



PEMBROKE

Olive Downs Coking Coal Project
Draft Environmental Impact Statement

Appendix E
Surface Water
Assessment

Report**Olive Downs Coking Coal Project EIS –
Surface Water Assessment****H354065-0000-228-230-0005**

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Appendix A

Model Sensitivity Assessment Results

- A.1 Scenario 1: Rejects Cells Decant Return Rate Increased by 5%
- A.2 Scenario 2: Rejects Cells Decant Return Rate Decreased by 5%
- A.3 Scenario 3: Global Increase of AWBM Soil Capacity by 20%
- A.4 Scenario 4: Global Decrease of AWBM Soil Capacity by 20%
- A.5 Scenario 5: 25% Global Increase of Source Salinity by 25%

Appendix B

Geomorphology Report

1. Introduction

1.1 Background

Pembroke Olive Downs Pty Ltd (Pembroke) proposes to develop the Olive Downs Coking Coal Project (the Project), a metallurgical coal mine and associated infrastructure within the Bowen Basin, located approximately 40 kilometres south east of Moranbah, Queensland (see Figure 1-1).

The Project provides an opportunity to develop an open cut metallurgical coal resource within the Bowen Basin mining precinct that can deliver up to 20 million tonnes per annum (Mtpa) run-of-mine (ROM) coal. The Olive Downs Coking Coal Project is hereafter referred to in this report as the Project.

Hatch was commissioned by Pembroke to undertake a surface water impact assessed for the Project. The surface water impact assessment will form part of an Environmental Impact Statement (EIS) for the Project under Sections 70 and 71 of the *Environment Protection Act 1994* (QLD).

This report presents the following:

- An overview of the regulatory framework which applies to the Project (including aspects which do not directly relate to the surface water assessment);
- A description of the existing surface water environment surrounding the Project, and the associated environmental values;
- A detailed description of the proposed water management strategy to manage water in and around the Project and details of the expected performance of the proposed water management system;
- A discussion of the potential impacts of the Project and the proposed mitigation and management measures to mitigate these potential impacts. This include a cumulative impact assessment of the Project considering potential compounding interactions with similar impacts from other projects within an appropriate region of influence.

Details of the Project relating to flooding, the proposed Ripstone Creek diversion and flood protection levees are not covered in this report. This information is provided in a separate Flood Assessment report (Hatch, 2018).

1.2 Project Description

The Project comprises the Olive Downs South and Willunga domains and associated linear infrastructure corridors, including a rail spur connecting to the Norwich Park Branch Railway, a water pipeline connecting to the Eungella pipeline network, an electricity transmission line (ETL) and access roads (Figure 1-2).

The proposed Olive Downs South domain open cut pits are generally aligned from north to south and are located on the western side of the Isaac River (Figure 1-3). At peak development of the Olive Downs South domain, production of ROM coal is expected to approximately 12 Mtpa.

The proposed Willunga domain open cut pits are located on the eastern side of the Isaac River (Figure 1-4). The Willunga domain is expected to produce approximately 8 Mtpa ROM coal at peak operation.

The main surface water-related activities associated with the development of the Project include:

- up to 20 Mtpa of ROM coal production (15 Mtpa product) for an operational mine life of approximately 79 years, including mining operations using conventional mining equipment (e.g. excavators, dozers, front end loaders and trucks) and strip mining, associated with:
 - ◆ development of the Olive Downs South domain open cut pits and out-of-pit waste rock emplacements within Mining Lease Application (MLA) 700032, MLA 700033, MLA 700035 and MLA 700036 (within Mineral Development Licenses [MDL] 3012 and MDL 3013); and
 - ◆ development of the Willunga domain open cut pits and out-of-pit waste rock emplacements within MLA 700034 (within MDL 3014).
- progressive placement of waste rock in emplacements adjacent to and nearby the open pit extents;
- progressive backfilling of the mine voids with waste rock behind the advancing open cut mining operations;
- progressive development of new haul roads and internal roads, including an Isaac River road crossing to provide access between the Olive Downs South and Willunga domains;
- installation and operation of on-site ROM coal handling and crushing facilities at the Willunga domain;
- transfer of crushed ROM coal from the Willunga domain to the CHPP at the Olive Downs South domain, via either haul road or conveyor with an Isaac River crossing;
- storage and disposal of CHPP rejects (coarse and fine rejects) during the initial years (until in-pit containment facilities become available) in initial rejects storage facilities including tailings cells;

- disposal of CHPP rejects (coarse and fine rejects) on-site within appropriate in-pit containment facilities, including mine voids behind the advancing open cut mining operations, and where circumstances allow, disposal in other out-of-pit containment facilities;
- progressive development of sediment dams and water storage dams and installation of pumps, pipelines and other water management equipment and structures (including up-catchment diversions and levees);
- wastewater and sewage treatment by package sewage treatment plants;
- advance dewatering of Olive Downs South and Willunga domain open cut pits and construction and use of a groundwater supply borefield subject to the prevalence of suitable hydrogeological conditions;
- installation of a raw water supply pipeline from the existing Eungella pipeline network;
- discharge of excess water off-site in accordance with relevant principles and conditions of the Model Water Conditions for Coal Mines in the Fitzroy Basin (DEHP, 2013);
- construction of a new rail loop and rail spur from the Norwich Park Branch Railway, and rail loadout facility including product coal stockpiles at the Olive Downs South domain for rail transport of coking and PCI coal products and by-products (i.e. thermal coal) for the export market via the DBCT (subject to availability of rail and port allocation); and
- other associated minor infrastructure, plant, equipment and activities.

Existing local and regional infrastructure would be used to transport product coal to the port for export including the Norwich Park Branch Railway and the Dalrymple Bay Coal Terminal (DBCT).

Indicative general arrangements for Years 2027, 2043, 2066 and 2085 of the Project are shown on Figure 1-5 to Figure 1-11. These indicative general arrangements are based on planned maximum production and mine progression. The mining layout and sequence may vary to take account of localised geological features, coal market volume and quality requirements, mining economics and Project detailed engineering design.

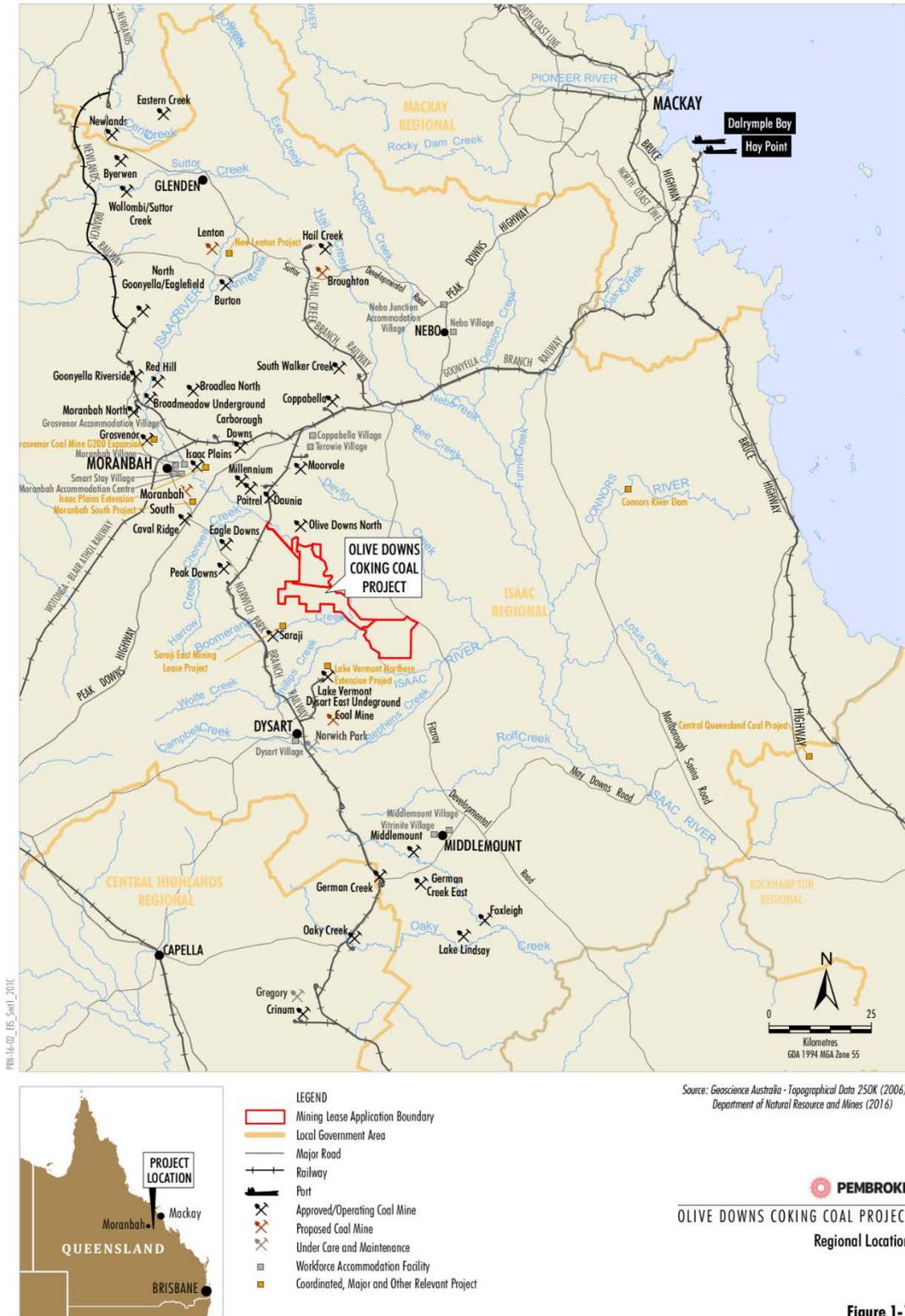


Figure 1-1: Olive Downs Coking Coal Project – Regional Location

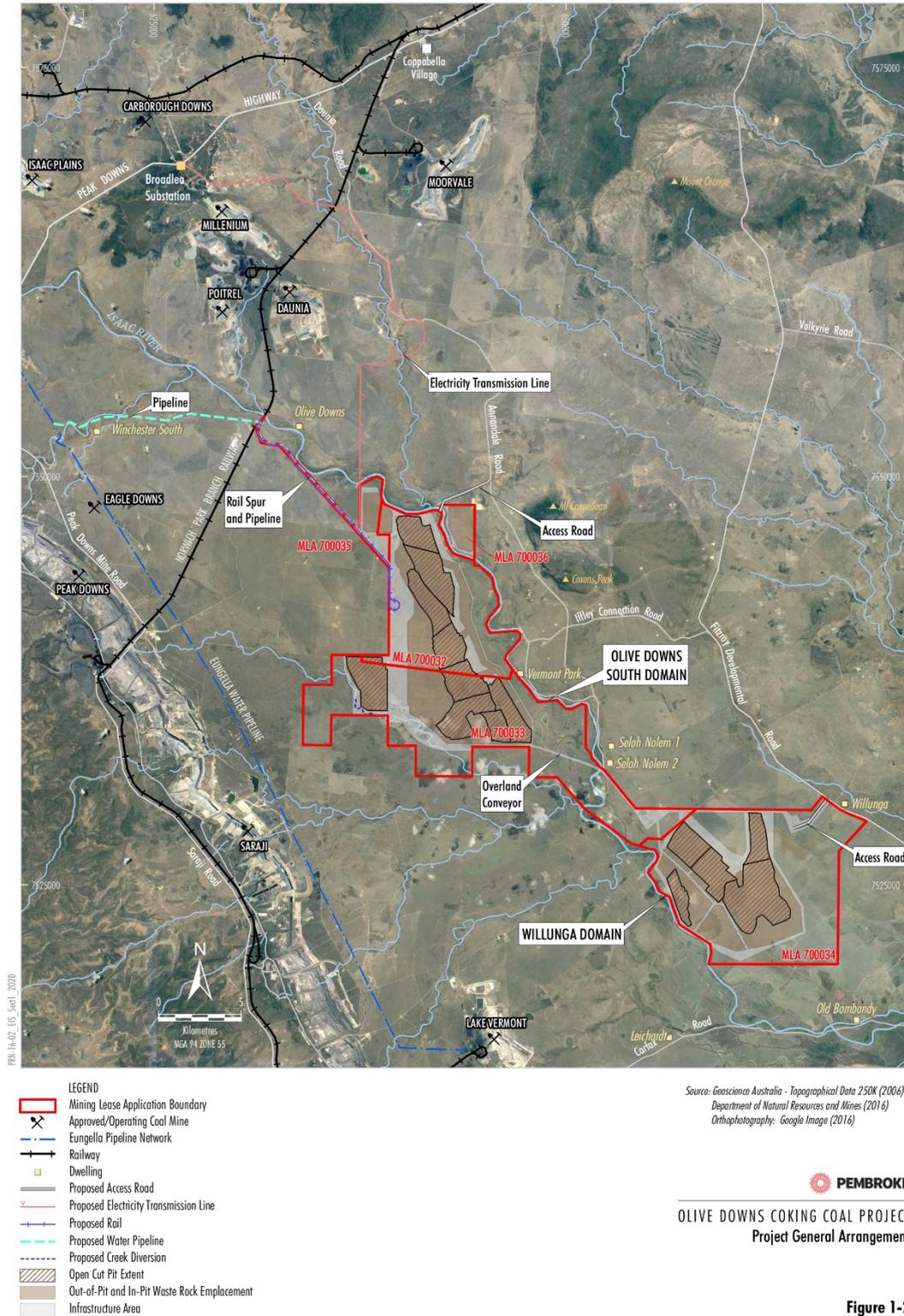


Figure 1-2: Olive Downs Coking Coal Project – Project General Arrangement

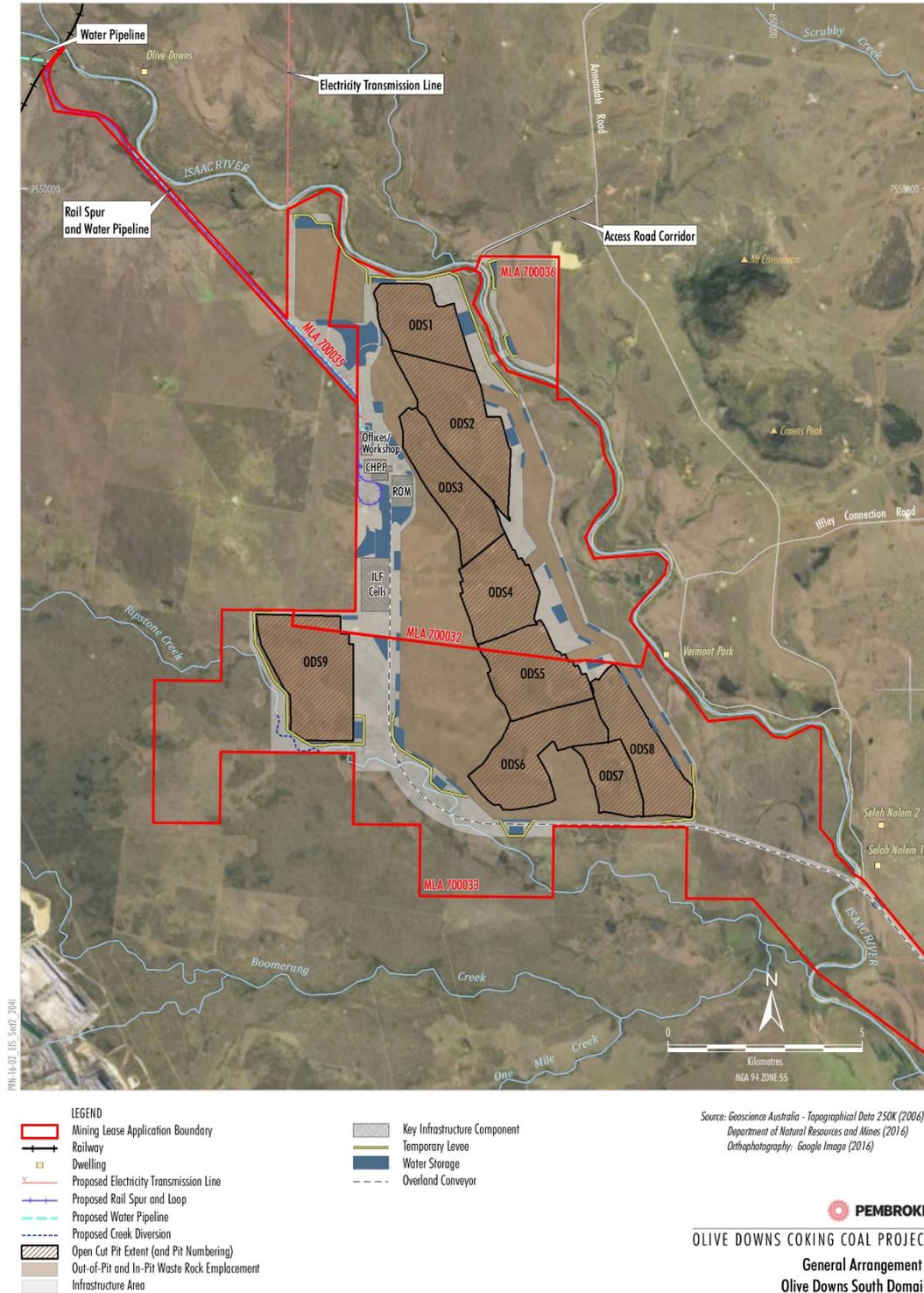


Figure 2-1

Figure 1-3: General Arrangement – Olive Downs South Domain



Figure 2-2

Figure 1-4: General Arrangement - Willunga Domain

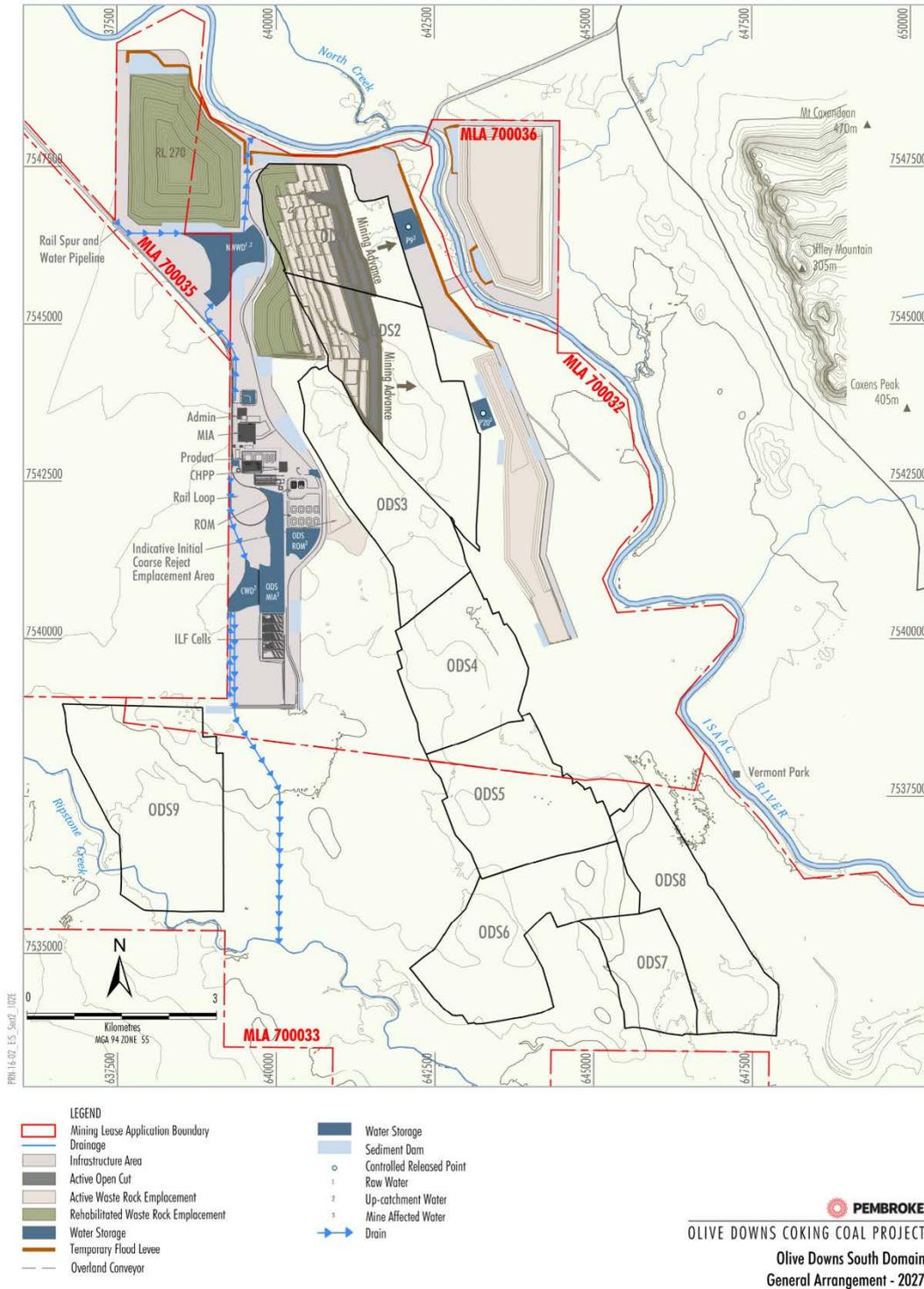


Figure 2-3

Figure 1-5: Olive Downs South General Arrangement - 2027

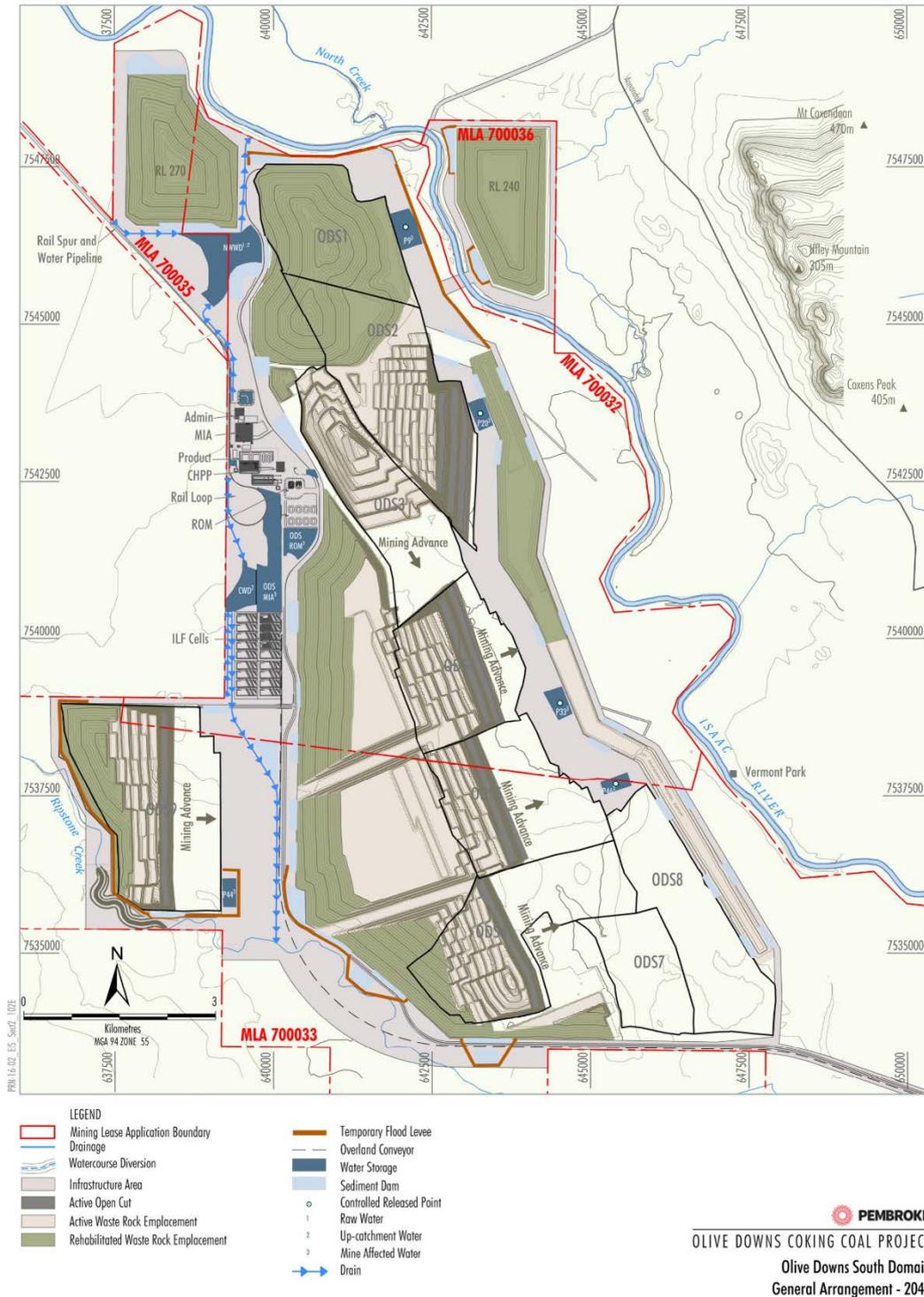
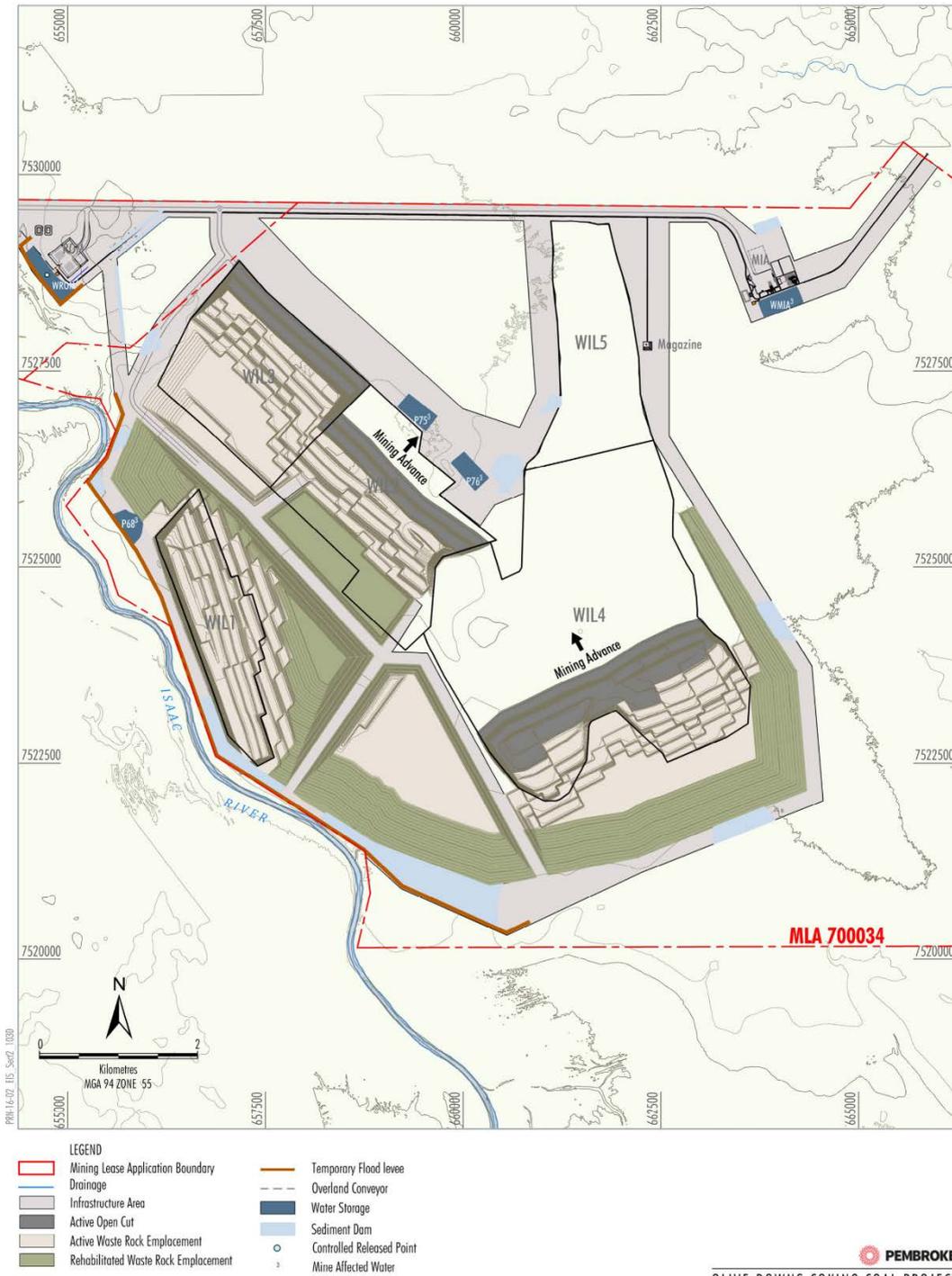


Figure 2-4

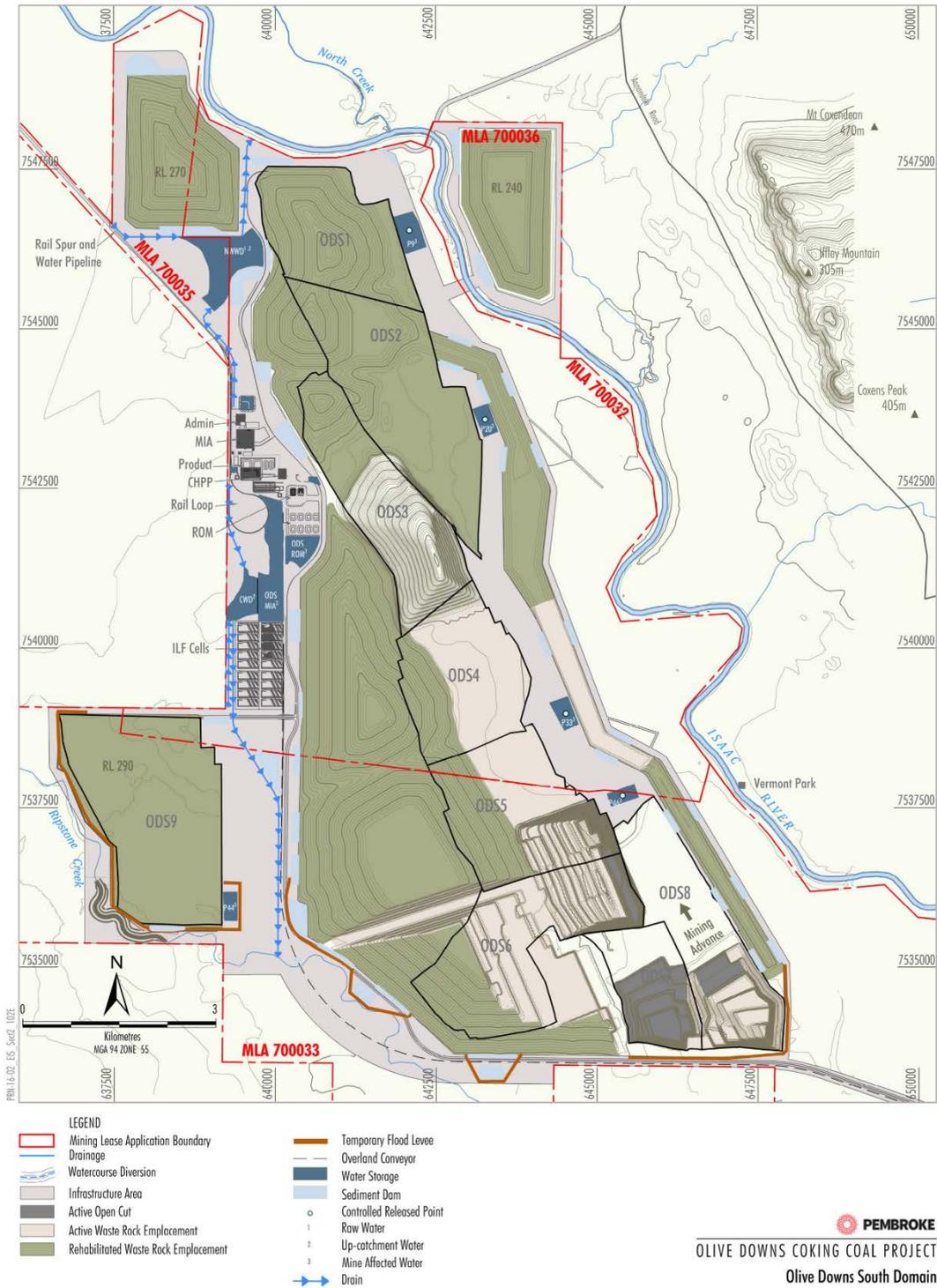
Figure 1-6: Olive Downs South General Arrangement - 2043



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 Willunga Domain
 General Arrangement - 2043

Figure 2-5

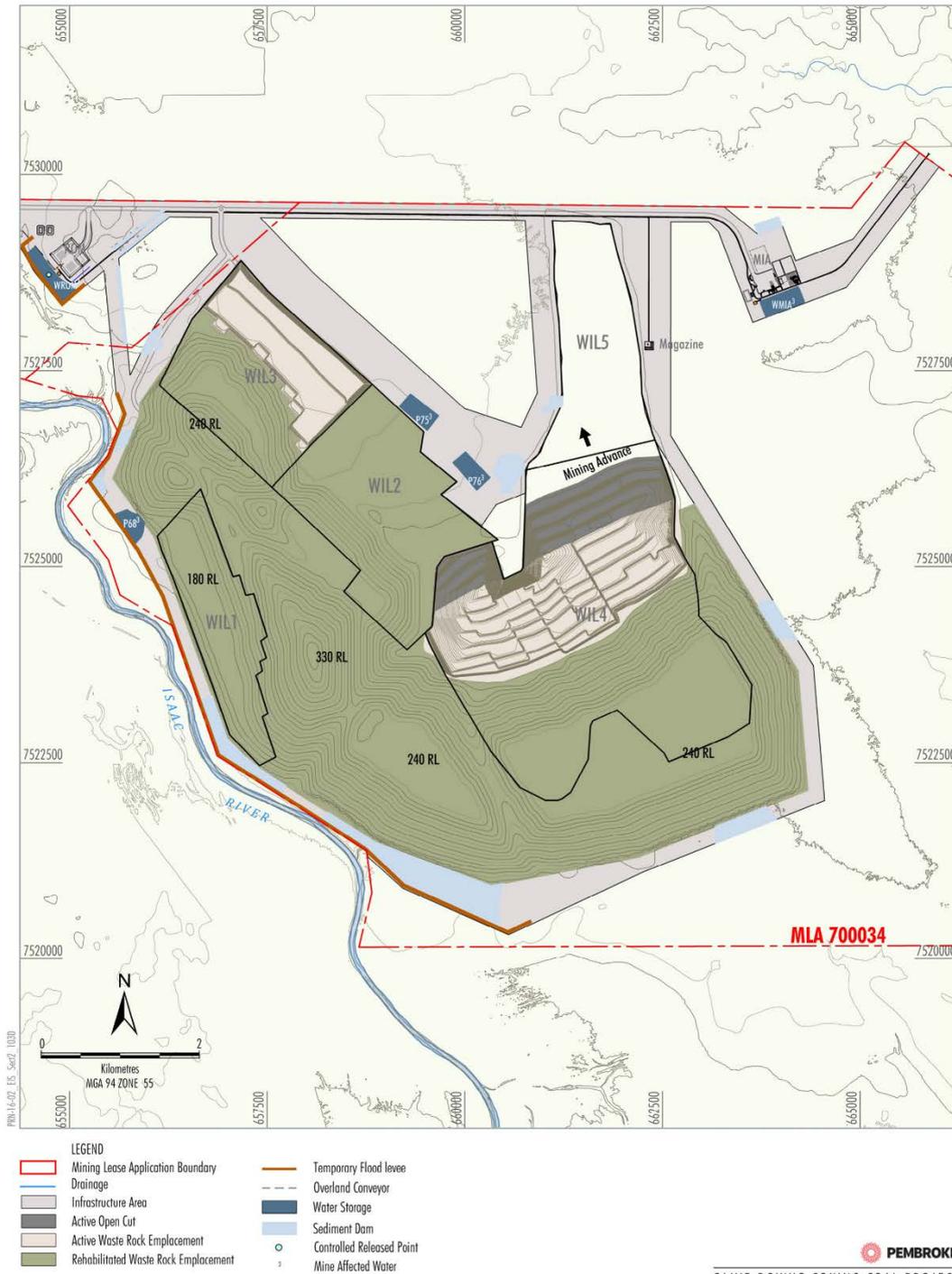
Figure 1-7: Willunga General Arrangement - 2043



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 Olive Downs South Domain
 General Arrangement - 2066

Figure 2-6

Figure 1-8: Olive Downs South General Arrangement - 2066



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 Willunga Domain
 General Arrangement - 2066

Figure 2-7

Figure 1-9: Willunga General Arrangement - 2066

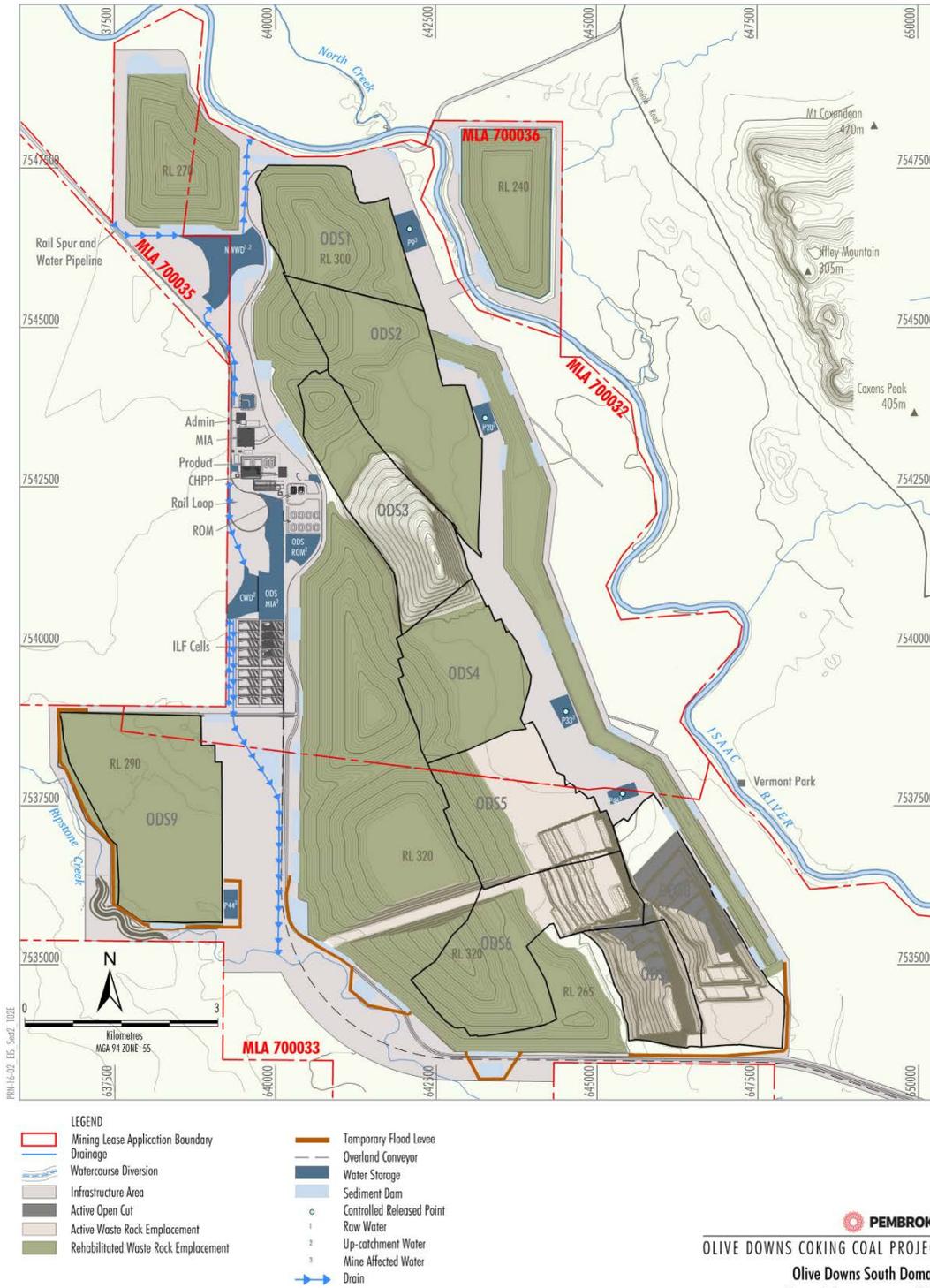
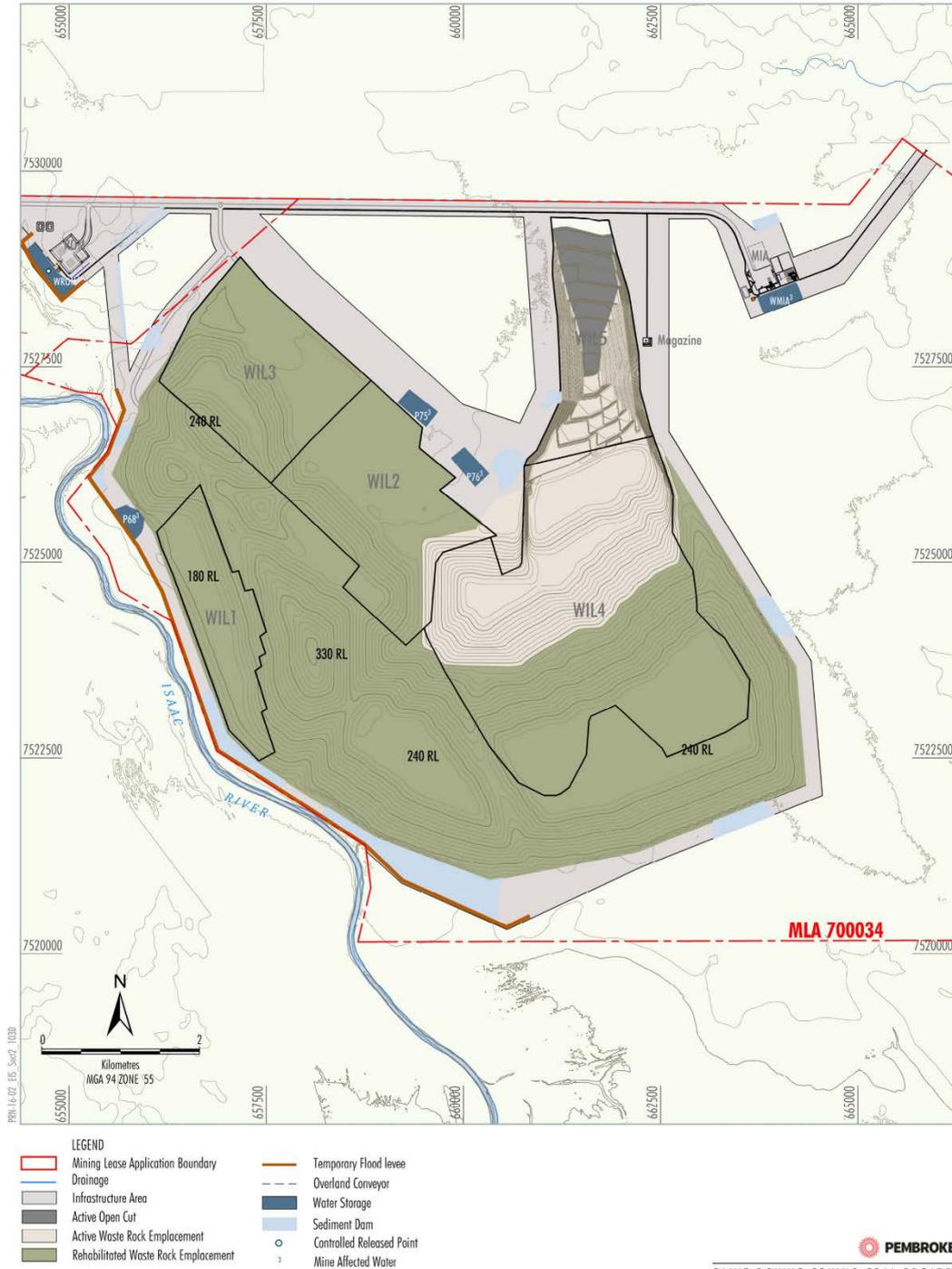


Figure 2-8

Figure 1-10: Olive Downs South General Arrangement - 2085



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 OLIVE DOWNS COKING COAL PROJECT
 Willunga Domain
 General Arrangement - 2085

Figure 2-9

Figure 1-11: Willunga General Arrangement - 2085

2. Terms of Reference for EIS – Surface Water

The site-specific Terms of Reference (TOR) seek information corresponding to the project assessment requirements of the EP Act. The EIS process applies to site-specific environmental authority (EA) applications for undertaking resource projects that meet any of the Department of Environment and Heritage Protection’s (DEHP) EIS triggers in the guideline “*Environmental impact statement – Triggers for environmental impact statements under the Environmental Protection Act 1994 for mining, petroleum and gas activities*”.

This assessment, which forms part of the EIS, addresses the TOR concerning surface water. Table 2-1 lists the elements of the TOR relevant to this assessment and the sections of this report where those TORs are addressed.

Table 2-1: Final Terms of Reference for the Project – Surface Water Resources

Key Issue	Requirement	Report Section
10. Project description		
<ul style="list-style-type: none"> 10.10 Climate 	Describe the site’s climate patterns that are relevant to the environmental assessment, with particular regard to discharges to water and air and the propagation of noise. Climate information should be presented in a statistical form including long-term averages and extreme values, as necessary.	Section 5.2
11. Assessment of project specific matters		
<i>Matters of national environmental significance - Assessment requirements</i>		
<ul style="list-style-type: none"> 11.12 	The EIS should include an assessment of the cumulative impacts, with respect to each controlling provision for each proposed action and all identified consequential actions related to each proposed action and all known developments (of which the proponent should reasonably be aware) that have been, or are being, taken or that have been approved in the region affected by each proposed action.	Section 10.6
<ul style="list-style-type: none"> 11.13 	With respect to each controlling provision for each proposed action, describe any avoidance measures proposed to reduce the impact on MNES and the anticipated result of proposed avoidance measures. Supporting evidence should be provided to demonstrate the appropriateness of avoidance measures proposed. Where the likely success of avoidance measures cannot be supported by evidence, identify contingencies in the event the avoidance is not successful.	Section 10
<ul style="list-style-type: none"> 11.14 	With respect to each controlling provision for each proposed action, describe any mitigation measures proposed to reduce the impact on MNES and the anticipated result of proposed mitigation measures. Supporting evidence should be provided to demonstrate the appropriateness of mitigation measures proposed. Where the likely success of mitigation measures cannot be supported by evidence, identify contingencies in the event the mitigation is not successful.	Section 10
<ul style="list-style-type: none"> 11.15 	With respect to each controlling provision for each proposed action, describe the residual significant impacts of each proposed action after all proposed avoidance and mitigation measures are taken into account and any compensatory measures proposed.	Section 10
<i>A water resource, in relation to coal seam gas development and large coal mining development</i>		

Key Issue	Requirement	Report Section
• 11.24	In relation to the proposed mine site and access road (EPBC 2017/7867), the EIS must provide details on the current state of groundwater and surface water in the region as well as any use of these resources.	Section 5
• 11.25	The EIS must describe and assess the impacts to water resources giving consideration to the Significant Impact Guidelines 1.3: Coal seam gas and large coal mining developments – impacts on water resources.	Sections 10.1, 10.3, 10.4, 10.5 & 10.6
• 11.26	The EIS must address the information requirements contained in the Information Guidelines for the Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals and provide a cross-reference table to identify where each component of the guidelines has been addressed.	Section 3.1.2
<i>Water quality – information requirements</i>		
• 11.62	Detail the chemical and physical characteristics of surface waters and groundwater within the area that may be affected by the project in accordance with Department of Environment and Heritage Protection's TOR guideline – Water.	Section 5.4
• 11.64	Identify the quantity, quality and location of all potential discharges of water and waste water by the project, whether as point sources (such as controlled discharges from regulated dams) or diffuse sources (such as seepage from waste rock dumps or irrigation to land of treated sewage effluent). Assess the potential impacts of any discharges on the quality and quantity of receiving waters taking into consideration the assimilative capacity of the receiving environment and the practices and procedures that would be used to avoid or minimise impacts.	Sections, 7.10, 8.3.5, 8.3.6, 8.3.7 & 10.5
• 11.65	Demonstrate how the implementation of mitigation strategies would mitigate significant impacts of water discharges on the receiving environment. Information should be supported with references to relevant legislation, policies, guidelines and modelling	Section 10
• 11.66	Describe how the achievement of the objectives would be monitored and audited, and how corrective actions would be managed.	Section 10.7
<i>Water resources – information requirements</i>		
• 11.68	Provide details of any proposed impoundment, extraction (i.e. volume and rate), discharge, injection, use or loss of surface water or groundwater. Identify any approval or allocation that would be needed under the Water Act 2000.	Sections 7.8, 7.9 & 8.3
• 11.69	Detail any significant diversion or interception of overland flow including an assessment of impacts in accordance with the DNRME Guideline on Watercourse Diversions and include the consideration of alternatives. Include maps of suitable scale showing the location of diversions and other water-related infrastructure in relation to mining infrastructure.	Refer to Flood Assessment Report
• 11.70	Describe the options for supplying water to the project, and assess any potential consequential impacts in relation to the objectives of the Water Plan (Fitzroy Basin) 2011 and any resource operations plan that may apply	Sections 7.8, 8.3.4 & 10.3
• 11.72	Develop hydrological models as necessary to describe the inputs, movements, exchanges and outputs of all significant quantities and resources of surface water and groundwater that may be affected by the project.	Section 6.5

Key Issue	Requirement	Report Section
	The models should address the range of climatic conditions that may be experienced at the site, and adequately assess the potential impacts of the project on water resources including to the post-decommissioning phase. The models should also include a site water balance. This should enable a description of the project's impacts at the local scale and in a regional context including proposed: <ul style="list-style-type: none"> (a) changes in flow regimes from diversions, water take and discharges (b) alterations to riparian vegetation and bank and channel morphology (c) direct and indirect impacts arising from the development 	
<ul style="list-style-type: none"> • 11.74 	Provide details of the management strategies for mine-affected water for the life of the project to demonstrate minimisation of any impacts to land and waters, in particular off-site.	Section 6
<i>Flooding and regulated dams – information requirements</i>		
<ul style="list-style-type: none"> • 11.108 	Describe current flood risk for a range of a range of annual exceedance probabilities up to the probable maximum flood for potentially affected waterways and assess (through flood modelling) how the project may potentially change flooding characteristics and be affected by floods. Flood modelling should consider all infrastructure and disturbance areas associated with the project including levees, roads and linear infrastructure and all proposed measures to avoid or minimize impacts.	Refer to Flood Assessment Report
<ul style="list-style-type: none"> • 11.109 	List and describe all dams and levees proposed or existing on the project site and undertake an assessment to determine the consequence category of each dam or levee assessed (low, significant, or high), consistent with the criteria in the EHP Manual for Assessing Consequence Categories and Hydraulic Performance of Structures. Illustrate how any regulated structure on site would be managed during periods of high incidental rainfall and/or flooding on site so that any potential impacts to land or water are minimised.	Section 7.13

3. Regulatory Framework

This section describes the regulatory framework (legislation, policies and standards) at Commonwealth and State level that would apply to surface water management for the Project.

3.1 Commonwealth

3.1.1 *EPBC Act*

The Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) outlines the requirements relating to the management and protection of matters of national environmental significance (MNES). The following Project actions have been deemed to be controlled actions under the EPBC Act:

- Olive Downs Coking Coal Project Mine Site and Access Road, 40 km south-east of Moranbah, Queensland (EPBC 2017-7867);
- Olive Downs Coking Coal Project Water Pipeline, 40 km south-east of Moranbah, Queensland (EPBC 2017-7868);
- Olive Downs Coking Coal Project Electricity Transmission Line, 20 km east of Moranbah, Queensland (EPBC 2017-7869); and
- Olive Downs Coking Coal Project Rail Spur, 30 km south-east of Moranbah, Queensland (EPBC 2017-7870).

Note that only the Olive Downs Coking Coal Project Mine Site and Access Road controlled action includes 'a water resource, in relation to coal seam gas development and large coal mining development (sections 24D & 24E)' as the relevant controlling provision, which is of relevance to the Surface Water Assessment.

3.1.2 *Independent Expert Scientific Committee*

The Independent Expert Scientific Committee (IESC) on Coal Seam Gas and Large Coal Mining Developments provides scientific advice to decision makers on the impact that coal seam gas and large coal mining development may have on Australia's water resources.

The IESC provides independent, expert scientific advice on coal seam gas and large coal mining proposals as requested by the federal and state government regulators. The IESC assess the proposals against the Information Guidelines for Independent Expert Scientific Committee advice (IESC, 2018) on coal seam gas and large coal mining development proposals where there is a significant impact on water resources. The core purpose of the guideline is to determine whether a coal seam gas (CSG) or large coal mining development has or is likely to have a significant impact on a water resource.

As described in Section 2.1.1, on 3rd March 2017, the Olive Downs Coking Coal Project Mine Site and Access Road was deemed a controlled action under the EPBC Act, with one of the controlling provisions being 'a water resource, in relation to coal seam gas development and large coal mining development (sections 24D & 24E)' and therefore requires approval from the Australian Government Environment Minister (the Minister).

The report sections where the IESC information requirements for individual proposals have been addressed are outlined in Table 3-1.

Table 3-1: IESC Information Requirements

Project information	Report Section
<p><u>Description of the proposal</u></p> <p>Provide a regional overview of the proposed project area including a description of the geological basin; coal resource; surface water catchments; groundwater systems; water-dependent assets; and past, current and reasonably foreseeable coal mining and CSG developments.</p>	Section 1.2
Describe the proposal's location, purpose, scale, duration, disturbance area, and the means by which it is likely to have a significant impact on water resources and water-dependent assets.	Section 1 & Section 6
Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies.	Section 2
Describe how impacted water resources are currently being regulated under state or Commonwealth law, including whether there are any applicable standard conditions.	Section 2
<p><u>Surface water – context and conceptualisation</u></p> <p>Describe the hydrological regime of all watercourses, standing waters and springs across the site including:</p> <ul style="list-style-type: none"> • Geomorphology, including drainage patterns, sediment regime, and floodplain features; • Spatial, temporal and seasonal trends in streamflow and/or standing water levels; • Spatial, temporal and seasonal trends in water quality data (such as turbidity, acidity, salinity, relevant organic chemicals, metals, metalloids and radionuclides); and • Current stressors on watercourses, including impacts from any currently approved projects. 	Section 5
Describe the existing flood regime, including flood volume, depth, duration, extent and velocity for a range of annual exceedance probabilities. Provide flood hydrographs and maps identifying peak flood extent, depth and velocity. This assessment should be informed by topographic data that has been acquired using lidar or other reliable survey methods with accuracy stated.	Refer to Flood Assessment Report
Provide an assessment of the frequency, volume, seasonal variability and direction of interactions between water resources, including surface water/groundwater connectivity and connectivity with sea water.	Refer to Groundwater Assessment Report
<p><u>Surface water – analytical and numerical modelling</u></p> <p>Provide conceptual models at an appropriate scale, including water quality, stores, flows and use of water by ecosystems.</p>	Section 6.5
Use methods in accordance with the most recent publication of <i>Australian Rainfall and Runoff</i> (Ball et al. 2016).	Refer to Flood Assessment Report
Develop and describe a program for review and update of the models as more data and information becomes available.	Section 8.5
Describe and justify model assumptions and limitations and calibrate with appropriate surface water monitoring data.	Section 6.5
Provide an assessment of the risks and uncertainty inherent in the data used in the modelling, particularly with respect to predicted scenarios.	Section 8.5
Provide a detailed description of any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	Section 8.5

Project information	Report Section
<p><u>Surface water – impacts to water resources and water-dependent assets</u></p> <p>Describe all potential impacts of the proposed project on surface waters. Include a clear description of the impact to the resource, the resultant impact to any assets dependent on the resource (including water-dependent ecosystems such as riparian zones and floodplains), and the consequence or significance of the impact. Consider:</p> <ul style="list-style-type: none"> • Impacts on streamflow under the full range of flow conditions. • Impacts associated with surface water diversions. • Impacts to water quality, including consideration of mixing zones. • The quality, quantity and ecotoxicological effects of operational discharges of water (including saline water), including potential emergency discharges, and the likely impacts on water resources and water-dependent assets. • Landscape modifications such as subsidence, voids, post rehabilitation landform collapses, onsite earthworks (including disturbance of acid-forming or sodic soils, roadway and pipeline networks) and how these could affect surface water flow, surface water quality, erosion, sedimentation and habitat fragmentation of water-dependent species and communities. 	Section 10.1
Discuss existing water quality guidelines, environmental flow objectives and requirements for the surface water catchment(s) within which the development proposal is based.	Section 4 & Section 5.4
Identify processes to determine surface water guidelines and quantity thresholds which incorporate seasonal variation but provide early indication of potential impacts to assets.	Section 8
Propose mitigation actions for each identified significant impact.	Table 7-5
Describe the adequacy of proposed measures to prevent or minimise impacts on water resources and water-dependent assets.	Section 8, Section 9 & Section 10
Describe the cumulative impact of the proposal on surface water resources and water-dependent assets when all developments (past, present and/or reasonably foreseeable) are considered in combination.	Section 10.6
Provide an assessment of the risks of flooding (including channel form and stability, water level, depth, extent, velocity, shear stress and stream power), and impacts to ecosystems, project infrastructure and the final project landform.	Refer to Flood Assessment Report
<p><u>Surface water – data and monitoring</u></p> <p>Identify monitoring sites representative of the diversity of potentially affected water-dependent assets and the nature and scale of potential impacts, and match with suitable replicated control and reference sites (BACI design) to enable detection and monitoring of potential impacts.</p>	Section 10.7
Ensure water quality monitoring complies with relevant National Water Quality Management Strategy (NWQMS) guidelines (ANZECC/ARMCANZ 2000) and relevant legislated state protocols (e.g. QLD Government 2013).	Section 10.7
Identify data sources, including streamflow data, proximity to rainfall stations, data record duration and a describe of data methods, including whether missing data has been patched.	Section 5.2.2
<p>Develop and describe a surface water monitoring programme that will collect sufficient data to detect and identify the cause of any changes from established baseline conditions and assess the effectiveness of mitigation and management measures. The program will:</p> <ul style="list-style-type: none"> • Include baseline monitoring data for physico-chemical parameters, as well as contaminants (e.g. metals). • Comparison of physico-chemical data to national/regional guidelines or to site- specific guidelines derived from reference condition monitoring if available. • identify baseline contaminant concentrations and compare these to national guidelines, allowing for local background correction if required. 	Section 10.7

Project information	Report Section
Describe the rationale for selected monitoring parameters, duration, frequency and methods, including the use of satellite or aerial imagery to identify and monitor large-scale impacts.	Refer to Geomorphology Report
Develop and describe a plan for ongoing ecotoxicological monitoring, including direct toxicity assessment of discharges to surface waters where appropriate.	
Identify dedicated sites to monitor hydrology, water quality, and channel and floodplain geomorphology throughout the life of the proposed project and beyond.	
<u>Water-dependent assets – context and conceptualisation</u>	
Identify water-dependent assets, including: <ul style="list-style-type: none"> Water-dependent fauna and flora and provide surveys of habitat, flora and fauna (including stygofauna) (see Doody et al. [in press]). Public health, recreation, amenity, Indigenous, tourism or agricultural values for each water resource. 	Refer to Aquatic Ecology Report
Identify GDEs in accordance with the method outlined by Eamus et al. (2006). Information from the GDE Toolbox15 (Richardson et al. 2011) and GDE Atlas (CoA 2017a) may assist in identification of GDEs (see Doody et al. [in press]).	Refer to Groundwater Assessment Report
Describe the conceptualisation and rationale for likely water-dependence, impact pathways, tolerance and resilience of water-dependent assets. Examples of ecological conceptual models can be found in Commonwealth of Australia (2015).	
Estimate the ecological water requirements of identified GDEs and other water-dependent assets (see Doody et al. [in press]).	
Identify the hydrogeological units on which any identified GDEs are dependent (see Doody et al. [in press]).	
Provide an outline of the water-dependent assets and associated environmental objectives and the modelling approach to assess impacts to the assets.	Section 4.1
Describe the process employed to determine water quality and quantity triggers and impact thresholds for water-dependent assets (e.g. threshold at which a significant impact on an asset may occur).	Section 5.4
<u>Water-dependent assets – impacts, risk assessment and management of risks</u>	
Provide an assessment of direct and indirect impacts on water-dependent assets, including ecological assets such as flora and fauna dependent on surface water and groundwater, springs and other GDEs (see Doody et al. [in press]).	Section 10
Describe the potential range of drawdown at each affected bore, and clearly articulate the scale of impacts to other water users.	Refer to Groundwater Assessment Report
Indicate the vulnerability to contamination (e.g. from salt production and salinity) and the likely impacts of contamination on the identified water-dependent assets and ecological processes.	Refer to Aquatic Ecology Report
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion and habitat fragmentation of water-dependent species and communities.	Section 9
Provide estimates of the volume, beneficial uses and impact of operational discharges of water (particularly saline water), including potential emergency discharges due to unusual events, on water-dependent assets and ecological processes.	Section 8 and Section 10.5
Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	Section 10
Identify the proposed acceptable level of impact for each water-dependent asset based on leading-practice science and site-specific data, and ideally developed in conjunction with stakeholders.	Section 3.2.1
Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	Section 10

Project information	Report Section
<u>Water-dependent assets – data and monitoring</u>	
Identify an appropriate sampling frequency and spatial coverage of monitoring sites to establish pre-development (baseline) conditions, and test potential responses to impacts of the proposal (see Doody et al. [in press]).	Section 10.7
Consider concurrent baseline monitoring from unimpacted control and reference sites to distinguish impacts from background variation in the region (e.g. BACI design, see Doody et al. [in press]).	
Develop and describe a monitoring program that identifies impacts, evaluates the effectiveness of impact prevention or mitigation strategies, measures trends in ecological responses and detects whether ecological responses are within identified thresholds of acceptable change (see Doody et al. [in press]).	
Describe the process for regular reporting, review and revisions to the monitoring program.	
Ensure ecological monitoring complies with relevant state or national monitoring guidelines (e.g. the DSITI guideline for sampling stygofauna (QLD Government 2015)).	Refer to Aquatic Ecology Report
<u>Water and salt balance and water management strategy</u>	
Provide a quantitative site water balance model describing the total water supply and demand under a range of rainfall conditions and allocation of water for mining activities (e.g. dust suppression, coal washing etc.), including all sources and uses.	8
Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	Section 7.8 and Section 8.3
Provide estimates of the quality and quantity of operational discharges under dry, median and wet conditions, potential emergency discharges due to unusual events and the likely impacts on water-dependent assets.	Section 8
Provide salt balance modelling that includes stores and the movement of salt between stores and takes into account seasonal and long-term variation.	Section 8.3.8 and Section 10.5.3
<u>Cumulative impacts – context and conceptualisation</u>	
Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Section 10.6
Consider all past, present, and reasonably foreseeable actions, including development proposals, programs and policies that are likely to impact on the water resources of concern in the cumulative impact analysis. Where a proposed project is located within the area of a bioregional assessment consider the results of the bioregional assessment.	Section 10.6
<u>Cumulative impacts – impacts</u>	
Provide an assessment of the condition of affected water resources which includes: <ul style="list-style-type: none"> • Identification of all water resources likely to be cumulatively impacted by the proposed development. • A description of the current condition and quality of water resources and information on condition trends. • Identification of ecological characteristics, processes, conditions, trends and values of water resources. • Adequate water and salt balances. • Identification of potential thresholds for each water resource and its likely response to change and capacity to withstand adverse impacts (e.g. altered water quality, drawdown). 	Section 5
Assess the cumulative impacts to water resources considering: <ul style="list-style-type: none"> • The full extent of potential impacts from the proposed project, (including whether there are alternative options for infrastructure and mine configurations which could reduce impacts), and encompassing all linkages, including both direct and indirect links, operating upstream, downstream, vertically and laterally. • All stages of the development, including exploration, operations and post closure/decommissioning. • Appropriately robust, repeatable and transparent methods. 	Section 10.6

Project information	Report Section
<ul style="list-style-type: none"> The likely spatial magnitude and timeframe over which impacts will occur, and significance of cumulative impacts. Opportunities to work with other water users to avoid, minimise or mitigate potential cumulative impacts. 	
<u>Cumulative Impacts – Mitigation, monitoring and management</u>	
Identify modifications or alternatives to avoid, minimise or mitigate potential cumulative impacts. Evidence of the likely success of these measures (e.g. case studies) should be provided.	Section 10.6
Identify measures to detect and monitor cumulative impacts, pre and post development, and assess the success of mitigation strategies.	Section 10.7
Identify cumulative impact environmental objectives.	Section 10.6
Describe appropriate reporting mechanisms.	Section 10.7
Propose adaptive management measures and management responses.	Section 8.5
<u>Final landform and voids – coal mines</u>	
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	Section 9
Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	Section 9
<p>Provide an assessment of the long-term impacts to water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should consider:</p> <ul style="list-style-type: none"> Groundwater behaviour – sink or lateral flow from void. Water level recovery – rate, depth, and stabilisation point (e.g. timeframe and level in relation to existing groundwater level, surface elevation). Seepage – geochemistry and potential impacts. Long-term water quality, including salinity, pH, metals and toxicity. Measures to prevent migration of void water off-site. <p>For other final landform options considered sufficient detail of potential impacts should be provided to clearly justify the proposed option.</p>	Section 9
Assess the probability of overtopping of final voids with variable climate extremes, and management mitigations.	
<u>Acid-forming materials and other contaminants of concern</u>	
Identify the presence and potential exposure of acid-sulphate soils (including oxidation from groundwater drawdown).	
Identify the presence and volume of potentially acid-forming waste rock, fine-grained amorphous sulphide minerals and coal reject/tailings material and exposure pathways.	
Identify other sources of contaminants, such as high metal concentrations in groundwater, leachate generation potential and seepage paths.	
Describe handling and storage plans for acid-forming material (co-disposal, tailings dam, encapsulation).	Refer to Geochemical Report
Assess the potential impact to water-dependent assets, taking into account dilution factors, and including solute transport modelling where relevant, representative and statistically valid sampling, and appropriate analytical techniques.	
Describe proposed measures to prevent/minimise impacts on water resources, water users and water-dependent ecosystems and species.	

3.2 Queensland

3.2.1 EP Act 1994

Resource activities are defined as environmentally relevant activities (ERAs) under the Queensland Environmental Protection Act 1994 (EP Act) and as such, the development and operation of the Project are governed by the EP Act. The object of the EP Act is to:

Protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development).

3.2.1.1 Environmental Authority

An environmental authority (EA) is granted in accordance with the EP Act and details the prescribed conditions that govern the ERA. In the context of surface water management, the EA sets out conditions that will be relevant to the Project, including:

- Management of contained water including release;
- Water management plan requirements;
- Regulation of water structures including dams and levees;
- Saline drainage management;
- Acid rock drainage management; and
- Storm water and sediment laden runoff management.

3.2.1.1.1 Model Mining Conditions

New mining project applications should apply the model mining conditions as outlined in *Model mining conditions* (DEHP, 2017). The purpose of the model mining conditions is to provide a set of model conditions to form the general environmental protection commitments given for EA's for mining activities administered under the EP Act. The model conditions may be used as a basis for proposing environmental protection commitments in application documents (such as an EIS).

Model conditions can be modified to suit the specific circumstances of a mining project, subject to the assessment criteria outlined in the EP Act. It is unlikely that the administering authority will accept less rigorous environmental protection commitments or EA conditions without clear evidence that the risk of the environmental harm is addressed by environmental management practices, technologies or the nature of the EVs impacted by the project.

Schedule F – Water (Fitzroy model conditions) form the basis of the requirements for the Project Water Management System design.

3.2.1.2 Environmental Protection (Water) Policy 2009

The *Environmental Protection (Water) Policy 2009* (EPP Water) is the primary instrument for surface water management under the EP Act. The EPP Water governs discharge to land, surface water and groundwater, aims to protect environmental values (EVs) and sets water quality guidelines and objectives.

The processes to identify Environmental Values (EVs) and to determine Water Quality Guidelines (WQGs) and Water Quality Objectives (WQOs) in Queensland waters based on the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ guidelines).

3.2.1.3 *Isaac River Sub-basin Environmental Values and Water Quality Objectives 2011*

The relevant document, pursuant to the EPP Water, for the Project is the *Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part)*, including all waters of the Isaac River Sub-basin (including Connors River, September 2011) (DEHP, 2011). The document is made pursuant to the provisions of the EPP Water. It contains Environmental Values (EVs) and Water Quality Objectives (WQOs) for waters in the Isaac River Sub-basin, and they are listed under Schedule 1 of EPP Water. Refer to Section 4 for further details.

3.2.1.4 *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures*

The *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (the Manual) defines the methodology and assessment criteria to determine if a structure associated with an ERA should be regulated under the EP Act. The manual details the hydraulic design requirements for regulated structures and this document has been used as a reference in the preliminary design of the water management system and preliminary sizing of dams associated with the Project.

3.2.1.5 *Guideline – Application Requirements for Activities with Impacts to Water*

This guideline focuses on the types of impacts that environmentally relevant activities (ERAs) can have on water and outlines the information to be provided to the department as part of the ERA application process.

Section 4 of the guideline requires the applicant to provide details on a number of surface water-related issues, including:

- Discharges and releases;
- Unplanned and uncontrolled releases;
- Water infrastructure;
- Wetlands;
- Hydrology of receiving waters; and
- Mixing zones.

Table 3-2 lists the elements of the guideline relevant to this assessment and the sections of this report where those elements are addressed.

The guideline also refers to the department's technical guideline "Wastewater releases to Queensland waters", which is discussed in Section 3.2.1.5.1.

Table 3-2: Application Requirements for Activities with Impact to Water - Guideline

Item	Report Section
Discharges and releases	
<ul style="list-style-type: none"> • Identify the location, depth and configuration of all potential discharge points 	Section 6.4
<ul style="list-style-type: none"> • Details of the water to be released 	Sections 6.4, 7.11 & 8.3.5
Unplanned and uncontrolled releases	
<ul style="list-style-type: none"> • Identify activities that could lead to indirect impacts and unplanned/uncontrolled release of contaminants to water, such as, spills and leaks or stream bed and/or bank disturbance and describe the magnitude of the disturbance 	Sections 6.1, 6.4, 6.5
<ul style="list-style-type: none"> • Identify the location, depth and configuration (if relevant) of the areas where the unplanned/uncontrolled release could be discharge to waters 	Sections 6.4
<ul style="list-style-type: none"> • Identify infrastructure (including containment devices) with the potential to release unplanned/uncontrolled contaminants to waters. 	Sections 6.4, 8.3.6, 8.3.7
<ul style="list-style-type: none"> • Identify the potential contaminant type and quantities that could be released on infrastructure 	Section 7.12
Water infrastructure	
<ul style="list-style-type: none"> • Provide details on the location and storage capacity of water infrastructure on the site which may include regulated structures, tailings dams, waste rock dams, water storage dams, levees, heap leach pads and any other water management infrastructure. 	Sections 6, 7.2.1, 7.4 & 7.5
Wetlands	
<ul style="list-style-type: none"> • Applicants must describe how the existing environmental values of any wetlands on, or adjacent to, the site will be maintained, or enhanced. 	Section 10.5.4
Hydrology of Receiving Waters	
<ul style="list-style-type: none"> • Describe, preferably through the use of water quality monitoring or modelling, how the proposed ERA will impact on hydrology of receiving waters. 	Section 10
Mixing Zones	
<ul style="list-style-type: none"> • For planned/controlled release to water, describe the impact to any initial mixing zone(s) 	Section 6.4.1

3.2.1.5.1 Technical Guideline – Wastewater Release to Queensland Waters

This guideline is provided to support a risk-based assessment approach to licensing releases of wastewater to surface water and applies the philosophy of the ANZECC & ARMCANZ (2000) Water Quality Guidelines and the intent of the Environmental Protection (Water) Policy 2009.

The information requirements identified in this guideline are as follows:

- Describe the proposed activity.
- Describe the receiving environment.
- Predict outcomes or impacts of the proposed wastewater release.
- Set circumstances, limits and monitoring conditions.

Table 3-3 lists the elements of the guideline relevant to this assessment and the sections of this report where those elements are addressed.

Table 3-3: Wastewater Release to QLD Waters – Technical Guideline

Item	Report Section
Step 1 – Describe the proposed activity	
• Define the industry type and size	Section 1.2
• Identify the potential contaminants of concern in the proposed release	Section 7.12
• Assess the characteristics of the proposed release	Sections 7.11, 8.3.5, 8.3.6 & 8.3.7
• Check the location and configuration of the proposed release	Section 6.4
Step 2 – Describe the receiving environment	
• Identify water bodies potentially affected by the proposed release	Sections 5.1 & 5.3.3
• Provide all relevant information on the receiving environment	Section 5
• Consideration of temporary streams	Section 5
• Identify all relevant EV and WQO's	Section 4
• Ensure all government planning requirements applying to the water bodies have been considered	Section 3
• Check the location and configuration of the proposed release	Section 6.4
Step 3 – Predict outcomes of the proposed wastewater release	
• Assess whether contaminants are potentially toxic	Section 7.12
• Consideration of an initial mixing zone	Section 6.4.1
• Predict the assimilative capacity and sustainable load	Sections 7.11, 8.3.5, 10.5.3 & 10.6.3
• Consider other potential impacts	Section 10
Step 4 – Set circumstances, limits and monitoring conditions	
• Specify any circumstances related to the approved wastewater release	Section 7.11
• Derive end-of-pipe limit from approved release loads and characteristics	Section 7.11
• Include a receiving environment monitoring program (REMP) requirement	Section 10.7
• Include reporting requirements for approved activity	Section 10.7.5

3.2.2 **Water Act 2000**

In Queensland, the Water Act 2000 (Water Act) is the primary statutory document that establishes a framework for the planning, allocation and use of non-tidal water. The Water Act is primarily administered by the Department of Natural Resources, Mines and Energy (DNRME) and the Department of Energy and Water Supply (DEWS).

The main purpose of the Water Act is to provide a framework for the following:

- The sustainable management of Queensland's water resources and quarry material by establishing a system for:
 - ◆ The planning, allocation and use of water; and
 - ◆ The allocation of quarry material and riverine protection.
- The sustainable and secure water supply for the south-east Queensland region and other designated regions;

- The management of impacts on underground water caused by the exercise of underground water rights by the resource sector; and
- The effective operation of water authorities.

A watercourse is defined by the Water Act as a river, creek or stream in which water flows permanently or intermittently and includes the bed and banks and any other element of a river, creek or stream confining or containing water. The DNRME have published a watercourse identification map of the state that shows: watercourses (other than their lateral limits); the downstream limit of watercourses; drainage features; lakes; and springs. This watercourse map is discussed in Section 5.3.3.

3.2.2.1 *Water Plan (Fitzroy Basin) 2011*

The Water Plan (Fitzroy Basin) 2011, which replaces the Water Resource (Fitzroy Basin) Plan 2011, is subordinate legislation to the Water Act. The plan is developed and administered by DNRME. The purpose of the plan is:

- To define the availability of water in the Fitzroy Basin;
- To provide a framework for sustainably managing water and the taking of water;
- To identify priorities and mechanisms for dealing with future water requirements;
- To provide a framework for establishing water allocations;
- To provide a framework for reversing, where practicable, degradation in natural ecosystems;
- To regulate the taking of overland flow water; and
- To regulate the taking of groundwater.

3.2.2.2 *Water Regulation 2016*

Water Regulation 2016 is subordinate legislation to the Water Act and provides details, protocol and instruction for the following:

- Water rights and planning;
- Statutory authorisations to take or interfere with water;
- Matters relating to water licenses;
- Water allocations;
- Water supply and demand management;
- Declarations about watercourses.

3.2.3 ***Water Supply (Safety & Reliability) Act 2008***

The Water Supply (Safety and Reliability) Act 2008 provides for the safety and reliability of water supply in Queensland. The purpose is achieved primarily by:

- Providing a regulatory framework for providing water and sewerage services in the State;
- Providing a regulatory framework for providing recycled water and drinking water quality, primarily for protecting public health;
- The regulation of referable dams; and
- Stating flood mitigation responsibilities.

4. Environmental Values

The Olive Downs South Domain is located within the Isaac western upland tributaries developed areas (refer Section 3.2.1.3) of the Isaac River sub-basin and the Willunga domain is located on the border of Isaac northern tributaries-developed areas and Isaac and lower Connors River main channel-developed areas, shown in Figure 4-1. The following EVs have been nominated broadly to the mapped areas for protection of zone:

- Aquatic ecosystems
- Irrigation
- Farm supply/use
- Stock Water
- Aquaculture (Isaac western upland tributaries only)
- Human consumption
- Primary recreation
- Secondary recreation
- Visual recreation
- Drinking water
- Industrial use
- Cultural and spiritual values

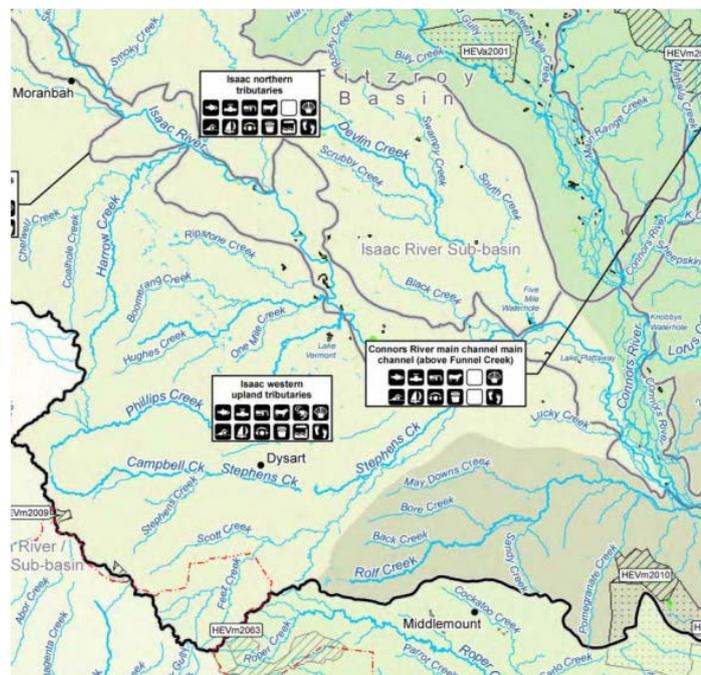


Figure 4-1: Isaac River Sub-Basin EVs

The following WQOs for the above EVs are provided in Table 4-1. Where different EVs have different WQOs the lowest value has been adopted. WQOs are displayed for physio-chemical parameters only.

Table 4-1: Water Quality Objectives for the Upper Isaac River catchments waters

Parameter	WQO	Relevant EV
Ammonia N	< 20 µg/L	Aquatic ecosystem ^a
Oxidised N	< 60 µg/L	Aquatic ecosystem ^a
Organic N	< 420 µg/L	Aquatic ecosystem ^a
Total nitrogen	< 500 µg/L	Aquatic ecosystem ^a
Filterable Reactive Phosphorus (FRP)	< 20 µg/L	Aquatic ecosystem ^a
Total Phosphorus	< 50 µg/L	Aquatic ecosystem ^a
Chlorophyll a	< 5 µg/L	Aquatic ecosystem ^a
Dissolved oxygen	85-110% saturation > 4 mg/L at surface	Aquatic ecosystem ^a Drinking water ^b
Turbidity	< 50 NTU	Aquatic ecosystem ^a
Suspended solids	< 55 mg/L	Aquatic ecosystem ^a
pH	pH 6.5-8.5	Aquatic ecosystem ^a
Conductivity (EC) baseflow	720 µS/cm	Aquatic ecosystem ^a
Conductivity (EC) high flow	250 µS/cm	Aquatic ecosystem ^a
Sulphate	25 mg/L	Aquatic ecosystem ^a
Total Dissolved Solids	< 2000 mg/L	Stock watering ^c
Colour	50 Hazen Units	Drinking water ^b
Total Hardness	150 mg/L as CaCO ₃	Drinking water ^b
Sodium	< 30 mg/L	Drinking water ^b
Aluminium	< 5 mg/L < 0.055 mg/L	Stock watering ^c Aquatic ecosystem ^d
Arsenic	2.0 mg/L 0.5 mg/L up to 5 mg/L < 0.024 mg/L	Irrigation ^{b, e} Stock watering ^f Aquatic ecosystem ^d
Beryllium	< 0.5 mg/L	Irrigation ^g
Boron	< 5 mg/L < 0.37 mg/L	Stock watering ^{f, e} Aquatic ecosystem ^d
Cadmium	< 0.01 mg/L < 0.0002 mg/L	Stock watering ^{f, e} Aquatic ecosystem ^d
Chromium	< 1 mg/L < 0.001 mg/L	Stock watering ^{f, e} Aquatic ecosystem ^d
Cobalt	< 0.1 mg/L	Irrigation ^g
Copper	< 1 mg/L < 0.0014 mg/L	Stock watering (cattle) ^{f, e} Aquatic ecosystem ^d
Fluoride	< 2 mg/L	Irrigation ^g
Iron	< 10 mg/L	Irrigation ^g

Parameter	WQO	Relevant EV
Lead	< 0.1 mg/L < 0.0034 mg/L	Stock watering ^{f, e} Aquatic ecosystem ^d
Lithium	< 2.5 mg/L	Irrigation ^g
Manganese	< 10 mg/L < 1.9 mg/L	Irrigation ^g Aquatic ecosystem ^d
Mercury	< 0.002 mg/L < 0.00006 mg/L	Irrigation ^g Aquatic ecosystem ^d
Molybdenum	< 0.05 mg/L	Irrigation ^g
Nickel	< 1 mg/L < 0.011 mg/L	Stock watering ^{f, e} Aquatic ecosystem ^d
Selenium	< 0.02 mg/L < 0.005 mg/L	Stock watering ^{f, e} Aquatic ecosystem ^d
Uranium	< 0.1 mg/L	Irrigation ^g
Vanadium	< 0.5 mg/L	Irrigation ^g
Zinc	< 5 mg/L < 0.008 mg/L	Irrigation ^g Aquatic ecosystem ^d

a/ Table 2 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem - moderately disturbed

b/ Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV

c/ Table 10 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering EV: salinity

d/ Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)

e/ short-term trigger value

f/ Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering EV: heavy metals and metalloids

g/ Table 9 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Irrigation EV: heavy metals and metalloids

4.1 Aquatic Ecosystem Environmental Values

DPM EnviroScience's Pty Ltd (DPM) have undertaken baseline aquatic ecology surveys for the Project. This work identified the following wetlands and Matters of State Environmental Significance (MSES).

4.1.1 Wetlands

DPM identified a total of 60 palustrine wetlands mapped as occurring within the Project area and wider surrounds, including 11 wetlands of High Ecological Significance (HES) and 49 wetlands of General Ecological Significance (GES). A further 16 previously unmapped GES wetlands were also identified during the aquatic ecology surveys. The HES wetlands include a paleochannel lake, ox-bow lakes and flood channel wetlands on the Isaac River floodplain, as well as vegetated swamps in depressions on and beyond the floodplain. The GES wetlands include riverine wetlands of the Isaac River, as well as numerous floodplain and non-floodplain palustrine wetlands. Seven lacustrine wetlands are mapped as occurring within the Project area, comprising dams ranging in size from approximately 1 to 12 ha. These dams provide a water source for an array of aquatic and terrestrial fauna, domestic livestock, as well as foraging and breeding habitat for water birds, wader birds, frogs, reptiles, water rats and other mammals.

4.1.2 **Matters of State Environmental Significance (MSES)**

DPM identified Matters of State Environmental Significance (MSES) within the Project area to include regulated vegetation (terrestrial Regional Ecosystems), state significant drainage lines (waterways that intersect regulated vegetation) and HES wetlands. These MSES provide habitat and connectivity important for both aquatic and terrestrial flora and fauna. This includes areas of State biodiversity significance, including the Isaac River corridor. MSES aquatic fauna species that are likely to occur within the broader area include the critically endangered southern snapping turtle and vulnerable Fitzroy River turtle, each listed under the Queensland Nature Conservation Act 1992. However, neither species is likely to occur within the Project area due to lack of their preferred habitat. No MSES aquatic flora species are likely to occur within the Project area.

4.1.3 **Aquatic Ecosystem Environmental Values Summary**

DPM identified that the aquatic flora and fauna within the Project area are “generally well adapted to environmental extremes, including the wetting and drying cycles expected in these seasonal and ephemeral systems. This is expected to include tolerance of a wide range of water quality conditions, such as elevated conductivity and fluctuating dissolved oxygen in senescing pools between flow events.”

4.1.4 **Fitzroy Basin Aquatic Ecosystem Health**

The Fitzroy Partnership for River Health is a collaboration between Government, industry, research organisations and community to facilitate improved water quality monitoring, collate and assess data, and publicly report on waterway health and sustainable use.

In 2015-16 the Fitzroy Basin (including the Upper Isaac and Lower Isaac areas covering the Project area) received a B grade for aquatic ecosystem health:

- Physical-chemical results were generally good and comparable to the long-term average. Salinity and sulfate results were stable. Turbidity results improved in the Upper Isaac and pH results were generally excellent or good across all catchments.
- Copper and aluminium continue to stand out as the toxicants of interest across the Basin and further investigation is being considered.

4.2 **Matters of National Environmental Significance (MNES)**

DPM identified that aquatic fauna species that are Matters of Environmental Significant (MNES) have been recorded in the broader area surrounding the Project area. This includes the critically endangered southern snapping turtle (*Elseya albagula*) and vulnerable Fitzroy River turtle (*Rheodytes leukops*), each listed under the EPBA Act. DPM state that although the Project area falls within the potential distributional range of these species, it is unlikely that either species occur within the waterways or wetlands of the Project area as either resident or transient occurrences due to the lack of their preferred habitat. Habitat for these species was not encountered within the Project area during the early wet aquatic surveys in December 2016.

No MNES aquatic flora species are likely to occur within the Project area, nor are any aquatic Threatened Ecological Communities expected to occur.

5. Existing Surface Water Environment

5.1 Location and Catchment Context

The Project is located within the headwaters of the Isaac sub-catchment of the greater Fitzroy Basin. The Isaac River is the main watercourse which bisects the Project area and flows in a north-west to south-east direction, passing the township of Moranbah and the Millennium, Poitrel and Daunia coal mines upstream of the Project area. The Isaac River flows to the north/east of the Olive Downs South domain and then further downstream to the south of the Willunga domain before continuing in a south-easterly direction.

The Connors River, which has a catchment area similar to the upstream Isaac River, flows into the Isaac River approximately 85 kilometres (km) downstream of the Project area. The Isaac River finally converges with the Mackenzie River a further approximate 50 km downstream.

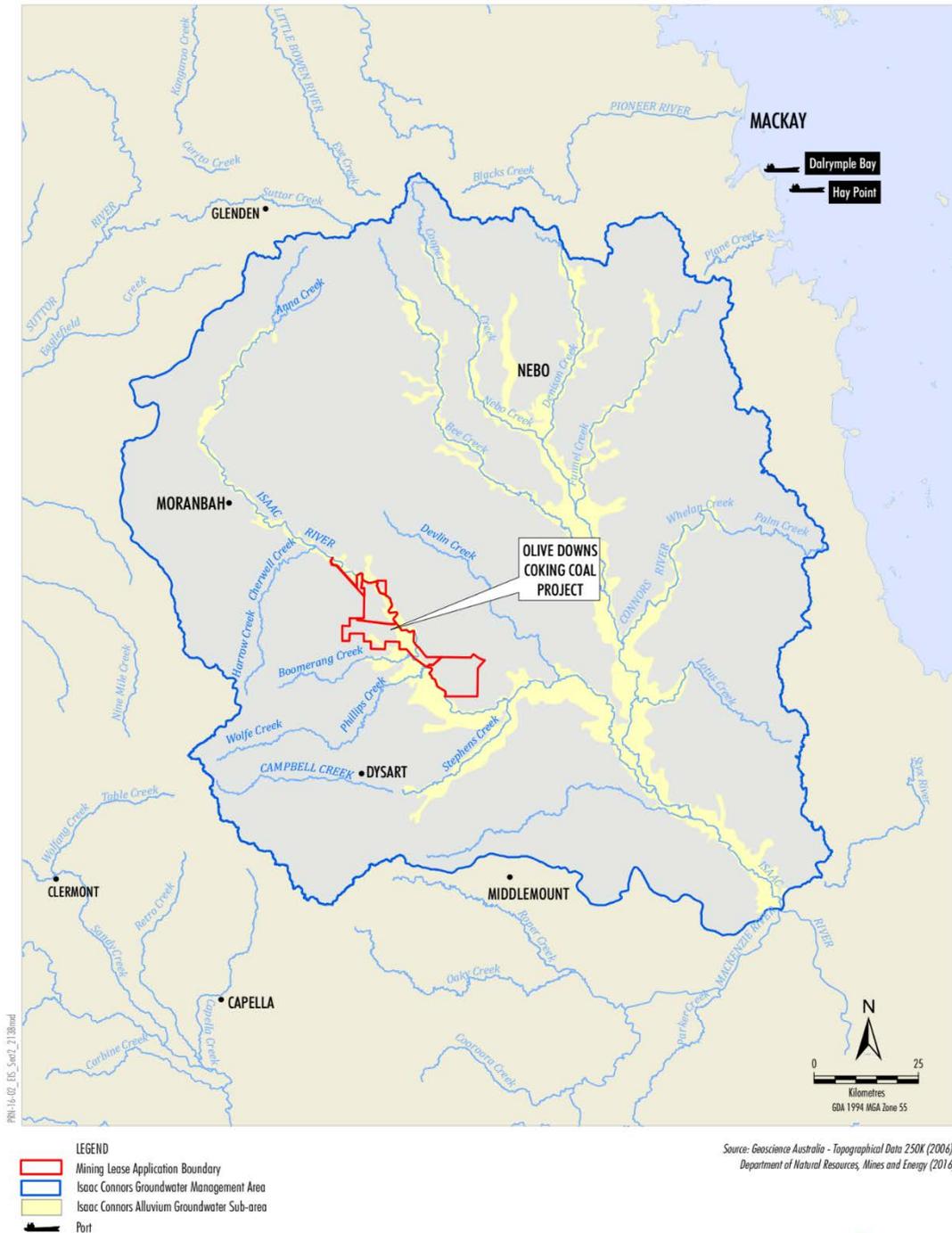
Ultimately, the Mackenzie River joins the Fitzroy River, which flows initially north and then east towards the east coast of Queensland and discharges into the Coral Sea southeast of Rockhampton near Port Alma.

At a regional scale, the greater Isaac-Connors sub-catchment area (at the confluence with the Mackenzie River) is approximately 22,364 square kilometres (km²) of the total Fitzroy River catchment of 142,665 km², or if represented as a percentage, it accounts for 15 percent of the overall Fitzroy River catchment area.

The Project mining lease application area is approximately 250 km² and represents one percent and 0.2 percent of the overall Isaac-Connors and Fitzroy river catchment areas, respectively.

Figure 5-1 presents the location of the Olive Down Project area and Isaac River catchment upstream of confluence with Connors River. Figure 5-2 is a photo of the Isaac River, upstream of the Project area and Figure 5-3 is a photo of the Isaac River, downstream of the Project area.

The Isaac River is a seasonally flowing watercourse, typically with surface flows in the wetter months from November to April, reducing to shallow subsurface flows from about May to October. All other waterways of the Project area are expected to be ephemeral and experience flow only after sustained or intense rainfall in the catchment. Stream flows are highly variable, with most channels drying out during winter to early spring when rainfall and runoff is historically low, although with some pools expected to hold water for extended periods. Therefore, physical attributes, water quality, and the composition of aquatic flora and fauna communities are also expected to be highly variable over time.



PEMBROKE
 OLIVE DOWNS COKING COAL PROJECT
 Isaac Connors
 Sub-Catchment of the Fitzroy Basin

Figure 2-12

Figure 5-1: Isaac River Catchment and Project Area

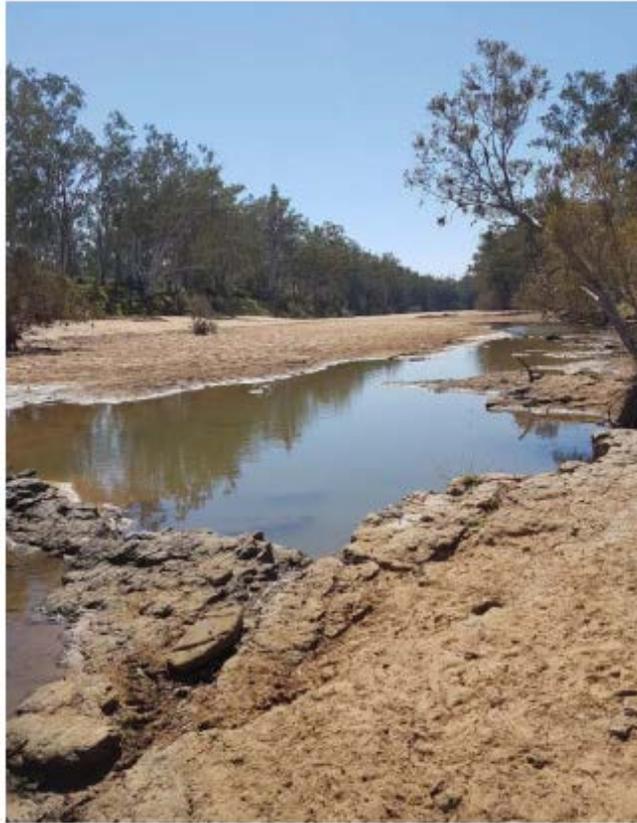


Figure 5-2: Isaac River Upstream of the Project



Figure 5-3: Isaac River Downstream of the Project

5.1.1 **Local Drainage**

Tributaries of the Isaac River in the vicinity of the Project area include (from upstream to downstream) (see Figure 5-13 for locations):

- North Creek;
- Ripstone Creek;
- Boomerang Creek; and
- Phillips Creek.

North Creek enters the Isaac River immediately to the north of the Project area. The North Creek catchment area upstream of its confluence with the Isaac River is approximately 342 km² with predominant land use within the catchment being stock grazing and mines. The existing Moorvale Mine has approval to release to North Creek and the approved Olive Downs North Mine may be constructed and operated within the North Creek catchment. A photograph of North Creek is shown in Figure 5-4.

Ripstone Creek runs west to east, south of the Olive Downs South pits, while intersecting the satellite pit to the south west of the main Olive Downs South pits. The Ripstone Creek catchment area is approximately 286 km² with predominant land use within the catchment being stock grazing and open cut mining. The existing Peak Downs Mine has approval to release to Ripstone Creek). A photograph of Ripstone Creek is shown in Figure 5-5. Note that Figure 5-5 is showing a farm dam, rather than a permanent water body or billabong.

Boomerang Creek runs west to east, south of the Olive Downs South domain and joins the Isaac River between the Olive Downs South domain and Willunga domain. The Boomerang Creek catchment area is approximately 156 km² with predominant land use within the catchment being stock grazing and the Saraji Coal Mine. The Saraji Coal Mine has an existing diversion of Boomerang Creek and has approval to release to Boomerang Creek.

Phillips Creek runs west to east into the Isaac River adjacent to the Willunga domain. It has a catchment area of approximately 487 km² to the confluence with the Isaac River. Land uses within the Phillips Creek catchment include low intensity cattle grazing and open cut mining. The existing Saraji Mine and Lake Vermont Mine both have existing diversions/levees on Phillips Creek and approval to discharge to Phillips Creek. A photograph of Phillips Creek is shown in Figure 5-6.



Figure 5-4: North Creek Upstream of the Project



Figure 5-5: Ripstone Creek Upstream of the Project



Figure 5-6: Phillips Creek Upstream of the Project

5.2 Rainfall and Evaporation

5.2.1 Local Climate Data

Table 5-1 shows summary details of Bureau of Meteorology (BOM) and DNRME rainfall and evaporation recording stations with a significant period of record near the Project. These stations are shown in Figure 5-10.

Table 5-1: BOM & DNRME Rainfall & Evaporation Stations in Project Vicinity

Station No.	Station Name	Data Obtained	Elevation (mAHD)	Distance from Project	Opened	Closed
130414	Isaac River at Goonyella	Rainfall	245	50 km	1983	2011
534003	Isaac River at Deverill	Rainfall	-	adjacent to Project	1968	-
034035	Moranbah Airport	Rainfall, Min. & Max. Temp.	232	29 km	2012	-
034038	Moranbah Water Treatment Plant	Rainfall, Evaporation, Min. & Max. Temp.	260	36 km	1972	2012

The data from the Moranbah Water Treatment Plant station is presented within this section as this station has the longest concurrent rainfall and evaporation dataset within the region.

Table 5-2 shows the long term monthly rainfall and evaporation averages for the period of record at the Moranbah Water Treatment Plant (WTP). Table 5-3 shows the variability in monthly rainfall at the Moranbah WTP.

Figure 5-7 shows the annual distribution of monthly rainfall and evaporation at the Moranbah WTP. Both rainfall and evaporation are higher in the warmer months, with evaporation substantially exceeding rainfall in all months.

Table 5-2: Mean Monthly Rainfall and Pan Evaporation

Month	Rainfall	Pan Evaporation
	Moranbah WTP (Apr 1972 – Mar 2012)	Moranbah WTP (Apr 1972 – Mar 2012)
January	98.7	240.2
February	95.8	207.5
March	51.4	208.5
April	34.6	160.6
May	33.7	119.5
June	21.6	91.2
July	17.1	108.5
August	24.4	142.7
September	8.4	183.8
October	33.9	234.6
November	65.9	239.6
December	98.9	243.1
TOTAL	584.4	2,180

Table 5-3: Monthly Rainfall Statistics for Moranbah WTP (mm/month)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	99	96	51	35	34	22	17	24	8.4	34	66	99	584
Maximum	315	347	268	271	197	170	104	247	61	147	220	350	1,109
90 th %ile	214	214	185	81	75	48	63	72	21	104	154	200	877
Median	89	86	33	24	19	10	5.8	9.8	3.6	15	53	82	543
10 th %ile	17	6.0	1.2	0.3	0.0	0.0	0.0	0.0	0.0	0.0	4.0	18	327
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	101

Rainfall across the Project area is expected to be greatest during the summer months, with the lowest rainfalls occurring mid-winter, as inferred from the 40 years of data collected at the Moranbah Water Treatment Plant.

Evaporation across the Project area is also expected to be greatest during the summer months, with the lowest evaporation rates generally occurring mid-winter, as inferred from the 26 years of data collected at the Moranbah WTP.

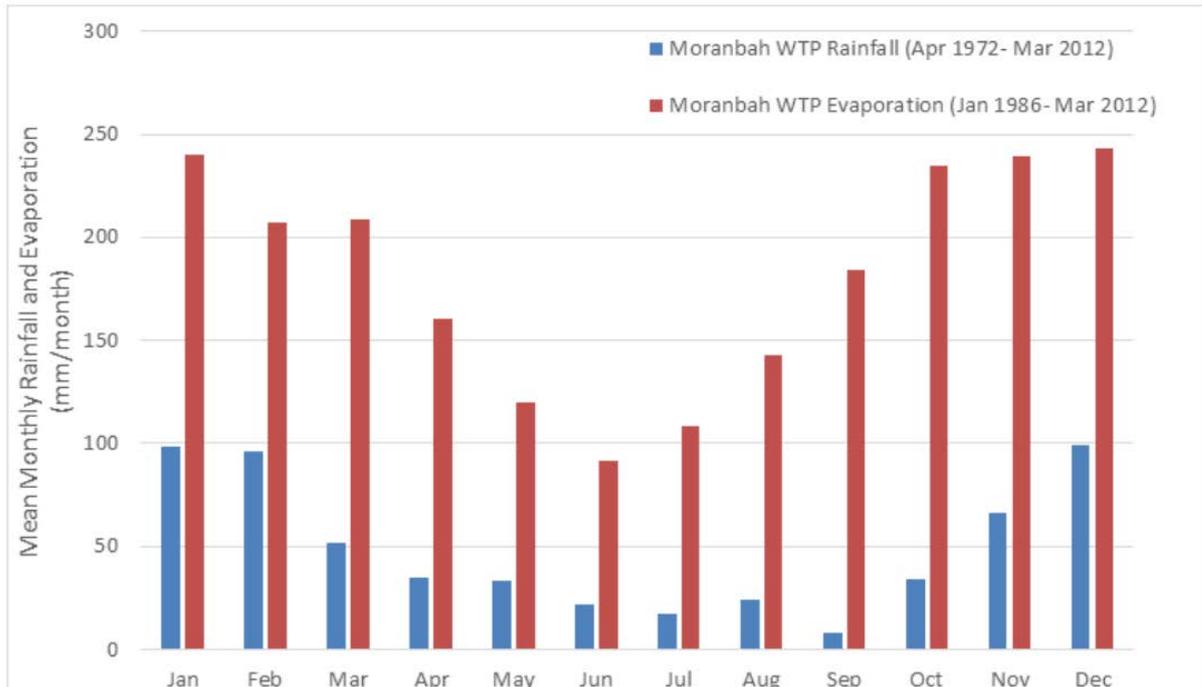


Figure 5-7: Distribution of Monthly Rainfall and Pan Evaporation – Moranbah WTP

5.2.2 DataDrill Climate Data

5.2.2.1 Rainfall

As described in Section 5.2.1, there is around 46 years of recorded rainfall data available for the Moranbah WTP and Moranbah Airport gauges. In order to extend the dataset, long term daily rainfall data for the Project area from 1 January 1889 to 31 December 2017 (129 years) was obtained from the DSITIA Data Drill service. This data set is corrected for accumulated daily rainfall totals and missing data.

Given the long mine life (79 years), a stochastic rainfall data set based on the DataDrill rainfall data using the Stochastic Climate Library (SCL) software which forms part of the eWater CRC catchment modelling toolkit has been generated. The SCL User Guide (SCL, 2004) explains stochastic climate data as follows:

“In short, stochastic climatic data are random numbers that are modified so that they have the same characteristics (in terms of mean, variance, skew, long-term persistency, etc...) as the historical data from which they are based. Each stochastic replicate (sequence) is different and has different characteristics compared to the historical data, but the average of each characteristic from all stochastic replicates is the same as the historical data.”

Using historical climate data as inputs into hydrological models provides results that are based on only one realization of the past climate. Stochastic climate data provide alternative realizations that are equally likely to occur and can therefore be used as inputs into hydrological and ecological models to quantify uncertainty in environmental system associated with climate variability.”

Using the SCL, 100 replicates of a 79-year rainfall sequence have been generated for use in the water balance model. The model generates 100 sets of results (or realisations) that reflect the variation in the historical rainfall data (1939 to 2017).

The annual rainfall totals for each year of the DataDrill rainfall dataset have been ranked and compared against the 100 replicates generated by the SCL program and is presented in Figure 5-8.

Review of Figure 5-8 shows that the stochastically generated annual rainfall totals appears to consistently represent (with variation) the historical rainfall dataset, with a few outliers at the low end of the probability curve.

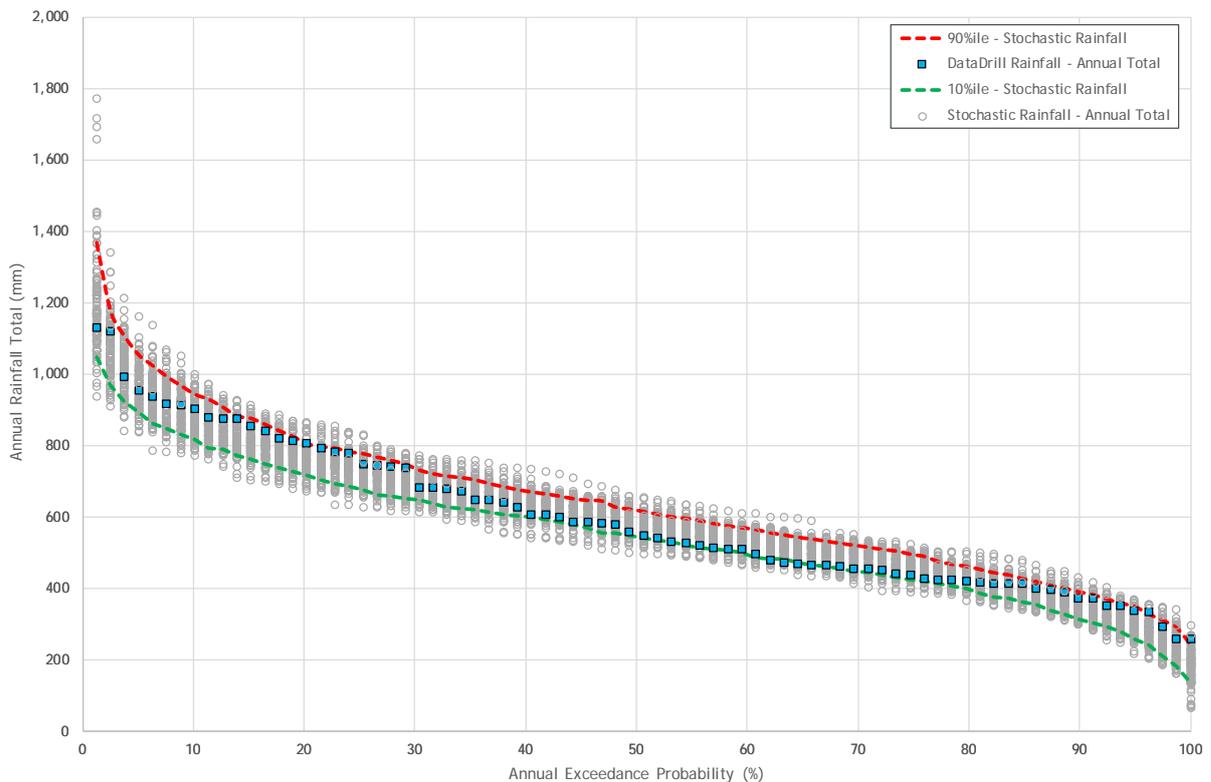


Figure 5-8: Comparison of DataDrill vs Stochastic Rainfall Data

5.2.2.2 *Evaporation*

Morton's equation for Lake evaporation has been used to estimate evaporation losses from storages. Table 5-4 shows the long-term monthly averages for Morton's Lake evaporation and DataDrill rainfall.

Figure 5-9 shows the annual distribution of monthly rainfall and Morton's Lake evaporation. Average annual lake evaporation is more than three times the average annual rainfall.

Table 5-4: Long-term Average Rainfall and Evaporation – DataDrill (1889-2017)

Month	SILO DataDrill Rainfall (mm)	Morton's Lake Evaporation (mm)
January	111.2	201.2
February	96.6	169.9
March	66.2	170.0
April	30.9	134.6
May	27.6	104.1
June	30.7	83.0
July	21.4	93.3
August	19.7	120.3
September	17.2	153.2
October	31.6	190.0
November	52.0	200.7
December	85.8	212.2
TOTAL	591	1,833

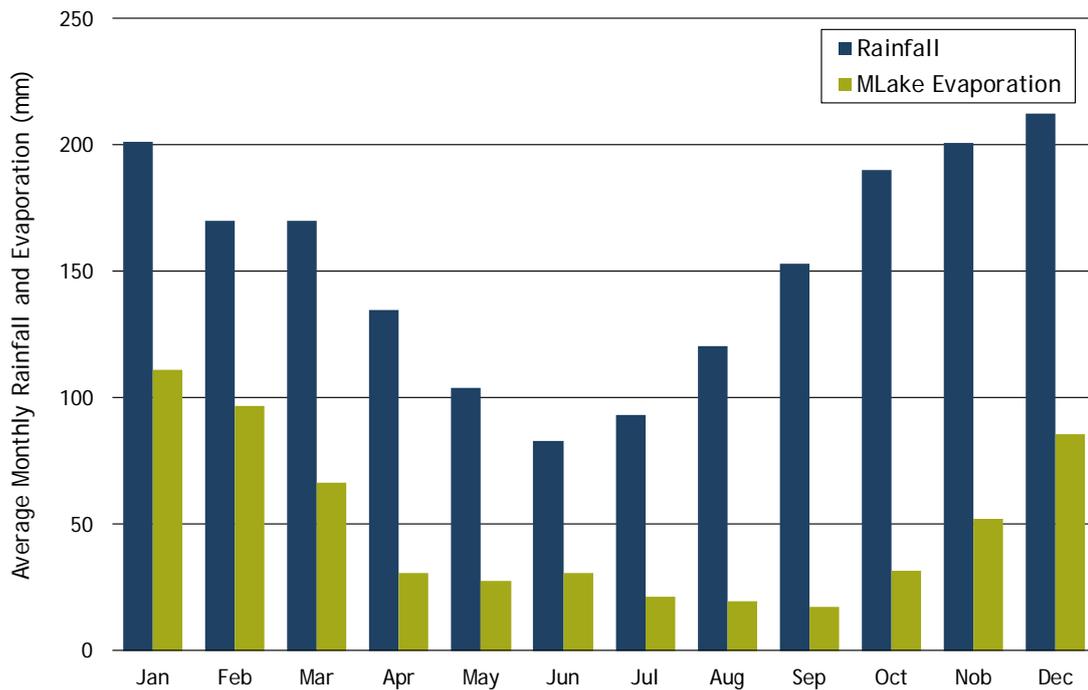


Figure 5-9: Distribution of Monthly Rainfall and Evaporation – DataDrill (1889-2017)

Estimates of soil moisture evapotranspiration and open pit evaporation have been derived through the application of the following factors:

- AWBM Evapotranspiration Factor: 0.97
- Open Pit Evaporation Factor: 0.70

5.3 Streamflows

5.3.1 DNRME Streamflow Gauges

There are five DNRME streamflow gauges located upstream of the Project receiving waters. Of these, three are located on the Isaac River itself (at Burton Gorge, Goonyella and Deverill). The gauge at Burton Gorge is not operational.

The other two are located on Phillips Creek and Scotts Creek, however these gauges are no longer operational. The details and locations of these gauges are provided in Table 5-5 and Figure 5-10.

The nearest downstream gauge on the Isaac River is located at Yatton. The details of this gauge are provided in Table 5-5.

Table 5-5: DNRME Stream Gauges Along the Isaac River

Gauge No.	Gauge Name	Stream	AMTD (km)	Catchment Area (km ²)	Distance from Project (km)	Start	End
130402A	Burton Gorge	Isaac R	208.3	551	63	01/05/1964	30/09/1988
130414A	Goonyella	Isaac R	242.8	1,214	50	24/05/1983	-
130410A	Deverill	Isaac R	174.7	4,092	adjacent to Project	20/05/1968	-
130401A	Yatton	Isaac R	43.0	19,720	60	01/10/1962	-
130409A	Tayglen	Phillips Ck	34.3	344	24	18/05/1968	27/10/1988
130415A	Norwich Park	Scotts Ck	25.0	388	37	20/10/1972	28/02/1988

Historical flow and river height monitoring data (1968-2018) for the Isaac River at Deverill (DNRME monitoring station 130410A), located to the north-west of the Project area, provides an indication of the local flow regime (refer Figure 5-11). Surveyed cross section data for this gauging station in September 2014 (DNRME, 2017a) indicates that sediment covers the bottom one metre of the gauge range. The mean river height data shown in Figure 5-11 suggests that surface flow above the sand is more likely to occur only in the wetter months from November to April, reducing to shallow subsurface flows from about May to October in an average year.

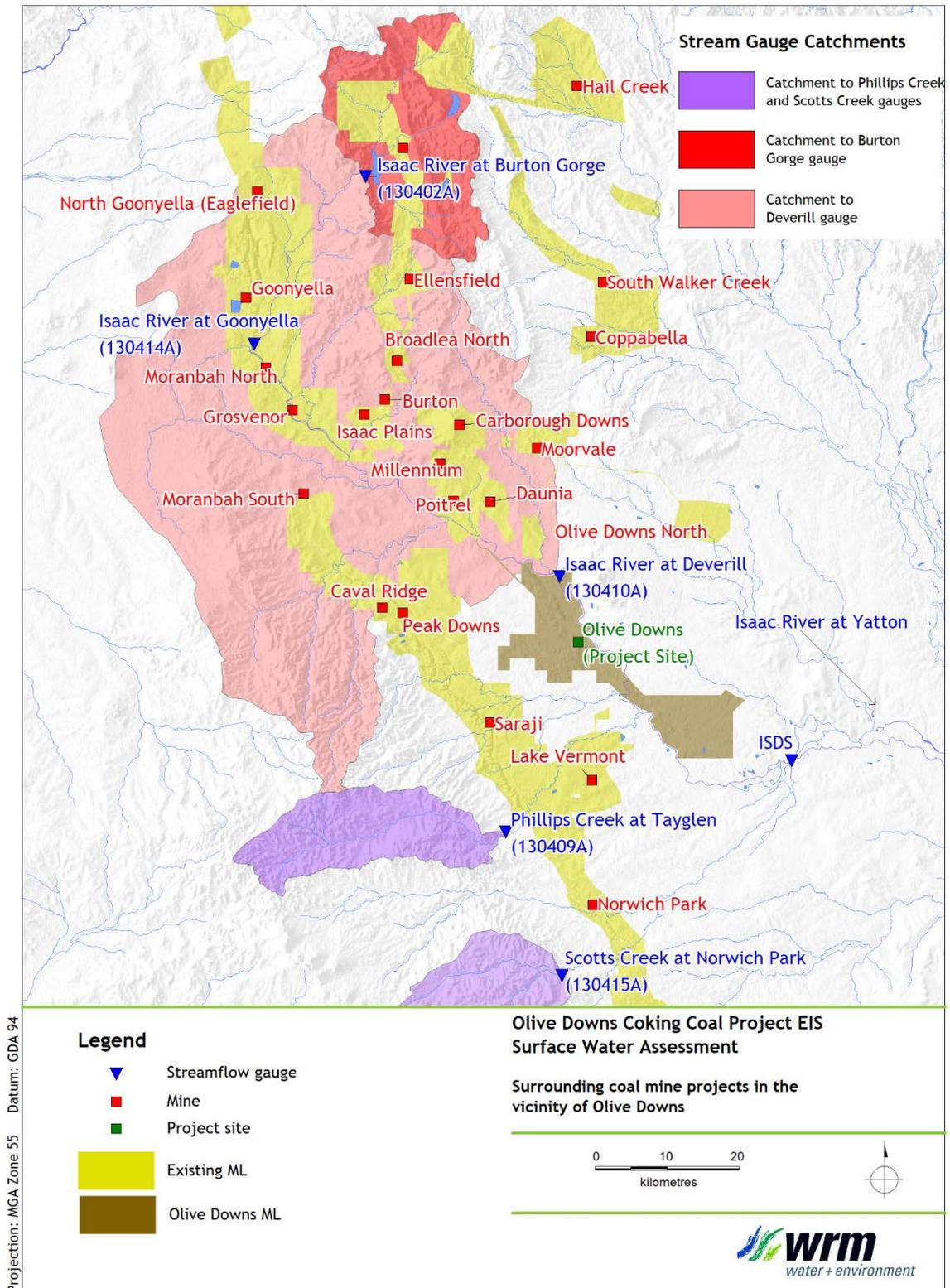


Figure 5-10: DNRME streamflow gauges and other coal mine projects in the vicinity of the Project

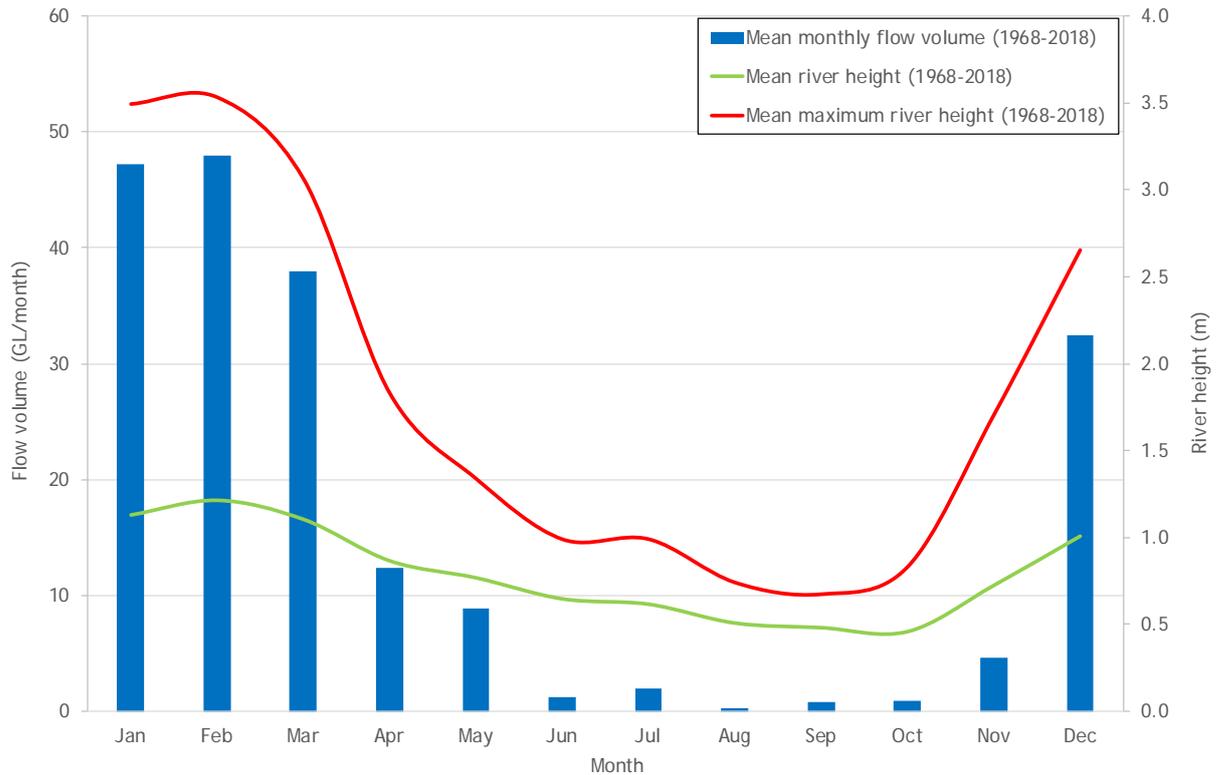


Figure 5-11: Flow Volume and River Height in the Isaac River at Deverill (DNRME station 130410A, located to the northwest of the Project area)

5.3.2 ISDS Data

Pembroke installed a monitoring station on the Isaac River, downstream of the Project area, named “ISDS”, to collect baseline water quality and flow information. The monitoring station, shown in Figure 5-10 and Figure 5-14, is located to the west of the Fitzroy Development Road Bridge and was commissioned in December 2016.

The monitoring station was installed in compliance with the relevant manuals, standards and guidelines. It continuously records water level, pH, EC and water temperature, and converts water level to discharge using a rating curve developed by Hatch. The station is included in the bi-monthly maintenance and calibration schedule along with all other Project surface water monitoring stations.

Sub-daily monitoring data has been recorded from 22 December 2016 and most recently downloaded on 29 June 2018. The recorded Isaac River flow data is displayed in Figure 5-12.

Figure 5-12 shows that there have been 5 flow events recorded (with a peak flow greater than 1 m³/s) since installation, with the highest recorded discharge of 804 m³/sec occurring in March 2017. Data has been omitted from the 29th of March at 4:20pm to the 1st of April at 1:00pm due to an error in the monitoring station. The flow increased instantaneously from a value of 804 m³/s to 7,999 m³/s which has been deemed an error in the gauge. This error has been attributed to the effects of Cyclone Debby which occurred late March 2017.

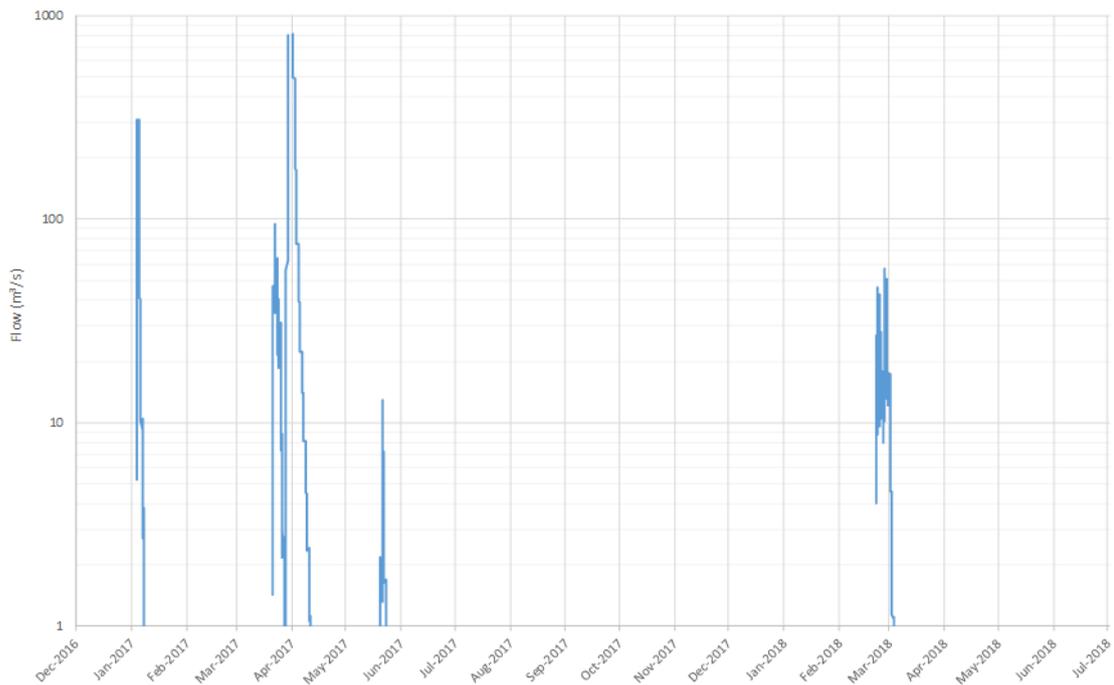


Figure 5-12: ISDS Gauge Recorded Flow Rate

5.3.3 **Watercourse Classification**

The Queensland Wetlands Map 2009 (DSITI 2015) identifies riverine systems, watercourses, waterways or drainage lines (here referred to collectively as waterways) for the Project area.

There are 21 waterways mapped for the Study area, including:

- 16 waterways of (Strahler) stream order one;
- three waterways of stream order two;
- one waterway of stream order three (Ripstone Creek); and
- one waterway of stream order six (the Isaac River).

The DNRME (2017) watercourse identification map identifies the Isaac River and Ripstone Creek as waterways that exhibit the characteristics of a watercourse as defined by the Water Act 2000 (refer Section 3.2.2), as well as several smaller waterways corresponding with the Queensland Wetland Map 2009 (DSITI, 2015).

The nearby waterways of Phillips Creek and Boomerang Creek have also been identified as watercourses. The other waterways are classified as drainage features that facilitate overland flow.

5.3.3.1 *Drainage Line 1 Determination*

Drainage Line 1 is located within MLA700036, at the north-eastern extent of the ODS Domain on the eastern side of the Isaac River. Pembroke recently sought a watercourse determination from the DNRME for this drainage line. In a letter dated 21 June 2018, the DNRME confirmed that Drainage Line 1 is not a watercourse, rather it is a drainage feature as defined under the Water Act 2000 that facilitates overland flow (DNRME, 2018).

5.3.4 **Geomorphology**

A geomorphological characterisation of the Project study area has been undertaken by Fluvial Systems (Fluvial Systems, 2018). A summary of the assessment is as follows:

- Repeatable field and desktop methods were used to characterise geomorphological attributes of the Project study area. Most of the stream reaches were in a stable, close to natural geomorphic condition. Some streams were potentially impacted by factors that reduced their condition, in particular high loads of sand in the bed, but without historical data concerning condition prior to the land cover and drainage being modified for agricultural and mining use, this remains uncertain. No knickpoints or zones of major geomorphic instability were observed.
- The risk of erosion of the Isaac River channel and floodplain was assessed using the method of maximum permissible bed shear stress and velocity assessment, with the hydraulic variables modelled as part of the flood study. This assessment of the most critical areas found that while there could be isolated areas subject to somewhat higher risk of scour compared to the existing situation, the overall risk of rapid and significant geomorphic change in the Isaac River due to the proposed mining activity was low.
- Geomorphic monitoring should include topographic survey of Isaac River channel and floodplain, repeated every year for 3 years, and then either every five years, or after every flood event exceeding the 5 year ARI (20% AEP) event. This should be done using LiDAR technology, flown when the flow is very low. A Before-After, Control-Intervention monitoring design should be used, with tolerable limits of change in the intervention reaches set by the observed degree of change in control reaches.
- Mitigation measures would be triggered by unexpectedly large change in channel morphology identified through monitoring. The most appropriate response would need to be assessed at the time.

Refer to Attachment A for the full geomorphological assessment report.

5.4 **Water Quality**

Water quality monitoring results for the area surrounding the Project area are available from a number gauging stations, in addition to the baseline monitoring that has been undertaken by Pembroke. Details on the various gauges are displayed in Table 5-6 and their locations are shown in Figure 5-13 and Figure 5-14.

Table 5-6: Water Quality Data Monitoring Locations

Site Name	Watercourse	Location		Data Source	Duration of Record	No. of Samples	Analytes
		Lat. (decimal degrees)	Long. (decimal degrees)				
Deverill	Isaac River (US of Project Area)	-22.17	148.35	DNRME	6 Jul 1964 – 24 Nov 2016	50	Range ¹
Red Hill Mine Lower Isaac	Isaac River (US of Project Area)	-21.87	147.97	BMA (Red Hill Mining Lease EIS)	14 Nov 2010 – 4 Apr 2011	51	Range ²
Red Hill Mine Upper Isaac	Isaac River (US of Project Area)	-21.80	147.99	BMA (Red Hill Mining Lease EIS)	18 Nov 2010 – 4 Apr 2011	45	
Riverine 1 (R1)	Unnamed tributary of the Isaac River	-22.42	148.60	DPM Aquatic Ecology Data	12 Dec 2016	1	Temp, EC, pH, DO, Turbidity
Riverine 2 (R2)	Isaac River	-22.40	148.53	Pembroke (EDM Aquatic Ecology Report)	14 Dec 2016	1	
Riverine 3 (R3)	Unnamed tributary of Ripstone Creek	-22.31	148.44	Pembroke (EDM Aquatic Ecology Report)	17 Dec 2016 – 8 Jul 2017	2	
Riverine 4 (R4)	Unmapped riverine wetland	-22.28	148.44	DPM Aquatic Ecology Data	7 Jul 2017	1	
Riverine 5 (R5)	Ripstone Creek	-22.28	148.37	DPM Aquatic Ecology Data	6 Jul 2017	1	
Riverine 6 (R6)	Isaac River	-22.27	148.46	Pembroke (EDM Aquatic Ecology Report)	14 Dec 2016 – 9 Jul 2017	2	
Riverine 7 (R7)	Unnamed tributary of the Isaac River	-22.18	148.37	DPM Aquatic Ecology Data	4 Jul 2017	1	
Riverine 8 (R8)	Isaac River	-22.32	148.47	Pembroke (EDM Aquatic Ecology Report)	16 Dec 2016 – 10 Jul 2017	2	
Lake Vermont (AQ3)	Phillips Creek	-22.46	148.36	Lake Vermont Resources Pty Ltd (ARC)	13 - 16 May 2013	1	
Lake Vermont (AQ4)	Phillips Creek	-22.39	148.42	Lake Vermont Resources Pty Ltd (ARC)	13 - 16 May 2013	1	Range ³
Lake Vermont (MP3)	Isaac River (DS of Project Area)	-22.39	148.42	Lake Vermont Resources Pty Ltd (ARC)	13 - 16 May 2013	1	Range ³
Olive Downs ISDS	Isaac River (DS of Project Area)	-22.42	148.70	Pembroke (Gauge)	22 Dec 2016 – 15 Nov 2017	Continuous monitoring station	pH, EC and Temp
SW1 (original)	Isaac River	-22.15	148.34	Pembroke (Gauge)	15 Aug 2017 – 14 Sep 2017	6	Range ⁴
SW1 (new)		-22.16	148.35				
SW2	Isaac River	-22.16	148.37	Pembroke (Gauge)	19 Jul 2017 – 14 Sep 2017	8	Range ⁴
SW3	Isaac River	-22.17	148.38	Pembroke (Gauge)	15 Aug – 14 Sep 2017	10	Range ⁴

Site Name	Watercourse	Location		Data Source	Duration of Record	No. of Samples	Analytes
		Lat. (decimal degrees)	Long. (decimal degrees)				
SW4 (original)	Ripstone Creek	-22.26	148.32	Pembroke (Gauge)	20 Jul 2017	1	Range ⁴
SW4 (new)		-22.26	148.33				
SW6	Ripstone Creek	-22.31	148.40	Pembroke (Gauge)	20 Jul 2017	1	Range ⁴
SW8	Isaac River (DS of Boomerang Creek)	-22.33	148.46	Pembroke (Gauge)	20 Jul 2017	1	Range ⁴
SW11 (original)	Isaac River	-22.42	148.54	Pembroke (Gauge)	13 Sep 2017	5	Range ⁴
SW11 (new)		-22.45	148.56				
SW12	Isaac River	-22.42	148.70	Pembroke (Gauge)	13 Sep 2017	7	Range ⁴

Range 1: Conductivity @ 25C , Turbidity, Colour True, pH, Total Alkalinity as CaCO₃, Hydroxide as OH, Carbonate as CO₃, Bicarbonate as HCO₃, Hardness as CaCO₃, Hydrogen as H, Total Dissolved Solids, Total Dissolved Ions, Total Suspended Solids, Calcium as Ca soluble, Chloride as Cl, Magnesium as Mg soluble, Nitrate as NO₃, Total Nitrogen, Organic Nitrogen, Nitrate + nitrite as N soluble, Ammonia as N – soluble, Oxygen (Dissolved), Total Phosphorus as P, Total React P, Potassium as K, Sodium as Na, Sulphate as SO₄, Aluminium as Al soluble, Boron as B, Copper as Cu soluble, Fluoride as F, Iron as Fe soluble, Manganese as Mn soluble, Silica as SiO₂ soluble, Zinc as Zn soluble.

Range 2: Total Aluminium, Total Ammonia, Total Antimony, Total Arsenic, Total Barium, Total Beryllium, Total Boron, Total Cadmium, Total Calcium, Total Chloride, Total Chromium, Total Copper, Total Cyanide, Total Fluoride, Total Iron, Total Lead, Total Magnesium, Total Manganese, Total Mercury, Total Molybdenum, Total Nickel, Total Nitrate, Total Nitrite, Total Oxygen, pH, Total Potassium, Total Selenium, Total Sodium, Total Sulphate, Total Zinc, Total Ammonium, Chlorophyll a, Filterable Reactive Phosphorus, Electrical Conductivity, Total Nitrogen, Total Phosphorus, Total Dissolved Solids, Total Suspended Solids, Turbidity, Cobalt, Dissolved Aluminium, Dissolved Antimony, Dissolved Arsenic, Dissolved Beryllium, Dissolved Boron, Dissolved Cadmium, Dissolved Calcium, Dissolved Chromium, Dissolved Copper, Dissolved Iron, Dissolved Lead, Dissolved Magnesium, Dissolved Manganese, Dissolved Mercury, Dissolved Molybdenum, Dissolved Nickel, Dissolved Potassium, Dissolved Selenium, Dissolved Zinc, Oil and Grease, MBAS, Chemical Oxygen Demand, Bicarbonate Alkalinity, Total Alkalinity, C6-C9, C10-C14, C15-C28, C29-C36, BOD, C10-C36 Fraction, NO₂+NO₃, Orthophosphate as P, Dissolved Cobalt, Total Silver, Dissolved Silver, Dissolved Uranium, Total Uranium, Dissolved Vanadium, Total Vanadium.

Range 3: pH, EC, DO, Total Alkalinity, Turbidity, Sulphate (SO₄²⁻), Suspended Solids, Sodium, Total Chloride, Ammonia, Total Nitrogen, Total Phosphorus, Oxidised N, Aluminium, Arsenic, Boron, Cadmium, Cobalt, Chromium, Copper, Manganese, Nickel, Lead, Vanadium, Zinc, Molybdenum, Selenium, Silver, Iron, Uranium, Mercury, Total Aluminium, Total Arsenic, Total Boron, Total Cadmium, Total Cobalt, Total Chromium, Total Copper, Total Manganese, Total Nickel, Total Lead, Total Vanadium, Total Zinc, Total Molybdenum, Total Selenium, Total Silver, Total Iron, Total Uranium, Total Mercury.

Range 4: 1,2-Dichloroethane-D4 %, 4-Bromofluorobenzene %, >C10 - C16 Fraction, >C10 - C16 Fraction minus Naphthalene (F2), >C10 - C40 Fraction (sum), >C16 - C34 Fraction, >C34 - C40 Fraction, Dissolved Aluminium, Total Aluminium, Ammonia as N, Dissolved Arsenic, Total Arsenic, Benzene, Dissolved Boron, Total Boron, C10 - C14 Fraction, C10 - C36 Fraction (sum), C15 - C28 Fraction, C29 - C36 Fraction, C6 - C10 Fraction, C6 - C10 Fraction minus BTEX (F1), C6 - C9 Fraction, Dissolved Cadmium, Total Cadmium, Dissolved Chromium, Total Chromium, Dissolved Cobalt, Total Cobalt, Dissolved Copper, Total Copper, Dissolved Oxygen % saturation, Dissolved Oxygen, Electrical Conductivity (Temperature Compensated), Electrical Conductivity (Non Compensated), Ethylbenzene, Fluoride, Dissolved Iron, Total Iron, Dissolved Lead, Total Lead, Dissolved Manganese, Total Manganese, Dissolved Mercury, Total Mercury, meta- & para-Xylene, Dissolved Molybdenum, Total Molybdenum, Naphthalene, Dissolved Nickel, Total Nickel, Nitrate as N, Nitrite + Nitrate as N, Nitrite as N, ortho-Xylene, pH, Reactive Phosphorus as P, Dissolved Selenium, Total Selenium, Dissolved Silver, Total Silver, Dissolved Sodium, Sulfate as SO₄ - Turbidimetric, Sum of BTEX, Suspended Solids (SS), Temperature, Toluene, Toluene-D8 %, Total Hardness as CaCO₃, Total Kjeldahl Nitrogen as N, Total Nitrogen as N, Total Phosphorus as P, Total Xylenes, Turbidity, Dissolved Uranium, Total Uranium, Dissolved Vanadium, Total Vanadium, Dissolved Zinc, Total Zinc.

Range 5: pH, Conductivity, Total Suspended Solids, Total Iron, Total Sodium, Total Potassium, Total Calcium, Total Magnesium, Total Chloride, Total Sulphate, Total Fluoride, Total Manganese, Total Aluminium, Total Boron, Total Cadmium, Total Copper, Total Lead, Total Zinc.

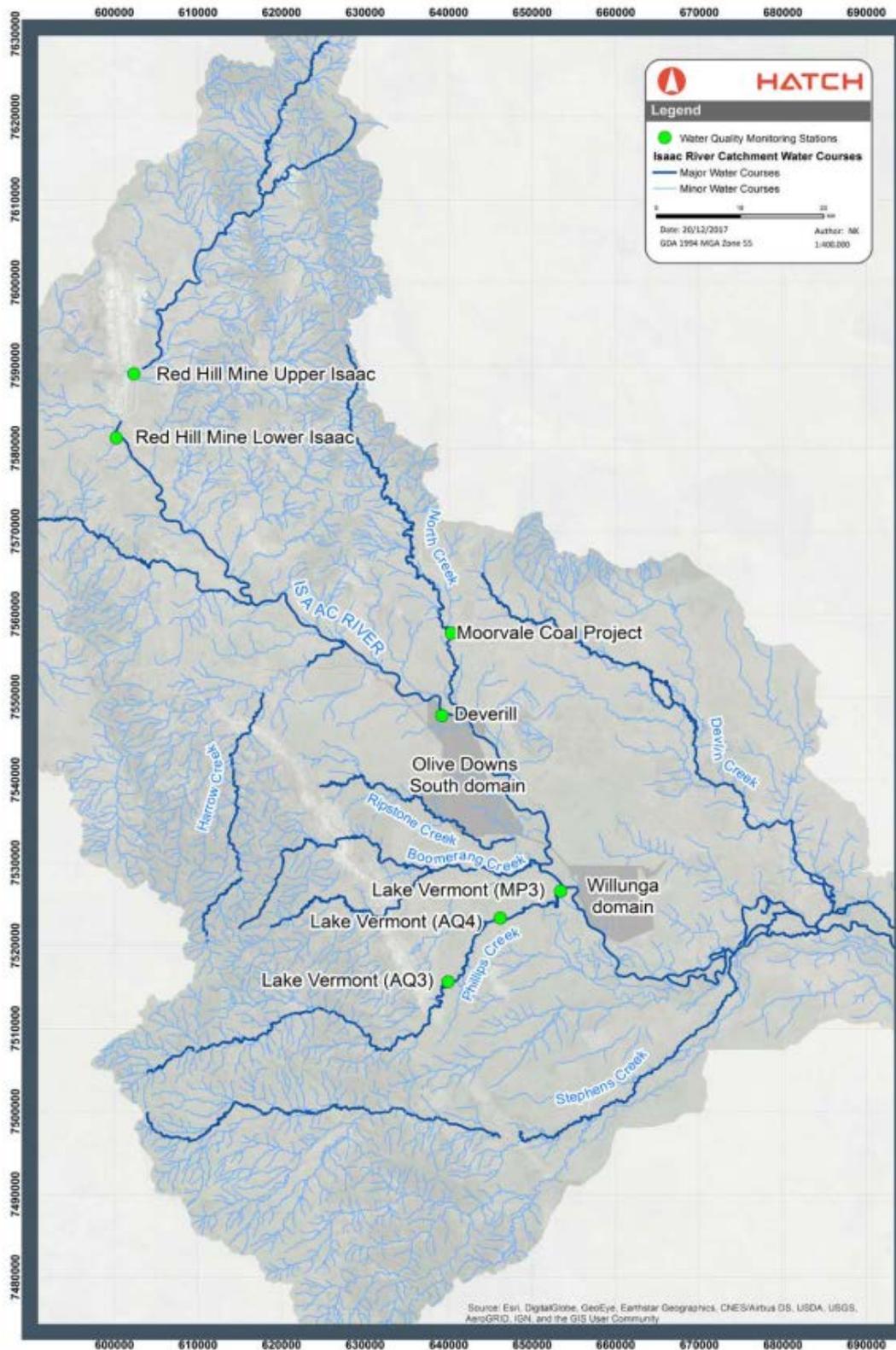


Figure 5-13: Regional Water Quality Monitoring Locations

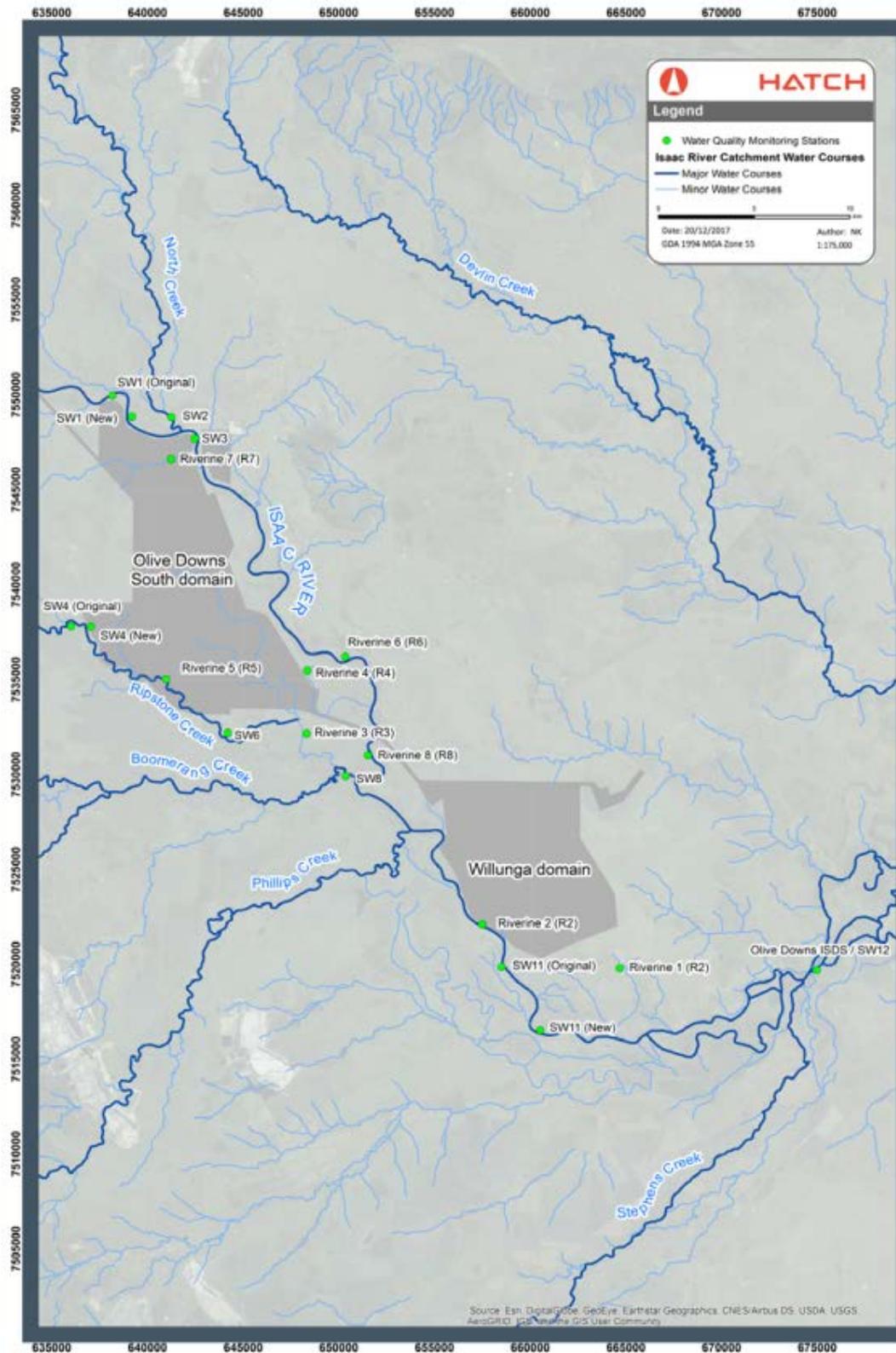


Figure 5-14: Local Water Quality Monitoring Locations

5.4.1 Regional Water Quality

Publicly available regional water quality data for the Isaac River at the Deverill Gauging Station and at Red Hill Mining Lease (Lower and Upper Isaac River locations) have been analysed and a comparison of median water quality at these sites are displayed in Table 5-7. These sites were selected as complete datasets (i.e. individual sample analysis results) are publicly available as opposed to only summary data being publicly available.

The Red Hill stations are located downstream of the Goonyella, North Goonyella, Broadlea and Burton mines and therefore includes mine release water quality. It is also about 80 km upstream of the Project. However, it provides an indication of water quality and in particular metal toxicants in the Isaac River at this location.

Review of Table 5-7 shows that some readings at the Red Hill Mining Lease are at or above the regional WQO. These include the following:

- Total aluminium (1.7 times higher than the WQO for stock watering)
- Dissolved aluminium (13 times higher than the WQO for aquatic ecosystems)
- Total cobalt (70 times higher than the WQO for irrigation)
- Total iron (1.1 times higher than the WQO for irrigation)
- Total suspended solids (7 times higher than the WQO for aquatic ecosystems)
- Turbidity (12 times higher than the WQO for aquatic ecosystems).

Based on the limited data set available at Deverill, there was an exceedance of dissolved zinc (1.3 times higher than the WQO for aquatic ecosystems), as well as exceedances of total suspended solids and turbidity.

Table 5-7: Regional Water Quality Monitoring Data Summary

Parameter	Unit	Isaac River at Deverill	Red Hill Mining Lease Lower Isaac	Red Hill Mining Lease Upper Isaac	WQO (refer Table 4-1)
Aluminium - Total	mg/L	-	8.5	8.5	< 5 (stock)
Aluminium - Dissolved	mg/L	0.05	0.42	0.405	< 0.055 (aquatic)
Ammonia - Total	µg/L	-	0.01	0.02	< 20 (aquatic)
Arsenic - Total	mg/L	-	0.0025	0.0025	<2.0 (irrigation) < 0.5 (stock)
Arsenic - Dissolved	mg/L	-	0.0005	0.0005	< 0.024 (aquatic)
Beryllium - Total	mg/L	-	0.0025	ND	< 0.5 (irrigation)
Beryllium - Dissolved	mg/L	-	0.0025	ND	-
Boron - Total	mg/L	0.06	0.05	0.05	< 5 (stock)
Boron - Dissolved	mg/L	-	0.04	0.04	< 0.37 (aquatic)
Cadmium - Total	mg/L	-	0.00025	0.00025	< 0.01 (stock)
Cadmium - Dissolved	mg/L	-	0.00005	0.00005	<0.0002 (aquatic)
Cobalt - Total	mg/L	-	7	6	< 0.1 (irrigation)
Cobalt - Dissolved	mg/L	-	0.0005	0.0005	-
Calcium - Dissolved	mg/L	16	ND	ND	-
BOD	mg/L	-	0.001	0.001	-

Parameter	Unit	Isaac River at Deverill	Red Hill Mining Lease Lower Isaac	Red Hill Mining Lease Upper Isaac	WQO (refer Table 4-1)
C6-C9	mg/L	-	0.025	0.025	-
C10-C14	mg/L	-	0.025	0.025	-
C15-C28	mg/L	-	0.1	0.1	-
C29-C36	mg/L	-	0.025	0.025	-
C10-C36 Fraction	mg/L	-	0.1	0.1	-
Chemical Oxygen Demand	mg/L	-	33	31.5	-
Chloride - Total	mg/L	32	Non-Detect (ND)	ND	-
Chlorophyll a	µg/L	-	ND	ND	< 5 (aquatic)
Chromium - Total	mg/L	-	0.016	0.015	< 1 (stock)
Chromium - Dissolved	mg/L	-	0.0005	0.0005	< 0.001 (aquatic)
Copper - Total	mg/L	-	0.011	0.011	<1 (stock)
Copper - Dissolved	mg/L	0.03	0.003	0.002	< 0.0014 (aquatic)
EC	µS/cm	261	220	170	< 720 (baseflow) < 250 (high flow)
Filterable Reactive Phosphorus	µg/L	0.35	0.43	0.294	< 20 (aquatic)
Fluoride - Total	mg/L	0.14	0.1	0.1	< 2 (irrigation)
Iron - Total	mg/L	-	11	11	< 10 (irrigation)
Iron - Dissolved	mg/L	0.06	0.24	0.26	-
Lead - Total	mg/L	-	0.005	0.006	< 0.1 (stock)
Lead - Dissolved	mg/L	-	0.0005	0.0005	< 0.0034 (aquatic)
Magnesium - Total	mg/L	-	0.273	ND	-
Manganese - Dissolved	mg/L	0.01	0.002	0.0025	< 1.9 (aquatic)
Manganese - Total	mg/L	-	0.251	0.261	< 10 (irrigation)
Mercury - Total	mg/L	-	0.00005	0.00005	< 0.002 (irrigation)
Mercury - Dissolved	mg/L	-	0.00005	0.00005	< 0.00006 (aquatic)
Molybdenum - Total	mg/L	-	0.0025	0.0025	< 0.05 (irrigation)
Molybdenum - Dissolved	mg/L	-	0.001	0.0005	-
Nickel - Total	mg/L	-	0.019	0.015	< 1 (stock)
Nickel - Dissolved	mg/L	-	0.002	0.002	< 0.005 (aquatic)
Nitrate - Total	mg/L	1.4	0.05	0.02	-
Nitrogen - Total	µg/L	0.76	ND	ND	< 500 (aquatic)
NO2+NO3	mg/L	-	0.14	0.085	-
pH	-	7.6	7.8	7.8	6.5-8.5 (aquatic)
Phosphorus - Total	µg/L	0.35	ND	ND	< 50 (aquatic)
Potassium - Total	mg/L	4.55	ND	ND	-
Selenium - Total	mg/L	-	0.0025	0.0025	< 0.02 (stock)
Selenium - Dissolved	mg/L	-	0.0025	0.0025	< 0.005 (aquatic)
Silver - Total	mg/L	-	0.00025	0.00025	-
Silver - Dissolved	mg/L	-	0.00005	0.00005	-
Sodium - Total	mg/L	22	ND	ND	< 30 (drinking water)
Sulphate - Total	mg/L	10.9	0.0048	0.002	< 25 (aquatic)
Total Alkalinity	mg/L	78	ND	ND	-

Parameter	Unit	Isaac River at Deverill	Red Hill Mining Lease Lower Isaac	Red Hill Mining Lease Upper Isaac	WQO (refer Table 4-1)
Total Dissolved Solids	mg/L	155	254	200	< 2,000 (stock)
Total Suspended Solids	mg/L	135	380	340	< 55 (aquatic)
Turbidity	NTU	247	597	450	< 50 (aquatic)
Uranium - Total	mg/L	-	0.0005	0.0005	<0.1 (irrigation)
Uranium - Dissolved	mg/L	-	0.0002	0.0002	-
Vanadium - Total	mg/L	-	0.029	0.0265	<0.5 (irrigation)
Vanadium - Dissolved	mg/L	-	0.0025	0.0025	-
Zinc - Total	mg/L	-	0.03	0.024	< 5 (irrigation)
Zinc - Dissolved	mg/L	0.01	0.0025	0.0025	< 0.008 (aquatic)

The Department of Natural Resources Mines and Energy (DNRME) has collected daily electrical conductivity data at the Isaac River at the Deverill and Yatton gauges. Electrical conductivity, which is a measure of the salt concentration with the flows, has been used to define the potential water quality impacts of the Project. The Deverill gauge is located near the upstream boundary of the Project and would be representative of water quality that drains past the site. The Yatton gauge is located downstream of the Connors River confluence but includes mining releases from all mines within the Isaac River catchment.

Figure 5-15 presents a time history of recorded instantaneous EC and stream flow for the Isaac River at Deverill gauging station. Figure 5-16 details the relationship between instantaneous flow and EC at the Isaac River at Deverill gauging station. The data collected by DNRME at the Deverill gauging station spans the period from 2011 to 2018 and indicates:

- The EC for high flows greater than 200 m³/s are generally below the high flow WQO EC of 250 µS/cm.
- The EC of instantaneous flows below 100 m³/s vary significantly from 50 µS/cm to 1,870 µS/cm with many recorded values exceeding the low flow WQO EC of 720 µS/cm.
- The mean daily EC has exceeded the low flow WQO on a total of 23 days over this period and all of these days experienced some flow (not stagnant flow).
- The stream flows are highly ephemeral with baseflows ceasing within a few days or weeks of a runoff event, or at least flowing below the top of the sandy bed.

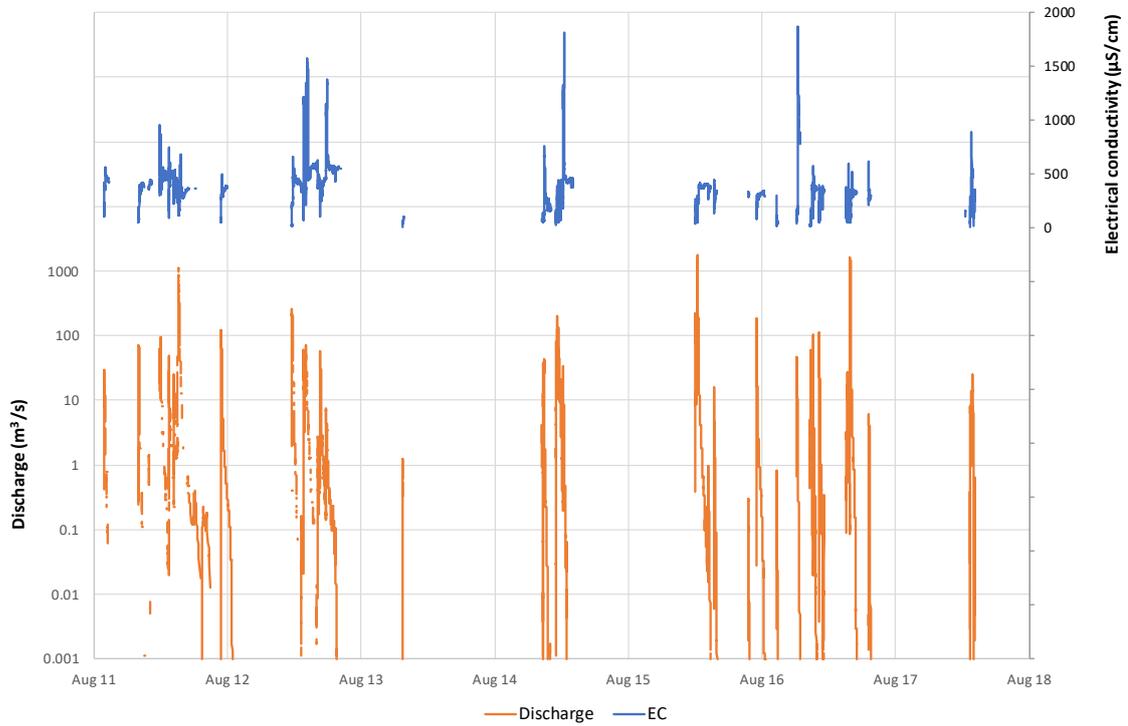


Figure 5-15: Electrical Conductivity and Flow (Isaac River at Deverill Gauge)

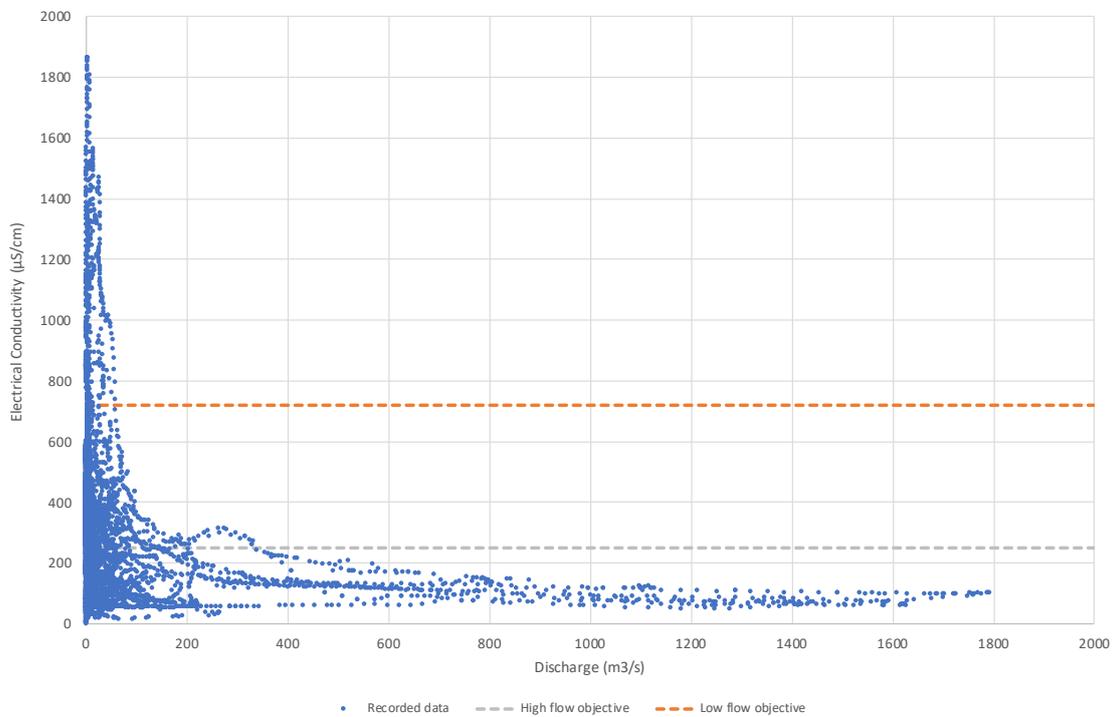


Figure 5-16: Flow vs Electrical Conductivity (Isaac River at Deverill Gauge)

Figure 5-17 presents a time history of recorded instantaneous EC and stream flow for the Isaac River at Yatton gauging station. Figure 5-18 details the relationship between instantaneous flow and EC at the Isaac River at Yatton gauging station recorded from 1995 to 2011 as well as from 2011 to 2018. The latter data period has been shown to provide a direct comparison with the period of record common with the Isaac River at Deverill gauge. The figures indicate:

- The EC for high flows greater than 200 m³/s vary much more than at Deverill but are generally below 400 µS/cm.
- The high flow EC since 2011 has generally been below the high flow WQO.
- The low flow EC has frequently been above the low flow WQO of 410 µS/cm. Figure 5-17 shows that EC rises during extended baseflow periods, which would be associated with either the Connors River or an increase in baseflow in the reach between Deverill and Yatton gauges.
- The recorded low flow EC is generally less than at Deverill.

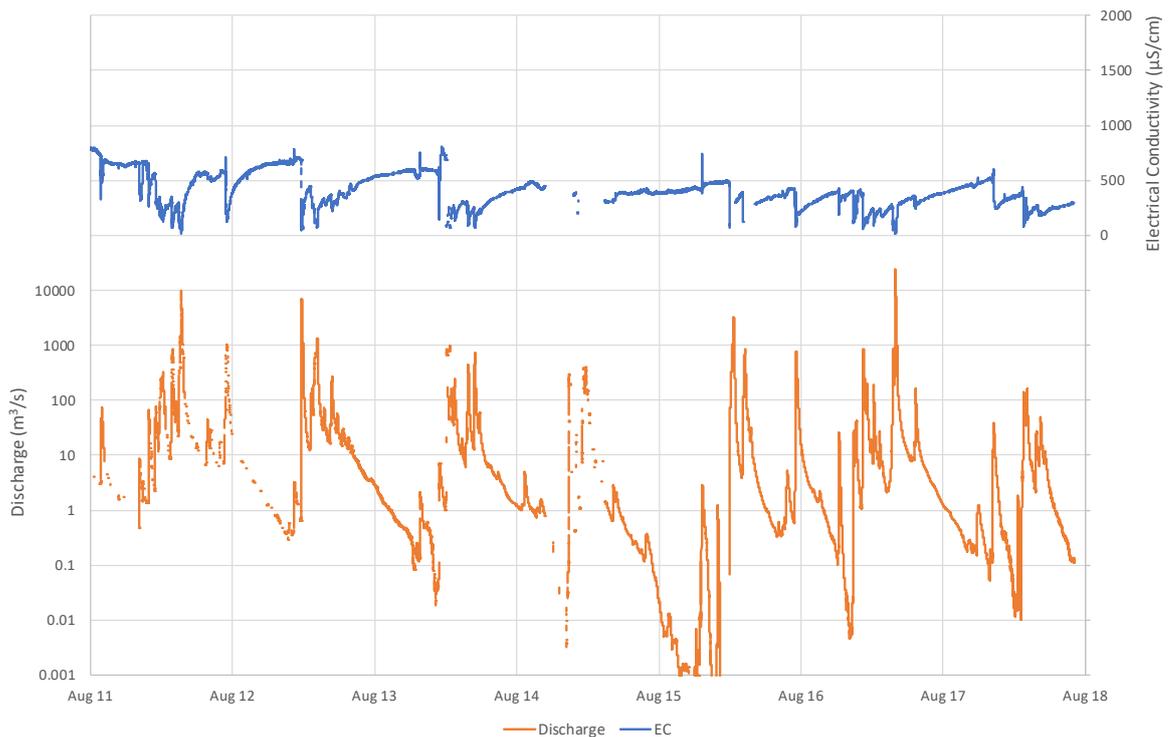


Figure 5-17: Electrical Conductivity and Flow (Isaac River at Yatton Gauge)

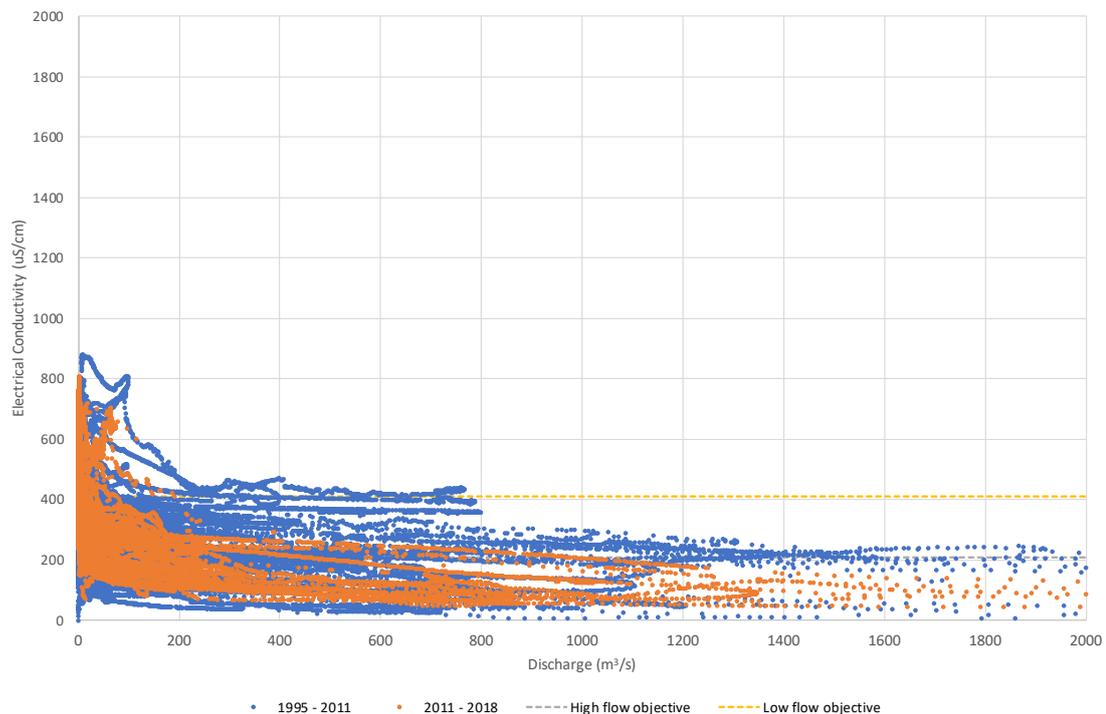


Figure 5-18: Flow vs Electrical Conductivity (Isaac River at Yatton Gauge)

5.4.2 ISDS Data

As mentioned in Section 5.3.2 Pembroke installed a monitoring station on the Isaac River, downstream of the Project area, named “ISDS”, to collect baseline water quality and flow information. Sub-daily monitoring data has been recorded from 22 December 2016 and most recently downloaded on 29 June 2018. The Isaac River flow discharge and its relationship with electrical conductivity and pH are displayed in Figure 5-19 and Figure 5-20 respectively.

Review of Figure 5-19 shows an increase in EC (above typical background levels) at the ISDS gauge starting from around 1 April 2017, continuing until 12 April. The recorded EC was within the Isaac River WQO’s (i.e. less than 720 µS/cm) for most of the event, however there was a period of elevated EC included a spike of around 3,100 µS/cm on 6 April 2017. This spike occurred for about 12 hours and was not recorded at the Deverill gauge.

The cause of this spike in EC is not known but may due to the release of water from an operating mine between the Deverill and ISDS gauges. According to the DEHP website (<https://www.ehp.qld.gov.au/land/mining/water-releases>), ten coal mines upstream of the ISDS gauge released to the Isaac River catchment during this period.

There was a second short period of elevated EC in May 2017 that exceed the Isaac River WQO’s. However, there were no recorded releases upstream of the gauge during this period.

This information shows that the water quality in the Isaac River during and after significant flow events has exceeded the Isaac River WQO's in the past for short periods of time. However, for the most part, the water quality in the Isaac River is within the WQO's.

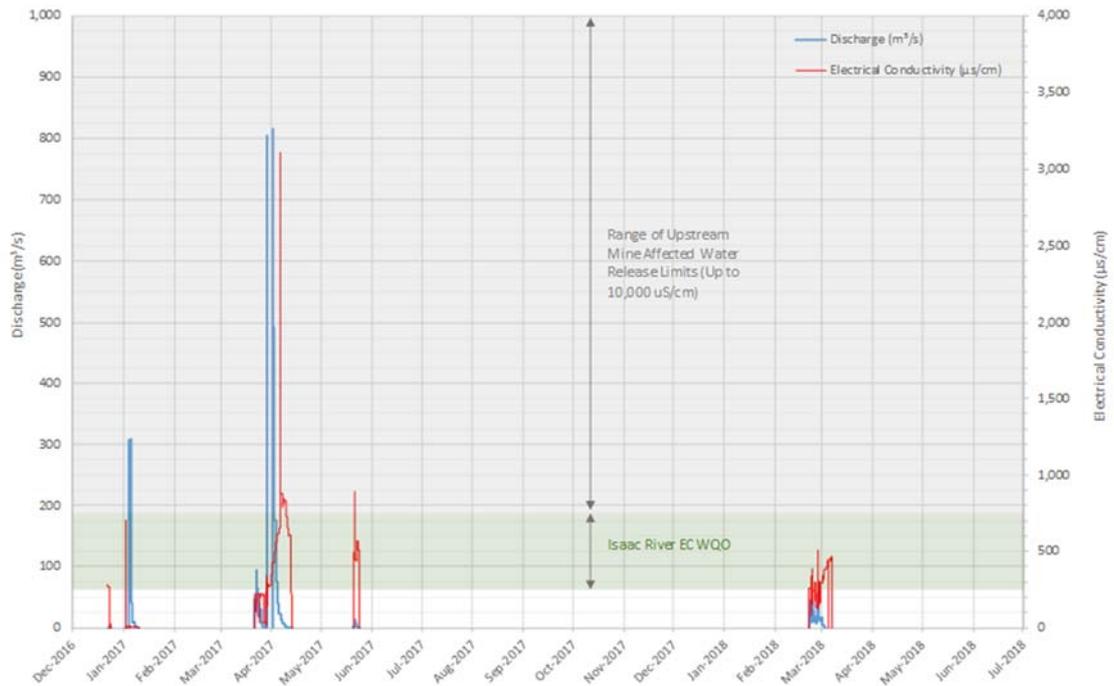


Figure 5-19: ISDS Flow and Electrical Conductivity

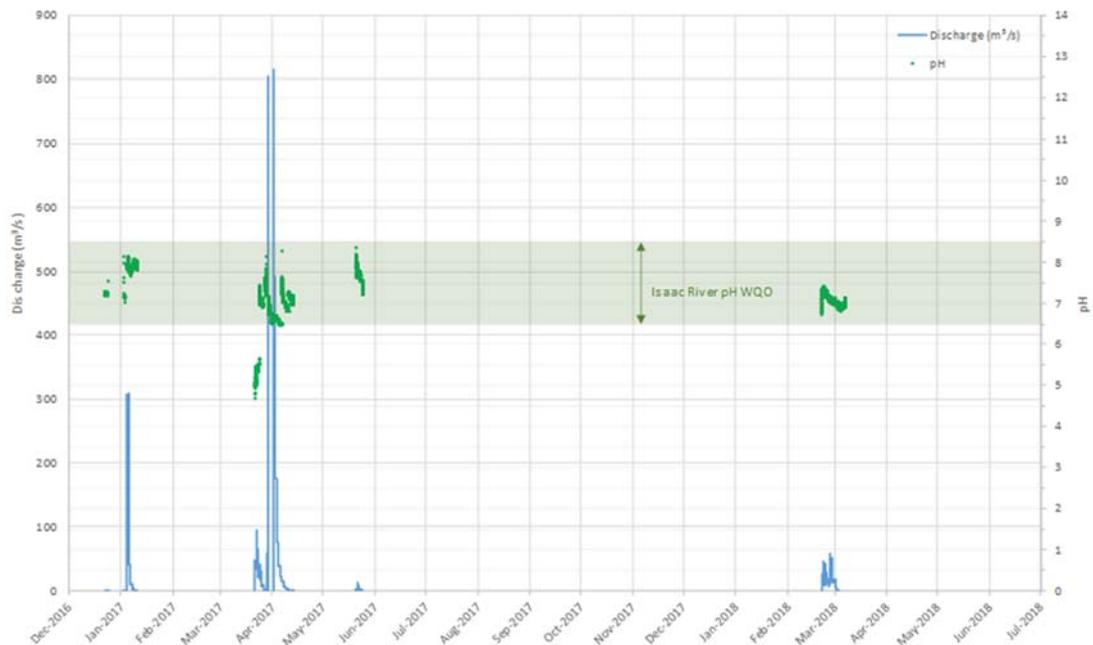


Figure 5-20: ISDS Flow and pH

5.4.2.1 *Olive Downs South Water Quality Data*

Water quality sampling was undertaken as a component of the baseline surface water quality sampling in between July 2017 and July 2018 for the Project. Analyses for a range of physio-chemical parameters were completed at sites SW1, SW2, SW3, SW4, SW6, SW8, SW11 and SW12. Note that the some of these samples are taken from pooled water as no flow was present at the time of sampling.

Review of Table 5-8, Table 5-9 and Table 5-10 shows that certain baseline water quality values surrounding the Project do not meet the WQOs for the region. These include:

- Dissolved aluminium;
- Dissolved copper;
- Dissolved zinc;
- Ammonia as N;
- Dissolved oxygen (% Saturation);
- Electrical conductivity;
- pH;
- Sulfate as SO₄
- Suspended solids;
- Total hardness as CaCO₃;
- Total Nitrogen as N;
- Total Phosphorus as P; and
- Turbidity.

Table 5-8: Physio-chemical Water Quality Parameters, July 2017 to May 2018 (SW1 & SW2)

Parameter	Unit	SW1						SW2								WQO (refer Table 4-1)
		15/08/17	14/09/17	12/10/17	16/11/17	14/12/17	25/01/18	19/07/17	15/08/17	14/09/17	12/10/17	15/2/18	14/03/18	13/04/18	23/05/18	
No. of samples	-	6						8								-
1,2-Dichloroethane-D4	%	102	98.5	98.2	109	117	103	100	98.9	99.5	102	109	97.2	103	97.5	-
4-Bromofluorobenzene	%	97.9	91.8	104	95.5	93.2	96.2	96.4	98.5	91.7	98.9	93.4	97.4	101	101	-
>C10 - C16 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
>C10 - C40 Fraction (sum)	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	120	160	<100	170	160	-
>C16 - C34 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	120	160	<100	170	160	-
>C34 - C40 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
Aluminium - Total	mg/L	0.28	0.30	0.27	0.21	0.36	1.10	0.80	0.74	1.30	1.01	1.11	3.76	0.58	0.58	< 5 (stock)
Aluminium – Dissolved	mg/L	0.02	0.08	0.11	0.15	0.05	0.05	0.04	0.07	0.07	0.13	0.61	0.36	0.05	0.05	< 0.055 (aquatic)
Ammonia as N	mg/L	0.04	0.10	0.05	0.03	0.12	0.21	<0.01	<0.01	0.04	0.04	0.16	0.08	0.12	0.05	< 0.02 (aquatic)
Arsenic - Total	mg/L	<0.001	0.001	0.001	0.002	0.001	0.002	<0.001	<0.001	0.001	0.002	0.002	0.002	0.002	0.001	< 0.5 (stock)
Arsenic – Dissolved	mg/L	<0.001	0.001	0.001	0.002	0.001	0.001	<0.001	<0.001	<0.001	0.002	0.001	0.001	0.001	<0.001	< 0.024 (aquatic)
Benzene	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-
Boron - Total	mg/L	<0.05	0.05	0.05	0.06	0.05	0.07	0.06	<0.05	0.07	0.08	<0.05	<0.05	0.06	0.06	< 5 (stock)
Boron – Dissolved	mg/L	<0.05	<0.05	<0.05	0.06	0.06	<0.05	<0.05	0.05	0.05	0.08	<0.05	<0.05	0.06	0.10	< 0.37 (aquatic)
C10 - C14 Fraction	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	-
C10 - C36 Fraction (sum)	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	50	140	<50	150	140	-
C15 - C28 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	140	<100	150	140	-
C29 - C36 Fraction	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	50	<50	<50	<50	<50	-
C6 - C10 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-
C6 - C10 Fraction minus BTEX (F1)	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-
C6 - C9 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-
Cadmium - Total	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.01 (stock)
Cadmium – Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.00002 (aquatic)
Chromium - Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.001	0.001	0.001	0.003	<0.001	<0.001	< 1 (stock)
Chromium – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Cobalt - Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.002	0.002	<0.001	0.002	<0.001	<0.001	< 0.1 (irrigation)
Cobalt – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	-
Copper - Total	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	0.002	<0.001	0.003	0.004	0.003	0.004	0.004	0.001	0.001	< 1 (stock)
Copper – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	0.002	0.002	0.002	0.001	<0.001	0.002	< 0.0014 (aquatic)
Dissolved Oxygen % Saturation	%	59.3	52.4	56.5	60.8	42.0	44.5	73.1	39.8	33.1	94.9	24.8	3.1	16.1	4.0	85-110 (aquatic)
EC (Non-Compensated)	µS/cm	389	398	467	475	464	449	399	479	493	516	124	203	319	261	< 720 (baseflow) < 250 (high flow)
Ethylbenzene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Fluoride	mg/L	0.2	0.2	0.2	0.2	<0.1	0.2	0.2	0.2	0.3	0.3	<0.1	0.2	0.2	0.3	< 2 (irrigation)
Iron - Total	mg/L	0.28	0.42	0.40	0.44	0.81	2.71	0.73	0.65	1.54	1.55	1.20	3.95	1.12	1.12	< 10 (irrigation)
Iron – Dissolved	mg/L	0.08	0.14	0.09	0.18	0.12	0.07	<0.05	<0.05	<0.05	0.16	0.52	0.30	0.06	0.09	-
Lead - Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.001	<0.001	0.002	<0.001	<0.001	<0.001	< 0.1 (stock)

Parameter	Unit	SW1						SW2						WQO (refer Table 4-1)		
		15/08/17	14/09/17	12/10/17	16/11/17	14/12/17	25/01/18	19/07/17	15/08/17	14/09/17	12/10/17	15/2/18	14/03/18		13/04/18	23/05/18
Lead – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0034 (aquatic)
Manganese - Total	mg/L	0.350	0.344	0.157	0.2697	0.469	0.781	0.136	0.157	0.980	1.430	0.094	0.408	0.309	0.098	< 10 (irrigation)
Manganese - Dissolved	mg/L	0.280	0.278	0.073	0.294	0.370	0.562	0.007	0.002	<0.001	0.922	0.016	0.005	0.028	0.056	< 1.9 (aquatic)
Mercury – Total	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.002 (irrigation)
Mercury - Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00006 (aquatic)
meta- & para-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Molybdenum – Total	mg/L	<0.001	0.001	0.001	0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.05 (irrigation)
Molybdenum - Dissolved	mg/L	0.001	0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Naphthalene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-
Nickel – Total	mg/L	<0.001	0.001	0.002	0.002	0.002	0.003	0.002	<0.001	0.003	0.004	0.004	0.005	0.002	0.002	< 1 (stock)
Nickel - Dissolved	mg/L	<0.001	<0.001	0.001	0.002	0.002	0.001	<0.001	0.001	<0.001	0.002	0.003	0.002	0.002	0.002	< 0.011 (aquatic)
Nitrate as N	mg/L	<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	-
Nitrite + Nitrate as N	mg/L	<0.01	<0.01	<0.01	<0.01	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	-
Nitrite as N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
ortho-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
pH	-	8.29	8.21	8.32	8.36	8.24	7.87	8.32	8.24	8.07	7.74	6.37	7.07	6.67	7.43	6.5 - 8.5 (aquatic)
Reactive Phosphorus as P	mg/L	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	-
Selenium – Total	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02 (stock)
Selenium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.005 (aquatic)
Silver – Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	-
Silver – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	-
Sodium - Dissolved	mg/L	33	38	57	53	41	37	30	33	38	50	4	15	17	28	-
Sulfate as SO4 - Turbidimetric	mg/L	6	4	8	3	3	4	2	1	1	<1	<1	<1	<1	<1	< 25 (aquatic)
Sum of BTEX	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-
Suspended Solids (SS)	mg/L	11	11	16	13	12	66	24	28	58	51	14	24	17	25	< 55 (aquatic)
Temperature	°C	21.94	28.44	28.21	28.82	29.41	23.54	22.51	18.92	23.36	23.88	23.46	17.55	17.50	16.70	-
Toluene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Toluene-D8	%	101	99.9	98.7	99.0	108	99.7	104	104	100	99.7	102	97.7	103	100	-
Total Hardness as CaCO3	mg/L	98	109	132	160	186	-	130	137	162	190	32	74	106	124	< 150 (drinking)
Total Kjeldahl Nitrogen as N	mg/L	0.3	0.5	0.4	0.5	0.3	1.3	0.5	0.6	1.1	1.4	0.8	0.7	0.6	0.8	-
Total Nitrogen as N	mg/L	0.3	0.5	0.4	0.5	0.3	1.3	0.5	0.6	1.1	1.4	0.8	0.7	0.6	0.8	< 0.5 (aquatic)
Total Phosphorus as P	mg/L	0.02	0.02	0.03	0.04	0.02	0.10	0.05	0.04	0.09	0.14	0.25	0.09	0.04	0.05	< 0.05 (aquatic)
Total Xylenes	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Turbidity	NTU	7.4	8.3	15.2	62.3	30	123	55.3	56.2	132	82.0	30.2	109	51.7	-	< 50 (aquatic)
Uranium – Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	-	<0.001	<0.001	<0.001	< 0.1 (irrigation)
Uranium - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	-	<0.001	<0.001	<0.001	-
Vanadium – Total	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.5 (irrigation)
Vanadium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Zinc – Total	mg/L	<0.005	<0.005	0.025	<0.005	0.01	<0.005	<0.005	0.011	0.006	<0.005	<0.005	0.012	<0.005	<0.005	< 5 (irrigation)
Zinc - Dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	< 0.008 (aquatic)

Table 5-9: Physio-chemical Water Quality Parameters, July 2017 to May 2018 (SW3, SW4, SW6 & SW8)

Parameter	Unit	SW3										SW4	SW6	SW8	WQO (refer Table 4-1)
		15/08/17	14/09/17	12/10/17	16/11/17	14/12/17	25/01/18	15/02/18	14/03/18	13/04/18	23/05/18	20/07/17	20/07/17	20/17/17	
No. of samples	-	10										1	1	1	-
1,2-Dichloroethane-D4	%	100	103	96.4	107	114	108	103	98.7	104	95.3	94.0	95.4	95.2	-
4-Bromofluorobenzene	%	101	95.8	103	113	96.8	98.1	89.6	97.6	106	101	97.4	97.9	97.8	-
>C10 - C16 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
>C10 - C40 Fraction (sum)	µg/L	<100	<100	<100	<100	<100	130	<100	<100	<100	<100	<100	<100	<100	-
>C16 - C34 Fraction	µg/L	<100	<100	<100	<100	<100	130	<100	<100	<100	<100	<100	<100	<100	-
>C34 - C40 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
Aluminium - Total	mg/L	0.11	0.27	0.15	0.12	0.04	0.07	10.5	0.39	0.22	0.26	0.11	1.15	0.43	< 5 (stock)
Aluminium – Dissolved	mg/L	0.09	0.07	0.05	0.05	0.02	0.02	0.52	0.12	0.04	0.04	0.05	0.08	0.11	< 0.055 (aquatic)
Ammonia as N	mg/L	0.04	0.03	0.05	0.04	0.2	<0.01	0.17	0.06	0.06	0.15	<0.01	<0.01	0.02	< 0.02 (aquatic)
Arsenic – Total	mg/L	<0.001	<0.001	0.002	0.002	<0.001	0.002	0.004	<0.001	0.001	0.001	<0.001	<0.001	<0.001	< 0.5 (stock)
Arsenic – Dissolved	mg/L	<0.001	<0.001	0.001	0.001	0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	< 0.024 (aquatic)
Benzene	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-
Boron – Total	mg/L	<0.05	0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	0.05	0.05	0.09	0.11	0.08	< 5 (stock)
Boron – Dissolved	mg/L	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	<0.05	0.06	0.07	0.10	0.11	0.08	< 0.37 (aquatic)
C10 - C14 Fraction	µg/L	<50	<50	<50	<50	<50	50	<50	<50	<50	<50	<50	<50	<50	-
C10 - C36 Fraction (sum)	µg/L	<50	<50	<50	<50	<50	210	<50	<50	<50	<50	<50	<50	<50	-
C15 - C28 Fraction	µg/L	<100	<100	<100	<100	<100	110	<100	<100	<100	<100	<100	<100	<100	-
C29 - C36 Fraction	µg/L	<50	<50	<50	<50	<50	50	<50	<50	<50	<50	<50	<50	<50	-
C6 - C10 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-
C6 - C10 Fraction minus BTEX (F1)	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-
C6 - C9 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-
Cadmium – Total	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.01 (stock)
Cadmium – Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.00002 (aquatic)
Chromium – Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	0.001	<0.001	<0.001	0.011	<0.001	<0.001	< 1 (stock)
Chromium – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Cobalt – Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	0.001	<0.001	<0.001	0.001	<0.001	< 0.1 (irrigation)
Cobalt – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	-
Copper – Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.011	<0.001	<0.001	<0.001	<0.001	0.003	0.002	< 1 (stock)
Copper – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.002	0.002	0.002	< 0.0014 (aquatic)
Dissolved Oxygen % Saturation	%	41.5	30.7	23.8	33.6	42.2	57.2	27.1	29.8	17.3	5.1	78.0	62.2	59.5	85-110 (aquatic)
EC (Non-Compensated)	µS/cm	330	311	317	313	322	358	218	225	297	295	781	1230	2020	< 720 (baseflow) < 250 (high flow)
Ethylbenzene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Fluoride	mg/L	0.2	0.1	0.2	0.1	<0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.4	0.3	< 2 (irrigation)
Iron – Total	mg/L	0.15	0.35	0.65	0.91	0.80	1.41	12.6	0.44	0.57	1.28	0.20	1.04	0.31	< 10 (irrigation)
Iron – Dissolved	mg/L	0.06	0.09	0.39	0.63	0.61	0.47	0.31	0.1	0.2	0.3	<0.05	<0.05	0.07	-
Lead – Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.1 (stock)

Parameter	Unit	SW3										SW4	SW6	SW8	WQO (refer Table 4-1)
		15/08/17	14/09/17	12/10/17	16/11/17	14/12/17	25/01/18	15/02/18	14/03/18	13/04/18	23/05/18	20/07/17	20/07/17	20/17/17	
Lead – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0034 (aquatic)
Manganese - Total	mg/L	0.083	0.217	0.978	1.1	0.407	0.679	0.288	0.075	0.962	0.530	0.019	0.201	0.024	< 10 (irrigation)
Manganese - Dissolved	mg/L	0.045	0.144	0.9	1.05	0.418	0.576	0.011	0.070	0.916	0.504	0.005	0.106	0.006	< 1.9 (aquatic)
Mercury - Total	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.002 (irrigation)
Mercury - Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00006 (aquatic)
meta- & para-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Molybdenum - Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.003	0.002	< 0.05 (irrigation)
Molybdenum - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.003	0.002	-
Naphthalene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-
Nickel - Total	mg/L	<0.001	0.002	0.001	0.001	<0.001	0.002	0.015	0.002	0.002	0.002	0.002	0.004	0.003	< 1 (stock)
Nickel - Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	0.002	0.001	0.002	0.003	0.002	< 0.011 (aquatic)
Nitrate as N	mg/L	<0.01	<0.01	<0.01	0.25	<0.01	<0.01	0.02	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	-
Nitrite + Nitrate as N	mg/L	<0.01	<0.01	<0.01	0.25	<0.01	<0.01	0.02	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	-
Nitrite as N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
ortho-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
pH	-	8.04	7.17	7.51	7.67	8.18	8.08	6.40	7.44	7.00	7.45	8.38	8.33	8.47	6.5 - 8.5 (aquatic)
Reactive Phosphorus as P	mg/L	<0.01	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Selenium - Total	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02 (stock)
Selenium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.005 (aquatic)
Silver - Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Silver – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Sodium - Dissolved	mg/L	34	32	39	38	36	39	19	23	30	34	105	197	300	-
Sulfate as SO4 - Turbidimetric	mg/L	8	6	5	4	5	5	9	6	5	5	57	156	410	< 25 (aquatic)
Sum of BTEX	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-
Suspended Solids (SS)	mg/L	11	10	<5	<5	<5	6	38	<5	<5	13	5	28	<5	< 55 (aquatic)
Temperature	°C	18.81	22.75	25.44	26.26	26.62	25.15	23.31	16.65	18.05	18.60	13.9	14.3	19.1	-
Toluene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Toluene-D8	%	99.7	101	97.6	98.4	113	101	99.8	96.9	103	100	103	104	103	-
Total Hardness as CaCO3	mg/L	65	72	79	86	105		48	57	82	96	147	149	300	< 150 (drinking)
Total Kjeldahl Nitrogen as N	mg/L	0.3	0.2	0.2	0.4	0.4	0.6	1.1	0.1	0.5	0.5	0.6	0.9	0.8	-
Total Nitrogen as N	mg/L	0.3	0.2	0.2	0.6	0.4	0.6	1.1	0.1	0.5	0.5	0.6	0.9	0.8	< 0.5 (aquatic)
Total Phosphorus as P	mg/L	0.01	0.02	0.02	0.03	0.02	0.04	0.28	0.07	0.03	0.02	0.02	0.07	0.05	< 0.05 (aquatic)
Total Xylenes	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Turbidity	NTU	7.7	1.7	0.5	35.7	4.4	12.4	498	10.4	15.2	-	4.9	95.4	14.5	< 50 (aquatic)
Uranium - Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	0.001	0.001	< 0.1 (irrigation)
Uranium - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	0.001	0.001	-
Vanadium - Total	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.5 (irrigation)
Vanadium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Zinc - Total	mg/L	<0.005	<0.005	0.017	<0.005	<0.005	0.008	0.026	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	< 5 (irrigation)
Zinc - Dissolved	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	< 0.008 (aquatic)

Table 5-10: Physio-chemical Water Quality Parameters, July 2017 to May 2018 (SW11 & SW12)

Parameter	Unit	SW11					SW12							WQO (refer Table 4-1)
		13/09/17	12/10/17	16/11/17	14/12/17	14/03/18	13/09/17	12/10/17	16/11/17	14/1 2/17	25/01/18	14/03/18	23/05/18	
No. of samples	-	5					7							-
1,2-Dichloroethane-D4	%	101	95.7	109	115	98.6	99.2	100	112	120	104	98.4	97.6	-
4-Bromofluorobenzene	%	92.9	99.3	97.6	96.5	96.7	91.8	99.0	97.9	89.5	94.2	96.0	101	-
>C10 - C16 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
>C10 - C40 Fraction (sum)	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	260	<100	100	-
>C16 - C34 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	260	<100	100	-
>C34 - C40 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-
Aluminium - Total	mg/L	0.84	0.43	0.59	0.62	2.70	0.55	0.21	0.63	0.56	1.27	2.83	0.87	< 5 (stock)
Aluminium – Dissolved	mg/L	0.28	0.20	0.14	0.16	0.27	0.12	0.11	0.11	0.12	0.05	0.23	0.04	< 0.055 (aquatic)
Ammonia as N	mg/L	0.05	0.14	0.03	0.10	0.10	0.04	0.07	0.03	0.06	0.02	0.10	0.02	< 0.02 (aquatic)
Arsenic – Total	mg/L	<0.001	0.002	0.002	0.003	0.001	<0.001	0.003	0.002	0.002	0.003	0.001	0.001	< 0.5 (stock)
Arsenic – Dissolved	mg/L	<0.001	0.001	0.002	0.002	<0.001	<0.001	0.003	0.001	0.002	0.002	<0.001	<0.001	< 0.024 (aquatic)
Benzene	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-
Boron – Total	mg/L	0.06	<0.05	0.06	<0.05	<0.05	0.07	0.07	<0.05	0.09	0.10	<0.05	0.06	< 5 (stock)
Boron – Dissolved	mg/L	0.05	<0.05	0.05	0.07	<0.05	0.05	0.06	<0.05	0.09	0.08	<0.05	0.06	< 0.37 (aquatic)
C10 - C14 Fraction	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	-
C10 - C36 Fraction (sum)	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	300	<50	<50	-
C15 - C28 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	180	<100	<100	-
C29 - C36 Fraction	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	120	<50	<50	-
C6 - C10 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-
C6 - C10 Fraction minus BTEX (F1)	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-
C6 - C9 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-
Cadmium – Total	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.01 (stock)
Cadmium – Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.00002 (aquatic)
Chromium – Total	mg/L	0.001	<0.001	<0.001	0.001	0.005	<0.001	<0.001	0.001	<0.001	0.003	0.005	0.001	< 1 (stock)
Chromium – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.001 (aquatic)
Cobalt – Total	mg/L	<0.001	<0.001	0.001	0.001	0.001	<0.001	0.001	0.001	<0.001	0.002	0.002	0.001	< 0.1 (irrigation)
Cobalt – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Copper – Total	mg/L	0.002	0.001	0.008	<0.001	0.004	0.002	<0.001	0.002	<0.001	0.002	0.004	<0.001	< 1 (stock)
Copper – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	< 0.0014 (aquatic)
Dissolved Oxygen % Saturation	%	57.9	25.5	29.5	7.0	34.6	44.8	79.3	22.8	11.8	31.0	12.7	3.2	85-110 (aquatic)
EC (Non-Compensated)	µS/cm	595	590	515	515	262	612	631	571	556	784	237	414	< 720 (baseflow) < 250 (high flow)
Ethylbenzene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Fluoride	mg/L	0.2	0.2	0.2	<0.1	0.1	0.2	0.2	0.2	<0.1	0.3	0.1	0.2	< 2 (irrigation)
Iron – Total	mg/L	0.94	0.85	0.92	1.50	3.20	0.67	1.29	1.41	1.60	2.55	3.70	1.80	< 10 (irrigation)
Iron – Dissolved	mg/L	0.15	0.34	0.19	0.38	0.17	0.1	0.87	0.18	0.25	0.07	0.2	0.1	-
Lead – Total	mg/L	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	< 0.1 (stock)
Lead – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.0034 (aquatic)

Parameter	Unit	SW11					SW12						WQO (refer Table 4-1)	
		13/09/17	12/10/17	16/11/17	14/12/17	14/03/18	13/09/17	12/10/17	16/11/17	14/1 2/17	25/01/18	14/03/18		23/05/18
Manganese – Total	mg/L	0.024	0.129	0.784	1.30	0.064	0.196	1.06	0.817	0.861	0.866	0.221	0.242	< 10
Manganese - Dissolved	mg/L	0.006	0.091	0.709	1.43	0.002	0.116	1.000	0.591	0.794	0.726	0.097	0.206	< 1.9 (aquatic)
Mercury – Total	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	< 0.002 (irrigation)
Mercury - Dissolved	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.00006 (aquatic)
meta- & para-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Molybdenum – Total	mg/L	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	< 0.05 (irrigation)
Molybdenum - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	-
Naphthalene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	-
Nickel – Total	mg/L	0.003	0.002	0.003	0.002	0.005	0.002	0.002	0.003	0.004	0.005	0.005	0.003	< 1 (stock)
Nickel - Dissolved	mg/L	<0.001	0.002	0.002	0.003	0.001	0.002	0.002	0.002	0.002	0.003	0.002	0.002	< 0.011 (aquatic)
Nitrate as N	mg/L	<0.01	<0.01	0.13	<0.01	0.19	<0.01	<0.01	0.18	<0.01	<0.01	0.05	<0.01	-
Nitrite + Nitrate as N	mg/L	<0.01	<0.01	0.13	<0.01	0.19	<0.01	<0.01	0.18	<0.01	<0.01	0.05	<0.01	-
Nitrite as N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
ortho-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
pH	-	8.32	7.21	7.22	7.26	7.10	7.73	7.44	7.73	7.90	8.10	7.03	7.44	6.5 - 8.5 (aquatic)
Reactive Phosphorus as P	mg/L	<0.01	<0.01		<0.01	<0.01	<0.01	0.02		<0.01	<0.01	<0.01	<0.01	-
Selenium – Total	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.02 (stock)
Selenium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.005 (aquatic)
Silver – Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Silver – Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Sodium - Dissolved	mg/L	78	83	65	63	23	64	85	67	75	85	21	30	-
Sulfate as SO4 - Turbidimetric	mg/L	47	39	36	27	13	36	14	15	6	8	12	9	< 25 (aquatic)
Sum of BTEX	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-
Suspended Solids (SS)	mg/L	16	<5	17	15	16	11	<5	16	10	51	28	27	< 55 (aquatic)
Temperature	°C	28.92	22.3	24.48	23.18	17.73	29.8	23.81	25.22	25.95	23.00	17.20	13.50	-
Toluene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Toluene-D8	%	101	95.9	96.8	109	98.2	99.0	99.7	96.6	105	99.8	98.5	101	-
Total Hardness as CaCO3	mg/L	110	142	125	146	61	119	166	132	157		64	104	< 150 (drinking)
Total Kjeldahl Nitrogen as N	mg/L	0.5	0.4	0.4	0.4	0.4	0.5	0.7	0.9	0.5	1.3	0.8	0.6	-
Total Nitrogen as N	mg/L	0.5	0.4	0.5	0.4	0.6	0.5	0.7	1.1	0.5	1.3	0.8	0.6	< 0.5 (aquatic)
Total Phosphorus as P	mg/L	0.03	0.03	0.04	0.03	0.12	0.04	0.11	0.07	0.04	0.14	0.11	0.06	< 0.05 (aquatic)
Total Xylenes	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	-
Turbidity	NTU	26.4	8.8	84.3	35.2	101	12.5	1.7	77.6	40.6	104	125	-	< 50 (aquatic)
Uranium – Total	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	< 0.1 (irrigation)
Uranium - Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-
Vanadium – Total	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.5 (irrigation)
Vanadium - Dissolved	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
Zinc - Total	mg/L	<0.005	<0.005	0.012	0.009	0.013	<0.005	<0.005	<0.005	<0.005	0.006	0.010	<0.005	< 5 (irrigation)
Zinc – Dissolved	mg/L	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	< 0.008 (aquatic)

5.4.2.2 REMP Outcomes at Nearby Mine Sites

We have undertaken a review of various The Receiving Environment Management Plan (REMP) and Annual Return documents which were provided by DES for nearby operating coal mines. These include:

- Lake Vermont Mine:
 - ◆ 2016 Receiving Environment Monitoring Program (November 2016)
 - ◆ Receiving Environment Monitoring Program Progress Report (July 2017)
- Peak Downs Mine:
 - ◆ Receiving Environment Monitoring Program – Annual Report – end June 2013 (July 2014)
 - ◆ Receiving Environment Monitoring Program – Annual Report – end June 2017 (December 2017)
- Saraji Mine:
 - ◆ Receiving Environment Monitoring Program – Annual Report – 2015/16 (April 2017)
 - ◆ Receiving Environment Monitoring Program – Annual Report – end June 2017 (December 2017)

A summary of the key outcomes from the various documents are summarized in Table 5-11.

Table 5-11: Summary of Key Outcomes from REMP's at nearby mine sites

Site	Document	Key Outcome
Lake Vermont Mine	2016 REMP	<ul style="list-style-type: none"> • There were some occasions in the past few years where certain in-situ water quality parameters were outside EA limits. • These were observed at upstream reference sites and downstream impacted sites. • Based on spatial trends and timing in relation to release events, these occurrences do not appear to correlate with mine releases. • Exceedances during periods of no mine releases were observed for Al, Cu, Fe, MN, Zn, Pb, Hg and B. • The current release limits are largely sufficient to protect the receiving waters. • There is no evidence of mine-affected water release impacts on the receiving environment watercourses downstream of mine operations or releases or any impacts on the ecological community and aquatic habitat.
Lake Vermont Mine	2017 REMP	<ul style="list-style-type: none"> • Variation in reference and impact sites from 2013-2017 for physio-chemical parameters, total metals, dissolved metals and petroleum hydrocarbons was minimal, indicating that mining activities are unlikely to impact water quality. • Few exceedances of specific WQOs related to the EVs relevant to the Project were recorded indicating that EVs are not at risk from mining activity throughout the Project.
Peak Downs Mine	2013 REMP	<ul style="list-style-type: none"> • The median EC downstream Ripstone Creek (2,084µS/cm) was greater than the upstream average 80th percentile.

Site	Document	Key Outcome
		<ul style="list-style-type: none"> The average upstream 80th percentile (293µS/cm) and the Isaac River upstream 80th percentile (590µS/cm) were well below the current EA trigger for downstream Isaac River (2,000µS/cm) and the Queensland guideline for the Fitzroy North region (720µS/cm). The current EA trigger of 2,000µS/cm accommodates the natural variation in each stream and aligns with recent ecotoxicology studies (Prasad, et al., 2012) using ANZECC & ARMCANZ (2000) methodology which found salinity levels up to 2,000µS/cm-2,500µS/cm provide 95% protection (acceptable for SMD systems) for aquatic species in the Fitzroy Basin
Peak Downs Mine	2017 REMP	<ul style="list-style-type: none"> Electrical conductivity was at times above the ANZECC & ARMCANZ (2000) aquatic ecosystem (720 µS/cm) and ADWG (2011) drinking water (400 µg/L) guideline at downstream Isaac River Seloh Nolem (MP18), however remained well below the EA trigger and other ANZECC & ARMCANZ (2000) guidelines. Dissolved aluminium and copper were above the ANZECC & ARMCANZ (2000) ecosystem guideline at upstream and downstream sites, however downstream concentrations of these analytes remained below their respective EA triggers. Total aluminium, iron and manganese were above ANZECC & ARMCANZ (2000) recreational, irrigation and livestock guidelines at upstream and downstream sites. Downstream concentrations of these analytes were generally below or within the range of values recorded upstream, and well within historical ranges, indicating a natural enrichment in the area. In conclusion, the results indicate values above guidelines generally occurred both upstream and downstream of mining and are likely a function of background and associated land use influences outside of mining. Downstream median concentrations for these metals during the overall REMP study remained within the upstream 80th percentile considered acceptable for slightly-to-moderately disturbed systems (QWQG, 2009).
Saraji Mine	2015/16 REMP	<ul style="list-style-type: none"> Electrical Conductivity was above drinking water (400 µg/L) and ecosystem (720 µg/L) guidelines at Hughes Creek DS and Phillips Creek DS recording 843 µg/L and 1,920 µg/L respectively during flows in February. However, these recordings were below the EA trigger value (2,000 µg/L) and historical ranges. High EC levels were also detected at upstream and downstream sites during nil flow periods, with most sites staying within the EA trigger value and historical ranges. Only Phillips Creek US exceeded the EA trigger, recording 2,411 µg/L during May 2016. Samples taken during nil-flow periods commonly exhibit elevated salt concentrations. Dissolved zinc concentrations in Hughes Creek US and Phillips Creek DS (50 and 60 µg/L respectively) were detected above the ecosystem guideline and EA trigger (8 µg/L) in February 2016. These readings are likely the result of a laboratory error as total zinc concentrations (7 and 18 µg/L) were well below dissolved concentrations at the same sites on the same day Total aluminium, iron and manganese exceeded recreational and irrigation guidelines during flow and nil-flow sampling both upstream and downstream, however these metals are naturally enriched in the area In conclusion, the results indicate that exceedances of guideline values occurred both upstream and downstream of mining and are likely a function of background and associated land use influences outside of mining. Where analytes were recorded downstream in high concentrations, the amount was either below the EA trigger value, or within the range of historical data recorded at upstream sites or remained within the upstream 80th percentile considered acceptable for slightly to moderately disturbed systems (QWQG, 2009).

Site	Document	Key Outcome
Saraji Mine	2017 REMP	<ul style="list-style-type: none"> • Water quality results for 2016/2017 were mostly within the Queensland and Australian guidelines for livestock watering, irrigation, general use, and raw water for drinking. Where exceptions occurred, they were mainly both upstream and downstream of mining. Where concentrations were higher downstream, the level was either below the EA trigger value, or within the range of historical data recorded at upstream sites, or the downstream median remained within the upstream 80th percentile considered acceptable for slightly-to-moderately disturbed systems (QWQG, 2009). • Downstream medians from between 2010 and 2017, mostly remained below the upstream 80 percentile, defined as acceptable by the Queensland Water Quality Guidelines (2009) for slightly-to moderately disturbed ecosystems, with some exceptions. • The downstream medians for these analytes were however below available guidelines pertinent for the area and/or the EA trigger value, indicating the increase presents a low risk to environmental values. • Statistical analysis of data captured during the REMP study (since 2010) found a new EA trigger value should be considered for aluminium. • Recommendation: A new trigger value of 534 µg/L is proposed for aluminium, based on the average upstream 80th percentile, because the current EA trigger of 416 µg/L is more than one standard error (96 µg/L) below background conditions.

5.4.2.3 Aquatic Ecology Data

DPM undertook baseline aquatic ecology surveys in December 2016 and July 2017 for the Project. Part of the baseline surveys included collection of physiochemical water quality parameters at riverine sites R2, R3, R6 and R8, refer Table 5-12. Note that riverine sites R1 and R5 were unable to be sampled during the December 2016 surveys due to dry conditions and sites R4 and R7 were unable to be sampled due to restricted access. Riverine sites R1 and R7 were unable to be sampled in July due to restricted access.

Review of Table 5-12 show that water samples at a range of sites exceeded the regional WQOs for dissolved oxygen and turbidity. It is noted that the flow conditions (e.g. flowing or ponded water) at the time of sampling is expected to have influenced the parameters sampled.

5.5 Upstream and Downstream Users

Detailed information regarding individual licences for Isaac River surface water users was obtained through analysis of water licences data provided by DNRME. Some limitations in the dataset include the absence of names of water users, and in some cases, allocated volumes for water licenses due to privacy restrictions. Details regarding the volume, source and purpose of the licences is included in Table 5-13.

Table 5-12: Physio-chemical Water Quality Parameters, December 2016 and July 2017

Parameter	Units	Riverine Sites									WQO (refer Table 3-1)
		R2	R3		R4	R5	R6		R8		
		14/12/16	17/12/16	08/07/17	07/07/17	06/07/17	14/02/17	09/17/17	16/12/16	10/07/17	
Temperature	°C	26.7	32.6	18.6	19.5	20.4	31.5	20.0	31.0	20.9	-
EC	µS/cm	151	221	220	182	680	193	293	244	287	< 720 (base flow) < 250 (high flow)
pH	-	7.73	7.59	6.9	7.3	7.60	7.24	7.5	7.86	7.4	6.5-8.5
Dissolved Oxygen (DO)	%	82.5	97.0	77.2	59.4	81.0	88.6	81	88.3	86.3	85-110
	mg/L	6.61	6.94	7.1	5.30	7.40	6.50	7.4	6.56	7.7	> 4
Turbidity	NTU	459	11.7	27.7	23.4	12.8	274	51	168	26.1	< 50

Table 5-13: List of Isaac River Surface Water Licences

Study Sub-catchment	Watercourse	Authorisation Reference	Authorisation Type	Authorisation Status	Authorisation Expiry Date	Purpose	Allocation	Location Land List	Location
Fitzroy Basin	Isaac River	0548416L	Licence to take water	Issued	30/06/2111	Mining	100 ML	ML 70108	Isaac River U/S of Project Area
Fitzroy Basin	Isaac River	174800	Licence to interfere by diversion channel	Issued	30/06/2111	Divert the course of flow	NULL	ML 70109	Isaac River U/S of Project Area
Fitzroy Basin	Isaac River	405577	Licence to take water	Issued	30/06/2111	Irrigation; Stock Intensive	60 ML	14/ROP89	Isaac River D/S of Project Area
Fitzroy Basin	Isaac River	405578	Licence to take water	Issued	30/06/2111	Irrigation	150 ha	14/ROP89	Isaac River D/S of Project Area
Fitzroy Basin	Isaac River	43173WL	Licence to take water	Issued	30/06/2111	Water harvesting	NULL	18/SP1133 22	Isaac River U/S of Project Area
Fitzroy Basin	Isaac River	43174L	Licence to take water	Issued	30/06/2111	Water harvesting	NULL	18/SP1133 22	Isaac River U/S of Project Area
Fitzroy Basin	Isaac River	45202U	Licence to take water	Issued	30/06/2111	Stock	NULL	A ON ROP185	Isaac River D/S of Project Area
Fitzroy Basin	Isaac River	45321U	Licence to take water	Issued	30/06/2111	Irrigation	40 ha	14/ROP89	-
Fitzroy Basin	Isaac River	55557L	Licence to interfere	Issued	30/06/2111	Impound water	NULL	11/RP8524 66	Isaac River U/S of Project Area
Fitzroy Basin	Isaac River	55661L	Licence to take water	Issued	30/06/2111	Domestic supply; Mining; Stock	1,700 ML	11/RP8524 66	-
Fitzroy Basin	Isaac River	54781U	Licence to take water	Issued	30/06/2111	Irrigation	40 ha	6/ RP86005 1	Isaac River D/S of Project Area
Fitzroy Basin	Isaac River	617184	Licence to take water	Issued	15/03/219	Construction	5 ML	11/KL135; 9/CNS98	Isaac River at Project Area

6. Proposed Surface Water Management Strategy and Infrastructure

6.1 Types of Water Generated on Site

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants when compared to natural runoff. The proposed strategy for the management of surface water at the Project is based on the separation of water from different sources based on anticipated water quality.

Definitions of the types of water generated within the Project are shown in Table 6-1.

Table 6-1: Types of Water

Water type	Definition
Mine affected water	<p>In accordance with the DEHP Guideline Model Mining Conditions, mine affected water means the following types of water:</p> <ul style="list-style-type: none"> i) pit water, tailings dam water, processing plant water ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the Environmental Protection Regulation 2008 if it had not formed part of the mining activity iii) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated v) groundwater from the mine dewatering activities vi) a mix of mine affected water (under any of paragraphs i to v) and other water
Sediment water	<p>Surface water runoff from areas that are disturbed by mining operations (including out-of-pit waste rock emplacements). This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads but does not contain elevated level of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals). This runoff must be managed to ensure adequate sediment removal prior to release to receiving waters.</p>
Clean catchment water	<p>Surface runoff from areas unaffected by mining operations. Clean catchment water includes runoff from undisturbed areas and fully rehabilitated areas.</p>
Raw water	<p>Untreated water, generally from an external water supply, that has not been contaminated by mining activities.</p>
Potable water	<p>Treated water suitable for human consumption.</p>

6.2 Water Management Strategy Overview

The water management system for the Project aims to protect the identified downstream EV's and comprises the following key objectives:

- clean/mine affected water separation to ensure that up-catchment water and mine affected water remain separate wherever practicable;
- capture of mine affected runoff (e.g. mine industrial area, haul road/overland conveyor runoff, storage and priority reuse as mine water supply);
- diversion of up-catchment water runoff from upstream catchments around the active mining area;
- minimise external catchment runoff draining into pits;
- use of erosion and sediment control (ESC) measures to manage sediment from disturbed catchment areas (e.g. out-of-pit waste rock emplacements, cleared/pre-strip areas) prior to release offsite;
- preferential reuse of onsite water (e.g. mine affected water) to support mine operational water demands (and therefore reduce release of mine affected water under normal operating conditions); and
- management of any mine affected water releases to the receiving environment to meet environmental release conditions.

The Project water management system will include up-catchment diversions, a watercourse diversion (Ripstone Creek Diversion), mine water drainage, mine water storages, ESC, pit water storages and flood protection works (i.e. levees). Further details of the mine site water management strategy are provided in Section 6.5.

6.3 Proposed Water Management Infrastructure

Figure 6-1 to Figure 6-12 show indicative locations of the key features of the mine, including infrastructure related to the management of water on the Project site for seven different phases of mining (Stage 1 to Stage 7). The main components of water-related infrastructure include:

- sediment dams to collect and treat runoff from out-of-pit waste rock emplacement areas;
- drains to divert sediment-laden runoff from out-of-pit waste rock emplacement areas to sediment dams;
- up-catchment water drains to divert runoff from undisturbed catchments around areas disturbed by mining; and
- a mine-affected water system to store water pumped out of the open cut mining areas and to collect runoff from the CHPP and coal stockpile area.

Details of proposed water storages, including indicative storage sizes and pumping rules are provided in Section 6.5.

6.4 Release of Waters to the Receiving Environment

There are three key mechanisms through which water from the Project can enter the receiving environment:

- Controlled release through authorised release points;
- Overflows from sediment dams; and
- Runoff from rehabilitated catchments.

Both controlled releases and overflows from sediment dams are point sources. Model predictions of volumes and salt loads from these sources are provided in Section 8.3.5 and 8.3.6.

Runoff from rehabilitated catchments is likely to be both a point and diffuse source of water to the receiving environment. When a sediment dam catchment is completely rehabilitated, and water quality monitoring of the runoff has established that it is consistent with natural background conditions, the sediment dam and associated drainage infrastructure will be decommissioned. Surface runoff and seepage from the rehabilitated catchment will be allowed to shed directly to the receiving environment.

6.4.1 *Controlled Release Mixing zones*

Controlled release of water from the water management system will occur directly to the Isaac River from a number of mine affected water dams directly to the Isaac River through a gravity discharge arrangement. The maximum distance between the controlled release point and the Isaac River is around 1.6 km, where it will mix directly with flow in the Isaac River.

Controlled releases will only occur in accordance with the proposed controlled release strategy discussed in Section 7.11. This proposed strategy has been developed to ensure that the release rate does not exceed 12.5% of the Isaac River discharge (as measured at Deverill gauge).

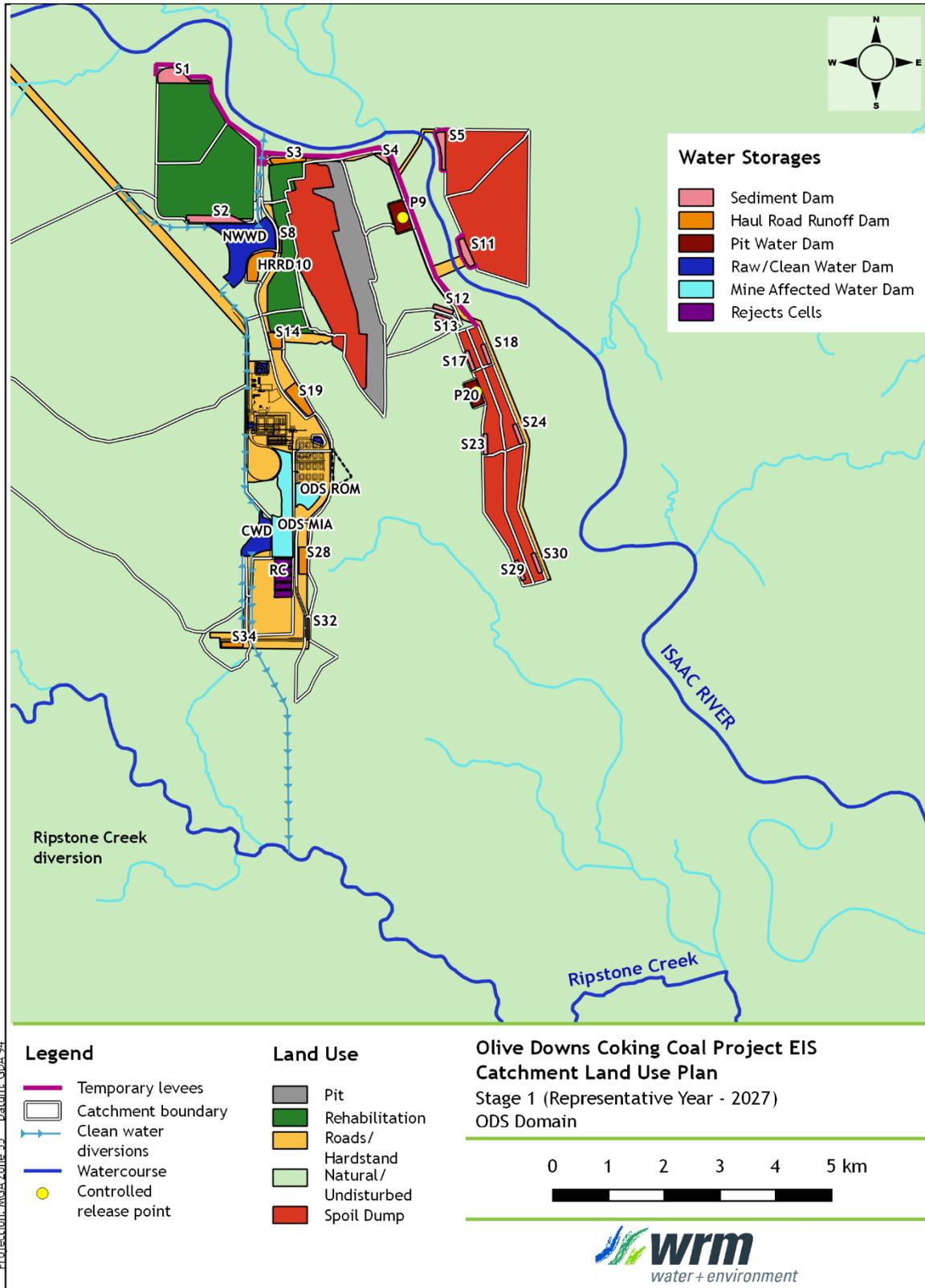


Figure 6-1: Olive Downs South domain – Stage 1 (Year 2027) Mine Plans

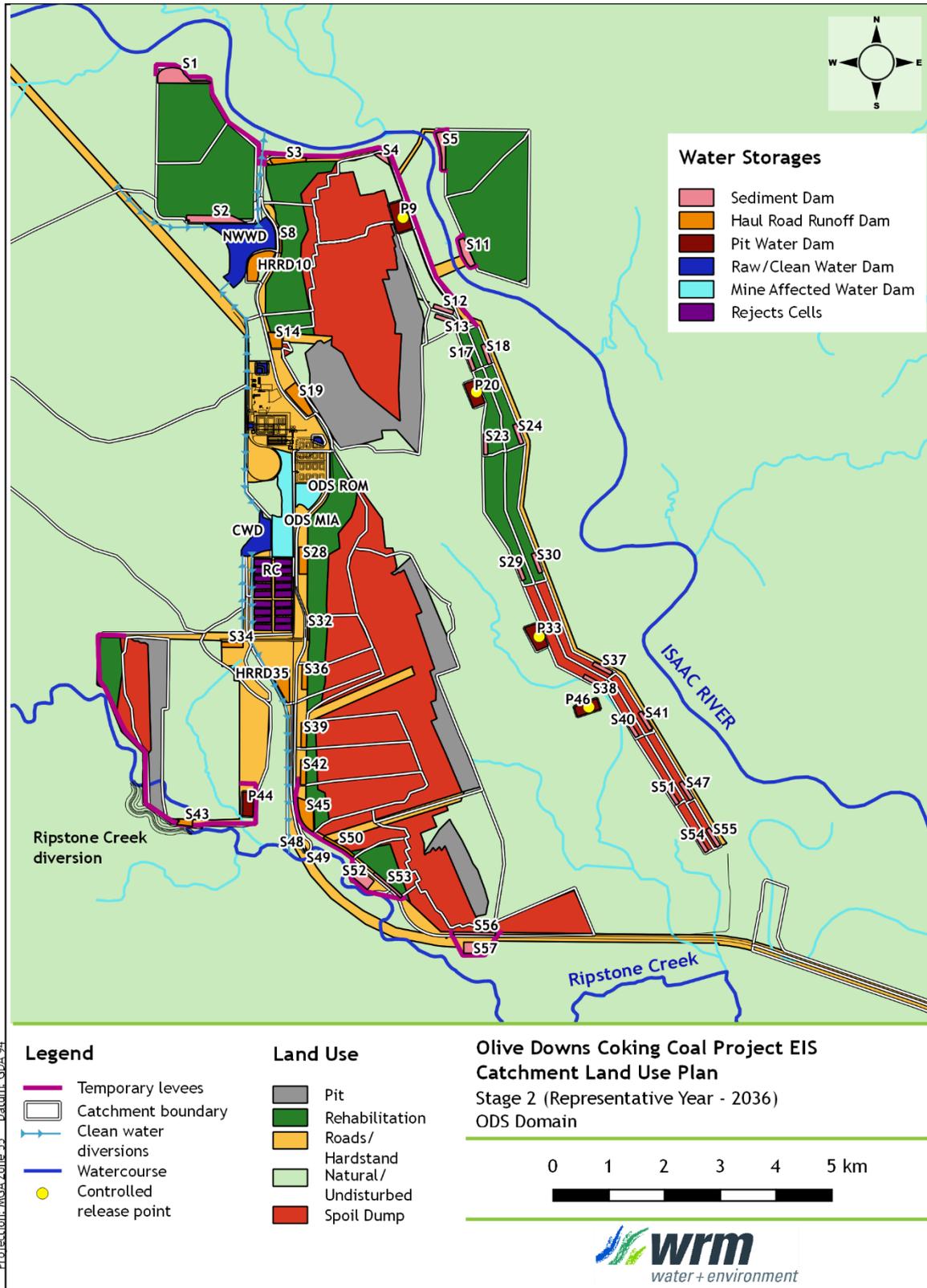


Figure 6-2: Olive Downs South domain – Stage 2 (Year 2036) Mine Plans

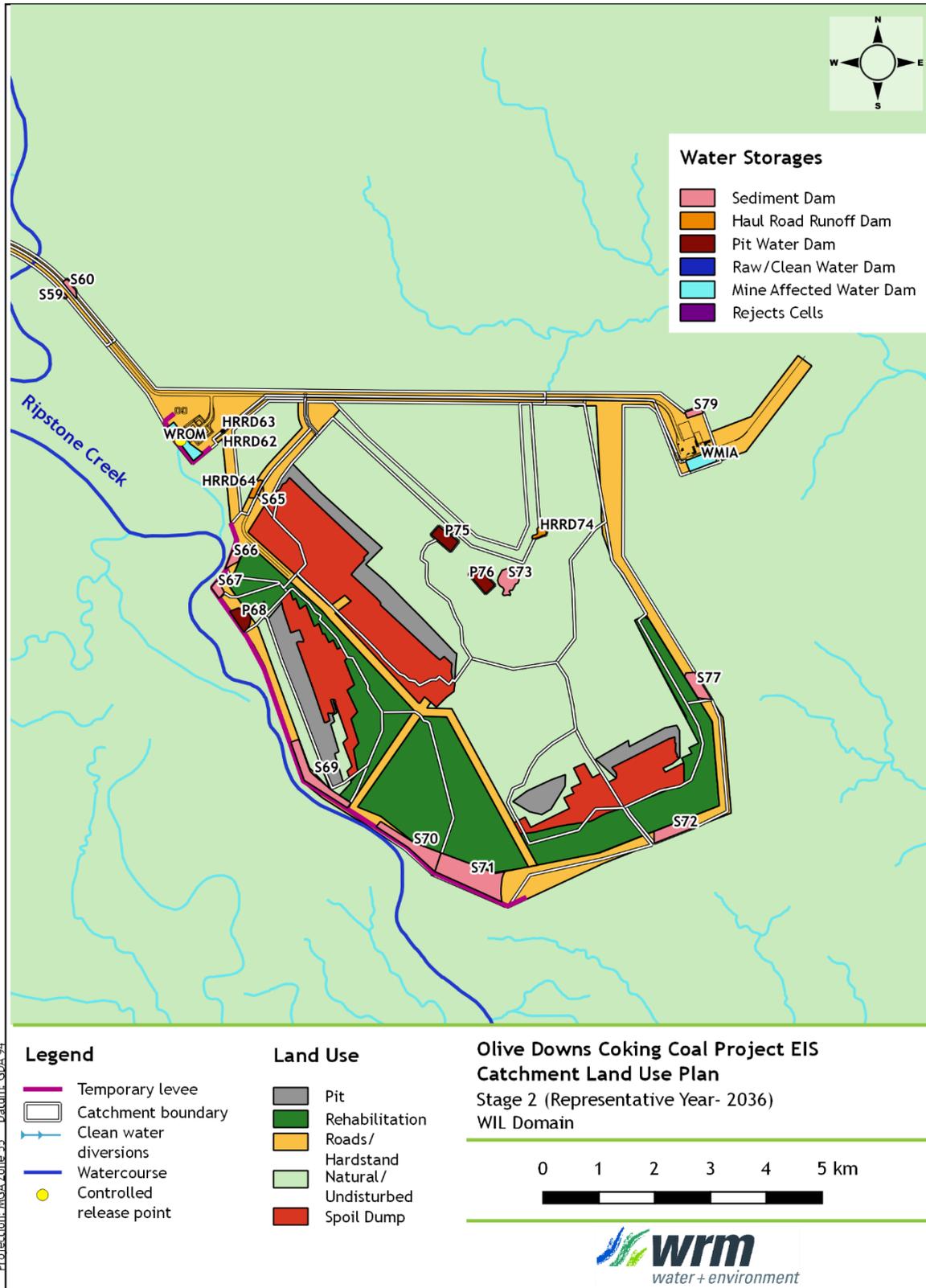


Figure 6-3: Willunga domain – Stage 2 (Year 2036) Mine Plans

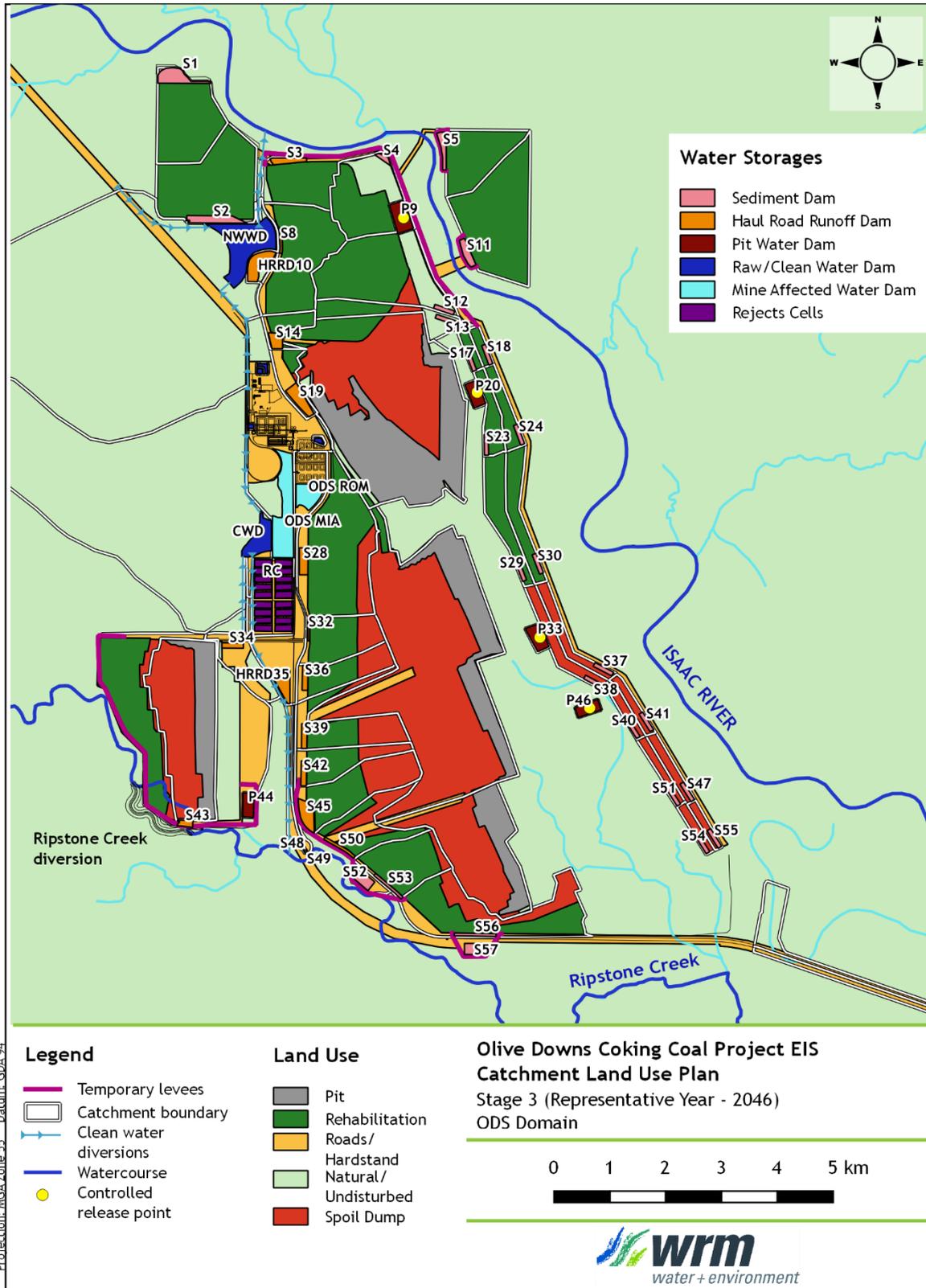


Figure 6-4: Olive Downs South domain – Stage 3 (Year 2046) Mine Plans

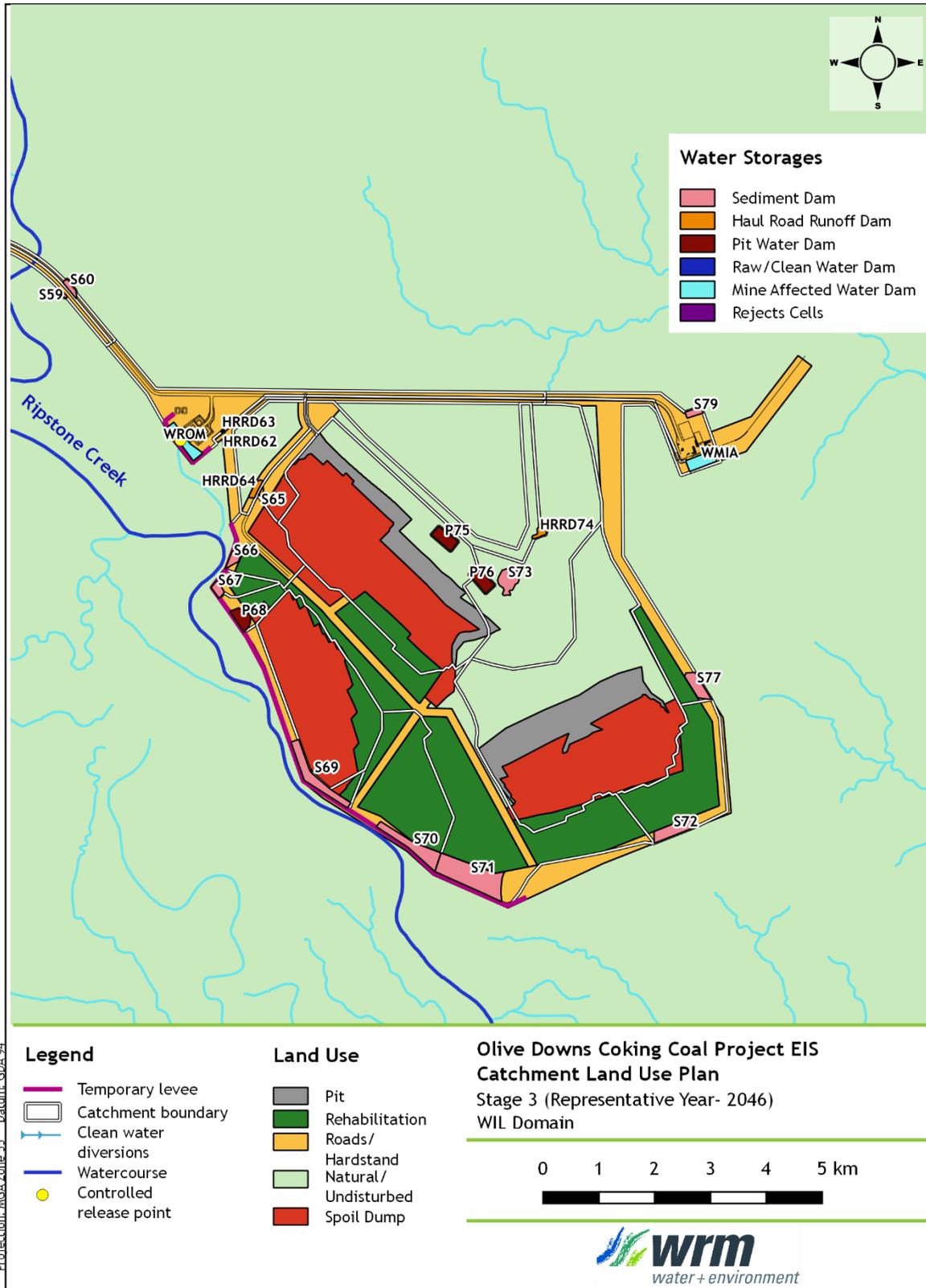


Figure 6-5: Willunga domain – Stage 3 (Year 2046) Mine Plans

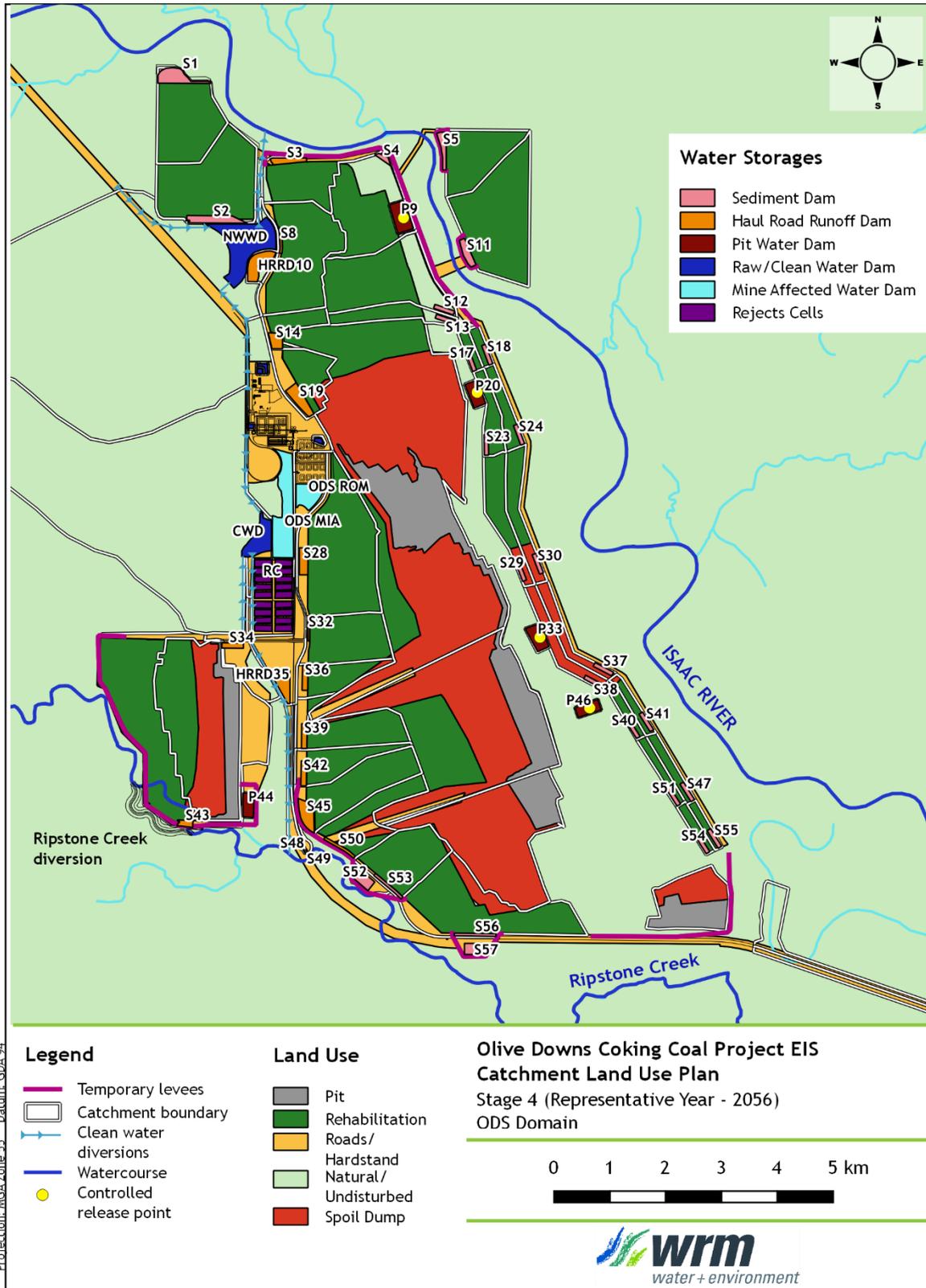


Figure 6-6: Olive Downs South domain – Stage 4 (Year 2056) Mine Plans

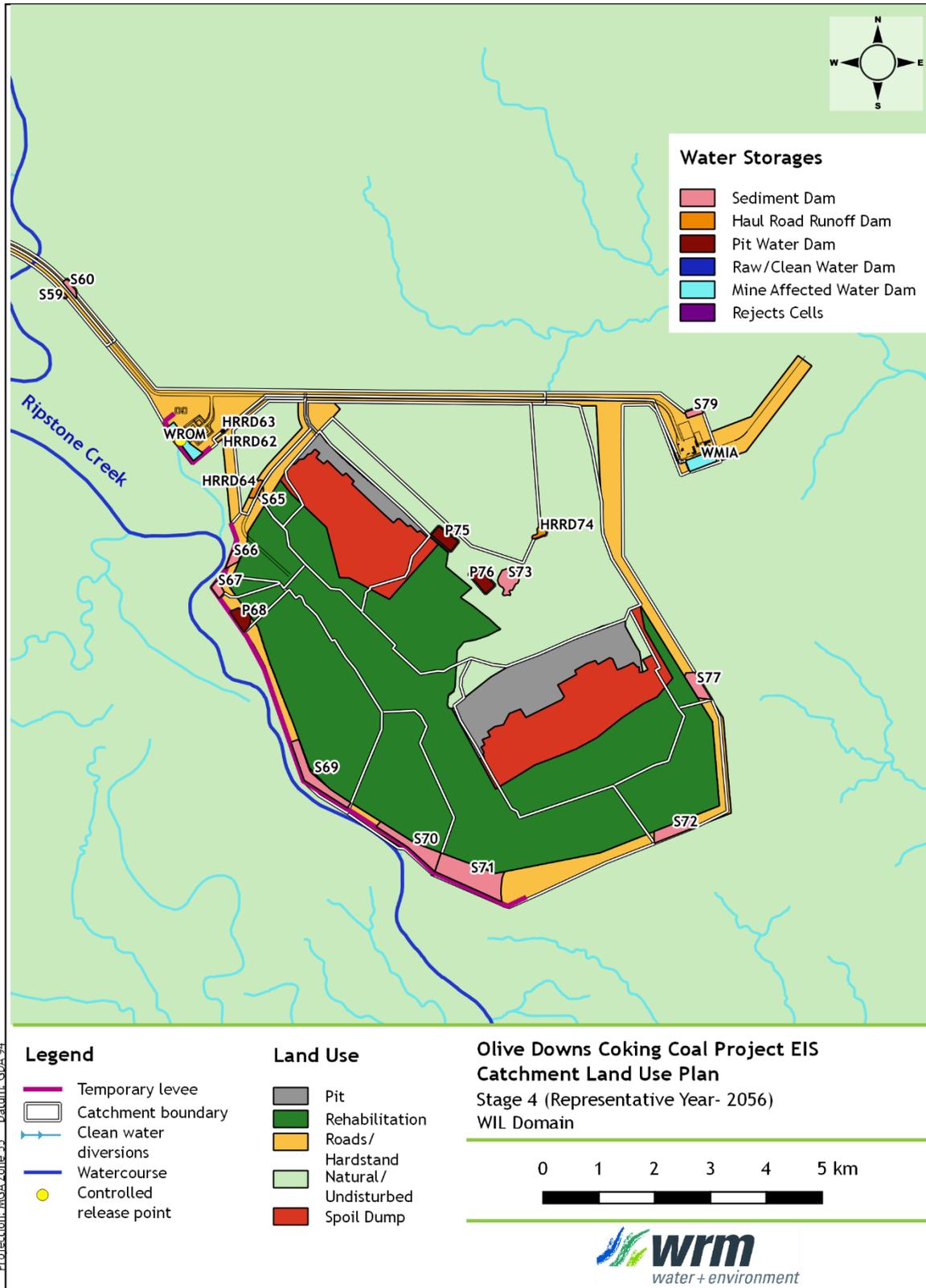


Figure 6-7: Willunga domain – Stage 4 (Year 2056) Mine Plans

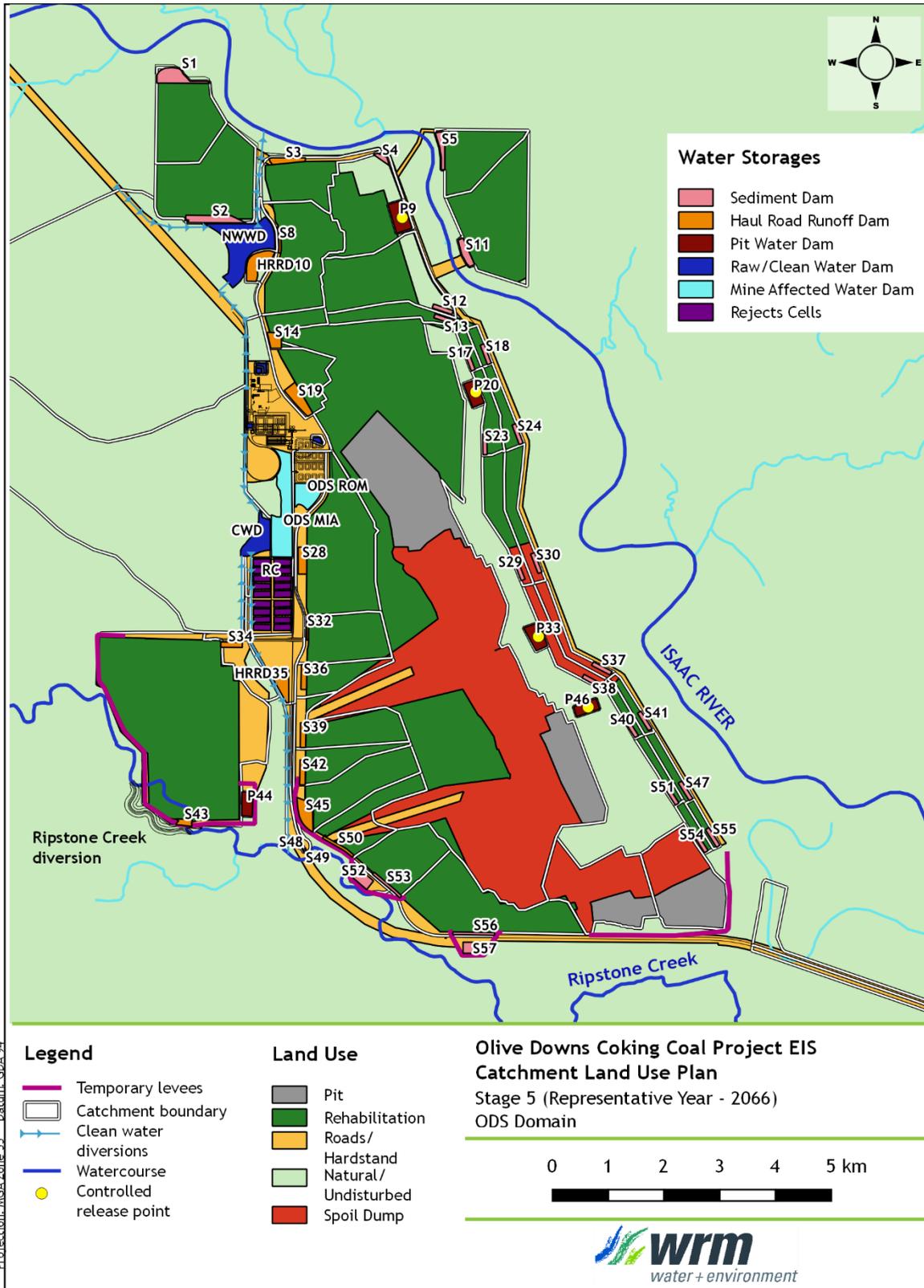


Figure 6-8: Olive Downs South domain – Stage 5 (Year 2066) Mine Plans

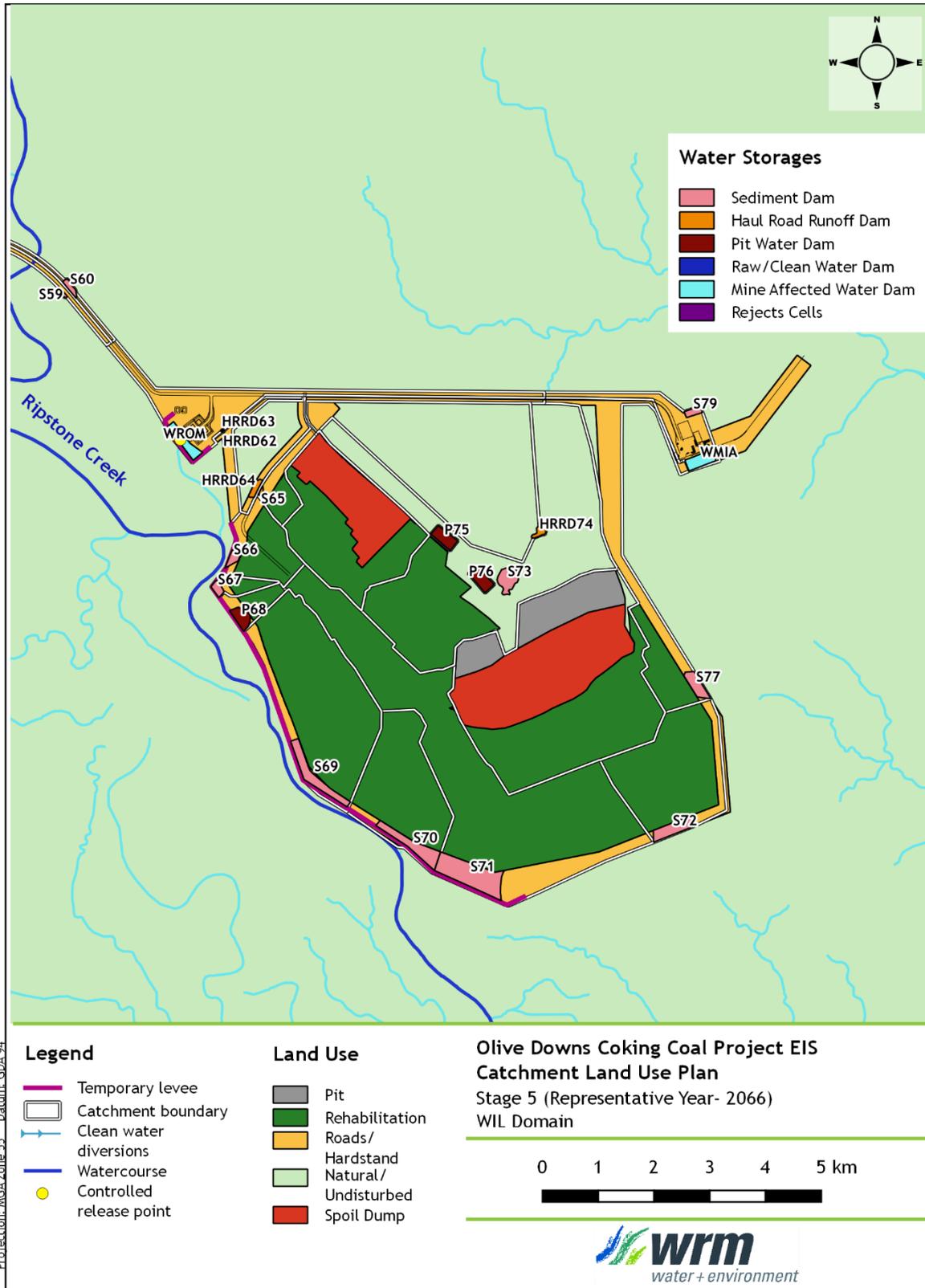


Figure 6-9: Willunga domain – Stage 5 (Year 2066) Mine Plans

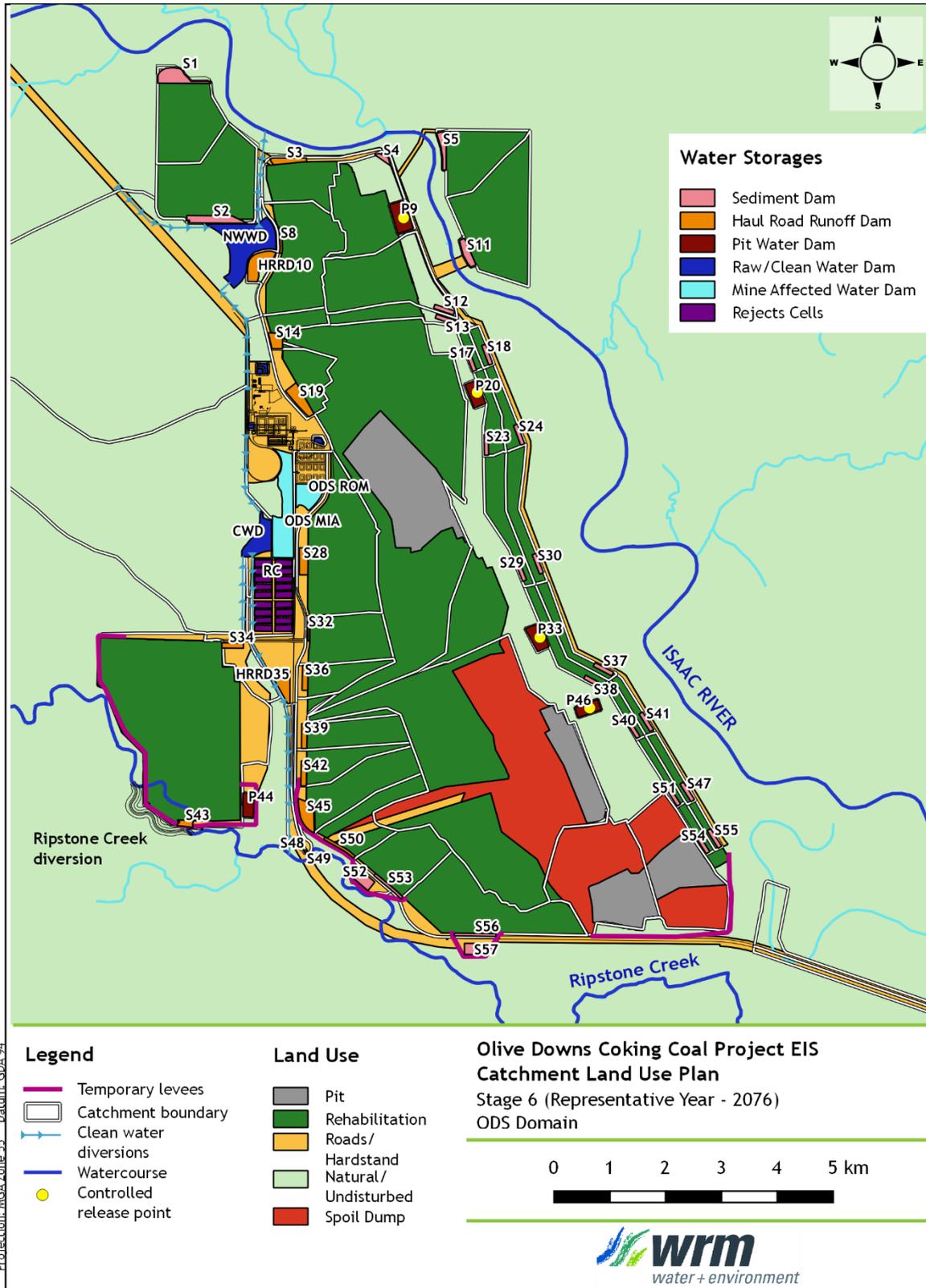


Figure 6-10: Olive Downs South domain – Stage 6 (Year 2076) Mine Plans

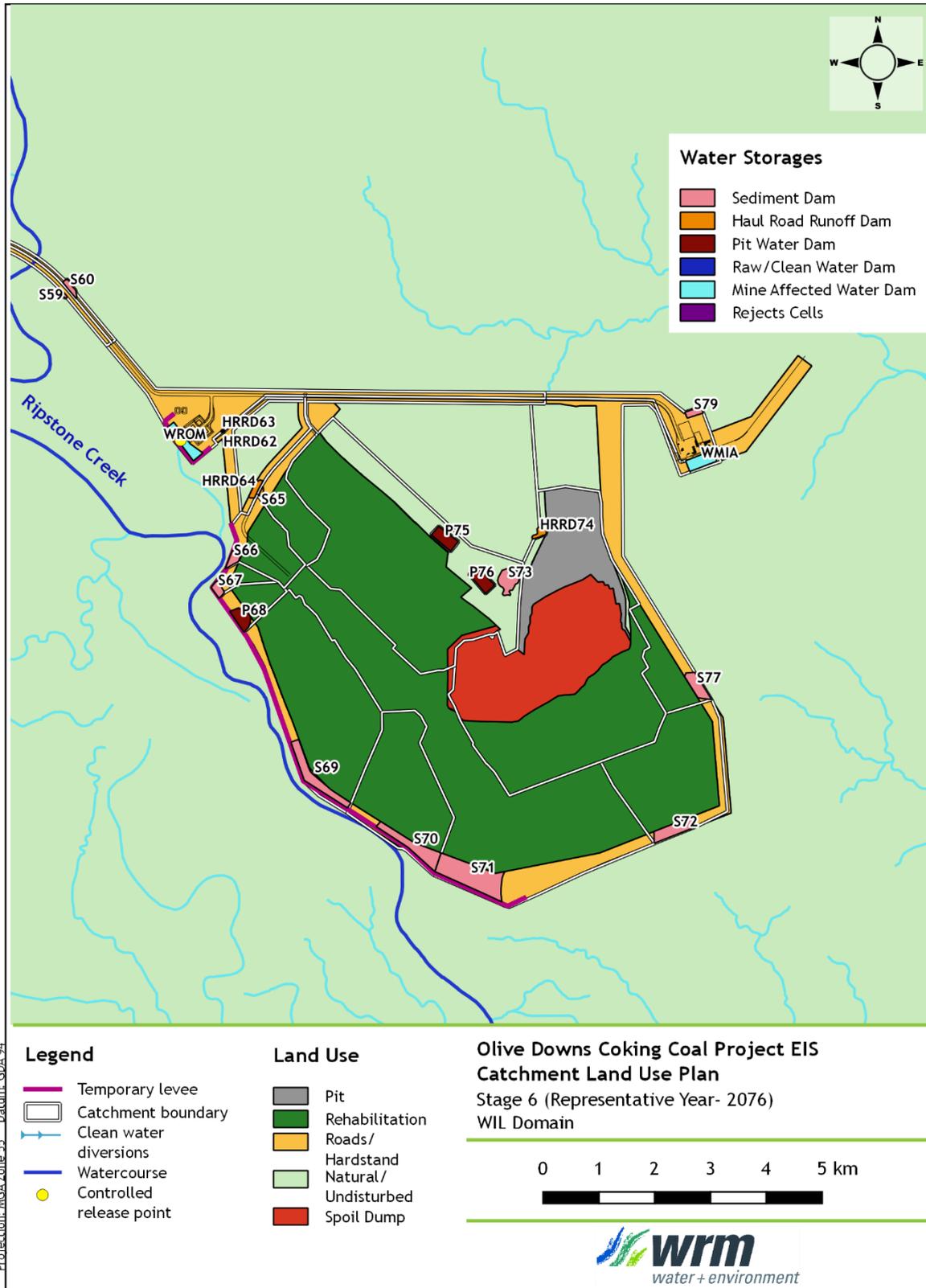


Figure 6-11: Willunga domain – Stage 6 (Year 2076) Mine Plans

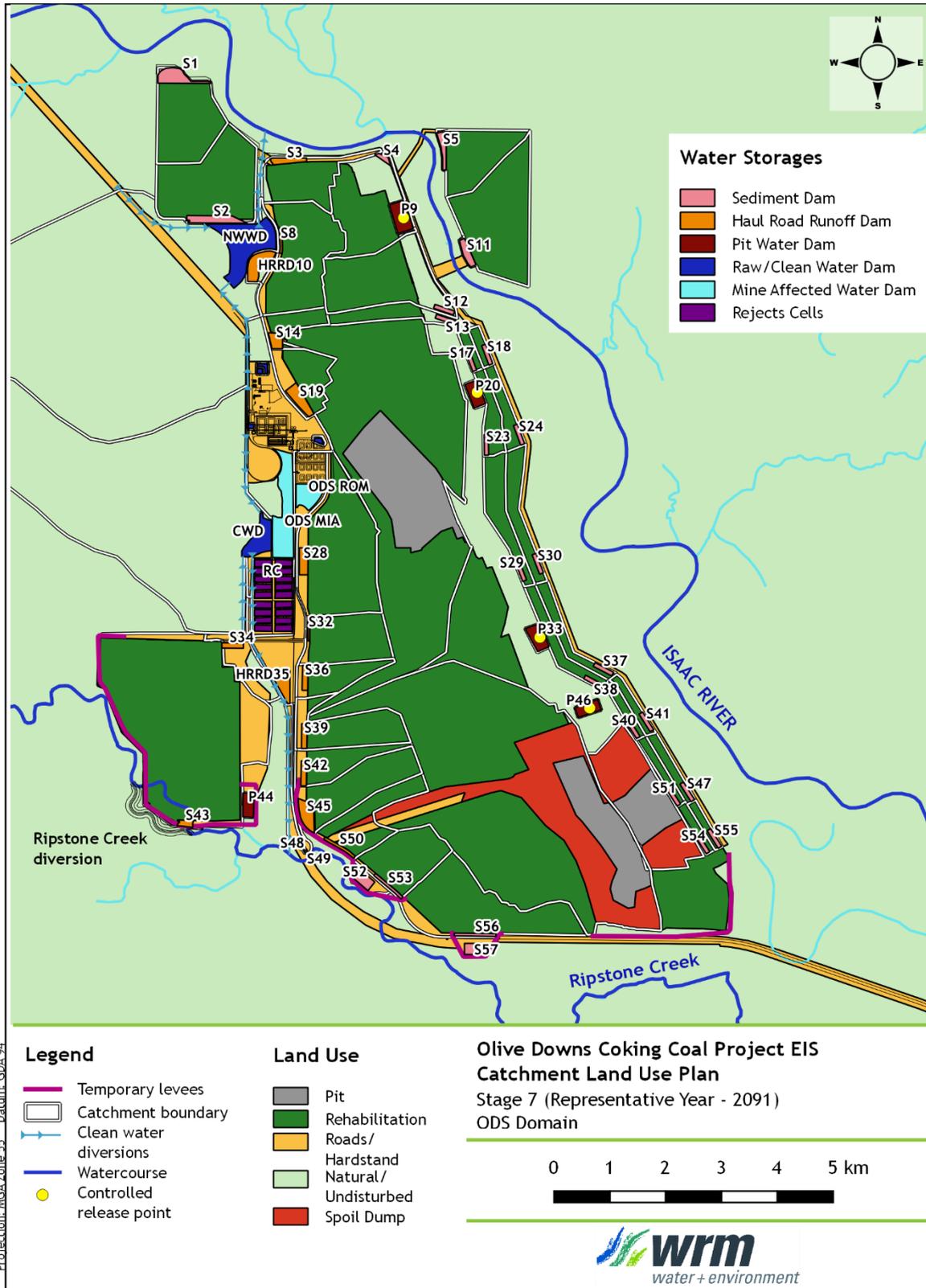


Figure 6-12: Olive Downs South domain – Stage 7 (Year 2091) Mine Plans

6.5 Sewage and Effluent Disposal

Containerised sewage treatment plants and effluent disposal systems will be constructed to service the mine infrastructure areas at the ODS and Willunga domains. Until the sewage treatment plants are operational, sewage from temporary ablution blocks (to be used during the construction phase) will be pumped by a licensed contractor and transported to a local council sewage treatment plant.

Waste sludge will be pumped to storage tanks before being pumped out and transported off-site by a licensed contractor to a licensed disposal facility.

The effluent disposal systems will discharge through an irrigation system. Based on the design capacity of 50 kL per day per plant, a minimum effluent irrigation area of 2.5 ha will be required at the ODS and Willunga domains. The irrigation areas will be located within Project mining tenements and have been designed with prescribed setback distances, but strategically positioned beyond the extent of the 1:1000 AEP flood event to reduce the potential for dispersion off site.

The location of the irrigation areas also considered the proximity to existing groundwater users to reduce potential of effluent seepage to groundwater sources.

Effluent will not be irrigated immediately prior to expected rainfall or if pooling of water was evident at the site, to reduce the potential for runoff contamination. During these periods, effluent will be stored within wet weather storage tanks until such time as irrigation could recommence.

As part of the detailed design phase, modelling will be conducted to confirm the design of the effluent irrigation system and wet weather storage tank capacities, using the Model for Effluent Disposal Using Land Irrigation (MEDLI) software.

The sewage treatment plants will be designed and installed in accordance with the Queensland Government guidelines and relevant Australian Standards

7. Water Balance Model Configuration

7.1 Overview

A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the mine water balance under conditions of varying rainfall and catchment conditions throughout the development of the Project. The OPSIM model dynamically simulates the operation of the water management system and keeps complete account of all site water volumes and representative water quality on a daily time step.

The model has been configured to simulate the operations of all major components of the water management system. The simulated inflows and outflows included in the model are given in Table 7-1.

Table 7-1: Simulated Inflows and Outflows to the Water Management System

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Catchment runoff	CHPP demand
Groundwater inflows to the open cut pit	Haul road dust suppression demand
Raw water supply	Coal crushing/conveyor dust suppression demand
	Miscellaneous raw water demands
	Mine infrastructure demands
	Potable WTP demands
	Dam overflows
	Controlled releases

7.2 Simulation Methodology

7.2.1 Modelled Staging of Mine Plans

The Project water management system will change over the 79-year mine life, including changes in catchment areas, production profile and site water demands. To represent the evolution of the mine layout over time, the Project was modelled in six discrete stages. Seven representative years have been selected to reflect the average conditions over the mine stage.

The modelled mining phases stages are summarised in Table 7-2. Construction activities are proposed during Years 2018 and 2019, and these two years have not been included in the water balance modelling assessment.

Table 7-2: Application of Representative Mine Stages to Full Mine Life

Representative Mine Stage	Representative Year	Applied Range of Mine Life	Stage Duration
Stage 1	2027	Year 2020 – 2030	11 years
Stage 2	2036	Year 2031 – 2040	10 years
Stage 3	2046	Year 2041 – 2050	10 years
Stage 4	2056	Year 2051 – 2060	10 years
Stage 5	2066	Year 2061 – 2072	12 years

Representative Mine Stage	Representative Year	Applied Range of Mine Life	Stage Duration
Stage 6	2076	Year 2073 – 2085	13 years
Stage 7	2091	Year 2086 – 2098	13 years

7.3 Catchment Yield Parameters

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton, 2003) to estimate runoff from rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff. The AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evaporation (surface stores only). Simulated surface runoff occurs when the conceptual storages fill and overflow.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily water balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying the contributing catchment area.

The model parameters define the storage depths (C1, C2 and C3), the proportion of the catchment draining to each of the storages (A1, A2 and A3), and the rate of flux between them (K_{base} , K_{surf} and BFI). Catchments across the site have been characterised into the following land use types:

- Natural/undisturbed, representing areas in their natural state;
- Roads and hardstand areas;
- Open cut mining pit floor;
- Spoil dump, representing uncompacted dumped overburden material; and
- Rehabilitated, representing established rehabilitated spoil areas.

The adopted AWBM parameters are shown in Table 7-3. These parameters have been based on parameters typical for coal mines in this part of the Bowen Basin.

Table 7-3: Adopted AWBM parameters

Parameter	Natural/ undisturbed	Roads/ hardstand	Mining pit	Spoil dump	Rehab
A1	0.134	0.1	0.134	0.07	0.134
A2	0.433	0.9	0.433	0.10	0.433
A3	0.433	-	0.433	0.83	0.433
C1	5.7	4	2.6	5	5.1
C2	57.8	16	26.7	10	52.0
C3	115.7	-	53.3	200	104.1
C_{avg}	75.9	14.8	35.0	167	68.3
BFI	0	0	0	0.5	0.5

Parameter	Natural/ undisturbed	Roads/ hardstand	Mining pit	Spoil dump	Rehab
K _{base}	0	0	0	0.9	0.9
K _{surf}	0.1	0	0	0.1	0.1
C _v *	15.7%	37.2%	25.8%	10.1%	16.9%

* Long term volumetric runoff coefficient

7.4 Conceptual Water Management System Configuration and Schematic

A conceptual water management system layout for the Project has been developed based on the water management principles described in Section 6 and is presented in Figure 6-1 to Figure 6-12. A schematized plan for the modelled Project's water management system configuration is shown in Figure 7-1.

The proposed Project water management system has been split up into two separate domains; the Olive Downs South (ODS) domain and the Willunga domain. A summary of the mine affected water and clean water storages within the proposed water management system are provided in Table 7-4. Refer to Section 7.14 for details regarding the proposed sediment dams.

A description of summary of the modelled water management system configuration is outlined in Table 7-5.

Table 7-4: Olives Downs Project – Proposed Storage Details

Storage Name	Storage Type	Overflows To
<u>Olive Downs South domain</u>		
ODS MIA	Mine affected water dam	Mining pit
ODS ROM	Mine affected water dam	Mining pit
P9	Pit water dam	Mining pit
P20	Pit water dam	Mining pit
P33	Pit water dam	Mining pit
P44	Pit water dam	Ripstone Creek
P46	Pit water dam	Mining pit
NWWD	Clean water dam	Isaac River
CWD	Clean water dam	Ripstone Creek
<u>Willunga domain</u>		
WROM	Mine affected water dam	Isaac River
WMIA	Mine affected water dam	Isaac River
P68	Pit water dam	Mining pit
P75	Pit water dam	Mining pit
P76	Pit water dam	Mining pit

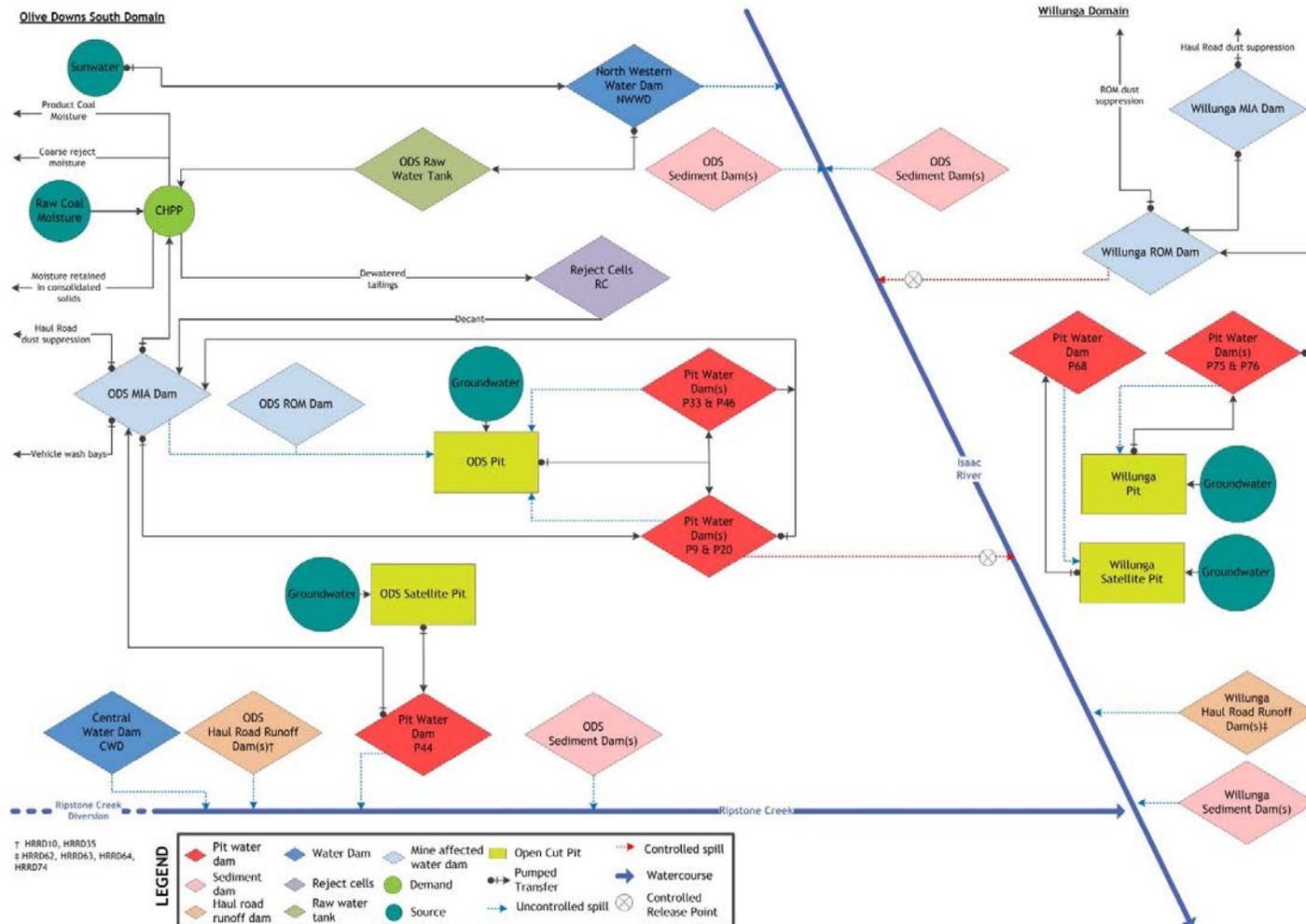


Figure 7-1: Water Management System Schematic

Table 7-5: ODS and Willunga Domains – Modelled Water Management System Configuration

Item		
1.0	<u>External water supply</u>	
1.1	Sunwater via Eungella pipeline network	<ul style="list-style-type: none"> • Supplementary supply to the CHPP (via NWWD and ODS Raw Water Tank) • Supplementary supply to mine infrastructure and raw water demands
2.0	<u>Supply to demands</u>	
2.1	CHPP	<ul style="list-style-type: none"> • Demand supplied from ODS MIA Dam (1st priority) and ODS Raw Water Tank (2nd priority) • Transfers water to the Rejects Cells within the tailings waste stream
2.2	Haul road dust suppression	<ul style="list-style-type: none"> • Demand supplied from ODS MIA Dam and WMIA Dam
2.3	Coal crushing / conveyor dust suppression	<ul style="list-style-type: none"> • Demand supplied from ODS MIA Dam
2.4	Miscellaneous raw water demands	<ul style="list-style-type: none"> • Demand supplied from ODS Raw Water Tank
2.5	Mine infrastructure demands	<ul style="list-style-type: none"> • Demand supplied from ODS MIA Dam
2.6	Potable water treatment plant (PWTP)	<ul style="list-style-type: none"> • Demand supplied from ODS Raw Water Tank
3.0	<u>Transfer of pit water</u>	
3.1	ODS Pits	<ul style="list-style-type: none"> • Includes Pit 1, Pit 2, Pit 3, Pit 4, Pit 6, Pit7 and Pit 8 • Pit dewatering directed to ODS MIA Dam via the following storages: <ul style="list-style-type: none"> ○ P9 ○ P20 ○ P33 (Stage 2 onwards) ○ P46 (Stage 2 onwards)
3.2	ODS Satellite Pit	<ul style="list-style-type: none"> • Includes Pit 9 • Pit dewatering directed to ODS MIA Dam via P44 (Stage 2 onwards)
3.3	Willunga Pits	<ul style="list-style-type: none"> • Includes Pit 2, Pit 3, Pit 4 and Pit 5 • Pit dewatering directed to WROM/WMIA Dam via the following storages: <ul style="list-style-type: none"> ○ P75 ○ P76
3.4	Willunga Satellite Pit	<ul style="list-style-type: none"> • Pit dewatering directed to WROM/WMIA Dam via the following storages: <ul style="list-style-type: none"> ○ P68
4.0	<u>Operation of mine affected water dams</u>	
4.1	ODS MIA	<ul style="list-style-type: none"> • Supplies water to the coal crushing and conveyor, haul road dust suppression, CHPP and other mine industrial demands • Receives decant water from the reject cells • Receives pumped inflows from P9, P20, P33, P44, P46 and ODS ROM

Item		
		<ul style="list-style-type: none"> Pumped transfer to P9 and P20 (for controlled release) Overflows to the mining pit
4.2	ODS ROM	<ul style="list-style-type: none"> Pumped transfer to ODS MIA Dam Overflows to mining pit
4.3	P9	<ul style="list-style-type: none"> Pumped transfer to ODS MIA Dam Controlled discharge to the Isaac River via a controlled release point Overflows to mining pit
4.4	P20	<ul style="list-style-type: none"> Pumped transfer to ODS MIA Dam Controlled discharge to the Isaac River via a controlled release point Overflows to mining pit
4.5	P33	<ul style="list-style-type: none"> Pumped transfer to ODS MIA Dam Overflows to mining pit
4.6	P44	<ul style="list-style-type: none"> Pumped transfer to ODS MIA Dam Overflows to Ripstone Creek
4.7	P46	<ul style="list-style-type: none"> Pumped transfer to ODS MIA Dam Overflows to mining pit
4.8	P68	<ul style="list-style-type: none"> Pumped transfer to WROM Dam Overflows to mining pit
4.9	P75	<ul style="list-style-type: none"> Pumped transfer to WROM Dam Overflows to mining pit
4.10	P76	<ul style="list-style-type: none"> Pumped transfer to WROM Dam Overflows to mining pit
4.11	WROM	<ul style="list-style-type: none"> Supplies water to ROM dust suppression Receives pit dewatering from Willunga Pits and Willunga Satellite Pit Controlled discharge to the Isaac River via a controlled release point Overflows to the Isaac River
4.12	WMIA	<ul style="list-style-type: none"> Transfers water to haul road dust suppression Receives pit dewatering from Willunga Pits and Willunga Satellite Pit Pumped transfer to WROM dam Overflows to Isaac River
4.13	Reject cells	<ul style="list-style-type: none"> Receives water within the tailings waste stream Decant water pumped to ODS MIA Dam Overflows to ODS MIA Dam
4.14	Haul road runoff dams	<ul style="list-style-type: none"> Up to 6 haul road runoff dams active over the life of the project Receive catchment runoff from haul road catchments Overflow to receiving environment
5.0	<i>Operations of clean water dams</i>	
5.2	NWWD	<ul style="list-style-type: none"> Receives local catchment inflows and raw water supply from the Eungella pipeline

Item		
		<ul style="list-style-type: none"> Overflows to the Isaac River
5.3	CWD	<ul style="list-style-type: none"> Overflows to Ripstone Creek
6.0	<u>Operations of sediment dams</u>	
6.1	Sediment dams	<ul style="list-style-type: none"> Up to 53 sediment dams active over the life of the project Assumed to be emptied within 5 days (not modelled) Overflow to receiving environment
7.0	<u>Miscellaneous</u>	<ul style="list-style-type: none"> All storages and pits receive local catchment runoff and lose water through evaporation

7.5 Mine Affected Water Dam Capacities

Table 7-6 shows the capacities of the proposed mine affected water dams at the ODS and Willunga domains. These proposed dam capacities are preliminary only and will be confirmed as part of the detailed design process.

Table 7-6: Proposed Mine Affected Water Dam Capacities

Storage	Full Supply Volume (ML)	Target Operating Volume (ML)	Full Supply Surface Area (ha)
<u>ODS domain</u>			
ODS MIA	1,380	1,118	54.2
ODS ROM	552	456	18.4
P9	412	358	21.7
P20	359	312	18.9
P33	236	174	12.4
P44	165	122	8.7
P46	171	126	9.0
<u>Willunga domain</u>			
WMIA	159	104	11.0
WROM	207	153	11.8
P68	956	707	9.0
P75	188	139	9.9
P76	186	138	9.8

7.6 CHPP Water Circuit

The CHPP at the ODS domain will operate 24 hours, seven days a week. Crushed ROM coal from the ODS and Willunga domains will be stockpiled adjacent to the CHPP for direct reclaim and feed.

There are two waste products generated by the CHPP; coarse rejects and fine rejects. Coarse rejects will be transferred to the rejects bin for reclaim by truck and placement to in-pit waste rock emplacement within the final pit footprint, or a separate emplacement area until such time as in-pit disposal areas become available.

Fine rejects from the fine coal circuit will be thickened for transfer (via pipeline) to the Reject Cells, where flocculants will be added and water recovered and recycled in the CHPP. Dewatered and dried fine rejects will be excavated and trucked for disposal with the in-pit disposal area (below existing ground level) and later buried by spoils (generally within three months of placement).

Water is supplied to the CHPP for materials processing from ODS MIA Dam (as a first priority) and ODS Raw Water Tank (as a second priority). The CHPP will use mine affected water as a first priority, and only use raw water when mine affected reserves are depleted.

The moisture contained with the coarse rejects stream (nominally 15% w/w moisture content) is lost from the system during the emplacement process. The moisture contained within the fine rejects stream (nominally 65% w/w moisture content) is partially recovered from the Rejects Cells and recycled back to the CHPP water circuit via ODS MIA Dam. The remaining moisture is either entrained within the dried fine rejects (which is disposed of in-pit) or evaporated from the surface of the Rejects Cells.

Mine affected water generated by the CHPP is contained within the CHPP/Rejects Cells/ODS MIA Dam water circuit, as does not interact with the rest of the water management system. Further details on the CHPP circuit water balance is provided in Section 7.8.1.

7.7 Clean Water Storages and Diversions

7.7.1 *Up catchment (Clean) Water Management System*

There are two proposed up-catchment (i.e. clean) water storages which form part of the proposed water management system, namely:

- *North Western Water Dam (NWWD)*: an existing farm dam that will continue to collect up-catchment runoff from a catchment of around 2,015 ha, with a modelled capacity of 438 ML. NWWD also operates as a buffer storage for raw water direct from the Eungella pipeline. Overflows from NWWD will discharge north to the Isaac River via a clean water drain.
- *Central Water Dam (CWD)*: a partitioned water storage to segregate up-catchment runoff from the mine affected water management system (i.e. ODS MIA). CWD collects runoff from a catchment of around 1,425 ha, with a modelled capacity of 311 ML. Overflows from CWD will discharge south to Ripstone Creek via a clean water drain. There will be no harvesting of water (or water take) from CWD.

The configuration of the proposed NWWD and CWD storages, as well as the associated up-catchment diversions, is presented in Figure 7-2.

An assessment of the expected annual average water take from NWWD to the Project is provided in Section 8.3.4.1.

7.7.2 *Highwall Clean Water Management*

During the Project development, there is a large clean water catchment located between the pit highwall and the temporary flood levees and permanent highwall emplacement (which acts as a levee).

Between Stage 1 and Stage 3 of the Project, this catchment will be managed by directing the runoff south via a series of clean water drains. This runoff will ultimately drain to Ripstone Creek via an unnamed drainage feature.

By Stage 4 (when Pit ODS8 begins development), the south-eastern section of the proposed Ripstone Creek levee will be constructed, cutting off the unnamed drainage feature. From Stage 4 onwards, the highwall catchment (which reduces in area over the life of the Project) will be captured within a system of clean water drains and dams, which will be pumped directly to either Ripstone Creek or the Isaac River following rainfall.

Design of the highwall clean water management system will be undertaken during the detailed design process.

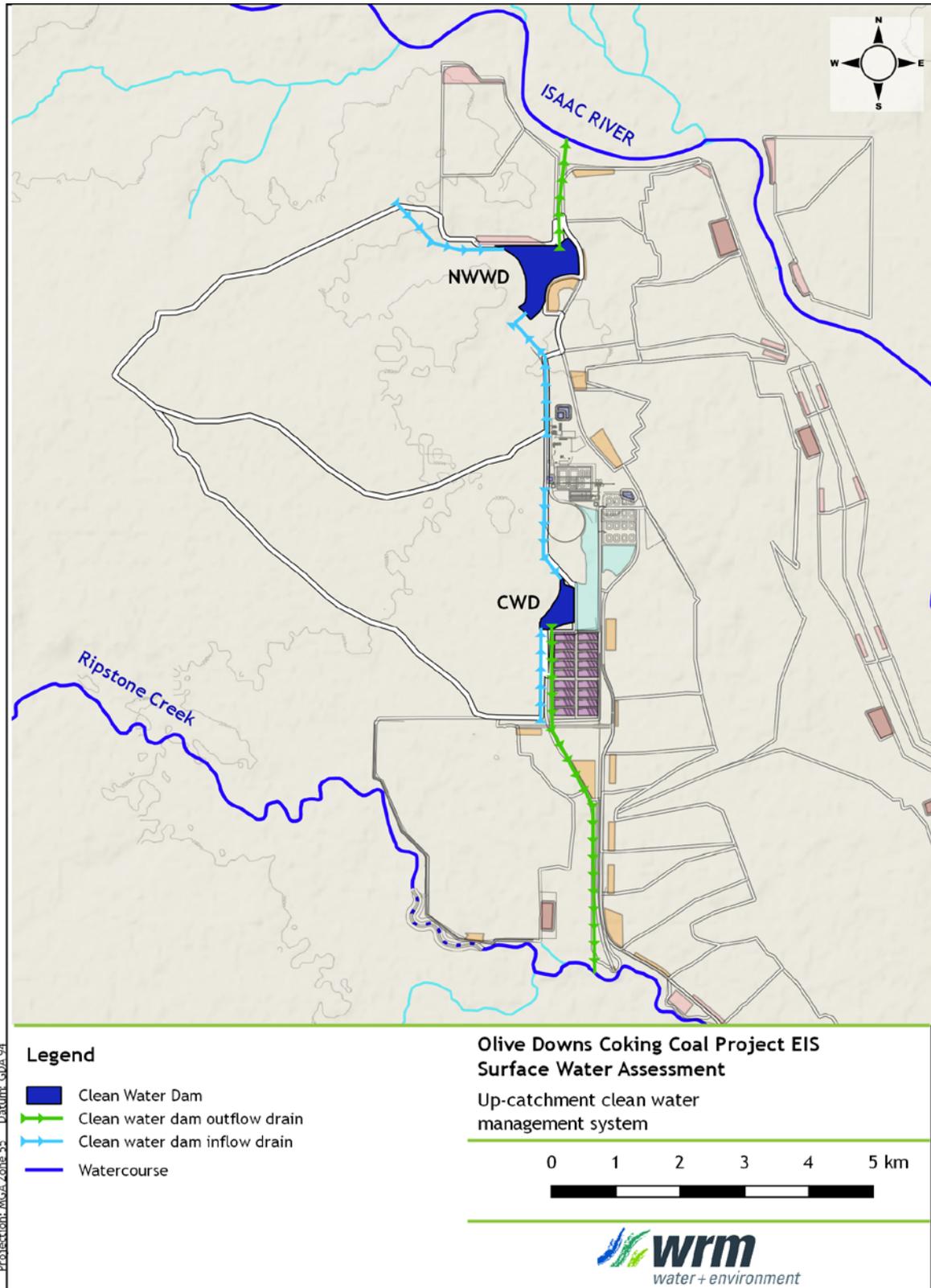


Figure 7-2: Configuration of Proposed Up-catchment Storage and Diversions

7.8 Site Water Demands

7.8.1 Coal Handling and Preparation Plant (CHPP)

The projected annual coal production schedule for the Project, broken down by domain, is summarized in Table 7-7. The key parameters for the CHPP water balance are shown in Table 7-8.

The adopted decant return rate (provided by Phronis) from the Rejects Cells to the CHPP (via ODA MIA Dam) is 70%. This decant return rate is considered appropriate for the proposed configuration of the fine rejects circuit. This decant rate significantly reduces the net CHPP makeup water requirement.

The estimated gross and net annual CHPP water makeup requirement for each year is provided in Table 7-9 and presented in Figure 7-3.

Table 7-7: Forecast Annual Production Data

Stage	Year	ROM (Mtpa) (wet)			Product (Mtpa) (wet)		
		ODS	Willunga	Total	ODS	Willunga	Total
1	2020	1.00	0.00	1.00	0.76	0.00	0.76
	2021	3.00	0.00	3.00	2.19	0.00	2.19
	2022	5.70	0.00	5.70	4.15	0.00	4.15
	2023	6.00	0.00	6.00	4.32	0.00	4.32
	2024	6.00	0.00	6.00	4.44	0.00	4.44
	2025	5.93	0.00	5.93	4.38	0.00	4.38
	2026	6.00	0.00	6.00	4.44	0.00	4.44
	2027	6.00	0.00	6.00	4.42	0.00	4.42
	2028	5.91	0.00	5.91	4.41	0.00	4.41
	2029	5.40	0.00	5.40	4.06	0.00	4.06
	2030	5.64	0.12	5.76	4.22	0.08	4.29
2	2031	6.00	5.00	11.00	4.53	3.28	7.81
	2032	9.00	4.83	13.83	6.81	3.12	9.93
	2033	12.00	6.00	18.00	9.15	3.95	13.09
	2034	12.00	8.00	20.00	9.15	5.43	14.58
	2035	11.82	8.00	19.82	8.98	5.58	14.56
	2036	12.00	8.00	20.00	9.11	5.74	14.85
	2037	12.00	8.00	20.00	9.24	5.80	15.05
	2038	12.00	8.00	20.00	8.98	5.81	14.79
	2039	12.00	8.00	20.00	9.20	5.80	15.00
	2040	12.00	8.00	20.00	9.15	5.79	14.94
3	2041	11.56	8.00	19.56	8.72	5.91	14.63
	2042	10.60	8.00	18.60	7.96	5.79	13.76
	2043	11.14	8.00	19.14	8.39	5.69	14.08
	2044	12.00	8.00	20.00	9.07	5.93	15.00
	2045	11.75	7.13	18.87	8.84	5.27	14.12
	2046	12.00	6.86	18.86	9.12	5.25	14.37
	2047	9.49	6.74	16.23	7.12	5.11	12.24

Stage	Year	ROM (Mtpa) (wet)			Product (Mtpa) (wet)		
		ODS	Willunga	Total	ODS	Willunga	Total
	2048	7.70	6.04	13.74	5.61	4.63	10.24
	2049	7.57	7.63	15.20	5.55	5.86	11.41
	2050	9.75	4.92	14.66	7.05	3.89	10.93
4	2051	6.34	4.50	10.83	4.92	3.47	8.39
	2052	2.97	3.89	6.86	2.31	3.04	5.35
	2053	4.98	4.69	9.67	3.89	3.67	7.56
	2054	5.09	3.98	9.07	3.96	2.99	6.95
	2055	5.95	4.12	10.06	4.62	3.27	7.89
	2056	6.64	3.51	10.15	5.18	2.72	7.90
	2057	3.08	4.78	7.86	2.40	3.69	6.08
	2058	3.77	3.51	7.29	2.90	2.68	5.58
	2059	2.85	3.55	6.39	2.21	2.74	4.95
	2060	3.00	4.66	7.67	2.28	3.60	5.88
5	2061	2.93	3.64	6.56	2.29	2.80	5.08
	2062	2.24	4.50	6.75	1.69	3.49	5.18
	2063	1.05	4.13	5.19	0.80	3.20	4.00
	2064	2.22	3.11	5.32	1.68	2.34	4.02
	2065	1.20	4.06	5.26	0.87	3.09	3.96
	2066	2.62	4.31	6.93	2.00	3.26	5.26
	2067	2.59	4.18	6.78	1.98	3.13	5.11
	2068	0.84	4.81	5.65	0.63	3.64	4.28
	2069	0.98	4.77	5.75	0.75	3.63	4.38
	2070	1.34	3.46	4.79	1.03	2.51	3.54
	2071	0.71	0.18	0.89	0.56	0.15	0.71
	2072	1.36	0.61	1.98	1.04	0.52	1.55
6	2073	0.75	0.80	1.56	0.58	0.66	1.24
	2074	1.05	1.92	2.98	0.82	1.52	2.35
	2075	0.71	1.35	2.06	0.54	1.02	1.57
	2076	0.92	2.41	3.33	0.72	1.86	2.58
	2077	1.07	1.82	2.89	0.79	1.35	2.13
	2078	0.97	2.14	3.12	0.73	1.65	2.38
	2079	1.37	1.32	2.69	1.03	1.04	2.07
	2080	0.85	1.71	2.56	0.64	1.32	1.96
	2081	1.29	1.64	2.94	0.96	1.27	2.23
	2082	1.27	1.31	2.58	0.94	1.00	1.94
	2083	1.08	1.54	2.62	0.83	1.15	1.98
	2084	1.26	1.75	3.02	0.96	1.31	2.27
	2085	1.39	1.69	3.08	1.06	1.25	2.32
7	2086	1.47	0.00	1.47	1.12	0.00	1.12
	2087	1.78	0.00	1.78	1.35	0.00	1.35
	2088	1.71	0.00	1.71	1.31	0.00	1.31
	2089	1.84	0.00	1.84	1.44	0.00	1.44
	2090	0.40	0.00	0.40	0.31	0.00	0.31

Stage	Year	ROM (Mtpa) (wet)			Product (Mtpa) (wet)		
		ODS	Willunga	Total	ODS	Willunga	Total
	2091	0.62	0.00	0.62	0.48	0.00	0.48
	2092	0.56	0.00	0.56	0.43	0.00	0.43
	2093	0.38	0.00	0.38	0.29	0.00	0.29
	2094	0.58	0.00	0.58	0.45	0.00	0.45
	2095	0.81	0.00	0.81	0.63	0.00	0.63
	2096	1.13	0.00	1.13	0.88	0.00	0.88
	2097	1.43	0.00	1.43	1.13	0.00	1.13
	2098	1.42	0.00	1.42	1.09	0.00	1.09

Table 7-8: Key CHPP Water Balance Parameters

Item	Moisture Content (% w/w)
<i>Moisture contents</i>	
ROM coal	7.0
Product coal	10.0
Coarse rejects	15.0
Fine rejects	65.0
Coarse reject split	77%
Fine reject split	23%

Table 7-9: Estimated Annual CHPP Makeup Requirements

Stage	Year	Gross CHPP Makeup Requirement	Decant Return Volume	Net CHPP Makeup Requirement
		(ML/a)	(ML/a)	(ML/a)
1	2020	145.5	74.2	71.3
	2021	468.8	244.0	224.8
	2022	900.7	470.1	430.6
	2023	963.8	505.3	458.4
	2024	914.7	472.8	441.8
	2025	907.4	469.6	437.7
	2026	916.7	474.2	442.5
	2027	922.0	477.7	444.3
	2028	887.1	456.6	430.5
	2029	800.0	410.1	389.8
	2030	868.5	447.5	421.0
2	2031	1810.4	955.3	855.1
	2032	2234.6	1173.5	1061.1
	2033	2840.3	1482.2	1358.0
	2034	3143.2	1638.6	1504.7
	2035	3072.2	1595.4	1476.8

Stage	Year	Gross CHPP Makeup Requirement	Decant Return Volume	Net CHPP Makeup Requirement
		(ML/a)	(ML/a)	(ML/a)
	2036	3031.3	1564.5	1466.8
	2037	2952.6	1512.4	1440.2
	2038	3055.1	1580.3	1474.8
	2039	2973.1	1526.0	1447.1
	2040	2994.8	1540.3	1454.4
3	2041	2919.4	1500.3	1419.2
	2042	2843.7	1471.2	1372.5
	2043	2955.3	1533.2	1422.1
	2044	2971.0	1524.6	1446.4
	2045	2819.0	1448.9	1370.1
	2046	2707.6	1375.6	1332.1
	2047	2386.8	1221.2	1165.6
	2048	2067.3	1064.8	1002.5
	2049	2255.2	1156.9	1098.3
2050	2204.1	1135.0	1069.2	
4	2051	1500.7	754.0	746.7
	2052	935.3	467.6	467.7
	2053	1312.4	655.0	657.3
	2054	1289.0	652.7	636.3
	2055	1356.1	675.3	680.8
	2056	1392.9	697.6	695.3
	2057	1092.5	549.4	543.1
	2058	1037.8	525.9	511.9
	2059	887.4	446.1	441.3
	2060	1087.3	550.3	537.0
5	2061	910.8	457.9	453.0
	2062	953.1	481.8	471.3
	2063	725.4	365.5	359.8
	2064	779.8	398.5	381.3
	2065	774.8	396.6	378.1
	2066	1007.0	513.4	493.7
	2067	993.7	508.0	485.7
	2068	825.1	421.3	403.9
	2069	827.3	420.6	406.7
	2070	732.8	379.2	353.7
	2071	113.4	55.4	57.9
	2072	263.8	131.0	132.8
6	2073	200.3	98.2	102.1
	2074	395.6	196.1	199.5
	2075	296.8	151.0	145.8
	2076	462.3	232.3	229.9

Stage	Year	Gross CHPP Makeup Requirement	Decant Return Volume	Net CHPP Makeup Requirement
		(ML/a)	(ML/a)	(ML/a)
	2077	444.2	230.1	214.1
	2078	447.1	227.0	220.0
	2079	380.4	192.4	188.1
	2080	364.3	184.5	179.8
	2081	424.8	216.3	208.5
	2082	380.8	195.0	185.7
	2083	380.2	193.8	186.3
	2084	444.5	227.6	216.9
	2085	455.5	233.4	222.1
7	2086	210.9	107.2	103.7
	2087	259.2	132.2	127.0
	2088	242.1	122.6	119.5
	2089	247.9	123.5	124.5
	2090	53.8	26.8	27.0
	2091	83.1	41.4	41.7
	2092	77.3	38.9	38.4
	2093	51.6	25.9	25.8
	2094	77.2	38.4	38.8
	2095	112.4	56.4	55.9
	2096	154.8	77.5	77.3
	2097	190.4	94.4	96.1
	2098	203.3	103.1	100.2

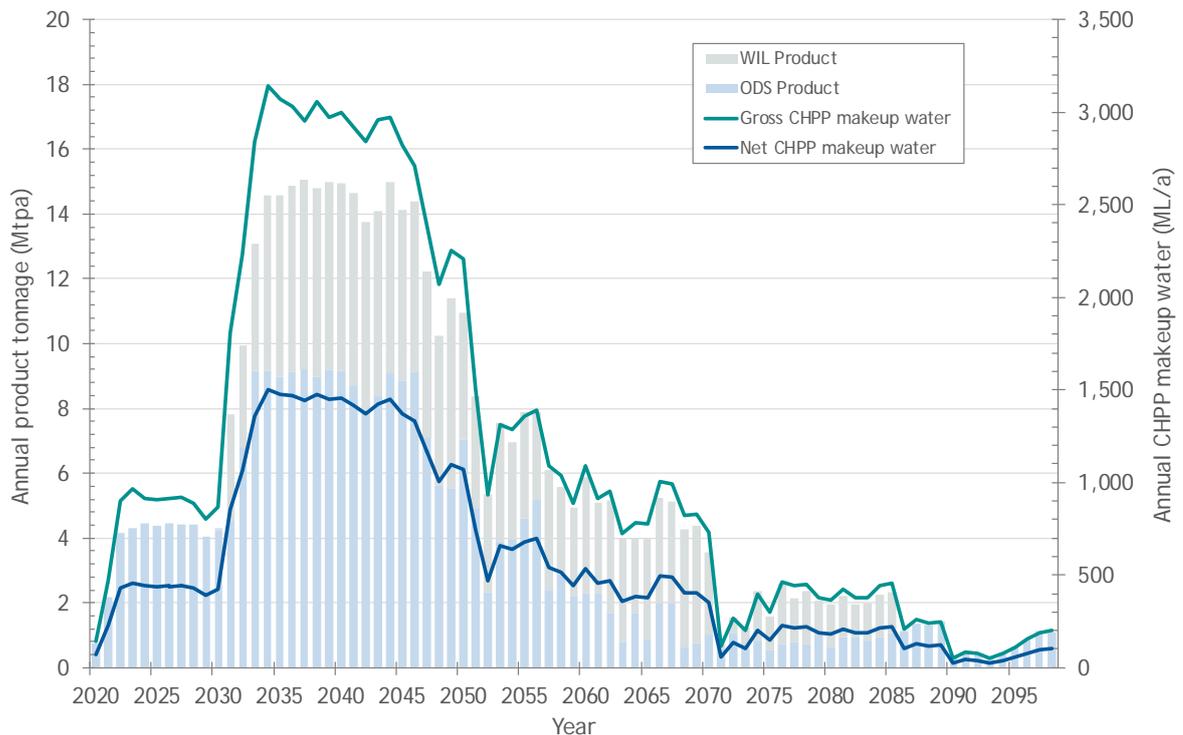


Figure 7-3: Estimated Gross and Net Annual CHPP Makeup Water Requirements

7.8.2 Haul Road Dust Suppression

Water for haul road dust suppression is sourced from the ODS and Willunga MIA dams. Haul road dust suppression watering rates have been applied to the haul road areas that vary as mining progresses. Haul road length were measured from the provided mine plans and are summarised as follows:

- Stage 1 – approximately 9.5 km of haul road
- Stages 2 to 6 – approximately 39.0 km of haul road

The following rules were used to determine the applied dust suppression rate on any given day of the historical rainfall record:

- The assessment used daily pan evaporation rates sourced from the SILO Datadrill evaporation dataset.
- For a dry day (zero rainfall), the haul road watering rate is equal to the daily evaporation rate.
- For a rain day when rainfall is less than the daily evaporation rate, the watering rate is reduced and is only required to make up the remaining depth to the daily evaporation rate.
- For a rain day when rainfall exceeds the daily evaporation rate, no haul road watering is required.
- It was assumed that 27.5 metres of the haul road width would be watered.

The estimated consumption rates for each phase are summarised in Table 7-10.

Table 7-10: Forecast Haul Road Dust Suppression Usage

Stage	Haul Road Length (km)	Avg. Daily Application Rate (mm/d)	Max. Daily Application Rate (mm/d)	Avg. Annual Usage (ML/a)	Avg. Daily Usage (ML/d)
1	9.5	5.0	14.2	473	1.3
2 to 7	39.0	5.0	14.2	1,948	5.3

7.8.3 Coal Crushing / Conveyor Dust Suppression

Water for coal crushing and conveyor dust suppression will be supplied from the mine affected water system at an estimated annual rate of 400 ML/a.

7.8.4 Miscellaneous Raw Water Demands

Miscellaneous raw water demands will be supplied from the Raw Water Tank at an estimated annual rate of 80 ML/a.

7.8.5 Mine Infrastructure Demands

Mine infrastructure demands will be supplied from the mine affected water system at an estimated annual rate of 40 ML/a.

7.8.6 Potable Water Treatment Plant Demands

The proposed Potable Water Treatment Plant (PWTP) will be supplied by the Raw Water Tank at an estimated annual rate of 50 ML/a.

7.8.7 Construction Water Supply Demands

The estimated the use of water during construction would be approximately 570 ML/a (i.e. approximately 1.6 ML/day). The construction phase of the Project has not been modelled.

7.9 Water Sources

7.9.1 Groundwater Inflows

The adopted groundwater inflows to the open cut pits are based on estimates provided by SLR Consulting and have been provided annually between 2020 and 2055 and as 5-year averages between 2055 and 2098. A summary of the predicted groundwater inflows (grouped by main pit area) are provided in Table 7-11 and Figure 7-4.

Table 7-11: Estimated Annual Groundwater Inflows

Stage	Year	ODS Main Pits	ODS Satellite Pit	Willunga Main Pits	Willunga Satellite Pit	TOTAL
		(ML/a)	(ML/a)	(ML/a)	(ML/a)	(ML/a)
1	2020	0	0	0	0	0
	2021	31	0	0	0	31
	2022	150	0	0	0	150
	2023	261	0	0	0	261
	2024	373	0	0	0	373

Stage	Year	ODS Main Pits	ODS Satellite Pit	Willunga Main Pits	Willunga Satellite Pit	TOTAL
		(ML/a)	(ML/a)	(ML/a)	(ML/a)	(ML/a)
	2025	364	0	0	0	364
	2026	367	0	0	0	367
	2027	353	0	0	0	353
	2028	397	0	0	0	397
	2029	401	0	0	0	401
	2030	336	0	88	0	423
2	2031	560	0	317	0	877
	2032	729	6	213	0	947
	2033	757	45	153	0	955
	2034	720	134	124	0	978
	2035	684	109	98	410	1,302
	2036	622	115	95	588	1,420
	2037	598	108	126	748	1,581
	2038	532	93	127	716	1,458
	2039	496	53	124	674	1,347
	2040	530	44	121	563	1,257
3	2041	543	45	127	474	1,190
	2042	577	41	139	772	1,530
	2043	582	40	135	640	1,397
	2044	724	54	165	504	1,448
	2045	485	38	113	0	636
	2046	366	41	107	0	514
	2047	277	41	78	0	396
	2048	138	41	26	0	205
	2049	144	41	45	0	230
	2050	219	40	53	0	312
4	2051	213	40	37	0	290
	2052	676	32	34	0	742
	2053	696	38	37	0	771
	2054	517	40	38	0	594
	2055	448	17	34	0	498
	2056	205	0	17	0	222
	2057	204	0	17	0	222
	2058	204	0	17	0	222
	2059	204	0	17	0	222
	2060	205	0	17	0	222

Stage	Year	ODS Main Pits	ODS Satellite Pit	Willunga Main Pits	Willunga Satellite Pit	TOTAL
		(ML/a)	(ML/a)	(ML/a)	(ML/a)	(ML/a)
5	2061	151	0	26	0	177
	2062	151	0	26	0	177
	2063	151	0	26	0	177
	2064	152	0	26	0	177
	2065	151	0	26	0	177
	2066	110	0	30	0	140
	2067	110	0	30	0	140
	2068	110	0	30	0	140
	2069	110	0	30	0	140
	2070	110	0	30	0	140
	2071	79	0	18	0	97
	2072	79	0	18	0	97
6	2073	79	0	18	0	97
	2074	79	0	18	0	97
	2075	79	0	18	0	97
	2076	60	0	43	0	103
	2077	59	0	43	0	102
	2078	59	0	43	0	102
	2079	59	0	43	0	102
	2080	60	0	43	0	103
	2081	51	0	100	0	151
	2082	51	0	100	0	151
	2083	51	0	100	0	151
	2084	51	0	100	0	151
	2085	51	0	100	0	151
7	2086	67	0	28	0	95
	2087	67	0	28	0	95
	2088	68	0	28	0	96
	2089	67	0	28	0	95
	2090	67	0	28	0	95
	2091	71	0	5	0	76
	2092	72	0	5	0	76
	2093	71	0	5	0	76
	2094	71	0	5	0	76
	2095	71	0	5	0	76
	2096	71	0	5	0	76

Stage	Year	ODS Main Pits	ODS Satellite Pit	Willunga Main Pits	Willunga Satellite Pit	TOTAL
		(ML/a)	(ML/a)	(ML/a)	(ML/a)	(ML/a)
	2097	71	0	5	0	76
	2098	71	0	5	0	76

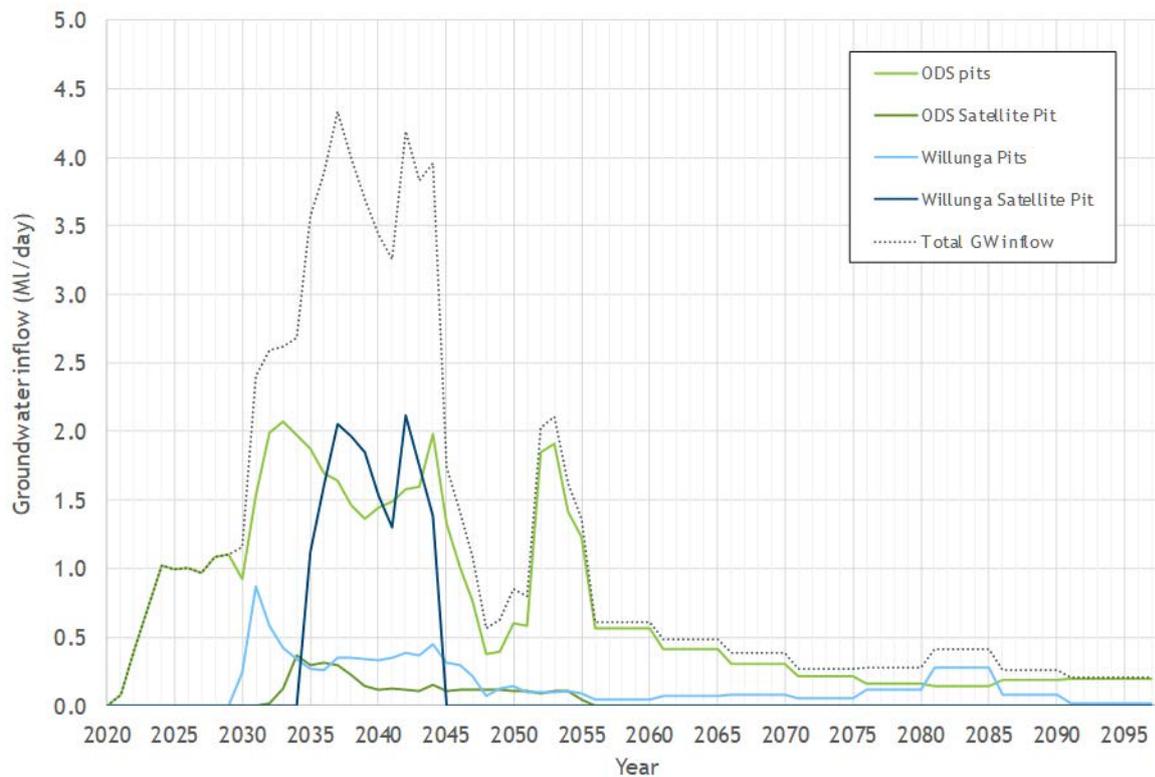


Figure 7-4: Estimated Annual Groundwater Inflows

7.10 Isaac River Flow Modelling

Flows in the Isaac River are simulated using a calibrated AWBM parameter set, as summarised in Table 7-12. This AWBM parameter set was calibrated against recorded stream flows at the Goonyella Gauge (130414A) between June 1998 and July 2000. This period was chosen as it is a known period where there were no discharges from Burton Gorge Dam. The outcomes from the calibration are presented in Figure 7-5.

Table 7-12: Adopted AWBM parameters for Isaac River

Parameter	Isaac River
A1	0.134
A2	0.433
A3	0.433
C1	15.4
C2	91.2
C3	181.0

Parameter	Isaac River
C _{avg}	119.9
BFI	0.35
k _{base}	0.6
k _{surf}	0.1

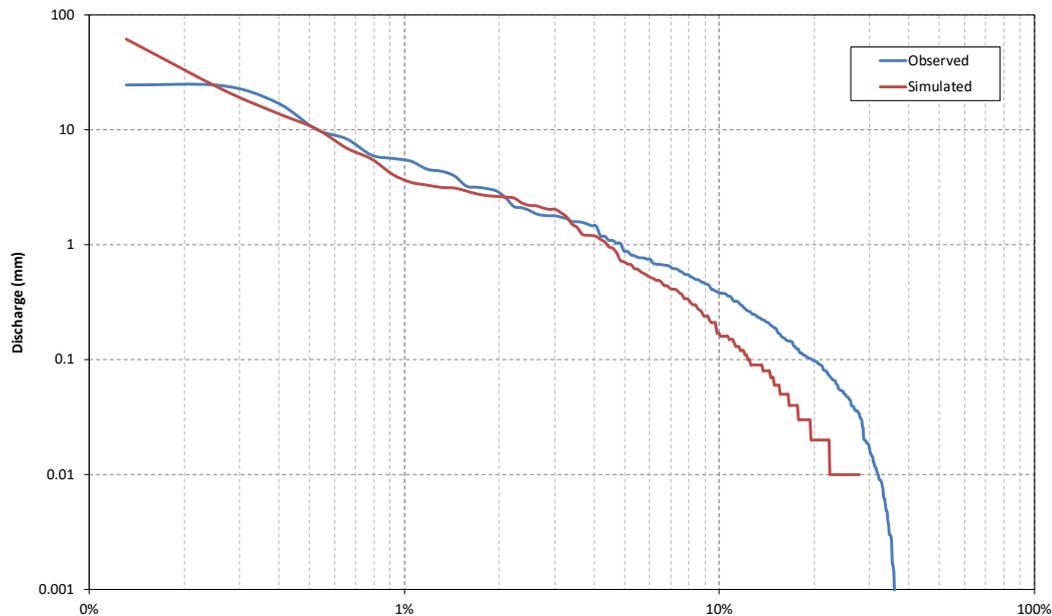


Figure 7-5: Isaac River Catchment AWBM Parameter Calibration, Flow Duration Relationship – Simulated vs Observed

7.11 Controlled Releases

Water release conditions have been developed for releases to the Isaac based on the *DEHP Guideline Model Mining Conditions*. The water balance model has been configured to simulate these release conditions, using salt measured as electrical conductivity as the target contaminant. A summary of the proposed release conditions is provided in Table 7-13 and presented in Figure 7-6.

The proposed controlled releases strategy comprises a number of mine affected water dams which will have the ability to discharge water to the Isaac River through a gravity pipe system. There are four proposed controlled release points (RP's) at the ODS domain and one at the Willunga domain. However, due to the progressive mining activities from north to south at the ODS domain, it is likely that only two of the four dams would operate simultaneously.

The release point dams are proposed to be above ground turkey's nest type dams around 5 m deep. They will be constructed above the natural surface to provide sufficient driving head for gravity discharge. The gravity discharge solution is preferred because it allows for an efficient discharge mechanism and can provide significant discharge capacity during the relatively short discharge opportunities for the Isaac River flow regime.

Potential pump solutions to supplement to gravity release system will be considered during the detailed design process.

Table 7-13: Proposed Mine Affected Water Release Limits (During Flow Events)

Receiving waters	Release Point (RP)	Gauging Station	Receiving Water Flow Criteria for Discharge	Maximum Release Rate (for all combined RP flows) ^{*2}	Electrical Conductivity Release Limits
Isaac River	P9 P20 P33 P46 WROM P44 ^{*1} WMIA ^{*1}	130410A Isaac River @ Deverill	Medium Flow		
			4 m ³ /s	0.5 m ³ /s	1,000 µs/cm
			10 m ³ /s	1.0 m ³ /s	1,200 µs/cm
			High Flow		
			50 m ³ /s	2.0 m ³ /s	4,000 µs/cm
			100 m ³ /s	3.0 m ³ /s	6,000 µs/cm
			Very High Flow		
300 m ³ /s	5.0 m ³ /s	10,000 µs/cm			

Note: ^{*1} Although P44 and WMIA are designated release points, they are not part of the overall controlled release strategy.

^{*2} The specified Maximum Release Rate represents the combined discharge rate from all active release points. This will likely include only two or three controlled release points at any stage of the Project.

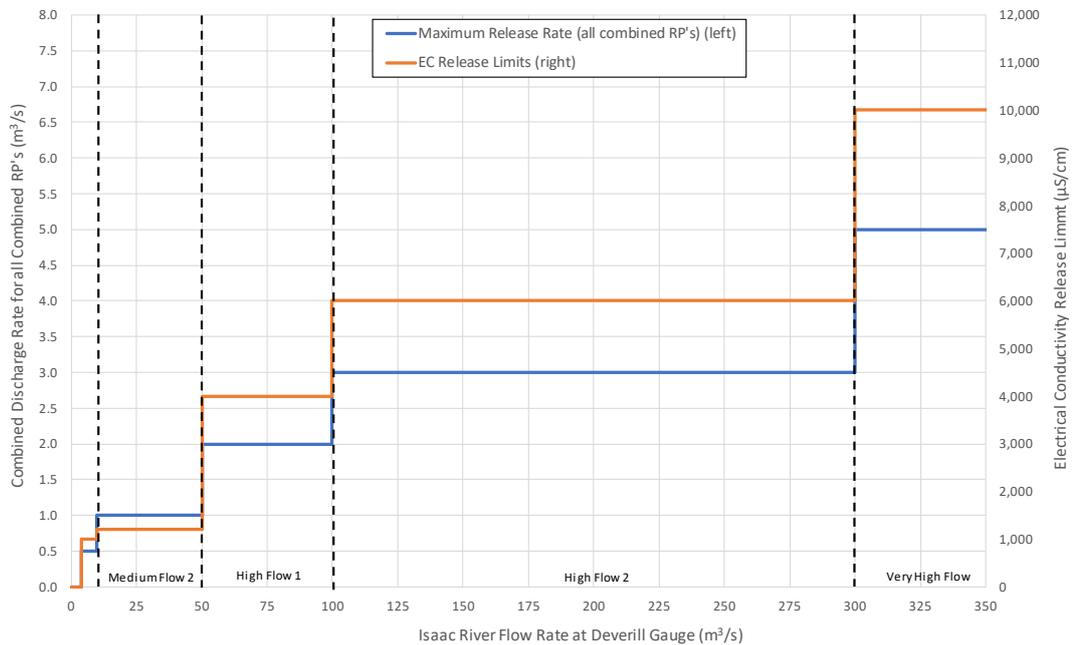


Figure 7-6: Proposed Controlled Release Strategy

7.12 Water Quality Modelling

7.12.1 Overview

The Project water balance model is configured to use salinity as an indicator of water quality. This has been achieved by assigning representative electrical conductivity (EC) values to runoff from catchments and other sources of water.

The geochemical characterisation of the potential spoil (Terrenus, 2018) provided the following commentary regarding other contaminants:

- The total sulfur concentration of potential spoil is low. Almost all spoil samples are classified as Non Acid Forming (NAF) and most (93% of) NAF samples are further classified as 'barren' with respect to sulfur concentrations.
- Total metal and metalloid concentrations in potential spoil samples are very low compared to average element abundance in soil in the earth's crust.
- Soluble multi-element results indicate that leachate from bulk spoil has the potential to contain slightly elevated soluble aluminium, arsenic and/or selenium concentrations compared to applied ANZECC (2000) aquatic ecosystem protection water quality guideline concentrations. Slightly elevated concentrations for some metals/metalloids for spoil and coal reject materials are common at coal mines in the Bowen Basin and generally do not result in any significant water quality issues.
- It is important to note that the results represent an 'assumed worst case' scenario as the samples are pulverised (to minus 75 micrometres) prior to testing. Therefore, samples have a very high surface area compared to materials in the field. Materials would also be well mixed at storage locations. Hence, it is expected that the concentration of metal/metalloids in surface run-off and seepage from spoil (and coal reject) materials in the field would be significantly less than the laboratory results from these 'pulped' samples.

Given the outcomes from the geochemical characterisation report, modelling of other contaminants has not been undertaken as part of this surface water assessment. If, when operations commence, monitoring indicates that there are other contaminants of concern, then the water balance model can be updated to include additional water quality parameters.

7.12.2 **Adopted Salinity Parameters**

The proposed EC values are shown in Table 7-14, with discussion relating to the source of the proposed values.

Table 7-14: Adopted Salinity Concentrations

Water Source/ Land Use	EC (µs/cm)	Comment
Isaac River flows	80-800 (dependent on flow)	Flow vs EC relationship developed based on recorded EC at Deverill Gauging Station between 2011 and 2017. Refer to Section 7.12.3 for further details
Natural/undisturbed	300	Based on typical values of water quality samples taken at various Riverine sites between Dec-16 and Jul-17
Roads/hardstand	900	Value adopted for Lake Vermont Northern Extension SWA
Mining pit	4,500	Value adopted for Lake Vermont Northern Extension SWA
Spoil	350	Based on median value from the Terrenus geochemical assessment (Terrenus, 2018)
Rehab	300	Assumed to be similar to natural/undisturbed
Pit groundwater inflows	8,910	Based on Fitzroy Plan WQO – shallow groundwater (80 th percentile)
Raw water (pipeline)	200	Based on recorded data at a nearby operations
ROM Coal moisture	10,000	Salinity of ROM Coal unknown, conservatively high value adopted

Salt is lost from the system through the product coal, coarse rejects and fine rejects streams. The amount of salt lost varies depending on the EC of the feed water supply to the CHPP water circuit. Salt is also lost through haul road dust suppression.

7.12.3 **Isaac River salinity**

As described in Section 5.4.1, EC has been continuously monitored and recorded at the Deverill gauging station since August 2011. This monitoring data has been analysed and a relationship between EC and discharge (expressed as runoff depth) has been developed, as shown in Figure 7-7. This relationship flow-EC relationship for the Isaac River has been incorporated into the water balance model.

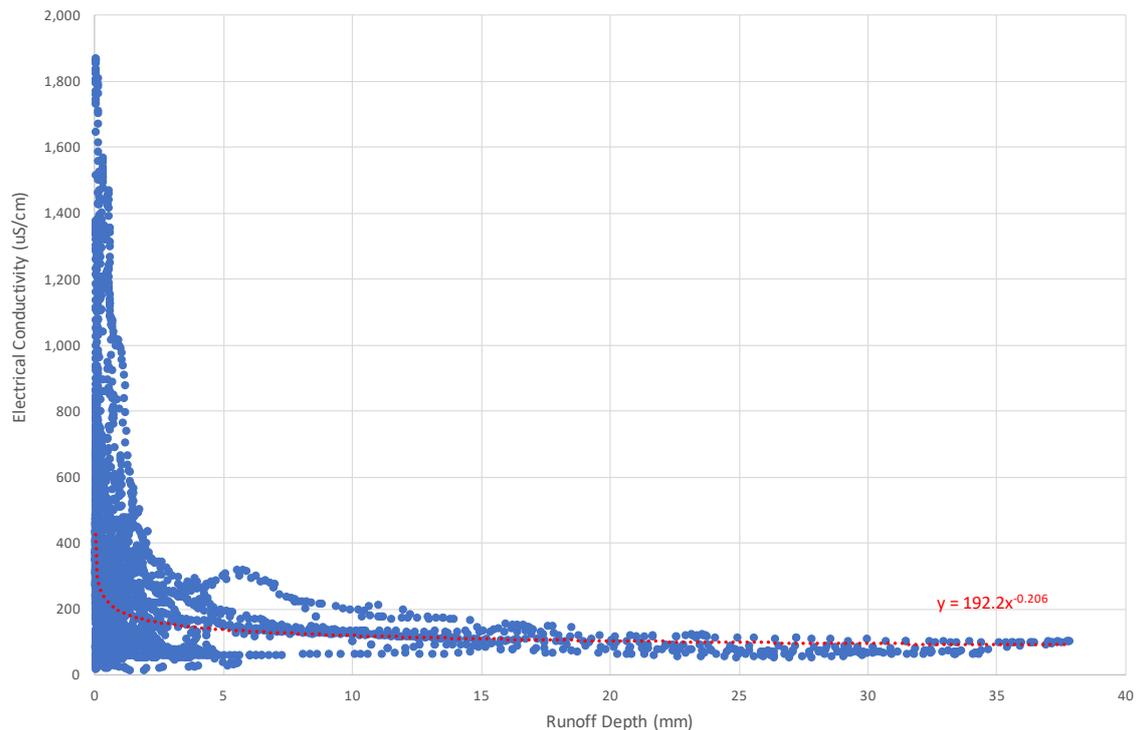


Figure 7-7: Relationship between EC and Excess Rainfall Depth at Deverill Gauge

7.13 Preliminary Consequence Category Assessment

All proposed mine affected water dams which overflow internally (i.e. do not discharge to the receiving environment) have been assigned a preliminary category of low consequence due to the low risk of significant consequence in the event of a failure to contain or dam break.

There are only three mine affected water dams that can discharge to the receiving environment:

- P44 (ODS domain)
- WROM (Willunga domain); and
- WMIA (Willunga domain).

These dams have been assessed against Table 1 of the Manual and have been assigned a low consequence category for the failure to contain criteria based on the predicted water quality results from the water balance model. Refer to Section 8 for the water balance model results.

7.14 Sediment Dams

7.14.1 Conceptual Sizing

Catchment runoff from both active and newly rehabilitated overburden dumps at the ODS and Willunga domains will be managed in accordance with an ESCP. The sediment dams have been sized in accordance with the IECA method (IECA, 2008), and have been based on the following design standards and methodology:

- “Type F” sediment basins;
- total sediment basin volume = settling zone + sediment storage volume. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted. The settling zone is the minimum required free storage capacity that must be restored within 5 days after a runoff event;
- sediment basin settling volume based on 85th percentile 5-day duration rainfall with an adopted volumetric event runoff coefficient for disturbed catchments of 0.45 (Group C soils – loamy clay); and
- solids storage volume = 50% of settling zone volume.

The adopted design standard does not provide 100% containment for runoff from disturbed areas. Hence, it is possible that overflows will occur from sediment dams if rainfall exceeds the design standard.

A summary of the conceptual sediment dam capacities and the surface areas (based on average 5 m depth) is provided in Table 7-15.

Table 7-15: Conceptual Sediment Dam Capacities and Surface Areas

Sediment Dam	Max. Catchment Area (ha)	Total Volume Required (ML)	Dam Surface Area (ha)
S1	235.0	51.5	1.37
S2	248.0	54.3	1.45
S3	122.1	26.8	0.71
S4	254.2	55.7	1.49
S5	144.9	31.8	0.85
S8	202.2	44.3	1.18
S11	320.6	70.3	1.87
S12	304.4	66.7	1.78
S13	66.1	14.5	0.39
S14	43.1	9.4	0.25
S17	72.2	15.8	0.42
S18	22.1	4.8	0.13
S19	97.7	21.4	0.57
S23	29.8	6.5	0.17
S24	31.6	6.9	0.18
S28	313.4	68.7	1.83

Sediment Dam	Max. Catchment Area (ha)	Total Volume Required (ML)	Dam Surface Area (ha)
S29	60.5	13.3	0.35
S30	72.6	15.9	0.42
S32	130.3	28.5	0.76
S34	85.0	18.6	0.50
S36	97.8	21.4	0.57
S37	60.0	13.2	0.00
S38	48.6	10.6	0.28
S39	133.2	29.2	0.78
S40	23.4	5.1	0.42
S41	30.3	6.6	0.00
S42	133.9	29.3	0.78
S43	614.8	134.7	3.59
S45	153.4	33.6	0.90
S47	22.9	5.0	0.00
S48	25.8	5.7	0.15
S49	17.0	3.7	0.64
S50	109.5	24.0	0.14
S51	31.1	6.8	0.28
S52	18.1	4.0	0.14
S53	126.4	27.7	0.18
S54	34.4	7.5	0.11
S55	34.5	7.6	0.00
S56	277.1	60.7	0.74
S57	21.5	4.7	0.20
S58	24.3	5.3	1.62
S59	62.4	13.7	0.13
S60	93.5	20.5	0.14
S65	162.9	35.7	0.95
S66	139.3	30.5	0.37
S67	33.6	7.4	0.81
S69	512.5	112.3	0.20
S70	353.3	77.4	2.99
S71	1026.0	224.8	2.06
S72	357.6	78.4	5.99
S73	1180.9	258.8	2.09
S77	468.9	102.8	6.90

8. Water Management System Assessment

8.1 Overview

The Project OPSIM model was used to assess the performance of the Project water management system, using the following key performance indicators:

- overall water balance – the average inflows and outflows of the water management system based on all model realisations (Section 8.3.1);
- mine water inventory – the risk of accumulation (or reduction) of the overall mine water inventory (Section 8.3.2);
- in-pit storage – the risk of accumulation of water in the mining pits, and the associated water volumes (Section 8.3.3);
- external water demand – the risk and associated volumes of requiring imported external water (via the SunWater pipeline) to supplement site mine water supplies (Section 8.3.4);
- controlled water releases – the risk and associated volumes (and salt loads) of controlled water releases to the receiving environment (Section 8.3.5);
- uncontrolled spillway discharges – the risk and associated volumes (and salt loads) of uncontrolled discharge from the mine affected water storages and sediment dams to the receiving environment (Section 8.3.6);
- rehabilitated catchment discharges – the risk and associated volumes (and salt loads) of runoff from rehabilitated catchments to the receiving environment (Section 8.3.7);
- overall salt balance – the average salt loads in and out of the water management system based on all model realisations (Section 8.3.8)

The use of a large number of climate sequences reflecting the full range of historical climatic conditions provides an indication of the system performance under very wet, very dry and average climatic conditions. It is important to note that the results of the water balance modelling are dependent on the accuracy of input assumptions. There is inherent uncertainty with respect to some key site characteristics (e.g. catchment yield/runoff, groundwater inflows etc.).

8.2 Interpretation of Model Results

In interpreting the results of the water balance assessment, it should be noted that the results provide a statistical analysis of the water management system's performance over the 79 years of mine life, based on 100 stochastically generated climatic rainfall sequences and historical average monthly evaporation.

The model results are presented as a probability of exceedance. For example, the 10th percentile represents 10% probability of exceedance and the 90th percentile results represent 90% probability of exceedance. There is an 80% chance that the result will lie between the 10th and 90th percentile traces.

Whether a percentile trace corresponds to wet or dry conditions depends upon the parameter being considered. For site water storage, where the risk is that available storage capacity will be exceeded, the lower percentiles correspond to wet conditions. For example, there is only a small chance that the 1 percentile storage volume will be exceeded, which would correspond to very wet climatic conditions. For off-site site water supply volumes (for example), where the risk is that insufficient water will be available, there is only a small chance that more than the 1 percentile water supply volume would be required. This would correspond to very dry climatic conditions.

It is important to note that a percentile trace shows the likelihood of a particular value on each day and does not represent continuous results from a single model realisation. For example, the 50th percentile trace does not represent the model time series for median climatic conditions.

8.3 Water Balance Model Results

8.3.1 Overall Water Balance

Water balance results for all of the 100 model realisations are presented in Table 8-1, averaged over each model phase. The results presented in Table 8-1 are the average of all realisations and will include wet and dry periods distributed throughout the mine life. Rainfall yield for each stage is affected by the variation in climatic conditions within the adopted climate sequence.

Table 8-1 provides an indication of the long-term average annual inflows and outflows. Key outcomes from the overall water balance are as follows:

- Average annual inflows from rainfall runoff are largely consistent between Stage 2 and Stage 7.
- External water requirements are highest in Stage 1, and consistently reduce between Stage 2 and Stage 7.
- The change in stored volume per stage is small in comparison to the inflow and outflow volumes and therefore the water management system is generally in balance.

Table 8-1: Average Annual Water Balance – All Realisations

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
INFLOWS (ML/a)							
Rainfall/runoff	6,170	17,531	18,016	18,619	19,147	18,498	18,940
Groundwater inflows	258	1,214	787	398	147	116	80
External water	1,129	775	700	522	465	378	371
ROM coal moisture	361	1,279	1,224	601	361	190	76
TOTAL INFLOWS	7,918	20,799	20,727	20,141	20,119	19,183	19,468
OUTFLOW (ML/a)							
Evaporation from storages	2,323	4,416	4,658	3,747	3,491	3,453	3,786
Dam overflows (offsite)							
<i>Mine affected water</i>	0	0	0	0	0	0	0
<i>Sediment water</i>	999	5,235	5,057	3,851	2,384	3,102	4,291
<i>Rehab/up-catchment water</i>	2,335	5,265	5,637	8,533	10,482	9,265	8,099
Controlled releases	404	650	547	800	906	760	665
CHPP							
<i>Product moisture</i>	381	1,346	1,308	666	392	207	84
<i>Coarse rejects moisture</i>	193	688	634	282	178	93	36
<i>Fine rejects - entrained</i>	216	609	565	288	206	137	91
Haul road dust suppression	475	1,551	1,688	1,709	1,600	1,524	977
Coal crushing/conveyor dust suppression	400	400	400	400	400	400	400
Miscellaneous raw water demands	80	80	80	80	80	80	80
Mine infrastructure demands	40	40	40	40	40	40	40
Potable WTP demands	50	50	50	50	50	50	50
TOTAL OUTFLOWS	7,896	20,331	20,666	20,446	20,209	19,112	18,600
CHANGE IN VOLUME (ML/a)							
Change in stored volume	22	468	61	-305	-90	71	866

8.3.2 Mine Affected Water Inventory

Figure 8-1 shows the combined forecast inventory for the key out-of-pit mine affected water storages over the 79-year forecast. To prevent uncontrolled discharges from the mine water storages, target operating volumes (TOVs) have been set for the out-of-pit mine affected water storages. The TOV is the volume at which pumping from the open cut pits to the mine affected water storages ceases. This was included as an operating rule in the OPSIM model. Also shown is the combined Full Supply Volume (FSV), which is the combined capacity of these dams.

The model results show the following:

- For the 10th percentile results (wet climatic conditions), the peak inventory in the out-of-pit storages reaches a volume of around 2,450 ML.

- For the 50th percentile results (median climatic conditions), the peak inventory in the out-of-pit storages reaches a volume of around 1,280 ML.
- The combined out-of-pit mine affected water inventory is maintained well below the combined capacity of all the mine affected water dams. This is primarily due to the ODS MIA Dam (the largest mine affected water dam) being operated at a low level to provide adequate buffer for large storm events, given its large surface area and catchments.

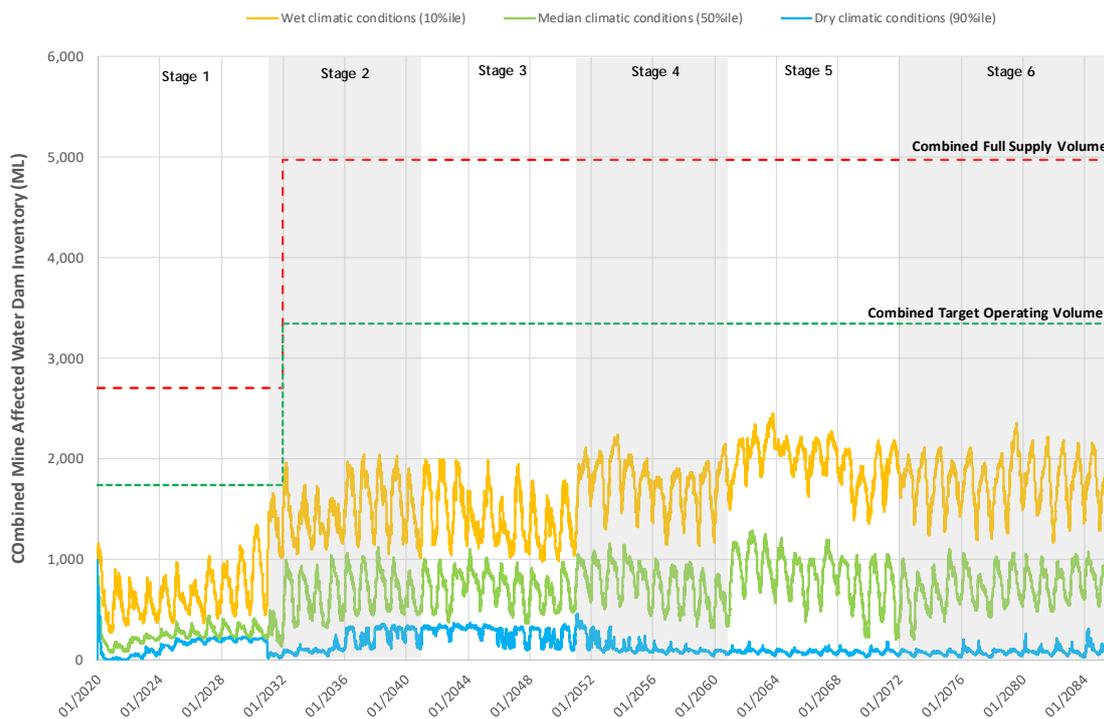


Figure 8-1: Forecast Mine Affected Water Inventory

8.3.3 In-pit Storage

Figure 8-2, Figure 8-3 and Figure 8-4 shows the forecast inventory for the ODS, Willunga and combined mining pits, respectively, over the 79-year simulation. A build-up of water in the mining pit generally occurs when the out-of-pit mine affected water storages are too full to accept additional pit water or the pumping infrastructure is unable to dewater the pits quickly enough. In other words, it is used to determine whether additional out-of-pit storage is required.

The forecast modelling results for the mining pit inventory are summarised as follows:

- ODS pits (Figure 8-2):
 - ◆ For the 10th percentile results (wet climatic conditions), water begins to accumulate at the beginning of Stage 2 and reaches a peak inventory of around 9,100 ML by the end of the Project.

- ◆ For the 50th percentile results (median climatic conditions), water begins to accumulate at the beginning of Stage 5 and reaches a peak inventory of around 2,000 ML by the end of the Project.
- Willunga pits (Figure 8-3):
 - ◆ For the 10th percentile results (wet climatic conditions), water begins to accumulate at the beginning of Stage 2 and reaches a peak inventory of around 9,900 ML during Stage 2, before reducing by Stage 6.
 - ◆ For the 50th percentile results (median climatic conditions), water accumulates during Stage 2 and 3, but generally empties from Stage 4 onwards.
- Combined pits (Figure 8-4):
 - ◆ For the 10th percentile results (wet climatic conditions), water begins to accumulate at the beginning of Stage 2 and reaches a peak inventory of around 12,580 ML during Stage 3 of the Project.
 - ◆ For the 50th percentile results (median climatic conditions), water accumulates during Stage 2 and 3, then reduces to an inventory of around 2,000 ML by the end of the Project.
- By the end of Stage 3, a substantial amount of additional storage capacity (around 550 GL) will be available within the Pit 1/2/3 void as mining has been completed by this time. These voids would be used to store excess water as required, depending on the prevailing climatic conditions.

Overall, the results suggest that sufficient out-of-pit storage has been provided. Should wet conditions prevail, Pembroke shall:

- Store excess water temporarily in an active pit until there is sufficient out-of-pit storage available; or
- Construct additional pit water dams ahead of mining in the ODS domain to temporarily store any excess mine affected water until there is sufficient out-of-pit storage available.

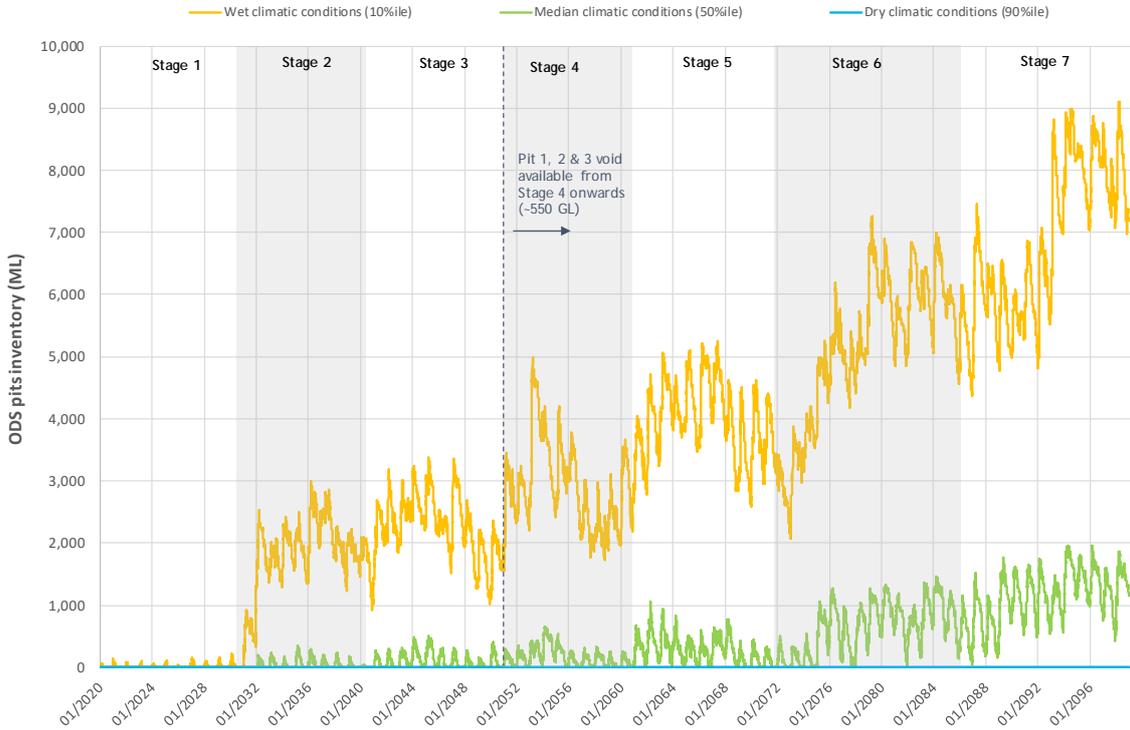


Figure 8-2: Forecast Pit Inventory - ODS

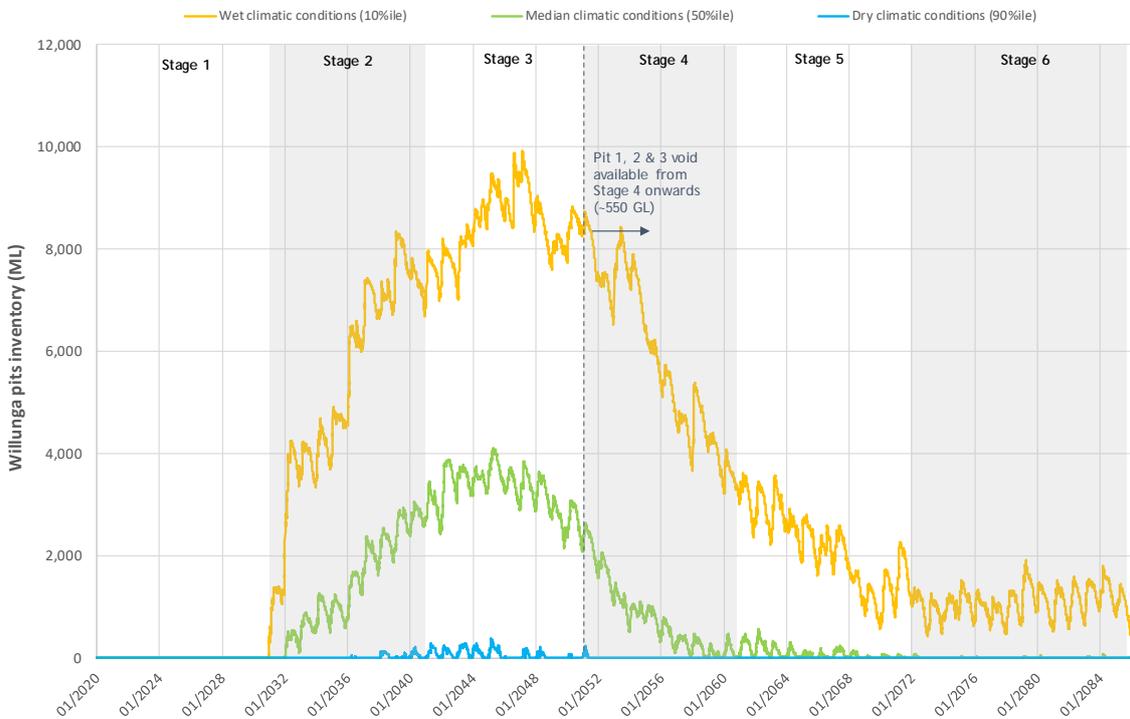


Figure 8-3: Forecast Pit Inventory - Willunga

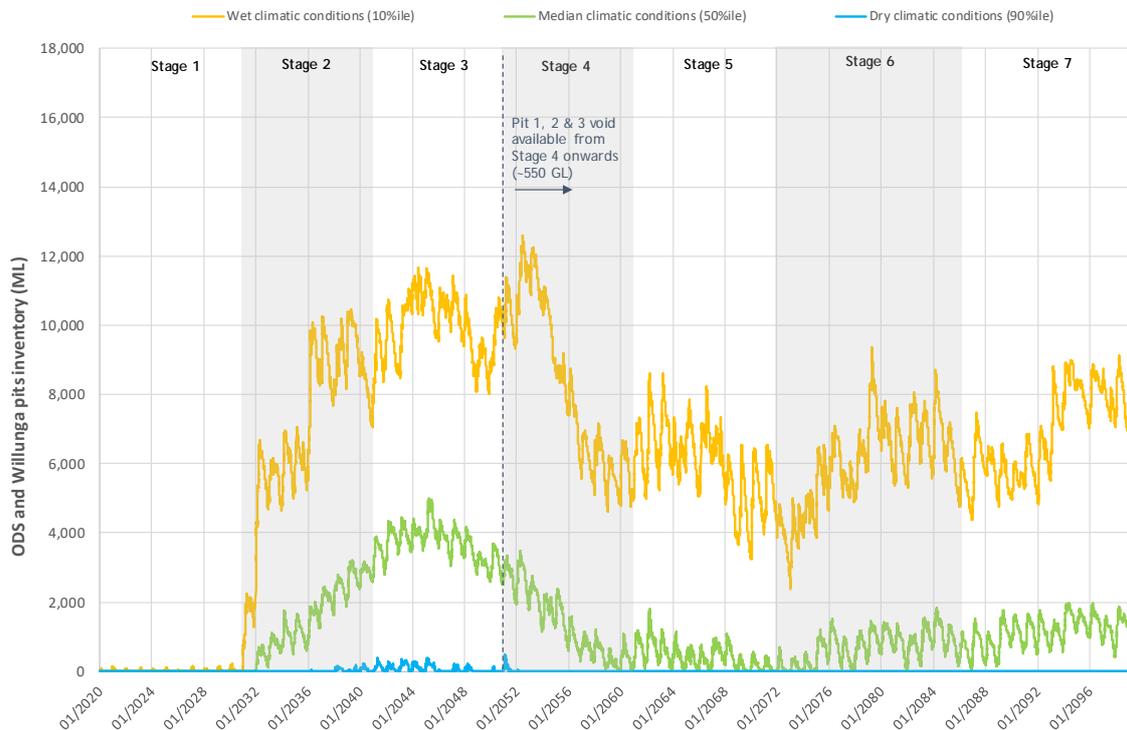


Figure 8-4: Forecast Pit Inventory - Combined

8.3.4 External Makeup Requirements

Water from external sources is required to meet operational water demands, primarily during extended dry climatic periods and periods of low groundwater inflows. In addition to the water captured within the water management system from surface runoff within the operational areas and groundwater inflows, water will also need to be sourced from external sources (e.g. the SunWater pipeline supply).

A key objective of the mine site water management system is to maximise the reuse of captured surface water runoff and groundwater inflows. Recycling mine water will minimise the volume of water from external sources that is required to satisfy site demands. However, the volume of water captured on site is highly variable dependent upon climatic conditions and groundwater inflows. Hence, the required makeup water volume from the external sources is likely to vary significantly from year to year.

Figure 8-5 shows the total annual modelled demand for water from external sources over the 79-year simulation.

The modelling results show the following:

- During Stage 1, the requirement for external supply is highest. There is a:
 - ◆ 10% risk of requiring 2,120 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 1,450 ML/a (or more) from the pipeline.

- During Stage 2, the requirement for external supply increases during dry climatic conditions but reduces during median and wet climatic conditions. There is a:
 - ◆ 10% risk of requiring 2,250 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 860 ML/a (or more) from the pipeline.
- The external supply requirement reduces over the remainder of the Project. By Stage 5, there is little to no external water required under median climatic conditions.
- During Stage 6 and Stage 7, there is a 10% risk of requiring around 1,710 ML/a (or more) from the pipeline.

The modelling results show that external water requirements generally reduce over the life of the Project. This is primarily due to the continual increase in mine disturbance area over time (and subsequent capture of rainfall runoff), as well as the reduction in predicted CHPP water consumption from Stage 3 onwards as the production throughput decreases.

Pembroke has an agreement with SunWater to provide a water supply via the Project pipeline from the Eungella network for the life of the Project, up to an annual volume of 2,250 ML/a. To supplement the SunWater supply, Pembroke has applied to DNRME for licences for take of unallocated general reserve water from the Isaac River under the Water Act.

In the unlikely event additional external water is required, additional water allocation from the Eungella or Burdekin networks operated by Sunwater could be sought by Pembroke over the life of the Project to meet raw water demands. It is also noted that Pembroke has applied for two licences for the take of 65 ML of unallocated general reserve water from the Isaac River. Any additional requirement for extraction from the Isaac River would be subject to separate licences to be applied for at a later date (in accordance with the *Water Plan (Fitzroy Basin) 2011*), to ensure no adverse impacts on water availability for other licenced water users.

Subject to availability of flows and obtaining relevant licences, direct pumping of water from the Isaac River may be undertaken opportunistically to minimise the external water supply requirements as required. The pump and associated infrastructure would be located at the ODS access road. Pumping of water from the Isaac River would be undertaken in a manner as to avoid and minimise potential impacts on aquatic ecology, including:

- starting the pump slowly and then gradually ramping up velocity;
- installing a suitable self-cleaning screen; and
- regularly inspecting the pump and screen.

There are also potential water harvesting opportunities from the site up-catchment water dams and sediment dams, as well as water saving measures such as dust suppressants.

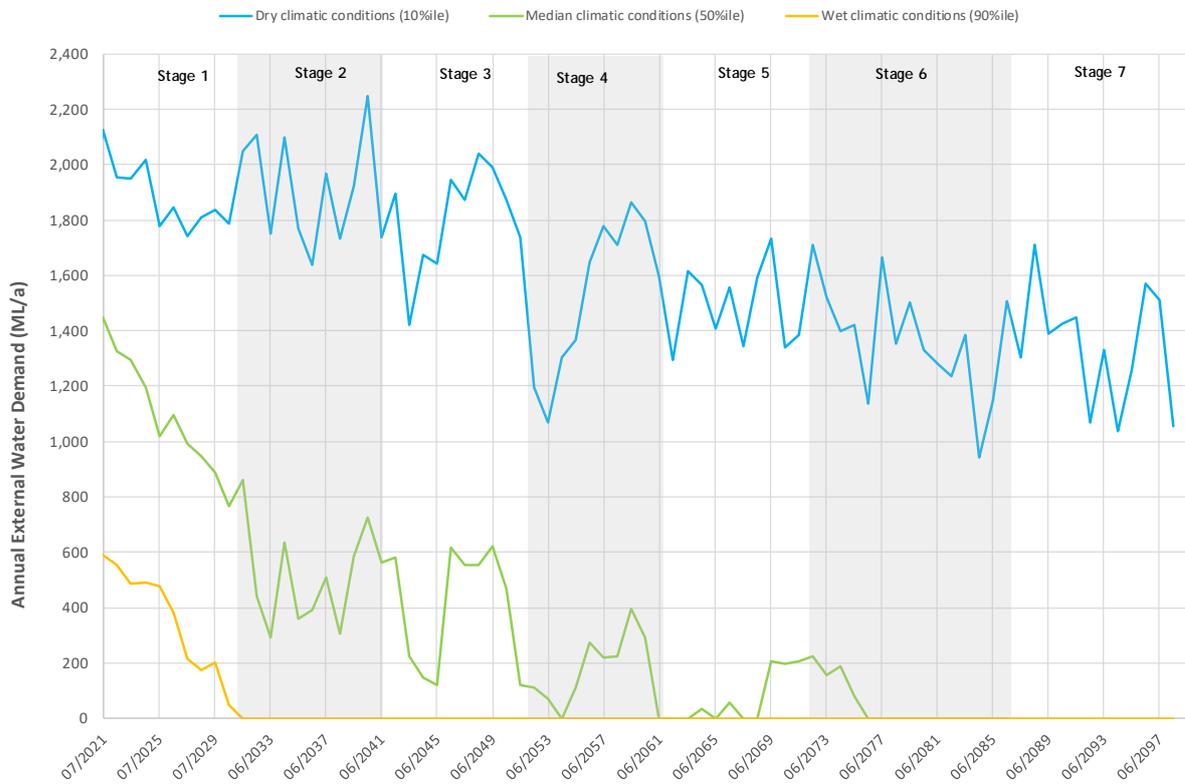


Figure 8-5: Forecast Annual External Water Requirements

8.3.4.1 Overland flow capture

As described in Section 7.7, NWWD is used to store water from the Eungella pipeline prior to its use within the Project. As it has as contributing catchment of 1,425 ha, this storage will capture some up-catchment runoff.

An assessment has been undertaken to estimate the average annual volume of up-catchment runoff that is used within the Project using the water balance model. The outcomes from this assessment (broken up by Phase) are provided in Table 8-2.

Review of Table 8-2 shows the estimated average annual “water take” from NWWD is between 417 ML/a (in Phase 1), reducing down to 151 ML/a by the end of the Project.

There is no modelled water take from the CWD.

Table 8-2: Estimated Annual Average Water Take from NWWD

Process	Average Annual Volume (per Phase)							Comment
	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7	
Pipeline Supply	1,129	775	700	522	465	378	371	Water supplied to NWWD via pipeline
Supply to Demand	1,546	1,020	932	727	652	539	521	Water supplied to site demands from NWWD
Est. Water Take	417	246	232	205	187	161	151	Balance is contribution from NWWD catchment runoff or “water take”

8.3.5 Controlled Water Releases

The water balance model is configured to release water in accordance with the rules outlined in Section 7.10. The predicted annual controlled release volumes from the mine affected water dams are provided in Figure 8-6. The results show that:

- For wet climatic conditions (10%ile), predicted annual controlled releases range between 500 and 2,140 ML/a, with the highest releases occurring during Stage 2 to Stage 5.
- For median climatic conditions (50%ile), predicted annual controlled releases range between 90 and 890 ML/a.
- For dry climatic conditions (90%ile), predicted annual controlled releases range between 15 and 370 ML/a.

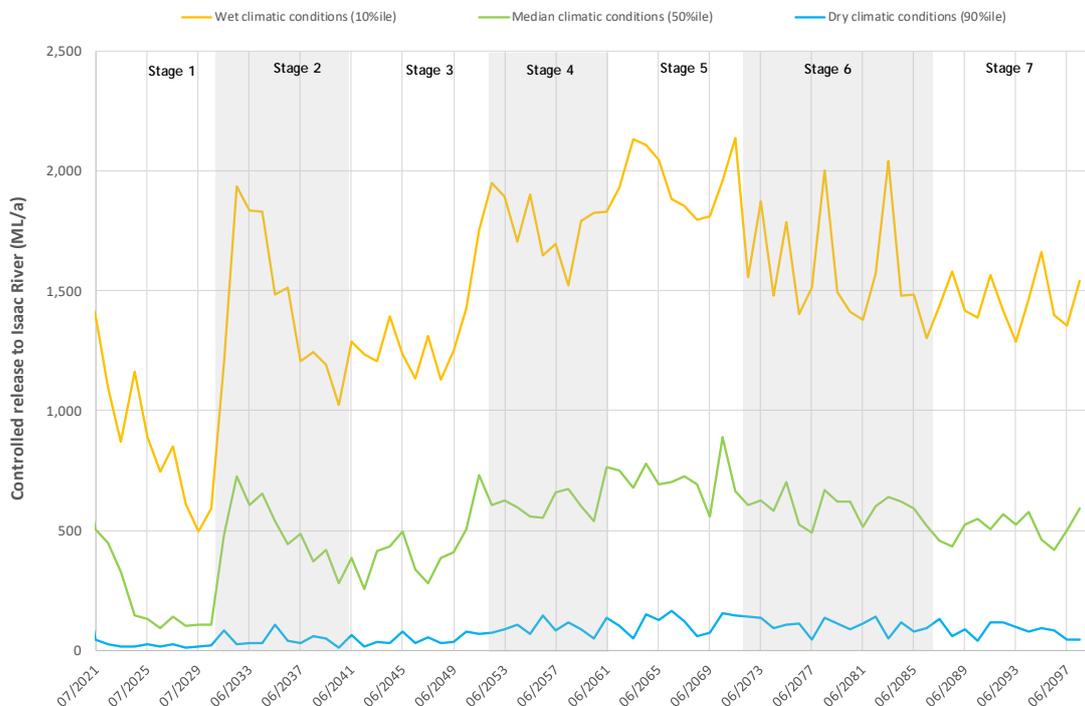


Figure 8-6: Forecast Annual Controlled Release Volumes

An assessment of the predicted annual salt load discharged through the controlled release system to the receiving environment has been undertaken for a representative “median” climatic sequence over the 79-year Project life. The annual salt loads have been ranked and presented as an AEP in Figure 8-7, which shows that under median climatic conditions:

- The annual salt load in rehabilitated and clean catchment discharges is around 35 tonnes/year (or more) for 90% of years.
- The annual salt load in rehabilitated and clean catchment discharges is around 630 tonnes/year (or more) for 50% of years.
- The annual salt load in rehabilitated and clean catchment discharges is around 2,500 tonnes/year (or more) for 10% of years.

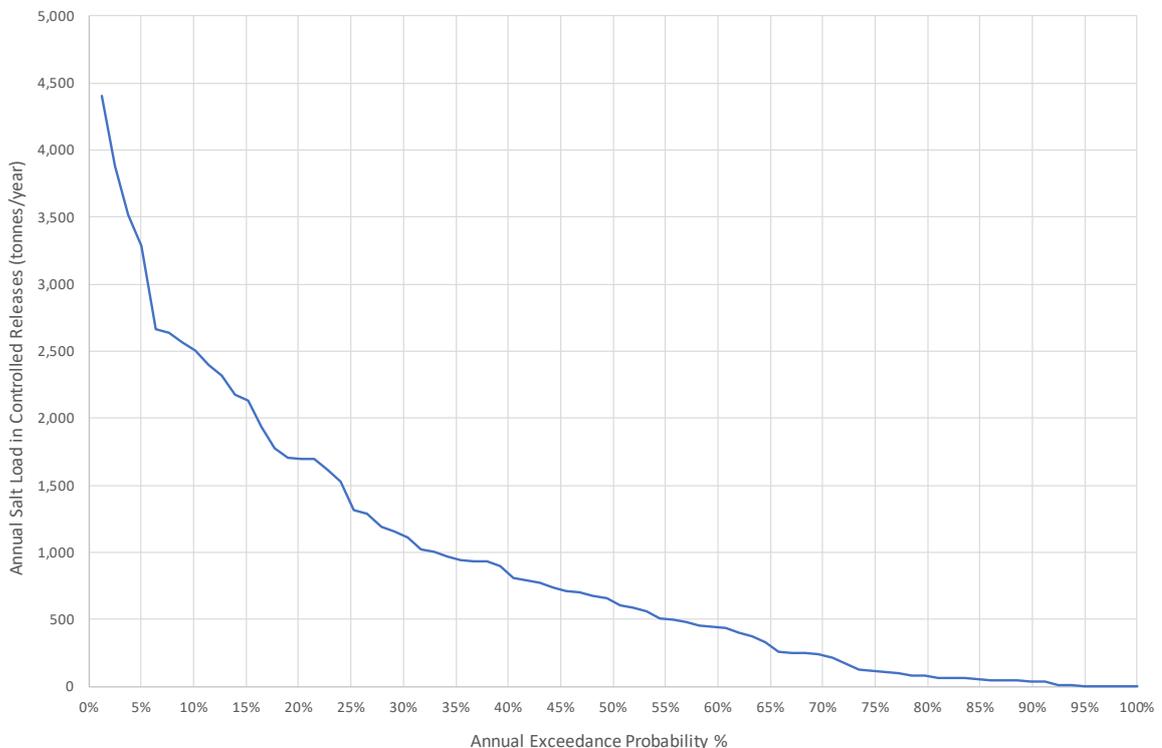


Figure 8-7: Controlled Release System Discharges – Annual Salt Load

8.3.5.1 Dilution Ratio of Controlled Releases to Isaac River Flows

An assessment of the dilution ratio of controlled releases to Isaac River flow has been undertaken, where the dilution ratio is the daily volume of the Isaac River flow divided by the daily volume of controlled releases to the Isaac River. Figure 8-8 shows a ranked plot of the minimum modelled daily dilution ratio on release days within each release category, for a represent median climatic cycle (Cycle 50). The results show that:

- The minimum modelled dilution ratio that occurred from all release categories throughout the median realisation is 22;

- The minimum modelled dilution ratio that occurred within each category was not less than the target dilution ratio under the controlled release rules; and
- 50% of release days exceed a minimum dilution ratio of:
 - ◆ 241:1 for Medium Flow 1 regime.
 - ◆ 229:1 for Medium Flow 2 regime.
 - ◆ 243:1 for High Flow 1 regime.
 - ◆ 444:1 for High Flow 2 regime.
 - ◆ 1,350:1 for Flood Flow regime.

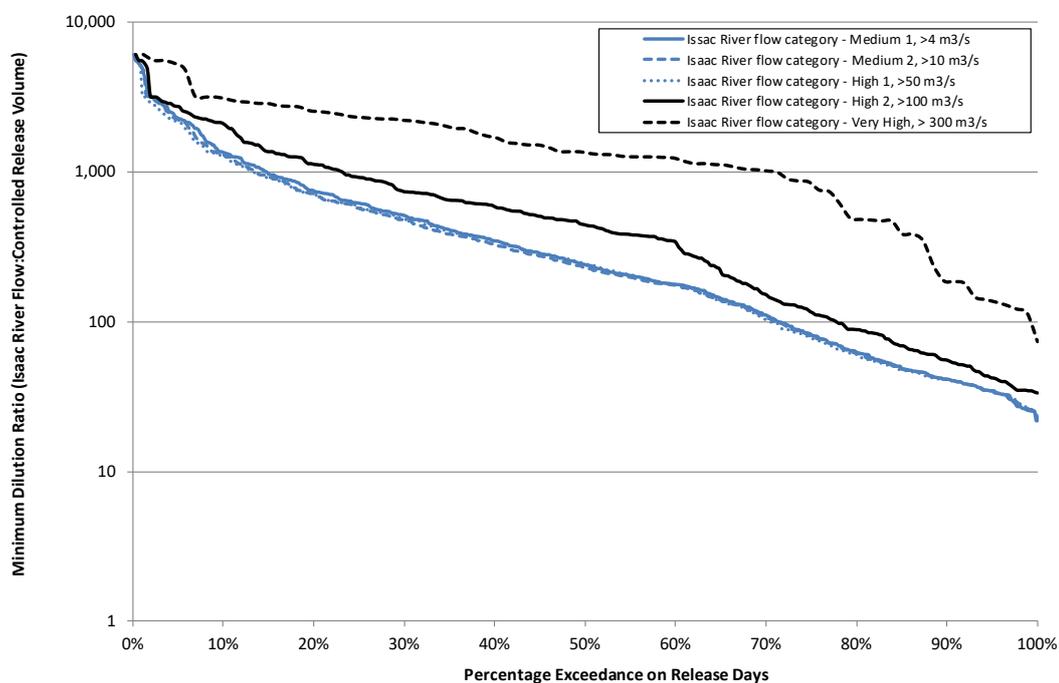


Figure 8-8: Ranked Plot of Minimum Dilution Ratios on Release Days

8.3.5.2 Release Scenarios

The water balance model results were analyzed in further detail to assess the modelled controlled releases from the Project. The release scenarios that were investigated include:

- Scenario 1 – The highest concentration of EC released from the Project; and
- Scenario 2 – The highest flow rate released from the Project.

The release events were compared to the proposed flow criteria detailed in Table 7-13. The release scenarios were assessed against the following four conditions:

- Flow criteria – The flow criteria is based on the flow rate within the receiving waters. The flow criteria specify the maximum release rate and EC release limit for all release points;
- Maximum release rate – The maximum combined release rate from all release points for a given flow criteria;
- EC release limit – The maximum EC for releases from mine water dams for a given flow criteria; and

For a release scenario to be in compliance, the maximum release rate and EC release limit must be below the specified corresponding flow criteria in Table 7-13.

8.3.5.2.1 Scenario 1 – Highest concentration of EC released

The highest modelled release EC for the Project is 9,600 $\mu\text{S}/\text{cm}$. Figure 8-9 and Figure 8-10 show the release rate and EC from the Project compared to the flow rate in the Isaac River. The proposed receiving water flow criteria and release conditions listed in Table 7-13 are also shown.

There are three different flow criteria and corresponding maximum release rates during this release:

- The Very High flow criteria of greater than 300 m^3/s at the start of the release. This flow criteria allows a maximum release rate of 5.0 m^3/s with a maximum EC of 10,000 $\mu\text{S}/\text{cm}$;
- When the receiving waters flow rate declines below 300 m^3/s , the High Flow 2 flow criteria “steps down” to 100 m^3/s . This flow criteria allows a maximum release rate of 3.0 m^3/s with a maximum EC of 6,000 $\mu\text{S}/\text{cm}$;
- When the receiving waters flow rate declines below 100 m^3/s , the High Flow 1 flow criteria “steps down” to 50 m^3/s . This flow criteria allows a maximum release rate of 2.0 m^3/s with a maximum EC of 4,000 $\mu\text{S}/\text{cm}$;

The OPSIM model predicts that during Scenario 1 release, the controlled release from the Project would be compliant in terms of release rates and EC using the proposed flow criteria in the receiving waters (Table 7-13).

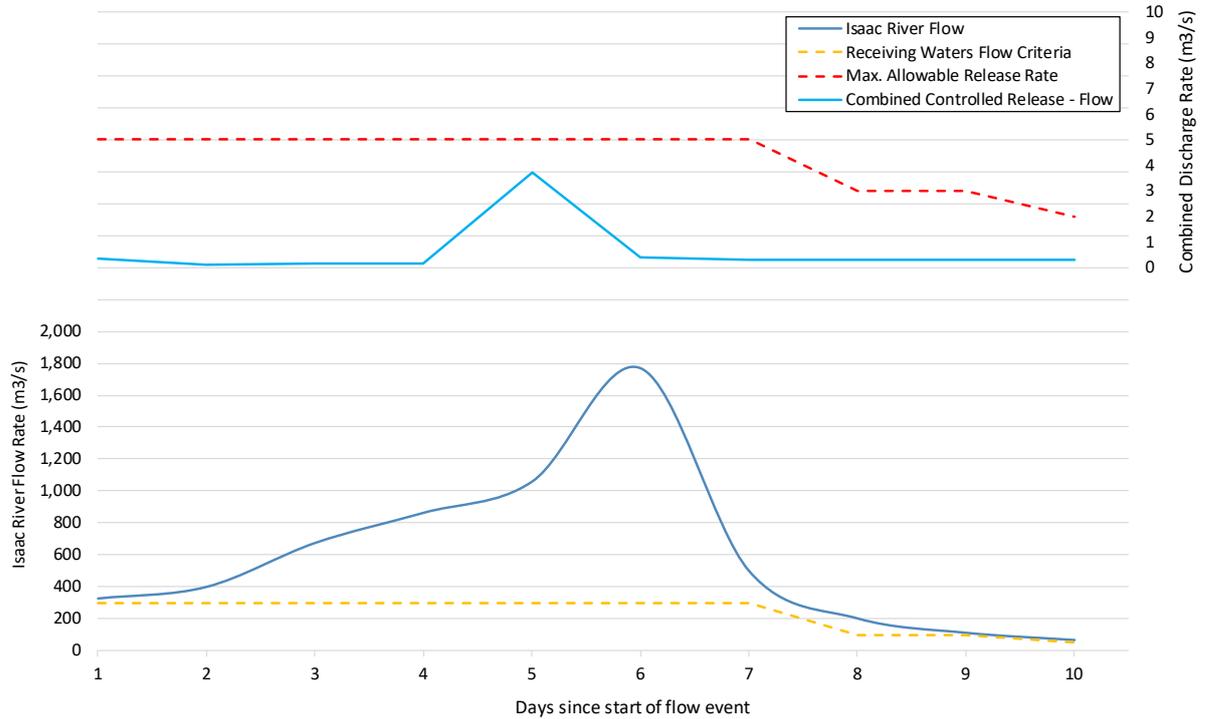


Figure 8-9: Release Rate Compared to Flow Rate in Isaac River and Corresponding Flow Criteria and Maximum Release Rate – Scenario 1

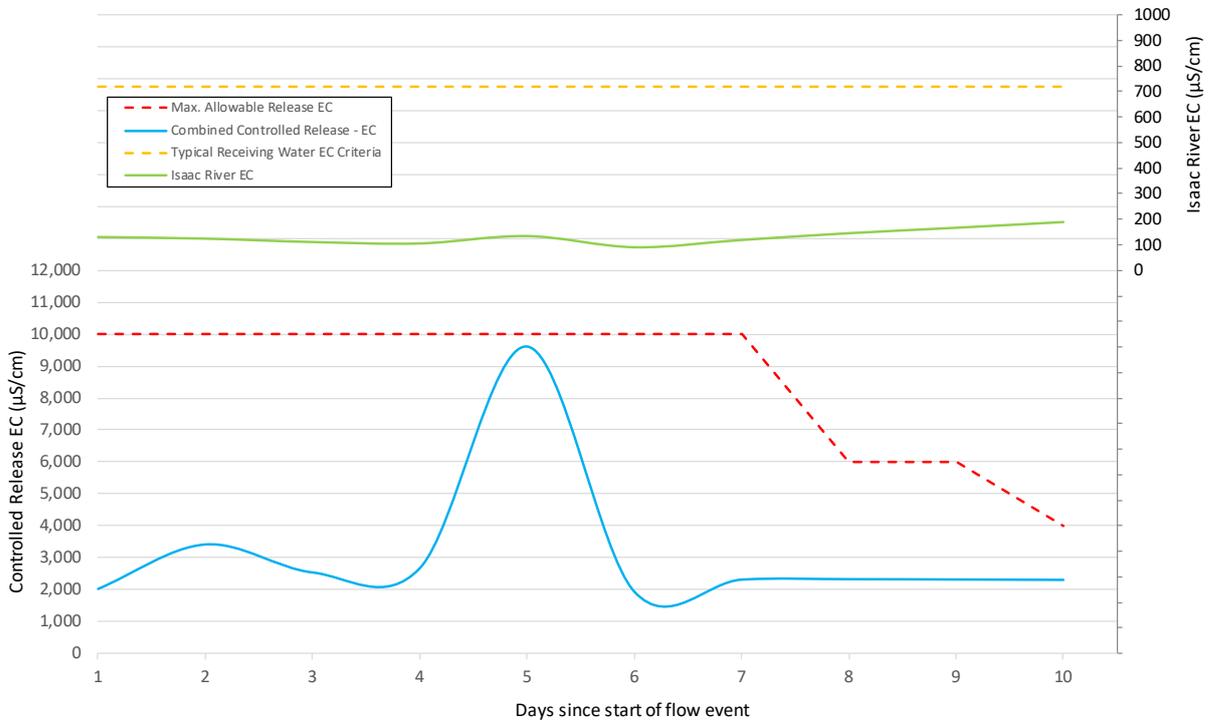


Figure 8-10: Release Water EC Compared to EC in Isaac River and Corresponding Flow Criteria and Maximum Release Rate – Scenario 1

8.3.5.2.2 Scenario 2 – Highest release flow rate

The highest modelled release rate for the Project is 5.0 m³/s (daily averaged), which is the maximum allowable discharge rate under the proposed release strategy. Figure 8-11 and Figure 8-12 show the release rate and EC from the Project compared to the flow rate in the Isaac River. The proposed receiving water flow criteria and release conditions listed in Table 7-13 are also shown.

There are five different flow criteria and corresponding maximum release rates during this release:

- The Very High flow criteria of greater than 300 m³/s at the start of the release. This flow criteria allows a maximum release rate of 5.0 m³/s with a maximum EC of 10,000 µS/cm;
- When the receiving waters flow rate declines below 300 m³/s, the High Flow 2 flow criteria “steps down” to 100 m³/s. This flow criteria allows a maximum release rate of 3.0 m³/s with a maximum EC of 6,000 µS/cm;
- When the receiving waters flow rate declines below 100 m³/s, the High Flow 1 flow criteria “steps down” to 50 m³/s. This flow criteria allows a maximum release rate of 2.0 m³/s with a maximum EC of 4,000 µS/cm;
- When the receiving waters flow rate declines below 50 m³/s, the Medium Flow 2 flow criteria “steps down” to 10 m³/s. This flow criteria allows a maximum release rate of 1.0 m³/s with a maximum EC of 1,200 µS/cm;
- When the receiving waters flow rate declines below 10 m³/s, the Medium Flow 1 flow criteria “steps down” to 4 m³/s. This flow criteria allows a maximum release rate of 0.5 m³/s with a maximum EC of 1,000 µS/cm;

The OPSIM model predicts that during Scenario 2 release, the controlled release from the Project would be compliant in terms of release rates and EC using the proposed flow criteria in the receiving waters (Table 7-13).

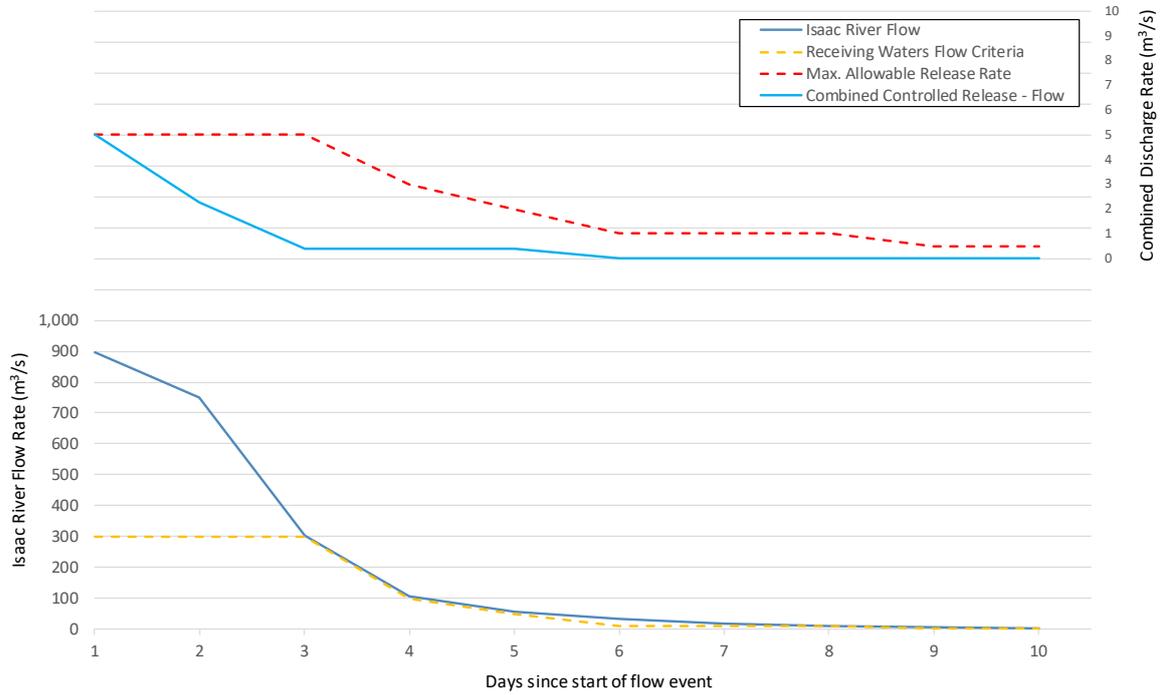


Figure 8-11: Release Rate Compared to Flow Rate in Isaac River and Corresponding Flow Criteria and Maximum Release Rate – Scenario 2

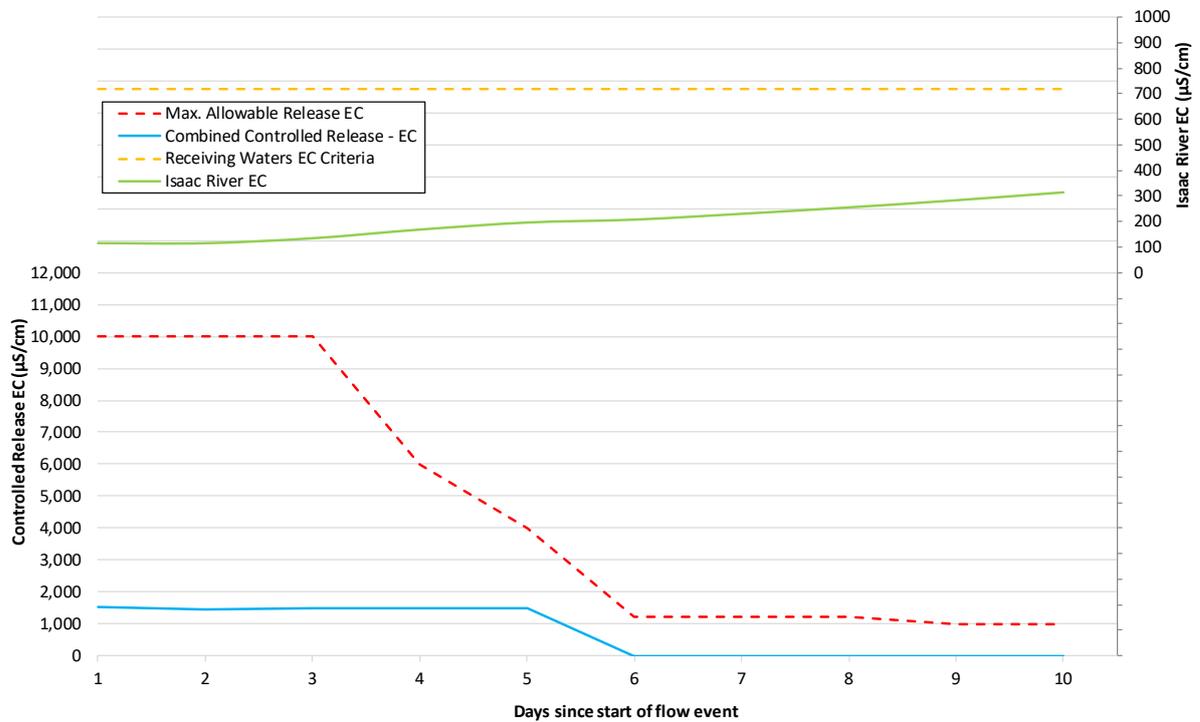


Figure 8-12: Release Water EC Compared to EC in Isaac River and Corresponding Flow Criteria and Maximum Release Rate – Scenario 2

8.3.6 **Uncontrolled Spillway Discharges**

8.3.6.1 *Mine Affected Water Dams*

The Project water balance model was used to assess the risk of uncontrolled offsite spills from the mine affected water management system. The mine water dams that could potentially overflow directly to the receiving environment if rainfall exceeded the storage design criteria include:

- P44 (to Ripstone Creek);
- WROM (to the Isaac River); and
- WMIA (to the Isaac River).

There were no modelled overflows from P44, WROM and WMIA to the Isaac River during any of the model realisations over the life of the Project.

8.3.6.2 *Sediment Dams*

The adopted design standard for sediment dams does not provide 100% containment for captured runoff. Hence overflows will occur from sediment dams when rainfall exceeds the design standard.

The potential for overflows from the proposed sediment dams has been assessed using a forecast assessment simulation. For simplicity, sediment dams have been modelled using a passive overflow rather than active release (to regain storage capacity within 5 days).

The predicted annual combined sediment dam overflows under this scenario are provided in Figure 8-13. Note that Figure 8-13 only include active sediment dams with catchments that are not fully rehabilitated. The results show that:

- During wet climatic conditions (10%ile) where rainfall events often exceed the dam design standard, modelled sediment dam overflows are between 1,730 ML/year and 12,960 ML/year.
- During median climatic conditions (50%ile) where rainfall events sometimes exceed the dam design standard, modelled sediment dam overflows are between 250 ML/year and 5,400 ML/year.
- During dry climatic conditions (90%ile) where few rainfall events exceed the dam design standard, modelled sediment dam overflows are between 0 ML/year and 1,340 ML/year.

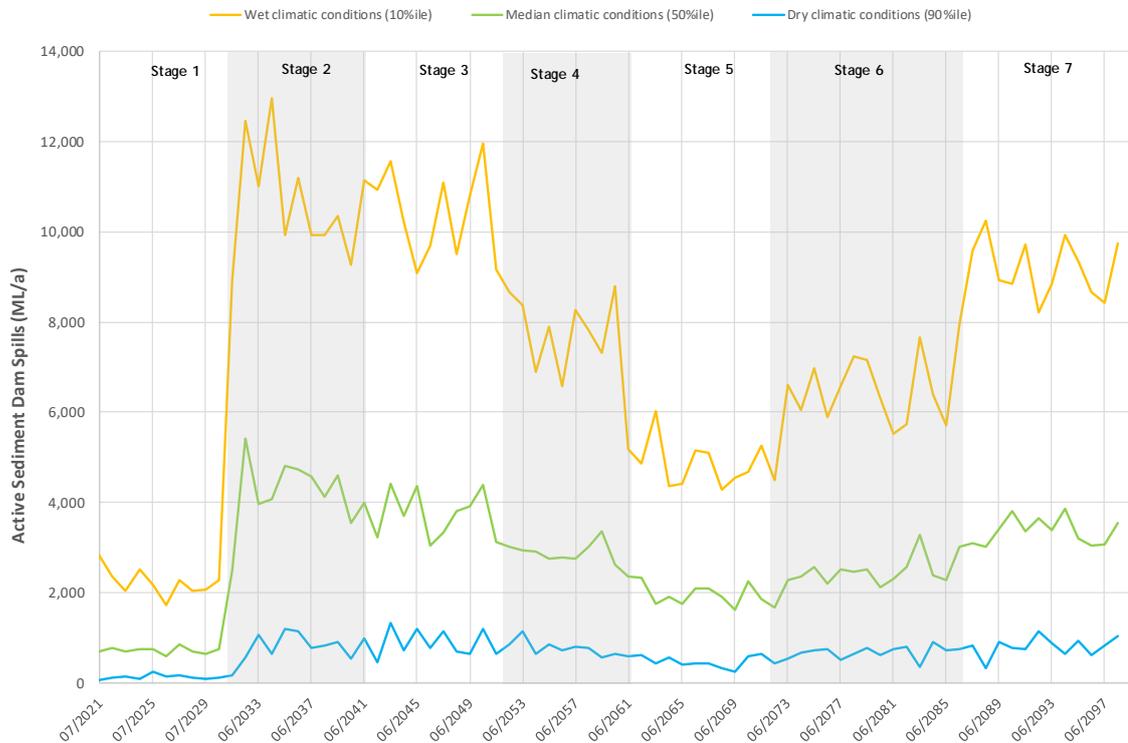


Figure 8-13: Forecast Annual Sediment Dam Overflows to Receiving Waters

An assessment of the predicted annual salt load discharged from the sediment dams to the receiving environment has been undertaken for a representative “median” climatic sequence over the 79-year Project life. The annual salt loads have been ranked and presented as an AEP in Figure 8-14, which shows that under median climatic conditions:

- The annual salt load in sediment dam overflows is around 1,40 tonnes/year (or more) for 90% of years.
- The annual salt load in sediment dam overflows is around 1,200 tonnes/year (or more) for 50% of years.
- The annual salt load in sediment dam overflows is around 4,600 tonnes/year (or more) for 10% of years.

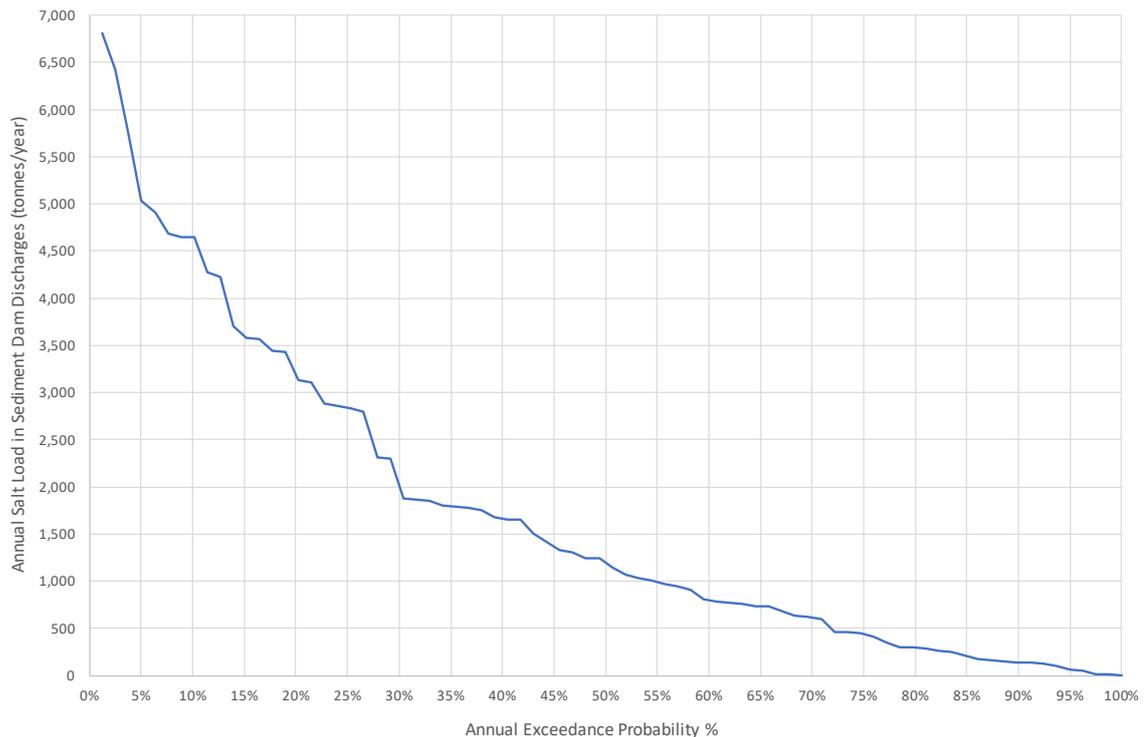


Figure 8-14: Sediment Dam Overflows – Annual Salt Load

8.3.7 *Rehabilitated Catchment Discharges*

As described in Section 6.4, when a sediment dam catchment is completely rehabilitated, and water quality monitoring of the runoff has established that it is consistent with natural background conditions, the sediment dam and associated drainage infrastructure will be decommissioned. Surface runoff and seepage from the rehabilitated catchment will be allowed to shed directly to the receiving environment.

The predicted annual combined rehabilitated catchment discharges are presented in Figure 8-15. Note that Figure 8-15 also includes runoff from diverted clean water catchments. The results show that:

- During wet climatic conditions (10%ile) modelled rehabilitated and clean catchment discharges are between 4,330 ML/year and 29,610 ML/year.
- During median climatic conditions (50%ile) modelled rehabilitated and clean catchment discharges are between 1,110 ML/year and 9,760 ML/year.
- During dry climatic conditions (90%ile) modelled rehabilitated and clean catchment discharges are between 40 ML/year and 2,490 ML/year.

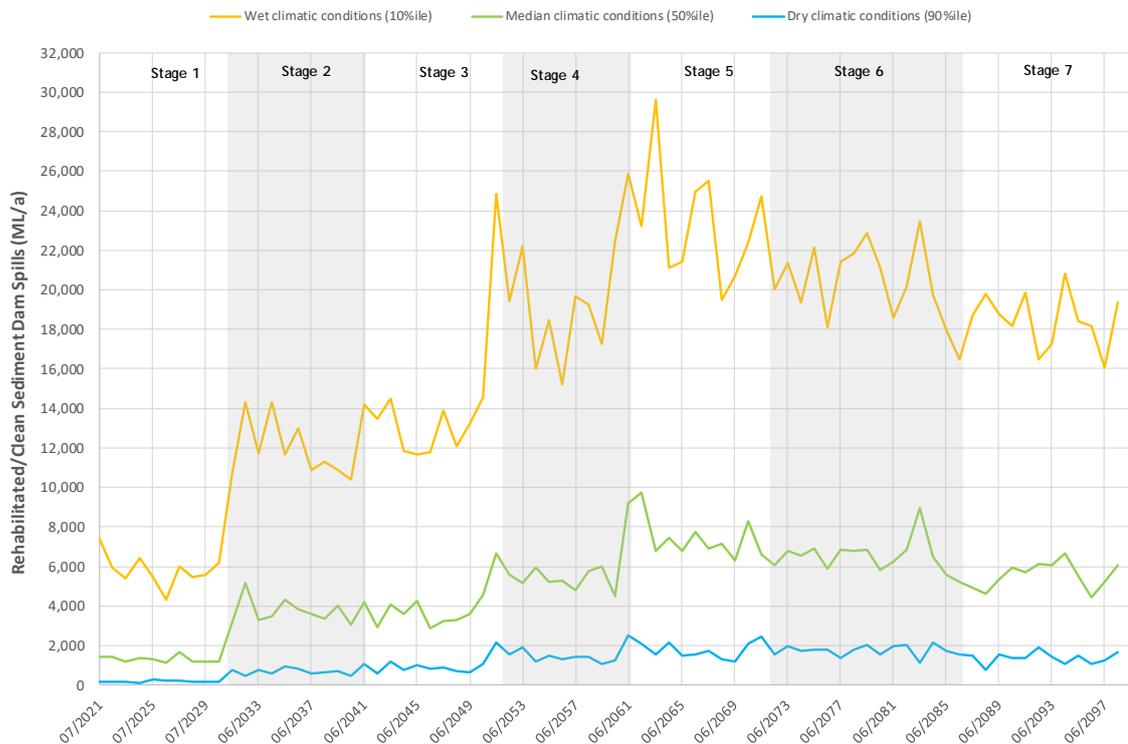


Figure 8-15: Forecast Annual Rehabilitated Catchment Discharges

An assessment of the predicted annual salt load discharged from the rehabilitated and clean catchments to the receiving environment has been undertaken for a representative “median” climatic sequence over the 79-year Project life. The annual salt loads have been ranked and presented as an AEP in Figure 8-16, which shows that under median climatic conditions:

- The annual salt load in rehabilitated and clean catchment discharges is around 190 tonnes/year (or more) for 90% of years.
- The annual salt load is rehabilitated and clean catchment discharges is around 1,560 tonnes/year (or more) for 50% of years.
- The annual salt load is rehabilitated and clean catchment discharges is around 5,130 tonnes/year (or more) for 10% of years.

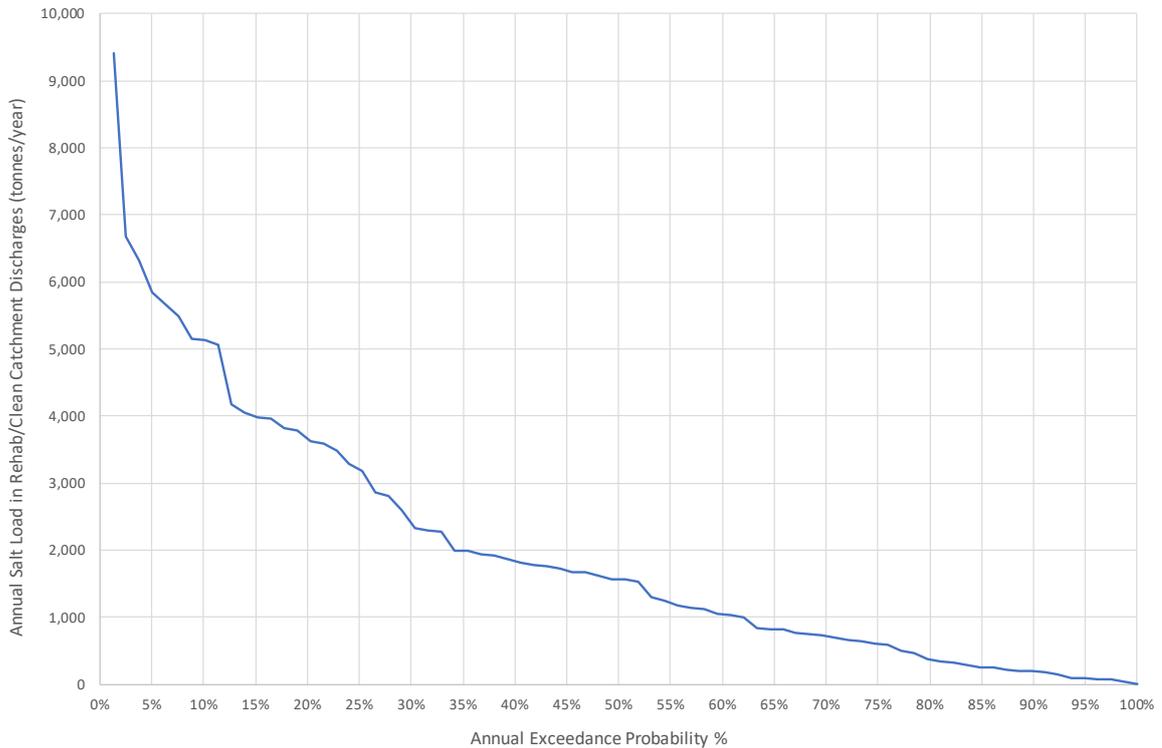


Figure 8-16: Rehabilitated/Clean Catchment Discharges – Annual Salt Load

8.3.8 Overall Salt Balance

Figure 8-17 shows a schematic of the salt inputs and outputs from the Project. Salt inputs to the Project include salts in the groundwater inflows, catchment runoff, direct rainfall, and external water. Salt outputs from the Project include salts which are lost through the CHPP in the rejects and product coal, site demands (including dust suppression and industrial usage), discharges through the controlled release strategy and offsite (spillway) discharges from the water management system.

The CHPP is a net user of water, as during the washing and sizing process the moisture content of the coarse and fine rejects and product materials is increased. This process traps water (and salt) in the coarse and fine rejects material. The material is then disposed of in dedicated zones within the open cut mining areas.

Table 8-3 shows the average annual salt balance for the Project, for each stage. The results indicate the following:

- The largest contributor to the Project salt load is through rainfall runoff from the various surfaces on the site. Significant salt loads are also imported via groundwater inflows and within the ROM coal moisture;
- The largest losses of salt from the Project are generally within the CHPP processing circuit (product coal and coarse rejects). Relatively large salt loads are also exported through dust suppression and sediment dam overflows; and
- The change in stored salt load is generally low in comparison to the total inputs and outputs, which suggests salt will not accumulative on site.

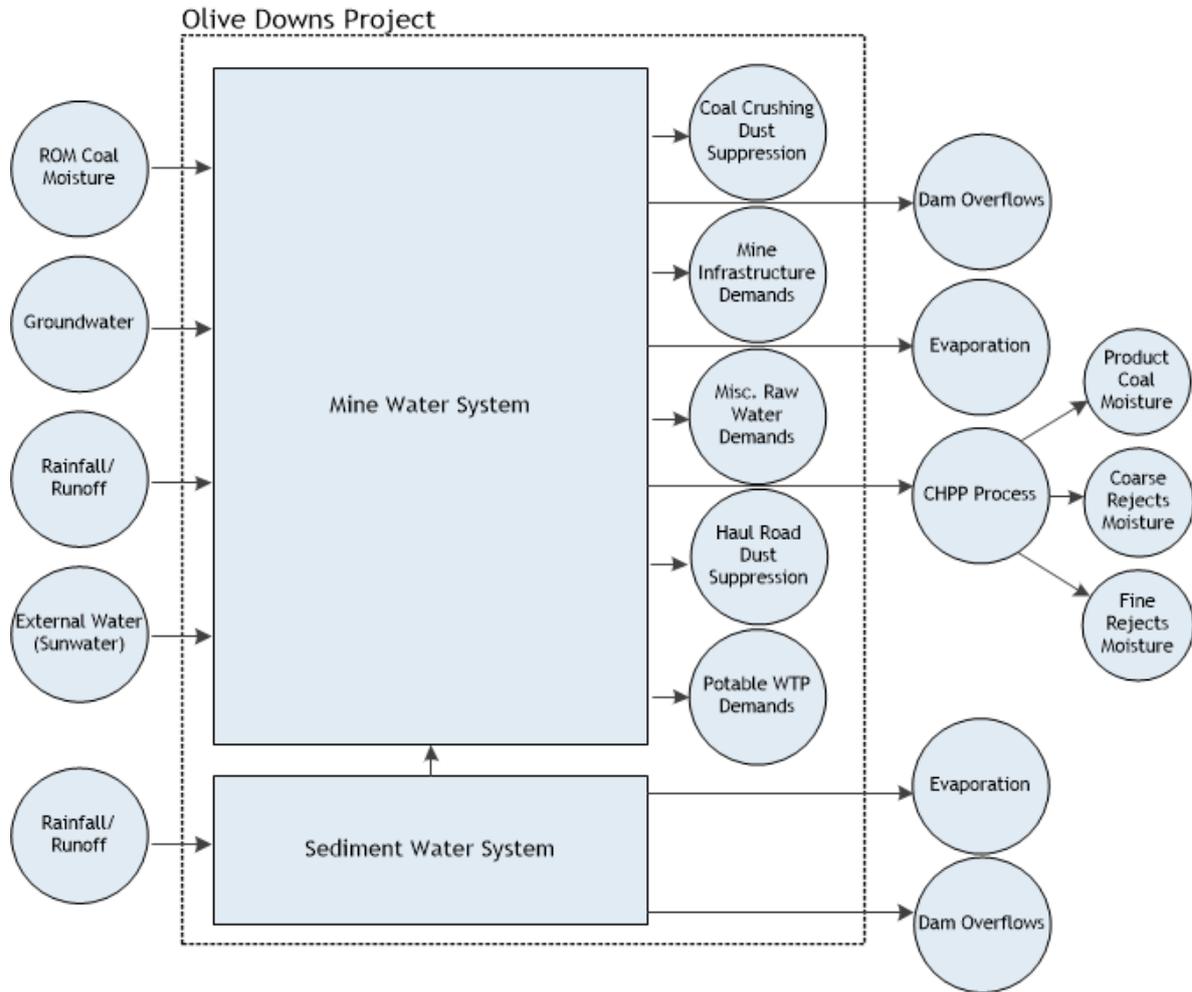


Figure 8-17: Simplified Surface Water Salt Balance Schematic

Table 8-3: Average Annual Salt Balance

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
SALT INPUTS (tonnes/year)							
Rainfall/runoff	2,404	9,357	9,935	9,166	8,775	8,689	9,111
Groundwater inflows	1,659	7,572	4,909	2,485	915	724	499
External water	158	102	98	73	53	53	52
ROM coal moisture	2,528	8,952	8,570	4,209	2,524	1,333	534
TOTAL INPUTS	6,749	25,990	23,512	15,933	12,278	10,798	10,196
SALT OUTPUTS (tonnes/year)							
Evaporation from storages	0	0	0	0	0	0	0
Dam overflows (offsite)							
<i>Mine affected water</i>	0	0	0	0	0	0	0
<i>Sediment water</i>	331	2,558	2,430	1,898	1,167	1,436	2,303
<i>Rehab/up-catchment water</i>	590	1,547	1,626	2,420	3,201	2,766	2,476
Controlled releases	784	1,395	1,157	1,209	1,100	965	815
CHPP							
<i>Product moisture</i>	1,040	5,543	4,979	2,429	1,195	618	244
<i>Coarse rejects moisture</i>	1,354	4,816	4,440	1,975	1,247	654	252
<i>Fine rejects - entrained</i>	457	2,277	1,946	854	469	259	122
Haul road dust suppression	806	4,956	4,377	3,791	2,748	2,777	1,674
Coal crushing/conveyor dust suppression	696	1,718	2,171	1,397	1,003	933	686
Miscellaneous raw water demands	139	276	241	213	159	151	137
Mine infrastructure demands	70	138	121	107	79	75	69
Potable WTP demands	10	12	12	13	13	13	13
TOTAL OUTPUTS	6,275	25,235	23,500	16,306	12,380	10,649	8,792
CHANGE IN SALT LOAD (tonnes/year)							
Change in stored salt load	474	755	12	-373	-102	149	1,404

8.4 Model Sensitivity Assessment

A suite of sensitivity analyses have been undertaken to assess the potential impact of variations in key parameters to the performance of the proposed water management system. These sensitivity scenarios that have been assessed are as follows:

- Scenario 1: Rejects cells decant return rate increased by 5%
- Scenario 2: Rejects cells decant return rate decreased by 5%
- Scenario 3: Global increase in AWBM soil capacity by 20%
- Scenario 4: Global decrease in AWBM soil capacity by 20%
- Scenario 5: Global increase in source salinity by 25%

The results from these sensitivity analyses are provided in Appendix A.

8.5 Adaptive Management of the Water Management System

The model results presented above represent the application of the proposed water management system rules over the mine life, regardless of climatic conditions. In reality, there are numerous options for adaptive management of the mine water system to respond to climatic conditions and the current site water inventory in a way that will reduce the risks of impacts to surface water resources.

A site water balance model will be developed once the mine is operational and will be updated regularly (annually or biennially) using site monitoring data.

8.6 Climate Change Assessment

8.6.1 Methodology

8.6.1.1 Approach

The climate change impact assessment for the Project was undertaken adopting the projections and methodologies given in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Commonwealth Bureau of Meteorology (BoM) report entitled "*Climate Change in Australia Technical Report*" (CSIRO, 2015). This report provides guidance on the possible projections of future climate for the East Coast based on a current understanding of the climate system, historical trends and model simulations of the climate response to changing greenhouse gas and decreasing aerosol emissions.

Projections are given for a number of climatic variables including (but not limited to) temperature, rainfall, solar radiation, wind speed, cyclones, potential evapotranspiration and sea levels for both short-term (2030) and long-term (2090) climate projections.

CSIRO (2015) presents a number of possible approaches to quantify risks associated with climate change impacts. The Project has adopted the 'sensitivity analysis' approach for the assessment of climate change impacts. Sensitivity analysis approach involves running a climate impact model with an observed climate dataset to establish a baseline level of risk, and then rerunning the model with the same input data, modified to represent 'best', 'worst' and 'maximum consensus' climate change scenarios to determine how sensitive the Project is to the scenario assessed.

For this assessment, the Representative Concentration Pathway 4.5 (RCP4.5) emissions scenario has been adopted.

8.6.1.2 Sensitivity Parameters

The climate variable inputs (rainfall and evaporation) to the Project water balance model (see Section 5.2.2) were adjusted to undertake the climate change impact assessment. Table 8-4 shows the adopted long-term (2090) climate projections for the 'best case' and 'worst case' RCP4.5 climate change scenarios. The 'maximum consensus' scenario has not been run as it falls between 'best case' and 'worst case' scenarios. These ranges were obtained using the projection builder tool provided in the Climate Change Australia website.

Table 8-4: Adopted Climate Change Impact Projections

Case	Change in Annual Rainfall	Change in Annual Evapotranspiration	Comments
Best Case	-19.8%	+6.9%	Representative model: GFDL-ESM2M Consensus: Low
Worst Case	+4.4%	+5.5%	Representative model: NorESM1-M Consensus: Low

Note: changes in annual rainfall and evapotranspiration are relative to the climate dataset (which was based on the 1889 to 2017 SILO dataset)

8.6.2 **Potential Climate Change Impacts**

8.6.2.1 *Overview*

Climate change impacts to the water balance were assessed for the operational period of the Project (2020-2098). The water balance model developed for the Project was used to simulate the 'best' case and 'worst' case climate scenarios. The water balance model climate inputs (rainfall and evaporation) were factored by the values given in Table 8-4.

8.6.2.2 *In-pit Storage*

Figure 8-18 and Figure 8-19 show the forecast inventory for the combined ODS and Willunga mining pits for the 'best' and 'worst' case climate scenarios in comparison to the base case results.

The model results are summarised as follows:

- 'Best' case climate scenario (Figure 8-18):
 - ◆ For the 10th percentile results (wet climatic conditions), the 'best' case modelled in-pit inventories are, on average, around 700 ML lower than the base case results.
 - ◆ For the 50th percentile results (median climatic conditions), the 'best' case modelled inventories are, on average, around 300 ML lower than the base case results.
- 'Worst' case climate scenario (Figure 8-19):
 - ◆ For the 10th percentile results (wet climatic conditions), the 'worst' case modelled in-pit inventories are, on average, around 1,200 ML lower than the base case results.
 - ◆ For the 50th percentile results (median climatic conditions), the 'worst' case modelled inventories are, on average, around 420 ML lower than the base case results.

Both climate cases result in a significant reduction in pit inventory during wet climatic conditions. This is likely due the increased evaporation for both climate cases.

Interestingly, the results for the ‘best’ case (or low rainfall case) show higher pit inventories worse than the ‘worst’ (or high rainfall case). This is due to the significant reduction in controlled release opportunities under the ‘best’ case due to less Isaac River flows. Refer to Section 8.6.2.4 for further details of the controlled release volumes for both climate scenarios.

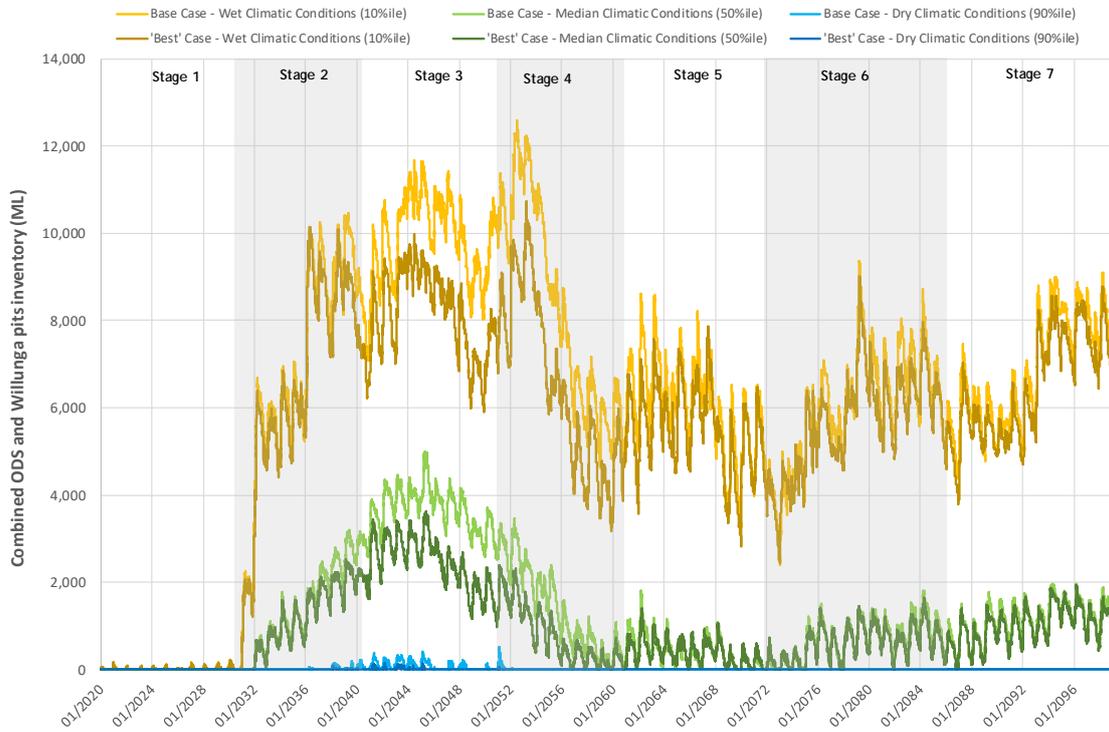


Figure 8-18: Forecast Pit Inventory – Combined - ‘Best’ Case Climate Change Sensitivity Assessment

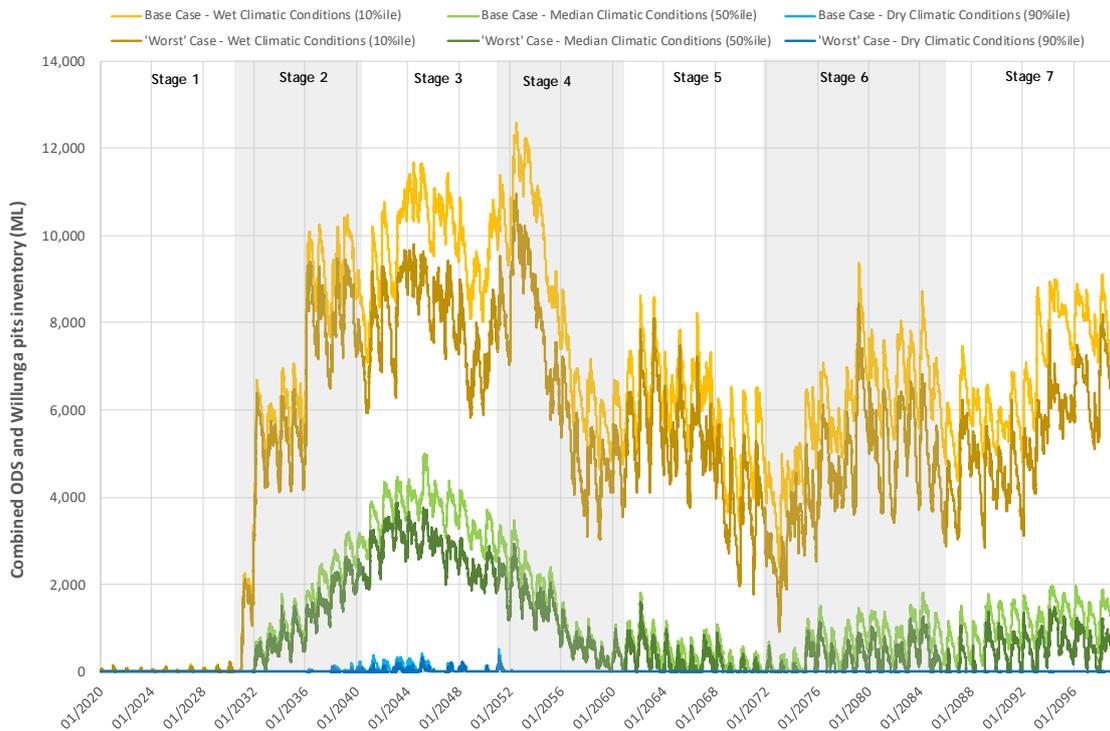


Figure 8-19: Forecast Pit Inventory – Combined - ‘Worst’ Case Climate Change Sensitivity Assessment

8.6.2.3 External Makeup Requirements

Figure 8-20 and Figure 8-21 show the forecast annual modelled demand for water from external sources for the ‘best’ and ‘worst’ case climate scenarios in comparison to the base case results.

The model results are summarised as follows:

- ‘Best’ case climate scenario (Figure 8-20):
 - ◆ For the 10th percentile results (dry climatic conditions), the ‘best’ case modelled annual external water demands are, on average, around 70 ML/a higher than the base case results.
 - ◆ For the 50th percentile results (median climatic conditions), the ‘best’ case modelled annual external water demands are, on average, around 10 ML/a higher than the base case results.
- ‘Worst’ case climate scenario (Figure 8-21):
 - ◆ For the 10th percentile results (dry climatic conditions), the ‘worst’ case modelled annual external water demands are, on average, around 200 ML/a higher than the base case results.
 - ◆ For the 50th percentile results (median climatic conditions), the ‘worst’ case modelled annual external water demands are, on average, around up to 100 ML/a higher than the base case results.

There is an increase in external water demand requirements under both the 'best' and 'worst' climate scenarios, when compared with the base case results. This is due to the increase in evaporation under both scenarios, which is enough to offset the increase in rainfall under the 'worst' case conditions.

Pembroke have sufficient allocation to meet site water demands under most climatic condition, for both climate change scenarios.

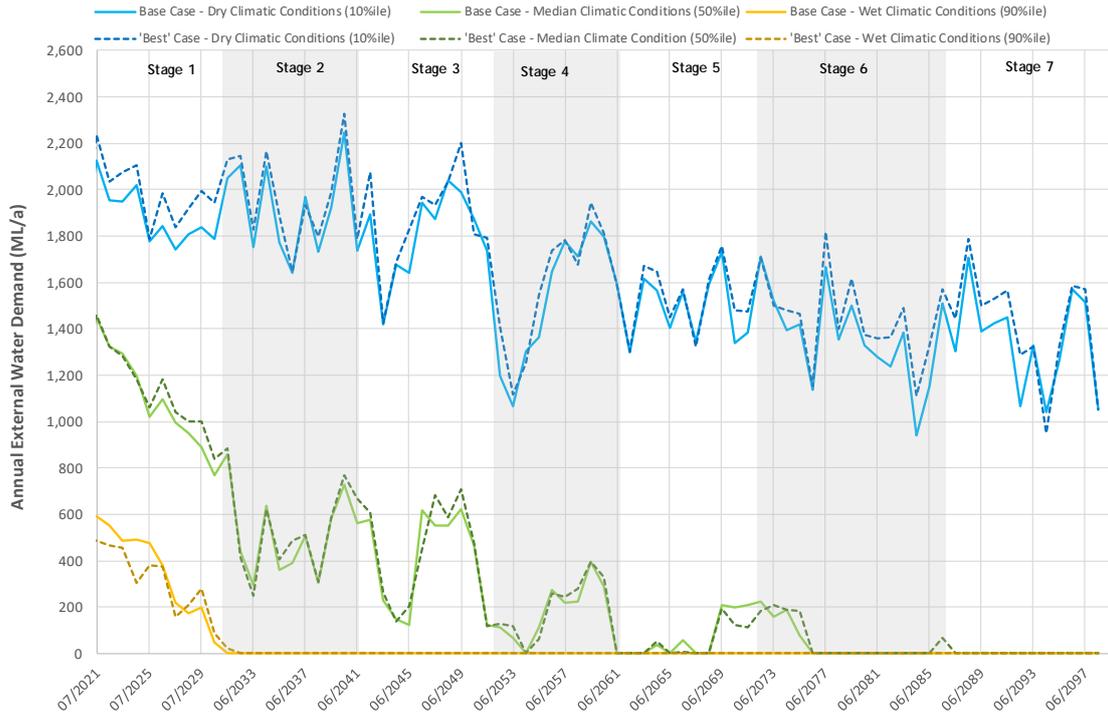


Figure 8-20: Forecast Annual External Water Requirements – 'Best' Case Climate Change Sensitivity Assessment

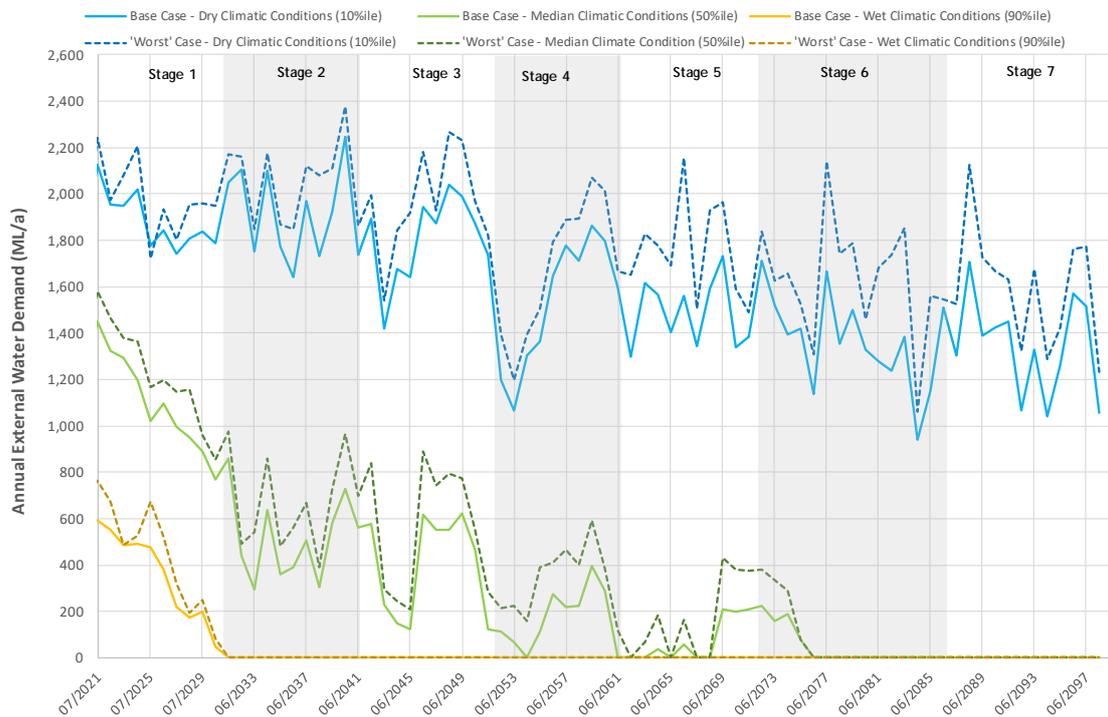


Figure 8-21: Forecast Annual External Water Requirements – ‘Worst’ Case Climate Change Sensitivity Assessment

8.6.2.4 Controlled Water Releases

Figure 8-22 and Figure 8-23 show the forecast annual controlled release volumes from the mine water storages for the ‘best’ and ‘worst’ case climate scenarios in comparison to the base case results.

The model results are summarised as follows:

- ‘Best’ case climate scenario (Figure 8-22):
 - ◆ For the 10th percentile results (wet climatic conditions), the ‘best’ case modelled annual controlled releases volumes are up to 920 ML/a lower than the base case results.
 - ◆ For the 50th percentile results (median climatic conditions), the ‘best’ case modelled annual controlled releases volumes are up to 430 ML/a lower than the base case results.
- ‘Worst’ case climate scenario (Figure 8-23):
 - ◆ For the 10th percentile results (wet climatic conditions), the ‘best’ case modelled annual controlled releases volumes are up to 330 ML/a lower than the base case results.
 - ◆ For the 50th percentile results (median climatic conditions), the ‘best’ case modelled annual controlled releases volumes are up to 190 ML/a lower than the base case results.

There is an overall decrease in annual controlled release volumes under both the 'best' and 'worst' climate scenarios, when compared with the base case results. The decrease is far more significant under the 'best' case climate scenario. This is primarily due to the reduction in average rainfall resulting in a significant lower number of release opportunities in the Isaac River.

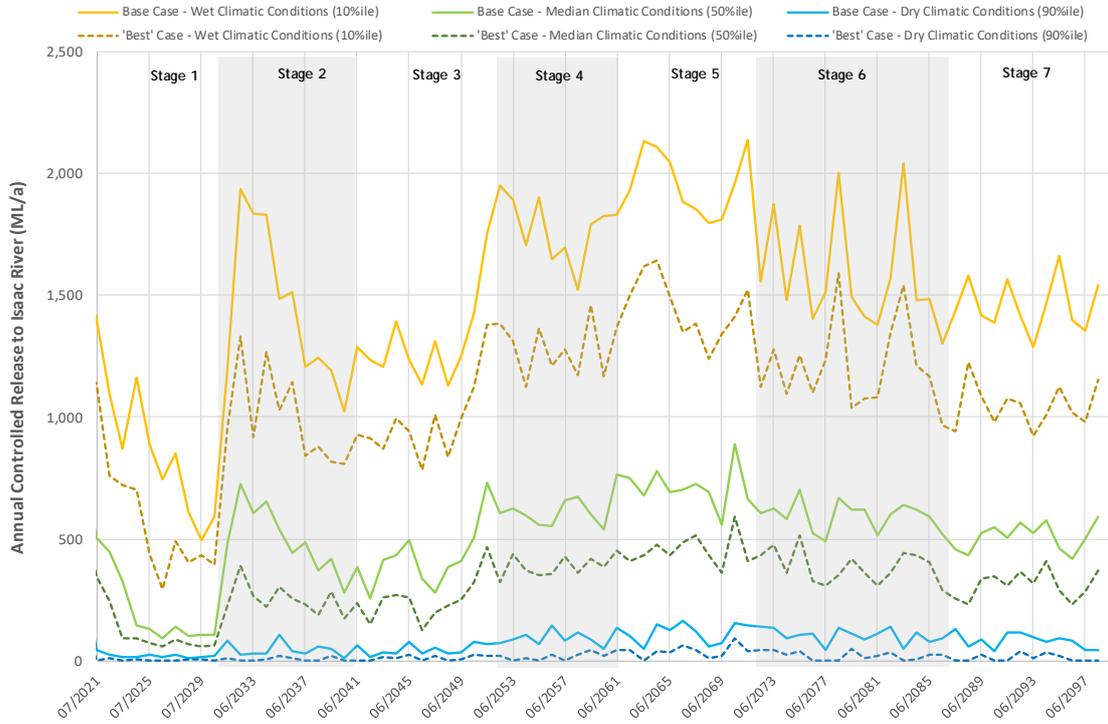


Figure 8-22: Forecast Annual Controlled Release Volumes – 'Best' Case Climate Change Sensitivity Assessment

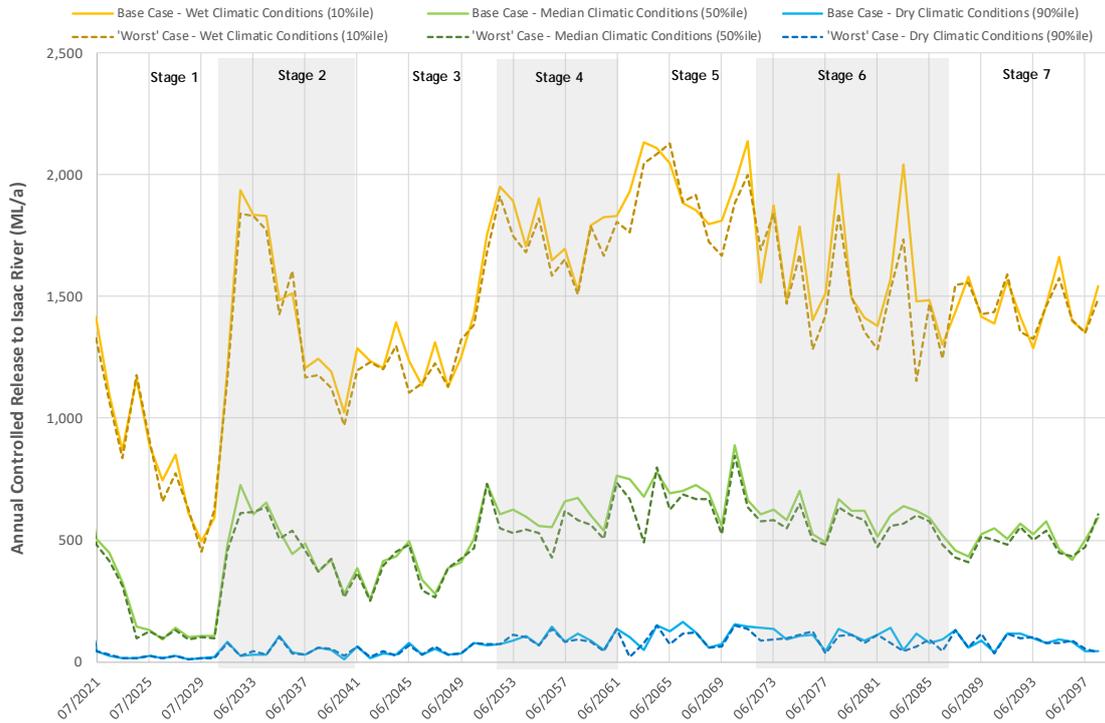


Figure 8-23: Forecast Annual Controlled Release Volumes – ‘Worst’ Case Climate Change Sensitivity Assessment

9. Final Void Behaviour

9.1 Overview

Water levels in the final voids will vary over time, depending on the prevailing climatic conditions, and the balance between evaporation losses and inflows from rainfall, surface runoff, and groundwater. A GOLDSIM model (separate to the OPSIM model used for the operational modelling) was used to assess the likely long-term water level behaviour of the final voids. The historical rainfall and evaporation sequences (128 years) were repeated 5 times to create a long-term climate record.

A linearly varying depth-dependent storage evaporation factor has been applied to each void to simulate the change in evaporation as void water levels increase. The storage evaporation factors are as follows:

- Bottom of void – 0.5
- 10m from top of void – 0.95
- Top of void – 1.0

The volume of water in the voids is calculated at each time step as the sum of direct rainfall to the void surface, catchment runoff, and groundwater inflows, less evaporation losses.

9.2 Final Void Configuration

The final void configuration and contributing catchment areas are shown in Figure 9-1 and Figure 9-2 and summarised in Table 9-1. The final catchment draining to the voids will be minimised using up-catchment diversions. The proposed up-catchment diversion drains for the final voids will be designed to the following design criteria:

- Slope of drains to match slope of existing natural gully lines in the vicinity, which is in the order of 0.3% to 0.4%. The slopes will be designed to minimize scouring during major flood events.
- Side slopes of drain batters to be in the order of 1 vertical to 6 horizontal.
- Where drains are constructed in spoil areas, the spoil zone under drains shall be compacted to a depth of 500mm.
- Any fill embankments required for the drains shall be compacted in layers not exceeding 200mm.
- Drains will be designed to convey a 0.1% AEP flow with a minimum freeboard of 1.0 m.
- Drains to be vegetated to match vegetation in existing natural gully lines in the vicinity.
- Erosion and sediment control measures shall be implemented until vegetation in the drains is established.
- Drains to meander to create “natural” looking flow paths.

- Drains to be designed and constructed to be self-sustaining and to avoid ongoing maintenance.

Table 9-1: Contributing Catchment to Final Voids

Final Void	Contributing Catchment (ha)
Pit 3	1,191
Pit 7/8	1,208
Willunga	2,506

9.3 Stage-storage Characteristics

The stage-storage curve for Pit 3, Pit 7/8 and Willunga voids Void have been estimated from the final landform terrain model provided by Pembroke. The geometries of the final voids are summarised in Table 9-2.

Table 9-2: Modelled Final Void Geometry

Final Void	Depth (m)	Pit Void Overflow Level/Volume	Overflow Level/Volume to Receiving Environment
Pit 3	275	172 mAHD/ 339,200 ML	194 mAHD/ 477,000 ML
Pit 7/8	289	163 mAHD/ 619,400 ML	178 mAHD/ 749,300 ML
Willunga	227	157 mAHD/ 648,600 ML	161 mAHD/ 689,000 ML

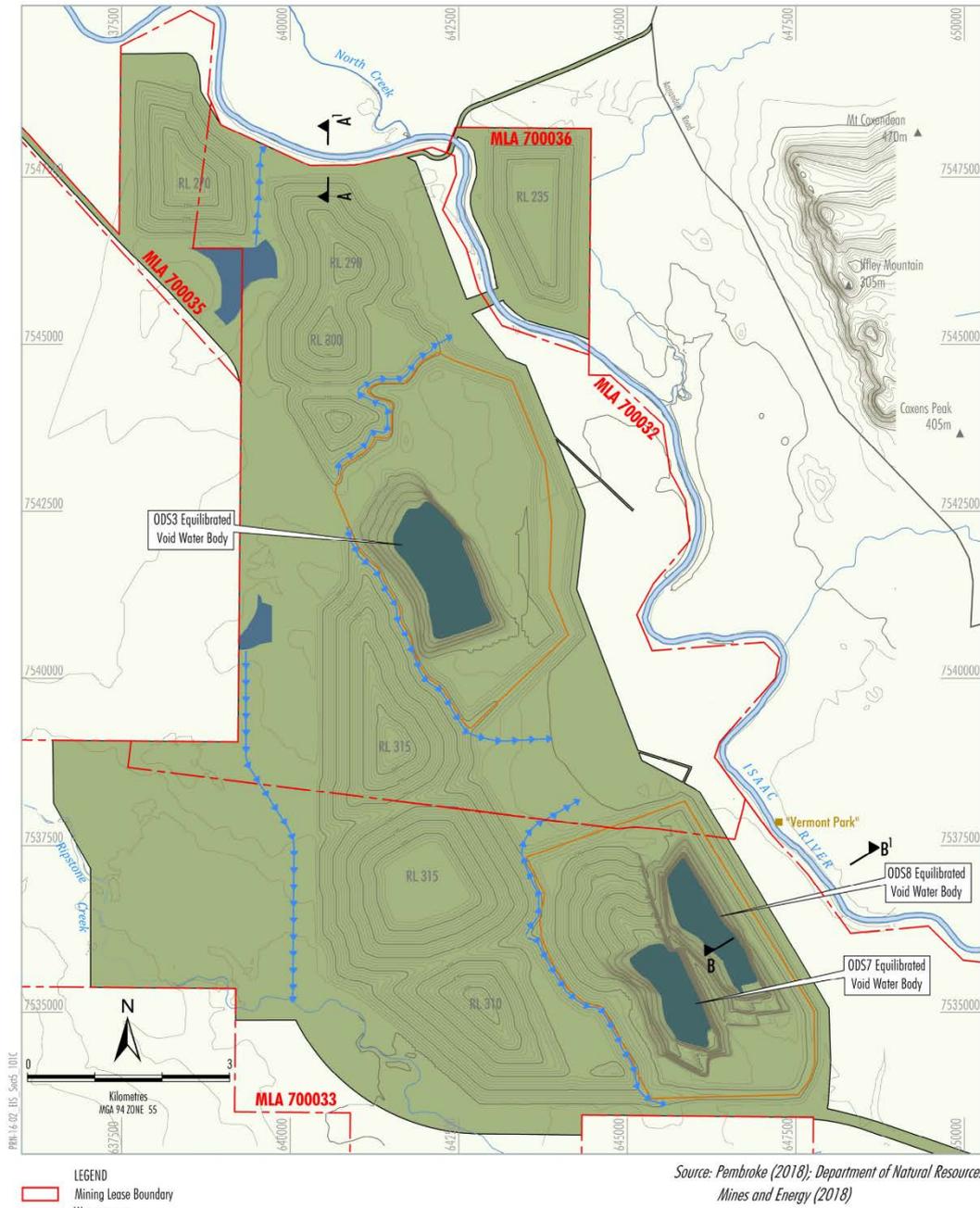
9.4 Final Void Runoff Salinity

The adopted salinity concentrations for the final void catchment are as follows:

- Mining pit floor: 4,500 $\mu\text{s/cm}$
- Rehabilitated landform: 300 $\mu\text{s/cm}$

The adopted runoff salinity for the final void assessment is applied at a fixed concentration and does not include any allowance for decay in runoff salinity over time.

The adopted salinity for groundwater inflows to the final void is the same as that adopted for operational groundwater inflows (8,910 $\mu\text{s/cm}$).



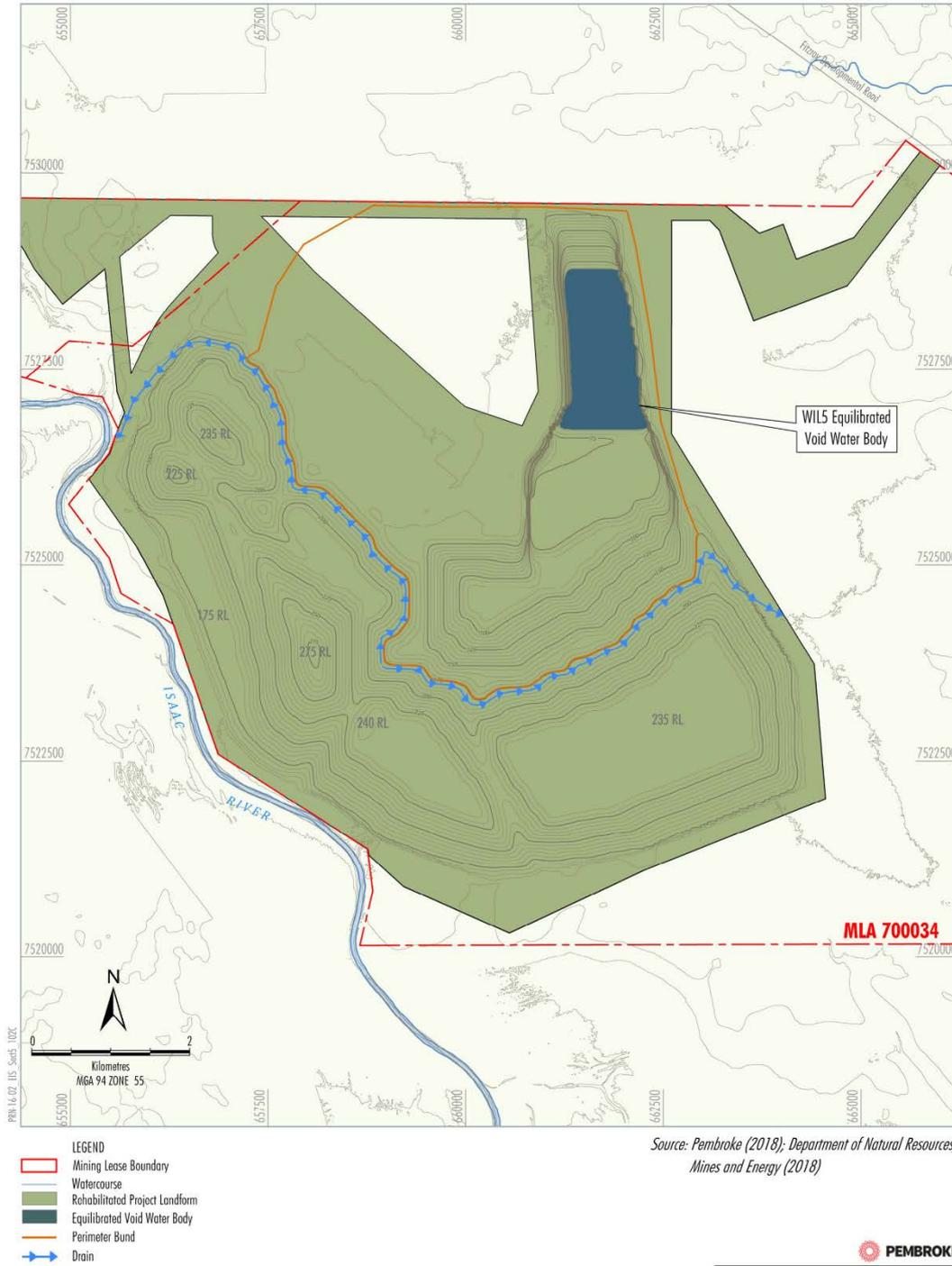
- LEGEND**
- - - Mining Lease Boundary
 - Watercourse
 - - - Proposed Creek Diversion
 - Dwelling
 - Rehabilitated Project Landform
 - Equilibrated Void Water Body
 - Perimeter Bund
 - Dam
 - ➔ Drain

Source: Pembroke (2018); Department of Natural Resources, Mines and Energy (2018)

PEMBROKE
 OLIVE DOWNS COKING COAL PROJECT
 Conceptual Final Landform -
 Olive Downs South Domain

Figure 5-2

Figure 9-1: Final Void Configuration – ODS Domain



PEMBROKE
 OLIVE DOWNS COKING COAL PROJECT
 Conceptual Final Landform -
 Willunga Domain

Figure 5-3

Figure 9-2: Final Void Configuration – Willunga Domain

9.5 Groundwater Inflows

Groundwater inflows to the final voids were provided by SLR. Figure 9-3, Figure 9-4 and Figure 9-5 shows the pit water level versus groundwater inflow rates for the Pit 3, Pit 7/8 and Willunga final voids.

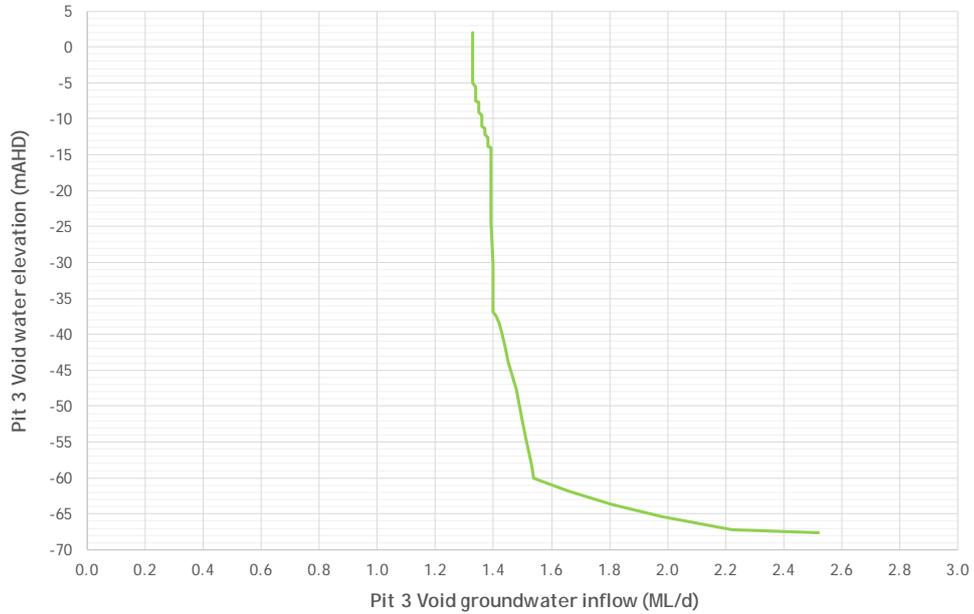


Figure 9-3: Water Level vs Groundwater Inflow Relationship – Pit 3 Final Void

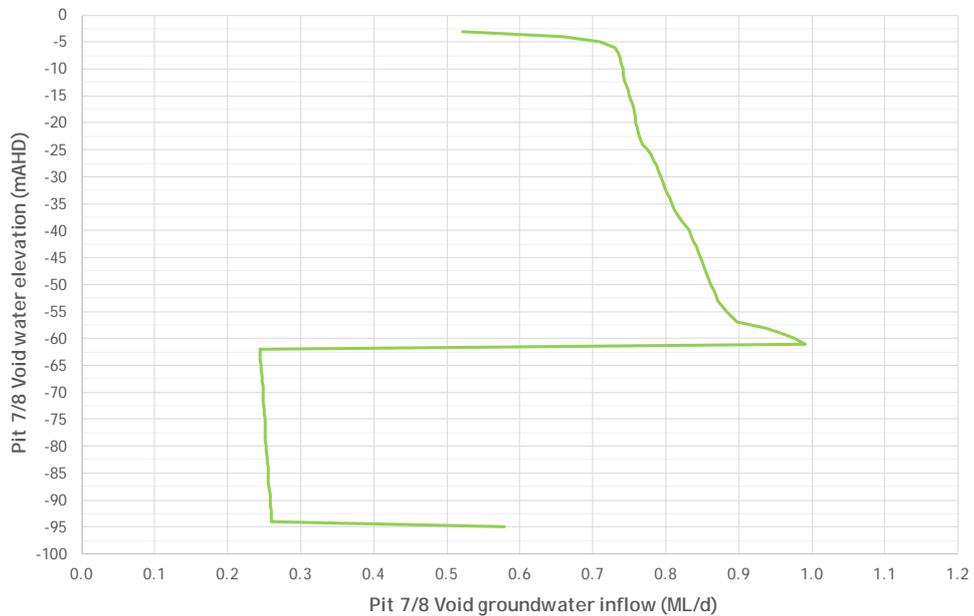


Figure 9-4: Water Level vs Groundwater Inflow Relationship – Pit 7/8 Final Void

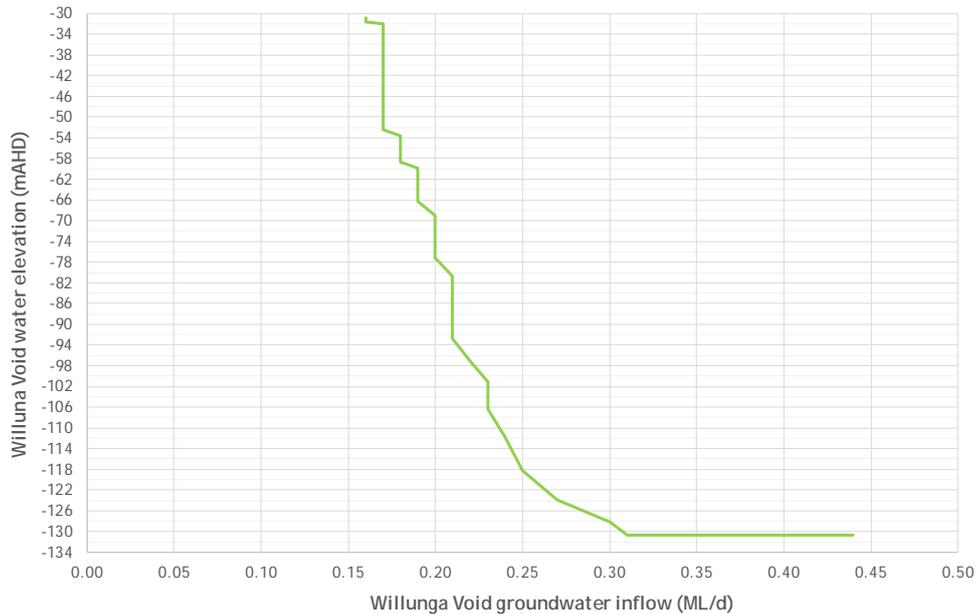


Figure 9-5: Water Level vs Groundwater Inflow Relationship – Willunga Final Void

9.6 Model Results

Figure 9-6, Figure 9-7 and Figure 9-8 show the simulated long-term water levels in the final voids. The model results show the following:

- Pit 3 void
 - ◆ The water level reaches equilibrium between 80 mAHD and 90 mAHD after 200 years and generally remains at these levels throughout the remainder of the simulation.
 - ◆ The maximum modelled water level is around 82 m below the Pit 3 void overflow level, and around 100 m below the level at which overflows would reach the receiving environment.
 - ◆ Salt accumulates within the Pit 3 void at an average rate of around 5,000 tonnes per year. The void becomes hyper-saline (>35,000 mg/L) after around 550 years of simulation.
- Pit 7/8 void
 - ◆ The water level reaches equilibrium between 20 mAHD and 30 mAHD after 150 years and generally remains at these levels throughout the remainder of the simulation.
 - ◆ The maximum modelled water level is around 130 m below the Pit 7/8 void overflow level, and around 145 m below the level at which overflows would reach the receiving environment.

- ◆ Salt accumulates within the Pit 7/8 void at an average rate of around 3,800 tonnes per year. The void becomes hyper-saline (>35,000 mg/L) after around 550 years of simulation.
- Willunga void
 - ◆ The water level reaches equilibrium between 55 mAHD and 70 mAHD after 100 years and generally remains at these levels throughout remainder of the simulation.
 - ◆ The maximum modelled water level is around 85 m below the Willunga void overflow level, around 90 m below the level at which overflows would reach the receiving environment.
 - ◆ Salt accumulates within the Willunga void at an average rate of around 3,000 tonnes per year. The void approaches hyper-salinity (>35,000 mg/L) towards the end of the 600 year simulation.

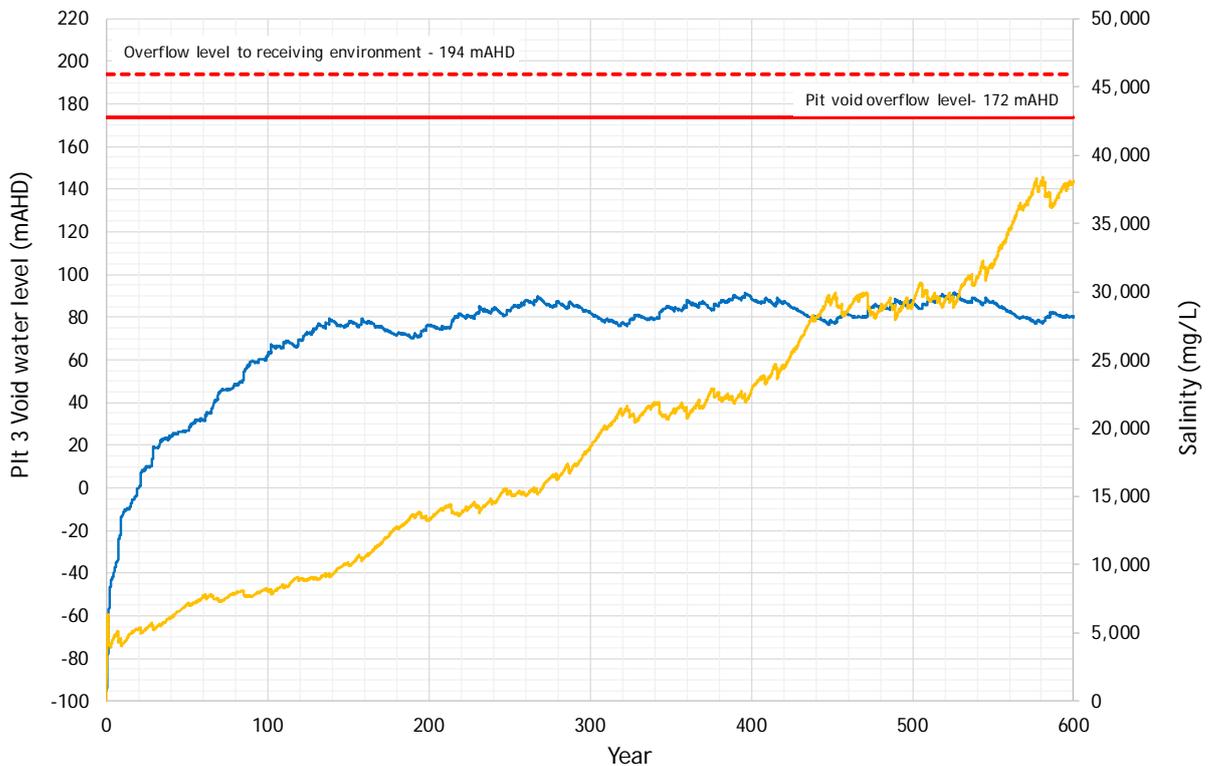


Figure 9-6: Final Void Water Levels and Salt Load – Pit 3 Void

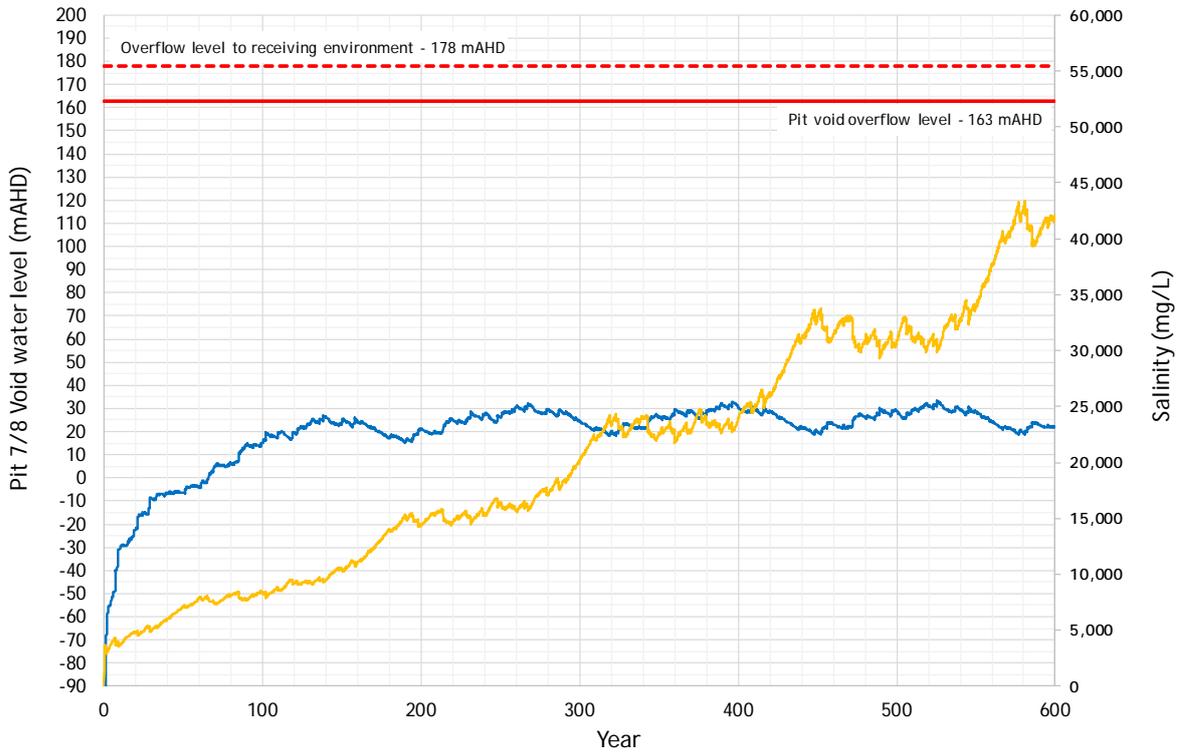


Figure 9-7: Final Void Water Levels and Salt Load – Pit 7/8 Void

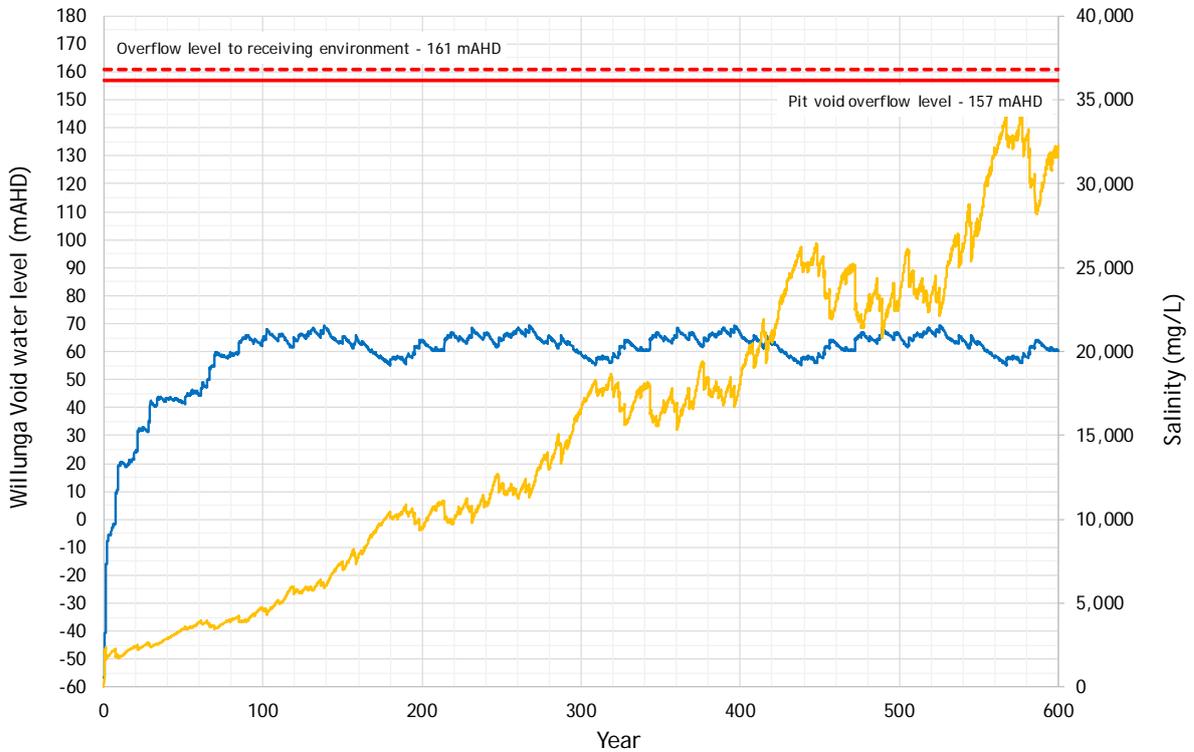


Figure 9-8: Final Void Water Levels and Salt Load – Willunga Void

The final void modelling indicates that the expected water levels are below the full supply levels for each void, and the voids will remain as long-term groundwater sinks (Hydrosimulations, 2018). As there is no mechanism to lose salt within the closed void system, the voids continually accumulate salt over time and become hypersaline or approach hypersaline conditions over the 600-year simulation.

9.7 Sensitivity Analysis

A sensitivity analysis has been undertaken to assess the potential impact of the adopted evaporation factors on the equilibrium level within the final voids.

As described in Section 9.1, a linearly varying depth-dependent storage evaporation factor has been applied to each void to simulate the change in evaporation as void water levels increase. The storage evaporation factors adopted for the base case model are as follows:

- Bottom of void – 0.5
- 10m from top of void – 0.95
- Top of void – 1.0

There is currently very little information available within the mining industry regarding void evaporation factors, and this introduces some uncertainty into the modelling outcomes. To address this uncertainty, a sensitivity assessment using increase and decreased evaporation factors has been undertaken. The proposed modified factors are as follows:

- Reduced evaporation factors:
 - ◆ Bottom of void – 0.3
 - ◆ Top of void – 0.7
- Increased evaporation factors:
 - ◆ Bottom of void – 0.8
 - ◆ Top of void – 1.0

The results from these sensitivity analyses are provided in the following section.

9.7.1 *Impact of Evaporation Factors on Final Void Water Levels*

The impact of variation in evaporation factors for the Pit 3, Pit 7/8 and Willunga final void water levels is presented in Figure 9-9, Figure 9-10 and Figure 9-11. The results show the following (in comparison to the base case results):

- Pit 3 Void (Figure 9-9):
 - ◆ With reduced evaporation factors, the equilibrium level takes around 100 years longer to be reached and is around 40 m higher.
 - ◆ With increased evaporation factors, the equilibrium level is reached in a similar timeframe and is around 20 m lower.

- Pit 7/8 Void (Figure 9-10):
 - ◆ With reduced evaporation factors, the equilibrium level takes around 100 years longer to be reached and is around 30 m higher.
 - ◆ With increased evaporation factors, the equilibrium level is reached in a similar timeframe and is around 20 m lower.
- Willunga Void (Figure 9-11):
 - ◆ With reduced evaporation factors, the equilibrium level is reached in a similar timeframe and is around 20 m higher.
 - ◆ With increased evaporation factors, the equilibrium level is reached in a similar timeframe and is around 5-10 m lower.

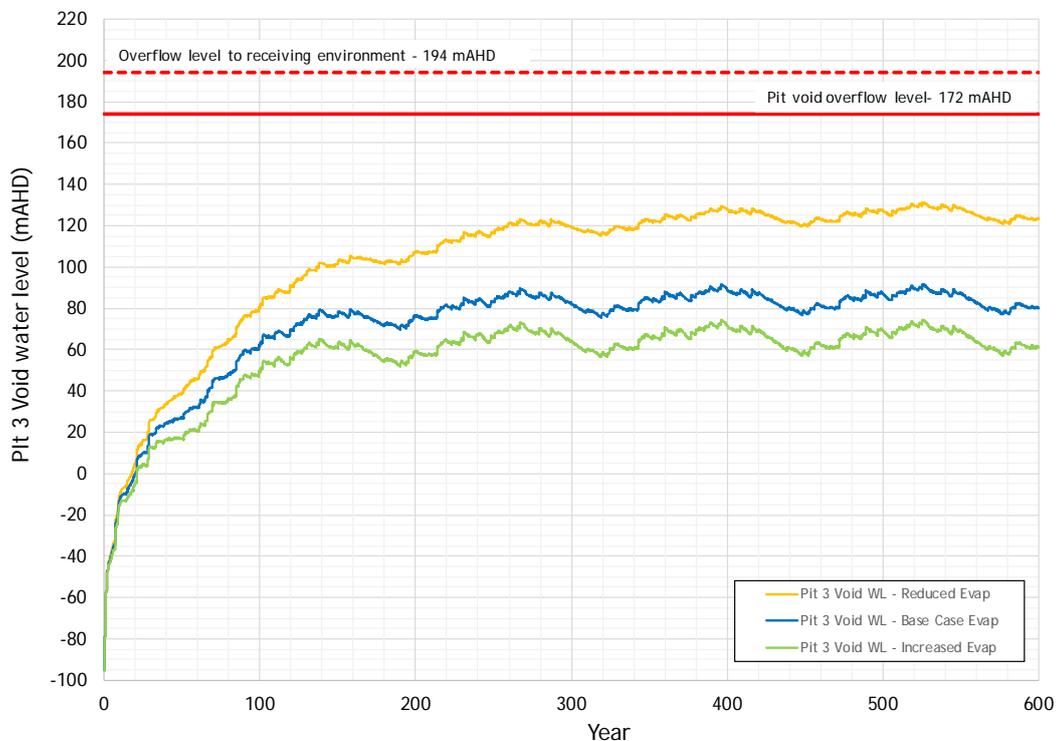


Figure 9-9: Evaporation Factor Sensitivity Analysis - Final Void Water Level – Pit 3 Void

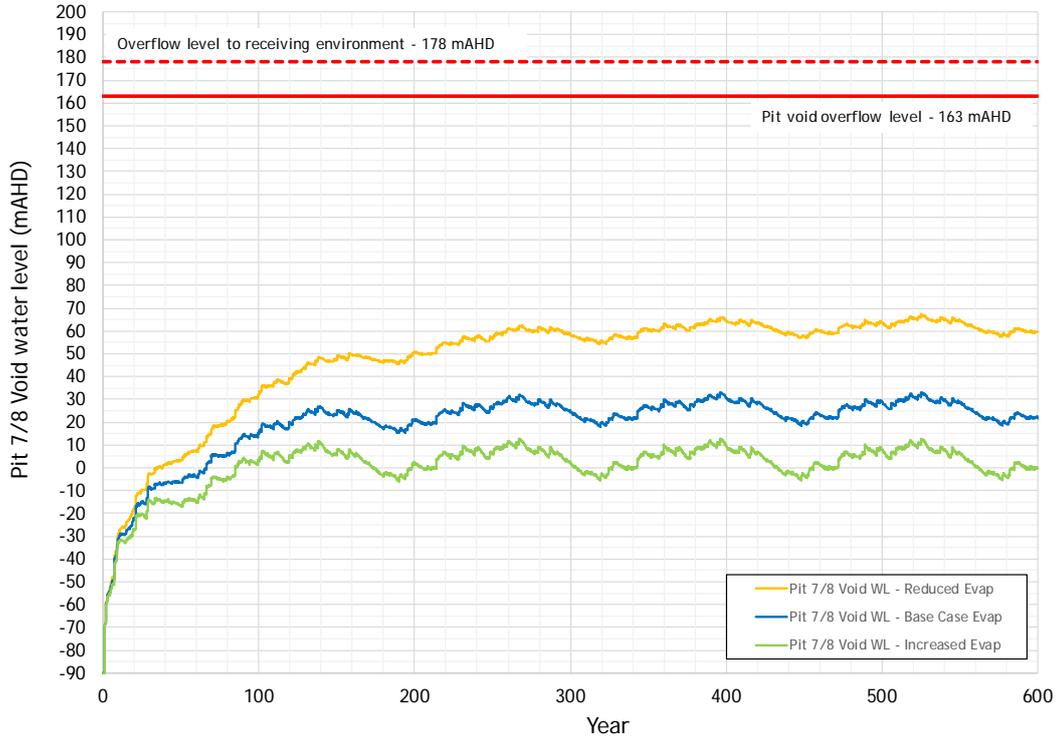


Figure 9-10: Evaporation Factor Sensitivity Analysis - Final Void Water Levels - Pit 7/8 Void

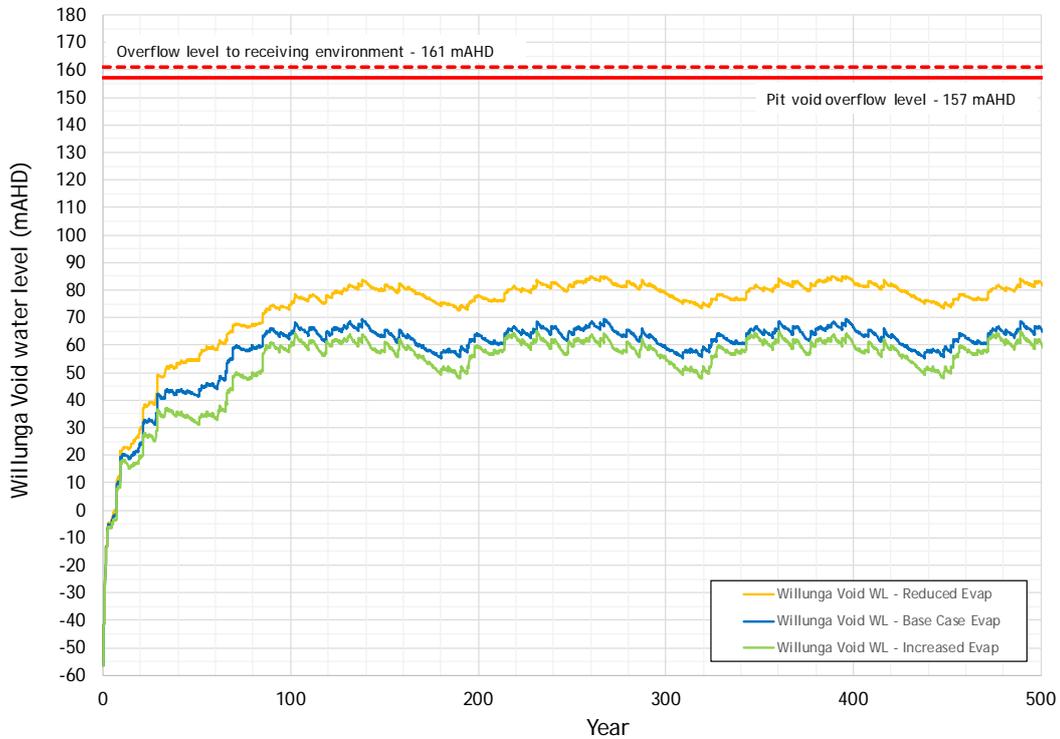


Figure 9-11: S Evaporation Factor Sensitivity Analysis - Final Void Water Levels – Willunga Void

9.7.2 **Impact of Evaporation Factors on Final Void Salinity**

The impact of variation in evaporation factors for the Pit 3, Pit 7/8 and Willunga final void salinity is presented in Figure 9-12, Figure 9-13 and Figure 9-14. The results show the following (in comparison to the base case results):

- Pit 3 Void (Figure 9-12):
 - ◆ With reduced evaporation factors, the void salinity following the 600 year simulation is around 40% lower.
 - ◆ With increased evaporation factors, the void salinity concentration following the 600 year simulation is around 30% higher.
- Pit 7/8 Void (Figure 9-13):
 - ◆ With reduced evaporation factors, the void salinity following the 600 year simulation is around 50% lower.
 - ◆ With increased evaporation factors, the void salinity following the 600 year simulation is around 70% higher.
- Willunga Void (Figure 9-14):
 - ◆ With reduced evaporation factors, the void salinity following the 600 year simulation is around 35% lower.
 - ◆ With increased evaporation factors, the void salinity following the 600 year simulation is around 10% higher.

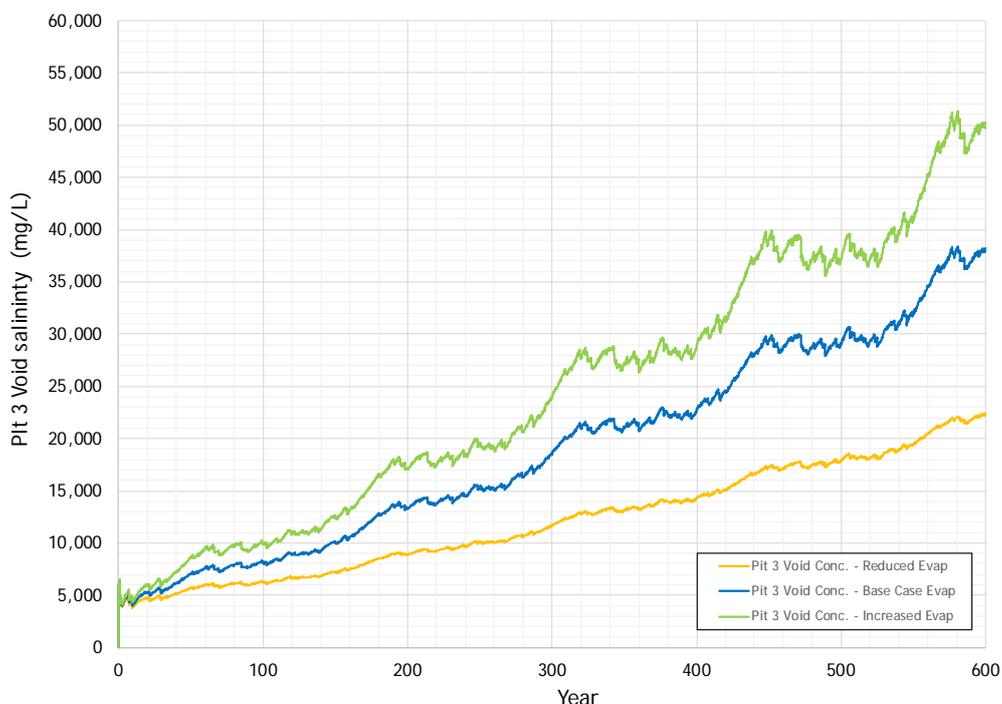


Figure 9-12: Evaporation Factor Sensitivity Analysis - Final Void Water Level – Pit 3 Void

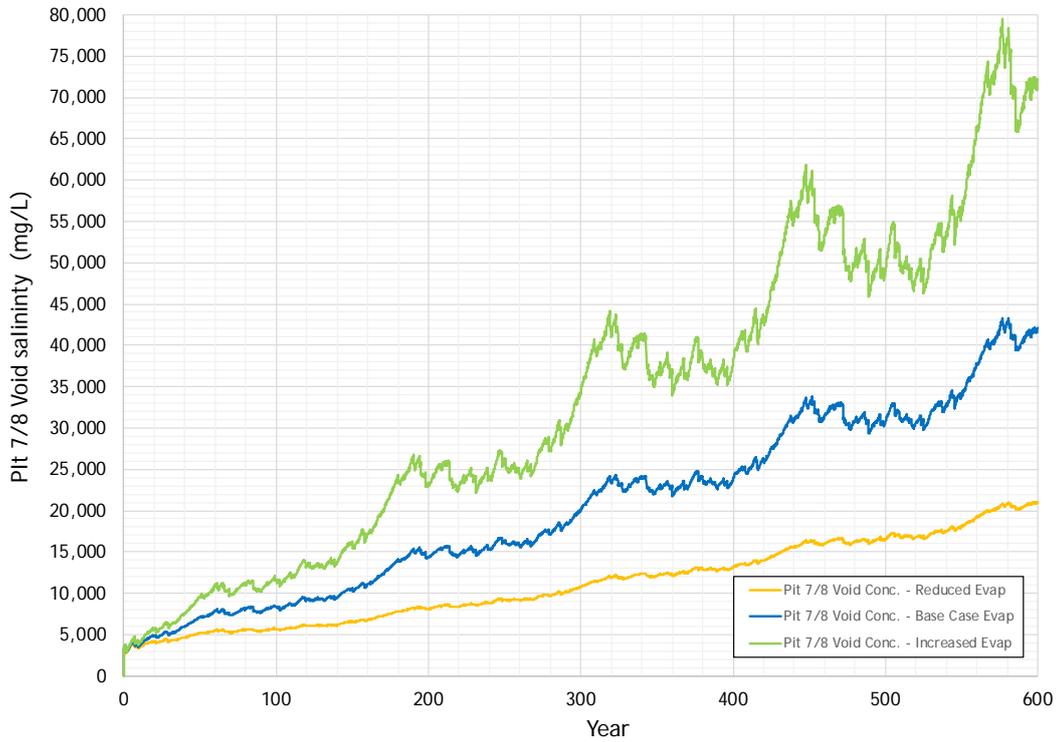


Figure 9-13: Evaporation Factor Sensitivity Analysis - Final Void Water Levels - Pit 7/8 Void

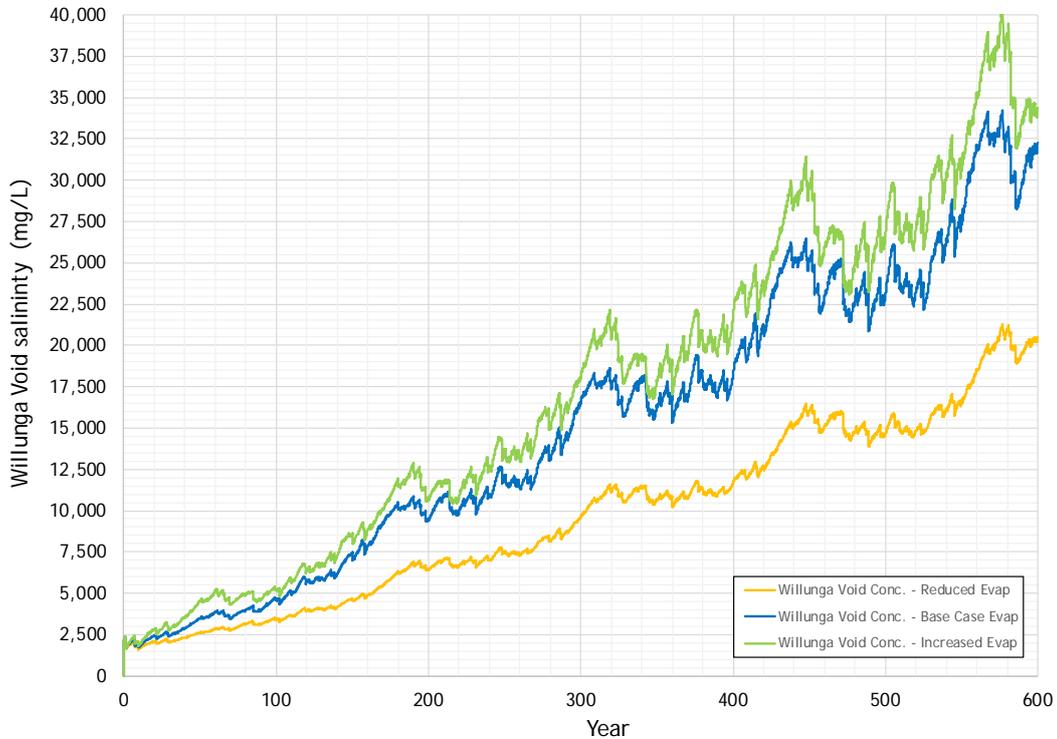


Figure 9-14: S Evaporation Factor Sensitivity Analysis - Final Void Water Levels – Willunga Void

10. Mitigation and Management Measures

10.1 Potential Impacts

The potential impacts of the Project on surface water resources include:

- impacts on flows and the flooding regime in Ripstone Creek and the Isaac River;
- impacts on regional water availability due to the potential need to obtain water from external sources to meet operational water requirements of mining operations;
- impacts on stream flows due to loss of catchment area draining to local drainage paths due to capture of runoff within onsite storages and the open cut pit;
- adverse impacts on the quality of surface runoff draining from the disturbance areas to the various receiving waters surrounding the Project, during both construction and operation of the Project;
- adverse impacts on environmental values in the Isaac River associated with controlled releases from the mine water management system;
- impact of water management system on adjacent wetlands; and
- cumulative impacts of all projects in the region on the environmental values of the receiving waters.

An assessment of each of these potential impacts of the Project is provided in the following sections.

The assessment of surface water impacts has been undertaken based on commonly applied methodologies for the simulation of hydrologic and hydraulic processes using currently available data. The adopted approach is considered suitable for quantifying impacts to a level of accuracy consistent with current industry practice. Certain aspects of the project, such as changes to landforms due to construction of out-of-pit waste rock emplacements or mine subsidence, will create impacts that are irreversible, although this does not mean that any such impacts are necessarily detrimental to the environmental values of receiving waters.

10.2 Flooding

Potential impacts of the Project on flood levels and flood velocities in Ripstone Creek and the Isaac River are addressed in a separate report (Hatch, 2018). Refer to this report for further details regarding the flood-related impact assessment.

10.3 Regional Water Availability Impacts

A significant proportion of mine site water requirements will be sourced from water collected on the site, including rainfall runoff and groundwater inflows to the open cut pit which will be stored in the mine affected water dams for recycling and reuse.

The results of the water balance modelling (see Section 8.3.4) show that there is less than a 10% probability that the proposed water licence allocation of 2,250 ML will require supplementing in any one year.

If, during operations, there was a risk that the allocation could be exceeded, the site water demands could be adjusted (e.g. dust suppressants) or alternative water harvesting measures could be implemented.

10.4 Stream Flow Impacts

10.4.1 *During Active Mining Operations*

During active mining operations, the Project water management system will capture runoff from areas that would have previously flowed to the receiving waters of Ripstone Creek and the Isaac River. The loss of catchment affects an 8 km reach of Ripstone Creek. The captured catchment area will change as the mine develops, and out-of-pit waste rock emplacement are progressively rehabilitated. A breakdown of the catchment areas reporting to the Project water management system is provided in Table 10-1 and excludes areas managed under the ESCP strategy and areas that are fully rehabilitated. Areas managed under the ESCP will drain from the site following treatment.

Table 10-1 and Figure 10-1 shows the maximum catchment area captured within the Project water management system during active mining operations (excluding ESC managed or fully rehabilitated areas). The maximum captured catchment areas represent:

- Less than 13% of the Ripstone Creek catchment to its confluence with the Isaac River; and
- Less than 1% of the Isaac River at a location downstream of the Project (the ISDS stream gauge).

Given that the runoff volumes from the ESCP areas will be higher than under natural conditions, the loss of stream flows will likely be less than the loss of catchment area. The loss of catchment to Ripstone Creek only affects an 8 km reach the creek.

Table 10-1: Catchment Area Captured Within the Project Water Management System

Catchment	Total Catchment Area (km ²)	Captured Catchment Area (km ²)						
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Ripstone Creek (to the confluence with Isaac River)	286	6	21	26	31	36	35	35
Isaac River (to the ISDS stream gauge)	7,782	10	48	50	48	49	51	38

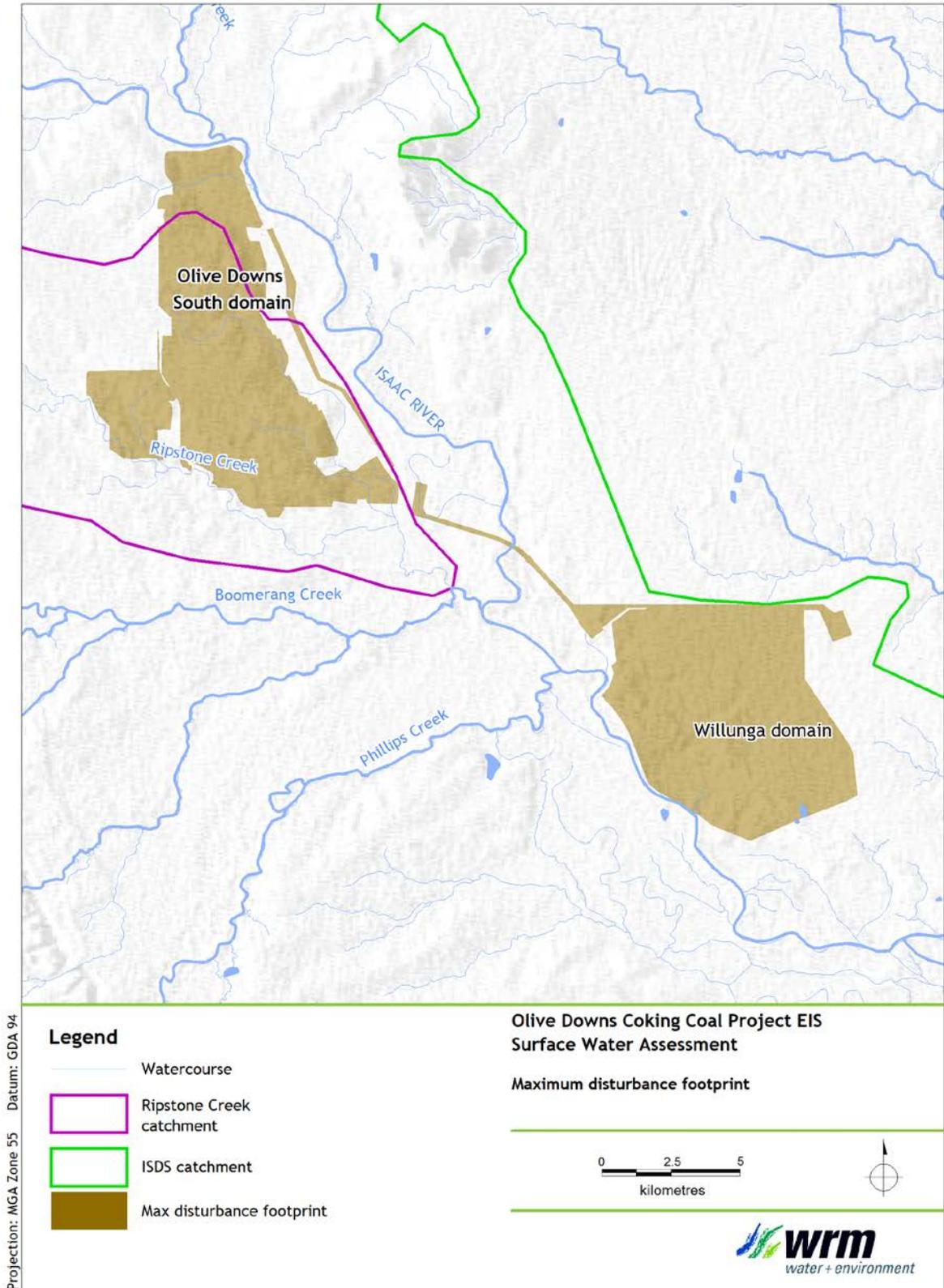


Figure 10-1: Maximum Captured Catchment During Operations

10.4.2 **Post-mining Final Landform**

At the completion of mining, permanent drainage of out-of-pit waste rock emplacement areas will be installed to minimise capture of surface runoff in the final void in general accordance with the configurations shown in Figure 9-1 and Figure 9-2. An area of approximately 49 km² will continue to drain to the final voids.

The net change in catchment area draining from the site is summarised in Table 10-2. The changed topography as a result of the Project final landform will have the following impacts on catchment areas:

- The catchment draining to Ripstone Creek will reduce by around 19 km² (compared to pre-mining conditions), a decrease of less than 7%.
- The catchment draining to the Isaac River will reduce by around 49 km² (compared to pre-mining conditions), a decrease of less than 1%.

Table 10-2: Final Landform – Captured Catchment Areas

Receiving Watercourse	Pre-mining Catchment Area (km ²)	Post-mining Catchment Area (km ²)	Post-mining Captured Catchment Area (km ²)
Ripstone Creek (to the confluence with Isaac River)	286	267	19
Isaac River (to the ISDS stream gauge)	7,782	7,733	49

10.5 **Regional Water Quality and Environmental Values**

10.5.1 **Overview**

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff by increasing sediment loads from spoil areas and releasing mine affected water with high salt loads. Section 6.2 outlines the proposed water management strategy to manage these risks.

10.5.2 **Performance of the Proposed Water Management System**

10.5.2.1 *Mine Affected Water*

An assessment of the mine affected water management system is given in Section 8.3. The results of the water balance modelling indicate that, under the current model assumptions and configuration, there is nil risk of uncontrolled spills of mine affected water from the Project to the receiving environment.

An overflow would only occur during an extreme rainfall event which would also generate significant volumes of runoff from the surrounding undisturbed catchment, as well as in the receiving waterways. Hence it is unlikely that mine affected dam overflows will have a measurable impact on receiving water quality and therefore the environmental values.

10.5.2.2 *Sediment Water*

In the operational phase, progressive rehabilitation of the out-of-pit rock emplacements will minimise the potential generation of sediment. An Erosion and Sediment Control Plan will be developed and implemented throughout construction and operations. A 'best practice' approach will be adopted which is consistent with the International Erosion Control Association (IECA) recommendations. The following broad principles will apply:

- Minimise the area of disturbance;
- Where possible, apply local temporary erosion control measures;
- Intercept run-off from undisturbed areas and divert around disturbed areas; and
- Where temporary measures are likely to be ineffective, divert run-off from disturbed areas to sedimentation basins prior to release from the site.

If implemented effectively, environmental risks from disturbed area runoff are expected to be low. In rainfall events below the design standard, runoff from disturbed areas will be intercepted and treated by sediment dams. In larger events that exceed the design standards, these dams will overflow following a period of settlement.

Available geochemical information indicates that the runoff draining to the sediment dams should have low salinity. Overflows would only occur during significant rainfall events which will also generate runoff from surrounding undisturbed catchments. Hence it is unlikely that sediment dam overflows will have a measurable impact on receiving water quality or environmental values.

Water quality in these dams will be monitored regularly to confirm the geochemical information. Water may be pumped into the mine water management system if required to manage this risk.

10.5.3 **Controlled Releases**

Figure 10-2 shows a plot of modelled EC in the Isaac River (notionally downstream of the Deverill gauge, but upstream of ISDS) on days when there is a controlled release opportunity (i.e. the Isaac River flow exceeds the minimum flow criteria). The plot shows the modelled EC in the Isaac River both with and without controlled releases from the Project. That is, it shows the potential impact of controlled releases on the Isaac River.

Figure 10-2 shows the following:

- The minimum EC in the Isaac River on a release day is around 75 $\mu\text{s}/\text{cm}$ during the largest flood events;
- There is a 50% chance that the downstream Isaac River EC will be greater than 180 $\mu\text{s}/\text{cm}$ during a controlled release;
- There is a 10% chance that the downstream Isaac River EC will be greater than 250 $\mu\text{s}/\text{cm}$ during a controlled release;
- The EC in the Isaac River is below the receiving water contaminant trigger level of 700 $\mu\text{s}/\text{cm}$ on all release days.

- The proposed strategy potentially increases the EC in the Isaac River (in the vicinity of the Project) by up to 50 $\mu\text{S}/\text{cm}$, however it is well below the typical receiving water contaminant trigger level of 700 $\mu\text{S}/\text{cm}$.

The outcomes from the water balance modelling indicates that the proposed controlled release strategy will generally achieve the regional WQO's for the Isaac River and therefore not impact on its environmental values.

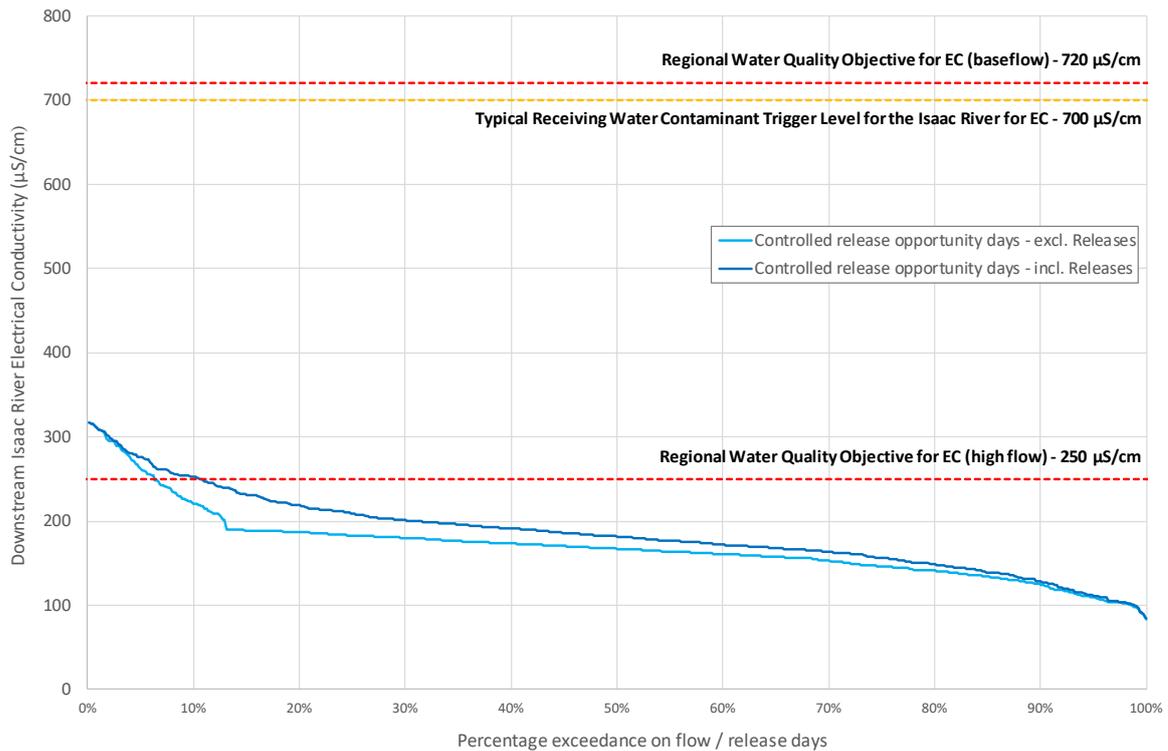


Figure 10-2: Modelled Isaac River Receiving Water Quality – Median Model Realisation (Cycle 50)

10.5.4 Impact of Water Management System on Adjacent Wetlands

There are a number of Wetland Protection Areas located within and adjacent to the Project area. Further details of these wetlands are provided in the Aquatic Ecology report (Appendix C of the EIS).

The proposed water management system (including the controlled release system) has been designed to have no interaction with the wetland areas. Therefore, the proposed water management system will have no impact of the wetland areas.

The potential impact of the proposed flood protection levees on the wetland areas is discussed in the Flood Assessment (Appendix F of the EIS).

10.6 Cumulative Impacts – Surface Water

10.6.1 Overview

The objective of this assessment is to identify the potential for impacts from the Project to have compounding interactions with similar impacts from other projects, including activities proposed, under development or already in operation within a suitable region of influence of the Project.

There are three levels at which cumulative impacts may be relevant:

- ***Localised cumulative impacts*** – These are the impacts that may result from multiple existing or proposed mining operations in the immediate vicinity of the project. Localised cumulative impacts include the effect from concurrent operations that are close enough to potentially cause additive effect on the receiving environment. For the purposes of this assessment, we have included all existing and proposed projects located within the Isaac River catchment.
- ***Regional cumulative impacts*** – These include the project's contribution to impacts that are caused by mining operations throughout the Bowen Basin region or at a catchment level. Each coal mining operations in itself may not represent a substantial impact at a regional level; however, the cumulative effect on the receiving environment may warrant consideration.
- ***Global cumulative impacts*** – These includes impacts that the project might contribute to at a global scale. The only potential global scale impact for the project is greenhouse gas (GHG) emissions, and as such has not been addressed in this assessment.

We understand that the Commonwealth Department of Environment and Energy (DoEE) has recently approved the Lake Vermont Coal Mine Northern Extension Project, which is located upstream of the Project adjacent to Phillips Creek. The cumulative impact assessment provided in the following sections has considered the impact of this approval.

10.6.2 Relevant Projects

10.6.2.1 Existing Projects

Projects which are currently operating within the Isaac River catchment upstream of the ISDS streamflow gauge and have been included in the cumulative impacts assessment for the Project are listed in Table 10-3.

Table 10-3: Existing Projects Considered in the Cumulative Impact Assessment

Project	Proponent	Description	Operational Status	Relationship to the Project Area	
				Timing	Location
Burton Mine	Peabody Energy Australia	Open cut coal mine	Ceased production indefinitely	May have overlapping operational phases with the construction and operations of the project, although unlikely given the current operational status.	30 km to the north-northwest of the project area. Located within Isaac River catchment (upstream).
Moorvale Mine	Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	18 km to the north of the project area. Located within Isaac River catchment (upstream).
Eaglefield Mine	Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	60 km to the north-northwest of the project area. Located within Isaac River catchment (upstream).
North Goonyella Mine	Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	60 km to the north-northwest of the project area. Located within Isaac River catchment (upstream).
Millennium Mine	Peabody Energy Australia	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	15 km to the north-northwest of the project area. Located within Isaac River catchment (upstream).
Goonyella Riverside Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	45 km to the northwest of the project area. Located within Isaac River catchment (upstream).
Moranbah North Mine	Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	40 km to the northwest of the project area. Located within Isaac River catchment (upstream).
Grosvenor Mine	Anglo American	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	25 km to the northwest of the project area. Located within Isaac River catchment (upstream).
Carborough Downs Mine	Fitzroy Queensland Resources	Underground coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	20 km to the north-northwest of the project area. Located within Isaac River catchment (upstream).
Isaac Plain Mine	Stanmore Coal	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	25 km to the north northwest of the project area. Located within Isaac River catchment (upstream).

Project	Proponent	Description	Operational Status	Relationship to the Project Area	
				Timing	Location
Poitrel Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	10 km to the north-northwest of the project area. Located within Isaac River catchment (upstream).
Daunia Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	5 km to the north-northwest of the project area. Located within Isaac River catchment (upstream).
Caval Ridge Coal Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	25 km to the west of the project area. Located within Isaac River catchment (upstream).
Peak Downs Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	15 km to the west of the project area. Located within Isaac River catchment (upstream).
Saraji Mine	BMA	Open cut coal mine	Operating	May have overlapping operational phases with the construction and operations of the project.	10 km to the southwest of the project area. Located within Isaac River catchment (upstream/downstream).
Norwich Park Mine	BMA	Open cut coal mine	Ceased production indefinitely	May have overlapping operational phases with the construction and operations of the project.	25 km to the southwest of the project area. Located within Isaac River catchment (downstream).
Lake Vermont Mine	Jellinbah Group	Open cut coal mine	Operating NE Extension Project approved	May have overlapping operational phases with the construction and operations of the project.	20 km to the south of the project area. Located within Isaac River catchment (adjacent), and upstream of the Project on Phillips Creek.

10.6.2.2 *New or Developing Projects*

Relevant projects that have been considered include:

- Projects within the predicted sphere of influence of the project, as listed on the Department of State Development, Infrastructure and Planning (DSDIP) website that are undergoing assessment under the State Development and Public Works Organisation Act 1971 (SDPWO Act) for which an Initial Advice Statement (IAS) or an EIS are available; and
- Projects within the predicted sphere of influence of the project, which are listed on the website of the Department of Environment and Science (DES) that are undergoing assessment under the Environmental Protection Act 1994 (EP Act) for which an IAS or an EIS are available.
- Projects within the predicted sphere of influence of the project, which are listed on the website of the Department of Infrastructure, Local Government and Planning (DILGP) that are undergoing assessment under the Regional Planning Interests Act 2014 (RPI Act) for which an Assessment Application is available.

Projects currently undergoing assessment or having recently completed assessment under these processes and included in the cumulative impact assessment for the project are listed in Table 10-4.

10.6.3 **Cumulative Impacts – Surface Water Resources**

10.6.3.1 *Water Quality*

The project is located in the Isaac River catchment, which is a major tributary within the Fitzroy basin. The Fitzroy basin is the largest catchment in Queensland draining into the Pacific Ocean and also the largest catchment that drains to the Great Barrier Reef, although it does not contribute significant freshwater flows to the coastal environment when compared to river systems further north.

In 2008, the Queensland Government undertook an investigation into the cumulative effects of coal mining in the Fitzroy River basin on water quality (EPA, 2009). The investigation found that:

- There were inconsistencies in discharge quality limits and operating requirements for coal mine water discharges as imposed through environmental authorities.
- In some cases, discharge limits and operating conditions of coal mines were not adequately protecting downstream environmental values.

Table 10-4: New or Developing Projects Considered in the Cumulative Impact Assessment

Project	Proponent	Description	Status	Relationship to the Project Area	
				Timing	Location
Eagle Downs Mine	Bowen Central Coal Joint Venture	Underground coal mine	Construction on hold – site on care and maintenance	May have overlapping operational phases with the construction and operations of the project.	24 km to the northwest of the project area. Located within Isaac River catchment.
Red Hill Mining Lease Project	BMA	Underground coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	66 km to the north-northwest of the project area. Located within Isaac River catchment.
Olive Downs North Project	Peabody Energy Australia	Open cut coal mine	Approved project	May have overlapping operational phases with the construction and operations of the project.	4 km to the north of the project area.
New Lenton Coal Project	New Hope Corporation	Open cut coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	90 km to the north-northwest of the project area. Located within Isaac River catchment.
Saraji East Mining Lease Project	BMA	Underground coal mine	EIS active	May have overlapping operational phases with the construction and operations of the project.	15 km to the southwest of the project area. Located within Isaac River catchment.
Dysart East Coal Mine	Bengal Coal	Underground coal mine	Application made	May have overlapping operational phases with the construction and operations of the project.	35 km to the south of the project area. Located within Isaac River catchment.
Bowen Gas Project	Arrow Energy	CSG field & production facilities	Approved project	May have overlapping operational phases with the construction and operations of the project.	The Project lies within the Bowen EIS Study Area.

These conclusions led to a number of inter-related actions by Queensland Government and other stakeholders:

- Water quality objectives were developed for the Fitzroy Basin and added to Schedule 1 of the Environmental Protection (Water) Policy 2009 (EPP (Water)) in October 2011.
- Model water conditions were developed for coal mines in the Fitzroy basin (DERM February 2012). These model water conditions are designed to manage water discharges to meet the water quality objectives set out in the EPP (Water) and to provide consistency between mining operations in the Fitzroy basin.
- Environmental authorities for a number of mining operations were amended to introduce conditions consistent with the model water conditions.
- A number of mining operations entered into Transitional Environmental Programs (TEP) under the EP Act. These TEPs were focussed on actions that would allow mines to achieve compliance with new environmental authority conditions and upgrade operating conditions.

With these measures in place, a strong strategic and policy framework is now in place for management of cumulative water quality impacts from mining activities. This framework allows for management of individual mining activities in such a way that overarching water quality objectives can be achieved.

Mine affected water from the proposed Project will be managed through a mine water management system which is designed to operate in accordance with typical EA conditions and the model water conditions. That is, it will have discharge conditions and in-stream trigger levels aligned with the water quality objectives in the EPP (Water).

An extensive review of the release conditions at other coal mines in the vicinity of the Project has been undertaken. A summary of these release conditions is provided in Table 10-5 and the locations of the release points at nearby mines is shown in Figure 10-3. The development of proposed release conditions for the Project (as described in Section 7.10) have taken into consideration the conditions at the nearby mines.

Review of Table 10-5 shows the following:

- The receiving water contaminant trigger levels for:
 - ♦ EC range between 864 and 2,000 $\mu\text{s}/\text{cm}$
 - ♦ pH ranges vary between 6.5 to 8.0 and 6.5 to 9.0
 - ♦ suspended solids range between 300 and 1,000 mg/L (with many to be determined)
- The mine affected water release during flow events varies significantly. The mines closest to the Project (Peak Downs Mine, Saraji Mine and Lake Vermont Mine) have maximum EC release limits of up to 10,000 $\mu\text{s}/\text{cm}$.

Table 10-5: EA Release Conditions at Mines in the Vicinity of the Project

Mine	EA	Location	Receiving Water Contaminant Trigger Levels	Mine Affected Water Quality Limits	Conditions Relating to Receiving Water
Isaac Plains Coal Mine	EPML00932713	Isaac River U/S of the Project Area	<ul style="list-style-type: none"> EC: 1000 $\mu\text{S/cm}$ pH: 6.5 – 8.0 Suspended Solids: TBD Sulphate: 1000 mg/L 	<ul style="list-style-type: none"> EC: 720-8000 $\mu\text{S/cm}$ (dependant on flow) pH: 6.5 – 9.0 Turbidity: No Limit Suspended Solids: No Limit Sulphate: 250-400 mg/L (dependant on flow) 	Release rates vary (2-3 m ³ /s) depending on receiving water flows
Millennium Coal Mine	EPML00813213	Isaac River U/S of The Project Area	<ul style="list-style-type: none"> EC: 1000 $\mu\text{S/cm}$ pH: 6.5 – 8.0 Suspended Solids: TBD Sulphate: 1000 mg/L 	<ul style="list-style-type: none"> EC: 1,400 $\mu\text{S/cm}$ pH: 6.5 – 9.0 Turbidity: N/A Suspended Solids: N/A Sulphate: 1000 mg/L 	Release rates calculated as percentage of flow in receiving waters (1% in Isaac and 20% in New Chum Creek)
Poitrel Coal Mine	EPML00963013	Isaac River U/S of The Project Area	<ul style="list-style-type: none"> EC: 1000 $\mu\text{S/cm}$ pH: 6.5 – 8.0 Turbidity: 750 NTU Suspended Solids: TBD Sulphate: 250 mg/L Sodium: TBD 	<ul style="list-style-type: none"> EC: 720-7000 $\mu\text{S/cm}$ pH: 6.5 – 9.0 Turbidity: 500 NTU Suspended Solids: N/A Sulphate: 250-1000 mg/L 	Release rates vary (14-290 m ³ /s) depending on receiving water flows
Daunia Coal Mine	EPML00561913	Isaac River U/S of The Project Area	<ul style="list-style-type: none"> EC: 864 $\mu\text{S/cm}$ – Cease Release pH: 6.5 – 8.5 Sulphate: 1000 mg/L 	<ul style="list-style-type: none"> EC: 5000 $\mu\text{S/cm}$ pH: 6.5 – 9.0 Sulphate: 1000 mg/L 	Release allowed when minimum flow in the receiving water (Isaac River via New Chum Creek) is greater or equal to 3m ³ /s
Caval Ridge Coal Mine	EPML00562013	Isaac River U/S of The Project Area	<ul style="list-style-type: none"> EC: 2000 $\mu\text{S/cm}$ pH: 6.5 – 8.5 Sulphate: 1000 mg/L 	<ul style="list-style-type: none"> EC: 10000 $\mu\text{S/cm}$ pH: 6.5 – 9.0 Sulphate: N/A 	Release allowed when minimum flow in the receiving water (3m ³ /s in Isaac River and 0.5m ³ /s in Cherwell Creek)

Mine	EA	Location	Receiving Water Contaminant Trigger Levels	Mine Affected Water Quality Limits	Conditions Relating to Receiving Water
Eagle Downs Coal Mine	EPML00586713	Isaac River U/S of The Project Area	<ul style="list-style-type: none"> EC: 1000 μS/cm pH: 6.5 – 8.0 Turbidity: N/A Suspended Solids: TBD Sulphate: 100 mg/L 	<ul style="list-style-type: none"> EC: 1000 μS/cm pH: 6.5 – 9.0 Turbidity: N/A Suspended Solids: 80th percentile of upstream background sites Sulphate: 1000 mg/L 	
Moorvale Coal Mine	EPML00802813	Isaac River U/S of The Project Area	<ul style="list-style-type: none"> EC: 2000 μS/cm pH: 6.5 – 8.0 Turbidity: 4000 NTU 	<ul style="list-style-type: none"> EC: 2500 μS/cm pH: 6.5 – 9.0 Turbidity: 4000 NTU Suspended Solids: N/A Sulphate: 1000 mg/L 	Release allowed when minimum flow when the minimum flow in the receiving water (0.02m ³ /s in North Creek)
Lake Vermont Mine	EPML00659513	Isaac River adjacent to The Project Area	<ul style="list-style-type: none"> EC: 1000 μS/cm pH: 6.5 – 8.0 Suspended Solids: 1,500 mg/L Sulphate: 300 mg/L Sodium: 180 mg/L 	<i>Isaac River RP's</i> <ul style="list-style-type: none"> EC: 1,500 μS/cm (Sulphate: 30 mg/L <i>Phillips Creek RP's</i> <ul style="list-style-type: none"> EC: 720-5,500 μS/cm (dependant on flow) Sulphate: 300-1,400 μS/cm (dependant on flow) 	Release allowed when minimum flow in the receiving water (7.5m ³ /s in Isaac River)
Peak Downs Coal Mine	EPML00318213	Isaac River U/S of The Project Area	<ul style="list-style-type: none"> EC: 2000 μS/cm pH: 6.5 – 9.0 	<ul style="list-style-type: none"> EC: 10000 μS/cm pH: 6.5 – 9.5 Sulphate: N/A (correlated with EC) 	Release allowed when minimum flow in the receiving water (3m ³ /s in Isaac River and 0.1m ³ /s in Boomerang Creek)
Saraji Coal Mine	EPML00862313	Isaac River U/S of The Project Area	<ul style="list-style-type: none"> EC: 2000 μS/cm pH: 6.5 – 9.0 	<ul style="list-style-type: none"> EC: 10000 μS/cm pH: 6.5 – 9.5 	Release allowed when minimum flow in the receiving water (3m ³ /s in Isaac River, 0.1m ³ /s in Hughes Creek/One Mile Creek/Spring Creek/Phillips Creek)

Mine	EA	Location	Receiving Water Contaminant Trigger Levels	Mine Affected Water Quality Limits	Conditions Relating to Receiving Water
				<ul style="list-style-type: none"> Sulphate: N/A (correlated with EC) 	
Norwich Park Coal Mine	EPML00865013	Isaac River D/S of The Project Area	<ul style="list-style-type: none"> EC: 2000 $\mu\text{S/cm}$ pH: 6.5 – 9.0 Sulphate: 1000 mg/L 	<ul style="list-style-type: none"> EC: 10000 $\mu\text{S/cm}$ pH: 6.5 – 9.0 Sulphate: N/A (correlated with EC) 	Release allowed when minimum flow in the receiving water (Scott Creek/Stephens Creek/Rolf Creek) is greater or equal to 1m ³ /s
Middlemount Coal Mine	EPML00716913	Isaac River D/S of The Project Area	<ul style="list-style-type: none"> EC: 2000 $\mu\text{S/cm}$ pH: 6.5 – 8.5 Suspended Solids: 562-1062 mg/L (dependant on flow) Sulphate: 250 mg/L Sodium: TBD 	<ul style="list-style-type: none"> EC: 700-6000 $\mu\text{S/cm}$ (dependent on flow) pH: 6.5 – 9.5 Turbidity: N/A Suspended Solids: 562-1062 mg/L (dependent on flow) Sulphate: 250-500 mg/L (dependent on flow) 	Release rates vary (0.4-5.6m ³ /s) depending on receiving water flows (Roper Creek)
German Creek Coal Mine	EPML00732613	Isaac River D/S of The Project Area	<ul style="list-style-type: none"> pH: 6.5 – 8.5 Turbidity: Mine waters released must not exceed background level Sulphate: 250 mg/L Sodium: TBD 	<ul style="list-style-type: none"> EC: <10000 $\mu\text{S/cm}$ pH: 6.5 – 9.0 Turbidity: Turbidity limit for discharge is defines as being equal to or less than the upstream turbidity value for the receiving waters Suspended Solids: 80th percentile of upstream background sites Sulphate: <3000 mg/L 	Release allowed when minimum flow in the receiving water (0.6m ³ /s in German Creek, 0.5m ³ /s in Cattle Creek, 0.143m ³ /s in Parrot Creek and 1.0m ³ /s in Roper Creek) Maximum combined release rate of 2.0m ³ /s Release ceased when flow in receiving waters is reduced to 0.5 m ³ /s.
Foxleigh Coal Mine	EPML00744813	Isaac River D/S of The Project Area	<ul style="list-style-type: none"> pH: 6.5 – 8.5 Suspended Solids: 650 mg/L 	<ul style="list-style-type: none"> EC: <10000 $\mu\text{S/cm}$ pH: 6.5 – 9.0 	Release allowed when minimum flow in the receiving water (0.66m ³ /s in Cockatoo Creek and 0.95m ³ /s in Roper Creek) Maximum combined release rate of 2.0m ³ /s

Mine	EA	Location	Receiving Water Contaminant Trigger Levels	Mine Affected Water Quality Limits	Conditions Relating to Receiving Water
			<ul style="list-style-type: none"> Sulphate: <250 mg/L Sodium: TBD 	<ul style="list-style-type: none"> Turbidity: Derived from suspended solids limit and demonstrated correlation between turbidity to suspended solids historical monitoring for dam water Suspended Solids: 650 mg/L Sulphate: <3000 mg/L 	Release ceased when flow in receiving waters is reduced to 0.5 m ³ /s

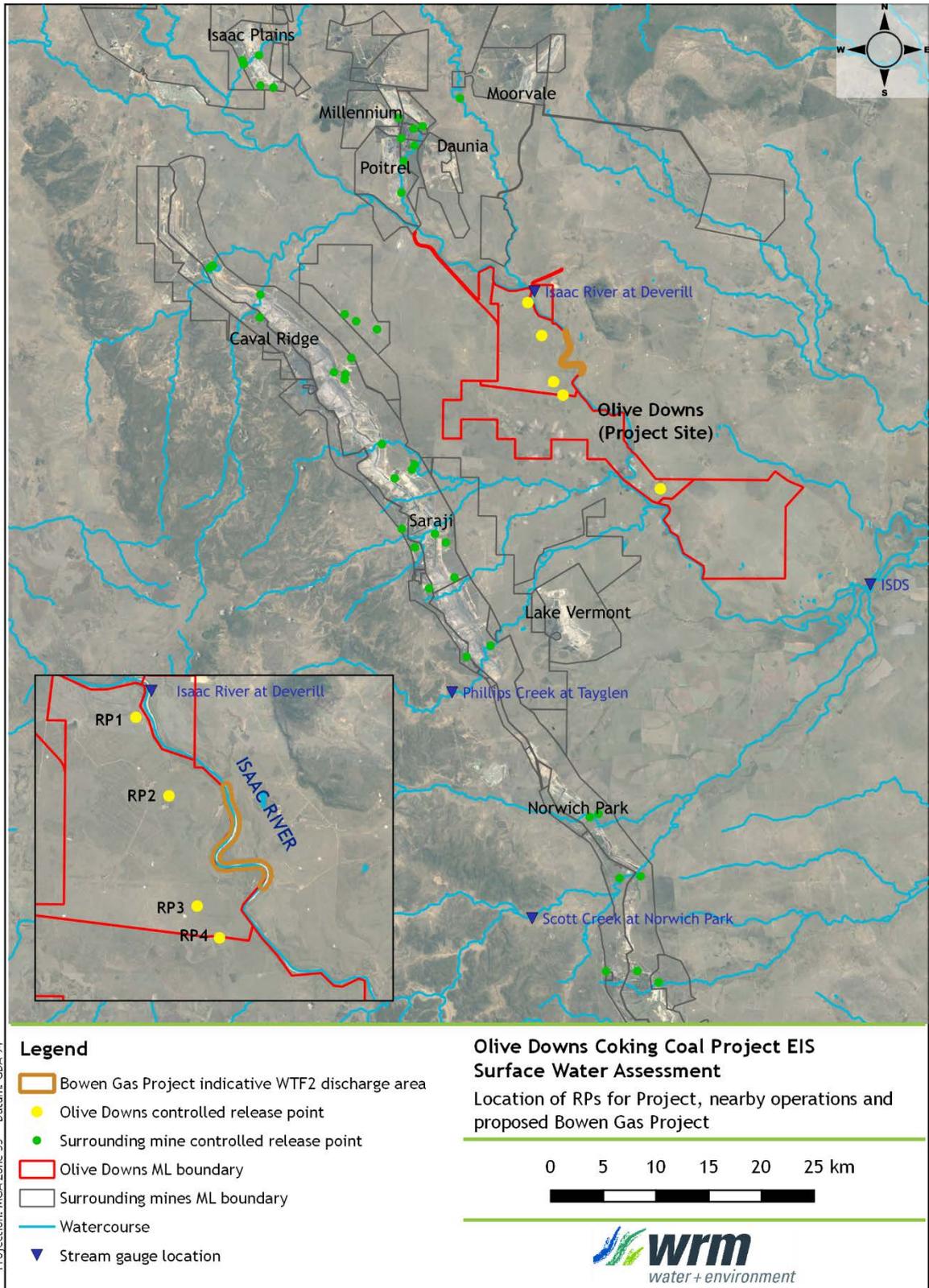


Figure 10-3: Cumulative Impact Assessment – Location of Nearby Release Points

Using the Project water balance model, an analysis has been undertaken on the ability of the proposed water management system to demonstrate compliance with the proposed EA conditions. The outcomes from this assessment is provided in Section 10.5.3.

The Queensland Government commissioned an assessment of mine affected water releases in the Fitzroy River basin during the 2012–2013 wet season (known as the Pilot Scheme). The report, prepared by consultants Gilbert and Sutherland (G&S, 2016), concluded that the Fitzroy as a whole is not currently ‘at capacity’ in terms of salt load at a catchment or sub-catchment scale.

The operational policy of the Pilot Scheme aims to manage the cumulative impact of mine affected water releases across the Fitzroy Basin. To achieve this, trigger values have been derived for six monitoring locations across the basin. If in-stream electrical conductivity (EC) triggers are exceeded during times when mine affected water releases are being undertaken upstream, the regulator has the ability to issue a “cease release” notification to all coal mines in the Fitzroy Basin with conditions that authorise the release of mine affected water.

Given that the proposed Project mine affected water releases are being managed within an overarching strategic framework for management of cumulative impacts of mining activities, the proposed management approach for mine water from the project is expected to have negligible cumulative impact on surface water quality and associated environmental values.

While the EPA cumulative impact assessment of mining in the Fitzroy Basin focused on salinity as the key water quality issue related to mining activities, surface disturbance associated with mining activities can result in erosion and increased sediment levels in surface waters. The Great Barrier Reef outlook report also identified that the Fitzroy Basin contributed one of the highest sediment loads to the reef, largely attributing sediment loads to use of land for agricultural activities (GBRMPA 2009). Water quality data presented in Section 5.4 indicates that suspended solids and turbidity in the upper Isaac River and local tributaries are in excess of water quality objectives and hence, cumulative assessments must consider additional sediment inputs.

The water quality assessment undertaken for the project has identified that sediment inputs can be controlled through drainage, erosion and sediment control measures. On this basis, the proposed project is not expected to make any significant contribution to cumulative sediment loads in the Fitzroy River Basin.

10.6.3.1.1 ACARP Project C18033 Extension

A study was undertaken in 2012 with the aim of gathering information on the tolerances of freshwater macroinvertebrates from the Fitzroy Catchment to saline mine water, that could potentially be utilized for developing guidelines for mine water discharge. Part of this study involved developing ecosystem protection toxicant trigger values calculated from species sensitivity distribution derived from commercial tests. A 95% ecosystem protection trigger value of 2,000 $\mu\text{s}/\text{cm}$ and a 99% ecosystem protection trigger value of 900 $\mu\text{s}/\text{cm}$ were developed.

These trigger levels are significant higher than the WQO's for the Upper Isaac River catchments water, particularly for 95% ecosystem protection. These trigger values were consistent with the lower range of previously published toxicological and other effects data on relevant aquatic species. These toxicant trigger values derived from the study could be used to inform the regulation of mine water releases were aquatic ecosystem toxicity from salinity is the primary issue of concern.

10.6.3.1.2 Bowen Gas Project EIS

The Project lies within the study area of the Bowen Gas Project (BGP), and there are two water treatment facilities (WTF's) proposed as part of the BGP development. The indicative locations of the WTF discharge points are as follows:

- A section of the upper Isaac River, located downstream of Burton Mine; and
- A section of the Isaac River adjacent to the ODS domain.

The impact assessments for the EIS and SREIS for the BGP indicated that surface water resources within the BGP Project area had been impacted by different historic and current land uses such as agriculture, mining and urban development. The EIS determined that through the implementation of appropriate mitigation measures, the potential impacts on surface water quality could be minimized. In addition, the set of principles for CSG water discharges developed in the SREIS study would allow for CSG water to be discharged without having any significant impact to the receiving environment. It was noted that in the context of the large volumes of mine affected water that are discharged into the Isaac River by coal mines operating in the region, any CSG water that may be released into the Isaac River by the BGP Project would have an insignificant effect on the receiving environment.

Given that the proposed WTF's for the BGP have a design capacity of up to 20 ML/d and water would only be discharged the prescribed limit of an environmental authority, the impact of BGP discharges on the receiving environment are expected to be insignificant from a cumulative impact perspective.

10.6.3.2 *Loss of Catchment and Stream Flows in the Isaac River*

As detailed in Section 10.4, the Project will result in a loss of catchment to the Isaac River during operations and post-mining. The surface runoff volume lost from the catchment will generally be in proportion to the loss of catchment area. The Project area is less than 2% of the catchment area of the Isaac River to the downstream boundary of the Project (at the ISDS stream gauge). Of this, around 63% of this area is managed through the ESCP and then released to the downstream environment following treatment.

There are approximately 15 existing coal mines upstream of the Project that also capture runoff from the Isaac River catchment, as shown in Figure 10-4. The total estimated captured area of all these projects (including the Project) combined represents around of 9% of the Isaac River catchment to the ISDS stream gauge. If the same percentage of ESCP for the Project is applied to the other mines, then the estimated captured catchment areas reduce to around 37% of the total area (around 2.6% of the Isaac River catchment to the ISDS gauge).

In addition, these mines have discharge licences which return captured surface water, as well as groundwater collected in underground workings, to the Isaac River catchment. Site discharges would reduce the impact on surface water volumes. Unfortunately, there is limited information available on actual discharge volumes from the 15 upstream mines to the Isaac River.

A comparison of the captured catchment areas of the existing mining projects considered in the cumulative impact assessment with the Isaac River catchment to the ISDS gauge is provided in Table 10-6, which indicates the following:

- The combined total catchment area of the existing mines (including the Project) represents around 9% of the total catchment area of the Isaac River to the ISDS gauge.
- The combined mine affected catchment area (estimated) represents less than 3.5% of the total Isaac River catchment area to the ISDS gauge.

When taking into account potential discharges from the operating mines in accordance with their current release rules, the overall loss of catchment area and associated stream flow is relatively small.

Table 10-6: Catchment Areas of Existing Project Considered in the Cumulative Impact Assessment

Catchment	Total Catchment Area (km ²)	Estimated Mine Affected Catchment Area (km ²)
The Project	136	51
Other Mines	550 (est.)	206 (est.)
Combined	686 (est.)	257 (est.)
Isaac River (to the ISDS stream gauge)	7,782	

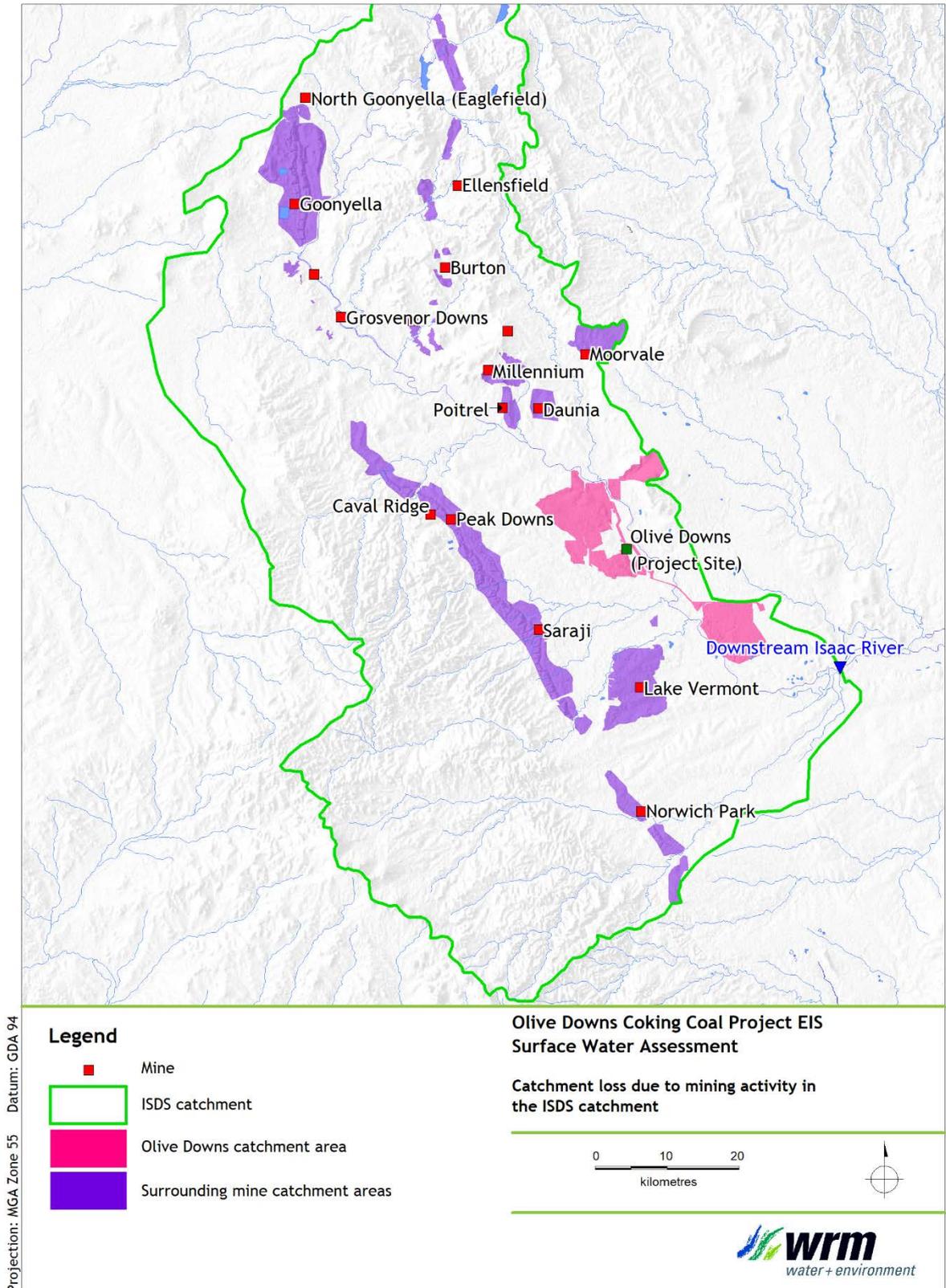


Figure 10-4: Cumulative Impact Assessment – Location of Existing Mines Upstream of the ISDS Gauge

10.7 Surface Water Monitoring Program

10.7.1 Overview

Monitoring of surface water quality both within and external to the mine site will form a key component of the surface water management system. Monitoring of upstream, onsite and downstream water quality will assist in demonstrating that the site water management system is effective in meeting its objective of minimal impact on receiving water quality and will allow for early detection of any impacts and appropriate corrective action.

The surface water monitoring protocols will:

- ensure compliance with the Project Environmental Authority;
- provide valuable information on the performance of the water management system; and
- facilitate adaptive management of water resources on the site.

10.7.2 Water Quality Monitoring Locations

The Proponent has previously monitored a number of surface water locations in the Project vicinity (as detailed in Section 5.4). The Surface Water Monitoring Program will include the continued monitoring of a number of these sites to monitor surface water flows and quality upstream and downstream of the mine.

The water quality monitoring program will also include dam monitoring, including all dams which contain mine affected water and discharge to the receiving environment. This includes the following dams:

- P44;
- WROM; and
- WMIA.

Locations of the proposed surface water monitoring locations are shown in Figure 10-5 and summarised in Table 10-7.

Table 10-7: Proposed Surface Water Monitoring Program

Site Name	Waterway	Location	
		Easting (decimal degrees)	Longitude (decimal degrees)
SW1	Isaac River (upstream of Project)	-22.15	148.35
SW2	Isaac River (upstream of North Creek confluence)	-22.16	148.37
SW3	Isaac River (downstream of North Creek confluence)	-22.17	148.38
SW4	Ripstone Creek (upstream of Project)	-22.26	148.33
SW6	Ripstone Creek (upstream of Isaac River confluence)	-22.31	148.40

Site Name	Waterway	Location	
		Easting (decimal degrees)	Longitude (decimal degrees)
SW8	Isaac River (downstream of Boomerang Creek confluence)	-22.33	148.46
SW11	Isaac River (downstream of Phillips Creek confluence)	-22.45	148.56
SW12/ISDS	Isaac River (downstream of Project)	-22.42	148.70
RP1	Dam P9	-22.18	148.38
RP2	Dam P20	-22.21	148.39
RP3	Dam P33	-22.25	148.40
RP4	Dam P46	-22.27	148.42
RP5	Dam WROM	-22.34	148.50
RP6	Dam P44	-22.28	148.35
RP7	Dam WMIA	-22.34	148.59

10.7.3 Water Quality Monitoring Schedule

Table 10-8 defines the proposed frequency and parameters to be sampled at each location during the discharge of mine affected water. Table 10-9 defines the proposed frequency and parameters to be sample across the dams which can discharge to the receiving environment. The proposed water quality monitoring program provides regular monitoring of key mine site storages.

Table 10-8: Release Event Water Quality Monitoring Schedule

Location	Parameter*	Monitoring Frequency
SW1, SW2, SW3, SW4, SW6, SW8, SW11 & SW12/ISDS	pH, EC, Suspended Solids, Sulphate and Sodium	Daily during release

Note: * Water quality monitoring parameters to be confirmed as part of the Environmental Authority application process.

Table 10-9: Dam Monitoring Schedule

Location	Parameter*	Monitoring Frequency
RP1, RP2, RP3, RP4, RP5, RP6 & RP7	pH, EC, Sulphate, Fluoride, Aluminium, Arsenic, Cadmium, Cobalt, Copper, Lead, Nickel and Zinc	Monthly

Note: * Water quality monitoring parameters to be confirmed as part of the Environmental Authority application process.

The event-based sampling will enable quantification of pollutant loads from the site and their corresponding impact on the water quality of receiving waters. On-site monthly sampling from the water storages allows for any potential problem areas with respect to pollutant generation on-site to be identified in advance ensuring appropriate remedial action can be taken.

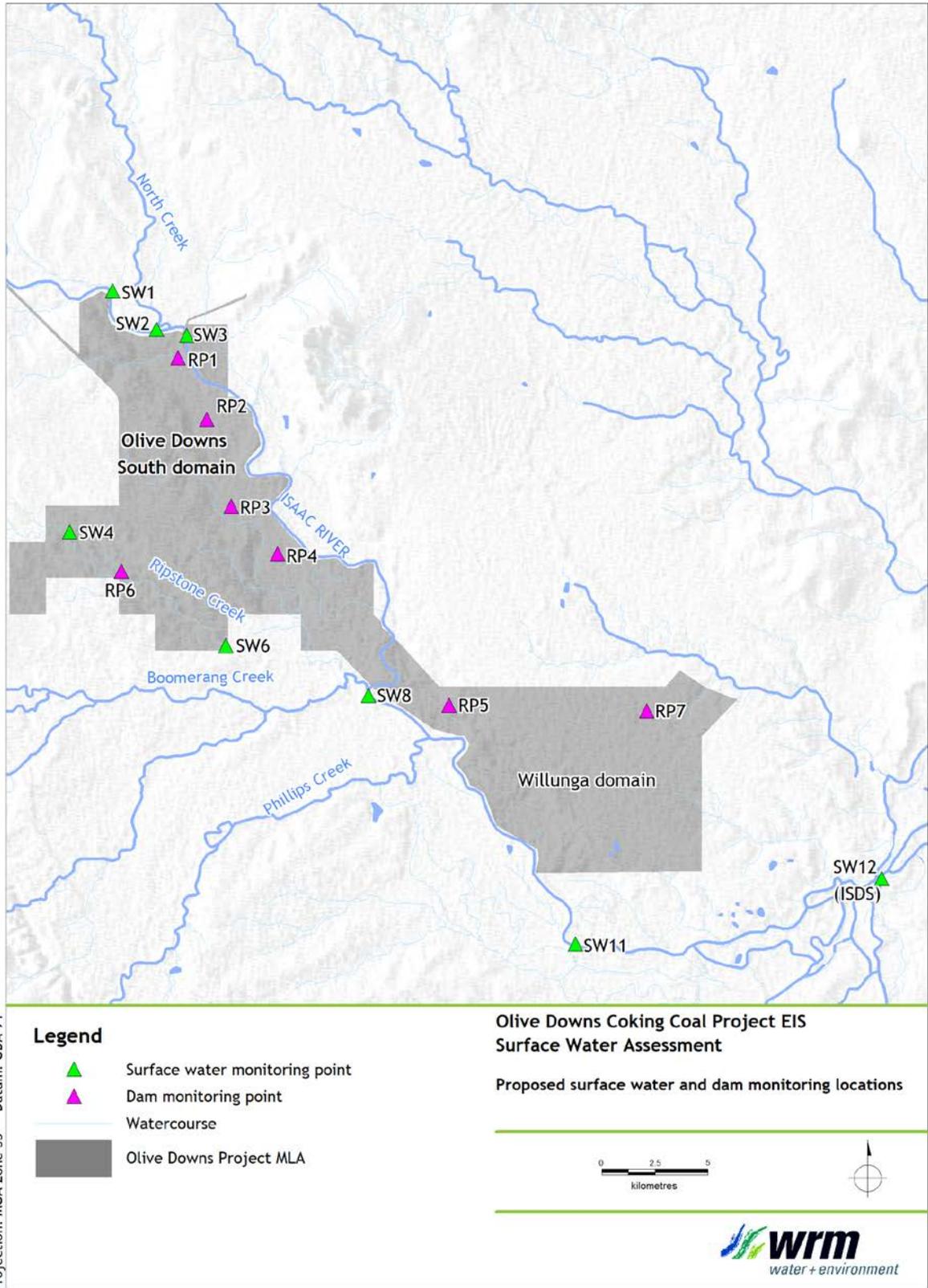


Figure 10-5: Proposed Surface Water Monitoring Locations

10.7.4 Sediment Dam Monitoring

Surface runoff and seepage from spoil piles, including any rehabilitated areas, would be monitored for 'standard' water quality parameters including, but not limited to pH, EC, major anions (sulfate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), TDS and a broad suite of soluble metals/metalloids.

The sediment dam monitoring would be used to validate the anticipated quality of water runoff reporting to sediment dams and haul road runoff dams. Initially, the sediment dam monitoring would occur on a regular (e.g. monthly) basis to demonstrate the water quality of stored waters is consistent with the relevant operating parameters to allow releases from sediment dams to occur when required. Subject to demonstrating the water quality objectives can be met, the frequency of monitoring and suite of parameters for the sediment dam monitoring would be reviewed and updated accordingly (e.g. to occur only when releases occur).

10.7.5 Receiving Environment Monitoring Program (REMP)

A REMP document will be developed that specifies the proposed monitoring program for the local receiving waters. The REMP will incorporate the historical and proposed monitoring as described in Section 5.4, Section 10.7.2 and Section 10.7.3

The main objective of the REMP will be to report against WQOs for local waterways potentially affected by discharge from the Project and will assist in assessing general aquatic ecosystem health.

11. Summary of Findings

11.1 Overview

The potential impacts of the Project on surface water resources will be mitigated through the implementation of a mine site water management system to control the flow and storage of water of different qualities across the site. A surface water monitoring program will be implemented to continually assess environmental impacts and ensure that the site water management system is meeting its objectives.

11.2 Water Management System Performance

The performance of the mine water management system has been investigated using a detailed site water balance model. The model simulated water inflows and outflows through the various stages of mine development for 100 stochastically generated rainfall sequences which are based on the DataDrill climate dataset.

Water collected on the site will be used as first priority to satisfy site demands, such as coal processing and dust suppression. Water will be drawn from off-site sources only when required to make up a shortfall in water available on the site.

Pembroke is proposing to acquire a 2,250 ML annual water licence allocation from the Sunwater Pipeline. The water balance model results show that there is a greater than 90% probability that the proposed annual water licence allocation of 2,250 ML would be sufficient to meet all site demands, in any one year across the Project life.

If additional external water is required, additional water licences would be sought and purchased by Pembroke over the life of the Project to meet raw water demands. Alternatively, production will be reduced until sufficient supplies are available. Water required from external sources will be obtained under appropriate Water Access Licences to ensure no adverse impacts on water availability for other licensed water users.

Overall, the results suggest that sufficient out-of-pit storage has been provided to prevent uncontrolled spills to the downstream environment and to ensure the pit can be dewatered. The results of the water balance modelling indicate that there is a small probability (around 10% AEP) of large volumes of mine affected water accumulating within the water management system. From the end of Stage 3, there will be a number of inactive voids available to temporarily store mine affected water. Should wet conditions prevail prior to these voids being available for storage, Pembroke shall:

- Store excess water temporarily in an active pit until there is sufficient out-of-pit storage available; or
- Construct additional pit water dams ahead of mining in the ODS domain to temporarily store any excess mine affected water until there is sufficient out-of-pit storage available.

The model results show that is only a very small risk (less than 1% AEP) of uncontrolled spills of mine affected water to the receiving environment, which is consistent with the proposed operating strategy for the mine water management system.

11.3 Impacts of Downstream Water Quality

Controlled releases from the water management system will occur when water quality and river flows meet the proposed release trigger levels. The water balance modelling results (shown in Section 10.5.3) indicate that the proposed controlled release strategy will achieve the WQO's for the Isaac River sub-basin.

11.4 Reduction in Downstream Flows During Operations

The Project will reduce the catchment area draining to receiving watercourses due to capture of runoff from disturbed catchment areas within the water management system. The maximum mine affected catchment areas represent:

- Approximately 13% of the Ripstone Creek catchment.
- Less than 1% of the Isaac River catchment to the downstream ISDS gauge, which is not significant.

The loss of catchment to Ripstone Creek only affects the furthest downstream reach (approximately 8 km) of the creek adjacent to the Project and within the tenement areas.

11.5 Long Term Reduction in Catchment Runoff

At the completion of mining, surface runoff from rehabilitated out-pit waste rock emplacement areas will be released from the site. An area of approximately 49 km² will continue to drain to the mine final voids. The changed topography following completion of the Project will have the following impacts on catchment areas:

- the catchment draining to Ripstone Creek will reduce by around 19 km² (compared to pre-mining conditions), a decrease of less than 7%.
- the catchment draining to the Isaac River will reduce by around 49 km² (compared to pre-mining conditions), a decrease of less than 1%.

11.6 Final Voids

Water balance simulation of the final voids shows that the water surface is expected to reach an equilibrium water level well below the void overflow level and regional water table and will remain a groundwater sink. The pit void lakes will generally take around 100 to 200 years to reach an equilibrium level.

11.7 Cumulative Impacts

The development of the proposed release strategy to the Isaac River has based on the existing release conditions for nearby operating coal mines. The release conditions have developed by the regulators within an overarching strategic framework for the management of the cumulative impacts of water releases mining activities and are therefore expected to have negligible cumulative impact on surface water quality and associated environmental values. In any case, the site water management system has been designed such that the risk of off-site release of mine affected water is very low.

12. References

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Appendix A

Model Sensitivity Assessment Results

A.1 Scenario 1: Rejects Cells Decant Return Rate Increased by 5%

For the Scenario 1 sensitivity analysis, the decant return rate from the rejects cells was increased from 70% to 75%. This impact of this change on the performance of the water management system is presented in the following sections.

A.1.1 In-pit Storage

Figure A1 shows the forecast inventory for the combined mining pits, respectively, over the 79-year simulation for the Scenario 1 sensitivity assessment. The forecast modelling results for the mining pit inventory are summarised as follows:

- For the 10th percentile results (wet climatic conditions), water begins to accumulate at the beginning of Stage 2 and reaches a peak inventory of around 12,600 ML during Stage 3 of the Project.
- For the 50th percentile results (median climatic conditions), water accumulates during Stage 2 and 3, then reduces to an inventory of around 2,000 ML by the end of the Project.
- By the end of Stage 3, a substantial amount of additional storage capacity (around 550 GL) will be available within the Pit 1/2/3 void as mining has been completed by this time. These voids would be used to storage excess water as required, depending on the prevailing climatic conditions.

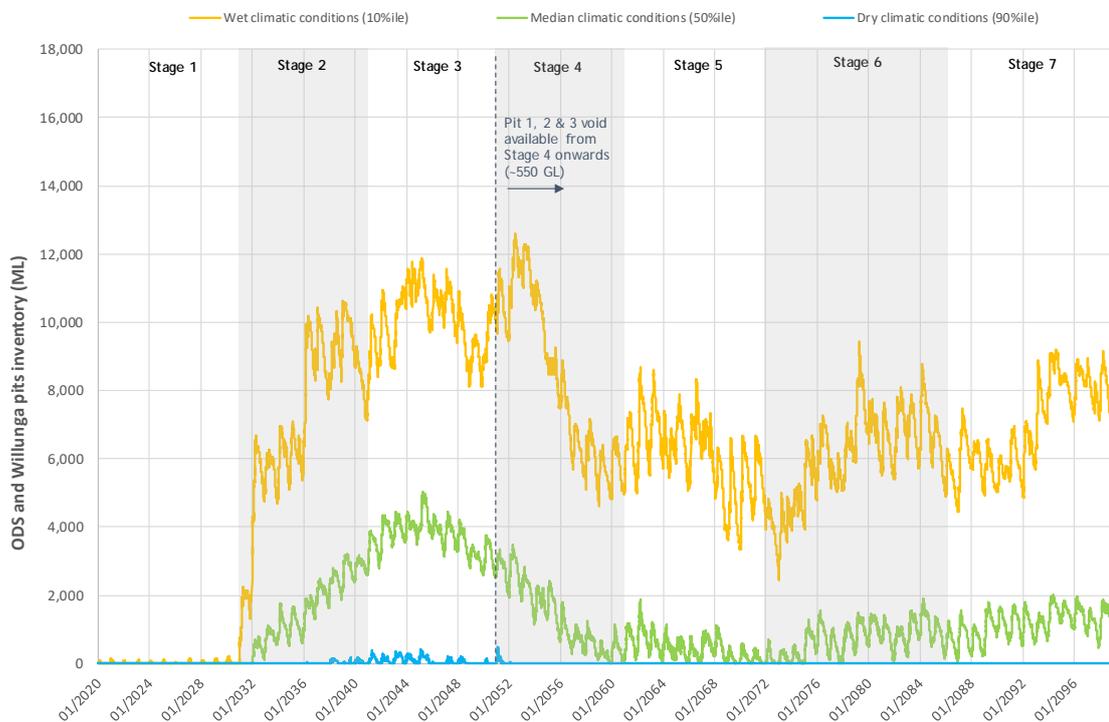


Figure A1: Forecast Combined Pit Inventory – Sensitivity Scenario 1

A.1.2 External Makeup Requirements

Figure A2 shows the total annual modelled demand for water from external sources over the 79-year simulation for Scenario 1. The modelling results show the following:

- During Stage 1, the requirement for external supply is highest. There is a:
 - ◆ 10% risk of requiring 2,090 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 1,410 ML/a (or more) from the pipeline.
- During Stage 2, the requirement for external supply increases during dry climatic conditions but reduces during median and wet climatic conditions. There is a:
 - ◆ 10% risk of requiring 2,210 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 820 ML/a (or more) from the pipeline.
- The external supply requirement reduces over the remainder of the Project. By Stage 5, there is little to no external water required under median climatic conditions.
- During Stage 6 and Stage 7, there is a 10% risk of requiring around 1,700 ML/a (or more) from the pipeline.

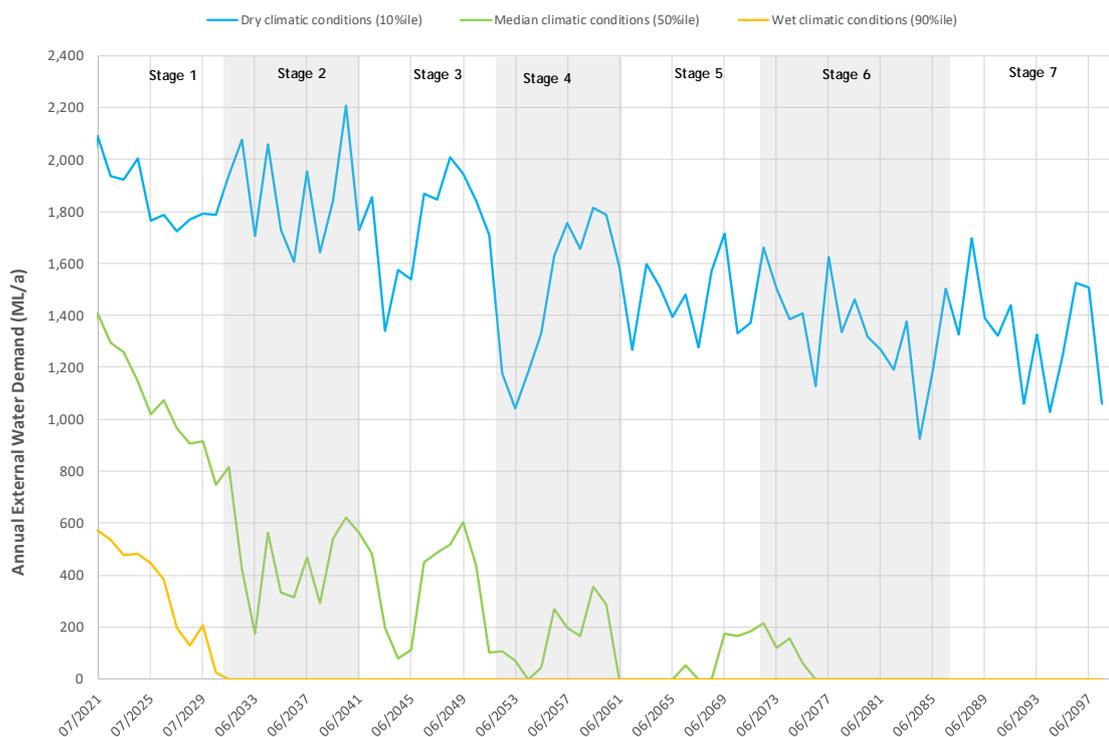


Figure A2: Forecast Annual External Water Requirements – Sensitivity Scenario 1

A.1.3 Controlled Releases

The predicted annual controlled release volumes from the mine affected water dams for Scenario 1 are provided in Figure A3. The results show that:

- For wet climatic conditions (10%ile), predicted annual controlled releases range between 500 and 2,140 ML/a, with the highest releases occurring during Stage 2 to Stage 5.
- For median climatic conditions (50%ile), predicted annual controlled releases range between 90 and 900 ML/a.
- For dry climatic conditions (90%ile), predicted annual controlled releases range between 15 and 390 ML/a.

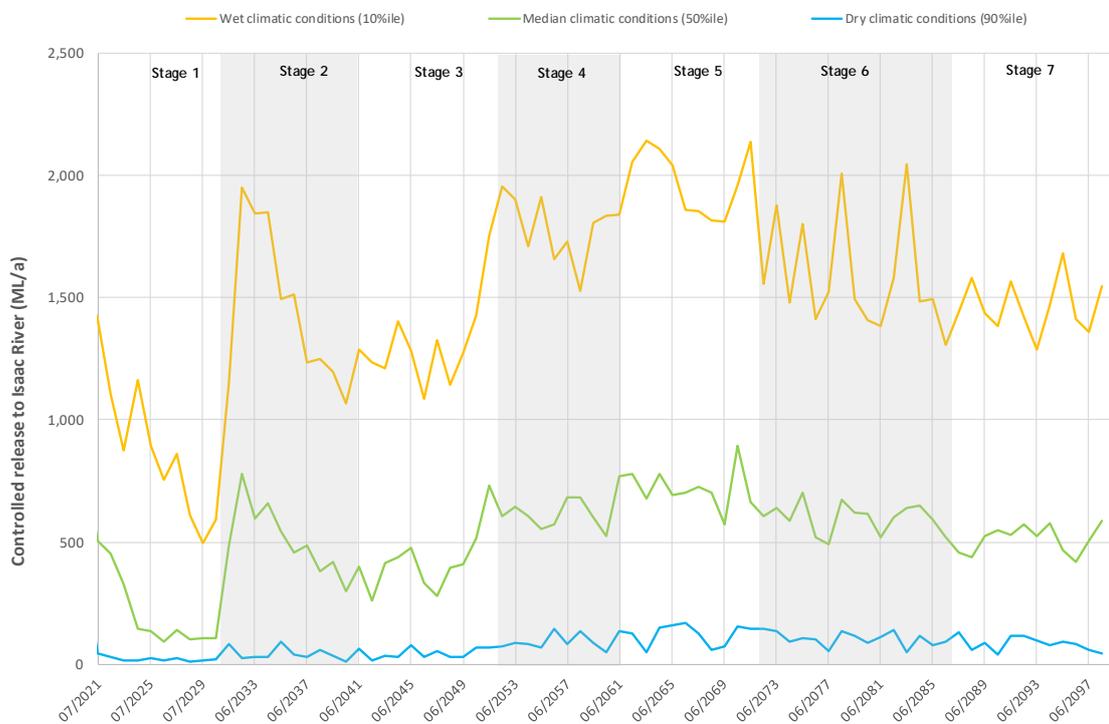


Figure A3: Forecast Annual Controlled Release Volumes – Sensitivity Scenario 1

A.2 Scenario 2: Rejects Cells Decant Return Rate Decreased by 5%

For the Scenario 2 sensitivity analysis, the decant return rate from the rejects cells was decreased from 70% to 65%. This impact of this change on the performance of the water management system is presented in the following sections.

A.2.1 In-pit Storage

Figure A4 shows the forecast inventory for the combined mining pits, respectively, over the 79-year simulation for the Scenario 2 sensitivity assessment. The forecast modelling results for the mining pit inventory are summarised as follows:

- For the 10th percentile results (wet climatic conditions), water begins to accumulate at the beginning of Stage 2 and reaches a peak inventory of around 12,550 ML during Stage 3 of the Project.
- For the 50th percentile results (median climatic conditions), water accumulates during Stage 2 and 3, then reduces to an inventory of around 2,000 ML by the end of the Project.
- By the end of Stage 3, a substantial amount of additional storage capacity (around 550 GL) will be available within the Pit 1/2/3 void as mining has been completed by this time. These voids would be used to storage excess water as required, depending on the prevailing climatic conditions.

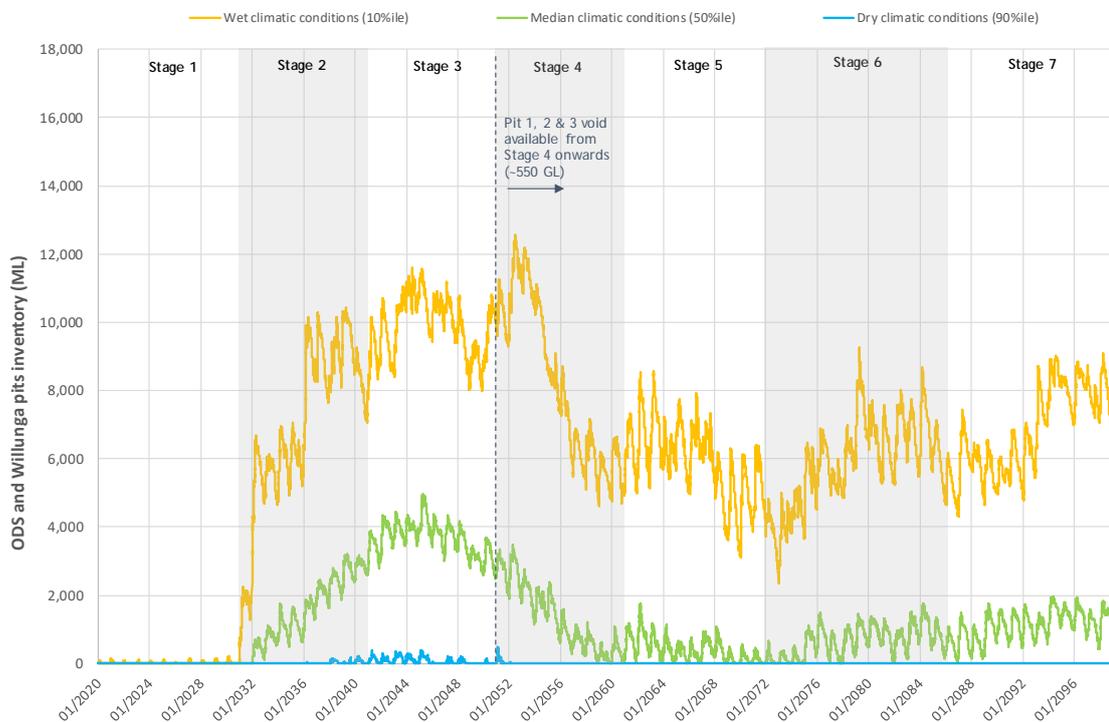


Figure A4: Forecast Combined Pit Inventory – Sensitivity Scenario 2

A.2.2 External Makeup Requirements

Figure A5 shows the total annual modelled demand for water from external sources over the 79-year simulation for Scenario 2. The modelling results show the following:

- During Stage 1, the requirement for external supply is highest. There is a:
 - ◆ 10% risk of requiring 2,150 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 1,450 ML/a (or more) from the pipeline.
- During Stage 2, the requirement for external supply increases during dry climatic conditions but reduces during median and wet climatic conditions. There is a:
 - ◆ 10% risk of requiring 2,250 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 890 ML/a (or more) from the pipeline.
- The external supply requirement reduces over the remainder of the Project. By Stage 5, there is little to no external water required under median climatic conditions.
- During Stage 6 and Stage 7, there is a 10% risk of requiring around 1,710 ML/a (or more) from the pipeline.

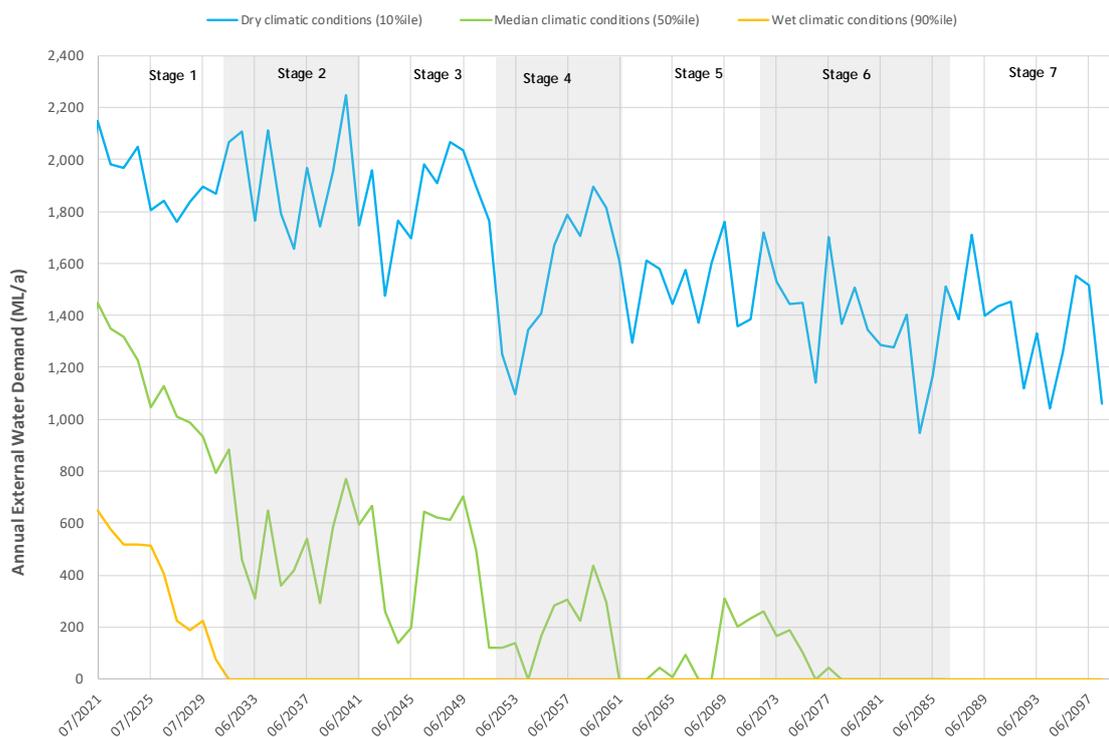


Figure A5: Forecast Annual External Water Requirements – Sensitivity Scenario 2

A.2.3 Controlled Releases

The predicted annual controlled release volumes from the mine affected water dams for Scenario 2 are provided in Figure A6. The results show that:

- For wet climatic conditions (10%ile), predicted annual controlled releases range between 500 and 2,120 ML/a, with the highest releases occurring during Stage 2 to Stage 5.
- For median climatic conditions (50%ile), predicted annual controlled releases range between 90 and 880 ML/a.
- For dry climatic conditions (90%ile), predicted annual controlled releases range between 10 and 370 ML/a.

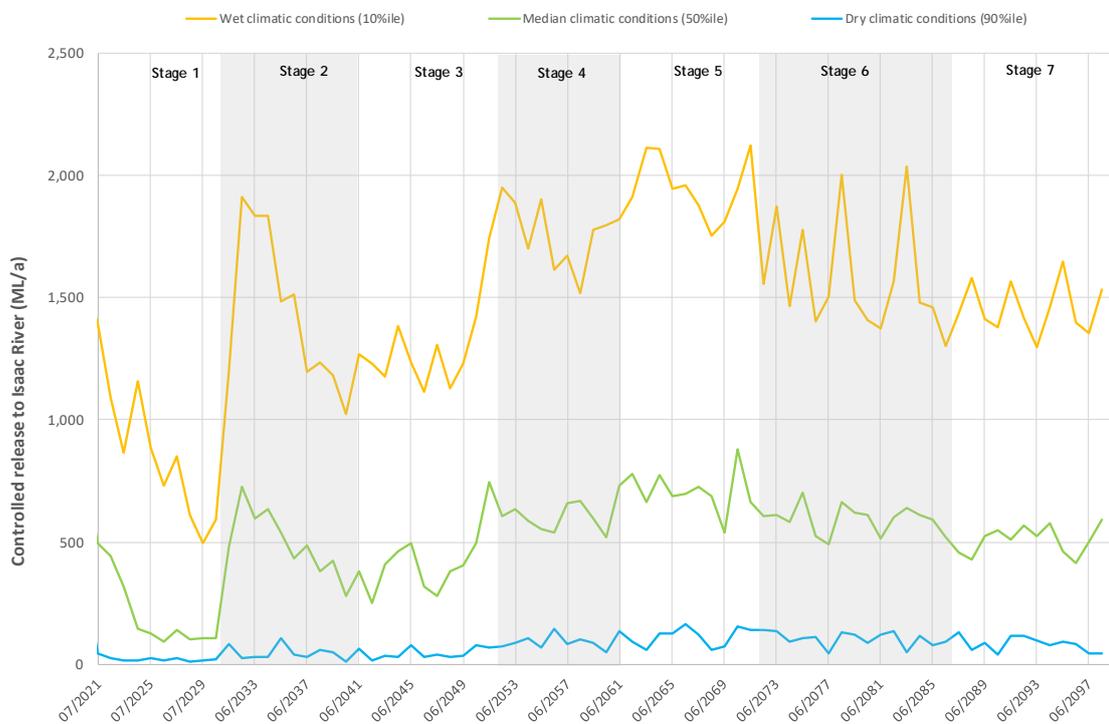


Figure A6: Forecast Annual Controlled Release Volumes – Sensitivity Scenario 2

A.3 Scenario 3: Global Increase of AWBM Soil Capacity by 20%

For the Scenario 3 sensitivity analysis, the soil capacity for each of the AWBM rainfall runoff parameter sets have been increased by 20%, resulting in reduced rainfall runoff. This impact of this change on the performance of the water management system is presented in the following sections.

A.3.1 In-pit Storage

Figure A7 shows the forecast inventory for the combined mining pits, respectively, over the 79-year simulation for the Scenario 3 sensitivity assessment. The forecast modelling results for the mining pit inventory are summarised as follows:

- For the 10th percentile results (wet climatic conditions), water begins to accumulate at the beginning of Stage 2 and reaches a peak inventory of around 8,740 ML during Stage 3 of the Project.
- For the 50th percentile results (median climatic conditions), water accumulates during Stage 2 and 3, then reduces to an inventory of around 500 ML by the end of the Project.
- By the end of Stage 3, a substantial amount of additional storage capacity (around 550 GL) will be available within the Pit 1/2/3 void as mining has been completed by this time. These voids would be used to storage excess water as required, depending on the prevailing climatic conditions.

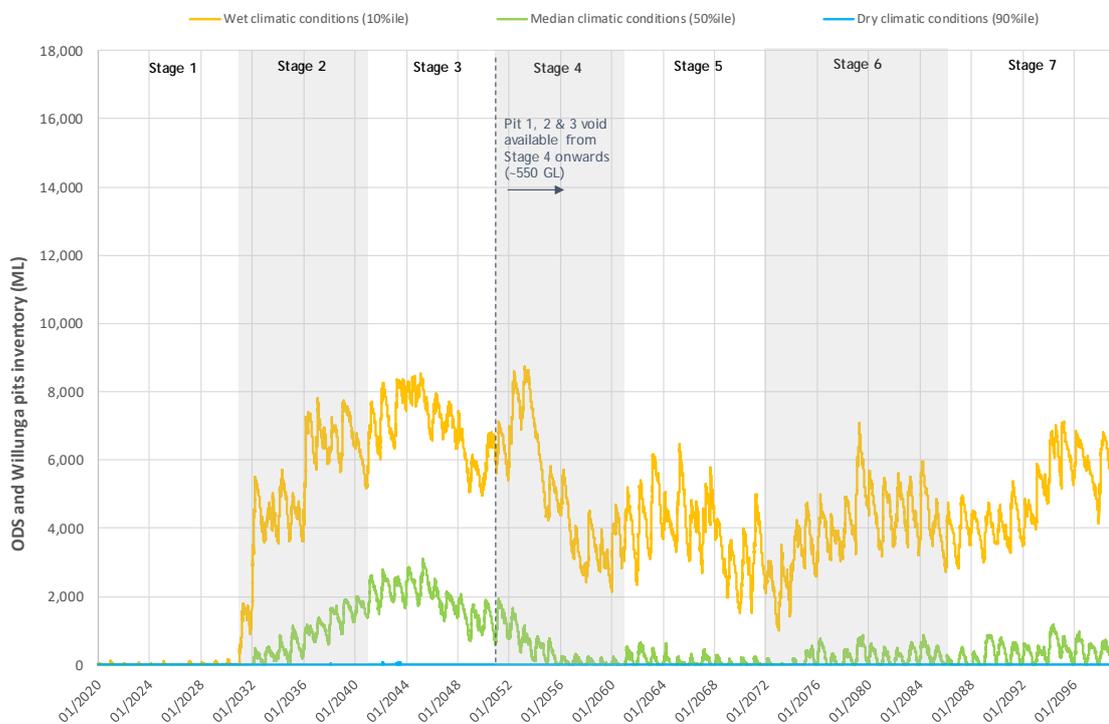


Figure A7: Forecast Combined Pit Inventory – Sensitivity Scenario 3

A.3.2 External Makeup Requirements

Figure A8 shows the total annual modelled demand for water from external sources over the 79-year simulation for Scenario 3. The modelling results show the following:

- During Stage 1, there is a:
 - ◆ 10% risk of requiring 2,180 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 1,520 ML/a (or more) from the pipeline.
- During Stage 2, the requirement for external supply is highest. There is a:
 - ◆ 10% risk of requiring 2,410 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 1,070 ML/a (or more) from the pipeline.
- The external supply requirement reduces over the remainder of the Project. By Stage 5, there is little to no external water required under median climatic conditions.
- During Stage 6 and Stage 7, there is a 10% risk of requiring around 1,950 ML/a (or more) from the pipeline.

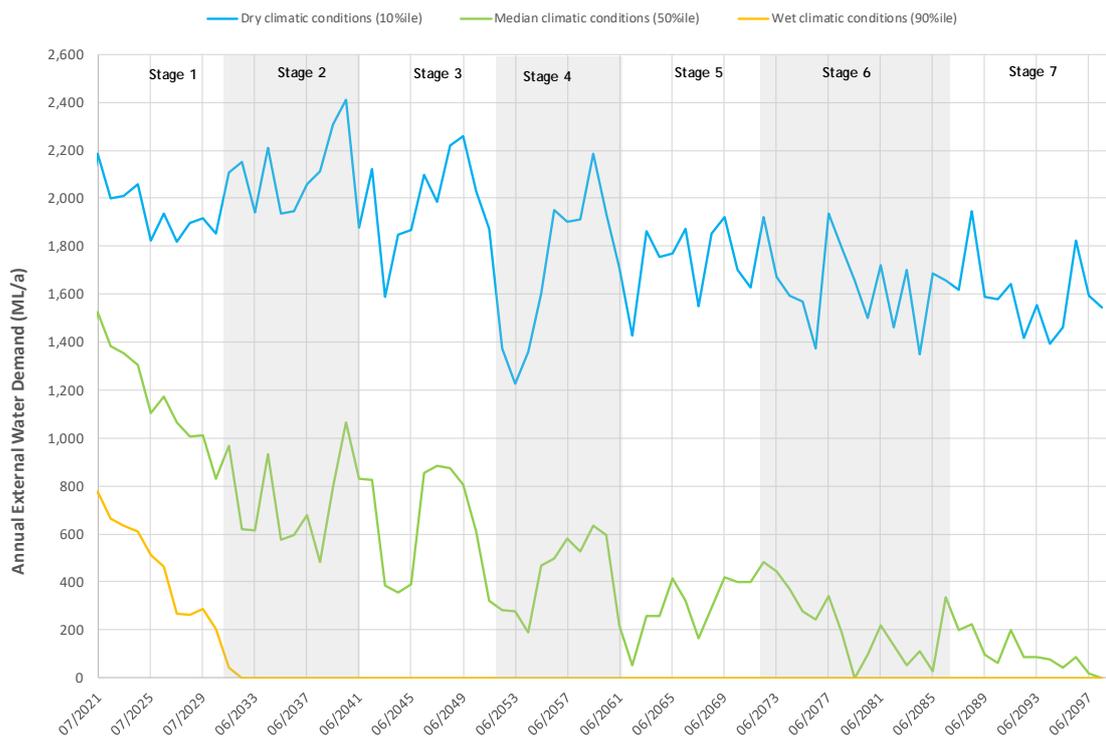


Figure A8: Forecast Annual External Water Requirements – Sensitivity Scenario 3

A.3.3 Controlled Releases

The predicted annual controlled release volumes from the mine affected water dams for Scenario 3 are provided in Figure A9. The results show that:

- For wet climatic conditions (10%ile), predicted annual controlled releases range between 450 and 2,090 ML/a, with the highest releases occurring during Stage 2 to Stage 5.
- For median climatic conditions (50%ile), predicted annual controlled releases range between 90 and 770 ML/a.
- For dry climatic conditions (90%ile), predicted annual controlled releases range between 10 and 370 ML/a.

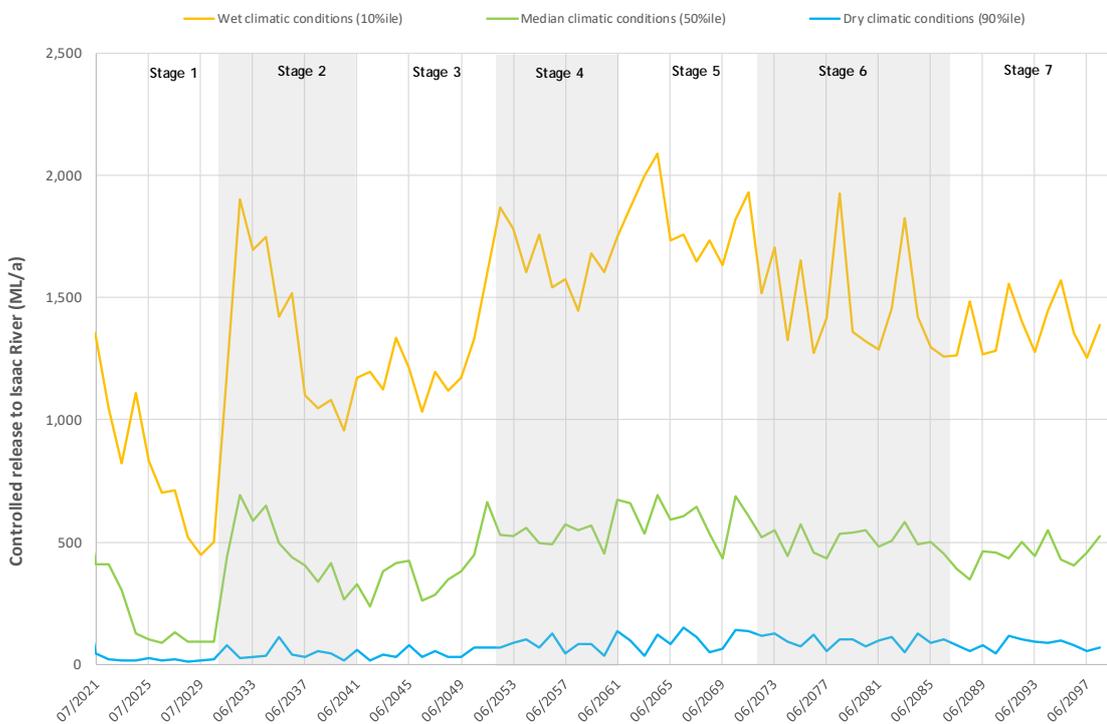


Figure A9: Forecast Annual Controlled Release Volumes – Sensitivity Scenario 3

A.4 Scenario 4: Global Decrease of AWBM Soil Capacity by 20%

For the Scenario 4 sensitivity analysis, the soil capacity for each of the AWBM rainfall runoff parameter sets have been decreased by 20%, resulting in increased rainfall runoff. This impact of this change on the performance of the water management system is presented in the following sections.

A.4.1 In-pit Storage

Figure A10 shows the forecast inventory for the combined mining pits, respectively, over the 79-year simulation for the Scenario 4 sensitivity assessment. The forecast modelling results for the mining pit inventory are summarised as follows:

- For the 10th percentile results (wet climatic conditions), water begins to accumulate at the beginning of Stage 2 and reaches a peak inventory of around 18,140 ML during Stage 3 of the Project.
- For the 50th percentile results (median climatic conditions), water accumulates during Stage 2 and 3, then reduces to an inventory of around 3,500 ML by the end of the Project.
- By the end of Stage 3, a substantial amount of additional storage capacity (around 550 GL) will be available within the Pit 1/2/3 void as mining has been completed by this time. These voids would be used to storage excess water as required, depending on the prevailing climatic conditions.

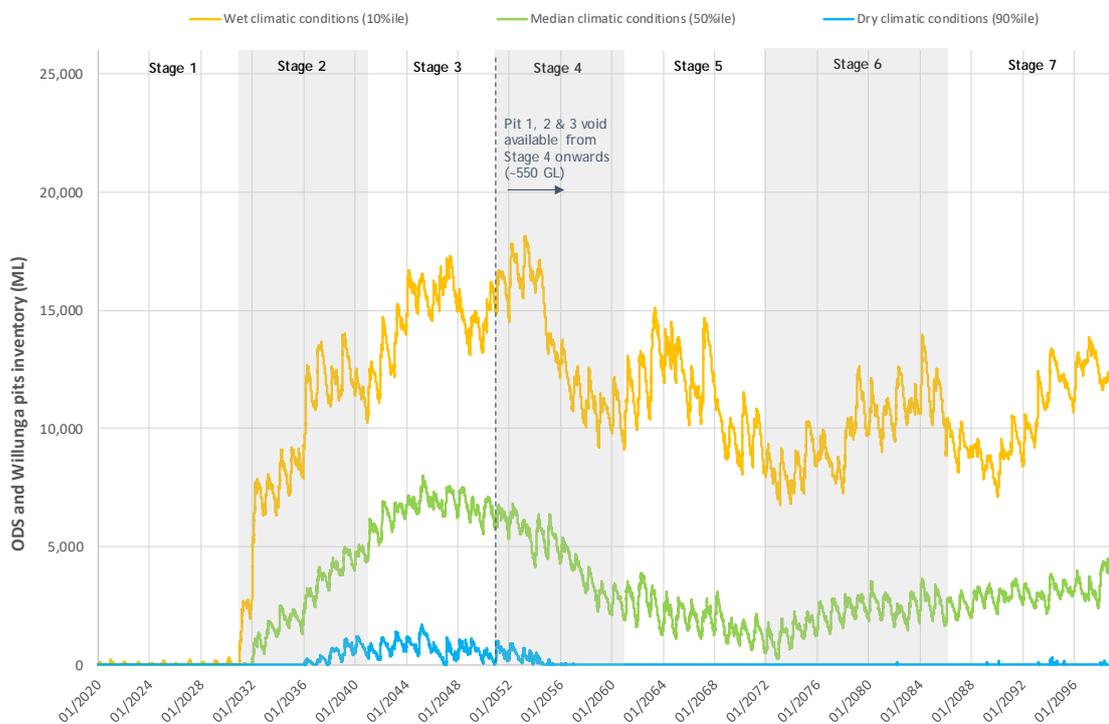


Figure A10: Forecast Combined Pit Inventory – Sensitivity Scenario 4

A.4.2 External Makeup Requirements

Figure A11 shows the total annual modelled demand for water from external sources over the 79-year simulation for Scenario 4. The modelling results show the following:

- During Stage 1, the requirement for external supply is highest. There is a:
 - ◆ 10% risk of requiring 2,090 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 1,310 ML/a (or more) from the pipeline.
- During Stage 2, the requirement for external supply increases during dry climatic conditions but reduces during median and wet climatic conditions. There is a:
 - ◆ 10% risk of requiring 2,020 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 670 ML/a (or more) from the pipeline.
- The external supply requirement reduces over the remainder of the Project. By Stage 5, there is little to no external water required under median climatic conditions.
- During Stage 6 and Stage 7, there is a 10% risk of requiring around 1,240 ML/a (or more) from the pipeline.

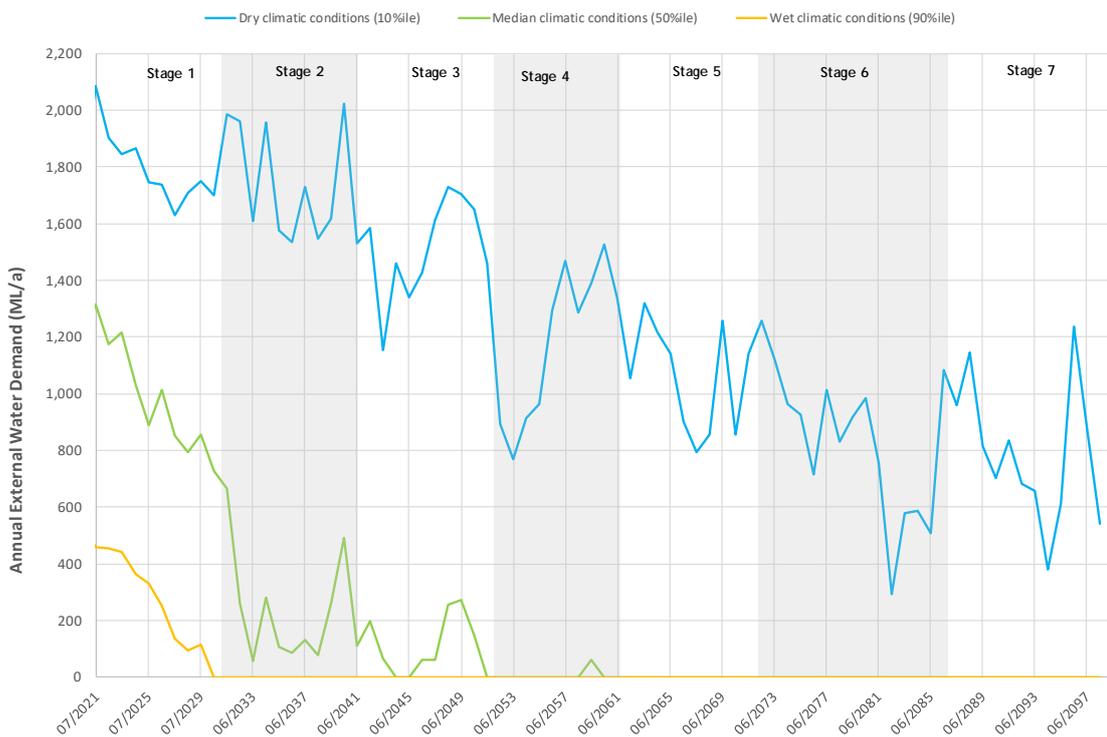


Figure A11: Forecast Annual External Water Requirements – Sensitivity Scenario 4

A.4.3 Controlled Releases

The predicted annual controlled release volumes from the mine affected water dams for Scenario 4 are provided in Figure A12. The results show that:

- For wet climatic conditions (10%ile), predicted annual controlled releases range between 570 and 2,380 ML/a, with the highest releases occurring during Stage 2 to Stage 6.
- For median climatic conditions (50%ile), predicted annual controlled releases range between 100 and 1,070 ML/a.
- For dry climatic conditions (90%ile), predicted annual controlled releases range between 15 and 380 ML/a.

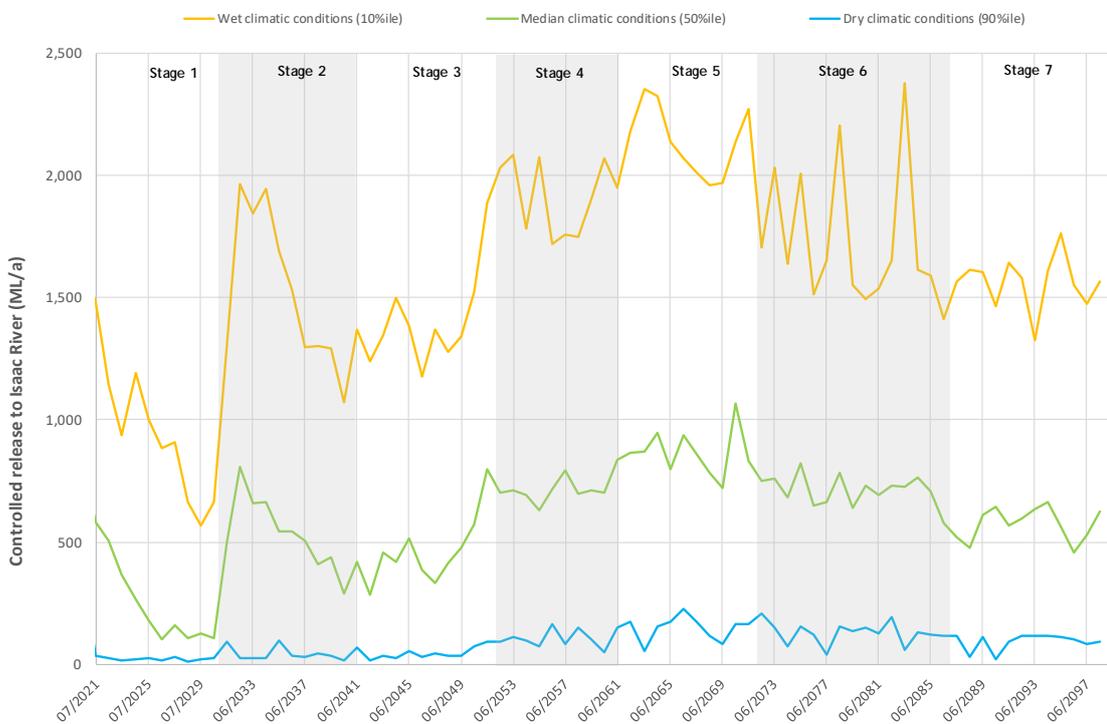


Figure A12: Forecast Annual Controlled Release Volumes – Sensitivity Scenario 4

A.5 Scenario 5: 25% Global Increase of Source Salinity by 25%

For the Scenario 5 sensitivity analysis, the salinity concentration applied to all water sources (including rainfall runoff) has been increased by 25%. This impact of this change on the performance of the water management system is presented in the following sections.

A.5.1 In-pit Storage

Figure A13 shows the forecast inventory for the combined mining pits, respectively, over the 79-year simulation for the Scenario 5 sensitivity assessment. The forecast modelling results for the mining pit inventory are summarised as follows:

- For the 10th percentile results (wet climatic conditions), water begins to accumulate at the beginning of Stage 2 and reaches a peak inventory of around 12,550 ML during Stage 3 of the Project.
- For the 50th percentile results (median climatic conditions), water accumulates during Stage 2 and 3, then reduces to an inventory of around 2,000 ML by the end of the Project.
- By the end of Stage 3, a substantial amount of additional storage capacity (around 550 GL) will be available within the Pit 1/2/3 void as mining has been completed by this time. These voids would be used to storage excess water as required, depending on the prevailing climatic conditions.

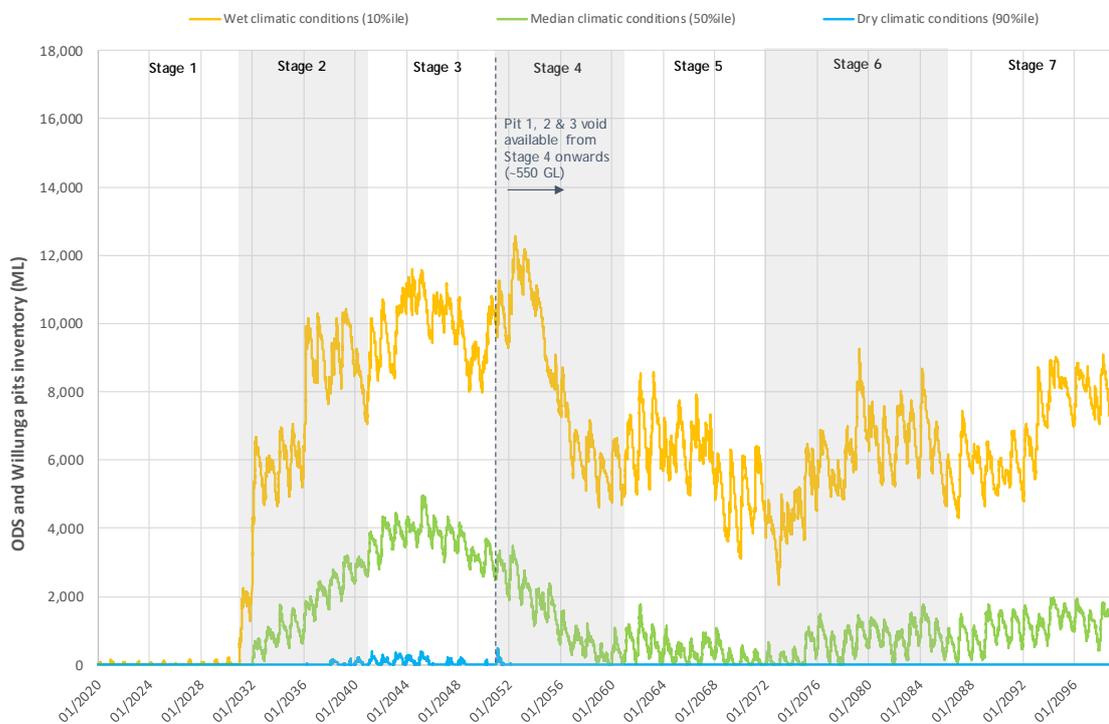


Figure A13: Forecast Combined Pit Inventory – Sensitivity Scenario 5

A.5.2 External Makeup Requirements

Figure A14 shows the total annual modelled demand for water from external sources over the 79-year simulation for Scenario 5. The modelling results show the following:

- During Stage 1, there is a:
 - ◆ 10% risk of requiring 2,120 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 1,430 ML/a (or more) from the pipeline.
- During Stage 2, the requirement for external supply is highest. There is a:
 - ◆ 10% risk of requiring 2,230 ML/a (or more) from the pipeline.
 - ◆ 50% risk of requiring 850 ML/a (or more) from the pipeline.
- The external supply requirement reduces over the remainder of the Project. By Stage 5, there is little to no external water required under median climatic conditions.
- During Stage 6 and Stage 7, there is a 10% risk of requiring around 1,700 ML/a (or more) from the pipeline.

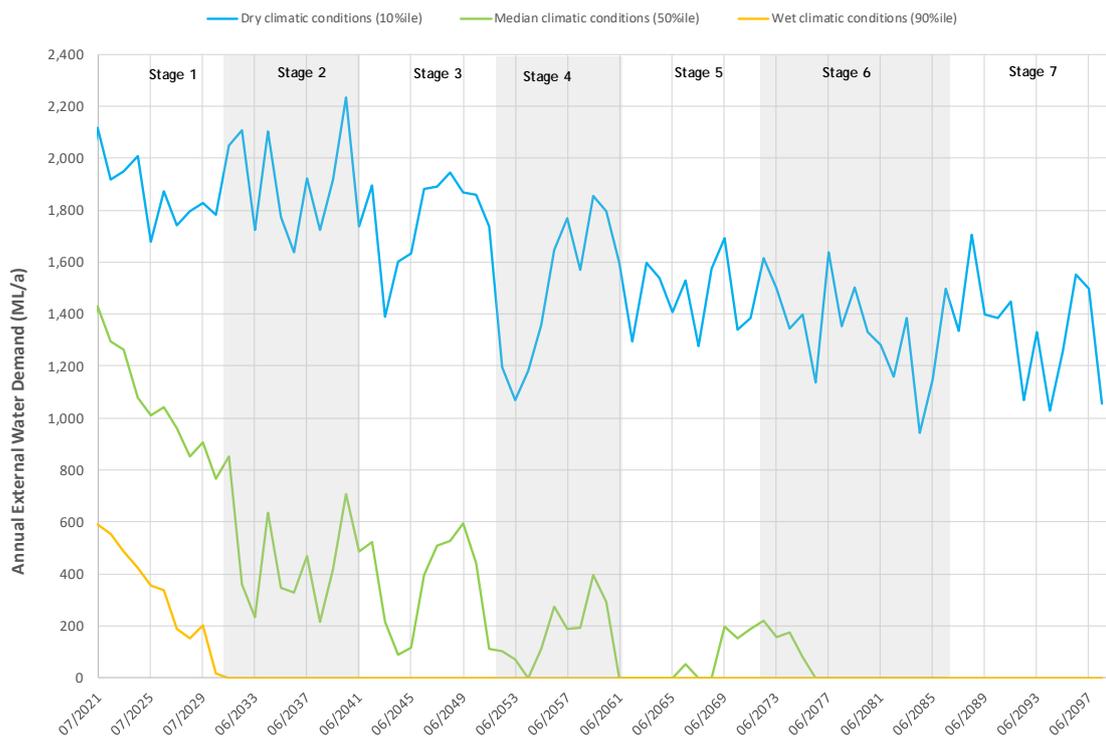


Figure A14: Forecast Annual External Water Requirements – Sensitivity Scenario 5

A.5.3 Controlled Releases

The predicted annual controlled release volumes from the mine affected water dams for Scenario 5 are provided in Figure A15. The results show that:

- For wet climatic conditions (10%ile), predicted annual controlled releases range between 460 and 2,140 ML/a, with the highest releases occurring during Stage 2 to Stage 5.
- For median climatic conditions (50%ile), predicted annual controlled releases range between 90 and 820 ML/a.
- For dry climatic conditions (90%ile), predicted annual controlled releases range between 10 and 370 ML/a.

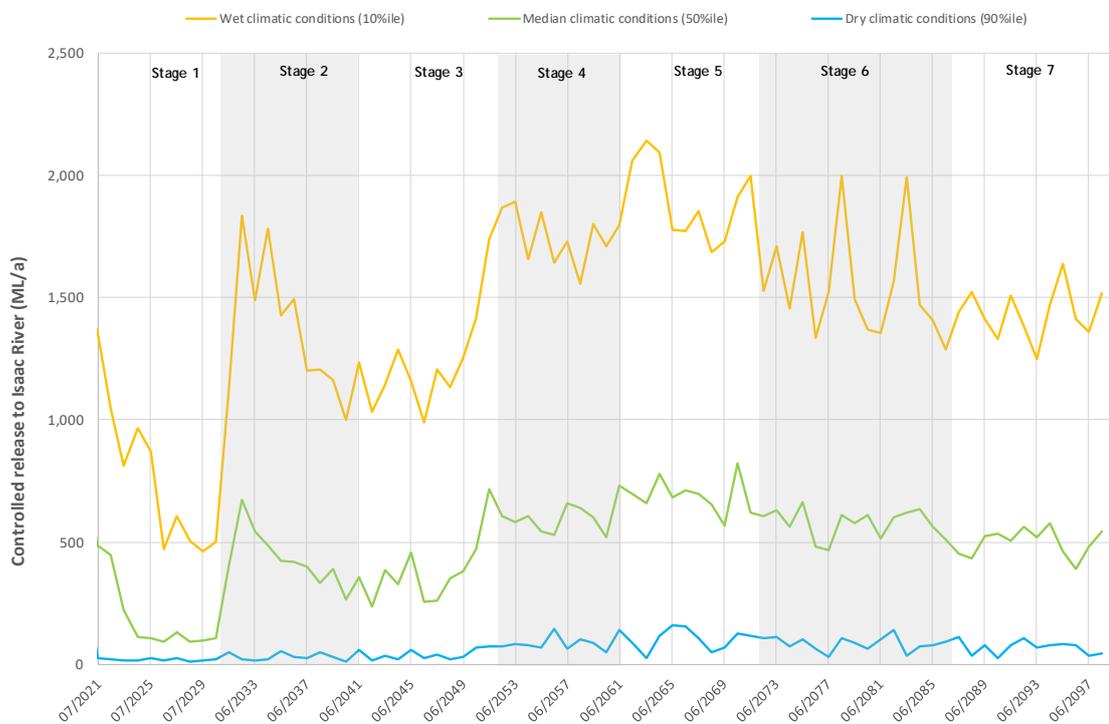


Figure A15: Forecast Annual Controlled Release Volumes – Sensitivity Scenario 5

Appendix B

Geomorphology Report