ASHTON LONGWALL 102 – END OF PANEL REPORT

1 INTRODUCTION

This report has been prepared by Ashton Coal Operations Pty Ltd (ACOL).

The report has been prepared to satisfy the requirements of the "*Subsidence Management Plan Approval ULD Seam Longwalls 1 to 4",* Condition 18:

"Within 4 months of the completion of each longwall panel, an end of panel report must be submitted to the Director General. The end of panel report must:

a) include a summary of the subsidence and environmental monitoring results for the applicable longwall panel;
b) include an analysis of these monitoring results against the relevant;
  - *impact assessment criteria;*
  - *monitoring results from previous panels; and*
  - *predictions in the SMP;*
c) identify any trends in the monitoring results over the life of the activity; and
d) describe what actions were taken to ensure adequate management of any potential subsidence impacts due to longwall mining."

2 BACKGROUND

Longwall 102 (LW102) began extraction on the 10th of November 2013, and extraction works completed on the 8th August 2013. Longwall 102 is 2,240m long, 205m wide. No unexpected impacts to the surface environment or infrastructure above resulted from secondary extraction of LW102.

The effects of subsidence were monitored in accordance with the document "*Ashton Coal Project Upper Liddell Seam Extraction Plan, Longwalls 1 to 8*"; this included regular survey monitoring and visual inspection of environmental, land and infrastructure features.

3 MINE SUBSIDENCE

3.1 LW102 EXTRACTION

The Upper Liddell (ULD) Seam section was mined along the length of LW102 at Ashton Underground Mine. Mining height was nominally in the 2.3m to 2.6m range. The seam dipped to the southwest at a grade of up to 1 in 10. Overburden ranges in thickness from 165m near the start of the longwall panel to 105m at the take-off end. The final extraction void is nominally 216m wide. This includes the 5.5m width of development drivage either side of the longwall block. Maingate chain pillars are nominally at a centre to centre width and length of 30m and 150m respectively. Tailgate chain pillars are at a centre to centre width and length of 30m and 150m respectively.

Ashton's longwall mining operation commenced in February 2007. Since then 11 panels have been extracted. The progress of longwall extraction is shown in **Figure 1**.

3.2 SUBSIDENCE SURVEYS

Ashton Coal has monitored the subsidence movement on the surface during extraction of Longwall's 1-8 in the ULD Seam using longitudinal subsidence lines. These are located over the start and finish lines of each panel, a main cross line extending over all seven southern panels and a dedicated cross line extending over Longwall 6B, 7B and 8. All panels have monitoring data for each start and end lines and various cross lines relevant to the panel, surface features or strata features.

The ULD seam LW102 utilises panel centre lines (CL1 and CL2), the Pikes Gully (PG) seam LW2 panel centre lines and the cross block survey monitoring lines that were used for PG seam longwall. The subsidence monitoring lines relevant to LW102 are LW102-CL1&2, LW2 CL1&2 and XL5 as shown in **Figure 2.**

The following table (**Table 1**) outlines the maximum subsidence parameters predicted and recorded for LW102 during regular survey of subsidence lines as the longwall passed each location.

Table 1 Subsidence of Longwall Panel 102 - Predicted vs. Actual

Seam	**Incremental Subsidence ULD Seam (m)**	**Max Incremental Tilt (mm/m)**	**Max Incremental Strain (mm/m)**	**Maximum Subsidence (m)**	**Max Tilt (mm/m)**	**Max Strain (mm/m)**
Predicted for LW102	2.5	139	55	4.0	189	76
Measured on LW102CL1	2.1	33	14	3.2	38	12
Measured on XL5	2.3	66	18	3.2	54	24
Measured on LW102CL2 background	2.1	27	5	3.2	33	4
Measured on LW102CL2 stacked	2.1	87	*65*	3.4	*193*	*107*
Measured on LW102CL2 10-30m undercut	2.1	136	*80*	3.4	*243*	*122*
Measured at completion of LW102CL2	2.1	77	45	3.4	*190*	*83*

The magnitude of both incremental and vertical subsidence is within predictions with a small margin that is sufficient for most practical purposes. Given the improvements in understanding of the mechanics involved in multi-seam subsidence that this data has provided, there is some potential to improve the predictions of maximum cumulative subsidence by about 10% if a more accurate estimate is required.

The predictions of tilt and strain are more variable, but at the completion of mining LW102, the maximum measured values of tilt and strain are close to and only just greater than the predicted maxima.

The tilts and strains vary with the circumstances of goaf interactions and several scenarios can be differentiated:

- Two goafs mined remote from goaf edge effects;
- An offset geometry where the chain pillars are significantly offset;

- A directly stacked goaf edge geometry; and
- A geometry where the overlying solid coal is undercut by a distance less than the separation between the two seams.

Estimation of the tilts and strains was recognised as likely to be more uncertain due to the multi-seam subsidence effects and the lack of previous experience of monitoring subsidence above multi-seam extraction. For most of the panel, the maximum tilts and strains are much less than the maxima predicted, but the predictions were locally exceeded at the stacked geometry near the end of the panel. At this stacked location, the tilts and strains returned to only slightly above predicted values by the end of the panel.

3.3 AUSGRID 132KV POWER TRANSMISSION LINE

To manage subsidence impacts 132kV timber poles above LW101 and LW102 were reassessed and replaced with concrete poles in 2012. These powerlines have been fitted with rollers prior to longwall extraction.

Visual and survey monitoring of existing 132kV power transmission structures over LW102 was undertaken regularly. During longwall undermining, Ausgrid 132kV Southern Major Interconnector TARP has been followed as per Ausgrid Asset Management Plan. There has been no adverse impacts or damage observed on the 132kV powerlines and powerlines remain serviceable.

The 132kV poles have been referenced as SET24 – A, B & C, and SET 25. The 132kV transmission line was surveyed prior to, during and post undermining. Survey data from the 132kV power lines was recorded and supplied to Principal Subsidence Engineer as per the "*Ashton Mine Subsidence Monitoring Programme Longwall 102*". The effects of subsidence on the 132kV structures can be seen in **Figure 3** and **Figure 4**. Maximum subsidence measured on power poles (SET24 – A, B & C, and SET 25) during Longwall 102 mining was: 1.21m, 1.19m, 1.17m and 0.06m respectively. The measured subsidence on power poles has not exceeded predictions.

3.4 ACCESS ROAD

A section of primary Right of Way (ROW) access to Property 130 was undermined by LW102. This section of ROW traversing the active longwall panel is likely to suffer perceptible subsidence impacts (e.g. surface cracking). Thus this section of access road was closed off on 2/12/2013 prior to undermining and an alternate access has been adopted. Relevant road users were notified prior to the road closure. Road closed and detour signs were installed on the same time.

Powerline clearance signs within alternate access road were updated prior to ROW closure to ensure the safety for the movement of plant and equipment under and in the vicinity of these overhead lines.

Remediation works on the road have been completed on 22/7/2014. ROW was reopened following the completion of remediation works.

3.5 TELSTRA PHONE LINE

A buried Telstra phone cable has been undermined by LW102. There were no adverse impacts or damage observed on the Telstra cable.

4 LAND MANAGEMENT

Surface subsidence cracks have developed along each gate edge of the Longwall panel. These generally run parallel to the gate road within the longwall block. Some cracks have also occurred parallel to the retreating face. Where this has occurred the features have usually started from a parallel pillar edge crack and continued around to align with the face.

The maximum subsidence movements detected over Longwall 102 are less than those predicted in the SMP. This occurred for all centreline survey monitoring lines and cross lines. Horizontal movement has occurred in the coal seam up dip direction (North East-East) above each of the Longwall panels. This movement has predominantly occurred within the longwall panels with limited displacement detected outside the panel edge.

Rehabilitation of the surface cracks was completed during extraction of the panel, post settling. The work has been completed with a small excavator smoothing over surface cracks. Effected surface access road has only required a grader to smooth compression humps and minor cracks.

5 GROUNDWATER MONITORING

Ashton has an extensive monitoring network of piezometers, ground water inflow monitoring and laboratory analysis of water quality for monitoring groundwater pressure, levels and quality. Groundwater monitoring around LW102 was intensified for the period of extraction to identify any potential sudden changes that may occur.

The groundwater monitoring has been reviewed by RPS Aquaterra - independent hydro-geologists. A report on the impacts of extracting LW102 panel has been attached in **Appendix A**.

Figures

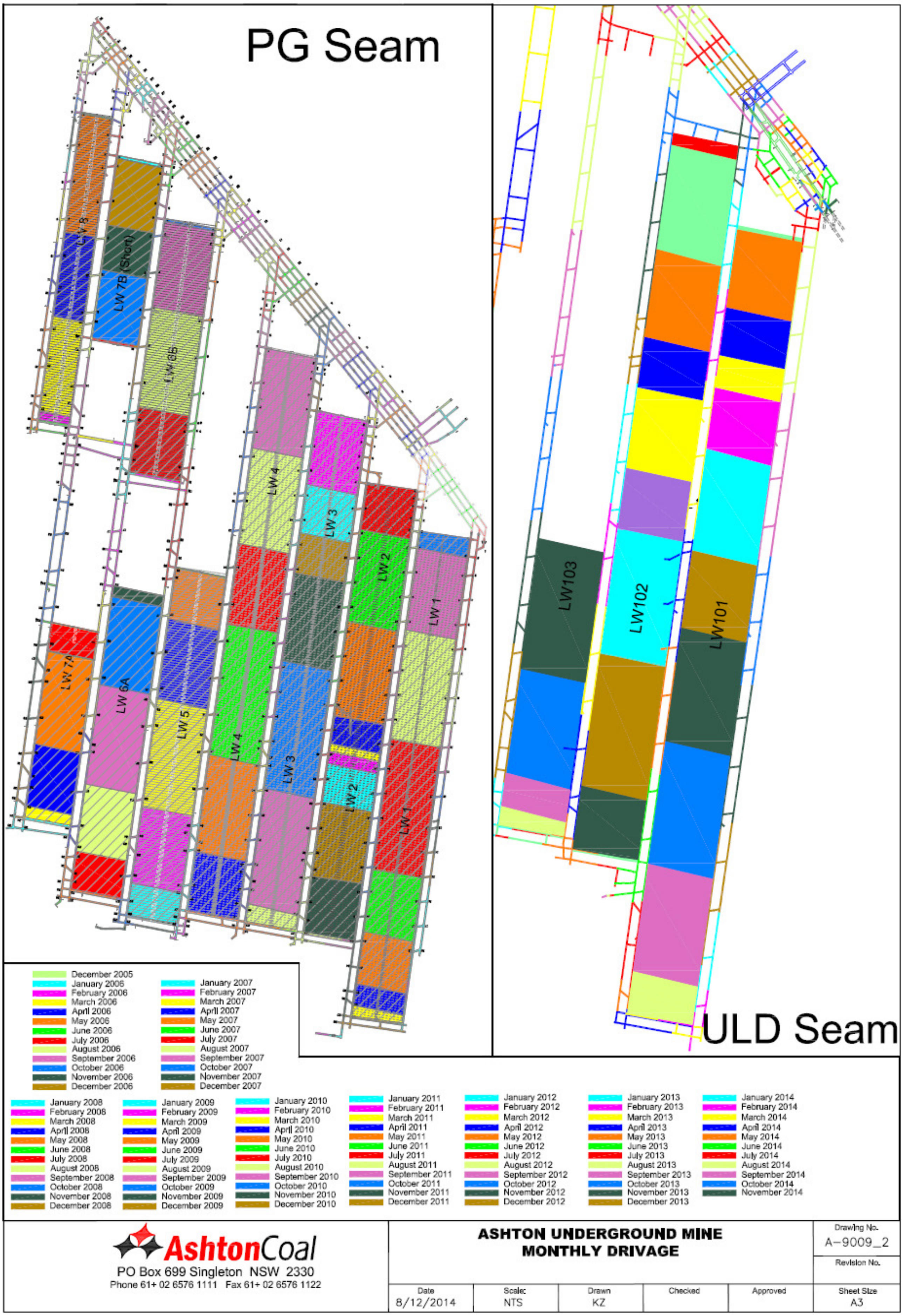

Figure 1 Progression of Longwall Extraction in the Pikes Gully and Upper Liddell Seams

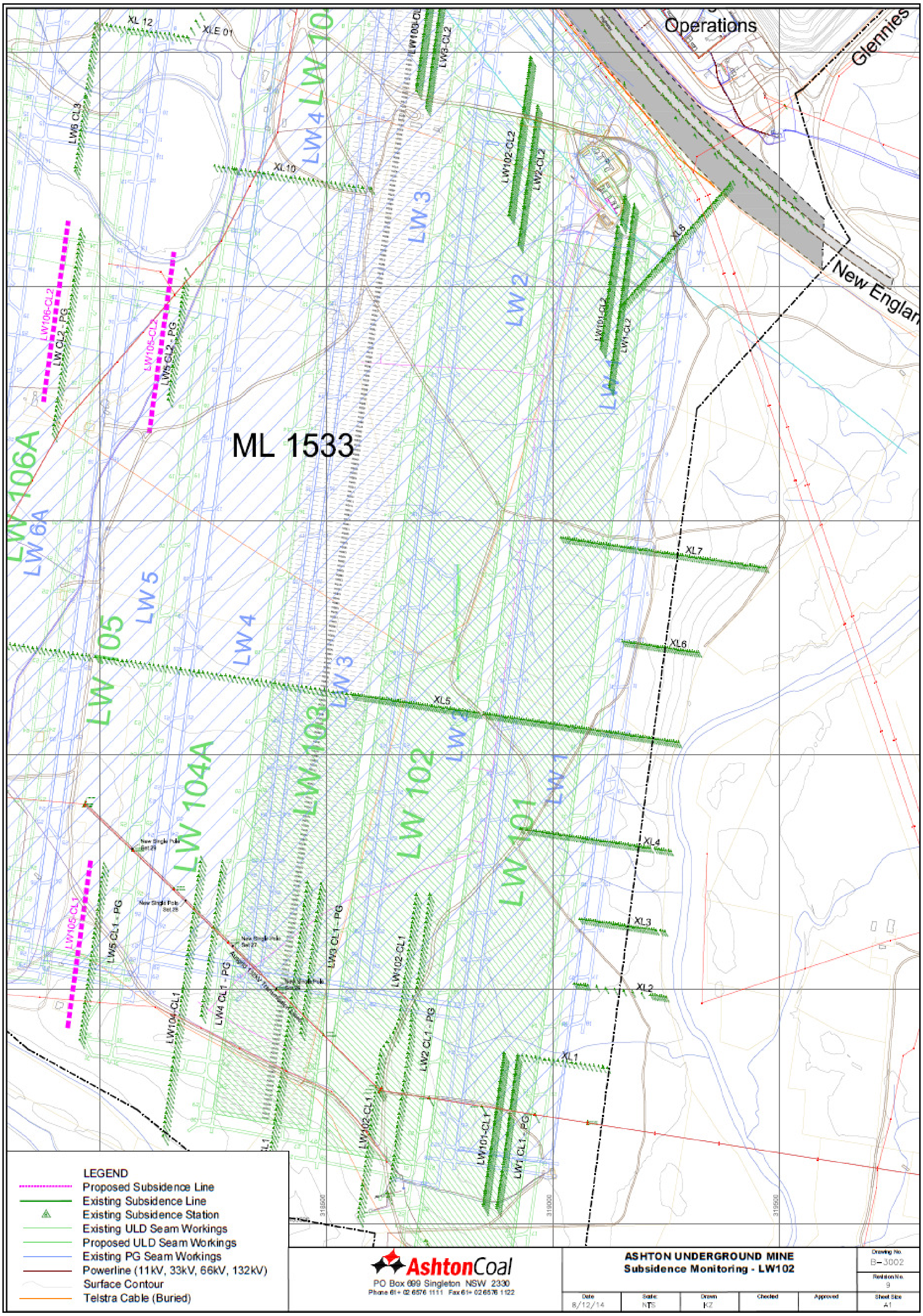

Figure 2 Plan Location of Subsidence Monitoring Lines

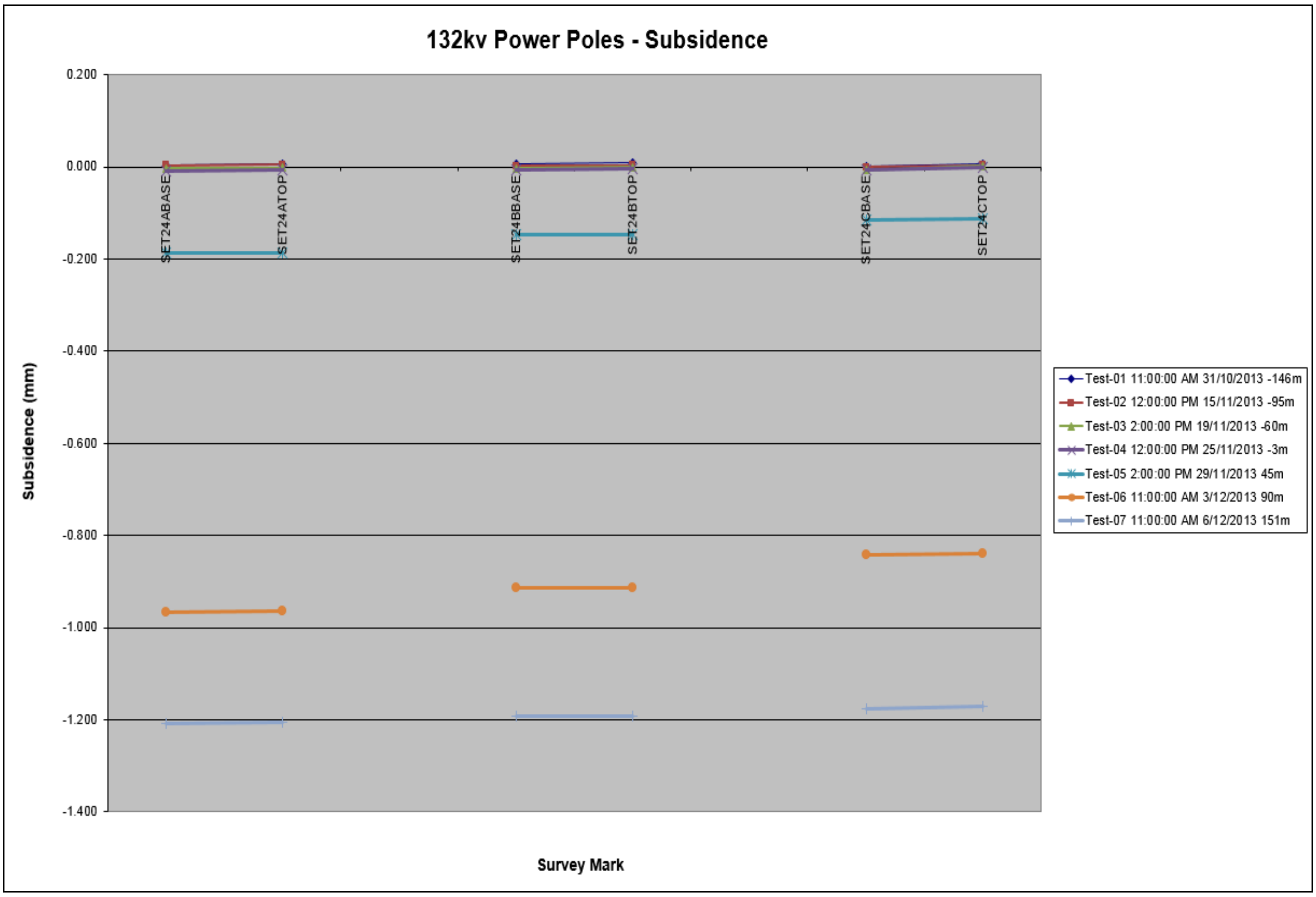
132kv Power Poles - Subsidence

Figure 3 Subsidence Monitoring Data 132kv Power Poles – Set 24 A, B & C

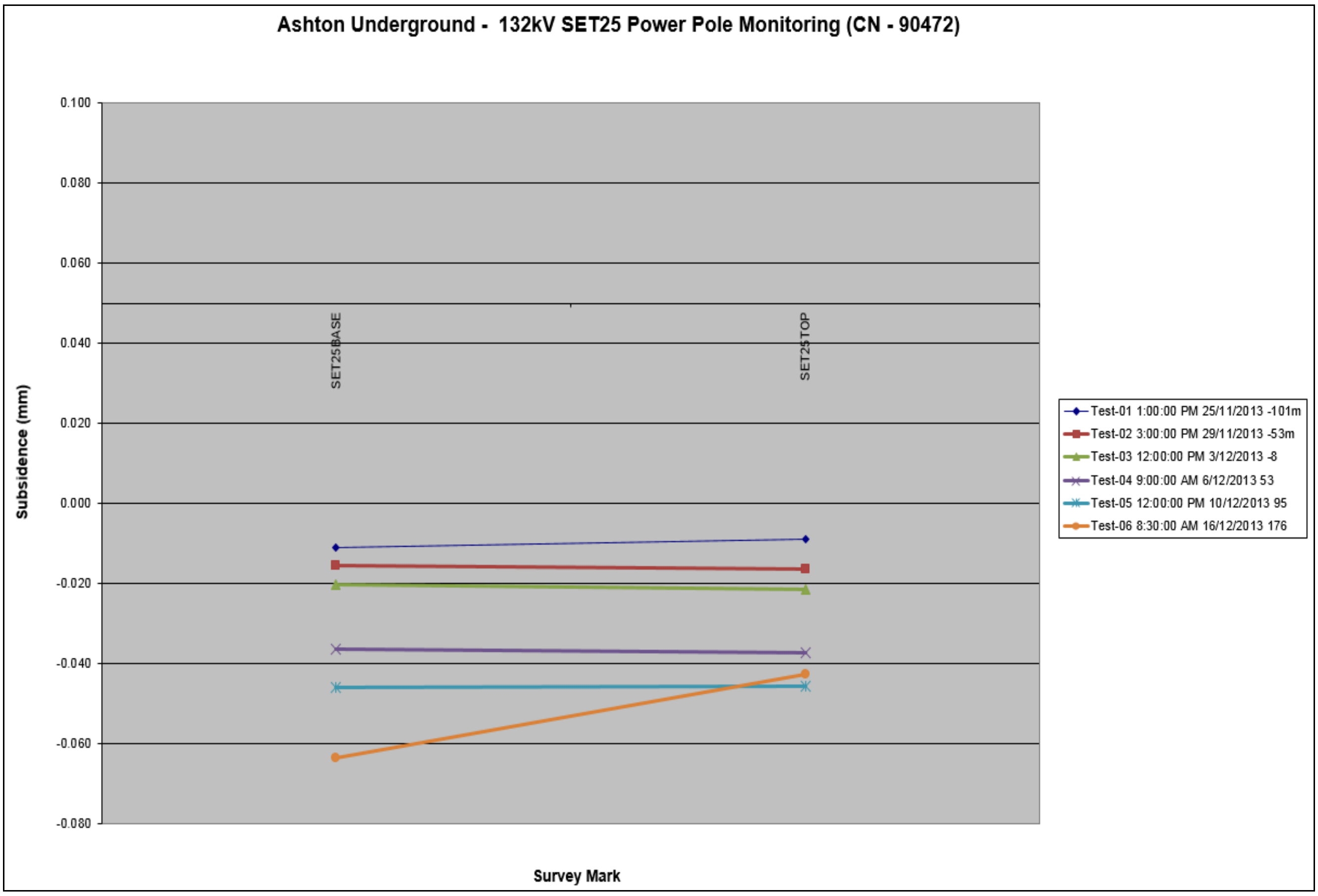
Ashton Underground - 132kV SET25 Power Pole Monitoring (CN - 90472)

Figure 4 Subsidence Monitoring Data 132kv Power Poles – Set 25

APPENDIX A: End of Panel Groundwater Review – Longwall 102

ASHTON COAL UNDERGROUND MINE
LONGWALL 102 END OF PANEL
GROUNDWATER REVIEW

ASHTON COAL UNDERGROUND MINE LONGWALL 102 END OF PANEL GROUNDWATER REVIEW

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Revision A	26/11/2014	Draft for Review
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	Name	**Position**	**Signature**	**Date**
Author	Greg Sheppard	Principal Hydrogeologist		8/12/2014
Reviewer	Brad Woods	Principal Engineer		8/12/2014

Disclaimer

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FIGURES (compiled at end of report)

1. INTRODUCTION

The Ashton Coal Project (ACP) is located 14 km west of Singleton in the Hunter Valley region of NSW (Figure 1).

The ACP was granted development consent on 11 October 2002 (DA No. 309-11-2001-i) by the Minister for Planning under the State Significant and Integrated Development provisions of Part 4 of the *Environmental Planning and Assessment Act 1979*.

The ACP consists of both open cut and underground mining to access a series of coal seams within the Permian Foybrook Formation. Mining commenced at the north east open cut mine (NEOC) in 2003 with open cut mining completed in 2011. Coal was recovered from eleven seams of varying thickness down to and including the Lower Barrett Seam.

Underground mine development commenced in July 2006 with the extraction of the first longwall panel (LW1) in the Pikes Gully (PG) seam commencing on 12 March 2007. The ACP underground mine has extracted coal from the PG seam and the underlying Upper Liddell (ULD) seam.

The underground mine is located south of the New England Highway and is accessed from the northern side of the highway via a portal in the Arties Pit (Figure 1). The approved underground mine plan includes a diversion of Bowmans Creek via two excavated and lined diversion channels that have re-routed the surface creek to areas that will not be undermined.

In accordance with Section 13.1.2 of the approved Ashton Coal Water Management Plan (WMP) post-mining longwall panel subsidence monitoring reports are produced to assess impacts against predictions made in the ACP environmental assessments.

This report reviews the groundwater impacts associated with the extraction of longwall panel 102 (LW102) in the ULD seam. The results from groundwater monitoring over the extraction period are assessed and compared to the impact predictions from the 2012 Upper Liddell Seam Extraction Plan: Groundwater Impact Assessment (2012 GIA) (RPS Aquaterra, 2012).

1.1 Previous Groundwater Impact Reviews

This report forms the thirteenth groundwater impact review completed in support of end of panel and mid-panel reporting. Table 1.1 provides a list of the previously completed reviews for the relevant longwall panels.

Table 1.1: Ashton Coal Project - Groundwater Impact Reviews

Longwall Panel	Mined Seam	Start date	End date	Longwall Panel report
LW1	PG	12/03/2007	15/10/2007	Aquaterra, 2008
LW2	PG	10/11/2007	21/07/2008	Aquaterra, 2009
LW3	PG	20/08/2008	03/03/2009	Aquaterra, 2009
LW4	PG	02/04/2009	15/10/2009	Aquaterra, 2010
LW5	PG	04/01/2010	07/06/2010	Aquaterra, 2011
LW6A	PG	09/07/2010	22/11/2010	RPS Aquaterra, 2011
LW7A	PG	23/03/2011	05/08/2011	RPS Aquaterra, 2012
LW7B	PG	03/10/2011	17/01/2012	RPS Aquaterra, 2012
LW8	PG	27/02/2012	05/06/2012	RPS Aquaterra, 2012
LW101 – Mid Panel	ULD	03/08/2012	31/01/2013	RPS Aquaterra, 2013
LW101	ULD	03/08/2012	16/06/2013	RPS Aquaterra, 2013
LW6B	PG	14/07/2013	27/10/2013	RPS, 2014
LW102	ULD	10/11/2013	07/08/2014	This Report

2. SITE DESCRIPTION

The Ashton underground mine is located in an area bounded by New England Highway to the north, the Hunter River to the south, and two of its tributaries, Glennies Creek and Bowmans Creek, to the east and west respectively (Figure 2). LW102 is located west of Glennies Creek in the south-east section of the underground mining area.

2.1 Longwall Panel 102

Mining of longwall panel 102 (LW102) in the ULD seam commenced on 10 November 2013 and was completed on 7 August 2014. LW102 is the second panel to recover coal from the ULD seam.

LW102 underlies the previously mined PG LW2. The longwall panels accessing the ULD seam are offset 60m to the west of the overlying PG goaf. This offset is designed to reduce the resulting subsidence and associated impacts to the surrounding environment.

Glennies Creek is a perennial watercourse situated within a small alluvial floodplain immediately east of the underground mine. At its closest point Glennies Creek passes approximately 450 meters (m) east of the edge of the LW102 goaf (Figure 2).

LW102 does not undermine any alluvium, however, the saturated alluvial deposits associated with the Glennies Creek floodplain (GCA) are located adjacent to the southern portion of LW101 on its eastern side (Figure 2). There is also saturated Hunter River Alluvium (HRA) located to the south of LW102 (Figure 2).

2.2 Rainfall

Table 2.1 presents the monthly rainfall data collected at the Ashton onsite weather station. This data is compared with the long-term median rainfall for rainfall at the Jerry's Plains weather station, situated approximately 14 km to the southwest of the ACP.

During the LW102 extraction period (10 November 2013 to 7 August 2014) the Ashton area received 604.4 mm of rainfall, significantly greater than the long-term median for the same period of 482.3 mm.

Table 2.1: Ashton Coal LW102 Monthly Rainfall

	Nov 12	Dec 12	Jan 12	Feb 12	Mar 12	Apr 13	May 13	Jun 13	Jul 13
Rainfall (mm)	175.2	22.6	6.8	136.6	119.2	76.4	4.0	21.0	42.6
LTM (mm)	83.6	63.8	44.1	107.4	51.1	34.1	24.3	48.8	25.1

- LTM: long-term median, data from the NSW bureau of meteorology station number 061397

Monthly rainfall and the long-term median are plotted on the hydrographs to assist with interpretations of observed groundwater responses (Figures 8 to 17).

2.3 Hydrogeological Environment

The pre-mining hydrogeological environment is described in detail in the 2012 GIA (RPS Aquaterra, 2012). In general, there are two main aquifer systems within the Ashton underground mining area:

- A hard rock aquifer system in the Permian coal measures, in which groundwater flows predominantly along cleat fractures in the coal seams.
- A porous-medium aquifer in unconsolidated alluvial sediments associated with Bowmans Creek, Glennies Creek and the Hunter River.

Groundwater flow in the Permian rocks is dominated by fracture flow, particularly in the coal seams. The hydraulic conductivity (permeability) of the coal seams is generally lower than the unconsolidated alluvium aquifers. The hydraulic conductivity of the coal seams has been observed to gradually decline with greater depth of cover.

The PG overburden comprises sandstone, siltstone, conglomerate, mudstone, shale and minor coal measures. The shallow overburden, referred to as the Permian coal measures overburden (CMOB), is characterised by low hydraulic conductivity and generally forms an aquitard beneath saturated alluvium deposits in the ACP area.

The unconsolidated alluvial sediments generally comprise clay and silt-bound sands and gravels, with occasional lenses or coarser grained horizons where sands and gravels have been concentrated.

There is limited alluvium associated with Glennies Creek to the east of ULD LW101. Where present, the Glennies Creek Alluvium (GCA) has moderate to low permeability, with hydraulic conductivity values generally less than 1 m/d. Occasional coarser, more permeable horizons are found within the GCA with hydraulic conductivities of up to 10m/d.

The hydraulic connection between alluvial deposits and shallow weathered Permian sediments is limited to small localised variations, which is of particular relevance to water management. The limited hydraulic connection is evidenced by; differences in groundwater levels, differences in groundwater quality, and differing responses to recharge or mining activity.

2.3.1 Groundwater Levels / Pressure

The groundwater levels in the Permian formations were historically elevated above the water levels in the alluvium and creeks prior to mining activity. The upwards hydraulic gradient meant that under natural conditions, groundwater discharged from the Permian to the alluvium and to the surface streams. This is reflected in baseline studies that show relatively higher salinities in the alluvium in some areas, and also in the surface flow at times of low rainfall and runoff.

Following the extraction of the PG seam, there has been substantial depressurisation of the Permian lithologies above, and immediately below, the PG Seam. This local depressurisation has reversed the hydraulic gradient in areas overlying and adjacent to the extracted longwall panels. This impact was predicted and approved in the 2009 GIA with sections of Bowmans Creek Alluvium overlying longwall panels is expected to completely dewater by the end of underground mining in the ULD seam.

2.3.2 Groundwater Quality

Groundwater quality varies according to its source and interaction with other water sources. The following observations are noted:

- Alluvial groundwater in the floodplains of Bowmans Creek, Glennies Creek and the Hunter River is generally of a quality suitable for stock and domestic use.
- Shallow coal measures groundwater, colluvial groundwater and some of the alluvial groundwater is brackish to saline in quality and is not used for consumptive purposes.
- Groundwater in the coal measures is saline and is not used for consumptive use, apart from mine purposes.

A summary assessment of the natural variation of groundwater quality is provided in Table 2.1.

Table 2.2: Baseline Groundwater Quality Data Summary

Aquifer	**pH (pH units)**		**Electrical Conductivity (µS/cm)**	
	Mean	**Range**	**Mean**	**Range**
Bowmans Creek Alluvium	7.23	6.44 - 10.04	1,622	722 – 9,920
Hunter River Alluvium	6.97	6.76 - 7.14	2,091	1375 – 2,540
Glennies Creek Alluvium	7.05	6.53 - 7.79	3,202	300 – 16,300
Colluvium	6.91	6.52 - 7.87	6,682	1300 – 13,860
Pikes Gully Seam	6.87	5.29 - 7.78	2,088	86 – 8,820
Upper Liddell Seam	7.64	6.81 - 8.99	4,304	200 – 9,370
Arties Seam	7.23	6.35 - 8.03	3,432	648 – 6,350
Shallow Permian Coal Measures	7.36	6.35 - 11.97	5,611	320 – 18,200

3. SUBSIDENCE MONITORING

As underground mining progresses, subsidence survey monitoring is undertaken in accordance with the approved Subsidence Monitoring Programme (ACOL, 2013). Three survey lines established across LW102 were monitored during extraction of the panel. The subsidence survey lines are shown on Figure 2 and include:

- LW102 Centre Line 1 (LW102 CL1), located along the longwall centre line, across the southern end of LW102.
- LW102 Centre Line 2 (LW102 CL2), located along the longwall centre line, across the northern end of LW102
- LW102 Cross Line 5 (LW102 XL5) located approximately midway along longwall panel and oriented perpendicular to the longwall.

The subsidence profiles are plotted on Figures 3, 4 and 5.

LW102 started approximately 350 m further south than the overlying LW2. LW102 CL1 shows the maximum subsidence due to ULD seam extraction only, to be around 1.3 m, this then increases to 1.9m combined subsidence with LW2.

LW102 CL2 shows a maximum subsidence of around 2.09 m coinciding with the end of the overlying LW2, subsidence then decreases to around 1.6 m

LW102 X5 shows the greatest subsidence, with a maximum of 3.18m, with an additional 1.73 m of subsidence due to ULD extraction.

Subsidence survey monitoring also monitors the degree of tilt and strain exerted on the formations. In general there has been no excessive tilt or strain recorded outside of the area of longwall extraction.

Along LW102 CL1 and CL2, strains are generally in the range of 10 to -10 mm/m. A notable exception is on LW102 CL2 above the endpoint of PG LW2, where the multiple seam extraction has resulted in strains of the order of 80 to -74 mm/m. These large compressive and tensile strains are likely to express as surface cracking, as is noted in the fortnightly subsidence report for the end of LW102 (ACOL, 2013).

Strains recorded along LW102 X5 are generally in the range of +/- 10 to 20 mm/m and are not considered to be excessive.

4. Groundwater Monitoring Network

The ACP groundwater monitoring network includes piezometers targeting the key hydrogeological units (alluvium, CMOB, Lemington seams, PG seam, ULD seam and underlying coal seams). The network is geographically distributed across the underground mining area with particular focus on areas of saturated alluvium and those areas predicted to be impacted by mining.

Targeted monitoring of individual hydrogeological units is achieved through the use of sealed standpipe piezometers and fully grouted multi-level vibrating wire piezometers (VWPs).

4.1 LW102 Monitoring Network

Twenty-seven (27) piezometers were selected from the ACP groundwater monitoring network to provide key groundwater monitoring data during the LW102 extraction period. The selection includes nineteen (19) standpipe piezometers and eight (8) vibrating wire piezometers. The piezometer selection was based on relative proximity to the longwall and the available monitoring locations.

Table 4.1 lists the key piezometers and monitored hydrogeological unit (strata) with the piezometer locations relative to LW102 presented in Figure 2.

It is noted that review of monitoring of Bowmans Creek is not included as this is considered to be outside the area that may reasonably be expected to be impacted from LW102 extraction.

Table 4.1: Selected Piezometers for Groundwater Monitoring for LW102

Piezometer ID	Piezometer type	Hydrogeological Unit
WML120B	Standpipe	GCA
WML129	Standpipe	GCA
WML239	Standpipe	GCA
WML241	Standpipe	GCA
WML252	Standpipe	GCA
WML120B	Standpipe	GCA
RA27	Standpipe	HRA
WML278	Standpipe	HRA
WML279	Standpipe	HRA
WML280	Standpipe	HRA
WML336	Standpipe	HRA
WML337	Standpipe	HRA
WML338	Standpipe	HRA
WML119	Standpipe	PG
WML120A	Standpipe	PG
WML261	Standpipe	ULD
WML262	Standpipe	ULD
WMLP301	Standpipe	Arties
WMLP302	Standpipe	Arties
WMLC144	VWP	Permian
WML189	VWP	Permian
WML191	VWP	Permian
WMLC248	VWP	Permian
WMLC333	VWP	Permian
WMLC334	VWP	Permian
WMLC335	VWP	Permian
WMLC339	VWP	Permian

Notes:

GCA – Bowmans Creek Alluvium

HRA – Hunter River Alluvium

CMOB – Permian coal measures overburden

5. GROUNDWATER LEVELS

5.1 Glennies Creek Alluvium – Figures 6 and 7

Figures 6 and 7 present hydrographs of the key standpipe piezometers monitoring water levels within the GCA. Figure 6 presents the water level trends since ULD extraction began, and is presented with monthly rainfall, while Figure 7 presents the longer term water level trends with the long-term cumulative rainfall deviation.

The cumulative rainfall deviation plots the cumulative deviation of actual monthly rainfall from the long term average monthly rainfall, and provides an indication of longer term climatic trends. A downwards trending plot indicates sustained, below average rainfall and conversely, a sustained upwards trend indicates sustained above average rainfall.

Water levels in the GCA piezometers are shown to respond relatively rapidly to extreme rainfall events with this response most pronounced in the piezometers closer to the creek (such as WML129 and WML241). The GCA piezometers show a strong recharge response following the commencement of LW102 followed by a general regression over the period of LW102 extraction. At the end of LW102 extraction another smaller recharge response is observed.

In general, groundwater levels within the GCA appear to be responding to long term climatic conditions, over printed by shorter term responses to high intensity rainfall events. During the period of extraction of the ULD seam there is a general correlation with the CRD.

No evidence of impacts due to longwall extraction are observed.

5.2 Hunter River Alluvium – Figures 8 and 9

Figures 8 and 9 present hydrographs of the key piezometers monitoring water levels within the HRA. Figure 8 presents the water level trends since ULD extraction began, and is presented with monthly rainfall, while Figure 9 presents the longer term water level trends with the long-term cumulative rainfall deviation.

In general all of the HRA piezometers appear to be continuing a decline that commenced in early 2012 follow a period of groundwater recharge and rising water levels (Figure 8). The decline coincides with the commencement of the LW101 development headings, however, as the decline is observed in all HRA piezometers, including those well away from LW101, this timing is noted to be a coincidence and unrelated. It is also noted that during the period of HRA water level decline there was also a decline in mine inflows and dewatering requirement, thus supporting the conclusion that the HRA water level decline is not related with mining at ACP.

Over the period of LW102 extraction the general water level decline has continued, and is over-printed by two small recharge events. The decline stabilises towards the end of LW102 extraction at WMLP278, WMLP279, WMLP280 and WMLP337, which are all located in close proximity to the Hunter River and may indicate equilibration of the HRA groundwater levels and the Hunter River level in this vicinity. WMLP336 and WMLP338 are located further from the Hunter River and continue to decline.

Figure 9 shows a close correlation between long term water levels and the cumulative rainfall deviation. The continued water level decline during ULD extraction is attributed to longer term climatic and recharge conditions rather than a mining related response.

RA27

Following the recharge event near the start of LW102, RA27 is observed to enter a period of erratic water level responses, fluctuating between saturated and dry conditions. For the latter half of LW102 extraction RA27 remained mostly dry with the shallow water table below the base of the screen. It is noted that there is approximately 4m of alluvium below the base of RA27 and it is inferred that the alluvium remains saturated when RA27 is dry. Following completion of LW102 water levels appear to recover again. The reason for this erratic behaviour and apparent sudden decline in water level is not clear. Ongoing monitoring may help to resolve the issue but consideration should also be given to the replacement of RA27 with a new piezometer that penetrates the full sequence of alluvium.

5.3 Grouped Piezometers Site 1 – Figure 10

Figure 10 presents a hydrograph displaying the piezometric water levels at a group of piezometers situated within the Glennies Creek barrier (Figure 2). Each piezometer is screened within a separate lithology allowing a useful comparison of the piezometric water levels. WML120B is screened within the GCA, WML120A within the PG and WMLP302 within the Arties Seam.

Groundwater levels within all three lithologies exhibit a strong response to rainfall. The piezometers are close to the PG seam outcrop and displays relatively rapid response to recharge events with no evidence of any significant delay in responses between the three piezometers (Figure 10).

Following the commencement of the PG underground development headings the water level is shown to respond near the Glennies Creek barrier. This is observed with a partial depressurisation in WML120A over the period July 2006 to October 2006 (Figure 10). Importantly the water level in WML120B within the overlying GCA does not mirror this response and only shows a small initial decline and then remains relatively stable. This demonstrates limited vertical hydraulic connectivity across the 4.5m sandstone confining layer.

Following the depressurisation associated with the LW1 development headings water levels within the PG seam are observed to slowly re-equilibrate with water levels in the GCA over a 3 year period. As there has been no corresponding decline in GCA water levels over this period of PG recovery, it is assumed that the PG seam is recharged directly at subcrop rather than from the alluvium over this period.

The GCA and PG seam respond to a significant recharge event in May 2012 (24 mm over 2 days). A sharp increase in water level is observed in both lithologies with the increase approximately 0.8m higher in the PG seam. WMLP302, located in Arties Seam also shows a similar response over this period.

It appears that the observed recharge to PG and Arties seam is derived from direct rainfall/runoff recharge and not through the vertical leakage from the alluvium which would be delayed.

The groundwater levels within the Arties seam (WMLP302) shows a strong response to rainfall and have typically been 0.1 to 0.2 m below those in the GCA. A depressurisation response of approximately 1 m relative to the PG and GCA is observed in the Arties Seam following the commencement of LW101 extraction. The greater response observed in Arties Seam may indicate a greater connection between Arties Seam and the ULD goaf, or a higher seam hydraulic conductivity along which the impacts can propagate.

No additional responses are observed in relation to LW102 extraction.

5.4 Grouped Piezometers Site 2 – Figure 11

Figure 11 presents a hydrograph displaying a second group of piezometers (Site 2) situated approximately 700 m south of grouped piezometer Site 1. The Site 2 piezometers are completed in the ULD (WML262), the Arties Seam (WMLP301), the Pikes Gully Seam (WML119) and the GCA (WML239) with locations shown on Figure 2.

The ULD groundwater levels, as measured in WML262, show considerable depressurisation, with a consistent decline in piezometric pressure following the commencement of the LW101 development heading that has continued throughout LW102 extraction. There appears to be some degree of response to rainfall as the depressurisation effects slowed during the high rainfall experience from January to March 2013. However, the dominant influence on groundwater levels is LW101 extraction within the seam.

The Arties Seam (WMLP301) shows limited or no depressurisation during the installation of the LW101 development headings. Depressurisation of the Arties seam becomes increasingly pronounced as the ULD extraction approaches WMLP301 showing a hydraulic connection with the Arties seam. This is most likely the result of mining associated subsidence causing connective cracking between the Arties seam and the ULD goaf. Following the early initial drop, depressurization at WMLP301 has slowed but is still ongoing. Some minor recharge responses are apparent and overprinted on the water level decline.

There is no observed response to ULD extraction in the PG seam (WML119) or GCA (WMLP239). The PG seam was previously depressurised as a result of extraction in the PG seam, however, the lack of response to ULD extraction does suggest limited hydraulic connectivity between the PG seam and the ULD longwall goaf.

No response to LW102 extraction is observed in any of the piezometers.

5.5 Lemington Seam – Figure 12

Figure 12 presents hydrographs of the key VWPs monitoring piezometric pressures within the Lemington 15 seam. It is noted that the hydrographs are presented as piezometric pressure (m) above the VWP and have not been reduced to mAHD, this representation makes it easier to assess whether a VWP has been completely depressurised.

The Lemington 15 seam was observed to be progressively depressurised in response to coal extraction in the underlying PG seam. This response (observed in WML106, WML107, WML189 and WML191) commenced during the PG development headings with significant depressurisations occurring during extraction of longwall panels LW1, LW2 and LW3 (Figure 12).

WML106 and WML189 are shown to be completely depressurised prior to ULD extraction. WMLC333 shows a further stepped depressurisation during early LW101 extraction and again following the completion of LW102 extraction. WML107 showed a similar, but smaller scale, stepped decline during LW101 extraction. Communication was then lost, likely due to subsidence, with WML107 during early extraction of LW102.

5.6 Arties Seam – Figure 13

Figure 13 presents hydrographs of the key standpipe piezometers and VWPs monitoring water levels within the Arties seam. As with Figure 12, the hydrographs are presented as piezometric pressure (m) above the VWP rather than mAHD.

Pressure responses to LW101 extraction are observed in the Arties seam in piezometers WML189, WMLP301, WML302, and WMLC335 (Figure 13). As indicated by WML189, the Arties seam initially showed a significant depressurisation (approximately 20 m head) due to Pikes Gully extraction. With the extraction of LW102, WML189 shows an initial decline in pressure with the longwall advance followed by major depressurisation associated with subsidence. Communication to the VWP was then lost, presumably due to the shearing of the communication cable.

Both WMLC334 and WMLC335 show depressurisation responses to LW102 extraction.

5.7 Upper Liddell Seam – Figure 14

Figure 14 presents hydrographs of the key standpipe piezometers and VWPs monitoring water levels within the ULD seam.

The most notable response observed in the ULD is a depressurisation response in WML191 that commenced in 2007 in response to extraction of the overlying Pikes Gully seam. The depressurisation then accelerated with the development headings and extraction of LW101. Communication to WML191 was lost due to subsidence during LW102 extraction.

Piezometer WML261 shows no significant response to ULD extraction. WMLC334 shows a significant depressurisation during LW102 extraction.

All other ULD hydrographs in the vicinity of LW102 show a continued gradual decline with no significant change due to LW102 extraction.

5.8 Hydrostatic Profiles – Figures 15, 16, and 17

VWPs; WML107A, WML189, and WML191 are located above LW102 and lost communication during the extraction of LW102. The closest intact VWPs are WMLC334, WMLC335 and

WMLC339. Hydrostatic profiles for these three VWP installations are provided on Figures 15, 16, and 17.

Where available, data is presented for pre, or start, of LW101 extraction, and then for start, mid and end of LW102 extraction.

At WMLC334, over the period of LW102 extraction, there has been significant depressurisation in the underlying Upper Lower Liddell (ULLD) seam and the Lower Lower Liddell (LLLD) seam. There has been no significant additional depressurisation following the LW101 extraction above Lemington 19 seam, and no significant depressurization due to multi seam extraction above Lemington 10 seam.

At WMLC335 there has been minor additional depressurisation due to LW102 extraction in all monitored seams, with the most pronounced depressurisation in the ULLD, PG, and Arties seams.

At WMLC339 there has been complete depressurisation in all sensors above the PG seam during LW102 extraction.

6. GROUNDWATER QUALITY

A summary of water quality parameters of electrical conductivity (EC) and pH as monitored in key LW102 piezometers over the duration of the extraction period is presented on Table 6.1 and 6.2.

Plots of the EC data, grouped by aquifer, are presented on Figures 18 to 20 to provide an understanding of the long term trends.

6.1 Electrical Conductivity

EC is used as a key screening parameter as it provides an easily measurable representation of water quality. Each water body (surface, alluvium or the Permian) typically has a distinct salinity and EC range.

Results from the monitoring of groundwater quality over the LW6B extraction period have generally aligned with the baseline trend of low salinity within the GCA and low to moderate salinity within the CMOB.

Glennies Creek Alluvium – Figure 18

A long-term trend of reducing EC levels is observed within the Glennies Creek alluvium throughout longwall mining. This is attributed (in part) to the reduced effects of upward leakage from the Permian coal measures.

WML129 and WML120B show a net increase in EC during the LW102 extraction period, however, the increase is within historical limits. WML129 generally shows a trend of decreasing EC during periods of low rainfall with EC then gradually increasing following large rainfall events. This response is the opposite of what would be expected and may result from the mobilisation of salts accumulated in the subsurface during recharge events.

During the LW101 extraction period, WML239 and WML120B displayed very similar trends.

The EC range observed in the GCA during the LW102 extraction period is generally consistent with the baseline range for the GCA of 300 to 16,300 µS/cm as detailed in the 2012 WMP (Section 8.3.2, Table 8.2).

Hunter River Alluvium – Figure 19

WMLP279 is the most up-stream piezometer and shows a slight decline since the commencement of ULD extraction. WMLP280 and WMLP278, located adjacent to longwalls LW5 and LW6 respectively, continued a generally increasing trend that commenced during LW101 extraction at WMLP278, and at the commencement of LW102 extraction at WMLP280. WMLP337 continued an increasing trend that commenced in June 2012.

It is noted that the maximum observed EC, of approximately 3,500 µS/cm, is above the baseline range of 1,375 to 2,540 µS/cm, as detailed in the 2012 WMP (Section 8.3.2, Table 8.2). This exceedance, and the continued rising trends, observed at a number of the monitoring locations is not considered to be related to longwall extraction, in fact the opposite impact of lowering EC would be expected to be seen. The trend of increasing EC is therefore attributed to natural fluctuation. No impacts associated with LW102 extraction are indicated.

Permian Coal Measures Overburden – Figure 20

Figure 20 shows two distinct ranges in water quality within the shallow Permian lithologies. WML119, WML120A, WML261, and WMLP302 show EC levels that are generally below 2,000 µS/cm, with one spike at WML119 to around 2,700 µS/cm. At these locations the shallow CMOB subcrops beneath the GCA and reflect the change hydrostatic condition from an upwards hydraulic gradient to a downwards hydraulic gradient and leakage from GCA and Glennies Creek surface flow to CMOB. The low EC values are therefore indicative of leakage and recharge from the GCA. WML120A and WML261show a gradual increase in EC over the LW102 extraction period as is also observed in the GCA monitoring data.

WML262 and WMLP301 are more indicative of Permian lithologies that are not hydraulically connected with alluvial bodies or that are not directly influenced by recharge. Over the reporting period EC at WMLP262 ranged from 6,200 to 8,900µS/cm.

The EC values observed in CMOB piezometers over the LW102 extraction period are generally consistent with the baseline range of 320 to 18,200 µS/cm, as detailed in the 2012 WMP (Section 8.3.2, Table 8.2).

6.2 pH

pH data for the LW102 extraction period are compared with baseline data on Table 6.2.

Average pH values for the LW102 extraction period are generally slightly higher than the average baseline values for individual piezometers presented on Table 6.2

pH values for the GCA and HRA ranged from 6.57 to 8.38 and 6.73 to 8.48, respectively. The higher values are outside the baseline ranges of 6.53 to 7.79 (GCA) and 6.74 to 7.14 (GCA) as detailed in the 2012 WMP (Section 8.3.2, Table 8.2) although it is noted that the baseline data range is limited when compared to the life of mining, and may not be representative of the full range of natural fluctuations.

pH values for the PG and ULD seams ranged from 6.52 to 8.15, and 6.17 to 8.79, respectively. The higher pH values for the PG seam are outside the baseline range of 5.29 to 7.78, while pH values for the ULD seam are within the baseline range of 6.81 to 8.99 as detailed in the 2012 WMP (Section 8.3.2, Table 8.2).

While a number of pH values are noted outside of the WMP baseline range, the values are not sustained and do not reach the trigger value as defined in the 2012 WMP, i.e. "... an observable variation from baseline salinity or other parameter by 50% in comparison to baseline conditions, sustained over 3 months".

Table 6.1: Groundwater Quality: Electrical Conductivity

Aquifer/Seam	**Bore ID**	**Baseline Range**		**LW102 extraction period**	
		(4/01/2006-26/06/2013)		**(10/11/2013 - 7/08/2014)**	
		Range (µS/cm)	**Average (µS/cm)**	**Range (µS/cm)**	**Average (µS/cm)**
Glennies Creek Alluvium	WML120B	438 – 1,930	1,113	624 – 801	732
	WML129	378 – 789	476	269 – 430	343
Hunter River Alluvium	WML278	1100 - 2150	1650	1158 - 2292	1928
	WML280	1518 - 1950	1643	1518 - 9880	2137
	WMLP337[1]	1940 - 3040	2580	2610 - 3540	3006
Pikes Gully	WML119	86 – 6470	1744	91 - 2694	795
	WML120A	448 - 1290	743	442 - 707	573
Upper Liddell	WML261	132 - 2510	599	348 - 819	524
	WML262	5220 - 7960	7,177	391 - 8910	7180

Note: [1] Piezometer WMLP337 was installed following the baseline monitoring period.

Table 6.2: Groundwater Quality: pH

Aquifer/Seam	Bore ID	Baseline Range		LW102 extraction period	
		(4/01/2006-26/062013)		(10/11/2013 - 7/08/2014)	
		Range (pH)	Average (pH)	Range (pH)	Average (pH)
Glennies Creek Alluvium	WML120B	6.09 - 7.43	6.88	6.57 - 8.38	7.17
	WML129	6.53 - 8.15	7.22	6.9 - 7.92	7.52
Hunter River Alluvium	WML278	7 - 7.68	7.32	6.8 - 8.16	7.32
	WML280	6.9 - 7.64	7.38	6.73 - 8.26	7.43
	WMLP337[1]	6.78 - 7.79	7.04	6.94 - 8.48	7.34
Pikes Gully	WML119	5.29 - 8.19	7.08	6.69 - 8.87	7.4
	WML120A	6.22 - 7.69	6.94	6.52 - 8.44	7.27
Upper Liddell	WML261	5.7 - 8.71	6.74	6.17 - 8.48	7.49
	WML262	6.54 - 8.35	7.71	7.39 - 8.79	7.82

Note: [1] Piezometer WMLP337 was installed following the baseline monitoring period.

7. Permeability Testing

In accordance with the 2012 WMP (Section 9.3 and Table 9.3), monitoring the effects of subsidence on hydraulic conductivity (permeability) of the overlying strata is required.

Hydraulic testing (comprising a combination of rising and falling head slug tests) has been undertaken at key LW102 piezometers to assess if subsidence following LW102 extraction has materially altered the permeability of the GCA or the shallow CMOB in the vicinity of the longwall extraction.

7.1 Testing Programme

The permeability testing was undertaken at a number of standpipe piezometers installed in the adjacent to Glennies Creek (Table 7.1 and Figure 2). Piezometers were tested in 2012 prior to commencement of LW101 and then repeated in November 2014 to assess any change in permeability arising from the extraction of longwalls LW101 and LW102. The formations tested are generally fairly shallow and range in depth from 7 to 60 mbgl.

7.2 Analysis and Results

Analysis of the hydraulic tests was undertaken using standard rising and falling head analysis methods (Bouwer and Rice, 1976, and Hvorslev, 1951). Table 7.1 outlines the results of the hydraulic testing as performed prior to and following the completion of longwall extraction.

Table 7.1: Hydraulic Testing Results

Piezometer Formation	Screened Interval	(mbgl)	Hydraulic Conductivity (m/day)		
			Pre LW101 mining	Post LW102 mining	Net Change
WML129	GCA	7-9	0.45	0.43	No change
WML120A	PG	12-15	0.09	0.16	up
WML181	PG	32	1.17	2.62	up
WMLP301	ART	38-41	0.27	0.2	down
WMLP302	ART	20.5-23.5	5.5	7.4	up
WMLC262	ULD	57-60	0.07	0.046	down

The post LW102 testing for the GCA (WML129) indicates no significant variation in permeability. Although the repeat test was marginally lower, this is within the anticipated margin of error and repeatability for this kind of testing.

Within the shallow Permian formations there is a mix of higher and lower permeabilities derived from the post LW102 testing. The apparent reductions at WMLP301 and WMLC262 are not substantial and may be a result of discrepancies in test methodology and analysis, or alternatively, the reduced permeability may be real and could arise from silting of the bore or fouling/encrustation of the screens and/or gravel pack.

Testing within the shallow PG seam at WML120A and WML181 indicates a near doubling of the derived hydraulic conductivity values. A less substantial increase is observed at WMLP302 in the Arties seam. These increases could be due to the effects of subsidence and fracture dilation, possibly combined with flushing through of fines. However, no associated impacts such as increased groundwater inflows, drawdown within the overlying GCA, or losses of surface flow are observed.

8. GROUNDWATER INFLOWS

Groundwater extraction from the underground mine is monitored in accordance with the approved WMP (ACOL, 2012). Groundwater inflows into the underground mine are determined using a water balance approach, which requires balancing total water extracted from the mine against the volume of water pumped into the mine that is used for operational purposes.

The net dewatering volumes are determined by recording cumulative flows at water meters on the discharge pipelines and the imported water pipeline. The calculated net dewatering provides an estimate of mine inflows and is presented on Figure 21 along with predicted inflow volumes.

Within the underground workings water is often diverted to holding areas for operational reasons, this will impact on the resulting water balance as the volume of water that is diverted / stored underground is not accounted for until it is pumped out. At times this leads to underestimates of the groundwater inflow rates and conversely when water is abstracted from the mine it can lead to overestimates of the groundwater inflow component. The best representation of actual inflows is therefore a calculated monthly average (Figure 21).

Water is exported from the mine via borehole pumps and direct to the mine water supply circuit via pipelines along the gate-roads to the sump in Arties Pit near the mine portal. Two sump boreholes are currently in operation for dewatering. Borehole 2 (BH2) located to the south of LW6A in the PG seam is used to dewater the western underground area. Borehole pump BH3 installed south of LW101 abstracts water from the current ULD mining area.

The total inflow rate is provided as an averaged mine abstraction rate in Figure 21. Over the LW102 extraction period the net mine inflows ranged from approximately 16 to 31 litres per second (L/s) and averaged around 22.5 L/s.

The elevated inflows observed at the start of LW102 extraction are the result of an inflow event that occurred during LW6B extraction. These inflows caused an exceedance of the inflow trigger value that was sustained for a period of three months and has been reported separately (RPS, 2014).

For the later part of LW102 extraction, inflows remained below the trigger value as described in the 2012 WMP.

The component of inflows attributable to LW102 extraction, as abstracted from BH3, was generally of the order of 2 to 3 L/s over the LW102 extraction period.

9. COMPARISON WITH PREDICTIONS AND TRIGGER VALUES

The predicted and approved impacts from the ACP were most recently revised in the 2012 Upper Liddell Seam Extraction Plan – Groundwater Impact Assessment (RPS Aquaterra 2012). These predictions were incorporated into the 2012 WMP which developed trigger values and a Trigger Action Response Plan (TARP) to facilitate impact identification and response.

9.1 Groundwater Level Drawdown

By the end of extraction of ULD LW104, the modelling completed for the 2012 Upper Liddell Seam Extraction Plan – Groundwater Impact Assessment (2012 GIA) (RPS Aquaterra 2012) predicted substantial depressurisation of Permian lithologies and up to 1m of localised drawdown in the GCA in the area overlying subcropping coal seams and adjacent to the southern half of LW101. The predicted drawdown was located in the alluvium to the east of the creek.

In the HRA, up to 1 m of drawdown in the vicinity of the confluence with Bowmans Creek and to the west of the southern end of LW104 is predicted.

To date, no mining induced water level decline has been identified in the GCA or HRA.

9.2 Mine Inflows

The 2012 GIA predicted mine inflows during LW102 extraction, ranging from 14.9 L/s (1287 m^3/d) to 18.1 L/s (1564 m^3/d), with a predicted inflow of approximately 15 L/s (1296 m^3/d) at the end of LW102 extraction. Following the LW6B inflow event, mine dewatering has exceeded the 2012 GIA predicted inflow rates (Figure 21), however, this is not attributable to the extraction of LW102.

The elevated inflows following LW6B extraction have been addressed in the LW6B End of Panel Groundwater Review, and in a separate inflow investigation report (RPS, 2014b).

9.3 WMP Trigger Values

The current predicted rates for mine inflows are documented in the 2012 Upper Liddell Seam Extraction Plan – Groundwater Impact Assessment (RPS Aquaterra 2012). The trigger value is derived from this prediction and documented in the WMP (Section 7.3.5) as:

> *"... an observed rate 50% in excess of the predicted rate (for the equivalent stage of mining) sustained over a period of three consecutive months*."

For the current stage of mining, the predicted inflow rate is approximately 15 L/s. Therefore, the corresponding trigger value is 22.5 L/s. As predicted inflows vary with mine development, so too does the equivalent trigger value for inflows – the trigger value of 1.5 x the predicted inflow is provided on Figure 21.

Following the reduction in inflows after the LW6B inflow event, groundwater inflows have remained below the WMP trigger value for the remainder of LW102 extraction period.

No exceedances of WMP trigger values are noted for LW102 extraction.

It is noted that following the completion of LW102, inflows have again exceeded the WMP trigger level (Figure 21). These inflows are associated with the drilling of dewatering service hole BH4A into the PG underground, in preparation for the dewatering PG LW6A and 7A prior to being undermined in the ULD. Once completed, BH4A will be fully sealed and the elevated inflows will be eliminated.

10. CONCLUSIONS

Mining of LW102 was completed between 10 November 2013 and 7 August 2014 with coal extracted from the ULD seam. Glennies Creek and the Hunter River lie approximately 450m east and 200 m to the southwest of the LW102 goaf edge at the closest points. Previously extracted LW101 is situated between LW102 and the GCA.

To facilitate the identification of any potential impacts to the GCA or HRA, extensive monitoring of groundwater levels and quality was conducted along with subsidence surveying. Analysis of the monitoring demonstrates that mining has not had any observable adverse impacts to groundwater within the alluvial aquifers.

Subsidence effects are predicted to have substantial depressurisation effects on the Permian strata above each panel area within the zone of subsidence across the LW102 footprint. Monitoring results to date indicate variable depressurisation has occurred above, or outside the LW102 goaf. At WMLC339 above the as yet unmined LW103, the overlying Permian strata is completely depressurised, while to the south of LW102 outside of the active mining footprint, WMLC334 shows the Permian strata to remain saturated with partial depressurisation at the main coal seams, and at WMLC335 no significant depressurisation is observed at a distance of approximately 150 m from LW101.

10.1 Comparison against EIS and the 2012 EA

A comparison of observed impacts with the EIS, EA and SMP predictions has led to the following conclusions:

- The 2012 GIA predicted mine inflows during LW102 extraction to range from 14.9 L/s (1287 m^3/d) to 18.1 L/s (1564 m^3/d) with a predicted inflow of approximately 15 L/s (1296 m3/d) at the end of LW102 extraction. Mine dewatering has exceeded the 2012 GIA predicted inflow rates since the LW6B inflow event. However, following a reduction of inflows below the WMP trigger values in early 2014, there were no further exceedances of the inflow trigger during LW102 extraction.
- There is no observed drawdown in the GCA or HRA attributable to LW102 mining.
- To date estimated seepage rates from the GCA have been at, or below, the EIS, EA and SMP predictions at all stages of mining. The EIS predicted seepage rates of around 4 L/s from the GCA for the equivalent stage of mining. With the extraction of LW101 and LW102, all inflows from the eastern side of the mine are now expected to be captured by the goaf and report to BH3. The pumping rate from BH3 has averaged approximately 2.5 L/s over the LW102 extraction period, and includes contributions from the longwall operation and Permian groundwater inflows. It is therefore concluded that actual Glennies Creek seepage rates are well below modelled predictions.
- Mining of LW102 has not resulted in an observable reduction in HRA storage and consequently, no losses from the HRA to underground workings are anticipated to have occurred.

11. REFERENCES

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FIGURES

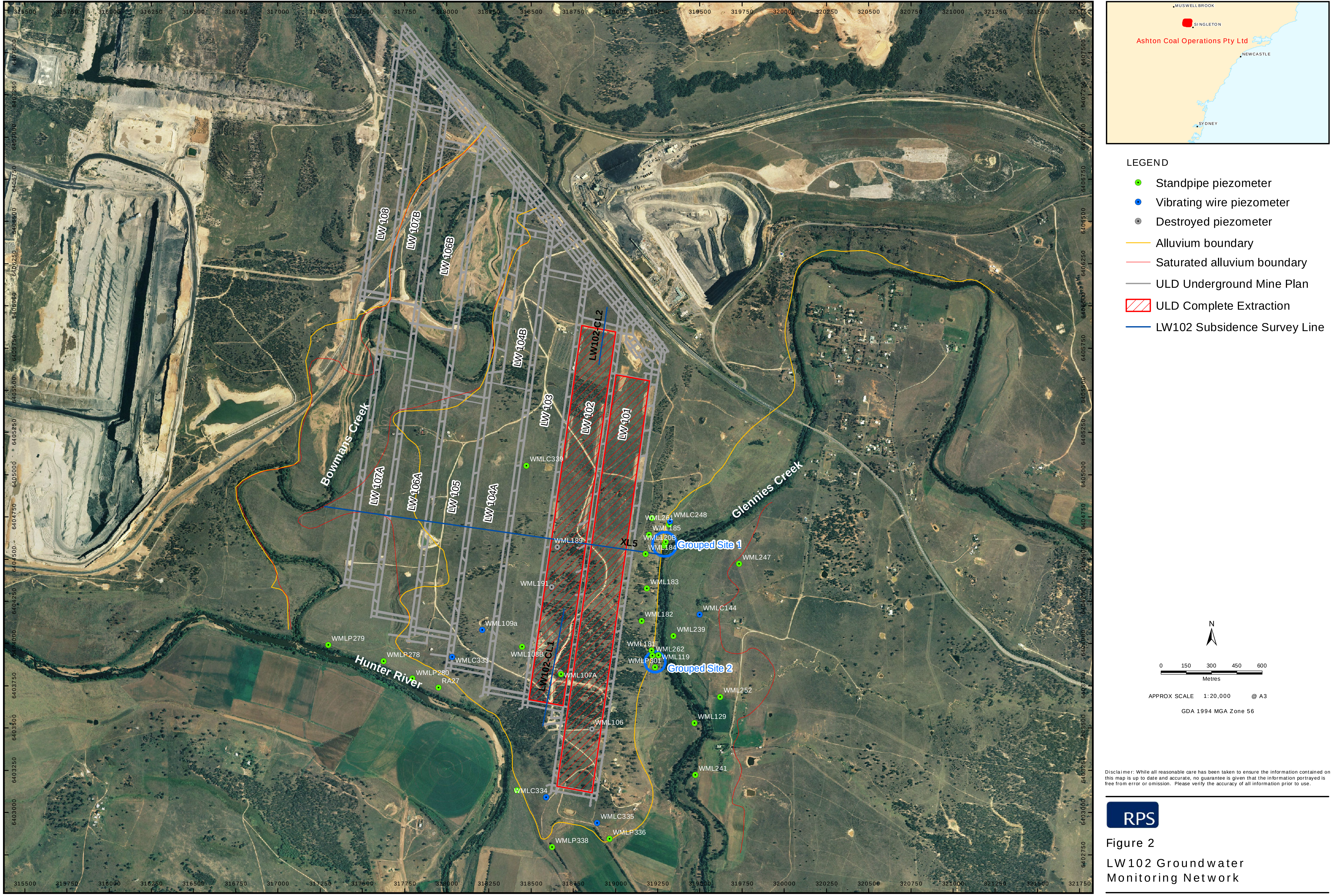
Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Please verify the accuracy of all information prior to use.

RPS

FIGURE 1

Ashton Project Area

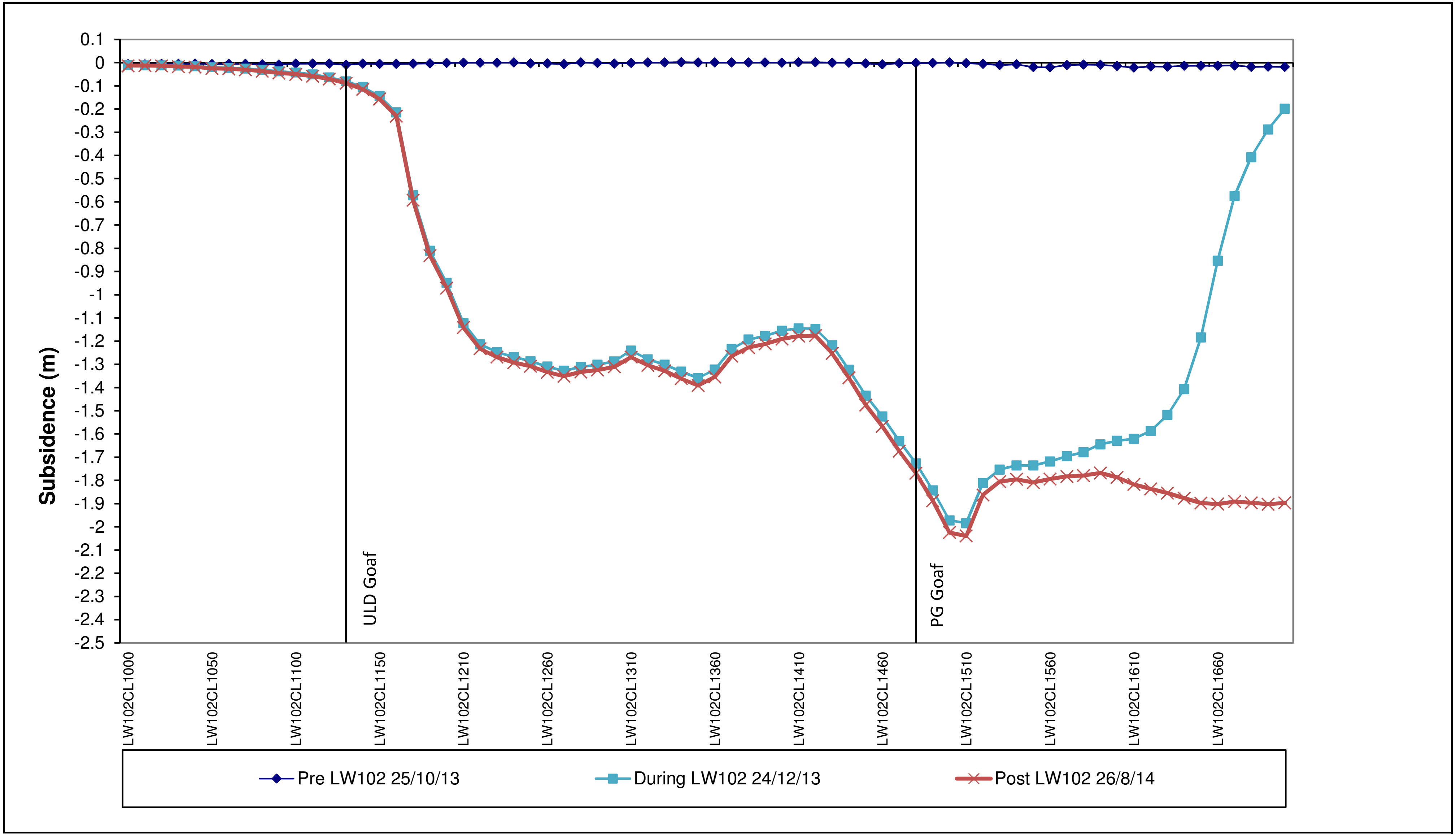
003a_Figure_1_Ashton_Coal_Project.mxd Produced: JC Reviewed: GS Date: 05/11/2014



RPS

Figure 2

LW102 Groundwater Monitoring Network



SUBSIDENCE LINE LW102 CL1 FIGURE 3

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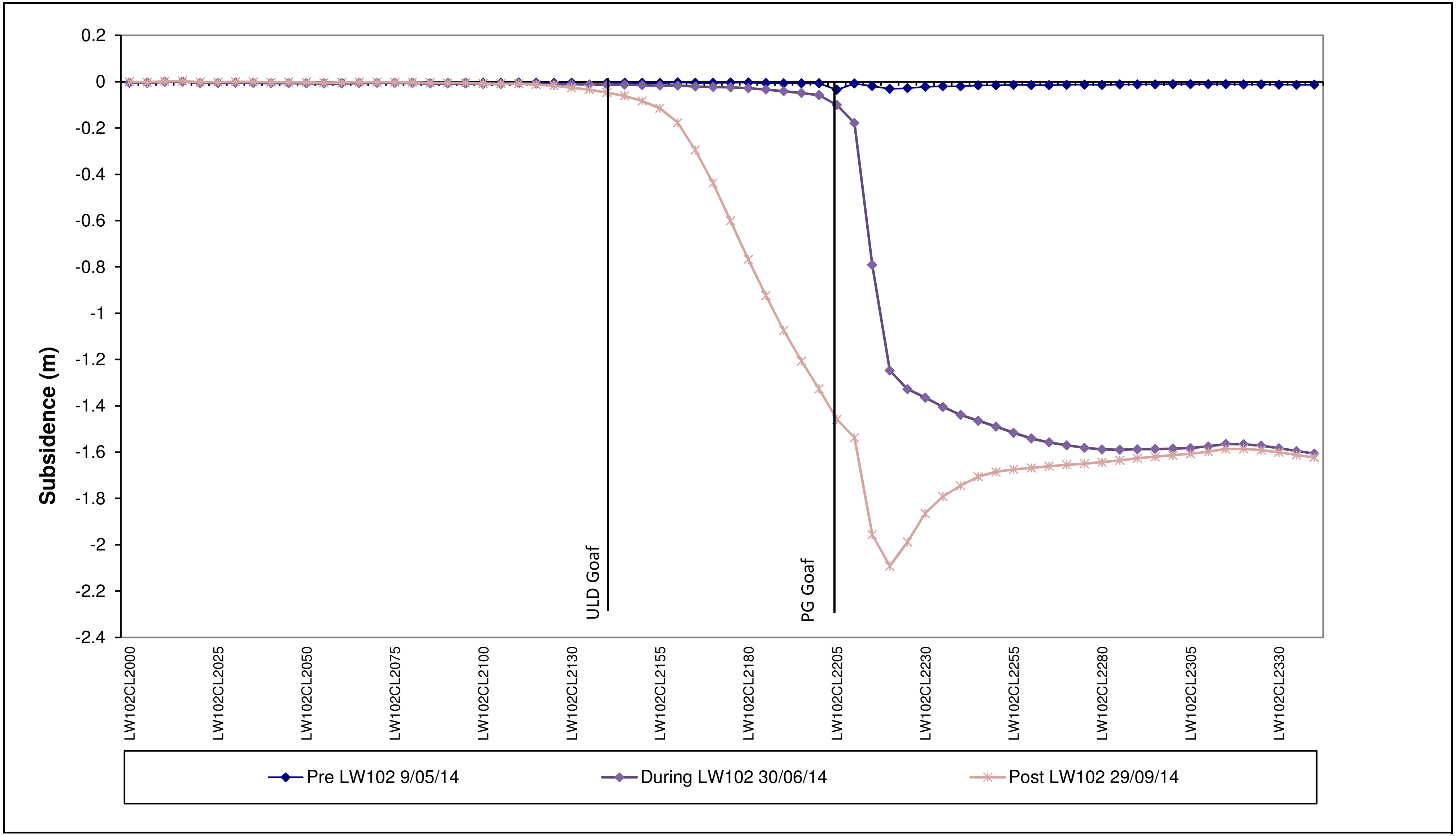

SUBSIDENCE LINE LW102 CL2 FIGURE 4

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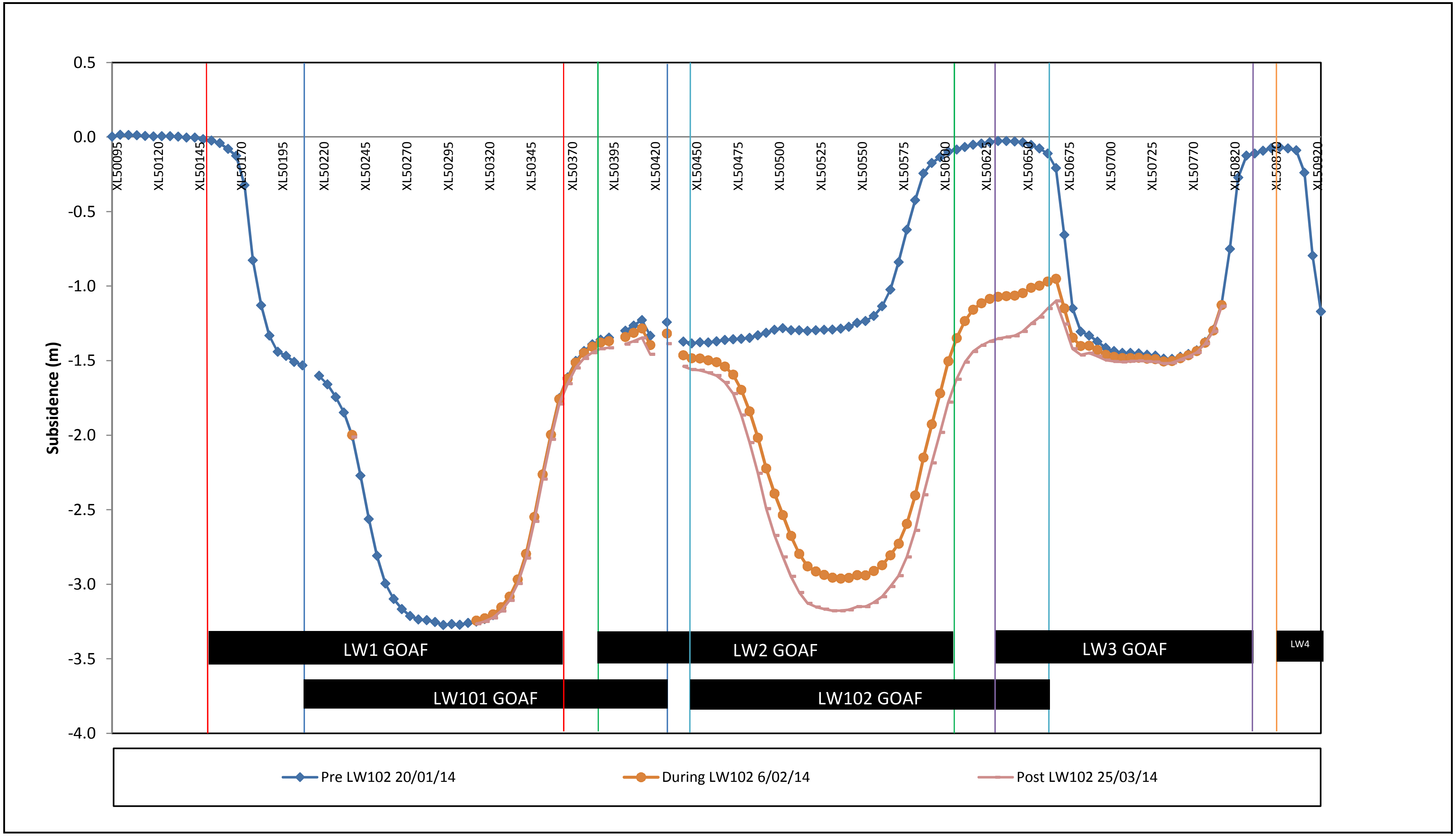

SUBSIDENCE LINE LW102 X5 FIGURE 5

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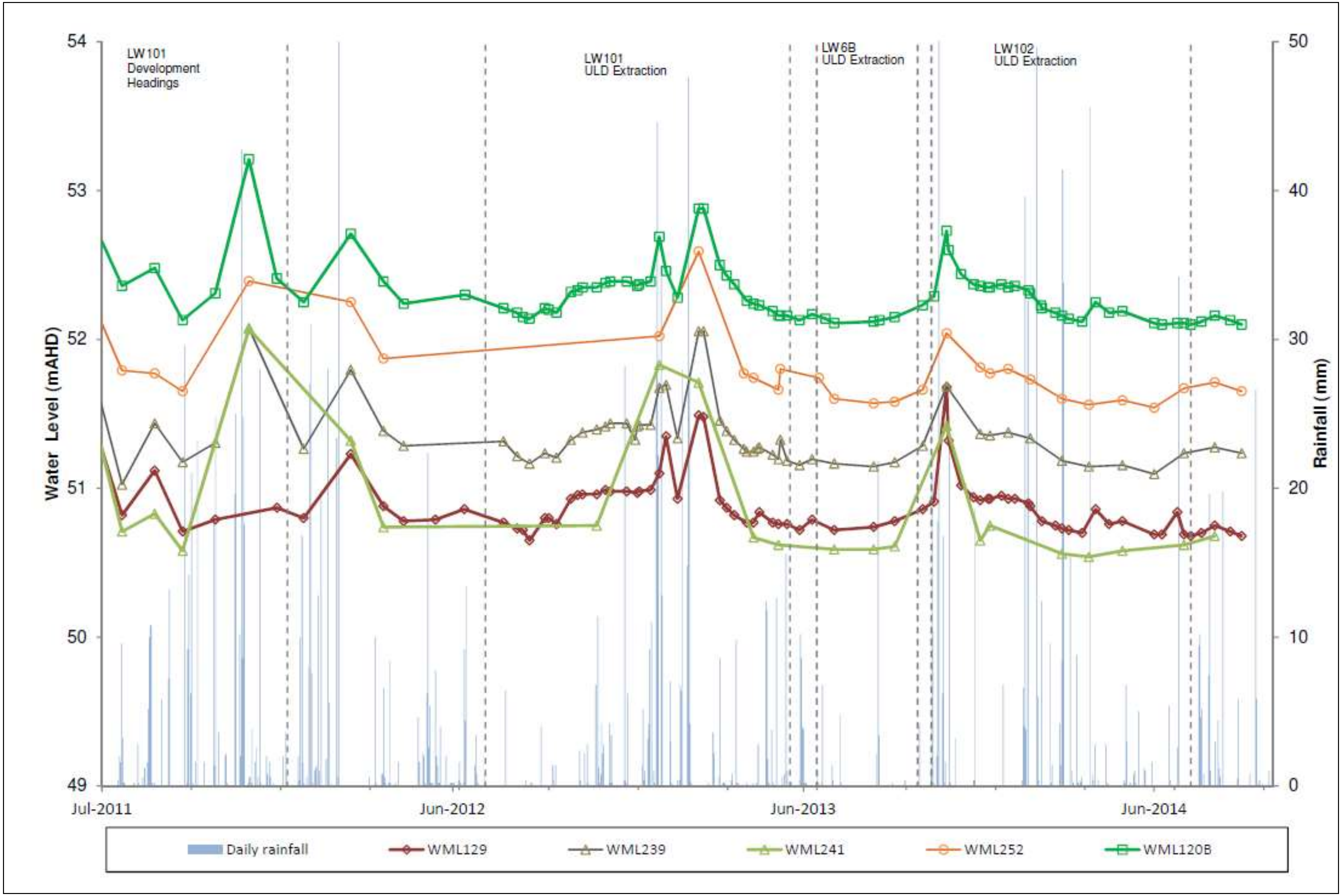

HYDROGRAPH – GLENNIES CREEK ALLUVIUM FIGURE 6

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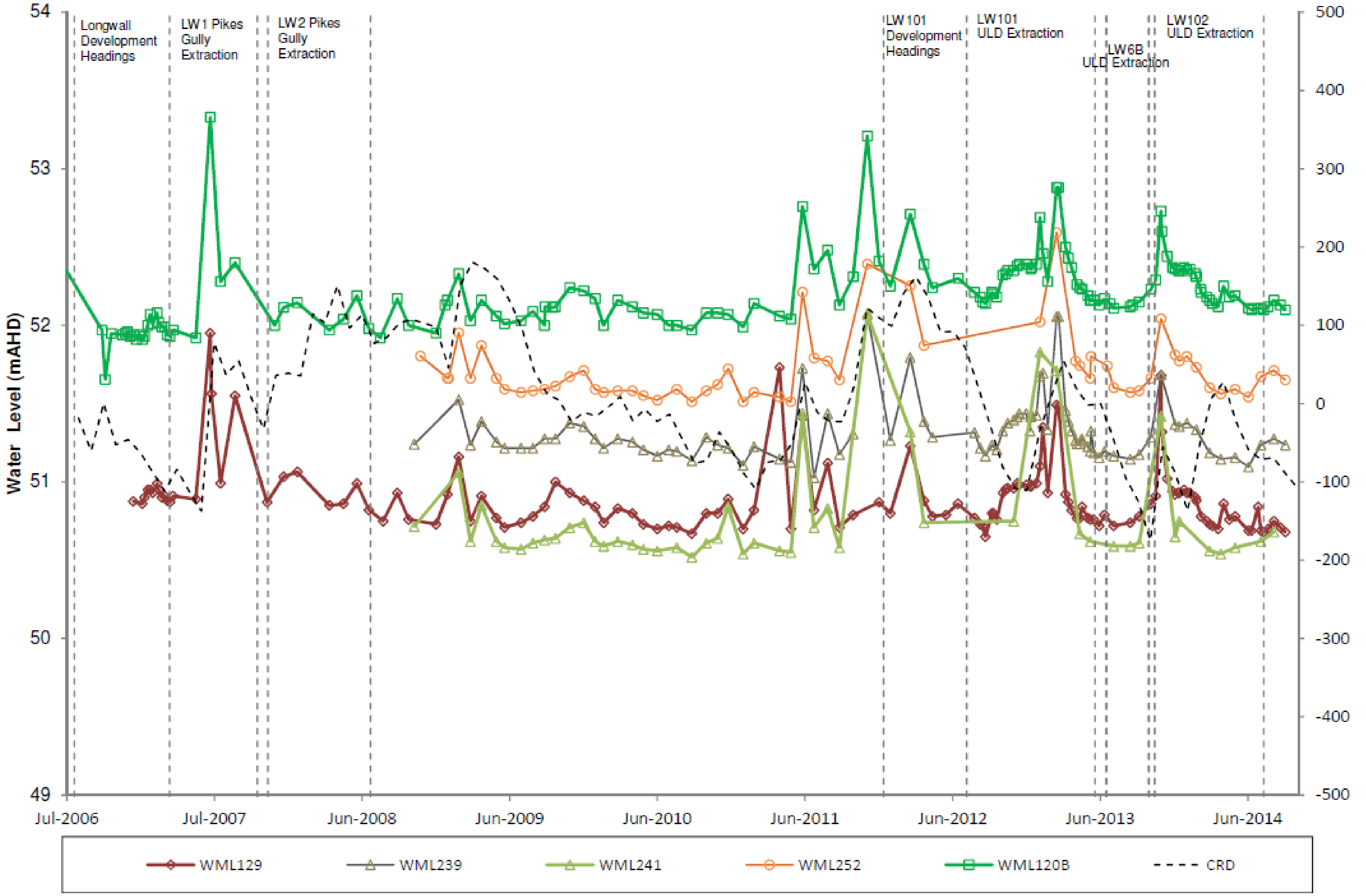

HYDROGRAPH – GLENNIES CREEK ALLUVIUM WITH CUMULATIVE RAINFALL DEVIATION FIGURE 7

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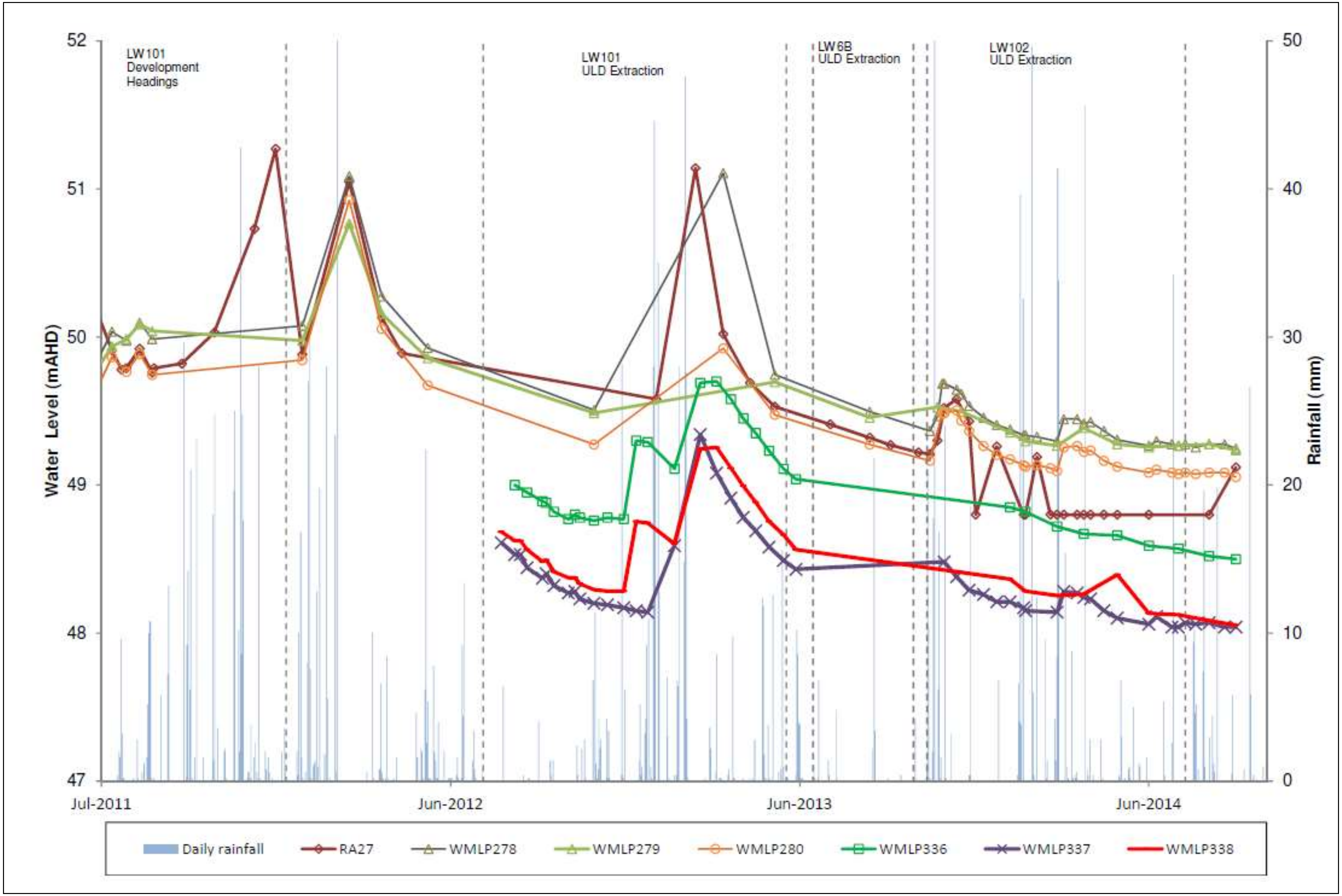

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HYDROGRAPH – HUNTER RIVER ALLUVIUM FIGURE 8

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HYDROGRAPH – HUNTER RIVER ALLUVIUM WITH CUMULATIVE RAINFALL DEVIATION FIGURE 9

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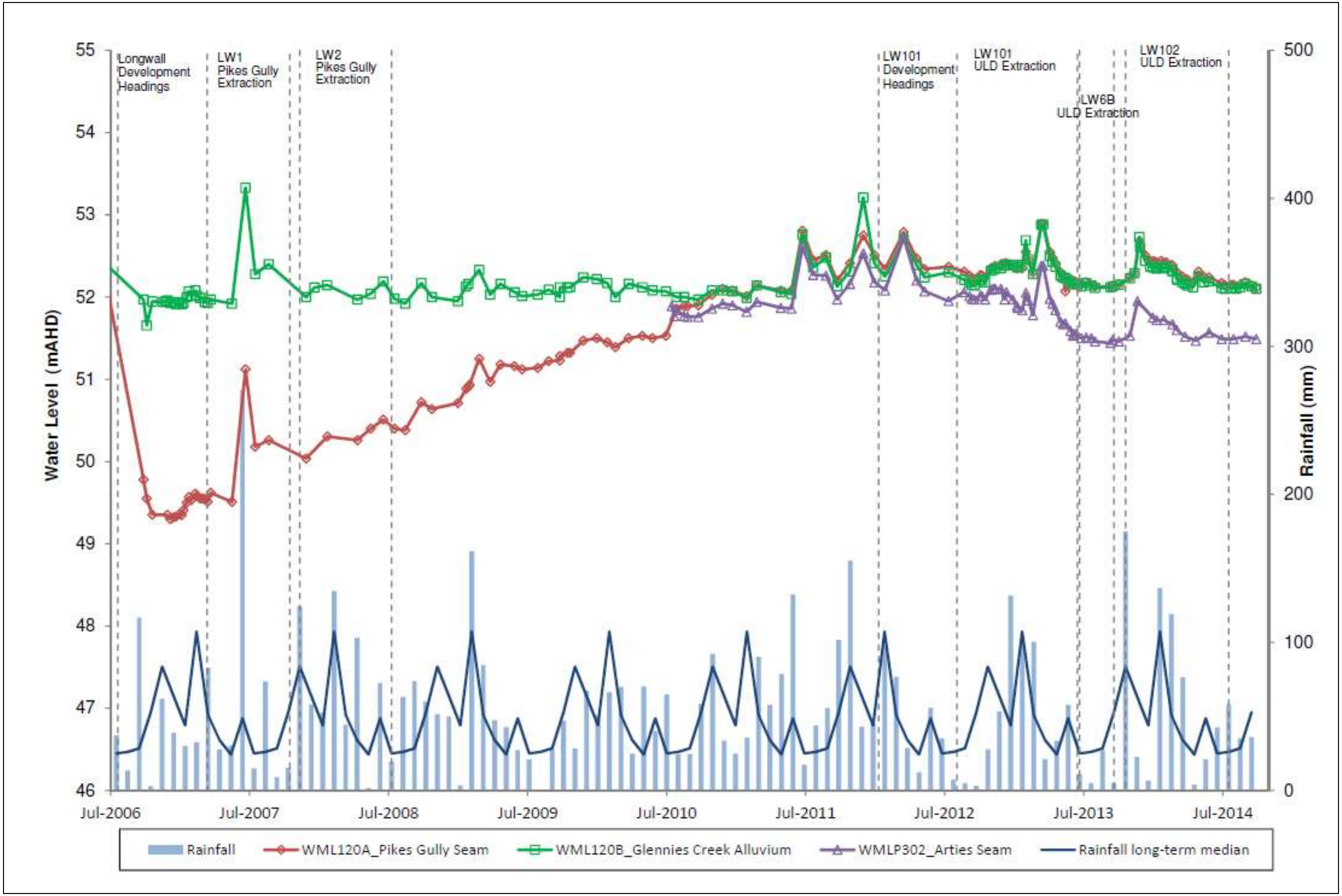

HYDROGRAPH – GROUPED PIEZOMETER SITES 1 FIGURE 10

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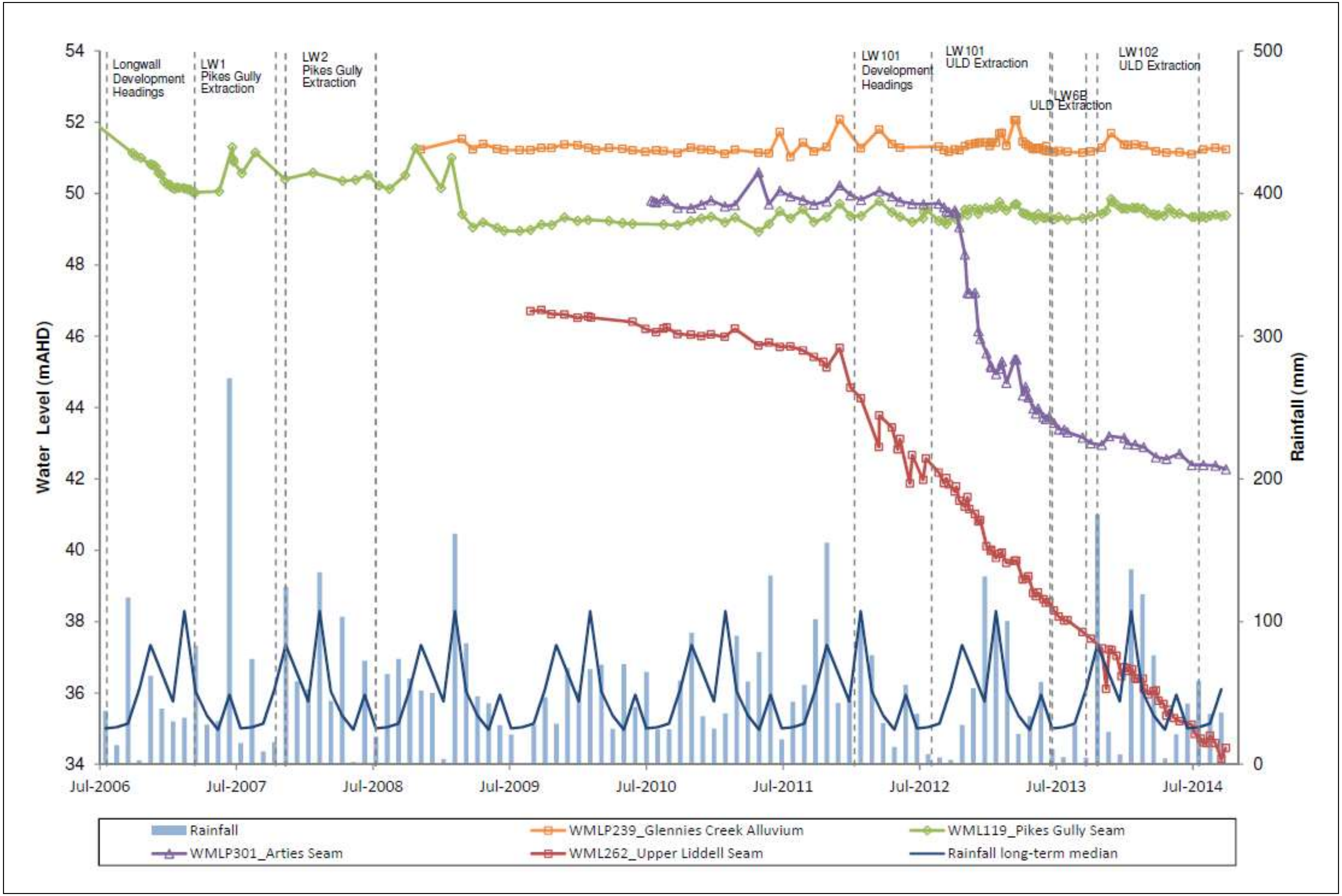

HYDROGRAPH – GROUPED PIEZOMETER SITES 2 FIGURE 11

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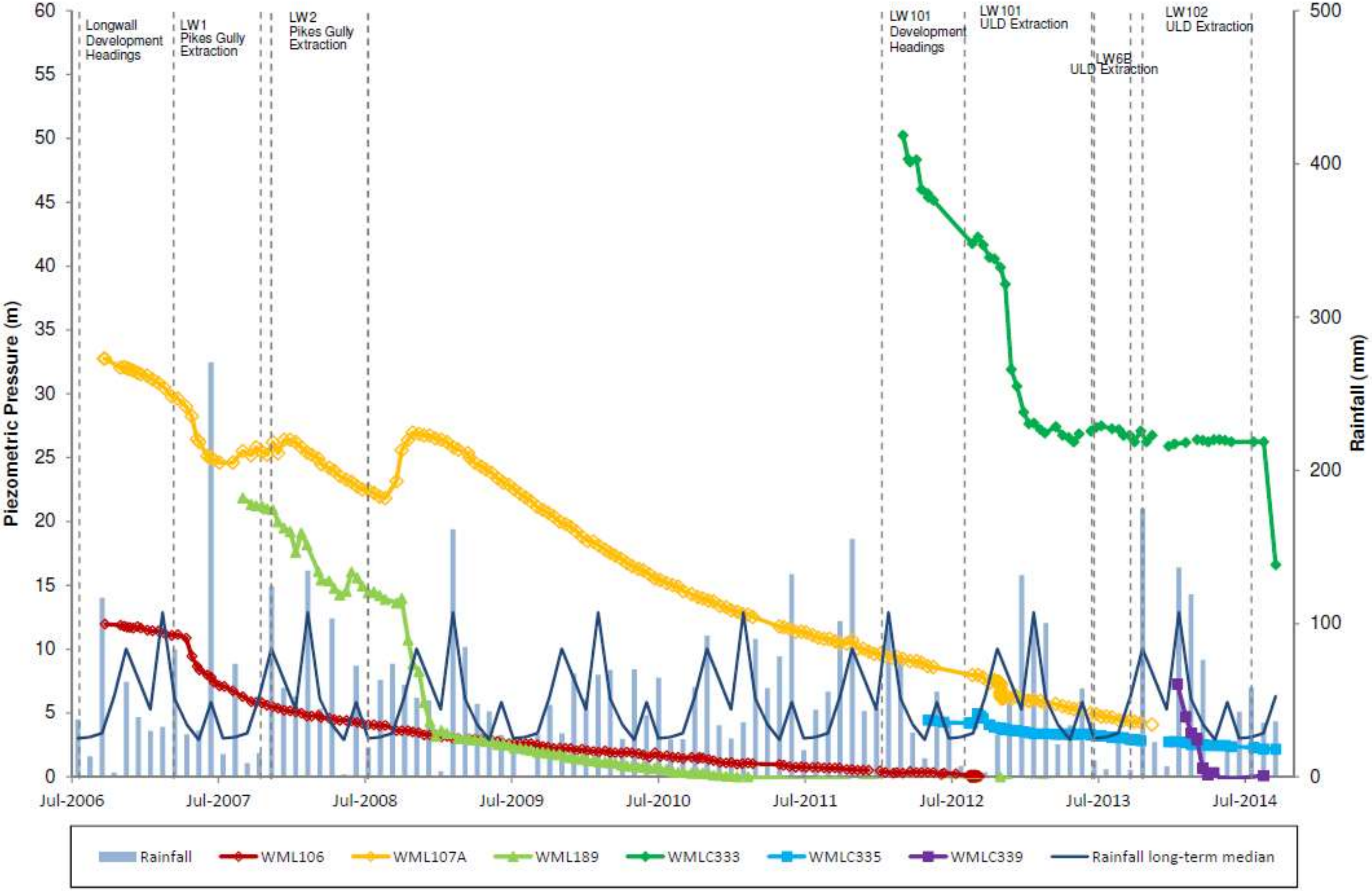

HYDROGRAPH – LEMINGTON 15 SEAM FIGURE 12

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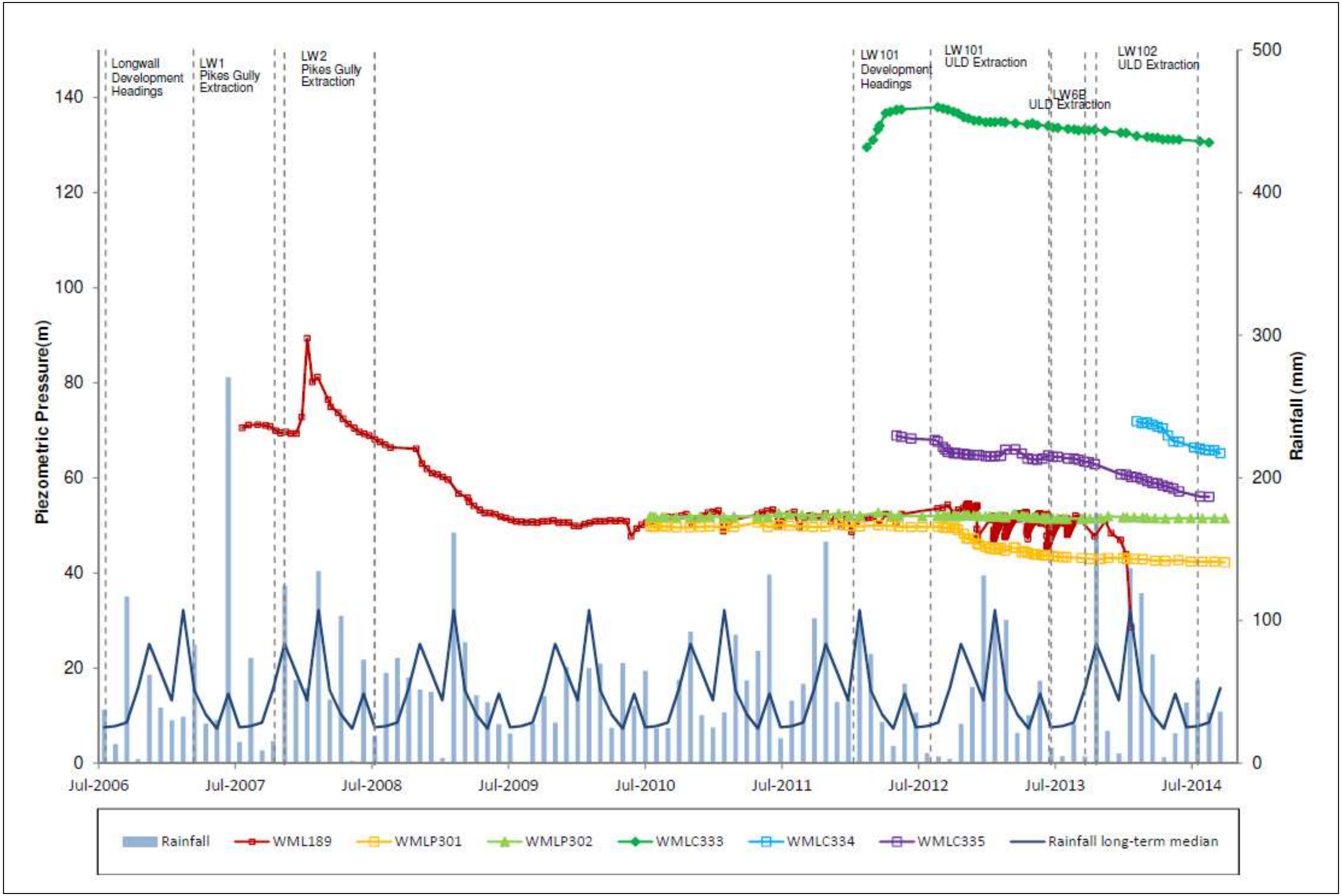

HYDROGRAPH – ARTIES SEAM FIGURE 13

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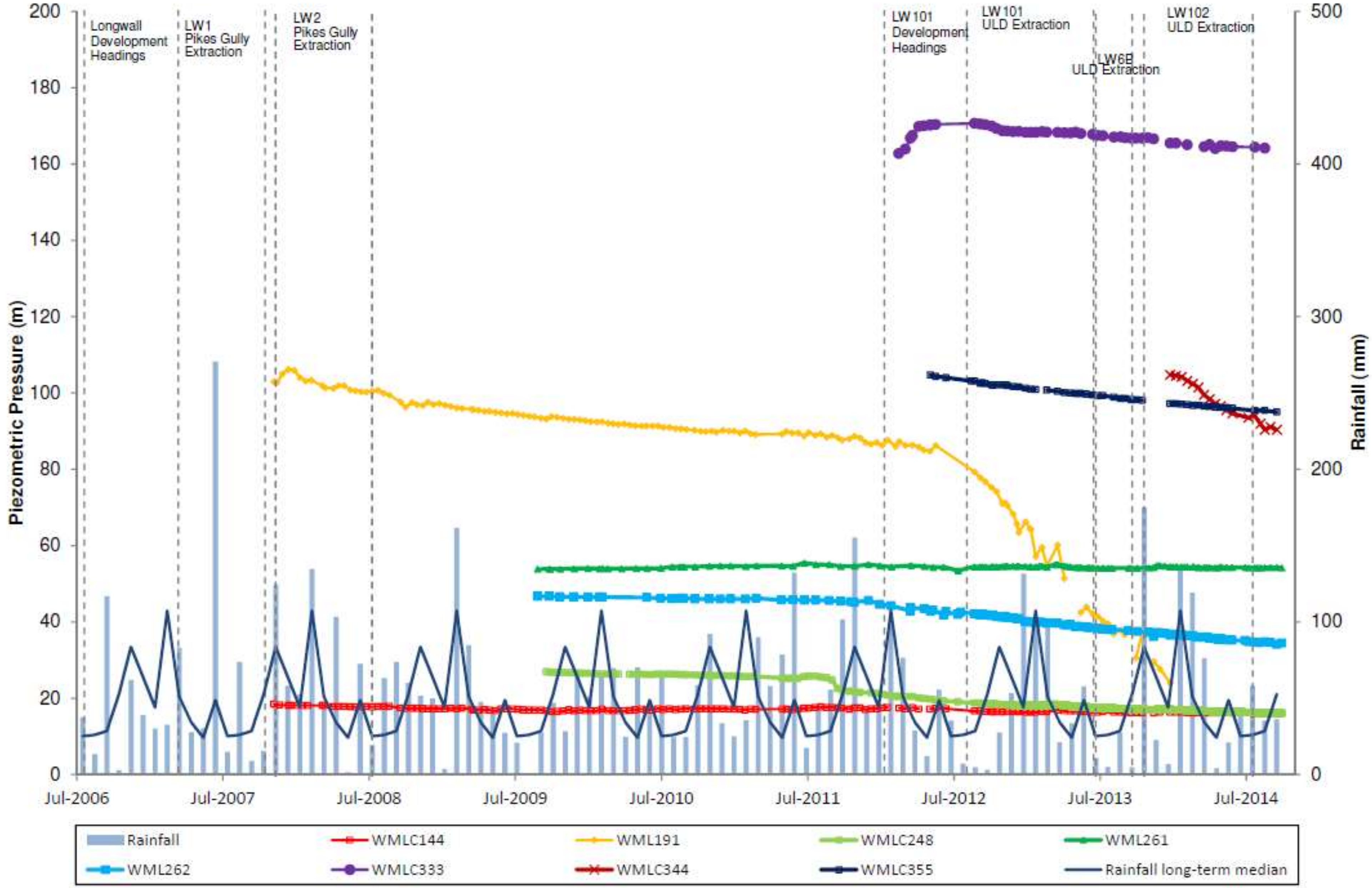
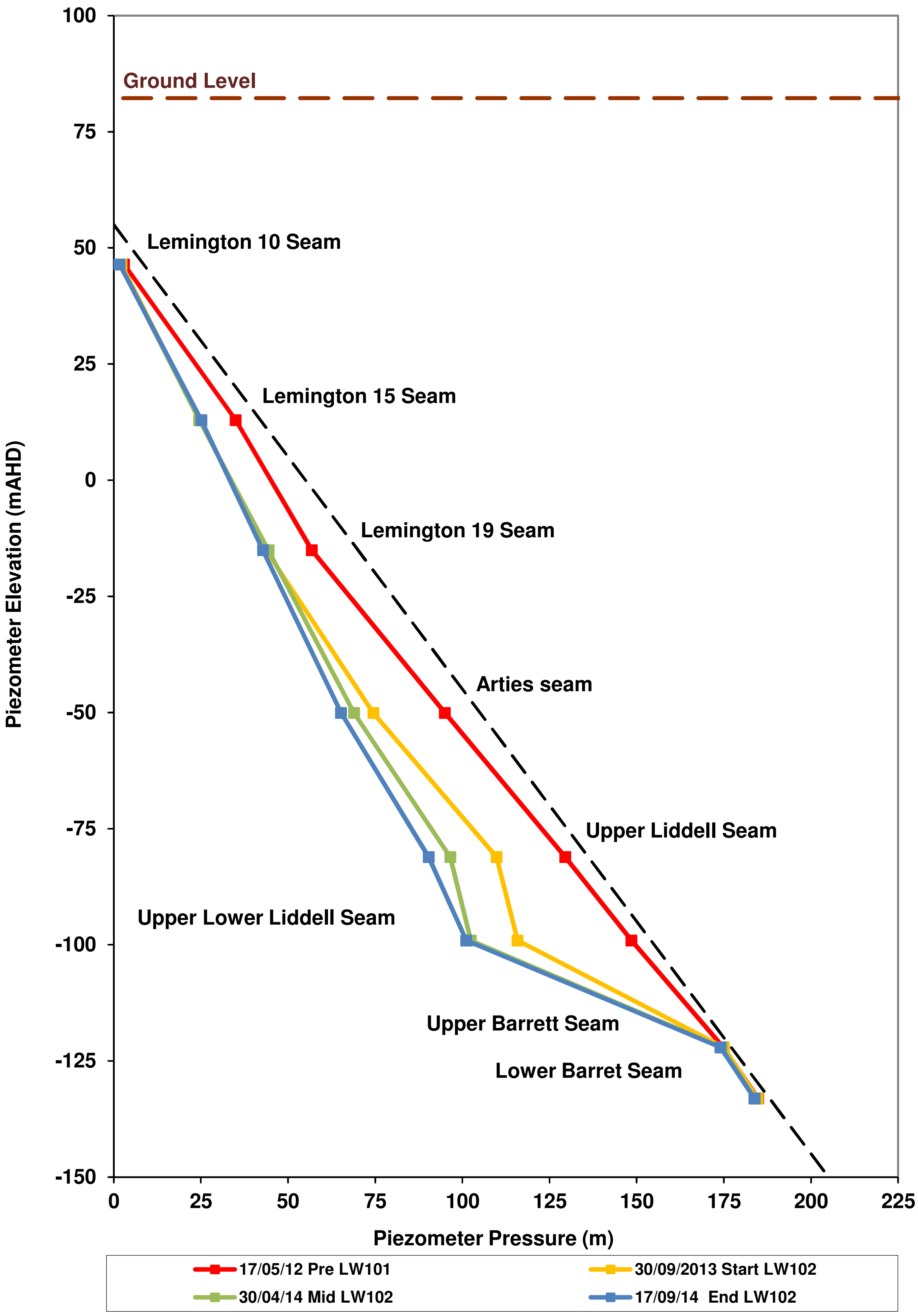
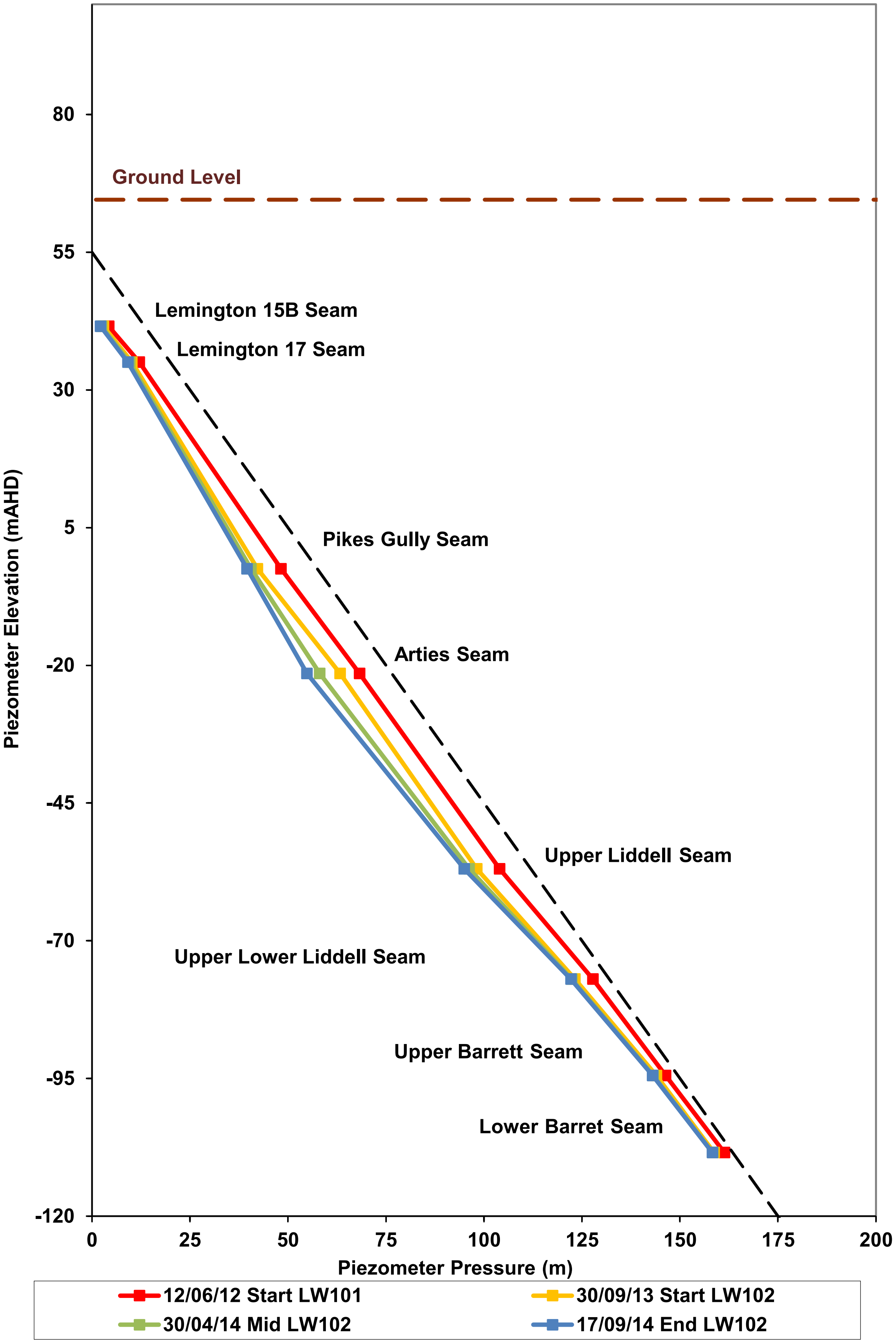


HYDROGRAPH – ULD SEAM FIGURE 14



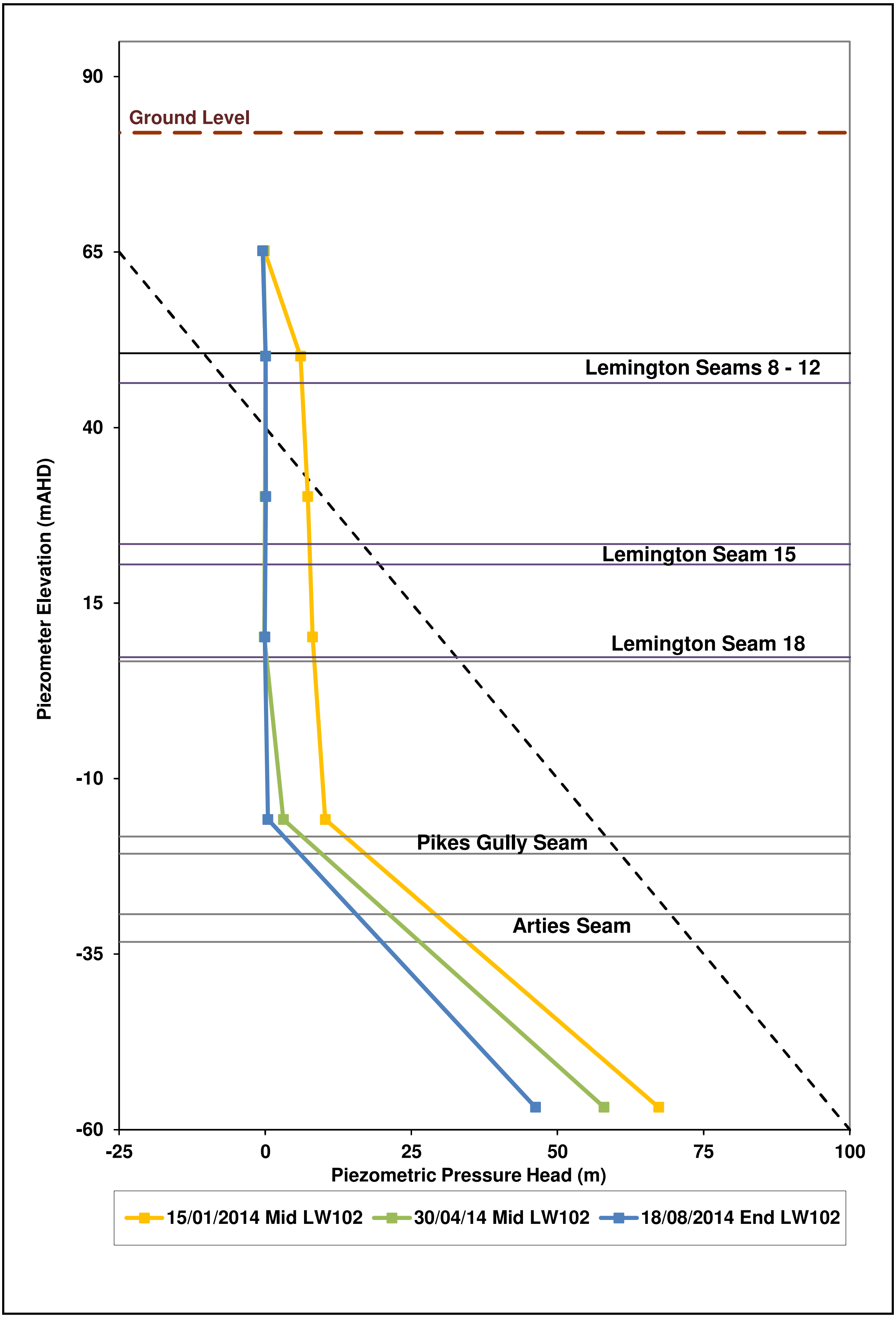
WMLC334 HYDROSTATIC HEAD PROFILE FIGURE 15

F:\Jobs\S55Q\300\Excel\003a\Projects\[003a_Hydrostatic heads Figs.xls]FIGURE 15



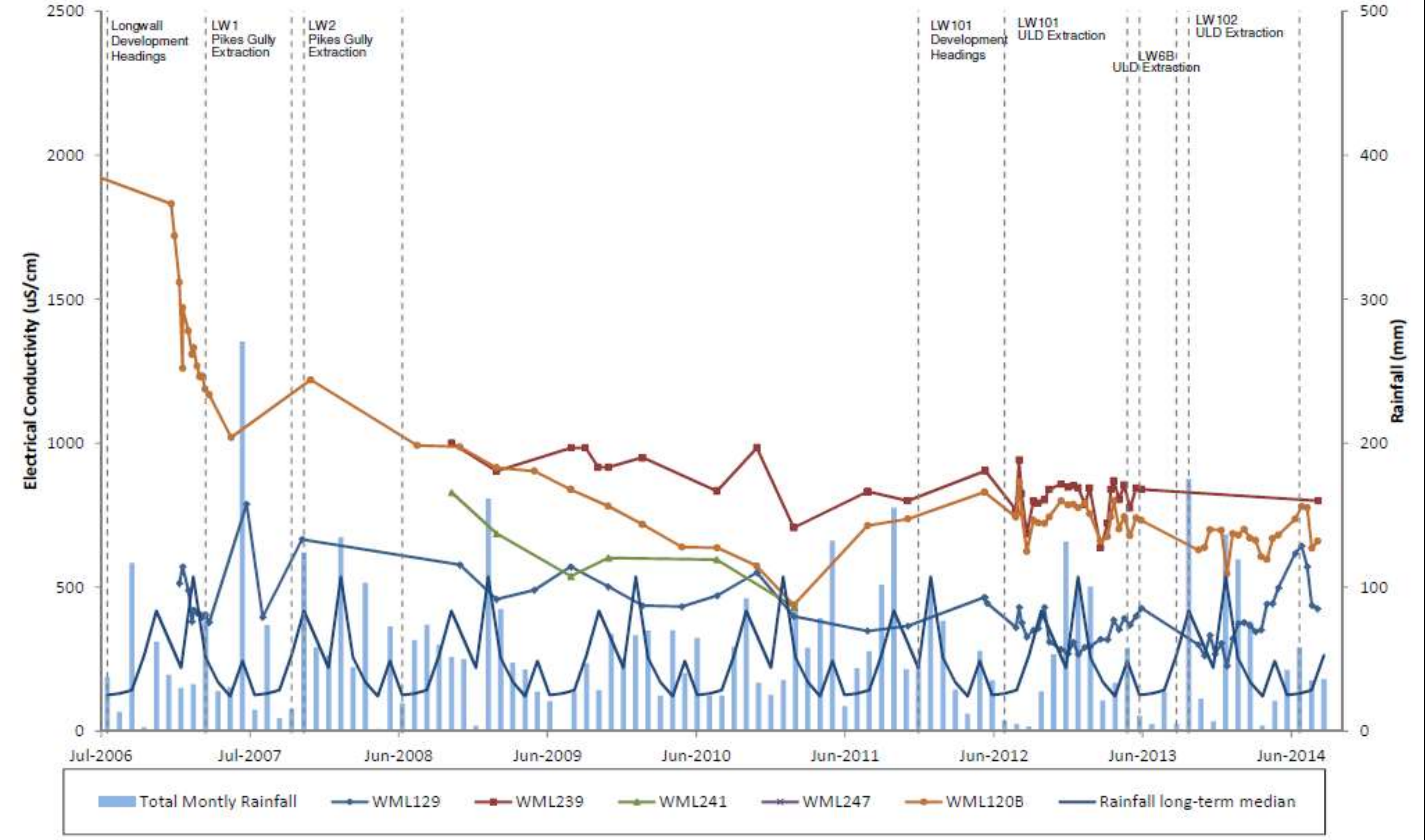
WMLC335 HYDROSTATIC HEAD PROFILE FIGURE 16

F:\Jobs\S55Q\300\Excel\003a\Projects\[003a_Hydrostatic heads Figs.xls]FIGURE 16



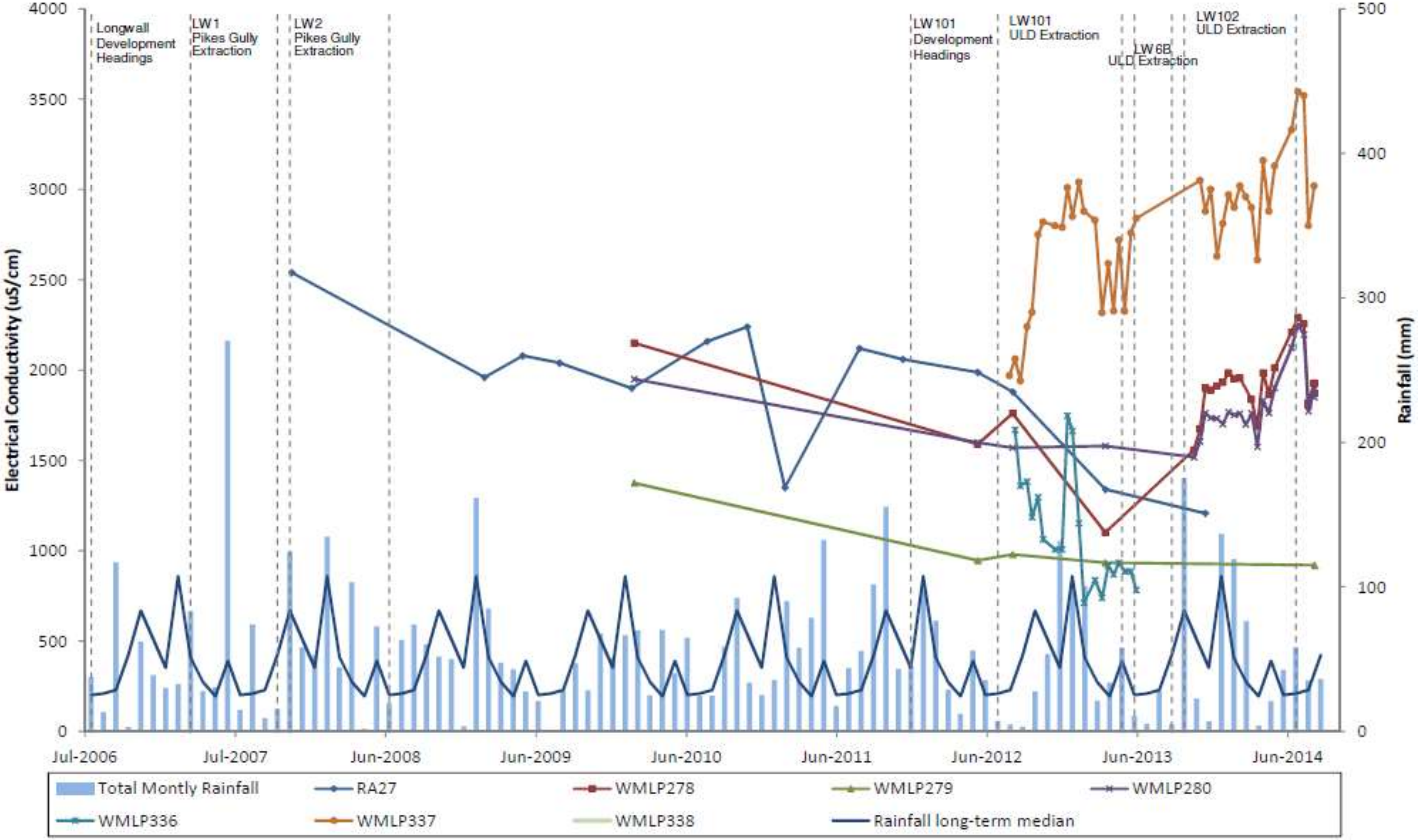
WMLC339 HYDROSTATIC HEAD PROFILE FIGURE 17

F:\Jobs\S55Q\300\Excel\003a\Projects\[003a_Hydrostatic heads Figs.xls]FIGURE 17



ELECTRICAL CONDUCTIVITY – GLENNIES CREEK ALLUVIUM FIGURE 18

f:\jobs\s55q\600\figures\word\figure18_ec_gca_alluvium.docx



ELECTRICAL CONDUCTIVITY – HUNTER RIVER ALLUVIUM FIGURE 19

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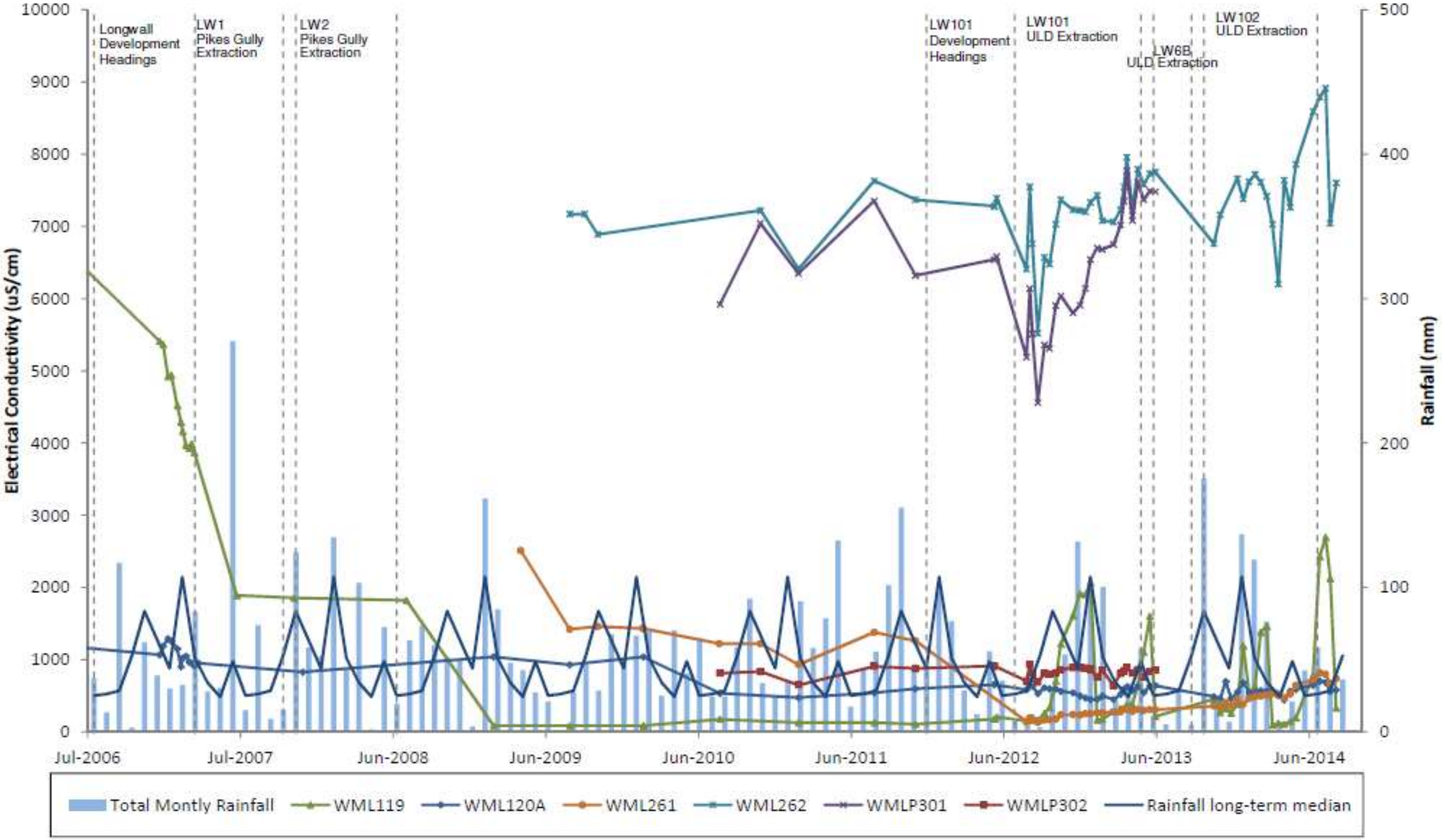

ELECTRICAL CONDUCTIVITY – PERMIAN COAL MEASURES FIGURE 20

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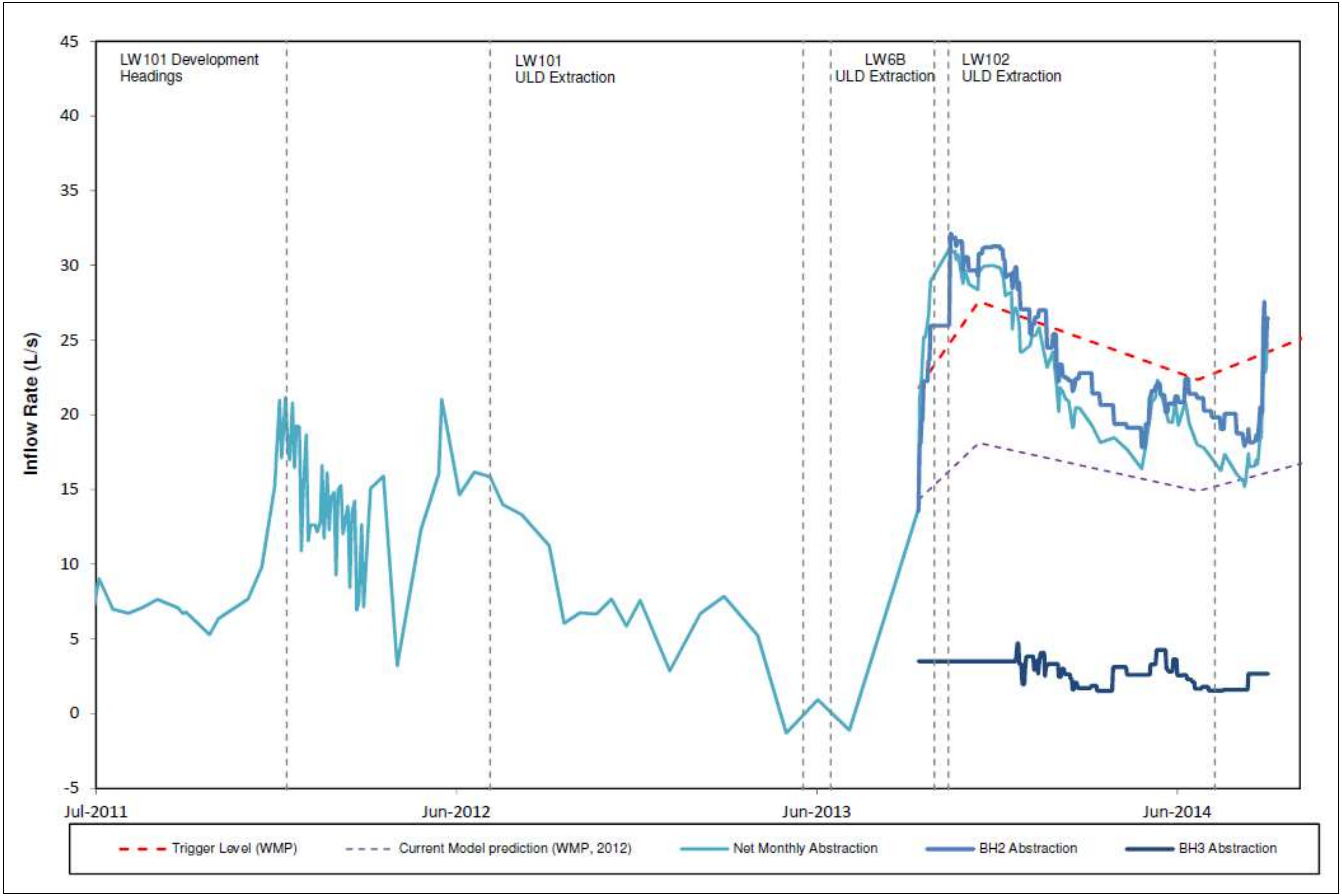

MINE DEWATERING FIGURE 21