Memorandum

To:	Brendan Dillon	**At:**	Whitehaven Coal
From:	Derwin Lyons	**At:**	SLR Consulting Australia Pty Ltd
Date:	12 June 2019	**Ref:**	620.13245-M01-v1.0
Subject:	Winchester South Project Exercising Underground Water Rights EA Application		

1 Introduction

SLR Consulting Pty Ltd (SLR) has been engaged by Whitehaven Coal Limited (WHC) to provide technical assistance in satisfying EA Application underground water requirements for the Winchester South Project (the Project). The purpose of this memo is to provide the information required for documentation supporting the EA Application, to address the following specific issues with respect of underground water rights related to the Project:

- the areas in which underground water rights are proposed to be exercised;
- for each aquifer affected, or likely to be affected, by the exercise of underground water rights:
  - a description of the aquifer;
  - an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers and surface water; and
  - a description of the area of the aquifer where the water level is predicted to decline because of the exercise of underground water rights; and
  - the predicted quantities of water to be taken or interfered with because of the exercise of underground water rights during the period in which resource activities are carried out;
- the environmental values that will, or may, be affected by the exercise of underground water rights and the nature and extent of the impacts on the environmental values;
- any impacts on the quality of groundwater that will, or may, happen because of the exercise of underground water rights during or after the period in which resource activities are carried out; and
- strategies for avoiding, mitigating or managing the predicted impacts on the environmental values or the impacts on the quality of groundwater.

The information presented in this memorandum has been developed to satisfy the requirements outlined above. As information is not yet available on a local scale, publicly available information from surrounding project approvals documentation has been sourced; this principally takes the form of the documentation prepared for Pembroke Resources' Olive Downs Coking Coal Project (ODP) located on immediately adjacent tenure southeast of Winchester South (Pembroke Resources, 2019 and HydroSimulations, 2018).

Local scale information is expected to be derived during the Project's EIS studies, which for groundwater are scheduled to commence in earnest in Q3 2019.

2 The areas in which underground water rights are proposed to be exercised

The Winchester South Project is a proposed greenfield development consisting of an open cut metallurgical coal mine and associated infrastructure. The infrastructure is set to comprise access roads, a rail loop and train load-out facility, electricity transmission line, water supply pipeline, workshops, administrative offices and a coal handling and preparation plant. The Project is located on tenement MDL 183 (**Figure 1**) and is estimated to produce up to 15 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal for approximately 30 years.

The Project is located approximately 200km southwest of Mackay and 30 kilometres south east of Moranbah, central Queensland. The Project is located within the Isaac Regional Council (IRC) Local Government Area (LGA) of the Bowen Basin.

The Project is located in the Isaac Connors Groundwater Management Area (GMA) Zone 34 defined under the *Water Plan (Fitzroy Basin), 2011* made under the Queensland *Water Act, 2000* (Water Act). The Project is located within the Isaac Connors Groundwater Management Area (GMA) (Zone 34) of the Fitzroy Basin. Groundwater units of the GMA and related to the Study Area are classified as:

- Groundwater Unit 1 – (containing aquifers of the Quaternary alluvium); and
- Groundwater Unit 2 – (sub-artesian aquifers).

WHC are therefore proposing to exercise underground water rights as part of resource development operations for the Project that are likely to affect groundwater within the Isaac Connors GMA.

3 Aquifers likely to be affected by the exercise of underground water rights

As described above, publicly available information from surrounding project approvals documentation has been sourced for the memorandum; this principally takes the form of the EIS documentation prepared in 2018 for the ODP located on immediately adjacent tenure southeast of Winchester South. Local scale information specific to the Winchester South project area is expected to be derived during the Project's EIS studies, which for groundwater are scheduled to commence in earnest in Q3 2019.

3.1 Description of aquifers

The rock units with the potential to form aquifers within and in proximity to the Project site include:

- Surficial Cainozoic-aged regolith material including alluvium and colluvium; and
- Permo-Triassic aged rock units of the Bowen Basin that underly the surficial regolith material.

3.1.1 Cainozoic Units

3.1.1.1 Alluvium

Alluvium associated with the Isaac River is present just outside the northern and northeastern edges of the Project site but not within the Project site (refer **Figure 1**). Studies undertaken for the ODP suggest that the extent and thickness of these unconsolidated sediments are generally less than 12 m thick but can be up to 30 m thick within a narrow corridor along the Isaac River, thinning out with distance from the river. Lithological logs for ODP bores indicate the alluvium comprises a heterogeneous distribution of fine to coarse grained sands interspersed with lenses of clays and gravels.

Geological logs from the ODP site indicate the alluvium is underlain by low permeability stratigraphy (i.e. claystone, siltstone and sandstone), which likely restricts the rate of downward leakage to underlying formations. Localised perched water tables within the alluvium are evident where waterbodies continue to hold water throughout the dry period (e.g. pools in the Isaac River and floodplain wetlands) occurring where clay layers slow the percolation of surface water.

The ODP EIS found that water within the Isaac River is largely fresh, while water within the alluvium is fresh to moderately saline with an average TDS of 1,458 mg/L, ranging between 201 mg/L and 3,430 mg/L.

3.1.1.2 Regolith

The surficial regolith material covering much of the Project site comprises Cainozoic (Quaternary to Tertiary) aged sediments, including alluvium and colluvium (**Figure 1**). Based on geological logs from the immediately adjacent ODP site, the regolith comprises a heterogeneous distribution of fine to coarse grained sand, clay, sandstone and claystone and is generally 15 m to 45 m thick. At the ODP site, the units are all recorded as being highly weathered, with the depth of weathering extending to around 50 m below surface, into the underlying Permian-aged coal measures.

Water within the regolith, where it is saturated, occurs at depths of around 8 m to 19 m below surface at the ODP site. Water within the regolith material at the ODP site was found to be generally highly saline, but can be brackish to moderately saline with an average TDS of 9,757 mg/L, ranging between 1,460 mg/L and 18,600 mg/L.

3.1.2 Permo-Triassic Units

Permo-Triassic aged rock units of the Bowen Basin underly the surficial regolith material that covers much of the Project site. The Permo-Triassic units include the Triassic-aged Rewan Group, and the Permian-aged Blackwater Group units (Rangal Coal Measures and Fort Cooper Coal Measures). The Permian coal-bearing strata of the Blackwater Group forms the main economic resource of the numerous mines in the area surrounding the Project, as well as at the Project. The Permo-Triassic aged rock units are orientated in a northwest-southeast trending syncline structure within the Project area (refer **Figure 1**), with the older Fort Cooper Coal Measures occurring at subcrop and minor outcrop on the southwestern and northeastern edges of the Project site.

3.1.2.1 Rewan Group

The Triassic-aged Rewan Group is up to approximately 300 m thick where it occurs at the adjacent ODP site. The Rewan Group strata includes two formations, the Rewan Formation that comprises green lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanolithic pebble conglomerate, and the underlying Sagittarius Sandstone unit that comprises lithic sandstone interbedded with mudstones and siltstones with scattered carbonaceous plant material.

The low permeability lithologies that comprise the Rewan Group mean that the Rewan Group is typically considered to form a significant regional aquitard, and where it exists the Rewan Group typically limits groundwater flow between the aquifer units of the Project area and surrounds.

3.1.2.2 Permian Coal Measures

The Rangal Coal Measures comprise light grey, cross-bedded, fine to medium grained labile and well cemented sandstones, grey siltstones, mudstones, shale and coal seams. The underlying Fort Cooper Coal Measures comprises tuffaceous sandstones, siltstones, mudstones and coal seams. The transition between the Rangal Coal Measures and the older Fort Cooper Coal Measures is marked by the 0.5 m to 1.5 m thick Yarrabee Tuff; a basin-wide marker bed comprised of weak, brown tuffaceous claystone. The non-coal portions of the sequence being predominantly sandstones, siltstones, mudstone and shales are referred to as interburden in the mining context.

Within the Permian units, as with most of the Bowen Basin groundwater is predominately found within the coal seams themselves, with the non-coal interburden typically having aquitard-like properties that confine the groundwater in the coal seams. The coal seams are dual porosity in nature with a primary matrix porosity and a secondary (dominant) porosity provided by fractures (joints and cleats). Hydraulic conductivity of the coal decreases with depth due to increasing overburden pressure reducing the aperture of fractures.

Broad hydrochemical mapping undertaken by the DERM for the Fitzroy Basin shows that groundwaters in the Project area fit into the 'Isaac-Dawson' groundwater zone, characterised by Sodic water types (Raymond and McNeil, 2011). Groundwater in this region was found to contain moderate to high salinities, dominated by Sodium and Chloride ions. Deep groundwater in the vicinity of the Project area exhibited high levels of electrical conductivity relative to other areas within the Fitzroy Basin (Raymond and McNeil, 2011). The ODP EIS found that this is consistent with anecdotal evidence which suggests that the groundwater extracted from historical bores in the Project area yield water that is unsuitable for stock and domestic purposes. The ODP EIS also found that:

- The regional assessment of groundwater quality (Raymond and McNeil, 2011) aligns with monitoring of groundwater quality at the Project monitoring sites and data obtained through the groundwater bore census.
- Water within the Permian coal measures can range between fresh and highly saline, but is generally saline within the coal seams, and brackish to moderately saline within the interburden units

3.2 Analysis of underground water movement

3.2.1 Cainozoic Units

3.2.1.1 Alluvium

The ODP EIS reported that groundwater occurs within the Isaac River alluvium at depths of around 10 to 20 metres below ground level (mbgl), and more than 4.5 m below the base of the Isaac River. This was taken to indicate that under current conditions the Isaac River is disconnected from the groundwater system. Regionally, groundwater flow within the alluvium is a subdued reflection of topography, with groundwater flowing in a south-easterly direction consistent with the alignment of the Isaac River. However, local groundwater levels within the alluvium are highest within 300 m of the river, indicating a potential local flow direction away from the river to the east and west. This also indicates potential losing conditions from the river to the underlying alluvium during flow periods.

Isaac River Alluvium groundwater elevations were reported in the ODP EIS to range from around 167 mAHD at the northern end of the ODS domain, down to 140 mAHD at the southeast.

Recharge to the alluvium is considered to be mostly from stream flow or flooding (losing streams), with direct infiltration of rainfall also occurring where there are no substantial clay barriers in the shallow sub-surface. Groundwater within the alluvium is likely discharged as evapotranspiration from riparian vegetation growing along the Isaac River, as well as potential baseflow contributions after significant rainfall and flood events.

3.2.1.2 Regolith

The groundwater flow processes for the regolith material were reported in the ODP EIS to be similar to those of the alluvium, however with groundwater fluxes expected to be significantly lower due to the dominance of clay within the Tertiary sediments. In areas near the Isaac River and creeks (i.e. Ripstone Creek), water has been detected within the regolith material at depths of around 8 to 19 mbgl. Outside of these areas the regolith material is largely unsaturated.

The regolith material comprises low permeability strata (i.e. clay and claystone), which likely restricts rainfall recharge. Groundwater discharge is likely to occur primarily via evapotranspiration, with some baseflow to streams from the regolith under wet climatic conditions. Vertical seepage through the regolith is likely to be limited by the underlying low permeability Rewan Group and other aquitards.

3.2.2 Permo-Triassic Units

3.2.2.1 Rewan Group

Groundwater monitoring conducted at the ODP included three Vibrating Wire Piezometers (VWP) with operational sensors targeting the Rewan Group. Confined groundwater conditions occur within the Rewan Group sediments. Groundwater elevations range from 163 mAHD at the northern end of ODS domain, down to 136 mAHD at the southeast, indicating a general south-easterly hydraulic gradient. However, it was reported that that the very low permeability strata that comprise the Rewan Group likely meant that groundwater transmission and flow within this unit is very limited.

3.2.2.2 Permian Coal Measures

The ODP EIS reported that vertical movement of groundwater (including recharge) within the Permian Coal Measures is limited by the confining interburden layers, meaning that groundwater flow is primarily horizontal through the seams. Regionally, groundwater within the Permian coal measures flows in a south-easterly direction, however flow paths are significantly altered at the local scale due to the extensive history of coal mining in the area. Permian groundwater elevations range from around 170 mAHD to the north of the ODP, down to 130 mAHD at the southeast of ODP. Recharge to the Permian coal measures occurs where the unit occurs at subcrop. Groundwater discharge dominantly occurs via evaporation and abstraction from active mine areas in the region.

3.3 Description of the area of the aquifer where water levels are predicted to decline

Generally speaking, the process of mining reduces water levels in surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of depressurisation in a confined aquifer and zone of drawdown within the water table. Depressurisation and drawdown are greatest at the working coal-face, and gradually reduce with distance from the mine.

As described in **Section 1**, the groundwater study and impact assessment for the Project will be undertaken as part of the Project's EIS that is scheduled to commence in Q3 2019. The impact assessment will include numerical groundwater modelling to determine the predicted area of water level decline in the aquifers within and surrounding the Project area. However, for the purposes of the EA Application it is considered that the groundwater impact predictions provided in the ODP EIS are appropriate to provide contextual information for the likely impacts that may arise from the Project.

The numerical groundwater model developed for the ODP EIS was developed in part to simulate and predict the extent and area of influence of dewatering and the level and rate of drawdown at specific locations. The results of the ODP EIS model indicated:

- Maximum areal extent of drawdown within alluvium was predicted up to between 3 and 5 km from the proposed ODP pits.
- Maximum areal extent of drawdown within the regolith material (where saturated) was predicted up to between 6 and 11 km from the proposed ODP pits.
- Maximum areal extent of drawdown within the Leichhardt Seam of the Rangal Coal Measures was predicted up to between 5 and 8 km from the proposed ODP pits.
- Maximum areal extent of drawdown within the Vermont Seam of the Rangal Coal Measures was predicted up to between 5 and 11 km from the proposed ODP pits.
- Groundwater level drawdown within the mined coal seams is influenced by the geologic structure of the unit; drawdown is limited to where the coal is present (i.e. not sub-cropped or out-cropped) and extends furthest to the west of the ODP.

3.4 Quantities of water to be taken or interfered with

As described in **Section 1**, the groundwater study and impact assessment for the Project will be undertaken as part of the Project's EIS that is scheduled to commence in Q3 2019. The impact assessment will include numerical groundwater modelling to determine the quantities of groundwater to be taken or interfered with by the Project. However, for the purposes of the EA Application it is considered that the groundwater impact predictions provided in the ODP EIS are appropriate to provide contextual information for the volumetric quantities of water take that may arise from the Project.

The numerical groundwater model developed for the ODP EIS was developed in part to assess the groundwater inflow to the mine workings as a function of mine position and timing. This predicted total inflow volumes include water removed in rock material with mining, as well as water evaporated from the pit surface. It is therefore considered an over-estimate of water that could report to the site water balance. The combined inflows to the open cut operations were predicted to peak at approximately 4.5 ML/day (1,636 ML/year), while the average is expected to be about 1.7 ML/day (638 ML/year) over the duration of mining. The majority of water intercepted is sourced from Isaac Connors GMA Groundwater Unit 2 (i.e. non-Quaternary alluvium aquifers) at up to 1,199 ML/year, with up to 623 ML/year sourced from Groundwater Unit 1 (aquifers of the Quaternary alluvium).

4 Environmental values that may be affected by the exercise of underground water rights

The establishment of the Environmental Values of groundwater at and surrounding the Project will occur as part of the Project's EIS groundwater studies scheduled to commence in Q3 2019. For the purposes of the EA Application it is considered that the description of the groundwater Environmental Values provided in the ODP EIS remains appropriate to provide contextual information until that time. The following presents a summary of that information.

4.1 Groundwater Use

A groundwater bore census was conducted across the ODP area and surrounds in 2017 and 2018. The majority of the bores surveyed were located along the Isaac River and its tributaries. The bore census identified:

- 40 existing bores that were in use;
- 25 existing bores that were not in use;
- 7 bores that could not be accessed (and their usage status unknown); and
- 28 bores that were abandoned and destroyed.

For those bores in the census with water use information:

- 49 are used for stock water;
- 17 are used for groundwater monitoring; and
- 6 are used for domestic water supply.

For those bores in the census with available geological information:

- 22 intersect alluvium;
- 10 intersect regolith material; and
- 30 intersect Permian coal measures.

With the exception of the alluvium aquifer, the moderate to high salinities observed in groundwater within the region (refer **Section 3.1**) likely preclude stock and domestic usage across most of the Project area and surrounds.

4.2 Groundwater Dependant Ecosystems

Regional scale broadbrush mapping of potential Groundwater Dependant Ecosystems (GDEs) is available the National Atlas of GDEs (Bureau of Meteorology, 2016). This mapping indicates that it is mainly the Isaac River floodplain and main channel that have the potential to contain GDEs, with the potential GDEs described in the Atlas as follows:

- The Isaac River main channel is a GDE with a high potential for groundwater interaction, reliant on surface expression of groundwater.
- Some areas immediately adjacent the Isaac River main channel have a moderate potential for groundwater interaction, including vegetation reliant on subsurface groundwater.
- Some Isolated areas immediately adjacent tributaries to the Isaac River have a high potential for groundwater interaction, including vegetation reliant on subsurface groundwater.

- Wetlands on the Isaac River floodplain have a moderate potential for groundwater interaction, and are mapped as GDEs reliant on surface expression of groundwater.
- Vegetated swamps in depressions beyond the Isaac River floodplain have a moderate potential for groundwater interaction, and are mapped as GDEs reliant on surface expression of groundwater.

The wetlands of the Isaac River floodplain include a palaeochannel lake, ox-bow lakes and floodchannel wetlands. Field investigations conducted for the ODP failed to detect any fish within the palaeochannel lake waterbody, suggesting that it may be subject to complete drying and wetting cycles that limit the persistence of a diversity of aquatic biota. It was considered likely that the clay-rich substrates of this waterbody hold surface run-off for extended periods, but less likely that surface expressions of groundwater would make substantial contributions to wetted habitat at this location.

4.3 Stygofauna

A *Desktop Assessment: Likelihood of Stygofauna Occurrence in the Bowen Basin* (4T Consultants Pty Ltd, 2012) was prepared for the Bowen Gas Project EIS and identified areas of possible, likely and high likelihood of suitable stygofauna habitat in the vicinity of the Project. With the exception of areas associated with the Isaac River and tributaries located generally beyond the ODP tenements, almost all areas were identified as having limited stygofauna habitat (4T Consultants Pty Ltd, 2012). Given that it is unlikely groundwater discharges to surface water in the region surrounding the Project, therefor it can be concluded that it is likely that only groundwater associated with the Isaac River alluvium has potential to support an aquatic ecosystem Environmental Value.

5 Impacts on the quality of groundwater that may happen because of the exercise of underground water rights

As the mine progresses, waste rock material will be placed within out-of-pit and in-pit waste rock emplacement areas. Waste rock emplacement areas may produce seepage as a result of rainfall inundation, and waste rock analysis will be undertaken as part of the Project's EIS studies to determine the chemical composition of any such seepage. It may be expected that the results of this analysis would be similar to that conducted for the adjacent ODP EIS, given the very similar geological setting. The analysis undertaken for the ODP indicated that the waste rock material exhibited similar to improved water quality compared to water within regolith material. However, the waste rock material generally exhibited poorer water quality compared to the alluvium. Seepage from in-pit emplacements would not be expected to migrate to the alluvium however as the groundwater level that would ultimately equilibrate within the waste rock would be below the base of the alluvium.

Water within any final voids associated with the Project would evaporate from the lake surface and draw in groundwater from the surrounding geological units. Evaporation from the lake surface would concentrate salts in the lake slowly over time. However, based on the results of the ODP EIS groundwater modelling, this gradually increasing salinity would not pose a risk to the surrounding groundwater regime as the final voids would most likely remain permanent sinks.

6 Strategies for avoiding, mitigating or managing the predicted impacts on the environmental values or the impacts on the quality of groundwater

6.1 Groundwater Monitoring Program

WHC would implement a number of environmental management and impact mitigation measures to minimise the potential impacts of the Project, which will be determined during the Project's EIS. For groundwater, these would include at a minimum a formalised Groundwater Monitoring Program that would contain the following components:

- Establishment of groundwater monitoring infrastructure to allow routine groundwater monitoring (levels and quality) in the aquifers likely to be affected by the Project, being alluvium, regolith and Permian coal measures.
- Establishment of monitoring criteria to monitor predicted impacts on both environmental values and predicted changes in groundwater quality.
- Automated groundwater level monitoring for at least 2 years prior to Project construction in order to establish a robust pre-mining baseline groundwater level dataset.
- Monthly groundwater quality sampling for at least 2 years prior to Project construction in order to establish a robust pre-mining baseline groundwater quality dataset.
- Ongoing routine groundwater level and quality monitoring for the life of the Project.
- Establishment of groundwater quality trigger levels developed in accordance with the Department of Science, Information Technology and Innovation (DSITIA) guideline *Using monitoring data to assess groundwater quality and potential environmental impacts* (DSITI, 2017), once a suitable baseline dataset has been collected.
- An annual review of groundwater level and quality trends that will be conducted by a suitably qualified person and provided to the regulator. The review will assess the change in groundwater level and quality over the year, compared to historical trends and impact assessment predictions. The annual review will discuss any groundwater trigger exceedances or where trends show potential for environmental harm.
- Every five years the validity of the model predictions would be assessed and if the data indicates significant divergence from the model predictions, an updated groundwater model would be constructed for simulation of mining.

Monthly baseline groundwater monitoring commenced at the Project site in February 2019 from a network of 12 existing monitoring bores installed in the Permian coal measures (refer **Figure 1**). This includes automated groundwater level loggers set to record at four-hourly intervals. The baseline groundwater quality monitoring suite includes:

- Field parameters (EC, pH, temperature)
- Laboratory analysis:
    - pH, EC, TDS, SS, turbidity and SAR
    - Major cations
    - Major anions
    - Hardness and alkalinity
    - Metals (dissolved and total)

- Nutrients
- TPH, TRH and BTEXN

WHC currently has plans to expend the existing monitoring network further, supplementing the existing 12 monitoring bores at the Project site.

6.2 Third Party Bore Impacts

Should the Project's groundwater impact assessment presented in the future EIS show predicted impacts to third party groundwater users, WHC would engage with those third parties in accordance with its obligations under Chapter 3 of the Water Act and seek to establish make good agreements with those affected parties.

7 Closing

We trust the information contained within this memorandum meets your requirements. Please do not hesitate to contact Derwin Lyons with any further queries.

8 References

4T Consultants Pty Ltd, 2012 — Desktop Assessment: Likelihood of Stygofauna Occurrence in the Bowen Basin

Bureau of Meteorology, 2016 — National Atlas of Groundwater Dependent Ecosystems.

DSITI, 2017 — Using monitoring data to assess groundwater quality and potential environmental impacts

Raymond and McNeil, 2011. — Regional chemistry of the Fitzroy basin groundwater.

Pembroke Resources, 2019. — Olive Downs Project – Environmental Authority Application Supporting Information

HydroSimulations, 2018. — Olive Downs Project Groundwater Assessment

Checked/
Authorised by: IE

Figure 1 Locality Plan