Appendix 18

Environmental Impact Assessment Groundwater

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BYERWEN COAL PTY LTD

ENVIRONMENTAL IMPACT ASSESSMENT

GROUNDWATER ASPECTS

Contents

1.0 INTRODUCTION

This assessment has been undertaken to evaluate the groundwater issues related to the proposed Byerwen Coal project (the project) to be undertaken by Byerwen Coal Pty Ltd (the proponent). The project is located about 20km west of Glenden and 45km south of Collinsville in the northern Bowen Basin.

The coal resources are contained within six Mining Lease Application (MLA) areas: MLA 10355, MLA 10356, MLA 10357, MLA 70434, MLA 70435 and MLA 70436.

2.0 SCOPE OF WORK

The scope of the work undertaken is defined in the Terms of Reference for the Byerwen Coal Project (dated July 2011)[1], portions of which are reproduced below:

Section 3 Environmental Values and Management Impacts

Detail the environmental protection and mitigation measures incorporated in the planning, construction, rehabilitation, commissioning, operations and decommissioning of all facets of the project. Measures should prevent, or where prevention is not possible, minimise environmental harm and maximise environmental benefits of the project. Identify and describe preferred measures in more detail than other alternatives.

The objectives of the following subsections are to:

- *describe the existing environmental values of the area that may be affected by the project, using background information and/or new studies to support statements (include reference to all definitions of environmental values set out in relevant legislation, policies and plans)*
- *describe the potential adverse and beneficial impacts of the project on the identified environmental values and the measures taken to avoid, minimise and/or mitigate those impacts*
- *describe any cumulative impacts on environmental values caused by the project, either in isolation or in combination with other known existing or planned projects*
- *present objectives, standards and measurable indicators that protect the identified environmental values*
- *examine viable alternative strategies for managing impacts (present and compare these alternatives in view of the stated objectives and standards to be achieved)*
- *discuss the available techniques to control and manage impacts in relation to the nominated objectives.*

Information is required to show that measures have been taken to avoid and minimise potential adverse impacts of the project. Environmental offsets may be proposed, consistent with the Queensland Government Environmental Offsets Policy.[6]

[1] Queensland Government, The Coordinator General, July 2011. Byerwen Coal project Terms of Reference for and Environmental Impact Statement

Define and describe practical measures for achieving the objectives for protecting and enhancing environmental values including:

- *monitoring programs: describe the monitoring parameters, monitoring points, frequency, data interpretation and reporting methods*
- *auditing programs: describe how progress towards achieving the objectives will be measured*
- *management strategies: describe the strategies to be used to ensure the environmental protection objectives are achieved and control strategies implemented for each element of the environment.*
- *The EIS should follow the format and content outlined in these TOR; however, changes to the structure can be discussed with the EIS project manager. The mitigation measures, monitoring programs etc., identified in this section of the EIS should be used to develop the EMP for the project (see Part B, section 8, Environmental management plan).*

Section 3.4.1 Description of Environmental Values

Describe the existing water resources that may be affected by the project in the context of environmental values, as defined in such documents as the EP Act, Environmental Protection (Water) Policy 2009 (EPP (Water)), Australia and New Zealand Guidelines for Fresh and Marine Water Quality[A2] and the Queensland Water Quality Guidelines 2009[A3]

Provide an indication of the quality and quantity of water resources in the vicinity of the project area that may be affected by the project describing:

- *existing surface and groundwater in terms of physical, chemical and biological characteristics. Parameters should include a broad range of water quality indicators including, but not necessarily limited to:*
- *electrical conductivity major cations and anions dissolved metals*
- *minor ions (such as ammonia, nitrite, nitrate, fluoride) hydrocarbons*
- *any other potential toxic or harmful substances turbidity*
- *suspended sediments - pH.*
- *existing surface drainage patterns, flows, history of flooding including extent , levels and frequency and present water uses.*

Describe the environmental values of the surface waterways and groundwater of the affected area in terms of:

- *values identified in the EPP (Water)*
- *the physical, chemical and biological characteristics of existing surface water*
- *existing surface drainage patterns, flows, history of flooding including extent, levels and frequency, and present water uses*
- *physical integrity, fluvial processes and morphology, including riparian zone vegetation and form, if relevant*
- *any impoundments (e.g. dams, levees, weirs etc.)*
- *hydrology of waterways and groundwater*

- *sustainability, including both quality and quantity*
- *dependent ecosystems*
- *existing and other potential surface and groundwater users*
- *water resource plans relevant to the affected catchments.*

All sampling should be performed in accordance with the Monitoring and Sampling Manual 200^ or the most current edition. The description of water quality should include medians, ranges and percentiles appropriate for comparison with appropriate trigger levels and guidelines for the protection of aquatic ecosystems and downstream users.

Investigate the relationship between groundwater and surface water to assess the nature of any interaction between the two resources and any implications of the proposed mine that would affect the interaction.

Groundwater

If the project is likely to use or affect local sources of groundwater, describe groundwater resources in the area in terms of:

- *geology/stratigraphy*
- *aquifer type—such as confined, unconfined*
- *depth to and thickness of the aquifers*
- *depth to water level and seasonal changes in levels*
- *groundwater flow directions (defined from water level contours)*
- *interaction with surface water*
- *possible sources of recharge*
- *potential exposure to pollution*
- *current access to groundwater resources in the form of bores, springs and ponds (including quantitative yield of water and locations of access).*

Review the quality, quantity and significance of groundwater in the project area, together with groundwater use in neighbouring areas. Refer to relevant legislation or water resource plans for the region. The review should also provide an assessment of the potential take of water from the aquifer and how current users, the aquifer itself and any connected aquifers will be affected by the take of water.

Include a survey of existing groundwater supply facilities (bores, wells, or excavations) to the extent of any environmental harm. Gather the following information for analysis:

- *location, type and status of existing groundwater entitlements and associated infrastructure (bores, wells or excavations)*
- *pumping parameters*
- *draw down and recharge at normal pumping rates*

- *seasonal variations (if records exist) of groundwater levels.*

Develop a network of observation points that would satisfactorily monitor groundwater resources both before and after commencement of operations.

The data obtained from the groundwater survey should be sufficient to enable specification of the major ionic species present in the groundwater, pH, electrical conductivity and total dissolved solids.

Section 3.4.2 Potential Impacts and Mitigation Measures

- *an assessment of the potential to contaminate surface and groundwater resources and measures to prevent, mitigate and remediate such contamination.*

Groundwater aspects of the TOR are addressed in this report.

3.0 HYDROGEOLOGY

The occurrence and flow of groundwater at any location is intimately linked to the geology of that location. The discussion of the geology of the Byerwen area given below is intended to set the scene for later discussion of the hydrogeological regime.

3.1 Geology and Stratigraphy

The geology of the Byerwen area was first comprehensively described by Malone in 1969[2]. Byerwen is located in the Northern Bowen Basin on the western edge of the Collinsville Shelf. The Collinsville Shelf is a depositional province which is infilled by Permian and Triassic sedimentary rocks overlain by Tertiary sediments and basalt extrusives, with minor alluvial development along the larger watercourses. The western limit of deposition approximates the western limit of Permian outcrop.

The Mount Coolon 1:250,000 sheet (which wholly contains the Byerwen MLAs) was mapped systematically by the Bureau of Mineral Resources (BMR) and the Geological Survey of Queensland for the first time in the 1960s (Malone and others[3,]), and more recently in the 1990s (Hutton and others[4]).

Figure 1 shows the surficial geology of the Byerwen area. For reference the Byerwen lease boundaries and the dedicated groundwater monitoring bores are also shown. The dedicated groundwater monitoring bores will be discussed in detail later in the report.

[2] Malone, E.J., (1969), Mount Coolon, Queensland 1:250 000 Geological Series Sheet and Explanatory Notes.
[3] Malone, EJ, Corbett, DWP, & Jensen, AR, 1964: Geology of the Mount Coolon 1:250,000 Sheet area. *BMR,* Report **64**.
[4] Hutton, LJ, Grimes, KG, Law, SR, & McLennan, TPT, 1998: Mount Coolon 1:250 000 geological series, second edition. Dept Mines & Energy, Queensland.

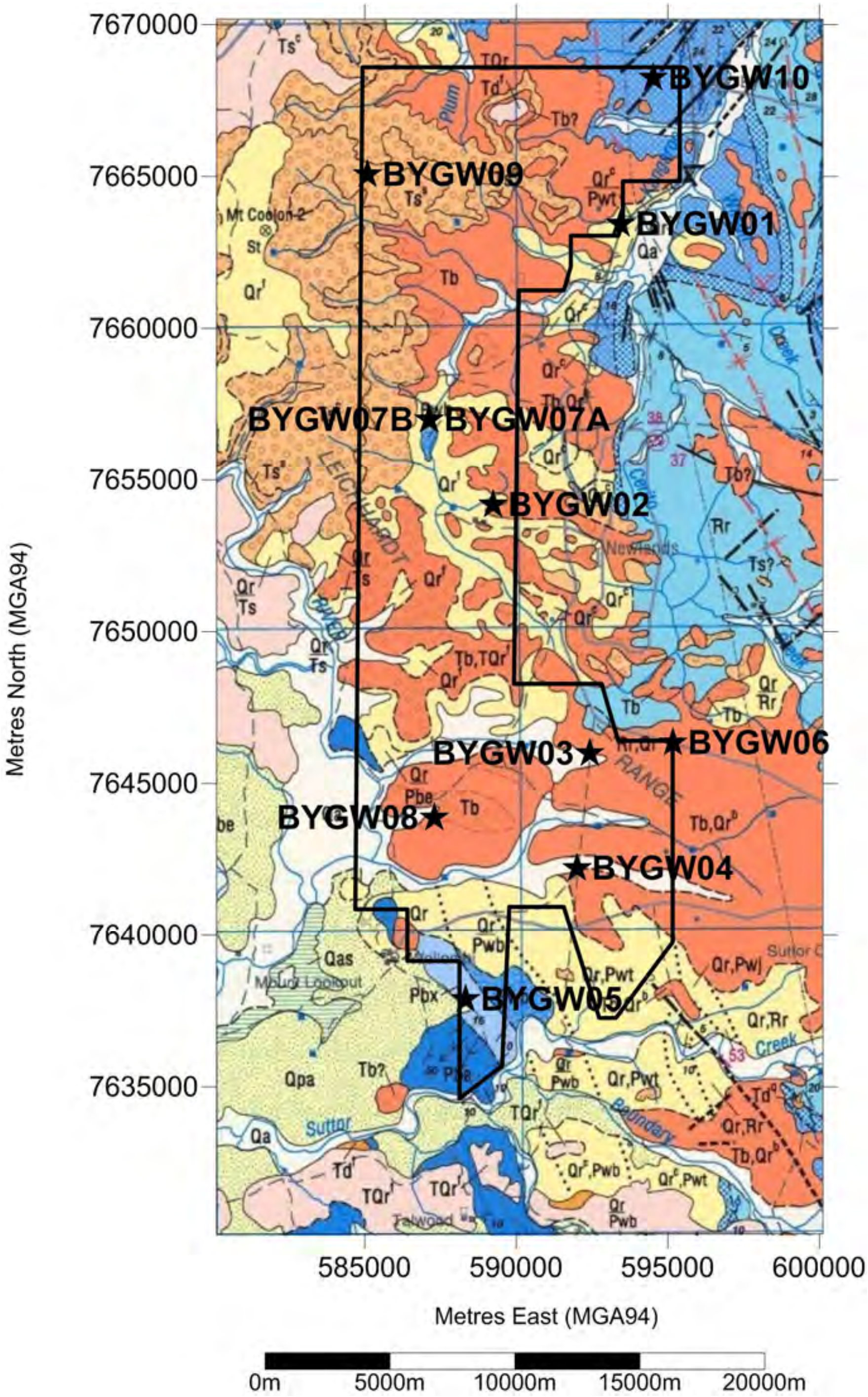


Figure 1: Surficial Geology of the Byerwen Area
Source (Mount Coolon, Queensland 1:250 000 Geological Series Sheet)

Figure 1a shows the published geological mapping legend that pertains to Figure 1.

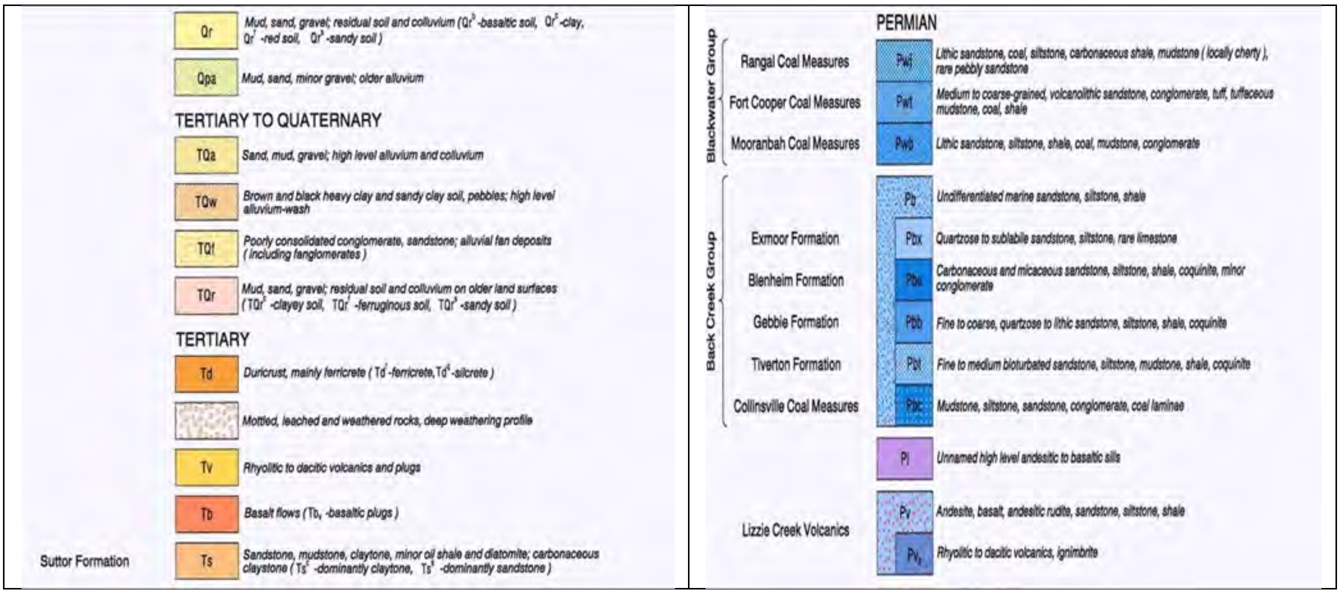


Figure 1a: Published Geological Mapping Legend
Source (Mount Coolon, Queensland 1:250 000 Geological Series Sheet)

Of the units listed in Figure 1, only the following are hydrogeologically relevant to the Byerwen project:

- Tertiary sand beneath Basalt Flows;
- Suttor Formation;
- Rangal Coal Measures;
- Fort Cooper Coal Measures; and
- Exmoor Formation

Table 1 shows the stratigraphy of the project area.

<table>
<tr><th colspan="5">Table 1: BYERWEN AREA – STRATIGRAPHIC SUMMARY</th></tr>
<tr><th>AGE</th><th colspan="2">UNIT</th><th>LITHOLOGY</th><th>TOPOGRAPHY</th></tr>
<tr><td>Quaternary</td><td colspan="2"></td><td>Silt, sand, clay soil</td><td>Occurs on floodplains of major watercourses and as outwash fan deposits</td></tr>
<tr><td rowspan="3">Tertiary</td><td colspan="2">Suttor Formation</td><td>Sandstone & conglomerate, locally silicified</td><td>Breakaways; table-top mesas</td></tr>
<tr><td colspan="2">Tertiary Basalt</td><td>Olivine basalt, fresh and vesicular in places</td><td>Slightly elevated lands</td></tr>
<tr><td colspan="2">Sand below Basalt</td><td>Unconsolidated sand and minor gravel; lag deposits from formerly exposed topography</td><td>Not exposed at surface</td></tr>
<tr><td rowspan="3">Triassic</td><td colspan="2">Moolayember Formation</td><td>Micaceous & lithic sandstone & siltstone</td><td>Recessive; flat areas on Clematis Group tablelands</td></tr>
<tr><td colspan="2">Clematis Group</td><td>Medium–coarse quartz sandstone & pebble conglomerate</td><td>Tablelands; steep scarps</td></tr>
<tr><td colspan="2">Rewan Group</td><td>Green lithic sandstone; red, brown & green mottled mudstone</td><td>Recessive</td></tr>
<tr><td>Late Permian</td><td rowspan="3">Bowen Basin</td><td>Blackwater Group
Includes Rangal Coal Measures and Fort Cooper Coal Measures</td><td>Coal; grey, brown, green sandstone; siltstone; shale; chert; minor conglomerate; fossils</td><td>Generally recessive, subdued</td></tr>
<tr><td rowspan="2">Early Permian</td><td>Back Creek Group
Includes Exmoor Formation</td><td>Grey to purple fine sandstone & siltstone; local coarse sandstone; grey carbonaceous shale; cocquinite lenses; fossils</td><td>Generally recessive sandstone ridges</td></tr>
<tr><td>Lizzie Creek Volcanics</td><td>Andesite; subordinate rhyolite & shale</td><td>Not exposed in project area. Regarded as basement for the hydrogeological regime</td></tr>
</table>

The Permian sedimentary strata around the Byerwen area are generally conformable but are largely obscured by younger Tertiary and Quaternary cover.

No large-scale regional faults have been mapped in the Byerwen area but once again these may be obscured by Tertiary and Quaternary cover. Small-scale local faulting is common causing vertical and lateral disruption of the coal seams. Economic coal seams in the area occur in the Rangal, Fort Cooper and Moranbah Coal Measures of the Blackwater Group, which are all of Permian age. The Blackwater Group is comprised of labile sandstone, siltstone, mudstone and thick sequences of interbedded coal and carbonaceous shale.

All of abovementioned Permian geological units contain a proportion of sandstone. Sandstone is traditionally regarded as a groundwater hosting lithology. No distinction between the sandstone contained in the separate Permian units is made for the purposes of this report and they are all similar regardless of the geological unit within which they are incorporated.

The Permian sequence is conformably overlain by green-grey siltstone and lithic sandstone of the Rewan Group of Triassic age. There is only a small area of the Rewan Group on the Byerwen leases - just to the north of dedicated groundwater monitoring bore BYGW03.

Extensive sediments and sedimentary rocks of Early–Mid Tertiary age include fluvial and lacustrine sediments—notably sandstone, siltstone, mudstone and claystone of the Suttor Formation, up to 60m thick, especially in the northwestern part of the MLAs, consisting predominantly of indurated mudstone.

Tertiary Basalt flows dominate the central section of the Byerwen MLAs in a more or less north - south trending belt that corresponds to the Leichhardt Range. These are clearly shown on Figure 1. Basalt erupting on the east side of a palaeo-valley may have diverted the palaeo-drainage westwards. Remnant basalt flows locally underlie the Redcliffe Tableland, and also underlie the Leichhardt and Denham Ranges. The lower basalt is relatively fresh, but the upper basalts are deeply weathered and ferruginised. Fresh basalt forms heavy black clay soils; weathered basalt forms dark red loam, commonly with an ironstone ‘gravel’ of ferruginised mud. The basalt flows are constrained by the Suttor River to the west and Cerito Creek to the east on the Byerwen MLAs.

Residual sand and fine-grained gravel of Tertiary age are encountered in some boreholes on the Byerwen leases. These are laterally discontinuous and appear to occur as 'shoestrings' (analagous to present-day braided stream deposits). It is interpreted that they are 'bedsand deposits' that occur in the beds of streams that traversed the landscape prior to the eruption of the basalt. These sediments are not exposed at the surface.

Residual soils including blanketing sands, loams and clays cover much of the area. Preferential induration of old valley floor material now stands up locally as inverted relief. Silcretes up to 10m thick, nodular ferricretes and clay-indurated duricrusts also occur.

Deep weathering is responsible for the strongly mottled and bleached profiles of the basalts and the Suttor Formation.

3.2 Byerwen Groundwater Investigation Bores

As there was little or no groundwater information available from either private groundwater facilities or previous groundwater investigations over the Byerwen MLAs, the proponent installed dedicated groundwater bores to investigate the hydrogeology of the MLAs, the locations of which are shown on Figure 1. These eleven bores also comprise the dedicated groundwater monitoring bore suite for the project.

Table 2 shows summarised location and depths of the dedicated groundwater monitoring bore suite. Table 3 shows details of standing water levels, airlift yield, field electrical conductivity and hydrostratigraphy details from the bores. Airlift yields of >5L/s are considered to be significant and are highlighted in yellow.

TABLE 2: LOCATION AND DEPTH DETAILS OF BYERWEN GROUNDWATER INVESTIGATION BORE SUITE

Bore_ID	*Easting MGA 94*	*Northing MGA94*	*Date drilled*	*Total depth (TD) (m)*
BYGW01	593438	7663430	17/09/2011	59.5
BYGW02	589229	7654175	8/09/2011	59.5
BYGW03	592422	7645985	8/09/2011	67.0
BYGW04	591997	7642215	6/09/2011	119.0
BYGW05	588323	7637881	16/09/2011	105.0
BYGW06	595167	7646339	14/09/2011	120.0
BYGW07A	587122	7656990	9/09/2011	68.5
BYGW07B	587115	7656973	9/09/2011	52.0
BYGW08	587279	7643867	11/09/2011	66.0
BYGW09	585089	7665060	13/09/2011	97.0
BYGW10	594512	7668243	18/09/2011	52.0

TABLE 3: STANDING WATER LEVELS, AIRLIFT YIELD AND FIELD WATER QUALITY IN BYERWEN GROUNDWATER INVESTIGATION BORE SUITE

Bore_ID	*First water intercept (m)*	*Perforated Interval (m from - m to)*	*Standing water level (m btoc)**	*Airlift Yield (L/s)*	*Electrical Conductivity (µS/cm)*	*Hydrostratigraphic Unit*
BYGW01	59.0	47.5-59.5	11.24	0.8	1,870	Rangal Coal Measures
BYGW02	46.0	47.5-53.5	33.77	0.4	11,050	Fort Cooper Coal Measures
BYGW03	56.0	56-62	36.58	0.8	2,720	Fort Cooper Coal Measures
BYGW04	66.0	95-107	78.53	0.1	8,410	Fort Cooper Coal Measures
BYGW05		99-105; 81-93	94.70	0.0	No water intersected	Exmoor Formation
BYGW06	45.0	103-115	55.89	0.1	7,580	Rangal Coal Measures
BYGW07A	26.0	65-69	21.18	10.0	2,020	Tertiary Sand below Basalt

TABLE 3: STANDING WATER LEVELS, AIRLIFT YIELD AND FIELD WATER QUALITY IN BYERWEN GROUNDWATER INVESTIGATION BORE SUITE						
Bore_ID	***First water intercept (m)***	***Perforated Interval (m from - m to)***	***Standing water level (m btoc)****	***Airlift Yield (L/s)***	***Electrical Conductivity (µS/cm)***	***Hydrostratigraphic Unit***
BYGW07B	27.0	46-52	22.86	0.3	4,400	Basalt
BYGW08	59.0	56.5-65.5	43.37	0.1	20,200	Basalt
BYGW09	88.0	91-97	71.51	4.0	1,560	Moranbah Coal Measures
BYGW10	35.0	40-52	43.02	0.1	5,970	Rangal Coal Measures

Note: * = metres below top of casing

The geological and construction logs for the dedicated groundwater monitoring bores are presented in Appendix 1.

A number of significant preliminary conclusions can be drawn from the data in table 3:

- The depth at which groundwater was first encountered in the basalt and the Tertiary sand below the basalt is relatively shallow;

- The airlift yield supplies from the various coal measures intersected in the dedicated groundwater monitoring bores are so low as to be almost insignificant;

- The standing water level in all of the groundwater monitoring bores is higher than the depth at which the groundwater was intersected indicating that all of the hydrostratigraphic units drilled contain confined aquifers; and

- Unconsolidated Quaternary sediments consisting predominantly of sand and gravel are associated with the Suttor River, to the west and southwest, and Kangaroo Creek to the north and northeast. This geological unit is also colloquially referred to as 'alluvium' and this report used both terms for discussion purposes. These sediments appear to be only a thin veneer (<2m) thick, if indeed they are present at all. Two of the dedicated groundwater monitoring bores (BYGW04 and BYGW08) were located to assess the thickness of the alluvium as alluvium was shown to cross the southern part of the Byerwen leases. Neither BYGW04 nor BYGW08 intersected any alluvium.

4.0 SURVEY OF EXISTING GROUNDWATER FACILITIES

4.1 Location, Type and Status of Private Groundwater Facilities

A search of records held in the Department of Natural Resources and Mines (NRM) groundwater database revealed details regarding privately owned groundwater facilities in the project area. The search was conducted within the following MGA Coordinates:

South-west corner:	Easting 580000	Northing 7630000
North-east corner:	Easting 600000	Northing 7671200

The search bounds encompass the entire Byerwen MLAs and extend for approximately 5km beyond any of the proposed Byerwen pits.

The search revealed only seven privately owned existing groundwater facilities.

Nine abandoned and destroyed bores also existed within the search area.

The private groundwater facilities are shown on Figure 2.

RN's 60458, 60459, 100092 and 100274 were originally mining exploration holes that are now shown as ‘existing’ in the groundwater database. There is no record of pumping equipment for these four bores.

Table 4 summarises the data available for the existing bores. The acronym RN refers to the facility's registered number.

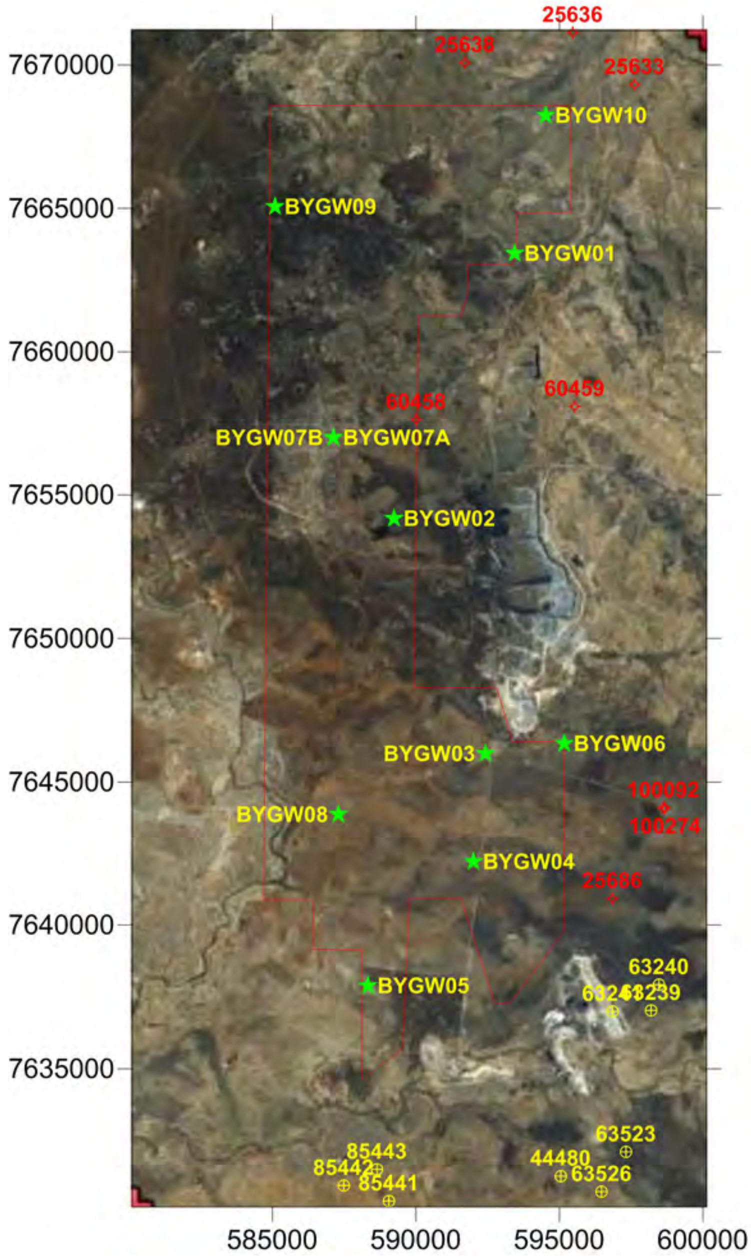


Figure 2: Locations of Private Groundwater Facilities in the Byerwen MLAs Vicinity
Existing third party bores labeled red
Project monitoring bores labeled yellow with green marker
Abandoned and destroyed bores labeled yellow with yellow marker

TABLE 4: SUMMARY OF NRM GROUNDWATER DATA FOR EXISTING PRIVATE GROUNDWATER FACILITIES							
Property or Holding	***Bore Name***	***RN***	***Easting MGA94***	***Northing MGA94***	***Cased Depth (m)***	***Reported Discharge (L/s)***	***Pumping Equipment)***
Weetalaba	Rockhole	25633	597618	7669314	18.3	1.25	Windmill
Weetalaba	3-ways	25636	595464	7671126	37.2	0.88	Windmill
Weetalaba	Millers Well	25638	591706	7670079	16.4	0.5	Windmill
Not stated (P37 Par Herbert)	Not recorded	25686	596844	7640920	6.4	0.32	Windmill
Byerwen	AGC26	60458	589906	7657632	56	2.1	-
Byerwen	AGC35	60459	595533	7658096	45	1.5	-
Not stated (PH1994)	MGC Suttor Creek No 2	100092	598620	7644095	No strata log, no casing information	Not reported	-
Not stated (PH1994)	MGC Suttor Creek No 4	100274	598678	7644094	No strata log, no casing information	Not reported	-

4.2 Pumping Parameters, Drawdown and Recharge

Apart from the discharge data shown in table 4, there are no records of pumping rates, drawdown and recharge measurements from any of the private groundwater facilities in the NRM groundwater database. As the bores are mostly used for stock watering, they are equipped with either windmills or low discharge diesel-powered pumps. Bores of this type with this sort of equipment pump at low discharge rates and result in very little drawdown. The discharges reported for the bores are low. In general the pumping equipment is selected to cater for these low discharge rates.

4.3 Seasonal Groundwater Level Variations in Private Groundwater Facilities

There are no records of seasonal groundwater level measurements from any of the private groundwater facilities in the NRM groundwater database with which to assess seasonal groundwater level variation.

NRM owns a groundwater monitoring bore (RN 12030094) on the left bank[5] of the Suttor River on the Collinsville–Mt Coolon Road, about 8km to the west of the Byerwen MLAs (at Easting 577734, Northing 7666087 MGA94 datum).

This bore is 72.3m deep and its screen is located from 70.3 to 72.3m depth. The bore monitors sand and claystone of the Suttor Formation. The groundwater quality in the bore is very poor with a total dissolved solid content of 6,200mg/L.

[5] The left bank of any stream is as viewed looking in the direction of water flow i.e. downstream.

This bore was monitored for groundwater level on a regular basis from 1975 to 1986 and those records give insight into the seasonal variations that may be expected in the groundwater monitoring bores on the Byerwen MLAs. Figure 3 shows the trend in seasonal variation in the groundwater level in RN 12030094.

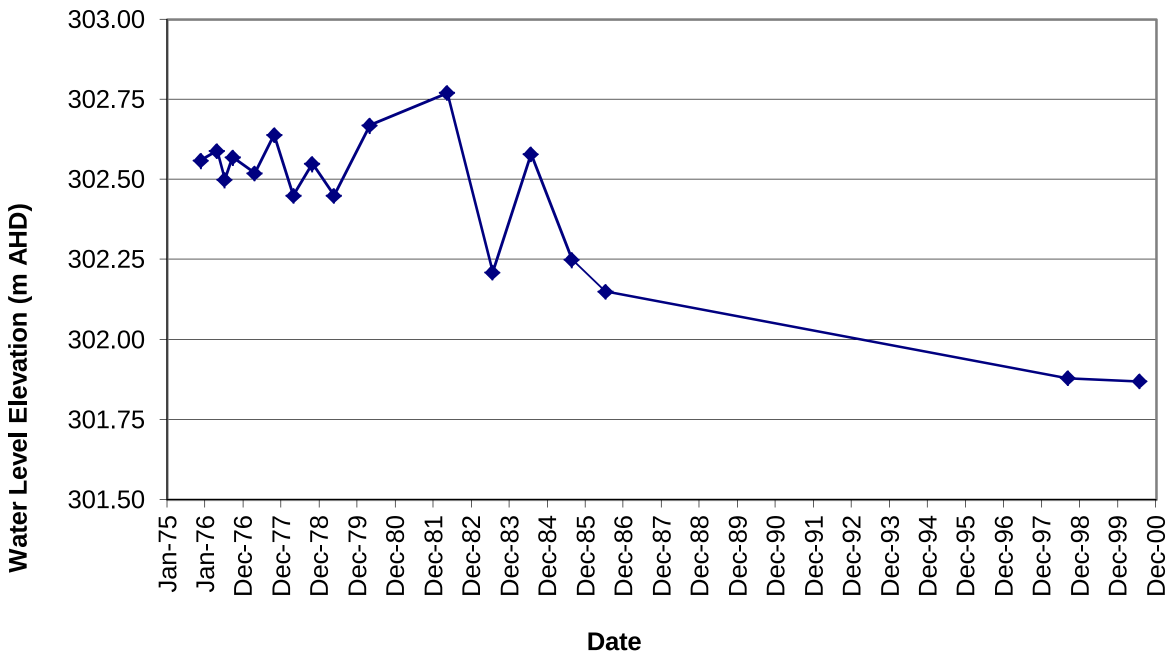


Figure 3: Seasonal Groundwater Level Variation in NRM groundwater monitoring bore 12030094.

Based on Figure 3, the seasonal variation in groundwater level in the project bores can be expected to be small, as the measured groundwater levels appear to fluctuate by no more than 0.6m; a conservative maximum range of fluctuation could be assumed to be one or two metres.

4.4 Unregistered Private Groundwater Facilities

There are no known unregistered bores within the search area.

4.5 Groundwater Quality in Private Groundwater Facilities

The only information on groundwater quality in private groundwater facilities is a groundwater chemical analysis from RN 25686 from 1965. This facility is only 6.4m deep and extracts groundwater from the basalt. The groundwater chemistry information for this facility is shown in Table 5.

TABLE 5: GROUNDWATER ANALYSIS FROM RN 25686	
RN	25686
DATE	18/08/1965
DEPTH (m)	11
CONDUCTIVITY (µS/cm)	1550
PH	8
HARDNESS (mg/L)	5758
ALKALINITY (mg/L)	7845
TOTAL_IONS (mg/L)	19050.3
TOTAL_SOLIDS (mg/L)	14187.55
NA (mg/L)	3632.2
K (mg/L)	No Results
CA (mg/L)	514.8
MG (mg/L)	1086.8
FE (mg/L)	No Results
MN (mg/L)	No Results
HCO_3 (mg/L)	9566.7
CO_3 (mg/L)	No Results
CL (mg/L)	3832.4
F (mg/L)	2.7
NO_3 (mg/L)	No Results
SO_4 (mg/L)	414.7

4.6 Springs

There are no known springs within the project area nor are any springs known within the search area.

4.7 Groundwater Information from Exploration Bores

The proponent has undertaken extensive coal exploration drilling programs in a 7km by 4k area in the southern section of the MLAs, to the west of BYGW04 and to the north of BYGW05. Many of those exploration bores encountered groundwater. Two hundred and seven exploration bores were drilled in this area. Of these, 198 recorded a standing water level (SWL) and 69 recorded both a SWL and an airlift yield (ALY). In many instances it was necessary to install pre-collar casing to preclude hole caving so that drilling to target depth could be achieved.

The information from the mineral exploration bores enables a better appreciation of the occurrence of groundwater in the stratigraphic units at Byerwen. The tables below show the groundwater data that were recorded by the well-site geologist or the driller. Within these tables the abbreviation TD is used to indicate the total depth of the borehole.

Basalt and Tertiary Sand below the Basalt

Table 6 shows the information from mineral exploration bores that intersected groundwater in basalt or basalt and basal sand.

TABLE 6: GROUNDWATER INFORMATION FROM BASALT AND BASALT/SAND EXPLORATION BORES

Hole_ID	*Easting*	*Northing*	*TD(m)*	*Cased depth(m)*	*SWL(m)*	*Contributing Lithologies*	*Aggregate ALY (L/s)*	*Comments*
BY134	587317	7643386	134	111	22	BA	3.50	
BY137	587200	7642875	121	4	37	BA	1.25	
BY031	585549	7655623	205	85	30	BA		
BY032	585865	7655513	44	0	28	BA	2.50	
BY032R	585865	7655513	39		34	BA		
BY037	587672	7649196	109	112		BA		
BY041	586097	7656037	33		20	BA		
BY042	585688	7655857	63.5	24	27.5	BA		
BY050	587375	7647288	108	47	37	BA		Abandoned, high water flow
BY057	588032	7647746	212	49	22.5	BA		
BY060	587164	7649650	182	144	55	BA		
BY062	586915	7650063	152	124	51	BA		
BY064	587545	7650779	236	133	98	BA		
BY066	587428	7644674	179	79	53.5	BA		
BY069	588265	7644711	263	132	36	BA		
BY071	587335	7658327	199	74	39	BA		
BY074	586857	7656318	259	86	35.5	BA		
BY076C	587962	7643117	186	34	50	BA		
BY081	587570	7643679	180	91	82.5	BA	18.75	
BY082	587840	7643641	205	60	35	BA		
BY084	587649	7643116	180	96	70	BA	0.50	
BY085	587859	7643152	204	86	52	BA	0.38	
BY088	587373	7643586	102	0	51	BA	1.88	
BY090	587665	7642273	152	86	43	BA		
BY091	587340	7642138	116	97	70	BA		
BY096	587367	7642868	140	110	42	BA	12.50	
BY097	587664	7642880	176	85	41	BA		
BY100	587321	7643136	144	121	98	BA	12.50	
BY113	589068	7642564	141	0	46.5	BA		
BY116	589227	7642249	260	61	35.5	BA		Salty
BY135	586740	7643108	110	93	39	BA	0.63	
BY136	587231	7642632	128	101	82	BA	12.50	
BY138	587190	7643118	146	127	65.6	BA	0.75	
BY174	588234	7643597	224	81	14	BA		
BY175	588505	7643554	266	81	38.5	BA	7.50	

TABLE 6: GROUNDWATER INFORMATION FROM BASALT AND BASALT/SAND EXPLORATION BORES								
Hole_ID	***Easting***	***Northing***	***TD(m)***	***Cased depth(m)***	***SWL(m)***	***Contributing Lithologies***	***Aggregate ALY (L/s)***	***Comments***
BY176	588731	7643545	254	75	48.5	BA		
BY177	589065	7643518	272	90	35	BA		
BY178	588688	7643733	248	102	29.5	BA		
BY179	588090	7644304	210	125	30	BA		
BY184	591928	7646936	330	135	48	BA		
BY187	592020	7663127	306	54	22.5	BA		
BY192	587665	7644181	79	18	59	BA		
BY192R	587673	7644183	196	121	43	BA	1.00	
BY194	587398	7644995	180	85	49	BA		
BY200	588443	7643782	272	87	53.5	BA	3.75	
BY201	589170	7644266	272	123	37	BA		
BY202	588684	7644264	278	108	29.5	BA		
BY203	588747	7644718	134	-	63	BA	6.25	
BY204	588571	7645122	248	105	55	BA	12.50	
BY205	588367	7645476	188	84	30	BA		
BY206	588753	7646061	234	82	36.5	BA		
BY220	589157	7647823	293	81	39.5	BA		
BY227	587719	7648038	146	83	23.5	BA		
BY191	588118	7643829	234	120	73	BA CO (GYMD)	8.50	
BY072	587197	7656946	86			BA SA	100.00	
BY073	587136	7656973	265	97	68	BA SA	100.00	

Key:

BA Basalt
BW Weathered Basalt
CL Clay
CO Coal
CO (GYLO) Coal- Goonyella Lower seam
CO (GYMD) Coal- Goonyella Middle seam
CO (PSEA) Coal- P seam
CO (PSMR) Coal- P Rider
CS Claystone
GR Gravel
IN Intrusion
MS Mudstone
SA Sand
SL Siltstone
SS Sandstone
XL Carbonaceous Siltstone
XM Carbonaceous Mudstone

Table 6 shows that:

- There is a wide range in the SWL in exploration boreholes in the basalt and in the Tertiary sand below the basalt;

- The ALY from individual bores in the basalt and in the Tertiary sand below the basalt vary from zero to about 12.5L/s, with an exceptional ALY of 100L/s being estimated in BY073 (the method of estimation is not recorded).

This information indicates that the aquifer/s in the basalt and in the Tertiary sand below the basalt are not hydraulically continuous.

Coal Seams

Table 7 shows the information from mineral exploration bores that intersected groundwater in coal seams.

TABLE 7: GROUNDWATER INFORMATION FROM COAL SEAM EXPLORATION BORES							
Hole_ID	***Easting***	***Northing***	***TD(m)***	***Cased depth(m)***	***SWL(m)***	***Contributing Lithologies***	***Aggregate ALY (L/s)***
BY115	588973	7642232	241.0	64.0	64.0	CO	0.63
BY139	588189	7639713	104.0	62.0	39.5	CO	0.19
BY145	588909	7643271	258.0	78.0	45.5	CO	0.63
BY098	587646	7642636	170.0	104.0	44.0	CO (GYLO)	0.13
BY123	587941	7641675	135.0	54.0	35.5	CO (GYLO)	5.00
BY125	588041	7641253	126.0	46.0	47.0	CO (GYLO)	8.75
BY089	587489	7643373	156.0	80.0	22.5	CO (GYLO) IN (GYLO78)	0.88
BY086	587897	7643354	204.0	60.0	33.0	CO (GYMD)	0.50
BY092	587944	7642258	175.0	75.0	80.0	CO (GYMD)	
BY093	588241	7642265	197.0	56.0	112.0	CO (GYMD)	
BY119	588513	7641606	174.0	50.0	45.5	CO (GYMD)	2.50
BY122	588191	7642047	180.0	45.0	37.0	CO (GYMD)	1.50
BY126	588184	7641713	159.0	30.0	36.0	CO (GYMD)	0.88
BY128R	588110	7641849	163.0	80.0	35.0	CO (GYMD)	0.63
BY087	588163	7643322	229.0	42.0	40.0	CO (GYMD) CO (GYLO)	1.88
BY124	588275	7641320	133.0	18.0	39.5	CO (GYMD) CO (GYLO)	2.50
BY103	588260	7643101	234.0	48.0	38.0	CO (GYMD) CO (GYLO78)	2.50
BY127	588639	7642433	246.0	42.0	43.5	CO (GYMD) IN	3.00
BY101	588492	7643322	264.0	53.5	54.0	CO (GYMD) SS	2.50
BY141	589150	7642819	264.0	90.0	40.0	CO (GYMD) XL	4.88
BY102	588731	7643321	276.0	61.0	46.0	CO (PSEA)	0.63
BY228	588423	7648699	297.0	115.0	51.5	CO (PSEA)	2.50
BY106	588403	7642867	246.0	54.0	61.5	CO (PSEA) CO (GYMD) CO (GYLO)	4.25
BY105	588721	7643042	246.0	60.0	51.0	CO (PSEA) SS CO (GYLO)	4.25
BY142	589129	7643016	264.0	84.0	32.0	CO (PSMR)	0.50

Key:

BA Basalt
CO (GYLO) Coal- Goonyella Lower seam
CS Claystone
SA Sand

BW Weathered Basalt
CO (GYMD) Coal- Goonyella Middle seam
GR Gravel
SL Siltstone

CL Clay
CO (PSEA) Coal- P seam
IN Intrusion
SS Sandstone

CO Coal
CO (PSMR) Coal- P Rider
MS Mudstone
XL Carbonaceous Siltstone

XM Carbonaceous Mudstone

Table 7 shows that:

- There is a also a wide range in the SWL in the exploration boreholes in the coal seams; and

- The airlift yields from individual bores in the coal seam aquifers are much more moderate that those from the basalt aquifers with an exceptional ALY of 8.75L/s being reported in BY125.

Other Lithologies

Table 8 shows the information from bores that intersected groundwater in other lithological units.

TABLE 8: GROUNDWATER INFORMATION FROM EXPLORATION BORES IN OTHER LITHOLOGICAL UNITS

Hole_ID	*Easting*	*Northing*	*TD(m)*	*Cased depth(m)*	*SWL(m)*	*Contributing Lithologies*	*Aggregate ALY (L/s)*	*Comments*
BY039	587397	7647874	120.0	48.0	44.5	BW		
BY059	587818	7647094	180.0	66.0	35.0	BW		
BY146	589406.6	7642813	127.0	84.0	41.0	BW		
BY147	589389.6	7643012	318.0	102.0	50.5	BW		
BY148	589442.1	7642566	312.0	95.0	38.0	BW		
BY180	589913.8	7642593	306.0	71.0	41.5	BW		
BY181	589818.5	7642014	318.0	62.0	36.5	BW		
BY183	589476.1	7642208	270.0	68.0	34.0	BW		
BY185	592338	7646928	192.0	95.0	35.0	BW		
BY068	587990	7644693	236.0	100.0	40.0	CL		
BY190	587782	7643809	204.0	97.0	30.0	CL	1.88	
BY036	588415	7650358	222.0	48.0	33.0	CS	2.50	
BY056	588457	7647535	234.0	48.0	14.5	CS		
BY058	588397	7647833	240.0	72.0	12.0	CS		
BY065	586938	7644770	107.0	71.0	28.0	CS		
BY067	587711	7644659	206.0	71.0	16.5	CS		
BY075	587770	7643150	144.0	36.0	29.0	CS		
BY129	589189.3	7642559	270.0	78.0	33.5	CS		
BY130	587977.7	7640682	104.0	71.0	45.0	CS		Basalt water potable, water in sand salty
BY131	587715.7	7641783	134.0	42.0	36.0	CS		
BY146R	589415.7	7642818	276.0	97.0	47.0	CS		
BY153	588856.1	7639971	158.0	56.0	43.0	CS		
BY158	589725.9	7640270	230.0	43.0	21.5	CS		
BY197	587333	7645949	174.0	48.0	24.0	CS		
BY225	589103	7646875	296.0	80.0	39.0	CS		
BY083	587664.3	7643359	180.0	66.0	55.0	CS CO (GYLO)	20.00	

TABLE 8: GROUNDWATER INFORMATION FROM EXPLORATION BORES IN OTHER LITHOLOGICAL UNITS

Hole_ID	*Easting*	*Northing*	*TD(m)*	*Cased depth(m)*	*SWL(m)*	*Contributing Lithologies*	*Aggregate ALY (L/s)*	*Comments*
BY217	593269	7666482	229.0	13.0	12.5	GR SS		
BY049	587643	7649693	242.0	122.0	108.5	IN		
BY051	587202	7647722	102.0	30.0	49.5	IN		
BY241	585533	7663419	210.0	6.0	10.5	IN		
BY046	588088	7649735	200.0	72.0	78.0	MS		
BY052	587763	7647275	162.0	31.0	46.0	MS		
BY112	588697.7	7642604	266.0	44.0	45.0	MS		
BY118	587950.8	7641861	152.0	39.0	71.0	MS		
BY133	588917.6	7640897	182.0	42.0	44.0	MS		
BY218	588227	7661803	234.0	66.0	53.0	MS		
BY040	585233	7655896	151.0	66.0	30.0	SA		
BY210	594216	7667650	324.0	34.0	14.5	SA		
BY034	587767.5	7641088	104.0	72.0	71.5	SL		
BY045	588171	7650049	236.0	37.0	43.0	SL		
BY048	587598	7650324	206.0	64.0	63.5	SL		
BY070	587203	7655938	217.0	9.5	91.0	SL	0.38	
BY079	588204.1	7641901	164.0	48.0	45.0	SL		
BY095	587376.6	7642624	140.0	117.0	117.0	SL		
BY111	588457.1	7642557	236.0	43.0	45.0	SL		
BY114C	588742	7642240	168.0	43.0	55.0	SL		
BY117	589237	7642006	254.0	47.0	47.0	SL		
BY140	588906.7	7642418	276.0	58.0	37.0	SL		
BY150	587852.4	7639787	80.0	60.0	57.0	SL	0.13	
BY160	588375.9	7641839	162.0	45.0	37.5	SL		
BY186	592990	7663267	324.0	24.0	122.5	SL		
BY195	587661	7645437	192.0	91.0	63.5	SL		
BY209	588034	7647492	173.0	50.0	27.0	SL		
BY214	594262	7668196	330.0	24.0	269.0	SL		
BY240	585981	7663331	252.0	25.0	25.0	SL	0.01	
BY035	588854	7650390	314.0	60.0	60.0	SS		
BY038	587221	7649159	80.0	35.0	57.5	SS		
BY047	588128	7650493	230.0	40.0	49.5	SS		
BY053	587757	7647653	132.0	36.0	47.5	SS	0.13	
BY054	588278	7647227	157.0	34.0	46.0	SS		
BY055	588784	7647235	174.0	30.0	47.5	SS		
BY077	588380.4	7641054	90.0	42.0	22.0	SS		
BY078	588670.9	7641106	156.0	42.0	31.0	SS		
BY080	587285.6	7643872	161.0	126.0	127.0	SS		
BY094	588465.2	7642252	218.0	41.0	39.5	SS		
BY099	587917.8	7642551	188.0	92.0	41.0	SS	0.38	
BY108	588967.2	7642015	228.0	42.0	43.0	SS	10.00	

TABLE 8: GROUNDWATER INFORMATION FROM EXPLORATION BORES IN OTHER LITHOLOGICAL UNITS								
Hole_ID	***Easting***	***Northing***	***TD(m)***	***Cased depth(m)***	***SWL(m)***	***Contributing Lithologies***	***Aggregate ALY (L/s)***	***Comments***
BY109	588415.3	7642126	204.0	36.0	38.0	SS		
BY110	588238.8	7642562	199.0	57.0	98.0	SS		
BY114	588721	7642243	242.0	31.5	43.0	SS		
BY120	588404	7641992	198.0	58.0	56.0	SS	1.00	Salty
BY121	587976.6	7641981	180.0	79.0	101.5	SS	2.50	
BY128	588104.9	7641886	84.0	48.0	48.0	SS		
BY132	588893	7641126	203.0	33.0	44.0	SS		
BY151	588512.1	7639649	127.0	56.0	37.0	SS	0.25	
BY152	588843.3	7639667	152.0	53.0	42.0	SS		
BY154	589376.2	7639778	214.0	54.0	24.5	SS		
BY155	589114.4	7639979	194.0	57.0	26.0	SS		
BY156	589348.8	7640013	230.0	57.0	38.5	SS		
BY157	589589.5	7640029	248.0	46.0	60.5	SS		
BY159	589067.7	7640222	199.0	50.0	41.0	SS		First water in fractured zone
BY170	589489.3	7640393	238.0	39.0	50.5	SS		
BY171	589079.1	7640677	204.0	18.0	45.0	SS		
BY172	589422	7640850	248.0	41.0	47.0	SS		
BY173	589337	7641414	264.0	51.0	39.5	SS	7.50	
BY182	589922.4	7641687	288.0	68.0	30.0	SS	2.50	
BY189	593689	7667959	324.0	21.0	28.5	SS	3.75	
BY193	587950	7645003	240.0	85.0	86.0	SS	0.05	
BY196	587126	7645399	120.0	58.0	44.5	SS		
BY198	587875	7646242	186.0	42.0	48.0	SS		
BY199	587682	7646550	150.0	30.0	44.0	SS		
BY207	588774	7647776	256.0	25.5	48.0	SS		
BY208	588751	7647485	290.0	39.0	45.5	SS		
BY211	593082	7668557	324.0	24.0	24.0	SS	0.38	
BY212	593642	7668461	324.0	24.0	96.0	SS		
BY215	594533	7669093	330.0	12.0	12.5	SS		
BY216	592598	7668853	300.0	17.0	85.0	SS		
BY221	589226	7648282	296.0	60.0	73.0	SS		
BY222	588513	7647062	288.0	41.0	46.5	SS	0.63	
BY224	588839	7646479	276.0	48.0	59.5	SS	0.50	
BY226	588749	7648224	275.0	56.0	58.5	SS		
BY143	588892	7642805	252.0	71.0	34.5	SS CO (GYMD) XL	4.63	Abandoned due to high water flow
BY188	591064	7663040	56.0	54.0	29.0	SS SA	10.00	
BY107	588600.4	7642796	258.0	48.0	29.0	SS SL CO (GYMD)	5.25	Small supply only

TABLE 8: GROUNDWATER INFORMATION FROM EXPLORATION BORES IN OTHER LITHOLOGICAL UNITS								
Hole_ID	***Easting***	***Northing***	***TD(m)***	***Cased depth(m)***	***SWL(m)***	***Contributing Lithologies***	***Aggregate ALY (L/s)***	***Comments***
BY213	593608	7668962	324.0	18.0	166.0	SS SS		
BY219	586324	7663364	234.0	18.0	17.5	SS SS	4.38	
BY144	588928.6	7642951	258.0	74.0	45.0	SS XL	3.75	
BY149	589893	7643002	318.0	84.0	29.5	XL/SS CO (GYLO)	2.63	
BY061	587355	7649921	194.0	136.5	129.0	XM	3.75	
BY104	588447.9	7643032	258.0	46.0	47.0	XM SS	2.50	
BY078C	588680.5	7641118	162.0	72.0	72.0			
BY083C	587676	7643353	102.0	72.0	39.5			
BY093C	588273.6	7642264	126.0	92.0	35.0			
BY097C	587675	7642875	102.0	83.0	18.5			
BY111C	588475.6	7642561	156.0	54.0	30.0			
BY124C	588282.6	7641315	120.0	25.0	34.5			
BY160C	588383.7	7641836	156.0	84.0	30.0			

Key:

BA Basalt	**BW** Weathered Basalt	**CL** Clay	**CO** Coal
CO (GYLO) Coal- Goonyella Lower seam	**CO (GYMD)** Coal- Goonyella Middle seam	**CO (PSEA)** Coal- P seam	**CO (PSMR)** Coal- P Rider
CS Claystone	**GR** Gravel	**IN** Intrusion	**MS** Mudstone
SA Sand	**SL** Siltstone	**SS** Sandstone	**XL** Carbonaceous Siltstone
XM Carbonaceous Mudstone			

The information from Table 8 shows that there is little groundwater of any significance in mudstone and siltstone and that the only significant groundwater is associated with sandstone.

These results are as expected. It is also evident that the larger ALY in the sandstone are very localised, suggesting that fracture (secondary) porosity and not intergranular (primary) porosity is the dominant mechanism for groundwater accumulation and flow.

4.8 Hydraulic Conductivity Testing Program

Falling head permeability tests were conducted on all of the dedicated groundwater monitoring bores and on exploration bore BY073. The data from the tests were analysed using the Bouwer and Rice[6] analytical method.

Table 9 shows the hydraulic conductivity of the perforated zones within each dedicated groundwater monitoring bore.

[6] Bouwer, Herman and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research 12(3) 423–428.

TABLE 9: CALCULATED PERMEABILITY VALUES					
Bore_ID	***Perforated Interval (m from - m to)***	***Lithologies tested***	***Hydrostratigraphic unit***	***Permeability (m/s)***	***Permeability (m/d)***
BYGW01	47.5-59.5	Sandstone and interbedded coal	Rangal Coal Measures	6.48E-07	0.0560
BYGW02	47.5-53.5	Coal	Fort Cooper Coal Measures	4.63E-07	0.0401
BYGW03	56-62	Sandstone	Fort Cooper Coal Measures	1.16E-06	0.1006
BYGW04	95-107	Sandstone and interbedded coal	Fort Cooper Coal Measures	2.02E-09	0.0002
BYGW05	99-105; 81-93	Sandstone	Exmoor Formation	4.32E-10	0.0000
BYGW06	103-115	Sandstone and interbedded coal	Rangal Coal Measures	9.88E-09	0.0009
BYGW07A	65-69	Sand below Basalt	Tertiary Sand below Basalt	1.67E-05	1.4407
BYGW07B	46-52	Basalt	Basalt	2.17E-07	0.0187
BYGW08	56.5-65.5	Basalt	Basalt	8.85E-07	0.0765
BYGW09	91-97	Sandstone	Moranbah Coal Measures	2.03E-07	0.0176
BYGW10	40-52	Sandstone and interbedded coal	Rangal Coal Measures	1.58E-08	0.0014
BY073*	Open hole 97 - 265	Sandstone and interbedded coal	Not interpreted	1.48E-07	0.0128

Note : * It is important to note that the results from BY073 represent the gross permeability of the open hole from 97 to 265m depth.

Table 9 shows that the hydraulic conductivity values for all lithologies tested are relatively low (10^{-7} to 10^{-10} m/s) with the only exceptions being the Tertiary sand below the basalt in BYGW07A and the sandstone in BYGW03. These are regarded as exceptional.

The variations in calculated hydraulic conductivity explain the wide variations in ALY obtained by both the groundwater monitoring bores and the mineral exploration bores, and reinforce the conclusion that fracture porosity, not primary porosity, is the dominant mechanism for groundwater accumulation and flow.

The primary purpose of the groundwater monitoring bores was to install the screened intervals adjacent to the aquifer sequence to be monitored. The aquitards above the screened intervals were grouted off appropriately to isolate the aquifer sequences targeted for monitoring. However, it is well understood that that by their very nature, the hydraulic conductivity of the aquitards will be significantly less than that of the aquifers.

5.0 HYDROGEOLOGICAL REGIME

The data from the search of the NRM groundwater database, the dedicated groundwater monitoring bores and the exploration bores, and the hydraulic conductivity testing program permits a good assessment of the hydrogeological regime.

5.1 Aquifers

Aquifers beneath the project leases occur in a number of stratigraphic units as discussed below.

Alluvium

The Suttor River is the major drainage west of the Byerwen MLAs. The Suttor rises in the Leichhardt Range—underlain by mudstone and claystone of the Tertiary Suttor Formation. Little alluvial development of any significance has occurred along the Suttor above its confluence with Diamond Creek downstream of the Byerwen MLAs.

Two of the dedicated groundwater monitoring bores (BYGW04 and BYGW08) were located to assess the thickness of the alluvium as alluvium was shown to cross the southern part of the Byerwen leases. Neither BYGW04 nor BYGW08 intersected any alluvium.

None of the remaining groundwater monitoring bores intersected any alluvial sequence.

Therefore, the alluvium is not regarded as an aquifer on the Byerwen MLAs.

Suttor Formation

The Suttor Formation is dominated by clay and claystone. It is noted as a poor aquifer owing to low yields and poor groundwater quality. As it occurs areally extensively, it is a conduit for groundwater recharge to deeper aquifer sequences despite its predominantly clayey nature. Recharge through this stratigraphic unit will be slow as a result.

Any aquifers in this formation would be unconfined or semi-confined.

Basalt

A northwest-trending line of Tertiary basalt outcrops possibly marks the position of an ancestral tributary of the Bowen River. The yields from the basalt are low to moderate and no reports of significant vesicles occur. Fracture porosity is the dominant mechanism for groundwater storage and flow in the basalt

Any aquifers in this formation would be unconfined or semi-confined.

Tertiary Sand below the Basalt

The Tertiary sand aquifer at the base of the basalt is lensoid and discontinuous but locally high yielding. This aquifer is not used for stock water probably due to the random nature of occurrence of the basal sands, the landholders tending to rely more heavily on dams and piped water.

Any aquifers in this formation would be confined.

Coal Seams

Potentially high yielding aquifers occur in sandstone within the Bowen Basin coal measure sequence. The Fort Cooper Coal Measures, for example, contain extensive medium- to coarse-grained sandstone and conglomerate beds. The aquifers within the sandstone are discontinuous which shows that fracture porosity is the dominant mechanism for groundwater storage and flow in the sandstone.

Because many coal measure sandstones were deposited in a brackish water environment and/or have a clay-rich matrix, the groundwater quality in the coal seams is generally very poor and may be unsuitable for stock. The waters are sodium chloride type with a high total dissolved salt (TDS) content. The sulphate content is also high.

Any aquifers in this formation would be confined.

Basement (Lizzie Creek Volcanics)

Aquifers within the Lizzie Creek Volcanics are not reported. In any case they would be too deep to be accessible by pastoralists. Generally andesitic and rhyolitic sequences contain poor aquifers. Basement aquifers are not regarded as significant at Byerwen.

Any aquifers in this formation would be confined.

5.2 Aquifer Importance

An assessment of the relative importance of the aquifers at the project was undertaken. The aquifer units are listed in order of significance, from highest (1) to lowest (5), based on the criteria used in Table 10. It should be noted that these criteria were developed by RLA based on significant Bowen Basin hydrogeological experience, for the purpose of this report to assist in better understanding the hydrogeological regime.

TABLE 10: AQUIFER UNITS AND SIGNIFICANCE					
Aquifer Unit	***Significance***	***Criterion 1: Yield***	***Criterion 2: Permeability***	***Criterion 3: Hydraulic Continuity***	***Criterion 4: Groundwater quality***
Tertiary Sand below Basalt	1	High	High	Discontinuous, probably lensoid	Brackish
Coal Seam aquifers (mainly sanbdstone)	2	Low to moderate	Low	Discontinuous	Very Poor
Basalt	3	Low	Moderate	Discontinuous	Poor
Suttor Formation	4	Low	Low	Discontinuous	Very Poor
Alluvium	5	No significant alluvial sequences are evident on the Byerwen MLAs			
Basement	6	No groundwater occurrence or use form the Lizzie Creek Volcanics is known or has been reported in the Byerwen area.			

5.3 Depth to Water Table and Thickness of Aquifers

The depth to the standing water level and thickness of aquifers are shown in the data in Table 3. The perforated intervals in dedicated groundwater monitoring bores correspond to the assessed thickness of the aquifer intervals.

Figure 4 shows the standing water levels in the dedicated groundwater monitoring bores.

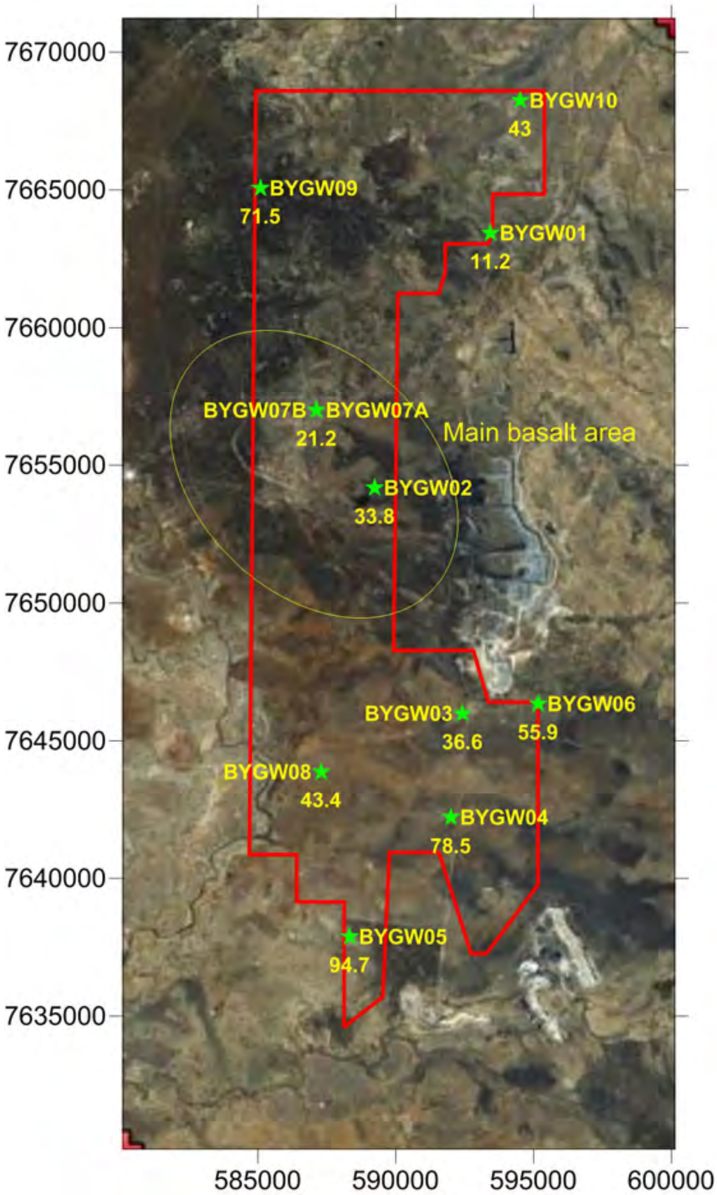


Figure 4: Standing Water Level in Groundwater Monitoring Bores
(shown in metres below ground level)
Note that only the standing water level for BYGW07A is shown for that site

Figure 4 shows that the standing water level is relatively shallow beneath the basalt and much deeper where there is no basalt cover. This suggests that the basalt is a storage mechanism for groundwater and that groundwater within the Tertiary sequences is perched above the underlying Permian sequences.

Both the standing water levels and thickness of aquifers show wide ranges, reinforcing that there is little hydraulic continuity in the aquifers beneath the Byerwen MLAs. If the Tertiary and Permian aquifers were in hydraulic connection a relatively uniform depth standing water level would be expected.

5.4 Aquifer Connectivity

There are no alluvial aquifers of any significance on the Byerwen leases.

It was discussed above that the Tertiary sequence aquifers do not appear to be in hydraulic connectivity with the deeper Permian sequence aquifers.

The aquifers within the sandstones contained in the Permian coal seams are discontinuous. Therefore the hydraulic connectivity within the coal seam aquifers will be at best very limited (as evidenced by the low hydraulic conductivity values derived from the testing program.

There are no aquifers of significance in basement.

In summary, the following apply:

- Hydraulic connection between alluvium and Tertiary aquifers does not exist as there are no alluvial aquifers;
- Hydraulic connection between the Tertiary basalt and sand aquifers and the underlying Permian sequence does not exist as the groundwater in the basalt and sand aquifers is perched well above the Permian aquifers;
- Hydraulic connection between Permian coal seam aquifers is considered to be limited;
- Hydraulic connection between Permian coal seam aquifers and the underlying basement probably does not exist as basement lithologies are regarded as impermeable; and
- Hydraulic connection between the Suttor Formation and the underlying Permian sequences is very limited based on the available data.

5.5 Groundwater Flow Directions

It has been concluded earlier in this report that there is little, if any, hydraulic continuity either horizontally or vertically beneath the Byerwen MLAs.

As discussed previously, there is no alluvial groundwater and the groundwater within the Tertiary sequences is perched above the underlying Permian sequences. Therefore, it is considered reasonable to assess the regional potentiometric surface for the Permian sequences based on the groundwater level elevations from the aquifers within the coal seams beneath the project.

This assumes that there is at least limited hydraulic connectivity between the coal seam aquifers. Therefore contouring of the groundwater elevation can only give, at best, an indication of groundwater flow directions within the Permian sequences beneath the project MLAs.

Figure 5 shows a contour map of groundwater elevation in October 2011. These contours exclude the groundwater level data from the Tertiary aquifer sequences.

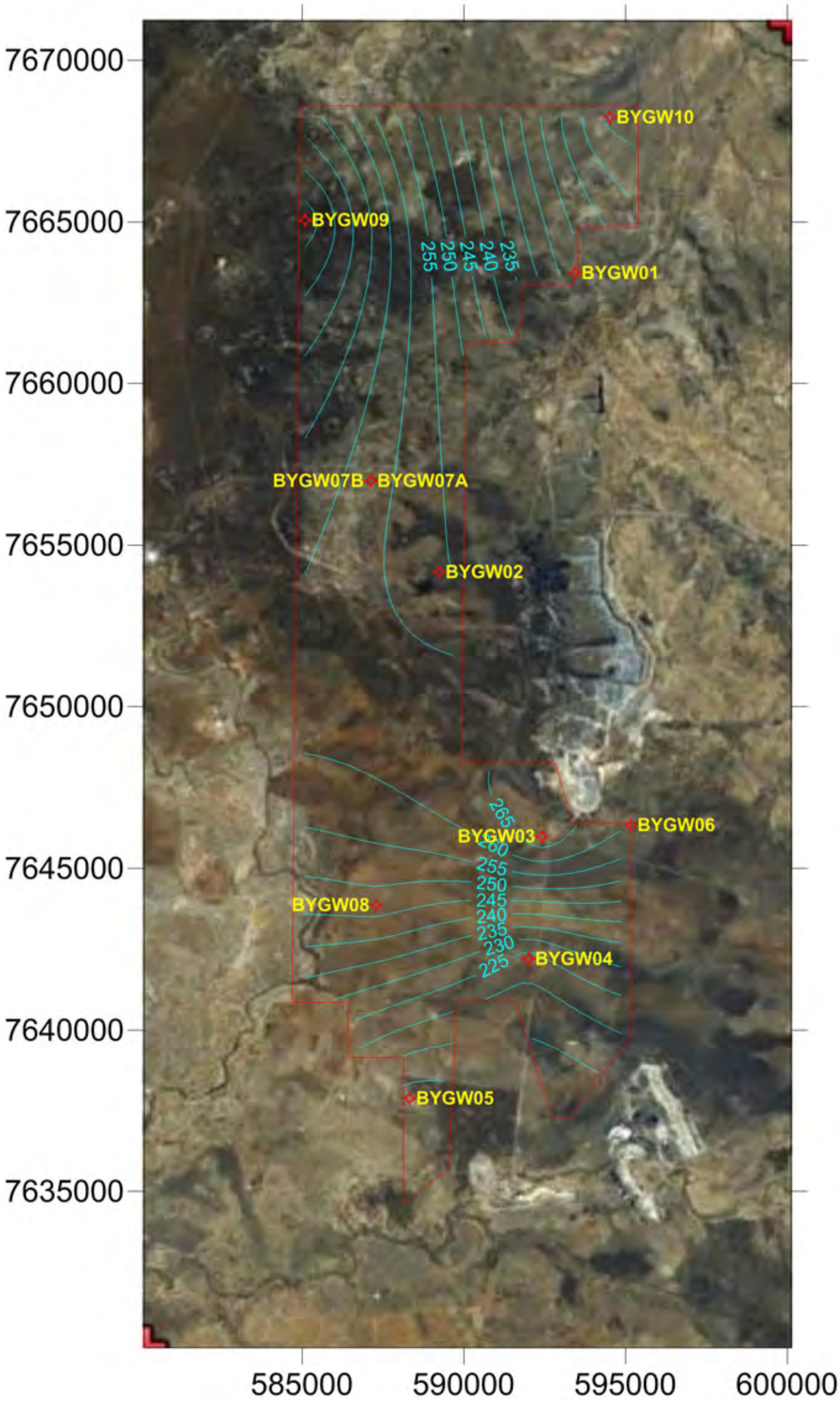


Figure 5: Groundwater Elevation Contours - Permian Aquifer Sequences, October 2011
(Contour Interval 5m, Datum AHD)

The contours suggest that groundwater flow is both to the north east and to the south with a groundwater divide between BYGW02 and BYGW03.

5.6 Groundwater - Surface water Interactions

Data from NRM observation bore RN 120300945 (see Figure 4) indicate that there is little or no hydraulic connection between the Suttor Formation aquifers and the Suttor River. The groundwater level in this bore is generally well below the depth of incision of the river bed.

The data from the groundwater monitoring bores and mineral exploration bores shows that the SWL beneath the Byerwen MLAs ranges from about 20 to 80 m bgl (below ground level). None of the drainage features that traverse the MLAs is incised to any more than about 5m. Furthermore there is no alluvial development of any significance.

BYGW04 intersected its first significant groundwater at 102m bgl and the SWL in this bore is over 70m bgl. Similarly BYGW08 intersected its first significant groundwater at 66m bgl and the SWL in this bore is over 40m bgl. The strata from surface to 37m bgl in BYGW08 consists of mottled clay, which must be regarded as a significant aquitard, especially as the standing water level in this bore is below that depth. This is significant evidence that the aquifers at the Byerwen project are not hydraulically connected to the Suttor River or any of the major watercourses.

It is concluded that there is little or no groundwater - surface water interaction across the Byerwen MLAs, as the standing water levels are deep and there is generally a significant thickness of low permeability material above any aquifers that are encountered.

5.7 Groundwater Recharge

Recharge of the Tertiary aquifers occurs by direct infiltration of rainfall. As the Tertiary and Permian sequences are not hydraulically connected the Tertiary aquifers cannot contribute recharge to the Permian aquifers.

Recharge to the coal measure sandstone aquifers, also occurs via direct (but slow) infiltration of rainfall. The majority of the recharge to the Permian coal sequence aquifers probably derives from slow infiltration through the predominantly clayey Suttor Formation.

There is no recharge from the alluvium to the Permian sequence aquifers as there are no significant alluvial aquifers on the Byerwen leases. In other areas in the Bowen Basin it has been estimated that only about 3% of incident rainfall results in recharge to the consolidated aquifers.

Byerwen Coal has installed automatic groundwater level data loggers in several of the dedicated groundwater monitoring bores to assess seasonal groundwater level fluctuation. Figures 6a, 6b and 6c show the groundwater level variation in bores BYGW05, BYGW07A and BYGW09 for an eight month period from December 2011 to August 2012.

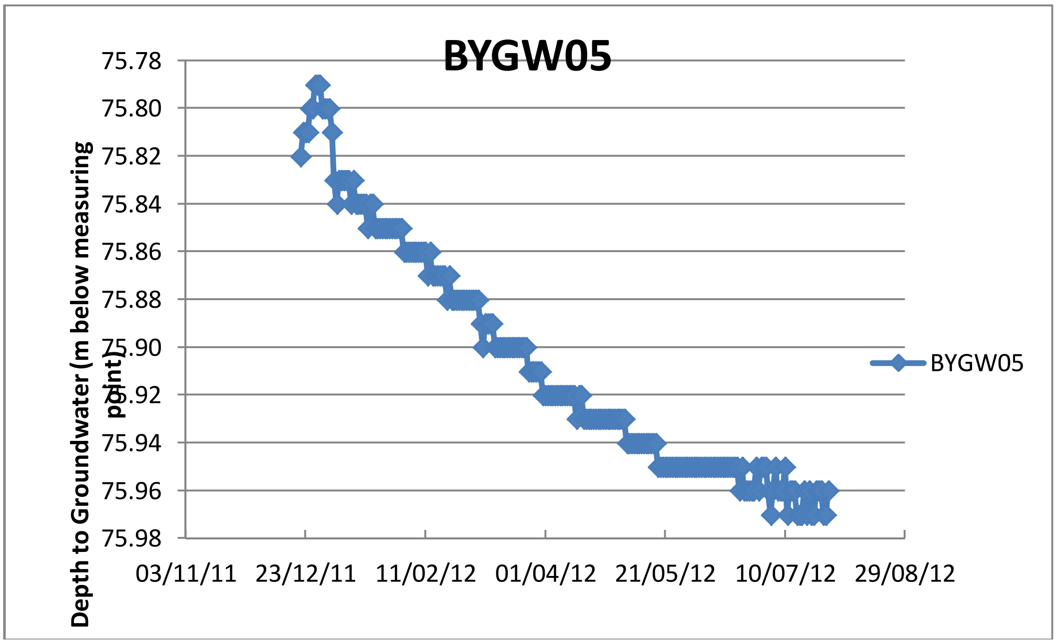


Figure 6a: Depth to Groundwater Chart BYGW05 December 2011 to August 2012

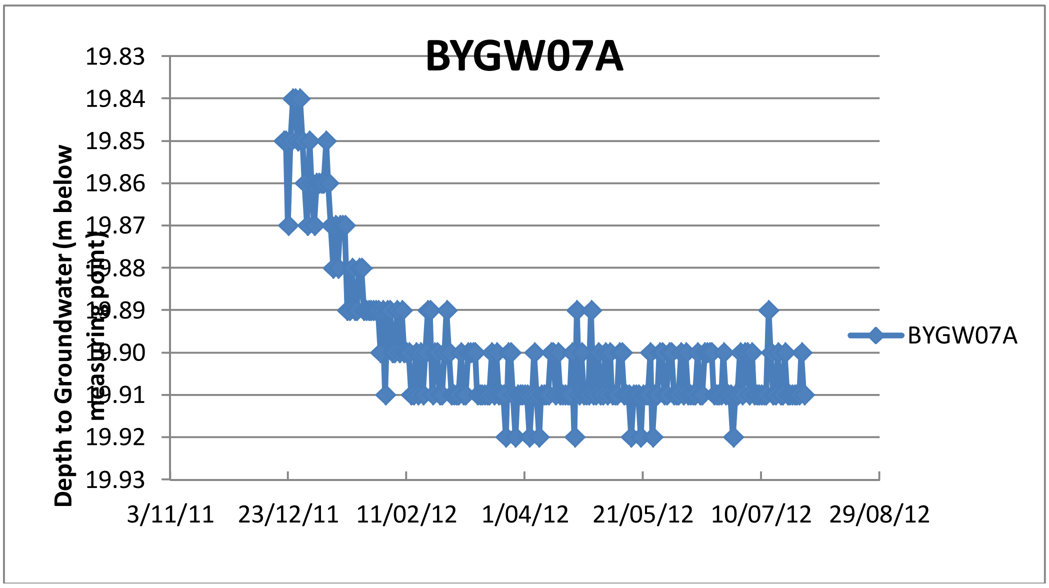


Figure 6b: Depth to Groundwater Chart BYGW07A December 2011 to August 2012

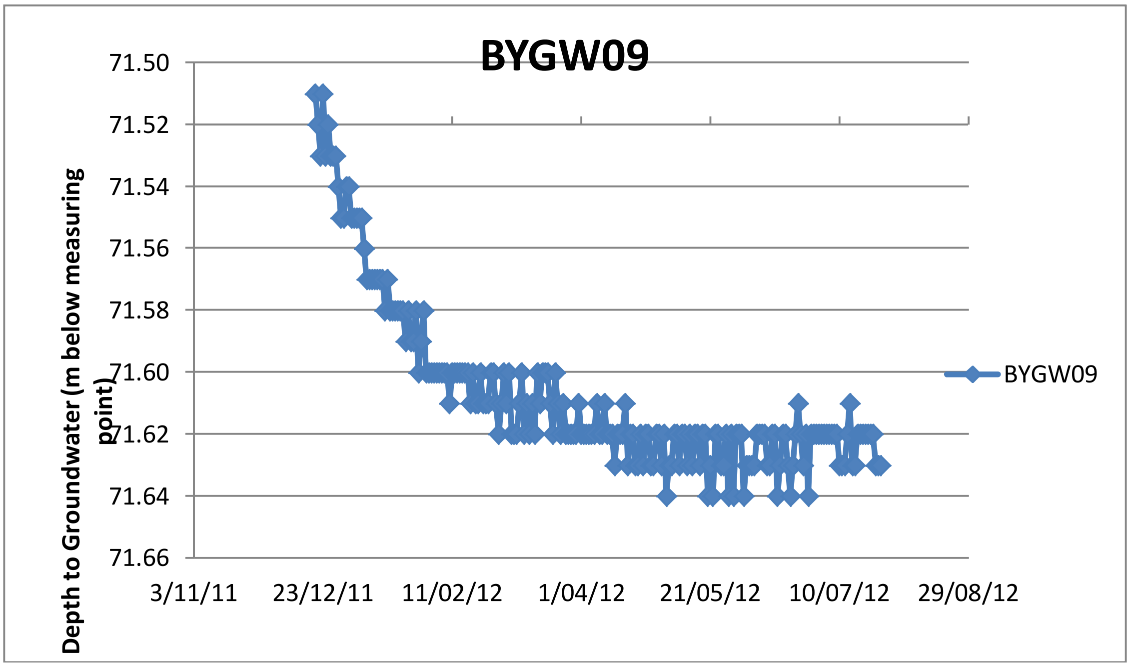


Figure 6c: Depth to Groundwater Chart BYGW09 December 2011 to August 2012

It can be seen that the seasonal decline in groundwater level in each of these three bores ranges from 0.08 to 0.16m. Such small amplitudes of seasonal groundwater level variation are typical of low hydraulic conductivity aquifers. Significantly it is noted that these results for bores across the project are directly comparable to the fluctuation of groundwater level measured, over an approximate 10 year period, in bore RN120300094 located in the Suttor Formation 8km to the west of the project (see Section 4.3).

5.8 Groundwater Chemistry in Dedicated Groundwater Monitoring Bores

The proponent is routinely collecting groundwater samples from the dedicated groundwater monitoring bores. Water samples are collected in accordance with the Queensland Water Quality Guidelines 2009 unless circumstantial departures from the prescribed methods occur at the time of sampling (such as equipment failure), in which case results are considered indicative and may still be used in interpretation of the hydrogeology. Such circumstances prevailed in August 2012 when dedicated groundwater monitoring bores were measured for SWL; during that sampling round effective purging could not be achieved due to equipment failure and as a consequence, the existing water sample analysis results will be compared to subsequent confirmatory sampling and monitoring results.

Tables 11 and 12 shows the analyses of the groundwater from the groundwater monitoring bores taken in October and December 2011.

BYGW04 has not yielded water sufficient water to permit a valid groundwater sample to be obtained. The electrical conductivity of the water from it was measured at 2,720 µS/cm at time of drilling, indicating that the groundwater in that bore is brackish.

As with scientific data collection of any kind, a larger data set will enable more robust analyses an interpretation, in comparison to smaller data sets. As such, a more robust statistical analysis of data will be available for water quality parameters (e.g. mean and median values, ranges and percentiles) to 'characterise' the groundwater quality, with ongoing sampling in the early stages of project development.

TABLE 11: GROUNDWATER CHEMICAL ANALYSES FROM OCTOBER AND DECEMBER 2011												
Analyte	**Units**	**LOR**	05/10/11	20/12/11	06/10/11	20/12/11	06/10/11	20/12/11	06/10/11	20/12/11	06/10/11	20/12/11
Groundwater Monitoring bore >>			**BYGW01**	**BYGW01**	**BYGW02**	**BYGW02**	**BYGW03**	**BYGW03**	**BYGW05**	**BYGW05**	**BYGW06**	**BYGW06**
Hydrostratigraphic unit* >>>>>>			**RCM**	**RCM**	**FCCM**	**FCCM**	**FCCM**	**FCCM**	**Exmoor**	**Exmoor**	**RCM**	**RCM**
pH Value	pH Unit	0.01	9.44	8.23	7.63	7.57	7.91	7.89	12.0	10.70	12.0	11.00
Sodium Absorption Ratio	-	0.01	31.7	18.2	22.4	20.2	11.5	11	30.6	33.2	6.71	14
Electrical Conductivity @ 25°C	µS/cm	1	1870	2001	11600	10550	2930	2755	21300	19270	7140	3950
Total Dissolved Solids (Calc.)	mg/L	10	1220	1310	7540	7280	1900	1840	13800	12400	4640	2420
Total Hardness as CaCO3	mg/L	1	27	87	1540	1550	314	276	1680	1670	959	334
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	<1	<1	1720	25	949	60
Carbonate Alkalinity as CaCO3	mg/L	1	87	<1	<1	<1	<1	<1	75	67	43	30
Bicarbonate Alkalinity as CaCO3	mg/L	1	58	249	595	699	232	237	<1	<1	<1	<1
Total Alkalinity as CaCO3	mg/L	1	144	249	595	699	232	237	1790	92	991	90
Sulfate as SO4 2-	mg/L	1	184	155	1140	982	32	36	88	102	20	30
Chloride	mg/L	1	406	410	3350	3070	810	736	4480	6470	759	1010
Calcium	mg/L	1	6	20	175	191	55	51	672	661	384	124
Magnesium	mg/L	1	3	9	268	260	43	36	<1	4	<1	6
Sodium	mg/L	1	381	391	2020	1830	470	421	2880	3120	478	588
Potassium	mg/L	1	4	3	19	16	5	5	188	60	15	9
Fluoride	mg/L	0.1	0.5	0.2	0.1	0.1	0.2	0.1	0.4	0.2	0.5	0.2
Ammonia as N	mg/L	0.01	1.17	0.66	1.94	2.02	0.07	0.21	3.42	1.55	1.13	0.84
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	0.02	<0.01	0.01	<0.01	0.02	<0.01	0.03	<0.01	0.07	<0.01
Nitrite + Nitrate as N	mg/L	0.01	0.02	<0.01	0.01	<0.01	0.02	<0.01	0.03	<0.01	0.07	<0.01
Total Phosphorus as P	mg/L	0.01	0.08	0.49	0.03	0.14	0.04	0.06	0.36	<0.01	0.04	0.04
Dissolved Metals by ICP-MS												
Aluminium	mg/L	0.01	0.07	0.02	<0.01	0.02	0.02	0.03	0.13	<0.01	0.80	0.79
Arsenic	mg/L	0.001	0.007	0.003	0.003	0.008	0.003	0.004	0.006	<0.001	<0.001	0.002
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	mg/L	0.001	<0.001	<0.001	0.002	0.004	<0.001	0.002	0.033	<0.001	0.001	0.002
Lead	mg/L	0.001	<0.001	<0.05	<0.001	0.09	<0.001	0.22	0.005	0.08	<0.001	<0.05

TABLE 11: GROUNDWATER CHEMICAL ANALYSES FROM OCTOBER AND DECEMBER 2011

Analyte	**Units**	**LOR**	05/10/11	20/12/11	06/10/11	20/12/11	06/10/11	20/12/11	06/10/11	20/12/11	06/10/11	20/12/11
Groundwater Monitoring bore >>			**BYGW01**	**BYGW01**	**BYGW02**	**BYGW02**	**BYGW03**	**BYGW03**	**BYGW05**	**BYGW05**	**BYGW06**	**BYGW06**
Hydrostratigraphic unit* >>>>>>			**RCM**	**RCM**	**FCCM**	**FCCM**	**FCCM**	**FCCM**	**Exmoor**	**Exmoor**	**RCM**	**RCM**
Manganese	mg/L	0.001	<0.001	<0.001	0.721	<0.001	0.776	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.005	<0.005	0.131	<0.005	0.367	<0.005	0.608	<0.005	0.002	<0.005	<0.001
Iron	mg/L	0.05	<0.05	<0.005		0.011		0.008	<0.50	<0.005	<0.50	<0.005

Notes: * RCM = Rangal Coal Measures, FCCM = Fort Cooper Coal Measures, Tert Sand = Tertiary Sand, Basalt = Basalt, Exmoor = Exmoor Formation

TABLE 12: GROUNDWATER CHEMICAL ANALYSES FROM OCTOBER AND DECEMBER 2011

Analyte	**Units**	**LOR**	05/10/11	20/12/11	05/10/11	20/12/11	06/10/11	20/12/11	06/10/11	20/12/11	05/10/11	20/12/11
Groundwater Monitoring bore >>			**BYGW07A**	**BYGW07A**	**BYGW07B**	**BYGW07B**	**BYGW08**	**BYGW08**	**BYGW09**	**BYGW09**	**BYGW10**	**BYGW10**
Hydrostratigraphic unit* >>>>>>			**Tert Sand**	**Tert Sand**	**Basalt**	**Basalt**	**Basalt**	**Basalt**	**MCM**	**MCM**	**RCM**	**RCM**
pH Value	pH Unit	0.01	8.72	9.15	8.17	8.08	12.0	9.47	8.20	7.02	11.9	11.40
Sodium Absorption Ratio	-	0.01	20.4	17.1	21.8	21.3	31.0	24.6	4.49	1.24	6.27	22.6
Electrical Conductivity @ 25°C	µS/cm	1	2010	402	4370	4150	22400	19810	1610	485	3790	1785
Total Dissolved Solids (Calc.)	mg/L	10	1310	311	2840	2600	14600	12900	1050	138	2460	1010
Total Hardness as CaCO3	mg/L	1	75	5	278	227	1760	2750	331	49	527	17
Hydroxide Alkalinity as CaCO3	mg/L	1	<1	<1	<1	<1	1700	<1	<1	<1	633	165
Carbonate Alkalinity as CaCO3	mg/L	1	70	27	<1	<1	78	20	<1	<1	62	100
Bicarbonate Alkalinity as CaCO3	mg/L	1	372	61	425	446	<1	3	281	29	<1	<1
Total Alkalinity as CaCO3	mg/L	1	442	88	425	446	1770	23	281	29	695	265
Sulfate as SO4 2-	mg/L	1	13	26	271	226	154	231	30	7	253	59
Chloride	mg/L	1	406	63	1020	867	4740	6700	339	41	175	167
Calcium	mg/L	1	12	2	37	30	707	613	42	8	211	7
Magnesium	mg/L	1	11	<1	45	37	<1	296	55	7	<1	<1

TABLE 12: GROUNDWATER CHEMICAL ANALYSES FROM OCTOBER AND DECEMBER 2011												
Analyte	**Units**	**LOR**	05/10/11	20/12/11	05/10/11	20/12/11	06/10/11	20/12/11	06/10/11	20/12/11	05/10/11	20/12/11
Groundwater Monitoring bore >>			**BYGW07A**	**BYGW07A**	**BYGW07B**	**BYGW07B**	**BYGW08**	**BYGW08**	**BYGW09**	**BYGW09**	**BYGW10**	**BYGW10**
Hydrostratigraphic unit* >>>>>>			**Tert Sand**	**Tert Sand**	**Basalt**	**Basalt**	**Basalt**	**Basalt**	**MCM**	**MCM**	**RCM**	**RCM**
Sodium	mg/L	1	407	88	835	738	2990	2960	188	20	331	217
Potassium	mg/L	1	4	1	6	6	251	45	10	3	57	3
Fluoride	mg/L	0.1	0.3	0.3	0.2	0.1	0.4	<0.1	0.2	<0.1	0.5	0.4
Ammonia as N	mg/L	0.01	0.47	<0.01	0.57	0.48	2.33	1.43	0.10	0.05	3.56	6.07
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	0.02	0.99	0.02	<0.01	0.04	<0.01	0.03	0.01	0.04	<0.01
Nitrite + Nitrate as N	mg/L	0.01	0.02	0.99	0.02	<0.01	0.06	<0.01	0.03	0.01	0.04	<0.01
Total Phosphorus as P	mg/L	0.01	0.09	0.32	0.06	0.24	0.02	<0.01	0.10	0.05	0.06	0.07
Dissolved Metals by ICP-MS												
Aluminium	mg/L	0.01	0.03	0.19	<0.01	0.08	0.11	<0.01	0.02	0.22	0.25	2.71
Arsenic	mg/L	0.001	0.012	0.018	<0.001	0.004	0.002	<0.001	0.019	<0.001	0.001	0.004
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	mg/L	0.001	<0.001	0.004	<0.001	0.004	0.006	<0.001	<0.001	0.002	0.008	0.003
Lead	mg/L	0.001	<0.001	0.36	<0.001	1.04	0.002	<0.05	<0.001	0.29	0.002	0.08
Manganese	mg/L	0.001	0.009	0.002	0.114	<0.001	<0.001	<0.001	0.145	<0.001	<0.001	<0.001
Zinc	mg/L	0.005	<0.005	0.006	<0.005	0.096	<0.005	0.001	<0.005	0.01	<0.005	0.002
Iron	mg/L	0.05	<0.05	0.015	<0.05	0.028	<0.50	<0.005	0.07	0.037	<0.05	0.006

Notes: * MCM = Moranbah Coal Measures, RCM = Rangal Coal Measures, FCCM = Fort Cooper Coal Measures, Tert Sand = Tertiary Sand, Basalt = Basalt, Exmoor = Exmoor Formation

The data in tables 11 and 12 show that:

- The natural electrical conductivity(EC) and the total dissolved solids (TDS) content of the groundwater ranges from moderate to high;

- The groundwater across the Byerwen MLAs is moderately to highly alkaline with pH in excess of 10.0 being measured in BYGW05, BYGW06, BYGW08 and BYGW10, while BYGW01 recorded a pH of 9.44. These bores are also high in electrical conductivity, TDS and ammonia. This groundwater chemistry is invariably associated with the coal seams;

- Dissolved arsenic concentrations have been below the ANZECC/ARMCANZ 2000 stockwater guideline value of 0.5mg/L;

- Dissolved cadmium concentrations have been below the ANZECC/ARMCANZ 2000 stockwater guideline value of 0.01mg/L;

- Dissolved copper concentrations have been below the ANZECC/ARMCANZ 2000 stockwater guideline value of 1mg/L;

- Dissolved lead concentrations have generally been below the ANZECC/ARMCANZ 2000 stockwater guideline value of 0.1mg/L except for the water from bores BYGW07B and BYGW09 in December 2011;

- Dissolved zinc concentrations have been below the ANZECC/ARMCANZ 2000 stockwater guideline value of 20mg/L;

- Nitrate concentrations have been below the Australian Drinking Water Guideline value of 50mg/L which is the most stringent guideline value for water in Australia;

- Nitrite concentrations have been below the Australian Drinking Water Guideline value of 3mg/L;

- Sulphate concentrations in the groundwater are within the generally accepted stock watering guideline value of 1,000mg/L except for the groundwater from BYGW02.

The groundwater in its natural state is generally brackish to saline and of poor quality.

5.9 Ionic Speciation of Groundwater

Data on major cations and anions, as well as the physico-chemical parameters EC and pH are shown for the groundwater monitoring bores in the project area in Tables 11 and 12. These data were used to assess the ionic speciation of the groundwater by using the graphical Piper Diagram method.

Figure 7 shows the Piper Diagram for the Byerwen groundwater from October 2011.

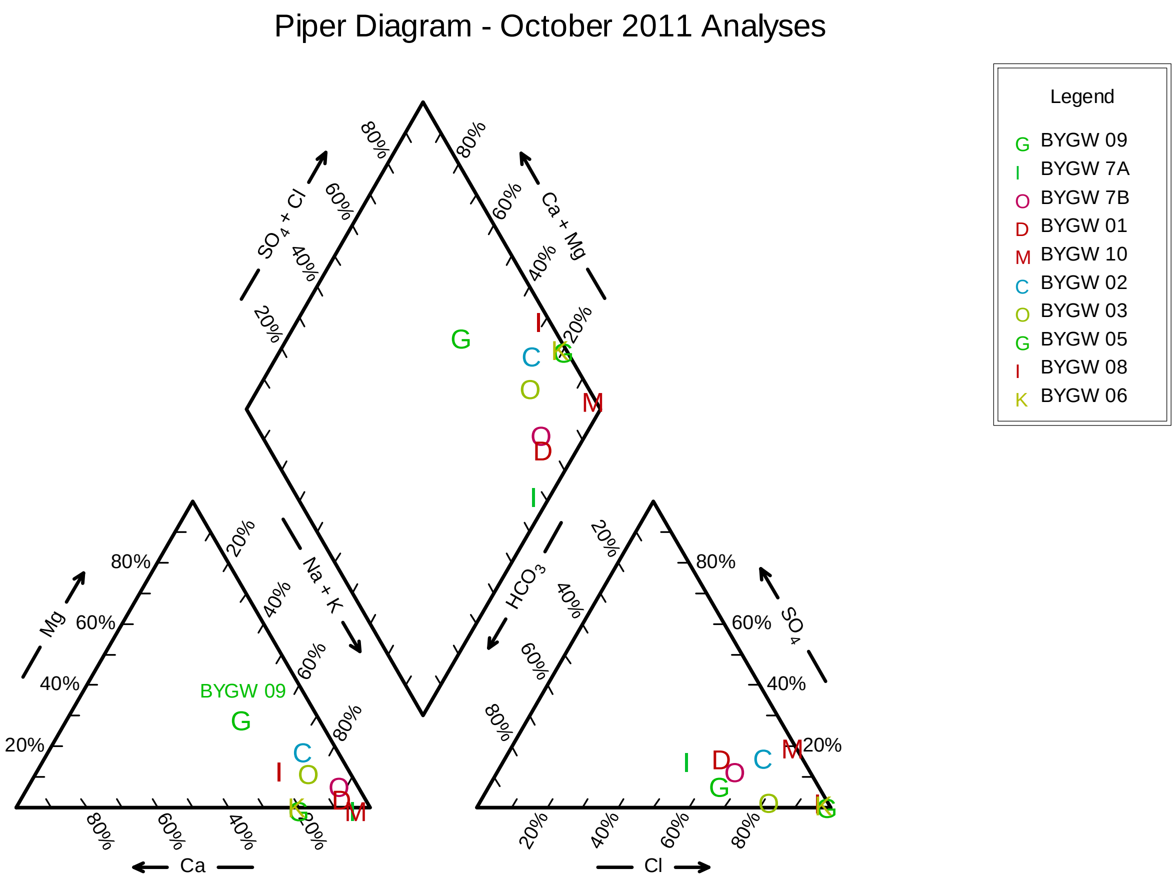


Figure 7: Piper Diagram for October 2011 Groundwater Chemical Analyses

The groundwater from all formations beneath the Byerwen MLAs is of the sodium chloride type.

5.10 Hydrocarbons in Groundwater

No groundwater related industries other than extraction for mine dewatering or agricultural use exist in the project area or adjacent to the project area, within the coal measure aquifers. As such, the presence of anthropogenic dissolved hydrocarbons within the groundwater in the area is considered extremely unlikely. Furthermore groundwater is in some instances being used for livestock watering and no naturally occurring hydrocarbons have been reported.

Accordingly hydrocarbon data was not prioritised as part of the initial baseline data set; however confirmatory groundwater sampling will be undertaken prior to commencement of mining to verify the absence of dissolved hydrocarbons in groundwater.

6.0 GROUNDWATER DEPENDENT ECOSYSTEMS

Groundwater Dependent Ecosystems (GDE) fall into four categories:

- Terrestrial GDE (woodlands dependent on shallow groundwater, and vegetation along dry riverbeds). There are no terrestrial GDE on the Byerwen Leases although they may exist along the Suttor River to the west of the Byerwen leases. It is considered that there is no groundwater - surface water interaction between the aquifer sequences beneath the Byerwen leases and the Suttor River alluvium so mining activities at Byerwen will have no impact on terrestrial GDE;

- River Baseflow GDE (ecosystems reliant on groundwater discharging to streams, springs, seeps and swamps). No springs, seeps or swamps are known on the Byerwen leases and there is no groundwater - surface water interaction between the aquifer sequences beneath the Byerwen leases and the watercourses that traverse the Byerwen leases. Mining activities at Byerwen will have no impact on river baseflow GDE;

- Aquifer GDE (ecosystems that exist in the subsurface, entirely dependent on groundwater). Stygofauna is subject to a separate study as part of the project EIS and is not discussed in this report.

- Wetland GDE. There are no records of wetland GDE in the Belyando Suttor river systems.

With the exception of stygofauna about which this report does not comment, it is concluded that there are no GDE which can be impacted by mining activities at Byerwen.

7.0 LEGISLATION

7.1 Water Resource (Burdekin Basin) Plan (2007)

The Water Resource (Burdekin Basin) Plan of 2007 applies only to surface water. There is currently no legislation or other water resource plan that refers to groundwater in the Belyando-Suttor section of the Burdekin Basin (which contains the Byerwen leases).

The groundwater component of this EIS is not considered to be directly relevant to any future Water Resource Plan for the Belyando-Suttor section of the Burdekin River catchment as the following apply:

- There is very little groundwater of any significance,

- The aquifers are in limited hydraulic connectivity and have low Hydraulic conductivity;

- The natural groundwater quality is poor;

- There is no groundwater - surface water interaction; and

- There are no GDE's which can be impacted by mining.

7.2 Great Artesian Basin Water Resource Plan

The groundwater component of this EIS has no relevance to the Great Artesian Basin (GAB) Water Resource Plan as the project area is many kilometres to the east of the closest section of the GAB (Figure 8).

Figure 8: Location of Byerwen Project Area in relation to the GAB

8.0 PIT GROUNDWATER INFLOW INITIAL ESTIMATES

Figure 9 shows the planned infrastructure of the project in relation to the Byerwen lease boundaries.

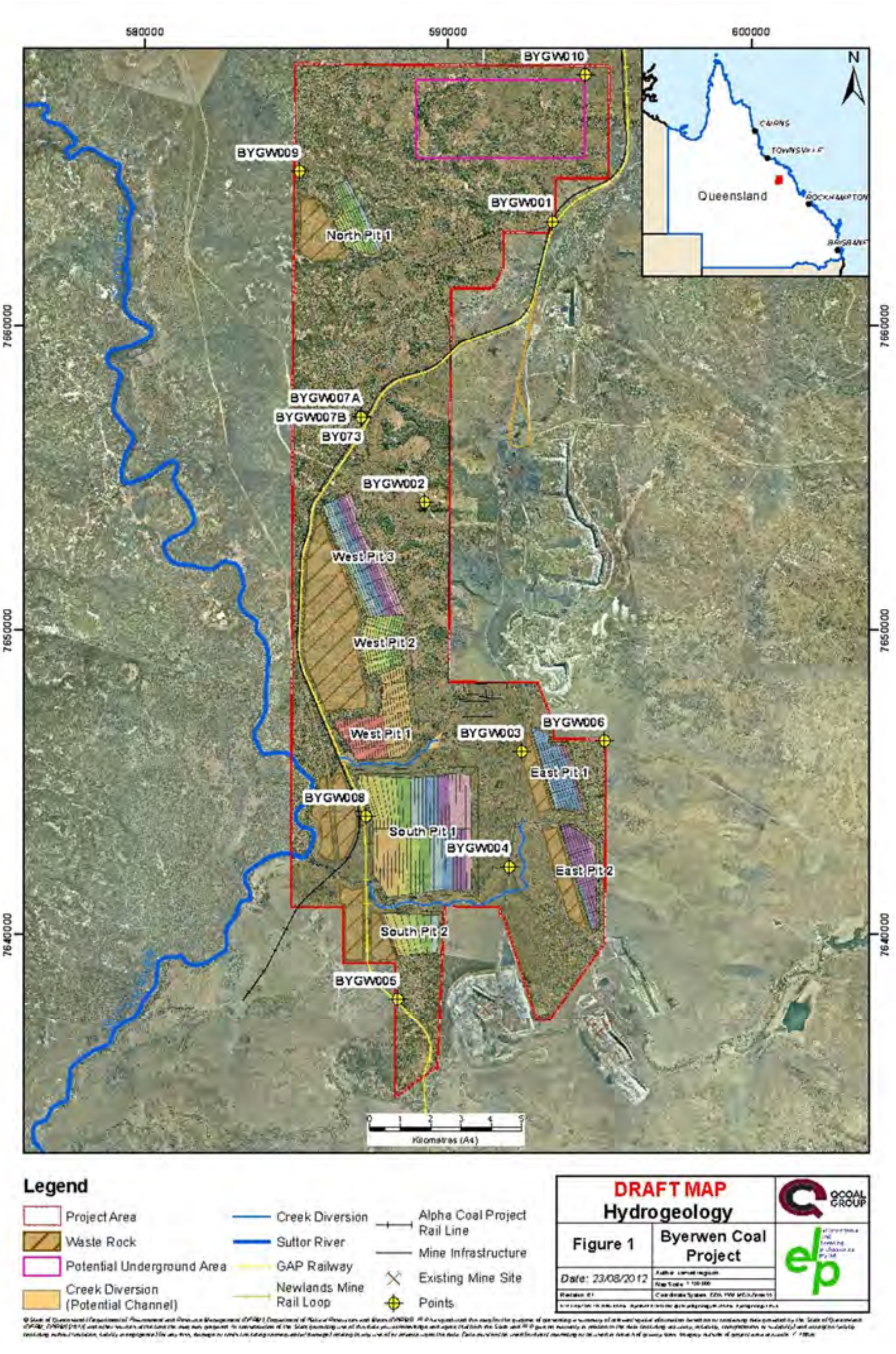


Figure 9: Planned Mining Pit Infrastructure for Byerwen Project

Estimates of groundwater inflow to the various pits were required as input to the water management strategy being developed by Kellogg Brown and Root as part of this EIS.

An analytical hydrogeological model using equations developed by Marinelli and Niccoli (2000)[7] were used to assess the impact on groundwater levels and the radius of influence of this impact for each scenario to be tested. Marinelli and Niccoli present modeling equations for estimation of the radius of influence of an open pit or excavation and groundwater inflow rates. This requires a simplification of the hydrogeological environment that can be used to provide a range of potential drawdown and pit inflow estimates.

The equations presented, model groundwater inflow from the pit walls, and from the base of the pit separately, based on the conceptual model presented in Figure 10.

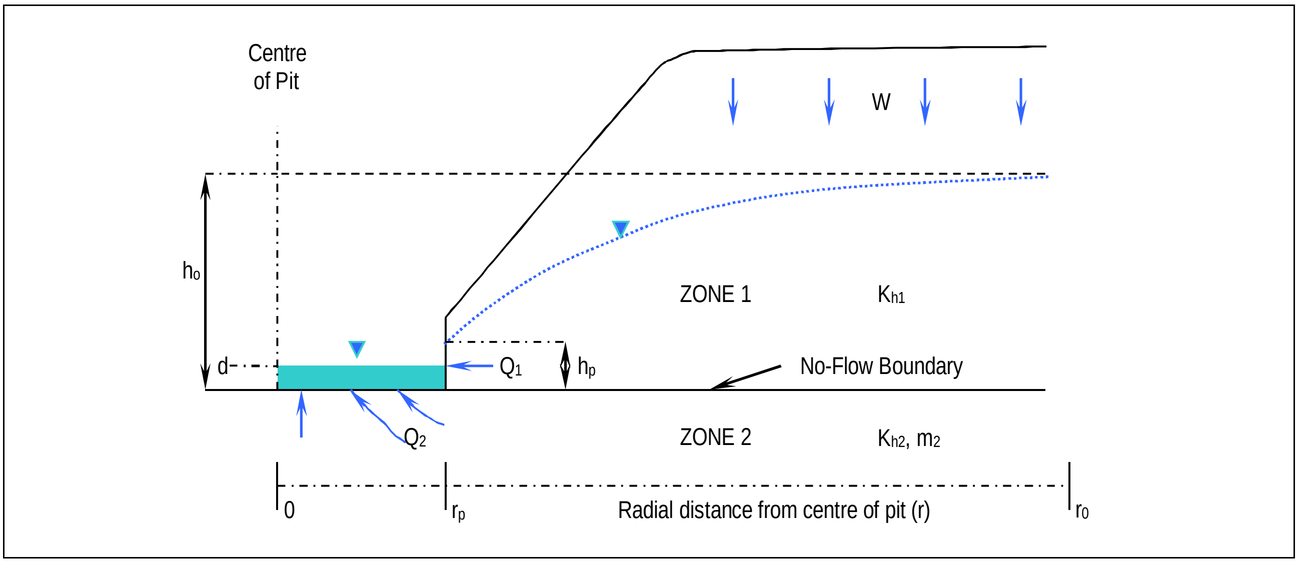


Figure 10: Pit Inflow Analytical Model Concepts (after Marinelli and Niccoli [2000])

Groundwater inflows were calculated for Zone 1 and Zone 2 using the following equations:

Zone 1 $$Q_1 = W \pi (r_o^2 - r_p^2) \qquad m^3/day$$

Zone 2 $$Q_2 = 4 r_p \left\langle \frac{K_{h2}}{m_2} \right\rangle (h_o - d)$$

$$m_2 = \sqrt{\frac{K_{h2}}{K_{v2}}}$$

where:

k_{h1} — *hydraulic conductivity value for the aquifer*

h_o — *saturated thickness of aquifer*

[7] Marinelli and Niccoli (2000). "Simple Analytical Equations for Estimating Groundwater Inflow to a Mine Pit", Vol 38, No. 2 - Ground water – March-April 2000 (pages 311-314)

W — *rainfall recharge rate*

h_p — *the height of the aquifer seepage face in the open excavation*

r_p — *equivalent radius of mine pit as a cylinder*

k_{v2} — *vertical hydraulic conductivity values for the aquifer*

d_o — *depth of water level in pit*

The extent of drawdown due to the nett groundwater loss then allows for determination of the radius of influence of the loss on the water table by iteration from the following equation:

$$h_0 = \sqrt{h_p^2 + \frac{W}{K_{h1}}\left[r_o^2 \ln\left(\frac{r_o}{r_p}\right) - \frac{(r_o^2 - r_p^2)}{2} \right]}$$

For Zone 1 (see Figure 10) the analytical solution considers steady-state, unconfined, horizontal, radial flow and assumes that:

- the excavation walls are approximated as a circular cylinder;
- groundwater flow is horizontal; the Dupuit-Forchheimer approximation is used to account for changes in saturated thickness due to depression of the water table;
- the static (pre-mining) water table is approximately horizontal;
- uniform distributed recharge occurs across the site as a result of surface infiltration from rainfall; all recharge within the radius of influence (cone of depression) of the excavation is assumed to be captured by the excavation;
- groundwater flow toward the excavation is axially symmetric.

Inflows from Zone 2 (see Figure 10) were not assessed as the majority of the groundwater inflow to the pits will occur within Zone 1 during pit development.

8.1 Hydraulic Conductivity (Permeability)

The data from the hydraulic conductivity tests discussed in Section 4.8 were used for the initial estimates of groundwater inflow to the proposed pits.

As previously discussed, the dedicated project groundwater monitoring bores range in depth from 52m bgl to 120m bgl, with AYL ranging from 0L/s to 10L/s.

There also exists airlift yield data for 25 coal exploration bores. These bores range in depth from 104 to 297m bgl. The airlift yields from those 25 bores range from 0L/s to 8.25L/s.

The ranges of airlift yield in the dedicated groundwater monitoring bores and in the coal exploration bores are similar. It is therefore reasonable to adopt the calculated hydraulic conductivity values from the dedicated groundwater monitoring bores as being representative for the purposes of this assessment.

Table 9 shows that the permeability values for all lithologies tested are relatively low (10^{-7} to 10^{-10} m/s) with the only exceptions being the Tertiary sand below the basalt in BYGW07A and the sandstone in BYGW03. These are regarded as being the exception rather than the rule.

The variations in calculated permeability explain the wide variations in ALY obtained by the exploration bores and reinforce the conclusion that fracture porosity, not primary porosity, is the dominant mechanism for groundwater accumulation and flow.

For the purposes of this assessment the geometric mean of the values for BYGW03, BYGW04, BYGW05, BYGW06 and BYGW08 (2.45×10^{-8} m/s) was used for inflow estimation to the South and East Pits and the geometric mean of the values for BYGW02, BYGW03 and BYGW08 (7.81×10^{-7} m/s) was used for inflow estimation to the West Pits.

It should be noted that bores BYGW03 and BYGW08 are common to both sets of bores used for calculating the geometric means. As the geometric means from each data set are one order of magnitude different, it was considered valid that inflow estimates should be carried out according to a low hydraulic conductivity scenario (using 2.45×10^{-8} m/s as the value for this scenario), and also according to a high hydraulic conductivity scenario (using 7.81×10^{-7} m/s as the value for this scenario), <u>for the East, West and South Pits</u> as they are all in reasonable proximity.

For the purposes of the inflow estimates to North Pit 1 the geometric mean of the values for BYGW01, BYGW09, and BYGW10 was used. This geometric mean is 1.28×10^{-7} m/s. As only these three bores were used for calculation of the geometric mean, only one hydraulic conductivity scenario (using 1.28×10^{-7} m/s as the value for this scenario) has been undertaken for North Pit 1

In summary, the hydraulic conductivity values used for the scenarios for the Byerwen Pits are as shown in Table 14:

TABLE 14: HYDRAULIC CONDUCTIVITY VALUES USED FOR INFLOW ESTIMATES

	Low hydraulic conductivity	***High hydraulic conductivity***
North Pit	Not applicable	1.28×10^{-7} m/s
South Pits	2.45×10^{-8} m/s	7.81×10^{-7} m/s
East Pits	2.45×10^{-8} m/s	7.81×10^{-7} m/s
West Pits	2.45×10^{-8} m/s	7.81×10^{-7} m/s

8.2 Recharge Flux

The distributed recharge flux was assessed using data from the Bureau of Meteorology Station 33013 Collinsville Post Office as shown in Table 15.

Although rainfall - recharge response data is limited, the available data showed a lack of significant response in groundwater levels in the groundwater monitoring bores over the 2011-2012 wet season and thereafter. This is expected and is typical of the hydrogeology of the area as discussed in Section 5.7. Based on similar aquifers in the area it is considered that only 1% of wet season rainfall results in recharge to the deep aquifers. This factor has been adopted for this assessment.

TABLE 15: ASSESSMENT OF RECHARGE FLUX

Month	Mean monthly rainfall (mm)	Mean monthly evaporation (mm)	Rainfall > evaporation	Recharge at 1% of rainfall (mm)
Jan	134.8	186.0	no	1.348
Feb	162.3	156.8	yes	1.623
Mar	97.8	161.2	no	0.978
Apr	42.3	132.0	no	
May	32.4	105.4	no	
Jun	27.2	87.0	no	
Jul	20.3	99.2	no	
Aug	17.8	127.1	no	
Sep	11.4	159.0	no	
Oct	21.6	198.4	no	
Nov	51.8	207.0	no	
Dec	96.8	210.8	no	

Recharge flux ***3.95E-03 m/annum***
Recharge flux ***1.25078E-10 m/s***

8.3 Inflow Estimates

Inflow estimates were assessed for the various pits according to their floor levels for successive stages of development. The pit floor levels were supplied by Minserve and they are shown in Table 16. Note that the abbreviations NP, SP, EP, WP are used for North Pit, South Pit, East Pit and West Pit respectively. The numeric suffix refers to the respective pit number in each group of pits.

TABLE 16: BYERWEN PIT FLOOR LEVELS FOR STAGES OF PIT DEVELOPMENT			
APPROXIMATE BYERWEN FLOOR LEVELS (mAHD)			***COMMENTS***
YEAR 1			Basal Seam
Pit	Floor RL	Adjacent Topo	
WP1	240	300	GYMD
YEAR 3			
Pit	Floor RL	Adjacent Topo	
WP1	230	315	GYMD
SP1	205	290	Note: Pit not yet at Floor - Mining Bench RL 205
YEAR 5			
Pit	Floor RL	Adjacent Topo	
WP1	185	300	GYMD
SP1	135	290	GYLO
YEAR 10			
Pit	Floor RL	Adjacent Topo	
WP1	90	310	GYMD
SP1	80	290	GYLO
SP2	220	300	GYLO
YEAR 16- North Pit Only			
Pit	Floor RL	Adjacent Topo	
NP1	175	280	GYMD
YEAR 25			
Pit	Floor RL	Adjacent Topo	
WP1	Backfilled		
WP2	50	305	GYLO
WP3	220	310	GYLO
SP1	25	300	GYLO
SP2	70	300	GYLO
EP1	270	305	LEICHHARDT
NP1	100	300	GYMD
YEAR 46			
Pit	Floor RL	Adjacent Topo	
WP1	Backfilled		
WP2	Backfilled		
WP3	82	295	GYLO
SP1	-80	300	GYLO
SP2	Backfilled		
EP1	Backfilled		
EP2	191	315	LEICHHARDT
NP1	80	300	GYMD

The inflow estimates for the East, West and South Pits, calculated using the Zone 1 equation, are shown in Tables 17 and 18.

TABLE 17: PIT INFLOW ESTIMATES FOR THE LOW HYDRAULIC CONDUCTIVITY CASE					
	Pit	***Bottom level mAHD***	***Inflow m^3/day***	***Inflow L/s***	***Comments***
Year 25	East Pit 1	270	0	0.00	above Water table
Year 46	East Pit 2	191	13	0.15	
Year 03	South Pit 1	205	9	0.10	
Year 05	South Pit 1	135	44	0.51	
Year 10	South Pit 1	80	84	0.97	
Year 25	South Pit 1	25	135	1.57	
Year 46	South Pit 1	-80	260	3.01	
Year 10	South Pit 2	220	4	0.05	
Year 25	South Pit 2	70	92	1.06	
Year 01	West Pit 1	240	4	0.04	
Year 03	West Pit 1	230	6	0.07	
Year 05	West Pit 1	185	24	0.28	
Year 10	West Pit 1	90	90	1.04	
Year 25	West Pit 2	50	14	0.16	
Year 25	West Pit 3	220	9	0.10	
Year 46	West Pit 3	82	96	1.12	

TABLE 18: PIT INFLOW ESTIMATES FOR THE HIGH HYDRAULIC CONDUCTIVITY CASE

	Pit	***Bottom level mAHD***	***Inflow m^3/day***	***Inflow L/s***	***Comments***
Year 25	East Pit 1	270	0	0.00	Above water table
Year 46	East Pit 2	191	76	0.88	
Year 03	South Pit 1	205	116	1.34	
Year 05	South Pit 1	135	750	8.67	
Year 10	South Pit 1	80	1547	17.90	
Year 25	South Pit 1	25	2630	30.42	
Year 46	South Pit 1	-80	5307	61.39	
Year 10	South Pit 2	220	44	0.51	
Year 25	South Pit 2	70	1712	19.80	
Year 01	West Pit 1	240	33	0.39	
Year 03	West Pit 1	230	76	0.88	
Year 05	West Pit 1	185	392	4.54	
Year 10	West Pit 1	90	1688	19.52	
Year 25	West Pit 2	50	22	0.25	
Year 25	West Pit 3	220	129	1.49	
Year 46	West Pit 3	82	1822	21.08	

It is considered that the low permeability case is more pertinent to the East, West and South Pits.

Table 19 shows the inflow estimates for North Pit 1 also using the Zone 1 equation.

TABLE 19: PIT INFLOW ESTIMATES NORTH PIT 1					
	Pit	***Bottom level mAHD***	***Inflow m^3/day***	***Inflow L/s***	***Comments***
Year 16	North Pit 1	175	70	0.81	
Year 25	North Pit 1	100	256	2.97	
Year 46	North Pit 1	80	320	3.70	

8.4 Estimate of Extent of Drawdown

The Marinelli and Niccoli method is considered a highly suitable analytical hydrogeological model for the estimation of potential drawdown associated with the project dewatering activities. The suitability of this model for project planning is further reinforced by the highly conservative assumption that groundwater inflow to the pit is axially symmetric. In reality this is an oversimplification of the data in Table 7, where the airlift yields show that the aquifers are evidently not symmetric, but rather they appear highly heterogeneous. This is reinforced by groundwater inflow observations to most open pit coal mines in the north Bowen Basin where there is often many metres separating discrete pit inflows.

Based on the mine planning calculations, South Pit 1 in Year 46 will have a maximum depth of 380 mbgl which is nominally 320m below the existing water table. This is the most extensive pit of all of the Byerwen Pits. This is considered to be the 'worst-case scenario'.

The dimensions of the deepest bench of South Pit 1 in Year 46 are approximately 3,600m long and 160m wide. Therefore, the assumed effective radius of the disk sink is about 1200m (being the radius at which the circumference of the assumed exposed disk matches the actual planned bench/wall distance as a rectangle). Given the highly conservative nature of this model and the previous assumptions made, this assumed radial value is considered suitable.

As stated above it is considered that the low permeability case is more pertinent to the South Pit. Figure 11 is a chart of the estimated drawdown from the pumping sump of the South Pit at its full development. As this pit will be progressively developed and deepened from west to east, the pumping sump for the scenario illustrated in Figure 10 will be at the furthest eastern extent of the South Pit. Figure 12 is a pictorial representation of the estimated extent of maximum drawdown under this scenario.

Obviously drawdown will be at its maximum i.e. 320m below the existing water table at the pumping sump within the pit, and will gradually diminish as distance from the pit increases. Based on these calculations the South Pit will induce drawdown to a distance of 2,300m. There are no groundwater users, GDE or hydraulic connections to the Suttor River within that radial distance.

Ultimately the dedicated groundwater monitoring bores will be used to accurately measure any actual drawdown impacts of the pits as they are developed.

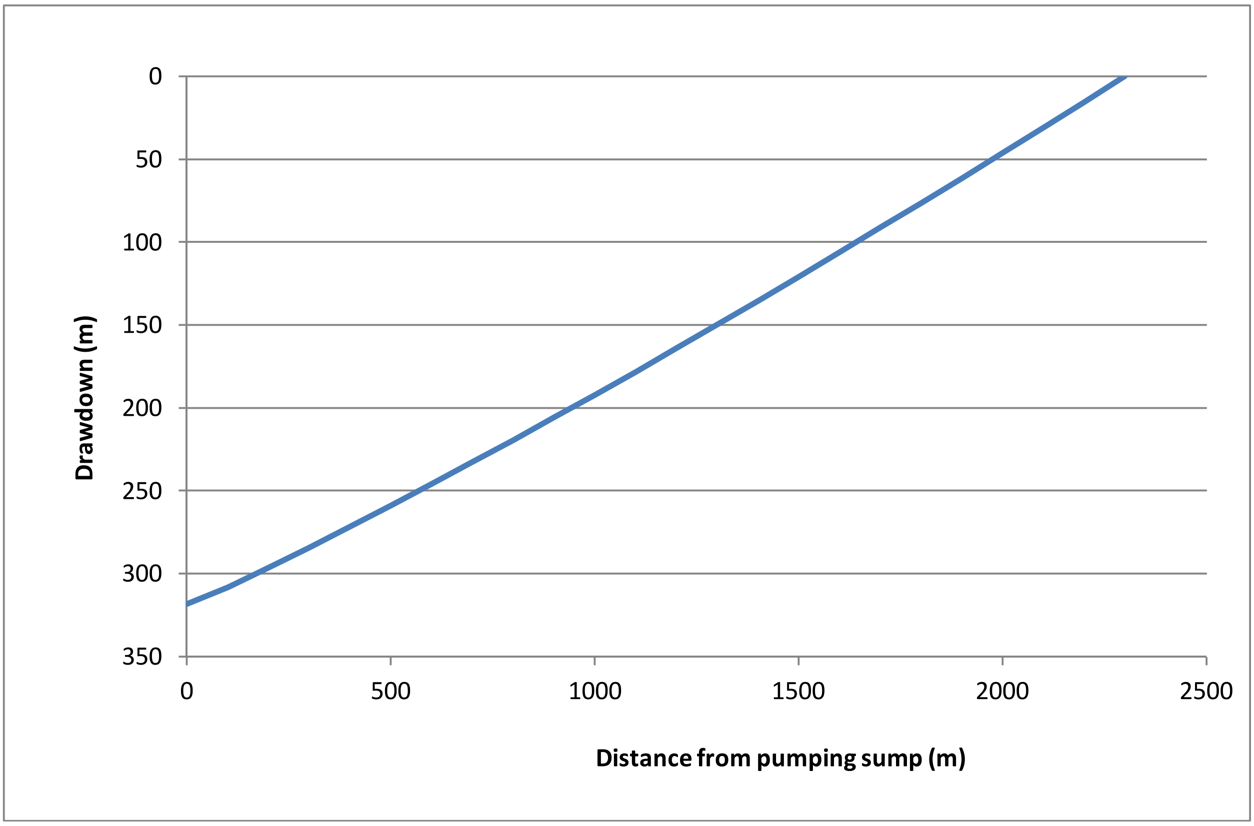


Figure 11: Estimated Drawdown with Distance from South Pit at Full Pit Development

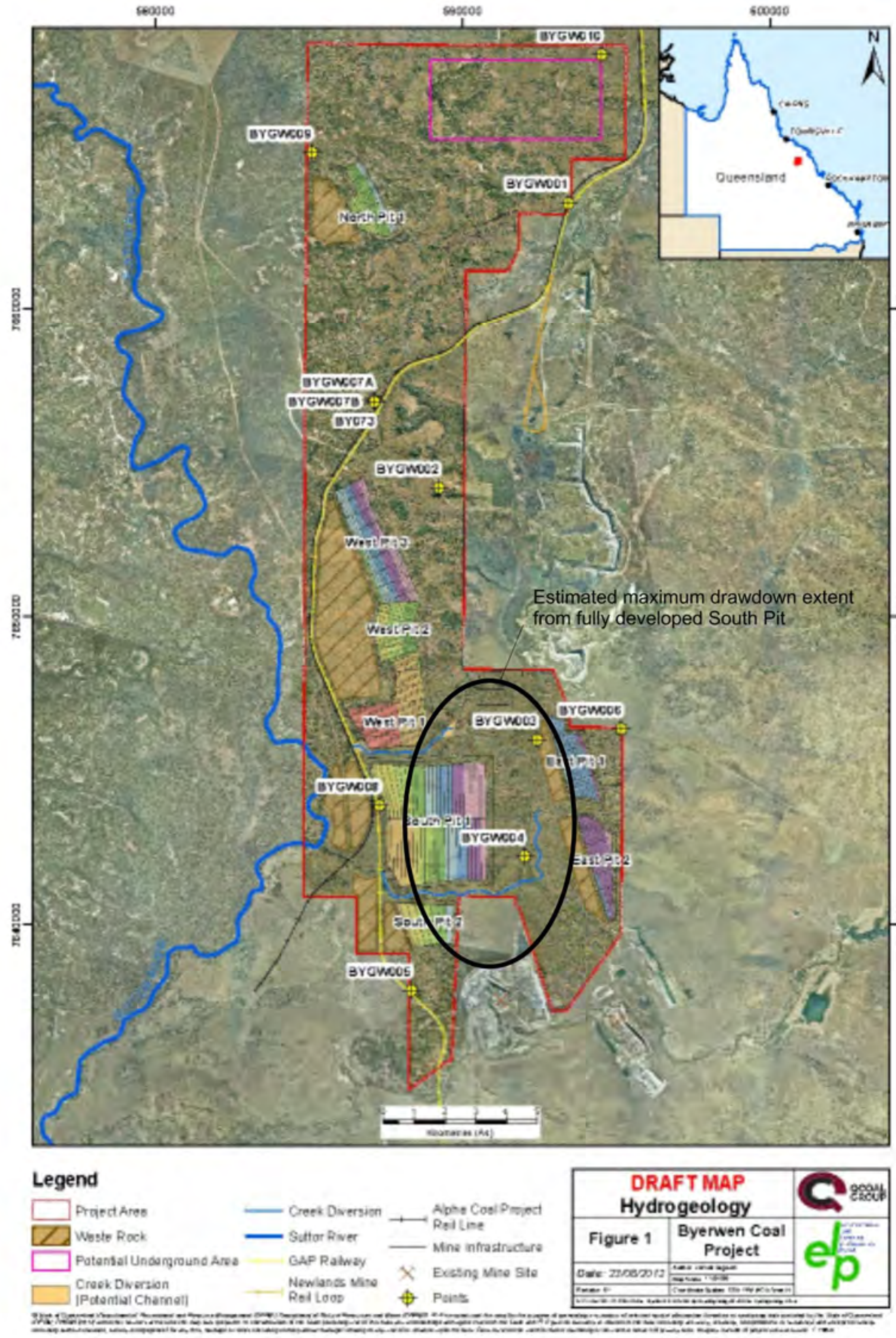


Figure 12: Estimated Drawdown Impact of South Pit at Full Pit Development

8.5 Limitations

The inflow estimates above are based on data from widely distributed bores that do not necessarily penetrate to the full depth of the proposed pits. However, the results from these bores have been noted as being of the appropriate order of magnitude for similar coal measures elsewhere in the Bowen Basin. Given the highly conservative methodology and assumptions, the inflow estimates are therefore considered suitable for interpretation and water management planning.

An additional measure of conservatism within the inflow estimates, is that the inflow estimates shown above are based on pristine water table conditions and are therefore high. Inflow volumes will almost certainly decrease significantly (to be less that the estimates shown) as the potentiometric surface declines with development of the site.

It is noted that depressurization of the potentiometric surface will occur as the pits develop.

9.0 PROJECT IMPACTS ON PRIVATE GROUNDWATER FACILITIES

9.1 Regional Groundwater Level Drawdown

Owing to their proximity to the Byerwen leases it is conceivable that bores 25633, 25638, 25686, 60458, 60459, 100092 and 100274 (shown in Figure 3) could be impacted by the project. The expected impact on each of the bores is discussed below:

- RN 25633 is located approximately 10km to the north-north-east of proposed North Pit. The bore is only 18.3m deep and extracts groundwater from a 'rock hole'. It is considered to be too far away from North Pit to be impacted by that pit. Groundwater levels in this area will be detected by BYGWB10.

- RN 25636 is located approximately 9km to the north-east of proposed North Pit. The bore is only 37.2m deep and extracts groundwater from coal measures aquifers. It is considered to be too far away from North Pit to be impacted by that pit. Groundwater levels in this area will be detected by BYGWB10.

- RN 25638 is located approximately 8km to the north-east of proposed North Pit. The bore is only 16.4m deep and probably extracts groundwater from basalt aquifers. It is considered to be too far away from North Pit to be impacted by that pit. Groundwater levels in this area will be detected by BYGWB10.

- RN60458 is located on the eastern boundary of the Byerwen project. Its use status is not known. It was formerly a mineral exploration bore. It is located approximately 5km to the east-north-east of proposed West Pit 3. This bore could be impacted by depression on the regional water table as it is mid-way between the Newlands mine pits to its east and proposed West Pit 3. The use status of the bore should be confirmed and groundwater levels should be measured in RN 60458 when mining at West Pit 3 commences. Groundwater monitoring bore BYWWB02 is well located to monitor groundwater level and groundwater quality impacts on RN 60458.

- RN60459 is located well to the east of the Byerwen project. Its use status is not known. It was formerly a mineral exploration bore. It is located east of the Newlands mine pits and any impacts on that bore would result from that mine. It is assessed that RN 60549 will not be impacted by the Byerwen project.

- RNs 100092 and 10274 are located about 5km to the east of the proposed East Pits of the Byerwen project. Their use status is not known. They were formerly a mineral exploration bore. They are also located very close to each other and would likely interfere with each other when pumping simultaneously, if they are equipped. There is some potential for these bores to be impacted by depression on the regional water table when the East Pits are developed, however regional water table depressurisation should already have occurred as a result of the Newlands (to the north) and Suttor Creek (to the south) mine pits. Groundwater monitoring bore BYGW06 is ideally located to assess groundwater level and groundwater quality impacts on these bores if they were to occur.

The following general aspects apply in regard to potential impacts of mining at Byerwen to private groundwater facilities:

- There are few privately owned groundwater facilities close to the Byerwen MLAs;

- There is in generally very sparse information available for those bores;

- The groundwater discharge from these bores is relatively meagre and would only sustain domestic or stock water uses;

- The groundwater quality from RN 25686 is, in general, only suitable for stockwatering, being naturally too high in chloride and sulphate for human consumption.

As there is only stock-watering use of groundwater in the Byerwen MLA vicinity, use of groundwater for infrastructure development or dewatering from any mining infrastructure on the Byerwen leases is expected to have little or no impact on neighbouring landholders.

In the unlikely event of regional depressurisation of the water table, the dedicated Byerwen groundwater monitoring bores are well located to measure those impacts.

RNs 25633, 25638, 25686, 60458, 60459, 100092 and 100274 should be measured for their groundwater level and groundwater quality before mining at Byerwen commences to establish their groundwater status at that time. It would be prudent to obtain quarterly measurements of groundwater level and groundwater quality in these bores for twelve months after nearby mining commences to assess whether the groundwater in these private groundwater facilities is impacted.

9.2 Groundwater Vulnerability to Pollution

The vulnerability to pollution of any aquifer is directly related to:

- Hydraulic condition (confined or unconfined);

- Proximity to the pollutant source; and

- Hydraulic conductivity of the subsurface sequence.

Alluvium

The unconfined to semi-confined Suttor Formation is predominantly clayey and therefore of low It has been demonstrated in previous discussion that there are no alluvial aquifers present on the Byerwen leases. Pollution of the groundwater in this aquifer formation from surface activities is therefore not possible.

The vulnerability to pollution of this formation from surface activities is considered to be low.

Suttor Formation

The unconfined to semi-confined Suttor Formation is predominantly clayey and therefore of low bulk hydraulic conductivity. It already contains saline groundwater (as evidence by NRM groundwater monitoring bore RN 12030094. The groundwater quality in the bore is very poor with a total dissolved solids content of 6,200mg/L.

The groundwater quality in this bore is typical of groundwater from the Suttor Formation.

The vulnerability to pollution of the groundwater in this aquifer formation from surface activities is considered to be low.

Tertiary Sands below Basalt

The confined Tertiary sands below the basalt occur in 'shoestring' aquifers. The groundwater quality in BYGW07A is mildly brackish with total dissolved solids content of 300 to 1,300mg/L. The Tertiary sands are confined beneath a significant thickness of fresh basalt which provides a barrier to the direct ingress of pollution from surface activities.

The vulnerability to pollution of the groundwater in this aquifer formation from surface activities is considered to be low.

Coal Seam Aquifers

The confined coal seam aquifers are both discontinuous and of low hydraulic conductivity. The groundwater quality in the coal seam aquifers is naturally very poor as shown in Tables 11 and 12.

The vulnerability to pollution of the groundwater in this aquifer formation from surface activities is considered to be low.

10.0 GROUNDWATER ENVIRONMENTAL VALUES

Table 13 identifies the groundwater environmental values, potential threats to those values and management needs associated with the Byerwen project.

TABLE 13: GROUNDWATER VALUES – BYERWEN PROJECT			
Value	***Description***	***Potential Threats***	***Management Requirements***
Groundwater Use	• Bores in the region are used for stock-watering • Groundwater use will be minor as aquifers generally yield meagre quantities of poor quality water	• Groundwater contamination from chemical spills and tailings storage dam • Reduction in available groundwater resource for stock-watering	• Adoption of sound chemical handling, storage and spill clean up procedures will minimise impact on groundwater quality • Monitoring of groundwater levels and groundwater quality in dedicated groundwater monitoring bore suite (and selected private groundwater facilities both before and for one year after mining commences). • Maintain minimum use of groundwater for the project
Hydrological	• Groundwater exchange with watercourses • Dewatering during mining unlikely to impact on groundwater levels	• Assessed to be minimal owing to location of water table and incision depths of streams. • Only minor dewatering of the coal seams is likely to be required, owing to measured very low hydraulic conductivity	• Maintain minimum use of groundwater for the project • Groundwater inflow to open pits expected to be minimal based on low measured hydraulic conductivity data Measure and record inflows as they are encountered. • Continue monitoring of groundwater levels around site as mining proceeds. • Review results of groundwater level and groundwater quality monitoring on an annual basis, in the form of a borefield performance review

TABLE 13: GROUNDWATER VALUES – BYERWEN PROJECT			
Value	***Description***	***Potential Threats***	***Management Requirements***
			report.
Surface water quality	• Escape of poor quality groundwater at the surface	• Contaminated groundwater discharge may impact on surface water	• Assessed that groundwater – surface water exchange is only likely to occur during wet season • Do not construct infrastructure that can cause ground water contamination within 50m of any watercourse. • Implement bund wall diversions • Continue groundwater quality monitoring in dedicated groundwater monitoring bore suite.

11.0 GROUNDWATER MONITORING STRATEGY

The following monitoring strategy should be implemented by Byerwen Coal:

- The groundwater monitoring bore suite should consist of the following bores
  - BYGW01
  - BYGW02
  - BYGW03
  - BYGW04
  - BYGW05
  - BYGW06
  - BYGW07A
  - BYGW07B
  - BYGW08
  - BYGW09
  - BYGW10

- Groundwater levels should be measured and recorded in all the groundwater monitoring bores at quarterly intervals;

- Automatic water level data loggers should remain in BYGWB05, BYGW07A and BYGW09. It is sufficient for these data loggers to capture daily groundwater levels;

- RNs 25633, 25638, 25686, 60458, 60459, 100092 and 100274 should be measured for their groundwater level and groundwater quality before mining at Byerwen commences to establish their groundwater status at that time. It would be prudent to obtain quarterly measurements of groundwater level and groundwater quality in these bores for twelve months after nearby mining commences to assess whether the groundwater in these private groundwater facilities is impacted;

- Groundwater samples should be retrieved at minimum quarterly intervals to increase the data set and allow more robust statistical analysis of data;.;

- The dedicated groundwater monitoring bores should continue to be sampled in accordance with the Water Quality Sampling Manual produced by the Department of Environment and Resource Management[8].;

- All groundwater samples should be submitted to a NATA accredited laboratory for analysis of the parameters shown in tables 11 and 12.

- Daily rainfall should be measured and recorded;

- The data from the groundwater monitoring bores should be reviewed by Byerwen staff at minimum six-monthly intervals;

- A borefield performance review report should be undertaken annually.

Rob Lait and Associates Pty Ltd

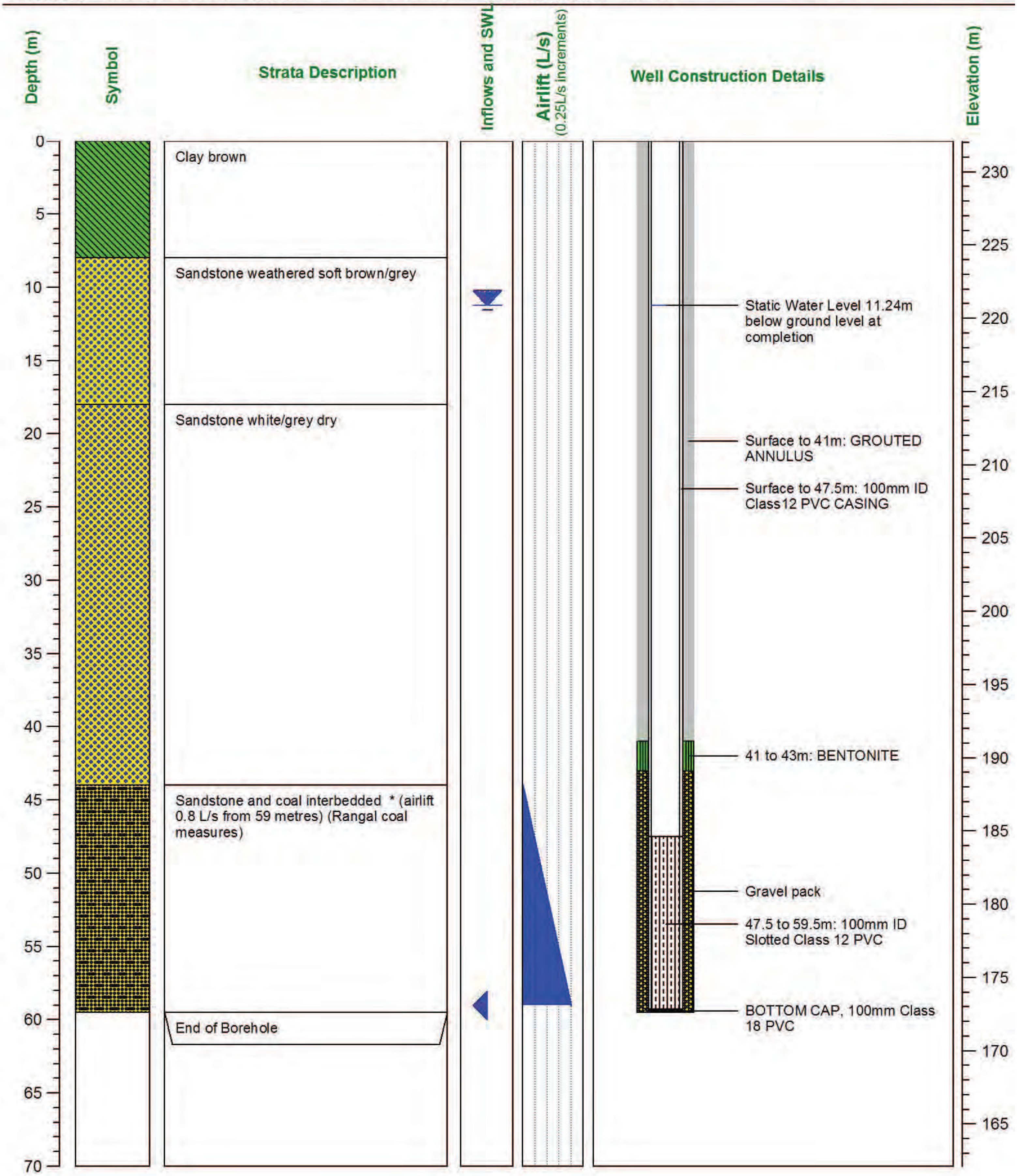
ROB LAIT
Principal Hydrogeologist

[8] Department of Environment and Resource Management, Water Quality and Sampling Manual 2009, Version 1, September 2009.

Borehole No: BYGW1

Client: Byerwen Coal Pty Ltd

Location:	Byerwen	**Date Drilled:**	**19/9/2011**	**Project:**	184
Easting:	593438	**Northing:**	766430	**GL Elev (m):**	232.12
Method:	Rotary Air Blast	**Driller:**	Serra Drilling	**Drilling Rig:**	IRT4W



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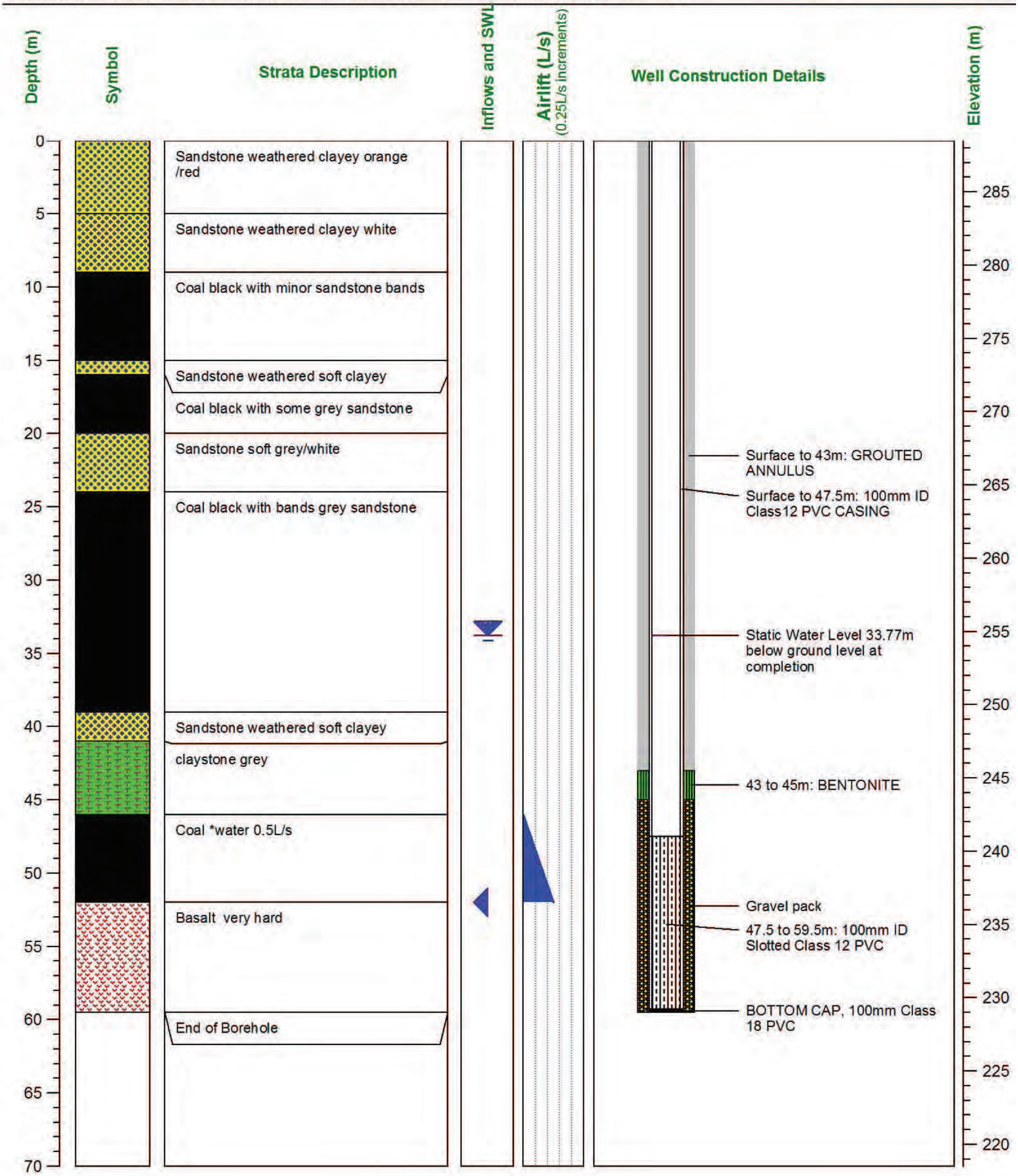
Datum:GDA94

Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: BYGW02 | **Client: Byerwen Coal Pty Ltd**

Location:	Byerwen	**Date Drilled:**	**8/9/2011**	**Project:**	184
Easting:	589229	**Northing:**	7654175	**GL Elev (m):**	288.505
Method:	Rotary Air Blast	**Driller:**	Serra Drilling	**Drilling Rig:**	IRT4W



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Notes:

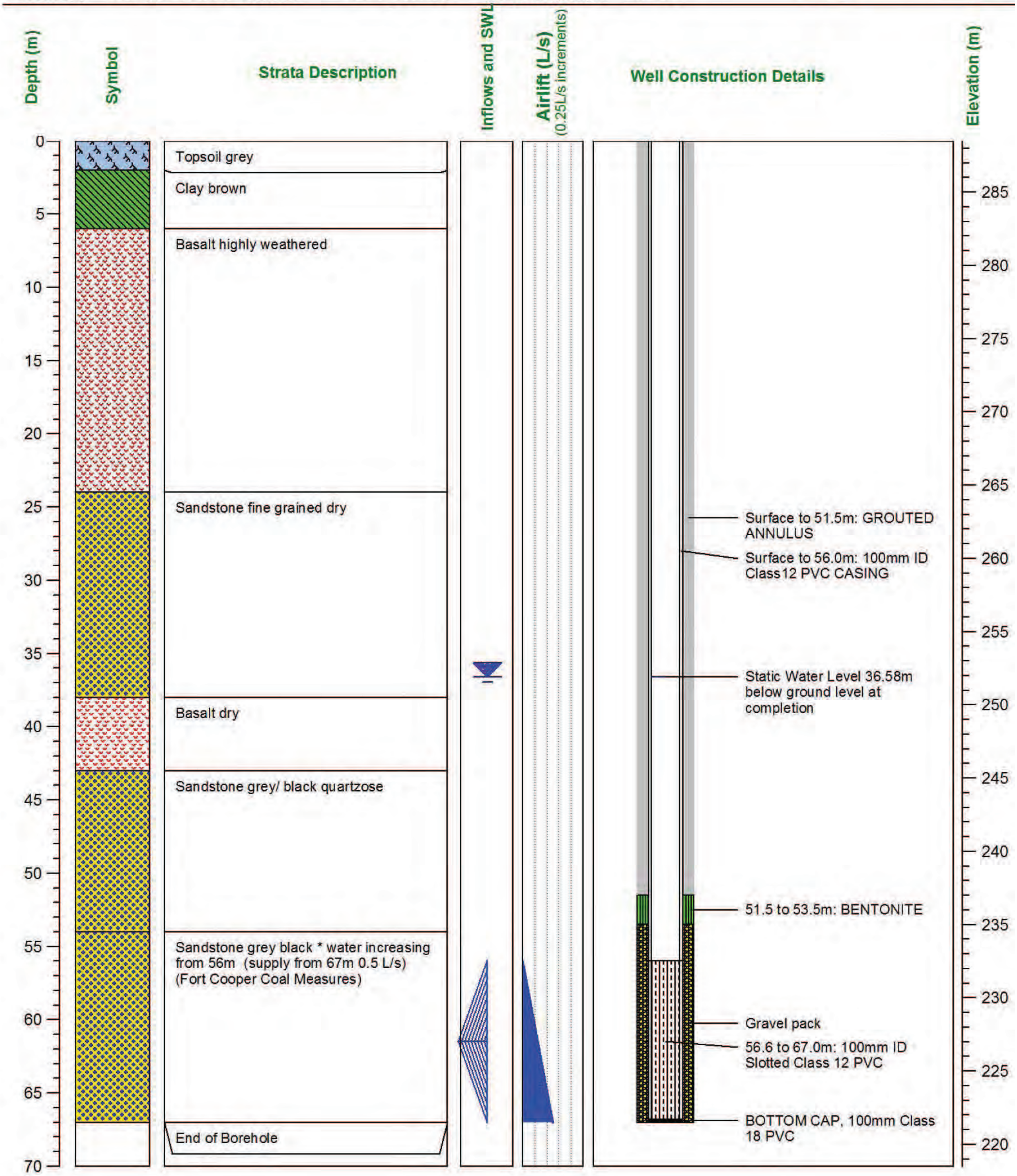
Datum:GDA94/AHD

Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: BYGW03

Client: Byerwen Coal Pty Ltd

Location:	Byerwen	**Date Drilled:**	**8/9/2011**	**Project:**	184
Easting:	592422	**Northing:**	7645985	**GL Elev (m):**	304.939
Method:	Rotary Air Blast	**Driller:**	Serra Drilling	**Drilling Rig:**	IRT4W



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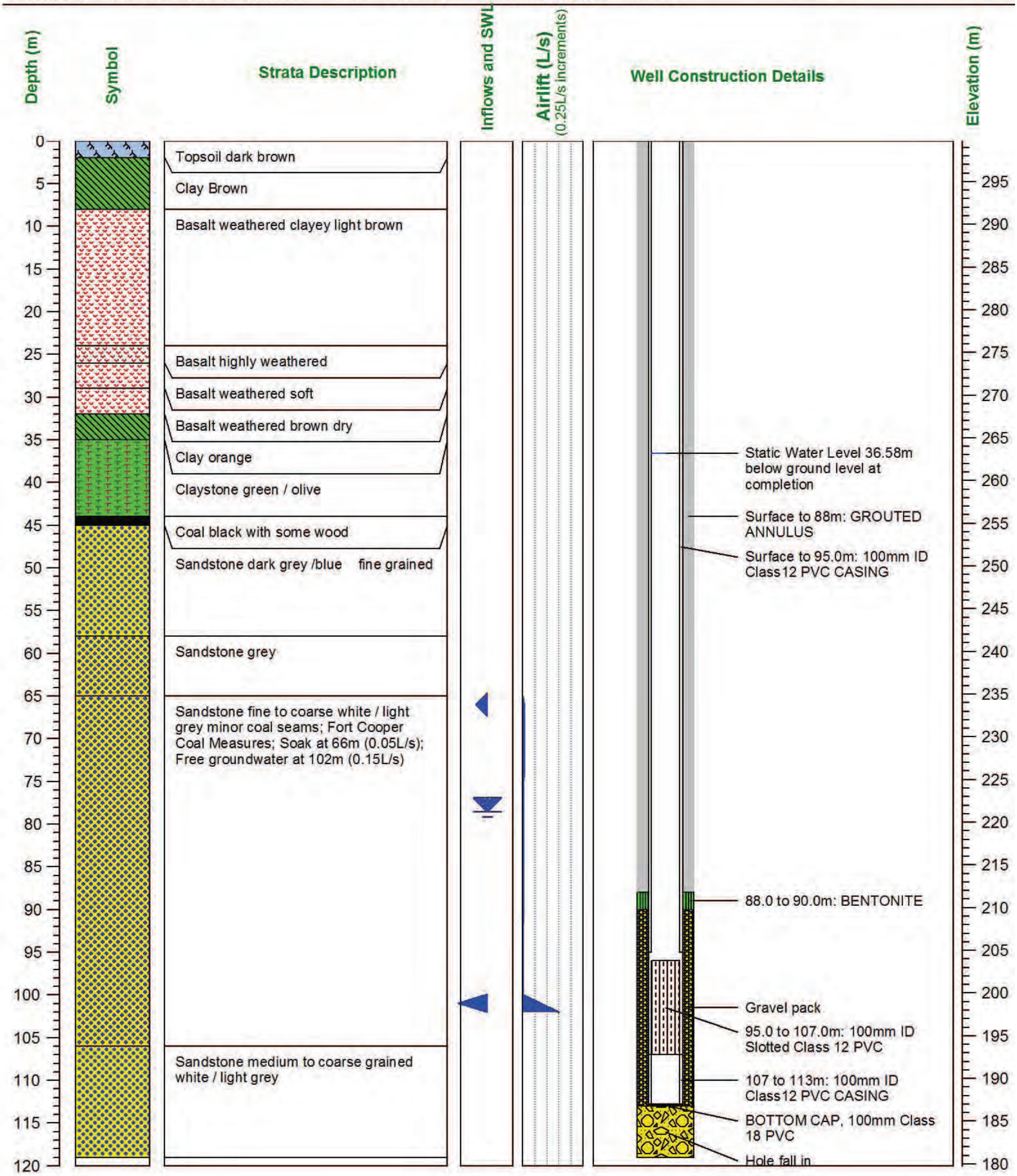
Notes:

Datum:GDA94/AHD

Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: BYGW04 **Client: Byerwen Coal Pty Ltd**

Location:	Byerwen	**Date Drilled:**	**6/9/2011**	**Project:**	184
Easting:	591997	**Northing:**	7642215	**GL Elev (m):**	299.773
Method:	Rotary Air Blast	**Driller:**	Serra Drilling	**Drilling Rig:**	IRT4W



Notes:

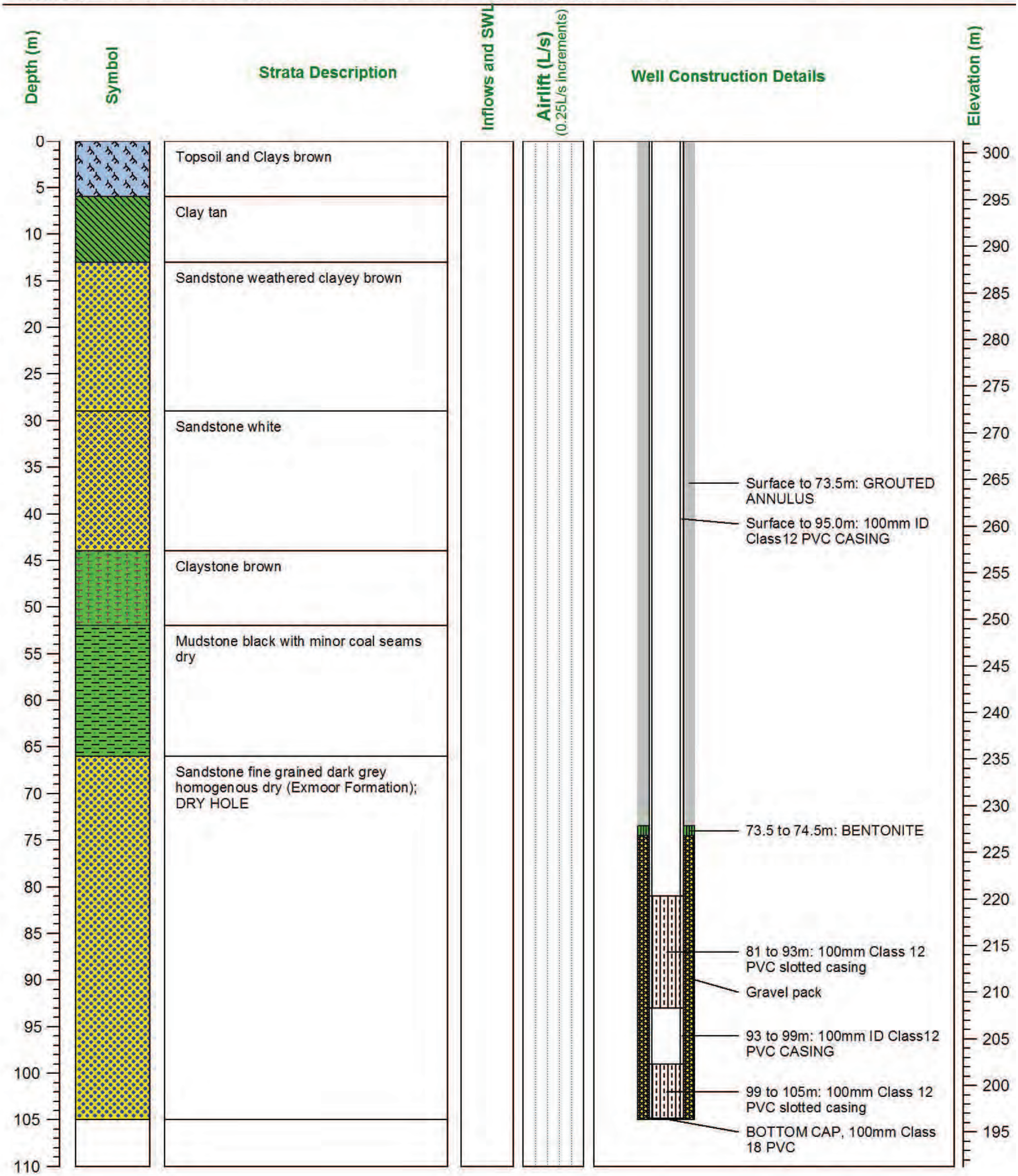
Datum:GDA94/AHD

Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: BYGW05

Client: Byerwen Coal Pty Ltd

Location:	Byerwen	**Date Drilled:**	**16/9/2011**	**Project:**	184
Easting:	588323	**Northing:**	7637881	**GL Elev (m):**	301.311
Method:	Rotary Air Blast	**Driller:**	Serra Drilling	**Drilling Rig:**	IRT4W



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Notes:

Datum:GDA94/AHD

Byerwen Coal Project
Strata description compiled by Alan McDonald

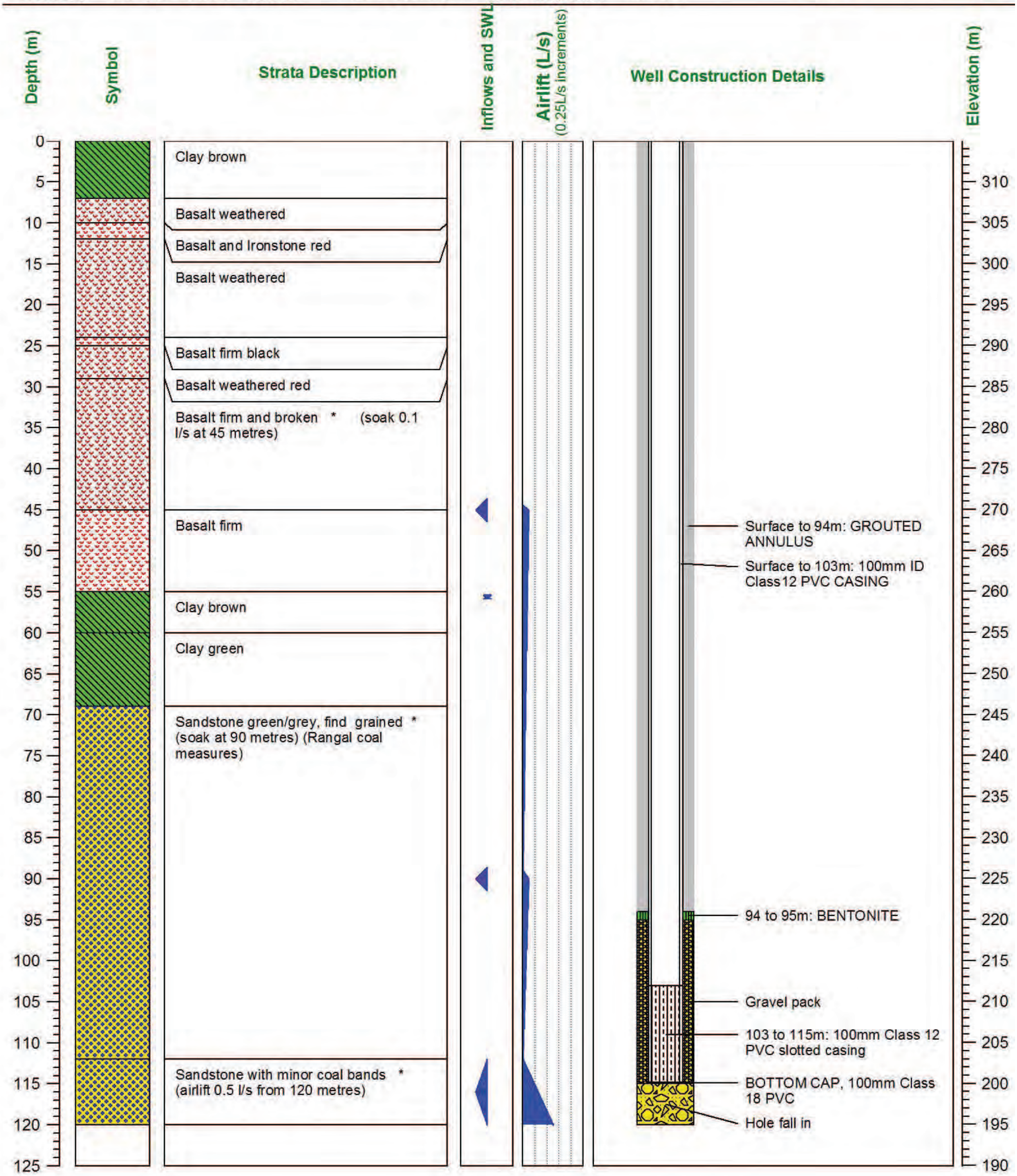
Borehole No: **BYGW06**

Client: **Byerwen Coal Pty Ltd**

Location: Byerwen **Date Drilled:** 14/9/2011 **Project:** 184

Easting: 595167 **Northing:** 7646339 **GL Elev (m):** 314.946

Method: Rotary Air Blast **Driller:** Serra Drilling **Drilling Rig:** IRT4W



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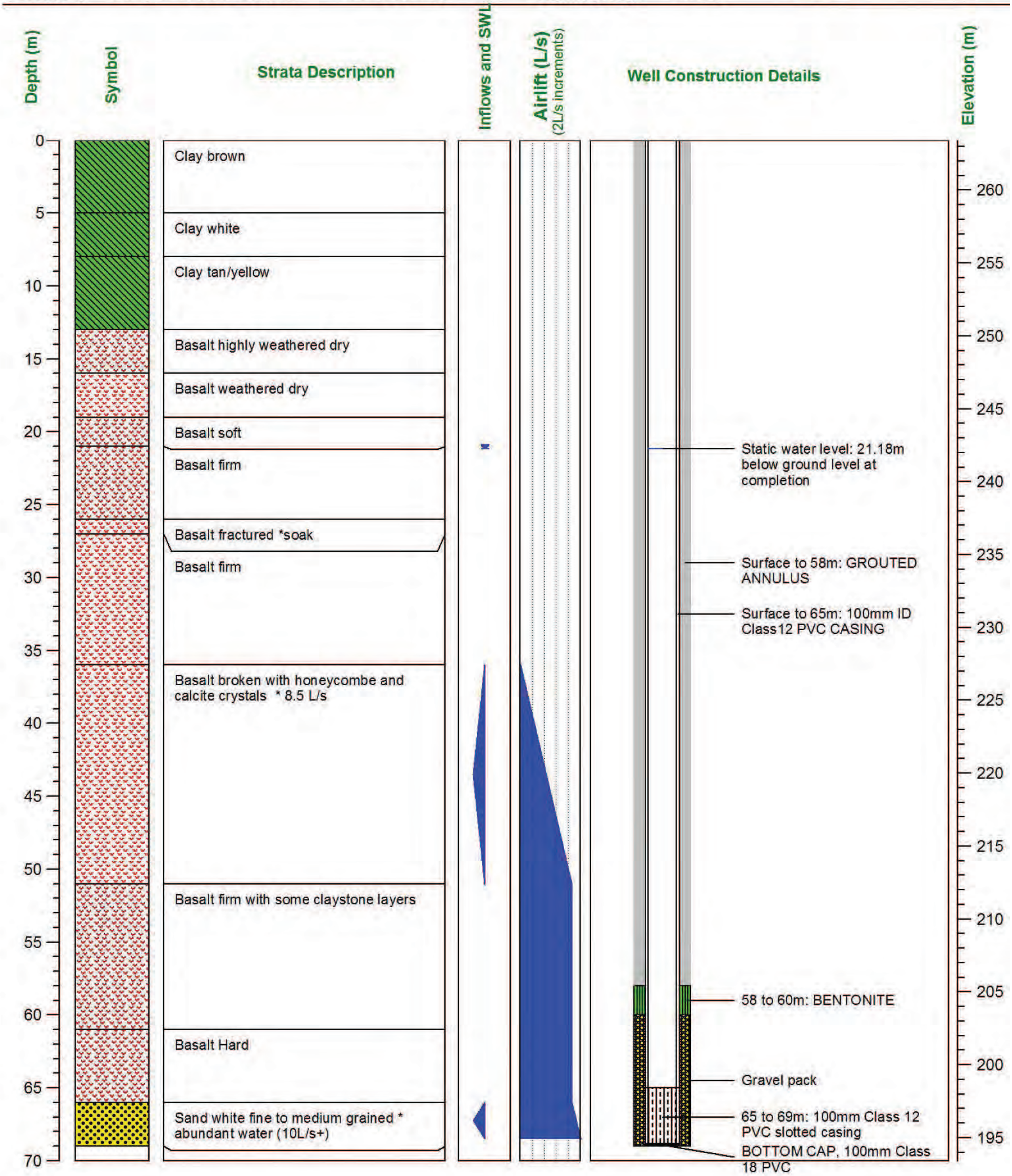
Notes:

Datum:GDA94/AHD

Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: BYGW07A **Client: Byerwen Coal Pty Ltd**

Location:	Byerwen	**Date Drilled:**	**9/9/2011**	**Project No:**	184
Easting:	587122	**Northing:**	7656990	**Elevation (m):**	263.42
Method:	Rotary Air Blast	**Driller:**	Serra Drilling	**Drilling Rig:**	IRT4W



Page 1 of 2 **Notes:**

Datum:GDA94/AHD

Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: BYGW07A **Client: Byerwen Coal Pty Ltd**

Location:	Byerwen	**Date Drilled:**	9/9/2011	**Project No:**	184
Easting:	587122	**Northing:**	7656990	**Elevation (m):**	263.42
Method:	Rotary Air Blast	**Driller:**	Serra Drilling	**Drilling Rig:**	IRT4W

Depth (m)	Symbol	Strata Description	Inflows and SWL	Airlift (L/s) (1L/s increments)	Well Construction Details	Elevation (m)

Notes:

Datum:GDA94/AHD

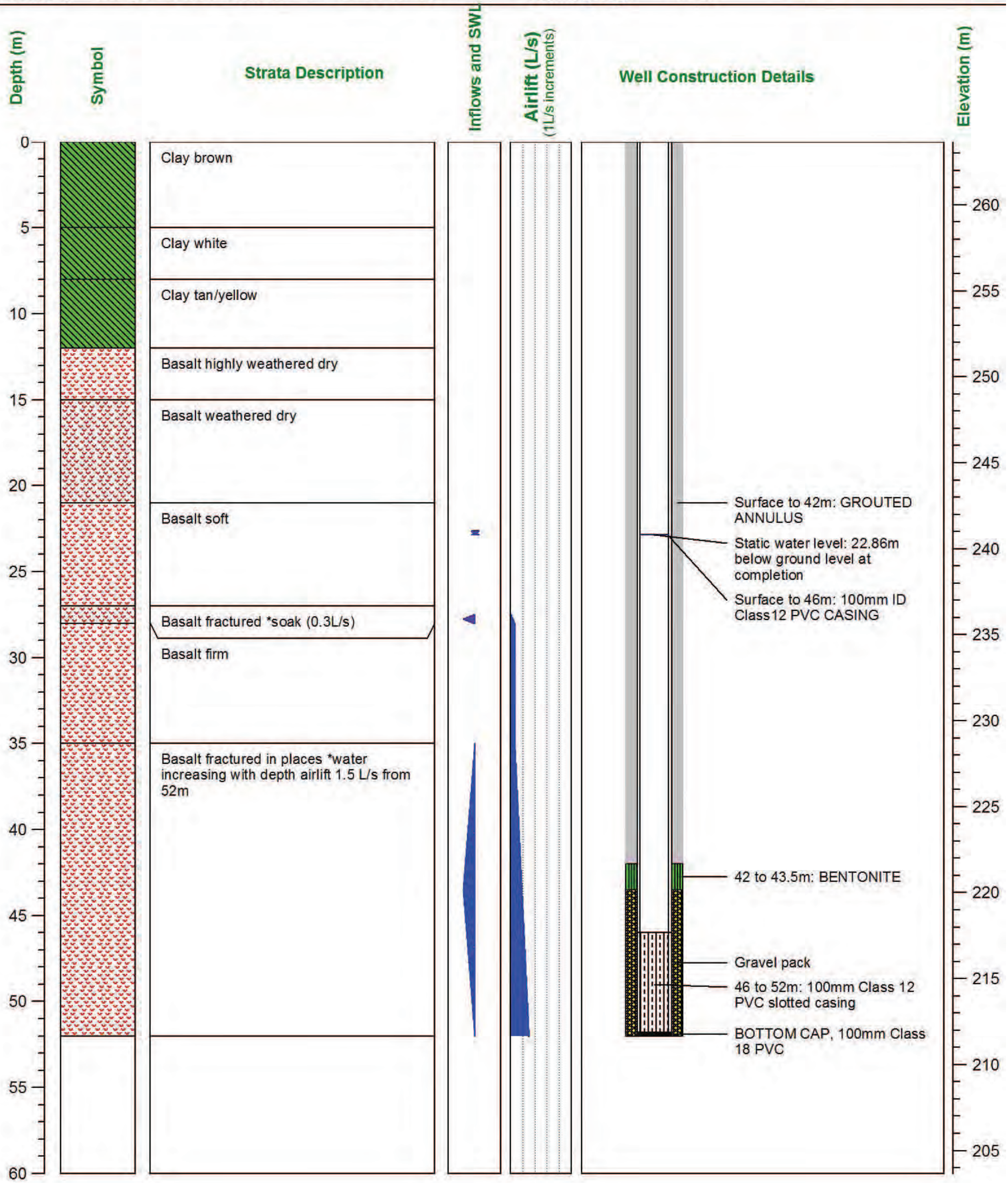
Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: BYGW07B | **Client: Byerwen Coal Pty Ltd**

Location: Byerwen | **Date Drilled: 9/9/2011** | **Project No:** 184

Easting: 587115 | **Northing:** 7656973 | **Elevation (m):** 263.671

Method: Rotary Air Blast | **Driller:** Serra Drilling | **Drilling Rig:** IRT4W



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Notes:

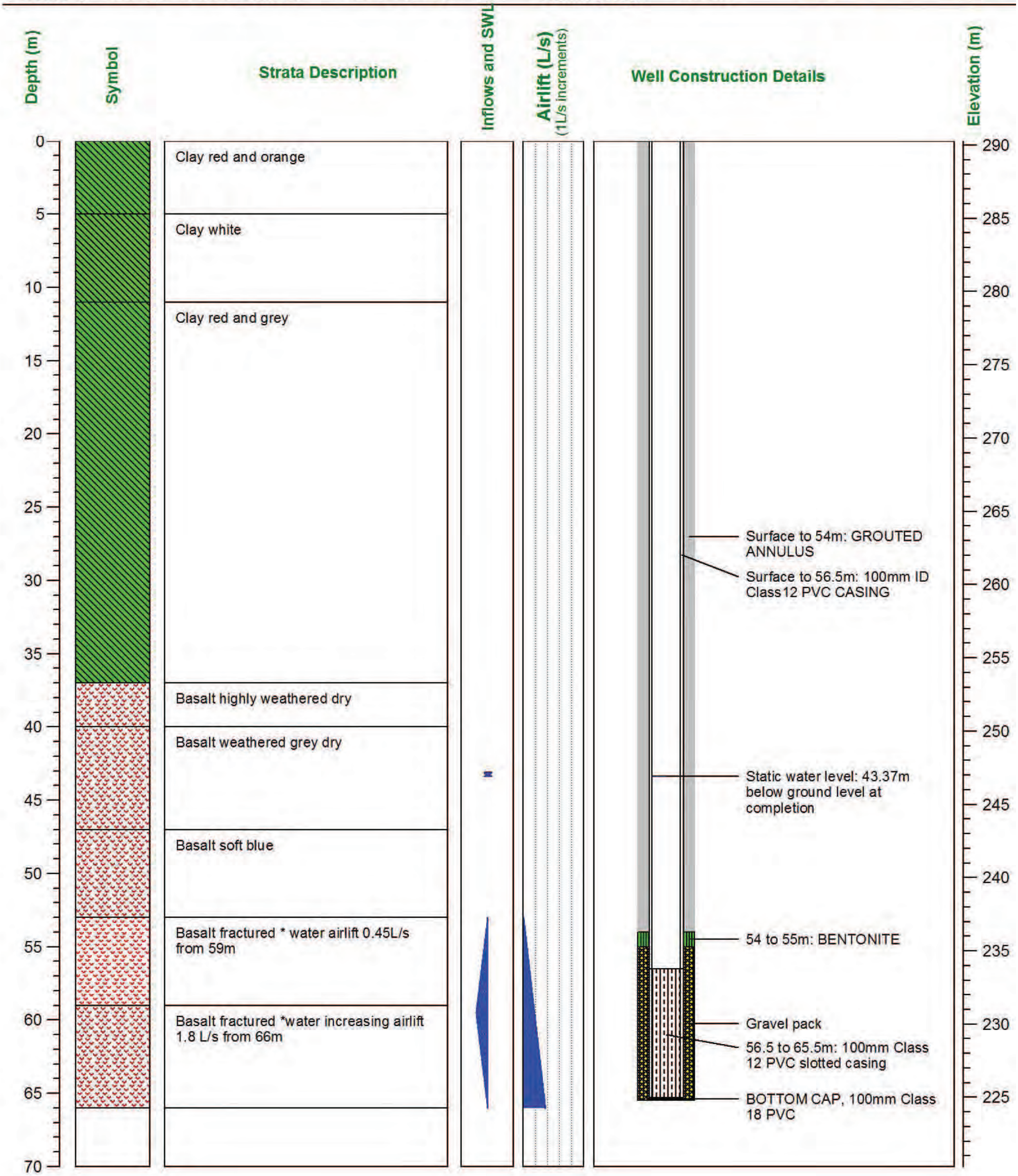
Datum:GDA94/AHD

Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: BYGW08

Client: Byerwen Coal Pty Ltd

Location:	Byerwen	**Date Drilled:**	**11/9/2011**	**Project No:**	184
Easting:	587279	**Northing:**	7643867	**Elevation (m):**	290.281
Method:	Rotary Air Blast	**Driller:**	Serra Drilling	**Drilling Rig:**	IRT4W



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Notes:

Datum:GDA94/AHD

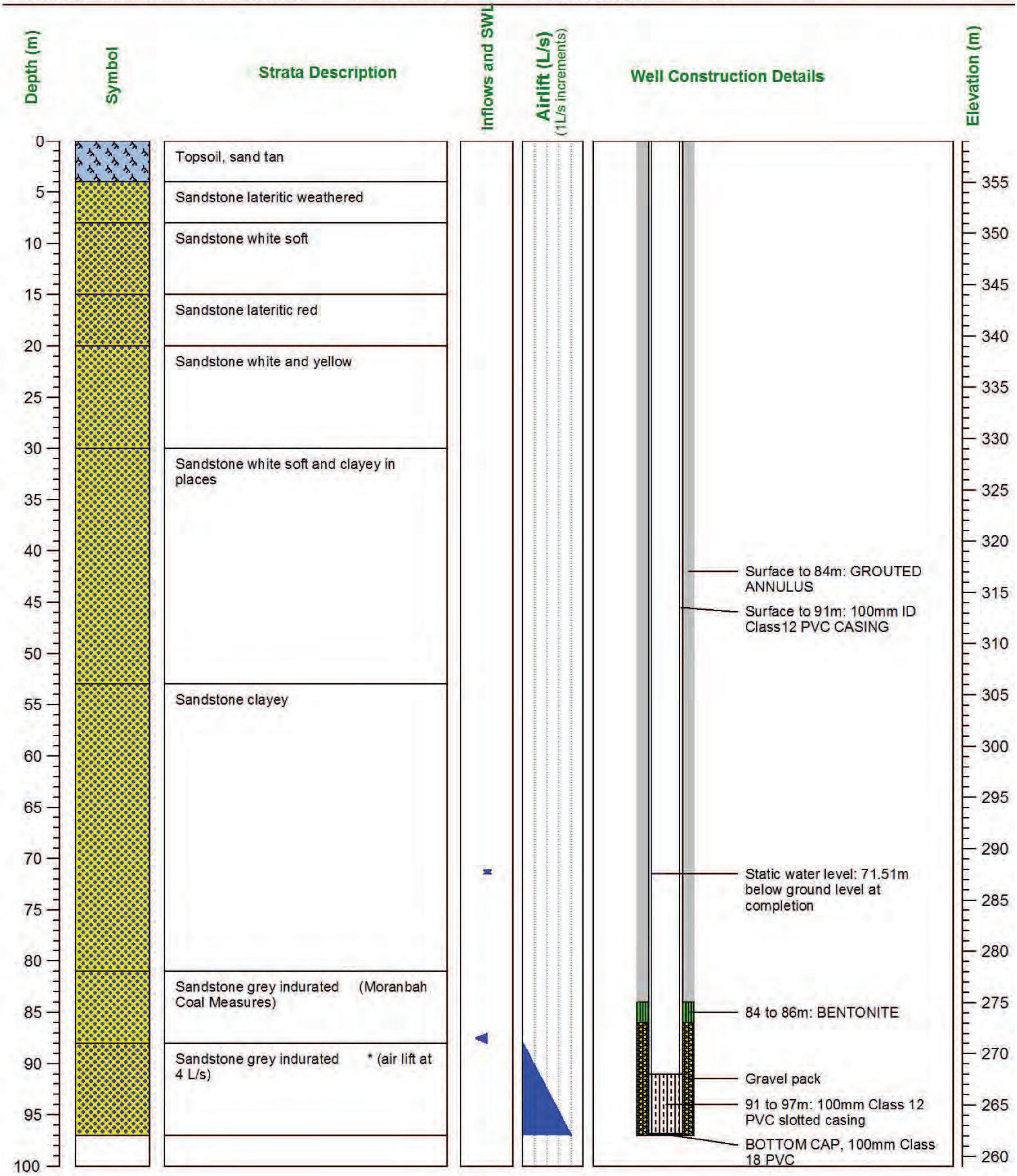
Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: **BYGW09** **Client:** **Byerwen Coal Pty Ltd**

Location: Byerwen **Date Drilled:** 13/9/2011 **Project No:** 184

Easting: 585089 **Northing:** 7665060 **Elevation (m):** 359.04

Method: Rotary Air Blast **Driller:** Serra Drilling **Drilling Rig:** IRT4W



Notes:

Datum:GDA94/AHD

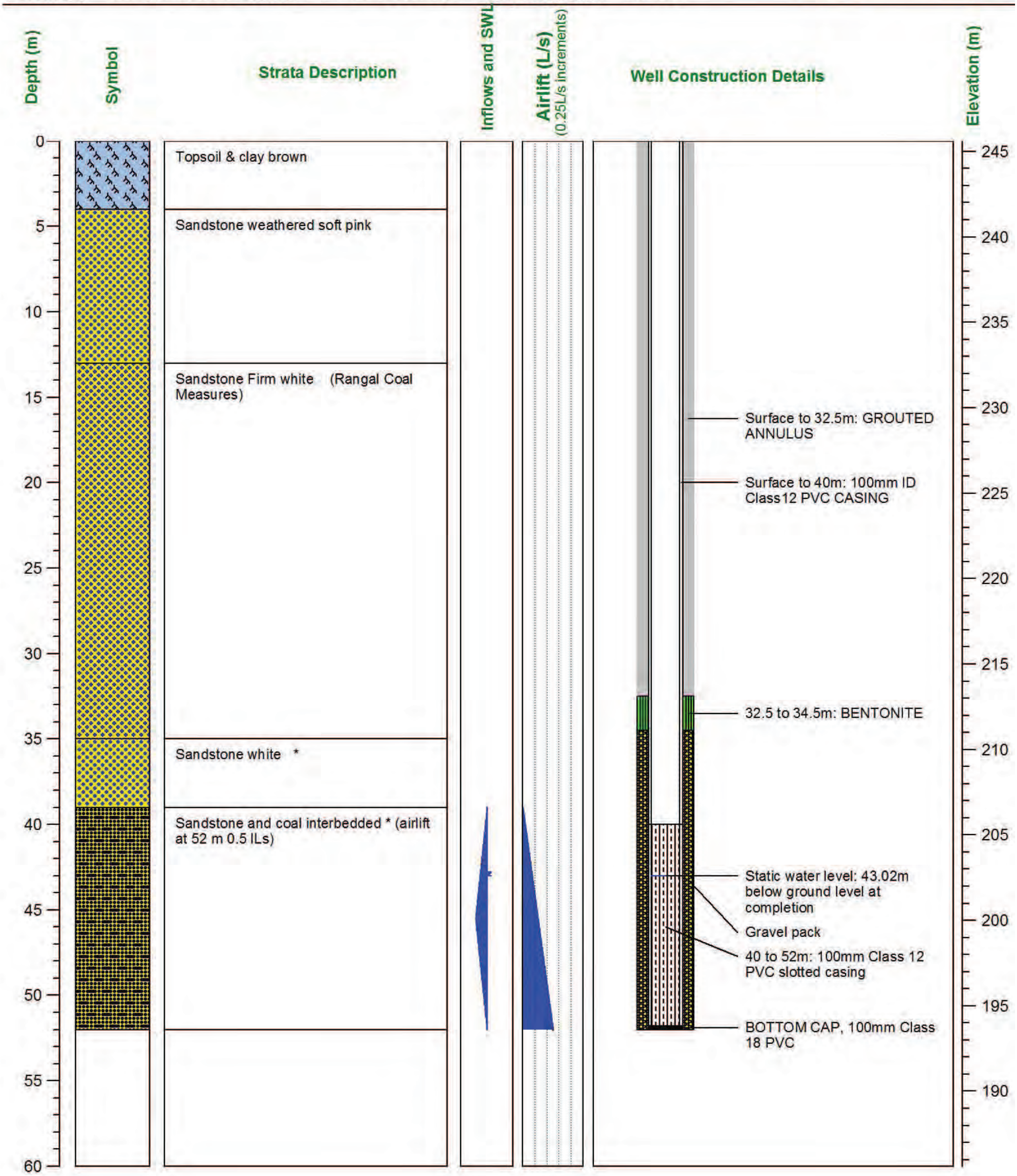
Byerwen Coal Project
Strata description compiled by Alan McDonald

Borehole No: BYGW10 **Client: Byerwen Coal Pty Ltd**

Location: Byerwen **Date Drilled: 18/9/2011** **Project:** 184

Easting: 594512 **Northing:** 7668243 **GL Elev (m):** 245.616

Method: Rotary Air Blast **Driller:** Serra Drilling **Drilling Rig:** IRT4W



Notes:

Datum:GDA94/AHD

Byerwen Coal Project
Strata description compiled by Alan McDonald