ASHTON COAL LONGWALL 6B – END OF PANEL REPORT AND INVESTIGATION PROGRESS UPDATE

1 INTRODUCTION

This report has been prepared by Ashton Coal Operations Pty Ltd (ACOL) to meet the requirements of the Subsidence Management Plan (SMP) Condition 18 and the reporting obligations of Section 10.4.4 of the Water Management Plan (WMP).

The "*Subsidence Management Plan Approval Pikes Gully Seam Longwall 6B",* Condition 18 states:

"Within 4 months of the completion of longwall panel 6B, 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 6B (LW6B) began extraction on the 14th of July 2013, and extraction works completed on the 27th October 2013. Longwall 6B is 1,030m long, 205m wide. No unexpected impacts to the surface environment or infrastructure above resulted from secondary extraction of LW6B.

Impacts to the Bowmans Creek alluvium (BCA) were less than those predicted in the 2009 Bowmans Creek Diversion Groundwater Impact Assessment (2009 GIA) and the alluvium has remained saturated. A TARP under the Water Management Plan was triggered with regard to an increase in inflow rates and this was reported in accordance with the Water Management Plan. A more detailed report on the groundwater impacts can be found in Appendix A.

The effects of subsidence were monitored in accordance with the document "*Ashton Coal Project Pikes Gully Longwall 6B Extraction Plan"*; this included regular survey monitoring and visual inspection of environmental, land and infrastructure features.

3 MINE SUBSIDENCE

3.1 LW6B EXTRACTION

The Pikes Gully Seam section was mined along the length of Longwall 6B 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 140m near the start of the longwall panel to 106m 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 nominally at a centre to centre width and length of 30m and 150m respectively.

Ashton's longwall mining operation commenced in February 2007. Since then 10 panels have been extracted. The progress of longwall extraction is shown in **Figure 1**.

3.2 Subsidence Surveys

Ashton Coal monitored the subsidence movement on the surface during extraction of Longwall's 1-8 in the Pikes Gully (PG) 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 in the PG Seam. 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 Pikes Gully Seam (PG) Longwall 6B utilises panel centre lines (CL3 and CL4) and the cross block survey monitoring lines (XL12 and XL13) that were used for the PG Seam longwall 6B, 7B and 8. A subsidence monitoring line (LEM01) was used along the Lemington Road and four survey lines (XLE01, XLE02, XLE03 and XLE04) were also monitored along the Bowmans Creek Diversion. The subsidence monitoring lines relevant to LW6B are LW6B-CL3, LW6B-CL4, XL12, XL13, LEM01 and XLE01, 02, 03 and 04 as shown in **Figure 2.**

The following table (**Table 1)** outlines the maximum subsidence parameters predicted and recorded for LW6B during regular survey of subsidence lines as the longwall passed each location. Subsidence data for previous mined longwall blocks within PG seam is outlined in **Table 2**.

No commentary comparing LW101 monitoring results to previous panels has been included in this report as LW101 is the first panel in the Upper Liddell Seam and it is therefore irrelevant to compare this with Pikes Gully monitoring data given the multi-seam effects.

There are no exceedences of the EIS and SMP/EP predictions.

3.3 Excised Bowmans Creek Channel

Pre-inspection and survey has been undertaken. Regular subsidence visual inspection of excised creek channel was conducted during longwall undermining.

Excised Bowmans Creek channel has been undermined with no identified subsidence cracks on the creek bed and creek banks. Parts of the excised Bowmans Creek are currently holding water and have not experienced any significant water level drop to date. To avoid unnecessary disturbance, surface ponding within the excised creek channel will be remediated only as a result of increased mine inflows and/or mine safety risks where the excised Bowmans Creek is reasonable considered to be the source.

Table 1: Subsidence of Longwall Panel 6B - Predicted vs. Actual

	Predicted EIS / BCD Mod	**Predicted EP**	**Maximum Measured**			
LW6B			**CL3**	**CL4**	**XL13**	**106BCL4**
Subsidence (mm)	1430[1]/1600[2]	1600	>1390	1360	1210	1230
Tilt (mm/m)	29[1]/70[2]	70	25	34	27	31
Horizontal Movement (mm)	-	300-500	445	355	400	300
Tensile Strain (mm/m)	4[1]/30[2]	30	6	18	9	15
Compressive Strain (mm/m)	5[1]/30[2]	30	6	11	9	9

[1] Maximum EIS predictions – note that the original EIS was based on a different mining geometry and the Newcastle Coalfield subsidence guidelines. A much greater understanding of the multi seam subsidence impacts has since been obtained to inform later modifications.
[2] Revised predictions for Bowmans Creek Diversion Modification.

Table 2: Subsidence of Previous Mined Longwall Panels - Predicted vs. Actual (SCT Longwall 6B End of Panel Subsidence Report, 2013)

	Maximum Predicted EIS	Maximum Predicted SMP	Maximum Measured			
North End of LW1			**CL2**	**XL8**		
Subsidence (mm)	1430	1800	1528	1500		
Tilt (mm/m)	122	244	100	103		
Horizontal Movement (mm)	-	>500	476	500		
Tensile Strain (mm/m)	16	73	40	15		
Compressive Strain (mm/m)	25	98	28	27		
Remainder of LW1			**CL1**	**XL5**		
Subsidence (mm)	1690	1700	1318	1436		
Tilt (mm/m)	60	141	60	75		
Horizontal Movement (mm)	-	300-500	480	503		
Tensile Strain (mm/m)	8	42	49	17		
Compressive Strain (mm/m)	12	56	23	24		
Longwall 2			**CL1**	**CL2**	**XL5**	
Subsidence (mm)	1690	1600	1296	1513	1266	
Tilt (mm/m)	91	102	40	82	78	
Horizontal Movement (mm)	-	300-500	440	298	390	
Tensile Strain (mm/m)	12	30	17	16	11	
Compressive Strain (mm/m)	18	41	16	32	28	
Longwall 3			**CL1**	**CL2**	**XL5**	
Subsidence (mm)	1500	1600	1420	1354	1429	
Tilt (mm/m)	65	78	41	48	97	
Horizontal Movement (mm)	-	300-500	463	345	394	
Tensile Strain (mm/m)	9	23	10	17	22	
Compressive Strain (mm/m)	13	31	7	18	24	
Longwall 4			**CL1**	**CL2**	**XL5**	**XL10**
Subsidence (mm)	1430	1600	1397	1194	1546	1263
Tilt (mm/m)	46	78	36	40	53	33
Horizontal Movement (mm)	-	300-500	230	560	360	258[1]
Tensile Strain (mm/m)	6	23	10	18	9	6
Compressive Strain (mm/m)	9	31	9	67	9	10
	Maximum Predicted EIS	**Maximum Predicted SMP**	**Maximum Measured**			
Longwall 5			**CL1**	**CL2**	**XL5**	
Subsidence (mm)	1430	1600	1266	1326	1376	
Tilt (mm/m)	29	67	23	29	35	
Horizontal Movement (mm)	-	300-500	399	339[2]	360	
Tensile Strain (mm/m)	4	20	21	6	15	
Compressive Strain (mm/m)	5	27	9	8	17	
Longwall 6A			**CL1**	**CL2**	**XL5**	
Subsidence (mm)	1430	1600	1400	1280	1360	
Tilt (mm/m)	22	70	18	25	39	
Horizontal Movement (mm)	-	300-500	280	250	320	
Tensile Strain (mm/m)	3	30	7	4	8	
Compressive Strain (mm/m)	4	30	7	9	9	

Longwall 7A			**CL1**	**CL2**	**XL5**	
Subsidence (mm)		1600	1415	860[2]	1391	
Tilt (mm/m)		70	24	13	23	
Horizontal Movement (mm)		300-500	338	118	365	
Tensile Strain (mm/m)		30	7.6	2.4	10	
Compressive Strain (mm/m)		30	9.6	3.8[2]	12	
Longwall 7B			**CL3**	**CL4**	**XL13**	
Subsidence (mm)		1600	1375	1237	1500[3]	
Tilt (mm/m)		70	30	22	30[3]	
Horizontal Movement (mm)		300-500	321	209	395	
Tensile Strain (mm/m)		30	10	3.4	1.6	
Compressive Strain (mm/m)		23	6.9	4.3	1.8	
Longwall 8			**CL1**	**CL2**	**XL13**	**XL14**
Subsidence (mm)		1200	700[3]	800[3]	569	900[3]
Tilt (mm/m)		50	8	10	12	21
Horizontal Movement (mm)		300-500	90	83	218	243
Tensile Strain (mm/m)		15	0.8	2.1	2.5	0.4
Compressive Strain (mm/m)		20	1.0	2.2	2.1	2.3

[1] XL10 was installed after some horizontal movement associated with the previous longwall may have occurred so not all horizontal movements were measured.
[2] Maximum measured at end of line so actual maximum expected to be greater.
[3] Estimated from the shape of the profile because subsidence line did not extend across the area of greatest subsidence.

3.4 Lemington Road

Monitoring of the Lemington road was conducted pre and post extraction of LW6B panel. Monitoring and management of the impacts were completed as per the Asset Management Plan. Signage of active subsidence area and ACOL contact number was erected on Thursday (19/9/2013) directly off New England Highway and 200m prior to subsidence impact area. A licensed traffic control contractor was engaged to manage subsidence impacts to Lemington Road, including traffic control and road maintenance.

The observed behaviour is considered to have been essentially as predicted with less subsidence at 74mm compared to the maximum 300mm predicted. Observed cracking of 5-10mm was less than the up to 30mm predicted and this cracking occurred in the area expected.

Figure 3 and **Figure 4** show photographs of the minor cracking that was observed on Lemington Road.

Lemington Road remediation works were conducted by external consultant who was engaged by Mine Subsidence Board.

3.5 Telstra Phone Line

A buried Telstra phone cable has been undermined by LW6B. There were no adverse impacts or damage observed on the Telstra cable.

4 LAND MANAGEMENT

Surface subsidence cracks typically develop along each gate edge of the Longwall panel. These generally run parallel to the gate road within the longwall block. Some cracks can also occur 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 6B are less than those predicted in the SMP. This occurred for all centreline (CL) 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.

No rehabilitation of the surface cracks was required during extraction of the panel, post settling. Majority of the surface cracks were observed around mid-panel areas. These cracks were parallel to the retreating face and closed off once the longwall face has passed these areas.

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 LW6B was intensified for the period of extraction to identify any potential sudden changes that may occur.

During the course of LW6B extraction, water level decline in the BCA was observed in excess of natural water level fluctuations and has been attributed to longwall extraction. The observed declines have remained within the predictions of the 2009 GIA and the BCA has remained saturated. The 2009 GIA predicts complete dewatering of portions of the BCA overlying the longwall panels.

Inflow rates to the mine were observed to increase towards the completion of extraction in LW6B and this was reported in accordance with the Water Management Plan.

The groundwater monitoring and impacts have been reviewed by RPS - independent hydro-geologists. A report on the impacts of extracting LW6B panel has been attached in **Appendix A**.

Figures

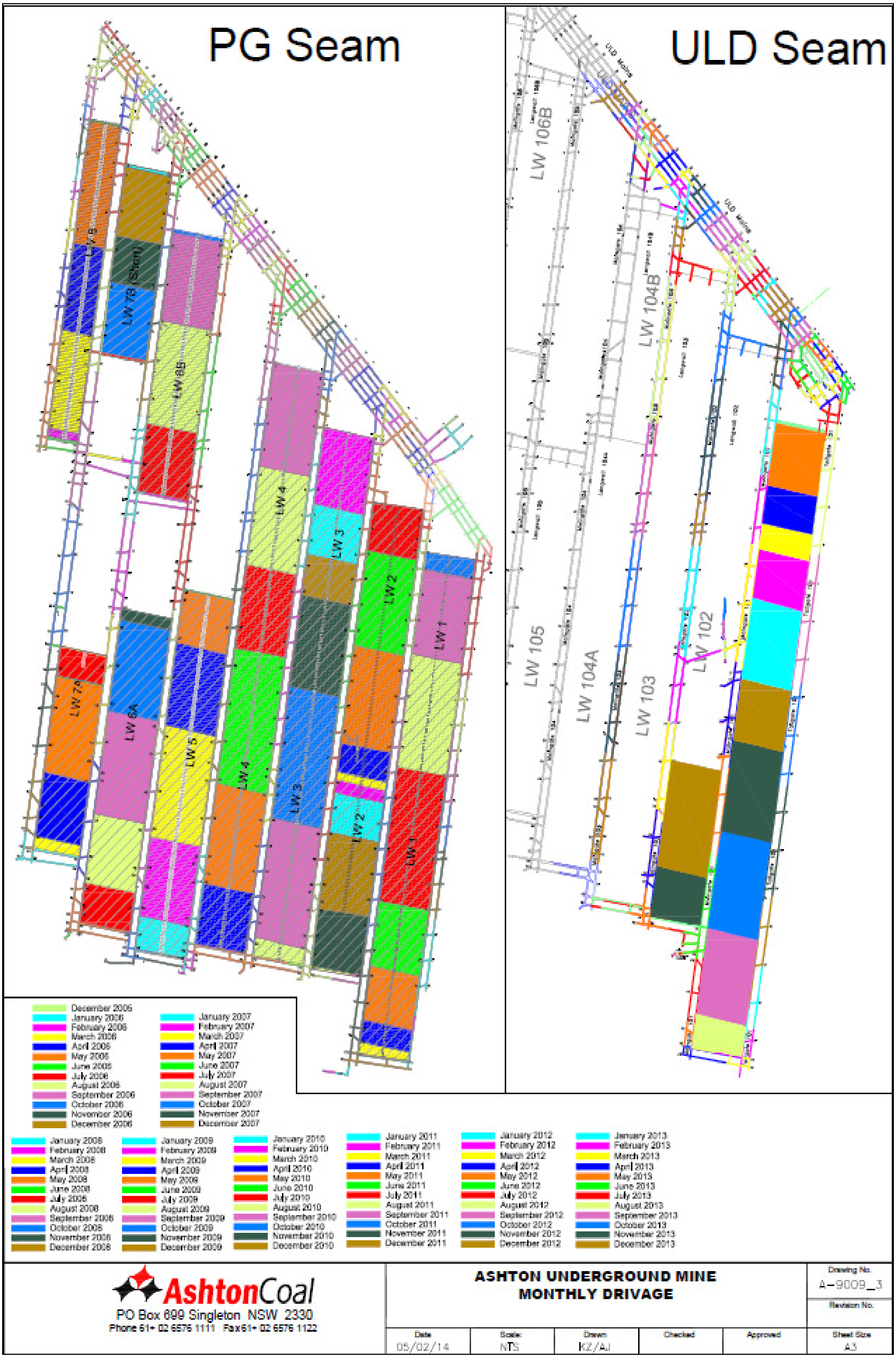

Figure 1: Progression of Longwall Extraction in the Pikes Gully and Upper Liddell Seams

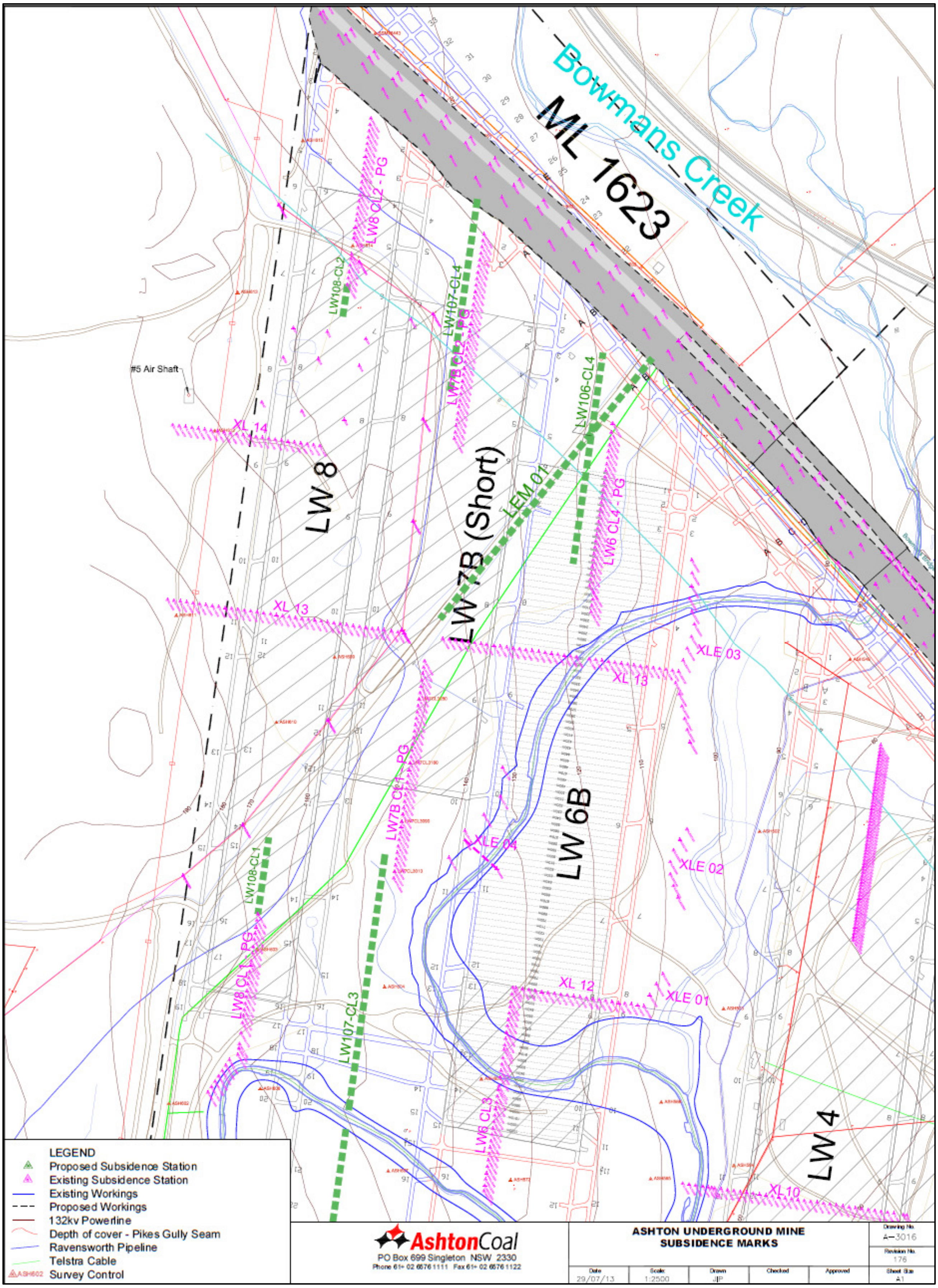

Figure 2: Plan location of Subsidence Monitoring Lines.

Figure 3 Minor cracking observed alongside Lemington Road (Looking South)

Figure 4 Minor cracking observed on Lemington Road (Looking South)

APPENDIX A: Groundwater Review – Longwall 6B

ASHTON COAL UNDERGROUND MINE END OF PANEL GROUNDWATER REVIEW LONGWALL 6B

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TABLE OF CONTENTS

TABLES

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. The ACP consists of both open cut and underground mining to access a series of coal seams within the Permian Foybrook Formation (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*.

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 (Figure 1). The channels 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 6B (LW6B) in the PG seam. The results from groundwater monitoring over the extraction period are assessed against the impact predictions from the 2009 Bowmans Creek Diversion: Groundwater Impact Assessment (2009 GIA).

1.1 Previous Groundwater Impact Reviews

This report forms the tenth groundwater impact review completed in support of End of 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	Groundwater review reference
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*	ULD	03/08/2012	31/01/2013[1]	RPS Aquaterra, 2013
LW101	ULD	03/08/2012	16/06/2013	RPS Aquaterra, 2013
LW6B	PG	14/07/2013	27/10/2013	This report

Note: * Mid panel review for longwall panel LW101

2. SITE DESCRIPTION

The Ashton underground mine is located north of the Hunter River, 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 1).

2.1 Longwall 6B

LW6B is located in the north western section of the underground mine area. The LW6B extraction area and groundwater monitoring network is shown in Figure 2.

LW6B lies adjacent to the eastern creek diversion channel and undermines the excised section of Bowmans Creek. The LW6B panel is largely overlain by saturated alluvial sediments associated with the Bowmans Creek floodplain.

The overburden thickness above the LW6B varies as a consequence of the west-south-westerly dip on the coal measures strata. Thickness of the overburden ranged from 100 m at the northern end to approximately 140 m at the south-western extent of LW6B.

Coal extraction at LW6B commenced on 14 July 2013 and was completed on 27 October 2013. LW6B was 1030 metres (m) long and the PG seam varied in thickness from 2.4 m to 2.5 m throughout the panel.

2.2 Hydrogeology

Two main aquifer systems occur 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.

The Bowmans Creek alluvium (BCA) is characterised by fine silts and clays, sometimes containing large cobbles, and silty sands. The presence of fine silts and clays within the cobbles and sands has a strong influence on the hydraulic conductivity.

Baseline hydraulic testing of the Bowmans Creek alluvium (Aquaterra, 2008) revealed a high variability in hydraulic conductivity, with values in the range 0.0002 to 15 m/d, and a median value of 0.7 m/d.

2.3 Baseline Groundwater Data

Groundwater data has been routinely collected across the ACP since 2001. Water levels and pressures from selected monitoring sites are collected monthly and indicative water quality parameters of EC, pH and TDS are generally collected quarterly. Groundwater sampling for comprehensive analysis is completed every six months.

A comprehensive baseline dataset is now available and is used to enable identification of impacts outside of natural climatic variations.

2.3.1 Groundwater Levels / Pressure

The groundwater levels in the Permian formations were historically higher than the water level elevation in both the alluvium and in the streams prior to mining activity. The resulting 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.

Mining in the PG seam 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 expected to completely dewater by the end of underground mining in the ULD seam.

In places where drawdown impacts from mining have lowered groundwater levels in the Permian, the hydraulic gradient has been reversed. This results in the potential for vertical leakage of water from the alluvium to the underlying Permian. The rate of this leakage is dictated by the permeability of the alluvium and the underlying Permian.

2.3.2 Groundwater Quality

Groundwater quality varies according to its source and interaction with other water sources:

- 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 2.1: Baseline Groundwater Quality Data Summary

Aquifer screened	pH (pH units)		Electrical Conductivity (µS/cm)	
	Mean	Range	Mean	Range
Bowmans Creek Alluvium	7.23	6.44 - 10.04	1622	722 - 9920
Hunter River Alluvium	6.97	6.76 - 7.14	2091	1375 - 2540
Glennies Creek Alluvium	7.05	6.53 - 7.79	3202	300 - 16300
Colluvium	6.91	6.52 - 7.87	6682	1300 - 13860
Pikes Gully Seam	6.87	5.29 - 7.78	2088	86 - 8820
Upper Liddell Seam	7.64	6.81 - 8.99	4304	200 - 9370
Arties Seam	7.23	6.35 - 8.03	3432	648 - 6350
Shallow Permian Coal Measures	7.36	6.35 - 11.97	5611	320 - 18200

3. HYDRAULIC TESTING

In accordance with the 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 LW6B piezometers to assess if subsidence following LW6B mining has materially altered the permeability of the BCA or the shallow CMOB in the vicinity of the longwall extraction.

3.1 Testing Programme

The permeability testing was undertaken at a number of standpipe piezometers installed in the LW6B area (Table 3.1 and Figure 2). Piezometers were tested in July 2013 prior to commencement of LW6B and then repeated in February 2014 following the completion of mining.

3.2 Analysis and Results

Analysis of the hydraulic tests was undertaken using the Bouwer-Rice method (Bouwer and Rice, 1976) for the slug permeability tests. Table 3.1 outlines the results of the hydraulic testing as performed prior to and following the completion of longwall extraction.

Table 3.1: Hydraulic Testing Results

Piezometer	Piezometer Type	Test Horizon	Hydraulic Conductivity (m/day)	
			Pre LW6B mining	Post LW6B mining
WMLP308	Shallow	BCA	0.4	1.7
WMLP323	Shallow - Paired	BCA	3.3	2.2
WMLP324	Deep - Paired	CMOB	Low (data not sufficient for analysis)	0.06
WMLP311	Shallow - Paired	BCA	4.8	1.4
WMLP325	Deep - Paired	CMOB	0.4	1.5

Results from hydraulic testing show both increases and decreases in the hydraulic conductivities (permeabilities) derived for the BCA and CMOB following LW6B mining.

The apparent changes in permeability are not considered significant or related to longwall extraction and associated subsidence. Rather, the variation is likely to be related to the decreased water levels for the post-LW6B testing.

No subsidence related permeability changes or impacts are inferred.

4. SUBSIDENCE MONITORING

As underground mining progresses, subsidence survey monitoring is undertaken in accordance with the approved Subsidence Monitoring Programme (ACOL, 2013). Five survey lines established across LW6B (LW6 CL3, XL13, LW106 CL4, LW6 CL4-PG and LEM01) were monitored during extraction of the panel (Figure 2).

Plots of strain versus distance are presented for snapshots in time over the LW6B extraction period (Figures 3 to 7). The results were examined for potential for excess (positive) strain on the edges of the goaf, which might indicate an extensional fracturing environment and horizontal movement. The maximum predicted strain during LW6B extraction was 30 mm/m (SCT, 2011). No strain exceeding 20 mm/m was measured, in most locations the strain is shown to be less than 10 mm/m.

The magnitude of the measured strain (<20 mm) is within approved predictions (30 mm) and considered unlikely to cause extensional fracturing or horizontal shearing. In the absence of any shearing, the permeability of the BCA would not have undergone any significant change.

In order to quantify any permeability changes associated with these lateral movements, hydraulic testing of piezometers installed along the longwall margins has been undertaken as discussed in Section 3.

5. GROUNDWATER MONITORING

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).

5.1 LW6B Monitoring Network

Eighteen (18) piezometers were selected from the ACP groundwater monitoring network to provide key groundwater monitoring data during the LW6B extraction period. The selection was based on relative location to the longwall face and the monitored hydrogeological unit.

Nine (9) of the selected piezometers were equipped with automatic data loggers over the extraction period. The data loggers enabled high frequency (six hourly) measurements of pressure/quality to be obtained and related to the position of the longwall face.

Table 5.1 lists the key piezometers and monitored hydrogeological unit (strata) with the piezometer locations relative to LW6B presented in Figure 2.

Table 5.1: Selected Piezometers for Groundwater Monitoring at LW6B

Piezometer ID	Piezometer type	Hydrogeological Unit	Data Logger
WMLP308	Standpipe	BCA	Yes
WMLP311	Standpipe	BCA	Yes
WMLP323	Standpipe	BCA	Yes
WMLP328	Standpipe	BCA	Yes
WML115C	Standpipe	BCA	No
T2A	Standpipe	BCA	No
T5	Standpipe	BCA	Yes
T6	Standpipe	BCA	No
T7	Standpipe	BCA	No
RA18	Standpipe	BCA	Yes
RA30	Standpipe	BCA	No
Ashton Well	Well	BCA	No
WML115B	Standpipe	CMOB	No
WMLP324	Standpipe	CMOB	Yes
WMLP325	Standpipe	CMOB	Yes
RSGM1	Standpipe	CMOB	No
T2P	Standpipe	CMOB	No
WMLP361[1]	VWP	Permian Coal seams and interburden	Yes

Notes:

[1] - WMLP361 was installed following the commencement of LW6B on 2 September 2013

BCA – Bowmans Creek Alluvium

CMOB – Permian coal measures overburden

5.2 Longwall 6B Monitoring Programme

In accordance with Section 9.3 of the WMP the monitoring frequency at the selected piezometers (Table 5.1) was intensified from monthly to fortnightly for water levels/pressures during the extraction of LW6B.

The monitoring frequency at the selected piezometers was further increased to weekly in September 2013, following the identification of an accelerated water level decline within the BCA overlying the LW6B area (refer Section 6.1).

5.3 Rainfall

Monthly rainfall data measured on site from the Ashton weather station is compared against the Long Term Median (LTM) in Table 5.2. During the months of LW6B extraction (July 2013 to October 2013) the area received 48mm of rainfall, which was less than half the LTM of 131.3 mm for the same time period.

Table 5.2: Ashton Coal 2013 Rainfall

Month	2013 Ashton Coal Project Rainfall (mm)	Long-term Median[1] (mm)
January	131.6	50.4
February	100	137.8
March	100.4	48.6
April	21.2	32.2
May	33.6	24.8
June	57.8	46.1
July	10.8	24.2
August	5.0	23.0
September	27.4	29.6
October	4.8	54.5
November	175.2	83.6
December	22.6	66.6
Annual	690.4	660.1

[1]Data obtained from the Bureau of Meteorology Singleton STP Station number 061397

*Shaded cell denote the LW6B extraction period

The LTM is used for comparison. This measurement provides a robust and representative measure of typical seasonal rainfall for the catchment. An extreme rainfall event will have less effect on the median than it will have on the arithmetic mean.

Daily rainfall is plotted on the hydrographs (Figures 8 to 16) and BCA water quality plots (Figures 19 to 22) to help interpret the trends observed in groundwater level and quality.

6. GROUNDWATER LEVELS

6.1 Bowmans Creek Alluvium – Figures 8, 9 and 10

Over the LW6B extraction period the following observations are noted in regard to water levels within the BCA:

- At all times the BCA has remained saturated in areas above longwall 6B as well as retaining substantial saturated thickness to the east and south of longwall 6B.
- BCA piezometers T2A, WML328 and RA18 located to the south of the LW6B extraction area (Figure 10) show no impact during LW6B extraction with groundwater levels maintained within baseline ranges.
- A water level decline is observed in the BCA overlying and adjacent to LW6B following the commencement of longwall extraction (Figures 8 and 9). The decline commenced in August 2013 and continued over a period of approximately two (2) months.

The observed water level decline is most pronounced at piezometer T5, located above the LW6B/LW7B chain pillar, with a drawdown of over 3m (Figure 9). Water levels at T5 declined to around 0.5m above the base of alluvium. The water level decline is shown to be relatively localised to piezometers immediately east (Figure 8) and west of LW6B extraction (Figure 9) of LW6B extraction. A similar initial water level decline to that observed at T5 is also observed at T6, located to the north of T5, however, blockage of the bore approximately 1m above the base of the BCA has prevented further observation of the water level decline. Additional piezometers in the vicinity of T5 will be installed during 2014 (pending licence approval) and water quality monitoring will be undertaken at an alternate monitoring location.

Over the LW6B extraction period groundwater recharge was minimal with below average rainfall experienced. This is thought to have contributed to the observed water level decline however, vertical leakage to the underlying CMOB is attributed as the dominant factor. The CMOB is inferred to have been depressurised resulting from subsidence associated with longwall extraction (refer Section 6.4).

It should be noted that the groundwater modelling completed for the 2009 GIA predicts complete dewatering of portions of the BCA overlying the longwall panels. Therefore the observed decline is expected and within the approved predicted impacts in the 2009 GIA (Aquaterra 2009).

Following the completion of LW6B, water levels within the BCA are observed to fully recover following a large rainfall event in November 2013. The drawdown in BCA piezometers is observed to continue at comparable rates following this recharge event.

6.2 Glennies Creek Alluvium – Figure 11

Piezometers which monitor the Glennies Creek alluvium (GCA) have shown no response to the extraction of LW6B.

Water levels in the GCA are generally observed to gradually decline over the LW6B extraction period correlating with low rainfall recharge over the period. One piezometer, WML129, shows a slight increase in response to a moderate rainfall event in September.

Water level 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 alluvium and the BCA (outside of the LW6B extraction area).

Groundwater levels in the GCA show a significant response to the large rainfall event in mid-November 2013.

6.3 Hunter River Alluvium – Figure 12

Piezometers which monitor the Hunter River Alluvium (HRA) have shown no response to the extraction at LW6B.

The HRA water levels reflect a rainfall controlled natural recharge and discharge pattern with a general decreasing trend observed over the LW6B extraction period.

All piezometers show a declining water level following above average rainfall earlier during February and March 2013. The observed decline of the groundwater levels is attributed to a reduction in rainfall recharge over the period, rather than as a result of underground mining activity. There has been no discernible response to mining in the HRA to date.

6.4 Permian Shallow Coal Measures Overburden – Figure 13

Up until LW6B extraction, the continuation of a general gradual declining trend in the CMOB was observed following the extraction longwall 7B (LW7B). This gradual decline is attributed to vertical leakage in response to mining related subsidence. The complete dewatering of the CMOB in the area is anticipated as per the predictions from the 2009 EA.

Following the commencement of LW6B, a marked drop was observed at WML324 and WML325 coinciding with the passage of the LW6B face at each location. This depressurisation has been shown at paired sites (WMLP323/324 and WMLP311/325) to significantly increase the hydraulic gradient between the CMOB and the overlying BCA (Figures 14 and 15). This response is consistent with the groundwater model, with the increased hydraulic gradient driving the predicted draining of the overlying BCA. A slight decline is also observed at WML115B and RSGM1.

Following the November recharge event partial water level recovery is observed in all the CMOB piezometers with increases of 1.0 to 3.5 m observed (Figure 13). T2P was the exception showing only a minor increase in water levels. This is attributed to reduced recharge due to lower hydraulic conductivity of the BCA in the area.

6.5 Paired Groundwater Monitoring Sites – Figures 14, 15 and 16

Paired monitoring sites consist of two adjacent standpipe piezometers installed to monitor both the unconfined BCA and the shallow CMOB immediately below. For LW6B monitoring, three paired sites were monitored on a fortnightly basis as shown in Table 6.1.

As previously discussed, the groundwater levels (piezometric surface) in the Permian were generally higher than in the overlying alluvium prior to the commencement of mining in the area (Aquaterra 2009). Drawdown impacts from mining have lowered groundwater levels in the Permian resulting in a reversed hydraulic gradient with water levels in the alluvium now observed above corresponding levels in the Permian. This has resulted in the potential for water to seep at a greater rate from the alluvium into the underlying Permian.

Table 6.1: Paired Sites Construction Summary

Site	Piezometer ID	Depth (m)	Hydrogeological Unit
Paired Site 1 (Figure 14)	WMLP323	7.3	Bowmans Creek Alluvium
	WMLP324	14.1	Permian Sandstone
Paired Site 2 (Figure 15)	WMLP311	7.6	Bowmans Creek Alluvium
	WMLP325	14.6	Permian Sandstone
Paired Site 3 (Figure 16)	T2-A	8.9	Bowmans Creek Alluvium
	T2-P	14.9	Permian Sandstone

Over the LW6B extraction period the following is noted:

- At all three paired sites groundwater levels in the BCA are above the groundwater level in the CMOB. This demonstrates a general downward hydraulic gradient and a potential for water to seep at a greater rate from the BCA into the underlying Permian.
- The elevated groundwater levels in the BCA piezometers also demonstrate the absence of a high permeability hydraulic connection allowing the levels to equilibrate.
- Increased depressurisation is observed at CMOB piezometers WML324 and WML325 coinciding with LW6B extraction (Figures 14 and 15). Corresponding water level declines are also observed in the overlying BCA piezometers (WMLP323 and WMLP311) however at a

relatively reduced rate. This results in an increase in the hydraulic gradient between the units.

- Nested site 3, south of the LW6B extraction area, shows no impacts attributable to longwall mining (Figure 16). A gradual water level decline is observed in BCA piezometer T2A and CMOB piezometer T2P. This response is attributed to low rainfall recharge over the extraction period with a complete recovery observed following the November rainfall event.
- The BCA and the CMOB are shown to remain saturated at all three paired sites.

The relatively slower water level decline in the BCA piezometers is attributed to both a higher storage within the BCA and lack of direct hydraulic connection (fracturing) between the CMOB and BCA, thus limiting the rate of vertical leakage.

The increased water level decline observed in the BCA is consistent with the 2009 GIA Groundwater Model with the increased hydraulic gradient driving the predicted draining of the overlying BCA.

6.6 Pikes Gully Seam – Figure 17

Figure 17 shows the gradual drawdown of piezometric pressures in the PG seam observed from the end of July 2006 following the progression of the longwall 1 development headings below the water level in July 2006. The complete depressurisation of the PG seam following PG extraction is consistent with groundwater model predictions as outlined in the 2009 GIA (Aquaterra, 2009), and previous versions.

PG piezometers WML115A, WML213 and WML21 show clear impacts from underground mining prior to the commencement of LW6B extraction. As the PG seam was completely depressurised prior to LW6B mining, no further impacts are observed within the mine footprint. WML213, situated to the south west of the underground, maintains a gradual declining trend.

6.7 Hydrostatic Head Profile – Figure 18

Figure 18 presents the hydrostatic head profile for VWP WMLP361, located to the west of LW6B (Figure 2). This profile is plotted against a 45 degree “hydrostatic line” to demonstrate the vertical difference in pore water pressure across the various formations. Generally, under pre-mining conditions in the Ashton area, pressures plot close to the “hydrostatic line”, although there was a slight shift from the line due to the upward head gradient.

The PG seam in the area is demonstrated to be depressurised. The depressurisation is observed to have propagated above the PG seam to the Lemington 15A and 15B seams. The shallower Lemington 8 seam is shown to be pressurised indicating subsidence impacts have not impacted above the Lemington 8 seam in this location.

6.8 Groundwater Recharge

A rainfall event on 18 November 2013 (following LW6B extraction) deposited in excess of 150 mm of rain. The rainfall caused minor flooding and high stream flow rates through the ACP area and resulted in a significant aquifer recharge event.

The recharge was observed to completely reset groundwater levels in the BCA, and partial recovery was observed in the CMOB with up to 3.5 m recovery at WMLP325 (Figure 13).

Water levels have since resumed a similar rate of decline to that observed prior to the recharge event.

7. GROUNDWATER QUALITY

A summary of water quality parameters of EC and pH as monitored in key LW6B piezometers over the duration of the extraction period is presented on Table 7.1 and 7.2.

Plots of the EC data, grouped by aquifer, are presented on Figures 19 to 22 to provide an understanding of the long term trends.

7.1 Electrical Conductivity

Electrical conductivity (EC) is used as the 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 level and therefore 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 BCA and low to moderate salinity within the CMOB.

Bowmans Creek Alluvium – Figure 19

The piezometers that monitor the BCA show that the groundwater EC levels have generally remained steady across the LW6B extraction period. The following observations are noted in regard to the groundwater EC within the BCA over the review period:

- No adverse impacts attributable to LW6B extraction were observed, with minor fluctuations within baseline ranges and correlating with rainfall recharge.
- A slight increasing trend is observed at T7 and WML115C, during the initial extraction of LW6B, however these trends are short lived and followed by a subsequent decline.
- A long-term decreasing trend in the EC level at piezometer T7 was observed. This trend has been attributed to the cessation of upward leakage of saline groundwater from the underlying Permian coal measures following the extraction of LW8.
- A slight freshening trend (decreased EC) in a number of piezometers is observed to coincide with the large rainfall event in November following the completion of LW6B extraction.
- WMLP308 is used to monitor water levels, however the bore has been damaged and is not able to be bailed or pumped for a representative sample. Therefore water quality data is not able to be presented for this piezometer. This piezometer will be replaced in an upcoming drilling programme.
- Piezometers T6 and T7 had insufficient saturated thickness for purging and sampling at the end of the extraction period due to the water level decline and were not able to be sampled.

The EC range observed in BCA piezometers over the LW6B extraction period is generally consistent with the baseline range (722 to 9920 µS/cm) as detailed in the 2012 WMP (Section 8.3.2, Table 8.2). The upper limit of the range has substantially reduced with salinities now typically observed in the range of 800 to 2500 µS/cm.

Permian Shallow Coal Measures Overburden – Figure 20

Key piezometers that monitor the CMOB continue to follow the established water quality trends with EC levels ranging from 1033 µS/cm to 4,070 µS/cm over the LW6B extraction period. The following observations are noted in regard to the salinity levels within the CMOB:

- A declining EC trend is observed in piezometer RSGM1 over the extraction period. This decline is attributed to LW6B extraction increasing the rate of vertical leakage from the overlying BCA.
- Piezometer WML115B was blocked and unable to be sampled over the review period. Additional piezometers in the vicinity of WML115B will be installed during 2014 (pending licence approval) and water quality monitoring will be undertaken at an alternate monitoring location.

The EC range observed in CMOB piezometers over the LW6B extraction period is generally consistent with the baseline range (320 to 18,200 μS/cm) as detailed in the 2012 WMP (Section 8.3.2, Table 8.2).

Glennies Creek Alluvium – Figure 21

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.

The EC range observed in the GCA during the LW6B extraction period is generally consistent with the baseline range for the GCA (300-16,300 μS/cm) as detailed in the 2012 WMP (Section 8.3.2, Table 8.2).

Hunter River Alluvium – Figure 22

The EC range observed in the HRA over the LW6B extraction period is generally within or below the baseline range (1,375 to 2,540 μS/cm) as detailed in the 2012 WMP (Section 8.3.2, Table 8.2).

7.2 pH Level

pH measurements at the key BCA piezometers ranged from 6.64 to 7.94 pH units and in the CMOB ranged from 7.16 to 7.66 pH units over the LW6B extraction period (Table 7.2). These values are within the baseline ranges as detailed in the 2012 WMP (Section 8.3.2, Table 8.2) for the BCA and CMOB of 6.44 to 10.04 and 6.35 to 11.97 respectively, and no detrimental trends are evident.

Table 7.1: LW6B Water Quality Monitoring at Key Piezometers – Electrical Conductivity (µS/cm)

Piezometer ID	Prior to LW6B	During LW6B					Following LW6B			
	12-Apr-13	5-Aug-13	3-Sep-13	18-Sep-13	2-Oct-13	16-Oct-13	30-Oct-13	13-Nov-13	11-Dec-13	24-Dec-13
Bowmans Creek Alluvium										
WMLP311	1150	1197	1231	1271	1240	1231	1223	1103	1072	1072
WMLP323	875	1006	1050	1148	1197	1215	1114	993	839	858
WMLP328	879	1022	1136	1177	1173	1137	1079	971	989	928
WML115C	-	1665	1815	1945	1804	1812	1935	1703	1434	1034
T5	1070	1074	1063	1088	1051	-	-	-	-	1049
T6	1040	1056	1066	1107	-	-	-	-	-	-
T7	2360	1948	2331	2491	2378	-	-	-	-	-
RA30	1160	1347	1304	918	1281	-	-	-	1299	1316
Shallow Permian Coal Measures and Overburden										
WMLP324	835	1033	1123	1163	1104	1086	1114	993	1175	1123
WMLP325	1460	1546	1347	1296	1306	1304	1295	1311	1275	1303
RSGM1	4530	4070	3650	3740	3320	3200	3380	3110	2428	3760

Note:

- Indicates piezometer was unable to be sampled due to low water table.

Table 7.2: LW6B Water Quality Monitoring at Key Piezometers – pH

Piezometer ID	Prior to LW6B	During LW6B					Following LW6B			
	12-Apr-13	5-Aug-13	3-Sep-13	18-Sep-13	2-Oct-13	16-Oct-13	30-Oct-13	13-Nov-13	11-Dec-13	24-Dec-13
Bowmans Creek Alluvium										
WMLP311	7.39	7.48	7.21	7.63	6.89	6.97	7.45	8.01	6.81	
WMLP323	7.64	7.37	7.34	7.63	7.07	6.88	7.33	8	6.91	7.18
WMLP328	7.64	6.78	6.64	7.72	6.95	7.16	7.52	8.27	7.09	7.53
WML115C	-	7.33	7.26	7.94	7.16	7.06	7.5	7.82	6.95	7.57
T5	7.49	7.13	7.28	7.43	6.9	-	-	-	-	7.2
T6	7.44	7.17	7.27	7.57	-	-	-	-	-	-
T7	7.76	7.68	7.65	7.36	7.34	-	-	-	-	-
RA30	7.19	7.35	7.32	7.37	6.84	-	-	-	6.7	7.33
Shallow Permian Coal Measures and Overburden										
WMLP324	7.86	7.46	7.48	7.59	7.5	7.63	7.24	8.42	7.26	7.13
WMLP325	7.95	7.66	7.16	7.5	7.25	7.48	7.71	7.14	7.47	7.16
RSGM1	7.55	7.59	7.48	7.45	7.35	7.33	7.51	8.29	7.07	7.43

Note:

- Indicates piezometer was unable to be sampled due to low water table.

8. MINE DEWATERING

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 (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 23 along with predicted inflow volumes.

It is important to note that prior to mining at LW6B and LW7B the dewatering of the underground was being undertaken significantly beneath predictions at approximately 5 L/sec.

Over the LW6B extraction period groundwater inflows are inferred to have begun increasing on 10 October 2013. The increase was identified via an increased pumping rate at the automated dewatering borehole No. 2 (BH2). Extraction from BH2 has subsequently plateaued at a pumping rate of approximately 30 L/s. A decline in this rate has been observed correlating with a prolonged period of below average rainfall. The rate has reduced to as low as 26 L/s.

The timing of the increased inflows represents a significant lag from when water level decline in the BCA was first observed during early August. Therefore, there is potential that inflows may have drained to the underground goaf prior to the increased pumping rate observed at BH2. The area of potential storage is no longer an accessible part of the mine and therefore cannot be inspected.

The source of the increased inflows is subject to a detailed investigation. A preliminary investigation report was submitted to NoW, DRE and DP&I in January 2014.

From Figure 23, it is apparent that for the majority of mining, the actual mine dewatering was below the predictions of the groundwater model and approved impact assessments.

During the months of June, July and August 2013 coinciding with the early extraction of LW6B, minimal water was pumped out of the mine. It is assumed that any inflows that may have occurred over this period were stored within the mine goaf down gradient of the LW6B extraction.

9. COMPARISON WITH PREDICTIONS AND TRIGGER VALUES

The predicted and approved impacts from the ACP were most recently revised in the 2009 GIA (Aquaterra 2009) with groundwater model predictions refined for 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.

The following groundwater impacts were identified over the LW6B extraction period:

- A decline in groundwater levels observed in the BCA over the review period.
- A portion of the BCA water level decline is attributed to natural water level regression but the majority is expected to result from increased vertical leakage to the underlying CMOB. The CMOB is inferred to have been depressurised due to subsidence related fracturing associated with longwall extraction.
- Mine dewatering rates were observed to rise toward the end of the LW6B extraction period and level off at a rate of approximately 30 L/sec. A decline in this rate has been observed correlating to a prolonged period of below average rainfall.

These impacts are compared against the predicted and approved impacts in the following sections.

9.1 2009 Bowmans Creek Diversion Groundwater Impact Assessment

9.1.1 Groundwater Level Drawdown

The modelling completed for the 2009 GIA predicted complete dewatering of the BCA overlying the longwall panels following the completion of extraction in the ULD seam, with substantial dewatering also predicted at the end of mining in the PG seam (Aquaterra 2009 and Appendix A). The water level decline in the BCA during LW6B extraction is less than that predicted by the 2009 GIA modelling and therefore the observed impacts on groundwater level are lower than the approved and predicted impacts.

9.1.2 Groundwater Mine Inflows

The 2009 GIA predicted mine inflows to peak at approximately 1386 m^3/d or 16 L/s by the end of PG extraction (Figure 23), with this value being the weighted mean value over a year of longwall extraction and inflows. Mine dewatering has exceeded predicted inflow rates following the completion of mining at LW6B.

Prior to LW6B, mine dewatering and inflow rates have been well below predictions. As inflow rates have now been observed above this predicted peak for the last four months, a detailed investigation is underway into the source of the inflows and an update and recalibration of the existing groundwater model has been commissioned.

9.2 WMP Trigger Values

The predicted value for mine inflows is 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 15.7 L/sec. Therefore, the calculated trigger value is 24 L/sec.

At the end of LW6B extraction the WMP inflow trigger level had not been reached. However, at the time of writing, following the completion of LW6B, the trigger level has been reached, with an exceedance observed for a period of three months. In accordance with the WMP the exceedance has been reported and a detailed investigation into the cause of the exceedance has been commissioned.

10. CONCLUSION

The extraction of LW6B was completed between 14 July 2013 and 27 October 2013.

Groundwater level and quality monitoring has been conducted in accordance with the WMP. Hydraulic testing has also been undertaken to assess the impact of LW6B extraction on the shallow aquifers in the vicinity of the longwall.

During the course of LW6B extraction, water level decline in the BCA was observed in excess of natural water level fluctuations and has been attributed to longwall extraction.

Towards the end of mining at LW6B an increased dewatering rate was observed from dewatering borehole BH2. The increased dewatering rate was correlated with the BCA water level decline and attributed to increased groundwater inflow from both the Permian lithologies and the BCA. In response to the increased inflows, ACOL initiated an investigation into the source of the inflows.

The following key observations are concluded over the LW6B extraction period:

- No change in shallow aquifer permeability has been observed through hydraulic testing. However a greater degree of hydraulic connection through the CMOB can be inferred following the observed water level decline in the vicinity of LW6B.
- No detrimental water quality impacts have been observed.

11. REFERENCES

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FIGURES

LEGEND

- Groundwater Monitoring Site
- Pikes Gully Seam Extraction
- LW6B Extraction
- Pikes Gully Underground Mine Workings
- Alluvium boundary
- Saturated alluvium boundary
- Bowmans Creek Diversion

N

0 150 300 450 600

Metres

APPROX SCALE 1:17,000 @ A3

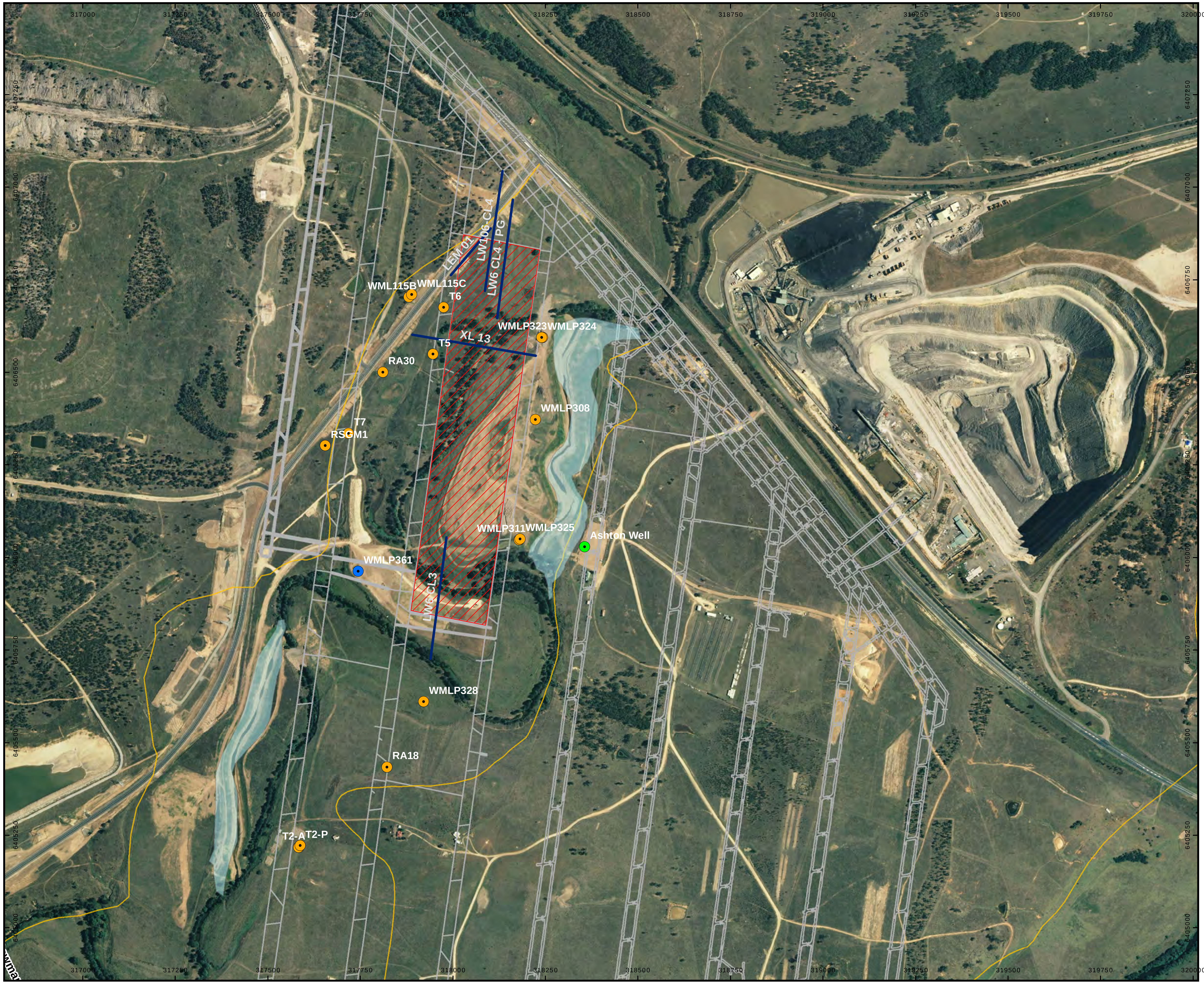
GDA 1994 MGA Zone 56

RPS

FIGURE 1

Ashton Coal
Groundwater Monitoring Network

S55D_027a_DD01_Ashton_Coal_Project.mxd Produced: JC Reviewed: SC Date: 07/02/2014



LEGEND

- Standpipe Piezometer
- Vibrating Wire Piezometer
- Well
- Subsidence Monitoring Line
- LW6B Extraction
- Pikes Gully Underground Mine Workings
- Alluvium boundary
- Bowmans Creek Diversion

N

0 100 200 300 400
Metres

APPROX SCALE 1:10,000 @ A3

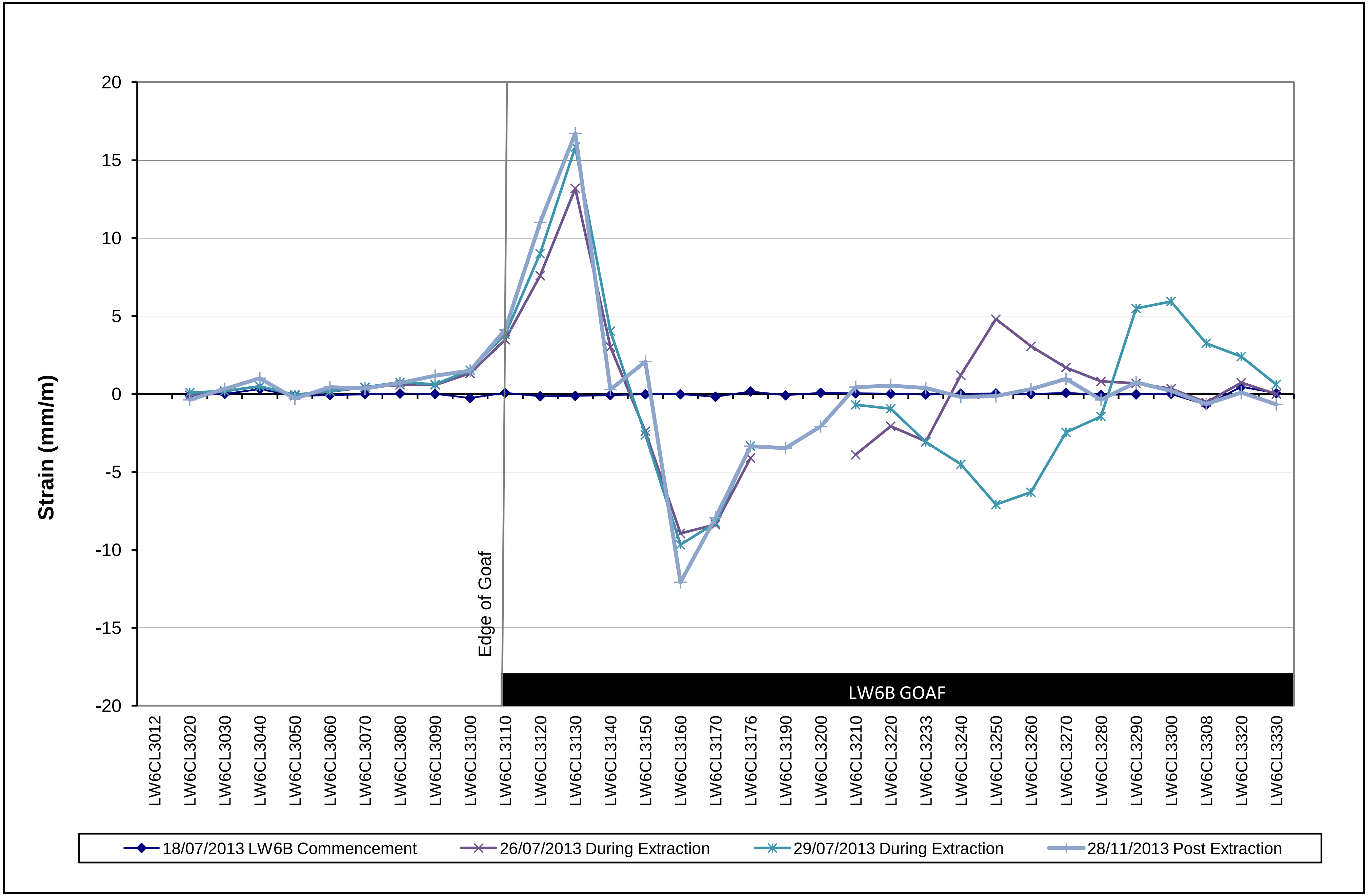
GDA 1994 MGA Zone 56

RPS

FIGURE 2

Ashton Coal
LW6B Groundwater Monitoring

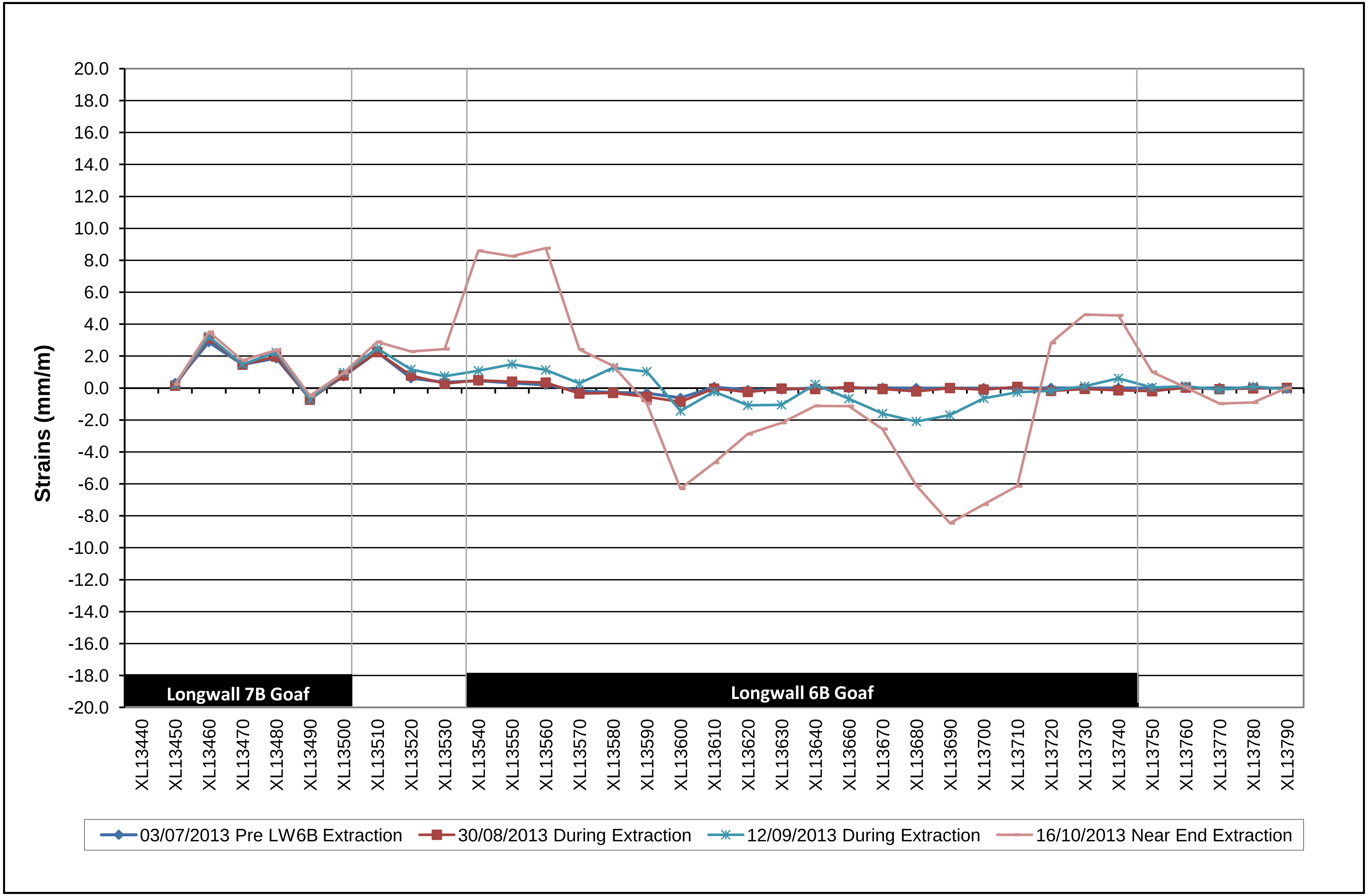
027a_DD02_Ashton_Coal_LW6B_Groundwater_Monitoring_Network.mxd Produced: JC Reviewed: SC Date: 07/02/2014



RPS

LATERAL DISPLACEMENT - SUBSIDENCE LINE LW6 CL3 FIGURE 3

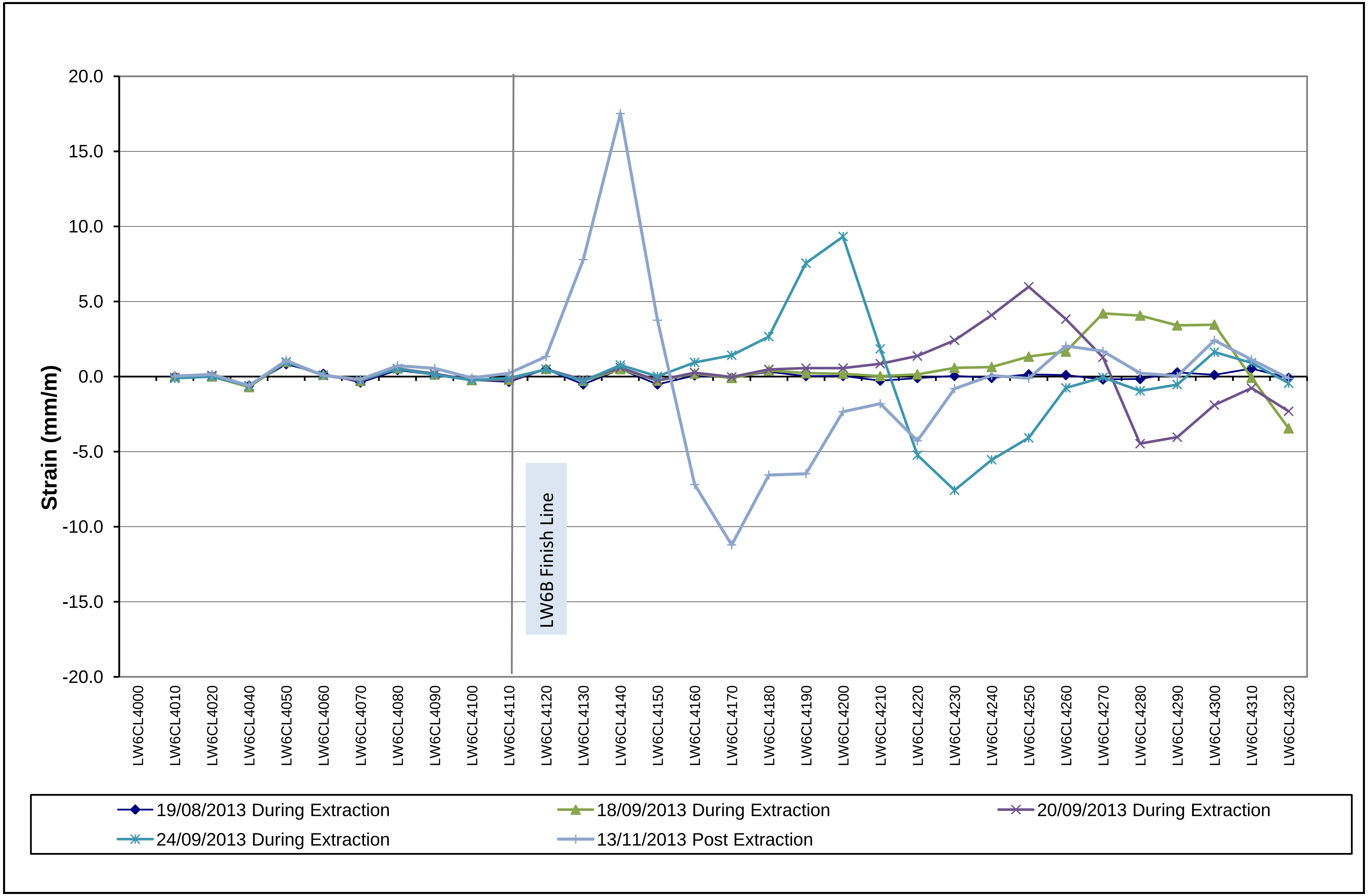
F:\Jobs\S55D\300\Subsidence\EOP LW6B\[029a.xls]FIGURE 3



RPS

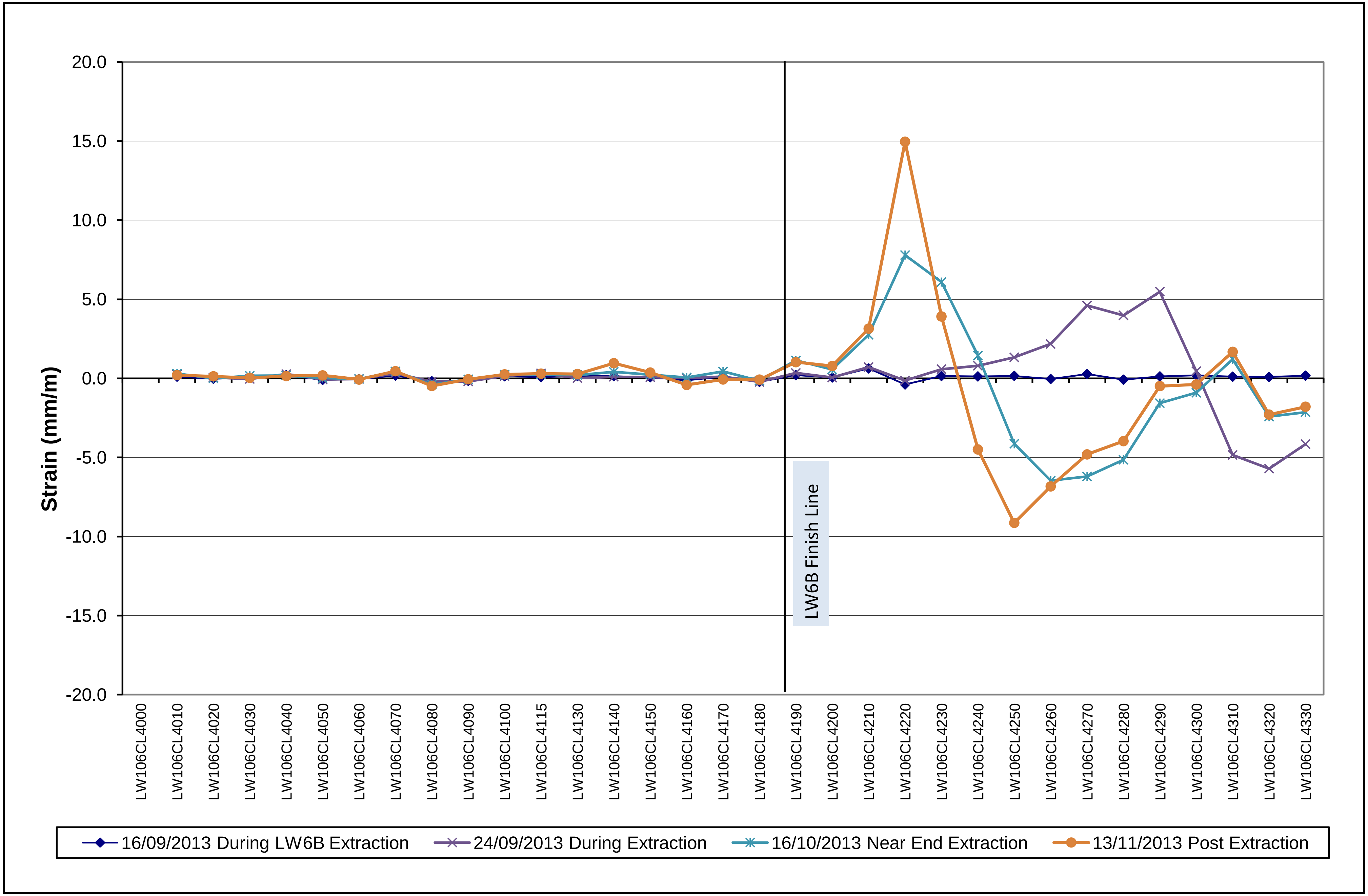
LATERAL DISPLACEMENT - SUBSIDENCE LINE XL13 FIGURE 4

F:\Jobs\S55D\300\Subsidence\EOP LW6B\[029a.xls]FIGURE 4



LATERAL DISPLACEMENT - SUBSIDENCE LINE LW6 CL4 FIGURE 5

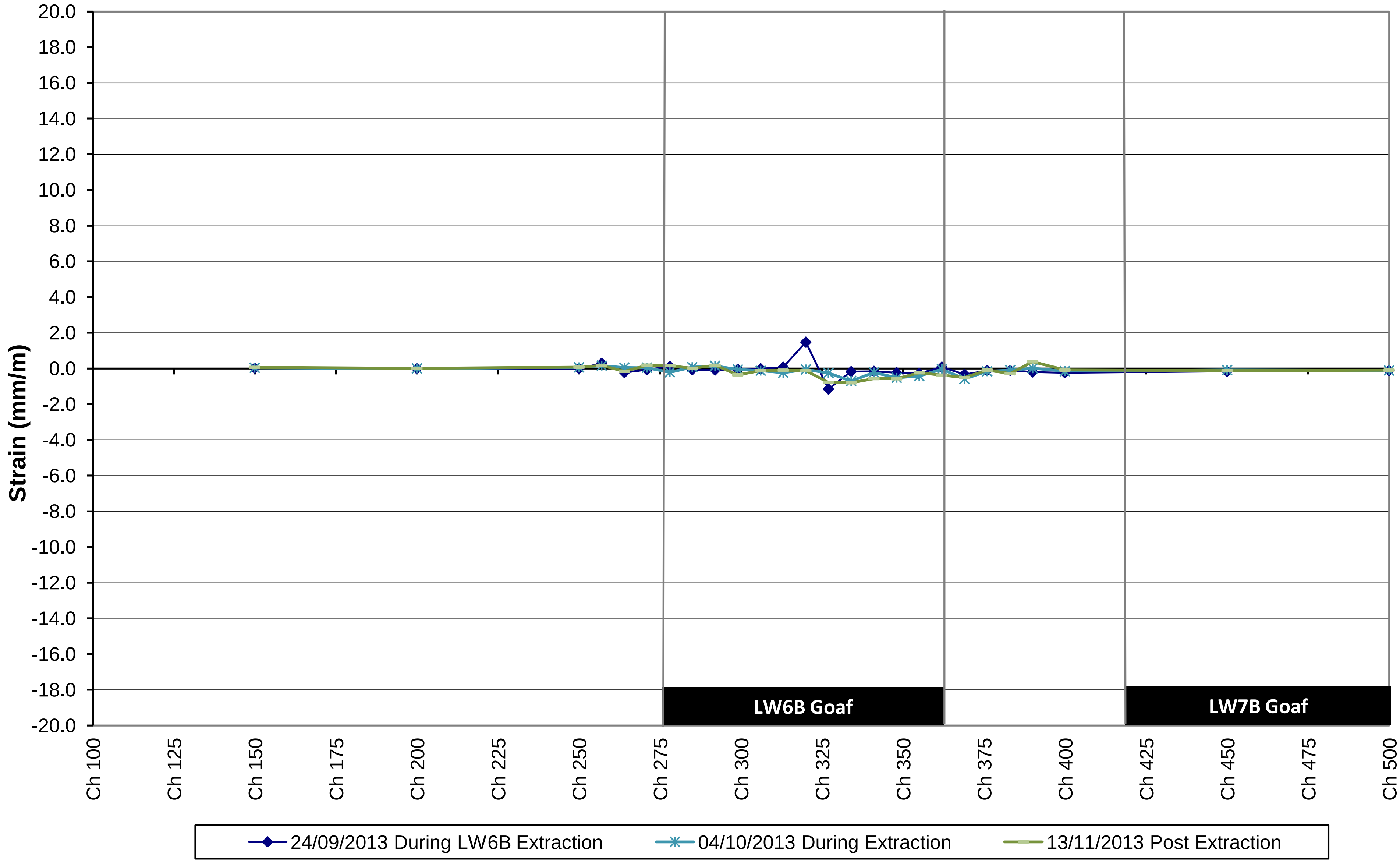
F:\Jobs\S55D\300\Subsidence\EOP LW6B\[029a.xls]FIGURE 5



RPS

LATERAL DISPLACEMENT - SUBSIDENCE LINE LW106 CL4 FIGURE 6

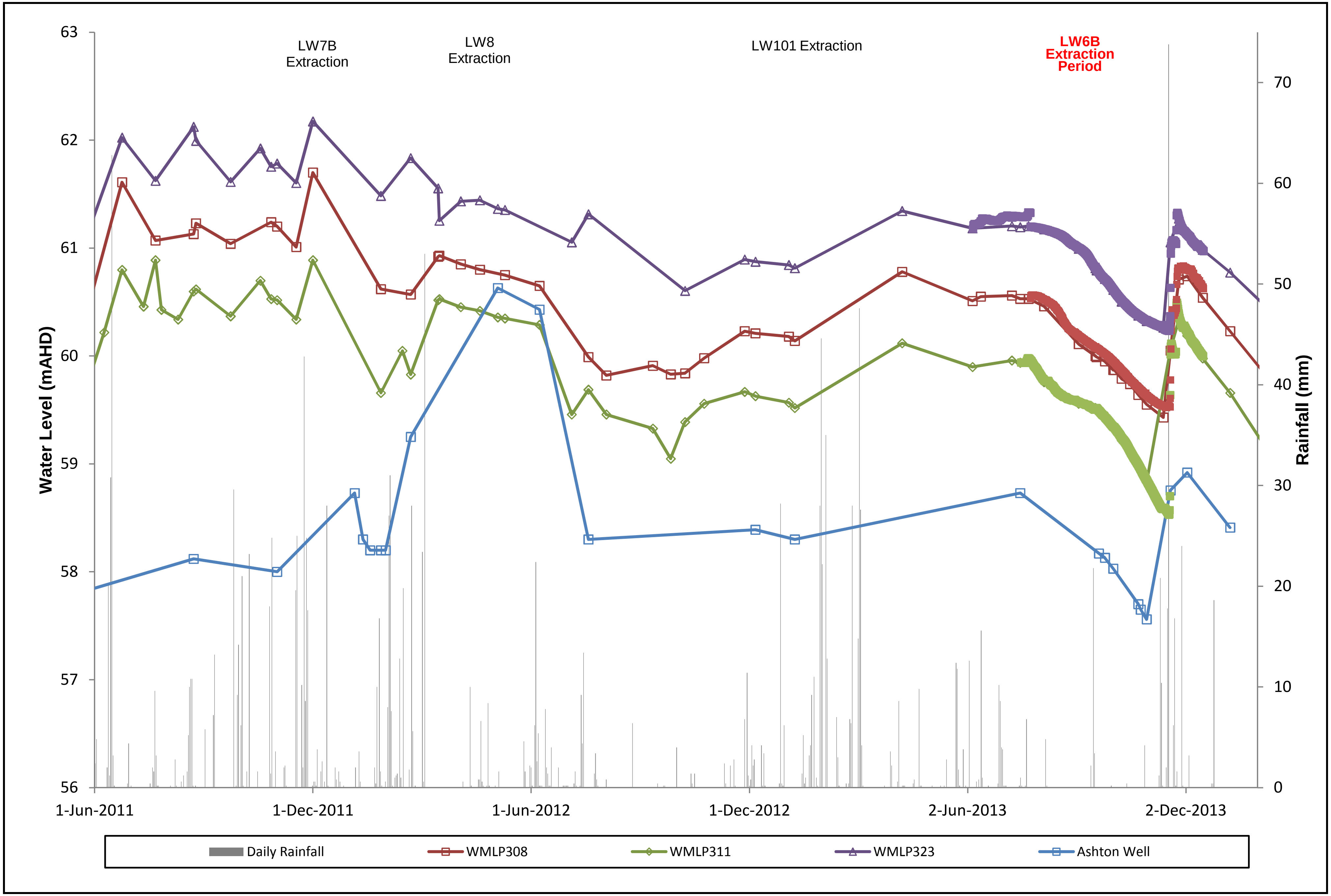
F:\Jobs\S55D\300\Subsidence\EOP LW6B\[029a.xls]FIGURE 6



RPS

LATERAL DISPLACEMENT - SUBSIDENCE LINE LW6B LEM01 FIGURE 7

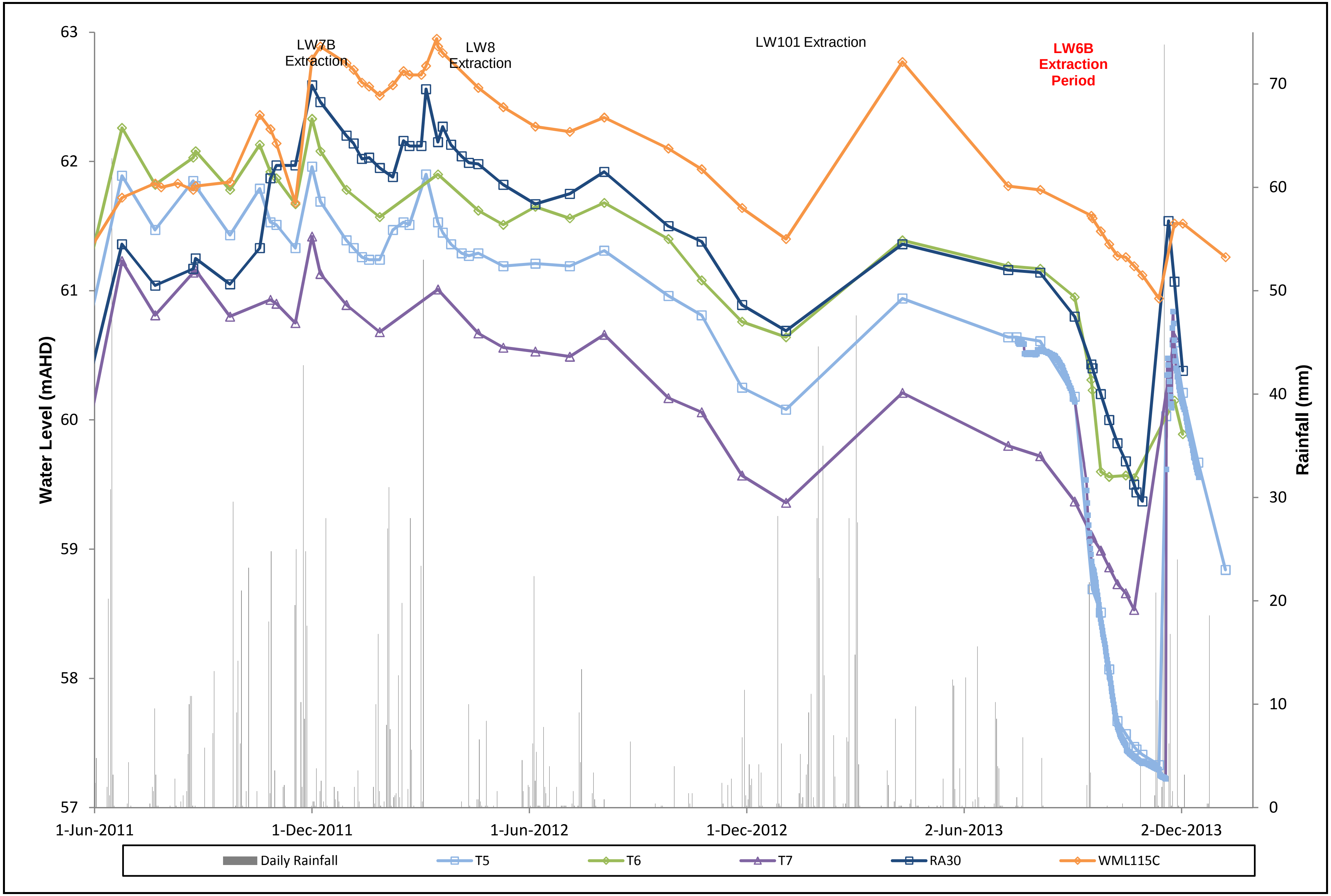
F:\Jobs\S55D\300\Subsidence\EOP LW6B\[029a.xls]FIGURE 7



RPS

BOWMANS CREEK ALLUVIUM (EAST LW6B) FIGURE 8

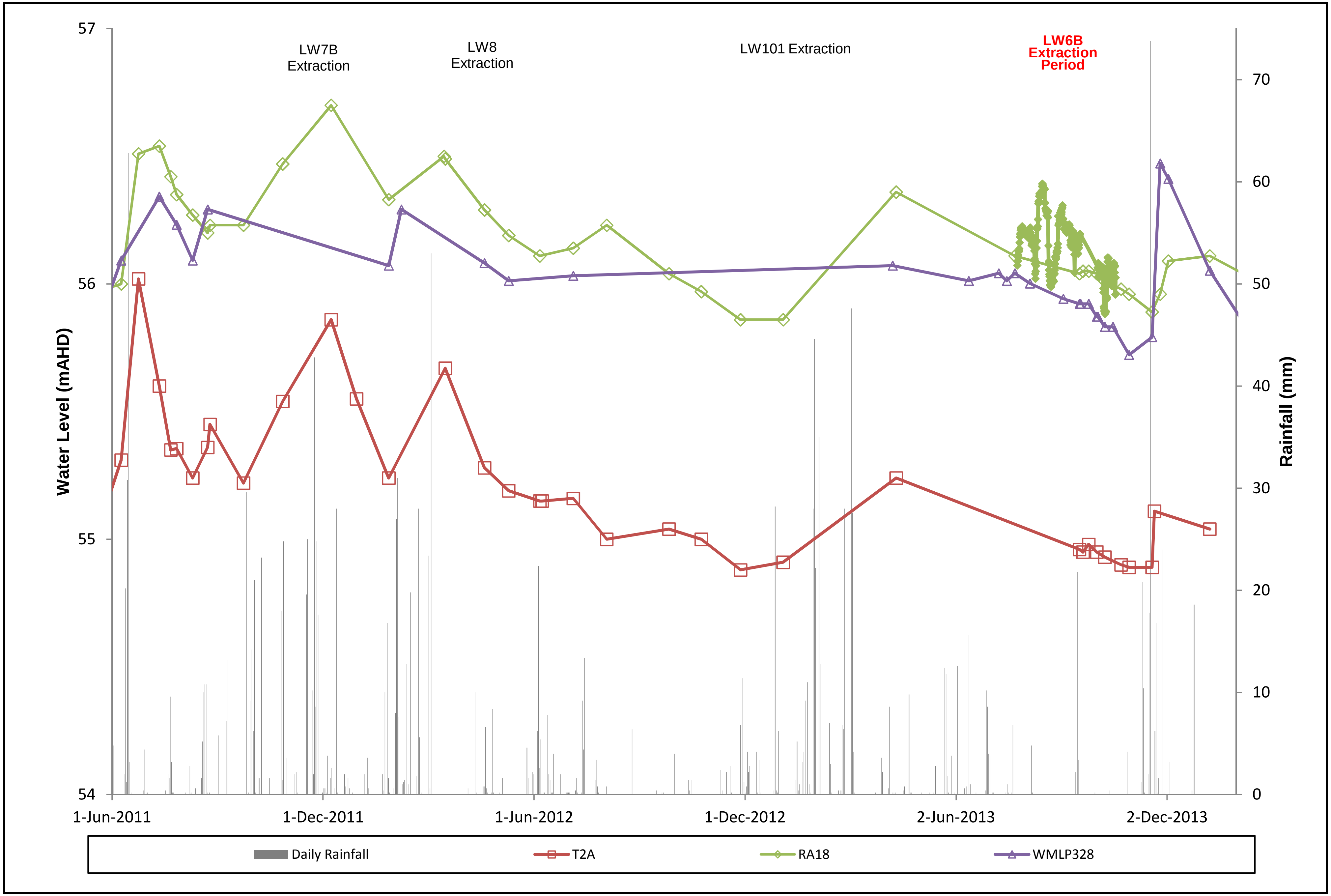
F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 8



RPS

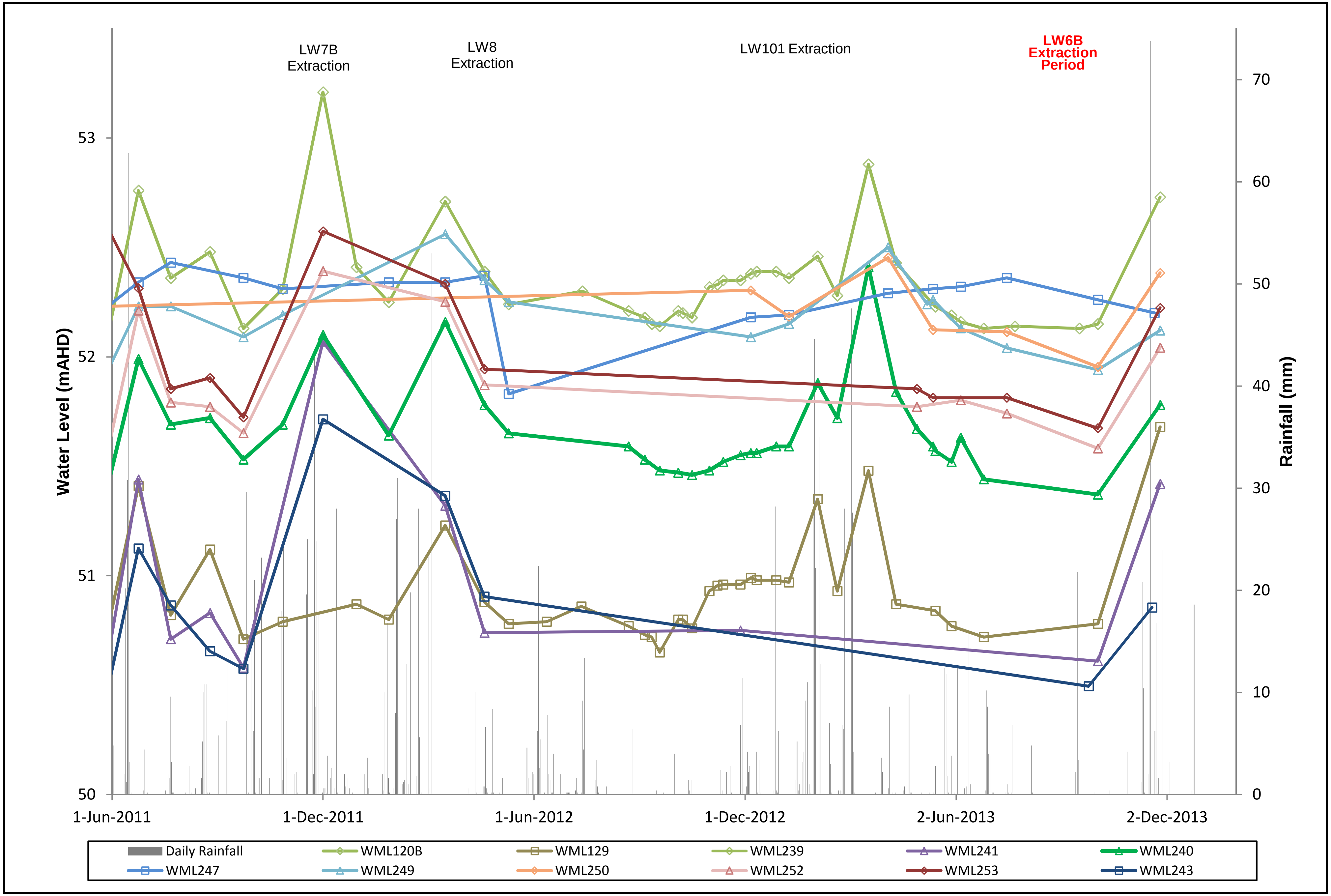
BOWMANS CREEK ALLUVIUM (WEST OF LW6B) FIGURE 9

F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 9



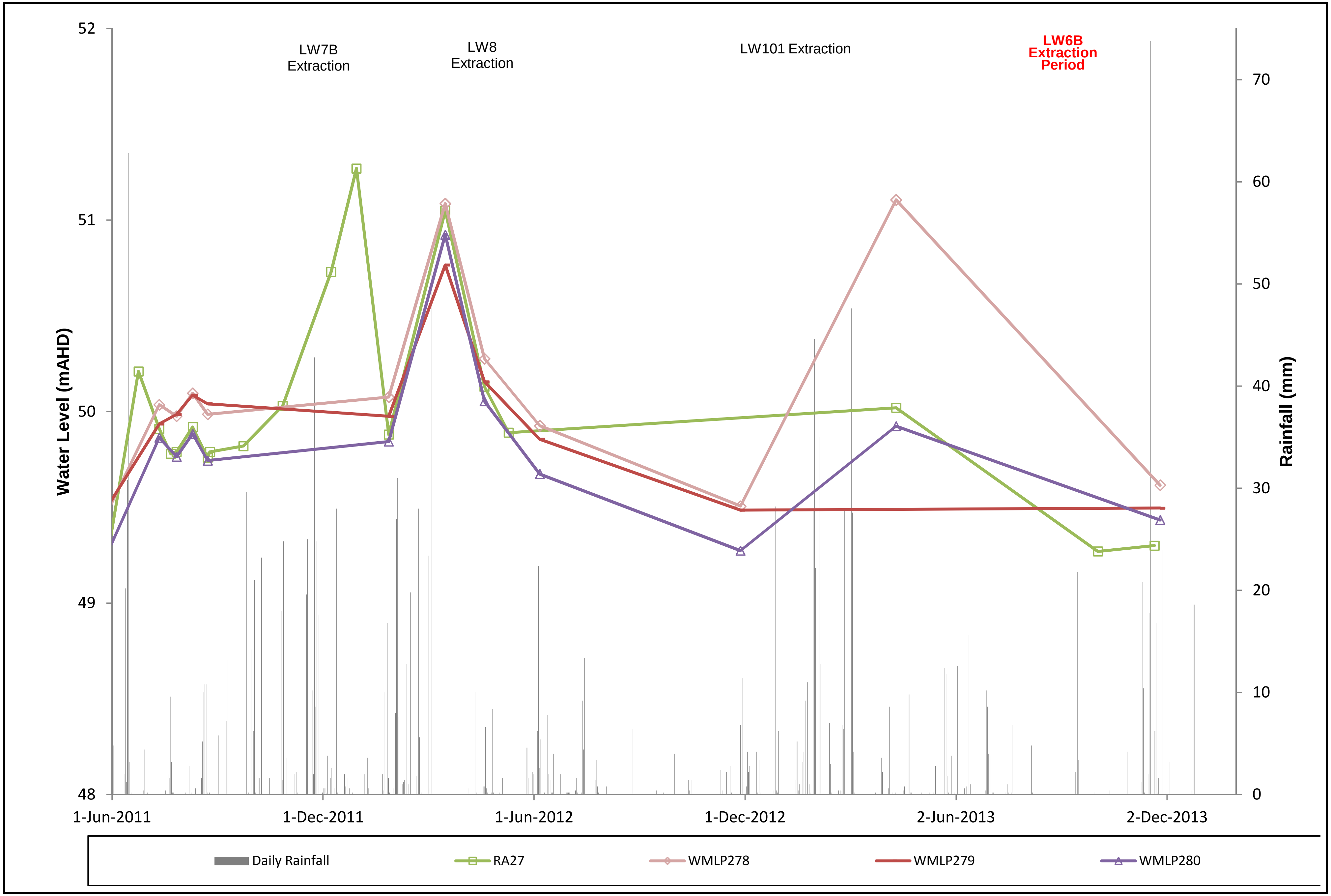
BOWMANS CREEK ALLUVIUM (SOUTH OF LW6B) FIGURE 10

F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 10



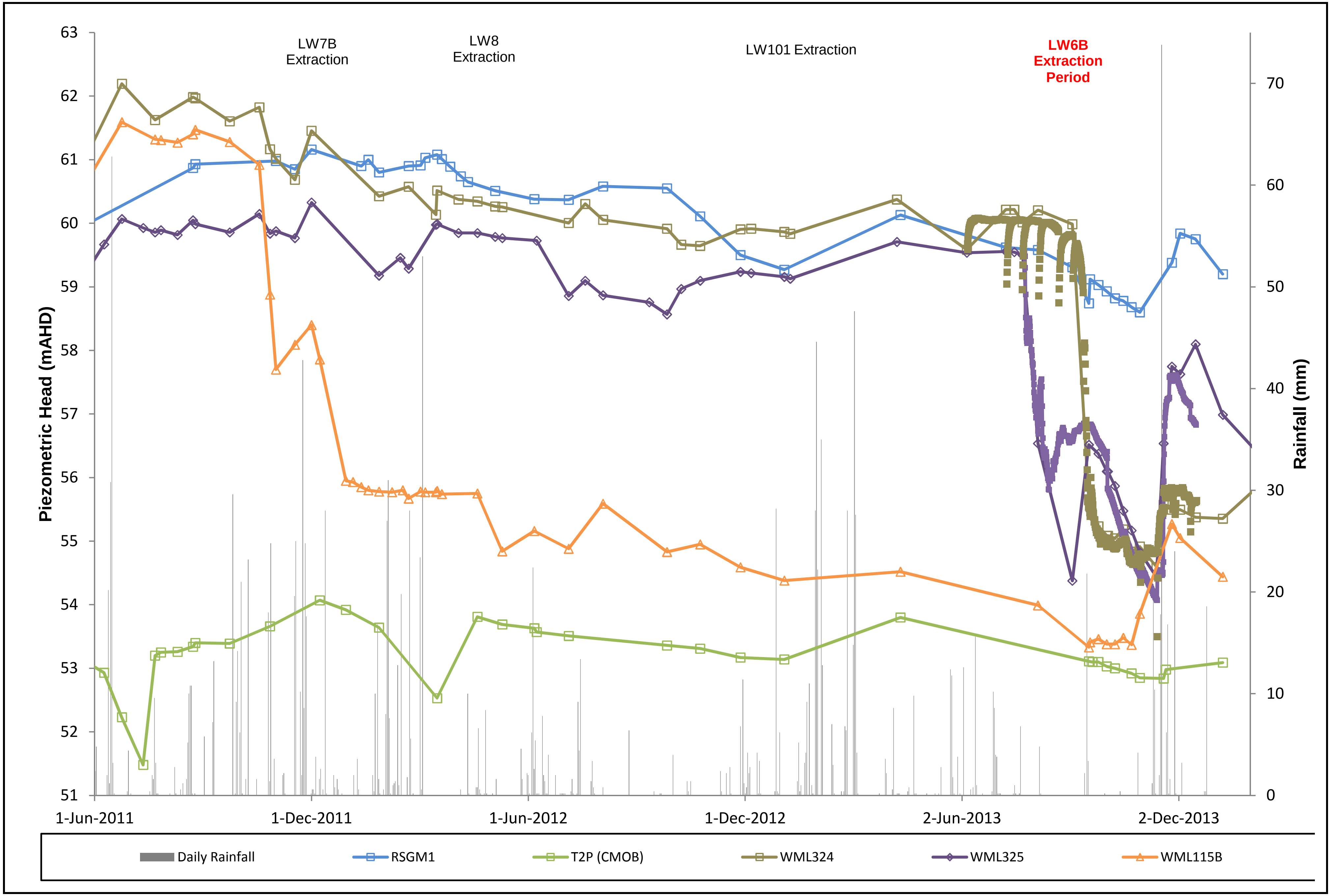
GLENNIES CREEK ALLUVIUM (SOUTH EAST OF LW6B) FIGURE 11

F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 11



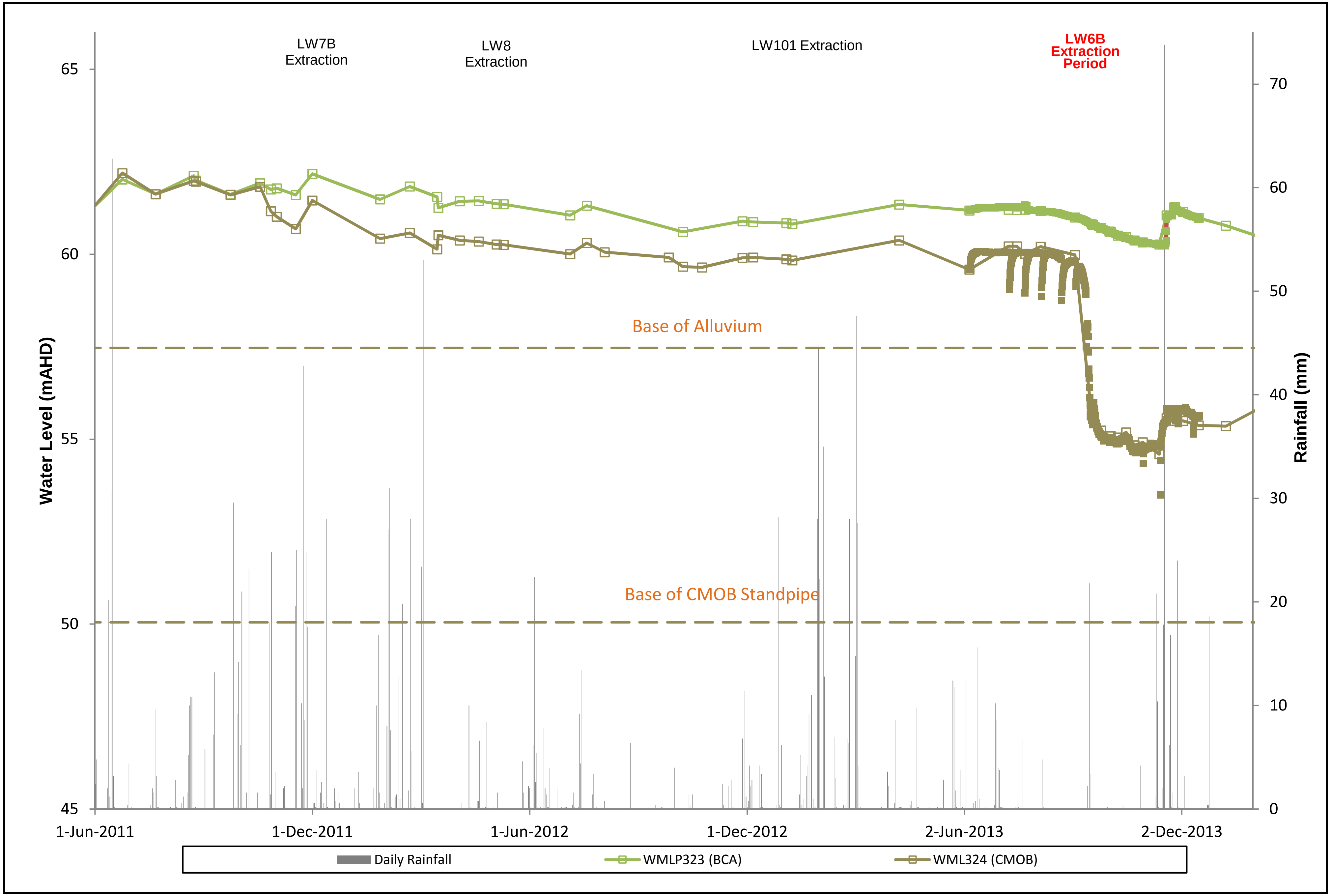
HUNTER RIVER ALLUVIUM (SOUTH OF LW6B) FIGURE 12

F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 12



PERMIAN SHALLOW COAL MEASURES OVERBURDEN FIGURE 13

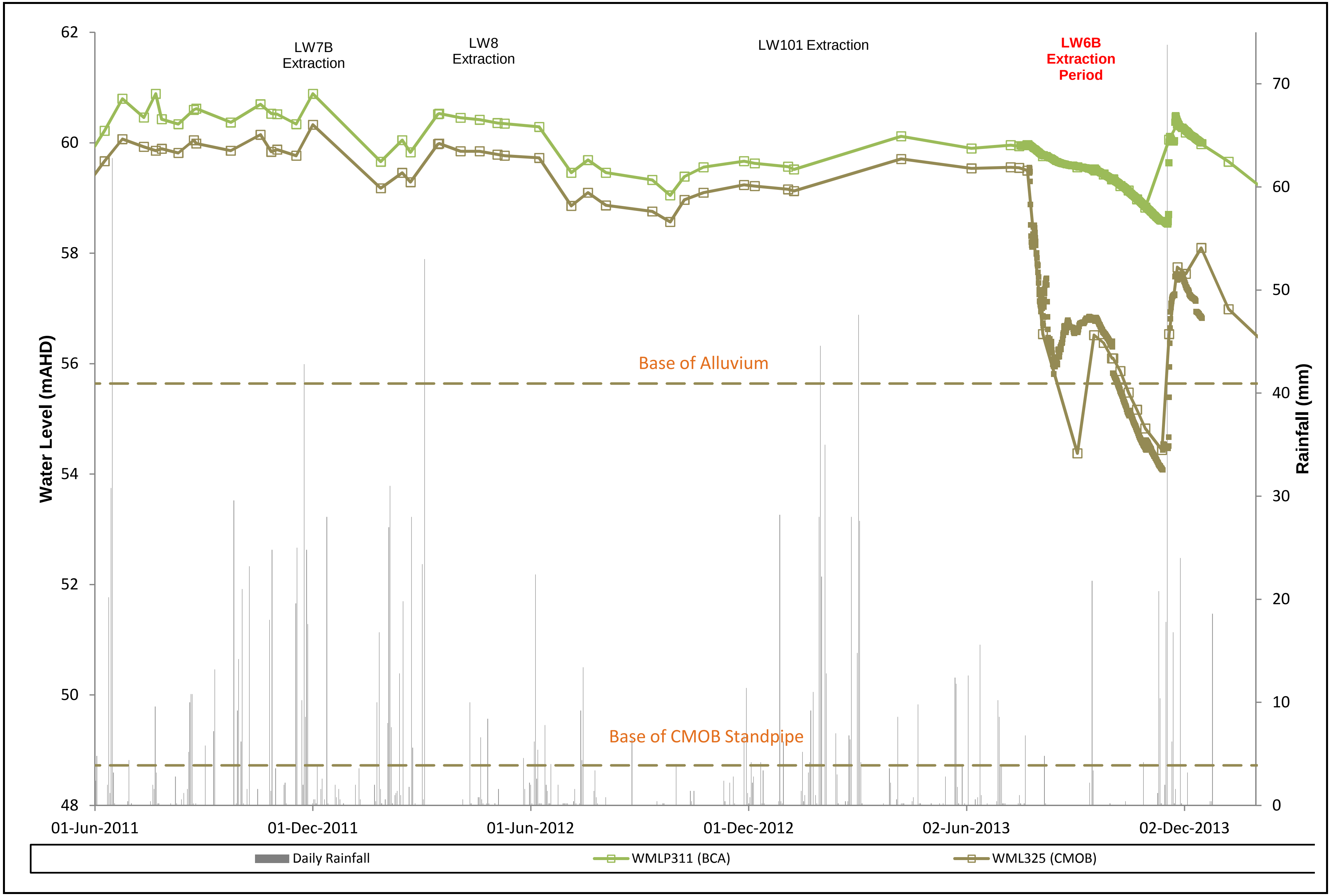
F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 13



RPS

PAIRED SITE 1 (NORTH EAST OF LW6B) FIGURE 14

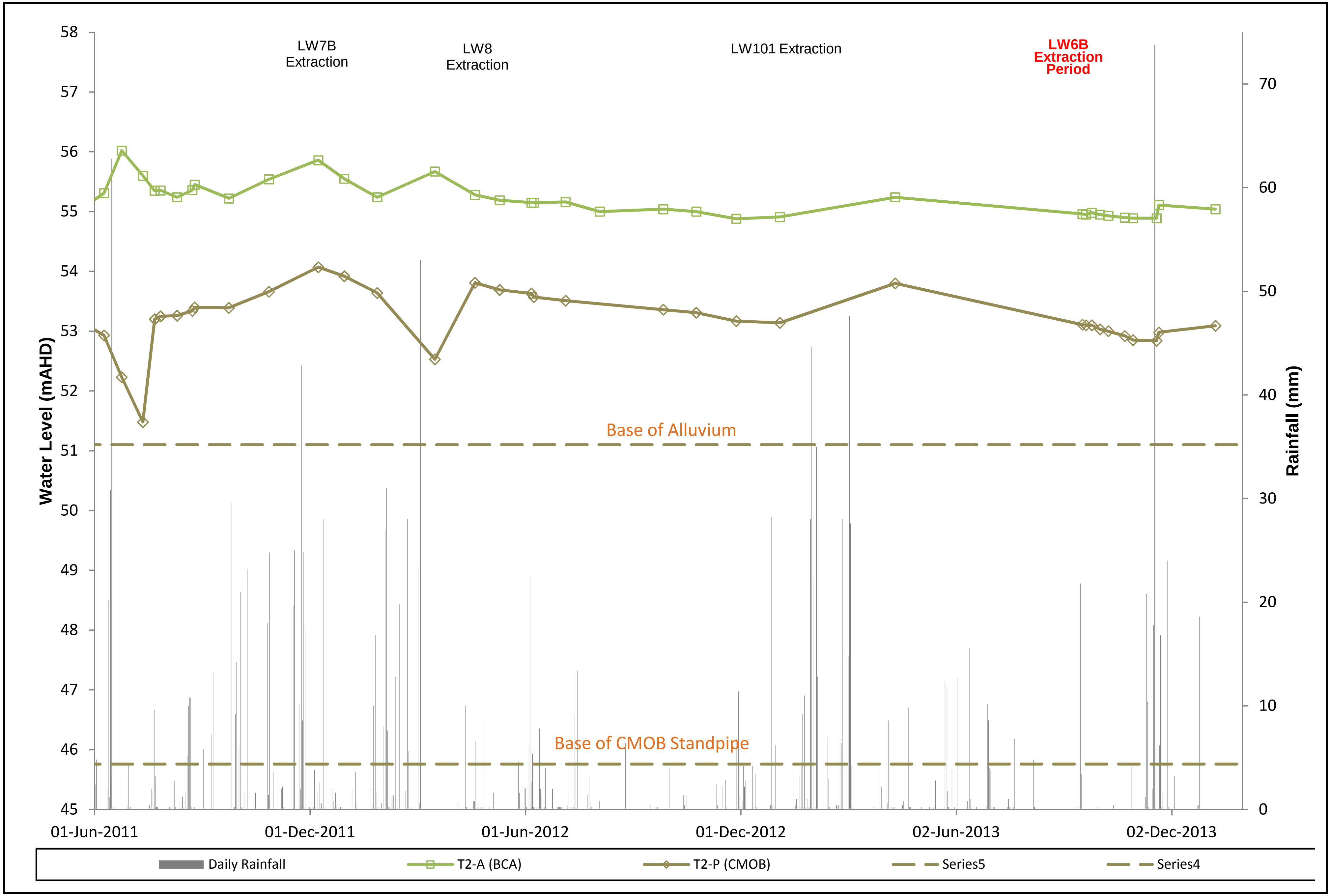
F:\Jobs\S55D\300\Water Levels\[027a_Hydrographs.xls]Figure 14



RPS

PAIRED SITE 2 (SOUTH EAST OF LW6B) FIGURE 15

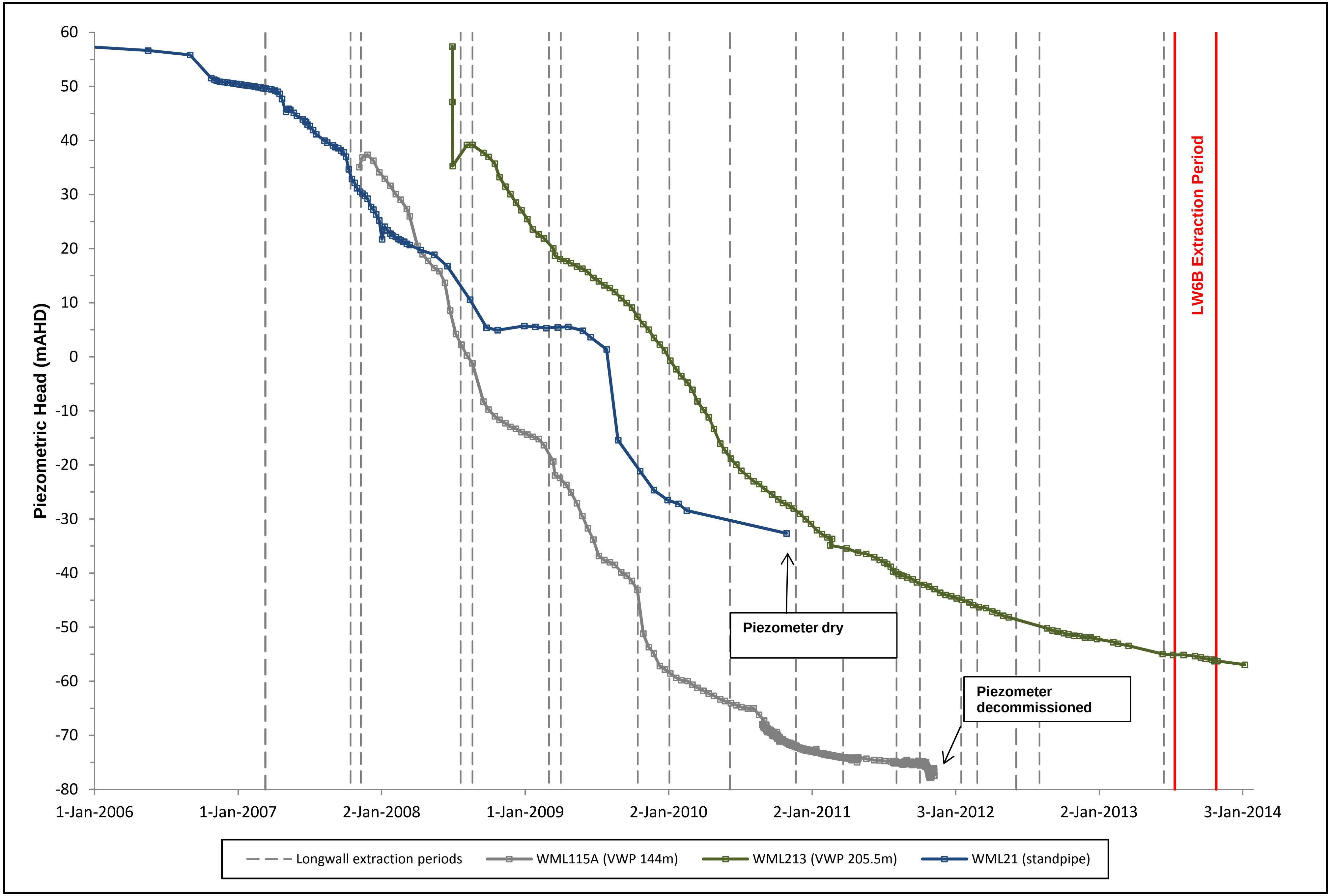
F:\Jobs\S55D\300\Water Levels\[027a_Hydrographs.xls]Figure 15



RPS

PAIRED SITE 3 (SOUTH OF LW6B) FIGURE 16

F:\Jobs\S55D\300\Water Levels\[027a_Hydrographs.xls]Figure 16



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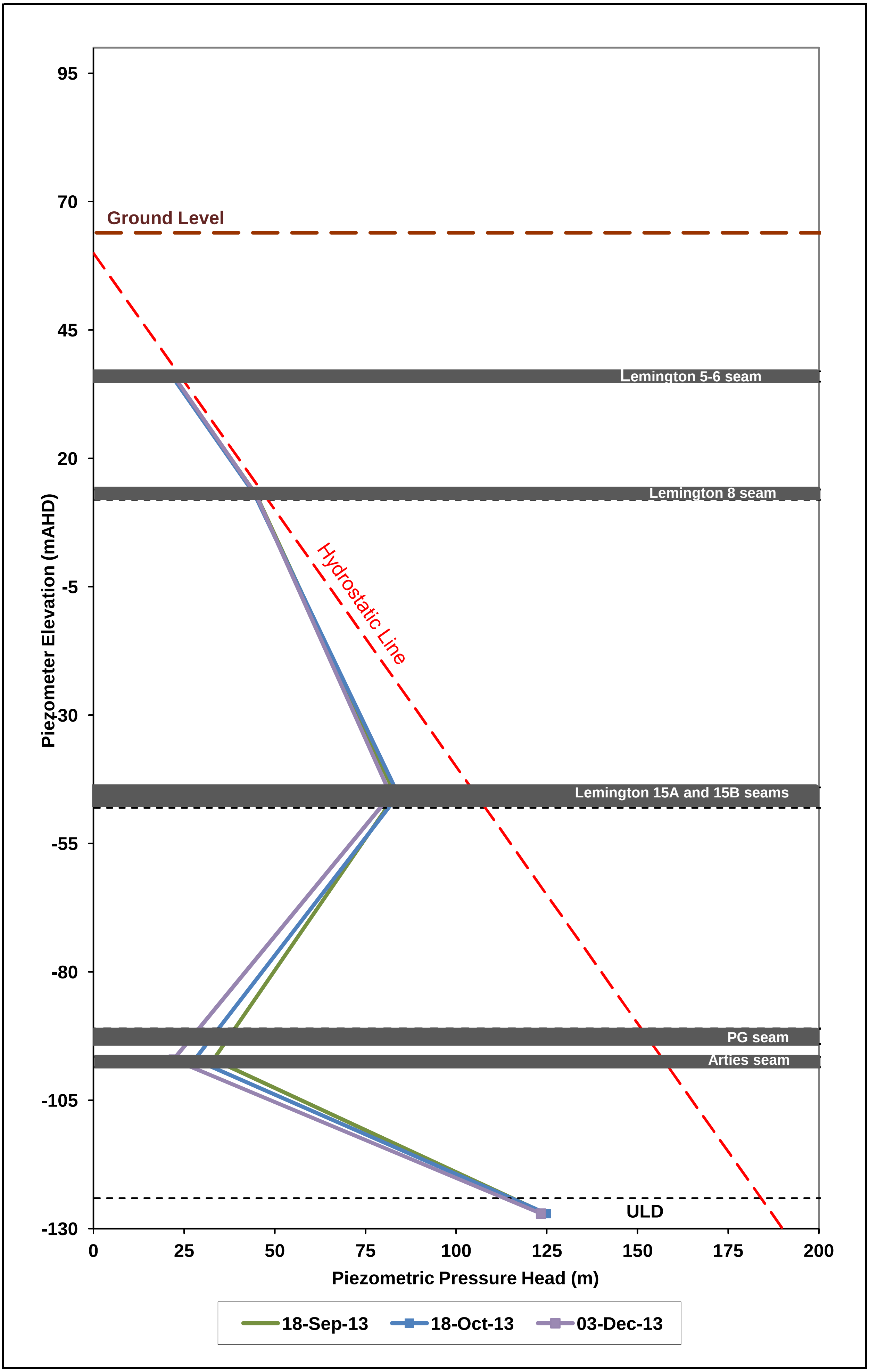
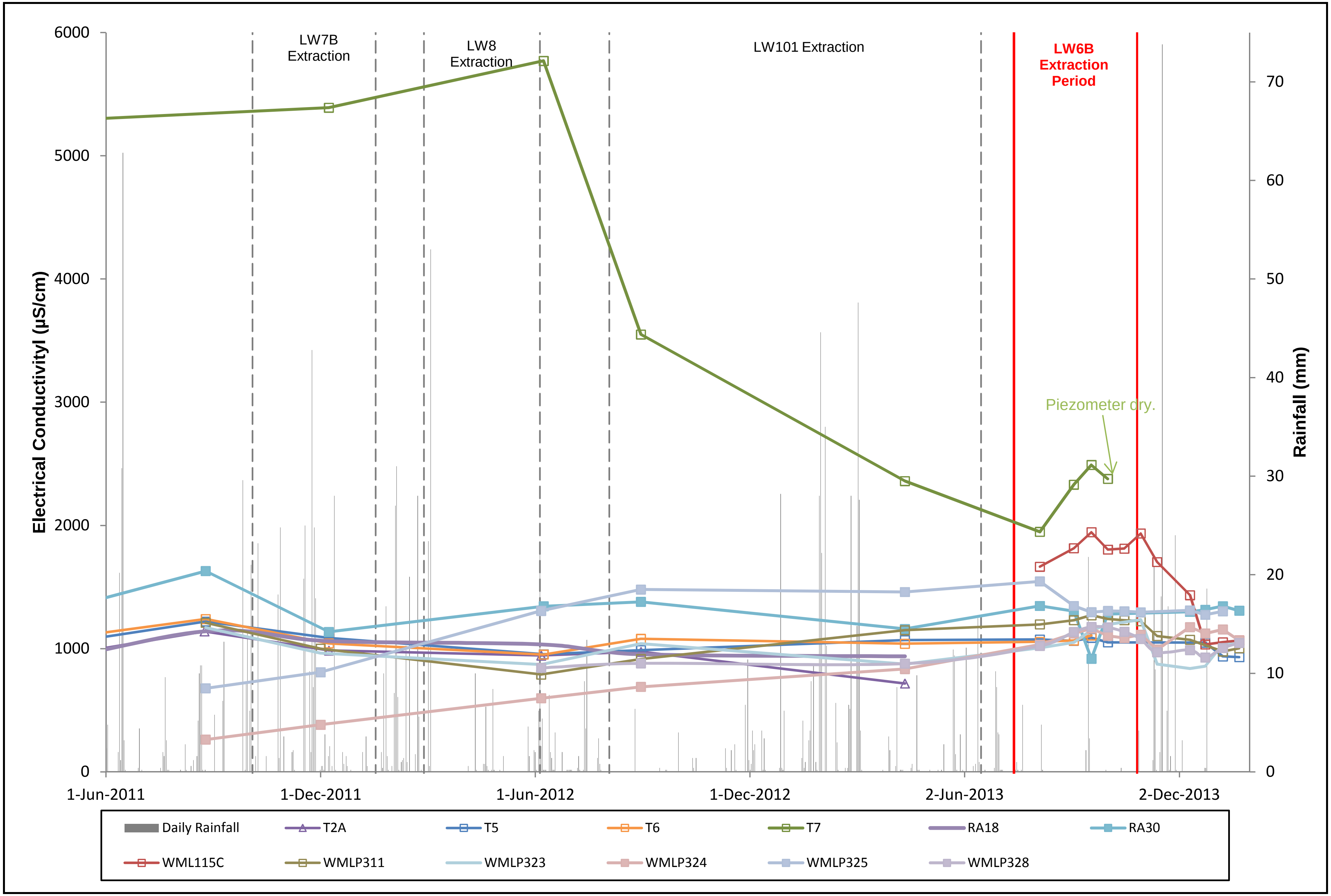
PIKES GULLY SEAM (LONGWALLS 5-8 AREA) FIGURE 17

F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 17



WMLP361 HYDROSTATIC HEAD PROFILE FIGURE 18

F:\Jobs\S55D\300\Water Levels\[027a_Hydrostatic Profiles.xls]FIGURE 18



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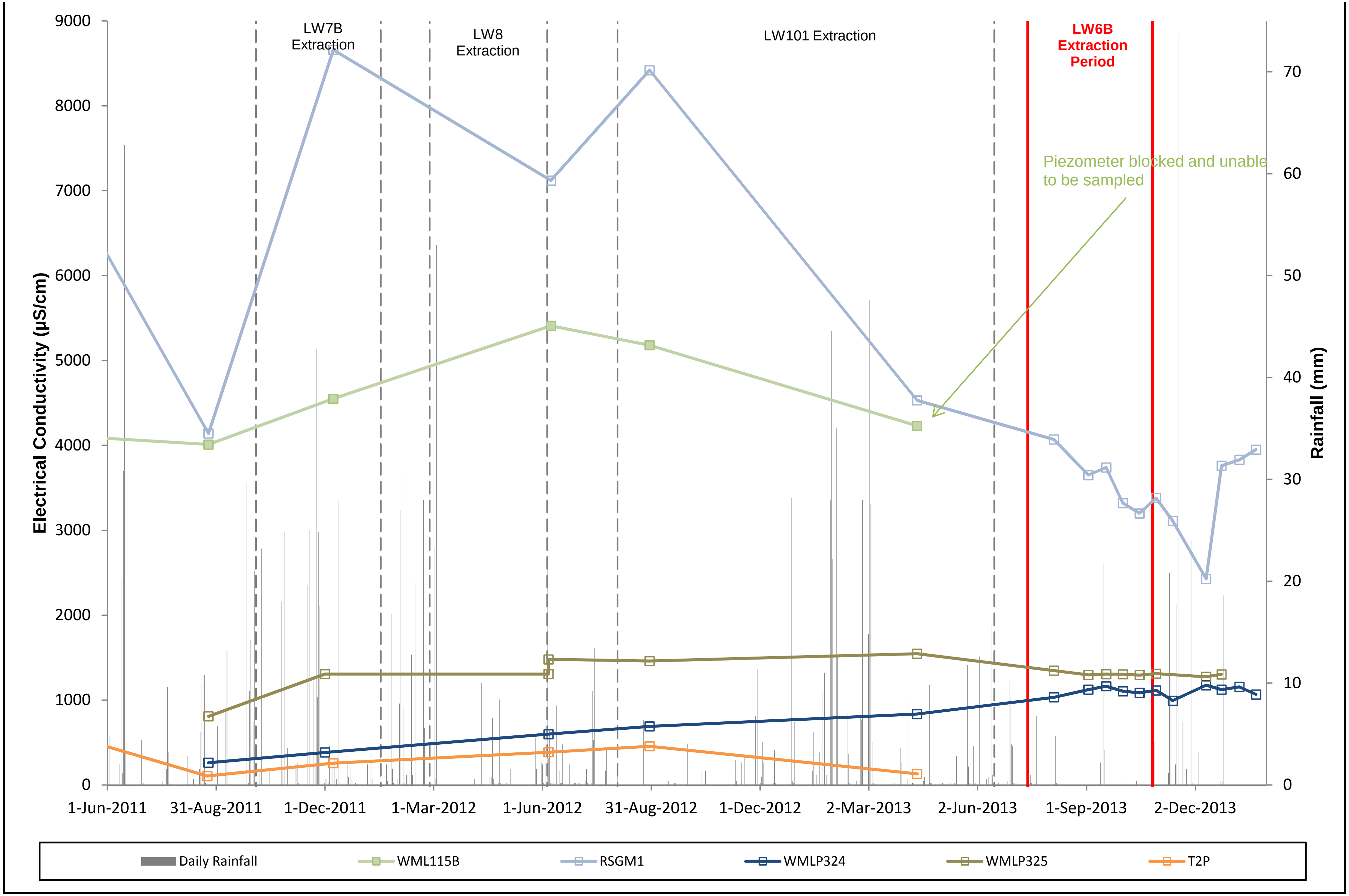
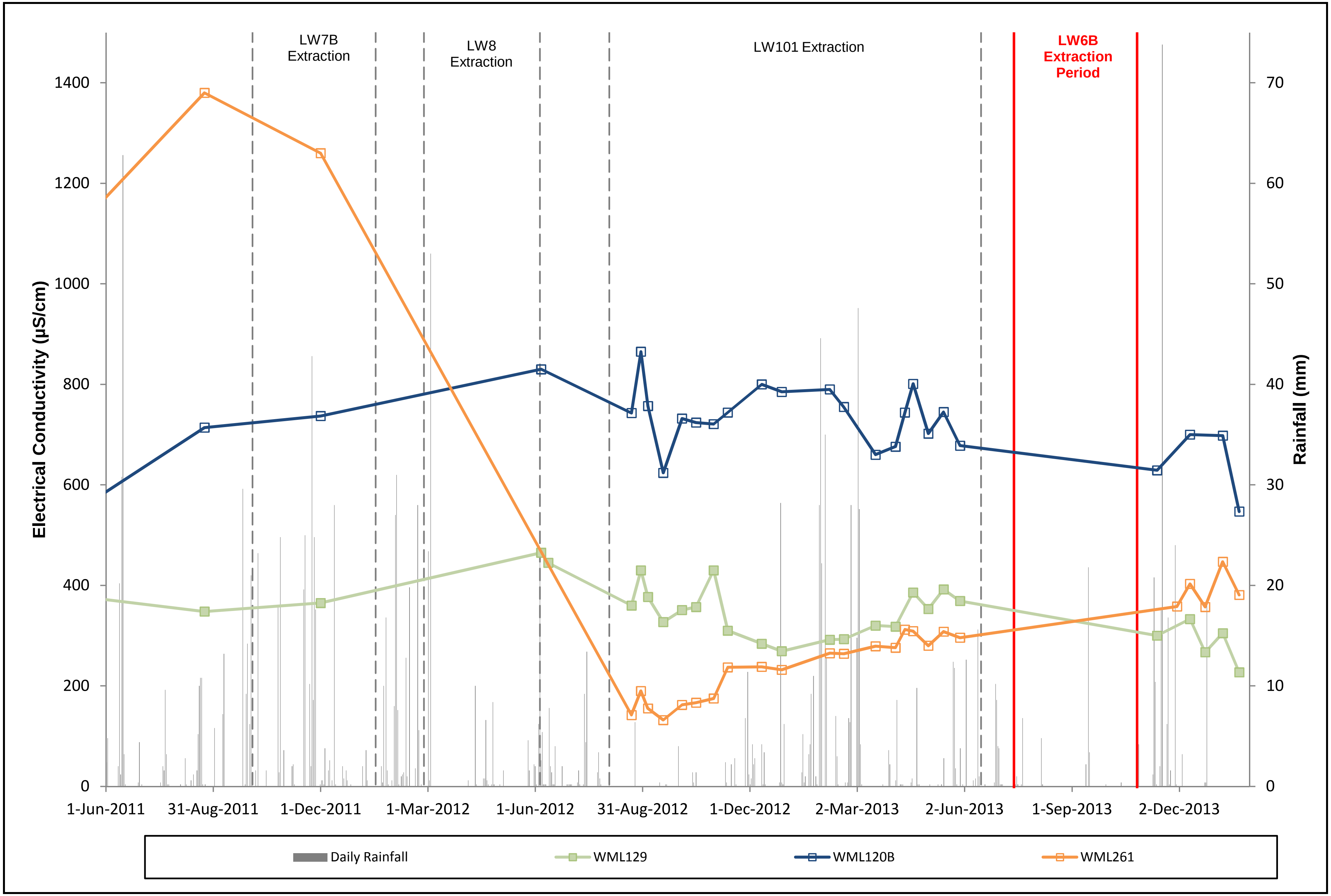
ELECTRICAL CONDUCTIVITY - KEY BOWMANS CREEK ALLUVIUM PIEZOMETERS FIGURE 19

F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 19



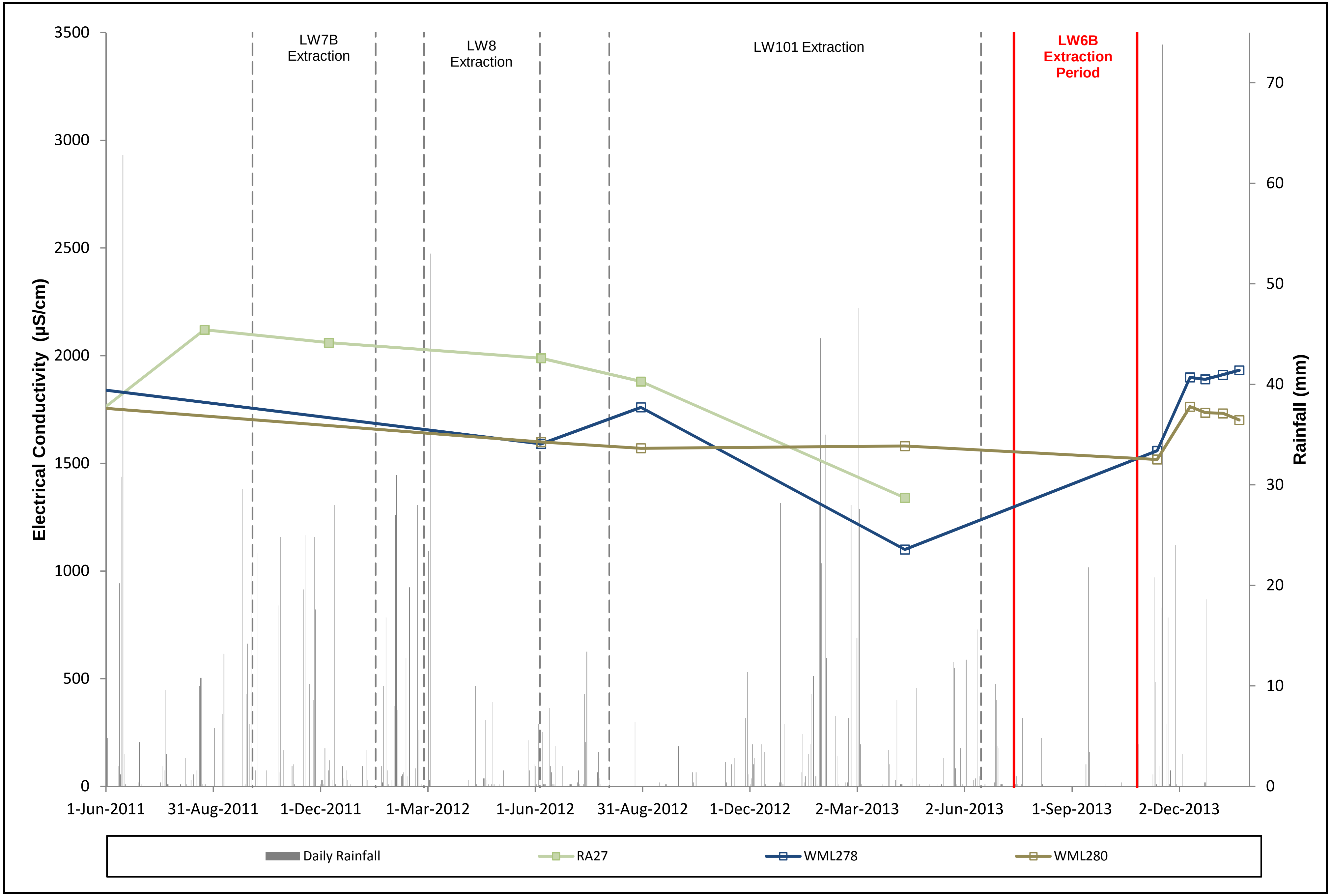
ELECTRICAL CONDUCTIVITY - KEY PERMIAN COAL MEASURES OVERBURDEN PIEZOMETERS FIGURE 20

F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 20



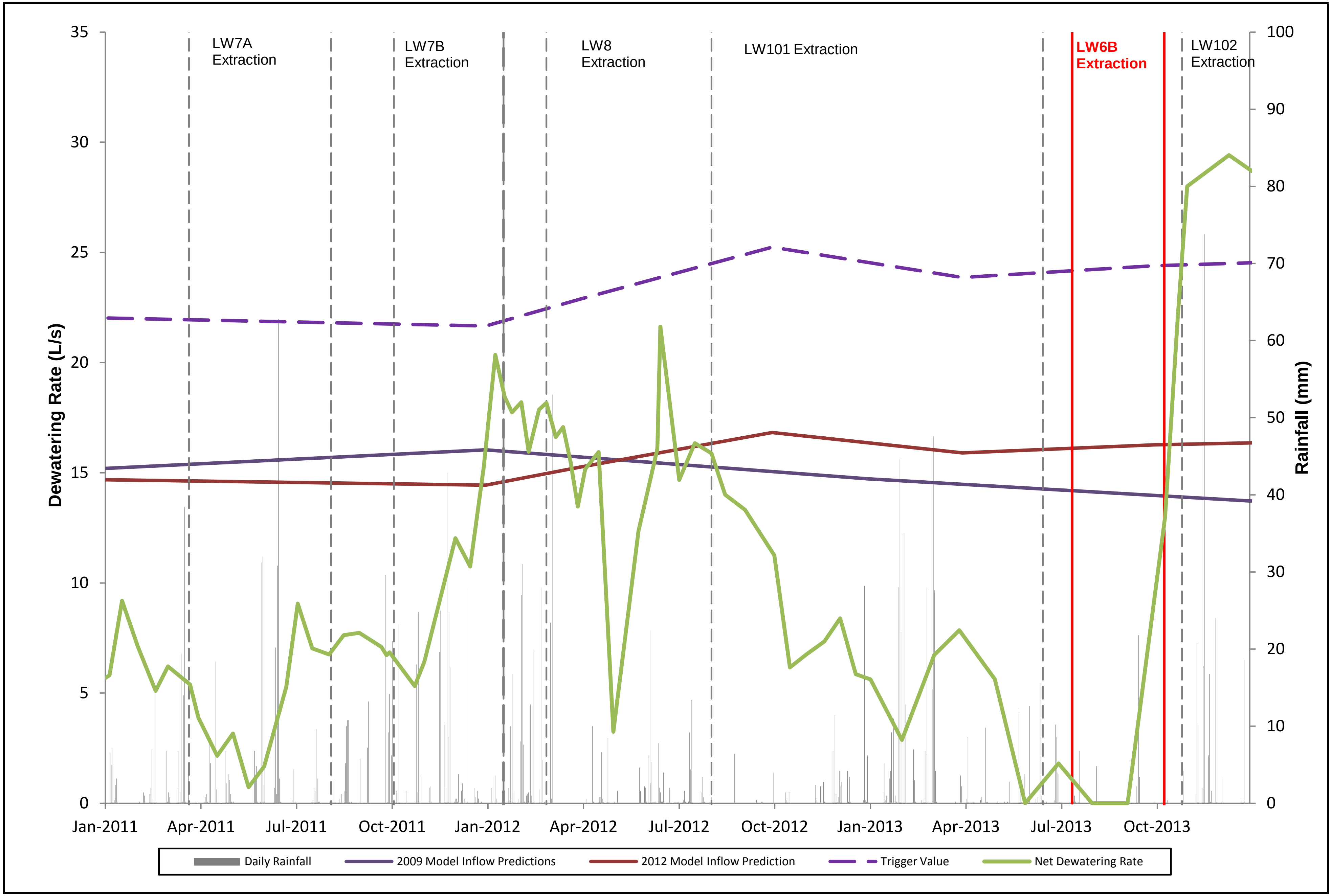
ELECTRICAL CONDUCTIVITY - GLENNIES CREEK ALLUVIUM PIEZOMETERS FIGURE 21

F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 21



ELECTRICAL CONDUCTIVITY - HUNTER RIVER ALLUVIUM PIEZOMETERS FIGURE 22

F:\Jobs\S55D\300\Water Levels\[027b.xls]Figure 22



MINE DEWATERING AND PREDICTED INFLOWS FIGURE 23

F:\Jobs\S56B\300\Mine Inflows\[081a.xls]Figure 23