



WATER MANAGEMENT
PLAN
(01027243)

SOUTH32 WORSLEY ALUMINA

WATER MANAGEMENT PLAN

JANUARY 2021



CONTENTS

1	Context, Scope and Rationale.....	3
1.1	Proposal Background.....	3
1.2	Purpose and Scope.....	3
1.3	Current Ministerial Condition Requirements	3
1.3.1	Boddington Bauxite Mine	3
1.3.2	Refinery.....	3
1.3.3	Bunbury Port	4
1.4	Legislative Policy and Guidance	4
1.4.1	Legislation	4
1.4.2	Guidance.....	5
1.5	Relevant Key Environmental Factors.....	6
2	State of Knowledge, Risk Context and Management Approach	8
2.1	State of Knowledge	8
2.1.1	Climate	8
2.1.2	Boddington Bauxite Mine	8
2.1.3	Refinery.....	8
2.2	Project Risks	9
2.2.1	Water Resource Impact Assessment.....	10
2.3	Management Approach.....	14
2.3.1	Mine Planning.....	14
2.3.2	Working Arrangements.....	15
2.3.3	Boddington Bauxite Mine	15
2.3.4	Refinery.....	20
2.3.5	Monitoring Program Intent and Design Principles.....	21
3	Plan Provisions.....	22
3.1	Boddington Bauxite Mine	22
3.1.1	Water Monitoring Program	22
3.1.2	Buffer Zones.....	22
3.1.3	Spills Management.....	22
3.1.4	Sediment Control.....	22
3.2	Refinery.....	23
3.2.1	Water Monitoring Program	23
3.2.2	Hazardous Materials and Spills Management.....	23
3.3	Bunbury Port	23
3.3.1	Water Monitoring Program	23
3.3.2	Spills Management.....	23
3.4	Trigger and Action Response Plan (TARP)	24

3.4.1	Overview	24
3.4.2	TARP Plan.....	24
3.5	Audit and Reporting Requirements	25
3.5.1	Compliance Auditing	25
3.5.2	Reporting.....	25
3.6	Plan Review	26
4	Definitions, Terms and Abbreviations.....	27
5	References	28
6	Document Control	30

FIGURES

Figure 1-1:	Worsley Project Location and Regional Hydrology	7
-------------	-------------------------------------------------------	---

TABLES

Table 1-1:	Relevant State Legislation and Regulations	4
Table 2-1:	Groundwater quality TDS (5-yearly average) based on mining areas (GHD 2020)	8
Table 2-2:	Water Resource Potential Impacts - BBM	10
Table 2-3:	Water Resource Potential Impacts – Refinery.....	13
Table 2-4:	Water Resource Potential Impacts - Port	14
Table 2-5	Water Protection Guidelines and Worsley’s impact mitigation measure	19

1 CONTEXT, SCOPE AND RATIONALE

1.1 Proposal Background

South32 Worsley Alumina Propriety Limited (Worsley) consists of mining and development envelopes at the Boddington Bauxite Mine (BBM), transport corridors which are inclusive of conveyors, the Worsley Alumina Refinery (the Refinery) and the Bunbury Port. Mining and alumina production are currently permitted at a rate of 18.8 Million tonnes and 4.7 Million tonnes per annum, respectively.

Current mining operations are subject to Ministerial Statement No. 719 (MS719). MS719 contains a number of environmental conditions relating to the extension of mining activities into new areas beyond those where mining had previously been approved. It also consolidates and replaces environmental management commitments as set out in previous approval documents.

1.2 Purpose and Scope

Worsley's water management plan and associated monitoring program, has been designed in order to meet the following management objectives:

- Ability to detect groundwater trends at the earliest possible opportunity;
- Ability to rapidly detect and respond to any environmental impact associated with operational activities;
- Ensure compliance with legal obligations;
- Protection of Public Drinking Water Source Areas (PDWSA) and
- Determine whether current controls are effective.

The scope of this document includes the BBM, the Refinery and Bunbury Port (the Port). These areas are collectively referred to as the Project Area and are shown in Figure 1-1.

All current legislative requirements have been considered in the development of this document.

1.3 Current Ministerial Condition Requirements

1.3.1 BODDINGTON BAUXITE MINE

Commitment 1 of MS719 requires Worsley to manage all water resources within the BBM and Overland Conveyor (OLC) areas with the following objective:

- To ensure that the environmental values of surface and groundwater resources are maintained and protected from adverse impacts of bauxite mining activities and construction of bauxite transport corridors.

1.3.2 REFINERY

Commitment 7 of and Conditions 2 and 13 of MS719 require Worsley to manage all water resources at the Refinery with the following objective:

- To ensure that the environmental values of surface and groundwater resources are maintained from adverse impacts of refinery operations.

1.3.3 BUNBURY PORT

There are no specific conditions in MS719 relating to water sampling requirements at the Port.

1.4 Legislative Policy and Guidance

1.4.1 LEGISLATION

Monitoring and management of water resources undertaken by Worsley within the BBM and the Refinery is governed by a range of State legislation. These are summarised below in Table 1-1.

Table 1-1: Relevant State Legislation and Regulations

State Legislation	Relevance	Regulatory Authority
<i>Contaminated Sites Act 2003</i>	Identification, recording, management and remediation of contaminated sites	Department of Water and Environmental Regulation (DWER)
<i>Environmental Protection Act 1986</i>	Prevention, control and abatement of pollution; and, conservation, protection and enhancement of the environment	DWER
<i>Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992</i>	Regulate the manufacture, importation and use of explosives, and the classification, marking, storage, carriage, and sale of explosives and dangerous goods; and for other incidental purposes	Department of Mines, Industry Regulation and Safety (DMIRS)
<i>Rights in Water and Irrigation Act 1914</i>	Regulation, management, use and protection of water resources, and for related purposes	DWER
<i>Metropolitan Water Supply Sewerage and Drainage Act 1909</i>	Identify management purposes and protection of water resources within PDWSA	DWER and Water Corporation
<i>Metropolitan Water Supply Sewerage and Drainage Bylaws 1957</i>	Identify management purposes and protection of water resources within PDWSA	DWER and Water Corporation
<i>Water Agencies Powers Act 1984</i>	Establish the Water Resources Ministerial Body and the Water Resources Council, for management of water for public supply from PDWSA.	DWER
<i>Water Corporation Act 1995</i>	Establishment and accountabilities of Water corporation. Management and supply of public water from PDWSA.	DWER and Water Corporation

1.4.1.1 Relevant Licences

Boddington Bauxite Mine

Recycled water sampling is required under the current BBM *Environmental Protection Act 1986* (EP Act) Licence (L5960-1983-11). The licence dictates the sampling frequency, sample point locations and analytes to be sampled with regards to recycled water.

All BBM water sampling currently occurs at locations and frequencies as outlined in Appendix A.

Refinery

Aspects of the surface water monitoring program are required under the Refinery's current surface water licence (SWL68041 [4]).

Worsley also has specific obligations under the *Alumina Refinery (Worsley) Agreement Act 1973* (Worsley State Agreement) for the protection of water resources from operations at the Refinery.

Bunbury Port

Water sampling at the Port is not currently required under any specific licence requirements. The Port has a Dangerous Goods Site Licence (DGS009760) under the *Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992*.

1.4.2 GUIDANCE

1.4.2.1 Forest Management Plan 2014 – 2023

The Forest Management Plan 2014 – 2023 (Conservation Commission of WA 2013) was developed to align with the principles of ecologically sustainable forest management (ESFM).

The overall objectives of the Forest Management Plan are to:

- Conserve biodiversity and self-sustaining populations of native species and communities and to allow for the recovery of biodiversity from disturbance operations;
- Maintain ecosystem health and vitality;
- Protect soil and water resources;
- Adapt to climate change and sustain the contribution of the areas covered by the plan to global carbon cycles, consistent with relevant legislation and the achievement of other goals;
- Sustain the productive capacity of native forest ecosystems and plantations as they progressively adapt to changing climatic conditions;
- Protect and maintain Noongar and other Australian cultural heritage;
- Sustain social and economic benefits, through the provision of a range of goods and services valued by the community; and
- Ensure that management is undertaken in a systematic manner in accordance with the plan and is continually improved to achieve desired outcomes.

A number of these objectives are applicable to the successful management of water resources within Worsley's mining and refinery areas. The objectives relevant to this Water Management Plan will be achieved via formal requirements for water monitoring and impact mitigation and are discussed further in Section 3.

1.4.2.2 South Dandalup Dam Catchment Area Protection Plan (2005)

Plan generated as required to determine the protection status and management strategies for the South Dandalup Public Drinking Water Source Area (PDWSA) Catchment areas. Protection mechanisms determined by the priority rating of locations within collection areas.

- Priority 1 (P1) source protection areas are defined to ensure that there is no degradation of the water source. P1 areas are declared over land where the provision of high-quality public drinking water is the prime beneficial land use. P1 areas are managed in accordance with the principle of risk avoidance.
- Priority 2 (P2) areas are defined to ensure that there is no increased risk of pollution to the water source. P2 areas are declared over land where low intensity development (such as rural) already exists. Protection of public water supply sources is a high priority relative to other land use values in these areas. P2 areas are managed in accordance with the principle of risk minimisation.

1.4.2.3 Water Quality Protection Guidelines, Mining and mineral Processing (Water & Rivers Commission 2000)

The document comprises a set of guidelines for protecting the quality of water resources in areas where mining and mineral processing occur. comprises of ten specific guidelines (Table 2-5) which address water quality issues relating to mining and mineral processing proposals.

1.4.2.4 Water Quality Protection note series (Department of Water and Environment Regulation)

Includes specific publications regarding management and monitoring methods for water supply. Relevance for Worsley for areas that exist within PDWSA's.

1.5 Relevant Key Environmental Factors

This Plan specifically addresses the key environmental factors of Inland Waters. The Environmental Protection Authority's (EPA) objective for this factor is "*To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.*"

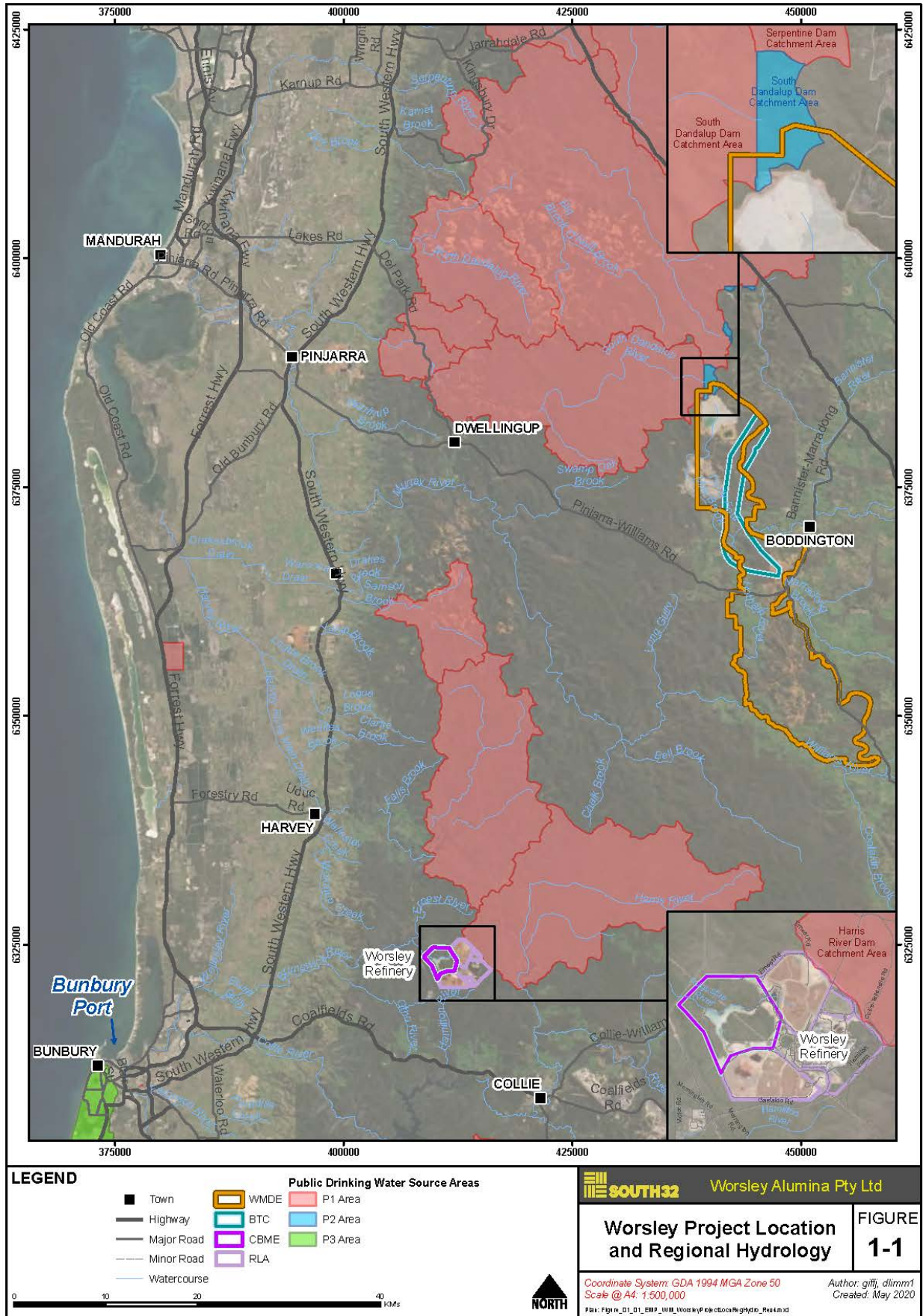


Figure 1-1: Worsley Project Location and Regional Hydrology

2 STATE OF KNOWLEDGE, RISK CONTEXT AND MANAGEMENT APPROACH

2.1 State of Knowledge

2.1.1 CLIMATE

The climate in the Project Area is considered a Mediterranean climate with typically hot, dry summers (December to February) and mild, wet winters (June to August). The closest Bureau of Meteorology (BoM) rainfall station (Station No. 9509) is located within the Marradong region of the BBM and provides representative rainfall data for the BBM area. The mean annual rainfall recorded since 1907 at the Marradong station (9509) is approximately 715 mm (BoM 2020a). A reduction in annual rainfall and an increase in the frequency of drought years has been noted since the 1970s, with the mean annual rainfall for the last decade (2009-2019) measuring approximately 576 mm (BoM 2020a). Higher average rainfall has been recorded at the Refinery, which receives an annual average rainfall of approximately 870 mm.

2.1.2 BODDINGTON BAUXITE MINE

The BBM mining areas occur within the Murray River System which is a proclaimed Surface Water Area under the *Rights in Water and Irrigation Act 1914* (RIWI Act). Surface water resources within proclaimed Surface Water Areas are managed and allocated by the DWER. Taking or diversion of surface water within these areas requires a licence granted by the DWER in accordance with the RIWI Act.

Two permanent water features intersect the Mine, the Hotham River and Williams River. Flow in the Hotham River is seasonal and both river systems are typically brackish, with salinity ranging from 2,500 to 12,000 mg/L in the Hotham River and 2,000 to 14,000 mg/L in the Williams River. The ephemeral tributaries that feed these water courses range from fresh to brackish.

2.1.2.1 Soil and Groundwater Salinities

Croton and Dalton (2004) found that the soil-salt storages of the present mine area were approximately half of the size of those quoted in the literature; that is in the range from 0.85 to 1.10 kg/m³ compared with 1.94 kg/m³ from Tyskin & Croton (1988).

Groundwater quality is variable within the existing mining areas, ranging from fresh to 15,000 mg/L salinity. A groundwater assessment undertaken by GHD (2020) has provided a five-year average of Total Dissolved Solids (TDS) in groundwater across the broad areas (Table 2-1). Higher levels of salinity are recorded in the northern extents of the Boddington region adjacent to the existing gold mining operations.

Table 2-1: Groundwater quality TDS (5-yearly average) based on mining areas (GHD 2020)

Area	Average (TDS)	Average Minimum (TDS)	Average Maximum (TDS)
Saddleback	1,975 mg/L	142 mg/L	8,075 mg/L
Marradong	1,686 mg/L	53 mg/L	7,143 mg/L
BGM	4,227 mg/L	108 mg/L	8,636 mg/L

2.1.3 REFINERY

Access to water is a critical enabler for the Refinery operations and a key resource for all communities within the South West. On a regional scale, the challenges associated with water management are likely to increase, with modelling suggesting a decrease in mean annual rainfall of 7 per cent and a 14 per cent reduction in surface water runoff in the period 2021 to 2050 relative to

the period 1961 to 1990. If current climate trends continue, the South West of Western Australia (WA) will potentially experience 80 per cent more drought-months by 2070¹.

The Refinery occurs within the Augustus River catchment, a tributary of the Brunswick River which is primarily used for agricultural purposes. The Freshwater Lake at the Refinery was built in 1983 as a water supply dam for the Refinery. Fresh water is fed directly to the Freshwater Lake through diversion structures to prevent the mixing of fresh water and potential contaminants (GRM 2015).

Supplementary water can be supplied via direct purchase through local providers. The main source of purchased water is from Wellington Dam. Water can be imported directly to the Refinery catchment lake if modelled rainfall and/or drought are likely to impact Refinery production. The site managed water balance calculations determine the amount to be purchased.

2.1.3.1 Environmental Water Provisions

In May 2001, the Water and Rivers Commission (WRC, now the DWER) released the Environmental Water Provisions Policy for Western Australia, which formally recognised the setting aside of water for the environment. The policy aims to provide for the protection of water dependent ecosystems while allowing for the management of water resources for their sustainable use and development to meet the needs of current and future users.

The DWER has adopted the concepts of ecological water requirements and environmental water provisions. Ecological water requirements are defined as: *'the water regimes needed to sustain key ecological values of water-dependent ecosystems at a low level of risk'* (WRC 2000). The DWER defines environmental water provisions as: *'the water regimes that are provided as a result of the water allocation decision-making process taking into account ecological, social and economic impacts'* (WRC 2000).

Ecological water requirements are determined based on the best scientific information available and are the primary consideration in the determination of environmental water provisions. Environmental water provisions may meet in part or in full the ecological water requirements. The DWER's preference is for the environmental water provisions of a water resource to be no less than the ecological water requirements.

Worsley will work with the DWER to ensure any changes to operational water supply or requirements at the Refinery are in line with the Water Provisions Policy.

2.2 Project Risks

Activities associated with the Project have potential to directly or indirectly impact on the key environmental factor of Inland Waters (see Section 1.4.2.2).

Potential impacts to the environment or public drinking water sources (direct and indirect) that may result from Project activities such as vegetation clearing, water abstraction, vehicle and machinery movements, and construction and other mining activities, include:

- Riverbank erosion, sedimentation, scouring of streams or release of excessively turbid water as a result of clearing riparian vegetation and alteration of surface water drainage patterns;

¹ Australian Government Department of the Environment and Energy;
<https://www.environment.gov.au/climate-change/climate-science/impacts/wa>

- Decline of aquatic fauna from changes in flow regime and water quality, potentially leading to impediment of upstream pre-spawning migrations of freshwater fishes;
- Contamination of groundwater and/or surface water from PASS material and contaminants during removal of soils and sediment at river crossings;
- Contamination of surface water as a result of spills or stormwater run-off;
- Contamination of groundwater as a result of seepage of stored chemicals;
- Deterioration or change in background water quality, such as salinity, due to indirect impact of mining activities;
- Changes to groundwater levels in the shallow aquifer as a result of clearing of native vegetation, disturbance to soil profile and rehabilitation;
- Potential impacts on surface water and groundwater values through increased water use;
- Changes to vegetation structure in Groundwater Dependent Ecosystems (GDEs) as a result of groundwater level rise; and
- Contamination (particularly hydrocarbon) of groundwater and/or surface water from operation of the Refinery (including Bauxite Residual Disposal Areas – BRDAs) and the Port.

2.2.1 WATER RESOURCE IMPACT ASSESSMENT

2.2.1.1 Boddington Bauxite Mine

A number of studies have been undertaken to assess potential impacts on water resources associated with mining activities at the BBM. The potential impacts and mitigation measures that have been implemented by Worsley are summarised in Table 2-2. Additional detail on the mitigation measures is provided in Section 0.

Table 2-2: Water Resource Potential Impacts - BBM

Potential Impact	Mitigation Measure
Dryland salinity caused by rising groundwater tables associated with clearing of deep-rooted native vegetation	<ul style="list-style-type: none"> • Minimise disturbance where possible and use existing cleared areas where practical • Progressive rehabilitation of disturbed land • Detailed flux density analysis (FDA) of new mining areas to model potential changes in groundwater levels and determine salinity risks associated with mining activities. Additional salt storage investigations of high-risk areas if determined by the FDA outputs • Ongoing monitoring of stream and groundwater quality and quantity, with investigation trigger levels developed for mining areas to monitor salinity increases
Changes to groundwater levels in the shallow aquifers	<ul style="list-style-type: none"> • Detailed FDA of new mining areas to determine groundwater mounding risks • Regular sustainable yield testing for all production bores • Monitoring of groundwater levels and development of investigation trigger levels for the protection of sensitive receptors reliant on shallow aquifers

Potential Impact	Mitigation Measure
Decline in surface water and groundwater values through increased water use	<ul style="list-style-type: none"> • Progressive rehabilitation of disturbed land <hr/> <ul style="list-style-type: none"> • Water efficiency measures to minimise water use for operational requirements • Regular sustainable yield testing for all production bores • Ongoing monitoring of groundwater and surface water in the BBM and Refinery with applicable investigation trigger levels outlined in the Trigger Action Response Plan (TARP)
Changes to vegetation structure in GDEs	<ul style="list-style-type: none"> • Detailed FDA of new mining areas to determine groundwater mounding risks • Regular sustainable yield testing for all production bores • Investigations into the sensitivities and tolerances of the conservation significant GDE vegetation structures to groundwater mounding predictions • Monitoring of groundwater levels and development of investigation trigger levels for the protection of GDEs reliant on shallow aquifers if required • Regular hydrological reviews and vegetation health assessments of at-risk conservation significant GDEs • Progressive rehabilitation of disturbed land
Reduced surface water quality associated with erosion and increased sediment	<ul style="list-style-type: none"> • Assessment of the river crossing locations and designs will take into account bank stability and hydraulic studies to ensure bridge designs avoid excessive erosion and scouring • Detailed bridge designs will ensure flood relief culverts under the bridges and erosion protection measures on the riverbanks are adequate to deal with modelled predictions • Minimise disturbance where possible and use existing cleared areas where practical • Progressive rehabilitation of disturbed land • Installation of water management infrastructure (sumps, drainage lines etc) for all operational areas including haul roads in accordance with the existing Worsley Site Drainage Standard (STA-402) and the Trunk Haul Road Design and Construction Specification (00112148) • Regular inspection and maintenance of sumps • Reference guidance management measures (section 1.4.2). • Allocated Water Resource Management Plans and PDWSA Working arrangements agreed between Worsley and stakeholders to PDWSA
Contamination of surface water and/or groundwater from spills, chemicals or stormwater run-off	<ul style="list-style-type: none"> • Environmentally hazardous material releases will be managed in accordance with the Spill Management Standard Work Instruction (SWI) (01027460) for all activities including but not limited to construction of river crossings and mining activities • Retention and treatment of potentially contaminated stormwater runoff workshops and hydrocarbon storage areas • Lined hydrocarbon storage area for contaminated soils awaiting removal from site by a licenced contractor • Consider Australian Drinking water quality guidelines (2011) risk categorisation for activities in PDWSA.

Potential Impact	Mitigation Measure
	<ul style="list-style-type: none"> • Construction Environmental Management Plan (CEMP) to be developed for any river crossing construction programs to ensure appropriate usage and storage of chemicals and hydrocarbons • Hydrocarbon and chemical analysis of selected bore monitoring programs to identify any contamination as a result of Worsley's operations • Consultation with DWER and Water Corporation regarding any activities in the Priority 1 (P1) and Priority (P2) PDWSA of the South Dandalup Dam Catchment Area to align expectations and implementation
Decline of aquatic fauna	<ul style="list-style-type: none"> • Progressive rehabilitation of disturbed land • Continuation of existing monitoring programs (physical, chemical and biological) to determine and identify any impacts to aquatic fauna ecosystems
Contamination of water resources from exposure to PASS material	<ul style="list-style-type: none"> • A CEMP will be developed with an included acid sulfate soil (ASS) management plan to outline the identification, sampling and management of any ASS expected to be encountered for the construction of any river crossings • Surface water monitoring at haul road bridge crossing locations to detect any alterations in stream flow quality as a result of Worsley's activities during and up to 12 months post construction. • The ASS management plan, as part of the CEMP, will be developed in accordance with the relevant DER (now DWER) guidelines 'Identification and investigation of acid sulfate soils and acidic landscapes' (DER, 2015a) and 'Treatment and management of soils and water in acid sulfate soil landscape' (DER, 2015b)

2.2.1.2 Refinery

Potential impacts on water resources associated with the Refinery activities are based on the assessment identified as part of the *Environmental Review and Management Programmes assessed for the Worsley Bauxite Alumina Project and previous expansion (2004)*. The identified potential impacts and key mitigation measures, which have been implemented by Worsley, are summarised in Table 2-3. Additional detail on the mitigation measures is provided in Section 3.2.

Table 2-3: Water Resource Potential Impacts – Refinery

Potential Impact	Mitigation Measure
Groundwater contamination from operation of the Refinery (including BRDAs)	<ul style="list-style-type: none"> BRDA engineered design which includes clay liners and an underdrainage system Grout curtains Concrete bunding for all Refinery process areas and hydrocarbon storage areas Separation of the Refinery Lease Area (RLA) into two catchment areas: clean (diverted to the Freshwater Lake (FWL)) and dirty (diverted to the Refinery Catchment Lake (RCL)) Depression bores located between BRDAs and FWL with capacity to divert contaminated underflow from BRDAs to the dirty catchment if required Ongoing groundwater monitoring program (includes underflows) with applicable investigation trigger levels outlined in the TARP
Impact on quality of surface water resources	<ul style="list-style-type: none"> Separation of the RLA into two catchment areas: clean (diverted to the FWL) and dirty (diverted to the RCL) BRDA engineered design Pipe head dams Erosion control measures (silt traps, contouring etc) Ongoing surface water and ecological monitoring programs with applicable investigation trigger levels outlined in the TARP Installation of water management infrastructure (sumps, drainage lines etc) for all operational areas including haul roads in accordance with the existing Worsley Site Drainage Standard (STA-402) and the Trunk Haul Road Design and Construction Specification (00112148) Regular maintenance and inspections Emergency Response Plans
Contamination of surface water and/or groundwater from spills, chemicals or stormwater run-off	<ul style="list-style-type: none"> Environmentally hazardous material releases will be managed in accordance with the Refinery Spill Management Procedure (00113581) Concrete bunding for all Refinery process areas and hydrocarbon storage areas Lined hydrocarbon storage area for contaminated soils awaiting removal from site by a licenced contractor Hydrocarbon and chemical analysis of selected bore monitoring programs to identify any contamination as a result of Worsley's operations Separation of the RLA into two catchment areas: clean (diverted to the FWL) and dirty (diverted to the RCL) Tank Integrity Maintenance System

Potential Impact	Mitigation Measure
	<ul style="list-style-type: none"> • Dangerous Goods Licence and training • Spill kits • Oil / water separators
Insufficient water supply to support operations due to drying climate	<ul style="list-style-type: none"> • Water efficiency measures to minimise water use for operational requirements • Licence to take water from FWL • Installation of a water supply pipeline to Wellington Dam • Development of a long-term water supply strategy • Sustainable yield testing for all production bores • Ongoing monitoring of groundwater and surface water with applicable investigation trigger levels outlined in the TARP •

2.2.1.3 Bunbury Port

Potential impacts to water resources at the Port and key mitigation measures, which have been implemented by Worsley, are summarised in Table 2-4. Additional detail on the mitigation measures is provided in Section 3.3.

Table 2-4: Water Resource Potential Impacts - Port

Potential Impact	Mitigation Measure
Contamination of surface water and/or groundwater from spills, chemicals or stormwater run-off (known pre-existing hydrocarbon contamination)	<ul style="list-style-type: none"> • Safe Work Instructions for chemical loading/unloading activities • Dangerous Goods Licence and training • Routine maintenance and inspections • Bunding and sumps • Worsley Tank Integrity Maintenance System • Automated control and interlock systems • Tank level control • Ongoing monitoring and hydrocarbon and chemical analysis of groundwater and runoff to identify any contamination as a result of Worsley's operations • Spill kits • Registration of site under <i>Contaminated Sites Act 2003</i>

2.3 Management Approach

2.3.1 MINE PLANNING

The Ten Year Mine Plan is annually updated and submitted to the EMLG for review and acceptance. The Ten Year Mine Plan includes the anticipated disturbance within the project area for the next two years for both mining and infrastructure development. The Ten Year Mine Plan also maps and advises on areas deferred from disturbance. Areas deferred for biodiversity and water related values are identified in the Biodiversity and Forest Management Plan (01012523).

2.3.2 WORKING ARRANGEMENTS

Working Arrangements in Public Drinking Water Supply Areas

The northern extent of the BBM intersects a small area of the South Dandalup Dam Catchment Area P1 and P2 PDWSA. The South Dandalup Dam Catchment is managed by the DWER under the *Water Resource Protection Series (WRP 55 – 2005) - 'South Dandalup Dam Catchment Area and South Dandalup Pipehead Dam Catchment Area – Drinking Water Source Protection Plan'* (DWER 2005). Water Corporation also has obligations for management of risk within the South Dandalup dam Catchment area. Exploration and mining in PDWSAs require coordination and consultation with the DWER and Water Corporation. Agreed working arrangements will be required between DWER, Water Corporation and Worsley to be established prior to the commencement of activities in PDWSAs at the BBM. Worsley will generate a dedicated Water Resource Management Plan for activities that may occur within PDWSA.

Although ultimate direction will be received from DWER, actions to be undertaken by Worsley in PDWSAs at the BBM will be based on the *Water and River Commission Water Quality Protection Note Extractive Industries within Public Drinking Water Source Areas (2000)* and considered risks will be assessed using the *Australian Drinking Water Quality Guidelines (2011)*.

The working arrangements for operating in PDWSA will include accountabilities of Worsley and stakeholders based on information to be generated and supplied, regarding detailed information on baseline data, ongoing monitoring programs and management requirements. Proposed management practises are expected to be consistent with current compliance with existing water management techniques employed at the BBM. The arrangements will be scheduled to commenced when exploration drilling activity in the area is identified by the 10 Year plan or earlier.

2.3.3 BODDINGTON BAUXITE MINE

2.3.3.1 Water Use and Efficiency

Water Efficiency

To supply water for current operations, groundwater is extracted from a series of bore fields located within each domain. Dust suppression on haul roads and plant sites, which utilises surface water runoff, is responsible for the majority of the BBMs water consumption. The balance is used as potable water for domestic drinking purposes.

Worsley aims to reduce water usage across the operations at the BBM.

The following methods are employed to reduce water usage:

- Employees and contractors are made aware of appropriate water conservation practices;
- Water truck operator training to ensure haul roads are not over watered, nor are they watered when not required; and
- Dust suppressant chemicals or surface binding agents are used wherever they are cost and operationally effective.

Water Supply

In order to meet operational water supply requirements, groundwater is pumped from production bore fields to either a dam, bladder or tank located in close proximity to each bore field. Water usage is recorded via flow meters situated on each production bore, and at the outlet from each dam.

Consideration will also be given for:

- Potential for harvesting surface runoff from haul roads; and
- Sourcing water from borrow pits.

Development of alternative future water sources needs to take into account the location and timing of future mining operations and the potential impacts from additional water abstraction.

Alternative Water Sources

The opportunity exists for Worsley to continue to develop groundwater at the BBM as a supply for mining operations. Depending on underlying geology, deep bores may provide a means of locating water supplies nearby future mining operations.

The 2018 drilling program to establish deep bores and the 2019 review of available private property bores was successful in targeting and developing relatively high-yielding aquifers. By drilling new bores in zones associated with dolerite dykes, bore yields are typically greater than 100 kL/day.

Future considerations for surface water sources will depend on the local situation and factors such as prevailing topography, stream flow and stream water quality characteristics, etc.

2.3.3.2 *Salinity Hazard Assessment and Salt Storage*

All proposed mining areas within the Worsley lease area will be subject to salinity risk evaluation using the FDA technique prior to the commencement of mining. FDA is a modelling technique that identifies areas at risk of groundwater rise due to the temporary removal of vegetation for mining, particularly valley floor ecosystems that are influenced by groundwater. The maps created using FDA allow the relative impacts of mining in different areas to be compared and for possible salinity hazard 'hot spots' to be defined (i.e. defines potential new areas of groundwater discharge).

Where the FDA indicates potential salt risk, further evaluation will be undertaken, which may include an evaluation of soil-salt storage through a drilling and sampling program.

2.3.3.3 *Water Table Rise*

Predictive Modelling

A fundamental output of the FDA is the prediction of water table rise associated with mine-related clearing.

The FDA will be applied as the key tool for prediction of water table rise in new mining areas, with the modelling predictions to be tested by the monitoring program outlined in Section 3.1.1 and Appendix A.

2.3.3.4 Groundwater and Surface Water Dependent Ecosystems

The identification, assessment and management of groundwater and surface water dependent ecosystems in areas to be mined are required to be developed in line with the proposed methodologies for the Scope of Biodiversity-related Investigations (Condition 8 of MS719).

Two types of GDEs, as defined by BoM (2020b), occur within the Project Area. These are:

- Aquatic ecosystems that rely on surface expression of groundwater. Within the BBM this includes the surface watercourses that receive groundwater inflow (Hotham River, Thirty Four Mile Brook, Marradong Brook and their tributaries), groundwater fed springs and swamps within the study area and their respective biological values; and
- Terrestrial ecosystems that rely on the subsurface presence of groundwater. Within the BBM and surrounding area this is considered to include riparian and phreatophytic terrestrial vegetation (depth to groundwater < 10m), where vegetation has a seasonal or occasional dependence on groundwater.

Characterising Landforms

A system of landform characterisation will be implemented to define the range of landform types and identify unusual areas, including areas of possible ecological significance within the mining lease area. This desktop mapping exercise will utilise a combination of published and available data which may include:

- Aerial photography;
- Vegetation complex mapping;
- Soil mapping;
- LANDSAT images;
- Vegetation Leaf Area Index;
- Digital terrain (elevation) models;
- Airborne geophysics;
- Depth to groundwater from individual bores (where available); and
- Other map features such as streams and rock outcropping.

The resultant landform classification will be overlain with mining envelopes to help guide the fauna and flora surveys and to define areas of potential special interest.

The desktop study will produce a map (or series of maps) illustrating the range of landform types existing within the mining lease area.

Identifying Groundwater Dependent Ecosystems

The studies into GDEs have been divided into the components outlined below:

- Information gathered during the landform characterisation process will be used in an FDA to identify areas where groundwater may be playing a role in the ecosystems of the valley floor areas. Aerial photographs and LANDSAT analysis will aid the process by highlighting where vegetation form and density also indicate possible groundwater dependence. Areas that are identified as potentially being of special interest will be investigated to establish any groundwater dependency during the field investigations. These areas will also be assessed in combination with data collected through the vegetation and fauna investigations.
- Stream flow and stream water quality monitoring programs are integrated for streams in the vicinity of new mining and bauxite transport areas. The intention is to define which streams flow under “normal” winter conditions and which, if any, have some persistence of base flow into spring/summer. If stream flow is identified, the rate will be estimated, and a sample will be taken and tested initially for salinity (at each monitoring point).

The FDA will be undertaken as a desktop study which will determine any areas that require field assessment. The selection process to establish the number and location of permanent monitoring sites will be developed and reviewed when GDEs may be impacted from disturbance activities as required.

Identifying Surface Water Dependent Ecosystems

Surface water dependent ecosystems will largely be identified through the studies outlined above which have been established to characterise GDEs.

An additional factor for characterising surface water dependent ecosystems is that any wetland or stream (ephemeral or permanent) found to have persistent or intermittent base flow will require special consideration in flora and fauna investigations, particularly if the area is determined to be at risk.

2.3.3.5 Protection of Public Drinking Water Source Areas

The Worsley Mine Expansion represents the first time the Worsley operation has the potential to operate within a Public Drinking Water Source Area (PDWSA). In order to assess any potential impacts and to ensure that Worsley has adequate management and mitigation measures in place, a review against the Water Quality Guidance notes 2-11 (*Water & Rivers Commission 2000*) has been undertaken and is provided in Table 2-5.

There is no intention within the future mining proposal to construct facilities, including administration, workshop or other minesite related buildings with the PDWSA. The risk therefore to contamination through hazardous wastes, putrescible wastes, human waste or turbidity associated with these types of buildings is negligible.

Recycled waste water will not be used for dust suppression within the PDWSA's.

Table 2-5 Water Protection Guidelines and Worsley's impact mitigation measure

Water Protection Guideline	Potential Impact	Mitigation Measure
#2 Tailings facilities	Contamination	No impact Worsley Tailings located within Refinery Lease Area
#3 Liners for waste containment	Contamination	No Impact No waste storage systems will be placed within or adjacent to the PDWSA
#4 Installation of minesite groundwater monitoring bores	Turbidity Contamination	Installation of bores will be undertaken in accordance with best practice, as outlined in the, Quality Protection Guidelines No. 4, (<i>Water and Rivers Commission 2000</i>)
#5 Minesite water quality monitoring	Quality	Refer to section 2.3.5 and 3.1.1
#6 Minesite stormwater	Turbidity Contamination	Refer to section 3.1.3 and 3.1.4
#7 Mechanical Servicing and workshop facilities	Contamination	No impact Worsley will not undertake servicing or build workshop facilities within the P1 PDWSA In emergency situations in pit servicing may be required, however existing procedures as outlined in sections 3.1.3 & 3.1.4 provide environmental protection.
#8 Laboratory waste discharge	Contamination	No Impact Worsley laboratories located within the Refinery Lease Area
#9 Acid mine drainage	Contamination	No Impact Worsley mining processes do not impact on soils at risk of acidification.
#10 Above ground fuel & chemical storage	Contamination	No Impact Worsley commits to not install any fuel or chemical storage within the PDWSA
#11 Mine Dewatering	Water table impact	No Impact Worsley does not undertake mine de-watering as part of its operations

2.3.4 REFINERY

2.3.4.1 Strategic Water Source Planning

Worsley has developed a long-term water supply strategy (Worsley 2007; WorleyParsons 2011; GHD 2012) in response to the changing rainfall patterns and predicted water scarcity risks in the region, to ensure there are sufficient and secure source(s) of water to meet the demands of the existing and expanded Refinery. The water supply strategy will:

- Involve consideration of water efficiency measures, increased harvesting of water from the RLA and the use of new or existing offsite sources;
- Allow for the purchase of water from offsite supply; and
- Be developed in consultation (where appropriate) with DWER, DMIRS and the Water Corporation.

The Refinery Water Balance has been developed to assess both short and long-term water sources and efficiencies that will provide protection in times of drought or an oversupply of water.

2.3.4.2 Water Efficiency

Worsley aims to improve water use efficiency and thereby reduce freshwater usage across the operation. Water saving initiatives have been identified for the Refinery, which are currently being incorporated into a water use and supply strategy for the Refinery operation. Example methods include;

- Running models on reducing evaporation by maintaining water in continual flow through digestion processes rather than exported to the RCL and returned into the system. Modelled reduction of 0.38GL/year. The project is planned for initiation in FY22.
- Decanting and returning available water from BRDA surfaces to the RCL; and
- FWL release review against baseline flow rates.

2.3.4.3 Augustus River

Overview

The isolation of potentially contaminating activities to the area within the RCL catchment and the robust design and safeguards of the BRDAs are considered adequate for the protection of downstream water quality in the Augustus River. The location of the FWL immediately downstream of the RCL and the pipe head dams of the BRDAs offer a second barrier against the accidental release or movement of potentially contaminating materials into the Augustus River. Additionally, both the FWL and the Augustus River downstream of the FWL are routinely monitored for changes in water quality.

Operating Strategy

Worsley has developed an operating strategy that outlines the arrangements, agreed with DWER, as part of the Surface Water Licence (SWL68041(4)) issued under Section 5C of the RIWI Act. The operating strategy outlines commitments regarding the extraction, diversion and use of surface water from the Augustus River.

Ecological Monitoring Program

The Ecological Monitoring Program was designed via a collaborative process between Worsley, DWER and Wetland Research & Management. Under the monitoring program, baseline data from the Augustus River, together with reference data from the Hamilton River, will be used to compare the response of aquatic biota to the modified releases from the FWL and therefore, determine the ability of the ecosystem to adapt.

Between 2010 and 2013, baseline hydrological and ecological data has been collected as part of the EMP for the Augustus River (WRM 2014).

2.3.5 MONITORING PROGRAM INTENT AND DESIGN PRINCIPLES

A water monitoring program has been designed and implemented to manage water related aspects associated with operations at the BBM and Refinery. Detailed discussion of the monitoring program is provided in Section 3.

2.3.5.1 Monitoring Program Intent

Worsley's Water Monitoring Program is designed to:

- Assess environmental impacts associated with operational activities;
- Comply with legal obligations; and
- Verify the effectiveness of current controls to manage the environmental impacts.

In addition to the above, the monitoring program should also be leveraged off technology (where possible) to enable the rapid detection and management of emerging environmental issues.

2.3.5.2 Monitoring Program Design Principles

Pre-Operational/ Baseline Monitoring

Where bores are available for sampling, a minimum of two years' worth of baseline data is to be collected prior to disturbance activities taking place in operational areas.

Active Mining/ Abstraction/ Refining/ Shipping

Ongoing monitoring is required during active operations and groundwater abstraction. Monitoring should be suitable in terms of scale and identified risk and in line with the content of this review.

Post-Operational/ Rehabilitation Monitoring

Monitoring should continue as described above for a pre-determined 'sunset' period post mining. The duration of this sunset period will be determined by the rehabilitation plan specific to each operation.

3 PLAN PROVISIONS

This section of the Plan described the measures that Worley implements to meet the requirements established by the ministerial conditions and other legislative instruments, as outlined in Section 1.3 and Section 1.4 respectively.

All sample analysis will be undertaken by an appropriately accredited laboratory.

3.1 Boddington Bauxite Mine

3.1.1 WATER MONITORING PROGRAM

All water sampling at the BBM currently occurs at locations and frequencies as outlined in Appendix A. This includes compliance requirements in accordance with the EP Act Licence (L5960-1983-11).

Results that exceed predetermined trigger levels are investigated and managed in accordance with the TARP outlined in Section 3.4 of this document.

As new mining areas are developed, further monitoring programs and TARPs will be developed.

3.1.2 BUFFER ZONES

Establishment of Buffer Zones

All rivers and streams within the BBM operational area will be subject to the criteria applicable to the informal reservation of river and stream zones under the *Forest Management Plan 2013-2023* (Conservation Commission of WA, 2013).

Where the construction of critical infrastructure such as haul roads and conveyor systems are deemed necessary, DWER will need to approve the construction of the infrastructure in advance (unless it forms part of a referral request). The placement of this infrastructure upslope from informal reserves other than stream zones will be avoided (where possible), particularly for all-weather access roads to minimise the risk of introducing *Phytophthora cinnamomi* (dieback).

3.1.3 SPILLS MANAGEMENT

All facilities at the BBM operate in accordance with the EP Act Licence (L5960-1983-11) and the *Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992*. Worsley manages all facilities at the BBM in accordance with the Hazardous Substance, ANPRESS facility (oily waste separation unit) and BBM spill management procedures. Additional procedures for spill management will be developed for future mining and transport operations that occur in PDWSAs.

The Spill Management SWI (01027460) is required to be followed in the event of a spill.

3.1.4 SEDIMENT CONTROL

Drainage Management

Drainage in BBM areas of disturbance is managed to control storm water runoff to prevent environmental effects including erosion, sedimentation of streams, release of excessively turbid water and spread of forest disease.

Drainage is managed in accordance with the Site Drainage Standard (STA-402) and Trunk Haul Road Design and Construction specification (00112148).

3.2 Refinery

3.2.1 WATER MONITORING PROGRAM

All water sampling at the Refinery currently occurs at locations and frequencies as outlined in Appendix B.

Results that exceed predetermined trigger levels will be investigated and managed in accordance with the TARP outlined in Section 3.4 of this document.

3.2.2 HAZARDOUS MATERIALS AND SPILLS MANAGEMENT

Hazardous Materials

The Refinery has a Dangerous Goods Site Licence (DGS009760) under the *Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992*, issued and enforced by DMIRS. The licence outlines the conditions on the storage and handling of hazardous materials.

Spills Management

Spills are managed at the Refinery in accordance with the Refinery Spill Management Procedure (00113581).

3.2.2.1 Hydrocarbon Contamination

Phase separated hydrocarbons have been encountered in a shallow monitoring bore at the Refinery since it was drilled in 2001 (Peter Clifton, 2009 and Hydrosearch, 2002 in Golder 2014). Investigations into this contamination indicate that a clay layer beneath the aquifer appears to be preventing the downward migration of the hydrocarbon.

The hydrocarbon contamination issue has been reported to DWER under the requirements of the *Contaminated Sites Act 2003*. Monitoring of bores for hydrocarbon contamination will occur at the location and frequency as outlined in Appendix C.

3.3 Bunbury Port

3.3.1 WATER MONITORING PROGRAM

All water sampling at the Port currently occurs at locations and frequencies as outlined in Appendix C.

Results that exceed predetermined trigger levels will be investigated and managed in accordance with the TARP outlined in Section 3.4 of this document.

3.3.2 SPILLS MANAGEMENT

Spills Management

Spills management at the Port is managed in accordance with the Refinery Spill Management Procedure (00113581).

Hazardous Material

The Port has a Dangerous Goods Site Licence (DGS009760) under the *Explosives and Dangerous Goods (Dangerous Goods Handling and Storage) Regulations 1992*, issued and enforced by DMIRS. The licence outlines the conditions on the storage and handling of hazardous materials.

3.4 Trigger and Action Response Plan (TARP)

3.4.1 OVERVIEW

Sensors deployed in the groundwater of targeted aquifers will sample a range of water quality parameters including temperature, pressure (water level) and electrical conductivity. This data will be logged at specified intervals and transmitted to a centralised database every 24 hours. Any reading outside of a specified range (refer to Appendix D) will trigger an automatic alert to key management personnel via email. The data is available for examination at any time but will be analysed in detail for any exceedance or data request.

An investigation will commence in the event that:

- Data is not received when expected (i.e. communication or equipment issues);
- Received data is outside historic norms (i.e. trigger levels have been breached); and
- The validity of the data is in question for any other reason.

The investigation will be specific to the type of trigger and will be modified as necessary to achieve a thorough understanding of the event and confirmation of any associated remedial actions.

The TARP outlined in Section 3.4.2 summarises the process that will form the basis of the investigation.

3.4.2 TARP PLAN

Trigger

- Monitoring results outside the relevant trigger level;
- Visual inspection identified potential contamination / issue; and/or
- Complaint raised concerning water quality and quantity.

Action

- Conduct field analysis on identified sample point;
- Review monitoring results against historical monitoring data;
- Review recent monitoring results for adjacent downstream and upstream monitoring sites;
- Review any relevant operational data that may have led to the trigger alert;
- Determine if an incident has potentially occurred; and

- Record any incidents, outcomes and actions in the relevant risk and incident management software (G360).
- Report any Environment Incidents in accordance with applicable internal requirements and operational licences.

Response

- Investigate the exceedance;
- Increase monitoring frequency where relevant;
- Undertake additional monitoring if necessary or when requested by stakeholders; and
- Develop corrective/preventative actions based on the outcomes of the investigation and/or additional monitoring.

Plan

- Prioritise actions based on the risk to the environment and likelihood of a repeat incident;
- Monitor the completion of actions to ensure they have been effective; and
- Review incident potential for other locations and nominate action list to relevant supervisor via appropriate risk software (G360).

3.5 Audit and Reporting Requirements

3.5.1 COMPLIANCE AUDITING

Worsley will report on implementation and compliance with the provisions set out in this document and with all requirements of Ministerial Approvals, in an Annual Compliance Report. The Annual Compliance Report, along with an Audit Compliance Report, will be included in the Annual Environmental Report produced at the end of each fiscal year for the preceding twelve-month period.

3.5.2 REPORTING

3.5.2.1 Boddington Bauxite Mine

Worsley is required to provide the DWER with an annual monitoring report for the BBM by 30 September each year as part of its environmental licence. This Annual Environmental Report contains a summary of data collected over the previous financial year (1 July to 30 June). This includes a discussion of the monitoring data and other collected data against historical data (trend analysis), known standards and targets set in the licence.

Water related data is collected and managed through an Environmental data management software, 'Equis' (Earthsoft). Equis allows for the storage, management, alert and reporting of data outputs. The software was initiated at Worsley in 2019.

Worsley is also required to adhere to the reporting conditions set out in the BBM EP Act Licence (L5960-1983-11).

3.5.2.2 Worsley Refinery

Annual interpretation and reporting of hydrological monitoring data, including trend analysis, is to be included as part of the Annual Environmental Report and Annual Hydrological Monitoring Report. These reports are prepared by hydrological consultants for Worsley for regulatory authorities associated with Worsley's mining and Refinery operations at Boddington and Collie, including the Environmental Management Liaison Group (EMLG) and the OEPA.

Worsley is also required to adhere to the reporting conditions set out in the Refinery Surface Water Licence (SWL68041(4)).

3.6 Plan Review

This Plan will undergo an internal review and audit that is aligned with the recommendations schedule (3 yearly, Strategen 2008) and the Environmental Audit Schedule specification (00113088). The review of this Plan will consider:

- Effectiveness of monitoring controls / systems;
- Monitoring report outcomes;
- Relevance to current monitoring and analysis systems and performance indicators;
- Technology improvements;
- Changes to operational activities leading to changes in the risk;
- Best practice monitoring processes;
- Actions from incident and audit outcomes;
- Changes to relevant legislation, policy, guidelines and guidance material; and
- Benchmarking against other similar operations.

4 DEFINITIONS, TERMS AND ABBREVIATIONS

Term	Description
G360	Global 360 – Risk and Incident Management Software.
BBM	Boddington Bauxite Mine
BRDA	Bauxite Residue Disposal Area
DMIRS	Department of Mines, Industry Regulation and Safety
DWER	Department of Water and Environmental Regulation
EMLG	Environmental Management Liaison Group
EMP	Ecological Monitoring Program
EP Act	<i>Environmental Protection Act 1986</i>
FDA	Flux Density Analysis
FWL	Fresh Water Lake
MS719	Ministerial Statement No. 719
PDWSA	Public Drinking Water Source Area
the Port	Bunbury Port
RCL	Refinery Catchment Lake
RLA	Refinery Lease Area
Refinery	Worsley Refinery
RIWI Act	<i>Rights in Water and Irrigation Act 1914</i>
TARP	Trigger and Action Response Plan
Worsley	South32 Worsley Alumina Pty Ltd
Worsley State Agreement	<i>Alumina Refinery (Worsley) Agreement Act 1973</i>
WRC	Water and Rivers Commission

5 REFERENCES

- 01012523** Biodiversity and Forest Management Plan
-
- 00113088** *Environmental Audit Schedule Specification*
-
- 00112148** Trunk Haul Road Design and Construction Specification
-
- 00113581** Refinery Spill Management Procedure
-
- 01027460** Spill Management Standard Work Instruction
-
- STA – 402** Site Drainage Standard
-
- Alumina Refinery (Worsley) Agreement Act 1973*
-
- Bureau of Meteorology (BoM) 2020a, *Climate Data Online*.
<http://www.bom.gov.au/climate/data/>
-
- Bureau of Meteorology (BoM) 2020b, *Groundwater Dependent Ecosystems Atlas*.
<http://www.bom.gov.au/water/groundwater/gde/>
-
- Conservation Commission of Western Australia 2013, *Forest Management Plan 2014-2023*, Government of Western Australia.
-
- Croton, J.T. 1991, *Relationships of groundwater levels and salt storages to the geomorphology of the Intermediate Rainfall Zone of the northern jarrah forest*, Environmental Research Bulletin No. 24. Alcoa of Australia Ltd.
-
- Croton, J.T. and Dalton, J.A. 2004, *Soil salt storages and salinity risk assessment for the Boddington Bauxite Mine*, Water & Environmental Consultant reports to Worsley Alumina Pty Ltd.
-
- Croton, J.T. and Dalton, J.A. 2007, *Summary of soil salt storages for Boddington bauxite mine*, Water & Environmental Consultant reports to Worsley Alumina Pty. Ltd.
-
- Department of Environment Regulation (DER – now DWER) 2015a, *Identification and investigation of acid sulfate soils and acidic landscapes*.
-
- Department of Environment Regulation (DER – now DWER) 2015b, *Treatment and management of soils and water in acid sulfate soil landscape*.
-
- GHD Group Pty Ltd (GHD) (2012), *Refinery Water Balance Strategy. Investigation into Key Strategic Projects Ensuring Refinery Operational Security*, June 2012.
-
- GHD Group Pty Ltd (GHD) 2020, *Hotham Bauxite Groundwater and Surface Water Studies*, Unpublished report prepared for South32 Worsley Alumina.
-
- Golder Associates 2004, *Worsley Alumina's Bauxite Mining Lease Area 258SA Stream Flow and Salinity Analysis*, Unpublished report prepared for Worsley Alumina Pty Ltd, Nov 2004.
-
- Groundwater Resource Management (GRM) 2015, *Triennial Aquifer Review July 2011 to June 2014*.
-
- Johnston, C.D. 1981, *Salt content of soil profiles in bauxite mining areas of the Darling Range, Western Australia*, CSIRO Australia, Division of Land Resources Management Technical Paper No. 10:1-19.
-
- Water and Rivers Commission Water, 2000. *Quality Protection Guidelines (2-11)*
-
- Slessar, G.C., Murray, N.J. & Passchier, T. 1983, *Salt storage in the bauxite laterite region of the Darling Range, Western Australia*, Environmental Research Bulletin No. 16, Alcoa of Australia Ltd.
-
- Stokes, R.A., Stone, K.A. & Loh, I.C. 1980, *Summary of soil salt storage characteristics in the northern Darling Range*, Water Resources Branch, Public Works Depart. W.A., Tech. Rep. No. WRB 94.
-

Strategen Environmental Review (2005), Worsley Alumina Environmental Review and Management Program.

Strategen (2008) Audit Program - Ministerial Statements No. 719 and 751. Unpublished Report for Worsley Alumina Pty Ltd, Jan 2008

Tsykin, E.N. & Croton, J.T. 1988, *General salt storage terrain relationships for the Darling Range, W.A.* Environmental Research Note No. 14. Alcoa of Australia Ltd.

Tsykin, E.N. & Slessar, G.C. 1985, *Estimation of salt storage in the deep lateritic soils of the Darling Plateau, Western Australia*, Australian Journal of Soil Research 23: 533–41.

Water and Rivers Commission (WRC) 2000, *Environmental Water Provisions Policy for Western Australia*, Water and Rivers Commission, Statewide Policy No. 5.

WRM, 2014, Augustus River Ecological Monitoring Program, Milestone Report – Aquatic Fauna Baseline Survey.

Worley Parsons, 2011 Worsley Alumina Water Balance Strategy.

Worsley 2007, WAPL Proposed Water Supply Strategy

6 DOCUMENT CONTROL

Approval Circulation

Role	Name	Endorsed	Date
Environmental Supervisor	Craig Kimpton	✓	29.01.2021
Manager HSERT	Dale McAtee	✓	15.02.2021

Document Details

Version	4
WAPL Doc No.	01027243
Deployed	18 February 2021
Revalidate	18 February 2024
UNCONTROLLED WHEN PRINTED	

APPENDIX A: BODDINGTON BAUXITE MINE WATER MONITORING PROGRAM

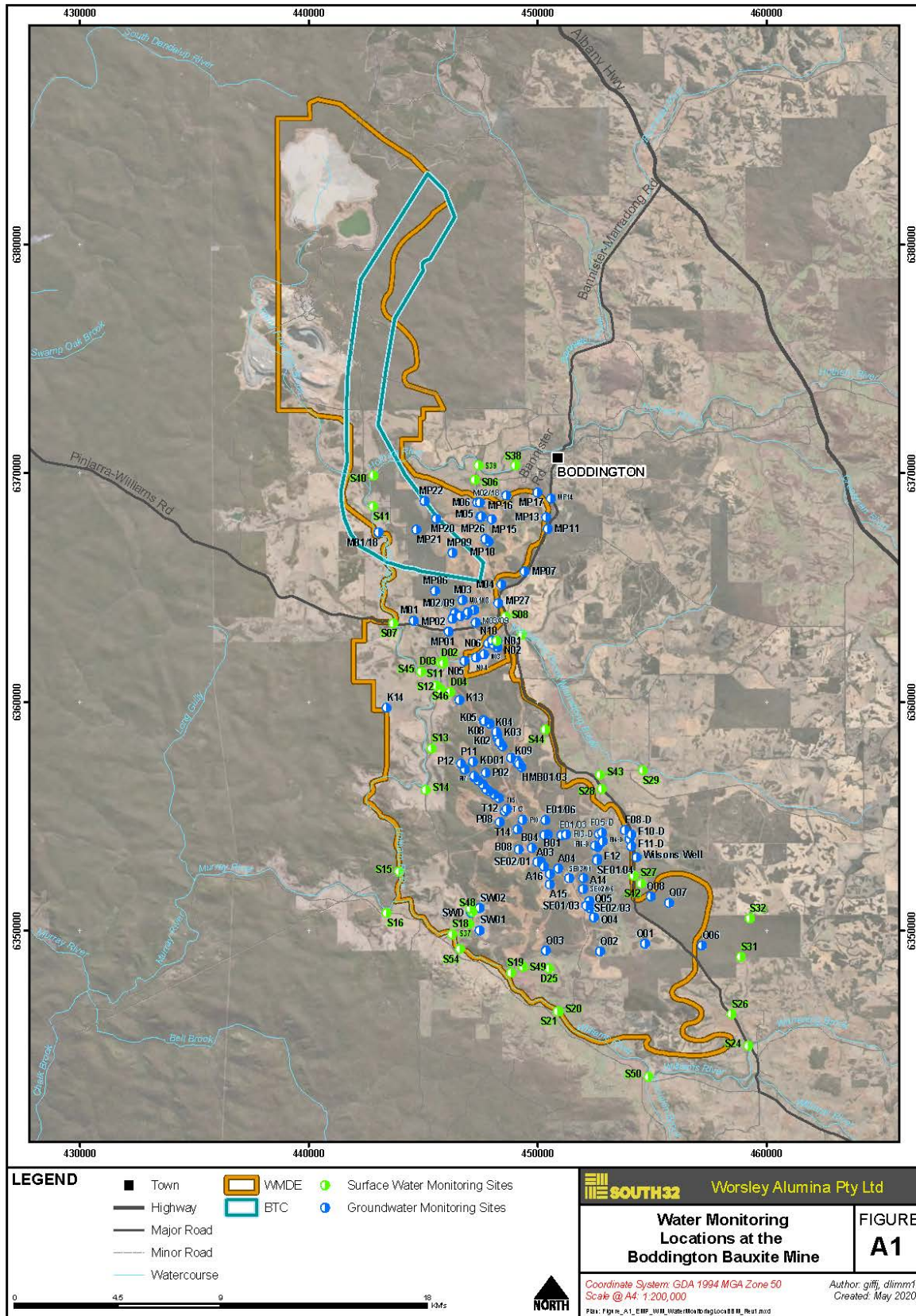


Figure shows all historical BBM monitoring locations.

Table 1: BBM Groundwater Monitoring Program

Program	Frequency	Analysis Required	Analysis	Sites Monitored
Groundwater	Continuous	Water Level (WL)	Logger	A04, A04A, K04, K05, K14, M01, M03, MP03, N01, N04, N05, N07, N10, P12, Q05, T05, T11A
	Annually	<i>pH, EC, TDS, Silicon as SiO₂, N, Ca, Mg, Na, K, Cl, SO₄, Alkalinity, Fluoride, As, Cd, Cr, Pb, Ni, Zn, Hg, Mn, Se, Al, Fe,</i>	Lab	A04, A04a, B01, B04, B04/20, E01/03, E01/06, F06-D, K01, K04, K05, K06, K07, K08, K09, K14, M01, M01/08, M01/18, M02/08, M03, M03/09, M04, M06, MP10, MP17, M21, M26, N01, N04, N05, N07, N10, P12, Q01, Q02, Q03, Q05, Q07, Q08, SE01/01, SE01/03, SE01/04, SE02/03, SE02/06, SW01, T05, T06B, T07A, T07C, T11, T12, T13, T14
	Biannually	Water Level (WL), EC, Temp °C, pH and DO	Field	HMB01/03, HMB02/03
	In response to trigger/alert	TRH	Lab	As required

Table 2: BBM Surface Water Monitoring Program

Program	Frequency	Analysis Required	Analysis	Sites Monitored
Surface Water	Continuous	EC	Logger	S11, S33
	Monthly	EC, pH, DO, Temp °C and Turbidity	Field	S07, S11, S15, S16, S18, S21, S24, S33, S39, S43, S50
		TSS	Lab	
Livestock Dams	Monthly	EC, pH, DO, Temp °C and Turbidity	Field	D02, D03,

Table 3: BBM Recycled Water Monitoring Program (accordance with the EP Act Licence (L5960-1983-11 3.6.1))

Program	Frequency	Analysis Required ^{2F}	Analysis Type	Sites Monitored
Treated Hydrocarbon Contaminated Wastewater	Monthly	pH, TDS, TRH, Cr, Cu and Zn	Lab	ANP01, KD01

² If field data confirms trigger exceedance lab analysis work should progress.

Table 4: BBM Water Monitoring Program Trigger Levels:

Sample Site Type	Analyte	Unit	Lower Trigger Level	Upper Trigger Level
Groundwater				
Groundwater	Water Level	mbgl	Concerning trend identified within the triennial aquifer review by a qualified hydrologist	
Surface Water				
Livestock Dams	TDS	mg/L	N/A	4000
Regional Surface Water	EC, Turbidity, TSS	Various	Downstream monitoring point water quality is inferior to upstream water quality and is >2SDEV from the mean upstream monitoring point and historical average	

APPENDIX B: REFINERY WATER MONITORING PROGRAM

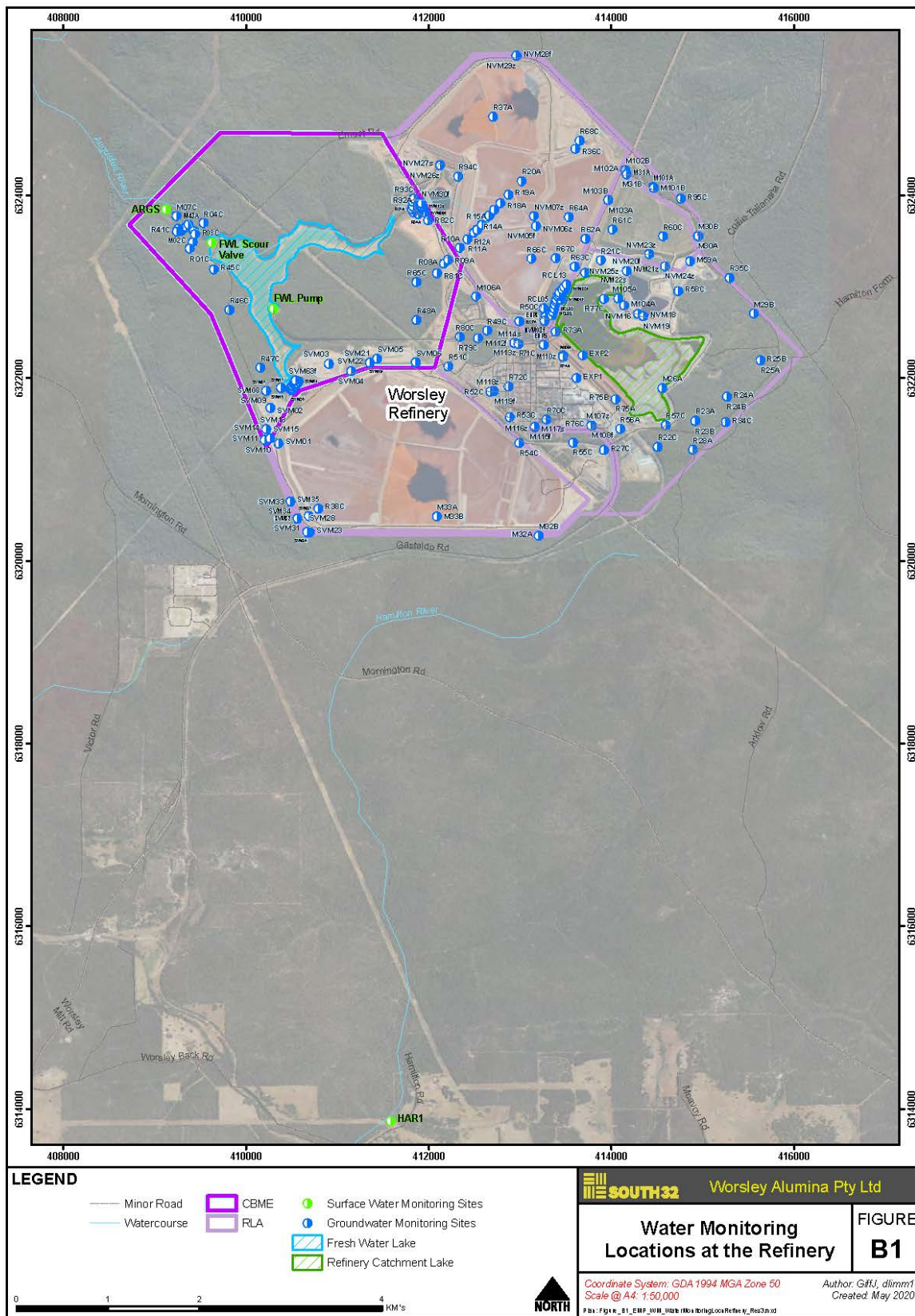


Figure B1 shows all historical Refinery bore monitoring locations.

Table 5: Refinery Groundwater Monitoring Program

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Groundwater	Real-time (6 hour interval)	Water Level, EC, Temp °C	Down Bore Sensor	SVM36, SVM60, SVM54, SVM55, NVM12f, NVM11s, NVM10z, NVM01f, NVM02z, M111s, M116z, M112f, M113z, M114s, R25B, SVM24, NVM28f
	Biannually ³	pH, EC, Alkalinity, K, Na, Ca, Mg, Fe, Al, Cl, SO ₄ , Sb, As, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, and Hg (<i>Calculated Results: TDS, NA/CL, HCO₃, CO₃, OH</i>)	Lab	
	In response to trigger / alert	pH, EC, Alkalinity, K, Na, Ca, Mg, Fe, Al, Cl, SO ₄ , Sb, As, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, and Hg (<i>Calculated Results: TDS, NA/CL, HCO₃, CO₃, OH</i>)	Lab ⁵	As Required

Table 6: Refinery Surface Water Monitoring Program

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Regional Surface Water ⁶	Real time ⁷	Water level, flow rate, DO, pH, EC, and Temp °C	Sonde	ARGS
	Weekly ⁸	Water Volume Level ⁹	Real Time	FWL
	Monthly	Temp °C ¹⁰ , EC, pH, Turbidity	Field	ARGS, FWL Pump, FWL Dam Wall, HAR1, BRR1, FWLUF1, FWLUF2, FWLUF3
		EC, pH, Na, Cl	Lab.	
Quarterly ¹¹	SO ₄ , K, Ca, Mg, Fe, Al, Alkalinity (as CaCO ₃), EC, pH, Na, Cl, TDS, Turbidity, Heavy metals (B, As, Be, Cd, Cu, Cr, Hg, Ni, Pb and Zn)	Lab	Lab	

Table 7: Refinery Water Monitoring Program Trigger Levels:

Analyte	Unit	Minimum Action Level	Maximum Action Level
Regional Surface Water			
Aluminium	mg/L		0.2
Chlorine	mg/L		400
Dissolved Oxygen	%	90	
Electrical Conductivity	uS/cm	120	300

³ Biannual sampling campaign of select groundwater monitoring bores as recommended by GRM.

⁴ Initial investigation to confirm anomalous reading.

⁵ If field data confirms trigger exceedance lab analysis work should progress.

⁶ Refinery SWL only requires sampling to be conducted for FWL Pump Station and ARGS.

⁷ Water level, DO and Temp for ARGS only.

⁸ Licence condition that this is done at a weekly frequency however, Worsley have the ability to collect it in real time.

⁹ FWL level only.

¹⁰Temp for ARGS only.

¹¹DO and DO% saturation for ARGS only during quarterly sampling.

Iron	mg/L		0.3
Manganese	mg/L		0.1
Nitrate as N	mg/L		0.7
Nitrate as NO3	mg/L		0.7
pH	pH unit	6.5	8
Sodium	mg/L		300
Sulfate	mg/L		400
Total Alkalinity as CaCO3	mg/L		500
Turbidity	NTU		20
Groundwater			
EC	uS/cm		95 th Percentile
Water Level	mbgl	5 th Percentile	

APPENDIX C: BUNBURY PORT WATER MONITORING PROGRAM



Figure C1 shows all historical Port monitoring locations.

Table 8: Proposed Bunbury Port Groundwater Monitoring Program

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Groundwater	Real-time (6-hour interval)	Water Level, EC and Temp °C	Down Bore Sensor	B17A, B21A
	In response to trigger / alert	Water Level (WL), EC, Temp °C, pH and DO pH, EC, Alkalinity, K, Na, Ca, Mg, Fe, Al, Cl, SO ₄ , Sb, As, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, and Hg (<i>Calculated Results: TDS, NA/CL, HCO₃, CO₃, OH</i>),	Field Lab	As required

Table 9: Proposed Bunbury Port Surface Water Monitoring Program

Program	Frequency	Analysis Required	Analysis Type	Sites Monitored
Surface Water	At the time of release. ¹²	EC and pH	Field	Caustic Tank Bund

¹² Bunbury Port to test the water in caustic tank bund and record the results prior to releasing into environment.