Dubbo Quarry

Water Management Plan

Prepared for Holcim (Australia) Pty Limited

January 2024

Dubbo Quarry

Water Management Plan

Holcim (Australia) Pty Limited

E230410 RP1

January 2024

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Executive Summary

Holcim (Australia) Pty Limited (Holcim) own and operate the Dubbo Quarry (the quarry), located on Sheraton Road, Dubbo. The quarry produces high quality aggregates for use in the construction industry and has operated since 1980 under a development consent granted by Talbragar Shire Council and Environment Protection Licence No. 2212.

In 2019 Holcim prepared a State Significant Development (SSD 10417) application for the Dubbo Quarry Continuation Project (the Continuation Project), which involved continued operations in the existing quarry and the development of two new resource areas, the Western and Southern Extension Areas. The SSD application was approved by the Minister for Planning on 23 March 2023.

This report is a Water Management Plan that addresses the Conditions B35 (Discharge Characterisation Report) and B39 (Water Management Plan). It includes:

- a description of soil and water related consent conditions and the requirements of Conditions B35 and B39
- a description of the water cycle (surface water, groundwater and water quality) and the quarry's existing water management system
- a description of the water management approach for the Continuation Project and proposed water management measures
- a description of water inflow and discharge regimes from the quarry's water management system and a Discharge Characterisation Assessment
- monitoring, trigger action and reporting plans
- an approach to address water regulations.

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1 Introduction

1.1 Site background

Holcim (Australia) Pty Limited (Holcim) own and operate the Dubbo Quarry (the quarry), located on Sheraton Road, Dubbo. The quarry produces high quality aggregates for use in the construction industry and has operated since 1980 under a development consent (SPR79-22) granted by granted by Talbragar Shire Council and Environment Protection Licence (EPL) No. 2212 (the EPL).

In 2019 Holcim prepared a State Significant Development (SSD 10417) application for the Dubbo Quarry Continuation Project (the Continuation Project), which involved continued operations in the existing quarry and the development of two new resource areas, the Western Extension Area (WEA) and Southern Extension Area (SEA). The SSD application was approved by the Minister for Planning on 23 March 2023.

1.2 Water assessment background

A Water Assessment was prepared by EMM Consulting Pty Limited (EMM) in 2020 as part of the SSD application. The assessment was reviewed by the NSW Environment Protection Authority (EPA), the Department of Planning, Industry and Environment Water (DPIE Water) and the Natural Resource Access Regulator (NRAR) who provided submissions. Some of the issues raised in the submissions could not be reliably addressed via the EIS process due to limitations with the available data. The Water Assessment was revised during the Response to Submission process. The revised assessment is referred to as the Water Assessment Addendum Report (EMM 2022), revisions include an updated description of the water cycle, a water monitoring plan and a proposal to resolve certain issues via post approval studies and engineering design. This approach was accepted, and the consent includes the following conditions that require further assessments to be undertaken in consultation with NSW government agencies:

- **B33 Surface Water Diversion** – requires that drainage works are constructed to divert surface water runoff from upgradient catchments that currently drain into the East Pit around the East Pit into Eulomogo Creek. The proposed diversion works are referred to as the East Pit surface water diversion in this document.
- **B35 Water Discharge Management** – requires that a Discharge Characterisation Report is prepared in consultation with the EPA and DPE Water.
- **B36 Sediment Basins** – requires that the sedimentation basins proposed near the Eulomogo Creek crossing are designed in consultation with DPE Water.
- **B37 Eulomogo Creek Crossing** - requires that the design of the proposed Eulomogo Creek crossing is undertaken in consultation with DPE Water.
- **B39 Water Management Plan** – requires that a Water Management Plan (WMP) is prepared in consultation with EPA, DPE Water and Dubbo Council (formerly Talbragar Shire Council).

In December 2022, Holcim commenced the water monitoring program that was proposed in the Water Assessment Addendum Report (EMM 2022). The initial results have provided sufficient information to enable Conditions B35 and B39 to be addressed.

In June 2023, Holcim completed concept designs of several East Pit surface water diversion options. This study identified that the diversion may require works outside of the approved SSD disturbance area and that a consent modification would therefore be required. Following consultation, the Department of Planning and Environment (DPE) revised the timeframes for implementing the diversion, requiring that any consent modification is submitted by January 2024 and the diversion is constructed by June 2025.

1.3 Report purpose and structure

This Water Management Plan (WMP) addresses Condition B35 (Discharge Characterisation Report) and B39 (Water Management Plan). It includes:

- a description of soil and water related consent conditions and the requirements of Conditions B35 and B39 (Chapter 2)
- an updated description of the water cycle (surface water, groundwater and water quality) and the quarry's existing water management system (Chapter 3)
- a description of the water management approach for the Continuation Project and proposed water management measures (Chapter 4)
- a description of water inflow and discharge regimes from the quarry's water management system (Chapter 5)
- a monitoring, trigger and action and reporting plan (Chapter 6)
- an approach to address water regulations (Chapter 7)
- a summary of commitments (Chapter 8)

Some information in this report is provided to address Conditions B35 and B39 and is not relevant to the future implementation (ie day to day operation) of this WMP. The information in Chapters 4, 6 and 7 is relevant to the future implementation of this WMP.

1.4 Quarry stages

This WMP describes the quarry operation for the following stages:

- **Historic Operations** – refers to the operation prior to the commencement of the Continuation Project. Information on the historic operations is provided for context and to demonstrate the improvements that will be realised by the new water management approach that will be implemented as part of the Continuation Project.
- **Consent Transition Period** – refers to the period from commencement of development approved under the Continuation Project consent (SSD 10417) up to the surrender of the existing development consent (SPR79-22) granted by Talbragar Shire Council. The implementation of this WMP will commence at this stage.
- **Continuation Project** – refers to the operation of the Continuation Project after surrender of the existing consent (SPR79-22). The implementation of this WMP will continue for this stage.

Table 1.1 describes each quarry stage and the applicable timeframes. The layout of the Historic Operations and the Continuation Project is shown in Figure 1.1 and Figure 1.2 respectively. A potential alignment for the East Pit surface water diversion is shown in Figure 1.2.

It is noted that a rehabilitation plan for the Continuation Project is described separately in the Rehabilitation Management Plan (required by Condition B58).

Table 1.1 Quarry stages described in this WMP

Quarry stage	Description	Applicable timeframes
Historic Operations	This scenario is representative of operations prior to the commencement of the Continuation Project. It includes dewatering of the East Pit to maintain access for quarrying.	Up to the commencement of the Continuation Project
Consent Transition Period	This scenario is representative of the transition period from commencement of development approved under the Continuation Project consent (SSD 10417) up to the surrender of existing consent (SPR79-22). It includes: • continuation of activities approved under SPR79-22, including extraction and rehabilitation within the East Pit • development of the Western Extension Area	From the commencement of the Continuation Project to surrender of the existing consent (within 12 months of commencement of the Continuation Project or another timeframe approved by the Planning Secretary as per condition A15 of SSD 10417). The Continuation Project commenced in November 2023.
Continuation Project	This scenario is representative of the Continuation Project. It includes: • cessation of East Pit dewatering • development of the Western Extension Area • development of the Southern Extension Area • operation of the East Pit surface water diversion (which is required to be constructed by June 2025).	Post surrender of the existing consent (SPR79-22). Note, the East Pit surface water diversion may be constructed 6 to 12 months after the existing consent is surrendered.

1.5 Plan revision

This WMP will be updated and revised within 12 months following the commissioning of the East Pit surface water diversion (ie by June 2026). The updated plan will address Condition B35 (Discharge Characterisation Report) and B39 (Water Management Plan) and will be prepared in consultation with Council, the EPA and DPE Water. It will include updated modelling and will be informed by approximately 30 months of additional data, including:

- at least 15 months of data collected following the cessation of East Pit dewatering, which will occur during the Consent Transition Period (November 2023 to November 2024)
- approximately 9 months of data collected following the commissioning of the East Pit surface water diversion.

Source: EMM (2023); DFSI (2017); Metromap (2023)

KEY

- Pit boundary
- Surveyed site boundary
- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)

Site feature

1. East Pit Lake
2. West pit
3. Rehabilitation area
4. V-notch weir
5. Pump 1
6. East pit
7. Diesel store
8. Processing area
9. Stockpile area
10. Pug mill
11. Laydown area
12. Site office
13. Toilets
14. Truck parking
15. Culvert
16. Settling pond
17. Current site access
18. Transformer station
19. Jet patcher/ paveline loading facility
20. Bitumen emulsion plant
21. Spare part storage
22. Employees car park
23. Pre coat plant

Historic operations layout

Dubbo Quarry Continuation Project
Water management plan
Figure 1.1

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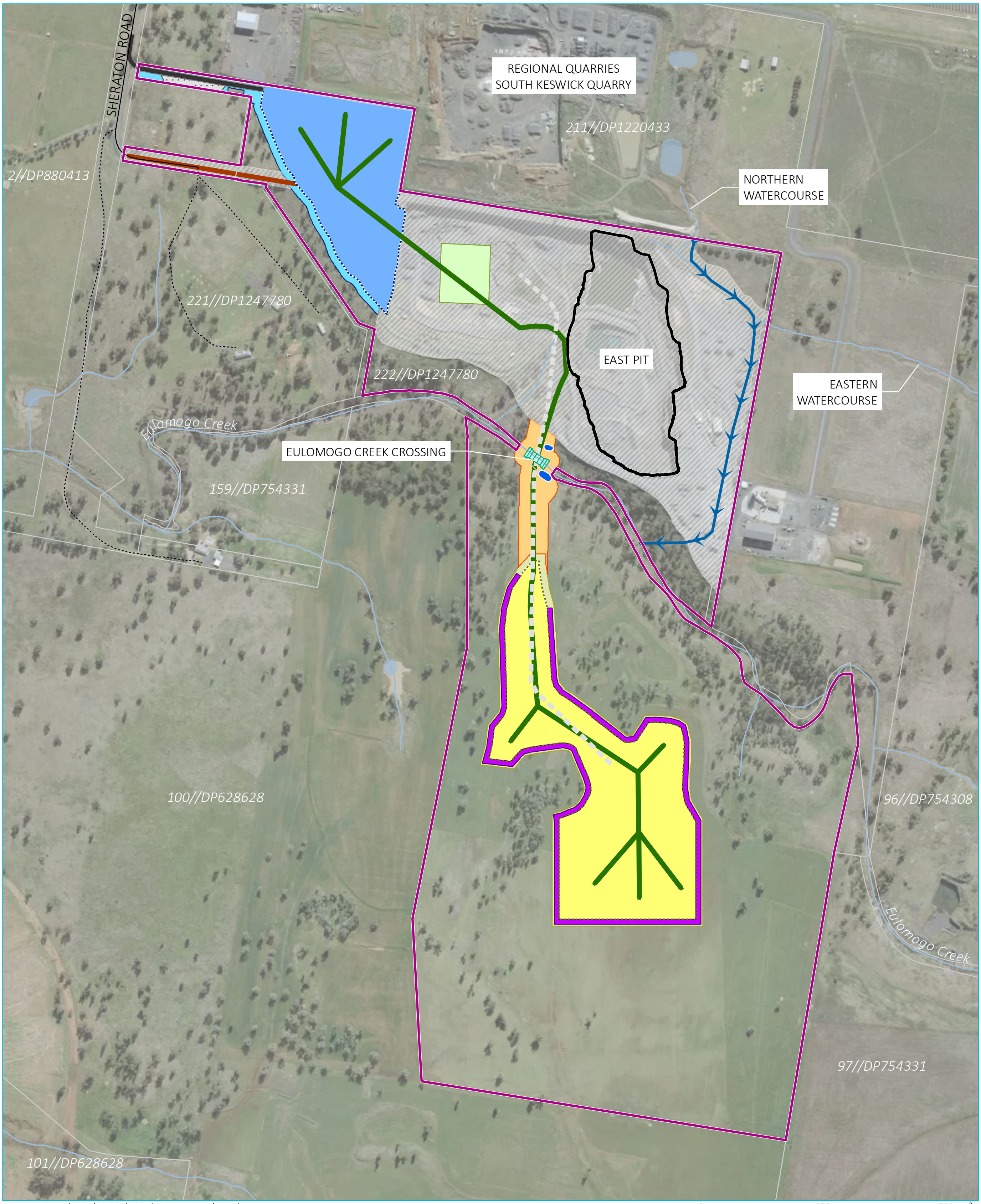

Source: EMM (2023); DFSI (2017); Metromap (2023)

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KEY

- Project area
- Pit boundary
- Indicative existing disturbance area
- Existing access road
- Alternative access road
- Alternative truck tarping area
- Bund wall
- Sediment pond
- Indicative proposed water crossing
- Western extension area
- Western disturbance area
- Haul road disturbance area
- Southern extension area
- Southern disturbance area
- Processing plant
- Proposed overland conveyor
- Proposed haul road
- East Pit surface water diversion - potential alignment (post June 2025)
- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)

Continuation project layout

Dubbo Quarry Continuation Project
Water management plan
Figure 1.2

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2 Plan requirements

The consent includes 16 conditions related to soil and water. Section 2.1 describes Holcim's approach to address each of the soil and water consent conditions. Section 2.2 describes how Conditions B35 (Discharge Characterisation Report) and B39 (Water Management Plan) are addressed in this WMP.

2.1 Soil and water consent conditions

Table 2.1 describes the approach to address the soil and water conditions.

Table 2.1 Consent conditions related to soil and water

Condition	Relates to	Approach to address condition
B25 to B28	Water supply and licensing	Chapter 7 provides an approach to address these conditions which relate to the need to hold appropriate water access entitlements and report surface and groundwater take.
B29 to B32	Compensatory Water Supply	The SSD did not identify any potential impacts to third-party water supply works. A procedure to address any potential impacts that are identified in the future is provided in Chapter 6.
B33	East Pit surface water diversion	Holcim will engage a suitably qualified person/s approved by the Planning Secretary to undertake design of the East Pit surface water diversion. Initially, the design will consider several options. Once a preferred alignment is identified, Holcim will consult with DPE and will seek to prepare any consent modification application that may be required by January 2024. Holcim will seek to construct the diversion by the end of June 2025.
B34 and B35	Water Discharge Management	This WMP addresses consent condition B35. It will be provided to the EPA for review prior to finalising.
B36	Sediment Basins	To address Condition B36, a preliminary design of the sedimentation basins that will be constructed near Eulomogo Creek is provided in Appendix C. It is noted that this design may be superseded by the final design for the Eulomogo Creek crossing, which will be submitted separately to DPE to address Condition B37.
B37	Eulomogo Creek Crossing	Holcim will engage a suitably qualified person/s approved by the Planning Secretary to undertake a detailed design of the Eulomogo Creek Crossing, adjoining haul road and sedimentation basins. The design will be prepared in consultation with DPE Water and will be completed separately to this WMP.
B39 to B41	Water Management Plan	This document is a WMP that addresses B39. It will be provided to EPA, DPE Water and Dubbo Council for review prior to finalising.

2.2 Requirements for this plan

This WMP addresses consent conditions B35 (Discharge Characterisation Report) and B39 (Water Management Plan). Table 2.2 describes the requirements of these conditions and how they are addressed in this plan.

Table 2.2 Consent conditions addressed in this plan

Condition			Plan overview
B35 - Within 12 months of the completion of the clean water diversion installation required by condition B33, the Application must prepare a **Discharge Characterisation Report** for the development and submit it to the Planning Secretary for information. This report must:			
a)	be prepared by suitably qualified and experienced person/s whose appointment has been approved by the Planning Secretary		This WMP has been prepared by Chris Kuczera (Associate Water Resources Engineer) who was approved by DPE on 25/5/2023
b)	be prepared in consultation with the EPA and DPE Water		WMP (Version 3) was provided to the EPA and DPE Water for comment. WMP V4 was updated to address issues raised in submissions received.
c)	include:		
	i)	measures to avoid the need for discharges as far as reasonable and feasible;	Each of these assessment requirements is addressed in Section 5.4.
	ii)	analysis of the frequency and volume of discharges during dry, median (or average) and wet conditions;	
	iii)	sufficient baseline water quality data from the East Pit	
	iv)	characterisation of the expected water quality and frequency of proposed discharges	
	v)	assessment of the impact of discharges to Eulomogo Creek; and	
	vi)	measures to prevent pollution of Eulomogo Creek and any other potential downstream impacts	
B39 - The Applicant must prepare a **Water Management Plan** for the development. This plan must:			
a) be prepared by suitably qualified and experienced person/s whose appointment has been approved by the Planning Secretary			This WMP has been prepared by Chris Kuczera (Associate Water Resources Engineer) and Samuel Cook (Associate Hydrogeologist) who were approved by DPE on 25/5/2023
b) be prepared in consultation with the EPA, DPE Water and Council; and			WMP (Version 3) was provided to Council, the EPA and DPE Water for comment. WMP V4 was updated to address issues raised in submissions received.
c) include a:			

Table 2.2 Consent conditions addressed in this plan

Condition		Plan overview
i)	**Site Water Balance** that: • includes details of: – sources and security of water supply; – water use and management on the site; – any off-site discharges or water transfers; – metering of captured water volumes in all water storages and measuring of volumes of water – pumped between water storages; and – reporting procedures, including the annual preparation of a Site Water Balance; and • uses accurately measured volumes of captured water and water pumped around the water storages within the development's water management system and measured groundwater inflows to the water storages; and • minimises clean and potable water use on the site;	The water balance model documented in the Water Assessment Addendum Report (EMM 2022) has been updated to include the water management system for each quarry stage and the revised water cycle conceptualisation that is established in Chapter 3 of this report. Key model results are presented in Chapter 5 and a detailed description of the model approach and assumptions are provided in Appendix B.
ii)	**Surface Water Management Plan** that includes: • detailed baseline data on surface water flows, water quality, riparian condition and geomorphic stability in watercourses and/or water bodies that could potentially be affected by the development; • surface water impact assessment criteria, including trigger levels for investigating any potentially adverse impacts, and surface water management performance measures; • a detailed description of the surface water management system on the site, including the: – clean water diversion system; – erosion and sediment controls; – dirty water management system; and – water storages; • a program to monitor and report on; – any surface water discharges; – stream stability, riparian condition and geomorphic processes in receiving watercourses; – the effectiveness of the water management system; – surface water flows and quality in watercourses and/or waterbodies that could potentially be impacted by the development; and • a protocol for identifying and investigating any exceedances of the surface water impact assessment criteria and for notifying the Department and relevant stakeholders of these events.	A water cycle description that is informed by baseline data is provided in Chapter 3 A description of the water management system for the Continuation Project is provide in Chapter 4. The system includes descriptions of storages and measures to manage clean and dirty water. Monitoring, trigger action and reporting plans are provided in Chapter 6. The plans include: • a commitment for ongoing water quality and level monitoring and water metering • trigger thresholds that will require actions if exceeded, and • a commitment to provide an annual water management review as part of the AEMR. Chapter 7 describes a surface water licencing approach. It includes: • information on existing entitlements • methodologies to estimate surface water take each water year, and • a commitment to report the estimated water take each water year

Table 2.2 Consent conditions addressed in this plan

Condition	Plan overview
iii) **Groundwater Management Plan** that includes: • detailed baseline data of groundwater levels, yield and quality for groundwater resources potentially impacted by the development, including groundwater supply for other water users and groundwater dependent ecosystems; • a detailed description of the groundwater management system; • groundwater performance criteria, including trigger levels for investigating any potentially adverse groundwater impacts; • a program to monitor and report on: – groundwater levels, yield and quality of groundwater resources potentially impacted by the development; – groundwater inflows into the extraction areas; – impacts of the development on groundwater dependent ecosystems; and – impacts of the development on groundwater supply for other water users; • a protocol for identifying and investigating any exceedances of the groundwater performance criteria and for notifying the Department and relevant stakeholders of these events; and • a protocol to obtain appropriate water licence(s) to cover the volume of any unforeseen groundwater inflows into the extraction areas including details to monitor and verify water take.	Chapter 3 describes local groundwater systems that interact with the quarry's water management system. The descriptions are informed by data from bore logs and groundwater level monitoring. A description of the water management system for the Continuation Project is provide in Chapter 4. The system includes several measures to reduce groundwater inflows into the East Pit. Monitoring, trigger action and reporting plans are provided in Chapter 6. The plans include: • a commitment for ongoing groundwater quality and level monitoring • trigger thresholds that will require actions if exceeded, and • a commitment to provide an annual water management review as part of the AEMR. Chapter 7 describes a groundwater licencing approach. It includes: • information on existing entitlements • methodologies to estimate groundwater take each water year • a commitment to report the estimated water take each water year

3 Water cycle description

The Water Assessment Addendum Report (EMM 2022) included descriptions of the quarry's water management system as well as surface and groundwater systems that interact with the quarry's water management system. In December 2022 Holcim commenced the water monitoring program that was proposed in the Water Assessment Addendum Report (EMM 2022). This chapter provides an updated water cycle description using the results from the initial seven months of the recent monitoring program and other available information. It includes:

- a description of available data (Section 3.1)
- information on surface water (Section 3.2) and groundwater systems (Section 3.3) that interact with the quarry's water management system
- a description of the East Pit Lake water cycle (Section 3.4)
- a description of the quarry's water management system for the Historic Operations (Section 3.5)
- a description of surface and groundwater quality (Section 3.6).

The water management approach for the Continuation Project is described in Chapter 4 and water inflows and discharges from the quarry's water management system and Holcim's water licencing approach are described separately in Chapter 5 and 7 respectively.

3.1 Available data

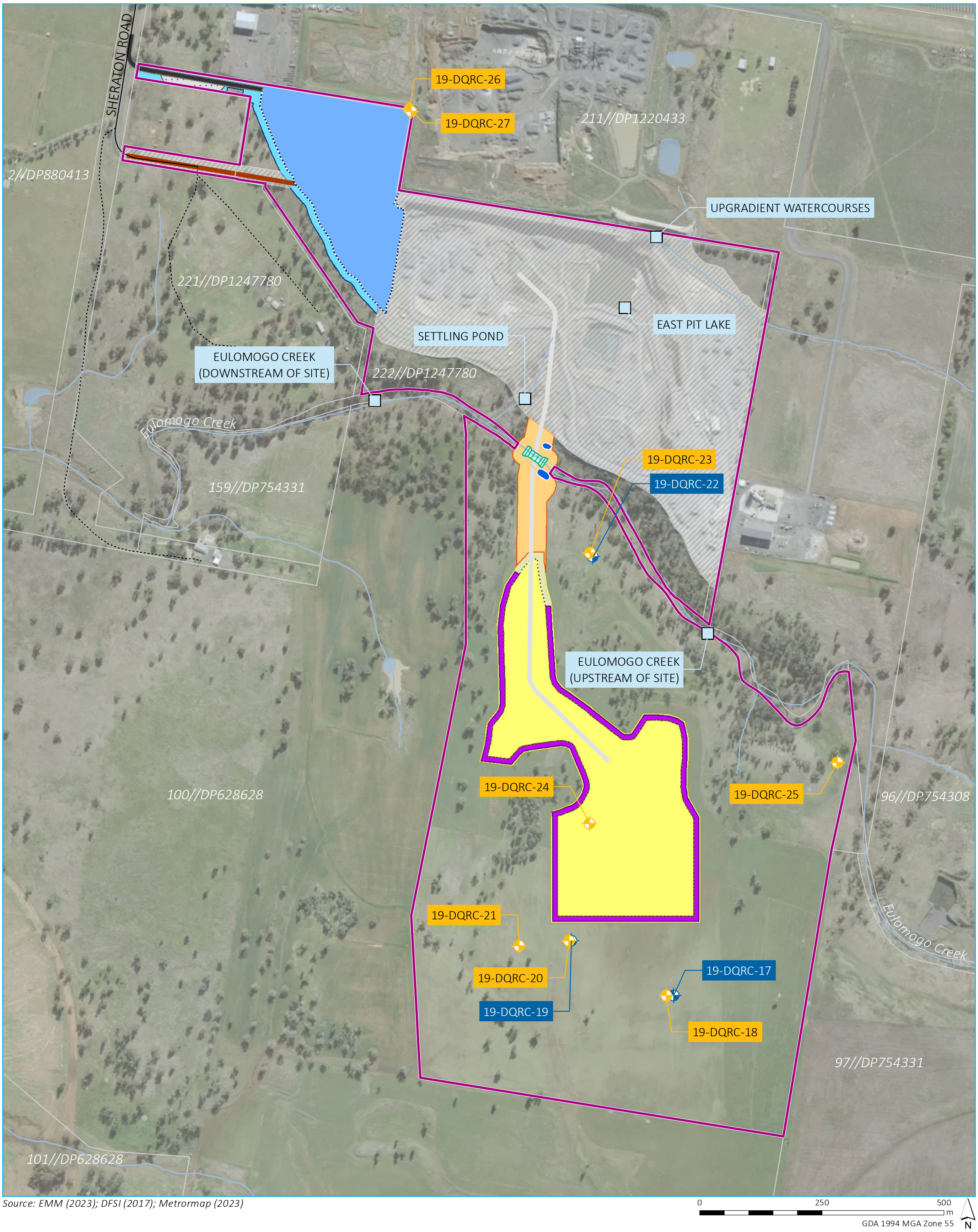
Table 3.1 provides a summary of data that has been used to inform the water cycle description and notes whether the data is new information (ie not available to inform the SSD). Figure 3.1 shows the surface and groundwater monitoring locations.

Table 3.1 Data used to in inform water cycle description

Data and source	Status
1. Drilling logs and bore construction details from a network of monitoring bores installed in 2019 were provided by Chief Drilling Pty Ltd	Considered in SSD
2. Publicly available bore logs from neighbouring groundwater users	Considered in SSD
3. Detailed survey undertaken by Western Survey Pty Ltd in February 2023	New information
4. 16 aerial surveys of the East Pit that were completed between December 2020 and June 2023	New information
5. Observations from numerous site visits undertaken by EMM and information provided by Holcim	Considered in SSD
6. Water quality data (monitoring locations are indicated in Figure 3.1)	
a) Data from historic water monitoring program (2013 – 2018)	Considered in SSD
b) Data from SSD water monitoring program that was undertaken by EMM 2020	Considered in SSD
c) Data from recent monitoring program (December 2022 to July 2023)	New information
7. Water level data (monitoring locations are indicated in Figure 3.1)	

Table 3.1 Data used to in inform water cycle description

Data and source	Status
a) Groundwater levels at eight monitoring bores on the project site from December 2020 to July 2023.	SSD considered data up to May 2021. Data from May 2021 to July 23 is new information
b) Surface water levels between December 2022 to July 2023 at the East Pit, Settling Pond and at a culvert location upstream of the East Pit	New information



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Source: EMM (2023); DFSI (2017); Metromap (2023)

KEY

- Project area
- Surface water monitoring location
- Groundwater monitoring bore
  - Basalt
  - Palaeochannel
- Sediment pond
- Indicative existing disturbance area
- Bund wall
- Existing access road
- Alternative access road
- Alternative truck tarping area
- Indicative proposed water crossing
- Western extension area
- Western disturbance area
- Haul road disturbance area
- Southern extension area
- Southern disturbance area
- Proposed haul road
- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)

Water monitoring locations
(recent monitoring program)

Dubbo Quarry Continuation Project
Water management plan
Figure 3.1

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3.2 Surface water setting

3.2.1 Eulomogo Creek

The quarry is within the Eulomogo Creek catchment which has a 52 km² catchment area that extends to the east of the quarry. Eulomogo Creek it is known to have an intermittent flow regime which means that during an average rainfall year streamflow will occur for most of the year but may cease for weeks or months, typically in late summer or early autumn. Streamflow will also cease for extended periods of time during dry periods. A flood assessment (undertaken by GRC Hydro in 2019 as part of the SSD application) described flooding within Eulomogo Creek as being confined to the channel and immediate overbank areas.

The Continuation Project includes a haul road crossing of Eulomogo Creek to access the SEA. To address Condition B37 the design of this crossing will be prepared in consultation with DPE Water as a separate process to this WMP (discussed further in Chapter 4).

3.2.2 Upgradient watercourses

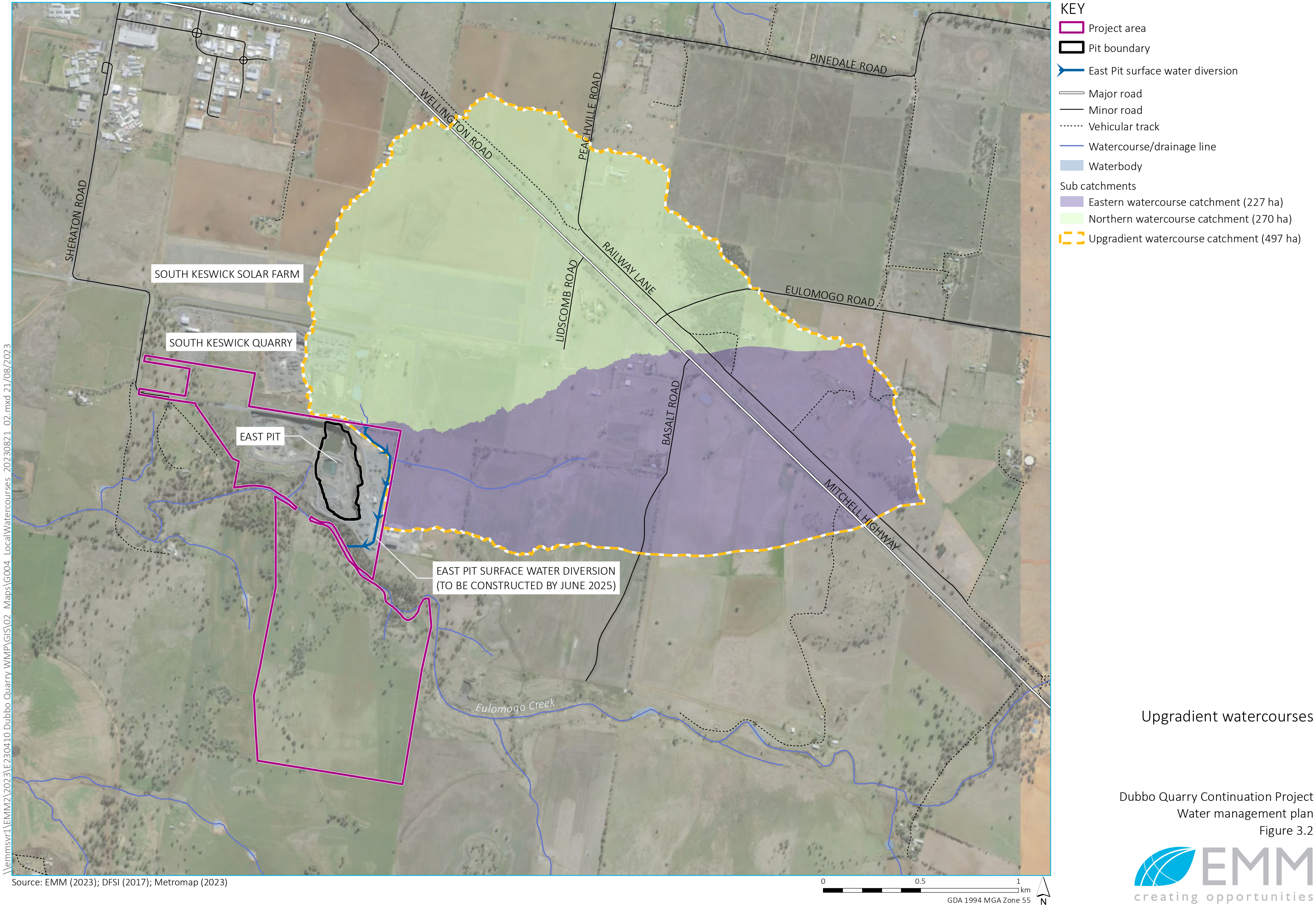
Two 1st order watercourses flow into the quarry's East Pit. These watercourses were referred to as the Eastern and Northern Watercourses in the SSD and are collectively referred to as the upgradient watercourses in this WMP. The Eastern Watercourse has a 227 ha catchment area that extends to the east of the quarry and the Northern Watercourse has a 270 ha catchment area that extends to the north of the quarry. The combined catchment area of both watercourses is 497 ha (nearly 5 km²). The catchments are nearly entirely cleared agricultural land. The South Keswick Solar Farm and South Keswick Quarry (a hard rock quarry that is operated by Maas Group) are in the Northern Watercourse catchment. Figure 3.2 shows the catchment areas and abovementioned features.

Both watercourses are known to have ephemeral flow regimes which means that streamflow only occurs following significant rainfall. In December 2022 a water level meter was installed upstream of the East Pit (location is indicated Figure 3.2). No streamflow was recorded between December 2022 and July 2023, which was characterised as a dry period that did not contain any significant rainfall events.

Condition B33 requires that Holcim construct the East Pit surface water diversion by June 2025. The purpose of the diversion will be to divert runoff from the upgradient watercourses around the East Pit, into Eulomogo Creek. A possible alignment of the East Pit surface water diversion is shown in Figure 3.2. Note this alignment is subject to a consent modification (discussed in Section 1.2).

3.2.3 Stream and riparian condition

Condition B39cii) requires that the WMP includes baseline data on the riparian condition and geomorphic stability of watercourses that could potentially be affected by the quarry. DPE advised that this condition can been addressed via photographs of watercourses at key locations where impacts could occur. Appendix D includes baseline photographs at seven locations on Eulomogo Creek and at one location on the Eastern and Northern Watercourses (near the site boundary). A figure and table that show and describe the monitoring locations is also included in Appendix D.



Source: EMM (2023); DFSI (2017); Metromap (2023)

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Upgradient watercourses

Dubbo Quarry Continuation Project
Water management plan
Figure 3.2

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3.3 Hydrogeological conceptualisation

3.3.1 Hydrostratigraphic units

The local groundwater resource is hosted within four key hydrostratigraphic units (HSUs):

- shallow, disconnected alluvial deposits associated with watercourses
- fractured Tertiary basalt deposits (referred to as fractured basalt in this report)
- the porous medium of a buried, palaeochannel system
- a porous rock system associated with the sedimentary basement rocks.

The Tertiary basalt deposits store and transmit groundwater via secondary porosity (fractures, joints and fissures). The fractured rock system is recharged directly via rainfall (in areas of outcrop) or indirectly via leakage from overlying alluvium (where present). The system discharges to surface watercourses and via leakage to the underlying palaeochannel aquifer.

A palaeochannel is buried below the Tertiary basalt deposits. Reference to bore log GW061634 indicates a 4 m thick coarse gravel lens underlying a basalt deposit approximately 2 km south of the quarry and GW014999 intersected a 3 m thick gravel lens underlying basalt approximately 1 km east of the quarry. Environmental Earth Sciences (2013) reported buried sand and gravel deposits south of the project around Toongi, considered to be hydraulically connected to the alluvial deposits.

The Triassic sedimentary basement rocks form a regional porous rock groundwater system. Groundwater flow is governed by secondary porosity (joints, bedding plane separation, faults and cavities) (DPIE 2019). Areas of high flow are encountered where there is a high density of open and interconnected fractures. Recharge to these systems is primarily through infiltration from rainfall, runoff and surface water within the outcropping areas. Recharge can also occur from leakage from overlying permeable strata that coincides with layers of the sedimentary sequences that have sufficient permeability for groundwater exchange to occur (DPIE 2019).

3.3.2 Groundwater level data

In December 2020, pressure transducers (data loggers) were installed in the eight groundwater monitoring bores (see Figure 3.1). Of the eight bores:

- two are screened in the palaeochannel (DQRC-17 and DQRC -22)
- three are screened in the saturated fractured basalt (DQRC -18, DQRC -23 and DQRC -24)
- DQRC-21 is screened in the saturated fractured basalt but the logger malfunctioned
- DQRC-20 is screened in the fractured basalt but has been consistently dry
- DQRC-19 records are deemed to be unreliable due to a suspected bore construction issue.

Three additional bores were drilled in 2019 (DQRC-25, 26 and 27). These bores were dry on completion, no further monitoring has taken place.

Recorded water level data from December 2020 to July 2023 is provided in Figure 3.3 and Figure 3.4. The figures include rainfall data (presented as a five-day moving total) from Bureau of Meteorology (BoM) weather station at Dubbo airport (station 65070) to inform trend analysis.

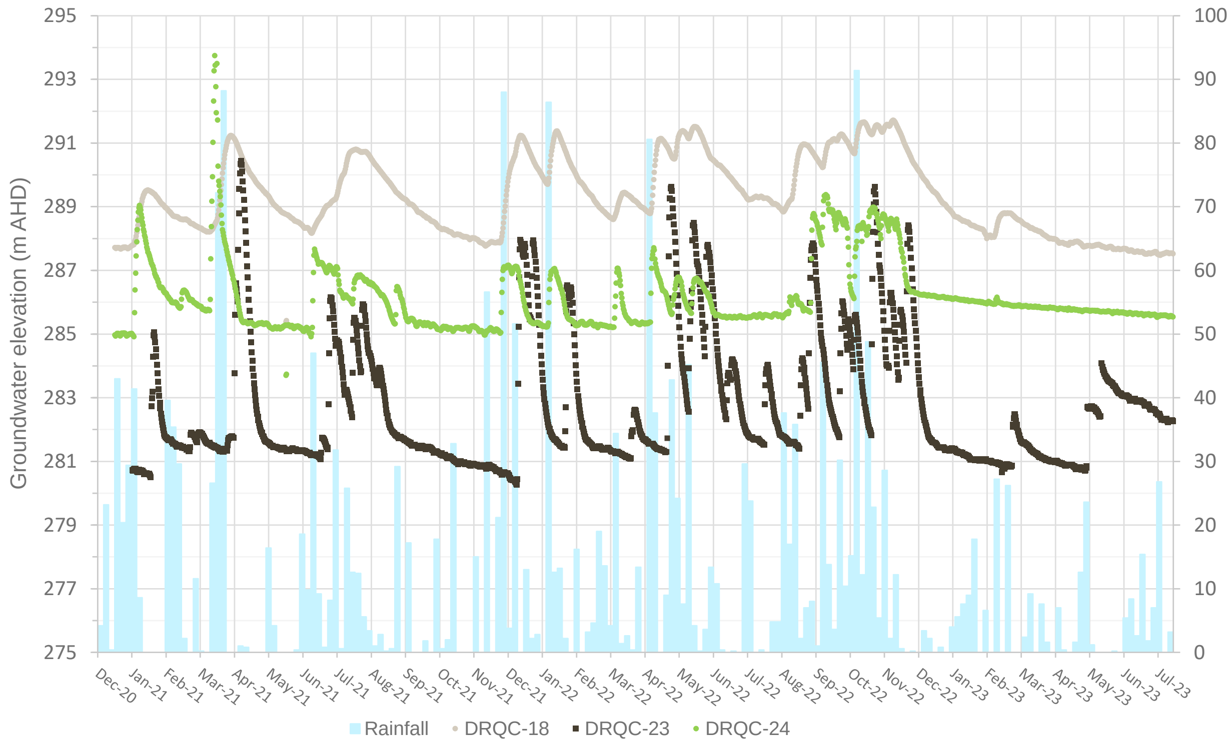


Figure 3.3 Groundwater level data – basalt

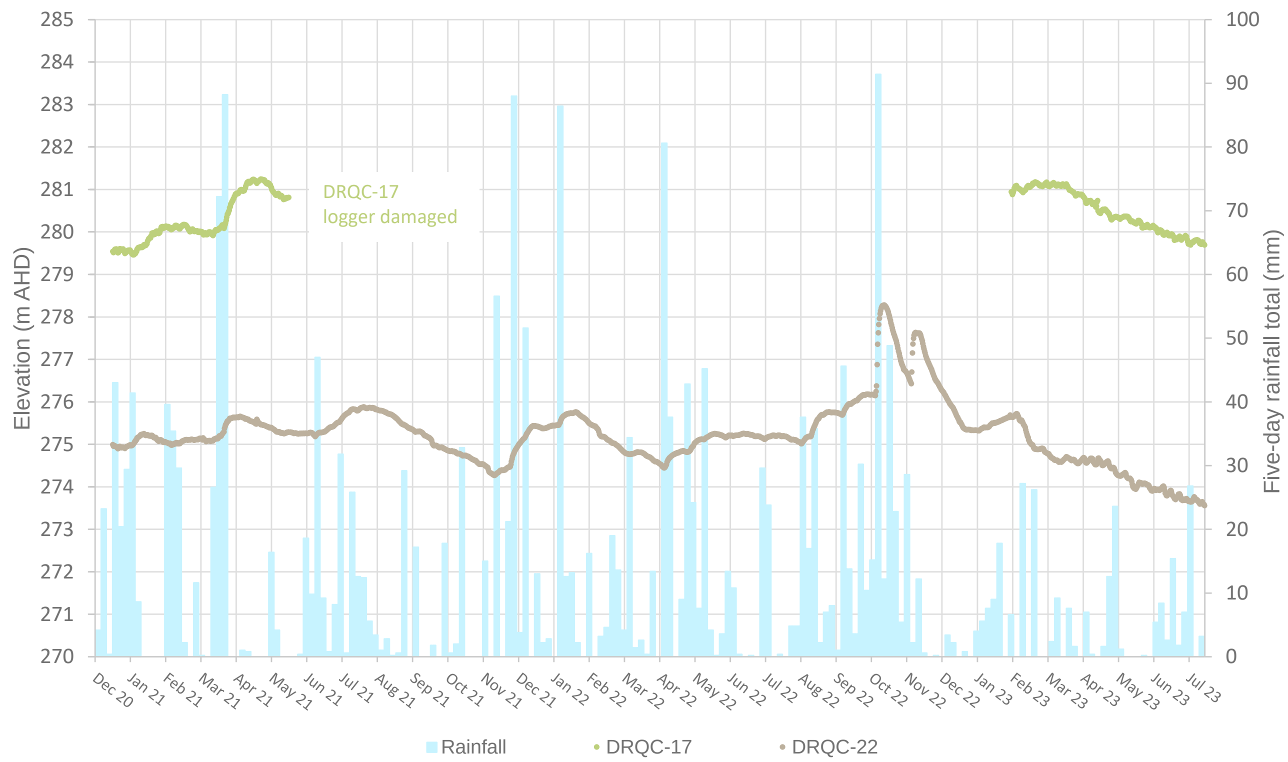


Figure 3.4 Groundwater level data – palaeochannel

i Basalt results discussion

Short-term responses to rainfall recharge are observed within the bores screened within the basalt (Figure 3.3). These responses are typical of a low storage system that receives direct rainfall recharge.

The groundwater levels generally subside to baseline levels within a month or two following rainfall. This long-term equilibrium level, observed between rainfall events, is considered representative of the 'phreatic surface' within the fractured rock aquifer.

ii Paleochannel results discussion

The groundwater heads in the palaeochannel show a muted response to rainfall recharge with the gradient between DQRC-17 and DQRC-22 indicating the aquifer has a northerly flow direction (Figure 3.4). The muted response to rainfall is attributed to leakage from the overlying basalt, high porosity of the aquifer (corresponding to large storage capacity) and high transmissivity of the unconsolidated sediments.

A rapid increase in groundwater head was observed at DQRC-22 in October and November 2022. This elevated head is attributed to the connectivity between the palaeochannel and East Pit Lake (discussed in Section 3.4).

3.3.3 Conceptual flow model

The key groundwater systems at the project area are an overlying basalt unit (confining layer) and an underlying palaeochannel (confined aquifer). The regional groundwater flow is inferred from south to north.

Locally, groundwater heads indicate a downward vertical gradient driving leakage from the basalt into the palaeochannel, regional watercourses and alluvial groundwater systems.

i Basalt system

The basalt system receives inflow from rainfall recharge, which enters discrete fractures within the basalt. The fractures have low storage capacity as seen by the groundwater level response following recharge events. The system discharges into the palaeochannel, regional watercourses and alluvial groundwater systems.

ii Paleochannel system

The paleochannel system is interpreted to be a confined aquifer that has a northerly flow gradient, a high storage capacity and is highly transmissive. Groundwater response to rainfall is muted and delayed by an overlying confining layer (basalt). The connectivity between the paleochannel and East Pit is discussed in Section 3.4.

3.4 East Pit water cycle concept

3.4.1 Water cycle overview

The East Pit water cycle is influenced by the following factors:

- **Paleochannel inflows** - historic quarry activities in the floor of the East Pit intercepted the underlying palaeochannel, resulting in groundwater from the palaeochannel entering the East Pit. At times water from the East Pit Lake (ie the water that ponds in the pit) flows back into the palaeochannel. The groundwater inflow rate is a function of the head differences between the East Pit Lake and groundwater in the adjoining paleochannel and the hydraulic connectivity between the aquifer and the pit floor.

- **Inflows from upgradient watercourses** – runoff from the upgradient watercourses enters the northern portion of the East Pit. As these watercourses are ephemeral, runoff only occurs occasionally following substantial rainfall. The watercourses have a contributing catchment area of 497 ha (see Section 3.2.2) and therefore have potential to contribute large volumes of runoff during flood producing rainfall. For example, approximately 500 megalitres (ML) runoff would occur from a rainfall event that produces 100 mm of runoff from the catchment.

- **Surface water runoff from the quarry area** – the East Pit receives surface water runoff from a 24.4 ha quarry area, which includes the East Pit and a stockpiling area.
- **Water extraction for operational use** – water is extracted via pumping from the East Pit for operational uses.
- **Dewatering of the East Pit Lake** – Holcim have historically dewatered the East Pit Lake to maintain access to the quarry floor. The dewatering has been undertaken via pumping water into the Settling Pond, which overflows into Eulomogo Creek.

Figure 3.5 is a conceptual diagram that shows the interpreted extent of the paleochannel and the East Pit water cycle concept. The figure includes several features that are discussed in this section.

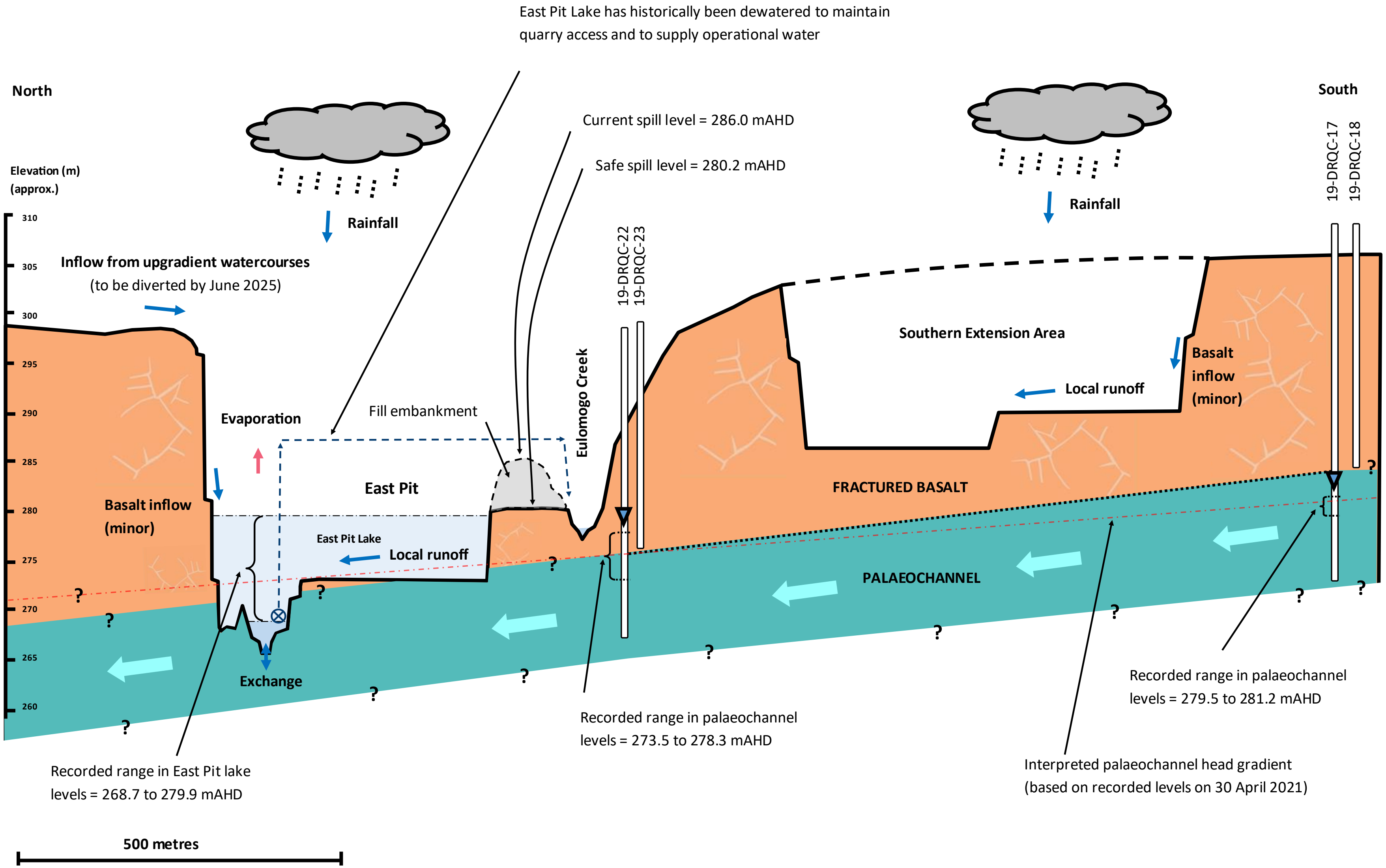


Figure 3.5 Conceptual model of East Pit water cycle

3.4.2 East Pit storage and overflows

Water storage in the East Pit can potentially occur between the pit floor (265 m AHD) and the current overflow level of 286 m AHD. The current overflow location is a low point on a haul road that is to the west of the East Pit. The haul road immediately to the south of the overflow location is on a fill embankment. Holcim have surveyed the competent rock level under the fill embankment as being 280.2 m AHD. This level has been adopted as the safe spill level for the East Pit. Holcim propose to install drainage through the fill embankment at the safe spill level to mitigate the risk of water ponding against the fill embankment (discussed further in Chapter 4).

The East Pit storage volume has been estimated using data from an aerial survey completed on August 2023. Figure 3.6 shows the estimated inundation extent of the East Pit Lake at the safe spill level and the current overflow level. A storage level curve is also provided in Figure 3.7. The total storage up to the safe spill level is 310 ML and the total storage between the safe spill level and the current overflow level is 410 ML.

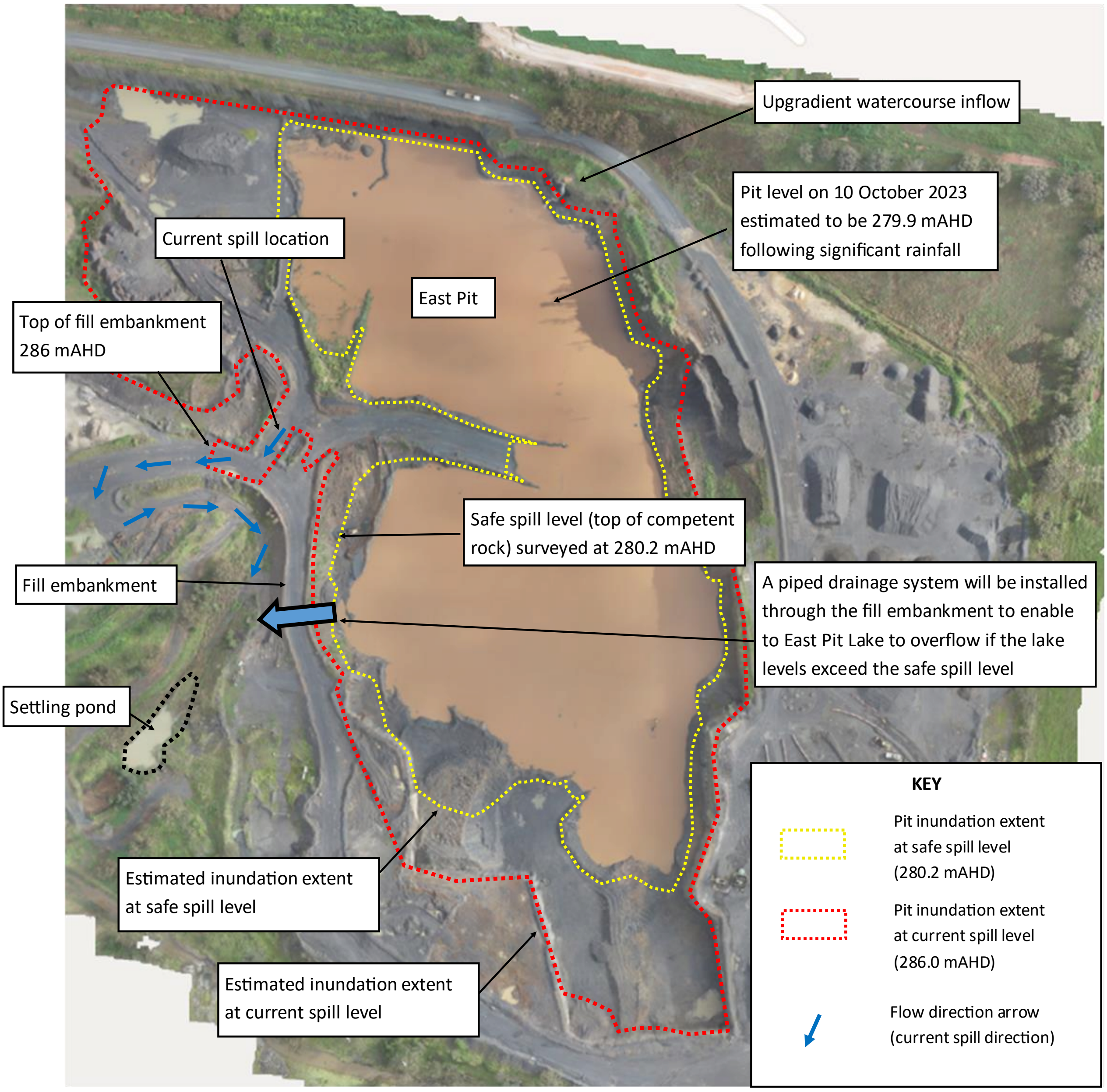


Figure 3.6 East Pit storage

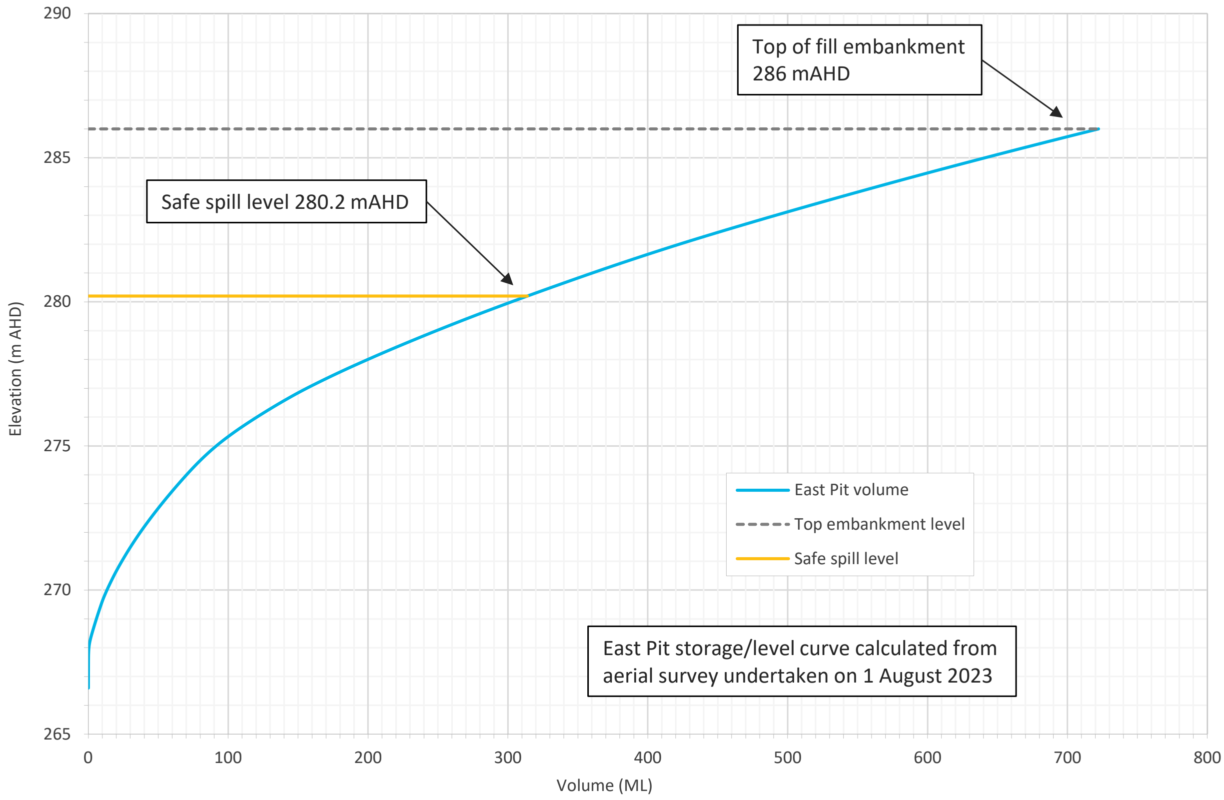


Figure 3.7 East Pit Storage level curve

3.4.3 Water level data

i Available data

The available East Pit Lake water level data includes:

- Continuous water level data recorded by a water level logger that was installed in the East Pit in December 2022. Water level data from December 2022 to May 2023 is presented in the report.
- Spot water levels from 16 aerial surveys that were completed between December 2020 and June 2023.

Figure 3.8 shows the abovementioned East Pit Lake water level data. Groundwater levels recorded at the two paleochannel bores (DQRC-17 and DQRC-22) and the five-day moving rainfall total are also included.

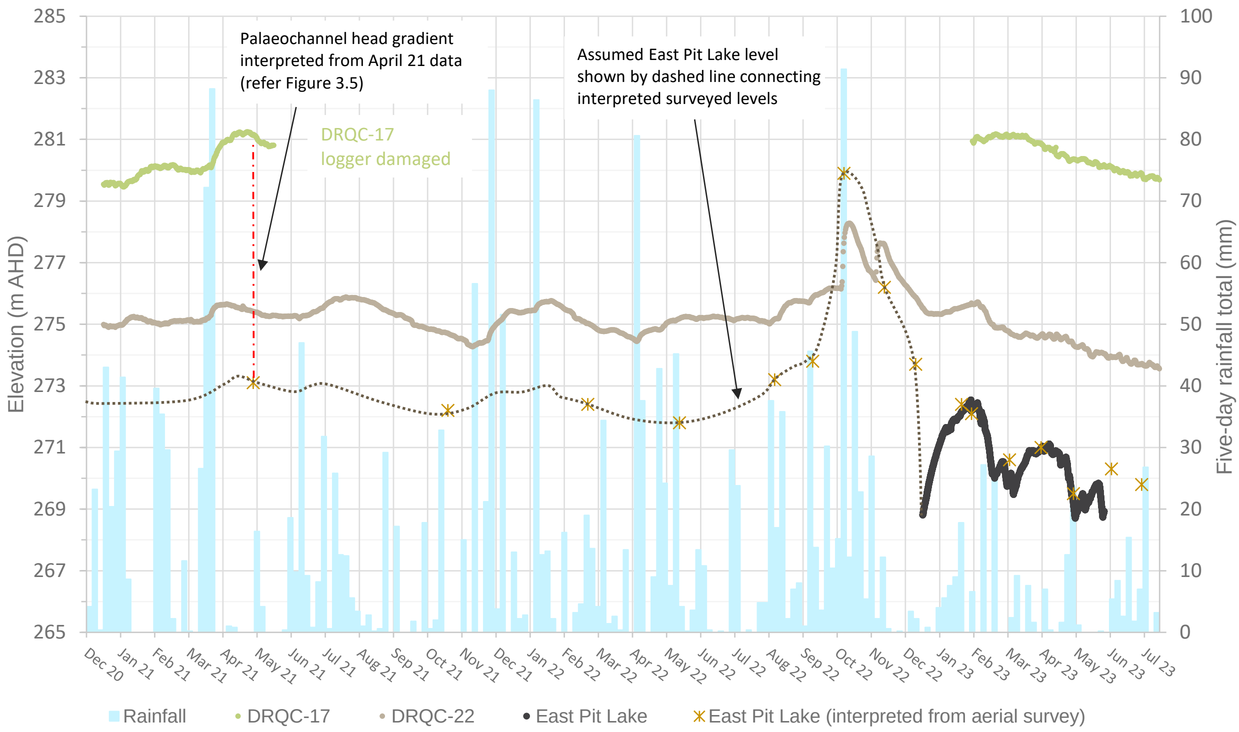


Figure 3.8 Water level data – East Pit Lake

ii Chronology

The following chronology is relevant to interpreting the water level data in Figure 3.8:

- **December 2020 to August 2022** – this period was characterised by above average rainfall. During this period Holcim maintained the East Pit Lake level at approximately 273 m AHD using a dewatering pump on a float switch.
- **September 2022 and October 2022** – significant wet weather occurred during this period which resulted in flooding in regional river systems. During this period Holcim observed that runoff from the upgradient watercourses entered the East Pit Lake, which lead to the lake levels rising 6 m to approximately 280 m AHD, indicating that 200 to 250 ML of runoff occurred.
- **November 2022 and December 2022** – the wet conditions ceased in early November and Holcim dewatered the East Pit Lake to around 269 m AHD in early December.
- **December 2022 and January 2023** – dewatering of the East Pit Lake ceased and the pit was allowed to fill via paleochannel inflows.
- **February 2023 to June 2023** – Holcim intermittently dewatered the East Pit Lake to access resource in the lower levels of the pit.

iii Data review

The following interpretations of the water level data in Figure 3.8 are relevant to understanding interactions between the East Pit Lake and the paleochannel:

- Between December 2020 and August 2022 the East Pit Lake level was maintained at approximately 273 m AHD by dewatering. During this period the groundwater heads (or water levels if unconfined) at:

- DQRC-22 (which is screened in the paleochannel and is located approximately 400 m upgradient of the East Pit) were consistently approximately 2.5 m higher than the interpreted East Pit Lake levels
- DQRC-17 (which is screened in the paleochannel and is located approximately 1,200 m upgradient of the East Pit) were approximately 5 m higher than the groundwater head at DQRC-22 and 7.5 m higher than the interpreted East Pit Lake levels.

The head gradient (ie the difference in head / horizontal distance) between the East Pit and DQRC-22 and DQRC-17 was approximately 0.6% for both bores (Figure 3.5 shows the head gradient on 30 April 2021). This data indicates that paleochannel has had a northerly flow direction towards the East Pit and that the head gradient does not materially change between DQRC-22 and DQRC-17. A steeping head gradient would indicate the presence of a drawdown effect.

- In September and October 2022 inflows from the upgradient watercourses entered the East Pit which resulted in the water level rising approximately 6 m, to around 280 m AHD. The groundwater heads at DQRC-22 increased rapidly by approximately 2.5 m and the East Pit Lake level estimated from the October 2022 aerial survey was approximately 1.5 m higher than the level at DQRC-22. This data indicates that water outflow from the East Pit Lake into the paleochannel occurred.
- The East Pit Lake was dewatered from approximately 280 m AHD to 269 m AHD in November and early December 2022, before being allowed to fill to approximately 273 m AHD. The recorded groundwater heads at DQRC-22 responded to periods of East Pit Lake dewatering and filling.

Collectively the data demonstrates that the East Pit Lake is connected to the paleochannel and that the palaeochannel is somewhat depressurised by dewatering activities. The extent and magnitude of depressurisation cannot be established from the available data as there is no sustained period without dewatering and limited data available from the upgradient bore (DQRC-17). However, as the paleochannel has a northerly flow gradient, a high storage capacity and is highly transmissive the depressurisation is not expected to be significant and could be in the 0.5 to 2.0 m range.

iv Calculated inflow rates

In November and early December 2022 Holcim dewatered the East Pit Lake from approximately 280 to 269 m AHD. In mid-December 2022 dewatering ceased and did not resume until early February 2023. There was no significant rainfall over this period so all the water level increases can be attributed to paleochannel inflows.

This resulted in a six-week period where the pit was allowed to fill via paleochannel inflows without other material influences. The inflow rates over this period were calculated based on the change in lake water levels and the level storage curve (see Figure 3.7). The calculated weekly inflow volumes over the six-week period are shown in Figure 3.9.

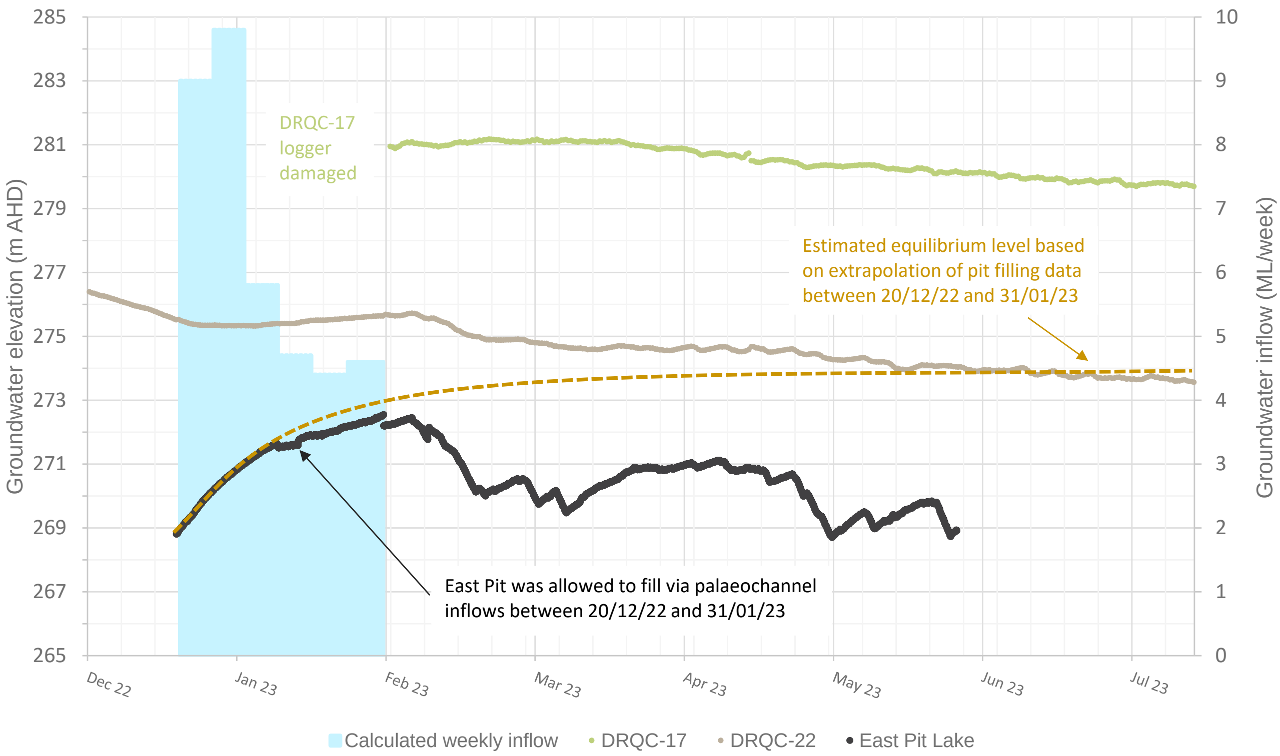


Figure 3.9 East Pit Lake - paleochannel inflow volumes

The calculated inflow rates ranged from approximately 4.5 to 10 ML/week. The change in inflow rates correlated well with the head difference between the East Lake level and DQRC-22, which was approximately 6 m at the start of the period and 3 m at the end of the period. This trend is consistent with expectations.

Figure 3.9 shows an extrapolated East Pit water level curve from the period. This extrapolation indicates that, if the pit was allowed to continue filling, the water level would reach an equilibrium level of around 274 to 275 m AHD by mid-2023. It is noted that this curve does not account for any local re-pressurisation of the paleochannel that may occur as the inflows into the East Pit reduce.

3.4.4 East Pit Lake and paleochannel interaction

At commencement of the Continuation Project, East Pit dewatering activities will cease, and the pit will be allowed to fill (see water management measures in Chapter 4). As the pit lake equilibrates with heads in the intersected palaeochannel, groundwater inflows to East Pit will reduce and the level of the pit lake will ultimately find a balance between the fluctuating inputs and outputs of the system. The equilibrium level may vary over time in line with changes in groundwater pressure in the palaeochannel (the equilibrium level range). If the equilibrium level at any point in time is exceeded due to surface water inflows into the East Pit, water may temporarily flow from the pit lake into the palaeochannel, as occurred in September and October 2022 (see Section 3.4.3).

The equilibrium level range cannot be reliably established until dewatering activities cease and water levels in the pit and adjoining paleochannel are monitored for a period of time, which could be several years. From the currently available data it is estimated that the equilibrium range will be between 274 and 279 m AHD (the estimated equilibrium range), with an expectation that the ultimate range will be narrower (ie water levels will vary by 1 to 2 m overtime) and be in the lower half of this estimated range (ie between 274 and 276.5 m AHD). The basis for the estimated range and the expected guidance is:

- It is known that dewatering was required to maintain an East Pit Lake level of approximately 273 m AHD. Hence, the equilibrium range is above 273 m AHD.

- The conceptual flow model (see Section 3.3.3) established that the confined palaeochannel aquifer has a northerly flow gradient, a high storage capacity and is highly transmissive. This means that:
  - The equilibrium level in the East Pit Lake is expected to be below the groundwater head level at DQRC-22 (the upgradient bore), which varied between 274 and 276 m AHD over the monitoring period, excluding the period in September and October 2022 when water levels in the East Pit Lake exceeded the equilibrium level at that time, resulting in backflow from the East Pit Lake into the paleochannel.
  - Due to the aquifer characteristics, it is unlikely that significant re-pressurisation of the aquifer will occur as inflows from the paleochannel into the East Pit reduce. This means that the groundwater head range at DQRC-22 (the upgradient bore) may readjust to a slightly, but not significantly higher range than the recorded range from December 2020 to July 2023, excluding the September and October 2022 period (see Figure 3.8).

Figure 3.10 shows a conceptual flow exchange curve between the East Pit Lake and the paleochannel based on the estimated equilibrium range. The estimated paleochannel inflow rates from the December 2022 to January 2023 period (discussed in Section 3.4.3) are shown for context. It is noted that the weekly inflow rates have been converted to daily inflow rates.

The average flow exchange curve has been applied to the water balance model and the implications of a higher or lower exchange curves are discussed qualitatively.

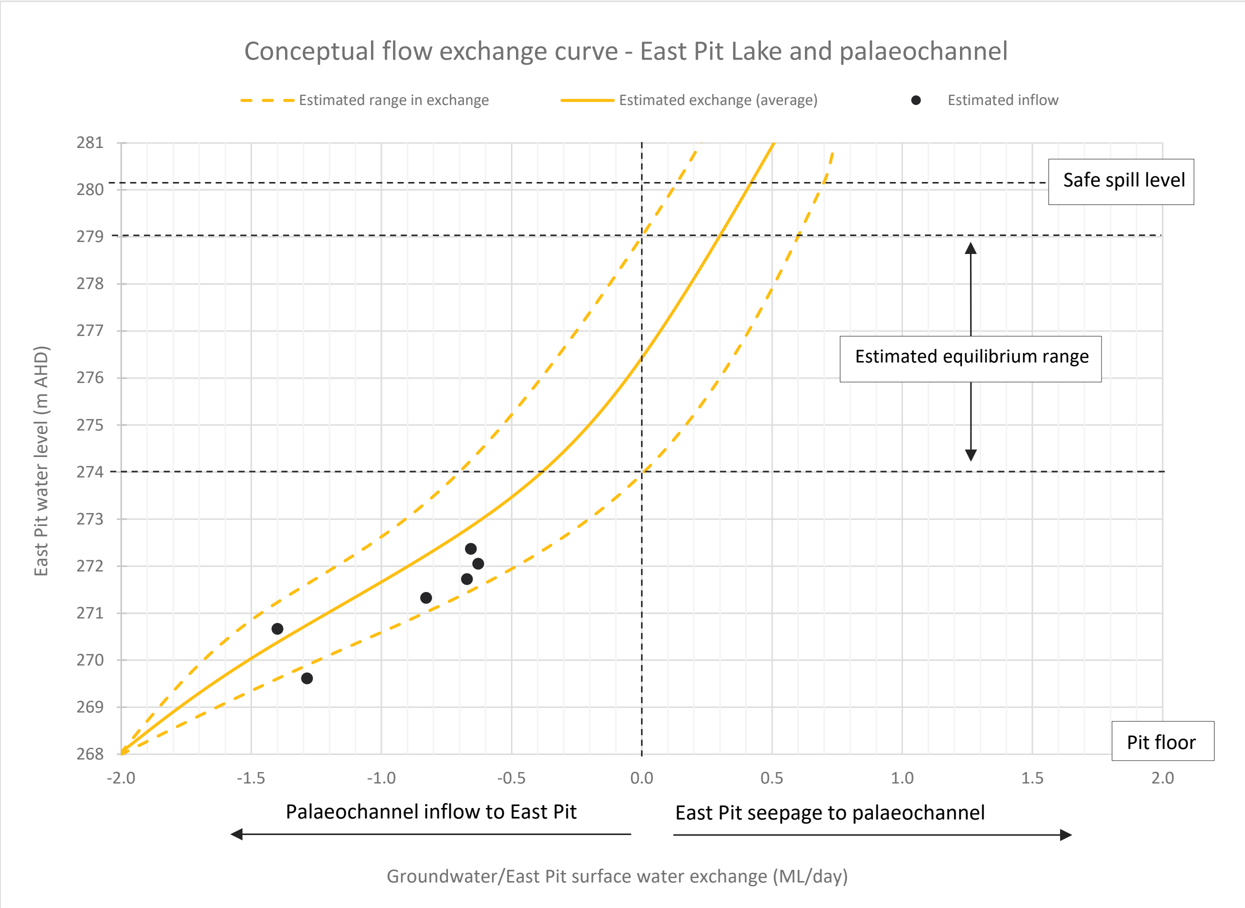


Figure 3.10 Paleochannel exchange with East Pit Lake

3.4.5 Application to this WMP

The uncertainty in the equilibrium range is acknowledged and addressed in this WMP. The associated management approach is described in the following chapters:

- Chapter 4 describes how the East Pit Lake will be managed following the commencement of the Continuation Project.
- Chapter 6 describes a monitoring, trigger and action plan that includes continued monitoring and assessment of the East Pit Lake and paleochannel levels. Actions are proposed if the estimated equilibrium range is exceeded.
- Chapter 7 includes a methodology to calculate water take from the paleochannel each water year using monitoring data.

3.5 Water management system for Historic operations

This section provides an overview of the water management system for the Historic Operations, which refers to the quarry operation prior to the commencement of the Continuation Project (Section 1.4).

The water management system has been operated to:

- manage runoff from a 32.1 ha quarry area,
- manage water accumulation in the East Pit due to inflows from the upgradient watercourses and paleochannel
- provide water for operational uses, which include haul road dust suppression and material processing.

Inflows into the system occur from:

- runoff from the quarry area
- runoff from the upgradient watercourses
- groundwater inflows into the East Pit.

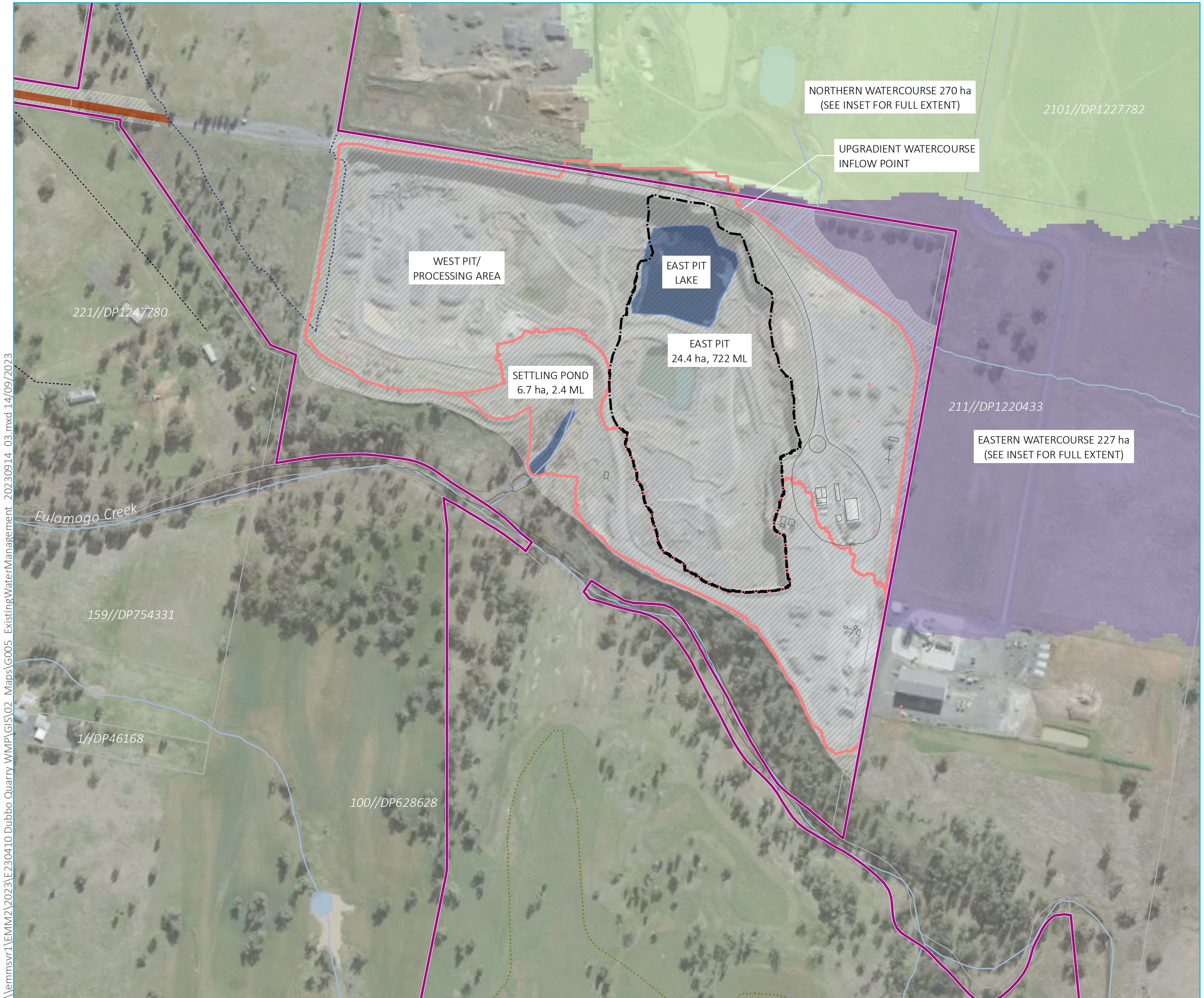
Discharges from the system occur due to:

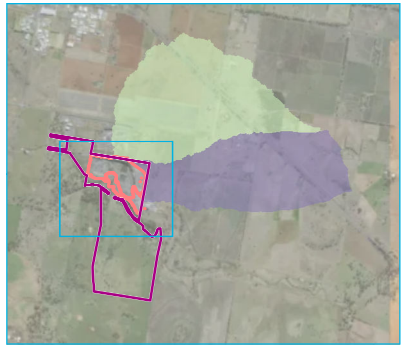
- dewatering the East Pit (via pumping into the Settling Pond which overflows into Eulomogo Creek)
- overflows from the Settling Pond due to runoff from its contributing catchment area.

The system layout is shown in Figure 3.11 and the system framework is shown in Figure 3.12.

Information on the water storages, catchment areas and operating principles is provided in Appendix B.

It is noted that the quarry is not connected to potable water. Water for the amenities is sourced from a rainwater tank and / or the East Pit and bottled drinking water is provided.





KEY

- Project area
- East pit (extraction boundary)
- Existing project infrastructure
- Indicative existing disturbance area
- Catchment boundary
- The Eastern Watercourse - 277 ha
- The Northern Watercourse - 270 ha
- Existing water management storage
- Existing access road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)

Source: EMM (2023); DFSI (2017); Metromap (2023)

\\emmsvr1\EMM2\2023\E230410 Dubbo Quarry WMP\GIS\02_Maps\G005_ExistingWaterManagement_20230914_03.mxd 14/09/2023

Historic operations -
water management system layout

Dubbo Quarry Continuation Project
Water management plan
Figure 3.11

EMM
creating opportunities

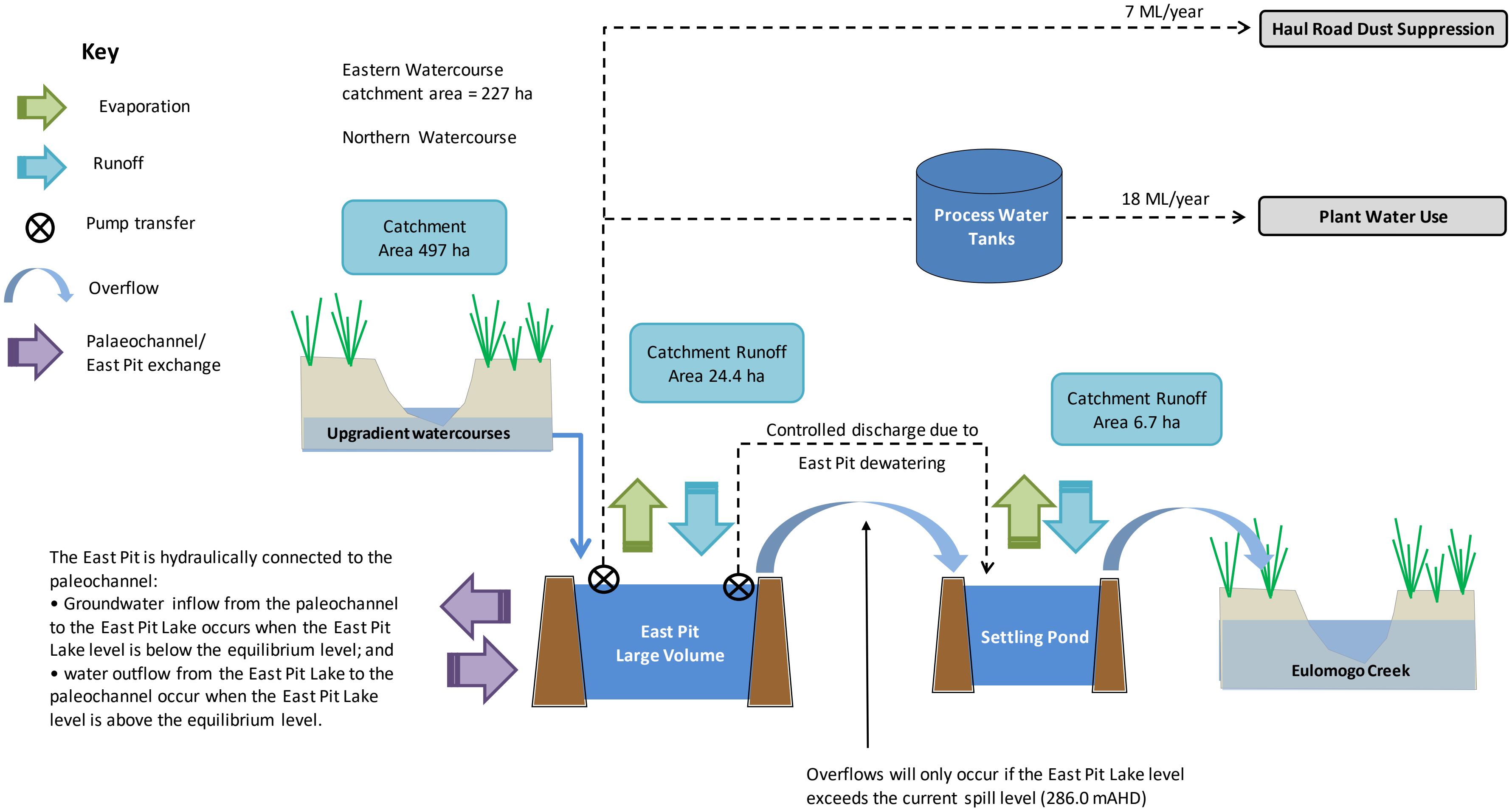


Figure 3.12 Historic Operations - water management system framework

3.6 Water quality characteristics

This section describes the water quality characteristics of:

- groundwater in the paleochannel and fractured basalt groundwater systems
- the East Pit and the Settling Pond
- Eulomogo Creek

It is informed by data from three sampling programs completed between 2013 to July 2023. Section 3.6.1 describes the sampling programs, Section 3.6.2 describes default guideline values for Eulomogo Creek and the water quality characteristics of each system are described in Section 3.6.3.

3.6.1 Sampling programs

Water quality data is available from the following water quality monitoring programs:

- **2023 sampling** – In January 2023 Holcim commenced the water monitoring program that was proposed in the Water Assessment Addendum Report (EMM 2022). Three sampling events were completed by Ramboll Australia Pty Ltd (Ramboll) between January and July 2023. All samples were collected during dry conditions.
- **2020 sampling** – EMM collected samples from Eulomogo Creek and several water management dams at the quarry on 9 July 2020. Samples were collected approximately nine weeks after significant rainfall that occurred in June 2020. The results were documented in the Water Assessment (EMM 2020).
- **Holcim sampling** – Holcim have monitored water quality in Eulomogo Creek and key water management storages at the quarry from 2013 to 2018. Samples were generally collected during wet weather conditions when overflows from the Settling Pond were occurring (due to East Pit dewatering).

i Sampling locations

The sampling locations and number of samples collected from each program are described in Table 3.2. Sample locations are shown in Figure 3.1.

Table 3.2 Sample locations

	Number of samples available		
	2023 sampling (January – July 2023)	**2020 sampling (9 July 2020)**	**Holcim Sampling (2013 to 2018)**
Receiving water			
Eulomogo Creek - upstream of site boundary (EIS and 2023 programs)	3	1	-
Eulomogo Creek - downstream of site boundary (EIS and 2023 programs)	3	1	-
Eulomogo Creek - upstream of Settling Pond (Holcim sampling program)	-	-	20

Table 3.2 Sample locations

	Number of samples available		
	2023 sampling (January – July 2023)	2020 sampling (9 July 2020)	Holcim Sampling (2013 to 2018)
Eulomogo Creek - downstream of Settling Pond (Holcim sampling program)	-	-	41
Existing quarry			
East Pit Lake	3	1	45
Settling Pond	3	1	45
Groundwater			
DRQC-17 (palaeochannel)	3	-	-
DRQC-22 (palaeochannel)	3	-	-
DRQC-18 (basalt)	3	-	-
DRQC-21 (basalt)	2	-	-
DRQC-23 (basalt)	1	-	-
DRQC-24 (basalt)	1	-	-

ii Analytes

Analytes of each sampling program area described in Table 3.3.

Table 3.3 Sample program analytes

Category	Sampling analytes
2023 sampling	
Physico-chemical properties	pH, electrical conductivity, turbidity, total suspended solids, total dissolved solids
Nutrients	total nitrogen, ammonia, oxidised nitrogen and total kjeldahl nitrogen total phosphorus and reactive phosphorus
Metals (dissolved)[1]	Al, As, B, Cr, Co, Cu, Fe, Mn, Ni and Zn
2020 sampling	
Physico-chemical properties	pH, electrical conductivity, turbidity, total suspended solids, total dissolved solids
Nutrients	total nitrogen, ammonia, oxidised nitrogen and total kjeldahl nitrogen total phosphorus and reactive phosphorus
Metals (dissolved)[1]	Al, As, Cr, Cd, Cu, Fe, Hg, Mn, Ni, Pb, Se and Zn
Holcim sampling	
Physico-chemical properties	pH, electrical conductivity, turbidity

Table 3.3 Sample program analytes

Category	Sampling analytes
Nutrients	oxidised nitrogen, reactive phosphorus
Other	chemical oxygen demand

1. Dissolved metals were field filtered using a 0.45 µm filter.

3.6.2 Default guideline values

Water quality data is compared to water quality objectives established in the National Water Quality Management Strategy (NWQMS). The NWQMS references the *Australian & New Zealand Guidelines for Fresh & Marine Water Quality* (ANZG 2018), which has replaced the ANZECC/ARMCANZ 2000 guidelines.

ANZG 2018 has a stated long-term objective of providing regional Default Guideline Values (DGVs) for the Murray-Darling basin and other regional basins in Australia. These DGVs are yet to be incorporated into ANZG 2018.

The *Macquarie-Castlereagh water quality management plan* (NSW DoI 2018) provides water quality targets for the Macquarie-Castlereagh water resource plan area, which includes Eulomogo Creek. The targets were developed as part of the Murry-Darling Basin Plan using the methods recommended in the ANZECC/ARMCANZ 2000 guidelines and include targets for water dependant ecosystems. As these targets were developed using catchment specific data, they are considered more relevant than the generic default values provided in ANZECC/ARMCANZ 2000 and are therefore used for this assessment.

Table 3.4 describes the DGVs that have been adopted for this WMP. It is noted that the DGVs are catchment scale water quality objectives and may not be representative of ambient water quality in Eulomogo Creek or downstream receiving waters.

Table 3.4 Default Guideline Values adopted for this assessment

Indicator	DGV	Source
Turbidity	The annual median value should be < 20 NTU	Macquarie-Castlereagh water quality management plan (NSW DoI 2018) – water quality targets for water dependant ecosystems
Total phosphorus	The annual median value should be < 35 ug P/L	
Total nitrogen	The annual median value should be < 600 ug N/L	
Dissolved oxygen	The annual median value should be >8 mg/L or within the 90-110% range	
pH	The annual median value should be within the 7.0-8.0 range.	
Temperature	Between the 20th and 80th percentile of the natural monthly water temperature range	
Salinity	Median value 504 µS/cm 80th percentile 744 µS/cm	
Toxicants	Values for slightly-to-moderately disturbed freshwater ecosystems described in the ANZG 2018 guidelines.	Macquarie-Castlereagh water quality management plan (NSW DoI 2018) and ANZG 2018.

3.6.3 Water quality results

Water quality results for each of the sampling programs are presented in Appendix A. The results are compared to the DGVs established in Table 3.4. A summary of key results is provided in Table 3.5.

Table 3.5 Summary of water quality results

Indicator	Results summary
Groundwater - Basalt	
Available data	Data is available from seven samples collected as part of the 2023 sampling program. The samples were collected from four monitoring bores that are located to the south of Eulomogo Creek, near the SEA (see Table 3.2). All results are provided in Table A.1 (in Appendix A).
pH	The pH ranged from 7.5 to 8.8, relative to a DGV range of 7 to 8 (annual median range).
Salinity	The electrical conductivity ranged between, 129 to 884 µS/cm, averaging 470 µS/cm. The electrical conductivity was above the DGV of 544 µS/cm (median range) in 3 of 7 samples.
Nutrients	• Total nitrogen concentrations ranged from 3.6 to 20.5 mg/L (averaging 10.7 mg/L). The nitrogen is predominately in oxidised form. The total nitrogen was above the DGV of 0.6 mg/L in all samples. • Total phosphorus concentrations ranged from 0.03 to 0.58 mg/L (averaging 0.15 mg/L). The total phosphorus was above the DGV of 0.035 mg/L in 5 out of 7 samples.
Metals	• Copper exceeded the DGV in all samples. • Aluminium, copper, iron, nickel and zinc exceeded the DGV in at least one sample.
Comments	Groundwater from the basalt is interpreted to flow into the paleochannel (see Section 3.3.3)
Groundwater - Paleochannel	
Available data	Data is available from six samples collected as part of the 2023 sampling program. The samples were collected from DQRC-17 and DQRC-22 which are screened in the paleochannel upgradient of the East Pit. All results are provided in Table A.1 (in Appendix A).
pH	The pH ranged from 7.2 to 8.3, relative to a DGV range of 7 to 8 (annual median range).
Salinity	The electrical conductivity ranged from 297 to 3,290 µS/cm (averaging 1,057 µS/cm). The electrical conductivity was above the DGV of 544 µS/cm (median range) in 3 of 6 samples.
Nutrients	• Total nitrogen concentrations ranged from 5.3 to 16.1 mg/L (averaging 10.7 mg/L). The nitrogen is predominately in oxidised form. The total nitrogen was above the DGV of 0.6 mg/L in all samples. • Total phosphorus concentrations ranged from 0.04 to 0.34 mg/L (averaging 0.11 mg/L). The total phosphorus was above the DGV of 0.035 mg/L in all samples.
Metals	• Copper exceeded the DGV in all samples. • Zinc exceeded the DGV in at least one sample.
Comments	The paleochannel water quality is similar to the basalt water quality, which is expected given that groundwater from the basalt is interpreted to flow into the paleochannel (see Section 3.3.3)
East Pit Lake	
Available data	Data is available from 49 samples completed over the three sampling programs (see Table 3.2). Results are provided in Table A.1, Table A.3 and Table A.5 (in Appendix A).
pH	The pH ranged from 6.3 to 9.0 (averaging 7.5), relative to a DGV range of 7 to 8 (annual median range)
Salinity	The electrical conductivity ranged from 310 to 6,810 µS/cm (averaging 987 µS/cm). The electrical conductivity was above the DGV of 544 µS/cm (median range) in 44 of 49 samples.

Table 3.5 Summary of water quality results

Indicator	Results summary
Turbidity	The turbidity ranged from 0.4 to 299 NTU, averaging 9.2 NTU. Turbidity levels were above the DGV of 20 NTU in 2 out of 49 samples
Nutrients	• Total nitrogen[1] concentrations ranged from below detection to 10.6 mg/L (averaging 3.9 mg/L). The nitrogen was primarily in oxidised form. The total nitrogen was above the DGV of 0.6 mg/L in 44 of 49 samples. • Total phosphorous[1] concentrations ranged from below detection to 0.73 mg/L (averaging 0.32 mg/L). The total phosphorus was above the DGV of 0.035 mg/L in 47 of 49 samples.
Metals	• Zinc exceeded the DGV in 1 out of 4 samples. • Concentrations of all other metals were consistently below the DGVs.
Comments	For the Historic Operations the East Pit has received near continuous groundwater inflows from the paleochannel and intermittent surface water inflows from the upgradient watercourses and the East Pit catchment area. The East Pit Lake water quality is described using the results from 49 samples collected between 2013 to 2023. The data indicates that the water quality is variable but can contain elevated salinity, phosphorus and nitrogen, which is primarily in the form of oxidised nitrogen. Comparison to the paleochannel groundwater quality indicates that the groundwater inflows from the paleochannel are the primary source of the elevated salinity and nutrients in East Pit Lake.
Settling Pond	
Available data	Data is available from 49 samples completed over the three sampling programs (see Table 3.2). Results are provided in Table A.2, Table A.3 and Table A.5 (in Appendix A). It is noted that the Settling Pond has historically received runoff from its contributing catchment as well as water that has been pumped from the East Pit.
pH	The pH ranged from 6.8 to 9.0 (averaging 7.7), relative to a DGV range of 7 to 8 (annual median range)
Salinity	The electrical conductivity ranged from 343 to 6,180 µS/cm (averaging 892 µS/cm). The electrical conductivity was above the DGV of 544 µS/cm (median range) in 38 of 49 samples.
Turbidity	The turbidity ranged from 0.4 to 646 NTU, averaging 97 NTU. Turbidity levels were above the DGV of 20 NTU in 21 out of 49 samples
Nutrients	• Total nitrogen[1] concentrations ranged from 0.05 to 6.9 mg/L (averaging 3.0 mg/L). The nitrogen was primarily in oxidised form. The total nitrogen was above the DGV of 0.6 mg/L in 38 of 49 samples. • Total phosphorous[1] concentrations ranged from below detection to 0.77 mg/L (averaging 0.36 mg/L). The total phosphorus was above the DGV of 0.035 mg/L in 47 of 49 samples.
Metals	• Copper exceeded the DGV in 1 of 4 samples. • Zinc exceeded the DGV in 1 of 4 samples.
Comments	The Settling Pond water quality is similar to the East Pit Lake water quality which is expected given the East Pit Lake has been dewatered into the Settling Pond.
Eulomogo Creek (upstream)	
Available data	Data is available from 24 samples completed over the three sampling programs (see Table 3.2). Results are provided in Table A.2, Table A.3, Table A.4 and Table A.5 (in Appendix A).
pH	The pH ranged from 6.8 to 9.0 (averaging 7.7), relative to a DGV range of 7 to 8 (annual median range)
Salinity	The electrical conductivity ranged from 280 to 3,940 µS/cm (averaging 1,128 µS/cm). The electrical conductivity was above the DGV of 544 µS/cm (median range) in 15 of 24 samples.
Turbidity	The turbidity ranged from 1.1 to 358 NTU, averaging 28 NTU. Turbidity levels were above the DGV of 20 NTU in 4 out of 24 samples

Table 3.5 Summary of water quality results

Indicator	Results summary
Nutrients	• Total nitrogen[1] concentrations ranged from 0.1 to 5.1 mg/L (averaging 0.95 mg/L). The nitrogen was primarily in oxidised form. The total nitrogen was above the DGV of 0.6 mg/L in 10 of 24 samples. • Total phosphorous[1] concentrations ranged from below detection to 0.84 mg/L (averaging 0.31 mg/L). The total phosphorus was above the DGV of 0.035 mg/L in 22 of 24 samples.
Metals	• Concentrations for all metals were consistently below the DGVs.
Comments	The Eulomogo Creek water quality upstream of the quarry is variable but can contain salinity and turbidity levels and concentrations of nutrients that are above DGVs. These characteristics are typical for an intermittent watercourse that receives some groundwater inflows and has a catchment comprising mostly cleared agricultural land.
Eulomogo Creek (downstream)	
Available data	Data is available from 45 samples completed over the three sampling programs (see Table 3.2). Results are provided in Table A.2, Table A.3, Table A.4 and Table A.5 (in Appendix A).
pH	The pH ranged from 7.0 to 8.8 (averaging 7.8), relative to a DGV range of 7 to 8 (annual median range)
Salinity	The electrical conductivity ranged from 481 to 6,300 µS/cm (averaging 1,050 µS/cm). The electrical conductivity was above the DGV of 544 µS/cm (median range) in 40 of 45 samples.
Turbidity	The turbidity ranged from 0.5 to 995 NTU, averaging 36 NTU. Turbidity levels were above the DGV of 20 NTU in 8 out of 45 samples
Nutrients	• Total nitrogen[1] concentrations ranged from 0.1 to 16.5 mg/L (averaging 2.6 mg/L). The nitrogen was primarily in oxidised form. The total nitrogen was above the DGV of 0.6 mg/L in 27 of 45 samples. • Total phosphorous[1] concentrations ranged from below detection to 1.5 mg/L (averaging 0.33 mg/L). The total phosphorus was above the DGV of 0.035 mg/L in 43 of 45 samples.
Metals	• 1 of 4 samples exceeded the DGV for aluminium, arsenic, copper, iron, manganese and zinc.
Comments	The Eulomogo Creek water quality downstream of the quarry is similar to the upstream water quality except total nitrogen concentrations were higher, with the average increasing from 1.0 to 2.6 mg/L. This may be attributed to East Pit dewatering which had an average total nitrogen concentration of 3.9 mg/L.

1. Most of the data is from the Holcim Sampling program which only analysed oxidised nitrogen and reactive phosphorus. The concentrations of these analytes were assumed to be total nitrogen and phosphorus respectively for the purposes of providing a concise summary.

4 Continuation Project water management

This chapter describes the water management approach for the Continuation Project, which involves the continued operations in the existing quarry and the development of two new resource areas, the WEA and SEA. Section 4.1 describes the water management approach and system and Section 4.2 describes the proposed measures.

4.1 Water management system description

The water management system for the two expansion areas will be integrated with the quarry's existing water management system. This will require construction of new infrastructure, some modifications to existing infrastructure and new operating principles. The following sections describe the water management objectives and approach and the water management system layout and functionality.

4.1.1 Objectives and approach

Table 4.1 describes the water management objectives and approach. It is noted that the objectives and approach for monitoring, review and water licencing are discussed separately in Chapters 6 and 7.

Table 4.1 Water management objectives: Continuation Project

Water management objective	Approach
1. Minimise groundwater inflows into existing and new quarry pits	• The WEA and SEA pits will be developed such that they do not intersect the paleochannel. • The East Pit will be allowed to fill to the equilibrium level range (see Section 3.4) which will minimise groundwater inflows from the paleochannel into the East Pit.
2. Minimise the risk of East Pit Lake levels exceeding the safe spill level (280.2 m AHD) - discussed in Section 3.4.2	• A piped drainage system will be installed through the fill embankment to enable the East Pit Lake to overflow to the Sediment Pond if the lake levels exceed the safe spill level (280.2 m AHD) • The East Pit surface water diversion will be constructed by June 2025. Once constructed this diversion will minimise surface water inflows into the East Pit from the upgradient watercourses.
3. Cease controlled discharges from quarry pits	• The East Pit will be allowed to fill to the equilibrium level range which is expected to be below the safe spill level (see Section 3.4). Therefore, controlled discharged from the East Pit are not expected. • Water collected in the sumps of the WEA and SEA pits will be pumped to the East Pit or managed in a way that does not require discharge of surplus water. For example, water could be used to fill water carts. The East Pit will provide a significant storage that can be utilised to minimise discharges and provide a reliable supply of water to the quarry. • Sedimentation dams will be dewatered to a quarry pit following rainfall.
4. Provide a reliable water supply for the quarry operation	• Operational water will be extracted from the East Pit Lake, which is a reliable water supply due to its connectivity with the paleochannel.
5. Provide industry best practice erosion and sedimentation controls for disturbance areas that do not drain to a quarry pit.	• Drainage, erosion and sediment controls will be constructed and maintained in all areas disturbed by the quarry or associated construction activities that do drain to a quarry pit. The controls will be designed, constructed and operated in accordance with the methods recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008). • The sediment treatment volume in sedimentation dams will be dewatered to a quarry pit within 5 days following the cessation of rainfall so that capacity is available to capture runoff from the next event.

4.1.2 System description

The water management system will be constructed and operated to achieve the water management objectives described in Table 4.1. Key changes to the water management system for the Historic Operations (see Section 3.5) include:

- Dewatering of the East Pit will cease, and the East Pit Lake will be allowed to fill to the equilibrium level range, which is estimated to be between 274 and 279 m AHD (see Section 3.4.4), below the safe spill level (280.2 m AHD). This will minimise groundwater inflows from the paleochannel and eliminate the need for controlled discharges to Eulomogo Creek that have historically been associated with the dewatering activities.

- A piped drainage system will be installed through the fill embankment to enable the East Pit Lake to overflow to the Sediment Pond if the lake levels exceed the safe spill level (280.2 m AHD).

- By June 2025, the East Pit surface water diversion will be constructed which will minimise inflows into the East Pit from the upgradient watercourses.

- The surface water system will be expanded to manage runoff from the WEA and SEA and associated connecting haul roads.

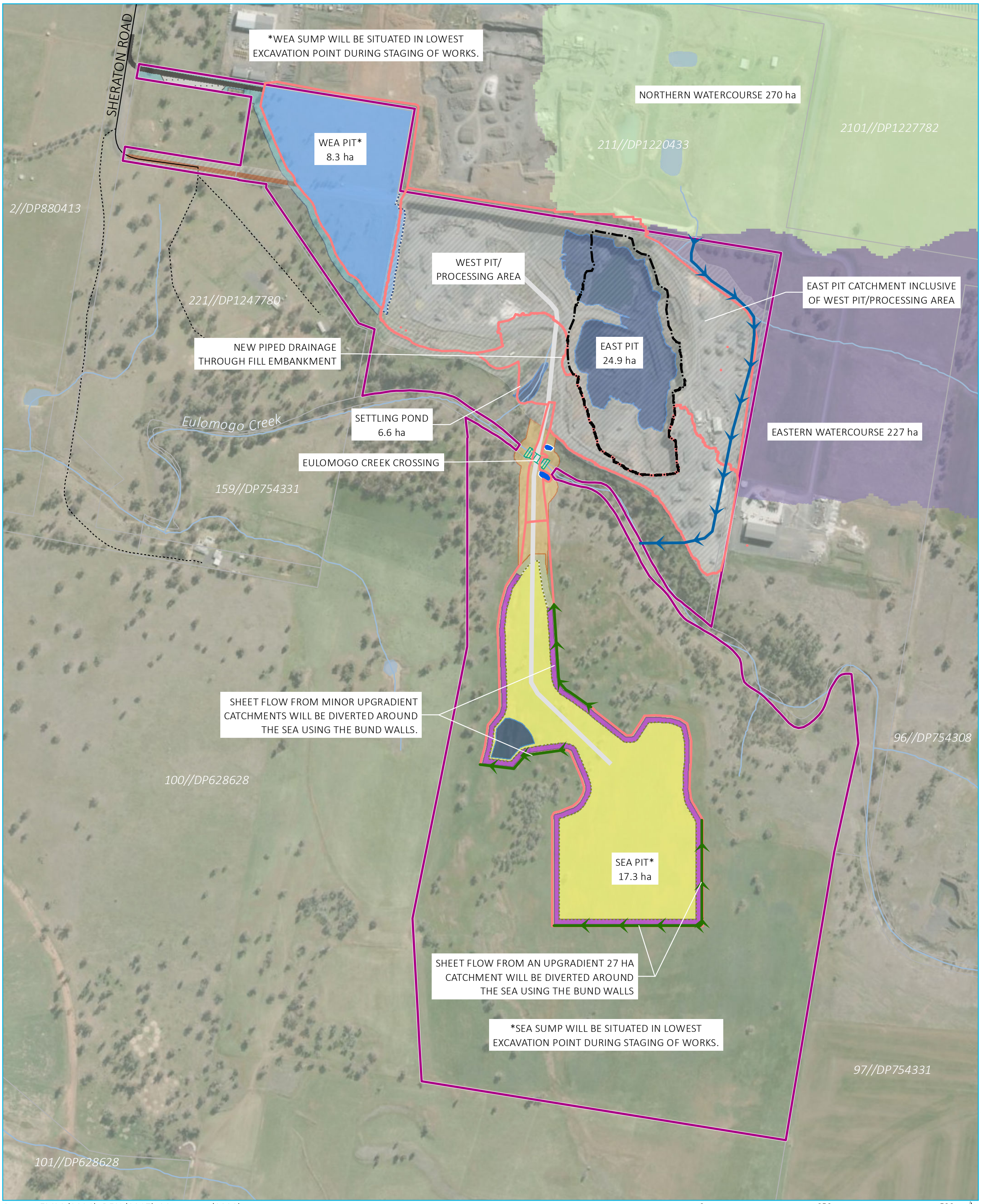
The East Pit Lake will continue to be utilised as a central storage that will receive water pumped from other surface water storages and supply water for operational uses.

The system layout is shown in Figure 4.1 and the system framework is shown in Figure 4.2.

Water inflows and discharges for each quarry stage are described in Chapter 5.

4.2 Water management measures

Table 4.2 (shown after the figures) provides an itemised list of water management measures that will be implemented as part of the Continuation Project. The table includes a description of each measure, expected outcomes and timeframes for implementation. Each measure is also given an ID for reference in other parts of this WMP.



Source: EMM (2024); DFSI (2017); Metromap (2023)

0 250 500 m
GDA 1994 MGA Zone 55
N

KEY

- Project area
- Proposed sub catchment
- The Eastern Watercourse - 277 ha
- The Northern Watercourse - 270 ha
- Indicative existing disturbance area
- East pit (extraction boundary)
- Proposed water management storage
- Proposed sedimentation pond
- Indicative proposed water crossing
- Bund wall
- Alternative access road
- Alternative truck tarping area
- Existing access road
- Proposed haul road
- Western extension area
- Western disturbance area
- Haul road disturbance area
- Southern extension area
- Southern disturbance area
- Potential watercourse diversion (post
- Upgradient catchment diversion
- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)

Continued operations water management system layout

Dubbo Quarry Continuation Project
Water management plan
Figure 4.1

EMM
creating opportunities

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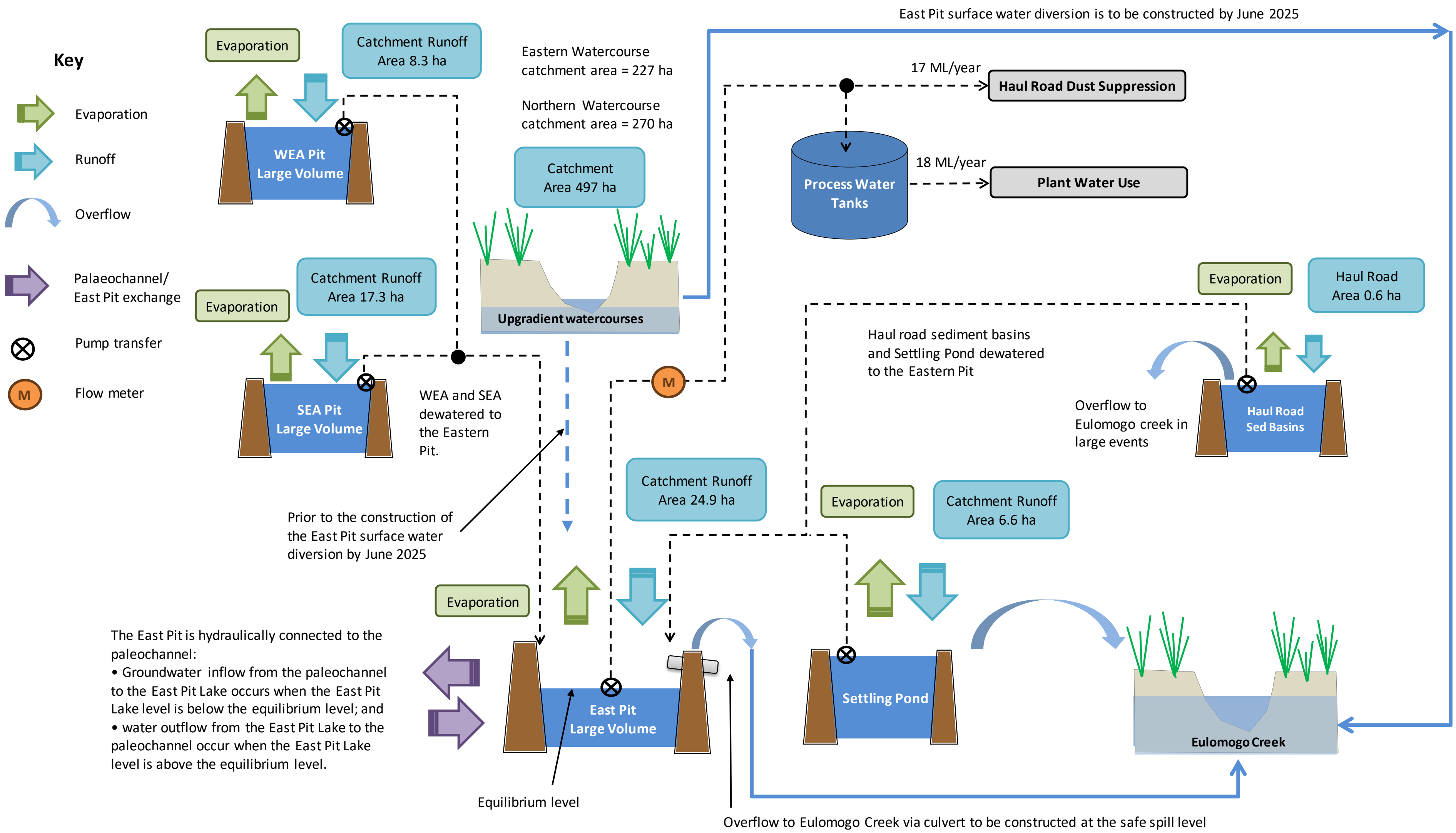


Figure 4.2 Water management system framework – Continuation Project

Table 4.2 Water management measures – Continuation Project

ID	Description	Outcomes	Implementation timeframes
1	**Groundwater inflow management**		
1.1	**WEA and SEA pit development** Condition A8 requires that extraction must not be undertaken below a level of 285 m AHD in the WEA and 288.5 m AHD in the SEA and must be 2 m above the regional alluvial aquifer. To address this condition, Holcim will validate the extent and levels of the palaeochannel (the regional alluvial aquifer) in the extraction areas using available data and (if required) data from additional drilling. This data will be used to ensure that the pit floor is at least 2 m above the top of the paleochannel as required under condition A8. This validation and pit design process will be undertaken incrementally. The palaeochannel is the alluvial aquifer media (ie comprising alluvial deposited material such as gravel, sand and clay). The top of the palaeochannel may therefore be higher than the water table.	• The paleochannel will not be intersected by the new extension areas • Compliance with Condition A8	For the duration of the construction and operational phases of the Continuation Project[1]
1.2	**East Pit Lake dewatering** Dewatering of the East Pit Lake to Eulomogo Creek will cease, and the lake will be allowed to fill to the equilibrium level range (see Section 3.4)	• Groundwater inflows from the paleochannel to the East Pit will be minimised • Controlled discharges to Eulomogo Creek that have historically been associated with the East Pit dewatering activities will cease	For the duration of the operational phase of the Continuation Project[1]
2	**Surface water management during operations**		
2.1	**East Pit safe overflow arrangement** A piped drainage system will be installed through the fill embankment to enable the East Pit Lake to overflow to Eulomogo Creek if the lake levels exceed the safe spill level (280.2 m AHD). A potential location of piped drainage system is indicated in Figure 4.1 and Figure 3.6. The Sediment Pond is to be configured so that any overflows from the East Pit bypass the pond and flow into Eulomogo Creek.	The East Pit Lake will overflow via a gravity operated system if the East Pit Lake level exceeds the safe spill level. This will mitigate the risk of water ponding against the fill embankment for an extended period of time.	These works will be constructed as part of the Eulomogo Creek crossing (see Measure 4.1), which requires reconfiguration of the existing haul road at the overflow location.

Table 4.2 Water management measures – Continuation Project

ID	Description	Outcomes	Implementation timeframes
2.2	**East Pit surface water diversion** Drainage works will be constructed to divert runoff from the upgradient watercourses around the East Pit, into Eulomogo Creek. A potential alignment for the diversion works is shown in Figure 4.1. A preliminary design of the drainage works will be provided to DPE separately to this WMP. The approved concept will be constructed, and any maintenance and monitoring requirements established during the consultation process will be implemented.	• Minimise surface water ingress into the East Pit • Compliance with Condition B33	• A preliminary design of the proposed East Pit surface water diversion works will be submitted to DPE by January 2024 (unless otherwise agreed by the DPE) • Any required consent modification will be submitted to DPE by January 2024 (unless otherwise agreed by the DPE) • Construction of the works will be completed by June 2025 (unless otherwise agreed by the DPE)
2.3	**Drainage within quarry areas that drain to a pit sump** Drainage will be constructed and maintained such that: • surface runoff does not drain away from the pit sump during intense rainfall events • the drains do not become significantly eroded Where practical, the use of viaducts or fill embankments to direct water to a pit sump will be avoided. The WEA and SEA pit sumps will be either dewatered to the East Pit or managed in a way that does not require discharge of surplus water. For example, water could be used to fill water carts.	• Ensure that surface water runoff from any area disturbed by the quarry does not drain away from the quarry's water management system • Minimise erosion within quarry areas • Avoid controlled discharges from the quarry pits to Eulomogo Creek	For the duration of the construction and operational phases of the Continuation Project[1]

Table 4.2 Water management measures – Continuation Project

ID	Description	Outcomes	Implementation timeframes
2.4	**Drainage within catchments that do not drain to a pit sump** Examples include the Settling Pond and Haul Road sedimentation dams (see Figure 4.1). • Drainage, erosion and sediment controls will be constructed and maintained in all areas disturbed by the quarry that do not drain to a quarry pit. The controls will be designed, constructed and operated in accordance with the methods recommended in *Managing Urban Stormwater Soils and Construction: Volume 1 (Landcom 2004) and Volume 2E Mines and Quarries (DECC 2008).* • The sediment treatment volume in sedimentation dams will be dewatered to a quarry pit within 5 days following the cessation of rainfall to ensure capacity is available to capture runoff from the next event.	• Ensure that best practice erosion and sediment controls are implemented in quarry areas that do not drain to a pit sump • Compliance with Condition B36. It is noted that to address Condition B36, a preliminary design of the sedimentation basins is provided in Appendix C. This preliminary design may be superseded by the final design of the Eulomogo Creek crossing that will include the basins and haul road and be prepared in consultation with DPE Water as a separate process to this WMP (see Measure 4.1).	For the duration of the construction and operational phases of the Continuation Project[1]
2.5	**Operational water supply** Operational water will be sourced from the East Pit Lake (which is a reliable water supply) or from the WEA and SEA pit sumps or sedimentation dams when water is available.	• Ensure that the quarry has a reliable water supply to meet operational requires for dust suppression and material processing	For the duration of the construction and operational phases of the Continuation Project[1]
2.6	**Management of fuel, oil and chemical products** Chemical products, including fuels and oils will be stored and handled in accordance with relevant Australian Standard AS1940:2004 and the Bunding and spill management guidelines: Storing and Handling Liquids: Environmental Protection: Participant's Manual (DECC 2007).	• Ensure that best practice source controls are implemented in areas that fuel, oil and chemicals are stored and handled.	For the duration of the construction and operational phases of the Continuation Project[1]

Table 4.2 Water management measures – Continuation Project

ID	Description	Outcomes	Implementation timeframes
2.7	**Clean water management in SEA and WEA** The WEA is located on a high point in the terrain that only receives upgradient runoff from a small area that is part of the South Keswick Quarry operation. Runoff from this area is managed in the South Keswick Quarry's water management system. Hence, no clean water diversions are required for the WEA. The SEA receives sheet flow from a 27 ha catchment located to the south-east of the extraction area, and from minor areas (1-2 ha) near the centre of the SEA. Runoff from these catchments will be diverted around the extraction area using the bunds that will be established around the perimeter of the pit. Drainage along the toe of the bunds will have a positive gradient and will therefore be free draining (ie no head water dams, earthworks or pumping will be required). The bund drains are indicated in Figure 4.1.	• Ensure separation of clean and dirty water in the new extraction areas.	For the duration of the construction and operational phases of the Continuation Project[1]
3	**Water management during construction works**		
3.1	**Earthworks in areas that do not drain to a quarry pit sump** An erosion and sediment control plan will be prepared for any earthworks that: • have a disturbance area greater than 0.25 ha; and • are in an area that does not drain to a quarry pit sump Examples include, construction of the East Pit surface water diversion, construction of haul roads and initial development of the SEA and WEA. Each plan will be prepared in accordance with the methods described in Managing Urban Stormwater Soils and Construction: Volume 1 (Landcom 2004) and Volume 2E Mines and Quarries (DECC 2008). The ESC will be implemented during the duration of the construction works.	• Ensure that best practice erosion and sediment controls are implemented for construction works in areas that do not drain to a quarry pit sump.	Prior to earthworks commencing outside of an area that drains to a quarry pit sump.

Table 4.2 Water management measures – Continuation Project

ID	Description	Outcomes	Implementation timeframes
4	**Eulomogo Creek Crossing**		
4.1	**Design and construction of creek crossing** A detailed design of the Eulomogo Creek crossing, haul road sedimentation basins and the adjoining haul road areas will be prepared in consultation with DPE Water as a separate process to this WMP. The approved design will be constructed, and any maintenance and monitoring requirements established during the consultation process will be implemented.	• Compliance with consent condition B37 • Haul road crossing of Eulomogo Creek to access the SEA.	The design and construction will occur prior to the commencement of developing the SEA.

Note 1 – Requirements for the rehabilitation phase of the project are described separately in the Rehabilitation Management Plan

5 Water inflows and discharges

This chapter describes water management system inflow and discharge regimes from the quarry for the Historic Operations and Continuation Project quarry stages. The initial two sections describe the contributing processes for each inflow (Section 5.1) and discharge (Section 5.2) mechanism. Section 5.3 presents water balance model results that are used to describe the estimated inflow and discharge regimes for the following scenarios (the water balance scenarios):

- Historic Operations
- Continuation Project (no East Pit surface water diversion)
- Continuation Project (with East Pit surface water diversion)

The two Continuation Project scenarios are provided to show the positive effect that the East Pit surface water diversion will have on reducing system inflows and discharges and should not be confused with the quarry stages described in Section 1.4.

The water inflow descriptions and estimates are used in this WMP to describe the functionality of the proposed water management system and to address water licensing requirements (addressed in Chapter 7). Water discharge estimates are used to address the requirements of the Discharge Characterisation Report that is required by Condition B35. Section 5.4 specifically addresses the requirements of this condition.

5.1 System inflows

The water management systems for the Historic Operations and the Continuation Project are described in Sections 3.5 and 4.1 respectively. This section describes the following system inflows which are relevant to all quarry stages:

- inflows from the paleochannel to the East pit (Section 5.1.1)
- groundwater seeps from the basalt into the East Pit (Section 5.1.2)
- surface water runoff from upgradient watercourses (Section 5.1.3)
- surface water runoff from the area disturbed by the quarry (Section 5.1.4)

5.1.1 Paleochannel inflows

Historic quarry activities in the East Pit intercepted the underlying palaeochannel which has resulted in the East Pit Lake being hydraulically connected to the palaeochannel aquifer. Inflows from the paleochannel into the East Pit have historically occurred as the East Pit Lake was dewatered to levels below the equilibrium level to maintain quarry access. Dewatering will permanently cease when the Continuation Project is commenced (see Measure 1.2 in Table 4.2). This will allow the East Pit Lake to fill to the equilibrium level range which is estimated to be between 274 and 279 m AHD, with an expectation that the ultimate range will be narrower (ie water levels will vary by 1 to 2 m overtime) and be in the lower half of the estimated range (ie between 274 and 276.5 m AHD) - see Section 3.4.4).

i Historic Operations

For the Historic Operations quarry stage, inflows into the East Pit occur due to:

- surface water runoff from the East Pit Catchment (24.4 ha)

- runoff from the upgradient watercourses which drain into the East Pit
- groundwater inflows into the East Pit from the paleochannel – when the pit lake level is below the equilibrium level.

Outflows occur due to:

- East Pit dewatering to maintain quarry access
- water extraction for operation uses
- evaporation losses

A water balance model has been applied to estimate paleochannel inflows based on the above system inflows and outflows and the East Pit paleochannel flow exchange curve (see Figure 3.10). The water balance was configured to dewater the pit when the East Pit Lake water level exceeds 273 m AHD.

ii Continuation Project

a Pit filling period

The volume of water required to fill the East Pit Lake to the equilibrium level range will depend on the initial pit lake level and the ultimate equilibrium range. Assuming an initial pit lake level of 273 m AHD, from the level storage curve (Figure 3.7), between 20 and 200 ML of water would be required to fill the pit to the lower and upper levels in the estimated equilibrium range of 274 to 279 m AHD.

The pit filling time and portion of the fill volume that originates from the paleochannel will depend on the pit fill volume and the weather during the filling period as surface water runoff from the East Pit catchment (24.4 ha) and the upgradient watercourse could contribute to filling.

A pit filling scenario is not included in the water balance model as the process can be described qualitatively. Water take during the pit filling period will be calculated using monitoring data. A methodology is provided in Chapter 7.

b Following pit filling

Once the East Pit Lake has filled to the equilibrium level range, ongoing groundwater inflows from the paleochannel to the East Pit will occur:

- to replace evaporation losses from the East Pit Lake
- to replace water extracted for operational purposes
- due to temporal changes in the paleochannel groundwater heads. For example, if groundwater heads in the paleochannel rise following an extended wet period the equilibrium level will rise by a commensurate amount which will result in additional inflows from the paleochannel.

It is noted that the magnitude of groundwater inflows due to the above mechanisms will be offset by surface water inflows into the East Pit which will occur intermittently during wet weather.

The water balance model estimates paleochannel inflows based on evaporation and water extraction rates and surface water inflows. The model does not account for temporal changes in the paleochannel groundwater heads which is a limitation.

Chapter 7 includes a methodology for calculating the annual water take due to paleochannel inflows to the East Pit using a combination of monitoring data and estimates of evaporation losses.

5.1.2 Basalt inflows

The groundwater level observed in monitoring bores screening the Tertiary basalt experience short-term fluctuations with rainfall (Figure 3.3). The longer-term equilibrium level observed at each bore (between rainfall event) represents the 'phreatic surface' within the fractured rock aquifer.

The southern and western extension areas are proposed to be excavated to 286 and 283 m AHD. At these depths it is not anticipated that the excavations will intercept the phreatic surface.

The phreatic surface at monitoring bore DRQC-23 (near East Pit) is approximately 281 m AHD. East Pit was excavated to below 270 m AHD and therefore may intercept groundwater. For the Continuation Project, the East Pit Lake will be allowed to fill to the equilibrium level range (274 and 279 m AHD) which will mean that the aquifer depressurisation resulting from East Pit could be between 2 and 7 m.

To address water licencing requirements, the component of East Pit inflow that is derived from the fractured rock aquifer has been estimated using an analytical calculation. A modified version of the Dupuit-Theim equation for unconfined aquifer conditions was employed to provide a steady state estimate for inflows to East Pit.

$$Q = 2\pi Kb \frac{s}{\ln\left(\frac{ro}{rw}\right)}$$

Textbook hydrogeological parameters for basalt were used and appropriate hydrogeological assumptions (refer Table 5.1). The adopted value for hydraulic conductivity was varied by an order of magnitude to account for the potential variation in the fractured rock geology.

Table 5.1 East Pit inflow calculation

Parameter	Description	Unit	Assumed value
K	hydraulic conductivity	m/d	0.1 - 0.01
b	aquifer thickness	m/d	20
s	Drawdown	m	5
rw	radius of pit	m	100
ro	radius of cone of depression	m	250
t	time since inflow started	days	365
Sy	Specific yield	%	10
Q	inflow to pit	kL/d	6 - 60

Based on the above methodology and assumptions, the groundwater inflows to East Pit from the fractured rock aquifer is estimated to be between 6 to 60 kL/day (equating to 2 to 22 ML/year).

As this estimate is sensitive to the East Pit Lake level it will be calculated and reported annually, using the average pit lake level over each water year and a maximum value for hydraulic conductivity (ie 0.1 m/d). This is discussed further in Chapter 7 which describes the approach to address water regulations.

5.1.3 Inflows from the upgradient watercourses

Runoff from the upgradient watercourses enters the northern portion of the East Pit. As these watercourses are ephemeral, runoff only occurs occasionally following substantial rainfall. The watercourses have a contributing catchment area of 497 ha (see Section 3.2.2) and therefore have potential to contribute large volumes of runoff during flood producing rainfall. For example, approximately 500 ML of runoff would occur from a rainfall event that produces 100 mm of runoff from the catchment. In September and October 2022 inflows from the upgradient watercourses entered the East Pit which resulted in the water level rising approximately 6 m, to around 280 m AHD, indicating that 200 to 250 ML of runoff occurred (see Section 3.4).

Holcim propose to construct the East Pit surface water diversion by June 2025 (see Measure 2.2 in Table 4.2). Once constructed, all runoff up to the design capacity of the diversion system will be diverted around the East Pit, into Eulomogo Creek.

Inflows from the upgradient watercourses are included in the water balance for the Historic Operation and Continuation Project (no East Pit surface water diversion) scenarios. It is assumed that all runoff is diverted to Eulomogo Creek for the Continuation Project (with East Pit surface water diversion) scenario.

To address water licencing requirements, annual water inflow volumes from the upgradient watercourses will be estimated each water year using monitoring data. A methodology is provided in Chapter 7.

5.1.4 Runoff from quarry areas

The quarry's water management system receives runoff from areas disturbed by the quarrying activities, which include areas that drain to pit sumps and areas that drain to sedimentation basins. The total quarry area for the Historic Operations is 31.1 ha. This will increase to 57.7 ha when the Continuation Project is fully developed.

The water balance model for each quarry stage applies runoff from each catchment to its receiving storage (either a pit sump or a sedimentation dam), catchment areas and storages are shown in Figure 3.11 (Historic Operations) and Figure 4.1 (Continuation Project). The water balance model assumes that all pit sumps and sedimentation dams are dewatered to the East Pit. However, it is noted that operational water could be used directly from any pit sump or sedimentation dam without impacting the water balance.

5.2 Water discharges

This section describes the following discharge mechanisms from the quarry's water management system:

- discharges from the East Pit due to dewatering activities, overflows and outflows into the paleochannel (Section 5.2.1)
- sedimentation dam overflows (Section 5.2.2)

It is noted that the WEA and SEA pit sumps will be either dewatered to the East Pit or managed in a way that does not require discharge of surplus water (see Measure 2.3 in Table 4.2). Hence, there will be no controlled discharge to Eulomogo Creek from these pit sumps.

5.2.1 East Pit

i Controlled discharges

Holcim have historically dewatered the East Pit Lake to maintain access to the quarry floor. The dewatering has been undertaken via pumping water into the Settling Pond, which overflows into Eulomogo Creek. For the Historic Operations water balance scenario, the model was configured to dewater the pit when the East Pit Lake level exceeds 273 m AHD.

Dewatering activities will permanently cease when the Continuation Project quarry stage commences (see Measure 1.2 in Table 4.2).

ii Overflows

Holcim propose to construct a piped drainage system through the fill embankment that is located to the west of the East Pit to enable the East Pit Lake to overflow to the Sediment Pond if the lake levels exceed the safe spill level of 280.2 m AHD (see Measure 2.1 in Table 4.2).

The safe spill level is above the estimated equilibrium level range which is between 274 and 279 m AHD, with an expectation that the ultimate range will be narrower (ie water levels will vary by 1 to 2 m overtime) and be in the lower half of this estimated range (ie between 274 and 276.5 m AHD). Accordingly, overflows from the East Pit are only expected to occur due to significant surface ingress from:

- the upgradient watercourses which have a 497 ha catchment area
- runoff from the East Pit Catchment (24.9 ha) and pumped inflows to the East Pit from other pit sumps and sedimentation dams (the quarry area for the Continuation Project is 57.7 ha, including the East Pit).

Holcim propose to construct the East Pit surface water diversion by June 2025. Once constructed the effective catchment area to the East Pit will reduce from 555 ha (ie upgradient watercourse plus quarry area) to 57.7 ha, nearly a 90% reduction. This will significantly reduce the frequency and volume of any overflows.

The water balance model is applied to estimate overflows for the three water balance scenarios. The current overflow level of 286 m AHD was applied to the Historic Operations scenario and the safe spill level of 280.2 m AHD was applied to the Continuation Project scenarios.

iii Outflows to the paleochannel

Section 3.4 established that as the East Pit is hydraulically connected to the groundwater system in the underlying paleochannel, and water from the East Pit Lake can flow into the paleochannel when the water level in the East Pit Lake exceeds the equilibrium level at a given point in time. This could occur:

- if surface water ingress into the East Pit Lake exceeds evaporation and water extraction volumes
- due to temporal changes in the paleochannel groundwater heads. For example, if groundwater heads in the paleochannel decline during an extended dry period the equilibrium level will reduce by a commensurate amount which will result in outflows from the pit lake to the paleochannel.

The water outflow volumes will be offset by evaporation losses and water extraction for operational purposes which will both remove water from the East Pit Lake, reducing the lake level. The East Pit surface water diversion (to be constructed by June 2025) will also significantly reduce surface water inflows into the East Pit Lake which will reduce the frequency and magnitude of outflows to the paleochannel.

The water balance model calculates the outflows to the paleochannel based on the East Pit paleochannel flow exchange curve (see Figure 3.10).

5.2.2 Sedimentation dam overflows

Runoff from quarry areas that do not drain to a quarry pit will be managed in sedimentation dams that will be sized using the methods recommended in *Managing Urban Stormwater: Volume 1* (Landcom 2004) and *Volume 2E* (DECC 2008) (see Measures 2.4 and 2.6 in Table 4.2). The sediment treatment volume within the dams will be dewatered to a quarry pit within 5 days following the cessation of rainfall to ensure capacity is available to capture runoff from the next event. Sedimentation dams will overflow to Eulomogo Creek when the design capacity is exceeded. The overflows will only occur for short periods of time during wet weather.

5.3 Water balance model results

The water balance model documented in the Water Assessment Addendum Report (EMM 2022) has been updated to reflect the water management systems for the Historic Operations and Continuation Project quarry stages that are described in the report and the revised conceptualisation of the flow exchange between the East Pit and the paleochannel (see Section 3.4). The model has been applied to simulate the following scenarios:

- Historic Operations
- Continuation Project (no East Pit surface water diversion)
- Continuation Project (with East Pit surface water diversion)

The two Continuation Project scenarios are provided to show the positive effect that the East Pit surface water diversion will have on reducing system inflows and discharges and should not be confused with the quarry stages described in Section 1.4.

The water balance model is described in Appendix B. Key model results are presented in this section. The model has certain limitations and uncertainties which are also discussed throughout the section.

5.3.1 Key model assumptions and limitations

Water balance models have been developed to simulate the functionality of the water management system for each scenario. The following key assumptions have been applied to the models:

- Water exchange between the East Pit Lake and the paleochannel is based on the average East Pit paleochannel flow exchange curve (see Figure 3.10). This curve assumes the equilibrium level is 276.5 m AHD, in the middle of the estimated equilibrium range (274 to 279 m AHD). This assumption has been applied to all scenarios. The flow exchange is calculated by the model on a daily time step based on the simulated water level in the East Pit Lake. The model does not account for any temporal changes in the paleochannel groundwater heads which will occur overtime and result in changes to the equilibrium level. This is a key limitation of the model.
- Rainfall runoff models have been parametrised using standard methods (described in Appendix B). The models have not been calibrated.
- Operational water use has been estimated using information provided by Holcim and standard methods (described in Appendix B).
- The Historic Operations scenario assumes that the East Pit Lake is dewatered when the water level exceeds 273 m AHD.
- The following assumptions have been applied to the Continuation Project model scenarios:
  - The water management measures described in Table 4.2 are implemented
  - The SEA and WEA pit sumps and all sedimentation dams are dewatered to the East Pit.
  - The East Pit surface water diversion diverts all runoff from the upgradient watercourses around the East Pit (for the with East Pit diversion scenario only).

In summary the models have been developed to simulate the functionality of the water management system for each scenario. The models for each scenario have been parameterised with similar assumptions which are predominately based on interpretations of limited data (ie the flow exchange curve) or typical values (ie the runoff models). Accordingly, the model results are useful for describing the relative changes to inflow and discharge regimes between each scenario but have considerable uncertainty in the predicted values and occurrence frequencies. For this reason, this WMP includes commitments to:

- monitor water level and quality at key locations so that:
  - water take and discharges can be calculated and assessed each year using monitoring data
  - calibrated models can be prepared in future if required
- revise this WMP if overflows from the East Pit Lake exceed certain thresholds (described in Chapter 6).

These commitments are discussed further in Chapters 6 and 7.

Model uncertainty is discussed further in Section 5.3.3.

5.3.2 Model results

i Results

The following model results are presented in this Section:

- Figure 5.1 is a daily exceedance probability chart that compares the simulated East Pit Lake water level for each water balance scenario to the assumed equilibrium level (276.5 m AHD).
- Figure 5.2 is an annual exceedance probability chart that shows the simulated paleochannel inflow volumes to the East Pit for each water balance scenario.
- Figure 5.3 is an annual exceedance probability chart that shows the simulated outflows from the East Pit to the paleochannel for each water balance scenario.
- Figure 5.4 is an annual exceedance probability chart that shows the simulated surface water inflow volumes to the East Pit due to runoff from the upgradient watercourse and the quarry area.
- Figure 5.5 is an annual exceedance probability chart that shows the simulated discharges from the East Pit to Eulomogo Creek due to controlled discharges (Historic Operations only) and East Pit overflows (Continuation Project scenarios only).

Appendix B contains water balance results in flow chart and table formats for dry, median and wet years for each water balance scenario. The results are discussed following the figures.

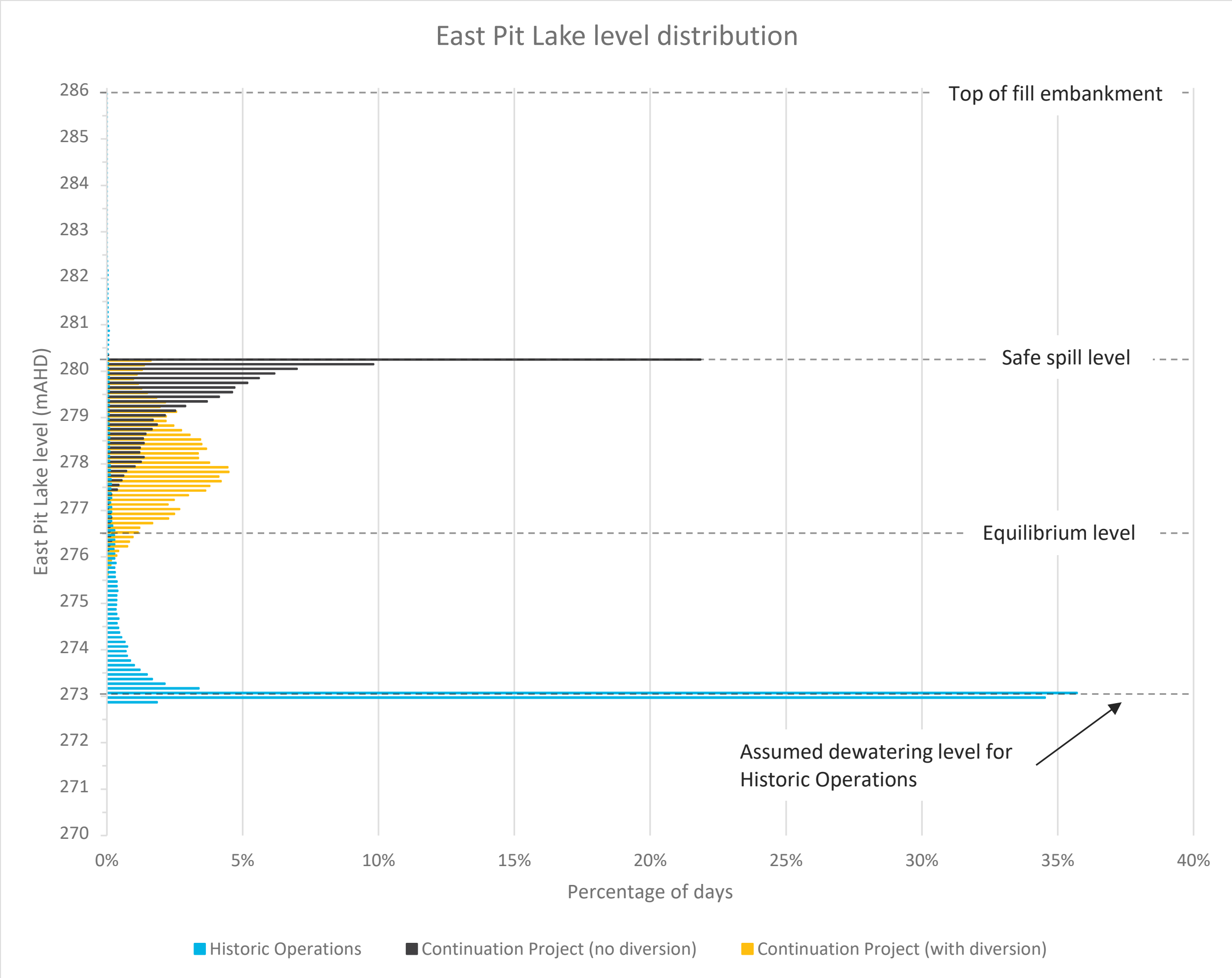


Figure 5.1 East Pit water level – daily exceedance probability

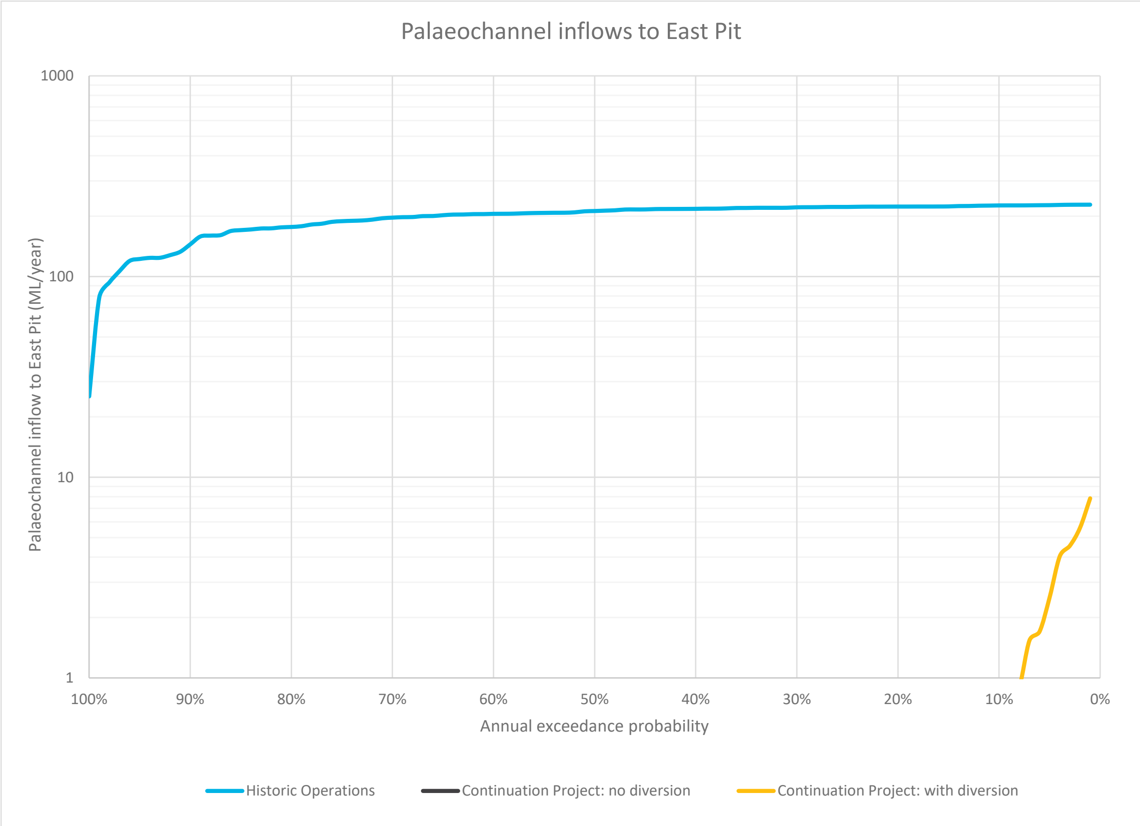


Figure 5.2 Paleochannel inflows to East Pit – annual exceedance probability

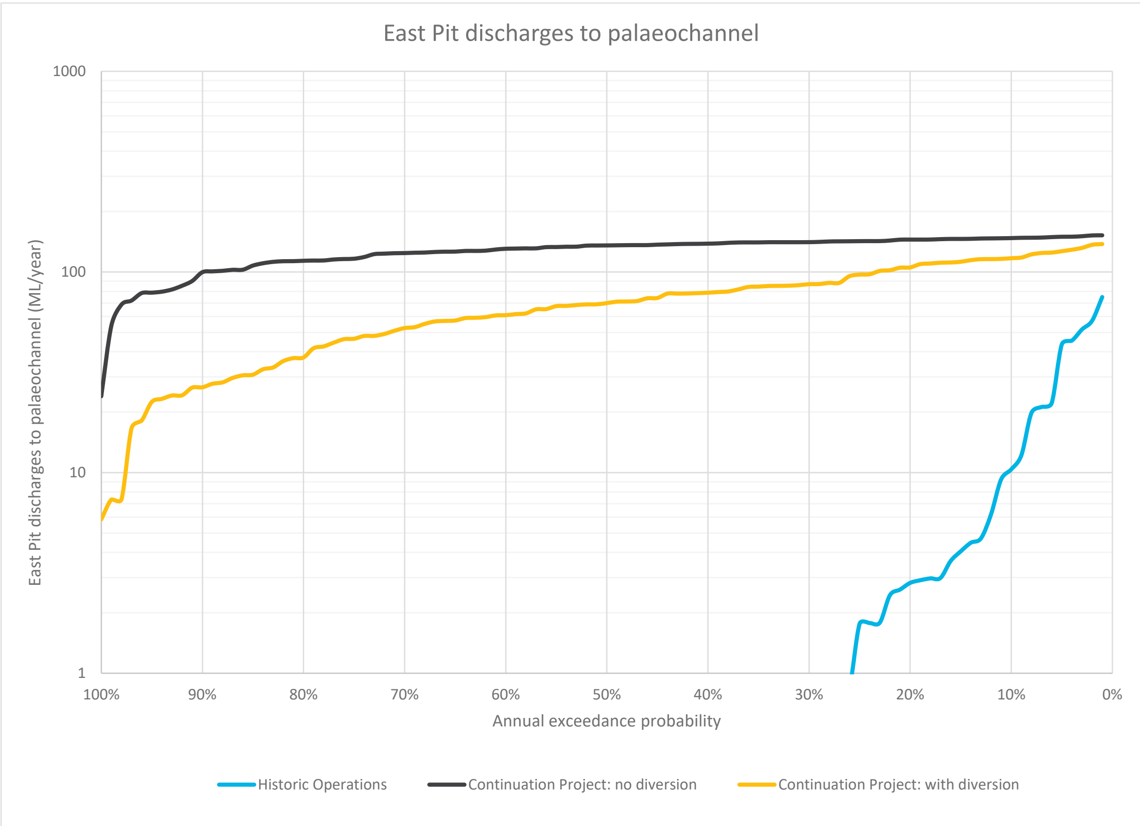


Figure 5.3 East pit outflows to palaeochannel – annual exceedance probability

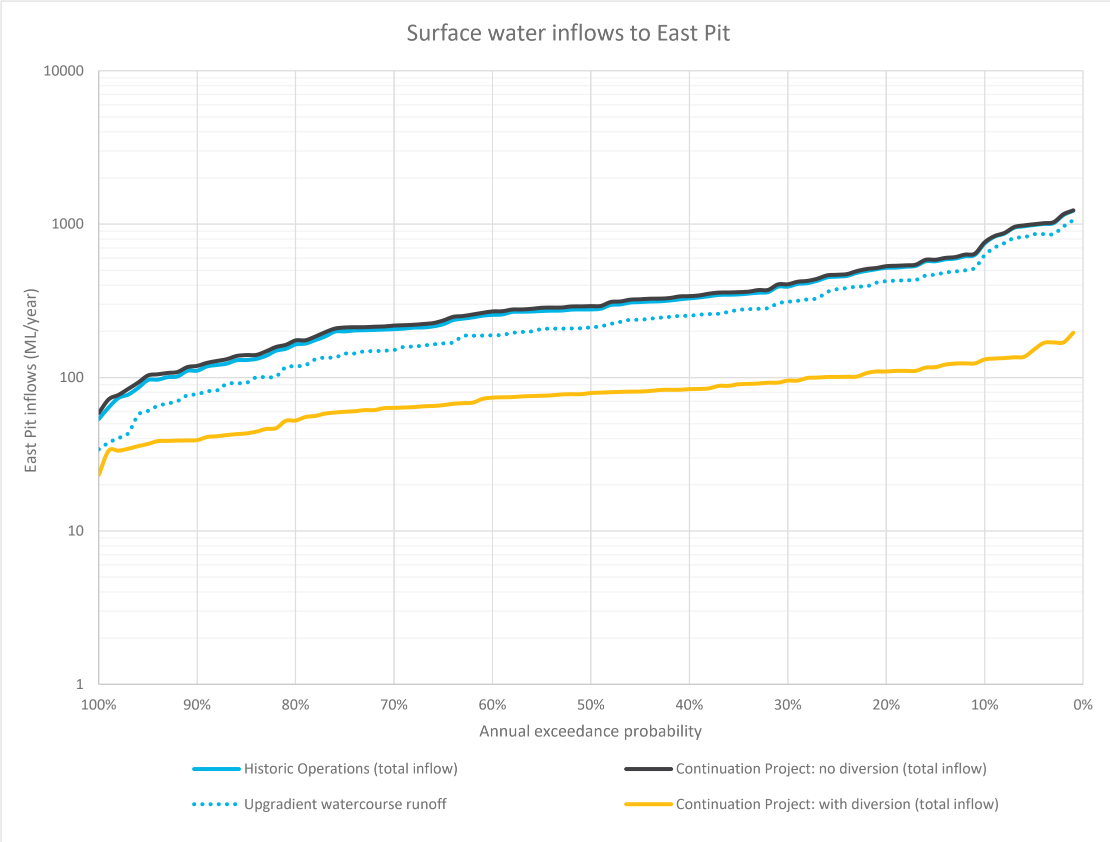


Figure 5.4 Surface water inflows to East Pit – annual exceedance probability

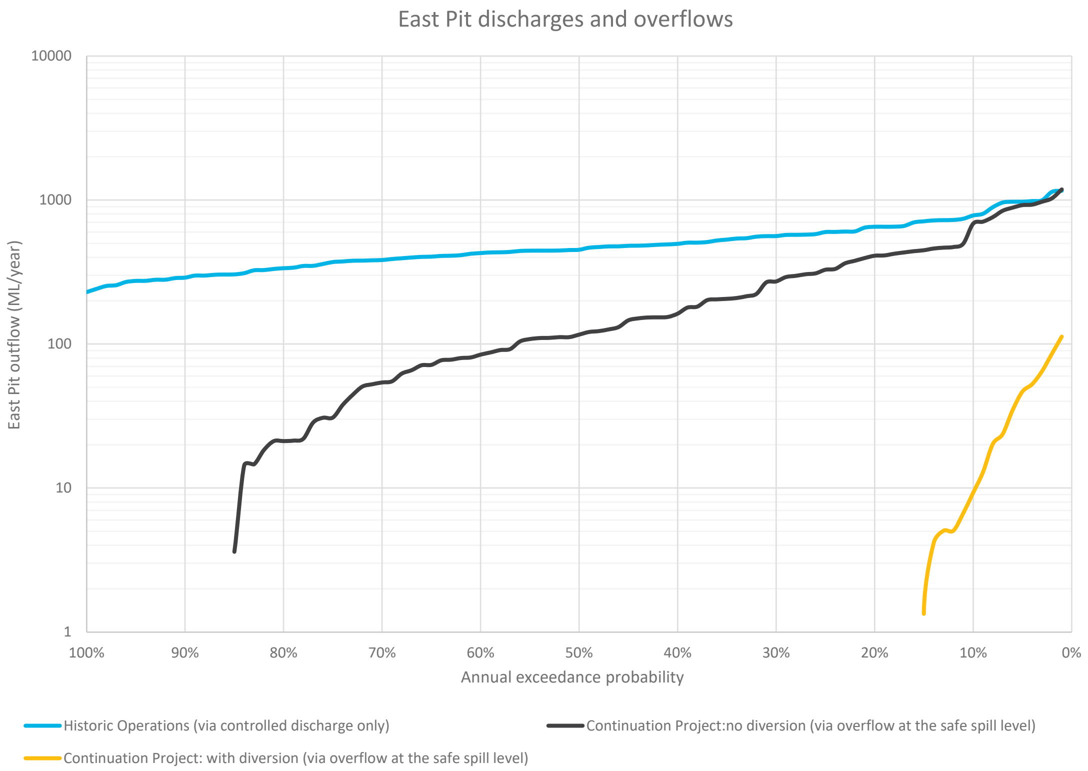


Figure 5.5 East Pit discharges to Eulomogo Creek – annual exceedance probability

ii Discussion

The water balance model results indicate that:

- Ceasing dewatering of the East Pit (as proposed as part of the Continuation Project) will significantly reduce groundwater inflows from the paleochannel to the East Pit (see Figure 5.2) and discharges from the East Pit to Eulomogo Creek (see Figure 5.5).
- The East Pit surface water diversion will significantly reduce surface water inflows into the East Pit (see Figure 5.4) and the frequency and magnitude of both East Pit Lake overflows to Eulomogo Creek (see Figure 5.5) and outflows from the East Pit to the paleochannel (see Figure 5.3).
- For the Continuation Project, the water level in the East Pit Lake may nearly always be above the equilibrium level (see Figure 5.1) as the simulated surface water inflow volumes exceed evaporation losses from the pit lake and water extracted for operation uses. It is noted that this could change if catchment runoff yields are lower than assumed.

5.3.3 Model uncertainty

As discussed in Section 5.3.1, the models have been developed to simulate the functionality of the water management system for each scenario. The models have been parameterised with similar assumptions which are predominately based on interpretations of limited data (ie the flow exchange curve) or typical values (ie the runoff models). Accordingly, the model results are useful for describing the relative changes to inflow and discharge regimes between each scenario but have considerable uncertainty in the predicted values and occurrence frequencies. The key aspects of the model that have considerable uncertainty are:

- the assumed equilibrium level
- the assumed East Pit / paleochannel flow exchange rate
- the assumed runoff volumes from the upgradient watercourses and quarry areas.

Table 5.2 describes each of these aspects and discusses the implications to the model results if the values are lower or higher than assumed.

Table 5.2 Water balance model – uncertainty analysis

Aspect	Description	Implications if lower than assumed	Implications if higher than assumed
Assumed equilibrium level	The water balance model assumes that the East Pit / paleochannel equilibrium level is 276.5 m AHD, which is in the middle of the estimated range (274 to 279 m AHD) but at the upper end of the expected range (274.5 to 276.5 m AHD) – see Section 3.4.4	**Historic Operation scenario** The model results are not sensitive to the assumed equilibrium level as the East Pit Lake level is kept below the equilibrium level due to simulated dewatering. **Continuation Project scenarios** If the equilibrium level is lower there would be more freeboard between the equilibrium level and the safe spill level. This would mean that: • outflows from the East Pit to the paleochannel would increase • overflows from the East Pit to Eulomogo Creek will reduce. It is possible that the changes could be substantial such that overflows to Eulomogo Creek only rarely occur.	**Historic Operation scenario** The model results are not sensitive to the assumed equilibrium level as the East Pit Lake level is kept below the equilibrium level due to simulated dewatering. **Continuation Project scenarios** If the equilibrium level is higher there would be less freeboard between the equilibrium level and the safe spill level. This would mean that: • outflows from the East Pit to the paleochannel would reduce • overflows from the East Pit to Eulomogo Creek will increase.
Paleochannel / East Pit flow exchange rate	Water exchange between the East Pit Lake and the paleochannel is calculated on each daily step based on: • the simulated water level in the East Pit Lake • the average East Pit paleochannel flow exchange curve (see Figure 3.10).	**Historic Operation scenario** If the flow exchange rate is lower than assumed both paleochannel channel inflows to the East Pit and East Pit discharge to Eulomogo Creek would reduce. **Continuation Project scenarios** If the flow exchange rate is lower than assumed: • outflows from the East Pit to the paleochannel would reduce • overflows from the East Pit to Eulomogo Creek will increase.	**Historic Operation scenario** If the flow exchange rate is higher than assumed both paleochannel channel inflows to the East Pit and East Pit discharge to Eulomogo Creek would increase. **Continuation Project scenarios** If the flow exchange rate is higher than assumed: • outflows from the East Pit to the paleochannel would increase • overflows from the East Pit to Eulomogo Creek will reduce.

Table 5.2 Water balance model – uncertainty analysis

Aspect	Description	Implications if lower than assumed	Implications if higher than assumed
Rainfall runoff models – upgradient watercourses	The water balance model calculates runoff from the upgradient watercourses using a rainfall runoff model that was parametrised to achieve the average runoff coefficient implied by the Maximum Harvestable Rights Dam Capacity tool (see Appendix B for further information).	**Historic Operation and Continuation Project (no East Pit diversion) scenarios** If runoff from the upgradient watercourses is lower than assumed both outflows from the East Pit to the paleochannel and discharges/overflows from the East Pit to Eulomogo Creek will reduce. **Continuation Project (with East Pit diversion) scenario** The model assumes that the East Pit surface water diversion diverts all runoff around the East Pit, into Eulomogo Creek and is therefore not sensitive to the rainfall runoff model results for the upgradient watercourses.	**Historic Operation and Continuation Project (no East Pit diversion) scenarios** If runoff from the upgradient watercourses is higher than assumed both outflows from the East Pit to the paleochannel and discharges/overflows from the East Pit to Eulomogo Creek will increase. **Continuation Project (with East Pit diversion) scenario** The model assumes that the East Pit surface water diversion diverts all runoff around the East Pit, into Eulomogo Creek and is therefore not sensitive to the rainfall runoff model results for the upgradient watercourses.
Rainfall runoff models – quarry area	The water balance model calculates runoff from the quarry areas using a rainfall runoff model that was parametrised to achieve the event-based runoff coefficients described in Managing Urban Stormwater Soils and Construction: Volume 1 (Landcom 2004) - (see Appendix B for further information).	**All stages** If runoff from quarry areas is lower than assumed both outflows from the East Pit to the paleochannel and discharges/overflows from the East Pit to Eulomogo Creek will reduce. **Continuation Project (with East Pit diversion) scenario only** It is possible that runoff volumes are lower than assumed surface water inflows into the East Pit Lake would be lower than evaporation losses and operational water use, which would mean that the pit lake level would predominately be below the equilibrium level.	**All stages** If runoff from quarry areas is higher than assumed both outflows from the East Pit to the paleochannel and discharges/overflows from the East Pit to Eulomogo Creek will increase.

5.4 Discharge characterisation assessment

This section documents a discharge characterisation assessment that addresses the requirements of Condition B35. It includes:

- a description of all discharges from the water management system for Continuation Project quarry stage (Sections 5.4.1 to 5.4.3)
- a summary table that addresses each of the requirements listed in Condition B35c (Section 5.4.4).

5.4.1 Discharge mechanisms

Discharges from the Continuation Project's water management system can occur due to the following mechanisms:

- **East Pit overflows**: will occur if the water levels in East Pit Lake reach the safe spill level of 280.2 m AHD. As the safe spill level is above the estimated equilibrium range (274 and 279 m AHD) overflows will only occur due to surface water ingress into the East Pit from either quarry areas or the upgradient watercourses (prior to the construction of the East Pit surface water diversion).
- **East Pit outflows to the paleochannel**: will occur whenever the water level in the East Pit Lake is higher than the equilibrium level.
- **Sedimentation Dam overflows**: will occur for short periods of time when the design rainfall depth that is recommended in *Managing Urban Stormwater Soils and Construction: Volume 1 (Landcom 2004) and Volume 2E Mines and Quarries (DECC 2008) is* exceeded.

5.4.2 East Pit water quality

For the Historic Operations the East Pit has received near continuous groundwater inflows from the paleochannel and intermittent surface water inflows from the upgradient watercourses and the East Pit catchment area. East Pit Lake water quality is described in Table 3.5 using the results from 49 samples collected between 2013 to 2023. The data indicates that the water quality is variable but can contain elevated salinity, phosphorus and nitrogen, which is primarily in the form of oxidised nitrogen. Comparison to the paleochannel groundwater quality (also in Table 3.5) indicates that the groundwater inflows from the paleochannel are the primary source of the elevated salinity and nutrients in East Pit Lake.

The East Pit Lake water quality profile for the Continuation Project is expected to change as:

- groundwater inflows from the paleochannel will be significantly reduced once the pit lake reaches the equilibrium level
- surface water runoff from the quarry areas will increase due to the expanded operations
- surface water runoff from the upgradient watercourses will be diverted around the East Pit following the construction of the East Pit surface water diversion by June 2025
- evaporation concentration will increase due to the greater lake surface area and reduced turnover of the lake water.

These changes will collectively result in the East Pit Lake water quality becoming surface water dominated, which is expected to result in lower salinity levels and nutrient concentrations. The lake water quality may take several years to adjust to the new regime.

Table 5.3 reproduces the descriptions of East Pit Lake water quality (for the Historic Operations) from Table 3.5 and describes the expected changes to the water quality due to the implementation of the Continuation Project.

Table 5.3 East Pit Lake – changes to water quality

	Water quality characteristics (Historic Operations) – reproduced from Table 3.5	Expected water quality characteristics (Continuation Project)
pH	The pH ranged from 6.3 to 9.0 (averaging 7.5), relative to a DGV range of 7 to 8 (annual median range)	The pH is expected to be within the 7 to 8 range as surface water runoff at the quarry is known to generally be within this range.
salinity	The electrical conductivity ranged from 310 to 6,810 µS/cm (averaging 987 µS/cm). The electrical conductivity was above the DGV of 544 µS/cm (median range) in 44 of 49 samples.	The salinity is expected to reduce as surface water runoff generally has low salinity (ie below 500 µS/cm). This may be partly offset by increased evaporation concentration. Salinity levels will likely be variable with higher levels occurring during dry periods and lower levels occurring during wet conditions, when pit overflows may occur.
turbidity	The turbidity ranged from 0.4 to 299 NTU, averaging 9.2 NTU. Turbidity levels were above the DGV of 20 NTU in 2 out of 49 samples	Runoff from the upgradient watercourses is known to be turbid (see aerial image in Figure 3.6 which was taken during a runoff event that occurred in September and October 2022). Hence, the potential for high turbidity levels will be reduced following the construction of the East Pit surface water diversion.
total nitrogen	Total nitrogen[1] concentrations ranged from below detection to 10.6 mg/L (averaging 3.9 mg/L). The nitrogen was primarily in oxidised form. The total nitrogen was above the DGV of 0.6 mg/L in 44 of 49 samples.	Total nitrogen concentrations are expected to reduce significantly due to lower groundwater inflows from the paleochannel.
Total phosphorus	Total phosphorous[1] concentrations ranged from below detection to 0.73 mg/L (averaging 0.32 mg/L). The total phosphorus was above the DGV of 0.035 mg/L in 47 of 49 samples.	Total phosphorus concentrations are expected to reduce due to lower groundwater inflows from the paleochannel.
metals	• Zinc exceeded the DGV in 1 out of 4 samples. • Concentrations of all other metals were consistently below the DGVs.	Metal concentrations are expected to continue to be generally below DGVs

5.4.3 Discharge characterisation

i Consent Transition Period

This quarry stage will have a duration of approximately 12 to 18 months (ie from commencement of development approved under the Continuation Project consent (SSD 10417) to the construction of the East Pit surface water diversion by June 2025). A detailed description of discharges during this 12 to 18-month period is not provided as the regime will be transitioning from the Historic Operations regime to the Continuation Project regime, which is described below.

ii Continuation Project

Table 5.4 describes the expected discharge regimes, water quality and potential receiving water impacts for the three discharge mechanisms. Proposed controls are also noted.

Table 5.4 Discharge characterisation – Continuation Project (after June 2025)

Mechanism	Discharge Regime	Expected water quality	Potential receiving water impacts	Proposed controls
East Pit overflows	The East Pit surface water diversion will significantly reduce the volumes of surface water that enter the East Pit, which will significantly reduce the frequency and magnitude of pit overflows. The water balance model estimates that material overflows (ie greater than 10 ML/year) will occur in approximately 10% of years (see Figure 5.5). It is noted that the reliability of this estimate is considered low due to uncertainties with the assumed equilibrium level, East Pit to paleochannel flow exchange rates and assumed runoff characteristics (discussed in Table 5.2). This discharge characterisation assessment and WMP has been prepared on the basis that overflows will only occur due to: • extended wet periods, such as a 90th percentile rainfall year or a contiguous period that contains greater than 90th percentile rainfall, or • a significant rainfall event, such as a 1 in 10 year event. Chapter 6 describes a trigger action plan that includes a commitment to review and update this WMP if future monitoring identifies that overflows occur due to lower magnitude rainfall events or other reasons (ie the equilibrium level is higher than the estimated range).	The future water quality of the East Pit is unknown, but it is expected to transition from being paleochannel dominated to surface water dominated. As a result, it is anticipated to have: • lower salinity levels and nitrogen and phosphorus concentrations than the historic range (see Table 5.4.2) • metal concentrations that are generally below DGVs. The water monitoring plan (discussed in Chapter 6) includes continued monitoring of the East Pit water quality, which will enable the future quality range to be reliably characterised over time.	Overflows will only occur during wet conditions when streamflow in Eulomogo Creek is occurring. Hence, any potential water quality impacts will be mitigated by mixing and dilution. The water monitoring plan (discussed in Chapter 6) includes monthly monitoring during periods of overflow to characterise the water quality of overflows and Eulomogo Creek, upstream and downstream of the overflow location.	• Increased monitoring during periods of overflow (discussed in Chapter 6) • Commitment to review and revise this WMP if overflows occur at a higher frequency than described in the Discharge Regime column in this table (this commitment is discussed in Chapter 6)
East Pit outflows to paleochannel	Outflows from the East Pit to the paleochannel will occur whenever the water level in the East Pit Lake is higher than the equilibrium level. The water balance model estimated that outflows will occur most of the time as surface water inflow volumes will exceed the combined volume of water lost to evaporation and extracted for operational purposes, which means that the outflows to the paleochannel will occur to balance inflows and outflows.	As per above	The water quality data presented in Table 3.5 established that the East Pit Lake water quality (for the Historic operations) is similar to the paleochannel water quality. As the future water quality in East Pit Lake is expected to have lower salinity and nitrogen and phosphorus concentrations, any outflow from the East Pit to the paleochannel is not expected to adversely impact the paleochannel water quality or potential for beneficial use.	The water monitoring plan (discussed in Chapter 6) includes continued water monitoring in the East Pit Lake and at the two paleochannel bores that are upgradient of the East Pit.

Table 5.4 Discharge characterisation – Continuation Project (after June 2025)

Mechanism	Discharge Regime	Expected water quality	Potential receiving water impacts	Proposed controls
Sediment Dam overflows	The sediment treatment volume in sedimentation dams will be dewatered to a quarry pit within five days of rainfall to restore capacity (see Measures 2.4 and 3.1 in Table 4.2). Accordingly, overflows will only occur for short periods of time when the design rainfall depth that is recommended in *Managing Urban Stormwater Soils and Construction: Volume 1 (Landcom 2004) and Volume 2E Mines and Quarries (DECC 2008) is* exceeded.	Sediment dam overflows may contain elevated suspended solids and turbidity.	There is minimal potential for water quality impacts to Eulomogo Creek as overflows will only occur occasionally for short periods of time during rainfall, when streamflow in Eulomogo Creek is occurring	• The sediment treatment volume in sedimentation dams will be dewatered to a quarry pit within five days of rainfall to restore capacity. • The water monitoring plan (discussed in Chapter 6) includes continued water monitoring in the Settling Pond (which is the largest permanent sedimentation dam in the Continuation Project's water management system).

5.4.4 Summary

Table 5.5 explains the approach to address each of the Condition B35c assessment requirements for the Continuation Project stage (see Section 1.4).

Table 5.5 Assessment of Condition B35c

Condition B35c		Approach to address condition
i.	measures to avoid the need for discharges as far as reasonable and feasible;	The following measures will be implemented as part of the Continuation Project to minimise discharges to Eulomogo Creek: • Controlled dewatering of the East Pit will cease (Measure 1.2) • The East Pit surface water diversion will significantly reduce surface water ingress into the East Pit, reducing the frequency and magnitude of overflows (Measure 2.2) • No controlled discharges from any quarry pit to Eulomogo Creek will occur (Measure 2.3) • The sediment treatment volume in sedimentation basins will be dewatered to a quarry pit within five days of rainfall to restore capacity (Measures 2.4 and 3.1)
ii.	analysis of the frequency and volume of discharges during dry, median (or average) and wet conditions	• Expected discharge regimes are described in Table 5.4
iii.	sufficient baseline water quality data from the East Pit	• Baseline water quality data from the East Pit, paleochannel and Eulomogo Creek is described in Section 3.6
iv.	characterisation of the expected water quality and frequency of proposed discharges	• The expected water quality and frequency of discharges is described in Table 5.4.
v.	assessment of the impact of discharges to Eulomogo Creek	• Potential impact to Eulomogo Creek water quality associated with discharges is described in Table 5.4
vi.	measures to prevent pollution of Eulomogo Creek and any other potential downstream impacts	The following measures will be implemented to minimise pollution in Eulomogo Creek: • Several measures will be implemented to minimise discharge frequency and volumes (see response to Condition B35ci) • The East Pit management approach will result in an improvement in water quality overtime (see Section 5.4.2). This will reduce water quality risks if overflows occur. • Discharges to Eulomogo Creek are only expected during wet weather when streamflow in Eulomogo Creek is occurring. Hence, any potential water quality impacts will be mitigated by mixing and dilution (see Table 5.4).

6 Monitoring and review

This chapter describes monitoring, trigger action and reporting plans.

6.1 Monitoring plan

6.1.1 Water monitoring

The water monitoring plan includes groundwater and surface water monitoring at key locations and metering of operational water use. The monitoring data will be used to:

- inform the calculation of surface and groundwater take each water year for water licensing purposes
- characterise any East Pit overflows that occur following the commencement of the Continuation Project.

The data can also be used to inform future calibration of the water balance model and water management studies, should they be required.

The plan will commence at the Consent Transition Period quarry stage.

i Monitoring plan

Table 6.1 describes the water monitoring plan. Monitoring locations are indicated in Figure 6.1.

Table 6.1 Water monitoring plan

Monitoring	Locations	Purpose
Water level monitoring		
Paleochannel • Continuous water level monitoring (water level loggers) • Six-monthly monitoring (manual measurements)	• DQRC-17 • DQRC-22	• Monitor the groundwater level regime in the paleochannel • Collect data that can be used to assess connectivity with the East Pit
Surface water • Continuous water level monitoring (water level loggers)	• East Pit Lake • Upgradient watercourse	**East Pit Lake** • Monitor changes in lake levels • Collect data that can be used to calculate groundwater and surface water take volumes and overflow durations and volumes **Upgradient watercourses** • Identify periods that runoff occurs
Basalt • Six-monthly monitoring (manual measurements)	• DQRC- 18, 20, 21, 23, 24, 25, 26, 27 • Monitoring at bores within the pit extraction areas can be discontinued once the bores are removed.	• Monitor the groundwater level
Water metering		

Table 6.1 Water monitoring plan

Monitoring	Locations	Purpose
Operational water use • Water extracted from the East Pit for operational water use	• Water meter with the reticulation line between the extraction and use points (see Figure 4.2)	• To measure the volume of water extracted from the East Pit for operational use (plant and dust suppression)
Water quality		
Surface Water and paleochannel (baseline) • Six-monthly water quality monitoring that is preferentially undertaken shortly after wet weather that results in surface water runoff. • Table 6.2 describes the monitoring analytes and methods.	**Paleochannel** • DQRC-17 • DQRC-22 **Surface water (if water is present)** • East Pit Lake • WEA Sump • SEA Sump • Settling Pond • Upgradient watercourses[1] / East Pit Diversion (US)[2] • East Pit Diversion (DS)[2] • Eulomogo Creek (US) • Eulomogo Creek (DS)	• To characterise the water quality in the paleochannel, at key locations in the water management system and in Eulomogo Creek.
Surface water (during East Pit overflows) • Monthly water quality monitoring undertaken when overflows from the East Pit occur. When an overflow event[3] commences, initial monitoring is to occur within three days followed by monthly monitoring until the overflow event[3] ceases. • Table 6.2 describes the monitoring analytes and methods.	• East Pit overflow • Eulomogo Creek (US) • Eulomogo Creek (DS)	• To characterise the quality of overflows from the East Pit and any changes to the water quality in Eulomogo Creek.

Notes: 1. Monitoring location applies to prior to the construction of the East Pit surface water diversion.

2. Monitoring location applies to after to the construction of the East Pit surface water diversion

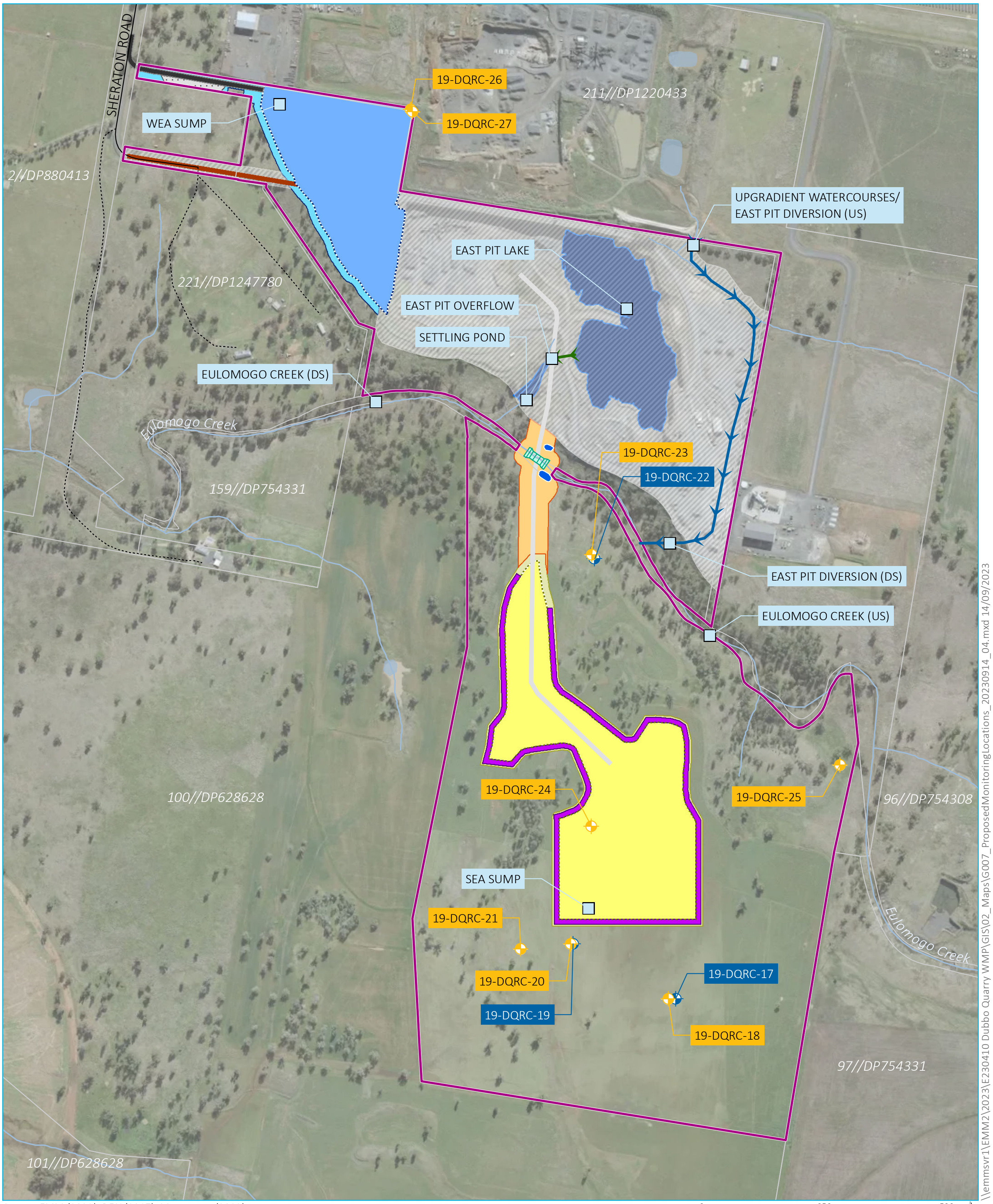
3. An overflow event could comprise overflows that occur intermittently for an extended period of time during wet conditions.

ii Monitoring analytes and methods

Table 6.2 describes the analytes and sampling and analysis methods for water quality monitoring. The analyte suite includes all of the analytes that were identified as exceeding DGVs in the surface water system and groundwater results that are presented in Section 3.6. These analytes include: electrical conductivity, oxidised and total nitrogen, total phosphorus, aluminium, copper, iron, nickel and zinc.

Table 6.2 Monitoring analytes and methods

Category	Analytes	Sampling and analysis methods
Physio-chemical parameters	pH, turbidity, electrical conductivity	Analysis is to be undertaken using a calibrated water quality meter OR by a NATA-certified laboratory.
	Total suspended solids Total dissolved solids Total hardness (as CaCO3) Ammonia, oxidised nitrogen (NOx), total kjeldahl nitrogen (TKN) and total nitrogen Reactive and total phosphorus	Analysis is to be undertaken by a NATA-certified laboratory.
Metals (field filtered)	Al, Cu, Fe, Ni and Zn	Analysis is to be undertaken by a NATA-certified laboratory. Samples are to be field-filtered using a 0.45 µm filter.



Source: EMM (2023); DFSI (2017); Metromap (2023)

0 250 500 m
GDA 1994 MGA Zone 55
N

KEY

- Project area
- East Pit overflow location
- Potential watercourse diversion (post June 2025)
- Surface water monitoring location

Groundwater monitoring bore

- Basalt
- Palaeochannel
- Indicative existing disturbance area
- Proposed water management storage
- Sediment pond
- Bund wall
- Existing access road
- Alternative access road
- Alternative truck tarping area
- Indicative proposed water crossing
- Western extension area
- Western disturbance area
- Haul road disturbance area
- Southern extension area
- Southern disturbance area
- Proposed haul road
- Minor road
- Vehicular track
- Watercourse/drainage line
- Waterbody
- Cadastral boundary (data does not align with surveyed site boundary)

Proposed monitoring locations

Dubbo Quarry Continuation Project
Water management plan
Figure 6.1

EMM
creating opportunities

6.1.2 Stream and riparian condition monitoring

Condition B39cii) requires that the WMP includes a program to monitor riparian condition and geomorphic stability of watercourses that could potentially be affected by the quarry. DPE advised that this condition can been addressed via maintaining a photographic record of watercourses at key locations where project impacts could occur. Appendix D includes baseline photographs at seven locations on Eulomogo Creek and at one location on the Eastern and Northern Watercourses (near the site boundary). A figure and table that show and describe the monitoring locations is also included in Appendix D.

Holcim will inspect the riparian condition at each location every year. During the inspection photographs will be taken to record the riparian condition.

Further investigations will be undertaken if the following conditions are encountered at the inspection locations or in nearby sections of watercourse:

- new significant erosion of creek bed or banks
- new accumulation of sediment, gravel or cobbles upstream of the Haul Road culverts or downstream of quarry discharge locations.

It is noted that the riparian condition in Eulomogo Creek will change over time due to natural erosion and deposition processes and that changes are most likely to occur after floods. It is also noted that riparian vegetation will change both seasonally and in response to wet and dry periods. Hence, any changes (ie new erosion or accumulation of alluvial material) requires investigation to establish if the change is due to the quarry's infrastructure or operations. Section 6.2 provides a Trigger Action Response Plan (TARP) which includes an item (TARP 9) that will be implemented if an investigation concludes that a change (ie new erosion or accumulation of alluvial material) is associated with the quarry.

6.2 Trigger action response plan

Table 6.3 is a trigger action response plan. The annual water management review (see Section 6.3.1) will describe any TARP items that were triggered during the review period and actions taken.

Table 6.3 Trigger action plan

ID	Trigger	Possible issue	Action
1	If future monitoring data identifies that the East Pit equilibrium level exceeds the estimated equilibrium level range (274 to 279 m AHD).	Overflows from the East Pit may occur more frequently than described in Section 5.4.	This WMP will be revised in consultation with the EPA and DPE Water. The revised WMP will address the requirements of Condition 35.
2	If, following the construction of the East Pit surface water diversion, overflows from the East Pit occur during periods that are not characterised by: • extended wet periods, such as a 90th percentile rainfall year or a contiguous period that contains greater than 90th percentile rainfall, or • a significant rainfall event, such as a 1 in 10 year event.	Overflows from the East Pit may occur more frequently than described in Section 5.4.	This WMP will be revised in consultation with the EPA and DPE Water. The revised WMP will address the requirements of Condition 35.

Table 6.3 Trigger action plan

ID	Trigger	Possible issue	Action
3	If the East Pit surface water diversion is not constructed	Overflows from the East Pit may occur more frequently than described in Section 5.4.	This WMP will be revised in consultation with the EPA and DPE Water. The revised WMP will address the requirements of Condition 35.
4	If a third-party water supply work is identified as being potentially impacted by the quarry operation.	Potential impact to a third-party water supply work	Holcim will investigate any claim, and if warranted engage a suitably qualified person to assess the claim and provide recommendations.
5	If, following the cessation of dewatering the East Pit (Measure 1.2) and allowing 1 year for the system to re-equilibrise, the groundwater level at bore DRQC-22 (which is screened in the paleochannel approximately 400 m upgradient of the East Pit) is lower than 272.5 m AHD. This level is approximately 1.0 m lower than the minimum level recorded between December 2020 and July 2023 – see Figure 3.4	Potential for the operation of the East Pit to be adversely impacting water levels in the paleochannel relative to the Historic Operation.	Holcim will engage a suitably qualified person to undertake a hydrological investigation to establish if the low groundwater level is due to the quarry operation.
6	If, following the cessation of dewatering the East Pit (Measure 1.2) and allowing 1 year for the system to re-equilibrise, the total dissolved solids concentration in the East Pit Lake exceeds 1,500 mg/L.	Potential for water outflow from the East Pit Lake to the paleochannel to impact the beneficial use of water from the paleochannel	Holcim will engage a suitably qualified person to undertake a water investigation to establish the source of the salinity in the East Pit Lake and the potential for outflows from the East Pit Lake to be impacting paleochannel water quality and its potential beneficial use.
7	If there is a material increase in the concentration or levels of key monitoring analytes between Eulomogo Creek upstream and downstream monitoring locations in two consecutive samples. Table 6.4 lists the key monitoring analytes and provides a definition for a material increase for each analyte.	Potential for water discharges to be impacting water quality in Eulomogo Creek	Holcim will investigate the source of an identified potential water quality impact. Additional monitoring may be required to confirm the impact or a suspected source. If a source is identified, Holcim will implement any practical measures to mitigate the issue. An example measure would be to pause any East Pit discharges that may be occurring during minimal streamflow in Eulomogo Creek.
8	If the East Pit Lake level increases by 2 m or more during or shortly after a wet weather event where significant runoff from the upgradient watercourses was observed to enter the pit.	Surface water take volume may exceed the held entitlements.	Holcim will calculate surface water take volumes for the water year using the methodology described in Section 7.4. If potential for a shortfall is identified, Holcim will implement the annual review procedure described in Section 7.6.

Table 6.3 Trigger action plan

ID	Trigger	Possible issue	Action
9	If the stream and riparian condition monitoring (Section 6.1.2) identifies that the quarry's infrastructure and/or operation is potentially impacting the riparian condition or geomorphic stability of a watercourse.	Potential impacts to a watercourse	Holcim will rectify the issue if the source is obvious, and the rectification works can be undertaken within the approved disturbance area and without disturbing the riparian zone. Holcim will consult with DPE to establish appropriate actions if rectification works are needed outside of the approved disturbance area and/or if the works require disturbing the riparian zone.

Table 6.4 lists the monitoring analytes that apply to TARP 7 and provides a definition for a material increase for each parameter. It is noted that thresholds for a material increase for each parameter have been established with consideration of typical natural variability in results. For example, metals occur at low concentrations, and it is not uncommon to have a ±50% variance in concentrations from samples that are collected from the same location. Conversely, electrical conductivity is known to be more stable. The thresholds are intended to identify material (ie significant) impacts. Analysis of long-term water quality trends is required to identify minor changes in water quality.

Table 6.4 Information to support TARP 7

Analyte	What constitutes a material increase[1]
pH	**A material increase is** a ± 1 change in pH between Eulomogo Creek (upstream) and Eulomogo Creek (downstream) **Does not apply if** the pH at Eulomogo Creek (downstream) is within the DGV range (7 – 8)
Electrical conductivity	**A material increase is** a 25% increase in electrical conductivity levels between Eulomogo Creek (upstream) and Eulomogo Creek (downstream) **Does not apply if** the electrical conductivity at Eulomogo Creek (downstream) is below the DGV (744 µS/cm)
Turbidity	**A material increase is** a 100% increase in turbidity levels between Eulomogo Creek (upstream) and Eulomogo Creek (downstream) **Does not apply if** the turbidity at Eulomogo Creek (downstream) is below the DGV (20 NTU)
Total suspended solids	**A material increase is** a 25% increase in total suspended solids concentrations between Eulomogo Creek (upstream) and Eulomogo Creek (downstream) **Does not apply if** the total suspended solids at Eulomogo Creek (downstream) is below 50 mg/L (a value often used in EPLs). It is noted that there is no DGV for total suspended solids.
Total Nitrogen	**A material increase is** a 25% increase in the total nitrogen concentration between Eulomogo Creek (upstream) and Eulomogo Creek (downstream) **Does not apply if** the total nitrogen concentration at Eulomogo Creek (downstream) is below the DGV (0.6 mg N/L)
Total Phosphorus	**A material increase is** a 100% increase in the total phosphorus concentration between Eulomogo Creek (upstream) and Eulomogo Creek (downstream) **Does not apply if** the total phosphorus concentration at Eulomogo Creek (downstream) is below the DGV (0.035 mg P/L)

Table 6.4 Information to support TARP 7

Analyte	What constitutes a material increase[1]
Metals (listed in Table 6.2)	**A material increase is** a 100% increase in any metal concentration between Eulomogo Creek (upstream) and Eulomogo Creek (downstream) **Does not apply if** – the metal concentration at Eulomogo Creek (downstream) is below the relevant DGV (DGVs for metals are provided in the Appendix A tables)

1. If the concentration of an analyte at Eulomogo Creek (upstream) is below detection limits and the concentration of the same analyte at Eulomogo Creek (downstream) is above both the DGV and detection limits, the increase can be calculated based on the difference between the DGV and the concentration at Eulomogo Creek (downstream).

6.3 Review and reporting

6.3.1 Annual water management review

Following the commencement of the Consent Transition Period quarry stage, Holcim will prepare an annual water management review that will include:

- all data from water monitoring completed over the period. The data will be reported against relevant DGVs and compared to historic trends (where available). Water level hydrographs will be provided for all continuous surface and groundwater level data collected
- an updated site water balance model informed by measured groundwater level, pit inflow and surface water data
- the outcomes from the stream and riparian condition monitoring (Section 6.1.2)
- calculated water take volumes for each water year (using the methodologies described in Chapter 7)
- information on any East Pit overflows that occurred over the period
- assessment of the trigger thresholds in the trigger action plan (Table 6.3)
- any proposed actions.

The review will be included in the Annual Environmental Management Report (AEMR). It is noted that if the AEMR period does not align with the water year period, water take estimates may need to be reported separately.

6.3.2 EPL reporting

Any reporting required by the EPL will be undertaken in accordance with EPL conditions.

6.3.3 Notification of discharges

Holcim will notify Council when East Pit discharges or overflows occur. The notification will be provided within 24 hours of a discharge occurring and will include information on the reason for the discharge and expected discharge duration.

7 Water licencing approach

Inflows into the quarry's water management system can occur due to:

- groundwater inflows into the East Pit from the paleochannel
- surface water inflows into the East Pit from the upgradient watercourses
- surface water runoff from catchments within the quarry's water management system
- groundwater inflows from the fractured basalt into the East Pit.

This chapter describes the water licencing approach for each of the above water take mechanisms. It includes a description of relevant water sharing plans, held entitlements and the licencing and reporting approach.

7.1 Water sharing plans

The following water sharing plans apply to surface and groundwater take at the quarry:

- Macquarie-Bogan Unregulated River Water Sources 2012 – the Maryvale Geurie Creek Water Source applies to surface water at the quarry.
- Murry Darling Basin Porous Rock Groundwater Sources 2020 – Gunnedah-Oxley water source applies to groundwater in the paleochannel and fractured basalt.

7.2 Approvals

7.2.1 Existing approvals

Table 7.1 describes existing works approvals that are held be Holcim.

Table 7.1 Existing works approvals

Works approval	Approval expiry date	Water Sharing Plan	Applies to
80WA707515	15/01/2032	MDB Porous Rock Groundwater 2020: Gunnedah-Oxley Water Source	Groundwater production bore that is unused
80WA716742	23/05/2027	MDB Porous Rock Groundwater 2020: Gunnedah-Oxley Water Source	Groundwater inflows into the East Pit
80WA726133	7/07/2030	Macquarie Bogan Unregulated Rivers 2012: Maryvale Geurie Water Source	Surface water inflows into the East Pit

7.2.2 Exemptions

Dams that are solely for the capture, containment or recirculation of drainage, consistent with best management practice to prevent the contamination of a water source, and that are located on a minor stream are considered to be excluded works under Schedule 1, item 3 of the NSW Water Management (General) Regulation 2018. The storages that are part of the water management system at the quarry are excluded works under this definition as they are not located on a major stream and the primary use of the storages is to prevent pollution of the downstream receiving environment.

7.2.3 Additional approvals

Clause 4.41 (1g) of the EP&A Act exempts an SSD authorised by a development consent from requiring a water use approval under section 89, a water management work approval under section 90, or an activity approval (other than an aquifer interference approval) under section 91 of the WM Act. This exemption applies to the project as it has been declared an SSD and, therefore, there is no requirement to obtain approvals under the WM Act, including water use, water management work or controlled activity approvals. The existing Work Approvals were required and issued prior to SSD approval processes.

7.3 Held water entitlements

Table 7.2 provides information on water entitlements that were held by Holcim in August 2023. The table includes information on linked work approvals and carryover conditions. It is noted that Holcim have also historically purchased temporary entitlements to meet shortfalls in prior years.

Table 7.2 Held water entitlements

WAL	Linked work approval	Water source	Category	Units	Carryover conditions[1]
Groundwater					
WAL29524	80WA707515 Well	MDB Porous Rock Groundwater 2020: Gunnedah-Oxley Water Source	Aquifer	5 unit shares	0.25 ML/unit share or 25% of entitlement
WAL34573	80WA716742 Excavation	MDB Porous Rock Groundwater 2020: Gunnedah-Oxley Water Source	Aquifer	90 unit shares	0.25 ML/unit share or 25% of entitlement
Application lodged ROI-22A-014	Yet to be linked	MDB Porous Rock Groundwater 2020: Gunnedah-Oxley Water Source	Aquifer	140 unit shares	Conditions yet to issue
Total Groundwater				**235 ML equivalent**	
Surface Water					
WAL43440	80WA726133 Excavation	Macquarie Bogan Unregulated Rivers 2012: Maryvale Geurie Water Source	Unregulated River	136 unit shares	1.0 ML/unit share or 100% of entitlement

Notes: 1. Refers to the maximum water allocation that may be carried over in the water allocation account from one water year to the next year

7.4 Water licencing approach

Table 7.3 describe the water licensing approach for each water take mechanism. The calculation methods noted in the table are provided after the table.

Table 7.3 Water licencing approach

Water storage / bore	Take mechanisms	Water sharing plan	Licencing approach	Water take volume calculation approach
1. East Pit	a) Surface water runoff from upgradient watercourses	Macquarie-Bogan Unregulated River Water Sources 2012 – the Maryvale Geurie Creek Water Source	Holcim will seek to hold water entitlements for the actual water take in each water year.	If inflows to the pit occur, water take will be calculated annually using Method 1. It is noted that water take is not expected once the East Pit surface water diversion is constructed (by June 2025).
	b) Surface water runoff from quarry area	Macquarie-Bogan Unregulated River Water Sources 2012 – the Maryvale Geurie Creek Water Source	Exempt[1]	Not required (subject to DPE confirmation)
	c) Groundwater inflows from paleochannel	MDB Porous Rock Groundwater 2020: Gunnedah-Oxley Water Source	Holcim will seek to hold water entitlements for the actual water take in each water year.	Groundwater inflows from the paleochannel to the East Pit will be calculated annually using Method 2.
	d) Groundwater inflows from fractured basalt	MDB Porous Rock Groundwater 2020: Gunnedah-Oxley Water Source	Holcim will seek to hold water entitlements for the actual water take in each water year.	Groundwater inflows from the Basalt into the East Pit will be calculated annually using Method 3
2. WEA Sump	a) Surface water runoff from quarry area	Macquarie-Bogan Unregulated River Water Sources 2012 – the Maryvale Geurie Creek Water Source	Exempt[1]	Not required (subject to DPE confirmation)
	b) Groundwater inflows from fractured basalt	MDB Porous Rock Groundwater 2020: Gunnedah-Oxley Water Source	No water take expected (see Section 5.1.2)	Not required
3. SEA Sump	a) Surface water runoff from quarry area	Macquarie-Bogan Unregulated River Water Sources 2012 – the Maryvale Geurie Creek Water Source	Exempt[1]	Not required (subject to DPE confirmation)
	b) Groundwater inflows from fractured basalt	MDB Porous Rock Groundwater 2020: Gunnedah-Oxley Water Source	No water take expected (see Section 5.1.2)	Not required
4. Sedimentation dams	a) Surface water runoff from quarry area	Macquarie-Bogan Unregulated River Water Sources 2012 – the Maryvale Geurie Creek Water Source	Exempt[1]	Not required (subject to DPE confirmation)

Note 1 – the water storage is an excluded work under Schedule 1, item 3 of the NSW Water Management (General) Regulation 2018

7.4.1 Water take calculation methods

Table 7.4 describes the water take calculation methods that are referenced in Table 7.3.

Table 7.4 Water take calculation methods

	Application	Calculation method
Method 1	Applies to calculating the volume of surface water runoff from the upgradient watercourses that enters the East Pit.	The upgradient watercourses are ephemeral which means that streamflow only occurs for a short period of time following significant rainfall. Runoff volumes will be calculated using the following methodology: • Data from the upgradient watercourse logger, which is located upstream of where the watercourse enters the East Pit (see Figure 6.1) be used to identify periods that streamflow in the watercourse occurs. • For each identified streamflow event, the water take volume will be calculated using data from the East Pit water level logger based on the change in water level and the level storage curve for East Pit (Figure 3.7). • The total annual water take volume will be the sum of the calculated volumes for each event over the water year.
Method 2	Applies to calculating the volume of groundwater that enters the East Pit from the paleochannel	Water take due to paleochannel inflows to the East Pit will occur when the East Pit Lake level is below the equilibrium level. Section 5.1.1 established that the water take volume can be conservatively estimated based on evaporation losses from the East Pit Lake, the volume of water extracted for operational use and any increases in lake levels that are not attributed to surface water runoff. If the lake level is below the equilibrium level or if the equilibrium level cannot be reliably estimated, water take due to paleochannel inflows will be calculated based on the sum of: 1. Evaporation losses from the East Pit Lake – this will be calculated using the average lake level over the period and the estimated annual evaporation loss from the relevant lake surface area (provided in Table 7.5) 2. The metered volume of water extracted from East Pit for operational uses 3. Inflows due to pit lake water level increases that are not associated with surface water runoff will be calculated based on the change in water level and the level storage curve for East Pit (Figure 3.7). This methodology applies to the pit filling and post pit filling periods. It is noted that the surface water runoff could also be considered in this method if deemed beneficial.
Method 3	Applies to calculating the volume of groundwater that enters the East Pit from the fractured basalt	The water take will be calculated each year using the methodology described in Section 5.1.2 and the average East Lake water level over the water year. The maximum calculated value will be used for water licencing purposes (ie using a hydraulic conductivity of 0.1 m/d)

Table 7.5 provides estimates of annual evaporation losses from the East Pit Lake at various levels that are within the estimated equilibrium range. These values are referenced in calculation Method 2.

Table 7.5 East Pit Lake – estimated annual evaporation volumes

East Pit water level (m AHD)	Surface area (m²)	Annual evaporation loss[1] (ML)
274	18,708	23
275	24,723	31
276	32,498	41
277	40,138	50
278	46,720	59

1. Assuming average annual pan evaporation of 1,793 mm and a pan coefficient of 0.7.

7.5 Adequacy of held entitlements

Table 7.6 provides a possible range of surface water and groundwater take volumes for the quarry before and after the construction of the East Pit surface water diversion (by June 2025). The possible ranges are compared to the held entitlements (from Table 7.2). This analysis indicates that the held entitlements:

- may be sufficient prior to the construction of the East Pit surface water diversion, however this will depend on the weather (for surface water) and the pit fill volume (for groundwater)
- are likely to be sufficient following the construction of the diversion.

Table 7.6 Adequacy of held entitlements

	Prior to the construction of the East Pit diversion (before June 2025)	After construction of the East Pit diversion (after June 2025)	Assumptions
Surface water			
Inflows from upgradient watercourse	Water balance model results indicate that the runoff volume from the upgradient watercourses could range from 0 to 1,000 ML/year and the held allocation amount of 136 ML would be exceeded in 70% of years (see Figure 5.4).	No water take is expected once the East Pit surface water diversion has been constructed.	It is noted that the water balance model could overstate the runoff volume and frequency of runoff events.
Held entitlements	136 ML/year	136 ML/year	Does not include any carry over provision
Groundwater take			
Basalt inflows to East Pit	20 ML/year	20 ML/year	Calculated using Method 3 (Table 7.4)
Paleochannel inflows			
– Pit filling	20 to 200 ML/year	0	From Section 5.1.1, it is assumed the lake filling will be complete by June 2025
– Evaporation losses	23 to 59 ML	23 to 59 ML	Range from Table 7.5

Table 7.6 Adequacy of held entitlements

	Prior to the construction of the East Pit diversion (before June 2025)	After construction of the East Pit diversion (after June 2025)	Assumptions
– Process water extraction	35 ML	35 ML	Estimated value from water balance
– Changes in East Pit Lake levels not associated with surface water runoff	0 to 50 ML/year	0 to 50 ML/year	Assumes up to 1 m increase in lake level
Paleochannel (possible range)	78 to 344 ML/year	58 to 144 ML/year	
Total groundwater	98 to 364 ML/year	78 to 164 ML/year	
Held entitlements	235 ML/year	235 ML/year	Does not include any carry over provision

7.6 Annual water licencing review

An annual water licencing review will be completed each water year. The following approach will be applied to calculate water licensing requirements for the year:

1. Surface and groundwater take volumes will be calculated using the approach and methods applied in Section 7.4.

2. The calculated water take will be compared to held entitlements and any available carryover from prior water years will be used (if required).

3. If a shortfall is identified, Holcim will seek to address the shortfall via a temporary trade or acquisition of additional entitlements. If additional entitlements cannot be acquired prior to water take occurring Holcim is to notify the Natural Resource Access Regulator of the non-compliance.

It is noted that any additional entitlements that are required to address a shortfall should be acquired ahead of the water take occurring. TARP 8 (Table 6.3) provides a trigger for initiating Steps 1 to 3 (above) ahead of the annual review process to enable additional entitlements to be acquired prior to water take occurring.

The following information will be included in the annual water return and management review:

- Held entitlements (including any temporary trade arrangements) and any available carry over from prior water years.

- Calculated water take for each mechanism.

- Utilised entitlements and any carry over for the next water year.

- Proposed or implemented actions to address any shortfall (ie engage in the water trading market).

- Information on any non-compliances.

8 Summary of commitments

The following commitments are made in this WMP:

- The water management measures described in Table 4.2 will be implemented as part of the Continuation Project. The measures include the following key changes to the water management system for the Historic Operations:
  - Dewatering of the East Pit will cease, and the East Pit Lake will be allowed to fill to the equilibrium level range, which is estimated to be between 274 and 279 m AHD, below the safe spill level (280.2 m AHD). This will minimise groundwater inflows from the paleochannel and eliminate the need for controlled discharges to Eulomogo Creek that have historically been associated with the dewatering activities.
  - A piped drainage system will be installed through the fill embankment to enable the East Pit Lake to overflow to Eulomogo Creek if the lake levels exceed the safe spill level (280.2 m AHD).
  - By June 2025, the East Pit surface water diversion will be constructed which will minimise inflows into the East Pit from the upgradient watercourses.
  - The surface water system will be expanded to manage runoff from the WEA and SEA and associated connecting haul roads.
- The water monitoring program described in Section 6.1 will be implemented. The plan includes monitoring of groundwater and surface water level and quality at key locations and metering of operational water use.
- The trigger action plan described in Table 6.3 will be implemented. The plan includes a commitment to revise this WMP in consultation with DPE Water and the EPA if overflows from the East Pit occur more frequently than described in discharge characterisation assessment (Section 5.4).
- Surface and groundwater take will be calculated each water year using the methodologies described in Chapter 7, which are predominantly based on monitoring data.
- An annual water management review report will be prepared each year as part of the AEMR. The review will include:
  - all data from water monitoring completed over the period. The data will be reported against relevant DGVs and compared to historic trends (where available). Water level hydrographs will be provided for all continuous surface and groundwater level data collected
  - an updated site water balance model informed by measured groundwater level, pit inflow and surface water data
  - calculated water take volumes for each water year (using the methodologies described in Chapter 7)
  - information on any East Pit overflows that occurred over the period
  - assessment of the trigger thresholds in the trigger action plan (Table 6.3)
  - any proposed actions.
- Annual returns will be prepared in accordance with EPL and water access licence conditions.

- This WMP will be updated and revised within 12 months following the commissioning of the East Pit surface water diversion (ie by June 2026). The updated plan will address Condition B35 (Discharge Characterisation Report) and B39 (Water Management Plan) and will be prepared in consultation with Council, the EPA and DPE Water. It will include updated modelling and will be informed by approximately 30 months of additional data, including:
  - at least 15 months of data collected following the cessation of East Pit dewatering, which will occur during the Consent Transition Period (November 2023 to November 2024)
  - approximately 9 months of data collected following the commissioning of the East Pit surface water diversion.

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Appendix A
Water quality data

creating opportunities

A.1 2023 sampling program

Table A.1 Groundwater/East Pit water quality results (2023 sampling program)

			Groundwater bores (basalt)			Groundwater bores (palaeochannel)			East Pit Lake		
	Units	DGV[1]	No. samples	Min	Max	No. samples	Min	Max	No. samples	Min	Max
Physio-chemical parameters											
pH	pH units	7.0-8.0	7	7.5	**8.8**	6	7.2	**8.3**	3	7.8	**8.9**
Electrical conductivity	µS/cm	504[2] 744[3]	7	129	**884**	6	297	**3,290**	3	423	**6,610**
Turbidity[4]	mg/L	20	7	91.3	703	6	3.6	1,000	3	2.9	**299**
Suspended solids	mg/L	-	7	47	650	6	30	1,700	3	< 5	8.3
Total dissolved solids	mg/L	-	7	148	566	6	171	2,140	3	275	4,230
Total hardness (as $CaCO_3$)	mg/L	-	7	110	270	6	160	260	3	230	360
Analytical results – nutrients (as N or P)											
Ammonia	mg/L	0.013	7	< 0.01	**0.06**	6	< 0.01	**0.37**	3	< 0.01	**0.42**
Oxidised nitrogen	mg/L	0.6[5]	7	**3.3**	**20**	6	**4.3**	**25**	3	**0.98**	**4.2**
Nitrate	mg/L	0.6[5]	6	**3.2**	**20**	4	**4.2**	**15**	3	0.01	**4.2**
Nitrite	mg/L	-	6	< 0.02	0.08	4	< 0.02	< 0.02	3	< 0.02	0.03
Total kjeldahl nitrogen	mg/L	-	7	0.3	2.4	6	0.7	2.6	3	< 0.02	0.4
Total nitrogen	mg/L	0.6	7	**3.6**	**20.5**	6	**5.3**	**16.1**	3	< 0.02	**4.2**
Total phosphorus	mg/L	0.035	7	0.03	**0.58**	6	0.04	**0.34**	2	0.01	0.01

Table A.1 Groundwater/East Pit water quality results (2023 sampling program)

			Groundwater bores (basalt)			Groundwater bores (palaeochannel)			East Pit Lake		
	Units	DGV[1]	No. samples	Min	Max	No. samples	Min	Max	No. samples	Min	Max
Reactive phosphorus	mg/L	0.035[6]	7	< 0.05	0.24	6	0.04	0.11	2	< 0.01	0.02
Analytical results – metals (0.45µm field filtered)											
Aluminium (Al)	mg/L	0.055	7	< 0.05	**0.59**	6	< 0.05	< 0.05	3	< 0.05	< 0.05
Arsenic (As)	mg/L	0.0013	7	0.001	0.005	6	< 0.001	< 0.001	3	< 0.001	< 0.001
Boron (B)	mg/L	0.94	7	< 0.05	0.52	6	0.2	0.2	3	0.05	0.07
Cadmium (Cd)	mg/L	0.0002	7	< 0.0002	< 0.0002	6	< 0.0002	< 0.0002	3	< 0.0002	< 0.0002
Total chromium (Cr)	mg/L	0.001[7]	7	< 0.001	0.004	6	< 0.001	< 0.001	3	< 0.001	< 0.001
Cobalt (Co)	mg/L	0.0014[8]	4	< 0.001	0.002	2	< 0.001	0.003	1	< 0.001	< 0.001
Copper (Cu)	mg/L	0.00001	7	**0.005**	**0.27**	6	**0.003**	**0.14**	3	< 0.001	< 0.001
Iron (Fe)	mg/L	0.3[8]	7	< 0.05	**0.74**	6	< 0.05	< 0.05	3	< 0.05	< 0.05
Lead (Pb)	mg/L	0.0044	7	< 0.001	0.002	6	< 0.001	< 0.001	3	< 0.001	< 0.001
Manganese (Mn)	mg/L	1.9	7	< 0.005	0.066	6	< 0.005	0.11	3	< 0.005	< 0.005
Nickel (Ni)	mg/L	0.011	7	< 0.001	**0.018**	6	< 0.001	0.003	3	< 0.001	< 0.001
Zinc (Zn)	mg/L	0.008	7	< 0.005	**0.085**	6	< 0.005	**0.008**	3	< 0.005	< 0.005

Notes: 1. The DGV for physico-chemical parameters and nutrients refer to the values for water quality targets developed for the Murray Darling Basin Plan (NSW DoI 2018). The DGV for toxicants refer to the values for slightly – moderately disturbed freshwater ecosystems that are reported ANZG (2018). Exceedances are noted in **bold**.
2. Median value.
3. 80th percentile value.
4. Turbidity DGV relevant for surface waters only.
5. TN DGV adopted.
6. TP DGV adopted.
7. For Cr (VI).
8. Refers to a low reliability DGV or an indicative working level sourced from ANZECC/ARMCANZ (2000) Volume 2.

Table A.2 Surface water quality results (2023 sampling program)

			Settling Pond			Eulomogo Creek (upstream)			Eulomogo Creek (downstream)		
	Units	**DGV**[1]	**No. samples**	**Min**	**Max**	**No. samples**	**Min**	**Max**	**No. samples**	**Min**	**Max**
Physico-chemical parameters											
pH	pH units	7.0-8.0	3	**8.2**	**8.9**	3	**8.1**	**9**	3	**8.3**	**8.8**
Electrical conductivity	µS/cm	504[2] 744[3]	3	**533**	**6,180**	3	**2,150**	**3,940**	3	**695**	**6,300**
Turbidity	mg/L	20	3	4.9	**113**	3	**35.8**	**358**	3	6.4	**995**
Suspended solids	mg/L	-	3	< 5	35	3	< 5	13	3	< 5	430
Total dissolved solids	mg/L	-	3	341	3,950	3	1,370	2,560	3	446	4,030
Total hardness (as $CaCO_3$)	mg/L	-	3	270	370	3	190	1,400	3	290	460
Analytical results – nutrients (as N or P)											
Ammonia	mg/L	0.013	3	< 0.01	**0.25**	3	< 0.01	**0.12**	3	< 0.01	**0.05**
Oxidised nitrogen	mg/L	0.6[4]	3	**1.5**	**3.8**	3	**1.4**	**4.1**	3	**0.89**	**2.5**
Nitrate	mg/L	0.6[4]	3	0.07	**3.8**	3	0.01	**4**	3	**0.87**	**2.5**
Nitrite	mg/L	-	3	< 0.02	0.04	3	< 0.02	0.1	3	< 0.02	0.04
Total kjeldahl nitrogen	mg/L	-	3	< 0.02	3.7	3	< 0.02	1	3	< 0.02	15
Total nitrogen	mg/L	0.6	3	< 0.02	**5.2**	3	< 0.02	**5.1**	3	< 0.02	**5.29**
Total phosphorus	mg/L	0.035	2	0.02	0.02	2	0.01	0.01	2	**0.23**	**0.23**
Reactive phosphorus	mg/L	0.035[5]	2	< 0.01	0	2	< 0.01	0	2	< 0.01	0.01

Table A.2 Surface water quality results (2023 sampling program)

			Settling Pond			Eulomogo Creek (upstream)			Eulomogo Creek (downstream)		
	Units	DGV[1]	No. samples	Min	Max	No. samples	Min	Max	No. samples	Min	Max
Analytical results – metals (0.45µm field filtered)											
Aluminium (Al)	mg/L	0.055	3	< 0.05	< 0.05	3	< 0.05	< 0.05	3	< 0.05	**2.2**
Arsenic (As)	mg/L	0.0013	3	< 0.001	< 0.001	3	< 0.001	< 0.001	3	< 0.001	**0.002**
Boron (B)	mg/L	0.37	3	0.06	0.06	3	0.05	0.06	3	0.07	0.07
Cadmium (Cd)	mg/L	0.0002	3	< 0.0002	< 0.0002	3	< 0.0002	< 0.0002	3	< 0.0002	< 0.0002
Total chromium (Cr)	mg/L	0.001[6]	3	< 0.001	< 0.001	3	< 0.001	< 0.001	3	< 0.001	0.001
Cobalt (Co)	mg/L	0.0014[7]	1	< 0.001	< 0.001	1	< 0.001	< 0.001	1	< 0.001	**0.013**
Copper (Cu)	mg/L	0.0014	3	< 0.001	< 0.001	3	< 0.001	**0.002**	3	< 0.001	**0.008**
Iron (Fe)	mg/L	0.3[7]	3	< 0.05	< 0.05	3	< 0.05	0.07	3	< 0.05	**3.4**
Lead (Pb)	mg/L	0.0034	3	< 0.001	< 0.001	3	< 0.001	< 0.001	3	< 0.001	0.002
Manganese (Mn)	mg/L	1.9	3	< 0.005	0.018	3	< 0.005	0.47	3	< 0.005	**2.1**
Nickel (Ni)	mg/L	0.011	3	< 0.001	< 0.001	3	< 0.001	0.002	3	< 0.001	0.008
Zinc (Zn)	mg/L	0.008	3	< 0.005	**0.016**	3	< 0.005	< 0.005	3	< 0.005	**0.011**

Notes:
1. The DGV for physico-chemical parameters and nutrients refer to the values for water quality targets developed for the Murray Darling Basin Plan (NSW DoI 2018). The DGV for toxicants refer to the values for slightly – moderately disturbed freshwater ecosystems that are reported in ANZG (2018). Exceedances are noted in **bold**.
2. Median value.
3. 80th percentile value.
4. TN DGV adopted.
5. TP DGV adopted.
6. For Cr (VI).
7. Refers to a low reliability DGV or an indicative working level sourced from ANZECC/ARMCANZ (2000) Volume 2.

A.2 2020 sampling program

Table A.3 Water quality results (2020 sampling program)

	Units	LOR	DGV[1]	Eulomogo Creek (upstream of site)	Eulomogo Creek (downstream of site)	East Pit Lake	Settling Pond
General water quality							
pH	-	0.01	7.0-8.0	**8.4**	**8.6**	**8.5**	**8.6**
Electrical Conductivity	µS/cm	1	504[2] 744[3]	**811**	**738**	**726**	**676**
Turbidity	NTU	0.1	20	3.1	2.5	13.8	15.6
Alkalinity							
Bicarbonate as $CaCO_3$	mg/L	1	-	164	246	236	237
Carbonate as $CaCO_3$	mg/L	1	-	6	24	20	<1
Hydroxide as $CaCO_3$	mg/L	1	-	<1	<1	<1	<1
Total alkalinity as $CaCO_3$	mg/L	1	-	170	270	256	237
Nutrients							
Ammonia	mg/L	0.01	-	<0.01	<0.01	**0.02**	<0.01
Oxidised Nitrogen	mg/L	0.01	0.6[4]	**0.6**	0.2	**2.33**	**0.74**
Total Kjeldahl Nitrogen	mg/L	0.1	-	0.3	0.3	0.5	0.7
Nitrite	mg/L	0.01	-	0.02	<0.01	0.01	<0.01
Nitrate	mg/L	0.01	0.6[4]	0.58	0.2	**2.32**	**0.74**
Total nitrogen	mg/L	0.1	0.6	**0.9**	0.5	**2.8**	**1.4**

Table A.3 Water quality results (2020 sampling program)

	Units	LOR	DGV[1]	Eulomogo Creek (upstream of site)	Eulomogo Creek (downstream of site)	East Pit Lake	Settling Pond
Total phosphorus	mg/L	0.01	0.035	<0.01	0.01	**0.14**	**0.07**
Inorganics							
Cyanide	mg/L	0.004	0.004	<0.004	<0.004	<0.004	<0.004
Inorganics							
Calcium	mg/L	1	-	33	34	28	26
Chloride	mg/L	1	-	164	62	58	52
Fluoride	mg/L	0.1	-	0.2	0.4	0.4	0.5
Sodium	mg/L	1	-	57	73	77	78
Magnesium	mg/L	1	-	39	29	28	20
Potassium	mg/L	1	-	6	9	7	8
Sulphate as SO_4	mg/L	1	-	8	23	22	23
Ionic Balance							
Anions	meq/L	0.01	-	8.19	7.62	7.21	6.68
Cations	meq/L	0.01	-	7.49	7.49	7.23	6.54
Ionic Balance	%	0.01	-	4.46	0.88	0.14	1.06
Dissolved metals							
Arsenic	mg/L	0.001	0.013	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	0.001	-	0.032	0.026	0.003	<0.001

Table A.3 Water quality results (2020 sampling program)

	Units	LOR	DGV[1]	Eulomogo Creek (upstream of site)	Eulomogo Creek (downstream of site)	East Pit Lake	Settling Pond
Beryllium	mg/L	0.001	-	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
Chromium (III+VI)	mg/L	0.001	0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	0.0014[5]	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	0.0014	0.001	0.001	0.001	**0.002**
Lead	mg/L	0.001	0.0034	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	1.9	0.02	0.074	<0.001	<0.001
Mercury	mg/L	0.0001	0.0006	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.001	0.011	0.001	0.002	<0.001	<0.001
Selenium	mg/L	0.01	0.011	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	0.01	0.006[5]	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.008	<0.005	<0.005	**0.010**	<0.005

Notes: 1. The DGV for physico-chemical parameters and nutrients refer to the values for water quality targets developed for the Murray Darling Basin Plan (NSW DoI 2018). The DGV for toxicants refer to the values for slightly – moderately disturbed freshwater ecosystems that are reported in ANZG (2018). Exceedances are noted in **bold**.
2. Median value.
3. 80th percentile value.
4. TN DGV adopted.
5. Refers to a low reliability DGV or an indicative working level sourced from ANZECC/ARMCANZ (2000) Volume 2.

A.3 Holcim sampling program

Table A.4 Receiving water quality results (Holcim sampling program)

			Eulomogo Creek (upstream of settling pond)					Eulomogo Creek (downstream of settling pond)				
	Units	DGV[1]	No. samples	Min	20th percentile	80th percentile	Max	No. samples	Min	20th percentile	80th percentile	Max
pH	pH units	7.0-8.0	20	6.8	7.3	7.9	**8.1**	41	7.0	7.5	7.8	**8.4**
Salinity	µS/cm	504[2] 744[3]	20	280	358	**1,352**	**2,150**	41	**481**	**758**	**1,256**	**1,891**
Turbidity	mg/L	20	20	1.1	2.0	13.3	**87.1**	41	0.5	2.1	**21**	**102**
Nitrate	mg/L	0.6[4]	20	0.1	0.18	**0.77**	**3.93**	41	0.10	0.20	**2.20**	**16.5**
Reactive phosphorus	mg/L	0.035[5]	20	**0.072**	**0.173**	**0.430**	**0.836**	41	**0.077**	**0.196**	**0.369**	**1.152**
Chemical oxygen demand	mg/L	-	20	6	19.4	61.1	133.1	0	-	-	-	-

Notes: 1. The DGV for physico-chemical parameters and nutrients refer to the values for water quality targets developed for the Murray Darling Basin Plan (NSW DoI 2018). Exceedances are noted in **bold**.
2. Median value.
3. 80th percentile value.
4. TN DGV adopted.
5. TP DGV adopted.

Table A.5 Water managment storages water quality results (Holcim sampling program)

	Units	DGV[1]	East Pit Lake No. samples	Min	20th percentile	80th percentile	Max	Settling Pond No. samples	Min	20th percentile	80th percentile	Max
pH	pH units	7.0-8.0	45	**6.3**	**6.6**	**8.0**	**9.0**	45	6.7	7.2	**8.2**	**8.6**
Salinity	µS/cm	504[2] 744[3]	45	310	**814**	**1,007**	**1,260**	45	343	**508**	**999**	**1,080**
Turbidity	mg/L	20	45	0.1	0.4	3.6	**23**	45	0.4	1.7	**220**	**646**
Nitrate	mg/L	0.6[4]	45	0.38	**1.5**	**6.1**	**10.6**	45	0.05	0.55	**5.05**	**6.92**
Reactive phosphorus	mg/L	0.035[5]	45	**0.088**	**0.194**	**0.438**	**0.729**	45	**0.133**	**0.224**	**0.514**	**0.766**
Chemical oxygen demand	mg/L	-	45	0.1	3.1	16.3	75.6	45	0.1	6.9	36.9	117.6

Notes: 1. The DGV for physico-chemical parameters and nutrients refer to the values for water quality targets developed for the Murray Darling Basin Plan (NSW DoI 2018). Exceedances are noted in **bold**.
2. Median value.
3. 80th percentile value.
4. TN DGV adopted.
5. TP DGV adopted.

Appendix B
Water balance model method statement and results

EMM
creating opportunities

B.1 Overview

This is a technical appendix to the Water Management Plan (WMP) for Holcim's Dubbo Quarry that describes a predictive water balance model (WBM). The WBM has been developed to simulate the functionality of the quarry's water management system for the following three scenarios described in the WMP:

- Historic Operations
- Continuation Project (no East Pit surface water diversion)
- Continuation Project (with East Pit surface water diversion)

The two Continuation Project scenarios are provided to show the positive effect that the East Pit surface water diversion will have on reducing system inflows and discharges and should not be confused with the quarry stages described in Section 1.4.

The model results are used in the main report to describe the surface and groundwater take and discharge regimes from the quarry for each scenario. Section B.2 and B.3 describes the methodology and assumptions and Section B.4 presents the model results for each scenario.

B.2 Modelling approach

The water balance model was developed in GoldSim version 14.0 (GoldSim Technologies 2021). The model applies a continuous simulation methodology that assesses the performance of the modelled water management system under a range of rainfall and evaporation sequences. The model was created by representing the water cycle as a series of elements, each containing pre-set rules and data, that were linked together to simulate the interaction of these elements. Key features of the model are described below:

- The model runs on a daily time-step and requires daily rainfall and evaporation rates as model inputs. The model results are available on a daily time step but are reported as annual averages to simplify the results presentation.
- The model runs as a continuous simulation and applies a long term (101 year) rainfall record that includes a wide range of embedded dry and wet periods as well as major flood events. The model results are processed to provide a statistical representation of the performance of each surface water management system, under a full range of climatic conditions.
- Results are presented in flow chart format for typical dry (10^{th} Percentile), median (50^{th} Percentile) and wet (90^{th} Percentile) years. Select results such as dam overflows are also presented as summary charts.

The model was broadly parametrised to approximate anecdotal information provided by Holcim.

B.3 Model assumptions

B.3.1 Climatic data

The model was run using representative rainfall data from January 1919 to December 2019, a circa 101-year period. This period includes several dry, average and wet weather sequences and is therefore adequate for simulating overflows from the proposed stormwater system. Historic climate data for rainfall and evaporation was sourced from the Scientific Information for Landowners database, available from the Queensland Government.

B.3.2 Calculation of runoff

The SIMHYD rainfall/runoff model was applied to simulate the rainfall runoff response from the catchments within the quarry's surface water management system. SIMHYD is one of the most used rainfall runoff models in Australia and has been extensively tested using data from across Australia (Chiew, 2005).

Each water management storage catchment was delineated into land surfaces that reflected soil hydrologic groups consistent with *Managing Urban Stormwater: Volume 1* (Landcom 2004). A runoff model for each soil group was parameterised to represent the 5-day runoff coefficients presented in Table F2 (Landcom 2004). The upgradient watercourses were parameterised independently to achieve an average annual runoff coefficient that is similar to value used in maximum harvestable rights calculator (DPIE), 0.6 ML/ ha or an average annual coefficient of 0.10.

The annual average runoff coefficient achieved for each runoff model type is presented in Table B.1.

Table B.1 SIMHYD model runoff coefficients

Soil hydrologic group (Landcom 2004)	Representative material types on site	Annual runoff coefficient
Type A	Stockpiles	0.22
Type B	Vegetated batters, farmland	0.33
Type D	Pit floor, compacted road base, hard stand etc.	0.51

It is noted that SIMHYD calculates runoff on a daily time step, as a function of soil moisture storage. Hence, C_v for any given rainfall event will generally be below the long term average C_v during dry conditions (due to the soils being dry before the event) and above the long term average C_v during wet conditions when the soils are close to saturated before the event. This represents the effects of antecedent soil moisture conditions when calculating daily runoff.

B.3.3 Process water demands

The model applies site water use to restore storage capacity after rainfall events. The following assumptions were applied:

- Plant water use was applied at a constant rate of 50 kL/day in the water balance model.
- No water is used for dust suppression when daily rainfall exceeds daily evaporation.
- Haul road dust suppression demands were calculated on a daily time step by applying the following equation:

$$DSupp(t) = ((Evap(t) - Rain(t)) + LossFactor) \times Area$$

- A daily loss factor of 2 mm/day and an application area of 0.6 Ha was applied for the Historic Operations model scenario.

- For the Continuation Project model scenarios, the application area was increased to 0.98 ha, representing the additional area of haul road connecting to the SEA.

B.3.4 Groundwater exchange

Water exchange between the East Pit Lake and the paleochannel is calculated on the East Pit paleochannel flow exchange curve (see Figure 3.10). This assumption has been applied to all scenarios. The flow exchange is calculated by the model on a daily time step based on the simulated water level in the East Pit Lake.

B.3.5 Water transfers

Water transfers between storages, demands and sources are controlled using transfer rules that are based on storage levels, demand requirements and source availability. It was assumed that all pumps on site were limited to 50 L/s capacity.

B.3.6 Water management storages

The water management storage details, catchment areas and operating principles applied to the water balance are outlined in Table B.2. The level/storage characteristics for the Historic Operations storages were estimate by EMM from aerial survey undertaken in August 2023.

B.3.7 Evaporation losses

Evaporation losses occur from all water storages. The model calculates evaporation losses on a daily timestep as a function of:

- Evaporation rates – daily pan evaporation extracted from SILO was included in the model. A Pan Coefficient of 0.7 was applied to all evaporation loss calculated from the water management dams.
- Water storage surface area – is a function of the volume and the surface area/volume properties of the storage. The surface area is calculated at each daily time step based on the volume and estimated area characteristics for each storage.

Table B.2 Modelled water management storages

Storage	Contributing catchment area	Operating principles	Groundwater inflows	Volume	Overflows to
Existing storages (Historic Operations)					
East Pit Lake	24.4 ha – quarry area 497 ha – upgradient watercourses **Total:** 521.4 ha	• Water extracted from East Pit Lake for processing use and haul road dust suppression. • The Pit is dewatered to Eulomogo Creek when the lake level exceeds 273 mAHD.	Groundwater inflows are modelled to occur below the average estimated equilibrium level of 265.5 mAHD. Refer to Figure 3.10 for the applied exchange curve.	722 ML (to the current spill level of 286 m AHD)	Settling Pond
Settling Pond	6.7 ha – processing and quarry area	No active management	No groundwater inflows are known to occur.	2.4 ML	Eulomogo Creek
Existing storages (Continuation Project)					
East Pit Lake	24.9 ha – quarry area 497 ha – upgradient watercourses (no East Pit diversion scenario only) **Totals:** 521.9 ha (no East Pit diversion) 24.9 ha (with East Pit diversion)	• Water extracted from East Pit Lake for processing use and haul road dust suppression.	Consistent with Historic Operations (as above).	314 ML (to the safe spill level of 280.2 mAHD)	Eulomogo Creek
Settling Pond	6.6 ha – processing and quarry area	Dewatered to the East Pit within 5 days following the cessation of rainfall.	No groundwater inflows are known to occur.	2.4 ML	Eulomogo Creek
New storages (Continuation Project)					
WEA sump	8.7 ha – quarry area	Runoff from the WEA will drain to a pit sump. Accumulated water will be either reticulated back to the East Pit or used within the WEA for haul road dust suppression. The model assumes that all water is dewatered back to the East Pit.	The pit will not be developed below the groundwater table, so no groundwater inflows are expected.	Large	No overflows expected in new pits due to large storage and operating principles.
SEA sump	17.3 ha – quarry area	Runoff from the SEA will drain to a pit sump. Accumulated water will be either reticulated back to the East Pit or used within the SEA for	The pit will not be developed below the groundwater table, so no groundwater inflows are expected.	Large	

Table B.2 Modelled water management storages

Storage	Contributing catchment area	Operating principles	Groundwater inflows	Volume	Overflows to
		haul road dust suppression. The model assumes that all water is dewatered back to the East Pit.			
Haul road sedimentation basins	0.6 ha – haul road	Dewatered to a quarry sump within 5 days following the cessation of rainfall. The model assumes that all water is dewatered back to the East Pit.	The basins will not require deep excavation (around 2m) and are, therefore, not expected to intercept the groundwater.	0.2 ML	Eulomogo Creek

B.4 Results

B.4.1 Historic Operations results

Table B.3 provides a summary of key inflows and outflows in typical 10th, 50th and 90th percentile rainfall years. Figure B.1 to Figure B.3 provide annualised results in flow chart format for typical 10th, 50th and 90th percentile rainfall years.

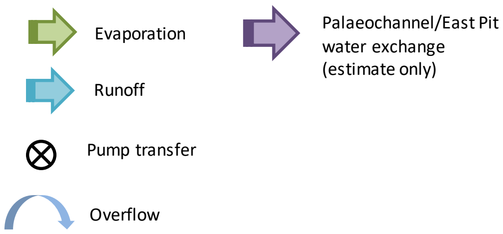
Table B.3 Summary of inflows and outflows: Historic Operations scenario

	Units	Annualised results		
		Dry year[1]	**Median year**	**Wet Year[1]**
Inflows				
Runoff				
– Quarry catchments	ML/year	42	82	142
– Upgradient watercourses	ML/year	74	210	584
Runoff total	ML/year	116	291	725
Palaeochannel inflows (estimate only)	ML/year	226	210	150
Total inflows	ML/year	**342**	**501**	**875**
Outflows				
Operational water use	ML/year	26	25	25
Evaporation	ML/year	26	26	31
Discharges				
– Sediment basin overflows	ML/year	3	10	22
– East Pit dewatering	ML/year	286	473	771
– East Pit seepage to palaeochannel	ML/year	0	1	22
– Discharges total	ML/year	289	484	815
Total outflows	ML/year	**340**	**535**	**871**
Balance (change in storage)	ML/year	**+2**	**-34**	**4**
Net palaeochannel/East Pit water exchange[2]	ML/year	**226**	**209**	**128**

Notes: 1. Dry year refers to a typical 10th percentile rainfall year Wet year refers to a typical 90th percentile rainfall year

2. Refers to the net water exchange between the palaeochannel and the East Pit. A positive number refers to a net groundwater inflow, while a negative number refers to a net seepage loss from the East Pit into the palaeochannel.

10th Percentile Annual Rainfall Conditions
Annual Rainfall 343 mm/year
All values ML/year



Results Summary

Inflows	
Total local runoff / rainfall	42
Eastern Watercourse inflow	74
Palaeochannel/East Pit exchange	226
Outflows	
Plant water use	18
Haul road dust supression	7
Overflows	289
Total evaporation loss	26
Change in storage	2.2

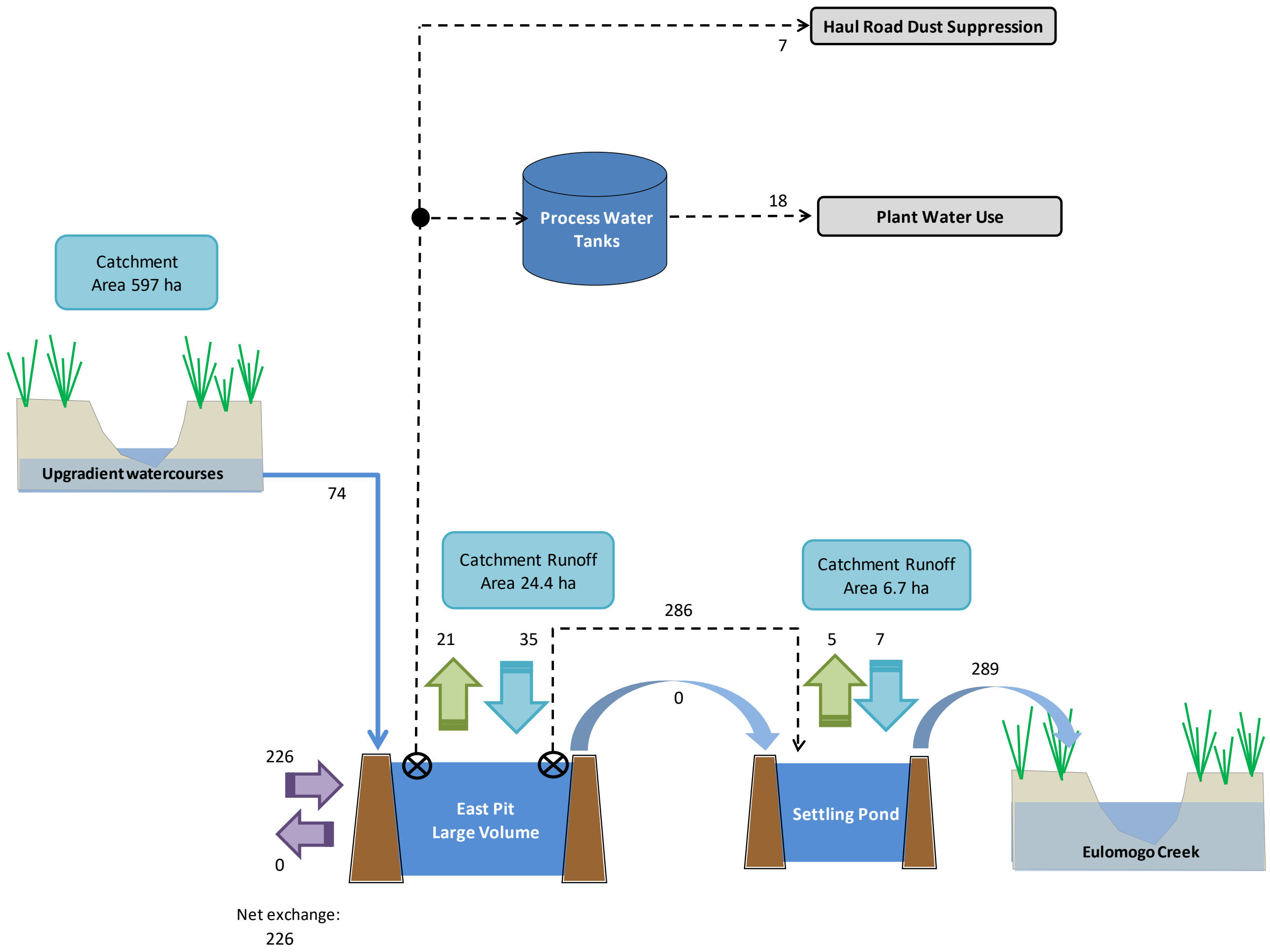


Figure B.1 Water balance: Historic Operations scneario – 10th percentile year

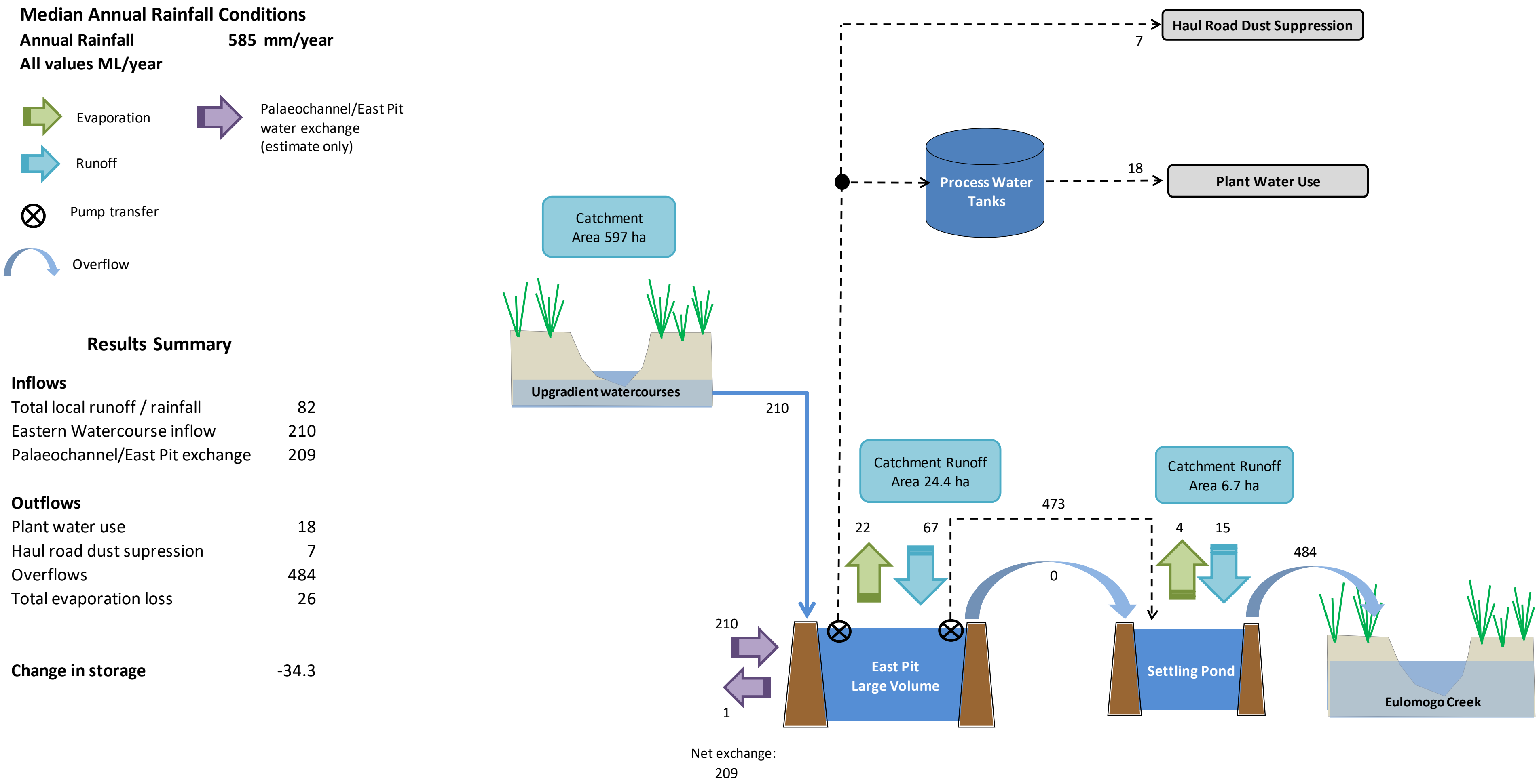


Figure B.2 Water balance: Historic Operations scneario – 50th percentile year

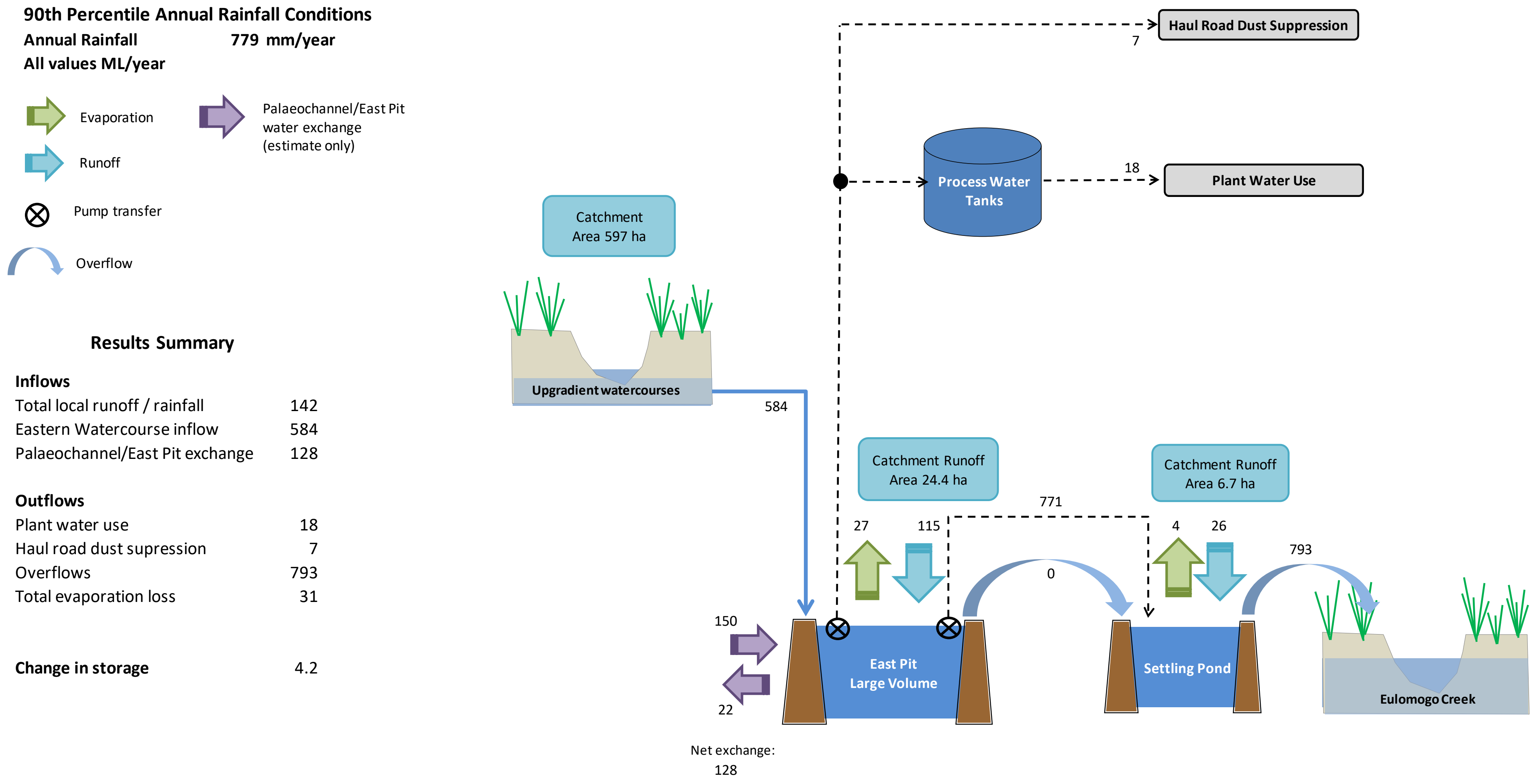


Figure B.3 Water balance: Historic Operations scneario – 90th percentile year

B.4.2 Continuation Project (no diversion) results

Table B.4 provides a summary of key inflows and outflows in typical 10th, 50th and 90th percentile rainfall years. Figure B.4 to Figure B.6 provide annualised results in flow chart format for typical 10th, 50th and 90th percentile rainfall years.

Table B.4 Summary of inflows and outflows: Continuation Project (no diversion) scenario

	Units	Annualised results		
		Dry year[1]	Median year	Wet Year[1]
Inflows				
Runoff				
– Quarry catchments	ML/year	83	160	267
– Upgradient watercourses	ML/year	74	210	584
Runoff total	ML/year	157	370	851
Palaeochannel inflows (estimate only)	ML/year	0	0	0
Total inflows	ML/year	**157**	**370**	**851**
Outflows				
Operational water use	ML/year	36	35	35
Evaporation	ML/year	66	68	69
Discharges				
– Sediment basin overflows	ML/year	0	0	3
– East Pit overflows	ML/year	6	104	559
– East Pit outflow to palaeochannel	ML/year	102	133	136
– Discharges total	ML/year	107	236	698
Total outflows	ML/year	**210**	**535**	**802**
Balance (change in storage)	ML/year	**-52**	**+30**	**+50**
Net palaeochannel/East Pit water exchange[2]	ML/year	**-102**	**-133**	**-136**

Notes: 1. Dry year refers to a typical 10th percentile rainfall year Wet year refers to a typical 90th percentile rainfall year

2. Refers to the net water exchange between the palaeochannel and the East Pit. A positive number refers to a net groundwater inflow, while a negative number refers to a net seepage loss from the East Pit into the palaeochannel.

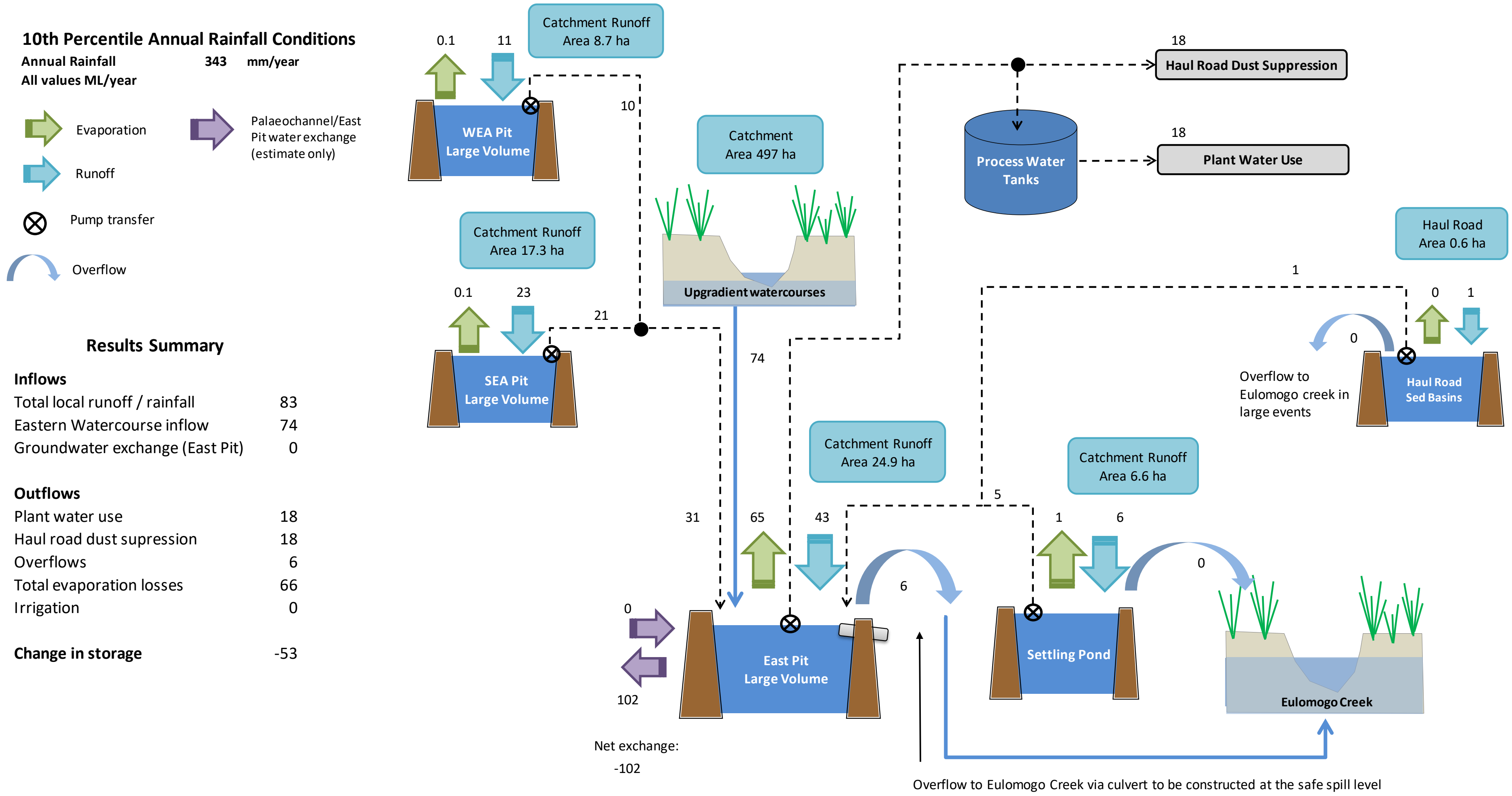


Figure B.4 Water balance: Continuation Project (no diverion) sceanrio – 10th percentile year

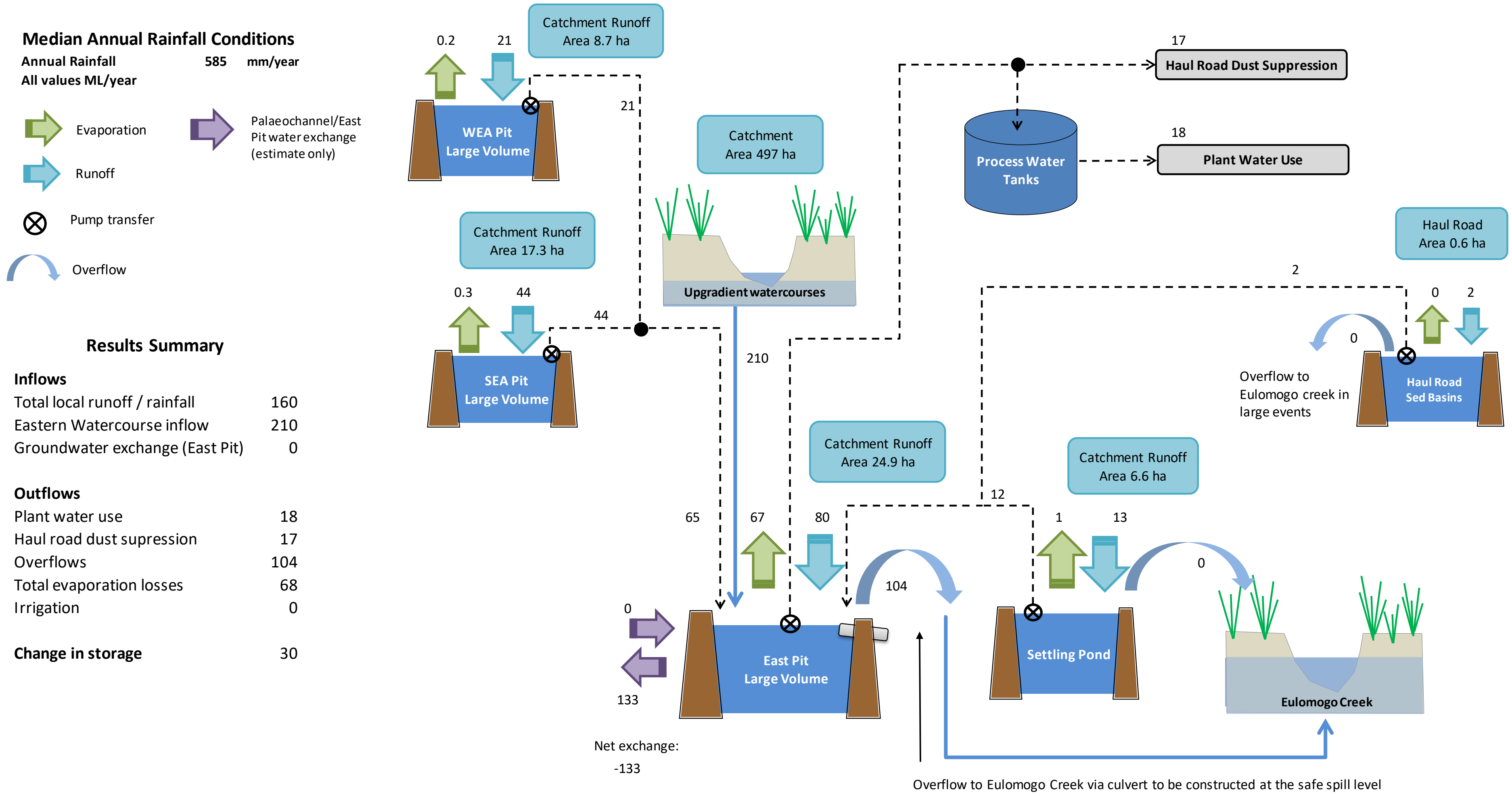


Figure B.5 Water balance: Continuation Project (no diverion) scneario – 50th percentile year

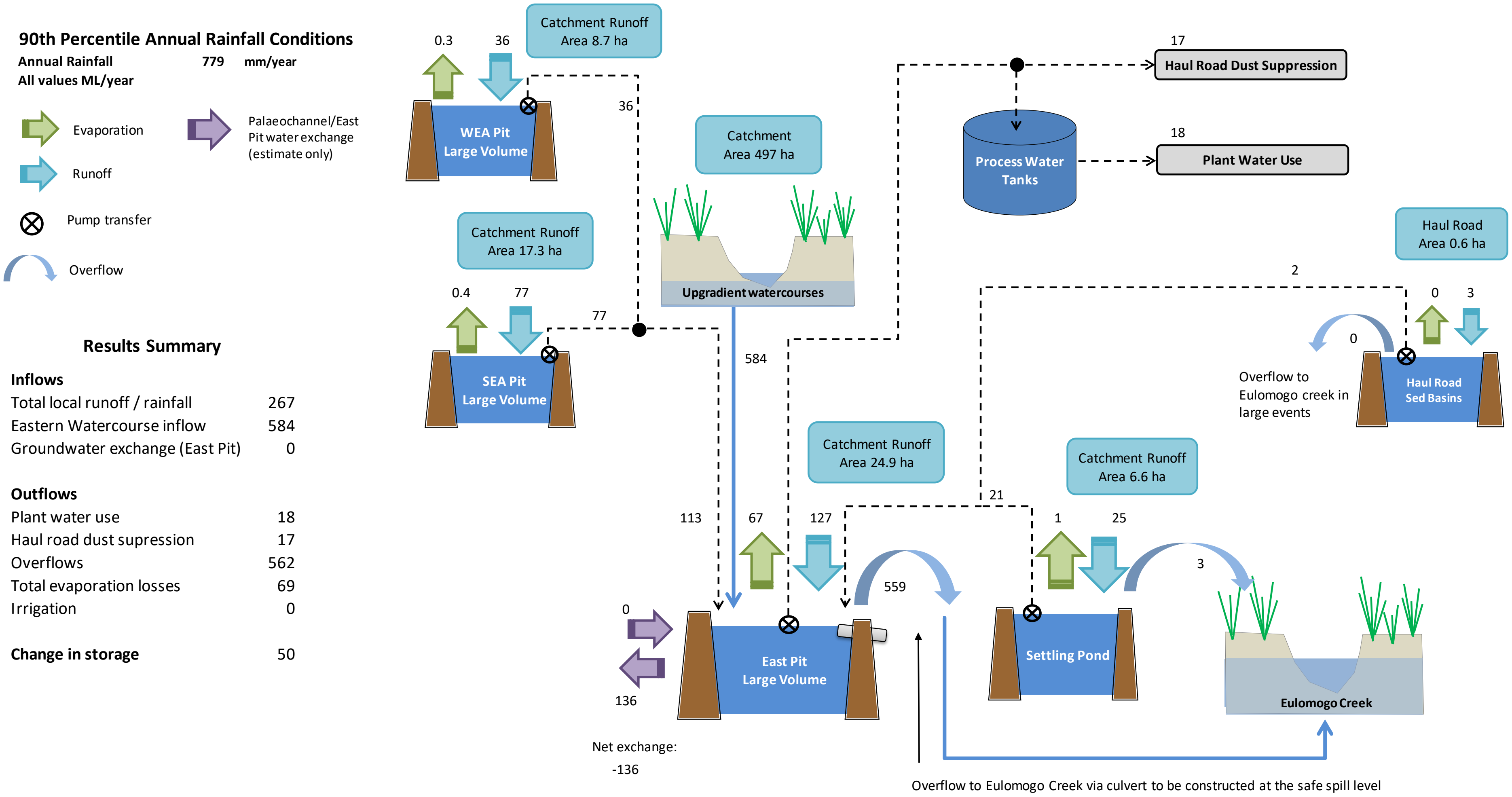


Figure B.6 Water balance: Continuation Project (no diverion) sceario – 90th percentile year

B.4.3 Continuation Project (with division) results

Table B.4 provides a summary of key inflows and outflows in typical 10th, 50th and 90th percentile rainfall years. Figure B.4 to Figure B.6 provide annualised results in flow chart format for typical 10th, 50th and 90th percentile rainfall years.

Table B.5 Summary of inflows and outflows: Continuation Project (with diversion) scenario

	Units	Annualised results		
		Dry year[1]	Median year	Wet Year[1]
Inflows				
Runoff				
– Quarry catchments	ML/year	81	157	266
– Upgradient watercourses	ML/year	0	0	0
Runoff total	ML/year	81	157	266
Palaeochannel inflows (estimate only)	ML/year	1	0	0
Total inflows	ML/year	**82**	**157**	**266**
Outflows				
Operational water use	ML/year	36	35	35
Evaporation	ML/year	54	57	62
Discharges				
– Sediment basin overflows	ML/year	0	0	3
– East Pit overflows	ML/year	0	0	3
– East Pit outflow to palaeochannel	ML/year	36	62	93
– Discharges total	ML/year	36	62	99
Total outflows	ML/year	**126**	**154**	**196**
Balance (change in storage)	ML/year	**-44**	**+3**	**+70**
Net palaeochannel/East Pit water exchange[2]	ML/year	**-35**	**-62**	**-93**

Notes: 1. Dry year refers to a typical 10^{th} percentile rainfall year Wet year refers to a typical 90^{th} percentile rainfall year

2. Refers to the net water exchange between the palaeochannel and the East Pit. A positive number refers to a net groundwater inflow, while a negative number refers to a net seepage loss from the East Pit into the palaeochannel.

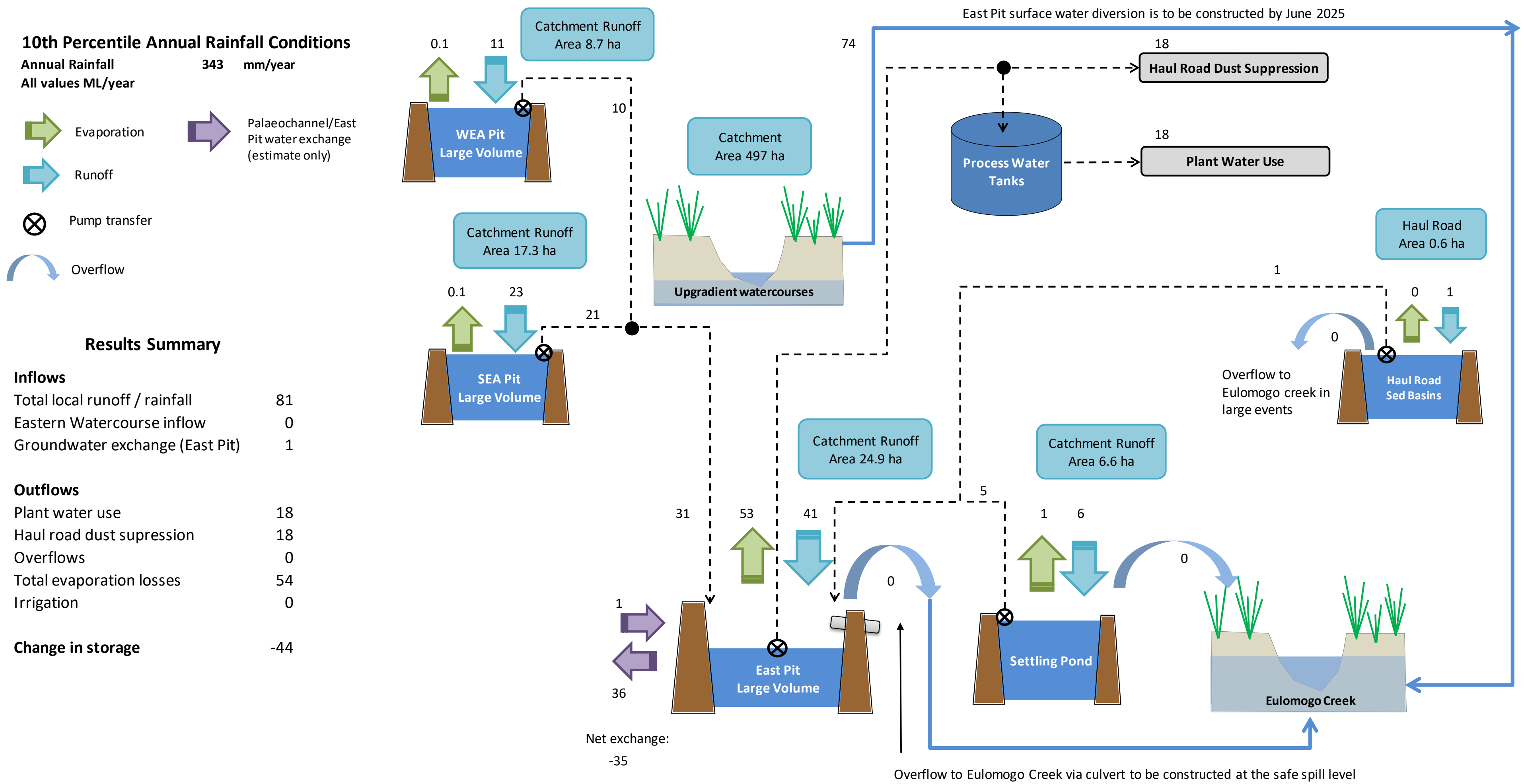


Figure B.7 Water balance: Continuation Project (with diversion) scenario – 10th percentile year

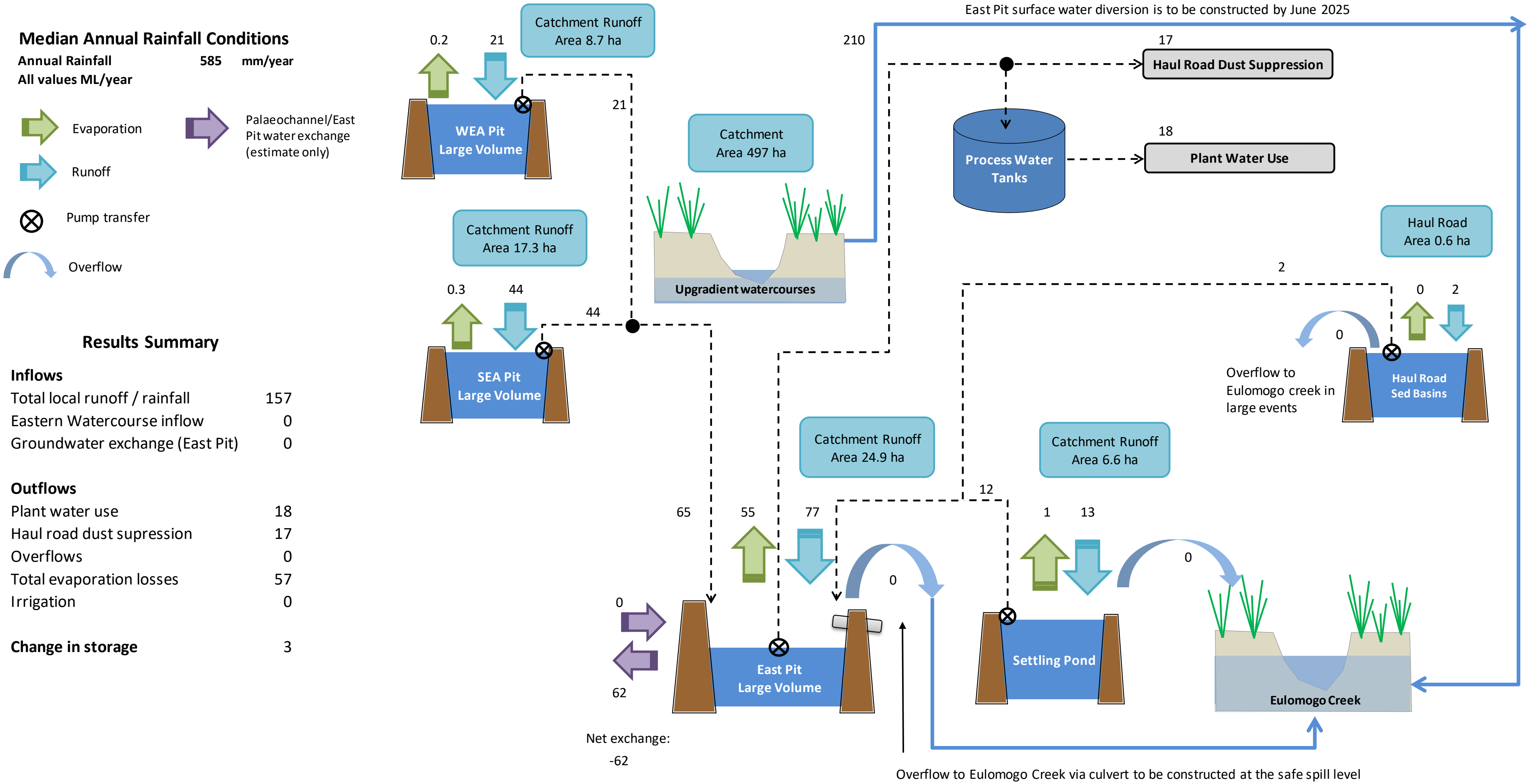


Figure B.8 Water balance: Continuation Project (with diversion) scenario – 50th percentile year

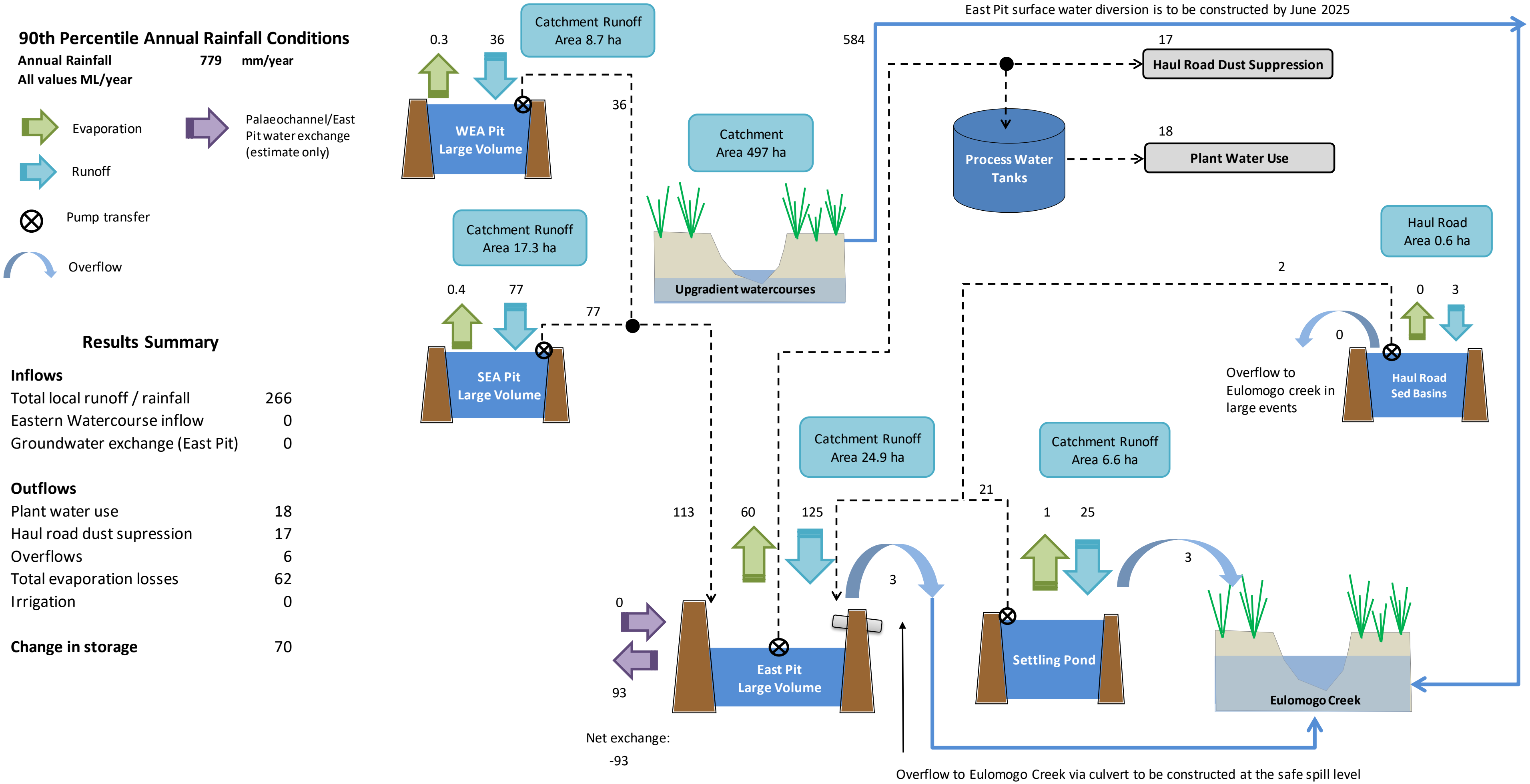


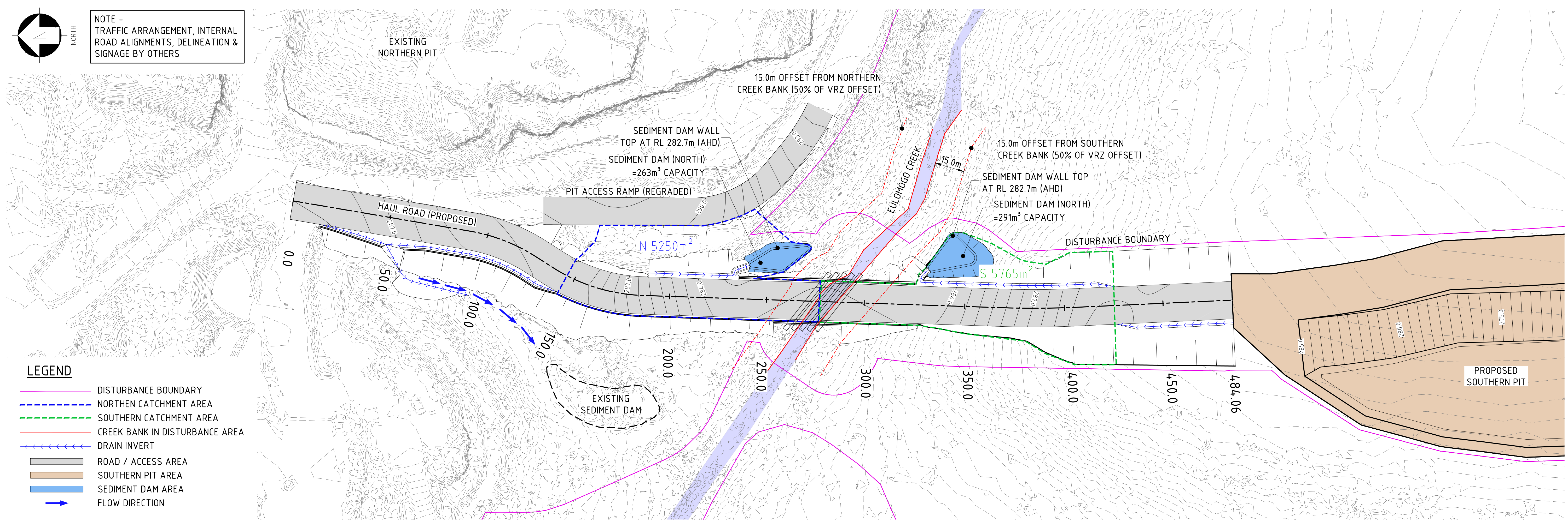
Figure B.9 Water balance: Continuation Project (with diversion) scenario – 90th percentile year

Appendix C
Preliminary design of Haul Road sedimentation basins

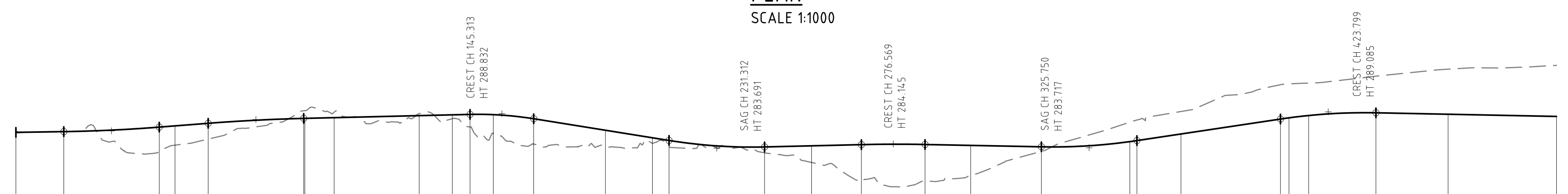
EMM
creating opportunities

C.1 Design notes provided by Holcim

To address condition B36, a preliminary design of the haul road sedimentation basins is provided in this appendix. This preliminary design will be updated and included in the Eulomogo Creek crossing design that is being prepared to address Condition B37. The updated design will address DPE-Water's comment on the preliminary design provided in their submission dated 27 October 2023 relating to riparian setbacks.



PLAN
SCALE 1:1000



Horiz Curve Data: R90m; R-90m; R-500m

Vertical Geometry Grade (%) / Vertical Grade Length: 0.8 % 30.047m; 3.9 % 45.376m; 1.2 % 77.281m; -8 % 67.523m; 1.201 % 55.431m; -1 % 61.563m; 7.5 % 75.107m; -1 % 71.74m

Vertical Curve Length (m) / Vertical Curve Radius (m): 30m VC R = 967.66; 30m VC R = 1110.99; 20m VC R = 217.4; 30m VC R = 326.07; 20m VC R = 908.81; 30m VC R = 352.95; 30m VC R = 352.96

DATUM R.L. 252.00

DEPTH OF CUT	0.278	-0.001	-3.857	-3.022	-2.476	1.196	1.213	0.867	0.330	-0.601	-1.953	-2.922	-3.986	-2.630	-0.873	-0.955
EXISTING SURFACE	286.276	286.118	282.967	283.995	284.947	289.385	289.407	289.170	288.954	288.148	286.863	285.859	284.150	283.703	284.280	283.779
DESIGN HEIGHT	285.998	286.119	286.824	287.017	287.424	288.189	288.193	288.304	288.624	288.749	288.816	288.781	288.136	286.333	285.153	284.734
CHAINAGE	0	15.047	45.047	50	60.423	90.423	90.799	100	126.717	137.127	142.704	150	162.704	185.244	200	205.227

DEPTH OF CUT	-0.916	-2.606	-5.744	-5.727	-4.638	-0.719	3.049	3.230	3.523	5.380	5.325	5.084	5.748	7.071	8.011
EXISTING SURFACE	282.798	281.286	278.336	278.373	279.319	283.015	287.599	287.940	289.270	293.473	293.608	293.730	294.815	295.912	296.511
DESIGN HEIGHT	283.715	283.892	284.080	284.100	283.957	283.734	284.550	284.709	285.747	288.092	288.283	288.646	289.067	288.841	288.500
CHAINAGE	235.227	250	265.658	285.658	300	322.22	350	352.22	366.06	397.328	400	406.189	427.328	450	484.06

HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:500

LONGITUDINAL SECTION - HAUL ROAD
SCALE 1:1000 2:1 EXAGGERATION

20 0 20 40 60 80 100m
SCALE 1:1000

REFERENCE DRG'S	
DRAWING	DRAWING TITLE

REV	REVISION DESCRIPTION	DRAWN	CHECKED	APPROVED	DATE
E	ISSUED FOR INFORMATION	SM	JS	JS	12.12.23
D	ISSUED FOR INFORMATION	SM	JS	JS	06.09.23
C	ISSUED FOR INFORMATON	SM	JS	JS	15.08.23
B	ISSUED FOR INFORMATION	SM	JS	JS	31.07.23
A	ISSUED FOR INFORMATION	SM	JS	JS	12.07.23

APPROVALS DUTY	NAME	DATE
DRAWN	SM	12.07.23
CHECKED	JS	12.07.23
DESIGNED	SM	12.07.23
ENG. APPROVED	JS	12.07.23
PROJ. APPROVED	ATW	12.07.23

DRAWINGS WHERE APPLICABLE ARE THIRD ANGLE PROJECTION

BG&E Resources

HOLCIM - DUBBO QUARRY
WATER QUALITY MANAGEMENT
SOUTHERN PIT ACCESS

SHEET	SCALE	DRAWING NUMBER	REV
A1	SHOWN	SKC-003	E

Appendix D
Stream and riparian condition – baseline photographs

creating opportunities

D.1 Photograph locations

The stream and riparian condition monitoring locations are shown in Figure D.1 and described in Table D.1. A photograph of each location is provided after the figure.

Table D.1 Photograph location descriptions

Location	Description
1	Eulomogo Creek, downstream of the Haul Road crossing and all discharge locations
2	Eulomogo Creek, downstream of Haul Road culverts and immediately downstream of where East Pit inflows enter Eulomogo Creek
3	Eulomogo Creek, downstream of the proposed Haul Road culverts and immediately upstream of where East Pit discharges enter Eulomogo Creek
4	Eulomogo Creek, immediately downstream of the proposed Haul Road culverts
5	Eulomogo Creek, immediately upstream of the proposed Haul Road culverts
6	Eulomogo Creek, immediately downstream of the proposed East Pit surface water diversion outlet into Eulomogo Creek
7	Eulomogo Creek, immediately upstream of the proposed East Pit surface water diversion outlet into Eulomogo Creek
8	Eastern Watercourse near the site boundary
9	Northern Watercourse near the site boundary

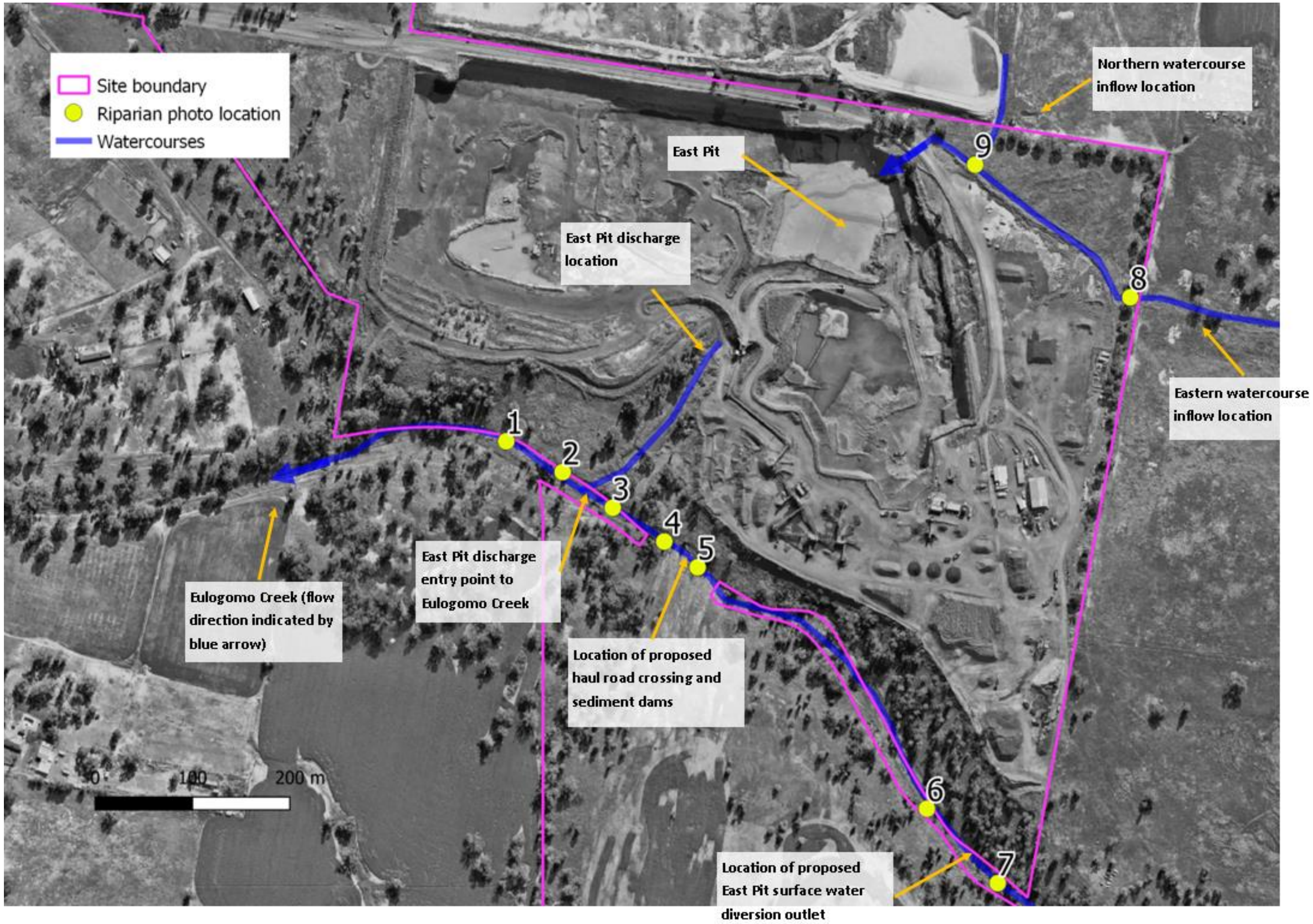
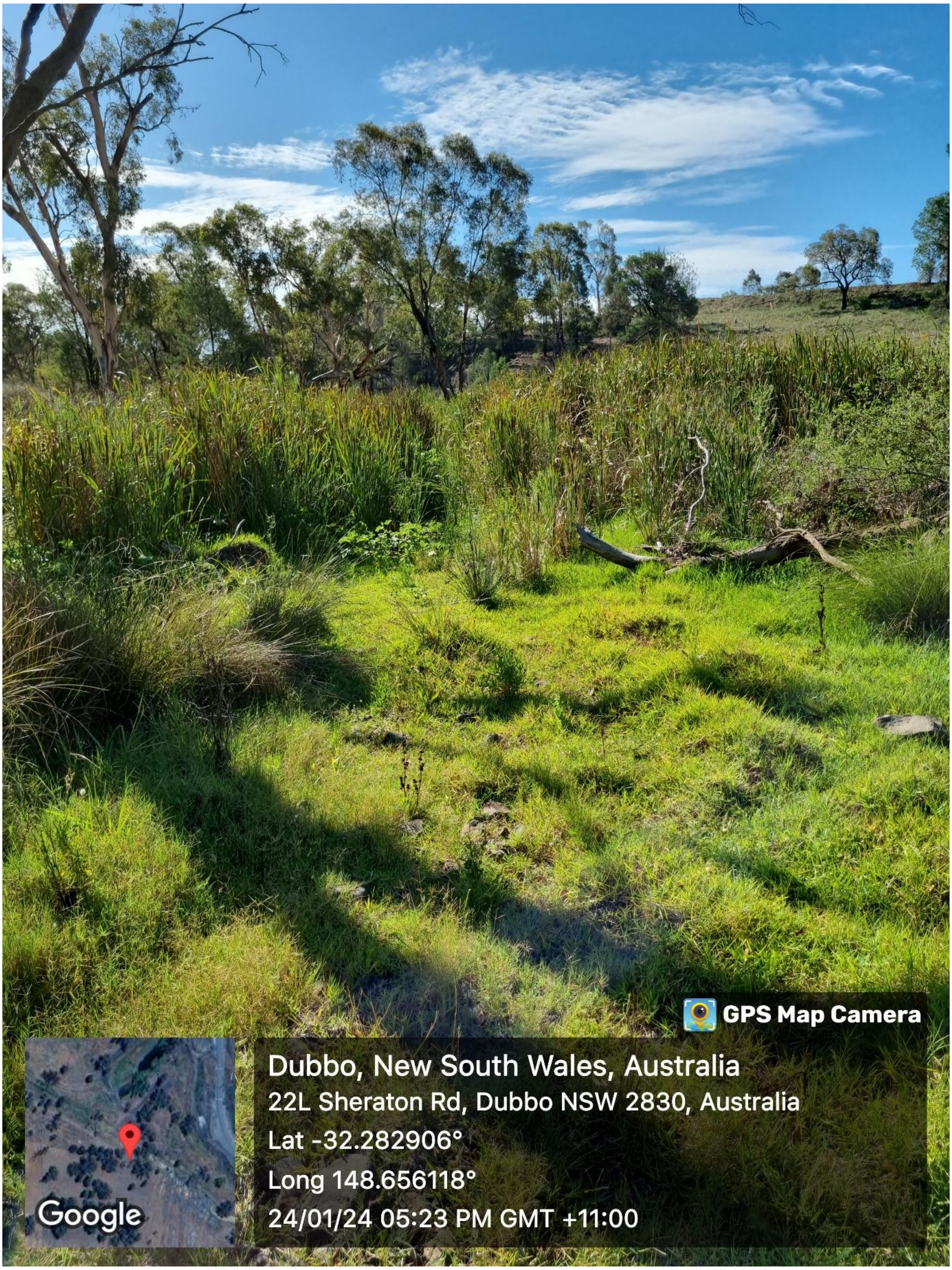


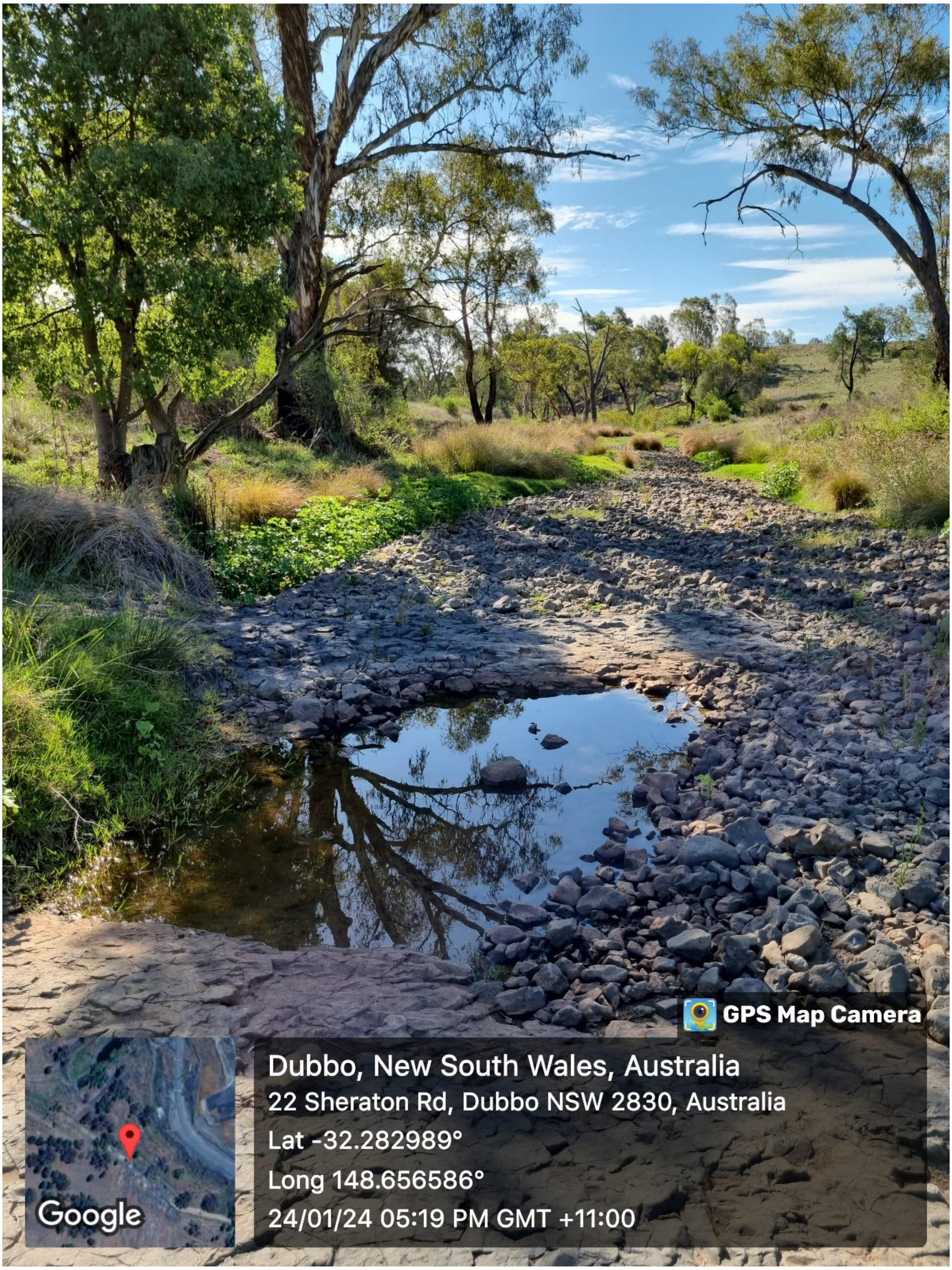
Figure D.1 Stream and riparian condition monitoring locations

Location 1 – Eulomogo Creek, downstream of Haul Road culverts and all discharge locations

Location 2 – Eulomogo Creek, downstream of Haul Road culverts and immediately downstream of where East Pit discharges enter Eulomogo Creek

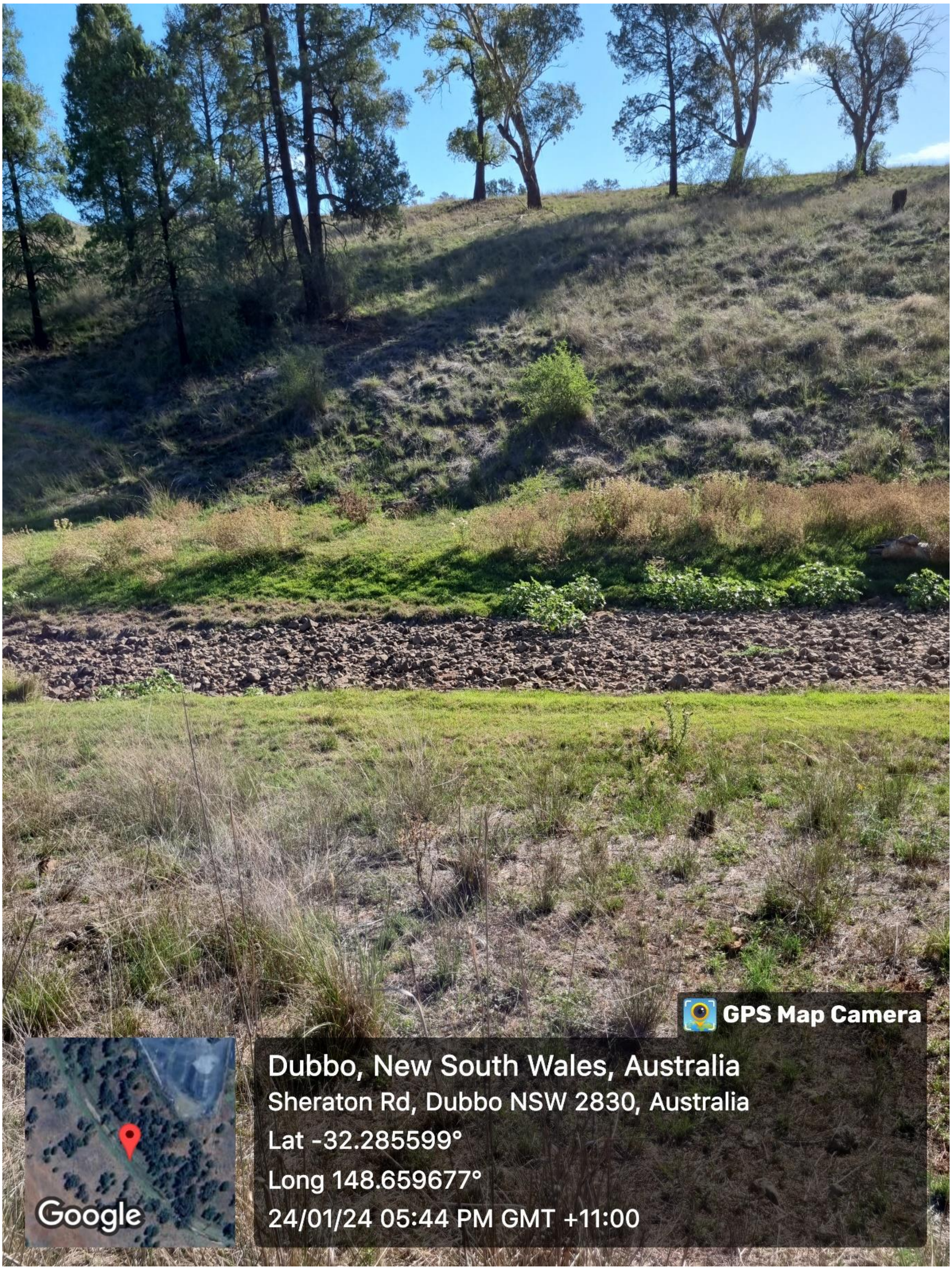


Location 3 – Eulomogo Creek, downstream of the proposed Haul Road culverts and immediately upstream of where East Pit discharges enter Eulomogo Creek

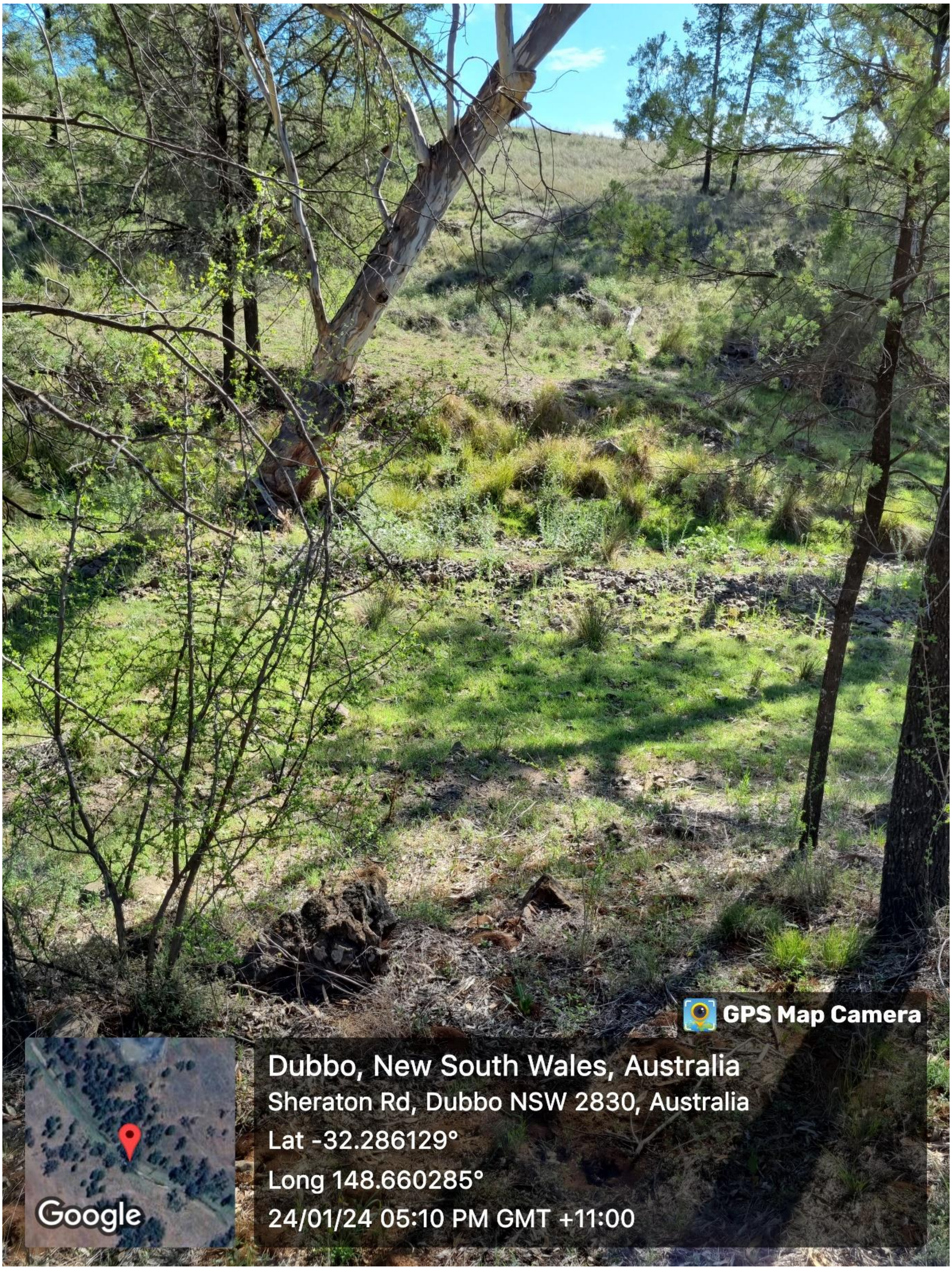


Location 4 – Eulomogo Creek, immediately downstream of the proposed Haul Road culverts

Location 5 – Eulomogo Creek, immediately upstream of the proposed Haul Road culverts



Location 6 – Eulomogo Creek, immediately downstream of the proposed East Pit surface water diversion outlet into Eulomogo Creek



Location 7 – Eulomogo Creek, immediately upstream of the proposed East Pit surface water diversion outlet into Eulomogo Creek

Location 8 – Eastern Watercourse near the site boundary

Location 9 – Northern Watercourse near the site boundary

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