UNITED WAMBO
JOINT VENTURE

GLENCORE

# Groundwater Management Plan

# Executive Summary

This Groundwater Management Plan (GWMP) has been developed to address groundwater related requirements of SSD 7142 and Environment Protection Licence (EPL) 3141 and EPL 529 as relevant to open cut mining operations associated with the United Wambo Open Cut Coal Mine Project (United Wambo). This GWMP is part of a set of documents that, together, form the Water Management Plan (WMP) for the United Wambo Joint Venture.

Specific measures and requirements to meet the objectives of this GWMP and to address impacts on adjacent shallow alluvial groundwater and underlying groundwater in the bedrock are outlined in ***Table 1***. Based on the Project's adopted water management and mitigation measures, it is considered that potential groundwater impacts that may arise as a result of the project can be effectively managed.

*Table 1*

| No | Mitigation / Management Measure | Section | Timing |
|---|---|---|---|
| **1** | Negligible impacts to the alluvial aquifer beyond those predicted in the document/s listed in Condition A2(c) (i.e. the Project EIS (Umwelt 2016)), including:<br>• negligible change in groundwater levels; and<br>• negligible impact to other groundwater users.<br>Triggers for unexpected groundwater level and groundwater quality changes are in place and TARPs outline appropriate responses. | ***Section 7.1***<br>***Section 6.2.7***<br>***Section 7.3*** and ***Appendix B - Groundwater TARPs*** | During mine design and operations |
| **2** | Maintain appropriate setbacks in accordance with the AIP (DPIE Water 2012). | ***Section 6.3*** | During mine design and operations |
| **3** | • Design, install and maintain above-ground mine water storage infrastructure to avoid unlicensed or uncontrolled discharge of mine water to the offsite environment.<br>• Above-ground mine water storages designed to contain the 100 year ARI storm event and minimise permeability.<br>• Operate underground water storages in a manner that minimises impacts. | ***Section 3.4*** of SWMP | During Operations |
| **4** | New tailings storage areas will be designed and maintained to encapsulate and prevent the release of tailings seepage/leachate. | ***Section 3.1.3*** of WMP | All tailings storage areas |
| **5** | • Design, install and maintain new emplacements to encapsulate and prevent migration of tailings, acid forming and potentially acid forming materials, and saline and sodic material. | ***Section 3.5*** of SWMP | During Operations |

| No | Mitigation / Management Measure | Section | Timing |
|---|---|---|---|
| | • Design, install and maintain new out-of-pit emplacements to prevent and/or manage long term saline seepage. | | |
| **6** | Chemical and hydrocarbon products will be stored in bunded areas in accordance with the relevant Australian Standard. | ***Section 3.1.3*** of WMP | During Operations |
| **7** | • Negligible environmental consequences (with respect to Groundwater Dependent Ecosystems – GDES) beyond those predicted in the document/s listed in condition A2(c) (ie the project EIS (Umwelt 2016).<br>• Maintain or improve baseline channel stability.<br>• Develop site-specific in-stream water quality objectives in accordance with the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ, 2000) and using the *ANZECC Guidelines and Water Quality Objectives in NSW* (DEC, 2006) | ***Section 6.2.8*** and *SWMP* | During Operations |

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# 1. Purpose

This Groundwater Management Plan (GWMP) has been developed to address groundwater related requirements of SSD 7142 Conditions of Consent (CoC) and Environment Protection Licence (EPL) 3141 and EPL 529 as relevant to open cut mining operations at United Wambo.

The key objectives of groundwater management at United Wambo are to:

- satisfy regulatory requirements, including meeting required performance criteria;
- ensure there are negligible impacts to adjacent groundwater users (both consumptive users and the environment);
- ensure the underlying and adjacent groundwater resources are not degraded;
- reuse mine impacted water within the WMS to reduce reliance on raw/clean water; and
- minimise adverse effects on downstream waterways (including hydraulic and water quality impacts).

# 2. Scope

The GWMP applies to all operational activities at United Wambo (i.e. excludes Wambo underground, CHPP and train load facility) and addresses the relevant conditions of United Wambo's development consent SSD 7142, mining and exploration leases and licences as detailed in **Section 4**.

The GWMP applies to all United Wambo employees and contractors working for, or on behalf of, United Wambo within the project approval boundary.

This GWMP also forms part of United Wambo's Environmental Management System (EMS) and should be read in conjunction with the United Wambo Environmental Management Strategy.

The GWMP excludes the operations at the Wambo mine, incorporating the Wambo CHPP, train loading facility and underground mine. These activities will continue to be managed by Wambo in accordance with the relevant development consent conditions and associated management plans.

This Groundwater Management Plan (GWMP) is part of a set of documents that, together, form the Water Management Plan for United Wambo Joint Venture (United Wambo) (refer to ***Figure 2-1***). The Water Management Plan is one of a series of Environmental Management Plans that, together, form the Environmental Management System (EMS) for United Wambo.

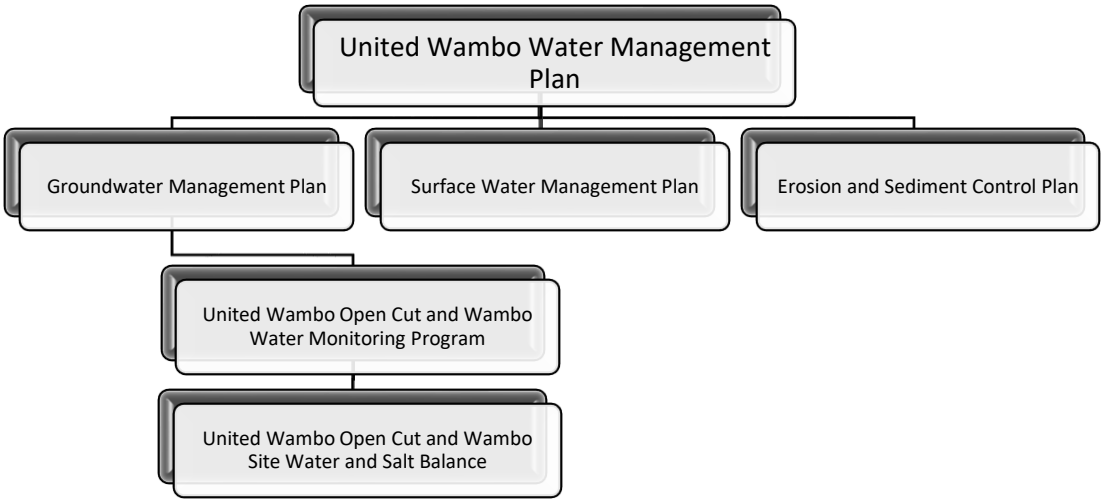


*Figure 2-1: United Wambo Water Management Plan Structure*

# 3. Objectives of the Groundwater Management Plan

The key objectives of this GWMP are to:

- ensure all CoC, performance measures, and licence/permit requirements relevant to groundwater are described, scheduled, and assigned responsibility as outlined in:
  - the EIS (Umwelt 2016);
  - the CoC for Development Application SSD 7142 granted to the Project on 29 August 2019 (see Section 1);
  - the Project's Environmental Protection Licence(s) (EPL); and
  - all relevant legislation and other requirements described in ***Section 4.1*** of this Plan;
- provide details of historical baseline monitoring data in the surrounding aquifers and regional groundwater (including groundwater and groundwater quality);
- detail the integrated groundwater monitoring strategy for United Wambo; and
- establish a Trigger Action Response Plan (TARP) for the assessment and response to monitoring data, including relevant groundwater performance criteria.

# 4. Environmental Requirements

## 4.1 Relevant Legislation and Guidelines

### 4.1.1 Legislation

The legislation relevant to this GWMP is included in ***Section1.5*** of the ***Water Management Plan***.

### 4.1.2 Guidelines and Standards

The relevant guidelines, specifications, and policy documents relevant to this Plan include:

- Groundwater Monitoring and Modelling Plans – Introduction for prospective mining and petroleum activities (NSW Department of Industry, Water (DPIE Water (formerly DPI Water)) 2014);
- National Water Quality Management Strategy (Department of Environment and Energy (DoEE) 2015);
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000);
- Approved Methods for Sampling and Analysis of Water Pollutants in New South Wales (DEC, 2004);
- Australian Standard/New Zealand Standard (AS/NZS) 5667:1998 Parts 1, 4 and 6;
- Environmental Planning and Assessment Act 1979;
- Fisheries Management Act 1994;
- Local Government Act 1993;
- NSW Aquifer Interference Policy 2012 (see ***Section 4.1.2.2***);
- NSW State Groundwater Policy Framework Document 2007;
- Protection of the Environment Operations Act 1997 (see ***Section 4.1.2.1***);
- Water Act 1912 and Water Management Act 2000 (see ***Section 4.1.2.3***);
- Water Sharing Plan (WSP) for the Hunter Regulated River Water Source 2016;
- WSP for the Hunter Unregulated and Alluvial Water Sources 2009; and
- WSP for the North Coast Fractured and Porous Rock Groundwater Sources 2016.

#### 4.1.2.1 Environment Protection Licences

Condition L1.1 of Environment Protection Licence (EPL) 3141 (United) and EPL 529 (Wambo) requires compliance with Section 120 of the Protection of the Environment Operations Act 1997 (POEO Act (1997)), which prohibits pollution of waters. The management measures and responses outlined in the Executive Summary and ***Appendix B - Groundwater TARPs*** will be implemented to achieve this.

#### 4.1.2.2 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (AIP) clarifies the water licensing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer during mining.

The AIP requires that potential impacts on groundwater sources, including their users and Groundwater Dependent Ecosystems (GDEs), be assessed against minimal impact considerations. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable.

The Level 1 minimal impact considerations for less productive groundwater sources are relevant to the groundwater sources at United Wambo and are as follows:

- **Water table**: less than or equal to 10 per cent cumulative variation in the water table, allowing for typical climatic 'post-water sharing plan' variations, 40 metres from any high priority GDE or high priority culturally significant site listed in the schedule of the relevant WSP. A maximum of a two metres decline cumulatively at any water supply work unless make-good provisions apply;
- **Water pressure**: a cumulative pressure head decline of not more than 40 per cent of the 'post-water sharing plan' pressure head above the base of the water source to a maximum of a 2 metres decline at any water supply work; and
- **Water quality**: any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 metres from the activity. For alluvial water sources, there should be no increase of more than 1 per cent per activity in the long-term average salinity in a highly connected surface water source at the nearest point to the activity.

Groundwater impacts associated with mining are assessed against the AIP in ***Section 6.3***.

#### 4.1.2.3 Water Management Act 2000

United and Wambo hold WALs under the WM Act 2000 for mining operations under both surface water and groundwater WSPs.

Surface water WALs held under the Hunter Regulated WSP (Hunter River) are summarised in the United Wambo Water Management Plan.

Groundwater WALs held under the WSP for the North Coast Fractured and Porous Rock Groundwater Sources 2016 (Sydney Basin – North Coast Water Source) total 1,947 ML/year and the groundwater WALs held under the WSP for the Hunter Unregulated and Alluvial Water Sources 2009 (Lower Wollombi Brook Water Source) total 370 ML/year, and are summarised in ***Table 4-1***.

*Table 4-1: Water Licences Held by United and Wambo Under WM Act 2000*

| Licence No | Holder | Entitlement [1] | Tenure Type |
|---|---|---|---|
| Groundwater: Lower Wollombi Brook Water Source[2] | | | |
| WAL23897 | Wambo | 70 unit shares | Perpetuity |
| WAL18437 | Wambo | 350 unit shares | Perpetuity |
| Groundwater: Sydney Basin – North Coast Porous Rock Water Source[3] | | | |
| WAL42373 | Wambo | 1549 unit shares | Perpetuity<br>6 x WALs consolidated December 2018<br>(WAL39735, WAL39738, WAL39803, WAL41494, WAL41528, WAL41520) |

| Licence No | Holder | Entitlement [1] | Tenure Type |
|---|---|---|---|
| WAL41532 | Wambo | 98 unit shares | Perpetuity |
| WAL41510 | United | 300 unit shares | Perpetuity |

*1 One unit share is equivalent to 1 ML/year unless reductions are in place via an annual available water determination.*
*2 Water source under the Hunter Unregulated and Alluvial Water sources WSP 2009*
*3 Water source under the North Coast fractured and Porous Rock Groundwater Sources WSP 2016*

#### 4.1.2.4 Guidelines

This plan has been prepared to be consistent with Groundwater Monitoring and Modelling Plans – Introduction for prospective mining and petroleum activities (DPIE Water 2014) and the National Water Quality Management Strategy (DoEE 2015).

#### 4.1.2.5 GCAA Requirements

The Glencore Coal Assets Australia (GCAA) ***Water Management Protocol*** (CAA HSEC PCL 0022 11.03) outlines the following principles, which focus on effective water management that is critical to supporting operations. Water management planning assists in managing a number of aspects, such that:

- our environmental obligations are met;
- we can demonstrate to external stakeholders that the local and regional surface water and groundwater resources are used efficiently;
- our operations are protected from flooding; and
- adequate water supplies are available for mining and processing operations.

## 4.2 Conditions of Consent

Condition B52 e(v) of SSD 7142 stipulates requirements for this GWMP as summarised in ***Table 4-2***. Relevant water performance measures, as listed in SSD 7142, are shown in ***Table 4-3***.

*Table 4-2: SSD 7142 Requirements for Groundwater Management*

| Condition | Condition Details | Document reference |
|---|---|---|
| B52 e(v) | The Water Management Plan must include a Groundwater Management Plan, which is consistent with *Groundwater Monitoring and Modelling Plans – Introduction for prospective mining and petroleum activities* (DPI Water, 2014) and the *National Water Quality Management Strategy* (DoEE, 2015) and includes: | ***Section 4.1.2.4*** |
| | • detailed baseline data of groundwater levels, yield and quality for groundwater resources potentially impacted by the development, including groundwater supply for other water users and groundwater dependent ecosystems; and | ***Section 5.3*** ***Section 5.4*** |
| | • a detailed description of the groundwater management system. | ***Section 5.3*** |

| Condition | Condition Details | Document reference |
|---|---|---|
| | • groundwater performance criteria, including trigger levels for identifying and investigating any potentially adverse groundwater impacts associated with the development, on: | ***Section 7.2*** |
| | - regional and local aquifers (alluvial and hardrock); | ***Section 6.2Table 7-4*** |
| | - groundwater supply for other water users such as privately-owned licensed groundwater bores; | ***Section 6.2.7*** |
| | - groundwater dependent ecosystems; and | ***Section 6.2.8*** |
| | - aquatic habitat and stygofauna. | ***Section 6.2.9*** |
| | • a program to monitor and evaluate: | |
| | - compliance with the relevant performance measures listed in Table 4 (see<br>- ), and the performance criteria established above; | ***Section 7.1*** |
| | - water loss/seepage from water storages into the groundwater system; | ***Section 7.1.3*** |
| | - groundwater inflows, outflows and storage volumes to inform the Site Water Balance; | ***Section 7.1*** |
| | - any hydraulic connectivity between the alluvial and hardrock aquifers; | ***Section 7.1*** |
| | - impacts on groundwater supply for other water users; | ***Section 7.1.4*** |
| | - impacts on groundwater dependent ecosystems; and | ***Section 7.1.2.4*** |
| | - the effectiveness of the groundwater management systems. | ***Section 9.1*** |
| | • reporting procedures for the results of the monitoring program; | ***Section 9.6*** |
| | • a plan to respond to any exceedances of the groundwater performance criteria, and repair, mitigate and/or offset any adverse groundwater impacts of the development; and | ***Section 9.6***<br>***Section 9.7***<br>***Appendix B - Groundwater TARPs*** |
| | • a program to periodically validate the groundwater model for the development, including an independent review of the model every three years, and comparison of monitoring results with modelled predictions. | ***Section 9.9*** |

*Table 4-3: Water Performance Measures*

| Feature | Performance Measure | Document Reference |
|---|---|---|
| **Water management - general** | • Maintain separation between clean, dirty, and mine water.<br>• Minimise the use of clean and potable water.<br>• Maximise water recycling, reuse and sharing opportunities.<br>• Minimise the use of make-up water from external sources.<br>• Design, install, operate and maintain water management infrastructure in a proper and efficient manner. | *Water Management Plan* |
| **Alluvial aquifers (including Wollombi Brook alluvium)** | Ensure negligible impacts to the alluvial aquifer beyond those predicted in the document/s listed in condition A2(c) (i.e. the project EIS (Umwelt 2016)), including:<br>• negligible change in groundwater levels; and<br>• negligible impact to other groundwater users. | ***Section 7.1***<br>***Section 6.2.7*** |
| | Maintain appropriate setbacks in accordance with the AIP (DPIE Water 2012). | ***Section 6.3*** |
| **Erosion and sediment control works** | • Design, install and maintain erosion and sediment controls in accordance with the guidance series Managing Urban Stormwater: Soils and Construction – Volume 1 (Landcom, 2004) and 2E Mines and Quarries (DECC, 2008).<br>• Design, install and maintain any infrastructure within 40 metres of watercourses in accordance with the guidance series for Controlled Activities on Waterfront Land (DPI Water, 2012).<br>• Design, install and maintain any creek crossings generally in accordance with the Fisheries *NSW Policy and Guidelines for Fish Habitat Conservation and Management* (DPI, 2013) and *Why Do Fish Need To Cross The Road? Fish Passage Requirements for Waterway Crossings* (NSW Fisheries, 2003). | *SWMP* |
| **Clean water diversions and storage infrastructure** | • Design, install and maintain the clean water system to capture and convey the 100 year ARI flood event.<br>• Maximise, as far as reasonable, the diversion of clean water around disturbed areas on the site, except where clean water is captured for use on the site. | *SWMP* |
| **Flood Levees** | Design, install and maintain appropriate flood levees to protect mining areas from a 1,000 year ARI flood event and to ensure no adverse effect on roads or privately-owned land. | *SWMP* |
| **Sediment dams** | Design, install and maintain sediment dams in accordance with the guidance series *Managing Urban Stormwater: Soils and* | *SWMP* |

| Feature | Performance Measure | Document Reference |
|---|---|---|
| | *Construction – Volume 1 (Landcom, 2004) and 2E Mines and Quarries (DECC, 2008).* | |
| **Mine water storages (including underground water storages)** | • Design, install and maintain above-ground mine water storage infrastructure to avoid unlicensed or uncontrolled discharge of mine water to the offsite environment.<br>• Above-ground mine water storages designed to contain the 100 year ARI storm event and minimise permeability.<br>• Operate underground water storages in a manner that minimises impacts. | *SWMP* |
| **Tailings storages** | Design and maintain new tailings storage areas to encapsulate and prevent the release of tailings seepage/leachate. | *SWMP* |
| **Overburden emplacements** | • Design, install and maintain new emplacements to encapsulate and prevent migration of tailings, acid forming and potentially acid forming materials, and saline and sodic material.<br>• Design, install and maintain new out-of-pit emplacements to prevent and/or manage long term saline seepage. | *SWMP* |
| **Chemical and hydrocarbon storage** | Chemical and hydrocarbon products to be stored in bunded areas in accordance with the relevant Australian Standard. | *SWMP* |
| **Creek diversion and restoration works** | • Diverted creek lines are hydraulically and geomorphologically stable.<br>• Incorporate erosion control measures based on vegetation and engineering revetments.<br>• Incorporate persistent/permanent pools for aquatic habitat.<br>• Revegetate with suitable native species. | *SWMP* |
| **Aquatic, riparian and groundwater dependent ecosystems (including GDE1 and GDE2)** | • Negligible environmental consequences beyond those predicted in the document/s listed in condition A2(c) (i.e. the project EIS (Umwelt 2016).<br>• Maintain or improve baseline channel stability.<br>• Develop site-specific in-stream water quality objectives in accordance with the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC & ARMCANZ, 2000) and Using the *ANZECC Guidelines and Water Quality Objectives in NSW* (DEC, 2006) | ***Section 6.2.8*** and *SWMP* |

## 4.3 Stakeholder Consultation

This GWMP was provided to DPIE Water and DPIE for review and comment. Records of this consultation are included in ***Appendix A - Consultation Records***.

## 4.4 Preparation of the Groundwater Management Plan

In recognition of the requirements of Condition B52 (a) of SSD 7142, the AQGHGMP prepared by United has been reviewed by a suitably experienced and qualified person/s, Liz Webb, from EMM. A letter of confirmation from EMM is provided in ***Appendix A - Consultation Records***.

# 5. Existing Environment

The existing environment is described in detail in the EIS (Umwelt 2016) and summarised with respect to groundwater in the sections below.

## 5.1 Topgraphy and Drainage

The project area is gently undulating, with elevation ranging between 60 metres Australian Height Datum (AHD) in the east and 215 metres AHD in the west. Outside of the project area, the topography grades into the flat alluvial lands associated with the adjacent water courses (50 metres AHD to 60 metres AHD) and rises to between 300 metres AHD and 650 metres AHD toward the Wollemi National Park escarpment to the west.

Due to historical farming and mining, the majority of the project area is cleared of vegetation. Wollemi National Park is densely vegetated with various plant communities, including open forests dominated by eucalypt species.

The project area is drained by Wollombi Brook and its minor tributary streams (***Figure 5-1***). Wollombi Brook flows in a north to north-easterly direction and joins with the Hunter River approximately 4 kilometres to the east of the project area. The minor drainage lines are ephemeral in nature, with flows dependent on rainfall events.

North Wambo Creek traverses from the west to the south-east of the project area and flows into Wollombi Brook. Redbank Creek occurs within the project area, flowing in an easterly direction towards Wollombi Brook. Stony Creek traverses in a south-easterly direction and joins with the north-easterly flowing Wambo Creek over 3 kilometres south of the project area.

Near the project area, the Wollombi Brook is classified as the Lower Wollombi Brook Water Source within the Hunter Unregulated WSP. The Hunter River is within the Hunter Regulated WSP.

Stream flow records from Water NSW gauging stations show that surface water flow is largely a function of rainfall. However, it is estimated that groundwater baseflow contributes up to 70 ML/day to the flows in Wollombi Brook, and up to 231 ML/day to the Hunter River. The baseflow in the Hunter River is likely to be less than estimated due to releases from the Glenbawn Dam that maintains a permanent flow for downstream users (Umwelt 2016).

The Groundwater Impact Assessment (AGE 2016) for the EIS estimated areas of losing and gaining conditions within the major rivers, as well as within the alluvium. Results show that, regionally, both the Hunter River and Wollombi Brook are predominantly gaining water from the surrounding alluvium. However, there are also areas where the river recharges the underlying alluvium (losing) and there is leakage into the coal measures, particularly around areas of active mining. As with the river zones,

the alluvium is largely gaining groundwater from the underlying coal measures, particularly within the Hunter River alluvium downstream of Foy Brook.

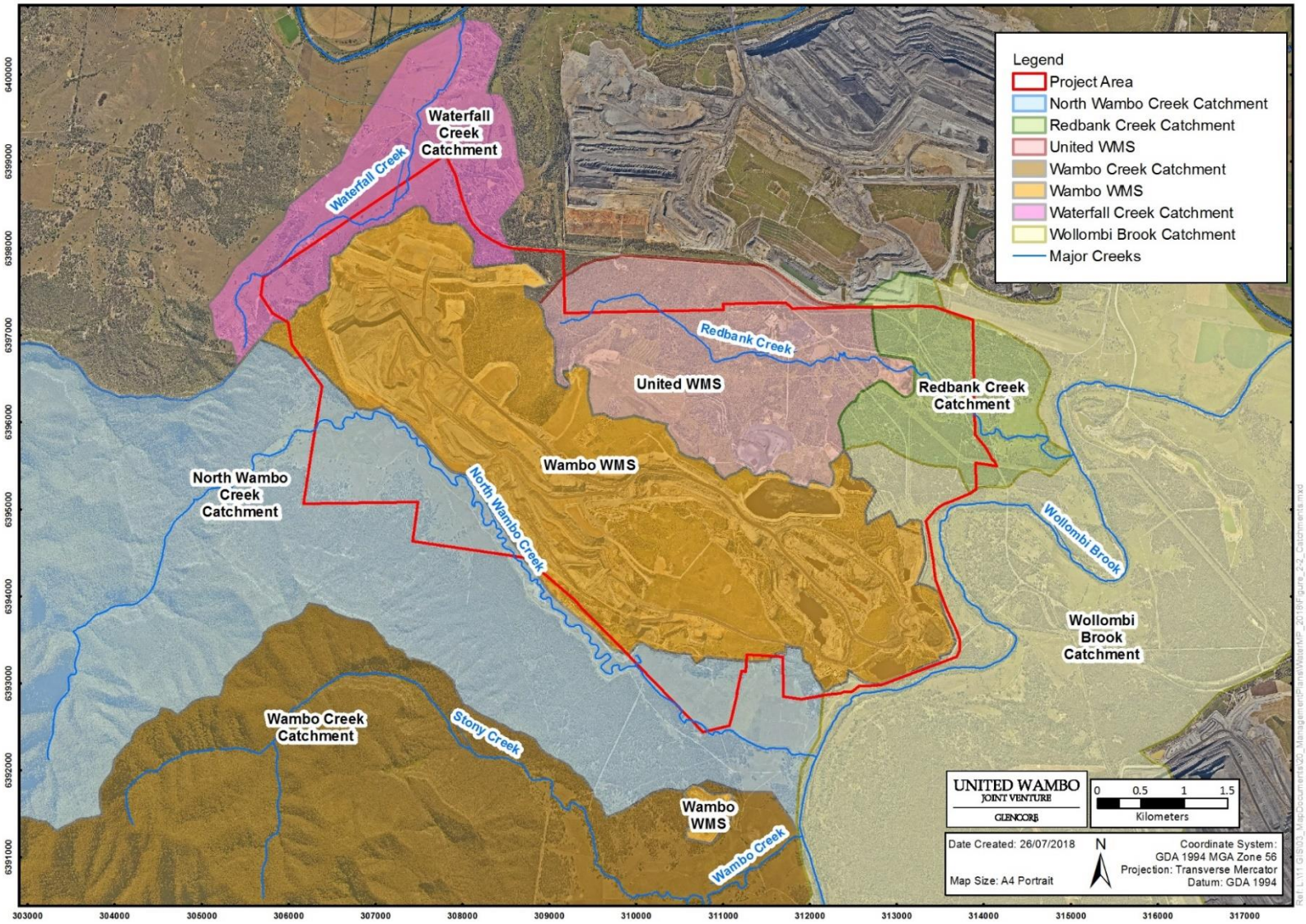


*Figure 5-1: Project Area Catchments*

## 5.2 Geological Setting

The Permian age Wittingham Coal Measures comprise economic coal seams in the project area, along with overburden and interburden consisting of sandstone, siltstone, tuffaceous mudstone, and conglomerate. The coal measures plunge in a general west to south-westerly direction, with the Wittingham Coal Measures outcropping to the north and east of the project area, near the Hunter River. The Permian sediments are unconformably overlain by thin Quaternary alluvial deposits. These deposits consist of silt, sand and gravel in the alluvial floodplain of the Wollombi Brook. To the east of the Wollombi Brook is a sequence of aeolian sands, known as the Warkworth Sands Formation, that form a thin capping on the underlying Permian bedrock.

The Permian coal measures are also unconformably overlain by the Triassic Narrabeen Group, which formed from uplift during the Triassic. The Narrabeen Group comprises primarily consolidated sandstone that form the ridge lines and high plateau areas within the Wollemi National Park.

Surficial weathering occurs across the project area. The weathering profile is typically present as a thin heterogeneous layer of unconsolidated and highly weathered material (regolith) overlying fresh bedrock.

The following main stratigraphic units occur within the project area and immediate surrounds (from youngest to oldest):

- Quaternary sediments (alluvium);
- Triassic Narrabeen Group;
- Permian Newcastle Coal Measures; and
- Permian Wittingham Coal Measures.

## 5.3 Hydrogeological Setting

Two broad types of groundwater systems occur in the vicinity of the project area associated with the Quaternary alluvium and Permian coal measures.

### 5.3.1 Quaternary Alluvium

The Quaternary alluvium occurs along Wollombi Brook and parts of its tributaries, and along the Hunter River to the north (see ***Figure 5-2***). Groundwater within the Wollombi Brook alluvium flows in a north to north-easterly direction towards the Hunter River.

Recharge to the alluvium occurs via rainfall and occasional high flow (flood) losses through the stream bed. The alluvium is also recharged by upward leakage from the underlying Permian bedrock, particularly along Wollombi Brook.

The available data (see ***Section 5.4***) for the alluvium indicates that it is largely unsaturated within the more elevated tributaries, with the alluvial groundwater largely restricted to the thicker sequences of sand and gravel ('highly productive' alluvium) along the Hunter River and Wollombi Brook (AGE 2016). While the alluvium is an unconfined unit, the upper sequences of the alluvium (approximately upper 8 metres) are largely clay rich and less permeable ('less productive') than the basal sands and gravels.

Groundwater levels within the alluvium along Wollombi Brook and the Hunter River in the immediate vicinity of the mining operations are generally four metres and 10 metres below surface, respectively. Groundwater quality is generally poorer at the base of the alluvium due to the upward leakage of groundwater from the underlying Permian bedrock. In some areas there may be localised downward

leakage from the alluvium to bedrock aquifers, particularly where more permeable coal seams subcrop beneath the alluvium and where active mining is present.

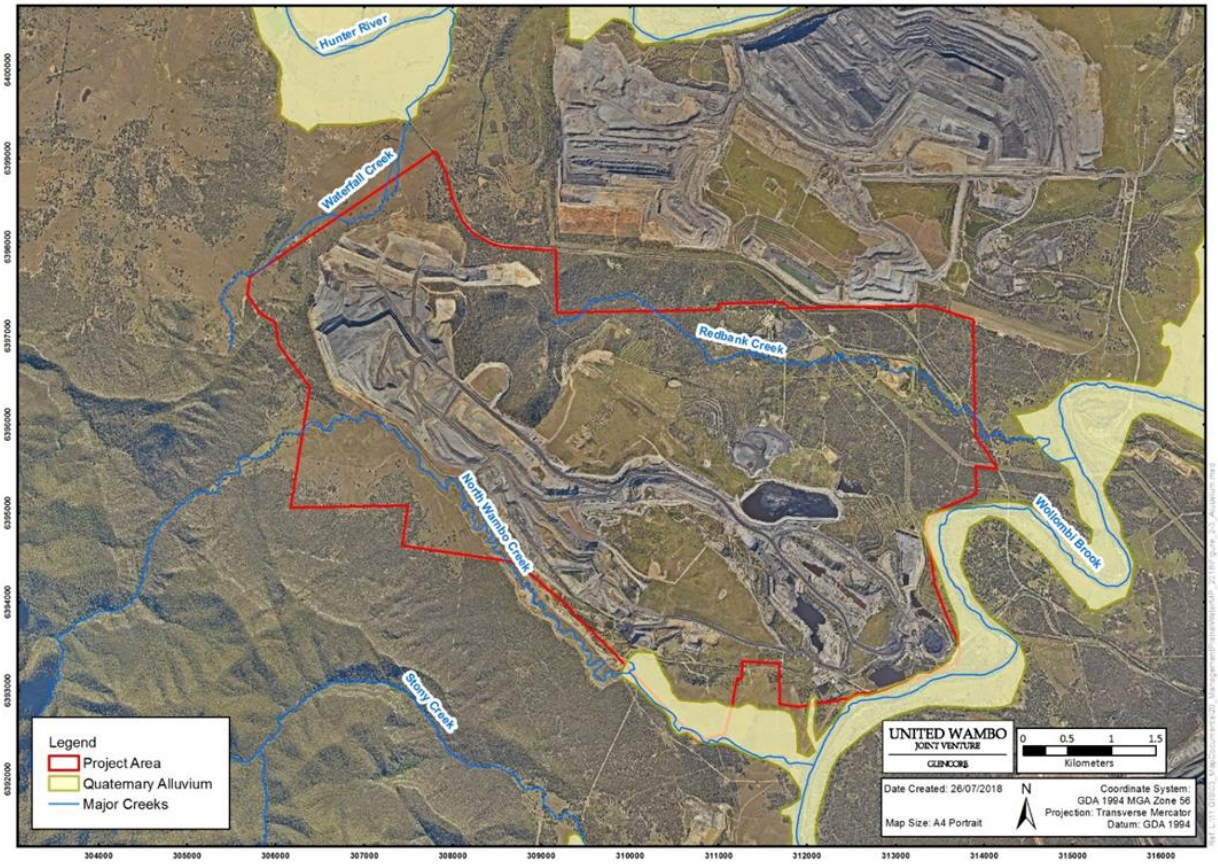


*Figure 5-2: Quaternary Alluvium*

### 5.3.2 Permian Coal Measures

The Permian coal measures comprise coal seams interbedded with low permeability sandstone and siltstone. The majority of groundwater is present within the more permeable coal seams, which is due to secondary porosity through cleats and fractures.

The Wittingham Coal Measures are saturated across their extent with groundwater levels generally 30 metres below the surface, ranging between 80 metres AHD to the south-west beneath the escarpment to 50 metres AHD near the Hunter River. The coal seams are recharged by downward leakage from overlying strata and from rainfall recharge where the sedimentary rocks outcrop to the north and east of the project area. In localised areas where there is drawdown and depressurisation due to mining activities, there may be some recharge from the overlying saturated Quaternary alluvium.

### 5.3.3 Groundwater Users

A search of the National Groundwater Information System (NGIS) database and bore census undertaken during the preparation of the EIS (Umwelt 2016) identified 66 registered bores and two unregistered bores within four kilometres of the proposed extraction area associated with the project.

A more recent check of the online NSW groundwater database (GWDB) for this portion of the Hunter Valley (available at *https://realtimedata.waternsw.com.au/water.stm*) identified more registered groundwater monitoring bores in and around the open cut mining operations but no new

private groundwater users. Close to the Hunter River and Wollombi Brook, water supply bores tap the Quaternary alluvium. There are no known groundwater works along North Wambo Creek until close to the confluence with Wollombi Brook. These are all located on Wambo mine-owned land. Away from the alluvial floodplain there are several water bores located in the Triassic Narrabeen Group sandstones and Permian Wittingham Coal Measures.

The private water bores that are not on mine-owned land and are within four kilometres of the project area operated by United Wambo are tabulated in ***Table 4-1*** and are shown in ***Figure 5-3***.

*Table 5-1: Private Water Bores and Wells (on Non Mine-Owned Land)*

| Private Bore (Reg # ID) | Aquifer Lithology | Total Depth (m) | Water Level (m)/ Salinity (µS/cm$^2$) | Intended/ Current Use |
|---|---|---|---|---|
| GW042998 | N/A | N/A | N/A<br>N/A | N/A<br>N/A |
| GW043225 | Wittingham Coal Measures | 22.6 | 12.1/<br>Brackish | Irrigation/<br>monitoring |
| GW078477 | Wittingham Coal Measures | 102.5 | Unknown/<br>~6000 | Stock and domestic/<br>unknown |
| GW064382 | Narrabeen Group sandstone | 60.0 | 18.5 / Fresh | Domestic/unknown |
| GW078574 | Wollombi tributary alluvium (Wambo Creek) | 12.0 | Unknown/<br>unknown | Stock and farming/<br>unknown |
| GW078575 | Wollombi tributary alluvium (Wambo Creek) | 12.0 | Unknown/<br>unknown | Stock and farming/<br>unknown |
| GW078576 | Wollombi tributary alluvium (Wambo Creek) | 7.0 | Unknown/<br>unknown | Stock and farming/<br>unknown |
| GW078577 | Wollombi tributary alluvium (Wambo Creek) | 12.0 | Unknown/<br>unknown | Stock, domestic and farming/unknown |
| GW078055 | Wittingham Coal Measures | 198.5 | Unknown/<br>~2500 | Test bore/unknown (cased – uncertain whether it exists) |
| GW060780[3] | Wittingham Coal Measures | 25.5 | Unknown/<br>unknown | Stock and domestic/<br>unequipped at present |

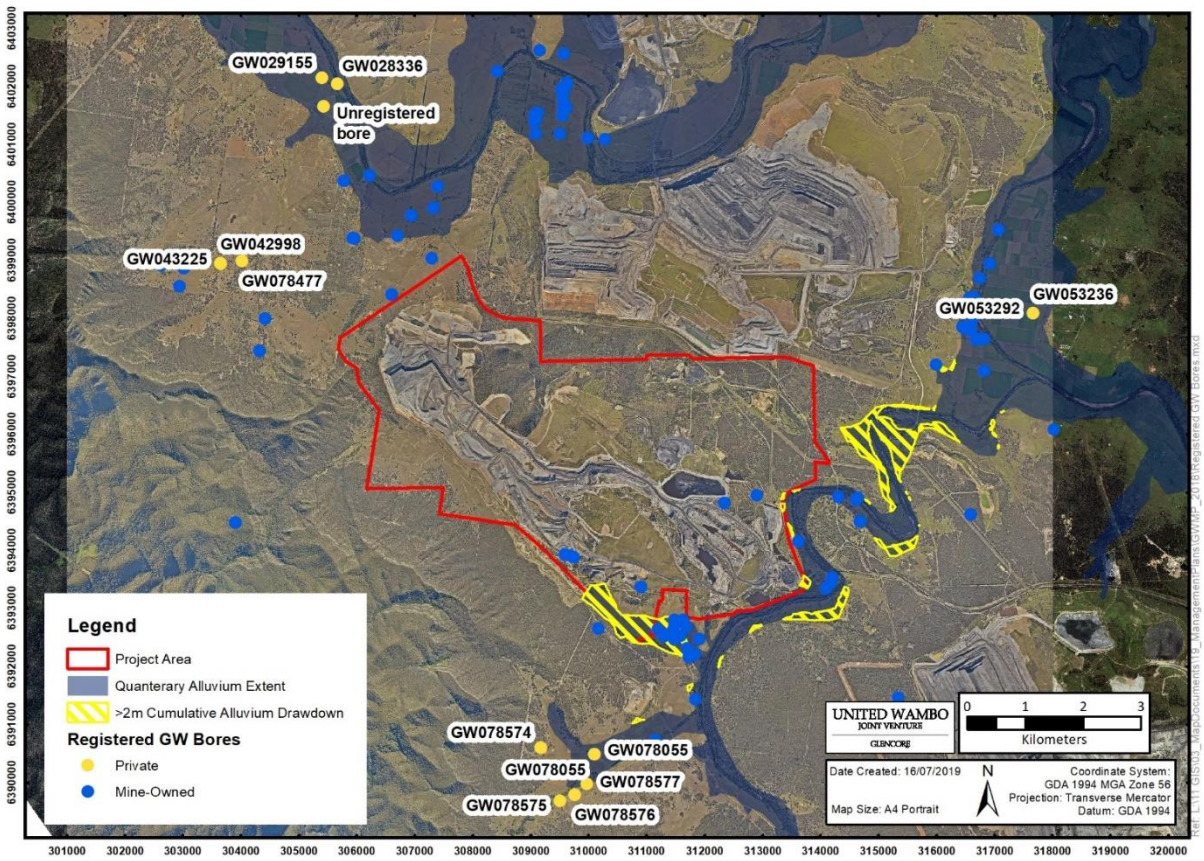


*Figure 5-3: Registered Groundwater Bores Within Four Kilometres of the Project Area*

## 5.3.4 Ecosystems that Potentially Rely on Groundwater

Terrestrial and subterranean groundwater dependent ecosystems (GDEs) are located immediately adjacent to the project area.

### 5.3.4.1 Terrestrial Ecosystems

The primary GDEs that could be impacted by water table drawdown associated with mining operations are terrestrial vegetation communities with deep rooting systems that tap fresh groundwater in the alluvial aquifers associated with Wollombi Brook and its major tributaries. No priority GDEs have been identified in the current WSP for the Hunter Unregulated and Alluvial Water Sources.

A recent check of the online Bureau of Meteorology (BoM) GDE atlas, which is based on regional remote sensing for this portion of the Hunter Valley (available at *http://www.bom.gov.au/water/groundwater/gde/map.shtml*) did not identify any known terrestrial GDEs but suggested there was moderate potential for GDEs along the riparian zone of Wollombi Brook and associated tributaries. There was low and unclassified potential for GDEs off the floodplain in mid-slope and higher elevation areas.

The Groundwater Impact Assessment for the project (AGE 2016) identified potential GDEs in the vicinity of the project area and assessed the potential for groundwater impacts to occur in the areas occupied by these potential GDEs. The terrestrial ecosystems assessed were:

- Warkworth Sands Woodland (unlikely to be dependent on regional groundwater, but may rely periodically on perched local groundwater);
- Central Hunter Swamp Oak Forest (likely to be periodically dependent on regional groundwater);

- Hunter Floodplain Red Gum Woodland Complex (uncertain groundwater dependency, but likely);
- Hunter Valley River Oak Forest (uncertain groundwater dependency, but likely);
- River Flat Eucalypt Forest (uncertain groundwater dependency, but likely); and
- stands of individual river red gum trees (groundwater dependent).

Only the river red gum areas are considered to be potentially high priority GDE areas and are, therefore, the GDE focus of this GWMP.

The Groundwater Impact Assessment (AGE 2016) identified two red gum areas within the zone of cumulative groundwater drawdown that are predicted to be subject to groundwater drawdown impacts that are at least, in part, attributable to the project. These two areas were identified for the purpose of the assessment as GDE1 and GDE2 and are shown on ***Figure 5-4***. Both of these areas are outside of the project area with GDE2 located on Wambo-owned land, while GDE1 is located on land not owned by United Wambo (on land owned by Hunter Valley Operations (HVO)).

Proposed monitoring and management responses are provided in ***Section 7.1.2.4***.

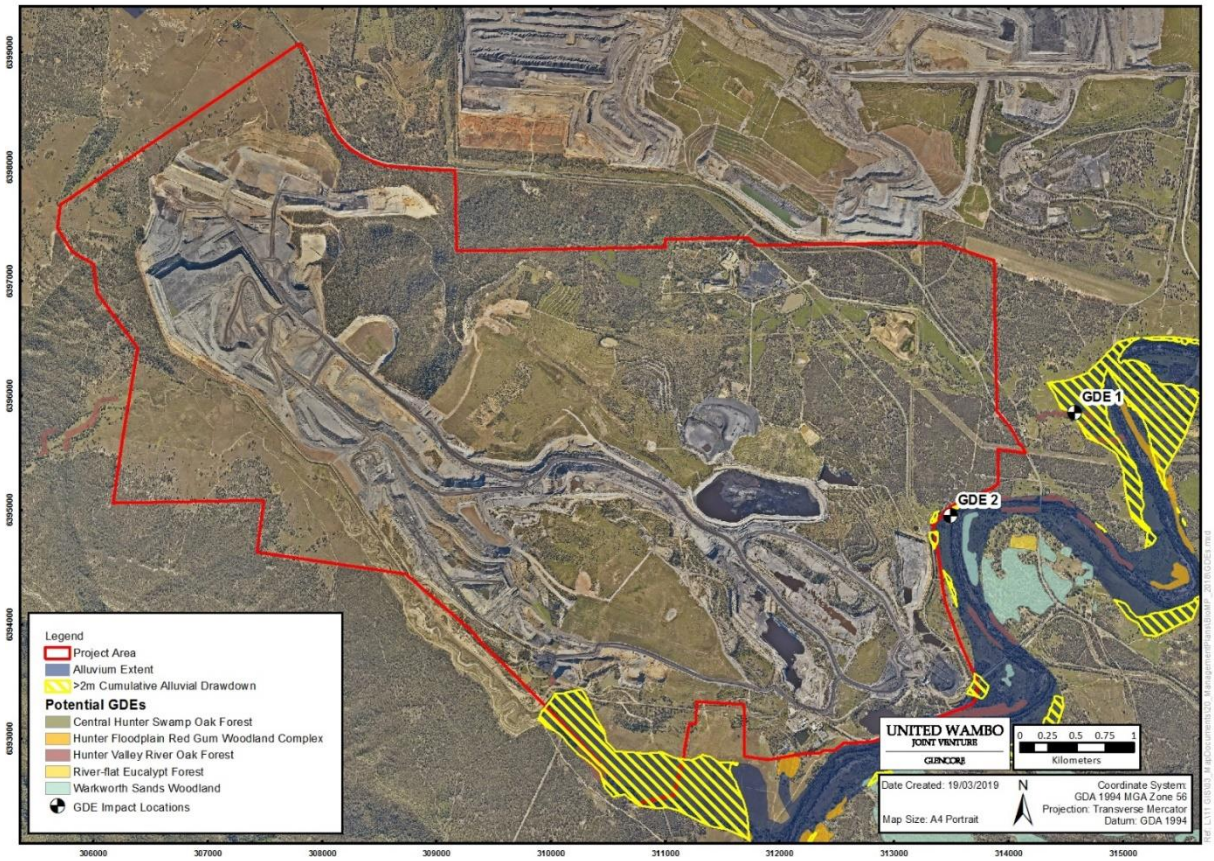


*Figure 5-4: Groundwater Dependent Ecosystems*

### 5.3.4.2 Subterranean Ecosystems

An assessment of the presence and potential impacts on stygofauna communities within the aquifers surrounding the project area was undertaken for the EIS (Umwelt 2016b). The assessment showed that stygofauna exists in small isolated populations within the shallow alluvial aquifers in the area surrounding the project, including those associated with Wollombi Brook and North Wambo Creek.

The relative consistency of the stygofauna community composition indicates connectivity within the shallow alluvial aquifers and consistency in the environmental conditions of this subterranean

ecosystem. The biodiversity of the stygofauna community across the alluvial aquifers was found to be high.

## 5.4 Baseline Data

A comprehensive review of the groundwater data (levels and quality) for United and Wambo was undertaken for the Groundwater Impact Assessment (AGE 2016), summarised in the EIS (Umwelt 2016b) and updated below to include data up to December 2018. Baseline and impact assessment data is mostly derived from onsite (purpose built) groundwater monitoring bores and has been collected since 2004. There is no baseline data for currently private groundwater users (apart from historical information from government bore databases and the field census completed in October 2015) and there is no baseline data for the GDEs.

The EIS documents are available at: *https://www.planningportal.nsw.gov.au/major-projects/project/25271*

### 5.4.1 Pre-Existing Groundwater Monitoring Program

Groundwater monitoring at Wambo occurs in accordance with the Wambo Groundwater Monitoring Plan, which was prepared in consultation with DPI Water (now DPIE Water) and last revised and approved in April 2018. Groundwater monitoring at the former United Underground occurred in accordance with the United Environmental Monitoring Program, which was prepared in consultation with DPI Water (now DPIE Water) and approved in May 2018.

The combined United and Wambo groundwater monitoring network currently comprises of 27 bores and 11 vibrating wire piezometers (VWPs) (55 sensors). Historically, groundwater bores at both United and Wambo have been monitored bi-monthly (every two months) for groundwater levels and quality (pH and electrical conductivity (EC)); although there are some bores that are fitted with dataloggers that continuously monitor groundwater levels.

United also undertake comprehensive annual groundwater quality monitoring for:

- pH
- EC
- Total dissolved solids (TDS)
- Sodium
- Potassium
- Calcium
- Magnesium
- Chloride
- Nitrate
- Sulphate
- Hardness
- Bicarbonate

Data from this monitoring is used for operational purposes and is reported internally as required.

Details of the groundwater bores currently monitored at United and Wambo are included in ***Table 7-3*** and locations are shown in ***Figure 5-5***. The results of groundwater level and quality monitoring are

reported annually in the Annual Review for United and Wambo and have been utilised in the development of the site-specific trigger levels detailed in ***Section 7.2***.

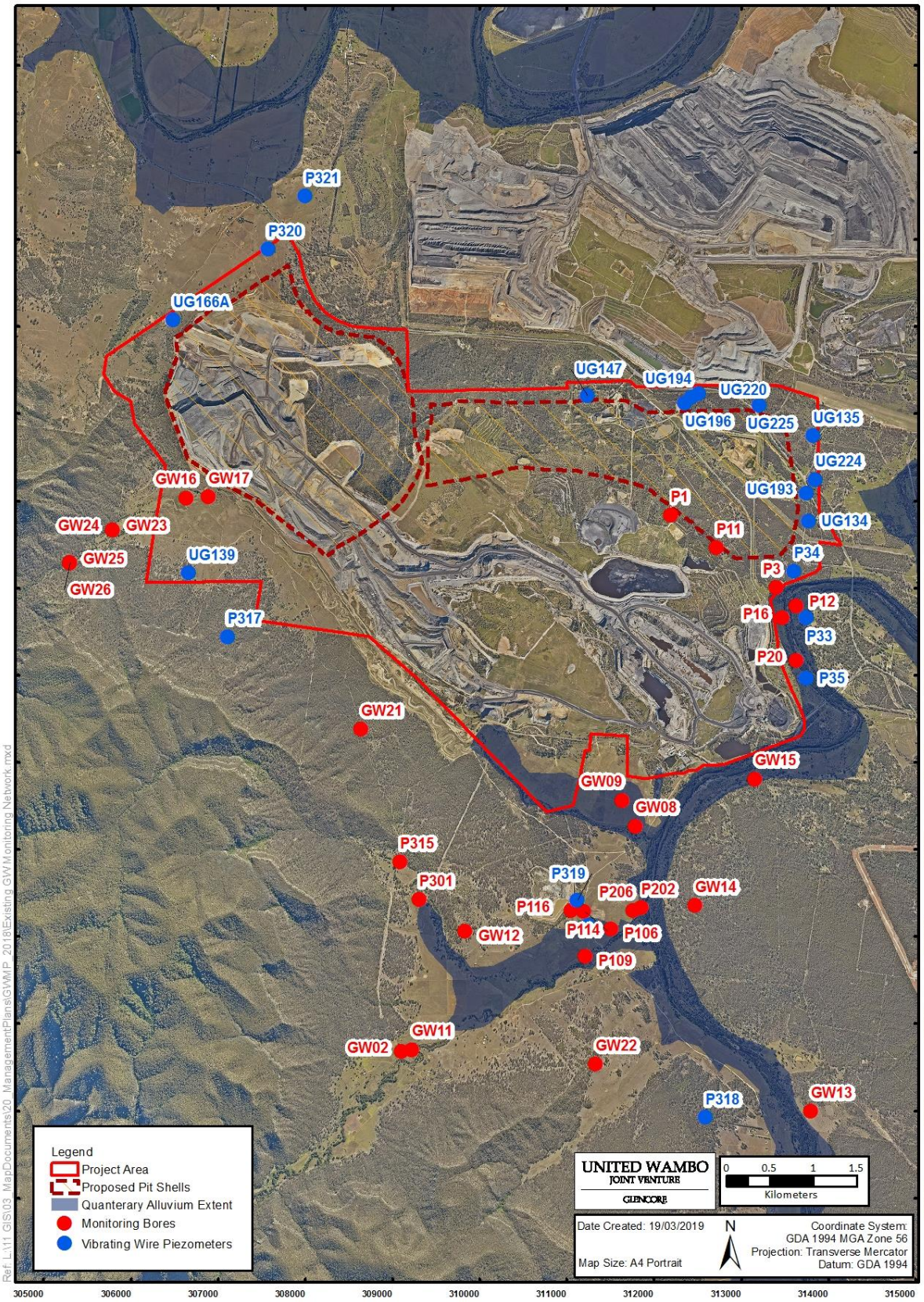


*Figure 5-5: Existing Groundwater Monitoring Bores and Extent of Alluvium*

### 5.4.2 Groundwater Level and Yield

The alluvium that forms the floodplains of Wollombi Brook and the Hunter River is 'highly productive' and is fully saturated with shallow water tables generally less than 10 metres from surface. Yields to wells, bores, and batteries of spearpoints are high and can exceed 25 litres per second (L/s). The alluvium associated with the tributaries of Wollombi Brook is less extensive and is 'less productive' with yields generally less than 5 L/s. Groundwater yields from deeper bores in the Permian coal measures are much lower and rarely exceed 1 L/s.

Groundwater level depends on the topographic location and proximity to mining activities but is generally in excess of 10 metres from surface in low lying areas, and in excess of 30 metres in more elevated areas.

Historic minimum, maximum and median groundwater level data from 2003-2018 is provided in ***Table*** 5-2.

*Table 5-2: Baseline Groundwater Level Data*

| Site | Groundwater Levels (mAHD) | | | | |
|---|---|---|---|---|---|
| | Min | Max | Median | 10th Percentile | 90th Percentile |
| GW02 | 70.5 | 75.1 | 73.3 | 71.2 | 74.1 |
| GW08 | 52.9 | 57.7 | 57.0 | 54.6 | 57.5 |
| GW09 | 54.8 | 59.2 | 57.9 | 55.2 | 58.6 |
| GW11 | 72.0 | 75.6 | 74.8 | 72.9 | 75.4 |
| GW12 | 86.4 | 89.5 | 86.8 | 86.5 | 89.0 |
| GW13 | 61.0 | 62.9 | 62.5 | 62.2 | 62.8 |
| GW15 | 49.6 | 51.2 | 50.2 | 49.7 | 50.9 |
| GW16 | 98.9 | 106.5 | 102.3 | 99.3 | 105.8 |
| GW17 | 97.0 | 102.9 | 98.5 | 97.2 | 101.3 |
| GW22 | 54.8 | 55.7 | 55.5 | 55.3 | 55.7 |
| P1 | 57.1 | 68.7 | 59.9 | 57.4 | 61.3 |
| P11 | 39.4 | 45.9 | 40.6 | 39.8 | 41.7 |
| P12 | 46.6 | 51.3 | 48.2 | 47.3 | 48.9 |
| P16 | 47.7 | 51.2 | 49.9 | 48.3 | 50.4 |
| P20 | 48.3 | 51.5 | 49.4 | 48.8 | 50.2 |
| P106 | 44.9 | 54.0 | 50.8 | 49.3 | 53.1 |
| P109 | 51.7 | 57.8 | 55.7 | 52.1 | 57.2 |
| P114 | 51.9 | 56.6 | 55.2 | 54.1 | 56.4 |
| P116 | 56.1 | 60.2 | 57.9 | 57.1 | 59.4 |
| P202 | 49.1 | 55.9 | 50.4 | 49.5 | 51.5 |
| P206 | 36.2 | 52.1 | 40.8 | 37.4 | 43.9 |
| P301 | 69.8 | 78.9 | 75.8 | 73.3 | 77.4 |
| P315 | 89.0 | 94.5 | 90.8 | 89.3 | 93.8 |

### 5.4.3 Groundwater Quality

Monitoring results show that groundwater within the 'highly productive' alluvium generally is 'fresh' due to rainfall recharge and episodic recharge from high river flows. The 'less productive' alluvium is generally 'brackish', with results ranging from fresh to saline. The higher salinity in the 'less productive' alluvium relates to reduced recharge in these areas from rainfall and stream flow and more dominant leakage from the underlying bedrock.

The water quality results for the Permian coal measures indicate that groundwater within the coal is generally moderately saline, with results ranging from fresh to saline. The interburden units are also generally moderately saline, with results ranging from fresh to highly saline. These higher salinities are due to the connate salts in the different rock units which were mostly deposited in marine and estuarine environments.

Historic minimum, maximum and median groundwater EC and pH data from 2003-2018 is provided in ***Table 5-3***.

*Table 5-3: Baseline Groundwater Quality Data*

| Site | EC (µs/cm) | | | | | pH | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Max | Median | 10th Per-centile | 90th Per-centile | Min | Max | Median | 10th Per-centile | 90th Per-centile |
| **GW02** | 439 | 908 | 517.0 | 471.0 | 629.0 | 6.3 | 7.7 | 7.0 | 6.7 | 7.3 |
| **GW08** | 1,424 | 2,248 | 1823.5 | 1640.3 | 1,925.7 | 5.9 | 8.4 | 7.2 | 6.8 | 8.0 |
| **GW09** | 287 | 1,456 | 515.5 | 387.8 | 1,302.6 | 7.5 | 8.8 | 8.1 | 7.6 | 8.4 |
| **GW11** | 427 | 691 | 512.0 | 467.0 | 641.0 | 6.6 | 7.6 | 7.0 | 6.7 | 7.3 |
| **GW12** | 19,200 | 22,300 | 21,400.0 | 19520.0 | 22,260.0 | 6.6 | 6.9 | 6.8 | 6.6 | 6.9 |
| **GW13** | 518 | 4,820 | 3,490.0 | 2875.0 | 4,290.0 | 6.8 | 7.3 | 7.0 | 6.9 | 7.1 |
| **GW15** | 521 | 879 | 626.0 | 598.6 | 699.8 | 6.3 | 7.5 | 7.0 | 6.7 | 7.1 |
| **GW16** | 294 | 889 | 640.0 | 354.2 | 810.4 | 6.6 | 11.7 | 7.5 | 7.2 | 11.2 |
| **GW17** | 4,610 | 5,490 | 5,150.0 | 4812.0 | 5,368.0 | 6.9 | 7.6 | 7.1 | 7.0 | 7.2 |
| **GW22** | 6,110 | 7,030 | 6,780.0 | 6542.0 | 6,956.0 | 7.9 | 8.5 | 8.3 | 8.1 | 8.4 |
| **P1** | 1,482 | 9,960 | 8,230.0 | 7089.0 | 8,757.0 | 6.5 | 8.2 | 6.9 | 6.7 | 7.2 |
| **P11** | 13,000 | 18,200 | 17,015.0 | 14098.0 | 17,948.0 | 6.6 | 7.5 | 7.0 | 6.7 | 7.5 |
| **P12** | 312 | 1,581 | 737.0 | 483.0 | 1,016.0 | 6.1 | 9.7 | 7.0 | 6.5 | 7.8 |
| **P16** | 6,700 | 18,200 | 8,495.0 | 7308.0 | 10,656.0 | 6.4 | 8.1 | 7.3 | 7.0 | 7.7 |
| **P20** | 1,000 | 18,500 | 9,150.0 | 6780.0 | 10,730.0 | 6.5 | 8.1 | 7.3 | 7.1 | 7.6 |
| **P106** | 427 | 1,072 | 651.0 | 481.6 | 939.5 | 6.2 | 8.6 | 6.9 | 6.7 | 7.9 |
| **P109** | 431 | 4,580 | 637.0 | 535.4 | 761.4 | 6.2 | 8.7 | 6.8 | 6.5 | 7.5 |
| **P114** | 509 | 10,360 | 649.0 | 548.4 | 6,902.0 | 5.4 | 8.7 | 7.0 | 6.5 | 7.8 |
| **P116** | 454 | 6,570 | 18,31.5 | 633.8 | 5,942.0 | 6.1 | 8.0 | 7.0 | 6.6 | 7.4 |
| **P202** | 2,310 | 10,520 | 4,620.0 | 3,552.0 | 6,958.0 | 6.4 | 8.0 | 7.3 | 6.7 | 7.7 |
| **P206** | 213 | 4,370 | 2,428.0 | 2,092.0 | 2,646.8 | 6.8 | 8.6 | 7.5 | 7.2 | 8.1 |
| **P301** | 1,086 | 9,270 | 6,070.0 | 2,839.0 | 9,190.0 | 5.8 | 7.6 | 6.7 | 6.2 | 7.1 |
| **P315** | 257 | 4,141 | 385.0 | 295.2 | 525.2 | 3.7 | 7.7 | 6.4 | 6.0 | 7.2 |

# 6. Environmental Aspects and Impacts

## 6.1 Aspects

Key aspects of the project that could result in adverse impacts to groundwater include:

- extent of mining areas: development of the United Open Cut, minor surface adjustment of approximately 3.8 hectares of additional disturbance and access of deeper seams within the existing Wambo Open Cut;
- infrastructure: upgrades of existing mine infrastructure area prior to its decommissioning and demolition/removal due to the progression of the United Open Cut, construction of temporary facilities during the construction phase of the project, and ongoing use, expansion and upgrade of the Wambo Mining Infrastructure Area;
- tailings and rejects: decommissioning and capping of existing tailings storage facilities located in areas proposed for overburden emplacement and ongoing use of existing tailings storage facilities and storages established in other mine voids as required; and
- water management: construction of mine water management controls including dams, use of the previously mined United underground voids for water storage.

## 6.2 Impacts

### 6.2.1 Overview

The potential for impacts on groundwater are discussed in the EIS (Umwelt 2016b) and summarised here. Impacts will be dependent on the nature, extent, and magnitude of construction and mining activities and their interaction with the natural environment. Potential impacts to groundwater attributable to the project include:

- groundwater interception by mining within the project area;
- drawdown in groundwater level in the adjacent alluvium and coal measures;
- changes in alluvial water resources availability;
- changes to surface water flow;
- impacts on supplies from private bores;
- drawdown at potential GDEs;
- impacts on stygofauna; and
- cumulative groundwater level drawdown.

The project area and its surroundings have been subject to open cut and underground mining operations for nearly 60 years. This existing mining has already significantly altered the groundwater environment within the vicinity, with some of the coal seams proposed for mining currently being significantly depressurised (Umwelt 2016b).

Some impacts on groundwater attributable to the project are anticipated and predicted in the groundwater model (AGE 2016). Relevant aspects and the potential for related impacts are identified in the United Wambo Environment and Community Risk Assessment (see United Wambo Environmental Management Strategy for more details).

***Section 9*** provides control measures that will be implemented to avoid or minimise those identified impacts.

### 6.2.2 Groundwater Interception

Groundwater interception is predicted by the groundwater model (AGE 2016). Groundwater inflow from the Permian coal measures due to the project at the United Open Cut is predicted to peak in Year 5 at 582 ML/year, while groundwater intercepted at the Wambo Open Cut peaks in Year 8 at 76 ML/year. Overall, the additional take of groundwater due to the project is predicted to peak in Year 7 at 633 ML/year, and will average 234 ML/year.

### 6.2.3 Groundwater Drawdown

Groundwater inflow to the open cut areas will result in a drawdown in the local Permian groundwater system (more specifically, within each aquifer/water bearing zone – primarily each coal seam) and will result in changes in groundwater level in the alluvial aquifers where they are hydraulically connected to the Permian system. There is no consumptive use of the groundwater from the Permian aquifers apart from the reuse of mine inflows into open cuts and adjacent underground workings.

The most significant modelled drawdowns (AGE 2016) within the alluvium are predicted to occur east of United Open Cut, along relatively small sections of Wollombi Brook and Redbank Creek, as well as north along the edge of the Hunter River alluvium. The model shows the predicted extent of drawdown assuming a largely homogeneous alluvial zone, however, as the alluvial zones have variable properties (including clay zones with low permeability and areas with limited groundwater), the actual drawdown may be less than predicted by the model.

In all coal seam layers, the magnitude of the depressurisation predicted due to the project is generally less than 10 metres at 1.5 kilometres from the edge of the extraction area.

The extent of drawdown due to the project is generally within the extent of the drawdown from currently approved mining to the north, east, and south of the project area. Increased predicted drawdown extent is largely restricted to the west of the project area, extending up to two kilometres from approved and proposed (by other mines) cumulative drawdown extents.

Drawdown is not predicted within the Triassic Narrabeen Group sandstones due to the strata being absent across the proposed mining area and occurring at higher elevations.

### 6.2.4 Alluvial Water Resources Availability

The change in alluvial water resources was determined in the EIS (Umwelt 2016b) by comparing water budgets for alluvial zones using versions of the numerical model (AGE 2016) that either contained or excluded the project. The two main alluvial resources are associated with Wollombi Brook and the Hunter River.

In accordance with the AIP, the groundwater model was used to determine the mining interference on each groundwater system and connected surface water sources.

<u>Wollombi Brook Alluvium</u>

The modelling assessed the potential change in flow from the Permian strata to the Wollombi Brook alluvium for the currently approved mine plans with and without the project. The assessment indicates that the Wollombi Brook alluvium is gaining groundwater from the Permian strata, even under continuing open cut mining. As the Permian strata become depressurised and groundwater level drops, flow from the Permian strata to the alluvium within the zone of depressurisation will progressively decrease. This can be considered beneficial as it reduces the inflow rate of higher salinity groundwater from the Permian strata to the overlying alluvium.

Groundwater model predications show the project reduces flow from Permian strata to the alluvium along Wollombi Brook by up to 40 ML/year in Year 7. The assessment found that this is a relatively small predicted additional impact on top of the cumulative impacts for currently approved mines which are predicted to be around 120 ML/year in Year 7 and reach a maximum of 175 ML/year in Year 24.

Hunter River Alluvium

Data and model predictions indicate that the Hunter River alluvium is overall leaking into the underlying Permian coal measures. The model predicts that the rate of alluvial groundwater leaking from the floodplain aquifers into the Permian strata will increase to a maximum 58 ML/year (Year 9), due to depressurisation of the Permian strata. The Hunter River is a losing stream in the local area immediately to the north of the project, most probably because of historical mining by other operators.

In total, the project will require up to 98 ML of water licences to account for the predicted interception of water from the Hunter River alluvium and the interception of leakage to the Wollombi Brook alluvium. It should be noted that while the reduction in flow from Permian strata to the alluvium along Wollombi Brook and increased losses from the Hunter alluvium may reduce water levels within the alluvium, these reductions should improve water quality within the alluvium in both areas

### 6.2.5 Changes to Surface Water Flow

Loss of groundwater from the alluvium may induce some loss of surface water from both the Wollombi Brook and Hunter River water sources.

Wollombi Brook

Overall Wollombi Brook will remain a net gaining stream, but with reduced baseflow flowing from the alluvium to the stream. Cumulative impacts from approved mining (i.e. HVO South, Mount Thorley Warkworth (MTW), and approved mining at Wambo) reduce the net baseflow to Wollombi Brook from 1450 ML/year to 1000 ML/year. The United Wambo project is predicted to account for a minor contribution with a maximum impact in Year 8 of approximately 37 ML/year of the cumulative impacts on baseflow in Wollombi Brook (around three per cent reduction in baseflow contribution).

Hunter River

The Groundwater Impact Assessment (AGE 2016) indicates that there would be a gradual reduction in Hunter River flow from 3500 ML/year to 2800 ML/year over the life of the project due to cumulative impacts. The project is predicted to account for a maximum impact in Year 11 of 58 ML/year of the cumulative impact on the Hunter River stream flow (around two per cent reduction in baseflow contribution).

North Wambo Creek

Minor subsidence of up to 1.5 metres has occurred in the vicinity of North Wambo Creek. This is associated with underground (longwall) mining operations and is not discussed further in this GWMP. Recent site inspections of the open cut pit face, and a review of the monitoring bore data (construction logs, etc) confirm there are no creek or shallow groundwater losses into the adjacent mine pits. The alluvium is thin, very clayey and dry along the full length of North Wambo Creek until close to the confluence with Wollombi Brook.

### 6.2.6 Water Licensing Requirements

United Wambo has a combined total entitlement of up to 370 ML/year assuming full allocation under the Hunter Unregulated and Alluvial WSP (Lower Wollombi Water Source), and up to 1,306 ML/year high security under the Hunter Regulated WSP (Hunter River). In addition, entitlements held by

United Wambo for water take from the Permian groundwater system under the North Coast Fractured and Porous Rock WSP, are 1947 ML/year.

Water entitlements and average annual project water take volumes from each of these water sources, based on numerical modelling results (AGE, 2016), are shown in ***Table 6-1***.

*Table 6-1: Water Entitlements and Average Annual Project Water Take*

| Licence No | Holder | Entitlement [1] | Project Water Take (ML/yr) [4] |
|---|---|---|---|
| **Groundwater: Lower Wollombi Brook Water Source[2]** | | | |
| WAL23897 | Wambo | 70 unit shares | 40 |
| WAL18549 | United | 100 unit shares | |
| WAL18445 | United | 200 unit shares | |
| **Groundwater: Porous Rock Water Source [3]** | | | |
| WAL42373 | Wambo | 1,549 unit shares | 633 |
| WAL41532 | Wambo | 98 unit shares | |
| WAL41510 | United | 300 unit shares | |

*Notes:*

*1 One unit share is equivalent to 1 ML/year, unless reductions are in place via an annual available water determination.*

*2 Water source under the Hunter Unregulated and Alluvial Water Sources WSP 2009.*

*3 Water source under the North Coast fractured and Porous Rock Groundwater Sources WSP 2016*

*4 Predicted average annual project water take over life of mine.*

The maximum cumulative water take based on the groundwater model (AGE, 2016) and based on the approved, foreseeable and the project mine plans for United Wambo and Wambo is:

- 1,778 ML/year from the Permian groundwater system under the North Coast Fractured and Porous Rock Groundwater Sources WSP;
- 84 ML/year from the Hunter River under the Hunter Regulated WSP;
- 260 ML/year from the Wollombi Brook alluvium under the Hunter Unregulated and Alluvial WSP (Lower Wollombi Water Source).

The maximum cumulative water take volumes are all within the licensed entitlement volumes for each of the respective water sources.

#### 6.2.6.1 North Wambo Creek

In comments received on 9 December 2019 (see ***Appendix B - Groundwater TARPs***), DPIE Water recommended:

> "The proponent commit to either accounting via a licensing offset the measurable stream losses along North Wambo Creek, or the Groundwater Management Plan present performance measures demonstrating how any such losses are quantitatively conserved e.g. re-saturation of the downstream alluvial aquifer."

Since December 2017, three (3) separate investigative drilling programs have been undertaken by Wambo in the North Wambo Creek alluvium, upstream of the North Wambo Creek Diversion, resulting in 33 investigative holes drilled. Thirteen of these have been converted in to alluvial (11) and weathered Permian (2) monitoring bores. Continuous groundwater level loggers have been installed at two (2) sites to capture rapid changes in groundwater level within the North Wambo Creek alluvium associated with intense weather events and periods of flow in North Wambo Creek.

In 2019, the Wambo groundwater model was updated to include greater temporal variability to better capture groundwater conditions along North Wambo Creek. This was further refined in the South Bates Extension LW21-24 Extraction Plan modelling undertaken by SLR (2020). The modelling noted that the alluvium and shallow weathered rock are less broadly saturated following the construction of the NWCD and interception of alluvial material by the Montrose Open cut. A contemporary groundwater model will be finalised in 2020 which incorporates the Wambo Underground and United Wambo Open Cut mines. Once the model is finalised the GMP will be reviewed, updated and submitted to DPIE and aligned with the Annual Review.

Intercepted groundwater will continue to be accounted for in the Wambo Underground and United Wambo Open Cut annual site water balance, which is reported in the Annual Review.

### 6.2.7 Impact on Groundwater Users

Groundwater modelling (AGE 2016) has indicated that the impact to private water bores will be limited to areas within the project area and there will be no impact on residual agricultural areas located up to 4 kilometres distance from the mine. Five bores were predicted to be impacted during mining operations: one private bore and four located on mine-owned land.

Since the Groundwater Impact Assessment (AGE 2016) was completed, the property at which the privately-owned bore (GW060780) is located has been purchased by United on behalf of the Joint Venture. As the bore is now owned by the Project, it is no longer planned to be monitored. It is also noted that this bore is not operational and had been abandoned by the previous owner.

There will be no exceedance of the Level 1 minimal impact considerations included in the AIP at any other private bores as a result of the project.

### 6.2.8 Terrestrial Ecosystems

Potential GDEs have been identified in proximity to the project area, primarily associated with riparian vegetation along the main watercourses. The Groundwater Impact Assessment (AGE 2016) determined the potential drawdown impacts associated with the project and other mining operations at GDEs (identified as GDE1 and GDE2 in ***Section 5.3.4***).

GDE1

At GDE1, groundwater level in the alluvium is predicted (AGE 2016) to decline, becoming largely unsaturated due to cumulative impacts from approved mining at HVO South, Wambo, and MTW. This desaturation occurs due to the existing approved mining, without the project. Based on the conceptual timing of the project, the project may result in this effect occurring approximately one year earlier, however, this depends on a range of factors, and is highly uncertain. Therefore, the project is not considered likely to result in impacts beyond those currently approved for GDE1.

GDE2

Around one metre in groundwater level decline is predicted at GDE2 due to cumulative impacts from mining (approved mining and the project). The decline in groundwater levels at GDE2 is along the fringes of Wollombi Brook. This drawdown is relatively limited in area and impacts upon only a small

portion of possible Hunter Valley River Oak Forest and possibly a small number of river red gum trees. Both species have a dependency on groundwater, but both also have a high degree of drought tolerance, particularly river red gum. The vegetation communities in which they occur are highly disturbed from historical land uses (primarily agricultural practices) and are affected by substantial weed establishment. It is expected that the impacts resulting from the drawdown will be masked by seasonal variations. Therefore, negligible impact is predicted on these species and the vegetation communities in which they occur. Hunter Valley River Oak Forest is not listed under the Environment Protection and Biodiversity Conservation (EPBC) or Threatened Species Conservation (TSC) Acts. However, river red gums are listed under the TSC Act as an endangered population in the Hunter Catchment and are, therefore, considered a high priority GDE. The potential impact on these trees would not be significant in terms of the impact on the endangered population.

### 6.2.9 Subterranean Ecosystems

The risk of the project to the subterranean ecosystem is considered low, based on the potential groundwater drawdown impacts on the alluvium of Wollombi Brook. Due to the consistency of stygofauna composition across the aquifer and the relatively small area of impact in terms of alluvial aquifer drawdown, no adverse impacts on stygofauna are predicted.

Although there is a low risk of impacts to stygofauna, United commits to monitoring stygofauna in the alluvial aquifers within (or near to, subject to bore suitability) the predicted drawdown areas prior to the commencement of mining and then every three years thereafter. See ***Section 7.1.2.5*** for further details.

### 6.2.10 Cumulative Drawdown

Approved coal mines within the region operate below the water table and, therefore, extract groundwater and create a cumulative drawdown on regional groundwater systems within the Permian coal measures.

Groundwater inflow to the open cut areas results in a drawdown in the local Permian groundwater system and will only result in changes in groundwater level in the alluvial aquifers where they are hydraulically connected to the Permian system.

The numerical groundwater model (AGE 2016) assessed the cumulative drawdown from surrounding mines, including approved and proposed operations at Wambo, HVO South, HVO North, Ravensworth and MTW that mine the Wittingham Coal Measures. The most significant modelled drawdowns within the alluvium are predicted east of United Open Cut, along Wollombi Brook and Redbank Creek.

In regard to the cumulative drawdowns in the key coal seams relevant to the project:

- cumulative drawdowns within the Wambo Seam are largely within the extent of approved cumulative drawdowns;
- cumulative drawdowns within the Glen Munro Seam extend up to one kilometre west of the extent of approved cumulative drawdown extent, but are within the extent elsewhere;
- cumulative drawdowns extend up to 2.5 kilometres west of the extent of approved cumulative drawdown for the Arrowfield Seam but are within the extent elsewhere; and
- cumulative drawdowns extend up to two kilometres south-west of the extent of approved cumulative drawdown for the Vaux Seam but are within the extent elsewhere.

## 6.3 Assessment Against Aquifer Interference Policy

Predicted groundwater impacts associated with mining were assessed in the Groundwater Impact Assessment (AGE 2016) in relation to the AIP, which states that any mining activity must consider minimal harm criteria with respect to groundwater sources (see ***Section 4.1.2.2***).

Based on the groundwater modelling, predicted impacts will be less than the Level 1 minimal impact considerations at all private water bore locations.

# 7. Measurement and Evaluation

## 7.1 Groundwater Monitoring Program

### 7.1.1 Purpose

The purpose of this groundwater monitoring program is to ensure that the monitoring is undertaken in a manner to detect potential residual impacts identified in ***Section 6.2***, to assess the performance of the project against derived performance criteria, and to ensure that relevant legislative and policy requirements are met. Monitoring locations, parameters, and frequency are outlined in this section. The monitoring methodology is detailed in ***Section 8***.

Data collected will:

- validate and refine/recalibrate (where necessary) the hydrogeological numerical model developed for United Wambo (i.e. assess predicted impacts against actual observed impacts);
- be used in the ongoing review and enhancement of groundwater performance and impact assessment/investigation triggers (***Section 7.2***; and
- provide input data for annual groundwater monitoring reviews (***Section 9.6***).

A general description of the groundwater monitoring program for United Wambo is included in this section. The groundwater monitoring locations, parameters, frequency and methodology of monitoring are outlined in the combined ***United Wambo Open Cut and Wambo Monitoring Program (WMProg)***.

### 7.1.2 Monitoring Network, Parameters and Frequency

#### 7.1.2.1 Groundwater Monitoring Program

The existing groundwater monitoring programs for United and Wambo will be combined, continued and revised throughout the life of the project. Replacement and/or additional groundwater monitoring bores and vibrating wire piezometers (VWPs) will be installed as required to ensure that a suitable long-term groundwater monitoring network is maintained in all key groundwater units and with adequate spatial and vertical depth coverage across the site.

Potential losses from North Wambo Creek through the alluvium into the mine pits will be a focus of the monitoring program. The alluvium is thin, very clayey and dry along the full length of North Wambo Creek until close to the confluence with Wollombi Brook. Currently, there is no groundwater inflow into the mine pits but monitoring of bores along North Wambo Creek will continue, together with visual inspection of the mine pit face.

Monitoring locations G19 and G20 along North Wambo Creek were considered for inclusion in the program, however, GW19 has been dry since 2009 and GW20 was removed as part of the construction of the Creek Diversion.

***Figure 7-1*** shows the groundwater monitoring network. Existing and proposed monitoring bores and VWPs are shown. The proposed bores and VWPs are shown at indicative locations.

***Table 7-1*** summarises the consolidated groundwater monitoring programs for United and Wambo.

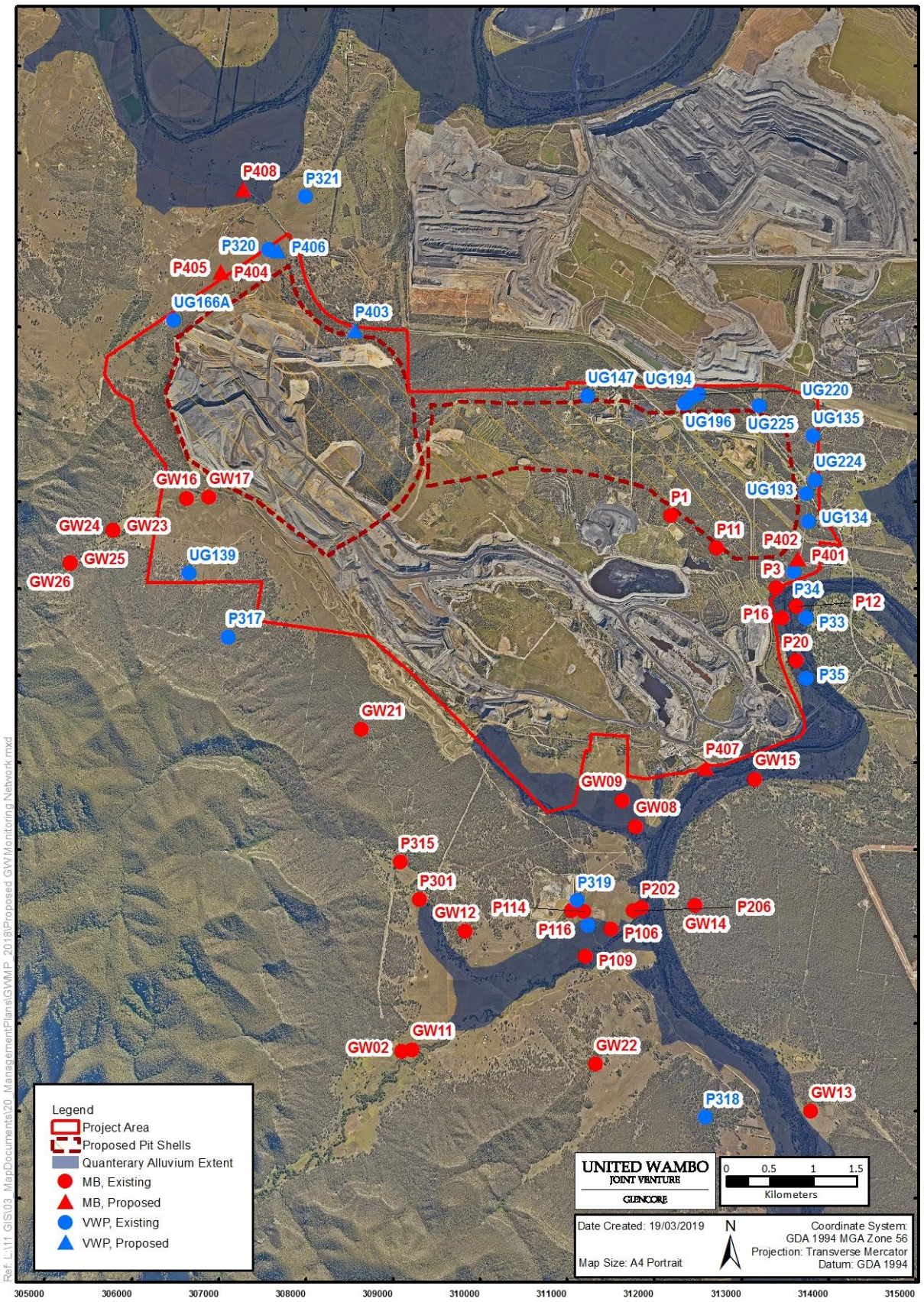


*Figure 7-1: Groundwater Monitoring Network*

*Table 7-1: Groundwater Monitoring Program*

| Bore ID | Bore type | Current status | Easting | Northing | Surface (mAHD) | Bore depth (mbgl) | Targeted unit | Monitoring program |
|---|---|---|---|---|---|---|---|---|
| **GW02** [1] | MB | A | 309109 | 6389680 | 80 | - | Wambo Creek Alluvium | SWL and WQ - 2m – full suite[6] |
| **GW08** | MB | A | 311793 | 6392266 | 61 | 6.3 | North Wambo Creek Alluvium | SWL and WQ - 2m – full suite[6] |
| **GW09** | MB | A | 311643 | 6392563 | 62 | 6.2 | North Wambo Creek Alluvium | SWL and WQ - 2m – full suite[6] |
| **GW11** [1] | MB | A | 309228 | 6389699 | 79 | - | Wambo Creek Alluvium | SWL and WQ - 2m – full suite[6] |
| **GW12** | MB | B | 309841 | 6391056 | 99 | 12.1 | Stony Creek Alluvium / Whybrow Interburden | SWL and WQ - 2m – full suite[6] |
| **GW13** | MB | A | 313810 | 6388990 | 68 | 15.0 | Wollombi Brook Alluvium | SWL and WQ - 2m – full suite[6] |
| **GW14** [2] | MB | B | 312478 | 6391358 | 65 | 18.0 | Regolith | SWL |
| **GW15** | MB | A | 313164 | 6392807 | 61 | 17.4 | Wollombi Brook (east) Alluvium | SWL and WQ - 2m – full suite[6] |
| **GW16** | MB | A | 306641 | 6396034 | 111 | 12.15 | North Wambo Creek Alluvium | SWL and WQ - 2m – full suite[6] |
| **GW17** | MB | A | 306895 | 6396048 | 110 | 14.0 | North Wambo Creek Alluvium | SWL* and WQ - 2m – full suite[6] |
| **GW21** | MB | A | 308647 | 6393378 | 119 | 36.0 | Overburden | SWL and WQ - 2m – full suite[6] |
| **GW22** | MB | A | 311335 | 6389535 | 91 | 54.0 | Overburden | SWL and WQ - 2m – full suite[6] |
| **P1** | MB | A | 312199 | 6395840 | 86 | 37.0 | Interburden | SWL and WQ - 2m – full suite[6] |
| **P11** | MB | A | 312728 | 6395462 | 72 | 31.0 | Interburden | SWL and WQ - 2m – full suite[6] |

| Bore ID | Bore type | Current status | Easting | Northing | Surface (mAHD) | Bore depth (mbgl) | Targeted unit | Monitoring program |
|---|---|---|---|---|---|---|---|---|
| **P12** | MB | EX | 313644 | 6394797 | 55 | 15.0 | Wollombi Brook (east) Alluvium | SWL[3] and WQ - 2m – full suite[6] |
| **P16** | MB | A | 313480 | 6394655 | 58 | 11.5 | Wollombi Brook (west) Alluvium | SWL and WQ - 2m – full suite[6] |
| **P20** | MB | A | 313639 | 6394166 | 57 | 10.6 | Wollombi Brook (west) Alluvium | SWL and WQ - 2m – full suite[6] |
| **P33** | VWP | EX | 313757 | 6394659 | 57 | 13.0 | Unnamed C Seam | SWL |
| | | | | | | 19.0 | Unnamed D Seam | |
| | | | | | | 46.5 | Unnamed E Seam | |
| | | | | | | 58.0 | Blakefield Seam | |
| | | | | | | 113.0 | Arrowfield Seam | |
| **P34** | VWP | EX | 313757 | 6393961 | 59 | 35.0 | Glen Munro Seam | SWL |
| | | | | | | 68.5 | Blakefield Seam | |
| | | | | | | 144.0 | Bowfield Seam | |
| **P35** | VWP | EX | 313611 | 6395196 | 59 | 16.0 | Interburden | SWL |
| | | | | | | 19.0 | Interburden | |
| | | | | | | 51.0 | Blakefield Seam | |
| | | | | | | 60.0 | Blakefield Seam | |
| | | | | | | 112.0 | Arrowfield Seam | |

| Bore ID | Bore type | Current status | Easting | Northing | Surface (mAHD) | Bore depth (mbgl) | Targeted unit | Monitoring program |
|---|---|---|---|---|---|---|---|---|
| **P106** | MB | A | 311518 | 6391084 | 60 | - | Wambo Creek Alluvium | SWL and WQ - 2m – full suite[6] |
| **P109** | MB | A | 311215 | 6390768 | 62 | - | Wambo Creek Alluvium | SWL and WQ - 2m – full suite[6] |
| **P114** | MB | A | 311205 | 6391288 | 62 | - | Wambo Creek Alluvium | SWL and WQ - 2m – full suite[6] |
| **P116** | MB | A | 311057 | 6391293 | 64 | - | Wambo Creek Alluvium | SWL and WQ - 2m – full suite[6] |
| **P202** | MB | A | 311859 | 6391330 | 59 | - | Overburden | SWL and WQ - 2m – full suite[6] |
| **P206** | MB | A | 311772 | 6391293 | 59 | - | Overburden | SWL and WQ - 2m – full suite[6] |
| **P301** | MB | A | 309311 | 6391425 | 89 | - | Stoney Creek Alluvium/Overburden | SWL and WQ - 2m – full suite[6] |
| **P315** | MB | A | 309091 | 6391852 | 98 | - | Stony Creek Alluvium/Regolith | SWL and WQ - 2m – full suite[6] |
| **P401** | MB | EX | 313660 | 6395336 | 68 | 40.0 | Overburden | SWL and WQ - 2m – full suite[6] |
| **P402** | MB | EX | 313660 | 6395336 | 68 | 120.0 | Arrowfield Seam | SWL and WQ - 2m – full suite[6] |
| **P403** | VWP | Prop | 308565 | 6397958 | 133 | 30.0 | Overburden | SWL |
| | | | | | | 125.0 | Arrowfield Seam | |
| | | | | | | 205.0 | Warkworth Seam | |
| | | | | | | 260.0 | Vaux Seam | |
| **P404** | MB | Prop | 307023 | 6398634 | 97 | 40.0 | Overburden | SWL and WQ - 2m – full suite[6] |
| **P405** | MB | Prop | 307025 | 6398634 | 97 | 110.0 | Arrowfield Seam | SWL and WQ - 2m – full suite[6] |

| Bore ID | Bore type | Current status | Easting | Northing | Surface (mAHD) | Bore depth (mbgl) | Targeted unit | Monitoring program |
|---|---|---|---|---|---|---|---|---|
| **P406** | VWP | Prop | 307681 | 6398872 | 88 | 30.0 | Overburden | SWL |
| **P407** | MB | Prop | 312599 | 6392933 | 62 | 12.0 | Wollombi Brook (west) Alluvium | SWL and WQ - 2m – full suite[6] |
| **P408** | MB | Prop | 307282 | 6399576 | 74 | 15.0 | Hunter River Alluvium | SWL and WQ - 2m – full suite[6] |
| **UG134** | VWP | EX | 313782 | 6395767 | 61 | 45.0 | Interburden | SWL |
| | | | | | | 116.0 | Interburden | |
| | | | | | | 175.0 | Warkworth Seam | |
| | | | | | | 190.0 | Mt. Arthur Seam | |
| | | | | | | 198.0 | Piercefield Seam | |
| | | | | | | 215.0 | Vaux Seam | |
| **UG135** | VWP | EX | 313831 | 6396748 | 65 | 50.0 | Interburden | SWL |
| | | | | | | 110.0 | Warkworth Seam | |
| | | | | | | 129.0 | Mt. Arthur Seam | |
| | | | | | | 146.0 | Piercefield Seam | |
| | | | | | | 176.0 | Vaux Seam | |
| | | | | | | 186.0 | Broonie Seam | |
| **UG139** | VWP | EX | 306665 | 6395173 | 129 | 263.0 | Unnamed D Seam | SWL |
| | | | | | | 281.0 | Unnamed E Seam | |

| Bore ID | Bore type | Current status | Easting | Northing | Surface (mAHD) | Bore depth (mbgl) | Targeted unit | Monitoring program |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 319.0 | Interburden | |
| | | | | | | 329.0 | Glen Munro Seam | |
| | | | | | | 375.0 | Interburden | |
| | | | | | | 382.0 | Arrowfield Seam | |
| | | | | | | 402.0 | interburden | |
| **UG147** | VWP | EX | 311245 | 6397207 | 108 | 90.0 | Glen Munro Seam | SWL |
| | | | | | | 157.0 | Interburden | |
| | | | | | | 209.0 | Mt Arthur Seam | |
| | | | | | | 242.0 | Piercefield Seam?? | |
| | | | | | | 249.0 | Vaux Seam?? | |
| | | | | | | 260.0 | Broonie Seam?? | |
| **UG166A** | VWP | EX | 306488 | 6398076 | 142 | 130.0 | Unnamed D Seam | SWL |
| | | | | | | 153.0 | Unnamed E Seam | |
| | | | | | | 183.0 | Blakefield Seam | |
| | | | | | | 200.0 | Glen Munro Seam | |
| | | | | | | 238.0 | Arrowfield Seam | |
| | | | | | | 254.0 | Bowfield Seam | |

| Bore ID | Bore type | Current status | Easting | Northing | Surface (mAHD) | Bore depth (mbgl) | Targeted unit | Monitoring program |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 260.0 | Bowfield Seam | |
| **UG193** | VWP | EX | 313757 | 6396090 | 58 | 27.0 | Glen Munro Seam | SWL |
| | | | | | | 61.0 | Arrowfield Seam | |
| | | | | | | 85.0 | Bowfield Seam | |
| | | | | | | 160.0 | Warkworth Seam | |
| | | | | | | 179.5 | Piercefield Seam | |
| | | | | | | 210.0 | Broonie Seam | |
| **UG194** | VWP | EX | 312436 | 6397191 | 82 | 20.0 | Blakefield Seam | SWL |
| | | | | | | 60.0 | Interburden | |
| | | | | | | 100.0 | Blakefield Seam | |
| | | | | | | 150.0 | Interburden | |
| | | | | | | 190.0 | Interburden | |
| | | | | | | 210.0 | Vaux Seam | |
| **UG196** | VWP | EX | 312364 | 6397122 | 81 | 45.0 | Glen Munro Seam | SWL |
| | | | | | | 80.0 | Arrowfield Seam | |
| | | | | | | 110.0 | Interburden | |
| | | | | | | 137.0 | Interburden | |

| Bore ID | Bore type | Current status | Easting | Northing | Surface (mAHD) | Bore depth (mbgl) | Targeted unit | Monitoring program |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 160.0 | Mt. Arthur Seam | |
| | | | | | | 230.0 | Broonie Seam | |
| **UG220** | VWP | EX | 312522 | 6397233 | 82 | 52.5 | Overburden | SWL |
| | | | | | | 77.0 | Arrowfield Seam | |
| | | | | | | 106.0 | Interburden | |
| | | | | | | 110.0 | Interburden | |
| | | | | | | 136.0 | Warkworth Seam | |
| | | | | | | 152.0 | Mt. Arthur Seam | |
| | | | | | | 207.0 | Vaux Seam | |
| **UG224** | VWP | EX | 313860 | 6396243 | 59 | 163.0 | Piercefield Seam | SWL |
| | | | | | | 172.0 | Interburden | |
| | | | | | | 191.0 | Vaux Seam | |
| **UG225** | VWP | EX | 313214 | 6397095 | 69 | 23.0 | Overburden | SWL |
| | | | | | | 58.5 | Arrowfield Seam | |
| | | | | | | 93.2 | Bowfield Seam | |
| | | | | | | 100.5 | Interburden | |
| | | | | | | 128.0 | Mt. Arthur Seam | |

| Bore ID | Bore type | Current status | Easting | Northing | Surface (mAHD) | Bore depth (mbgl) | Targeted unit | Monitoring program |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 178.0 | Vaux Seam | |
| | | | | | | 110.0 | Arrowfield Seam | |
| | | | | | | 135.0 | Warkworth Seam | |
| | | | | | | 200.0 | Vaux Seam | |

*Notes:*

*Coordinates are in MGA94 Zone 56*
*VWP Vibrating wire piezometer*
*MB Monitoring bore*
*A Bore currently monitored under existing GWMP, with individual trigger level for SWL, pH and EC*
*B Bore currently monitored undre existing GWMP, individual trigger to be established once sufficient data has been collected*
*EX Existing monitoring bore with baseline data available*
*Prop Bore proposed to be installed and included in the monitoring network*
*2m Monitoring frequency every two months, measuring water level, field pH and EC (as is currently in GWMP)*
*Full suite[6] Conduct water quality testing annually for revised full water quality suite (see **Section 7.1.2.3**)*
*SWL Static water level – VWP sensors record daily pressure (converted to SWL) – download results every six months*

*1 Private bores*
*2 GW14 has been dry since December 2011*
*3 Water level also recorded with datalogger at this site*

#### 7.1.2.2 Groundwater Level Monitoring

Both manual and automatic groundwater level monitoring will continue in selected monitoring bores. Manual groundwater level monitoring will continue to be conducted on a monthly to bi-monthly (every two months) basis, for calibration and cross reference to groundwater logger records. In addition to the conventional monitoring bores, daily readings (at a minimum) are recorded by the VWP dataloggers.

Ongoing water level monitoring will enable natural groundwater level fluctuations (such as responses to short term rainfall events and longer term climatic changes (i.e. droughts and flood events) to be distinguished from groundwater level impacts due to depressurisation from mining activities. Ongoing monitoring of groundwater level will also be used to assess the extent and rate of depressurisation against model predictions (AGE 2016).

Yearly reporting of the water level results from the monitoring network will be included in the Annual Review (see ***Section 9.6***). The Annual Review will also identify if any additional monitoring sites are required or if optimisation of the existing monitoring sites should be undertaken.

#### 7.1.2.3 Groundwater Quality Monitoring

Water quality monitoring is conducted at United Wambo on a monthly to bi-monthly basis for field water quality (EC and pH), and on an annual basis for more comprehensive water quality analysis at all monitoring bore sites.

Groundwater quality sampling will continue at key selected sites (mainly shallow alluvial sites) in order to detect any changes in groundwater quality during and post mining. Bi-monthly sampling for field water quality (EC and pH) will continue and the annual full quality suite will be expanded to include key analytes that will determine any changes in beneficial groundwater use (i.e. livestock drinking water). The revised full suite will include:

- physico-chemical indicators – pH, EC, total dissolved solids (TDS);
- major ions – calcium, fluoride, magnesium, potassium, sodium, chloride, sulphate;
- total alkalinity as $CaCO_3$, $HCO_3$, $CO_3$; and
- dissolved and total metals – aluminium, arsenic, barium, boron, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, silver, vanadium, and zinc.

Reporting of the water quality results from the monitoring network will be included in the Annual Review (see ***Section 9.6***). The Annual Review will consider if any additional monitoring sites are required or if optimisation of the existing monitoring sites is necessary. It will also address the frequency of sampling, and if an expanded or reduced analytical suite should be undertaken.

#### 7.1.2.4 GDE Monitoring

The requirement for monitoring of the alluvial groundwater in the downstream reaches of Redbank Creek area where GDE1 is located has been discussed with DoI Lands and Water (per comms JP Williams 18 Oct 2018).

The NSW GWDB suggests that monitoring bores already exist in the areas adjacent to GDE1 and GDE2. These would be useful sites (if still operational) to assess alluvial water level variations in the immediate vicinity of these GDEs. The status of these monitoring bores will be investigated, and if still operational, water level and water quality frequencies will be determined and details included in future versions of this GWMP. If bores are monitored and maintained by others then United Wambo will investigate entering into a data sharing agreement.

If no suitable sites exist then new shallow monitoring bores will be considered.

Water levels from the local monitoring network will be reviewed periodically together with floristic condition assessment surveys to ensure that water table drawdown is no greater than predicted by modelling. Three yearly data and model reviews will also assist with verifying (and if necessary) improving model predictions.

As required by Condition B51 of SSD 7142, United Wambo must, within 12 months of commencement under SSD 7142, undertake a Groundwater Dependent Ecosystem Study. This study must:

a) be prepared by suitably qualified and experienced person/s;

b) be developed in consultation with DPIE Water;

c) assess the hydrological and hydrogeological settings of the site;

d) be integrated with the similar studies being undertaken by nearby mines (where practicable);

e) further characterise groundwater dependent ecosystems (vegetation and communities) potentially impacted by the development, including the Central Hunter Swamp Oak Forest EEC (GDE1), Hunter Valley River Oak Forest (GDE2) and individual River Red Gums (GDE1 and GDE2) identified along the riparian buffers of Redbank Creek and Wollombi Brook;

f) detail the reliance of groundwater dependent ecosystems on surface and groundwater resources;

g) identify the potential risks to groundwater dependent ecosystems from the development and the Wambo Mining Complex, and other nearby mines (where practicable); and

h) use the results of this study to develop performance criteria to achieve the performance measures in SSD 7142 and inform the GWMP.

The GDE Study has been completed and can be found as Appendix C in this GWMP.

#### 7.1.2.5 Stygofauna Monitoring

Although there is a low risk of impacts to stygofauna, United Wambo commits to monitoring stygofauna in the alluvial aquifers within (or near to subject to bore suitability) the predicted drawdown areas every three years.. If groundwater monitoring indicates that impacts are greater than predicted within the shallow alluvial aquifers surrounding the Project Area, more regular monitoring for stygofauna will be triggered.

Monitoring for stygofauna will be undertaken at the following bores:

- Wollombi Brook Alluvium: P12, P16, P407 (once installed);
- North Wambo Creek Alluvium: GW08, GW16, GW17;
- Hunter River Alluvium: P408 (once installed); and
- Wambo Creek Alluvium: P116.

### 7.1.3 Mine Water Seepage Monitoring

Monitoring of mine water seepage will be undertaken to identify seepage rates and quality. The capture of incidental water is an important component of the site's water balance. If mine water is pumped to holding storages (such as South Wambo Dam) then pumped volumes will be also recorded via flow meters or other suitable gauging apparatus.

There will be a focus on North Wambo Creek where potential losses from the creek and adjacent alluvial areas to active mining pits are of concern to DPIE Water. There are currently no observed

losses from the ephemeral creek or clayey alluvium into the pit. Groundwater level observations and updated modelling will be used to calibrate current conditions and predict future impacts in this area.

Water samples of pumped (dewatered) mine water will be collected bi-monthly with the objective of providing an early indication of any mixing with (lower salinity) natural groundwater.

The water quality analytical suite will be the same as that adopted for groundwater monitoring bores. To summarise, the seepage monitoring program will include:

- metering the volume of water pumped from the mining pit areas using flow meters or other suitable gauging apparatus;
- monitoring quality of water pumped from the mining areas (full water quality suite); and
- correlation of rainfall records with mining area seepage records/model estimates so that the groundwater and any surface water/shallow alluvial incidental take can be separated.

### 7.1.4 Impact on Other Water Users

As discussed in ***Section 6.2.7***, there are five bores on mine-owned land predicted to be impacted during mining operations and there will be no impact on residual agricultural areas located up to four kilometres distance from the mine.

As such, there is no program proposed to monitor the impact on groundwater supply for other water users. Should a private bore be identified as being potentially impacted by United Wambo operations, a monitoring program will be developed and implemented in consultation with DPIE and DPIE Water.

Three yearly data and model reviews will assess whether predicted drawdowns from the model align with the actual observed drawdowns. In the unlikely event that a private water bore is predicted to be impacted by drawdown associated with the mine operations, then make-good arrangements will be negotiated with the owner.

## 7.2 Groundwater Impact Assessment Criteria

### 7.2.1 Trigger Values for Groundwater Level

Groundwater level triggers are proposed for alluvial monitoring bore sites and offsite bedrock monitoring bore sites in general accordance with the AIP. Triggers have not been proposed for the deeper VWP sites. Even though there are no nearby private water bores where a two metre cumulative drawdown would trigger make-good provisions in either the alluvial or bedrock aquifers, the proposed triggers are considered reasonable to protect the long-term viability and sustainability of these groundwater sources. The alluvial water sources (especially in the 'highly productive' groundwater source areas) require a higher degree of scrutiny and protection than the bedrock water sources because of the ongoing long-term beneficial uses of this water source post mining.

Statistical analysis of groundwater level in shallow monitoring bores was undertaken by Wambo and United to determine appropriate site specific trigger levels. The trigger values adopted are the 90th percentile of the recorded depth to groundwater in the historical dataset plus one metre allowing for seasonal variations.

Water level triggers for United have been determined based on statistical analysis of the dataset from 2008 to 2018.

The 10th and 90th percentile values for the monitoring bore sites are shown in

Table 7-2.

*Table 7-2: Monitoring Bore Water Levels that Trigger a Response [3]*

| Bore | Targeted Unit | Depth to Groundwater (mbTOC [4]) | |
|---|---|---|---|
| | | Minimum (10th percentile) | Maximum (90th percentile) |
| **Alluvial monitoring bores** | | | |
| GW02 | Wambo Creek Alluvium | 5.7 | 8.4 |
| GW08 | North Wambo Creek Alluvium | 3.3 | 7.0 |
| GW09[1] | North Wambo Creek Alluvium | Dry since 2016 | Dry since 2016 |
| GW11 | Wambo Creek Alluvium | 4.0 | 6.7 |
| GW13 | Wollombi Brook Alluvium | 4.9 | 6.3 |
| GW15 | Wollombi Brook (east) Alluvium | 10.2 | 11.4 |
| GW16[3] | North Wambo Creek Alluvium | 5.0 | 10.9 |
| GW17[3] | North Wambo Creek Alluvium | 8.2 | 12.1 |
| P12 | Wollombi Brook (east) Alluvium | 6.3 | 7.7 |
| P16 | Wollombi Brook (west) Alluvium | 7.0 | 8.6 |
| P20 | Wollombi Brook (west) Alluvium | 7.2 | 8.3 |
| P106 | Wambo Creek Alluvium | 6.6 | 9.6 |
| P109 | Wambo Creek Alluvium | 4.4 | 6.2 |
| P114 | Wambo Creek Alluvium | 5.4 | 7.3 |
| P116 | Wambo Creek Alluvium | 4.8 | 6.8 |
| P407[2] | Wollombi Brook (west) Alluvium | ND | ND |
| **Offsite bedrock monitoring bores** | | | |
| GW21 | Overburden | 36.3 | 36.6 |
| GW22 | Overburden | 34.9 | 36.7 |
| P11 | Interburden | 30.4 | 32.0 |
| P202 | Overburden | 7.6 | 9.0 |
| P206 | Overburden | 15.8 | 20.6 |
| P404[2] | Overburden | ND | ND |
| P405[2] | Arrowfield Seam | ND | ND |

*1 Specific trigger levels* for *GW09 have not been established however if GW09 does not recover within 12 months of the cessation of dewatering pumping, installation of replacement bores that allow monitoring of the alluvium and underlying interburden material may be considered.*

*2 Trigger will be developed as soon as there is sufficient data (ND – no historical data)*

*3 To obtain trigger value add one metre to the 90th percentile depth to groundwater value*

*4 mbTOC = metres below top of casing*

### 7.2.2 Trigger Values for Groundwater Quality

Water quality triggers are required to protect groundwater quality in the important groundwater sources so that saline discharges to groundwater and surface water sources do not occur and a range of beneficial uses is possible post mining. Again, the focus is on the alluvial water sources (especially in the 'highly productive' groundwater source areas). The adopted triggers relate to pH and salinity (EC) only as the natural range of other water quality parameters and analytes is too large to justify additional triggers. Natural variations in pH and EC can also occur due to flood and rainfall responses, and severe drought events, hence, it is proposed that a management response would not be triggered until exceedances occurred over three consecutive bi-monthly events.

The conceptual understanding is that with the coal measures being depressurised due to mining, there will be reduction in bedrock leakage to the alluvium (or increased recharge from the alluvium to the bedrock) and, overall, there should be an improvement in alluvial groundwater quality. If water quality improves over time then this is not considered an exceedance that will trigger any remedial action.

The number of Permian strata sites has been slightly reduced as there is a large variability in water quality spatially and it is very unlikely that there will be any future use of this water source.

Wambo have developed water quality triggers for EC based on the 90th percentile value observed in monitoring bores between 2008 and 2018. Where there is anomalous historical data, this data has been omitted from the data set. Although ANZECC and ARMCANZ (2000) recommend 80th percentile values as being suitable for trigger values, a trigger would be initiated 20 per cent of the time due to natural variability. Therefore, for the trigger to be a meaningful indicator of a possible mining effect, an investigation will not be triggered unless the 90th percentile value is exceeded on three consecutive bi-monthly monitoring events.

Similarly for pH, an investigation will not be triggered unless the 90th percentile value is exceeded on three consecutive bi-monthly monitoring events.

Poor quality mine water stored in onsite mine water dams is a potential risk to the adjacent alluvial water resources if there is leakage or overflows from these storages. Bores P114, P116, P202, and P206 provide suitable indicators near the South Wambo Dam to protect the Wambo Creek alluvium.

Water quality triggers for United have been determined based on statistical analysis of the dataset from 2008 to 2018.

Groundwater quality trigger levels for EC and pH are presented in ***Table 7-3***. For those sites where there is currently no or limited historical data, trigger values will be determined once there are two years of bi-monthly water quality data available. Once trigger levels are determined, the GMP will be updated and submitted for review during the following Annual Review.

The trigger values in ***Table 7-3*** were updated in June 2021, following an error in the data being identified. The triggers in the previous versions were incorrect, and have been updated. The trigger values now reflect the $10^{th}$ and $90^{th}$ percentiles of the historic data. These values now align with the values provided in ***Table 5-3***.

*Table 7-3: Monitoring Bore Water Quality Trigger Values*

| Bore | Electrical Conductivity (µS/cm) | pH | |
|---|---|---|---|
| | Maximum (90th Percentile) (Requires Three Consecutive Bi-Monthly Exceedances) | Minimum (10th percentile) (Requires Three Consecutive Bi-Monthly Exceedances) | Maximum (90th Percentile) (Requires Three Consecutive Bi-Monthly Exceedances) |
| **Alluvial monitoring bores** | | | |
| GW02 | 657 | 6.7 | 7.4 |
| GW08 | 1,980 | 6.8 | 8.0 |
| GW11 | 626 | 6.8 | 7.5 |
| GW13 | 4,447 | 6.9 | 7.1 |
| GW15 | 726 | 6.7 | 7.2 |
| GW16[1] | 1,145 | 7.2 | 11.2 |
| GW17[1] | 5,542 | 7.0 | 7.2 |
| P12 | 1,002 | 7.3 | 7.7 |
| P16 | 10,510 | 7.0 | 7.7 |
| P20 | 10,364 | 7.0 | 7.6 |
| P106 | 674 | 6.7 | 7.9 |
| P109 | 801 | 6.5 | 7.9 |
| P114 | 7,096 | 6.5 | 7.8 |
| P116 | 2,076 | 6.6 | 7.4 |
| **Offsite bedrock monitoring bores** | | | |
| GW21[2] | ND | ND | ND |
| GW22 | 7,028 | 8.2 | 8.4 |
| P202 | 8,368 | 6.7 | 7.7 |
| P206 | 2,372 | 7.3 | 8.1 |
| P401[2] | ND | ND | ND |
| P402[2] | ND | ND | ND |

*1 GW16 and GW17 are located upstream of the North Wambo Creek Diversion and in close proximity to the approved open cut*

*2 ND – Insufficient historical water quality data to determine triggers*

## 7.3 Groundwater Performance Criteria

The groundwater performance criteria for alluvial and bedrock aquifers, groundwater inflows, seepage/leachate are outlined in ***Table 7-4*** below with further descriptions provided in the sections below.

It should be noted that no groundwater performance criteria are included in ***Table 7-4*** for private water bores or GDEs. As discussed in ***Section 5.3.3*** there are no private water bores within the predicted zone of impact of the development, as such no performance criteria is required. Impacts

on such bores would be an unforeseen impact and as such responses to potential impacts are included in ***Section 9.10***. Similarly, measurement and evaluation criteria for GDEs will be included when the GDE Study required under SSD 7142 Condition B51 has been undertaken.

*Table 7-4: Groundwater Performance Measures*

| Aspect | Performance Measures | Performance Indicator/Trigger | Response |
|---|---|---|---|
| **Alluvial aquifers** | Negligible change in groundwater level (compared to predicted impacts[1]) | 90th percentile (and not related to seasonal variability) over three consecutive months. | TARP – Groundwater Level |
| | Negligible change in groundwater quality | Groundwater quality concentrations outside of adopted trigger values (***Table 7-3***) for at least one parameter for more than three consecutive months. | TARP – Groundwater Quality |
| **Bedrock aquifers** | Negligible change in groundwater level (compared to predicted impacts[1]) | 90th percentile (and not related to seasonal variability) over three consecutive months.<br>No trigger adopted for monitoring sites within the project area. | TARP – Groundwater Level |
| | Negligible change in groundwater quality | pH of 6.5 to 8.5<br>EC < 17,500 µS/cm | TARP – Groundwater Quality |
| **Groundwater inflows to mining pits** | Groundwater inflows to mining pits consistent with groundwater model predictions and all take is covered by relevant licences | Groundwater inflows to mining pits is >10% higher than predicted for three consecutive months, without logical reason (i.e. changes to mine plan or wetter than average climate conditions). | TARP – Groundwater Inflows |
| **Seepage/leachate** | Negligible seepage/leachate from water storages | Visual inspections of water storages (as per the United Wambo Erosion and Sediment Control Plan Checklists) shows seepage zones, and reporting water balance indicates seepage is greater than | The water storage integrity will be reviewed by a specialist.<br><br>Other actions as per Unforeseen Impacts Protocol (***Section 9.10***) |

| Aspect | Performance Measures | Performance Indicator/Trigger | Response |
|---|---|---|---|
| | | negligible (i.e. >5% of inflows to water storage) | |
| | All seepage/leachate from emplacement areas is captured in water management system | Visual inspections (as per the United Wambo's Erosion and Sediment Control Plan Checklists) indicates seepage areas and confirms location of drainage pathways outside of water management system | Seepage/leachate area to be investigated, including water quality, source of seepage. Works to be undertaken to determine any potential downstream impacts and to ensure seepage is ceased or diverted to water management system<br>Other actions as Unforeseen Impacts Protocol (***Section 9.10***) |
| | Negligible impacts of seepage/leachate impacts from backfilled voids on regional groundwater quality | No increasing trends in water quality parameters in monitoring bores downdip of backfilled voids. An increasing trend would be indicated by three consecutive water quality readings showing continual increases in analyte concentrations. | Other actions as per Unforeseen Impacts Protocol (***Section 9.10***) |
| | Seepage/leachate impacts from final voids are consistent with predictions in relevant environmental impact statements for the two approved final voids (United and Wambo Open Cuts) | Measures to be development as part of United Wambo Closure Plan (at least 5 years prior to completion mining) | TBA as part of United Wambo Closure Plan |

*1 Predicted impacts as determined in the numerical groundwater model (AGE 2016)*

# 8. Monitoring Methodology

## 8.1 Overview

All monitoring is to be undertaken in accordance with United Wambo procedures for environmental monitoring and evaluation outlined in the ***United Wambo Environmental Management Strategy***. The methodology for monitoring groundwater for the project includes:

- assessment of groundwater level (manual measurement and datalogger download prior to purging/sampling);
- sampling of groundwater (sampling after purging, or low-flow sampling); and
- implementation of a quality control plan including appropriate chain-of-custody for laboratory analysis and provision of appropriate documentation.

Groundwater monitoring will be overseen by personnel with appropriate qualifications and experience, with field sampling undertaken by trained personnel using appropriate personal protective equipment (PPE) and approved sampling procedures.

## 8.2 Groundwater Level and Purging

The static groundwater level within each groundwater monitoring bore will be measured to the nearest millimetre prior to purging (if required) or sampling, using an electronic groundwater level dip meter (dipper) referenced to a known (and consistent) surveyed point at the top of the bore casing. The groundwater level below top of casing will be corrected to mAHD using the survey data. Recorded groundwater level will be tabulated in both metres below top of bore casing (mbTOC) and mAHD.

The base of the bore will be measured to the nearest millimetre periodically by lowering the dipper to the base of the bore until it touches the bottom. These levels will be recorded.

Following water level measurement, the monitoring bore will be purged using an appropriate pump (selected based on the hydraulic characteristics of the bore) and a sample will be collected. If insitu low-flow sampling techniques are used (e.g. micropurge or hydrosleeve), purging will not be required.

Field physico-chemical water quality parameters (at a minimum pH and electrical conductivity) will be measured using calibrated equipment. Field parameters will also be measured during purging (if applicable).

The groundwater monitoring bore will be sufficiently purged when one of the following criteria is achieved (whichever occurs first):

- three bore volumes of water have been purged;
- the bore is purged until no more water can be removed (considered dry); or
- the water quality parameters have stabilised within 10 per cent over three consecutive recorded measurements.

In cases where a water level datalogger is installed in a monitoring bore, it will be removed from the bore and checked/maintained as necessary before being re-calibrated (if required) and returned to the bore at a known depth below the top of casing.

## 8.3 Sample Collection

At the completion of purging (if applicable), groundwater samples will be collected following the protocols outlined in the Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC 2000). Samples will be collected in dedicated laboratory-supplied sampling bottles with sufficient volume to satisfy the requirements for all analytes.

The following details will be recorded at the time of sampling for all groundwater monitoring samples:

- the date(s) and time(s) at which the sample was taken;
- the point at which the sample was taken; and
- the name of the person who collected the sample.

In the event of an apparently anomalous result, United Wambo will conduct a re-test as soon as is practicable to do so.

The samples will be placed into a chilled ice-chest for transport to the nominated laboratory(s). Where required (i.e. for dissolved metals analysis), the water sample will also be filtered in the field using a dedicated 0.45 micrometre water filter to remove fine suspended particles.

Cross-contamination of samples will be prevented through either dedicated tubing at the pump, dedicated sampling devices, or by decontamination of equipment with phosphate-free detergent and clean water between sampling locations.

## 8.4 Quality Assurance and Documentation

Quality assurance and control protocols during sampling will be undertaken in accordance with ANZECC (2000) to ensure the integrity of the dataset.

Samples will be transported to a NATA-accredited laboratory(s) under appropriate documented chain-of-custody. Laboratory guidelines on holding times for samples will be complied with where practicable.

Laboratory and field results will be checked for accuracy on receipt of all sampling data and laboratory certificates of analyses. Errors or discrepancies will be cross-checked with field and laboratory records and further investigation initiated if required.

## 8.5 Data Management Procedure

Validated data from the monitoring program will be entered into the GCAA Environmental Monitoring Database (EMD) in a form suitable for analysis.

# 9. Management and Mitigation

## 9.1 Groundwater Management System

The groundwater management system at United Wambo consists of:

- the groundwater monitoring program described in ***Section 7.1*** of this GWMP;
- management of the groundwater inflows into the open cut pits as described in the ***United Wambo Water Management Plan***; and

- management and monitoring of seepage/leachate as described in ***Section 7.3***.

## 9.2 Roles and Responsibilities (Accountabilities)

Refer ***United Wambo Water Management Plan***.

## 9.3 Training

Generic training on the aspects of the GWMP will be provided to all employees and contractors through the GCAA Generic Surface Induction and the Site Familiarisation process.

Regular workforce communication days and toolbox talks allow for discussion of the objectives and requirements of this and any other relevant Plans.

Selected site personnel whose duties directly involve the management of water at United Wambo, will undertake specific training with respect to site Operational Procedures which incorporate water management measures.

## 9.4 Monitoring and Inspection

This GWMP provides detailed inspection criteria including:

- groundwater monitoring locations;
- type of monitoring;
- parameters/analytes to be monitored;
- frequency of monitoring; and
- monitoring methodology

United Wambo's EMS documents relevant to this GWMP are listed in ***Table 11-1***.

## 9.5 Licences and Permits

The project activities will be regulated by EPL 3141 (United) and EPL 529 (Wambo) issued by the EPA. EPL 529 prescribes water quality parameters to be measured and associated discharge criteria from licensed discharge points. They also detail the monitoring and analytical requirements by reference to authority publications (e.g. Methods for Sampling and Analysis of Water Pollutants in NSW (EPA 2004)). There are no specific groundwater monitoring requirements in both EPLs.

Other relevant licences or permits will be obtained in the lead up to, and during construction of, the project as required.

## 9.6 Reporting and Review of Results

United Wambo will be responsible for coordinating a bi-monthly review of the monitoring results and associated trends in water quality. Measured values will be compared to background trends and 90th percentile trigger values. An investigation of potential causes will be undertaken when triggers are exceeded as described in ***Section 7.1*** and ***Section 7.2.2.*** This investigation will be undertaken by the United Wambo Environment and Community (E&C) Department following the investigation protocol described in ***Section 9.7***.

Monitoring results will be reviewed annually and reported as required in the Annual Review, which is distributed to government agencies and the Community Consultative Committee. Reporting will

include a comparison of water quality trends with those of previous years and will highlight any results that are inconsistent with trends in baseline data.

All monitoring data will be retained in an appropriate format on site and will be used to review the effectiveness of the United Wambo water management system on an ongoing basis.

Reporting requirements relevant to this GWMP are outlined in ***Table 9-1***. Additional reporting requirements for the project are outlined in the ***United Wambo Water Management Plan***.

*Table 9-1: Reporting Requirements*

| Schedule | Requirements | Recipient |
|---|---|---|
| **Monthly** | Review of the groundwater monitoring results and associated trends in groundwater quality against performance criteria. | United Wambo E&C Department |
| **Annually** | Review of groundwater monitoring results (including all water level, water quality and mine water seepage data).<br>Comparison of groundwater data trends with those of previous years highlighting any results that are inconsistent with trends in baseline data.<br>Comparison of groundwater data against specified trigger levels. | Government agencies (DPIE, DPIE Water, EPA) and the Community Consultative Committee |

Where monitoring results exceed the trigger values outlined in ***Section 7.1*** and ***Section 7.2.2*** of this GWMP, this will be reported as part of the Annual Review. Where it is deemed that an exceedance constitutes an incident (potential or actual environmental harm), reporting will be as per the United Wambo ***Pollution Incident Response Management Plan*** (PIRMP).

## 9.7 Investigation Protocol

In the event that groundwater water level and water quality trends deviate from background trends and the trigger values presented in ***Section 7.1*** and ***Section 7.2.2*** are exceeded, United Wambo will be responsible for initiating further site-specific investigations when:

- in their professional judgement, the deviation from background trends and performance criteria could result in environmental harm; or
- the performance criteria (indicators/triggers) trigger a response protocol.

A site-specific investigation will then be instigated and prepared in accordance with the protocols described in ***Section 9.8*** and ***Section 9.10***.

When groundwater performance has been investigated the findings of the investigation will be reported in the Annual Review (see ***Section 9.6***).

## 9.8 Criteria Exceedance Protocol

If the monitoring results are outside the impact assessment criteria outlined in ***Section 7.2***, further investigations are required and United Wambo will refer to the associated Trigger Action Response Plans (TARP) in ***Appendix B - Groundwater TARPs*** and the following Criteria Exceedance Protocol.

As per the TARPs within ***Appendix B - Groundwater TARPs***, if the criteria exceedance protocol is enacted, further investigations are required. United Wambo will:

- confirm the timing and general location of the exceedance(s);
- confirm the meteorological conditions at the time of the exceedance(s) (where relevant);
- identify any potential contributing factors;
- assess the monitoring results against background trends and relevant modelling predictions to identify any anomalies or causes;
- if the exceedance is not attributable to United Wambo, the routine monitoring program will be assessed for its effectiveness;
- where the exceedance is potentially attributable to United Wambo, appropriate mitigation and management strategies will be developed and implemented;
- where mitigation and management strategies have been implemented, additional monitoring and regular reviews will be undertaken to measure the effectiveness of the strategies undertaken; and
- report the exceedance in accordance with the reporting mechanisms outlined in ***Section 9.6***.

## 9.9 Groundwater Model Validation

Every three years, an independent review of the groundwater model (AGE 2016) will be undertaken to determine the validity of the groundwater model predictions and will include a comparison of monitoring results with modelled predictions.

If the data indicates significant divergence from the model predictions, an updated groundwater model will be constructed for simulating future mining.

## 9.10 Unforeseen Impacts Protocol

Due to the low likelihood of groundwater incidents occurring, any associated impacts have been characterised as unforeseen impacts.

Groundwater incidents, which may be addressed by the unforeseen impacts protocol, include impacts to GDEs and generally any non-compliance to groundwater conditions within the Conditions of Consent for the project, not covered by an associated protocol or Trigger Action Response Plan (TARP) (See ***Appendix B - Groundwater TARPs***).

Notification and incident response should be conducted in line with the Pollution Incident Response Management Plan (PIRMP).

If the investigation deems that the incident caused, or had potential to cause, material environmental harm, it must be reported immediately after the person becomes aware of it. Notification should be made verbally with written notice within seven days as per the requirements within condition R2 of the EPL.

Material environmental harm has the same definition as in section 147 of the POEO Act (1997).

Notification must be made for all incidents defined under the Development Consent to the Secretary and any other relevant agencies as soon as practicable after becoming aware of the incident. A detailed report shall be provided within seven days.

In the event of unforeseen impacts associated with the groundwater management system at United Wambo, the following protocol will be implemented:

- conduct a preliminary review of the nature of the impact, including:
  - initial assessment of environmental harm;
  - any relevant monitoring data; and
  - current mine activities and land use practices;
- commission an investigation by a suitably qualified expert into the unforeseen impact to confirm cause and effect and consider relevant options for amelioration of impact(s) as appropriate;
- prepare an action plan in consultation with the relevant stakeholders;
- mitigate causal factors where possible; and
- implement additional monitoring as necessary to measure the effectiveness of the controls implemented.

The outcomes of the investigations into any unforeseen impacts and the controls/remediation actions implemented will be reported in the Annual Review (***Table 9-1***)**.** The implementation of any mitigation measures will be undertaken in consultation with DPIE, DPIE Water, and the EPA.

## 9.11 Complaints Management Protocol

United Wambo operates a dedicated complaints hotline. The details of this hotline are on the United Wambo website and provided to the community via a six-monthly newsletter.

A procedure for handling complaints has been implemented as part of the United Wambo EMS to ensure a consistent approach to handling any complaint. All legitimate complaints will be thoroughly investigated by the United Wambo E&C Manager. With respect to complaints regarding groundwater the investigations will include, as a minimum:

- records of the timing and general location of the issue initiating the complaint;
- details of the meteorological conditions at the time of the issue initiating the complaint;
- identification of any potential contributing factors; and
- a review of any monitoring results relevant to the complaint.

Where the complaint is potentially attributable to United Wambo, appropriate mitigation and management strategies will be developed, implemented and monitored for the effectiveness of the strategies undertaken.

Feedback to the complainant will be provided within 24 hours of receiving the complaint.

Details of complaints relating to groundwater will be provided to relevant mine planning and production personnel, to assist in the improvement of management practices, where relevant. A summary of the complaints received by the community will be reported in the Annual Review (***Table*** 9-1)**.**

## 9.12 Auditing

Audits (both internal and external) will be undertaken to assess the effectiveness of environmental controls, compliance with this GWMP, consent conditions, and other relevant approvals, licenses, and guidelines.

Audit requirements are detailed in the ***United Wambo Environmental Management Strategy***.

# 10. Review and Improvement

## 10.1 Continuous Improvement

Continuous improvement of this GWMP will be achieved by the ongoing evaluation of environmental management performance against environmental policies, objectives and targets for the purpose of identifying opportunities for improvement.

The continuous improvement process will be designed to:

- identify areas of opportunity for improvement of environmental management and performance;
- determine the cause or causes of non-conformances and deficiencies;
- develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies;
- verify the effectiveness of the corrective and preventative actions;
- document any changes in procedures resulting from process improvement; and
- make comparisons with objectives and targets.

## 10.2 GWMP Update and Amendment

This GWMP will be reviewed, and if necessary revised, with any review of the ***United Wambo Water Management Plan***.

The GWMP will reflect any changes in environmental requirements, technology, and operational procedures.

# 11. Document Information

Relevant legislation, standards and other reference information must be regularly reviewed and monitored for updates and should be included in the site management system. Related documents and reference information in this section provides the linkage and source to develop and maintain site compliance information.

## 11.1 Related Documents

Related documents, listed in ***Table 11-1*** below, are *documents* directly related to or referenced from within this document.

*Table 11-1: Related Documents*

| Number | Title |
|---|---|
| GCAA-625378177-10320 | GCAA 11.03 Water Management Protocol |
| GCAA-625378177-10596 | GCAA 11.03 Water Accounting Framework Procedure |
| GCAA-625378177-10248 | GCAA 11.02 Pipeline Management Protocol |
| UWOC-1689771511-360 | United Wambo Environmental Management Strategy |
| UWOC-1689771511-374 | United Wambo Pollution Incident Response Management Plan |
| UWOC-1689771511-365 | United Wambo Water Management Plan |
| UWOC-1689771511-364 | United Wambo Surface Water Management Plan |
| UWOC-1689771511-369 | United Wambo Erosion and Sediment Control Plan |

## 11.2 Reference Information

Reference information, listed in ***Table 11-2*** below, is *information* that is directly referred to for the development of this document.

*Table 11-2: Reference information*

| Reference | Title |
|---|---|
| DPIE Water 2014 | *Groundwater Monitoring and Modelling Plans – Introduction for prospective mining and petroleum activities (DPIE Water 2014)* |
| DoEE 2015 | *National Water Quality Management Strategy (DoEE 2015)* |
| Umwelt 2016a | *United Wambo Open Cut Coal Mine Project – Surface Water Assessment (Umwelt, 2016a)* |
| AGE 2016 | *United Wambo Open Cut Coal Mine Project – Groundwater Impact Assessment* (AGE 2016) |

| Reference | Title |
|---|---|
| ANZECC 2000 | *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ 2000)*<br>*Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ 2000)* |
| Umwelt 2016b | *United Wambo Open Cut Coal Mine Project – Environmental Impact Statement* (EIS) (Umwelt 2016b) |
| Umwelt 2017a | *United Wambo Open Cut Coal Mine Project – Response to Submissions* (RTS) (Umwelt, 2017a) |

## 11.3 Change Information

Full details of the document history are recorded in the document control register, by version. A summary of the current change is provided in ***Table 11-3*** below.

*Table 11-3: Change information*

| Version | Date | Change Details |
|---|---|---|
| 1.0 | September 2019 | New document |
| 1.1 | December 2019 | Updated to address comments received from Department of Planning, Industry and Environment. Reviewed by EMM. |
| 1.2 | May 2020 | Updated template. Minor changes to document including sentence structure and definitions, references in Appendix A. |
| 2.0 | July 2020 | Document reviewed for Phase 2 commencement. |
| 3.0 | June 2021 | Updated following submission of Independent Audit and Annual Review. Trigger levels corrected. |

# 12. Accountabilities

Refer United Wambo Water Management Plan.

# Appendix A - Consultation Records

| Department | Comment | Response /Change |
|---|---|---|
| **DPIE** | Individual management plans need to make it clear what phases of the development and mining activities they apply (Phases 1A, 1B, 2 and 3 as defined in Development Consent SSD7142). Section 3 of the Water Management Plan indicates that the plan applies to "all operational activities at United Wambo", however, Section 3 indicates that the Wambo site Management Plan documents will continue to apply during Phase 1A and 1B. It is not clear if this is the intention for the other sub-water related management plans. | Further discussion and explanation on Phases of the development the management plan have been provided in the 'Scope' of each Management Plan. |
| **DPIE** | Provide evidence that the plans have been prepared by a suitably qualified and experienced person/s endorsed by the Planning Secretary (condition B52a). | Letter of endorsement has been added to the Appendix. |
| **DPIE Groundwater Management Plan** | Sections 5.4.2 and 5.4.3 – baseline data in relation to groundwater levels and quality is considered inadequate. A summary of existing groundwater data is required in order for any observable changes as a result of mining operations to be identified. | Summary of baseline data included. |
| **DPIE Water Groundwater Management Plan** | 1. The proponent commit to either accounting via a licensing offset the measurable stream losses along North Wambo Creek, or the Groundwater Management Plan present performance measures demonstrating how any such losses are quantitatively conserved, e.g. re-saturation of the downstream alluvial aquifer. | Section 6.2.6.1 included wording that Wambo is responsible for managing North Wambo Creek during Phase 1A and 1B. United Wambo assumes responsibility upon commencement of Phase 2. Commitment made to develop plan and include in a revised GWMP at Phase 2. |
| | 2. The proponent commit to on-going floristic condition assessment for 'High Priority' GDEs and reporting. | Commitment in Section 7.1.2.4 updated to reflect DPIE request. |

NSW GOVERNMENT | Planning, Industry & Environment

Planning and Assessment
Resource Assessments
Contact Melanie Hollis
Phone 8217 2048
Email melanie.hollis@planning.nsw.gov.au

Aislinn Farnon
Approvals Manager
United Wambo Joint Venture Project
134 Jerrys Plains Road
WARKWARTH NSW

Dear Ms Farnon

**United Wambo Open Cut Coal Mine (SSD 7142)**
**Water Management Plan**

I refer to your letter dated 10 December 2019, requesting the Planning Secretary's endorsement of suitably qualified and experienced persons to prepare the Water Management Plan (WMP) in accordance with condition B52(a) of SSD 7142.

The Department has reviewed the credentials of Ms Susan Shield and Ms Liz Webb and considers that they are suitably qualified and experienced to prepare the WMP.

The Planning Secretary therefore endorses the following personnel to prepare the WMP:

- Ms Liz Webb (EMM Consulting) - Groundwater Management Plan component; and
- Ms Susan Shield (Engeny Water Management) -- Water Management Plan including Site Water Balance, Salt Balance, Surface Water Management Plan and Erosion and Sediment Control Plan

Should you have any enquiries in relation to this matter, please contact Melanie Hollis.

Yours sincerely,

11/12/2019

Matthew Spratt
**Director**
**Resource Assessments**
as nominee of the Secretary

# Appendix B - Groundwater TARPs

| Aspect | Normal State | Trigger 1 | Trigger 2 | Actions |
|---|---|---|---|---|
| Groundwater quality | Groundwater quality within historical average for all parameters | **Trigger:**<br>Groundwater quality concentrations outside of the adopted trigger value for at least one parameter for more than three consecutive monitoring rounds.<br>**Response:**<br>Implement Criteria Exceedance Protocol (***Section 9.8***).<br>Repeat sampling.<br>Identify any potential contributing factors.<br>Investigate the source for the change in groundwater quality and whether it was caused by mining-related activities. | **Trigger:**<br>Groundwater quality concentrations trending outside of the adopted trigger values for at least one parameter, for more than 12 months.<br>**Response:**<br>Implement Criteria Exceedance Protocol (***Section 9.8***).<br>Increase investigations to determine if the source for the change in groundwater quality is mining-related.<br>Undertake additional monitoring until water quality improves or source/cause is identified. | **Trigger 1: Notify E&C Coordinator/ Manager**<br>**Trigger 2: Notify external agencies in accordance with PIRMP requirements** |

| Aspect | Normal State | Trigger 1 | Trigger 2 | Actions |
|---|---|---|---|---|
| Groundwater level | Groundwater level within historical average, based on climatic variation. | **Trigger:**<br>Depth to groundwater increases above the 90$^{th}$ percentile (and not related to seasonal variability) over three consecutive months.<br>**Response:**<br>Repeat monitoring and compare to levels predicted by hydrogeological modelling.<br>Identify any potential contributing factors.<br>Investigate the source for the change in groundwater level and whether it was caused by mining-related activities. Determine if the impact is within the approved impacts. | **Trigger:**<br>Groundwater levels do not recover after six months<br>Investigation into Trigger 1 identifies that change in groundwater level is due to mining-related activity.<br>**Response:**<br>Implement appropriate mitigation and management measures, which may include advice from independent groundwater specialists.<br>Undertake additional monitoring of mitigation and management measures.<br>Review of hydrogeological modelling predictions. | **Trigger 1: Notify E&C Coordinator/ Manager**<br>**Trigger 2: Notify external agencies in accordance with PIRMP requirements** |

| Aspect | Normal State | Trigger 1 | Trigger 2 | Actions |
|---|---|---|---|---|
| Groundwater inflows | Groundwater inflows consistent with modelled predictions | **Trigger:**<br>Groundwater inflow volume exceeds predictions by more than 10% for three consecutive months.<br>**Response:**<br>Review monitoring/in flow estimation methodology and validate inflow data. Identify any potential contributing factors.<br>Investigate the source for the change in groundwater inflows and whether it is sourced from aquifers or a contribution from seepage through spoils. | **Trigger:**<br>Groundwater inflow volume exceeds predictions by more than 20% for three consecutive months.<br>**Response:**<br>Review water balance for associated groundwater pit, including consideration of seepage through spoils.<br>Implement appropriate mitigation and management measures, which may include advice from independent groundwater specialists.<br>Undertake additional monitoring of mitigation and management measures.<br>Review of hydrogeological modelling predictions. | **Trigger 1: Notify E&C Coordinator/ Manager**<br>**Trigger 2: Notify DPIE Water and DPIE** |

| Aspect | Normal State | Trigger 1 | Trigger 2 | Actions |
|---|---|---|---|---|
| Downstream water users | No complaints from downstream water users regarding loss of surface water or groundwater availability (quality and/or quantity) | **Trigger:**<br>Complaint from downstream water user regarding loss of water availability (quality and/or quantity).<br>**Response:**<br>Implement Complaints Management Protocol (***Section 9.11***).<br>Review of relevant historical monitoring results (water quality and/or flow).<br>Identification of any potential contributing factors.<br>Investigate whether the change in water availability is due to mining-related activity.<br>Provide feedback to complainant. | **Trigger:**<br>Investigation into Trigger 1 identifies that change in downstream water availability is due to mining-related activity.<br>**Response:**<br>Implement appropriate mitigation and management measures, which may include advice from independent water resource specialists.<br>Undertake additional monitoring of mitigation and management measures.<br>Provide compensatory water supply to any landowner whose water supply has been adversely and directly impacted. | **Trigger 1: Notify E&C Coordinator/ Manager. Provide a response to complainant**<br>**Trigger 2: Notify DPIE Water and DPIE** |