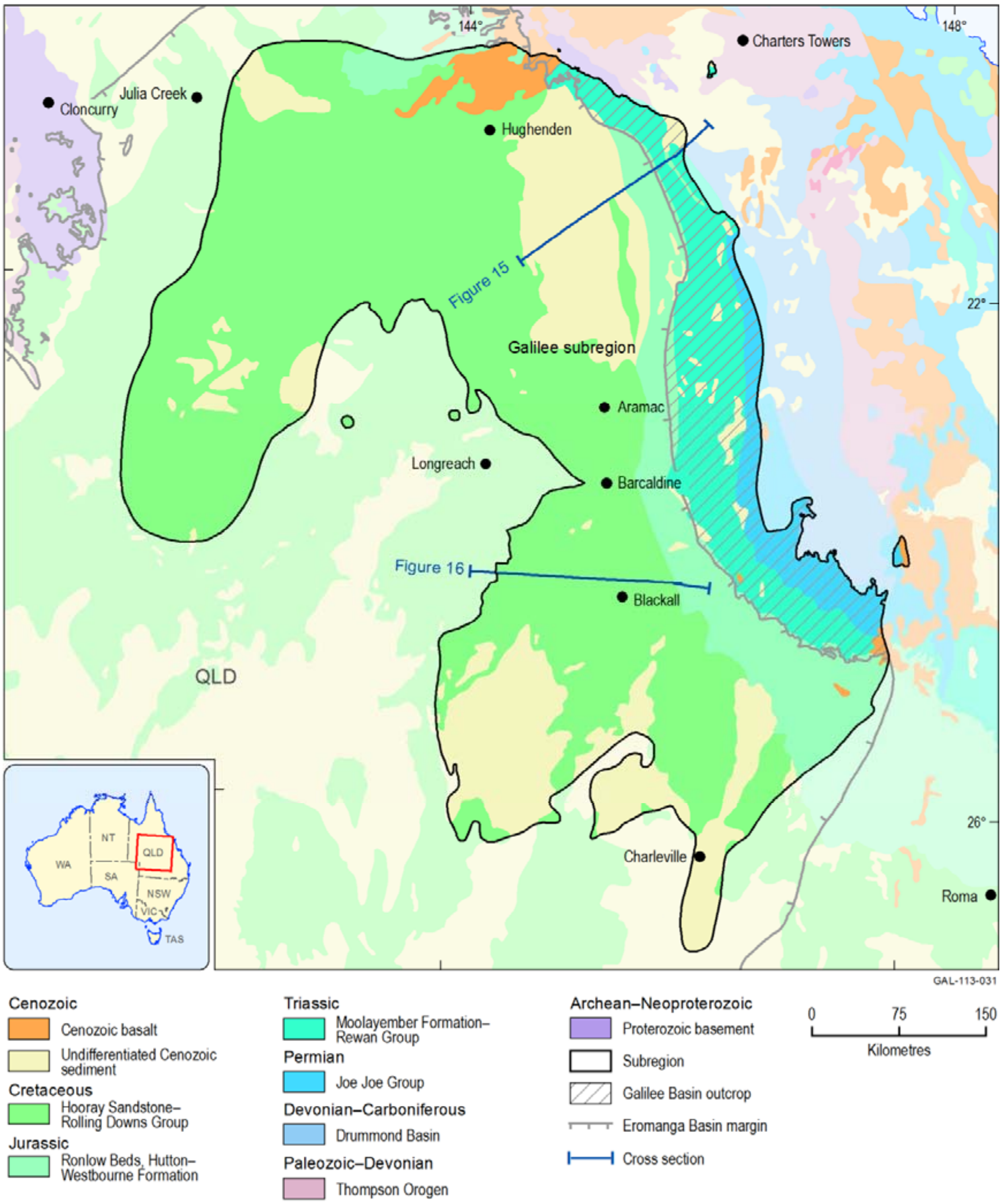


Figure 2-1 Sub-cropping regional geology (Evans et al., 2015)

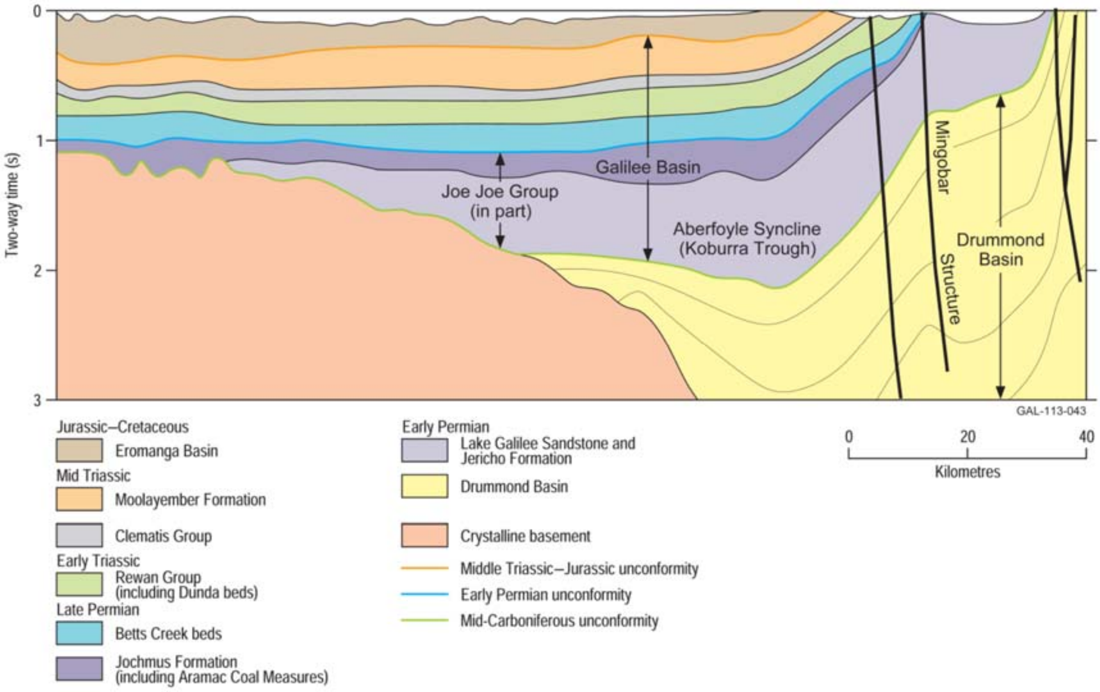


Figure 2-2 Cross section through Galilee Basin (line 15 of Figure 2-1) (Evans et al., 2015)

2.2 HYDROGEOLOGY

The Eromanga Basin region of the GAB unconformably overlies the coal bearing Galilee Basin units. The key aquifers of Eromanga Basin include the Cretaceous Winton and Mackunda Formations, the Wyandra Sandstone member of the Cadna-owie Formation, the Jurassic – Cretaceous Hooray Sandstone, and the Hutton Sandstone. The main aquifers of interest in with the Galilee Basin units are the Triassic Warang and Clematis Groups, and the Late Permian Colinlea Sandstone. The aquifers of the GAB are separated from those of the Galilee Basin by the Moolayember Formation, a variable sandstone and siltstone layer. The Rewan Formation further acts as a regional aquitard separating Permian coal seam layers from the overlying aquifers (Evans et al., 2015). Figure2-3 shows the regional hydrostratigraphy.

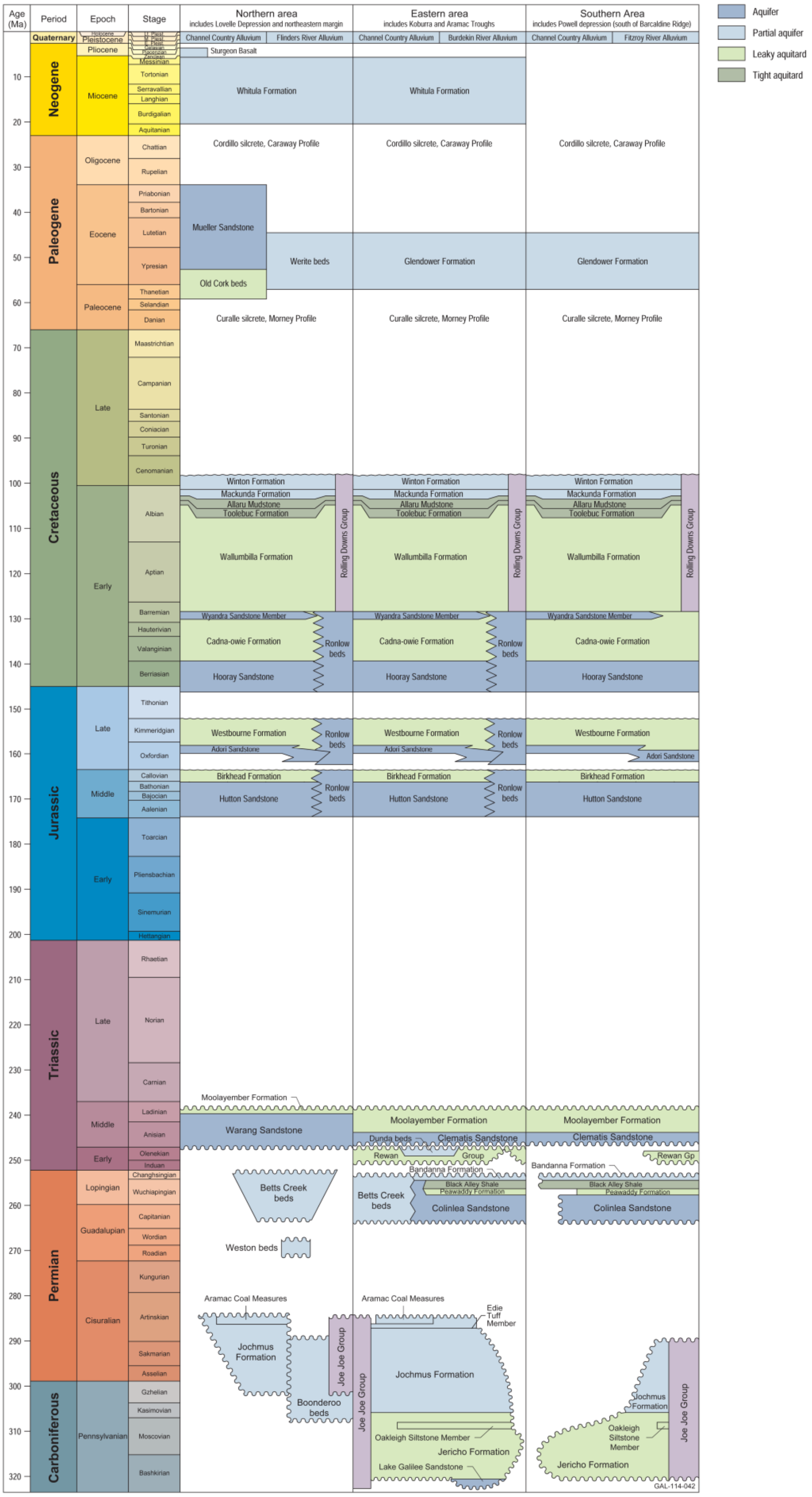


Figure2-3 Regional hydrostratigraphy

3 GROUNDWATER MODELLING

3.1 APPROACH TO MODELLING

Preliminary modelling has been undertaken by GA using a 1km by 1km grid spacing in the generic code MODFLOW-2005, resulting in approximately 4 million cells across a 12 layer model. HS has re-built the existing model into the new MODFLOW-USG platform, which allows flexible meshes giving better refinement around key features while at the same time reducing cell count. MODFLOW-USG uses a different underlying numerical scheme: control volume finite difference (CVFD), rather than traditional MODFLOW's finite difference (FD) scheme. USG is an acronym for Un-Structured Grid, meaning that MODFLOW-USG supports a variety of structured and unstructured model grids, including those based on cell shapes such as prismatic triangles, rectangles, hexagons, and other cell shapes (Panday *et al*., 2013). The CVFD method also means that a model cell can be connected to an arbitrary number of adjacent cells, which is not the case with a standard FD scheme.

In contrast with structured rectangular finite-difference grids, flexible meshes have a number of advantages. Firstly, they allow finer grid resolution to be focused solely in areas of a model that require it, as opposed to refinement over the entire grid, significantly decreasing cell count and consequently model runtimes. Secondly, spatial areas not required in the model may be omitted rather than deactivating cells or retaining "dummy" layers (e.g. for layer pinch-outs). Thirdly, flexible meshes allow cell boundaries to follow important geographical or geological features, such as watercourses or outcrop traces, more accurately modelling the physical system. Finally, the orientation of the flow interfaces between cells may vary, allowing preferential flow directions to be modelled with higher accuracy.

Additionally, MODFLOW-USG is able to simulate variably saturated flow and can handle desaturation and re-saturation of multiple hydrogeological layers without the "dry cell" problems of traditional MODFLOW. This is pertinent to models which simulate layers, such as surficial regolith, which frequently alternate between unsaturated and saturated, as well as the depressurisation and desaturation that occurs during mining. Traditional versions of MODFLOW can handle depressurisation and desaturation to some extent, but model cells that are dewatered (reduced below atmospheric pressure) are replaced by "dry" cells, which can interfere with the simulation of various processes and also cause model instability.

Both steady-state and transient models have been developed.

3.2 MODEL COMPLEXITY

GA has stipulated the model is to be of "Level 2 Confidence" in accordance with the Australian Groundwater Modelling Guidelines (Barnett *et al*., 2012) with the following key indicators (based on Table 2-1 of Barnett et al., 2012):

- groundwater head observations and aquifer extents are available and with a reasonable coverage throughout the entire model, however transient data is limited;
- rainfall and evaporation data are available from local weather stations, with daily recharge estimates for the entire model extent for the calibration period;
- streamflow data and baseflow estimates are available at a few points;
- transient calibration to historical data but not extended to present day;
- estimates of groundwater abstraction data are available but the accuracy of temporal water usage is questionable;
- seasonal fluctuations not accurately replicated in all parts of the model domain;
- scaled RMS error or other calibration statistics to be acceptable throughout most of the model, with some areas of poor calibration expected;

- mass balance closure error to be less than 1%; and
- model will be used for prediction of impacts of proposed developments in medium value aquifers.

Note that not all characteristics of a Level 2 Confidence model are likely to be achieved. In practice, any one model is likely to have a mixture of Level 1 to Level 3 attributes, for example:

- Stresses in predictions are more than 5 times higher than those in calibration (Level 1) due to Greenfield sites meaning no mining stresses are applied during calibration.

The Level 2 classification corresponds with an Impact Assessment Model of medium complexity as per the MDBC Groundwater Flow Modelling Guideline (MDBC, 2001):

> *"Impact Assessment model - a moderate complexity model, requiring more data and a better understanding of the groundwater system dynamics, and suitable for predicting the impacts of proposed developments or management policies."*

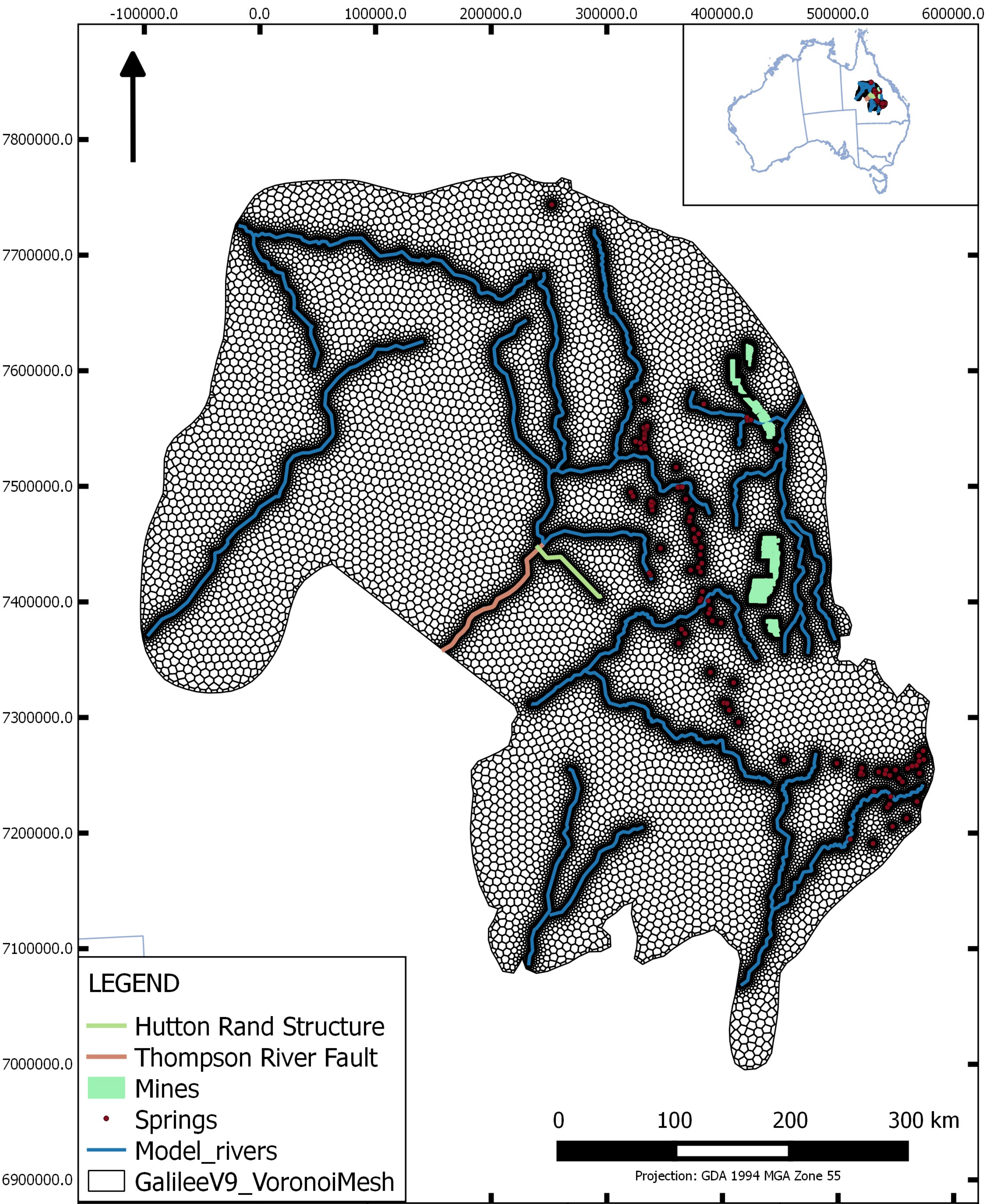
Appendix K presents Table 2-1 of Barnett et al., 2012 with an asterisk next to the applicable criteria for this model.

3.3 MODEL GEOMETRY

3.3.1 MODEL EXTENT

Due to its development with a structured grid, with high cell count and coarse (1km) resolution, the initial GA model does not cover the full extent of the Galilee Basin. The south-western and south-eastern lobes are omitted.

The redesigned USG model area includes the entire Galilee Basin sub-region and covers 299,400km^2 . Figure 3-1 shows an overview of the entire model area, extended across part of the Maneroo Shelf to include the Thomson River Fault, and about 30km to the east to include the full Belyando River adjacent to the proposed coal mines. The same mesh design applies to each model layer.



HYDRO SIMULATIONS

5 JUNE 2015	DRAWN BY: CT	FIGURE 3.1
GEOSCIENCE AUSTRALIA	GSA001 GALILEE BASIN MODEL	
Location of Galilee Sub-Region and Model Extent		

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3.3.2 MODEL LAYERING

The initial GA model represents the stratigraphy with 12 model layers.

The redesigned USG model consists of 13 layers, with the upper 12 layers as per the original GA model, plus an additional layer at the base to include the upper Joe Joe Group. This is included as the outcropping lithology on the eastern edge of the model along the Belyando River. It is also believed that a permeable unit in the otherwise low-permeability Joe Joe Group is the source for the Mellaluka Springs (at the southern end of the Carmichael mine lease)[1].

Layer 1 includes two spatially variable zones, one for alluvial deposits and another for general regolith. Layers 2, 4 and 6 are broken into east and west zones to represent the variable hydraulic properties at the intake areas versus the deeper groundwater system. Layer 13 is divided into three lateral zones, to allow differing hydraulic properties for the crystalline basement (west), Joe Joe group (central) and Drummond Basin units (east). All other layers have a single zone across their entire extent. Appendix A provides maps of the spatial extent of the active model area and zonation for each layer.

Model layer boundaries were determined using raster surfaces provided by GA. Minimum layer thickness was set to 0.05m where the defining formation was present, and a 0m layer thickness in areas where the formation was absent, with the exception of Layer 1 which was given a thickness of 10m of regolith across the full model extent in the absence of other data. The geological units included within each layer are shown in Table 3-1.

[1] Based on recent drilling results not in the public domain

Table 3-1 Model layer definition

LAYER	FORMATION	AQUIFER TYPE	MAX THICKNESS (M)	AVERAGE THICKNESS (M)	GA RASTER LAYER NAME
Layer1	Cenozoic (Alluvium and regolith)	Unconfined Aquifer	66	11	dem_1k and paleoneo_top
Layer2	Winton/ Mackunda Formation	Unconfined to semi-confined	782	61	wintonmackunda_top
Layer3	Allaru/ Toolebuc/ Wallumbilla Formation	Leaky Aquitard	756	166	rollingdwns_top
Layer4	Cadna-owie Formation/ Hooray Sandstone/ Gilbert River Formation/Ronlow Beds	Confined Aquifer	289	52	cadnaowie_top
Layer5	Westbourne/ Adori/ Birkhead Formation (Injune Creek Group)	Leaky Aquitard	432	67	westbourne_top, birkhead_top and adori_top
Layer6	Hutton Sandstone/ Precipice Sandstone and equivalents	Confined Aquifer	381	60	hutton_top. evergreen_top and precipice_top
Layer7	Moolayember Formation	Aquitard	706	85	moolyember_top
Layer8	Clematis Group/ Warang Sandstone	Confined Aquifer	573	56	clematis_top
Layer9	Rewan/ Dunda Beds Formation	Aquitard	474	88	rewan_top
Layer10	Top of Bandanna Formation to base of B Seam (BC1)	Confined Aquifer	416	50	betts_ck_top and bandanna_top
Layer11	Base B-Seam to top of E Seam (BC2)	Confined Aquifer	65	29	bseam_top*
Layer12	Top of E Seam to top of Joe Joe Group (BC3)	Confined Aquifer	223	25	eseam_top
Layer 13	Upper Joe Joe Group/ Drummond Basin sediments/ crystalline basement	Aquitard	1916	602	joejoe_top and basement_full

*Confirmed as a naming convention error where “bseam_top” actually represents “bseam_base” (pers.comm. T. Evans, GA)

3.3.3 MODEL GRID

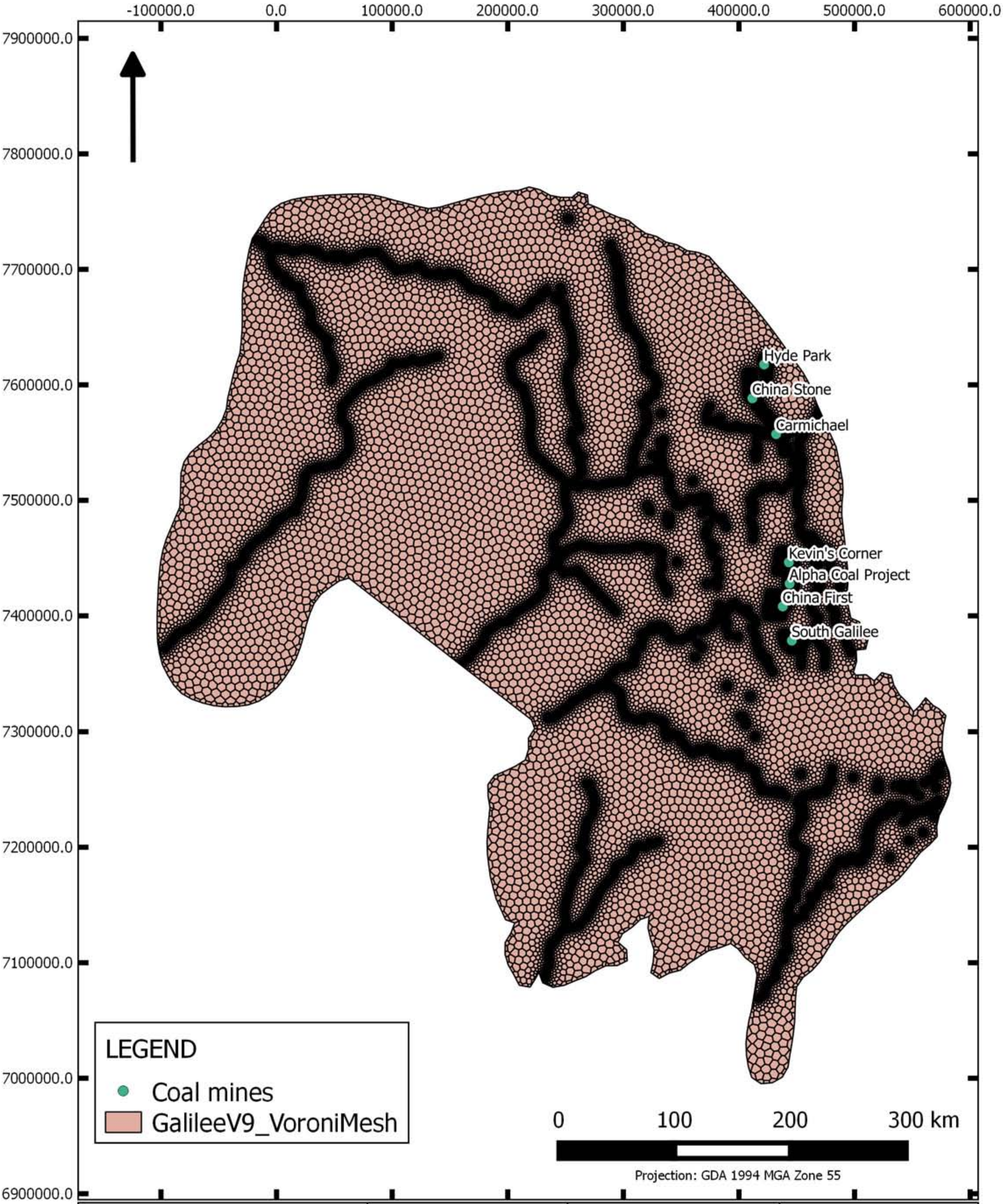
The initial GA model consists of 785 rows and 415 columns, with 325,775 model cells per layer.

The use of MODFLOW-USG allows the use of an unstructured or irregular mesh. For this project, a Voronoi-based mesh has been adopted which has the advantage of being irregular but maintaining the property that a line connecting adjacent cell-centres is perpendicular to the shared cell boundary. The Voronoi mesh was generated using the proprietary HydroAlgorithmics software 'AlgoMesh', which provides significant control over the mesh generation process, and can export MODFLOW-USG files, in addition to other formats (HydroAlgorithmics, 2014; Merrick and Merrick, 2015).

Each model layer is subdivided into Voronoi cells as shown in Figure 3-2. The mesh has a maximum of 148,641 cells per layer (46% of the GA model count), giving a maximum of 1,932,333 cells for 13 model layers (compared with 3,909,300 cells in the 12 layer GA model). MODLFOW-USG precludes the need to have layers being fully extensive across the model domain, so some model layers have less than the maximum148,641 cells present, depending on the presence or absence of certain hydrogeological units. The resulting model cell count after considering layer pinch-outs is 1,249,974 (32% of the GA model count).

The following constraints on model cell scale were used in mesh generation:

- Springs are located in the centre of cells of approximately 150 m diameter.
- Polylines along mapped rivers and creeks were used to ensure the mesh conformed to mapped drainage networks, with a maximum cell diameter of 300m.
- 300m diameter along the Thomson River Fault and the Hutton-Rand structure; allowing the application of the same or different physical properties to the prismatic cells defining these features allows control over their vertical extents and connections between layers.
- Longwalls at the mining areas are represented with square grid cells orientated along longwall strike, with the cell sizes for each mine as below (for example see Figure 3-3):
    - China First 250m (E-W)
    - Kevin's Corner 225m (N-S)
    - Carmichael 170m (Various angles)
    - South Galilee 195m (E-W)
    - China Stone 165m for southern section (E-W), 250m for northern section (E-W).
- Open pit mining areas, including the entire excavation areas for Alpha and Hyde Park, are discretised using Voronoi cells of maximum 200m diameter. If part of an open cut area falls within a proposed longwall area square grid cells take preference for the portion of overlap.
- Maximum cell size is approximately 10km in areas distant from mines, springs and watercourses.



5 JUNE 2015	DRAWN BY: CT	FIGURE 3.2
GEOSCIENCE AUSTRALIA	GSA001 GALILEE BASIN MODEL	
Voroni Mesh Discretisation		

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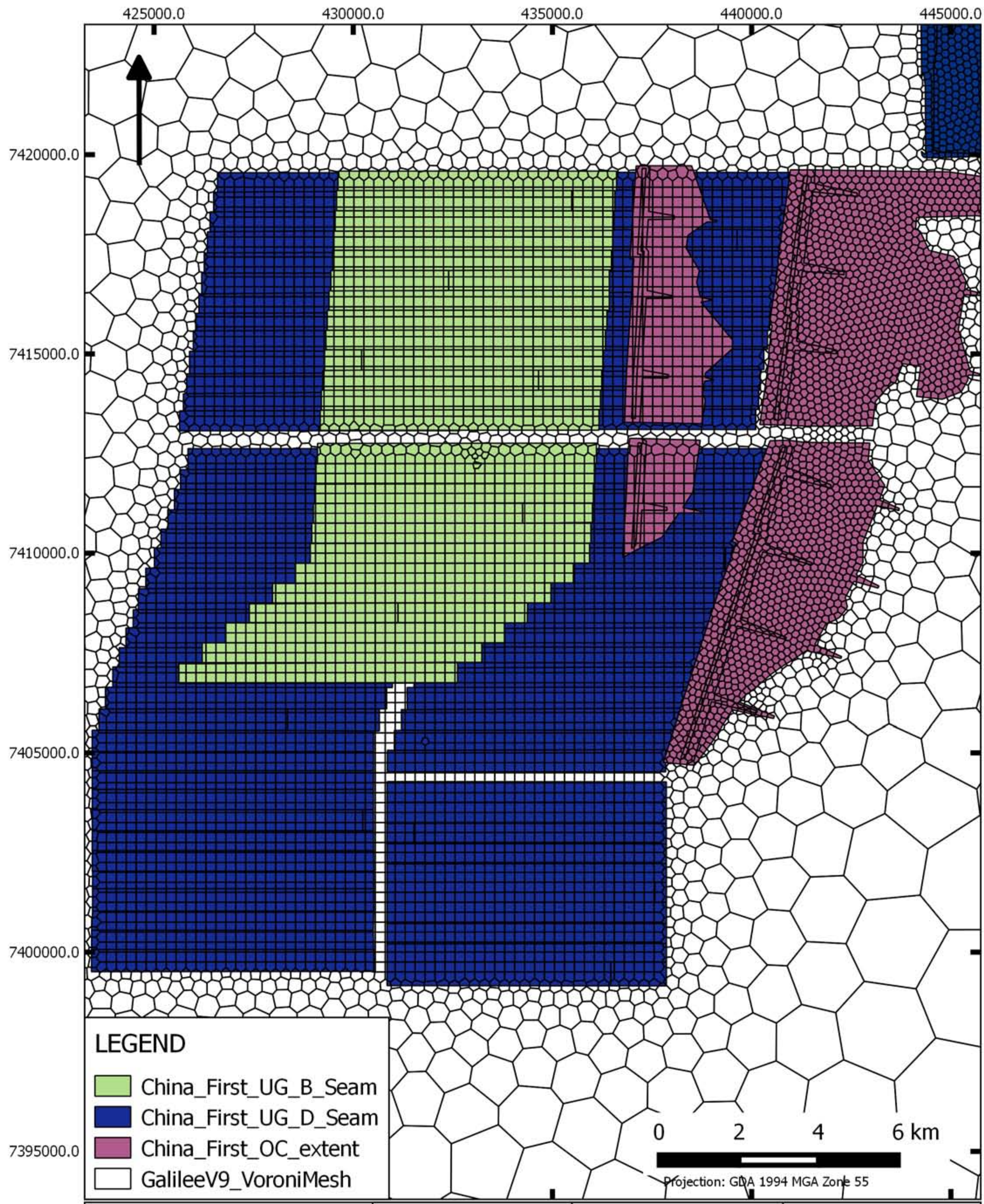

5 JUNE 2015	DRAWN BY: CT	FIGURE 3.3
GEOSCIENCE AUSTRALIA	GSA001 GALILEE BASIN MODEL	

Grid Resolution at Mine Areas

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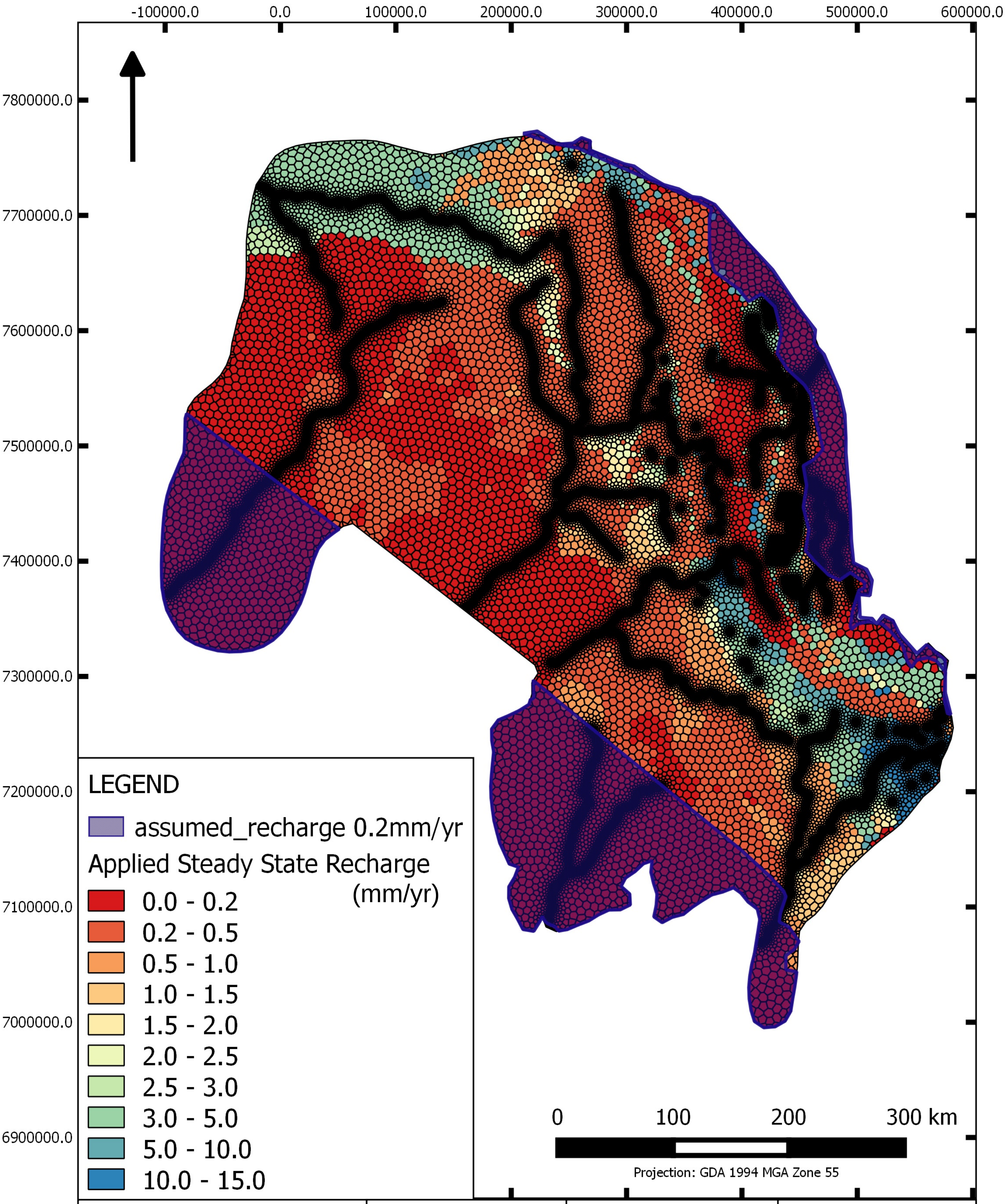
3.4 MODEL STRESSES AND BOUNDARY CONDITIONS

The model domain and boundary conditions have been selected to incorporate the significant hydrological processes identified in the conceptual model outlined in GA report Addendum 3, including features such as springs and watercourses that could be affected by mining. Following is a detailed description of each of the modelled boundary conditions.

3.4.1 RECHARGE

The MODFLOW Recharge (RCH) package is used to simulate diffuse rainfall recharge. The long term average recharge provided by GA, derived from Chloride Mass Balance (CMB) recharge estimates (Evans et al., 2015), was imposed on the upper layer of the model in the steady-state simulation (Figure 3-4).

The recharge distribution provided by GA is limited to the south-west and south-east according to the model extent of the initial GA model. HS has infilled the vacant areas within the USG model domain. For the areas of the model without a recharge estimate, an average recharge of 0.2mm/a has been assigned (see Figure 3-4).



HYDRO SIMULATIONS	29 JUNE 2015	DRAWN BY: CT	FIGURE 3.4
	GEOSCIENCE AUSTRALIA	GSA001 GALILEE BASIN MODEL	
	Average Recharge Applied to Steady State Model		

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For the transient simulation a series of recharge factors have been provided for the period 1983 to 2011 and are derived as follows (Chris Turnadge, CSIRO *pers.comm.,* 2015):

"Recharge fluxes were extracted from the continental scale AWRA landscape model for a distribution of point locations in the Galilee Basin area. These data were used to calculate a time series representing the daily recharge flux averaged across the spatial extent. This time series was then divided by its temporal mean so that it is now centred around a mean value of one. The time series values range from 0.4 to 3.4. These are dimensionless values and can be used to scale the steady-state recharge values in order to derive a transient recharge dataset."

A transient recharge series for input in to the model was therefore calculated by multiplying the annual average recharge used in the steady-state model with the recharge factors provided by CSIRO. This was calculated for each model node, maintaining the spatial recharge distribution. Due to the requirement to calibrate the model based on existing data to the end of 2012, HS has extended the provided recharge fluxes using a combination of daily rainfall and evapotranspiration data from the Beaconsfield weather station (near Longreach, Station 036066, 144.60°E 23.33°S). Daily recharge estimates were matched as closely as possible to the CSIRO dataset using the Penman-Grindley recharge model (Finch, 1994) (Figure 3-5). Recharge estimates for 2012, 2013 and 2014 derived using this estimate have been applied to the model, while those supplied by CSIRO are applied to 2011. A correlation co-efficient of 0.73 exists between the provided CSIRO recharge multiplication factors and those calculated by HS (Figure 3-6) using the Penman-Grindley method, which is considered sufficiently well matched to extend the provided data set by three years for calibration purposes.

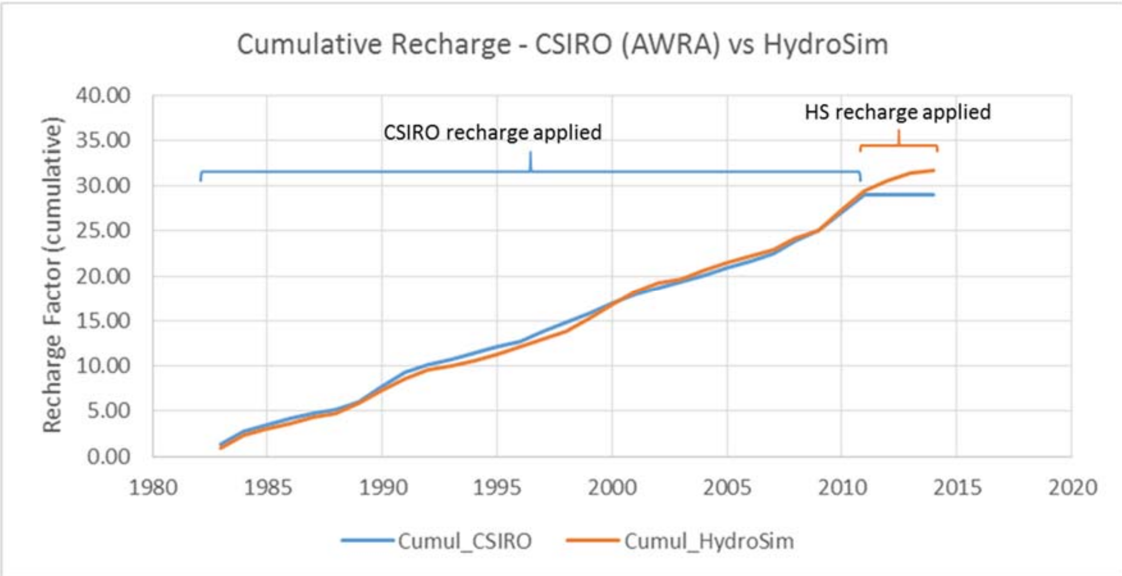


Figure 3-5 Comparison of HS calculated recharge multiplier to CSIRO recharge multiplier

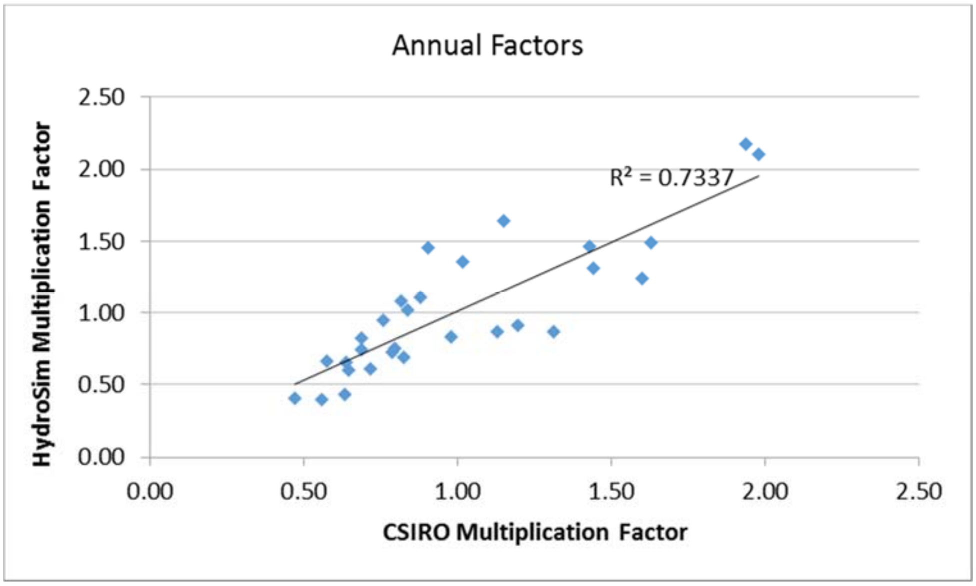


Figure 3-6 Relationship between HS and CSIRO calculated annual recharge multiplier

Fluctuations in the groundwater table result from temporal changes in rainfall recharge to aquifers. Typically, changes in the groundwater elevation reflect the deviation between the long-term monthly (or yearly) average rainfall, and the actual rainfall, usually illustrated by the Residual Mass Curve (RMC). The groundwater levels recorded during periods of rising RMC are expected to rise while those recorded during periods of declining RMC are expected to fall. If an aquifer unit shows correlation with the local RMC it can be interpreted as being influenced by rainfall recharge. Many of the units in the Galilee Basin are present close to the surface or in outcrop near the Basin's eastern margin along the Great Dividing Range, along with units such as the Hutton, Adori and Hooray Sandstones (members of the GAB aquifer system). Hydrographs with consistent long term data are plotted against RMCs from nearby rainfall monitoring stations (Figure 3-7) to identify areas in which local geology is influenced by rainfall recharge. A selection of analysed hydrographs is shown in Figure 3-8. Remaining hydrographs showing transient water level data for the region are located in Appendix B. These correlations further confirm the reports of the GA Conceptual Groundwater Model (Evans et al., 2015), with Cenozoic aquifers (occurring in Tertiary and Alluvial units seen in the graphs) and underlying Hooray, Adori, Rewan and basement groundwater units occurring in the east of the Galilee Basin as unconfined aquifers and intake zones.

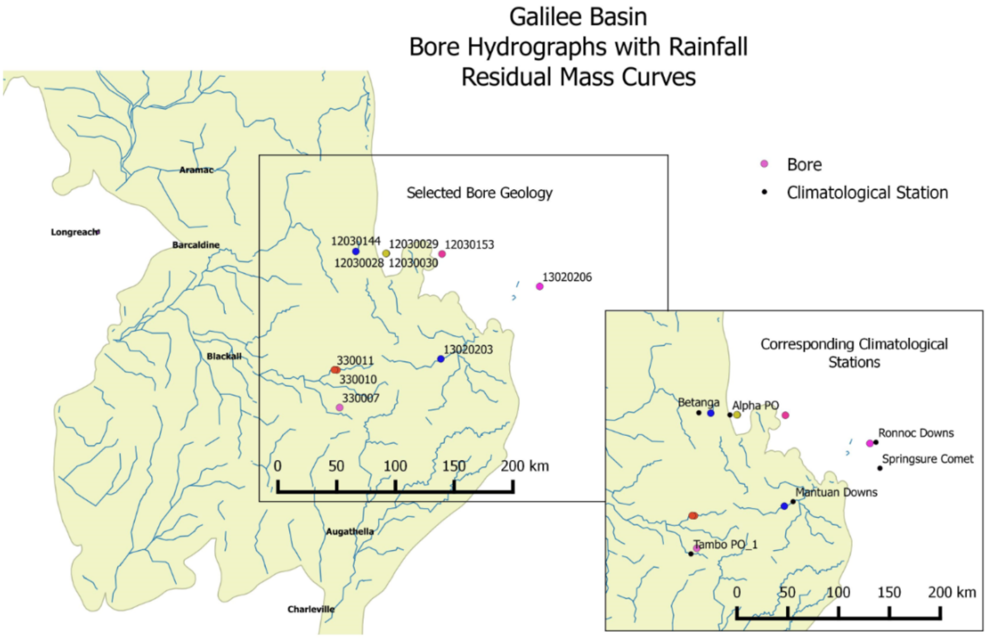
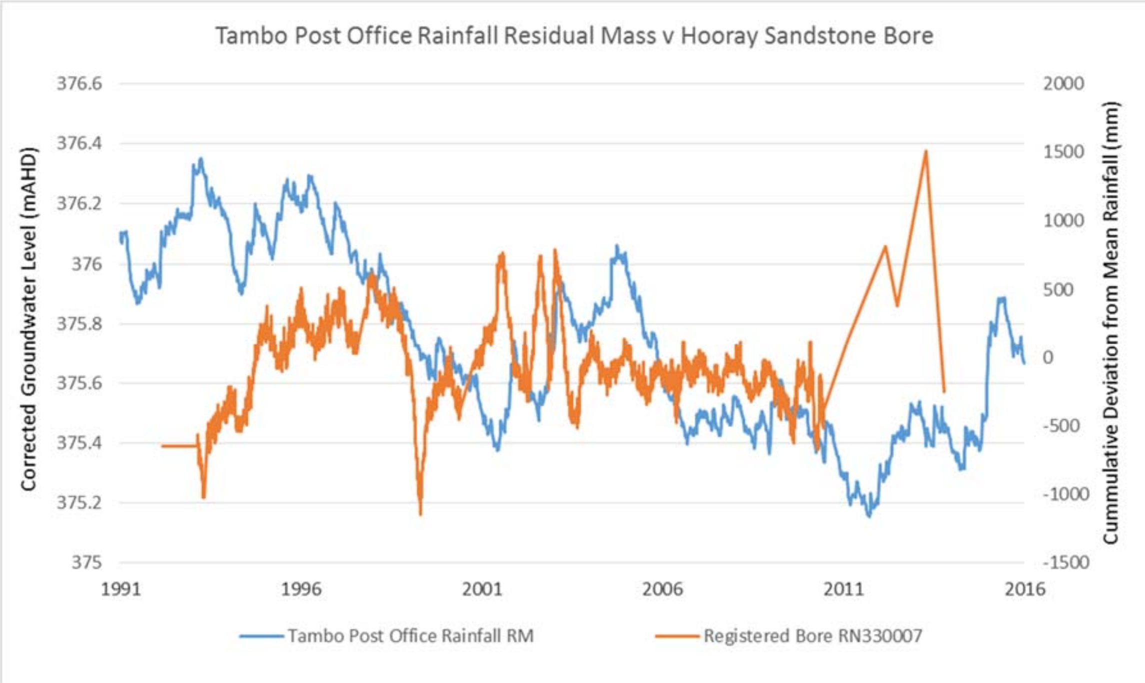
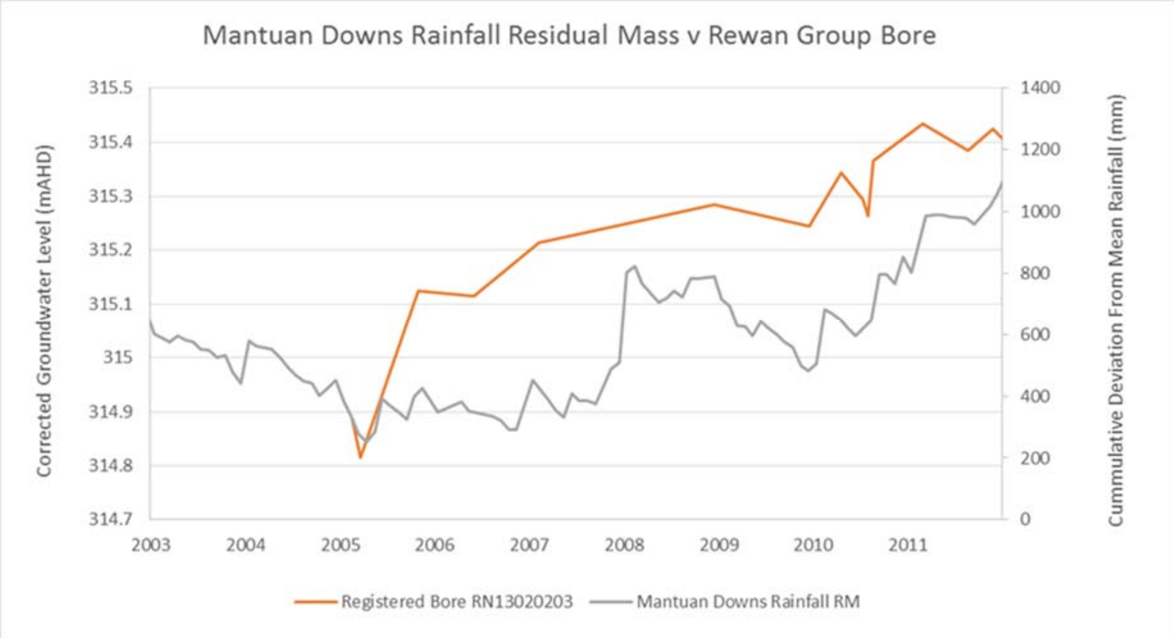
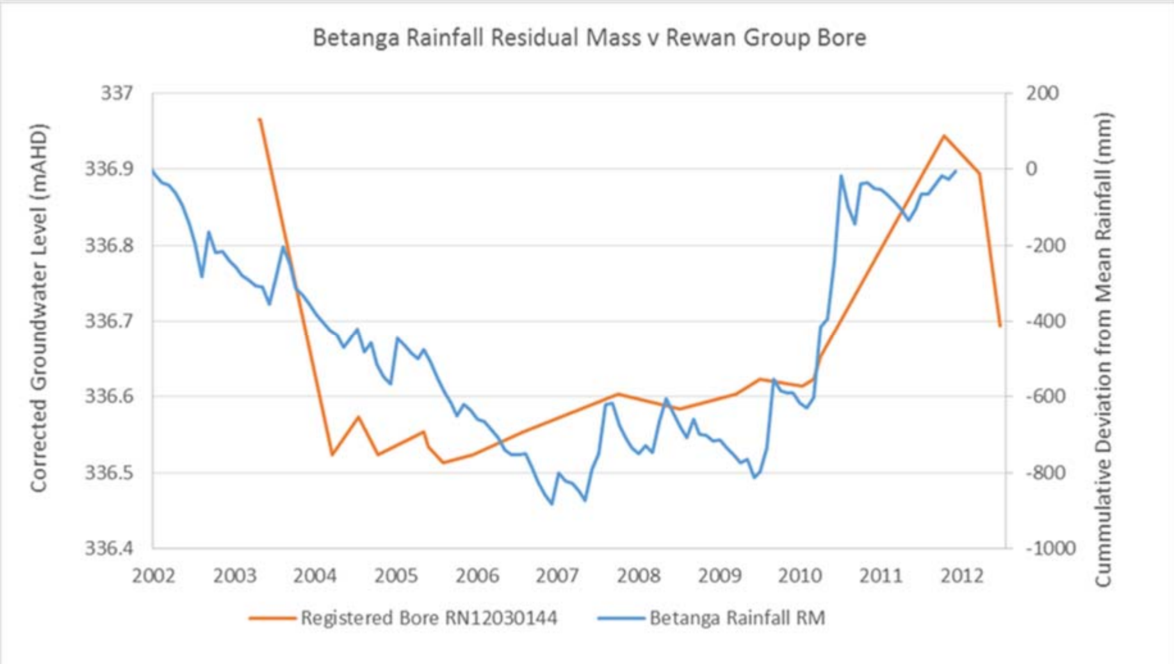
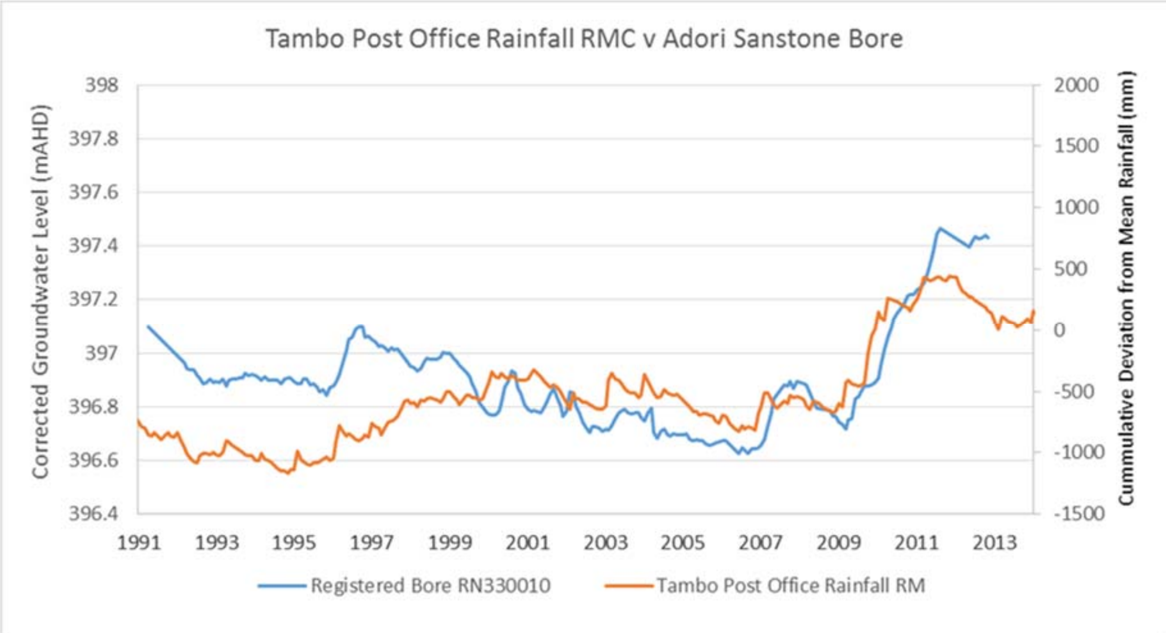


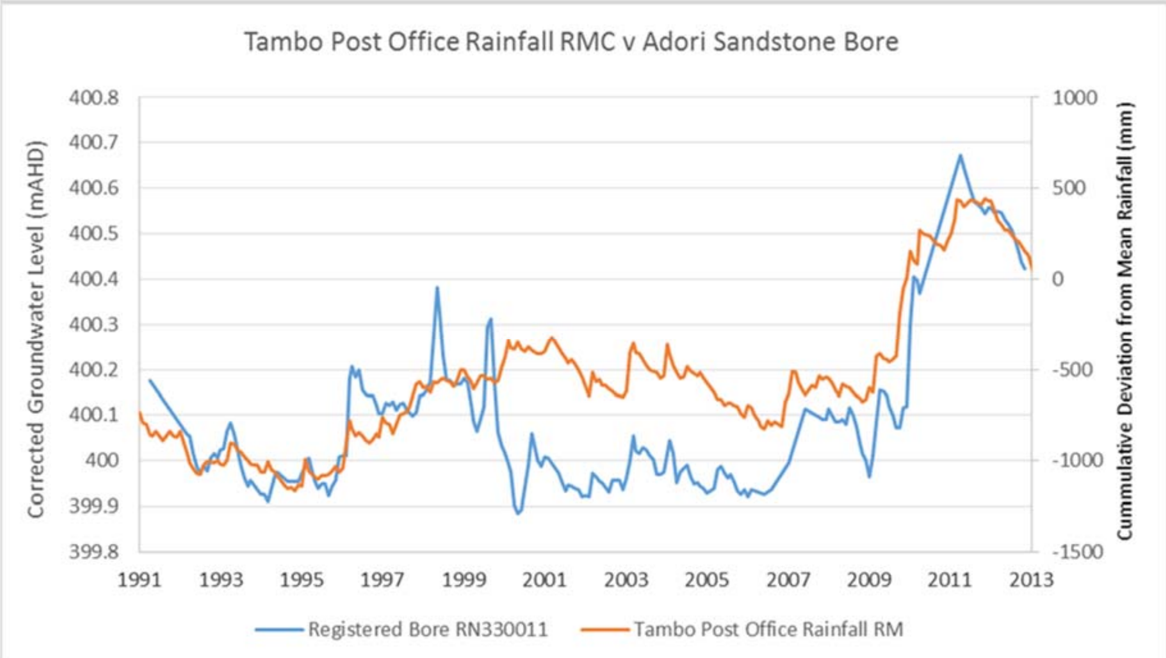
Figure 3-7 Location of interpreted bore sites with inset of corresponding Climatological Stations




Mantuan Downs Rainfall Residual Mass v Rewan Group Bore
Corrected Groundwater Level (mAHD)
Cummulative Deviation From Mean Rainfall (mm)
Registered Bore RN13020203
Mantuan Downs Rainfall RM


Betanga Rainfall Residual Mass v Rewan Group Bore
Corrected Groundwater Level (mAHD)
Cummulative Deviation from Mean Rainfall (mm)
Registered Bore RN12030144
Betanga Rainfall RM


Tambo Post Office Rainfall RMC v Adori Sanstone Bore
Corrected Groundwater Level (mAHD)
Cummulative Deviation from Mean Rainfall (mm)
398
397.8
397.6
397.4
397.2
397
396.8
396.6
396.4
2000
1500
1000
500
0
-500
-1000
-1500
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Registered Bore RN330010
Tambo Post Office Rainfall RM


Tambo Post Office Rainfall RMC v Adori Sandstone Bore
Corrected Groundwater Level (mAHD)
Cummulative Deviation from Mean Rainfall (mm)
400.8
400.7
400.6
400.5
400.4
400.3
400.2
400.1
400
399.9
399.8
1000
500
0
-500
-1000
-1500
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Registered Bore RN330011
Tambo Post Office Rainfall RM

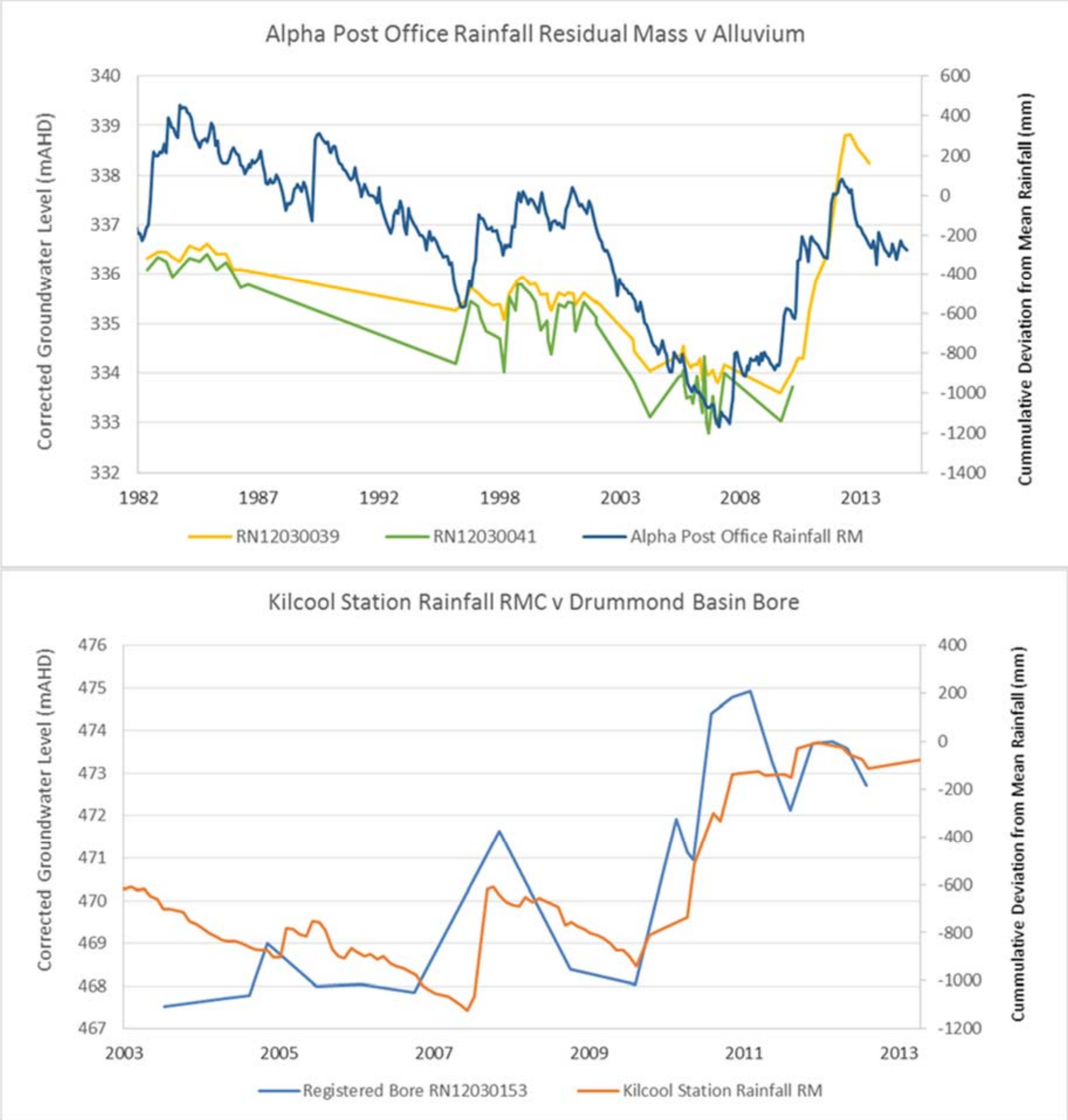
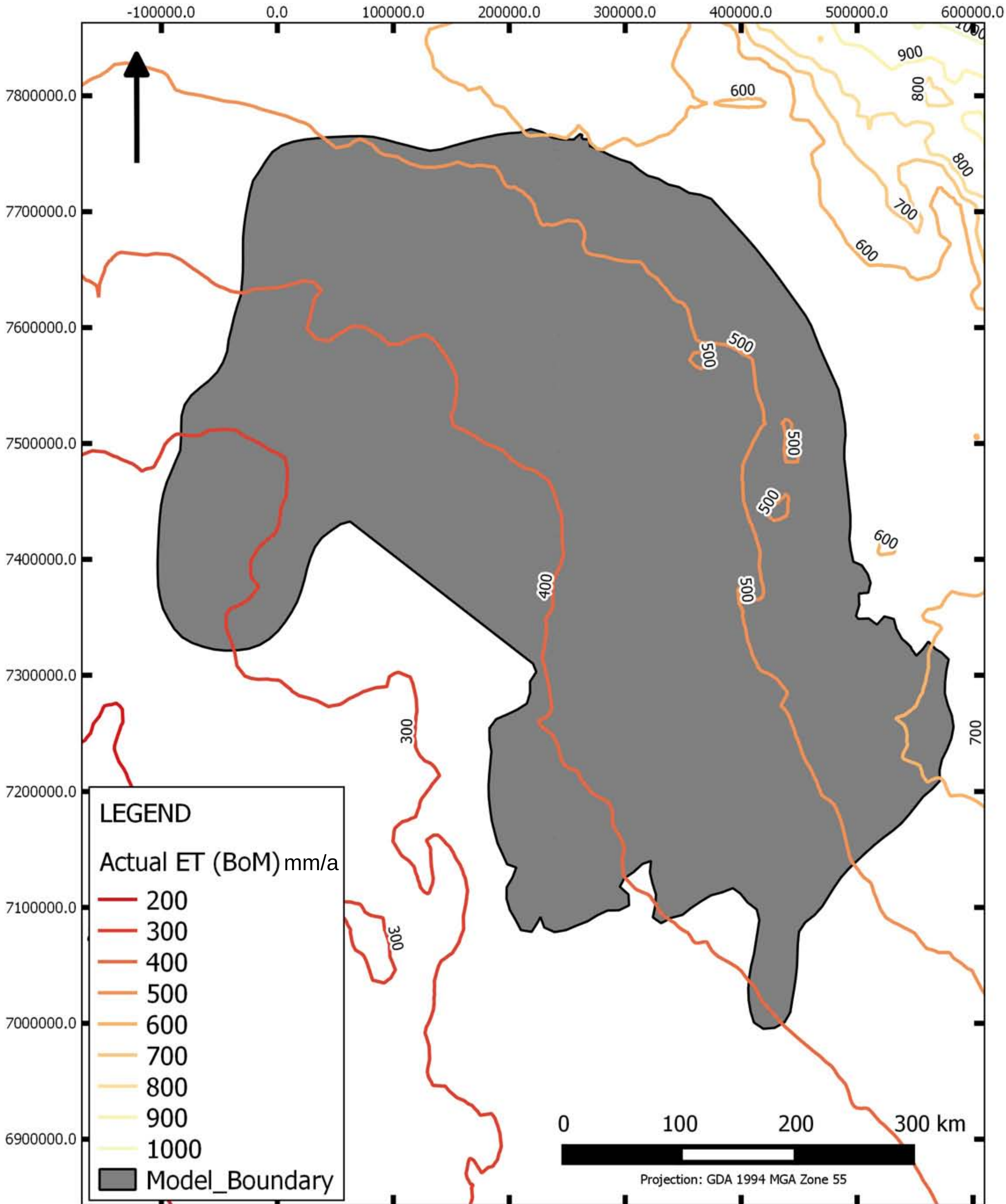


Figure 3-8 Interpreted groundwater hydrographs showing correlation with rainfall residual mass

3.4.2 EVAPOTRANSPIRATION FROM GROUNDWATER

The MODFLOW Evapotranspiration (EVT) package is used to simulate evapotranspiration from the groundwater system. Figure 3-9 shows the distribution of actual evapotranspiration across the model area as published by BoM (2015). The BoM definition for actual ET is: "... the ET that actually takes place, under the condition of existing water supply, from an area so large that the effects of any upwind boundary transitions are negligible and local variations are integrated to an areal average. For example, this represents the evapotranspiration which would occur over a large area of land under existing (mean) rainfall conditions."

Actual evapotranspiration (AET) values were used in preference to potential evaporation (PET) due to MODFLOW's simplified linear depth function meaning use of PET would result in significant overestimation of evaporation with increasing depth to water table. Using the AET values is considered appropriate for water-limited environments with deeper water tables, as occurs within the Galilee Basin. A maximum surface evapotranspiration rate of 1.87 mm/day (683 mm/a) was applied in the south east and a minimum of 0.65 mm/day (237 mm/a) in the west. Simplified land use data (BRS, 2010) was also assessed, and for forested areas an evapotranspiration extinction depth of 9m was applied, while an extinction depth of 1.5m was applied for the remaining areas (mostly open native grassland).



5 JUNE 2015	DRAWN BY: CT	FIGURE 3.9
GEOSCIENCE AUSTRALIA	GSA001 GALILEE BASIN MODEL	

Annual Average Actual Evapotranspiration

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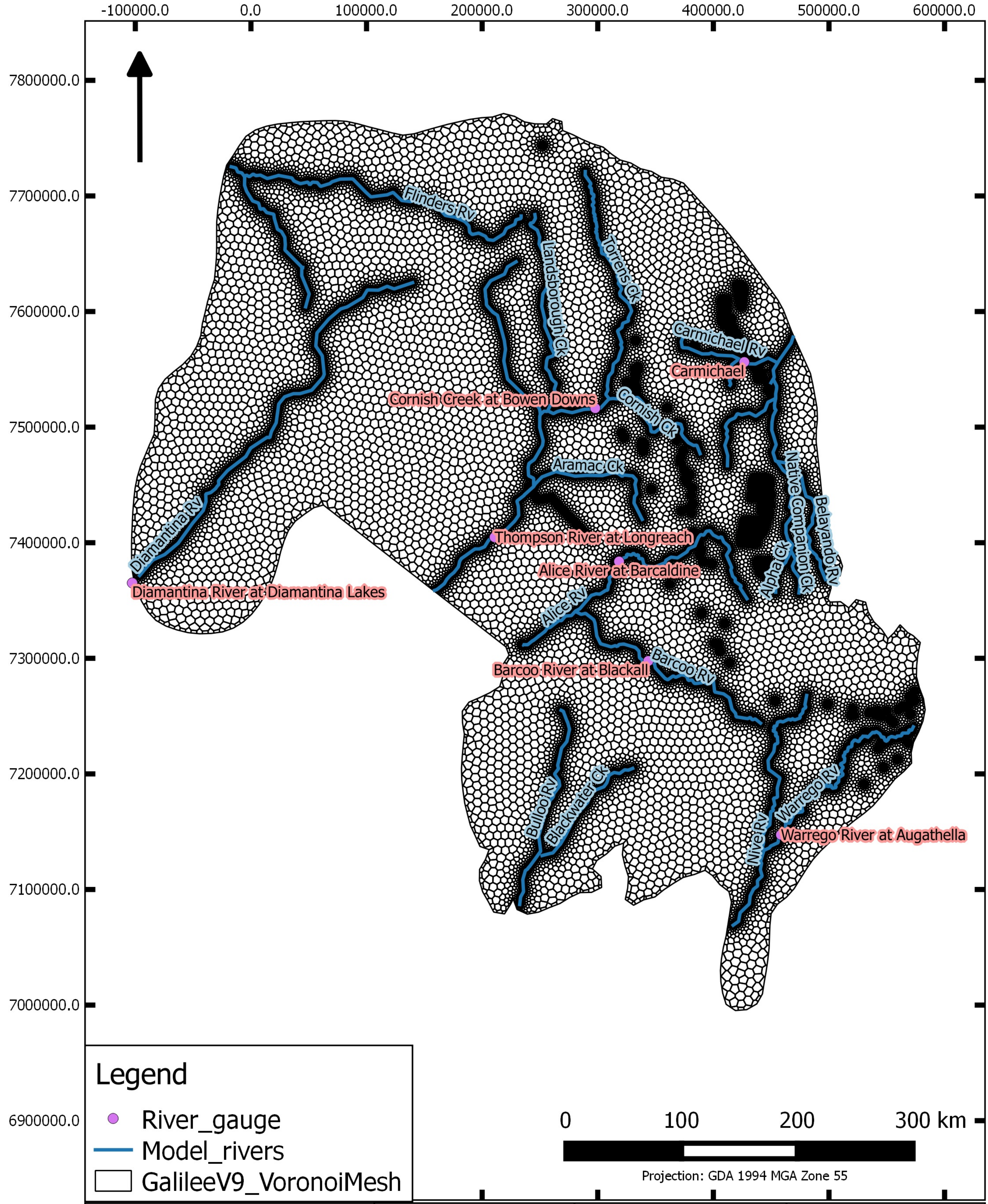
3.4.3 WATERCOURSES

The following watercourses are assumed to have connection to the groundwater system: the Carmichael River, Belyando River, Native Companion Creek, Alpha Creek, Aramac Creek, Thomson River, Flinders River, Diamantina River, Barcoo River, Warrego River and Blackwater Creek (Figure 3-10). These watercourses and their major tributaries are explicitly represented in the model using the MODFLOW River package, allowing two-way flow through the stream bed.

The bed elevation is set at 7m below the 1-second DEM based on a review of the data for available gauge stations within the model boundary (http://www.dnrm.qld.gov.au/water/water-monitoring-and-data/portal) (Table 3-2). The stream stage for the steady-state simulations is set at 1m for all rivers, which represents approximate annual average conditions for the calibration period. For the transient calibration, stream stage is set to vary according to annual average stage height as reported at the aforementioned website.

Table 3-2 Variation in model and recorded elevation data at river gauging stations

GAUGING STATION	GAUGE BANK ELEVATION (mAHD)	GAUGE ZERO ELEVATION (mAHD)	STREAM DEPTH (m)
Thomson River at Longreach	184	177.26	6.74
Alice River at Barcaldine	255	244.95	10.05
Cornish Creek at Bowen Downs	NA	215.32	
Barcoo River at Blackall	282	274.07	7.93
Warrego River at Augathella	365	358.98	6.02



5 JUNE 2015	DRAWN BY: CT	FIGURE 3.10
GEOSCIENCE AUSTRALIA	GSA001 GALILEE BASIN MODEL	

Location of Modelled Rivers and Stream Gauges

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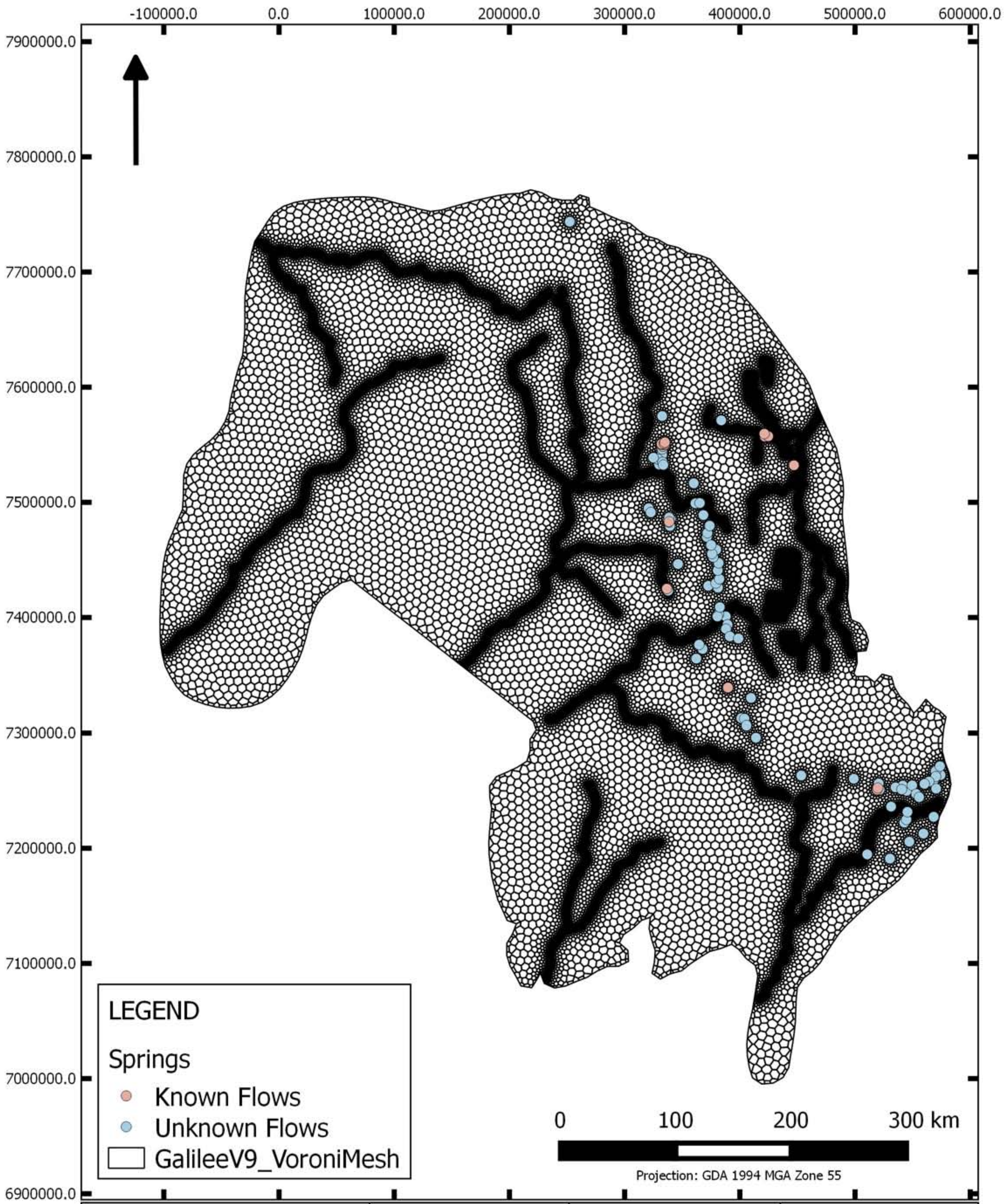
3.4.4 SPRINGS

Groundwater discharge from springs is simulated using the MODFLOW River package (head dependent boundary conditions). The stage and bed elevation of the river cells are set to be equal, effectively allowing one way flow (discharge from groundwater) only. The River package allows for the specification of spring-discharge observation points where the fluxes from these river cells are functions of the calculated groundwater head and assigned conductance. In all, 121 springs are included in the model (Figure 3-11).

Springs of significant value in terms of water discharged (>100m^3/day) include Doongmabulla, Mellaluka, Edgebaston, Coreena and Corinda springs, among others. A total of 27 springs (Jiang et al., 2015) (including those mentioned above) have flow records which are used during calibration as well as included in predictive model runs for impact assessment. The remaining springs do not have known flow volumes, but are included in the model to allow representation of known groundwater discharge pathways. The volume removed from each of these unidentified springs is limited to less than 100m^3/day (about 1 L/s) by reducing conductance to ensure simulation of realistic flows.

The source of a spring is assigned to a known aquifer where the information is available, or to the nearest known source aquifer whilst taking into consideration nearby springs and elevation of the discharge (i.e. ensuring the spring discharge elevation is at least above the base of the assigned aquifer). The stage of the river condition in the model is set at the recorded spring discharge elevation for all springs.



HYDRO SIMULATIONS	5 JUNE 2015	DRAWN BY: CT	FIGURE 3.11
	GEOSCIENCE AUSTRALIA	GSA001 GALILEE BASIN MODEL	
	Modelled Springs		

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3.4.5 REGIONAL GROUNDWATER FLOW

It is considered that no lateral inflow or outflow occurs along the eastern margin of the Galilee subregion where the layers outcrop at surface (Jiang et al., 2015). Thus, no boundary condition is assigned at the eastern edge of the model (effectively a no-flow boundary due to no model cells present) for all 13 layers.

General-head boundaries (GHBs) are applied to the western boundary for the major aquifers (Layers 2, 4 and 6) to represent the regional hydraulic gradient and communication with aquifers outside of the model domain. The time-invariant specified heads of these boundaries are derived from the interpreted corrected potentiometric contours observed in the groundwater units (supplied by GA). The observed/interpreted potentiometric maps are displayed in Appendix C.

All other model edge boundaries are no-flow, and several model layers pinch-out prior to reaching the model edge due to limited extent of the defining layer geology.

3.4.6 GROUNDWATER USE

Groundwater extractions for irrigation, industry and town water supplies have been compiled by GA and are represented in the model using the MODFLOW Well package. Wells in the alluvium and Winton-Muckunda formations are considered to be sub-artesian, while deeper wells are artesian. For steady-state simulations an average of the recorded well flows between 1983 and 2012 has been applied to be consistent with the data set used for calibration (abstractions totalling 613 ML/day). For the historical transient model the actual annual flow values are used, while a constant flow rate as for the year 2012 (895 ML/day) is applied to the predictive model (Figure 3-12). The provided data is in an annual time-series, however for over 70% of the bores the reported annual flow does not change over the duration of data records (1965 - 2012), which is likely to be indicative of low quality flow records as some reduction in flows is expected over time even for the artesian wells. There is also some uncertainty from which aquifer flows are being extracted in a few bores. The result of this is the possibility for well stresses to be misapplied in the model, and as such variable flow rates have been allowed during the model simulation to prevent incorrectly assigned pumping rates from drying out cells in low conductivity layers and causing model instability. Table 3-3 summarises the volume of water theoretically abstracted from each model layer for the year 2012 as per the provided GA dataset. Figure 3-13 shows the locations of each of the pumping wells and the aquifers they are extracting from.

It should be noted that, subsequent to the delivery of the first draft of this Milestone 3 report, GA has acknowledged the presence of anomalies in the data and believe the increase in abstraction over time is unlikely to be correct due to the known capping of free flowing artesian bores over recent years. The well stresses applied in the model are therefore likely to be overestimated and will have affected calibration success and parameterisation.

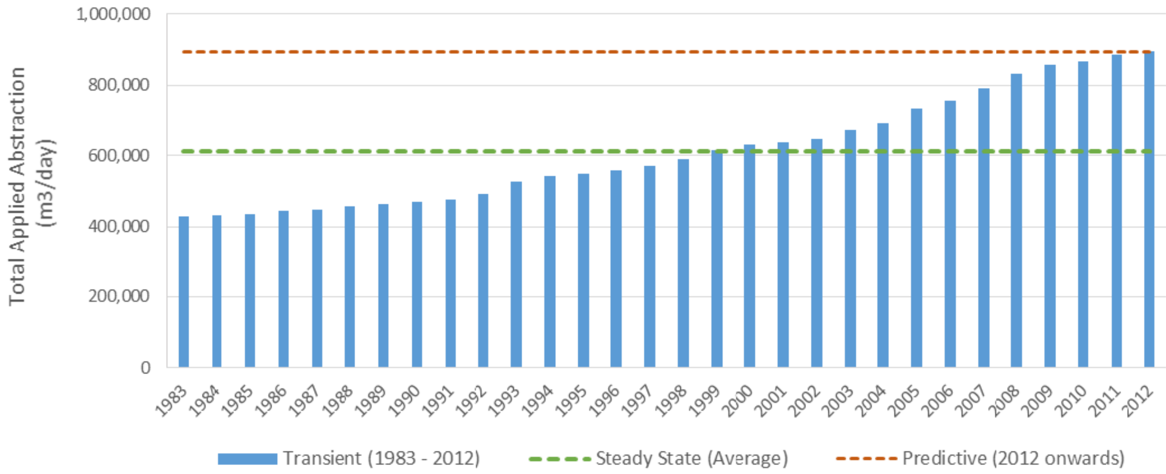
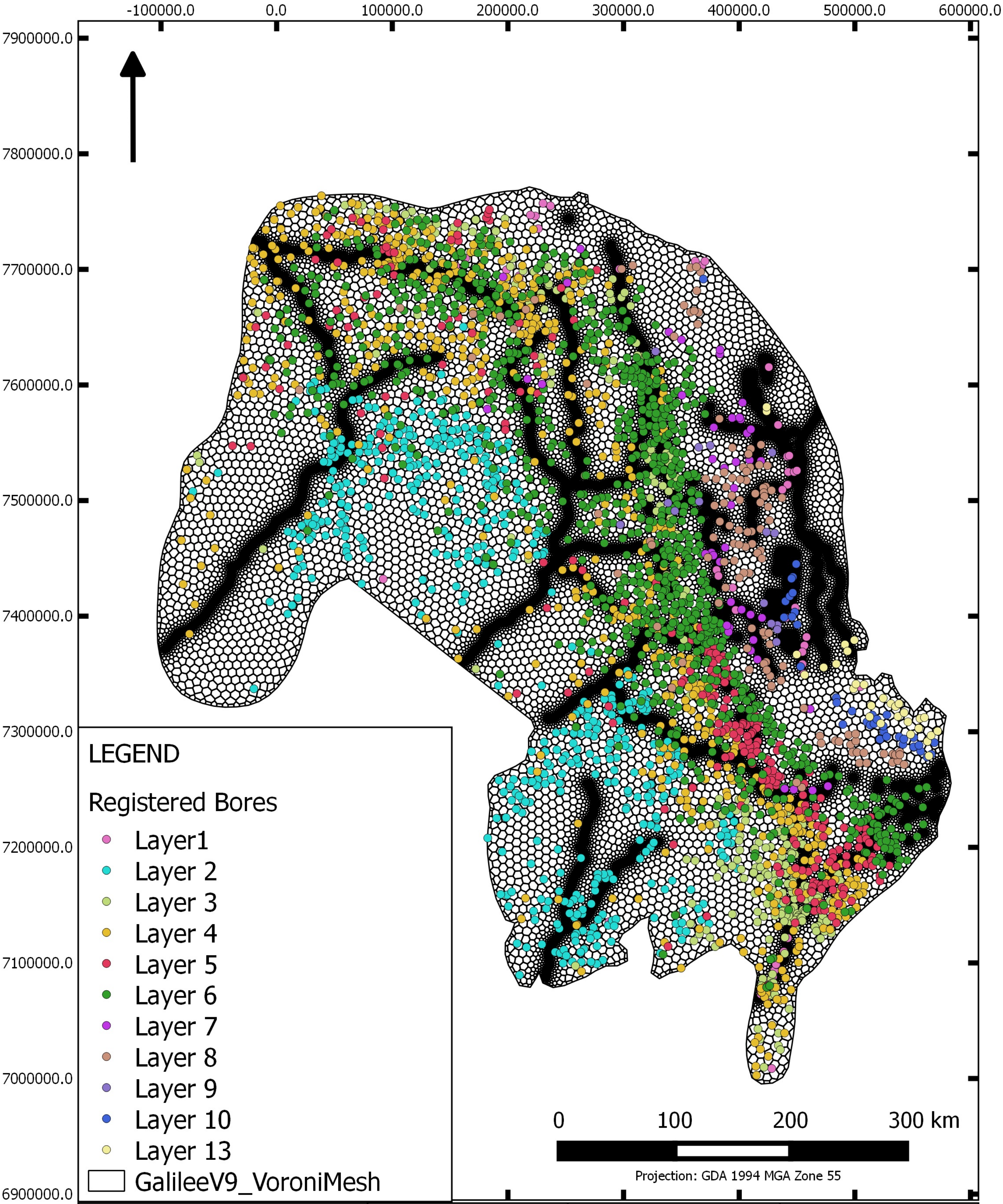


Figure 3-12 Applied well abstraction volumes for steady-state, transient and predictive model runs

Table 3-3 Modelled groundwater abstractions

Model Layer	Aquifer	V4 Revised Flow (ML/day)
1	Alluvium	2.9
2	Mackunda Formation	53.8
3	Wallumbilla Formation	26.6
4	Cadna-owie Formation	293.3
5	Adori Sandstone	87.8
6	Hutton Sandstone	419.3
7	Moolayember Formation	3.8
8	Clematis Group	5.4
9	Rewan Group	1.0
10	Bandanna Formation	0.8
13	Joe Joe Group	0.5
	TOTAL	**895.1**



5 JUNE 2015	DRAWN BY: CT	FIGURE 3.12
GEOSCIENCE AUSTRALIA	GSA001 GALILEE BASIN MODEL	
Location of Modelled Extraction Bores (V4)		

HydroSimulations

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3.4.7 MINE WORKINGS - DEWATERING

The MODFLOW Drain package is used to simulate mine dewatering in the predictive model, which integrates the proposed mine plans for the seven mines in terms of the location, timing, depth and methods of extraction. Drain boundary conditions allow a one-way flow of water out of the model. When the computed head drops below the stage of the drain, the drain cells become inactive (Rumbaugh, 2011). This is an effective way of theoretically representing removal of water seeping into a mine over time, with the actual removal of water being via pumping and ventilation.

Due to limited mine plan information and spatial coal seam elevation data, open pits are assumed to be the full thickness of the relevant target coal seam layer as indicated in the BA Coal Resource Assessment (Lewis *et al.*, 2014), and similarly the base of mined longwalls is assumed to be the base of the layer. This is likely to create deeper mining elevations than reality in most instances due to the lumping of coal seam and interburden layers. The drain inverts of the proposed coal mining areas are set at 0.1m above the model layer base containing the target coal seam, which is typical practice in models representing mining activities and allows representation of a seepage face as well as aiding model stability. Drain cells are progressively added in the transient model to simulate the extraction of panels over time; however, due to the limited mine scheduling data available, the accuracy of these drain activations in time and space is limited. Assumed mine progression plans for each location are shown in Appendix D.

3.4.8 MINE WORKINGS – OVERBURDEN DEFORMATION

Hydraulic parameters are changed with time in the goaf and overlying fractured zones during extraction of each longwall panel using the MODFLOW-USG Time-Variant Materials (TVM) package to simulate fracturing due to caving.

The height of the fractured zone above the longwall, and the uncertainty associated with that height, is calculated using a model developed by Ditton (the "Ditton model") as described in the following sub-sections.

Conceptual Model of Overburden Deformation

The conceptual model of deformation consists of four zones (Figure 3-14) (Ditton and Merrick, 2014):

- the A-Zone or "Continuous Cracking" zone - equivalent to the caved zone plus the connective-cracking part of the fractured zone;
- the B-Zone or "Lower Dilated" zone - equivalent to the disconnected-cracking part of the fractured zone, or the lower part of the constrained zone;
- the C-Zone or " Upper Dilated" zone - equivalent to the upper part of the constrained zone; and
- the D-Zone or "Surface Cracking" zone - equivalent to the surface zone.

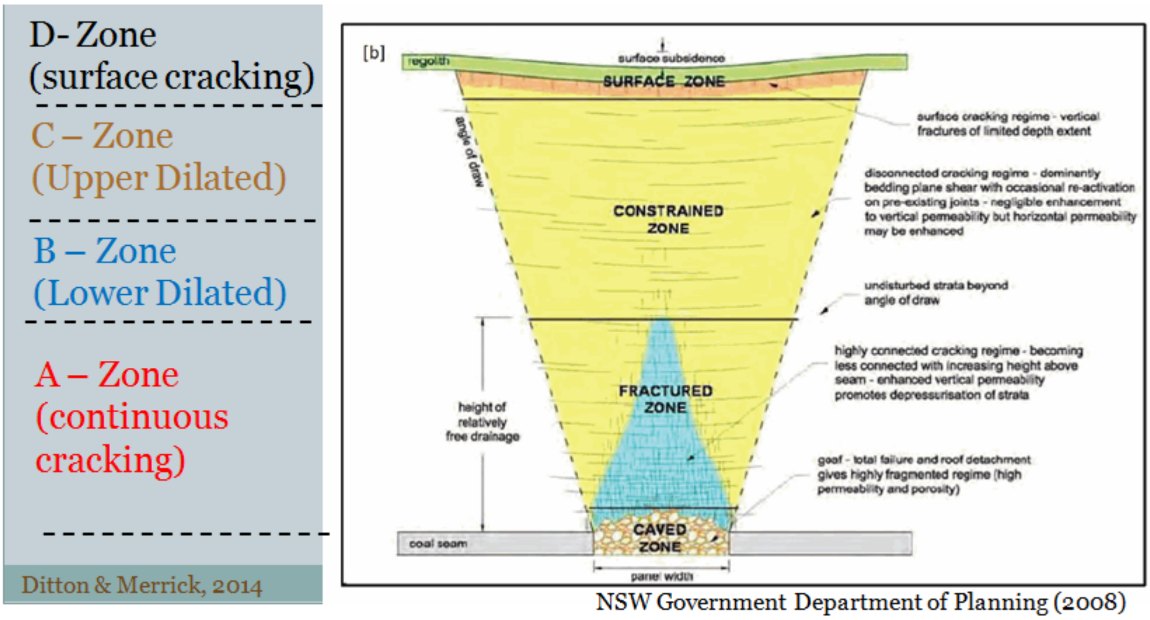


Figure 3-14 Conceptual Model of Subsidence and Deformation above Longwalls

The strata in the A-Zone would have a substantially higher vertical permeability than the undisturbed host rock. This will encourage groundwater to move out of storage within the rock and percolate downward toward the goaf. In the B-Zone, where disconnected-cracking occurs, the vertical movement of groundwater should not be significantly greater than under natural conditions, but horizontal permeability would be expected to be enhanced through dilation of bedding planes.

Depending on the width of the longwall panels and the depth of mining, and the presence of low permeability lithologies, there would be a constrained zone (C-zone) in the overburden that acts as a bridge (Figure 3-14). In this zone rock layers are likely to sag without breaking, and bedding planes are also likely to dilate. As a result, some increase in horizontal permeability can be expected.

In the surface zone, near-surface fracturing can occur due to horizontal tension at the edges of a subsidence trough. Fracturing would be shallow (<20 m), often transitory in that cracks can close or fill with sediment, and any water lost into the cracks would not continue downwards towards the goaf. MSEC (2013) notes that surface water lost to the subsurface re-emerges downstream.

Estimation of Fracturing Height

The Ditton model (Ditton and Merrick, 2014) includes the key parameters that govern the fracture height , i.e. panel width (W), cover depth (H), mining or cutting height (T) and local geology factors to estimate the A-Zone (connective cracking) and B-Zone (disconnected cracking) horizons above a given longwall panel. Segregation between the A-Zone and B-Zone is based on a threshold vertical strain of 8 mm/m.

Formulas are offered for two models:

- **Geometry Model**, which depends on W, H and T; and
- **Geology Model**, which depends on W, H, T and t' (where t' is the effective thickness of the bridging or spanning stratum where the A-Zone height occurs).

The formulas for fractured zone height (A) for single-seam mining are:

- **Geometry Model**: $A = 2.215\ W'^{0.357}\ H^{0.271}\ T^{0.372}$ +/- [0.1 - 0.16] W' (metres);
- **Geology Model**: $A = 1.52\ W'^{0.4}\ H^{0.535}\ T^{0.464}\ t'^{-0.4}$ +/- [0.1 - 0.15] W' (metres);

  where W' is the minimum of the panel width (W) and the critical panel width (1.4H).

The 95th percentile (maximum) A-Zone heights (the A95 height) are estimated by adding aW' to A, where a varies from 0.1 for supercritical panels to 0.16 (geometry model) or 0.15 (geology model) for subcritical panels.

For this project the geology model has been used as it is generally more conservative. Each mine is assigned known parameters where available. In the absence of detailed data, longwall properties are assumed to be comparable to those of the Carmichael project.

These models have been validated to 34 measured Australian case-studies (including West Wallsend, Mandalong, Springvale, Able, Ashton, Austar, Berrima, Metropolitan and Wollemi/North Wambo Mines in New South Wales and two mines in the Bowen Basin, Queensland) with a broad range of mining geometries and geological conditions included. The database also includes three cases in which connective cracking reached the surface (South Bulga, Homestead and Invincible Collieries in New South Wales). Statistics for the database are presented in Table 3-4.

Table 3-4 Statistics for the Ditton model database for Australian coalfields

STATISTIC	Panel Width [W (m)]	Cover Depth [H (m)]	Mining Height [T (m)]
Mean	191	254	3.0
Standard Deviation	65	138	0.8
Minimum	110	75	1.9
Median	179	213	2.8
Maximum	355	500	6.0

Ditton (2014, pers. comm.) has a procedure for estimating the increased fractured zone height for multi-seam mining, in which the mining height (T) in the above formulas is replaced by an effective mining height (T') for the upper mined seam that accounts for the additional subsidence caused by mining other seams. This relies on theoretical estimates of subsidence for single or multiple seams. The ratio of the increase in subsidence (due to mining another seam) to the subsidence for a single seam is taken to apply also to the increase in the effective mining height[2].

Representative statistics for characteristic ratios derived for the Ditton database are listed in Table 3-5 and Table 3-7. A common first-order estimate of fractured zone height is afforded by the ratio A/W, which is 0.45 for the Ditton concept at the median (Table 3-5). The Ditton B-Zone ratio is 0.60 at the median (Table 3-6). Another common first-order estimate of fractured zone height is afforded by the ratio A/T, which is 21-37 for the Ditton concept (Table 3-4). For the parameters W, H and T in turn, the median B-height exceeds the median A-height by 33%, 100% and 34% (Table 3-6).

[2] One unpublished case study in the Hunter Coalfield NSW showed an increase in the effective mining height of about 70%. This had the effect of increasing the A-height by 27%.

Table 3-5 Exceedance probabilities for Ditton continuous fracture zone (A-Zone) height for Australian coalfields.

EXCEEDANCE PROBABILITY	Height of Fracture Zone / Panel Width [A/W]	Height of Fracture Zone / Cover Depth [A/H]	Height of Fracture Zone / Mining Height [A/T]
20%	0.38	0.23	21
50%	0.45	0.43	32
80%	0.73	0.69	37

Table 3-6 Exceedance probabilities for Ditton discontinuous fracture zone (B-Zone) height for Australian coalfields.

EXCEEDANCE PROBABILITY	Height of Fracture Zone / Panel Width [B/W]	Height of Fracture Zone / Cover Depth [B/H]	Height of Fracture Zone / Mining Height [B/T]
20%	**0.47**	**0.60**	**27**
50%	**0.60**	**0.86**	**43**
80%	**1.07**	**0.95**	**71**

Calculations were carried out using the Ditton 'Geology Model' for the planned mining areas of the Galilee Basin, with data for mining geometries and subsidence taken from GA supplied EIS Subsidence reports. Some variation in detail of mining geometries existed in the supplied data, with some companies providing individual longwall scale information, while others generalised to the total mining zone. Table 3-7 presents calculated A-zone fracture heights and Depth to A-zone fracture range for generalised sections of underground mining activity.

Mine-scale images of fracture zones and uppermost fractured geological units can be found in Appendix E. In general, fracturing is predicted to reach ground surface along the eastern edges of mine footprints, or where multi-seam mining is planned. Along the western edges of mine footprints, where the coal is deeper, fracturing is expected to extend no higher than the Rewan Group.

The EIS models generally have applied either no fracturing or a constant fractured zone height for the entire mine footprint, without consideration of the Ditton (or similar) algorithms, or consideration of multi-seam mining effects:

- Carmichael: 160m;
- Kevin's Corner: no fractured zone was simulated;
- China First: 180m; and
- South Galilee: no fractured zone was simulated in the base model.

For Carmichael and China First, fracturing was simulated as extending to ground surface where coal is shallower, and to the top of the Rewan Group (Carmichael) or the base of the Rewan Group (China First) where coal is deeper. In general, the HS model for the Galilee Basin has adopted more elevated fractured zones than assumed in the EIS models, has allowed for multi-seam effects, and has taken into consideration the spatial variability in heights in accordance with geometrical and geological attributes for each mining project. Nevertheless, the height of fracturing remains considerably uncertain given that the Galilee Basin is a greenfield domain for coal mining.

Table 3-7 Estimated height of connected fracturing for underground mines

Mining Zone	Panel Width (m)	Range in Cover Depth (m)	A Zone Fracture Height Range (m)	Range of Depth to Fracture (m)	Fracture to Surface	Multiseam Mining
Carmichael Multi - Seam	310	120-400	180-264	(-40) - 146	Yes	Yes
South Galilee D1 Seam	360	50 - 240	58 - 253	(-8) - (-13)	Yes	Yes
South Galilee D2 Seam	360	60 - 250	50 - 188	12 - 62	Possible	No
China First - Northern	480	100 - 380	79 - 263	21 - 117	No	No
China First - Central	480	120 - 390	84 - 240	36 - 150	No	No
China First - Southern	480	100 - 390	71 - 240	29 - 150	No	No
China First - Western	480	90 - 250	100 - 259	(-10) -(-9)	Yes	Yes
Kevin's Corner - Northern	410	70 - 290	61 - 231	9 - 59	Possible	No
Kevin's Corner - Central	410	140 - 300	141 - 285	(-1) - 15	Yes	No
Kevin's Corner - Southern	410	120 - 280	122 - 270	(-2) - 10	Yes	No
China Stone- Northern	470	190 - 480	162 - 333	28 - 147	No	No
China Stone- Central	470	85 - 515	76 - 346	9 - 169	Possible	No
China Stone- Southern	320	70 - 405	64 - 276	6 - 174	Possible	No

Note: A negative value in 'range of depth to fracture' means that connected fracturing (the A-zone) is likely to extend to ground surface.

Change in Hydraulic Properties in Deformed Strata

During the prediction period, hydraulic parameters are changed using the TVM package of USG-beta (also known as "*VERSION further developments 2.0.0*"), which allows varying property values to be simulated over time. For the purposes of simulating the drainage of groundwater into mine voids, the height of Ditton's connective cracking ('A-zone') is of most relevance, because this zone is fractured through strata, thereby providing enhanced connective permeability for groundwater flow down into the void.

Because of the thicknesses of the Permian layers in this groundwater flow model, i.e. BC1 (model layer 10) and BC2 (model layer 11), which include both coal seams and interburden, simulating changes in hydraulic properties for the mined seam and caved zone, as distinguished from the rest of the A-zone, is not possible. Therefore only the changes normally applied by HS for the A-zone have been applied in this model.

Vertical and horizontal hydraulic conductivity in the fractured 'A' zone were enhanced according to a log-linear monotonic (ramp) function. The function varied the hydraulic conductivity field within the deformation zone overlying coal extraction areas and weighted the hydraulic conductivity changes on layer thickness. Limits for the variability were governed by predicted fracture height and assigned upper and lower bounds on hydraulic conductivity in the fractured zone, starting at a K_Z multiplier of 1000 in the layer hosting the mined coal seam, and then declining with height above that point.

3.4.9 HYDROGEOLOGICAL BEHAVIOUR OF WASTE AND SPOIL EMPLACEMENT

For open cut mining, Hawkins (1998) and Mackie (2009) indicate that spoil and waste rock are more permeable than the undisturbed strata. Based on review of that literature, the likely properties are presented in Table 3-8 including additional recharge due to the enhanced permeability allowing greater recharge.

Table 3-8 Hydraulic properties of spoil

K_h [m/d]	K_z [m/d]	Sy	Recharge
1	1	0.2	5% rainfall

Kh, Kv and Sy (specific yield) values are based on Hawkins (1998) and Mackie (2009).

3.5 MODEL VARIANTS

Both steady-state and transient models have been developed:

- Steady-state model of average pre-mining conditions.
- Transient model calibration/verification based on temporal pre-mining data at 30 annual time intervals from 1983 to 2012.
- Transient predictive model simulating both the proposed mining period for all seven mines and recovery periods up to year 2220, with stress periods of 1-5 years duration[3] to the end of the last mine (Hyde Park in 2077) and increasing period lengths to recovery. Table 3-9 summarises the model simulation periods.

Lewis (et al,. 2014) was used to determine mine timings for the majority of mines, however small variations in timing from this document are as follows:

1. Due to significant uncertainty in timing for Hyde Park (with a mine life between 30 and 60 years indicated by Resolve Coal (http://www.hydeparkcoal.com.au/), HS elected to run the excavation for 45 years.
2. Due to lack of available mine plan or schedule data provided by GA for the Carmichael mine, the Updated Mine Project Description (GHD, 2013) was used to determine rate and timing of mining.
3. Data provided for the Kevin's Corner mine schedule showed pre-mine infrastructure (access roadways etc) developed beyond the extent of scheduled mining. HS elected to interpolate the additional longwall schedule as per the average timing of excavation as per Figure 3-15.

[3] Annual periods were initially planned but the reduced modelling project time window necessitated coarsening of the time scale

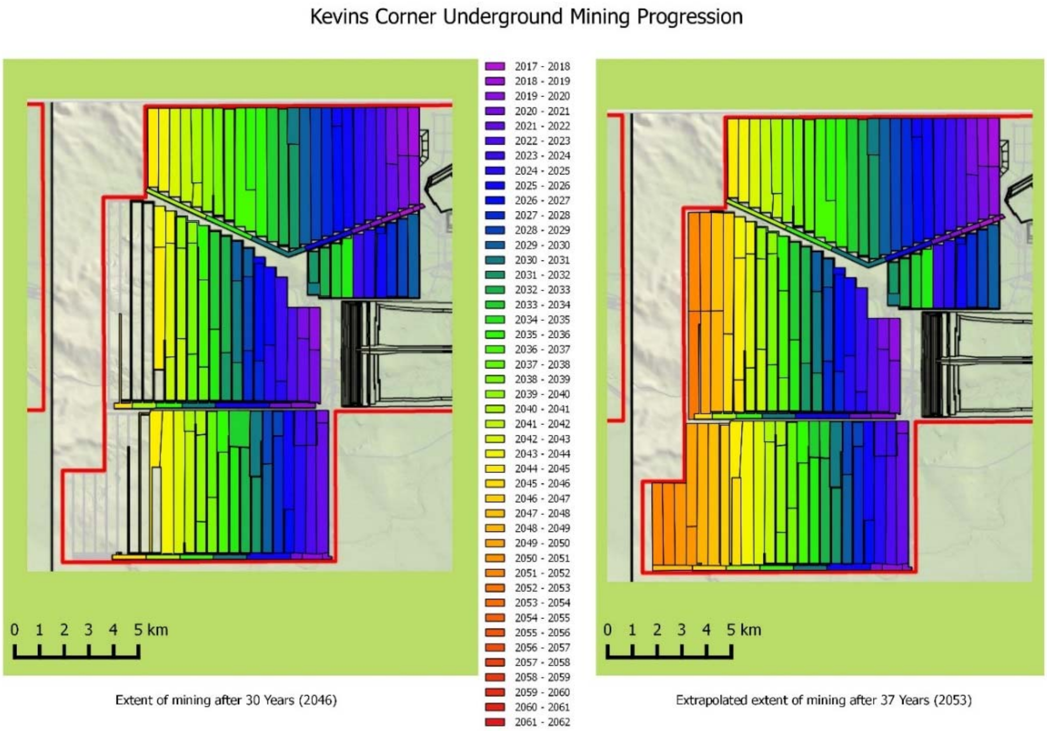
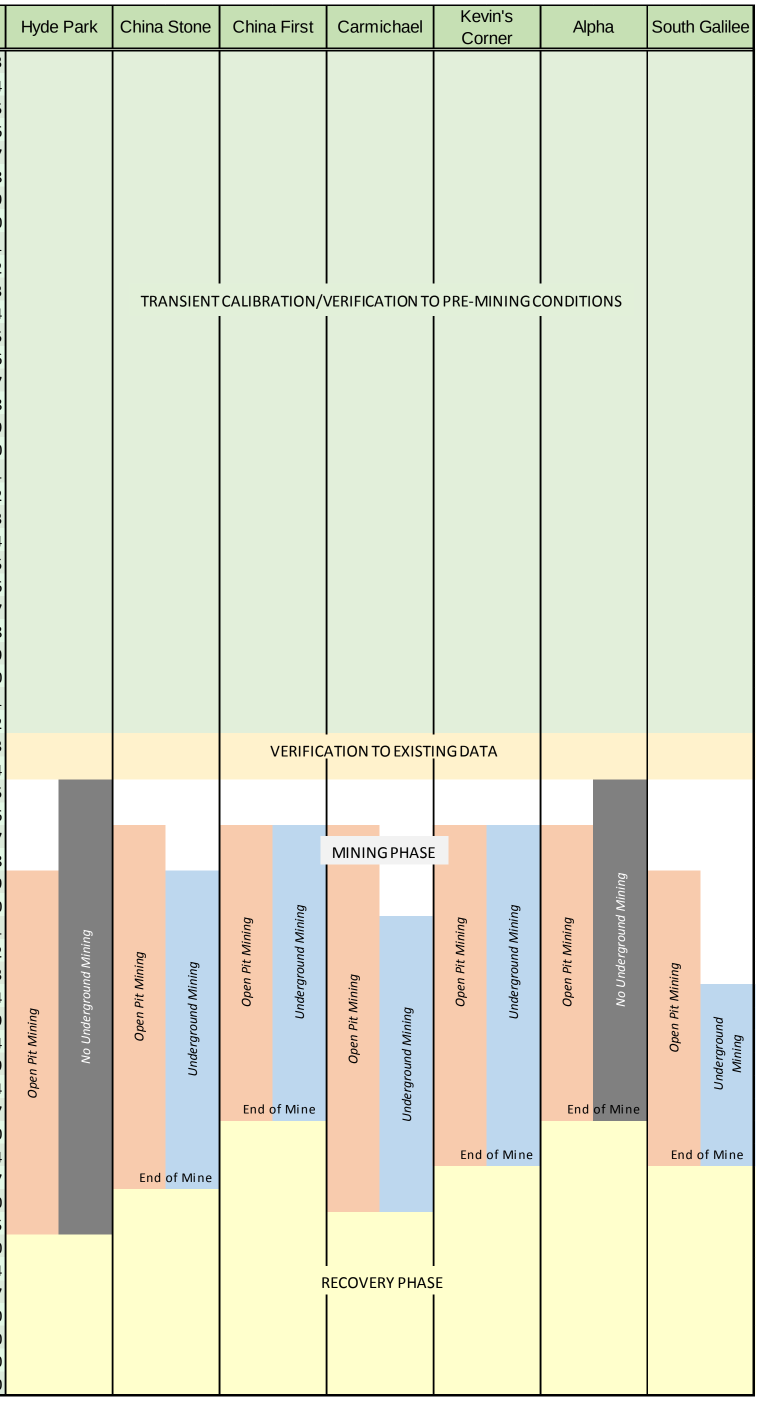


Figure 3-15 GA Provided mine schedule data for Kevin's Corner (left) and HS interpolated schedule (right)

Table 3-9 Transient model time-stepping

Stress Period	Length (Days)	Length (Years)	Start Date	End Date
1	365	1	1/01/1983	31/12/1983
2	366	1	1/01/1984	31/12/1984
3	365	1	1/01/1985	31/12/1985
4	365	1	1/01/1986	31/12/1986
5	365	1	1/01/1987	31/12/1987
6	366	1	1/01/1988	31/12/1988
7	365	1	1/01/1989	31/12/1989
8	365	1	1/01/1990	31/12/1990
9	365	1	1/01/1991	31/12/1991
10	366	1	1/01/1992	31/12/1992
11	365	1	1/01/1993	31/12/1993
12	365	1	1/01/1994	31/12/1994
13	365	1	1/01/1995	31/12/1995
14	366	1	1/01/1996	31/12/1996
15	365	1	1/01/1997	31/12/1997
16	365	1	1/01/1998	31/12/1998
17	365	1	1/01/1999	31/12/1999
18	366	1	1/01/2000	31/12/2000
19	365	1	1/01/2001	31/12/2001
20	365	1	1/01/2002	31/12/2002
21	365	1	1/01/2003	31/12/2003
22	366	1	1/01/2004	31/12/2004
23	365	1	1/01/2005	31/12/2005
24	365	1	1/01/2006	31/12/2006
25	365	1	1/01/2007	31/12/2007
26	366	1	1/01/2008	31/12/2008
27	365	1	1/01/2009	31/12/2009
28	365	1	1/01/2010	31/12/2010
29	365	1	1/01/2011	31/12/2011
30	366	1	1/01/2012	31/12/2012
31	365	1	1/01/2013	31/12/2013
32	365	1	1/01/2014	31/12/2014
33	365	1	1/01/2015	31/12/2015
34	366	1	1/01/2016	31/12/2016
35	365	1	1/01/2017	31/12/2017
36	365	1	1/01/2018	31/12/2018
37	365	1	1/01/2019	31/12/2019
38	366	1	1/01/2020	31/12/2020
39	365	1	1/01/2021	31/12/2021
40	365	1	1/01/2022	31/12/2022
41	365	1	1/01/2023	31/12/2023
42	366	1	1/01/2024	31/12/2024
43	1826	5	1/01/2025	31/12/2029
44	1826	5	1/01/2030	31/12/2034
45	1826	5	1/01/2035	31/12/2039
46	1827	5	1/01/2040	31/12/2044
47	1095	3	1/01/2045	31/12/2047
48	1096	3	1/01/2048	31/12/2050
49	1461	4	1/01/2051	31/12/2054
50	1096	3	1/01/2055	31/12/2057
51	1096	3	1/01/2058	31/12/2060
52	1826	5	1/01/2061	31/12/2065
53	1826	5	1/01/2066	31/12/2070
54	1461	4	1/01/2071	31/12/2074
55	1096	3	1/01/2075	31/12/2077
56	1095	3	1/01/2078	30/12/2080
57	3653	10	31/12/2080	31/12/2090
58	10956	30	1/01/2091	30/12/2120
59	36524	100	31/12/2120	30/12/2220



3.6 INITIAL CONDITIONS

The initial hydraulic properties were set as per GA's recommendation (Table 3-10) with Layer 13 properties added by HS. The major GAB aquifers are divided into east and west hydraulic conductivity zones based on the analysis of observed potentiometric head surfaces. The hydraulic gradients appear higher in the east than in the west, and are likely to be due to weathering of the rock outcrop resulting in the production of clay minerals, thus lower conductivities are applied in the east (Evans et al., 2015). Initial heads for the steady-state simulation were set 2m below the top of each layer and progressive model iterations used the simulated heads of the previous run. The transient model commenced with simulated steady-state heads using the 1983 flow rate for well stress.

Note that the three coal measures layers (10-12) are aggregates of interburden and coal seams. Separate representation of coal seams A-E, as done in the EIS models, would have made the model intractably large.

Table 3-10 Initial hydraulic conductivity and storage parameters

LAYER	FORMATION		K_H (m/day)	K_Z (m/day)	S_S (m^{-1})
1	Cenozoic		1.00E+0	1.00E-1	1.00E-3
2	Winton/Mackunda Formation		1.00 E+0	1.00E-1	1.50E-4
3	Allaru/Toolebuc/Wallumbilla Formation		3.00E-3	3.00E-4	5.00E-5
4	Cadna-owie Formation/ Hooray Sandstone/ Gilbert River Formation/ Ronlow Beds	WEST	1.50E+0	1.50E-1	5.00E-5
		EAST	5.00E-1	5.00E-2	5.00E-5
5	Westbourne/ Adori/ Birkhead Formation (Injune Creek Group)		5.00E-4	5.00E-4	5.00E-5
6	Hutton Sandstone/ Precipice Sandstone and equivalents	WEST	2.00E+0	2.00E-2	5.00E-5
		EAST	5.00E-1	5.00E-2	5.00E-5
7	Moolayember Formation		5.00E-3	5.00E-4	1.00E-5
8	Clematis Group/Warang Sandstone	WEST	2.00E+0	2.00E-1	1.00E-5
		EAST	5.00E-1	5.00E-2	1.00E-5
9	Rewan/Dunda Beds Formation		5.00E-4	5.00E-5	1.00E-6
10	Top of Bandanna to base of B Seam(BC1)		5.00E-2	5.00E-3	1.00E-5
11	Base of B Seam to top of E Seam (BC2)		1.25E-1	1.25E-4	1.00E-5
12	Top of E Seam to top of Joe Joe(BC3)		5.00E-2	5.00E-5	1.00E-5
13	Joe Joe Formation (Model Basement)		2.00E-4	2.00E-6	1.00E-5
13	Crystalline Basement (Model Basement)		2.00E-4	2.00E-6	1.00E-5
13	Drummond Basin (Model Basement)		2.00E-4	2.00E-6	1.00E-5

3.7 STEADY-STATE CALIBRATION

The following sections detail calibration work carried out using the most recent well flow data provided by GA on July 1, 2015.

3.7.1 CALIBRATION PARAMETERS

Steady-state calibration was undertaken manually and with the automated calibration utility PEST (Doherty, 2010). Calibration focused on both horizontal and vertical hydraulic conductivity, with parameter bounds informed as per Table 3-10. Vertical hydraulic conductivity was calibrated as a factor of horizontal conductivity (K_Z/K_H) with a maximum ratio of 1. It was found that K_Z was required to be reduced further than the limits suggested by GA, especially in the coal seam layers, with calibrated values constrained instead by K_Z/K_H factors reported in other EIS model results. Stream and spring conductance were also varied by layer to simulate estimated flows as closely as possible. Storage parameters are not required during steady-state calibration and recharge and ET were held constant. Calibrated parameters are shown in Table 3-11. Relative sensitivity of each of the calibrated parameters is shown in Figure 3-16 (as calculated by PEST using Jacobian sensitivity matrices), indicating that the horizontal hydraulic conductivity of the GAB aquifer layers as well as the Colinlea Sandstone (Layer 12) and Joe Joe Formation (Layer 13) tend to dominate the calibration results. It is also notable that the ratio between horizontal and vertical hydraulic conductivity is most sensitive in aquitard layers (Layers 3, 5, 7 and 9) where this property acts as the controlling feature on vertical flow between layers. Calibrated parameters were compared with other model results where possible, and are all in the same range as the individual mine EIS models and the Surat Basin regional model (Table 3-12), with the exception of Layer 12 (BC3) which has calibrated parameters higher than the other models.

Table 3-11 Initial and calibrated model hydraulic conductivity parameters (steady-state) (m/day)

Layer	Zone	Units	Min K_H	Max K_H	Calibrated K_H	Initial K_z	Calibrated K_z
1	20	Regolith	1.00E-01	1.00E+01	1.00E+00	1.00E-02	1.00E-02
1	1	Alluvium (Cenozoic)	1.00E-01	1.00E+01 *(5.00E+01)*	3.00E+01	1.00E-01	5.68E-01
2	2	Winton/ Mackunda Fm	1.00E-01	1.00E+01	2.57E-01	1.00E-01	1.27E-03
3	3	Allaru/ Toolebuc/ Wallumbilla Fm	3.00E-04	3.00E-02	3.04E-04	3.00E-04	3.04E-04
4	4	Cadna-Owie - EAST	5.00E-02	5.00E-01	1.72E-01	5.00E-02	8.30E-04
4	40	Cadna-Owie - WEST	1.50E-01	1.50E+00 *(3.00E+00)*	2.61E+00	1.50E-01	9.01E-01
5	5	Westbourne/ Adori	5.00E-05	5.00E-03	1.26E-04	5.00E-04	6.69E-05
6	60	Hutton/Precip ice - EAST	5.00E-02	5.00E-01	1.27E-01	5.00E-02	1.27E-01
6	6	Hutton/Precip ice - WEST	2.00E-01	2.00E+00	7.59E-01	2.00E-02	7.59E-02
7	7	Moolayember Fm	5.00E-04	5.00E-02 *(5.00E-01)*	2.26E-01	5.00E-04	2.26E-04
8	80	Clematis-Warang - EAST	5.00E-02	5.00E-01 *(2.50E+00)*	1.96E+00	5.00E-02	3.84E-02

8	8	Clematis-Warang - WEST	2.00E-01	2.00E+00 *(5.00E+00)*	4.02E+00	2.00E-01	2.11E-02
9	9	Rewan/ Dunda	5.00E-05	5.00E-03	3.00E-04	5.00E-05	6.00E-06
10	10	Top of Bandanna to base B Seam (BC1)	5.00E-02	5.00E-01	1.30E-01	5.00E-03	1.00E-04
11	11	Base B seam to Top E Seam (BC2)	1.25E-02	1.25E-00	7.40E-01	1.25E-04	1.00E-05
12	12	Top E seam to Top Joe Joe (BC3)	5.00E-03	5.00E-01 *(2.50E+00)*	2.50E+00	5.00E-05	1.00E-03
13	13	Joe Joe Grp (Model Basement)	*1.00E-03*	*1.00E-07*	8.77E-05	*1.00E-06*	8.77E-06
13	14	Drummond Basin (Model Basement)	*1.00E-02*	*1.00E-07*	2.00E-03	*1.00E-06*	7.35E-04
13	15	Crystalline Basement (Model Basement)	*1.00E-04*	*1.00E-07*	2.00E-05	*1.00E-06*	2.42E-07

Values in *RED italics* indicate where HS has modified or assigned the parameter limits during calibration – in most instances this was a half an order of magnitude increase. All other bounding values are as stipulated by GA (Jaing et al., 2015).

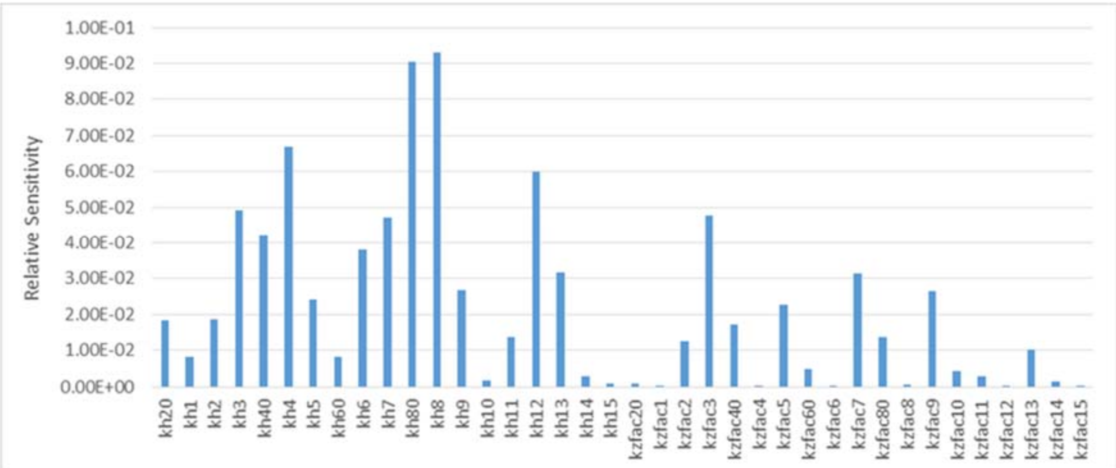


Figure 3-16 Parameter sensitivity for steady-state model (as calculated by PEST)

Table 3-12 Comparison to other model calibrated parameters

Formation	Calibrated K_H	Calibrated K_Z	K_H/K_Z	Other model K_H	Other model K_Z	Other model K_H/K_Z	Reference*
Regolith	1.00E+00	1.00E-02	1.00E+02	5.00E+00	1.00E-01	5.00E+01	1
				2.00E+01	2.00E+00	1.00E+01	1
Alluvium	3.00E+01	5.68E-01	5.28E+01	1.52E+00	1.24E-02	1.23E+02	2
				1.00E+02	1.00E+01	1.00E+01	5
Westbourne	1.26E-04	6.69E-05	1.88E+00	1.44E-03	5.68E-06	2.54E+02	3
Hutton SSt (east)	1.27E-01	1.27E-01	1.00E+00	5.23E-01	2.84E-02	1.84E+01	3
Hutton SSt (west)	7.59E-01	7.59E-02	1.00E+01				
Moolayember Fm	2.26E-01	2.26E-04	1.00E+03	1.42E-03	1.25E-04	1.14E+01	3
				9.99E-01	9.99E-01	1.00E+00	5
Clematis Sst (east)	1.96E+00	3.84E-02	5.10E+01	3.00E+00	1.00E-01	3.00E+01	1
				2.36E-01	2.72E-02	8.68E+00	2
Clematis Sst (west)	4.02E+00	2.11E-02	1.91E+02	1.99E-01	2.73E-02	7.29E+00	3
				5.00E+00	5.00E-01	1.00E+01	5
Rewan Fm	3.00E-04	6.00E-06	5.00E+01	2.30E-03	9.30E-05	2.47E+01	1
				8.47E-02	1.73E-04	4.90E+02	2
				5.44E-02	9.73E-05	5.59E+02	3
				9.39E-04	9.29E-05	1.01E+01	4
				1.38E-04	1.38E-05	1.00E+01	5
Top of Bandanna to base B Seam (BC1)	1.30E-01	1.00E-04	1.30E+03	2.30E-03	9.30E-05	2.47E+01	1
				1.70E-04	1.30E-06	1.31E+02	1
				1.50E-02	1.00E-05	1.50E+03	1
				1.50E-01	5.00E-05	3.00E+03	1
				3.65E-02	5.16E-04	7.07E+01	2
				2.05E-02	5.18E-08	3.96E+05	2
				3.18E-02	6.37E-06	4.99E+03	3
				1.70E-04	1.30E-06	1.31E+02	4
				5.62E-03	5.62E-04	1.00E+01	5
				1.70E-01	1.70E-02	1.00E+01	5
Base B seam to Top E Seam (BC2)	7.40E-01	1.00E-05	7.40E+04	1.50E-02	1.00E-05	1.50E+03	1
				1.50E-02	1.00E-05	1.50E+03	1
				5.00E+00	9.96E-03	5.02E+02	2
				1.00E+00	8.47E-02	1.18E+01	2
				1.54E-02	1.01E-05	1.52E+03	4
				1.54E-02	1.01E-05	1.52E+03	4
				1.70E-01	5.82E-05	2.92E+03	4
				2.23E-01	2.23E-02	1.00E+01	5
Top E seam to Top Joe Joe (BC3)	2.50E+00	1.00E-03	2.50E+03	1.30E-03	1.90E-04	6.84E+00	1
				1.03E-02	1.45E-06	7.10E+03	2
				1.24E-04	3.78E-09	3.28E+04	2
				1.54E-02	1.01E-05	1.52E+03	4
				variable	3.60E-05		5
Joe Joe Group	8.77E-05	8.77E-06	1.00E+01	1.70E-04	1.30E-06	1.31E+02	1

References: 1 - Galilee/China First (Heritage Computing, 2013); 2 - South Galilee (HS, 2012), 3 - Surat Basin (GHD, 2011); 4 - Alpha/Kevin's Corner (URS, 2012); 5 - Carmichael (GHD, 2013).

3.7.2 CALIBRATION STATISTICS

Steady-state calibration was assessed against water levels provided by GA, which have been corrected for temperature and salinity to ensure comparability with MODFLOW predictions which do not take account of density variation. Some QA of calibration targets was undertaken, and targets that were considered obviously dubious were removed. Key reasons for selected target removal include:

- locations where the only water level record was taken on the date of borehole drilling;
- where there were two or more levels within the same layer at the same location with significantly different readings; and
- where there was uncertainty in which model layer the reading was from.

Resulting calibration statistics for the steady-state simulation are shown in Table 3-13, and a graphical plot of observed vs modelled water levels is shown in Figure 3-17. Spatial plots of the target residuals for each layer are presented in Appendix F and average residuals are shown in Table 3-14. Predictions within ±10m of target levels are distributed evenly across the model domain, however a tendency remains to under-predicting heads in the west and over-predicting heads in the east. An area of significant over-prediction (>50m) occurs within Layers 11 and 12 at the south east of the model, however this is not in close proximity to any modelled mining activity. Target residuals at the southern group of mines (Kevin's Corner, Alpha, China First and South Galilee) are relatively good, with an over-prediction of approximately 13m being the most significant discrepancy. However at Carmichael, particularly north of the Carmichael River, significant model over-predictions of up to 38m occur within the coal seam layers. This is similar to the previous mine scale modelling carried out (GHD, 2013) who also had difficulty calibrating the northern portion of the model. This is possibly attributed to some un-registered water use (e.g. private abstraction bores) causing a reduction in observed groundwater levels that is not modelled, however this is speculative and not confirmed. No data was available for calibration at either China Stone or Hyde Park at the time of model development.

Table 3-13 Steady-state calibration statistics (from model run GAL_SS61)

Statistic	Value
Residual Mean (m)	5.71
Absolute Residual Mean (m)	17.62
Residual Standard Deviation (m)	23.27
Sum of Squares (m^2)	339,911
RMS Error (m)	23.94
Minimum Residual (m)	-100.00
Maximum Residual (m)	119.28
Number of Observations	593
Range in Observations (m)	506
Scaled RMS Error	4.6%
% Targets within ±10m	43%
% Targets within ±25m	73%

Table 3-14 Average residual by model layer (from model run GAL_SS61)

Model Layer	Formation	Average Residual (m)	Number of Locations
1	Cenozoic	10.7	153
2	Winton/Mackunda Formation	2.6	35
3	Allaru/Toolebuc/Wallumbilla Formation	11.7	31
4	Cadna-owie Formation/Hooray Sandstone/Gilbert River Formation/Ronlow Beds	-4.3	98
5	Westbourne/Adori/Birkhead Formation (Injune Creek Group)	-3.6	49
6	Hutton Sandstone/Precipice Sandstone and equivalents	-11.3	55
7	Moolayember Formation	2.7	14
8	Clematis Group/Warang Sandstone	13.5	28
9	Rewan/Dunda Beds Formation	-8.9	14
10	Top of Bandanna to base of B Seam (BC1)	4.8	17
11	Base of B Seam to top of E Seam (BC2)	46.5 (22.3)*	18
12	Top of E Seam to top of Joe Joe(BC3)	20.9 (5.8)*	31
13	Joe Joe Formation / Drummond Basin/ Crystalline Basement	9.5	50

*Average residual excluding over-predicted heads at south east model edge. Negative residuals indicate modelled heads too low, positive indicated modelled heads to high.

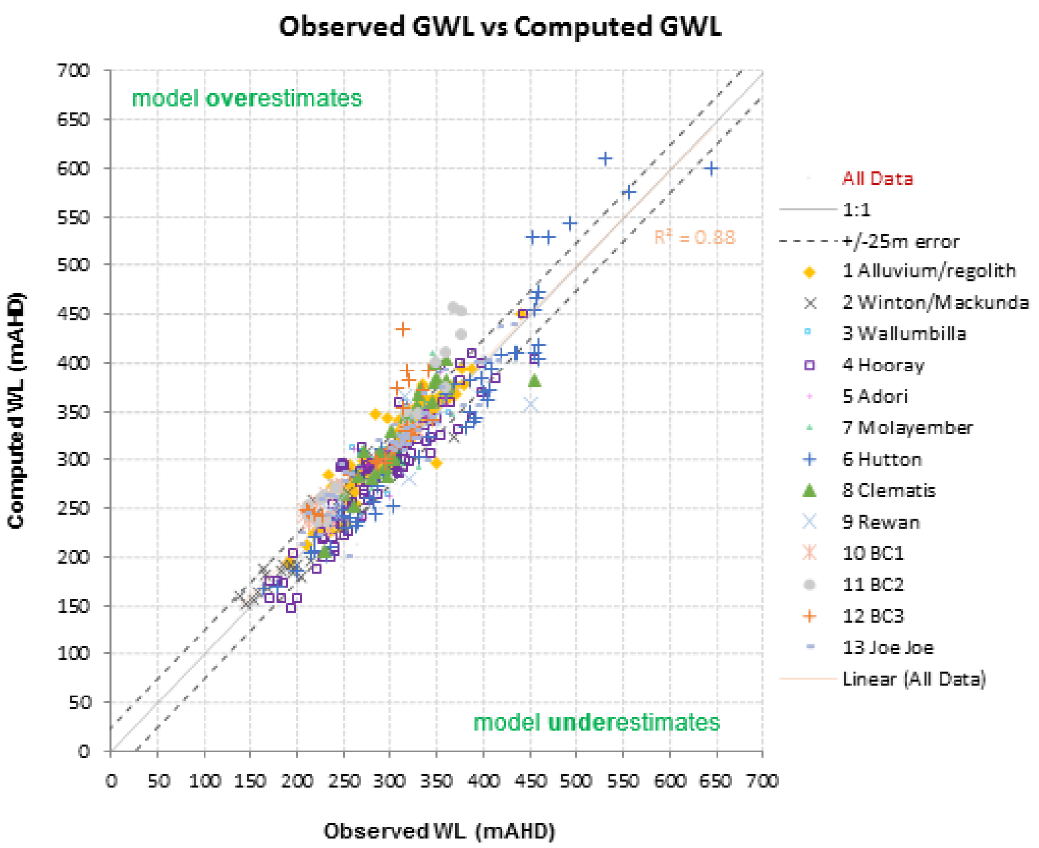


Figure 3-17 Plot of observed vs computed water levels for steady-state model

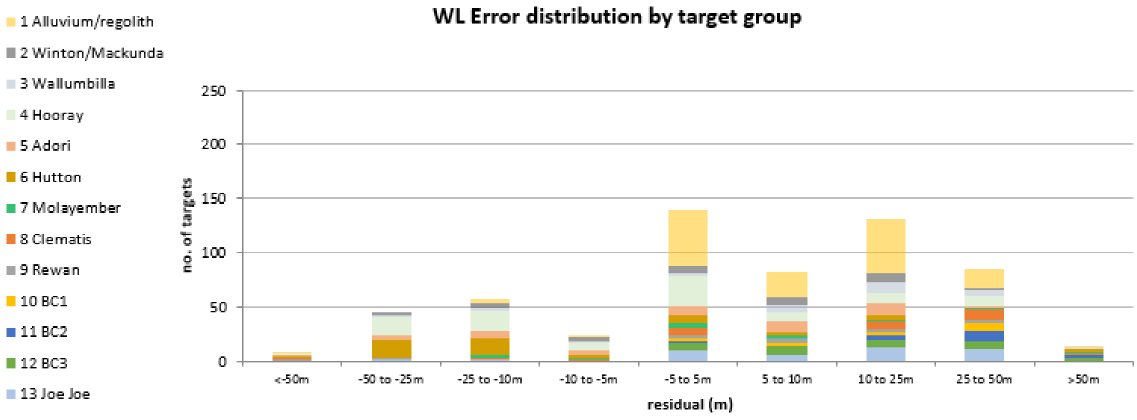


Figure 3-18 Residual error distribution for steady-state model

Data sources for target levels include single and long term piezometer records, single point vibrating wire piezometer (VWP) data and level data collected during packer testing. Where only a single data point was available for a given monitoring location this value was used as a calibration target regardless of the date, therefore some intrinsic variability in annual and seasonal conditions at the time of water level measurement exists. Additionally, the quality of data from packer testing and VWP records is not verified due to single measurement points and lack of long term data trends for analysis and it is possible that the data was affected by drilling and installation activities (i.e. the levels may not have stabilised prior to the recorded measurements). For the few locations where transient records are available, groundwater hydrographs (Appendix B) were analysed and an average water level was used as a steady-state target where considered appropriate. There are several instances in the data where targets from the same model layer in close proximity show >20m head variation, indicating the variability in the water levels of the dataset, as well as the actual variability of real-world potentiometric heads within each layer due to the bulking together of several hydrogeological units within the model.

3.7.3 COMPARISON TO INTERPRETED POTENTIOMETRIC HEAD SURFACES

Following from the GA Groundwater Conceptual Model, the nature of potentiometric surfaces occurring in the modelled region can be divided into Eromanga Basin units and the underlying Galilee Basin Units. Simulated model contours have been plotted against GA interpolated potentiometric surfaces and are shown in Appendix G.

Eromanga Basin

The potentiometric surface of the Cenozoic and Winton/ Mackunda Formation is seen to represent the regional water table. Observed heads approximately follow the regional dip and topography with flow to the west and southwest. Modelled heads replicate the groundwater flow direction well, and there is general agreement between interpreted and modelled contour elevations with typically less than 20m head difference across the model extent. The Hooray Sandstone aquifer shows less potentiometric surface variation over its extent than the overlying Winton/ Mackunda Formation and does not show correlation with topography other than near the intake beds in the eastern zone. Groundwater flow is to the west and southwest. Again modelled heads show good agreement with flow direction, but with a potentiometric elevation 10-30m below the observed data on average. The Hutton Sandstone is the last major aquifer unit of the Eromanga Basin and shows an interpreted head surface very similar to that seen in the Hooray Sandstone, with model results also showing the same properties as that of the Hooray unit.

Galilee Basin

The aquifer units present in the Galilee Basin system show slightly different potentiometric surfaces and flow directions. The southern section of the Clematis/ Warang Sandstone aquifer shows a northwest groundwater flow direction, with the central and northern sections showing a westerly and southwest flow respectively. Model results replicate these flow directions well, however again there is a general 10m to 20m under-prediction in model heads across most of the model, and an over-prediction of heads at the eastern intake areas. The Betts Creek Beds serve as a partial aquifer and house the coal seams targeted for mining in the region. Potentiometric surfaces for BC1, BC2 and BC3 show a groundwater divide to the west of the Koburra trough, with flow direction split into east (against regional dip) and west components. Modelled heads for BC1 to BC3 follow observed flow trends however with a similar overestimation of heads at the east as observed in many other layers. The underlying Joe Joe Group is seen as the regional aquitard, but also has the capacity to store and transmit groundwater locally. Modelled groundwater flow generally corresponds with the locally interpreted potentiometeric surface in the centre of the basin, but as with the coal seam layers there is a significant overestimation of heads at the east.

3.7.4 MASS BALANCE

The water balance for the steady-state simulation is presented in Table 3-15. It can be observed that just under half of the recharge to groundwater comes from direct rainfall recharge, with leakage from rivers and flow from regional boundaries providing roughly equal inflows. Most of the losses to the system occur via evapotranspiration, with well flows being the second highest loss followed by baseflow to rivers and loss to springs. Regional outflow to the Great Artesian Basin to the west is a relatively minor component of flow.

Table 3-15 Steady-state model mass balance

	Inflow (ML/day)	Outflow (ML/day)
RECHARGE (RCH)	858.3	0.0
ET (FROM GW) (EVT)	0.0	791.4
GW EXTRACTION (WEL)	0.0	584.2
SW-AQUIFER INTERACTION RIVERS AND SPRINGS (RIV)	588.4	351.4
REGIONAL GW FLOW (GHB)	543.3	263.0
STORAGE	NA	NA
TOTAL	1,990.0	1,990.0
% ERROR	0.0	0.0

GHB = General Head Boundary

3.7.5 CALIBRATION OF SPRING FLOWS AND BASEFLOW

Spring flows from the steady-state model are lower than observed flows which is likely to be due to simulated heads being too low in the location of some of the springs. Additionally, recorded flows appear to be approximated due to many springs having the same flow records. Total modelled spring flow under-estimates reported flows by approximately 1 order of magnitude.

Table 3-16 Values of observed vs modelled spring flow

Name	Layer	Observed (m3/day)	Modelled (m3/day)
Corinda	4	114	162
Corinda	4	9,846	167
Corinda	4	8,123	257
Corinda	4	2,559	216
Corinda	4	172	105
Corinda	4	1,114	165
Edgbaston	4	147	88
Coreena	4	1,977	0
Salvator Rosa National Park	6	17,237	0
Salvator Rosa National Park	6	2,166	128
Maryvale Springs	6	628	0
Doongmabulla	8	647	196
Doongmabulla	8	647	182
Doongmabulla	8	647	389
Doongmabulla	8	647	195
Doongmabulla	8	647	553
Doongmabulla	8	647	398
Doongmabulla	8	647	278
Doongmabulla	8	647	225
Doongmabulla	8	129	58
Doongmabulla	8	289	553
Doongmabulla	8	516	342
Doongmabulla	8	391	0
Doongmabulla	8	391	77
Doongmabulla	8	303	1075
Mellaluka	13	1,758	0
Mellaluka	13	1,758	0
	Total	**47,484**	**5,808**

Calibration to baseflow has not been possible due to uncertainty in actual baseflow records. HS considers the baseflow volumes calculated by GA to be too high in most instances to be representative of regional groundwater contribution to gauge flow (>30% of gauge flow in short duration stream flow hydrographs). It is considered more likely to represent local scale shallow interflow through the unsaturated zone which is not represented by the groundwater model. Additionally, the GA-calculated average annual baseflow exceeds the maximum possible annual baseflow (calculated by average catchment recharge supplied by GA multiplied by catchment area sourced from http://www.dnrm.qld.gov.au/water/water-monitoring-and-data/portal). For this reason, predictive impact modelling compares the relative reduction in baseflow (%) rather than actual volumes. Table 3-17 provides steady-state modelled river-aquifer interactions for each river at the gauge stations. The model results show that all but two rivers (Thomson and Diamantina) act as *net* losing systems overall (although there are gaining reaches along sections of these rivers, as shown in Table 3-17).

Table 3-17 Steady-state simulated river – aquifer interaction

Gauging Station	Modelled Baseflow (m3/day)	Modelled Leakage (m3/day)	Overall Status
Thomson River at Longreach	5,812	340	Gaining
Alice River at Barcaldine	15,456	18,290	Losing
Cornish Creek at Bowen Downs	18,230	88,586	Losing
Warrego River at Augathella	18,023	87,582	Losing
Diamantina River at model edge	56,872	29,054	Gaining
Carmichael River	8,643	11,010	Losing
Belyando River at model edge	21,428	60,940	Losing
Barcoo River at Blackall	4,420	12,857	Losing

3.8 TRANSIENT CALIBRATION

3.8.1 CALIBRATION PARAMETERS

Transient calibration/verification has been performed for the period from January 1983 to December 2012 using annual average target data from groundwater hydrographs. Due to the relatively limited data set for transient calibration, steady-state K_H and K_Z factors were held constant during transient calibration and only storage parameters (Ss and Sy) were changed for calibration. Recharge was set to be variable using the CSIRO and HS multiplication factors outlined in Section 3.4.1, and river stage was set to vary as per Section 3.4.3. Automatic calibration was attempted using PEST, however due to long model run times this became impractical and simpler manual calibration was carried out.

Calibrated storage parameters are shown in Figure 3-17. Hydraulic conductivities are as per steady-state. Specific storage values within the GAB layers were required to be quite high in order to prevent excessive drawdown due to well abstraction over the calibration period. Upon completion of this project it has been acknowledged that pumping rates are probably too high, thus it is probable that recalibration using corrected flow rates would reduce storage and hydraulic conductivity values. Storage properties for the coal seam layers were modelled at the lower limit of parameter bounds provided by GA.

Table 3-18 Initial and calibrated storage parameters (transient)

Layer	Units	Initial Ss	Minimum Ss	Maximum Ss	Calibrated Ss	Initial Sy	Calibrated Sy
1	Regolith	1.00E-03	1.00E-04	1.00E-02	1.00E-03	1.00E-03	1.00E-02
1	Alluvium (Cenozoic)	1.00E-03	1.00E-04	1.00E-02	1.00E-03	1.00E-03	1.00E-01
2	Winton / Mackunda Fm	1.50E-04	1.00E-05	1.50E-03 *(1.00E-02)*	1.00E-02	N/A	1.00E-02
3	Allaru /Toolebuc/ Wallumbilla Fm	5.00E-05	5.00E-06	5.00E-04	5.00E-04	N/A	1.00E-02
4	Cadna-Owie - EAST	5.00E-05	5.00E-06	5.00E-04	5.00E-04	N/A	1.00E-02
4	Cadna-Owie - WEST	5.00E-05	5.00E-06	5.00E-04	5.00E-04	N/A	8.00E-03
5	Westbourne/Adori	5.00E-05	5.00E-06	5.00E-04	5.00E-04	N/A	8.00E-03
6	Hutton/Precipice - EAST	5.00E-05	5.00E-06	5.00E-04	5.00E-04	N/A	1.50E-02
6	Hutton/Precipice - WEST	5.00E-05	5.00E-06	5.00E-04	5.00E-04	N/A	7.00E-03
7	Moolayember Fm	1.00E-05	1.00E-06	1.00E-04	1.00E-04	N/A	7.00E-03
8	Clematis-Warang - EAST	1.00E-05	1.00E-06	1.00E-04	1.00E-04	N/A	1.50E-02
8	Clematis-Warang - WEST	1.00E-05	1.00E-06	1.00E-04	1.00E-04	N/A	6.00E-03
9	Rewan/ Dunda	1.00E-06	1.00E-07	1.00E-05	1.00E-07	N/A	5.00E-03
10	BC1 AB seam	1.00E-05	1.00E-06	1.00E-04	1.00E-06	N/A	1.00E-02
11	BC2 Interburden	1.00E-05	1.00E-06	1.00E-04	1.00E-06	N/A	8.00E-03
12	BC3 E seam	1.00E-05	1.00E-06	1.00E-04	1.00E-06	N/A	1.00E-02
13	Joe Joe Grp/ Basement	1.00E-05	*1.00E-06*	*1.00E-08*	1.00E-07	N/A	7.00E-03
13	Drummond Basin	1.00E-05	*1.00E-06*	*1.00E-08*	1.00E-07	N/A	7.00E-03
13	Crystalline Basement	1.00E-04	*1.00E-06*	*1.00E-08*	1.00E-07	N/A	7.00E-03

Values in *RED* indicate where HS has modified or assigned the parameter limits during calibration. All other bounding values are as stipulated by GA (Jaing et al., 2015).

3.8.2 CALIBRATION STATISTICS

All available data for transient calibration occurred in the east of the model area. The majority of targets available for transient calibration occurred within the alluvium, with a few locations each for the Hooray, Adori, Hutton and Joe Joe, and single points for Wallumbilla and Rewan. Target locations and residuals are shown in Appendix F. Transient hydrographs for the alluvium targets tended to match within 5m in most instances (Figure 3-19), while for deeper layers the model simulates the overall trend in levels but not the absolute levels (Appendix H).

Model calibration results are shown in Table 3-19 and Figure 3-19.

Table 3-19 Transient model calibration statistics

Statistics	Value
Residual Mean (m)	5.72
Absolute Residual Mean (m)	11.31
Residual Standard Deviation (m)	15.87
Sum of Squares (m^2)	156,240
RMS Error (m)	16.85
Minimum Residual (m)	-33.01
Maximum Residual (m)	52.42
Number of Observations	550
Range in Observations (m)	268
Scaled RMS Error	5.9%
% Targets within ±10m	64%
% Targets within ±25m	89%

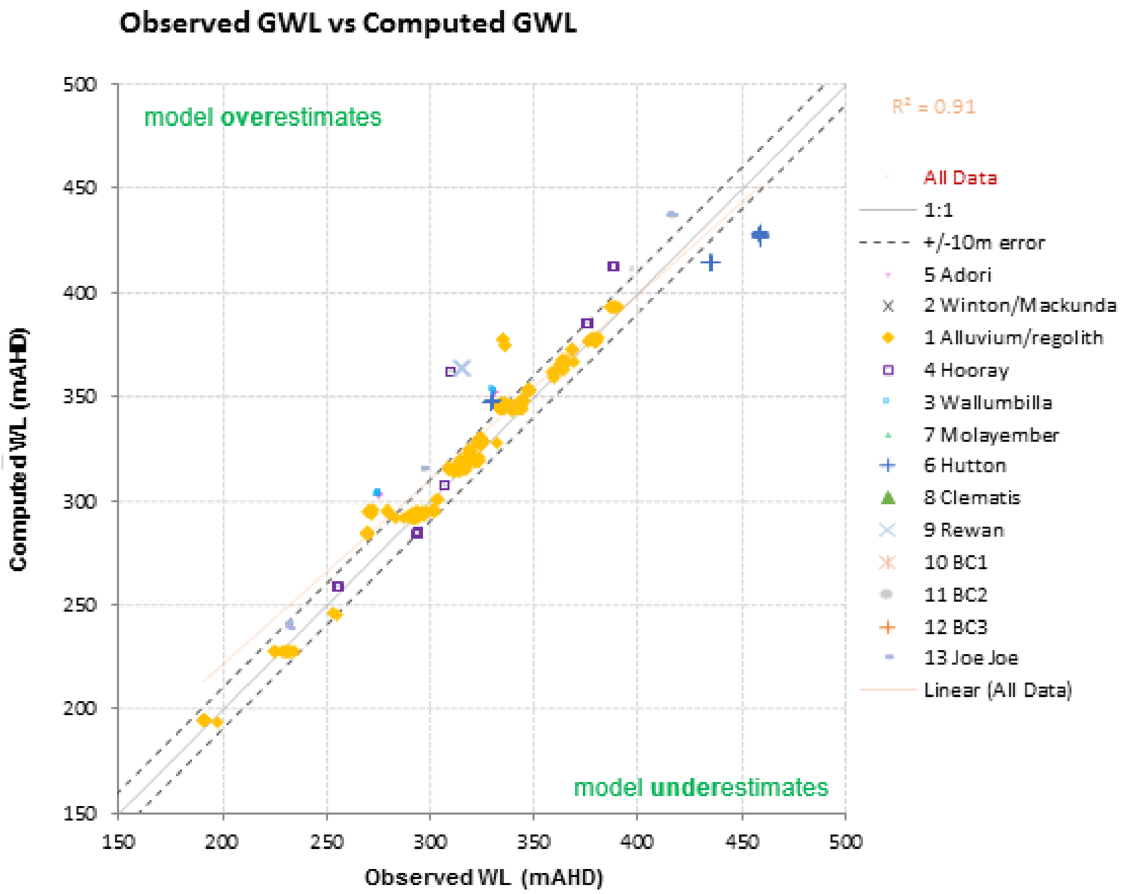


Figure 3-19 Plot of observed vs computed water levels for transient model

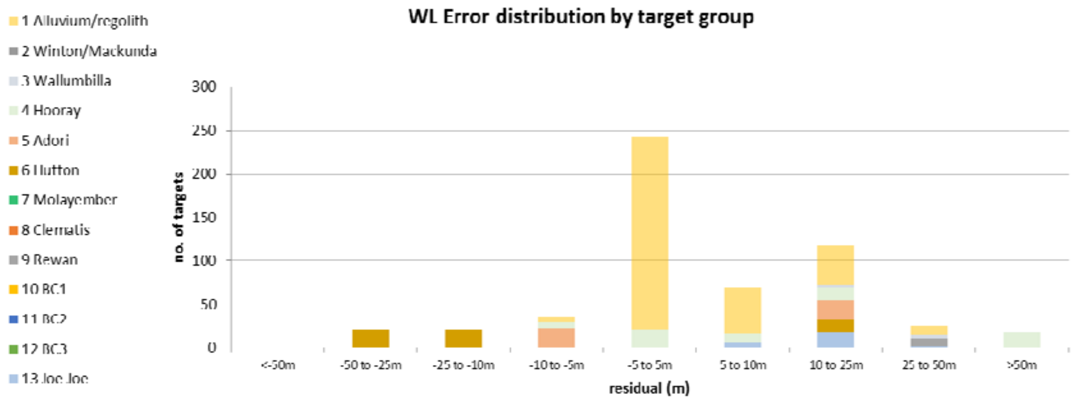


Figure 3-20 Residual error distribution for transient model

3.8.3 MASS BALANCE

The overall model transient mass balance at the end of the calibration period was stable with 0.0% error, and 0.0% error recorded for all time steps. Most water entering the model does so via river leakage and rainfall recharge. Approximately 60% of the outflows are due to evapotranspiration, and 15% from groundwater abstraction. Inflows from regional boundaries are approximately double that outgoing, and there is a net loss in storage of approximately 3.5GL/day (about 40% of throughflow) over the calibration period suggesting a depleting resource. It should be reiterated here that the model represents averaged annual conditions, and at any one point in a year the regional flow regime may vary considerably due to seasonal wet and dry cycles that affect particularly recharge, evapotranspiration and river-aquifer interactions. The average mass balance for the calibration period is presented in Table 3-20.

Table 3-20 Transient model mass balance

	Inflow (ML/day)	Outflow (ML/day)
RECHARGE (RCH)	865.0	0.0
ET (FROM GW) (EVT)	0.0	4,763.9
GW EXTRACTION (WEL)	0.0	1,129.4
SW-AQUIFER INTERACTION RIVERS AND SPINGS (RIV)	1,056.9	68.5
REGIONAL GW FLOW (GHB)	1093.8	568.2
STORAGE	4,860.4	1,346.2
TOTAL	7,876.2	7,876.2
% ERROR	0.0	0.0

All rivers are simulated to be *net* losing over their reaches during the transient calibration period (Table 3-21). This is consistent with EIS modelling for South Galilee (RPS Aquaterra, 2012) and China First (Heritage Computing, 2012). The EIS modelling carried out for Carmichael (GHD, 2013) modelled rivers such that leakage could not occur (comparable to the MODFLOW drain package), and therefore only baseflow was able to be reported in the mass balance. Modelling for Kevin's Corner and Alpha (URS, 2012) did not include any river boundary conditions. In consideration of these results, it is important to remember that the average annual river stage height was applied to the model as opposed to seasonally variable stage data as restricted by the annual time stepping of the model. In reality, large seasonal variations in river stage occur, and rivers are likely to change from losing to gaining status coinciding with these variations.

Table 3-21 Transient simulated river – aquifer interaction at gauge locations

Gauging Station	Average Modelled Baseflow (m3/day)	Average Modelled Leakage (m3/day)	Overall Status
Thomson River at Longreach	945	9,365	Losing
Alice River at Barcaldine	1,249	77,113	Losing
Cornish Creek at Bowen Downs	2,581	63,087	Losing
Warrego River at Augathella	8,807	66,579	Losing
Diamantina River at model edge	6,033	70,676	Losing
Carmichael River	2,034	23,286	Losing
Belyando River at model edge	5,008	134,504	Losing
Barcoo River at Blackall	1,924	50,221	Losing

4 PREDICTIVE MODEL SCENARIO ANALYSIS

4.1 MODELLING APPROACH

Using the hydraulic and storage parameters found during steady-state and transient calibrations, two predictive model scenarios were simulated. Each scenario was run to the year 2220, which is approximately 150 years beyond the current forecast mine life for all simulated mines, to allow simulation of water level recovery.

Scenario 1 (Baseline): A null (baseline) scenario with no coal mining stresses imposed on the model. This was used to predict future conditions with no mining activities and is used as the baseline run for assessing impacts of Scenario 2 (CRDP[4]). Stresses for the predictive run are as follows:

- Wells - set as per 2012 GA supplied pumping rates.
- Rivers - set as average conditions with 1m stage height for all rivers (as per steady-state model).
- Recharge - set as average CSIRO recharge as supplied by GA (as per steady-state model).
- Evapotranspiration - set as annual average actual ET as reported by BoM (as per steady-state model).

Scenario 2 (CRDP): A single prediction scenario for one coal resource development pathway to determine cumulative impacts of the seven mining operations. Stresses outside of the mining activities are as per Scenario 1 (Baseline). Additional stresses imposed in Scenario 2 include:

- Progressive excavation of the seven open cut and longwall mines with annual activation of drain boundary conditions at 0.1m above the base of the target coal seam layer to represent dewatering of mine pits and longwalls as per Section 3.4.7 and Appendix D.
- Progressive development of fractured zones above underground mines. Fracture zones are allowed to develop year by year with permeability varied dynamically using the TVM package of MODFLOW-USG beta (Section 3.4.8 and Appendix E). Section 4.1.1 outlines the changes to hydraulic properties applied to the fracture zones.
- Progressive placement of fill in open cut mines to end of mine life using modified hydraulic parameters and recharge as per Section 3.4.9 set at 5% of average annual recharge across the mining areas (equivalent to approximately 28mm/yr). This was applied to all open cut areas following completion of mining each segment, using the assumption that mine voids are progressively backfilled immediately after mining to depth.

4.1.1 APPLICATION OF FRACTURE AND DEFORMATION PROPERTIES

A series of conceptual zones of deformation occur above mined longwall panels (see Section 3.4.8)

A uniform increase to permeability of the model layer containing the mined seam has been adopted. Permeabilities for this model layer have been set at 100 m/day (horizontal) and 5 m/day (vertical). Note that this layer represents not only the mined coal seams, but also the interburden or overburden.

Due to the stratigraphic framework and geological layering specifically built for this study, in which multiple target seams of coal exist at undefined locations within model Layers 10 and 11, simulating the extent of the 'caved zone' is difficult. In light of this, a 'caved zone' has not been simulated. However, due to the layering specified for this model, the caved zone will lie within the same layer as the mined coal seam, and the increase in permeability applied to the mined

[4] Coal Resource Development Pathway

layer (see above) will replicate the enhanced permeability that would occur in the 'caved zone' immediately above the seam.

The other critical conceptual zone of deformation is the zone of connected fracturing, in which sub-vertical fracturing occurs and provides a pathway for groundwater flow. In simulating groundwater response the Ditton 'Geology Model' method, as was discussed in Section 3.4.8, estimates the height of this zone (the A-zone) (Ditton and Merrick, 2014).

The hydraulic conductivity of the fractured A-zone was enhanced in both vertical and horizontal dimensions using a log-linear (ramp) function. The model developed in this study uses:

- at the base of the A-zone, permeabilities of the host material enhanced by a factor of 1000;
- a log-linear trend through the A-zone; and
- at the top of the A-zone, permeabilities of the deformed strata were increased by factors of 50 (horizontal) and 333 (vertical); the geometric mean of these factors is 130 (1.3E+2) at the top of the A-zone, which is similar to the results found in the analysis of pre-mining and post-mining K values above longwall panels in Tammetta (2015), which suggested an increase of about 100 (1E+2).

If the calculated fracture zone was found to extend to the surface (Layer 1), the log-linear trend was not applied in Layer 1. Instead an increase in K_H and K_Z was limited to a factor of 2 x host. The permeability of the regolith (Layer 1) is already quite high (1 m/day), and the properties of the weathered material means that there would be less enhancement of permeability.

No modification to storage properties was made to mined seam or deformation zones, as in reality most of the increased porosity would occur in the mined seam and in the caved zone. Due to the substantial thickness of the coal measures layers, the caved zone in the model is lumped together with overburden material. HS considers that storage properties should be altered only across a small height above a coal seam.

Table 4-1 Fracture zone hydraulic properties

Layer	Host K_H	Deformed K_H	Host K_Z	Deformed K_Z
1	1.00E+00	1.76E+00	1.00E-02	1.40+00
2	2.57E-01	N/A	1.27E-03	N/A
3	3.04E-04	N/A	3.04E-04	N/A
4	1.72E-01	N/A	8.30E-04	N/A
5	1.26E-04	N/A	6.69E-05	N/A
6	1.27E-01	N/A	1.27E-01	N/A
7	2.26E-01	1.29E+01	2.26E-04	4.95E-04
8	1.96E+00	1.21E+02	3.84E-02	1.17E-01
9	3.00E-04	1.92E-1	6.00E-06	2.96E-04
10	1.30E-01	2.31E+02	1.00E-04	1.11E+00
11	7.40E-01	7.95E+01	1.00E-05	3.85E+00
12	2.50E+00	N/A	1.00E-03	N/A
13	8.77E-05	N/A	8.77E-06	N/A

N/A indicates fracturing does not occur in this layer

4.2 WATER BALANCE

Simulated average water balance components calculated for the calibration period (with varying recharge and well abstractions) are compared in Table 4-2 with those for the prediction period (with constant recharge and well abstractions). Mine inflow of 176ML/day is expected on average, which would mostly be obtained from storage. Variations in the other components of the mass balance are largely due to different stresses applied for recharge and wells. As it is not possible to determine the isolated effects of mining from this mass balance, this will be dealt with in the following sections.

Table 4-2 Transient model mass balance

	CALIBRATION PERIOD INFLOW (ML/DAY)	PREDICTION PERIOD INFLOW (ML/DAY)	CALIBRATION PERIOD OUTFLOW (ML/DAY)	PREDICTION PERIOD OUTFLOW (ML/DAY)
RECHARGE (RCH)	865.0	861.6	0.0	0.0
ET (FROM GW) (EVT)	0.0	0.0	4,763.9	3,029.6
GW EXTRACTION (WEL)	0.0	0.0	1,129.4	873.1
SW-AQUIFER INTERACTION RIVERS AND SPINGS (RIV)	1,056.9	1795.1	68.5	75.29
REGIONAL GW FLOW (GHB)	1093.8	729.7	568.2	313.7
STORAGE	4,860.4	1541.0	1,346.2	460.2
MINE INFLOWS (DRN)	N/A	0.0	N/A	175.5
TOTAL	7,876.2	4,927.4	7,876.2	4,927.4
% ERROR	0.0	0.0	0.0	0.0

4.3 PREDICTED MINE INFLOWS

Average and cumulative flows for each mine are listed in Table 4-3 and are shown in Figure 4-1. The predicted inflows for each mine are illustrated in Figure 4-2 and Figure 4-3, with average inflows at each mine ranging from 5 ML/day at Hyde Park to 78 ML/day at China First. The cumulative inflows for all mines over the predictive period total 2,822 GL.

The predicted rates are typically higher than other EIS models, most notably Alpha, Carmichael and Kevin's Corner, even though calibrated hydraulic parameters are comparable. One reason is the differing treatment of fractured zones for underground mining and time-varying properties for open cut mining. Another reason is the lack of layer resolution in the modelled coal seam layers resulting in drainage of a larger thickness than is likely in reality. Similarly, the bulked layer approach allows limited K_Z control on groundwater flows. Due to the lack of available data to correlate separate coal seams across the basin (or even between mine sites), information regarding individual coal seam depths and thickness was unable to be provided. Even had this data been available, including individual coal seams would have required upwards of an additional 10 or so model layers, which would have had a dramatic impact on computational run-time and would have been impractical in the given model development timeframe.

Table 4-3 Average inflows and total predicted inflows for each mine

Mine	Average Inflow ML/day	Average Inflow ML/day	Average Inflow EIS Models ML/day	Total Inflow (GL)	Total Inflow (GL)
Alpha_OC	36	36	5.3	255	255
Carmichael_OC	19	53	14.3	239	786
Carmichael_UG_AB	9			141	
Carmichael_UG_D1	26			406	
China First_OC	22	78	70	190	931
China First_UG_B	10			134	
China First_UG_D	46			607	
China Stone_UG	6	13	13.5#	100	241
China Stone_OC	7			141	
HydePark	5	5	3#	62	62
Kevin's Corner_OC	14	33	9.5	107	377
Kevin's Corner_UG	19			270	
South Galilee_OC	10	18	24.7	78	170
South Galilee_UG_D1	4			52	
South Galilee_UG_D2	4			39	
Total	238*		140.3	2,823	

*Note the total average inflow is higher than reported in the mass balance due to mines being operational over different time periods, therefore mass balance includes some periods of no flow at each mine while this table gives the average for only the operational periods at each mine.

Estimate by Kellett, J. (2015).

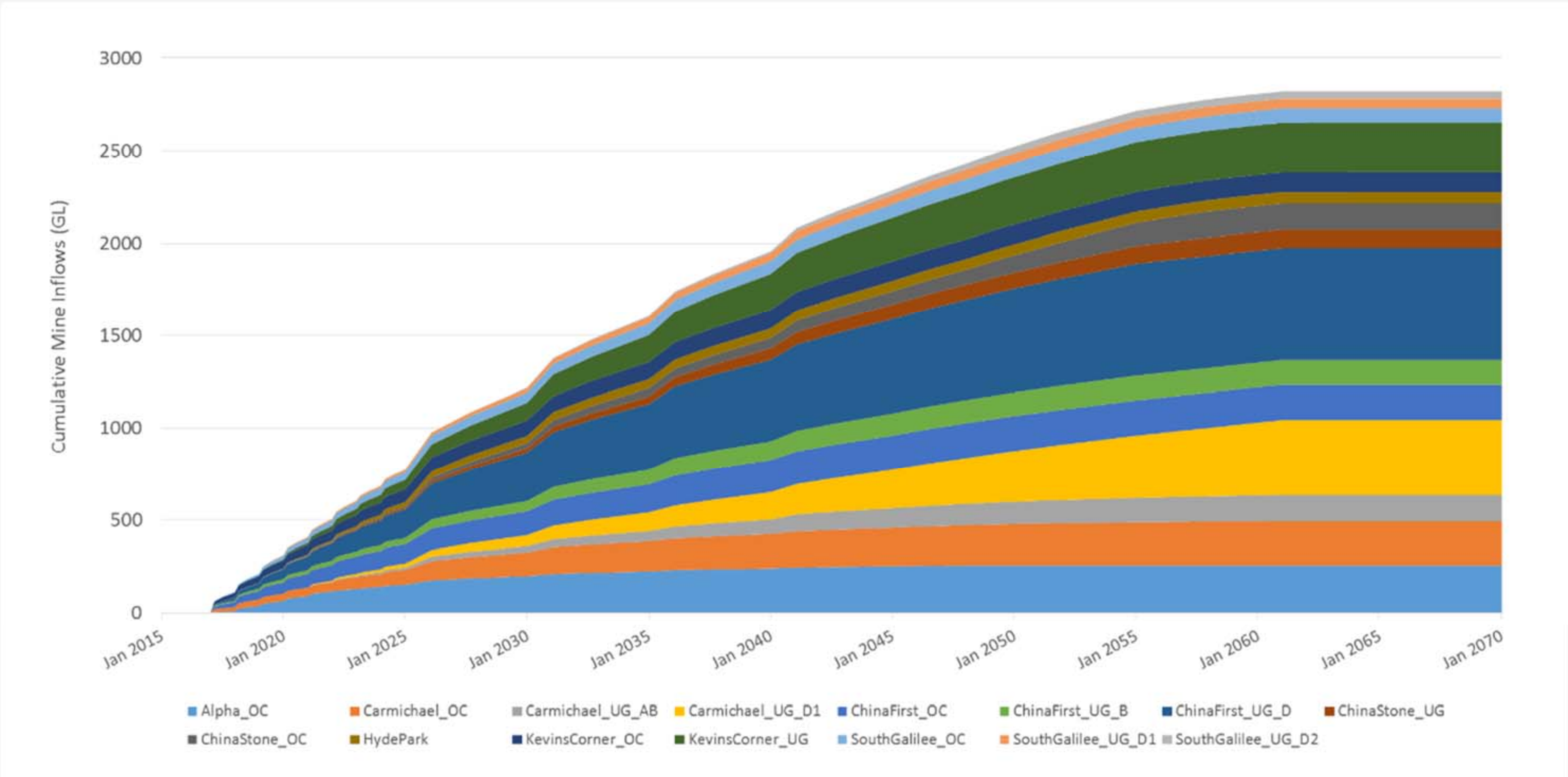


Figure 4-1 Cumulative mine inflows

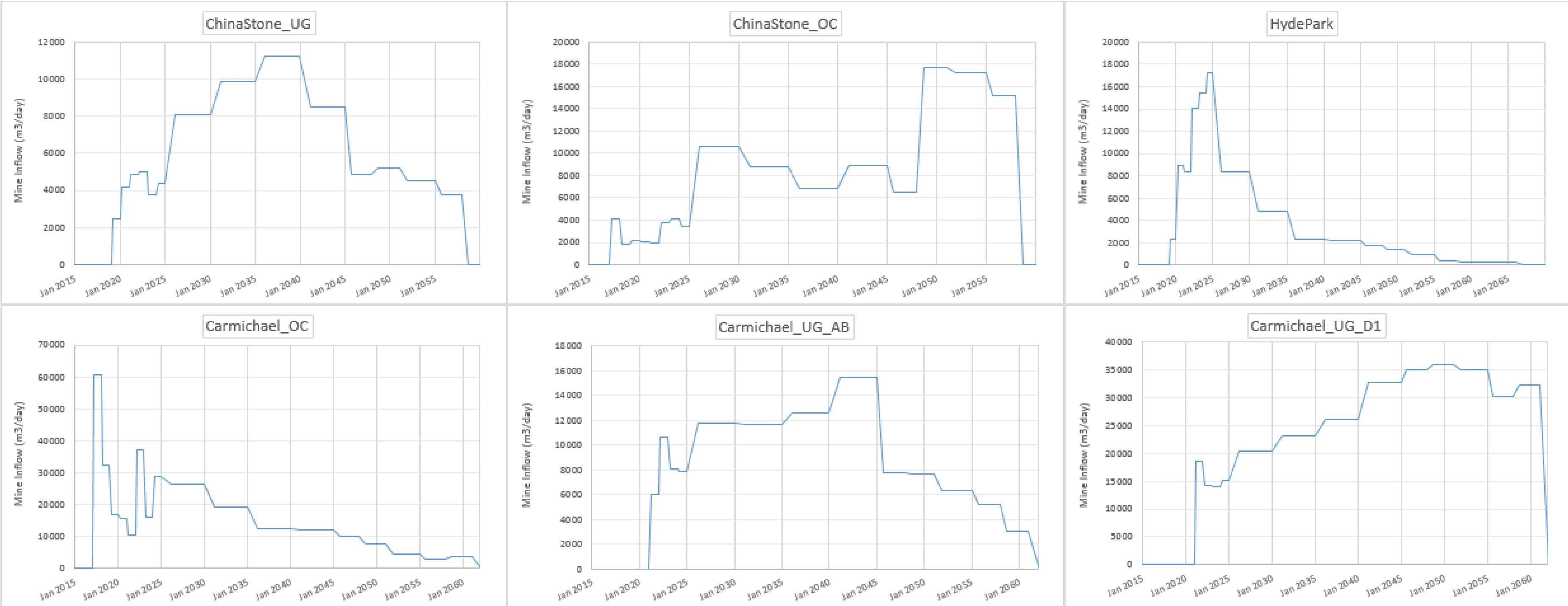


Figure 4-2 Predicted mine inflows for northern mines

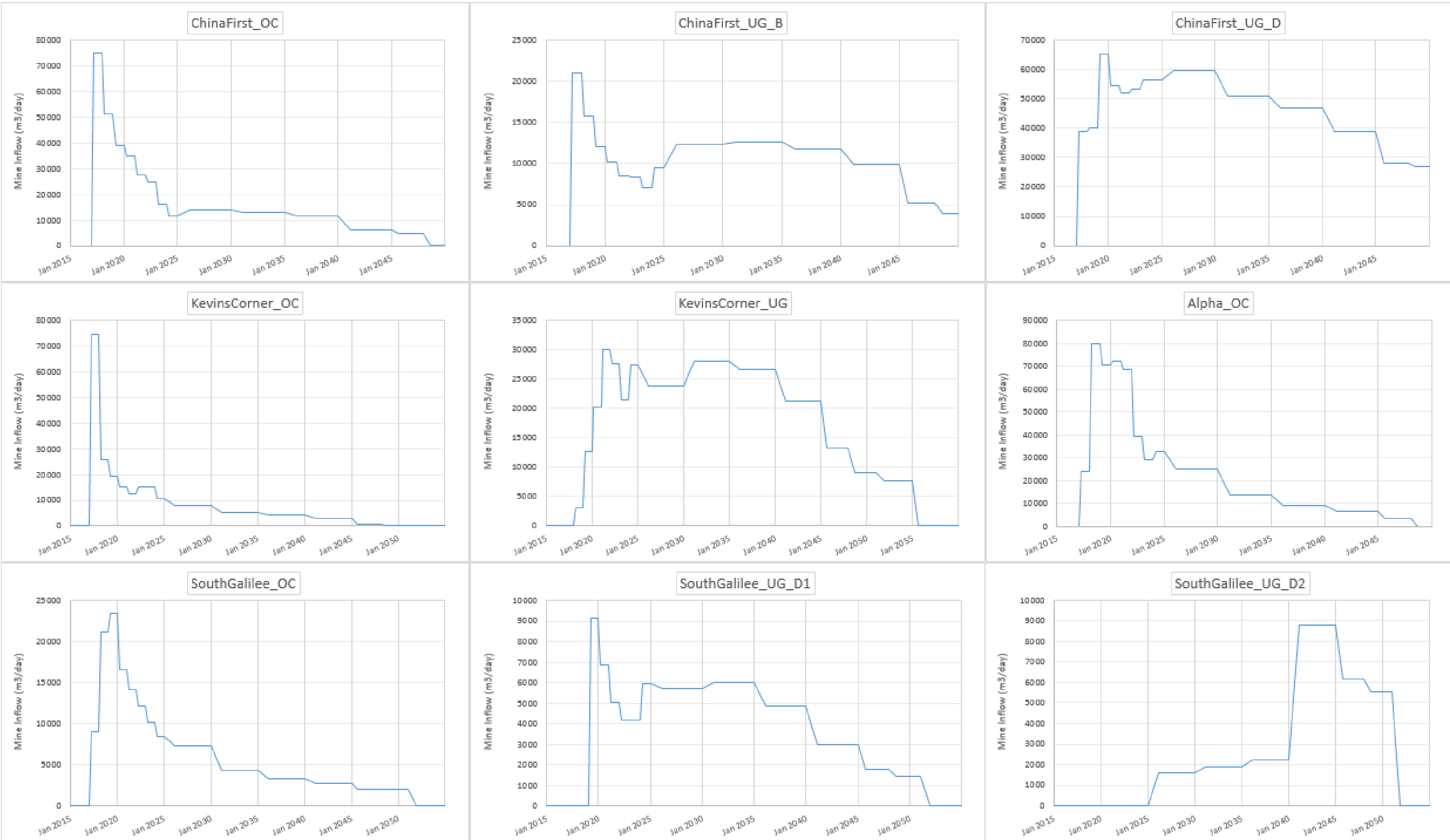


Figure 4-3 Predicted mine inflows for southern mines

4.4 PREDICTED DRAWDOWNS

Predicted drawdowns are largely localised to Permian coal seam layers (Layers 10 through 12) which are significantly depressurised during mining, as well as the Joe Joe Group (Layer 13). A cone of depression spanning approximately 500km north-south and 400km east-west is predicted to form in the Permian layers. Some minor drawdown is also predicted to occur within the GAB units in areas where the cone of depression associated with depressurisation of the coal seams extends further west than the Rewan Formation. Drawdown in the GAB layers typically does not exceed 5m except in close proximity to China Stone, where drawdown of up to 20m occurs in the Clematis Sandstone. Drawdown maps corresponding to 5 year intervals or the end of each mining operation (representing maximum drawdown for each mine) are provided in Appendix I.

4.5 PREDICTED POST MINING EQUILIBRIUM

The recovery of water levels after cessation of mining has been investigated by running a simulation for 150 years (immediately after completion of mining) without any mining stresses, with deformation due to fracturing and pit backfilling remaining as per Section 4.1. The final potentiometric head levels show a permanent lowering beneath the Rewan, with the cone of depression due to mining shallowing but not returning to pre-mining conditions within 150 years. Maximum drawdown after this time is 44m at China Stone, followed by 38m at South Galilee, both occurring within Layer 10 (Bandanna Formation).

5 POTENTIAL GROUNDWATER IMPACTS

5.1 IMPACT ASSESSMENT APPROACH

The potential impacts of the seven mine developments were assessed (cumulatively only) by making comparisons between the predictive Scenarios 1 (Baseline) and 2 (CRDP). This allows the simulated impact of the mine development to be isolated from other model processes (such as recharge and groundwater use) that also have a net effect on the water levels over time. Additionally, computing drawdown and assessing impacts by subtracting one model run from another, as opposed to comparing absolute model output values, is more reliable and reduces uncertainty associated with model calibration and parameterisation (Barnett *et al.,* 2012; Guiding Principle 7.4).

5.2 CHANGES IN HYDRAULIC PROPERTIES

A change in hydraulic properties will occur in the mining areas where backfilling of waste rock into open pit voids occurs. The mine waste rock will have a higher permeability than most natural *in situ* material (with the possible exception of alluvium), resulting in reduced hydraulic gradients across backfilled voids as well as increased rainfall recharge. A permanent increase in permeability and porosity in the rocks above caved longwall zones will also exist.

5.3 IMPACT ON GREAT ARTESIAN BASIN

Some drawdown is predicted to occur within the GAB aquifers in localised areas, namely to the west of Kevin's Corner/Alpha/South Galilee where the Rewan extent is narrow and the cone of depression from coal seam depressurisation extends beyond its cover; and, to the west of China Stone and Hyde Park. Drawdowns of less than 5m occur west of the southern mines in all GAB layers within the first 10-15 years of mining, however only Layer 8 (Clematis Sandstone) has continuing predicted drawdown of greater than 1m after the 150 year recovery period. Drawdowns occurring near to China Stone are of a much greater but more localised magnitude. In that area, drawdowns of up to 50m occur in the Clematis Sandstone only, with full rebound of heads seen by the end of the 150 year recovery period.

Particular caution should be given to any results from simulation of mining at China Stone and Hyde Park, as due to the very limited information provided for these mines it is probable that the mining activities have been misrepresented in the model. Detailed modelling with accurate mine plan information should be carried out to determine whether this impact is likely in reality.

5.4 IMPACT ON SPRINGS AND BASEFLOW

Drawdown at most spring locations is shown to be negligible (less than 1m). Five springs are shown to be in areas of drawdown greater than 1m, as listed in Table 5-1. Maximum drawdown of 41m occurs at the Mellaluka Springs which are modelled as flowing from the Joe Joe Formation near the Carmichael mine, and as such any wetland associated with these springs is likely to be dried out as a result of mining. Minor drawdowns occur at other springs (V356, V68 and V366), however these only have minor flows (<100m^3/day) and are not in the list of significant springs as designated by GA. Deeper drawdowns within the Permian layers occur below many other springs, however the depressurisation does not propagate vertically to affect springs flowing from the GAB. A list of all modelled springs and predicted maximum drawdown is given in Appendix J.

Table 5-1 Predicted drawdown at spring locations (>1m)

Spring	Source Aquifer	Max Drawdown (m)	Model Layer	Easting	Northing	Year of Max Drawdown
Mellaluka	Joe Joe Group	40.7	13	446981	7531995	2071
Mellaluka	Joe Joe Group	40.8	13	446949	7532131	2071
V356	Clematis Sandstone	1.3	8	383857	7571117	2083
V68	Hooray Sandstone	6.3	4	367636	7372582	2058
V366	Hooray Sandstone	1.6	4	364617	7376307	2059

A small reduction in baseflow to rivers nearest the mining operations is predicted. Further afield rivers see negligible impact. Table 5-2 shows the maximum predicted reduction in baseflow due to mining operations, showing that all but the Carmichael River are expected to have baseflow reductions of less than 1%, with Carmichael River only losing approximately 4% of baseflow. This is comparable with GHD (2013) SEIS modelling that predicts a 5% loss to baseflow. Again these values are only annual averages, and the volume of reduction to baseflow is likely to be seasonally variable.

Table 5-2 Predicted loss of baseflow due to mining

Gauging Station	Max Loss of Baseflow due to mining (m3/day)	% Reduction in Baseflow
Thomson River at Longreach	0.03	0.01
Alice River at Barcaldine	5.95	0.5
Cornish Creek at Bowen Downs	0.05	0.003
Warrego River at Augathella	2.15	0.01
Diamantina River at model edge	0.11	0.003
Carmichael River	71.5	4.2
Belyando River at model edge	4.48	0.2
Barcoo River at Blackall	0.09	0.008

5.5 IMPACT ON PRODUCTION BORES

A total of 3,405 registered production bores have been identified by GA to exist within the Galilee Basin model area. The majority of these bores are several tens or hundreds of kilometres away from the proposed mining activities and therefore are not expected to be impacted. Drawdown for each bore has been assessed using the maximum reduction in computed water level within the source aquifer/s for each bore, calculated by subtracting levels computed using Scenario 2 (CRDP) from Scenario 1 (Baseline). 89 bores are expected to have 1m or greater drawdown, and 30 with 5m or greater drawdown. Table 5-3 presents a summary of the expected number of bores affected by layer. Bores affected by the greatest drawdowns (more than 5m) are mostly restricted to the Permian layers. However there are several bores within the GAB layers that have predicted drawdowns between 1m and 5m, however these are localised to the locations discussed in Section 5.3. Details of all bores with greater than 1m predicted drawdown are listed in Table 5-4. It should be noted that the drawdown values are the maximum impact attained and would not occur at the same time. A list of all modelled bores and simulated drawdown is presented in Appendix I.

Table 5-3 Aquifers of potentially affected registered bores

Model Layer	GA Assigned Aquifer	Number of Bores in Model Domain	Number of Bores > 5m Drawdown	Number of Bores > 1m Drawdown
Layer 1	Alluvium/Tertiary Sediments	125	0	0
Layer 2	Winton/ Mackunda Formation	622	0	0
Layer 3	Wallumbilla Formation	303	0	0
Layer 4	Cadna-Owie/Hooray Sandstone	703	0	1
Layer 5	Adori Sandstone	333	0	4
Layer 6	Hutton Sandstone	1031	1	17
Layer 7	Moolayember Formation	49	0	11
Layer 8	Clematis Sandstone	142	0	25
Layer 9	Rewan Group/Dunda Beds	15	14	15
Layer 10	Bandanna Formation	46	11	12
Layer 11	Base B – Top E Seam	0	0	0
Layer 12	E – Seam and Colinlea Sandstone	0	0	0
Layer 13	Joe Joe Group	36	4	4

Table 5-4 List of all registered bores with predicted drawdown >1m.

RN	Max Draw-down (m)	Model Layer	Easting	Northing	Year of Max Draw-down	RN	Max Draw-down (m)	Model Layer	Easting	Northing	Year of Max Draw-down
290	1.4	7	389347	7391906	2097	**69157**	1.3	5	373392	7374485	2063
1117	1.6	8	420777	7386159	2097	**69161**	3.4	6	371937	7375764	2061
1174	18.7	9	432973	7388298	2175	**69163**	1.9	6	371720	7377854	2058
1175	25.0	9	433080	7392181	2143	**69164**	2.0	6	372117	7377858	2058
1251	5.6	9	297082	7479033	2066	**69165**	6.2	6	370315	7376611	2058
1376	1.9	6	356771	7388727	2059	**69719**	1.2	7	387796	7459269	2175
1377	1.6	5	353788	7389374	2058	**69730**	72.9	10	446387	7433792	2035
1377	1.6	6	353788	7389374	2058	**69731**	68.4	10	445197	7432429	2032
1399	1.0	6	366098	7413454	2120	**69732**	68.5	10	446285	7420154	2024
2147	1.1	6	365968	7409055	2107	**69735**	15.8	10	450238	7392579	2120
3068	1.6	8	400055	7432971	2143	**69744**	1.3	7	415751	7362478	2143
3069	1.6	8	403913	7437330	2143	**69745**	1.3	8	423295	7360240	2143
3089	2.1	7	390732	7386294	2107	**89327**	26.8	10	448027	7403347	2120
3090	1.5	7	391404	7390147	2107	**90025**	2.3	10	489620	7306247	2075
4250	1.1	6	282133	7415400	2078	**90084**	1.2	8	426778	7348221	2143
5646	1.5	4	363642	7390608	2067	**90085**	1.3	8	436089	7344227	2175
6821	1.4	6	357180	7393284	2058	**90145**	1.1	8	427870	7339787	2175
7884	1.2	7	383279	7446930	2220	**90157**	1.3	8	388146	7424621	2143
7904	1.4	6	363611	7378765	2058	**90217**	3.2	9	432275	7377579	2175
8500	1.3	8	395453	7462659	2175	**90234**	1.3	8	382232	7411379	2120
11538	1.8	6	357199	7388424	2061	**90256**	7.3	13	423671	7580877	2071
12159	1.6	8	426467	7375673	2120	**90259**	53.4	13	423688	7577245	2083
13852	1.3	7	410057	7370089	2143	**90372**	1.3	8	425610	7385301	2120
14103	12.4	9	338440	7497916	2063	**96545**	1.4	7	400295	7571749	2097
14265	13.4	9	344312	7490912	2063	**103008**	44.1	9	427720	7393488	2076
14512	56.2	10	439975	7412792	2048	**103120**	27.8	10	445735	7399351	2107
15021	1.3	8	387077	7446909	2143	**103175**	1.6	8	422536	7383290	2107
15172	1.1	5	366679	7390174	2068	**103253**	1.3	8	421464	7358686	2143
15406	63.2	10	443691	7417151	2022	**103318**	1.3	8	399920	7461859	2175
16060	8.1	9	327591	7628965	2063	**103441**	26.5	9	421353	7411207	2143
16772	1.7	6	363360	7369288	2056	**103479**	51.4	10	449262	7445025	2067
16774	1.4	6	366772	7370796	2058	**103480**	134.	10	438771	7398870	2058
17451	3.4	7	402862	7584727	2071	**103492**	1.2	8	437839	7356733	2175
35291	1.0	7	377654	7452460	2220	**103565**	11.8	9	428493	7541524	2120
37258	18.4	13	456551	7349081	2091	**103930**	1.2	8	408786	7353381	2143
38089	8.1	10	453063	7356275	2107	**118245**	23.1	9	365011	7546105	2062
38108	29.3	13	449765	7366726	2086	**118257**	1.3	8	423806	7353278	2143
38916	9.0	9	423618	7472707	2175	**118393**	19.0	9	365431	7499033	2062
39801	1.4	7	401316	7570265	2097	**118556**	1.1	6	365906	7408775	2107
43440	9.5	9	430672	7471760	2175	**118645**	27.6	9	374942	7547645	2061
51054	1.2	8	408762	7353607	2143	**118813**	1.0	6	360538	7396679	2120
51063	1.4	8	406908	7372026	2120	**132390**	1.1	8	427736	7338394	2175
54627	1.3	8	382895	7570700	2086	**132650**	1.5	8	395754	7447920	2143
69091	1.2	8	410901	7389411	2076	**146435**	1.2	6	359941	7383543	2058
69141	1.2	5	373424	7374086	2066						

6 PREDICTIVE MODEL SENSITIVITY ANALYSIS

In addition to the calibrated base case predictive models, two additional models have been developed to assess the sensitivity of the model predictions to key parameters:

Sensitivity 1: Vertical hydraulic conductivity one order of magnitude higher than calibrated in aquitard layers of the GAB (layers 3, 5, 7 and 9). Vertical hydraulic conductivity in these units is the key parameter controlling timing, location and intensity of impacts propagation up from the mined seams.

Sensitivity 2: No mining induced fracture zone (no TVM package), but the mine activities remain simulated using the Drain package. This defines the magnitude of influence of the simulated fracture zone on modelled impacts. The model is otherwise as per the base-case predictive models.

Results from these sensitivity runs show that there are only minimal variations between simulated inflows of the baseline predictive runs and those of the run without an induced fracture zone, with almost identical calibration statistics (Table 6-1) and less than 2% reduction from the inflow obtained with the TVM package (Table 6-2). However increasing the K_Z of the GAB aquitard layers results in a worsening of calibration statistics and a more significant effect of inflows, with an increase of 15% cumulative volume.

Table 6-1 Calibration statistics for sensitivity runs

Statistics	Base Case	Sensitivity 1: Increased K_Z	Sensitivity 2: No TVM
Residual Mean (m)	5.72	5.28	5.72
Absolute Residual Mean (m)	11.31	11.44	11.31
Residual Standard Deviation (m)	15.87	16.05	15.87
Sum of Squares (m^2)	156,240	156,728	156,238
RMS Error (m)	16.85	16.88	16.85
Minimum Residual (m)	-33.01	-35.57	-33.01
Maximum Residual (m)	52.42	51.29	52.41
Number of Observations	550	550	550
Range in Observations (m)	268	268	268
Scaled RMS Error	5.9%	6.0%	5.9%
% Targets within ±10m	64	58	64
% Targets within ±25m	89	88	89

Table 6-2 Simulated mine inflows for sensitivity model runs

	Base Case	Sensitivity 1: Increased K_Z	Sensitivity 2: No TVM
Mine	**Total Inflow (GL)**	**Total Inflow (GL)**	**Total Inflow (GL)**
Alpha_OC	255	269	253
Carmichael_OC	239	260	237
Carmichael_UG_AB	141	216	141
Carmichael_UG_D1	406	471	406
China First_OC	190	204	189
China First_UG_B	134	184	134
China First_UG_D	607	670	607
China Stone_UG	100	119	99
China Stone_OC	141	145	105
Hyde Park	62	73	63
Kevin's Corner_OC	107	113	106
Kevin's Corner_UG	270	313	270
South Galilee_OC	78	84	78
South Galilee_UG_D1	52	62	52
South Galilee_UG_D2	39	50	39
Total	2,823	3,234	2,780

Assessing the number of wells affected under each sensitivity scenario confirms that there is no significant difference between the model predictions with or without the fracture zone imposed. However the increase in vertical hydraulic conductivity of aquitard layers results in an additional 37 bores having greater than 1m of drawdown, with most of the additional impacted wells occurring in Layer 7 (Moolayember Formation) and Layer 8 (Clematis Sandstone).

**Table 6-3	Number of wells impacted for sensitivity runs**

	Base Case		Sensitivity 1: Increased K_Z		Sensitivity 2: No TVM	
Model Layer	**Number of Bores > 5m Drawdown**	**Number of Bores > 1m Drawdown**	**Number of Bores > 5m Drawdown**	**Number of Bores > 1m Drawdown**	**Number of Bores > 5m Drawdown**	**Number of Bores > 1m Drawdown**
Layer 1	0	0	0	0	0	0
Layer 2	0	0	0	0	0	0
Layer 3	0	0	0	0	0	0
Layer 4	0	1	0	0	0	1
Layer 5	0	4	0	0	0	4
Layer 6	1	17	0	7	1	17
Layer 7	0	11	1	30	0	11
Layer 8	0	25	0	60	0	25
Layer 9	14	15	10	14	14	15
Layer 10	11	12	11	11	11	12
Layer 11	0	0	0	0	0	0
Layer 12	0	0	0	0	0	0
Layer 13	4	4	4	4	4	4
Total	30	89	26	126	30	89

Figure 6-1 to Figure 6-7 show the drawdown extent for each layer for the sensitivity runs. For ease of display, the Base Case and no TVM run have been considered identical, with no notable variation between them. The increase in K_Z in aquitard layers has reduced the cone of depressurisation within the coal seam layers due to the leakage of water from above layers. There is notably more drawdown within the Clematis sandstone (Layer 8) with the increased K_Z's, and slightly more drawdown within the Hooray (Layer 4) and Hutton (Layer 6) Sandstone aquifers.

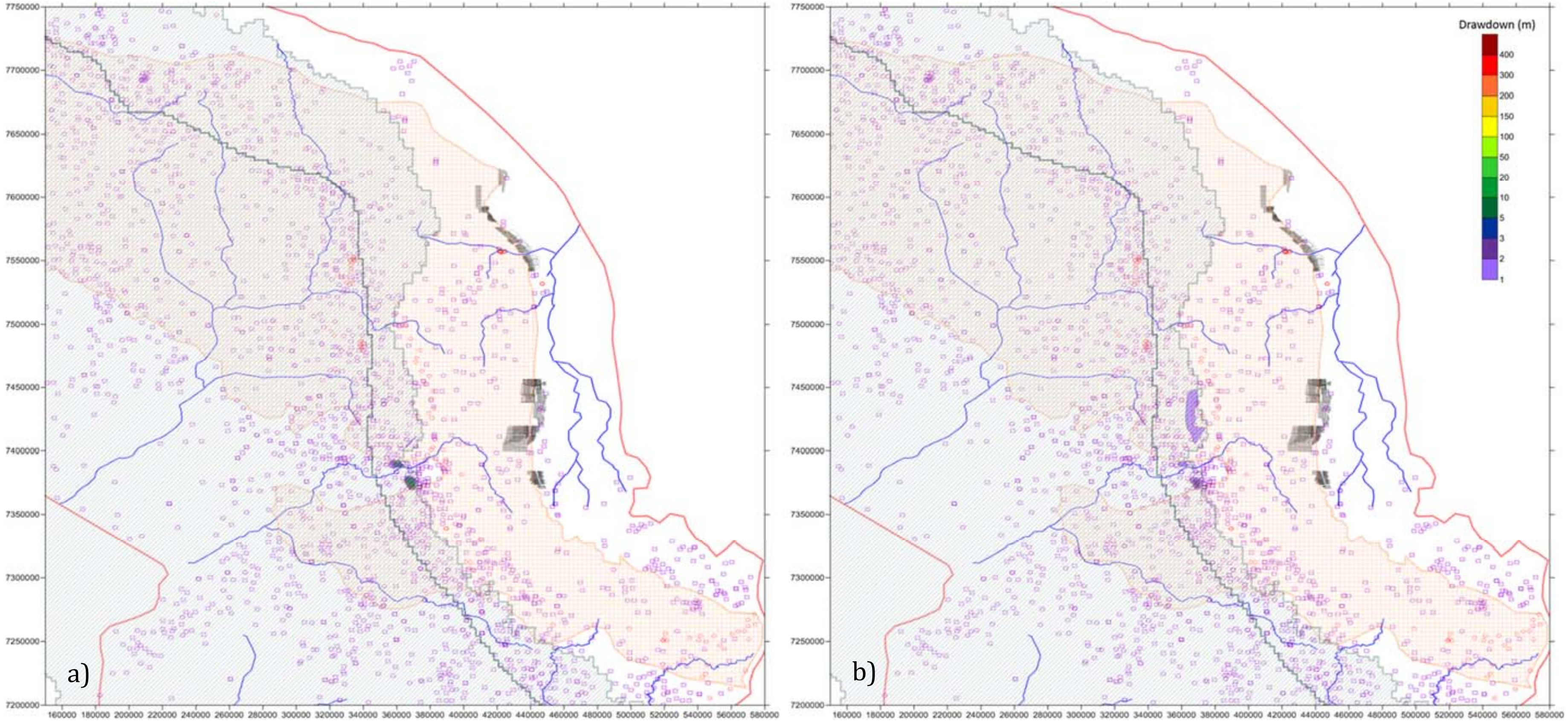


Figure 6-1 Maximum predicted drawdown in Layer 4 (Hooray Sandstone) for a) Base Case and Sensitivity #2 (no TVM) and b) Sensitivity#1 – increased K_Z

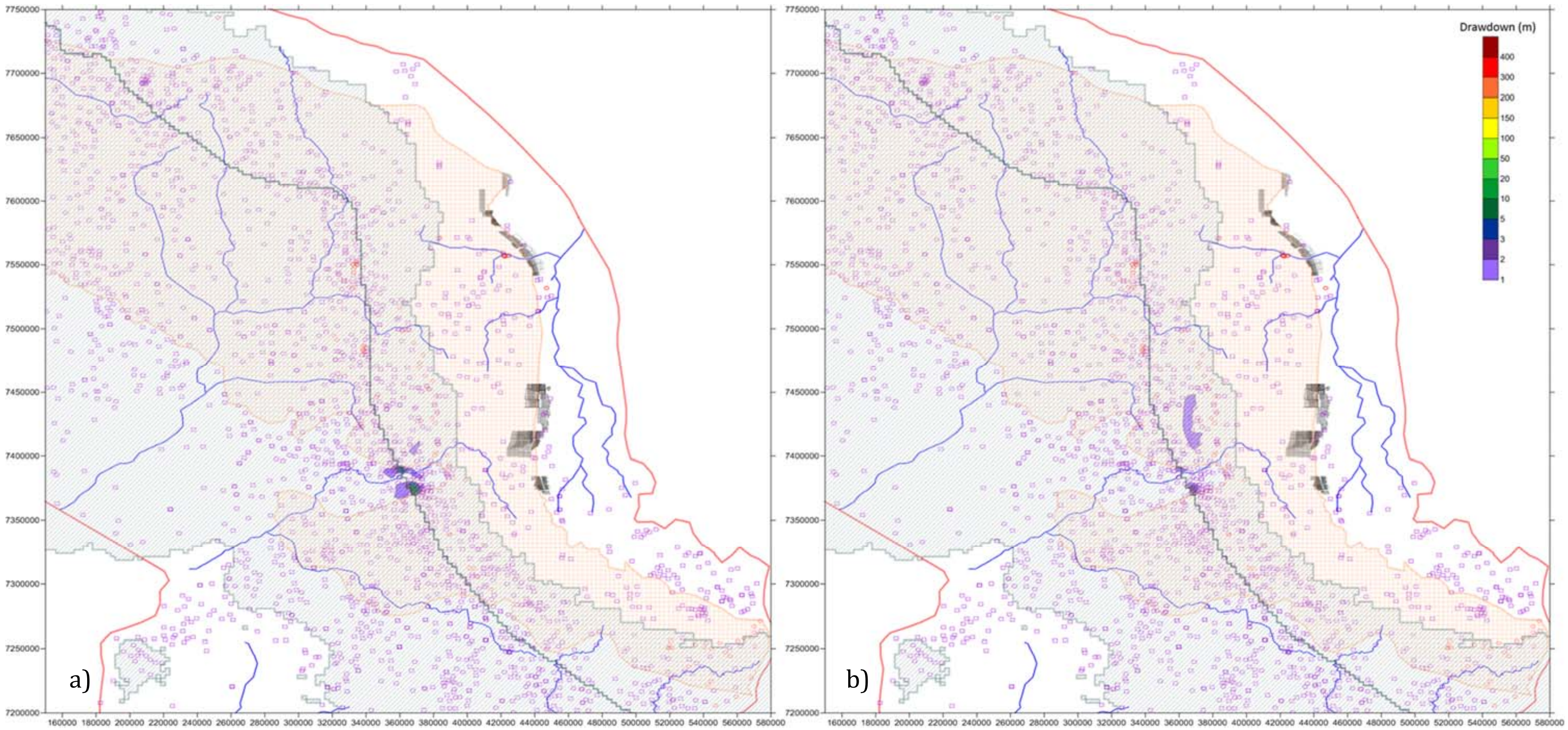


Figure 6-2 Maximum predicted drawdown in Layer 6 (Hutton Sandstone) for a) Base Case and Sensitivity #2 (no TVM) and b) Sensitivity#1 – increased K_Z

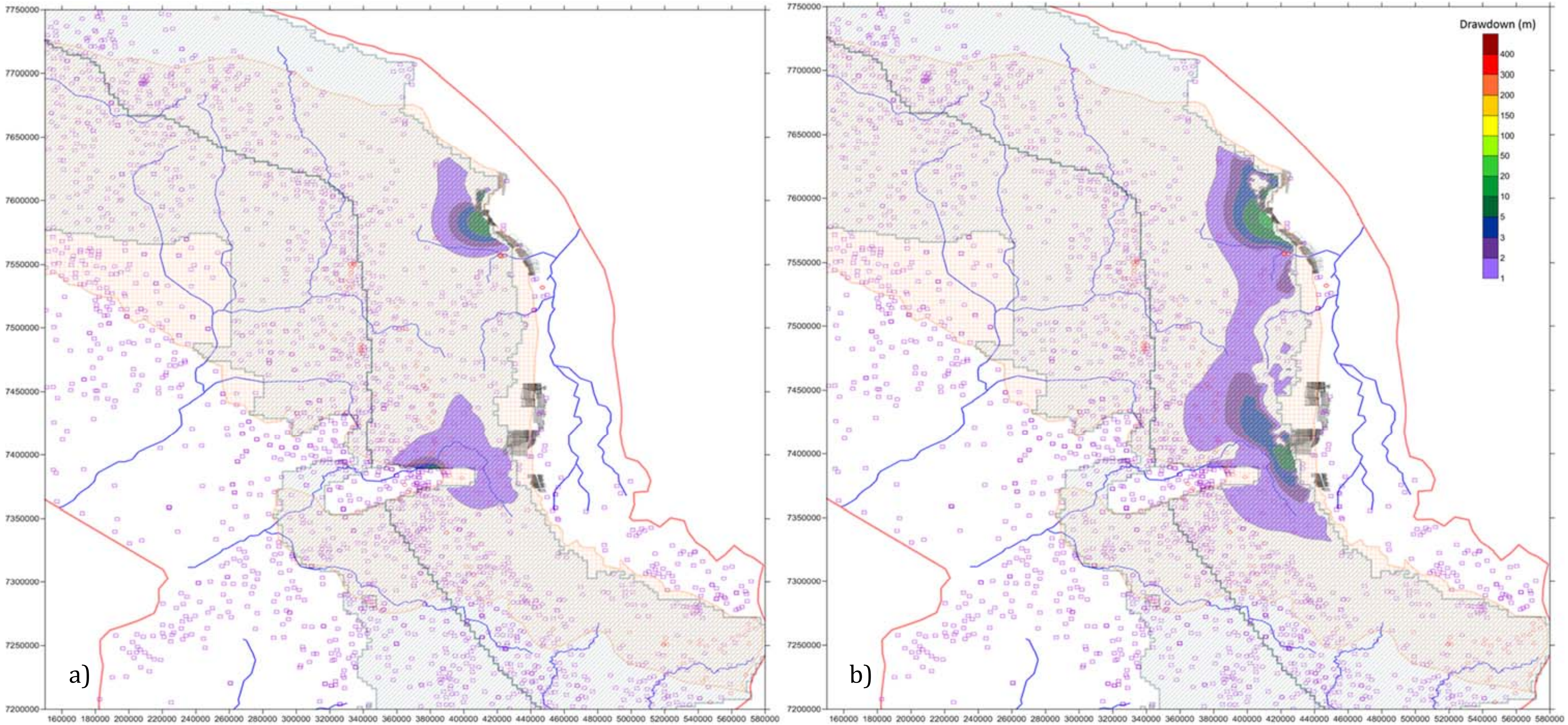


Figure 6-3 Maximum predicted drawdown in Layer 8 (Clematis Sandstone) for a) Base Case and Sensitivity #2 (no TVM) and b) Sensitivity#1 –increased K_Z

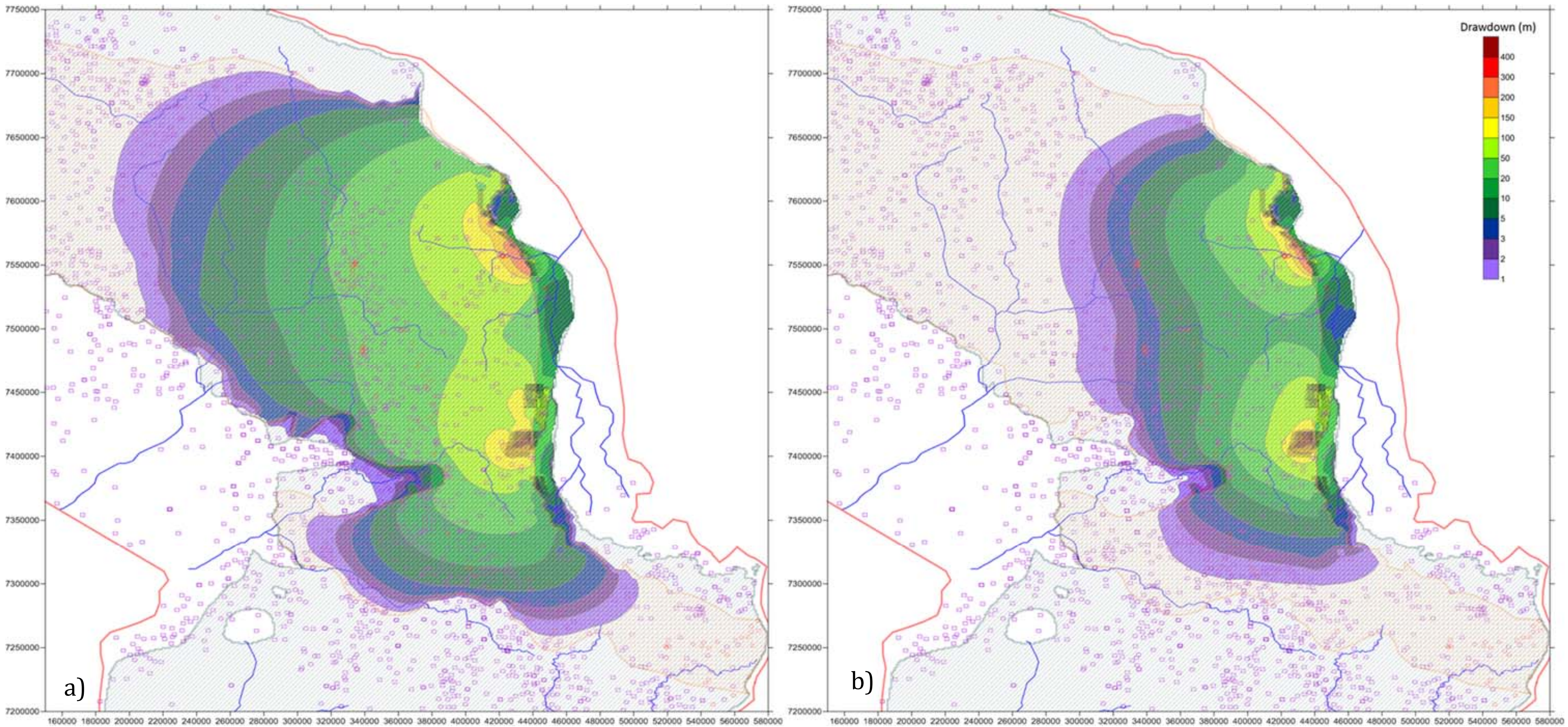


Figure 6-4 Maximum predicted drawdown in Layer 10 (BC1) for a) Base Case and Sensitivity #2 (no TVM) and b) Sensitivity#1 – increased K_Z

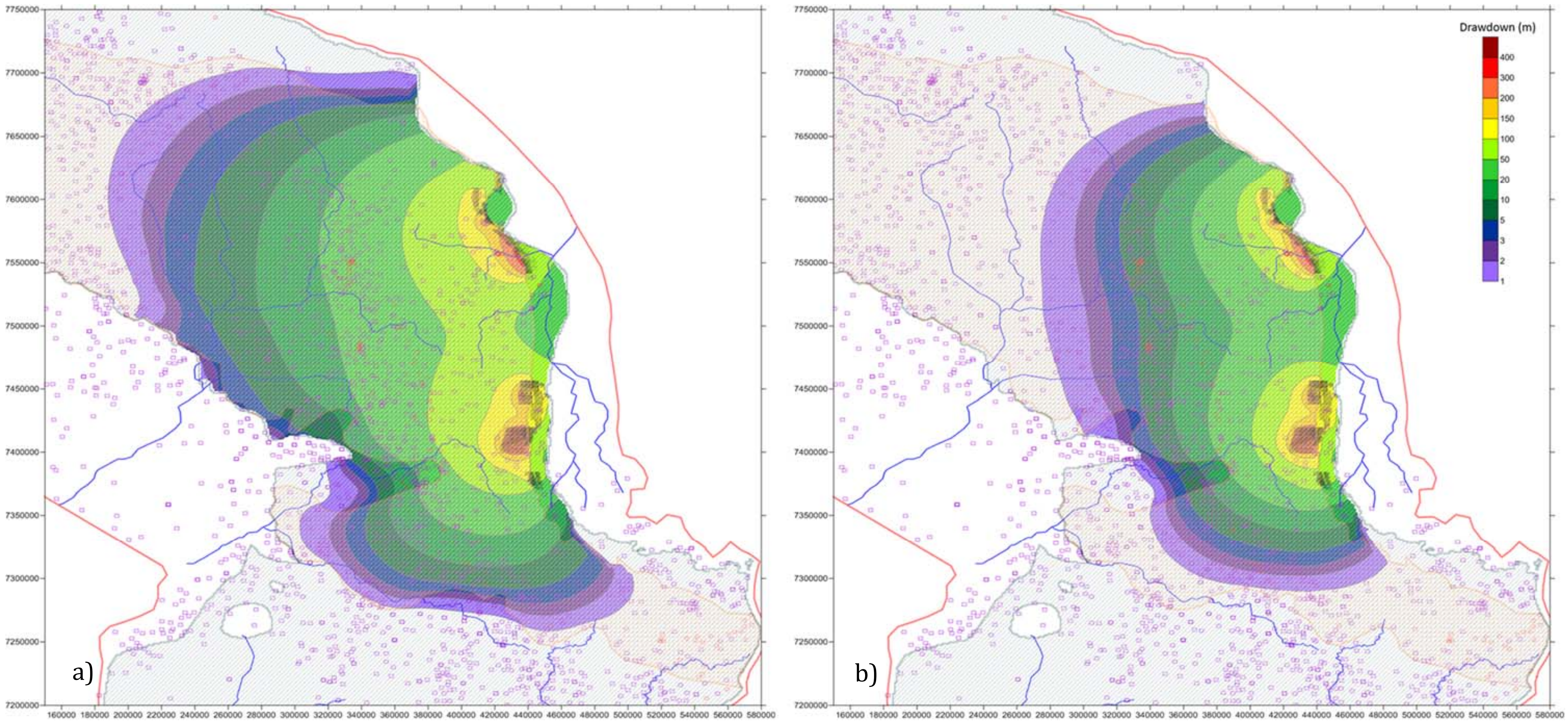


Figure 6-5 Maximum predicted drawdown in Layer 11 (BC2) for a) Base Case and Sensitivity #2 (no TVM) and b) Sensitivity#1 – increased K_Z

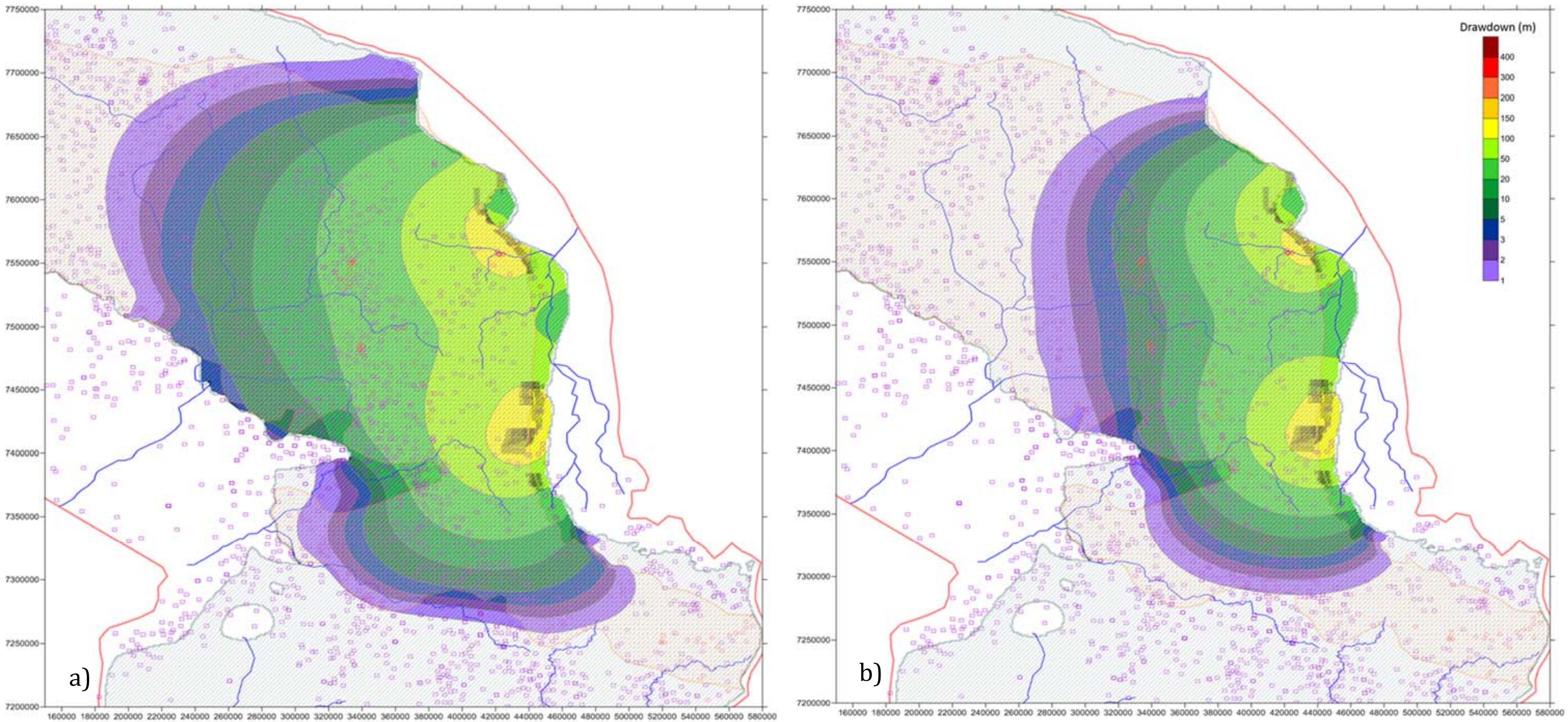


Figure 6-6 Maximum predicted drawdown in Layer 12 (BC3) for a) Base Case and Sensitivity #2 (no TVM) and b) Sensitivity#1 – increased K_Z

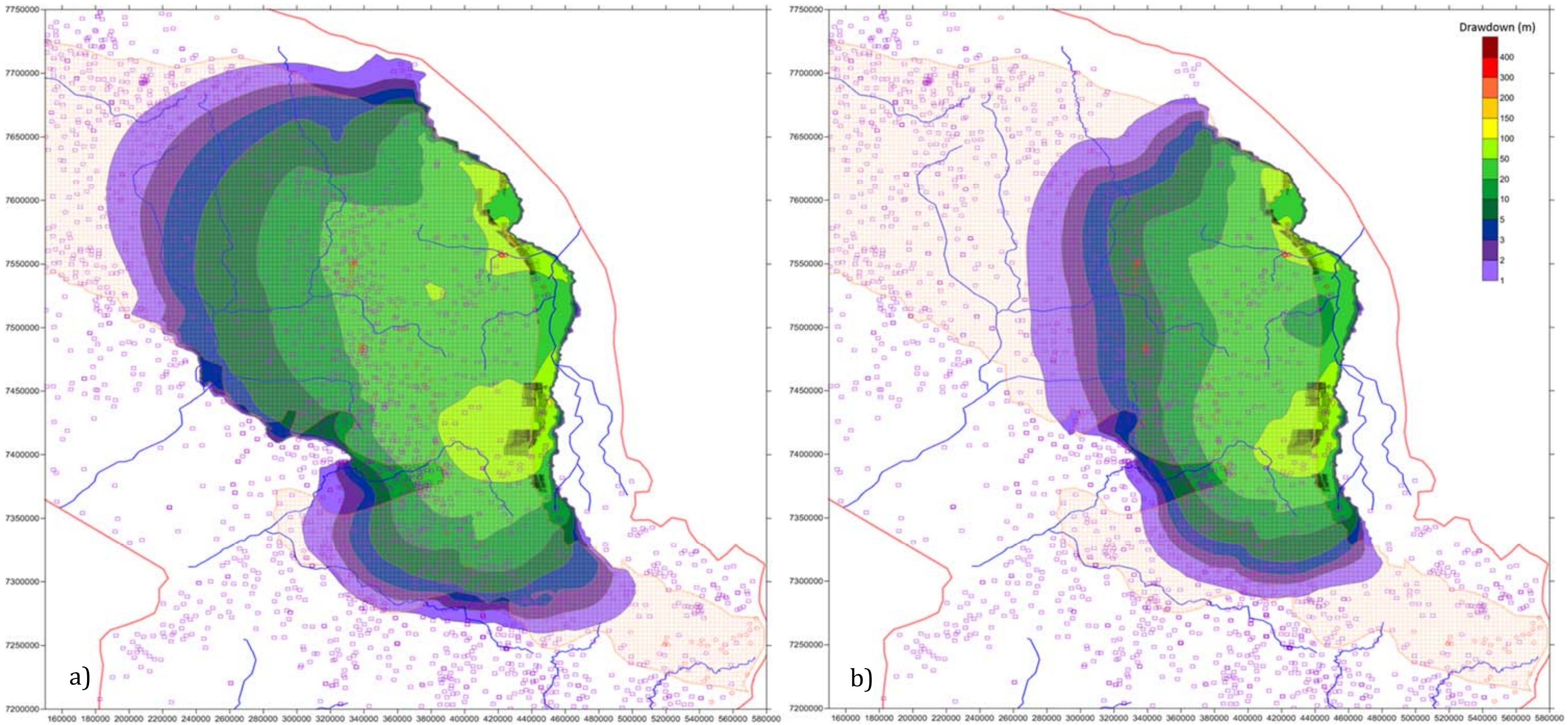


Figure 6-7 Maximum predicted drawdown in Layer 13 (Joe Joe Formation) for a) Base Case and Sensitivity #2 (no TVM) and b) Sensitivity#1 – increased K_Z

7 LIMITATIONS

There are several limitations within the model. Some of these include:

- Lumping together of several hydrogeological properties into single model layers means that representation of real-world groundwater levels for all members of the GAB and Galilee basins is not achievable. This is of particular significance in the Permian coal seam layers (BC1, BC2 and BC3 or Layer 10, 11 and 12 respectively), where bulk hydraulic conductivity parameters applied to the model representing coal seam layers are higher than those of the interburden layers (that are not included). Additionally, no vertical hydraulic conductivity variation exists within the bulked layers. This is likely to have led to an over-estimation of mine inflows and therefore greater drawdown and resulting impacts. The model was not able to be further subdivided into coal seam and interburden layers due to lack of spatially extensive geological information away from the mine sites (T. Evans, pers. comm., 2015). Additionally, a further 10+ model layers would be required to accurately model the target coal seam/interburden for all mines, dramatically increasing run times and computational memory requirements both for model simulation and data handling/processing.
- Data used for construction of the model has been collated by GA from a variety of sources, and as such there is likely to be transcription/allocation error in the data amalgamation process (of indeterminate magnitude). This has been observed in both the model layer boundary definition and well flow quantification provided, and is unavoidable due to the scale of the model area, the length of record history and the variable naming conventions used both spatially and temporally. Errors in these key datasets will have significantly affected model calibration and therefore also will have affected the model predictions. In particular, the over-abstraction of groundwater from the model due to erroneous data has likely resulted in calibrated hydraulic conductivities and storage properties being too high in order to compensate for excessive flows, which will have led to increased mine inflows and resulting drawdowns.
- Information made available for mine planning and scheduling is minimal, and, coupled with the coarse scale of model layering necessitated by the large model extent, means predictive simulations of mining activities and associated impacts are of a generalised nature. As coal seam floor elevation details were not provided, the excavation elevation was assumed to be the base of the BC1 and BC2 layers. If the assigned boundaries of these layers are lower than the real coal floors an over-estimation of mine inflows and drawdown will have occurred. The depth of cover used in fracture height calculations was also assigned using the assumption of the base of model layer representing the coal seam, meaning depth of cover may have been over-estimated in many cases, with consequent over-estimation of the height of fracturing.
- Application of changed hydraulic parameters due to fracturing above longwalls was limited to the A zone (refer to Section 3.4.8). In some locations this zone extended to ground surface (eastern and multi-seam portions of Carmichael, Kevin's Corner, South Galilee and China First). Where this did not occur, no other modification to hydraulic properties for the B and C zones were applied to the model. Additionally, the application of fracturing was assumed as a vertical prism above the mine footprint to include the expected arched shape of fracturing but did not include a wider area allowing for angle of draw. No disconnected surface cracking or change in ground elevation due to land subsidence was applied to the model. This is unlikely to have any notable impact on results due to cracking above the A zone not enhancing the vertical connection between the mine and the overlying layers; however, this has not been tested in any sensitivity analyses. In a greenfield situation such as the Galilee Basin, the fractured zone estimates for height and enhanced permeability remain considerably uncertain.

- Due to the limited time available for modelling and limited mine schedule information, stress periods simulating mining were interpolated to 1 – 5 year intervals to coincide with mine start and end dates in order to reduce model run time.
- Limited data was available for calibration; most data collected was of single point observations over a period of 30 years. Therefore, reliability of the data is unknown as long term trends were not able to be analysed. Flow data provided for wells also appear to be inaccurate and are likely to result in simulations of incorrect abstractions.
- Resolution of all locally important hydrogeological features (springs, rivers, faults, etc.) is not possible in a model of this scale, therefore a select number of key features have been chosen to be modelled in increased detail, while the remaining are assumed to be included in the bulk regional properties of the model. Due to the scale of the model, even the "detailed" resolution of springs and rivers is significantly greater than real conditions, with minimum cell size of 200m diameter used to represent these features, meaning the hydraulic gradient and therefore groundwater flow is only a rough approximation. The information provided by GA regarding spring flows and river baseflow are broad estimates at best, with possibly significant errors and/or generalisations associated with the datasets. For both of these reasons, calibration of the groundwater model to baseflow and spring flow volumes has been difficult. Significant springs such as the Albro and Hector springs have not been included, and many clusters of springs have been simplified down to one or two individual locations. Additionally, impacts at such features are simulated as relative to the base-case scenario (no mining), which may not match reality in all situations.
- Due to the greenfield nature of the projects, the volume of mine inflows is unknown for all mines and therefore no conclusive dataset is available to constrain hydraulic properties at the mine sites.
- Limited formal sensitivity analysis has been carried out due to the short model development timeframe and agreed scope for the project. It is therefore difficult to clearly indicate which parameter/s are controlling calibration, inflows and predicted impacts.
- As is the case for most groundwater models, surface water and unsaturated zone flow processes are not explicitly modelled. Therefore the effects of localised variations in groundwater recharge due to these processes are also not represented in detail, rather bulk estimates are applied. Additionally, use of the RIV package to model streams means water modelled as baseflow (groundwater discharge to streams) is effectively removed from the model at the applicable cell and no flow routing of excess water from gaining streams to downstream cells is applied.
- Drawdown in Layer 1 (alluvium/regolith) is not well represented in the model. This is in part due to the thickness of Layer 1 not being adequately deep enough to represent the water table depth (10m uniform thickness across the model except in localised patches of up to 66m where data was provided by GA). At the location of the mines, the regolith layer directly overlies the Permian units, meaning that drawdown is not shown in Layer 1 if the layer did not already show some saturation (i.e. if the water table depth is greater than 10m).
- It has been identified after the completion of this project that certain options within the MODFLOW-USG code do not allow the model to represent negative pressures (i.e. dry cells). This means that an artificial head is maintained at the base of each layer, which may result in an under-prediction of the magnitude of drawdown within each cell. This will have had particular implication for impacts predicted in Layer 1, essentially resulting in water being held at the base of Layer 1 for the entire model simulation and resulting in negligible reported drawdown within this layer.

8 RECOMMENDATIONS FOR FUTURE WORK

Although very few groundwater models in the past have attempted to cover a regional extent as great as the Galilee Basin, while maintaining stratigraphic definition and simulation of local scale processes, this model is still simplified in many respects in comparison to those used to represent individual mines in existing EIS studies (over much smaller portions of the eastern Galilee Basin). This is a consequence of the sheer scale of the model, limited data availability particularly regarding mine scheduling and coal seam layer extents, as well as due to a restrictive model development timeframe for complex data analysis and subsequent model refinement. HS suggests the following improvements to the model be considered during further work:

- The groundwater abstraction data applied in this model has had a significant impact on calibration and parameterisation, in particular leading to higher K and S values than expected. It has been acknowledged by GA that the data provided is likely to be incorrect, as the increasing trend in groundwater use is not consistent with the well capping scheme that has taken place in the GAB. It is recommended that well flow volume data is thoroughly scrutinised by all stakeholders and the model is re-calibrated using agreed correct flow data.
- An additional recharge zone of 5mm/year into alluvial deposits has been presented in the latest figures supplied by GA that was not in the original recharge data provided. It is recommended that the applied recharge is updated to include this during the required re-calibration associated with the application of the aforementioned well data. Sensitivity of predictions due to changing long term recharge should also be considered.
- Verification of the thickness of Layer 1 is advised due to the assumption of a 10m layer thickness where structural data supplied by GA indicated a lesser thickness. This assumption has potentially limited the possible “drawdown” within these layers where groundwater levels are near to the base of the layer in areas where the thickness of Cenozoic sediments is in fact greater than 10m.
- Verification of the easterly extent of the coal seam layers, Rewan Formation and the Clematis Sandstone, particularly in the vicinity of China Stone, is required for future model iterations due to the apparent misalignment of open-pit mining and the target layers in the geological model. This may have resulted in misleading drawdowns in the Clematis Sandstone in the area.
- A new version of AlgoMesh is now available that allows discontinuous sub-layers to be built into a model. It is strongly recommended that model layers 10, 11 and 12 are re-built to include detail of coal seams layers at least on the eastern side of the model locally to mines (i.e. not fully extensive across the model domain). This will allow for greater accuracy and control over mine inflows, fracturing heights and propagation of drawdown, while not drastically increasing computational run times.
- Layer zonation used in this model allowed for a maximum of three variable hydraulic parameters distributions per layer which has limited calibration. A region of this scale is unlikely to have uniform hydraulic properties across its full extent. A better calibration fit could be achieved if the hydraulic properties were automatically distributed using calibration to pilot points in PEST. This requires significantly more set-up and processing time; however the results are likely to be substantially improved. As a minimum it is suggested that further zones are added to differentiate between the north and south of the model to try to improve calibration north of the Carmichael River.
- The recovery runs carried out in this modelling work have shown that groundwater levels in the Galilee Basin layers (Bandanna to Joe Joe) do not recover from mining within the 150 year time period simulated. If/when the model is re-built to include greater detail in the mining areas, consideration should be given to extending the recovery simulation period until equilibrium is reached.

- Better representation of the system could be simulated if the length of calibration stress periods were reduced to monthly. This would allow for seasonal variation in controlling factors such as recharge, evapotranspiration and river leakage to be modelled with increased accuracy, allowing better calibration of the model and therefore greater confidence in the predicted results. However this would require significant improvements to the input data sets which are currently only refined to annual resolution, and uncertainties involved in the creation of such datasets may outweigh the benefits of modelling at the reduced intervals. It will also require longer model run times.
- Some improvement in predictive results may be seen by modifying all the predictive stress periods to annual intervals. This will result in a more gradual imposition of stresses and may help to smooth mine inflows and resulting drawdowns. However mine schedule data is currently not available at this resolution, so a large degree of uncertainty would still be associated with these refined model results as the timing of mine activities would only be an interpolation.
- Due to time constraints, limited sensitivity analysis was performed on predictive results. It is recommended that further work is carried out to assess the impacts of fracture zone hydraulic properties. The model is likely to be more sensitive to these parameters with the inclusion of extra resolution within the coal seam layers.
- Upon finalisation of this project it appears that some key datasets were not made available for use during calibration, notably data from the Jericho Shire Council monitoring bores in the Clematis Sandstone, and groundwater heads from private artesian bores monitored by Queensland DNRM. Future work could include verification of the model using this data, and potential re-calibration particularly of the transient model.
- Refinement of the model mesh to include additional rivers in the area to the south west where heads are typically over-predicted should be considered (to include rivers of the Fitzroy catchment). Addition of the Hector and Albro springs could occur at the same time.
- Investigation of MODFLOW-USG options to determine/create an appropriate version of the code for representing negative pressures (i.e. water levels dropping below the base of the layer). Currently the only form of the code allowing negative pressures occurs where vertical conductance is calculated using full layer thicknesses between vertically adjacent layers instead of dynamic saturated thicknesses. However, this can make the model unstable and additionally is not conceptually ideal. The other options for vertical conductance, which should be comparable to standard MODFLOW-2000 onwards, currently result in the “hanging up” of water levels at the base of each layer. This is likely to be improved with future versions of MODFLOW-USG.

9 CONCLUSIONS

A groundwater model has been prepared to predict the cumulative impacts of seven open cut and underground coal mines within the Galilee Basin for the Galilee Bioregional Assessment. The model was built using existing datasets provided by Geoscience Australia and has been simulated in the finite volume code MODFLOW-USG. Both steady-state and transient models were developed for calibration. A predictive model was run using simple mine plan information whereby drains were used to simulate both open cut and underground mining. Fracture formation above longwalls was included using the Time Varying Materials package.

Average groundwater inflow to each mine is expected to range from 5 ML/day at Hyde Park to about 78 ML/day at China First, with a total cumulative flow of about 2,800GL over the life of the seven mines.

Predictive modelling simulates an extensive cone of depression within the Permian coal seam layers. This extends approximately 500km north-south and 400km east-west. Where the cone of depression extends further than the Rewan Formation, localised drawdown in the GAB of up to 5m occurs. In close proximity to China Stone, the Clematis Sandstone obtains a predicted drawdown of up to 50m.

Over the prediction period all rivers are naturally net losing systems. Mining leads to minor reductions in baseflow in the Carmichael River of approximately 4%. All other modelled rivers have a predicted loss of baseflow of less than 1%. The Mellaluka Springs are the only “significant” springs (flows >100m^3/day) expected to be impacted by greater than 1m by mining. With drawdowns of over 40m at the Mellaluka Springs it is expected that these springs will stop flowing.

Eighty-nine registered production bores are predicted to have drawdowns greater than 1m due to the influence of mining. Of these, 57 are screened within the GAB units.

Sensitivity runs were carried out to assess the sensitivity of model predictions to both the existence of the fracture zone and the vertical hydraulic conductivity of the GAB aquitards. It was found that the model was relatively insensitive to the fracture zone, however an increase of vertical hydraulic conductivity by 1 order of magnitude resulted in an increase in mine inflows by 15%, as well as an increase in affected bore numbers to 126 bores with greater than 1m of drawdown mostly within the GAB units. Additional sensitivity and uncertainty analysis was unable to be done in the restricted model development timeframe and agreed scope for project completion.

There is some uncertainty over accuracy of predictions both within the alluvium (Layer 1) and the Permian coal seam layers. Errors in drawdown prediction appear to have occurred in Layer 1 due to inadequate spatial data available for assigning correct layer thickness across the model, combined with a “glitch” in the MODFLOW-USG code which has caused the water in each layer to be held at the base of the layer.

Predictions of mine inflows and drawdowns are likely to have been over-estimated due to the bulking together of coal seam and interburden layers, and the likely inaccurate (deeper) depth of mining applied in the model due to lack of detailed mine plan or coal seam layer data.

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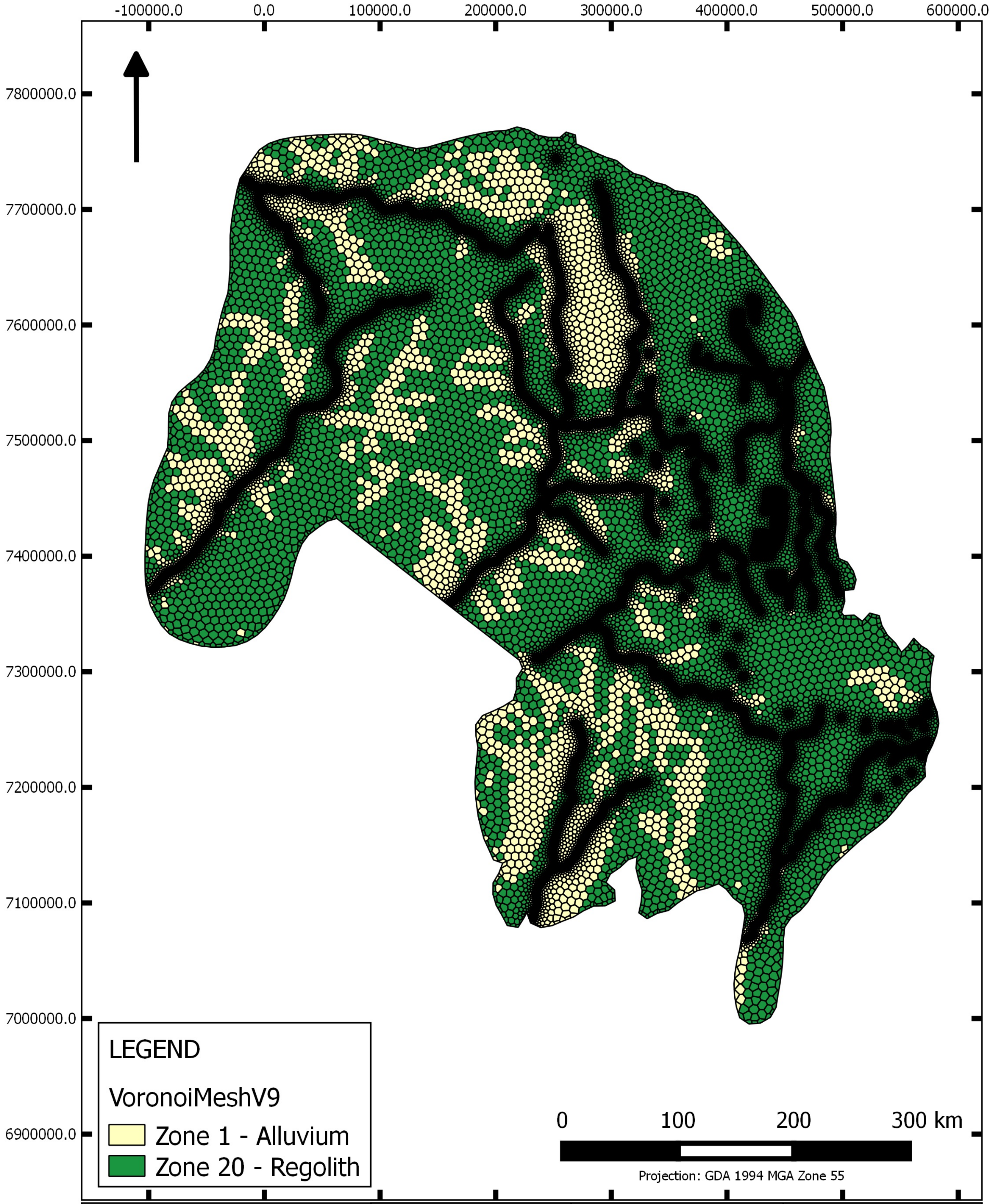
APPENDIX A – Model Layer Zonation



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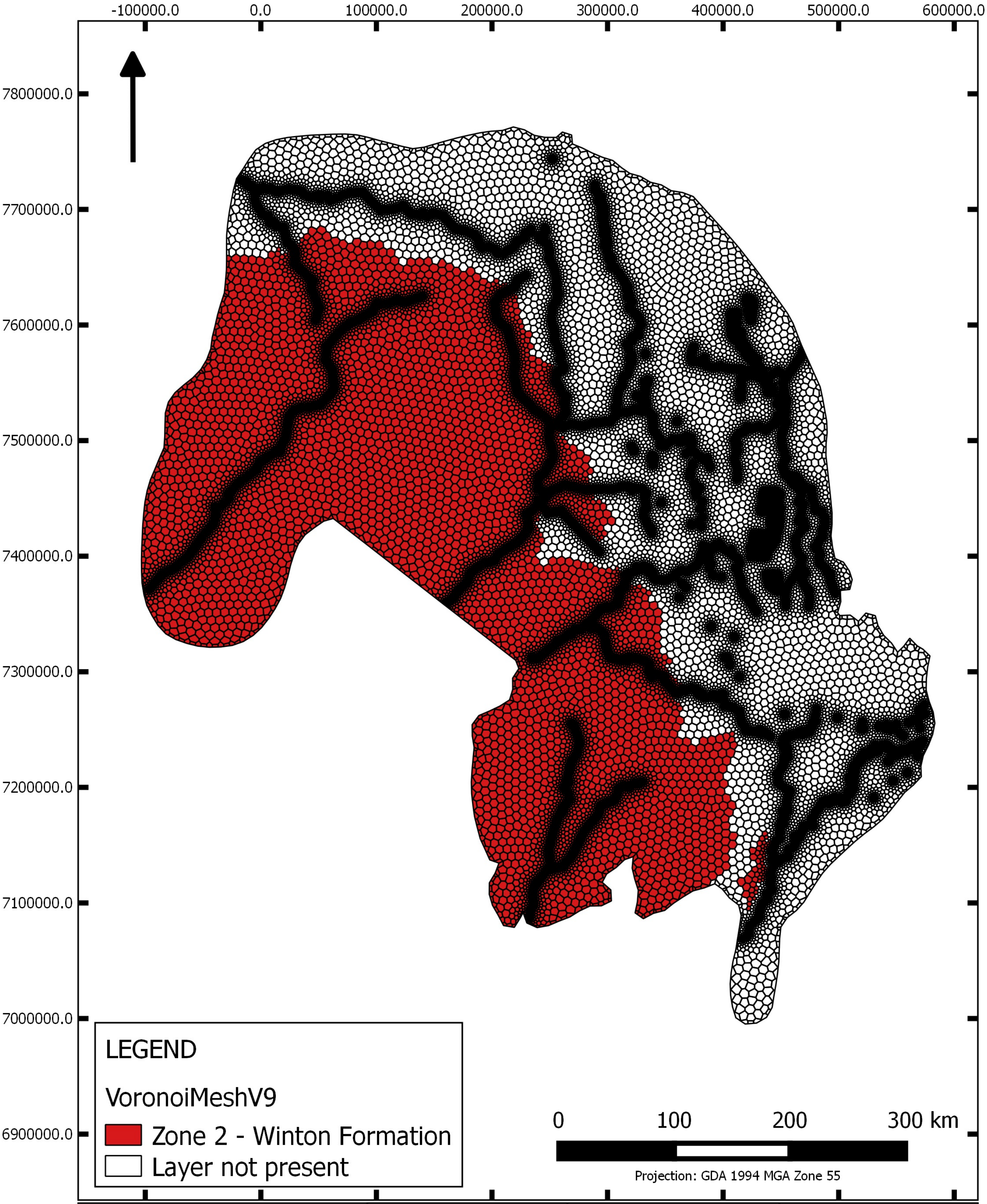

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HYDRO SIMULATIONS

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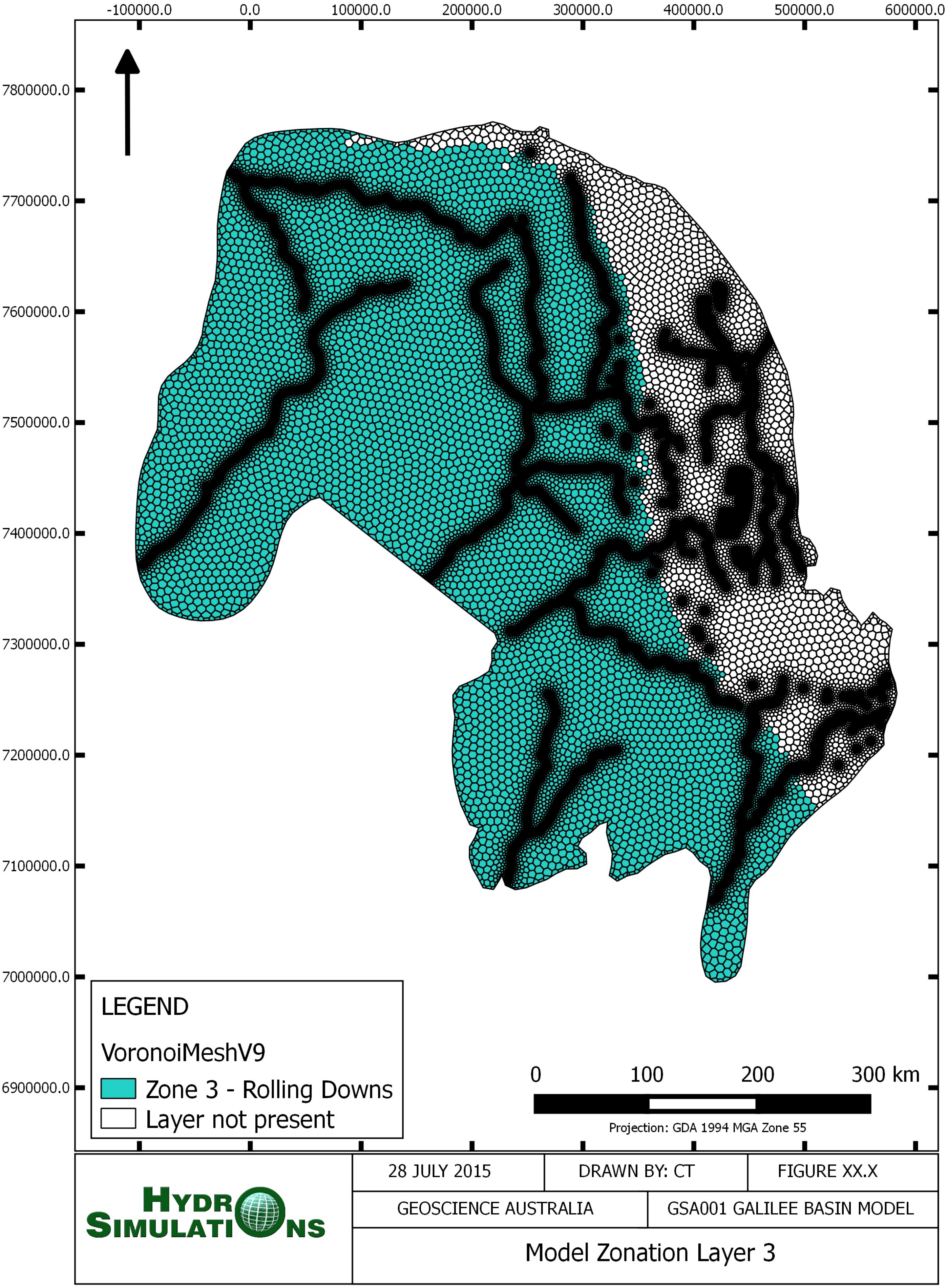

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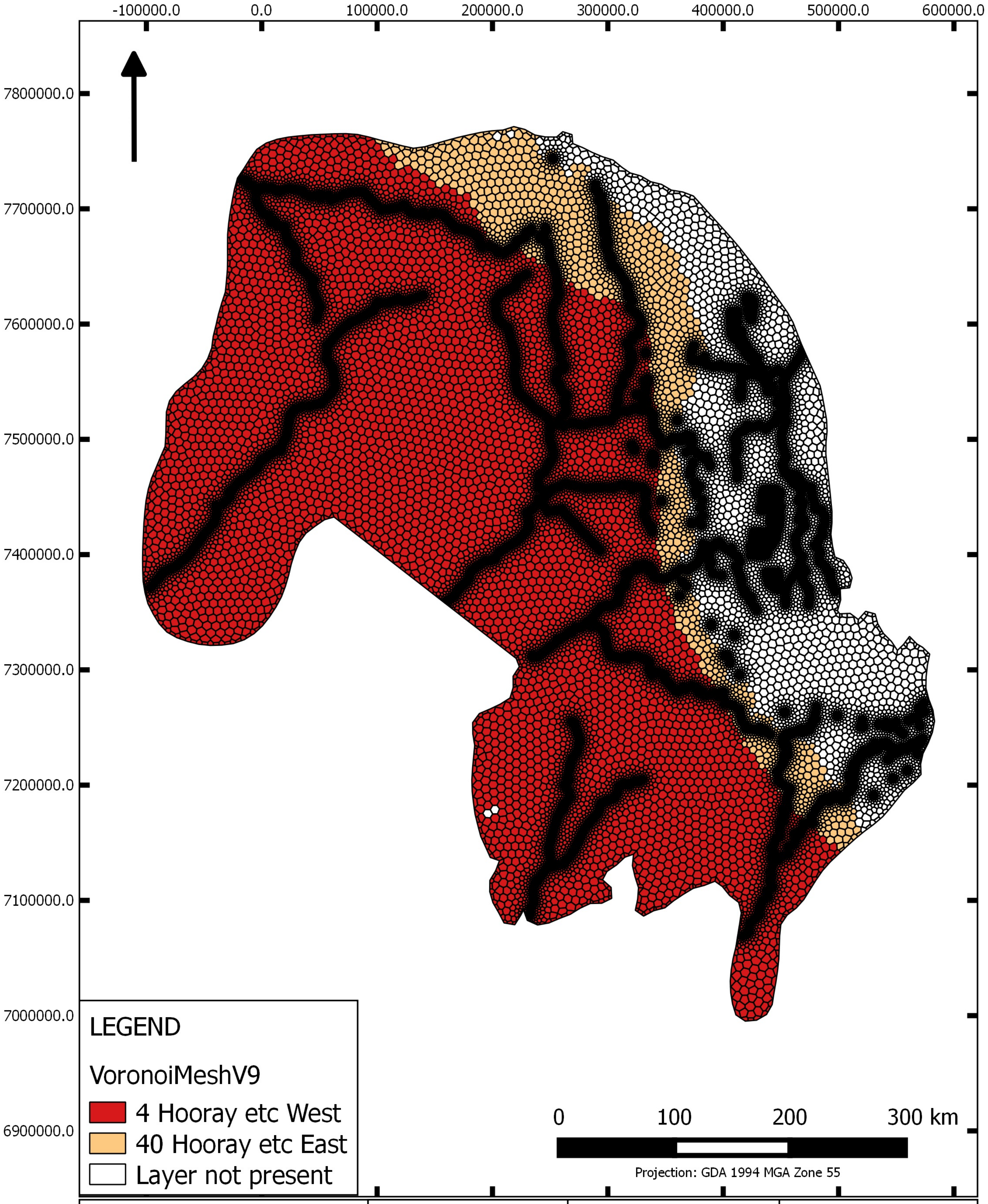

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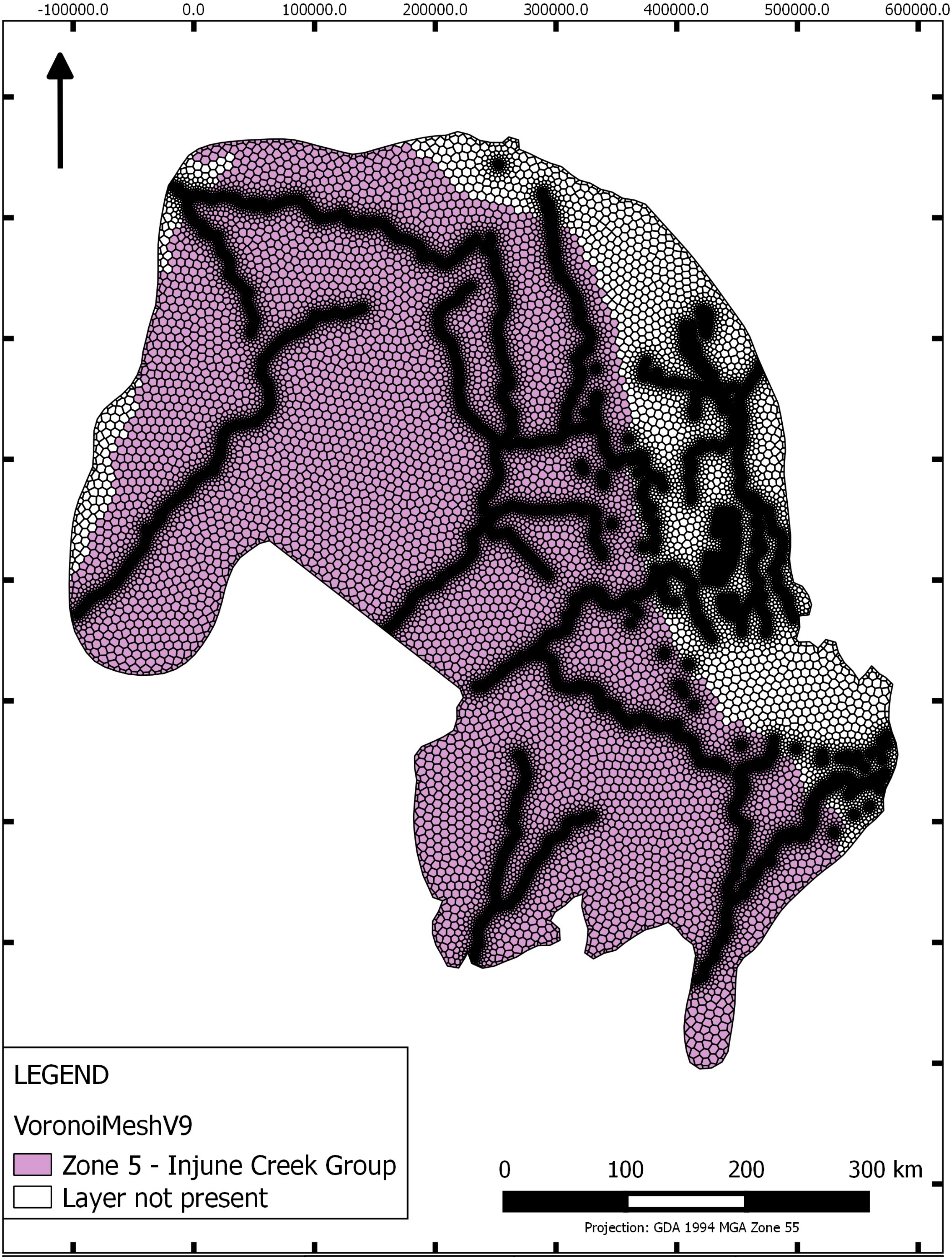

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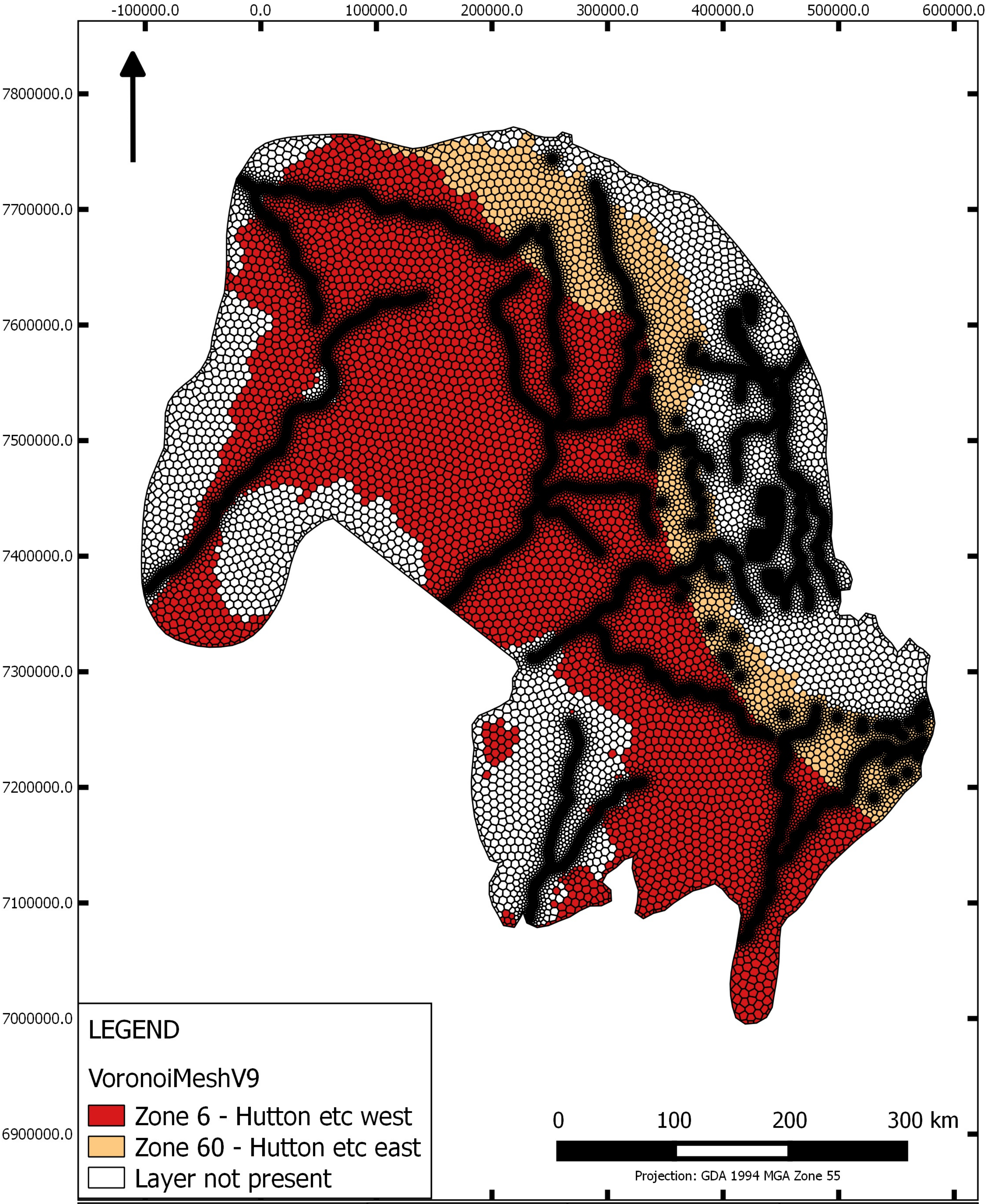

HYDRO SIMULATIONS

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Model Zonation Layer 6		

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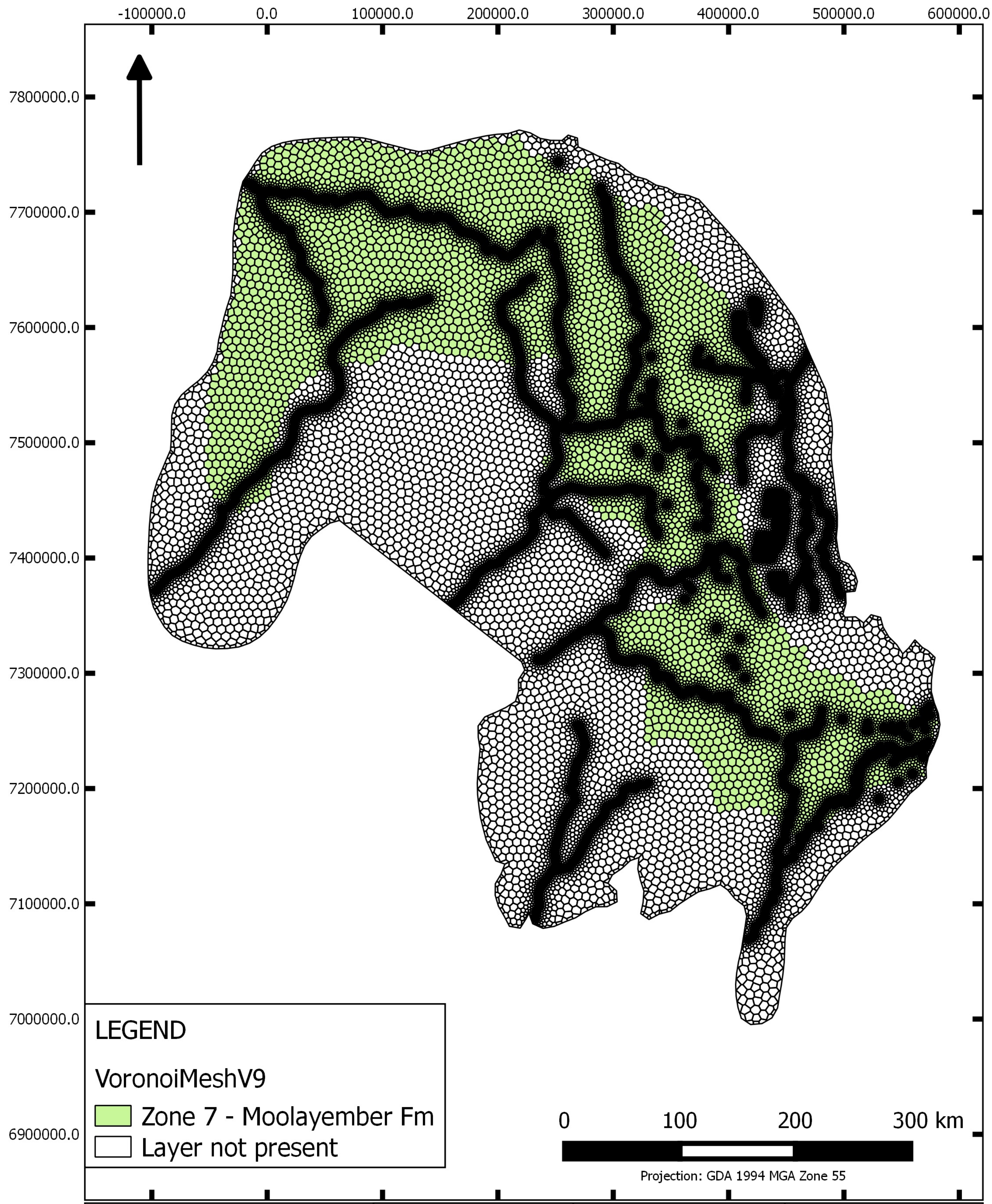

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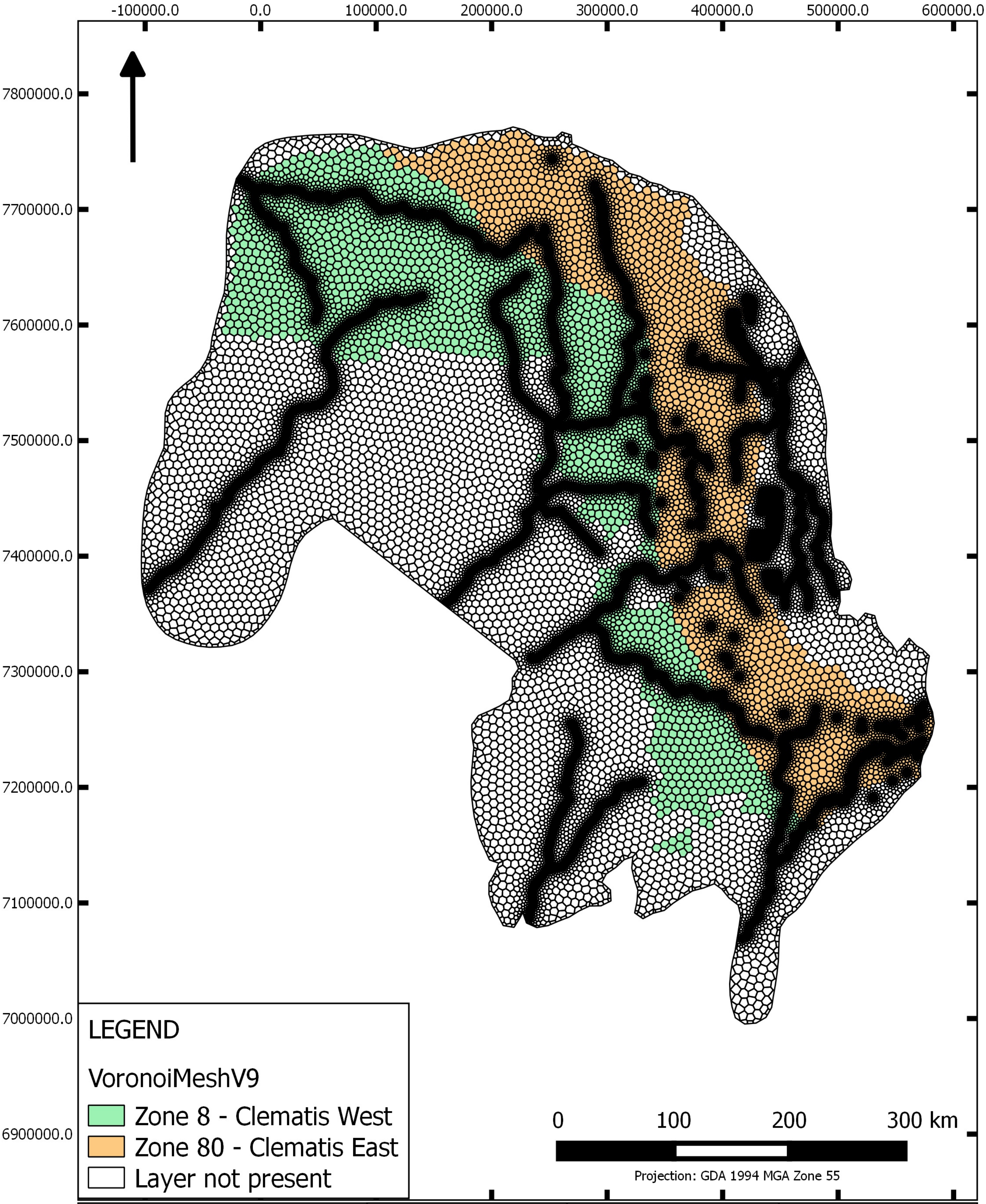

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Model Zonation Layer 8		

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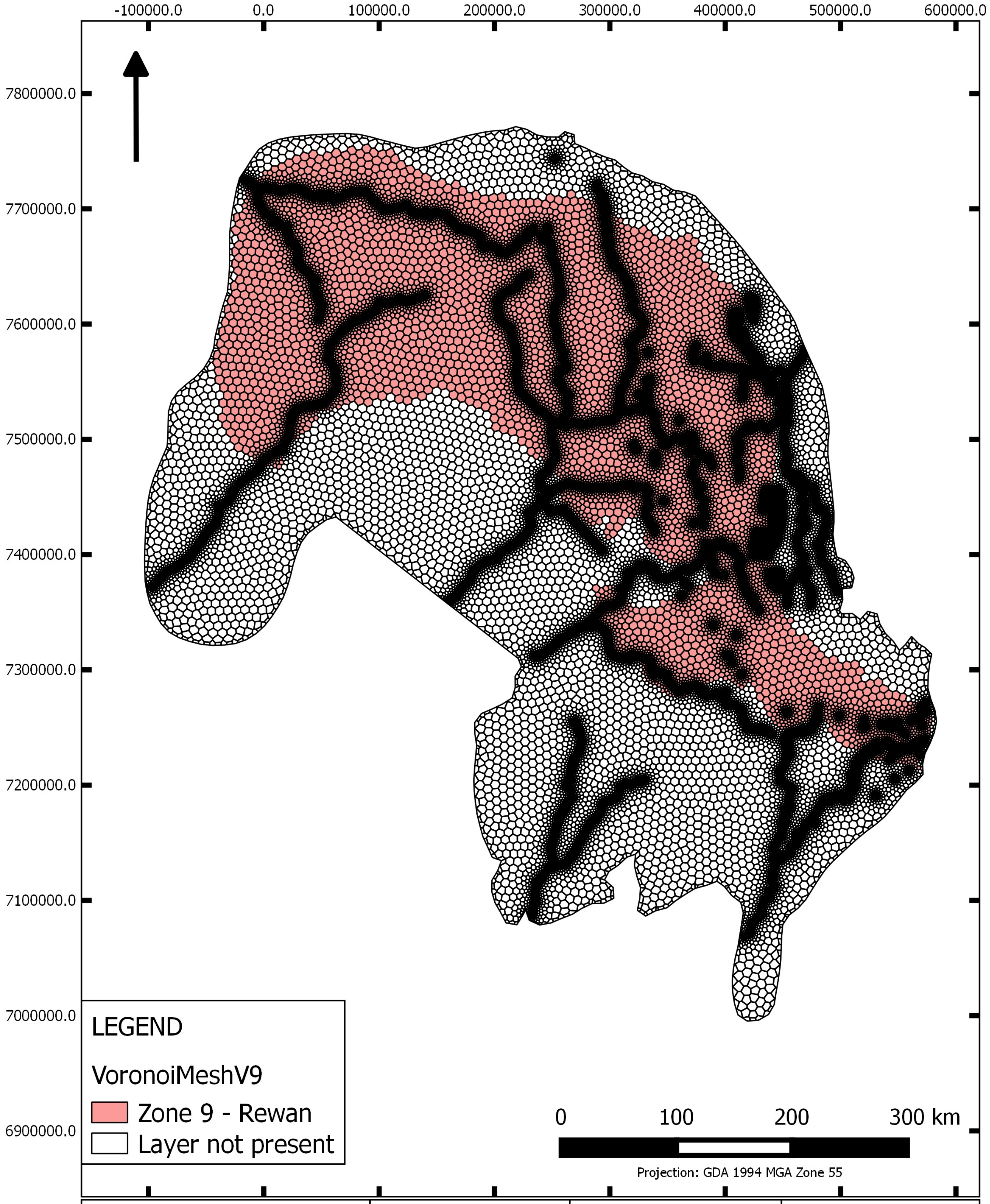

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Model Zonation Layer 9

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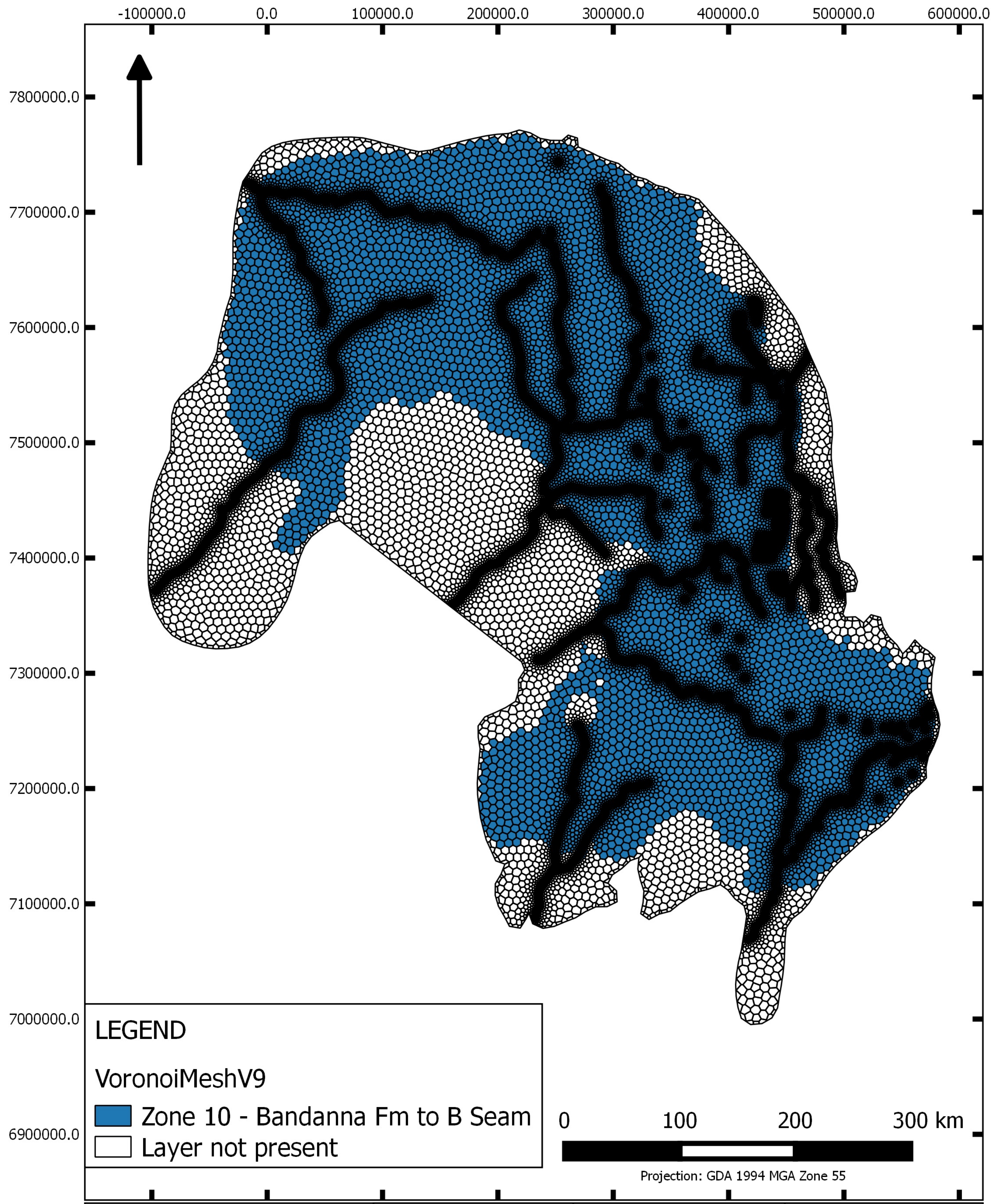

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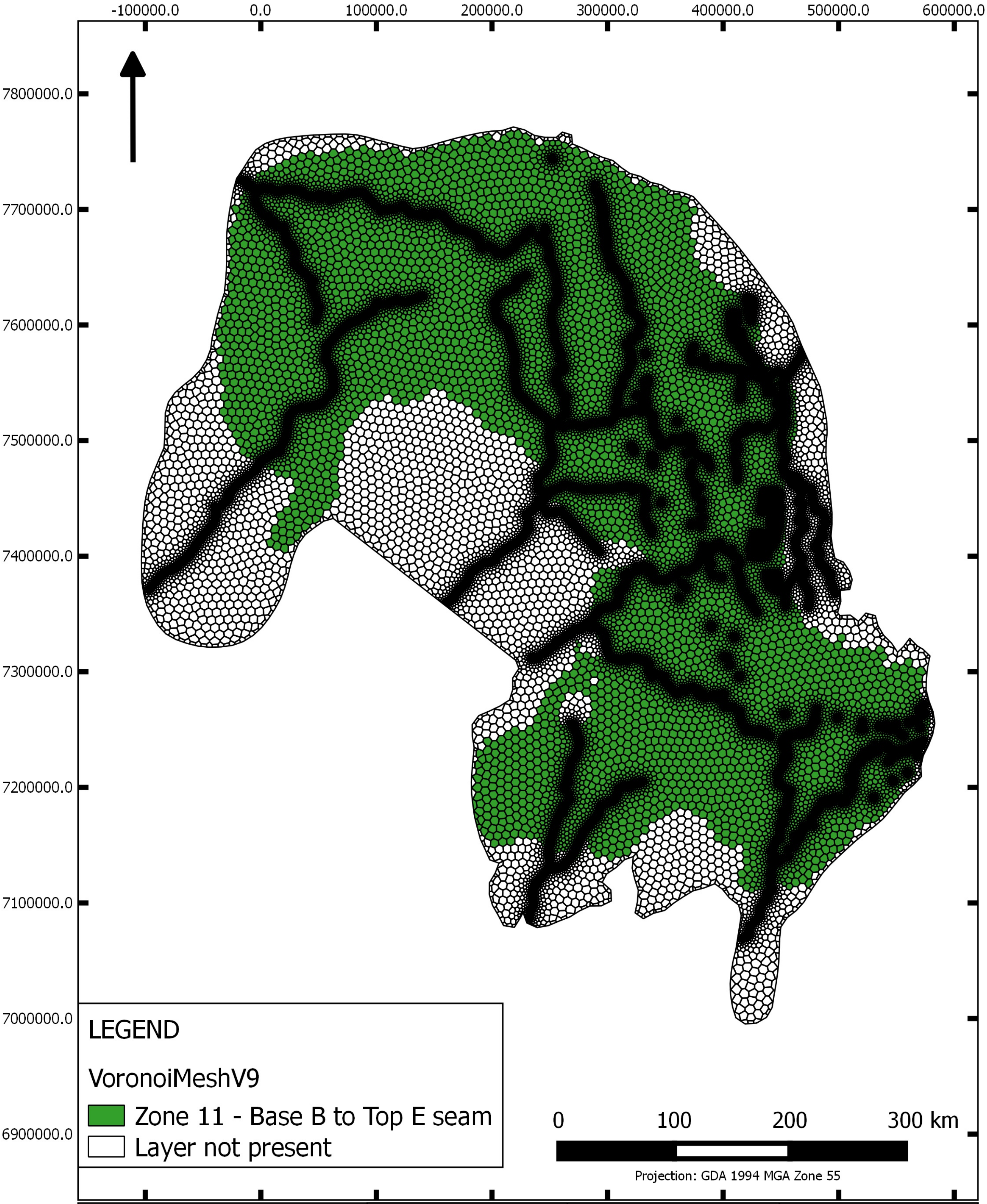

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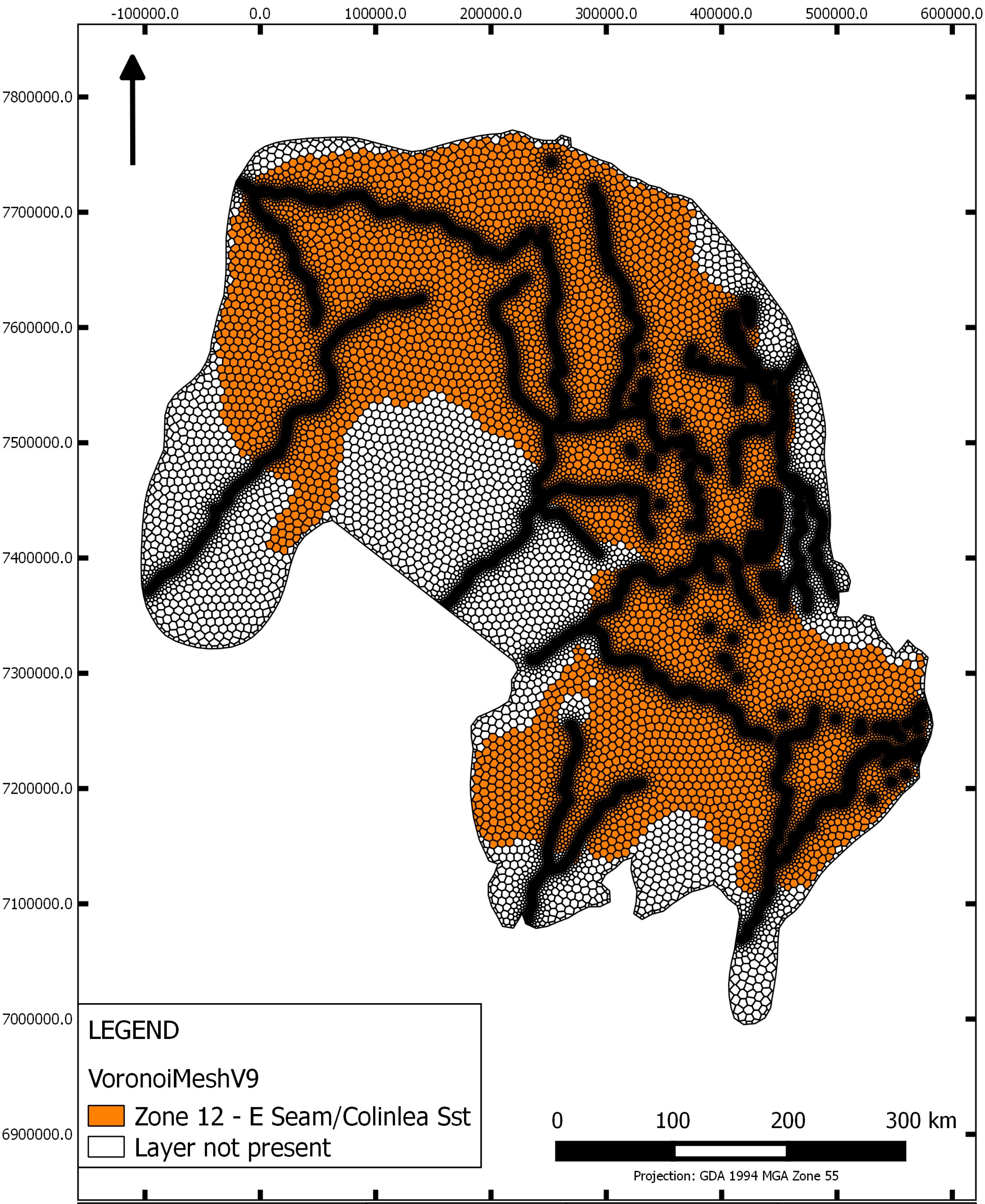

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Model Zonation Layer 12		

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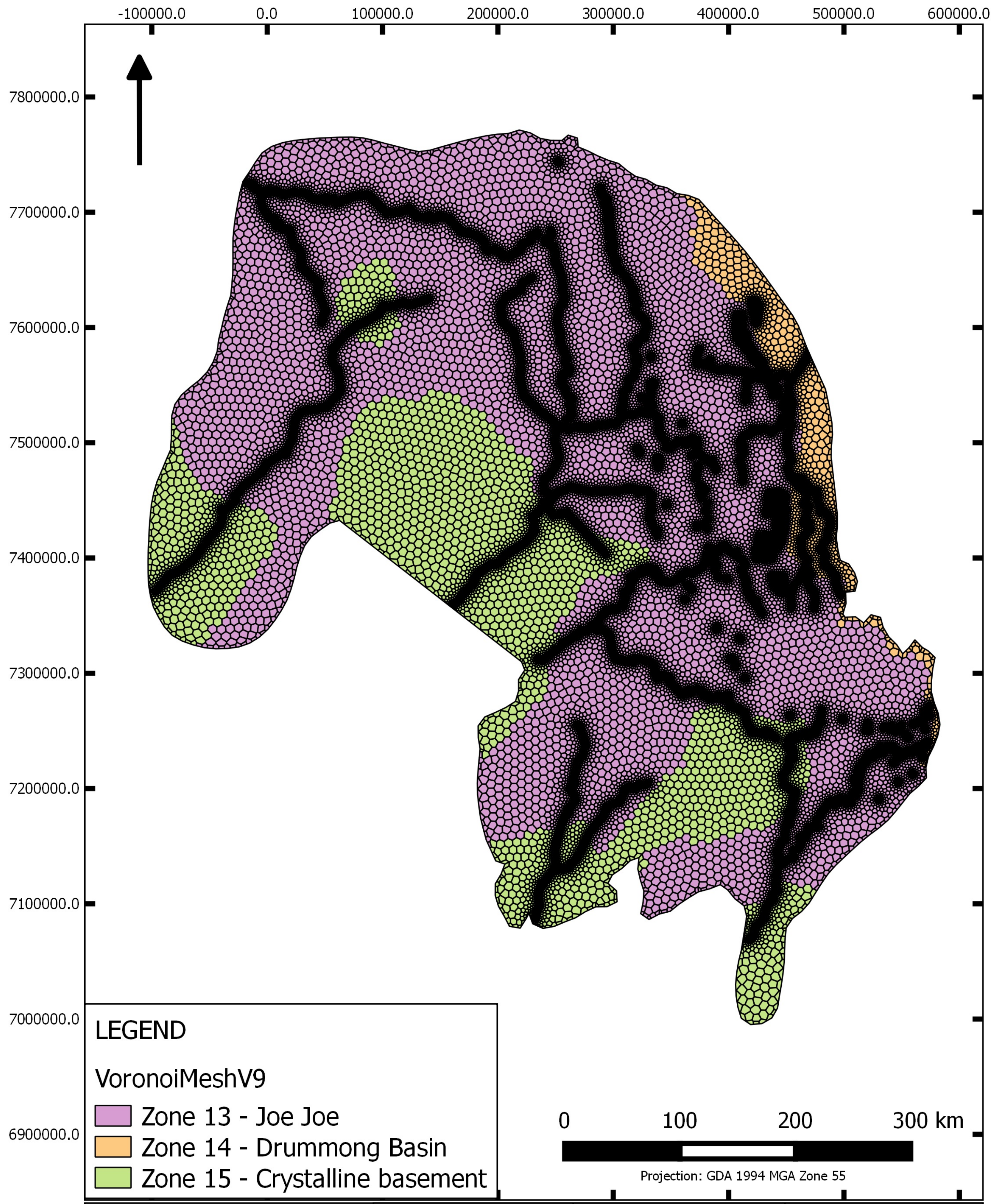

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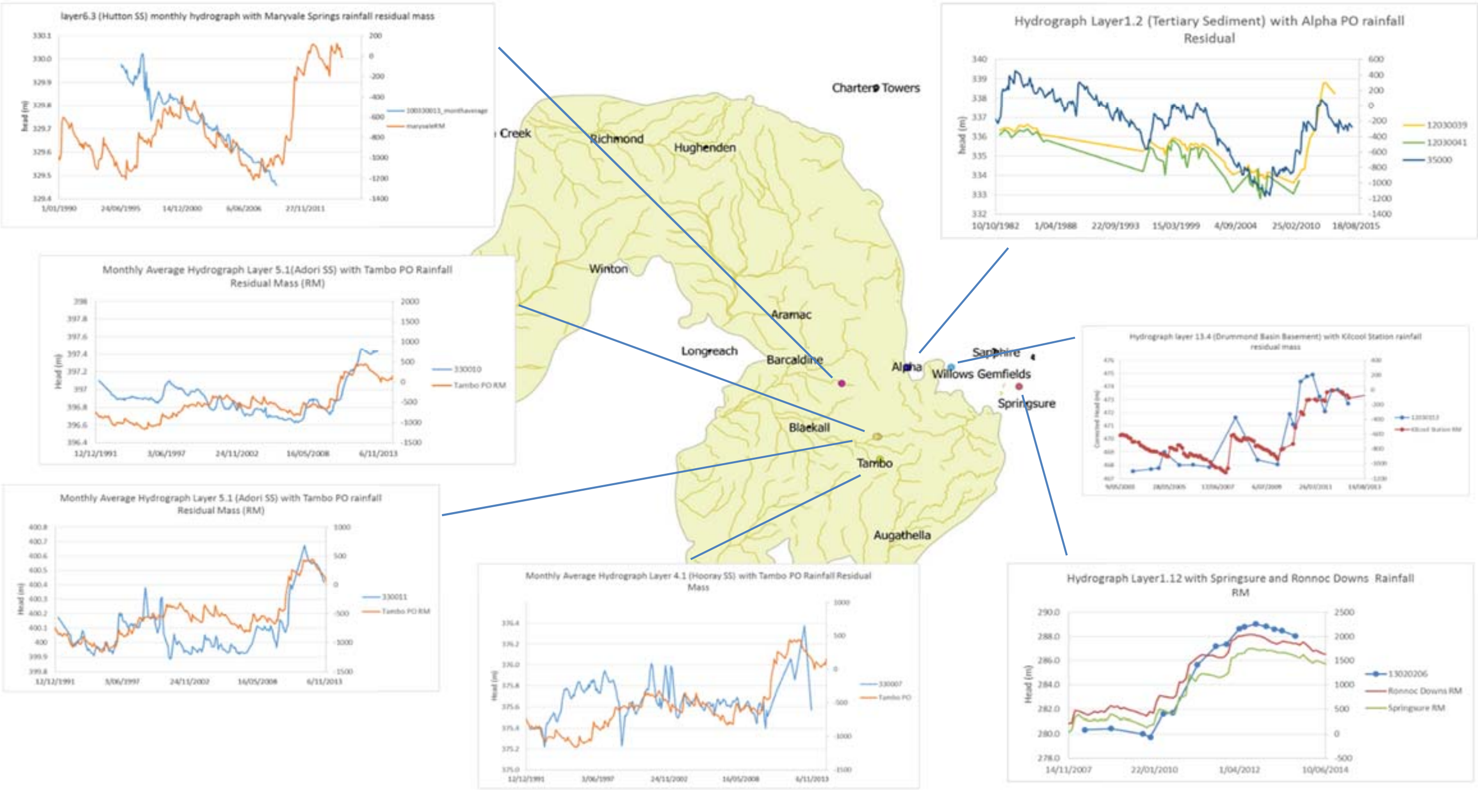
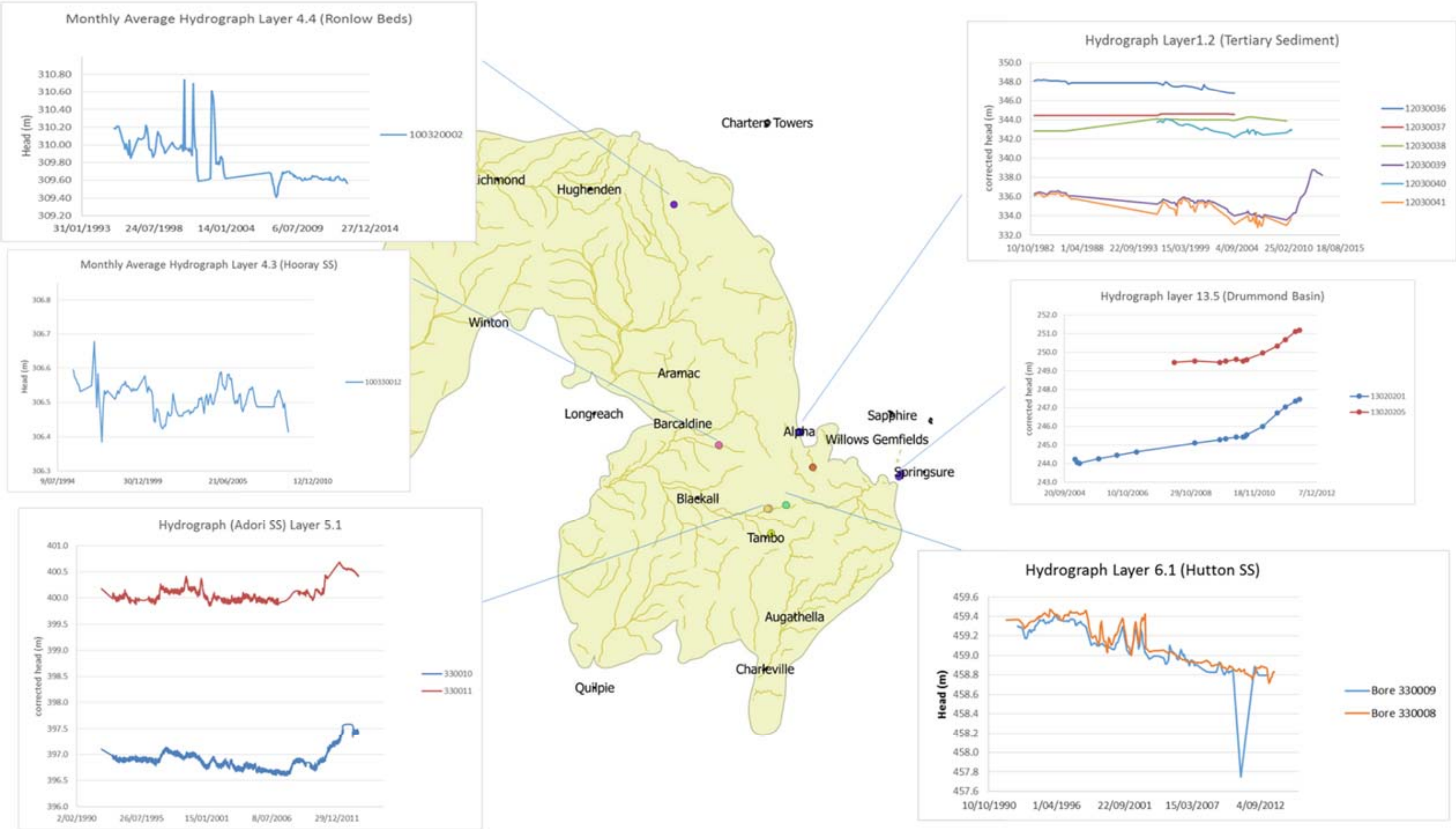
APPENDIX B – Transient Groundwater Hydrographs (Observed and Residual Mass)

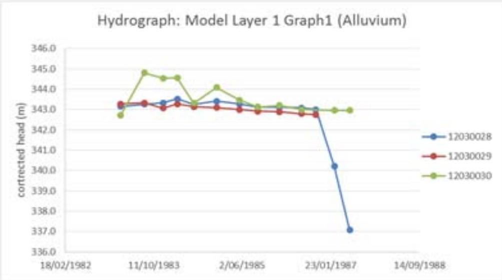
Example Hydrographs with rainfall RMC and their location in the Galilee Basin Subregion.

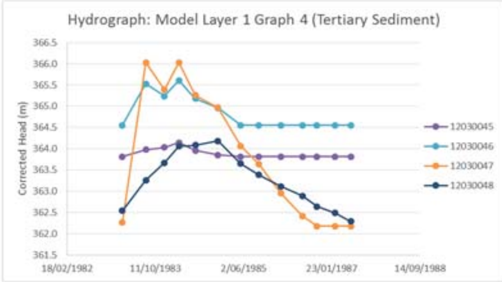


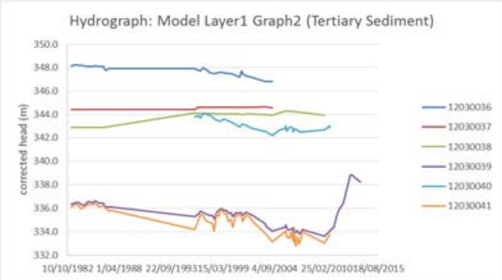
Example Hydrographs and their location in the Galilee Basin Subregion.

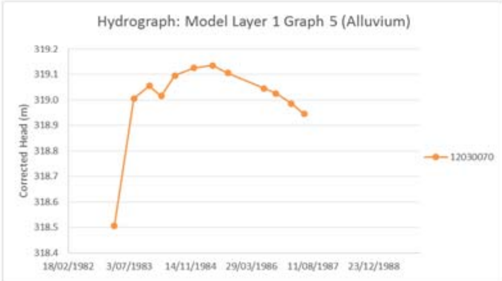


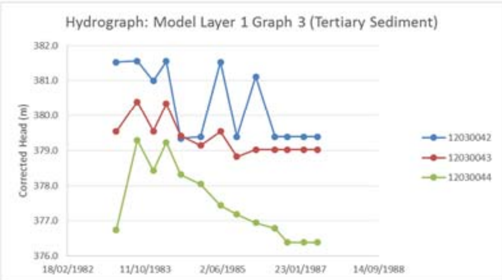
Transient Hydrographs taken form bore data supplied by GA.

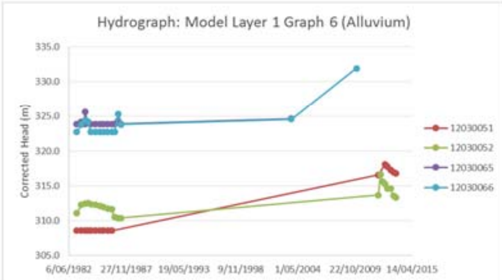


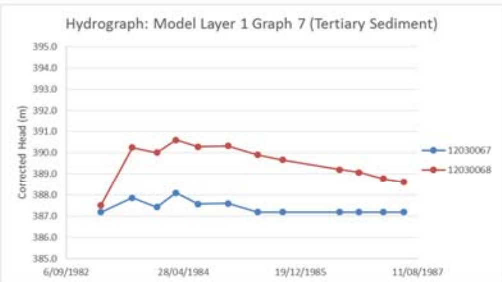


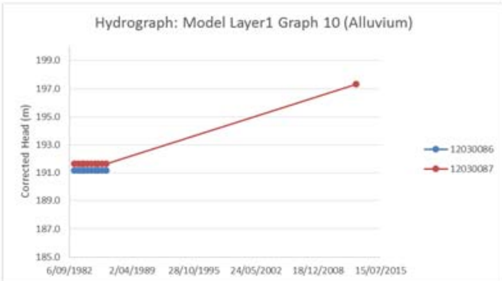


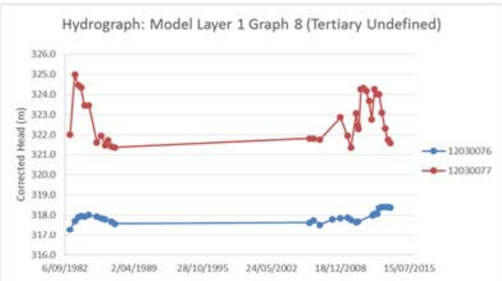


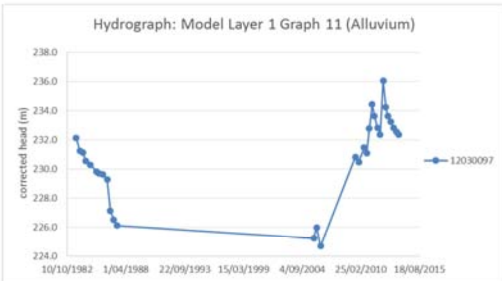


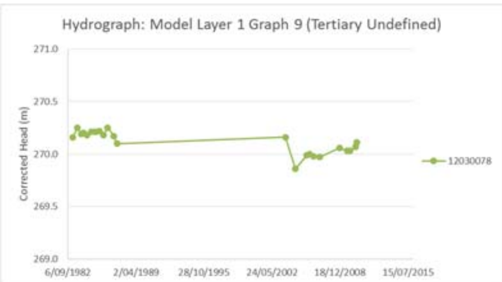


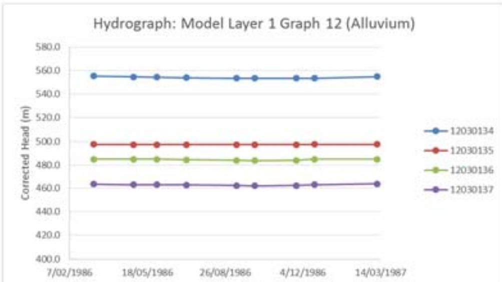


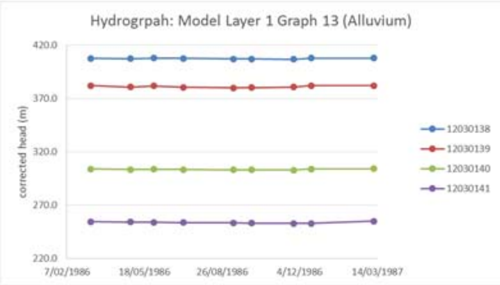








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370.0
320.0
270.0
220.0
7/02/1986
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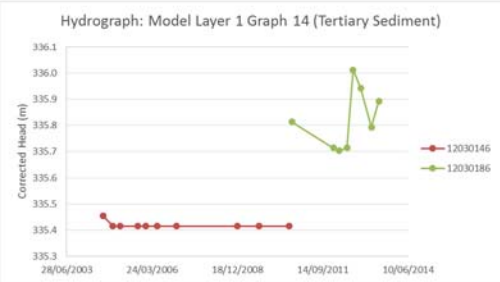
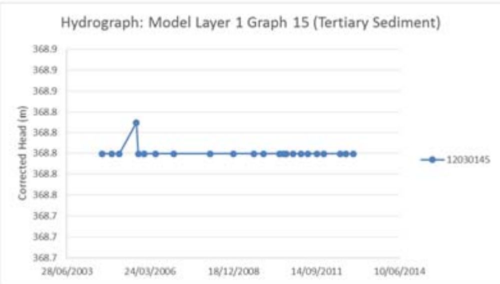
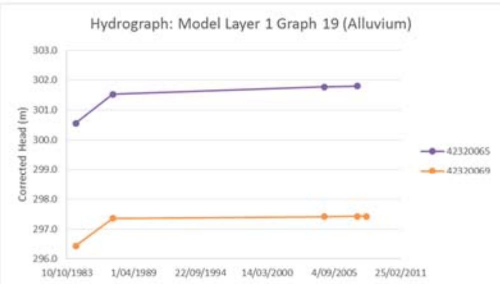
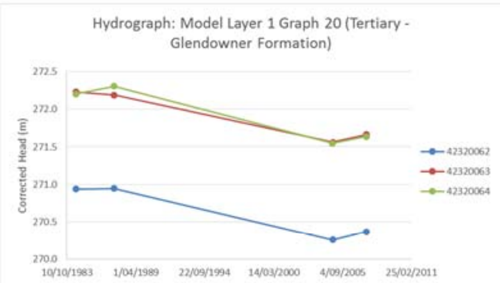
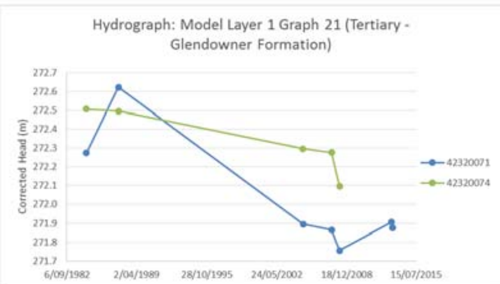
12030141

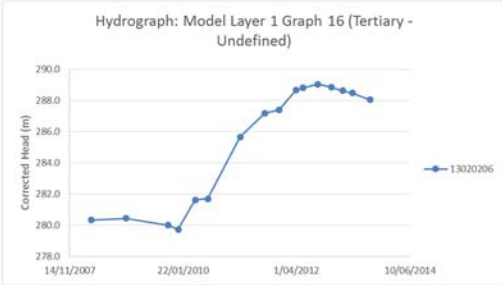

Hydrograph: Model Layer 1 Graph 14 (Tertiary Sediment)
Corrected Head (m)
336.1
336.0
335.9
335.8
335.7
335.6
335.5
335.4
335.3
28/06/2003
24/03/2006
18/12/2008
14/09/2011
10/06/2014
12030146
12030186

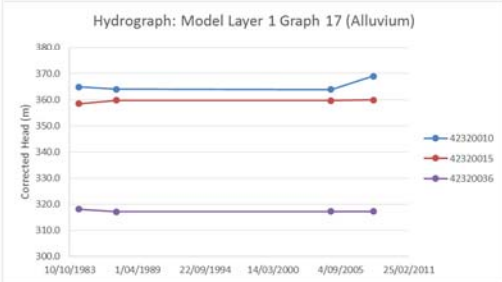

Hydrograph: Model Layer 1 Graph 15 (Tertiary Sediment)
Corrected Head (m)
368.9
368.9
368.9
368.8
368.8
368.8
368.8
368.8
368.7
368.7
368.7
28/06/2003
24/03/2006
18/12/2008
14/09/2011
10/06/2014
12030145

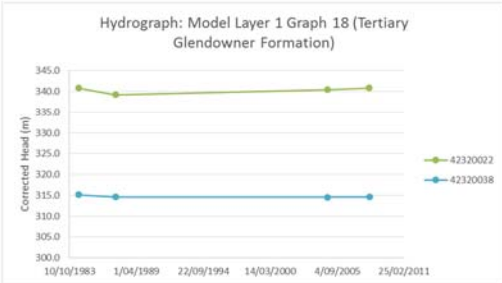

Hydrograph: Model Layer 1 Graph 19 (Alluvium)
Corrected Head (m)
303.0
302.0
301.0
300.0
299.0
298.0
297.0
296.0
10/10/1983
1/04/1989
22/09/1994
14/03/2000
4/09/2005
25/02/2011
42320065
42320069

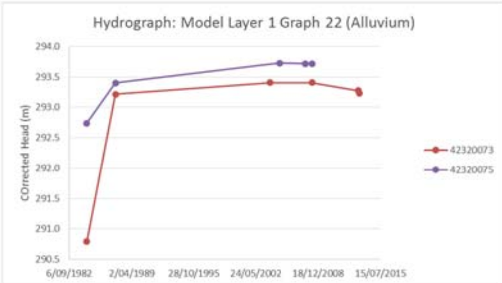

Hydrograph: Model Layer 1 Graph 20 (Tertiary - Glendowner Formation)
Corrected Head (m)
272.5
272.0
271.5
271.0
270.5
270.0
10/10/1983
1/04/1989
22/09/1994
14/03/2000
4/09/2005
25/02/2011
42320062
42320063
42320064

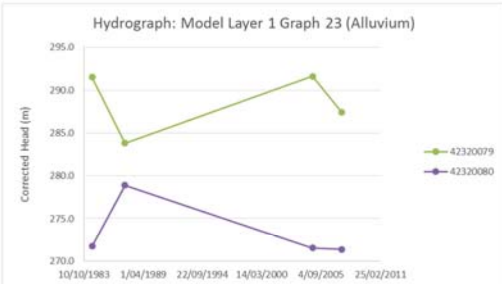

Hydrograph: Model Layer 1 Graph 21 (Tertiary - Glendowner Formation)
Corrected Head (m)
272.7
272.6
272.5
272.4
272.3
272.2
272.1
272.0
271.9
271.8
271.7
6/09/1982
2/04/1989
28/10/1995
24/05/2002
18/12/2008
15/07/2015
42320071
42320074

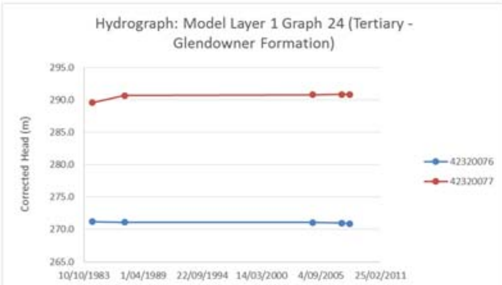

Hydrograph: Model Layer 1 Graph 16 (Tertiary - Undefined)
Corrected Head (m)
290.0
288.0
286.0
284.0
282.0
280.0
278.0
14/11/2007
22/01/2010
1/04/2012
10/06/2014
13020206

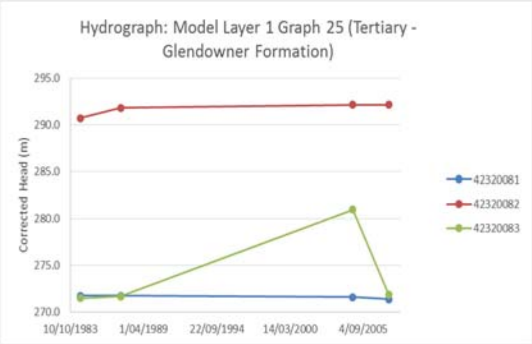

Hydrograph: Model Layer 1 Graph 17 (Alluvium)
Corrected Head (m)
380.0
370.0
360.0
350.0
340.0
330.0
320.0
310.0
300.0
10/10/1983
1/04/1989
22/09/1994
14/03/2000
4/09/2005
25/02/2011
42320010
42320015
42320036

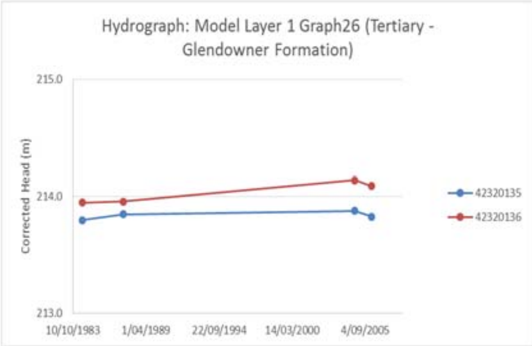

Hydrograph: Model Layer 1 Graph 18 (Tertiary Glendowner Formation)
Corrected Head (m)
345.0
340.0
335.0
330.0
325.0
320.0
315.0
310.0
305.0
300.0
10/10/1983
1/04/1989
22/09/1994
14/03/2000
4/09/2005
25/02/2011
42320022
42320038

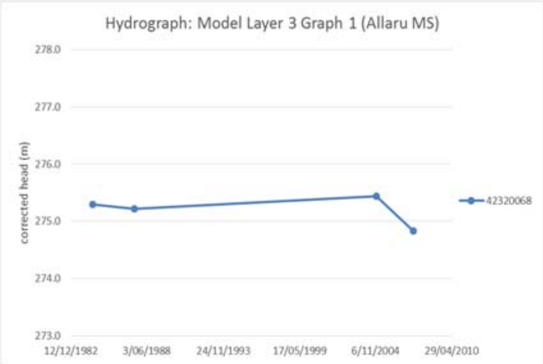

Hydrograph: Model Layer 1 Graph 22 (Alluvium)
COrrected Head (m)
294.0
293.5
293.0
292.5
292.0
291.5
291.0
290.5
6/09/1982
2/04/1989
28/10/1995
24/05/2002
18/12/2008
15/07/2015
42320073
42320075

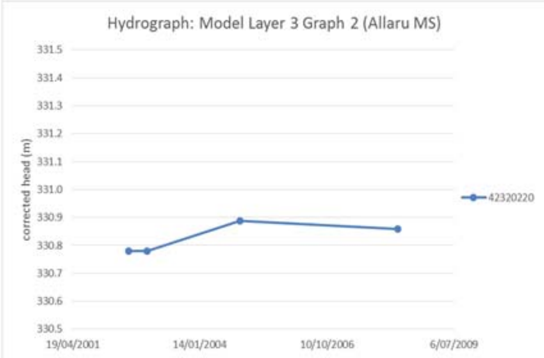

Hydrograph: Model Layer 1 Graph 23 (Alluvium)
Corrected Head (m)
295.0
290.0
285.0
280.0
275.0
270.0
10/10/1983
1/04/1989
22/09/1994
14/03/2000
4/09/2005
25/02/2011
42320079
42320080

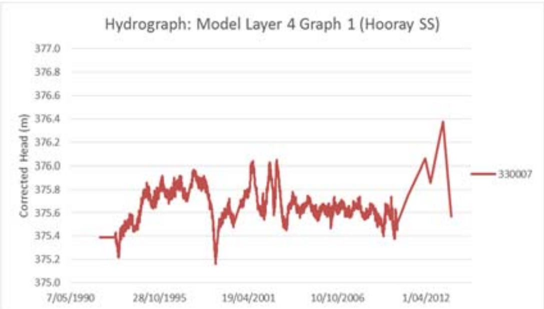

Hydrograph: Model Layer 1 Graph 24 (Tertiary - Glendowner Formation)
Corrected Head (m)
295.0
290.0
285.0
280.0
275.0
270.0
265.0
10/10/1983
1/04/1989
22/09/1994
14/03/2000
4/09/2005
25/02/2011
42320076
42320077

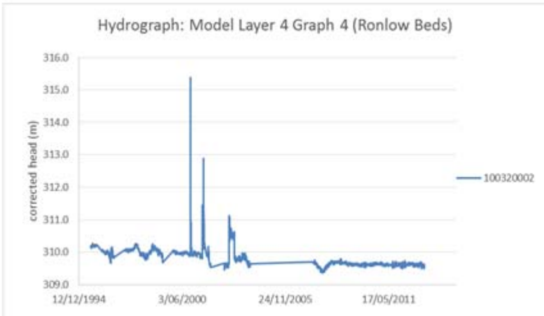

Hydrograph: Model Layer 1 Graph 25 (Tertiary - Glendowner Formation)
Corrected Head (m)
42320081
42320082
42320083

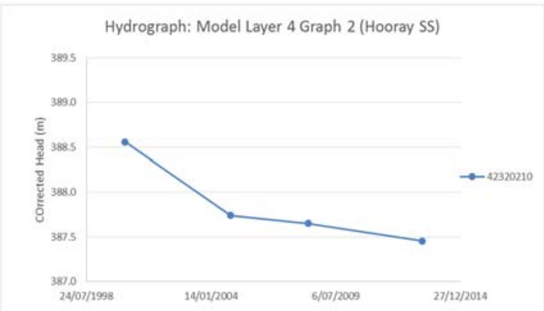

Hydrograph: Model Layer 1 Graph26 (Tertiary - Glendowner Formation)
Corrected Head (m)
42320135
42320136

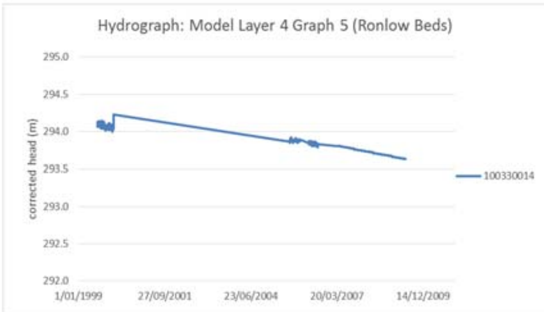

Hydrograph: Model Layer 3 Graph 1 (Allaru MS)
corrected head (m)
42320068

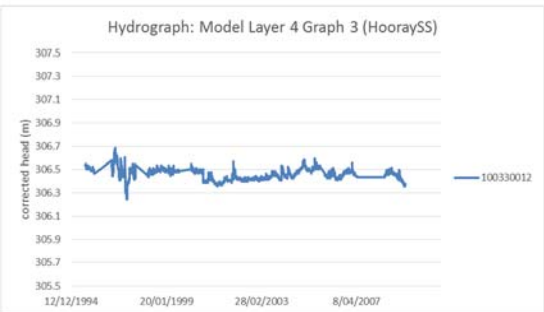

Hydrograph: Model Layer 3 Graph 2 (Allaru MS)
corrected head (m)
42320220

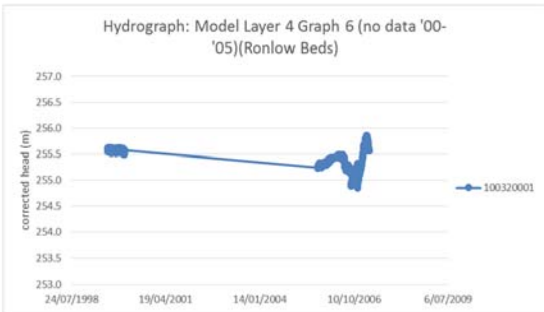

Hydrograph: Model Layer 4 Graph 1 (Hooray SS)
Corrected Head (m)
330007

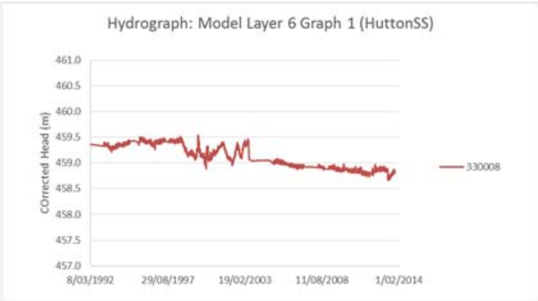

Hydrograph: Model Layer 4 Graph 4 (Ronlow Beds)
corrected head (m)
100320002

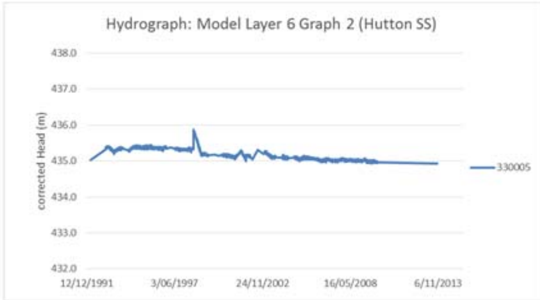

Hydrograph: Model Layer 4 Graph 2 (Hooray SS)
COrrected Head (m)
42320210

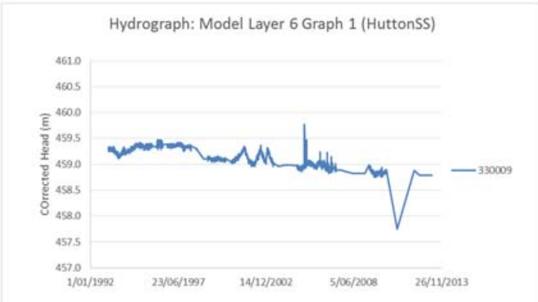

Hydrograph: Model Layer 4 Graph 5 (Ronlow Beds)
corrected head (m)
100330014

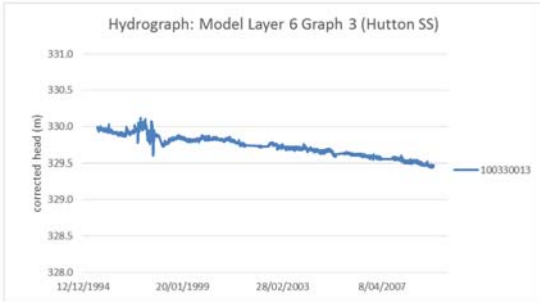

Hydrograph: Model Layer 4 Graph 3 (HooraySS)
corrected head (m)
100330012

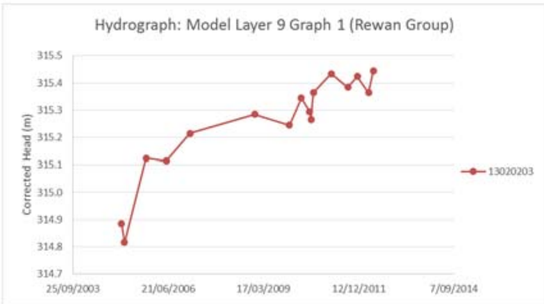

Hydrograph: Model Layer 4 Graph 6 (no data '00-'05)(Ronlow Beds)
corrected head (m)
100320001

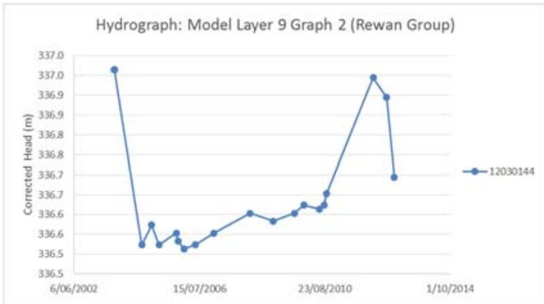

Hydrograph: Model Layer 6 Graph 1 (HuttonSS)
COrrected Head (m)
461.0
460.5
460.0
459.5
459.0
458.5
458.0
457.5
457.0
8/03/1992
29/08/1997
19/02/2003
11/08/2008
1/02/2014
330008

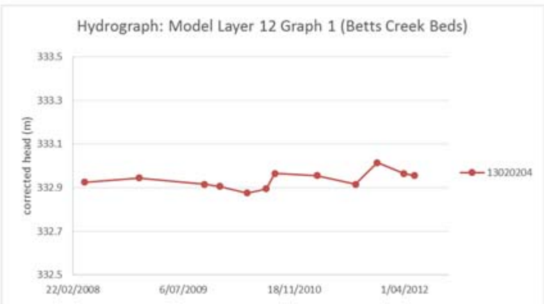

Hydrograph: Model Layer 6 Graph 2 (Hutton SS)
corrected Head (m)
438.0
437.0
436.0
435.0
434.0
433.0
432.0
12/12/1991
3/06/1997
24/11/2002
16/05/2008
6/11/2013
330005

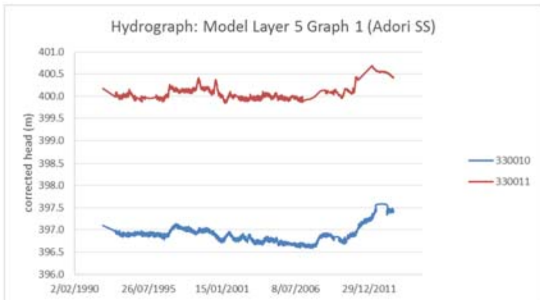

Hydrograph: Model Layer 6 Graph 1 (HuttonSS)
COrrected Head (m)
461.0
460.5
460.0
459.5
459.0
458.5
458.0
457.5
457.0
1/01/1992
23/06/1997
14/12/2002
5/06/2008
26/11/2013
330009


Hydrograph: Model Layer 6 Graph 3 (Hutton SS)
corrected head (m)
331.0
330.5
330.0
329.5
329.0
328.5
328.0
12/12/1994
20/01/1999
28/02/2003
8/04/2007
100330013


Hydrograph: Model Layer 9 Graph 1 (Rewan Group)
Corrected Head (m)
315.5
315.4
315.3
315.2
315.1
315.0
314.9
314.8
314.7
25/09/2003
21/06/2006
17/03/2009
12/12/2011
7/09/2014
13020203


Hydrograph: Model Layer 9 Graph 2 (Rewan Group)
Corrected Head (m)
337.0
337.0
336.9
336.9
336.8
336.8
336.7
336.7
336.6
336.6
336.5
336.5
6/06/2002
15/07/2006
23/08/2010
1/10/2014
12030144

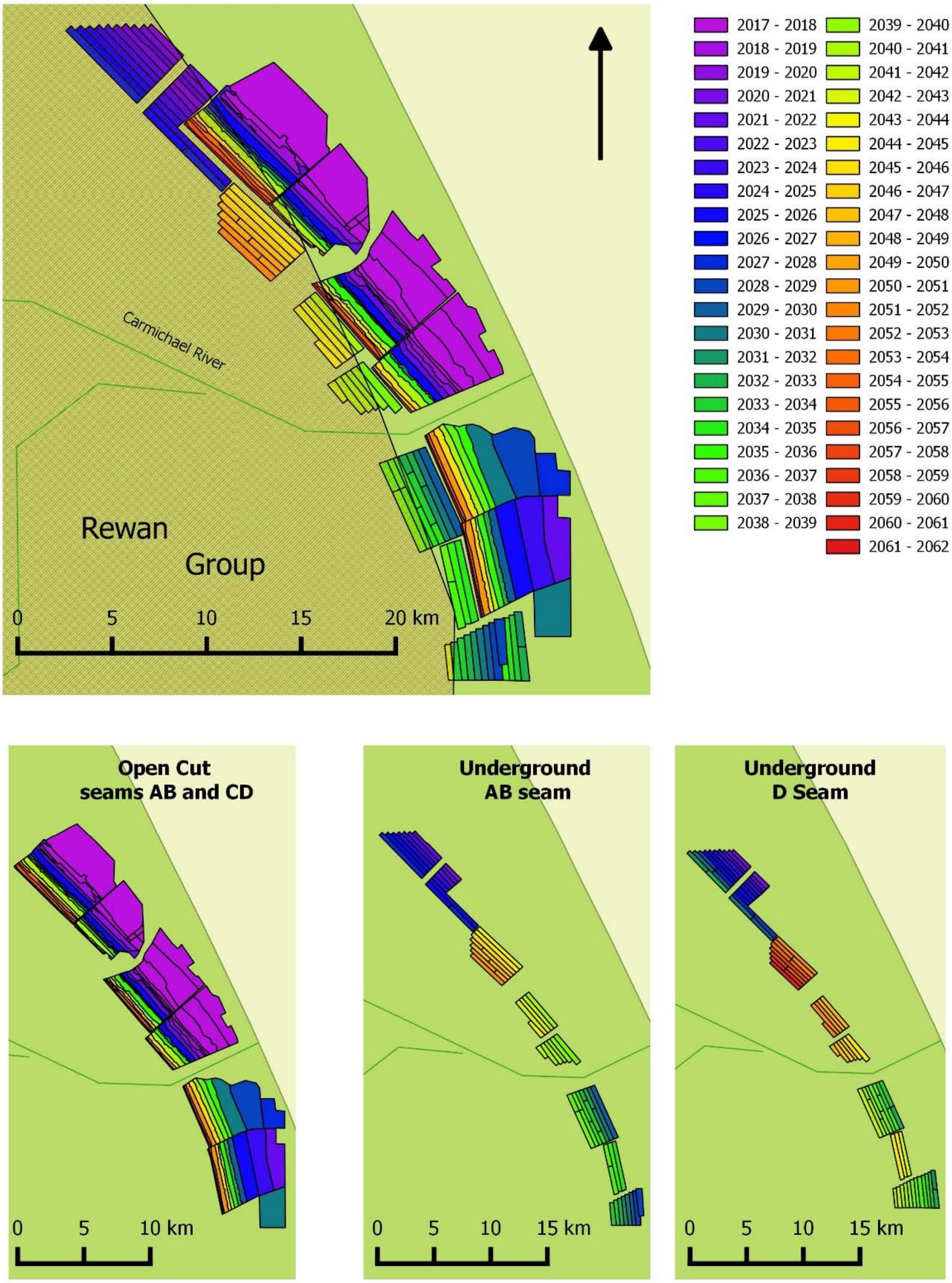

Hydrograph: Model Layer 12 Graph 1 (Betts Creek Beds)
corrected head (m)
333.5
333.3
333.1
332.9
332.7
332.5
22/02/2008
6/07/2009
18/11/2010
1/04/2012
13020204

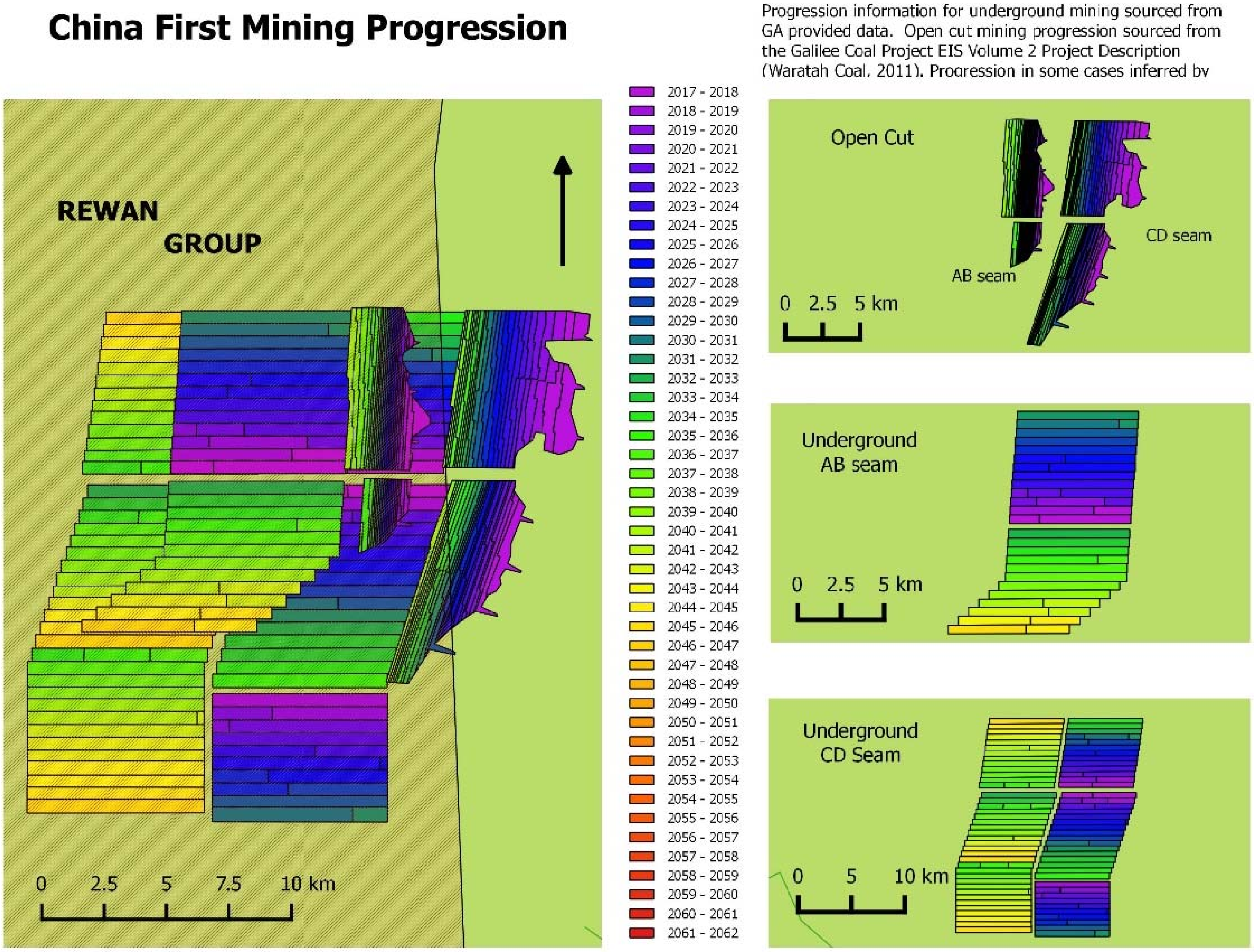

Hydrograph: Model Layer 5 Graph 1 (Adori SS)
corrected head (m)
401.0
400.5
400.0
399.5
399.0
398.5
398.0
397.5
397.0
396.5
396.0
2/02/1990
26/07/1995
15/01/2001
8/07/2006
29/12/2011
330010
330011

APPENDIX C – Mine Progression Plans

Carmichael Mining Progression

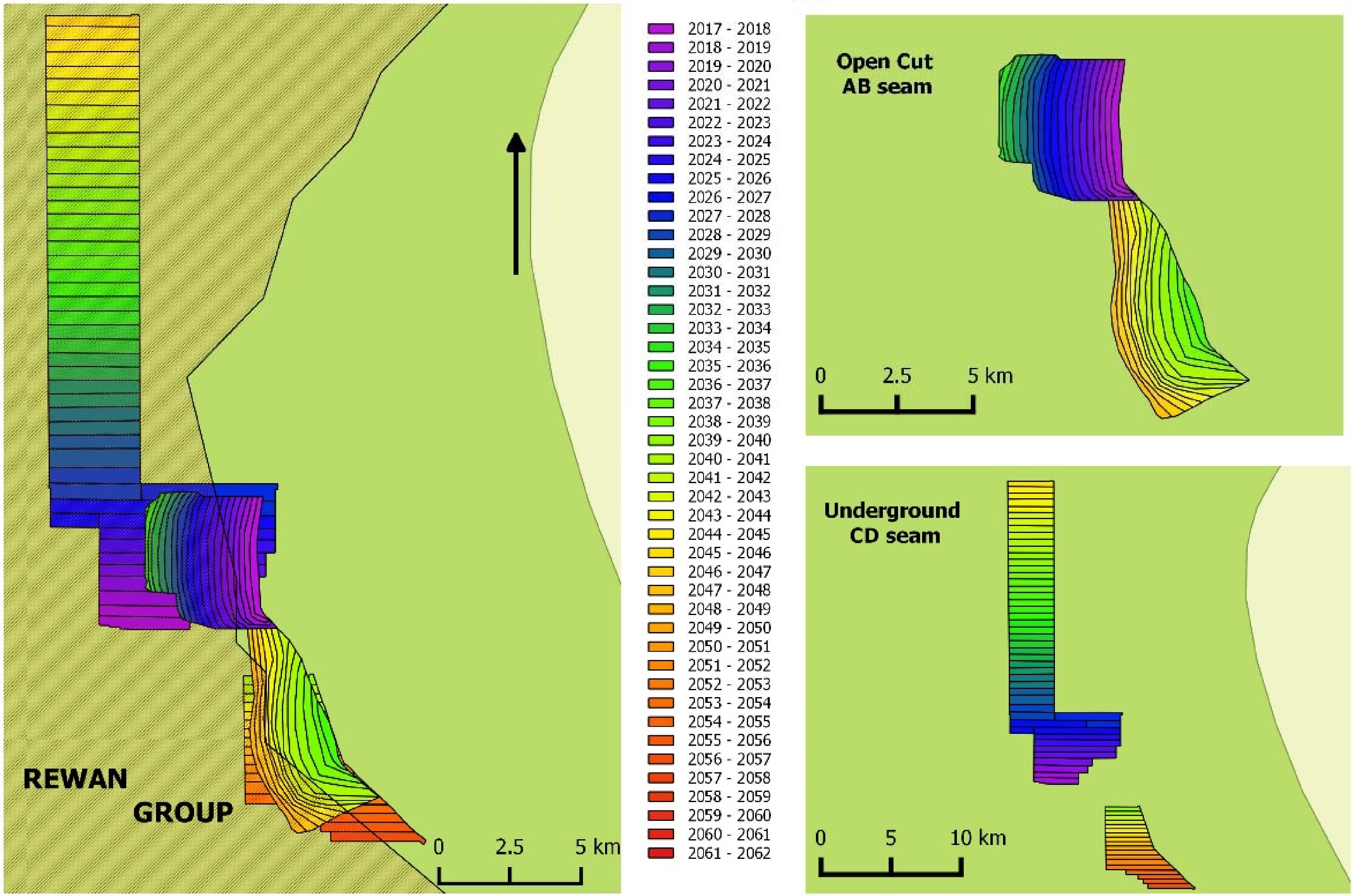
Mining progression information sourced online from Carmichael Coal Mine and Rail Project SEIS Documents (Adani Mining,2013). Shapefiles created from georeferenced mine progression and extent images.




China First Mining Progression
Progression information for underground mining sourced from GA provided data. Open cut mining progression sourced from the Galilee Coal Project EIS Volume 2 Project Description (Waratah Coal, 2011). Progression in some cases inferred by
REWAN GROUP
0 2.5 5 7.5 10 km
2017 - 2018
2018 - 2019
2019 - 2020
2020 - 2021
2021 - 2022
2022 - 2023
2023 - 2024
2024 - 2025
2025 - 2026
2026 - 2027
2027 - 2028
2028 - 2029
2029 - 2030
2030 - 2031
2031 - 2032
2032 - 2033
2033 - 2034
2034 - 2035
2035 - 2036
2036 - 2037
2037 - 2038
2038 - 2039
2039 - 2040
2040 - 2041
2041 - 2042
2042 - 2043
2043 - 2044
2044 - 2045
2045 - 2046
2046 - 2047
2047 - 2048
2048 - 2049
2049 - 2050
2050 - 2051
2051 - 2052
2052 - 2053
2053 - 2054
2054 - 2055
2055 - 2056
2056 - 2057
2057 - 2058
2058 - 2059
2059 - 2060
2060 - 2061
2061 - 2062
Open Cut
CD seam
AB seam
0 2.5 5 km
Underground AB seam
0 2.5 5 km
Underground CD Seam
0 5 10 km

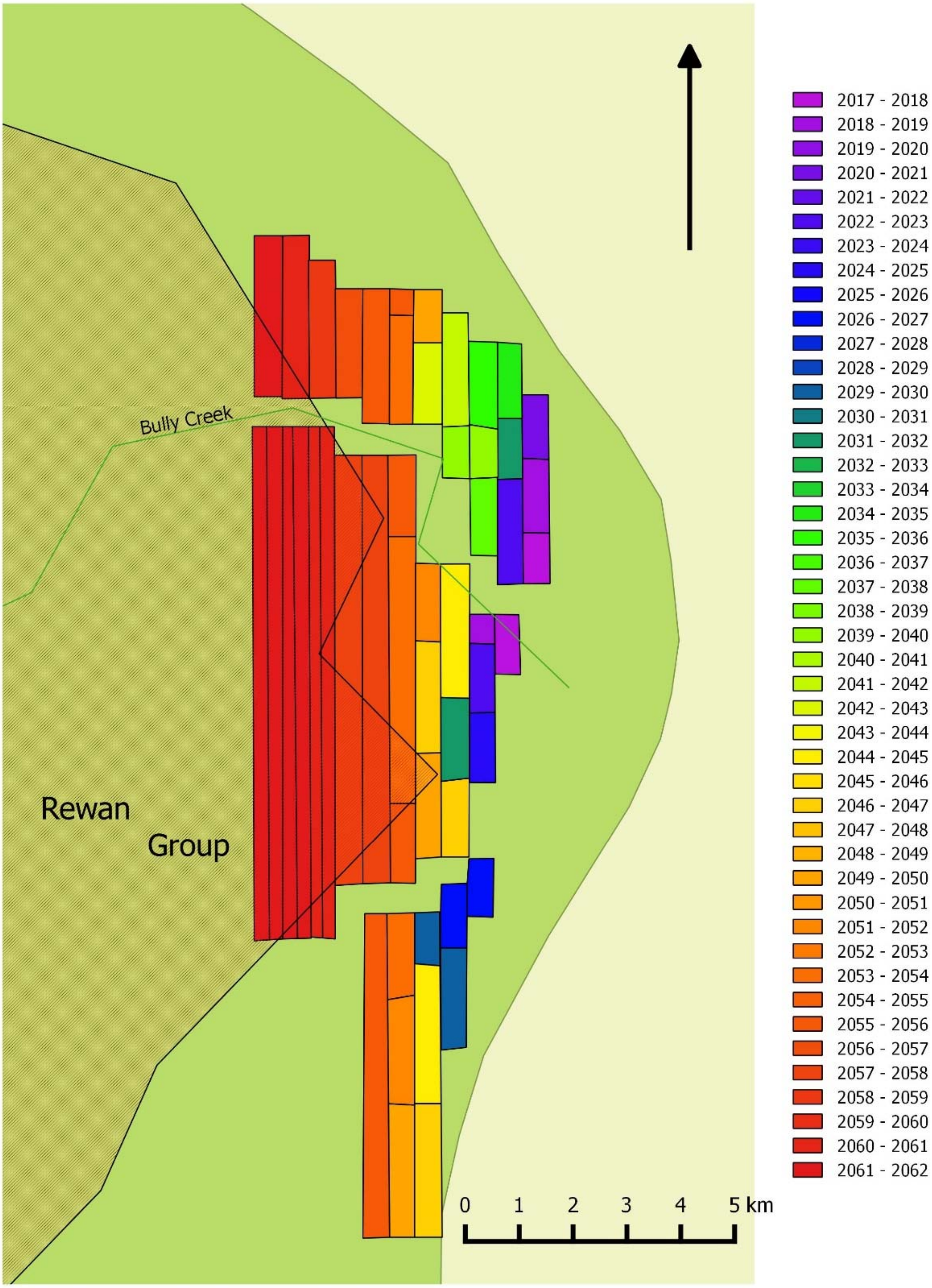
China Stone Mining Progression (inferred)

Progression inferred by Hydrosimulations for the purposes of modelling. Extent of open-cut and underground mining sourced and georeferenced from Project China Stone - Initial Advice Statement (Macmines Austrasia, 2012)



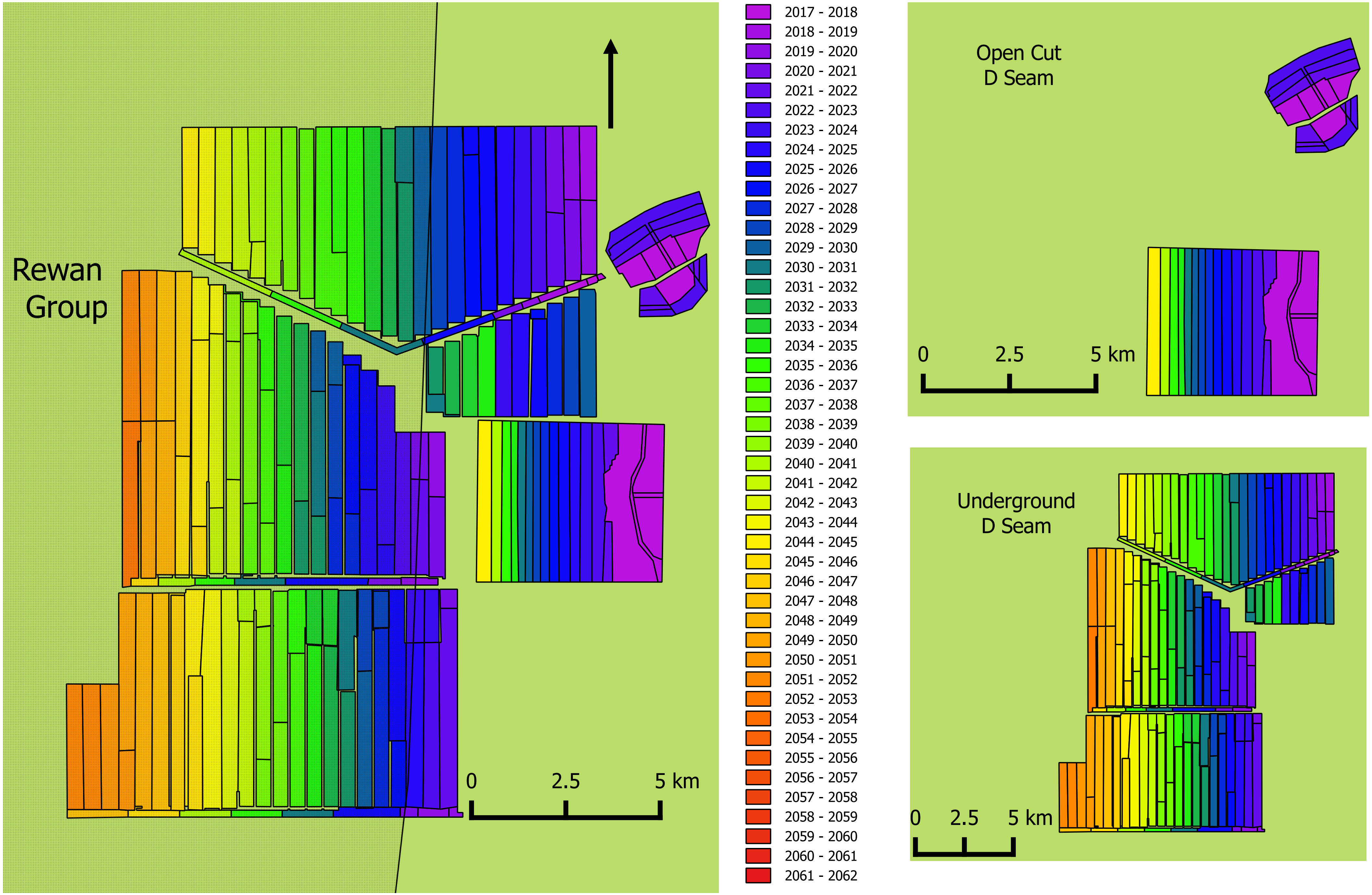
Hyde Park Mining Progression

Mining progression inferred by Hydrosimulations from GA supplied shapefile data and online from georeferneced images of The Hyde Park Coal Project (Resolve Coal, 2014) for modelling purposes.



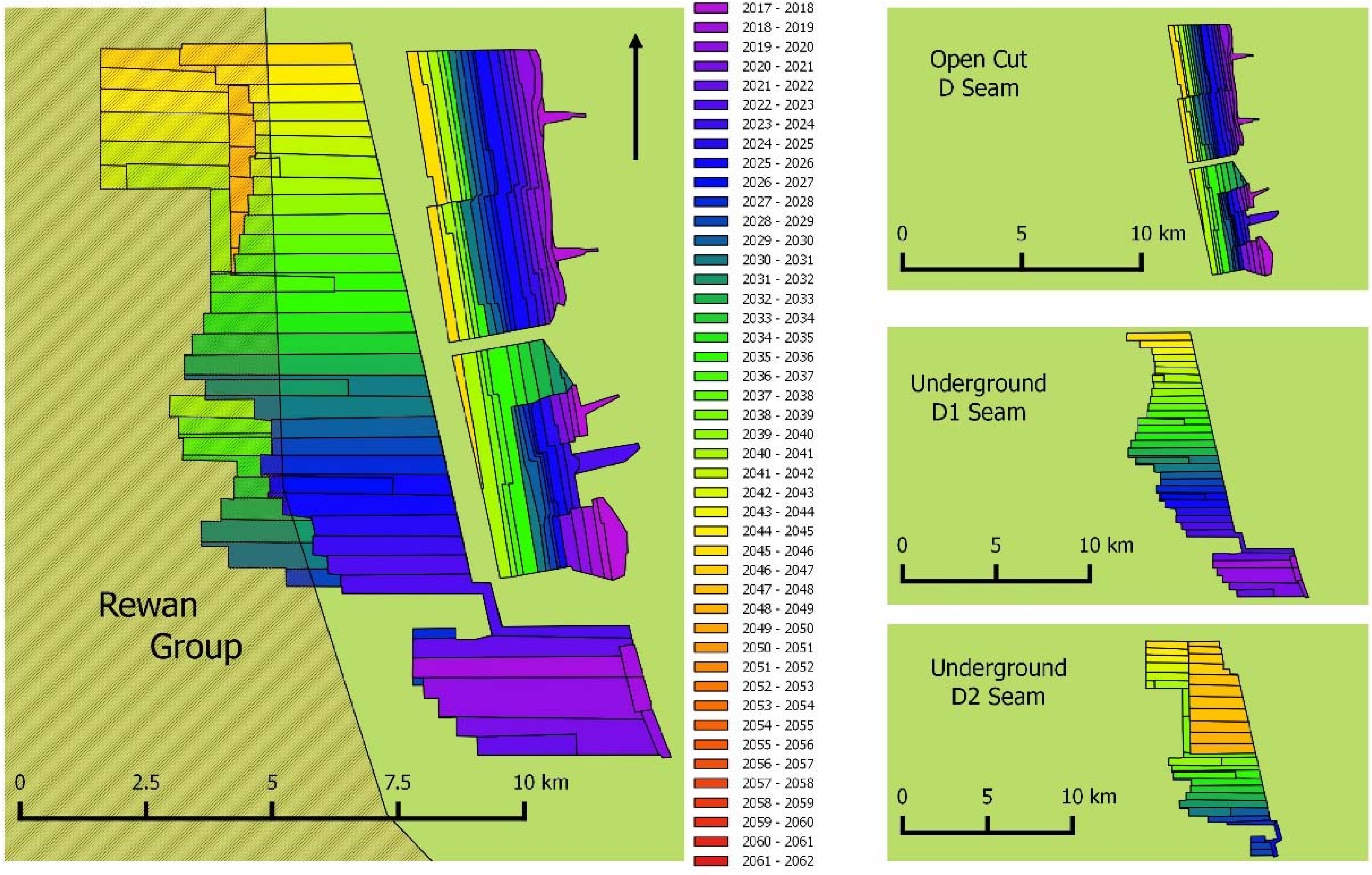
Kevins Corner Mining Progression

Progression information sourced from GA supplied data for underground mining, with annual time-step inferred by Hydrosimulations. Open-Cut progression sourced online from Kevins Corner EIS volume 1 section 2 Project Description. (Hancock Galilee, 2011).



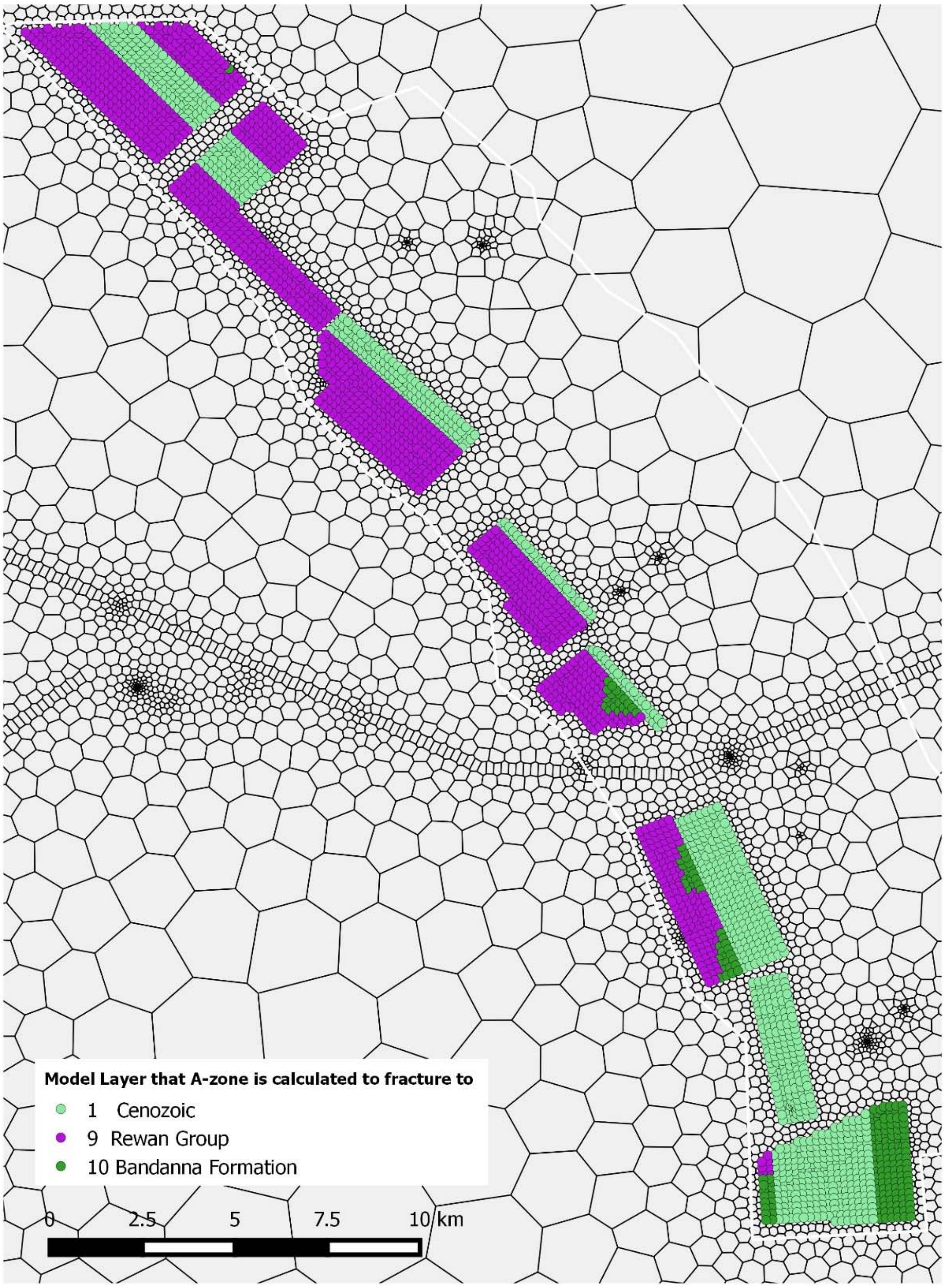
South Galilee Mining Progression

Mining progression information sourced online from the South Galilee Coal Project EIS Project Description (Alpha Coal, 2012). Time steps shown in some cases have higher resultion than sourced data, inferred by Hydrosimulations for modelling purposes.

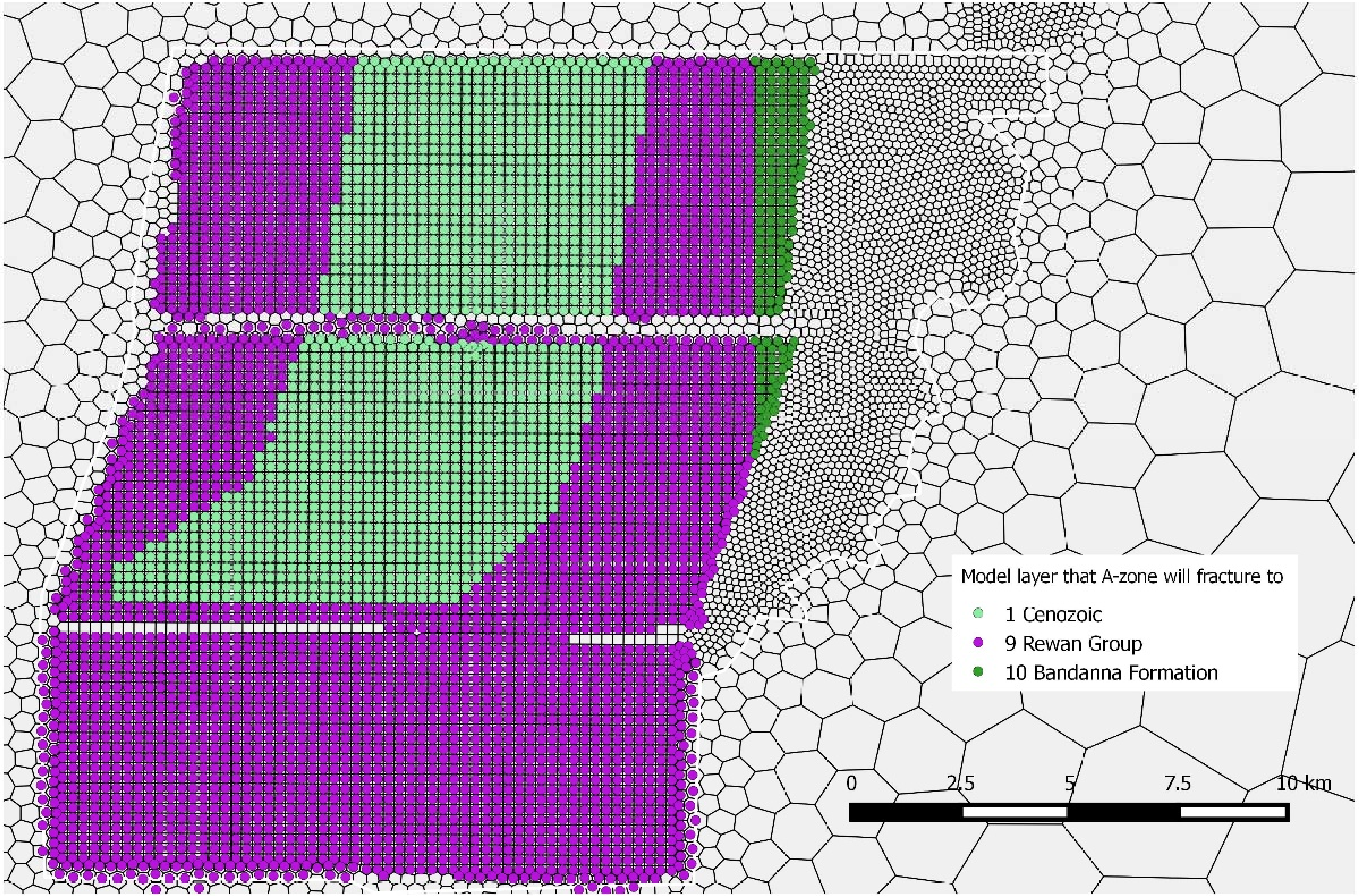


APPENDIX D – Uppermost Fractured Model Layers

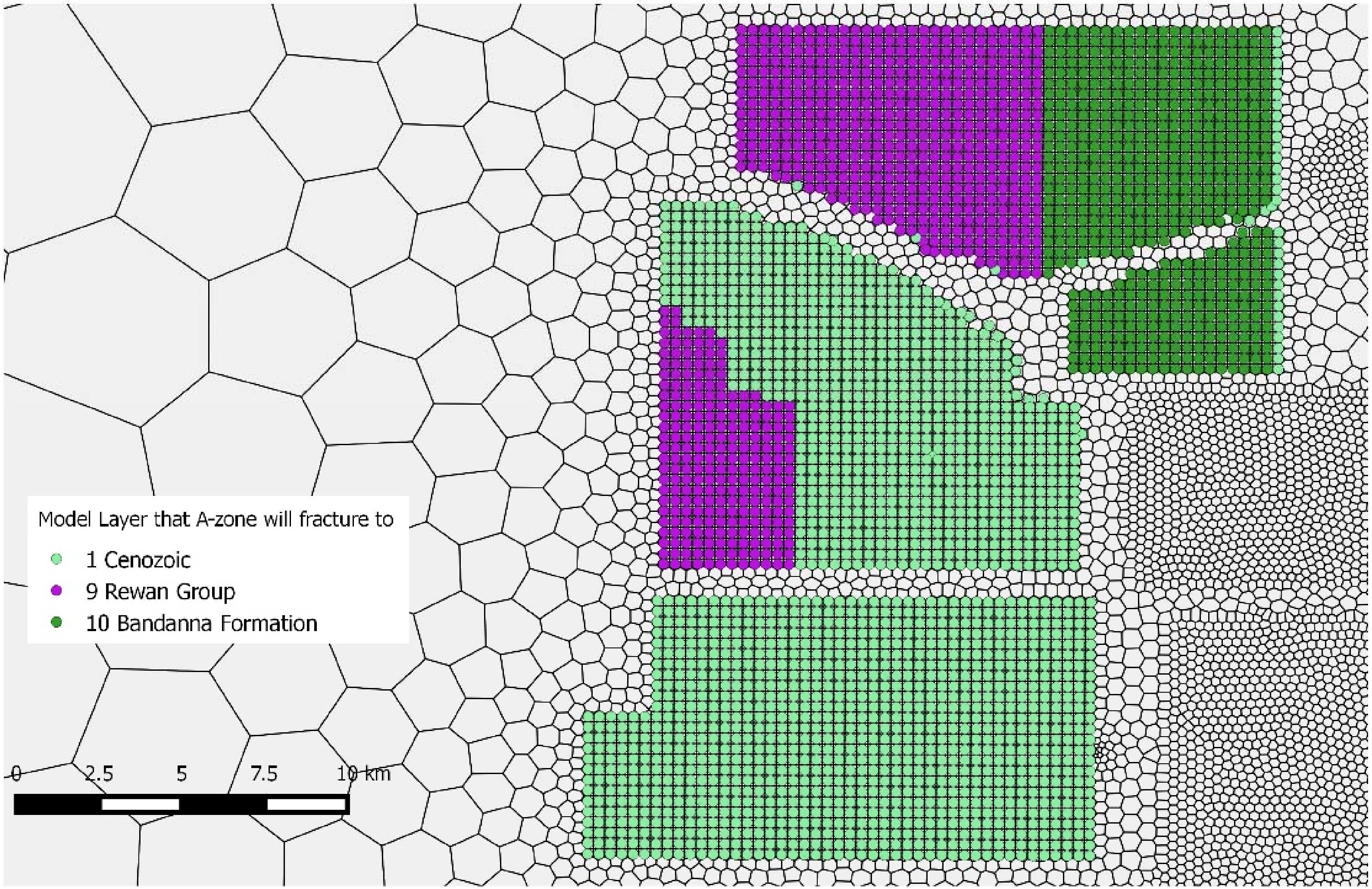
Proposed Carmichael Mine showing model layer that calculated A-zone will fracture to



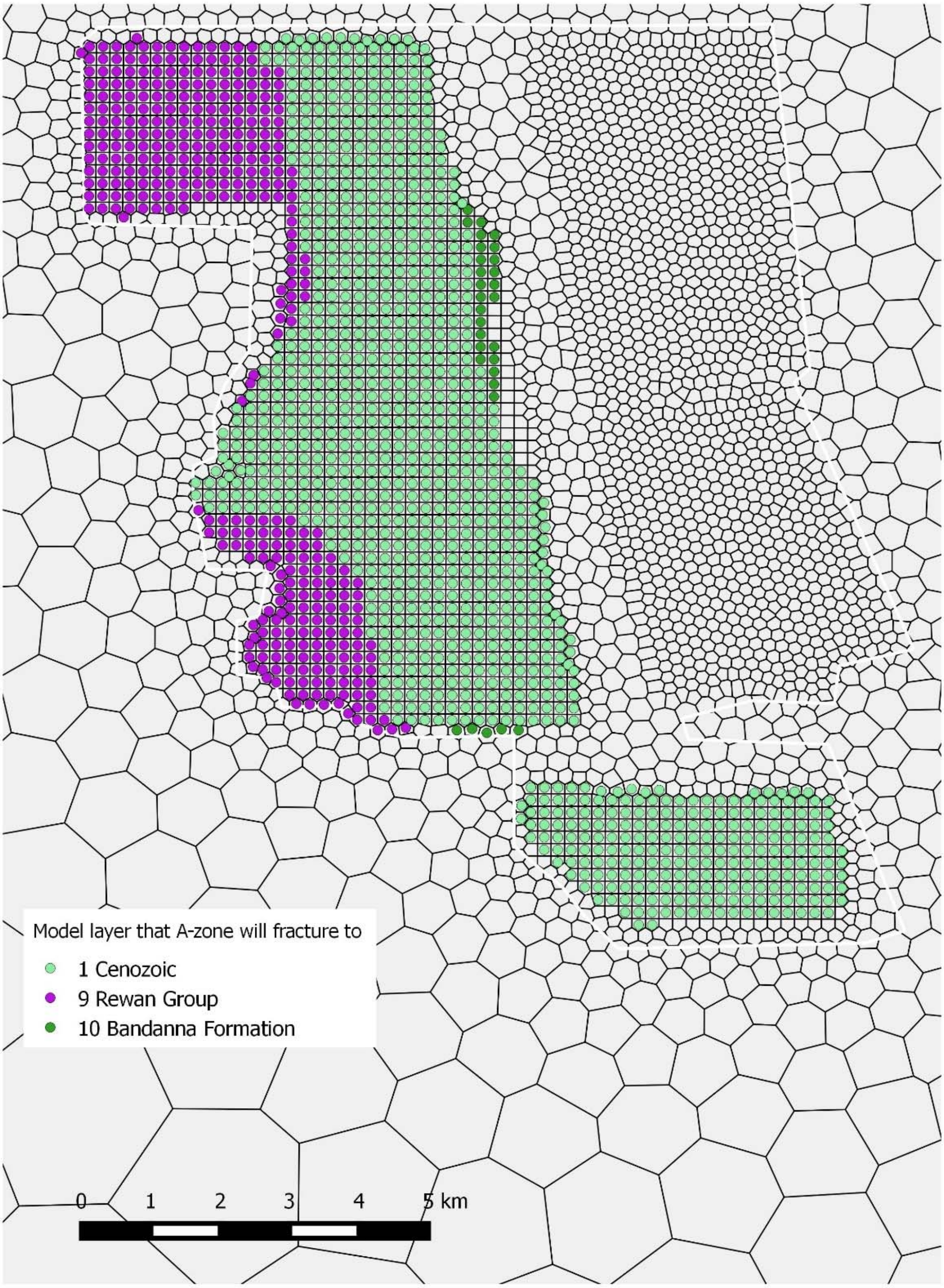
Proposed China First mine with model layer fractured to from calculated A-zone



Proposed Kevins Corner mine with model layer fractured to from calculated A-zone

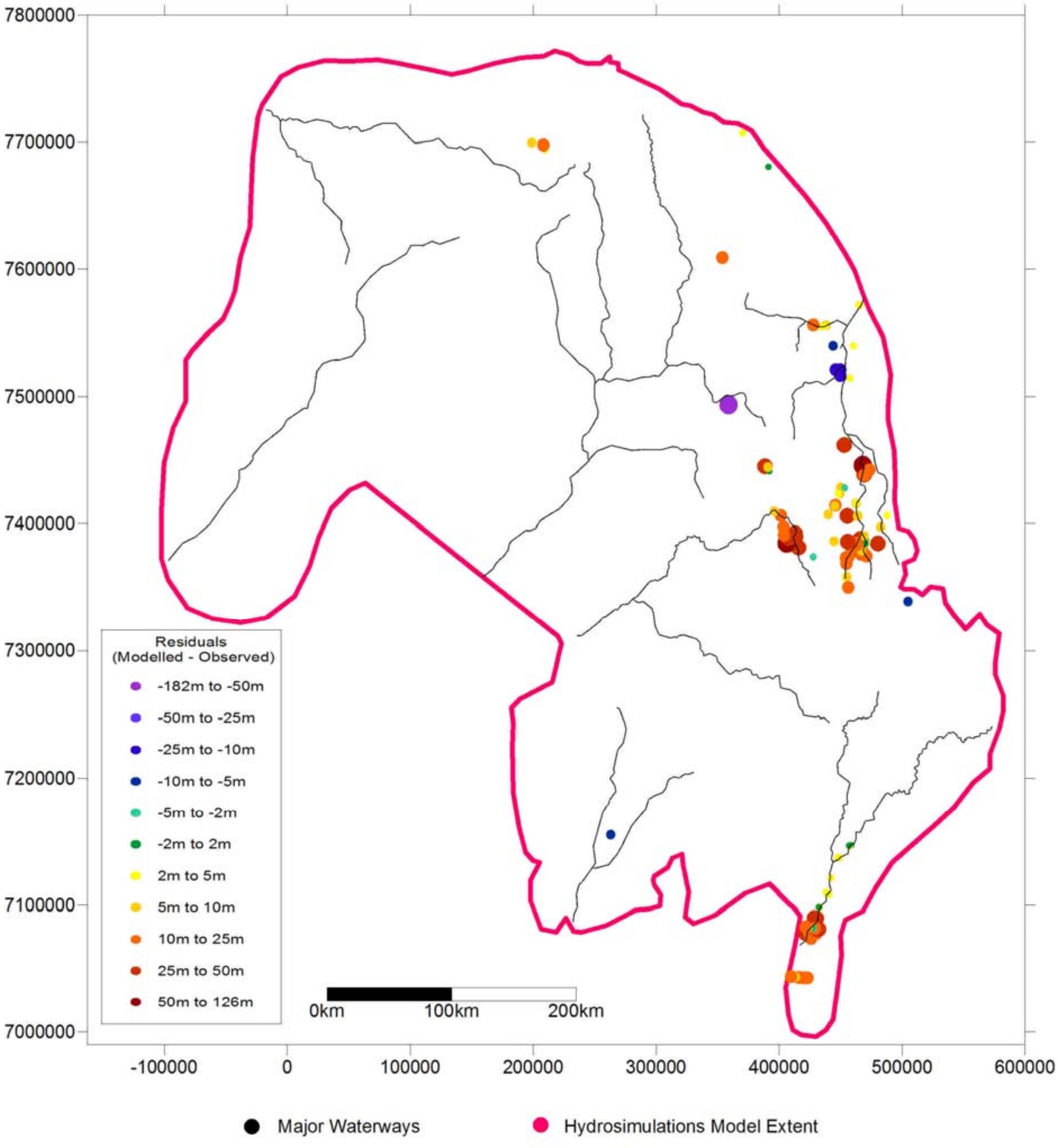


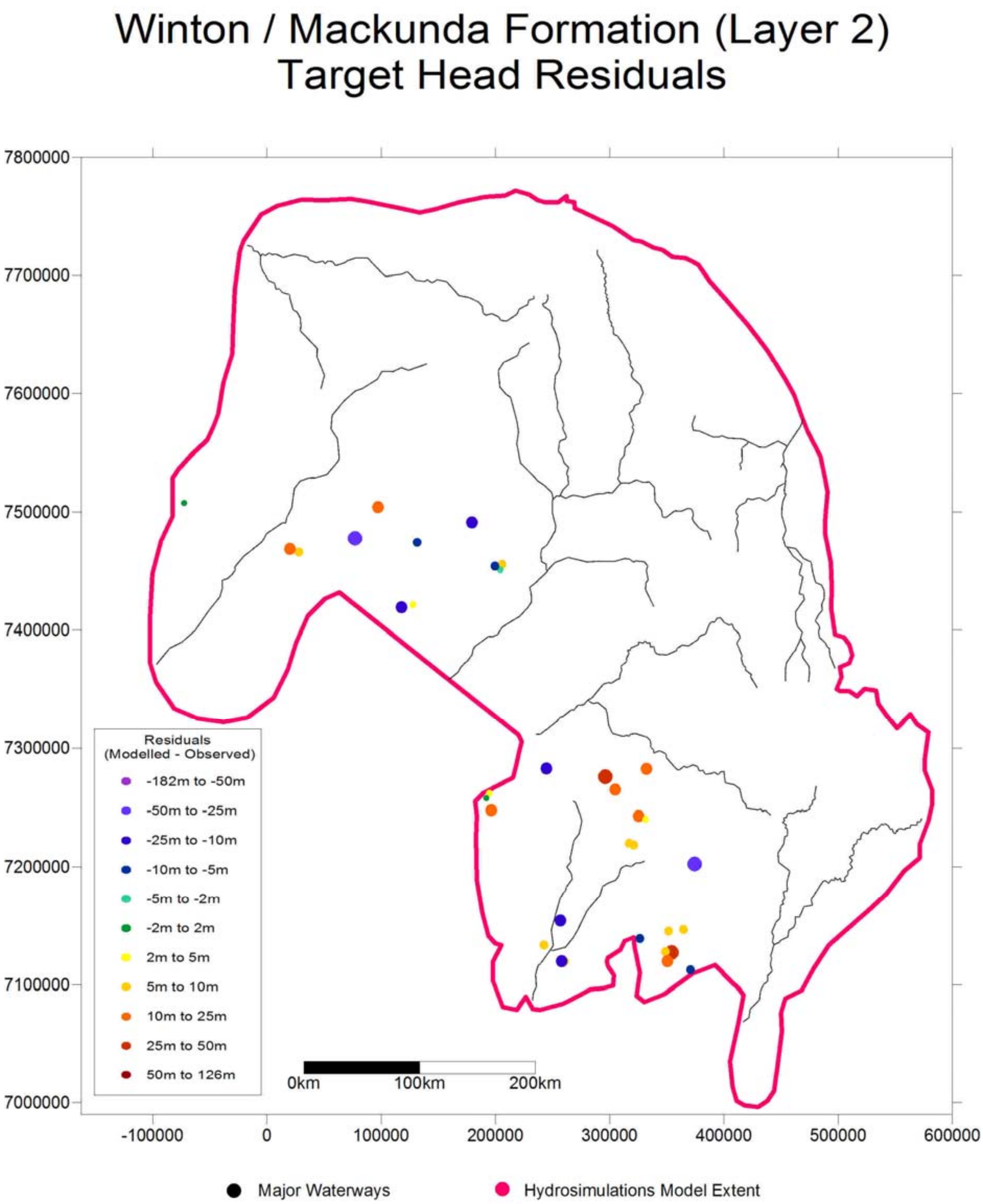
Proposed South Galilee mine with model layer fractured-to from calculated A-zone



APPENDIX E – Observed vs Modelled Steady-State Spatial Residual Plots

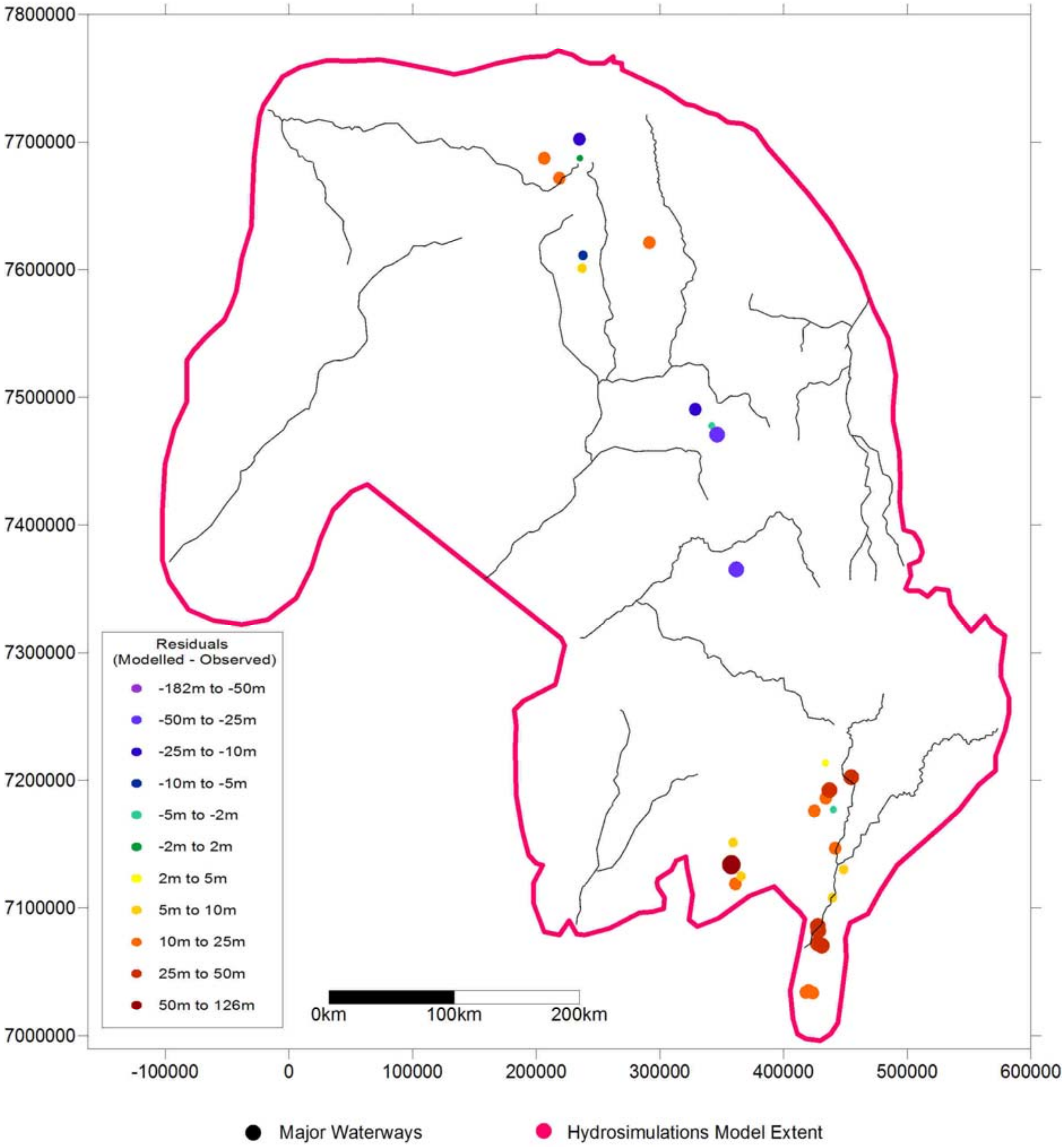
Tertiary / Alluvium (Layer 1) Target Head Residuals

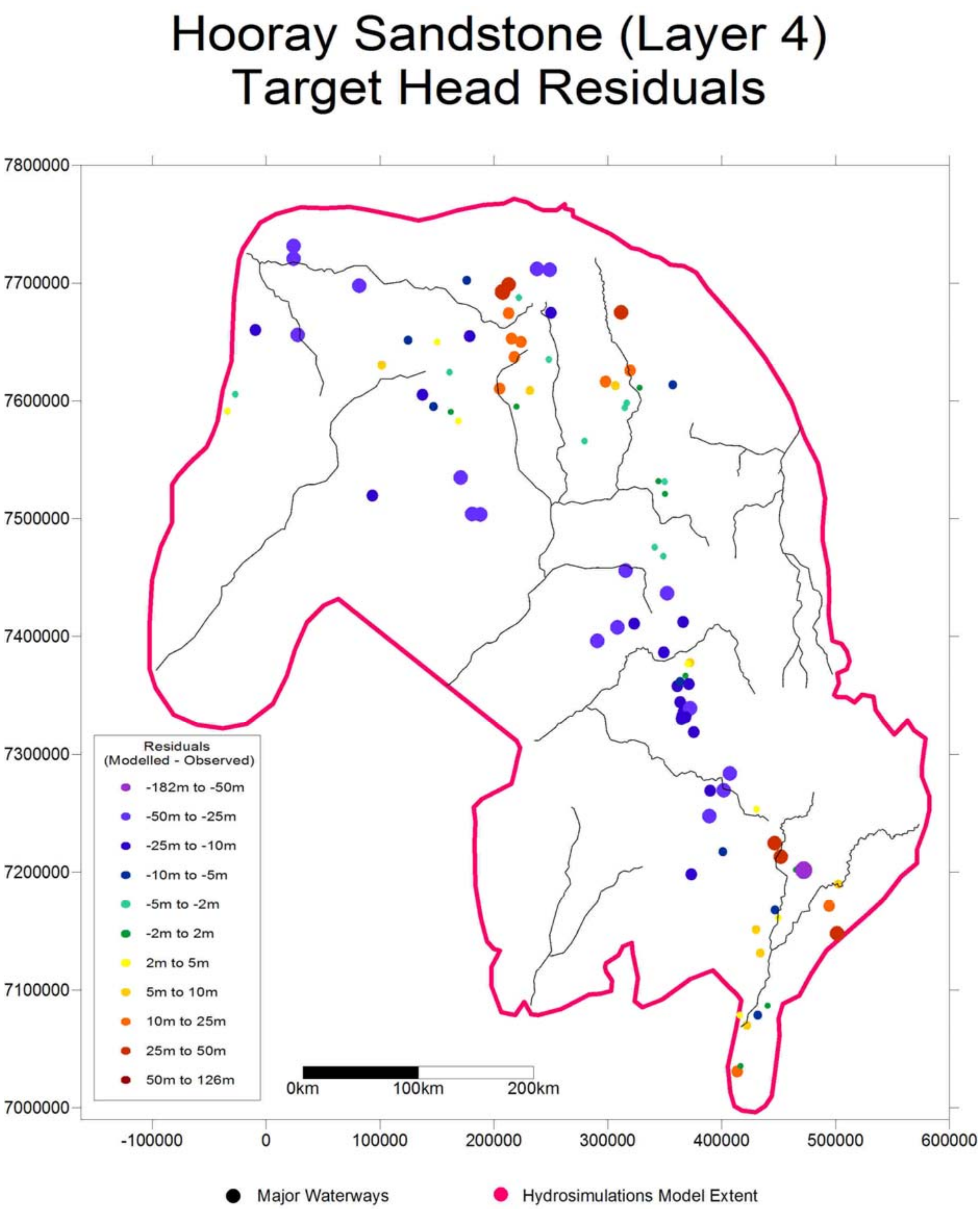




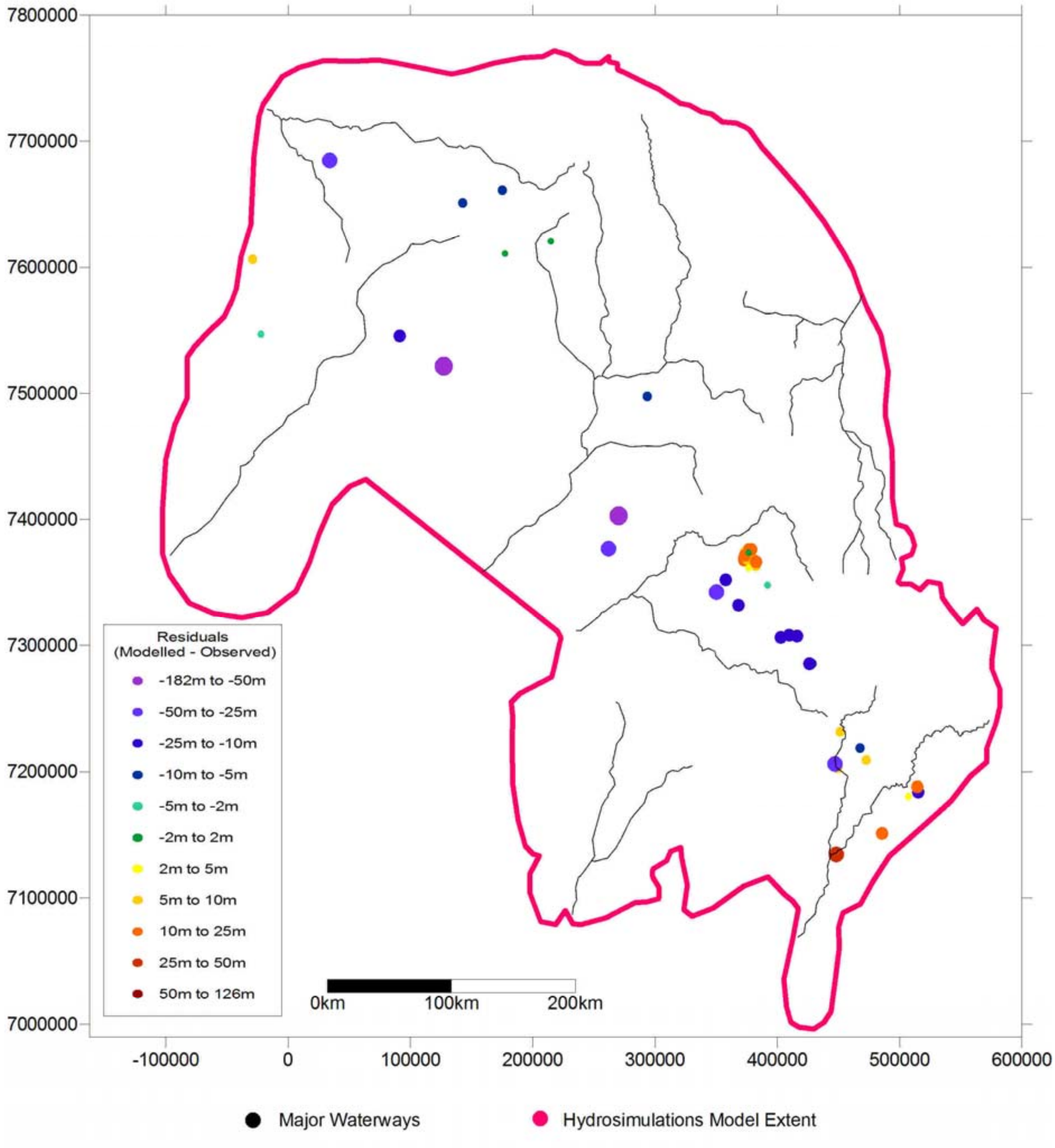
Winton / Mackunda Formation (Layer 2)
Target Head Residuals
Residuals (Modelled - Observed)
-182m to -50m
-50m to -25m
-25m to -10m
-10m to -5m
-5m to -2m
-2m to 2m
2m to 5m
5m to 10m
10m to 25m
25m to 50m
50m to 126m
0km
100km
200km
7800000
7700000
7600000
7500000
7400000
7300000
7200000
7100000
7000000
-100000
0
100000
200000
300000
400000
500000
600000
Major Waterways
Hydrosimulations Model Extent

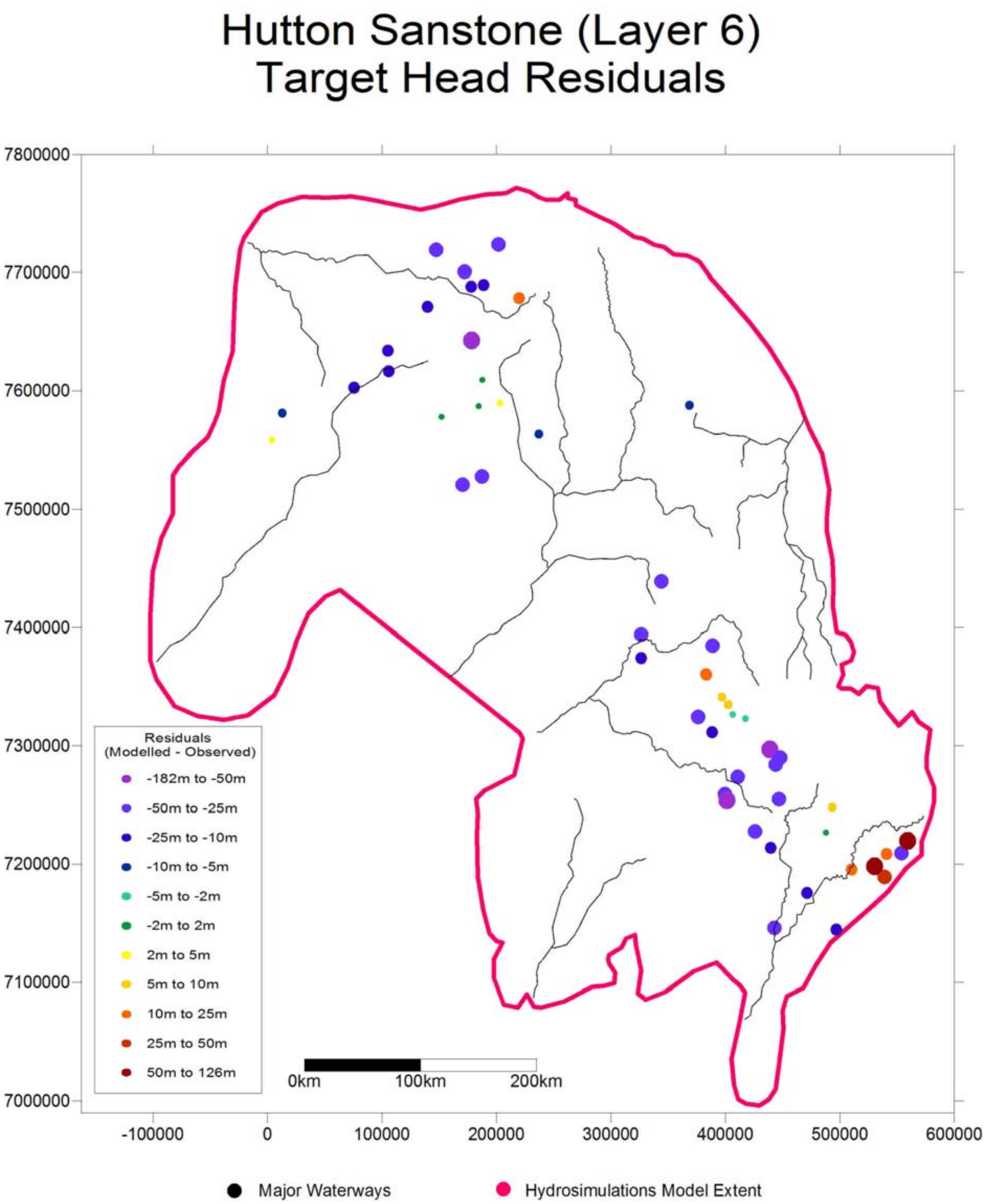
Allaru Mudstone / Wallumbilla Formation (Layer 3) Target Head Residuals

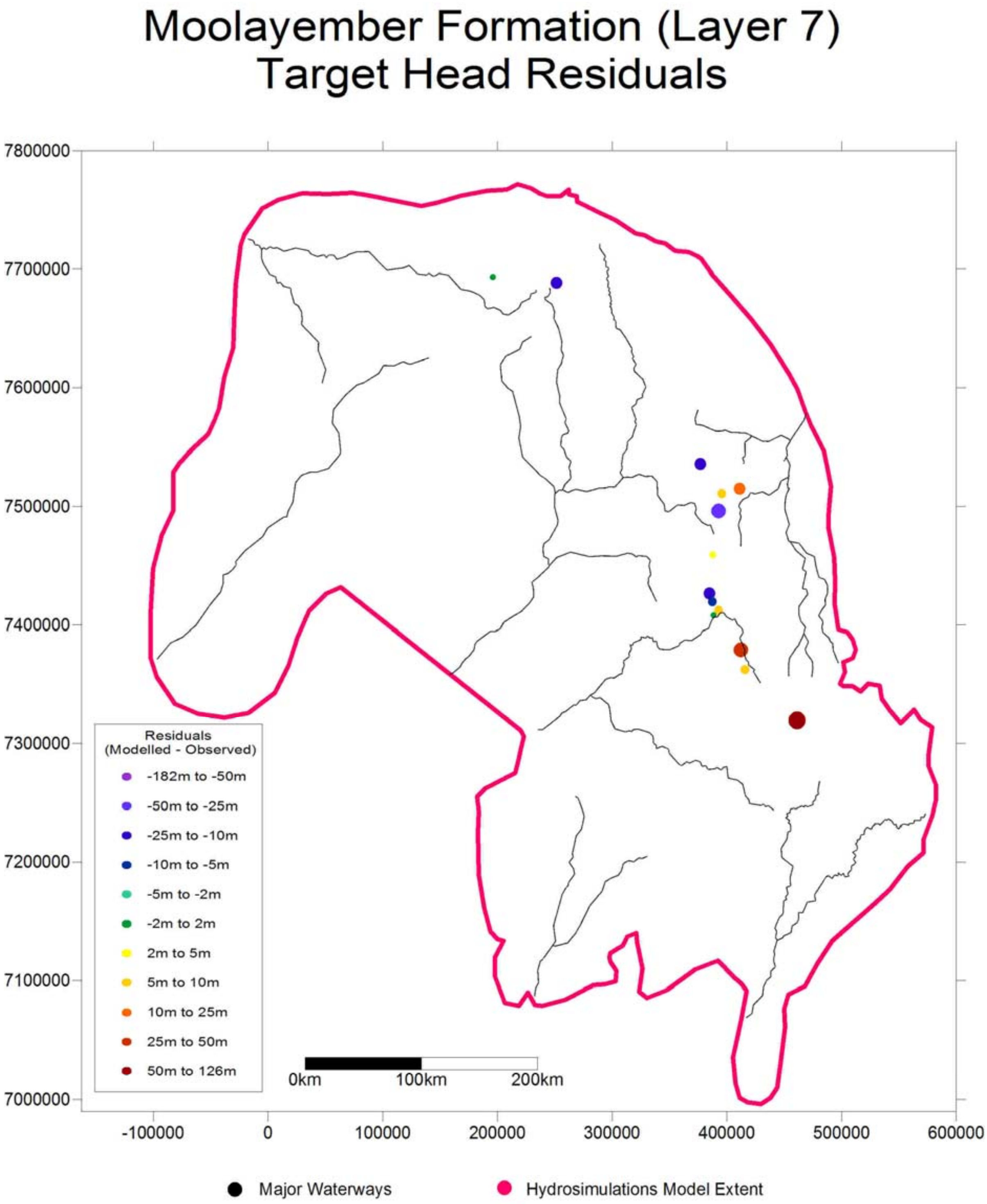


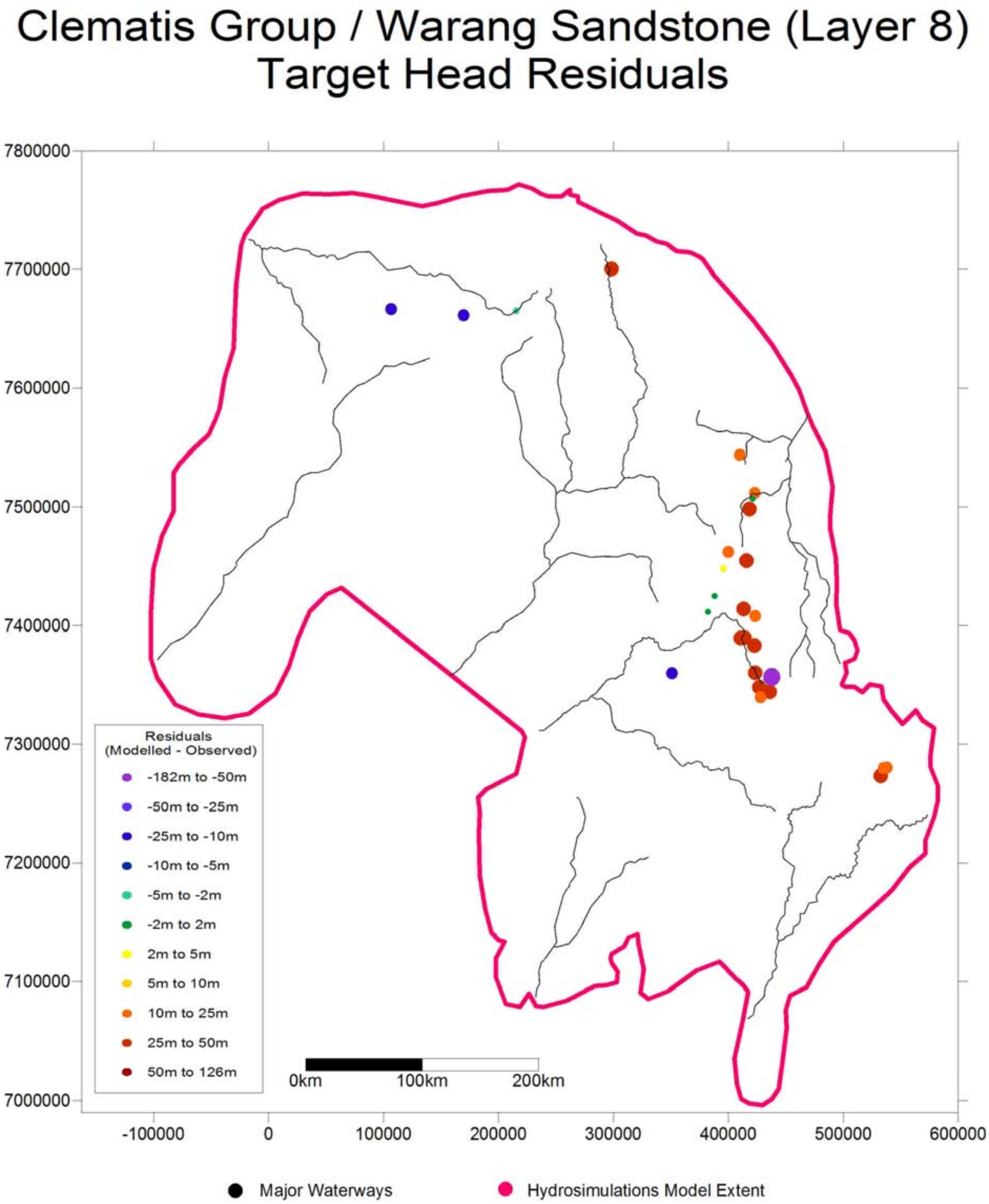

Hooray Sandstone (Layer 4)
Target Head Residuals
7800000
7700000
7600000
7500000
7400000
7300000
7200000
7100000
7000000
-100000
0
100000
200000
300000
400000
500000
600000
Residuals
(Modelled - Observed)
-182m to -50m
-50m to -25m
-25m to -10m
-10m to -5m
-5m to -2m
-2m to 2m
2m to 5m
5m to 10m
10m to 25m
25m to 50m
50m to 126m
0km
100km
200km
Major Waterways
Hydrosimulations Model Extent

Adori Sandstone / Injune Creek Group (Layer 5) Target Head Residuals

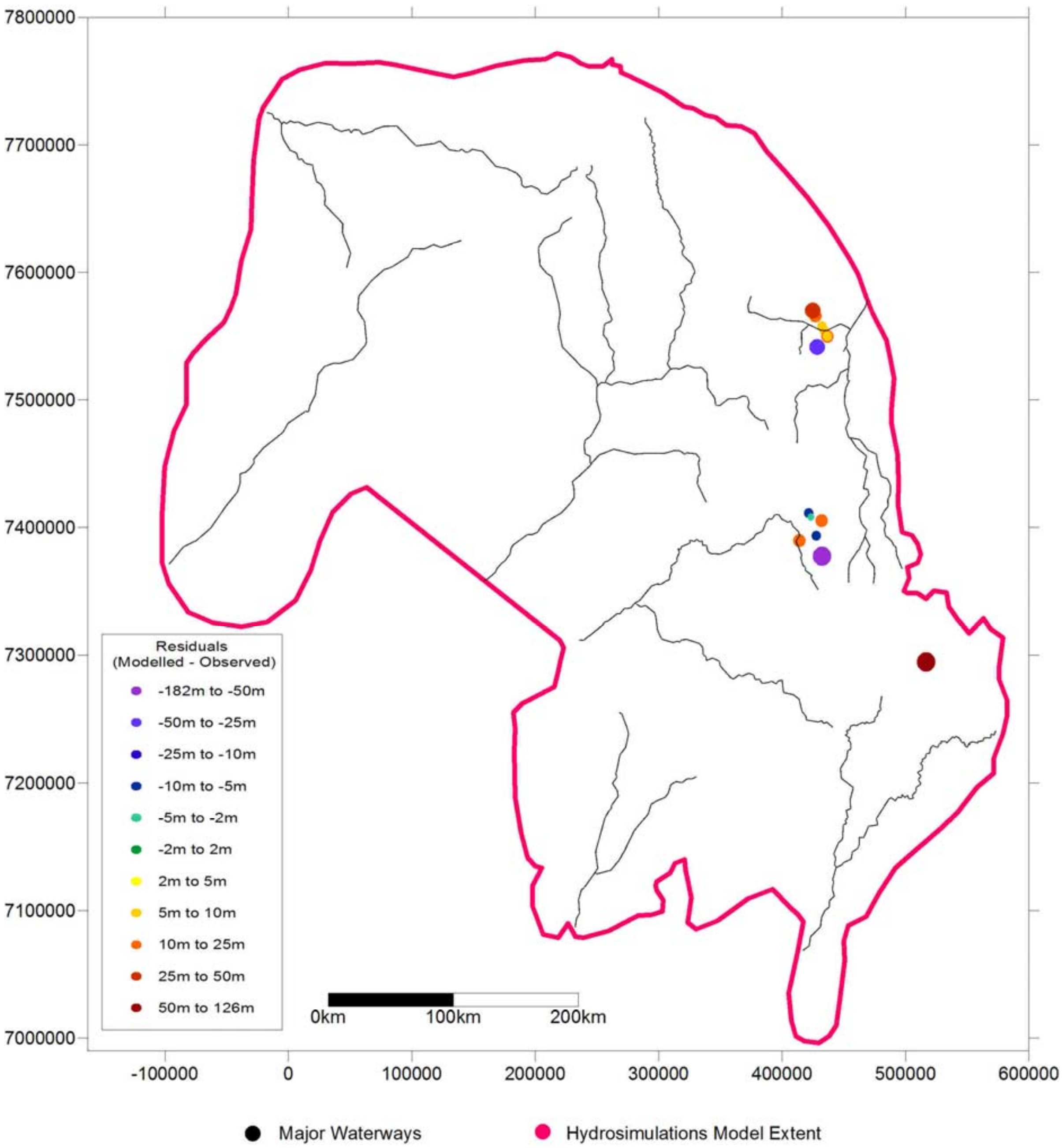



Hutton Sanstone (Layer 6)
Target Head Residuals
7800000
7700000
7600000
7500000
7400000
7300000
7200000
7100000
7000000
-100000
0
100000
200000
300000
400000
500000
600000
Residuals
(Modelled - Observed)
-182m to -50m
-50m to -25m
-25m to -10m
-10m to -5m
-5m to -2m
-2m to 2m
2m to 5m
5m to 10m
10m to 25m
25m to 50m
50m to 126m
0km
100km
200km
Major Waterways
Hydrosimulations Model Extent

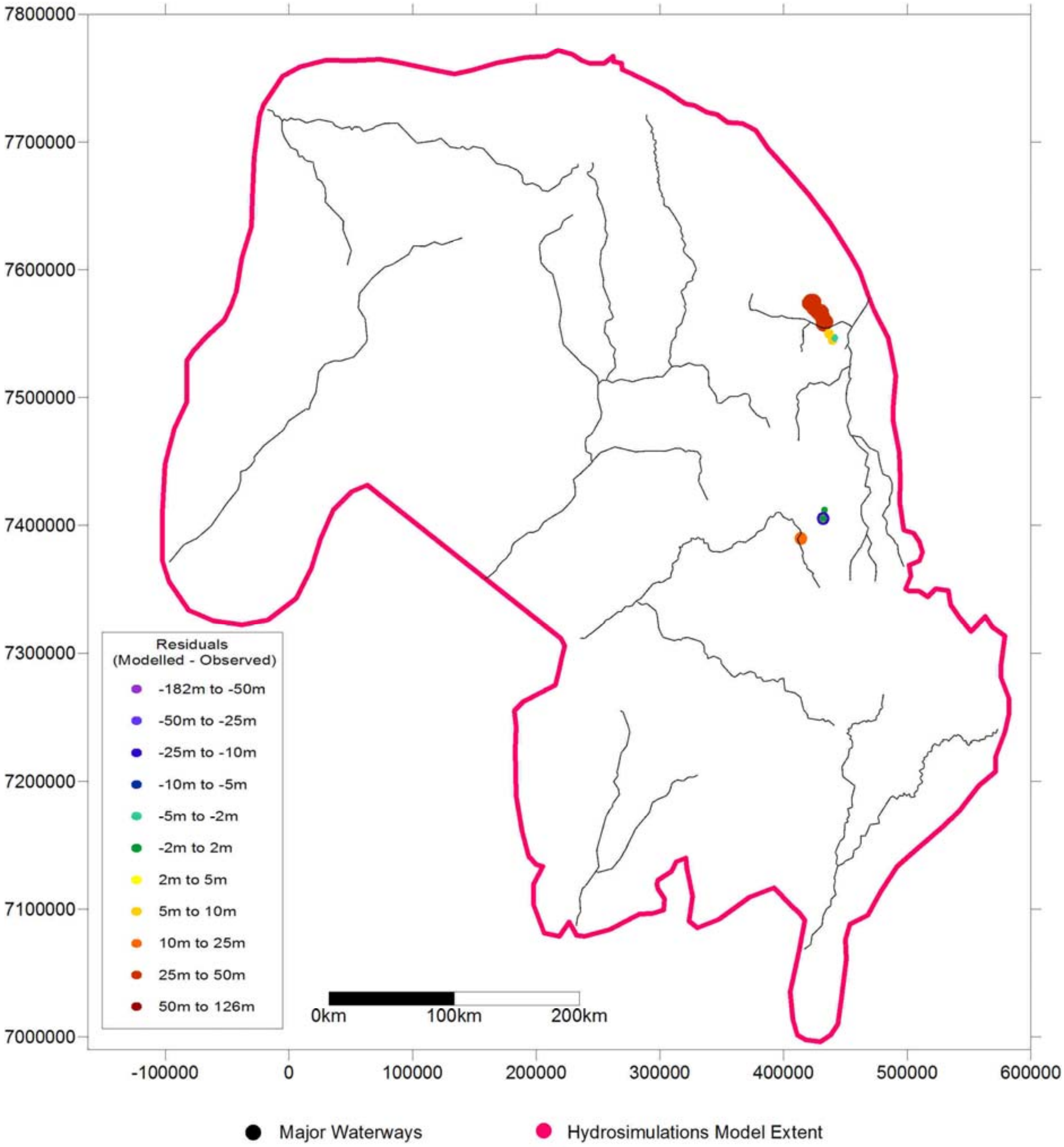

Moolayember Formation (Layer 7)
Target Head Residuals
7800000
7700000
7600000
7500000
7400000
7300000
7200000
7100000
7000000
-100000
0
100000
200000
300000
400000
500000
600000
Residuals
(Modelled - Observed)
-182m to -50m
-50m to -25m
-25m to -10m
-10m to -5m
-5m to -2m
-2m to 2m
2m to 5m
5m to 10m
10m to 25m
25m to 50m
50m to 126m
0km
100km
200km
Major Waterways
Hydrosimulations Model Extent

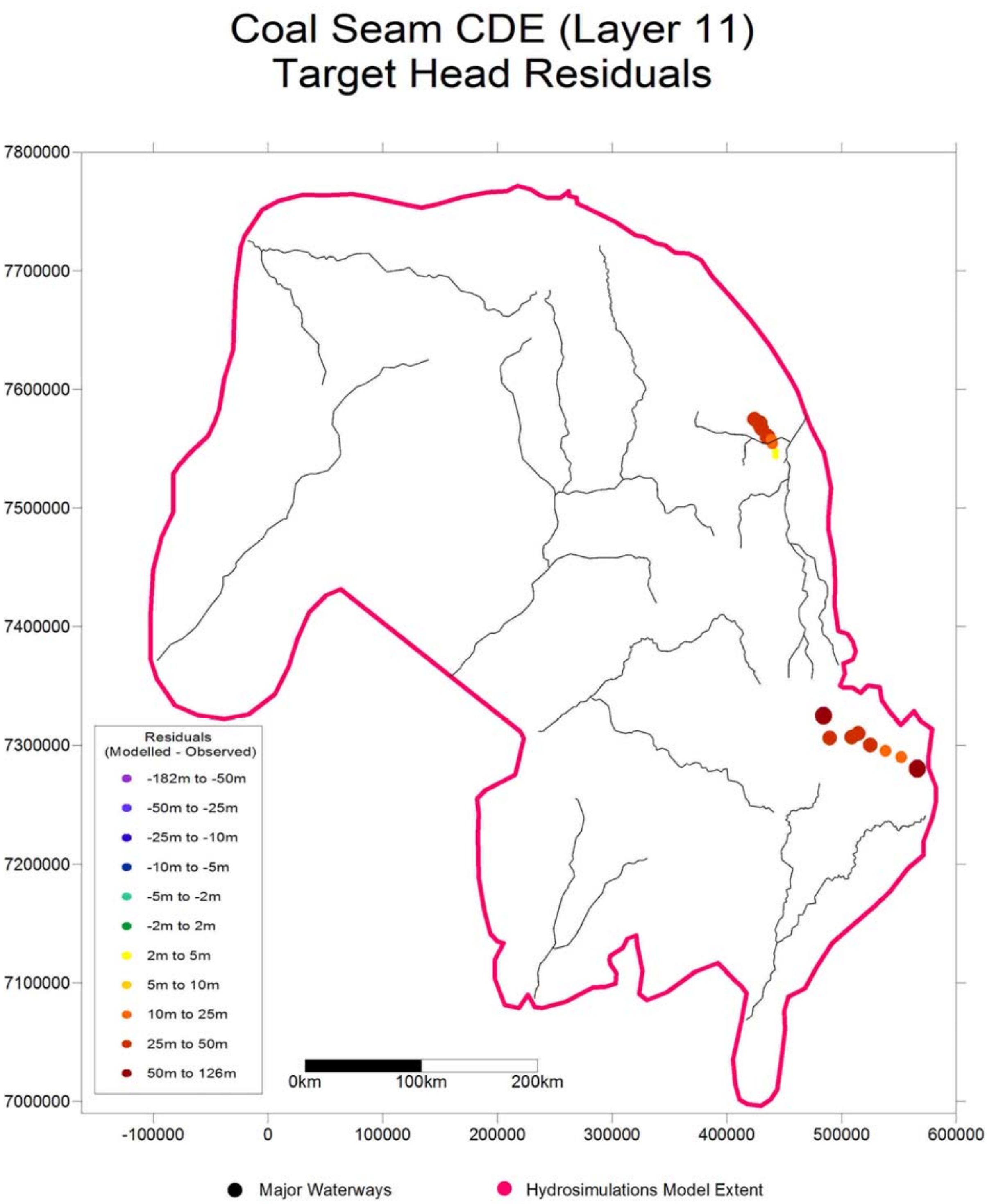

Clematis Group / Warang Sandstone (Layer 8)
Target Head Residuals
7800000
7700000
7600000
7500000
7400000
7300000
7200000
7100000
7000000
-100000
0
100000
200000
300000
400000
500000
600000
Residuals
(Modelled - Observed)
-182m to -50m
-50m to -25m
-25m to -10m
-10m to -5m
-5m to -2m
-2m to 2m
2m to 5m
5m to 10m
10m to 25m
25m to 50m
50m to 126m
0km
100km
200km
Major Waterways
Hydrosimulations Model Extent

Rewan Group / Dunda Beds (Layer 9)
Target Head Residuals

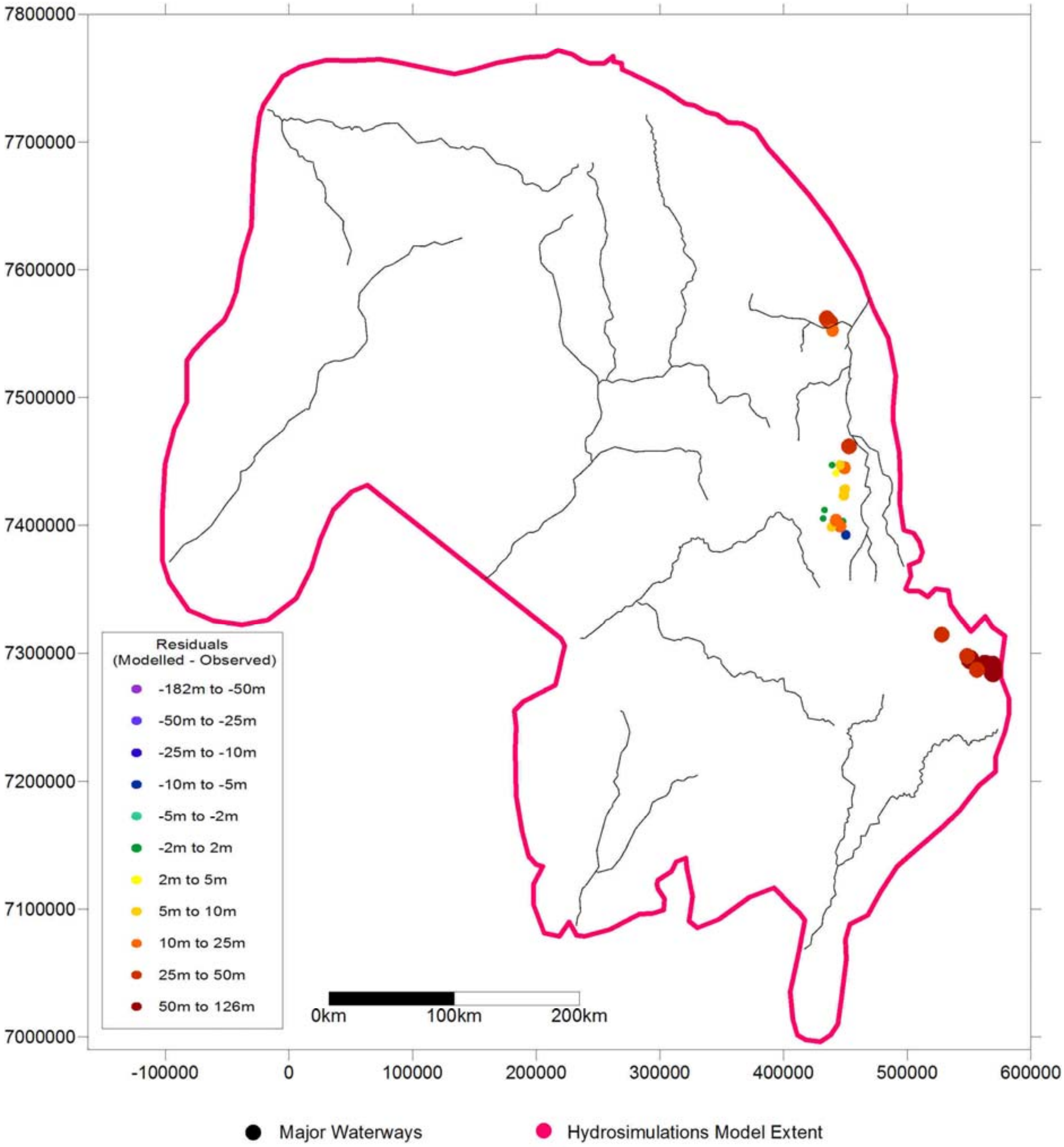


Bandanna Formation / Coal Seam B (Layer 10) Target Head Residuals

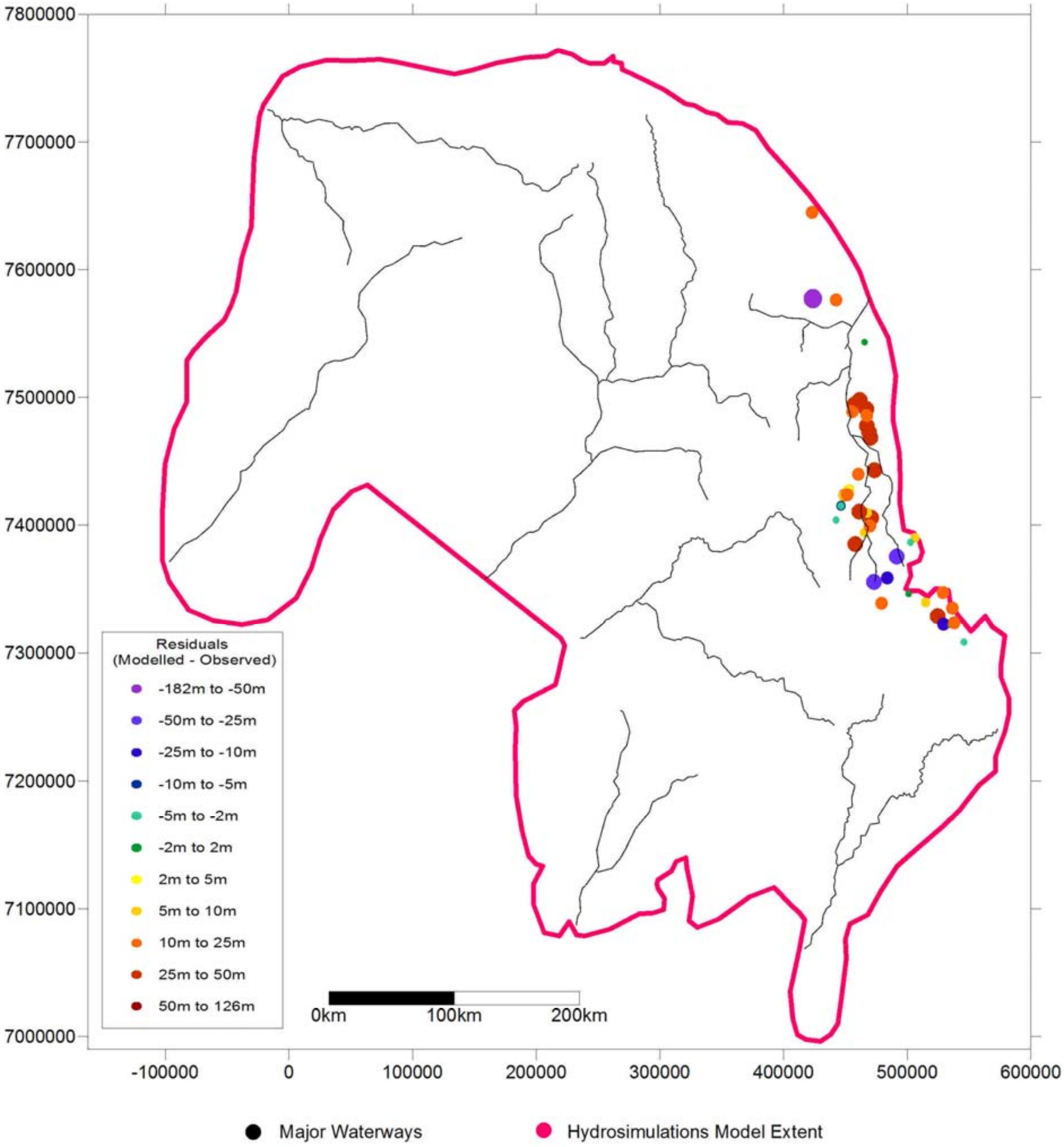


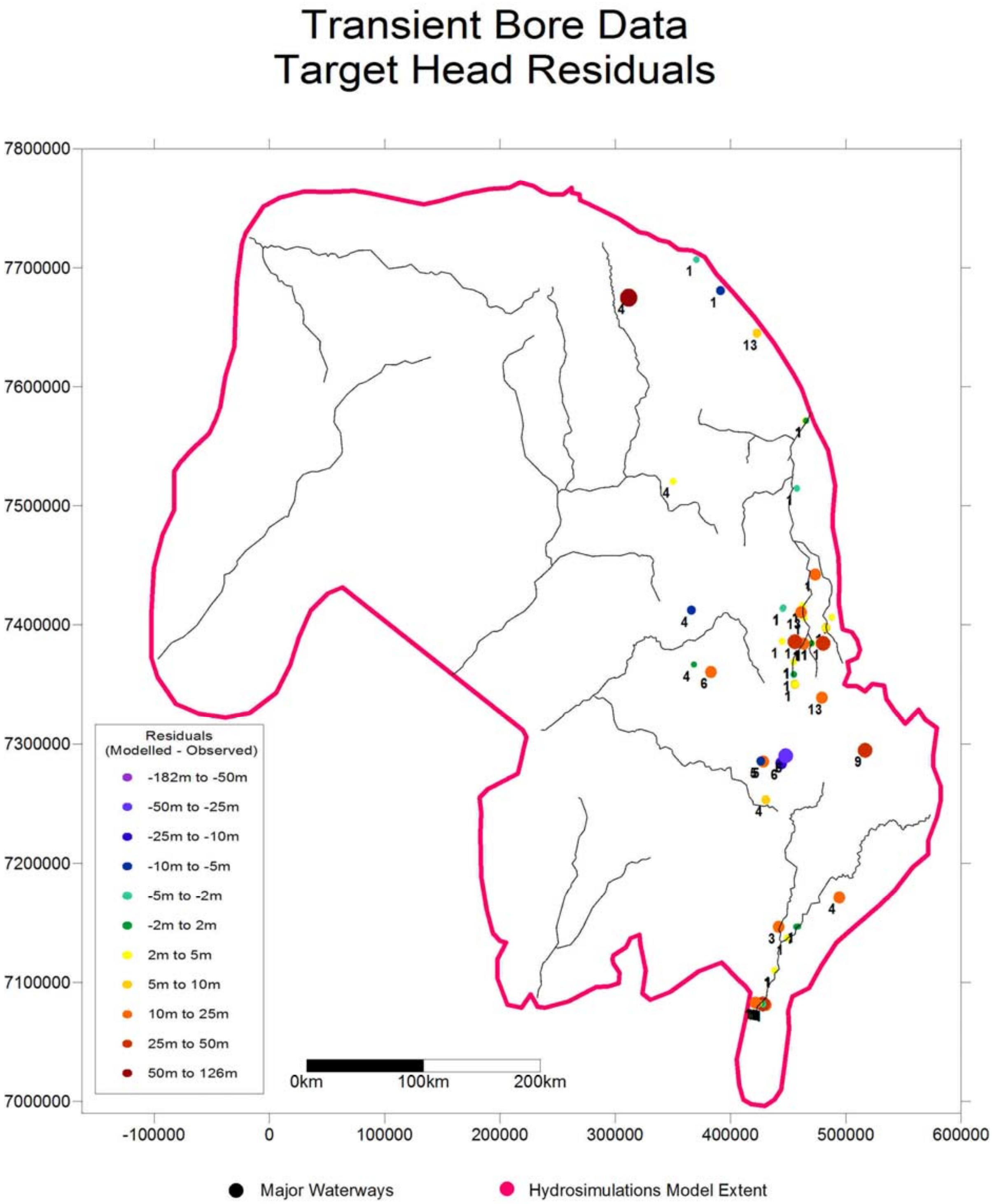

Coal Seam CDE (Layer 11)
Target Head Residuals
7800000
7700000
7600000
7500000
7400000
7300000
7200000
7100000
7000000
-100000
0
100000
200000
300000
400000
500000
600000
Residuals
(Modelled - Observed)
-182m to -50m
-50m to -25m
-25m to -10m
-10m to -5m
-5m to -2m
-2m to 2m
2m to 5m
5m to 10m
10m to 25m
25m to 50m
50m to 126m
0km
100km
200km
Major Waterways
Hydrosimulations Model Extent

Colinlea Sandstone / Coal Seam E (Layer 12) Target Head Residuals



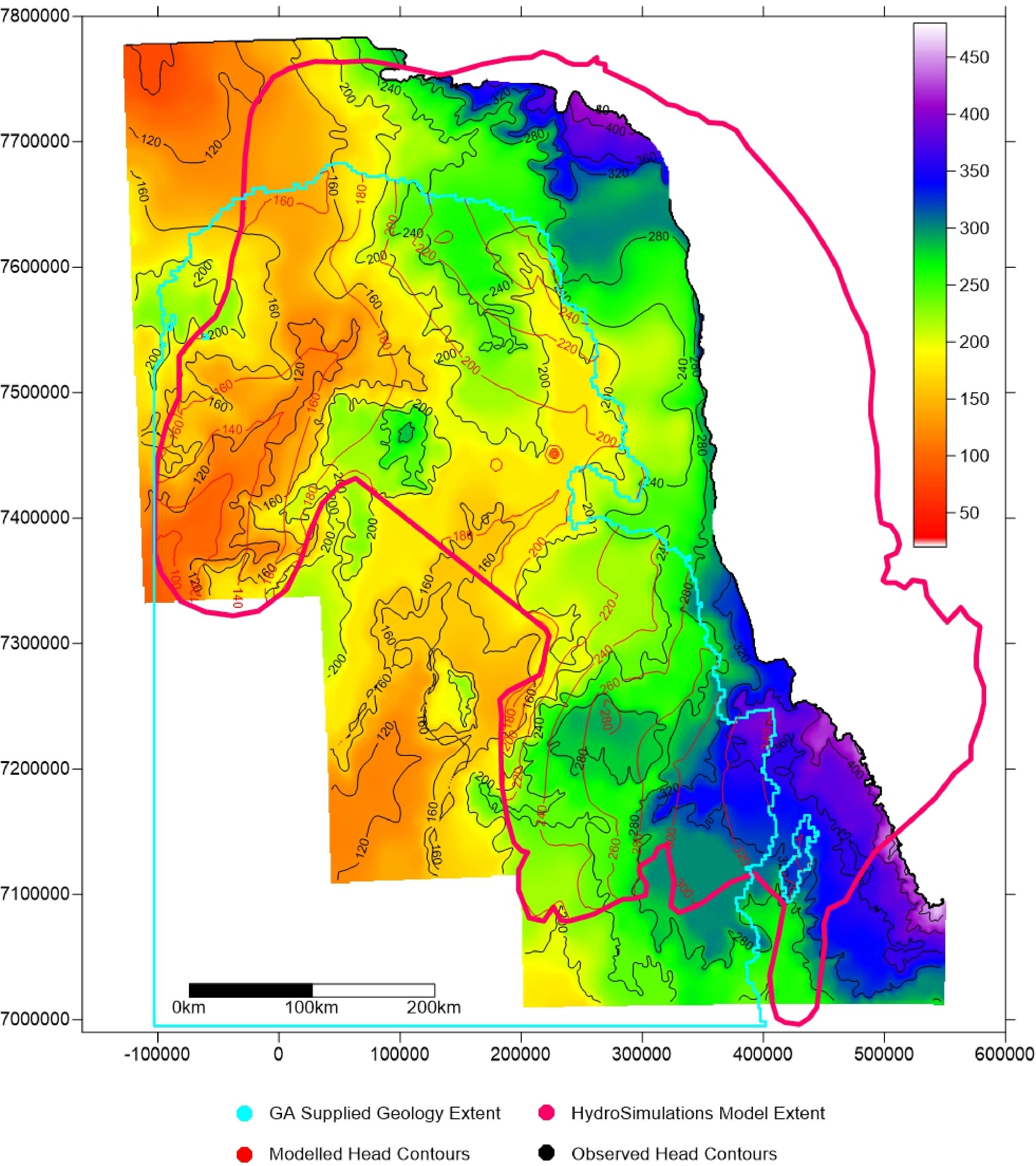
Joe Joe Group (Layer 13)
Target Head Residuals



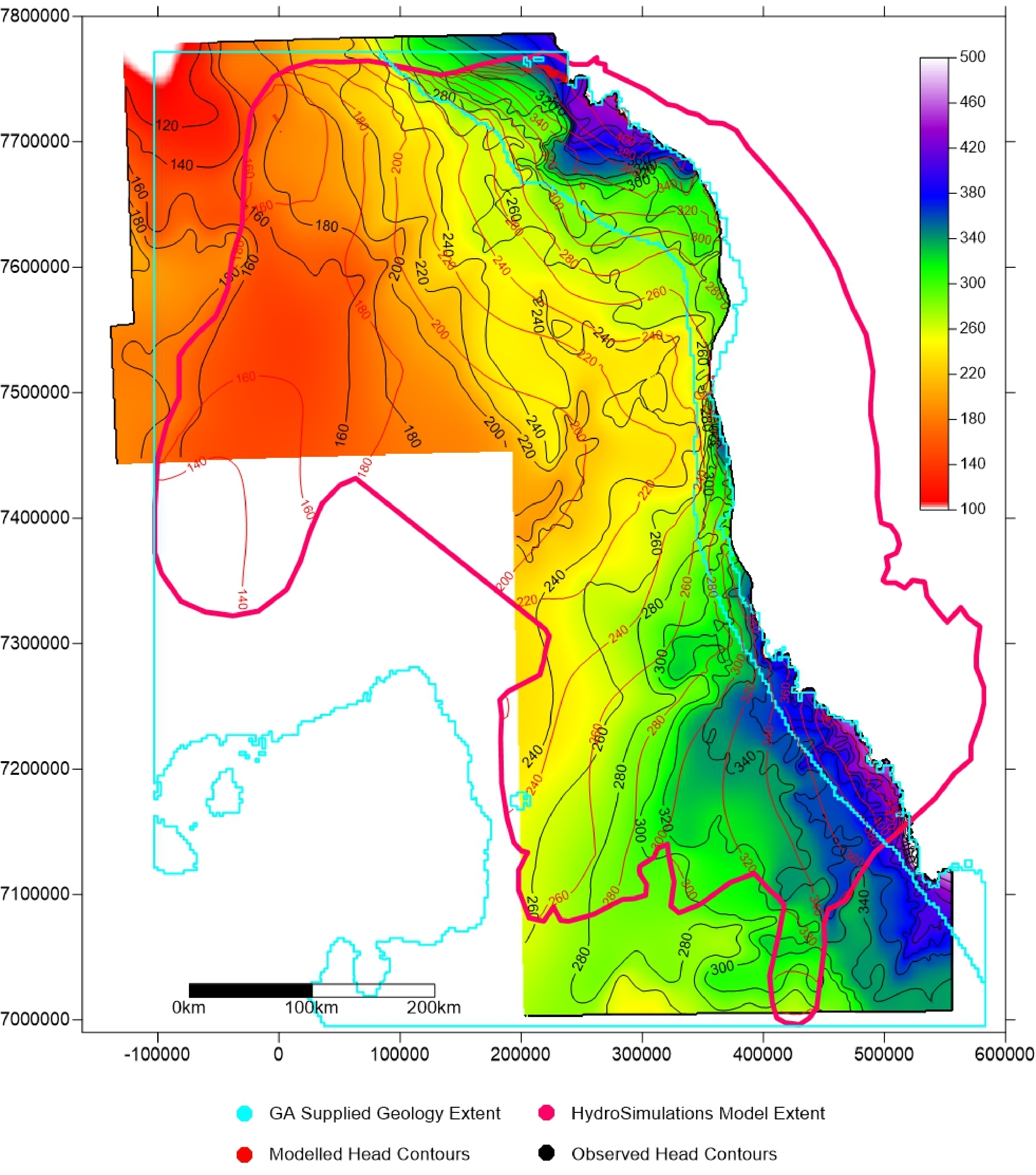

Transient Bore Data
Target Head Residuals
7800000
7700000
7600000
7500000
7400000
7300000
7200000
7100000
7000000
-100000
0
100000
200000
300000
400000
500000
600000
Residuals
(Modelled - Observed)
-182m to -50m
-50m to -25m
-25m to -10m
-10m to -5m
-5m to -2m
-2m to 2m
2m to 5m
5m to 10m
10m to 25m
25m to 50m
50m to 126m
0km
100km
200km
Major Waterways
Hydrosimulations Model Extent

APPENDIX F – Observed vs Modelled Steady-State Potentiometric Head Surfaces

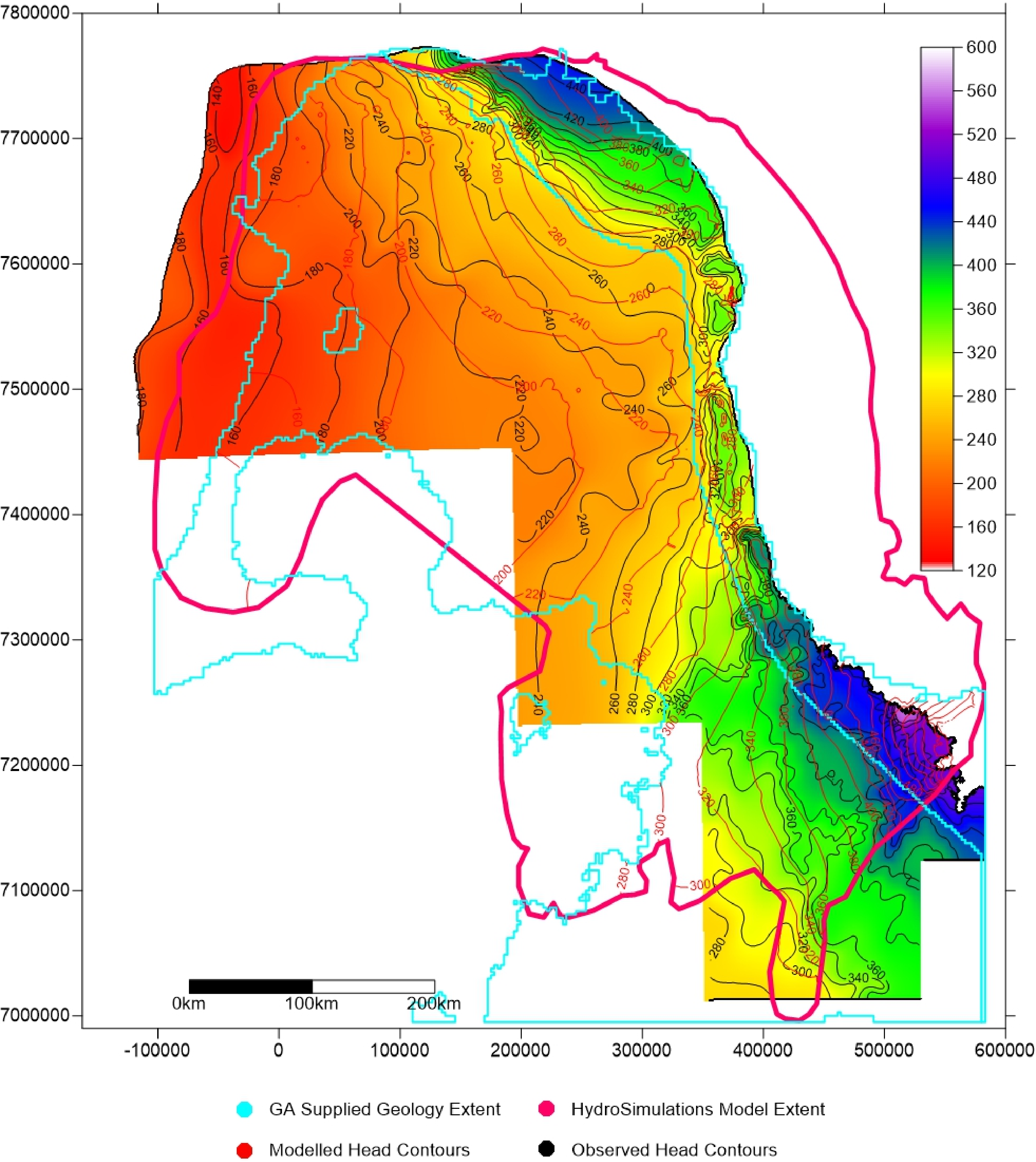
Obsereved and Modelled Head Contours for Galillee Basin Subregion -Winton/ Mackunda Formation (Layer 2)



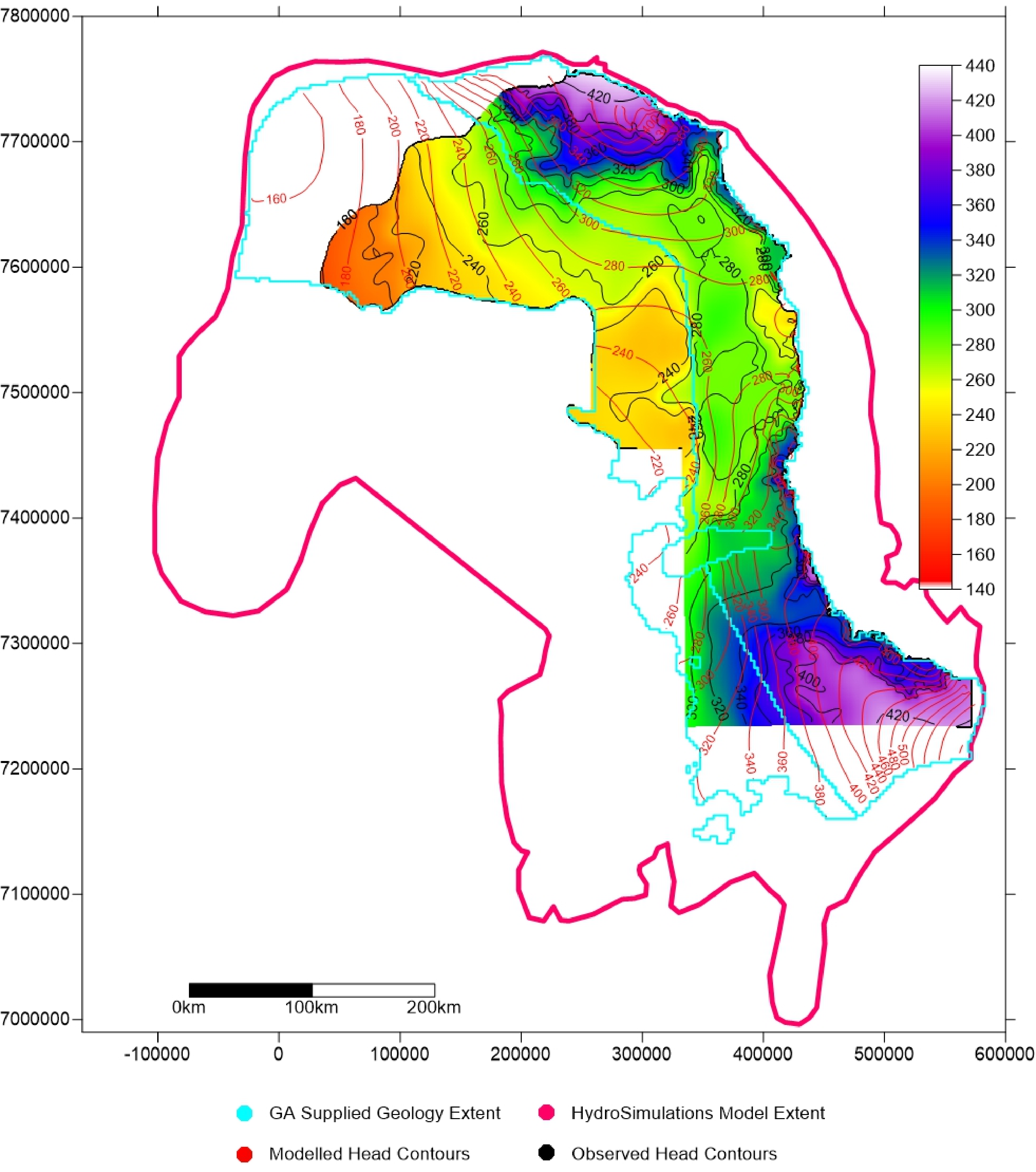
Obsereved and Modelled Head Contours for Galillee Basin Subregion - Cadna-owie Formation/ Hooray Sandstone (Layer 4)



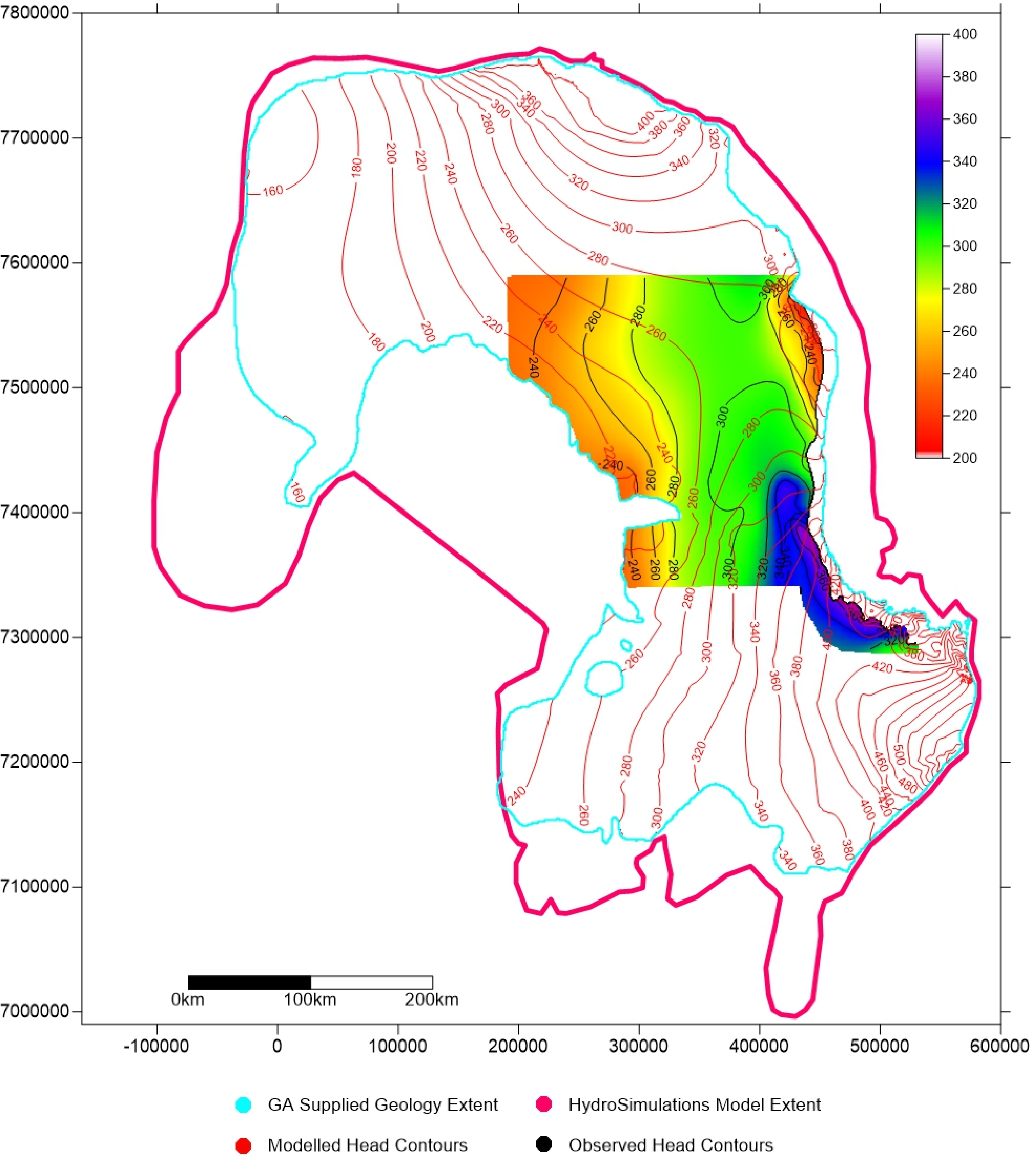
Obsereved and Modelled Head Contours for Galillee Basin Subregion - Hutton Sandstone (Layer 6)



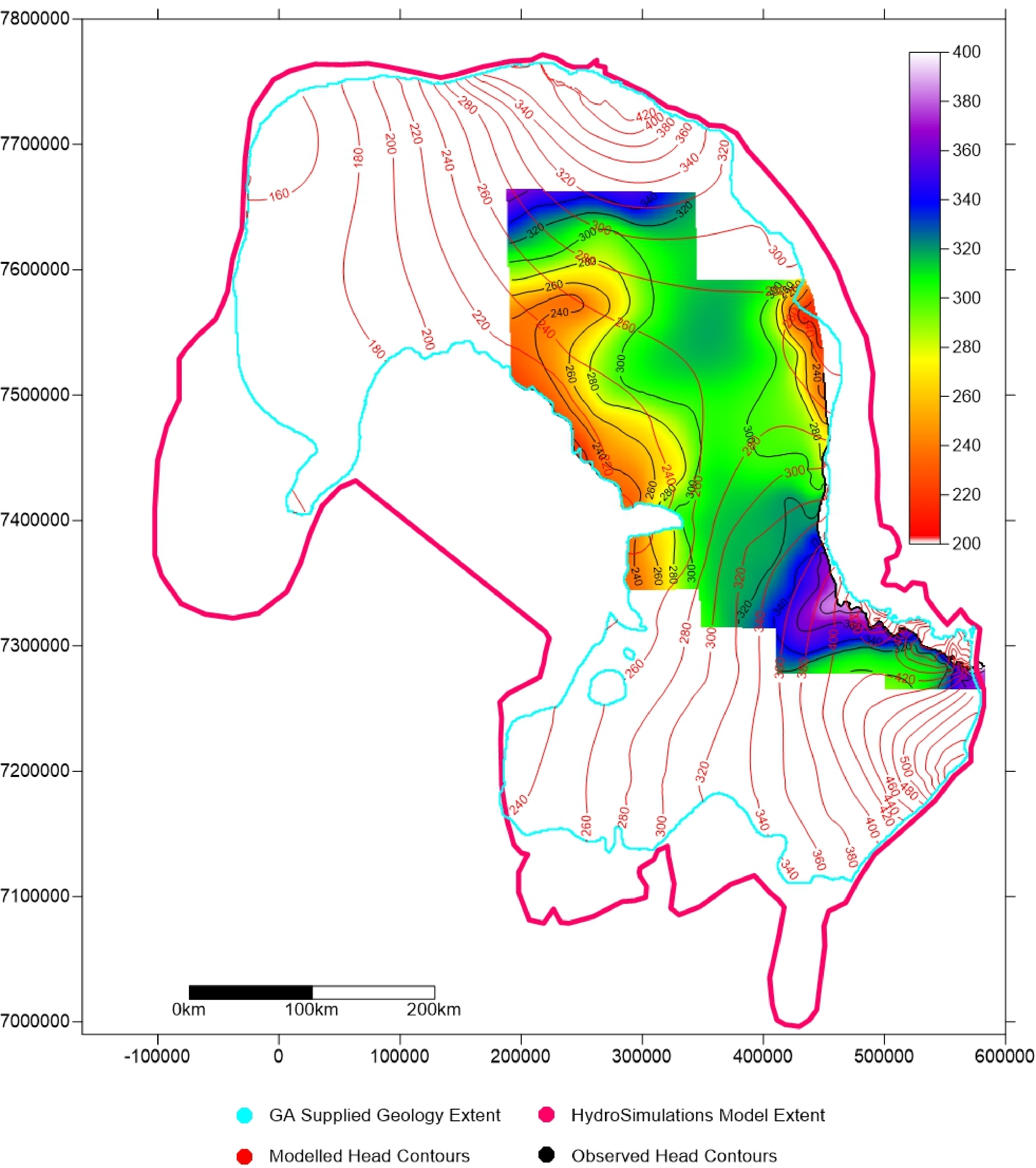
Obsereved and Modelled Head Contours for Galillee Basin Subregion - Clematis Group/ Warang Sandstone (Layer 8)



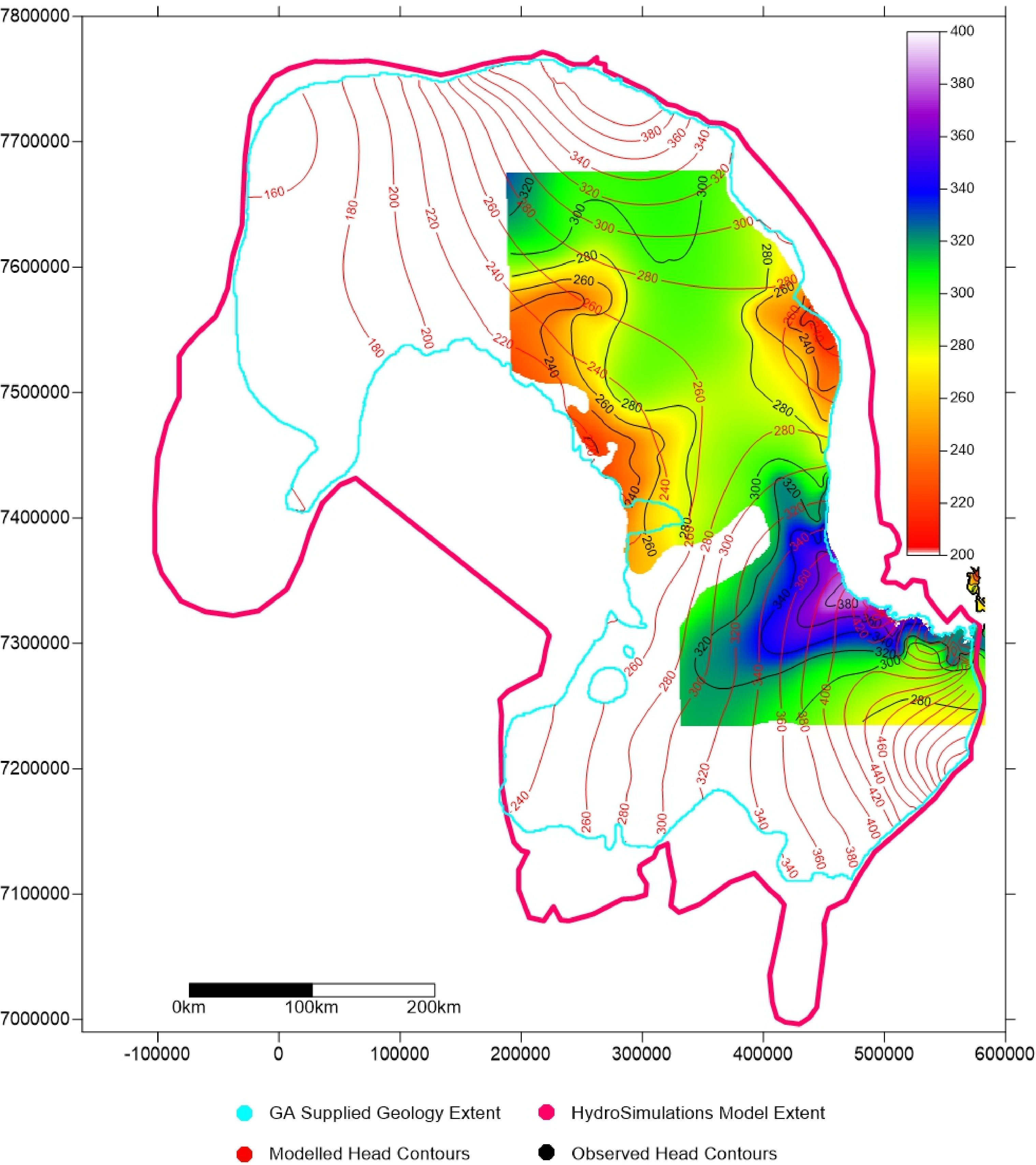
Obsereved and Modelled Head Contours for Galillee Basin Subregion - Bandanna Formation (Layer 10)



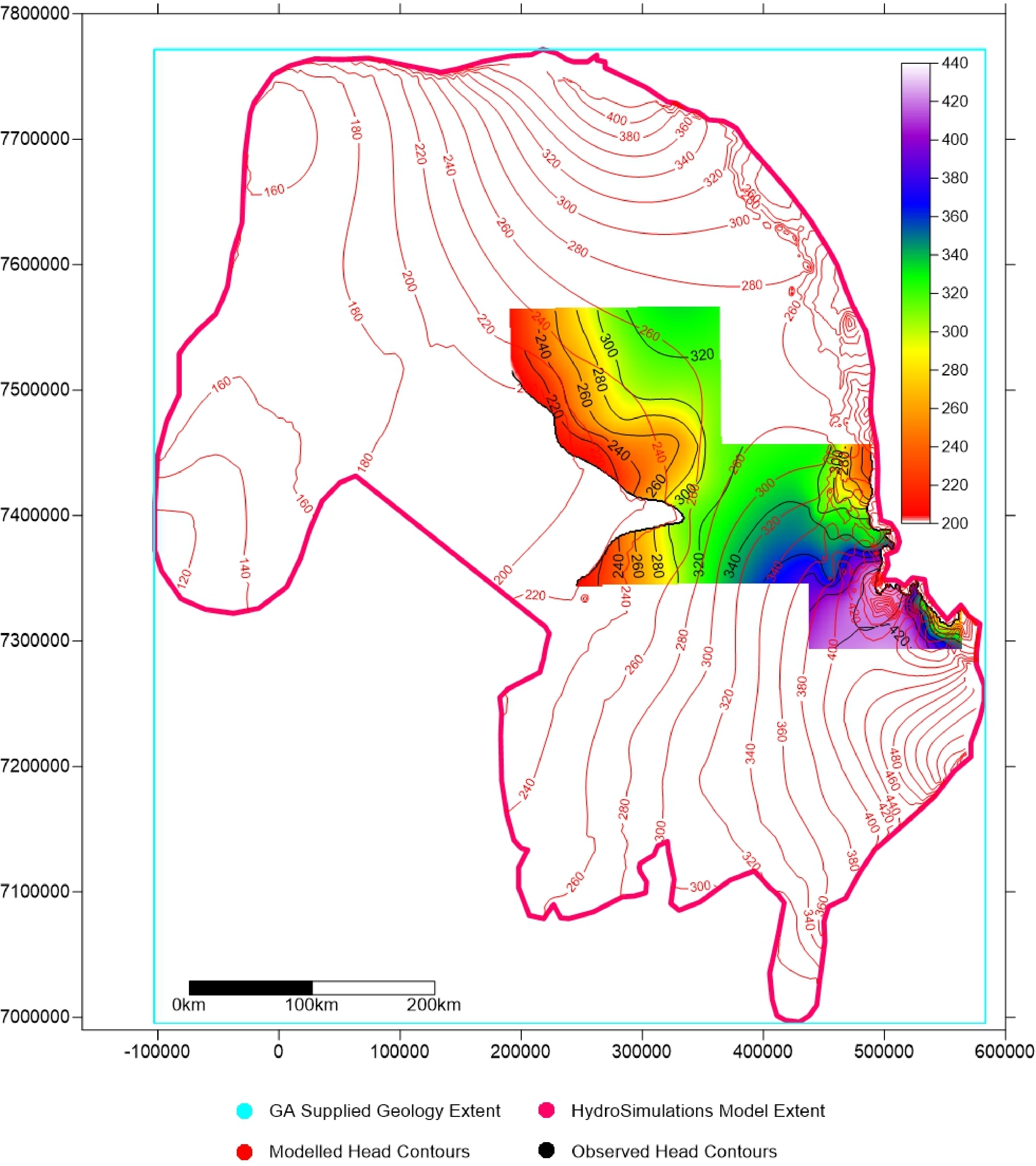
Obsereved and Modelled Head Contours for Galillee Basin Subregion - Coal Seam CDE (Layer 11)



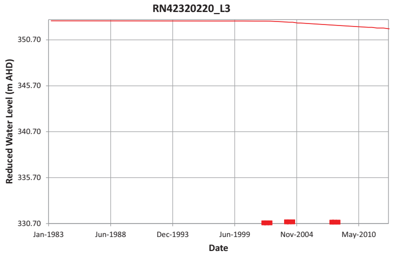
Obsereved and Modelled Head Contours for Galillee Basin Subregion - Colinlea Sandstone/ Coal Seam E (Layer 12)



Obsereved and Modelled Head Contours for Galillee Basin Subregion - Joe Joe Group (Layer 13)



APPENDIX G – Transient Hydrographs Observed v Modelled Heads



RN42320220_L3 - Computed RN42320220_L3 - Observed

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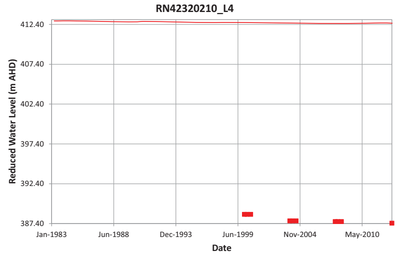
(RN42320220_L3)



RN42320210_L4 - Computed RN42320210_L4 - Observed

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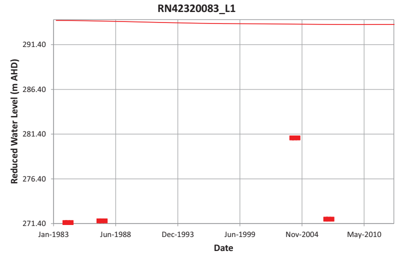
(RN42320210_L4)



RN42320083_L1 - Computed RN42320083_L1 - Observed

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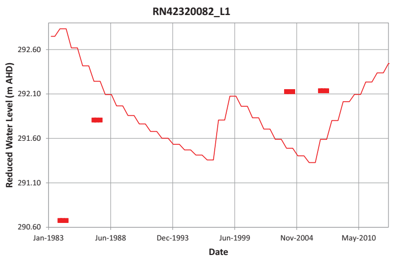
(RN42320083_L1)



RN42320082_L1 - Computed RN42320082_L1 - Observed

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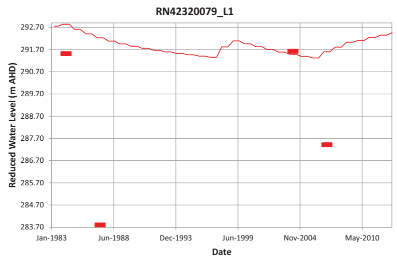
(RN42320082_L1)



RN42320079_L1 - Computed RN42320079_L1 - Observed

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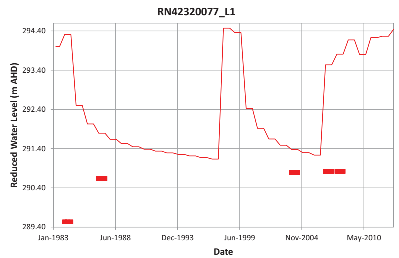
(RN42320079_L1)



RN42320077_L1 - Computed RN42320077_L1 - Observed

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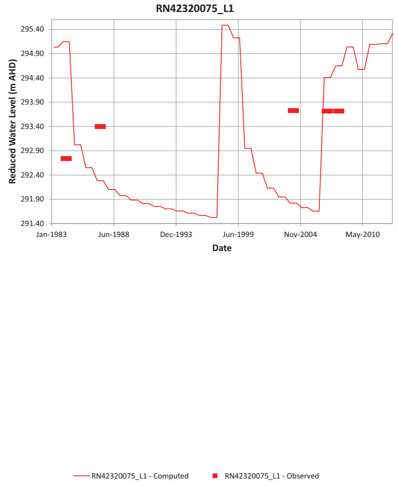
(RN42320077_L1)



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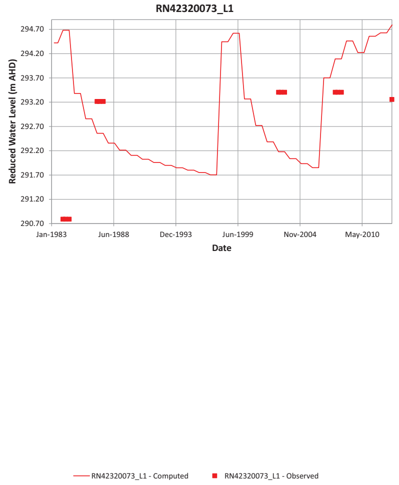
(RN42320075_L1)



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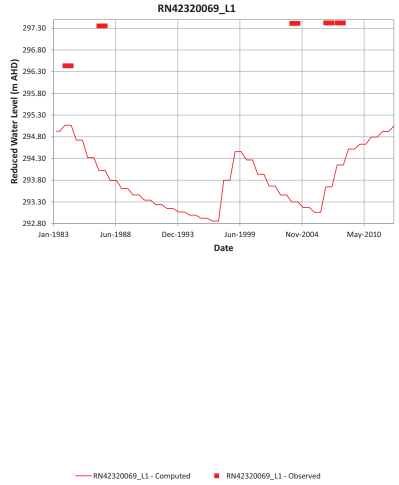

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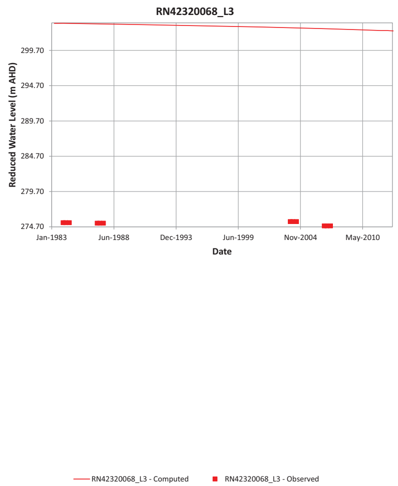
(RN42320069_L1)



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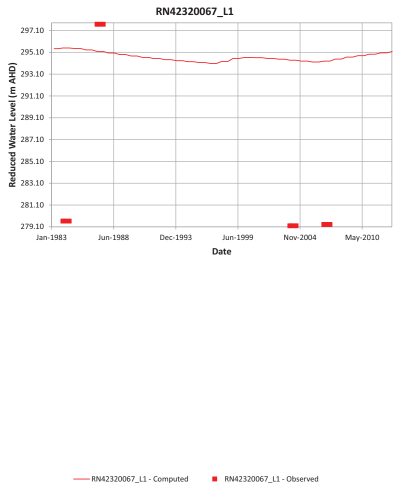
(RN42320068_L3)



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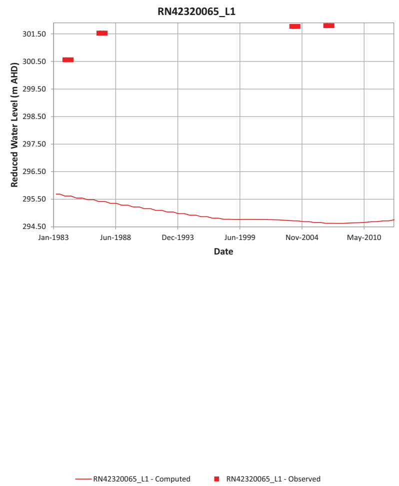

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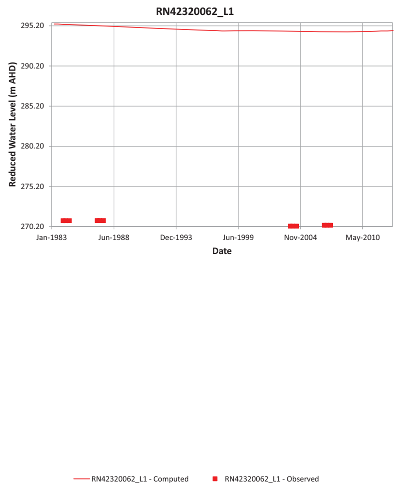

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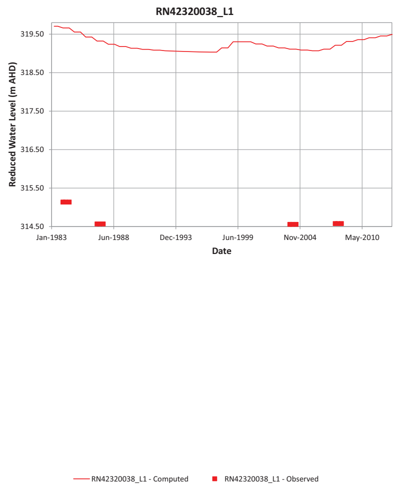

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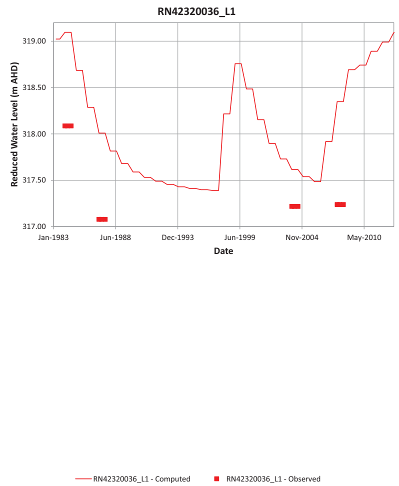
(RN42320038_L1)



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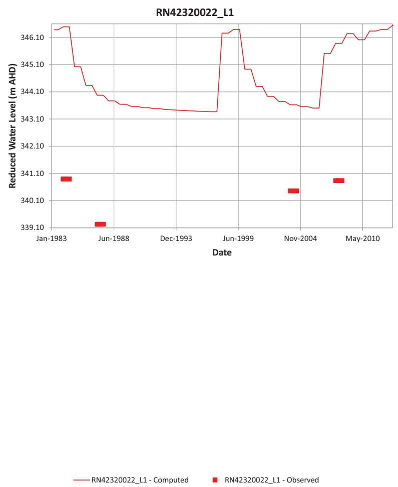

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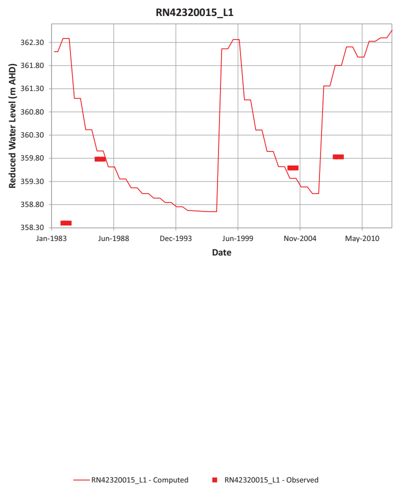

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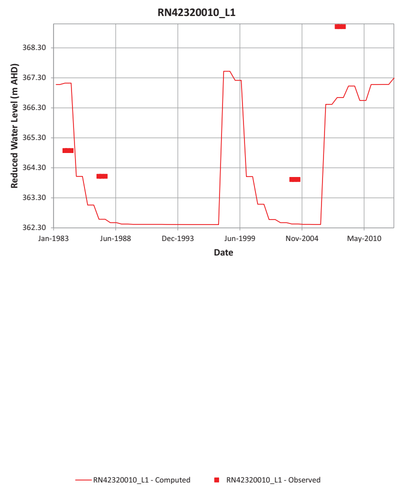

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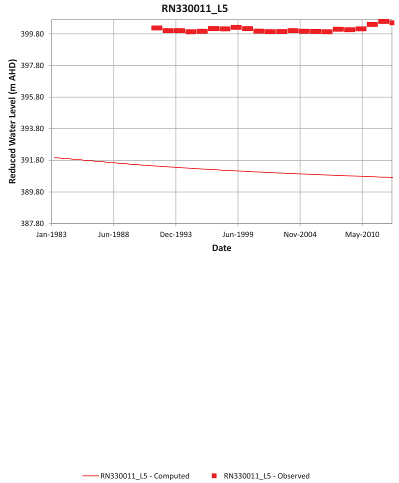

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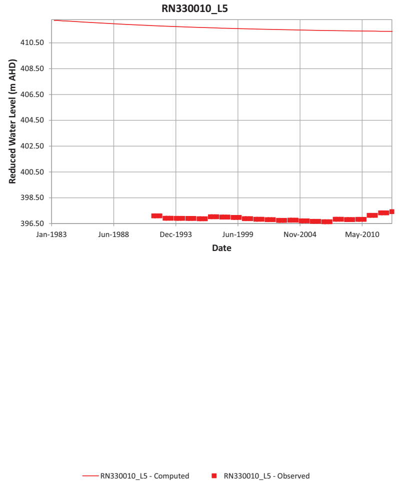
(RN330011_L5)



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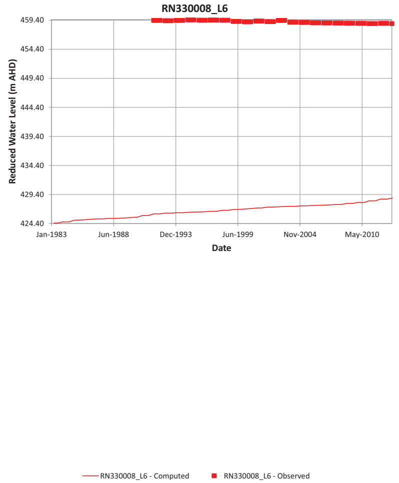
(RN330010_L5)



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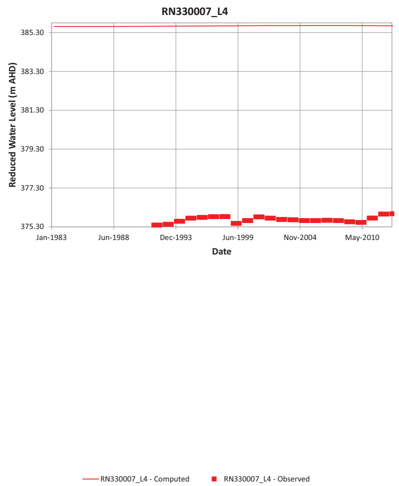

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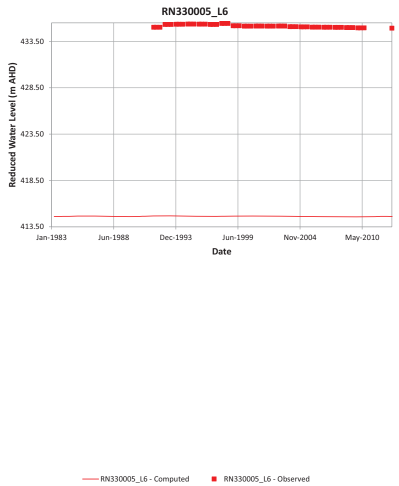

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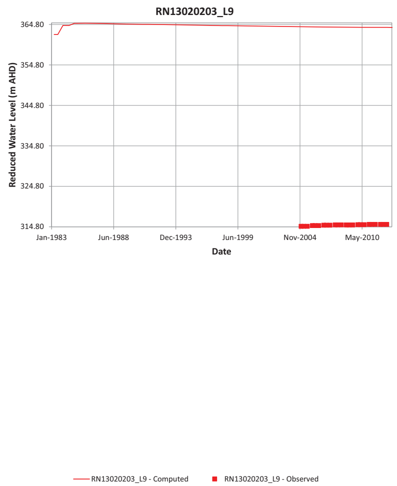

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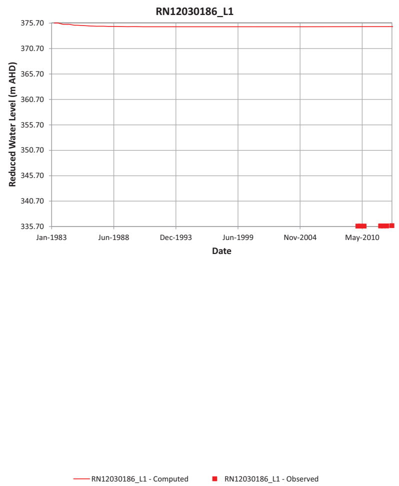

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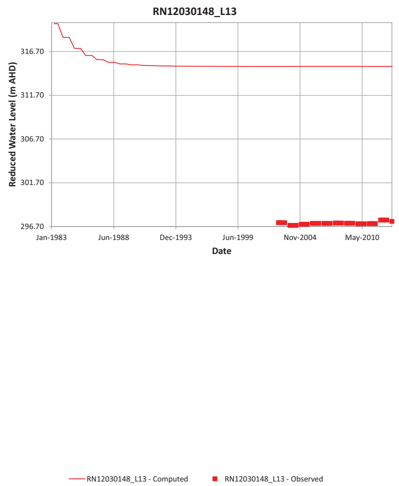

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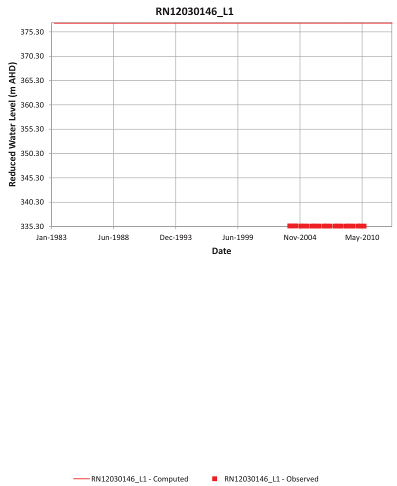
(RN12030148_L13)



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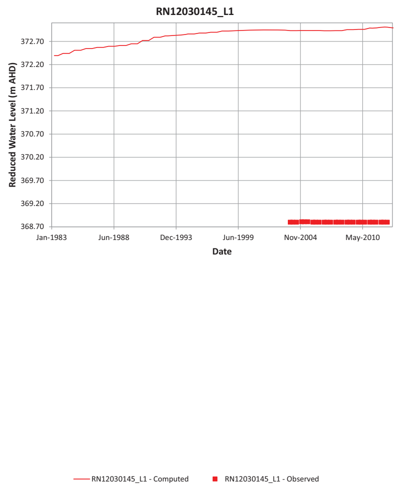

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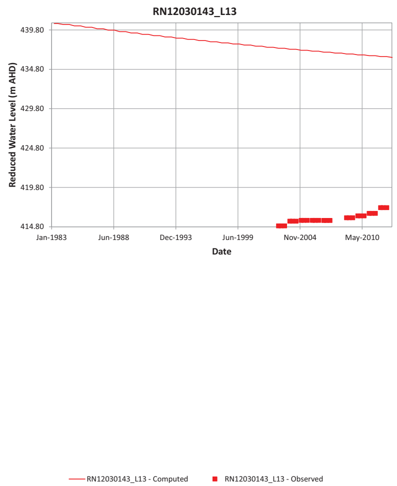
(RN12030145_L1)



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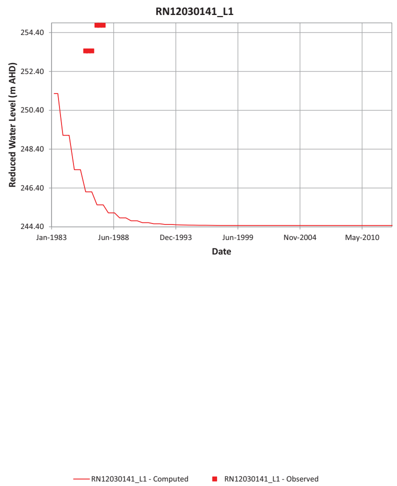

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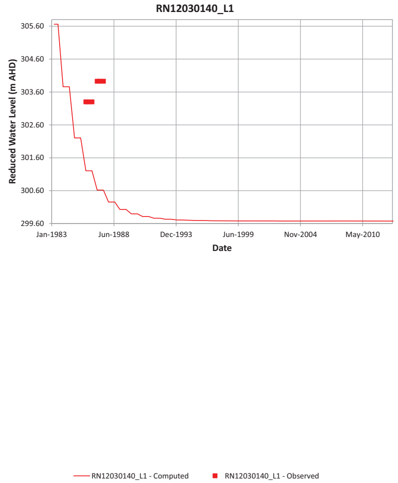

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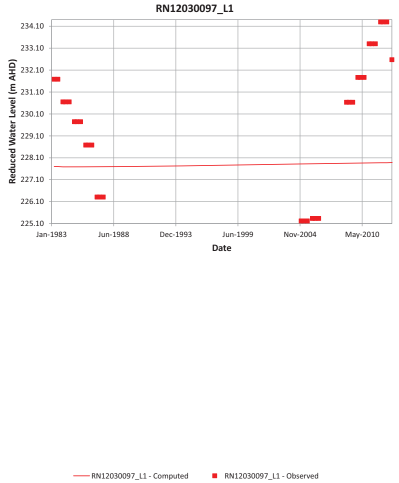

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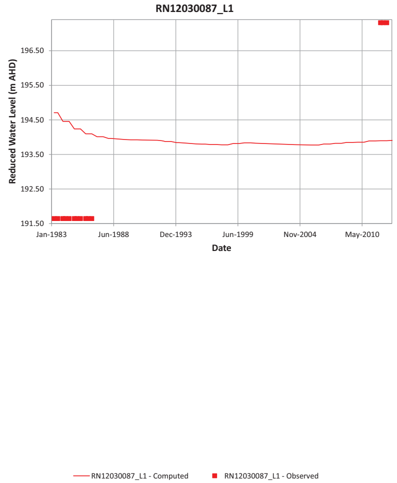

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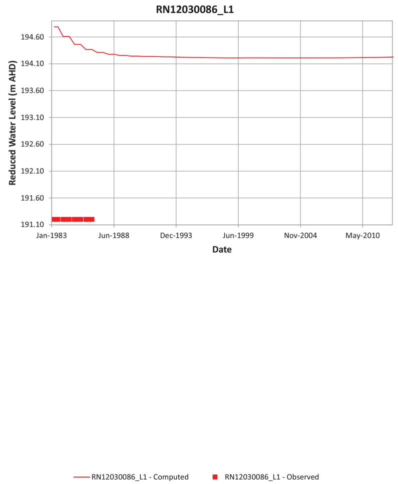

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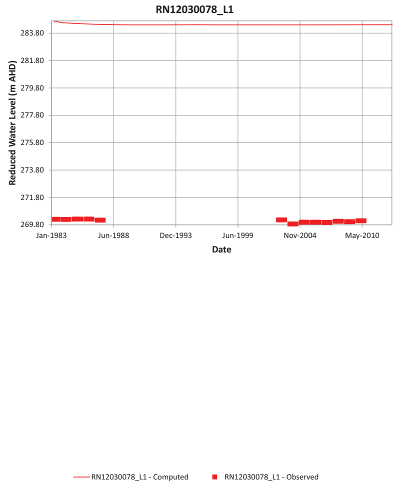

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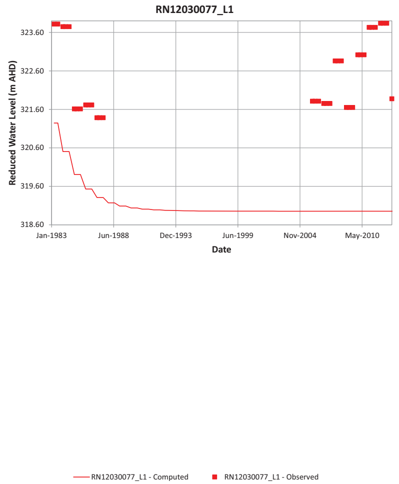

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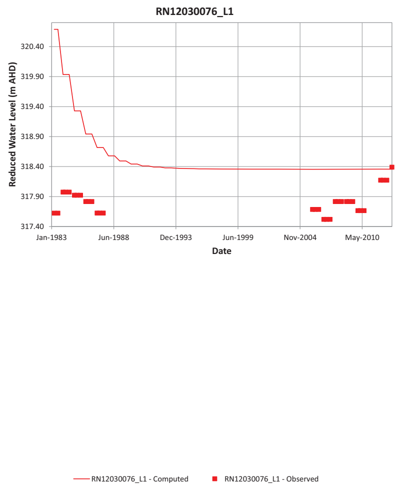

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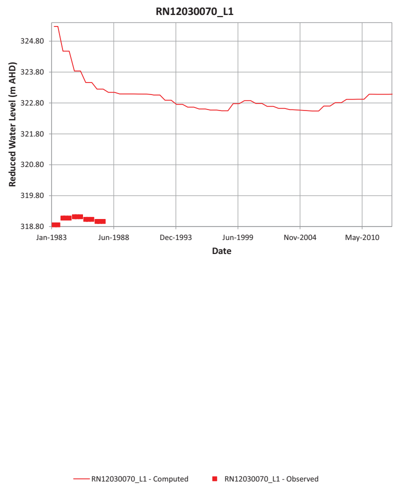

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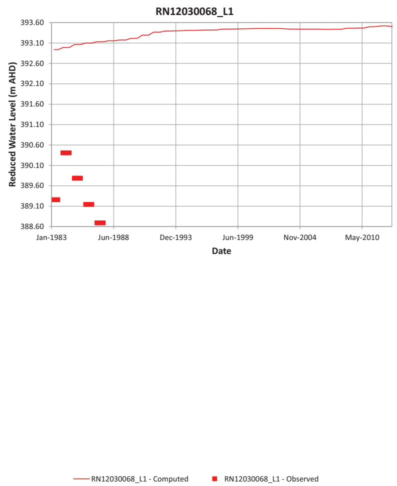

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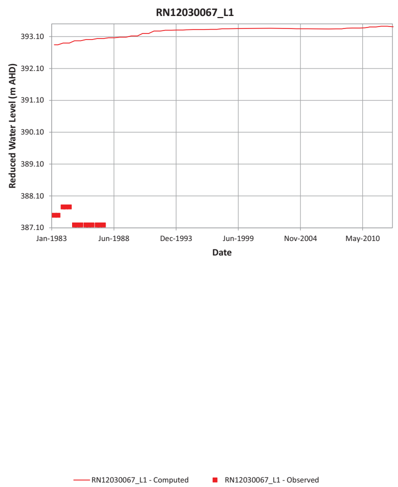

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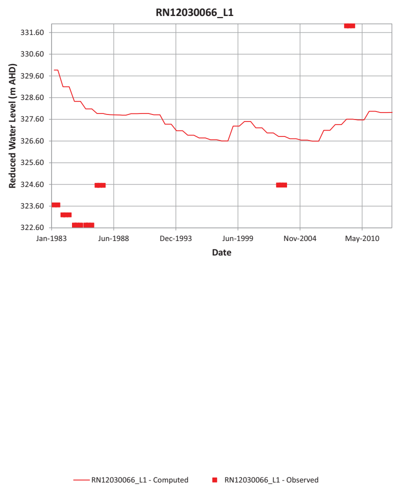

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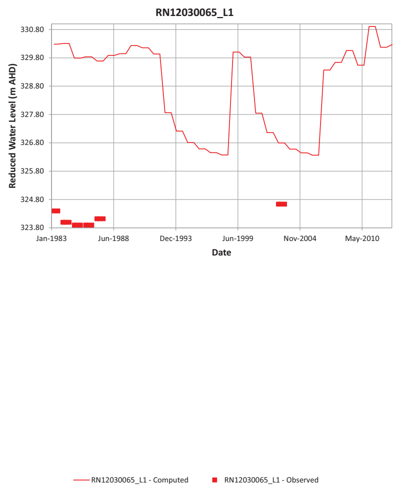

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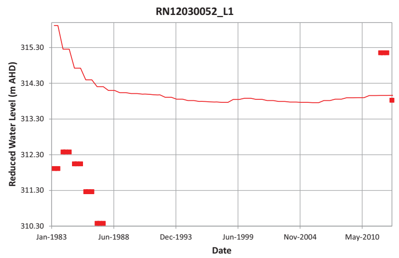

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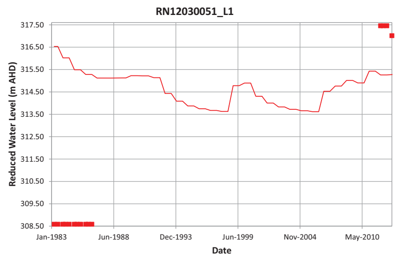

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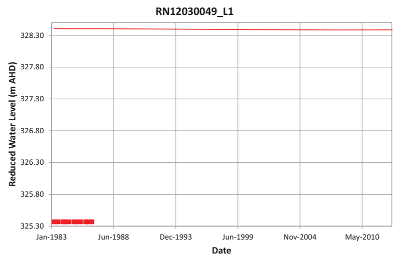

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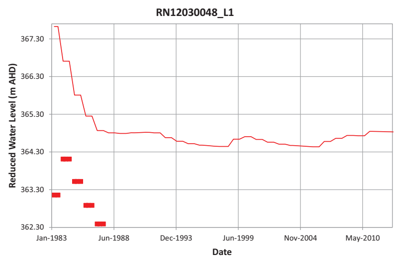

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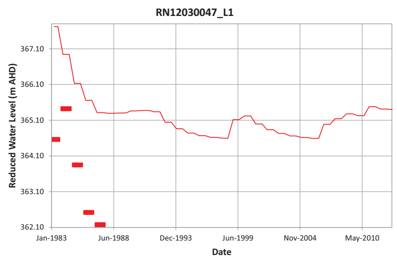

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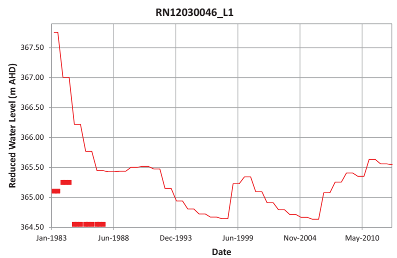

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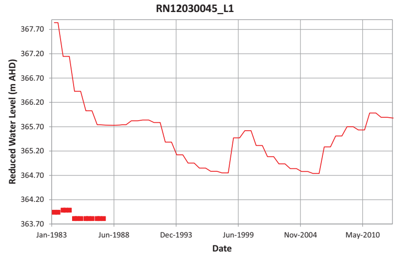

RN12030045_L1 - Computed RN12030045_L1 - Observed

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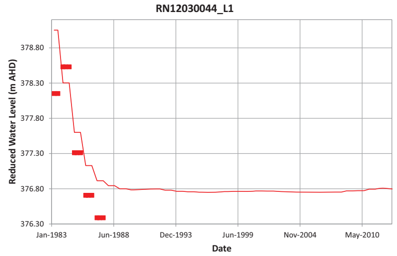

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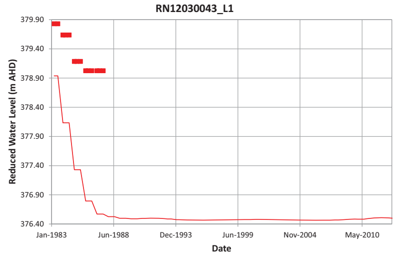

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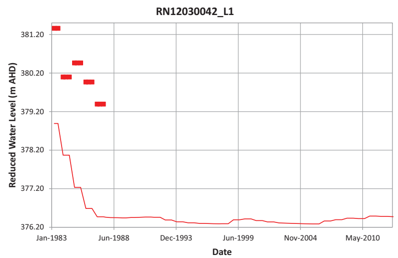

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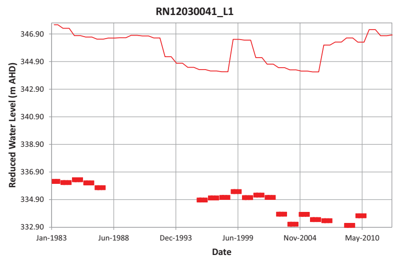

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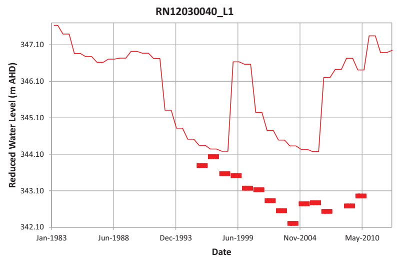

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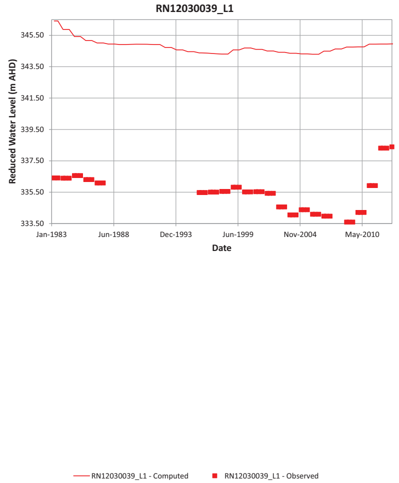

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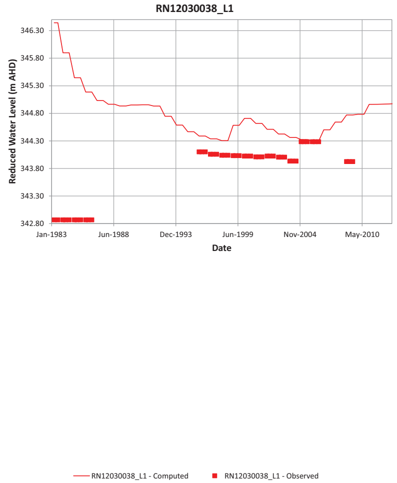

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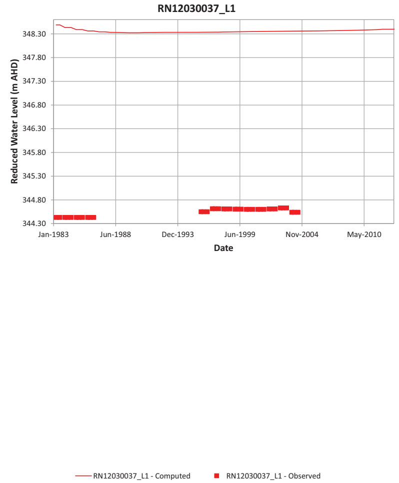

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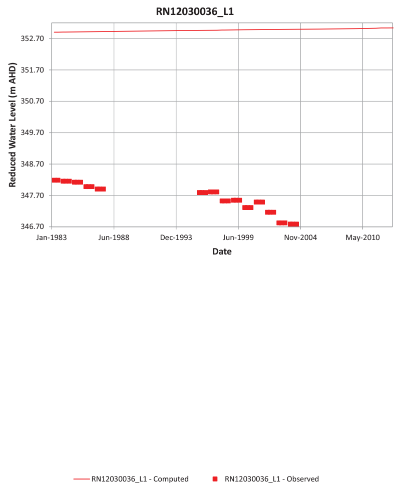

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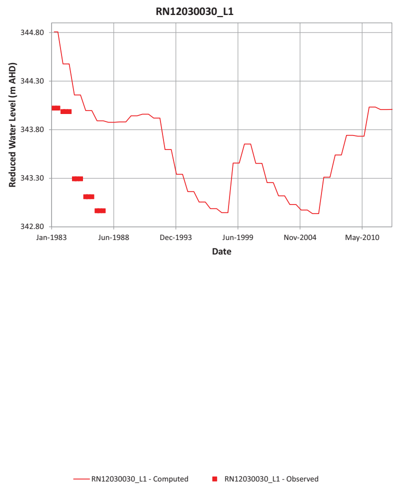

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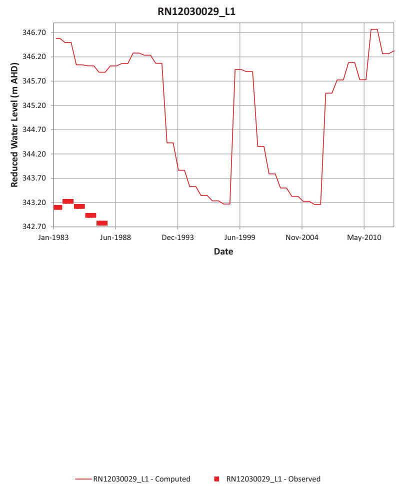

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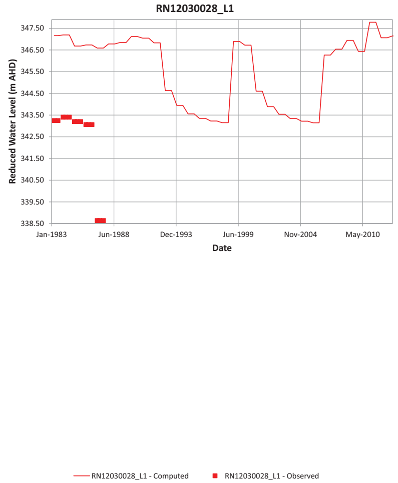

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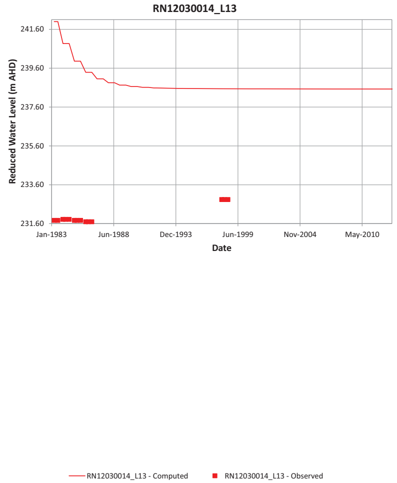

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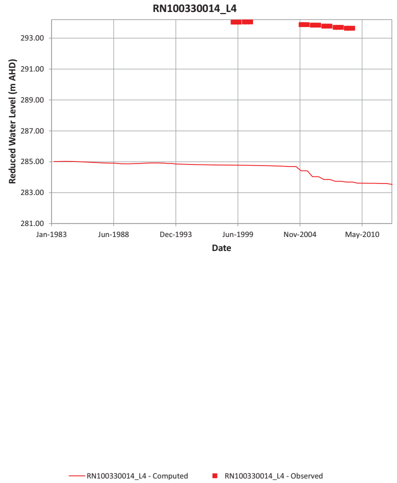

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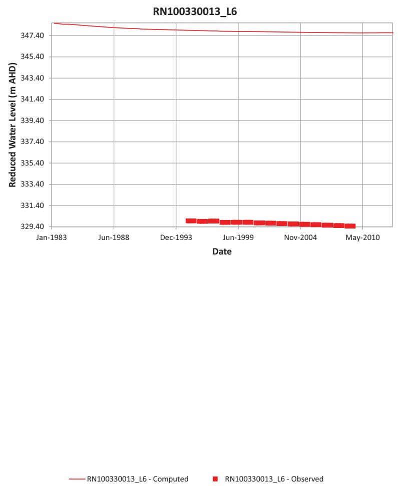

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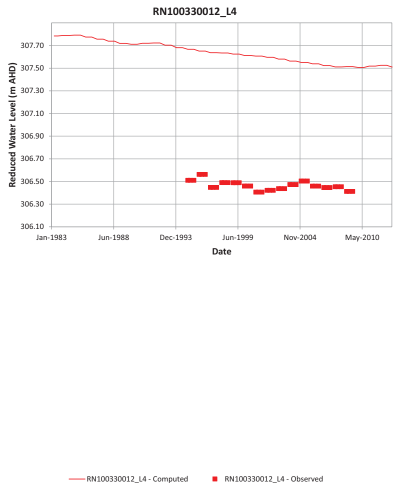

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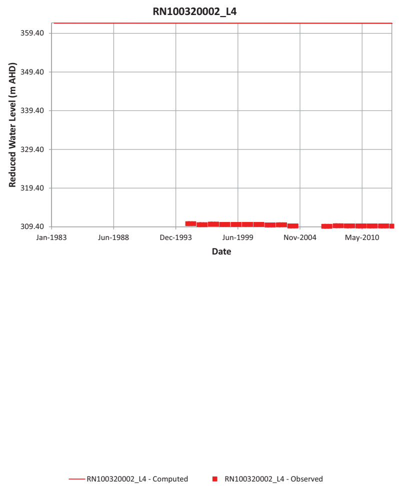

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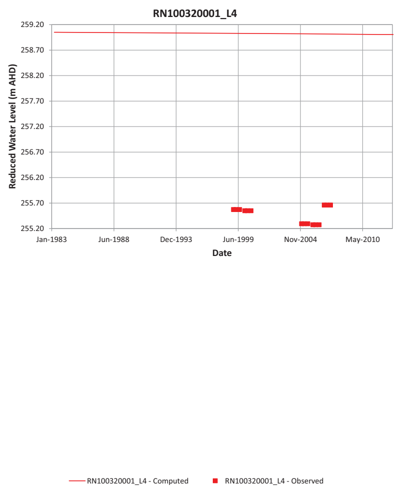

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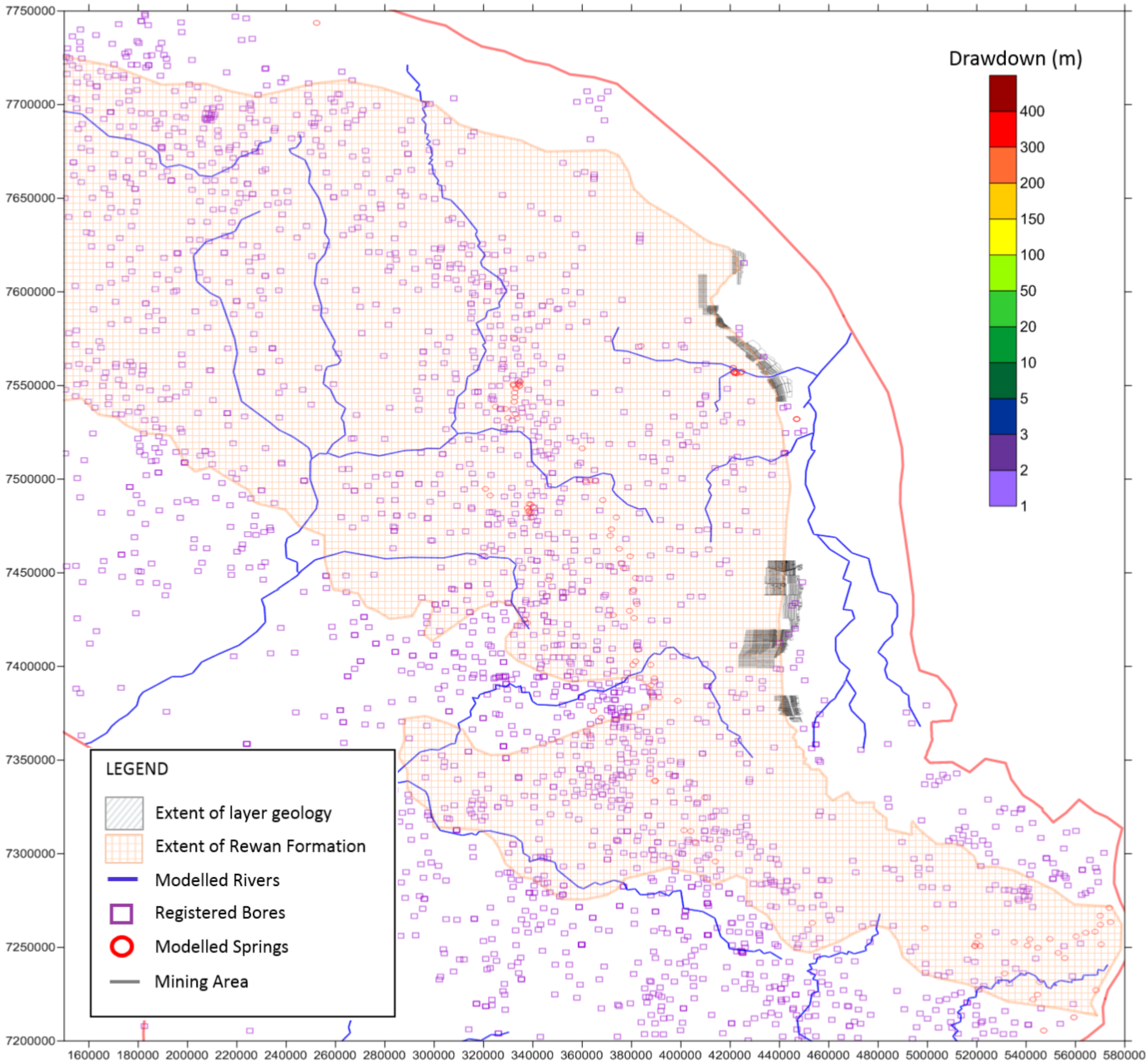
APPENDIX H – Predicted Drawdowns



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 1 Drawdown 2020		

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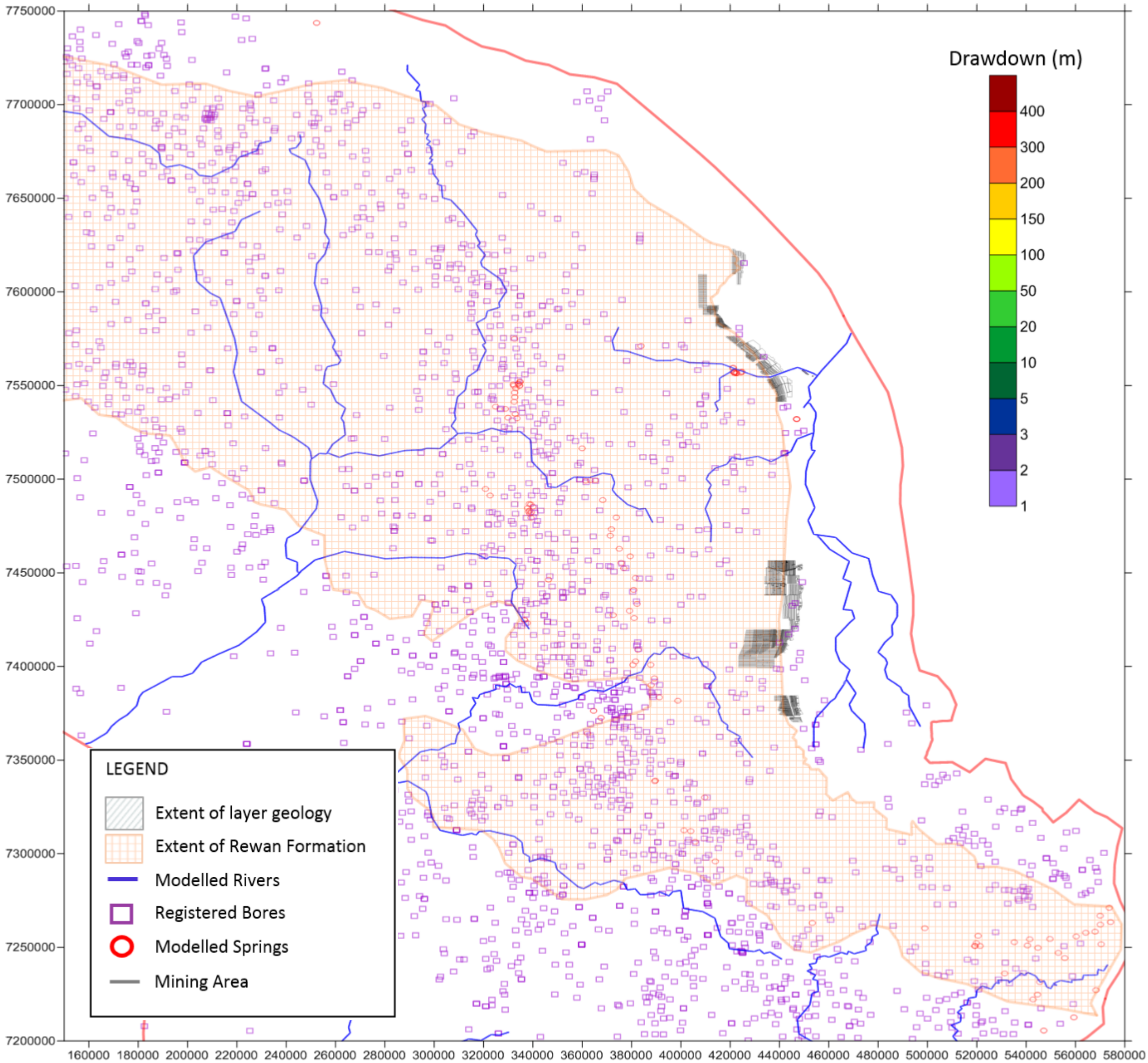

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 1 Drawdown 2025

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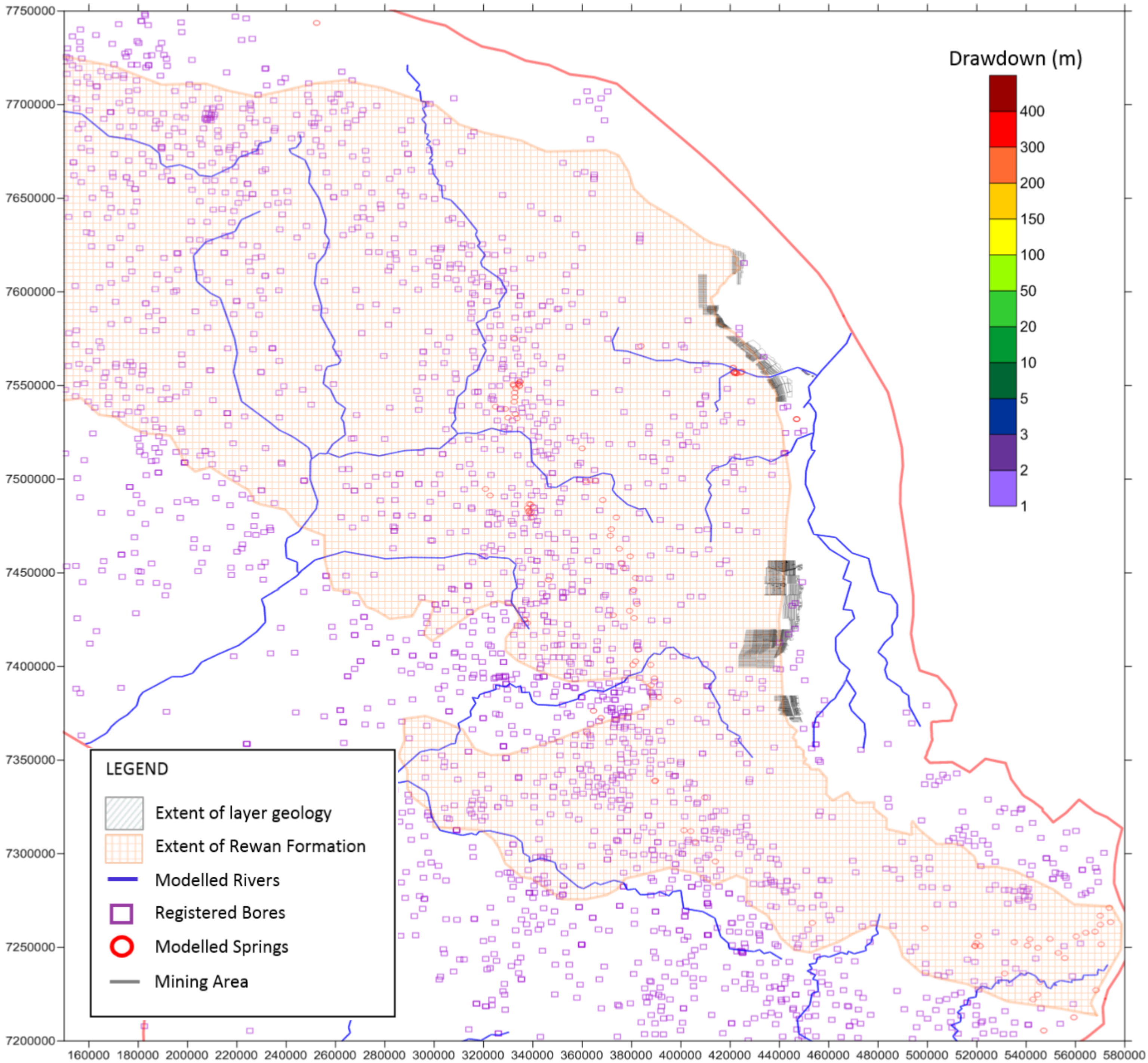

HydroSimulations

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 1 Drawdown 2035

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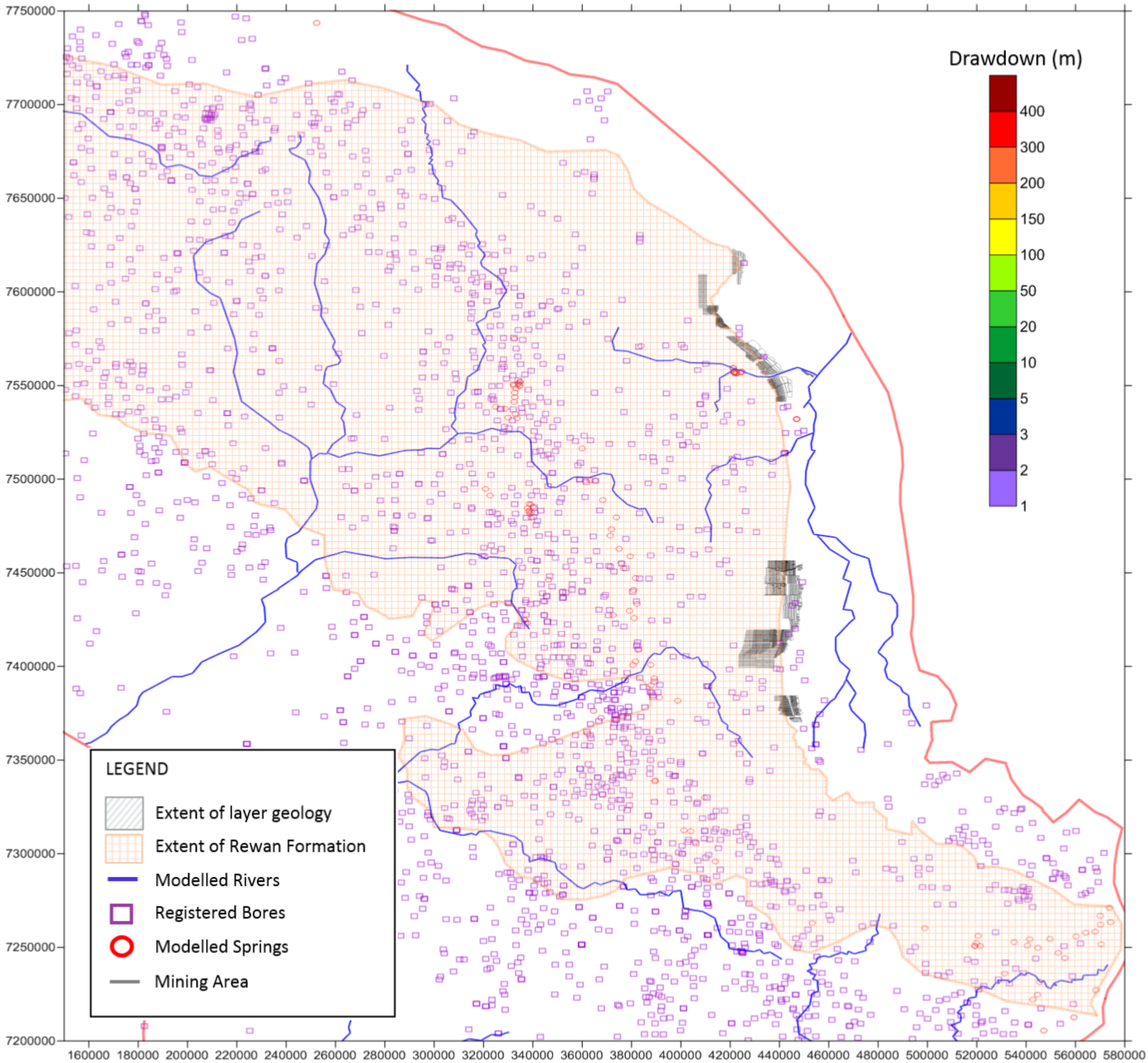
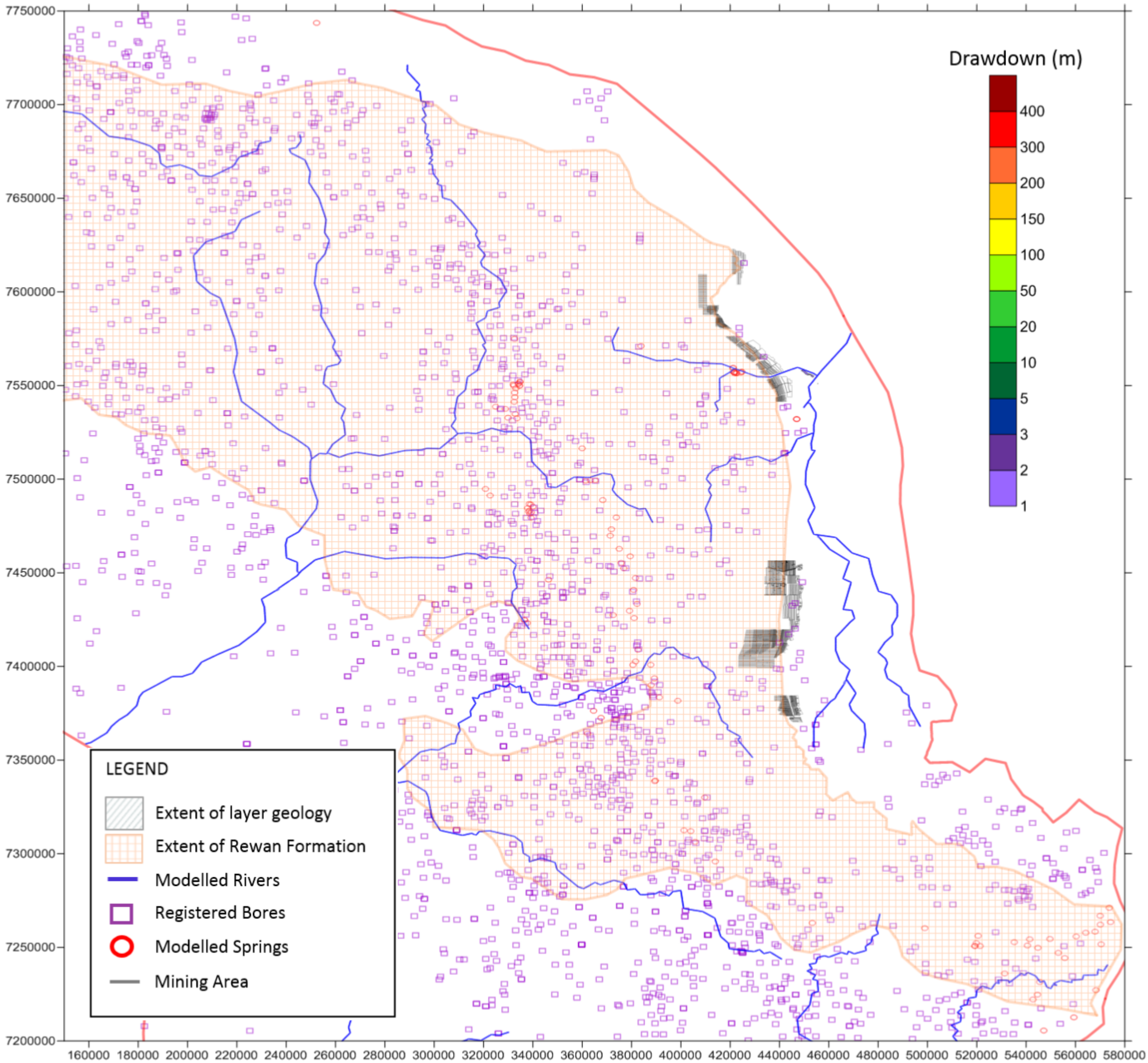


HYDRO SIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 1 Drawdown 2040

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

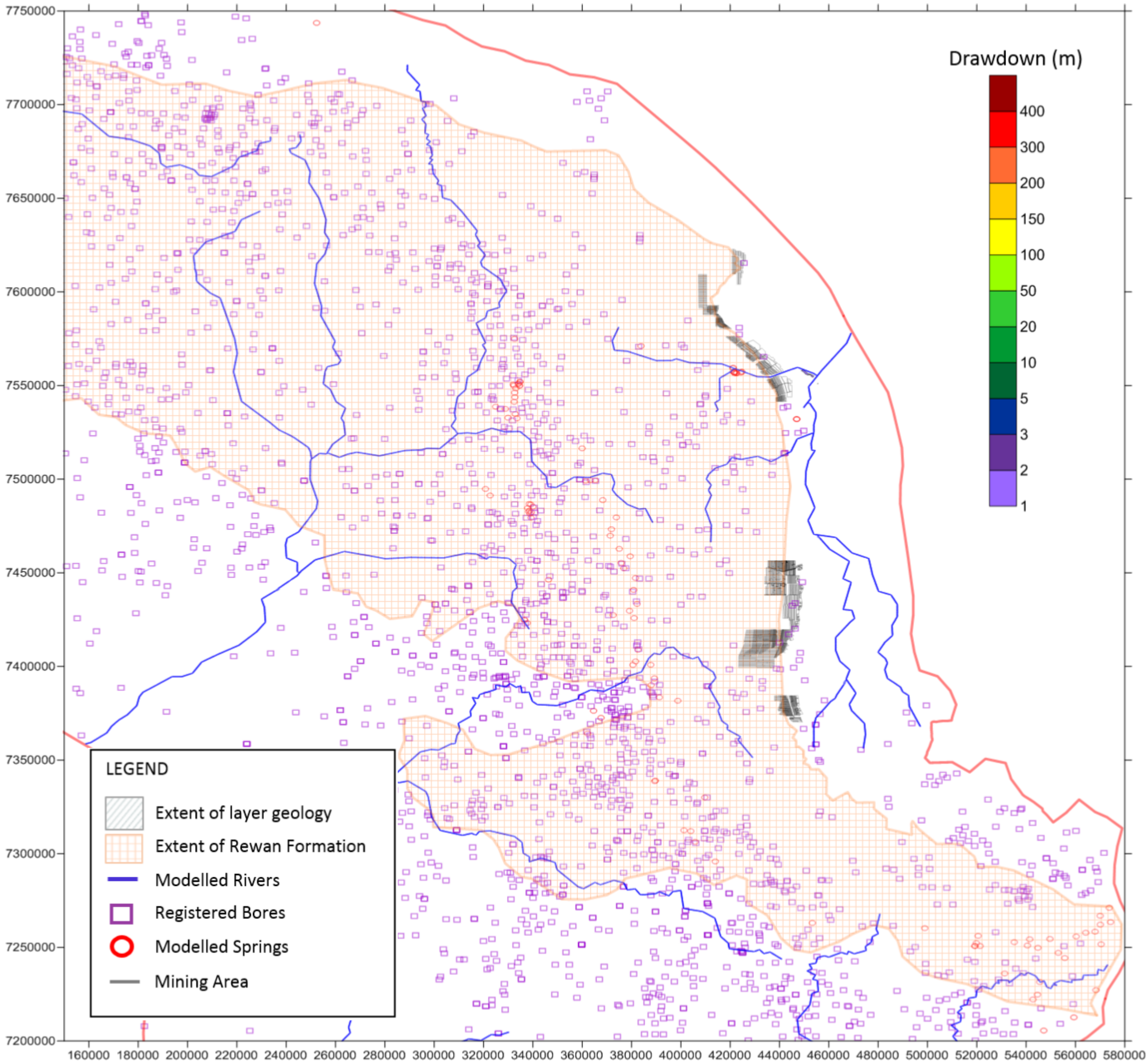


HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 1 Drawdown 2045

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



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	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
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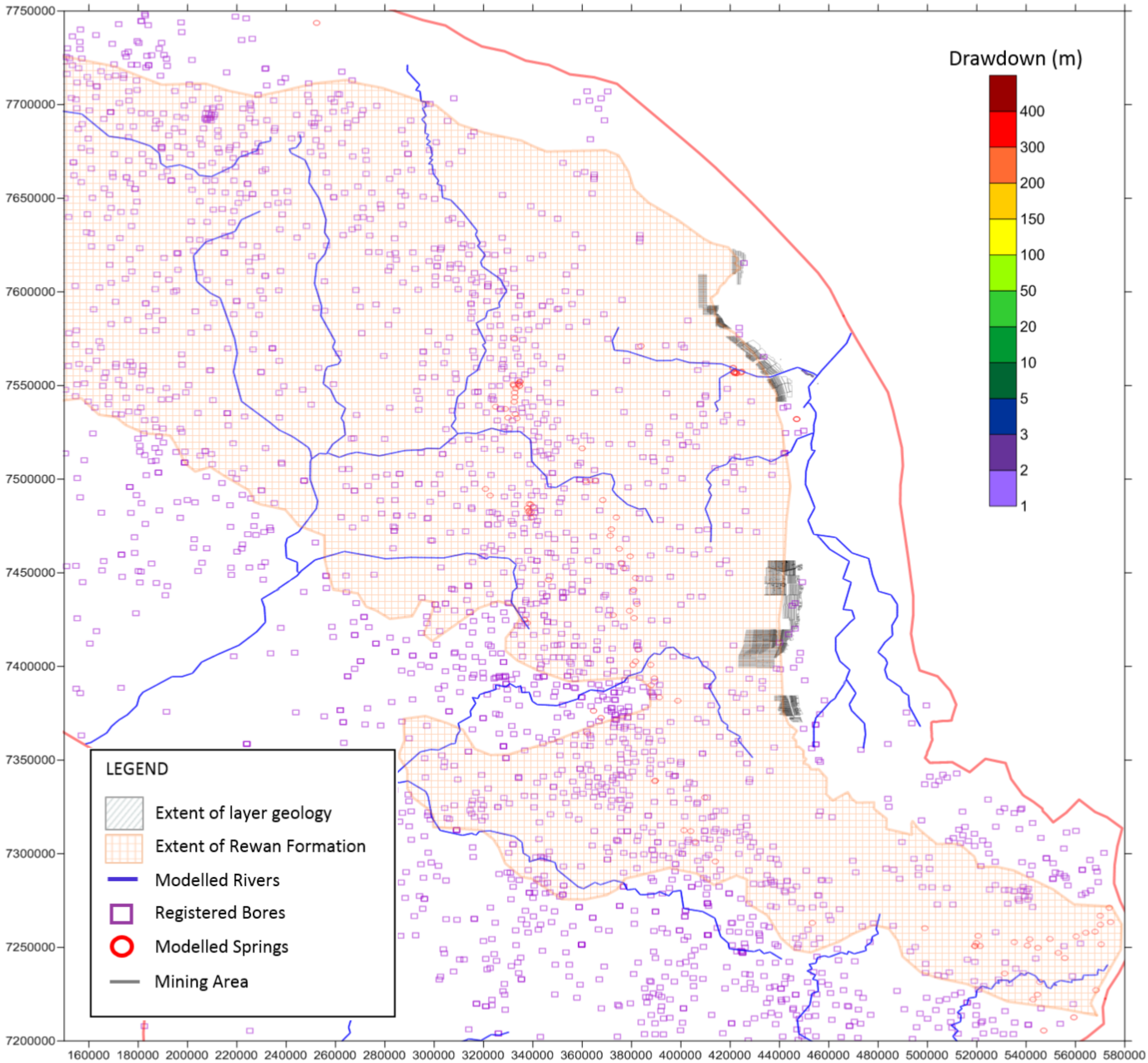

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 1 Drawdown 2050

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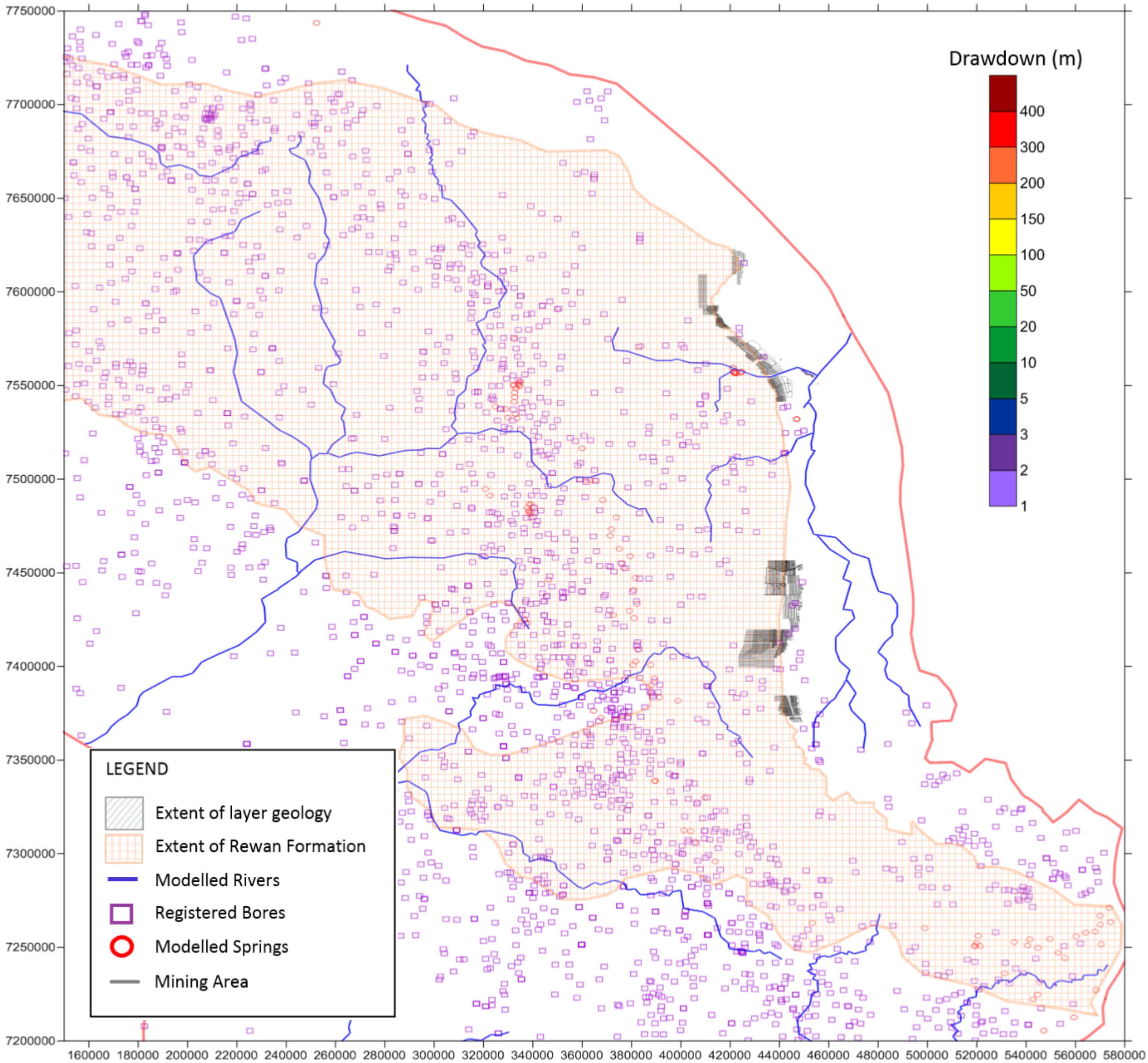
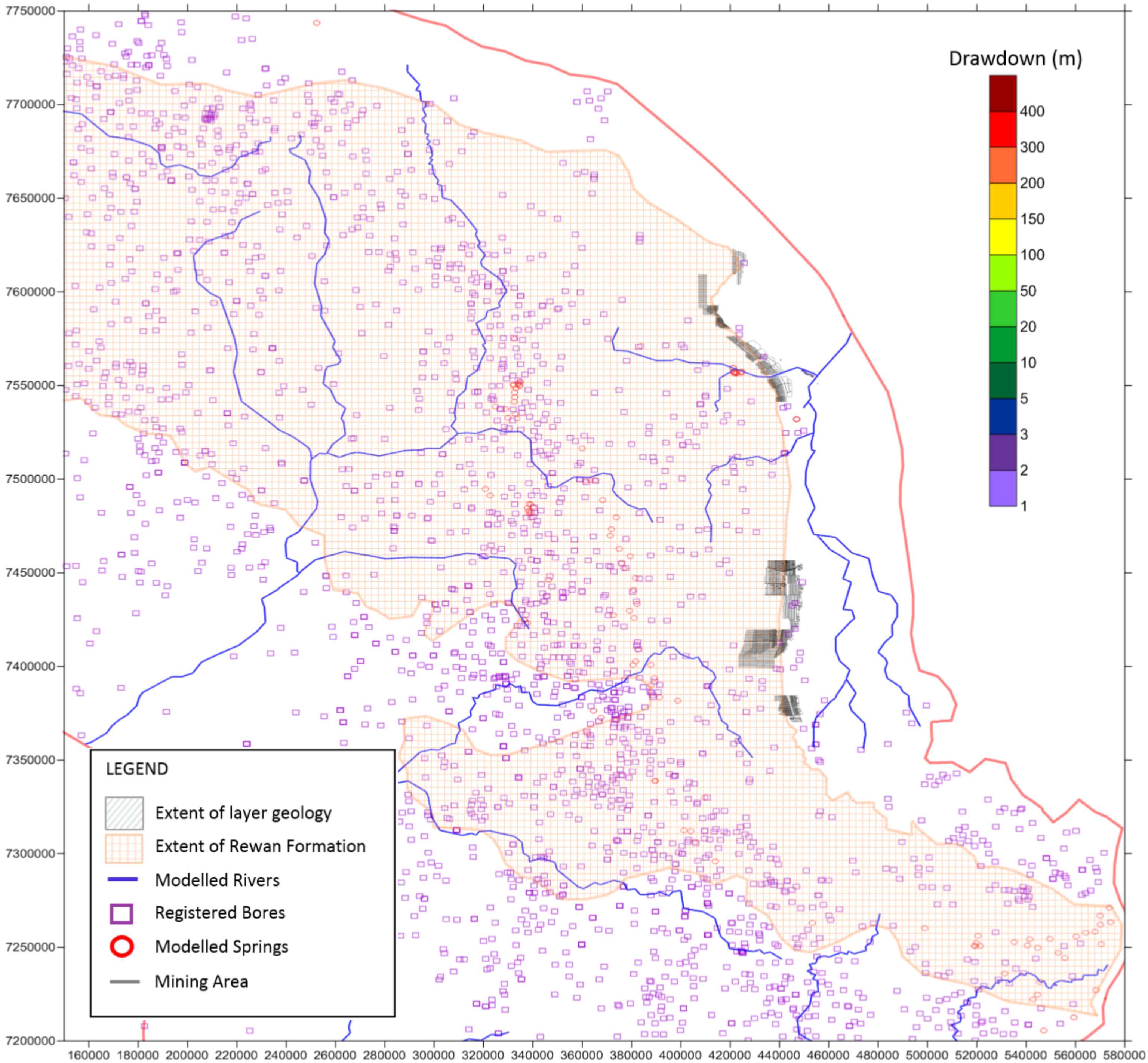


10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL

HYDROSIMULATIONS

Layer 1 Drawdown 2055

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
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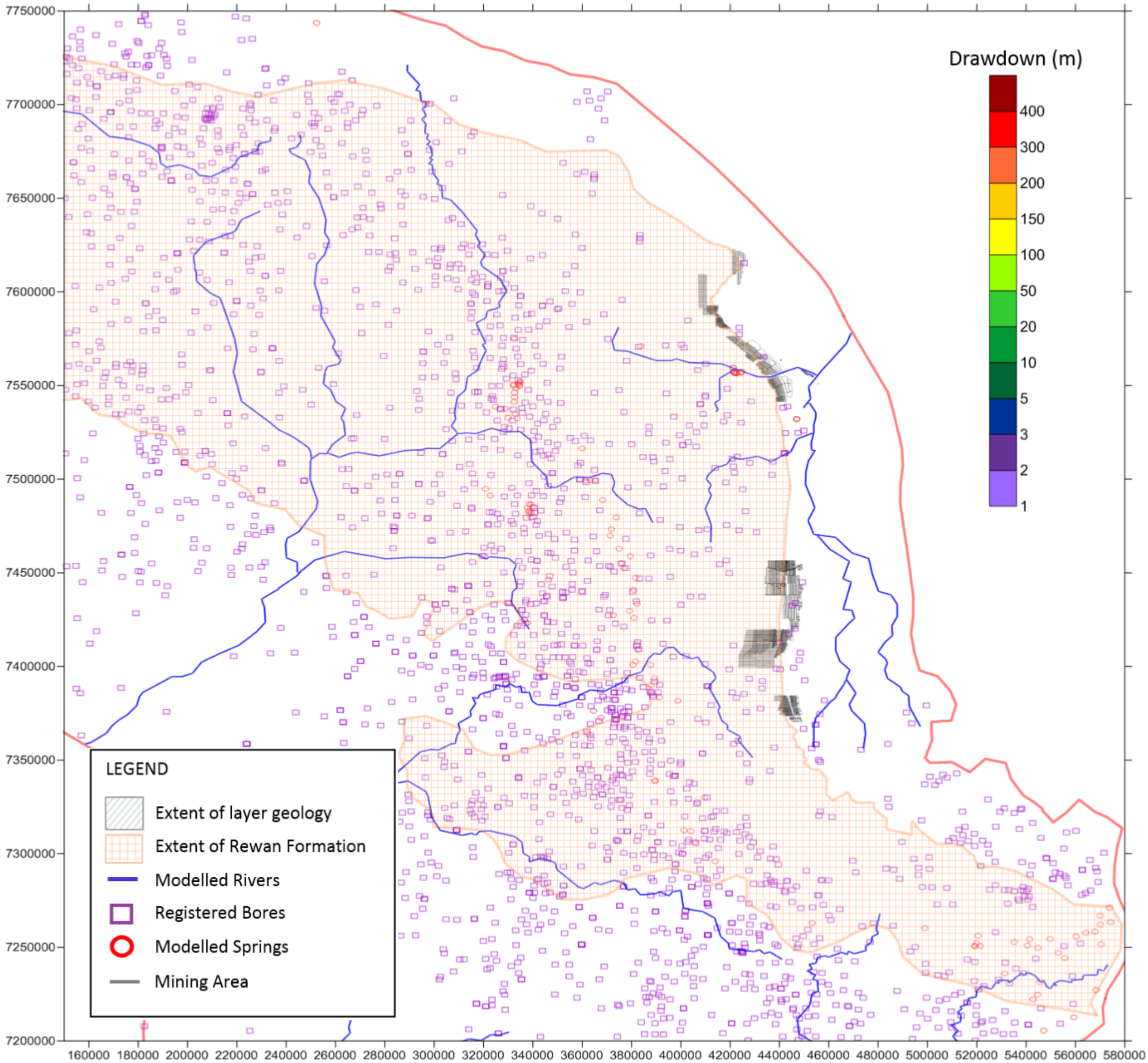

HYDRO SIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 1 Drawdown 2061

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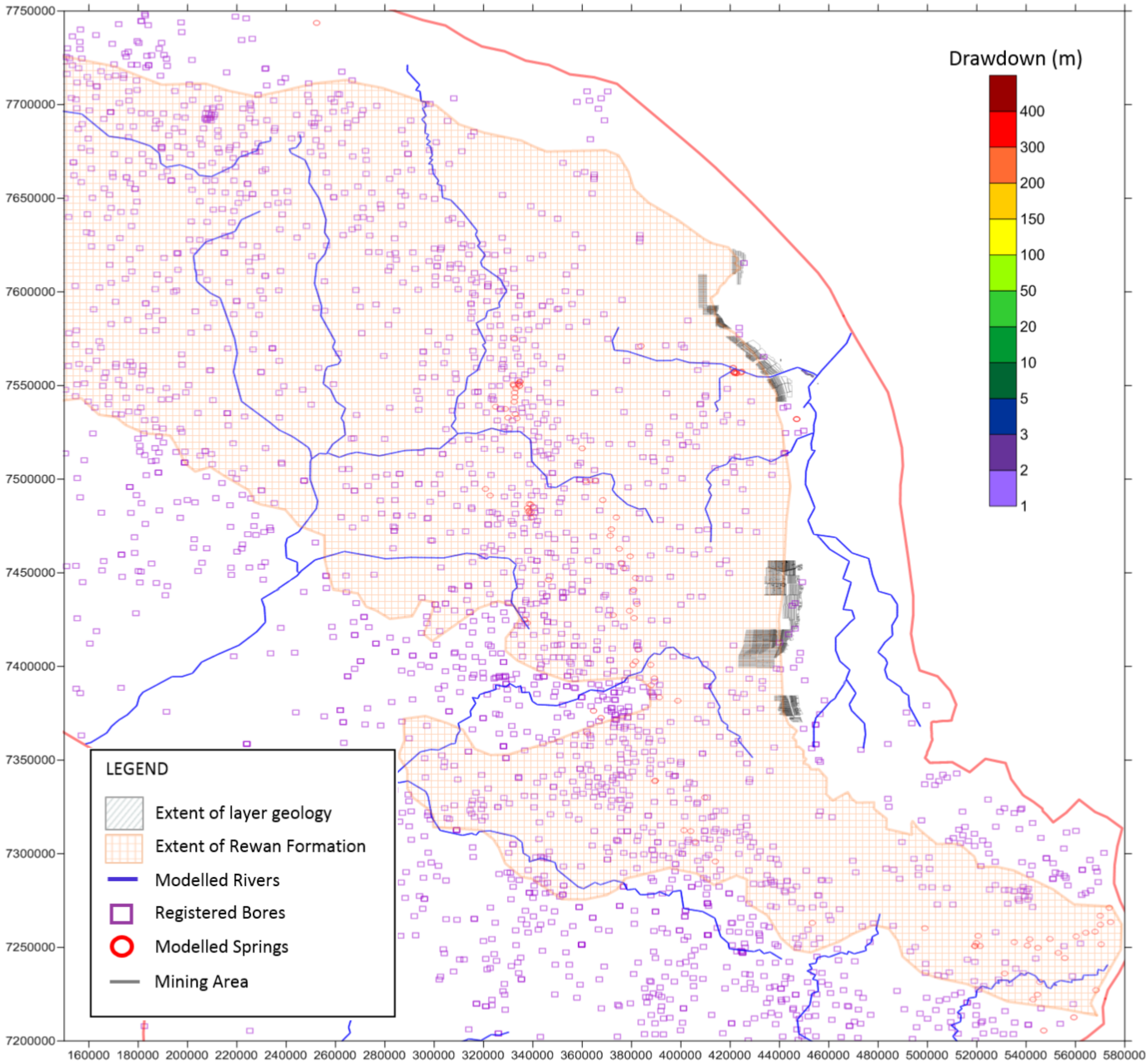

HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 1 Drawdown 2067		

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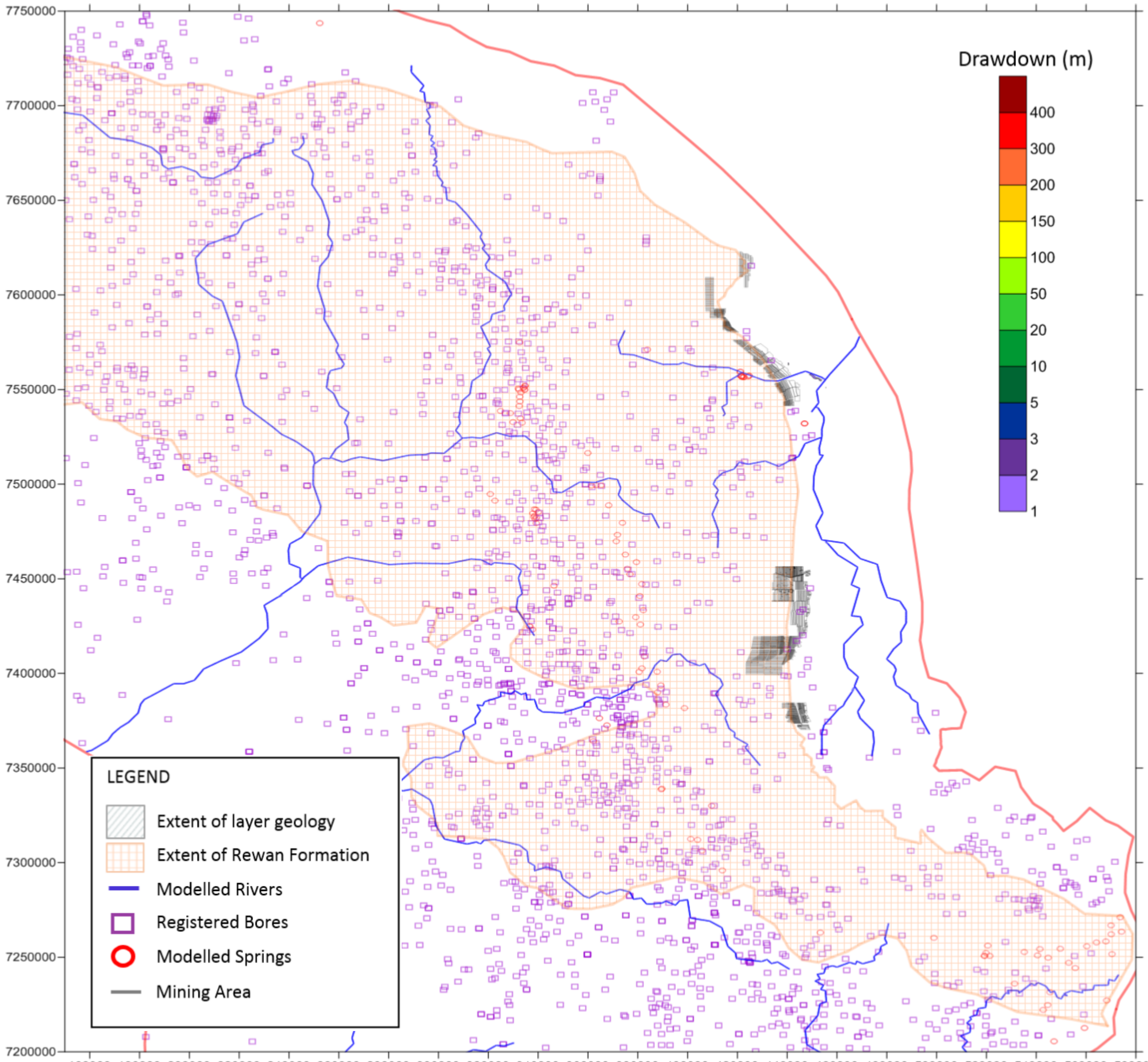

HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 1 Drawdown 2080		

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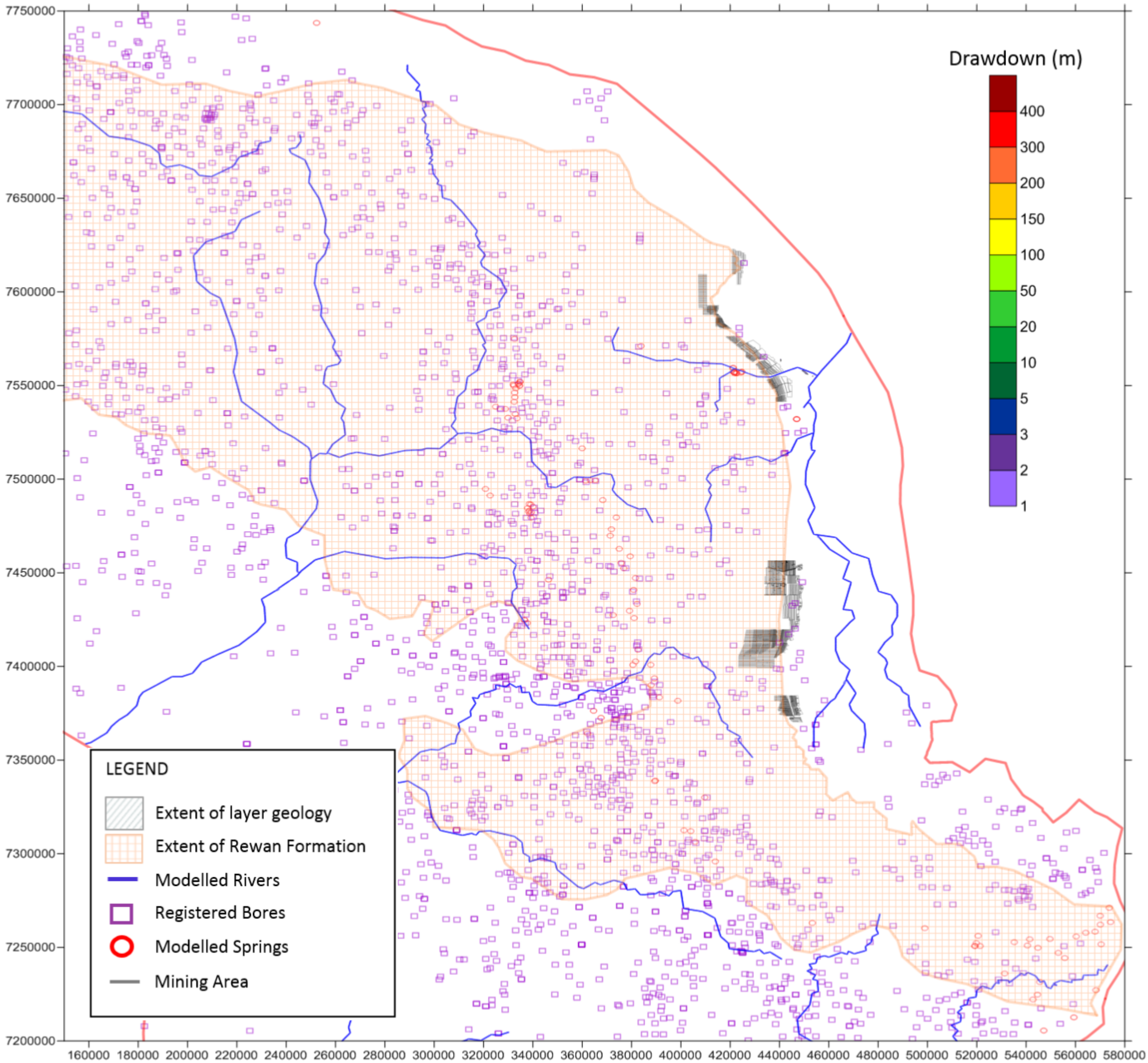
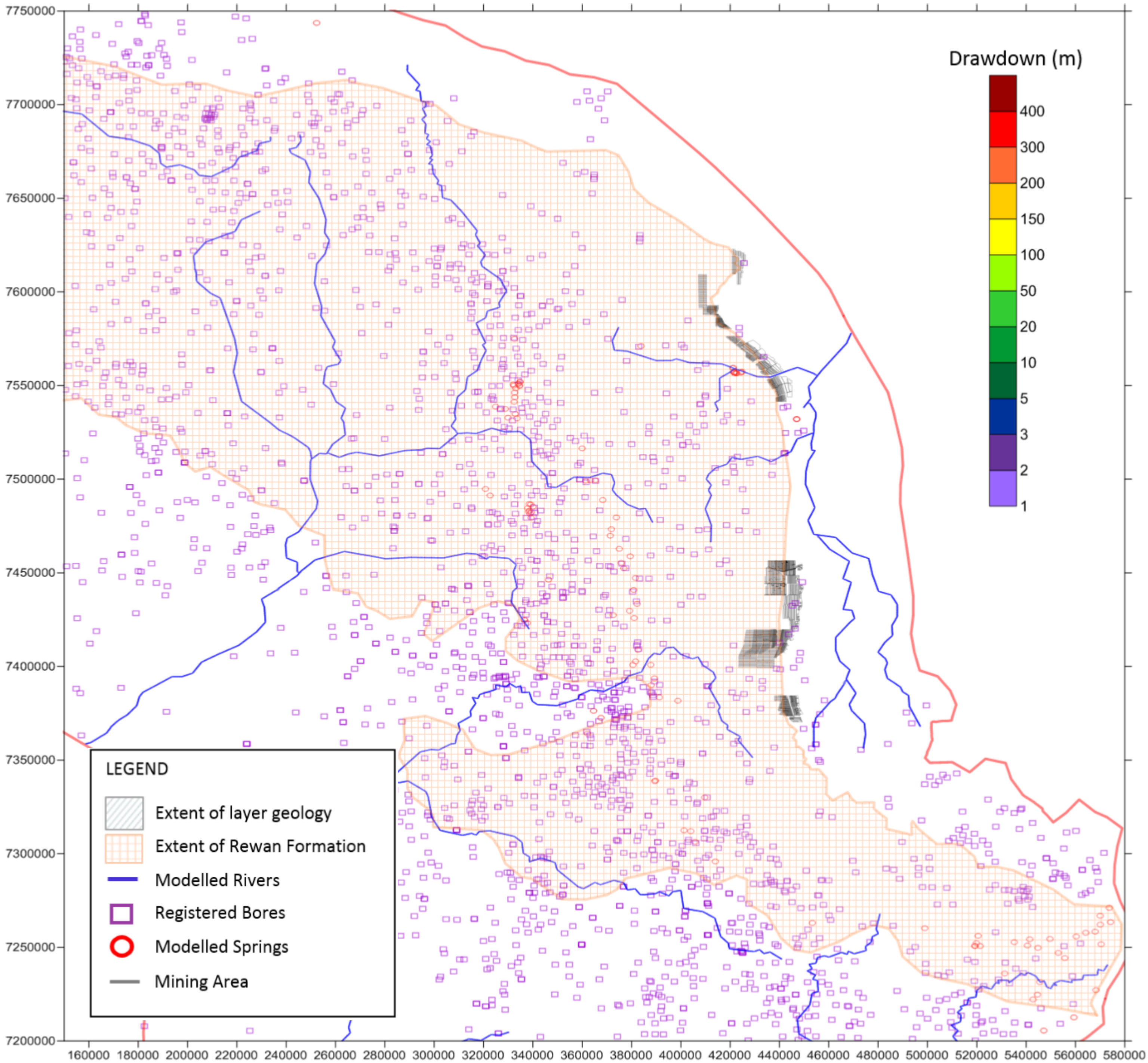


HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 1 Drawdown 2090

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

Layer 1 Drawdown 2110

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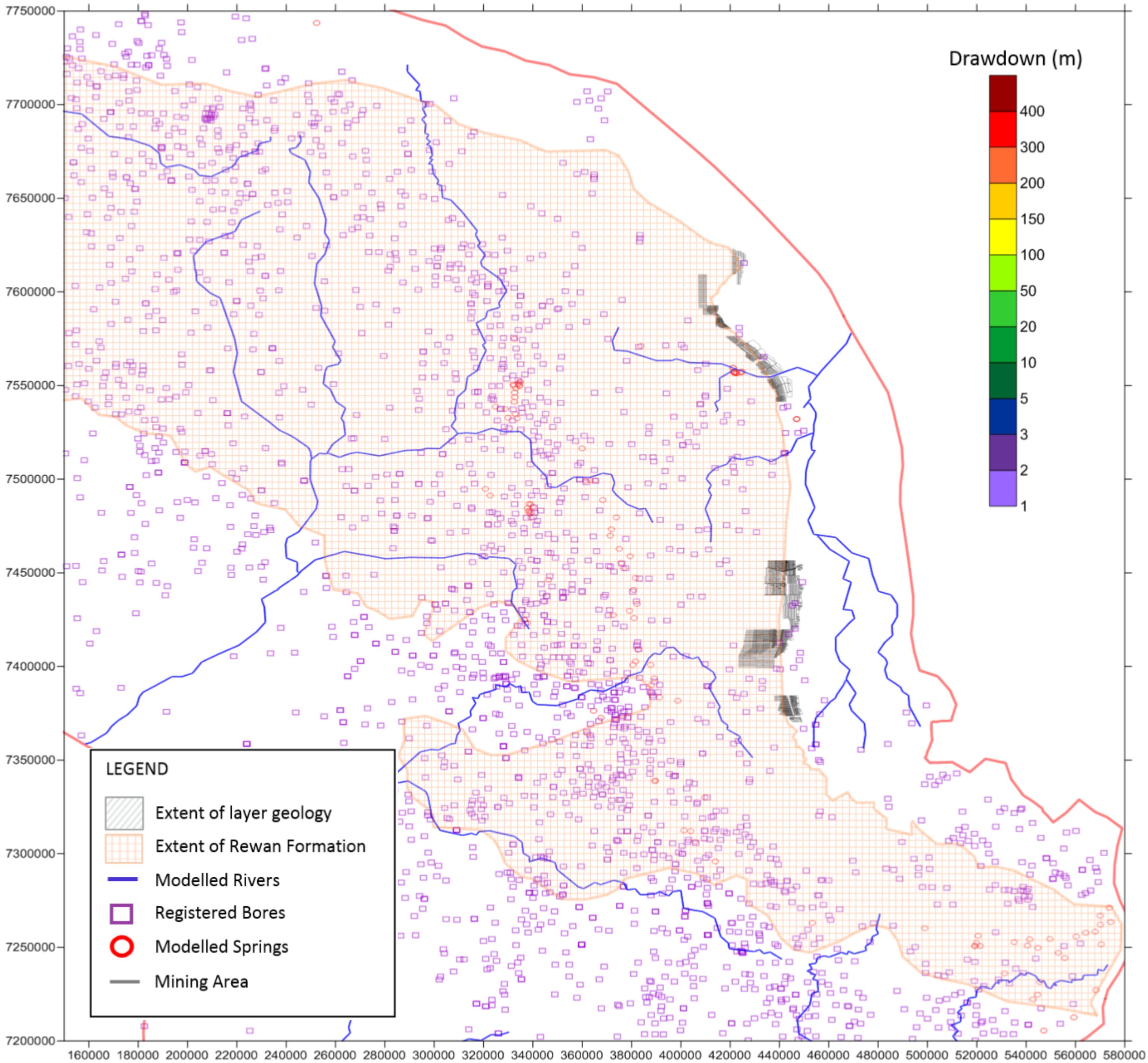

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

Layer 1 Drawdown 2200

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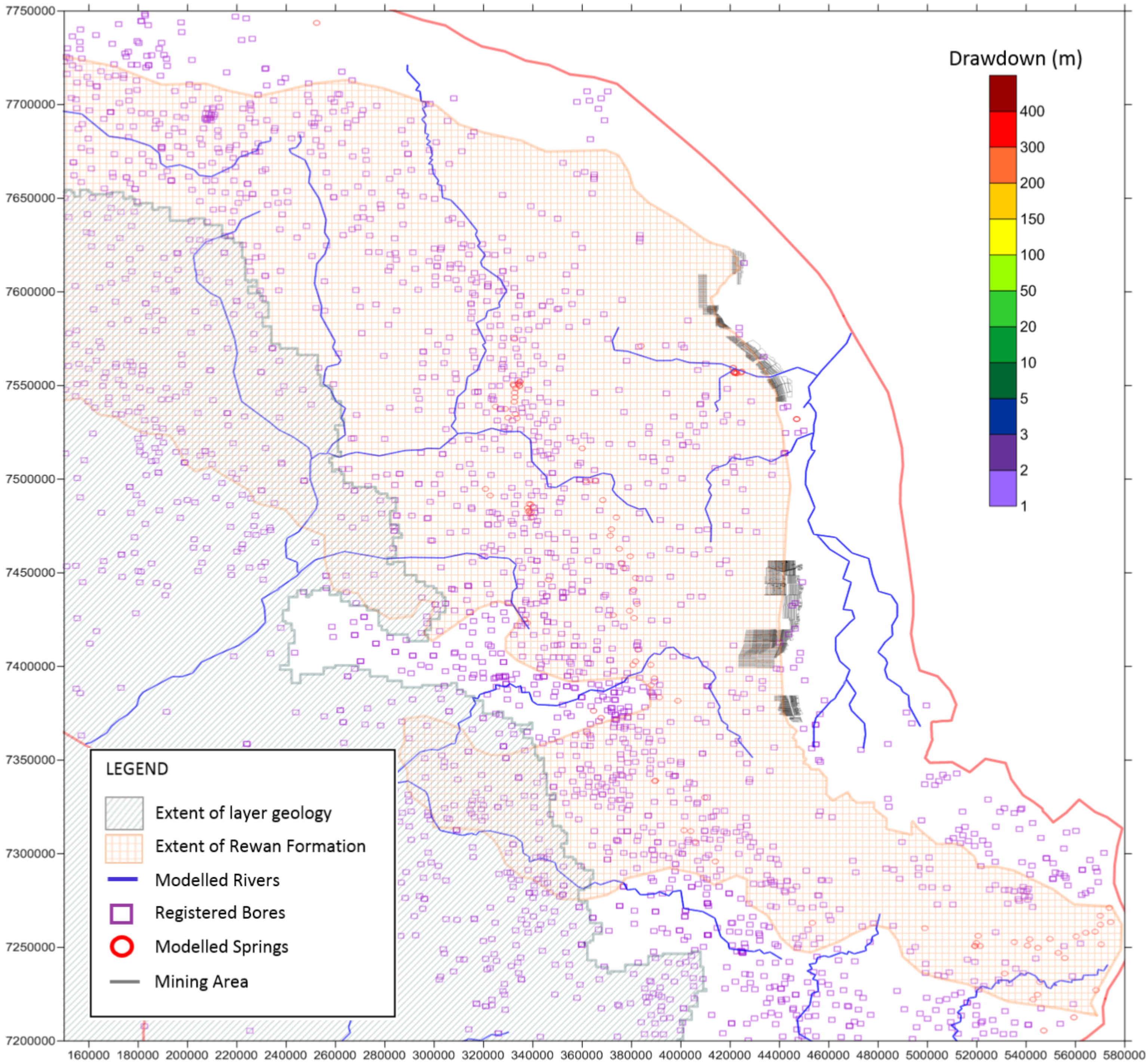
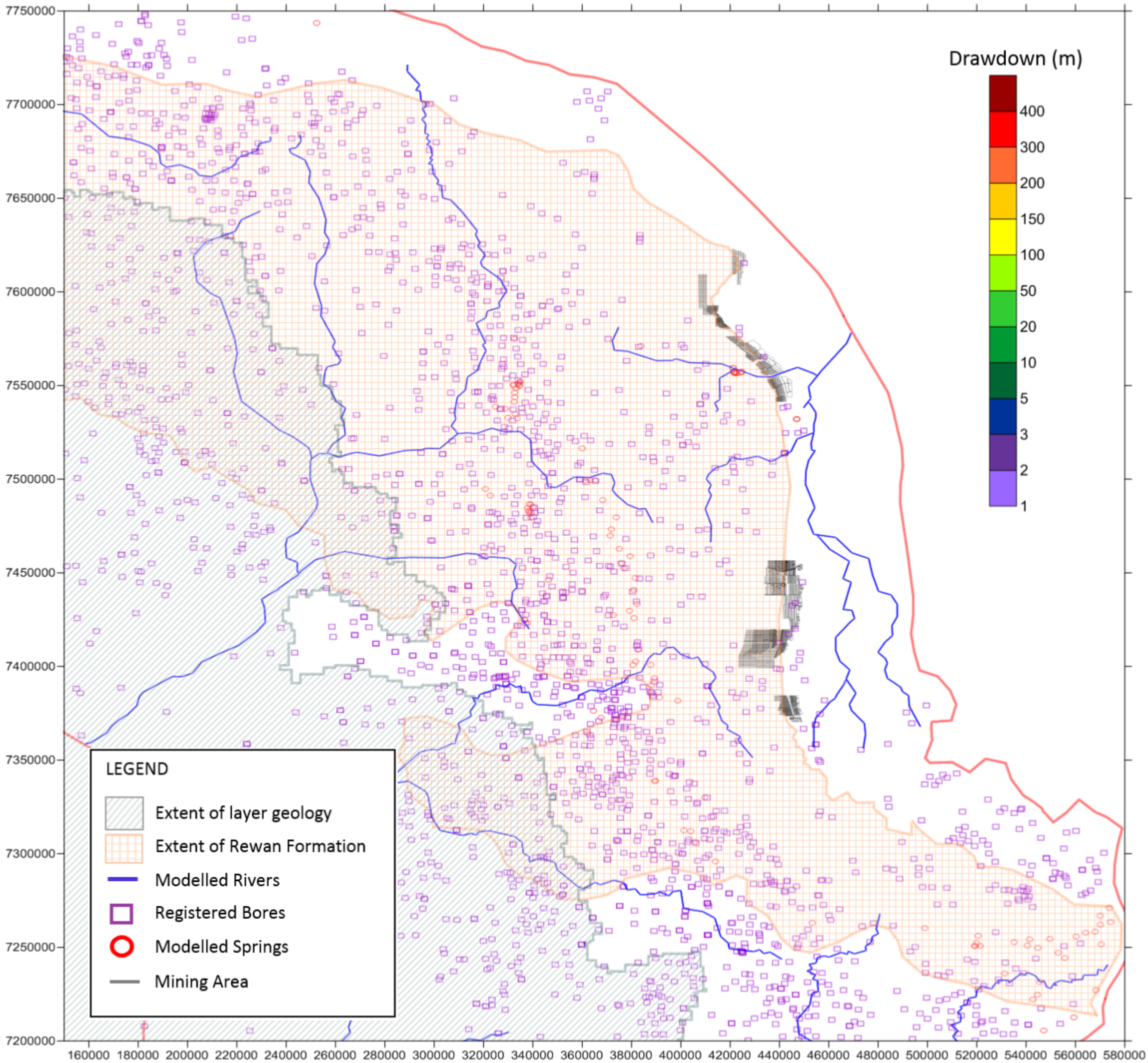


HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 2 Drawdown 2020		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 2 Drawdown 2025

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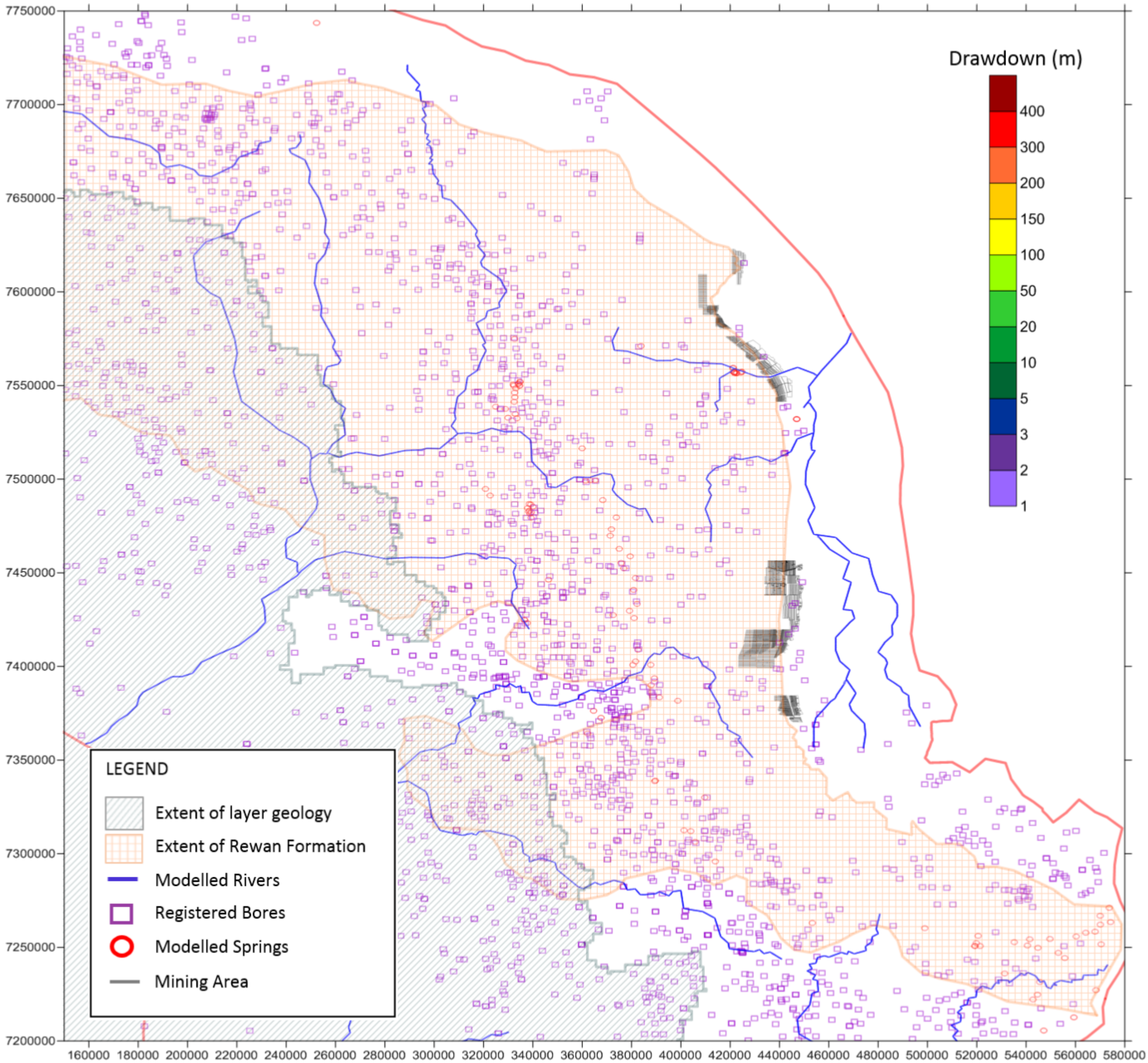
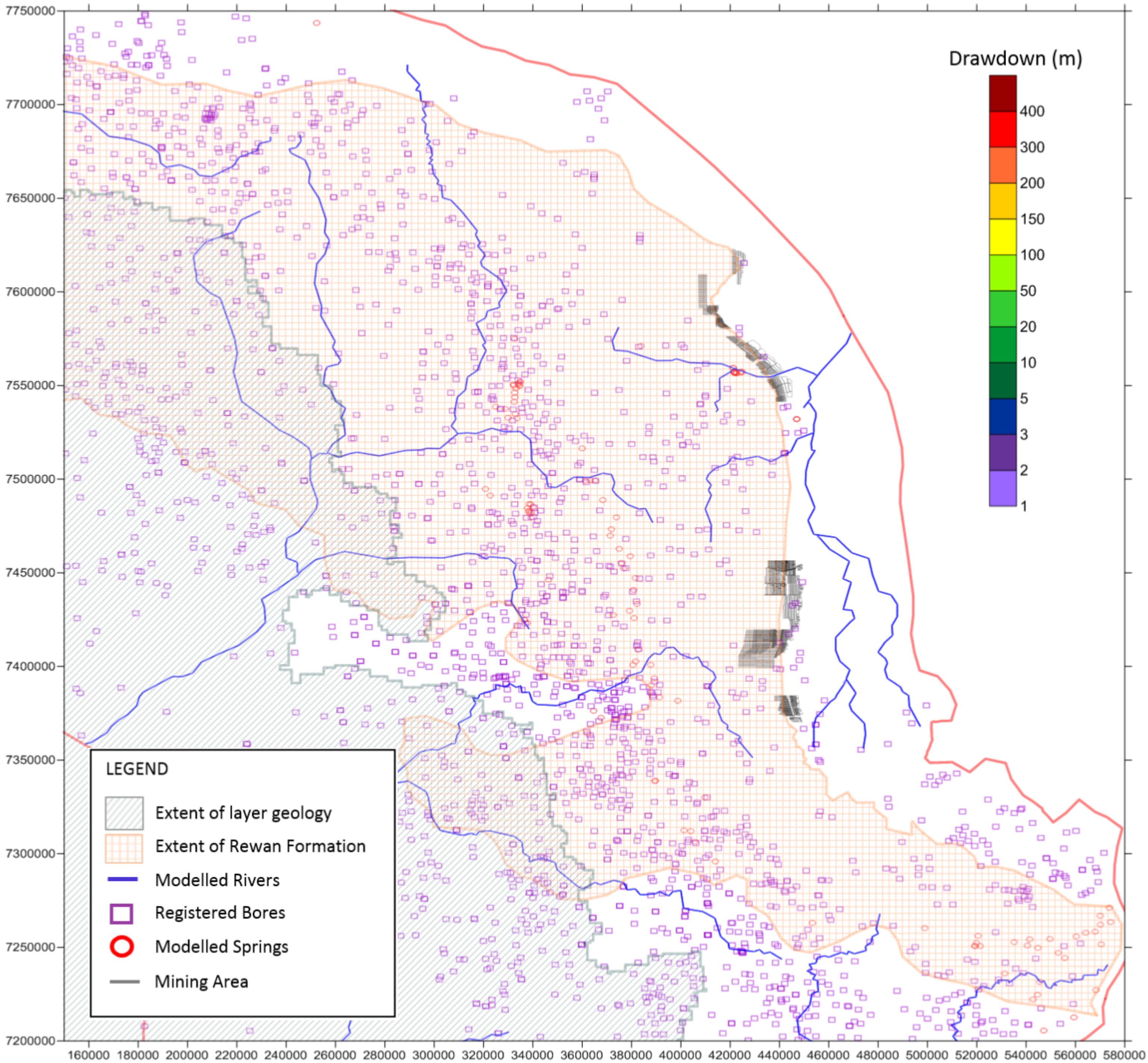


HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 2 Drawdown 2030		

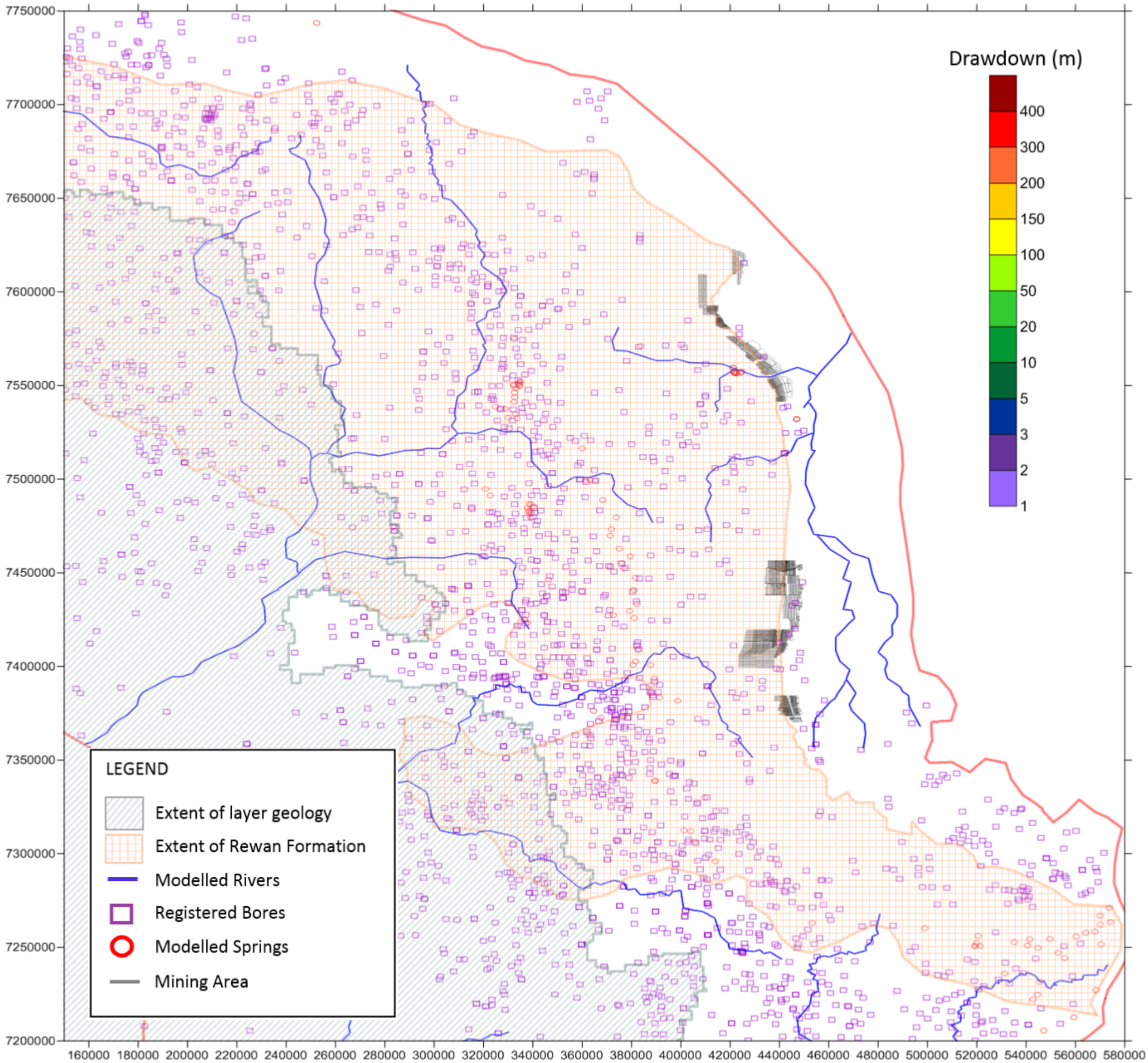
D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
Layer 2 Drawdown 2035		

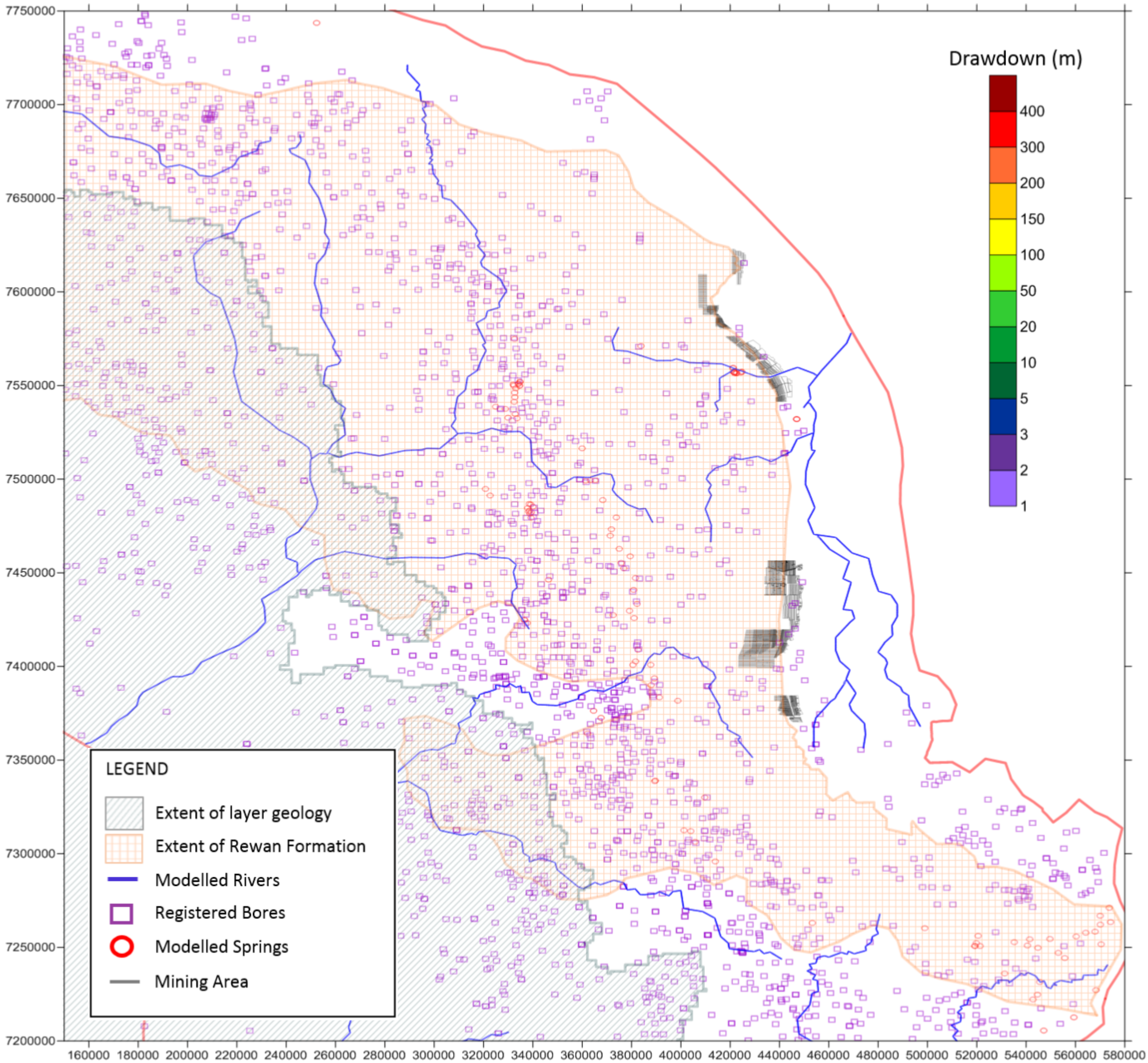
HYDROSIMULATIONS

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 2 Drawdown 2040		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

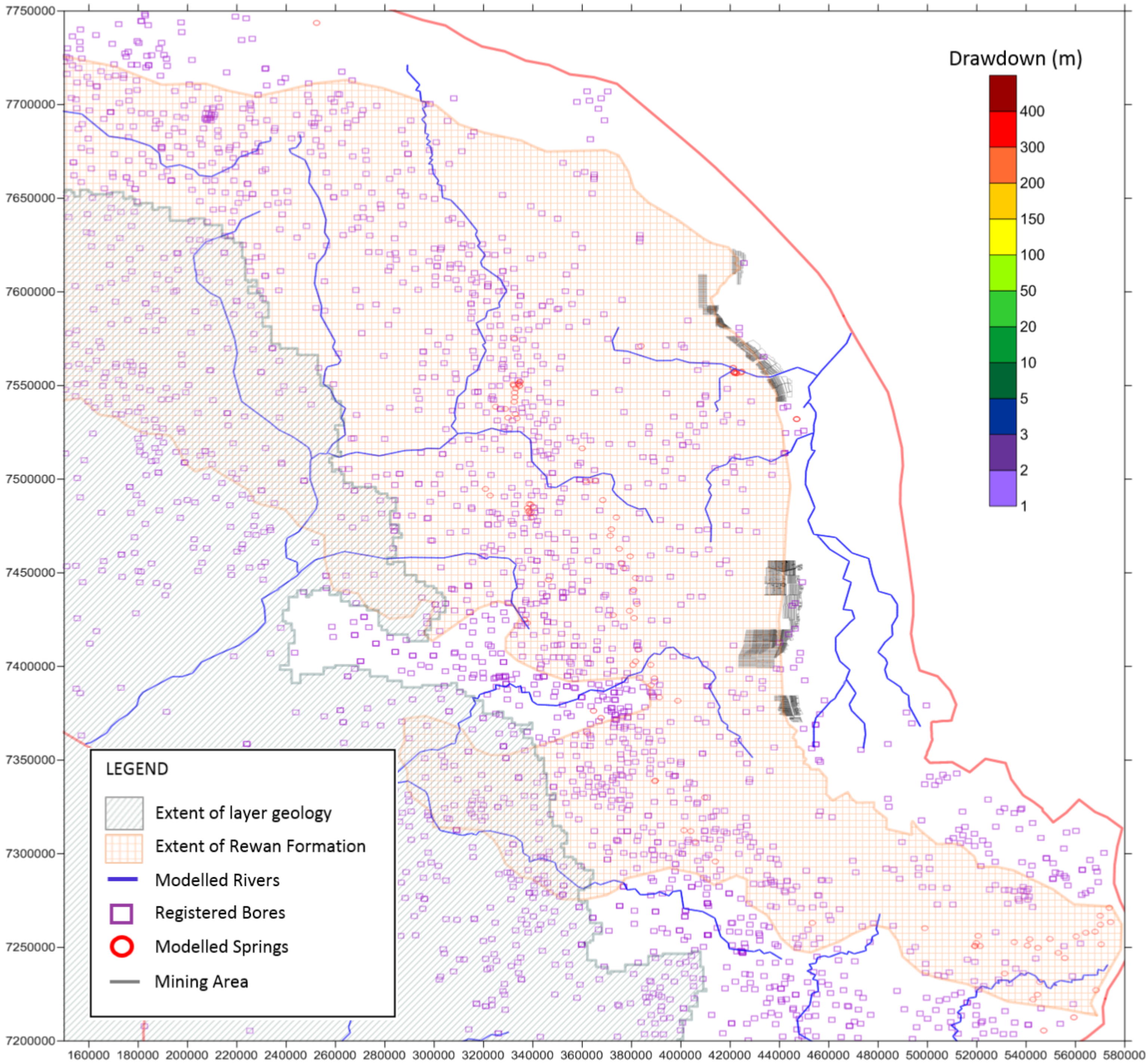


10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 2 Drawdown 2045

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

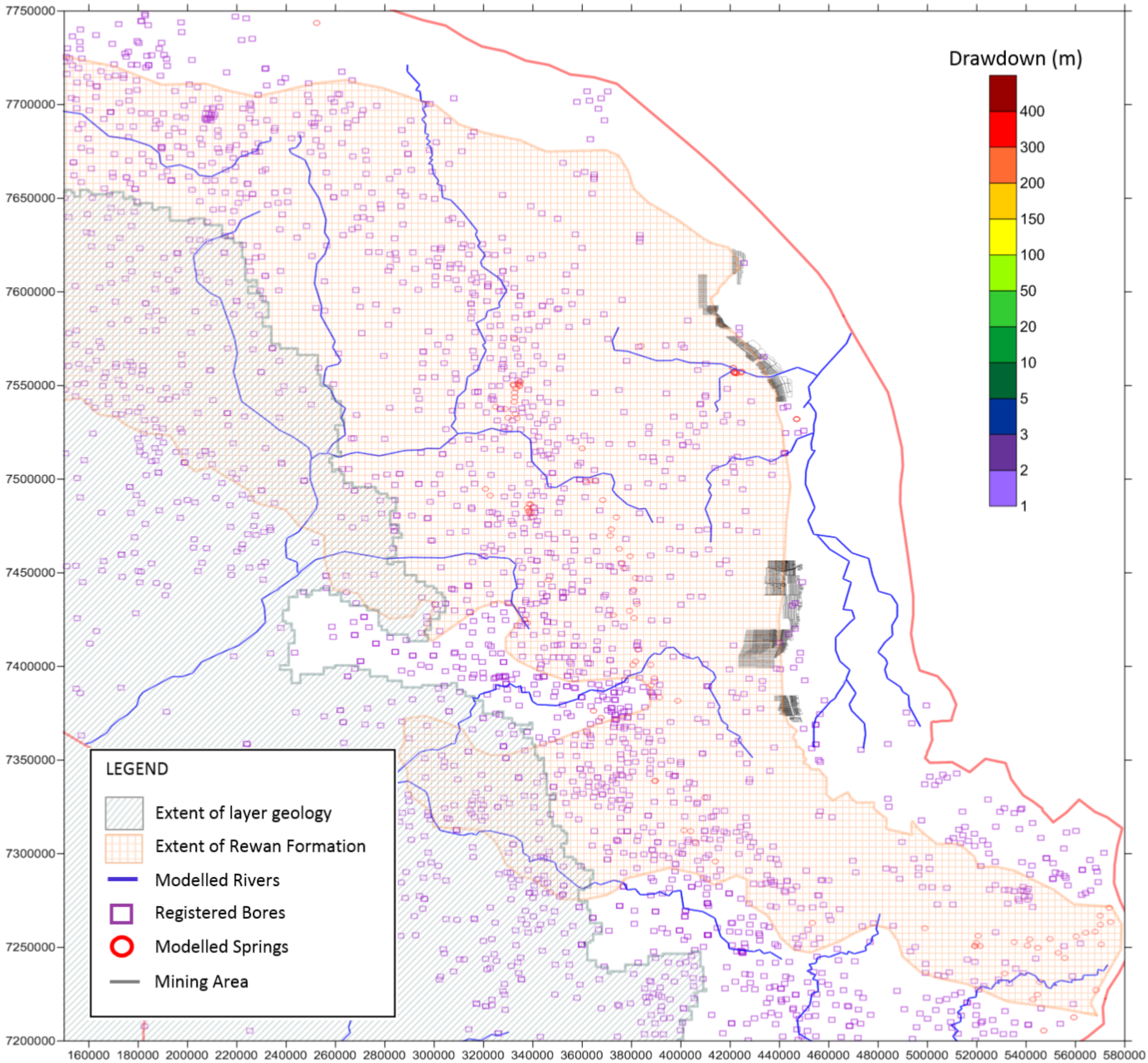


10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 2 Drawdown 2048

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



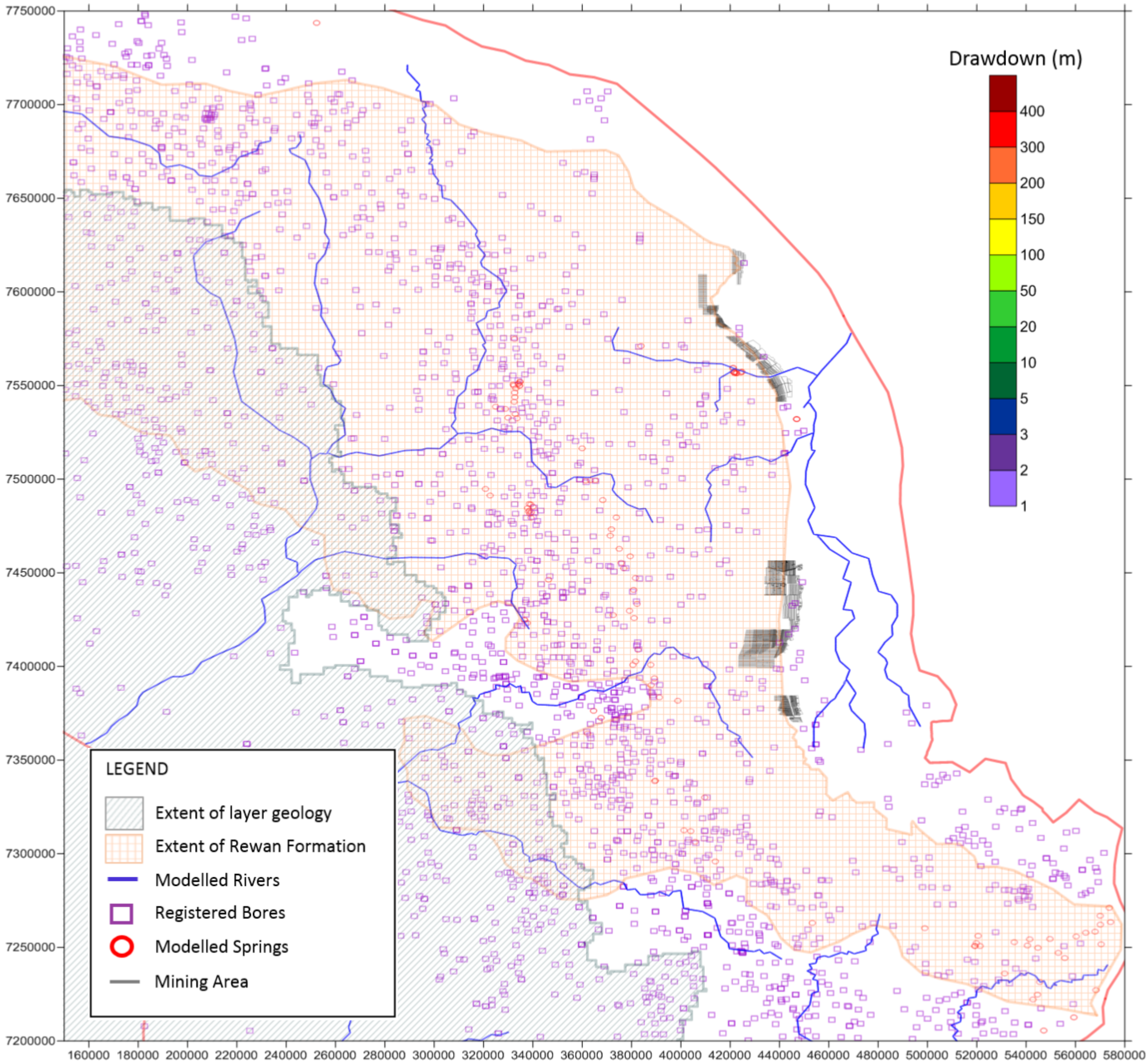
HYDROSIMULATIONS

10 OCTOBER 2015 | DRAWN BY: CT | Projection GDA 1994 MGA Zone 55

GEOSCIENCE AUSTRALIA | GSA001 - GALILEE BASIN MODEL

Layer 2 Drawdown 2050

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS

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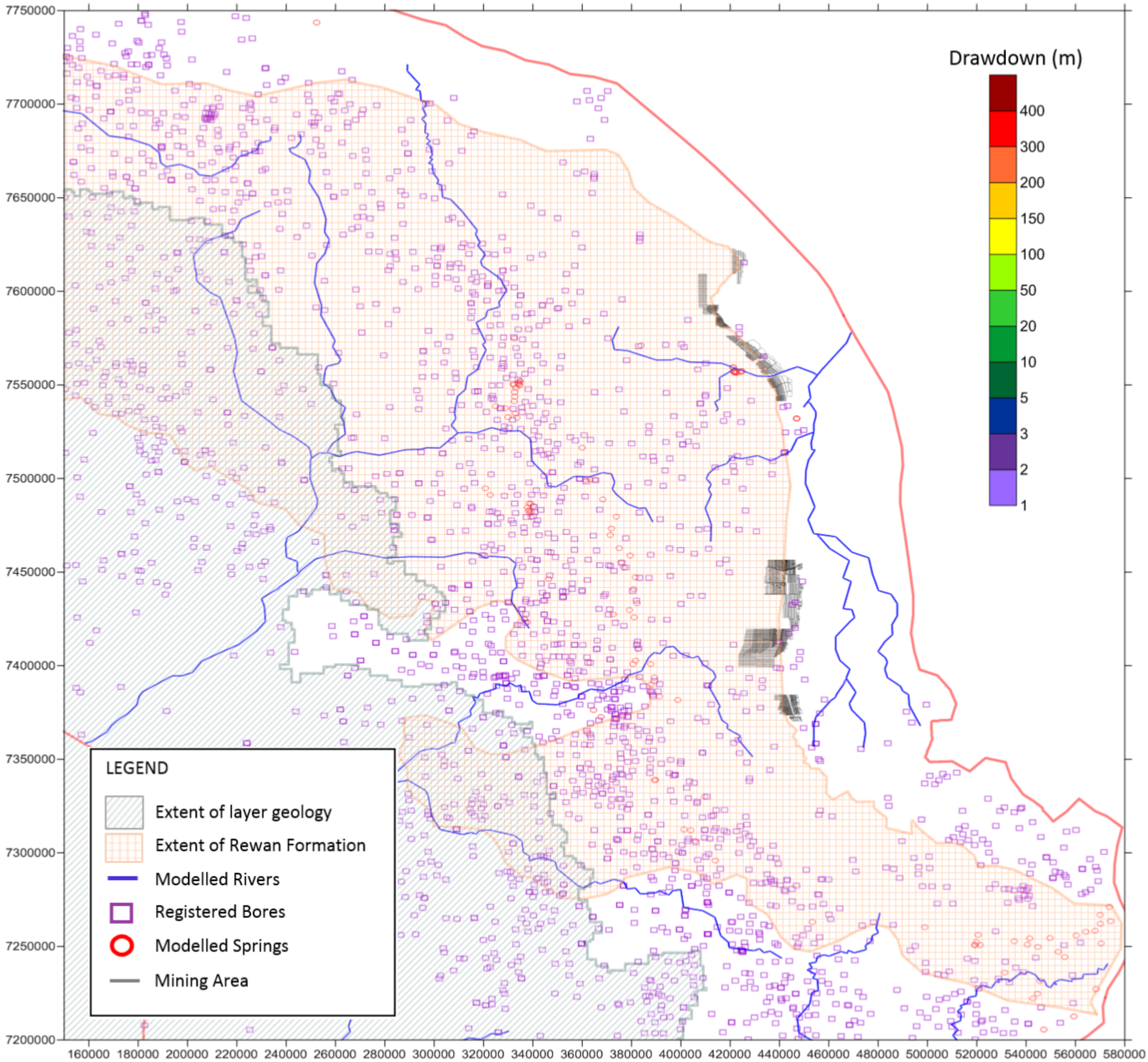
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 2 Drawdown 2055



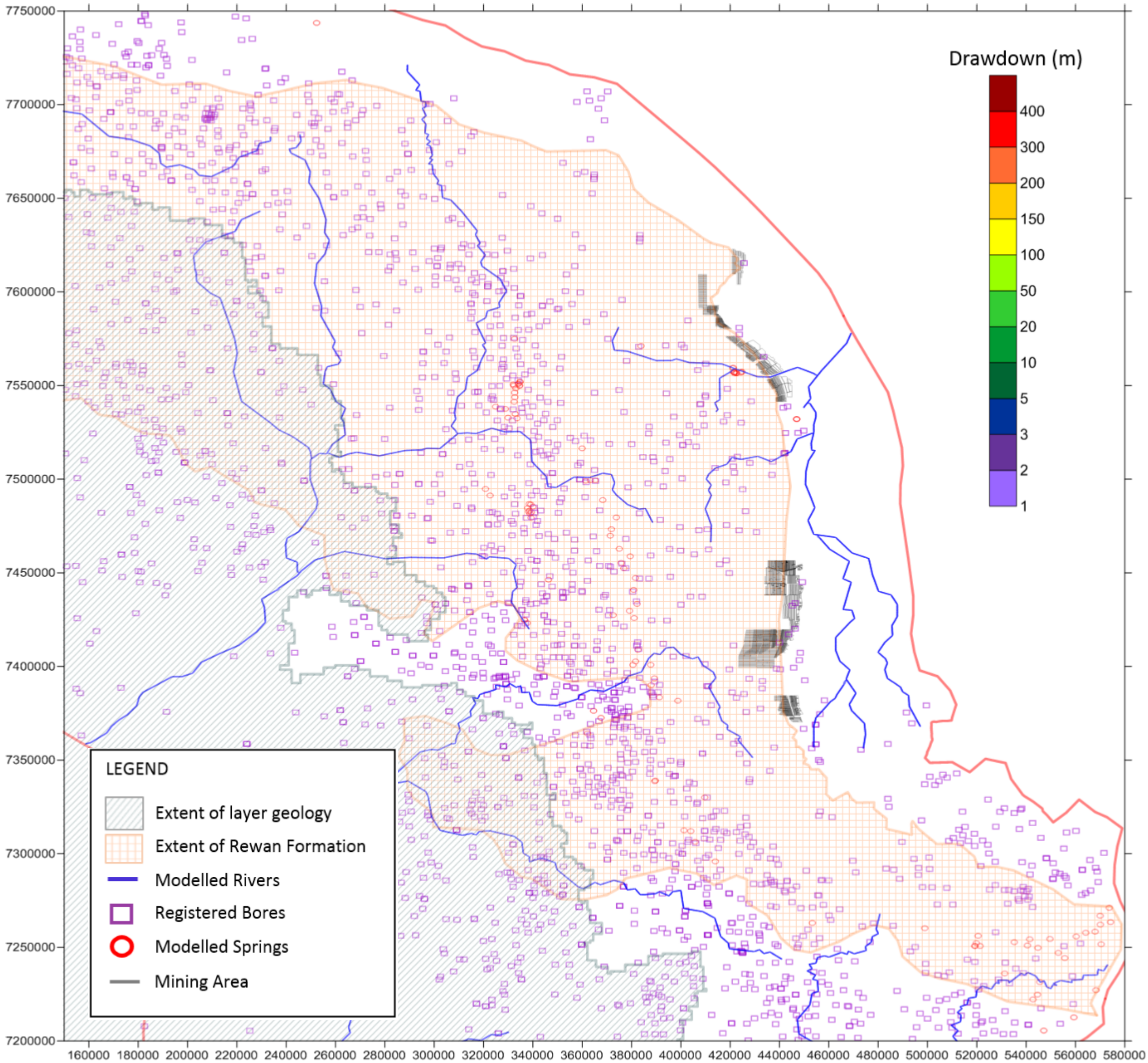
HYDROSIMULATIONS

10 OCTOBER 2015 | DRAWN BY: CT | Projection GDA 1994 MGA Zone 55

GEOSCIENCE AUSTRALIA | GSA001 - GALILEE BASIN MODEL

Layer 2 Drawdown 2058

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 2 Drawdown 2061

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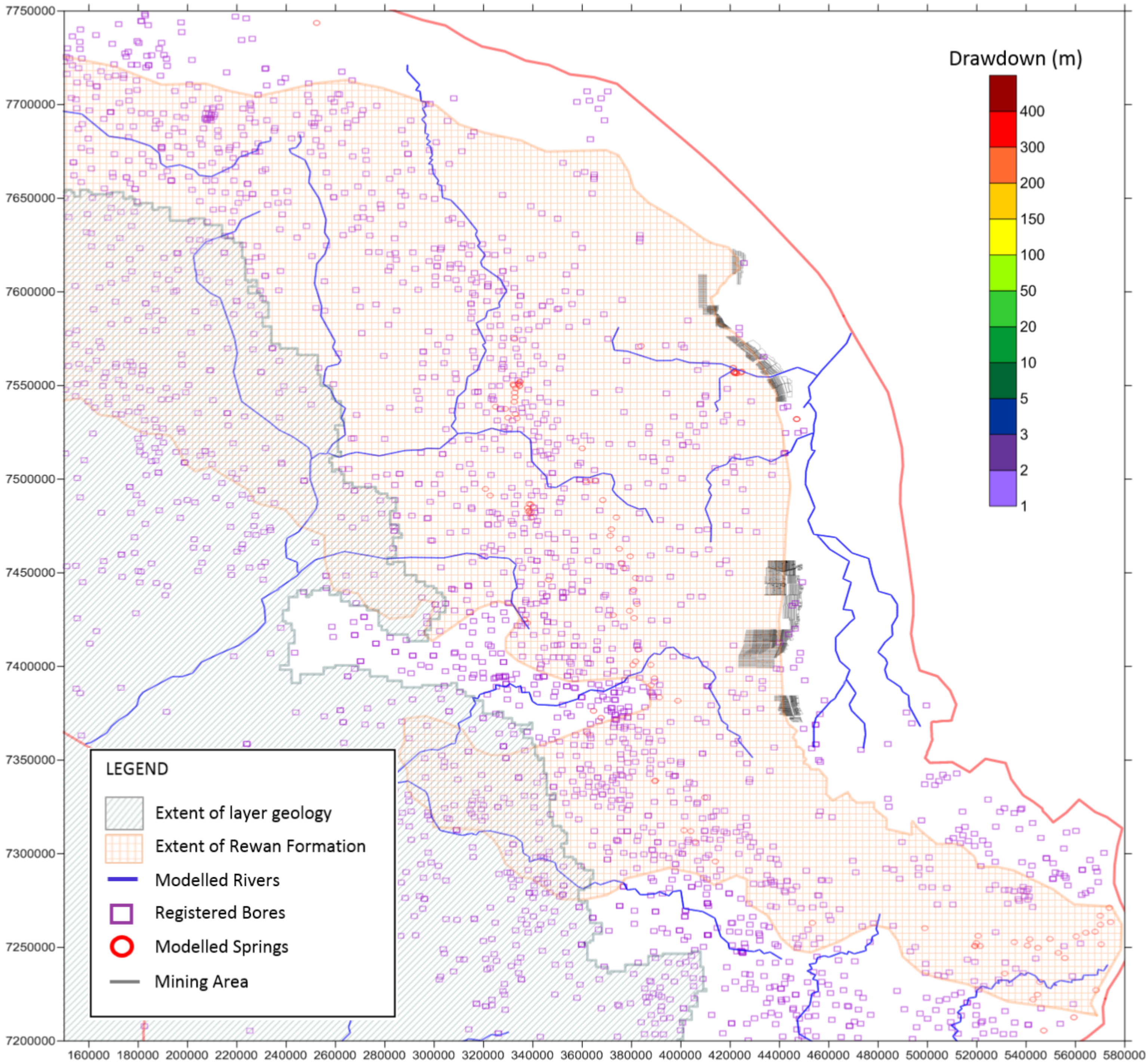
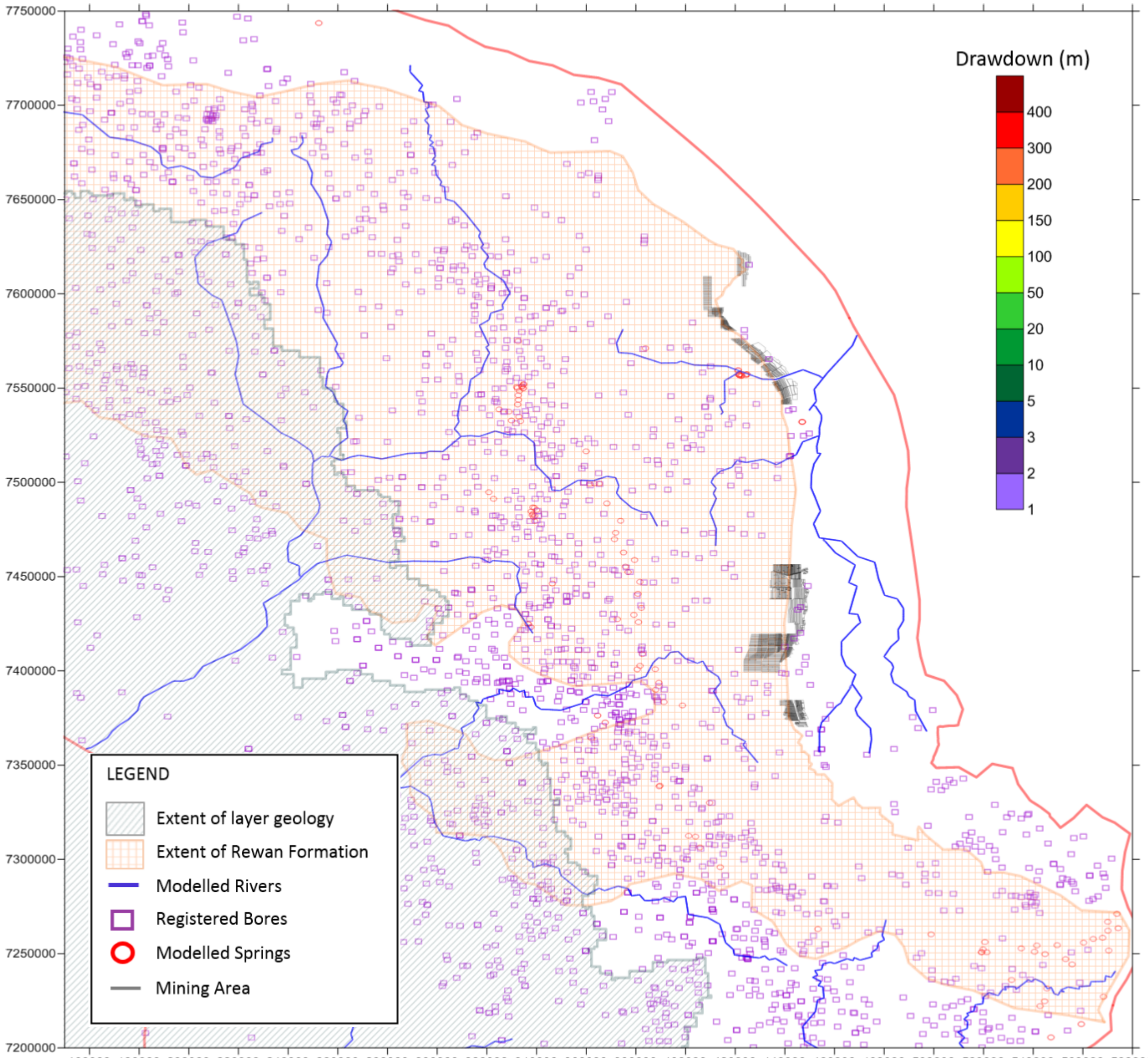


10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

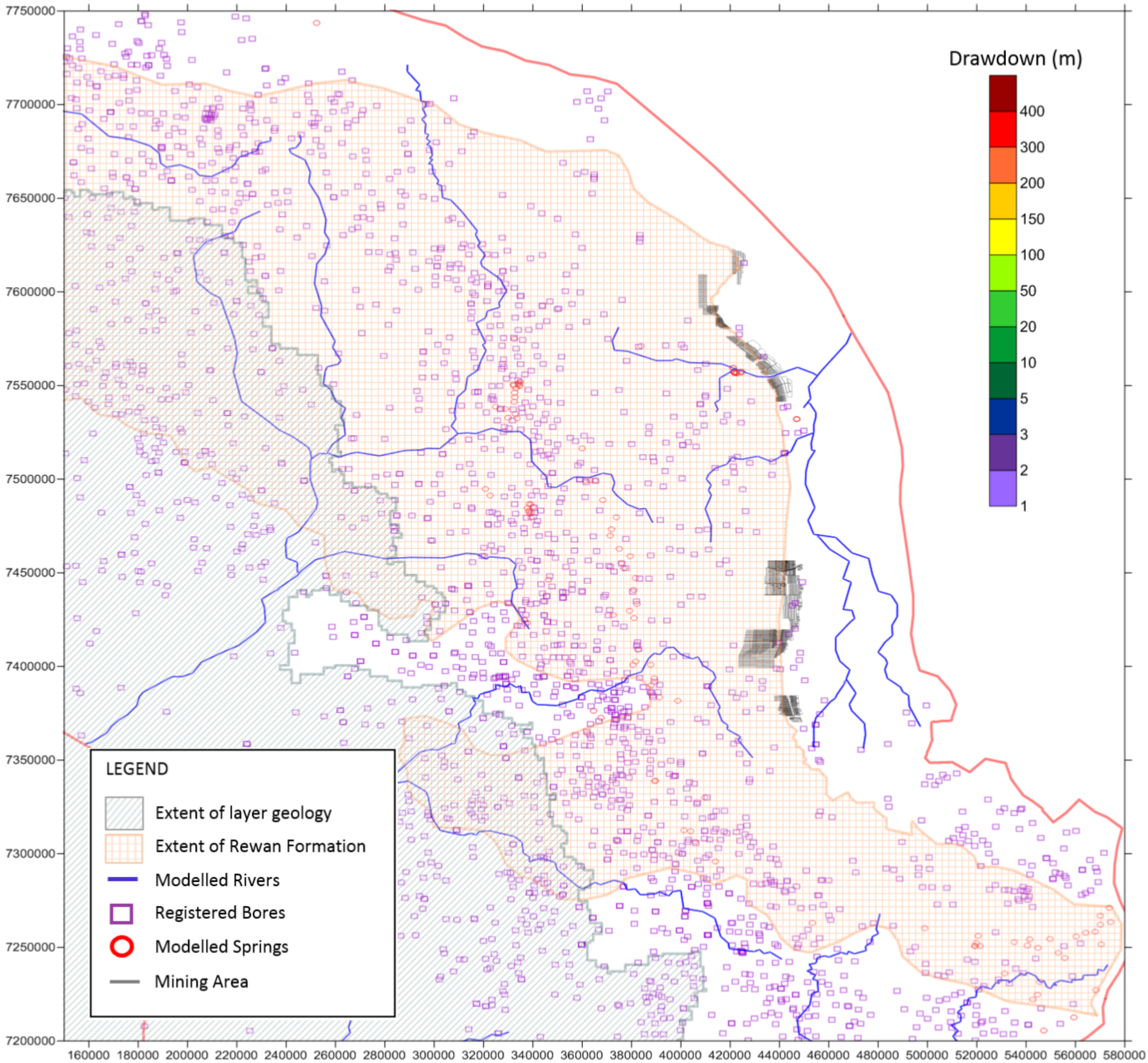
Layer 2 Drawdown 2067

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 2 Drawdown 2080		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 2 Drawdown 2090		

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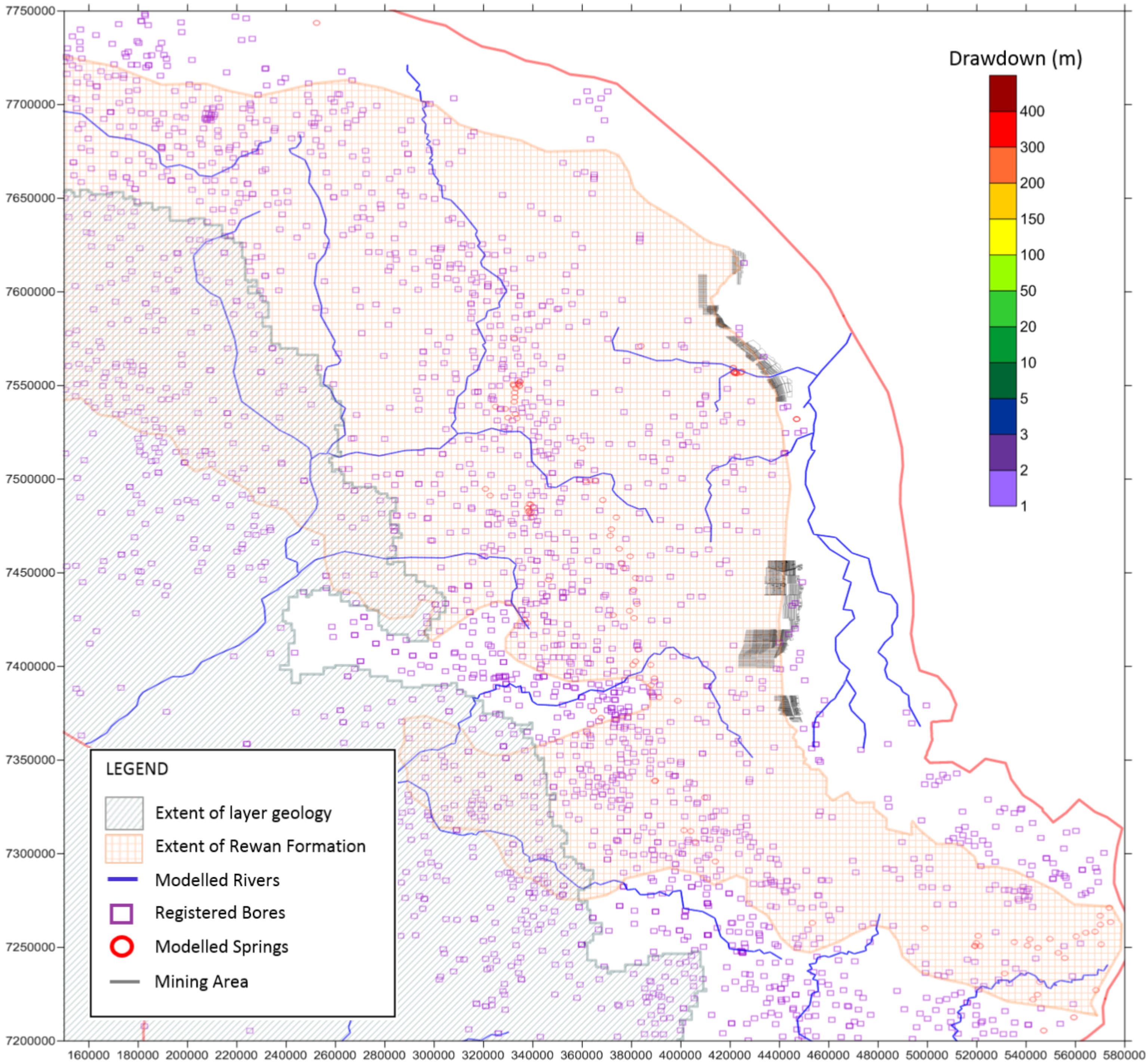
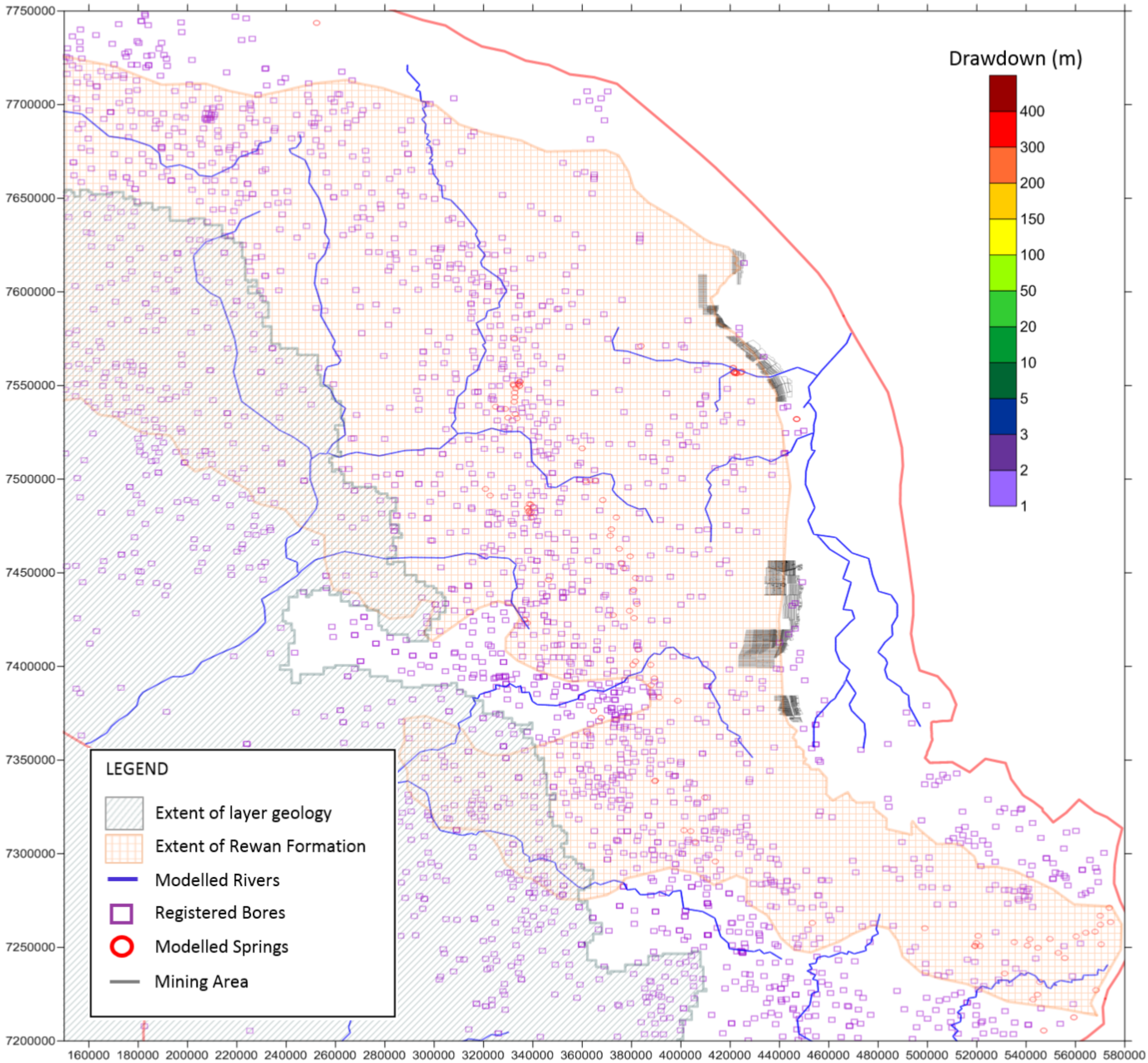


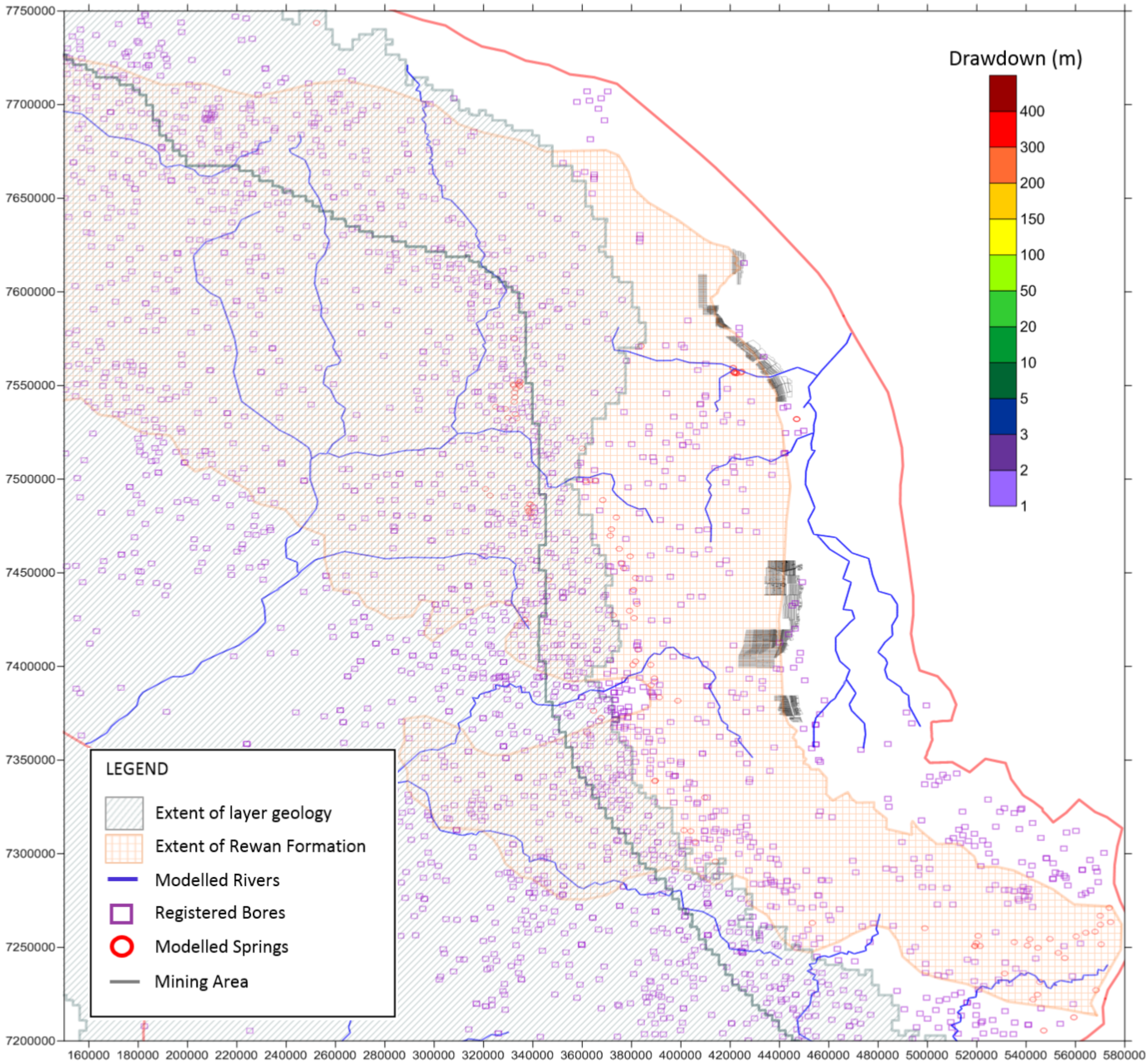
HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 2 Drawdown 2110		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 2 Drawdown 2200		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

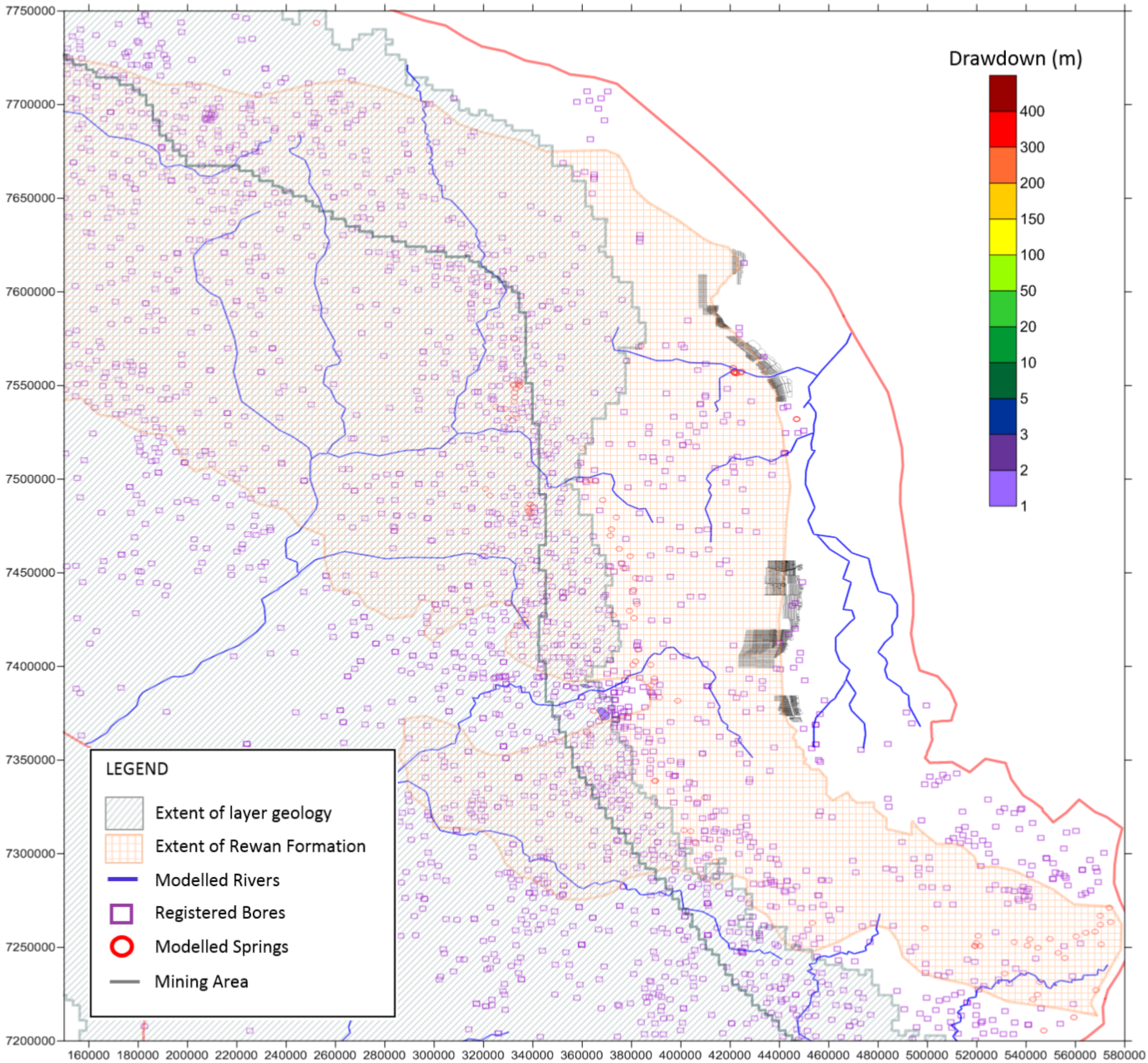


HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

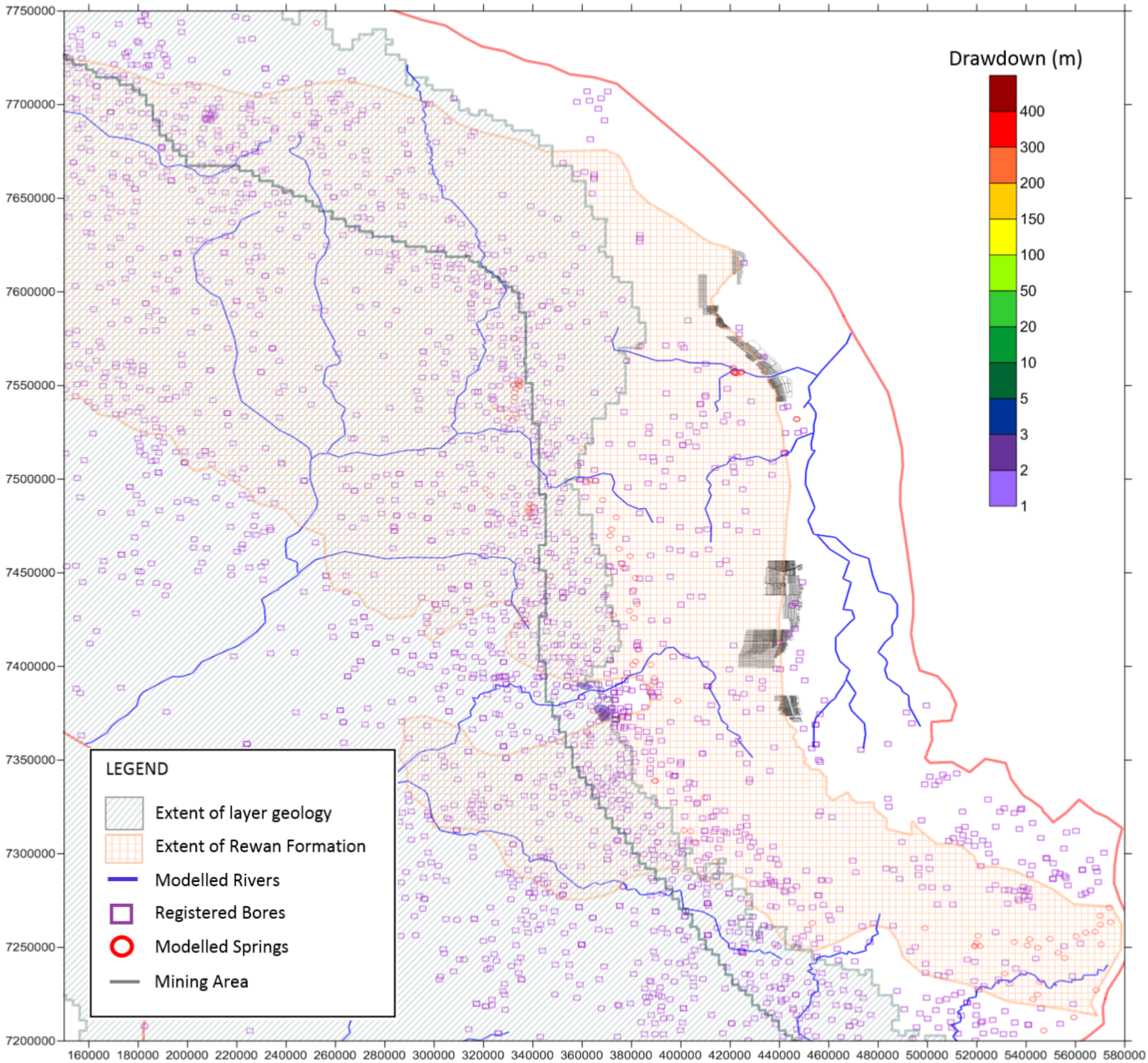
Layer 4 Drawdown 2020

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 4 Drawdown 2025		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

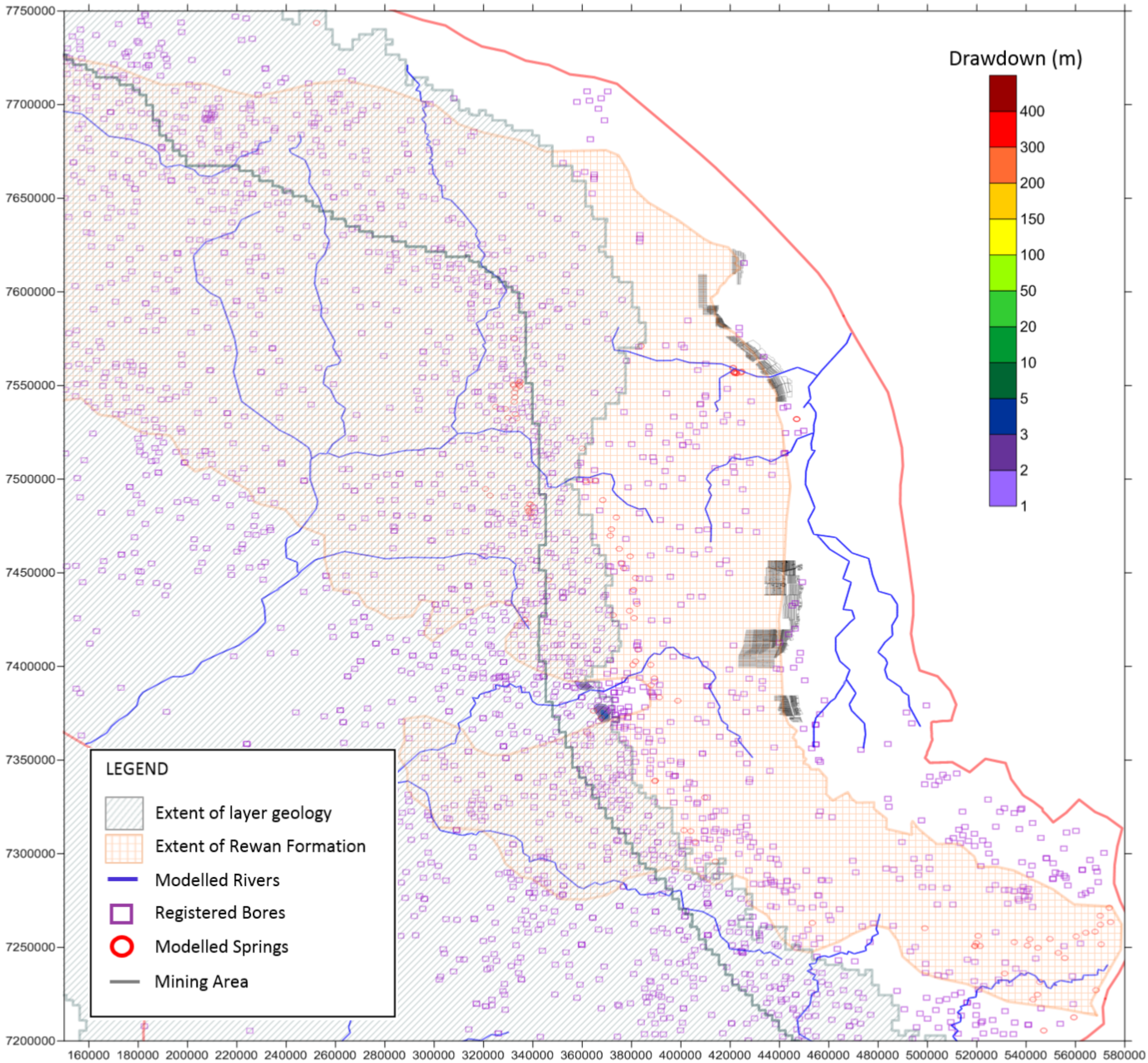


HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55	
GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL	

Layer 4 Drawdown 2030

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 4 Drawdown 2035		

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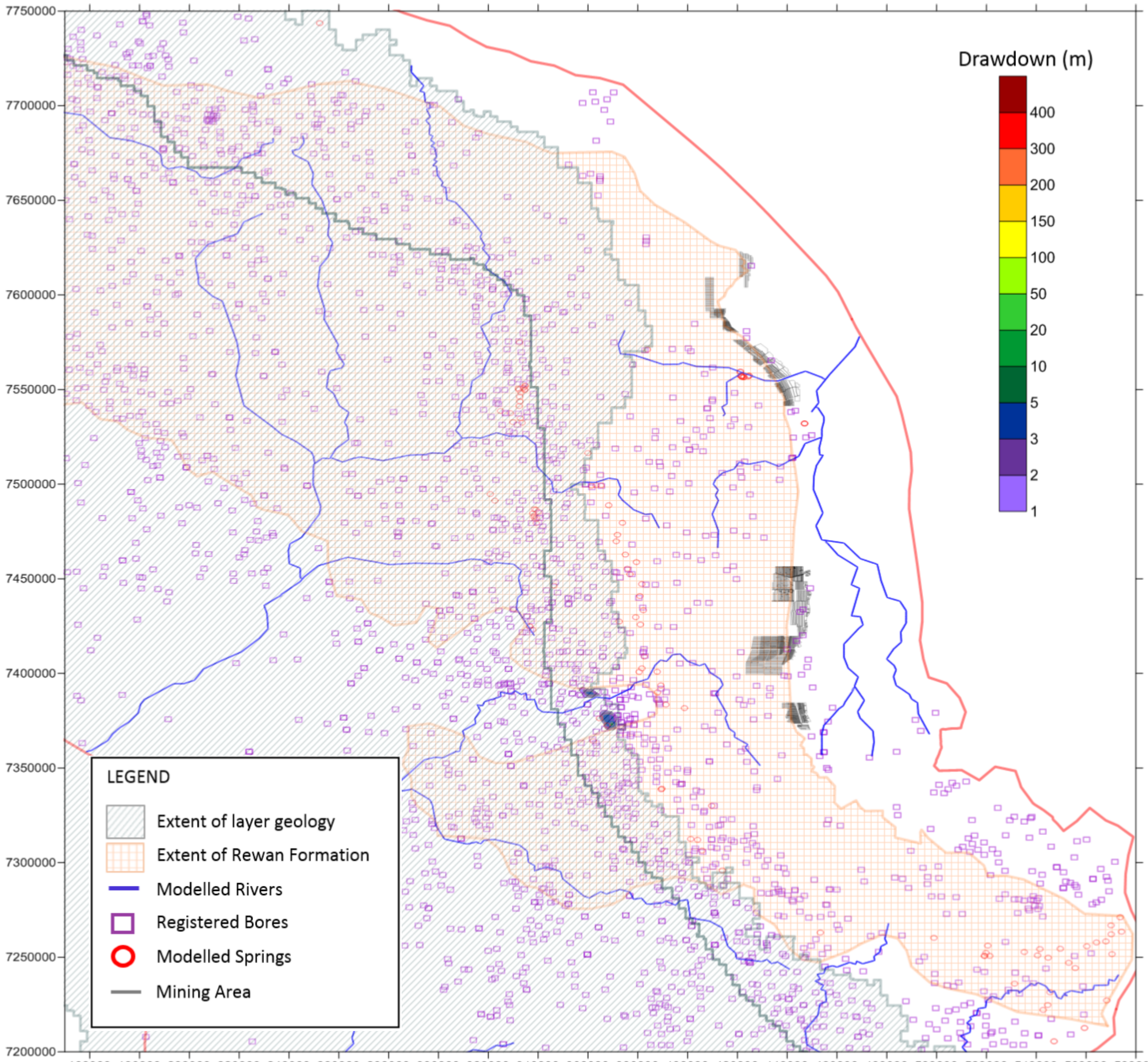

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55	
GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL	
Layer 4 Drawdown 2040			

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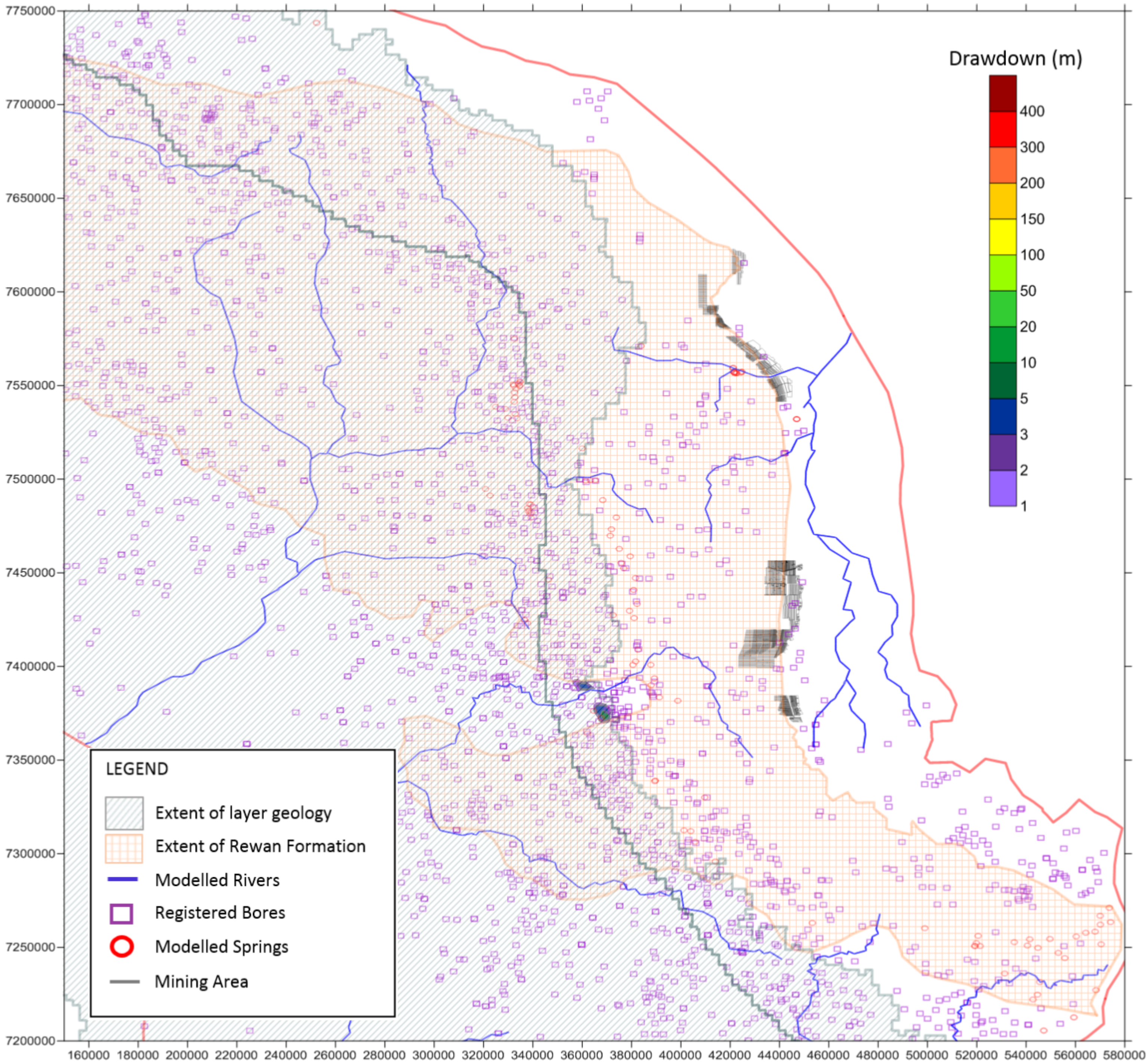

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 4 Drawdown 2045

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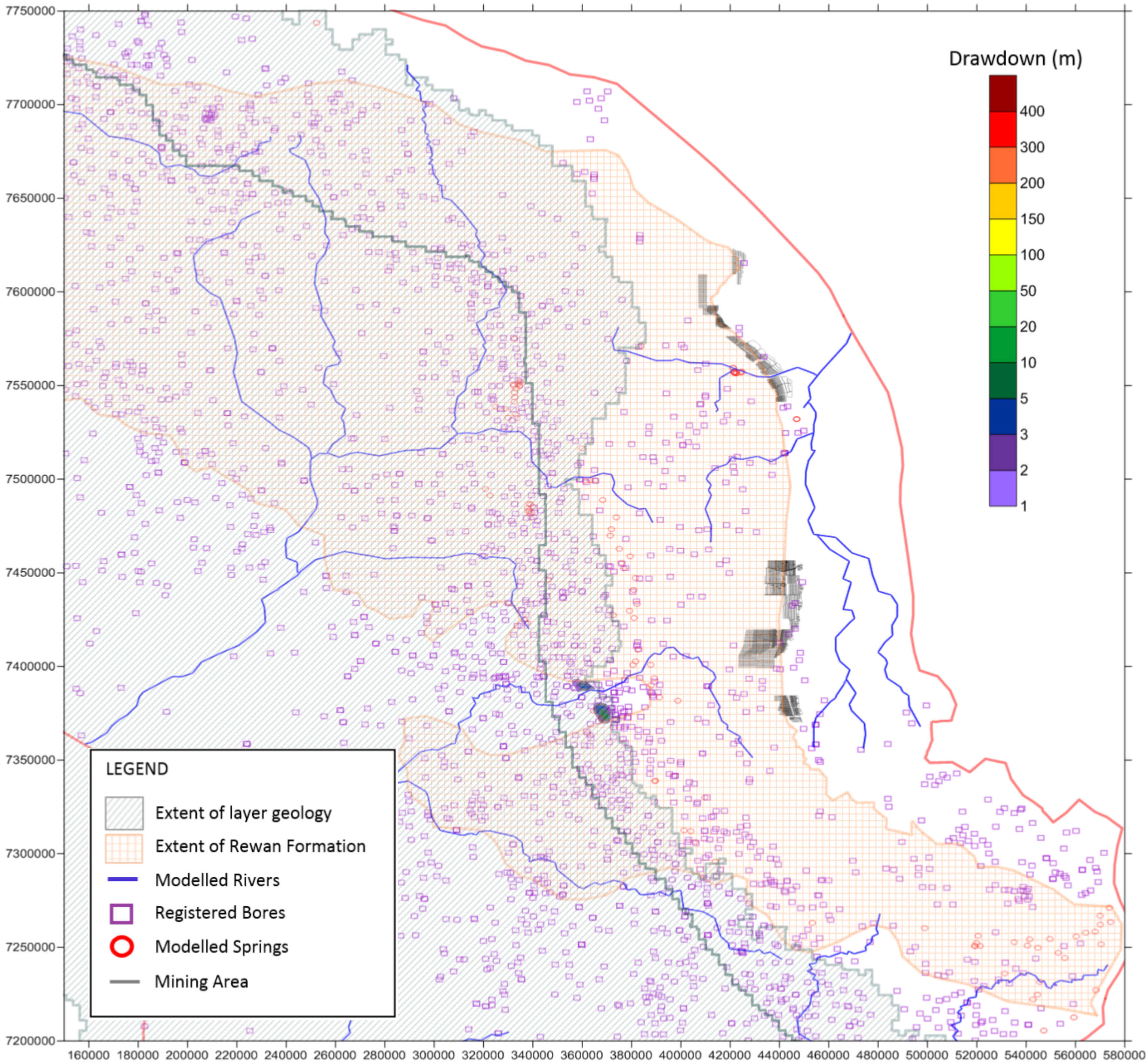

HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 4 Drawdown 2048		

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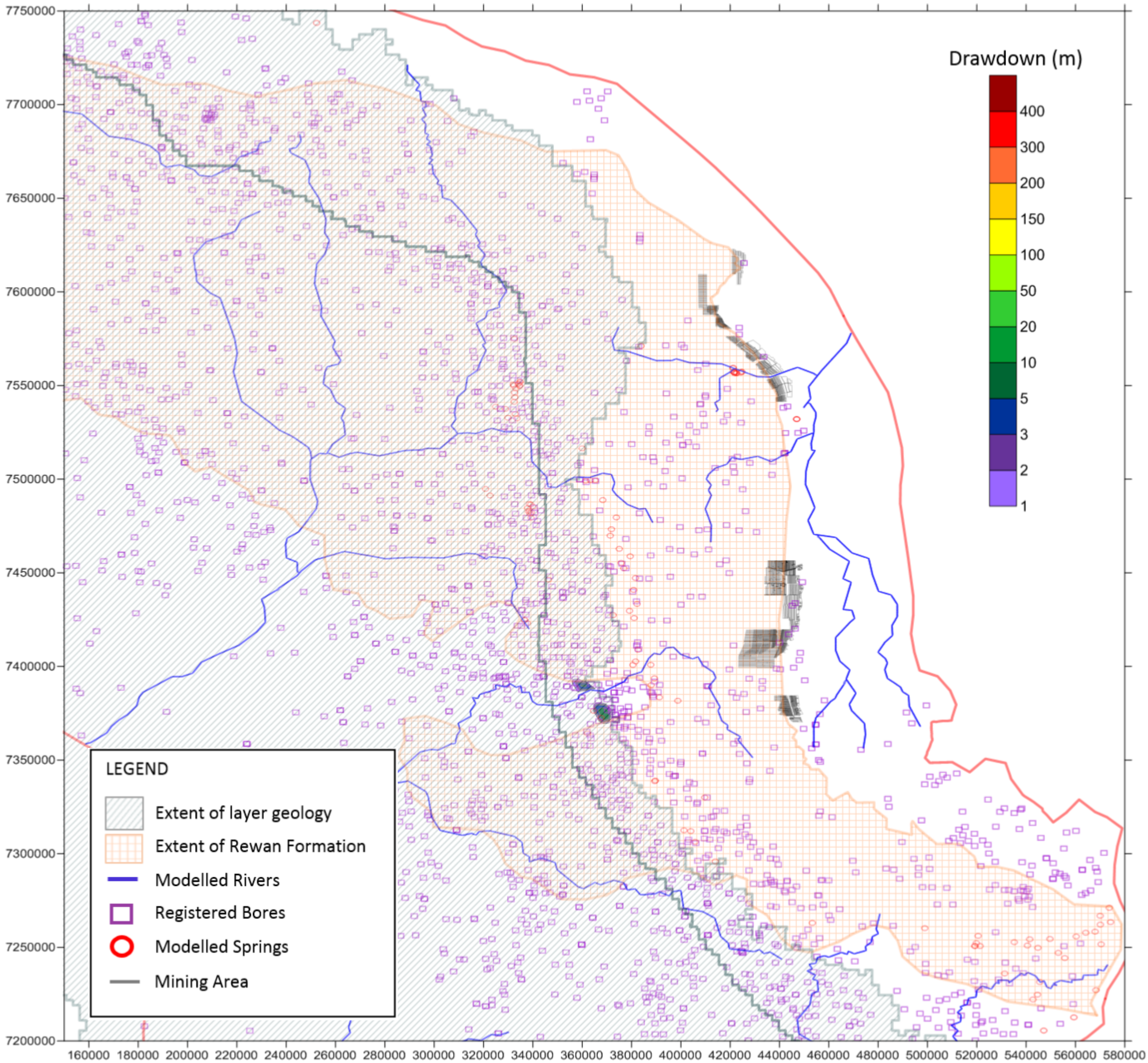

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 4 Drawdown 2050

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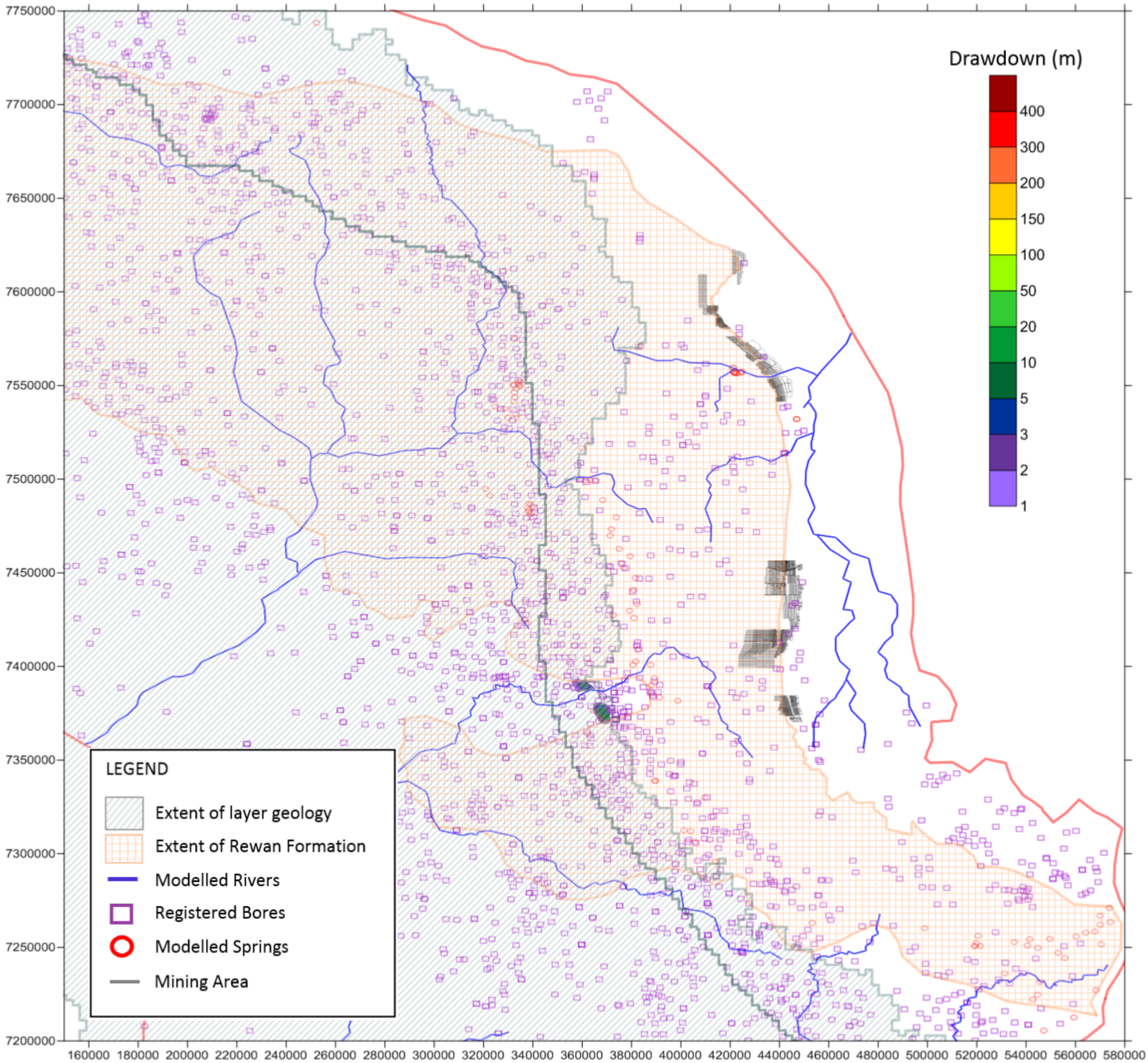

HYDRO SIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 4 Drawdown 2055

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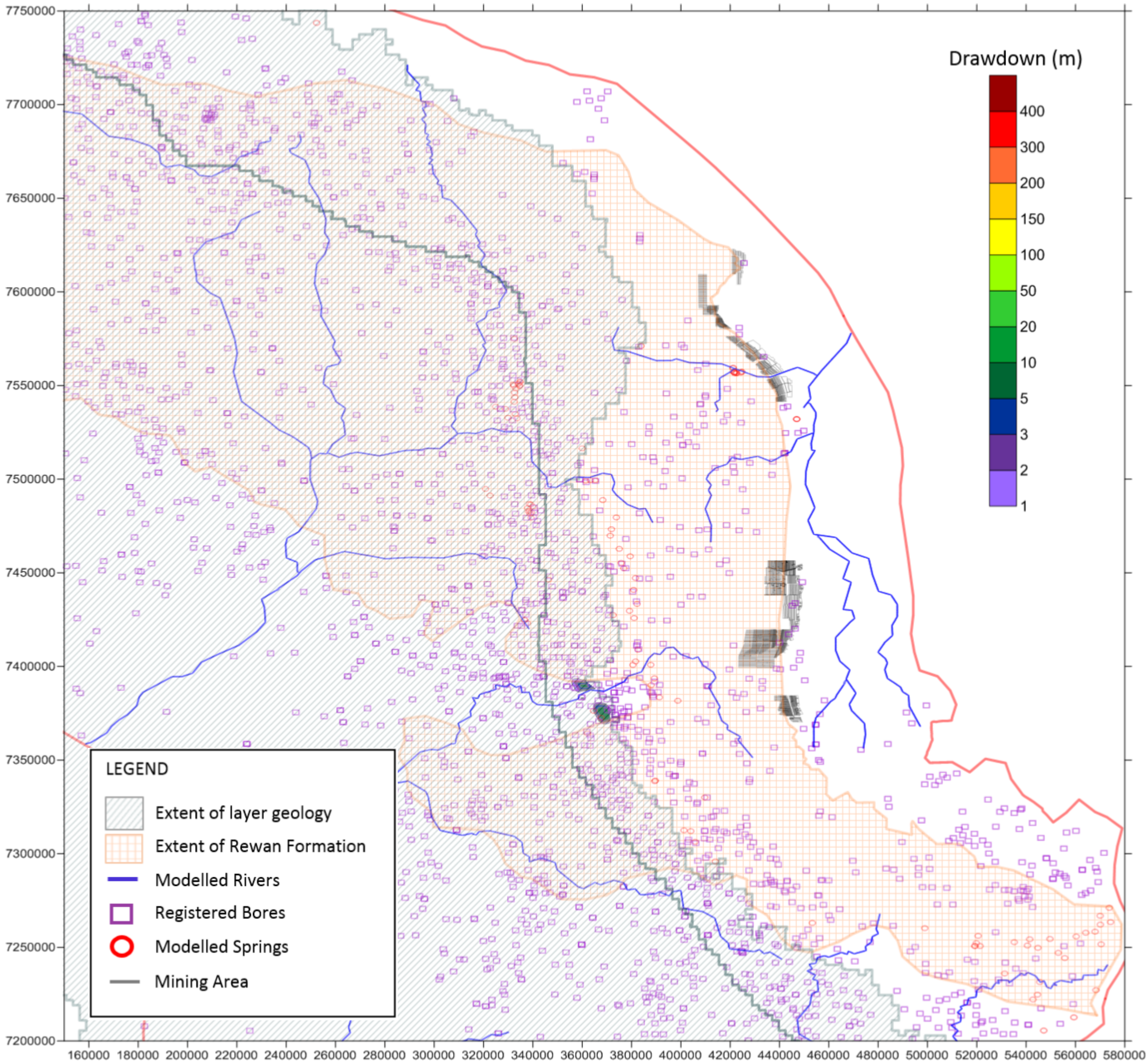

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 4 Drawdown 2058

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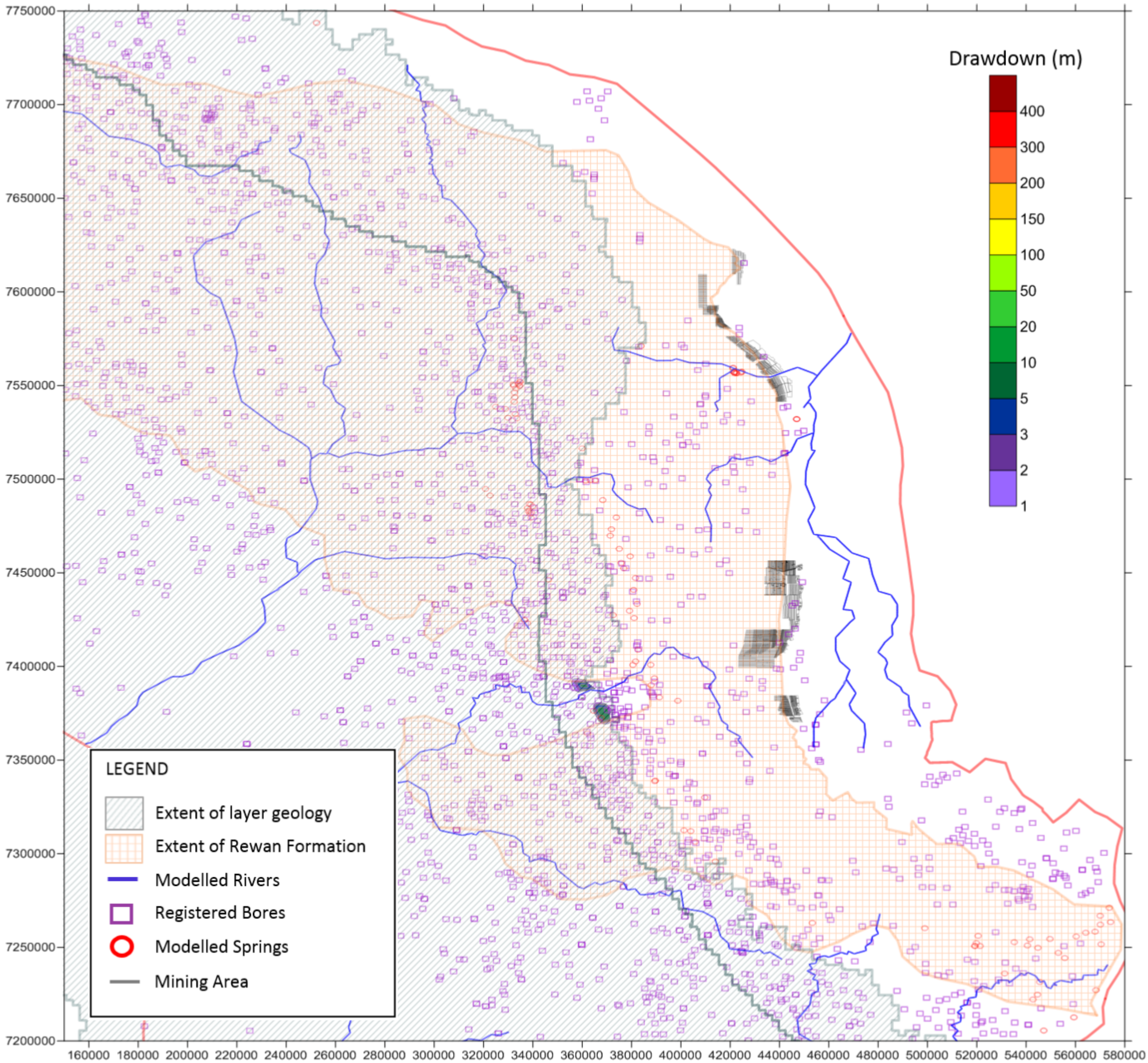

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 4 Drawdown 2061

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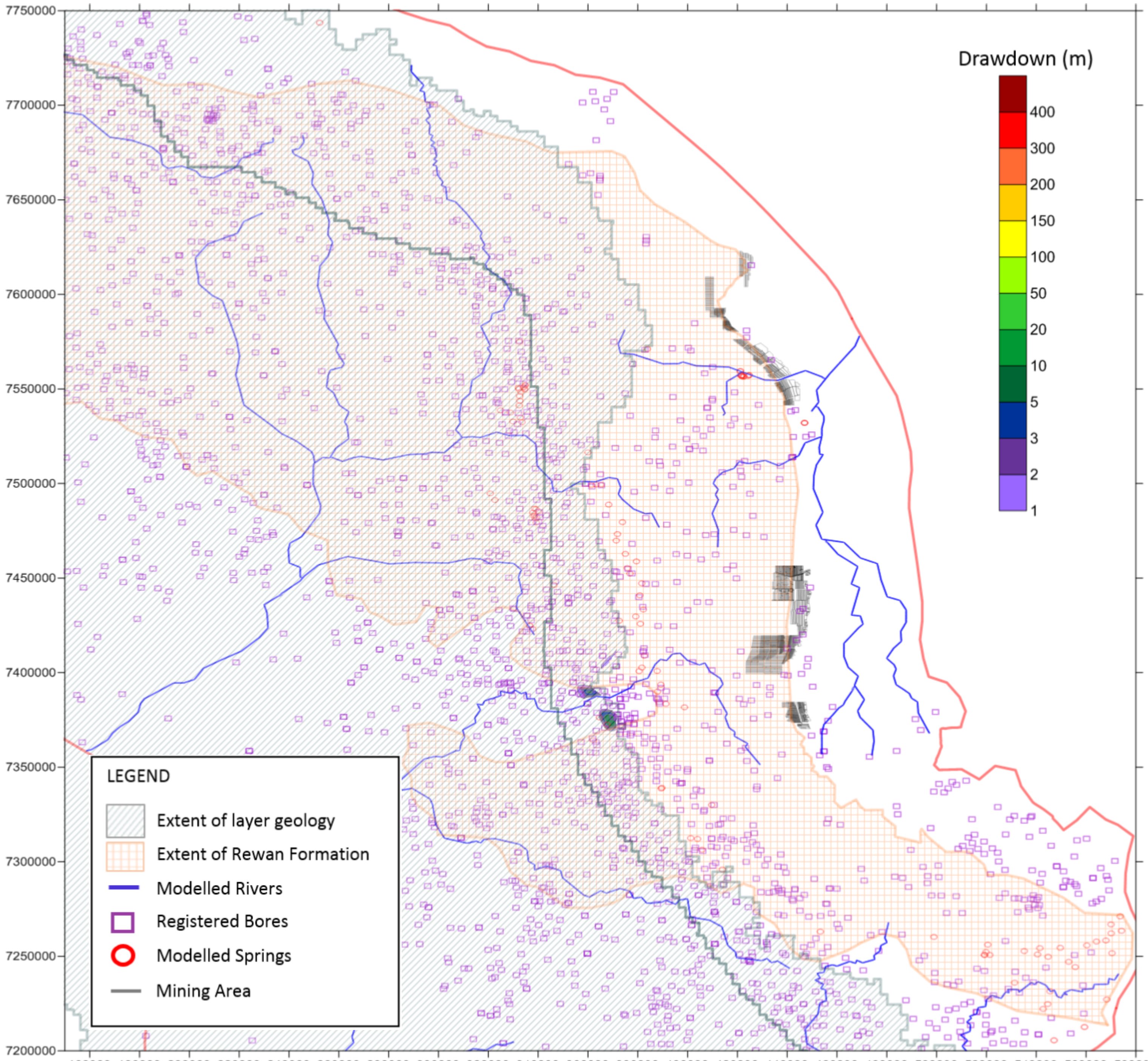

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 4 Drawdown 2067

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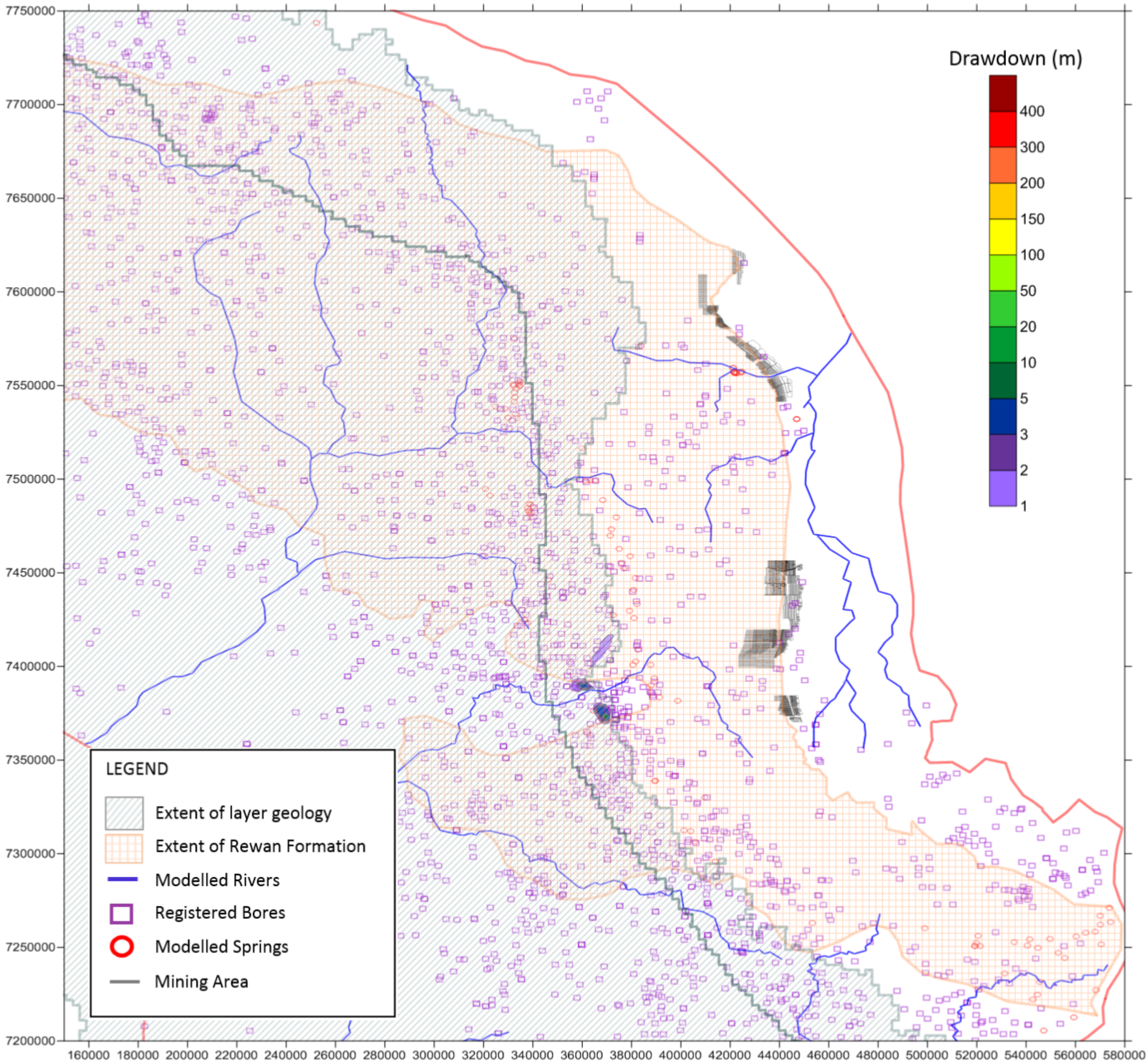

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 4 Drawdown 2080		

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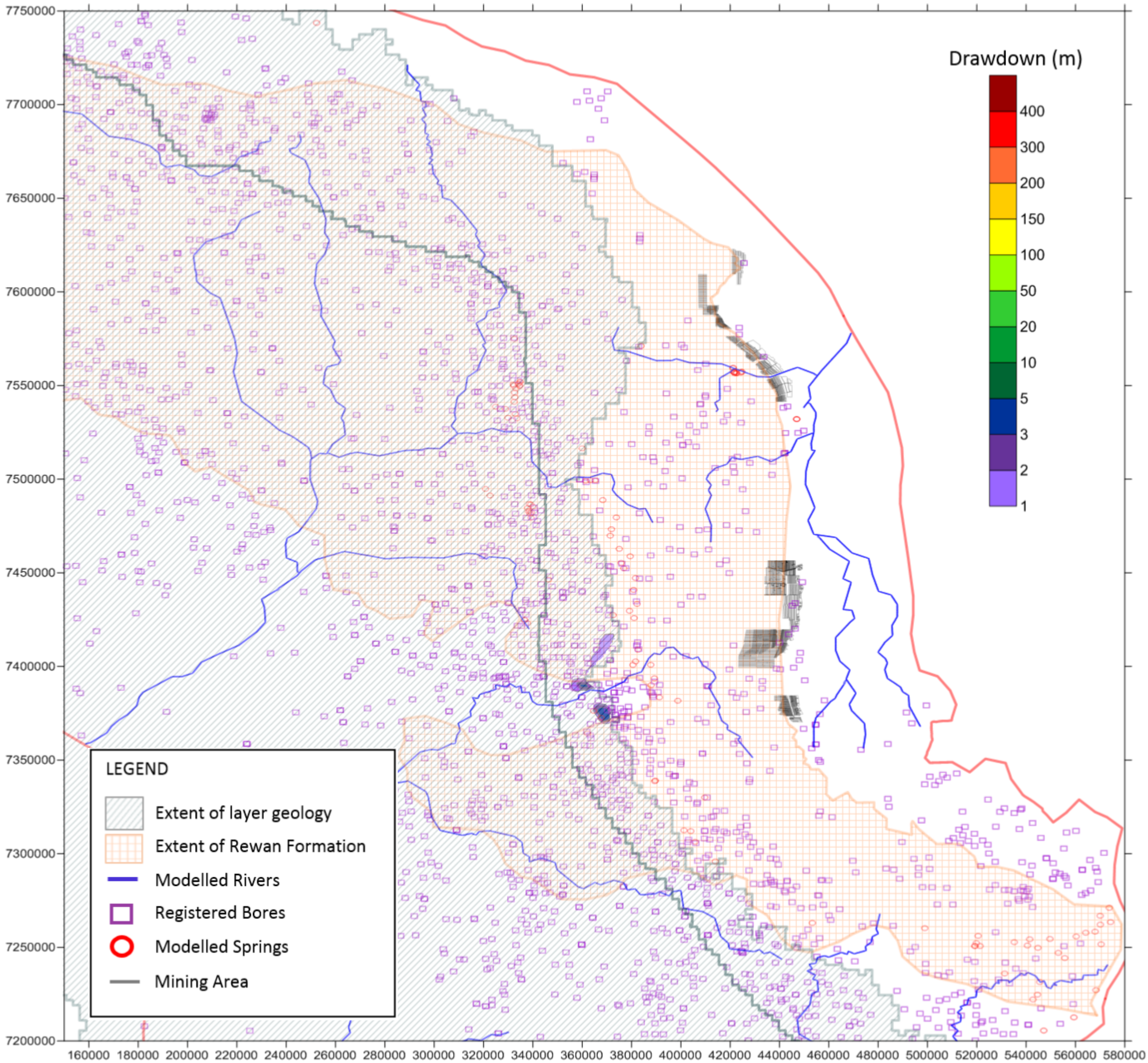

HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 4 Drawdown 2090		

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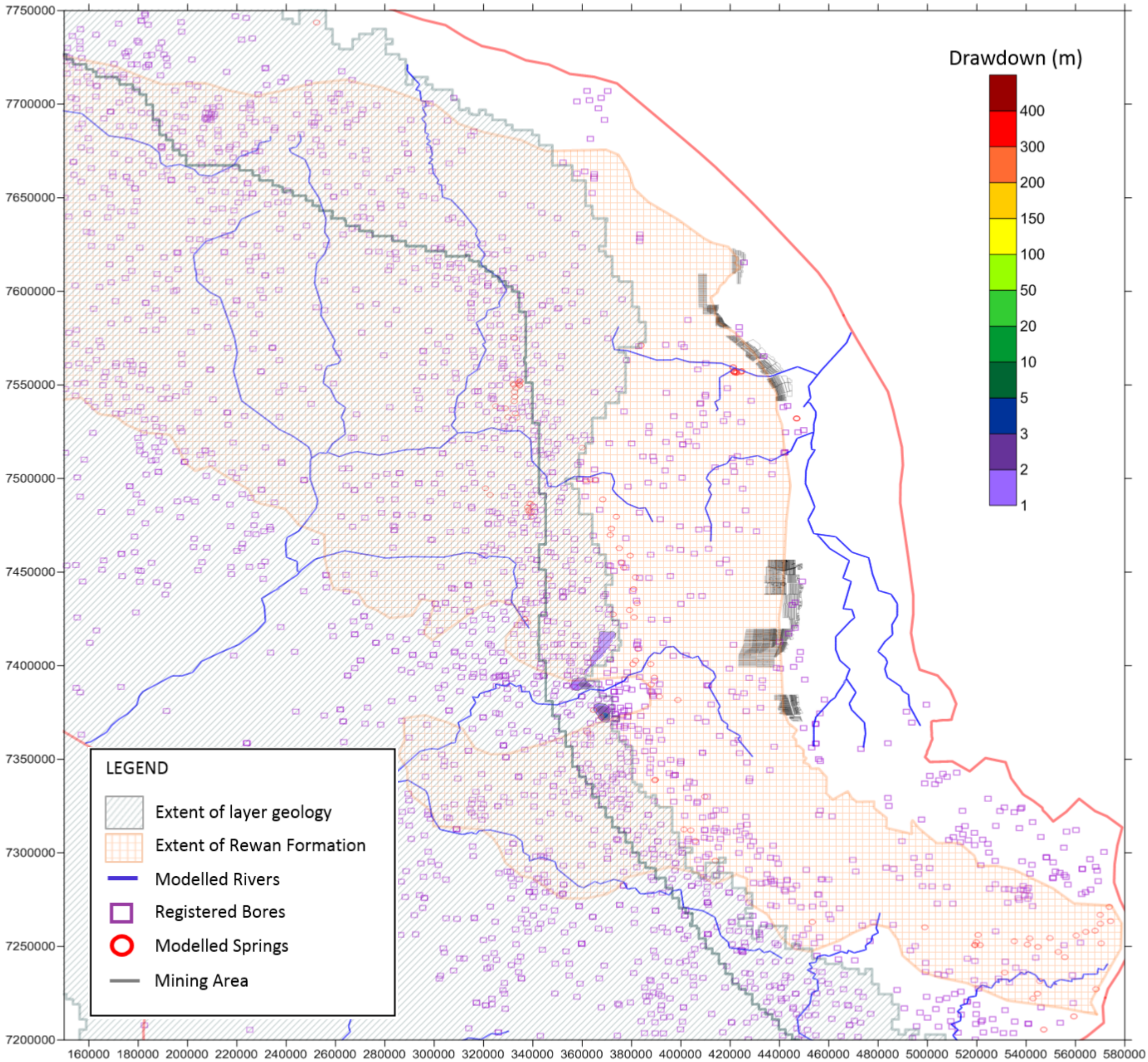

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 4 Drawdown 2110		

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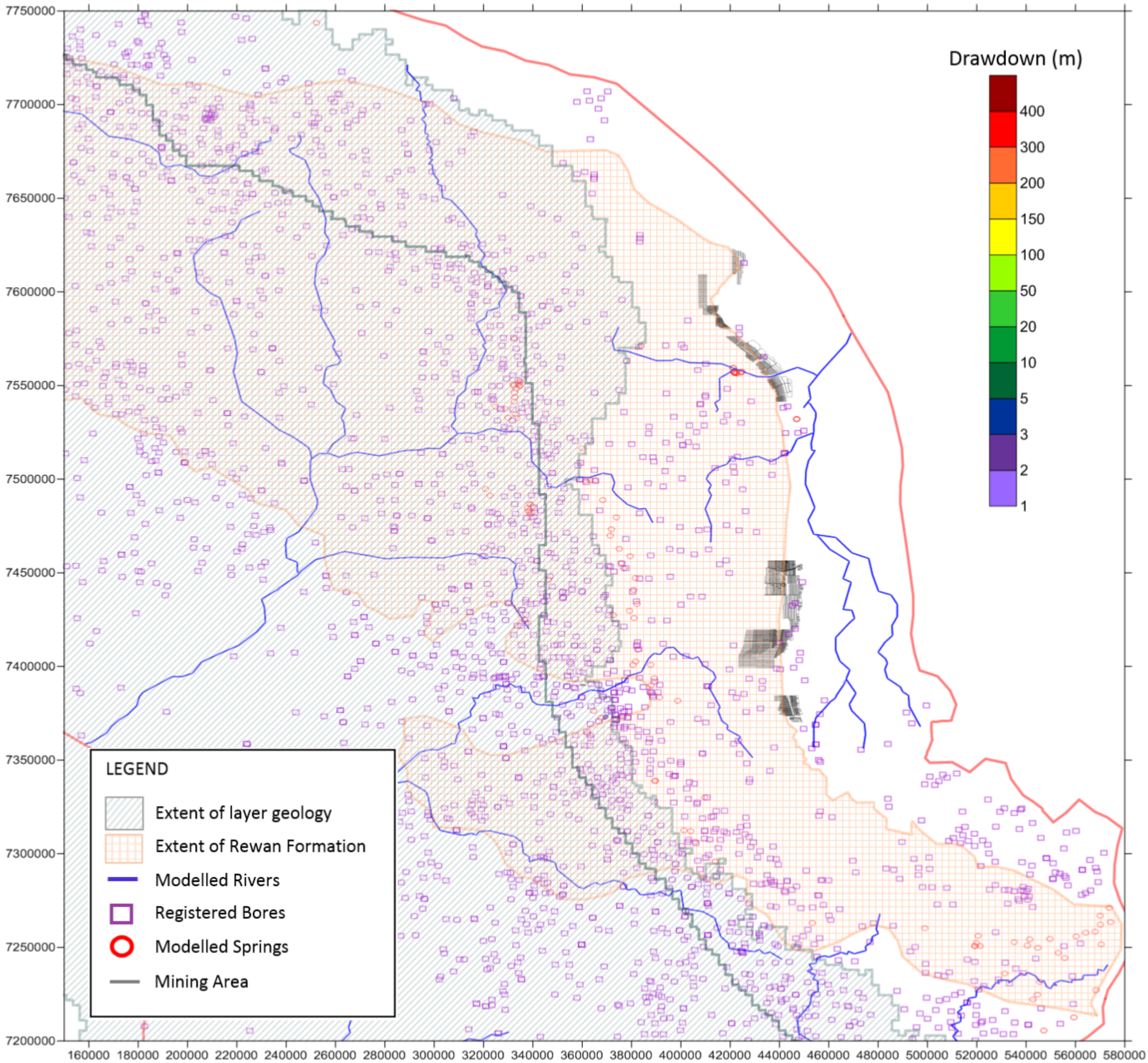

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

Layer 4 Drawdown 2200

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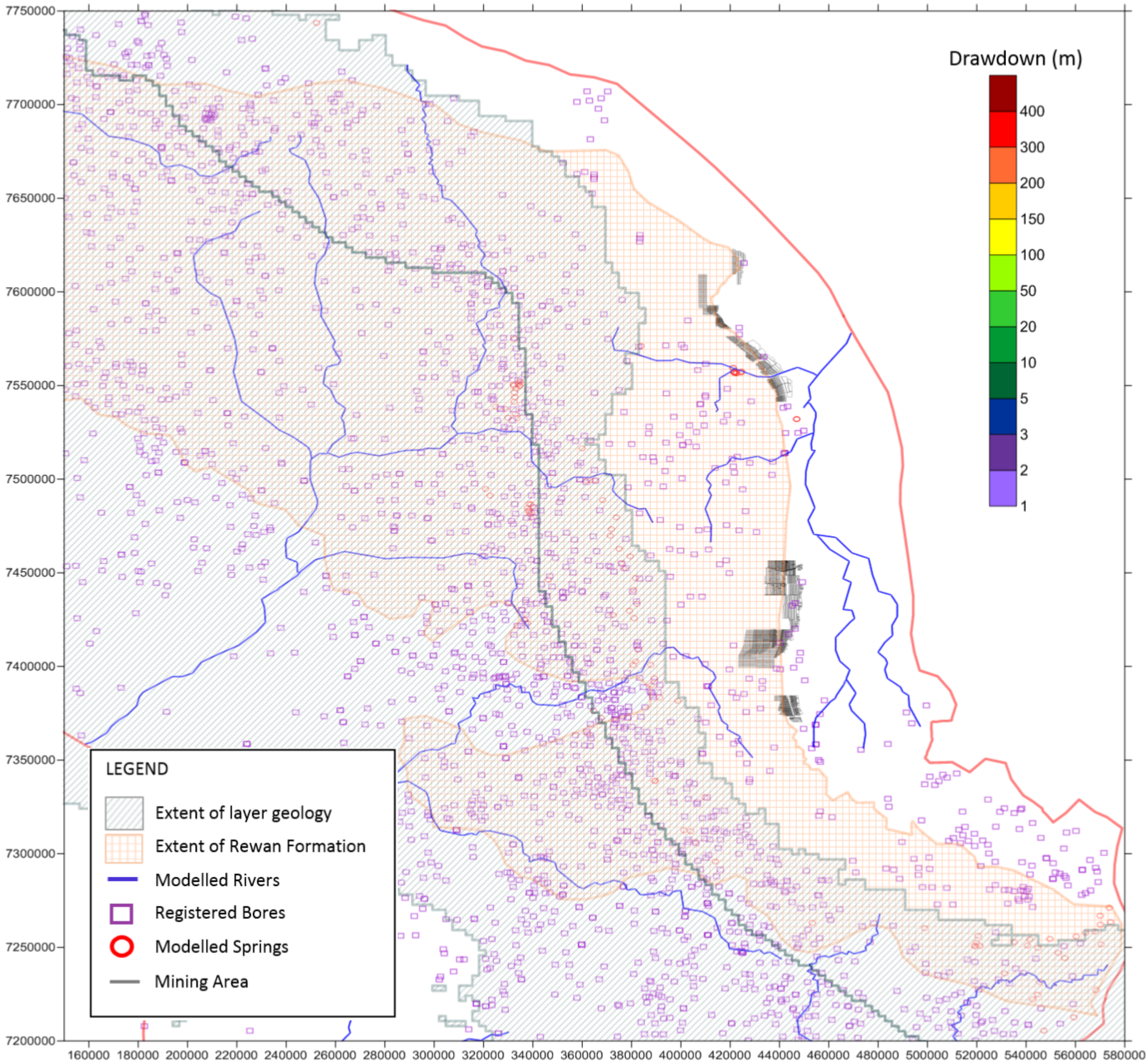

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL

Layer 6 Drawdown 2020

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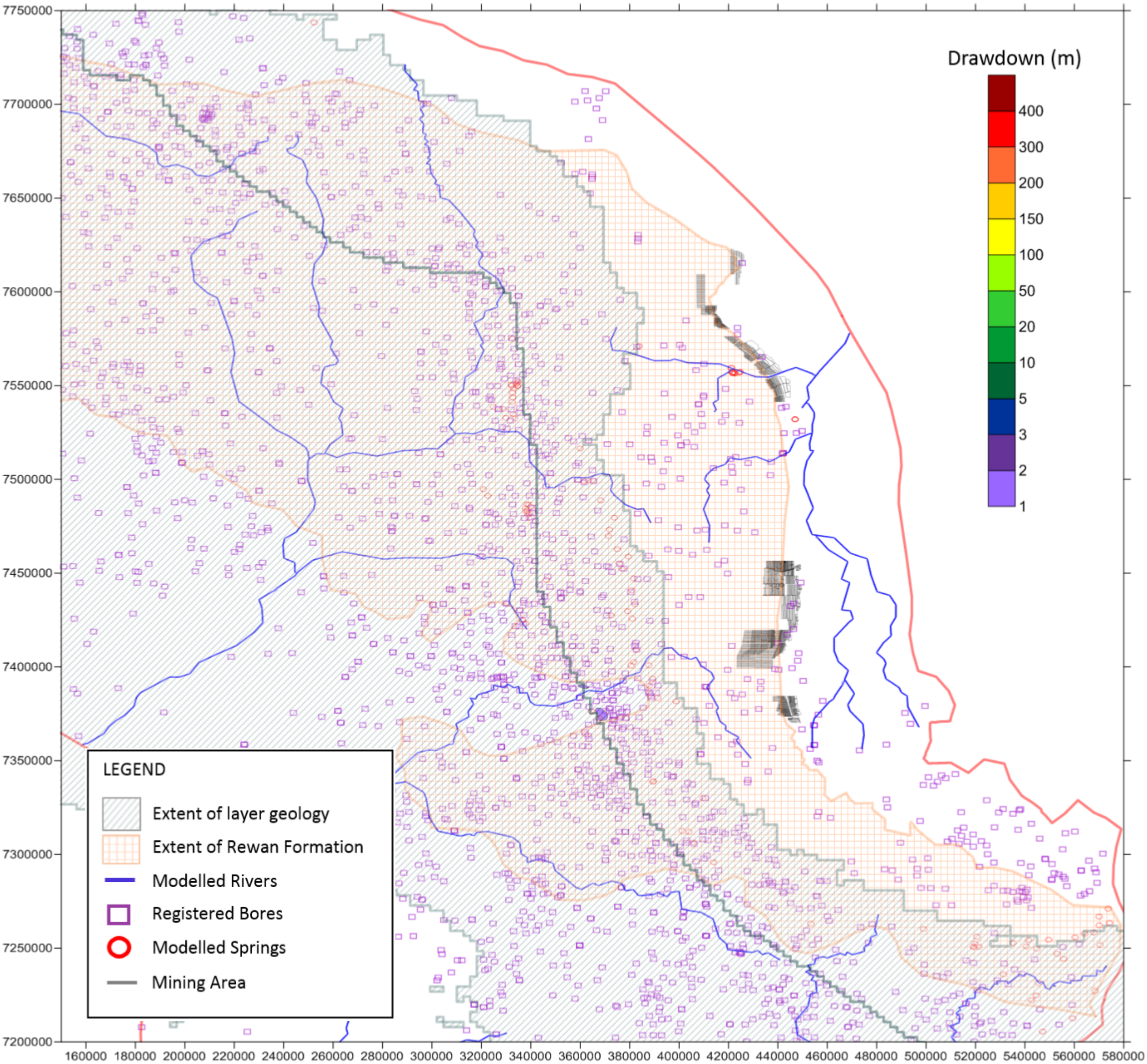


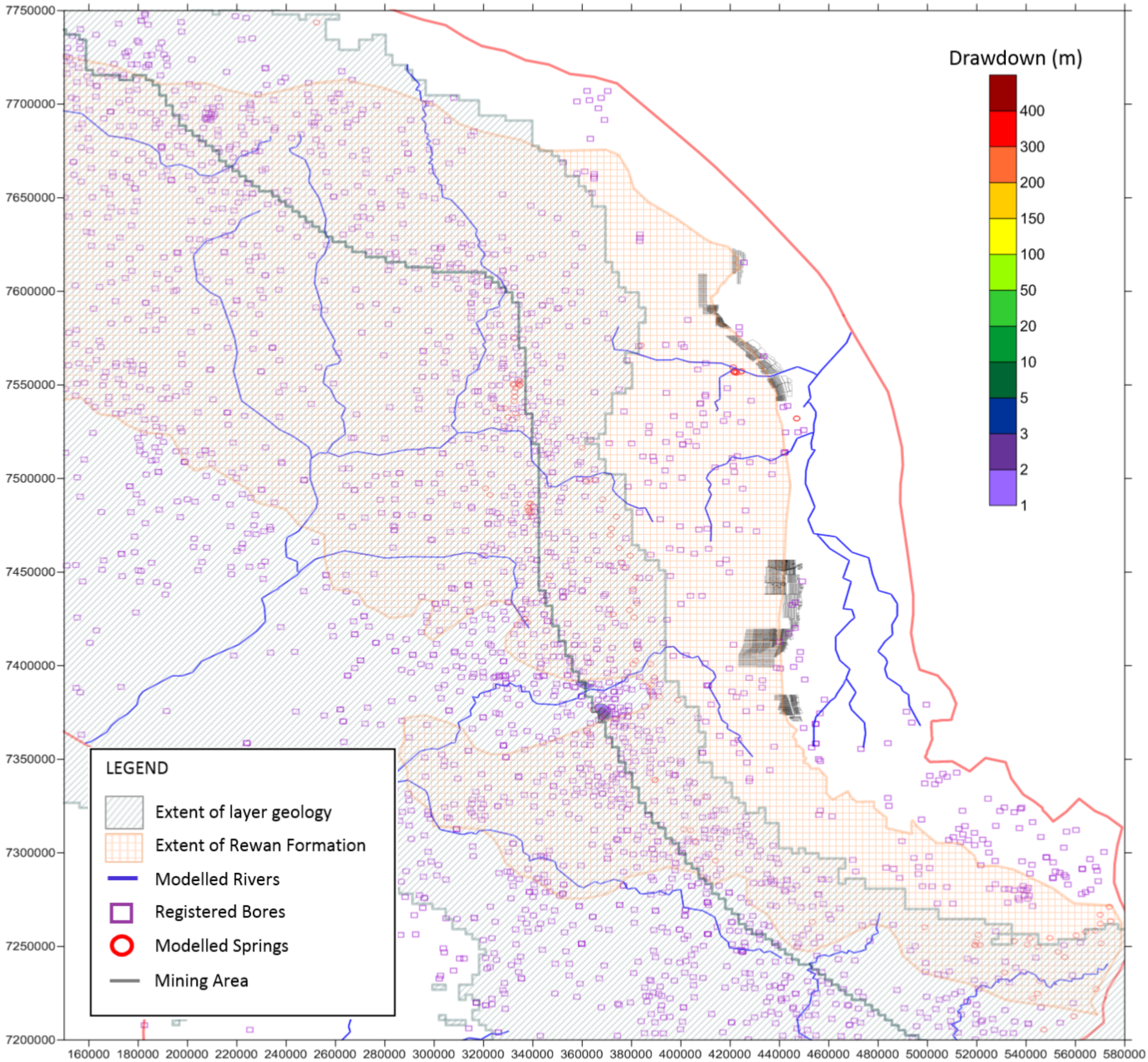
10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55

GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL

HYDRO SIMULATIONS

Layer 6 Drawdown 2025

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

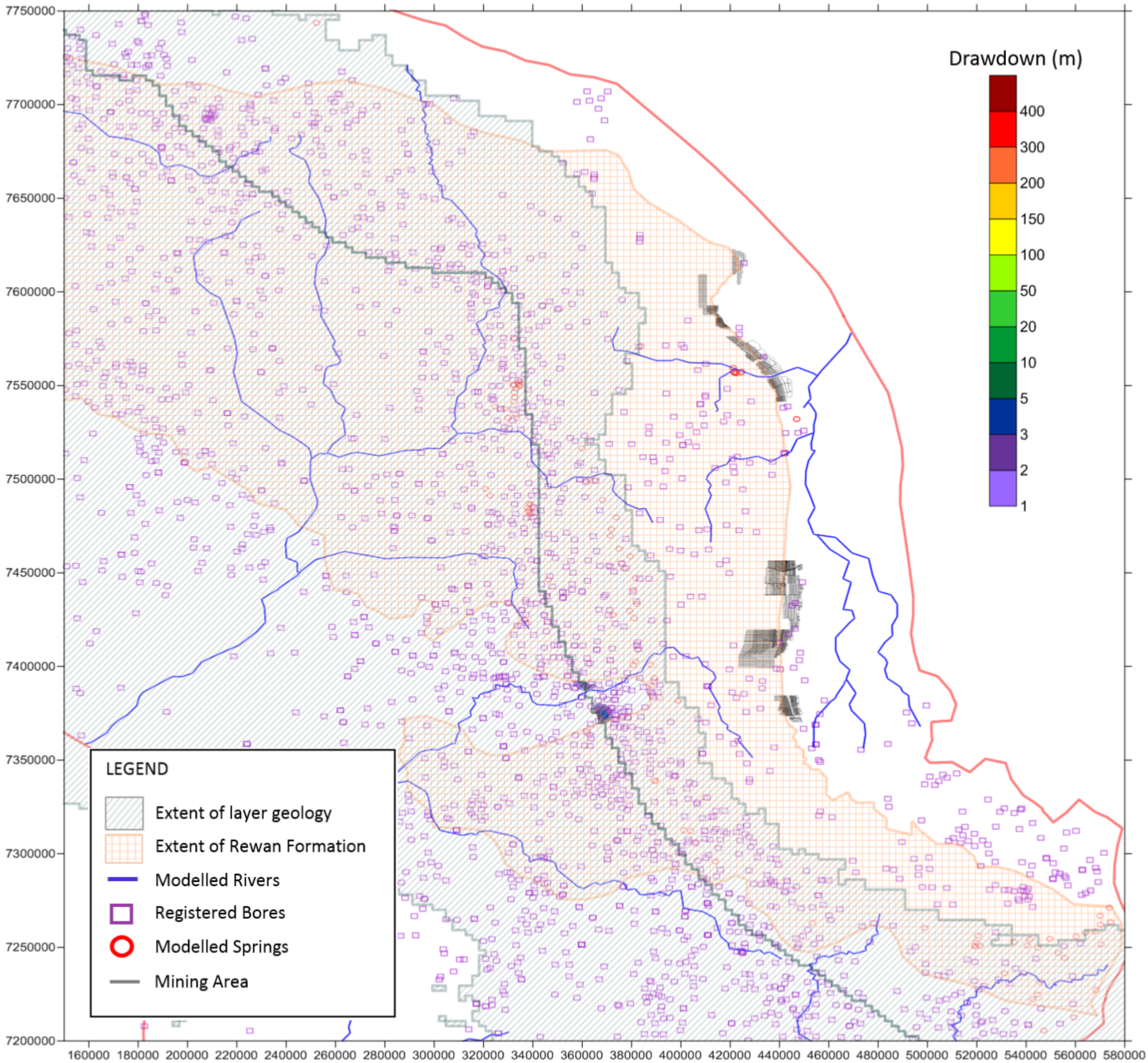


HydroSimulations

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 6 Drawdown 2030

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

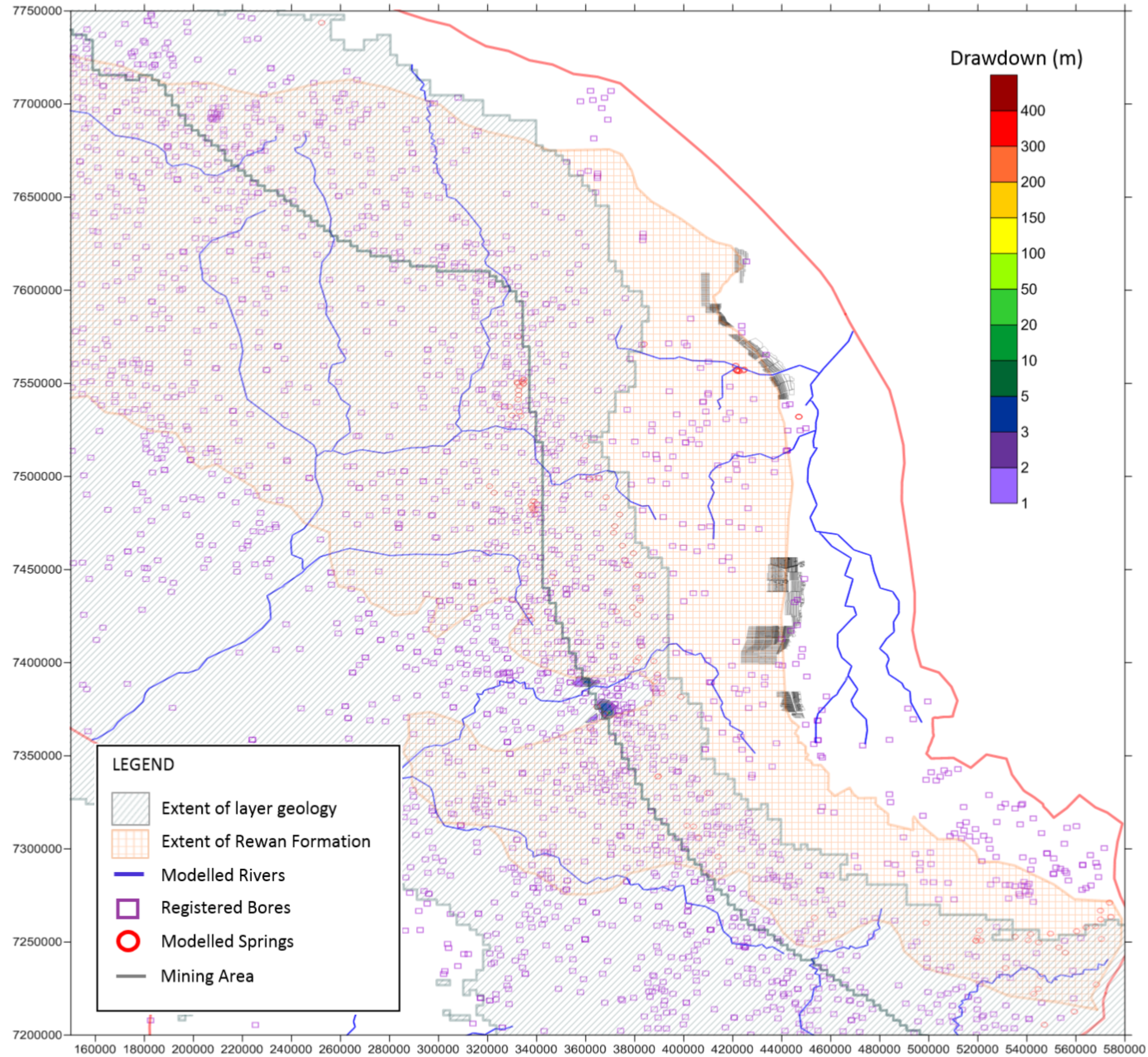


10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

Layer 6 Drawdown 2035

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 6 Drawdown 2040

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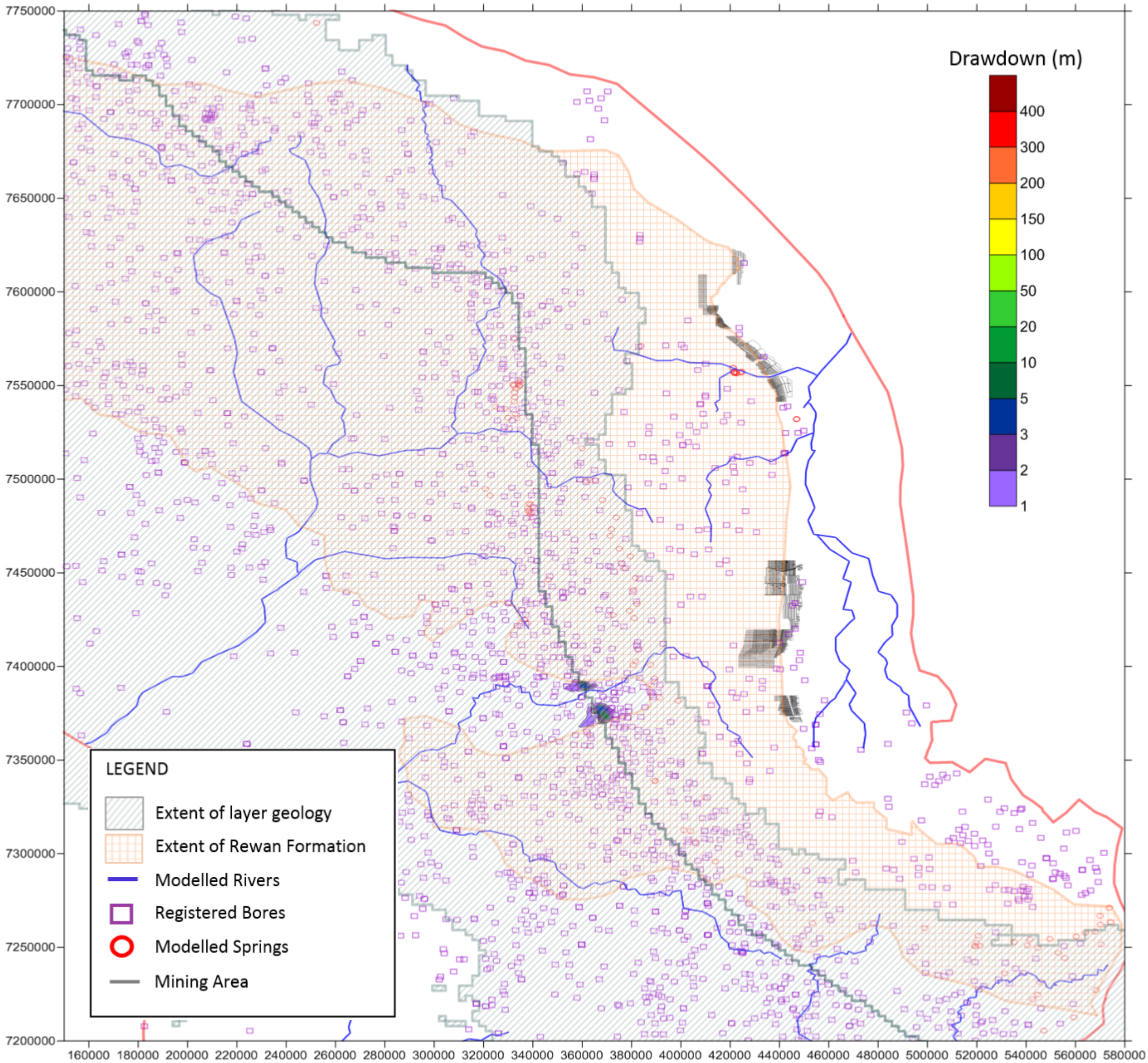

	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 6 Drawdown 2045		

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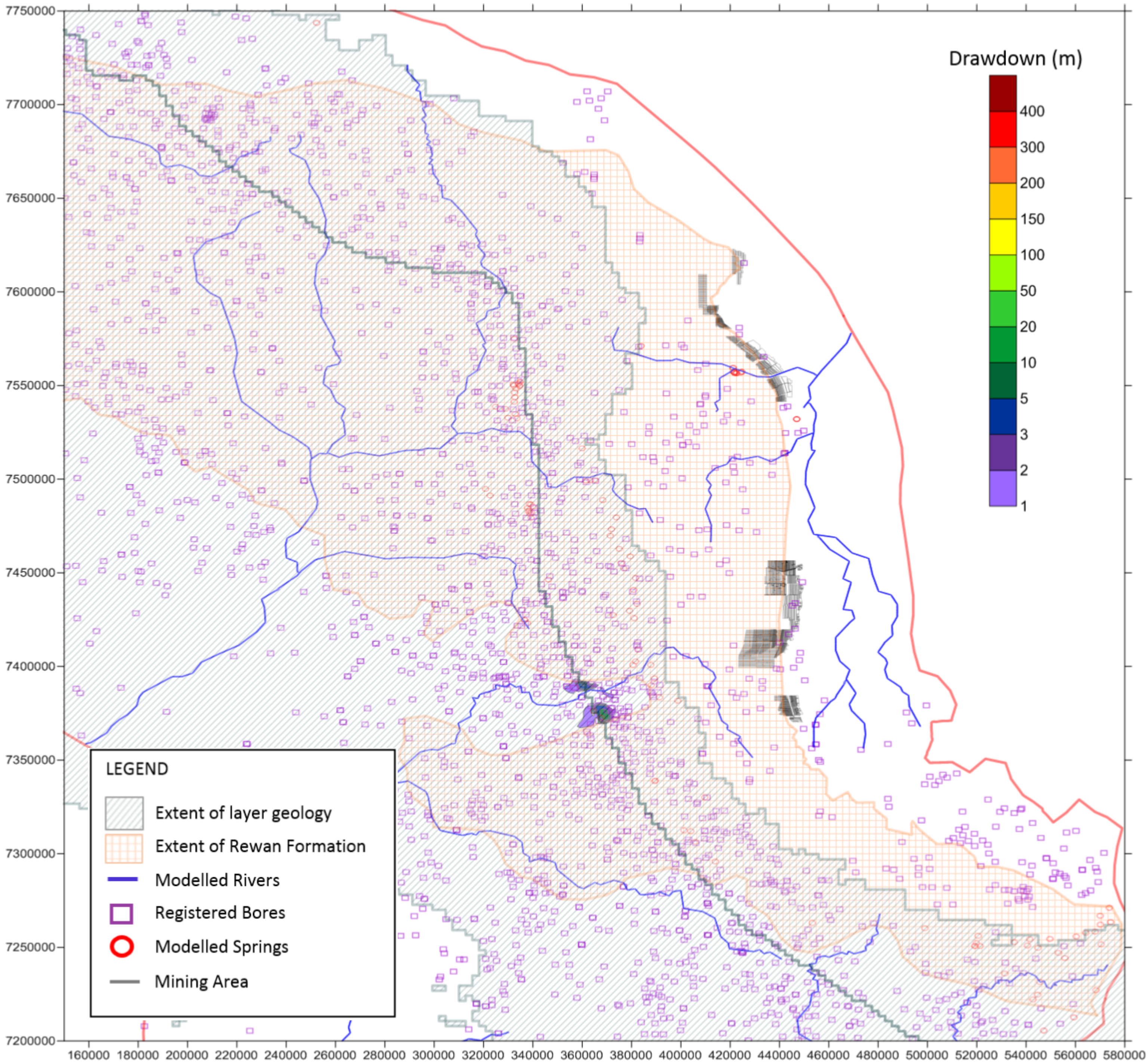

HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 6 Drawdown 2048		

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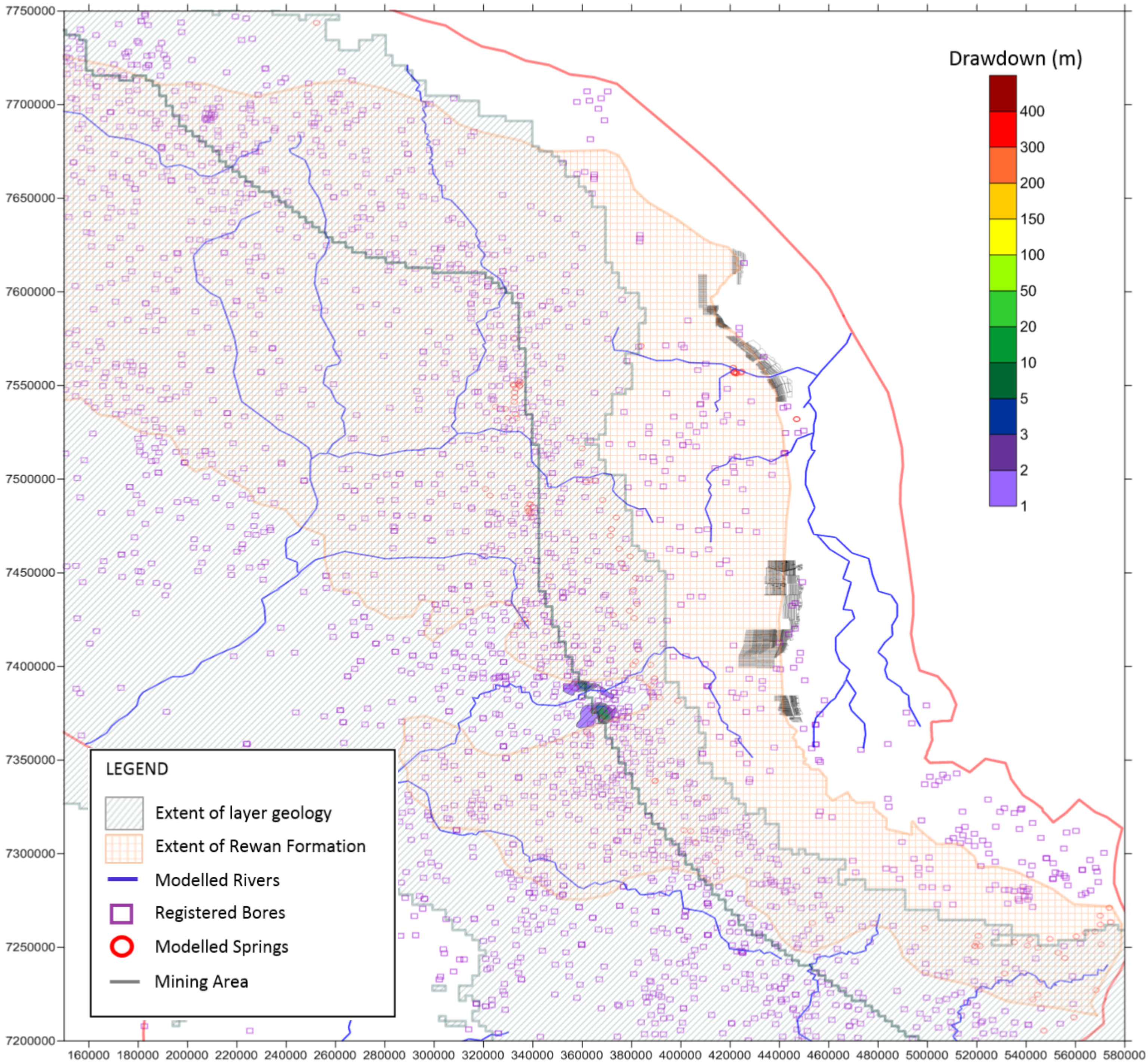

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 6 Drawdown 2050

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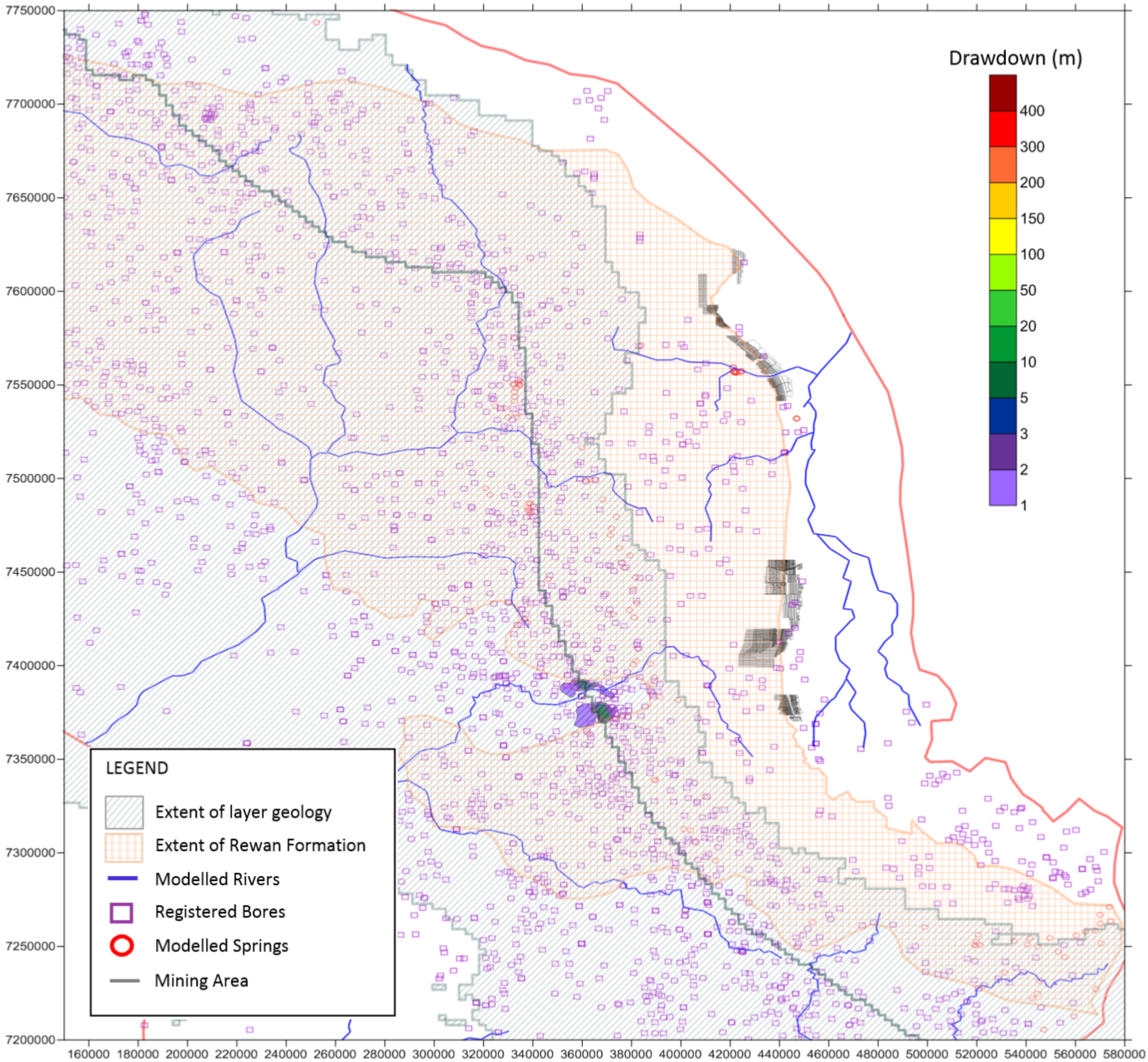

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 6 Drawdown 2055

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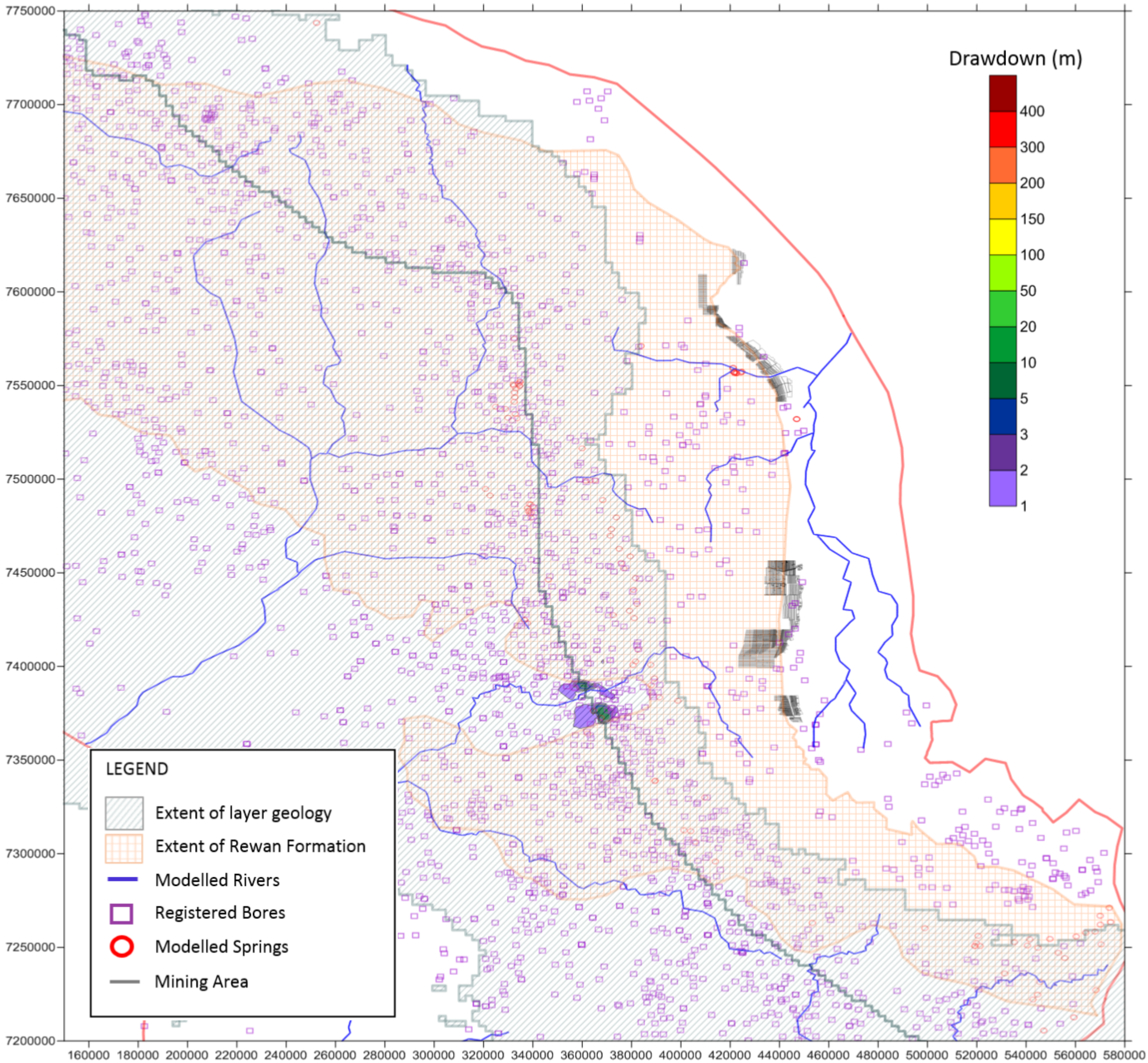
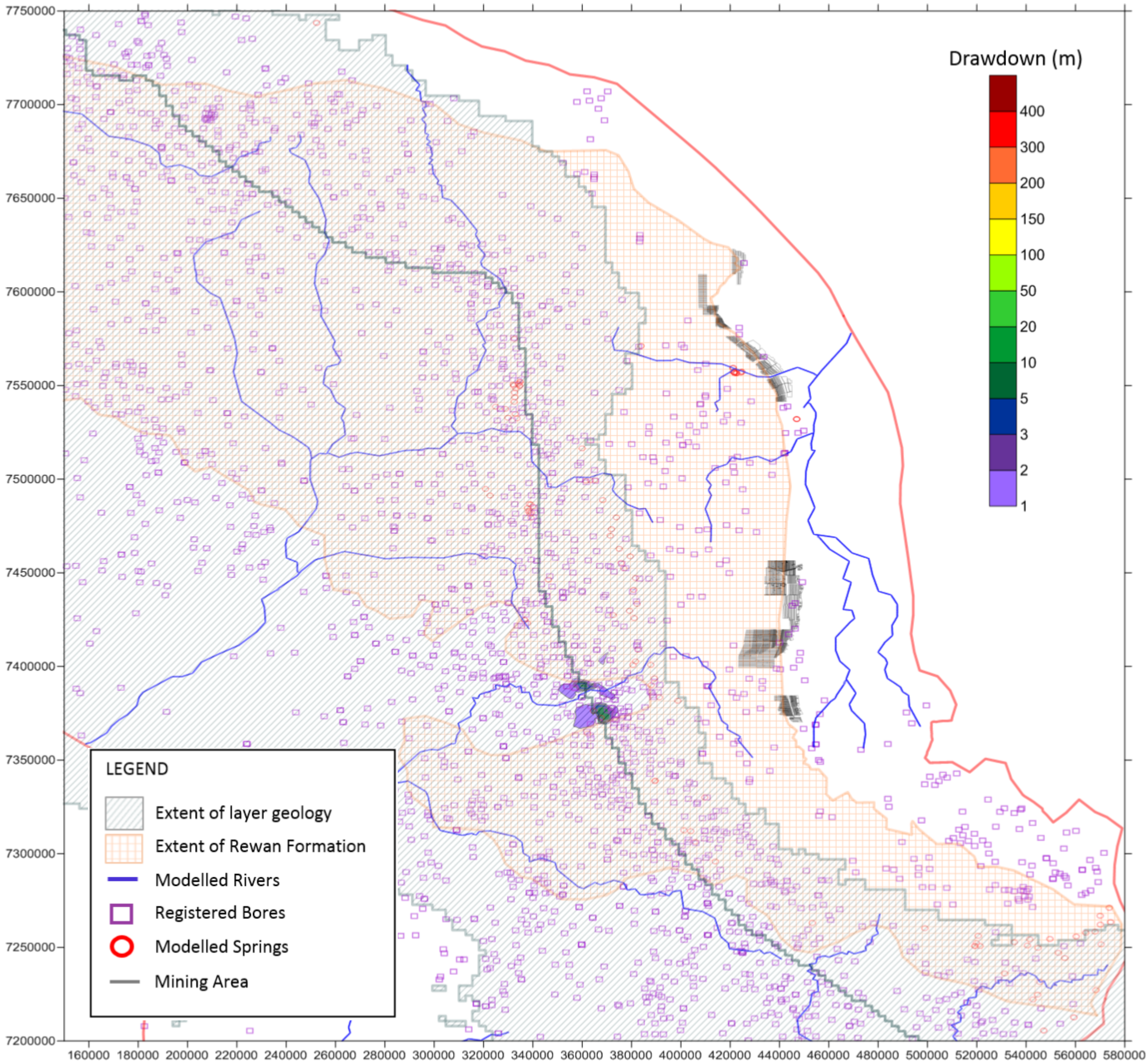


HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 6 Drawdown 2058		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



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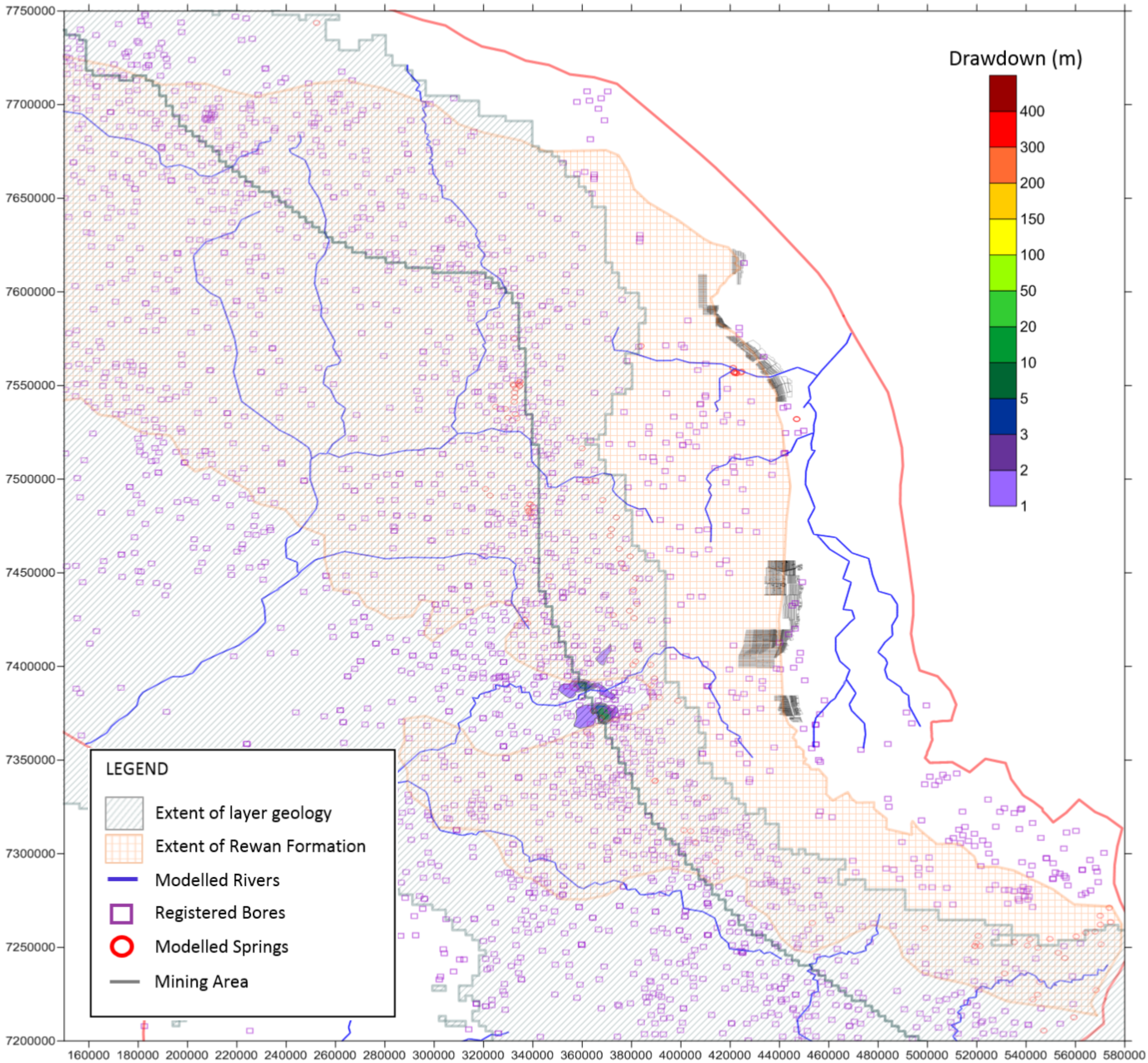
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

Layer 6 Drawdown 2061

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 6 Drawdown 2067

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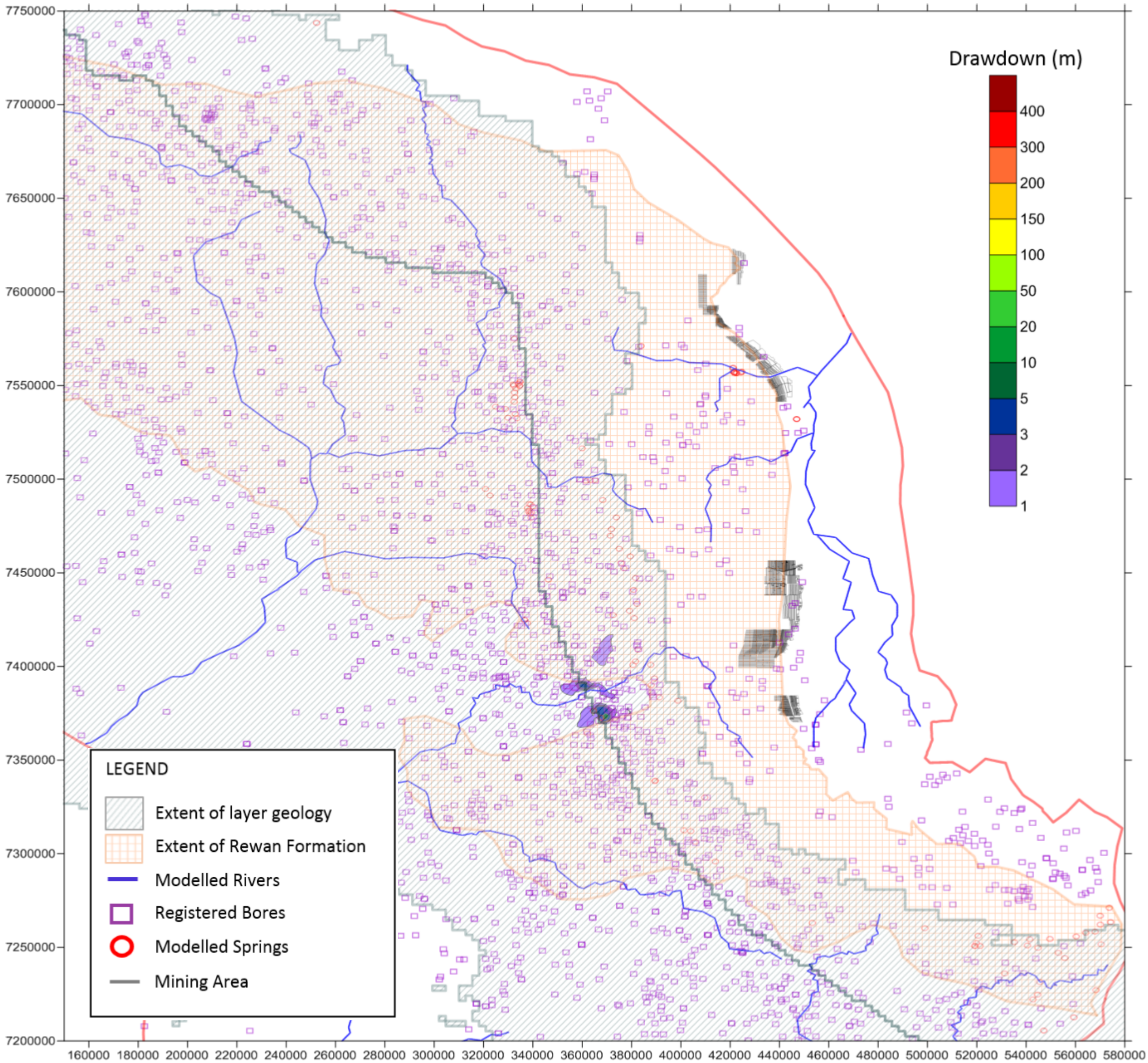

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

Layer 6 Drawdown 2080

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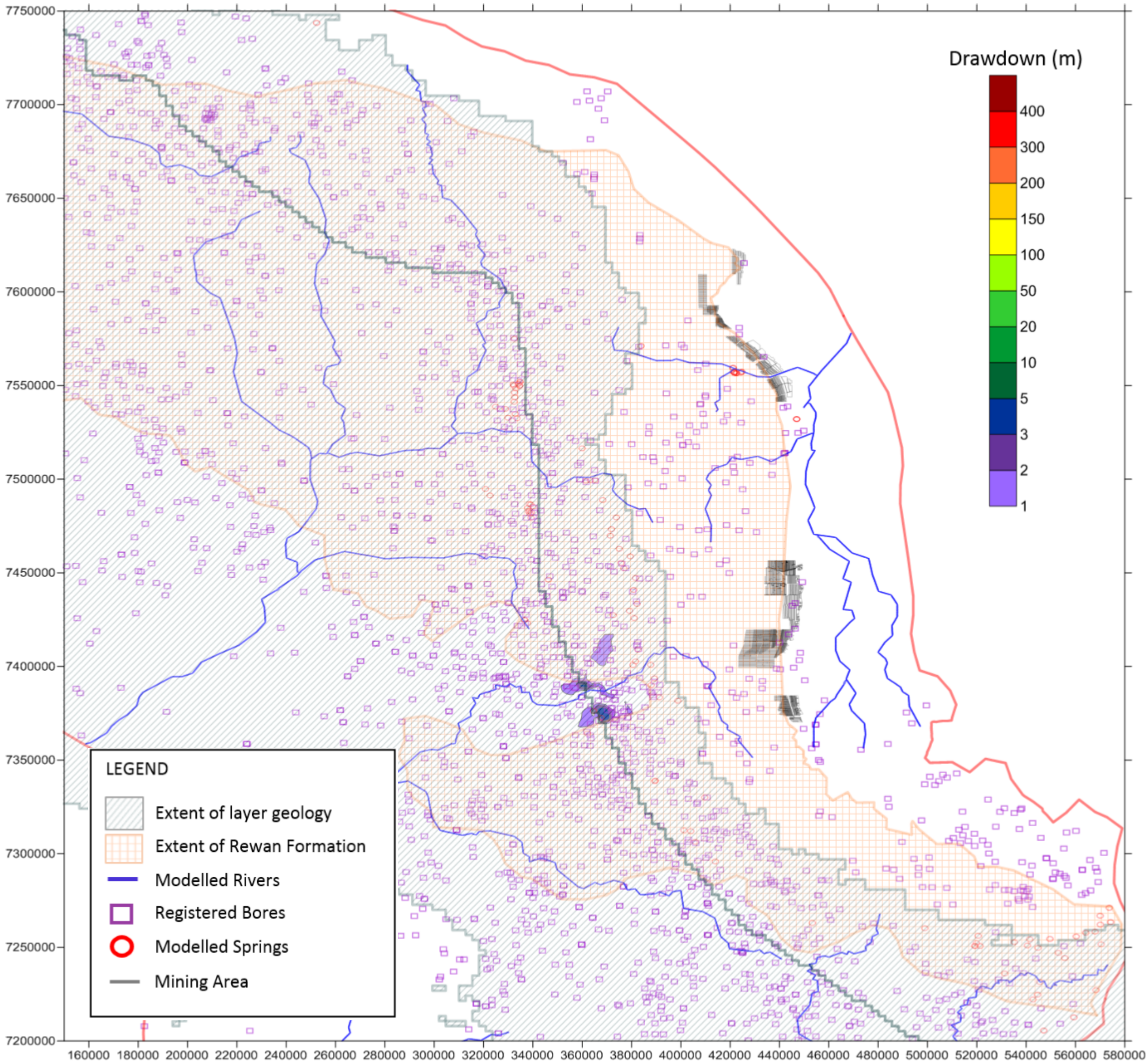
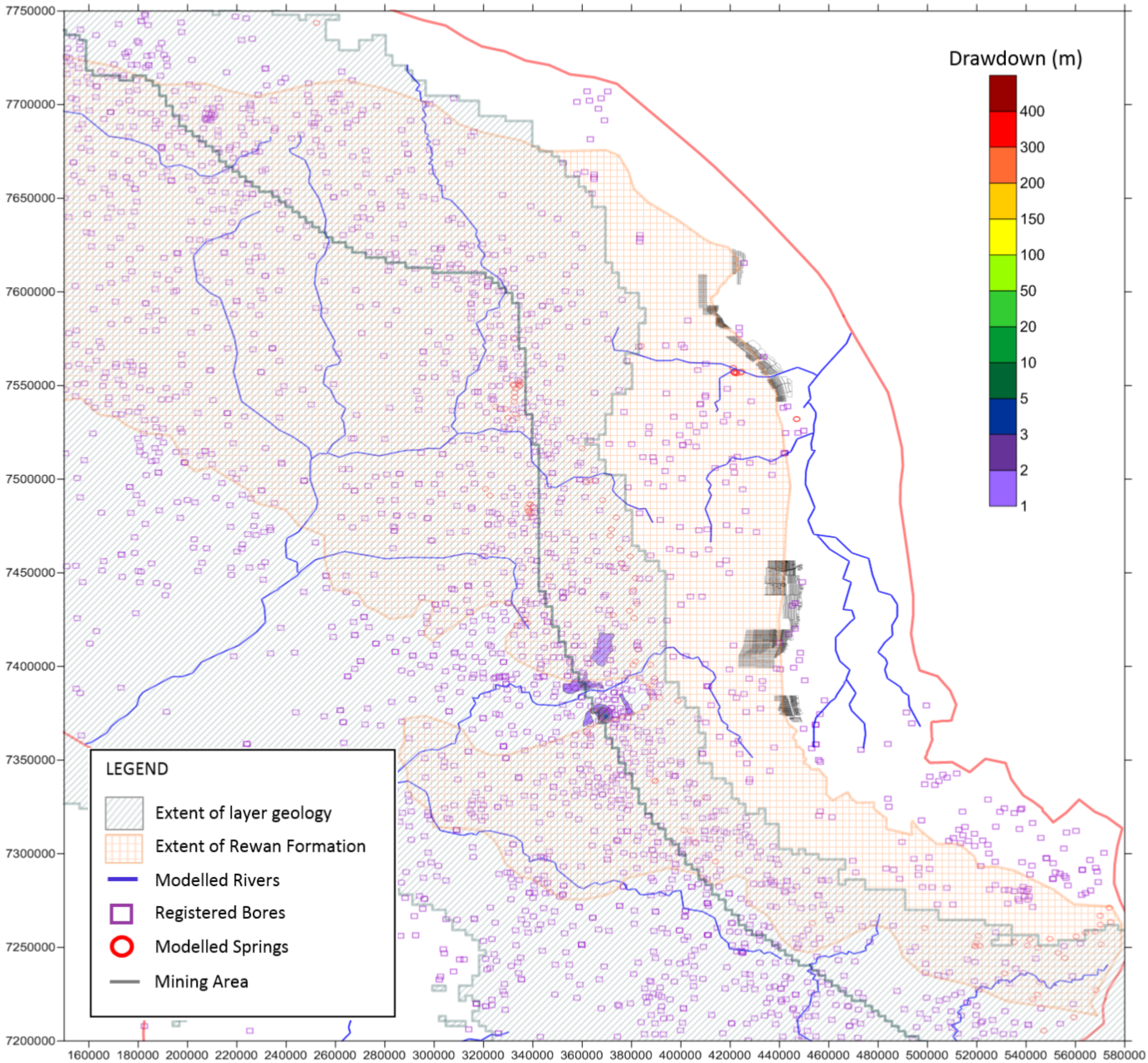


HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 6 Drawdown 2090		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 6 Drawdown 2110

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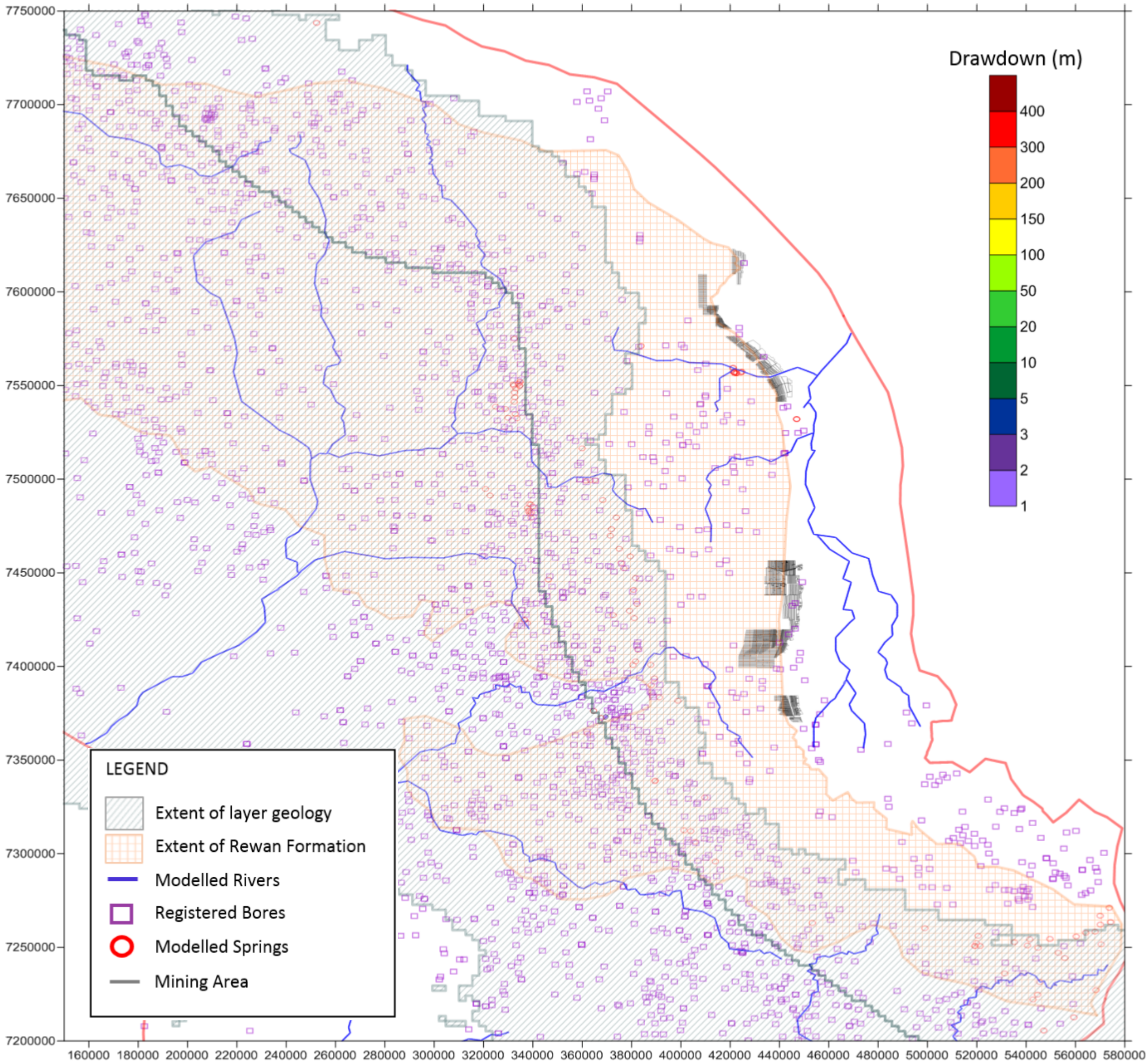

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

Layer 6 Drawdown 2200

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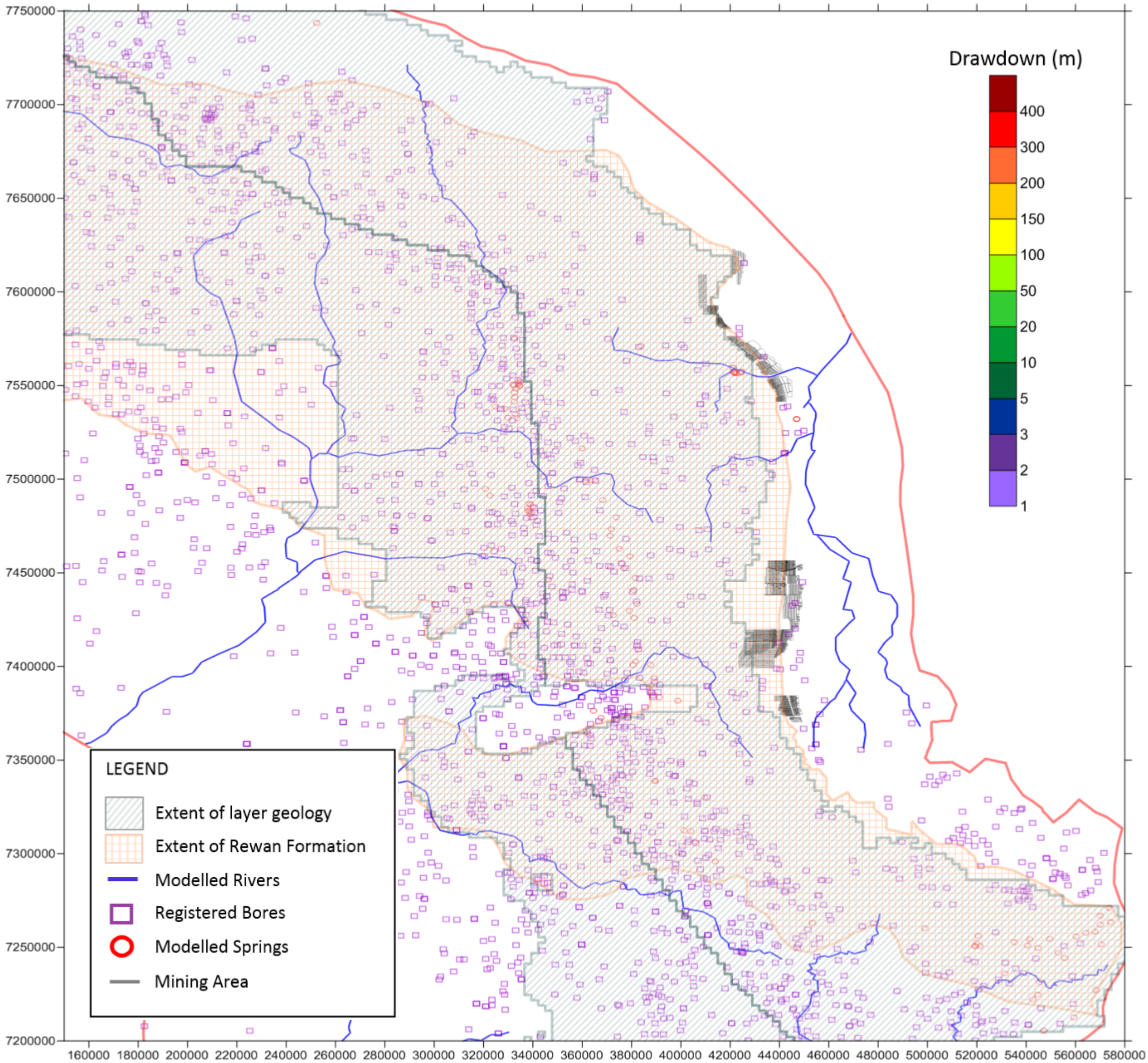
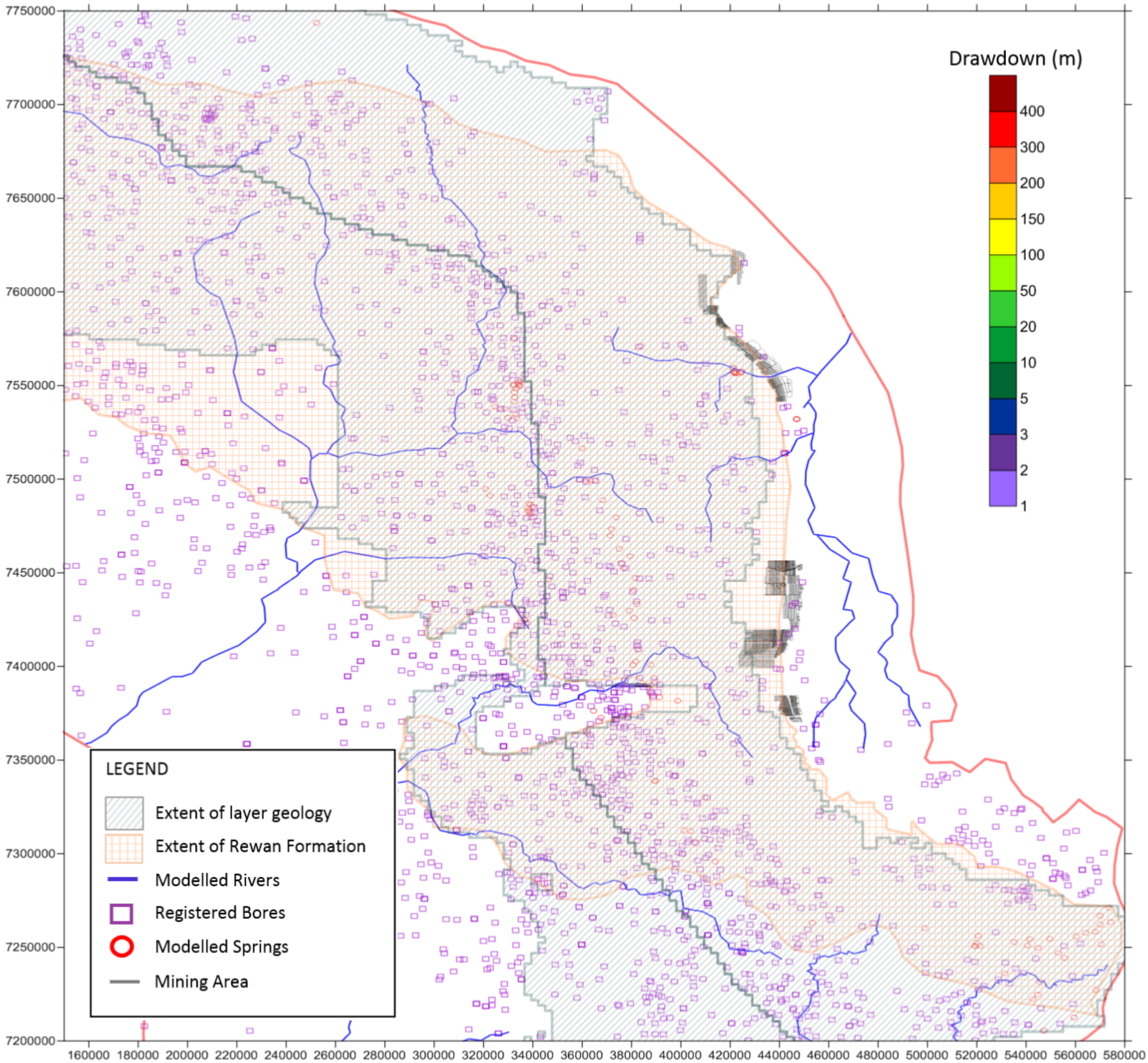


HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 8 Drawdown 2020

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



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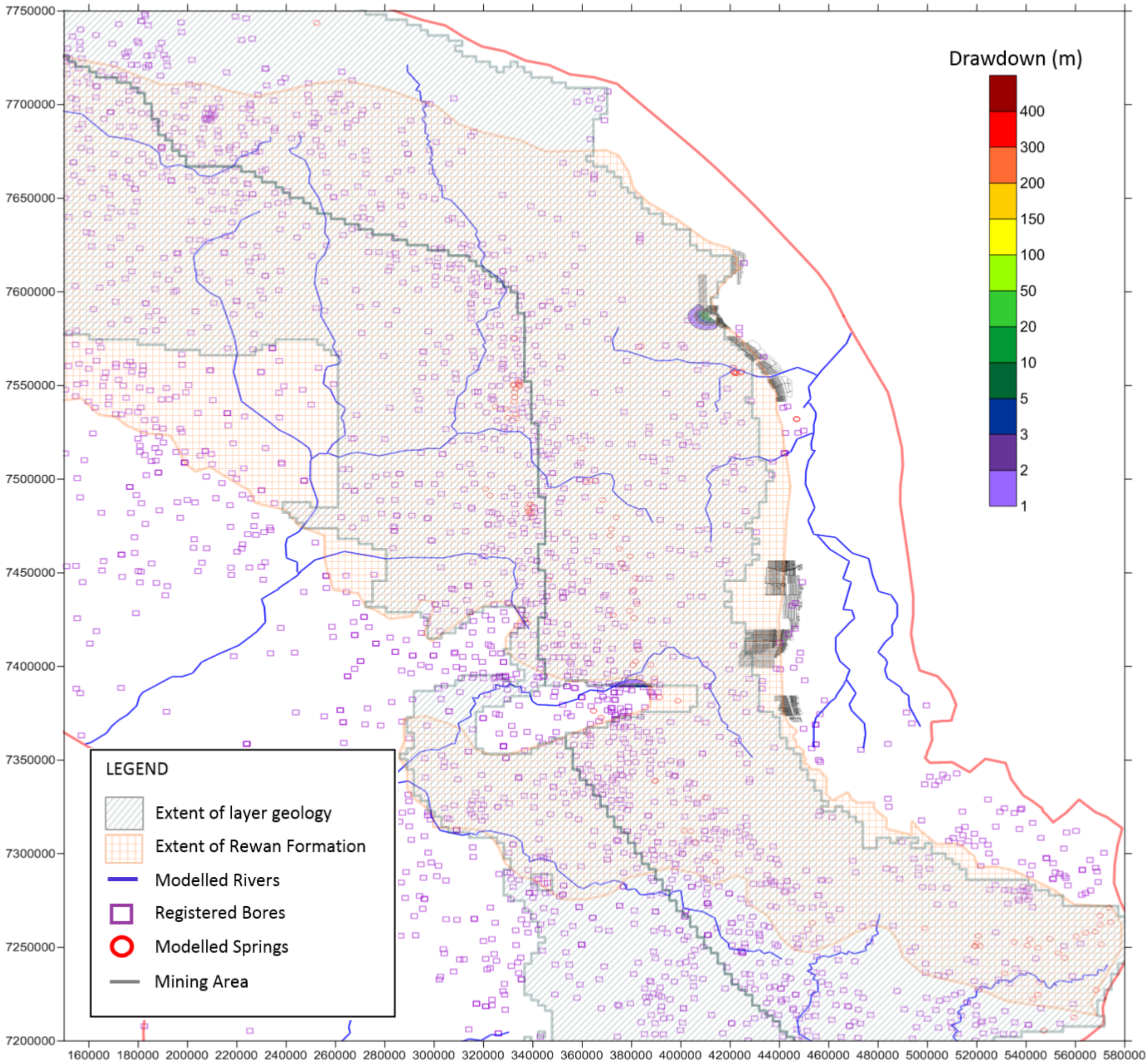
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

Layer 8 Drawdown 2025

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



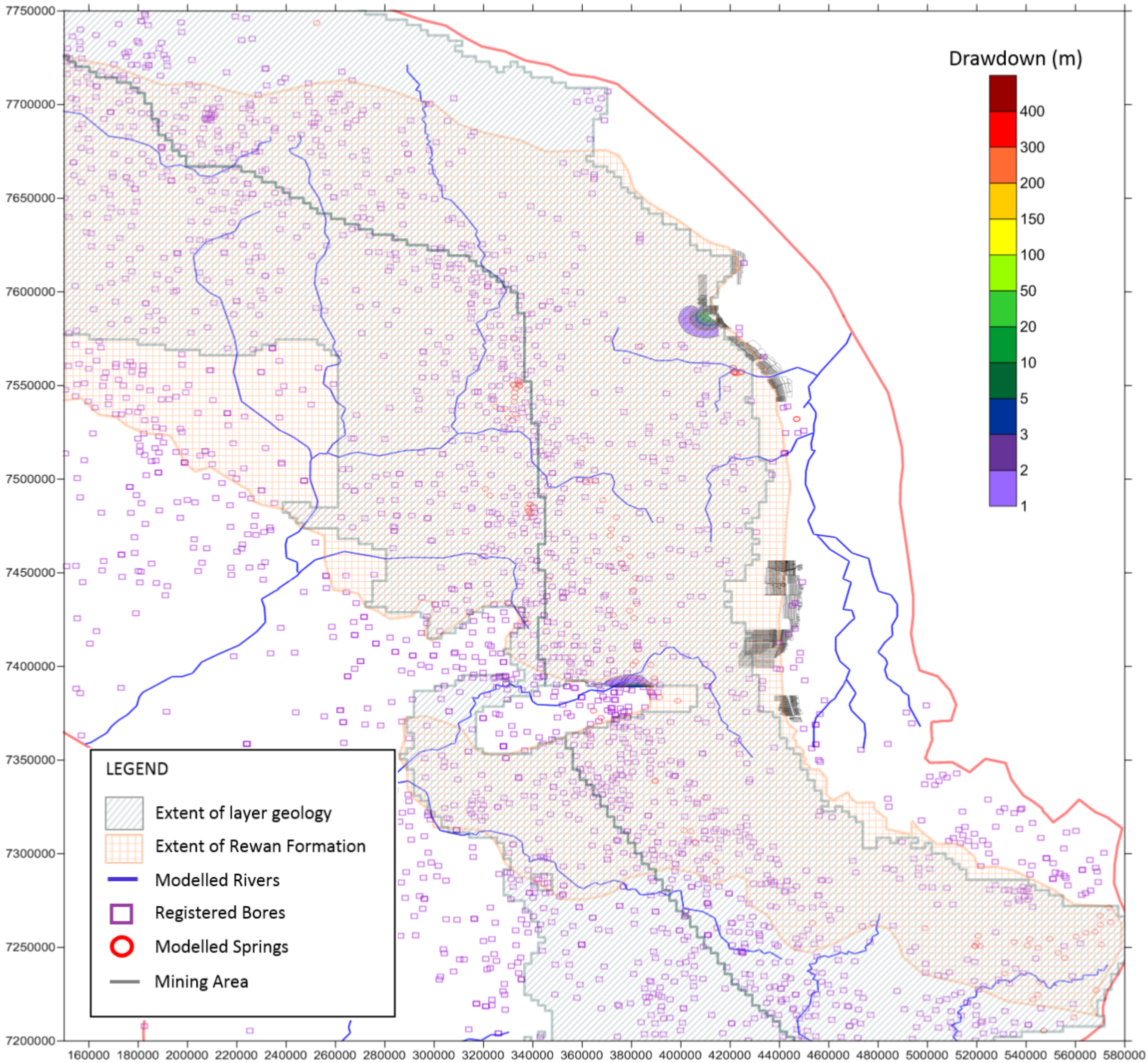
HYDROSIMULATIONS

10 OCTOBER 2015 | DRAWN BY: CT | Projection GDA 1994 MGA Zone 55

GEOSCIENCE AUSTRALIA | GSA001 - GALILEE BASIN MODEL

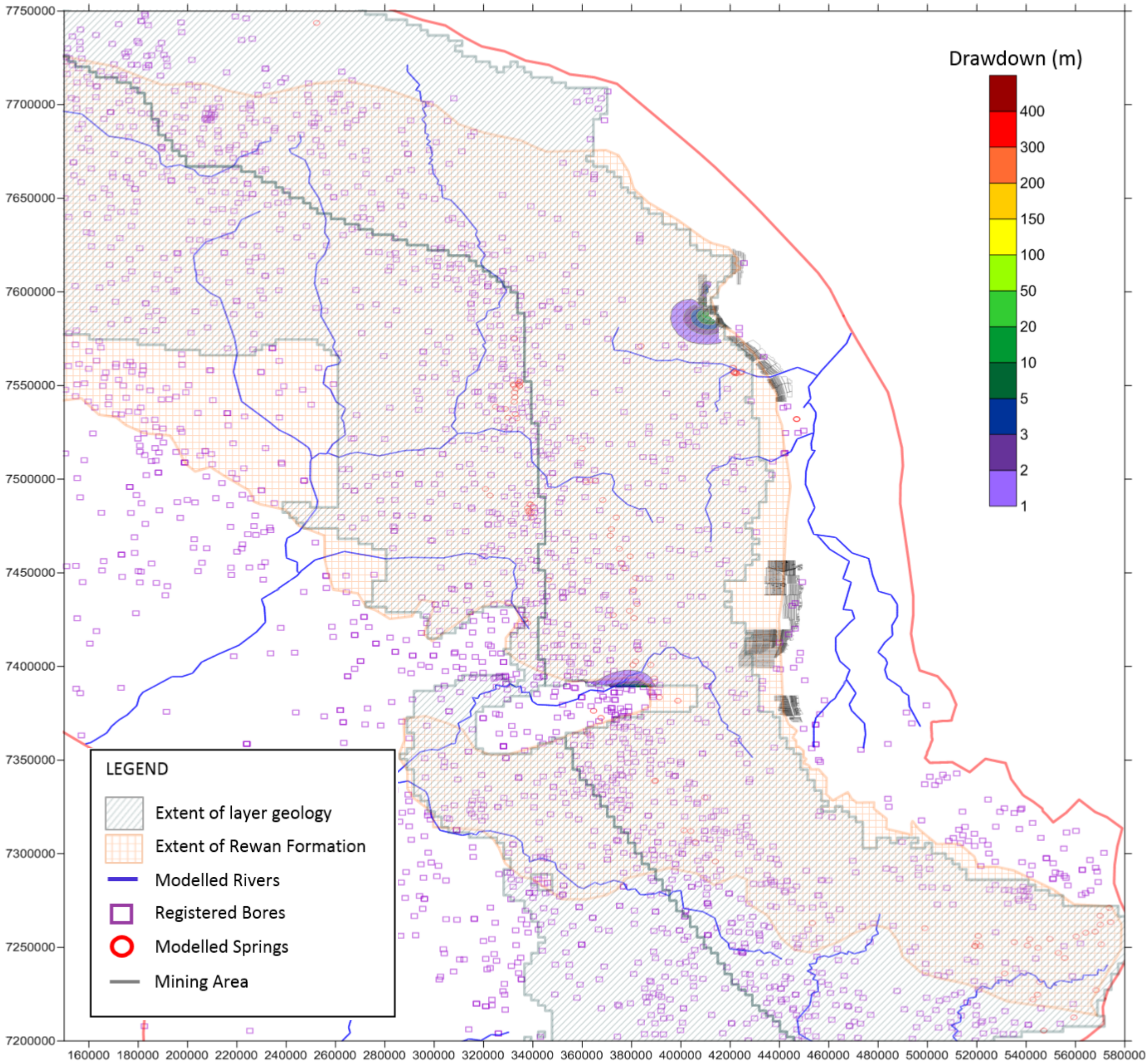
Layer 8 Drawdown 2030

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 8 Drawdown 2035		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 8 Drawdown 2040		

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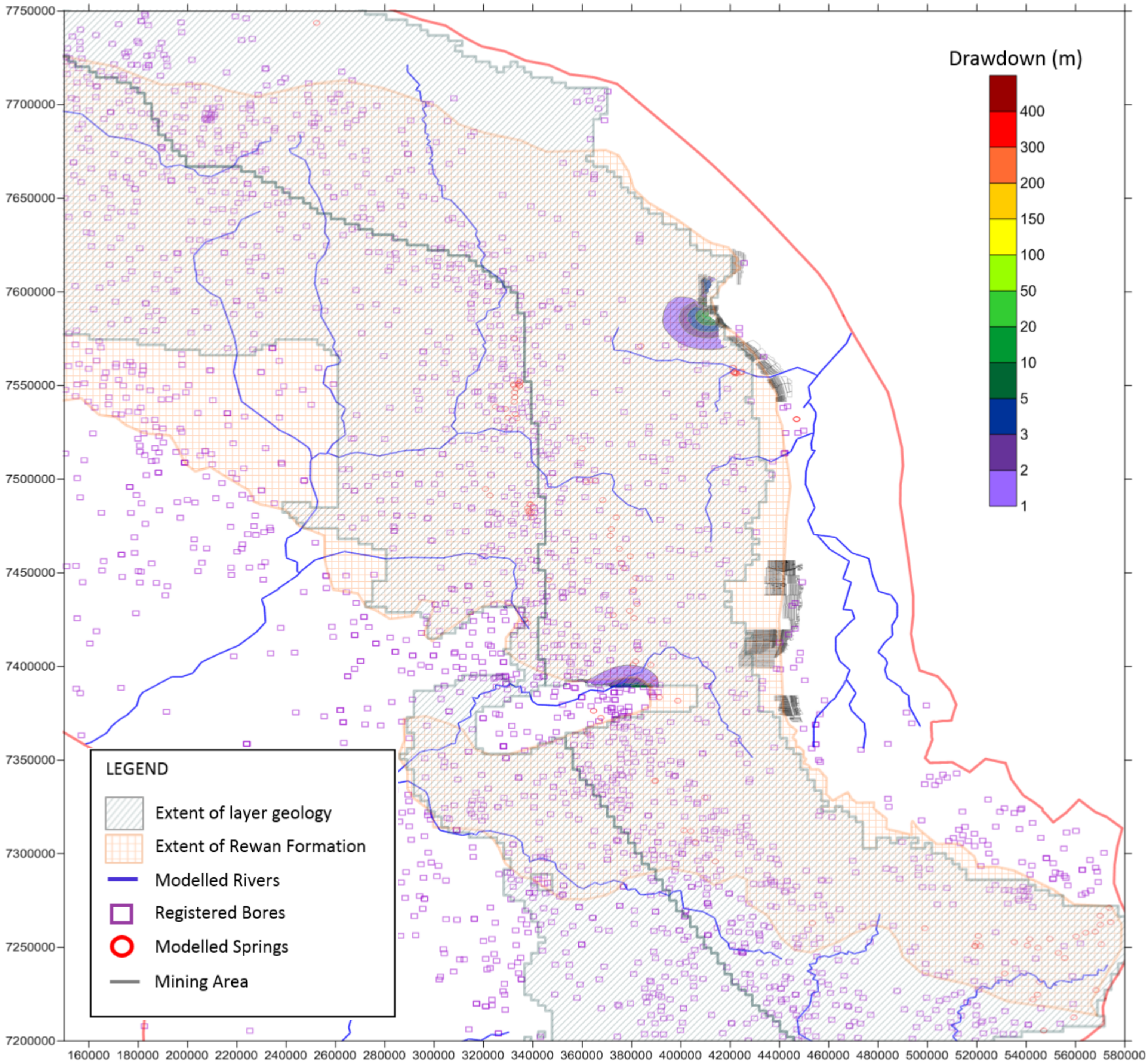

HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 8 Drawdown 2045		

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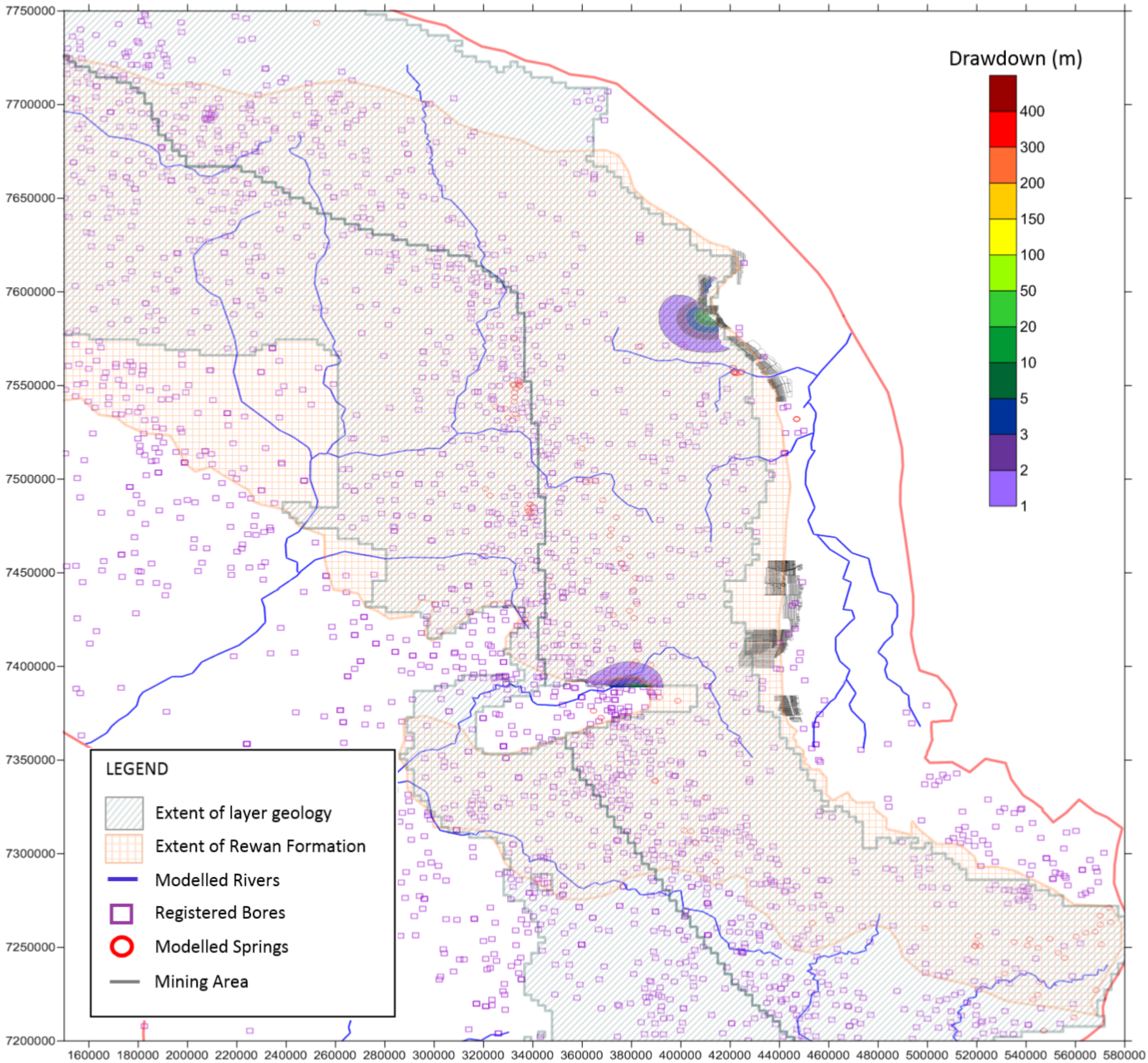

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 8 Drawdown 2048		

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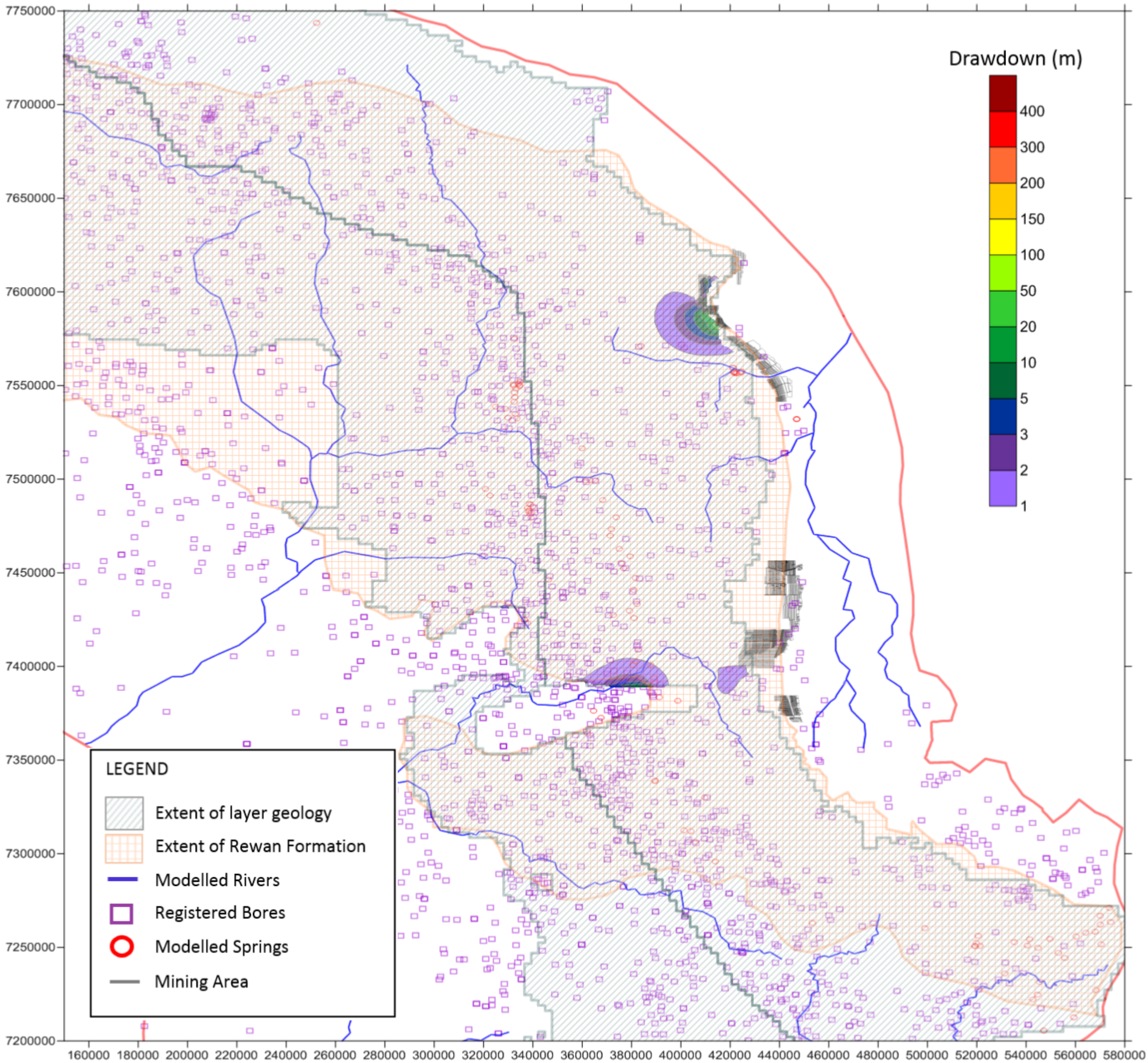

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 8 Drawdown 2050		

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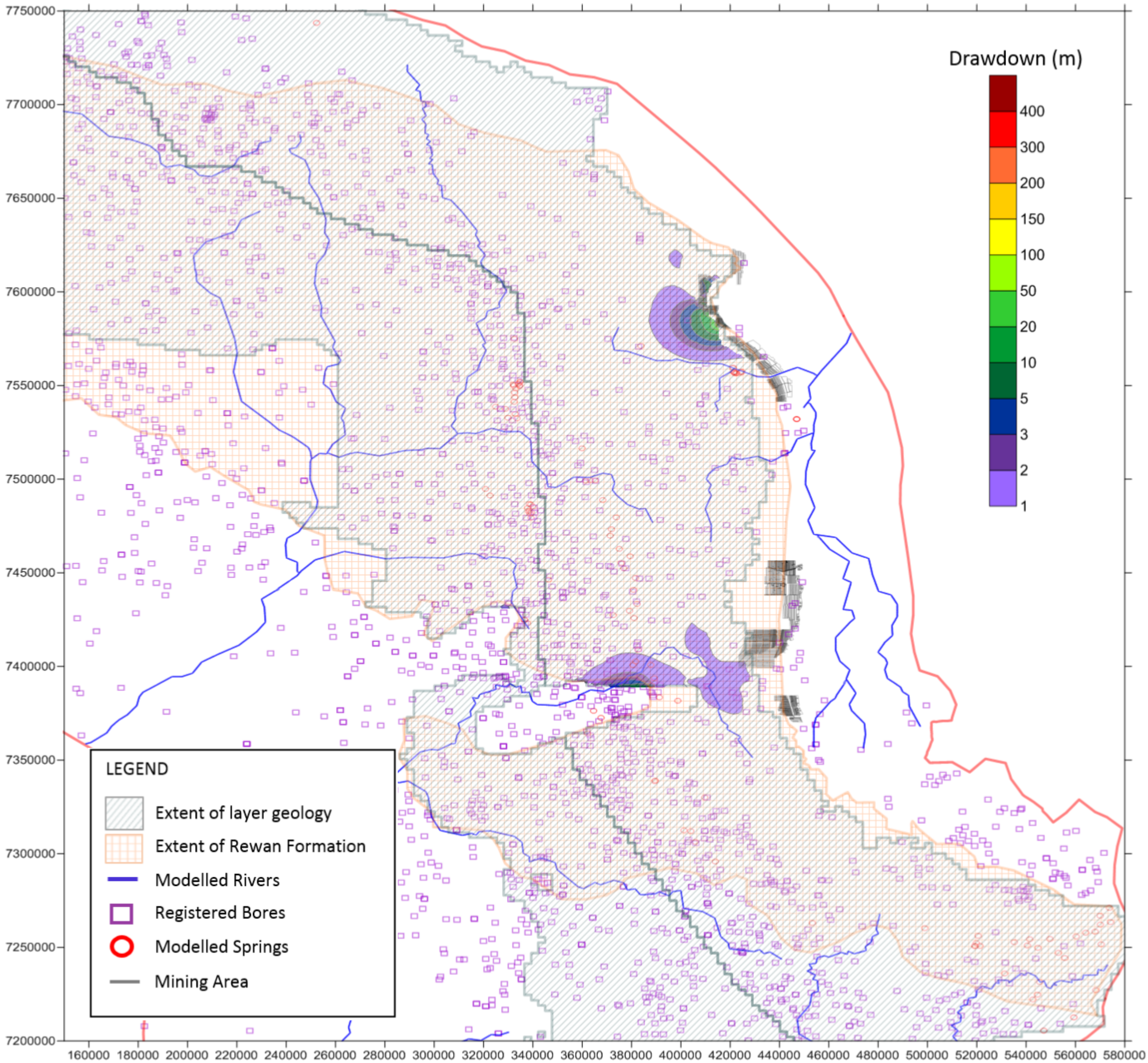

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 8 Drawdown 2055		

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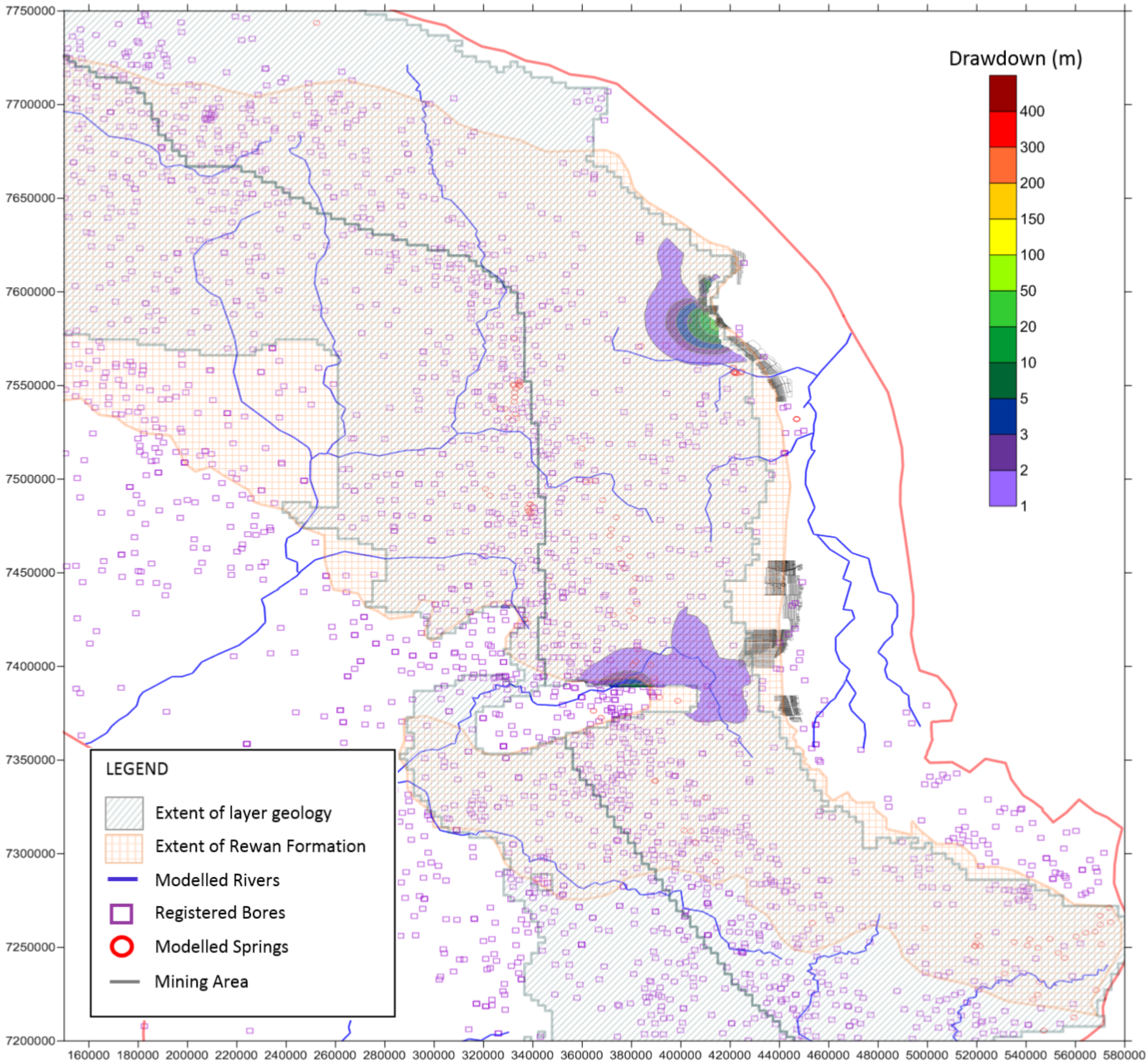
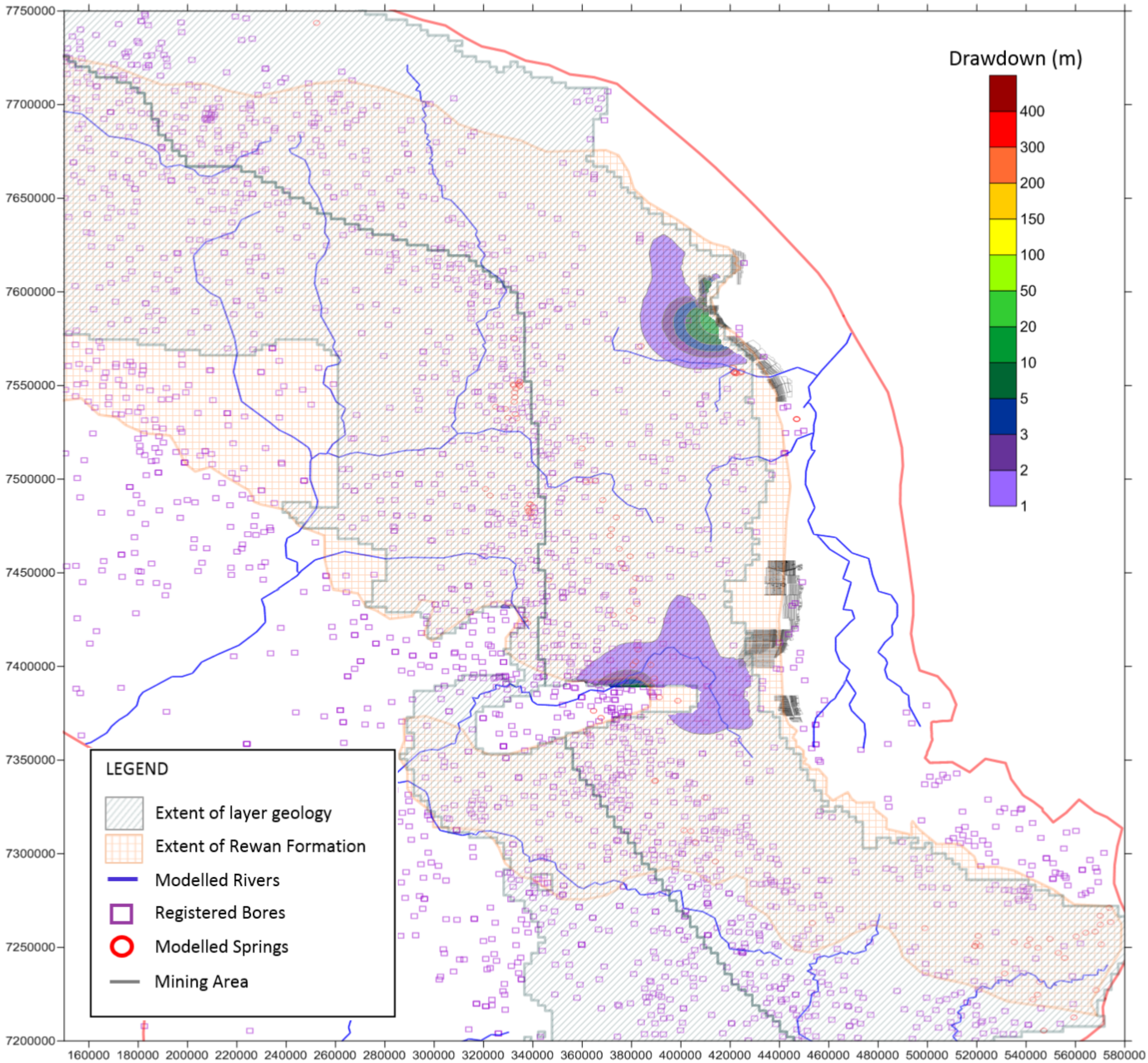


HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 8 Drawdown 2058

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 8 Drawdown 2061		

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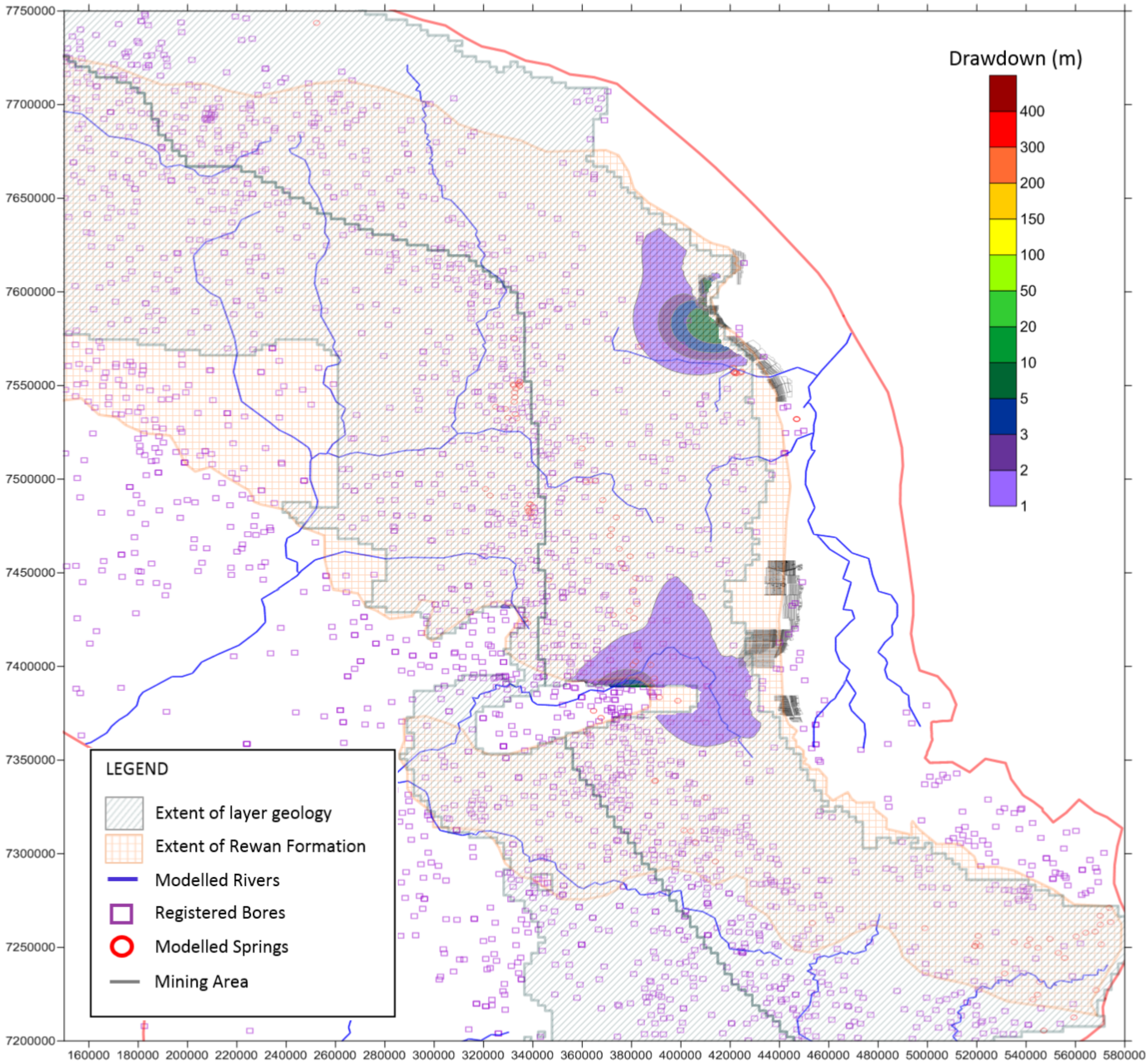

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 8 Drawdown 2067

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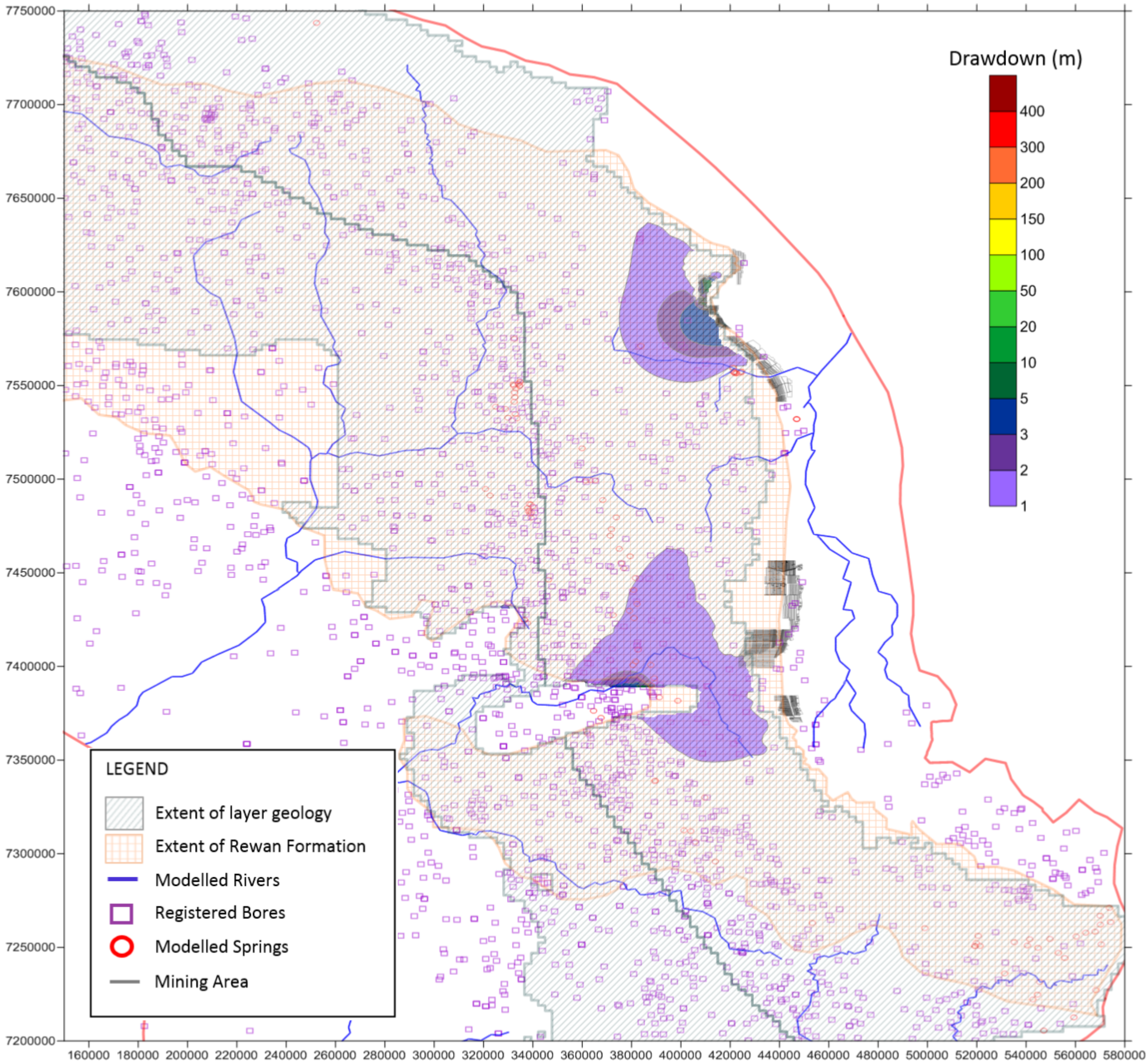

HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 8 Drawdown 2080		

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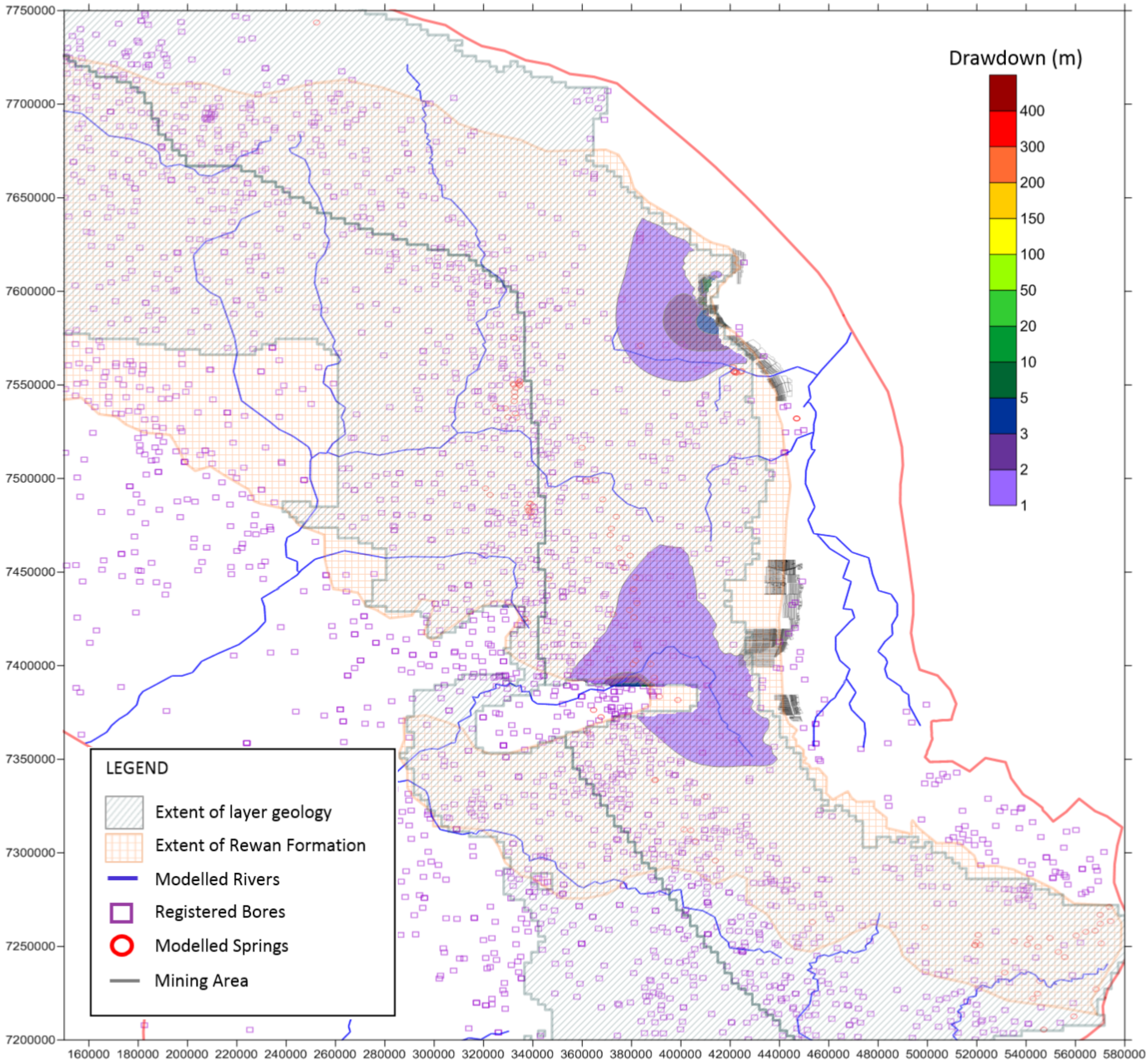

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 8 Drawdown 2090		

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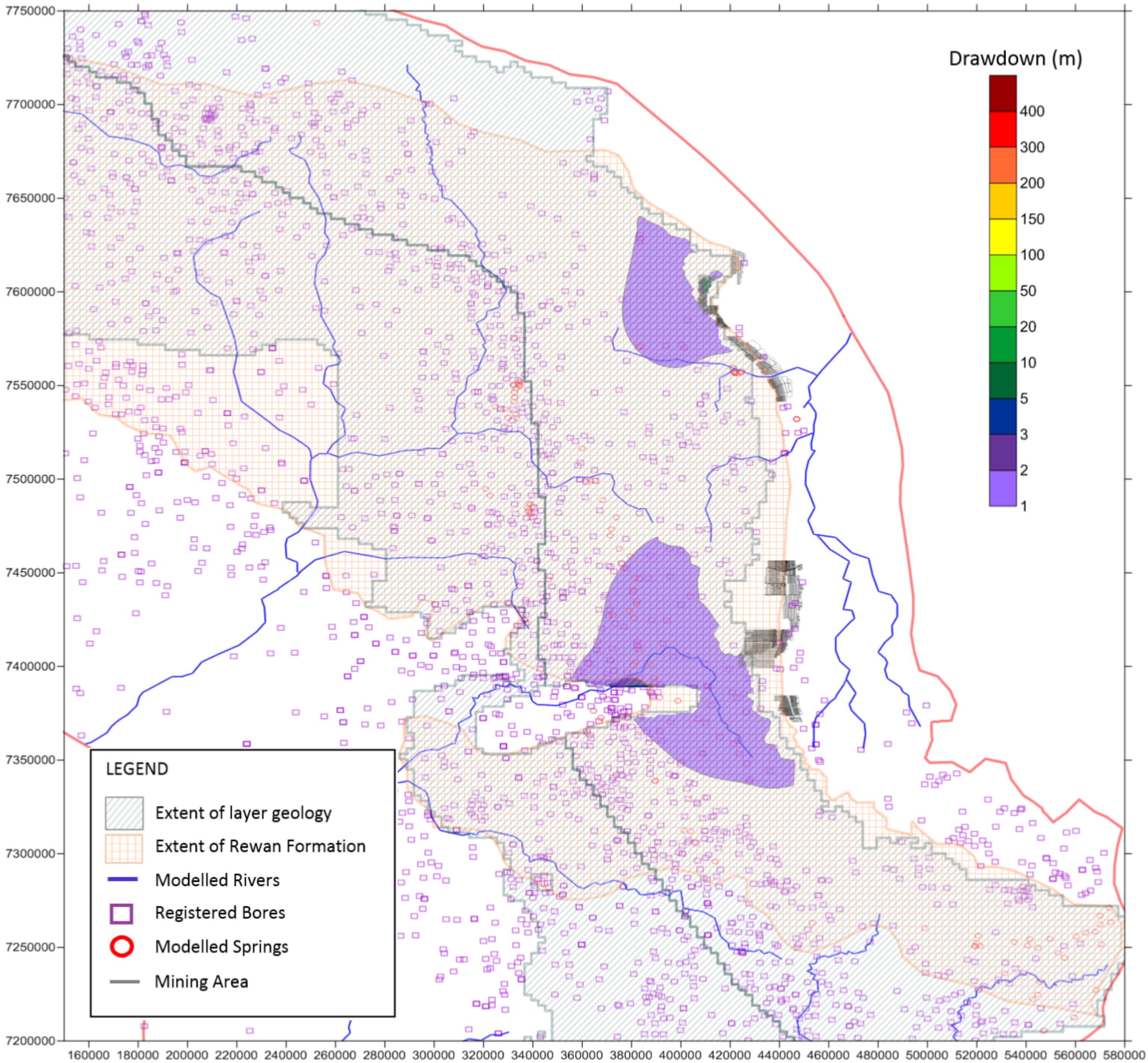

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	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 8 Drawdown 2110		

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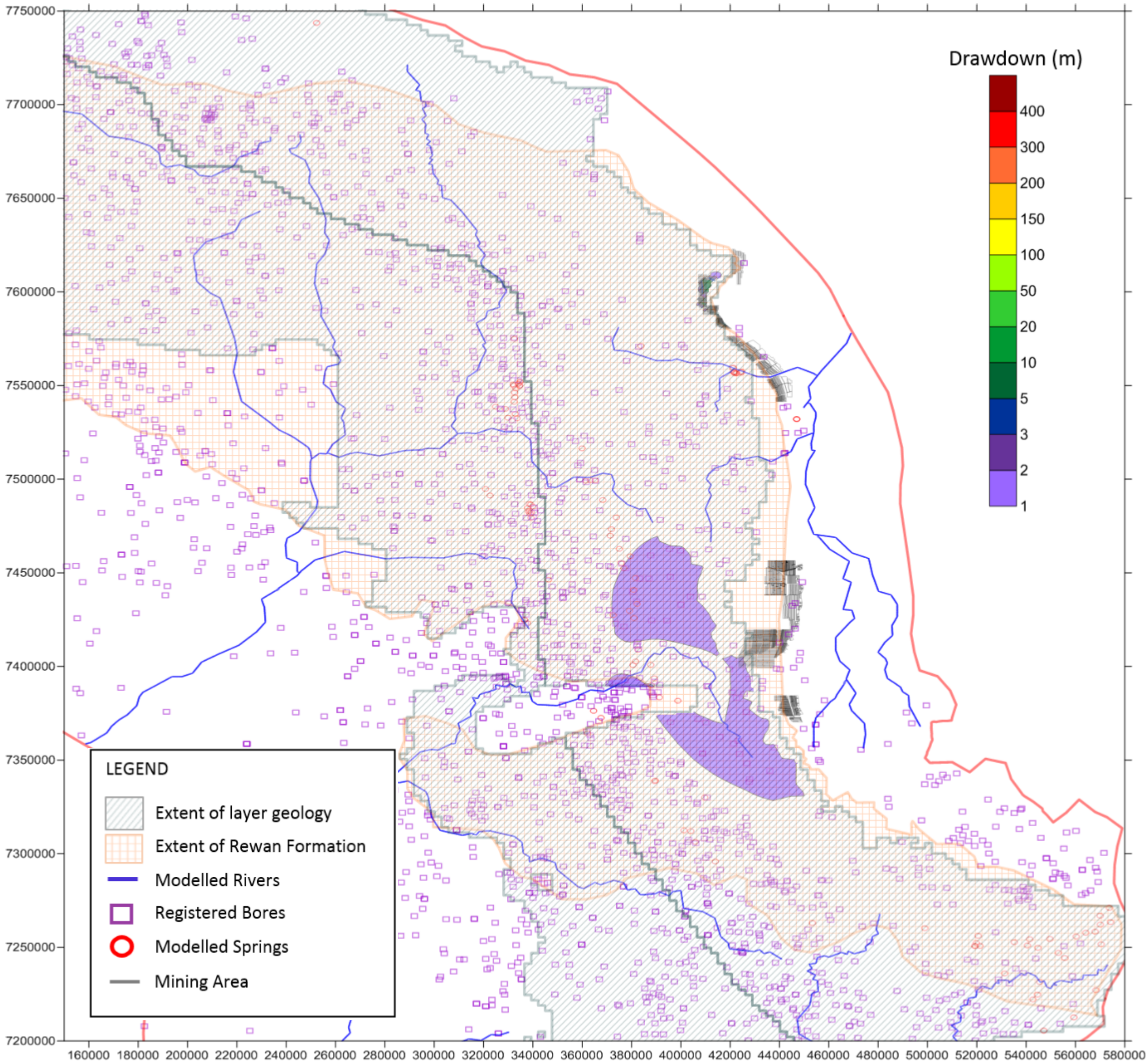

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 8 Drawdown 2200		

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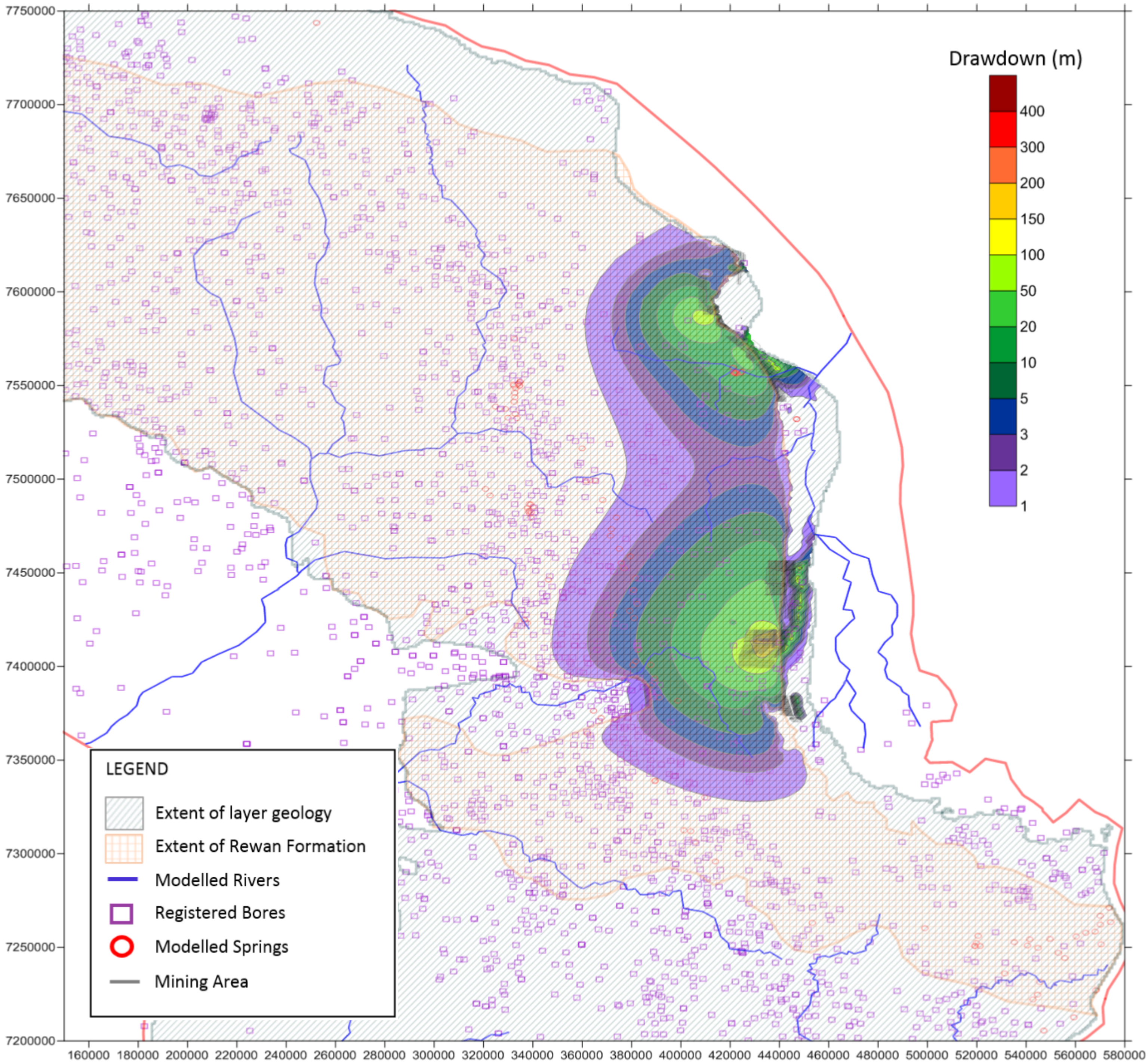

HYDROSIMULATIONS

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 10 Drawdown 2020

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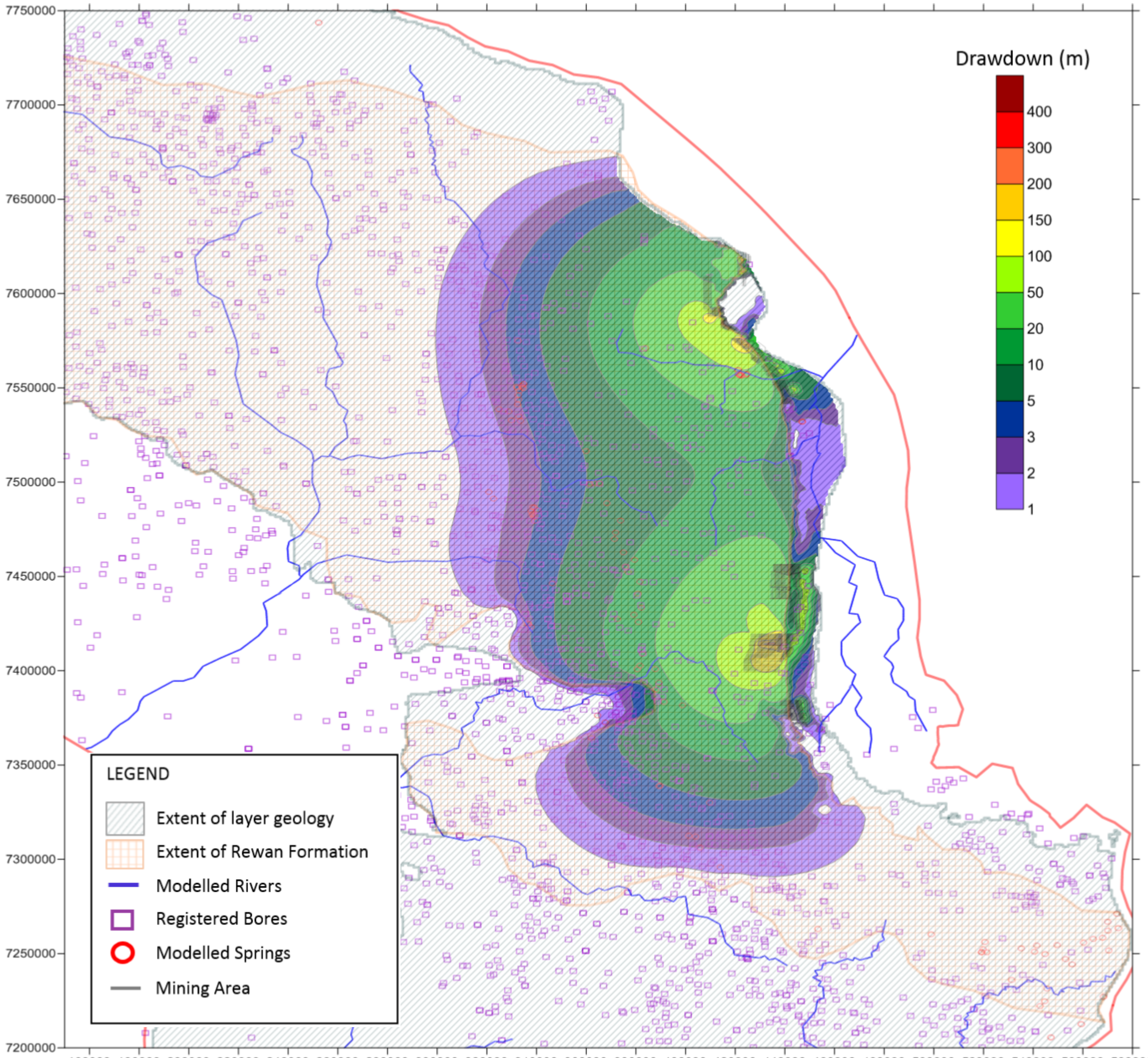

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 10 Drawdown 2025

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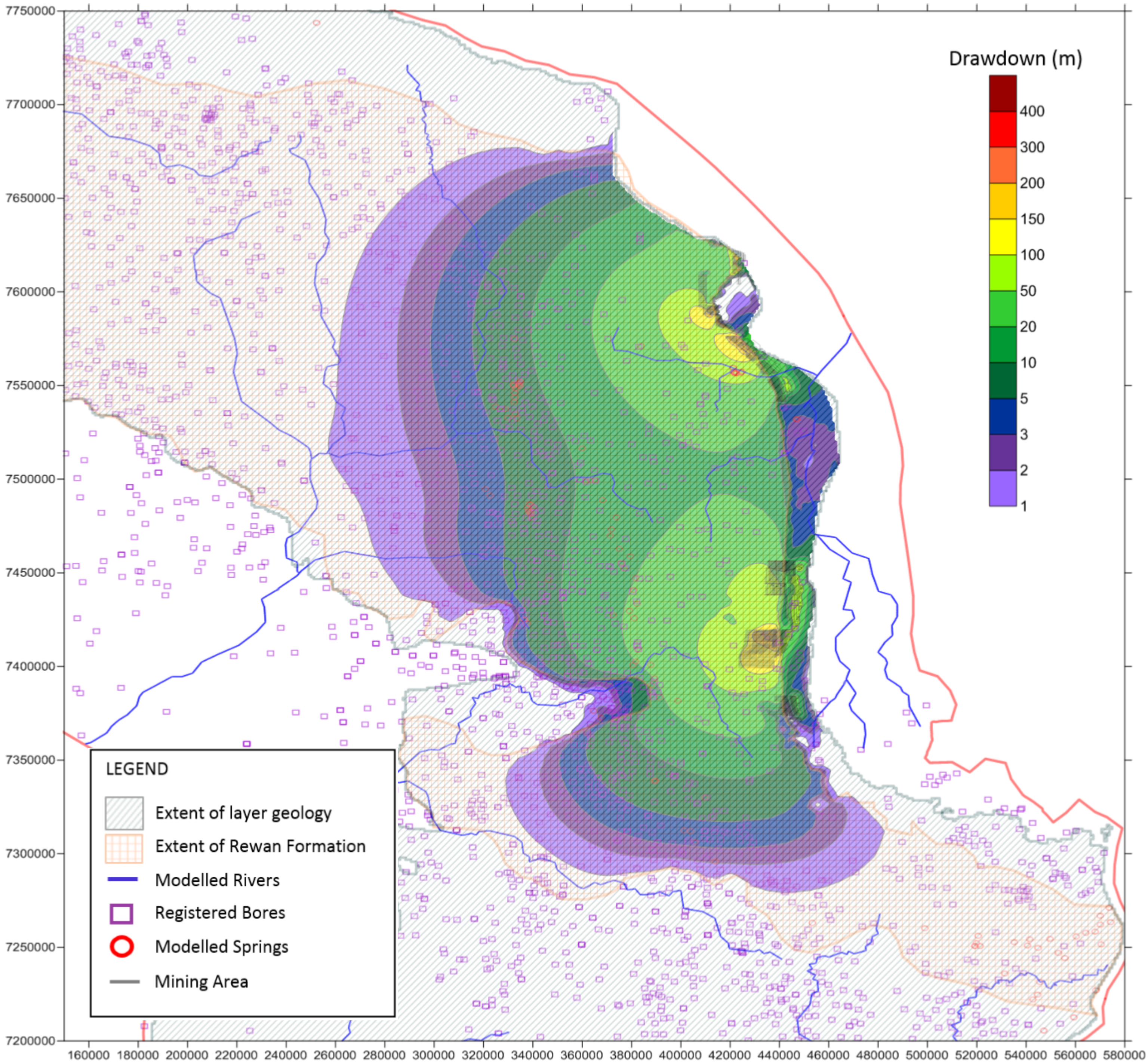

HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 10 Drawdown 2030		

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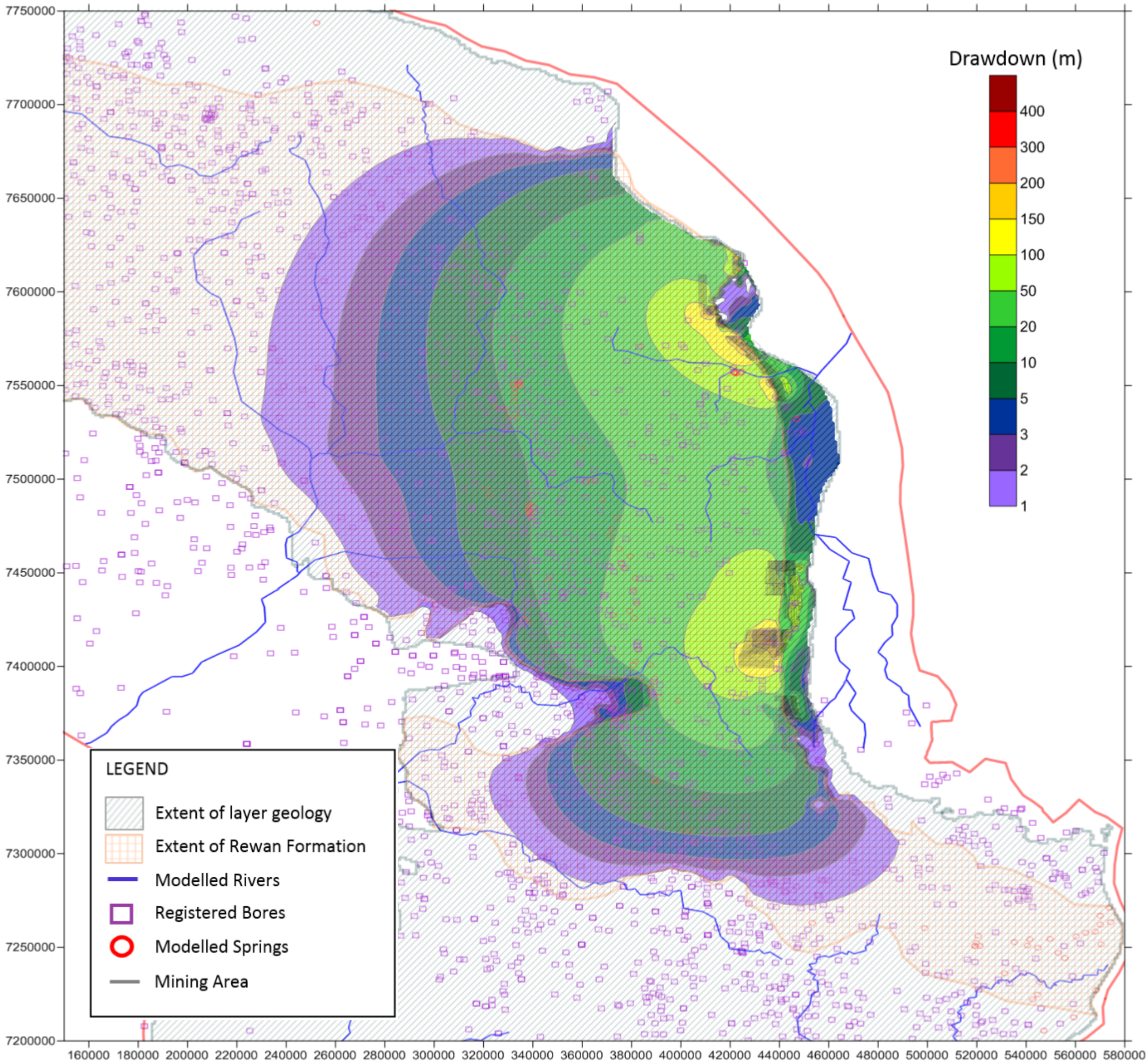


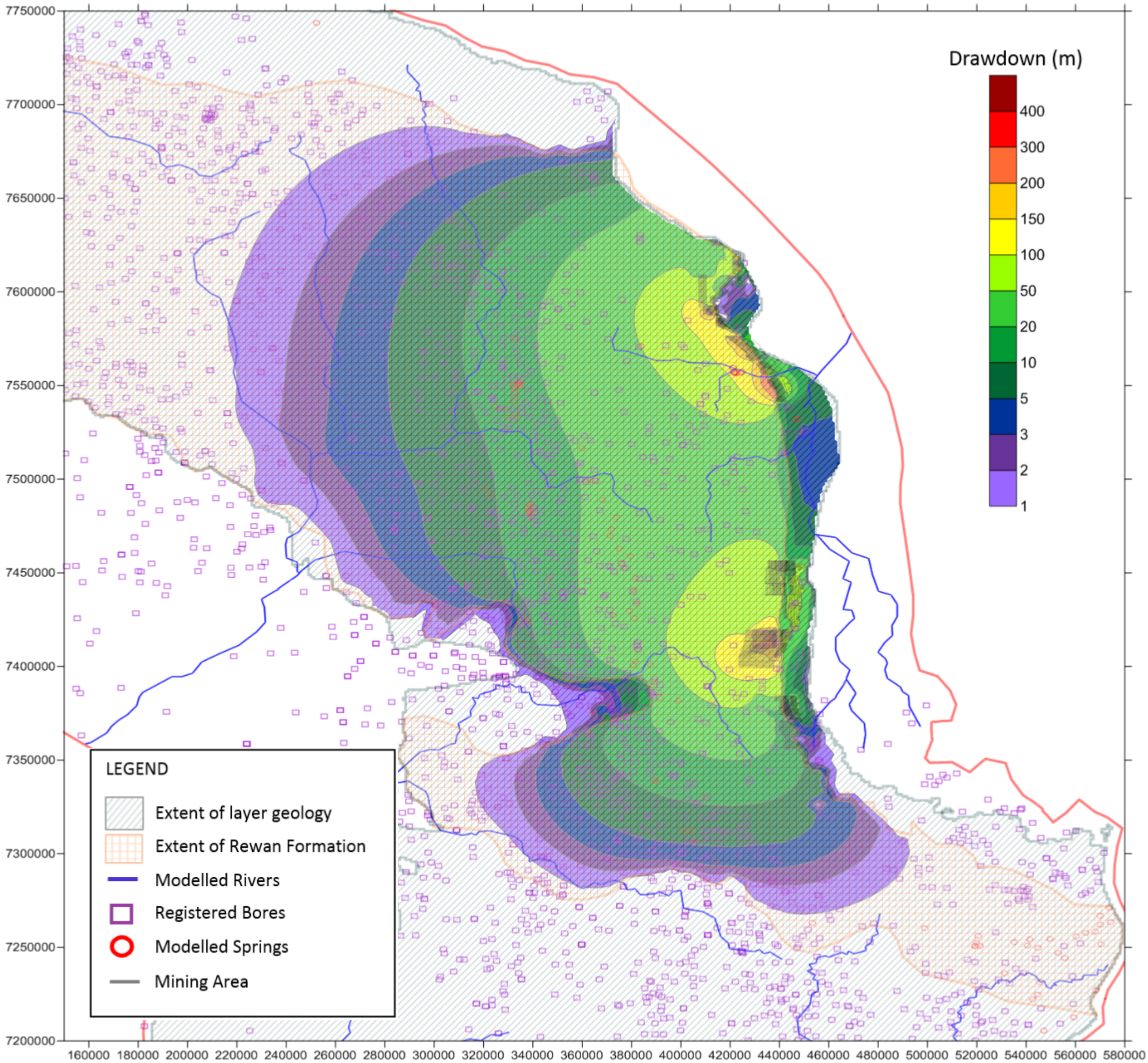
HYDROSIMULATIONS

10 OCTOBER 2015 | DRAWN BY: CT | Projection GDA 1994 MGA Zone 55

GEOSCIENCE AUSTRALIA | GSA001 - GALILEE BASIN MODEL

Layer 10 Drawdown 2035

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



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GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL

HYDROSIMULATIONS

Layer 10 Drawdown 2040

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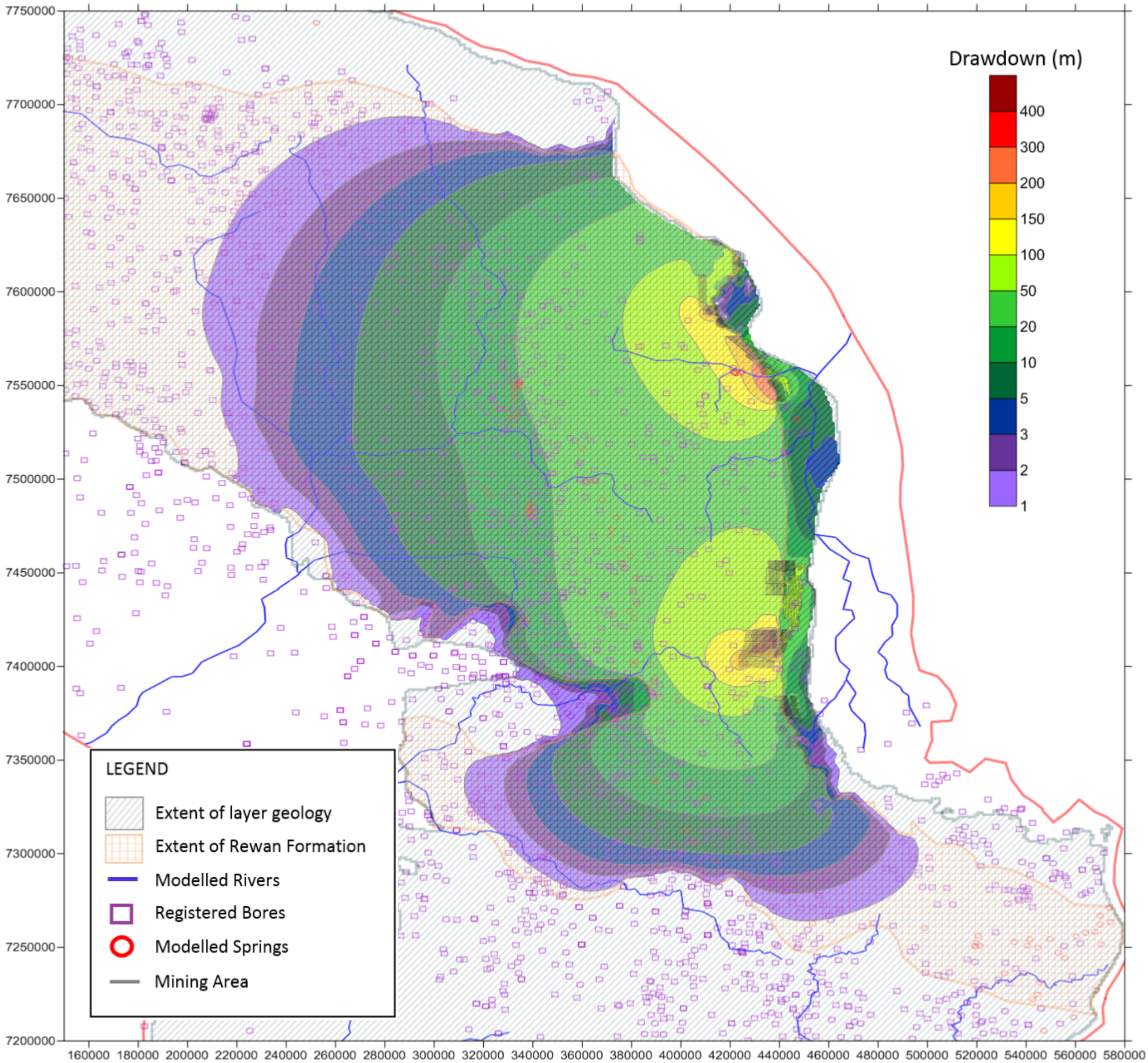

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HydroSimulations

Layer 10 Drawdown 2045

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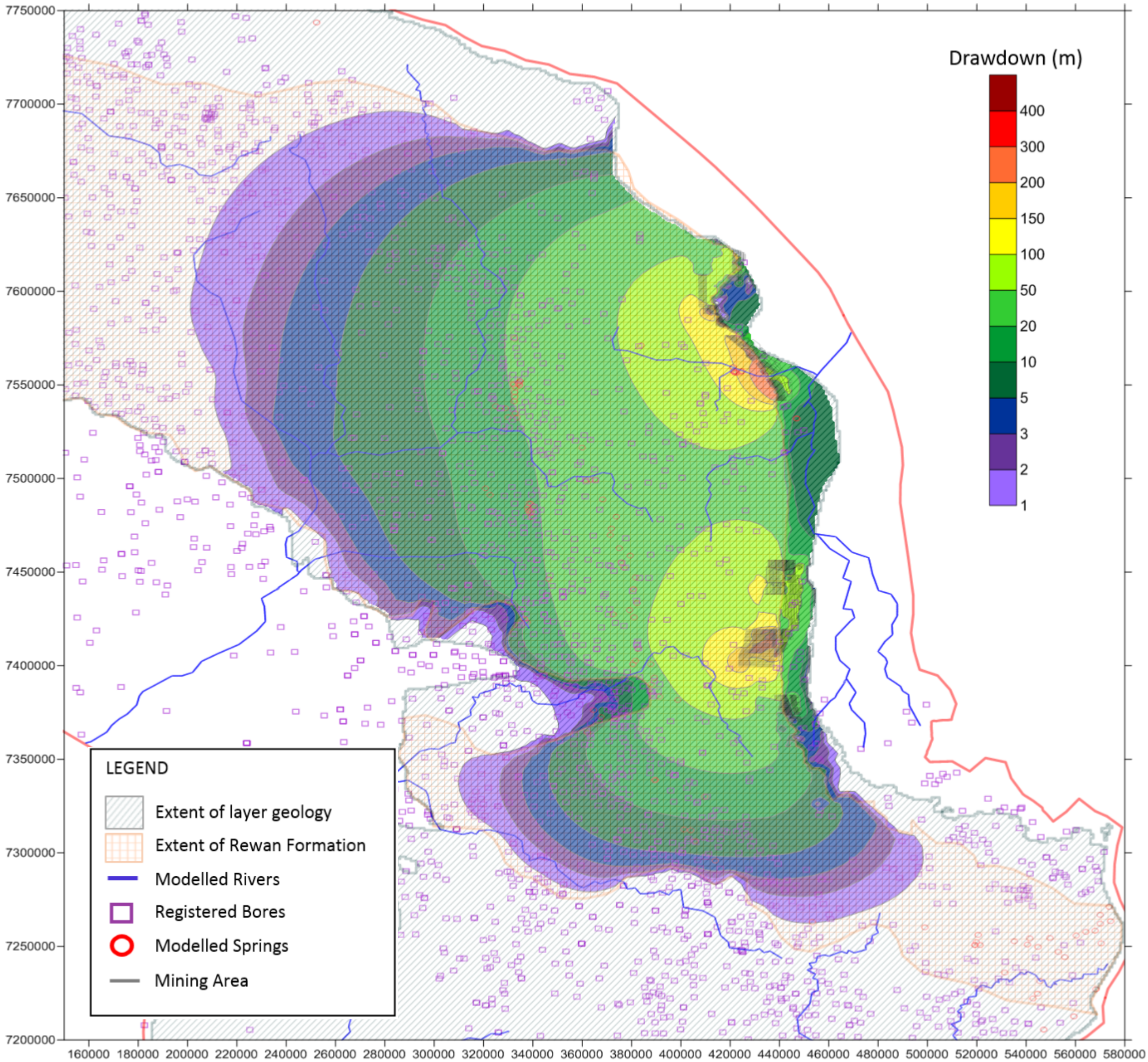

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 10 Drawdown 2048

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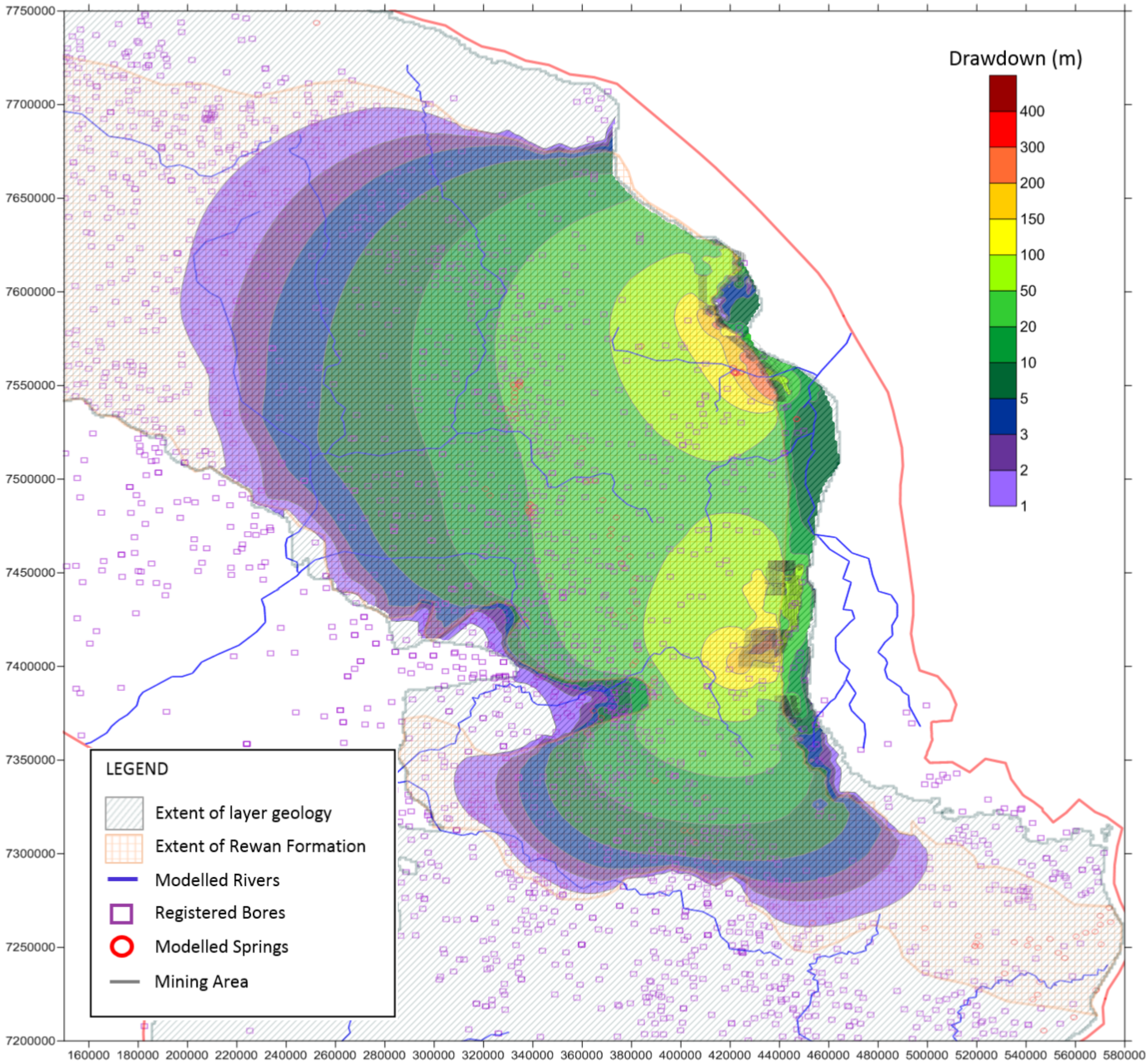

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55

GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL

HYDROSIMULATIONS

Layer 10 Drawdown 2050

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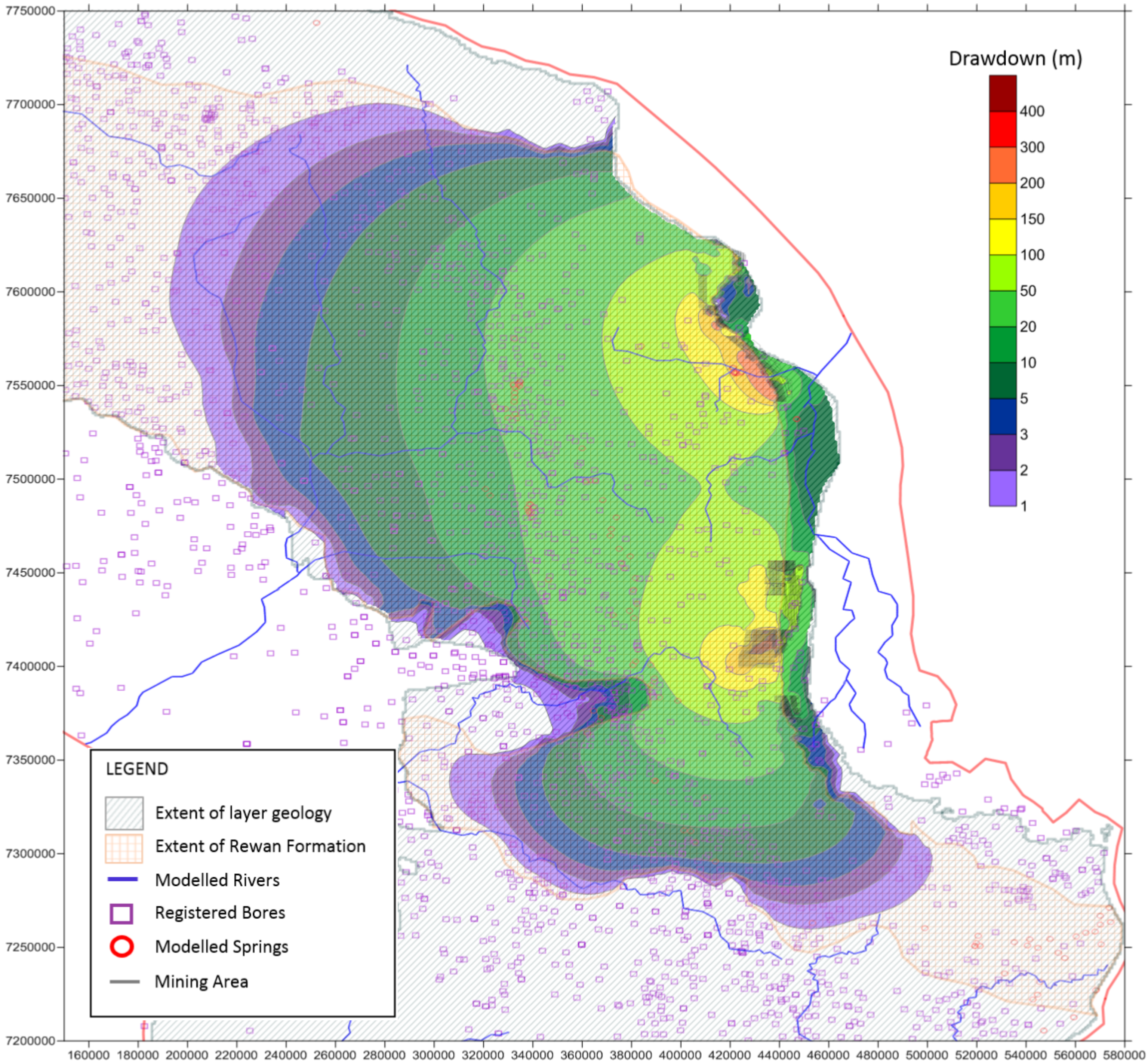

HYDRO SIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 10 Drawdown 2055

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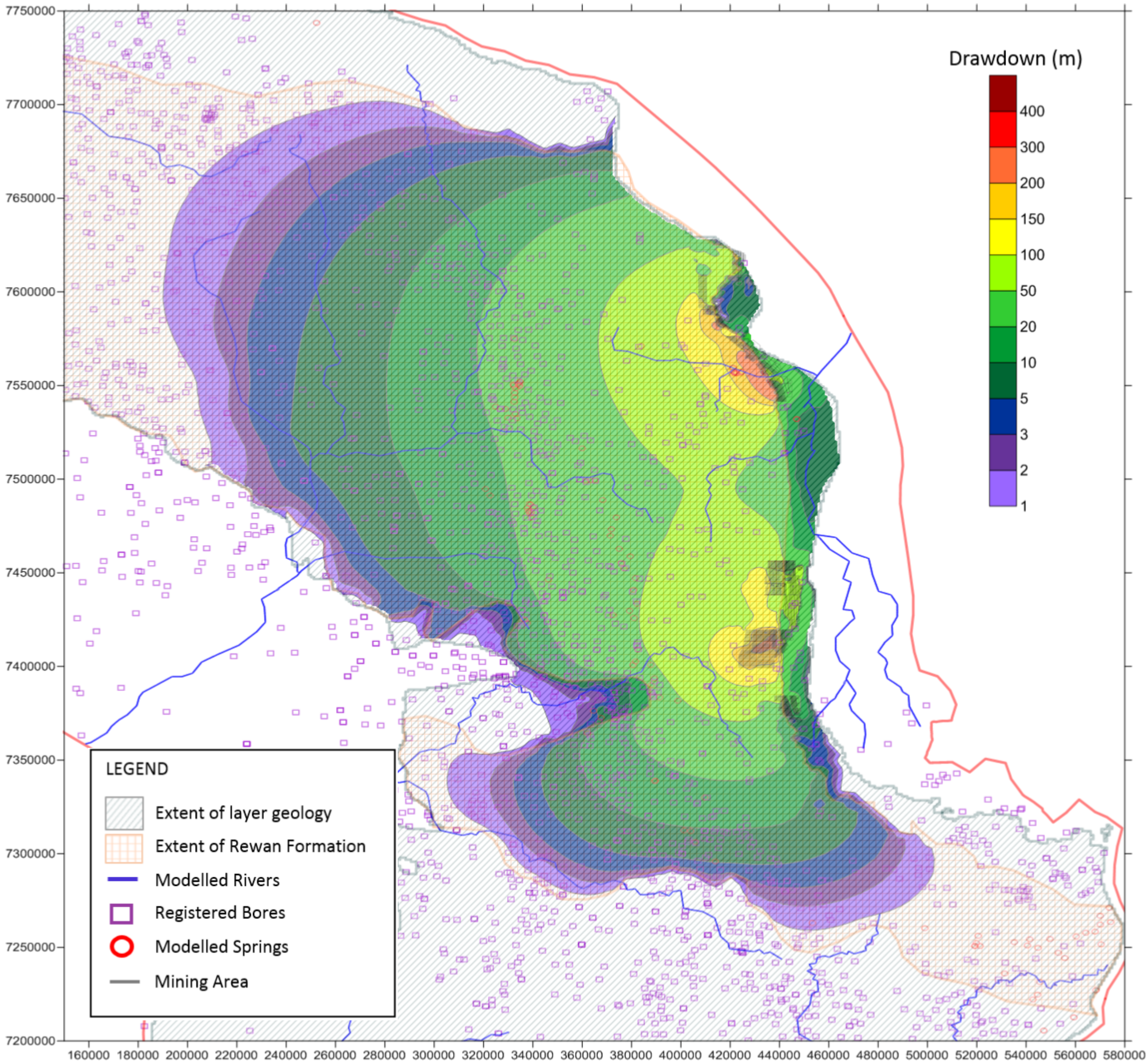

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 10 Drawdown 2058

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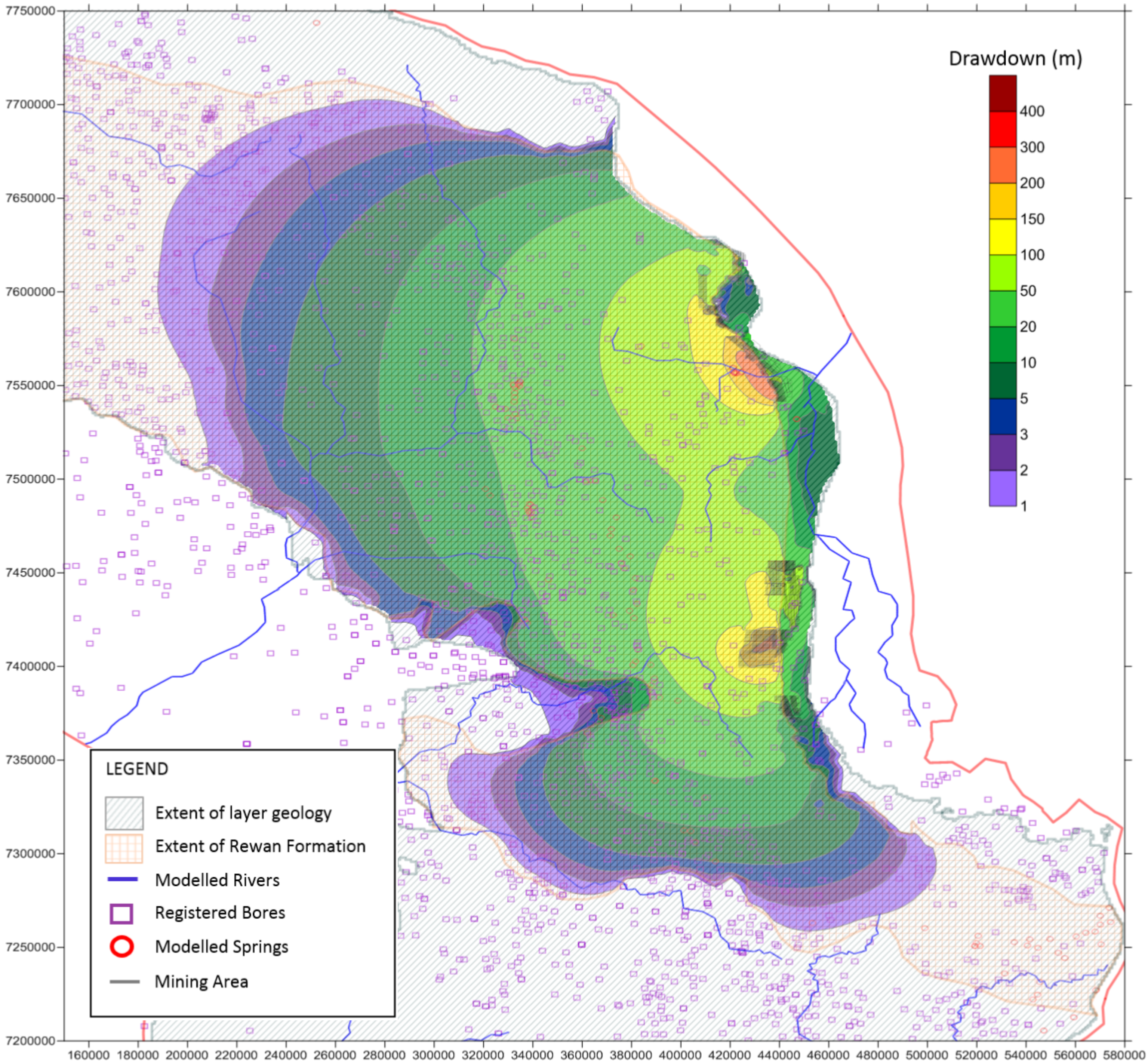

HYDRO SIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 10 Drawdown 2061

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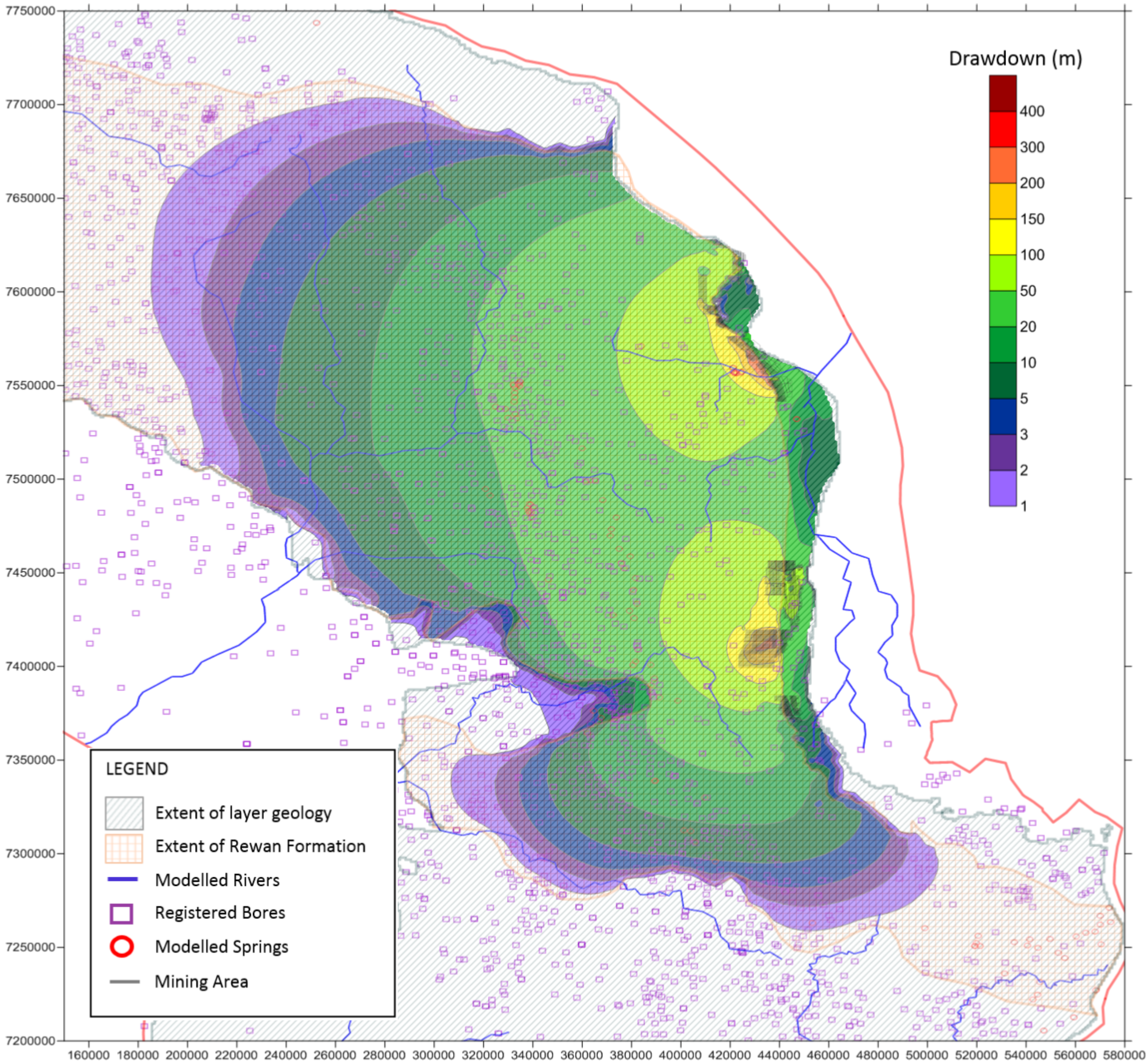


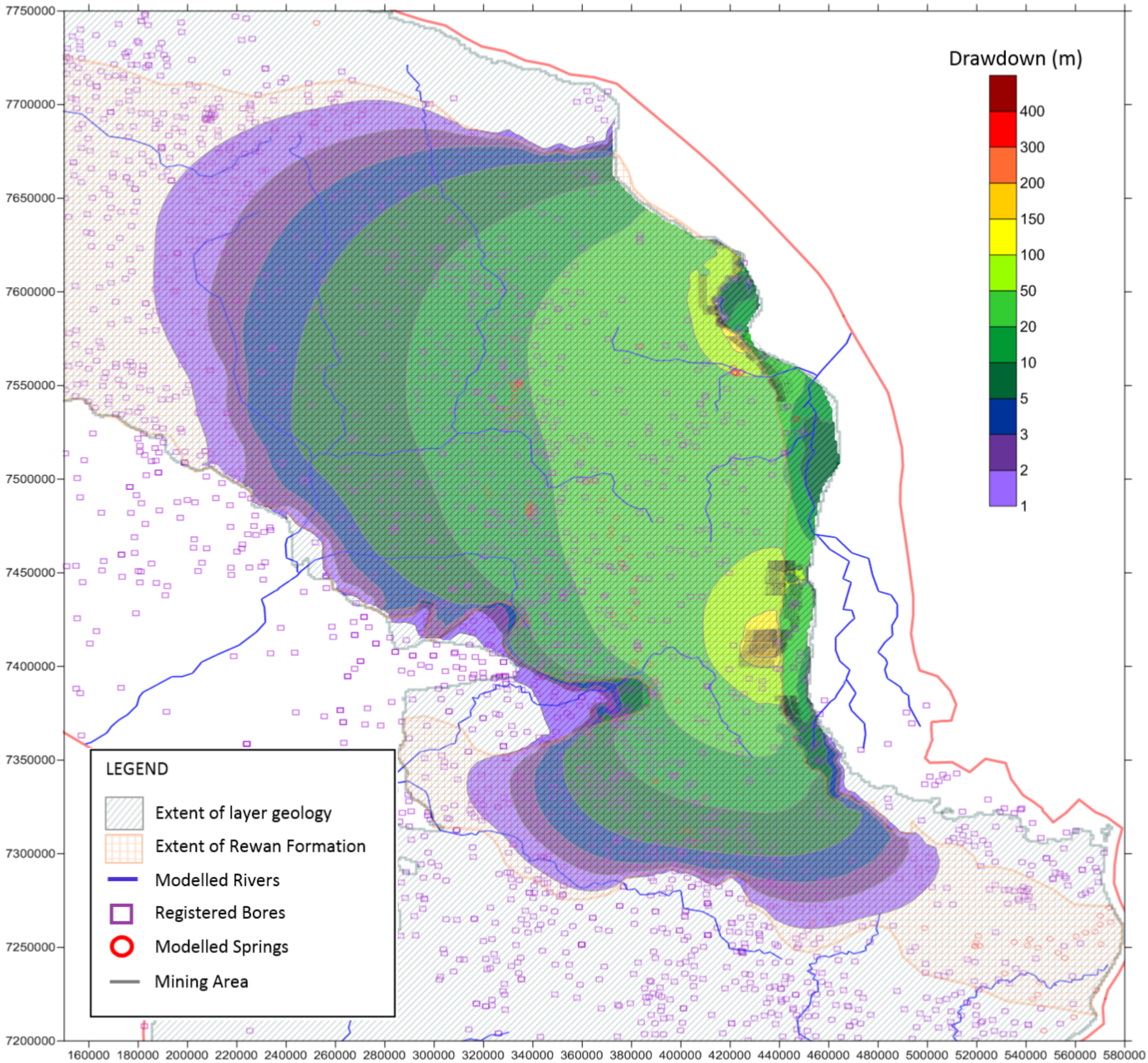
HYDROSIMULATIONS

10 OCTOBER 2015 | DRAWN BY: CT | Projection GDA 1994 MGA Zone 55

GEOSCIENCE AUSTRALIA | GSA001 - GALILEE BASIN MODEL

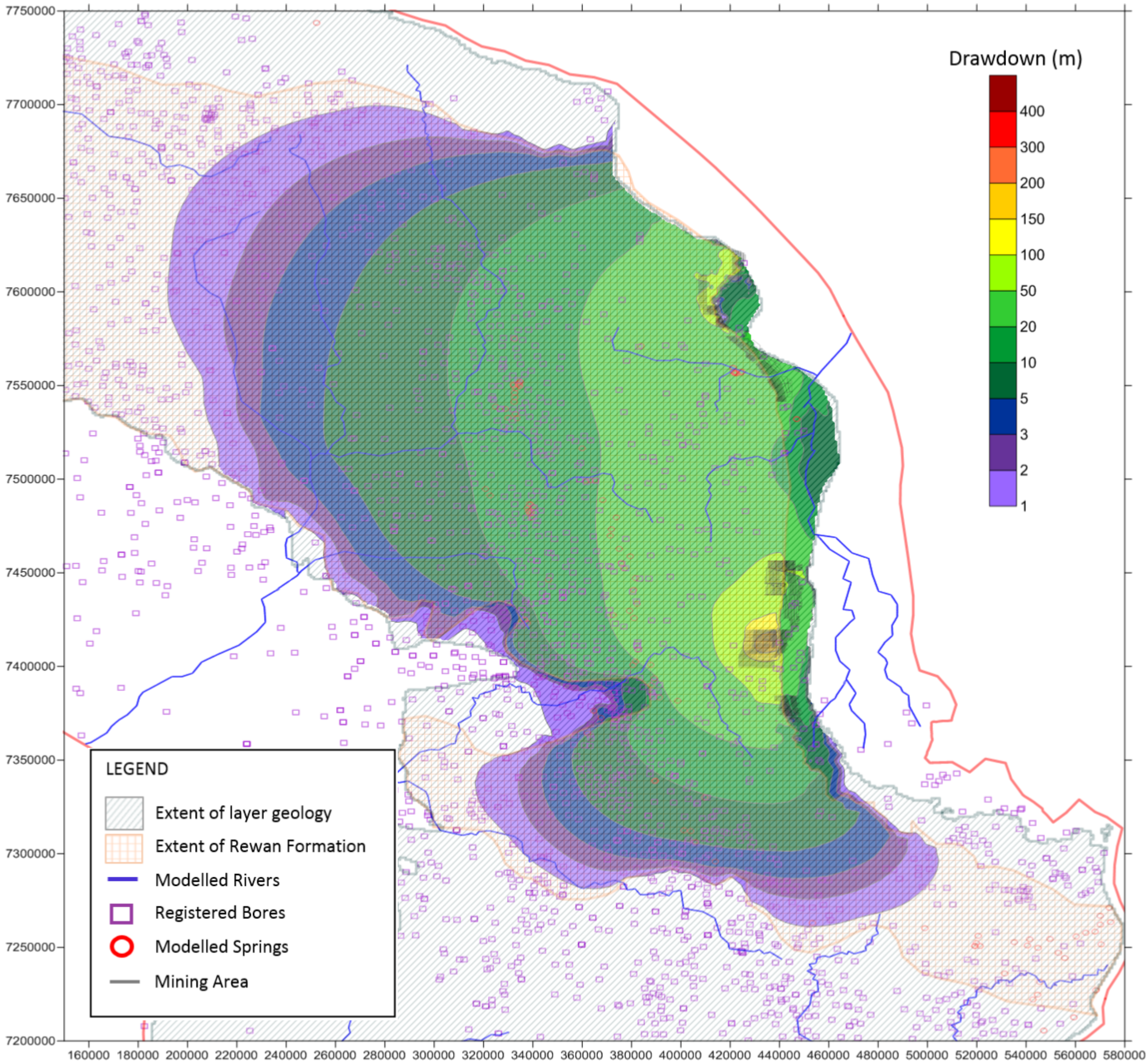
Layer 10 Drawdown 2067

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 10 Drawdown 2080		

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

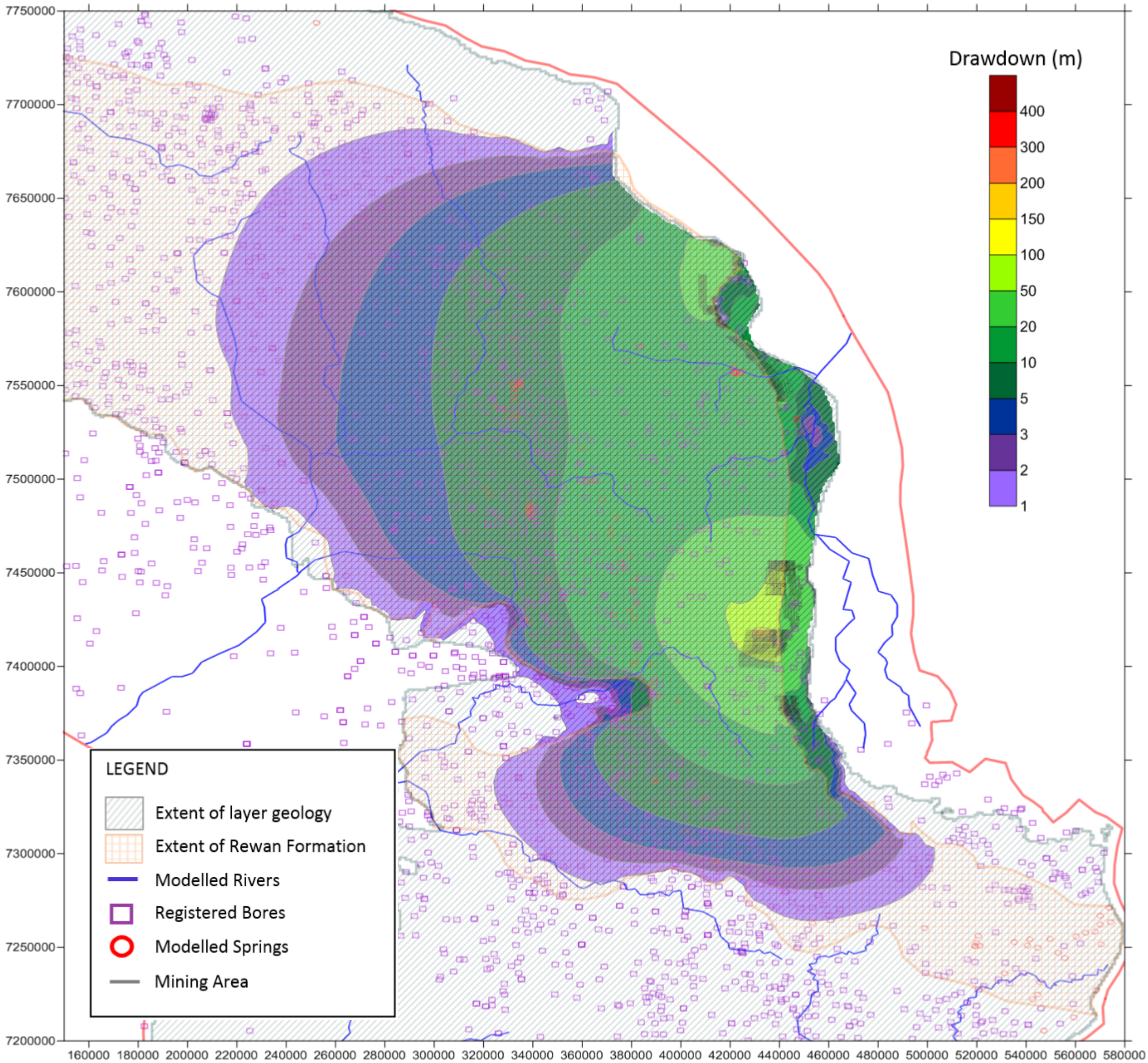


10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 10 Drawdown 2090

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 10 Drawdown 2110		

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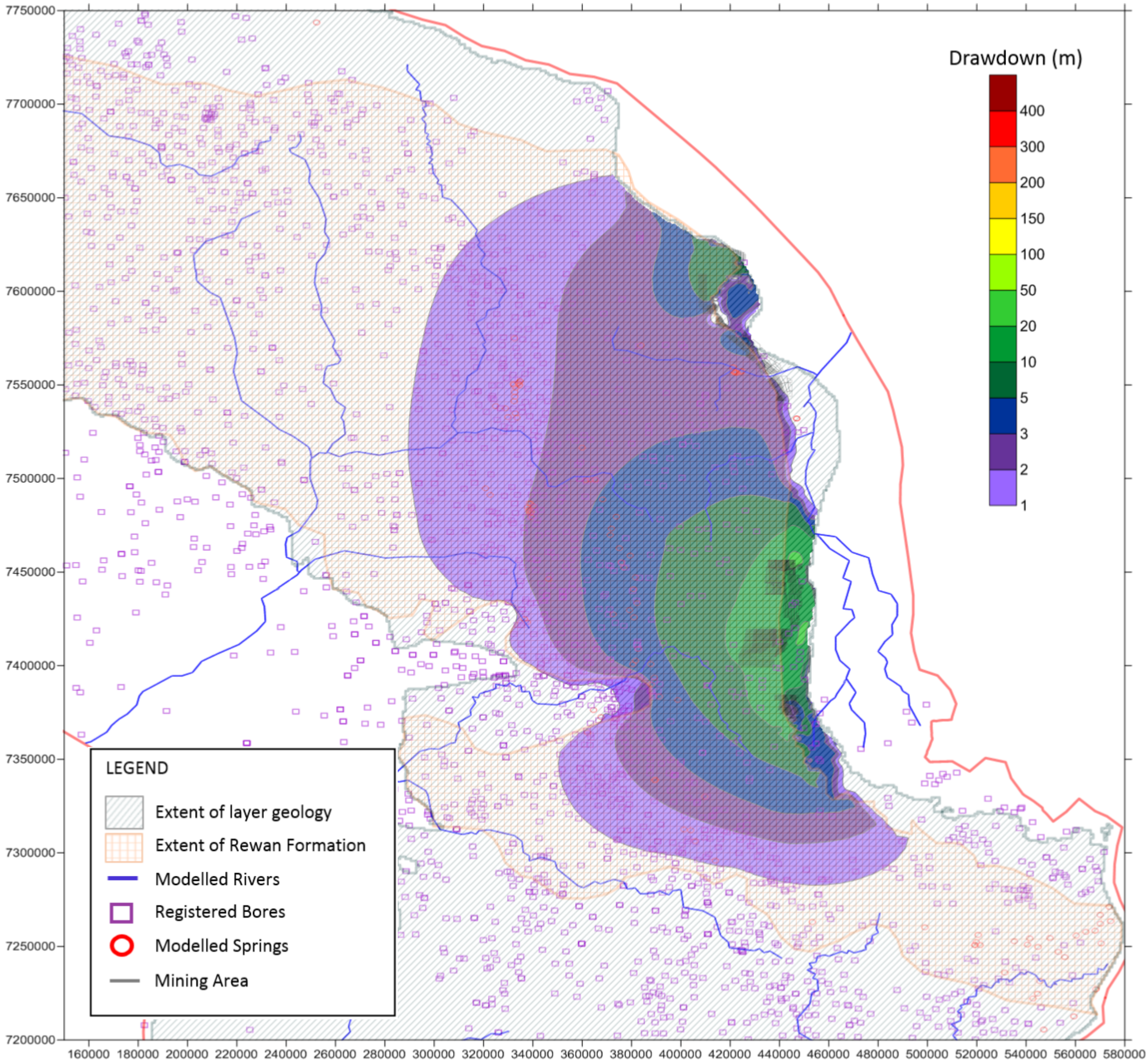

HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
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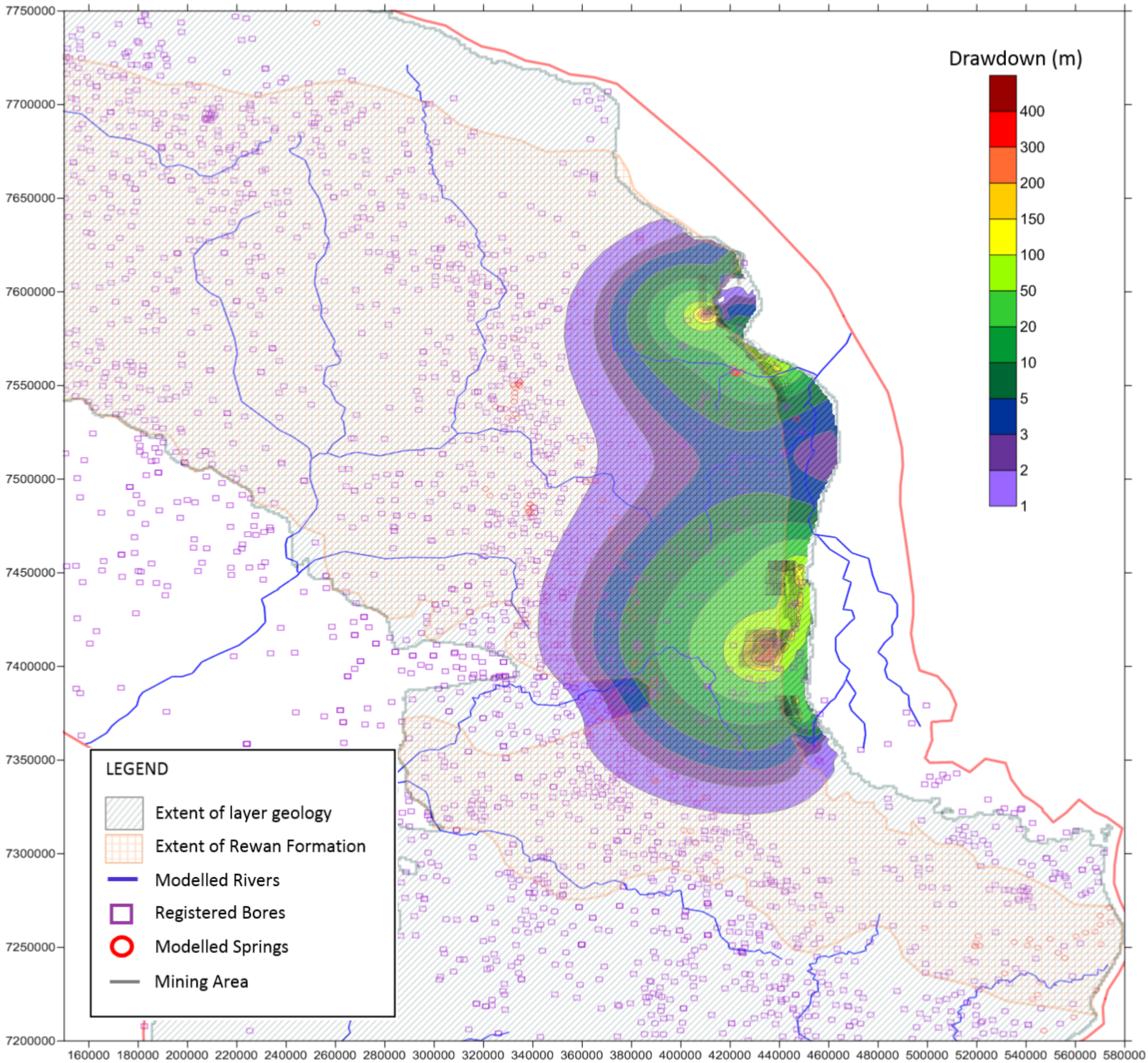

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 11 Drawdown 2020

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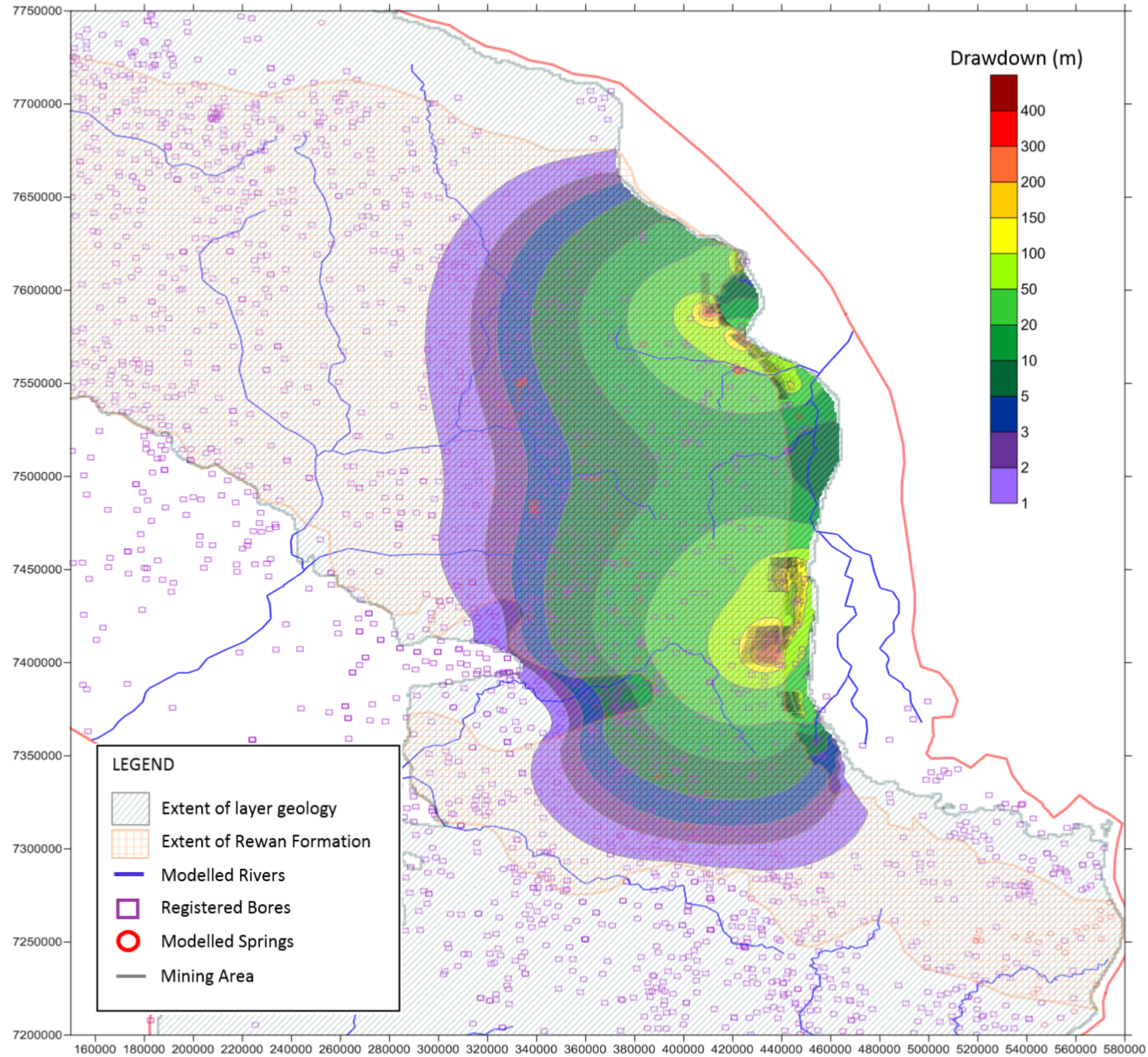

HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
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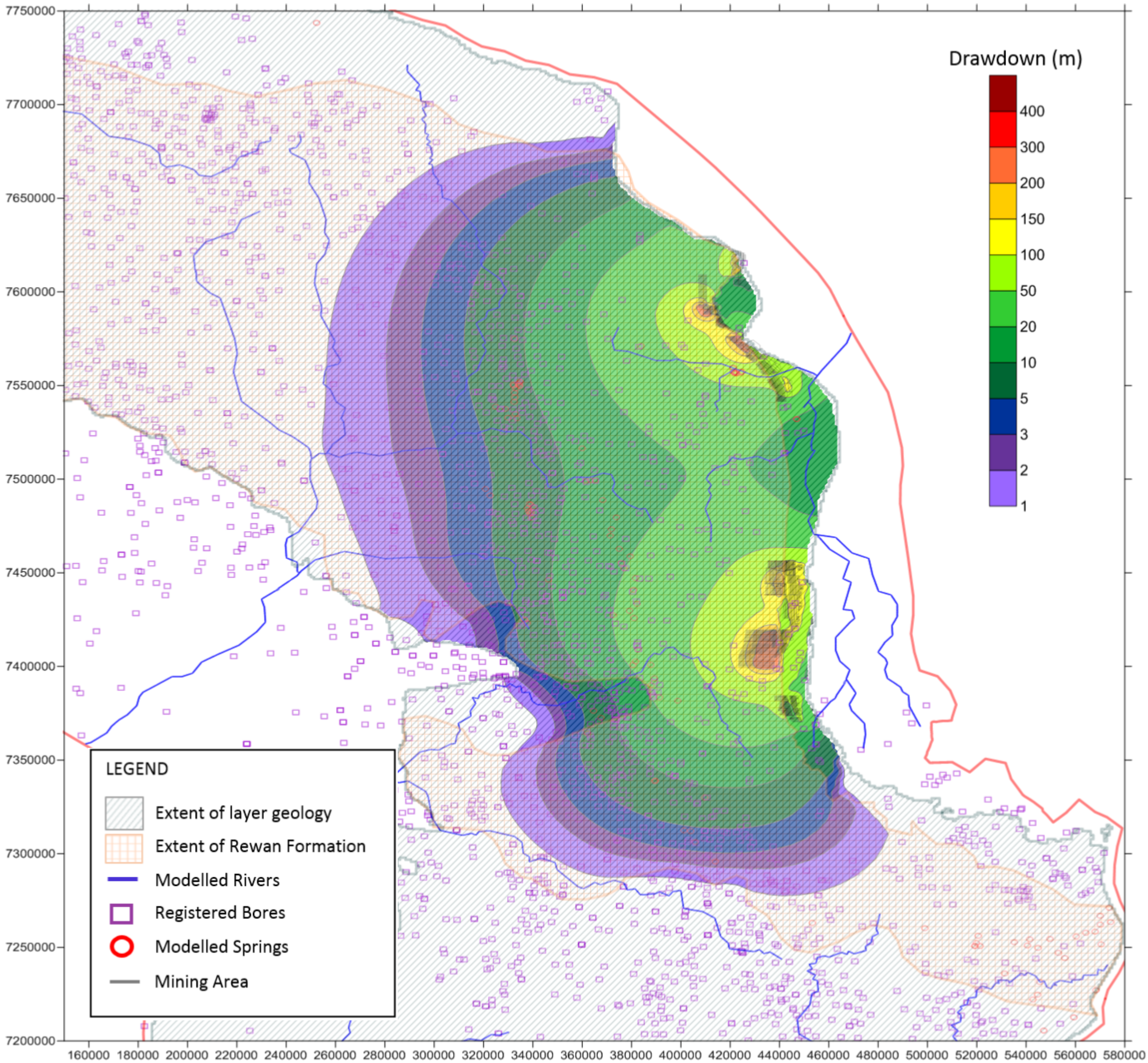

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 11 Drawdown 2030

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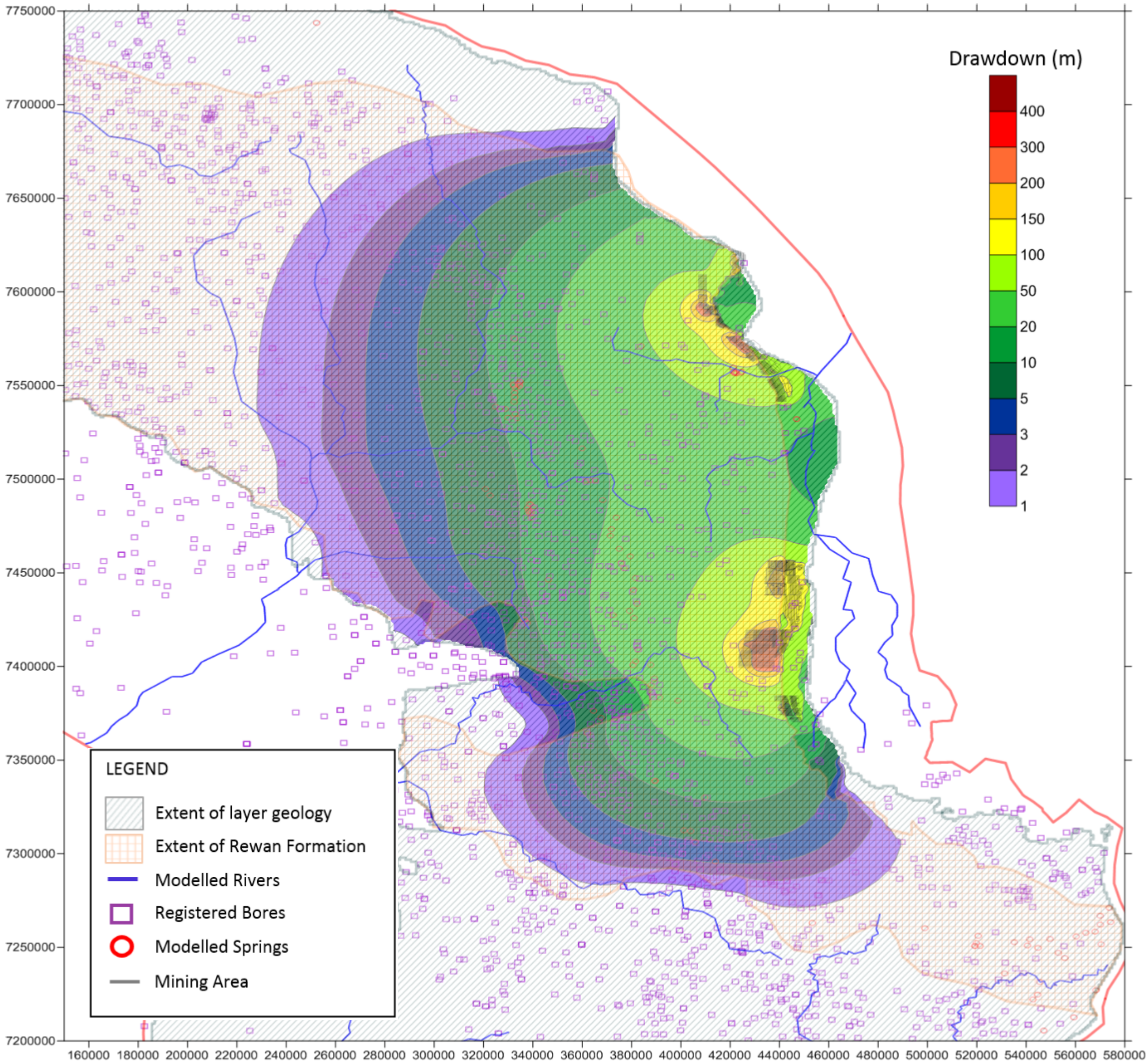

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 11 Drawdown 2035		

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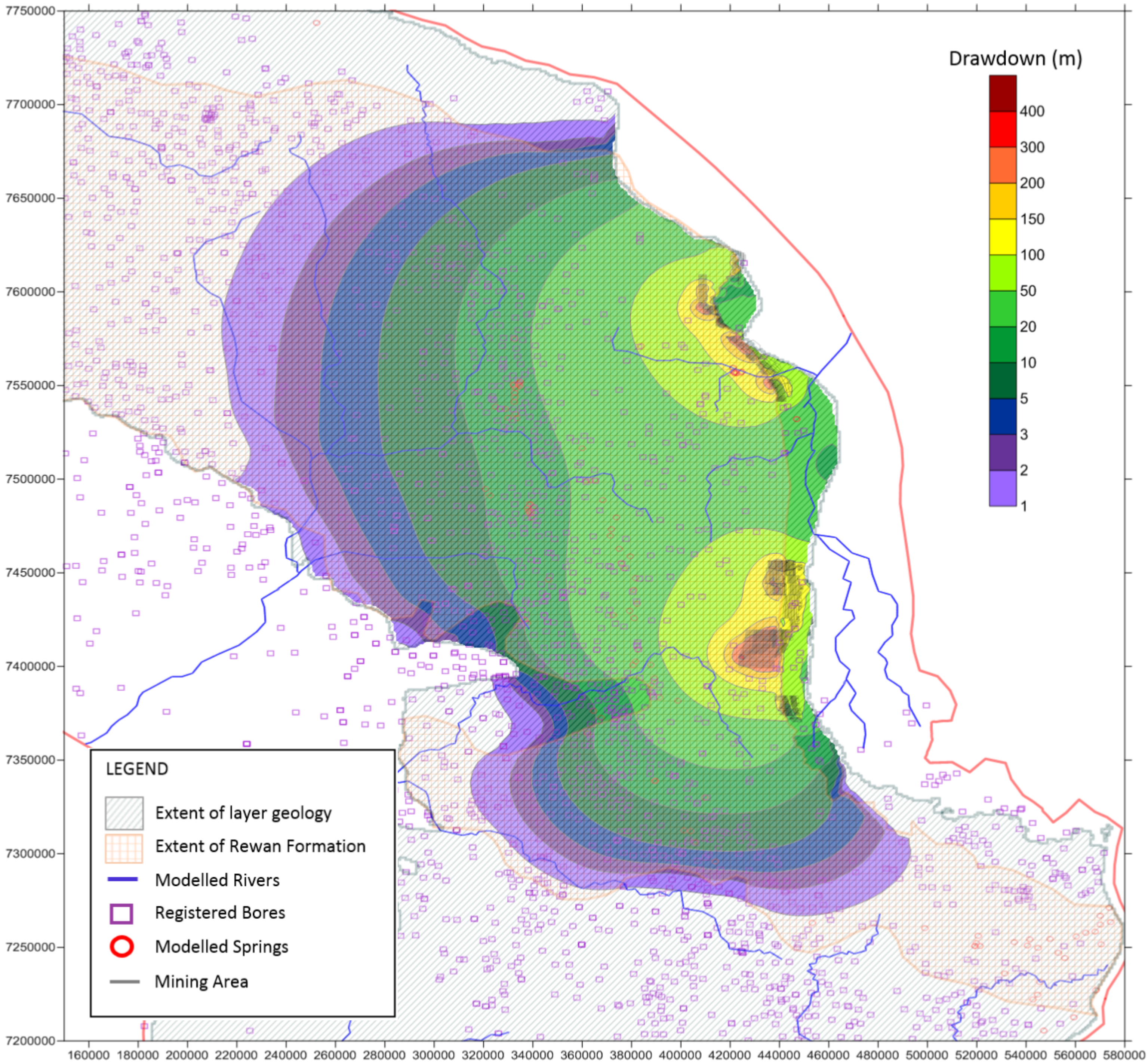

HydroSimulations

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55	
GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL	

Layer 11 Drawdown 2040

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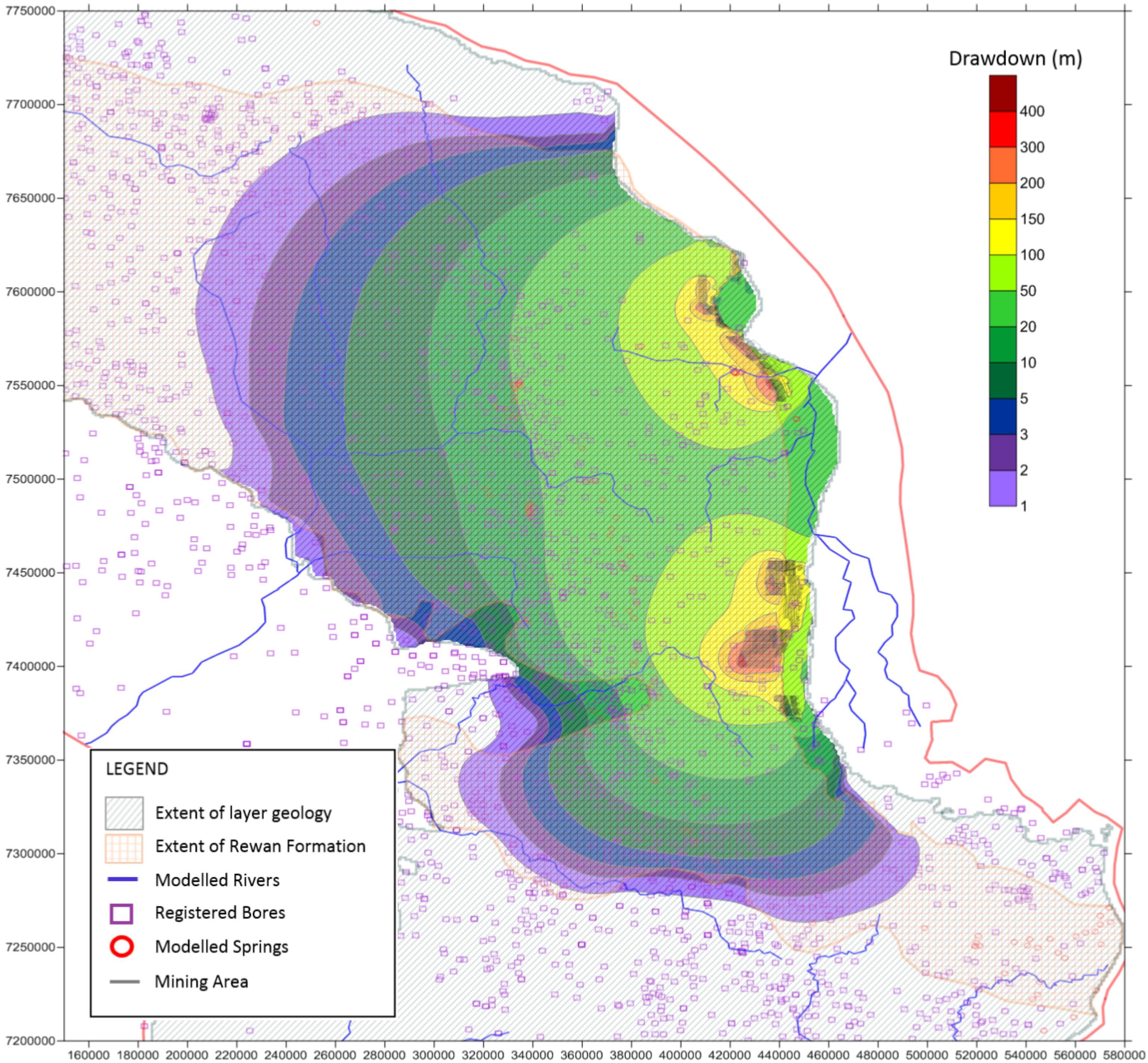

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 11 Drawdown 2045

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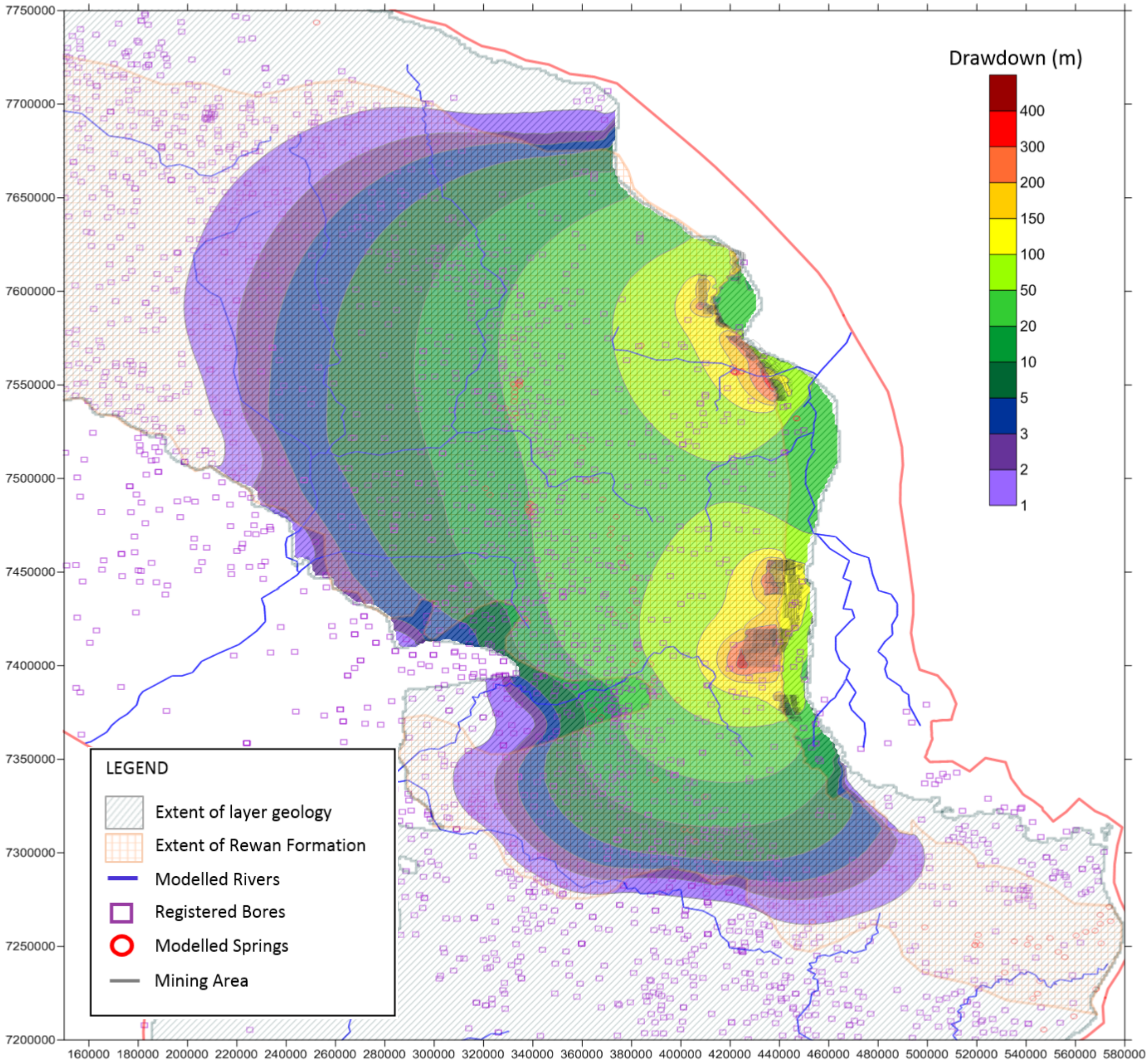

HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 11 Drawdown 2048		

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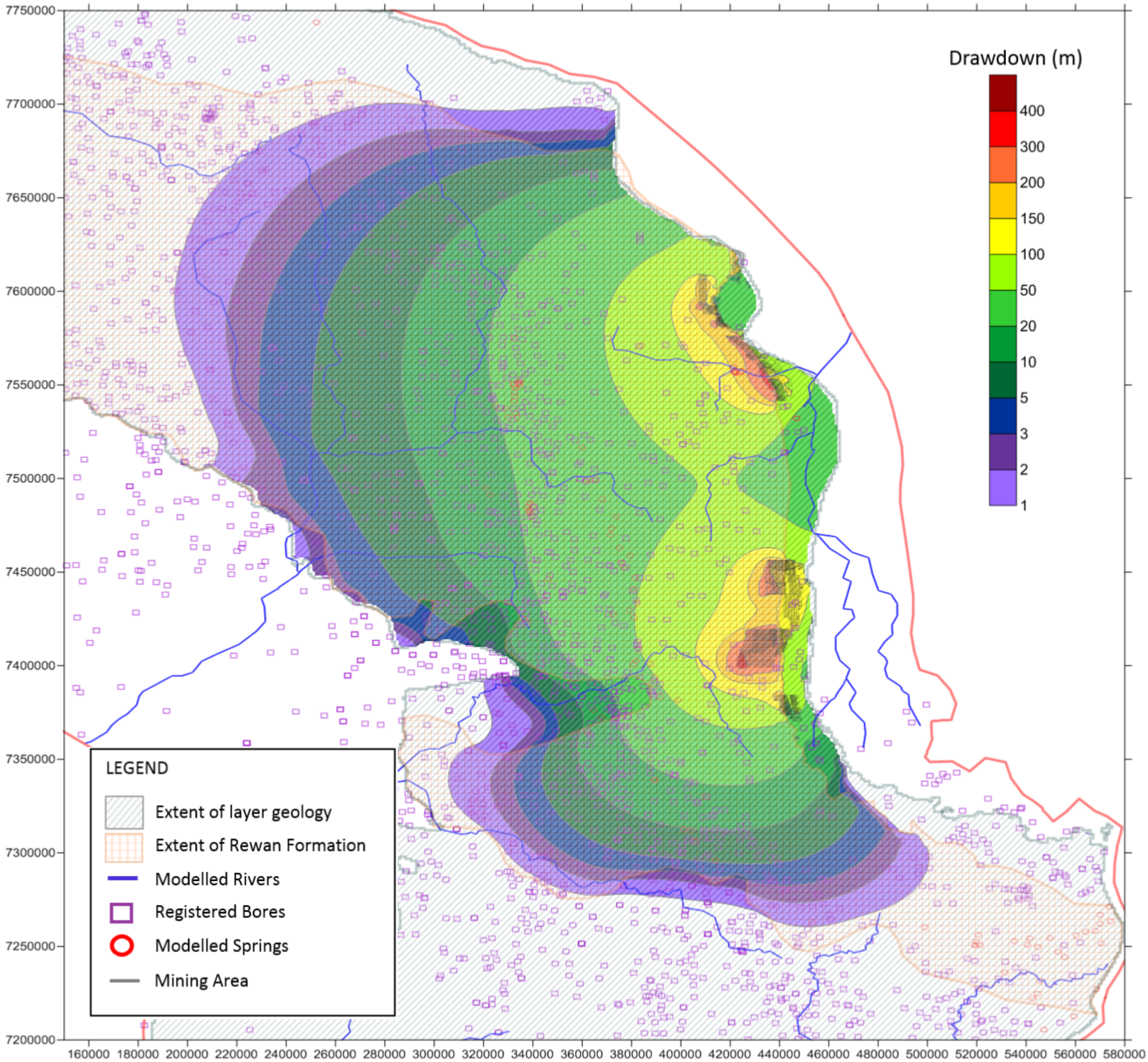

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 11 Drawdown 2050

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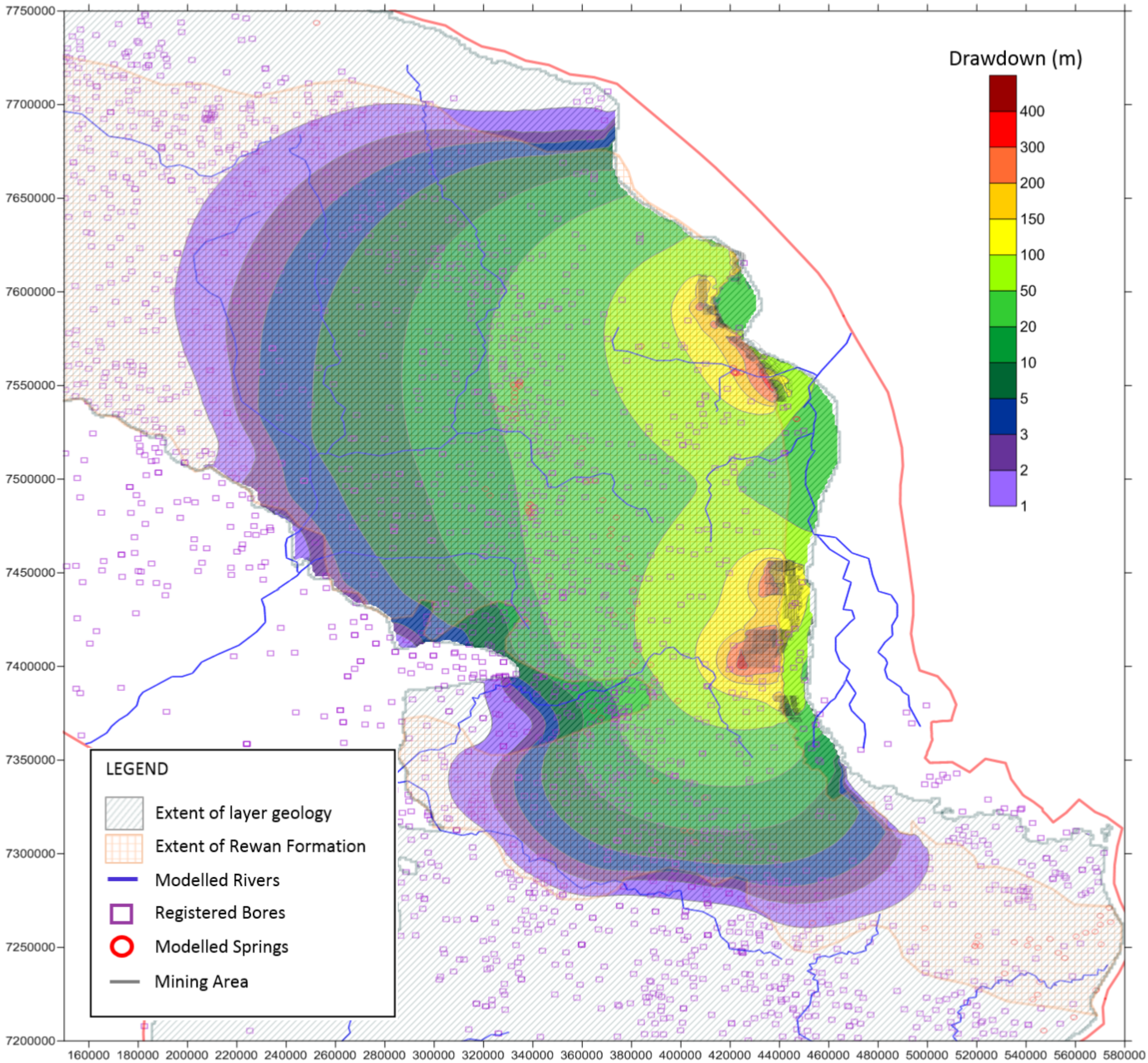

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GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL

Layer 11 Drawdown 2055

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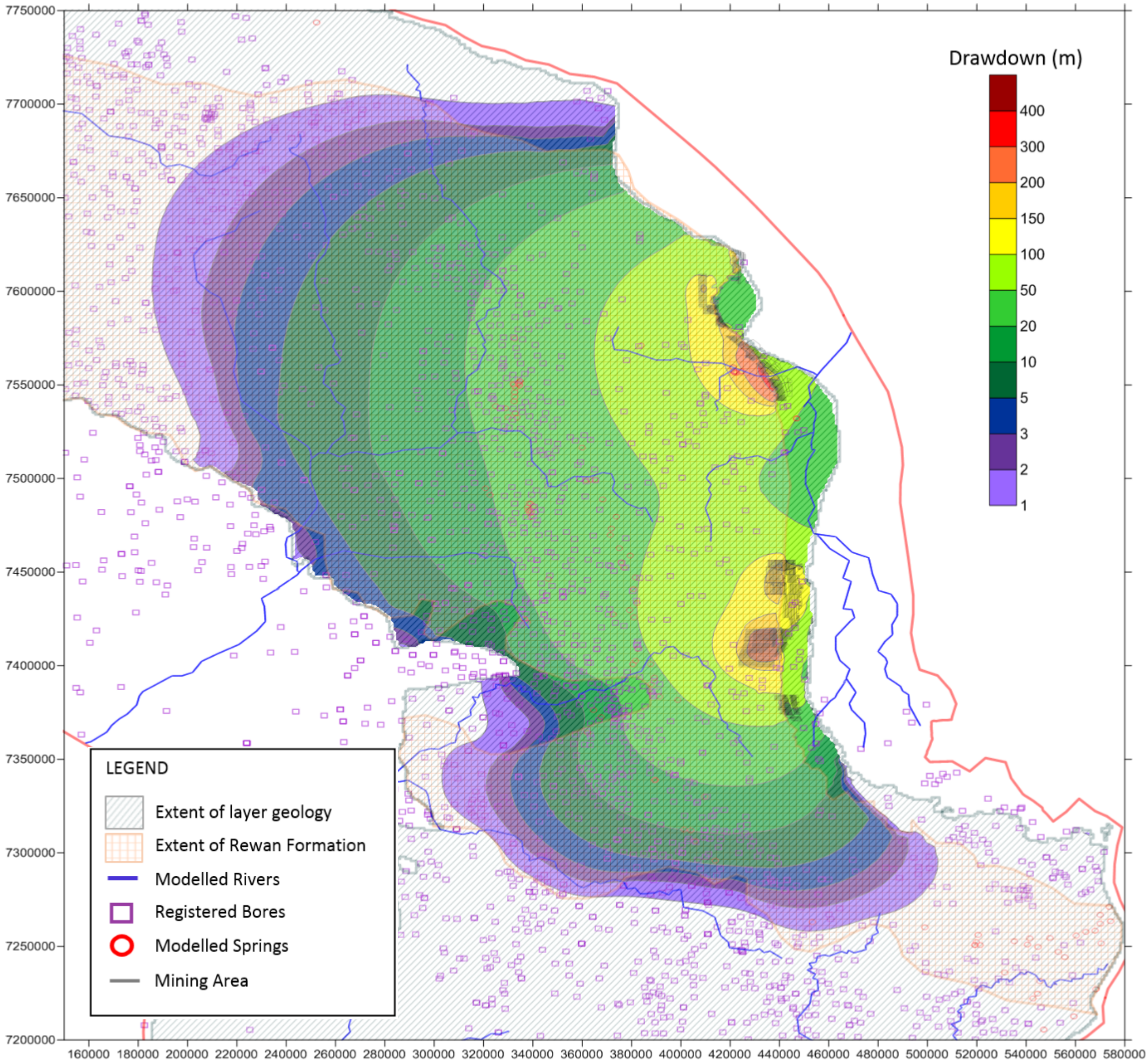

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55

HYDROSIMULATIONS

GEOSCIENCE AUSTRALIA | GSA001 - GALILEE BASIN MODEL

Layer 11 Drawdown 2058

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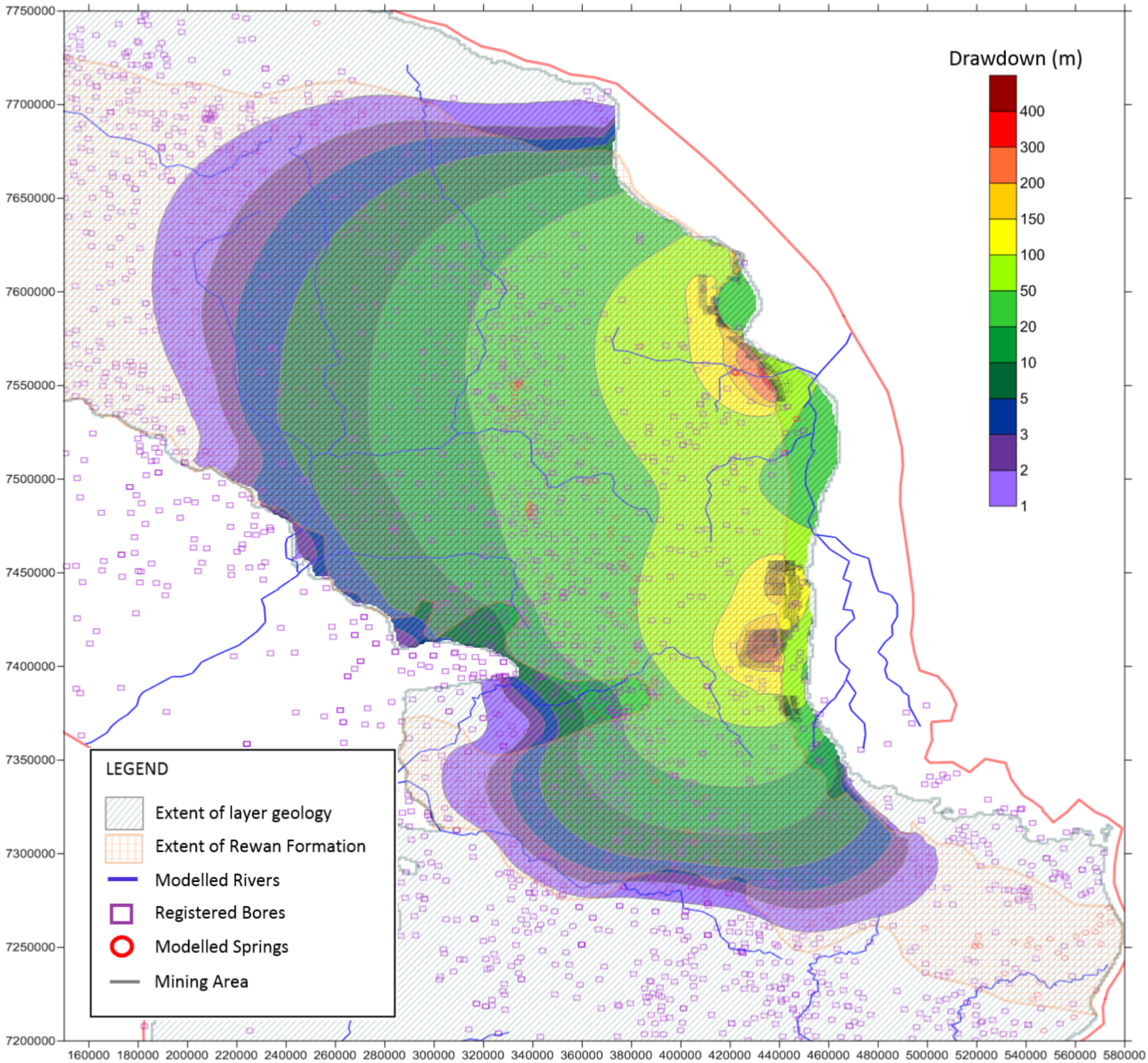

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 11 Drawdown 2061

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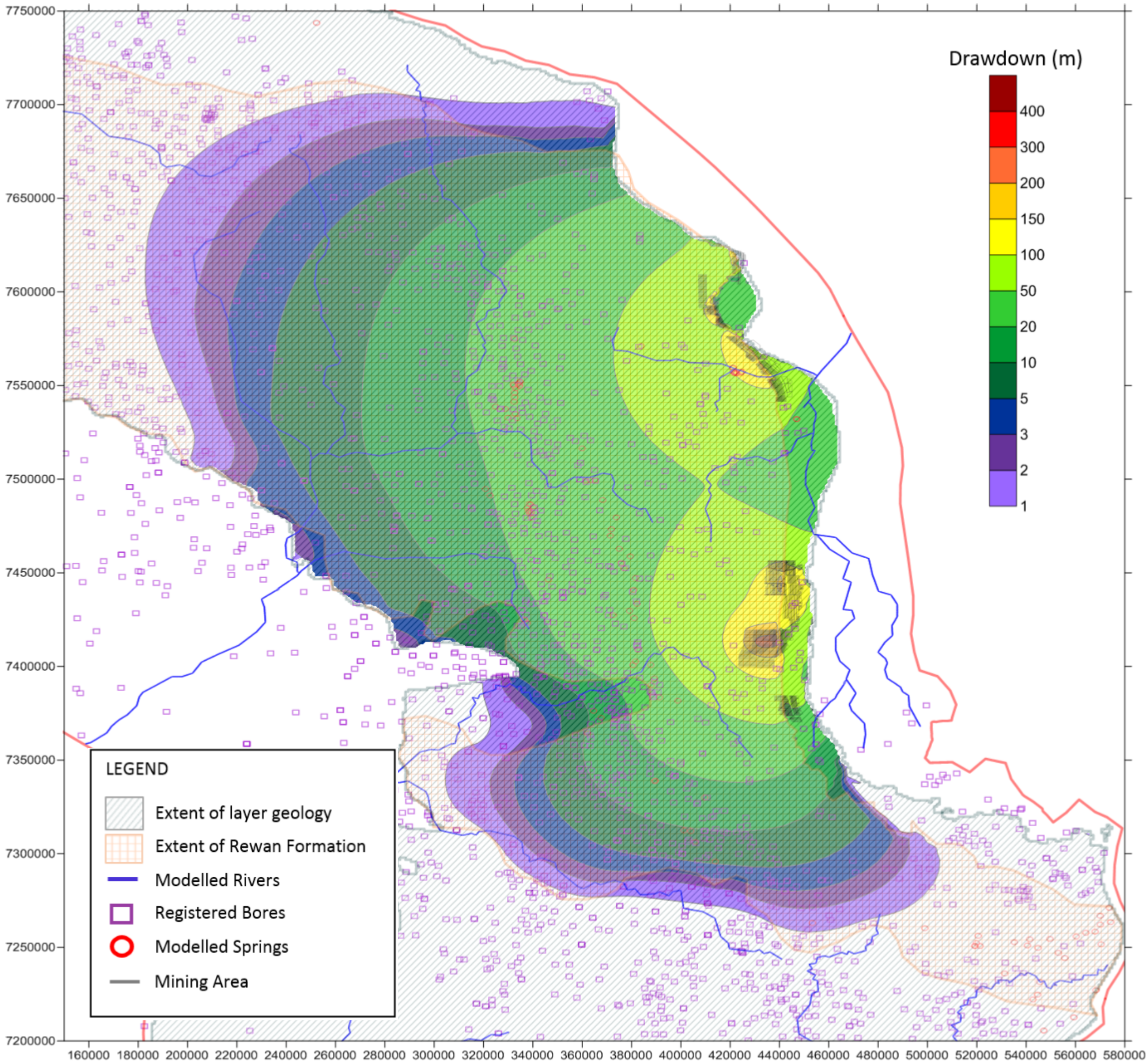

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 11 Drawdown 2067

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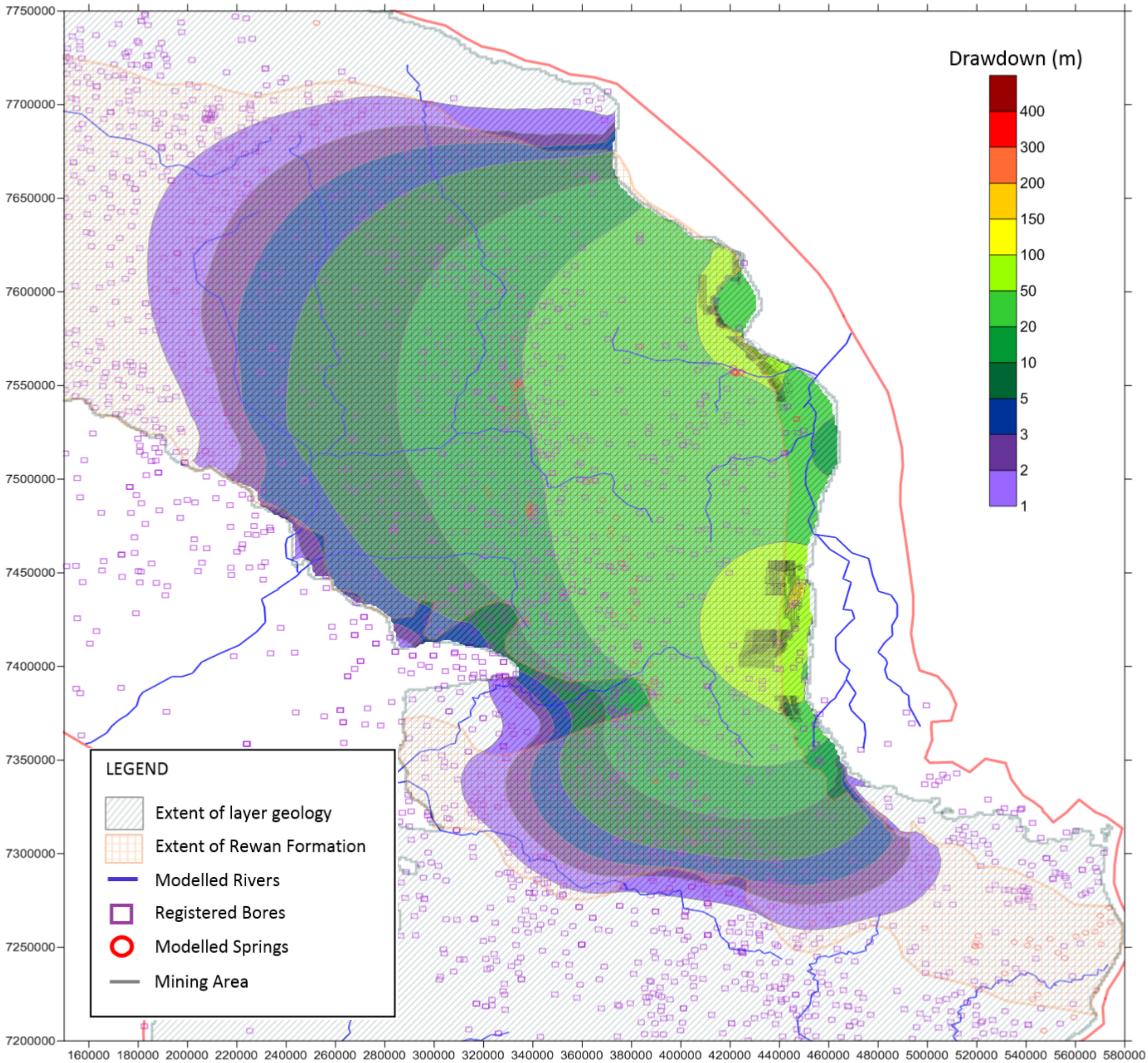

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 11 Drawdown 2080		

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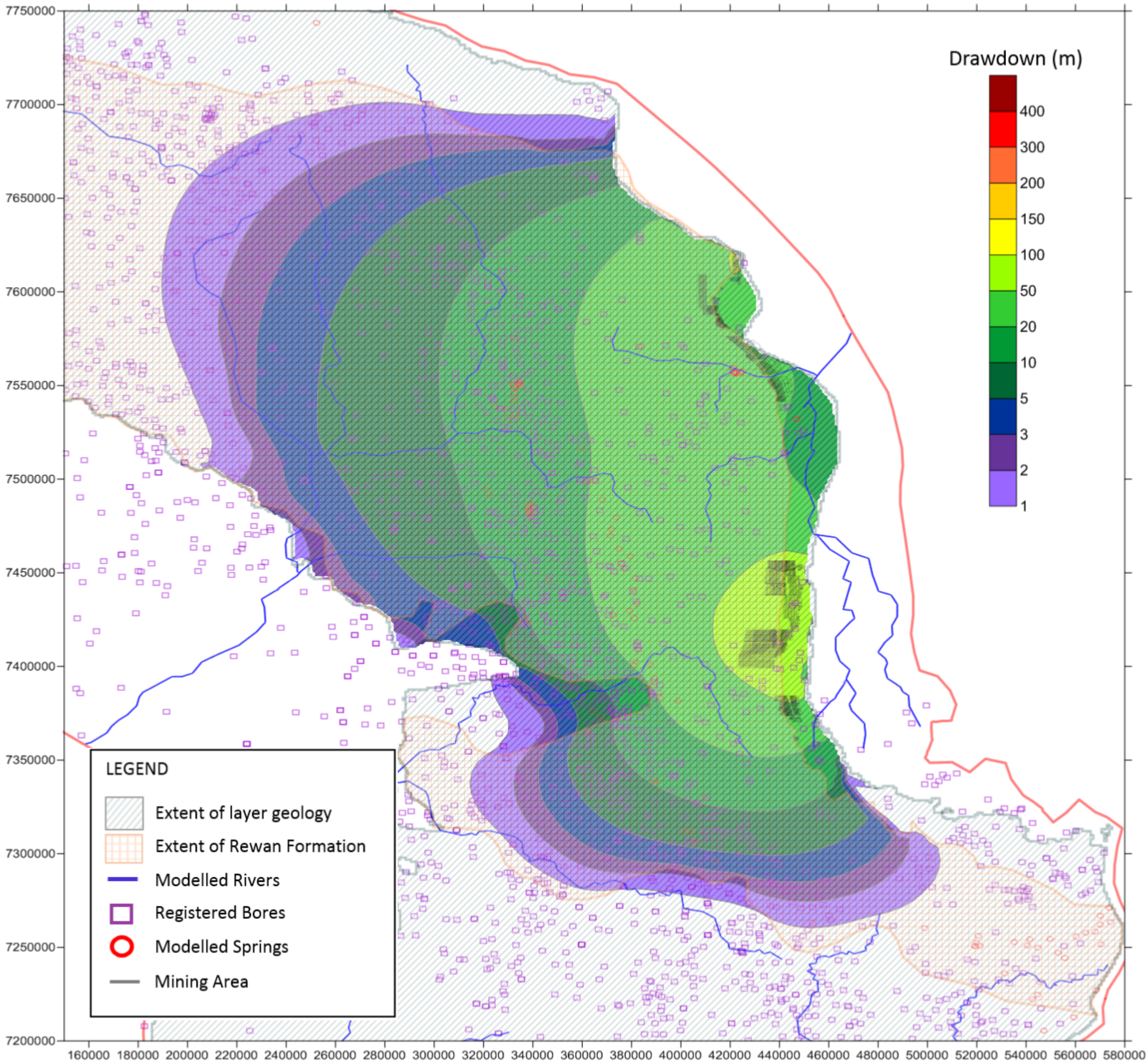

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 11 Drawdown 2090

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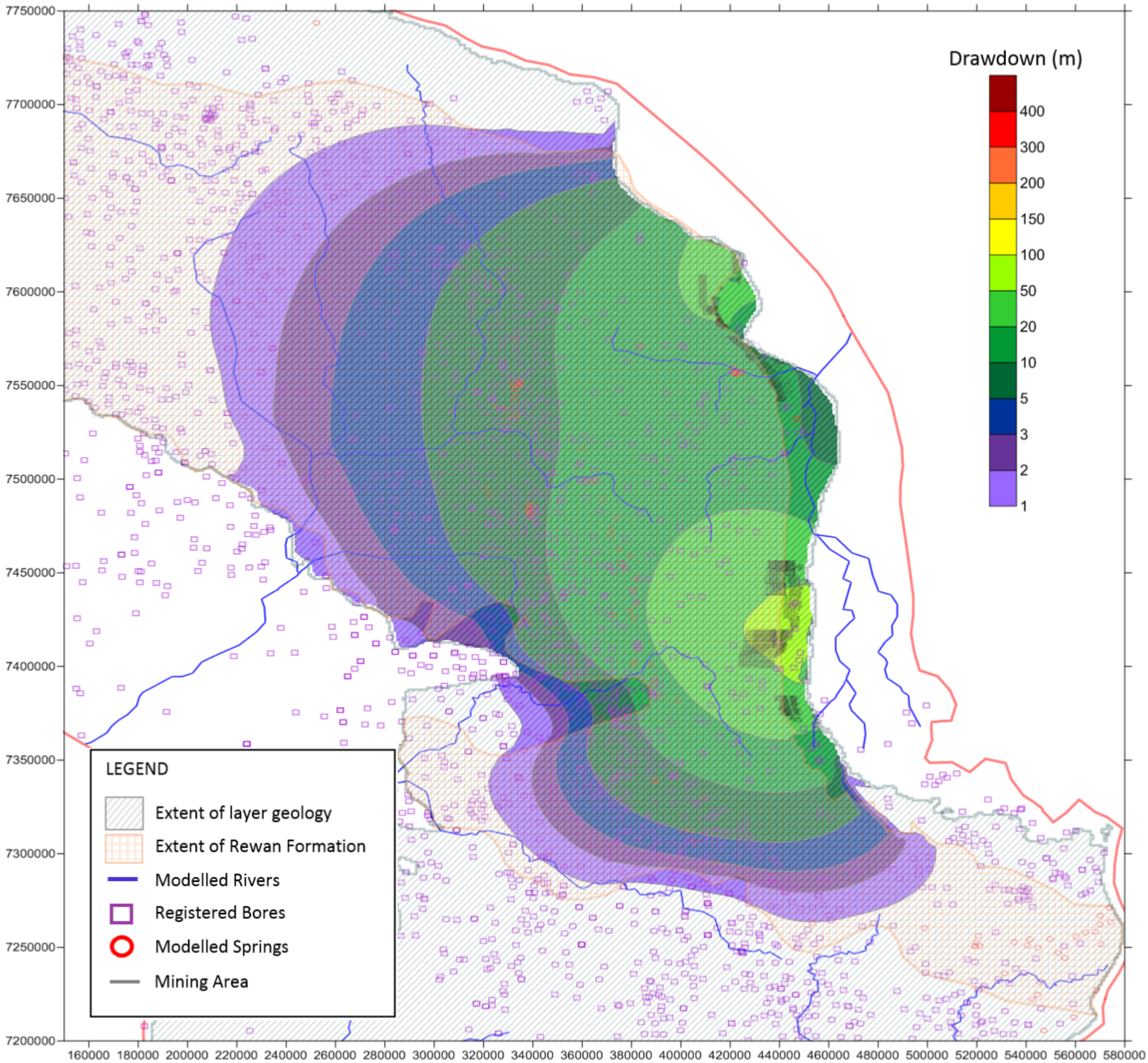

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 11 Drawdown 2110

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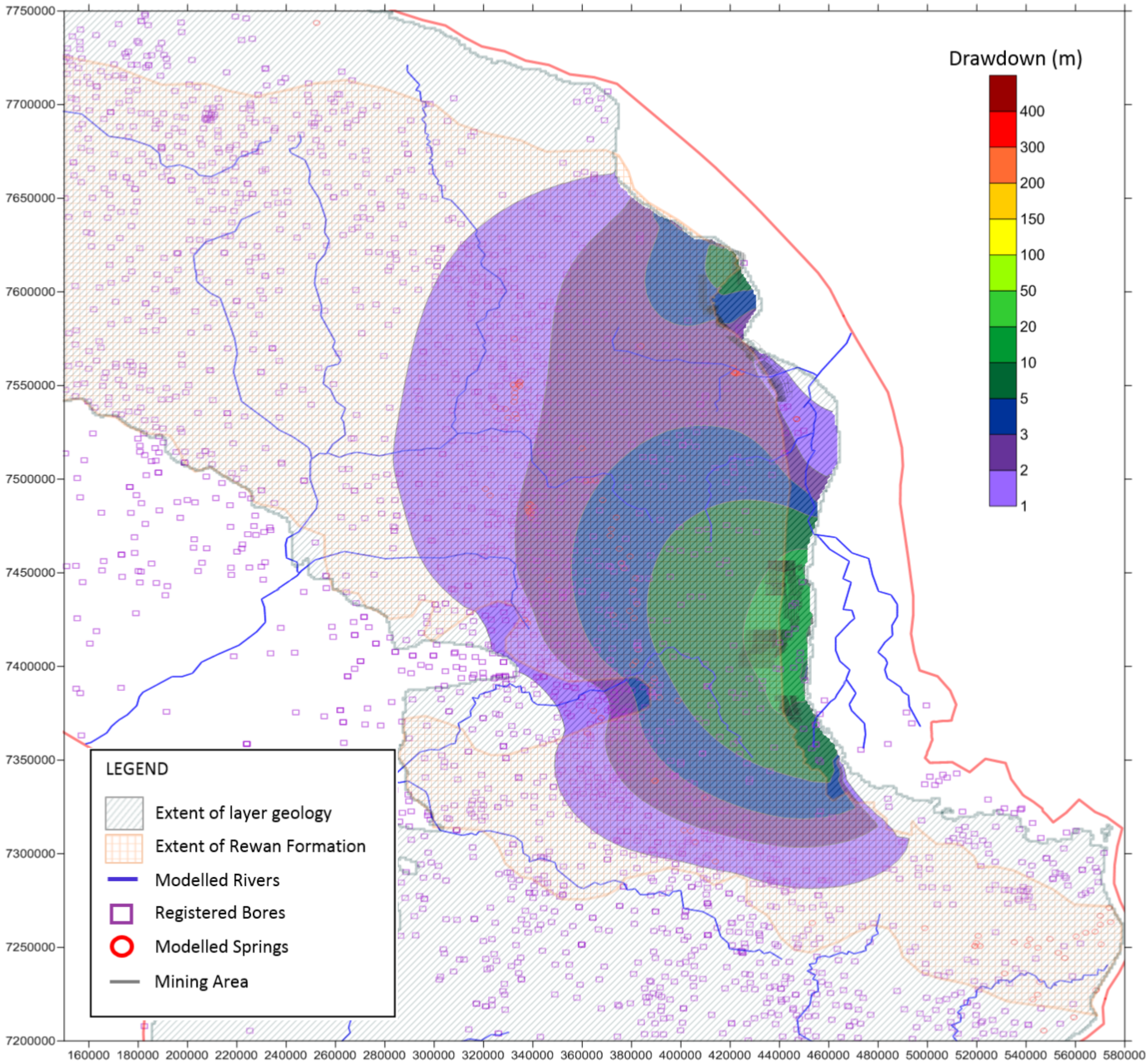

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 11 Drawdown 2200

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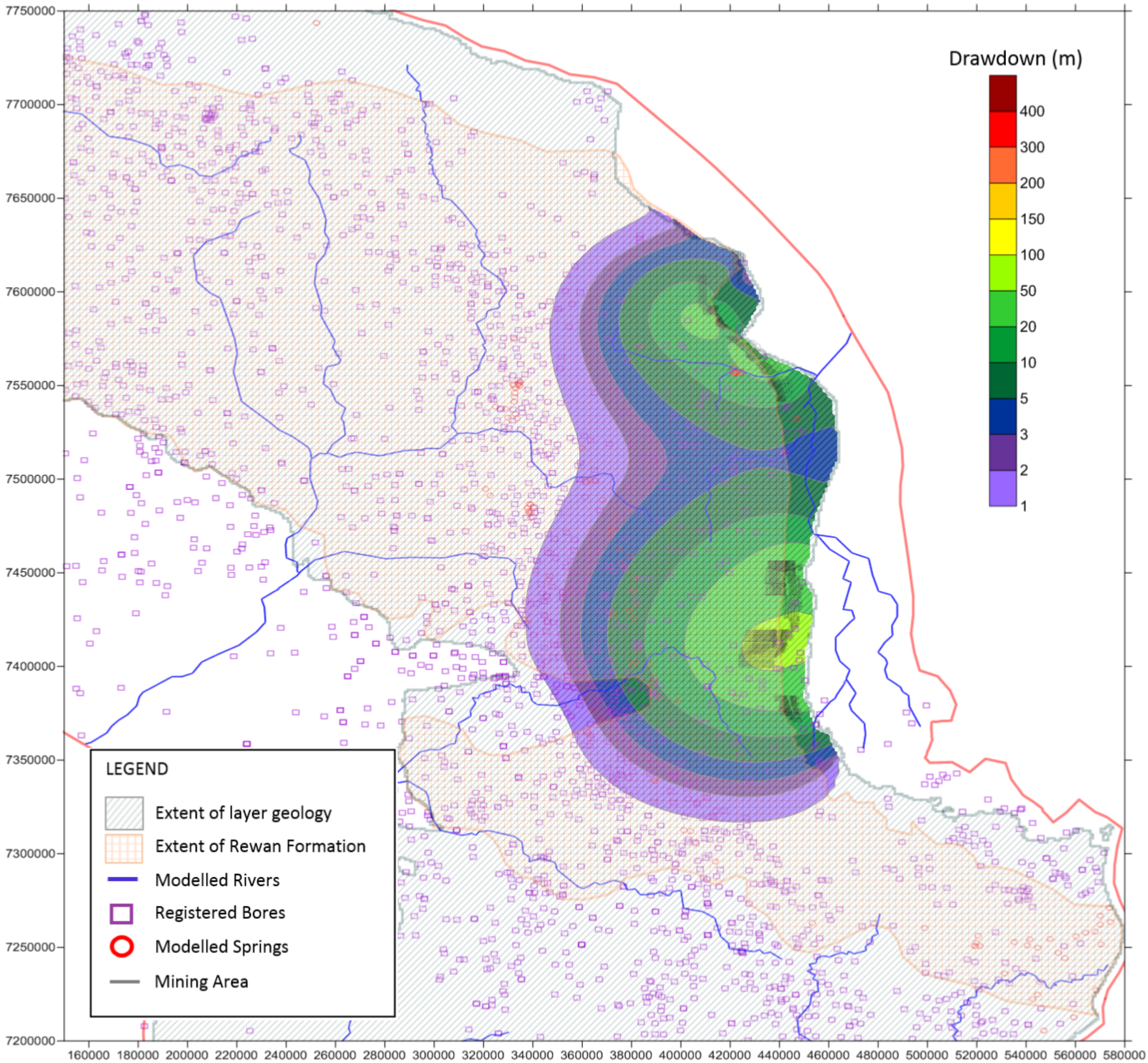

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 12 Drawdown 2020

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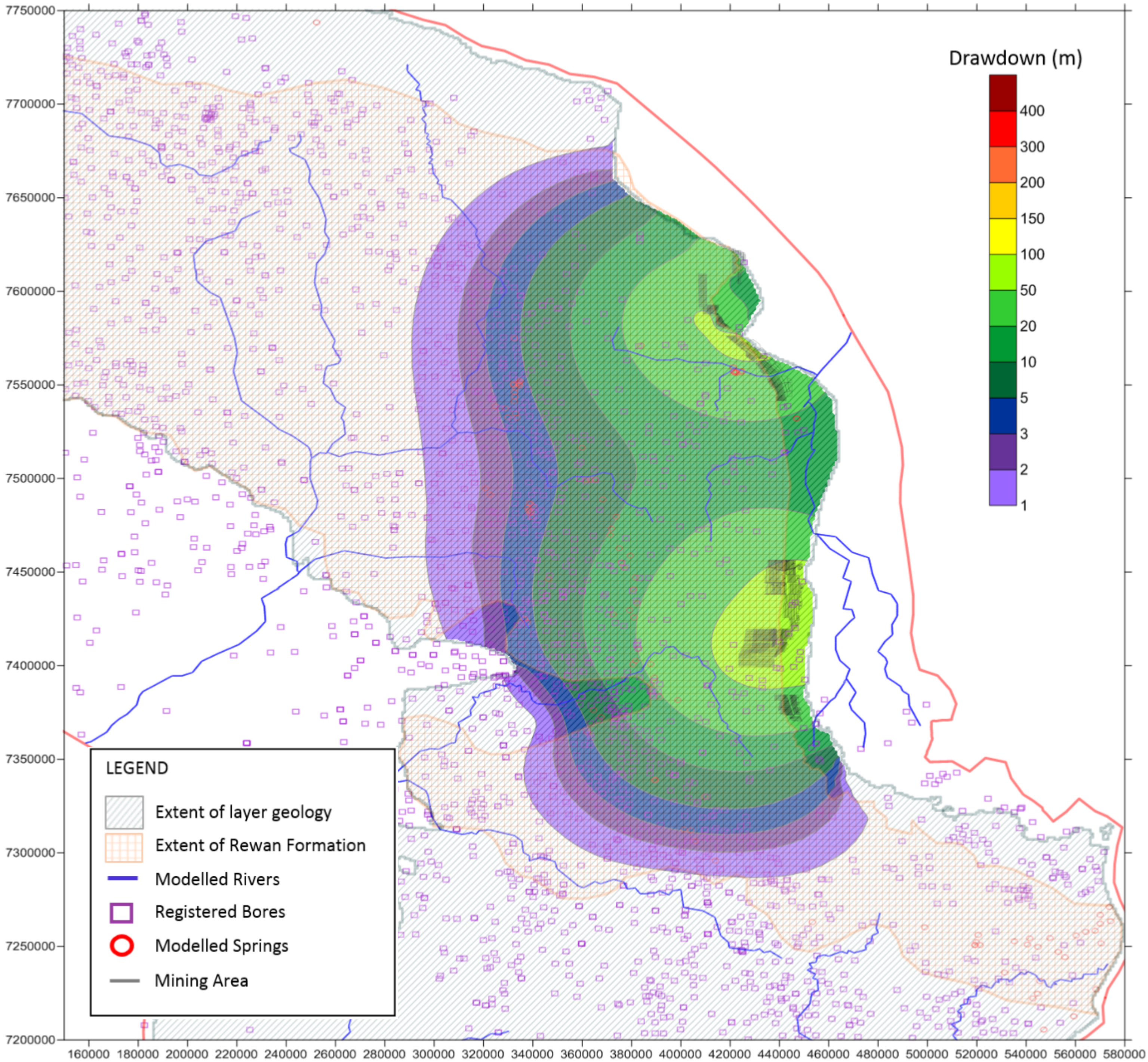

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 12 Drawdown 2025

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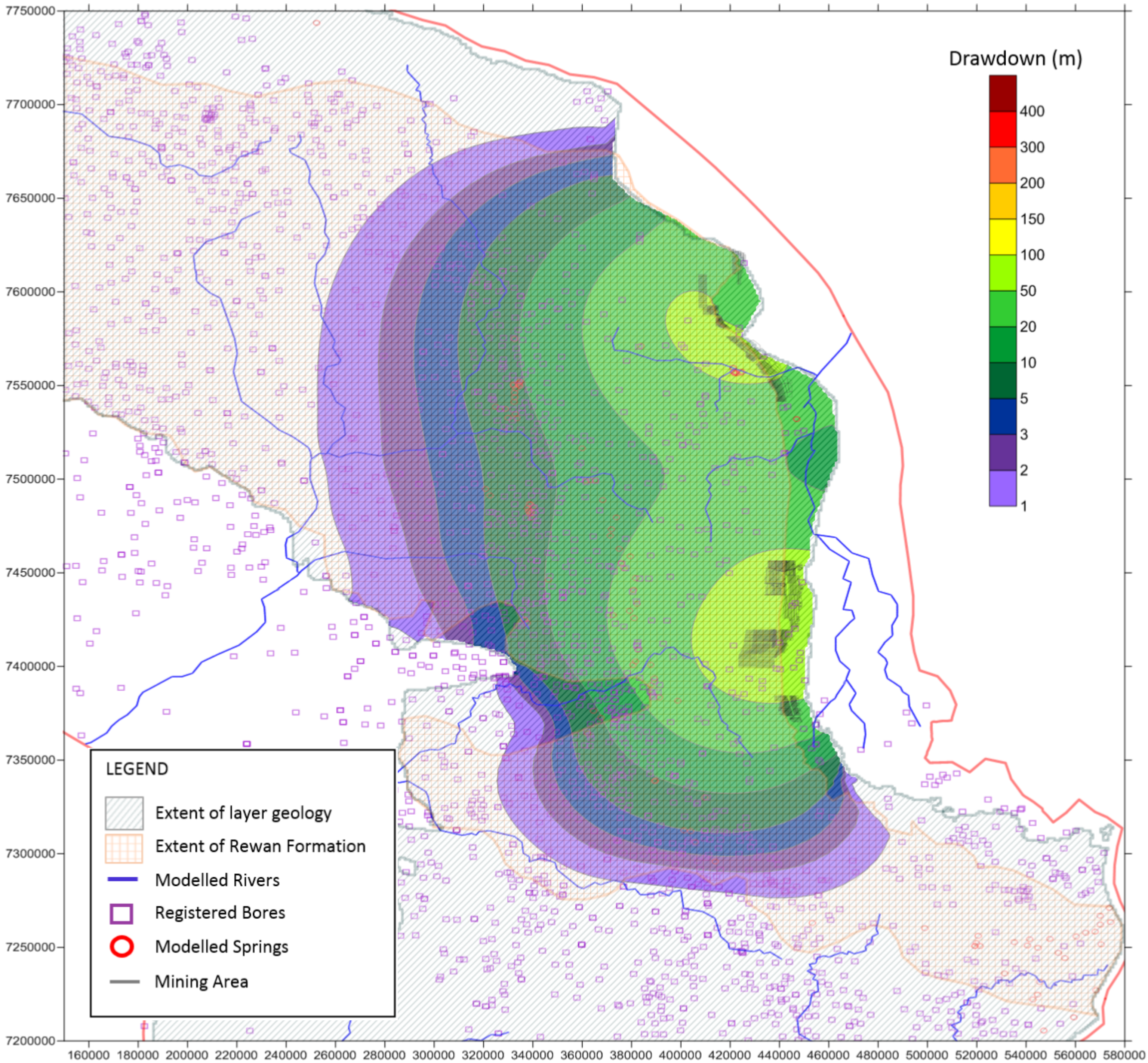

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GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL

HYDRO SIMULATIONS

Layer 12 Drawdown 2030

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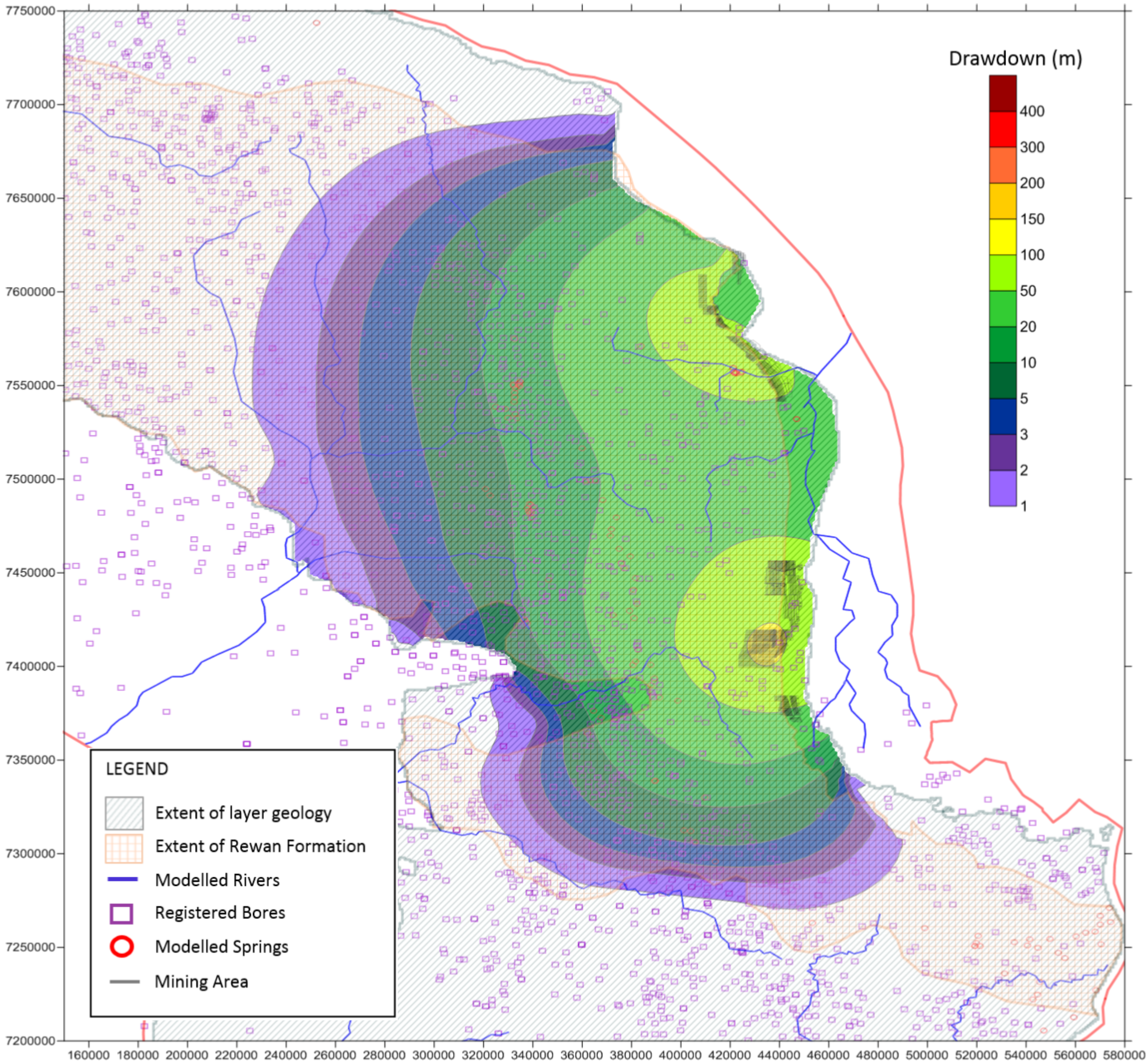

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GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL

Layer 12 Drawdown 2035

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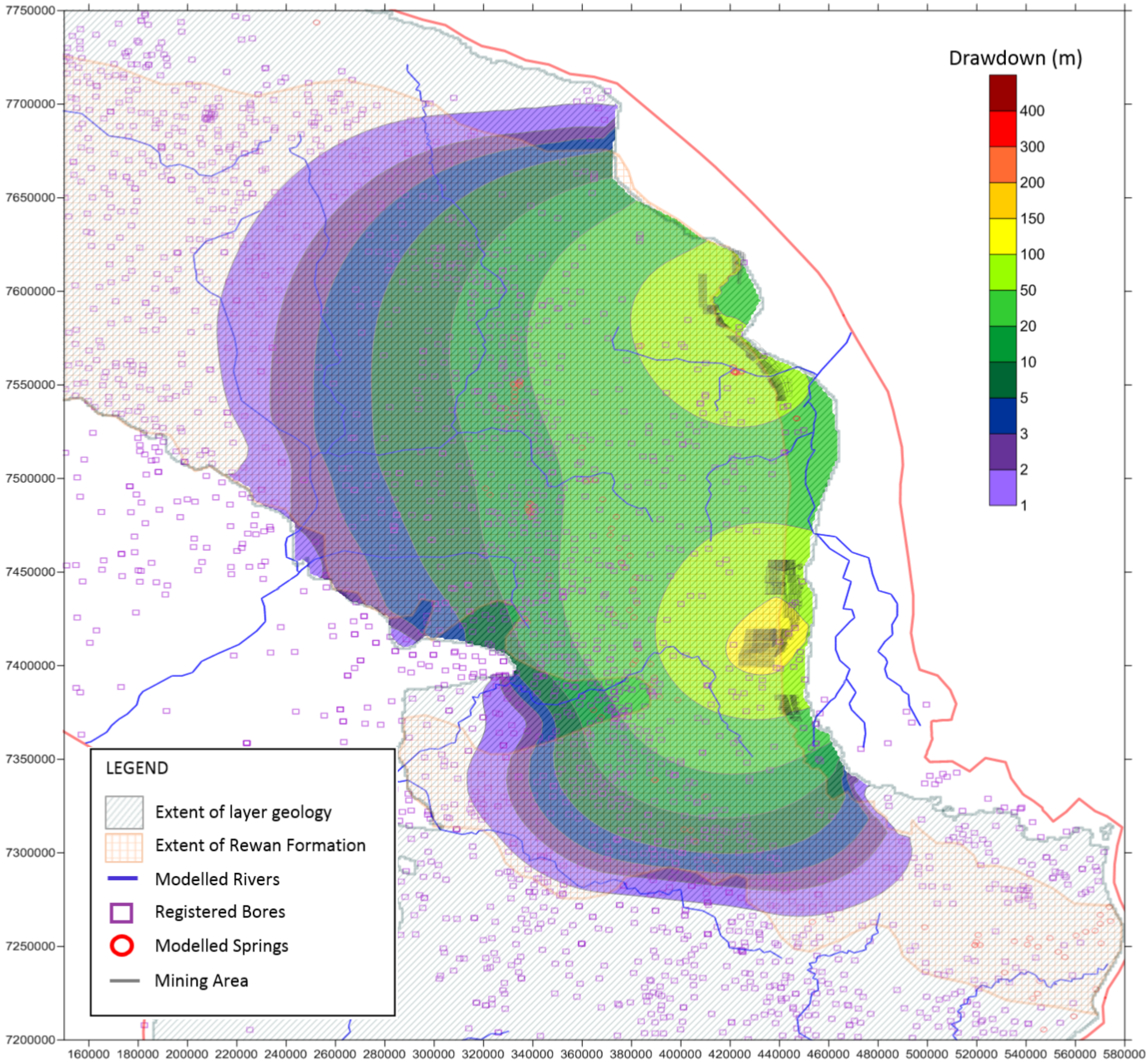

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 12 Drawdown 2040

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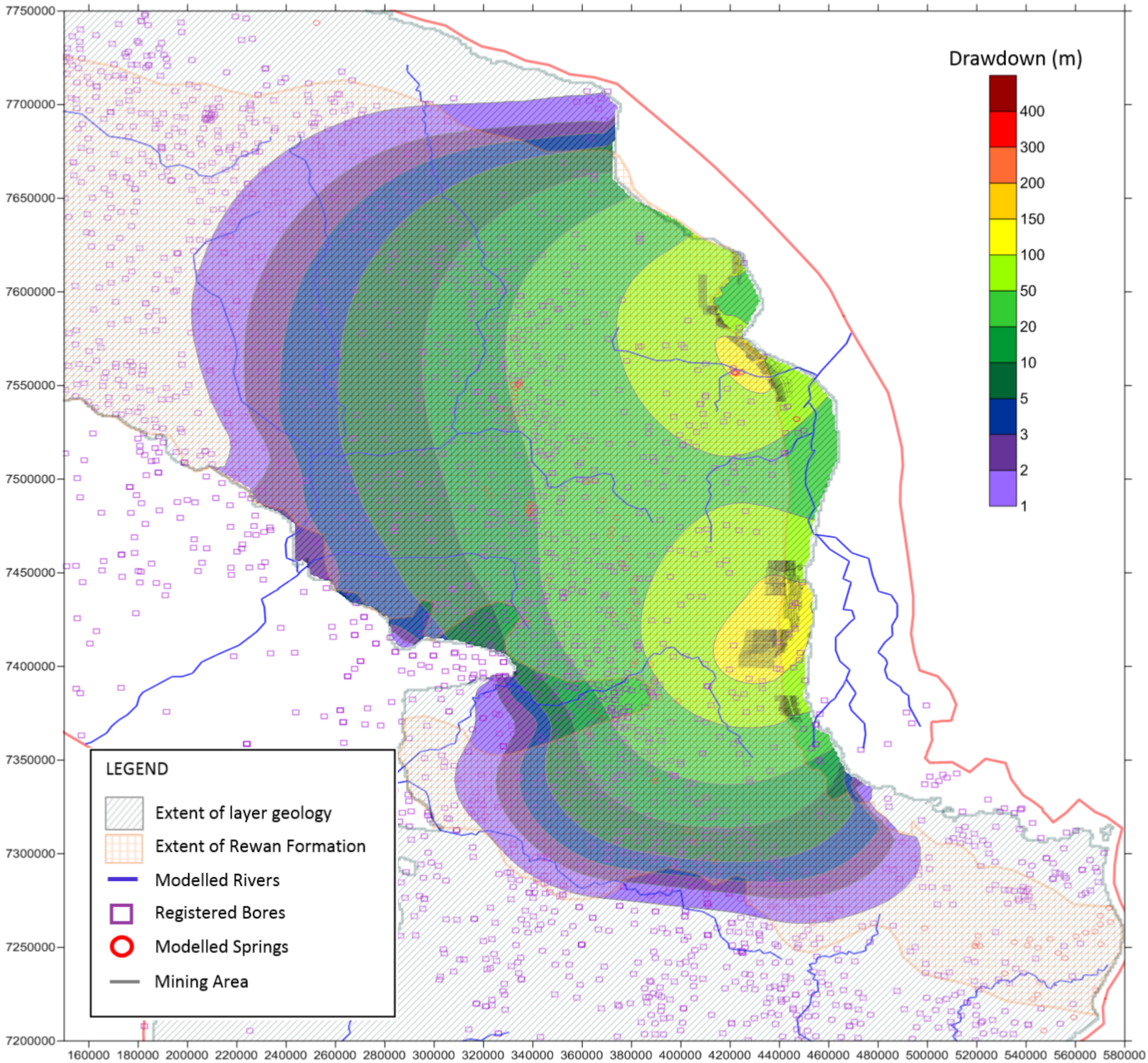

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 12 Drawdown 2045

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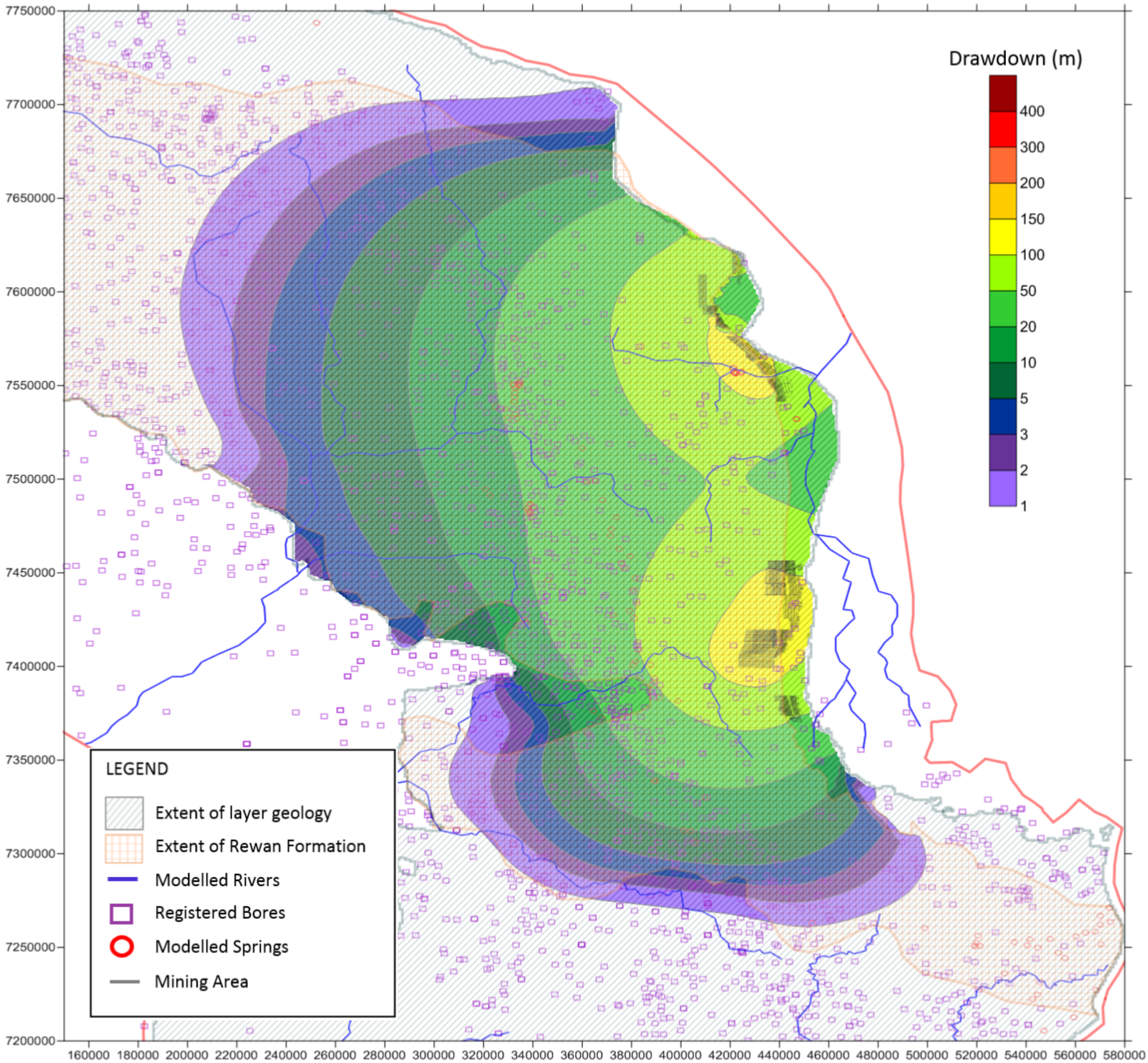

HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 12 Drawdown 2048

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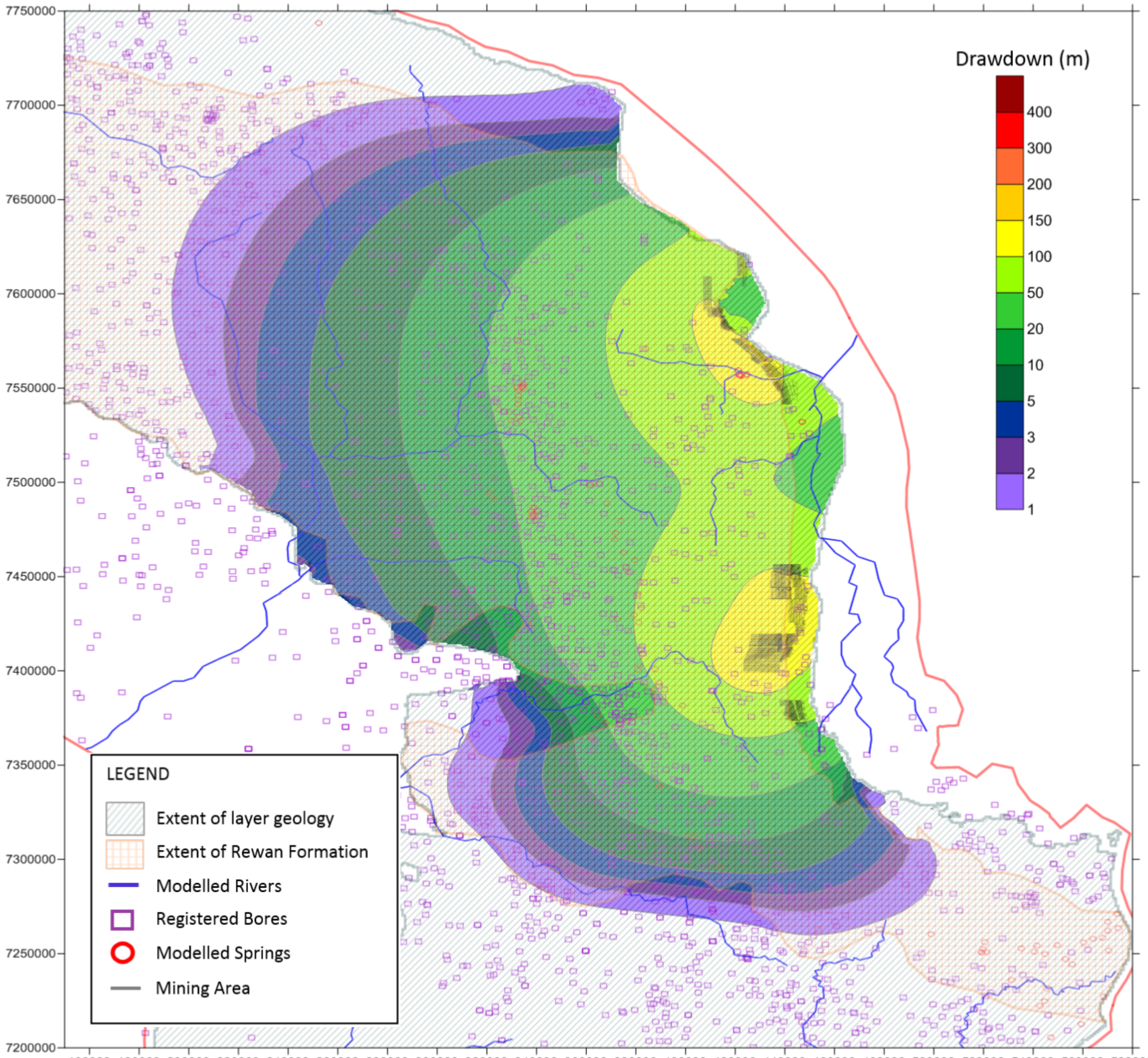

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 12 Drawdown 2050		

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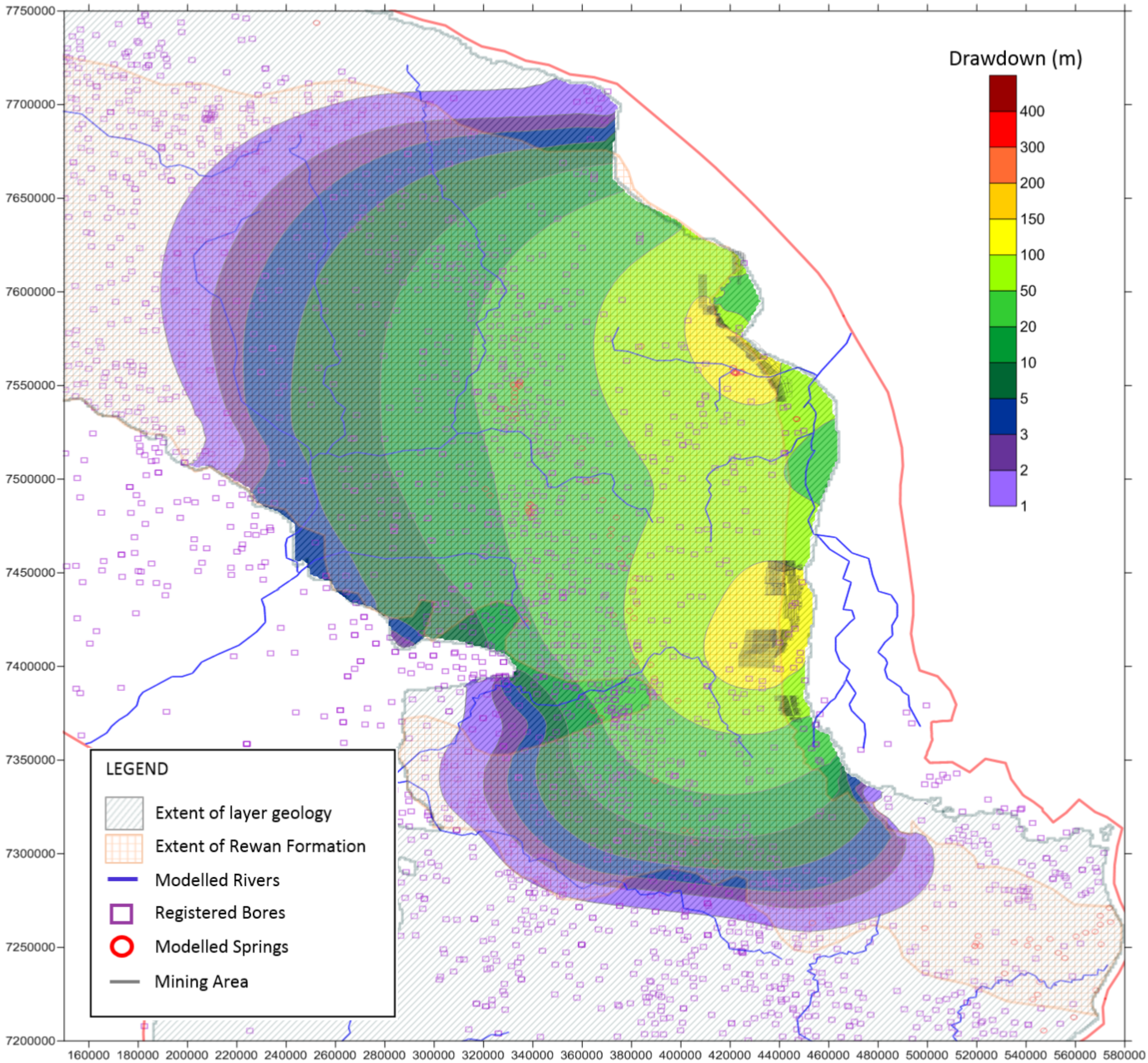

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDRO SIMULATIONS

Layer 12 Drawdown 2055

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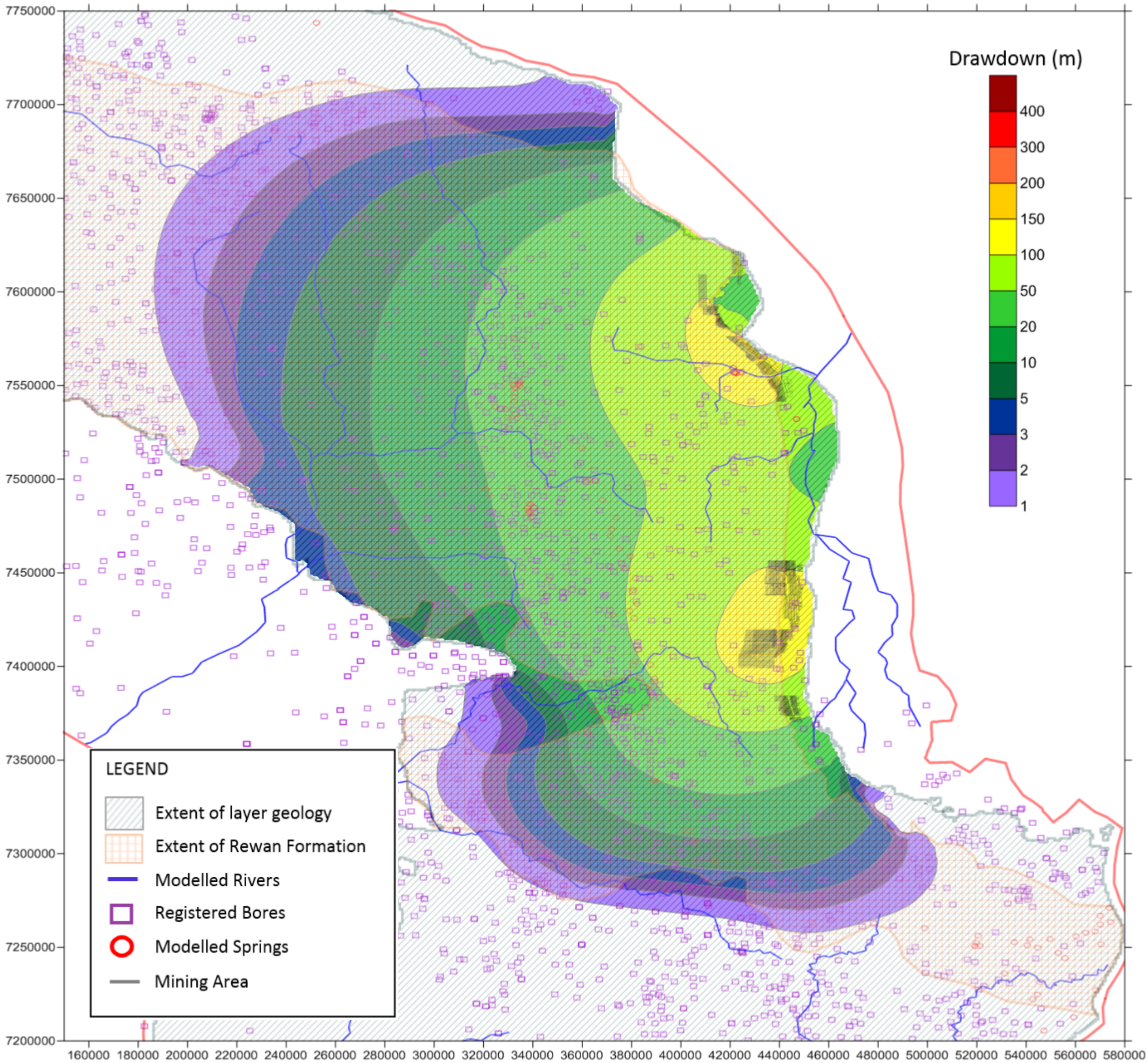

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 12 Drawdown 2058

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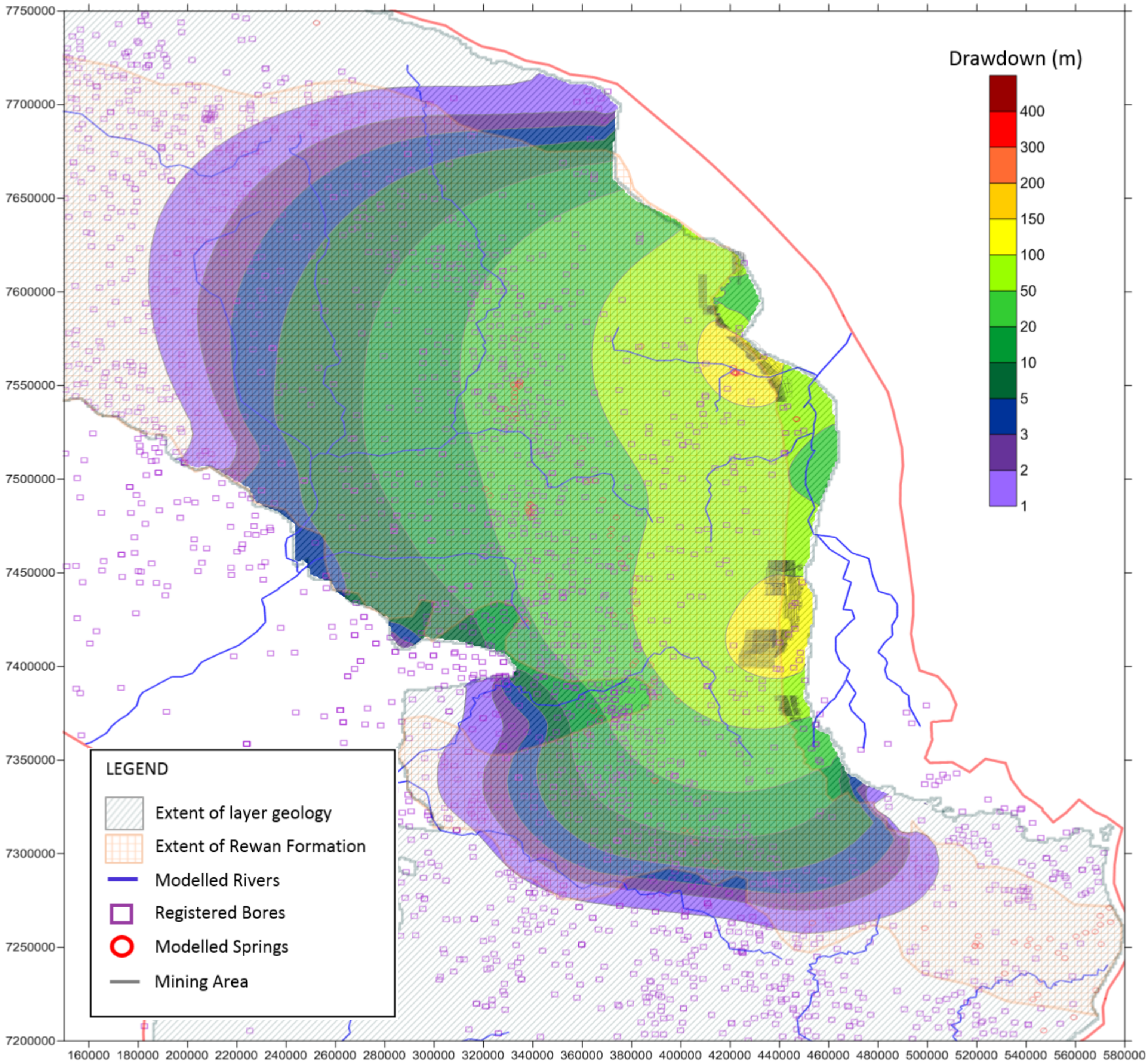

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 12 Drawdown 2061		

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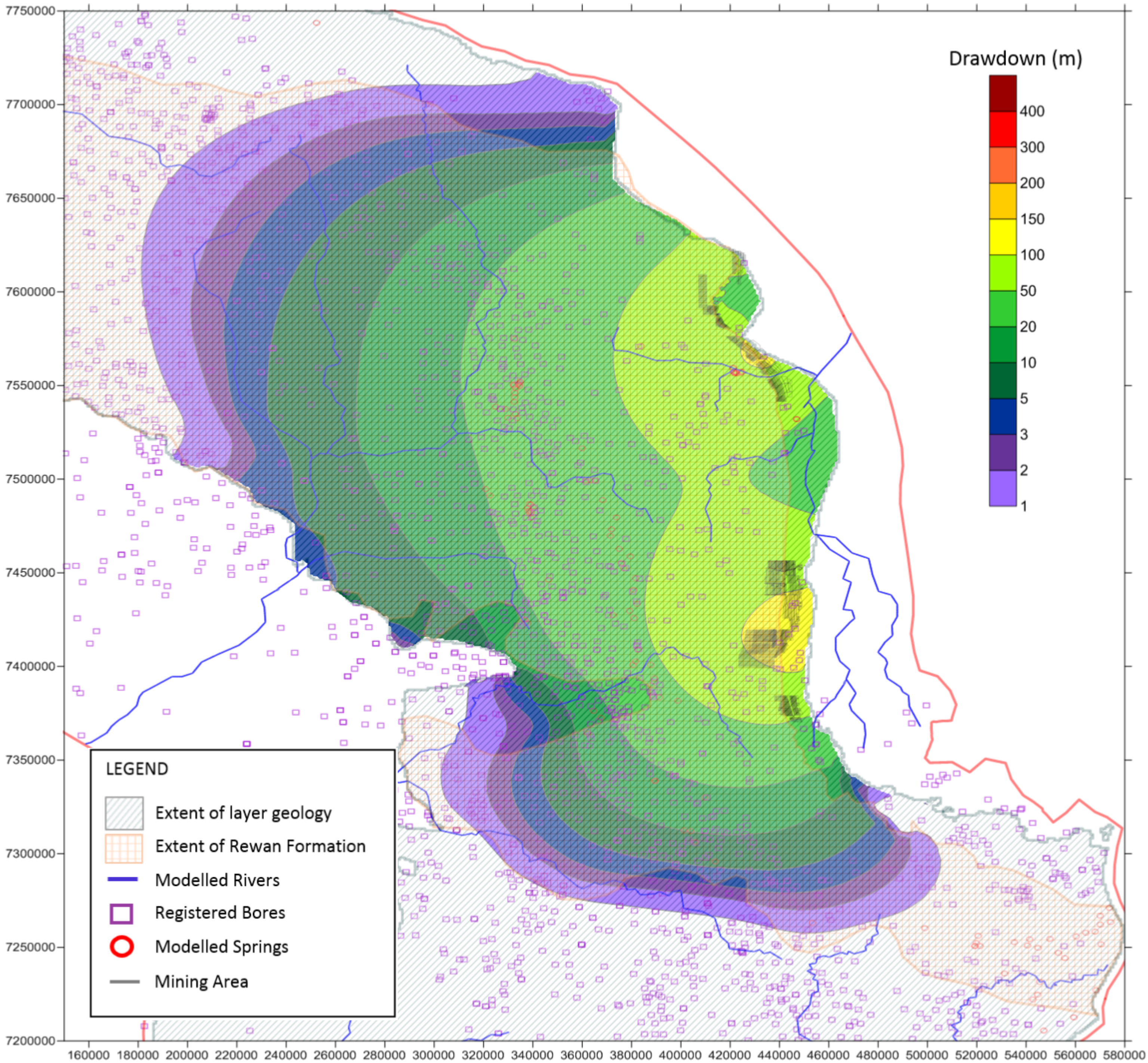

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	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 12 Drawdown 2067		

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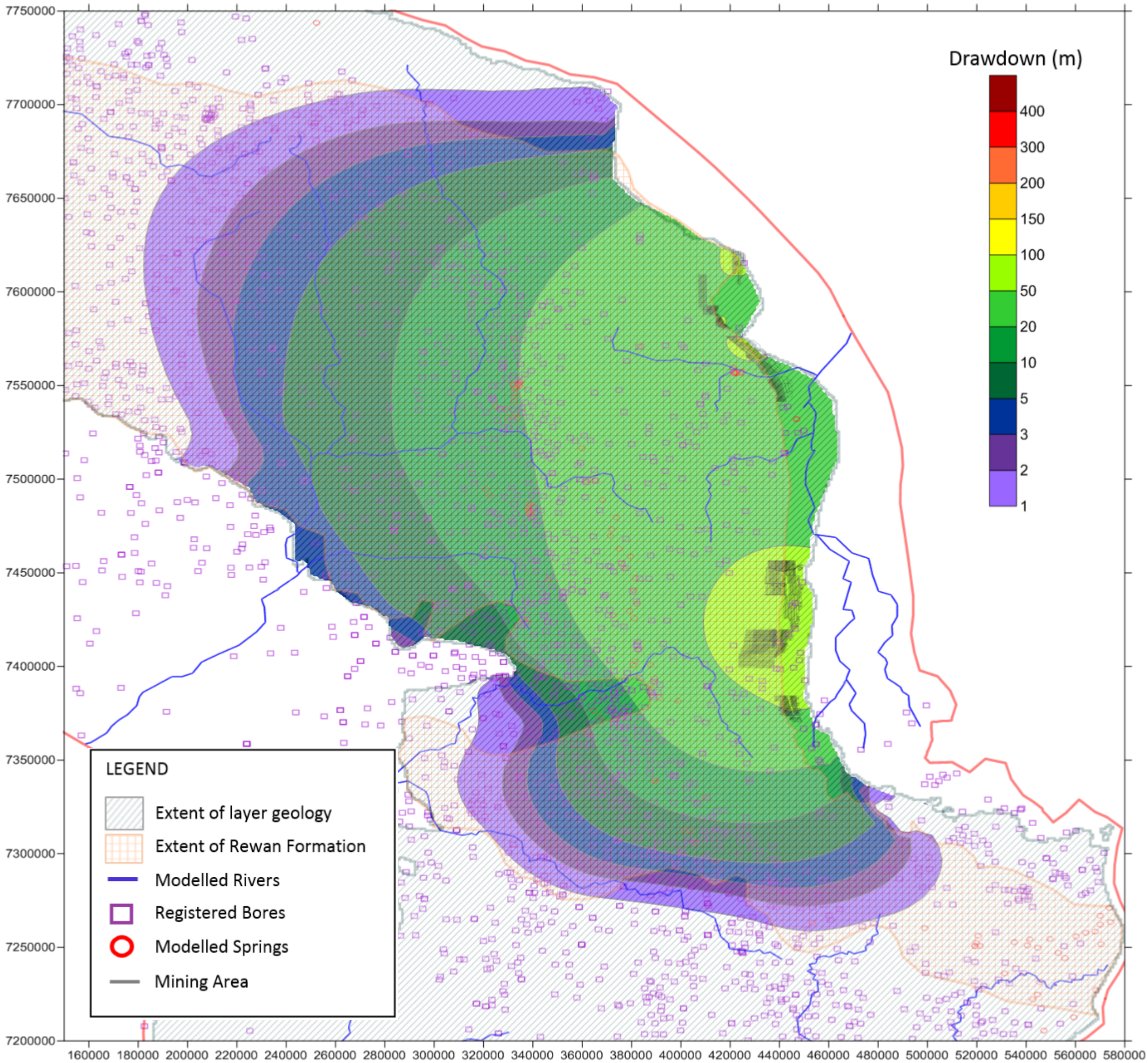

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 12 Drawdown 2080

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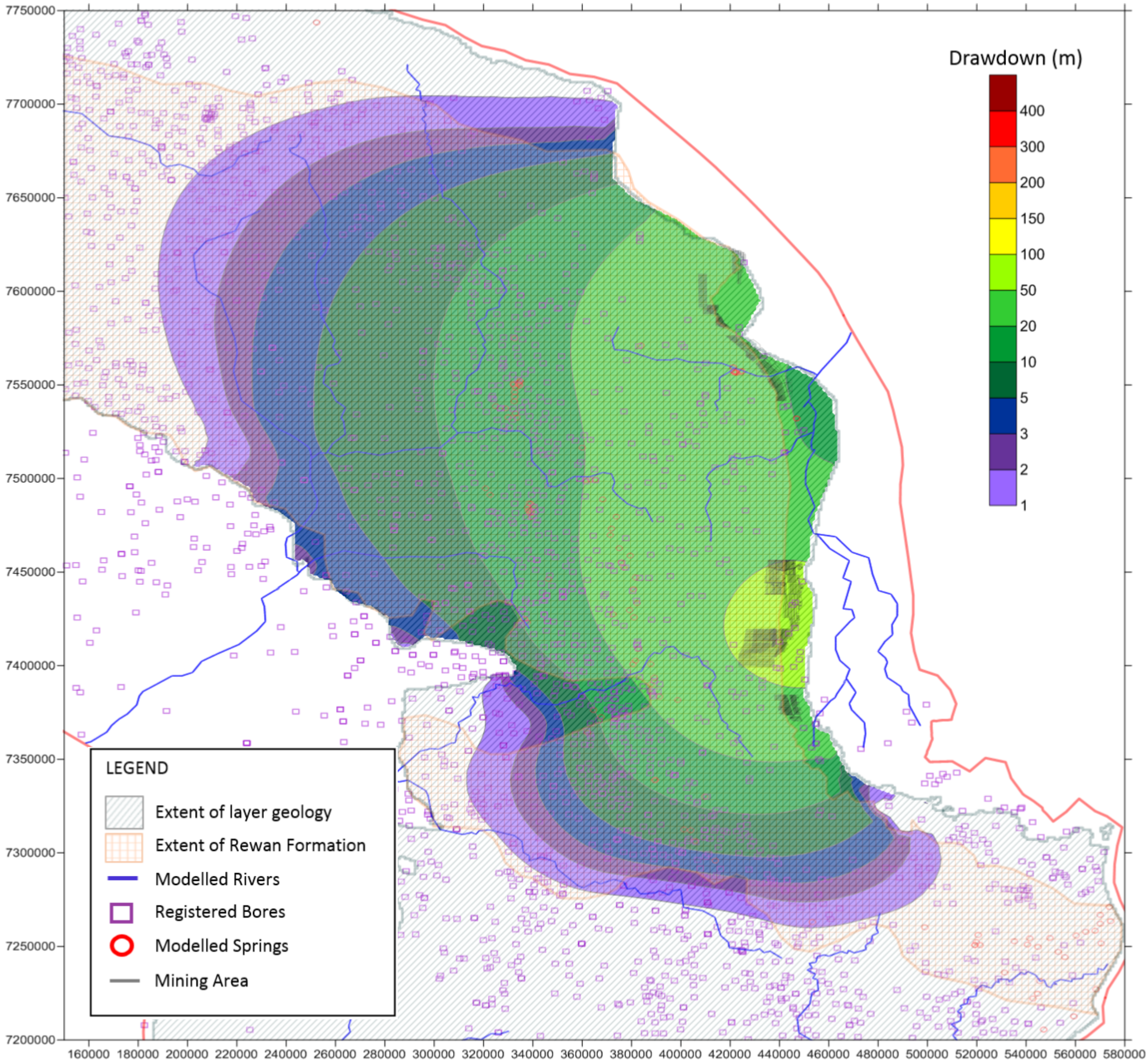

HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 12 Drawdown 2090		

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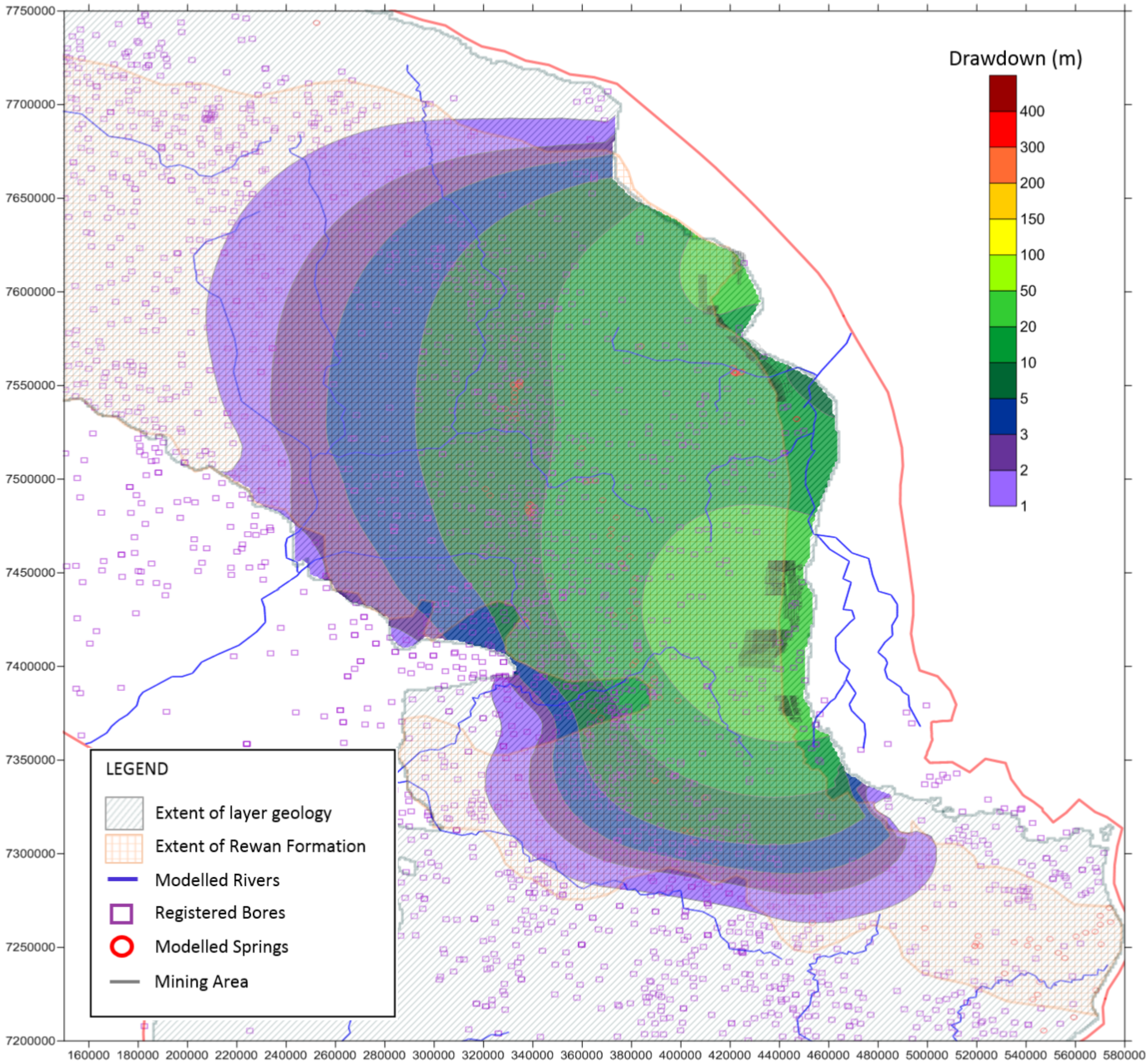

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	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 12 Drawdown 2110		

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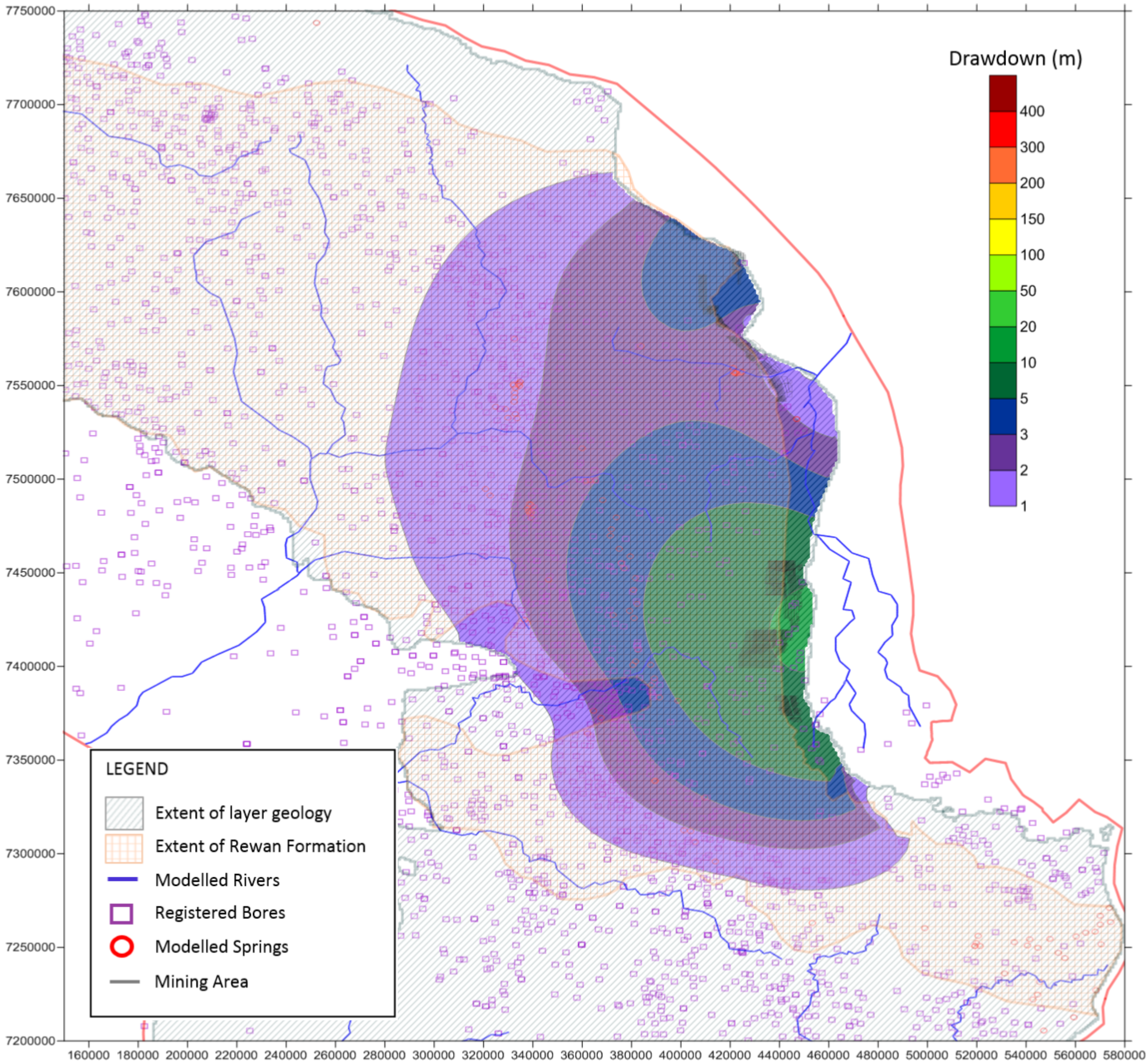

HydroSimulations	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL
	Layer 12 Drawdown 2200		

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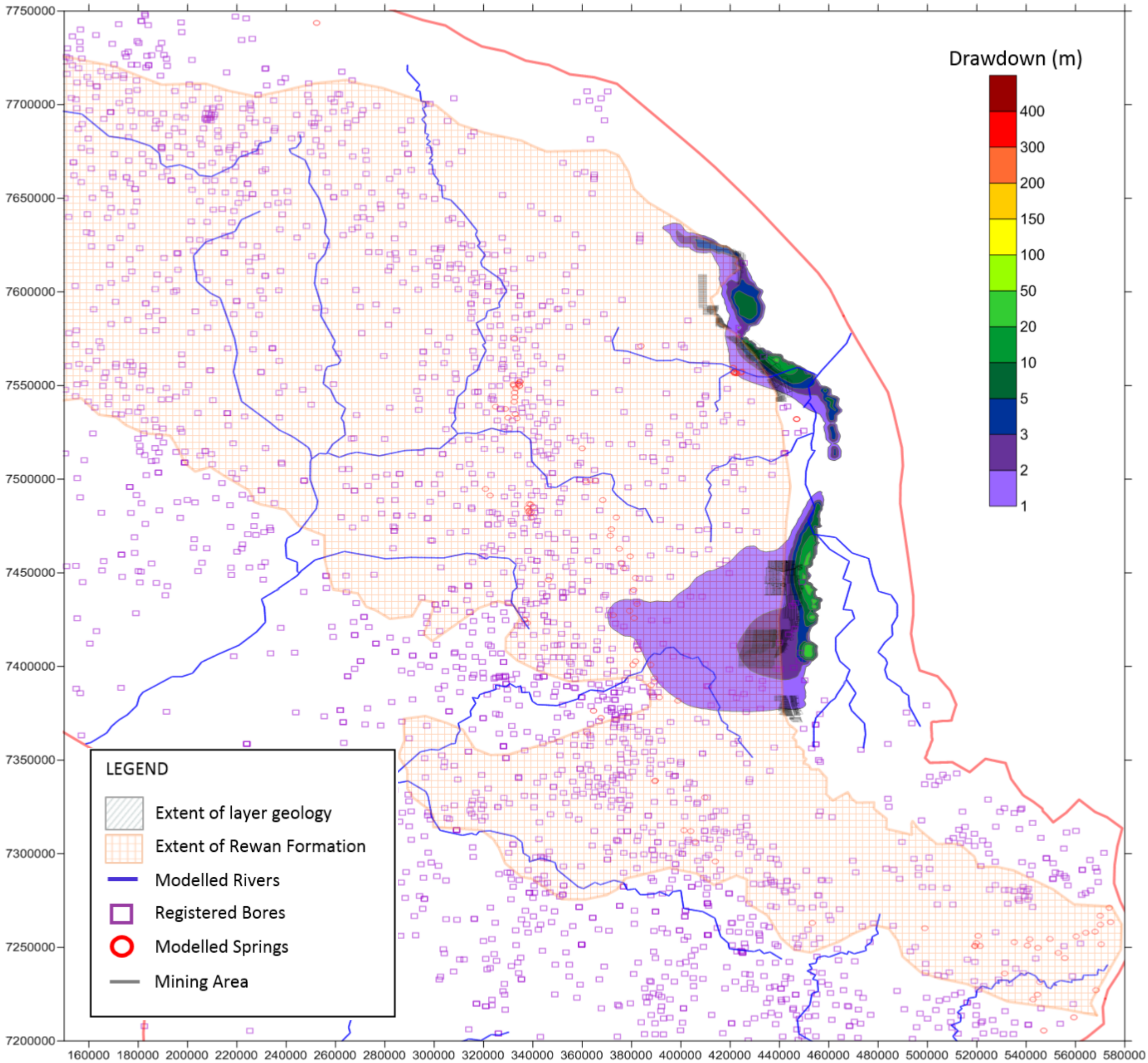

HYDROSIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 13 Drawdown 2020		

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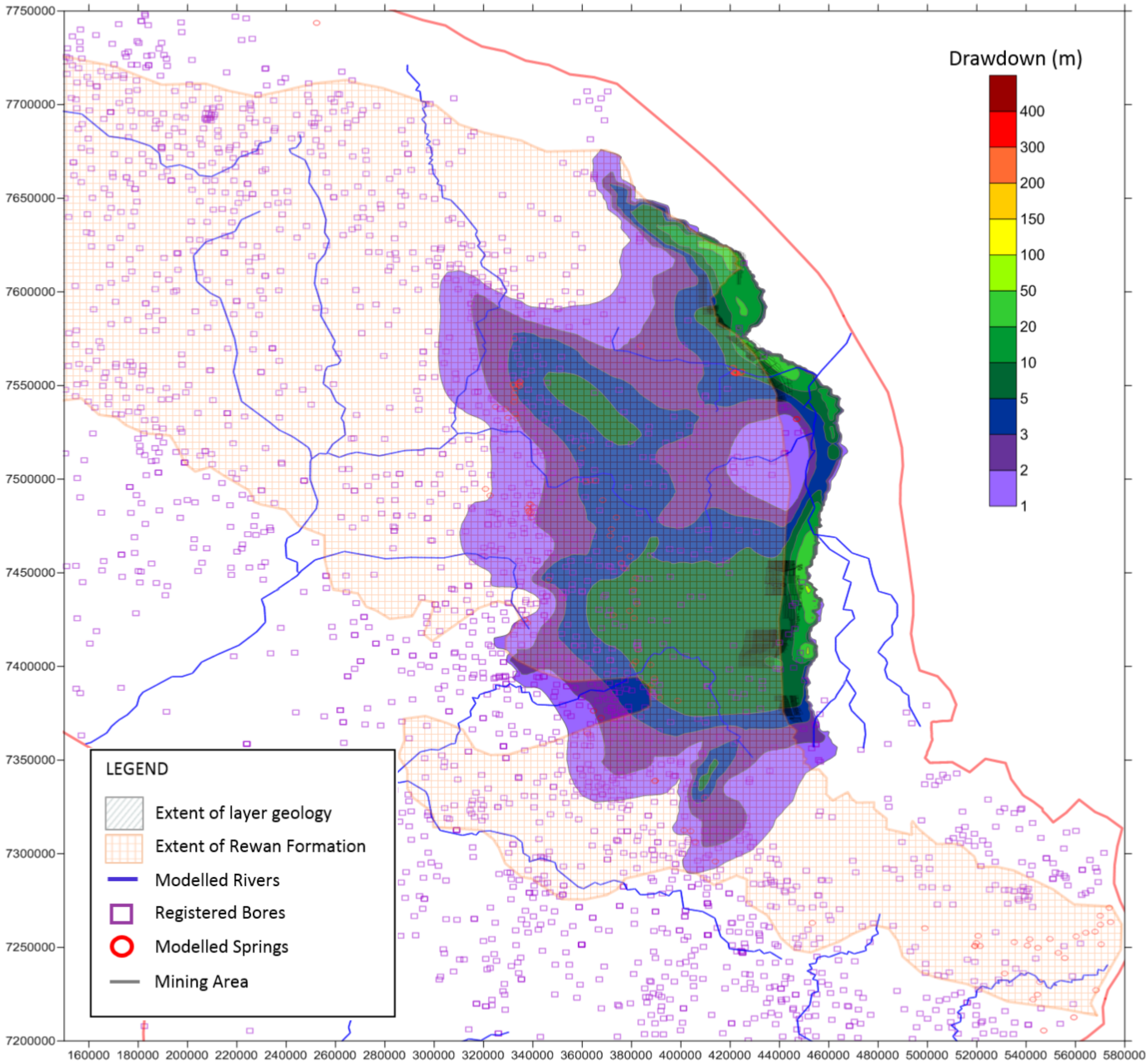

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 13 Drawdown 2025

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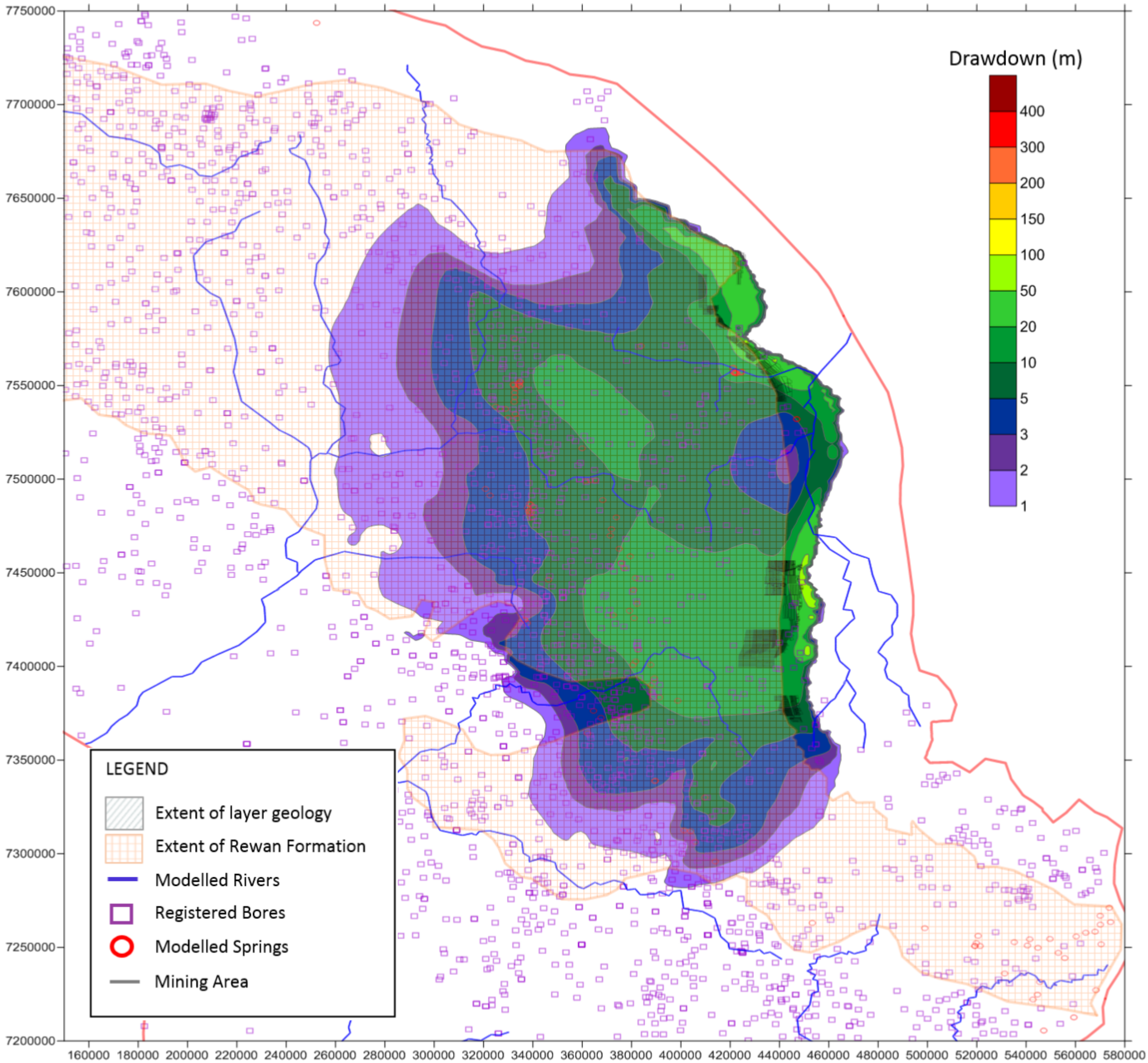

HYDROSIMULATIONS

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 13 Drawdown 2030

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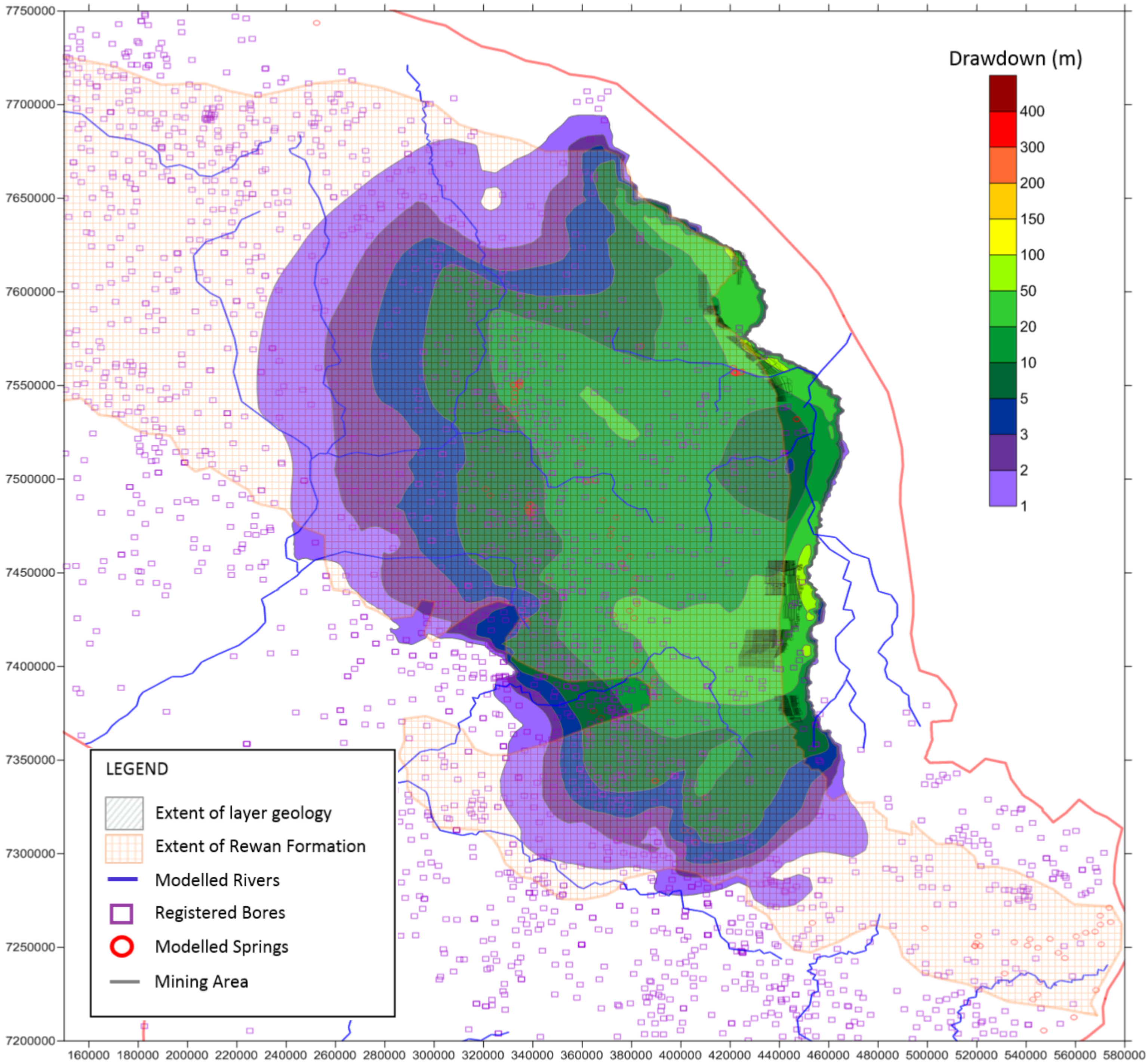

HYDROSIMULATIONS

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GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 12 Drawdown 2035

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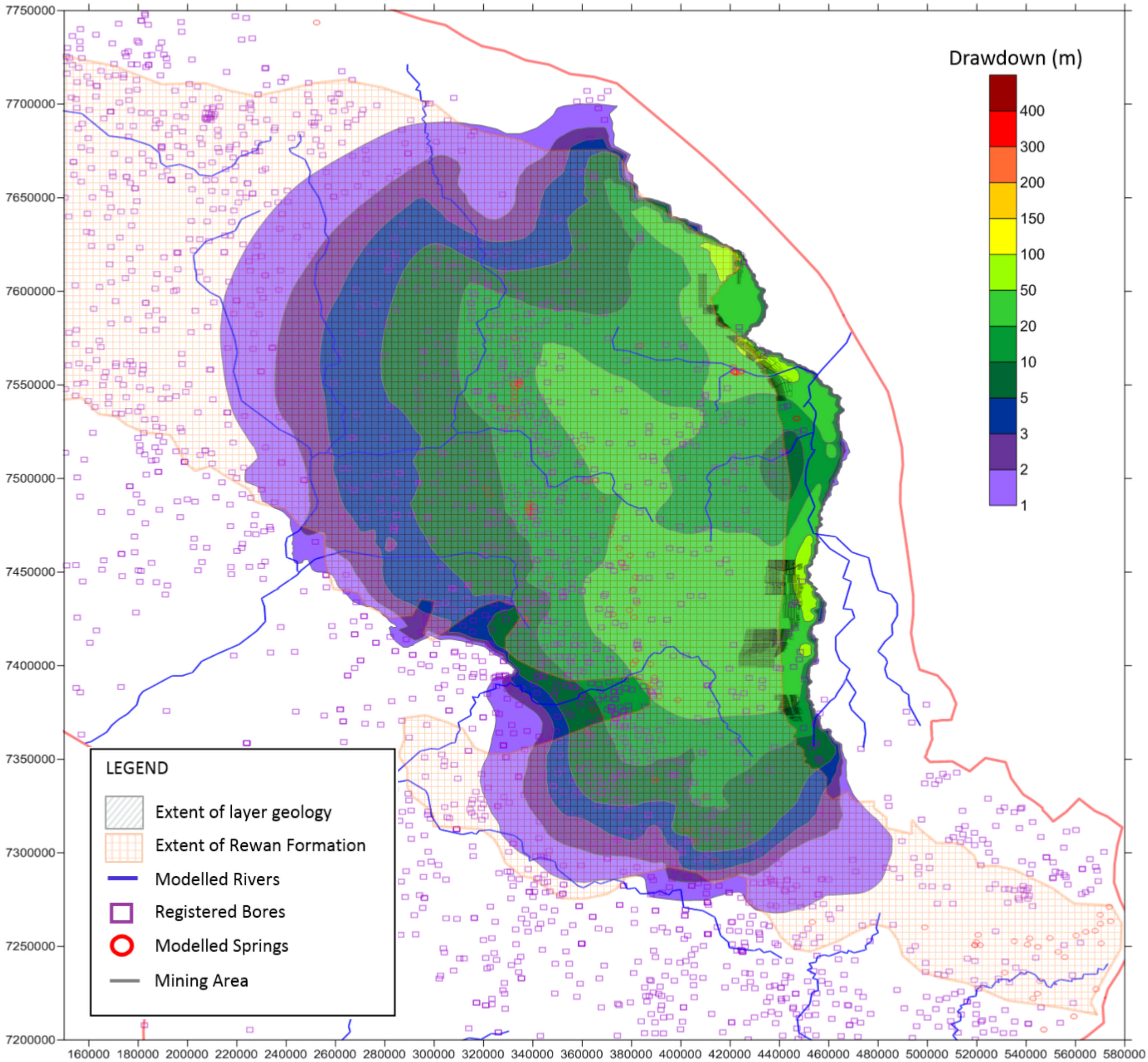

HYDROSIMULATIONS

10 OCTOBER 2015 | DRAWN BY: CT | Projection GDA 1994 MGA Zone 55

GEOSCIENCE AUSTRALIA | GSA001 - GALILEE BASIN MODEL

Layer 13 Drawdown 2040

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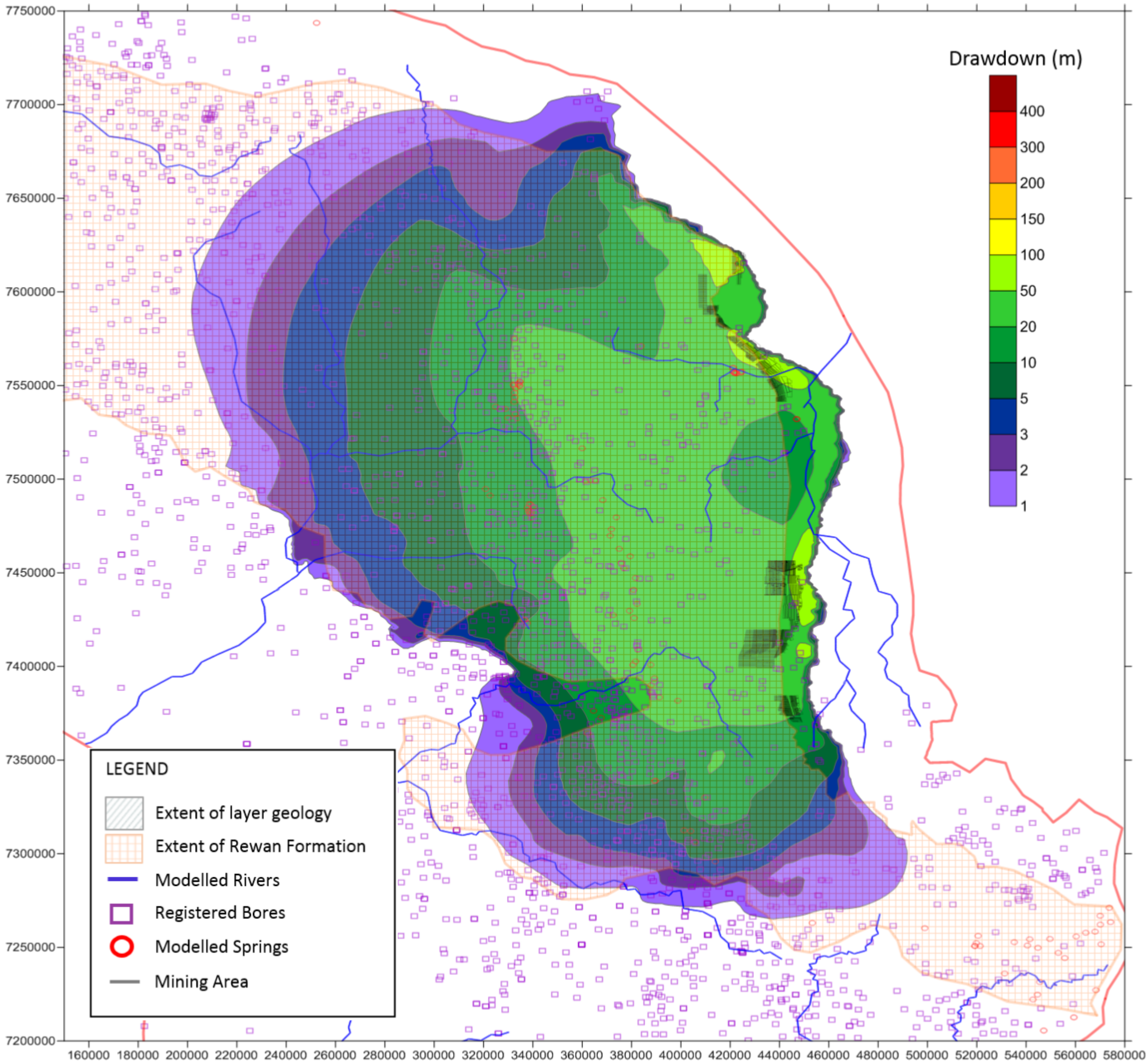

HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
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	Layer 13 Drawdown 2045		

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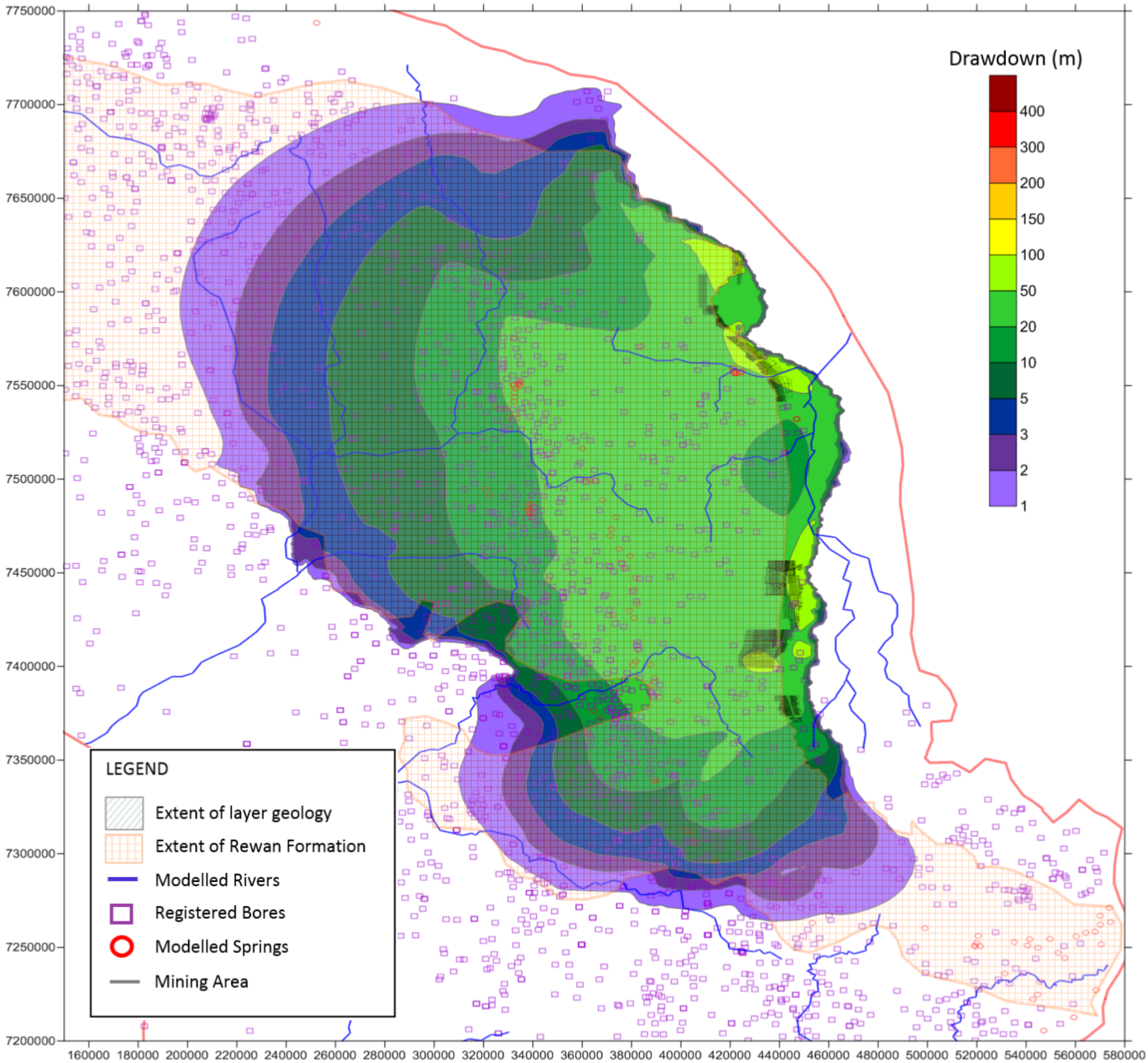
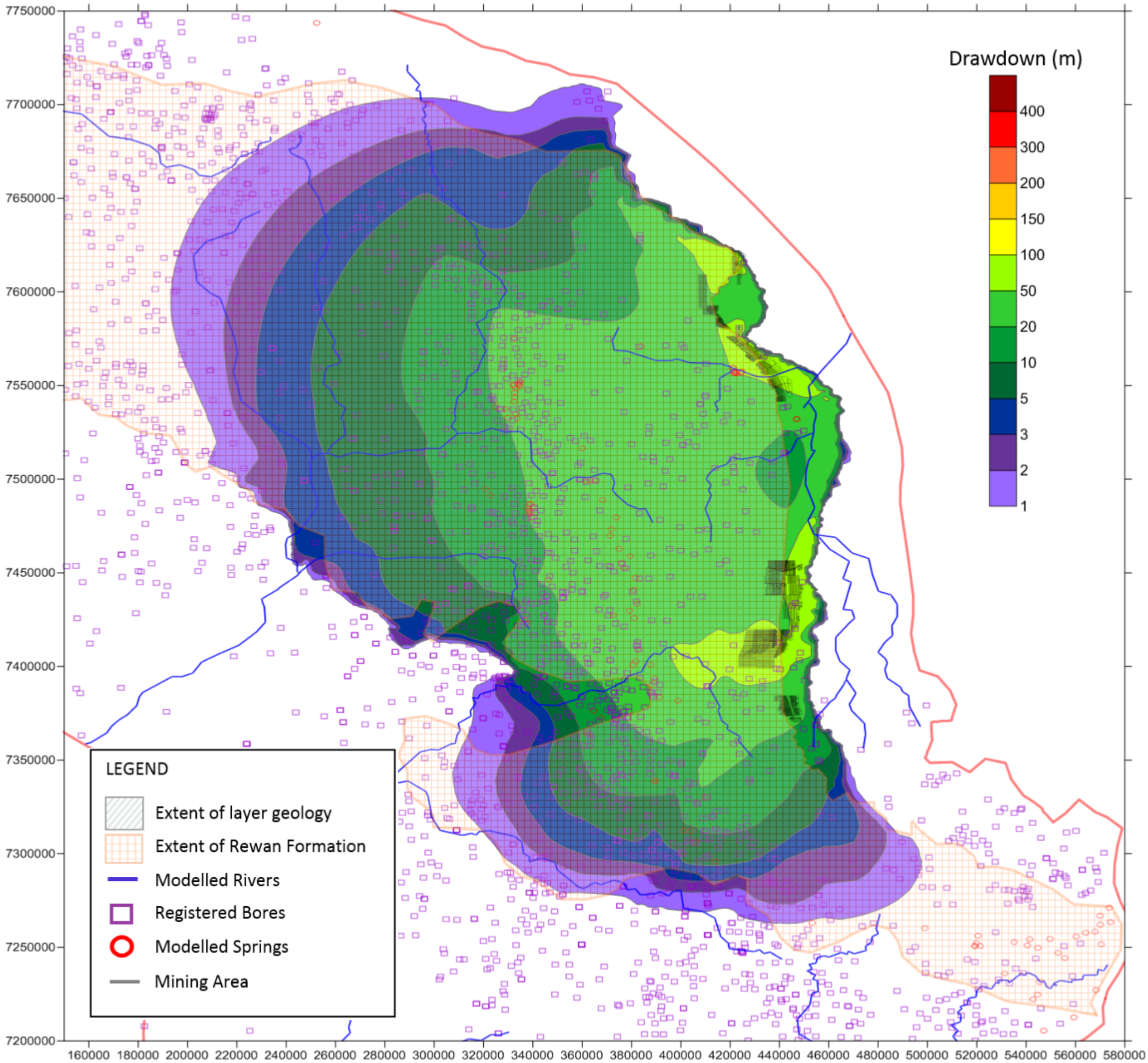


HYDRO SIMULATIONS	10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
	GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	
	Layer 13 Drawdown 2048		

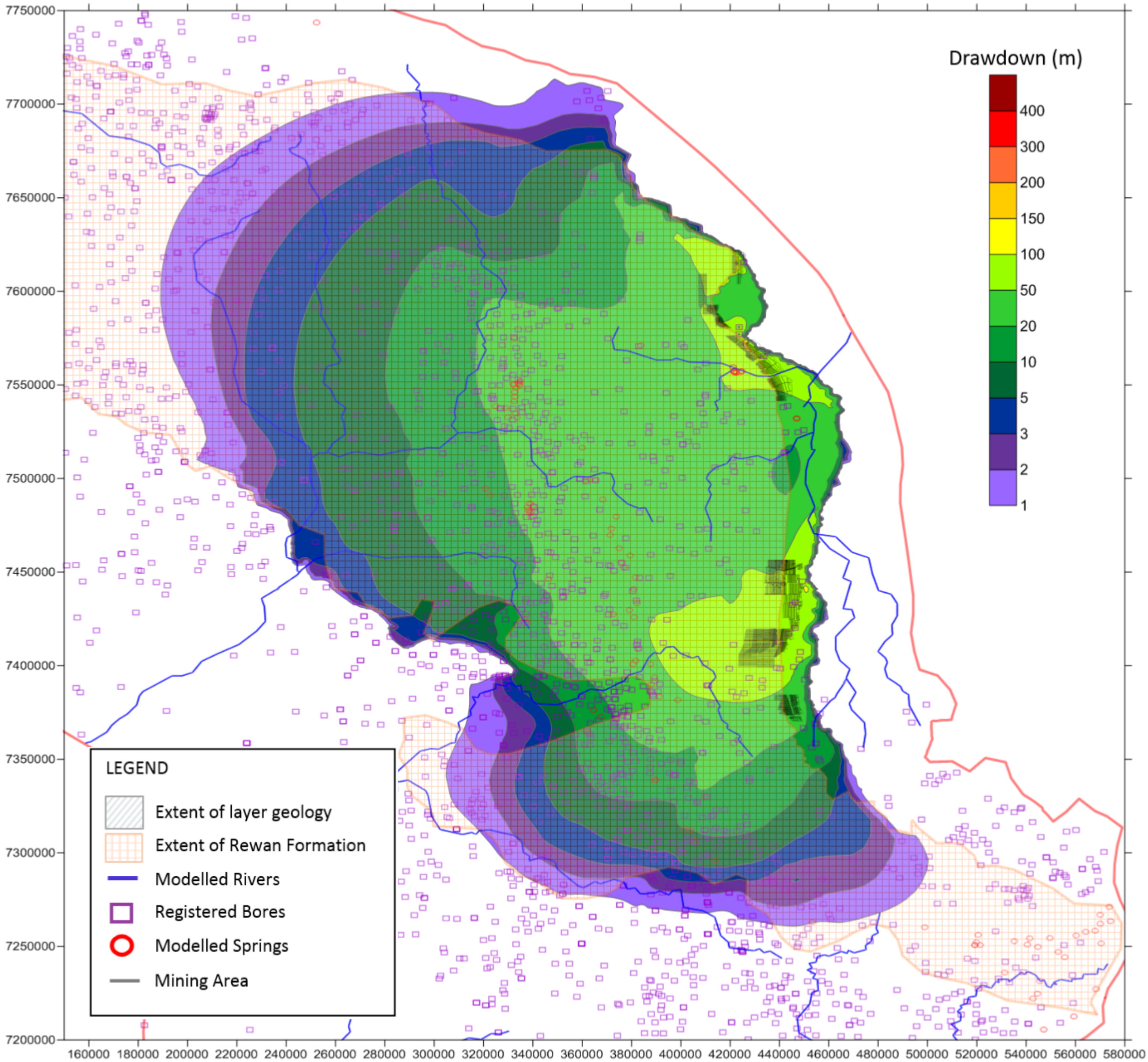
D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 13 Drawdown 2050

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

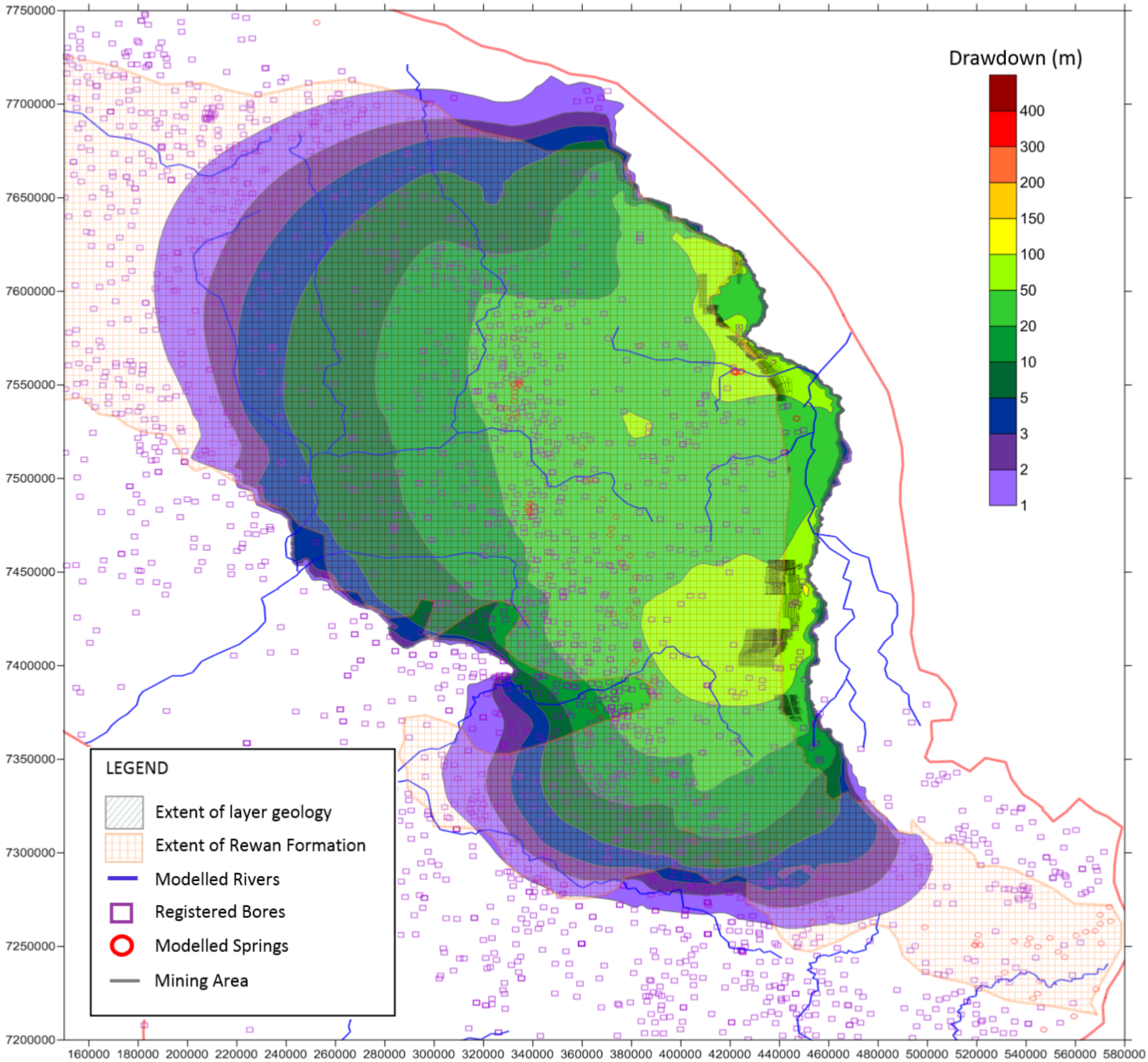


HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA		GSA001 - GALILEE BASIN MODEL

Layer 13 Drawdown 2055

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



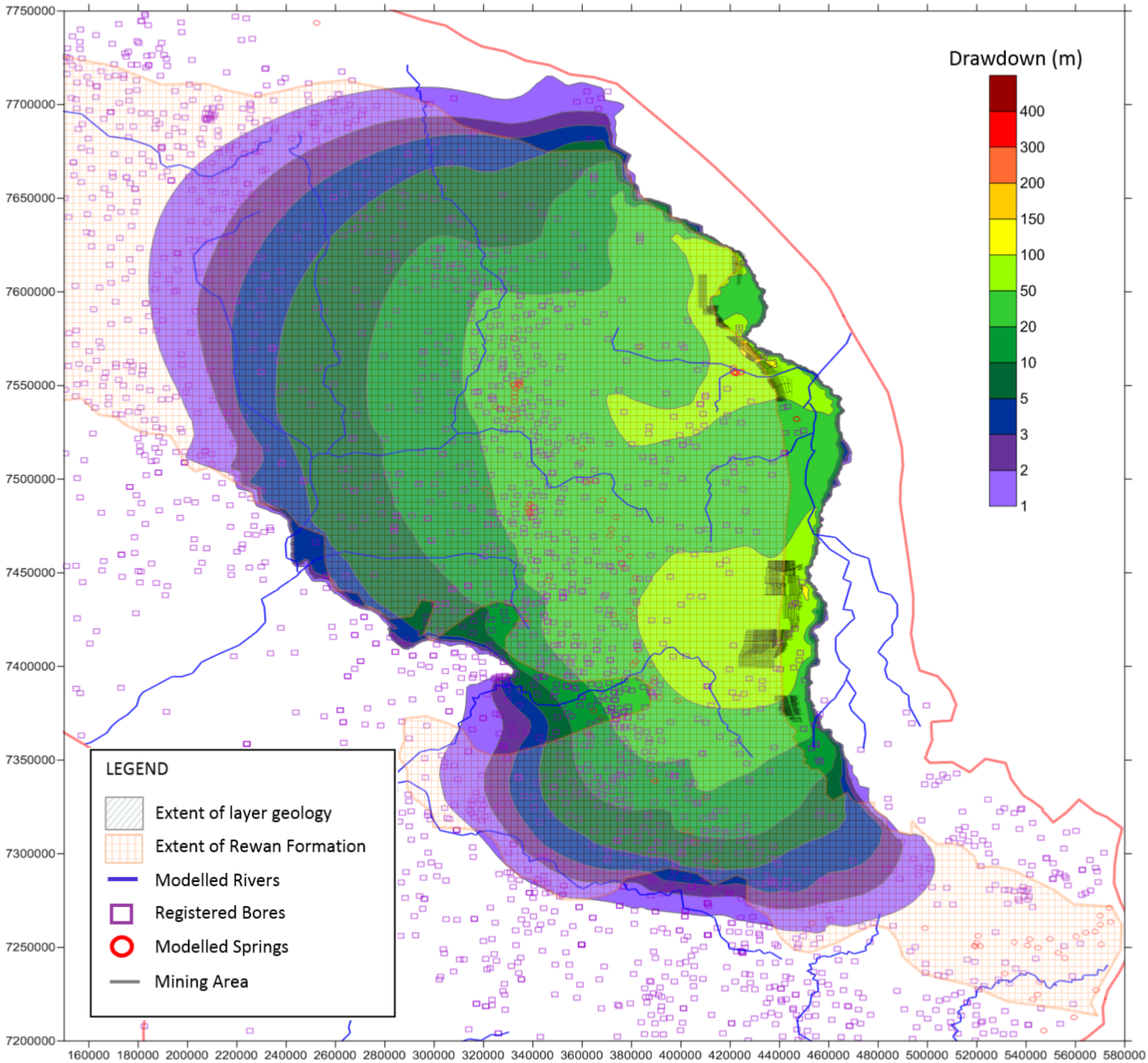
10 OCTOBER 2015 | DRAWN BY: CT | Projection GDA 1994 MGA Zone 55

HYDROSIMULATIONS

GEOSCIENCE AUSTRALIA | GSA001 - GALILEE BASIN MODEL

Layer 13 Drawdown 2058

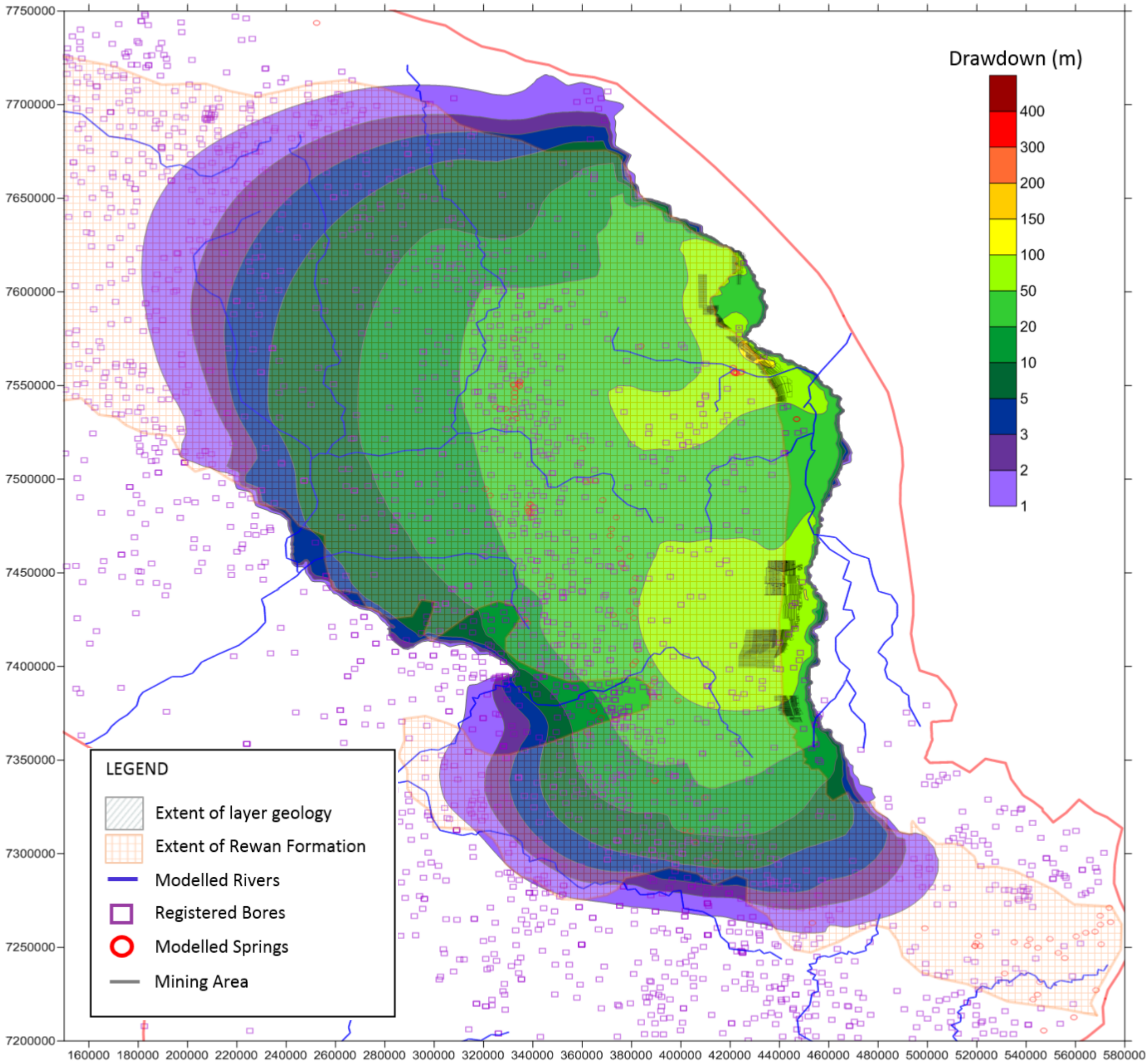
D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

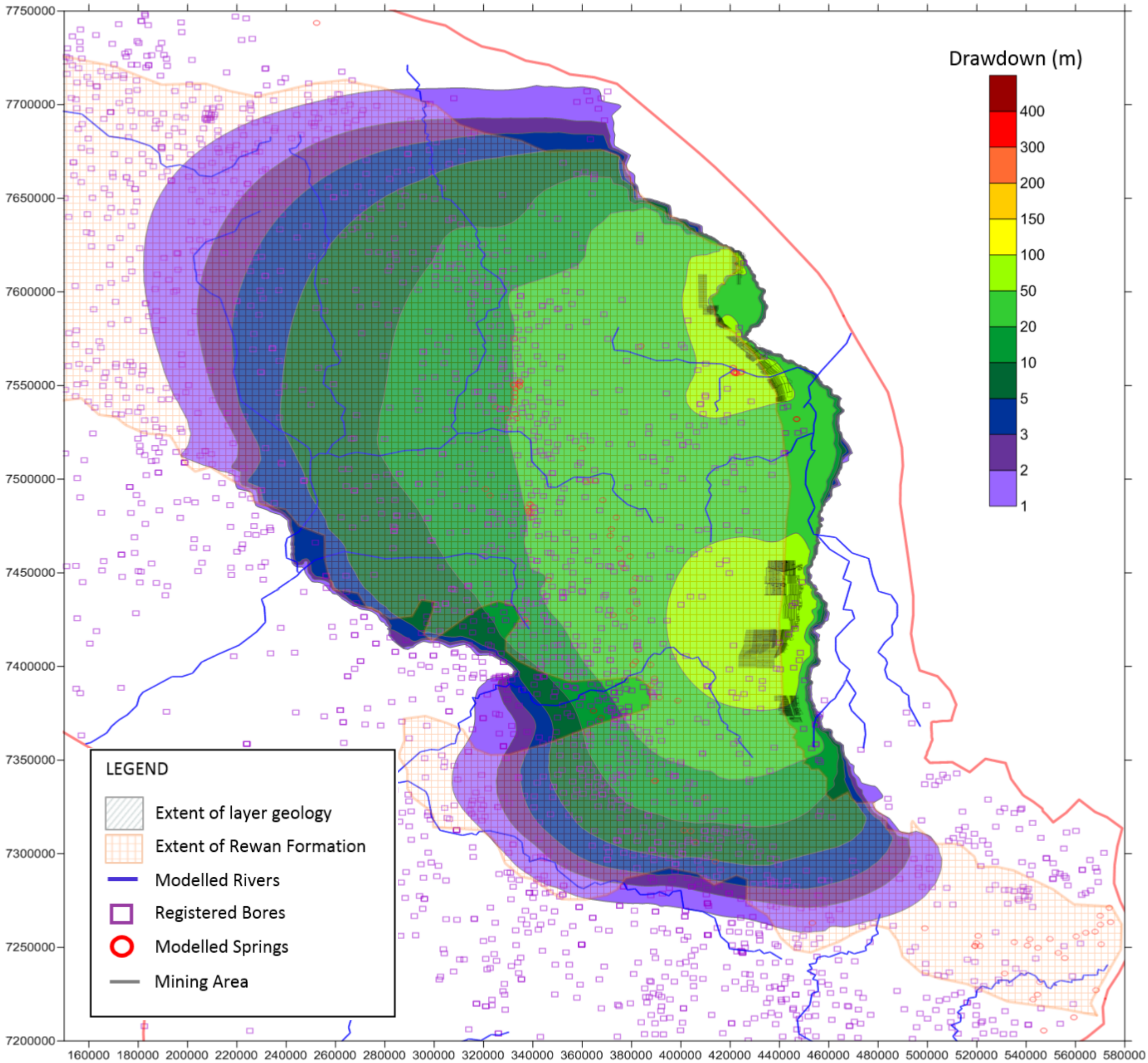
Layer 13 Drawdown 2061



10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 13 Drawdown 2067

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

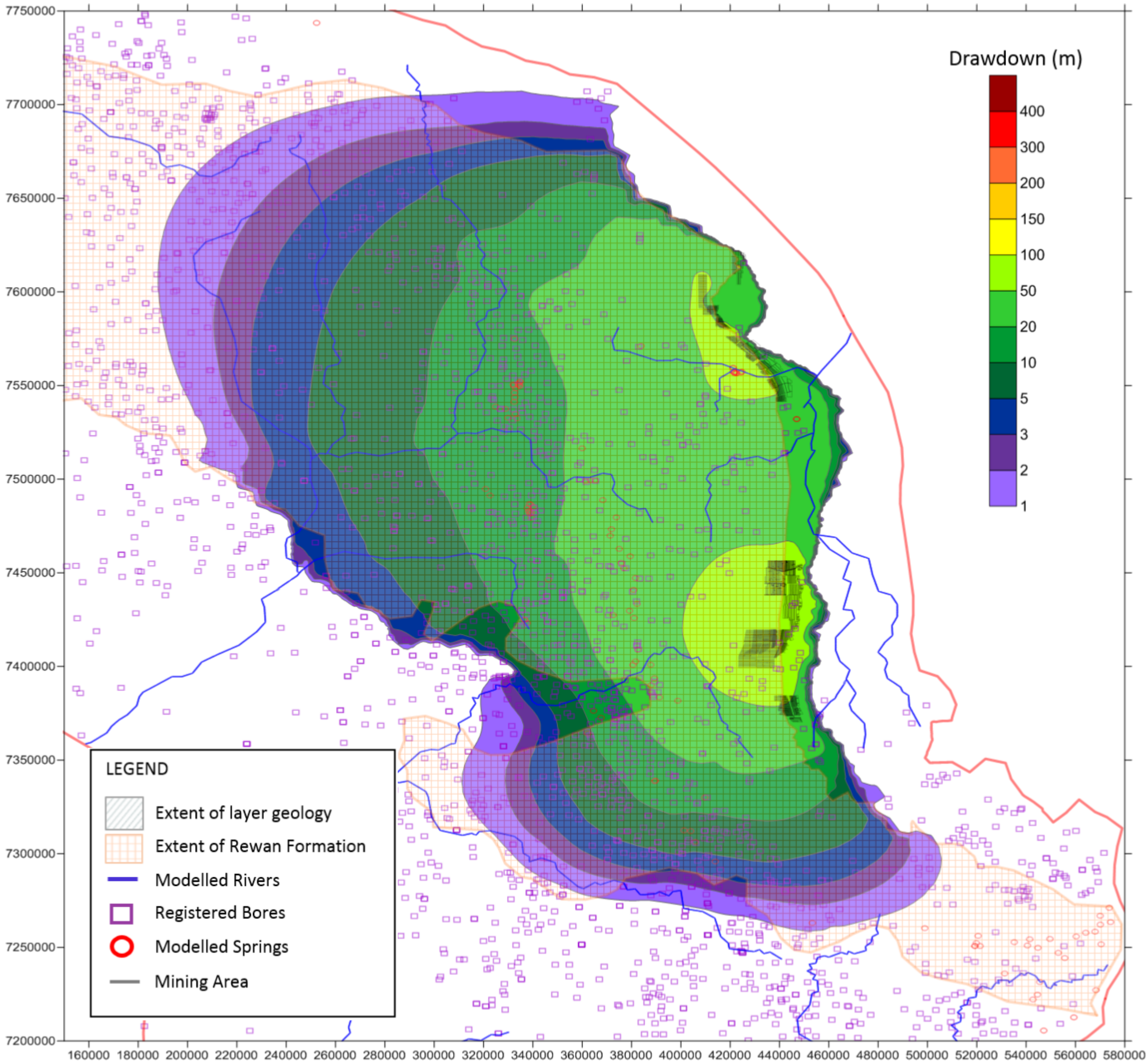


10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

HYDROSIMULATIONS

Layer 13 Drawdown 2080

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

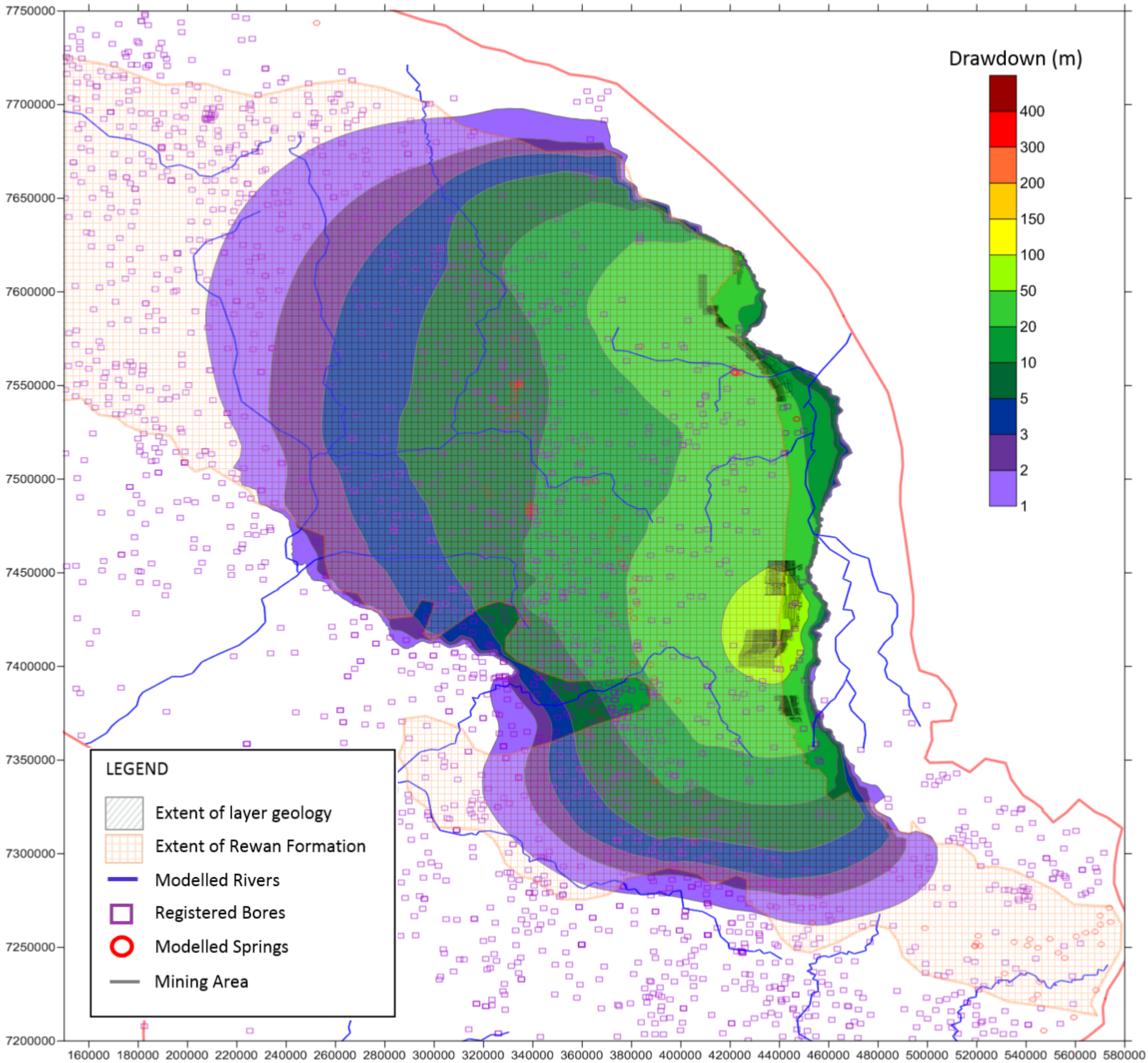


HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 13 Drawdown 2090

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

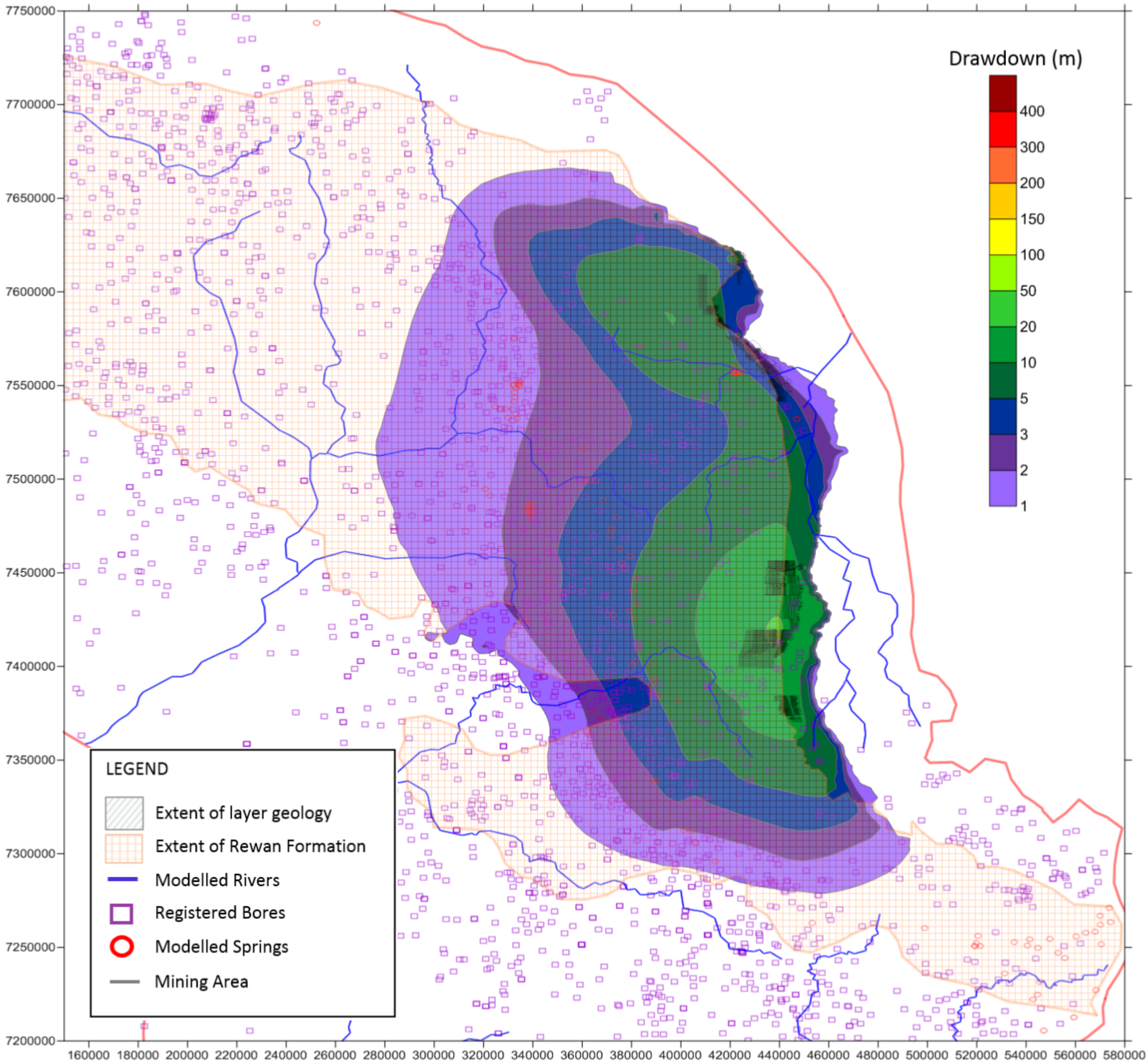


HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 13 Drawdown 2110

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed



HYDROSIMULATIONS

10 OCTOBER 2015	DRAWN BY: CT	Projection GDA 1994 MGA Zone 55
GEOSCIENCE AUSTRALIA	GSA001 - GALILEE BASIN MODEL	

Layer 13 Drawdown 2200

D:\HydroSim\GSA001\Model\Processing\Surfer\maths\TR45base-TR45\out\renamed

APPENDIX I – Predicted Drawdowns at Registered Bores

RN	Drawdown (m)	Model Layer	Easting	Northing
1	0.00	4	178693	7654966
60	0.00	6	72111	7642532
88	0.04	4	315542	7455718
94	0.00	4	359558	7293245
95	0.00	4	-60829	7517403
99	0.00	6	107285	7693359
108	0.00	6	-10810	7690971
110	0.00	5	338426	7114104
119	0.00	5	261947	7376637
119	0.00	6	261947	7376637
120	0.01	6	348893	7224873
121	0.01	6	251525	7690060
123	0.01	6	178397	7642788
126	0.00	6	82427	7591192
128	0.04	3	324553	7521459
135	0.00	6	243907	7375483
155	0.00	4	263567	7092503
166	0.00	4	23439	7720743
278	0.01	4	290631	7396328
290	1.37	7	389347	7391906
299	0.00	4	143336	7689178
305	0.00	4	259226	7132431
306	0.07	4	321546	7444024
308	0.11	6	247266	7499198
308	0.11	6	247266	7499198
308	0.11	6	247266	7499198
309	0.58	6	320753	7427156
311	0.00	5	458685	7146945
311	0.00	5	458685	7146945
311	0.00	5	458685	7146945
311	0.00	6	458685	7146945
311	0.00	6	458685	7146945
311	0.00	6	458685	7146945
313	0.30	6	325002	7394136
317	0.00	4	344410	7297657
318	0.05	6	344382	7298263
334	0.00	4	424503	7079244
335	0.00	5	424359	7079909
361	0.00	4	210984	7659534
362	0.02	6	208652	7626900
365	0.01	4	207849	7691726
367	0.01	4	207861	7691740
375	0.25	6	373768	7337570
376	0.00	5	290710	7307488
377	0.01	4	364937	7312107
378	0.00	4	331132	7275710
389	0.00	4	1270	7708688
391	0.00	4	49632	7702657
398	0.02	5	425066	7247139
399	0.02	6	425066	7247139

407	0.00	4	92975	7519332
1016	0.05	5	335024	7597793
1016	0.06	6	335024	7597793
1017	0.03	5	321717	7602941
1017	0.04	6	321717	7602941
1019	0.02	4	327840	7611097
1020	0.03	4	332257	7612313
1022	0.04	6	319532	7608023
1023	0.05	4	334300	7592772
1026	0.02	4	321816	7604326
1027	0.04	4	332874	7586268
1028	0.03	4	314983	7593483
1030	0.02	4	327043	7607582
1031	0.05	6	315575	7599457
1034	0.12	6	342275	7522573
1037	0.02	3	342922	7515197
1039	0.00	5	175263	7661171
1039	0.01	6	175263	7661171
1040	0.00	5	189481	7677429
1040	0.01	6	189481	7677429
1041	0.02	8	193432	7659437
1041	0.02	8	193432	7659437
1041	0.02	8	193432	7659437
1043	0.00	6	192405	7683486
1047	0.01	6	181841	7663104
1048	0.01	6	189501	7676352
1049	0.01	6	191746	7664449
1050	0.03	8	205004	7648408
1051	0.01	8	169742	7661394
1053	0.00	6	186896	7687262
1058	0.00	4	228353	7279543
1059	0.00	2	225730	7258431
1060	0.00	2	214446	7257525
1061	0.00	2	220984	7256765
1062	0.00	2	220173	7266295
1063	0.00	2	220319	7282833
1068	0.00	2	220078	7259857
1069	0.00	4	225370	7265229
1072	0.00	2	231229	7291053
1076	0.00	2	204861	7258678
1077	0.00	2	208640	7256849
1078	0.00	2	234025	7273033
1079	0.00	2	232407	7282547
1080	0.00	2	234775	7288319
1081	0.00	2	242314	7284334
1084	0.00	4	70822	7615745
1085	0.00	4	67822	7610729
1085	0.00	4	67822	7610729
1085	0.00	4	67822	7610729
1102	0.07	6	347149	7321118
1103	0.06	6	330513	7326851

1104	0.07	6	340473	7324782
1117	1.62	8	420777	7386159
1174	18.72	9	432973	7388298
1175	25.00	9	433080	7392181
1181	0.00	4	335378	7117789
1183	0.00	4	312911	7155189
1184	0.00	4	290419	7155670
1204	0.30	8	323138	7464659
1206	0.17	6	338044	7461693
1211	0.34	6	353576	7471502
1217	0.16	6	346186	7460788
1222	0.15	6	336535	7470990
1223	0.41	6	356893	7467688
1225	0.42	6	356889	7461876
1227	0.16	6	341676	7456433
1228	0.18	6	334358	7456354
1229	0.08	3	340757	7482042
1230	0.05	3	340516	7484838
1234	0.29	6	352153	7436545
1235	0.04	3	347796	7442685
1240	0.19	6	335794	7452678
1241	0.13	4	346858	7448243
1242	0.42	6	355950	7443904
1244	0.77	6	362136	7445746
1245	0.57	6	368781	7437230
1246	0.08	6	370690	7427306
1247	0.06	6	371138	7430155
1250	0.02	3	315278	7484127
1251	5.57	9	297082	7479033
1252	0.02	3	322007	7475582
1253	0.03	3	323615	7482412
1254	0.06	3	328479	7490741
1255	0.11	6	298392	7487912
1256	0.01	3	298666	7467302
1260	0.03	4	320173	7463419
1288	0.00	4	435321	7067567
1293	0.00	4	428330	7045870
1298	0.00	5	287103	7321841
1299	0.05	6	309536	7339632
1301	0.00	2	319146	7323880
1302	0.00	2	319997	7325830
1304	0.00	2	304263	7324421
1307	0.00	2	296436	7340744
1311	0.00	2	303991	7346327
1312	0.00	2	308109	7346998
1314	0.00	2	306208	7318478
1315	0.00	2	298422	7318277
1316	0.00	2	297376	7320417
1317	0.00	2	303085	7352561
1320	0.00	4	52418	7559422
1321	0.00	6	35326	7589275

1322	0.00	6	44970	7581473
1329	0.00	2	61469	7541116
1348	0.03	6	286951	7370549
1349	0.06	5	306051	7376048
1350	0.03	6	283493	7353757
1351	0.07	6	297008	7368324
1352	0.01	6	278316	7368419
1353	0.17	4	356649	7358148
1354	0.18	5	328964	7394502
1355	0.25	6	319515	7402387
1356	0.20	5	328114	7402352
1356	0.35	6	328114	7402352
1362	0.41	6	333273	7396084
1363	0.18	5	328842	7394995
1365	0.37	6	329167	7390553
1366	0.17	6	310422	7386321
1367	0.06	6	291227	7382397
1368	0.64	6	340539	7390343
1369	0.51	6	335609	7387489
1370	0.52	6	334457	7379138
1372	0.20	6	315513	7393986
1373	0.20	6	316059	7395655
1374	0.18	6	311026	7393831
1375	0.07	4	319912	7393703
1376	1.94	6	356771	7388727
1377	1.56	5	353788	7389374
1377	1.61	6	353788	7389374
1381	0.34	6	332268	7363875
1382	0.25	6	336711	7355136
1383	0.42	6	329659	7382406
1384	0.04	4	326392	7364184
1385	0.12	4	342574	7362185
1386	0.50	6	337674	7365084
1387	0.27	6	324985	7374810
1388	0.00	2	319869	7372357
1389	0.29	6	321521	7384955
1390	0.38	6	323730	7407041
1391	0.68	5	354072	7395037
1391	0.68	6	354072	7395037
1392	0.83	6	358729	7397298
1394	0.40	6	327075	7406945
1397	0.84	6	362404	7401639
1398	0.51	4	355569	7401389
1399	1.03	6	366098	7413454
1404	0.55	6	354962	7402490
1406	0.54	6	370142	7396081
1407	0.03	6	372879	7397643
1418	0.08	3	331504	7495390
1421	0.06	3	326907	7515641
1424	0.04	3	323059	7502216
1428	0.21	6	348014	7503283

1429	0.15	6	344634	7501373
1431	0.16	6	341428	7493651
1432	0.01	5	214905	7620882
1432	0.02	6	214905	7620882
1434	0.02	6	192436	7606480
1436	0.01	5	196054	7620658
1436	0.02	6	196054	7620658
1438	0.02	6	190488	7618150
1440	0.02	6	194439	7600011
1441	0.02	6	202516	7621921
1442	0.00	3	236993	7600832
1443	0.00	3	237694	7611147
1445	0.04	7	229463	7600635
1448	0.00	4	273540	7420909
1450	0.00	6	267748	7416798
1454	0.00	4	259042	7415756
1455	0.00	4	276400	7412244
1455	0.00	6	276400	7412244
1457	0.00	4	267357	7423706
1472	0.00	2	237812	7420596
1492	0.00	4	352491	7283021
1492	0.00	2	352491	7283021
1493	0.05	6	358796	7271546
1494	0.05	6	346655	7301181
1497	0.00	2	342313	7286560
1502	0.00	2	31046	7479158
1503	0.00	2	26988	7481747
1505	0.00	2	30914	7487143
1506	0.00	2	56253	7487901
1517	0.00	2	61409	7494710
1518	0.00	2	38298	7481539
1519	0.00	2	59367	7484106
1528	0.00	2	46373	7518142
1529	0.00	2	54616	7512739
1530	0.13	8	357905	7662963
1532	0.09	8	361012	7664065
1541	0.00	2	340235	7266537
1542	0.00	2	336995	7269545
1543	0.00	2	335364	7264911
1547	0.00	2	343123	7262201
1549	0.00	2	346923	7279412
1550	0.00	2	340652	7279218
1551	0.00	4	333195	7251171
1576	0.00	5	480914	7195440
1577	0.00	4	493500	7178258
1578	0.00	4	487854	7185759
1579	0.00	5	492682	7192376
1581	0.01	4	269018	7634390
1611	0.00	5	-38234	7547353
1628	0.03	4	302980	7492152
1629	0.03	4	302189	7502533

1630	0.12	6	314417	7508112
1631	0.10	6	284797	7480342
1632	0.10	6	284106	7488794
1633	0.03	4	281981	7538148
1634	0.03	4	284056	7496871
1637	0.12	6	316400	7497677
1638	0.10	6	285930	7502805
1639	0.06	5	293770	7497450
1639	0.11	6	293770	7497450
1644	0.12	6	312154	7494549
1646	0.06	5	283764	7472380
1646	0.10	6	283764	7472380
1647	0.01	3	284057	7474146
1648	0.12	8	278136	7488593
1649	0.11	6	290970	7480521
1650	0.12	6	266913	7474231
1651	0.14	6	262263	7479698
1653	0.11	6	283332	7463090
1671	0.00	4	-70858	7410033
1672	0.00	4	-53593	7458674
1673	0.00	4	-80951	7427516
1675	0.00	4	-65355	7443440
1681	0.00	4	-74607	7502100
1682	0.00	4	-57540	7487440
1750	0.00	4	12317	7748125
1751	0.00	4	478646	7128870
1752	0.00	4	489085	7149709
1753	0.00	4	498415	7156050
1754	0.00	5	481015	7163022
1755	0.00	4	481342	7152601
1755	0.00	4	481342	7152601
1757	0.00	3	468350	7131864
1763	0.00	4	472944	7129875
1768	0.00	3	471483	7136578
1773	0.00	4	501229	7147991
1775	0.00	3	470405	7120948
1779	0.01	6	102360	7754005
1789	0.00	3	94924	7752270
1798	0.00	4	69684	7755880
1799	0.00	4	64989	7757489
1812	0.00	4	383159	7117628
1836	0.01	6	201258	7673395
1837	0.01	6	205787	7667387
1838	0.01	6	207611	7659320
1840	0.01	6	198439	7677104
1841	0.00	4	210002	7668881
1842	0.07	6	304022	7561975
1845	0.08	6	300244	7554544
1846	0.07	6	295627	7567928
1847	0.06	6	297668	7578876
1850	0.06	6	306206	7575629

1851	0.07	6	295419	7561865
1852	0.07	6	301547	7571757
1853	0.03	4	293033	7547067
1858	0.00	4	94941	7721688
1859	0.00	4	101933	7739416
1861	0.00	4	78253	7736184
1861	0.00	4	78253	7736184
1861	0.00	4	78253	7736184
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1865	0.00	4	55371	7729649
1867	0.00	4	63326	7732408
1874	0.00	4	87403	7741863
1875	0.00	5	81012	7725558
1875	0.00	6	81012	7725558
1877	0.00	4	85271	7743874
1879	0.00	5	94465	7742153
1880	0.00	4	70126	7741683
1880	0.00	4	70126	7741683
1880	0.00	4	70126	7741683
1892	0.00	4	54818	7742337
1893	0.00	4	45009	7718362
1894	0.00	6	71930	7719600
1894	0.01	3	71930	7719600
1895	0.01	4	217983	7637064
1897	0.02	6	201533	7637606
1898	0.02	6	207947	7637372
1899	0.02	6	217372	7629747
1900	0.02	6	200840	7627893
1903	0.01	4	220583	7647493
1904	0.00	4	215314	7652961
1906	0.01	4	226378	7652221
1909	0.00	4	217613	7452735
1910	0.00	3	217771	7448859
1911	0.01	5	230693	7446357
1923	0.06	4	268364	7433847
1927	0.15	5	256118	7448547
1961	0.00	5	102937	7641293
1961	0.00	6	102937	7641293
1962	0.00	5	86284	7644271
1962	0.00	6	86284	7644271
1964	0.00	4	102379	7650000
1965	0.00	4	95834	7638901
1966	0.00	4	96214	7650435
1967	0.00	4	77860	7634840
1968	0.00	6	74455	7632532
1969	0.00	4	86252	7635240
1970	0.00	5	83467	7644846
1971	0.30	5	389299	7327708
1972	0.29	5	386795	7320331
1973	0.32	6	391851	7315116
1974	0.14	6	401546	7319862

1976	0.00	5	395890	7333325
1977	0.14	6	384867	7314015
1978	0.06	4	382676	7309567
1979	0.01	6	426019	7310395
1980	0.00	5	397666	7341643
1980	0.14	6	397666	7341643
1982	0.06	6	406714	7327402
1983	0.04	6	403509	7338208
1988	0.05	6	414333	7322836
1990	0.02	6	412350	7319564
1991	0.14	6	410620	7330042
1995	0.00	4	431587	7078676
1996	0.00	4	424573	7064185
2001	0.00	4	417338	7096323
2011	0.00	3	152096	7724727
2013	0.00	5	156572	7740091
2019	0.00	5	181334	7744633
2024	0.00	4	150131	7722962
2028	0.01	6	175984	7728216
2032	0.00	3	172076	7742950
2064	0.00	6	34584	7718925
2066	0.00	4	34751	7736197
2071	0.00	4	24126	7731495
2074	0.00	3	116884	7750187
2083	0.00	5	141268	7719606
2083	0.00	6	141268	7719606
2085	0.00	5	146716	7718428
2085	0.00	6	146716	7718428
2087	0.00	3	142621	7706871
2088	0.00	6	145707	7725204
2088	0.00	6	145707	7725204
2089	0.00	6	147274	7719384
2089	0.00	6	147274	7719384
2137	0.28	5	328237	7428905
2139	0.54	6	357556	7415958
2140	0.55	6	367796	7420452
2142	0.35	6	349962	7411423
2145	0.30	6	348378	7423533
2147	1.11	6	365968	7409055
2148	0.32	6	345382	7418765
2152	0.04	3	329941	7434032
2153	0.30	6	344628	7427333
2156	0.23	4	345914	7423878
2159	0.66	6	328968	7424699
2161	0.50	6	356949	7411184
2162	0.00	3	354141	7422415
2165	0.41	6	335614	7430189
2166	0.00	6	376907	7421300
2168	0.41	6	337194	7427642
2172	0.03	3	324031	7542370
2175	0.05	6	328105	7575377

2179	0.02	3	316536	7546437
2183	0.07	6	327456	7558831
2184	0.05	4	335001	7561407
2185	0.04	4	331911	7555375
2188	0.08	6	308673	7556494
2192	0.06	6	327581	7571277
2193	0.05	6	332298	7575496
2194	0.05	6	335898	7574335
2196	0.06	6	326707	7582037
2200	0.02	4	293533	7601126
2201	0.09	6	335534	7537882
2203	0.08	6	337619	7587869
2204	0.09	6	338339	7579773
2205	0.08	6	338152	7547752
2209	0.11	6	342922	7543495
2210	0.12	6	341917	7529644
2211	0.15	6	345155	7534905
2214	0.07	6	327687	7561482
2215	0.07	6	328090	7563947
2216	0.08	6	339337	7557915
2217	0.06	6	316604	7578505
2218	0.06	6	334092	7579668
2219	0.10	6	341007	7571373
2220	0.12	6	344175	7561500
2224	0.11	6	341839	7565629
2233	0.03	3	326951	7537328
2234	0.09	6	335703	7535423
2235	0.03	3	323609	7544211
2236	0.00	4	18875	7456039
2237	0.00	4	1721	7441896
2238	0.00	2	42151	7469565
2260	0.05	6	237141	7546098
2261	0.02	4	229801	7557182
2261	0.02	4	229801	7557182
2262	0.05	6	237177	7563143
2263	0.05	6	239035	7549658
2264	0.02	4	259170	7550731
2287	0.00	6	-2024	7574567
2289	0.00	8	19546	7595625
2290	0.00	4	15827	7600387
2348	0.00	6	202450	7463379
2349	0.00	2	188567	7483313
2350	0.00	5	176590	7495822
2350	0.00	6	176590	7495822
2351	0.00	4	178473	7469008
2354	0.00	2	177026	7482004
2356	0.00	2	165084	7482084
2362	0.00	2	205877	7455373
2381	0.00	4	150448	7513728
2393	0.79	6	348545	7383814
2394	0.26	8	350783	7359849

2395	0.22	4	363215	7363308
2396	0.28	4	349449	7364997
2397	0.29	4	357310	7363274
2398	0.20	6	363160	7357596
2399	0.10	4	344110	7358849
2401	0.01	6	388755	7383593
2402	0.47	6	383824	7373127
2403	0.25	6	385482	7378215
2440	0.68	8	403494	7528673
2441	0.62	8	400786	7518231
2442	0.67	8	406347	7525154
2486	0.00	5	45202	7504384
2486	0.00	6	45202	7504384
2513	0.29	5	396632	7305556
2514	0.15	5	400500	7304167
2515	0.02	5	403179	7307465
2516	0.26	4	399088	7300712
2517	0.14	5	397907	7294478
2518	0.28	4	400558	7299984
2518	0.28	5	400558	7299984
2519	0.14	5	395119	7297690
2522	0.11	6	413554	7311851
2523	0.00	5	409661	7312227
2523	0.19	6	409661	7312227
2525	0.12	5	390634	7306172
2526	0.09	5	388420	7302108
2527	0.10	4	392819	7299097
2628	0.00	2	147214	7452598
2629	0.00	2	157470	7445014
2651	0.11	6	348373	7335748
2652	0.10	5	359172	7345340
2652	0.14	6	359172	7345340
2653	0.10	6	352435	7332434
2655	0.07	4	350965	7352553
2656	0.05	5	351838	7344656
2657	0.12	8	341738	7337903
2658	0.22	4	376591	7334042
2659	0.20	5	375715	7328764
2660	0.53	5	377372	7359386
2661	0.51	5	375559	7353126
2663	0.50	5	378698	7356444
2665	0.37	6	375431	7345035
2666	0.46	6	380358	7343908
2667	0.22	6	372473	7340825
2668	0.36	4	375739	7342115
2669	0.45	5	378510	7348598
2670	0.10	5	368245	7331717
2671	0.10	6	366507	7325294
2673	0.01	3	357037	7330681
2675	0.06	4	360202	7341879
2680	0.00	3	183189	7719793

2681	0.01	6	185432	7726378
2682	0.01	5	184268	7721014
2682	0.01	6	184268	7721014
2683	0.00	4	179509	7721264
2777	0.54	6	342488	7394002
2778	0.33	5	344460	7394632
2778	0.52	6	344460	7394632
2779	0.51	6	341622	7394465
2781	0.04	3	342969	7398983
2782	0.26	4	343365	7401012
2784	0.04	6	248752	7705199
2786	0.04	6	239641	7714138
2789	0.05	5	260913	7705668
2792	0.01	3	264848	7687731
2793	0.01	3	268186	7691634
2796	0.02	6	259012	7696119
2798	0.00	3	249263	7701565
2803	0.01	3	252172	7681049
2805	0.01	4	256908	7686971
2866	0.00	5	429058	7103961
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2866	0.00	5	429058	7103961
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2867	0.00	4	449491	7110240
2868	0.00	4	403781	7109230
2885	0.03	6	409164	7250304
2886	0.04	6	411177	7256536
2887	0.03	4	420906	7263080
2888	0.03	5	429176	7266324
2889	0.03	5	427787	7257858
2890	0.04	5	423349	7258203
2909	0.01	6	211482	7489889
2925	0.00	4	37535	7607595
2925	0.00	4	37535	7607595
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2926	0.00	6	8615	7610811
2927	0.00	6	36838	7612787
2928	0.00	6	13728	7621238
2930	0.00	6	52017	7601252
2931	0.00	5	48380	7600410
2931	0.00	6	48380	7600410
2933	0.00	5	9601	7634533
2977	0.02	5	334218	7340863
2977	0.10	6	334218	7340863
2979	0.07	6	328275	7329840
2980	0.03	4	328118	7357390
2980	0.21	6	328118	7357390
2982	0.00	2	316945	7332622
2989	0.08	6	313892	7354552

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2990	0.07	6	319238	7342091
2997	0.00	6	190272	7695242
2998	0.00	6	187222	7691360
3003	0.00	4	197916	7685392
3005	0.01	4	217238	7677154
3006	0.00	4	212310	7686303
3007	0.00	4	205794	7678649
3011	0.01	4	222765	7683710
3012	0.00	4	205014	7681867
3018	0.00	5	270156	7402823
3018	0.00	6	270156	7402823
3019	0.00	3	264981	7394638
3026	0.00	4	243440	7407356
3033	0.00	2	258842	7304155
3034	0.00	4	268891	7323948
3035	0.00	2	256409	7289974
3036	0.00	2	241563	7299098
3039	0.00	2	246832	7263575
3042	0.00	2	259993	7284680
3043	0.00	2	248618	7300303
3044	0.00	2	262323	7298418
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3046	0.00	2	249811	7279329
3048	0.00	2	259378	7276266
3049	0.00	2	247199	7275865
3050	0.00	2	236383	7270369
3052	0.00	2	232124	7254892
3053	0.00	2	231340	7263437
3054	0.00	2	254459	7272763
3055	0.00	2	261109	7272171
3068	1.62	8	400055	7432971
3069	1.61	8	403913	7437330
3073	0.00	6	382159	7410998
3089	2.06	7	390732	7386294
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3107	0.86	7	370745	7453758
3127	0.01	8	168993	7623765
3128	0.01	6	177302	7635145
3129	0.00	6	149696	7651169
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3132	0.00	2	161440	7650246
3133	0.00	4	161113	7624310
3134	0.00	4	174808	7607009
3135	0.00	4	168435	7614454
3137	0.00	4	160977	7631218
3138	0.01	5	183174	7593871
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3149	0.00	5	143357	7617554
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3174	0.00	2	197106	7526877
3175	0.07	6	216454	7528675
3191	0.00	2	183294	7502090
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3277	0.00	6	361185	7490398
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3283	0.07	6	360803	7523168
3285	0.75	8	383219	7481776
3296	0.02	6	259270	7650526
3309	0.01	3	272395	7663050
3312	0.02	6	272438	7670404
3320	0.03	3	289360	7673670
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3330	0.02	5	224885	7616038
3331	0.03	6	225515	7611077
3333	0.01	4	231521	7608547
3335	0.01	6	426785	7209251
3336	0.01	6	417925	7228060
3337	0.00	4	430020	7227602
3338	0.00	6	413836	7194452
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3356	0.05	6	195338	7544083

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3382	0.00	2	182634	7531452
3384	0.00	2	161638	7524419
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3390	0.00	2	181034	7538194
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3397	0.00	2	319385	7196087
3398	0.00	2	323333	7199986
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3406	0.00	3	361857	7188252
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3411	0.00	3	383613	7186213
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3419	0.00	3	-68786	7539077
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3443	0.00	5	233679	7407009
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3485	0.01	6	295658	7287186
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3493	0.00	2	277097	7306970
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3495	0.00	2	268819	7313054
3504	0.00	4	173037	7388607
3542	0.00	4	-22617	7709452
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3566	0.00	2	121479	7585787
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3581	0.00	2	133608	7573841
3584	0.00	6	142943	7683890
3585	0.00	4	126312	7667288
3586	0.00	6	144599	7659035
3587	0.00	4	143562	7705238
3588	0.00	6	145945	7691655
3589	0.00	6	145945	7691665
3590	0.00	4	145944	7691712
3591	0.00	6	120652	7687244
3592	0.00	6	110045	7664233
3593	0.00	6	139783	7671344
3596	0.00	6	126673	7678231
3597	0.00	6	139853	7661380
3598	0.00	6	159718	7681825
3599	0.00	6	140066	7675662
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3603	0.00	6	147865	7704121

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3611	0.00	5	86760	7678366
3613	0.00	6	90312	7697707
3616	0.00	8	106751	7666558
3618	0.00	4	117903	7693567
3619	0.00	6	105666	7672955
3620	0.00	8	105053	7660451
3622	0.00	6	97764	7664303
3623	0.00	4	146315	7691027
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3655	0.00	3	208982	7558196
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3659	0.00	4	59034	7671928
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3670	0.00	5	69515	7653486
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3767	0.00	2	198417	7225614
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3772	0.00	2	391599	7228550
3776	0.02	6	405014	7233633
3778	0.02	6	393627	7234319
3779	0.00	3	399659	7241316
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3856	0.06	6	250159	7539824
3857	0.08	6	231649	7516586
3858	0.10	6	273208	7496410
3859	0.10	6	264346	7496263
3860	0.10	6	276285	7501227
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3881	0.06	4	419494	7278913
3882	0.09	6	437858	7285128
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3888	0.07	5	410330	7278242
3889	0.06	4	404397	7282324
3889	0.08	5	404397	7282324
3890	0.10	6	436339	7297424
3893	0.03	6	450863	7290962

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3897	0.15	6	427614	7291107
3898	0.04	6	460051	7267032
3899	0.03	6	451536	7259500
3901	0.04	6	448685	7270962
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3915	0.03	5	432745	7283659
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4065	0.01	6	366940	7232879
4070	0.00	4	124732	7651604
4071	0.00	4	115559	7652224
4074	0.00	4	133463	7642221
4080	0.00	3	413394	7159981
4089	0.00	4	401447	7121133
4090	0.00	5	426708	7157078
4090	0.00	5	426708	7157078
4090	0.00	5	426708	7157078
4090	0.00	6	426708	7157078
4090	0.00	6	426708	7157078
4090	0.00	6	426708	7157078
4092	0.00	6	107172	7565104
4094	0.00	2	138389	7532303
4096	0.00	6	116475	7545459
4097	0.00	2	110567	7545251
4106	0.00	2	103744	7543755
4108	0.00	2	98832	7537220
4112	0.00	2	143719	7561412
4115	0.00	6	96301	7573212
4122	0.00	2	87997	7533516
4129	0.00	2	122160	7531147
4130	0.00	2	105053	7518272
4131	0.00	2	115103	7528941
4133	0.00	2	97954	7545703
4160	0.06	6	330250	7300501
4162	0.00	4	256158	7347224
4163	0.00	5	270227	7351796
4164	0.00	5	252008	7333763
4165	0.00	2	229169	7339874
4166	0.00	4	263371	7359226
4167	0.00	4	263105	7370271
4167	0.00	6	263105	7370271
4168	0.00	6	-1617	7648755
4170	0.00	6	3239	7640326
4171	0.02	8	223105	7673714
4172	0.02	8	215448	7665244
4173	0.01	4	227392	7674831
4174	0.00	3	231617	7665514
4176	0.01	4	224383	7657701
4178	0.01	4	229184	7674830
4180	0.01	5	246035	7683928
4181	0.01	3	242196	7681940

4183	0.01	3	228615	7679329
4193	0.00	4	128677	7709164
4196	0.00	6	125898	7737335
4198	0.00	6	114964	7740517
4199	0.00	6	129488	7742576
4202	0.00	4	126324	7718436
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4210	0.00	6	135856	7704306
4212	0.00	6	121930	7742873
4214	0.00	3	132362	7700449
4215	0.00	3	114569	7720283
4216	0.00	6	125571	7734451
4217	0.00	3	103262	7722426
4218	0.00	6	112264	7733600
4220	0.00	4	103053	7709080
4224	0.00	6	86994	7712682
4228	0.00	3	117671	7742378
4237	0.11	8	268259	7600966
4241	0.04	6	228988	7587730
4242	0.02	4	284740	7590028
4243	0.03	5	234436	7569849
4243	0.05	6	234436	7569849
4245	0.04	6	230660	7596525
4246	0.04	6	208160	7580961
4249	0.02	5	225692	7592600
4250	1.09	6	282133	7415400
4251	0.06	4	271578	7426510
4253	0.06	4	291319	7405816
4254	0.03	6	286836	7397782
4256	0.00	4	284220	7407775
4256	0.01	6	284220	7407775
4269	0.00	4	200347	7330646
4283	0.05	4	308999	7399718
4284	0.46	6	311674	7421351
4285	0.28	6	301237	7430415
4287	0.30	6	302244	7418859
4288	0.30	6	308267	7429923
4289	0.25	6	316679	7405046
4290	0.04	4	304518	7397444
4291	0.39	6	314240	7411661
4294	0.56	6	315578	7418139
4295	0.05	3	315957	7424236
4297	0.14	4	323150	7419247
4300	0.17	6	299694	7405809
4303	0.13	5	313731	7443160
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4304	0.13	5	307179	7441415
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4305	0.24	8	295035	7436792
4306	0.16	5	300404	7433142
4306	0.24	6	300404	7433142

4308	0.41	6	314477	7428986
4308	0.41	6	314477	7428986
4309	0.23	6	304607	7433598
4309	0.23	6	304607	7433598
4310	0.27	6	313245	7435421
4311	0.14	5	300977	7411642
4365	0.00	4	37554	7752673
4369	0.00	5	111980	7628940
4369	0.00	6	111980	7628940
4370	0.00	6	112002	7611194
4371	0.00	6	80180	7604590
4372	0.00	5	66543	7599185
4372	0.00	6	66543	7599185
4373	0.00	6	56380	7600911
4374	0.00	5	94179	7589892
4375	0.00	5	103616	7602917
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4376	0.00	6	114992	7621186
4377	0.00	6	93471	7617918
4379	0.00	6	107975	7608477
4380	0.00	4	85347	7615308
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4381	0.00	5	72855	7575495
4382	0.00	4	132332	7606834
4383	0.00	4	126670	7611232
4388	0.00	4	137258	7632511
4389	0.00	4	126741	7633167
4390	0.00	6	130196	7622742
4413	0.00	2	180670	7444850
4414	0.00	2	180084	7450935
4436	0.02	6	432079	7241762
4437	0.02	6	438232	7251788
4439	0.03	5	431978	7256495
4441	0.00	4	433740	7234695
4443	0.00	6	153965	7662207
4444	0.00	5	153750	7669154
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4445	0.00	4	160978	7665808
4446	0.00	5	156906	7658589
4447	0.00	5	148430	7656378
4448	0.00	6	160463	7675291
4450	0.12	6	301779	7388114
4453	0.12	6	304111	7389684
4454	0.12	6	302846	7382590
4455	0.00	4	51628	7644591
4457	0.00	5	45466	7651051
4460	0.00	5	61771	7650045
4472	0.00	6	172355	7700819
4478	0.00	6	181396	7695316
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4483	0.01	4	170798	7715470
4484	0.00	2	312102	7243535
4485	0.00	2	291946	7266697
4489	0.00	2	327891	7226602
4494	0.00	2	328458	7230486
4497	0.00	2	316216	7265277
4498	0.00	2	326320	7289170
4500	0.00	2	333898	7242000
4501	0.00	2	317162	7219907
4502	0.00	2	322713	7238968
4503	0.00	2	302579	7234384
4504	0.00	2	307870	7237106
4629	0.02	4	270661	7577924
4666	0.04	6	273466	7621223
4668	0.04	6	284241	7620755
4669	0.04	6	292295	7612308
4672	0.04	6	311188	7612392
4673	0.04	6	305430	7607203
4674	0.04	6	301189	7613697
4675	0.04	6	301174	7613706
4677	0.04	6	315224	7606497
4729	0.00	4	145547	7500278
4740	0.00	2	120961	7490200
4744	0.00	2	123897	7485959
4753	0.00	2	126381	7498961
4761	0.00	2	136195	7547717
4762	0.00	2	143320	7544862
4763	0.00	2	131678	7550661
4765	0.00	2	131102	7548306
4766	0.00	2	123205	7518818
4767	0.00	2	118412	7508717
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4770	0.00	2	121124	7514885
4890	0.00	4	224030	7358618
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4891	0.00	2	255432	7373375
4898	0.01	6	272961	7377630
4899	0.00	4	282772	7381012
4900	0.00	2	191465	7375789
4910	0.00	2	191697	7339823
4932	0.00	2	85735	7541963
4938	0.00	4	221929	7734475
4963	0.00	4	440158	7086850
4964	0.00	4	451195	7100340
4972	0.00	4	-21133	7671266
4973	0.00	4	-19760	7695173
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4994	0.00	4	469108	7152415
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5013	0.04	6	410865	7256616
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5014	0.00	4	178785	7654997
5017	0.04	4	309253	7485756
5021	0.00	3	425995	7120280
5039	0.00	5	405640	7248588
5043	0.00	2	165338	7451291
5045	0.00	4	192783	7671707
5082	0.00	2	265723	7111705
5125	0.04	3	323165	7542976
5130	0.03	3	321130	7535570
5134	0.00	4	172583	7628734
5138	0.00	3	382685	7241858
5139	0.00	4	368919	7239741
5140	0.00	4	353431	7247343
5142	0.00	2	262790	7318458
5144	0.00	5	2498	7596494
5145	0.01	6	227368	7690434
5147	0.00	4	446561	7224754
5148	0.02	6	196119	7611781
5150	0.01	6	181661	7673676
5268	0.00	2	286630	7284651
5284	0.00	4	413510	7030916
5285	0.00	2	150973	7453520
5287	0.00	4	416755	7161849
5290	0.17	6	341172	7451150
5316	0.00	3	421346	7140065
5320	0.00	3	454000	7138866
5321	0.00	3	454455	7136192
5374	0.00	4	267750	7398753
5404	0.00	4	199001	7692994
5425	0.43	6	355893	7440950
5438	0.00	2	118257	7555978
5454	0.00	2	191012	7438015
5461	0.01	4	194865	7707233

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5466	0.00	2	118205	7572368
5480	0.00	2	175377	7560802
5510	0.00	4	212369	7682919
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5512	0.00	3	485406	7176929
5516	0.00	2	150485	7547765
5546	0.00	2	320934	7218542
5557	0.36	6	366501	7381806
5558	0.79	6	373437	7382042
5560	0.21	6	384802	7389006
5570	0.36	5	341643	7385279
5596	0.00	2	384311	7196002
5606	0.04	6	277613	7621188
5607	0.04	6	290727	7665108
5612	0.00	2	126225	7431417
5615	0.00	2	125123	7400790
5628	0.00	2	134153	7422956
5636	0.00	3	436634	7215084
5638	0.01	5	457197	7236327
5639	0.01	5	465938	7227124
5640	0.00	4	452888	7225762
5646	1.47	4	363642	7390608
5692	0.02	4	281453	7582414
5741	0.00	4	164309	7602298
5743	0.00	3	475713	7136033
5744	0.00	3	472253	7140886
5745	0.00	5	480159	7139978
5747	0.00	3	354467	7189405
5748	0.00	2	326022	7204022
5749	0.00	2	149404	7552484
5760	0.13	6	342569	7581661
5761	0.13	6	345851	7551398
5762	0.20	6	350936	7559013
5765	0.01	4	250434	7619100
5796	0.03	3	308167	7406968
5830	0.00	4	486788	7162349
5831	0.00	4	485568	7157150
5845	0.01	6	256277	7663681
5880	0.00	2	44700	7533142
5881	0.00	2	50290	7537406
5890	0.21	6	351283	7540686
5907	0.87	6	359627	7383587
5908	0.00	6	371354	7403351
5909	0.00	6	364996	7504857
5910	0.00	6	359014	7499882
5911	0.00	3	236740	7647532
5914	0.00	2	288629	7290221
5916	0.00	2	88999	7546672
5917	0.00	2	91297	7545531
5920	0.38	6	345297	7402664

5923	0.00	2	271697	7100790
5924	0.00	2	294085	7277407
5933	0.01	5	238393	7641369
5934	0.01	4	237445	7633388
5941	0.18	8	364878	7662682
5943	0.19	8	364820	7661363
5944	0.25	8	364793	7660208
5945	0.26	8	343679	7641921
5948	0.00	3	86031	7626913
5956	0.00	3	456580	7167022
5957	0.00	3	454723	7163386
5999	0.08	5	407841	7291690
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6012	0.00	2	244566	7255375
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6040	0.00	4	114317	7642397
6041	0.00	4	124052	7642193
6042	0.00	6	382874	7409320
6067	0.00	6	358260	7507318
6070	0.00	2	50419	7549898
6071	0.00	2	46749	7557564
6076	0.04	6	301480	7618107
6079	0.00	2	93246	7542345
6088	0.00	5	473942	7145412
6091	0.00	3	189470	7732992
6129	0.00	2	11333	7572917
6153	0.29	6	355151	7522022
6209	0.51	6	369428	7438250
6210	0.84	6	366798	7430317
6251	0.00	4	456397	7188647
6254	0.00	5	460002	7178968
6255	0.00	4	466135	7193196
6256	0.00	5	454415	7180088
6259	0.70	8	409444	7528647
6260	0.58	8	406194	7517373
6263	0.02	6	272168	7675353
6273	0.00	2	181536	7555817
6275	0.00	2	177819	7560729
6276	0.59	8	400494	7500410
6306	0.05	4	326891	7479188
6321	0.01	7	195803	7693454
6322	0.00	6	184866	7695227
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6363	0.00	2	212166	7241494
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6487	0.00	2	89464	7564068
6491	0.00	2	301734	7293521
6492	0.00	2	294623	7294342
6493	0.00	2	301110	7287911
6515	0.00	2	271991	7369059
6526	0.00	3	450312	7142606
6529	0.00	3	451571	7141103
6548	0.00	4	141849	7631042
6582	0.01	4	340609	7330664
6593	0.24	6	343937	7439046
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6739	0.00	3	440883	7153272
6740	0.00	3	439932	7147854
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6819	0.00	2	258421	7118684
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6846	0.02	6	187350	7589832
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6945	0.00	2	60335	7515246
6962	0.00	2	-19773	7337093
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7097	0.00	5	463415	7166028
7098	0.00	5	463011	7161166
7099	0.00	5	480143	7169109
7100	0.00	5	471201	7163863
7111	0.36	6	352664	7494993
7116	0.00	2	125022	7577060
7118	0.00	2	124092	7587204
7119	0.00	2	308112	7325828
7120	0.00	2	305240	7319111

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7185	0.00	6	519586	7208605
7186	0.01	6	531437	7215965
7187	0.01	6	546025	7217461
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7190	0.00	1	422568	7079987
7193	0.16	6	339456	7491323
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7228	0.00	6	525751	7199090
7247	0.00	4	431151	7144089
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7257	0.00	2	225077	7452843
7258	0.63	6	359941	7440293
7262	0.00	4	172996	7642659
7263	0.00	4	167633	7639595
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7319	0.00	4	342468	7307822
7321	0.29	3	352102	7379544
7353	0.00	4	88309	7755348
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7386	0.45	6	387721	7350016
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7668	0.00	6	93906	7632813
7675	0.11	6	300124	7497319
7676	0.00	4	79731	7625380
7686	0.00	4	27544	7715788
7687	0.00	2	151695	7560481
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7777	0.87	6	361952	7404496
7780	0.54	6	332268	7416954
7782	0.82	6	372179	7409571
7783	0.00	6	373484	7422901
7880	0.05	4	331329	7477700
7881	0.13	6	325581	7481480
7883	0.95	7	376086	7454880
7884	1.17	7	383279	7446930
7885	0.00	1	380428	7439913
7886	0.00	1	382015	7434756
7902	0.88	6	349027	7386526
7904	1.43	6	363611	7378765
7926	0.00	5	-9454	7615361
7934	0.00	4	436094	7222864
7939	0.00	3	433865	7028424
7940	0.00	4	57298	7746566
7961	0.03	5	424290	7265837
7991	0.07	6	334087	7552835
7999	0.00	4	195981	7677703
8001	0.00	3	111222	7747531
8011	0.00	2	323419	7219129
8017	0.00	2	191823	7442866
8038	0.00	2	229914	7453269
8049	0.09	6	436622	7284723
8056	0.01	6	511066	7224609
8057	0.00	6	516187	7220544
8087	0.14	6	340148	7479795
8089	0.00	2	348807	7269187
8376	0.00	4	495986	7171061
8377	0.00	4	436067	7228523
8378	0.01	4	210444	7643910
8393	0.00	4	444858	7076718
8395	0.00	5	471221	7167216
8400	0.00	4	501454	7172107
8480	0.00	6	523910	7186020
8481	0.00	6	518355	7187813
8486	0.09	8	483221	7292116
8487	0.17	8	469724	7296233
8489	0.08	8	486332	7291447
8490	0.05	8	494521	7297274
8495	0.01	6	508833	7236668
8496	0.03	8	510307	7272870
8497	0.04	8	503967	7272923
8498	0.03	8	507847	7281805
8499	0.01	8	525182	7280868
8500	1.31	8	395453	7462659
8520	0.29	7	350490	7591087

8542	0.00	4	451865	7114033
8552	0.04	4	310316	7506555
8664	0.00	3	394051	7142058
8897	0.07	6	322703	7564591
8898	0.06	6	322780	7581658
8908	0.00	5	157144	7724645
8913	0.00	2	92763	7567666
8997	0.06	6	315291	7589272
9002	0.00	1	424312	7080275
9004	0.39	6	350597	7404877
9045	0.15	6	342535	7469669
9077	0.12	6	315478	7503049
9078	0.00	4	402037	7242195
9085	0.00	2	114737	7540271
9117	0.00	2	289506	7331596
9184	0.03	5	419837	7258491
9268	0.00	4	485115	7138508
9269	0.00	4	486196	7142785
9270	0.00	4	484034	7134815
9271	0.00	4	492294	7139775
9279	0.00	2	155296	7500531
9299	0.00	2	41189	7498682
9300	0.00	2	45758	7498171
9305	0.00	2	129680	7521192
9306	0.00	2	125095	7520065
9308	0.02	4	287351	7636055
9312	0.02	6	269084	7656266
9443	0.00	2	388130	7190589
9446	0.00	2	114394	7561215
9447	0.00	3	191485	7724438
9461	0.00	2	13858	7471645
9468	0.00	2	259859	7141956
9479	0.00	2	259160	7158939
9605	0.00	2	114720	7556139
9690	0.00	2	79271	7580937
9703	0.00	2	273875	7130598
9778	0.00	2	75217	7547661
9784	0.30	10	510466	7308391
9785	0.08	10	515189	7314345
9786	0.19	10	516566	7306829
9787	0.01	10	527446	7295679
9789	0.37	10	513305	7305691
9790	0.02	10	524489	7304829
9791	0.05	8	497967	7282167
9792	0.05	13	514194	7322493
9793	0.08	10	519010	7310693
9911	0.64	6	378767	7378530
9933	0.00	3	385381	7228099
9953	0.00	2	173224	7459687
9957	0.00	6	395849	7370312
9965	0.01	5	473902	7223020

9985	0.00	5	492546	7185947
9987	0.00	4	492061	7156632
10262	0.00	1	387564	7386570
10263	0.00	1	388079	7385909
10266	0.01	6	504207	7235224
10267	0.00	6	519185	7242194
10279	0.00	2	9550	7473049
10363	0.00	2	273900	7308916
10373	0.00	3	393968	7183868
10375	0.00	4	455352	7175447
10408	0.00	4	151290	7730069
10416	0.00	2	304801	7285686
10431	0.22	13	522355	7307093
10520	0.03	4	332478	7602104
10528	0.00	3	456570	7144566
10529	0.00	3	405156	7229328
10530	0.23	6	350009	7518467
10550	0.00	2	323409	7222052
10572	0.00	2	13315	7409358
10576	0.11	6	340527	7525631
10612	0.00	4	449545	7161337
10617	0.00	3	444917	7195310
10633	0.00	2	302069	7232837
10634	0.00	3	346194	7519598
10635	0.00	3	344378	7512598
10642	0.10	6	335087	7526492
10644	0.00	4	-75478	7384538
10647	0.00	5	447607	7251457
10651	0.00	2	29040	7599237
10652	0.00	2	32663	7602551
10655	0.00	3	457367	7156351
10657	0.00	2	345938	7284539
10679	0.03	4	279945	7521474
10682	0.00	3	418412	7182778
10711	0.00	2	18263	7415754
10713	0.00	5	94728	7719318
10715	0.00	3	427989	7235435
10717	0.00	2	189403	7542581
10740	0.00	2	200438	7550247
10745	0.05	6	329647	7621966
10769	0.00	2	197713	7525133
10770	0.00	3	379539	7220111
10775	0.08	3	338731	7533302
10782	0.00	3	439495	7121949
10783	0.00	2	387394	7232146
10789	0.00	2	258995	7125315
10796	0.00	2	141521	7586220
10811	0.30	8	418509	7475451
10815	0.31	8	426196	7482873
10824	0.00	2	257806	7123353
10826	0.00	3	422825	7177852

10828	0.00	4	473604	7175126
10831	0.00	4	99379	7717282
10833	0.00	3	424391	7182229
10835	0.00	4	389723	7269114
10842	0.04	5	433750	7261702
10847	0.00	2	269442	7304292
10849	0.00	3	-5770	7682444
10868	0.00	4	104773	7713649
10878	0.30	5	372979	7386109
10884	0.00	2	87592	7558717
10900	0.00	3	428711	7162811
10901	0.09	6	307438	7536581
10915	0.00	6	513632	7213595
10922	0.09	3	333886	7512703
10927	0.03	4	304772	7526687
10937	0.07	5	303434	7513379
10937	0.11	6	303434	7513379
10952	0.00	2	260893	7118915
10957	0.00	2	105697	7557425
10967	0.10	6	431098	7298076
10974	0.00	5	387461	7342550
10977	0.00	3	400514	7197516
10982	0.00	2	132961	7541233
10988	0.00	2	128751	7534911
10993	0.00	2	74979	7458930
10995	0.00	2	179885	7521635
11004	0.01	4	212454	7703233
11031	0.00	2	154578	7544314
11038	0.00	3	463055	7155383
11039	0.01	3	311965	7625531
11055	0.01	4	218814	7643194
11059	0.02	6	205000	7627788
11060	0.01	4	232472	7646449
11066	0.00	3	469083	7158559
11068	0.00	2	140951	7541820
11070	0.00	3	408941	7233168
11081	0.06	6	417556	7311906
11086	0.00	6	65715	7622468
11115	0.00	2	30673	7469954
11120	0.00	5	156376	7729649
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11142	0.00	4	7342	7654888
11147	0.06	6	314915	7585763
11149	0.00	2	338087	7257928
11158	0.00	3	451336	7205424
11166	0.00	3	467846	7156103
11167	0.00	4	459744	7199823
11170	0.00	2	315559	7328419
11185	0.00	3	447623	7139888
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11194	0.00	2	120125	7411602

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11211	0.01	4	263112	7630306
11233	0.00	3	458454	7147556
11236	0.00	2	314554	7323236
11243	0.00	3	206509	7687280
11247	0.02	3	287356	7605014
11250	0.06	6	442327	7279395
11258	0.12	6	329095	7351079
11258	0.12	6	329095	7351079
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11265	0.00	2	143797	7587349
11266	0.00	2	325274	7242786
11267	0.00	2	100410	7523824
11271	0.00	2	119076	7561267
11284	0.00	4	3157	7754958
11295	0.00	3	266476	7521614
11296	0.02	6	464397	7270396
11301	0.00	4	444453	7233451
11308	0.01	4	204889	7610329
11312	0.04	6	455521	7277844
11318	0.00	3	447339	7148193
11321	0.19	6	397148	7327336
11326	0.00	3	415976	7144154
11335	0.00	5	435303	7177702
11341	0.11	4	366287	7340738
11343	0.01	4	401881	7269612
11343	0.01	4	401881	7269612
11344	0.01	6	499639	7223106
11345	0.00	4	454582	7213402
11346	0.00	4	334516	7285907
11350	0.00	2	177458	7557304
11359	0.00	2	329633	7289949
11369	0.24	6	264262	7448519
11371	0.00	6	528785	7232826
11372	0.00	5	150833	7725471
11380	0.05	4	362549	7335780
11393	0.01	4	426033	7249974
11399	0.00	2	347576	7263512
11400	0.00	4	-6611	7682449
11405	0.00	4	176152	7670152
11412	0.19	6	345615	7584336
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11419	0.01	4	414771	7260398
11427	0.00	2	389541	7209429
11441	0.21	6	346921	7594867
11445	0.00	4	344378	7270930
11449	0.00	6	355869	7593535
11455	0.00	2	213971	7497953
11462	0.73	6	368465	7383885
11484	0.05	6	353192	7600369
11486	0.00	4	89459	7639759

11487	0.00	3	197399	7743908
11503	0.05	5	385040	7299712
11504	0.00	2	207288	7515003
11515	0.00	6	359205	7599685
11517	0.00	2	181984	7560599
11528	0.01	5	256938	7656030
11534	0.01	6	250370	7690171
11538	1.80	6	357199	7388424
11552	0.17	6	343898	7592531
11557	0.36	6	351605	7411808
11561	0.00	5	470572	7145651
11564	0.01	5	460676	7225602
11566	0.00	2	258575	7315047
11567	0.00	2	144402	7566787
11586	0.00	2	182007	7558043
11595	0.00	2	286421	7256147
11606	0.05	6	438621	7271567
11607	0.03	6	248226	7635079
11615	0.00	3	397375	7231732
11620	0.01	6	186157	7666992
11635	0.00	4	134068	7606504
11636	0.00	5	464894	7144899
11638	0.00	2	281818	7141784
11639	0.00	5	451488	7160944
11641	0.00	2	295366	7270625
11642	0.00	2	334247	7236281
11644	0.61	8	378616	7495641
11652	0.03	6	305823	7638347
11657	0.33	6	297022	7426696
11658	0.03	4	356196	7338558
11660	0.01	5	222566	7625093
11661	0.00	4	446884	7213805
11663	0.00	3	400928	7194381
11675	0.00	2	163121	7563286
11680	0.00	2	265783	7326024
11698	0.02	6	278475	7644551
11710	0.00	2	158115	7510112
11730	0.00	2	350558	7134589
11731	0.00	3	58901	7755516
11734	0.00	3	258345	7097376
11737	0.00	5	169017	7644848
11742	0.01	6	212307	7676485
11745	0.00	2	148915	7468412
11746	0.00	2	144851	7473708
11748	0.00	4	483390	7160254
11756	0.00	2	345251	7133881
11774	0.00	2	270073	7319230
11791	0.01	6	504791	7221537
11793	0.00	5	514952	7192001
11794	0.03	4	307367	7520311
11801	0.00	4	434846	7220305

11805	0.00	2	207780	7463045
11809	0.01	3	235160	7686066
11841	0.09	6	311028	7539227
11854	0.05	6	234436	7569849
11863	0.00	2	14228	7461012
11864	0.00	3	453999	7155263
11869	0.00	2	398287	7181410
11876	0.00	2	369042	7150941
11888	0.11	6	314011	7521115
11902	0.63	3	353960	7375102
11904	0.00	2	207882	7116758
11905	0.00	2	373916	7133757
11910	0.03	6	244432	7629007
11919	0.00	2	291865	7131851
11939	0.01	6	188511	7729896
11941	0.00	5	509432	7210154
11942	0.00	3	431799	7153505
11947	0.00	1	429257	7088025
11949	0.00	5	465376	7152283
11960	0.12	6	320324	7516181
11965	0.00	2	320910	7243837
11979	0.00	2	224989	7253274
11990	0.00	2	21543	7478306
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12005	0.09	3	339078	7433272
12014	0.00	2	53453	7493617
12029	0.10	6	339011	7617895
12031	0.00	2	290230	7136627
12039	0.01	6	184328	7669940
12043	0.00	2	188451	7522856
12044	0.00	2	190057	7527014
12047	0.01	4	364064	7304404
12049	0.00	2	19992	7450614
12052	0.00	2	296011	7309380
12057	0.00	4	483869	7155794
12061	0.00	3	352093	7439744
12066	0.00	2	216081	7113366
12071	0.00	4	107288	7736428
12073	0.03	6	286561	7645797
12083	0.00	3	419215	7080090
12112	0.00	2	63692	7490952
12126	0.01	4	219932	7594965
12133	0.39	6	378036	7387967
12135	0.01	4	269997	7592037
12139	0.00	4	389737	7269108
12145	0.00	3	441986	7168505
12146	0.00	3	444311	7166330
12159	1.60	8	426467	7375673
12175	0.00	2	199309	7546315
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12197	0.00	2	253267	7142820

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12228	0.00	3	419554	7141808
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12237	0.00	2	284402	7173102
12240	0.01	4	235401	7652897
12250	0.00	2	296019	7275989
12266	0.00	2	293470	7137786
12270	0.00	3	415754	7135293
12274	0.05	6	445076	7274116
12282	0.00	2	191435	7548594
12290	0.00	2	287524	7176907
12319	0.00	2	170997	7561574
12326	0.00	3	138444	7739287
12331	0.00	3	423008	7199478
12333	0.00	2	298835	7295326
12343	0.00	2	277964	7137410
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12364	0.00	2	271832	7124837
12370	0.00	2	221984	7462914
12383	0.00	2	257427	7139356
12424	0.00	2	276889	7123662
12426	0.00	2	79887	7449881
12431	0.00	2	75041	7530917
12434	0.04	3	339962	7538851
12445	0.00	2	109041	7561576
12457	0.00	2	231439	7455636
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12460	0.00	2	288247	7276396
12471	0.08	4	331467	7368244
12494	0.07	6	446871	7282520
12498	0.00	2	282725	7176615
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12535	0.03	3	328486	7527963
12541	0.04	4	325671	7475812
12545	0.00	6	137443	7744039
12546	0.10	6	325587	7531314
12548	0.00	2	275367	7162394
12556	0.00	2	29285	7467659
12558	0.00	2	28193	7466021
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12574	0.00	2	33746	7477884
12577	0.00	2	39276	7497514
12578	0.00	2	323412	7254455
12589	0.03	4	297946	7399754
12597	0.00	4	446976	7127734
12599	0.00	6	133228	7744020
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12601	0.00	2	117863	7492865
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12614	0.00	2	222229	7491639
12615	0.00	4	434640	7103467
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12666	0.00	2	271204	7120947
12724	0.00	2	220070	7461292
12729	0.10	6	439479	7294178
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12737	0.00	2	304085	7246808
12739	0.01	4	443968	7242246
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12748	0.00	2	170916	7559940
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12769	0.00	3	445699	7161107
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12794	0.06	6	333878	7565441
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12817	0.00	3	416667	7189535
12818	0.00	4	429786	7191764
12819	0.00	6	361726	7584023
12828	0.21	6	349919	7590743
12836	0.00	2	108312	7540172
12837	0.00	5	434619	7180591
12848	0.00	2	51074	7511341
12855	0.53	6	333690	7421769
12872	0.00	2	331775	7108357
12876	0.00	2	195098	7196094
12881	0.08	6	308920	7553330
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12903	0.00	6	127978	7682116
12934	0.34	6	355431	7456387
12942	0.25	6	370450	7345852
12943	0.45	5	375724	7350389
12957	0.00	6	20774	7691967
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12983	0.00	3	422775	7077866
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13036	0.00	2	264201	7142250
13046	0.00	5	490719	7163553
13070	0.00	2	262794	7109220
13071	0.00	2	264823	7127730
13089	0.00	2	225692	7489701
13091	0.00	2	226957	7474948
13095	0.00	2	388822	7225451
13096	0.00	2	244409	7129657
13105	0.00	2	44205	7482087
13106	0.00	2	297576	7300570
13132	0.00	2	173481	7447867
13133	0.00	2	160414	7412246
13182	0.00	2	195876	7487750
13190	0.00	6	520650	7227489
13202	0.00	4	121668	7697062
13202	0.00	4	121668	7697062
13202	0.00	4	121668	7697062
13208	0.00	5	490625	7216951
13214	0.00	3	450380	7139499
13215	0.00	3	450981	7142516
13234	0.11	6	294676	7514004
13262	0.00	3	447784	7155363
13264	0.00	4	75044	7651981
13266	0.00	5	513532	7225837
13267	0.95	5	358960	7379274
13269	0.33	5	378973	7340635
13270	0.30	5	381643	7349086
13271	0.00	2	158245	7551139
13301	0.00	2	272074	7151040
13303	0.00	2	342227	7259452
13305	0.31	6	326288	7394127
13307	0.00	6	495583	7207388
13313	0.00	2	335725	7163585
13334	0.00	3	74313	7755687
13340	0.00	4	442571	7234458
13343	0.07	6	304835	7568106
13347	0.01	4	214080	7644229
13348	0.00	2	233056	7145783
13371	0.00	2	277017	7114490
13387	0.00	4	3616	7735044
13399	0.00	2	324080	7168668
13408	0.02	6	263778	7696649

13412	0.00	2	276755	7099031
13420	0.00	2	173170	7534520
13432	0.04	6	317064	7605011
13433	0.00	2	60169	7455575
13439	0.00	3	424234	7151003
13440	0.02	6	187657	7609238
13443	0.20	6	343379	7443895
13446	0.00	2	159718	7541470
13447	0.00	2	110087	7550694
13451	0.00	2	62016	7450973
13452	0.00	2	58535	7448959
13486	0.00	2	337446	7262289
13503	0.00	2	29089	7594613
13511	0.00	2	314016	7206201
13516	0.14	6	333747	7491262
13519	0.00	2	342079	7171079
13523	0.00	3	447278	7177540
13524	0.00	3	449517	7176072
13543	0.00	2	178566	7460634
13546	0.05	6	436455	7272049
13561	0.00	2	226792	7260176
13564	0.01	5	457099	7231620
13573	0.59	4	355129	7397109
13591	0.00	2	79157	7542126
13607	0.00	2	173994	7549996
13619	0.02	4	344244	7341253
13628	0.00	3	447429	7174741
13635	0.00	2	343072	7136810
13643	0.00	2	176146	7536122
13644	0.02	6	311183	7623505
13648	0.00	2	139728	7547613
13653	0.00	3	421372	7009644
13680	0.00	6	359975	7623464
13681	0.00	2	286622	7132444
13698	0.00	4	480033	7131703
13721	0.19	8	405481	7459872
13731	0.01	4	240581	7647838
13737	0.00	2	186859	7516604
13739	0.00	2	186725	7531751
13740	0.00	2	180679	7517863
13745	0.00	2	282034	7102168
13758	0.00	3	472714	7133289
13766	0.00	1	430476	7093293
13767	0.00	4	420083	7110062
13769	0.00	2	55621	7545792
13774	0.00	3	396524	7192779
13776	0.53	6	380759	7353354
13777	0.00	2	328800	7216705
13790	0.00	2	85130	7580259
13792	0.00	2	117966	7530274
13794	0.03	4	395347	7281655

13800	0.00	3	395764	7197080
13813	0.01	4	209119	7692633
13817	0.00	2	324329	7246435
13822	0.03	6	288247	7651418
13830	0.00	4	91361	7739297
13849	0.00	1	427560	7079217
13852	1.29	7	410057	7370089
13855	0.00	2	95773	7551225
13857	0.00	3	442749	7140545
13868	0.00	3	457874	7154537
13869	0.00	6	80536	7666900
13874	0.00	2	326022	7204022
13876	0.01	4	208079	7692734
13880	0.01	6	506814	7234608
13901	0.00	4	88291	7745848
13902	0.00	5	89604	7557727
13904	0.00	3	218518	7671544
13905	0.00	4	503432	7158880
13906	0.00	3	394915	7241927
13911	0.00	2	101603	7551189
13912	0.00	3	473922	7127231
13913	0.00	3	479736	7125642
13923	0.03	6	187151	7579483
13929	0.00	3	412384	7177972
13931	0.00	3	444392	7145901
13937	0.00	3	413533	7198806
13968	0.00	4	68337	7744628
13970	0.05	6	216285	7569745
13973	0.58	6	347735	7361102
13982	0.00	2	9521	7401826
13983	0.00	2	16765	7407559
13984	0.00	2	-5907	7412323
13985	0.00	4	114616	7714400
13993	0.00	2	233701	7472760
13994	0.00	2	231008	7471789
13998	0.00	2	227756	7470191
14016	0.00	3	455173	7145823
14028	0.57	6	372621	7362421
14030	0.00	3	435567	7024740
14051	0.00	3	430974	7140704
14052	0.00	3	412167	7143299
14053	0.00	6	126842	7730752
14053	0.00	6	126842	7730752
14054	0.00	4	129502	7732535
14056	0.00	4	87365	7705086
14068	0.00	3	290518	7691531
14069	0.00	3	300854	7679905
14073	0.00	2	37722	7495864
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14083	0.02	6	263708	7652867
14086	0.00	2	79665	7547781

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14104	0.00	4	381132	7262580
14112	0.00	4	389706	7244316
14122	0.01	4	230022	7618772
14125	0.00	4	124181	7594446
14125	0.00	5	124181	7594446
14125	0.00	6	124181	7594446
14126	0.00	2	207112	7514914
14129	0.00	2	391014	7224638
14130	0.00	2	276698	7275416
14145	0.00	4	440690	7222115
14154	0.08	6	382185	7292328
14164	0.00	4	93078	7704282
14167	0.00	2	385813	7223457
14168	0.00	2	162428	7538172
14215	0.00	3	153337	7736423
14226	0.01	4	376865	7300443
14227	0.00	2	344678	7284002
14235	0.00	2	47222	7539229
14239	0.00	2	290683	7322627
14240	0.00	3	137235	7731578
14264	0.00	2	49278	7549619
14265	13.37	9	344312	7490912
14266	0.00	4	99664	7705272
14269	0.00	4	92856	7519467
14295	0.00	4	438751	7067953
14309	0.00	6	522810	7229331
14311	0.01	6	535807	7238685
14325	0.00	6	534820	7203653
14335	0.04	6	303342	7655389
14340	0.00	2	71326	7541852
14397	0.00	3	430047	7147621
14438	0.00	2	57408	7476710
14439	0.00	2	60813	7478628
14441	0.00	2	59902	7474532
14443	0.02	5	466199	7234814
14445	0.00	2	292485	7256455
14465	0.00	2	247608	7099665
14470	0.00	3	437580	7144644
14474	0.00	3	432576	7068384
14475	0.00	2	14178	7444009
14476	0.00	3	430727	7072527
14477	0.00	5	466840	7168221
14478	0.00	2	310334	7243510
14485	0.00	3	434250	7159209
14487	0.00	6	156931	7676912
14491	0.00	2	73070	7531634
14503	0.00	1	424124	7079381
14512	56.20	10	439975	7412792
14520	0.00	2	245159	7108363
14521	0.00	2	240832	7109293

14522	0.00	2	255612	7100927
14545	0.03	6	273862	7630028
14566	0.00	2	229351	7115896
14567	0.00	2	223259	7136988
14579	0.00	4	370236	7296926
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14588	0.05	6	345928	7297293
14602	0.02	4	276446	7593298
14603	0.00	2	248383	7111259
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14608	0.00	2	156037	7561531
14612	0.00	2	159913	7558905
14619	0.00	2	273875	7130598
14640	0.00	2	166873	7556991
14641	0.00	2	175134	7543430
14737	0.00	2	22599	7443200
14827	0.00	2	345129	7278869
14894	0.00	2	182290	7524425
14900	0.00	5	521742	7175166
14902	0.00	2	340524	7282970
14908	0.34	6	344622	7409978
14934	0.01	6	473520	7261220
14939	0.14	6	332656	7486635
14951	0.07	3	341881	7477660
14959	0.00	3	120864	7729388
14960	0.00	4	218810	7659454
14969	0.00	2	48766	7525613
14977	0.00	2	154519	7571877
14989	0.00	1	367682	7703387
15003	0.00	2	60874	7476533
15006	0.00	2	-72523	7507801
15009	0.00	5	521623	7170767
15010	0.00	3	420313	7086189
15014	0.02	6	231478	7719072
15015	0.00	2	435600	7151033
15021	1.30	8	387077	7446909
15026	0.00	2	20191	7468607
15032	0.00	2	207614	7501372
15034	0.00	2	319972	7253364
15064	0.00	2	268796	7123429
15119	0.00	2	245489	7177866
15151	0.00	2	97892	7562682
15172	1.11	5	366679	7390174
15173	0.97	5	367500	7387229
15176	0.00	4	105188	7728201
15186	0.00	2	234941	7153242
15242	0.00	2	283315	7328149
15243	0.00	4	31559	7738114
15244	0.01	4	370860	7300912
15285	0.00	4	106093	7741669
15285	0.00	4	106093	7741669

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15294	0.02	6	459969	7285763
15295	0.00	2	222148	7144726
15296	0.00	2	182672	7512824
15297	0.00	2	173224	7459687
15358	0.00	2	322803	7271279
15362	0.00	4	155078	7698029
15370	0.00	2	74520	7516445
15381	0.00	4	109504	7718679
15406	63.19	10	443691	7417151
15411	0.09	4	366557	7336064
15413	0.00	4	82281	7661152
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15432	0.01	4	221294	7652602
15435	0.00	2	167895	7539952
15455	0.00	1	422655	7079434
15456	0.00	1	425914	7081207
15461	0.04	4	364551	7330170
15490	0.00	4	468031	7218424
15506	0.03	7	216838	7605094
15522	0.00	4	131523	7690993
15528	0.02	5	431992	7253665
15530	0.00	6	110944	7676454
15534	0.31	5	379081	7331193
15537	0.00	4	83092	7734545
15539	0.02	4	360355	7332067
15541	0.00	2	225279	7205458
15546	0.00	2	111124	7541321
15563	0.00	3	447635	7200612
15573	0.00	4	-9455	7734136
15577	0.05	4	311568	7398766
15578	0.00	2	243257	7198114
15606	0.02	6	215205	7629871
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15644	0.04	8	496401	7292462
15645	0.05	8	496296	7288735
15662	0.00	4	138545	7688931
15694	0.00	2	40585	7533484
15721	0.00	3	78390	7736221
15731	0.00	2	289755	7328092
15746	0.00	2	103743	7543817
15751	0.00	2	219932	7500213
15752	0.00	2	139499	7561316
15773	0.00	4	189667	7661332
15796	0.03	6	457786	7272715
15797	0.07	8	488708	7286606
15804	0.00	2	195371	7514496
15806	0.09	5	410729	7281843
15815	0.00	2	190207	7519535
15824	0.00	4	169621	7663471
15827	0.00	2	340065	7276412

15837	0.00	4	349088	7240743
15865	0.00	3	81359	7749388
15869	0.00	4	133782	7734629
15887	0.00	4	43015	7745669
15900	0.00	2	105111	7577440
15920	0.00	2	205122	7512561
15923	0.00	2	320610	7319714
15924	0.00	2	318998	7328863
15933	0.00	4	139237	7638284
15968	0.00	2	228655	7155055
15971	0.00	1	92075	7432030
15973	0.00	2	124653	7581734
15988	0.00	1	424093	7075258
15996	0.01	6	176832	7657910
16001	0.04	4	389092	7296638
16025	0.00	4	176230	7702198
16056	0.03	6	352870	7257503
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16061	0.00	2	392990	7212010
16063	0.03	6	321355	7620039
16064	0.03	6	324611	7619675
16081	0.00	2	179284	7491444
16083	0.00	6	122210	7675805
16085	0.00	3	448081	7193693
16096	0.00	4	507112	7160570
16118	0.00	4	437998	7229178
16120	0.00	4	113945	7736911
16121	0.00	3	202095	7702467
16122	0.00	3	433919	7039193
16130	0.00	4	154445	7603136
16131	0.10	6	280851	7502496
16132	0.00	2	73423	7427934
16143	0.00	1	461525	7154241
16167	0.13	4	369780	7335663
16176	0.03	4	293947	7542925
16198	0.00	2	182890	7476153
16203	0.00	4	375202	7272157
16207	0.06	4	365232	7332822
16236	0.14	6	395343	7342580
16238	0.01	3	125460	7744829
16240	0.00	2	209998	7507998
16255	0.00	3	70456	7750568
16261	0.00	2	389588	7203615
16266	0.02	4	223125	7533420
16271	0.00	5	67185	7659652
16282	0.00	5	471982	7216772
16297	0.00	2	138033	7567659
16309	0.00	2	275575	7263116
16314	0.00	2	350914	7277148
16315	0.00	4	315804	7298291
16353	0.01	5	381171	7269573

16371	0.00	6	370461	7574850
16394	0.00	2	343872	7248179
16398	0.01	4	207169	7692833
16419	0.00	4	468392	7208059
16424	0.00	2	31529	7594962
16435	0.00	2	33348	7484318
16437	0.00	2	249060	7153025
16440	0.00	4	483417	7182894
16442	0.00	2	43093	7596776
16456	0.00	1	422025	7078138
16474	0.01	6	496980	7214647
16479	0.06	6	342663	7316753
16491	0.00	2	69193	7534887
16500	0.00	4	480600	7180706
16501	0.00	5	529883	7184132
16521	0.44	6	294861	7417902
16525	0.01	4	424443	7248212
16526	0.00	2	200360	7148869
16535	0.00	2	40827	7555573
16543	0.00	2	315603	7303403
16587	0.05	3	336933	7540973
16588	0.08	6	317748	7546631
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16599	0.00	5	519406	7200300
16602	0.01	6	201835	7654476
16614	0.00	6	522656	7204048
16635	0.00	2	109018	7555566
16717	0.01	6	190457	7726546
16718	0.00	3	69391	7754764
16756	0.00	6	139976	7721765
16759	0.00	4	69500	7730726
16772	1.72	6	363360	7369288
16773	0.93	6	355477	7373487
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16786	0.00	2	285938	7317140
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16811	0.01	4	353422	7327088
16815	0.01	4	219438	7666697
16830	0.84	8	394110	7545740
16839	0.16	8	307952	7703365
16880	0.01	4	502346	7166724
16887	0.02	1	361984	7707093
16895	0.84	7	410060	7561627
16896	0.99	7	406868	7558257
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16899	0.09	6	436391	7286013
16910	0.00	6	60843	7722923
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17229	0.00	2	165997	7456264
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17274	0.00	2	321888	7334838
17275	0.00	3	131093	7738175
17283	0.03	6	286489	7653579
17307	0.00	2	209702	7513389
17321	0.09	6	348064	7330157
17362	0.00	1	423861	7078957
17366	0.00	4	59722	7726608
17379	0.01	4	200740	7710755
17381	0.00	2	72154	7467945
17383	0.00	3	386981	7181042
17406	0.00	2	54492	7542090
17419	0.36	8	364050	7652559
17442	0.01	4	370057	7303330
17451	3.39	7	402862	7584727
17480	0.00	6	107023	7650296
17554	0.00	4	170812	7594703
17562	0.00	4	110512	7728739
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17566	0.00	5	153331	7721026
17574	0.00	1	418861	7074796
17614	0.02	6	271205	7644851
17615	0.02	6	274727	7652930
17616	0.03	6	281956	7660349
17617	0.04	6	300209	7649660
17641	0.02	3	351662	7417438
17725	0.00	4	439276	7039250
17766	0.15	4	345630	7437618
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17867	0.00	2	74754	7464905
17949	0.01	5	209821	7653665
17950	0.16	6	327259	7462804
17982	0.17	1	433592	7565399
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18088	0.00	6	102547	7739215

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18198	0.00	3	445445	7216783
18220	0.17	6	346086	7513230
22076	0.00	4	258527	7421226
22132	0.30	6	341434	7433636
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22545	0.00	6	471175	7175521
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22646	0.06	6	330901	7289903
22658	0.48	6	335383	7421602
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22675	0.06	4	389274	7299457
22793	0.00	6	187372	7444560
22799	0.31	8	324383	7461505
22801	0.00	2	260603	7220537
22802	0.00	4	260603	7220537
22809	0.00	6	139177	7473835
22824	0.83	8	391643	7478205
22829	0.00	6	46230	7555637
22981	0.00	4	255621	7312707
22985	0.00	4	352419	7293205
23043	0.32	6	325251	7389197
23062	0.29	6	322586	7438611
23082	0.00	4	341613	7286279
23237	0.00	2	138512	7520908
23238	0.00	5	207650	7332891
23344	0.00	4	42095	7565386
23388	0.00	6	344637	7141165
23392	0.00	4	243554	7154812
23458	0.00	4	331968	7305006
23458	0.00	4	331968	7305006
23473	0.00	4	283847	7334066
23489	0.00	4	129263	7397814
23568	0.00	4	336142	7195532
23600	0.00	4	-22708	7650381
23604	0.00	4	-1725	7606211
23637	0.03	6	189912	7584909
24697	0.00	6	157305	7689604
24717	0.00	2	286558	7134659
24913	0.05	7	463442	7249171
24988	0.38	6	348270	7404853
24989	0.54	6	356102	7404901
26140	0.11	3	338996	7507928
26210	0.00	6	536673	7195835
26223	0.00	2	100731	7555019
26365	0.00	4	506456	7188285
26366	0.00	6	508751	7195697

26375	0.00	2	16549	7586033
26428	0.00	1	422845	7080143
26433	0.00	2	138600	7541765
26434	0.00	3	306103	7668341
26502	0.00	4	367775	7217418
26537	0.00	1	209617	7691489
30196	0.08	6	327697	7651756
30314	0.00	3	418135	7173332
30404	0.00	3	156357	7733466
30581	0.00	4	166110	7692352
30665	0.00	2	219948	7185701
30666	0.03	6	302976	7623640
30693	0.01	6	179591	7733856
30795	0.00	4	437223	7196784
30829	0.00	4	97067	7726686
30969	0.00	6	131515	7748256
30980	0.00	4	16353	7683756
31104	0.00	4	101359	7748045
31109	0.00	4	97760	7739106
31266	0.01	5	503206	7182934
32281	0.04	8	501873	7282112
32495	0.00	6	536068	7199743
32980	0.00	6	376195	7595709
32982	0.00	6	368786	7588049
33270	0.00	3	445582	7217553
33274	0.14	7	339175	7645753
33324	0.00	2	391922	7216124
33325	0.00	2	395599	7222182
33409	0.00	10	562509	7278022
33429	0.00	2	241565	7299036
33497	0.07	7	262573	7717565
33501	0.00	6	486101	7261515
33525	0.00	6	357264	7630667
33874	0.00	3	331281	7286400
34255	0.00	1	223772	7746076
34345	0.11	4	372019	7328547
34346	0.06	4	362694	7338366
34483	0.02	6	266733	7712929
34499	0.06	7	476708	7252860
34546	0.11	5	385417	7354346
34547	0.25	6	387045	7359496
34548	0.01	5	387548	7345812
34800	0.02	4	357764	7334164
34850	0.00	4	461221	7211301
35107	0.60	6	362463	7456576
35291	1.00	7	377654	7452460
35513	0.11	6	343893	7619626
35560	0.00	1	424633	7078781
35631	0.00	4	40336	7763294
35872	0.00	6	499162	7236363
35886	0.00	2	193705	7159190

35887	0.00	2	199272	7158702
35917	0.53	8	370992	7518841
35976	0.00	2	203231	7161440
36147	0.00	1	230302	7757134
36149	0.00	1	219404	7746990
36150	0.00	1	236781	7754988
36245	0.01	4	508258	7166660
36464	0.04	6	328153	7600643
36626	0.00	1	447941	7136906
36918	0.07	8	421717	7503505
37256	0.00	4	149475	7695911
37258	18.39	13	456551	7349081
37314	0.07	8	363306	7681510
37532	0.01	6	545229	7188703
37863	0.01	4	191760	7720669
37906	0.00	5	493908	7201081
37988	0.00	3	449553	7159184
38029	0.00	13	493632	7369635
38030	0.26	10	483933	7329339
38085	0.45	8	455940	7320324
38089	8.09	10	453063	7356275
38097	0.00	13	499548	7379195
38108	29.28	13	449765	7366726
38124	0.00	13	498875	7337103
38128	0.00	13	500958	7341172
38129	0.00	13	506238	7342220
38130	0.00	13	507955	7340668
38131	0.00	13	503010	7336700
38158	0.00	5	455178	7245055
38168	0.00	13	511847	7342852
38183	0.00	4	475988	7184236
38197	0.03	6	399912	7347749
38216	0.01	3	169492	7732432
38496	0.00	3	416247	7042749
38528	0.00	6	527617	7258094
38640	0.06	6	445021	7280667
38727	0.00	2	55799	7497601
38728	0.00	2	54032	7501251
38789	0.00	3	428802	7090084
38814	0.00	1	427822	7081956
38827	0.18	7	350045	7639059
38916	9.00	9	423618	7472707
38974	0.00	2	316407	7319630
38990	0.02	6	422548	7311534
39801	1.36	7	401316	7570265
39802	0.93	7	393860	7571399
43440	9.55	9	430672	7471760
43465	0.00	5	110748	7590428
43742	0.00	3	115894	7746497
43933	0.05	6	432124	7301403
43956	0.00	2	319366	7317729

44022	0.02	8	500646	7298009
44074	0.00	1	423036	7071345
44398	0.00	1	442161	7513949
44399	0.03	8	436963	7502294
44400	0.06	8	427971	7508716
44402	0.17	8	425052	7494552
44427	0.00	1	431835	7098653
44440	0.19	1	441533	7538108
44468	0.16	1	448436	7407327
44489	0.22	1	443275	7538796
44583	0.07	5	382313	7306929
47120	0.03	8	500872	7291853
47128	0.02	6	495008	7250203
47639	0.06	1	425622	7615419
50006	0.00	2	387185	7223530
50022	0.00	4	455076	7224908
50025	0.02	6	425012	7247369
50026	0.00	3	443772	7135750
50027	0.00	1	423148	7077696
50035	0.00	4	394458	7257612
50074	0.00	2	395534	7212399
50077	0.00	3	425712	7080919
50081	0.00	3	459176	7166015
50113	0.02	6	463878	7243143
50124	0.00	6	537254	7183683
50186	0.00	5	527258	7170388
50187	0.00	6	524088	7176146
50190	0.00	2	276300	7127161
50193	0.00	3	465432	7130965
50194	0.00	5	475207	7168485
50204	0.00	6	562027	7252033
50224	0.00	5	465409	7182367
50230	0.00	3	447941	7136906
50231	0.00	4	462878	7219180
50243	0.00	1	430205	7081846
50267	0.00	2	392183	7218495
50268	0.00	2	387993	7213877
50274	0.00	1	422129	7079370
50279	0.01	6	531552	7241833
50280	0.00	6	533236	7230817
50289	0.00	2	385252	7203640
50297	0.00	6	538772	7236247
50298	0.00	4	440581	7227959
50304	0.00	4	482817	7171942
50313	0.00	2	289354	7118389
50316	0.00	3	417024	7204119
50319	0.00	4	421887	7070188
50321	0.00	2	244283	7162047
50331	0.00	4	430310	7166388
50344	0.00	4	388949	7247756
50345	0.00	4	389085	7258770

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50347	0.00	5	460732	7264635
50348	0.01	6	478151	7262858
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50363	0.00	4	420544	7209523
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50419	0.00	4	450649	7217418
50423	0.00	3	487198	7171147
50424	0.00	3	443188	7059974
50434	0.00	3	448442	7129863
50435	0.00	3	439365	7108012
50436	0.00	3	359146	7151300
50437	0.00	4	440891	7220978
50438	0.00	2	242606	7133594
50440	0.00	2	262935	7155343
50445	0.00	2	364515	7146772
50446	0.00	2	351607	7145217
50449	0.00	3	357774	7133869
50452	0.00	1	423867	7078950
50453	0.00	3	360855	7118948
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50456	0.00	4	464994	7202083
50457	0.00	3	434034	7185879
50458	0.00	3	417935	7033837
50461	0.00	4	471790	7201699
50464	0.00	3	419941	7035266
50467	0.00	4	416571	7035521
50474	0.01	6	540876	7208711
50476	0.00	3	433927	7213502
50478	0.00	1	425228	7080519
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50494	0.00	2	256870	7154463
50499	0.00	3	371576	7128350
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50519	0.00	2	326452	7138940
50531	0.00	2	350502	7119972
50532	0.00	6	491401	7143989
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50537	0.09	5	414489	7287926
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50575	0.00	5	515334	7183818
50576	0.00	5	514445	7188156
50577	0.00	1	428101	7008515
50584	0.00	6	496802	7144514
50588	0.00	5	485825	7151059
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50595	0.00	6	530390	7198281
50600	0.00	3	454758	7202514
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50602	0.01	5	449138	7202494
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50613	0.00	1	423568	7084301
50615	0.00	6	510064	7195235
50616	0.00	5	468408	7189357
50618	0.00	6	543871	7244013
50621	0.00	6	555342	7250647
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50638	0.00	4	430139	7151159
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50694	0.07	6	438672	7297103
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50775	0.00	1	421915	7078014
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50780	0.00	1	422582	7080300
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50799	0.01	5	510244	7185324
50801	0.00	6	413047	7199970
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50804	0.00	1	418787	7072799
50806	0.00	1	421583	7077951
50810	0.00	1	422335	7080550
50811	0.00	2	263096	7190636
50814	0.00	4	426037	7235799
50815	0.00	4	468439	7207970
50816	0.00	1	425050	7078108
50823	0.06	6	401636	7266540
50828	0.00	1	426907	7081982
50829	0.00	3	430759	7176541
50830	0.00	4	422329	7079511
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50847	0.04	6	437421	7303853
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50853	0.01	6	429851	7212093
50854	0.00	5	462114	7161979
50859	0.00	5	467584	7218709
50866	0.00	4	429362	7078818
50869	0.00	6	522224	7210583
50870	0.01	6	526421	7211211
50871	0.00	3	424357	7078285
50876	0.00	3	442854	7060342
50881	0.00	5	472312	7151155
50882	0.07	6	440340	7282715

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50891	0.00	5	509923	7207088
50896	0.01	5	424685	7247834
50897	0.00	1	425876	7078223
50898	0.00	4	444530	7179981
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50906	0.00	6	413172	7191871
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50941	0.00	4	423551	7073464
50942	0.00	5	509634	7215836
50943	0.00	1	424535	7071349
50947	0.08	8	449603	7256019
50948	0.08	8	454099	7251732
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50966	0.00	3	430956	7170698
50972	0.00	5	481131	7190901
50973	0.00	5	492719	7185170
50974	0.00	4	433666	7131493
50987	0.00	5	486141	7197902
50992	0.00	5	460018	7178801
50997	0.00	4	493009	7166878
51005	0.00	4	121120	7742040
51013	0.00	4	112697	7710472
51022	0.00	1	236781	7754988
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51057	0.28	8	418349	7456648
51058	0.38	8	419635	7449843
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51069	0.01	3	222530	7697863
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51109	0.09	1	396894	7405238
51121	0.00	2	59413	7468751
51154	0.00	2	51670	7472502
51160	0.00	2	166303	7554115
51161	0.00	2	172055	7553110
51178	0.00	2	56799	7481904
51179	0.00	2	54842	7480367
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51187	0.05	6	309729	7601409
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51238	0.00	4	169030	7582904
51251	0.01	3	204095	7709368
51253	0.00	2	59817	7506289
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51258	0.00	2	309100	7312663
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51263	0.00	4	296149	7351018
51264	0.00	2	64072	7507798
51266	0.00	2	46724	7543532
51267	0.11	6	319107	7522473
51290	0.00	4	370846	7258867
51291	0.13	4	322019	7411758
51292	0.29	6	352153	7436545
51294	0.00	4	38120	7570482
51318	0.00	2	135595	7517020
51351	0.05	4	378313	7312038
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51352	0.03	6	309766	7615011
51353	0.06	6	237252	7532902
51365	0.02	6	175771	7585044
51367	0.00	2	192167	7257878
51368	0.00	2	196412	7247746
51370	0.07	6	315731	7568561
51384	0.01	6	175136	7725552
51385	0.06	6	325823	7324918
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51392	0.00	4	352090	7278216
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51407	0.00	2	317162	7219907
51414	0.02	6	228634	7705195
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51430	0.03	5	197734	7561093
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51454	0.00	2	123322	7486068
51461	0.06	6	322306	7575296
51469	0.05	6	344602	7288278
51505	0.00	2	121313	7513040
51508	0.04	6	297522	7322080
51531	0.00	4	289885	7361637
51532	0.13	4	375044	7328793
51535	0.05	6	315220	7326351
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51576	0.02	6	195695	7620645
51592	0.00	2	185400	7509554
51593	0.00	2	188424	7514234
51602	0.11	4	363652	7344527
51607	0.00	2	137538	7454742
51616	0.00	4	-20635	7718678
51621	0.00	4	152928	7703607
51623	0.00	2	165647	7549851

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51651	0.04	6	306474	7612806
51655	0.00	6	203022	7487583
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51659	0.02	6	201813	7723825
51667	0.07	3	371712	7324976
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51753	0.16	6	319533	7459034
51795	0.04	6	237942	7711917
51801	0.00	6	65389	7536215
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51827	0.22	6	348793	7468041
51830	0.00	4	154867	7388150
51834	0.01	4	212833	7674493
51840	0.01	4	209188	7693087
51884	0.38	8	410693	7473210
51885	0.24	8	411268	7462472
51904	0.00	6	102488	7680151
51905	0.00	6	46552	7654657
51917	0.00	4	1293	7689628
51918	0.00	4	93296	7519412
51943	0.00	6	57922	7583068
51945	0.00	6	105929	7616583
51946	0.00	6	26659	7473932
51983	0.18	4	372233	7339254
51985	0.13	8	298297	7700329
51986	0.02	4	279588	7565805
51988	0.13	5	357670	7352160
51989	0.00	4	324728	7263198
54627	1.25	8	382895	7570700
57188	0.00	13	571570	7300431
57268	0.00	13	542613	7316397
57270	0.02	13	537254	7313170
57280	0.00	10	556927	7283052
57284	0.00	13	564084	7279009
57291	0.01	10	542373	7293593
57295	0.01	13	565890	7296648
57296	0.01	13	568191	7292518
57300	0.00	13	560204	7312193
57338	0.02	13	548215	7297578
57341	0.00	8	538874	7280056
57344	0.00	8	540675	7275461
57345	0.00	8	537257	7274780
57346	0.00	8	542607	7271545
57382	0.00	13	556385	7311322
57660	0.10	1	447527	7524685
62120	0.03	10	521613	7293341
62539	0.00	10	550862	7286788

62556	0.00	10	550860	7286429
62750	0.77	8	409981	7544717
62751	0.70	7	407770	7539913
62752	0.70	7	409016	7534846
62753	0.73	7	418835	7534219
62754	0.69	8	418832	7548212
62798	0.00	1	441775	7513625
67187	0.01	10	524909	7300154
67626	0.76	8	424423	7530138
69010	0.02	6	259270	7650526
69013	0.01	4	221856	7687802
69039	0.00	4	161935	7590669
69040	0.05	6	300516	7608155
69048	0.00	4	96171	7730208
69050	0.01	3	234904	7702217
69055	0.00	4	170873	7534718
69059	0.00	4	137353	7605131
69065	0.01	3	291348	7621033
69070	0.00	6	139783	7671344
69079	0.04	5	350139	7342270
69086	0.07	4	368236	7331650
69091	1.21	8	410901	7389411
69092	0.13	6	376175	7324493
69095	0.04	6	298000	7616364
69099	0.01	5	177408	7610880
69102	0.00	5	75734	7675772
69107	0.00	1	226268	7735160
69110	0.00	4	179348	7712869
69111	0.00	5	-29147	7606314
69113	0.00	4	139042	7694114
69116	0.11	6	328087	7525190
69126	0.04	4	286904	7686346
69127	0.04	6	327840	7611097
69133	0.00	4	354805	7240761
69136	0.01	4	251351	7695665
69137	0.01	3	235422	7687450
69141	1.22	5	373424	7374086
69144	0.15	5	377158	7367874
69146	0.55	5	373218	7371746
69147	0.27	5	373731	7371351
69149	0.12	5	380102	7367806
69150	0.16	5	377026	7366796
69151	0.40	5	373011	7369530
69152	0.52	5	372745	7367589
69153	0.16	5	375434	7367551
69154	0.11	5	378504	7372745
69155	0.18	5	376210	7372849
69156	0.11	5	378504	7372745
69157	1.28	5	373392	7374485
69158	0.11	5	378816	7376008
69159	0.20	5	376947	7376085

69160	0.27	5	373731	7371351
69161	3.38	6	371937	7375764
69162	0.76	6	375489	7377672
69163	1.87	6	371720	7377854
69164	1.95	6	372117	7377858
69165	6.19	6	370315	7376611
69174	0.20	5	379162	7325892
69176	0.92	6	373154	7382296
69190	0.00	4	81849	7697628
69212	0.01	4	336556	7330984
69214	0.13	6	341213	7514565
69217	0.13	5	382663	7362629
69218	0.19	5	376515	7373528
69219	0.02	6	426786	7315094
69238	0.06	6	417689	7322949
69242	0.00	4	143350	7693675
69256	0.02	6	403061	7329223
69257	0.03	6	405406	7337390
69258	0.00	1	296562	7700308
69262	0.20	6	397046	7341362
69267	0.84	6	363273	7401530
69287	0.03	6	203156	7589593
69288	0.28	7	392873	7496093
69290	0.00	5	409575	7308135
69295	0.00	4	375223	7272154
69302	0.00	2	114885	7533843
69341	0.00	4	-9286	7660028
69341	0.00	5	-9286	7660028
69344	0.47	7	461311	7319532
69348	0.00	6	4040	7558467
69358	0.00	5	142598	7650893
69373	0.00	5	-22453	7546869
69388	0.21	6	328216	7450216
69400	0.00	6	108321	7687083
69406	0.20	6	349911	7531476
69407	0.14	6	344473	7531515
69414	0.00	3	249875	7674663
69422	0.02	6	184273	7586939
69424	0.01	6	177247	7721313
69427	0.00	6	12784	7580983
69428	0.10	1	440274	7398444
69433	0.00	4	167755	7714750
69436	0.00	6	26776	7575758
69441	0.01	8	420843	7510889
69442	0.03	8	422890	7511935
69443	0.03	8	421270	7506720
69448	0.05	6	395884	7349658
69459	0.00	5	91297	7545531
69470	0.00	6	382495	7412956
69471	0.03	6	300074	7623112
69476	0.10	6	268529	7534269

69485	0.29	6	326414	7374122
69487	0.00	4	150327	7650043
69488	0.00	4	102857	7702606
69489	0.00	6	105276	7634109
69490	0.00	4	29999	7694448
69494	0.00	4	188184	7503483
69496	0.06	6	218060	7503258
69501	0.05	6	187207	7527758
69512	0.00	4	147020	7595120
69514	0.01	6	143862	7575398
69527	0.01	4	223758	7650149
69531	0.95	7	392827	7412138
69532	0.00	2	320934	7218542
69536	0.02	5	380643	7299181
69541	0.00	6	102625	7546007
69547	0.00	13	483934	7358576
69553	0.00	5	416089	7307406
69557	0.00	2	331284	7240030
69558	0.01	4	358572	7318363
69573	0.00	4	27598	7655801
69576	0.07	4	375461	7319103
69588	0.00	4	62027	7639416
69591	0.01	6	174053	7714226
69604	0.00	2	181317	7487145
69608	0.00	3	213081	7698751
69617	0.28	8	415778	7454544
69623	0.43	6	335835	7405304
69628	0.60	7	395549	7510723
69630	0.00	1	209610	7694310
69647	0.41	6	330343	7433667
69650	0.26	6	350393	7482052
69651	0.04	3	346302	7470671
69657	0.19	6	308153	7440966
69658	0.20	6	314021	7442733
69693	0.03	5	402868	7306232
69694	0.00	1	198681	7699514
69695	0.00	2	332005	7282347
69698	0.11	6	402374	7334786
69699	0.00	5	392112	7347657
69702	0.13	4	323037	7410777
69703	0.35	6	370948	7359637
69706	0.00	6	188675	7689739
69714	0.00	1	456365	7374523
69719	1.16	7	387796	7459269
69730	72.93	10	446387	7433792
69731	68.35	10	445197	7432429
69732	68.48	10	446285	7420154
69735	15.83	10	450238	7392579
69736	0.00	2	97225	7504121
69737	0.45	5	376564	7361255
69742	0.01	4	207145	7692262

69744	1.29	7	415751	7362478
69745	1.28	8	423295	7360240
69746	0.00	13	473030	7355552
69754	0.13	6	378260	7396517
69756	0.00	1	208690	7694920
69757	0.20	6	360980	7357852
69758	0.23	6	363546	7361661
69759	0.07	5	382776	7366105
69766	0.04	6	406494	7326601
69767	0.00	2	304838	7265037
69773	0.00	3	231518	7608548
69776	0.00	4	101451	7630268
69777	0.01	4	254037	7677659
69778	0.08	4	334651	7442817
69779	0.00	4	6043	7727110
69780	0.00	4	71930	7719600
69781	0.00	4	12072	7710487
69782	0.00	5	101674	7714485
69800	0.01	6	232189	7691652
69801	0.01	6	225586	7699808
69816	0.00	5	183904	7751668
69827	0.00	6	193110	7349741
69828	0.00	6	75650	7602738
69832	0.60	7	397164	7533349
69838	0.62	8	393961	7519492
69839	0.00	5	33478	7708474
69840	0.00	6	52187	7694201
69851	0.00	4	-3749	7599136
69853	0.00	5	415187	7303002
69854	0.01	6	427645	7308986
69865	0.00	6	367115	7453688
69866	0.00	5	65438	7744511
69867	0.00	5	72871	7741137
69868	0.00	4	-2179	7743008
69870	0.00	6	33555	7678838
69871	0.05	4	332055	7476121
69872	0.80	6	349662	7390288
69873	0.11	4	324258	7433138
69877	0.13	4	368010	7337336
69879	0.30	6	344590	7427327
69881	0.00	4	-19729	7695143
69882	0.00	4	133717	7726902
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69884	0.00	4	-1143	7717327
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69887	0.05	6	321357	7595076
69888	0.18	6	388383	7311451
69891	0.08	5	410065	7297876
69892	0.00	6	44101	7745299
69893	0.00	4	106890	7716133

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69896	0.00	6	159373	7714744
69897	0.00	6	172551	7688205
69898	0.00	6	160197	7696903
69904	0.29	6	324320	7393555
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69911	0.00	4	-11569	7712937
69912	0.05	6	343175	7298526
69922	0.02	5	91056	7717102
69923	0.00	4	114279	7714457
69929	0.00	6	363398	7520696
69934	0.42	7	376951	7535804
69936	0.07	3	361813	7365235
69953	0.00	5	97257	7714803
69954	0.00	6	69492	7725332
69955	0.02	6	108332	7702946
69956	0.00	6	114956	7708431
69957	0.00	6	176059	7682572
69961	0.00	4	83698	7740289
69962	0.00	4	84900	7730969
69963	0.00	5	92097	7734372
69966	0.00	6	76969	7677295
69967	0.00	6	115486	7688846
69973	0.01	6	133950	7591268
69978	0.00	5	182702	7748408
69979	0.00	5	182828	7747484
69980	0.22	6	349171	7458046
69981	0.02	6	400007	7349002
70284	0.11	6	314974	7683144
70285	0.06	6	316105	7685371
76840	0.13	8	362964	7702115
76841	0.07	8	366570	7697782
76842	0.23	8	357864	7701415
76888	0.46	7	377993	7563183
84280	0.00	6	516214	7243489
84671	0.05	1	449836	7525877
89020	0.00	10	551860	7290018
89053	0.00	10	555469	7288208
89054	0.00	10	553666	7289413
89136	0.00	13	545971	7308464
89140	0.01	10	538359	7295480
89174	0.00	8	533014	7280649
89175	0.00	8	538806	7282335
89176	0.00	8	540244	7280052
89180	0.00	8	531202	7280605
89294	0.00	10	568767	7290486
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89327	26.83	10	448027	7403347
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89393	0.00	13	531157	7324252
89455	0.01	10	497598	7317806
89456	0.51	10	508640	7306856
90025	2.30	10	489620	7306247
90084	1.23	8	426778	7348221
90085	1.27	8	436089	7344227
90109	0.01	13	529385	7322366
90110	0.00	13	538192	7324200
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90118	0.01	13	562767	7291480
90145	1.14	8	427870	7339787
90157	1.35	8	388146	7424621
90158	0.00	10	566144	7280376
90172	0.01	10	550946	7294892
90196	0.38	13	512735	7312848
90217	3.20	9	432275	7377579
90234	1.27	8	382232	7411379
90236	0.00	13	491458	7375422
90242	0.91	8	408579	7437295
90256	48.40	13	423671	7580877
90259	53.36	13	423688	7577245
90261	0.76	8	409916	7543865
90372	1.29	8	425610	7385301
90434	0.93	7	402054	7405575
90435	0.64	6	359994	7439685
90438	0.01	8	527508	7283271
93011	0.14	5	397809	7294509
93015	0.00	4	78762	7526979
93058	0.61	8	388696	7511748
93059	0.55	8	380047	7518728
93061	0.00	4	-26991	7605605
93062	0.00	5	406088	7305634
93094	0.00	6	24569	7681595
93127	0.02	6	413205	7320074
93139	0.02	6	266981	7672327
93148	0.01	4	197636	7738679
93149	0.50	6	356951	7411143
93205	0.03	6	285065	7664115
93218	0.05	6	311231	7675107
93221	0.29	6	380089	7387158
93222	0.55	6	375010	7386111
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93231	0.00	6	155226	7711795
93232	0.00	4	170193	7721504
93327	0.00	2	115757	7512398
93353	0.00	6	177138	7696734
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93372	0.00	4	-10874	7690778
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93484	0.20	6	349207	7514952
93485	0.06	6	261597	7705488
93507	0.01	6	225757	7696864
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93541	0.00	6	35181	7632981
93548	0.00	4	93475	7578861
93555	0.00	6	357030	7613775
93558	0.03	6	353592	7609272
93581	0.00	4	124965	7723519
93582	0.00	6	160420	7711246
93583	0.00	5	69597	7736109
93590	0.00	6	88370	7659176
93591	0.05	6	364306	7265840
93592	0.13	6	321788	7475992
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93640	0.04	6	226866	7577545
93643	0.30	6	352360	7436869
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93693	0.44	6	335452	7411458
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93728	0.33	6	372978	7386142
93735	0.03	6	302565	7622583
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93765	0.02	4	259492	7701377
93768	0.62	8	400792	7518194
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93826	0.00	4	26820	7487169
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93837	0.07	6	328237	7560074
93842	0.08	3	340141	7520750
93845	0.00	4	156958	7363188
93869	0.71	6	360240	7411136
93872	0.00	6	104521	7617799
93880	0.05	6	282214	7613386
93882	0.00	3	228310	7624340
93883	0.02	6	217217	7486072
93887	0.01	7	251284	7688465
93890	0.00	4	194755	7687254
93901	0.01	4	224293	7657672
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93909	0.03	6	184853	7547386
93921	0.17	5	371805	7333436
93922	0.00	5	411724	7307594

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93925	0.01	3	258226	7703064
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93932	0.03	6	424152	7314266
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93986	0.15	6	331540	7469970
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93998	0.07	6	317223	7559485
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102616	0.59	7	383296	7626814
103008	44.13	9	427720	7393488
103015	0.01	6	388680	7384573
103055	0.00	8	539419	7277246
103056	0.00	8	540880	7281260
103057	0.00	8	541258	7277069
103077	0.89	7	371461	7453242
103120	27.80	10	445735	7399351
103129	0.09	10	519120	7304123
103170	0.00	1	394379	7424529
103175	1.62	8	422536	7383290
103184	0.00	1	458197	7381892
103202	0.00	1	411203	7389458
103203	0.00	1	410559	7389533
103253	1.29	8	421464	7358686
103318	1.32	8	399920	7461859
103319	0.03	10	527698	7314471
103334	0.06	8	418235	7498289
103364	0.98	7	412285	7379312
103395	0.16	10	484344	7325116
103405	0.00	10	562794	7291331
103407	0.01	10	548210	7297657
103421	0.20	10	514338	7309921
103441	26.45	9	421353	7411207
103479	51.38	10	449262	7445025
103480	134.22	10	438771	7398870
103492	1.23	8	437839	7356733
103546	0.01	10	541596	7288955
103561	0.75	8	408019	7540242
103562	0.01	8	532556	7273383
103563	0.00	8	537893	7280446
103564	0.00	8	535123	7279966
103565	11.82	9	428493	7541524
103566	0.00	10	556157	7287086
103574	0.39	8	456552	7322640
103802	0.00	1	504624	7338788

103881	0.00	8	536771	7275785
103930	1.23	8	408786	7353381
103982	0.00	1	437290	7509302
103983	0.00	1	442129	7514027
116000	0.00	6	521316	7190975
116007	0.00	6	527177	7205393
116014	0.00	5	480128	7169283
116016	0.00	3	429683	7082519
116017	0.01	4	476950	7213948
116019	0.00	6	500038	7211901
116022	0.00	3	428073	7082010
116025	0.00	5	478419	7187246
116033	0.00	5	504479	7207145
116035	0.04	5	411266	7272147
116036	0.05	6	420428	7263043
116038	0.00	5	489681	7158974
116041	0.01	5	503495	7199989
116044	0.00	5	512410	7203895
116052	0.05	7	439286	7250647
116054	0.03	6	404287	7245468
116057	0.00	4	420627	7209337
116066	0.02	6	438354	7241794
116067	0.04	5	392524	7278724
116068	0.00	3	445525	7194376
116070	0.00	4	451783	7118549
116080	0.02	6	426272	7080139
116083	0.00	5	483680	7183318
116085	0.02	6	380859	7235782
116086	0.00	3	374649	7121837
116089	0.00	4	496045	7170771
116095	0.00	4	458052	7159680
116096	0.00	4	448019	7211902
116106	0.00	3	379226	7114048
116109	0.02	6	387903	7231618
116118	0.00	5	440377	7154325
116125	0.00	5	503415	7216492
116132	0.00	5	470522	7242557
116135	0.00	3	440587	7227894
116141	0.00	6	473007	7149905
116142	0.00	4	418823	7077808
116144	0.00	5	488903	7165265
116158	0.04	5	431649	7257527
116162	0.00	4	482178	7171533
116169	0.00	4	259922	7133060
116172	0.00	1	424431	7078835
116184	0.00	6	524075	7185940
116185	0.00	6	515970	7220520
116192	0.00	4	427999	7079077
116205	0.06	6	441959	7280289
116211	0.00	5	453310	7155695
116212	0.00	5	497158	7153447

116230	0.11	4	397665	7290656
116234	0.03	6	457196	7285921
116237	0.05	7	447179	7249920
116258	0.00	5	483982	7134441
116259	0.03	5	425794	7252035
116271	0.01	6	422069	7231705
116284	0.04	6	399545	7259013
116288	0.04	5	428014	7262147
116289	0.00	6	521739	7209782
116296	0.03	6	455944	7277662
118008	0.05	6	314898	7593842
118009	0.14	6	302721	7452892
118010	0.09	6	326916	7537687
118026	0.01	4	73752	7707324
118027	0.00	4	57907	7703145
118051	0.23	6	345610	7437487
118052	0.03	6	207896	7606381
118054	0.00	4	23971	7720791
118070	0.47	6	370097	7382375
118086	0.86	6	349971	7372742
118089	0.30	6	345903	7423886
118098	0.44	6	336922	7422918
118099	0.01	4	244259	7694505
118100	0.12	6	315120	7484958
118119	0.00	1	208062	7697922
118120	0.01	4	255529	7605654
118125	0.01	3	310880	7636239
118133	0.01	4	255584	7589944
118167	0.00	2	204603	7244638
118169	0.50	7	387135	7528009
118185	0.65	8	399510	7523545
118187	0.00	6	181129	7450639
118189	0.01	6	493042	7247846
118219	0.01	6	179554	7707779
118232	0.80	7	409793	7401233
118245	23.09	9	365011	7546105
118246	0.00	6	121047	7665337
118254	0.24	6	351659	7565396
118257	1.26	8	423806	7353278
118266	0.12	6	315511	7366370
118268	0.00	6	155703	7686931
118291	0.62	8	403038	7519768
118303	0.10	6	286021	7502878
118304	0.10	6	267644	7493898
118319	0.05	6	341220	7298101
118339	0.00	4	97404	7554629
118340	0.00	4	70950	7548335
118341	0.00	5	98677	7702220
118355	0.01	4	217431	7474538
118356	0.06	4	291319	7405816
118365	0.02	5	93004	7519149

118366	0.03	6	256419	7624724
118368	0.05	6	358755	7271504
118371	0.61	8	389015	7509429
118372	0.01	5	47280	7734591
118373	0.01	5	43399	7729585
118385	0.15	6	378290	7323259
118390	0.18	5	52719	7706066
118391	0.05	4	299694	7405809
118393	18.96	9	365431	7499033
118394	0.25	6	357287	7520291
118406	0.39	6	331426	7393031
118407	0.06	4	308445	7407604
118408	0.03	6	21890	7658341
118426	0.03	5	101502	7695007
118427	0.14	7	297506	7479303
118441	0.01	6	383280	7393894
118442	0.00	6	377346	7392660
118455	0.00	4	75383	7697656
118469	0.05	6	392184	7360356
118483	0.01	6	174138	7715751
118519	0.13	6	27915	7670596
118525	0.00	6	127929	7682024
118526	0.26	6	350877	7487755
118538	0.32	6	352093	7439743
118547	0.02	4	253145	7559422
118548	0.00	6	148672	7490319
118550	0.01	4	252143	7591393
118552	0.02	6	271222	7639882
118556	1.11	6	365906	7408775
118557	0.00	6	-6631	7622061
118623	0.00	6	371359	7403317
118630	0.16	6	341636	7456442
118631	0.19	6	365858	7461543
118632	0.00	6	30982	7595141
118635	0.01	4	240462	7653821
118637	0.09	6	45267	7627236
118645	27.61	9	374942	7547645
118650	0.04	5	387325	7361391
118657	0.02	4	270567	7694552
118658	0.23	6	335046	7445269
118659	0.04	6	308853	7606261
118660	0.04	6	306570	7614560
118661	0.05	6	300455	7603701
118665	0.11	6	299251	7467178
118666	0.06	6	86050	7717344
118667	0.00	6	367096	7483324
118673	0.04	6	328937	7604342
118674	0.04	6	326274	7600293
118683	0.00	6	23431	7640149
118684	0.00	6	10371	7654049
118687	0.14	6	346084	7541237

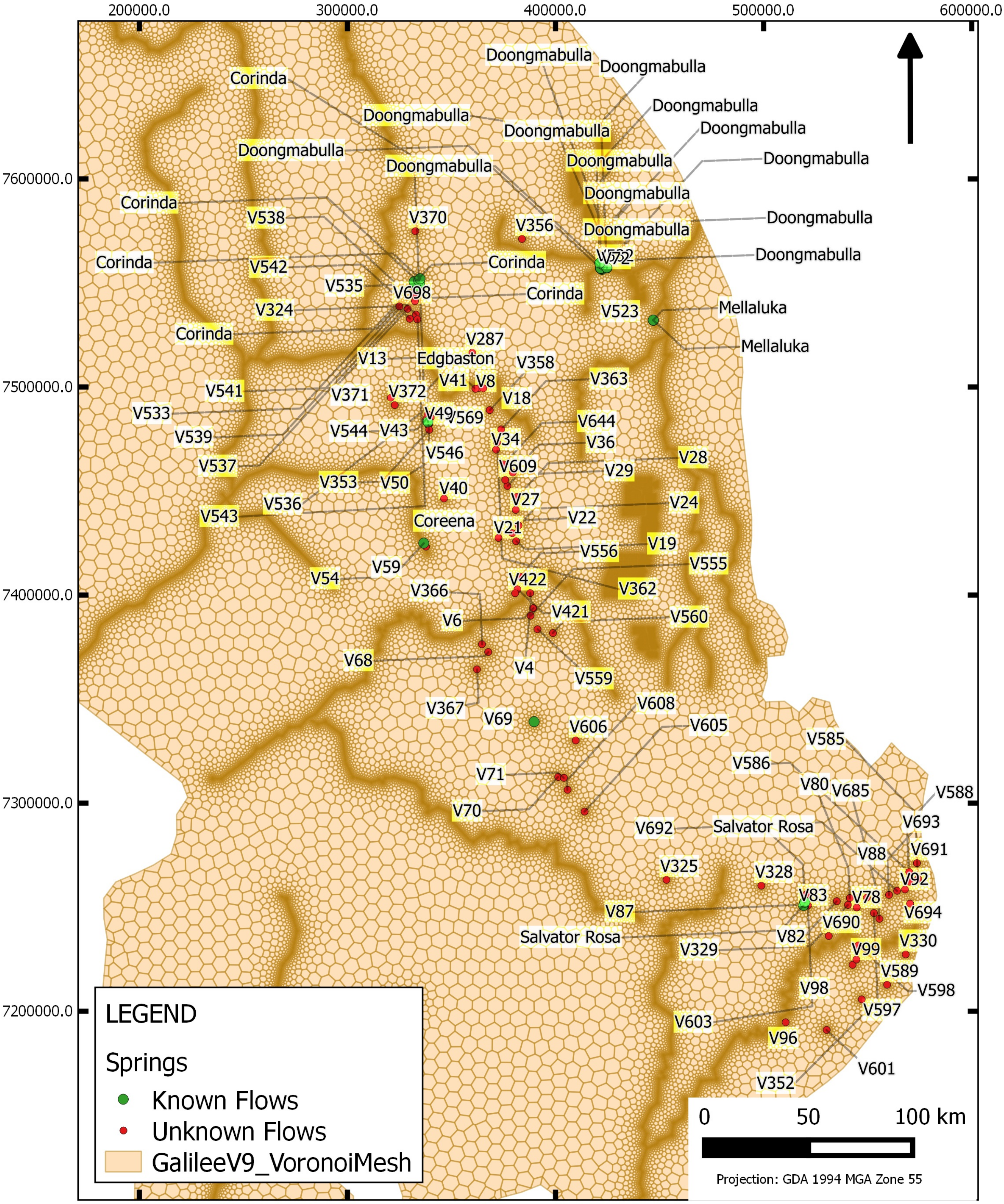
118690	0.00	2	80279	7451278
118693	0.00	6	108917	7531093
118701	0.20	6	347307	7460475
118702	0.17	6	339371	7457011
118703	0.01	6	154892	7579431
118709	0.05	6	316529	7598149
118710	0.00	4	51488	7729841
118737	0.00	4	3095	7676800
118738	0.12	5	390634	7306172
118744	0.00	6	115913	7724346
118745	0.05	6	333241	7569725
118761	0.00	2	116017	7535866
118762	0.00	2	114965	7539460
118772	0.12	6	312770	7472165
118797	0.00	6	267816	7416812
118809	0.29	5	386787	7320394
118810	0.35	6	297081	7423017
118812	0.00	6	264873	7394835
118813	1.04	6	360538	7396679
118814	0.00	2	199941	7488854
118815	0.00	2	197048	7479378
118816	0.00	3	202702	7467877
118841	0.04	6	366620	7259572
118878	0.27	4	373908	7342045
118879	0.11	4	366287	7340734
118880	0.00	4	180647	7623321
118936	0.05	5	276754	7699371
118943	0.04	6	299173	7664159
118961	0.00	2	101500	7568910
118968	0.07	6	218460	7519138
118970	0.00	4	49630	7702659
118973	0.00	4	-19074	7718043
118974	0.00	2	164199	7573645
118976	0.10	6	262731	7505355
118977	0.11	6	271885	7479140
118978	0.01	4	226373	7652315
118979	0.01	4	216901	7675820
118980	0.00	6	271552	7426373
118981	0.01	6	36505	7692225
118982	0.10	6	331742	7531351
118994	0.05	6	309101	7312663
118995	0.00	4	197	7689682
118996	0.01	4	223244	7673688
125537	0.18	8	352245	7668855
132356	0.42	8	407291	7472733
132357	0.05	8	413888	7505970
132390	1.12	8	427736	7338394
132650	1.49	8	395754	7447920
132698	0.70	8	399644	7474416
146012	0.02	4	261204	7567126
146013	0.05	6	226556	7569252

146016	0.00	6	2569	7660774
146018	0.00	4	35651	7625017
146020	0.00	3	230269	7664482
146021	0.00	3	298114	7675712
146034	0.26	6	344782	7434647
146073	0.41	6	335463	7430180
146093	0.04	6	201450	7578175
146094	0.01	6	29882	7694928
146095	0.01	6	32945	7685093
146096	0.00	6	59783	7685534
146098	0.06	6	246688	7547767
146099	0.16	6	343214	7483240
146102	0.10	6	209393	7558151
146103	0.06	6	418658	7310959
146115	0.00	6	33974	7728037
146116	0.07	6	295540	7568212
146117	0.09	4	329644	7387661
146118	0.03	4	293715	7536986
146120	0.10	6	284869	7480798
146128	0.21	6	328028	7357447
146147	0.11	6	339479	7588360
146150	0.03	3	289360	7673671
146153	0.38	5	376274	7341683
146155	0.01	6	200521	7661493
146158	0.01	4	254812	7672786
146159	0.00	2	296029	7275846
146160	0.02	6	195481	7600762
146166	0.08	6	374029	7307272
146167	0.00	2	160066	7568357
146168	0.00	2	164879	7570202
146172	0.00	4	169040	7604799
146190	0.00	4	-70902	7409959
146200	0.00	6	133433	7669372
146201	0.01	6	174668	7727222
146202	0.00	6	258830	7304039
146209	0.05	4	275611	7448998
146210	0.00	4	261235	7341880
146215	0.38	6	251830	7466175
146237	0.04	6	218738	7588054
146242	0.00	2	321471	7238244
146243	0.34	6	353387	7439474
146247	0.00	2	98077	7568365
146267	0.00	2	303706	7248984
146269	0.00	4	218733	7405420
146274	0.09	6	332027	7537280
146277	0.00	6	52235	7615730
146278	0.00	6	110615	7676838
146282	0.01	4	227558	7674968
146287	0.65	6	288675	7414133
146290	0.01	4	219966	7595283
146291	0.10	6	283417	7474801

146293	0.04	6	282179	7619953
146294	0.38	6	342538	7404855
146302	0.01	5	182960	7593817
146304	0.22	6	347425	7511068
146311	0.13	4	323099	7425035
146323	0.09	5	388388	7301992
146324	0.00	4	316305	7265155
146325	0.04	4	319827	7372422
146327	0.12	6	305999	7376014
146328	0.20	6	311568	7405163
146331	0.10	6	330340	7527104
146351	0.06	4	336389	7473832
146352	0.06	4	337337	7479413
146357	0.21	6	347805	7503352
146359	0.03	4	294664	7400808
146364	0.11	6	306515	7471454
146368	0.10	6	334265	7340329
146371	0.05	6	352234	7278205
146374	0.00	4	118136	7732752
146385	0.15	5	264389	7439685
146418	0.10	6	229943	7494122
146424	0.33	6	348637	7411300
146435	1.21	6	359941	7383543
146439	0.24	6	319808	7396669
146441	0.00	5	411264	7299398
146445	0.10	6	238228	7508185
146489	0.11	6	267408	7521799
146490	0.00	4	164933	7717827
146498	0.14	5	256244	7448215
146501	0.00	4	54951	7741985
146538	0.09	6	318094	7539289
146545	0.00	5	75562	7675507
146575	0.00	5	9637	7634466
146588	0.03	4	306766	7546148
146606	0.00	6	74114	7632598
12030009	0.21	10	369023	7691606
12030042	0.00	1	454705	7358400
12030043	0.00	1	454759	7358404
12030045	0.01	1	454630	7368942
12030046	0.01	1	454686	7368888
12030067	0.01	1	455886	7350061
12030140	0.00	1	370344	7707037
42320010	0.00	1	458477	7147115
42320015	0.00	1	456877	7146690
42320028	0.00	1	442028	7121341
42320036	0.00	1	438552	7109670
42320044	0.00	1	432162	7098372
42320068	0.00	3	427849	7082011
42320069	0.00	1	427859	7082009
42320073	0.00	1	426591	7082213
42320075	0.00	1	425947	7082326

42320077	0.00	1	424854	7082483
42320088	0.00	3	430849	7070405
42320089	0.00	3	427794	7072049
42320091	0.00	3	423923	7072695
42320094	0.00	3	420934	7072916
42320213	0.00	3	466615	7127382
42320214	0.00	3	465782	7144544
42320216	0.00	3	452876	7180095
42320219	0.00	3	478428	7153606
42320220	0.00	3	441856	7146674
91500027	0.00	1	210990	7694672
91500029	0.00	1	210576	7693524
91500033	0.00	1	209778	7694616
91500038	0.00	1	210183	7697473
91500039	0.00	1	210222	7698375
91500068	0.00	1	163345	7709561
91500069	0.00	1	163060	7709901
91500074	0.00	1	154770	7702745

APPENDIX J – Predicted Drawdowns at Modelled Springs



5 JUNE 2015	DRAWN BY: CT	APPENDIX J
GEOSCIENCE AUSTRALIA	GSA001 GALILEE BASIN MODEL	
Modelled Springs		

D:\HydroSim\GSA001\GIS\Maps\Deliverable\working\mesh_overview.qgs

Spring	Complex	Drawdown (m)	Layer	Easting	Northing
Doongmabulla	Moses	0.19	8	421666	7557001
Doongmabulla	Moses	0.28	8	422183	7556458
V367		0.24	4	362209	7364218
V29		0.00	6	376862	7452401
V694		0.01	8	570403	7251673
V609		0.00	6	375808	7455262
V28		0.00	6	381608	7447215
V27		0.00	6	380843	7440896
V330		0.01	8	568287	7227183
V22		0.00	6	379186	7429708
V597		0.00	6	547134	7205581
V589		0.01	6	559355	7212621
Doongmabulla	Moses	0.27	8	422659	7556724
V40		0.16	6	346386	7446342
V19		0.00	6	381059	7425850
V556		0.00	6	382628	7408917
V21		0.02	6	372564	7427431
V421		0.00	6	381662	7402705
V422		0.02	6	380556	7400814
V601		0.00	6	530291	7190909
V96		0.00	6	510574	7194591
V59		0.13	4	337722	7423219
Coreena	Caress	0.12	4	336671	7424927
Doongmabulla	Moses	0.28	8	422110	7556942
V54		0.12	4	336561	7424855
V442		0.00	8	252343	7743630
V72		0.19	8	424289	7556868
V324		0.04	4	329945	7532779
Doongmabulla	Moses	0.18	8	424745	7557229
Doongmabulla	Moses	0.21	8	424600	7557362
V523		0.71	8	421083	7559287
Mellaluka	Lachlan	40.75	10	446981	7531995
Mellaluka	Lachlan	40.84	10	446949	7532131
Doongmabulla	Moses	0.18	8	421677	7557012
V698		0.04	4	324936	7538695
V541		0.04	4	328862	7537521
Doongmabulla	Moses	0.74	8	421276	7559532
V83		0.00	6	519201	7250700
Salvator Rosa Nat	MajorMitcl	0.00	6	519231	7250772
V287		0.00	6	359976	7516464
Corinda	Caring	0.01	4	332270	7549993
V542		0.04	4	332919	7534787
V543		0.05	4	333565	7532471
Salvator Rosa Nat	MajorMitcl	0.00	6	519791	7252279
Doongmabulla	Moses	0.21	8	421609	7557038
V603		0.00	6	521324	7250717
Corinda	Caring	0.01	4	333109	7548468
V539		0.03	4	332636	7546203
V537		0.03	4	332718	7543762
V538		0.03	4	332430	7541259

V328			0.00	6	498893	7260259
V329			0.01	8	540521	7251008
V535			0.02	4	334099	7550825
V536			0.01	4	334607	7549852
Corinda	Caring		0.01	4	334599	7549924
Doongmabulla	Moses		0.19	8	421700	7557041
Corinda	Caring		0.01	4	334211	7551005
Corinda	Caring		0.02	4	332036	7550598
V78			0.01	8	544773	7249765
V690			0.01	6	531290	7236072
V533			0.02	4	334681	7551858
V87			0.00	6	520527	7256138
Corinda	Caring		0.01	4	334857	7552029
V82			0.01	8	535172	7252785
V80			0.01	8	541437	7254334
V88			0.01	8	549637	7254506
Doongmabulla	Moses		0.25	8	421567	7557052
V356			1.30	8	383857	7571117
V18			0.00	6	365271	7499337
V8			0.00	6	363318	7499428
V569			0.06	4	338548	7486728
V544			0.05	4	337892	7484561
V352			0.01	8	553038	7247082
V370			0.02	4	332588	7574867
V546			0.05	4	338297	7482682
V13			0.01	6	361468	7499089
V41			0.06	4	339177	7486466
Doongmabulla	Moses		0.21	8	421615	7557058
V560			0.02	6	398767	7381694
V372			0.06	4	322688	7491262
V371			0.05	4	320807	7494781
V358			0.00	6	368340	7488846
Edgbaston	Edgbaston/		0.05	4	338616	7483196
V598			0.00	6	545515	7231507
V605			0.29	6	413964	7295874
V559			0.03	6	391299	7383499
V363			0.00	6	373855	7479584
V50			0.06	4	338833	7481586
Doongmabulla	Moses		0.21	8	421731	7557038
V325			0.03	6	453305	7263047
V693			0.01	8	560281	7255820
V685			0.01	8	555656	7244309
V692			0.01	8	564160	7257814
V608			0.27	6	405784	7306335
V606			0.11	6	409680	7330062
V6			0.05	6	389270	7393684
V555			0.26	6	387976	7390042
V43			0.06	4	340039	7485268
V49			0.06	4	339343	7482241
Doongmabulla	Moses		0.20	8	421687	7557066
V586			0.00	8	570010	7266864

V71		0.29	6	404022	7312079
V70		0.32	6	401272	7312512
V362		0.00	6	371859	7473271
V353		0.07	4	339258	7479385
V99		0.00	6	544584	7224757
V69		0.44	6	389394	7338758
V68		6.25	4	367636	7372582
V36		0.00	6	379461	7458819
Maryvale Springs	Mary's	0.44	6	389682	7339082
V532		0.26	8	422543	7556520
V366		1.65	4	364617	7376307
V4		0.05	6	387796	7400886
V588		0.00	8	570086	7262177
V691		0.01	8	573693	7271112
V585		0.00	8	574231	7263511
V644		0.00	6	375023	7462788
V34		0.00	6	371373	7469829
V92		0.00	8	567952	7258415
V98		0.01	6	542757	7222197
V24		0.00	6	382238	7433376

APPENDIX K – Model Classification Table

Table 2-1: Model confidence level classification—characteristics and indicators

Confidence level classification	*Data*	*Calibration*	*Prediction*	*Key indicator*	*Examples of specific uses*
Class 3 Key indicators met: 2	• Spatial and temporal distribution of groundwater head observations adequately define groundwater behaviour, especially in areas of greatest interest and where outcomes are to be reported. • Spatial distribution of bore logs and associated stratigraphic interpretations clearly define aquifer geometry. • Reliable metered groundwater extraction and injection data is available. • Rainfall and evaporation data is available. • Aquifer-testing data to define key parameters. • Streamflow and stage measurements are available with reliable baseflow estimates at a number of points. • Reliable land-use and soil-mapping data available. • Reliable irrigation application data (where relevant) is available. • Good quality and adequate spatial coverage of digital elevation model to define ground surface elevation.	• Adequate validation* is demonstrated. • Scaled RMS error (refer Chapter 5) or other calibration statistics are acceptable. • Long-term trends are adequately replicated where these are important. • Seasonal fluctuations are adequately replicated where these are important. • Transient calibration is current, i.e. uses recent data. • Model is calibrated to heads and fluxes. • Observations of the key modelling outcomes dataset is used in calibration.	• Length of predictive model is not excessive compared to length of calibration period. • Temporal discretisation used in the predictive model is consistent with the transient calibration. • Level and type of stresses included in the predictive model are within the range of those used in the transient calibration. • Model validation* suggests calibration is appropriate for locations and/or times outside the calibration model. • Steady-state predictions used when the model is calibrated in steady-state only.	• Key calibration statistics are acceptable and meet agreed targets. • Model predictive time frame is less than 3 times the duration of transient calibration. • Stresses are not more than 2 times greater than those included in calibration. • Temporal discretisation in predictive model is the same as that used in calibration. • Mass balance closure error is less than 0.5% of total. • Model parameters consistent with conceptualisation. • Appropriate computational methods used with appropriate spatial discretisation to model the problem. • The model has been reviewed and deemed fit for purpose by an experienced, independent hydrogeologist with modelling experience.	• Suitable for predicting groundwater responses to arbitrary changes in applied stress or hydrological conditions anywhere within the model domain. • Provide information for sustainable yield assessments for high-value regional aquifer systems. • Evaluation and management of potentially high-risk impacts. • Can be used to design complex mine-dewatering schemes, salt-interception schemes or water-allocation plans. • Simulating the interaction between groundwater and surface water bodies to a level of reliability required for dynamic linkage to surface water models. • Assessment of complex, large-scale solute transport processes.
Class 2 Key indicators met: 6 *Cont'd overleaf*	• Groundwater head observations and bore logs are available but may not provide adequate coverage throughout the model domain.	• Validation* is either not undertaken or is not demonstrated for the full model domain. • Calibration statistics are generally reasonable but may suggest significant errors in parts of the	• Transient calibration over a short time frame compared to that of prediction. • Temporal discretisation used in the predictive model is different from that used in transient	• Key calibration statistics suggest poor calibration in parts of the model domain. • Model predictive time frame is between 3 and 10 times the duration of transient calibration. • Stresses are between 2 and 5 times greater than those	• Prediction of impacts of proposed developments in medium value aquifers. • Evaluation and management of medium risk impacts.

Confidence level classification	*Data*	*Calibration*	*Prediction*	*Key indicator*	*Examples of specific uses*
Class 2 *Cont'd*	• Metered groundwater-extraction data may be available but spatial and temporal coverage may not be extensive. • Streamflow data and baseflow estimates available at a few points. • Reliable irrigation-application data available in part of the area or for part of the model duration.	model domain(s). • Long-term trends not replicated in all parts of the model domain. • Transient calibration to historic data but not extending to the present day. • Seasonal fluctuations not adequately replicated in all parts of the model domain. • Observations of the key modelling outcome data set are not used in calibration.	calibration. • Level and type of stresses included in the predictive model are outside the range of those used in the transient calibration. • Validation* suggests relatively poor match to observations when calibration data is extended in time and/or space.	included in calibration. • Temporal discretisation in predictive model is not the same as that used in calibration. • Mass balance closure error is less than 1% of total. • Not all model parameters consistent with conceptualisation. • Spatial refinement too coarse in key parts of the model domain. • The model has been reviewed and deemed fit for purpose by an independent hydrogeologist.	• Providing estimates of dewatering requirements for mines and excavations and the associated impacts. • Designing groundwater management schemes such as managed aquifer recharge, salinity management schemes and infiltration basins. • Estimating distance of travel of contamination through particle-tracking methods. Defining water source protection zones.
Class 1 Key indicators met: 2	• Few or poorly distributed existing wells from which to obtain reliable groundwater and geological information. • Observations and measurements unavailable or sparsely distributed in areas of greatest interest. • No available records of metered groundwater extraction or injection. • Climate data only available from relatively remote locations. • Little or no useful data on land-use, soils or river flows and stage elevations.	• No calibration is possible. • Calibration illustrates unacceptable levels of error especially in key areas. • Calibration is based on an inadequate distribution of data. • Calibration only to datasets other than that required for prediction.	• Predictive model time frame far exceeds that of calibration. • Temporal discretisation is different to that of calibration. • Transient predictions are made when calibration is in steady state only. • Model validation* suggests unacceptable errors when calibration dataset is extended in time and/or space.	• Model is uncalibrated or key calibration statistics do not meet agreed targets. • Model predictive time frame is more than 10 times longer than transient calibration period. • Stresses in predictions are more than 5 times higher than those in calibration. • Stress period or calculation interval is different from that used in calibration. • Transient predictions made but calibration in steady state only. • Cumulative mass-balance closure error exceeds 1% or exceeds 5% at any given calculation time. • Model parameters outside the range expected by the conceptualisation with no further justification. • Unsuitable spatial or temporal discretisation. • The model has not been reviewed.	• Design observation bore array for pumping tests. • Predicting long-term impacts of proposed developments in low-value aquifers. • Estimating impacts of low-risk developments. • Understanding groundwater flow processes under various hypothetical conditions. • Provide first-pass estimates of extraction volumes and rates required for mine dewatering. • Developing coarse relationships between groundwater extraction locations and rates and associated impacts. • As a starting point on which to develop higher class models as more data is collected and used.

(*Refer Chapter 5 for discussion around validation as part of the calibration process.)