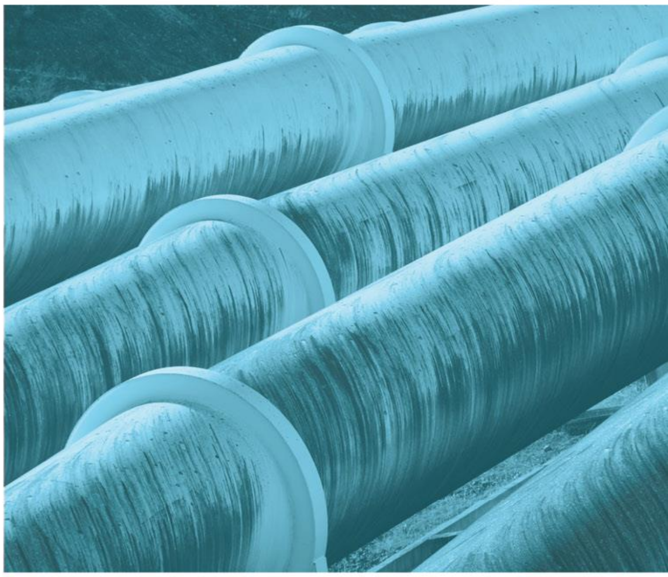
Addendum to Expert Witness Statement of Jarrah Muller

In the matter of the Fingerboards Mineral Sands Project EES

Prepared for Kalbar Operations Pty Ltd
February 2021



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Perth WA 6000

CANBERRA
PO Box 9148
Deakin ACT 2600

Addendum to Expert Witness Statement of Jarrah Muller

In the matter of the Fingerboards Mineral Sands Project EES

Inquiry and Advisory Committee
Proponent: Kalbar Operations Pty Ltd

Kalbar Operations Pty Ltd
February 2021

EMM Adelaide
Level 1, 70 Pirie Street
Adelaide SA 5000

T 08 8232 2253
E info@emmconsulting.com.au

www.emmconsulting.com.au

Addendum to Expert Witness Statement of Jarrah Muller

In the matter of the Fingerboards Mineral Sands Project EES

Client

Kalbar Operations Pty Ltd

Date

8 February 2021

Final

Prepared by

J Muller

Jarrah Muller
Associate Civil Engineer
8 February 2021

1 Addendum to expert witness statement

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

This document is an addendum to my export witness statement previously provided to the Inquiry and Advisory Committee (IAC). This addendum relates to consideration of the proposal by Kalbar Operations to dewater the fine tails stream using centrifuges, as described in a letter to the IAC dated 18 Jan 2021.

2 Scope and method

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

2.2 Additional work undertaken since preparation of the witness statement

Since preparation of the witness statement, the water balance model and results were updated following the letter from Kalbar to the IAC dated 18 January 2021 describing an error in the assumed efficiency of fine tailings dewatering plant and a change to use centrifuges to allow improved dewatering rates. Updated results are supplied as attachments in Appendix A.

3 Findings

3.1 Model Assumptions

A number of assumptions are included in the water balance model and are described in my expert witness statement.

A description of the assumptions which would change if centrifuges are adopted are provided below.

3.1.1 Water losses

i Entrainment, evaporation and seepage from fine tails

In November 2018, Kalbar advised EMM that ‘Mud Masters’ would be used to extract water from fine tails within tails cells. The tails cells were assumed to comprise of tails beaches and a decant pond.

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 Megalitres (ML)/day, and evaporation from the wet beach was estimated as [0.7 x pan evaporation rate].

Kalbar subsequently issued advice via a letter to the IAC dated 18 Jan 2021 that centrifuges could be used to achieve a water recovery rate of 80% to maintain the overall water balance, with fine tails placed as dried material. There would subsequently be no fine tails cells, beach or decant pond. The water balance showed that the adoption of centrifuges would reduce water loss from fine tails entrainment from 2.8 Gigalitres (GL)/year to 1.4 GL/year.

The effects of this change on the water balance are discussed further in Appendix A.

ii 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; and
- 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.

Updated data was provided to EMM by Kalbar in January 2021:

- densification of sand slurry to 73% solids by weight using water recovery cyclones, with supernatant water returned to the process plant; and
- 50% of sand tails emplacement water recovered by under-drains.

This updated information provided a rate of 1.15 GL/year lost from sand tailings, which is included in the updated model described in Appendix A.

3.2 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 3.1 Gigalitres (GL)/year (other than refilling storages following depletion during drought). This implies that Kalbar's proposal to obtain a 3 GL winter fill license has the correct magnitude.
- A secondary water supply (assumed to be groundwater) will be necessary.
- 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.

3.3 Water management dams

It is proposed that water management dams would be located on drainage lines downstream of mining activities.

It is proposed that water would be drained from the dams at a rate of 24 ML/day to the Dissolved Air Floatation (DAF) plant and 8 ML/day to the process water dam, for a total of 32 ML/day removed from the dams. The DAF plant would discharge treated water to the fresh water dam, and subsequently can only be operated when the fresh water dam is not full.

If centrifuges are adopted, the project water demand will decrease due to reduced water losses to tails. This will results in lower utilisation of the fresh water dam, and higher volumes of water stored in the fresh water dam for longer periods. During and immediately following the winter fill period, the fresh water dam may be full, and so there could be periods when it is not possible to operate the DAF plant. Subsequently, mine contact rainfall runoff may be stored for longer periods in water management dams if centrifuges are adopted. If mine contact water cannot be immediately treated and removed to the fresh water dam, there will be an increased probability of the dams filling and spilling.

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.

The overall probability of dams filling and spilling based on modelling using the historical climate record is summarised in Table 3.1.

Table 3.1 Water management dam spill probabilities

Mine configuration	Annual spill probability from dams in the	
	Mitchell River catchment	Perry River catchment
Year 5	0%	0%
Year 8	3.4% (4 spills in 116 years of climate data)	0.9% (1 spill in 116 years of climate data)
Year 15	1.7% (2 spills in 116 years of climate data)	0.9% (1 spill in 116 years of climate data)

The probability of spills when using centrifuges is very similar to the probability presented in the water balance report, but higher than that presented in my expert witness statement.

Mitchell River catchment spill probabilities are plotted in Figure 3.1, which shows that over the mine life the average annual probability of a spill is around 1.5%, slightly higher than might be anticipated given the 1% Annual Exceedance Probability (AEP) design criteria. The cumulative probability of a discharge over the 15 year mine life is around 20% (reported as 19% in the water balance model report). If each year of the mine life had been modelled, Figure 3.1 would be a smoother curve and the calculated average probability of spill would be slightly different. Year 8 is the mine year with the maximum disturbance and most number of dams active so it is not expected that any other year would have a higher individual yearly probability of spill.

Appendix A 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 in this addendum.

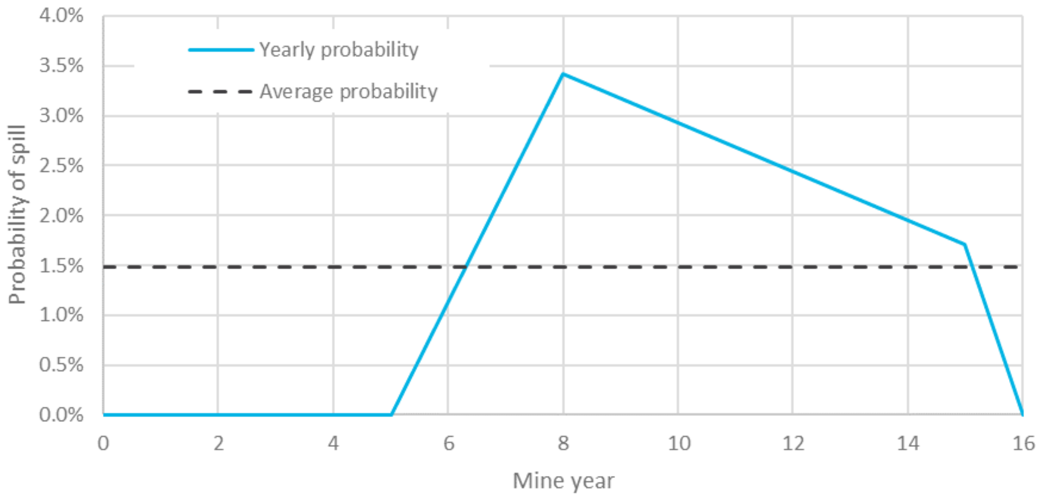

Figure 3.1 Probability of mine contact water spill through the mine life (Mitchell River catchment)

4 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 IAC.

Signed J Muller

Dated 8 February 2021

Appendix A

Additional work completed

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Level 1, 70 Pirie Street
Adelaide SA 5000

T 08 8232 2253
E info@emmconsulting.com.au

www.emmconsulting.com.au

8 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 response to this information, Kalbar developed an option of using centrifuges to achieve 80% water recovery from the fine tails stream so that the water balance described in the EES could be maintained. Kalbar advised the Inquiry and Advisory Committee (IAC) of this design change via a technical note dated 18 January 2021.

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:

- replacing the previous process water balance data relating to Mud Masters with process water balance data relating to centrifuges 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

Wave International provided a revised process water balance comparing the previous data which featured Mud Masters using an incorrect water recovery rate and new information describing water recovery using centrifuges. The required changes to the site water balance model to adopt centrifuges 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 apply centrifuges

Item	Data used in EES model	New data
Sand tails		
Water in sand tails cyclone feed	17,850 ML/year	11,790 ML/year
Water recovered from sand tails cyclones	13,585 ML/year	9,480 ML/year
Water recovered via tails underdrains	2,560 ML/year	1,155 ML/year
Water lost to seepage	1,705 ML/year	1,155 ML/year
Fine Tails		
Water in fine tails feed	5,600 ML/year	7,270 ML/year
Water recovered	4,490 ML/year	5,810 ML/year
Water lost to entrainment and evaporation	1,110 ML/year	1,460 ML/year
Total water lost to tails	2,815 ML/year	2,615 ML/year
Climate effects	Rainfall on fine tails harvested via the decant pond	Rainfall runoff from dried fine tails directed to pit sumps

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 500 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. Likewise, water recovery from fine tails could be adjusted by altering centrifuge parameters or flocculant dosing rates.

3 Results

The overall effect of applying centrifuges within the water balance model was a reduction in the total water requirements in the order of:

- 200 Megalitres (ML)/year (0.2 Gigalitres (GL)/year) from the data provided in the water balance report; and
- 1900 Megalitres (ML)/year (1.9 Gigalitres (GL)/year) from the data provided in my expert witness statement.

These changes are due to:

- achieving a water recovery rate of 80% from the fine tails stream, rather than 50% recovery
- reducing the volume of sand tails and processing a higher volume of material via the fine tails dewatering process.

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 2.6 GL/year (cf. the water balance report which showed 2.8 GL/year lost to entrainment); and
- the average water take from the Mitchell River is around 2.8 GL/year (cf. the water balance report which showed 2.9 GL/year).

Water sources and uses/losses are displayed in Figure 3.4. A total of 3.9 GL/year is expected to move through the site each year, with on average 72% of this volume supplied from winter fill (2.8 GL/year). Moisture in ore would supply 16% of the site water. Figure 3.4 shows 11% 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 9% 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 would use around 10% of the site water.

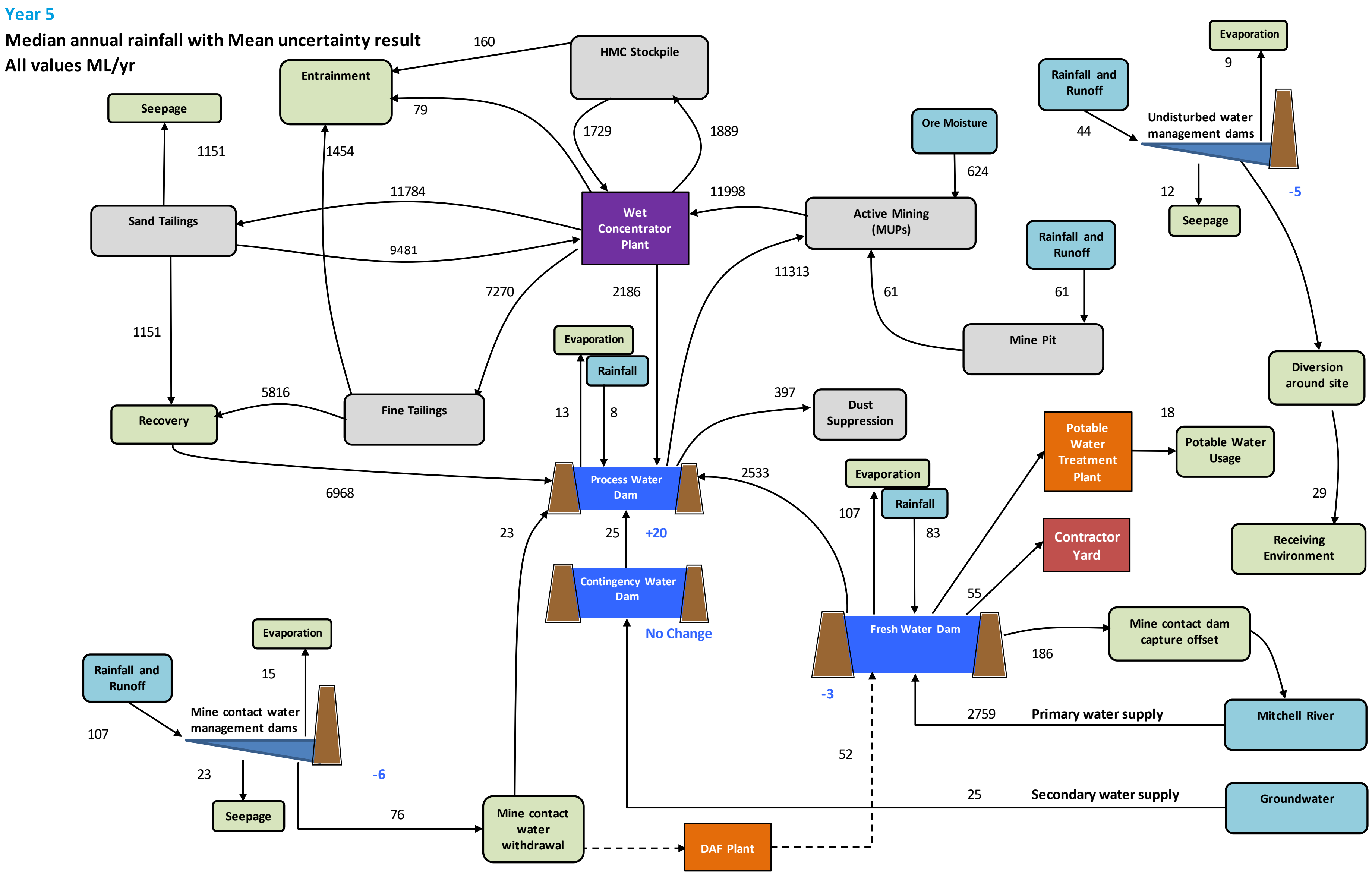
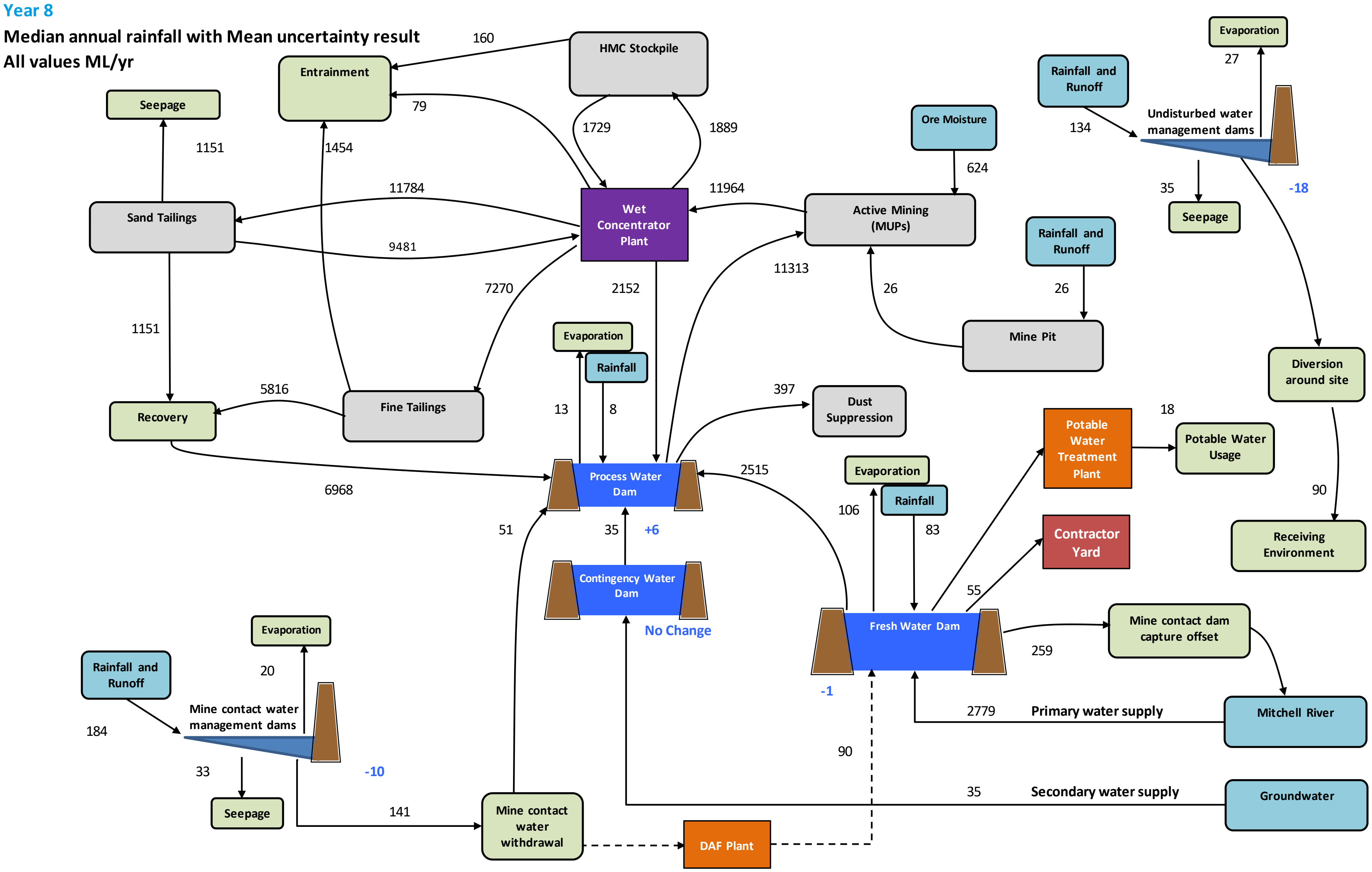


Figure 3.1 Annual transfer rates – Year 5 – Median conditions (black: flow rates; blue: change in storage over the year)


Year 8

Median annual rainfall with Mean uncertainty result

All values ML/yr

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

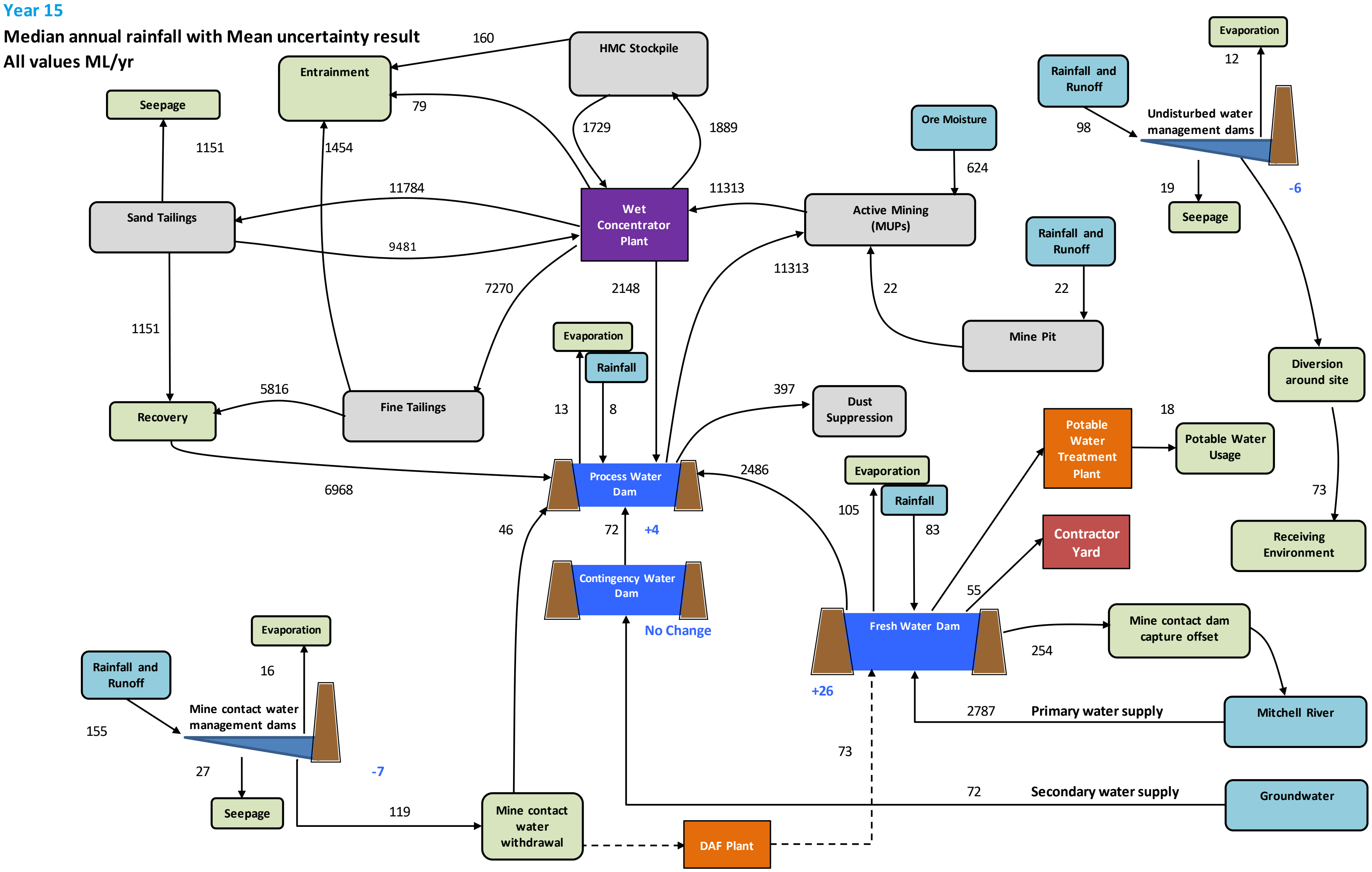


Figure 3.3 Annual transfer rates – Year 15 – Median conditions (black: flow rates; blue: change in storage over the year)

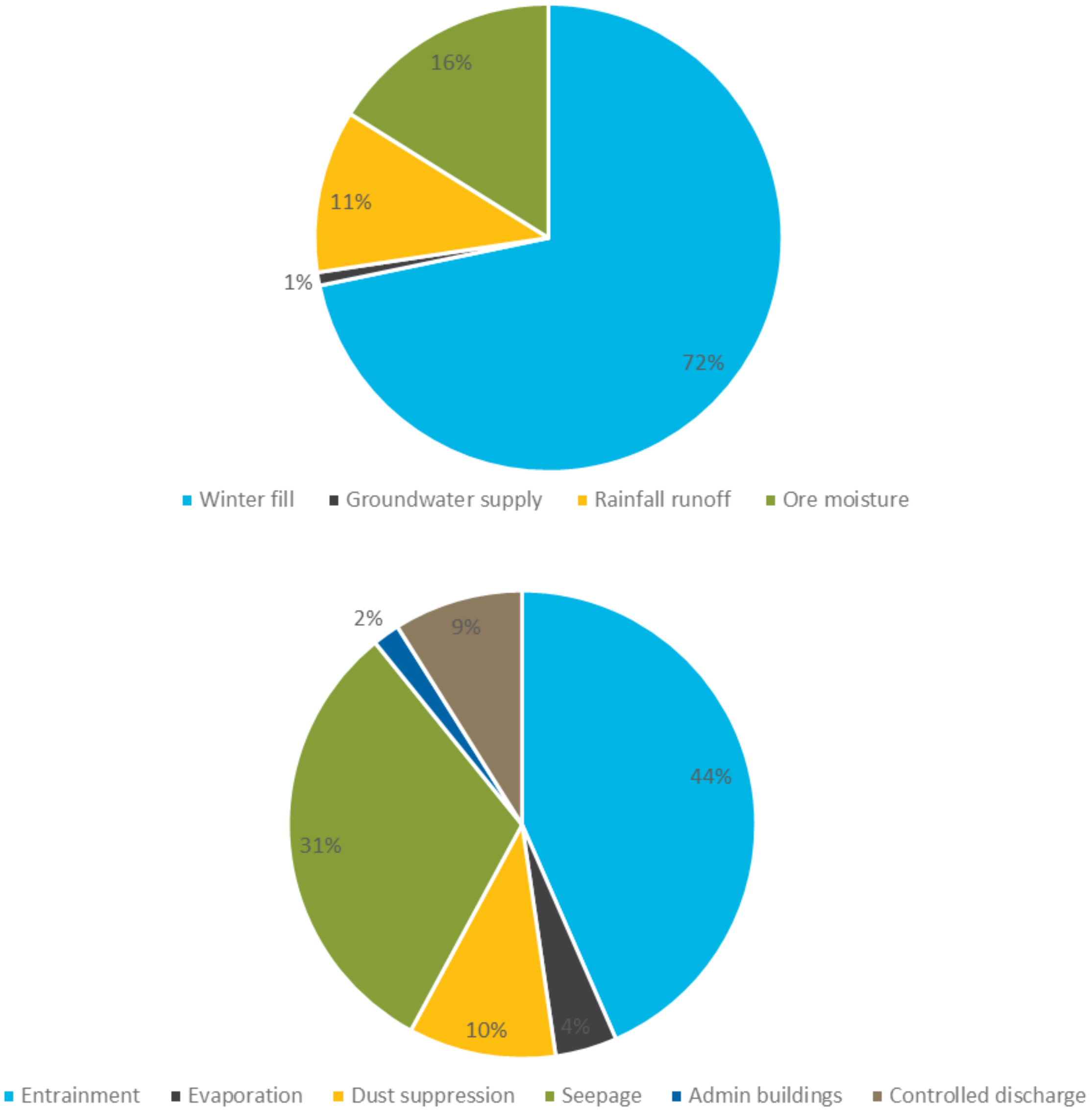


Figure 3.4 **Water balance (In: top; Out: bottom) (Year 8 mine layout) (Total in/out volume 3.9 GL/year)**

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

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 begin pumping groundwater (Figure 3.6) as an alternative water supply when the freshwater dam levels become low.

The groundwater take would be 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 groundwater use may begin earlier given drought forecasts, resulting in groundwater use coinciding with reduction in surface water use rather than following it. If groundwater use started earlier, the freshwater dam would not drain as rapidly and water security would increase.

It is expected (50%ile result in Figure 3.6) that in most years groundwater would not be required. However, the uncertainty analysis showed that there is a possibility (max result in Figure 3.6) that groundwater may be required every year if evaporation loss is higher than expected.

The time series groundwater extraction rates of Figure 3.6 are presented as a frequency distribution in Figure 3.8, which shows that up to 2 GL/year of groundwater may be required infrequently, but that in 90% of years the groundwater requirement would be less than 500 ML. The result from the exhibited water balance report is illustrated for comparison, showing that the reduction in water supply requirements has incrementally reduced the expected groundwater utilisation.

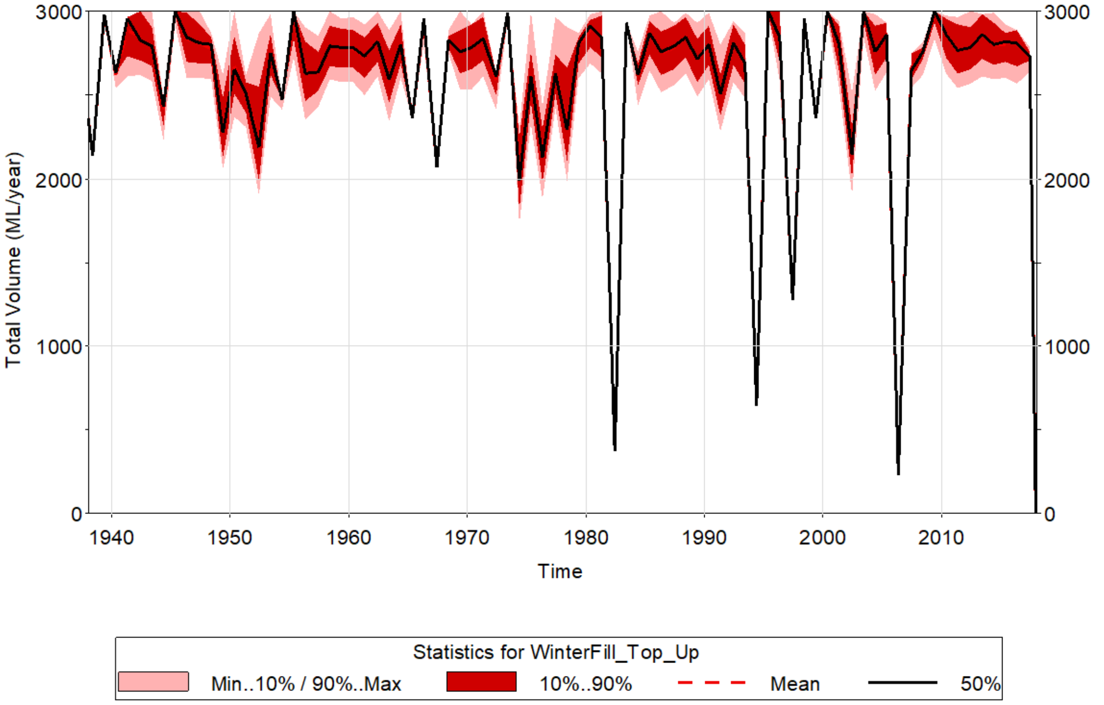


Figure 3.5 Modelled winter fill take (year 8 mine layout)

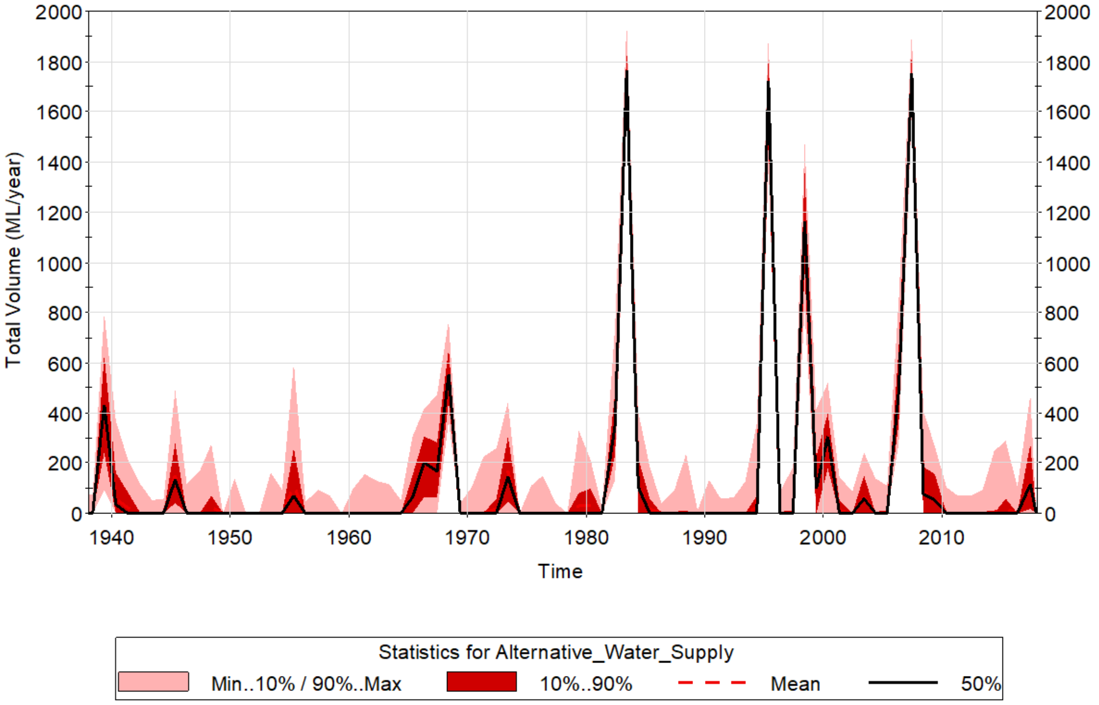


Figure 3.6 Modelled reliance on groundwater (year 8 mine layout)

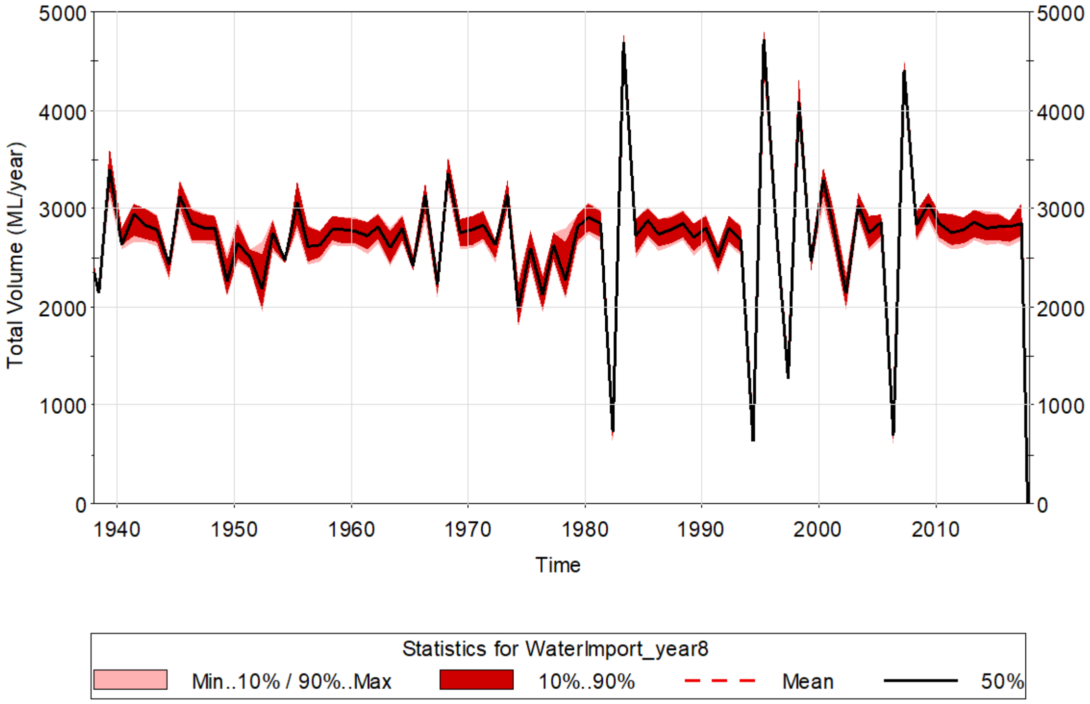


Figure 3.7 Total volume required from surface water and groundwater (year 8 mine layout)

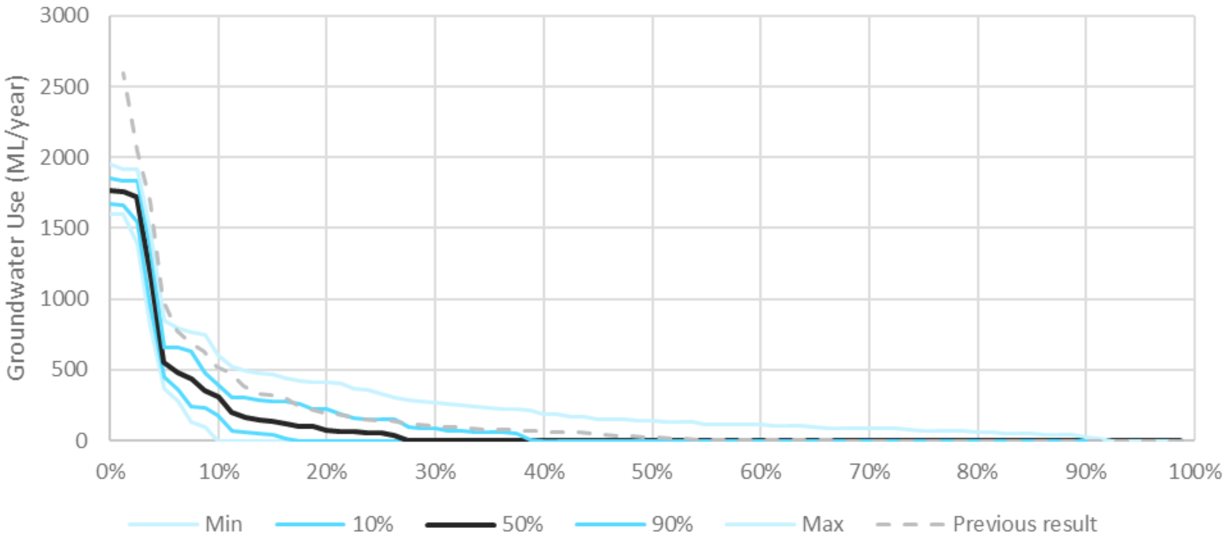


Figure 3.8 Groundwater volumes required (year 8 mine layout)

When compared to the data presented in the EES:

- The probability of water management dams overtopping and releasing water to the Perry River catchment remained unchanged, with one event predicted through 116 years of historical climate (Figure 3.9) when the mine was configured in either the year 8 or year 15 layout; and
- The frequency of spill to the Mitchell River catchment was similar to previous results, though with uncertainty ranges for the year 8 and year 15 mine layout results showing that there is a possibility that the yearly spill probability during year 8 of the mine could be between 1.7% and 5.2% (based on between 2 and 6 spills modelled over the 116 year climate record).

When compared to the data presented in my witness statement:

- the probability of water management dams filling and spilling is increased, due to an increased frequency of DAF plant operation restrictions when the fresh water dam is full.

The average probability of spill to the Perry River estimated from Figure 3.9 is around 0.5% p.a. over the mine life, while the average probability of spill to the Mitchell River estimated from Figure 3.10 is around 1.4% 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.

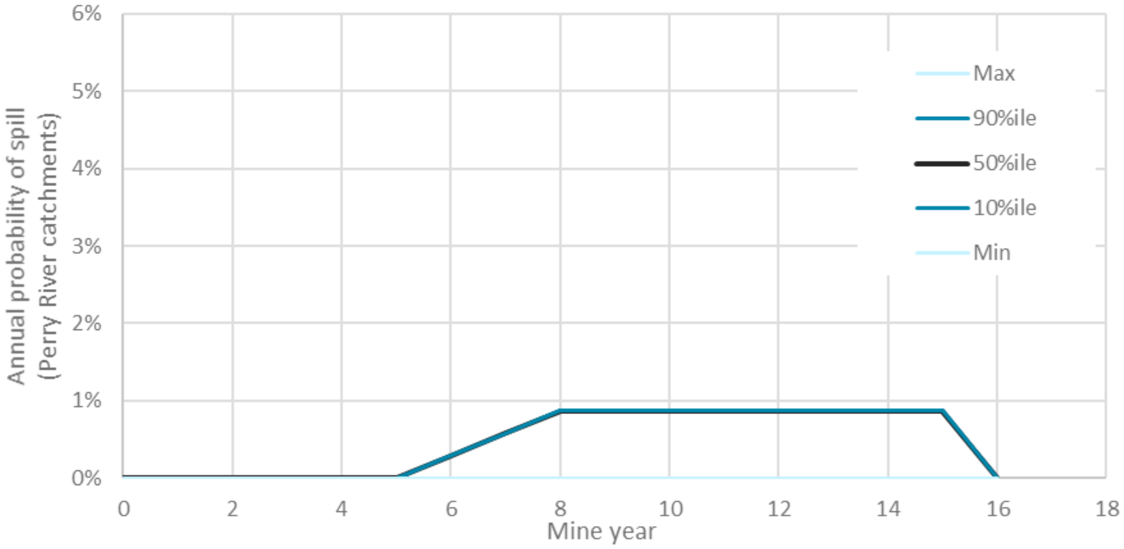


Figure 3.9 Predicted frequency of water management dam spill to Perry River

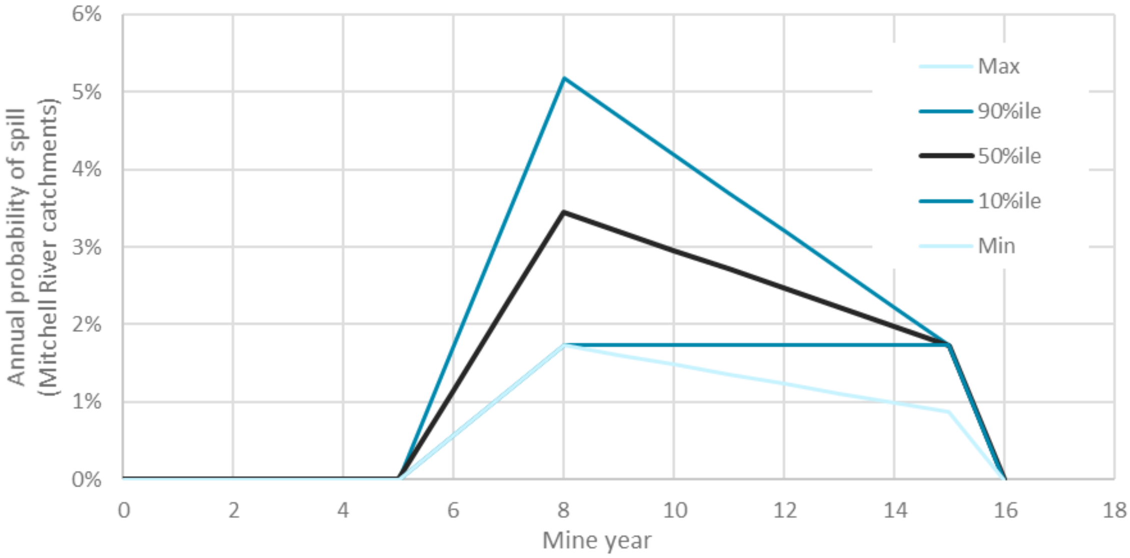


Figure 3.10 Predicted frequency of water management dam spill to Mitchell River

4 Conclusion

Kalbar’s decision to process fine tails using centrifuges will result in a decrease in site water use. The water sources required and the overall management of water on site remain similar to the concept presented in the water balance report, with the exception of the replacement of fine tails cells using a beach and decant pond with the placement of dried material.

The uncertainty analysis has shown that the annual probability of water management dam spills to the Perry River catchment, and the Mitchell River catchment for mine layouts for year 5 and year 15 are insensitive to evaporation rate and seepage assumptions, with the maximum probability of spill in the uncertainty analysis matching the spill probability reported in the exhibited water balance report. The year 8 mine layout could potentially result in a higher annual probability of spill to the Mitchell River than previously reported.

The exhibited water balance report 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 up to 2 GL of groundwater may be required, but that there is a low probability that some groundwater may be required every year.

J Muller

Jarrah Muller
Associate Civil Engineer
jmuller@emmconsulting.com.au

8 February 2021

EMM
creating opportunities

Level 1, 70 Pirie Street
Adelaide SA 5000

T 08 8232 2253
E info@emmconsulting.com.au

www.emmconsulting.com.au

To: Kalbar Operations

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

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

My expert witness statement included a similar technical memo, based on the water balance assuming the use of Mud Masters to dewater the fine tails. The data in this technical memo relates to the water balance after making updates relating to the use of centrifuges to dewater the fine tails stream.

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.

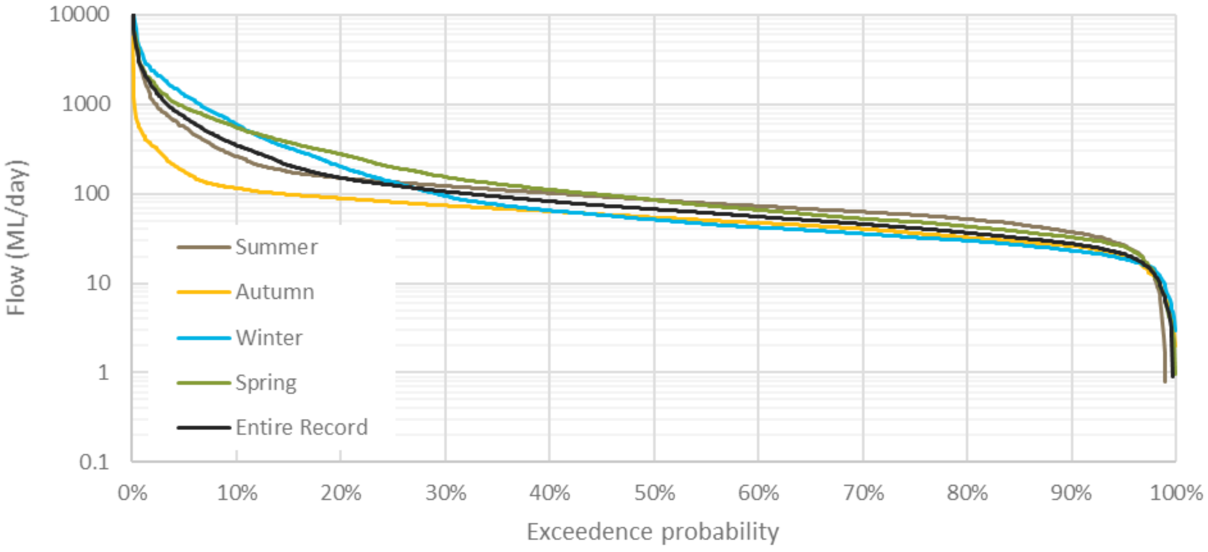


Figure 2.1 **Mitchell River flow duration curve at Glenaladale (gauge site 224222)**

3 Water balance model

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

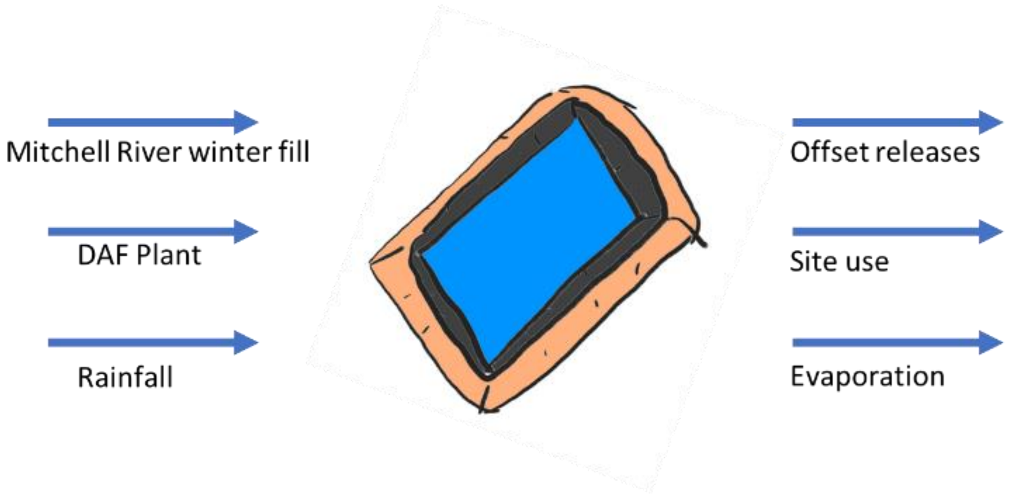


Figure 3.1 **Freshwater dam sources and demands**

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]

---

[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.

- evaporation and precipitation do not remove the tracer; and
- 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.

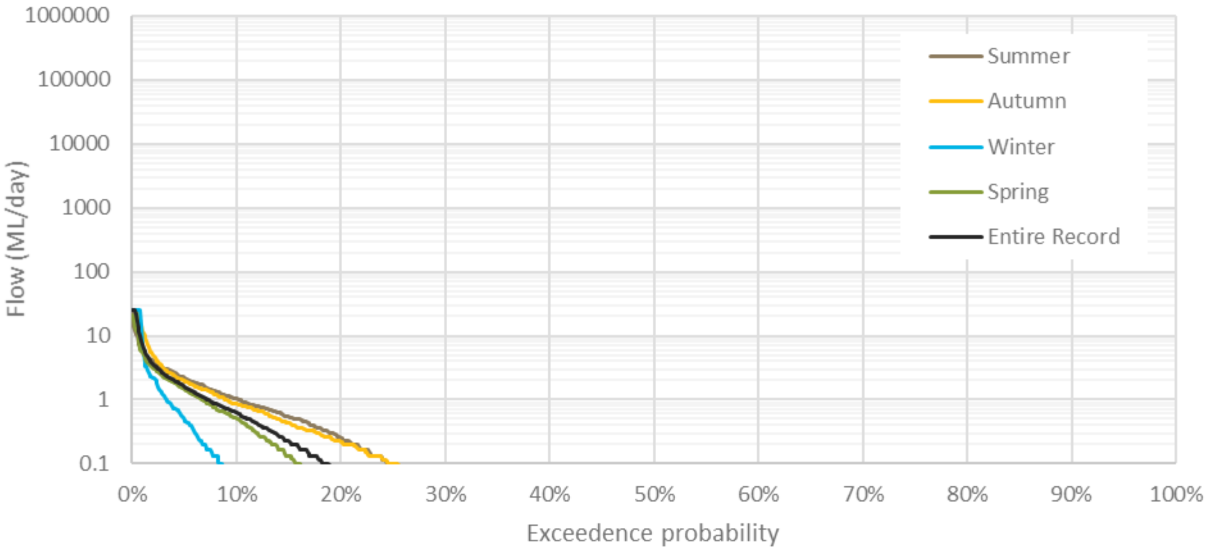


Figure 3.2 **Release from FWD flow duration curve**

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 significant 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.

There is a chance however that the FWD may have low volumes of water to dilute the DAF outputs, for example in the case of a drought when the site is primarily using groundwater, or at the end of summer when the FWD has been utilised to its full extent.

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

1) $\mathrm{Conc}_{DAF} \times \mathrm{Vol}_{DAF} + \mathrm{Conc}_{River} \times \mathrm{Vol}_{River} = \mathrm{Conc}_{Dam} \times \mathrm{Vol}_{Dam}$

2) $\mathrm{Vol}_{DAF} + \mathrm{Vol}_{River} = \mathrm{Vol}_{Dam}$

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 10 units indicating greater than 10:1 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), 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.

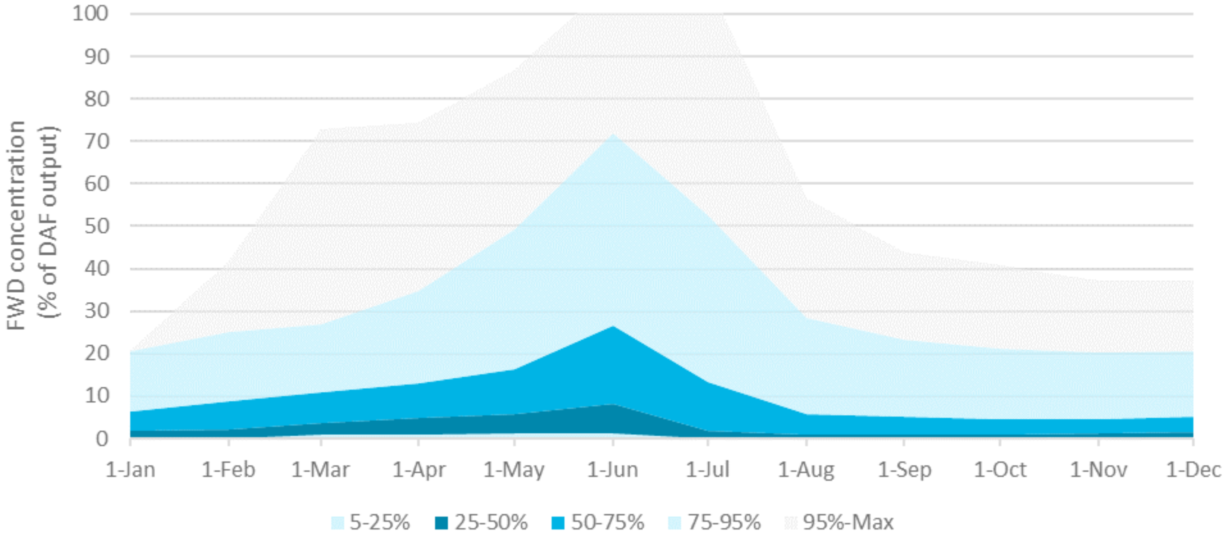


Figure 4.1 FWD concentration

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).

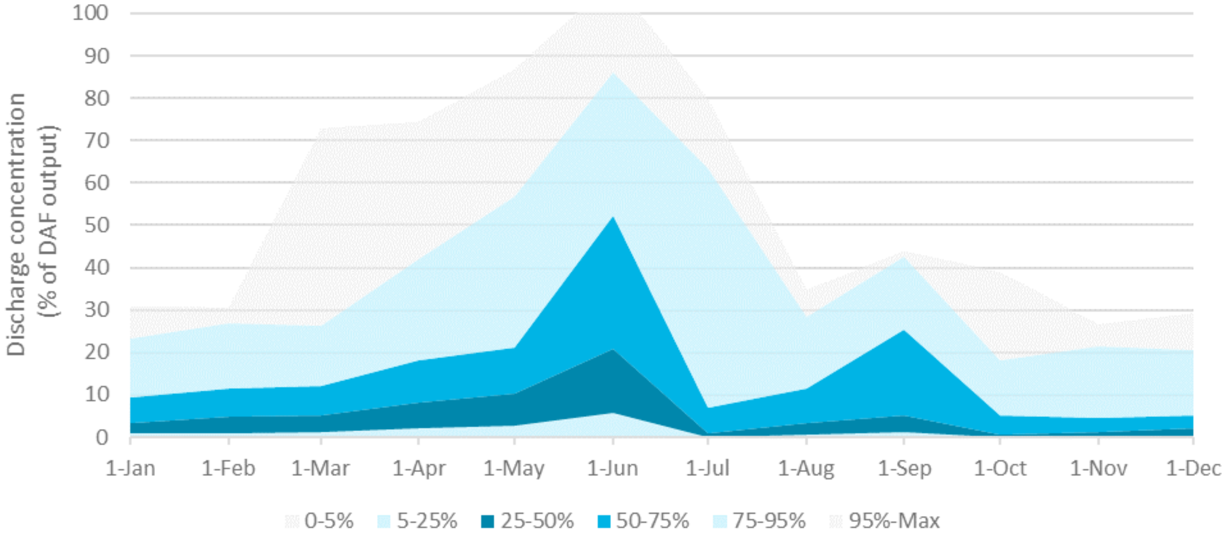


Figure 4.2 Modelled concentration of releases to Mitchell River

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.

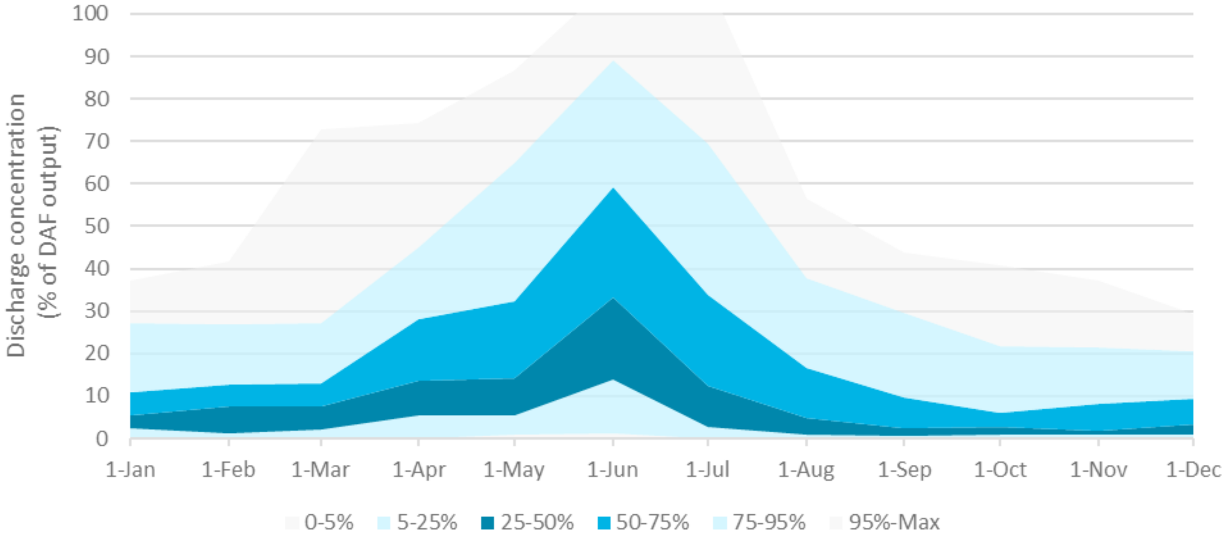


Figure 4.3 Modelled concentration of releases to Perry River

Figure 4.2 and Figure 4.3 indicate higher concentrations (ie less dilution) than the FWD concentrations shown in 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.

Releases to the Mitchell River would be further 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) (ie the 50% percentile result for the river lies along the bottom of the plot, with less than 1% of the DAF concentration).

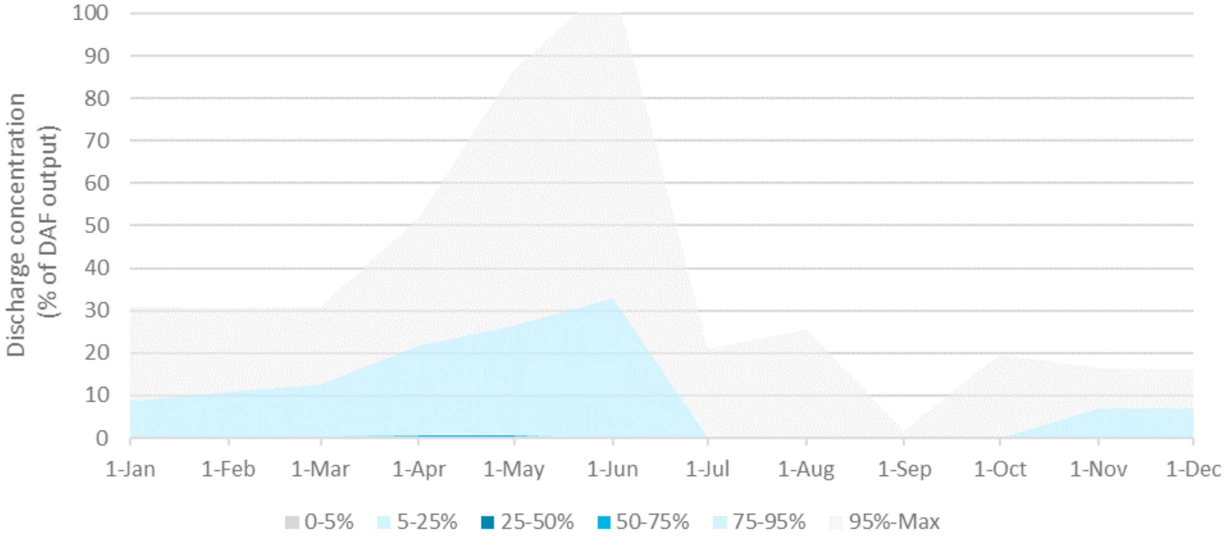


Figure 4.4 Modelled concentration within the Mitchell River

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, with:

- typical (50th percentile) dilution within the FWD of around 20:1;
- the least dilution within the FWD occurring in June, when FWD levels are lowest immediately before the commencement of the winter fill period;

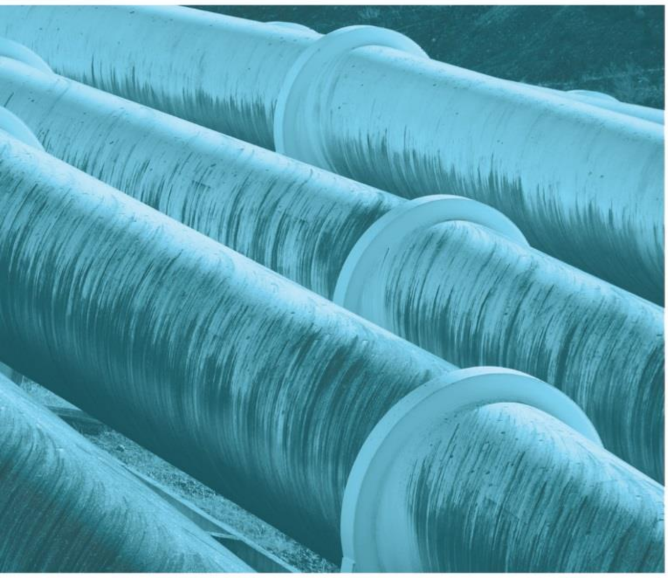
Releases from the FWD to the Mitchell River and Perry River may be further diluted by flow in those water courses occurring at the time of release:

- when releases are combined with Mitchell River flows, the overall dilution would typically be greater than 100:1;
- 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.

J Muller

Jarrah Muller
Associate Civil Engineer
jmuller@emmconsulting.com.au



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