APPENDIX
10

Water Balance

REPORT

Ulan Coal
Continued Operations Modification 6
Site Water Balance

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1.0 INTRODUCTION

This report describes the water and salinity balance for the proposed Ulan Coal Continued Operations Modification 6 (Proposed Modification).

1.1 MODIFICATION DESCRIPTION

The Ulan Coal Complex (UCC) is located approximately 38 kilometres (km) north-northeast of Mudgee and 19 km northeast of Gulgong in New South Wales. Operations at the UCC are located approximately 1.5 km east of the village of Ulan and entirely within the Mid-Western Regional Council Local Government Area. Coal mining has been undertaken in the Ulan area since the 1920s.

Ulan Coal Mines Pty Limited (UCMPL) was granted Project Approval (PA) 08_0184 under Part 3A of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 15 November 2010 for the Ulan Coal – Continued Operations Project (UCCO Project). Approved operations at the UCC consist of underground mining in the Ulan Underground and Ulan West areas, as well as open cut mining, associated coal handling, processing and transport through to August 2033. The open cut operations have been in care and maintenance since 2016. Existing operations are shown in Figure 1.

UCMPL is proposing a modification to PA 08_0184 pursuant to section 4.55(2) of the EP&A Act to maximise resource recovery from the existing underground mining operations within existing mining lease and exploration lease areas (refer to Figure 2). In addition to identifying additional mineable resources within existing mining lease areas, UCMPL has determined that there is a valuable mineable resource within Exploration Lease (EL) 7542 and is seeking to modify PA 08_0184 to enable access to this coal resource by extending the currently approved longwall panels in these areas (refer to Figure 2).

The Proposed Modification will extend the life of the existing operations by two years until 2035 and allow for an additional approximately 25 million tonnes (Mt) of extraction. The Proposed Modification generally comprises of:

- extension of Ulan Underground longwall (LW) panels LWW9 to LWW11 to the west;
- widening of Ulan Underground LWW11 by approximately 30 metres;
- extension of Ulan West LW9 to LW12 to the north.

UCMPL is also proposing some minor changes to surface infrastructure to support underground mining activities including provision of:

- 3 ventilation shafts and associated infrastructure corridors;
- 5 dewatering bores and associated infrastructure corridors;
- alternate access track; and
- infrastructure corridor and service borehole (to deliver gravel and other construction materials and to provide access and power to the underground mine) to the south-west of Ulan West.

A comparison between the approved development under PA 08_0184 and the Proposed Modification is provided in Table 1.

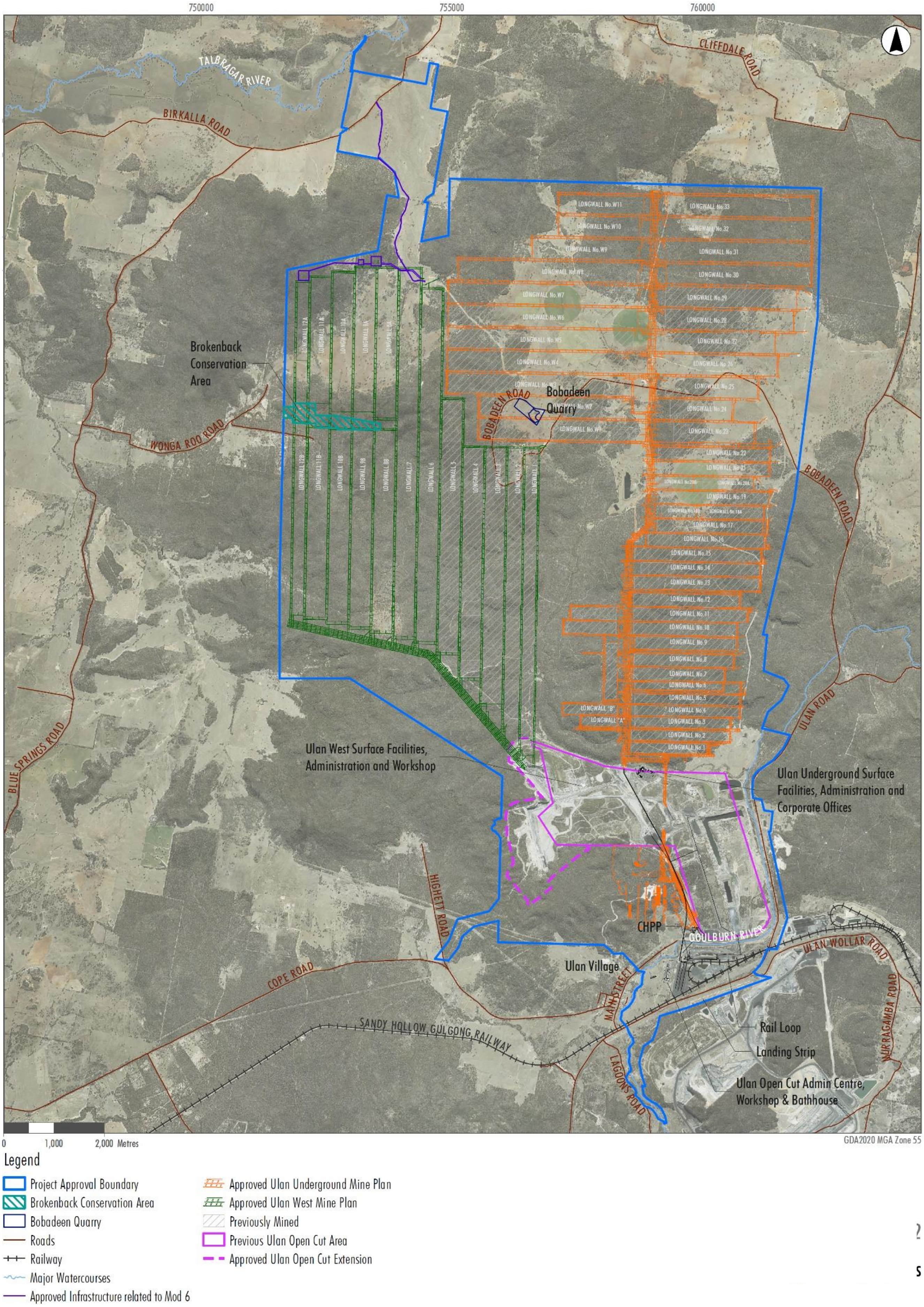

Figure 1 Ulan Coal Complex Approved Operations

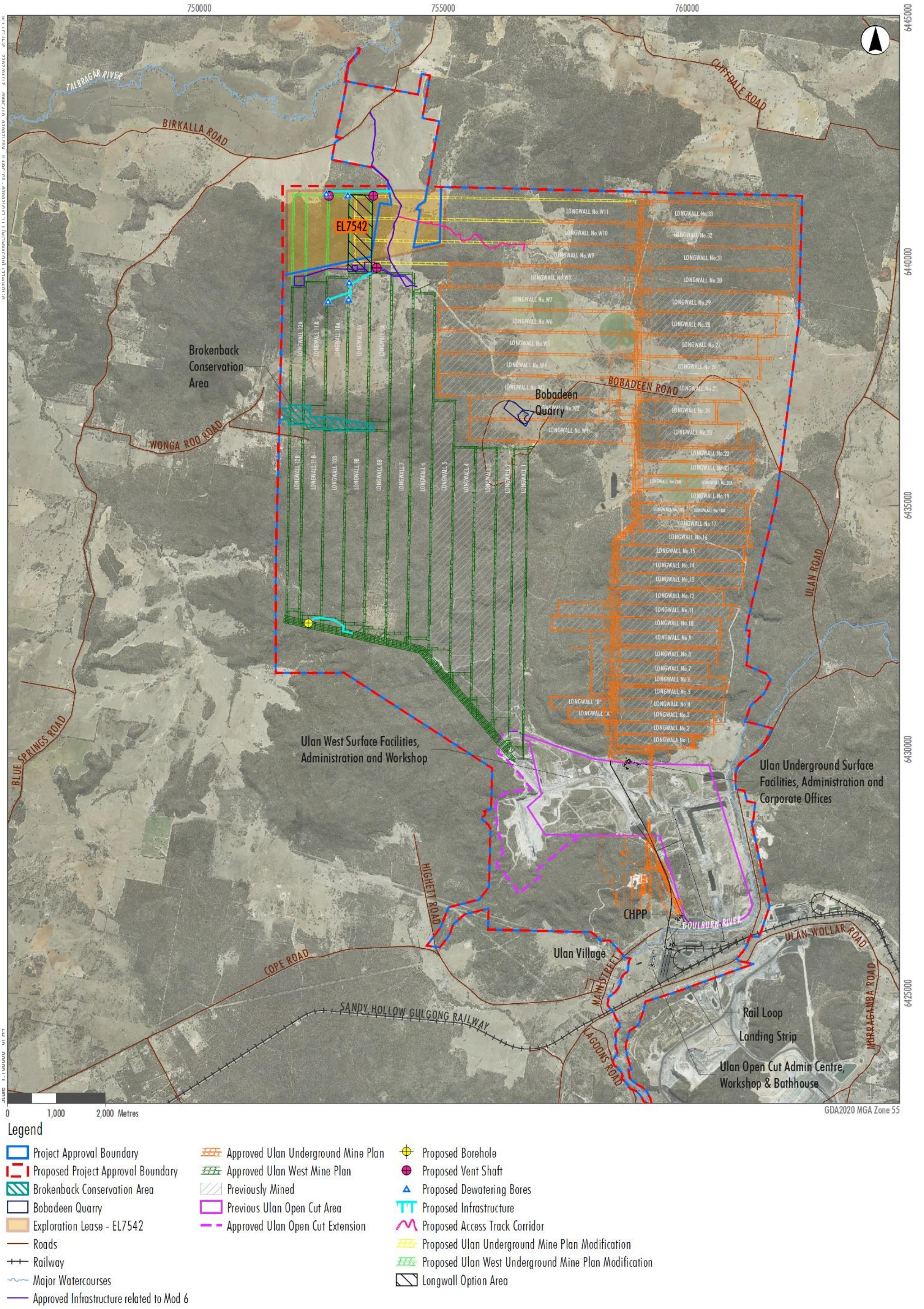

Figure 2 Proposed Modification

Table 1 Proposed Modification Summary

Project Component	Approved Operations	Modification
Mine life	Mining operations until 30 August 2033	Extension of life of mine until 30 August 2035 (an additional 2 years)
Limits of Extraction	20 million tonnes per annum (Mtpa) of coal (including a maximum of 4.1 Mtpa run-of-mine [ROM] from the Open Cut)	No change. A total additional 25 Mt of coal will be extracted from the Proposed Modification area without increasing the rate of extraction.
Operating Hours	24 hours per day, 7 days per week	No change
Project boundary	As per PA 08_0184	Extension of Project Approval Boundary to include the northern part of EL 7542 (refer to Figure 2)
Mine plan	As per PA 08_0184	Extension of Ulan Underground LWW9 to LWW11 and Ulan West LW9 to LW12. Widening of Ulan Underground LWW11. Refer to Figure 2.
Mining Method	Retreat longwall method	No change
Surface Infrastructure	As per PA 08_0184	Minor changes to infrastructure including dewatering bores, ventilation shafts and associated infrastructure to accommodate the proposed mine plan.
Coal Handling and Preparation Plant	As per PA 08_0184	No change
Coal Transportation	All coal transported from the site by rail. No more than 10 laden trains leave the site each day.	No change
Workforce	Approximately 930 people (Ulan Coal Complex)	No change

1.2 SCOPE OF WORK

Hydro Engineering & Consulting Pty Ltd (HEC) have been engaged by Umwelt (Australia) Pty Limited (Umwelt) (Proposed Modification environmental assessment lead consultants), to prepare a detailed mine site water balance for the life of the Proposed Modification including the following:

- accounting for available water sources;
- accounting for the water demand for the Proposed Modification;
- assessment of demand and supply requirements and storage requirements under a range of rainfall/evaporation, groundwater make and production conditions;
- identification of potential shortfalls in water supply and water sourcing options;
- identification of the risk and quantities of any predicted discharge from water storages into the environment;
- use of calibrated inflow figures for runoff, infiltration through spoil and groundwater inflows based on existing operational conditions; and
- inclusion of a salt balance as part of the Proposed Modification water balance.

HEC have developed an operational water and salinity balance model of the UCC. The model has been modified to simulate the future predicted water balance for the Proposed Modification, using future production and forecast underground groundwater inflow data provided by UCMPL. The operational model was developed with the aim of assessing future UCC water and salinity balance behaviour using historical climatic data for the period of the Proposed Modification. Simulation of both the approved operation and the Proposed Modification has been undertaken to allow comparison of forecasts.

Key operational model outputs were as follows:

- Predicted water supply security for the UCC Coal Handing and Preparation Plant (CHPP), for underground mining operations and for dust suppression use.
- Risk of spill occurring from UCC water storages to receiving creeks.
- Risk of accumulation of excess water at the UCC during the Proposed Modification period and prediction of water volume variations into the future.
- Evaluation of the relative proportions of:
  - water management system inflows obtained from different sources; and
  - system outflows to various demands/losses.

This report outlines model assumptions and describes results.

2.0 WATER MANAGEMENT SYSTEM DESCRIPTION

The surface water management system of the UCC involves a number of interlinked storages, their catchments, the CHPP, underground operations, water treatment facilities (WTFs), licensed discharge points (LDPs), the Bobadeen Irrigation Scheme and water pumping systems. A schematic of the water management system is provided in Figure 3. The UCC has historically operated in surplus (i.e. water make exceeding site water demands) with significant groundwater inflows to the Ulan Underground (UUG) mine (formerly known as the Ulan No. 3 Underground) and the Ulan West Underground (UWUG). As a result, there has been an emphasis on water treatment in the WTFs and licensed discharge.

Underground mining operations are dewatered, using a series of pumps and pipelines, to the surface for storage in either the Bobadeen Dam (in the north) or the East Pit (in the south). Surface runoff from operational areas, plus surplus water from the CHPP and other site water is also directed to the East Pit. No changes to the system schematic (refer Figure 3) are anticipated as part of the Proposed Modification.

The following describes the main UCC water storages:

- The <u>East Pit</u> is the main site water storage, with an estimated capacity of 26,100 megalitres (ML) (refer Section 4.4). The East Pit receives inflow from underground mine dewatering via the North West Sediment Dam (NWSD), pumped inflow from a number of small storages around the CHPP and open cut areas and tailings supernatant water from tailings storages located within the former pit access ramp. Water stored in the East Pit is used to supply the NWSD WTF as well as for blending with NWSD WTF product water prior to release via LDP19 (to achieve a target salinity in accordance with Environment Protection Licence [EPL] 394 conditions). East Pit water can also supply water to the neighbouring Moolarben Coal Mine under agreement. Groundwater studies undertaken in 2007 and 2008 indicate that seepage from the East Pit occurs to the UUG.
- The <u>NWSD</u> is a small (120 ML capacity) storage to the north of the East Pit. The NWSD receives water pumped from UUG dewatering, several water storages in the Ulan West surface area and wastewater (“residuals”) from the NWSD WTF. As well as spilling (almost continually) to the East Pit, water can be pumped from the NWSD to nearby Rowans Dam.
- <u>Rowans Dam</u> is a small (137 ML capacity) storage adjacent to the NWSD which pumps water to the UUG supply system. Rowans Dam also supplies water for truckfill (surface dust suppression) and for CHPP makeup via the NWSD WTF Residuals Tank.
- <u>Bobadeen Dam</u> is the main storage associated with the Bobadeen WTF, with an estimated capacity of 502 ML. It receives inflow from underground mine dewatering, excess WTF product water and WTF wastewater. As well as supplying feed water to the WTF, Bobadeen Dam supplies the Bobadeen Irrigation Area. The nearby smaller <u>Blend Dam</u> is used to blend WTF product water with UUG dewatering to meet the EPL 394 target salinity for release via LDP6.

A number of small water storages are located around the UCC principally to capture runoff from disturbed areas. The Moolarben Creek Dam is an off-site storage that is not presently connected to the mine water management system. The Waratah Pit and Barrier Pit are former open cut pits. Runoff from the Waratah Pit contributes seepage to nearby sumps which are dewatered to the NWSD. The Barrier Pit is used as a coarse reject storage with seepage to the UUG. Several small storages overlie former mining areas and do not accumulate water due to seepage to the underground operations as indicated in Figure 3.

Two tailings storages (TD1 and TD2) have been developed in the former entrance ramp to the East Pit, with a third (TD3) planned in the future. Supernatant water, seepage and rainfall runoff from the tailings storages reports to the East Pit.

Storage of water within the UUG and UWUG is kept to a minimum to facilitate on-going operations.

The majority of inflows to the system are from groundwater inflow to underground operations and runoff captured from disturbed areas. System outflows are dominated by licensed discharge.

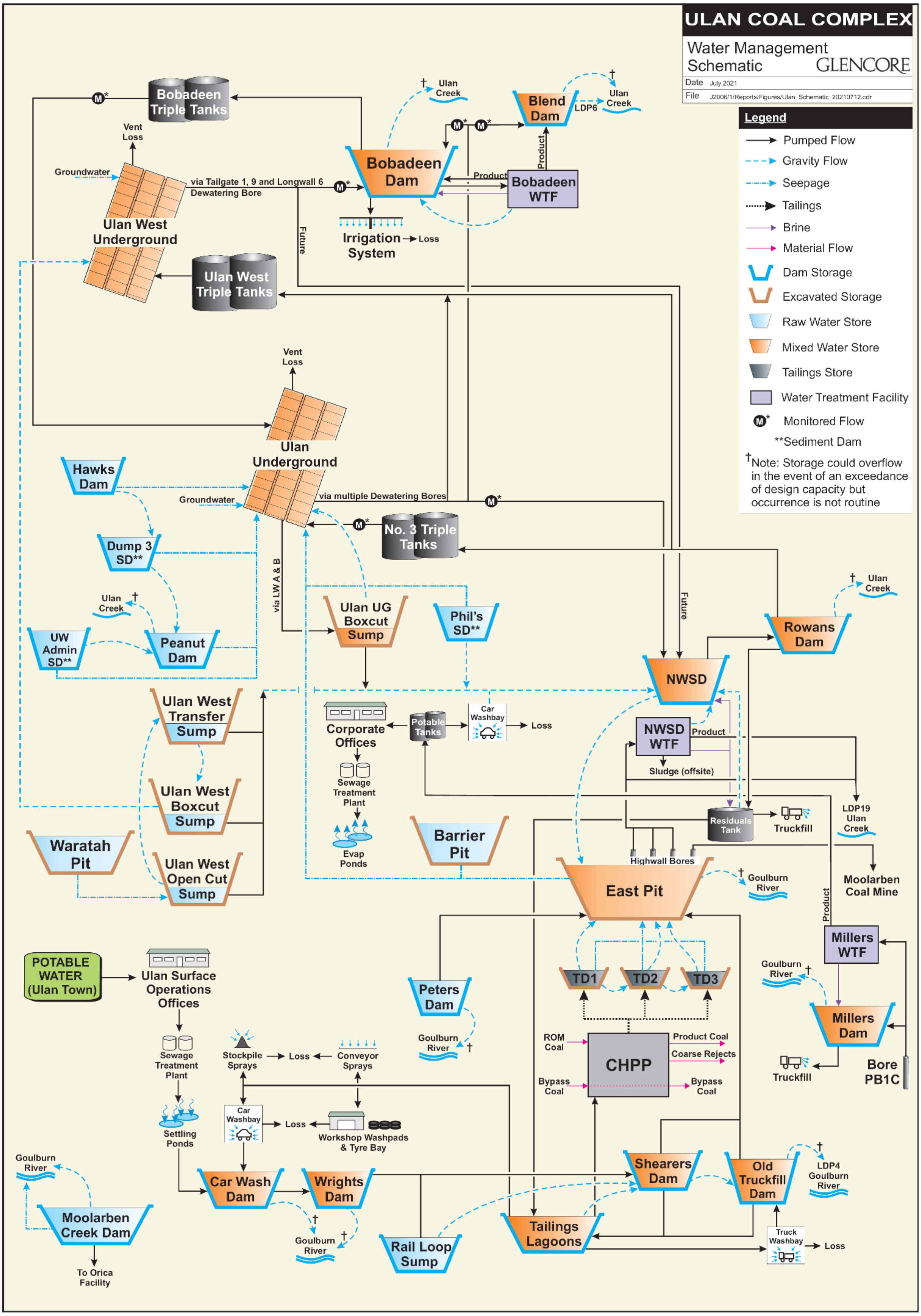

Figure 3 UCC Water Management System Schematic

3.0 WATER AND SALINITY BALANCE MODEL DESCRIPTION

The UCC water and salinity balance model has been developed to simulate the storages and linkages shown in schematic form in Figure 3. The model simulates the volume of water and the mass of salt held in and transferred between and discharged from all simulated water storages. For each storage, the model simulates:

Change in Storage = Inflow – Outflow

Where:

Inflow includes rainfall runoff, groundwater inflow (to the underground operations), seepage inflow (to the UUG), tailings bleed[1] (for the tailings storages) and all transfer inflows from other storages.

Outflow includes evaporation, evapotranspiration (irrigation areas), spill (if any), licensed discharge, seepage outflow (from the East Pit to the UUG) and all transfer outflows to other storages or to a demand sink (for example, the CHPP).

The model has been developed using the GoldSim® software package. The model operates on a maximum six hourly time-step and performs balance checks on the system as a whole and on sub-systems to ensure a balance is maintained at all times.

The model also simulates changes in the salinity (electrical conductivity - EC) of each storage by assigning EC values to inflow streams (runoff, groundwater, seepage and tailings water), converting these to total dissolved solids (TDS) values using a constant ratio (refer Section 4.3) and assuming conservation of mass.

Model simulations commence at the end of April 2021 and simulate the period to the end of operations (the end of August 2032 for the approved operations and August 2034 for the Proposed Modification). The model simulates 132 "realizations" derived using historical daily climatic data[2] from 1889 to 2020 inclusive. Realization 1 uses climatic data starting in 1889, realization 2 uses data starting in 1890, realization 3 uses data starting in 1891 and so on. The results from all realizations are used to generate water storage volume and salinity estimates and other relevant water balance statistics. This method effectively includes all recorded historical climatic events in the water balance model, including high, low and median rainfall periods.

The model can also be used to 'hindcast' the past system performance using monitored site rainfall, production, transfers and other data. This method was used to calibrate the model water balance (refer Section 5.0).

[1] Tailings 'bleed' refers to water liberated from tailings as settling occurs.

[2] Data was sourced from SILO Point Data for the UCC location. SILO Point Data is a system which provides synthetic data sets for a specified point by interpolation between surrounding point records held by the Bureau of Meteorology (https://www.longpaddock.qld.gov.au/silo/point-data/). Both rainfall and pan evaporation data were obtained from this source.

4.0 MODEL DATA

A summary of key model data is provided in the sub-sections below.

4.1 RAINFALL RUNOFF SIMULATION

Rainfall runoff in the water balance model is simulated using the Australian Water Balance Model (AWBM) (Boughton, 2004). The AWBM is a nationally-recognised catchment-scale water balance model that estimates catchment yield (flow) from rainfall and evaporation.

AWBM simulation of flow from seven different sub-catchment types was undertaken, namely: undisturbed (natural) areas, hardstand (for example, roads and infrastructure areas), open cut pit, waste rock emplacements or spoil, rehabilitated waste rock emplacements, stockpile areas and tailings. Each storage catchment area was divided into these sub-catchment areas which were estimated from aerial photography and mine plans. Model parameters were initially taken from literature-based guideline values or experience with similar projects. These were then adjusted on the basis of calibration (refer Section 5.0).

For water surface areas, rainfall was assumed to add directly to the storage volume with no losses.

4.2 CATCHMENT AREAS

Surface and sub-surface catchment areas were used to calculate the surface runoff reporting to storages. Little change is expected into the future hence catchment and sub-catchment areas for the simulated mine life were as shown in Figure 4 and Figure 5 with sub-catchment totals given in Table 2. The only change would be the development of the TD3 tailings storage in the former entrance ramp to the East Pit as shown in Figure 5. This will result in a reduction in the total catchment area reporting directly to the East Pit and an increase in the site tailings sub-catchment, with a corresponding decrease in other sub-catchment types – refer Table 2.

Table 2 Calculated Total Site Sub-Catchment Areas

Sub-Catchment Type	2021 Sub-Catchment Area (ha)	Life of Mine Sub-Catchment Area (ha)
Rehabilitated Waste Rock Emplacement	344	343
Undisturbed (Natural)	394	394
Hardstand	275	275
Waste Rock Emplacement	153	143
Coal Stockpile	37	37
Open Cut Pit	85	68
Tailings	33	60

Historical changes in catchments have been included in the model calibration simulations (refer Section 5.0) – principally associated with the development of the upslope diversion to the west of the Waratah Pit.

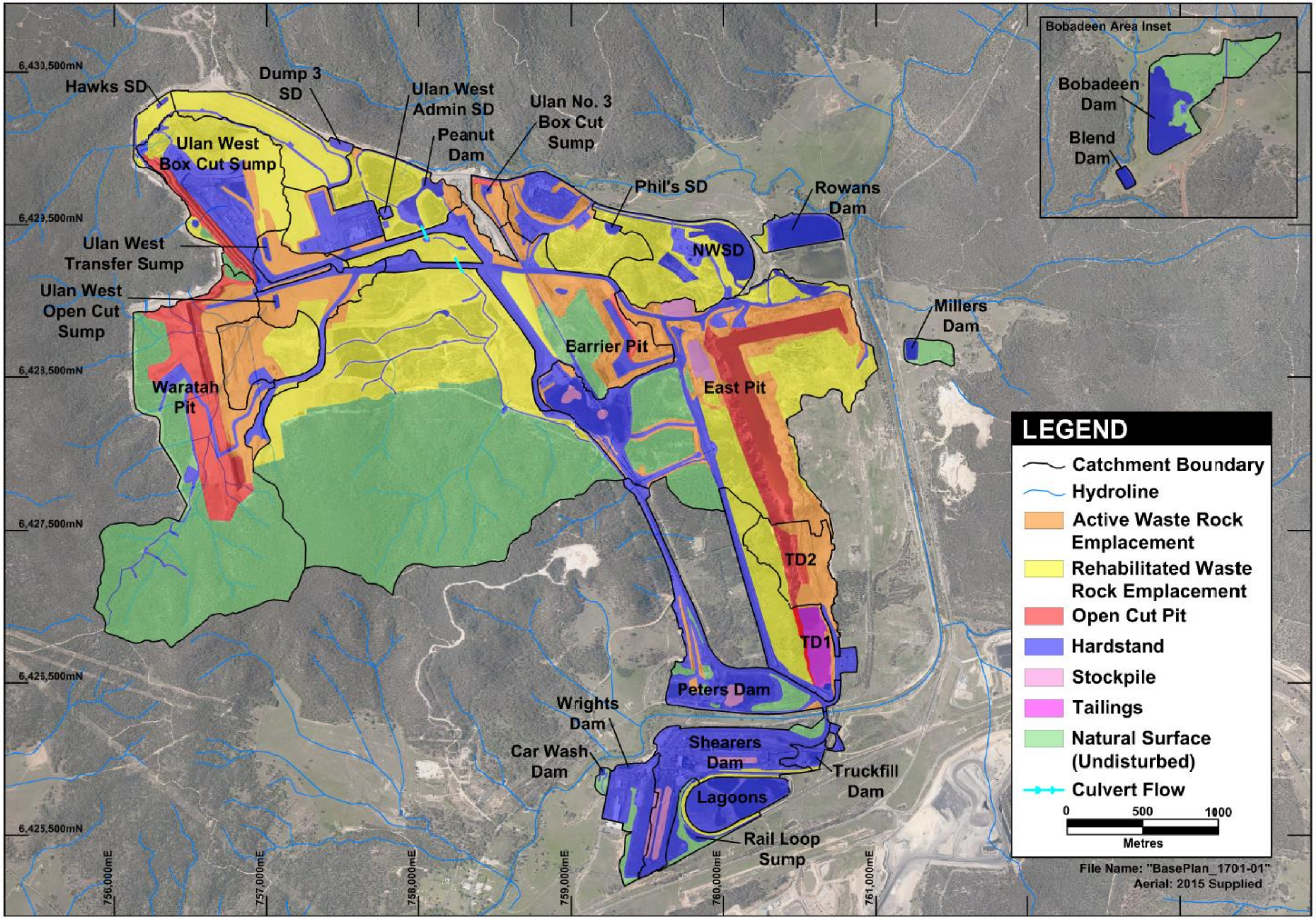

Figure 4 UCC Modelled 2020 Catchment and Sub-Catchment Areas

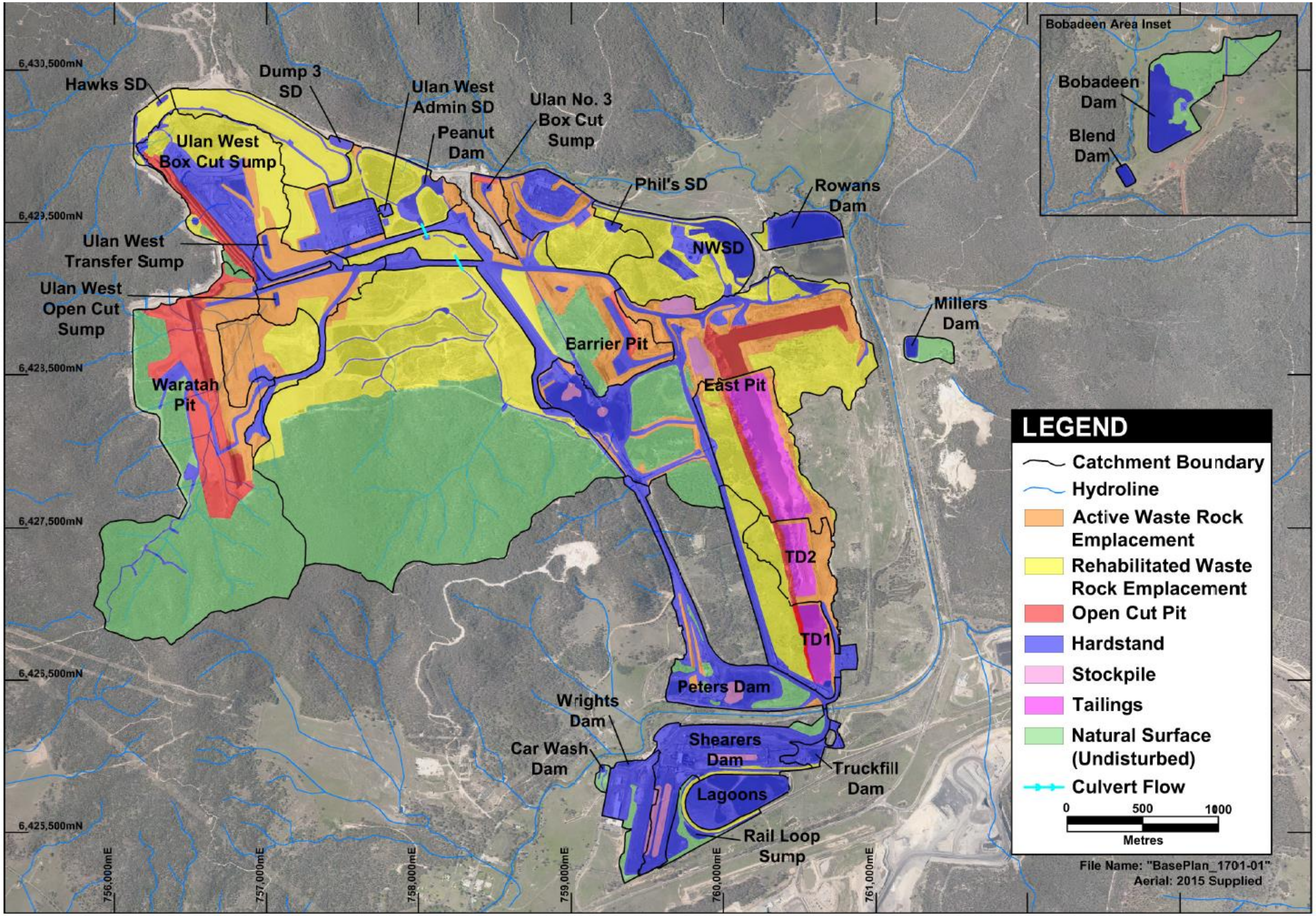

Figure 5 UCC Modelled Life of Mine Catchment and Sub-Catchment Areas

4.3 SALINITY VALUES

Constant EC values were assigned to modelled system inflows on the basis of monitoring data and experience with similar projects, with values adjusted as part of calibration (refer Section 5.2). Table 3 summarises modelled values. The EC of NWSD WTF product water varies with the EC of feed water from the East Pit as summarised in Table 4 (as advised by UCMPL), with values interpolated between tabulated values.

Table 3 Modelled Salinity (EC) Values

System Inflow or Component		Modelled EC (µS/cm)
Runoff	Rehabilitated Waste Rock	700
	Undisturbed (Natural)	300
	Hardstand	2,000
	Waste Rock Emplacement	1,700
	Coal Stockpile	2,500
	Open Cut Pit	1,800
	Tailings	4,000
Tailings Bleed		4,500*
UUG Groundwater		800
UWUG Groundwater		930
Bobadeen & Millers WTF Product		22
NWSD WTF Product		Varies with East Pit (feed) EC – refer Table 4

* For predictive simulations this was linked to the modelled salinity in the NWSD WTF residuals tank.

Table 4 Modelled Salinity (EC) Values – NWSD WTF Product

East Pit EC (WTF Feed) (µS/cm)	Modelled Product EC (µS/cm)
<=2,500	63
3,000	80
3,500	94
4,000	114
4,500	136
5,000	156
5,500	178
6,000	191
6,500	225
7,000	250
7,500	277

A multiplier of 0.75 was used to convert simulated total dissolved solids (TDS) to EC based on monitored average TDS and EC values for the East Pit (which contains the majority of water stored at the UCC).

4.4 EVAPORATION FROM SURFACE STORAGES

Storage volumes calculated by the model are used to derive storage surface area (i.e. water area) based on storage level-volume-area relationships for each water storage either provided by UCMPL or estimated from supplied plans. For some of the smaller storages (including the tailings storages) the full surface area was estimated from supplied plans and the modelled area derived as a proportion based on the modelled volume divided by the storage volume estimated as corresponding to the surface just being covered.

A storage level-volume-area relationship was derived for the East Pit from surface elevation and bathymetric survey provided by UCMPL. In addition, data were provided on the former open cut pit floor (now covered in waste rock). This was used to include an allowance for water stored in the void space of the waste rock material adjacent to the East Pit. The waste rock porosity was derived to be 0.16 as part of the calibration process (refer Section 5.2). The resulting East Pit level-volume-area relationship is shown in Figure 6 with the existing East Pit and in Figure 7 following the construction of the TD3 embankment.

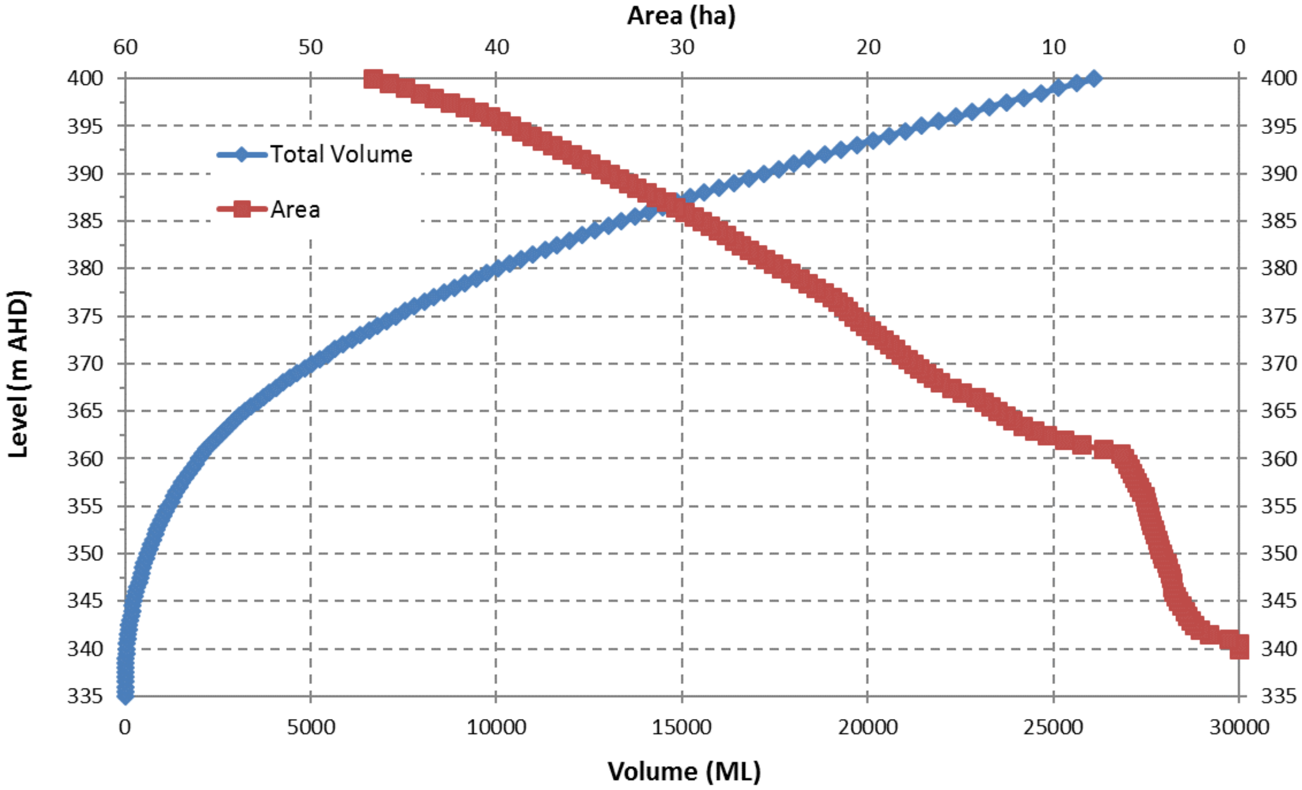

Figure 6 East Pit Existing Modelled Storage Characteristics

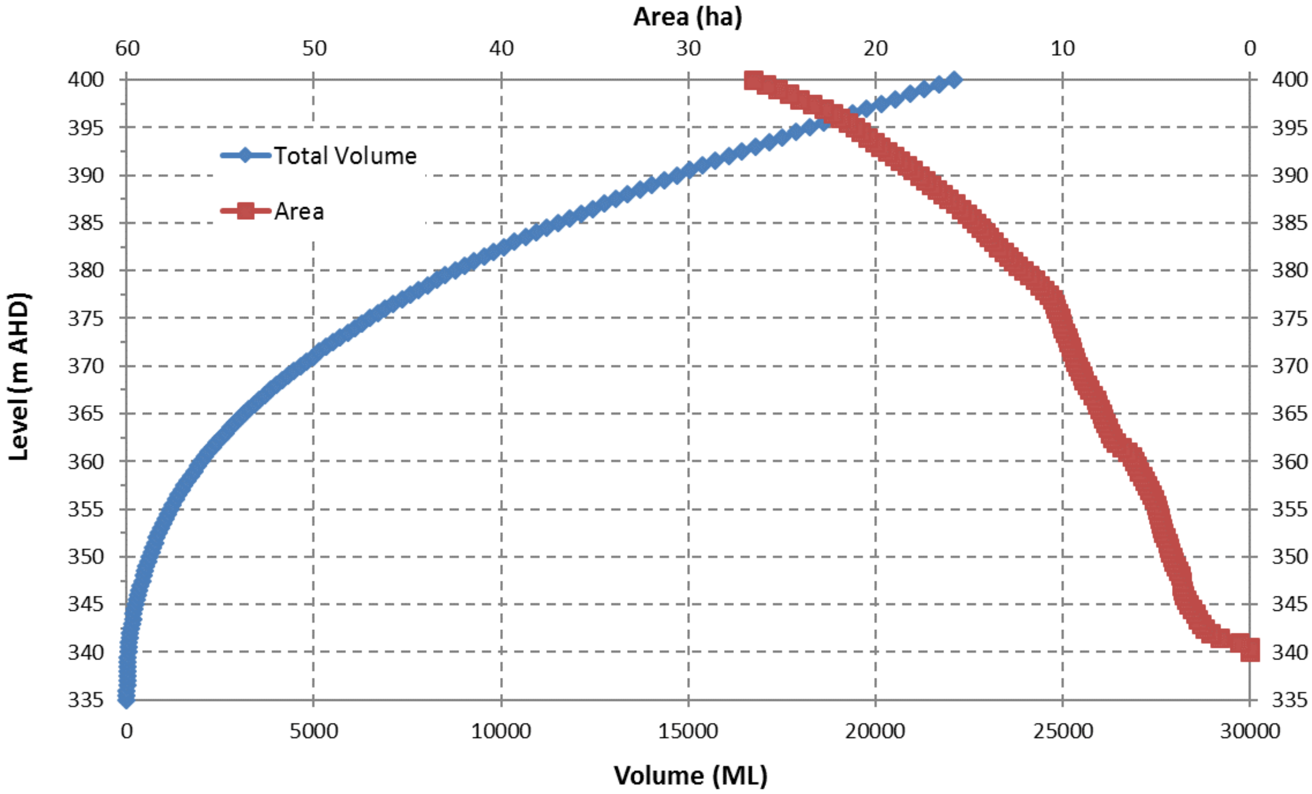

Figure 7 East Pit Modelled Storage Characteristics – with TD3

The following pan factors were assumed in the estimation of evaporation from various water storage areas (as a multiplier on daily pan evaporation):

- Above ground wet tailings surfaces (Lagoons): 1.0; due to the darker tailings surface;
- TD1, TD2 and TD3 within the East Pit: 0.7; due to shading effects and lower wind speed at depth;
- All open cut storages: monthly values varying from 0.45 in winter to 0.7 in summer due to the seasonally varying effects of shading; and
- All other storages = monthly values varying from 0.84 to 0.95 on the basis of values in McMahon et al. (2013) for Scone (located 105 km east of the UCC).

4.5 CHPP PROCESSING RATES AND CHPP DEMAND

Monthly planned bypass, ROM coal (CHPP feed) and tailings tonnages for the UCC are summarised in Figure 8 and Figure 9 (all at 9% moisture) as provided by UCMPL.

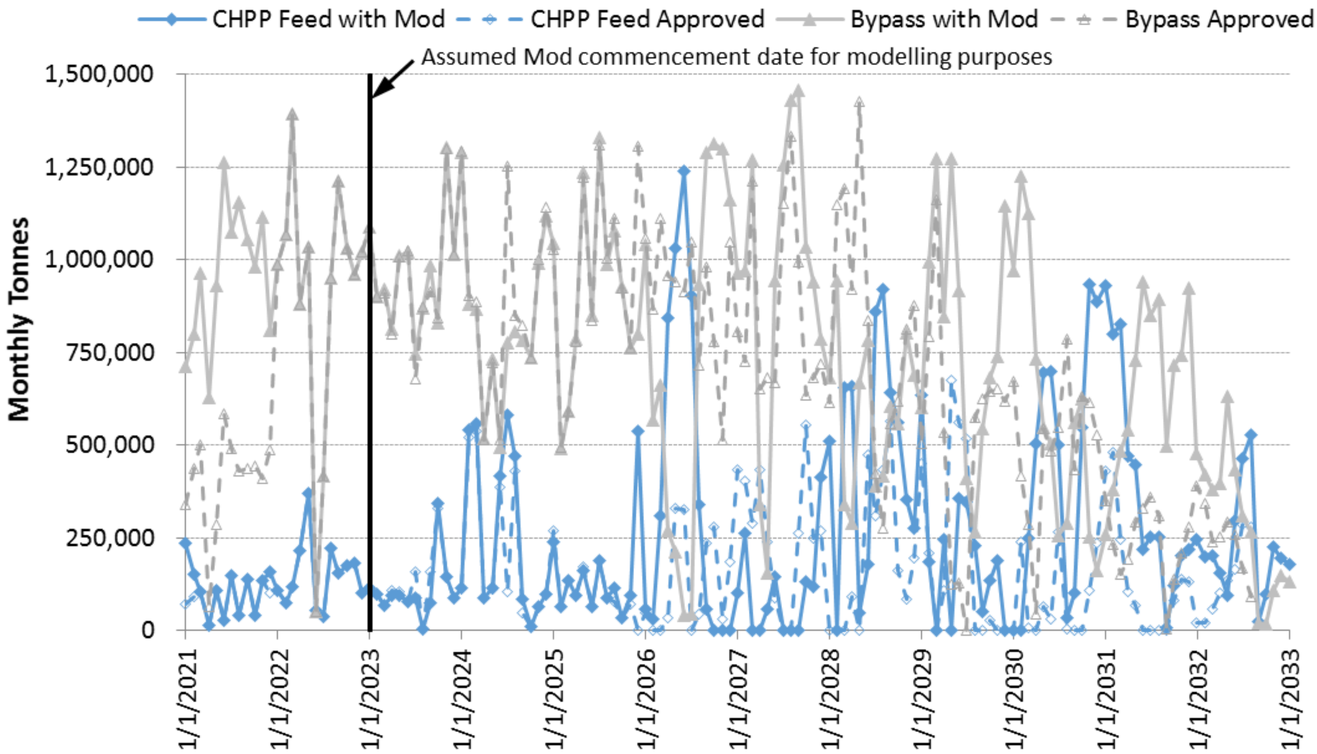

Figure 8 Planned Bypass and CHPP ROM Coal Feed Rate

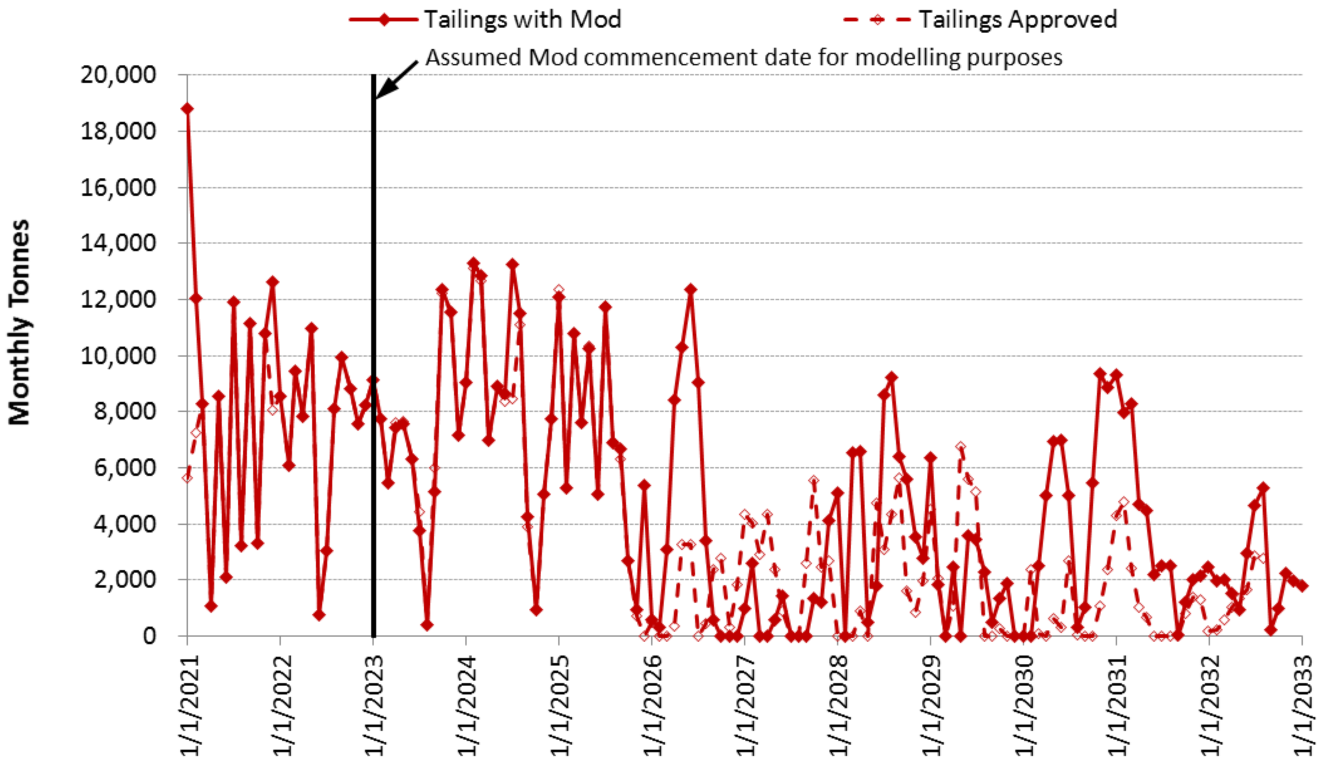

Figure 9 Planned CHPP Tailings Rate

Annual CHPP feed tonnages are summarised in Table 5. The data indicates changes to the tonnages to be processed by the CHPP as well as tailings over the life of the mine, although the tailings as a percentage of CHPP feed falls from 2.6% to 2.0% in total.

Table 5 Modelled Annual CHPP Feed Tonnages

Year:	2021	2022	2023	2024	2025	2026	2027
CHPP Feed Approved Operations (Mt):	1.02	1.82	1.45	2.52	1.26	1.51	3.22
CHPP Feed Proposed Modification (Mt):	1.30	1.82	1.29	3.14	1.81	4.81	1.23
Year:	2028	2029	2030	2031	2032	2033	2034
CHPP Feed Approved Operations (Mt):	2.32	2.55	0.96	1.68	1.07	-	-
CHPP Feed Proposed Modification (Mt):	5.66	2.38	5.15	4.74	2.72	0.98	1.06

Note: For modelling purposes assumed Mod commencement date is 1/1/2023.

Relevant coal and rejects properties which affect CHPP water demand are summarised below (provided by UCMPL) – refer also Section 4.6:

- ROM coal moisture (CHPP feed and bypass): 10.5%
- Product coal moisture: 9.0%
- Coarse reject moisture: 10%.

Monitored data on thickened tailings solids concentration was unavailable and so analysis was undertaken to determine an appropriate concentration for use in the assessment. Thickened CHPP tailings solids concentration is typically a low number and has a significant effect on CHPP water demand. Metered CHPP use and make-up supply data (from the NWSD WTF or Rowans Dam) was sourced and compared with calculated CHPP demand derived from recorded tonnages, the above moistures and an assumed (constant) thickened tailings solids concentration of 14%. Comparative monthly volumes are shown in Figure 10 and indicate a good match between calculated and metered volumes. Therefore a tailings solids concentration of 14% was adopted for predictive simulations.

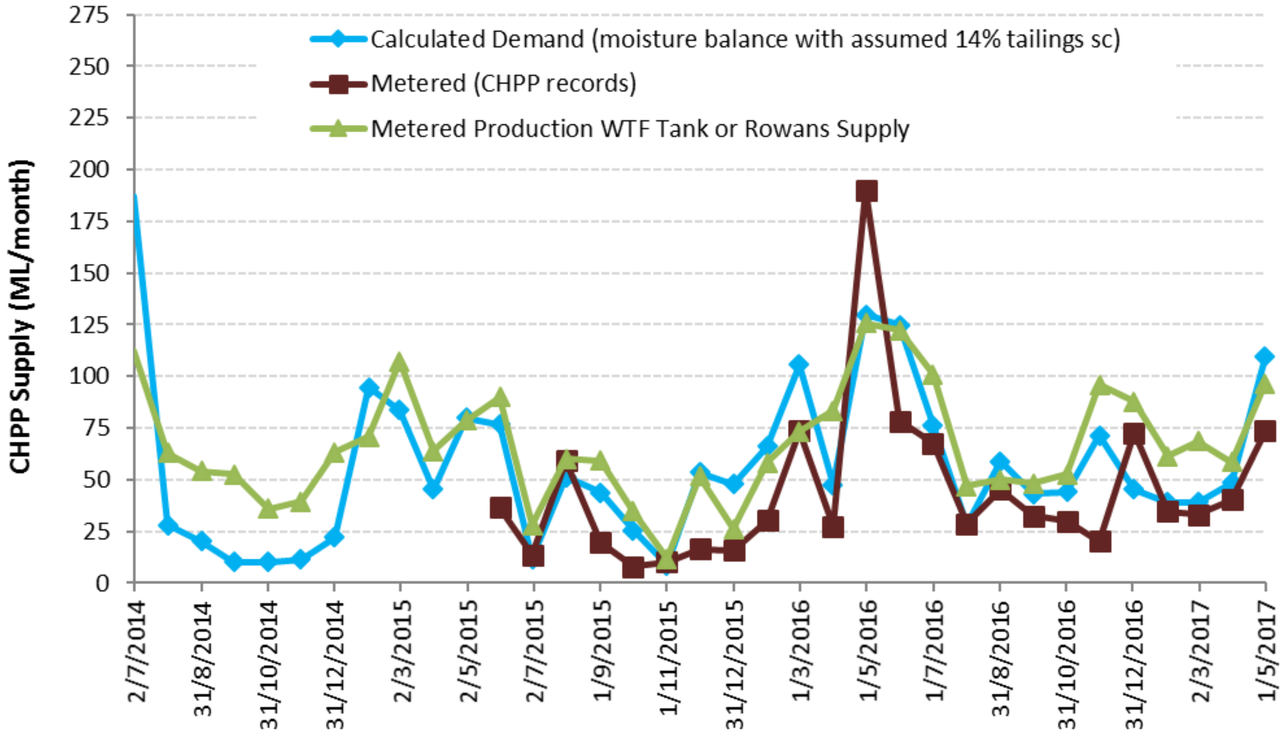

Figure 10 CHPP Historical Supply Monthly Volumes

The planned tonnages shown in Figure 8 and Figure 9 as well as the coal and tailings moistures listed above were used to calculate future CHPP water demand in the model for the UCC for both the approved operations and the Proposed Modification – this is summarised in Figure 11.

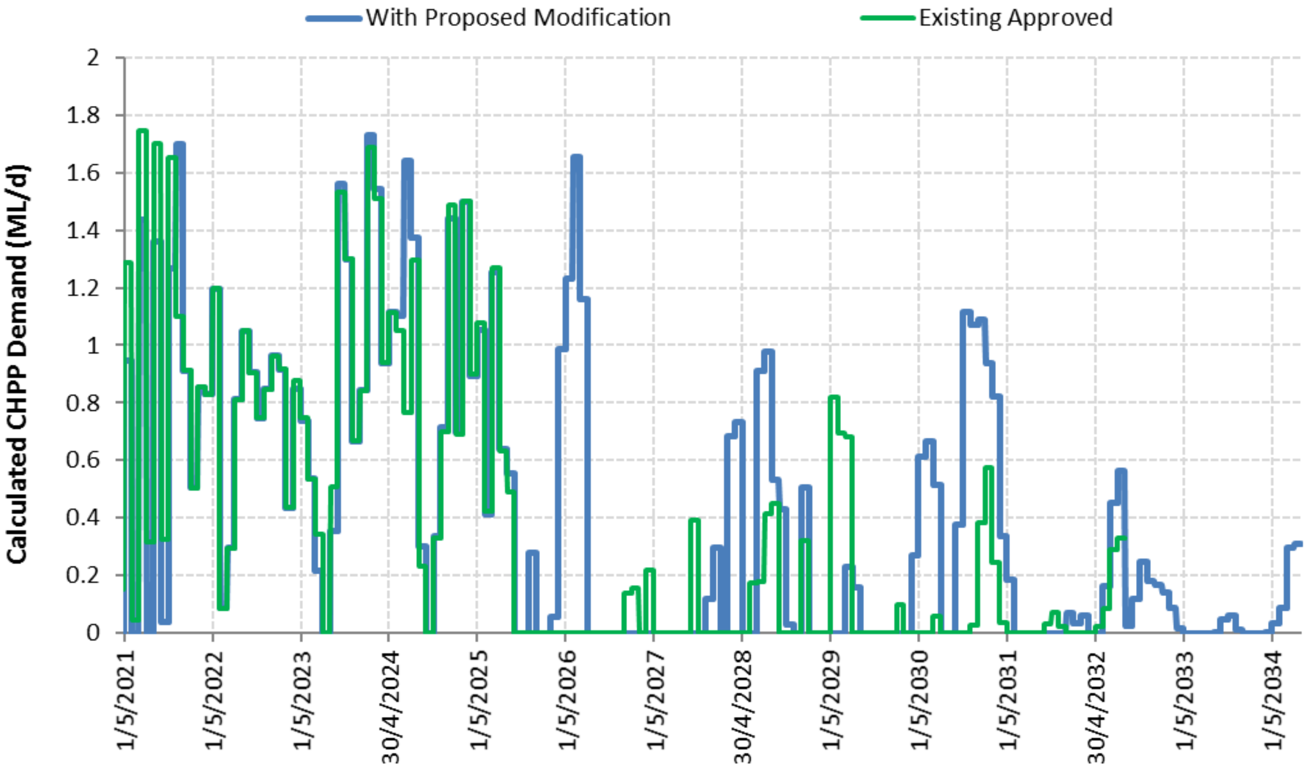

Figure 11 Calculated CHPP Make-Up Demand

4.6 TAILINGS DISPOSAL

The TD1 tailings storage has been filled to design capacity. Tailings discharge to TD2 is planned until the end of March 2023, with tailings discharge to TD3 thereafter.

Reclaim of supernatant tailings water (bleed) and rainfall runoff from the tailings storages was included in the water balance model. An initial settled density of 0.55 t/m^3 and a particle density of 1.9 t/m^3 were adopted for modelling as agreed with UCMPL and used to calculate the water bleed rate, which amounts to 79% of the water pumped out with the tailings. Bleed water and tailings storage rainfall runoff were modelled to either seep or spill to the East Pit.

4.7 ROAD WATER DEMAND

Recorded historical road water usage (truckfill) was provided by UCMPL. There was no clear or evident pattern of seasonal water use or any clear correlation between recorded volumes used and historical open cut operations (which would be expected to require more water). The average usage rate during months without any open cut operations was 0.69 ML/d, while the average rate during open cut operations was 1.22 ML/d. Open cut mining is currently in care and maintenance with no current plans for recommencement, therefore a rate of 0.69 ML/d was adopted as a constant for model forecast simulations. This was assumed sourced from the NWSD WTF residuals tank.

4.8 UNDERGROUND DEMAND AND RECOVERY

Recorded daily supply to both underground longwall operations was provided by UCMPL. The average supply rate to the UUG was 1.47 ML/d, which has been consistent since May 2015 and this rate has been adopted as a constant for predictive simulations. Supply was split into 19% drawn from Rowans Dam and 81% from Bobadeen Dam based on recorded data. UCMPL has advised that the demand for the UWUG has recently averaged 2.5 ML/d 5 days per week, drawn from UUG dewatering and this has been adopted for predictive simulations. UCMPL has also advised additional water is supplied to conveyor sprays for dust control, averaging approximately 0.1 ML/d for each underground operation and therefore this demand was added to each underground demand (7 days per week).

It was assumed that all water pumped to underground operations was subsequently recovered together with groundwater and seepage with no losses.

4.9 GROUNDWATER INFLOW

Modelled groundwater inflow rates to the underground operations were sourced from predictions undertaken by specialist groundwater consultants for the Proposed Modification. Figure 12 shows a plot of predicted inflow rates for the forecast period for both the existing approved operations and the Proposed Modification. These were used directly for predictive simulations. A notable increase is evident in the predicted groundwater inflows for the Proposed Modification.

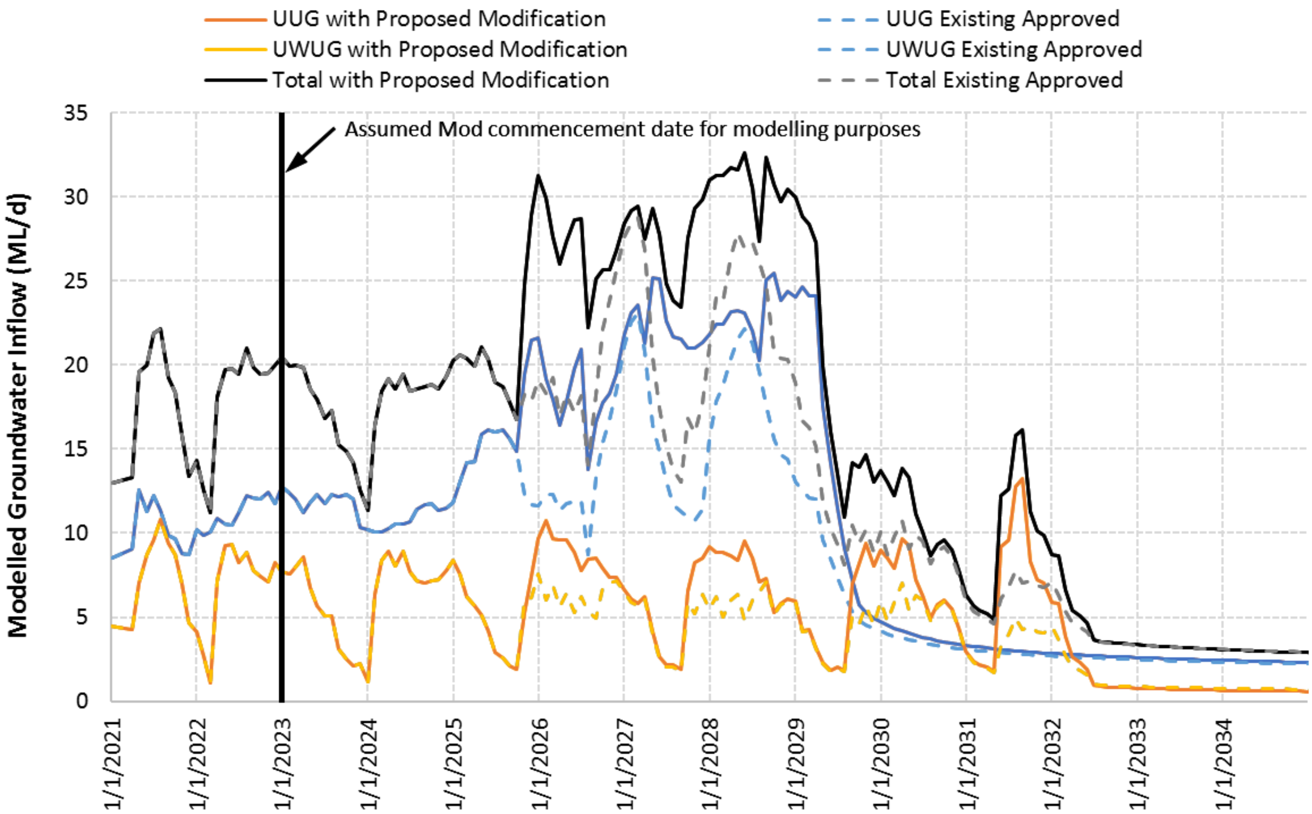

Figure 12 Predicted Groundwater Inflow Rates

4.10 NORTH WEST SEDIMENT DAM WATER TREATMENT FACILITY

The NWSD WTF treats water from the East Pit (via four highwall bores) to produce a very low salinity product stream (assumed EC 22 µS/cm – as advised by UCMPL personnel). This is blended with water from the East Pit for controlled release via LDP19, to meet a 50th percentile blended EC of 800 µS/cm. The WTF was initially commissioned in 2011 and upgraded in 2014.

The main by-product water stream from the WTF is reverse osmosis (RO) residuals water which is collected in a residuals tank. Water from the residuals tank (which can be topped up with water from Rowans Dam) has, in the past, been used as truckfill supply and to supply the CHPP Lagoons storage from which CHPP makeup is drawn. This has been assumed to continue for forecast simulations. A second WTF wastewater stream (including ultra-filtration backwash) is also simulated, with return direct to the NWSD.

As advised by UCMPL, the proportion of WTF that becomes permeate depends on the feed water EC, with a proportion of 0.75 for a feed water EC of 5,500 µS/cm or less, decreasing to 0.67 for a feed water EC of 7,500 µS/cm. The second wastewater stream is calculated as 0.05 times the feed water volume - a constant rate calculated from WTF records. The balance of the feed water becomes WTF product.

The following additional data was adopted for NWSD WTF operation (as advised by UCMPL):

- NWSD normal feed rate: 16.5 ML/d.
- LDP19 maximum rate: 14 ML/d.
- East Pit upper bound EC (WTF shuts down when this EC is reached): 7,500 µS/cm.
- East Pit restart EC (WTF restarts when EC falls below): 6,500 µS/cm.
- When the East Pit water level drops to a nominal 359 m AHD, the LDP19 maximum discharge rate is reduced to 3 ML/d until the water level rises to 360 m AHD.
- When the East Pit water level drops to a nominal 350 m AHD, the WTF stops operation until the water level rises to 351 m AHD.

4.11 BOBADEEN WATER TREATMENT FACILITY AND IRRIGATION

The Bobadeen WTF treats water from the Bobadeen Dam and the nearby (smaller) Leonards Dam (not included in the water balance model). The Bobadeen Dam is supplied from the UUG dewatering bores and the UWUG dewatering bore in order that the dam is kept 'topped up' to a 259 ML operating volume[3]. WTF product is discharged to the nearby Blend Dam where it is mixed with water from UUG dewatering prior to controlled release via LDP6. Product water in excess of Blend Dam requirements is returned to Bobadeen Dam. The Blend Dam is operated to maintain an EC of between 700 and 800 µS/cm. The WTF has a nominal production (feed) capacity of 2.9 ML/d, with permeate accounting for 0.75 of the feed. WTF reject (brine) is returned to Bobadeen Dam. Water from Bobadeen Dam is also used for irrigation via a system of centre pivot irrigators known as the Bobadeen Irrigation Scheme. Table 6 summarises modelled irrigation areas and pump rates – from information provided by UCMPL. Up to two irrigators can be operated at once.

Table 6 Bobadeen Irrigation Scheme Irrigation Areas and Pump Rates

Pivot No.	Area (ha)	Pump Rate (L/s)
1	22	30
2	45	55
3	55	60
4	50	60
5	70	70

Modelling of the soil moisture within each irrigation area occurs using a simple soil moisture store or 'bucket' model. The capacity of the soil moisture store is assumed to be 135 mm and additions occur from rainfall and irrigation, while depletion occurs due to evapotranspiration. Potential evapotranspiration is calculated as monthly average potential evapotranspiration times a crop factor. Average potential evapotranspiration was obtained from the Bureau of Meteorology (2018) gridded data, while crop factors were obtained from NSW Agriculture (1997). The data are summarised in Table 7.

Table 7 Irrigation Area Evapotranspiration Parameters

Month:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crop Factor:	0.70	0.70	0.70	0.60	0.50	0.45	0.40	0.45	0.55	0.65	0.70	0.70
ET (mm/d):	5.97	4.96	4.29	2.97	1.97	1.60	1.71	2.29	3.20	4.55	5.40	5.61

[3] This equates to a target level of 8.0 m – as advised by UCMPL personnel.

In the model, the pivots to irrigate were selected as those which had the lowest modelled soil moisture store values (i.e. the highest soil moisture deficits). The irrigation rate was calculated as the lower of the soil moisture deficit multiplied by the pivot area and the given pivot pump rate.

An upper bound target EC of 1,100 to1,200 µS/cm was modelled for Bobadeen Dam with the WTF feed rate reduced if the Bobadeen Dam EC increases.

Modelling assumed that the ability to dewater the UWUG to the NWSD as well as Bobadeen Dam would commence from the start of 2022. A pump rate of 134 L/s (11.6 ML/d) was assumed.

4.12 WATER SUPPLY TO MOOLARBEN COAL MINE

Water can be supplied via agreement from the East Pit to the Moolarben Coal Mine. Historically significant volumes have been supplied but the demand has decreased in recent years. Zero supply was assumed for predictive simulations.

4.13 PUMPING RATES

Modelled pumped transfer rates, from information provided by UCMPL, are summarised in Table 8.

Table 8 Modelled Pump Transfer Rates

Source	Pump Rate (L/s)
UUG	410*
UWUG (to Bobadeen Dam)	154*
UWUG (to NWSD)†	134
East Pit Highwall Bores	370
Residuals Tank to Lagoons	54
Ulan West Open Cut Sump	290
Ulan West Transfer Sump (Dam 2)	130
Ulan West Box Cut Sump (Dam 1)	130
Bobadeen Dam (to Blend Dam)	36
Old Truckfill Dam	65
Peters Dam	70
Rail Loop Dam	4
Shearers Dam	80
Wrights Dam	60
Car Wash Dam	60**
Ulan Underground Box Cut Sump	22
Rowans Dam	150

* Comprises a number of dewatering bores.
† From start of 2022.
** Assumed rate.

4.14 INITIAL STORAGE VOLUMES AND SALINITY

The storage initial volumes and EC for the smaller modelled storages were assumed (typically these storages were assumed to be at half capacity and an EC of 2,000 µS/cm). The initial water level and salinity for the East Pit for late April 2021 as advised by UCMPL were RL368.26 m and 2,700 µS/cm respectively.

4.15 STORAGE OPERATING VOLUMES

A number of operating volumes were adopted for modelling which affect when pumping to and from certain storages is triggered. Table 9 provides a summary of the adopted operating volumes for the UCC water balance model. Advised or estimated storage capacities are also given for reference.

Table 9 Adopted Operating Volumes and Storage Capacities

Storage	Volume	Modelled Operating Conditions
Bobadeen Dam	Low Operating Volume = 215 ML	Stop transfer to Blend Dam when below this volume.
	High Operating Volume = 259 ML	All pumping in ceases when dam above this volume. If above this volume look to transfer from UWUG to NWSD.
	Very High Operating Volume = 380 ML	If above this volume increase pump rate to Blend Dam to 45 L/s unless Blend Dam EC is elevated.
	Capacity = 502 ML	
Rowans Dam	Low Operating Volume = 27 ML	Transfer from NWSD commences when volume drops below Low and ceases when volume reaches High. Also look to transfer from UWUG to NWSD if NWSD is below capacity.
	High Operating Volume = 32 ML	
	Capacity = 137 ML	
Peters Dam	Low Operating Volume = 1.1 ML	Transfer to East Pit commences when volume rises above High and ceases when volume falls to Low.
	High Operating Volume = 4.3 ML	
	Capacity = 27 ML	
Shearers Dam	Low Operating Volume = 1.4 ML	Transfer to Lagoons or East Pit commences when volume rises above High and ceases when volume falls to Low.
	High Operating Volume = 4.5 ML	
	Very High Operating Volume = 23 ML	All pumping in ceases when dam above this volume.
	Capacity = 41 ML	
Old Truckfill Dam	Low Operating Volume = 0.8 ML	Transfer to Lagoons or East Pit commences when volume rises above High and ceases when volume falls to Low.
	High Operating Volume = 2.7 ML	
	Capacity = 14 ML	
Wrights Dam	Low Operating Volume = 0.5 ML	Transfer to Shearers Dam commences when volume rises above High (provided Shearers Dam is below its Very High Operating volume) and ceases when volume falls to Low.
	High Operating Volume = 3.2 ML	
	Capacity = 12 ML	
Lagoons	Low Operating Volume = 23 ML	Sourcing from Shearers and Old Truckfill Dam commences when volume falls below Normal and ceases when volume rises to High. Transfer from Shearers and Old Truckfill is directed to East Pit when volume is above High. Sourcing from Residuals Tank commences when volume falls below Low and ceases when volume rises to Normal.
	Normal Operating Volume = 27 ML	
	High Operating Volume = 31 ML	
	Capacity = 39 ML	
Rail Loop Sump	Dead (unrecoverable) Storage Volume = 2 ML	Transfer to Shearers commences when volume rises above 1.5 times Dead Storage and ceases when volume falls to below Dead Storage.
	Capacity = 0.5 ML	

Table 9 Adopted Operating Volumes and Storage Capacities (Continued)

Storage	Volume	Modelled Operating Conditions
Ulan West Open Cut Sump	Dead (unrecoverable) Storage Volume = 2 ML	Transfer to the NWSD commences when volume rises above three times Dead Storage and ceases when volume falls to below Dead Storage.
	Capacity = 155 ML	
Ulan West Transfer Sump	Dead (unrecoverable) Storage Volume = 2 ML	Transfer to the NWSD commences when volume rises above three times Dead Storage and ceases when volume falls to below Dead Storage.
	Capacity = 80 ML	
Ulan West Box Cut Sump	Dead (unrecoverable) Storage Volume = 11 ML	Transfer to the NWSD commences when volume rises above three times Dead Storage and ceases when volume falls to below Dead Storage.
	Capacity = 200 ML	

5.0 MODEL CALIBRATION

5.1 METHODOLOGY

Calibration was undertaken primarily by comparing model estimates of water level, volume and salinity in the East Pit with recorded levels, volume derived from levels and recorded salinity, with model parameters adjusted to improve the match between modelled and recorded data. No long term direct records of East Pit salinity were available, therefore salinity (EC) recorded at the NWSD WTF raw water tank was used. In addition, calibration considered the volume of water modelled as stored in the UUG goaf during the calibration period, as well as the salinity recorded in the NWSD and Bobadeen Dam.

5.2 DATA

The period of calibration was from the start of 2012 to September 2020. This was considered a sufficiently long period of time (8¾ years) and coincides with a period of generally good data availability. The following data was used in model calibration:

- Recorded daily rainfall data from the UMC M2 weather station located near the CHPP. Any short data gaps were infilled with SILO Point Data.
- Daily pan evaporation data sourced from the SILO Point Data.
- Surface water storage catchment and sub-catchment areas estimated from contour plans and aerial photography (refer Figure 4 and Figure 5).
- Recorded East Pit water levels, which were used along with the storage volume-area-level relationship (refer Figure 6) to estimate water storage volumes.
- Recorded salinity (EC) at the NWSD WTF raw water tank, in the NWSD and Bobadeen Dam.
- Recorded monthly CHPP feed tonnes, tailings and product tonnages and bypass tonnages to calculate CHPP demand using available moisture data (refer Section 4.5).
- Recorded monthly road dust suppression usage.
- Groundwater inflow estimates to the two underground operations from calibrated values reported by groundwater specialists.
- Daily recorded volumes released via LDP6 and LDP19 and irrigation volumes.
- Daily recorded volumes of water pumped from and supplied to the two underground operations.
- Daily WTF water volumes.
- Monthly recorded volumes supplied to the Moolarben Coal Mine.

As part of calibration, AWBM parameters for sub-catchments and underground groundwater inflow rates were adjusted iteratively to improve the match between modelled and estimated actual stored water volumes. Additionally, the storage level-volume-area relationship for the East Pit was modified by adjusting the in-pit waste rock porosity as described in Section 4.4 in order to provide an improved match between both modelled volumes and water levels in the East Pit.

As outlined in Section 2.0, seepage from the East Pit occurs to the UUG and from a number of smaller storages to both underground operations. The rate of seepage was also derived as part of calibration. For the East Pit a relationship between water level and seepage rate was developed, as given in Table 10. Seepage rates are interpolated between tabulated water levels and extrapolated beyond the water levels tabulated.

Table 10 East Pit to UUG Calibrated Seepage Rates

East Pit Water Level (m AHD)	Modelled Seepage Rate (ML/d)
364	3.2
378	4.4
382	7.5

For other (smaller) storages, a simple volumetric recession rate model was adopted, with seepage equalling a percentage of the volume in the source storage each day – as summarised in Table 11.

Table 11 Calibrated Storage Seepage Recession Rates

Source Storage:	Barrier Pit	Dump 3 Sed. Dam	Hawks Sed. Dam	Peanut Dam	Phil's Sed. Dam	Ulan West Admin Dam
Daily Seepage Rate (%):	5%	10%	10%	20%	10%	10%

The calibrated model rainfall-runoff (AWBM) parameters are given in Table 12.

Table 12 Calibrated AWBM Parameters

Parameter	Sub-catchment Type						
	Hardstand	Natural Surface	Open Cut	Waste Rock	Rehabilitated Areas	Stockpiles	Tailings
C_1 (mm)	5	6	5	5	5	5	0
C_2 (mm)	-	120	25	65	60	35	-
C_3 (mm)	-	200	-	-	150	-	-
A_1	1	0.012	0.2	0.2	0.1	0.2	1
A_2	0	0.63	0.8	0.8	0.65	0.8	0
A_3	0	0.358	0	0	0.25	0	0
K_s (d^{-1})	0	0.6	0.1	0.1	0.25	0.1	0
BFI	0	0.3	0.1	0.9	0.3	0.7	0
K_b (d^{-1})	-	0.975	0.96	0.985	0.975	0.98	-
Ev, Fact	0.85	0.85	0.8	0.85	0.85	1	1

Also as part of calibration, source EC values were adjusted with final values given in Table 3. The transfer of salt from the UUG to Bobadeen Dam and the NWSD was adjusted to improve the match between modelled and recorded EC in Bobadeen Dam. Total inflows of water (and salt) from the UUG are modelled, rather than the inputs of individual dewatering bores, which draw water from different parts of the underground. Monitoring data indicates that the salinity of different underground dewatering bores differs – refer Figure 13. Water from bores with higher EC (e.g. East 20, MG23) is normally directed to the NWSD rather than Bobadeen Dam in order to promote a lower salinity within Bobadeen Dam which supplies the Bobadeen Irrigation System.

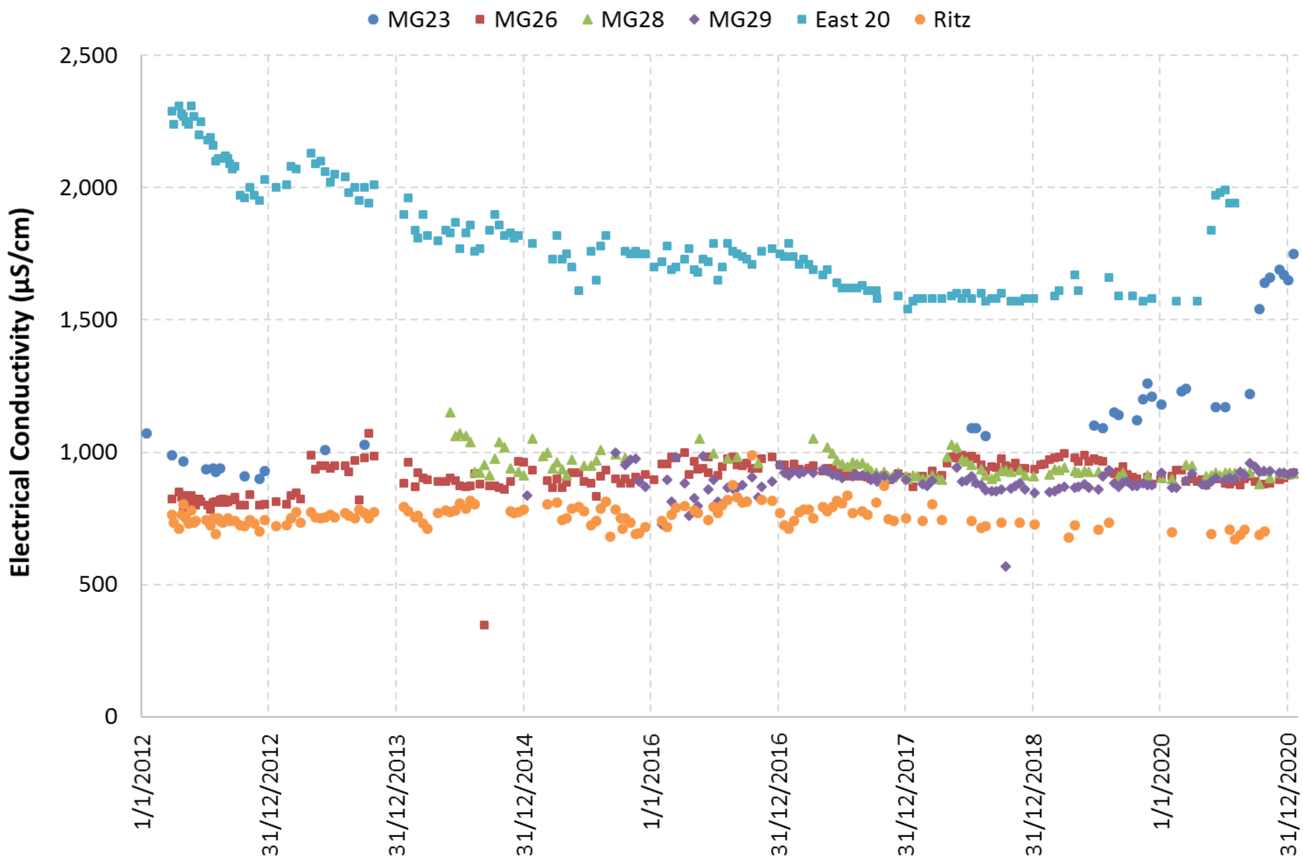

Figure 13 UUG Recorded Dewatering Bore Electrical Conductivity

Therefore in order to reflect this in the water balance model without modelling the individual parts of the UUG, a proportion of the salt transferred with water to the Bobadeen Dam was instead directed to the NWSD. This proportion changed with time but typically varied from 0.35 to 0.4 of the salt that was transferred with water to the Bobadeen Dam – directing this to the NWSD without changing the volume of water transferred (which was based on recorded volumes pumped). The proportion was set to 0.38, which is in the mid-range of values derived for the calibration period.

5.3 CALIBRATION RESULTS – STORED WATER VOLUME

A comparison between estimated actual total stored water volumes in the East Pit and those generated by the calibrated model is shown in Figure 14. It should be noted that the 'recorded' volumes plotted continuously in Figure 14 are based on a series of level records taken at discrete points in time (not daily) with intermediate levels interpolated between these points and volumes estimated from the storage level-volume relationship in Figure 6.

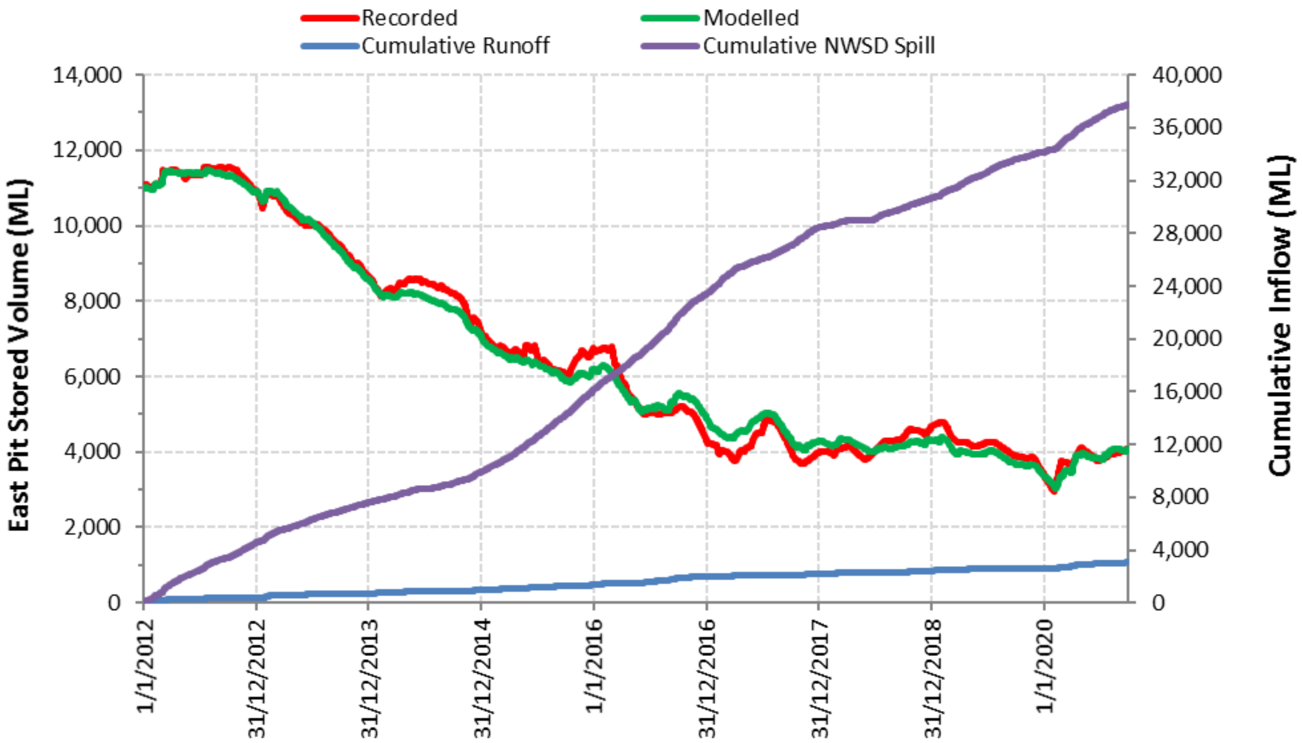

Figure 14 Calibrated Model and Estimated East Pit Stored Water Volume

Also shown in Figure 14 are plots of East Pit inflows from NWSD spill (mainly from underground dewatering) and cumulative rainfall runoff. These highlight that the main source of inflow to the East Pit is from underground dewatering, not rainfall runoff. Figure 14 indicates a good match between modelled and recorded East Pit water volumes. The linear correlation coefficient for the modelled to recorded stored water volumes (based on continuous data) is 0.991.

Figure 15 shows a similar plot for the East Pit water levels and recorded discrete data points.

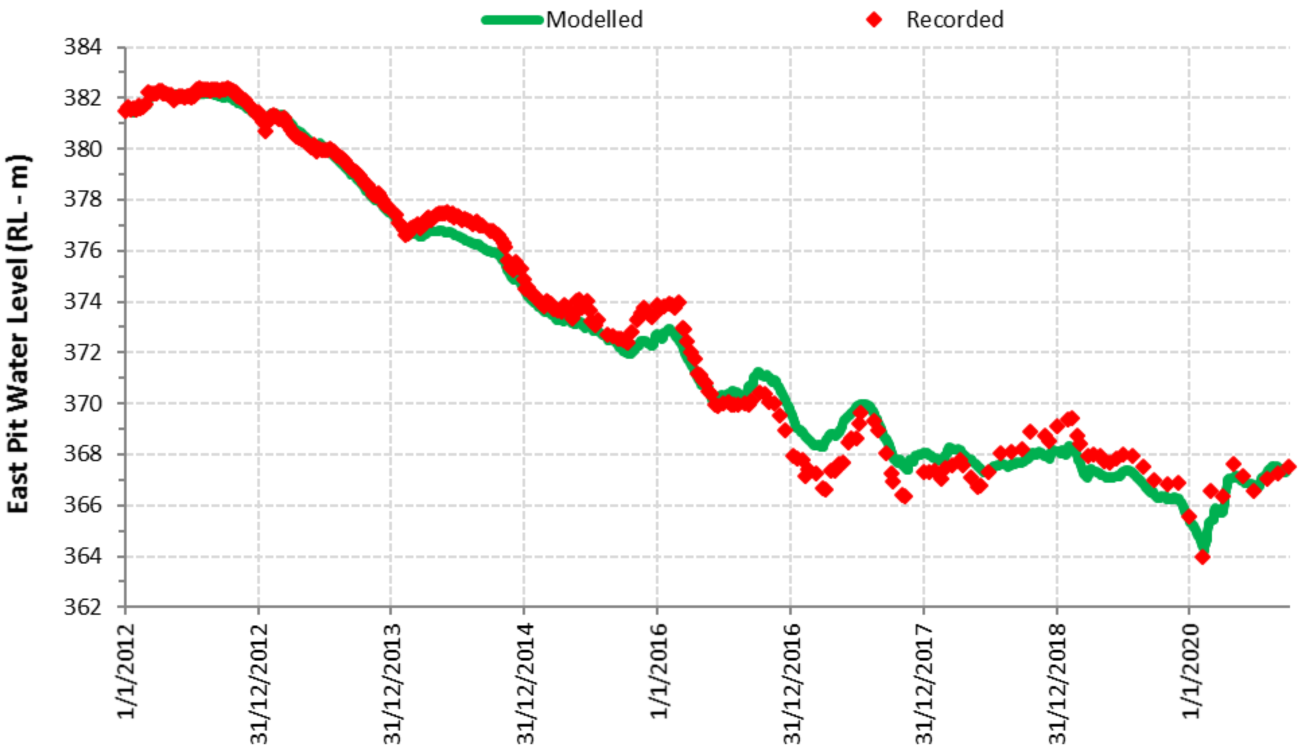

Figure 15 Calibrated Model and Recorded East Pit Water Levels

The model was able to replicate the total volume discharged via LDP6 and LDP19 to within 0.7%.

The simulated water volume in the UUG together with recorded daily total pumped dewatering rates are shown in Figure 16.

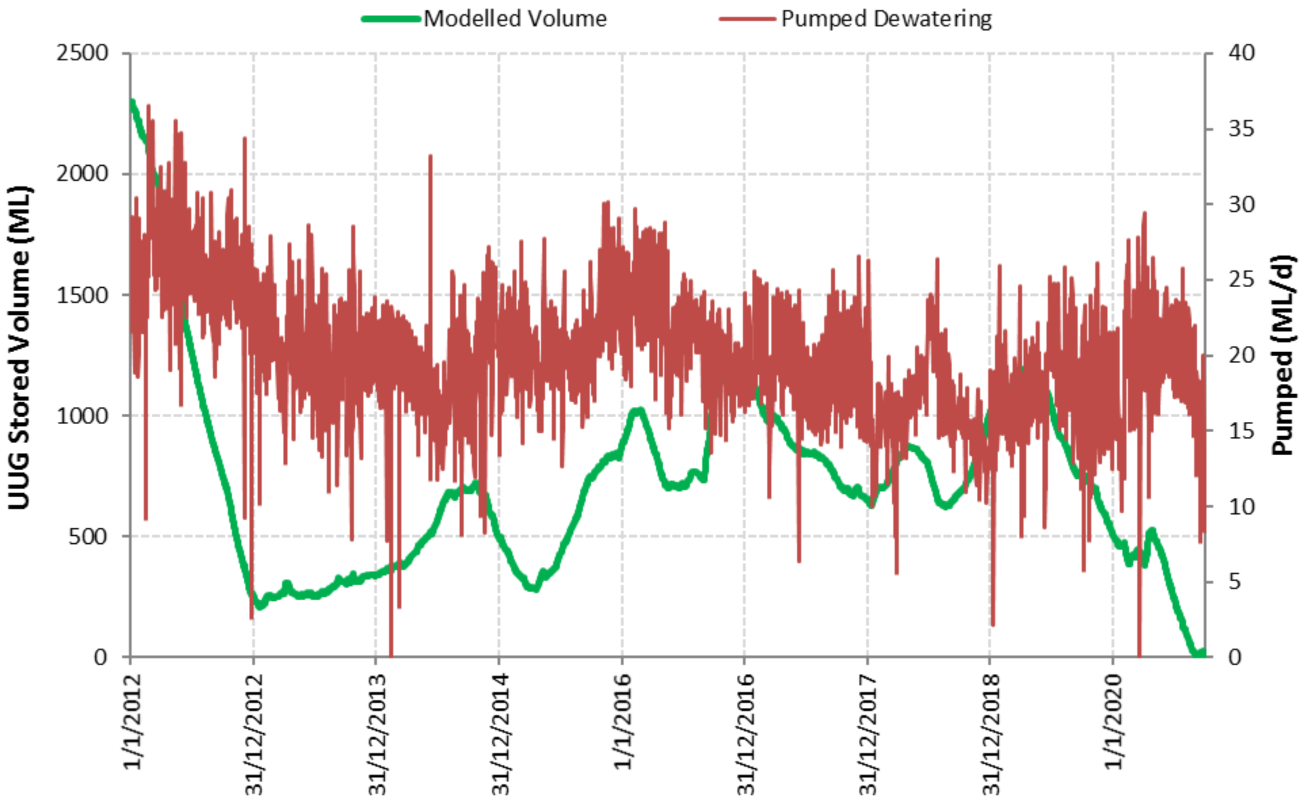

Figure 16 Ulan Underground Mine Modelled Volume and Recorded Dewatering Rates

In order for the model to maintain pumped dewatering at the recorded rates, a significant volume of water is assumed to be stored in the UUG at the start of the calibration period - Figure 16 indicates that the simulated volume in the UUG subsequently falls to near zero in late 2020.

The simulated main inflows to the UUG together with recorded daily total pumped dewatering rates are shown in Figure 17. This indicates that groundwater inflow is the greatest inflow contributor, while seepage from the East Pit diminishes as the water volume in the East Pit drops.

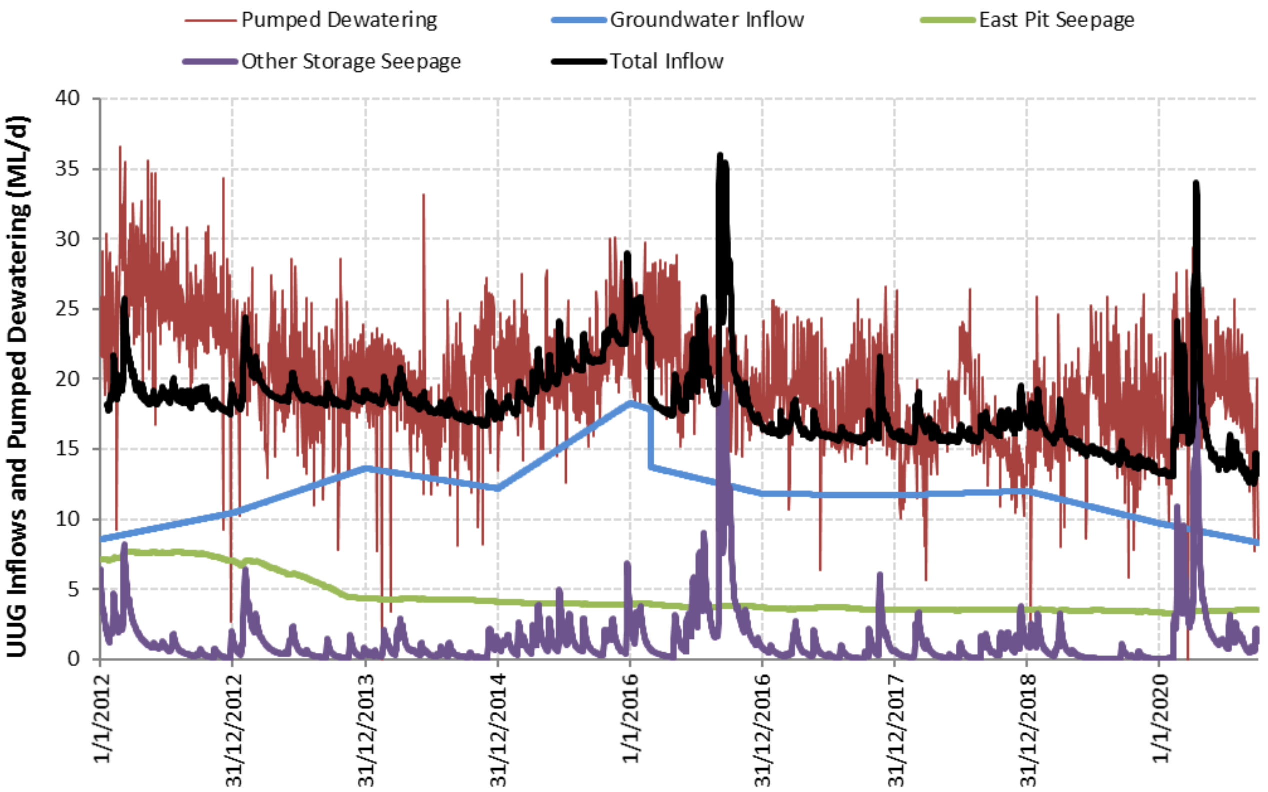

Figure 17 Ulan Underground Mine Main Modelled Inflows and Recorded Dewatering Rates

For calibration, forecast UUG groundwater inflows (provided by specialist groundwater consultants) were increased by 30% prior to February 2016 in order to reduce the simulated volume of water required to be held in the underground at the start of the calibration period and to provide a reasonable replication of recorded data.

5.4 CALIBRATION RESULTS – SALINITY

Simulated and recorded EC in the East Pit is plotted in Figure 18.

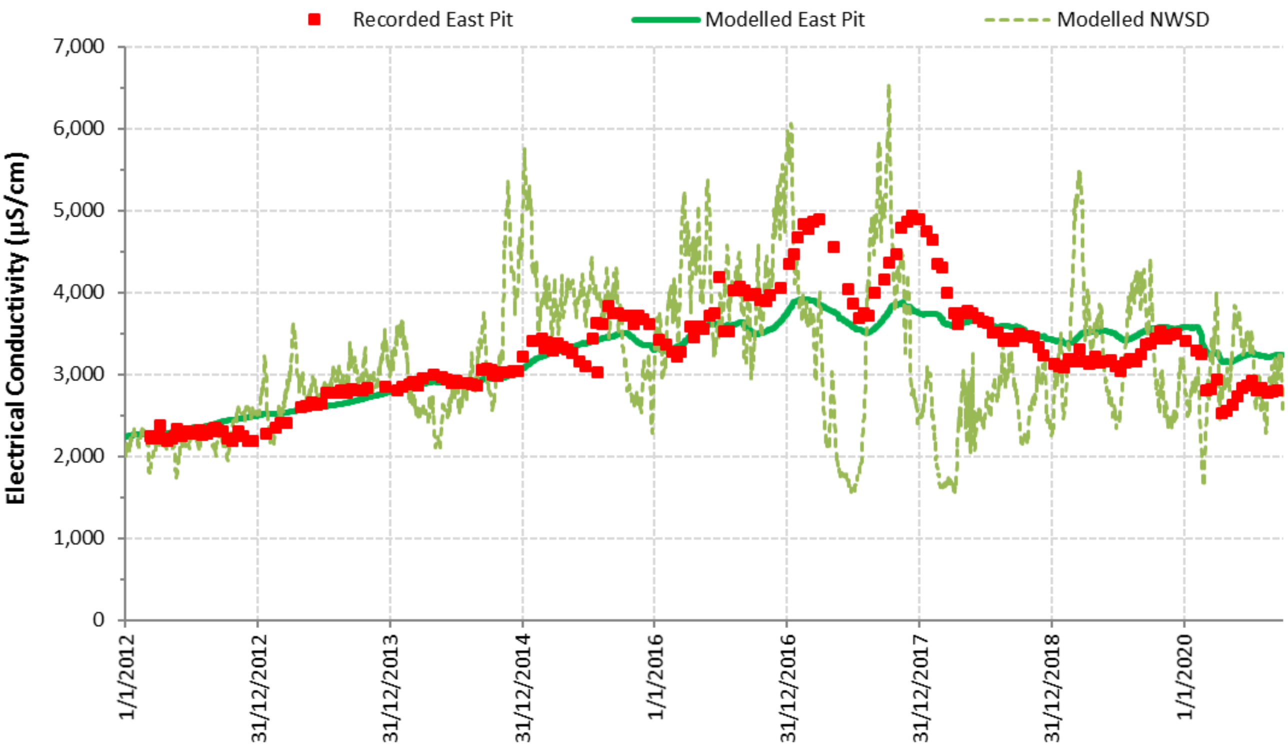

Figure 18 Calibrated Model and Recorded Electrical Conductivity – East Pit and NWSD

Figure 18 indicates a good match between modelled and recorded East Pit EC. The linear correlation coefficient for the modelled to recorded East Pit EC is 0.79.

Also plotted on Figure 18 is the modelled NWSD EC – the NWSD is the main inflow source for the East Pit. In Figure 18 there are periods where the recorded East Pit EC deviates somewhat from the modelled values – e.g. in 2017. Simulated East Pit salinity is inherently a fully mixed storage, whereas the East Pit is understood to exhibit salinity stratification and the recorded East Pit EC (recorded at the NWSD WTF raw water tank) may reflect this. During 2017 the modelled East Pit EC appears to be affected by the lower EC water simulated in the NWSD (lower as a result of suspension of the NWSD WTF operation), with modelled East Pit EC values typically in between recorded East Pit values and NWSD modelled values.

Simulated and recorded EC in Bobadeen Dam is plotted in Figure 19.

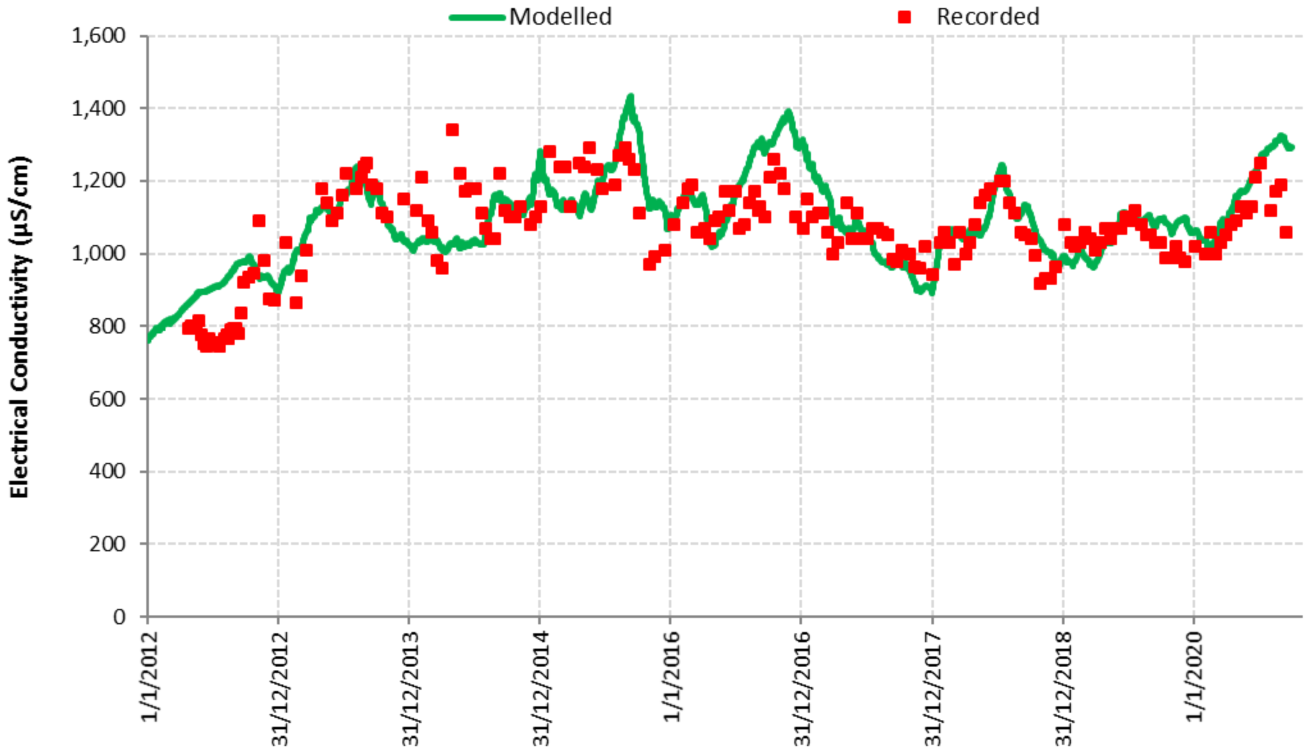

Figure 19 Calibrated Model and Recorded Electrical Conductivity – Bobadeen Dam

Figure 19 indicates a reasonable match between modelled and recorded Bobadeen Dam EC.

The overall salinity calibration is considered fit for assessment purposes.

6.0 FORECAST MODEL RESULTS

6.1 OVERALL SITE WATER BALANCE

Model predicted average inflows and outflows, averaged over all 132 realizations and the full simulation period (approximately 11½ years for the approved operations and 13½ years for the Proposed Modification), are shown in Figure 20.

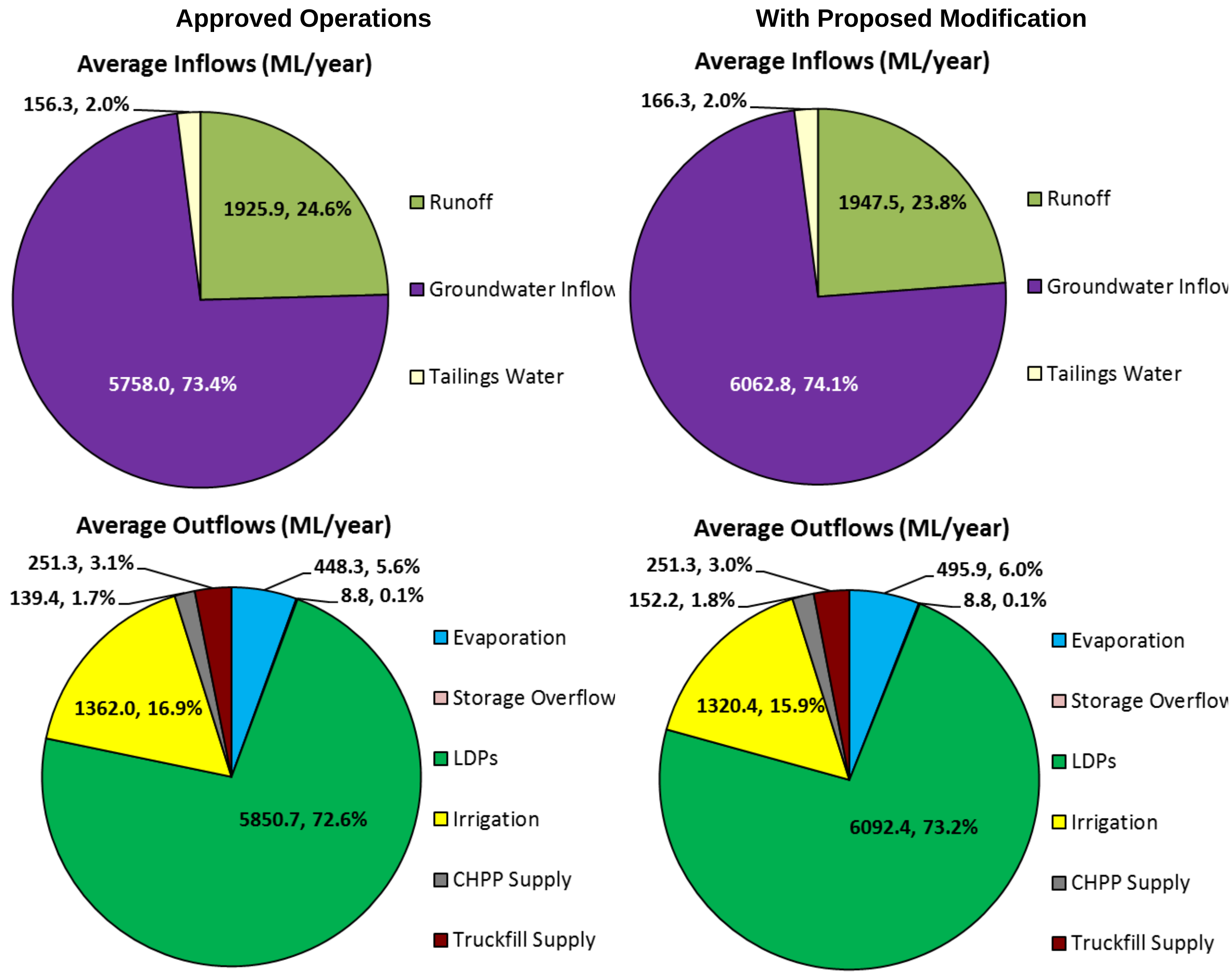

Figure 20 Average Modelled System Inflows and Outflows

In Figure 20 it can be seen that groundwater inflow provides the greatest average modelled system inflow, accounting for just under three quarters of total inflows, followed by rainfall runoff. Average groundwater inflow is forecast to increase slightly as a result of the Proposed Modification. The largest average outflow comprises licensed discharge (LDP6 and LDP19), again accounting for just under three quarters of total outflows and this is predicted to increase slightly as a result of the Proposed Modification. The forecast indicates slightly lower average volumes of irrigation via the Bobadeen Irrigation Scheme due to the way the model balances volumes between the Bobadeen Dam and NWSD.

Minor volumes of overflow are predicted from some storages – refer Section 6.3.

6.2 STORED WATER VOLUMES

Predicted total stored water inventory is shown in Figure 21 and Figure 22 for the existing approved operations and the Proposed Modification respectively as probability plots over the simulation period. These probability plots show the range of likely total stored water volumes with the solid central plot representing the median volumes and the broken upper and lower plots showing the 5th and 95th percentile volumes. There is a predicted 90% chance that the total water volume will fall in between the 5th/95th percentile volume plots. It is important to note that none of these plots represents a single climatic realization – these probability plots are compiled from all 132 realizations - e.g. the median volume plot does not represent model forecast volume for median climatic conditions.

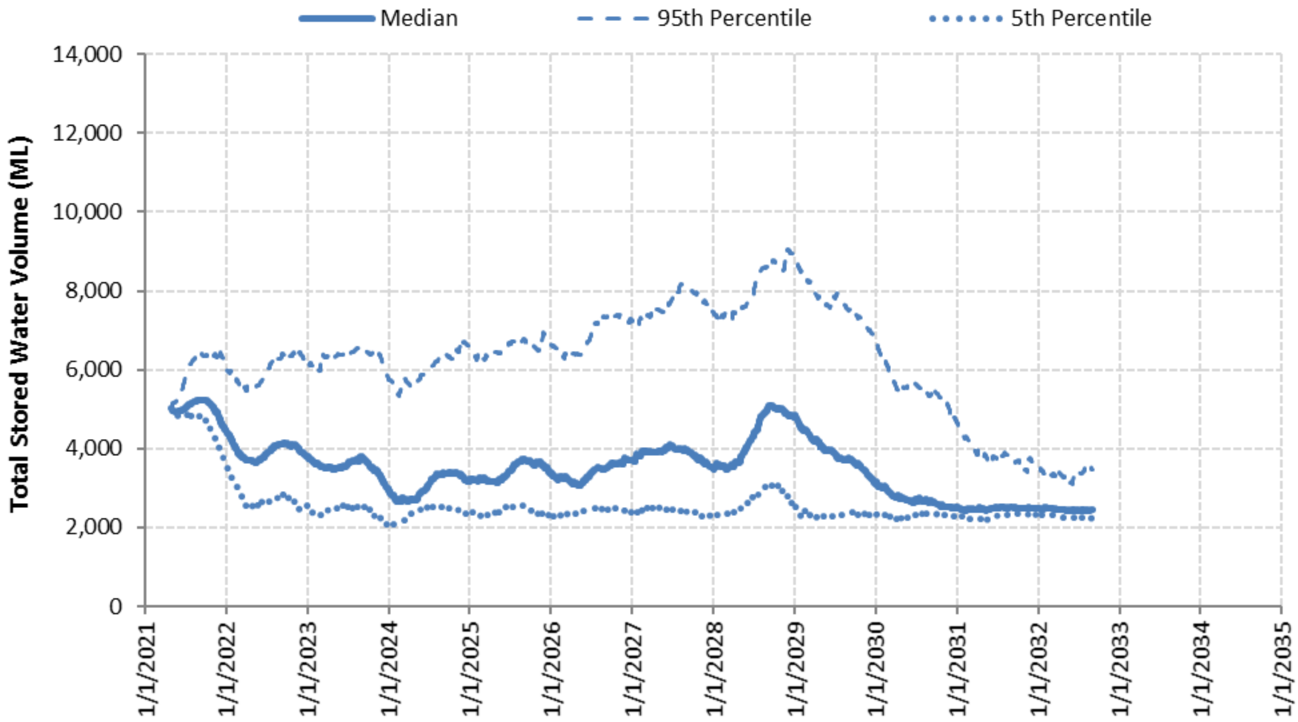

Figure 21 Simulated Total Stored Water Volume with Approved Operations

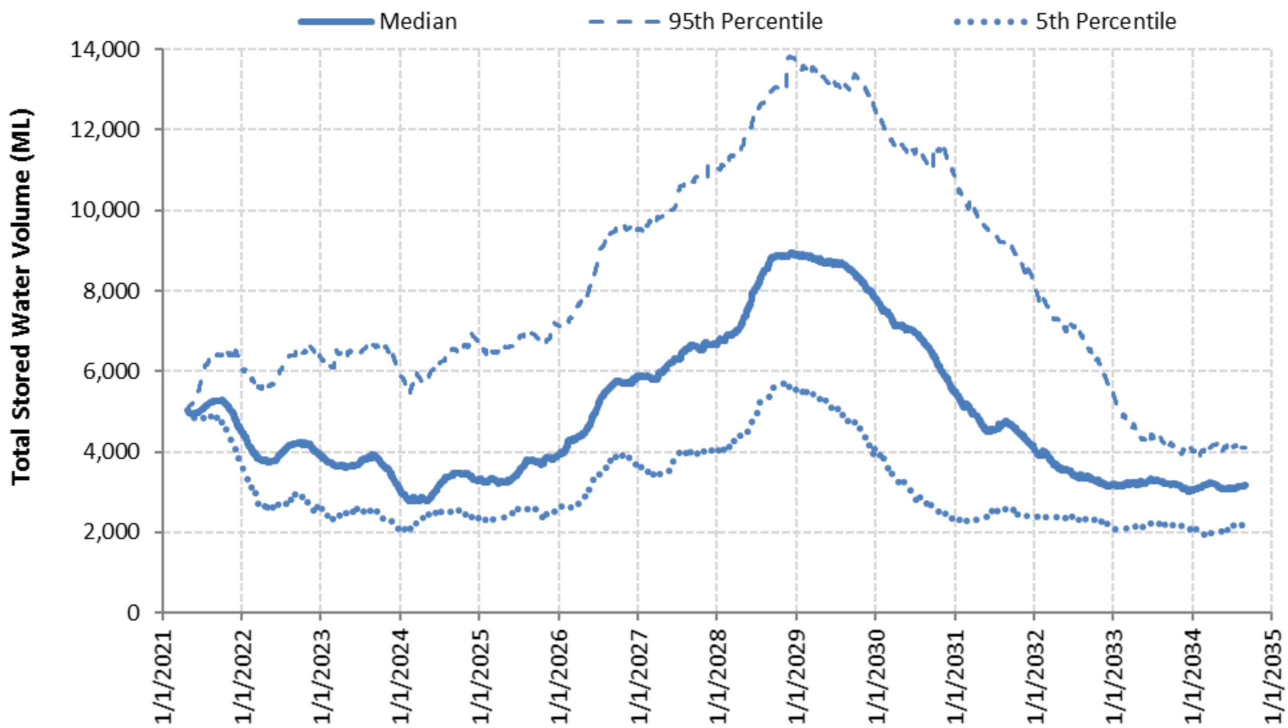

Figure 22 Simulated Total Stored Water Volume with Proposed Modification

The model results plotted in Figure 21 and Figure 22 indicate that stored water volumes are predicted to increase somewhat – mainly as a result of increased groundwater inflows. The forecast increase in inventory from 2026 to 2029 coincides with a forecast increase in groundwater inflow (refer Figure 12).

The majority of the forecast water inventory would be stored in the East Pit which, with an estimated capacity of 22,100 ML after the construction of TD3 (refer Figure 7), has more than adequate capacity to store the volumes indicated in Figure 22.

The significant predicted water inventory results in a secure water supply for the Proposed Modification, with no shortfalls predicted. No substantial build up of water is forecast in the underground operations.

6.3 STORAGE FORECAST OVERFLOWS

Predicted overflow volumes from dams are shown in Figure 23 and Figure 24 at different probabilities. These are expressed in total megalitres over the simulation period (approximately 11½ years for the approved operations and 13½ years for the Proposed Modification). No overflows (spillway discharge) are predicted from the East Pit. Overflows are only predicted from four storages as follows (refer Figure 4):

- The Peanut Dam which receives runoff from a catchment consisting almost entirely of rehabilitated areas and natural surface (undisturbed area). Release of surface water runoff from this area was described in the 2009 Continued Operations Environmental Assessment (Umwelt, 2009), hence this is considered now part of the project approval. Practical completion required the establishment of rehabilitation, including allowing time for vegetation cover to reach adequate levels in order to limit sediment generation, sampling of runoff that would demonstrate appropriate release water quality and variation of EPL 394 to approve release of the water. The sampling effort was hampered by drought conditions in 2018 to 2020. Sufficient sampling has now been achieved and UCMPL are progressing the EPL variation in consultation with the NSW Environment Protection Authority (EPA).
- The Old Truckfill Dam which receives runoff from a catchment on the eastern end of the UCC surface facilities area and is an EPL 394 licensed discharge point (LDP4).

- Wrights Dam is a small dam at the western end of the UCC surface facilities area with a catchment comprising a combination of predominantly hardstand area (including a workshop and other industrial area) and some grassed areas. Water is diverted away from Wrights Dam and water volume managed as low as possible.
- Peters Dam which is small dam comprising mainly a small stockpile area, roads and other hardstand areas. The predicted overflow events from Peters Dam are associated with three separate high rainfall events[4]. The risk of any one of these events occurring is therefore less than 3%. The predicted overflow magnitudes from Peters Dam for two of these events are less than 3 ML, while the third has an overflow volume of approximately 20 ML which results from an extreme rainfall event of 252 mm in 2 days (recorded in February 1955) – the highest 2 day rainfall period in the record. Water is diverted away from Peters Dam and water volume managed as low as possible.

The magnitude of the predicted overflow volumes is related to the capacity of the storage, the catchment area reporting to the storage, the pump capacity at the storage and the availability of the receiving storage to accept pumped inflow. The potential for overflows is extended by two years as a result of the Modification, but there is otherwise no change to the potential for overflows as a result of the Modification.

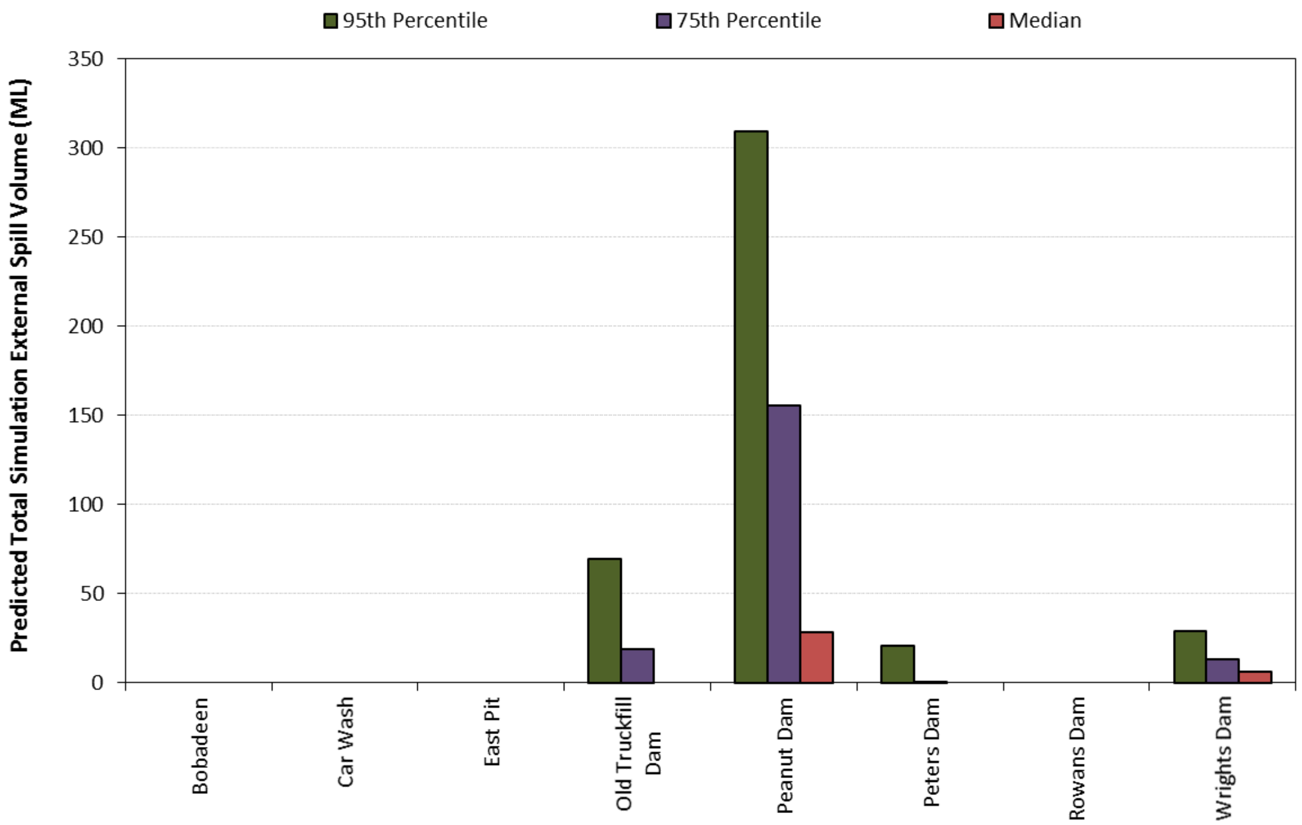

Figure 23 Predicted Storage Overflow Volumes with Approved Operations

[4] These three events are replicated and occur at different points in time in 39 of 132 modelled realizations.

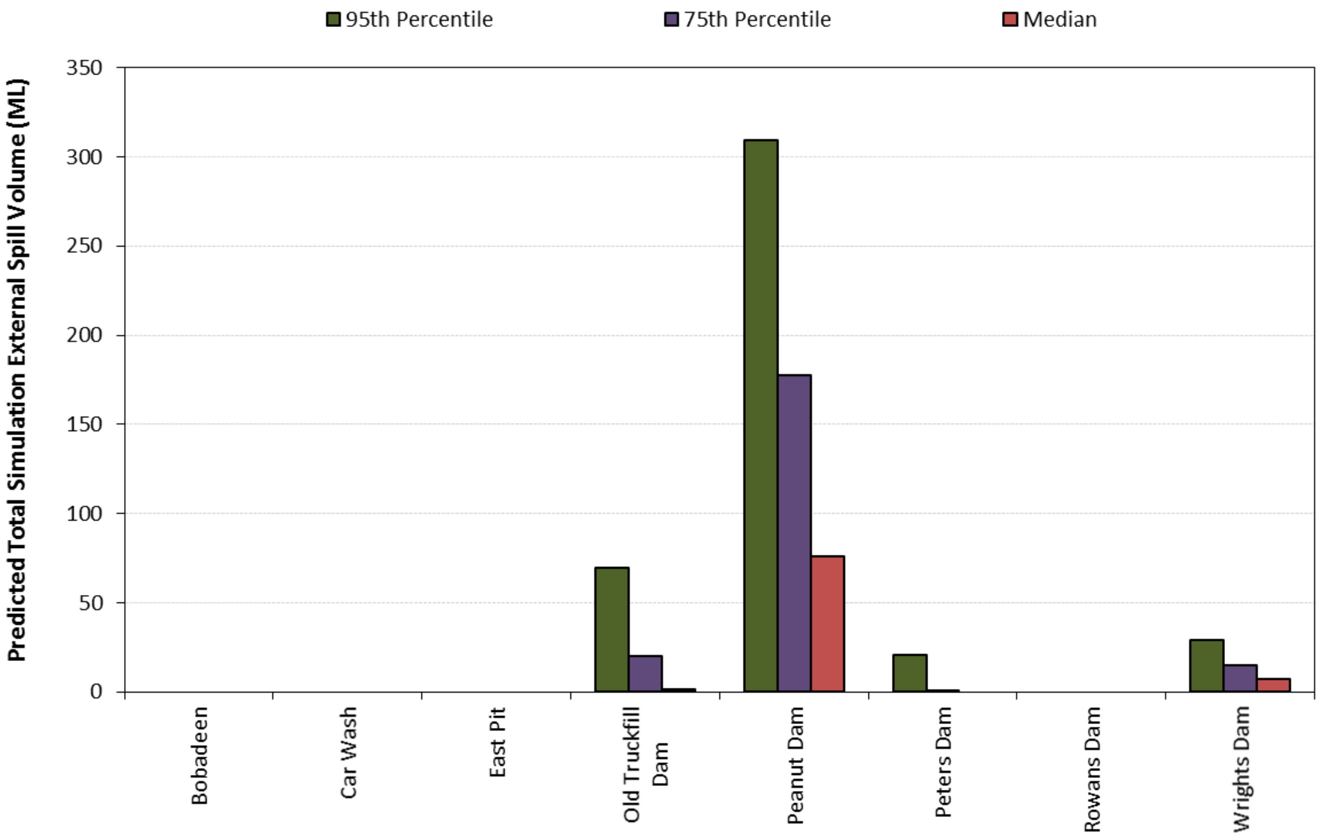

Figure 24 Predicted Total Outflow Volumes with Proposed Modification

7.0 REFERENCES

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