BHP

Orebody 29/30/35 Significant Amendment:

Groundwater Impact Assessment

November 2024
Version 1

Authorisation

Version	Description of Version	Position	Date
0	Initial version for Traditional Owner information	Superintendent Environmental Approvals	25 August 2024
1	Final version as part of EPA referral package for Orebody 29/30/35 Significant Amendment	Superintendent EPH Hydrogeology	22 November 2024

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1 Purpose

The purpose of this document is to provide an assessment of the impacts on groundwater water resources from the proposed increase in groundwater abstraction for mine dewatering at the Orebody 29/30/35 below water table (Orebody 29/30/35 BWT) mine to support the Orebody 29/30/35 Significant Amendment Proposal (the Proposal) (BHP 2024a).

The *Orebody 29/30/35: Ophthalmia Dam surplus water impact assessment* (BHP 2024b) documents the assessment of the impacts of discharge of surplus mine dewater from BHP's Eastern Pilbara mines to Ophthalmia Dam (including the contribution from Orebody 29/30/35).

2 Scope

The Proposal includes increased groundwater abstraction (for the purposes of dewatering) of approved deposits at the existing Orebody 29/30/35 mine. BHP has undertaken the *Orebody 29, 30 and 35 Detailed Hydrogeological Assessment* (Appendix A; BHP 2024c) to assess the potential impacts from the proposed (2024) dewatering plan at the Orebody 29/30/35 mine, to support *Rights in Water and Irrigation Act 1914* (RiWI) 5C licence and *Environmental Protection Act 1986* (EP Act) Part IV approval processes.

As the Proposal is a significant amendment to an Approved Proposal under Part IV of the EP Act, BHP has provided information in this document on the previous assessments of groundwater abstraction for the existing Orebody 29/30/35 mine and the combined effects that the Approved Proposal and the Proposal might have on the environment.

The key previous hydrogeological assessments relating to dewatering at Orebody 29/30/35 are:

- *Hydrogeological assessment of Orebodies 29, 30 & 35 for mining below water table approvals* (RPS Aquaterra 2013); Appendix B to *OB29/30/35 Below Water Table Mining Environmental Referral Supporting Information Document* (BHP Billiton 2013)
- *Western Ridge and OB29/30/35 Detailed Hydrogeological Assessment* (BHP 2022a); Appendix 16 to *Newman Hub (Western Ridge) Derived Proposal Request Ministerial Statement 1105* (BHP 2023).

3 Existing environment and environmental values

Orebody 29/30/35 mine is part of the Mt Whaleback mining operations in BHP's Newman Hub, in the Eastern Pilbara region of Western Australia (WA), which also includes the existing Mt Whaleback mine and the approved Western Ridge mine. The Orebody 29/30/35 mine is located approximately 7 km west southwest of the town of Newman (Figure 1).

The groundwater regime in the Newman area has been altered by groundwater abstraction for water supply and to dewater orebodies to access below water table ore. Groundwater abstraction started at Mt Whaleback in 1967 for water supply and for dewatering in 1984. The EP Act Part IV Approved Proposal (existing project) is Orebody 29/30/35 Mining Below Watertable, authorised under Ministerial Statement (MS) 963 in 2014. MS963 authorises groundwater abstraction for dewatering of up to 8 GL/a. Groundwater abstraction for mine dewatering activities at Orebody 29/30/35 commenced at OB29 in 2015 and OB35 in 2016. As at November 2024, dewatering of OB30 and the Western Ridge orebodies has not started.

The Proposal is located within the Priority 1 Public Drinking Water Source Area of the Newman Water Reserve (Figure 1). Groundwater is abstracted from the BHP operated Ophthalmia and Homestead borefields, to provide drinking water for the Newman town water supply. The Homestead Borefield is adjacent to the west of the Eastern Ridge mining operation and the Ophthalmia Borefield is located to the northeast of Orebody 29/30/35, within the Ethel Gorge aquifer.

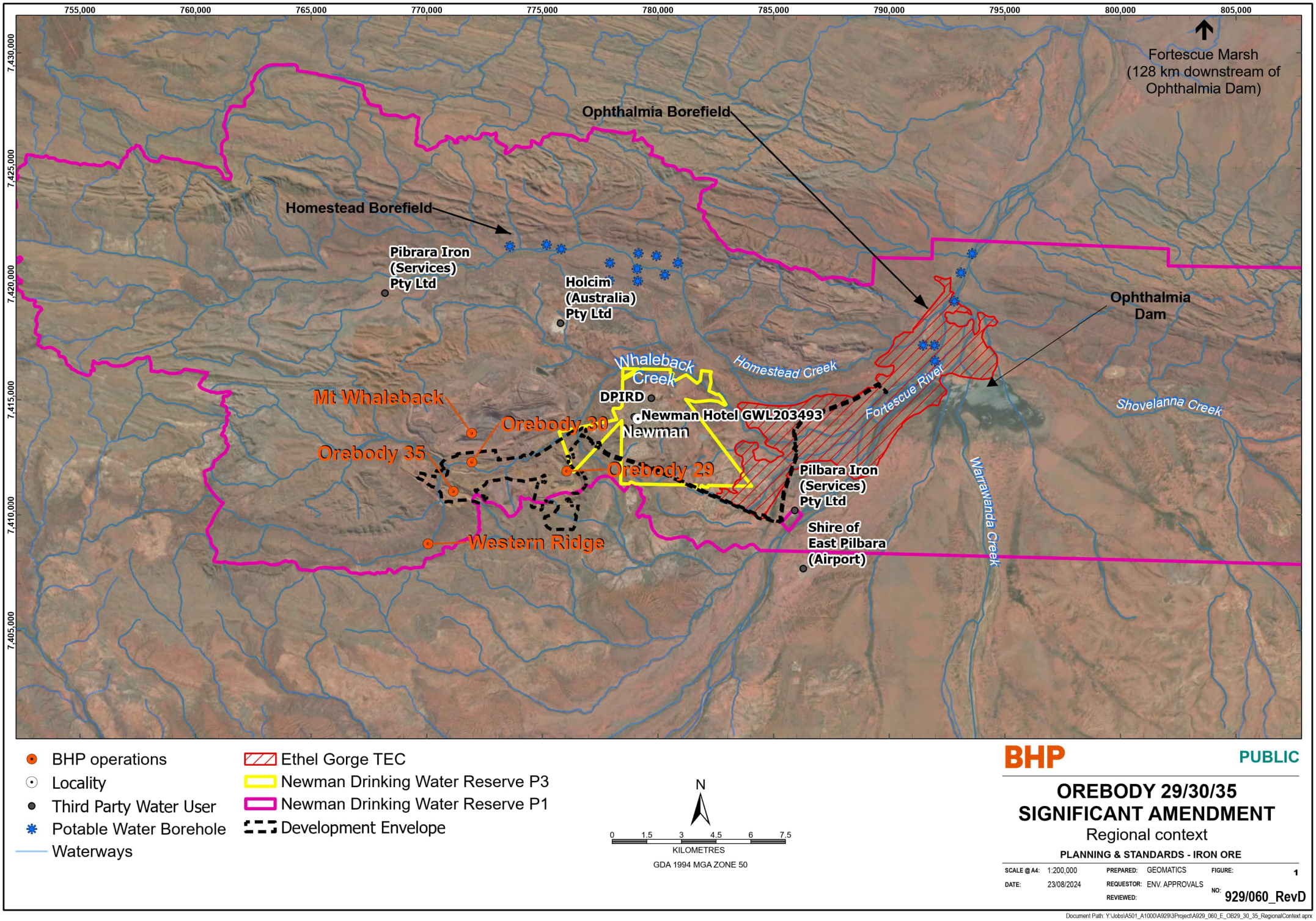
The Ophthalmia Dam system, located approximately 15 km east of Orebody 29/30/35, partially overlies the Ethel Gorge aquifer which supports the Ethel Gorge aquifer stygobiont community Threatened Ecological Community (Ethel Gorge TEC). Ophthalmia Dam was commissioned in 1981 as a Managed Aquifer Recharge (MAR) scheme, to maintain groundwater levels within the Ethel Gorge aquifer and to support the Ophthalmia Borefield, which BHP has operated since the 1970s. The Ophthalmia Dam system continues to maintain groundwater levels within the Ethel Gorge aquifer to protect the Ethel Gorge TEC habitat and also provides a discharge location for surplus water from approved BHP mines in the Eastern Pilbara area. Discharge to Ophthalmia Dam currently occurs from Orebody 29/30/35, Eastern Ridge, Jimblebar and OB31. Discharge is also authorised from the Western Ridge mine and OB32 BWT mine (part of the Eastern Ridge mining operations) (both approved in 2023), however, as at November 2024 discharge of surplus water has not started from these mines as dewatering has not yet started.

The main water-related environmental values that potentially may be impacted by groundwater abstraction from Orebody 29/30/35 are (Figure 1):

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

The hydrogeological assessment for the current (2024) Orebody 29/30/35 mine plan (BHP 2024c) identifies other groundwater users. Most of the nearby users are other BHP operations, however BHP has identified five third party groundwater users within 10 km of Orebody 29/30/35 (see Figure 1 for approximate locations).

Fortescue Marsh is located approximately 128 km north (downstream) of Ophthalmia Dam along the Fortescue River at the terminus of the Upper Fortescue River. The aquifer system underlying Fortescue Marsh is not connected to the Orebody 29/30/35 orebody aquifers and will not be impacted by groundwater abstraction (for dewatering) at the Orebody 29/30/35 mine.



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OREBODY 29/30/35 SIGNIFICANT AMENDMENT

Regional context

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4 Hydrogeology

The detailed hydrogeological assessment (BHP 2024c) describes the hydrogeology and conceptualisation of the Orebody 29/30/35 area in detail.

4.1 Historical and current groundwater levels

4.1.1 Orebody 29/30/35 area groundwater levels

Pre-development groundwater levels in the orebody and regional aquifers in the Orebody 29/30/35 area (prior to the 2015 hydrodynamic trial and the start of dewatering) varied between 519 metres above Australian Height Datum (mAHD) and approximately 526 mAHD. This is likely the result of natural fluctuations (local rainfall recharge and long-term trends) as well as water supply pumping. Groundwater levels in the southern part of the Silver Knight (Marra Mamba) orebody and in the unmineralised Brockman to the north of Bill's Hill at Western Ridge are much higher (greater than 570 mAHD and 580 mAHD respectively). The pre-development depth to groundwater in the regional aquifers ranged from a minimum of about 30 mbgl around OB29 to greater than 50 mbgl at the western edge of OB35 (Figure 2), which suggests that groundwater/surface water interaction and evapotranspiration do not occur in this area. Therefore, it is not expected that these aquifers support near surface and groundwater dependent ecosystems.

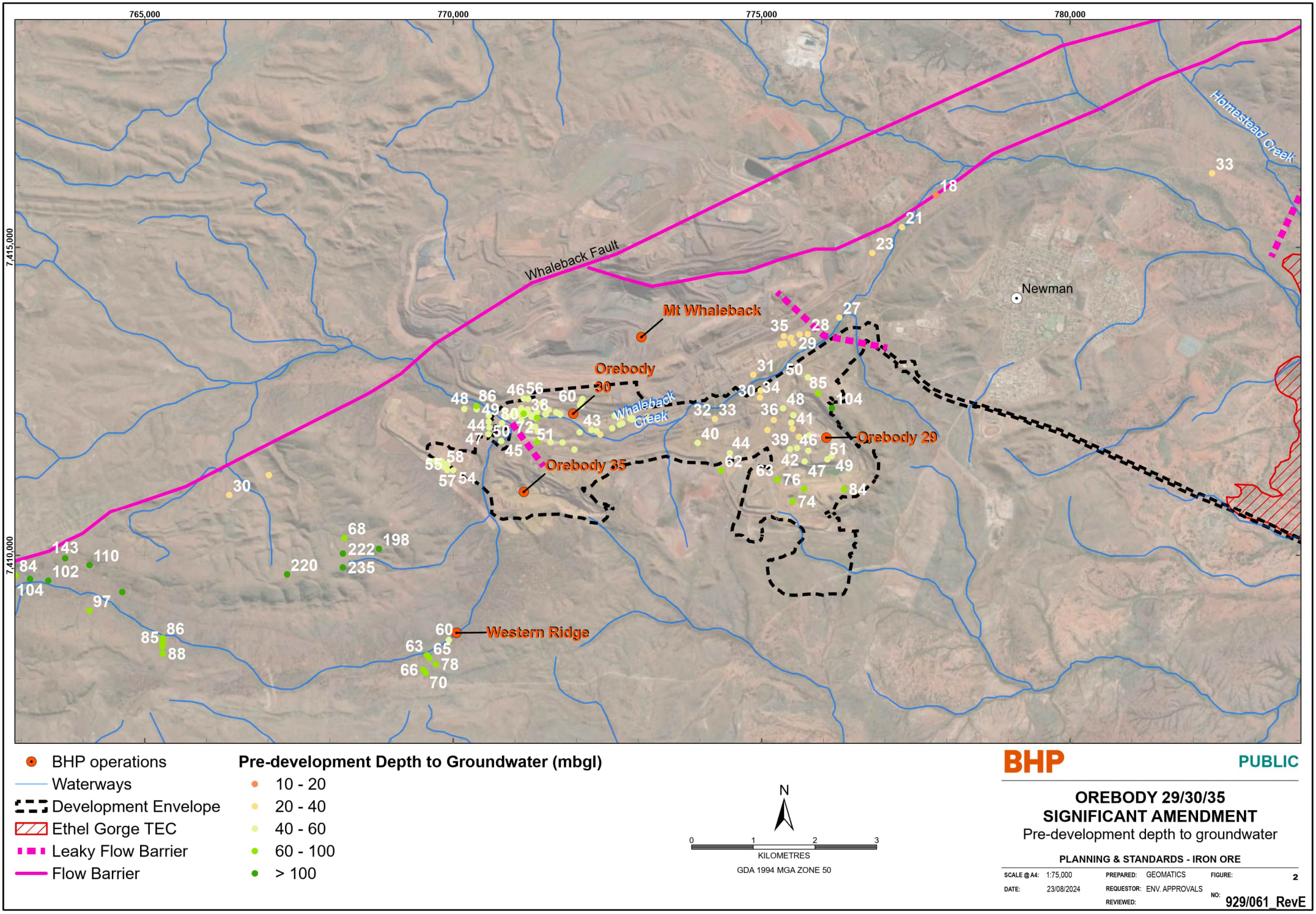
Figure 3 shows observed groundwater levels (mAHD) in the Orebody 29/30/35 area (green bores) since 2013. Since dewatering commenced at the Orebody 29/30/35 mine (2015), the groundwater level at OB29 has declined from approximately 525 mAHD to 490 mAHD (observed groundwater drawdown at OB29 reached a maximum of approximately 35 m). There was some recovery (about 15 m) when dewatering of OB29 temporarily ceased in November 2020, however groundwater levels have since declined to below the 2020 levels since dewatering recommenced in mid-2023 (Figure 3). A number of bores provide evidence for a leaky flow barrier across the regional aquifer east of OB29. Figure 3 (blue bores) shows that groundwater drawdown east of the leaky flow barrier is much less than west of the barrier. Groundwater levels at OB35 have declined by about 40 m and groundwater levels at OB30 have declined by about 20 m due to dewatering at OB29 and OB35 (BHP 2024c).

Figure 4 shows the current depth to groundwater in the Orebody 29/30/35 area, compared to the original ground level, as the ground level has changed due to mining. The current depths to groundwater in the orebody aquifer are generally greater than 70 mbgl at OB29 and greater than 90 mbgl at OB35. Current depths to groundwater in the regional aquifer are greater than 90 mbgl west of OB35 and are shallower to the northeast of OB29 across the leaky flow barrier (approximately 20 mbgl to 24 mbgl).

4.1.2 Ethel Gorge aquifer groundwater levels

Figure 3 also presents observed groundwater levels in the Ethel Gorge area since the early 1970s (orange bores) when monitoring began. Groundwater levels in the Ethel Gorge aquifer (north of the dam) have varied between 487 and 505 mAHD between the first observations in 1968 and the present (2024). The data for the Ethel Gorge aquifer shows the decline in groundwater levels (drawdown) during the 1970s due to abstraction from the Ophthalmia Borefield for the Newman town water supply (as discussed in Section 3) and the rapid groundwater level response following the commissioning of Ophthalmia Dam in 1981. Observed groundwater levels in the Ethel Gorge aquifer are generally higher since Ophthalmia Dam was commissioned. The dam has maintained groundwater levels nearer natural conditions, as groundwater levels would have declined without the dam due to the operation of the Ophthalmia Borefield and dewatering of OB23 and OB25 (which are located within the Ethel Gorge aquifer compartment (see Figure 5)).

As shown in Figure 3, groundwater levels in the Ethel Gorge aquifer do not show any response to the groundwater abstraction in the Orebody 29/30/35 area. This is mainly due to the infiltration of water from the dam and the distance of Orebody 29/30/35 from the Ethel Gorge aquifer (greater than 10 km). The depth to groundwater is less than 10 mbgl in the Ethel Gorge aquifer in the TEC.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Whaleback Fault
Homestead Creek
Whaleback Creek
Newman
Mt Whaleback
Orebody
Orebody 29
Orebody 35
Western Ridge
BHP operations
Waterways
Development Envelope
Ethel Gorge TEC
Leaky Flow Barrier
Flow Barrier
Pre-development Depth to Groundwater (mbgl)
10 - 20
20 - 40
40 - 60
60 - 100
> 100
N
0 1 2 3
KILOMETRES
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Pre-development depth to groundwater
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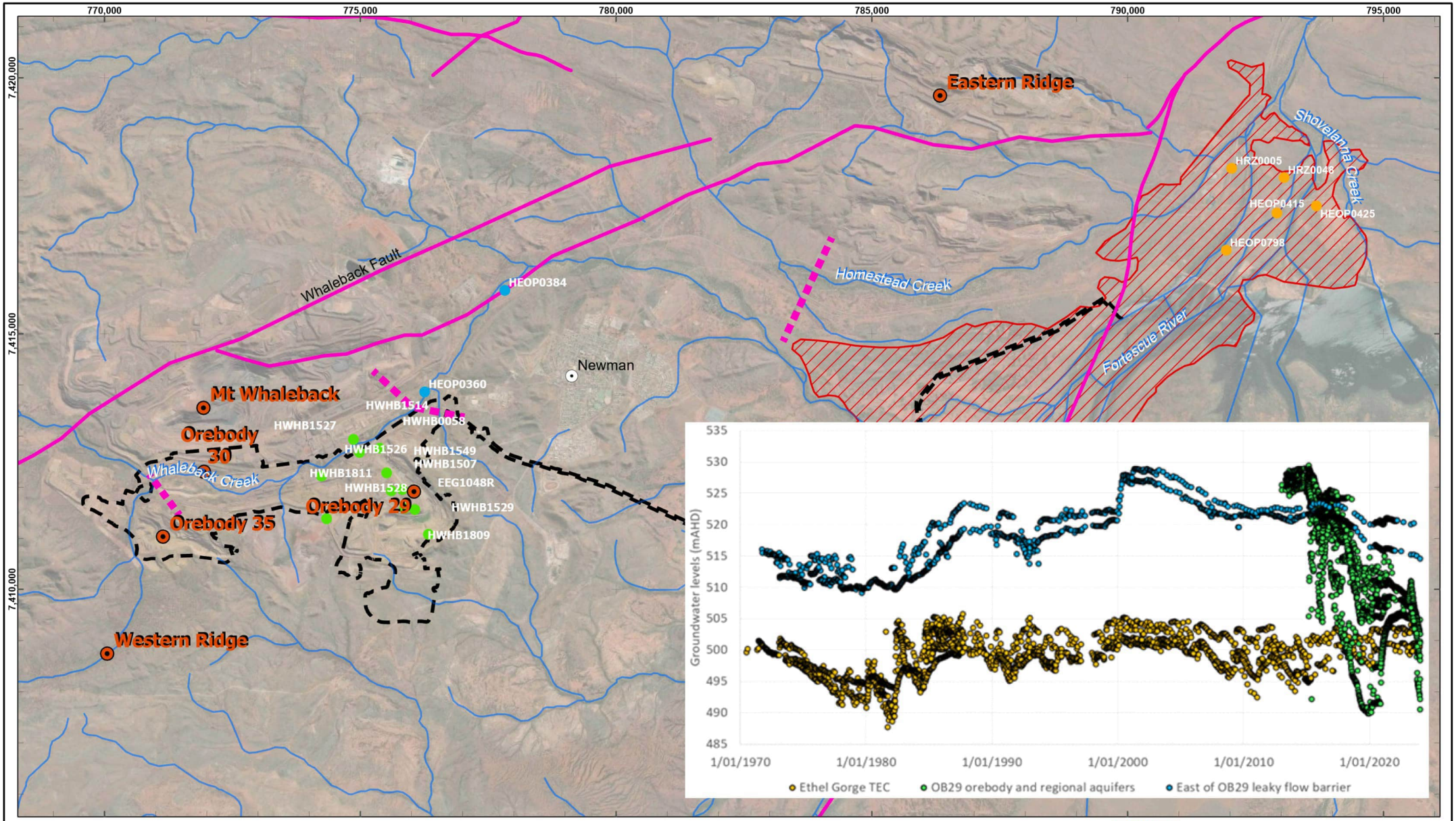

BHP Operations
Development Envelope
Ethel Gorge TEC
Waterways
Leaky Flow Barrier
Flow Barrier

Bore Group

- Ethel Gorge TEC
- Orebody 29 and Regional Aquifers
- East of Orebody 29 Leaky Flow Barrier

N

0 1 2 3 4

KILOMETRES

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OREBODY 29/30/35 SIGNIFICANT AMENDMENT

Observed groundwater levels over time

PLANNING & STANDARDS - IRON ORE

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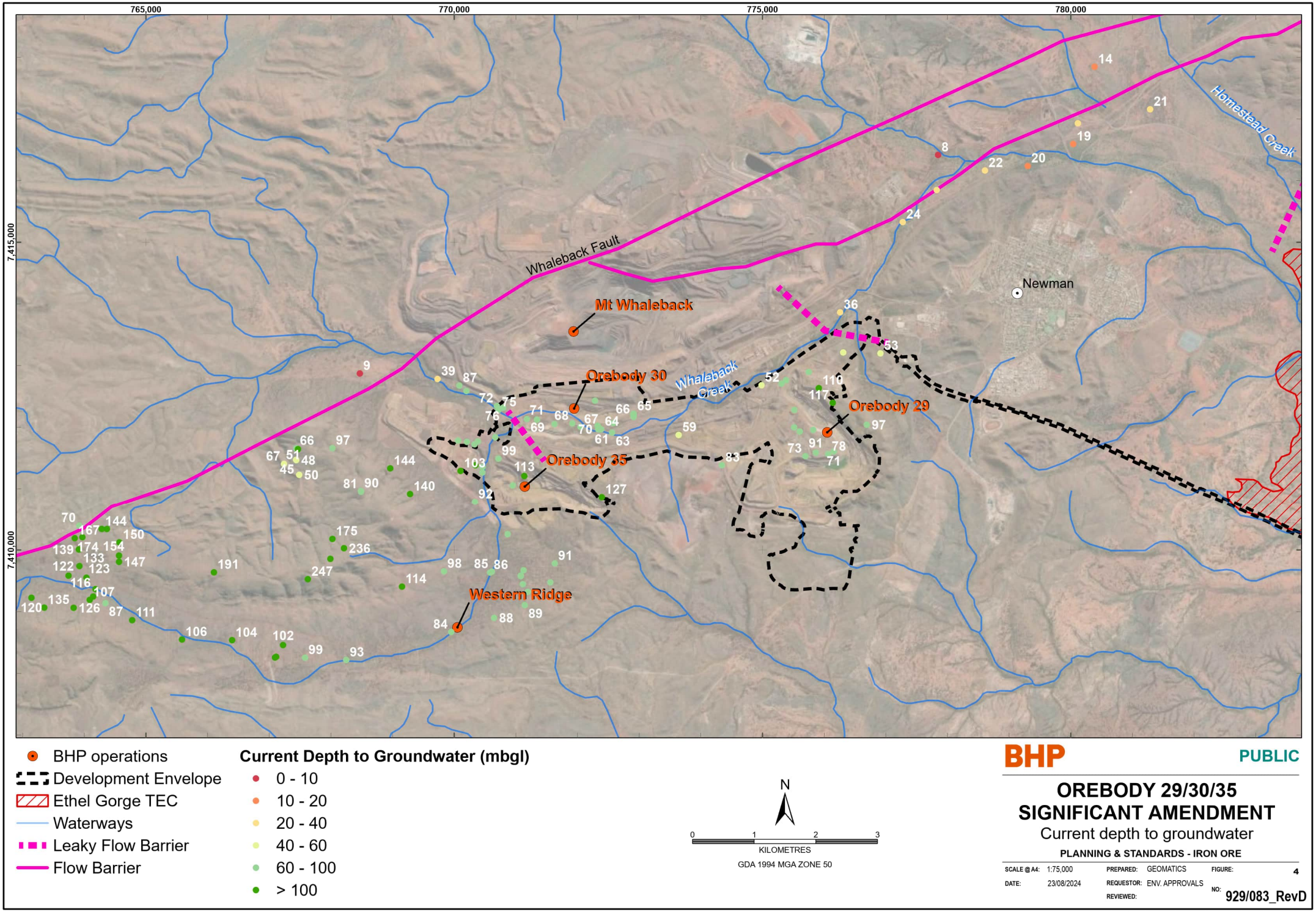
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Whaleback Fault
Mt Whaleback
Orebody 30
Orebody 35
Orebody 29
Western Ridge
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Waterways
Leaky Flow Barrier
Flow Barrier
Current Depth to Groundwater (mbgl)
0 - 10
10 - 20
20 - 40
40 - 60
60 - 100
> 100
N
0 1 2 3
KILOMETRES
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OREBODY 29/30/35
SIGNIFICANT AMENDMENT
Current depth to groundwater
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4.2 Hydrogeological conceptualisation

Figure 5 shows the conceptual groundwater system in the Orebody 29/30/35 area during operations (i.e. with groundwater abstraction activities). As the Orebody 29/30/35 and Western Ridge area forms a larger semi-continuous aquifer compartment, the Western Ridge area is also included in the conceptualisation. The Western Ridge mine includes the Eastern Syncline, Bill's Hill, Mount Helen and Silver Knight deposits.

4.2.1 Orebody 29/30/35 mine area conceptualisation

There are two main aquifer types in the Orebody 29/30/35 and Western Ridge area:

- The regional aquifers generally comprise weathered dolomite of the Paraburdoo Member of the Wittenoom Formation which occurs in sub-crop along the Whaleback and Southern Creek valleys. The overlying Tertiary detritals are above the water table through much of the area, but where they are saturated, they also form part of the regional aquifer system. The thickest sequence of Tertiary detritals (in excess of 150 m) is found to the west of the Mt Whaleback pit with other notable areas of thickness occurring south of the Mount Helen deposit (Western Ridge) and northeast of OB29.
- The orebody aquifers comprise the mineralised Brockman that make up the Whaleback, Bill's Hill and Mount Helen orebodies and the mineralised Marra Mamba that make up the Orebody 29/30/35, Silver Knight and Eastern Syncline orebodies. The orebody aquifers are usually well delineated by the extent of the high grade ore (assumed high permeability), with a halo of lower grade ore (assumed moderate permeability) around it (BHP 2024c).

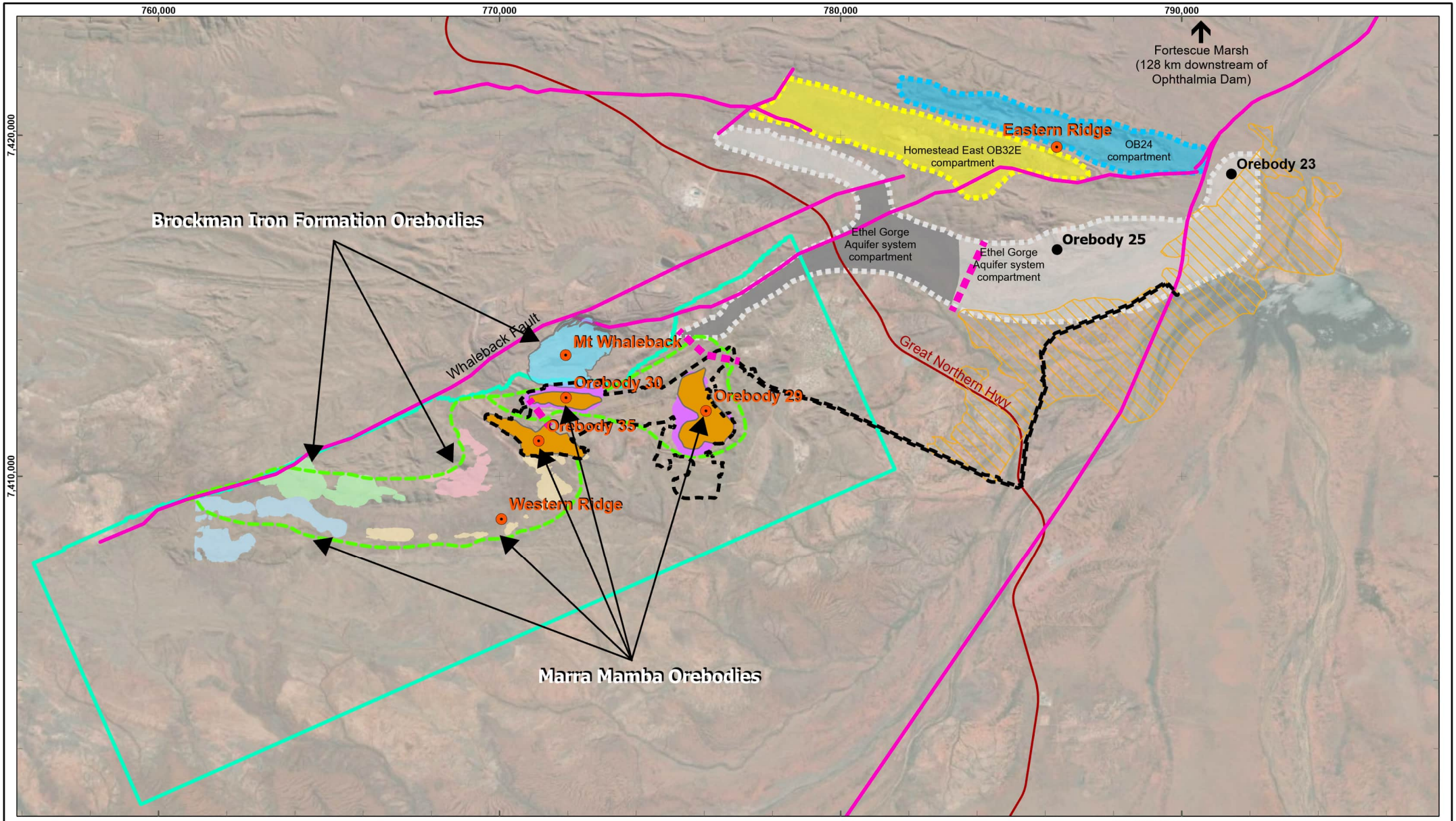
The Orebody 29/30/35 and Western Ridge area is characterised by hydraulically connected regional (weathered dolomite and some tertiary detritals) and Marra Mamba orebody aquifers, and less well connected Brockman orebody aquifers. The connection of the regional aquifer to the Marra Mamba orebodies (OB29, OB30, OB35 deposits and the Eastern Syncline and Silver Knight deposits at Western Ridge) is either through mineralisation or absence of the West Angela Shale. The regional dolomite aquifer over much of the area is likely to have both high storage (most likely karstic) and high hydraulic conductivity.

The Marra Mamba orebody aquifers and the regional dolomite aquifer are bounded by the low permeability Mt Sylvia Formation and Mt McRae Shale to the north (isolating this system from Whaleback orebody aquifer) and the low permeability Jeerinah Formation to the south. There is no evidence of any significant connection between the Whaleback orebody aquifer and the regional aquifers. The Mt Sylvia Formation and Mt McRae Shale appear to be less of a barrier to flow in the west however, allowing some flow between the regional aquifer and the Brockman orebody aquifers (Bill's Hill and Mt Helen at Western Ridge).

The regional aquifer system appears to be interrupted by at least two leaky flow barriers. One between OB30 and OB35 and the other just to the east of OB29 (Figure 5). The western side of the Whaleback Fault consists of the Jeerinah Formation which is considered very low permeability and presents a no flow boundary (BHP 2024c).

4.2.2 Regional conceptualisation from Orebody 29/30/35 to Ethel Gorge area

The regional Tertiary detrital / dolomite aquifers are conservatively assumed to be continuous from OB29 to the Ethel Gorge aquifer system. The aquifers pass north of Newman then turn southeast, passing to the south of OB25 and merging with the western side of the Ethel Gorge aquifer system (west of Ophthalmia Dam) (Figure 5). It seems likely that groundwater flow within the regional aquifer is inhibited (i.e. within the low transmissivity area between the local Western Ridge and Orebody 29/30/35 aquifer compartment in the west and Ethel Gorge aquifer compartment in the east (Figure 5)). The western boundary of this low transmissivity area is formed by the leaky flow barrier that exists just to the east of OB29 and the eastern boundary is formed by the leaky flow barrier that exists southwest of OB25 (BHP 2024c).



- BHP operations
- Western Ridge and Orebody 29/30/35 aquifer compartment
- Flow Barrier
- Leaky Flow Barrier
- Model domain
- Ethel Gorge Threatened Ecological Community
- Development Envelope
- Orebody 29/30/35 BWT MS963
- Orebody 29/30/35 Proposed Pit Expansion
- Whaleback Pit

Western Ridge Deposits

- Bill's Hill
- Eastern Syncline
- Mount Helen
- Silver Knight

N

0 2 4 6 8

KILOMETRES

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Conceptual groundwater system - operations

PLANNING & STANDARDS - IRON ORE

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5 2024 Orebody 29/30/35 mine groundwater modelling

The numerical groundwater model used to predict the impacts of the 2023 long-term mine (and dewatering) plan at the Orebody 29/30/35 mine (and updated 2024 mine plan) is described in the *Orebody 29, 30 and 35 Detailed Hydrogeological Assessment* (Appendix A; BHP 2024c). The groundwater model is based on the same model used to support the assessment of the Western Ridge proposal in 2022 and includes Western Ridge and Orebody 29/30/35, as Western Ridge is adjacent to Orebody 29/30/35 and the OB29, OB30, OB35 deposits are hosted in the same aquifer (Marra Mamba Formation) as some of the Western Ridge deposits (Eastern Syncline and Silver Knight). The model domain extends from the southwest of Western Ridge to northwest of OB29 (Figure 5).

5.1 Target mine pit dewatering depths

Figure 6 shows the target dewatering depths (groundwater levels) for the Orebody 29/30/35 proposal (initially to financial year (FY) 2056. To investigate mine plan variability, the 2024 mine plan considered extended Orebody 29/30/35 dewatering (longer dewatering period to FY65 and deeper target mine pit dewatering depths (Figure 6).

The proposed updated 2024 mine plan target dewatering depths are:

- OB29: 376 mAHD (36 m deeper than the original 412 mAHD target)
- OB30: 418 mAHD (12 m deeper than the original 430 mAHD target)
- OB35: 424 mAHD (12 m deeper than the original 436 mAHD target).

As discussed in Section 4.1.1, the pre-development groundwater levels varied between 519 and 526 mAHD. Therefore the maximum target dewatering depth (at OB29) is 143 to 150 m below pre-development groundwater levels. The target dewatering depths are used as an input for the groundwater modelling.

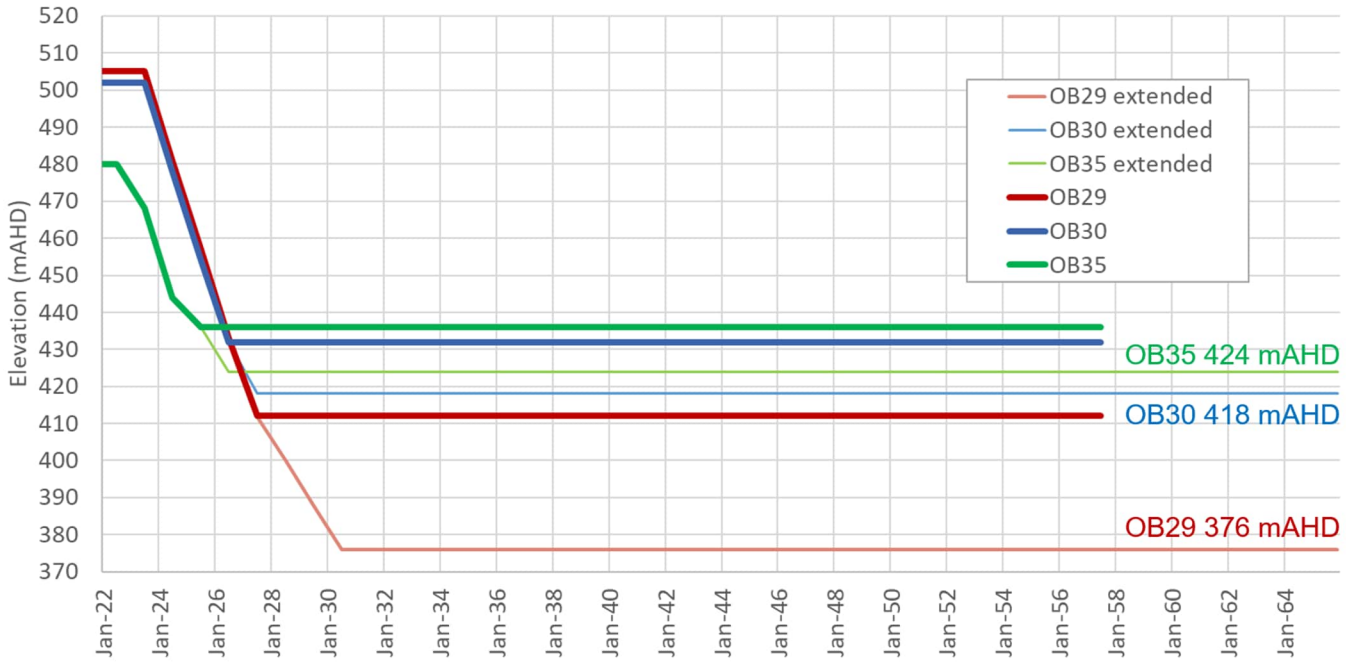

Figure 6: Target Orebody 29/30/35 mine pit groundwater levels

5.2 Model updates

The model updates were centred around:

- adding the local scale modifications to the north of OB29 from PFAS modelling in that area
- adjusting parameter values to improve the fit between simulated and observed groundwater levels (given that a year had passed since the last model calibration) (BHP 2024c).

The updated model was calibrated against the observed groundwater levels from January 2015 onwards. This is referred to as the 'base case' model.

5.3 Uncertainty analysis

An uncertainty analysis was undertaken with the calibrated model (the base case) to determine whether model outputs were sensitive to the following changes in the model. Four uncertainties scenarios were considered:

1. Drains uncertainty: using drains instead of wells in the Modflow numerical model
2. Conceptual uncertainty: moving the dolomite north of OB30 to the south and adding a structure connecting OB30 to the south of OB29
3. History match uncertainty: lower hydraulic connection across the two leaky flow barriers and higher storage close to the OB29 orebody
4. Mine plan uncertainty: varying the target dewatering rate – using 12 m/yr rather than the planned maximum 24 m/yr.

While some uncertainty remains, analysis of the outputs of the four runs showed that this uncertainty does not fundamentally change the predictive outcomes. The highest uncertainty was associated with the dewatering rate (BHP 2024c).

5.4 Predicted combined groundwater abstraction rates and drawdown

The model outputs represent the predicted combined effects of groundwater abstraction and drawdown for the Approved Proposal and the change for the Orebody 29/30/35 mine (the Proposal).

The predictive version of the model was run (for the base case and the four uncertainty scenarios) for 34 years from Financial Year (FY) 2022 to FY2056 to assess the impacts of dewatering, specifically to:

- predict the likely dewatering rates required to achieve the Orebody 29/30/35 target groundwater levels for a target dewatering rate of 24 m/yr (Figure 6)
- predict the vertical and lateral extent of drawdown as a result of the dewatering.

While the model domain includes the Western Ridge orebodies and conceptualisation, the model runs included dewatering from Orebody 29/30/35 only (as shown in Figure 6), i.e. they did not include dewatering from Western Ridge.

Figure 7a shows the predicted dewatering rates for the base case and the four uncertainty runs. The peak total dewatering rate for the Orebody 29/30/35 mine (total for all deposits) ranges between 44 ML/d (12 m/yr target dewatering rate uncertainty) and 66 ML/d (History match uncertainty).

The base case and history match uncertainty models were run with dewatering extended to FY2065 (an additional 9 years, 53 years total). Figure 7b shows the predicted dewatering rates for the extended dewatering runs. In both cases, the maximum dewatering rate increases compared to the FY56 outputs; up to 66 ML/d (in the base case and 67 ML/d in the history match uncertainty.

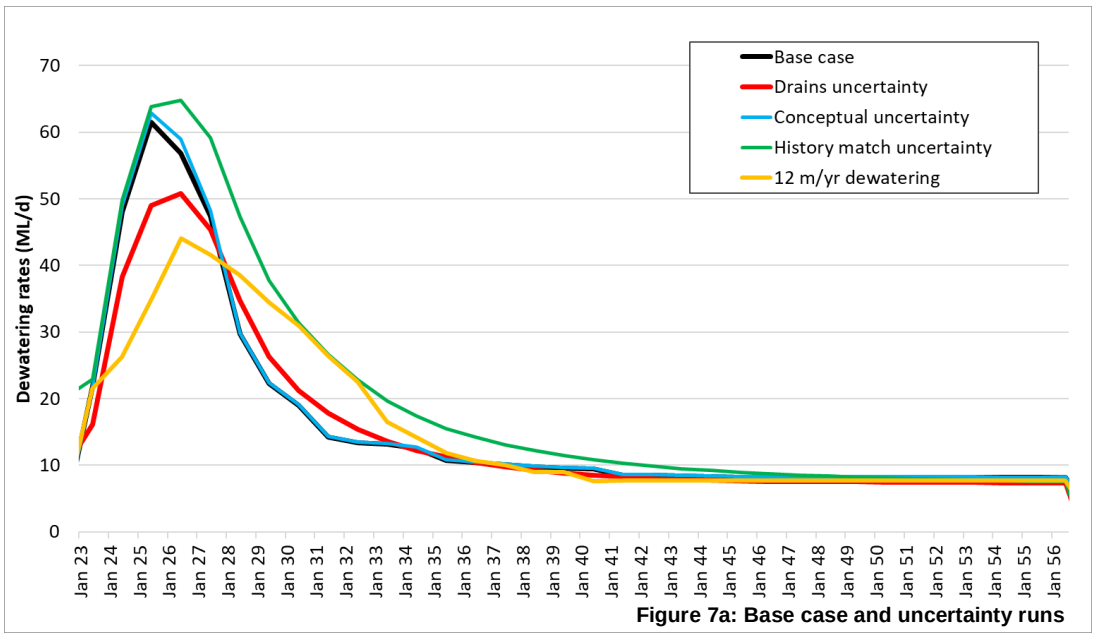

Figure 7a: Base case and uncertainty runs

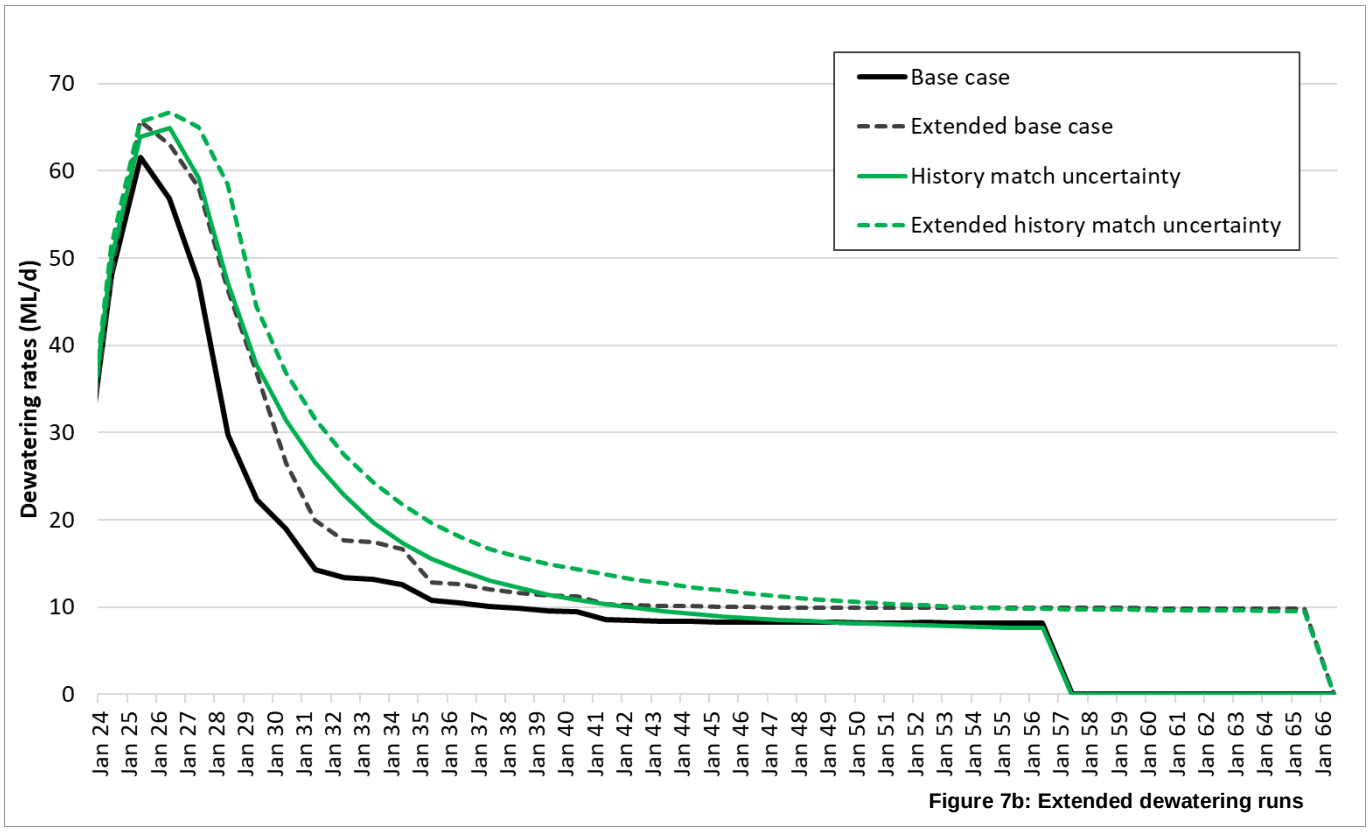

Figure 7b: Extended dewatering runs

Figure 7: Predicted Orebody 29/30/35 mine dewatering rates

Figure 8 shows the predicted drawdown at the end of the extended model simulation (FY2065) to achieve the target pit groundwater levels shown in Figure 6 for the base case (Figure 8a) and the run that predicts the highest dewatering rate (History match uncertainty) (Figure 8b). While there are some local differences in the model results between the two runs (e.g. base case over predicts drawdown at OB29 and history match uncertainty case has higher drawdown along the leaky flow barrier), the predicted drawdown at the model boundaries is similar.

The groundwater model predicts that at the end of dewatering (2065), the dewatering will result in a maximum vertical drawdown of up to approximately 80 m at the northern boundary of the model domain in the regional aquifer north of OB29, 80-90 m at the eastern boundary, and less than 2 m at the southern and western boundaries, compared to pre-development groundwater levels. Potential changes in groundwater levels for the combined Orebody 29/30/35 groundwater abstraction (the existing mine and the Proposal) and the Orebody 29/30/35 Proposal only are discussed in Sections 6.2 and 6.3 respectively.

Drawdown resulting from dewatering is likely to be contained within the aquifers by the low permeability Mt McRae and Mt Sylvia formations to the north, and by the low permeability Jeerinah Formation to the south. Drawdown is likely to be constrained by the Whaleback Fault west of Western Ridge (Figure 8). Drawdown will extend past the leaky flow barrier east of OB29. However, this drawdown is unlikely to go beyond the leaky flow barrier that cuts through the regional aquifer south of OB25 (BHP 2024c), because the drawdown lessens further to the east and the recharge from Ophthalmia Dam / storage of the aquifer increases. Potential changes to groundwater levels to the east, including in the Ethel Gorge aquifer compartment, are discussed in Section 6.4.

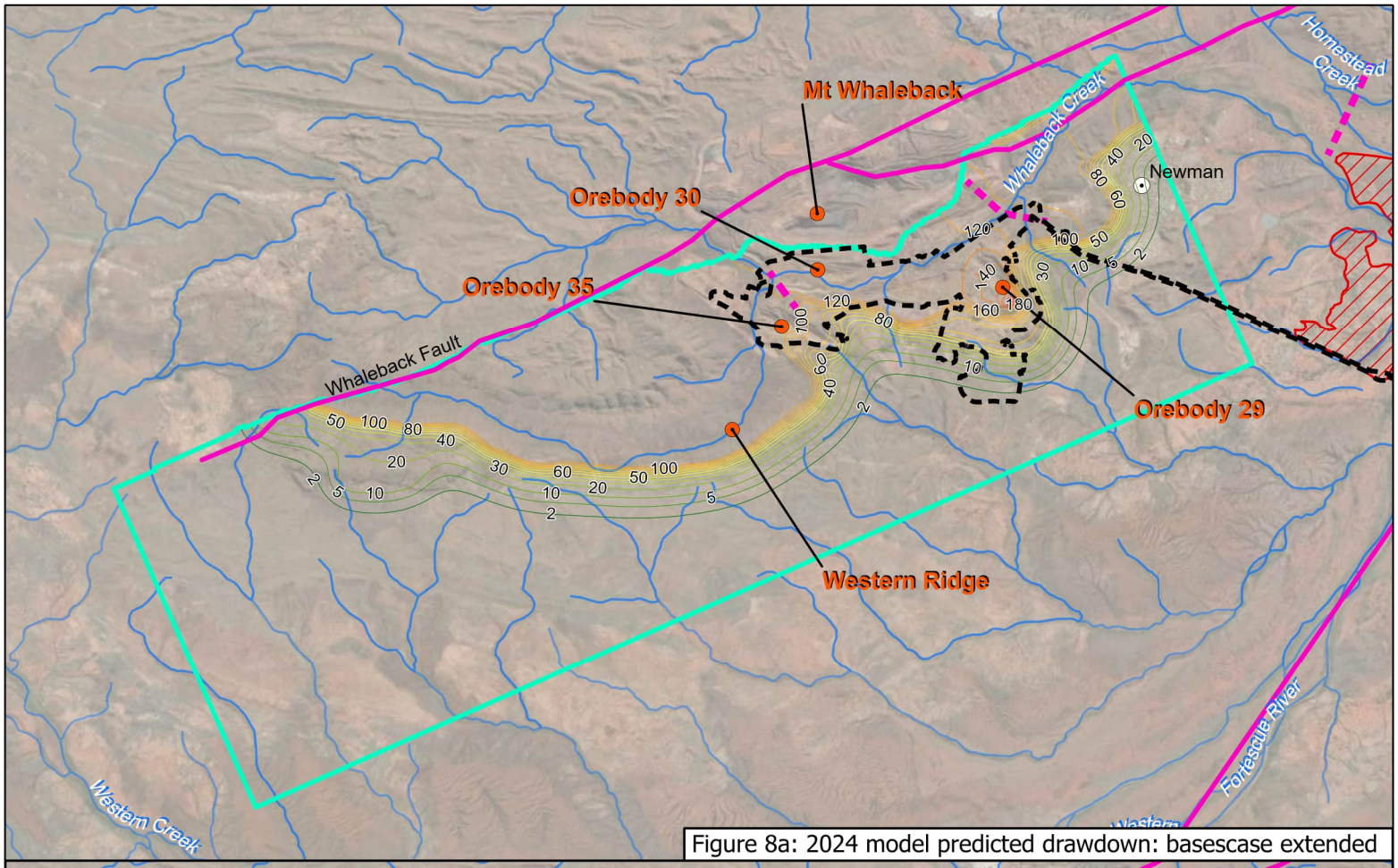

Figure 8a: 2024 model predicted drawdown: basescase extended

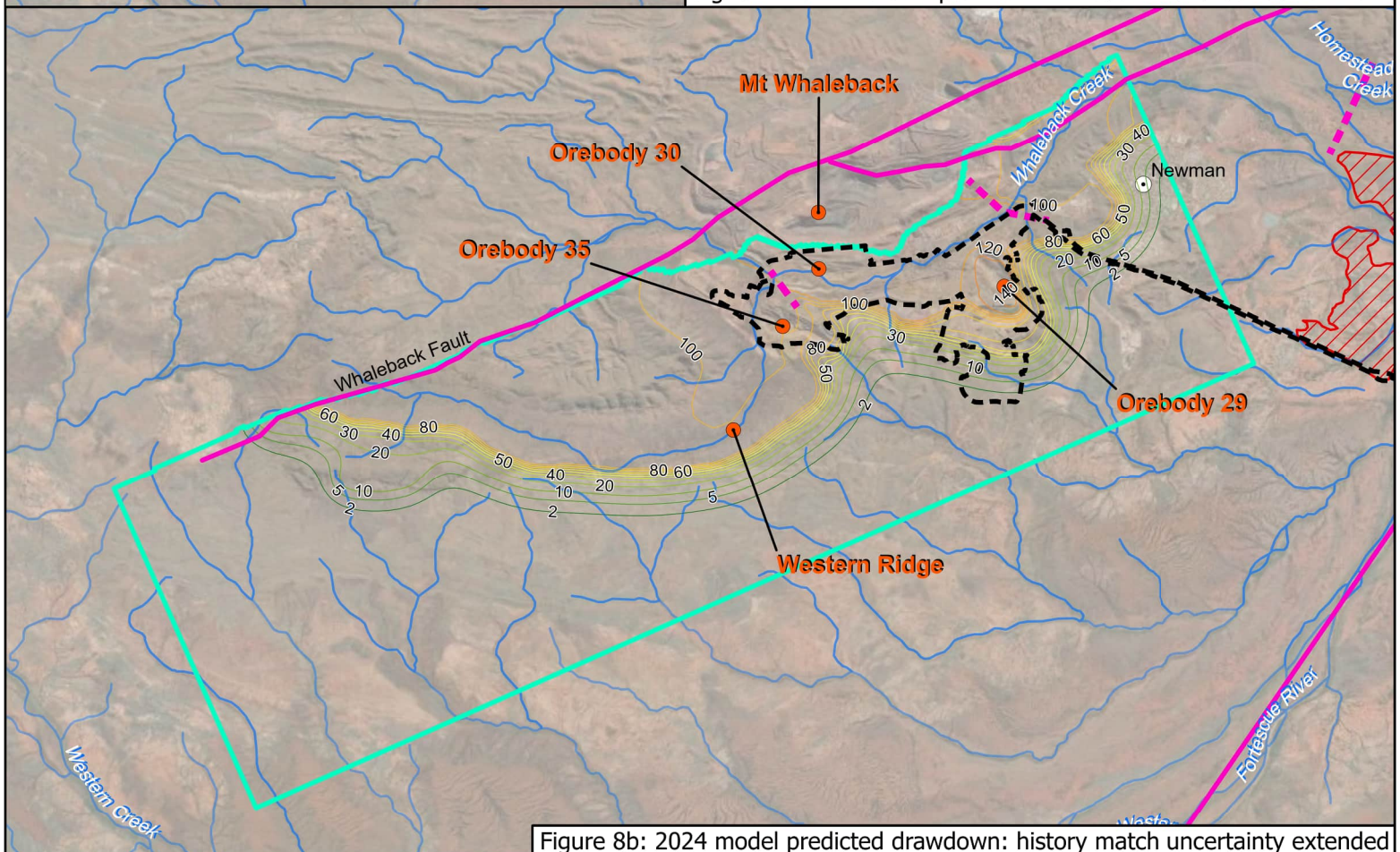

Figure 8b: 2024 model predicted drawdown: history match uncertainty extended

BHP operations
Development Envelope
Ethel Gorge TEC
Leaky Flow Barrier
Waterways
Flow Barrier
Model domain

Predicted Drawdown (m)

1
2
5
10
20
30
40
50
60
80
100
120
140
160
180

N

0 1 2 3 4 5
KILOMETRES

GDA 1994 MGA ZONE 50

BHP

PUBLIC

OREBODY 29/30/35
SIGNIFICANT AMENDMENT
Predicted combined Orebody 29/30/35 mine drawdown at 2065
PLANNING & STANDARDS - IRON ORE

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5.5 Post-mining water level recovery

The recovery of post-mining groundwater levels was modelled using the predictive post-mining closure version of the model for the base case scenario. The model was run (in early 2024) for 600 years for the following two closure scenarios:

1. Backfill: assumes all pit voids are backfilled (to above the pre-development groundwater level) with similar material that was mined out.
2. Partial backfill: assumes that the OB35 void is backfilled and the OB29 and OB30 pit voids are not backfilled.

For the backfill scenario, groundwater levels are predicted to recover to approximately 522 mAHD (i.e. pre-development level) approximately 219 years after dewatering ceases.

For the partial backfill scenario (voids remain in OB29 and OB30), the water levels in the voids are predicted to rise to between 476 and 480 mAHD in OB29, and 480 and 483 mAHD in OB30, forming pit lakes. The system is predicted to reach this equilibrium approximately 144 years after dewatering ceases (BHP 2024c). As the equilibrium pit lake water levels will be lower than the pre-development groundwater level, the pit voids would remain groundwater sinks (Figure 9).

As the closure strategy evolves, the backfill strategy may change. Depending on which pits are backfilled or left as open voids, the predicted time to reach equilibrium and the equilibrium water levels may change, however, pit lake water levels at equilibrium will be lower than the pre-development groundwater level and the pit voids would remain groundwater sinks.

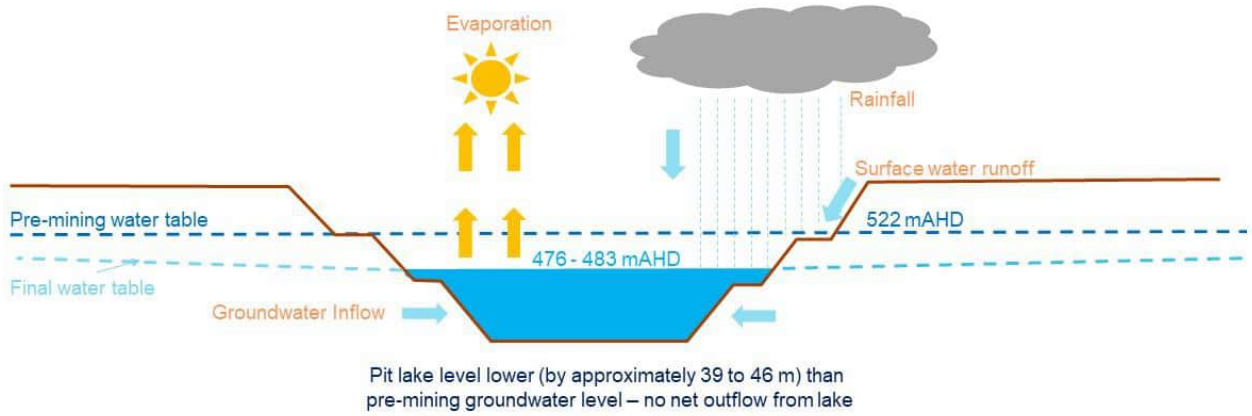


Figure 9: Conceptual pit lake diagram – sink

6 Groundwater abstraction and drawdown assessment

The 2024 Orebody 29/30/35 modelling includes predicted groundwater abstraction and drawdown from the Combined Proposal (Approved Proposal and Proposal). It is necessary to understand the previously assessed abstraction and drawdown for the Orebody 29/30/35 mine, to determine the predicted change in the groundwater regime for the Proposal (i.e. from the increase in groundwater abstraction for dewatering). The results from previous groundwater assessments and the results from the 2024 Orebody 29/30/35 numerical modelling were used to quantify the changes in the Orebody 29/30/35 mine groundwater abstraction and drawdown for the Proposal. Section 6.4 provides a summary table (Table 1) of the key groundwater information used for the analysis and outputs from the modelling and assessment discussed below.

6.1 Approved Proposal: Assessed abstraction and drawdown

Groundwater abstraction for the Approved Proposal was assessed under Part IV of the EP Act in 2013. As discussed in *OB29/30/35 Below Water Table Mining Environmental Referral Supporting Information Document* (Orebody 29/30/35 ERD) (BHP Billiton 2013), the proposed dewatering depths were as follows:

- OB29: up to 90 metres BWT (435 metres reduced level (mRL) equivalent to 432 mAHD)
- OB30: up to 60 metres BWT (465 mRL equivalent to 462 mAHD)
- OB35: up to 70 metres BWT (455 mRL equivalent to 452 mAHD)

While the dewatering depths were based on a groundwater level of 525 mRL (522 mAHD), BHP Billiton noted in the Orebody 29/30/35 ERD that the groundwater level at OB29 and OB30 ranged between 517 and 525 mRL (514 and 522 mAHD). The key characteristics of the proposal included mine dewatering on average between 2 and 5 GL/a (equivalent to between 5.5 ML/d and 14 ML/d), with periodic peaks of up to 8 GL/a (22 ML/d) (BHP Billiton 2013). Figure 10a shows the predicted drawdown assessed for the Approved Proposal.

6.2 Combined Proposal: 2024 predicted groundwater abstraction and drawdown

As discussed in Section 5.4, the 2024 Orebody 29/30/35 groundwater modelling for the Combined Proposal predicts a peak dewatering rate of between 44 and 67 ML/d for the Orebody 29/30/35 mine from the various runs. To be conservative, BHP has assumed that a combined peak dewatering rate of up to 67 ML/d (will be required and has evaluated the potential impact based on this. The selection of the run representing the highest dewatering rate (History match uncertainty) provides a higher level of confidence that dewatering volumes from the Orebody 29/30/35 mine will be within the predicted range.

Figure 10b shows the predicted drawdown at the end of dewatering (2065) for the Combined Proposal for the extended History Match uncertainty run (reproduced from Figure 8b). Drawdown in the orebody aquifer at the end of dewatering is predicted to reach a maximum of 140 m at OB29 (386 mAHD). As discussed in Section 5.4, the predicted drawdown in the regional aquifer to the southern and western boundaries of the model domain reduces to less than 2 m (approximately 520 mAHD), but is predicted to be up to approximately 80 m (approximately 442 mAHD) at the northern boundary and up to 80-90 m (approximately 442-432 mAHD) at the eastern boundary.

6.3 Proposal: Change in predicted groundwater abstraction and drawdown

6.3.1 Change in groundwater abstraction (dewatering)

The 2024 predicted combined Orebody 29/30/35 peak dewatering rate of 67 ML/d represents an increase of 45.1 ML/d (16.5 GL/a) compared to the 2013 Part IV groundwater abstraction rate of 8 GL/a (21.9 ML/d) for the Orebody 29/30/35 Approved Proposal, authorised in 2014 under MS963.

Therefore the proposed change for the Proposal is an increase in abstraction for dewatering of up to 45.1 ML/d (16.5 GL/a).

6.3.2 Change in drawdown

Drawdown for the Approved Proposal was assessed in 2013 (RPS Aquaterra 2013). Compared to the 2013 predicted drawdown for the Orebody 29/30/35 Approved Proposal (Figure 10a), the 2024 modelling results (Figure 10b) show that the predicted lateral extent of drawdown is similar to the north, east and south, but extends approximately 6 km further to the west. This is because since the 2013 Orebody 29/30/35 modelling, there is now data in the Western Ridge area which indicates that the regional aquifer in the Western Ridge area is connected to the OB35 area and bound by the Whaleback Fault in the north and west and the Jeerinah Formation to the south. Drawdown in the orebody aquifer at the end of dewatering is predicted to be greater by up to 60 m (maximum vertical drawdown of 140 m for the Proposal compared to 80 m for the Approved Proposal). The predicted drawdown for the Proposal compared to the Approved Proposal in the regional aquifer is similar in the south (1-2 m), but is deeper to the west, north and east within the 2024 model domain by up to approximately 80 m.

Since the Orebody 29/30/35 BWT mine was approved in 2014, increased groundwater abstraction from Orebody 29/30/35 was assessed in 2022 as part of the Western Ridge Approved Proposal, authorised by MS1105 (EP Act s45B Notice: Statement 1105 – No 2, September 2023). As discussed in *Newman Hub (Western Ridge) Derived Proposal Request Ministerial Statement 1105* (Western Ridge ERD) (BHP 2023), the 2022 groundwater modelling included planned increased dewatering at the existing Orebody 29/30/35 BWT mine (to allow for future deeper mining), due to the proximity of the Orebody 29/30/35 BWT mine to Western Ridge and as the OB29, OB30, OB35 deposits are hosted in the same aquifer (Marra Mamba Formation) as some of the Western Ridge deposits (Eastern Syncline and Silver Knight). The target Orebody 29/30/35 dewatering depths used in the 2022 Western Ridge modelling were deeper for OB29 (approximately 310 m) and OB30 (300 m) and slightly shallower at OB35 (440 m) compared to the target dewatering depths for the 2024 Orebody 29/30/35 mine plan and modelling.

The model scenario used for the Western Ridge drawdown assessment predicted a peak dewatering rate of 61 ML/d for the Orebody 29/30/35 mine (peak of 65 ML/d for Western Ridge and Orebody 29/30/35 dewatering) (BHP 2022a), which is similar to the peak dewatering rate predicted from the 2024 modelling for Orebody 29/30/35 only (67 ML/d in the history match uncertainty). Compared to the predicted drawdown for the Western Ridge Approved Proposal (Western Ridge and Orebody 29/30/35 dewatering) (Figure 10c), the 2024 modelling results for Orebody 29/30/35 only (Figure 10b) show that the predicted lateral extent of drawdown for the Combined Proposal is slightly less than the drawdown extent assessed for the Western Ridge Approved Proposal.

The predicted vertical drawdown in the orebody aquifer (140 m) for the 2024 Orebody 29/30/35 dewatering (Combined Proposal) (Figure 10b) is less than the predicted drawdown (215 m) for the 2022 Western Ridge and Orebody 29/30/35 dewatering (Figure 10c) due to the shallower target dewatering depths for the 2024 Orebody 29/30/35 mine plan. The predicted vertical drawdown in the regional aquifer for the 2024 Orebody 29/30/35 (Combined Proposal) dewatering is similar to the predicted drawdown for the 2022 Western Ridge and Orebody 29/30/35 dewatering at the southern, western and most of the eastern boundaries of the model domain. Drawdown is less in the vicinity of Western Ridge, as the 2024 Orebody 29/30/35 modelling does not include dewatering from Western Ridge (see Section 5.4). Predicted drawdown is up to 70 m deeper for the Combined Proposal dewatering close to the northern boundary of the model domain north and east of OB35. This is likely due to changes made to the groundwater model in this area (increased the hydraulic conductivity of the Mt Sylvia / Mt McRae Shale Formations), to support a groundwater modelling mixing assessment for Per - and Poly-fluoroalkyl Substances (PFAS).

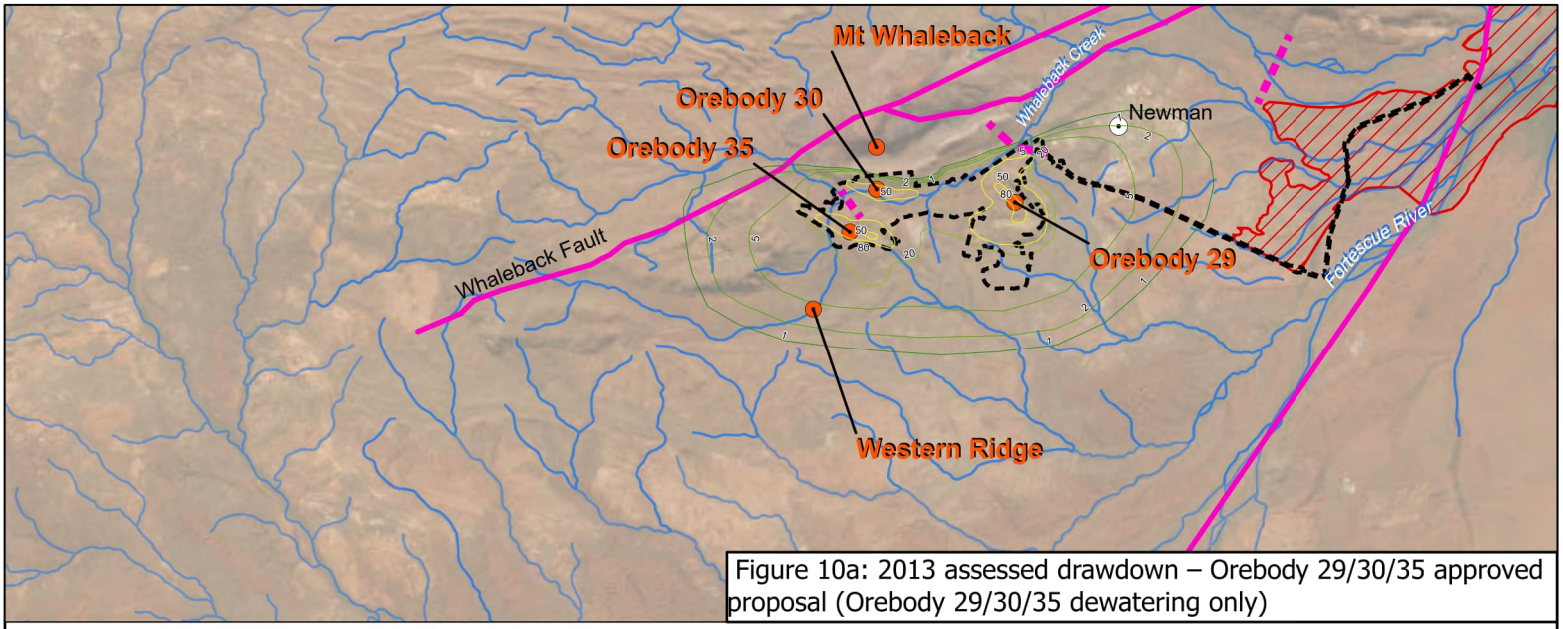


Figure 10a: 2013 assessed drawdown – Orebody 29/30/35 approved proposal (Orebody 29/30/35 dewatering only)

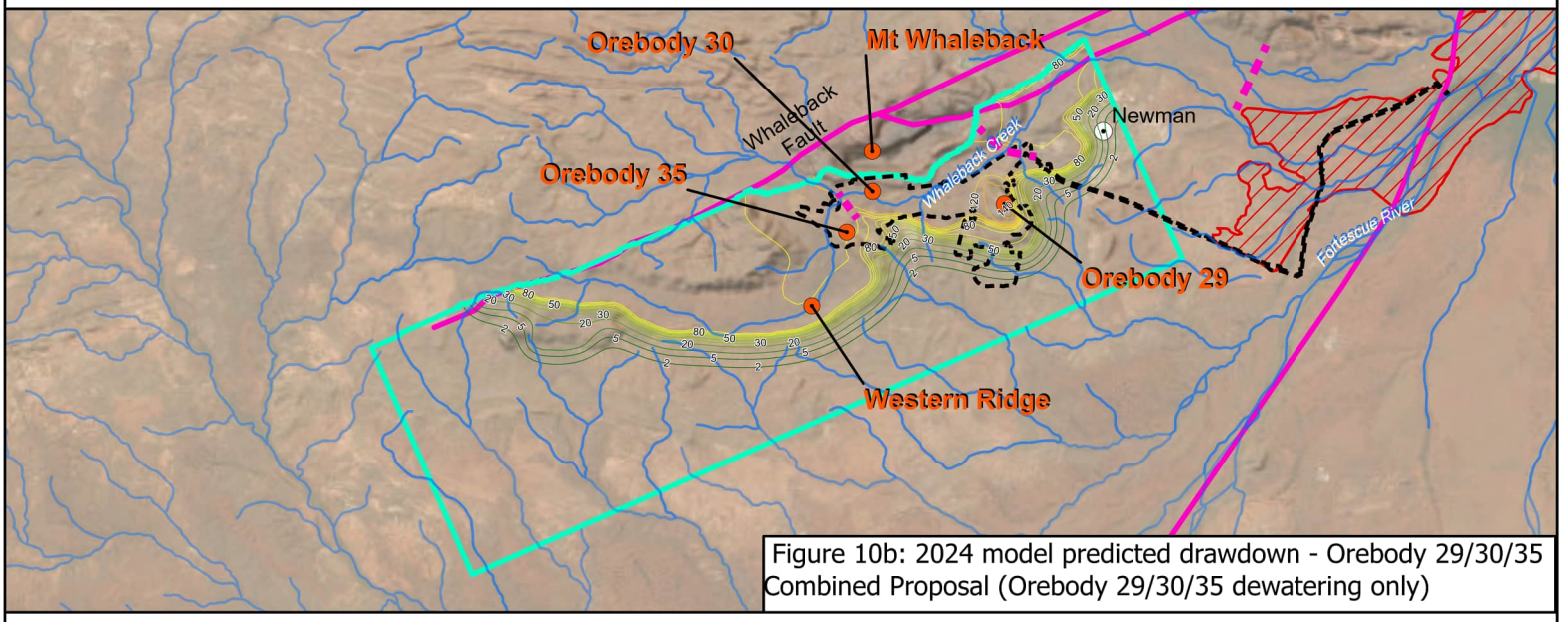


Figure 10b: 2024 model predicted drawdown - Orebody 29/30/35 Combined Proposal (Orebody 29/30/35 dewatering only)

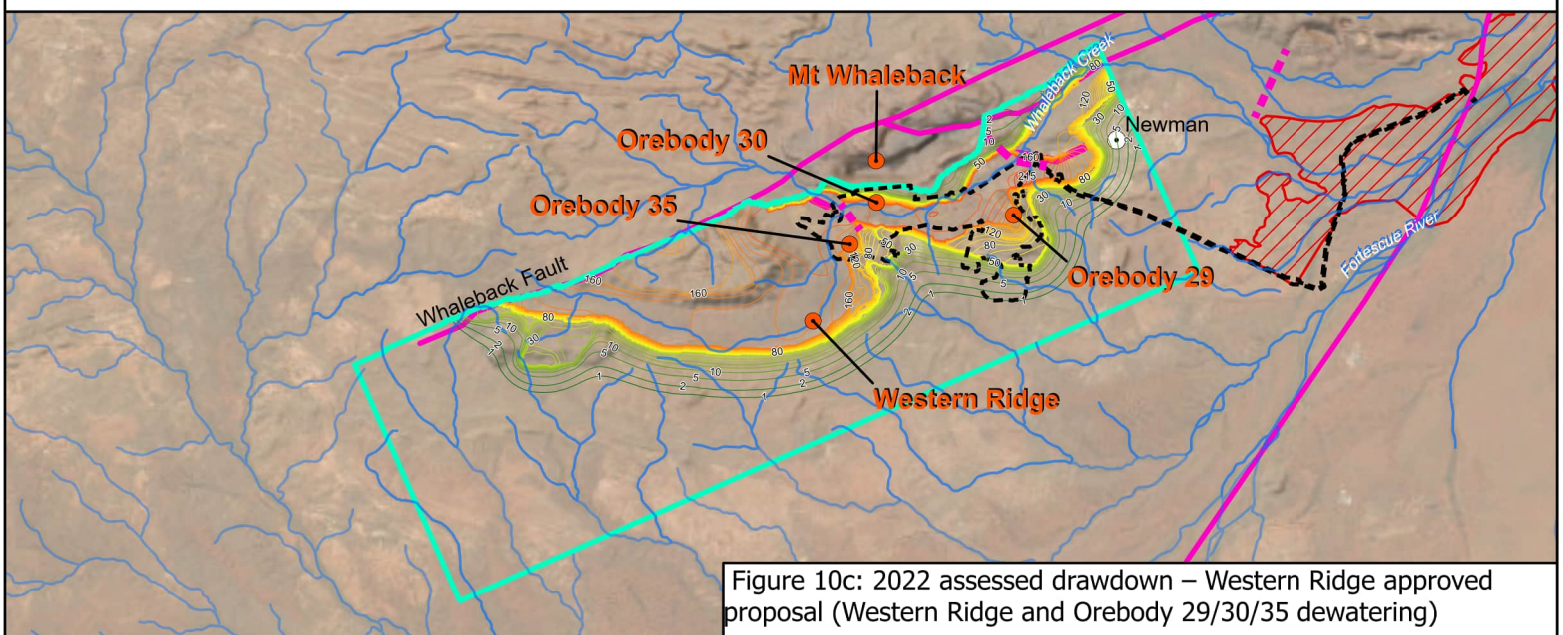


Figure 10c: 2022 assessed drawdown – Western Ridge approved proposal (Western Ridge and Orebody 29/30/35 dewatering)

- Locality
- BHP operations
- Model domain
- Leaky Flow Barrier
- Flow Barrier
- Waterways
- Development Envelope
- Ethel Gorge TEC

Predicted drawdown (m)

1, 2, 5, 10, 20, 30, 40, 50, 60, 80, 100, 120, 140, 160, 180, 200, 215

N

0 2 4 6 8 10
KILOMETRES

GDA 1994 MGA ZONE 50

BHP

PUBLIC

OREBODY 29/30/35 SIGNIFICANT AMENDMENT

Assessed and predicted drawdown for the Orebody 29/30/35 mine

PLANNING & STANDARDS - IRON ORE

SCALE @ A4: 1:225,000
PREPARED: GEOMATICS
DATE: 27/11/2024
REQUESTOR: ENV. APPROVALS
REVIEWED:
FIGURE: 10
NO: 929/064_RevK

Document Path: Y:\Jobs\A501_A1000\A929\3Project\A929_064_E_OB29_30_35_Assessed&PredictedDrawdown.aprx

6.4 Groundwater information summary

Table 1 provides a summary of the key groundwater information used for the analysis and results from the modelling and assessment. Table 1 summarises the changes from the 2024 groundwater modelling compared to the Approved Proposal (2013) assessment. As discussed in Section 6.3.2, increased groundwater abstraction from Orebody 29/30/35 was assessed as part of the Western Ridge Derived Proposal, which was approved in 2023.

Table 1: Groundwater information summary

Groundwater element	Pre-development (pre OB29/30/35 mining)	Current (2024)	Approved Proposal (Existing mine)	Combined Proposal (Approved Proposal and Proposal)	Proposal (Significant Amendment)
OB29/30/35 mine area groundwater level and depth					
Groundwater level (mAHD)	519 - 526	~490			
Depth to groundwater (mbgl)	30 - 50	>70 - 90			
Target mine pit dewatering depth (input to groundwater modelling)					
OB29 (mAHD)			432	376	56 m deeper
OB30 (mAHD)			462	418	44 m deeper
OB35 (mAHD)			452	424	28 m deeper
Predicted peak dewatering rate					
Peak rate (ML/d)			21.9	67	45.1 ML/d increase
Peak rate (GL/a)			8	24.5	16.5 GL/a increase
Predicted drawdown extent at end of dewatering					
Maximum vertical drawdown in orebody aquifer (m)			80 (Figure 10a)	140 (Figure 10b)	60 m increase
Lateral drawdown extent in regional aquifer			Figure 10a	Figure 10b	~6 km further west (similar to the north, east and south)
Predicted post-mining water level recovery					
Backfill scenario: Groundwater level (mAHD) Years to recovery			Not quantified	 522 (i.e. pre-development) 219 years	
Partial backfill scenario: Pit lake level (mAHD) Years to equilibrium			Not quantified	 476 – 483 144 years	

6.5 Cumulative drawdown

As discussed in Section 3, Orebody 29/30/35 is located in the Newman Hub where there are existing approved groundwater abstraction activities (for water supply from the Ophthalmia and Homestead borefields and for mine dewatering at Whaleback, Orebody 29/30/35 and Eastern Ridge) and the Ophthalmia Dam MAR system. The conceptual hydrological model and monitoring data indicates that there is no direct connection between Orebody 29/30/35 and Western Ridge (which are part of the same aquifer compartment), and the other operations (Whaleback and Eastern Ridge mines, and Ophthalmia and Homestead borefields) (BHP 2022b). However, the drawdown from Eastern Ridge (including from OB32), Western Ridge and Orebody 29/30/35 is predicted to overlap in the lower transmissivity area (shown in Figure 1Figure 5). Therefore, to understand the cumulative drawdown BHP has considered the predicted drawdown from Orebody 29/30/35 in the context of assessed drawdown for the Orebody 29/30/35, Western Ridge and Eastern Ridge (including OB32 BWT) approved proposals (which considered the impacts of water supply abstraction, where relevant). Figure 11 shows the following:

- 2013 Orebody 29/30/35 1 m drawdown contour (green solid line): represents the assessed drawdown extent for the Orebody 29/30/35 Approved Proposal (from Figure 10a)
- 2022 Western Ridge and Orebody 29/30/35 1 m drawdown contour (orange dashed line): represents the estimated maximum lateral extent of the predicted drawdown from the 2022 Western Ridge and Orebody 29/30/35 dewatering assessment for the Western Ridge Approved Proposal
- 2022 Cumulative Eastern Ridge 2 m drawdown contour (purple dashed line): represents the estimated maximum lateral extent of the cumulative effect of assessed drawdown for the Eastern Ridge approved proposals
- 2024 Orebody 29/30/35 1 m drawdown contour (red dotted line): represents the estimated maximum lateral extent of the predicted drawdown from the 2024 Orebody 29/30/35 dewatering assessment (Combined Proposal)
- 2024 additional OB29/30/35 drawdown extent: represents the predicted drawdown extent from the Proposal in addition to the assessed drawdown for the Orebody 29/30/35 Approved Proposal.

Within the model domain the area of drawdown is as predicted by the model. The numerical model domain does not extend to the east to the Ethel Gorge TEC. The regional aquifer is however continuous between the edge of the eastern model boundary to the Ethel Gorge TEC. The potential for drawdown from Orebody 29/30/35 to reach the Ethel Gorge TEC was extrapolated from both the predicted drawdown from Orebody 29/30/35 at the model boundary (as shown in Figure 10b), and monitoring and drilling data the area between the model boundary and the TEC.

The migration of drawdown towards the Ethel Gorge TEC will be controlled by three main factors:

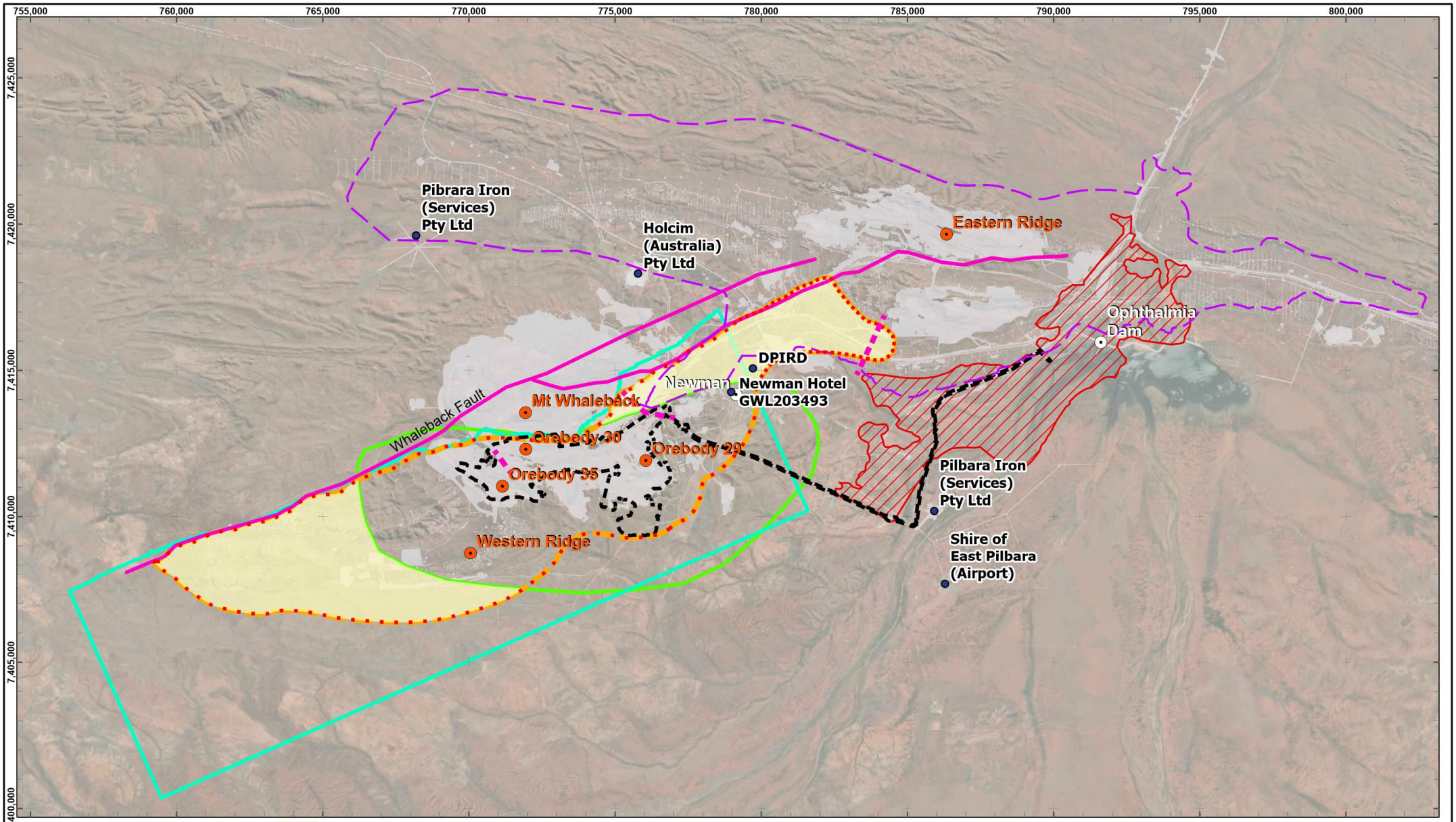
- the transmissivity of the aquifer between OB29 and the Ethel Gorge TEC, which monitoring strongly suggests is moderate to low
- the presence of at least one leaky flow barrier along the flow path (located to the south of OB25)
- the buffering effect of the Ophthalmia Dam MAR system, which will continue to capture surface water flows from the creeks that flow into it and the surplus water discharge from BHP's eastern mines.

An estimate of the final lateral extent of drawdown from Orebody 29/30/35, based on all of the above, is shown in Figure 11 (as the 2024 Orebody 29/30/35 1 m drawdown contour). As for the 2022 Western Ridge dewatering assessment (BHP 2022b), the results of the modelling, together with the drawdown controls above, indicate that the drawdown from the combined dewatering of Orebody 29/30/35 (Combined Proposal) will not extend further east than the leaky flow barrier located south of OB25 and will not reach the Ethel Gorge TEC, located approximately 15 km northeast of the Orebody 29/30/35 aquifer system, and will not increase the drawdown footprint associated with Eastern Ridge. The Ethel Gorge TEC and the Newman water supply borefields (Ophthalmia and Homestead) are located outside of the estimated groundwater drawdown extent of the proposed Orebody 29/30/35 dewatering and therefore are unlikely to be impacted by drawdown.

The identified third party groundwater users are unlikely to be impacted by abstraction from the Orebody 29/30/35 mine (Combined Proposal) as they are either on the boundary or outside the predicted drawdown extent. BHP will provide a monitoring strategy as part of the *Rights in Water and Irrigation Act 1914* (RiWI Act) s5C Licence to Take Water Groundwater Operating Strategy and will engage with relevant third party groundwater users if they may be significantly affected (BHP 2024c).

The predicted lateral extent of drawdown for the 2024 Orebody 29/30/35 assessment (red dotted line on Figure 11) extends to the south-west and north-west compared to the assessed drawdown extent for the Orebody 29/30/35 Approved Proposal (2013 Orebody 29/30/35 1 m drawdown contour (green solid line)). This is represented as the 2024 Additional Orebody 29/30/35 drawdown extent (yellow fill).

However, as shown on Figure 11, the predicted lateral extent of drawdown for the 2024 Orebody 29/30/35 assessment for the Combined Proposal is the same as the predicted drawdown extent for the 2022 assessment for the Western Ridge Approved Proposal (orange dashed line). There is no predicted additional lateral drawdown extent from the Proposal in addition to the assessed drawdown for the above approved proposals. This is because the drawdown at the eastern boundary is roughly the same with or without Western Ridge dewatering, as OB29 dewatering has the greatest control on the drawdown in that location (BHP 2024c). Therefore, the impacts from drawdown in this additional area were considered for the Western Ridge Approved Proposal and the cumulative groundwater drawdown extent for the Newman area (shown in Figure 11) is the same as for the Western Ridge Approved Proposal assessment (BHP 2022b).



- BHP operations
- Ethel Gorge TEC
- Model domain
- Development Envelope
- Flow Barrier
- Leaky Flow Barrier
- Indicative Cleared Area as at FY2023
- 2013 Orebody 29/30/35 1m Drawdown Contour
- 2022 Cumulative Eastern Ridge 2 m Drawdown Contour
- 2022 Western Ridge and Orebody 29/30/35 1m Drawdown Contour
- 2024 Orebody 29/30/35 1 m Drawdown Contour
- Third Party Water User
- 2024 Additional Orebody 29/30/35 Drawdown Extent

N

0 1 2 3 4 5

KILOMETRES

GDA 1994 MGA ZONE 50

BHP

PUBLIC

OREBODY 29/30/35 SIGNIFICANT AMENDMENT

Cumulative groundwater drawdown extent

PLANNING & STANDARDS - IRON ORE

SCALE @ A4:	1:175,000	PREPARED:	GEOMATICS	FIGURE:	11
DATE:	21/11/2024	REQUESTOR:	ENV. APPROVALS	NO:	A929/065_RevF
		REVIEWED:			

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7 Post-mining water level recovery assessment

7.1 Approved Proposal: Assessed post-mining water level

For the closure assessment for the Orebody 29/30/35 Approved Proposal, it was noted that the option of leaving pits as open voids at the completion of BWT mining would result in the development of pit lakes as groundwater levels recovered. The range of closure options considered for the Orebody 29/30/35 pits for the Orebody 29/30/35 Approved Proposal included (BHP Billiton 2013):

- in-filling (backfill) of pit voids to above the water table
- partial in-filling of pit voids, which would result in pit lakes forming but would reduce the pit lake surface area
- leaving the pits as fully open voids, which would result in pit lakes forming.

The 2013 Orebody 29/30/35 ERD (BHP Billiton 2013) and associated hydrogeological assessment report (ERD Appendix B; RPS Aquaterra) did not include a groundwater recovery assessment.

7.2 Combined Proposal: 2024 predicted combined post-mining water level recovery

As discussed in Section 5.5, the 2023 Orebody 29/30/35 groundwater modelling predicts for the backfill scenario that groundwater levels will recover to the pre-development groundwater level (522 mAHD) 219 years after dewatering ceases. For the partial backfill scenario (OB35 is backfilled), the pit lake levels in OB29 and OB30 are predicted to rise to between 476 and 480 mAHD in OB29, and 480 and 483 mAHD in OB30, and reach this equilibrium 144 years after dewatering ceases. The groundwater level at the backfilled OB35 will recover to the pre-development level (522 mAHD).

7.3 Proposal: Change in post-mining groundwater recovery predictions

As discussed in Section 7.1, the 2013 Orebody 29/30/35 assessment did not include a groundwater level recovery assessment, therefore BHP is not able to quantify the change in predicted groundwater level recovery from the Orebody 29/30/35 Proposal compared to the Orebody 29/30/35 Approved Proposal.

However, as discussed in Section 6.3, since the Orebody 29/30/35 BWT mine was approved in 2014, groundwater abstraction from Orebody 29/30/35 was assessed as part of the Western Ridge Approved Proposal in 2022. The model was run for 605 years for the following two closure scenarios (BHP 2022a):

1. Backfill: assumes all pit voids (Western Ridge and Orebody 29/30/35) are backfilled (to above the pre-development groundwater level). Groundwater levels were predicted to recover to the pre-development level (522 mRL) approximately 350 years after dewatering ceases.
2. No-backfill: no pit voids (Western Ridge and Orebody 29/30/35) are backfilled. Pit lakes are expected to form in all voids and equilibrium of the pit lake level is reached within approximately 150 years after dewatering ceases. The model predicted that water levels in the pit lakes would rise to approximately 405 mRL at OB29, and approximately 430 mRL at OB30 and OB35 (BHP 2022a).

For the backfill scenario, as discussed in Section 7.2, the 2024 Orebody 29/30/35 modelling predicts that groundwater levels at Orebody 29/30/35 will recover to the pre-development level after 219 years. Therefore, the 2024 Orebody 29/30/35 modelling predicts a faster groundwater level recovery than for the 2022 Western Ridge Approved Proposal (350 years).

As discussed in Section 7.2, the 2024 Orebody 29/30/35 modelling predicts for the partial backfill scenario that the pit lake levels at Orebody 29/30/35 will rise to between 476 and 480 mAHD in OB29, and 480 and 483 mAHD in OB30, and the groundwater level at the backfilled OB35 will recover to the pre-development level (522 mAHD).

Therefore, the 2024 Orebody 29/30/35 modelling predicts pit lake levels will reach equilibrium by a similar time (144 years) compared to the 2022 no-backfill scenario for the Western Ridge Approved Proposal (150 years) but will recover closer to the pre-development level.

Analysis of post-mining groundwater flow for the Western Ridge Approved Proposal (BHP 2022b) indicated that groundwater will flow east to west from the Ethel Gorge aquifer compartment to the Western Ridge, OB29 and OB30 voids in response to evapo-transpiration from the pit lakes. Most of the flow out of the Ethel Gorge aquifer compartment will be a result of the OB29 and OB30 pit voids, as they have a greater surface area than the Western Ridge pit voids and are closer to the Ethel Gorge aquifer. Post-mining groundwater flow out of the low transmissivity area of the Ethel Gorge aquifer compartment will be less than the groundwater flow out of the Ethel Gorge aquifer compartment during abstraction from the Ophthalmia Borefield (prior to dewatering of the OB23 and OB25 deposits at Eastern Ridge) (BHP 2022b).

Therefore, while the 2024 Orebody 29/30/35 partial backfill scenario is predicted to result in groundwater levels lower than pre-development levels within the groundwater model domain, with the continued operation of the Ophthalmia Dam system, groundwater levels in the Ethel Gorge aquifer would remain within historical levels.

8 References

BHP Billiton (2013) *OB29/30/35 Below Water Table Mining Environmental Referral Supporting Information Document*. 30 August 2013.

BHP (2022a) *Western Ridge and OB29/30/35 Detailed Hydrogeological Assessment*, November 2022. Appendix 16 to *Newman Hub (Western Ridge) Derived Proposal Request Ministerial Statement 1105*.

BHP (2022b) *Western Ridge: Groundwater impact assessment*, December 2022.

BHP (2023) *Newman Hub (Western Ridge) Derived Proposal Request Ministerial Statement 1105*, Version 1, 23 January 2023.

BHP (2024a) *Orebody 29/30/35 Significant Amendment: Environmental Review Document – referral supplementary report*. November 2024.

BHP (2024b) *Orebody 29/30/35: Ophthalmia Dam Surplus Water Impact Assessment*. November 2024.

BHP (2024c) *Orebody 29, 30 and 35 Detailed Hydrogeological Assessment*. May 2024.

RPS Aquaterra (2013) *Hydrogeological assessment of Orebodies 29, 30 & 35 for mining below water table approvals*, 24 July 2013. Appendix B to *OB29/30/35 Below Water Table Mining Environmental Referral Supporting Information Document* (BHP Billiton 2013).

Appendices

Appendix A Orebody 29, 30 and 35 Detailed Hydrogeological Assessment