Water and Environment

ASHTON COAL MINE 2009-2010 AEMR GROUNDWATER MANAGEMENT REPORT

Prepared for	Ashton Coal Operations Limited
Date of Issue	27 October 2010
Our Reference	S56C 003b

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	Date	Revision Description
Revision A	8/10/2010	First Draft
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EXECUTIVE SUMMARY

BACKGROUND

This report has been prepared in accordance with Consent Condition 9.2 (d) of the Ashton Coal Project Approval and covers the reporting period 1 September 2009 to 1 September 2010. This report has been prepared as a supporting document for the Ashton Coal Operations Ltd 2009-2010 Annual Environmental Management Report.

This report details the monitoring and other work carried out as part of the groundwater management activities for the project. The results of all groundwater monitoring are presented, together with analysis of trends. Actual impacts derived from the analysis of this data are compared to the impacts predicted for this stage of mining in both the EIS studies (HLA, 2001) and studies carried out in support of the LW1-4 SMP (Peter Dundon and Associates, 2006) and LW/MW 5-9 (Aquaterra, 2008a) Applications.

Over the 2009-10 reporting period:

- The groundwater monitoring network was expanded to improve monitoring of groundwater conditions in the:
    - Bowmans Creek and Hunter River alluvium, in support of the proposed Bowmans Creek Diversion and mining beyond LW6.
    - Main coal seams in the Upper Liddell SMP1-4 underground area.
- Groundwater monitoring frequency was increased during the early stages of LW5 and LW6 panel extraction, to monitor the impacts of subsidence in accordance with SMP Consent Condition 22.
- Apart from the initial drawdown observed in the Glennies Creek alluvium during the mining of LW1, no mining impacts have been observed in the Glennies Creek, Bowmans Creek or Hunter River alluvium as a result of underground mining.
- Large drawdown responses in the Pikes Gully Seam and Permian overburden units have been observed in the immediate LW1 - 6 mining area. Piezometers located in the barrier between LW1 and Glennies Creek have demonstrated a groundwater levels continue to show steady recovery of approximately 0.7 m/y, approximately 80% of the initial 3.0 m drawdown has now been recovered. The partial recovery in water levels suggests a steady reduction in the hydraulic conductivity of the Pikes Gully Seam between LW1 and the subcrop line beneath the Glennies Creek floodplain, possibly due to delayed response to the in-seam grouting carried out in 2007. The gradual recovery in water levels has been accompanied by a gradual reduction in the rate of underground seepage inflows to the tailgate 1 backroad weir. No additional responses to underground mining were observed.
- Total groundwater inflows to the underground (0.4 to 10 L/s) have been below inflow rates predicted in the EIS (16 to 17 L/s).
- Actual seepage inflow rates from the Glennies Creek alluvium (0.66 to 1.0 L/s), have been below the EIS predictions of 3 L/s, and there were no seepage losses from Bowmans Creek alluvium. The actual seepage rates have therefore continued to be less than the maximum rates contained in the EIS, LW1-4 and LW/MW 5-9 SMP predictions.

In conclusion, the monitoring program has been carried out in accordance with the Ashton Ground Water Management Plan (GWMP) and the requirements detailed in the Consent Conditions. All groundwater-related impacts from underground mining during the review period were below the levels predicted in the EIS (HLA, 2001), and in the LW1-4 SMP (Peter Dundon and Associates, 2006) and LW/MW 5-9 (Aquaterra, 2008a) groundwater assessments.

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FIGURES

1 INTRODUCTION

The Ashton Coal Project, located 14km west of Singleton in the Hunter Valley Region (**Figure 1**) consists of both open cut and underground mining operations to access a series of coal seams within the Permian Foybrook Formation.

The Ashton Coal Project was granted approval on 11 October 2002 (Department of Planning, 2002). The development approval (DA) included both the open cut mine located to the north of the New England Highway, and the underground mine.

The open cut mine commenced operations in 2003 and is ongoing. The coal has been recovered from several seams of varying thickness from two open cuts, the smaller Arties Pit and the larger Barrett Pit.

The underground mine is located south of the New England Highway with the mine accessed from the northern side of the highway via a portal in the Arties pit. The current approved mine plan comprises nine longwall/miniwall panels (LW/MW 1-9), which have been approved for mining the Pikes Gully seam under three SMP applications, viz:

- Longwall panels LW1 to LW4 – SMP approved in April 2007.
- Longwall panels LW5-6 miniwalls MW7-8 – SMP approved in July 2009.
- Longwall panel LW9 – Development Consent modification approved in March 2010.

Underground mine development commenced in July 2006, and underground mining of the Pikes Gully seam has now been completed in LW1 to LW5 panels. LW6 is in progress (**Figure 2**).

Consent Condition 9.2 of the DA requires that Ashton Coal Operations Pty Ltd (ACOL) prepare and submit an Annual Environmental Management Report (AEMR) throughout the life of the project and for five years after completion of mining in the DA area. Condition 9.2 (d) requires that the AEMR shall include (inter alia):

d) a Groundwater Management Report prepared by an independent expert to the satisfaction of DIPNR, addressing:

i) work done under and the level of compliance with, the groundwater management measures defined in the Groundwater Management Plan; and

ii) identification of trends in groundwater monitoring data and comparison with predictions, in documents referred to in condition 1.2 and any previous SMIARs, over the life of the mining operations.

This report covers the reporting period 1 September 2009 to 1 September 2010 and is prepared as a supporting document for ACOL's 2009-2010 AEMR.

This document presents a review of the groundwater management work undertaken and the level of compliance with the consent conditions and the Groundwater Management Plan (GWMP). A detailed analysis of trends displayed by the monitoring data is presented, together with a comparison of the observed trends with predictions made in the Environmental Impact Statement (EIS) for the Ashton Project (HLA, 2001) and the Subsidence Management Plan (SMP) Applications for LW1-4 (Peter Dundon and Associates, 2006) and LW/MW5-9 (Aquaterra, 2008a).

2 GROUNDWATER MONITORING

2.1 PIEZOMETERS

Ashton maintains a comprehensive groundwater monitoring program on 163 piezometers, at 87 sites, as well as mine inflow monitoring within the underground mine. The network of monitoring piezometers, their function and current status are detailed in **Table 2.1**. The piezometers include both open standpipes and multi-level vibrating wire piezometer bores. Locations are shown on **Figure 1**.

Table 2.1: Ashton Coal Project Monitoring Bore Network

Bore	Location	Aquifer / Geological Unit	Type of Monitoring Bore	Comments
North East Open Cut Monitoring:				
GM1	Rail loop	ULD	SP	EIS recommended monitoring bores. Installed 2003.
GM3	Camberwell Village	GC alluvium	SP	
GM3A	Village	UB	SP	
WML172	Glennies Ck		SP	Replacements for OC1 and OC2 (lost to mining activity). Installed 2007.
WML173	Glennies Ck		SP	
WML174	Glennies Ck Rd		SP	
Underground Mine Monitoring:				
RSGM1	Bowmans Ck	Seam unknown	SP	Pre-existing bore/well
Ashton Well		BC Alluvium ?	Well	
RM01*	Bowmans Ck		SP (Dry)	EIS Investigations. Installed 2001.
RM02			SP	
RM03			SP	
RM04			SP	
RM05			SP	
RM06			SP	
RM07			SP	
RM08			SP	
RM09			SP	
RM10			SP	
RA02			SP	
PB1		BC Alluvium	SP	
RA8		Colluvium	SP	Bowmans Creek

Bore	Location	Aquifer / Geological Unit	Type of Monitoring Bore	Comments
RA10		BC Alluvium	SP	alluvium investigations and baseline monitoring (2007 & 2010)
RA12		Colluvium	SP	
RA14		BC Alluvium	SP	
RA15		BC Alluvium	SP	
RA16		Colluvium	SP	
RA17		BC Alluvium	SP	
RA18		BC Alluvium	SP	
RA30		BC Alluvium	SP	
T1-A		BC Alluvium	SP	
T1-P		CM OB	SP	
T2-A		BC Alluvium	SP	
T2-P		CM OB	SP	
T3-A		BC Alluvium	SP	
T3-P		CM OB	SP	
T4-A		BC Alluvium	SP	
T4-P		CM OB	SP	
T5		BC Alluvium	SP	
T6		BC Alluvium	SP	
T7		BC Alluvium	SP	
T10		BC Alluvium	SP	
WMLP299		BC Alluvium	SP	
WMLP300		BC Alluvium	SP	
WMLP275		BC Colluvium	SP	
WMLP276		BC Colluvium	SP	
WMLP277	Hunter River Alluvium	HR alluvium	SP	
WMLP278		HR alluvium	SP	
WMLP279		HR alluvium	SP	
WMLP280		HR alluvium	SP	
RA27		HR Alluvium	SP	
WML20*	Above underground mine	PG	SP (Dry)	EIS Investigations. Installed 2001.
WML21*		PG	SP (WL >100m)	

Bore	Location	Aquifer / Geological Unit	Type of Monitoring Bore	Comments
WML106		Lem15	VW	Subsidence monitoring network–UG mine (2006-2007)
		Lem19		
		PG		
WML107A		Lem11	VW	
		Lem15		
		Lem19		
WML107B*		Lem8-9	SP (Dry)	
WML108A		Lem11-12	VW	
		Lem15		
WML108B		Lem8-9	SP	
WML109A*		Lem8-9	VW	
		Lem12		
		Lem15		
WML109B*		Lem7	SP (Dry)	
WML110A*		Lem6	VW	
		Lem8-9 IB		
		Lem11-12		
		Lem15		
WML110B*		CM OB	SP (Cemented up)	
WML110C		Alluvium	SP (Currently dry)	
WML111A		Lem4	VW	
		Lem7		
		Lem11-12		
		Lem15		
WML111B		CM OB	SP	
WML112A		Lem2-3	VW	Subsidence monitoring network–UG mine (2006-2007)
		Lem6-7		
		Lem8		
		Lem15		
WML112B		Bays 1-2	SP	
WML112C		Alluvium	SP	
WML113A		Bays2	VW	

Bore	Location	Aquifer / Geological Unit	Type of Monitoring Bore	Comments
		Lem3-4		
		Lem9		
		Lem10-12		
WML113B		Bays1	SP	
WML113C		Alluvium	SP	
WML114A*		Lem10-12	VW	
		Lem15		
		Lem19		
WML114B*		Lem6-9	SP (Dry)	
WML115A		Lem7	VW	
		Lem8-9		
		Lem15		
		Lem19		
		PG		
WML115B		CM OB	SP	
WML115C		Alluvium	SP	
WML189		Lem15	VW	Subsidence impacts of LW2-3 (2007)
		PG		
		Arties		
WML191		Lem15	VW	Subsidence impacts of LW2-3 and Multi-seam baseline monitoring (2007)
		PG		
		ULD		
		ULLD		
		LB		
WML213		Bays	VW	Multi-seam baseline monitoring (2008)
		Lem 8-9		
		Lem 15		
		Lem 19		
		PG		
		ULD		
		ULLD		
		LB		

Bore	Location	Aquifer / Geological Unit	Type of Monitoring Bore	Comments
WML269		Lem5	WV	Monitoring of subsidence impacts of LW5 (2010)
		Lem 7		
		Lem 8-9		
		Lem11-12		
		Lem15		
WML263		Regolith	SP	
WML119	Between Glennies Ck and LW1	PG	SP	Monitoring of impacts of LW1-4 on Glennies Ck alluvium (2006)
WML120A		PG	SP	
WML120B		GC alluvium	SP	
WML129		GC alluvium	SP	
WML181		PG	SP	Monitoring subsidence impacts in barrier between LW1 and Glennies Ck (2007)
WML182		PG	SP	
WML183		PG	SP	
WML184		PG	SP	
WML185		PG	SP	
WML186		PG	SP	
WMLC248		ULLD	VW	ULD subsidence management plan, baseline monitoring (2009)
		ULLLD		
		LB		
		Heb1		
WML261		ULD	SP	
WML262		ULD	SP	
WMLP301		ART	SP	
WMLP302		ART	SP	
South East Open Cut Monitoring:				
WMLC144	East of Glennies Ck	ULD	VW	Deeper seam baseline monitoring (2007)
		MLD1		
		MLD2		
		ULLD		
		LLLD		
		UB		
		LB		

Bore	Location	Aquifer / Geological Unit	Type of Monitoring Bore	Comments
WMLC245		ULD	VW	Deeper seam Baseline monitoring (2009)
		MLD		
		LB		
		LB-Heb interburden		
WML239		GC alluvium	SP	Glennies Ck alluvium baseline monitoring (2009)
WML240		GC alluvium	SP	
WML241		GC alluvium	SP	
WML243		GC alluvium	SP	
WML247		GC alluvium	SP	
WML249		GC alluvium	SP	
WML252		GC alluvium	SP	
WML253		GC alluvium	SP	
WML256		GC alluvium	SP	
WML294		GC colluvium	SP	
AP243		GC alluvium	SP	
AP244		GC alluvium	SP	
AP245		GC alluvium	SP	

Alluvium: BC = Bowmans Creek; GC = Glennies Creek; HR = Hunter River
Overburden: CM OB = coal measures overburden
Coal seams: Bays = Bayswater; Lem = Lemington; PG = Pikes Gully; ART = Arties; ULD = Upper Liddell seam; MLD = Middle Liddell; ULLD = Upper Lower Liddell; LLLD = Lower Lower Liddell; UB = Upper Barrett; LB = Lower Barrett
VW = multi-level vibrating wire piezometer bore; SP = standpipe piezometer
*Decommissioned/Dry Bores

The monitoring network has been expanded during the review period, viz:

- Paired monitoring piezometers consisting of standpipe piezometer (WML263) and multi-level vibrating wire piezometer (WML269) were installed in the regolith and coal measures (above the Pikes Gully Seam) at the southern end of LW5, to monitor subsidence impacts as a result of LW5 mining.
- Two additional standpipe piezometers (WML301 and WML302) were installed within the Arties Coal Seam between Glennies Creek and LW1 to allow hydraulic testing and baseline monitoring, in support of the Subsidence Management Plan for the mining of the Upper Liddell Seam.
- Two additional standpipe piezometers (WML299 and WML300) were completed within the Bowmans Creek Alluvium to allow hydraulic testing and baseline monitoring in support of the proposed Bowmans Creek Diversion Project.
- Four additional standpipe piezometers (WML277, WML278, WML279 and WML280) were completed within the Hunter River Alluvium and two additional standpipe piezometers (WML275 and WML276) were completed in the Bowmans Creek Alluvium at the southern end of LW6, to monitor subsidence impacts from LW5 and LW6 mining.

All new monitoring piezometers were installed on allotment 3 of DP1114623 under licence 20BL170596

The piezometers have been monitored at various frequencies during the review period, with the EIS investigation and monitoring bores generally monitored monthly in accordance with the GWMP, and piezometers associated with underground mining routinely monitored at least every 2 to 4 weeks, but generally more frequently (weekly) during critical stages of the longwall panel advance.

Over the review period, the monitoring frequency was intensified in the early stages of LW5 and LW6 extraction, above that specified in the GWMP, until the groundwater system response became clear. The monitoring frequency in most cases has then reverted to that outlined in the GWMP, while some bores in the Bowmans Creek alluvium and Permian continue to be monitored with increased frequency in preparation for the proposed extension of mining beyond LW6.

For a period of time, a number of the piezometers were equipped with dataloggers set to record water levels/pressures at hourly or 6-hourly intervals in order that any impacts related to subsidence effects of LW5 and LW6 could be detected and related precisely to the position of the active longwall face or other specific site activities occurring at the time. These were:

- WML110A, WML110B and WML110C
- WML111A and WML111B
- WML112A and WML112B
- WML113A
- WML114A and WML114B
- WML269
- WML299
- RM09 and T1-P
- RA16
- RA27

The standpipe piezometers have been monitored for water levels, and also sampled for water quality monitoring. Vibrating wire piezometers have been monitored for groundwater pressures only.

Selected monitoring bores were sampled periodically for detailed laboratory analysis, comprising TDS, EC, pH, major ions, dissolved metals, nutrients, cyanide, fluoride, turbidity and total suspended solids.

The recommended monitoring frequency for the next review period (September 2010 to August 2011 is summarised in **Table 2.2**.

Table 2.2: Ashton Coal Project – Proposed Piezometer Monitoring Frequency

Area	Piezometers (refer Table 2.1)	Current Monitoring Frequency (2009-2010)	Proposed Monitoring Frequency (2010-2011)	Logger/transducer
NEOC	GM1	monthly	monthly	
	GM3A and GM3B	quarterly	quarterly	
	WML172-174	quarterly	quarterly	
LW1-4 and LW/MW5-9 SMP Areas	RM01 to RM10	fortnightly	weekly or fortnightly	RM09
	RA02, RSGM1, PB1	monthly	monthly	

Area	Piezometers (refer Table 2.1)	Current Monitoring Frequency (2009-2010)	Proposed Monitoring Frequency (2010-2011)	Logger/transducer
	WML21	monthly	monthly	
	WML106-115, WML269	weekly or fortnightly	weekly or fortnightly	WML110C, WML111A, WML111B, WML115A, WML269
	WML189, 191 and 213	weekly or fortnightly	weekly or fortnightly	
	RA8-RA30, WML275-276, WML299-300	weekly or fortnightly	weekly or fortnightly	RA16
	T1-10	weekly or fortnightly	weekly or fortnightly	T1P
Hunter River	WML175 and 180	quarterly	quarterly	
	WML277-280, RA27	fortnightly	fortnightly	RA27
SEOC	WML239-WML256, AP243-AP245 and WML294	monthly	monthly	
	WML144 and WMLC245	monthly	monthly	
Barrier between Glennies Creek and LW1	WML119, 120A-B and 129	fortnightly	fortnightly	
	WML181-186	fortnightly	fortnightly	
	WML261, WML262, WML301 and WML302, WML248	monthly	monthly	WML299-300

2.2 UNDERGROUND MONITORING

Groundwater monitoring was also carried out within the underground mine, including:

- Groundwater inflow rates (metering of dewatering pipelines)
- Seepage inflows from the eastern rib of the LW1 tailgate, which is conveyed by pipeline to the LW1 backroad sump (V-notch weir at discharge from pipeline).
- Metering of water imported to the underground mine for longwall operation.
- Metering of total water volumes pumped from the mine to the dam beside the mine portal in Arties pit, or directly into the mine water management system.
- Water quality monitoring (EC) of seepage discharge from the LW1 backroad pipeline.
- Water quality monitoring at various in-mine sumps, and total water pumped out of the mine.

2.3 DISCUSSION OF GROUNDWATER LEVEL CHANGES

2.3.1 NORTH EAST OPEN CUT

Aside from piezometer G1 and WML172, piezometers which form the NEOC monitoring network were dry and were not monitored during the reporting period. Piezometer G1 which monitors the Upper Liddell seam, showed a steady decline through the review period (**Figure 2**). Bore GM3A (Glennies Creek Alluvium) remained dry during the reporting period.

Most coal measures piezometers within the SEOC monitoring network revealed a general downward trend over the years of Ashton mining, in response to mining from the NEOC. These piezometers are all stratigraphically lower than the Pikes Gully Seam, and have shown no response to underground mining. However, many of these SEOC piezometers, and some deeper piezometers from within the underground mine area, started to show a steady recovery in the Upper and Lower Barrett seams from about April 2009, which is thought to be due to the progressive backfilling of the NEOC void, and recovery of water levels within the backfill. These responses are discussed in more detail below.

2.3.2 UNDERGROUND MINE

Alluvium

Glennies Creek Alluvium

As reported in the LW1 End of Panel Report (Aquaterra, 2008b), a small drawdown of 0.4m was observed in alluvium monitoring bore WML120B, between June 2006 and December 2006, coinciding with the advance of TG1A past the bore location (**Figure 3**). All drawdown impacts occurred during the development heading stage of LW1 and no further drawdown occurred in the alluvium bores during subsequent extractions of LW1 to LW6.

Water table responses in Glennies Creek alluvium to the east of Glennies Creek are consistent with the rainfall controlled natural recharge and discharge responses also observed in the Hunter River and Bowmans Creek alluvium (**Figure 4** and **Figure 5**).

Bowmans Creek and Hunter River Alluvium

Piezometers which monitor the Bowmans Creek Alluvium and Hunter River Alluvium have not shown any response to mining. Instead the water table reflects the rainfall controlled natural recharge and discharge patterns (**Figure 4** and **Figure 5**).

All piezometers have shown a recent upward trend in response to rainfall recharge, starting in June 2010 (**Figure 3).** Prior to this a gradual recession following the previous, albeit small, recharge event in April 2009, was evident across all piezometers. The recession of the water table was associated with minimal rainfall recharge over the period April 2009 to June 2010, rather than underground mining, and there has been no discernable response to mining.

Permian Coal Measures

Composite plots of all Pikes Gully Seam and Permian overburden piezometers are presented in **Figures 6** to **11**. They include:

- Standpipe piezometers which monitor the weathered near surface coal measures overburden in the Bowmans Creek floodplain area (**Figure 6**),
- Multi level vibrating wires installed within the Permian overburden units - WML106 to WML115, WML189, WML191, WML269 and WML213 (**Figure 7** and **Figure 8**),
- Pikes Gully seam standpipe piezometers to the east of LW1 – WML119, WML120A, and WML181-WML186 (**Figure 9**),
- Pikes Gully seam standpipe/vibrating wire piezometers geographically distributed across the current area of underground LW1-4 mining (WML20, WML106-84m, WML189-93m and WML191-100m) and across the LW/MW5-9 mining area (WML21, WML115-144m and WML213-205m) (**Figure 10**); and
- Multi level vibrating wires installed within the Upper Liddell, Lower Liddell and Lower Barrett coal seams - WML144, WML245, WML191, and WML213 (**Figure 11**).

Near Surface Coal Measures

Groundwater levels in standpipe piezometers WML110B, WML111B, T1-P, T2-P, T3-P and T4-P, which monitor the upper-most water bearing horizon of the Permian coal measures (beneath the Bowmans Creek floodplain area) have declined in response to LW4 to LW6 extractions, while the alluvium piezometers have shown no response to mining (**Figure 4** and **Figure 6**).

WML110B which monitors the top of the coal measures above LW5, first responded to the mining of LW4, but became dewatered on 8 February 2010, during the mining of LW5 (**Figure 6**). The appearance of coal seam gas from this bore at this time suggested that there was probably connective cracking from the goaf to at least 24m below the surface, and the bore was cemented up for safety reasons. WML110C which is 14m deep and monitors the alluvium was dry when LW5 started and has remained dry since, but it has shown no air connection to the goaf, indicating no direct connection from the goaf to 14m below the surface. It is interpreted that connected cracking probably extends up from the goaf to between 14 and 24m below the ground surface above LW5.

WML111B which monitors the uppermost groundwater inflow zone near the top of the coal measures above LW6, showed a decline in water level of 0.9 m between January and March 2010 in response to the adjacent longwall panel LW5, but the water level stabilised at 9 m above the base of the screened interval. In July 2010, WML111B was undermined by LW6, and showed a small response to LW6, but the water level remains more than 8 m above the base of the screened interval. This indicates that the screened section of the Permian coal measures remains saturated with a positive head of at least 8 m, and confirms that this interval is not directly connected hydraulically with the LW6 goaf beneath, even though full subsidence has occurred with the associated fracturing extending upwards from the goaf. It means that connected cracking from the LW6 goaf does not extend higher than 18 m below ground surface, or 10 m below the top of the Permian.

Hydrographs of paired standpipe piezometers which monitor the uppermost water-bearing horizon in the Permian (T1-P, T2-P, T3-P and T4-P) and overlying Bowmans Creek Alluvium (T1-A, T2-A, T3-A and T4-A) are presented on **Figure 4** and **Figure 6**.

At each of the four sites, differences in water level were found to exist between the alluvium and Permian. At Sites T1 and T4, the Permian groundwater level was initially higher than the alluvium groundwater level, while at sites T2 and T3 the alluvium groundwater level was higher.

- Piezometer T1-P, located 80m west of the northern part of LW4, revealed a groundwater drop of about 2m in August 2009, which coincided with the passage of LW4 past this location. At the same time, no water level impact was observed in the alluvium bore T1-A at the same location. The goaf edge of LW4 is approximately 90m east of T1-A and T1-P. T1-P showed no response to the mining of LW5.
- Piezometer T4-P, which is located directly above the western goaf edge of LW6 and 220m west of the LW5 goaf edge, responded sharply to the passage of LW5, with a permanent water level drop of around 1m between 20 and 28 January 2010, and then further steady decline throughout the mining of LW5. It showed a further drop of about 1 m in August 2010 when LW6 progressed past this site, but still retains a positive head of more than 20 m above the screened interval at 29-32 m depth. T4-P had earlier shown a temporary decline of around 0.5m with the passage of LW4 in September-October 2009, but this was followed by almost complete recovery of the water level over the following months until the LW5 response.
- Piezometric responses observed in T2-P and T3-P were interpreted to be temporary pressure responses to subsidence impacts above LW4 or LW5, both of which are a considerable distance away (440m and 690m respectively from T2-P, and 310m and 550m respectively from T3-P). LW6 has not yet advanced past T3-P, which is located above the future miniwall MW7.

Bayswater and Lemington Seams

Varying drawdown impacts have been observed in piezometers that monitor the Bayswater and Lemington seams above the Pikes Gully seam. Hydrographs for these are presented in **Figures 7** and **8**.

Two Bayswater seam piezometers show definite drawdown, shown in WML113-40m and WML213-48m (**Figure 7**). These are believed to be responding to mining at the adjacent Narama mine, not the Ashton operation, as they have been on a consistent downward trend throughout the period of monitoring, starting before longwall mining commenced at Ashton.

Aside from WML115B, WML115-40m and WML112-43m which monitor the shallow Lemington 1 to 7 seams outside the area of current mining, all piezometers have now shown recognisable drawdowns in response to mining of LW1 to LW5. The magnitude of each response has varied according to the proximity of the piezometer to the active longwalls.

Whilst most piezometers had already responded during mining of LW1-4, further drawdowns were detected over the reporting period during the mining of LW5-6 (**Figures 7** to **8**), viz:

- WML269 – Lem7, Lem8-9, Lem10-12, Lem15 and Lem19 (within main gate pillars, south of LW5)
- WML110 – Lem6OB, Lem6, Lem8-9IB, Lem10-12 and Lem15 (southern end of LW5);
- WML114 – Lem15 and Lem19 (above middle section of LW5);
- WML111 – Lem4 and 7, Lem11-12, Lem15 (southern end of LW6);
- WML112 – Lem6-7, Lem 8 and Lem15 (above chain pillar between MW7 and MW8);
- WML113 – Lem9 (southern end of MW9), and
- WML213 – Lem8-9, Lem15 and Lem19.

VW piezometer responses in WML110A and WML269 indicate that there was significant disturbance of the strata around the period of 1-4 February 2010. All WML110 vibrating wire piezometers were lost during that period, presumably due to ground movements, although all were still pressurised at the time they ceased recording. The standpipe bore WML110B was also affected by direct or indirect connection with subsidence fracturing, as it was rapidly drained of water between 19 January and 12 February 2010. However, WML269, although it is located immediately adjacent to the LW5 goaf area, has shown only partial depressurisation at all piezometers, indicating that the subsidence fracturing has not caused dewatering of the Permian strata even a few metres from the edge of the LW5 goaf footprint (**Figure 2**). Piezometers at the Lemington 15 and Lemington 19 seams maintain pressures of close to 100m after completion of LW5.

The Lemington 6 (WML110-38m) and Lemington 5-9 responses (WML269-24m, WML269-56m and WML269-64m) are interpreted to be indicative of an increase in storage due to bed separation effects (**Figure 9**).

The deeper Lemington 11-15 seams in WML110 and WML269 responded differently. The head declines observed in WML269 represent slow dewatering from these intervals, whilst the temporary decline and recovery pressure responses at WML110 are considered to be temporary stress induced responses (**Figures 7** and **8**).

Pressure response was also observed in the shallow Lemington seams (Lemington 6-12), outside the current area of mining. Piezometers WML112, WML113 and WML213 located to the west and south west of LW6 showed marked drawdown responses to the mining of LW4, LW5 and LW6 (**Figure 7** and **Figure 8**). It is thought that this drawdown represents the lateral expression of bed separation effects above the extracted panels, not dewatering.

This effect does not lead to increased mine inflows, and is a transient level response that occurs in upper layers in advance of the impacts that occur due to mine dewatering. This effect and its implications for impact predictions are explained in the End of Longwall 4 report (Aquaterra, 2010a).

Pikes Gully Seam

Piezometers east of LW1 (between LW1 and Glennies Creek) have not indicated any response attributable to the mining of LW5-6 (**Figure 9**). The trends observed in the piezometers are continuations of trends established during mining of the LW1 development headings. All the seepage impact occurred during LW1 development, and the actual extraction of LW1 to LW6 has not caused any further drawdown impact.

Groundwater levels in WML120A and WML184 to WML186 have continued to show steady recovery of approximately 0.7 m/y, so that about 80% of the initial 3.0 m drawdown has now been recovered (**Figure 9**). The partial recovery in water levels suggests a steady reduction in the hydraulic conductivity of the Pikes Gully Seam between LW1 and the subcrop line beneath the Glennies Creek floodplain, possibly due to delayed response to the in-seam grouting carried out in 2007. The gradual recovery in water levels has been accompanied by a gradual reduction in the rate of underground seepage inflows (see **Section 2.5**).

Aside from a number of isolated rainfall recharge events, water levels in WML119, WML181 and WML182 were showing a steady drawdown trend of approximately 0.2 m/y since the mining of

LW1 began (**Figures 9**). Since mid 2009, these bores have all showed a reversal of trend, and water levels were rising throughout the mining of LW5, consistent with increased rainfall recharge during that time.

Piezometers which monitor the Pikes Gully Seam in the underground SMP area have all shown responses to underground mining (**Figure 10**).

Piezometers located inside the LW1-5 area responded during the mining of LW1 to 4. No significant responses were observed during the subsequent LW5 and LW6 extractions, as these were dry or exhibit small residual pressures, prior to LW5 and LW6 development headings. The groundwater responses observed to date are summarised as follows:

- WML106-84m and WML20 responded to LW1 development headings, with WML20 responding further to LW2 headings. WML20 became dry during the nearby mining of LW3 maingate headings.
- Vibrating wire piezometer WML191-100m located in the chain pillar between LW2 and LW3 showed dramatic depressurisation in response to the mining of LW3, but showed no response to the earlier passage of the LW2 development headings. WML189-93m, which is also located in the chain pillar to the north of WML191, showed marked drawdown as the LW2 development heading passed and no further responses during the extraction of LW3.
- WML21, located in the northern part of LW5, responded strongly to the advance of the North West Mains and LW4, LW5 and LW6 development headings past this point. The water level has fallen more than 100m below surface and could no longer be monitored before LW5 started. The Pikes Gully seam is 105m below surface at WML20, and is probably now fully dewatered at that site.

Whilst most responses were observed during the mining of LW1 to LW4, continuing depressurisation responses have been observed during the reporting period, in piezometers outside of the area of current mining, viz:

- WML115-144m is located closer to the North West Mains than the LW1-4 area. The continued drawdown response observed during the mining of LW5 is believed to be due primarily to drainage into the nearby North West Mains and development headings for LW4, LW5 and LW6, where the lowest point in the headings near WML115 is at an elevation of around -45mAHD.
- WML213 is remote from both LW1-5 and the North West Mains. The steady drawdown observed in WML213 during LW3 to LW5 is believed to be due to the combined effect of Ashton's underground operations and possibly mining activities on neighbouring mine sites.

Liddell and Barrett Coal Seams

Some piezometers which monitor seams below the Pikes Gully seam (Middle Liddell Seam down to the Lower Barrett Seam) have begun to show a gradual recovery (**Figure 11**). The recovery is thought to be due to the backfilling of the NEOC void and gradual recovery of water levels within the backfill, and is evident in the following piezometers:

- WML245-70m (Upper Barrett) and WML245-100m (Lower Barrett – Hebden interburden), located to the north of the proposed SEOC shell, have revealed steady recovery since monitoring began in February 2009.
- Prior to April 2009, all WML144 piezometers, from the Upper Liddell down to the Lower Barrett seams, had shown marked drawdowns in groundwater pressures in response to mining from the NEOC. However, WML144-32m (Middle Liddell), WML144-58m (Lower Lower Liddell) and WML144-98m (Lower Barrett), located within the proposed SEOC pit shell, have revealed steady recovery since April 2009. Groundwater pressures in WML144-26m (Upper Liddell) and WML144-45m (Middle Liddell 1), while not recovering, have stabilised over the same period.
- WML191-200m (Lower Barrett), located below the LW1-LW2 chain pillar, has revealed a steady recovery since February 2009.

- Note that deeper piezometers at WML213, which is more remote from the NEOC, have not shown recovery in the Liddell or Barrett seams.

Several piezometers continue to show a slow but steady downward trend in the upper to lower Liddell seams, which is considered to be unrelated to the Ashton underground mining, and is considered to be due primarily to the NEOC, but may also include a regional response to general mining activity in the broader region, viz:

- WML248-60m (Upper Lower Liddell)
- WML245-65m (Middle Liddell)
- WML213-247m (Upper Liddell) and WML213-275m (Upper Lower Liddell)
- WML191-132m (Upper Liddell) and WML191-155m (Upper Lower Liddell)
- WML144-50m (Upper Liddell)

2.4 GROUNDWATER QUALITY

The EC and pH data from sampling of piezometers and basic statistical analysis results are summarised in **Table 2.3** and **Table 2.4** respectively. Surface water EC from Bowmans Creek and Glennies Creek are presented in **Figures 12** and **13**, respectively. Groundwater EC's from the Bowmans Creek and Glennies Creek Alluvium are shown in **Figure 14**.

Table 2.3: Salinity Measured as Electrical Conductivity (µS/cm)

BORE	Sep-Dec 2007	Jan-Feb 2008	May-Jun 2008	Jul-Aug 2008	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
RM04	1310	1540	972	1240	1240	1220	1140	1110	1110	1040	972	1192	1540
RM06	1170	772	826	806	791	878	824	980	1100	1020	772	917	1170
RM07	1320	1230	-	890	813	874	845	897	982	1030	813	987	1320
RM09	1220	1350	1190	1080	997	930	921	930	989	997	921	1060	1350
RM10	1510	1690	1560	1440	1400	1290	1180	1060	1090	1130	1060	1335	1690
PB1	1560	1640	1520	1340	1260	1140	1080	1010	1030	974	974	1255	1640
RA10	1780	-	-	-	-	-	1940	2010	1940	1950	1780	1924	2010
RA14	2050	-	-	-	-	-	2190		2190	2220	2050	2163	2220
RA17	1190	-	-	-	-	-							
RA18	2100	-	-	-	-	-	1690		1650	1620	1620	1765	2100
RA30	1560	-	-	-	-	-	1530	1610	1450	1310	1310	1492	1610
WML112C	1360	-	-	1200	-	-	-	1700			1200	1420	1700
WML113C	1450	-	-	1250	-	-	-	1120			1120	1273	1450
WML115C	4100	-	-	5150	-	-	-				4100	4625	5150
T1-A	2040	-	-	-	-	-	1080	1080	1160	2230	1080	1518	2230
T2-A	1680	-	-	-	-	-	1270	1210	1160	1070	1070	1278	1680
T3-A	2150	-	-	-	-	-	2400	2400	2260	2340	2150	2310	2400
T4-A	2270	-	-	-	-	-	3470	4130	3550	3500	2270	3384	4130
T5	1330	-	-	-	-	-	1260	1310	1260	1210	1210	1274	1330

BORE	Sep-Dec 2007	Jan-Feb 2008	May-Jun 2008	Jul-Aug 2008	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
T6	1280						1420	1400	1400	1310	1280	1362	1420
T7	6420						5380	5770	4960	5740	4960	5654	6420
T9	2490										2490	2490	2490
T10	2050						2180				2050	2115	2180
Summary for all Bowmans Creek Alluvium:											**772**	**1681**	**6420**
RA27	2540						2080	2040			2040	2220	2540
WML 280										1950	-	-	-
WML 278										2150	-	-	-
WML 279										1375	-	-	-
WML 275										2300	-	-	-
WML 277										2430	-	-	-
Summary for all Hunter River Alluvium:											**1375**	**2108**	**2540**
WML120B	1220			992	992	915	903	839	781	639	639	910	1220
WML129	577			571		458	490	571	502	433	433	515	577
WML148	2610										2610	2610	2610
WML155	915										915	915	915
WML157	803										803	803	803
WML158	705										705	705	705
WML239						903		984	916		903	934	984
WML241						687		538	602		538	609	687
WML253						417		411	320		320	383	417

BORE	Sep-Dec 2007	Jan-Feb 2008	May-Jun 2008	Jul-Aug 2008	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
Summary for all Glennies Creek Alluvium:											**320**	**775**	**2610**
WML110C	9340			9340							9340	9340	9340
RA8	8370						7660	7660	6800	7490	6800	7596	8370
RA16	13400						11500	13300	12300	13800	11500	12860	13800
WML240						1640		1610	1710		1610	1653	1710
WML243						3740		5920	4770		3740	4810	5920
WML247						14800		15000			14800	14900	15000
WML249						15300		16300	13900		13900	15167	16300
WML252						3730		5830	5140		3730	4900	5830
WML256						3250		2240	2470		2240	2653	3250
WML294								4130	5950		4130	5040	5950
Summary for all Colluvium:											**1610**	**7921**	**16300**
RM02		2290	3630	3860	5250	4450	4410	4610	4600	4500	2290	4178	5250
RM05	2200	2310	2370	2220	2620	2360	2200	2420	2420	2230	2200	2335	2620
T1-P	9220						8510	7870	2740	1990	1990	6066	9220
T2-P	1070						320	648	633	925	320	719	1070
T3-P	2050						1280	1320	1350	1610	1280	1522	2050
T4-P	2000						1790	1870	1850	1790	1790	1860	2000
WML108B				15100			16100	16200	13300	16700	13300	15480	16700
WML109B				11400							11400	11400	11400
WML110B	9415			10000			9190	9610	8600		8600	9363	10000

BORE	Sep-Dec 2007	Jan-Feb 2008	May-Jun 2008	Jul-Aug 2008	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
WML111B	2580			2290			605	735	964	1810	605	1497	2580
WML112B	1720			1600			2100	1910	1910	2040	1600	1880	2100
WML113B	875			835			908	815	926	914	815	879	926
WML114B	6570			5200		4890	4900	5170	4700	-	4700	5238	6570
WML115B	3790			3440		3770	3720	3940	3600	4270	3440	3790	4270
Summary for all Weathered Coal Measures Overburden:											**320**	**4085**	**16700**
WML 20	9820	5720									5720	7770	9820
WML 21	6460	8280	8110	8390		7690	7550	7500	7070		6460	7631	8390
WML119	2320			1820							1820	2070	2320
WML120A	1260			810		1040	919	931	935	1050	810	992	1260
WML181	2380			2460		2680	2640	2600	2610	2670	2380	2577	2680
WML182	8680			6950		6510	6730	6390	6760	7900	6390	7131	8680
WML183	8180			5890		5950	5640	5950	5310	5570	5310	6070	8180
WML184	4580			5140		4940	4940	5210	5040	5440	4580	5041	5440
WML185	4430			2940		2900	2310	2710	2570	2650	2310	2930	4430
WML186	387				1930	933		1140	1300	1550	387	1207	1930
Summary for all Pikes Gully Seam:											**387**	**4352**	**9820**
WML261							2510	1420	1460		1420	1797	2510
WML262							6270	7170	6890		6270	6777	7170
Summary for all Upper Liddell Seam:											**1420**	**4105**	**6890**
WML301										6100			

aquaterra

BORE	Sep-Dec 2007	Jan-Feb 2008	May-Jun 2008	Jul-Aug 2008	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
WML302										920			
Summary for all Arties Seam:											**920**	**-**	**6100**
WML172				4880		3280	3200				3200	3787	4880
RSGM1	6250	10300	10200	10600	8760	6490	5590	8370	7070		5590	8181	10600
GM1	369	526	1100	3900	4990	5240	5450	5400	5960	6040	369	3898	6040
Summary for all Other Major Coal Seams:											**369**	**5634**	**10600**

2.4.1 SALINITY

The groundwater quality monitoring data has highlighted some variation from the normal pattern of low salinity in the alluvium and high salinity in the Permian. The main variances are as follows:

Bowmans Creek Alluvium:

- Salinities in the Bowmans Creek alluvium ranged from a minimum of 772 to a maximum of 6,420 µS/cm EC.
- The average EC for all Bowmans Creek alluvium samples is 2,108 µS/cm (**Table 2.3**).
- Due to the shallow depth of the water table and the cleaner nature of the alluvium in the northern reaches of Bowmans Creek (coarse silty sand, with stringers of gravels/cobbles), the aquifer is more responsive to direct rainfall recharge in that part of the floodplain, resulting in lower groundwater salinities than observed to the south (where the depth to water is greater and the alluvium comprises mostly silty sands).
- The alluvium and colluvium that exists above LW5 (RA8, RM2 and RA16) contains saline groundwater (4,500 to 13,800 µS/cm EC), indicating that it is not as actively recharged from rainfall, and is not strongly connected hydraulically with less saline groundwater in the rest of the alluvium aquifer.
- Bowmans Creek had ceased continuous flow by early 2007 during extended drought conditions, and water was maintained in disconnected pools only by virtue of small volume groundwater baseflow discharges. The total rate of groundwater baseflow was very small, insufficient to maintain continuous flow. The surface water EC at this time increased to 14,000 µS/cm at the monitoring point just downstream of the New England Highway (**Figure 12**). Flow resumed in the flood event of June 2007, and a reduction in EC has been observed, with occasional increases occurring during low flow periods, although to less than the peak salinity reached in early 2007 (**Figure 14**).

Glennies Creek Alluvium:

- The Glennies Creek alluvium also reported variable salinity, with ECs ranging from 320 to 2,610 µS/cm.
- The higher alluvium ECs are believed to be due to upward seepage of groundwater from the Permian into the alluvium and/or related to up-dip exposes of the Branxton Formation.
- The alluvium EC's are all noticeably higher than the EC of surface flow in Glennies Creek, which during the period ranged between 236 and 606 µS/cm (**Figure 14**).
- After some EC decline during the development headings stage of LW1, the ECs of Alluvium piezometers on the western side of Glennies Creek (WML120B and WML129) have remained steady during LW1 to LW6 panel extractions.

Hunter River Alluvium:

- The recently installed standpipe piezometers (WML277, WML278, WML279 and WML280) which were completed within the Hunter River alluvium, revealed groundwater salinities in the range 1,375 to 2,540 µS/cm EC, which is higher than the Hunter River surface flow (240 to 1170 µS/cm EC).

Pikes Gully Seam:

- Salinity of Pikes Gully seam groundwater ranged from 810 to 9,820 µS/cm EC. After some EC decline following the development headings stage of LW1, the ECs of WML120A on the western side of Glennies Creek remained steady during LW1 to LW6 panel extractions. Steady decreases in groundwater salinity have also been observed in WML182, WML183 and WML185 during the LW2 extraction, but salinities have been relatively stable through the mining of LW3 to LW6 (**Figure 15**).
- A dramatic decrease in reported groundwater salinity from 1,820 µS/cm to 86 µS/cm EC was observed in WML119 during the mining of LW3. This bore was found to have been damaged apparently after being hit by a vehicle. The very low EC has been caused by

ingress of local rainfall runoff into the bore hole (the measured EC is now much lower than the EC measured in Glennies Creek). The bore has now been repaired, and EC has returned to the background range.

Arties Seam

- Salinity of the Arties seam ranged from 920 to 6,100 µS/cm EC. The lower EC encountered in WML302 may reflect partial connection with the fresher groundwaters in the overlying alluvium.

Upper Liddell Seam:

- The groundwater salinity of the Upper Liddell Seam ranged from 1,420 to 6,890 µS/cm EC. The lower EC encountered in WML261 may reflect partial connection with the fresher groundwaters in the overlying alluvium.

Weathered Coal Measures Overburden:

- The groundwater salinity of the coal measures overburden ranged from 320 to 16,700 µS/cm EC.

Underground Seepage:

- Electrical conductivity (EC) data obtained from underground monitoring are presented in **Figure 15**. Corresponding EC's at various piezometers in the Glennies Creek valley or between Glennies Creek and the mine are plotted on **Figure 15**.
- After some EC decline during the development headings of LW1, the EC's of the LW1 back road pipeline have remained reasonably steady, revealing only a slight decreasing trend over the reporting period. The decrease in groundwater EC during LW1 development is similar to that observed in the Pikes Gully and Alluvium piezometers (between LW1 and Glennies Creek), and both are believed to be due to induced water flow from the Glennies Creek alluvium towards the mine through the Pikes Gully Seam. The salinity has stabilised at a level which reflects the relative proportions of alluvium and Permian groundwater in the seepage.

2.4.2 PH

The groundwater in the alluvium is near-neutral in pH (range 6.63 to 8.61). Likewise the coal measures groundwater is generally near-neutral, with most pH values lying within a similar range over the reporting period, all piezometers reported pHs within guideline limits for freshwater ecosystems (6.5 to 8). pH monitoring data are listed in **Table 2.4**.

Table 2.4: Groundwater pH

BORE	Feb-07	May-07	Aug-07	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
RM04	7.05	6.93	7.41	7.19	6.84	7.1	7.47	7.08	6.86	7.12	7.11	7.35		6.84	7.13	7.47
RM06	7.07	7.09	7.14	7.21	7.21	7.04	7.37	7.1	7.1	7.21	7.18	7.17		7.04	7.16	7.37
RM07	7.13	7.01	7.24	7.31	7.06		7.36	7.21	6.94	7.15	7.33	7.20		6.94	7.18	7.36
RM09	7.02	6.79		7.1	6.93	6.98	7.28	7.29	6.77	7.09	7.14	7.16		6.77	7.05	7.29
RM10	7.01	6.76	7.08	7.09	6.83	6.89	7.27	7.09	6.86	7.15	7.03	7.12		6.76	7.02	7.27
PB1	7.02	7.77	7.26	7.26	7.06	7.34	7.23	7.28	7.06	7.40	7.18	7.56		7.02	7.29	7.77
RA10				7.39					6.91	7.10	7.09	7.27		6.91	7.15	7.39
RA14				7.08					7.02	7.16		7.16		7.02	7.11	7.16
RA18				7.31					6.93	7.31		7.22		6.93	7.19	7.31
RA30				6.63					6.71	7.13		7.08		6.63	6.89	7.13
WML110C				7.13			7.04		6.56					6.56	6.91	7.13
WML112C				8.61			7.45		6.96	7.45	7.64			6.96	7.62	8.61
WML113C				7.13			6.99		6.58					6.58	6.90	7.13
WML115C				7.39			7.32							7.32	7.36	7.39
T1-A				7.82					7.08	7.47		7.20		7.08	7.39	7.82
T2-A				7.11					7.09	7.49		7.34		7.09	7.26	7.49

BORE	Feb-07	May-07	Aug-07	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
T3-A				6.97					6.69	6.9		7.02		6.69	6.90	7.02
T4-A				7.14					6.76	7.2		7.03		6.76	7.03	7.20
T5				7.04					6.88	7.03		7.3		6.88	7.06	7.30
T6				6.96					6.74	7.05		7.11		6.74	6.97	7.11
T7				7.09					6.74	7.12		7.2		6.74	7.04	7.20
T10				7.04					6.71	7.04				6.71	6.93	7.04
Summary for all Bowmans Creek Alluvium:														**6.56**	**7.13**	**8.61**
RA 27				6.94					6.76	7.14	7.04			6.76	6.97	7.14
Summary for all Hunter River Alluvium:														**6.76**	**6.97**	**7.14**
WML120B				7.1			6.96		6.74	7.07	7.11	6.84		6.74	6.97	7.11
WML129				7.33					6.88	7.3	7.13	7.00		6.88	7.13	7.33
WML239										7.01	7.14	7.32		7.01	7.16	7.32
WML241										6.96	7.05	7.38		6.96	7.13	7.38
WML253											7.24	7.37		7.24	7.31	7.37
Summary for all Glennies Creek Alluvium:														**6.74**	**7.10**	**7.38**
RA8				7.35					6.87	7.00	7.23	7.22		6.87	7.13	7.35
RA16				7.00					6.57	6.76	7.00	7.08		6.57	6.88	7.08

BORE	Feb-07	May-07	Aug-07	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
WML240									6.61		6.58	7.05		6.58	6.75	7.05
WML243									6.64	7.04	6.94			6.64	6.87	7.04
WML247									7.24		7.52			7.24	7.38	7.52
WML249									7.49		7.79	7.6		7.49	7.63	7.79
WML252									7.04		7.63	7.4		7.04	7.36	7.63
WML253									6.98		7.24	7.37		6.98	7.20	7.37
WML256									6.55		6.79	7.02		6.55	6.79	7.02
WML294											7.45	7.3		7.30	7.38	7.45
Summary for all Colluvium:														**6.55**	**7.10**	**7.79**
RM02	6.59	6.64			6.74	6.74	7.34	6.73	6.52	6.82	6.89	7.27		6.52	6.83	7.34
RM05											6.78	7.15		6.78	6.97	7.15
T2-P											7.27	7.25		7.25	7.26	7.27
T3-P											8.22	7.48		7.48	7.85	8.22
T4-P				9.69					7.39	7.84	7.74	7.38		7.38	8.01	9.69
WML108B							6.43		6.05	6.23	7.17	6.60		6.05	6.50	7.17
WML109B							6.76			6.13				6.13	6.45	6.76
WML110B				7.40			7.07		6.13	6.60	6.65	6.40		6.13	6.71	7.40

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BORE	Feb-07	May-07	Aug-07	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
WML111B				7.48			8.28		6.97	7.45	7.28	6.88		6.88	7.39	8.28
WML112B				8.89			7.50		7.09	7.46	7.96	7.15		7.09	7.68	8.89
WML113B				7.72			7.21		6.59	6.92	7.54	7.21		6.59	7.20	7.72
WML114B				7.34			7.90		7.2	7.76	7.31	7.06		7.06	7.43	7.90
WML115B							7.90		7.7	7.2	7.89	7.48		7.20	7.63	7.90
Summary for all Weathered Coal Measures Overburden:														**6.05**	**7.21**	**9.69**
WML20	7.48	7.72	8.16	8.2	8.26									7.48	7.96	8.26
WML21	7.89	7.95	8	8.4	7.64	7.52	7.66		7.62	7.91	8.46	7.9		7.52	7.90	8.46
WML119				5.29			7.27		6.73	7.75	7.46	6.5		5.29	6.83	7.75
WML120A				7.69			7.16		6.89	7.35	7.25	6.7		6.70	7.17	7.69
WML181							8.01		7.62	7.76	7.69	7.68		7.62	7.75	8.01
WML182				6.91			7.14		6.79	6.94	7.39	7.16		6.79	7.06	7.39
WML183				6.81			7.06		6.88	7.08	7.18	7.25		6.81	7.04	7.25
WML184				6.96			7.02		6.92	7.01	7.21	7.19		6.92	7.05	7.21
WML185				6.68			6.75		6.67	6.90	7.22	6.99		6.67	6.87	7.22
WML186				6.76			6.92		6.80		6.68	6.89		6.68	6.81	6.92
Summary for all Pikes Gully Seam:														**5.29**	**7.29**	**8.46**

BORE	Feb-07	May-07	Aug-07	Nov-07	Feb-08	May-08	Aug-08	Nov-08	Feb-09	May-09	Oct-09	Nov-09	May-10	Min	Ave	Max
WML261											6.93	7.2		6.93	7.07	7.20
WML262											7.95	7.64		7.64	7.80	7.95
Summary for all Upper Liddell Seam:														**6.93**	**7.43**	**7.95**
WML301																
WML302																
Summary for all Arties Seam:																
RSGM1	6.98	7.21	7.14	7.25	6.73	6.87	7.20	7.13	6.54	6.85	7.06	7		6.54	7.00	7.25
GM1	7.81	6.97	7.39	7.12	6.89	7.44	8.32	7.91	7.61	7.89	8.03	7.94		6.89	7.61	8.32
WML172							7.60		7.33	7.65	7.77	7.66		7.33	7.60	7.77
Summary for all Other Major Coal Seams:														**6.54**	**7.35**	**8.32**

2.5 GROUNDWATER MINE INFLOWS

2.5.1 NEOC

Approximately 0.5 ML/d (6 L/s) is pumped from the open cut mine on average. This comprises rainfall captured by the mine catchment, including rainfall infiltration to the in-pit waste, as well as groundwater inflows. Total groundwater inflows to the open cut are estimated to be only a small proportion of the total, probably less than 25% of the total or 0.13 ML/d (1.5 L/s).

2.5.2 UNDERGROUND MINE

The underground water balance has been closely monitored since the commencement of underground mining. Water balance components have been determined by a combination of V-notch weirs, in-line flow-meters, and timing of filling of storage tanks and sumps.

The main contributions to groundwater inflow are seepage into TG1A (the eastern gate road of LW1), small inflows to the North West Mains, and broadly distributed goaf seepage into the LW1 to LW6 goafs. Typically, no other persistent areas of seepage are seen.

Water is exported from the mine either via a borehole pump direct to the mine water supply circuit, or via pipelines along the gate-roads to a sump in the Arties Pit adjacent the mine portal. Prior to May 2010, a sump borehole situated at the south west corner of LW1 (shown on **Figure 2** as the Backroad Sump Borehole) was used, but since that date, a new sump borehole (Sump Bore No 2) located to the South of LW6, has been used.

Since extraction of LW1, access to TG1 has been lost, and seepage inflows to TG1A from Glennies Creek alluvium are now collected and conveyed via pipeline to a discharge point in the LW1 Backroad (**Figure 1**), where the flow rate is measured at a V-notch weir. This discharge then flows to the LW1 Backroad Sump.

Net groundwater inflows to the underground mine have been determined from the mine water balance, to have reached a peak of 7.14 L/s (on 7 January 2009), and averaged 4.7 L/s (0.4 ML/d) over the 2009-2010 review period. The inflow rate predicted in the EIS for this stage of underground mining ranged from 16.5 L/s to 18.6 L/s (1.4 to 1.6 ML/d). Inflows have therefore been well below the EIS predictions (**Figure 16**).

During the previous reporting periods, it was noted that most water inflow has occurred from seepage during advance of the development headings, with only moderate additional inflows occurring during subsequent longwall extraction. Smaller inflows have occurred from rib and roof seepages in other roadways. This trend has continued through the current review period.

Total measured seepage inflows from the Glennies Creek alluvium during the review period have continued to decrease, ranging from 0.6 L/s to 1 L/s, with an average inflow rate for the 2009-2010 year of 0.8 L/s. The average seepage rate into the underground mine predicted in the EIS for this stage of mining was 4 L/s. Hence seepage inflows from Glennies Creek alluvium have been well below the rates predicted in the EIS (**Figure 16**).

No seepage inflows from Bowmans Creek alluvium or Hunter River alluvium have been detected.

3 GROUNDWATER MODEL REVIEW

In accordance with Consent Condition 4.14, the performance of the groundwater system in response to mining operations was compared with impacts predicted in the EIS, based on the groundwater modelling undertaken in the EIS studies (HLA, 2001). The actual impacts were also compared with impacts predicted in the groundwater reports accompanying the LW1-4 SMP Application (Peter Dundon and Associates, 2006) and the LW/MW5-9 SMP Application (Aquaterra, 2008a).

The groundwater model used for the EIS studies has been modified to allow better definition of subsidence related impacts of underground mining. The modifications include re-definition of model layers, in particular assignment of separate model layers for the main coal seams and the interburdens (previously each seam and its overburden were treated as a single layer), and the subdivision of the Pikes Gully seam overburden into several layers (previously the Pikes Gully seam and its overburden constituted a single layer).

Successful calibration of the model was undertaken, and the model then used to predict the potential impacts of future mining in the LW/MW 5-9 SMP area (Aquaterra, 2008a). The calibration of this model was subsequently refined as part of the groundwater impact assessment for the proposed Bowmans Creek Diversion project (Aquaterra, 2008c), and the South East Open Cut project (Aquaterra, 2009d).

The Aquaterra (2008c) model was first run in steady state and transient modes to calibrate against observed impacts from open cut mining and underground mining from the Pikes Gully seam in LW1 and LW2 up to April 2008. The calibration modelling predicted baseflow reductions in Glennies Creek of 2.3 L/s by the end of the calibration period, which is consistent with observed inflows from the Glennies Creek alluvium into LW1 (around 2 L/s). Predicted groundwater level impacts also showed very good calibration with observed drawdowns in the large network of monitoring bores, which are distributed across the project area and in all the main hydrogeological units and model layers. Observed impacts are also at or below those predicted in the EIS studies.

The modelling has predicted a small baseflow reduction in Bowmans Creek from the LW/MW 5-9 mine plan, reaching a maximum of 1.2 L/s at the end of extraction from the Pikes Gully Seam. This is considerably less than the 4.3 L/s predicted in the EIS during extraction of the Pikes Gully seam.

The modelling predicted no further significant increase in seepage from the Glennies Creek alluvium with ongoing mining of the Pikes Gully seam, and negligible impact on Hunter River baseflows.

A comparison of actual impacts with EIS and SMP predictions over the 2009-10 reporting period showed the following:

- Total groundwater inflows to the underground (4.7 L/s) below inflow rates predicted in the EIS (16.5 to 18.6 L/s).
- Seepage inflows to the underground mine from Glennies Creek alluvium (0.6 to 1 L/s) have been below the EIS predictions (4 L/s).
- Groundwater level drawdown in the Glennies Creek alluvium has been significantly less than predicted in the EIS. Groundwater levels in bore WML120B (between Glennies Creek and LW1) indicated a residual net drawdown of about 0.4m by the completion of LW5, well below the EIS prediction of 2.2m for this locality by this stage of mining. There is no evidence of any drawdown in the alluvium east of Glennies Creek.
- Total groundwater inflows underground were not observed to increase significantly through direct recharge via open surface subsidence cracks above LW1-LW5 during any of the rainfall events during the 4+ years of longwall mining.

In summary, all groundwater-related impacts from underground mining during the review period were below the levels predicted in the EIS (2001), and in the SMP LW1-4 and LW/MW5-9 groundwater assessments.

Most of the impacts had stabilised prior to the end of LW1, and no significant incremental impact or influence from mining LW2 to LW6 has been observed.

4 REFERENCES

Aquaterra Consulting Pty Ltd, 2008a. *Ashton Underground Mine – LW-MW 5-9 Pikes Gully Seam Groundwater Impact Assessment Report*. Report to Ashton Coal, October 2008.

Aquaterra Consulting Pty Ltd, 2008b. *Ashton Coal - End of Panel 1 Groundwater Report.* Report to Ashton Coal, July 2008.

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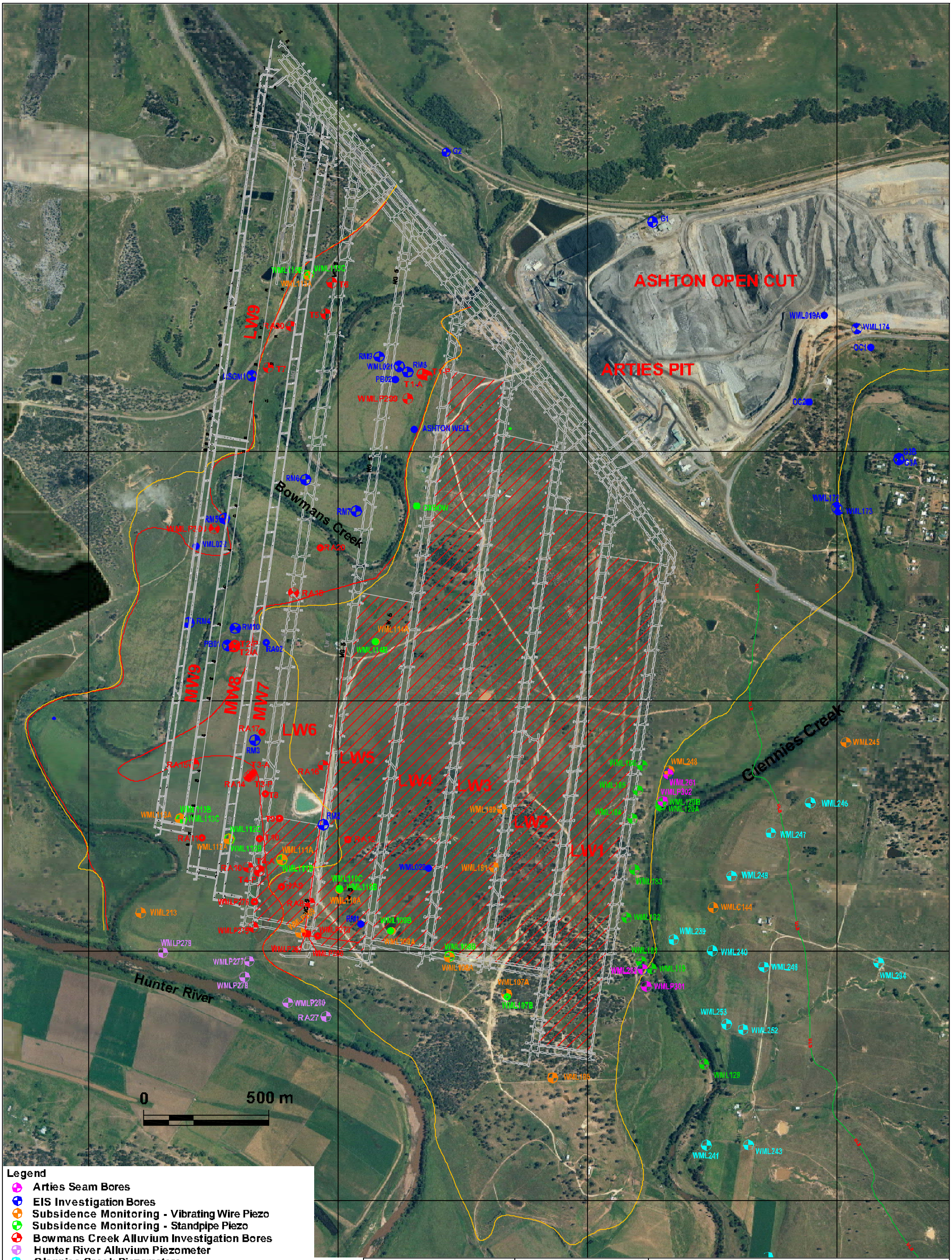
Peter Dundon and Associates Pty Ltd, 2006. *Ashton Coal Mine Longwall Panels 1-4, Subsidence Management Plan – Groundwater Assessment*.

Peter Dundon and Associates Pty Ltd, 2007. *Ashton Coal Mine Groundwater Impacts of Longwall 1, Comparison with EIS and SMP Predictions*.

FIGURES

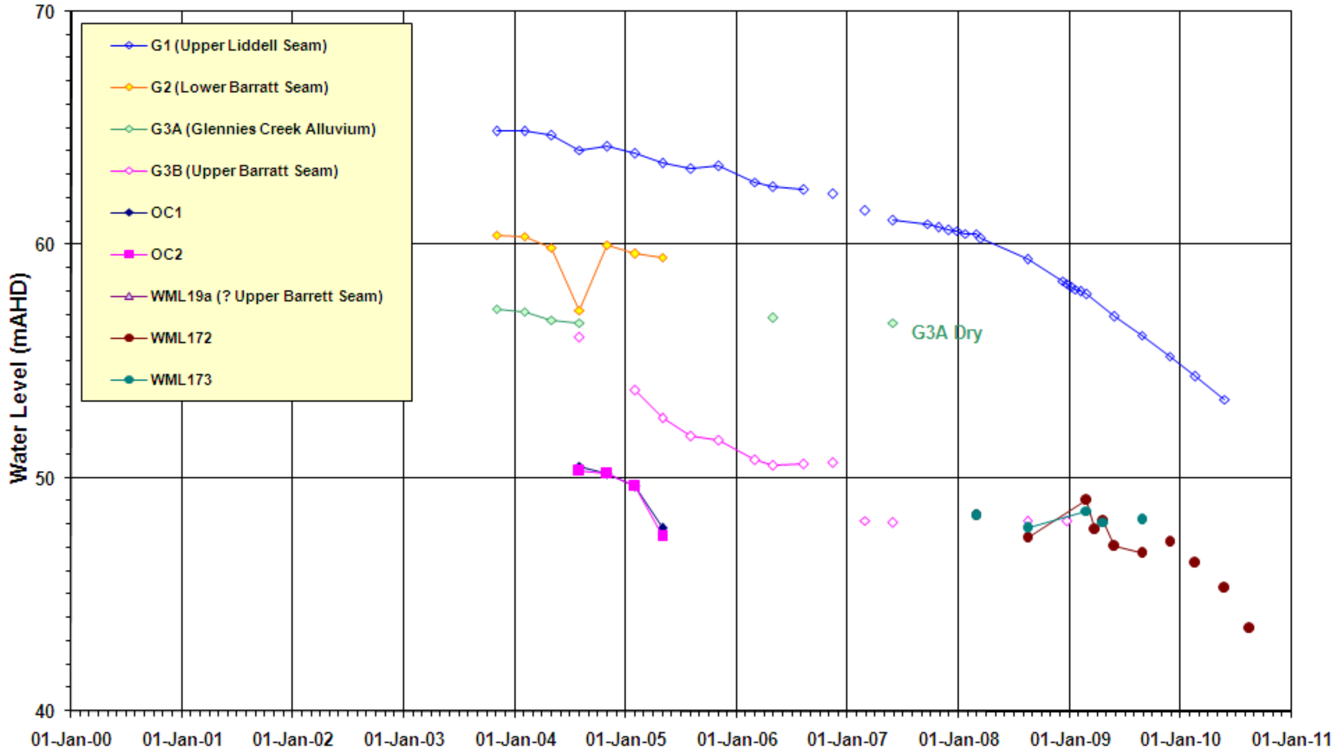


Legend

- Arties Seam Bores
- EIS Investigation Bores
- Subsidence Monitoring - Vibrating Wire Piezo
- Subsidence Monitoring - Standpipe Piezo
- Bowmans Creek Alluvium Investigation Bores
- Hunter River Alluvium Piezometer
- Glennies Creek Piezometers
- Upper Liddell Seam Monitoring Bores
- LW1 Barrier Piezometers
- Dry / Abandoned / Lost Bore
- Extent Of Alluvium
- Extent Of Saturated Bowmans Creek Alluvium
- Longwall Mining Completed - Pikes Gully Seam

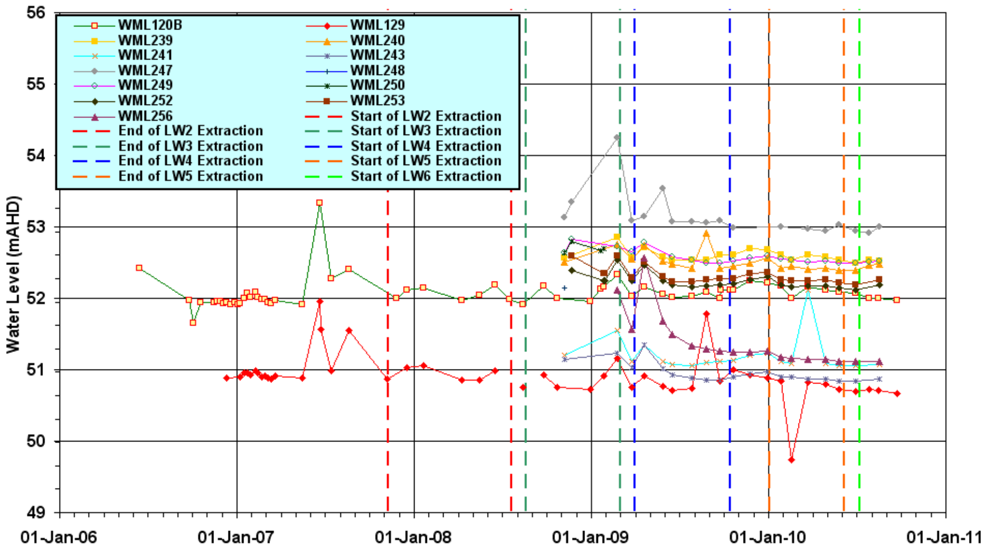
Date: 29 September 2010	Scale: as shown	Ashton Coal Operations Ltd
Initials: JVDA/SRD	Job No: S55 D4	ASHTON COAL MINE PIEZOMETER LOCATION PLAN FOR END OF LW5
Drawing No: S55-232i	Revision: I	
aquaterra		Figure 1

HYDROGRAPHS - ASHTON OPEN CUT MONITORING PIEZOMETERS

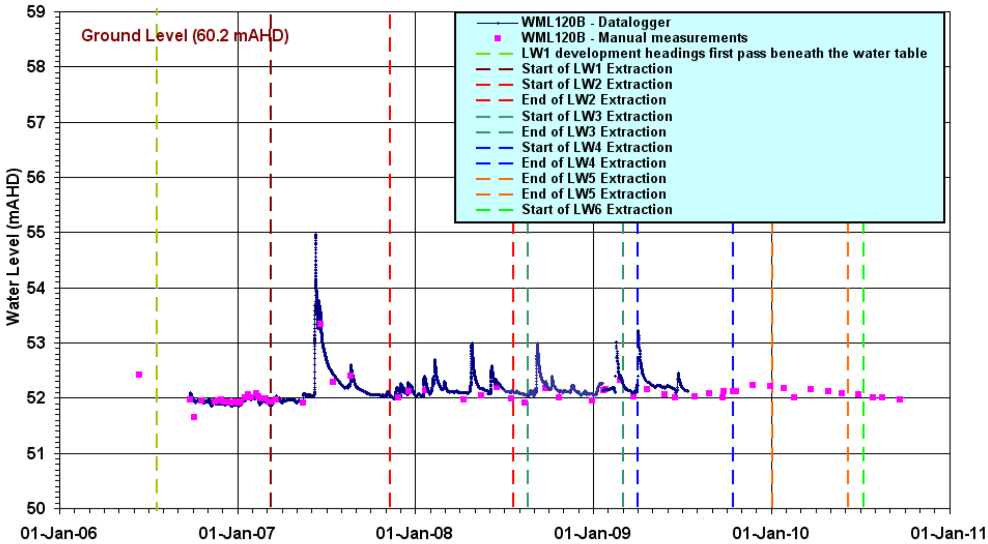


Date **06 September 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **SM**	Project **S56C**	GROUNDWATER LEVEL HYDROGRAPHS Open Cut Monitoring Bores
Drawing Number **S56-002**	Revision **B**	
aquaterra		**Figure 2**

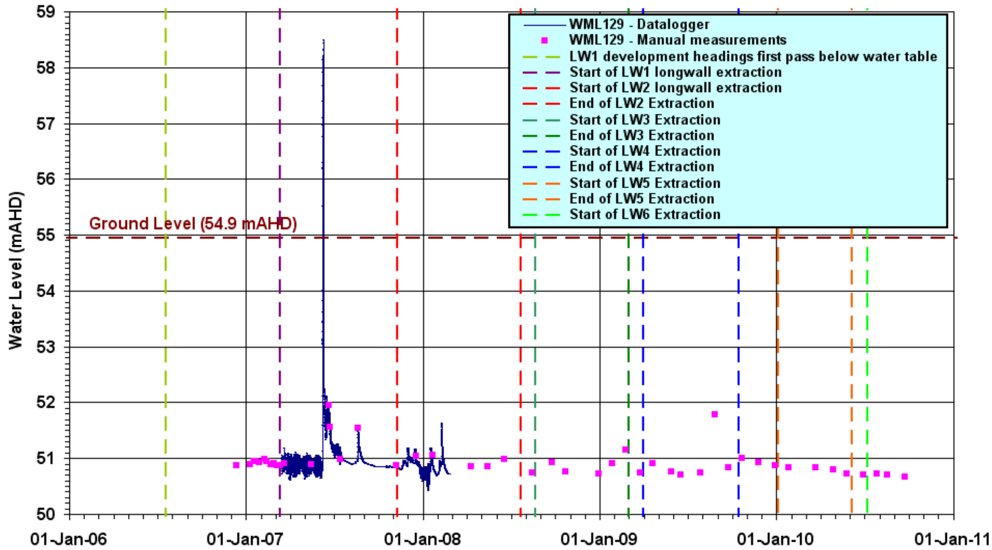
ALLUVIUM AQUIFER HYDROGRAPHS - GLENNIES CREEK ALLUVIUM



GROUNDWATER LEVEL HYDROGRAPH - WML120B (Glennies Creek Alluvium)

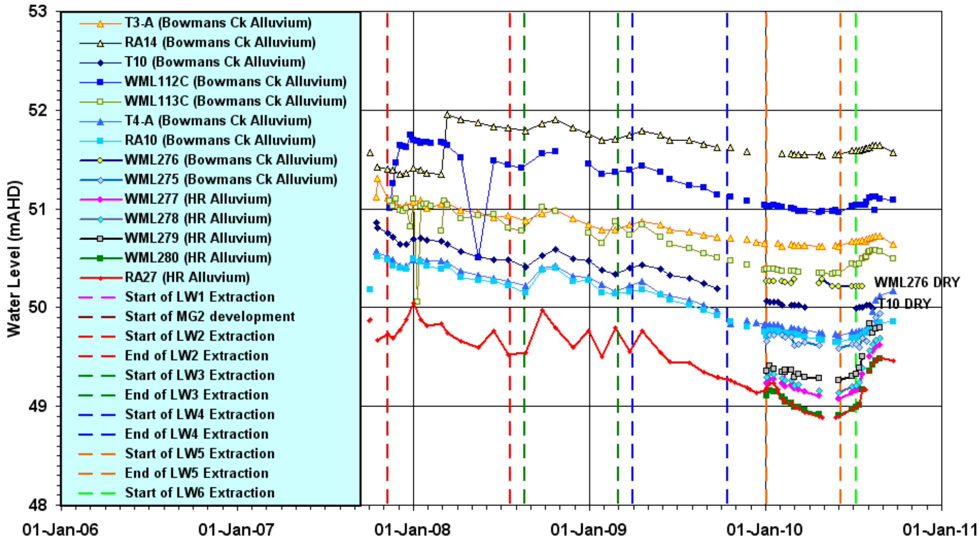


GROUNDWATER LEVEL HYDROGRAPH - WML129 (Glennies Creek Alluvium)

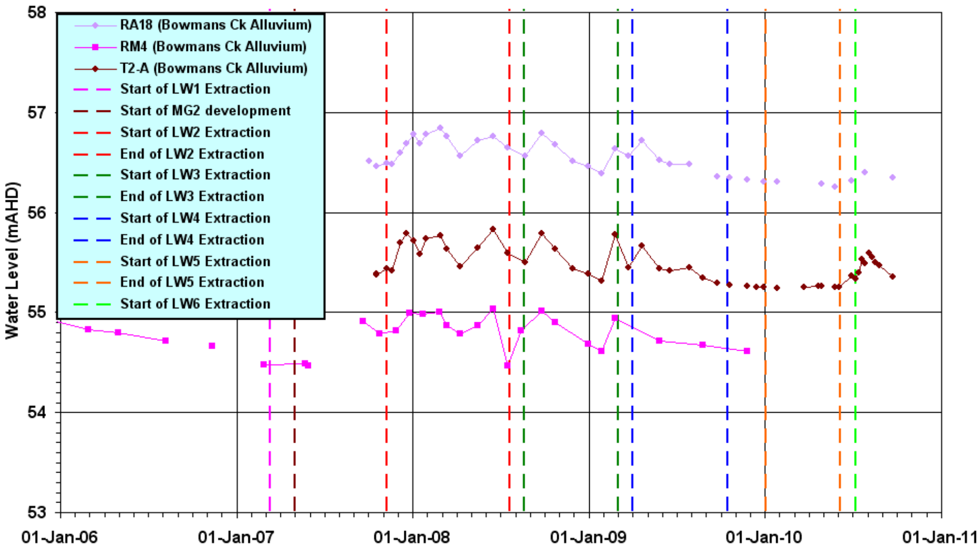


Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	**GROUNDWATER LEVEL HYDROGRAPHS** **Glennies Creek Alluvium**
Drawing Number **S56-003**	Revision **C**	
aquaterra		**Figure 3**

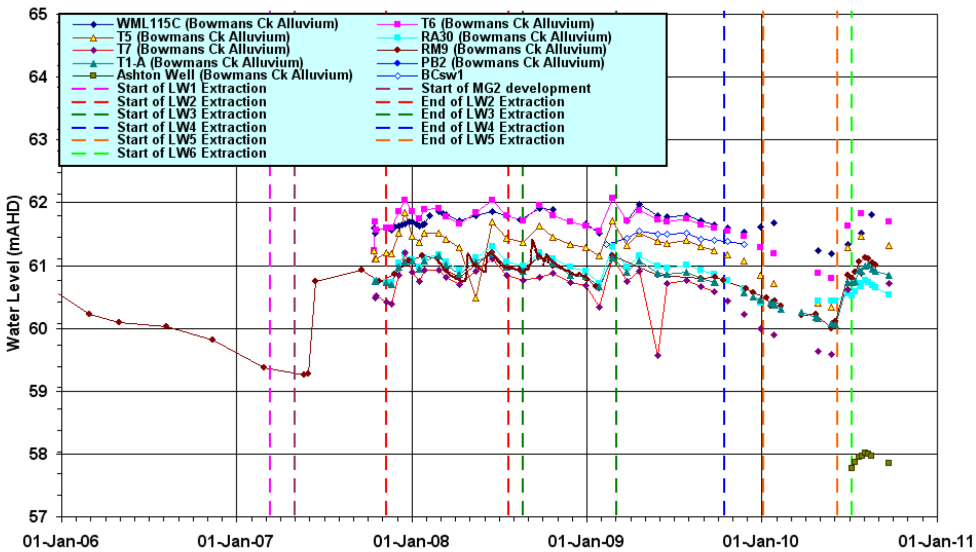
ALLUVIUM AQUIFER HYDROGRAPHS - BOWMANS CREEK (Southern Zone)



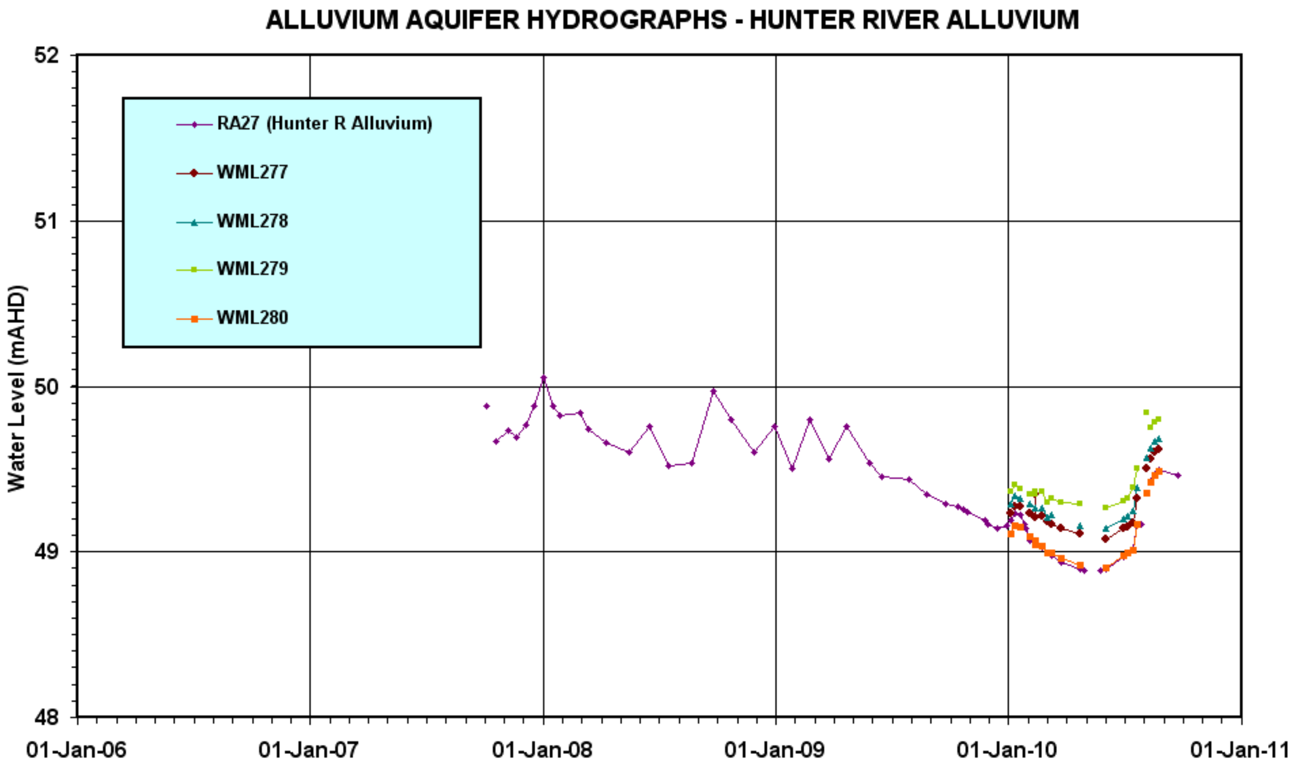
ALLUVIUM AQUIFER HYDROGRAPHS - BOWMANS CREEK (Central Zone)

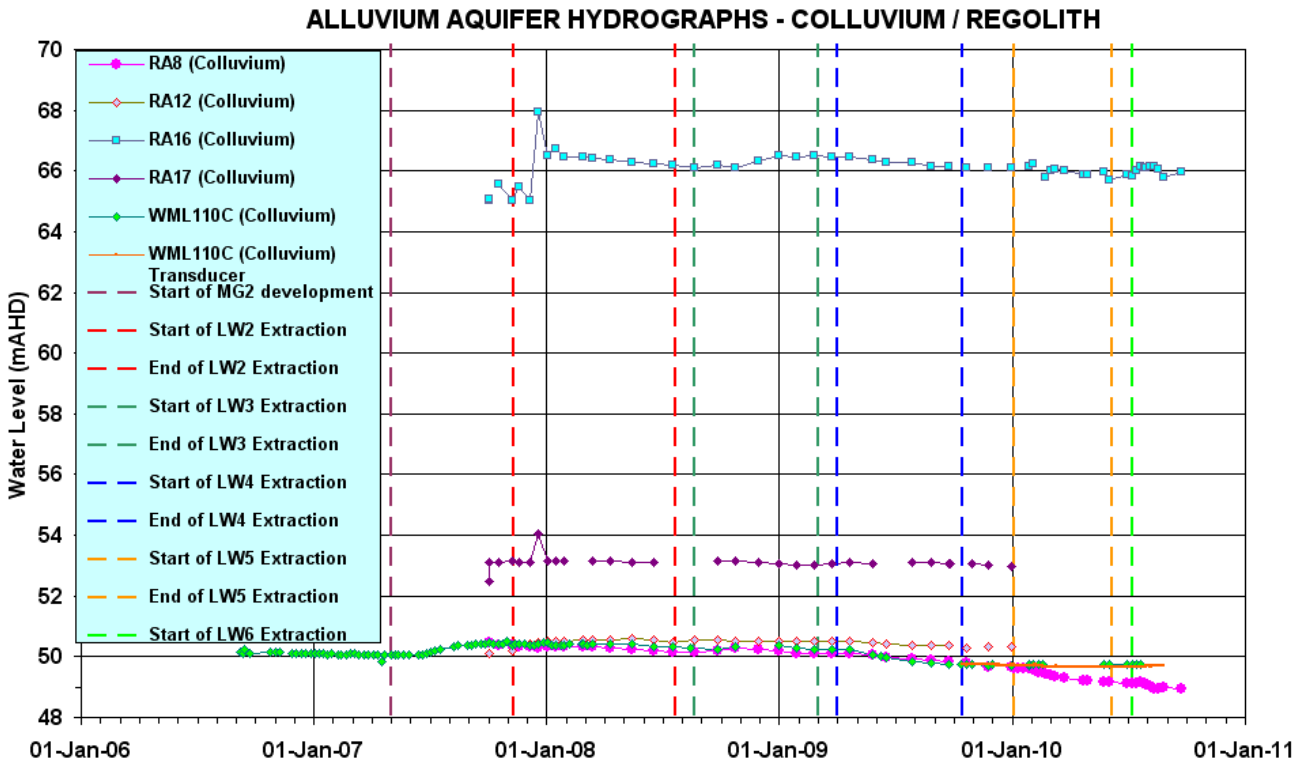


ALLUVIUM AQUIFER HYDROGRAPHS - BOWMANS CREEK (Northern Zone)

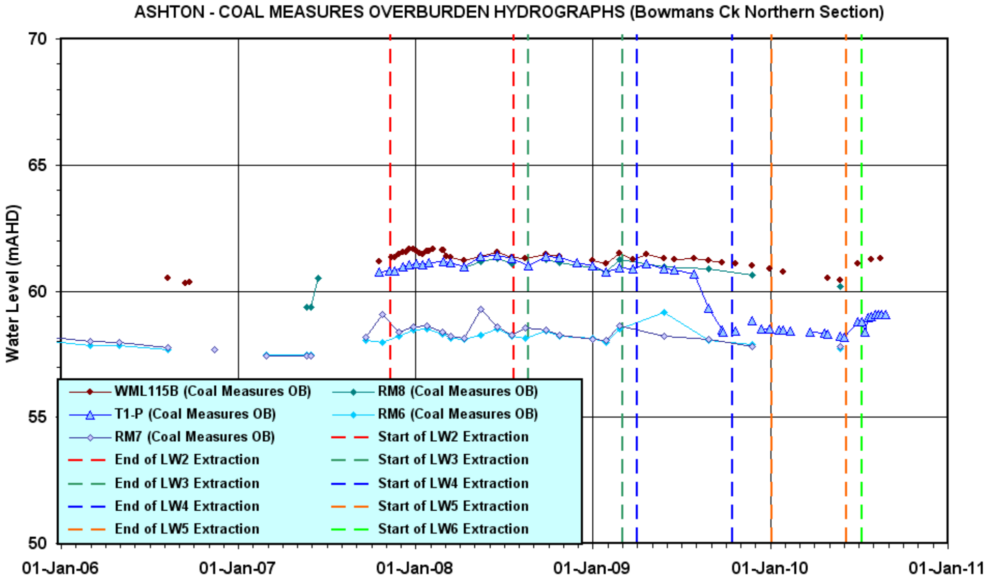


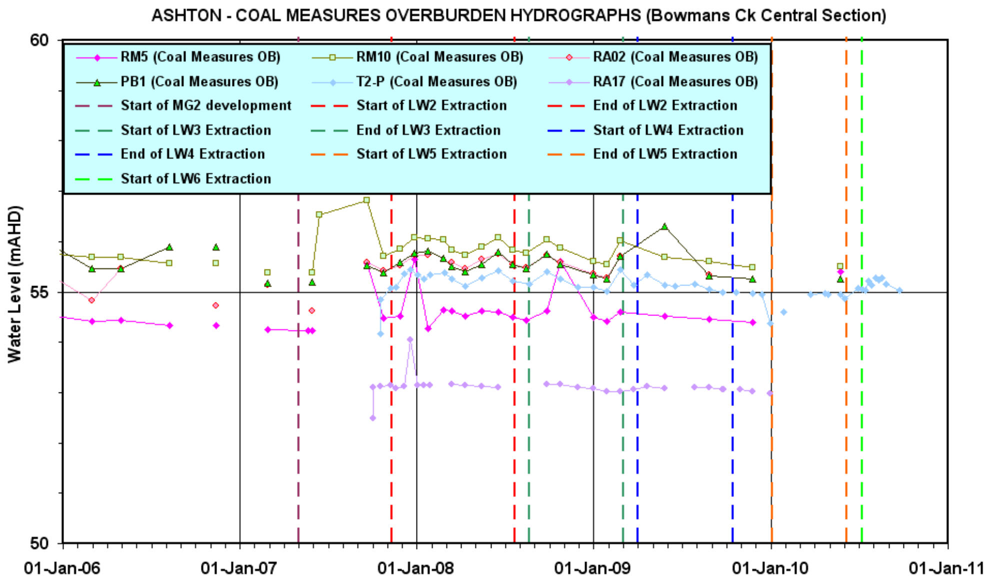
Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	**GROUNDWATER LEVEL HYDROGRAPHS** Bowmans Creek Alluvium
Drawing Number **S56-003**	Revision **C**	
aquaterra		**Figure 4**

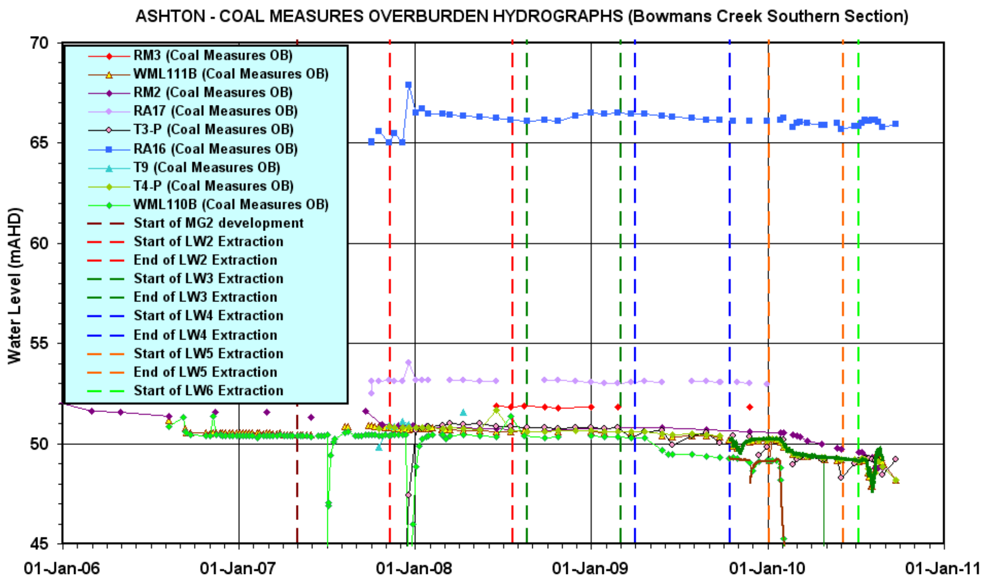




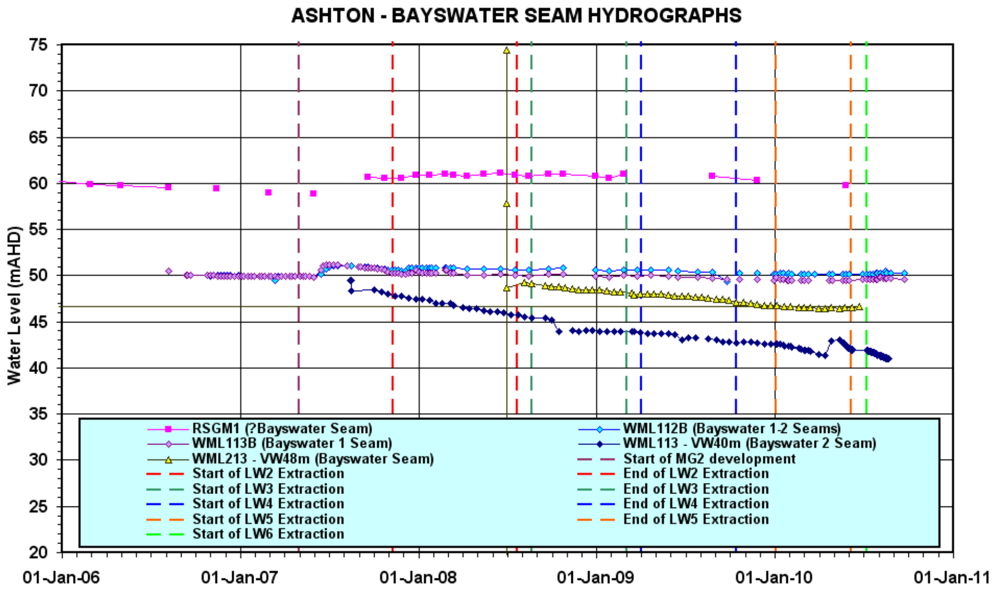
Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	GROUNDWATER LEVEL HYDROGRAPHS Hunter River Alluvium and Bowmans Creek Colluvium / Regolith
Drawing Number **S56-005**	Revision **C**	
aquaterra		**Figure 5**

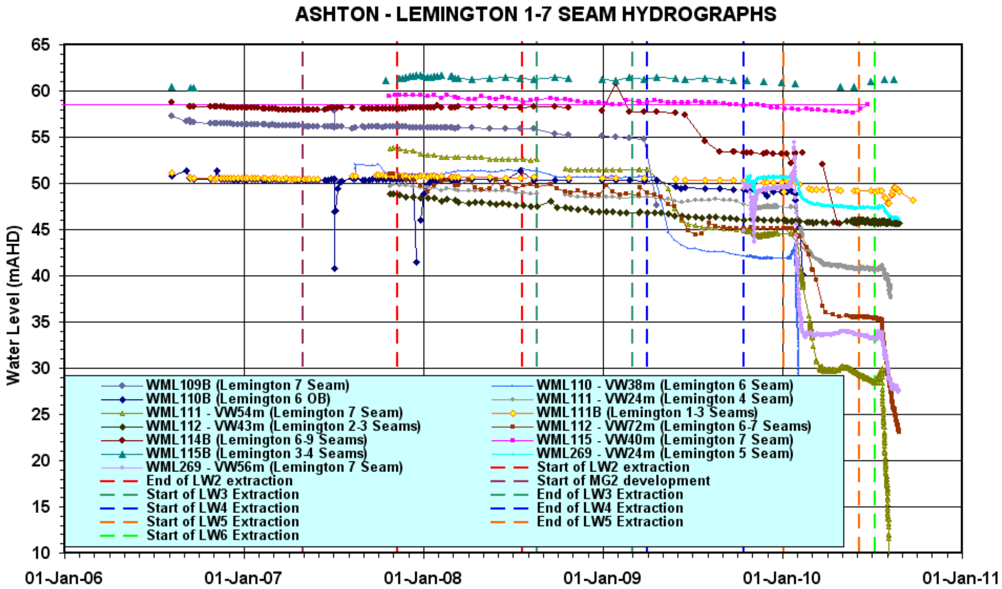


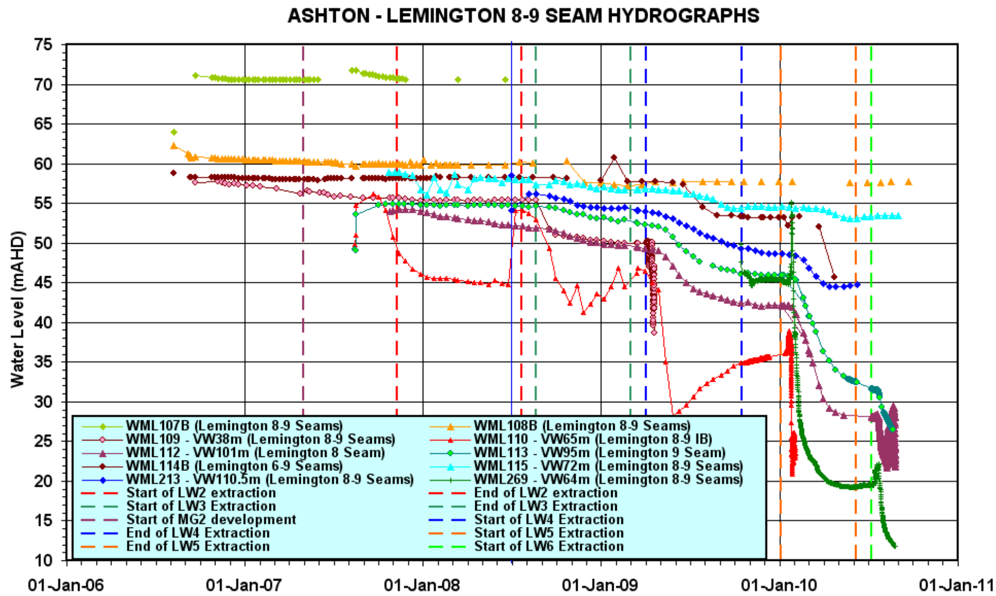




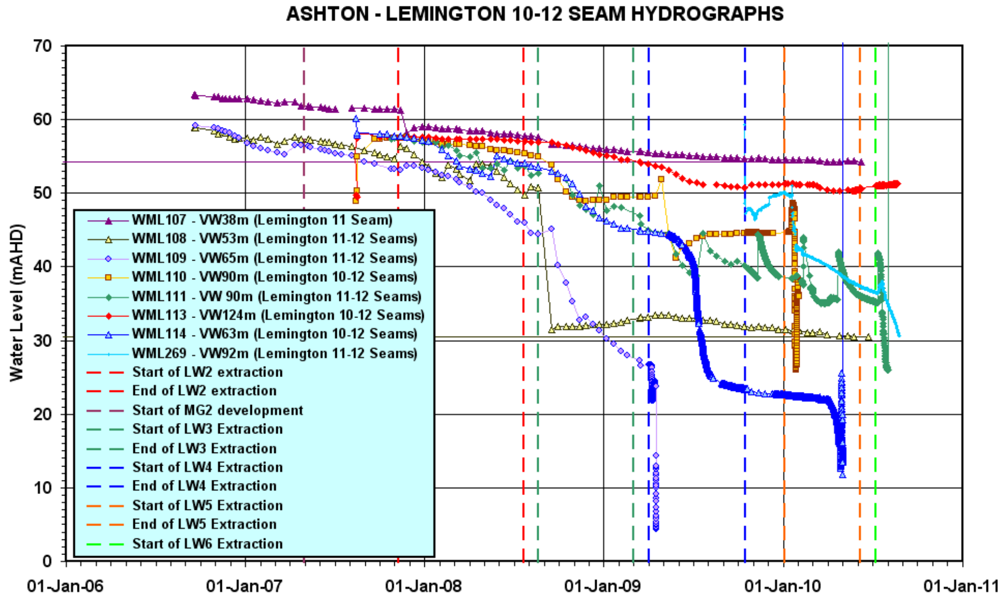
Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	**GROUNDWATER LEVEL HYDROGRAPHS**
Drawing Number **S56-006**	Revision **C**	**Weathered Near-Surface Coal Measures Overburden**
aquaterra		**Figure 6**

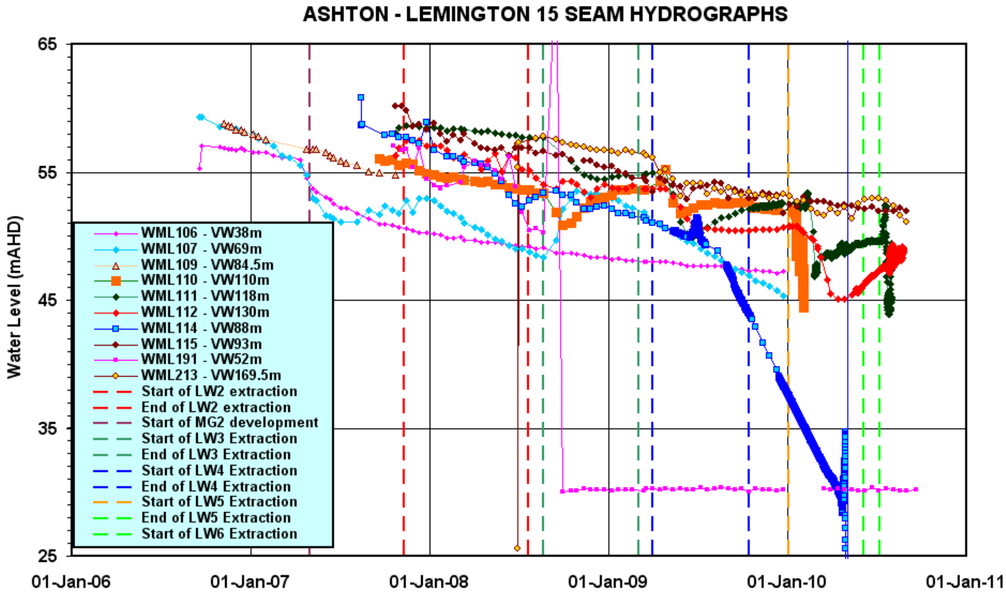


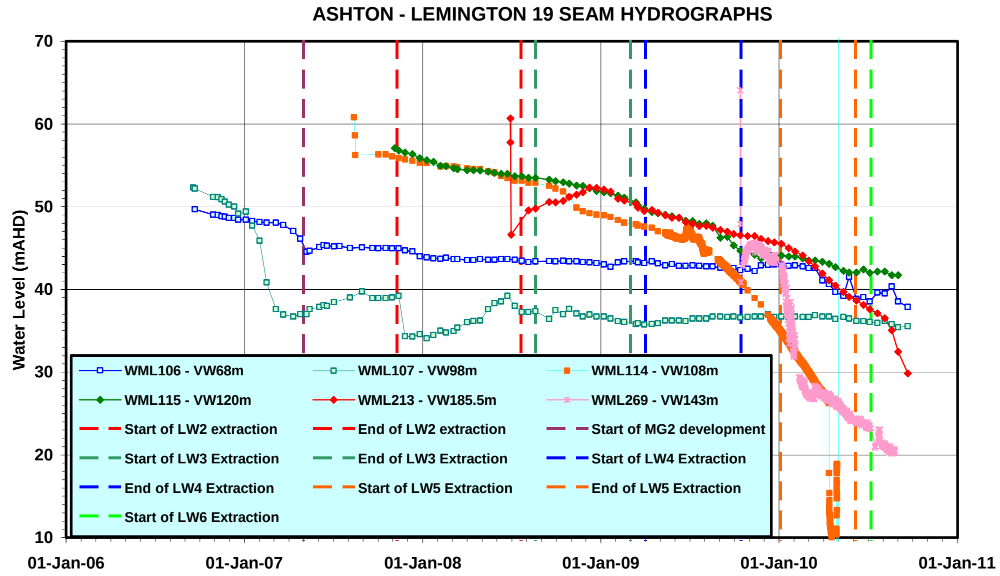




Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	GROUNDWATER LEVEL HYDROGRAPHS Bayswater Seam and Lemington 1-9 Seams
Drawing Number **S56-007**	Revision **C**	
aquaterra		**Figure 7**

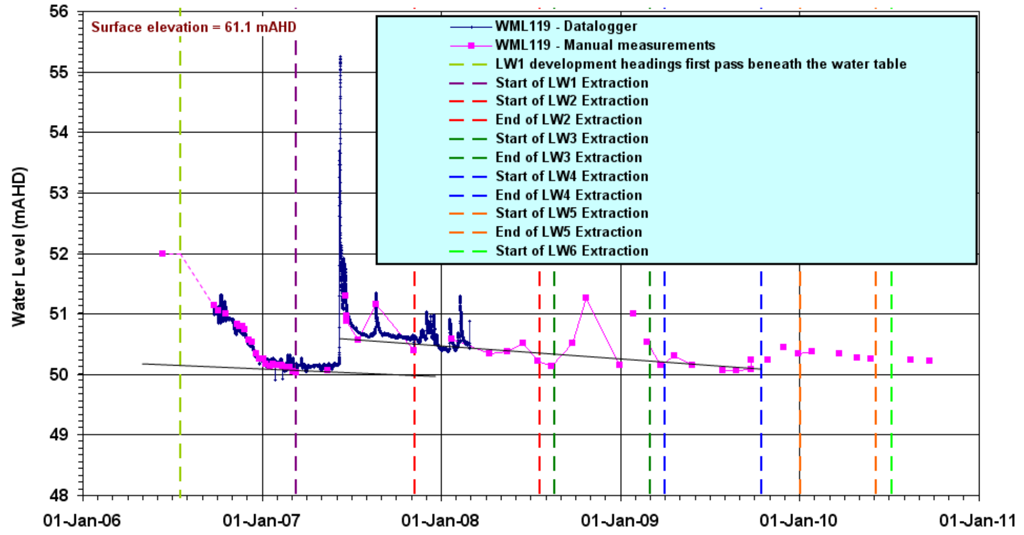




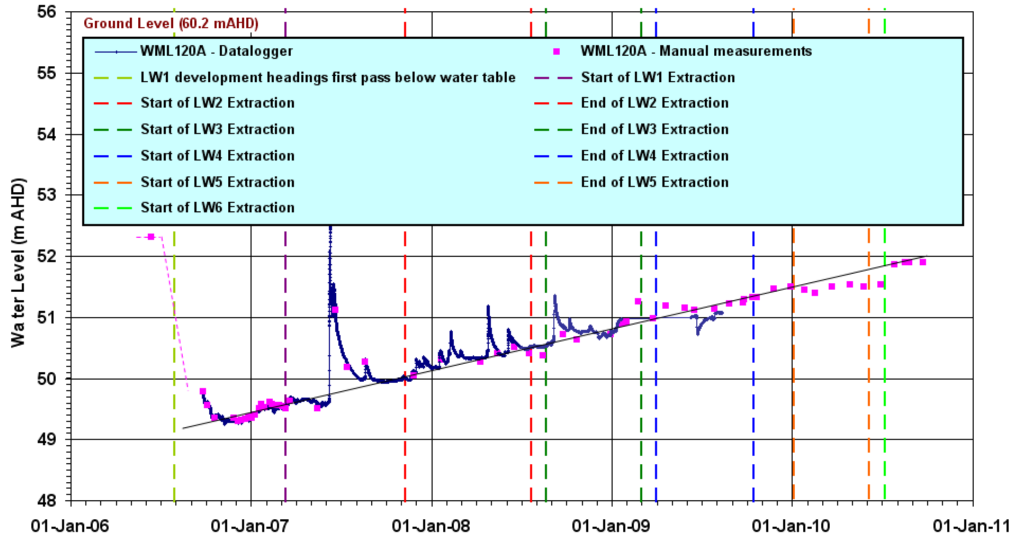


Date 06 October 2010	Scale As Shown	**Ashton Coal Operations Ltd**
Initials MA	Project S56C	**GROUNDWATER LEVEL HYDROGRAPHS** **Lemington Seams 10-19**
Drawing Number S56-008	Revision C	
aquaterra		**Figure 8**

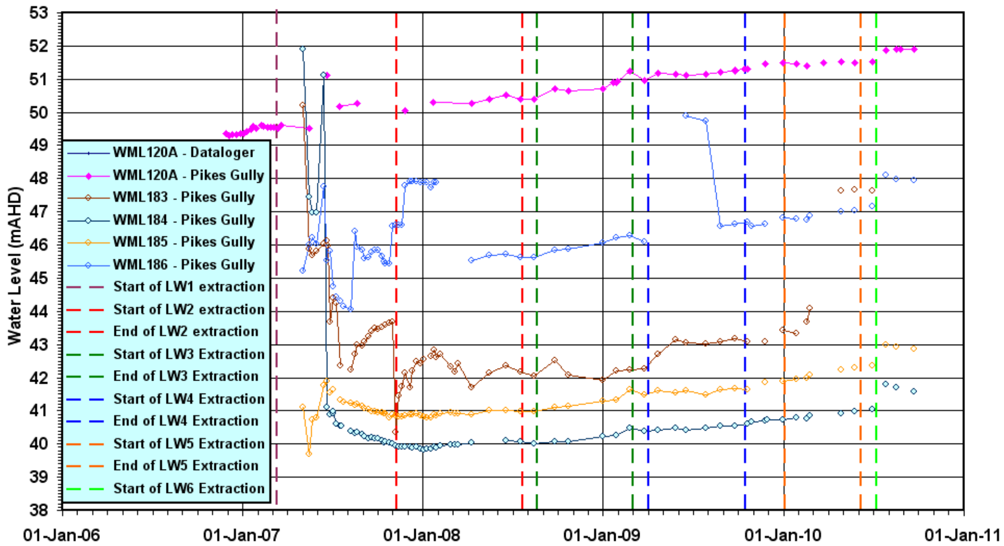
GROUNDWATER LEVEL HYDROGRAPH - WML119 (Pikes Gully Seam)



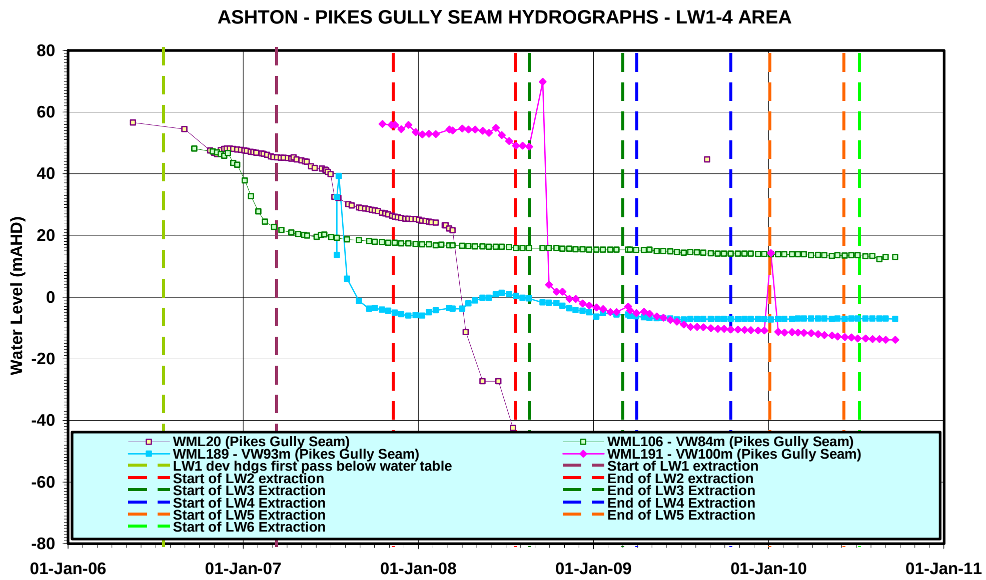
GROUNDWATER LEVEL HYDROGRAPH - WML120A (Pikes Gully Seam)

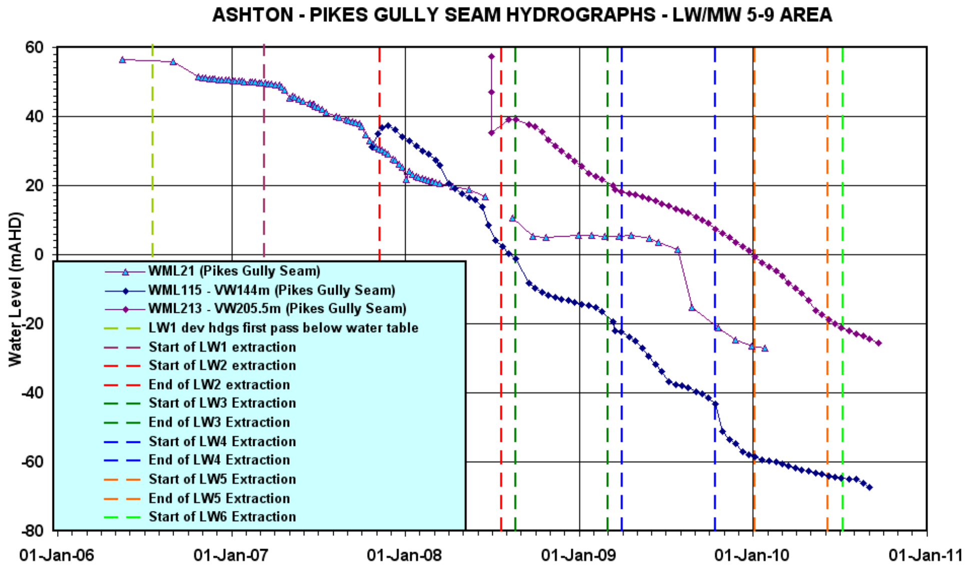


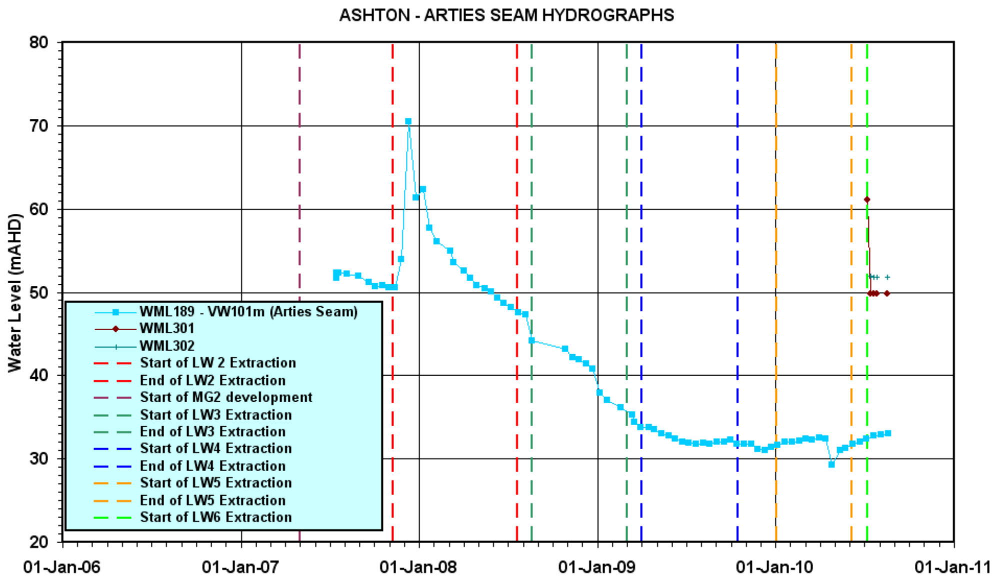
ASHTON - PIKES GULLY SEAM HYDROGRAPHS - EAST OF LW1



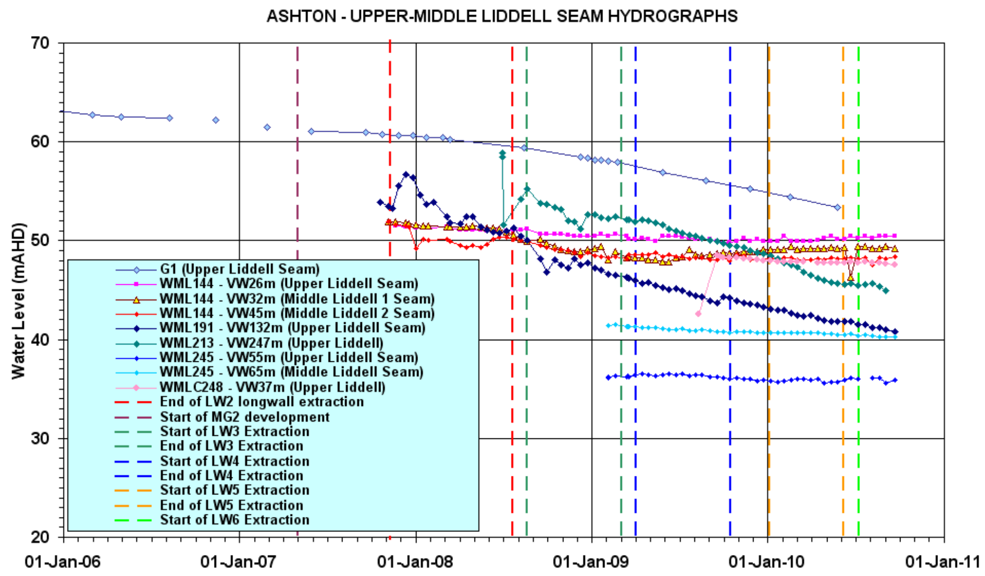
Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	**GROUNDWATER LEVEL HYDROGRAPHS East of LW1, WML119 and WML120A**
Drawing Number **S55F-009**	Revision **C**	
aquaterra		**Figure 9**

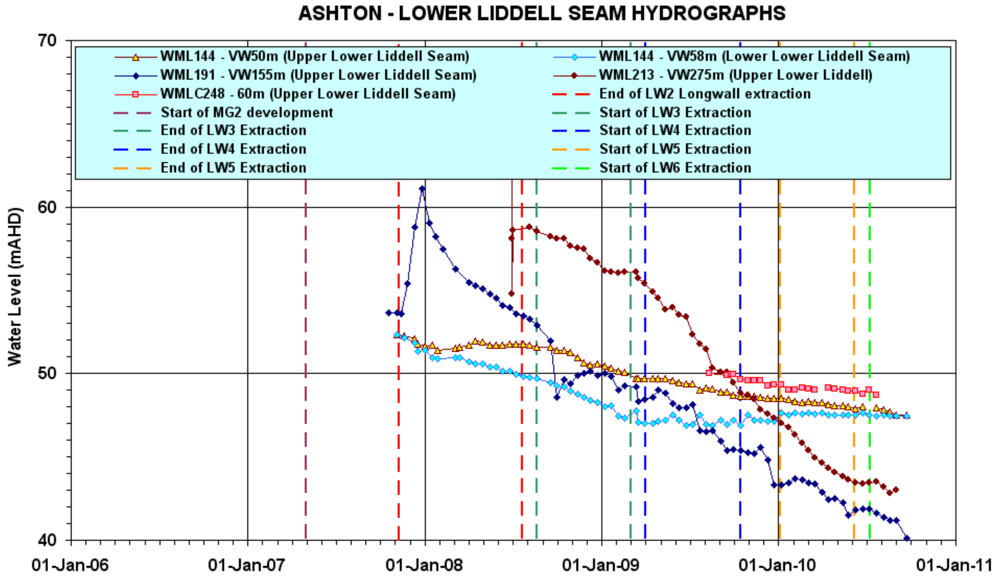


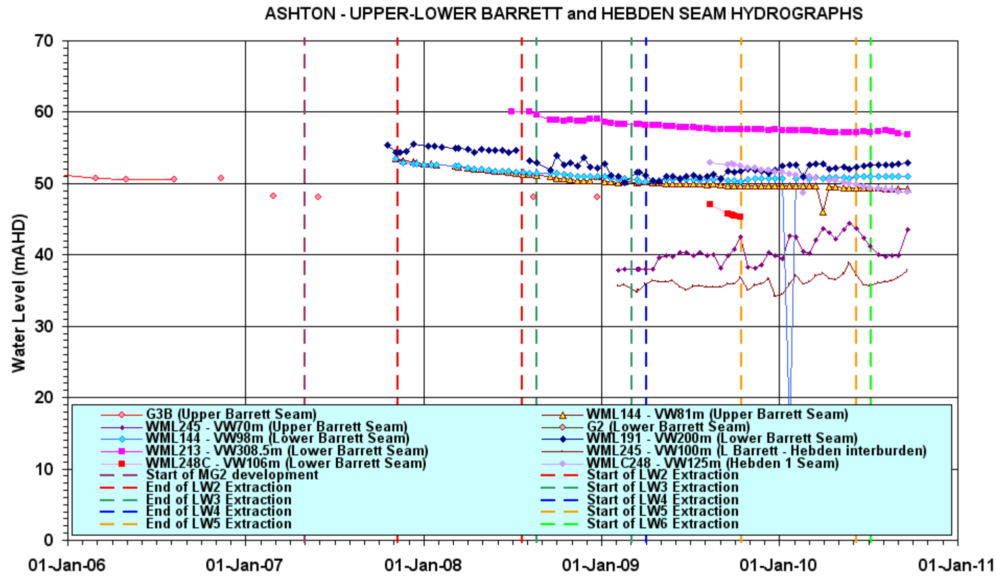




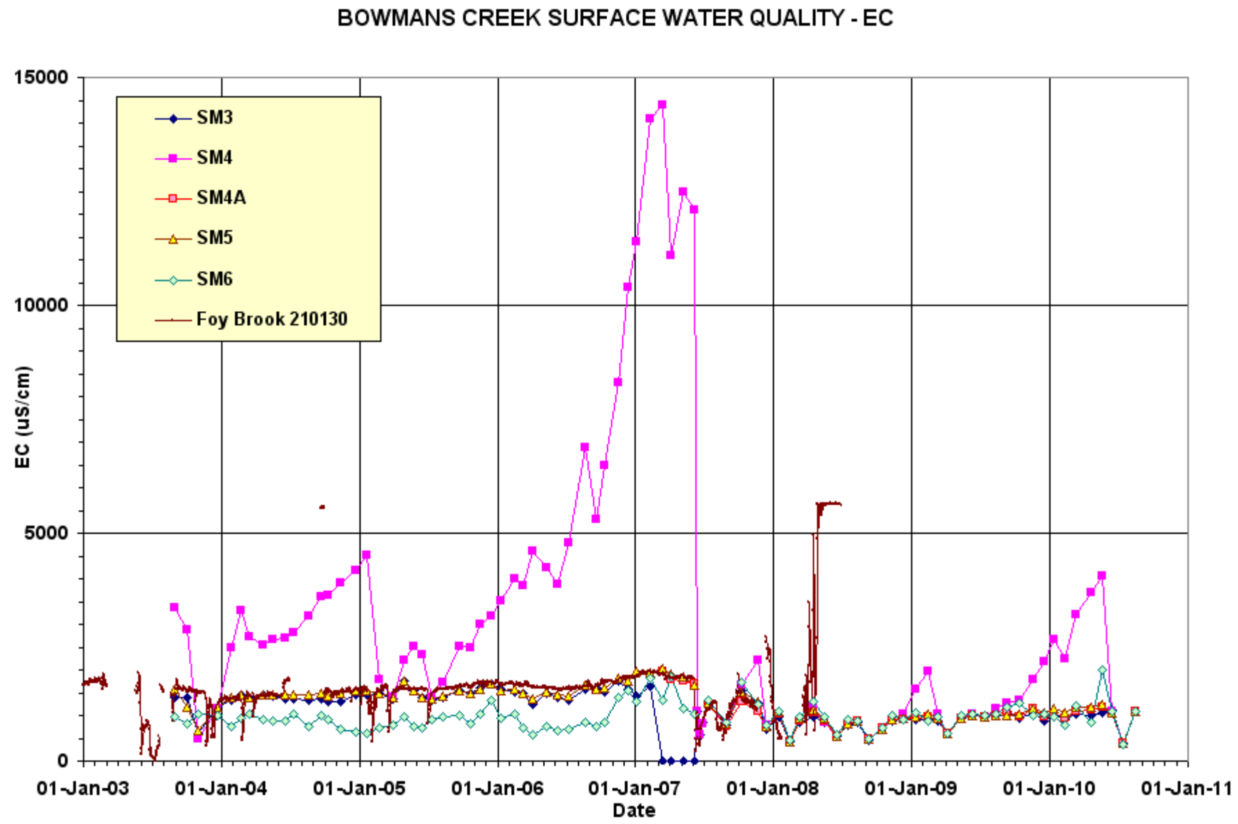
Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	**GROUNDWATER LEVEL HYDROGRAPHS LW1-4, LW5-9 and Arties Seam**
Drawing Number **S55F-010**	Revision **C**	
aquaterra		**Figure 10**

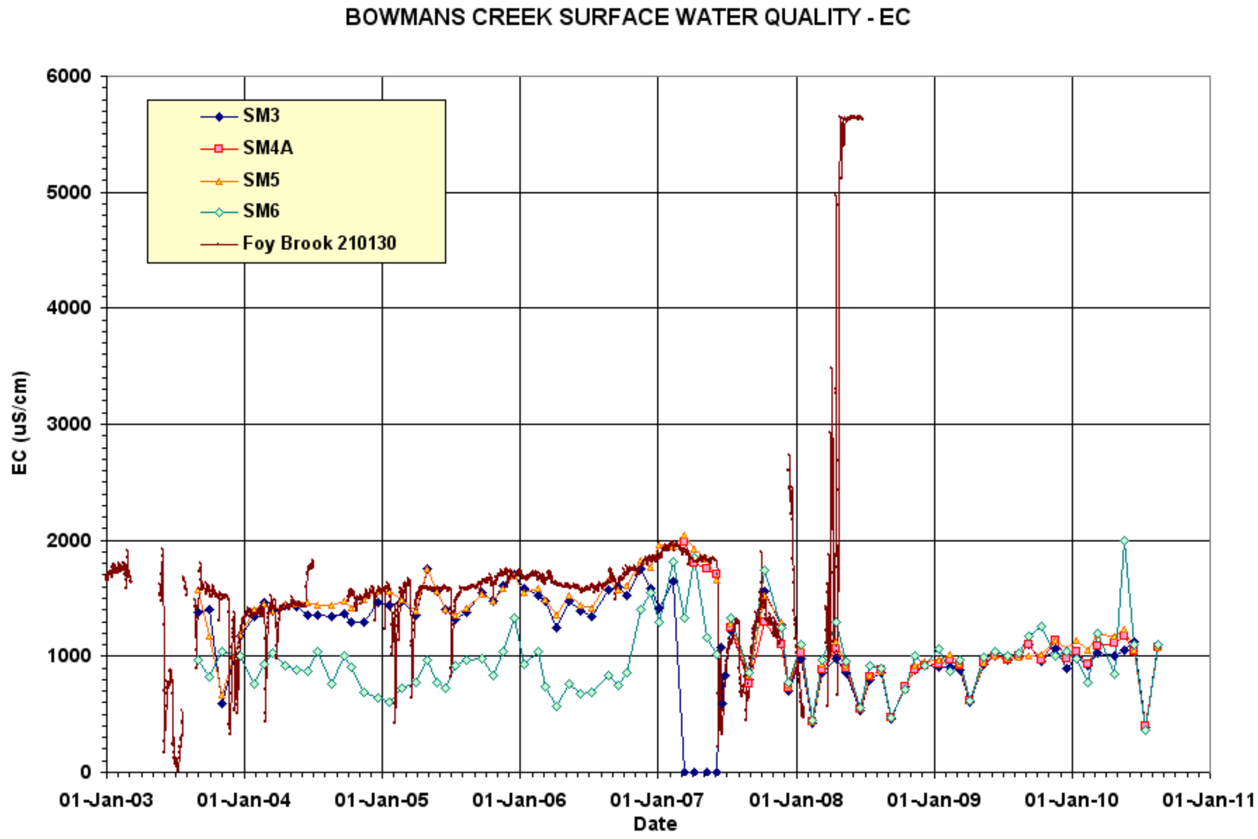




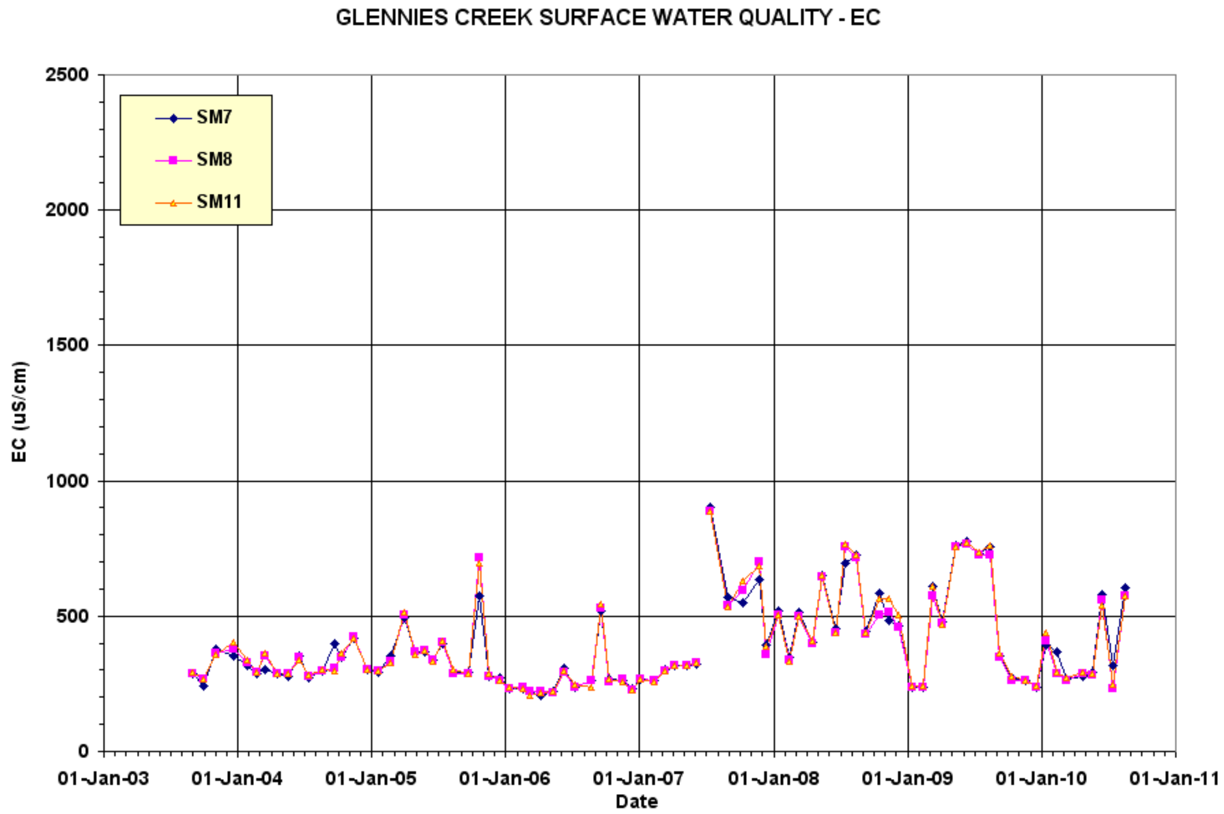


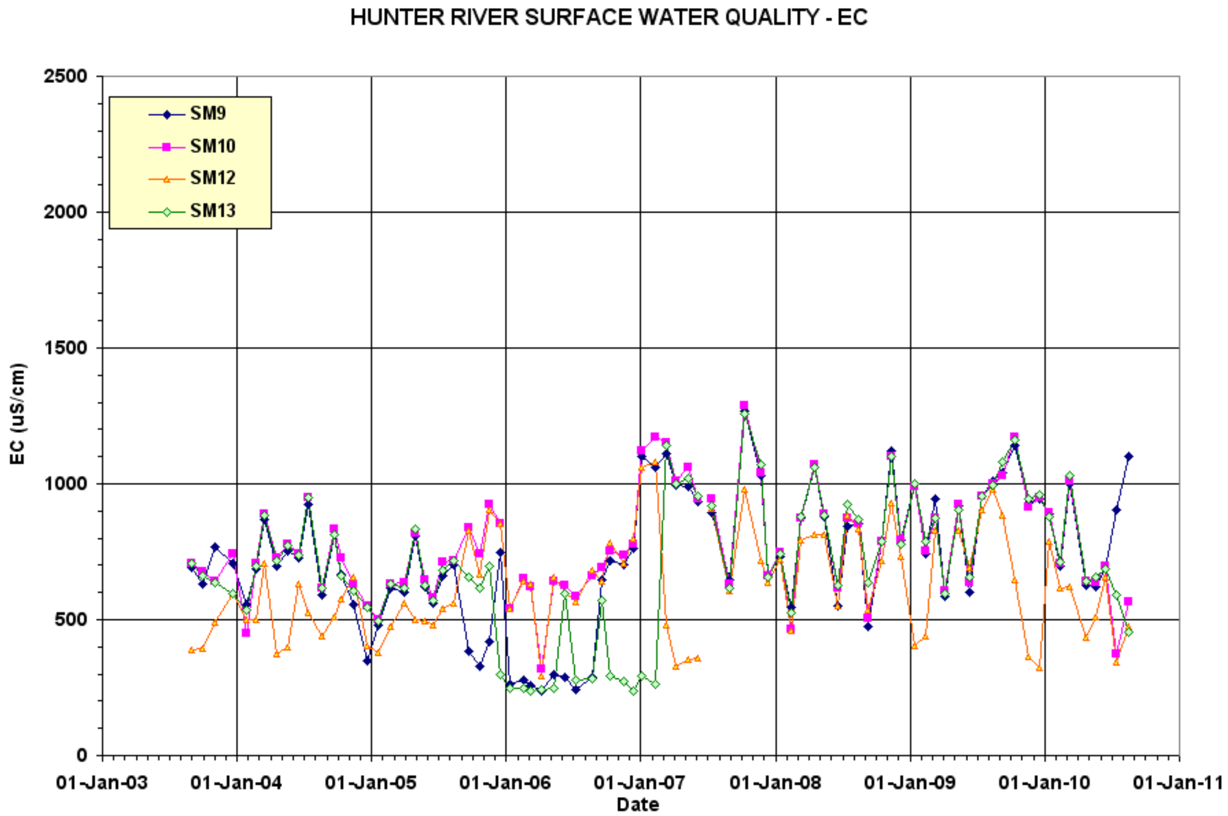
Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	**GROUNDWATER LEVEL HYDROGRAPHS**
Drawing Number **S55F-011**	Revision **C**	**Liddell and Barrett Seams**
aquaterra		**Figure 11**





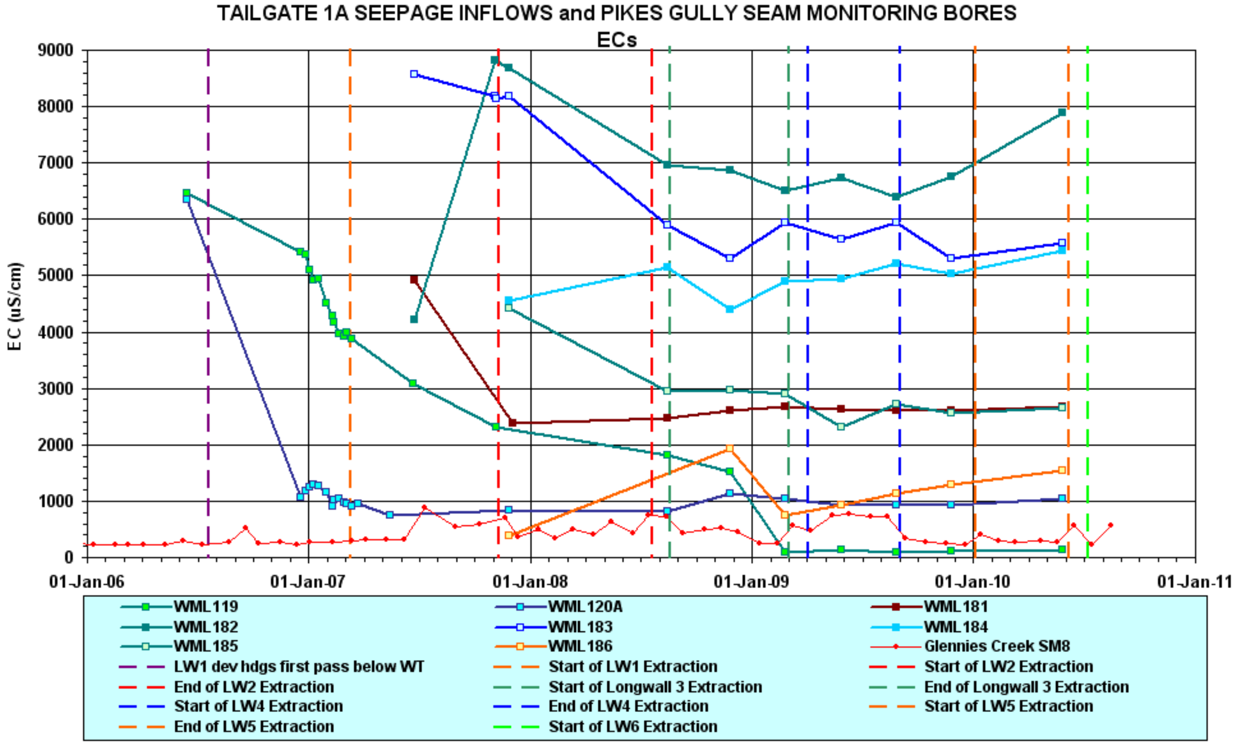
Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	**SURFACE WATER QUALITY** **Bowmans Creek - EC**
Drawing Number **S55F-012**	Revision **C**	
aquaterra		**Figure 12**



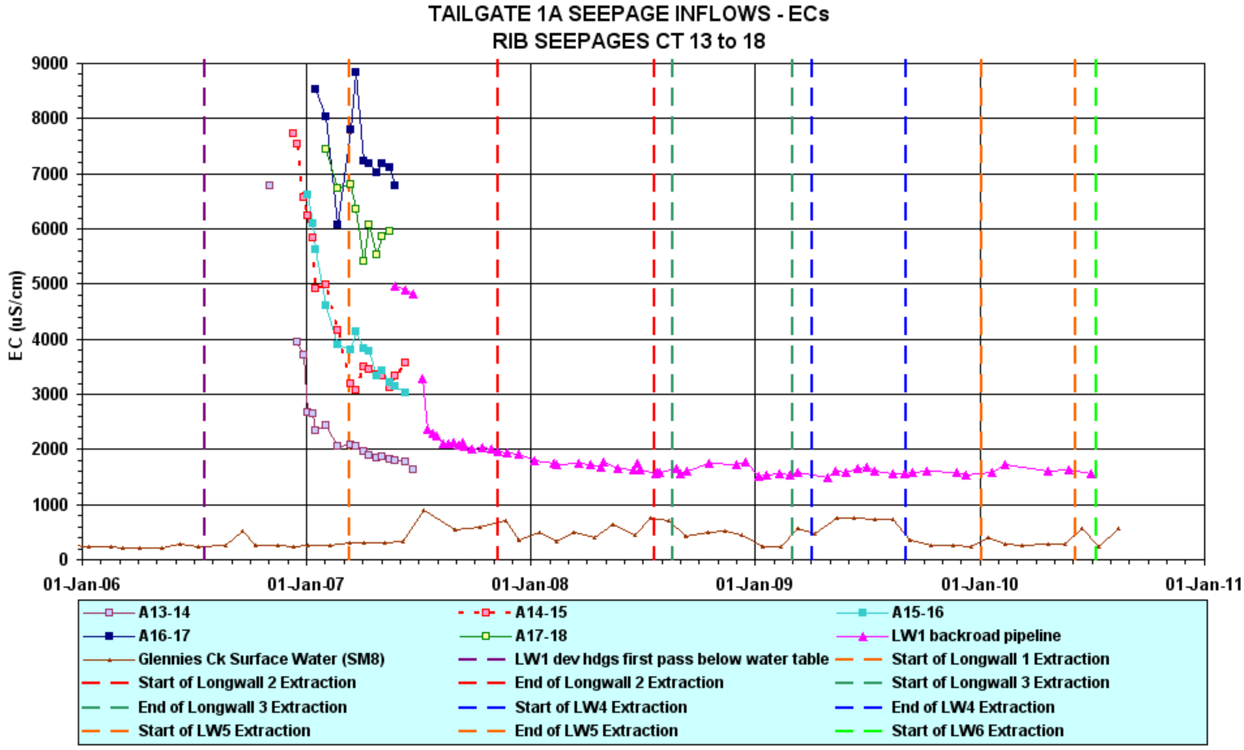


Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	**SURFACE WATER QUALITY** **Glennies Creek and Hunter River**
Drawing Number **S55F-013**	Revision **C**	
aquaterra		**Figure 13**

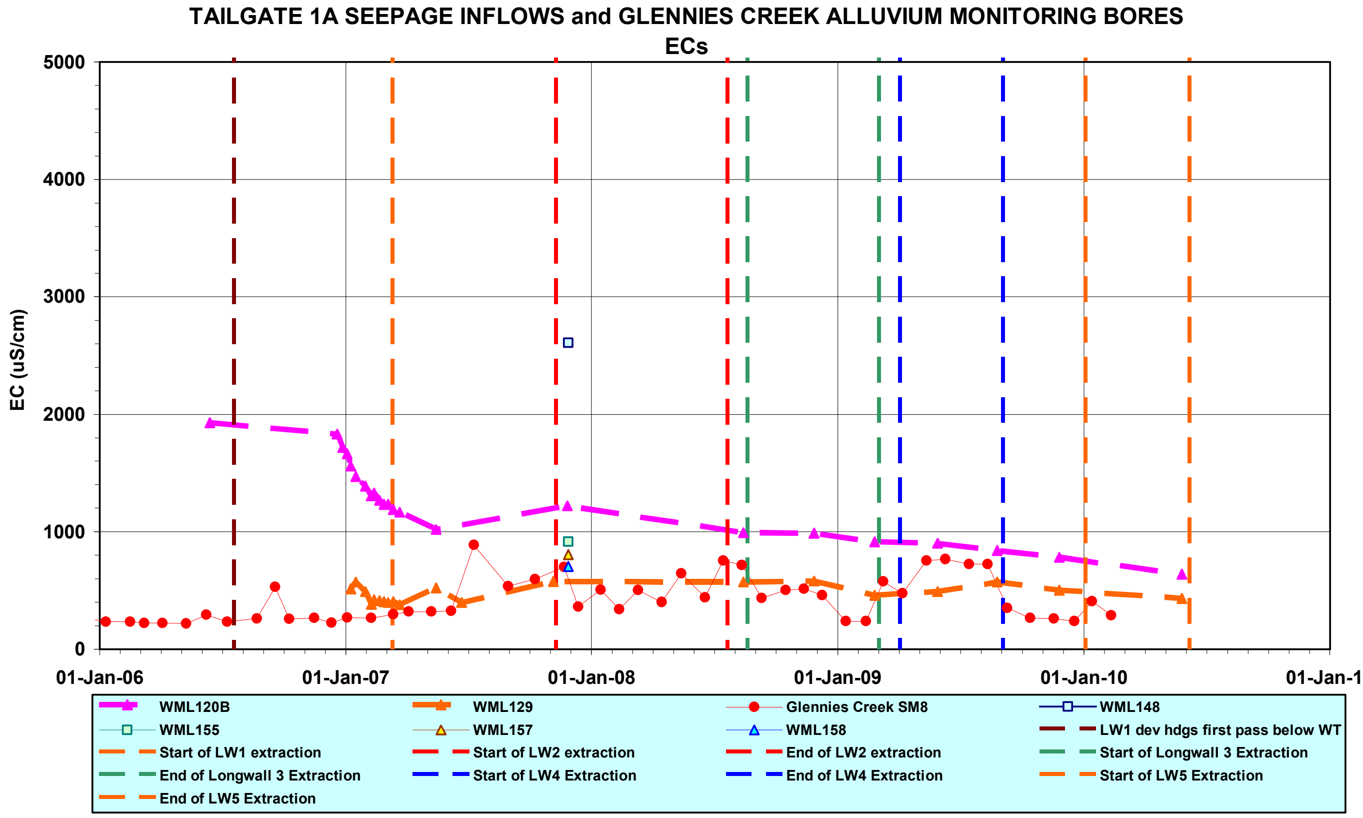
TAILGATE 1A SEEPAGE INFLOWS and PIKES GULLY SEAM MONITORING BORES ECs

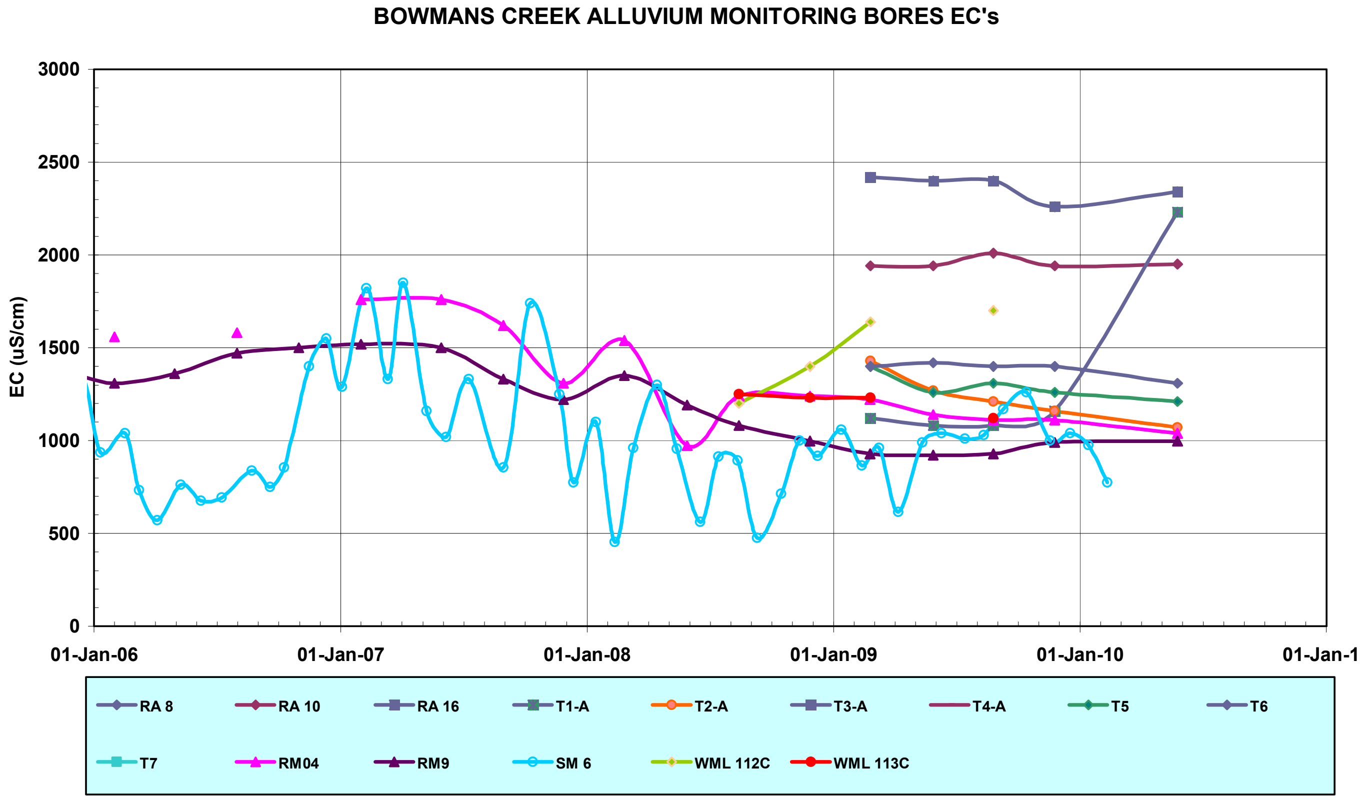


TAILGATE 1A SEEPAGE INFLOWS - ECs RIB SEEPAGES CT 13 to 18

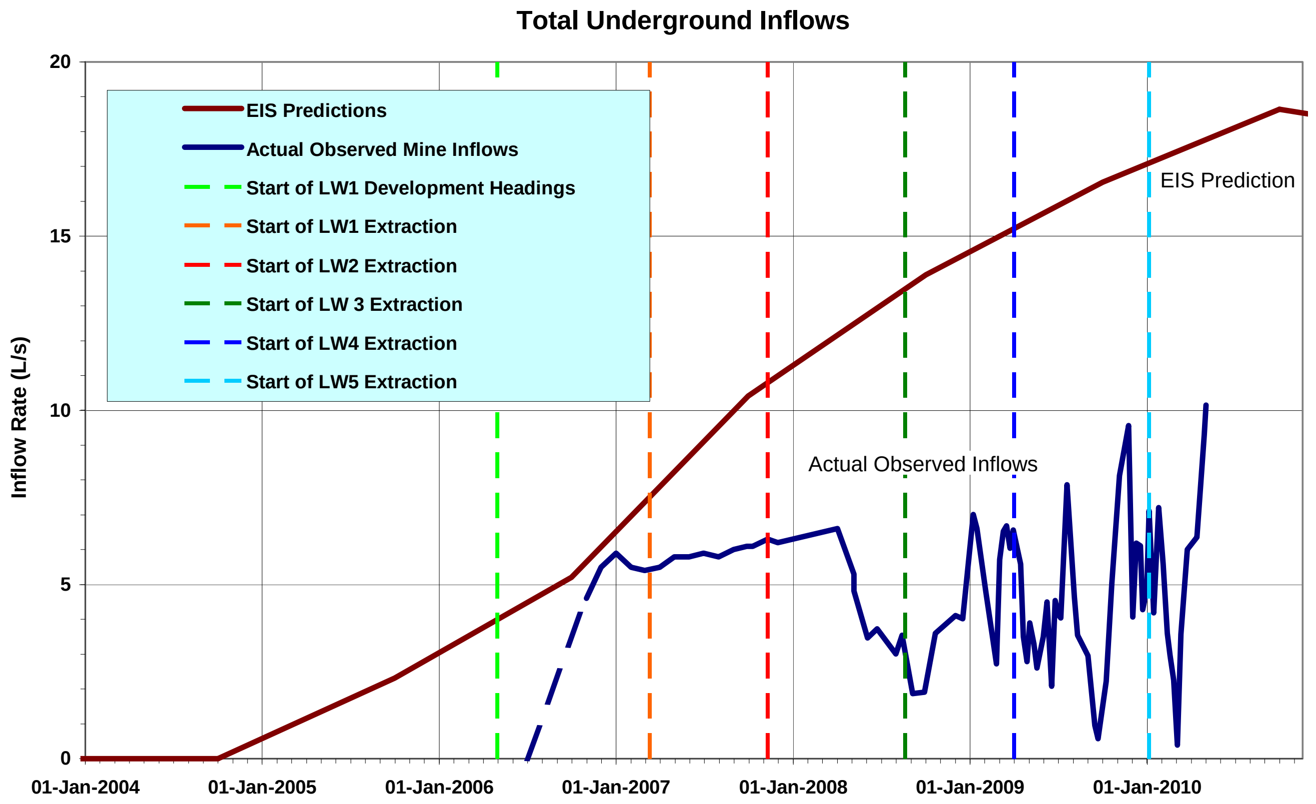


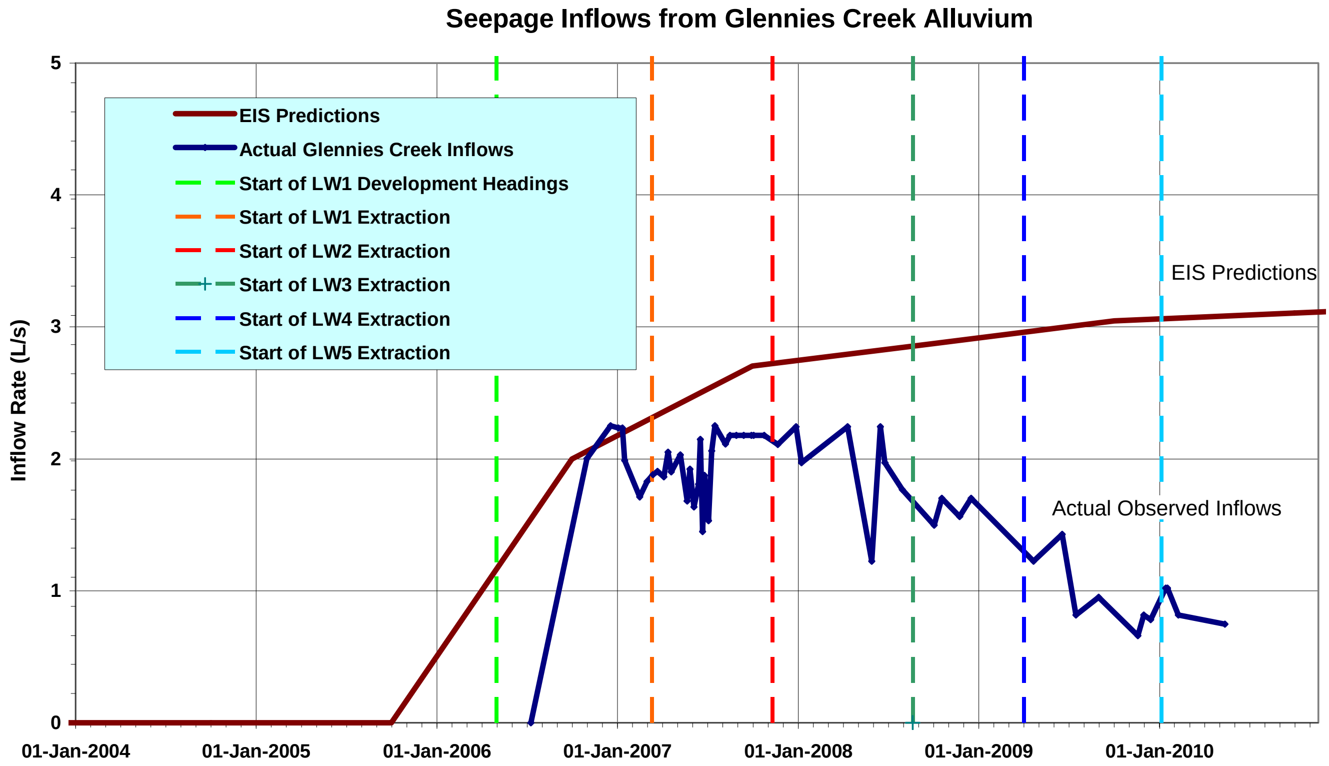
Date **06 October 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **MA**	Project **S56C**	**MINE SEEPAGE ECs**
Drawing Number **S55F-014**	Revision **C**	
aquaterra		**Figure 14**





Date 19 August 2010	Scale	**Ashton Coal Operations Ltd**
Initials TL	Project S56C	GROUNDWATER EC GLENNIES CREEK ALLUVIUM BOWMANS CREEK ALLUVIUM
Drawing Number S56C-015C	Revision A	
aquaterra		**Figure 15**





Date **06 September 2010**	Scale **As Shown**	**Ashton Coal Operations Ltd**
Initials **SM**	Project **S56C**	**GROUNDWATER INFLOWS vs EIS PREDICTIONS**
Drawing Number **S55F-016**	Revision **0**	
aquaterra		**Figure 16**

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