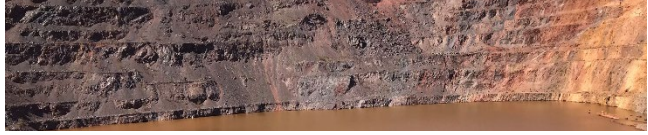
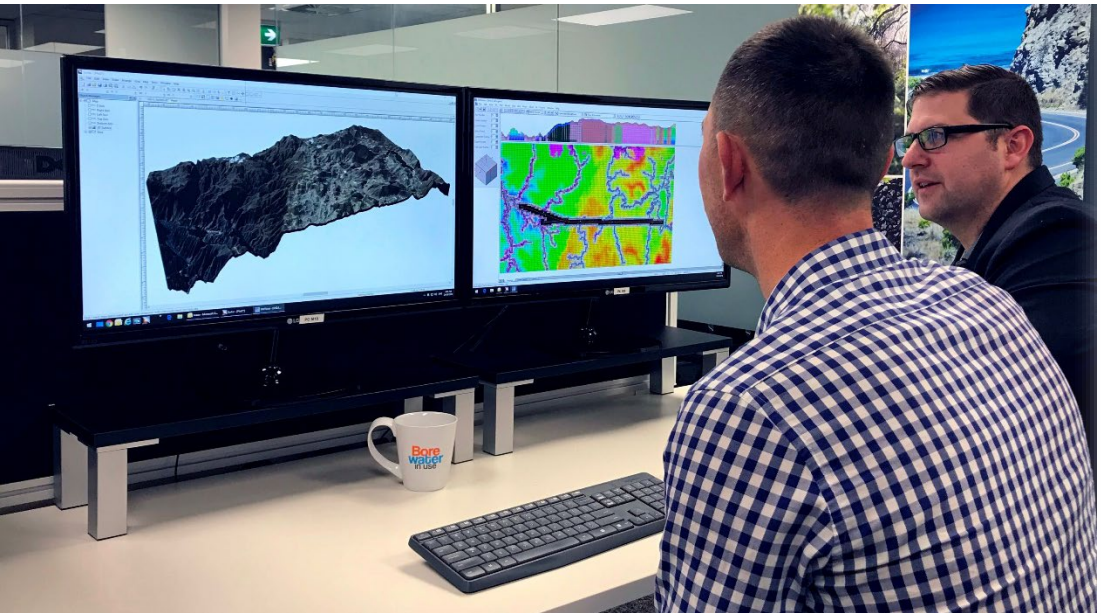


Fingerboards Mineral Sand Project

Inquiry and Advisory Committee (IAC) Panel Hearing- Groundwater

Joel Georgiou

14 May 2021



EMM
creating opportunities

Agenda

- Overview of key work
  - EES Role
  - Modelling study & key support studies
  - Results
- Issues raised during submissions. Major themes include:
  - Conceptual model
  - Pumping test and aquifer properties
  - Numerical modelling[1]
  - GDEs
  - Groundwater and seepage quality[2]

1. Numerical modelling issues addressed by Hugh Middlemis
2. Seepage quality issues addressed by John Sweeney

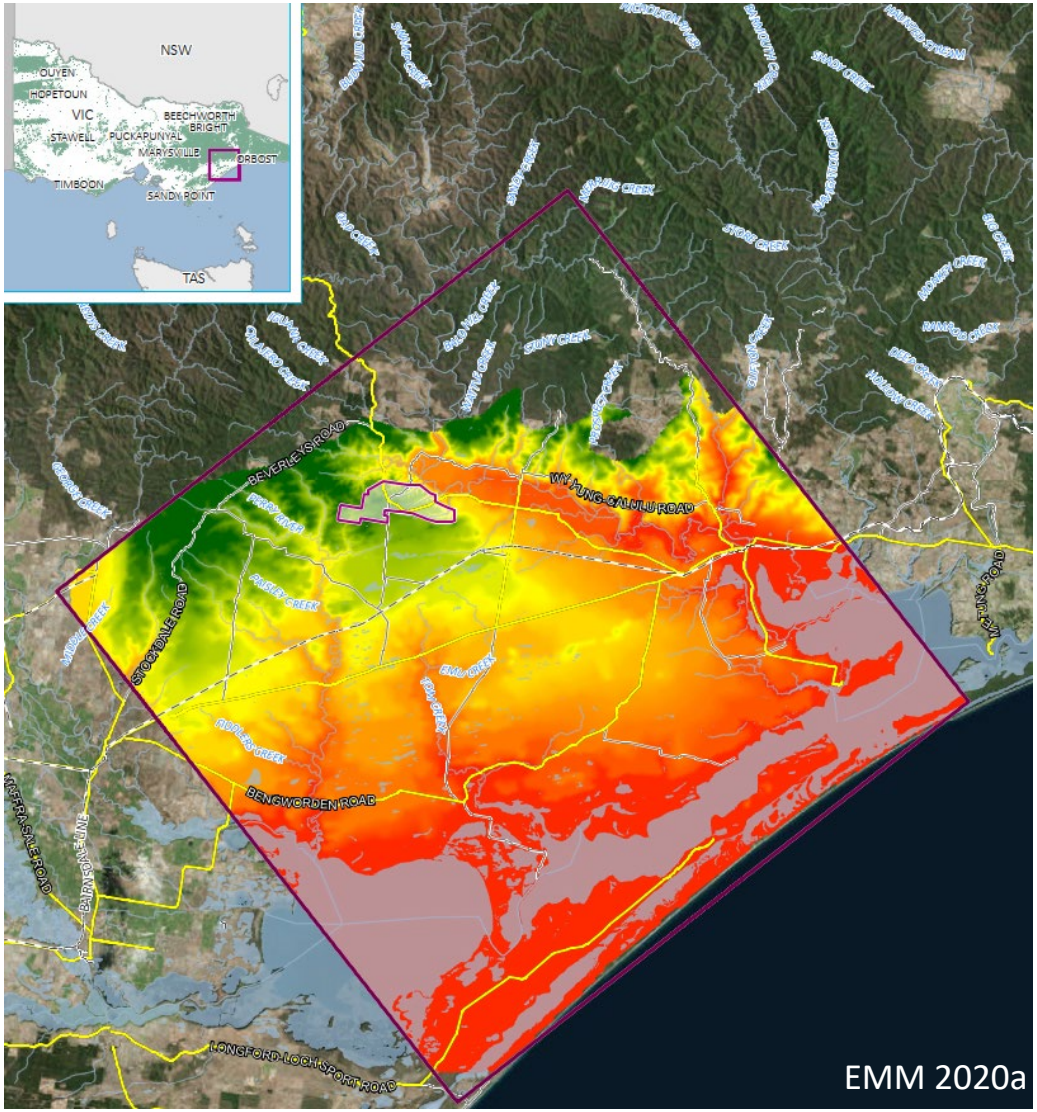
EMM
creating opportunities

EES role

- EMM was engaged by Kalbar to develop a numerical groundwater model to support the EES
- Main data sources:
  - Geology: VAF, geological block model, Lidar, transact drilling
  - Groundwater: state database, monitoring program, VAF
  - Pumping data: SRW and GHD ecoMarkets model (GHD, 2010)
  - GDEs: Scoping Requirements, BoM and EHP study
  - Aquifer properties: literature review, site base slug tests and laboratory test, pumping test (Latrobe Group)

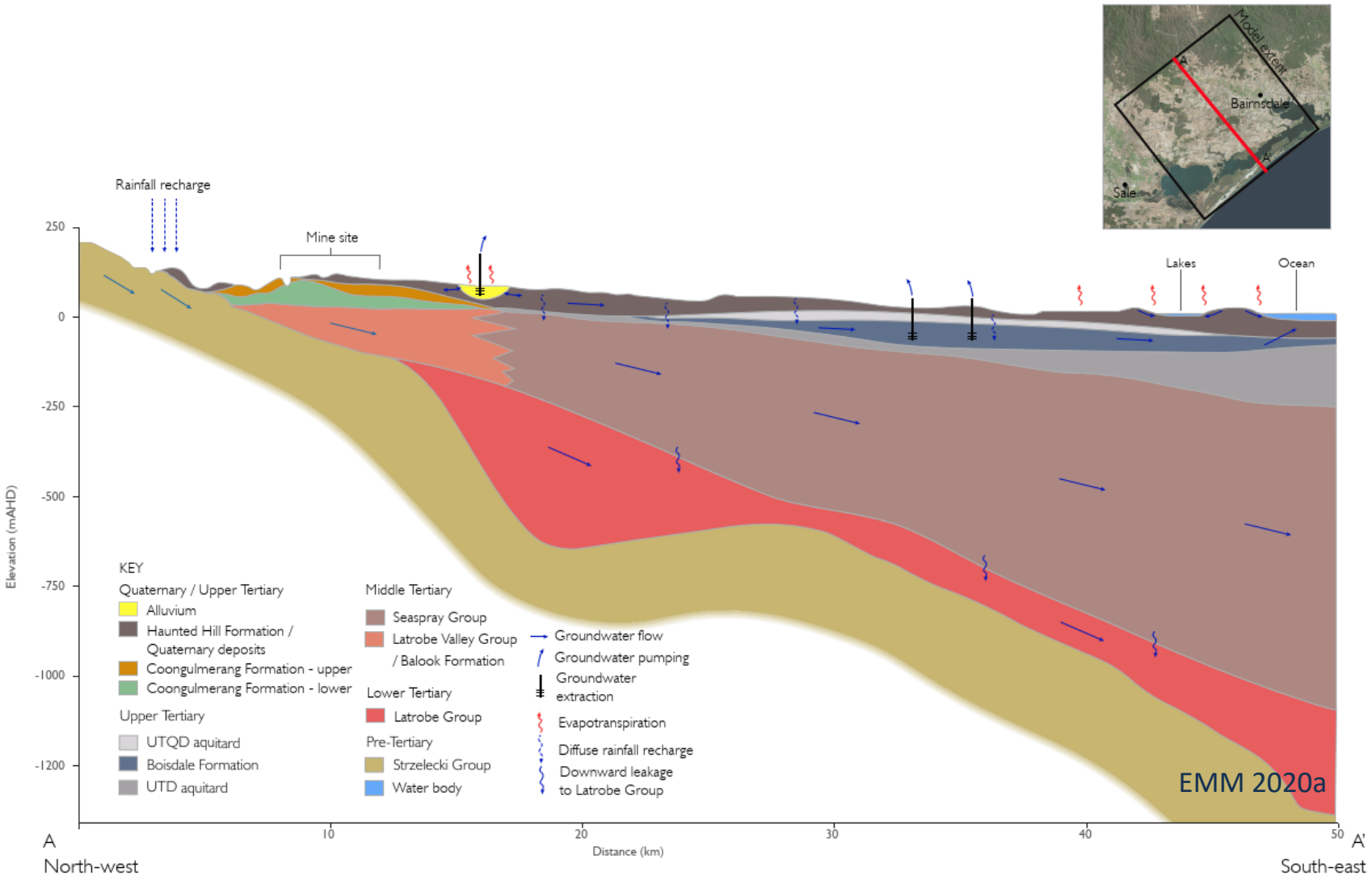
EMM
creating opportunities

Model domain

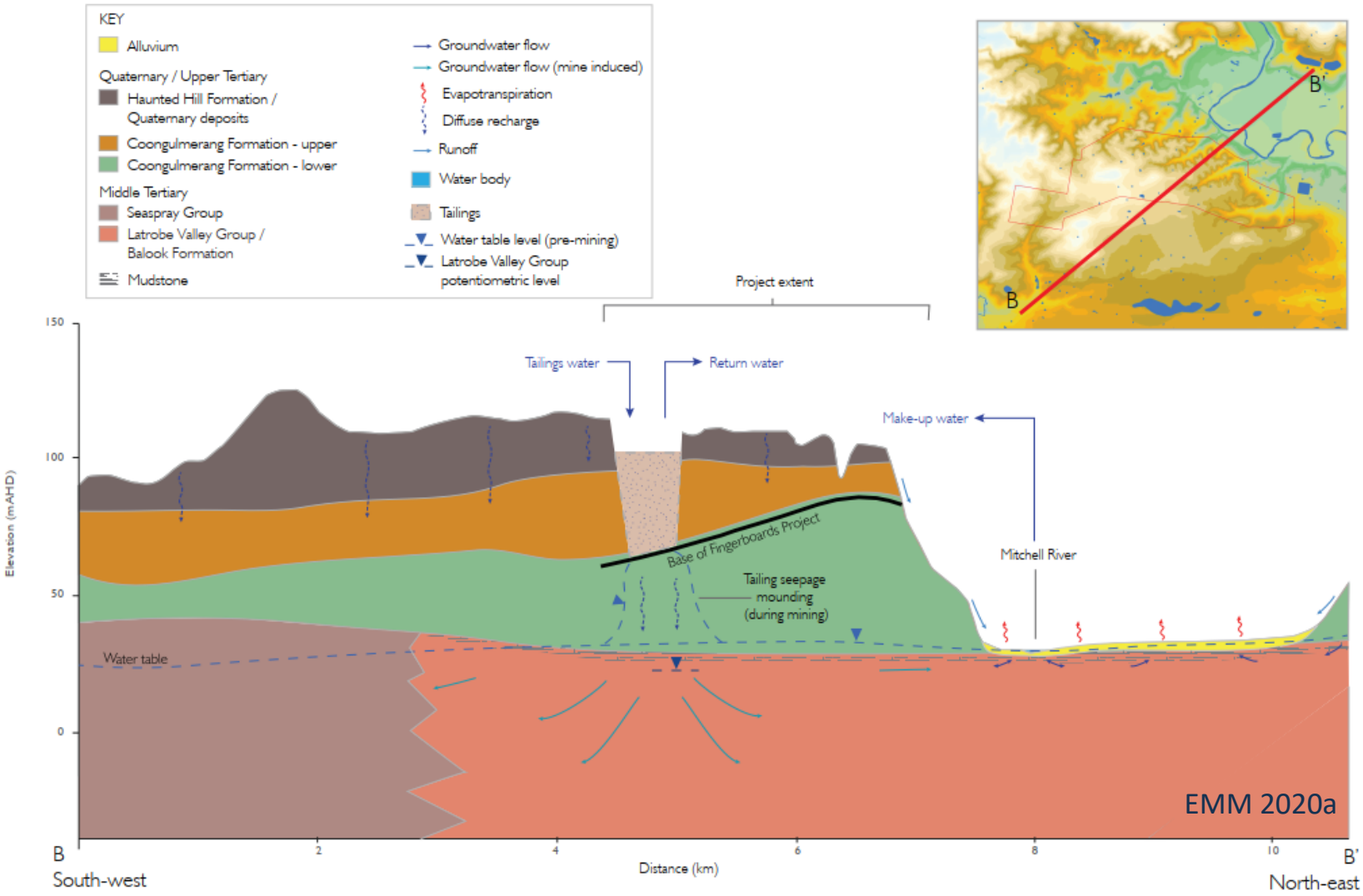


EMM
creating opportunities

Conceptual model (regional)



Conceptual model (local)



Groundwater receptors

- Mitchell river and alluvials
- Lower reaches of Moilun creek
- Vegetation associate with tributaries and gullies
- Providence ponds, chain of ponds
- Gippsland Lakes
- Woodglen ASR site
- Landowner bores
- Boisdale aquifer

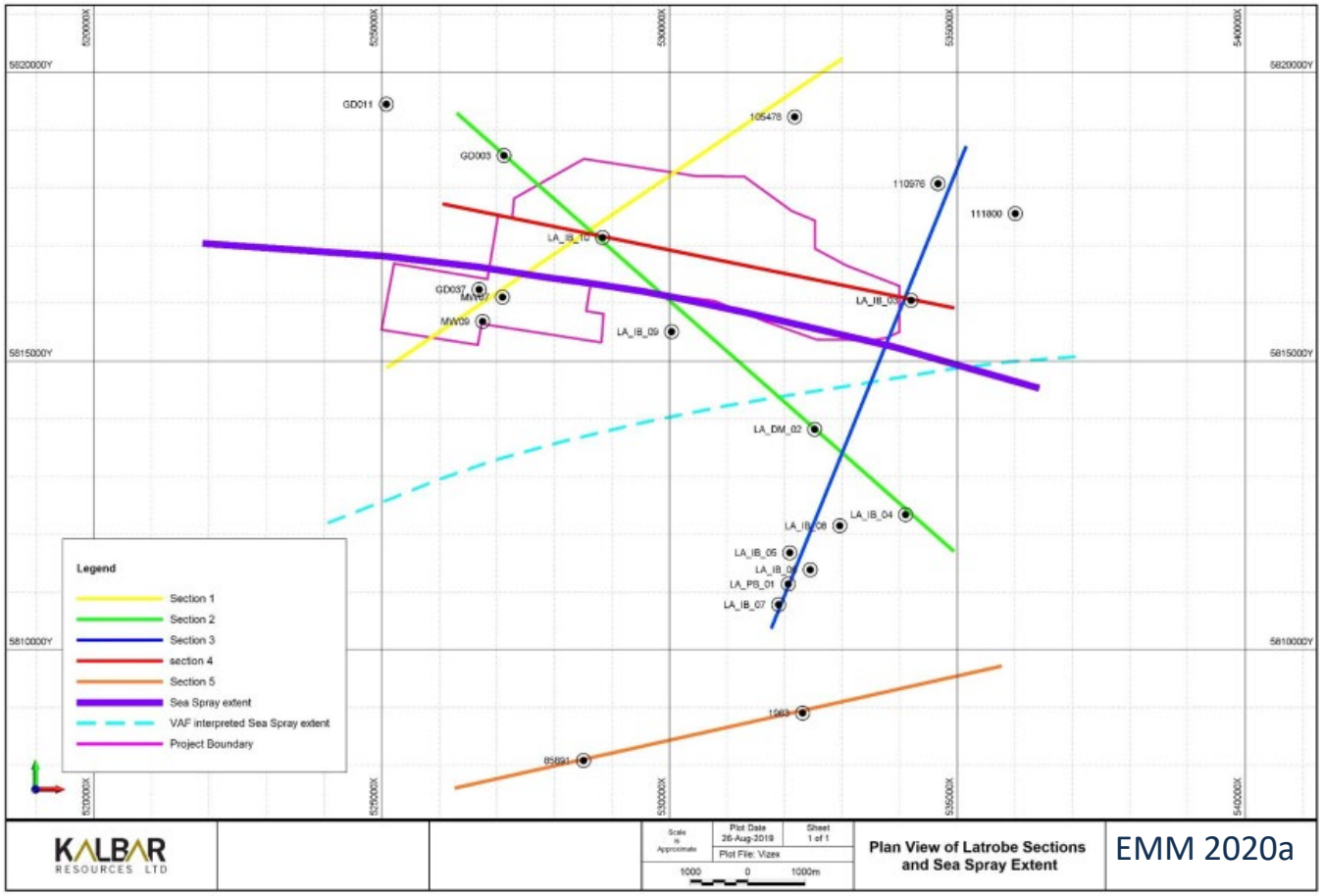
EMM
creating opportunities

Water effecting activities

- infiltration of tailings water from mined cells;
- infiltration of water from deposited tailings within the unlined mine voids and Perry Gully;
- permanent change to surface topography, altering groundwater flow directions;
- infiltration of water from engineered storage impoundments; and
- groundwater extraction from the Latrobe Group borefield for mine water supply.

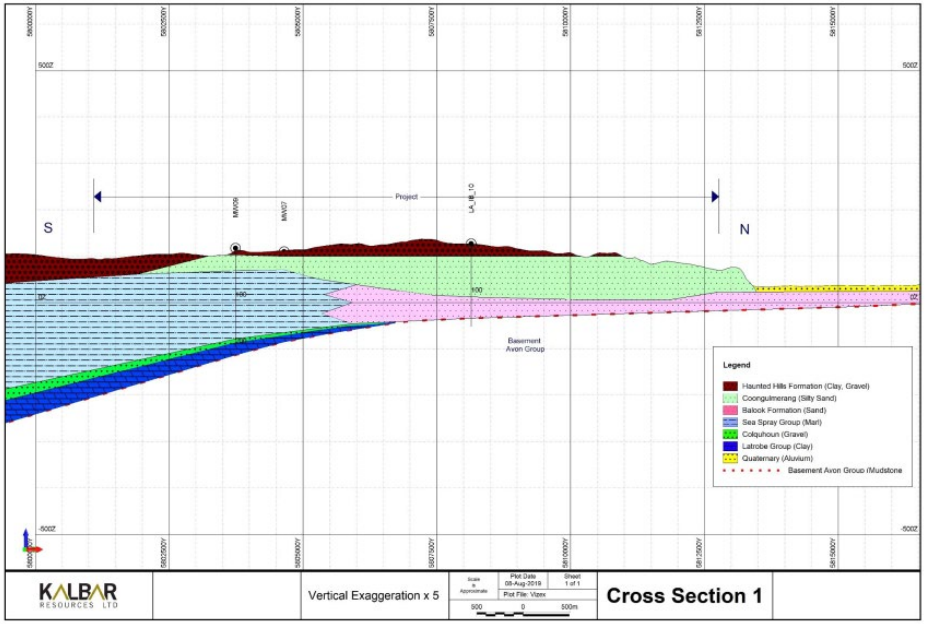
EMM
creating opportunities

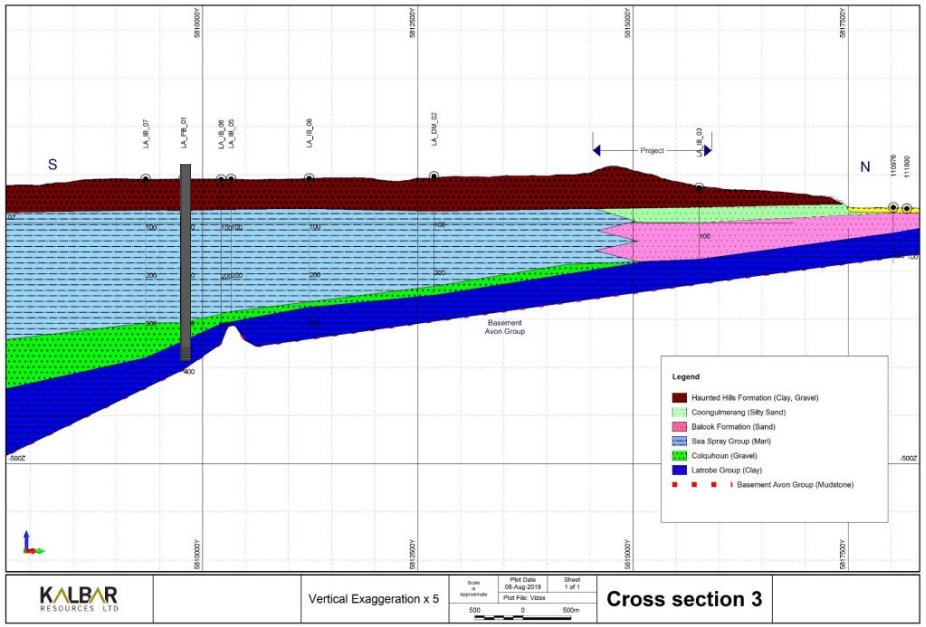
Drilling sections and pumping test (2018-2019)

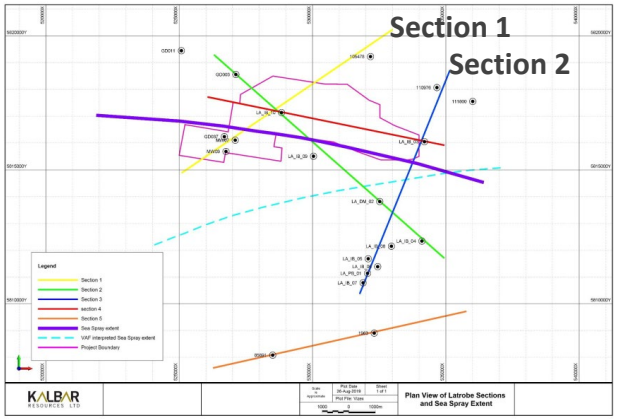


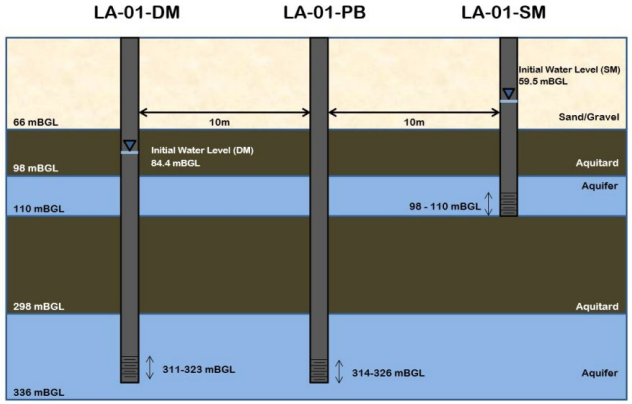
EMM
creating opportunities

Drilling sections and pumping test (2018-2019)









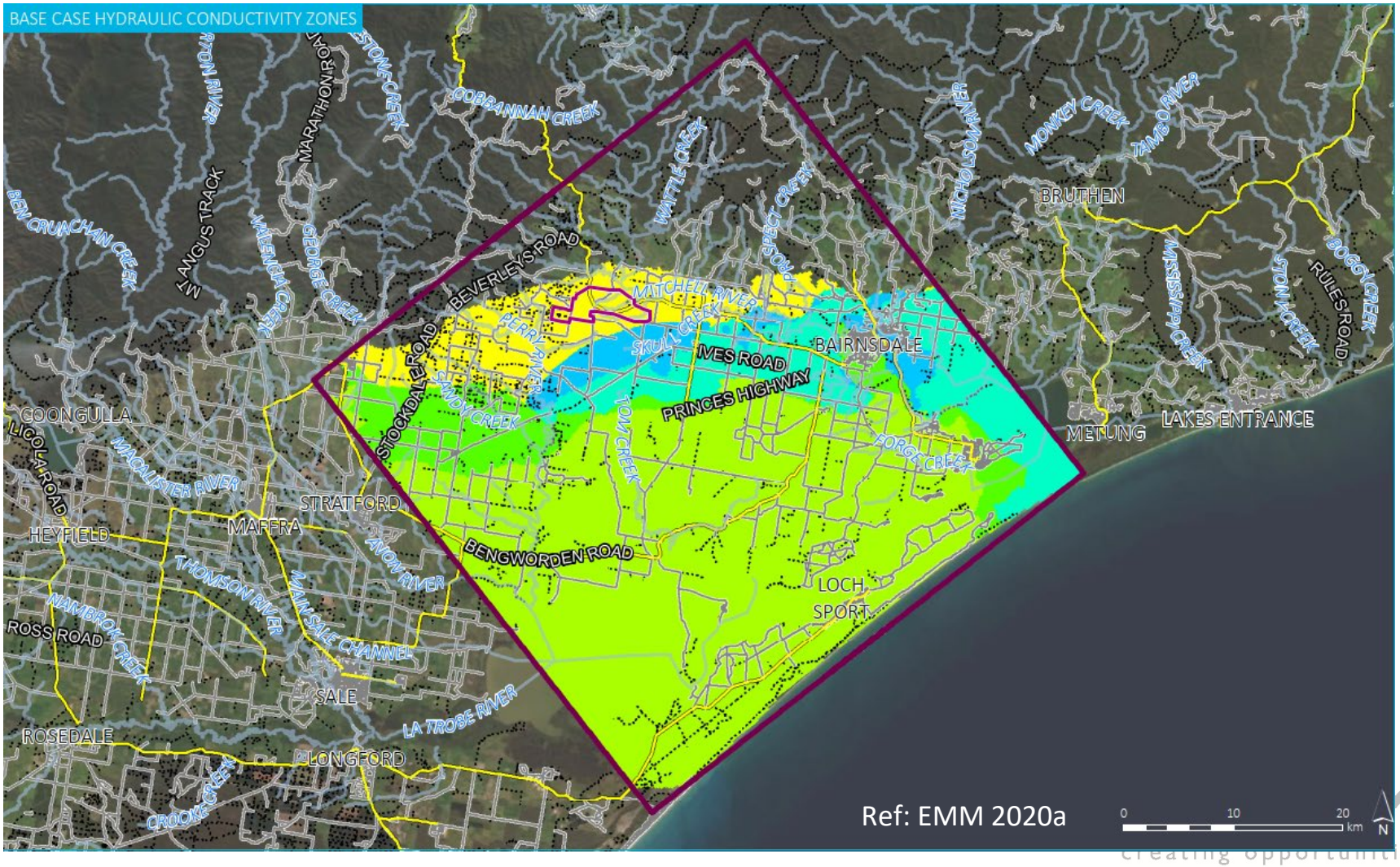
Ref: EMM 2020a

EMM
creating opportunities

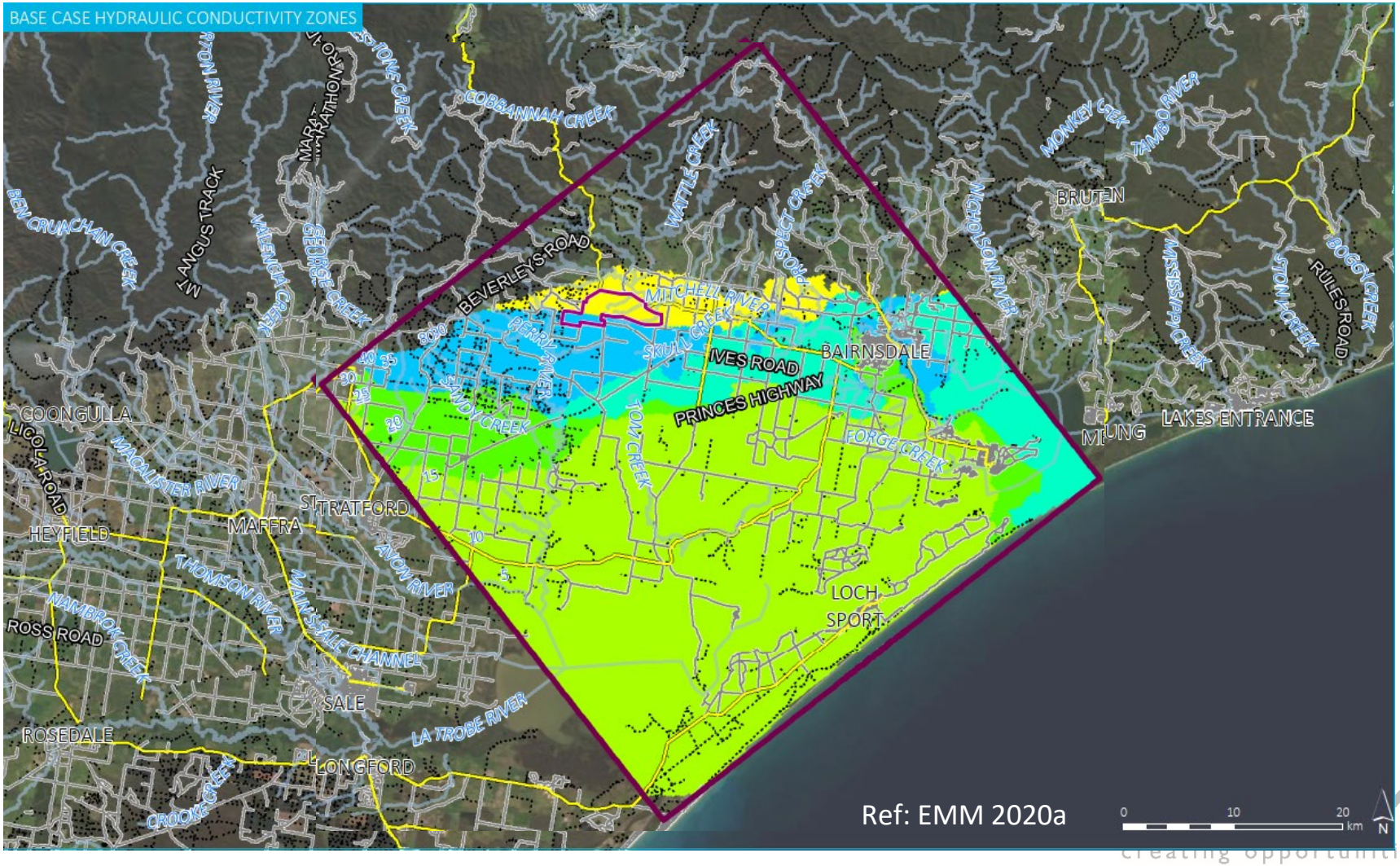
Model predictions: scenario definitions

- Scenario 1:
  - 3 year groundwater supply @ 3GL/yr from Latrobe Group (Gravels)
  - Seepage from tailings (53 L/s) for life of mine (15 yr)
- Scenario 2:
  - 15 year groundwater supply @ 3GL/yr from Latrobe Group (Gravels)
  - Seepage from tailings (53 L/s) for life of mine (15 yr)

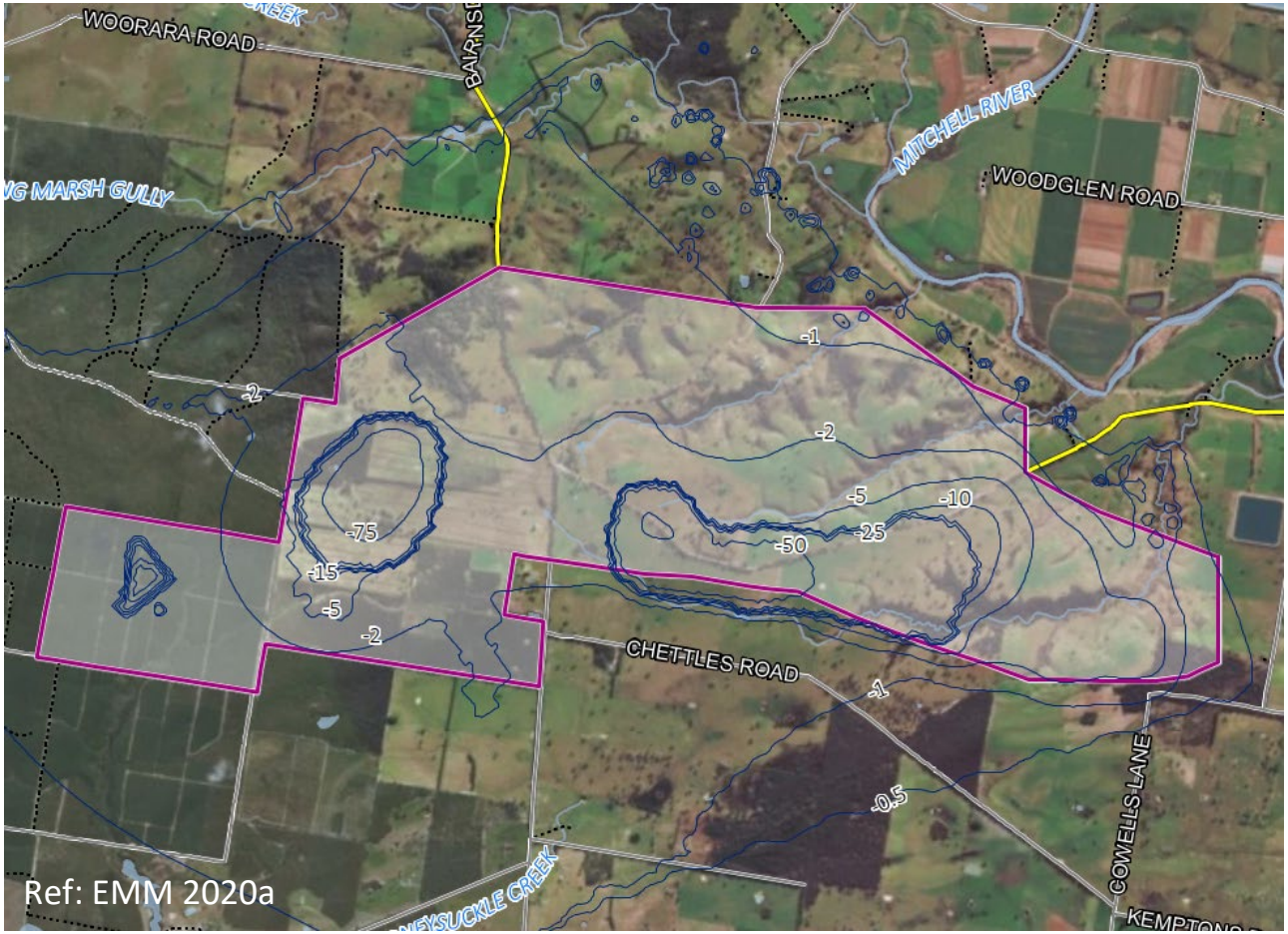
Basecase conceptualisation



Alternative conceptualisation



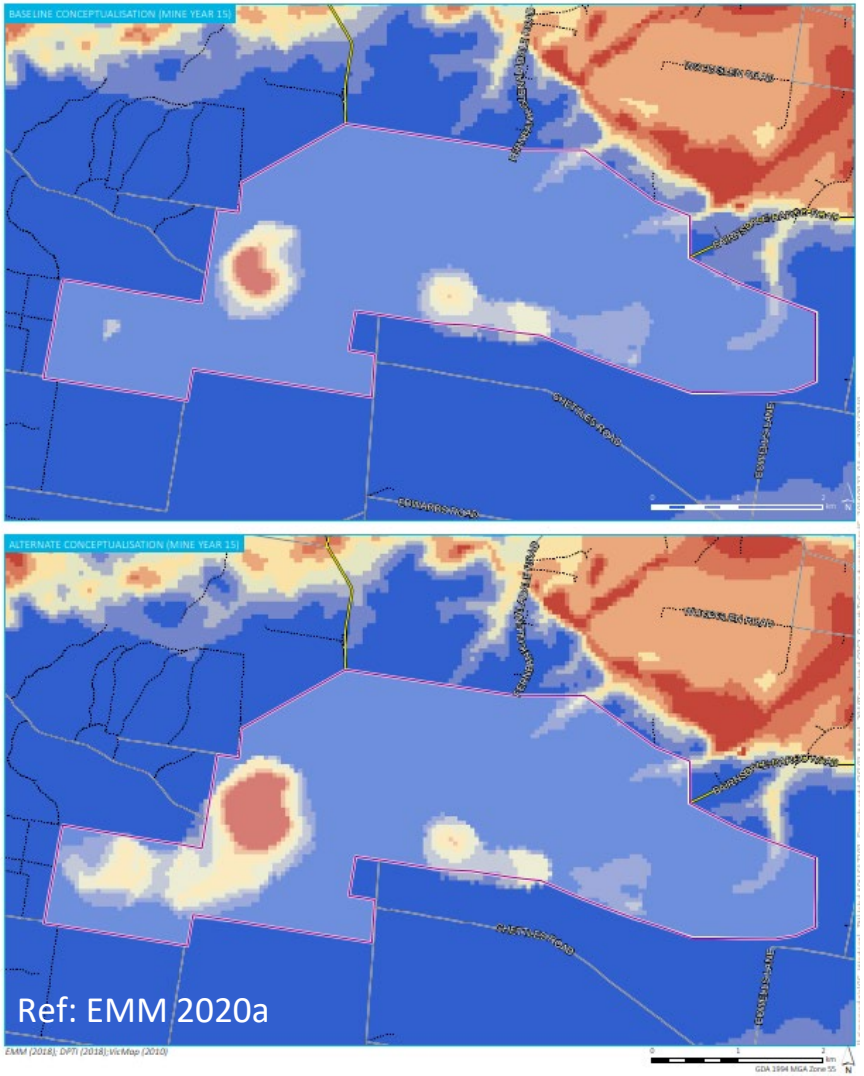
Model predictions: mounding (m) at 15 yr



Ref: EMM 2020a

creating opportunities

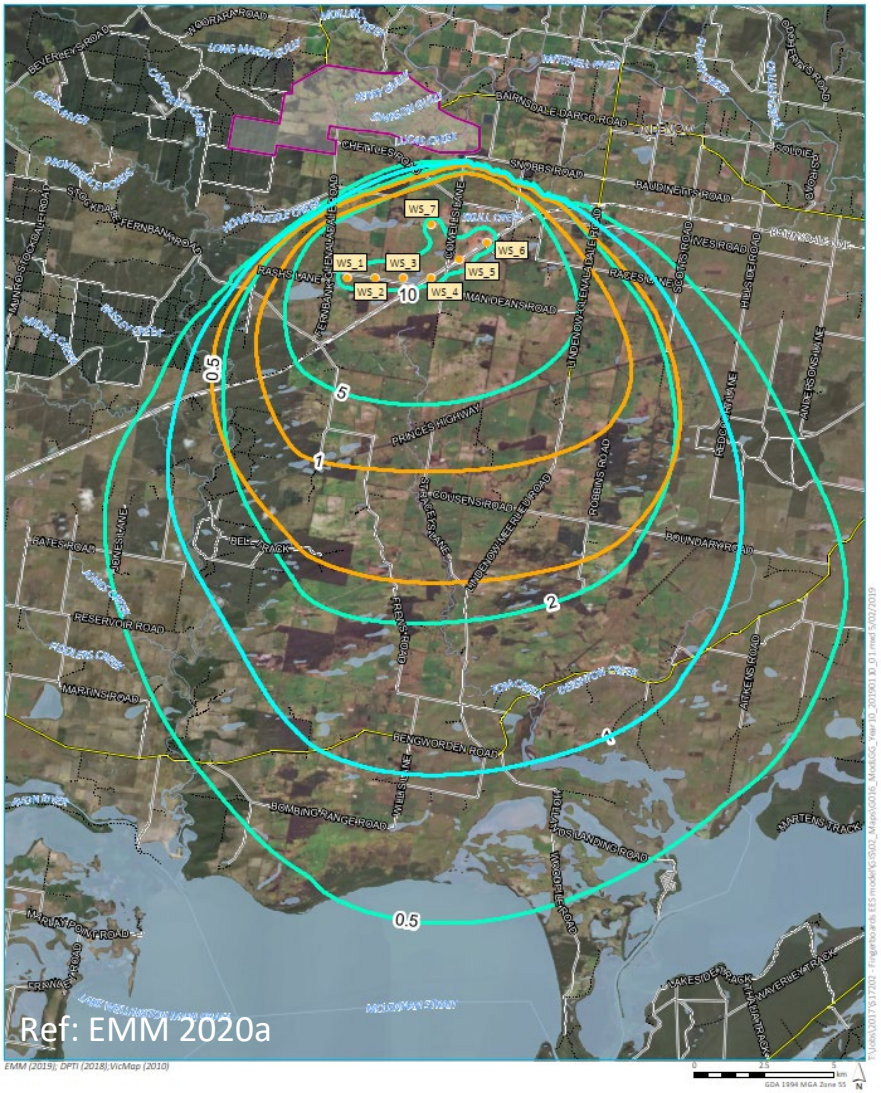
Model predictions: Depth to groundwater (m) at 15 yr



Ref: EMM 2020a

creating opportunities

Model predictions: borefield (deep confined aquifer) drawdown



Ref: EMM 2020a

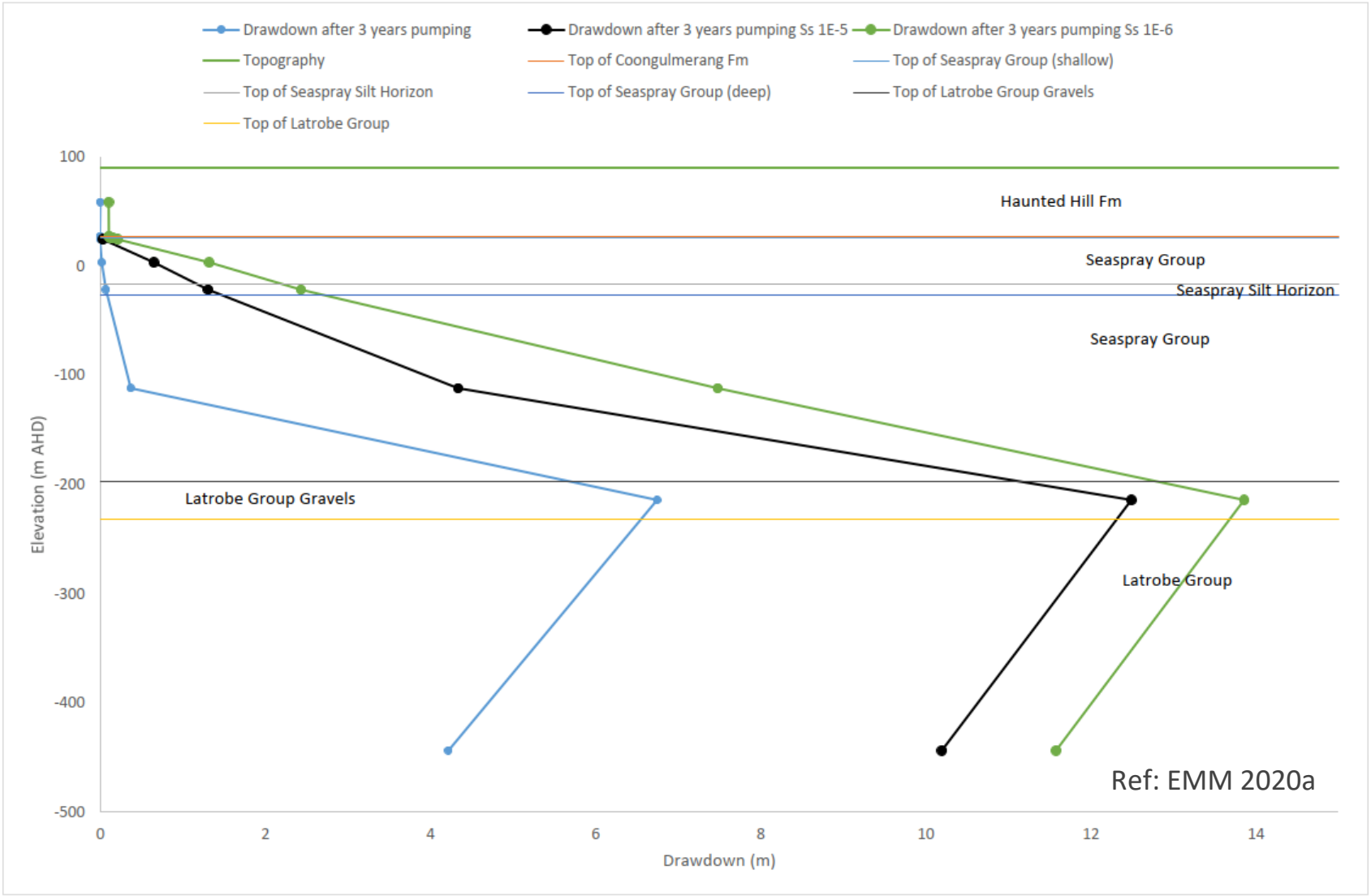
EMM
creating opportunities

Predictive uncertainty analysis

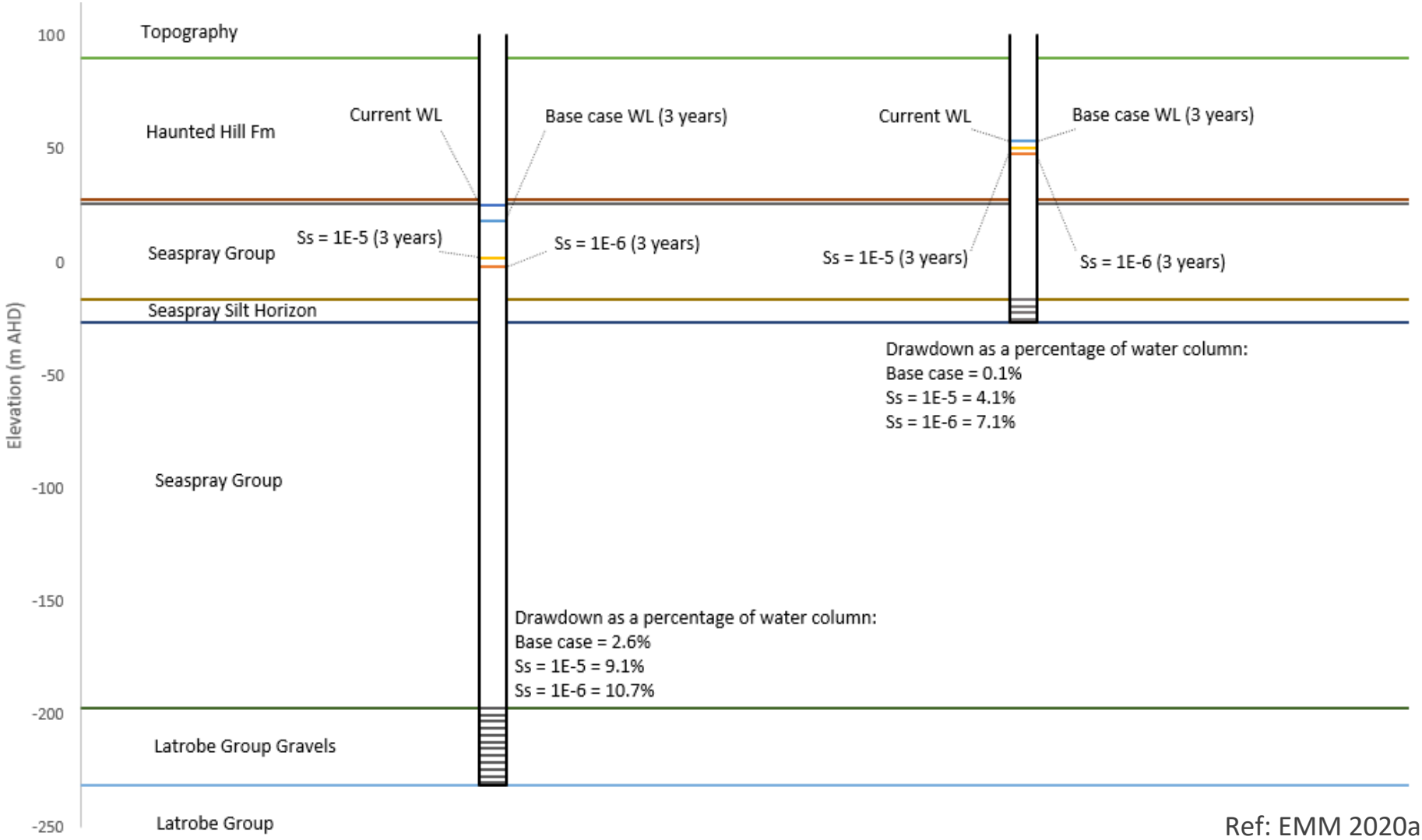
- 49 runs in total (all sensitivity analysis runs) plus 2x additional Ss runs and ET extinction run (1.5 m to 6 m)
- 'Worst case' scenarios defined as maximum area defined by 1 m contour (3yr for pumping, 15 yrs for seepage mounding)
- 'Best case' scenario defined as the smallest area covered by the 1 m contour (3yr for pumping, 15 yrs for seepage mounding)

EMM
creating opportunities

Model predictions: drawdown vs depth

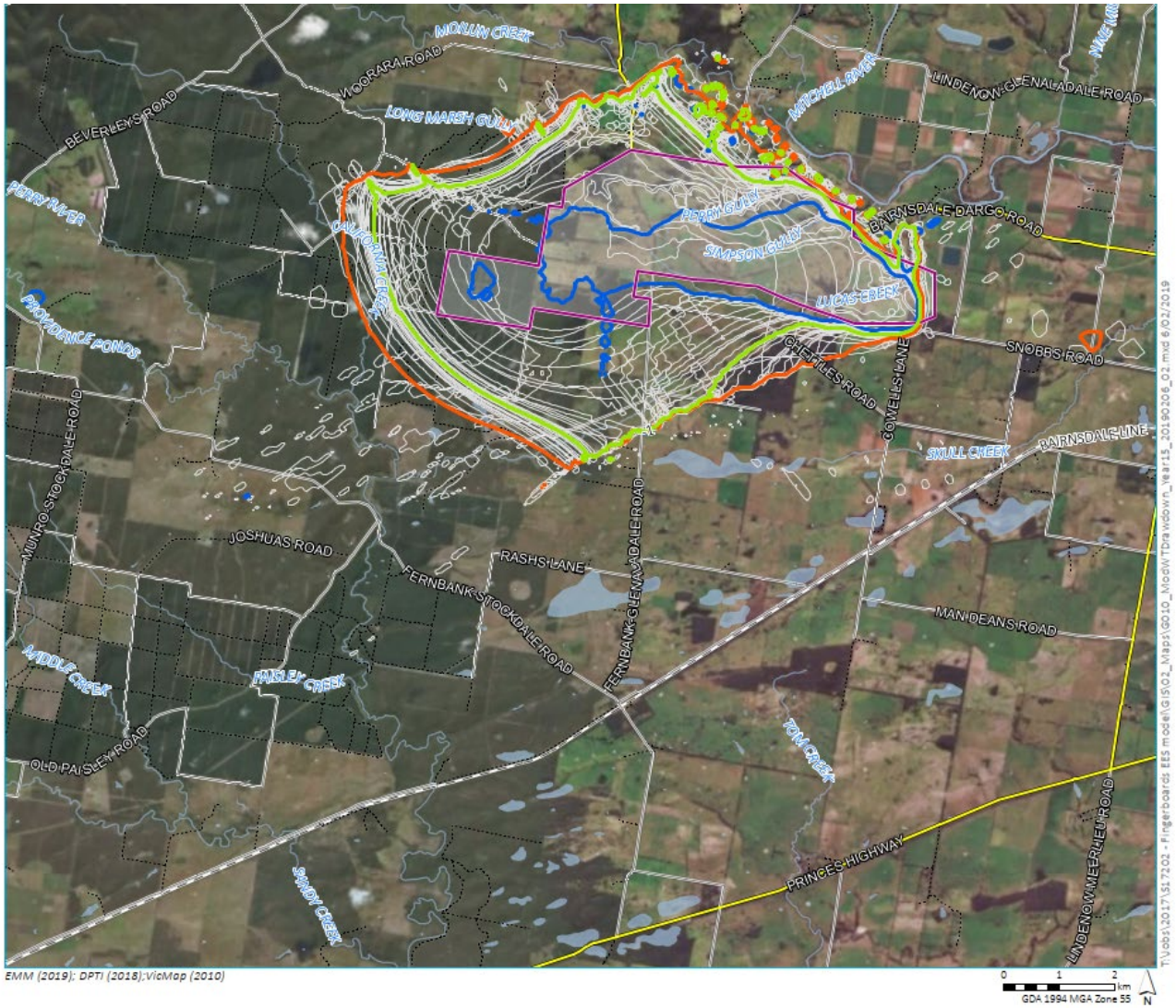


Model Predictions: max impact at borefield



Ref: EMM 2020a

Predictive uncertainty analysis: mounding

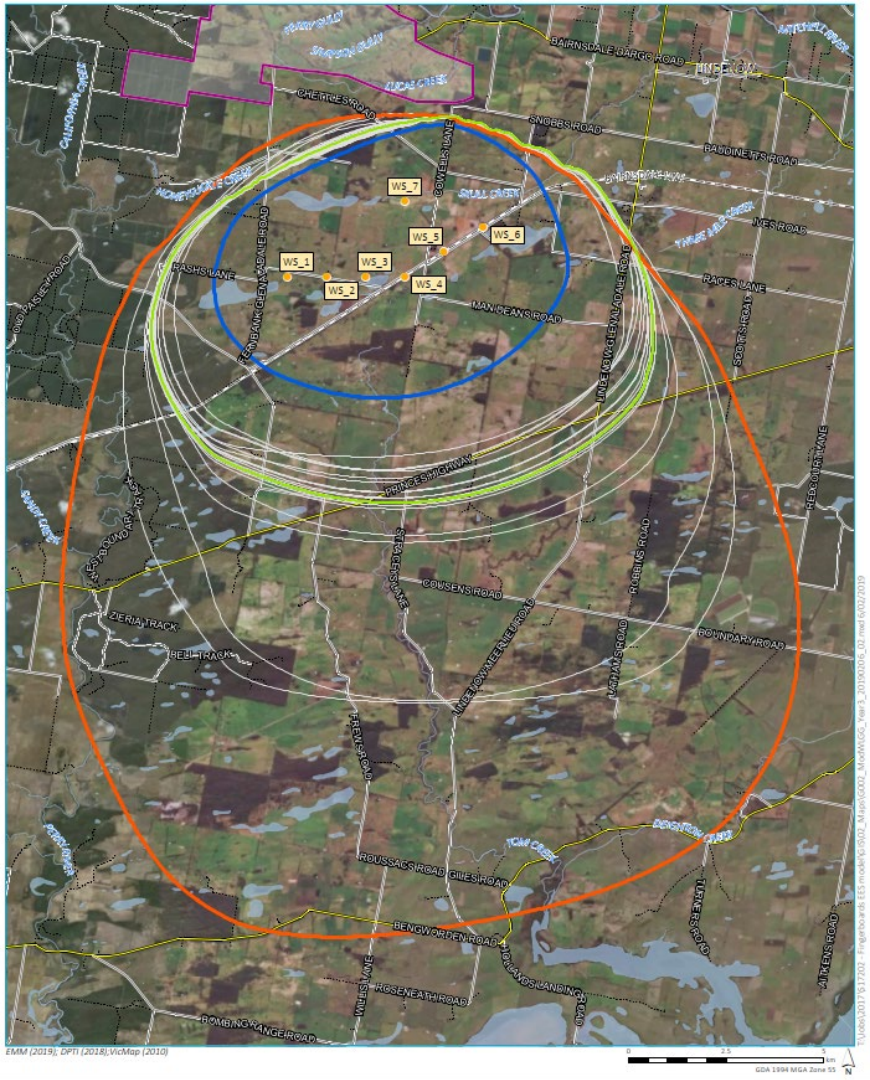


1 m mounding contour at 15 yrs

Ref: EMM 2020a

EMM
creating opportunities

Predictive uncertainty analysis: deep confined aquifer drawdown



1 m drawdown contour at 3 yrs

Ref: EMM 2020a

EMM
creating opportunities

GDE impact assessment

Water balance component	Basecase	Worst case	Best case	15 yr water supply
Mitchell River northern extent leakage	0.4	0.3	0.4	0.2
Mitchell River northern extent baseflow	0.8	0.7	0.8	0.5
Mitchell River 'extraction area' extent leakage	0.7	0.7	1.0	0.7
Mitchell River 'extraction area' extent baseflow	0.4	0.3	0.4	0.2
Mitchell River southern extent leakage	0.2	0.2	0.7	0.1
Mitchell River southern extent baseflow	0.3	0.4	0.9	0.3
Total Mitchell River leakage	0.2	0.2	0.2	0.1
Total Mitchell River baseflow	0.6	0.5	0.6	0.3
Perry River leakage	0.0	0.0	0.0	0.0
Perry River baseflow	1.0	1.3	4.7	1.0
Gippsland Lakes leakage	1.1	1.3	3.7	0.7
Gippsland Lakes baseflow	0.5	0.7	3.6	0.5
Providence Ponds inflow	1.1	1.6	1.4	1.4
Providence Ponds outflow	0.4	0.5	0.7	0.5
Boisdale aquifer inflow	0.3	0.4	0.2	0.3
Boisdale aquifer outflow	0.6	0.7	3.3	0.5
Mitchell River alluvial inflow	1.2	1.3	0.9	1.1
Mitchell River alluvial outflow	1.3	1.4	1.0	1.2

Notes: Water balance components showing a percentage change larger than one percentage between the 'No Mine' and 'Mine' case are highlighted in blue.

EMM
creating opportunities

Conclusions

- Localised mounding occurs due to low T of site aquifers
- 0.5 m mounding contour extends 4 km from mine (~60 m depth to watertable)
- Underlying LVG/Balook Fm dissipate mound
- Drawdown impacts largely constrained to Latrobe Group (gravels)
- 1.3 % change to flows (to and from) the Mitchell River alluvium and river. Insignificant impact to all other GDEs identified in Scoping Requirements
- Extraction from borefield has low impact on 3rd party users

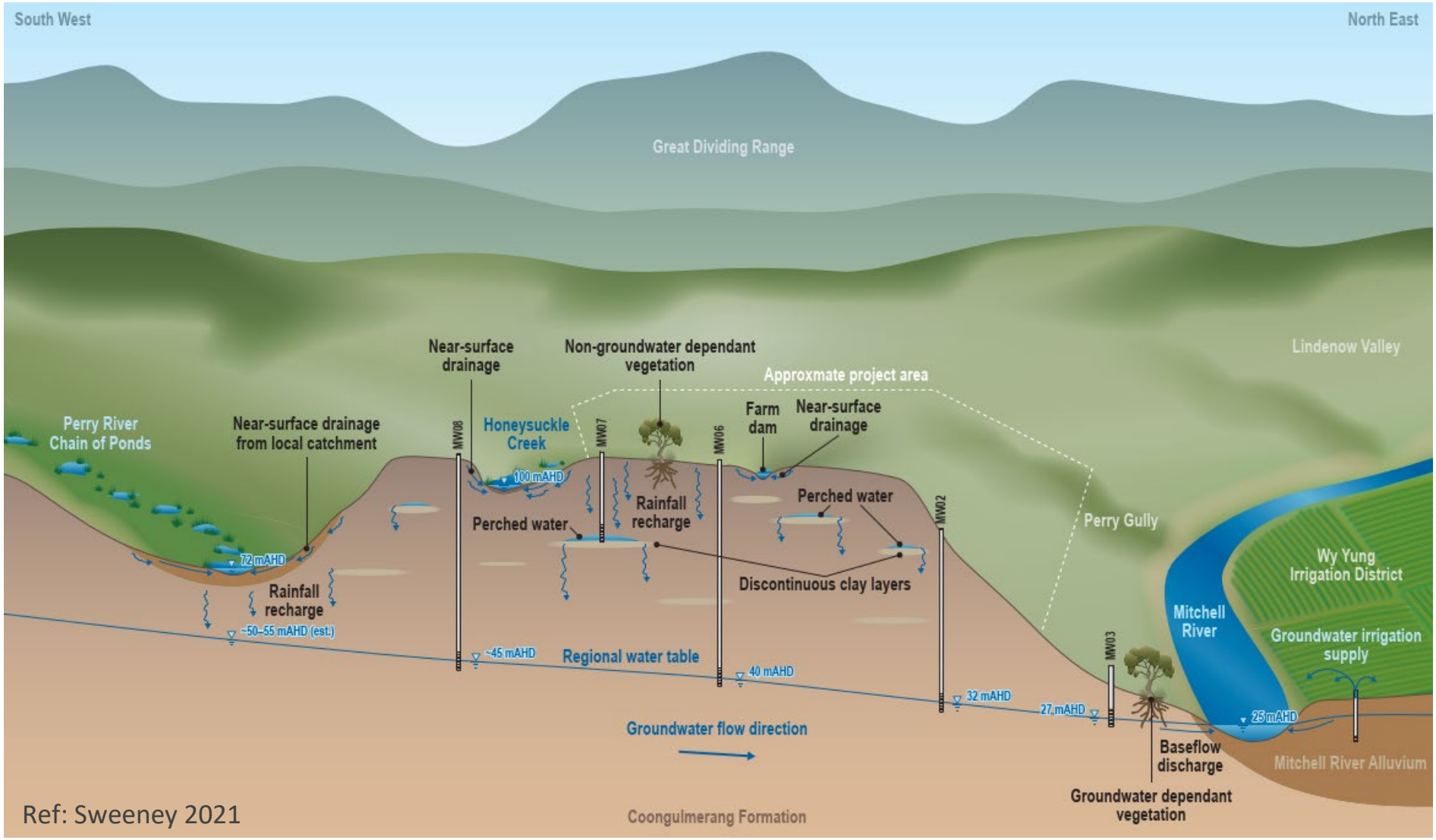
EMM
creating opportunities

Submissions- Conceptualisation

- Perched aquifers, exacerbated by tailing seepage
  - Clay layers sporadic, local phenomena
  - Can we managed operationally (site inspections, transect bores, in pit pumping, interception bores)
- Impacts to spring fed dams
  - Site inspection revealed these dams can have large surface catchments
  - Supported by “near surface drainage” and large soil water stores (within dunal sands)
  - Can be managed by water agreements, buffer zones etc

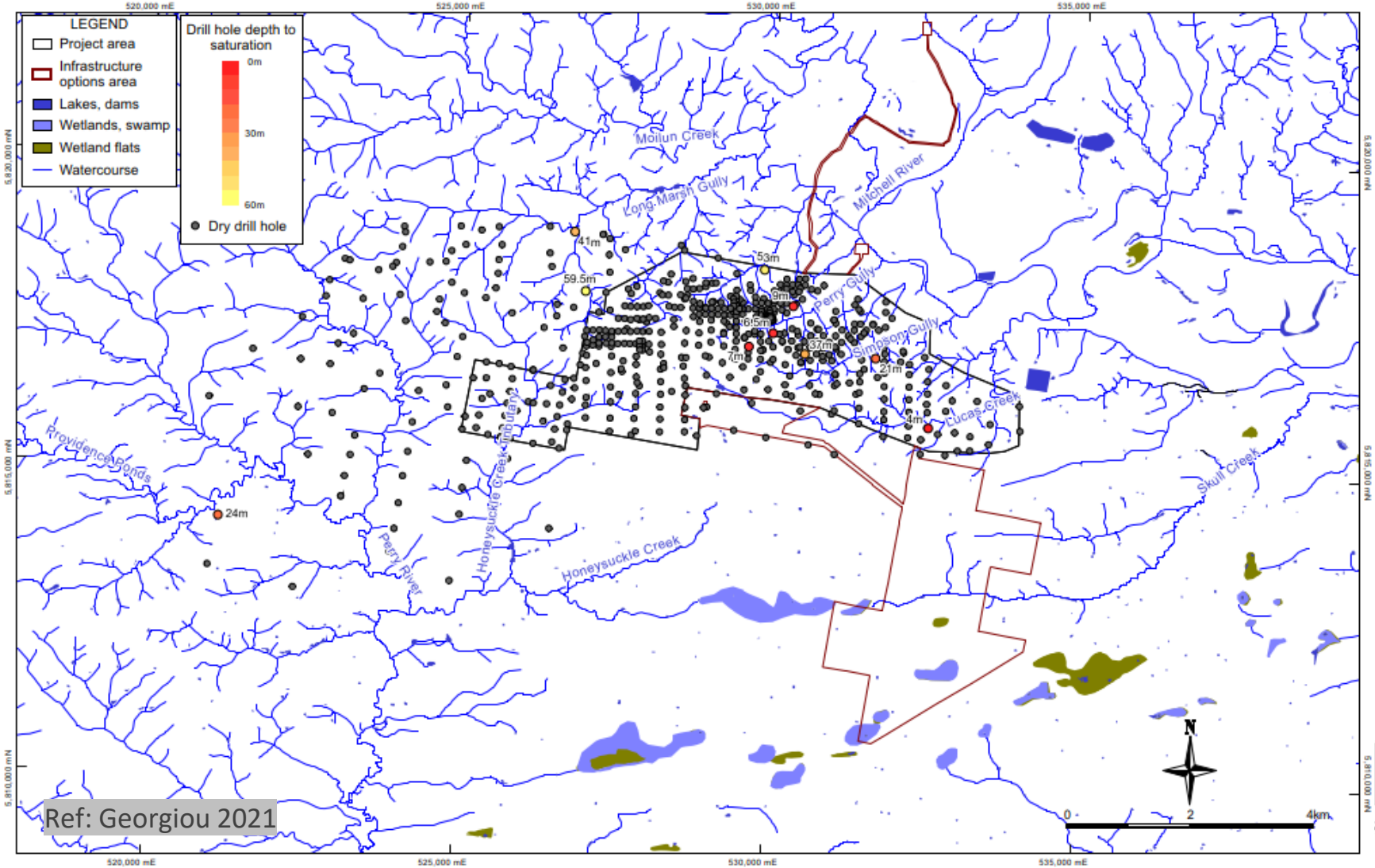
EMM
creating opportunities

Submissions- Conceptualisation



Ref: Sweeney 2021

Submissions- Conceptualisation

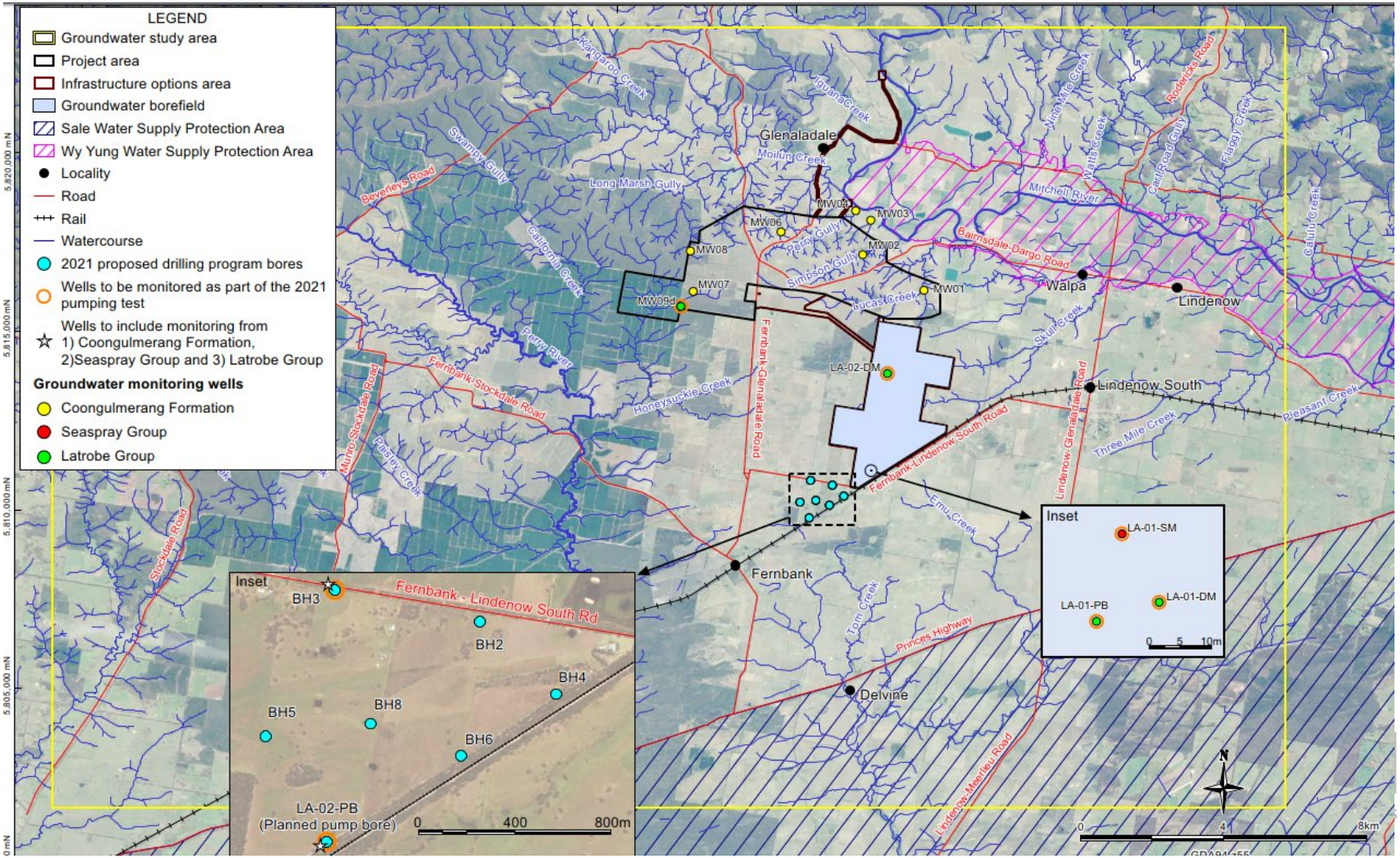


Ref: Georgiou 2021

Submissions- pumping test & aquifer props

- Current pumping test is inadequate and aquifer properties are questionable
  - 2018 pumping test used to obtain first site-based properties for the Latrobe Group. Consistent with literature review
  - It provides 'another' data point
  - Gravels do exist, with good quality water
  - Agree with boundary effects seen (not necessarily edge of aquifer)
  - Current work underway to better delineate gravels
  - Future pumping tests will aim to quantify sustainable rates
  - Improve bore design and longer pumping test period
  - SRW require a detailed model update as part of licence application

Submissions- pumping test & aquifer props



Submissions- GDEs

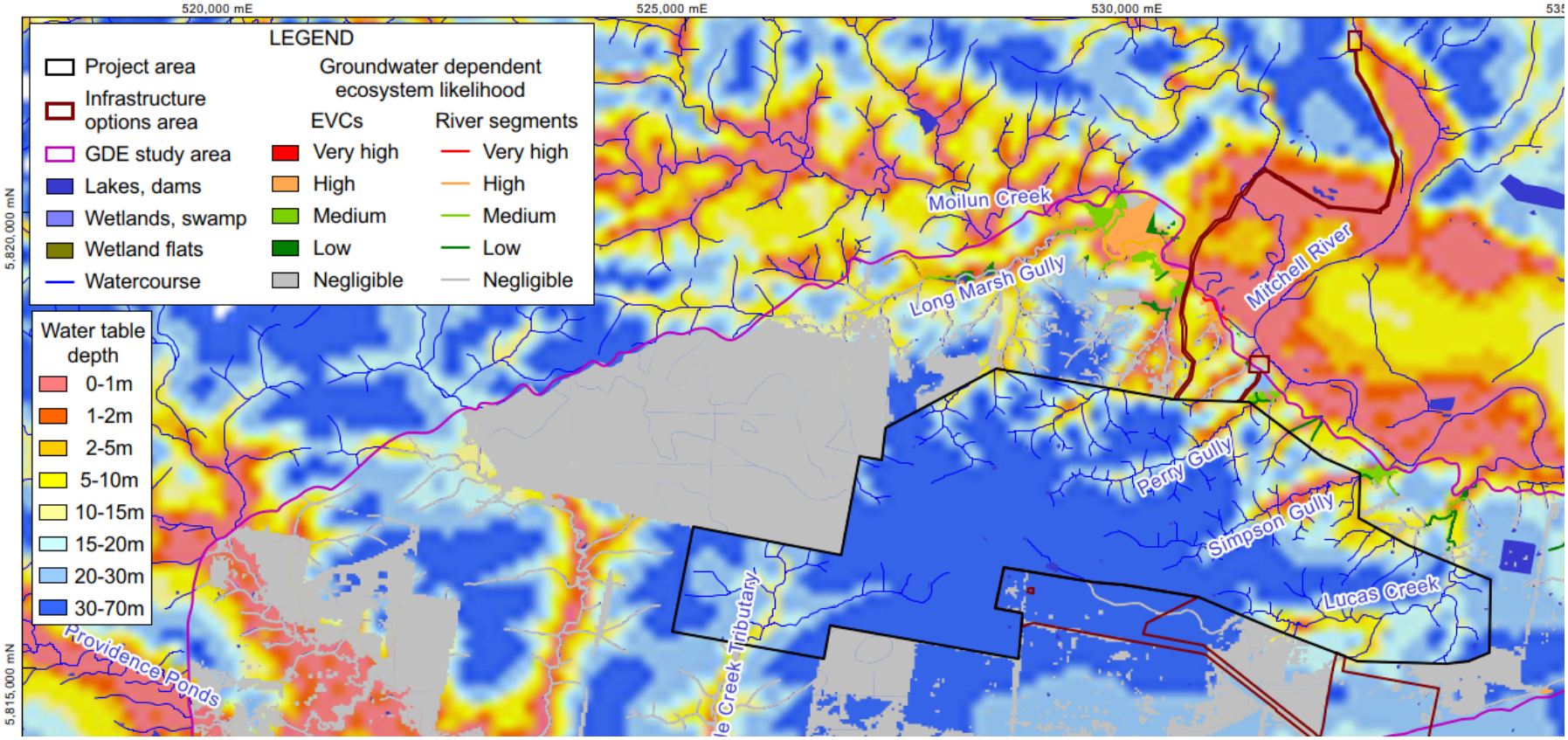
Main submission themes:

- a program is suggested to be undertaken to further assess and monitor the health of the GDEs
- a comprehensive review of all GDEs in the immediate vicinity of the project to identify which ones rely on shallow perched systems and/or the regional water table system
- greater understanding is required of the source water for Providence ponds.
- The level of certainty required to assess impacts to GDEs for the purpose of the EES was not agreed.[1]

1. Conclave disagreement

EMM
creating opportunities

Submissions- GDEs



Ref: Georgiou 2021

EMM
creating opportunities

Submissions- GDEs

Although timing not always aligned, Conclave generally agreed that:

- Regional water table is 10s meters below Providence Ponds and other chain of pond systems
- Monitoring bores to be installed at such locations, preferably nested sites
- Transect bores to be installed between mine site and receivers, inc Mitchell River
- Monitoring to commence as soon as practical to collect baseline data, improve conceptualisation and to inform management plans

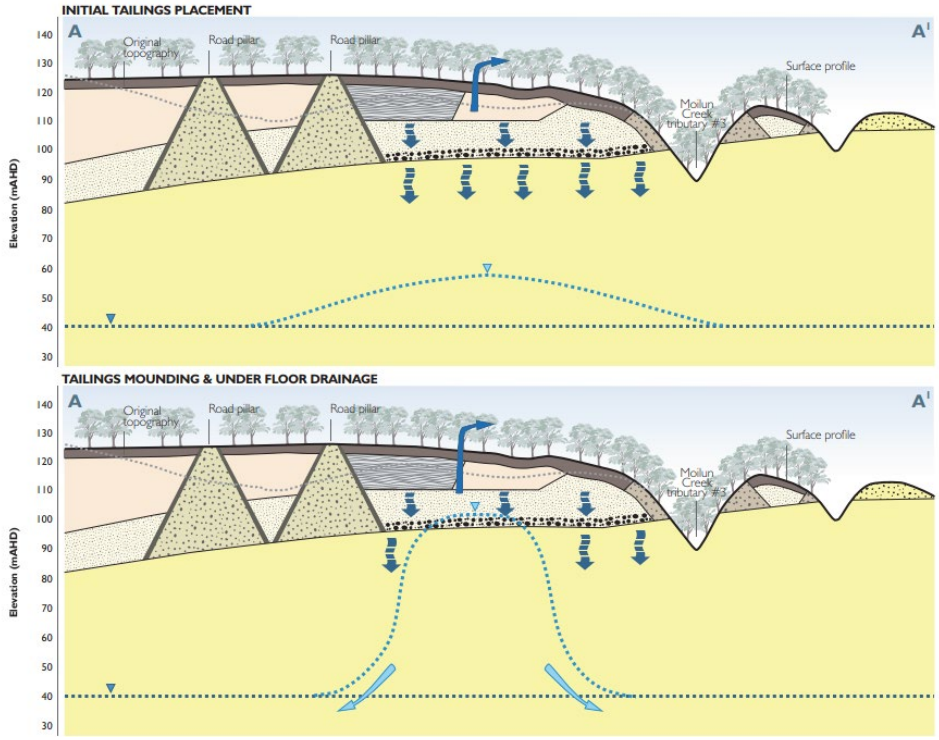
EMM
creating opportunities

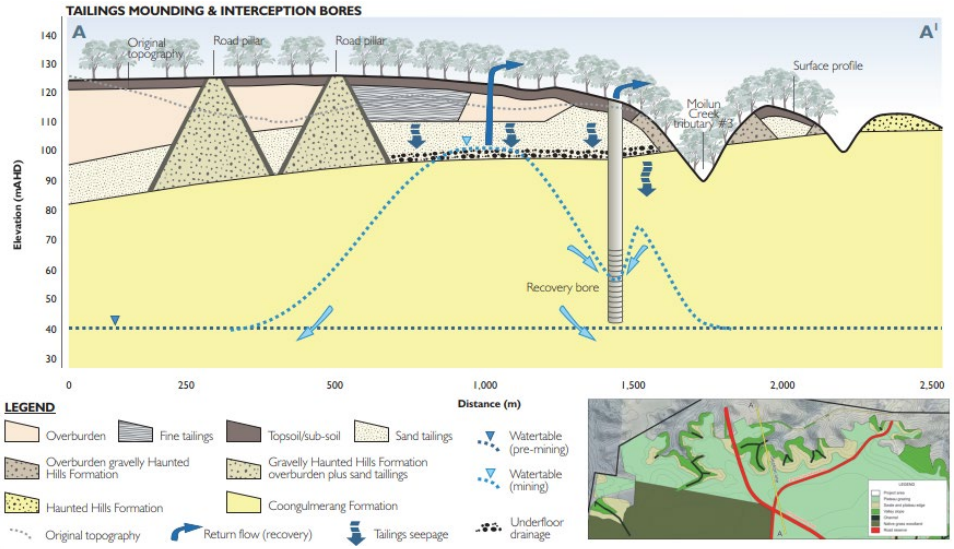
Submissions- Seepage volume

- Mounding simulated using conservative assumptions
- All water added to watertable instantaneously
- Volumes came from initial process flow diagram
- No lag-times (promotes quicker impacts)
- Consolidation of tailings will impede flow through the tailings floor over time
- Moisture contents will drop, and Sr will be >> gravity
- Seepage controlled by the ability of the Vadoze zone to transmit water downwards

EMM
creating opportunities

Submissions- Seepage mitigation





Ref: EMM 2020a

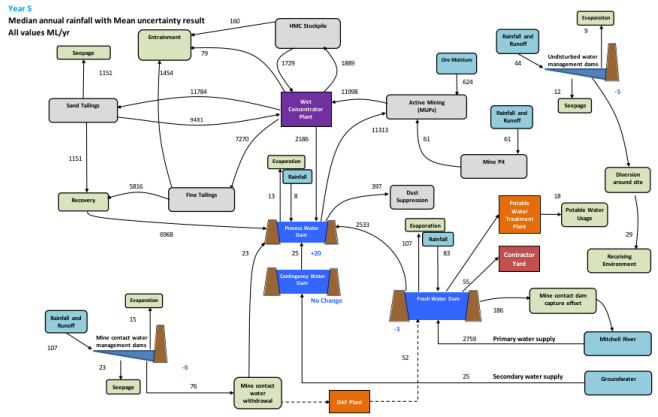
Mound mitigation supported by:

- Monitoring bores at GDEs / escarpments
- Early detection bores with trigger levels
- Daily inspections
- Management plans + actions
- Management is adaptive

EMM
creating opportunities

Post EES- additional work

1. Centrifuge studies
2. Updated site water balance



- EES scenarios included sand tails seepage at 1.71 GL/y, but centrifuge reduce seepage by 33% to 1.15 GL/y
- 90% of years, less than 0.5 GL from groundwater borefield
- 10% of years, maximum 2.0 GL from groundwater borefield
- EES impact assessment thus conservative

EMM
creating opportunities