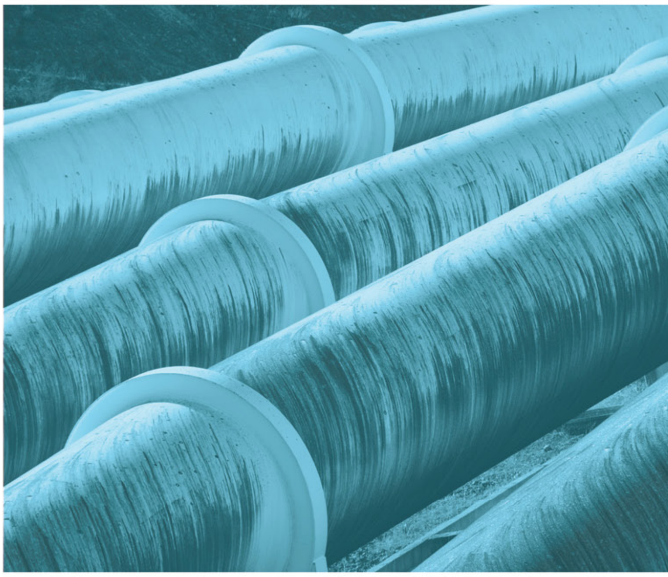



Expert Witness Statement of Jarrah Muller

In the matter of the Site Water Balance Calculations for the Fingerboards Mineral Sands Project EES

Prepared for Kalbar Operations Pty Ltd
February 2021

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Inquiry and Advisory Committee
Proponent: Kalbar Operations Pty Ltd

Kalbar Operations Pty Ltd
February 2021

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In the matter of the Site Water Balance Calculations for the Fingerboards Mineral Sands Project EES

Client

Kalbar Operations Pty Ltd

Date

2 February 2021

Final

Prepared by

J Muller

Jarrah Muller
Associate Civil Engineer
2 February 2021

1 Name and address

1.1 Personal details

My name is Jarrah Muller, and I am an Associate Civil Engineer in the discipline of surface water with EMM Consulting Pty Limited (EMM).

1.2 Business Address

My principal place of work is located at EMM's Adelaide office, being Level 4, 74 Pirie Street, Adelaide 5000.

2 Qualifications and experience

2.1 Area of expertise

I am a chartered professional civil engineer with 15 years' experience in the water industry. I am sufficiently qualified to make this expert statement because I have has successfully delivered numerous surface water, groundwater and hydraulic modelling projects for mining, energy, transport and infrastructure clients throughout Australia.

My Curriculum Vitae is provided in Appendix A.

2.2 Qualifications

- Bachelor of Engineering (Civil & Environmental) (1st Hons), University of Adelaide, 2005.
- Bachelor of Science (Environmental Biology), University of Adelaide, 2005.
- Chartered Professional Engineer (Civil), Engineers Australia, 2010.
- Registered Professional Engineer of Queensland (RPEQ).

3 Scope and method

3.1 Role in preparation of the EES

In 2018 EMM Consulting Pty Ltd (EMM) was commissioned by Kalbar to develop surface water management principles and a water balance model for the proposed Fingerboards mine site in response to the EES Scoping requirement "Prepare a water balance model to quantify / assess the functionality of the proposed water management system, over all stages of the project."

The EMM project team consisted of Sally Callander (Project Manager), Chris Kuczera (Project Director) and Jason O'Brien (modeller), whose qualifications are described in further detail below.

Descriptions of the project's anticipated approach to water management, water balance study direction, and report review comments were provided by Kalbar Resources employee Steve Thomas.

The "Final version 1.0" issue of EMM's report was delivered to Kalbar in January 2019.

In March 2019 the project management role of EMM's water balance modelling project was handed over to me.

I oversaw the delivery of the water balance model and report updates in response to Kalbar directions. Key updates that I oversaw were:

- the addition of the Dissolved Air Flotation (DAF) plant to the model; and
- consideration of Mitchell River historical flow sequences and the reliability of the proposed winter fill water supply.

After March 2019, model updates were completed by Jason O'Brien, report updates were completed by me, report review and approval to issue was provided by Chris Kuczera.

The final water balance report was exhibited as Appendix A to Appendix A006 of the EES (the water balance report).

For the purpose of this expert witness statement I have adopted the water balance report as the basis for my evidence, subject to the corrections and additional assessments presented in Part 4 of this statement.

3.2 Instructions for the IAC hearing

My letter of engagement for this expert witness statement from White & Case is provided in Annexure B.

During preparation of the EES, the Coffey, WaterTechnology and EMM experts collaborated in writing the respective reports. In preparing relevant witness statements, I and the other experts have conferred to confirm that each of the EES submissions that raised water issues were adequately reviewed and responded to. I was advised by White & Case that it was appropriate that experts conferred as outlined above.

3.3 Review process

During the development of this statement I reviewed the water balance report and the associated water balance model.

I also reviewed, but had no part in authoring, the following additional reports:

- Coffey (2020) Fingerboards Mineral Sands Project – Groundwater and surface water impact assessment, exhibited as Appendix A006 to the EES.
- WaterTechnology (2020) Fingerboards Mineral Sands Surface Water Assessment – Regional Study, exhibited as Appendix F to Appendix A006 to the EES.

3.4 Additional work undertaken since preparation of the report

Since preparation of the EES report, the following work has been undertaken (supplied as attachments in Annexure C):

- Water balance model results were analysed to develop an estimation of dilution ratios for water treated by the DAF plant which may be stored in the freshwater dam prior to release to the Mitchell River.
- The effects of considering evaporation uncertainty and seepage uncertainty were considered.
- Figure 5.1, Figure 5.2 and Figure 5.3 from the Conceptual Surface Water Management Strategy and Water Balance report were revised as the published versions erroneously omitted some sections of fine tails and soil emplacements.

3.5 Other persons who assisted

Persons who have assisted in the preparation of the EES water balance report included:

- Sally Callander, Project Manager Jan 2018 – March 2019

  Bachelor of Engineering (Environmental) (Hons 1), University of Newcastle, 2008

  As project manager, Sally oversaw the surface water management conceptualisation and delivery of the water balance model. Sally attended and presented at TRG meetings, and responded to TRG feedback through the development of the model and report.

- Chris Kuczera, Project Director

  Bachelor of Engineering (Hons 1), University of Newcastle

  As project director, Chris reviewed the water balance model and report prior to delivery. Chris attended and presented the water balance at TRG meetings.

- Jason O’Brien, Modeller

  Bachelor of Engineering (Environmental) (Hons 1), University of Newcastle, 2015

  Jason developed the water balance model using information provided by Kalbar and reported water balance results.

- Nick Simos, GIS Analyst

  Bachelor in Applied Geographical Information Systems, Flinders University, 2017

  Nick prepared the spatial figures presented in the water balance report using data provided by Kalbar.

Persons who have assisted myself in the preparation of my expert witness statement include:

- Paul Gibbons - Director at EMM's Adelaide office. Paul provided peer review of this statement.

4 Findings

4.1 Scope of the water balance

The report describes the water balance model developed for the proposed Fingerboards mine site in response to the EES Scoping requirement "Prepare a water balance model to quantify / assess the functionality of the proposed water management system, over all stages of the project."

The model includes representations of the following processes:

- Water take from the Mitchell River and groundwater sources, considering river flow thresholds and expected licence limits.
- Rainfall runoff from the mine site, storage of this water in basins, use on site, and volumetric accounting of this harvested runoff within the licensing framework.
- Rainfall runoff from unaffected catchments upstream of and within the site and diversion to the natural environment.
- Process plant water use and water recycling.
- Recovery of water from tails.
- Loss of water to evaporation, entrainment in product and tails, and seepage to groundwater.

The stages of the project considered in the model include:

- current, or pre-mining effects;
- the proposed year 5 mining layout;
- the proposed year 8 mining layout;
- the proposed year 15 mining layout; and
- final landscape after rehabilitation.

Each model was developed to assess environmental processes focusses on answering specific questions. A particular model may be appropriate at answering some questions but not others due to differences in physical or temporal scales or the range of accuracy or certainty required to make a decision.

The following aspects of water management were investigated by the conceptual water balance model:

- Water volumes required for the project.
- The effectiveness of proposed water management dams in preventing discharge of mine contact water to the environment.
- The effectiveness of proposed water storage dams for holding sufficient water to allow operation though varying climate conditions.
- Investigation of climate change effects on water requirements.
- Investigation of site layout changes through the mine life on water management.

The model also allowed testing of concepts such as the proposed DAF plant to confirm whether the anticipated effects on water management might be realised.

4.2 Items not included in the water balance scope

The following related aspects of water management are not addressed in the water balance report, and will be or were addressed in other material:

- Engineering design of water management infrastructure, including dam walls, diversion channels, stormwater infrastructure, and discharge points.
- Water quality.
- Ecological impacts of changes to water quality of flow regimes.
- Details of sub-daily processes such water truck movements or flooding.
- Detailed changes in water use by plants and catchment runoff through various stages of rehabilitation.
- Water licensing.
- Water management plans.
- Erosion and sediment control.

4.3 Water management concept

The proposed site water management concept is displayed in Figure 4.1. This figure shows:

- water enters the site from the Mitchell River and groundwater (bottom right of figure) and is stored in dams (centre of figure);

- water is used by the Plant (centre top of figure), goes to tails and is returned/recovered (cyclic arrows in top left of figure);
- water is lost to entrainment from tails (top left of figure) (the process of seepage to groundwater is also included in this part of the model);
- rainfall runoff from undisturbed parts of the site is released to the environment without interacting with the mine site process water system (top right of figure);
- rainfall runoff from disturbed parts of the site (bottom left of figure) are taken to the process water dam or DAF plant, and offset by water released to the environment from the fresh water dam (bottom right of figure);
- evaporation and rainfall effects are included in the model; and
- water for dust suppression, potable use and contractor yard will be supplied from the fresh water dam (right side of figure).

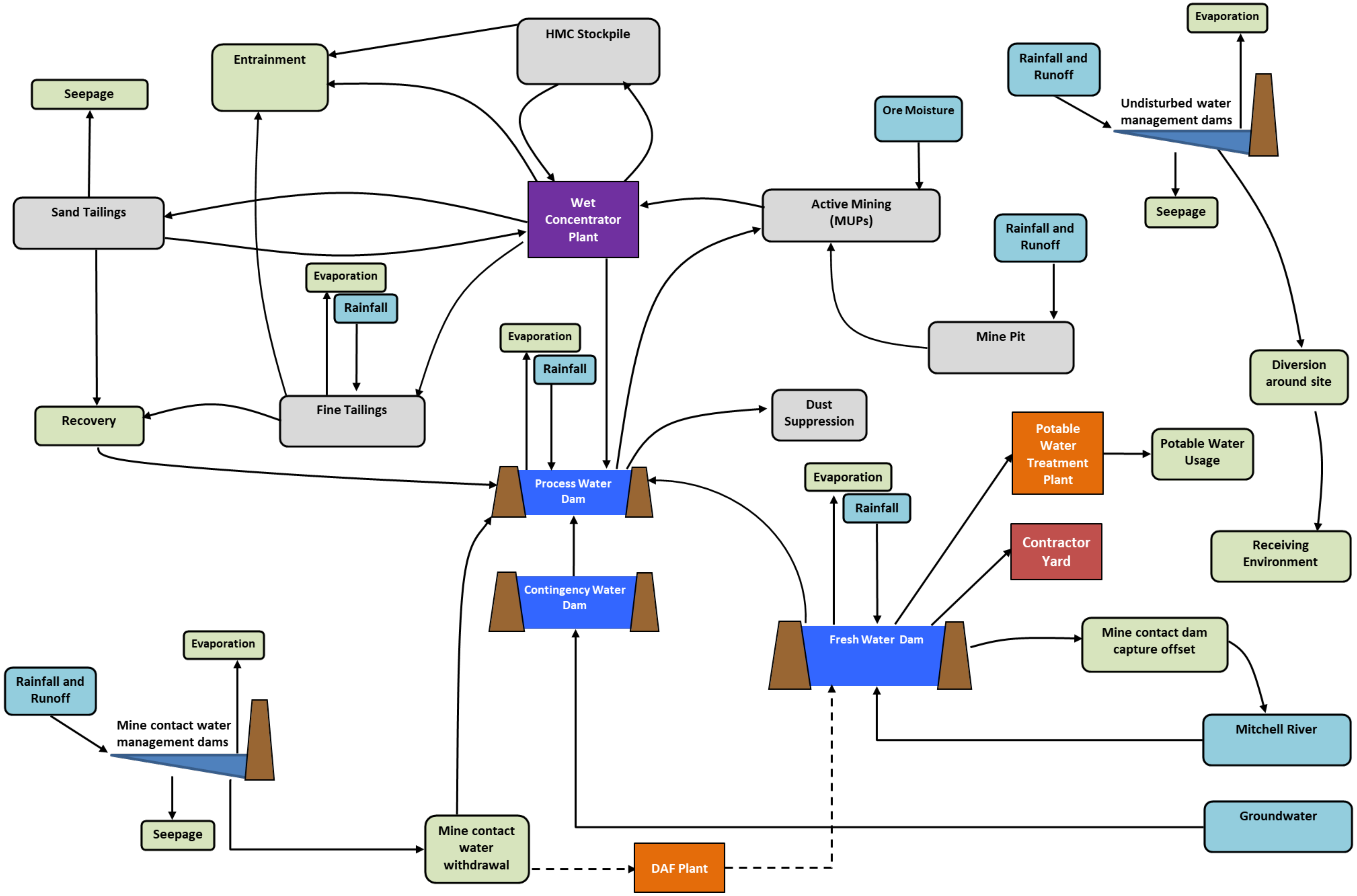

Figure 4.1 Water management system

4.4 Water volumes required by the site and reliability of supply

The water balance model showed that the water volumes required to be imported by the site vary with climate, as water lost to evaporation and water gained through rainfall on the pit void may vary year to year.

By testing the mine water balance with the historical climate sequence, the model showed that:

- The peak water requirement is likely to be around 4.7 Gigalitres (GL)/year (other than refilling storages following depletion during drought).
- Kalbar’s proposal to obtain a 3 GL winter fill license would need to be supplemented by an additional water supply, assumed in EES documentation to be a groundwater supply.
- During drought, winter fill volumes may not be fully allocated, and there is a possibility the site may not have access to river water. This means that the site may need to rely almost entirely on groundwater in drought conditions, or potentially adjust the rate of mining to adapt to the constrained water supply.

Climate change projections applicable to 2030-2040 provided “DELWP 2016, Guidelines for Assessing the Impact of Climate Change on Water Supplies in Victoria, State of Victoria Department of Environment, Land, Water and Planning” were applied to the year 15 mine layout snapshot modelling. These included:

- evaporation rates increased by 4.7%;
- annual rainfall totals reduced by 2.3%; and
- Mitchell River streamflow decreased by 11%.

The model showed that the effect of climate change would be a marginal increase in water demand (Figure 4.2), which would likely result in additional reliance on groundwater.

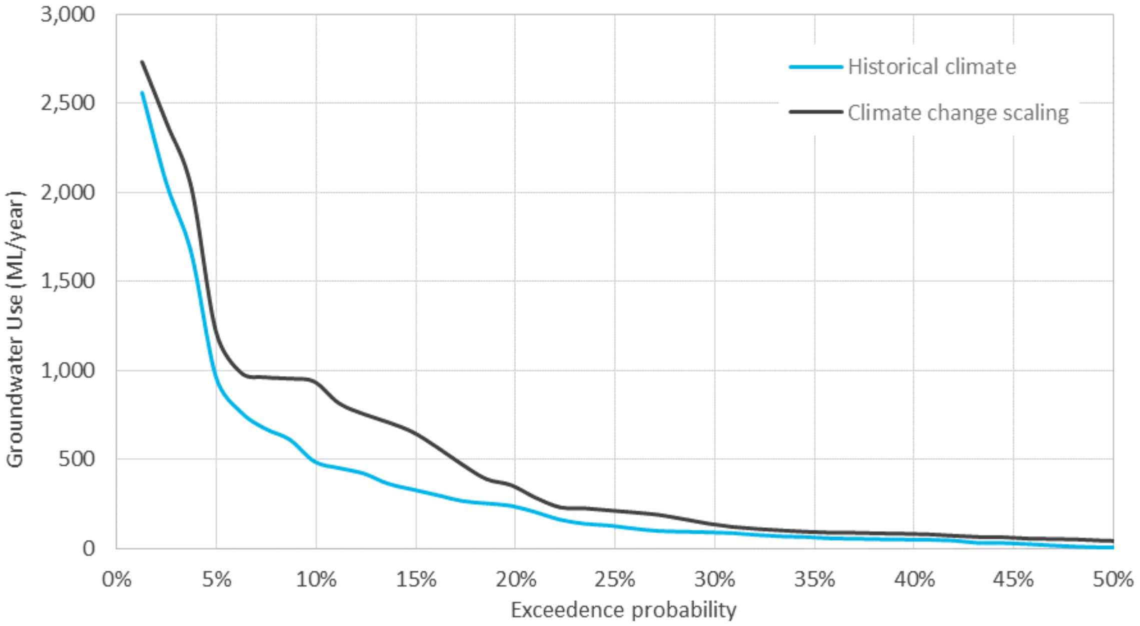

Figure 4.2 Groundwater volumes required per year with 2030-2040 climate change (from water balance report)

Chapter 11 of the water balance report stated that a 3 GL winter-fill license would be sufficient to meet the water demands of the site in 80% to 95% of years. This result describes an early model version that did not consider streamflow rates within the Mitchell River, and is incorrect.

4.5 Water management dams

It is proposed that water management dams would be located on drainage lines downstream of mining activities. Nineteen water management dams are proposed to be located across the project area over the life of the project, though not all would be active at the same time.

The function of each water management dam may change between undisturbed water and mine contact water management as the contributing catchment changes from undisturbed, disturbed by mining then rehabilitated.

Each of the water management dams would only be operational under the following circumstances:

- **Mine contact water dam** – mining (stripping, mining, overburden placement and active rehabilitation) is occurring within the catchment area to the dam. The catchment to water management dams may include mine areas as well as undisturbed areas as runoff from undisturbed areas may not always be diverted around the water management dam. Once runoff from undisturbed areas mixes with mine contact water the collective water is categorised as mine contact water.

- **Undisturbed water dam** – mining is occurring in the catchment downstream of the water management dam. The water management dam functions to limit the ingress of water into the mine void from upstream and enable bypassing of undisturbed water into the receiving waterways downstream of the mine.

Kalbar provided dam dimensions for each catchment based on the objective of providing sufficient volume to capture runoff for the 1% AEP 72-hour storm event. This storm event was selected as representative of a storm event caused by an ‘east coast low’. EMM assessed the long term water balance of these dams and found that there were wet sequences in the historical climate record which could cause these dams to fill and spill, not due to a rain event exceeding the 1% AEP 72-hour rainfall volume, but due to series of events occurring in a season with insufficient opportunity to drain the dams between events.

In the modelling presented in the EES, the fresh water dam was frequently full near the end of the winter fill period, and if significant rainfall events were to fall at this time it would not be possible to run the DAF without causing the fresh water dam to spill. In the model, the DAF plant did not run when the fresh water dam was full. This meant that water management dams had an opportunity to fill and spill.

In the revised modelling with a lower recovery rate from fine tails, the higher site water requirements meant that the freshwater dam was rarely full and the DAF plant could operate more often. This resulted in a decrease in the predicted frequency of spills from the water management dams.

As the Perry River is likely a more sensitive environment than the Mitchell River, Kalbar propose to dewater dams in the Perry River catchment prior to dewatering dams in the Mitchell River catchment. This has led to a lower probability of dam overflow in the Perry River catchment than in the Mitchell River catchment.

Based on modelling using the historical climate record, the overall probability of dams filling and spilling was assessed as:

- zero probability of spill to the Perry River catchment (Figure 4.3);
- zero probability of spill to the Mitchell River catchment when the mine is in the year 5 configuration; and
- a 0% to 1% annual probability of spill to the Mitchell River catchment when the mine site is in the year 8 and year 15 configurations (Figure 4.4).

If each year of the mine life had been modelled, Figure 4.4 would be a smoother curve and the calculated average probability of spill would be slightly different.

Annexure C presents additional probabilistic data relating to spill rates, however the mean results are unchanged from the earlier data presented in the water balance report and summarised here.

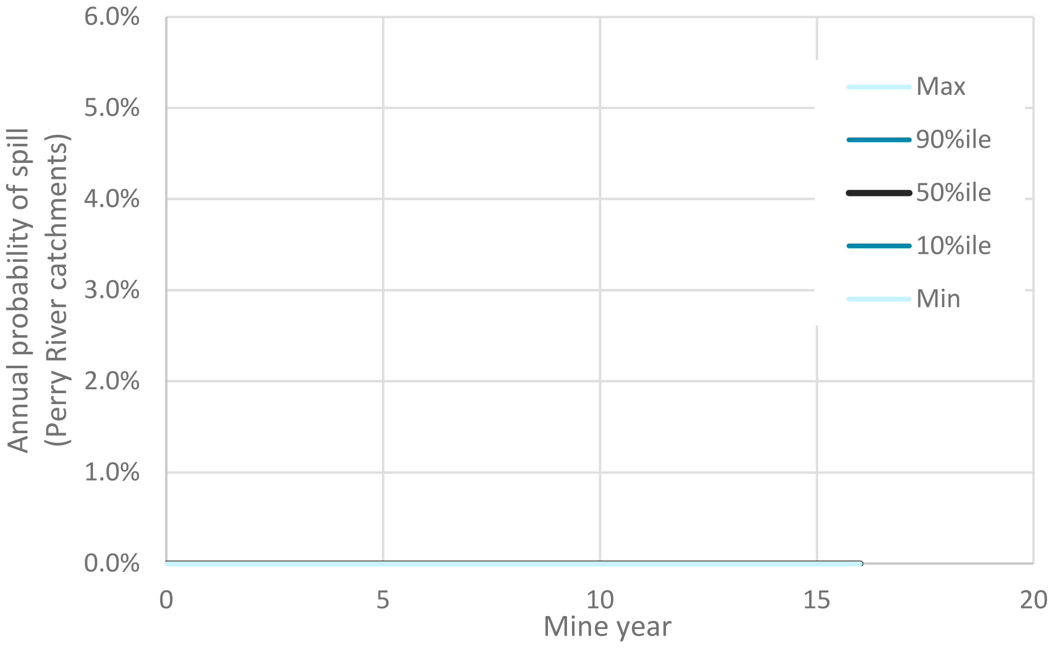

Figure 4.3 **Predicted frequency of water management dam spill to Perry River**

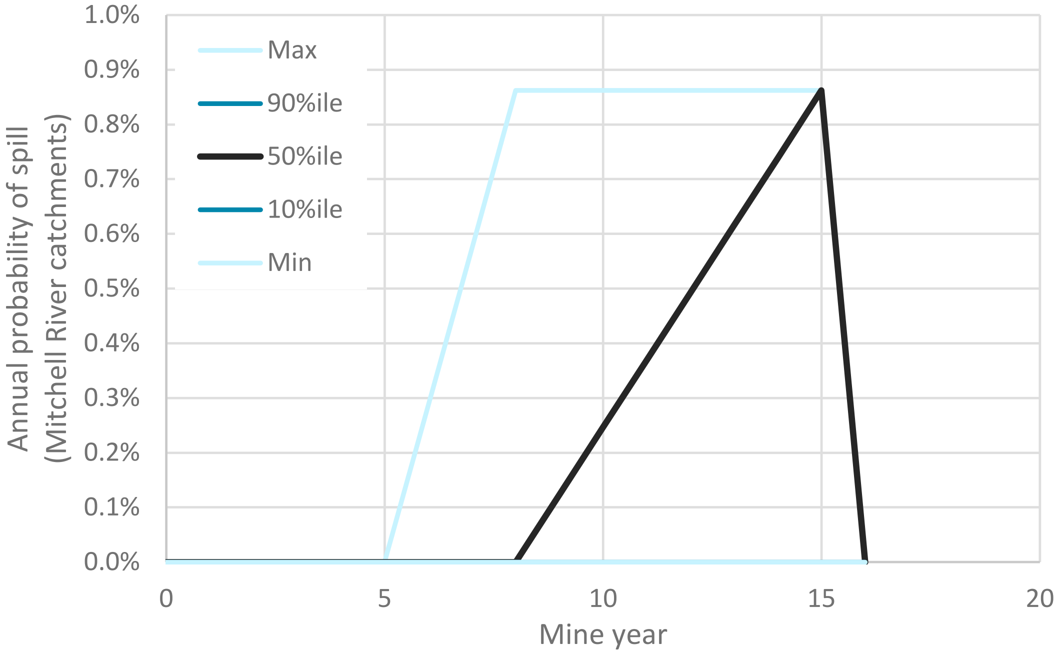

Figure 4.4 **Probability of mine contact water spill to the Mitchell River**

Sediment laden runoff may be generated from topsoil stockpiles and other minor disturbance activities that occur outside of 'mine contact' areas, and would be managed by sedimentation dams designed in accordance with the International Erosion Control Association Australasia's Best Practice Erosion and Sediment Control (BPESC) (IECA, 2008). Where practical, water captured in sedimentation dams would be dewatered to the process water system. When full the dams would overflow to receiving waterways. Type D sediment dams were proposed, which would have an average annual overflow frequency of 2-4 spills/year.

4.6 Model Assumptions

A number of assumptions are included in the water balance model. These can be grouped as:

- site rainfall runoff relationships, including current runoff rates, runoff rates from the disturbed site, and runoff rates from the site after rehabilitation;
- climate change, including future rainfall and evaporation, and future Mitchell River stream flow;
- process plant water use and recycling;
- ore moisture;
- water loss to evaporation, entrainment in product and tails, and seepage to groundwater;
- pump sizes; and
- licensing.

A description of the assumptions is provided below.

4.6.1 Rainfall runoff

The modelled approach to rainfall runoff is discussed in the water balance report Section 6.3.1iv.

Rainfall runoff relationships at the Fingerboards site are currently uncertain. While streamflow monitoring gauges were installed by Kalbar in three creeks:

- These have recorded little runoff due to drought conditions through the monitoring period.
- When runoff was recorded, the depths recorded were shallow and the resulting flow rate estimates not reliable. In general, shallow flows at streamflow gauges cannot be reliably converted to flow estimates as, for example, water may be pooled against an obstruction and not actually flowing, or shallow water may flow very slowly around rocks and weeds and have a different depth-flow relationship than when it is deeper and more free flowing.
- There are streamflow events in the record with no corresponding record of preceding rainfall. This is likely caused by patchy rainfall patterns, with rain landing on parts of the site but not at the meteorology station.

Kalbar has continued to monitor rainfall and runoff, and will collect additional data to calibrate runoff models during the dam design period that was not available during the development of the water balance model.

Regional runoff relationships were taken from work completed by Water Technology for this project and applied to the site to describe both current conditions, disturbed conditions, and post-rehabilitation conditions.

The use of a regional runoff relationship to describe runoff from the disturbed areas of the site will likely require refinement as the site is developed and the true runoff relationship is observed. The following aspects are likely to cause the true runoff relationship to be different from that used in the model:

- If the site has a higher prevalence of sand than the regional average (likely, given the prevalence of sandy soils at the site described in the soil assessment summarised in water balance report section 3.1.1), runoff may be lower.
- Compacted surfaces such as may occur due to heavy machinery movements may allow increased runoff.
- Rainfall may be captured within loose stockpiled materials and depressions such as wheel ruts, graded road verges, and bunded areas, and not contribute to runoff.

The sum total of these effects could be an increase or a decrease in runoff.

If runoff rates at the site are lower than those included in the model, management of mine contact water will be simpler, and potentially the likelihood of spills would decrease.

Conversely, if the site generates more runoff than the regional average then water management will be more difficult and there will be a higher probability that water management dams would fill and release mine contact water to the downstream environment.

Uncertainties relating to rainfall runoff do not affect the volumes of water required by the site from the Mitchell River or from groundwater sources.

4.6.2 Climate change

It was assumed that during the first 10 years of the mine, the climate conditions could be wet or dry but would remain within the bounds of the historical records. Climate change factors were applied to the year 15 model snapshot.

Climate change is an emerging and uncertain science, and published future climate predictions contain many caveats. It is possible that a drought worse than the previous worst drought on record could occur during the mine life, and this situation has not been explicitly modelled in the water balance model. If this situation occurred, the site would not receive winter fill allocation and would rely on groundwater. The effects of 100% reliance on groundwater have been modelled, and these effects are discussed in the numerical groundwater modelling report. If water supply is constrained, the mine production rate may be slowed.

4.6.3 Process plant water use

Details of water use and recycling pathways within the process plant were provided by Kalbar. Even if the plant used more water or less water than assumed in the water balance model, because the plant and process water dam represent a semi-closed circuit, increased water use in the plant will not affect site water requirements. The site water requirements would only be affected if water losses were to vary from the assumed rates (see next section).

The model was based on a mine rate of 1,500 tonnes/hour (t/hr). If this rate were to change then the rate of water use would likely change, in particular due to altered rates of water lost to entrainment in fine tails and product and seepage from sand tails.

4.6.4 Ore moisture

Kalbar provided information indicating that mine ore was expected to have a moisture content of 5% by weight, which is equivalent to 12% by volume. The volumetric soil moisture content field capacity for sandy soils is 15-25% by volume, so using 12% in the water balance is reasonable and allows for some evaporation during the excavation process. Soil field capacity is a measure of the water content in a soil after it drains by gravity, and so is a reasonable estimate of the moisture that would be in the sands at the site, which would in the past have been naturally wetted following rainfall infiltration and then drained by gravity to the aquifer.

The assumption of 5% moisture by weight means that the water balance gains 624 ML/year (0.62 GL/year) water from the mine ore.

Sands with greater than 2% moisture by weight experience significant reduction in dust generation, so it was assumed that dust suppression would not be required within the pit.

4.6.5 Water losses

In the model water is lost via:

- evaporation from water storage dams;
- entrainment in and evaporation from product stockpiles;
- entrainment, evaporation and seepage from fine tails;
- seepage from sand tails;
- use for dust suppression; and
- contractor yard use, and treatment for potable use.

i Evaporation from water storage dams

Evaporation from water storage dams was estimated as [pan evaporation] x [surface area] x 0.7.

The factor of 0.7 is a common factor used to convert the Bureau of Meteorology pan evaporation data to estimates of evaporation from lakes. However, the actual evaporation rate from any particular pond or lake will likely not be exactly 0.7 x the pan evaporation rate as:

- while evaporation pans have specific dimensions and are shallow, lakes and dams are typically deeper with greater thermal inertia;
- micro-climate effects can cause air moving over larger dam surfaces to become saturated with moisture, reducing its capacity to take water molecules from the water body; and
- evapotranspiring vegetation within or fringing water bodies may increase the overall evaporation rate from the waterbody.

There is published research which shows that evaporation factors change through the seasons. In particular, McMahon et al (2013)[1] includes evaporation factors calculated for lakes from a number of locations in Australia, with the closest to the Fingerboards site being East Sale Airport, 39 km south of the Fingerboards site. This data is reproduced below, showing that lake evaporation rates may be as high as [0.987 x pan evaporation] in October, with the yearly average factor being 0.918. This data shows that yearly evaporation losses from dams could be 30% higher than modelled (refer Annexure C).

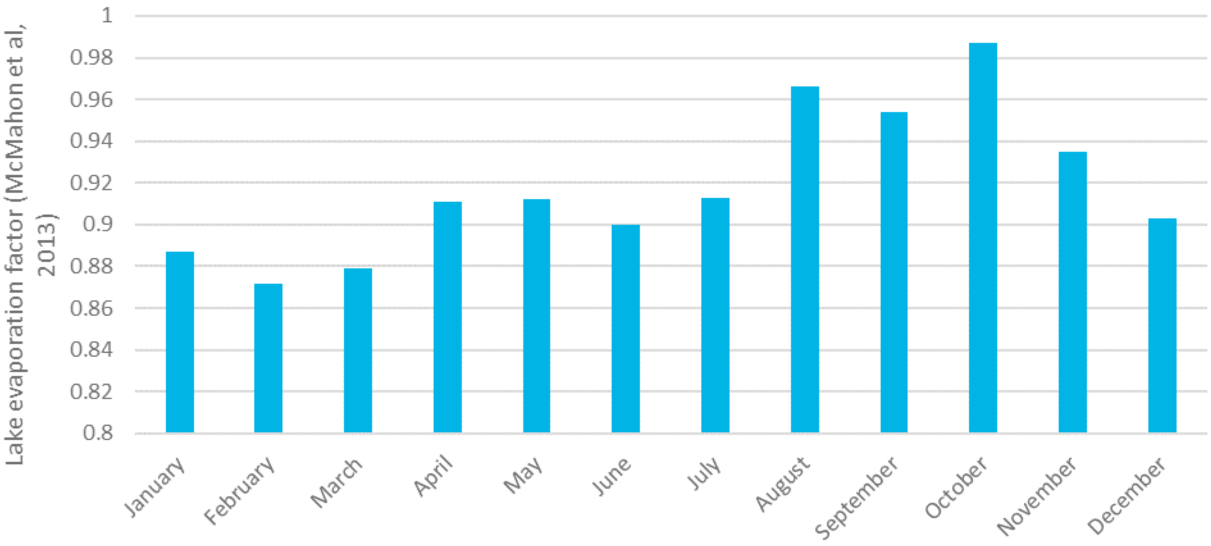

Figure 4.5 Lake evaporation factors for East Sale airport (McMahon et al, 2013)

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[1] McMahon et al (2013) *Estimating actual, potential, reference crop and pan evaporation using standard meteorological data: a pragmatic synthesis* Journal of Hydrology and Earth System Sciences (17) 1331-1363

ii Entrainment in and evaporation from product stockpiles

Kalbar provided details of water volumes entrained in product material after processing, and water volumes which would be recovered from product material before stockpiling. The net water lost to stockpiles was provided as 0.4 ML/day. This value was set as a constant in the model. As water entrainment in product material is a small volume in the context of the water balance, changes to assumptions relating to product wetness or water recovery would not change the overall water balance.

iii Entrainment, evaporation and seepage from fine tails

In November 2018, Kalbar supplied an entrainment estimate of 1,110 ML/year within fine tails. In January 2021 Kalbar advised EMM that this rate was incorrect as it was based on an assumption of 80% recovery of water from the fines slurry using 'Mud Masters', when a realistic estimate was 50% recovery. Changing the recovery rate to 50% would result in a loss of water to entrainment of 2,800 ML/year; a significant change to the water balance.

Entrained water within fine tails is assumed to remain in situ and be bound within the fine particle soil matrix, and so seepage was assumed to be 0 ML/day.

Based on information provided by Kalbar in November 2018, fine tails cells were modelled, with fines slurry (also called slimes) forming a beach and decant pond. Of the active fine tails area, it was assumed that:

- the fine tails cells would have the following sub-areas:
  - 22.5% of the area would be dry beach;
  - 60% would be active / wet beach; and
  - 17.5% would be a decant pond.

  The way that tails beaches develop is complex, with the portion that is wet changing over time in response to both operator decisions and the shape of the previously deposited tails beach, both of which will evolve over time. The complexity of tails beaching is typically simplified in water balance models, and the level of detail included in this model is appropriate for a mine which has not been constructed;
- Evaporation from the wet beach was estimated as [0.7 x pan evaporation rate]. A rate less than [1.0 x pan evaporation rate] was used as water contained within moist soil does not receive direct sunlight and so will evaporate slower than water in an evaporation pan.
- Evaporation from the decant pond was estimated as [0.8 x pan evaporation rate].
- Water would be harvested from the decant pond to use as process water.

I have seen mine water balance models developed by other professionals which used wet beach evaporation multipliers ranging between 0.4 and 1.0. Due to the complexity of tails beach management which typically cannot be replicated in water balance models explicitly, evaporation rate factors are often used to 'calibrate' models to observed data, leading to a wide range of evaporation rates used in the water industry, particularly in the case of tails beaches. Given the wide range of values applied by other professionals, the multiplier of 0.7 used in this model appears reasonable, but should be tested and updated once the mine has been established.

The evaporation multiplier of 0.8 from the decant pond is consistent with other mine site water balance models that I have seen.

If the tails evaporation was 50% higher than modelled, an additional 50 ML/year (0.05 GL/year) could be lost from the water balance, leading to a commensurate increase in water demand.

iv Seepage from sand tails

The water balance model presented in the EES used data provided by Kalbar in November 2018:

- Densification of sand slurry to 65% solids by weight using water recovery cyclones, with supernatant water returned to the process plant.

- 60% of sand tails emplacement water recovered by under-drains.

The water balance report shows 1.7 GL/year lost from sand tailings. This same volume is applied in the numerical groundwater model as seepage into the groundwater system.

The conceptual water balance report flow diagrams illustrates the unrecovered water from the sand tails with an arrow pointing to a box labelled 'entrainment' (water balance report Figures 4.3, 8.1 to 8.3, C.1 to C.6). This unrecovered water is not likely to remain entrained permanently, but rather a significant portion is expected to seep to the groundwater table. An adjusted figure is presented as Figure 4.1 of this statement.

The model assumes no evaporation losses from sand tails; with free draining conditions water contained in the tails is assumed to percolate downwards and not remain at surface. Once water is at depth it will not evaporate.

Rainfall runoff from the sand tails area was assumed to report to pit sumps and be harvested for process water use.

v Use for dust suppression

Dust suppression water requirements were estimated on the basis that mine site haul roads would be kept damp to reduce dust, and daily volumes of water required were calculated as [Area x (Evaporation – Rainfall + Overspray)] with evaporation and rainfall data taken from the SILO climate record and overspray estimated as 3 mm/day.

The area requiring dust suppression was assumed to be a 20 m wide road 10 km long throughout the mine life. In reality, the area requiring dust suppression will vary over time as the pit moves and as various construction and excavation activities take place. Dust suppression for stockpiles or exposed excavations were not considered.

The dust suppression calculation utilised in the water balance model is physically based but coarse. The use of [evaporation – rainfall] to estimate water requirements is reasonable, but the evaporation rate from haul road surfaces is uncertain. As an example of uncertainty: evaporation from soil is affected by particle size. Water molecules bind more tightly to finer soil particles through surface tension than to coarser particles, and so clays may remain wet longer than sands. The binding of water to soil particles at a microscopic level can reduce the effective evaporation rate. Wind may also affect the drying rate of soil differently in different parts of the site depending on aspect and elevation. The magnitude of these effects is difficult to predict in advance of dust suppression activities, and so dust suppression is best managed through adaptive management based on site observations.

Many sites utilise chemical surface treatments to reduce dust suppression requirements. The effects of surface treatments on haul roads were not considered in the water balance model. Using treatments on stockpiles would align with the modelled assumption that stockpiles do not require dust suppression. If surface treatments are used on haul roads, the volume required for dust suppression would decrease.

vi Contractor yard and potable use

Contactor yard and potable water use estimates were provided by Kalbar as 55 ML/year and 18 ML/year respectively. These volumes are small in the context of the water balance and variation in these numbers within reasonable ranges would not affect the overall water balance results.

4.6.6 Pump sizes

Dewatering pumping rates from mine contact dams are provided in water balance report Section 4.5.1i, and the pumping rate from the Mitchell River is described in Section 8.6.

A summary table of sizes and rates used in the model included in the water balance model Appendix B describes the total dewatering rate from water management dams as 45 ML/day, but this rate is incorrect and the data in section 4.5.1i should be used instead. Section 4.5.1i states gives rates of 24 ML/day to the DAF plant and 8 ML/day to the process water dam for a total of 32 ML/day.

A change in the rate of pumping from the Michell River is not expected to significantly affect the water balance results as:

- the final pump size would be selected after careful consideration and would be expected to fulfill the role of effectively providing water to the site; and

- the plant will use water from dams rather than directly from the river, so will not be directly affected by pump operations.

The rates at which water may be moved from the water management dams will affect the probability of dams filling and spilling during extended wet periods. I would recommend that Kalbar achieve dewatering rates meeting or exceeding the rates used in the model, so that water management dams will be drained at or faster than the rates modelled.

4.6.7 Licensing

Assumptions relating to licensing are described in the water balance report sections 5 and 6.5.

4.7 Final comments

The water balance model shows that with the current site water demand:

- the site will need to import on average 1.7 GL/year more water than the proposed winter fill licence volume, with this water presumed to be obtained from groundwater;
- as fresh water is used in preference over groundwater in the water balance model, the fresh water dam would regularly be dry. This subsequently means:
    - dilution of the DAF treated water within the fresh water dam may not occur when the fresh water dam contains low volume. Dilution of copper and nitrogen in the DAF treated water would then primarily take place at the point of discharge using the river flows.
    - the capacity to remove water from mine contact dams in winter months would be higher than presented in the EES, leading to lower rates of spill

Optimisation of proposed water management measures could potentially result in increased use of groundwater and maintaining greater water volumes in the fresh water dam for release to the environment.

5 Response to submissions

A response to submissions is included in Annexure D.

6 Declaration

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Inquiry and Advisory Committee.

Signed J Muller

Dated 2 February 2021

Appendix A

Curriculum vitae

Jarrah Muller

Associate Water Resources Engineer

Curriculum vitae

Jarrah Muller is a chartered professional civil engineer with 15 years' experience in the water industry. During this time, Jarrah has successfully delivered numerous surface water, groundwater and hydraulic modelling projects across clients and sectors, including mining and extractive, energy, transport and infrastructure.

Jarrah has successfully delivered projects including flood estimation, creek erosion estimates, integrated water management, site water balance modelling, water resource management and groundwater impact assessment modelling.

Jarrah is trained in using various modelling and project software including MIKE FLOOD, TUFLOW, RORB, HEC-RAS, MUSIC, GoldSim, commercial MODFLOW codes, FEFLOW, and ArcGIS.

Qualifications and memberships

- Bachelor of Engineering (Civil & Environmental) (1st Hons), University of Adelaide, 2005
- Bachelor of Science (Environmental Biology), University of Adelaide, 2005
- Chartered Professional Engineer (Civil), Engineers Australia, 2010

Career

- Associate Water Resources Engineer, EMM Consulting, 2018–present
- Senior Water Resources Engineer, Jacobs (formerly Sinclair Knight Merz), 2006–2018

Representative experience

Surface water modelling

- Snowy 2.0 EIS surface water impact assessment (Snowy Hydro)
- Carrapateena Mine surface water impacts assessment for approvals, SA (Oz Minerals)
- Hughenden Sun Farm runoff modelling, QLD (Overland Sun Farming)
- Northern Connector expressway wetland water balance modelling, and waterway crossing hydraulic modelling, SA (LendLease)
- Wallpolla Floodplain inundation measures concept design, SA (SA Water)
- Pike Floodplain inundation measures detailed design, SA (Department of Environment, Water and Natural Resources, SA)
- Hindmarsh Valley dam safety study, SA (SA Water)
- Baroota dam safety study, SA (SA Water)
- Central Eyre Iron Project, environmental impact statement and mining lease proposal, SA (Iron Road Mining)
- Glenelg barrages upgrade, SA (SA Water)
- Murray Valley irrigation channel 3, 5 and 6, hydraulic modelling, VIC (NVIRP)
- Deep Dale Line Rail Siding Extension, WA (Rio Tinto)

Surface water modelling

- Lower River Murray flood model calibration, SA (Department of Environment, Water and Natural Resources, SA)
- Crescent Heads frog habitat and drainage study, NSW, (Hunter Valley Operations)

Hydraulic engineering

- Yarrawonga Weir, fish elevator retrofit concept design, VIC (Goulburn Murray Water)
- Coorong Barrages, flow modelling, SA (Department of Environment, Water and Natural Resources, SA)
- Jimah East power station design project, Malaysia (Hyundai)
- Gold Coast Desalination Plant, offshore plume nearfield mixing, QLD (Veolia)
- Northern Victorian Irrigation Renewal Project, VIC (NVIRP)
- Pelican Point power station cooling water pipeline condition assessment, SA, International Power

Water resource management

- Fingerboards mine site concept water management plan, VIC, (Kalbar)
- Snowy Hydro 2.0 catchment runoff modelling and baseflow analysis, NSW, (Snowy Hydro)
- Lower Lakes salinity modelling, SA (Department of Environment, Water and Natural Resources, SA)
- Constraints Management Strategy, AU (Murray Darling Basin Authority)
- SARFIIP Pike Floodplain Inundation Measures, SA (Department of Environment, Water and Natural Resources, SA)
- River Torrens Protection of Adjacent Infrastructure project, SA (SA Water)
- Eyre Peninsula desalination plant siting study, SA, (SA Water)

Groundwater modelling

- Douglas mine impacts model, VIC, (Iluka)
- Carrapateena water supply and mine impacts groundwater model, SA, (OZ Minerals)
- Myalup sustainable extraction limits groundwater model, WA (Department of Water, WA)
- West Gate Tunnel Project dewatering assessment, VIC (Transurban)
- Bowden's Silver Mine mine impacts groundwater model, NSW (Kingsgate)
- McPhee Creek mine impacts groundwater model, WA (Atlas Iron)
- Lower De Grey River mine impacts groundwater model, WA (Atlas Iron)
- Lower De Grey River water supply impacts groundwater model, WA (Department of Water, WA)
- Lower Robe River groundwater model, WA (Department of Water, WA)
- Impacts of water trades modelling, VIC (Mallee CMA)
- Murray Darling Basin Sustainable Yields project, AU (CSIRO)
- Jacinth-Ambrosia mine impacts model, SA (Iluka)
- Jacinth-Ambrosia mine water supply model, SA (Iluka)

Publications

- Slarke, S, Muller, J, Stuart, I, O'Connor, J, Jones, M, and Turner, M, 2018, Cost Effective Modelling to Improve the Functionality of the Broken Creek Rice's Weir and Kennedy's Weir Vertical Slot Fishways, presented at *International Conference on Engineering and Ecohydrology for Fish Passage*, Albury, NSW
- Muller, J 2013, Modelling folded banded iron formation (BIF) with multiple pit lakes forming throughout the simulation, paper presented at *2nd Australian and New Zealand FEFLOW User Group Meeting*, Adelaide
- Muller, J and Nyquest, D 2012, Protecting concurrent use of the De Grey River alluvial aquifer for mining, ecosystems, and water supply, paper presented at *Oz Water*, Sydney
- Muller, J, Seil, G, and Hubbert, G 2011, Three modelling techniques used in Australia to model desalination plant brine dispersal in both the near-field and far field, paper presented at *International symposium on Outfall Systems*, Mar del Plata, Argentina
- Muller, J and Koomberi, H 2010, Modelling cyclone reliant aquifers supporting groundwater dependent ecosystems in the Pilbara; the Lower De Grey River groundwater model, paper presented at *Groundwater 2010 Conference Proceedings*, Canberra
- Barnett, BG and Muller, J 2008 Upper Lachlan Groundwater Model Calibration Report. A report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project. CSIRO, Australia
- Barnett, BG and Muller, J 2008 Upper Condamine Groundwater Model Calibration Report. A report

to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project. CSIRO, Australia

- Jewell, S, Muller, J, Telfer, A and Thompson, M 2007, Restoration plan for a wetland affected by saline groundwater *Water* 34(7), pp. 44-44.

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Appendix B

Instructions

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15 September 2020

Jarrah Muller
EMM Consulting
Level 3, 175 Scott Street
Newcastle, NSW 2300

By email: jmuller@emmconsulting.com.au

Confidential and subject to legal professional privilege

Dear Mr Muller

Fingerboards mineral sands project

We act as legal advisors to Kalbar Operations Pty Ltd (**Kalbar**), the proponent of the Fingerboards mineral sands project (**Project**).

This letter confirms and sets out the scope of your retainer to prepare an expert witness statement and potentially also present evidence at the inquiry hearing to be held in relation to the environment effects statement (**EES**) prepared for the Project pursuant to the *Environment Effects Act 1978* (Vic).

1. The Project

Kalbar proposes to develop the Project on an area of approximately 1,675 hectares within the eastern part of the Glenaladale mineral sands deposit in East Gippsland, Victoria. The Project site is located near the Mitchell River, approximately 2 km south of Glenaladale, 4 km south-west of Mitchell River National Park and 20 km north-west of Bairnsdale.

The Project includes the development of an open cut mineral sands mine and associated infrastructure. It is expected to have a mine life of 15–20 years and involve extraction of approximately 170 Mt of ore to produce approximately 6 Mt of mineral concentrate for export overseas.

2. Panel and EES inquiry

The EES and the studies and assessments that underpin it (together with a draft planning scheme amendment and application for an EPA works approval) are presently on public exhibition until the end of October 2020.

The inquiry is scheduled to convene its directions hearing on 13 November 2020, and the inquiry hearing is scheduled to commence on 7 December 2020. We will keep you informed of any relevant directions, including the timetable for filing evidence and, if required, any expert conferences.

3. Scope

This letter is confirmation of your engagement as an independent expert to:

(a) prepare an expert witness statement in which you:

  (i) set out your background and relevant expertise;

(ii) briefly describe and summarise the Conceptual Surface Water Management Strategy and Water Balance prepared in support of the EES and your role in preparing it. In particular, we ask that you detail whether there is anything in the report that you disagree with or wish to elaborate on and set out any additional information that you consider necessary to include, including any additional assumptions; and

(iii) consider the submissions that are relevant to your area of expertise and respond to any issues raised; and

(b) if required, prepare and present expert evidence at the inquiry hearing.

We will provide further instructions on the scope of your engagement and any new instructions as necessary.

4. Form of your expert witness statement

The form and content of your expert witness statement should be prepared in accordance with Planning Panel Victoria's *Guide to Expert Evidence* (**Guide**). We enclose a copy of the Guide for your reference. Please review the Guide and ensure your witness statement addresses the matters set out in it, in particular those matters listed under the heading 'The expert witness statement'. Please contact us if there is anything in the Guide that you do not understand, or if you have questions in relation to it.

Until your expert witness statement is in final form it should not be signed. You should, however, be aware that unsigned documents may need to be disclosed to other parties.

5. Your duties and responsibilities as an expert witness

Even though you are engaged by Kalbar, you are retained as an expert to assist the inquiry, and you have an overriding duty to it. The inquiry will expect you to be objective, professional and form an independent view as to the matters in respect to which your opinion is sought.

6. Timing

The timing for completion of your expert witness statement is to be advised. We will let you know as soon as we can.

7. Conflict of interest

It is important that you are free from any possible conflict of interest in providing your advice. You should ensure that you have no connection with any potential party to this matter that could preclude you from providing your opinion in an objective and independent manner.

15 September 2020

8. Costs and invoicing

EMM Consulting will continue to be contractually engaged by Kalbar and Kalbar will continue to be responsible for the payment of your fees. Your accounts should be sent directly to the appropriate person nominated by Kalbar.

9. Confidentiality

Your engagement and any documents you prepare under it should be marked "Confidential and subject to legal professional privilege".

If anyone other than ourselves, Kalbar or its technical advisers contact you about this engagement or the work you are undertaking under this engagement, please contact us immediately.

If you have any questions about this letter or require any additional information, please contact us.

Yours sincerely,

Tim Power

Tim Power
Partner

T +61 3 8486 8037
E tim.power@whitecase.com

Kirsty Campbell

Kirsty Campbell
Senior Associate

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Enc: Planning Panel Victoria's *Guide to Expert Evidence* - April 2019

Appendix C

Additional work completed

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2 February 2021

To: Kalbar Operations

Re: Dilution assessment of DAF outputs - Fingerboards mineral sands mine

The following technical memorandum provides a dilution assessment of Dissolve Air Flotation (DAF) plant outputs for the proposed Fingerboards mineral sands mine.

1 Scope

The proposed Fingerboards mineral sands mine conceptual water balance has been described in the Conceptual Surface Water Management Strategy and Water Balance report prepared by EMM Consulting Pty Limited (EMM) for Kalbar Operations.

The water management strategy features treatment of mine contact water from a DAF plant with the treated water stored in the freshwater dam (FWD). Water in the FWD may be used in the process plant, for dust suppression, in the contractor yard, or released to the environment to offset water captured in water management dams.

In submission 716, East Gippsland Shire Council highlight that the DAF plant may not remove dissolved metals, and that a dilution assessment is required to understand the potential effects on the FWD.

In submission 514, EPA requested a description of the timing, frequency and magnitude of releases in the context of dilution.

This letter describes a dilution assessment using the water balance model results. Interpretation of the results in ecological or regulatory terms will be provided by others.

2 Stream flow

Daily Mitchell River flow data recorded at the Glenaladale gauge is presented in Figure 2.1. This figure shows that:

- the average flow rate is around 67 Megalitres (ML)/day;
- high flows are more common in winter and spring, and less common in autumn and summer;
- the river is perennial, with flow recorded on more than 99% of days.

No historical gauge data is available for the Perry River, however for the purpose of this assessment by comparing catchment sizes an indication of likely dilution has been calculated.

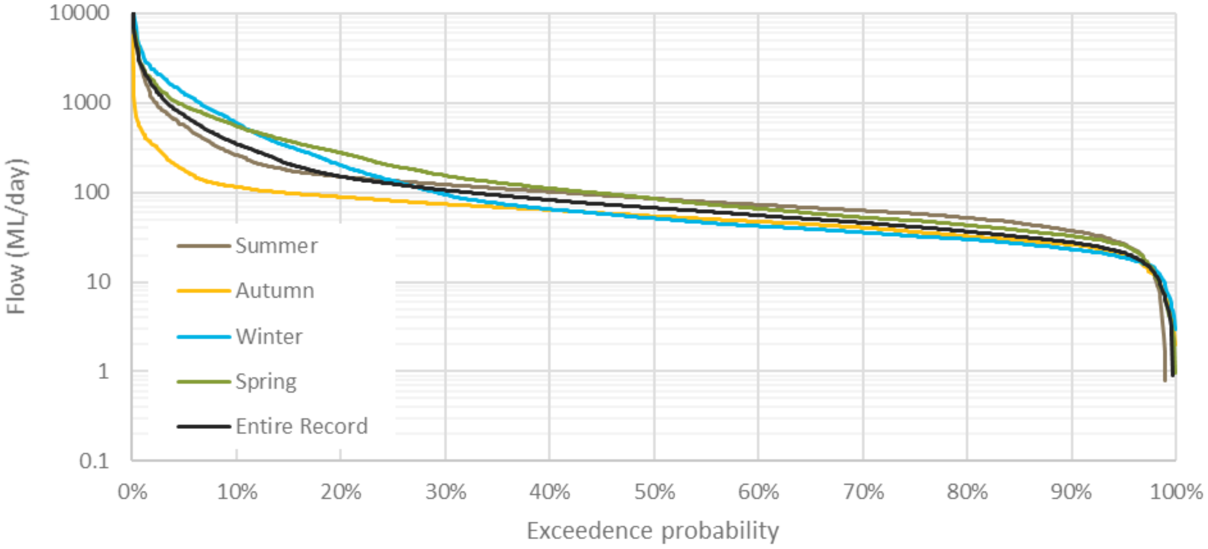

Figure 2.1 Mitchell River flow duration curve at Glenaladale (gauge site 224222)

3 Water balance model

The FWD receives and supplies water from/to a number of sources and demands (Figure 3.1).

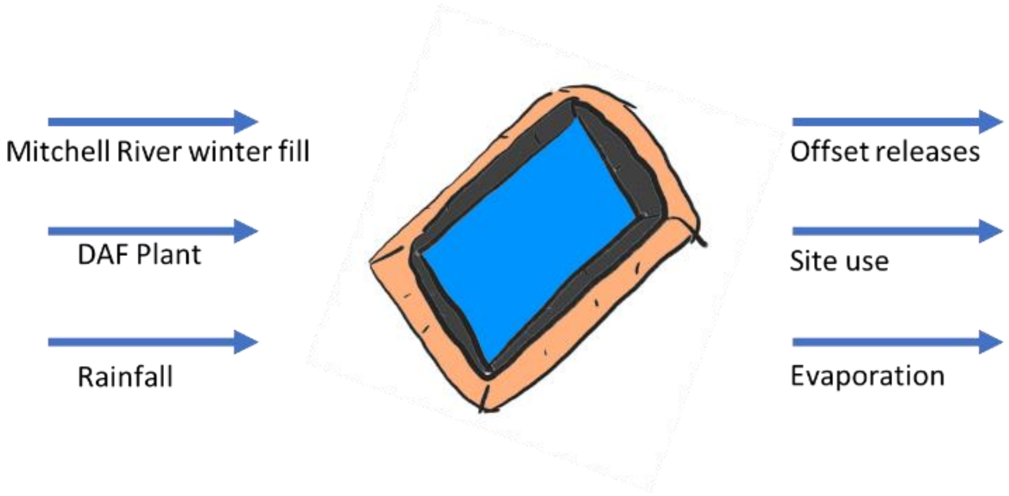

Figure 3.1 Freshwater dam sources and demands

For the purposes of assessing dilution, it is assumed that:

- water from the DAF plant contains 100 units/L[1] of a dissolved non-reactive tracer chemical species;
- water from the Mitchell River and rainfall contains 0 units/L of the tracer;
- water in the dam is fully mixed;[2]
- evaporation and precipitation do not remove the tracer; and

---

[1] 100 units/L was used as a dummy starting value to allow easy comparison of dilution rates in percentage terms

[2] Mixing would rely on diffusion, wind effects, and turbulence from inflows. The dam will have multiple compartments, preventing short circuiting of inflows directly to the outlet.

- releases and site use remove the salt at the rate of [take volume x dam concentration].

To illustrate dilution, the 'year 8' water balance results have been used. There will be some variance in other years as the size of disturbed catchments will be different. 'Year 8' has the greatest total disturbance of the modelled layouts.

The daily modelled release volumes are presented in Figure 3.2 with the same scale as Figure 2.1 for ease of comparison. This plot shows that:

- releases would be made on a relatively small number of days;
- releases would be more frequent in summer and autumn during higher flows, and rarer in spring and winter during lower flows;
- the peak modelled release volume is 25 ML/day, being the proposed treatment rate of the DAF plant.

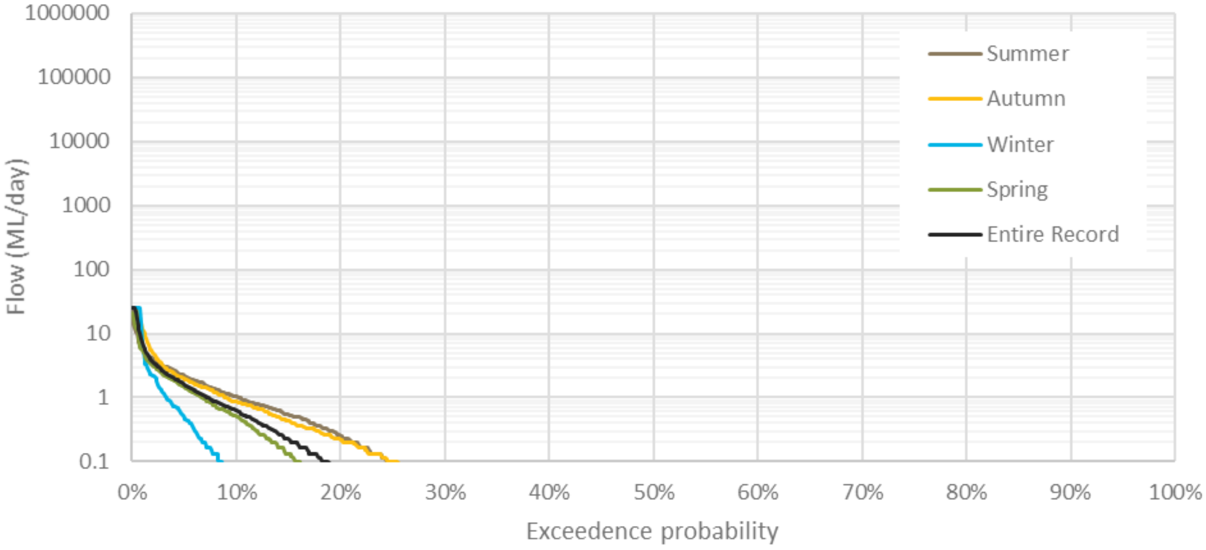

Figure 3.2 Release from FWD flow duration curve

4 Dilution results

The dilution assessment concluded that when the DAF plant operates to remove mine contact water from catchment management dams there would usually be a volume of water in the FWD already due to take from the Mitchell River during the winter-fill period which would dilute the DAF outputs.

Dilution ratios were calculated using the conservation of mass equations below.

1) $Conc_{DAF} \times Vol_{DAF} + Conc_{River} \times Vol_{River} = Conc_{Dam} \times Vol_{Dam}$

2) $Vol_{DAF} + Vol_{River} = Vol_{Dam}$

Equations 2) can be rearranged and substituted into 1) to make:

3) $Conc_{DAF} \times (Vol_{Dam} - Vol_{River}) + Conc_{River} \times Vol_{River} = Conc_{Dam} \times Vol_{Dam}$

which can be further simplified to solve for Vol_{River}:

4) $Vol_{River} = Vol_{Dam} (Conc_{Dam} - Conc_{DAF}) / (Conc_{River} - Conc_{DAF})$

Similar rearrangement can be done to solve for Vol_{DAF}, leading to:

5) $Vol_{DAF} = Vol_{Dam} (Conc_{Dam} - Conc_{River}) / (Conc_{DAF} - Conc_{River})$

The dilution ratio can be expressed as $Vol_{River}: Vol_{DAF}$ with Vol_{Dam} cancelled from each side as a common factor:

6) $(Conc_{Dam} - Conc_{DAF}) / (Conc_{River} - Conc_{DAF}) \; : \; (Conc_{Dam} - Conc_{River}) / (Conc_{DAF} - Conc_{River})$

As the concentration of the water sources were defined, the equation set becomes:

7) $(Conc_{Dam} - 100) / (0 - 100) \; : \; (Conc_{Dam} - 0) / (100 - 0)$

8) $-(Conc_{Dam} - 100) / 100 \; : \; Conc_{Dam} / 100$

9) $100 - Conc_{Dam} \; : \; Conc_{Dam}$

This leads to the following dilution ratios:

Table 4.1 Dilution ratios calculated from modelled FWD concentration

FWD concentration (units / L)	Dilution Ratio (Vol_{River}: Vol_{DAF})
100	0 : 1 (no dilution)
50	1 : 1 (or ’50 : 50’ dilution)
33	2 : 1
10	9 : 1
5	19 : 1
1	99 : 1

The 50th percentile result for FWD concentration is less than 5 units indicating greater than 20:1 dilution (refer Figure 4.1). In drought conditions it is possible that DAF outputs may be diluted only 2:1 (the 95th percentile concentration is around 33 units/L through much of Figure 4.1), with a possibility of no dilution in June if the FWD has been emptied prior to the start of the winter-fill period (maximum modelled concentration is 100 units/L).

From 1 July, the winter-fill period starts and freshwater will be pumped into the FWD allowing higher dilution ratios.

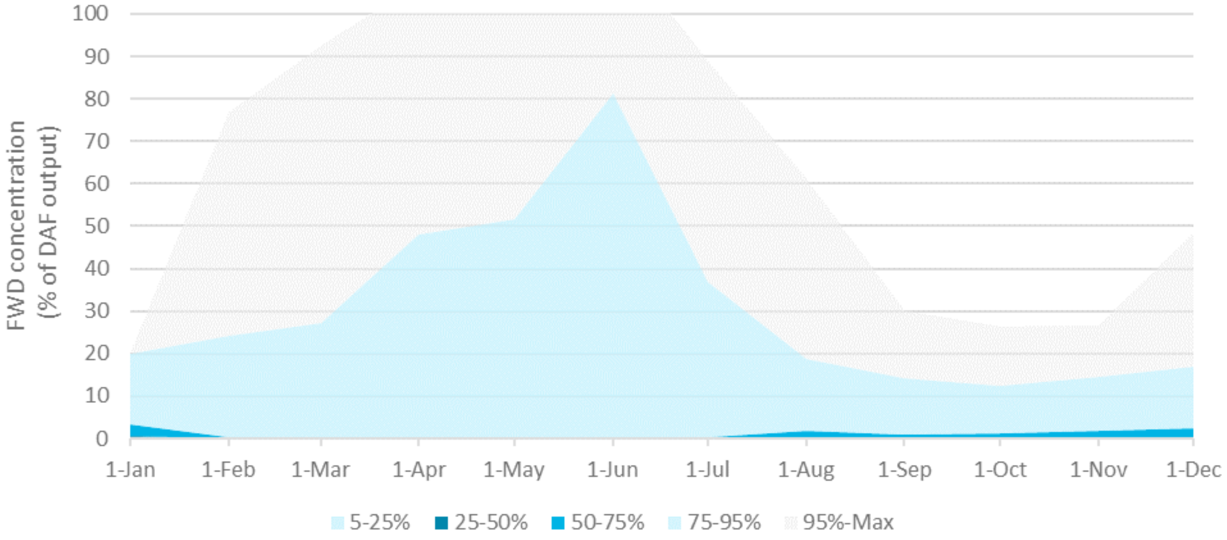

Figure 4.1 FWD concentration

Releases from the FWD to the Mitchell River are unlikely to occur during the winter-fill period as the site will typically be importing water from the river. Instead of releasing water from the FWD to offset site capture on one day and then the next day pumping water from the river back into the dam, the volume in question would be deducted from the winter-fill extraction license allocation and the mine contact water would remain onsite. This means that releases during July-October are likely to be small and highly diluted if they occur (Figure 4.2). Offsetting releases against take are not possible in the Perry River catchment, and July-October releases would follow the FWD concentration trends in Figure 4.3.

Both the release to Mitchell River (Figure 4.2) and release to Perry River (Figure 4.3) concentration results show high concentration within discharges through the March to June periods, while the fresh water dam is expected to have much lower concentrations through this period (Figure 4.1). This is because days with releases immediately follow days of DAF activity (ie offset releases and DAF activity are both driven by rainfall runoff) and so the data used to produce Figure 4.2 and Figure 4.3 are weighted towards the portion of data with higher tracer concentration in the dam.

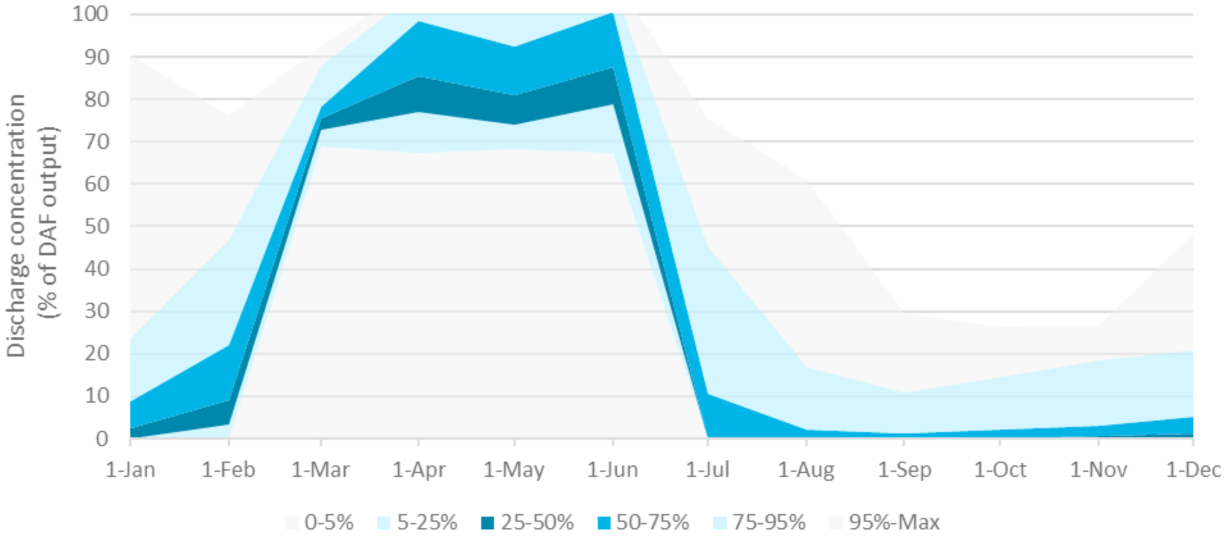

Figure 4.2 Modelled concentration of releases to Mitchell River

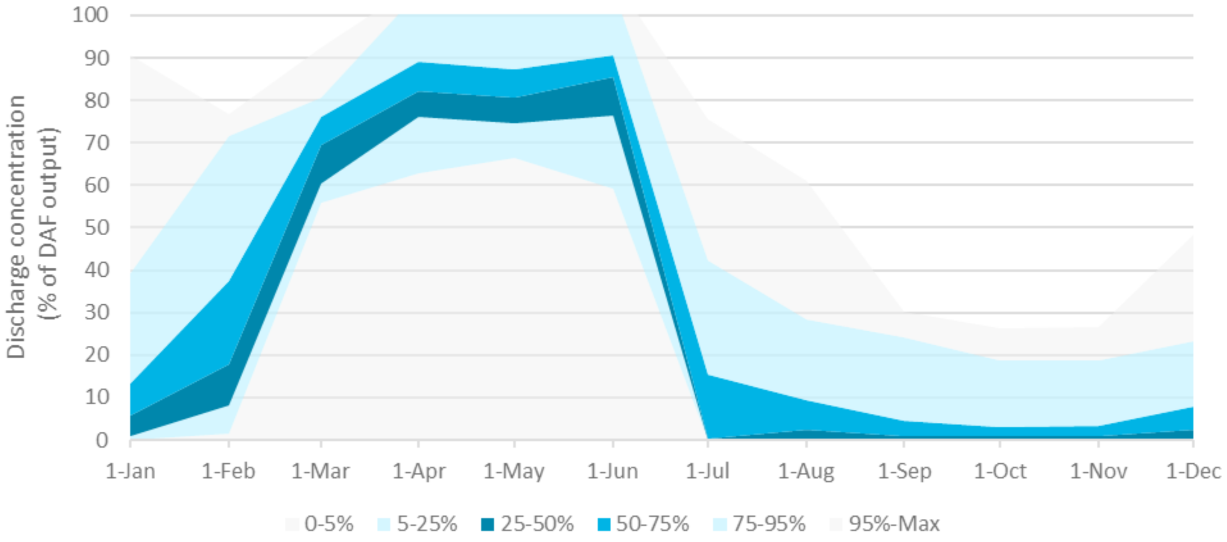

Figure 4.3 Modelled concentration of releases to Perry River

Releases to the Mitchell River would be diluted by the river flow. As the proposed Fingerboards mineral sands mine is small in comparison to the Mitchell River catchment, the contribution of runoff to the river is a small part of the total river flow. When the release volumes are combined with gauged flows, the result is significant dilution typically greater than 100:1 (Figure 4.4) with almost all results showed less than 1 unit/L and not appearing on the plot, with the maximum concentration modelled in low flow conditions still showing less than 10 units/L.

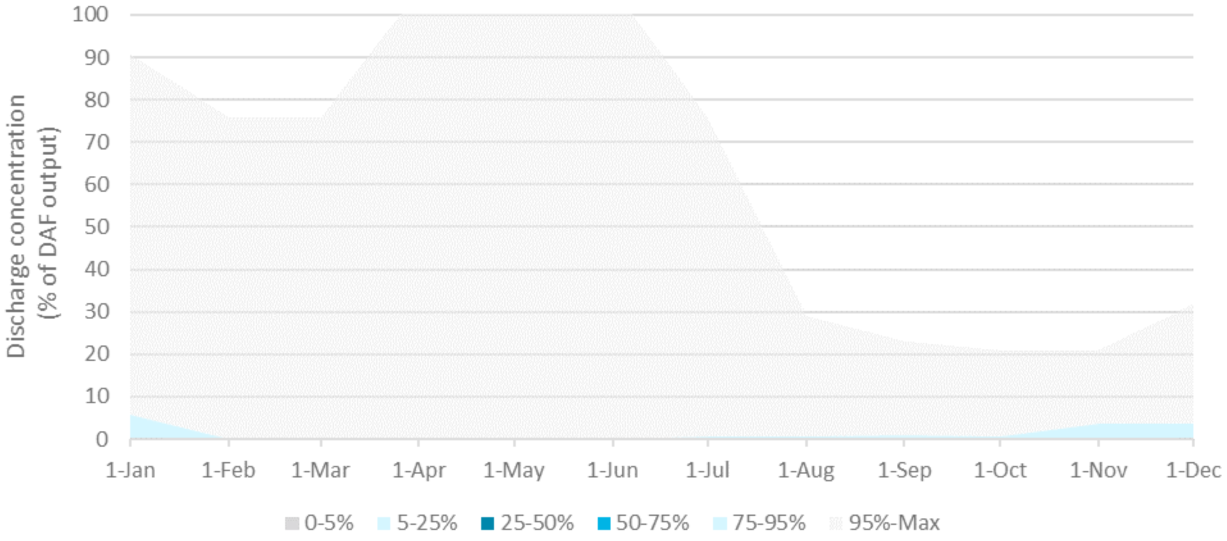

Figure 4.4 Modelled concentration within the Mitchell River

A dilution plot for the Perry River has not been produced as there is no historical gauge data for the discharge location, but an indication of possible dilution can be obtained by comparing catchment sizes. At the confluence of Honeysuckle Creek with the Perry River, the total upstream catchment is approximately 110 km^2. The area of the Honeysuckle Creek catchment within the project bounds is approximately 3 km^2. This means that there may be around 30:1 dilution of discharges to the Perry River if discharges are made during rain events. After rain events the Perry River flow would likely reduce, and discharges would be less diluted and closer to the concentration of the FWD at the time. A conservative approach would be to assume discharges take place several days after rainfall to allow site administrative process relating to discharges to occur, that the Perry River flow has largely subsided in the intervening time, and that the dilution ratios described via Figure 4.3 are applicable as a worst case as the discharge may represent a significant part of the total flow in the river at that time.

5 Conclusion

This assessment of dilution using water balance model results has shown that DAF plant outputs would be diluted within the FWD.

During the months of July to January, releases would typically have been diluted greater than 20:1. During February to June, releases may have close to zero dilution, as the mine site is predicted to be running on groundwater during these months and have little water stored in the fresh water dam.

Releases to the Mitchell River would typically be diluted greater than 100:1 due to river flows. It is recommended that releases not take place when the river has low flows that are insufficient to achieve acceptable dilution ratios.

The dilution factor of releases to the Perry River is not certain due to lack of gauged flow data and uncertain timing of releases after rain events. A conservative approach assuming low flows the Perry River indicates that during the months of July to January releases would typically have been diluted greater than 20:1 while during February to June releases may have close to zero dilution.

J Muller

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2 February 2021

To Kalbar Operations Pty Ltd

Re: Fingerboards Water Balance Model Revision and Uncertainty Analysis

The following technical memorandum provides an assessment of water balance model revision and uncertainty analysis for the proposed Fingerboards mineral sands mine.

1 Scope

Following the exhibition of the Fingerboards Mineral Sands Project Environment Effects Statement (EES), Kalbar's design engineering consultant (Wave International) advised that process water balance information provided by Kalbar to EMM Consulting Pty Ltd (EMM) during the development of the site water balance was incorrect. Rates of water recovery from fine tails using Mud Masters had been described as 80% water recovery, when 50% recovery was more likely to be achieved. A water recovery rate of 50% from the fine tails slurry would result in an additional 1.7 GL/year water use above that described in the EES.

In addition, following the exhibition of the EES, a number of submissions were received and displayed by the Victorian Department of Environment, Land, Water and Planning (DELWP). Submission 716B from East Gippsland Shire Council included a recommendation that the water balance sensitivity analysis should be expanded to assess modelling assumptions, such as dam seepage rates and dust suppression demand.

This document describes the results of:

- adjusting the previous Mud Masters fine tails water recovery rate from 80% to 50% within a revised water balance model; and
- an expanded uncertainty analysis applied to the revised water balance model.

This document is written with the assumption that the reader is familiar with the report *Fingerboards Mineral Sands Project Conceptual Surface Water Management Strategy and water Balance* (EMM 2020) prepared for Kalbar Operations Pty Ltd (the water balance report) and describes amendments to that report.

2 Method

2.1 Fine tailings water recovery

The process water balance Mud Master water recovery rate was updated from 80% to 50% as per advice provided by Water International. The required changes to the site water balance model are described in Table 2.1.

The following water balance model update was made at the same time:

- Dust suppression and catchment runoff calculations in the model had previously used monthly average evaporation rates from Bureau of Meteorology maps. This was altered so that dust suppression estimates used the same daily evaporation data as other components of the model.

Table 2.1 Model changes to adopt updated fine tails recovery rate

Item	Data used in EES model	New data
Sand tails		
Water in sand tails cyclone feed	17,850 ML/year	17,850 ML/year
Water recovered from sand tails cyclones	13,585 ML/year	13,585 ML/year
Water recovered via tails underdrains	2,560 ML/year	2,560 ML/year
Water lost to seepage	1,705 ML/year	1,705 ML/year
Fine tails		
Water in fine tails feed	5,600 ML/year	5,600 ML/year
Water recovered	4,490 ML/year	2,800 ML/year
Water lost to entrainment	1,110 ML/year	2,800 ML/year
Total water lost to tails	2,815 ML/year	4,505 ML/year
Climate effects	Rainfall on fine tails harvested via the decant pond	Rainfall on fine tails harvested via the decant pond

2.2 Uncertainty

The modified water balance model was used to assess the effects of uncertainty by:

1. Altering key inputs so that instead of being fixed numbers they were described in the model as ranges; and

2. Running the model stochastically, whereby each of the parameters described with a range would be chosen randomly from the defined range of possible values each model run, with 200 replicates.

The following parameters were converted from fixed values to ranges:

- an uncertainty range of ±30% was applied to the daily evaporation estimate;

- an uncertainty range of ±30% was applied to the estimate of the area requiring dust suppression; and

- the rate of seepage from water management dams was altered from 1% of the volume per day to a seepage rate of between 1×10^{-4} m/day, intended to represent the compacted vertical hydraulic conductivity of silty sand, and 0.05 m/day, which is the calibrated vertical hydraulic conductivity of the Haunted Hill Formation within the numerical groundwater model.

Uncertainty ranges were applied as even distributions except for the seepage rate from water management dams, which was applied using a log distribution.

Recovery rates from tails were not included in the uncertainty analysis as there is greater scope for Kalbar to respond to seepage and entrainment rates and alter mine practices. For example, if underdrains are performing with lower effectiveness than expected, then it is likely that Kalbar would adjust the seepage recovery method to maintain acceptable returns. Uncertainty in the returns rate may be mitigated by installing underdrains closer together, or installing seepage recovery bores to extract seepage below the tails..

3 Results

The overall effect of updating the fine tails water recovery rate within the water balance model was an increase in the total water requirements from previously published data in the order of 1.7 gigalitres (GL)/year.

Median yearly transfer rates around the site are shown in Figure 3.1 to Figure 3.3. These show that:

- the total water lost to entrainment and seepage is around 4.7 GL/year (cf. the water balance report which showed 2.8 GL/year lost to entrainment);
- the average water take from the Mitchell River is around 2.9 GL/year (cf. the water balance report which showed 2.9 GL/year); and
- the average water take from a secondary water supply is around 1.7 GL/year (cf. the water balance report which showed less than 0.01 GL/year).

Water sources and uses/losses are displayed in Figure 3.4. A total of 6.3 GL/year is expected to move through the site each year, with on average 46% of this volume supplied from winter fill (2.9 GL/year). Moisture in ore would supply 10% of the site water. Figure 3.4 shows 16% of the incoming water is from rainfall runoff. Most of this would be released from the site through diversions around the site or through offset releases from the freshwater dam, as 8% of outflows are described as controlled releases. The remaining portion of rainfall runoff that is not released represents rain landing on the pit, as this may be harvested and does not require a take and use license.

The largest water uses/losses are due to entrainment in the fine tails and seepage from sand tails. Dust suppression and would use around 6% of the site water.

Year 5

Median annual rainfall with Mean uncertainty result

All values ML/yr

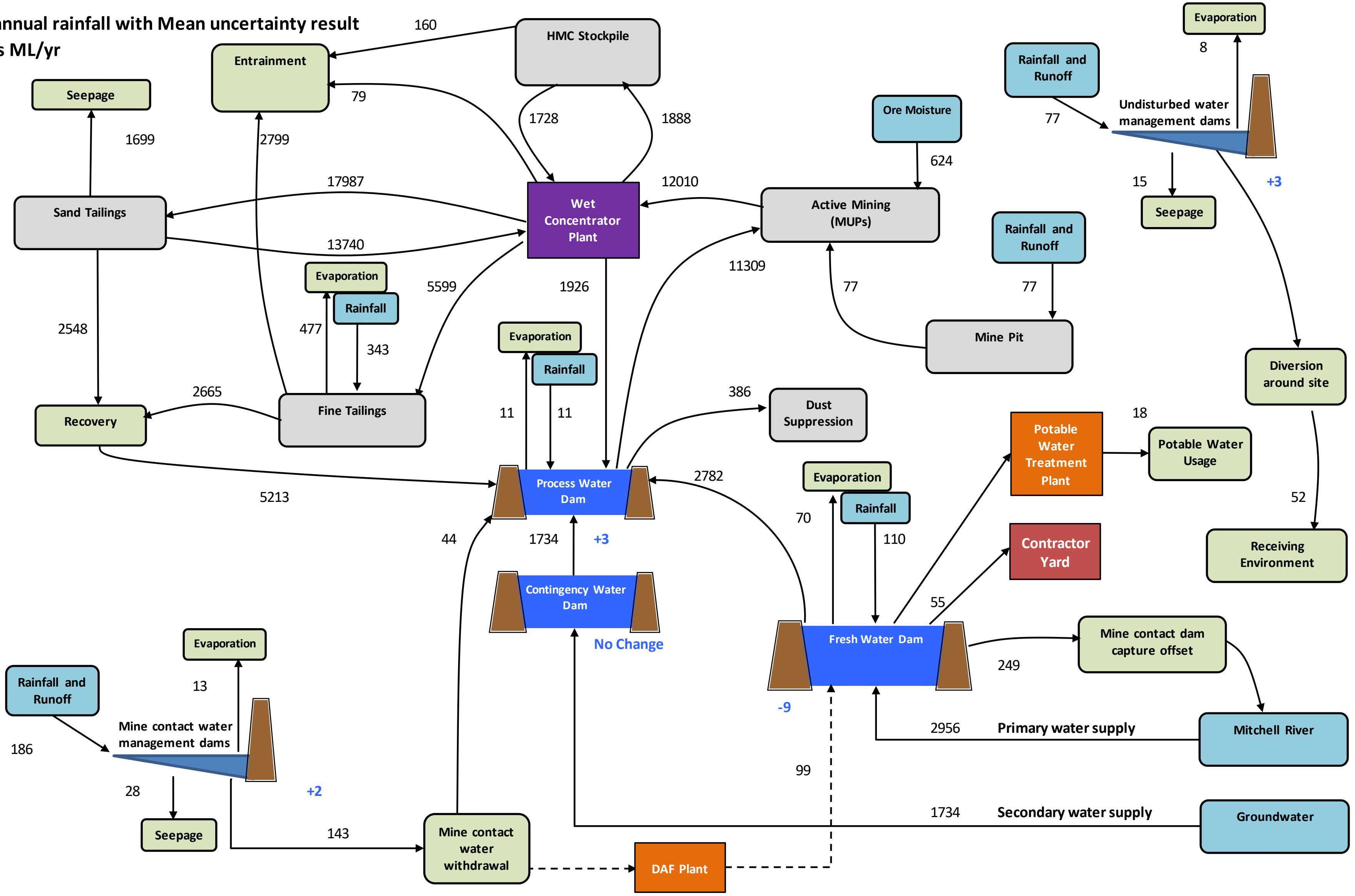


Figure 3.1 Annual transfer rates – Year 5 – Median conditions (black: flow rates; blue: change in storage over the year)

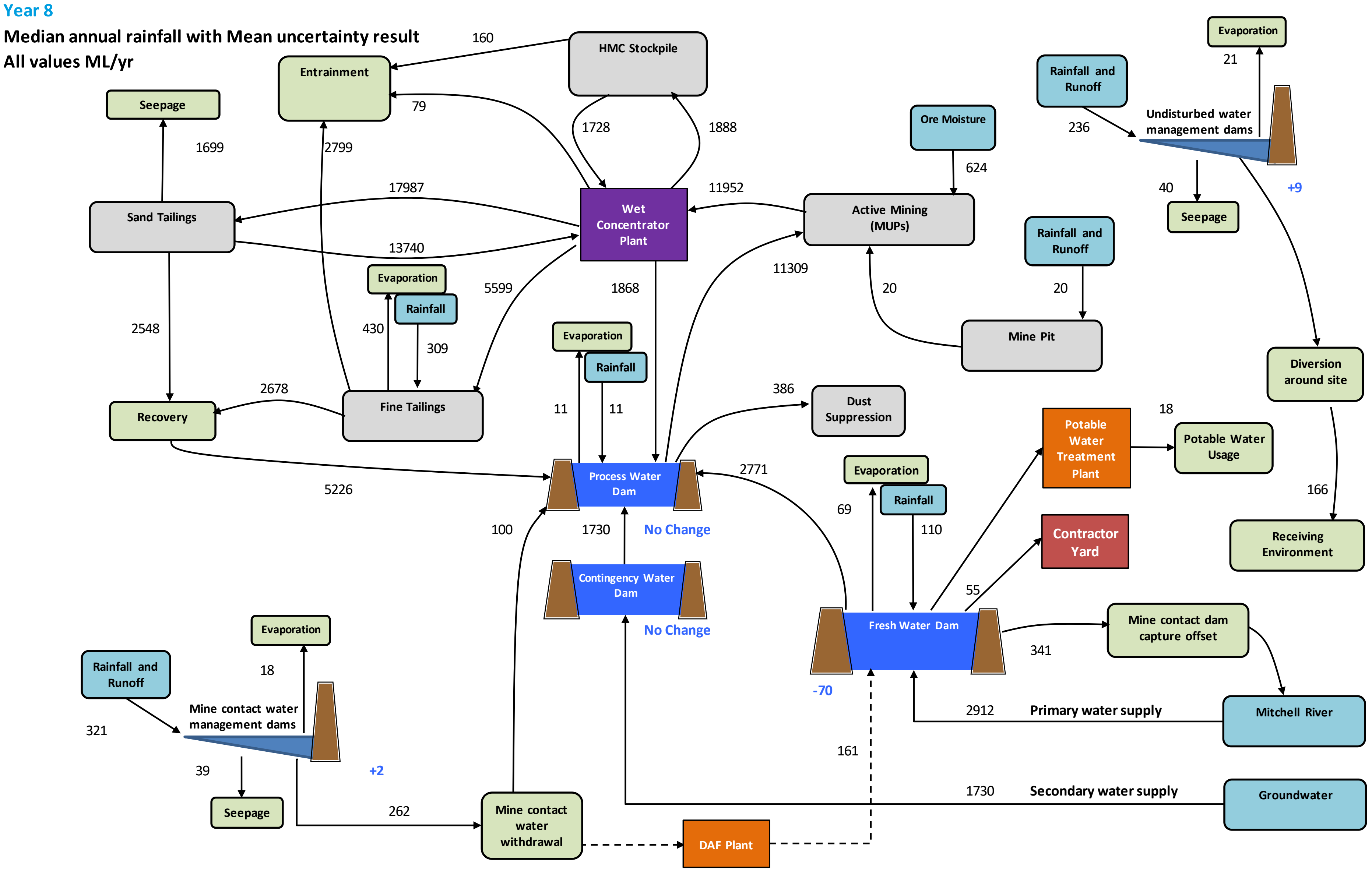


Figure 3.2 Annual transfer rates – Year 8 – Median conditions (black: flow rates; blue: change in storage over the year)

Year 15

Median annual rainfall with Mean uncertainty result

All values ML/yr

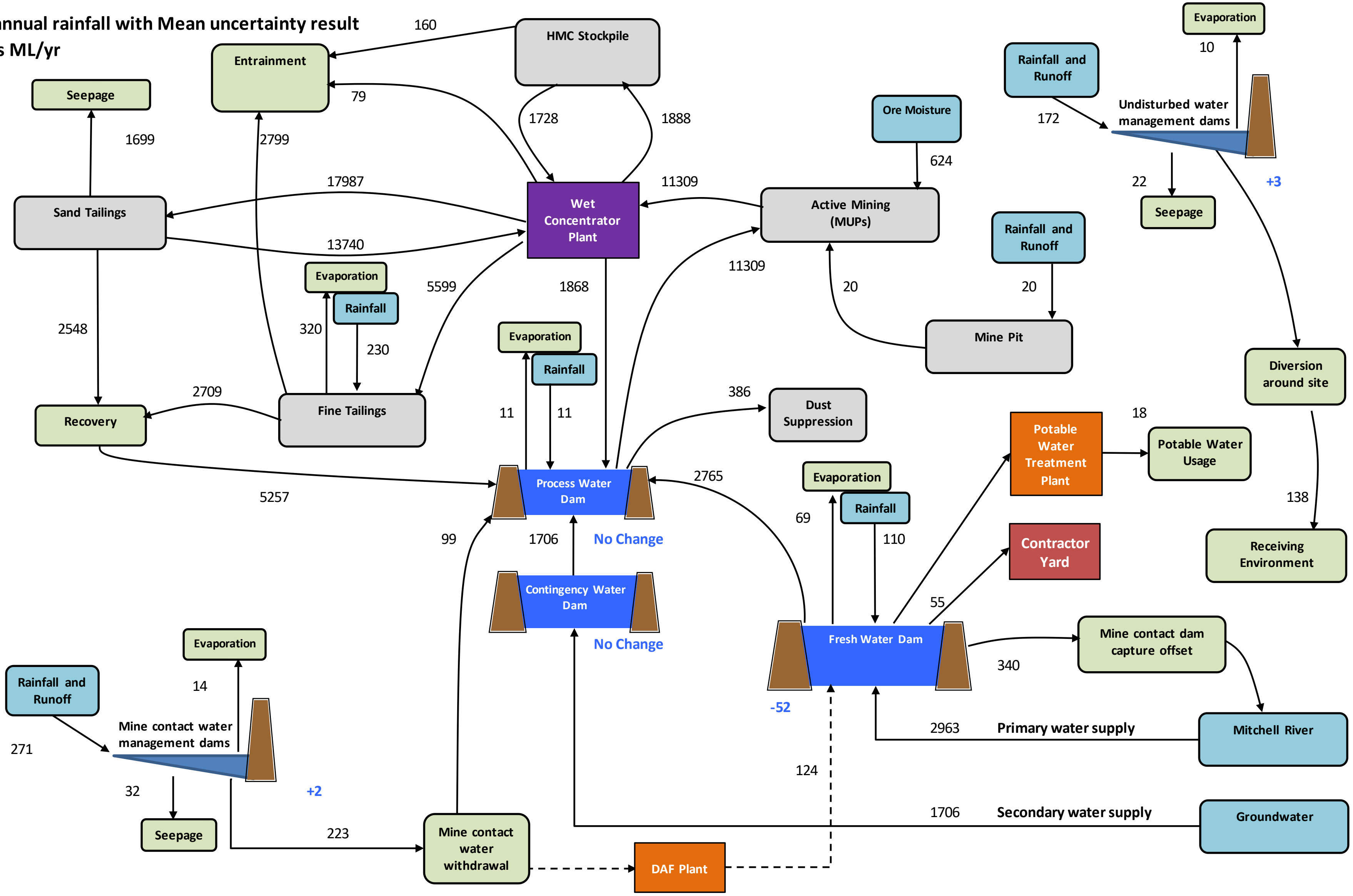
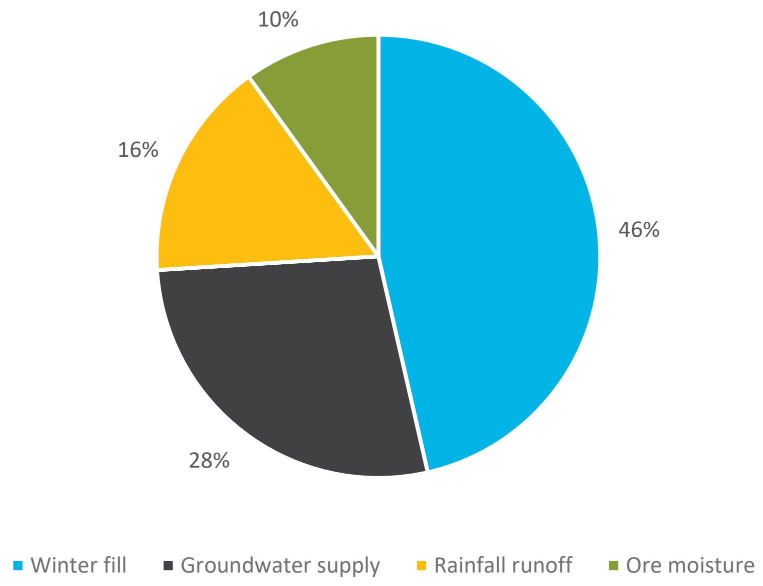


Figure 3.3 Annual transfer rates – Year 15 – Median conditions (black: flow rates; blue: change in storage over the year)



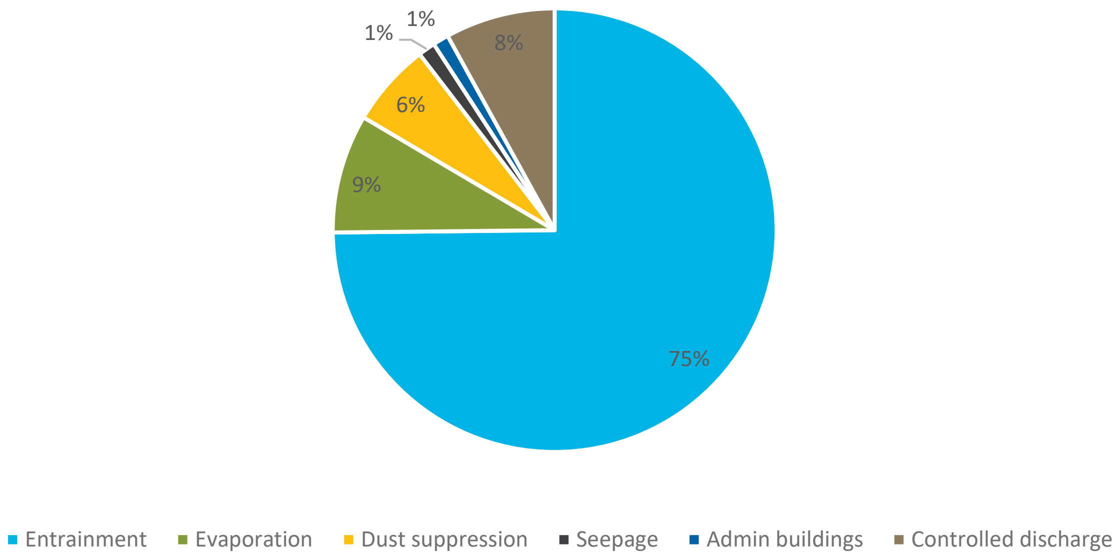


Figure 3.4 **Water balance (in: top; out: bottom) (year 8 mine layout) (total in/out volume 6.3 GL/year)**

In years with higher river flows, the water required by the site would be sourced from the Mitchell River and groundwater.

In drought years the river flow may not exceed the threshold flow rate that allows winter fill take, and the take of water from the Mitchell River would be limited (see 1983, 1995, 1998, and 2007 in Figure 3.5). In these years, the mine would utilise water stored in the freshwater dam, and rely more heavily on groundwater (Figure 3.6).

Groundwater will be required in all years (Figure 3.6) with take concentrated in the months January to June after the freshwater dam is depleted and before the winter fill period commences. At the commencement of the winter fill period, river water would be used to fill the freshwater dam while groundwater would continue to be pumped to supply the site, leading to (in the model) higher than average total take in years following restricted take as depleted storages are refilled (Figure 3.7). The actual timing of water take in these situations would depend on operator decisions, and it is possible that increased groundwater use may begin earlier given drought forecasts, resulting in groundwater use coinciding with reduction in surface water use rather than following it..

The time series groundwater extraction rates of Figure 3.6 are presented as a frequency distribution in Figure 3.8, which shows that in 90% of years the groundwater requirement would be more than 1,400 ML. The maximum groundwater requirement is shown to be 3.7 GL/year. The result from the exhibited water balance report is illustrated for comparison, showing that the reduction in fine tails water recovery has increased the expected groundwater utilisation.

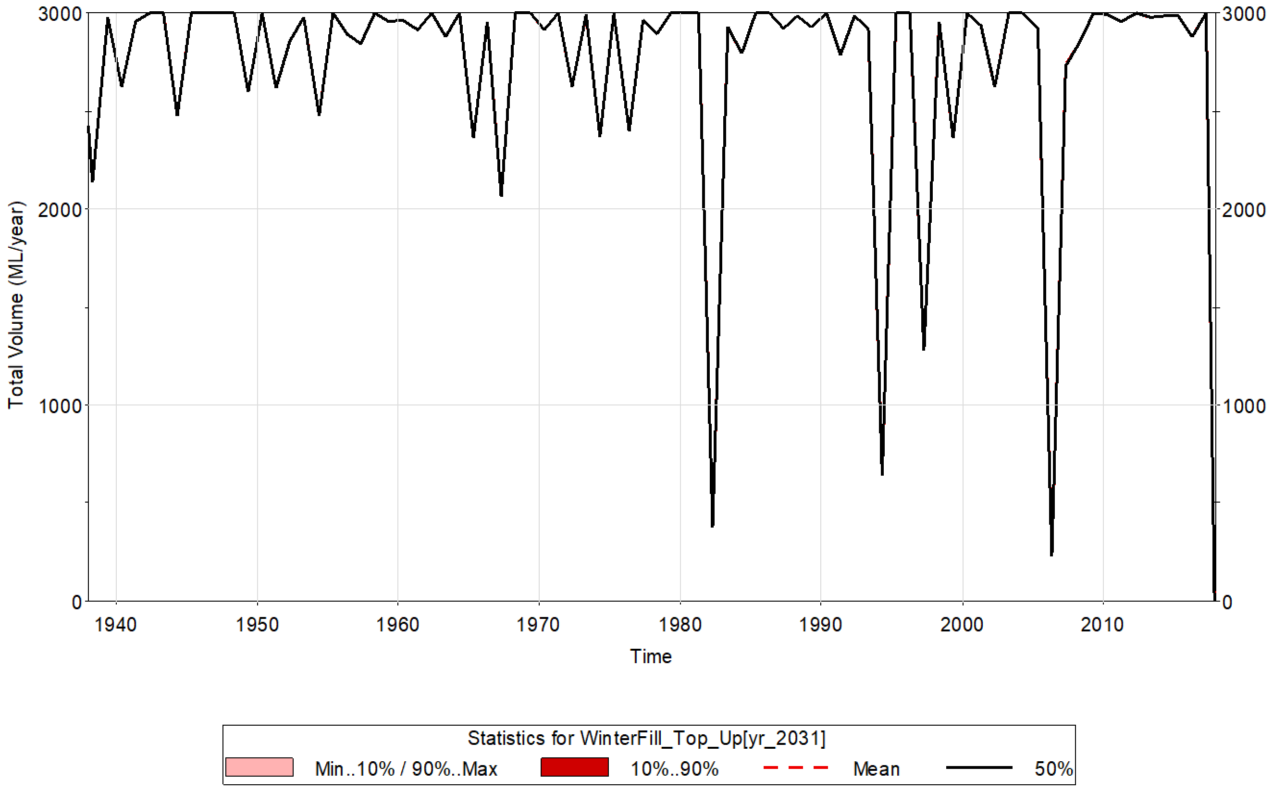


Figure 3.5 Modelled winter fill take (year 8 mine layout)

The uncertainty analysis developed based on evaporation and water management dam seepage uncertainty did not result in a range of results for the winter fill take presented in Figure 3.5 as the model found the site to require significantly more water than could be supplied from the winter fill allocation. In each model run the model took the maximum portion of winter fill water available, with no variance between runs.

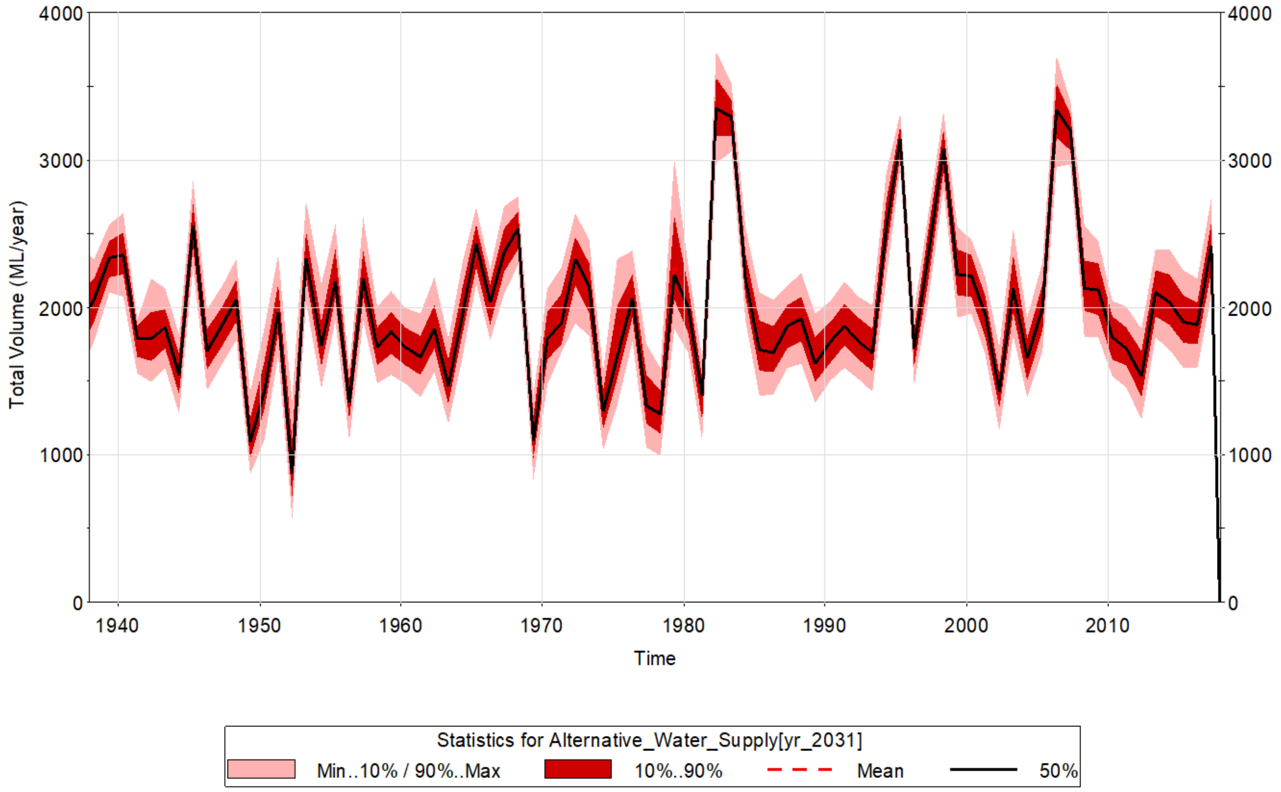


Figure 3.6 Modelled reliance on groundwater (year 8 mine layout)

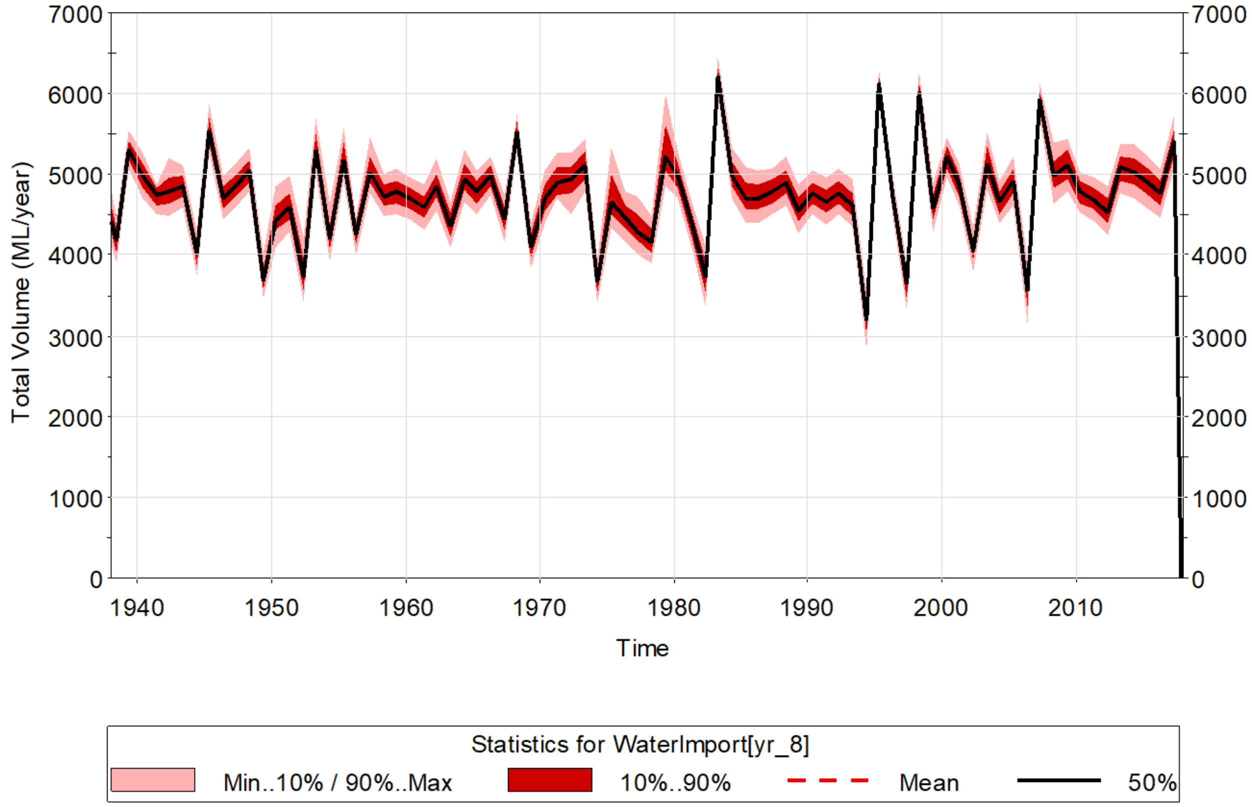


Figure 3.7 Total volume required from surface water and groundwater (year 8 mine layout)

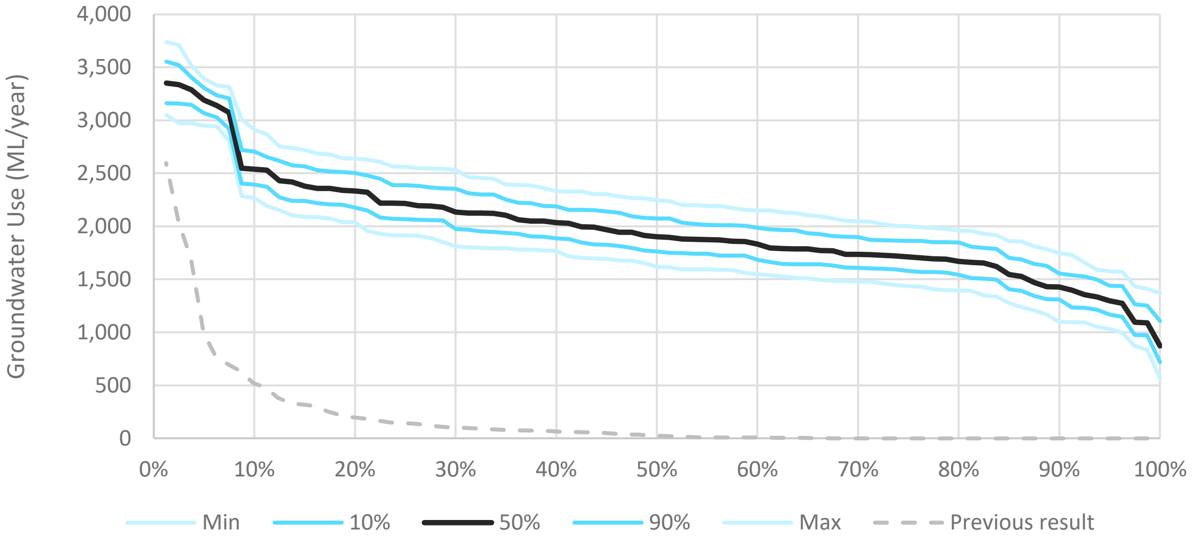


Figure 3.8 **Groundwater volumes required (year 8 mine layout)**

With the previous model assumptions the fresh water dam would fill each winter, but with the revised data the dam would rarely fill and would be drained within a short period, leaving the site dependent on continuous groundwater supply.

In the modelling presented in the EES, the DAF plant could not operate when the freshwater dam was full. During winter, the freshwater dam was filled from the river, and subsequent rainfall could not be treated by the DAF, leading to water management dams retaining water. The updated modelling with higher demands resulted in the freshwater dam being full less frequently, allowing the DAF plant to operate through winter. This resulted in a lower probability of spills from water management dams than reported in the EES.

The probability of water management dams overtopping and releasing water to the Perry River catchment reduced to zero events predicted through 116 years of historical climate (Figure 3.9).

The frequency of spill to the Mitchell River catchment was also reduced, with a yearly spill probability of between 0% and 0.9% (up to one spill modelled over the 116 year climate record) when the mine was configured in the year 8 layout.

No spills to the Perry River are estimated as shown Figure 3.9. The average probability of spill to the Mitchell River estimated from Figure 3.10 is less than 1% p.a. over the mine life. These estimates are coarse as they are based on snapshots of three mine layouts only, and a more graduated assessment would obtain a slightly different result.

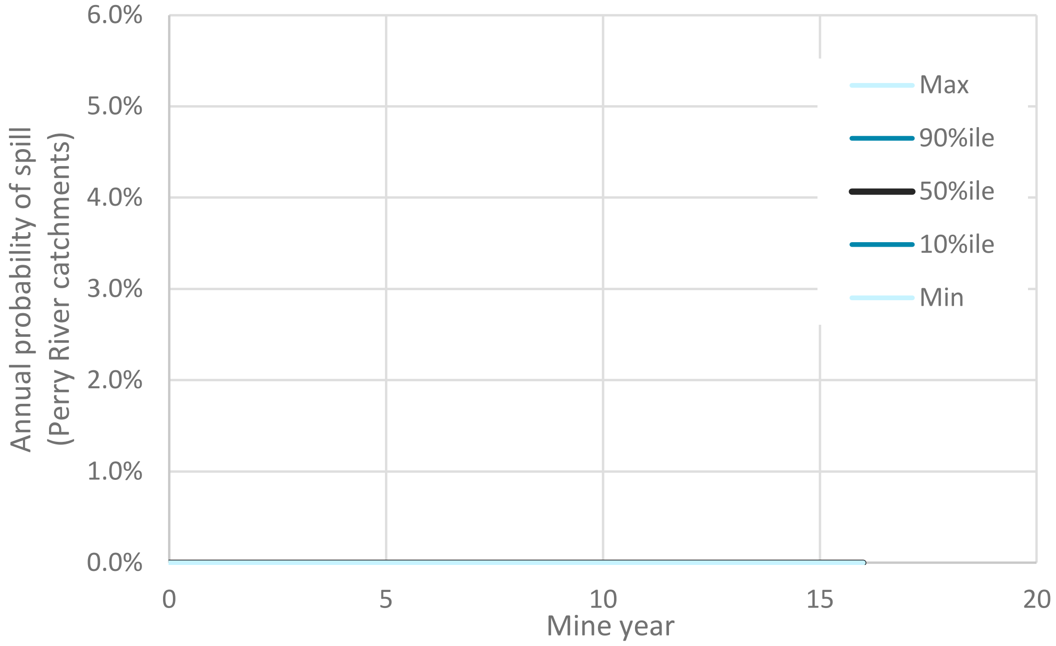


Figure 3.9 Predicted frequency of water management dam spill to Perry River

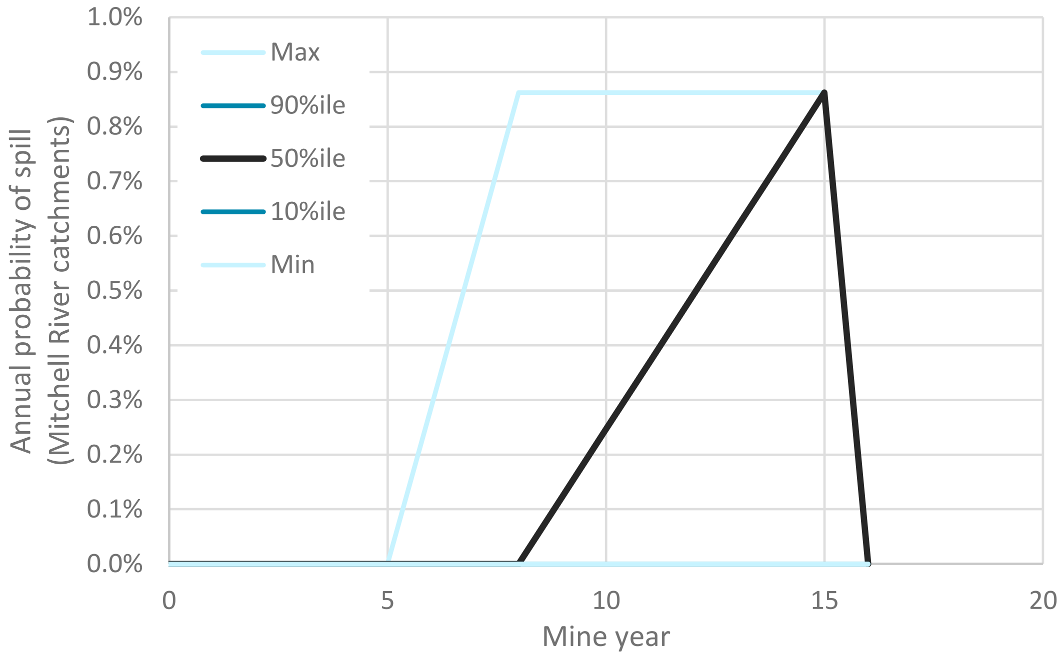


Figure 3.10 Predicted frequency of water management dam spill to Mitchell River

4 Conclusion

A fine tails water recovery rate of 50% would result in an additional 1.7 GL/year water use above that described in the EES. The water sources required and the overall management of water on site remain similar to the concept presented in the water balance report. However, a much greater reliance on groundwater as an alternative water supply would be required. The additional water would be entrained in the fine tails, with an increased volume evaporating. It is expected that seepage to groundwater would remain unchanged.

The annual probability of water management dam spills to the Perry River catchment, and the Mitchell River catchment are reduced form the previous reported values. This is due to an increased opportunity to dewater the water management dams to the freshwater dam and process water dam which maintain lower storage levels as a result of the additional (1.7 GL/year) water requirements.

The previous analysis showed that up to 2.6 GL of groundwater may be required when river water was not available, and that ground water would be required in 50% of years. The updated analysis presented here shows that groundwater is required every year up to a maximum of 3.7 GL/year.

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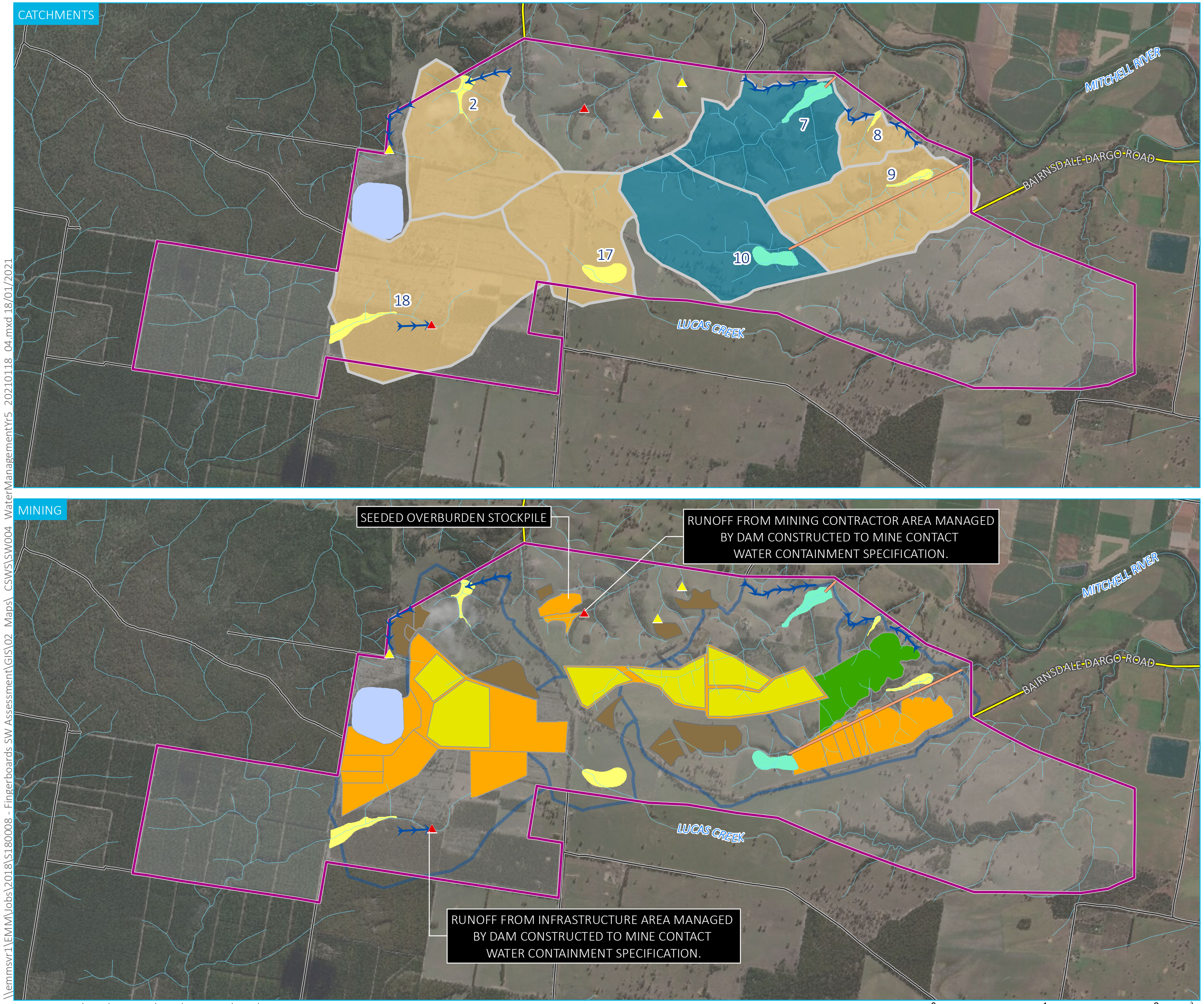

Source: EMM (2021); DELWP (2019); KALBAR (2018)

KEY

- ▲ Sedimentation dam
- ▲ Infrastructure and contractor area dam
- ═ Main road
- — Local road
- — Watercourse/drainage line
- ⤚ Diversion bund
- — Indicative discharge pipeline
- ☐ Project boundary
- ☐ Catchment area
- ■ Catchment area - mine contact
- ■ Catchment area - undisturbed
- ■ Freshwater dam

Dam location

- ■ Mine contact
- ■ Undisturbed

Year 5 mining status

- ■ Mining activity
- ■ Rehabilitation activity
- ■ Soil stockpile
- ■ Fine tailings cells

Water management concept
Year 5

Fingerboards mineral sands project
Conceptual surface water management strategy and water balance
Figure 5.2

creating opportunities

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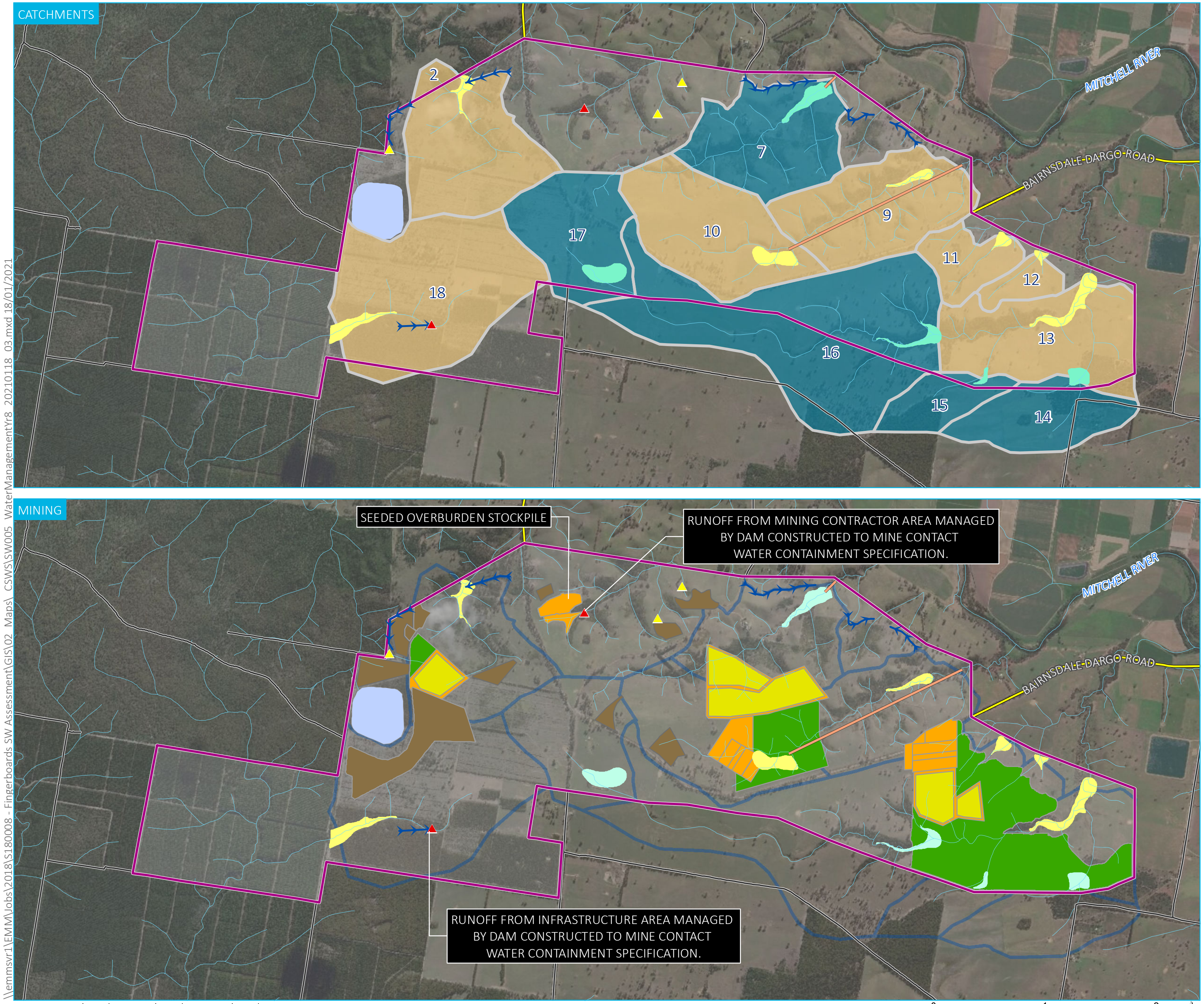

SEEDED OVERBURDEN STOCKPILE

RUNOFF FROM MINING CONTRACTOR AREA MANAGED BY DAM CONSTRUCTED TO MINE CONTACT WATER CONTAINMENT SPECIFICATION.

RUNOFF FROM INFRASTRUCTURE AREA MANAGED BY DAM CONSTRUCTED TO MINE CONTACT WATER CONTAINMENT SPECIFICATION.

Source: EMM (2021); DELWP (2019); KALBAR (2018)

KEY

- ▲ Sedimentation dam
- ▲ Infrastructure and contractor area dam
- ═ Main road
- — Local road
- — Watercourse/drainage line
- ⤚ Diversion bund
- — Indicative discharge pipeline
- ☐ Project boundary
- ☐ Catchment area
- ■ Catchment area - mine contact
- ■ Catchment area - undisturbed
- ■ Freshwater dam

Dam location

- ■ Mine contact
- ■ Undisturbed

Year 8 mining status

- ■ Mining activity
- ■ Rehabilitation activity
- ■ Soil stockpile
- ■ Fine tailings cells

Water management concept
Year 8

Fingerboards mineral sands project
Conceptual surface water management strategy and water balance
Figure 5.3

creating opportunities

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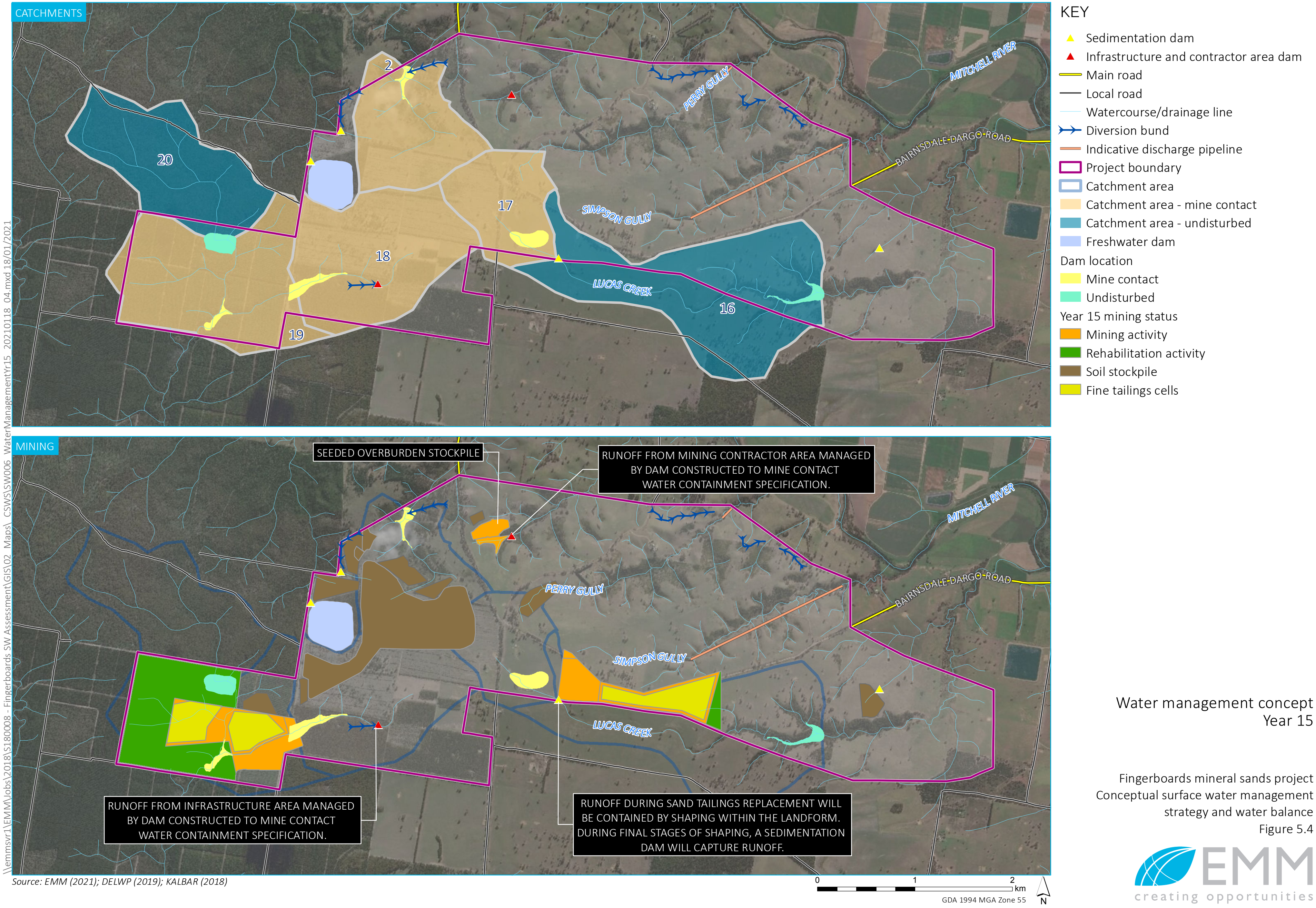

Source: EMM (2021); DELWP (2019); KALBAR (2018)

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Water management concept
Year 15

Fingerboards mineral sands project
Conceptual surface water management strategy and water balance
Figure 5.4

Appendix D

Detailed response to submissions

Table D.1 Response to submissions

Issue	Submission No.	Response	Any recommended new or modified mitigation measures
The Mitchell River doesn't have enough water for current users without restrictions, where will the additional 3 GL come from?	**267** **319** **344** **355** **365** **375** **384** **389** **390** **652** **781** **787**	The site would not seek to take water during the summer irrigation season when water resources are scarce. The site would only take water during winter months, and only during relatively high flow periods when the extraction would not affect current users. The site would take up to 40 ML/day only when the river flows are greater than 1,400 ML/day. During drought conditions, the winter fill threshold flow rate would not be met and the site would take no water from the river. If climate change reduces river flows during the winter fill period to below the winter fill threshold flow rate, the site would take no water from the river. If river water were not available due to low flow conditions, the site would obtain groundwater, or reduce production rate. .See also Mitigation measure SW01: "Surface water will be extracted from the Mitchell River in line with the conditions, timings, and limits detailed in any licence issued by Southern Rural Water." Regulatory oversight of water extractions would be applied to enable sharing of water resources by all water users.	-

Offset water releases will be complex to manage	**291**	A detailed plan for managing the runoff offset arrangements will be developed if the project EES is approved. It is likely that a plan would involve: • detailed survey of each water management dam so that the depth to volume relationship is known • installation of depth loggers in each dam with telemetry so that dam depth records will be automatically recorded at set periods, for example every hour • the depth data would be converted to volume estimates using the depth to volume relationships • the catchment runoff volumes would be calculated whenever dam levels increase due to runoff • a site water balance would be maintained tracking runoff volumes captured, volumes pumped to/from storages, and volumes released to the environment • the water balance model framework would be updated whenever dam arrangements are altered, likely more than once per year given the number of dams involved • releases to the environment would be made as soon as practical after rainfall events using designed release infrastructure and flow rates to prevent erosion at the release point See also Mitigation measures: • SW04 describing the development of a surface water sub-plan to manage water capture and release. • SW11 describing a water balance approach to dam design • SW24 runoff from undisturbed ground will be diverted around disturbance areas where possible • SW28 surface water will be managed with an adaptive management strategy SW32 mine contact water within the Perry River catchment will be emptied as a priority over those in the Mitchell River catchment	**Daily tracking of dam water volumes via depth sensors and telemetry** **Daily tracking of water volumes on site using a water balance model** **Modify SW04 to remove reference to 10% AEP retention as current modelling indicates greater retention is possible, and this number is inconsistent with SW11**

Table D.1 Response to submissions

Issue	Submission No.	Response	Any recommended new or modified mitigation measures
Kalbar plans to discharge polluted water	**335**	The Fingerboards site would be a net user of water. Water would be discharged only for one of two reasons: 1) To maintain flows in the Mitchell River and Perry River by replacing intercepted stormwater with stored river water or treated stormwater. Water quality would be tested prior to release, and these releases would be made solely for environmental benefit. 2) Rainfall runoff would be intercepted by sediment dams and water management dams, and soil particles would settle in the dams. If these dams overflow during extended wet periods, the excess stormwater would enter the receiving waterways and join runoff from urban and agricultural land. In some locations these dams will be designed to International Erosion Control Association Australasia's Best Practice Erosion and Sediment Control (BPESC) (IECA, 2008) guidelines. Where possible, larger water management dams will be constructed to bring the probability of discharge as close to zero as practical (average 1.5% annual probability over the project life anticipated via water balance modelling).	**Water quality testing of the freshwater dam to confirm and document that water is suitable for release to the environment**

Table D.1 Response to submissions

Issue	Submission No.	Response	Any recommended new or modified mitigation measures
Water management dams were sized for a 1% AEP rainfall event but modelling indicates that in the absence of the DAF plant the dams would spill for anything larger than a 10% AEP event. Relying on the DAF plant is unwise as it it could fail.	**358**	Kalbar proposes that when mine contact water is stored in water management dams, it can be taken to the process water dam at 8 ML/day and used in the mine plant, or to the DAF plant at 24 ML/day and then stored in the fresh water dam. If the DAF plant were offline, the dams could still be drained at a rate of 8 ML/day. Any down time for DAF plant maintenance would likely be in the order of a few days. Unscheduled DAF plant breakdown and weather sequences which may cause water management dams to fill are both very rare event, and the probability of these happening at the same time is negligible. See also Mitigation measures: SW33 the DAF plant will be required only when successive storm events require dams to be dewatered at a rate greater than can be achieved through process water demand	**The DAF plant should be used regularly for short periods to confirm operability**
Changing climate will lead to lower availability of winter fill water	**663**	Yes. It is acknowledged that winter fill may not be available every year, and that a secondary water supply would be required to maintain mine operations at full capacity	-
If allowance for dust suppression is made, it is likely that the site will need more water than described	**663**	The water balance model included allowance for dust suppression volumes, at a rate of 375 ML/year.	-

Table D.1 Response to submissions

Issue	Submission No.	Response	**Any recommended new or modified mitigation measures**
The open cut area will need a large volume of water for dust suppression	**663**	The mined sand is expected to have a field moisture capacity and moisture content sufficient to negate the need for dust suppression in the actively mined region of the pit. The area of the pit being filled with sand tails will be wet through the deposition of tails and will not need additional water added to prevent dust.	-

Table D.1 Response to submissions

Issue	Submission No.	Response	Any recommended new or modified mitigation measures
How was the 3% AEP spill design criteria determined	**716**	The criteria was set after water balance analysis as the practical limit of what could be achieved at site given the topography, climate conditions, and rates of water use on the site. The 3% spill rate was determined using the assumption of 80% water recovery from fine tails. The updated model with 50% recovery presented in this witness statement and annexures had a spill rate of below 1% per annum. See also Mitigation measures: • SW11 "A daily water balance approach will be applied to dam design to achieve a probability of spillway activation of once per 100 years on average (1% average-exceedance probability) for Perry River catchments, and three times per 100 years on average (3.3% average-exceedance probability) for Mitchell River catchments." • SW32 Mine contact water within the Perry River catchment will be emptied as a priority over those in the Mitchell River catchment SW33 The DAF plant will be required when successive storm events require dams to be dewatered at a rate greater than can be achieved through process water demand	-

Table D.1 Response to submissions

Issue	Submission No.	Response	Any recommended new or modified mitigation measures
Releases from the fresh water dam using DAF outputs could cause water quality problems in the Mitchell River if there is insufficient flow to allow dilution.	**638** **514** **716**	A dilution assessment has been undertaken using water balance model results and attached in Annexure C. This assessment showed that any constituents within DAF outputs would usually be diluted more than 100:1 when environmental flow releases are made to the Mitchell River.	-
The water balance should be expanded to assess modelling assumptions such as dam seepage rates, dust suppression demand etc	**716**	An expanded uncertainty analysis has been completed and is described in Annexure C.	-

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