BHP

Orebody 29/30/35 Significant Amendment:

Ophthalmia Dam Surplus Water Impact Assessment

November 2024
Version 1

Authorisation

Version	Description of Version	Position	Date
0	Initial version for Traditional Owner information	Superintendent Environmental Approvals	31 August 2024
1	Final version as part of EPA referral package for Orebody 29/30/35 Significant Amendment	Superintendent EPH Hydrogeology	08 November 2024

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1 Purpose

The purpose of this document is to present the assessment of potential impacts on water resources from the discharge of surplus mine dewater from BHP's eastern Pilbara mines to Ophthalmia Dam. The assessment uses the 2024 Eastern Pilbara Hub surplus water forecast, including the proposed increase in surplus water discharge from the Orebody 29/30/35 mine (*Orebody 29/30/35 Significant Amendment* (Orebody 29/30/35 Proposal) (BHP 2024a)). This updates the most recent impact assessment undertaken for the Jimblebar Hub Proposal (BHP 2023a).

The *Orebody 29/30/35 Significant Amendment: Groundwater impact assessment* (BHP 2024b) documents the assessment of the potential impacts of the proposed increase in groundwater abstraction for dewatering for the Orebody 29/30/35 Proposal.

2 Existing environment and environmental values

The existing Orebody 29/30/35 mine is authorised under Ministerial Statement 963 to discharge surplus water to the Ophthalmia Dam system, located approximately 15 km east of the Orebody 29/30/35 mine (Figure 1).

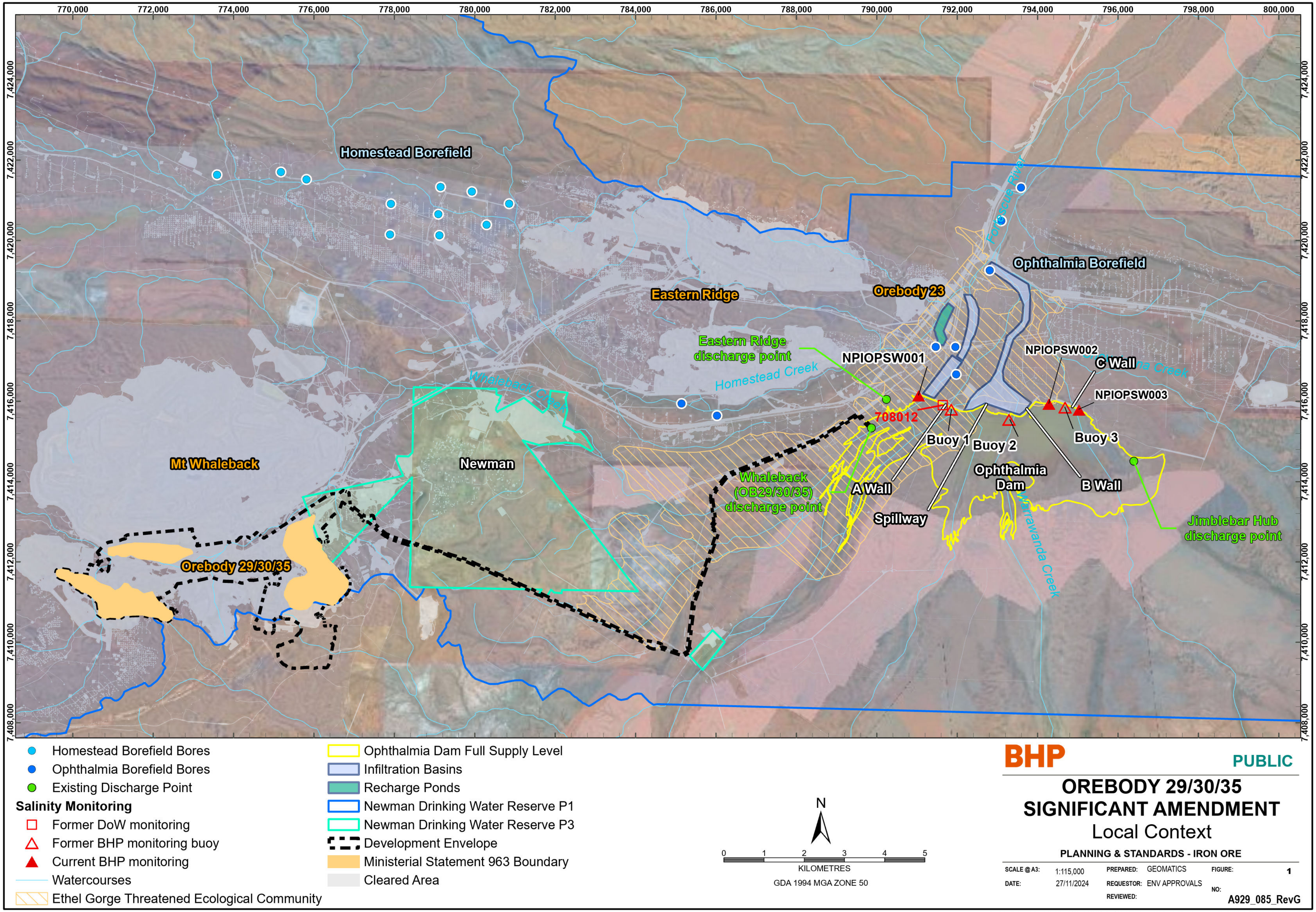
The Ophthalmia Dam system comprises the dam, two infiltration basins, three recharge ponds and connecting drainage system (EMM 2020) (Figure 1). The system was commissioned in 1981 as a managed aquifer recharge (MAR) scheme to address declining groundwater levels in the Ethel Gorge aquifer, due to groundwater abstraction from the Ophthalmia Borefield, which supplies drinking water to the Newman town.

Ophthalmia Dam is located within the Priority 1 Public Drinking Water Source Area of the Newman Water Reserve. Groundwater is currently sourced from the BHP operated Ophthalmia and Homestead borefields for the Newman town water supply. The Ophthalmia Dam system partially overlies the Ethel Gorge aquifer system which supports the Ethel Gorge aquifer Stygobiont community Threatened Ecological Community (Ethel Gorge TEC) (Figure 1).

The Ophthalmia Dam system continues to maintain groundwater levels within the Ethel Gorge aquifer system to support the Newman town water supply, the Ethel Gorge TEC and provides a location for the discharge of surplus water from BHP mines in the Eastern Pilbara area (currently Eastern Ridge, Orebody 29/30/35 and the Jimblebar Hub (Jimblebar and Orebody 31) (Figure 2)). Discharge of surplus mine dewater to Ophthalmia Dam first commenced in 2006 from Eastern Ridge, followed by Orebody 31 and Orebody 29/30/35 in 2016 and Jimblebar in 2019 (BHP 2019a). As at November 2024, discharge to Ophthalmia Dam from Orebody 32 below water table (OB32 BWT), part of Eastern Ridge, and Western Ridge has been approved but has not commenced.

The main water-related environmental values that may be impacted by the discharge of surplus dewater into Ophthalmia Dam from BHP's Eastern Pilbara mines (including from Orebody 29/30/35) are:

- local groundwater resource in the Newman Water Reserve, used for town water supply
- Fortescue River and tributaries
- Ethel Gorge aquifer (and TEC).



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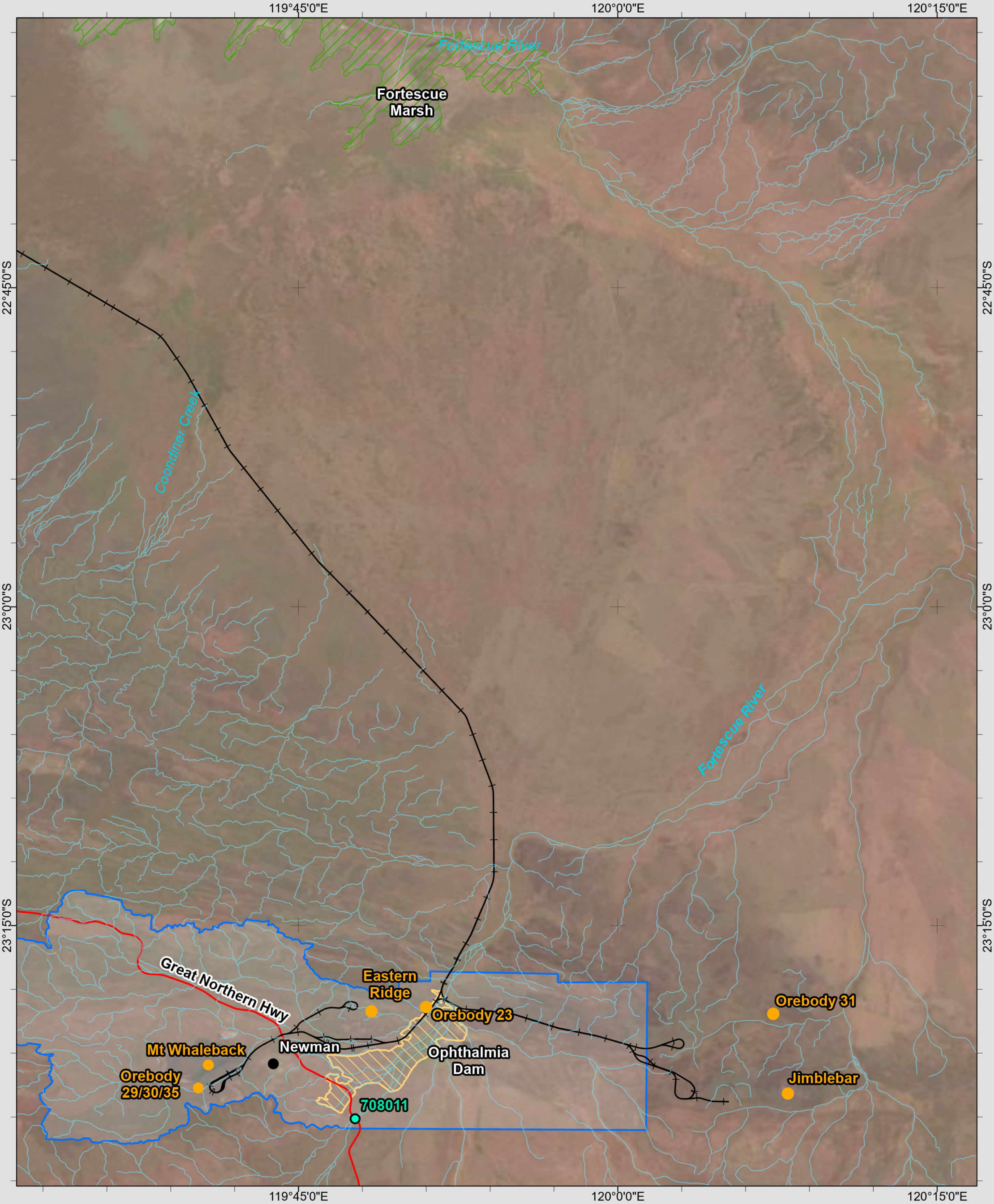
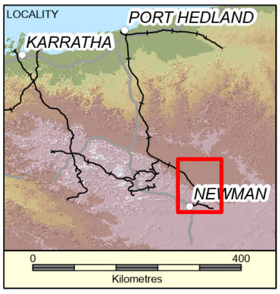


DWER Stream Gauging
Watercourses
Rail Line
Highways
Ethel Gorge Threatened Ecological Community
Fortescue Marsh Priority Ecological Community
Newman Drinking Water Reserve



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Geomatics - Studies Planning & Access
BHP IRON ORE

OREBODY 29/30/35 SIGNIFICANT AMENDMENT
Regional Context

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0 5 10 15
Kilometres

Coordinate System: GCS GDA 1994, Datum: GDA 1994, Units: Degree

Scale @ A4: 1:450,000	Prepared: GEOMATICS	Project No: A929_086_RevC	
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3 Surplus water regulation and management

3.1 Environmental regulation

3.1.1 Ophthalmia Dam system operation

There are no environmental approvals for the operation of Ophthalmia Dam under the EP Act, as the dam was constructed prior to the EP Act coming into force. A Notice of Intent (NoI) for the Newman Water Resources Development Project (which includes the Ophthalmia Dam system), was submitted in April 1981 (Mt Newman Mining Company 1981). The NoI sets out the justification for the Ophthalmia Dam system, operational parameters, description of the existing environment, potential environmental impacts and environmental monitoring measures. The Newman Water Resources Development Project (including the Ophthalmia Dam system) was approved by the Minister for Resource Development in May 1981. Ophthalmia Dam is not a prescribed premise and is not currently subject to regulation under Part V of the EP Act.

3.1.2 Discharge of surplus water to Ophthalmia Dam system

Discharge of surplus mine dewater from BHP mines to the Ophthalmia Dam system (i.e the dam and the recharge ponds) is currently regulated under various Part IV and Part V mine approvals (Table 1):

- Eastern Ridge Mining Operations
  - Eastern Ridge Revised Proposal: MS1037 and L6942/1997/13
  - OB32 BWT Proposal: MS1105 and EP Act s45B Notice: Statement 1105 – No 1
- Jimblebar Hub:
  - Jimblebar: MS1126 and L5415/1988/9
  - Orebody 31: MS1021 and L5415/1988/9.
- Whaleback
  - Orebody 29/30/35: MS963 and L4503/1975/14
  - Western Ridge: MS1105 and EP Act s45B Notice: Statement 1105 – No 2.

The impacts of discharge were not assessed under Part IV for Orebody 23 (EPA 1998) and dewatering at Orebody 23 has ceased (BHP 2024c). MS1021 for Orebody 31 contains conditions relating to discharge to Ophthalmia Dam, however, the discharge rate is not specified.

The approval for the discharge of surplus water from Eastern Ridge to the Ophthalmia Dam system includes direct discharge of surplus water to the dam and direct discharge to the recharge ponds and infiltration basins downstream of the dam.

Table 1: Approved discharge to Ophthalmia Dam system

Mine	Year approved (Part IV)	Surplus discharge to Ophthalmia Dam system (GL/a)	
		Part IV approved	Part V approved
Eastern Ridge mining operations			
Eastern Ridge mine (OB24, OB25 Pit 1 and 3, OB25 West)	2016	19[1]	19[1,2]
Orebody 23	1998	Not assessed	
Orebody 32 Below Water Table	2023	21.9	21.9[3]

Mine	Year approved (Part IV)	Surplus discharge to Ophthalmia Dam system (GL/a)	
		Part IV approved	Part V approved
Jimblebar Hub			
Jimblebar	2011	16.425	32.625[5]
Orebody 31	2015	(16.2)[4]	
Whaleback			
Orebody 29/30/35	2014	8	8
Western Ridge	2023	13	13[3]
Total		**94.525**	**94.525**

1. Approvals are for the Ophthalmia Dam system, i.e. include direct discharge of surplus water to recharge ponds and infiltration basins as well as direct discharge to the dam. Discharge of 5 ML/d (1.825 GL/a) assessed for Orebody 25 Extension project (EPA Report 1210) and increased to 13.9 GL/a via s45 to MS712 on 12 October 2015. Discharge of 19 GL/a approved under MS1037 on 21 September 2016.
2. Part V regulated as Eastern Ridge Iron Ore Mine, which includes Eastern Ridge mine and OB23
3. Works Approvals under Part V for OB32 BWT and Western Ridge were approved in April 2024. As at August 2024, licence amendments have been submitted to the Department of Water and Environmental Regulation (DWER) for both projects.
4. OB31 Part IV assessed up to 16.2 GL/a discharge, but the rate is not specified in MS1021
5. Part V regulated as Wheelarra Hill (Jimblebar) Iron Ore Mine, which includes Jimblebar and Orebody 31 mines.

3.1.3 Surplus water environmental management requirements

BHP manages the potential impacts to the environment from the discharge of surplus water to the Ophthalmia Dam system primarily through its *Eastern Pilbara Water Resource Management Plan* (EPWRMP) (BHP 2024c). (endorsed Revision 6.0, BHP 2018), which BHP has updated (Revision 8.1, BHP 2024c) for the Orebody 29/30/35 Proposal. The EPA is currently (as at November 2024) assessing Revision 8.0 of the EPWRMP as part of the Jimblebar Hub Proposal.

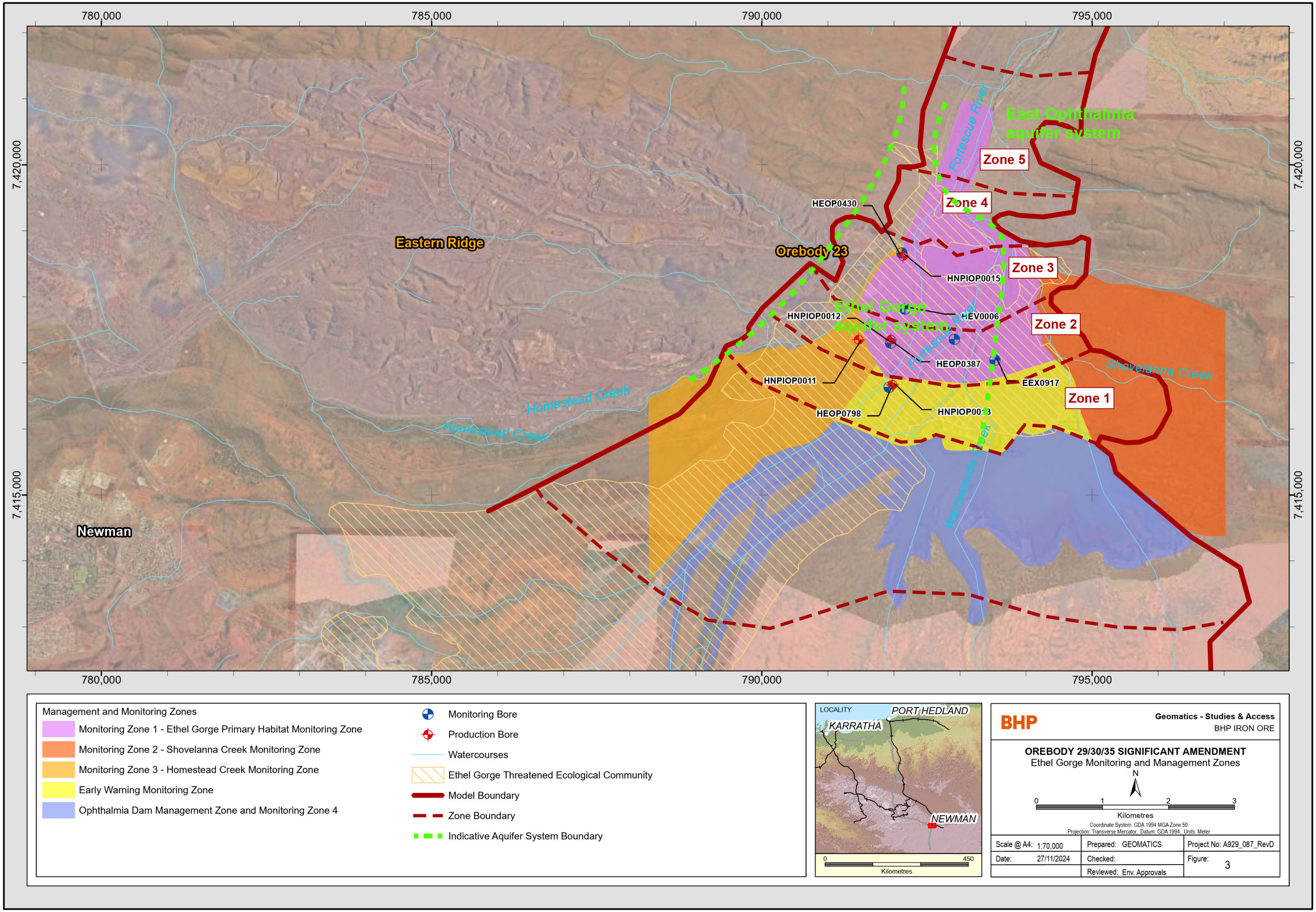
As a number of environmental approvals regulate the discharge of surplus water to Ophthalmia Dam, the EPWRMP focuses at a subregional level on the outcome of maintaining the hydrological conditions (groundwater levels and salinity) in the Ethel Gorge aquifer, to maintain the habitat of the Ethel Gorge TEC. The MS for Eastern Ridge (MS1037), Jimblebar (MS1126), Orebody 31 (MS1021), and OB32 BWT and Western Ridge (MS1105) all contain conditions requiring the implementation of an environmental management plan (the EPWRMP) to protect the Ethel Gorge TEC. The EPWRMP contains outcomes-based environmental criteria (early response indicators, triggers and thresholds) relating to groundwater level and groundwater salinity change in the Ethel Gorge aquifer that supports the Ethel Gorge TEC, for the Ethel Gorge Primary Habitat Monitoring Zone (Monitoring Zone 1) (Figure 3). Table 2 outlines the relevant triggers and thresholds in the EPWRMP (BHP 2024c).

Table 2: EPWRMP triggers and thresholds

Environmental criteria	Early response indicator	Trigger	Threshold
Groundwater levels Aquifer groundwater level in the Ethel Gorge Primary Habitat Monitoring Zone - Monitoring Zone 1	Aquifer groundwater level declines below 494 mRL	Aquifer groundwater level declines below 492 mRL	Aquifer groundwater level declines below 490 mRL
Groundwater quality Salinity as Total Dissolved Solids (TDS) in the Ethel Gorge Primary Habitat Monitoring Zone - Monitoring Zone 1	Groundwater salinity reaches 2,500 mg/L TDS	Groundwater salinity reaches 3,000 mg/L TDS	Groundwater salinity reaches 4,000 mg/L TDS

Response actions in the EPWRMP to manage groundwater levels and/or groundwater salinity include a seasonal controlled release, following a wet season from Ophthalmia Dam to upper Fortescue River tributaries. BHP notes in the EPWRMP that three months of controlled release into the Upper Fortescue following the wet season is considered appropriate and unlikely to develop permanent or ponding water downstream in the Fortescue River or have an impact on riparian vegetation (BHP 2024c). In 2019 correspondence to the EPA Services of the DWER, BHP also noted that discharge from the dam (i.e. releases) of less than three months duration during the dry season (i.e. when there are typically no natural flows) is unlikely to negatively impact riparian vegetation health and considered that biannual releases of water from the dam [total of up to 3 months] may be undertaken (BHP 2019b). Since Revision 8.0, the EPWRMP contains a threshold to limit the releases of water to the Fortescue River tributaries to 3 months total during natural no-flow conditions (i.e. the dry season) to maintain the ephemeral nature of the Fortescue River. Management options to limit releases to the Fortescue River in the dry season include releasing water from the dam during or following wet season (i.e. during natural flow events) or altering the surplus water discharge regime (amount of water discharged) from BHP mines to the Ophthalmia Dam system. There is no restriction when BHP discharges surplus water during natural flow events (BHP 2024c).

The Part V licences also contain requirements in relation to Ophthalmia Dam, including monitoring of discharge rates into the Ophthalmia Dam system, monitoring of discharge water quality (salinity and other parameters) and annual reporting (of exceedances of trigger values and details of investigations conducted, including outcomes, environmental impacts and remedial actions).



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4 Historical and recent water balance

4.1 Surface water system

The Ophthalmia Dam system was commissioned in late 1981. Ophthalmia Dam has an upstream catchment of approximately 4,320 km^2, with the Fortescue River and Fortescue River tributaries (including Warrawandu and Whaleback Creeks) all contributing flow to Ophthalmia Dam (Figure 1). Only the Fortescue River (at Newman (708011)) upstream of Ophthalmia Dam (see Figure 2 for location) has a long-term gauged record, providing reliable estimates of potential catchment inflows to Ophthalmia Dam (EMM 2020). The catchment area upstream of the DWER Fortescue River – Newman (708011) gauging station is 2,822.10 km^2, representing approximately 68% of the total catchment area contributing to Ophthalmia Dam.

The maximum operating storage capacity of the dam is estimated to be 25.33 GL at the service spillway elevation (513.5 mRL) covering a total area of approximately 1,476 ha (maximum inundation area) (EMM 2020). The maximum storage capacity is consistent with the approved design, set out in the 1981 NoI which documents the dam full supply level at 513.5 mRL (Minister for Minerals and Energy 1984) (Figure 1). When the dam fills from rainfall events and overtops the service spillway (uncontrolled release), water flows into the Fortescue River downstream of the dam. The typical water storage regime consists of dam filling events predominantly during the wet season from large Fortescue River flow events (although the dam does not fill every year), and rapid storage recessions during the dry season, due to seepage and evaporative losses. The minimum storage area is 15 ha at the spillway base elevation of 509.0 mRL (EMM 2020).

As discussed in Section 2, since 2006, Ophthalmia Dam also receives surplus water from BHP's eastern mines (current discharge points are shown on (Figure 1)). The Ophthalmia dam system also includes recharge ponds and infiltration basins. Surplus water that is discharged to the recharge ponds and infiltration basins directly recharges the Ethel Gorge aquifer. As discussed in Section 3.1.2, the approval for the discharge of surplus water from Eastern Ridge to the Ophthalmia Dam system includes direct discharge of surplus water to the dam and direct discharge to the recharge ponds and infiltration basins downstream of the dam.

4.2 Rainfall and streamflow

Rainfall and streamflow in the Ophthalmia Dam catchment are highly variable from year to year. Figure 4 shows the annual (water year) rainfall at the DWER Fortescue River - Newman station (507005) and annual streamflow at DWER Fortescue River - Newman station (708011) since 1981 when Ophthalmia Dam was commissioned. During this period, annual rainfall has varied between 52 mm and 902 mm and annual streamflow has varied between 51 ML and 391,234 ML. While annual rainfall and streamflow since 2010 are lower than the wet period between 1995 and 2010, they are higher than the dry period between 1981 and 1995.

Appendix A provides plots of daily rainfall and flow at the Fortescue River – Newman stations for each water year (September - August) since 1982 following commissioning of the dam in 1981. The plots are shown at the same scale to show the large variation in the Fortescue River streamflow in any particular year. Most streamflow occurs during the wet season (typically December to April) after a number of and/or large rainfall events. However, rainfall and streamflow also occur outside the wet season. Streamflow usually occurs following large rainfall events, particularly when there was a lot of rain in the preceding wet season resulting in wetter catchment conditions.

4.3 Discharge to Ophthalmia Dam system

As discussed in Section 3.1.2, the discharge of surplus water to the Ophthalmia Dam is regulated for each mine from where the surplus water originates, rather than the dam itself. Table 3 presents approved and recent actual discharge rates (average from financial year (FY) 2023 and FY2024) to the Ophthalmia Dam system (i.e including discharge to the recharge ponds and infiltration basins) from operating BHP mines that are currently discharging surplus water to the Ophthalmia Dam system (i.e excluding OB32 BWT and Western Ridge which were approved under Part IV in

September 2023 but are not yet discharging surplus water to Ophthalmia Dam). Figure 4 also shows the actual and approved discharge from all operating mines, since discharge commenced in 2006. Of the total licensed annual discharge rate (59.625 GL/a) for these mines, only a portion of this is actually discharged to the Ophthalmia Dam system. This is because the licensed rate is an annual peak rate that allows for fluctuations in dewatering rates according to the individual mine plans (the daily rates shown in Table 3 represent the average daily discharge rates based on the annual totals). The total actual recent average discharge rate from FY2023 and FY2024 from all BHP mines that are currently discharging surplus water to Ophthalmia Dam is approximately 69.8 ML/d (25.5 GL/a), corresponding to approximately 43% of the total licensed rate for these mines.

Table 3: Recent actual discharge to Ophthalmia Dam system

Mine	Surplus discharge to Ophthalmia Dam system		
	Part V licensed[1] (GL/a)	Recent actual[2] (GL/a)	Recent actual[2] (ML/d)
Eastern Ridge mine (OB24, OB25 Pit 3)	19[3]	7.5[3]	*20.5[3]*
Orebody 23			
Orebody 29/30/35	8	2.6	*7.2*
Jimblebar	32.625	15.3	*42.1*
Orebody 31			
Total	**59.625**	**25.5**	***69.8***

1. Part V licenced includes operating mines that are currently discharging surplus water to Ophthalmia Dam at October 2024.
2. Recent actual from average of FY23 and FY24 (July 2022 to June 2024)
3. Includes surplus water discharge to Ophthalmia Dam system recharge ponds and infiltration basins

At the annual scale, the recent total discharge (25.5 GL/a) is similar to the median annual Fortescue River streamflow (22.9 GL/a) at DWER Fortescue River - Newman station (708011). The plots in Appendix A also include the total daily discharge to Ophthalmia Dam only (excluding discharge to the recharge ponds and infiltration basins) since 2006, however the daily discharge (all less than 75 ML/d) is barely discernible at the scale plotted, as peak daily Fortescue River inflows regularly exceed 10.000 ML/d.

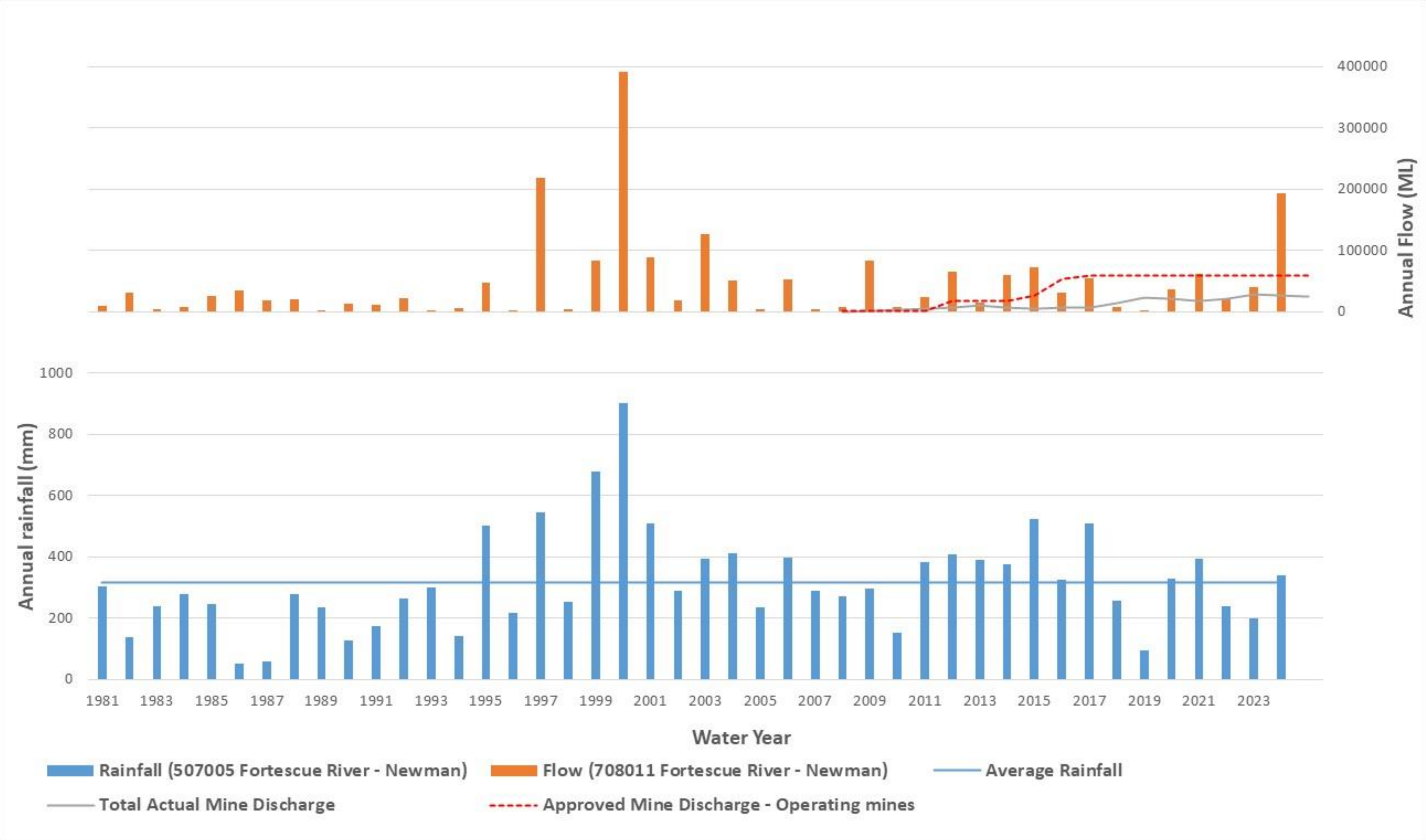


Figure 4: Fortescue River - Newman: Annual rainfall and streamflow

4.4 Ophthalmia Dam storage and inundation

Figure 5, Figure 6 and Figure 7 provide example plots of daily rainfall (507005), streamflow (708011) and dam storage (as the dam water level), and satellite imagery showing the storage inundation area (for low storage and high storage periods) compared to the maximum inundation area, before surplus water discharge from BHP mines commenced in late 2006 and since discharge commenced. The maximum inundation area is defined by the dam full supply level (513.5 mRL) set out in the NoI and approved in 1981. The Orebody 29/30/35 Proposal will not change the maximum inundation area.

Figure 5 shows the low storage conditions on 11 June 2005, prior to discharge from BHP mines. The plot shows that the dam water level (509.2 mRL) is almost at the minimum in the dry season following a very dry wet season (December to April), resulting in very little streamflow. The satellite imagery (although incomplete) shows that the dam is nearly empty with only a small amount of inundation upstream of the dam wall. No imagery was available for high storage conditions as imagery is usually obtained in the dry season.

Figure 6 shows the low storage conditions in July 2019, since discharge from BHP mines commenced. The plot shows that the dam water level (510.7 mRL) is low in the dry season following a very dry wet season (resulting in negligible streamflow). The satellite imagery shows that the dam is at low storage with inundation areas limited to the areas referred to as Fortescue pool (alluvial area) and Warrawanda pool (EMM 2020).

Figure 7 shows the high storage conditions on 31 March 2020, since discharge from BHP mines commenced. The plot shows that the dam water level (513.0 mRL) is high at the end of the wet season, following large rainfall events in the wet season (resulting in high streamflow filling the dam). The satellite imagery shows that the dam is at high storage with inundation areas extending almost to the dam full supply level (513.5 mRL).

The plots in Figure 6 and Figure 7 also show the total monthly discharge to Ophthalmia Dam from all BHP mines, assumed to be a constant daily discharge per month. This excludes discharge to the recharge ponds (as shown in Figure 1), as the recharge ponds are downstream of the dam wall. The flow in the second plot is magnified by a factor of 10 (Y-axis reduced from 20,000 ML/d to 2,000 ML/d) to show the discharge.

The data in Figure 5 to Figure 7 and Appendix A also show the following:

- Prior to surplus water discharge commencing from BHP mines in 2006, the dam storage reached full capacity (maximum inundation extent) and overtopped the spillway approximately every two to three years (except in the drier rainfall years between the late 1980s and early 1990s when the dam did not fill to capacity) and more frequently in the high rainfall years in the late 1990s to 2001.
- Prior to surplus water discharge commencing from BHP mines, the duration where the dam remained at full storage ranged between approximately one week and 4.5 months (in 2000).
- Since the dam started receiving surplus discharge from BHP mines (2006), the cycle of lower storage in the dry season and higher storage in the wet season (following sufficient streamflow) has continued, although dam water levels do not fall as low in the dry season. However, the contribution to dam storage is dominated by creek inflows following large rainfall events, rather than surplus discharge from BHP mines.
- Since the dam started receiving surplus discharge from BHP mines (2006), the dam has filled to the spillway capacity (resulting in overtopping over the spillway) the same number of times (11) as the period from 1981 to 2006. This reflects the drier years between 1987 and 1992 where the dam did not fill to capacity and the large rainfall events in 2021, 2022 and 2024 which has resulted in overtopping over the spillway.

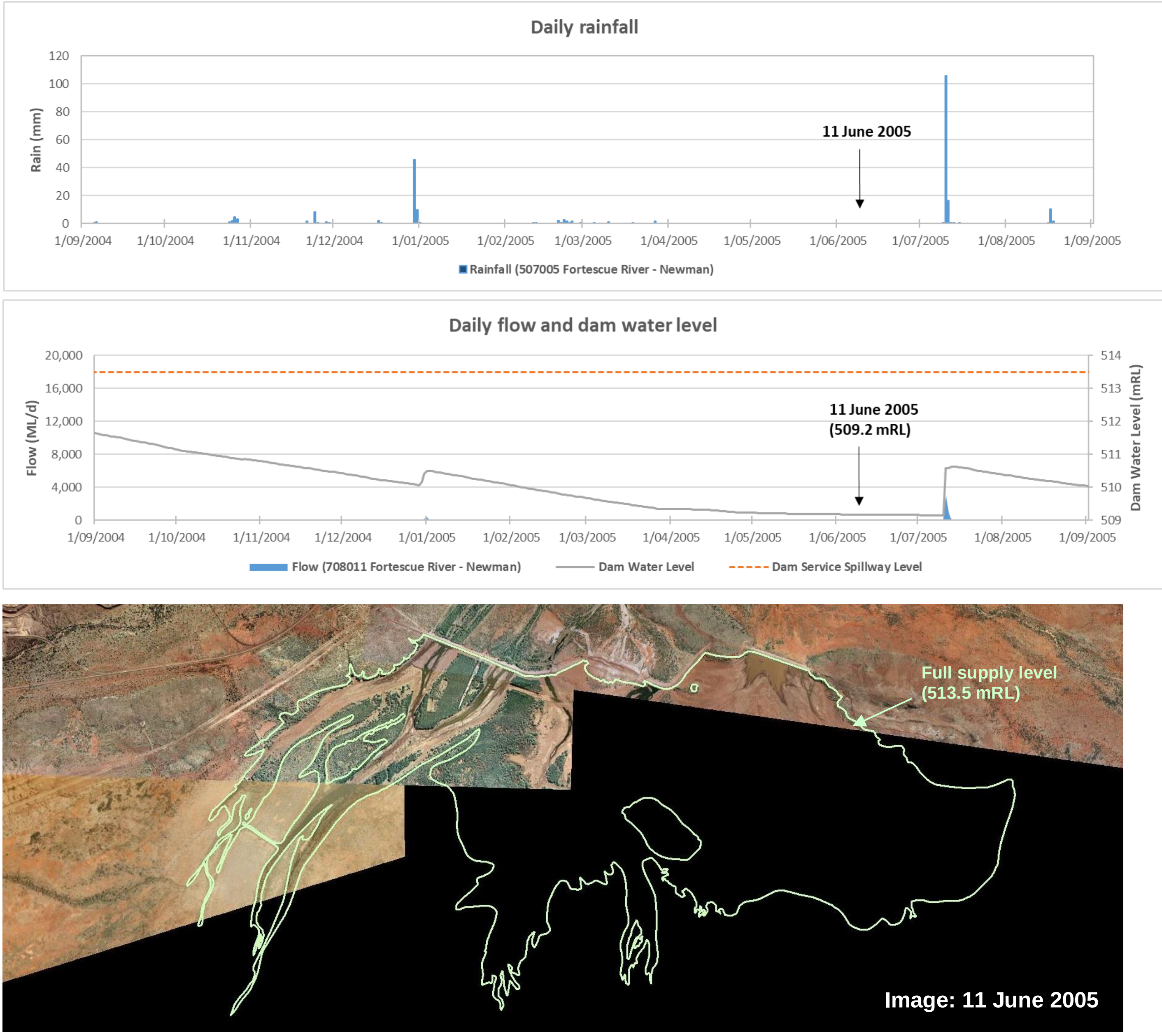


Figure 5: Fortescue River flow and Ophthalmia Dam low storage - prior to mine discharge

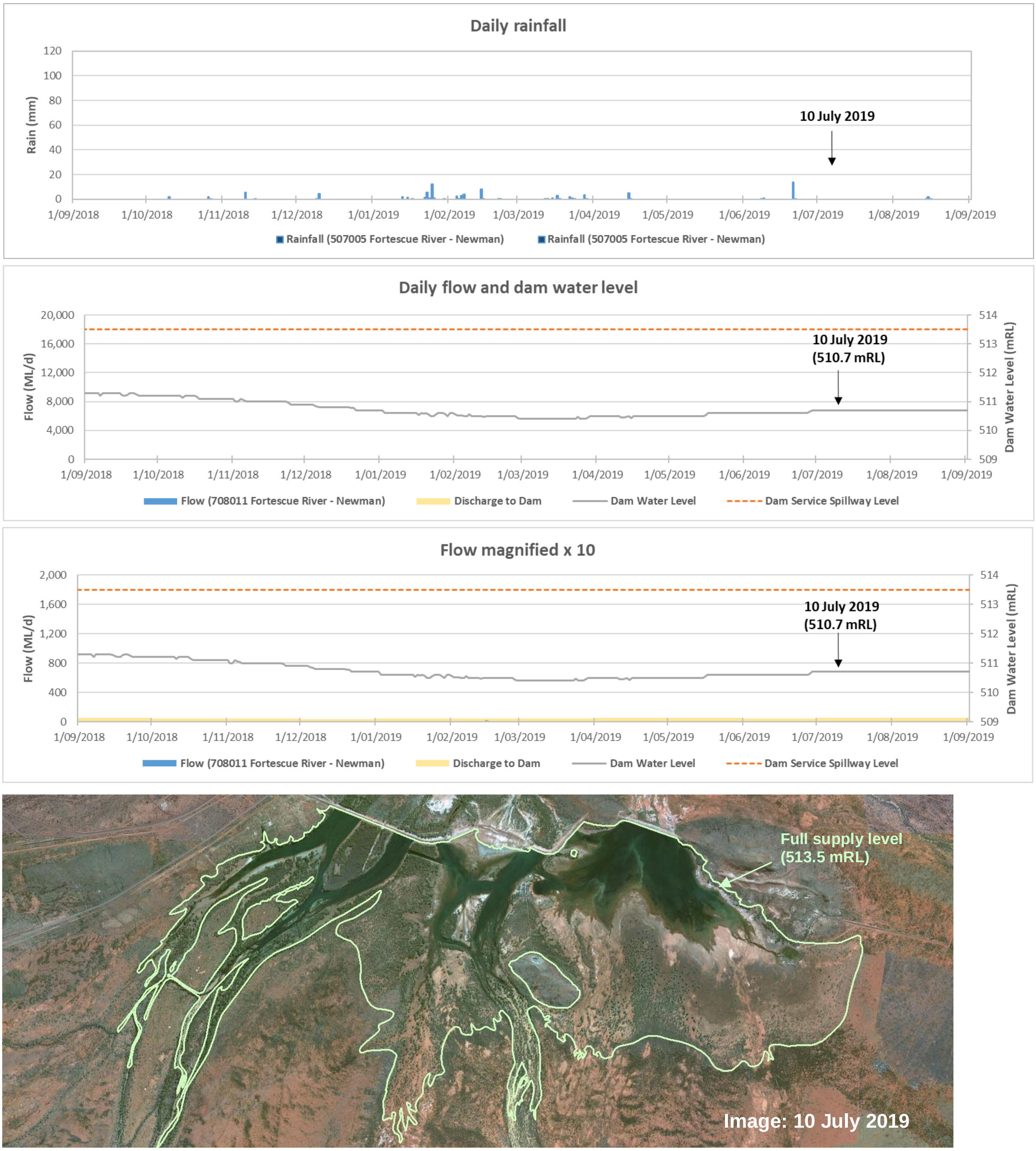


Figure 6: Fortescue River flow and Ophthalmia Dam low storage - since mine discharge

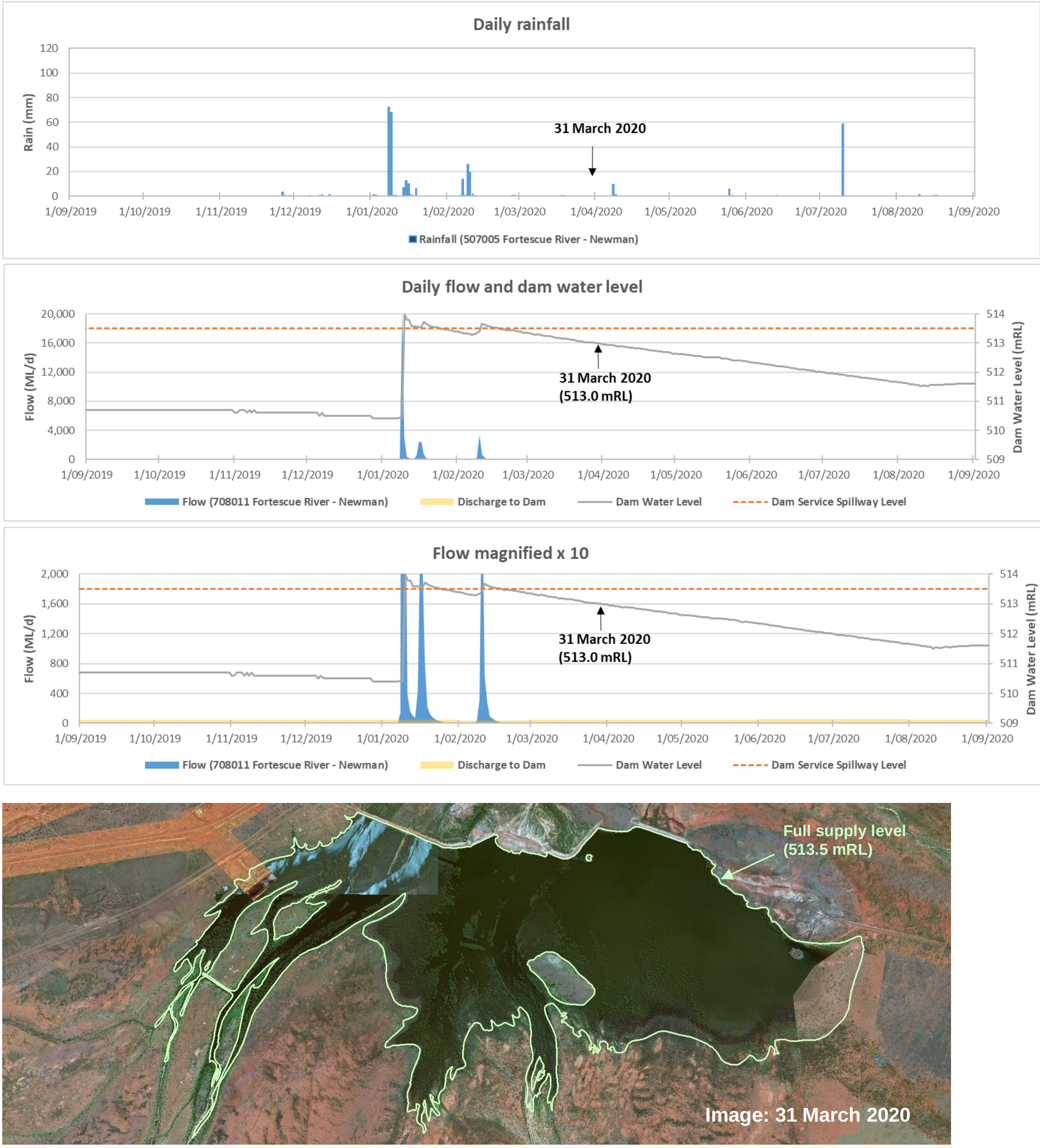


Figure 7: Fortescue River flow and Ophthalmia Dam high storage - since mine discharge

4.5 Ophthalmia Dam salinity

There is intermittent measured salinity data of surface water in Ophthalmia Dam since Ophthalmia Dam was commissioned in 1981. The former Department of Water (now DWER) undertook salinity measurements from 1981 to 1989. BHP undertook measurements from 1996 to 2001, then has taken measurements regularly since 2013. Figure 8 shows the observed salinity of surface water in Ophthalmia Dam (see Figure 1 for locations) since 1981 when Ophthalmia Dam was commissioned. There is a large variation in surface water salinity in the dam under natural conditions which is influenced by rainfall, inflow from surface water catchments as well as evaporation and infiltration processes. Analysis suggests that streamflow during major rainfall events after a few years of below average rainfall may be high in salinity as it dissolves surface salt such as calcrete (Parsons Brinkerhoff 2015).

Figure 9 shows observed salinity of surface water in Ophthalmia Dam, monthly rainfall at Newman and monthly mine discharge since 2006 when BHP started discharging mine surplus water to Ophthalmia Dam. As shown in Figure 9, the dam surface water salinity is highest following periods of no to low rainfall and decreases following large rainfall events. Therefore, the fluctuation in salinity in the dam is driven by rainfall (and natural flow events) rather than the discharge of surplus water to the dam. Salinity increases during the dry season due to evaporation, then decreases following major rainfall events in the wet season.

While there is no surface salinity data in the 5 years prior to mine discharge commencing in 2006, as shown in Figure 9, the data from the 1980s and late 1990s/early 2000s indicates that the salinity of the surface water in the dam was fresh (less than 500 mg/L) prior to 2006. The surface water salinity in the dam has increased the dry season salinity due to the higher salinity of the discharge water, compared to rainfall and natural streamflow. Since the start of regular salinity measurements in 2013 (Figure 9), the measured dam surface water salinity is typically less than 50 mg/L TDS shortly after filling of the dam in the wet season, however, the variability in antecedent conditions (i.e. dam storage and surplus water discharge) can influence dam water quality following surface flow events. The data shows that salinity is generally less than 800 mg/L TDS (with short periods up to 1,200 mg/L). The surplus water salinity (of the dewatered groundwater) varies across the operations: 550 mg/L TDS at Mt Whaleback (Orebody 29/30/35 and Western Ridge), 750 mg/L at the Jimblebar hub and 950 mg/L at Eastern Ridge, based on recent observed data (EMM 2020). Figure 9 shows that despite increasing discharge since 2013, there is no trend in increasing surface water salinity and the key driver of the salinity fluctuation is rainfall (and streamflow) as the salinity reduces more in wet years and stays elevated in dry years.

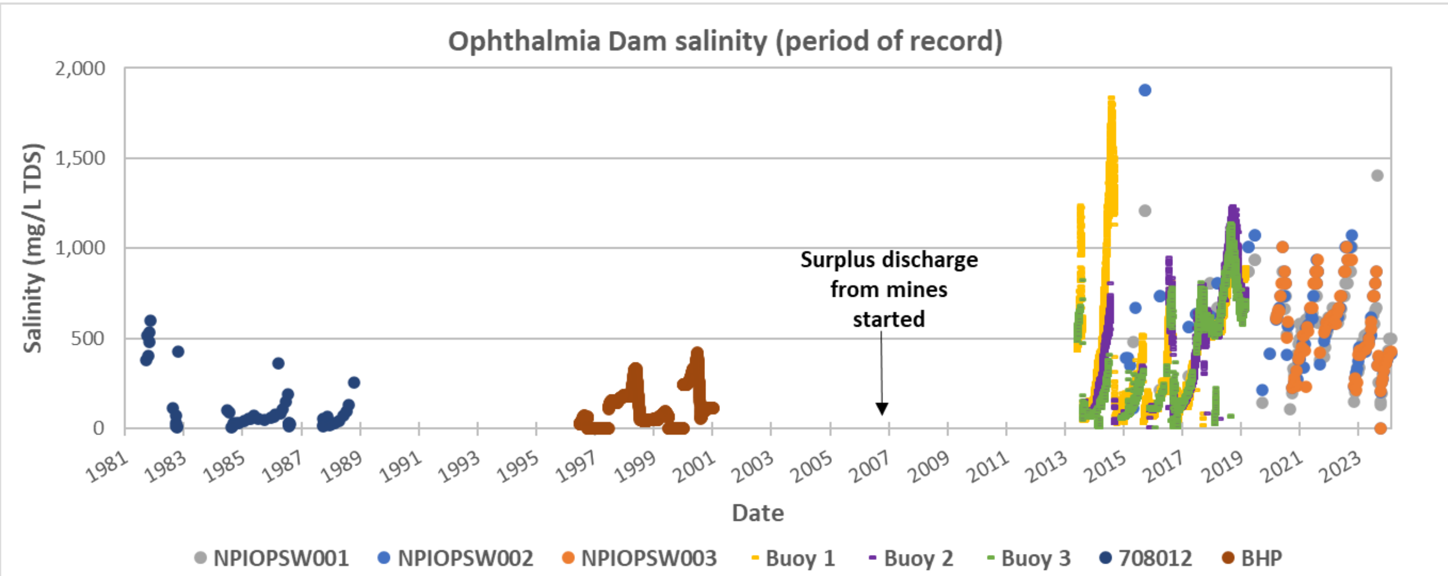


Figure 8: Ophthalmia Dam salinity – period of record

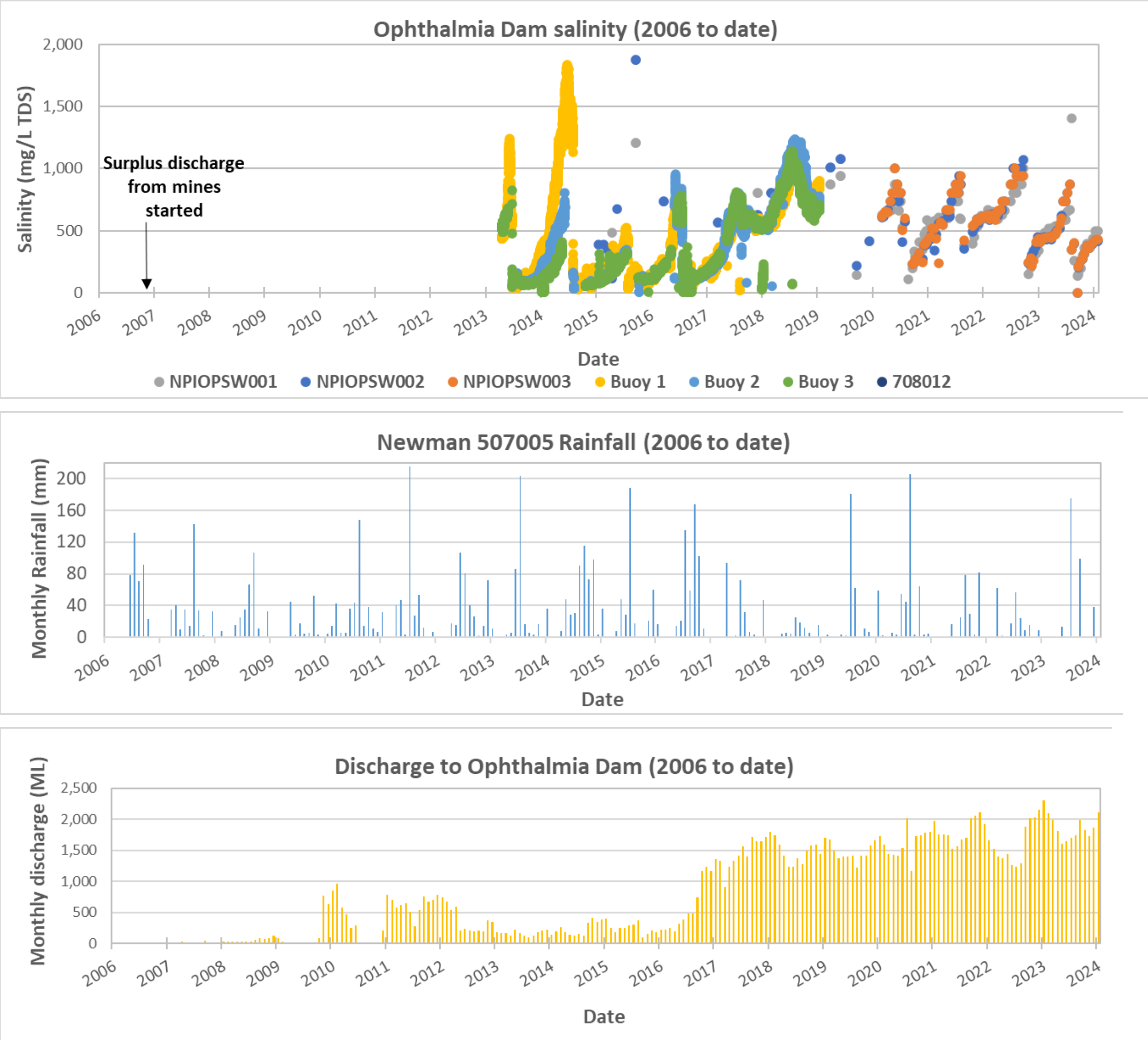


Figure 9: Ophthalmia Dam salinity – since 2006

4.6 Ophthalmia Dam releases

As discussed in Section 3.1.2, BHP may undertake controlled releases of water from Ophthalmia Dam to upper Fortescue River tributaries to manage groundwater levels and/or groundwater salinity in the Ethel Gorge aquifer. BHP may also release water from the dam for dam maintenance and safety purposes. The timing of these releases will depend on dam and catchment conditions, to enable the safe operation of the dam, however, where possible BHP will undertake releases during natural flow events. The Outlet Valve 3 at C wall (Figure 1) provides a controlled downstream release of water from the dam to Shovelanna Creek and into the downstream Fortescue River. The estimated maximum discharge (release) rate is approximately 136 ML/d at the service spillway storage capacity (513.5 mRL) (EMM 2020). Table 4 summarises release data since 2016. As shown in Table 4 and Appendix A, some of the controlled releases coincide with natural flow events (i.e. during or after the wet season), which is consistent with the management options in the EPWRMP to limit releases to the Fortescue River in the dry season (Section 3.1.3).

Table 4: Summary of controlled releases from Ophthalmia Dam

Release location	Release dates		Duration (months)	Estimated volume released (GL)	Natural conditions
	Opened	Closed			
C wall	28/01/2016	15/03/2016	1.6	5.625	Wet season (natural flows)
C wall	3/06/2016	15/08/2016	2.4	7.9	Dry season (no natural flows and late natural flows)
A wall	13/11/2016	29/01/2017	2.6	3.4	Dry season / start wet season (part natural flows)
C wall	13/03/2017	06/06/2017	2.8	10.5	Wet season (natural flows)
C wall[1]	27/08/2017	16/11/2017	2.7	9.5	Dry season (no natural flows)
C wall	09/02/2018	05/04/2018	1.8	6	Late wet season (part natural flows)
C wall[2]	23/01/2020	10/08/2020	6.7	26	Wet season / dry season (part natural flows)
C wall	02/03/2021	19/05/2021	2.6	2.5	Late wet season (part natural flows)
C wall	17/10/2021	20/12/2021	1.5	2.3	Dry season (no natural flow)
C wall[3]	26/01/2022	28/06/2022	5.0	17.5	Wet season / dry season (part natural flows)
C wall	01/07/2023	26/09/2023	2.9	9.1	Dry season (no natural flow)
C wall	31/01/2024	01/03/2024	1.0	3.9	Wet season (natural flows)
C wall	14/03/2024	14/04/2024	1.0	4.0	Wet season (natural flows)

Release location	Release dates		Duration (months)	Estimated volume released (GL)	Natural conditions
	Opened	**Closed**			
C wall	07/06/2024	27/08/2024	2.7	10.1	Dry season (no natural flow)

1. Discharge (release) trial (BHP 2019b)
2. Release for maintenance to lower water levels to allow remediation works on the dam wall.
3. Release to reduce risk and maintenance requirements for the dam. Commenced during wet season flow and coincides with late wet season (late February and April) flows.

4.7 Groundwater levels

Figure 10 shows observed groundwater levels in the Ethel Gorge aquifer (in the Ethel Gorge TEC) for bores with long term records extending before the commissioning of Ophthalmia Dam and after the start of discharge from BHP mines (see Figure 3 for locations). The data indicates that groundwater levels are relatively generally lower with increasing distance from the dam. Groundwater levels also vary due to groundwater abstraction and recharge from natural rainfall/streamflow events and discharge to the dam. The data shows the decline in groundwater levels during the 1970s due to abstraction of groundwater from the Ophthalmia Borefield for the Newman town water supply (as discussed in Section 2) and the rapid groundwater level recovery in the early 1980s following the commissioning of Ophthalmia Dam in 1981. Groundwater levels were higher following the large rainfall events in the late 1990s/early 2000s and were lower during the peak abstraction years between 2006 and 2012 at OB23 and OB25 Pit 3. Groundwater levels have recovered since abstraction at OB23 and OB25 Pit 3 decreased and from the large rainfall events since 2020.

The EPWRMP groundwater level criteria were revised in Revision 8.0 of the EPWRMP, to relate to groundwater level decline (BHP 2023b) as this is the risk to the Ethel Gorge TEC. Data from EPWRMP monitoring bores (EEX0917M and HEV0006M) indicates that the overall aquifer response in Monitoring Zone 1 (Primary Habitat Zone) has remained within (above) the groundwater level criteria (early response indicator, trigger and threshold) established in Revision 8.0 of the EPWRMP. With the recovery of groundwater levels at OB23 and OB25 Pit 3, and higher water levels in Ophthalmia Dam, groundwater levels in the Ethel Gorge aquifer are expected to remain at higher levels (BHP 2024c).

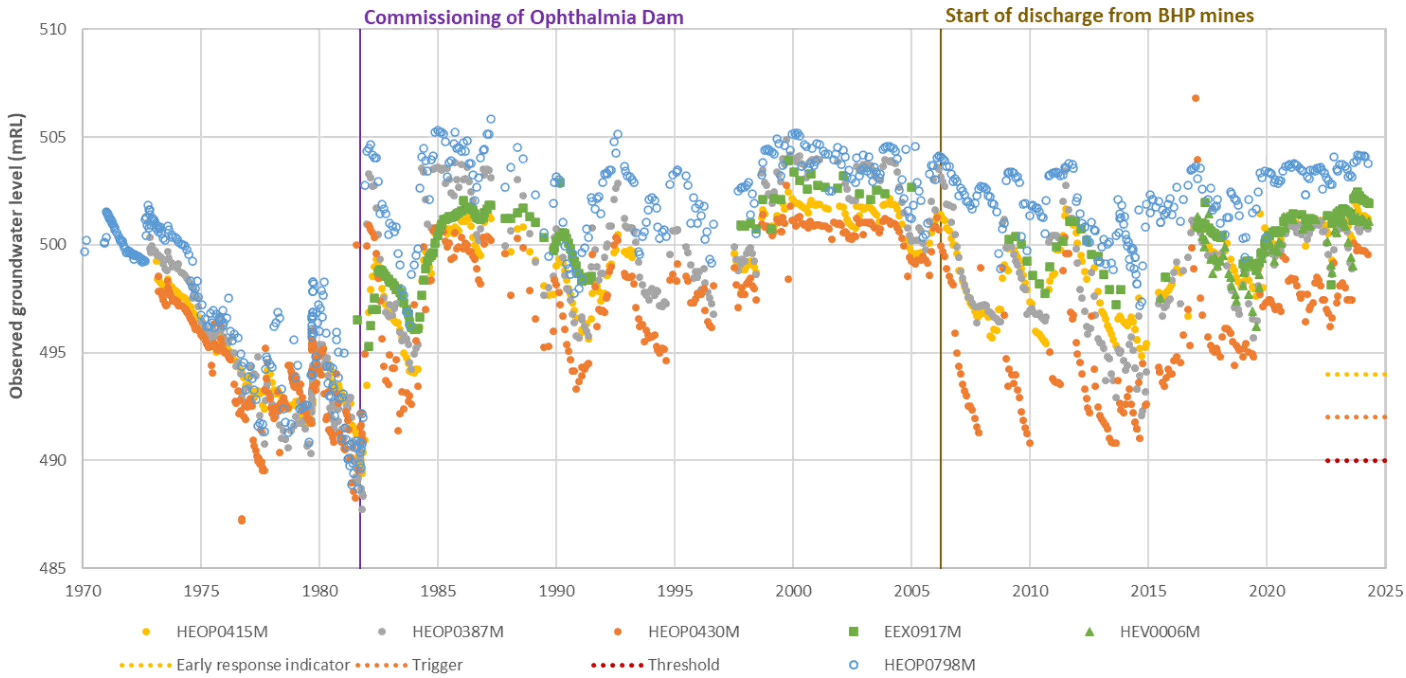


Figure 10: Ethel Gorge aquifer observed groundwater levels

4.8 Groundwater salinity

Measurements of groundwater salinity in the Ethel Gorge aquifer began in 1978, however, there are very few bores in the monitoring record that have both water level and salinity (Total Dissolved Solids (TDS)/Electrical Conductivity (EC)) measurements to determine potential cause and effect in salinity changes (EMM 2020) and that have data prior to 2015. Figure 11 shows long term salinity data at Ophthalmia Borefield water supply production bores HNPIOP0013P, HNPIOP0012P and HNPIOP0015P which are in the Ethel Gorge TEC (see Figure 3 for locations) and are close to HEOP0798M, HEOP0387M and HEOP0430M respectively, which are shown on the groundwater level plot in Figure 10.

The endorsed EPWRMP salinity criteria (early response indicator, trigger and threshold) were established in Revision 6.0 of the EPWRMP (BHP 2018). The criteria account for the naturally elevated salinity towards and in the East Ophthalmia aquifer where up to 4,000 mg/L has been recorded (BHP 2024c). Data from the bores indicates that groundwater salinity has generally remained at or below 1,500 mg/L TDS since the dam was commissioned in 1981. The exception is EEX0917 which is located close to / in the East Ophthalmia aquifer and has naturally elevated salinity. However, there is no trend in increasing salinity since dam started receiving surplus discharge from BHP mines 2006. Data from EPWRMP monitoring bores (EEX0917M and HEV0006M) indicates that the overall aquifer response in Monitoring Zone 1 (Primary Habitat Zone) has remained within (below) the groundwater salinity trigger since February 2018.

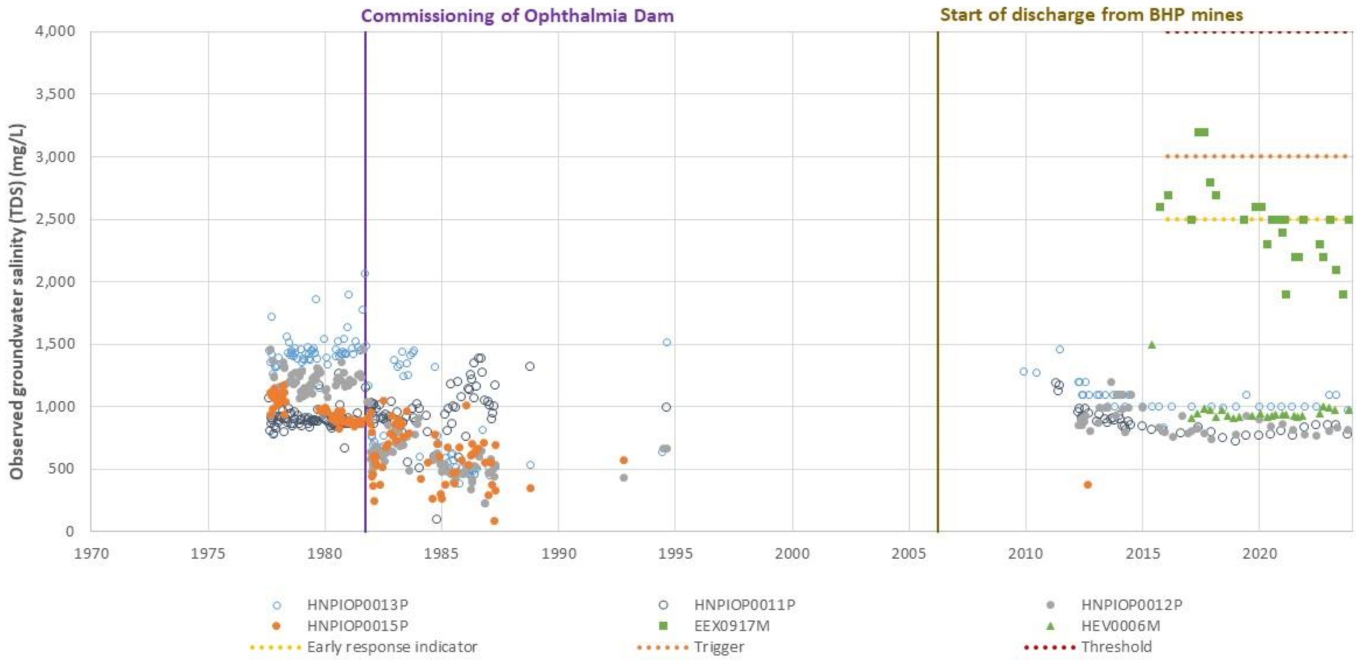


Figure 11: Ethel gorge aquifer observed groundwater salinity

5 Forecast water balance

BHP regularly updates the water balance for its Eastern Pilbara mines, as mine plans are updated. BHP estimates the forecast surplus water based on the forecast dewatering and water demand. BHP groups mine deposits and mines based on location and shared infrastructure (e.g. pipes).

The 2024 Eastern Pilbara water balance surplus water forecast to Ophthalmia Dam from BHP's Eastern Pilbara mines (including Orebody 29/30/35) has changed from the 2023 surplus water forecast discussed in the *Jimblebar Hub: Ophthalmia Dam surplus water impact assessment update* (BHP 2023a), due to changes in mine plans and the predicted increase in dewatering for the Orebody 29/30/35 Proposal (increase of 45.1 ML/d from the authorised dewatering rate of 8 GL/a (21.9 ML/d) to the 2024 modelled peak dewatering rate of up to 67 ML/d) (BHP 2024b).

Figure 12 shows the estimate of forecast surplus water discharge rates to Ophthalmia Dam from Orebody 29/30/35, based on the predicted increase in dewatering. The forecast peak rate of discharge of surplus water from Orebody 29/30/35 to Ophthalmia Dam is 57 ML/d (20.8 GL/a), based on a high case dewatering and assuming a water demand of 5 to 10 ML/d. The actual discharge rates will depend on the mine plan and the variability in dewatering rates, water demand and surplus pipe capacity. Therefore, the forecast rates and dates presented in Figure 12 are indicative, for assessment purposes only.

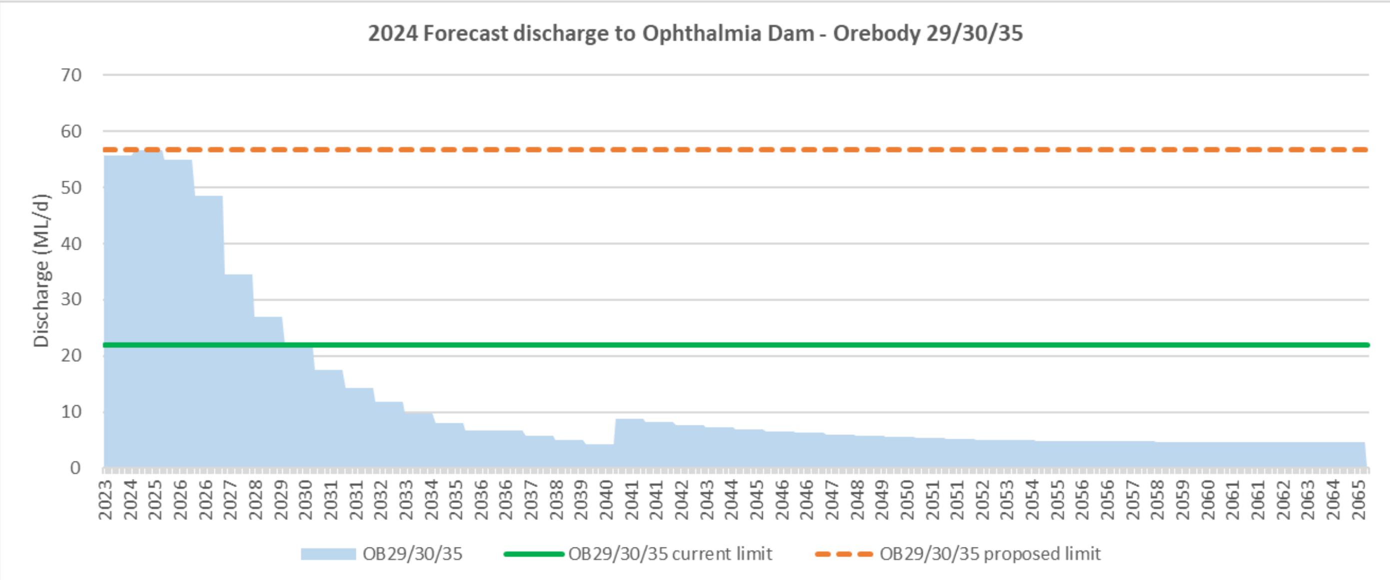


Figure 12: Forecast Orebody 29/30/35 discharge rates to Ophthalmia Dam

Table 5 summarises the approved and proposed discharge rates to Ophthalmia Dam from BHP's Eastern Pilbara mines. As shown in Figure 12, the forecast surplus discharge from Orebody 29/30/35 to Ophthalmia is greater than the approved (Part IV) discharge rate of 8 GL/a (21.9 ML/d) during part of the mine plan. To provide for flexibility for the Orebody 29/30/35 mine plan, changes in water demand and increased surplus pipe capacity, the proposed discharge to Ophthalmia Dam from Orebody 29/30/35 is the forecast peak discharge rate of 57 ML/d (20.8 GL/a).

Table 5: Approved and proposed discharge to Ophthalmia Dam

Mine hub	Mine	Surplus discharge to Ophthalmia Dam (GL/a)	Approved or proposed
Newman	Eastern Ridge mine: OB24, OB25, OB25 West OB32 BWT	19 21.9[1]	Approved
	Western Ridge	13[1]	Approved
	Orebody 29/30/35	8 (20.8[2])	Approved (Proposed)

Mine hub	Mine	Surplus discharge to Ophthalmia Dam (GL/a)	Approved or proposed
Jimblebar	Jimblebar	32.625[3]	Approved
	OB31		Approved
Total		**94.525** **(107.325)**	**Approved** **(Proposed)**

1. OB32 BWT and Western Ridge derived proposals were approved on 27 September 2023 (authorised under Pilbara Expansion Strategic Proposal, Ministerial Statement 1105 and EP Act s45B Notice: Statement 1105 – No 1 and No 2)
2. Orebody 29/30/35 Proposal includes increase in discharge to Ophthalmia Dam from 8 GL/a to 20.8 GL/a
3. Jimblebar Hub Part V licence L5415/1988/9 includes total discharge to Ophthalmia Dam of 32.625 GL/a: Jimblebar mine (16.425 GL/a) and Orebody 31 mine (16.2 GL/a).

As the EPA is currently assessing the Jimblebar Hub Proposal, the 2024 forecast surplus water discharge uses the 2023 forecast data used for the 2023 Jimblebar Hub Proposal assessment (from Jimblebar Hub, Eastern Ridge (including OB32 BWT) and Western Ridge) and the 2024 forecast surplus water discharge for Orebody 29/30/35 (Figure 12).

Figure 13 shows the 2024 cumulative forecast surplus water discharge to the Ophthalmia Dam system from BHP's Eastern Pilbara mines, with the 2023 forecast as a comparison, showing the forecast increase for the Orebody 29/30/35 Proposal. The forecast discharge (including an increase in OB29/30/35 discharge) starts in 2024 as that is the start of the modelling period. The forecast indicates that the highest surplus is skewed towards the first 10 years, then discharge rates reduce considerably. After 14 years, the total forecast discharge reduces to below the total recent actual discharge of 67.15 ML/d (Table 3).

The 2024 cumulative forecast peak discharge rate (179 ML/d) shown on Figure 13 is lower than the approved total rate for all approved projects of 259 ML/d (94.525 GL/a) and the proposed total rate of 294 ML/d (107.325 GL/a) in Table 5. The total forecast peak discharge rate (179 ML/d) is 70% of the total approved rate (259 ML/d) and 61% of the total proposed rate (294 ML/d). As discussed in Section 4.1 and shown in Table 3, only a portion of the approved rate is discharged to the Ophthalmia Dam system because the licensed rate is an annual peak rate that allows for fluctuations in dewatering rates according to the individual mine plans.

The total contributing catchment area for Ophthalmia Dam is estimated to be 4,320 km^2. As discussed in Section 4.1, only the Fortescue River has a long-term gauged record (Newman 708011), with a catchment area of 2,822 km^2 (65% of estimated contributing catchment to Ophthalmia Dam) providing reliable estimates of potential catchment inflows to Ophthalmia Dam (EMM 2020). The maximum annual total forecast discharge from the data in Figure 13 is 64,075 ML which is less than 14% of the maximum annual streamflow (391,234 ML) recorded at Newman 708011 (Figure 4) It is equivalent to the 80th percentile flow (i.e 20% of recorded flows at Newman 708011 since 1981 are greater than the maximum annual forecast discharge). The average annual total forecast discharge from the data in Figure 13 is 22,781 ML which is similar to the median annual streamflow (22,933 ML) and is approximately 48% of the average annual streamflow (47,371 ML) recorded at Newman 708011. As the catchment area of Newman 708011 is only 65% of the catchment contributing flows to Ophthalmia Dam, natural surface water inflows will likely continue to be the major contributor to the dam.

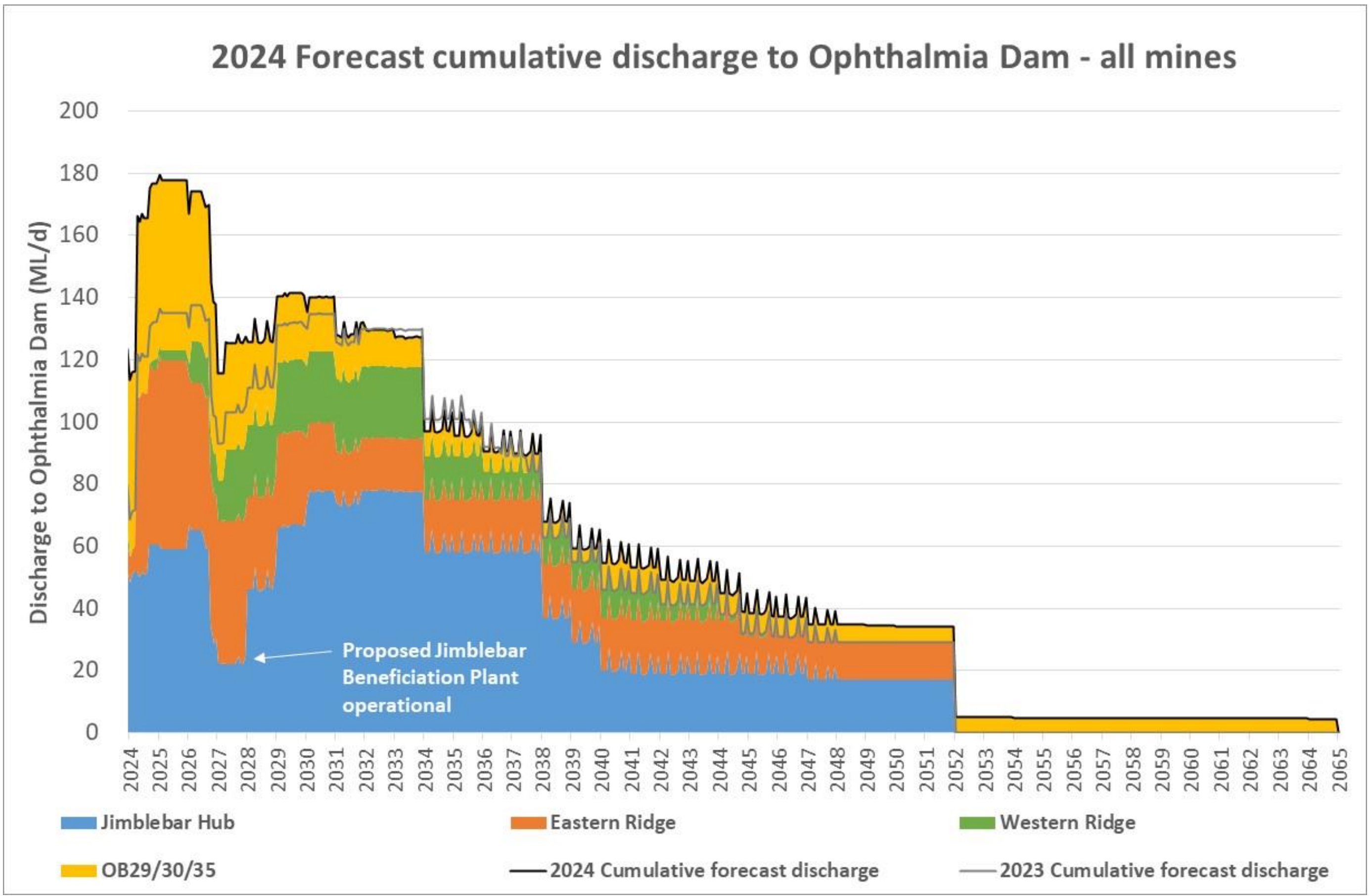


Figure 13: 2024 Forecast discharge to Ophthalmia Dam system - all BHP mines

6 Water balance model and scenario

6.1 Eastern Pilbara Hub integrated water balance model

Since Ophthalmia Dam was commissioned, BHP has conducted numerous water balance assessments for the Eastern Pilbara Hub, to understand changes in the Ethel Gorge aquifer system (groundwater levels and quality) from the interactions from groundwater abstraction (water supply and dewatering) and surplus water management at Ophthalmia Dam.

The integrated water balance model for the Ophthalmia Dam and Ethel Gorge aquifer system uses Goldsim, an industry standard simulation software used for analysing the risk of water resource management options. The existing Eastern Pilbara Hub (EPH) integrated water balance model provides a tool to support the mine planning process. The integrated model links to mine forecasts, includes surplus water management options (including Ophthalmia Dam), and has the functionality to assess the potential sensitivity on Ophthalmia Dam and the Ethel Gorge aquifer in response to surplus water discharge scenarios. Detail on the EPH integrated water balance model is provided in EMM (2020).

6.2 2020 Ophthalmia Dam capacity modelling

As discussed in *Eastern Pilbara Hub Water Balance: Integrated water balance model review and Ophthalmia Dam water management capacity scenarios* (EMM 2020), the EPH integrated water balance model was also used to investigate the sustainable capacity of Ophthalmia Dam, to accept surplus water discharge to the dam. Additional theoretical scenarios (excluding rainfall and catchment inflows) were run to determine the potential capacity of the dam to manage surplus water through evaporation and infiltration losses, with and without a 3-month controlled release of water from the dam to Shovelanna Creek and into the downstream Fortescue River. A controlled release period of up to 3 months total in the dry season when there are no natural surface water flows, is consistent with BHP's usual operation of the dam.

The modelling undertaken to assess the theoretical capacity of Ophthalmia Dam indicated that the potential maximum capacity of the dam to manage surplus water via infiltration, evaporation and controlled discharge, without overtopping of the dam spillway during the dry season, is potentially 135 ML/d with a 3-month controlled release of water from the dam to Shovelanna Creek and into the downstream Fortescue River. During the modelled 3-month dry season release of water from the C wall valve, up to 10.1 GL of water was predicted to be released in total, based on an estimated average controlled release rate of 113 ML/d over the 90 days (EMM 2020). This is comparable to the actual estimated volume released for durations of approximately 3 months as shown in Table 4.

6.3 2024 water balance modelling

6.3.1 Assessment purpose

BHP commissioned EMM in 2024 to update the Ophthalmia Dam water balance modelling (EMM 2024) that was undertaken in 2023 to support the Jimblebar Hub proposal (EMM 2023). The purpose of the *Eastern Pilbara Hub Water Balance - 2024 Forecast Surplus Discharge Assessment* (EMM 2024) was to:

- apply the recommended hydraulic conductivity (K) from the 2022 sensitivity analysis (*Eastern Pilbara Hub Water Balance OB32 Surplus Water GoldSim Modelling - Stochastic and Sensitivity Assessment* (EMM 2023), which reviewed the potential sensitivity of groundwater balance and salinity predictions to alternative water balance model parameterisations, and identified and tested a set of (feasible) water balance parameters and operational conditions against the EPWRMP groundwater level and salinity criteria
- update the water balance using the 2024 forecast discharge rates to Ophthalmia Dam (presented in Figure 13).

The model was run with the same parameters as the 2023 modelling undertaken for the Jimblebar Hub Proposal (including a three month controlled release of water from the dam to Shovelanna Creek and into the downstream Fortescue River) (BHP 2023a). The recommended change in the mean hydraulic conductivity of the groundwater modelling components (increase from 7 m/d to 49 m/d), supports observed data that the groundwater system can accept significant surplus inflows (i.e. from surplus discharge to the Ophthalmia Dam system) and groundwater salinity (TDS concentration) does not show a strongly historically increasing trend (EMM 2023).

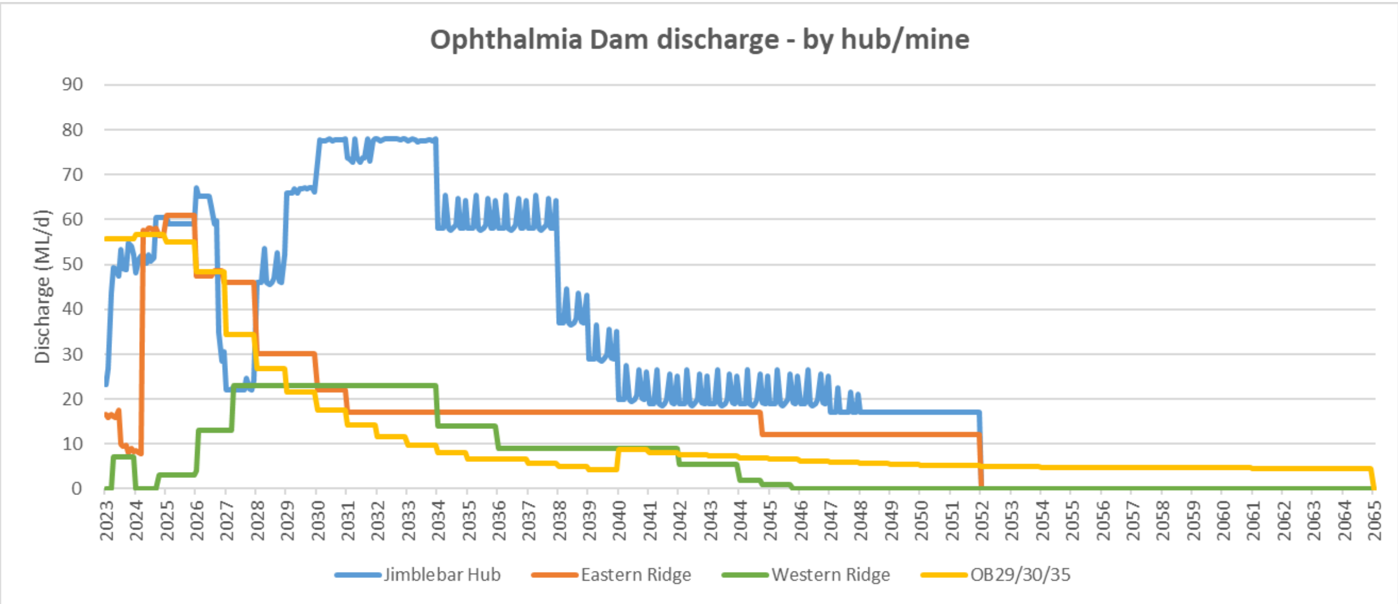
The assessment uses forecast rates rather than current approved and proposed surplus water rates (Table 5) because as discussed in Sections 4.1 and 5, only a portion of the approved licensed rate will be discharged into Ophthalmia Dam as the approved rate is a peak rate that allows for fluctuations in dewatering rates according to the individual mine plans.

6.3.2 Model scenario

EMM (2024) assessed the following scenario of surplus water discharge to Ophthalmia Dam (Figure 14):

- Scenario 10 (PR10): Apply 2023 forecast data used for Scenario 7 for the 2023 Jimblebar Hub Proposal assessment (from Jimblebar Hub, Eastern Ridge (including OB32 BWT) and Western Ridge) and the 2024 forecast surplus water discharge for Orebody 29/30/35.

The water balance model for the EPH 2024 forecast surplus discharge assessment was run for a 41-year simulation period from 2024 to 2065.



Source: EMM (2024), Figure 2.2

Figure 14: Scenario 10 – forecast discharge by hub/mine

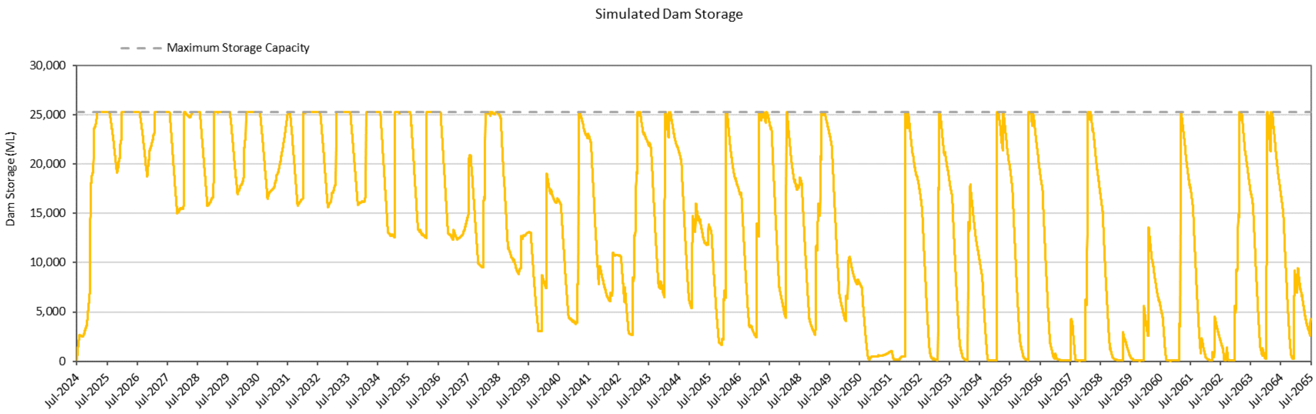
7 EPH 2024 forecast surplus discharge assessment

The results of the modelling (EMM 2024) represent the cumulative effects of surplus water discharge from all BHP's eastern mines.

7.1 Ophthalmia Dam water balance

7.1.1 Dam storage and inundation

Figure 15 shows the simulated (predicted) dam storage for the model run for the 'average' hydrology scenario, with a 3-month controlled release of water from the dam to Shovelanna Creek and into the downstream Fortescue River each year (EMM 2024).



Source: EMM (2024), Figure A.2

Figure 15: Predicted dam storage

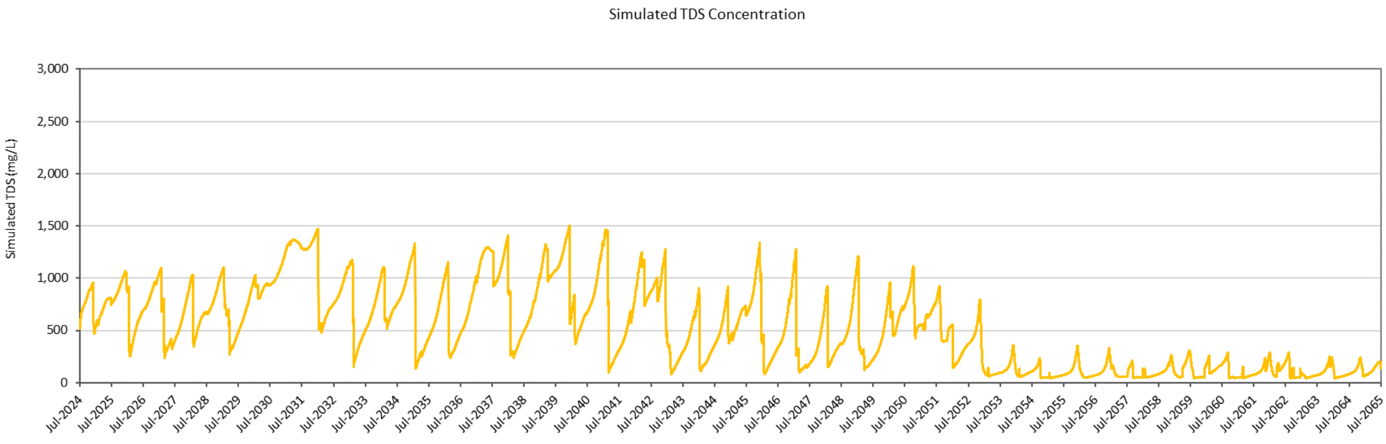
As discussed in Section 5, the 2024 cumulative forecast discharge includes a period of high surplus water discharge from all BHP's eastern mines to Ophthalmia Dam (at approximately or above 100 ML/d for the first 14 years), similar to the 2023 cumulative forecast discharge, and there is an associated predicted increase in dam storage (Figure 15).

As discussed in Section 4.1, the maximum inundation area is controlled by the maximum operating storage capacity of the dam at the service spillway elevation (513.5 mRL). There is no change to the storage capacity so there will be no change to the maximum inundation area. Figure 15 shows that there will still be the seasonal change in storage, however, dam storage will be relatively higher for longer periods during the higher forecast discharge years. During the periods where the dam storage is predicted to be higher from the 2024 cumulative forecast discharge, the inundation extent is similar to historical inundation in wet years. As discussed above, the predictions are for the 'average' hydrology scenario.

BHP also notes that the calibration for the modelling undertaken by EMM in 2020 shows that the model simulation over-estimated the volume of water in the dam compared to the measured volume of water in the dam (EMM 2020; Figure 4.6). Actual dam storage and inundation will depend on catchment and climate conditions, natural surface water flows, actual discharge from BHP mines to the dam, and releases of water from the dam (see Appendix A).

7.1.2 Dam salinity

There is the potential for the salt load in the dam to increase from increased discharge as the salinity of the discharge water from all BHP mines is higher than rainfall salinity. Figure 16 shows the predicted Ophthalmia Dam salinity. As for the modelling undertaken for other recent proposals (OB32 BWT, Western Ridge and Jimblebar Hub), the predictions using the 2024 cumulative forecast discharge show that the seasonal freshening will still occur. As for the other recent proposals, the predicted water salinity in Ophthalmia Dam ranges between approximately 50 and 1,500 mg/L TDS, with no trend over time. The predicted dam salinity also remains within historical observed concentrations (as shown in Figure 9).



Source: EMM (2024), Figure A.4

Figure 16: Predicted dam salinity

7.2 Groundwater criteria assessment

Figure 17 and Figure 18 show the predicted (simulated) groundwater levels and groundwater salinity in the Ethel Gorge aquifer. The model outputs are shown for model zones 2 to 5, as the EPWRMP Ethel Gorge Primary Habitat Monitoring Zone (Monitoring Zone 1) extends across these four zones of the model (as shown in Figure 3). As discussed in Section 6.3.1, the hydraulic conductivity has changed from 7 m/d to 49 m/d, however for comparative purposes, the results are presented for both the low and high hydraulic conductivity (K) scenarios.

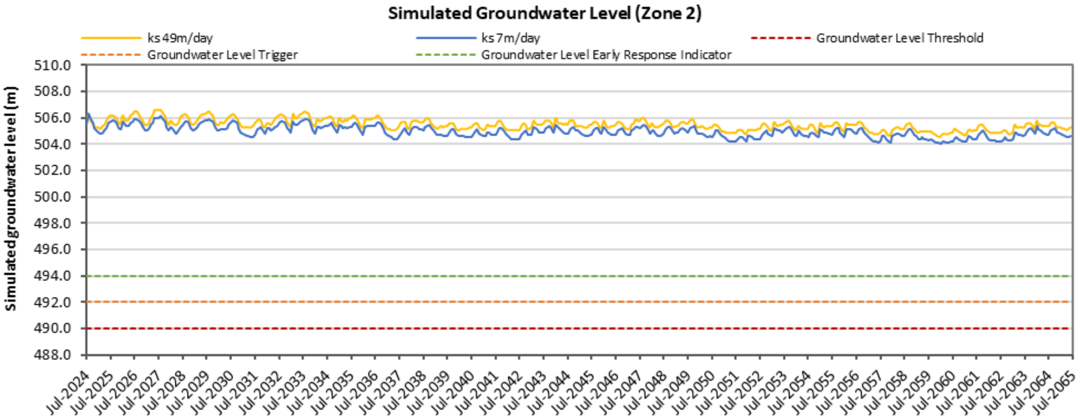
7.2.1 Groundwater levels

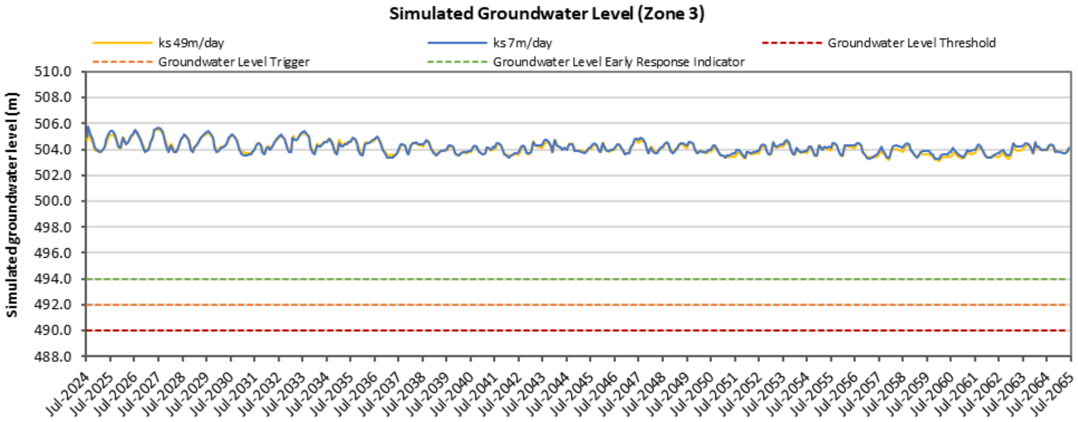
Figure 17 shows (as for the assessments for other recent proposals), that the predicted groundwater levels in all four model zones are relatively higher during periods of high discharge (shown in Figure 13) but there is no trend of increasing groundwater levels for either the low or high hydraulic conductivity scenarios. The predicted groundwater levels remain within the range of observed groundwater levels in the Ethel Gorge aquifer (Figure 10). For completeness, the predicted groundwater levels are compared to the proposed revised groundwater level criteria established in Revision 8.0 of the EPWRMP (BHP 2023b) (Table 6 in BHP 2024c), which relate to groundwater level decline only (as this has the potential to affect the Ethel Gorge TEC stygofauna habitat). However, as the discharge of surplus water to Ophthalmia Dam has the potential to increase not decrease groundwater levels, the proposed revised groundwater level criteria are no longer relevant to the Ophthalmia Dam discharge assessments.

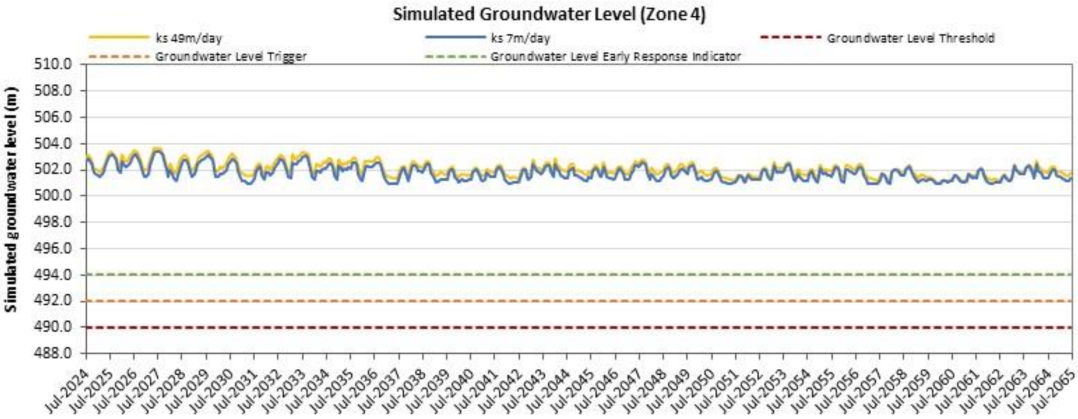
7.2.2 Groundwater salinity

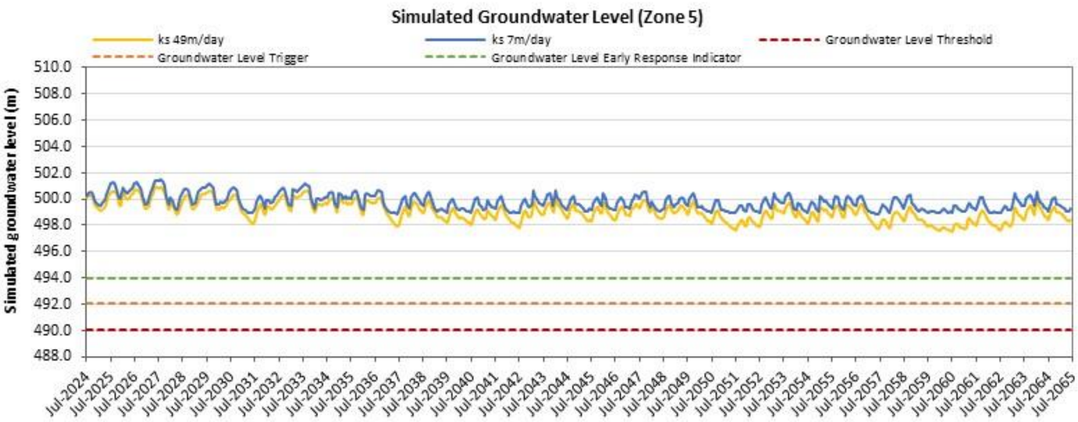
The main mechanism for increasing salinity in the Ethel Gorge aquifer is increasing groundwater levels, driven largely by enhanced dam seepage from increased discharge to the dam. As groundwater levels rise, groundwater is removed via evapotranspiration, which increases the concentration of salt and the model predicts a higher salinity in the aquifer (EMM 2020). Modelling indicates that increasing groundwater levels in the Ethel Gorge aquifer, driven largely by enhanced dam seepage, has the potential to lead to increasing groundwater salinity (TDS).

Figure 18 shows (as for the assessments for other recent proposals), that the predicted groundwater salinity in all four model zones increases over time, with the results for the recommended high (K=49 m/d) aquifer hydraulic conductivity predicting a smaller increase in salinity, which aligns with historical groundwater salinity observations (EMM 2024). The predicted salinity declines or stabilises by the middle to end of the modelling period. The modelled groundwater salinity for the high hydraulic conductivity model scenario remains at or below approximately 1,800 mg/L, within the range of observed groundwater salinity in the Ethel Gorge aquifer (Figure 11). Groundwater salinity in the high hydraulic conductivity scenario remains below the endorsed EPWRMP early response indicator of 2,500 mg/L TDS (Table 6 in BHP 2024c).



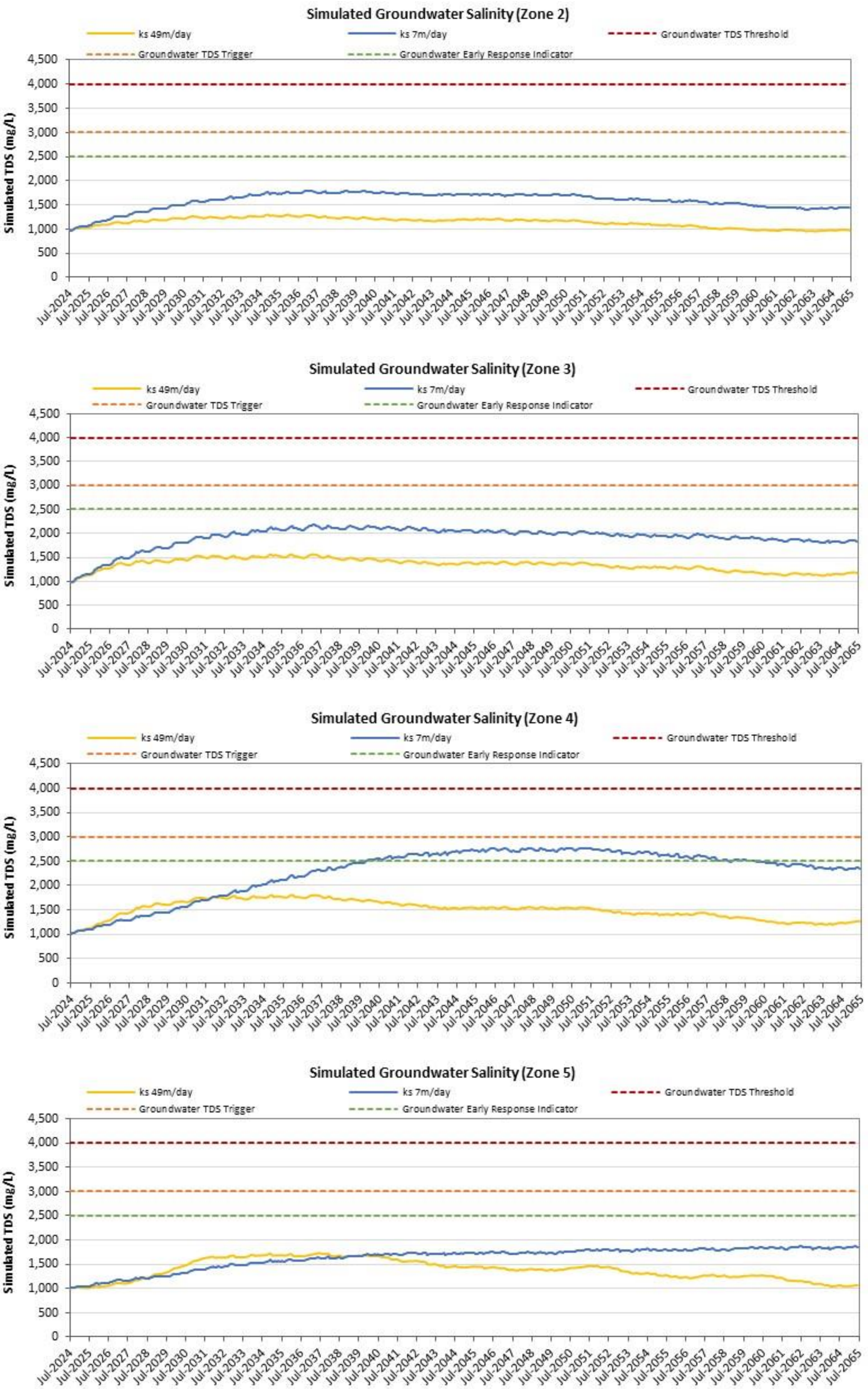






Source: EMM (2024), Figure A.7 to Figure A.10

Figure 17: Predicted Ethel Gorge aquifer groundwater levels



Source: EMM (2024), Figure A.7 to Figure A.10

Figure 18: Predicted Ethel Gorge aquifer groundwater salinity

7.3 Ophthalmia Dam capacity assessment

As discussed in Section 6.2, the 2020 Ophthalmia Dam capacity modelling predicted that the theoretical capacity of Ophthalmia Dam to accept surplus water discharge is 135 ML/d with a 3-month controlled release of water from the dam to Shovelanna Creek and into the downstream Fortescue River.

Figure 19 shows the Ophthalmia Dam theoretical capacity rate against the 2024 forecast surplus water discharge rates to Ophthalmia Dam. Although the dam capacity rate is theoretical only as it excludes catchment inflows and rainfall, Figure 19 indicates that Ophthalmia Dam is likely to have sufficient capacity to receive the 2024 cumulative forecast surplus discharge with the 3-month controlled release for most of the model simulation period. Figure 19 shows that discharge may exceed dam capacity in the early part of the simulation period during the estimated peak discharge years (2024 to 2027 and 2029-2031).

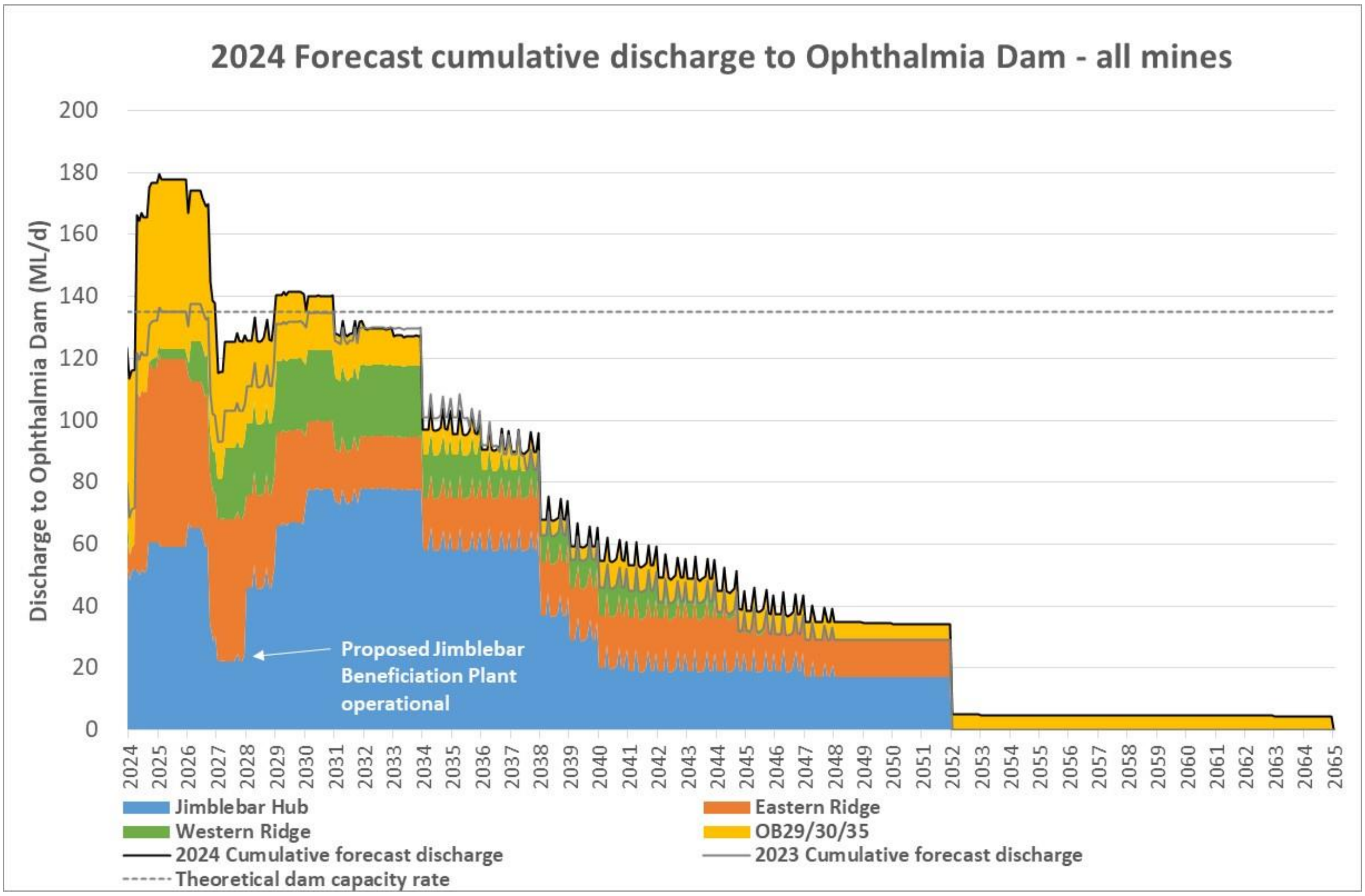


Figure 19: 2024 Forecast discharge and theoretical Ophthalmia Dam capacity rate

7.4 Conclusions

The review and updates to the integrated water balance model showed that simulated dam water balance results closely match historical Ophthalmia Dam water level and quality (TDS concentration) observations. Therefore, there is a high level of confidence in the Ophthalmia Dam water balance predictions based on future surplus water discharge scenarios (EMM 2020).

The groundwater component of the model (representing the Ethel Gorge aquifer system downstream of the dam) provides reasonable simulations of long-term observed groundwater level and salinity variability and trends. However, it is acknowledged that the modelling approach has a number of limitations with respect to accuracy and reliability of groundwater balance simulations owing to the inherent spatial and temporal variability in groundwater levels and salinity, in conjunction with model assumptions and numerical algorithms used to approximate (and simplify) the complex hydrological processes influencing the Ethel Gorge aquifer system. Therefore, predictions should be used to identify trends and magnitude of change, particularly for comparing relative changes between scenarios, rather than be considered accurate predictions of future groundwater conditions at a specific location. (EMM 2020).

Evaluation of the potential hydrological changes using the 2024 cumulative forecast discharge to Ophthalmia Dam (including the additional Orebody 29/30/35 contribution) indicates that groundwater levels and salinity will remain within the range of historical observations. Predictions show that none of the proposed EPWRMP groundwater level or endorsed groundwater salinity triggers or thresholds are exceeded for any of the hydrological scenarios over the 41-year simulation period, assuming a 3-month controlled release of water from the dam to Shovelanna Creek and into the downstream Fortescue River. A controlled release of up to 3 months total in the dry season (i.e. during natural, no flow conditions) is consistent with the response actions and threshold in the EPWRMP (3 months total continuous discharge per year during natural no-flow conditions) (BHP 2024c).

Modelling undertaken to assess the theoretical capacity rate to Ophthalmia Dam indicates that the potential maximum capacity of the dam to manage surplus water via infiltration, evaporation and controlled discharge, without overtopping of the dam during the dry season, is potentially up to 135 ML/d with a 3-month controlled release of water from the dam to Shovelanna Creek and into the downstream Fortescue River. The 2024 cumulative forecast discharge includes a period of higher surplus water discharge from all BHP's eastern mines to Ophthalmia Dam, with an associated predicted increase in dam storage. Therefore, it is possible that the capacity of Ophthalmia Dam may be reached during the estimated peak discharge years in the early part of the simulation period. However, actual dam storage will depend on catchment and climate conditions, natural surface water flows and actual discharge rates to the dam. Potential management options for dam storage are discussed in Section 8.

8 Surplus water management

As discussed in Section 7, model predictions indicate that the groundwater level and salinity criteria in the EPWRMP will continue to be met for the 2024 cumulative forecast surplus discharge to Ophthalmia Dam (including the additional Orebody 29/30/35 contribution). Therefore, BHP proposes to manage the additional surplus water discharge from the Orebody 29/30/35 Proposal in accordance with groundwater level and groundwater salinity criteria (triggers and thresholds) in the EPWRMP (Revision 8.1, BHP 2024c).

If future detailed surplus water forecasts indicate that the storage capacity of Ophthalmia Dam could be reached as a result of surplus water discharge to Ophthalmia Dam from BHP's mines, BHP will manage the surplus discharge volumes from its operations and the operation of the dam to avoid overtopping of the dam spillway and uncontrolled surface flows to the Fortescue River in the dry season, to meet the threshold in the EPWRMP (3 months total continuous discharge per year during natural no-flow conditions). Management options to limit releases to the Fortescue River in the dry season include the management measures and controls outlined in the EPWRMP, e.g. release water from the dam during wet season flow events or alter/temporarily cease surplus water discharge from its eastern mines to the Ophthalmia Dam system.

As communicated to the DWER-EPA Services, BHP is also implementing and investigating alternative surplus water management options for its Eastern Pilbara mines, including MAR and creek discharge in the Eastern Pilbara region, to minimise risk to operations and alleviate dependency on the dam. This includes implementation of the Caramulla surplus water scheme (MAR and creek discharge) in 2022 and investigations into alternative surplus water options as part of its Eastern Pilbara Regional Surplus Water study.

Future surplus water management may also depend on future climate and the management of the dam itself. A wetter or drier climate may require regular more frequent or longer duration releases from the dam, to maintain groundwater levels and salinity in the Ethel Gorge TEC and/or seasonal flows to the Fortescue River. Changes may also be required to meet contemporary dam engineering and safety standards (noting that Ophthalmia Dam was constructed in the 1980s). BHP will assess the potential environmental impacts of any proposed major changes, including if changes are required to the EPWRMP.

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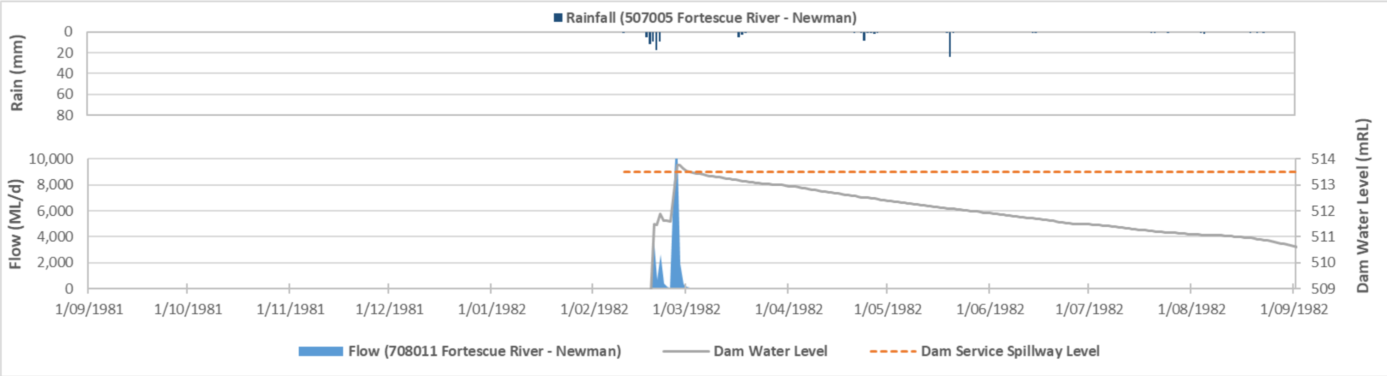
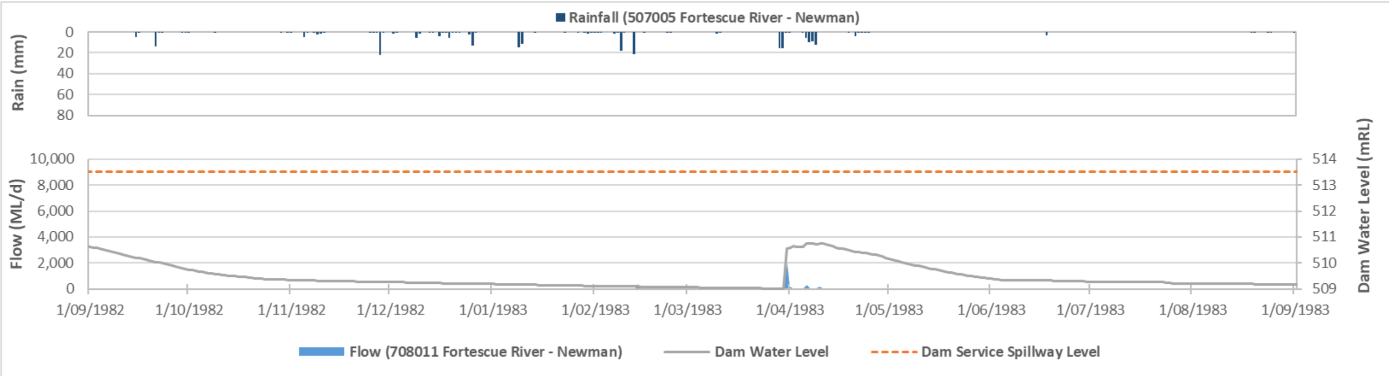
Appendices

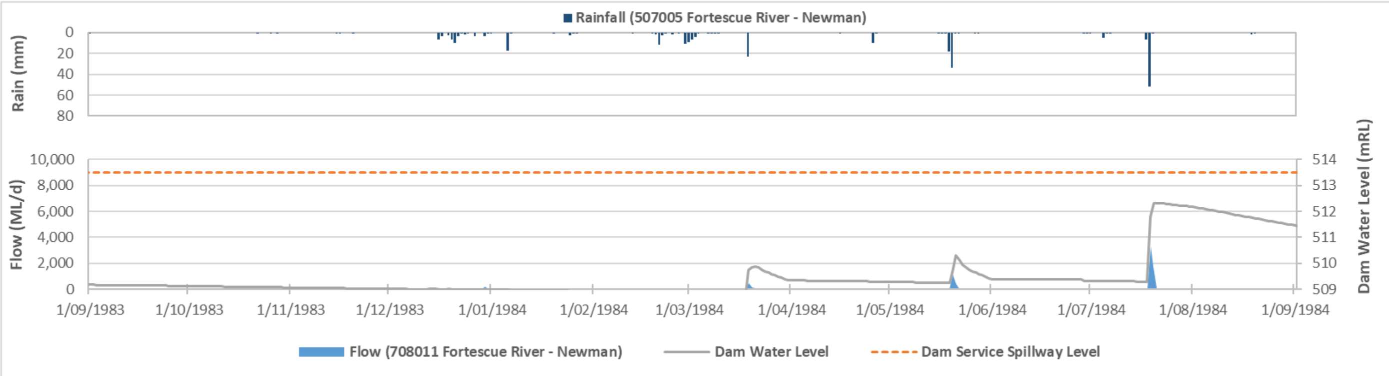
Appendix A Daily data: Fortescue River – Newman rainfall and flow, Ophthalmia Dam storage (dam water level) and discharge to Ophthalmia Dam

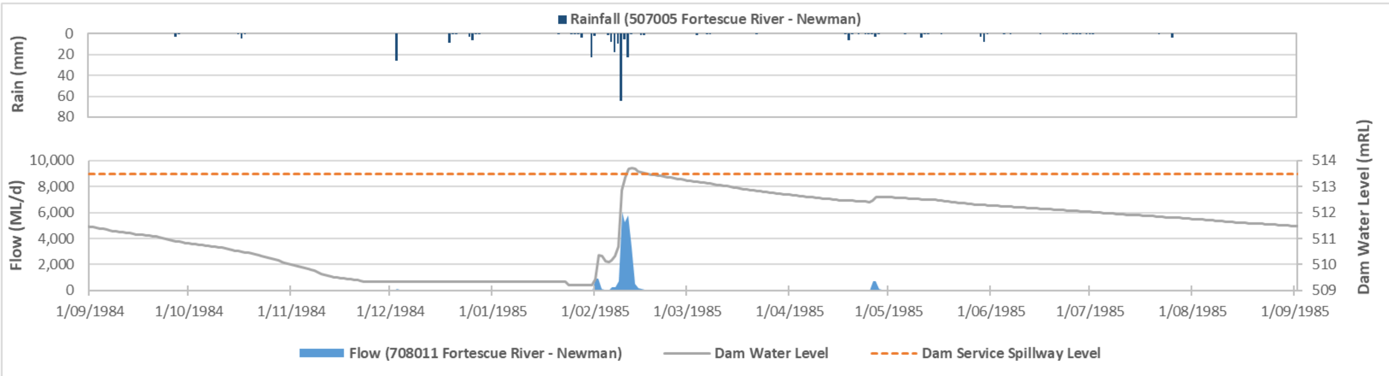
Note: Discharge is to Ophthalmia Dam only - excludes discharge to the recharge ponds (as shown in Figure 1), as the recharge ponds are downstream of the dam wall.

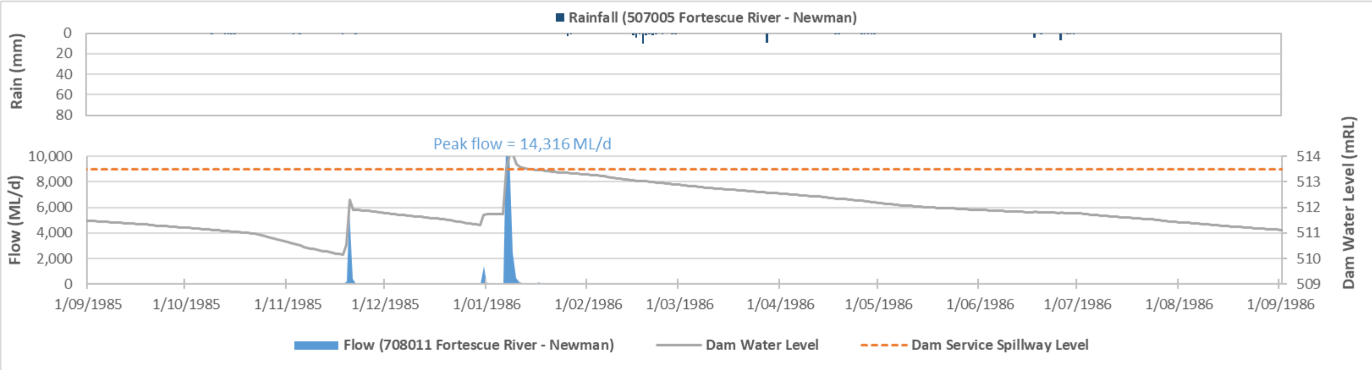
All plots are at the same scale to show variability. Plots are annotated where rainfall and/or flow exceeds y-axis limits.

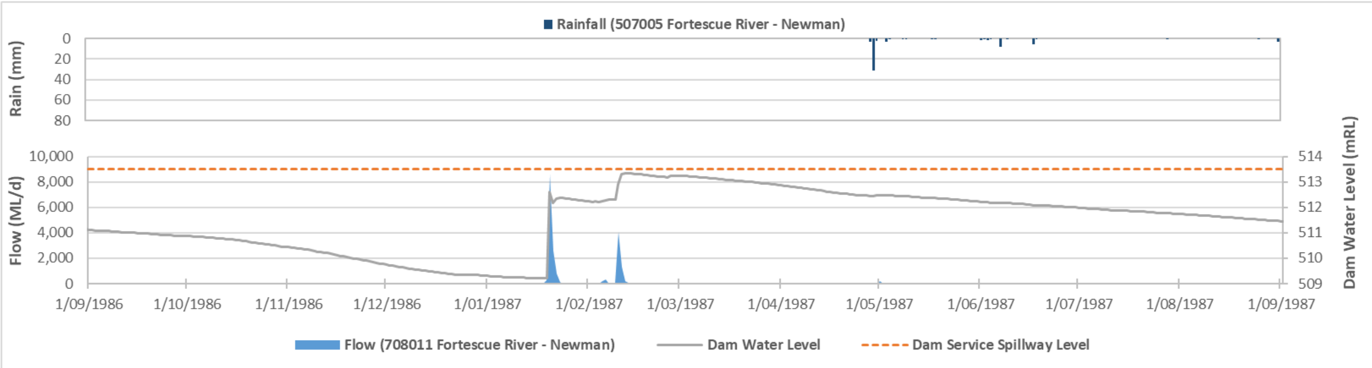

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1981
1/10/1981
1/11/1981
1/12/1981
1/01/1982
1/02/1982
1/03/1982
1/04/1982
1/05/1982
1/06/1982
1/07/1982
1/08/1982
1/09/1982
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

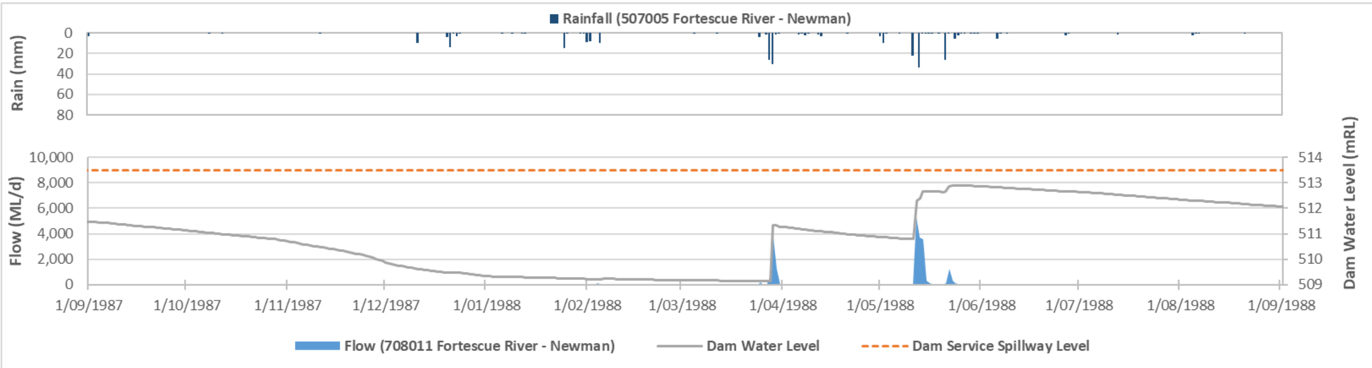

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1982
1/10/1982
1/11/1982
1/12/1982
1/01/1983
1/02/1983
1/03/1983
1/04/1983
1/05/1983
1/06/1983
1/07/1983
1/08/1983
1/09/1983
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

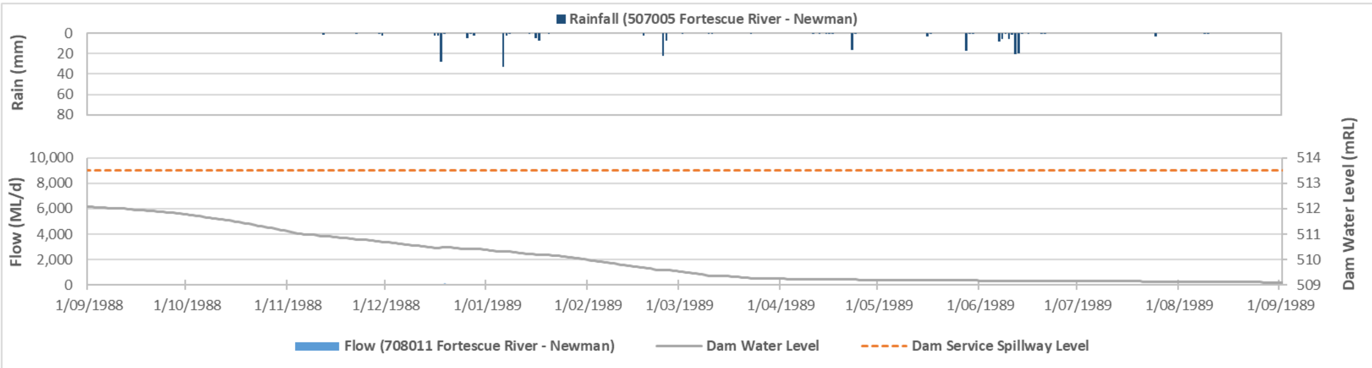

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1983
1/10/1983
1/11/1983
1/12/1983
1/01/1984
1/02/1984
1/03/1984
1/04/1984
1/05/1984
1/06/1984
1/07/1984
1/08/1984
1/09/1984
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

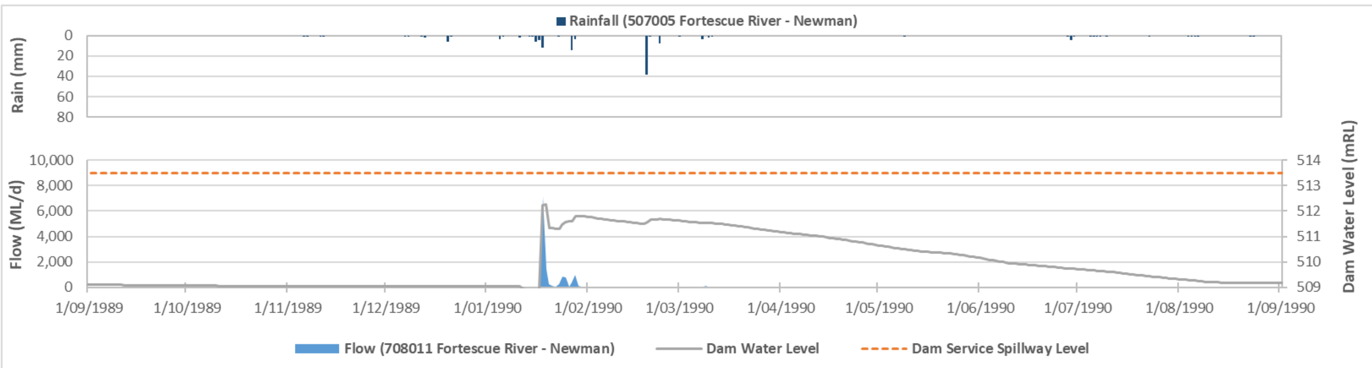

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1984
1/10/1984
1/11/1984
1/12/1984
1/01/1985
1/02/1985
1/03/1985
1/04/1985
1/05/1985
1/06/1985
1/07/1985
1/08/1985
1/09/1985
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

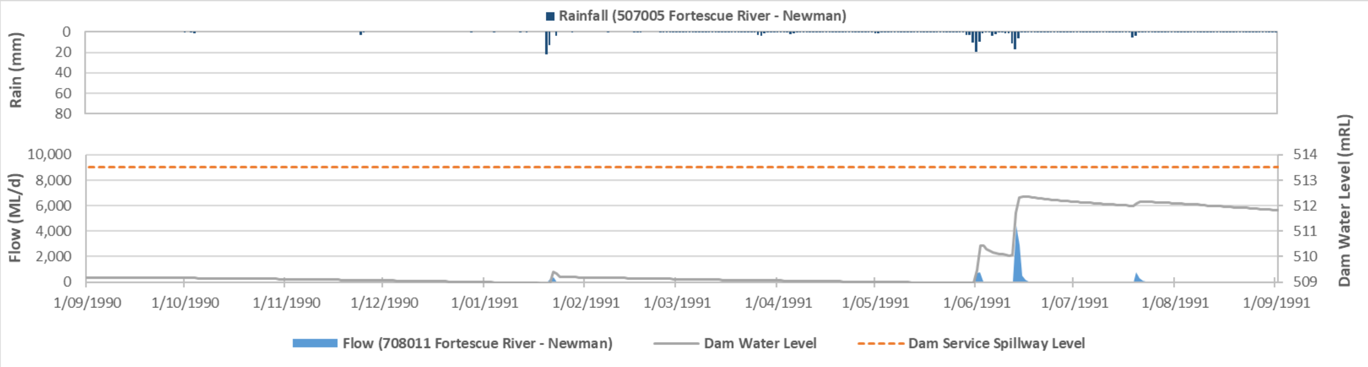

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak flow = 14,316 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/1985
1/09/1986
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

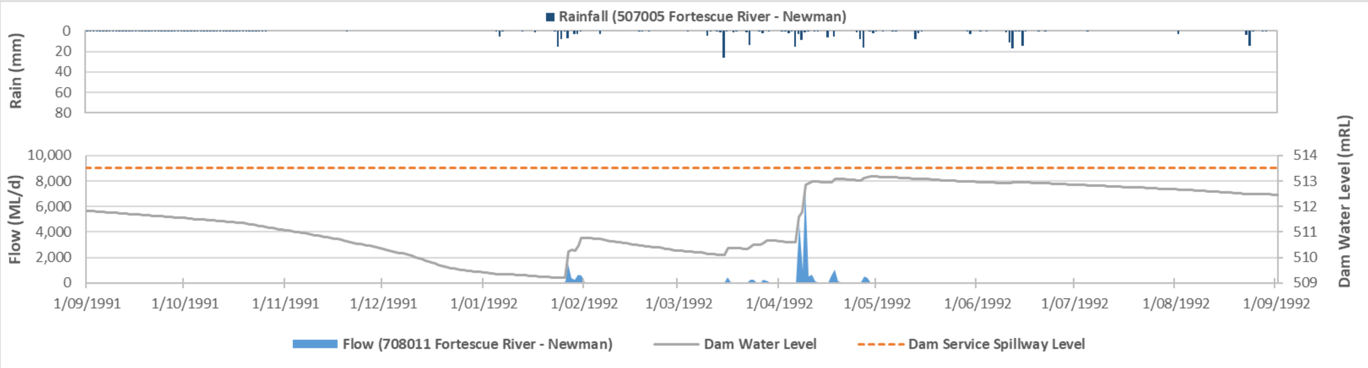

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1986
1/09/1987
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

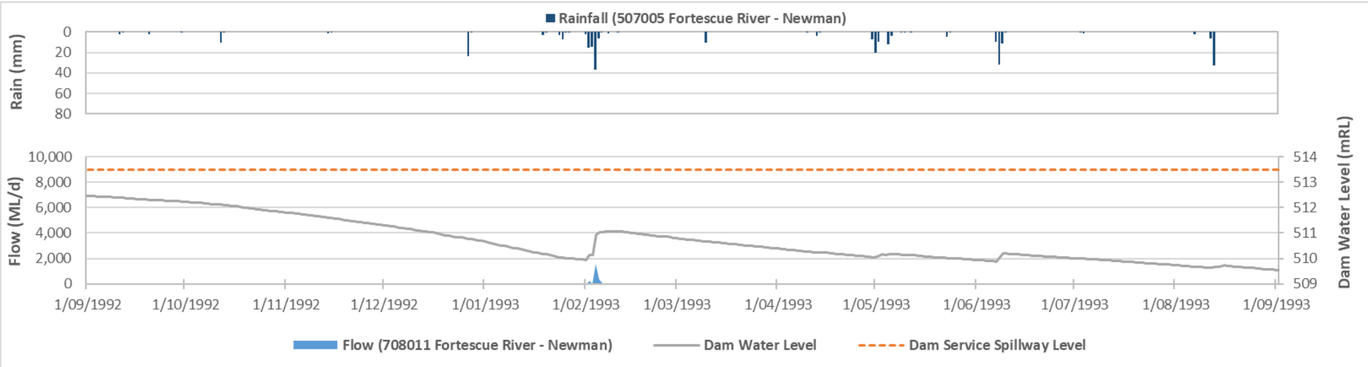

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1987
1/09/1988
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

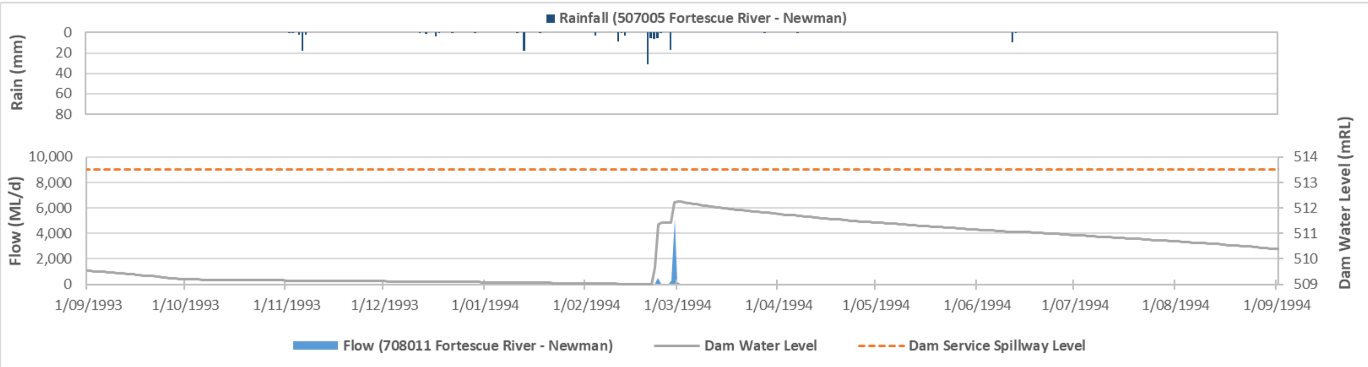

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1988
1/09/1989
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

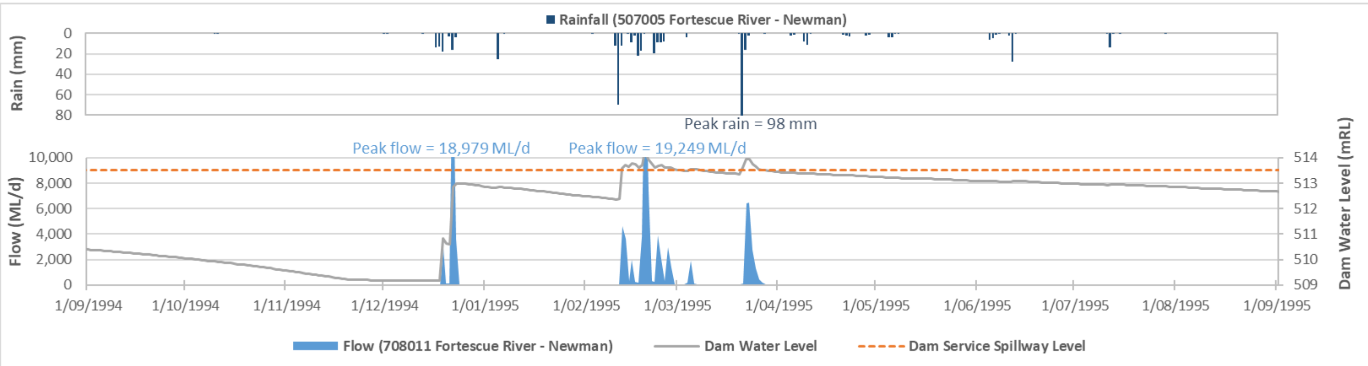

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1989
1/09/1990
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

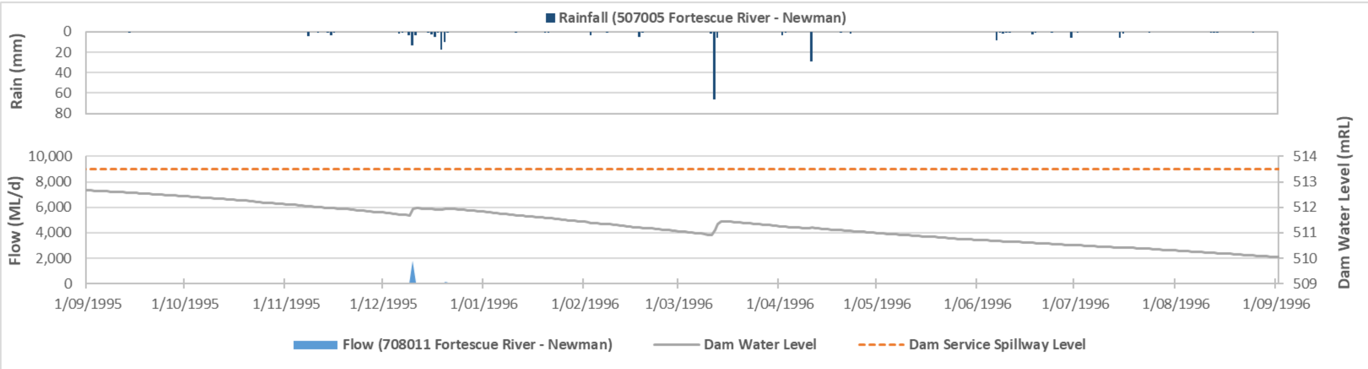

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1990
1/10/1990
1/11/1990
1/12/1990
1/01/1991
1/02/1991
1/03/1991
1/04/1991
1/05/1991
1/06/1991
1/07/1991
1/08/1991
1/09/1991
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

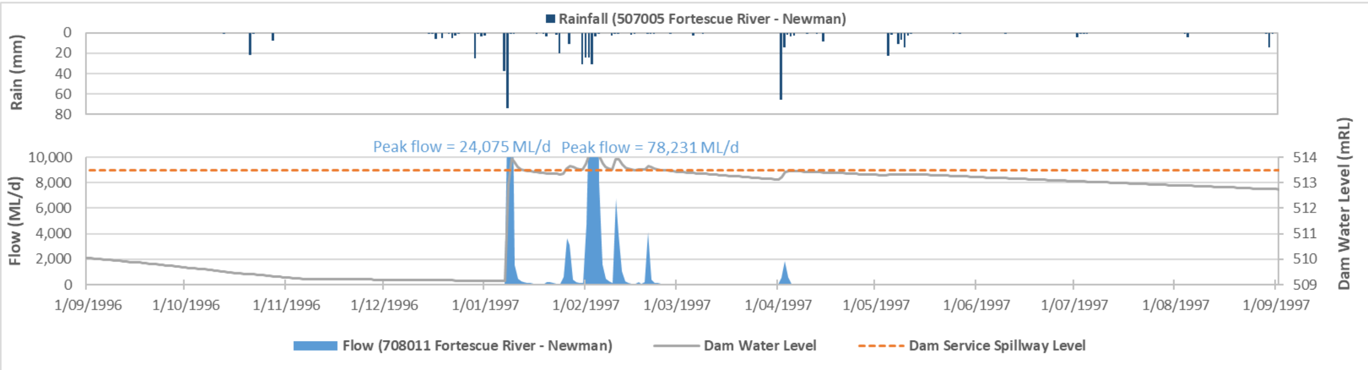

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1991
1/10/1991
1/11/1991
1/12/1991
1/01/1992
1/02/1992
1/03/1992
1/04/1992
1/05/1992
1/06/1992
1/07/1992
1/08/1992
1/09/1992
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

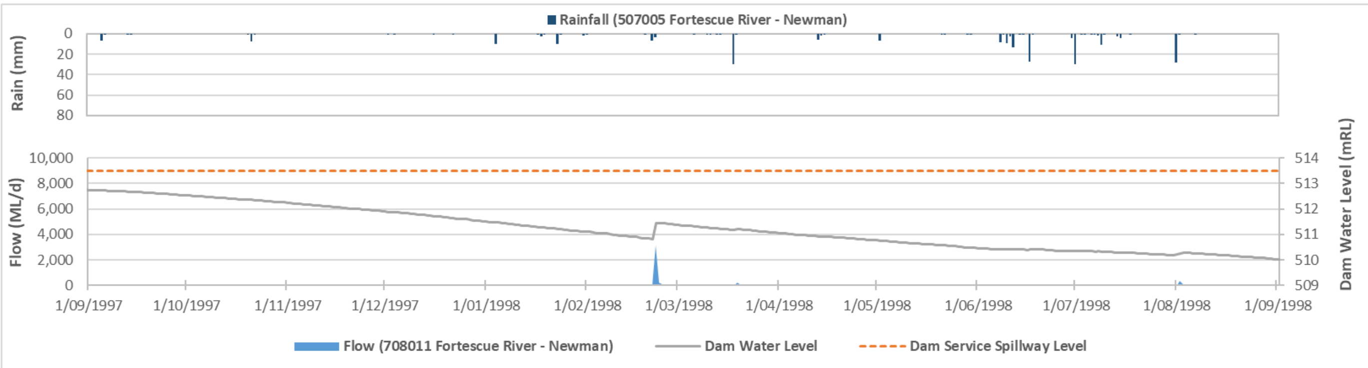

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1992
1/10/1992
1/11/1992
1/12/1992
1/01/1993
1/02/1993
1/03/1993
1/04/1993
1/05/1993
1/06/1993
1/07/1993
1/08/1993
1/09/1993
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

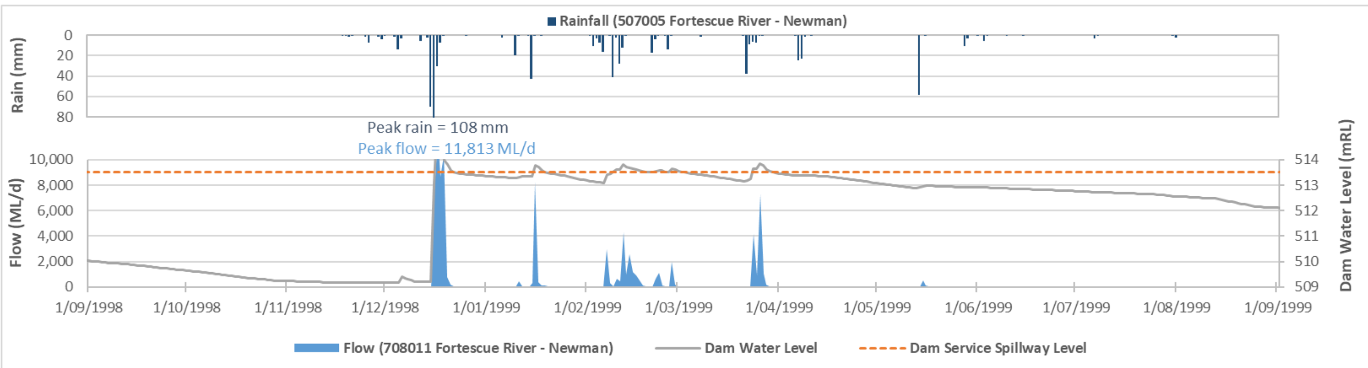

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1993
1/10/1993
1/11/1993
1/12/1993
1/01/1994
1/02/1994
1/03/1994
1/04/1994
1/05/1994
1/06/1994
1/07/1994
1/08/1994
1/09/1994
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

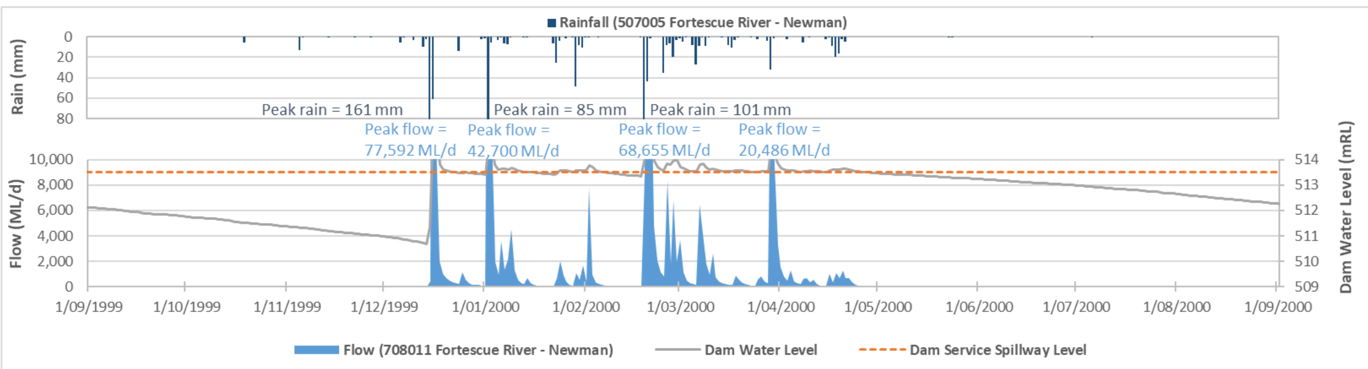

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak rain = 98 mm
Peak flow = 18,979 ML/d
Peak flow = 19,249 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/1994
1/10/1994
1/11/1994
1/12/1994
1/01/1995
1/02/1995
1/03/1995
1/04/1995
1/05/1995
1/06/1995
1/07/1995
1/08/1995
1/09/1995
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

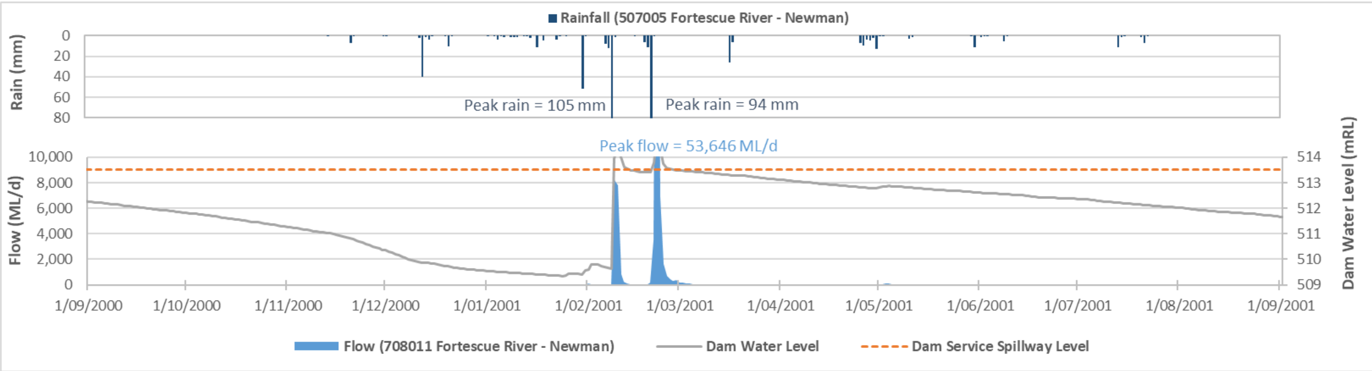

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1995 1/10/1995 1/11/1995 1/12/1995 1/01/1996 1/02/1996 1/03/1996 1/04/1996 1/05/1996 1/06/1996 1/07/1996 1/08/1996 1/09/1996
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

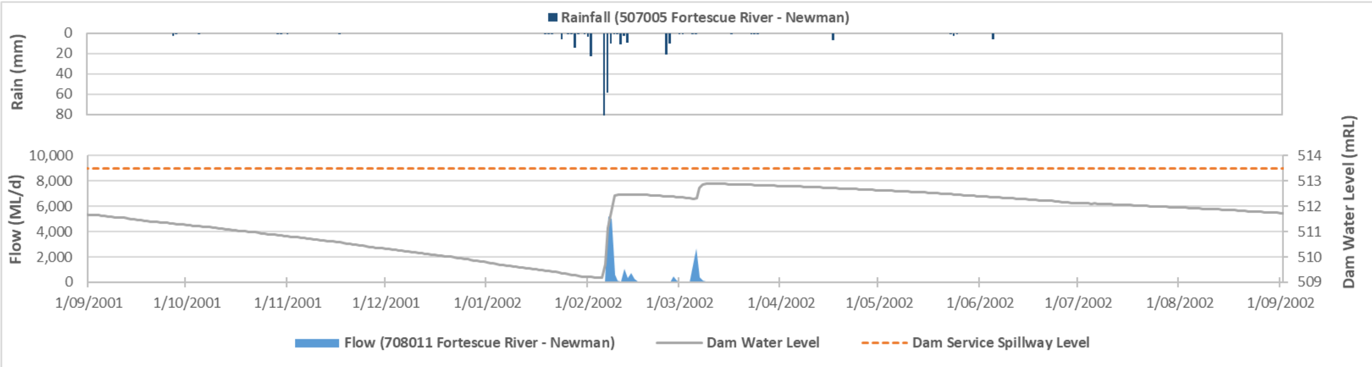

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak flow = 24,075 ML/d
Peak flow = 78,231 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/1996 1/10/1996 1/11/1996 1/12/1996 1/01/1997 1/02/1997 1/03/1997 1/04/1997 1/05/1997 1/06/1997 1/07/1997 1/08/1997 1/09/1997
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

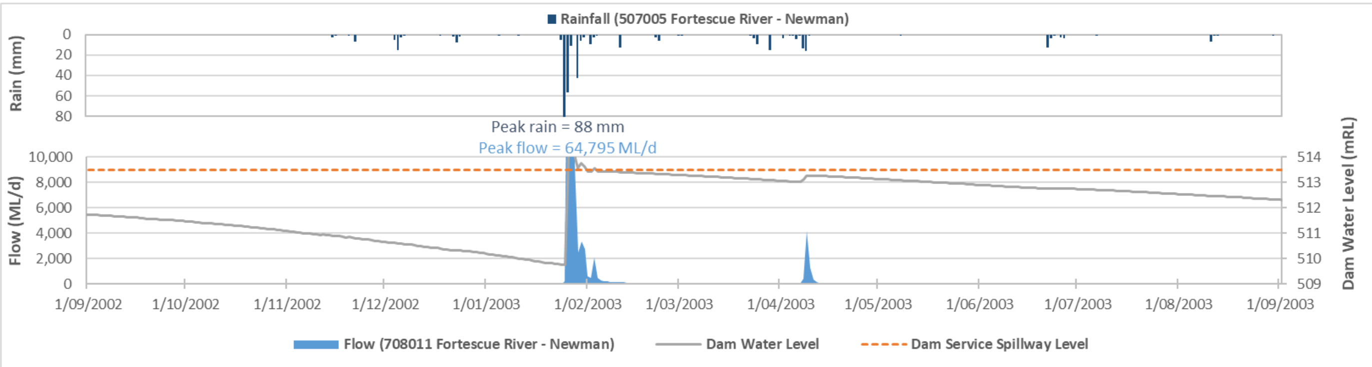

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/1997 1/10/1997 1/11/1997 1/12/1997 1/01/1998 1/02/1998 1/03/1998 1/04/1998 1/05/1998 1/06/1998 1/07/1998 1/08/1998 1/09/1998
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

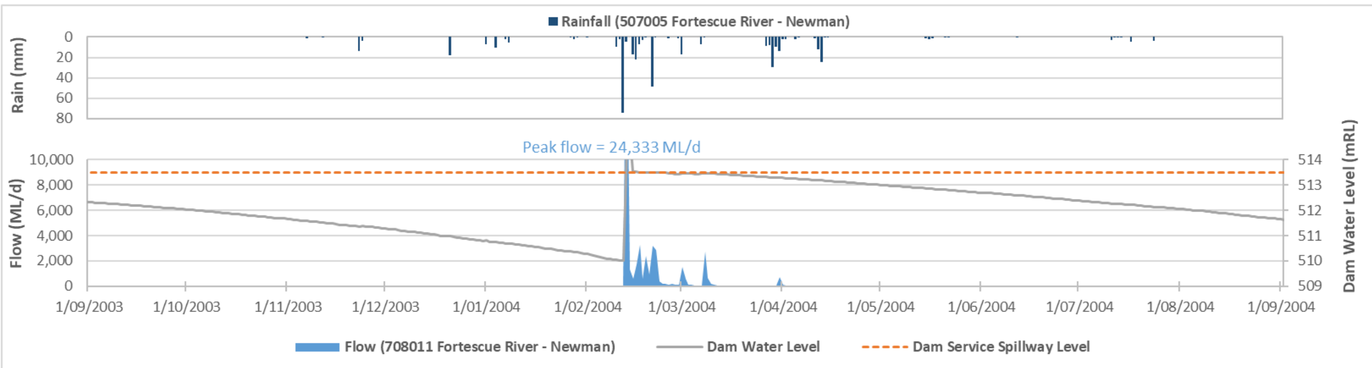

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak rain = 108 mm
Peak flow = 11,813 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/1998 1/10/1998 1/11/1998 1/12/1998 1/01/1999 1/02/1999 1/03/1999 1/04/1999 1/05/1999 1/06/1999 1/07/1999 1/08/1999 1/09/1999
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

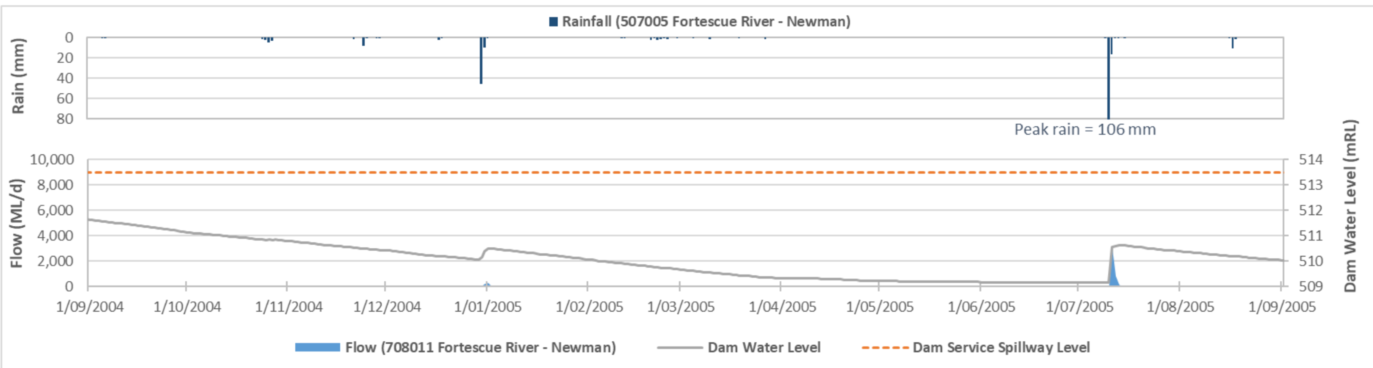

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak rain = 161 mm
Peak rain = 85 mm
Peak rain = 101 mm
Peak flow = 77,592 ML/d
Peak flow = 42,700 ML/d
Peak flow = 68,655 ML/d
Peak flow = 20,486 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/1999 1/10/1999 1/11/1999 1/12/1999 1/01/2000 1/02/2000 1/03/2000 1/04/2000 1/05/2000 1/06/2000 1/07/2000 1/08/2000 1/09/2000
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

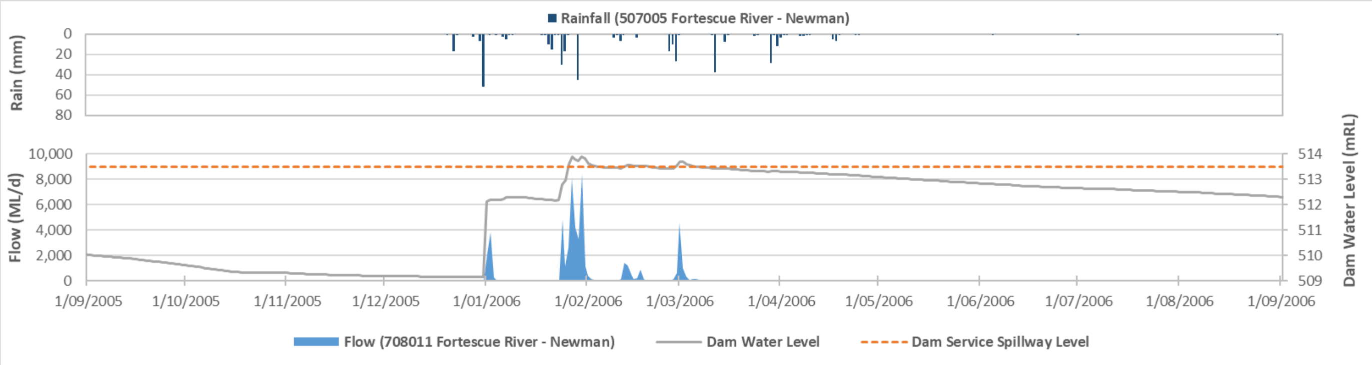

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak rain = 105 mm
Peak rain = 94 mm
Peak flow = 53,646 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/2000 1/10/2000 1/11/2000 1/12/2000 1/01/2001 1/02/2001 1/03/2001 1/04/2001 1/05/2001 1/06/2001 1/07/2001 1/08/2001 1/09/2001
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

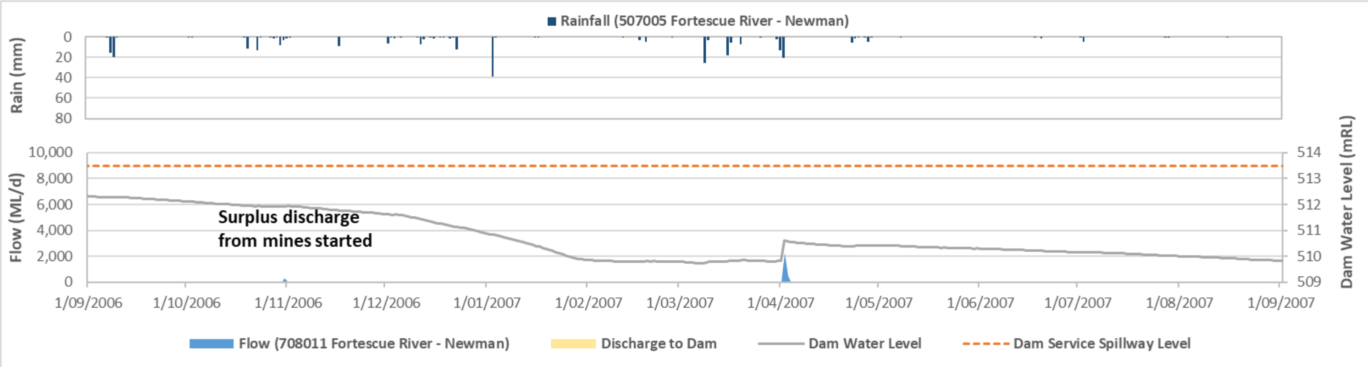

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/2001 1/10/2001 1/11/2001 1/12/2001 1/01/2002 1/02/2002 1/03/2002 1/04/2002 1/05/2002 1/06/2002 1/07/2002 1/08/2002 1/09/2002
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

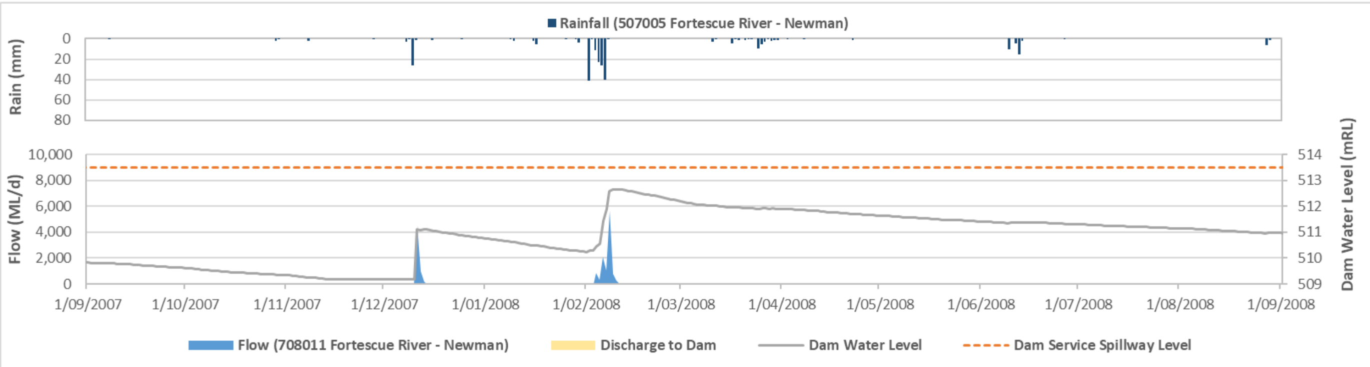

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak rain = 88 mm
Peak flow = 64,795 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/2002 1/10/2002 1/11/2002 1/12/2002 1/01/2003 1/02/2003 1/03/2003 1/04/2003 1/05/2003 1/06/2003 1/07/2003 1/08/2003 1/09/2003
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

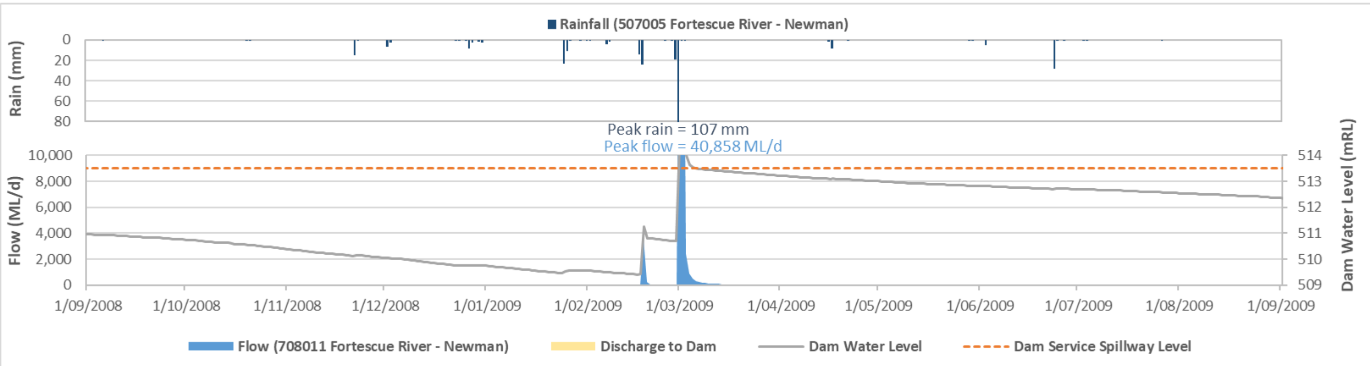

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak flow = 24,333 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/2003 1/10/2003 1/11/2003 1/12/2003 1/01/2004 1/02/2004 1/03/2004 1/04/2004 1/05/2004 1/06/2004 1/07/2004 1/08/2004 1/09/2004
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

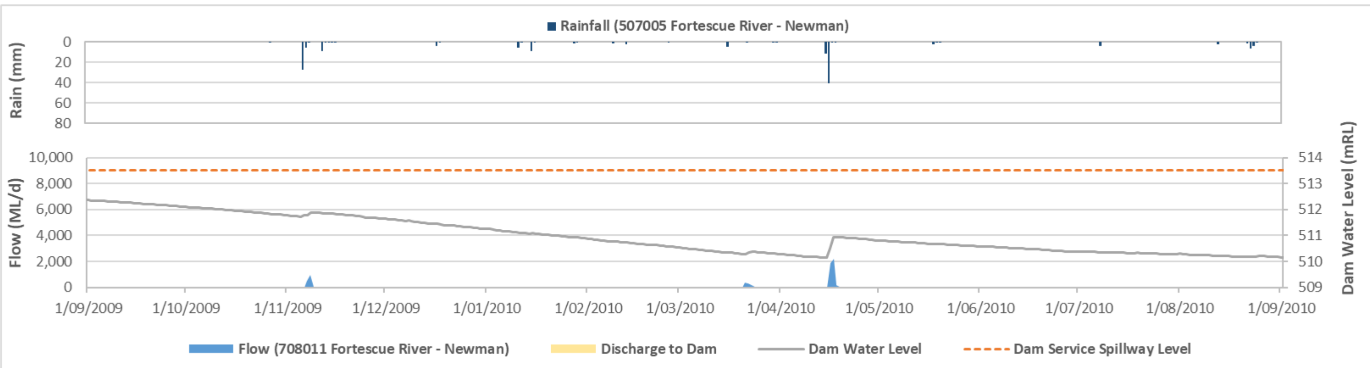

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak rain = 106 mm
Flow (ML/d)
Dam Water Level (mRL)
1/09/2004 1/10/2004 1/11/2004 1/12/2004 1/01/2005 1/02/2005 1/03/2005 1/04/2005 1/05/2005 1/06/2005 1/07/2005 1/08/2005 1/09/2005
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

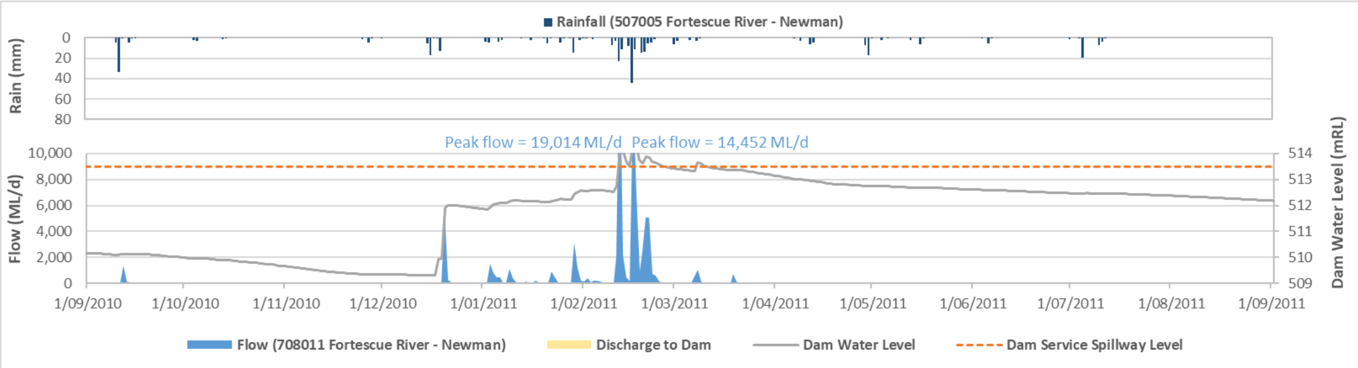

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/2005
1/10/2005
1/11/2005
1/12/2005
1/01/2006
1/02/2006
1/03/2006
1/04/2006
1/05/2006
1/06/2006
1/07/2006
1/08/2006
1/09/2006
Flow (708011 Fortescue River - Newman)
Dam Water Level
Dam Service Spillway Level

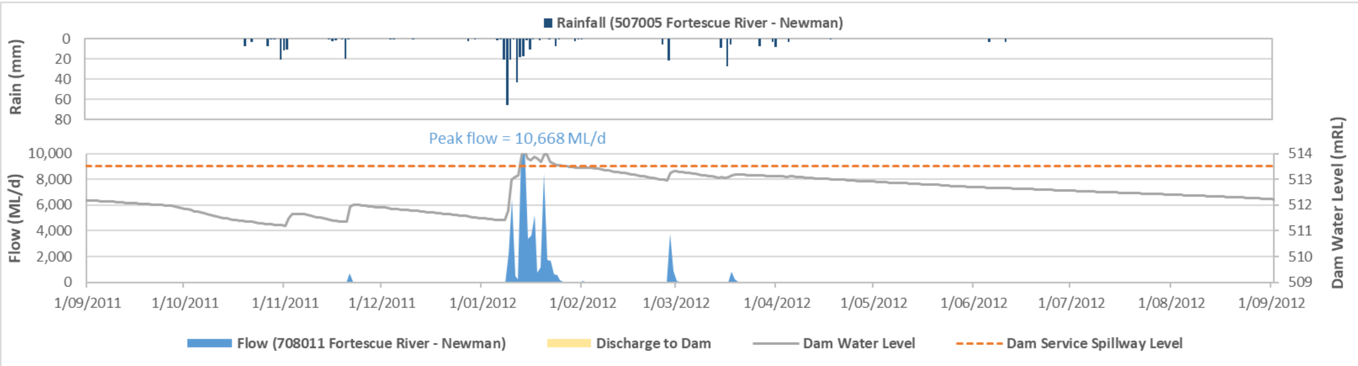

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
Surplus discharge
from mines started
1/09/2006
1/10/2006
1/11/2006
1/12/2006
1/01/2007
1/02/2007
1/03/2007
1/04/2007
1/05/2007
1/06/2007
1/07/2007
1/08/2007
1/09/2007
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

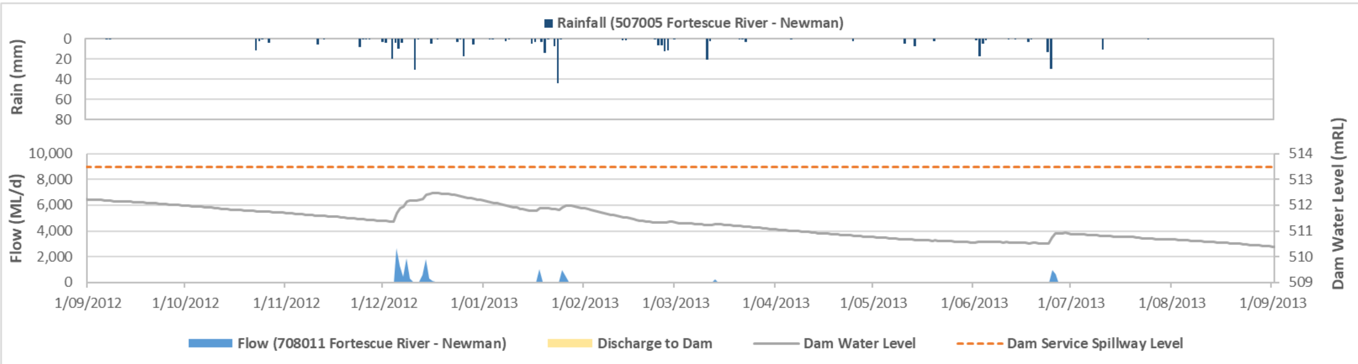

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/2007
1/10/2007
1/11/2007
1/12/2007
1/01/2008
1/02/2008
1/03/2008
1/04/2008
1/05/2008
1/06/2008
1/07/2008
1/08/2008
1/09/2008
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

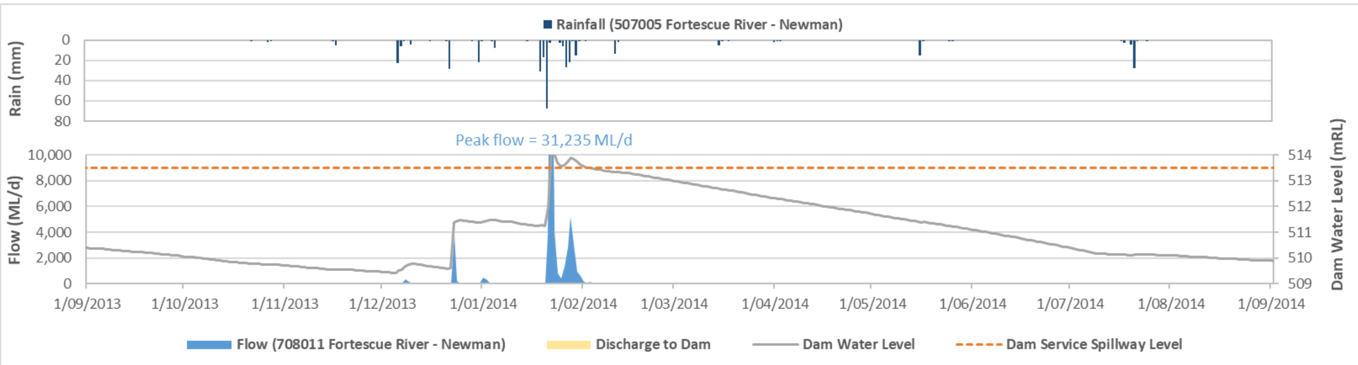

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak rain = 107 mm
Peak flow = 40,858 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/2008
1/10/2008
1/11/2008
1/12/2008
1/01/2009
1/02/2009
1/03/2009
1/04/2009
1/05/2009
1/06/2009
1/07/2009
1/08/2009
1/09/2009
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

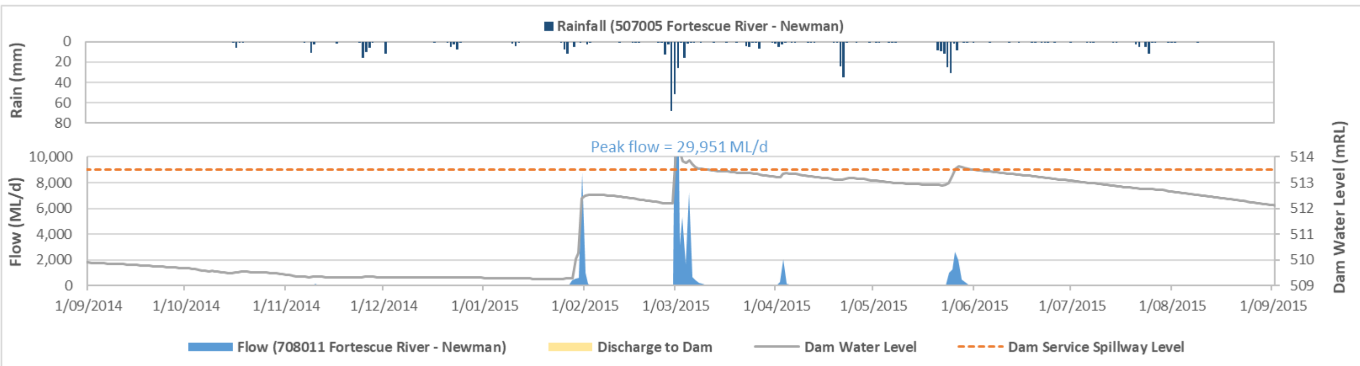

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/2009
1/10/2009
1/11/2009
1/12/2009
1/01/2010
1/02/2010
1/03/2010
1/04/2010
1/05/2010
1/06/2010
1/07/2010
1/08/2010
1/09/2010
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

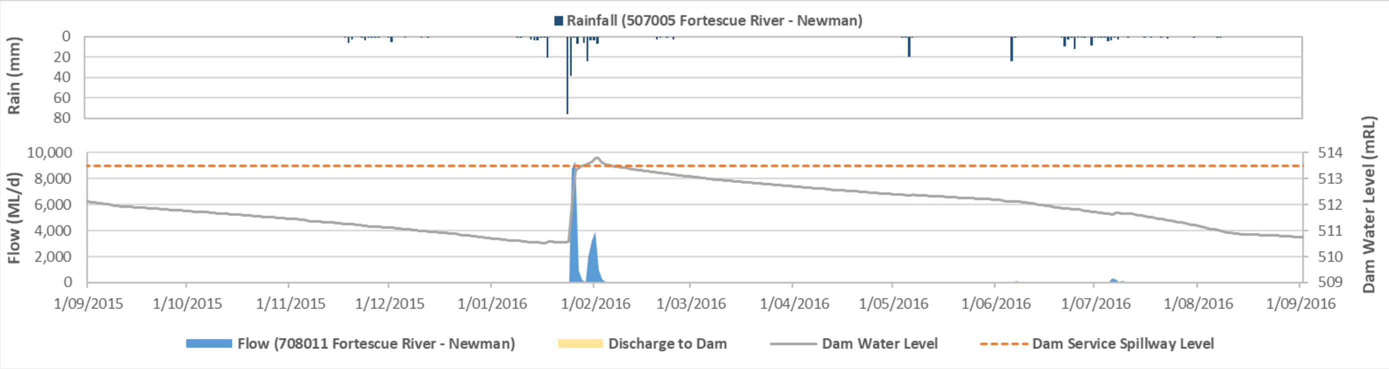

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
Peak flow = 19,014 ML/d
Peak flow = 14,452 ML/d
1/09/2010 1/10/2010 1/11/2010 1/12/2010 1/01/2011 1/02/2011 1/03/2011 1/04/2011 1/05/2011 1/06/2011 1/07/2011 1/08/2011 1/09/2011
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

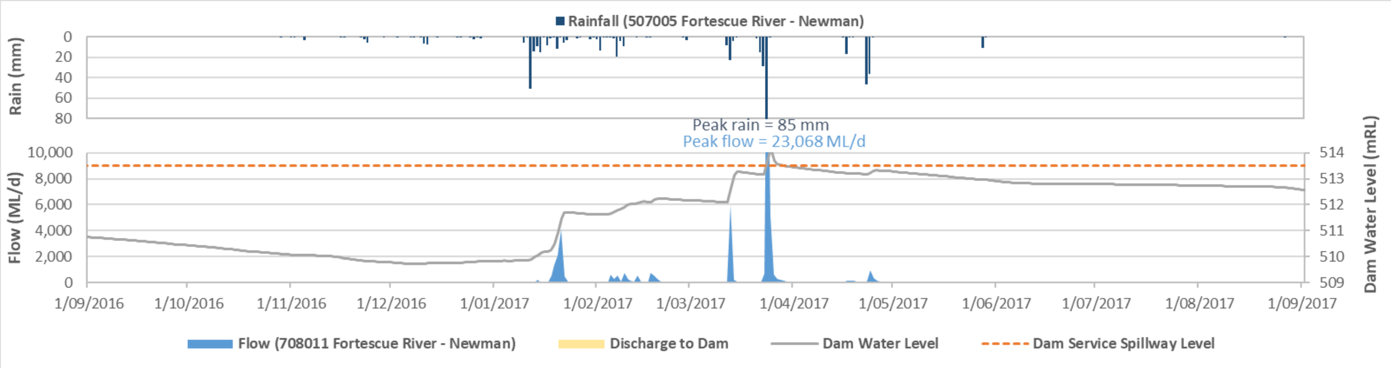

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
Peak flow = 10,668 ML/d
1/09/2011 1/10/2011 1/11/2011 1/12/2011 1/01/2012 1/02/2012 1/03/2012 1/04/2012 1/05/2012 1/06/2012 1/07/2012 1/08/2012 1/09/2012
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

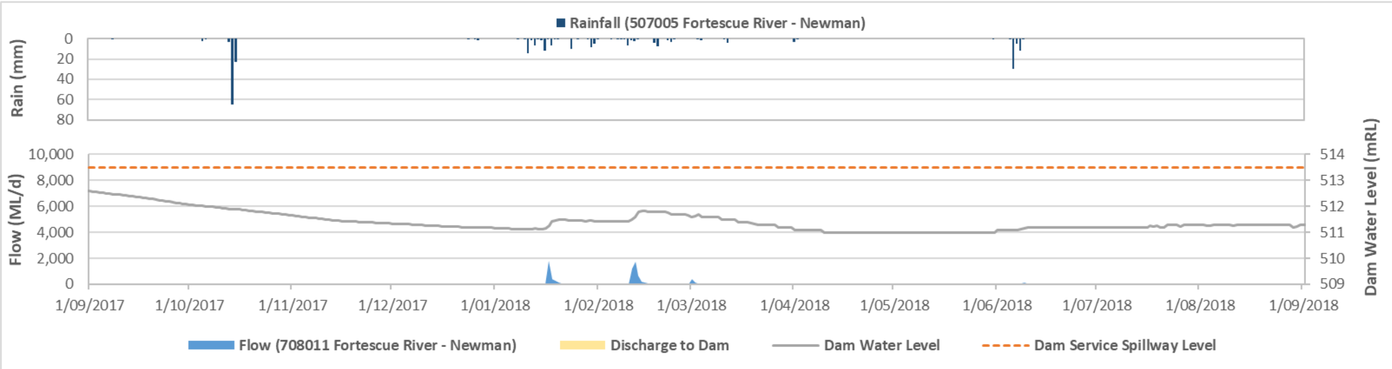

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/2012 1/10/2012 1/11/2012 1/12/2012 1/01/2013 1/02/2013 1/03/2013 1/04/2013 1/05/2013 1/06/2013 1/07/2013 1/08/2013 1/09/2013
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

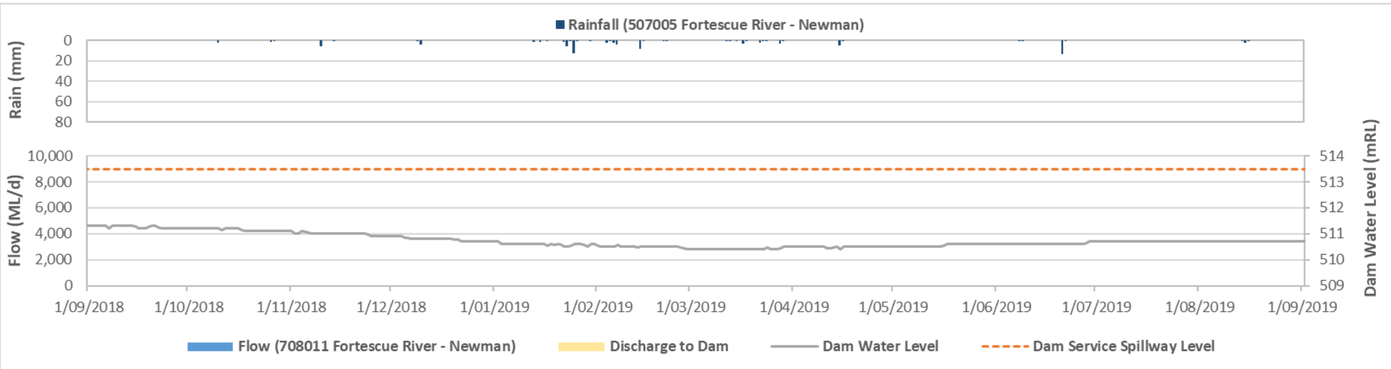

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
Peak flow = 31,235 ML/d
1/09/2013 1/10/2013 1/11/2013 1/12/2013 1/01/2014 1/02/2014 1/03/2014 1/04/2014 1/05/2014 1/06/2014 1/07/2014 1/08/2014 1/09/2014
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

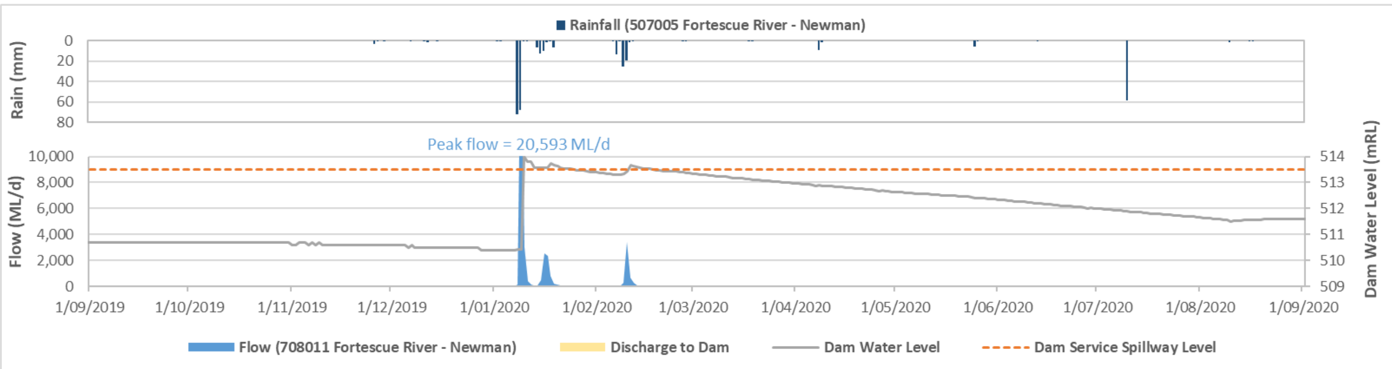

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
Peak flow = 29,951 ML/d
1/09/2014 1/10/2014 1/11/2014 1/12/2014 1/01/2015 1/02/2015 1/03/2015 1/04/2015 1/05/2015 1/06/2015 1/07/2015 1/08/2015 1/09/2015
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

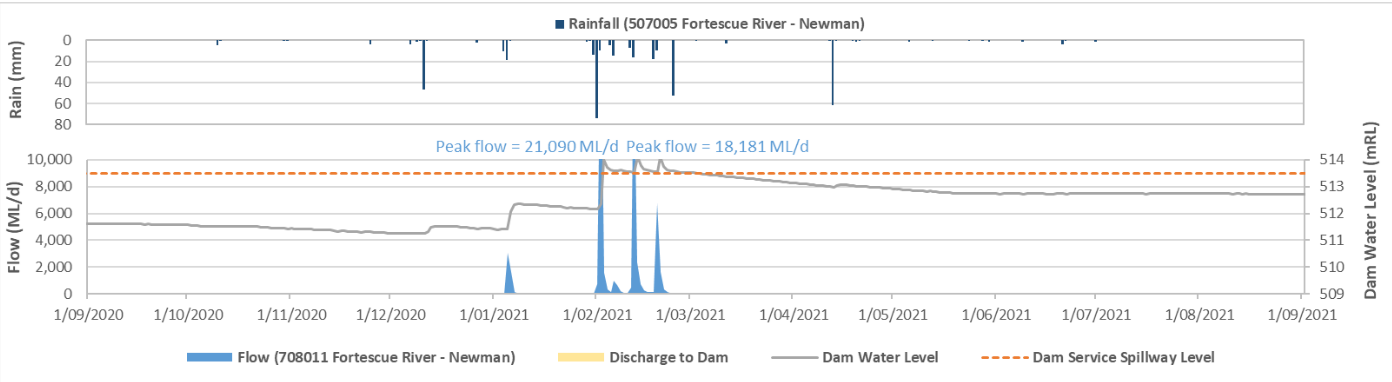

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/2015
1/10/2015
1/11/2015
1/12/2015
1/01/2016
1/02/2016
1/03/2016
1/04/2016
1/05/2016
1/06/2016
1/07/2016
1/08/2016
1/09/2016
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

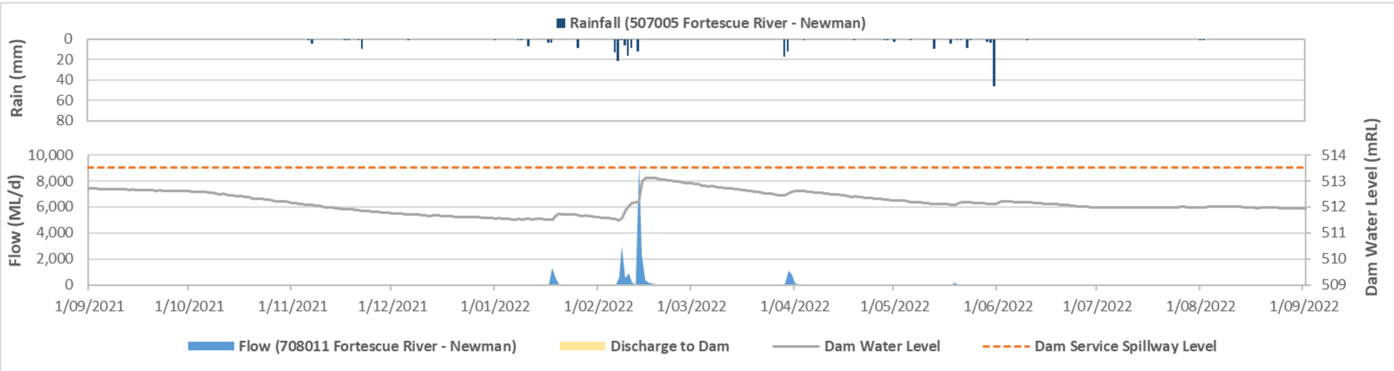

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak rain = 85 mm
Peak flow = 23,068 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/2016
1/10/2016
1/11/2016
1/12/2016
1/01/2017
1/02/2017
1/03/2017
1/04/2017
1/05/2017
1/06/2017
1/07/2017
1/08/2017
1/09/2017
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

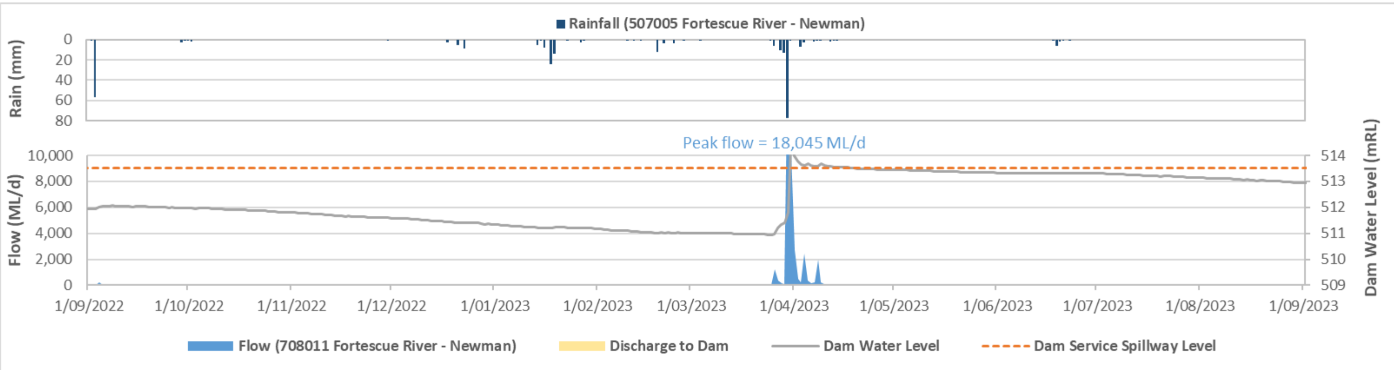

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/2017
1/10/2017
1/11/2017
1/12/2017
1/01/2018
1/02/2018
1/03/2018
1/04/2018
1/05/2018
1/06/2018
1/07/2018
1/08/2018
1/09/2018
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level

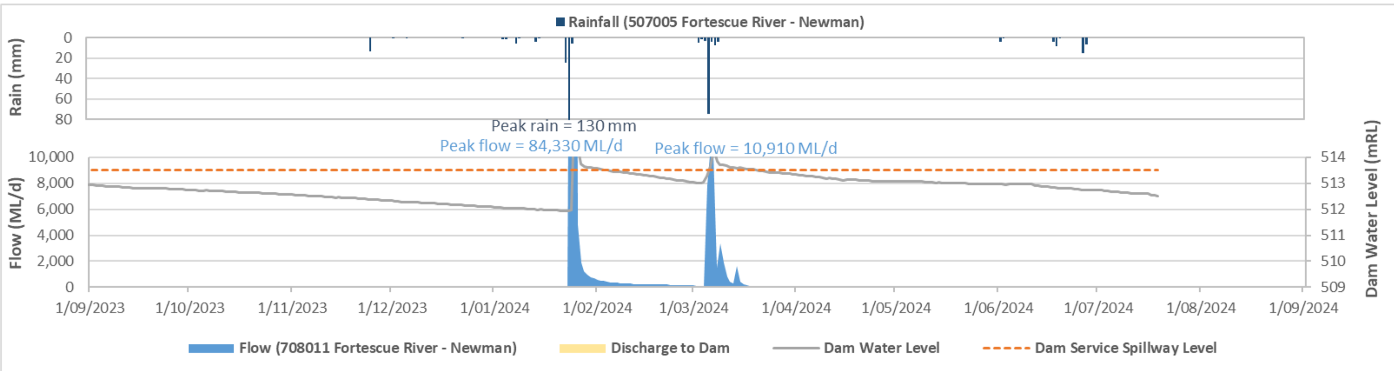

Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/2018
1/10/2018
1/11/2018
1/12/2018
1/01/2019
1/02/2019
1/03/2019
1/04/2019
1/05/2019
1/06/2019
1/07/2019
1/08/2019
1/09/2019
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level


Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Peak flow = 20,593 ML/d
Flow (ML/d)
Dam Water Level (mRL)
1/09/2019
1/10/2019
1/11/2019
1/12/2019
1/01/2020
1/02/2020
1/03/2020
1/04/2020
1/05/2020
1/06/2020
1/07/2020
1/08/2020
1/09/2020
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level


Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
Peak flow = 21,090 ML/d
Peak flow = 18,181 ML/d
1/09/2020
1/10/2020
1/11/2020
1/12/2020
1/01/2021
1/02/2021
1/03/2021
1/04/2021
1/05/2021
1/06/2021
1/07/2021
1/08/2021
1/09/2021
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level


Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
1/09/2021
1/10/2021
1/11/2021
1/12/2021
1/01/2022
1/02/2022
1/03/2022
1/04/2022
1/05/2022
1/06/2022
1/07/2022
1/08/2022
1/09/2022
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level


Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
Peak flow = 18,045 ML/d
1/09/2022
1/10/2022
1/11/2022
1/12/2022
1/01/2023
1/02/2023
1/03/2023
1/04/2023
1/05/2023
1/06/2023
1/07/2023
1/08/2023
1/09/2023
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level


Rainfall (507005 Fortescue River - Newman)
Rain (mm)
Flow (ML/d)
Dam Water Level (mRL)
Peak rain = 130 mm
Peak flow = 84,330 ML/d
Peak flow = 10,910 ML/d
1/09/2023
1/10/2023
1/11/2023
1/12/2023
1/01/2024
1/02/2024
1/03/2024
1/04/2024
1/05/2024
1/06/2024
1/07/2024
1/08/2024
1/09/2024
Flow (708011 Fortescue River - Newman)
Discharge to Dam
Dam Water Level
Dam Service Spillway Level