Appendix D

Quality Assurance / Quality Control Report
Chain of Custody Sheets (Field and Despatch)
Sample Receipts

Quality Assurance / Quality Control Report
Addendum Report on Hydrogeological Investigation and Monitoring
January to May 2014
Proposed Coal Mine, Bylong, Mid-Western NSW

Quality Assurance (QA) was maintained by:

- Compliance with a Project Quality Plan written for the objectives of the study;
- Using qualified engineers/scientists to undertake the field supervision and sampling;
- Following the Douglas Partners Pty Ltd (DP) operating procedures for sampling, field testing and decontamination as presented in Table 1; and
- Using NATA registered laboratories for sample testing that generally utilise standard laboratory methods of the US EPA, the APHA and NSW EPA.

Table 1: Field Procedures

Abbreviation	Procedure Name
FPM LOG	Logging
FPM DECONT	Decontamination of Personnel and Equipment
FPM ENVID	Sample Identification, Handling, Transport and Storage of Contamination Samples
FPM PIDETC	Operation of Field Analysers
FPM WATSAMP	Water Sampling

Notes to Table 1:
From DP Field Procedures Manual

Quality Control (QC) of the laboratory programme was achieved by the following means:

- Check replicate - a specific sample was split in the field, placed in separate containers and labelled with different sample numbers, and sent to the laboratory for analysis;
- Method blanks - the laboratory ran reagent blanks to confirm the equipment and standards used were uncontaminated;
- Laboratory replicates - the laboratory split samples internally and conducted tests on separate extracts; and
- Laboratory spikes - samples were spiked by the laboratory with a known concentration of contaminants and subsequently tested for percent recovery.

Discussion

A. Check Replicate

The Relative Percent Difference (RPD) between replicate results is used as a measure of laboratory reproducibility and is given by the following:

$$\text{RPD} = \frac{\text{ABS (Replicate result 1} - \text{Replicate result 2)}}{\text{(Replicate result 1} + \text{Replicate result 2)/2}} \text{ x } 100$$

The RPD can have a value between 0% and 200%. An RPD data quality objective of up to 50% is generally considered to be acceptable for organic analysis, and 35% for inorganics (i.e. Metals).

A summary of the results of the replicate QA/QC testing are provided in Table 2.

Table 2: Results of Quality Control Testing (Field Replicates)

Sample Identification	A12	D44	RPD (%)	A15	D46	RPD (%)	A18	D48	RPD (%)	AGE08	D50	RPD (%)	AGE08	D51	RPD (%)	Laboratory PQL
Date Sampled	Jan 2014			Feb 2014			Mar 2014			Apr 2014			May 2014			
	15/01/2014			19/02/2014			20/03/2014			14/04/2014			19/05/2014			
pH	7.0	6.9	1	6.3	6.5	3	5.9	5.9	0	7.7	7.7	0	5.9	5.9	0	0.1 pH unit
Electrical Conductivity (µS/cm)	280	290	4	300	300	0	320	320	0	1300	1300	0	1300	1300	0	1
Turbidity (NTU)	140	140	0	4.8	4.9	2	28	30	7	4.5	5.2	14	0.8	0.7	13	0.1
Alkalinity																
Hydroxide (OH^-)	<5	<5	N/A	<5	<5	N/A	<5	<5	N/A	<5	<5	N/A	<5	<5	N/A	1/5
Carbonate (CO_3^{2-})	<5	<5	N/A	<5	<5	N/A	<5	<5	N/A	<5	<5	N/A	<5	<5	N/A	1/5
Bicarbonate (HCO_3^-)	99	100	1	85	86	1	100	100	0	610	600	2	570	570	0	1/5
Total Alkalinity	99	100	1	85	86	1	100	100	0	610	600	2	570	570	0	1/5
Anions																
Chloride (Cl)	30	29	3	34	35	3	21	21	0	79	79	0	81	81	0	1
Ammonia (NH_3) as N	0.005	0.008	46	0.014	0.023	49	0.053	0.062	16	1.6	1.6	0	1.5	1.6	6	0.005
NO_x ($NO_2^- + NO_3^-$)	0.01	0.02	67	0.02	0.05	86	0.01	0.007	35	0.01	0.03	100	0.006	0.008	29	0.005
Sulphate (SO_4^{2-})	19	18	5	5	5	0	22	22	0	<1	<1	N/A	<1	<1	N/A	1
Cations - Dissolved																
Calcium	20	20	0	12	10	18	19	21	10	37	37	0	36	34	6	0.5
Potassium	3.5	3.4	3	2.8	2.6	7	14	15	7	15	16	6	13	13	0	0.5
Sodium	22	22	0	26	25	4	24	25	4	270	280	4	210	210	0	0.5
Magnesium	14	15	7	11	11	0	12	13	8	28	28	0	28	27	4	0.5
Metals - Dissolved																
Aluminium	<0.0005	<0.0005	N/A	0.007	0.006	15	0.005	0.005	0	0.002	0.0007	96	<0.005	<0.005	N/A	0.0005
Arsenic	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	0.001	0.001	0	<0.001	<0.001	N/A	0.001
Barium	0.057	0.054	5	0.024	0.022	9	0.079	0.082	4	0.16	0.15	6	0.16	0.16	0	0.001
Beryllium	<0.0001	<0.0001	N/A	<0.0001	<0.0001	N/A	<0.0001	<0.0001	N/A	<0.0001	<0.0001	N/A	<0.0001	<0.0001	N/A	0.0001
Cadmium	<0.0001	<0.0001	N/A	<0.0001	<0.0001	N/A	<0.0001	<0.0001	N/A	<0.0001	<0.0001	N/A	<0.0001	<0.0001	N/A	0.0001
Chromium	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	0.001
Cobalt	<0.001	<0.001	N/A	<0.001	<0.001	N/A	0.001	0.001	0	<0.001	<0.001	N/A	<0.001	<0.001	N/A	0.001
Copper	<0.001	<0.001	N/A	0.001	0.002	67	0.002	0.001	67	<0.001	<0.001	N/A	0.002	0.003	40	0.001
Iron (Fe^{2+})	0.061	0.066	8	0.017	0.019	11	0.62	0.58	7	0.14	0.14	0	0.19	0.19	0	0.01
Lead	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	0.001
Manganese	0.083	0.086	4	0.093	0.094	1	0.089	0.088	1	0.11	0.11	0	0.11	0.12	9	0.005
Mercury	<0.00005	<0.00005	N/A	<0.00005	<0.00005	N/A	<0.00005	<0.00005	N/A	<0.00005	<0.00005	N/A	<0.00005	<0.00005	N/A	0.00005
Nickel	0.004	0.004	0	0.002	0.002	0	0.007	0.007	0	0.053	0.053	0	0.040	0.042	5	0.001
Selenium	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	0.001
Vanadium	<0.001	<0.001	N/A	<0.001	<0.001	N/A	<0.001	<0.001	N/A	0.002	0.002	0	<0.001	<0.001	N/A	0.001
Zinc	0.010	0.010	0	0.015	0.021	33	0.049	0.031	45	0.22	0.23	4	0.23	0.25	8	0.001
Metals - Total																
Aluminium	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.0005
Arsenic	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Barium	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Beryllium	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.0001
Cadmium	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.0001
Chromium	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Cobalt	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Copper	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Iron (Fe^{2+})	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.01
Lead	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Manganese	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.005
Mercury	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.00005
Nickel	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Selenium	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Vanadium	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Zinc	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	NT	NT	N/A	0.001
Total Phosphorus	0.06	0.05	18	<0.05	<0.05	N/A	0.05	<0.05	N/A	<0.05	<0.05	N/A	<0.05	<0.05	N/A	0.05

Notes to Table 2: N/A – Not Applicable

Results expressed in mg/L unless otherwise indicated

The results of testing indicated slightly elevated RPDs for several analytes up to 100%, however, were less than the laboratory control acceptance criteria of five times PQL and therefore are considered acceptable. The elevated RPDs were in general found to be a result of small changes in concentration resulting in high RPDs. The results of replicate testing are therefore considered to be acceptable.

B. Method Blanks

All method blanks returned results lower than the laboratory detection limit, therefore are acceptable.

C. Laboratory Replicates

The average RPD for individual contaminants generally ranged from 0% to 40%. Elevated RPDs were found up to 130%, however, the concentrations were very low, resulting in a high RPD for a small difference in concentration.

The laboratory replicates were within the internal laboratory quality control criteria.

D. Laboratory Spikes

Recoveries in the order of 70% to 130% are generally considered to be acceptable for inorganic material and 60% to 140% for organic material. The average percent recovery for individual contaminants ranged from 70% to 139%, which is within the quality control objectives. The results should however be qualified and may slightly under-estimate or over-estimate contaminant concentrations in certain samples (i.e. biased low or high respectively).

Conclusions

In summary, while some slightly elevated results were found, they can be attributed to the relatively low concentration of contaminants.

It is also noted that the magnitude of RPDs for field replicates (i.e. blind replicates) are generally higher than those for laboratory replicates. Field replicates results generally show greater variability than laboratory replicates, because they measure both field and laboratory reproducibility.

The accuracy and precision of the water testing procedures, as inferred by the laboratory QA / QC data is considered to be of sufficient standard to allow the data reported to be used in interpret site contamination conditions.

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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong, NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: ALP Date: 13-16 Jan 2014	☑ Envirolab	
					By	Date	Time	Storage Location*	Date: see comments	
BY0016	–	–	W	P	ALP	13.1.14	12:55	Esky	✓	TNT Mudgee 14/1/14
BY0014	–	–					2:35		✓	
A13	–	–					3:45		✓	
AGE08	–	–				↓	4:35		✓	
RT4	–	–				14.1.14	6:45		✓	
SW4	–	–					7:30		✓	
A01-S	–	–					8:30		✓	
BY0015	–	–					8:40		✓	
A09	–	–							✓	
A14	–	–					↓		✓	
RT1	–	–				↓	11:50		✓	
A20	–	–				15/1/14	7:50		✓	TNT Mudgee 16/1/14
A06-S	–	–					8:30		✓	
A15	–	–					9:35		✓	
B3-S	–	–							✓	
B3-D	–	–					10:40		✓	
AGE10	–	–					12:30		✓	
A18	–	–					2:20		✓	
A12	–	D44				↓	3:25		✓✓	
A02-S	–	–	↓	↓	↓	16/1/14	8:40	↓	✓	

Default containers for soil: glass = clear 125/250 mL with teflon liner, plastic =press seal bag
*Default storage: Glass containers in fridge, plastic containers shelved, all water samples in fridge

M:/Environmental/QA-QC/AmendedC-O-C.doc Rev4/Feb 2005

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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong , NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: A.L.P. Date: 16/1/14	☑ Envirolab	
					By	Date	Time	Storage Location*	Date: 16/1/13	
AGE13	–	–	W	P	ALP	16/1/14	~~10~~ 9:35	esky	✓	TNF
RT5	–	–	↓	↓	↓	↓	10:20	↓	✓	Mudgee
RT3	–	–	↓	↓	↓	↓	↓	↓	✓	
RT2	–	45	↓	↓	↓	↓	12:00	↓	✓✓	

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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong, NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: AlP Date: 17/2/14	☑ Envirolab 18/2/14	
					By	Date	Time	Storage Location*	Date: & 20/2/14	
· SW4	–	–	W	P	ACP	17/2/14	1:15pm	Esky	✓	TNT Mudgee 18/2/14
· A01-S	–	–					2:00pm		✓	
BY0015	–	–				↓	2:15pm		✓	
A13	–	–				18/2/14	7:45am		✓	
A14	–	–							✓	
A09	–	–					↓		✓	
AGE08	–	–					10:50am		✓	
A06-S	–	–							✓	
A20	–	–					↓		✓	
· & RT4	–	–					1:30pm		✓	
· RT3	–	–					1:50pm		✓	
· RT2	–	–				↓	2:05pm		✓	
BY0014	–	–				19/2/14	8:10am		✓	TNT Mudgee 20/2/14
BY0016	–	–							✓	
AGE10	–	–							✓	
A15	–	D46							✓✓	
B3D	–	–							✓	
B3S	–	–							✓	
A12	–	–				↓	↓		✓	
A18	–	–	↓	↓		20/12/14	4:20pm	↓	✓	

Default containers for soil: glass = clear 125/250 mL with teflon liner, plastic =press seal bag
*Default storage: Glass containers in fridge, plastic containers shelved, all water samples in fridge

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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong, NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: ALP Date: 20/2/14	☑ Envirolab	
					By	Date	Time	Storage Location*	Date: 20/2/14	
AGE13	-	-	W	P	ALP	20/2/14	↓	esky	✓	TNT
A02-S	-	-	↓	↓	↓	↓	↓	↓	✓	Mudgee
RT5	-	-	↓	↓	↓	↓	↓	↓	✓	20/2/14
RT1	-	D47	↓	↓	↓	↓	11:10	↓	✓✓	

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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong, NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: ALP Date:	☑ envirolab 18/3/14 & Date: 20/3/14	
					By	Date	Time	Storage Location*		
BY0016	-	-	W	P	ALP	17/3/14	2:00pm	esky	✓	Mudgee
BY0014	-	-				↓	3:25pm		✓	TNT
A01-S	-	-				18/3/14	8:00am		✓	18/3/14
BY0015	-	-					8:10am		✓	
A13	-	-					9:00am		✓	
A14	-	-					10:00am		✓	
A09	-	-							✓	
AGE08	-	-					↓		✓	
RT3	-	-				↓	1:45pm		✓	
SW4	-	-				19/3/14	7:45am		✓	
A20	-	-							✓	Mudgee
A06-S	-	-					↓		✓	TNT
AGE10	-	-					10:45am		✓	20/3/14
A15	-	-					11:50am		✓	
B30	-	-							✓	
B35	-	-							✓	
A02-S	-	-					↓		✓	
A12	-	-				↓	3 30		✓	
RT4	-	-				20/3/14	-		✓	
A18	-	D48	↓	↓	↓	↓	↓	↓	✓✓	

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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong, NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: 20/3/14 Date:	☑ Envirolab Date: 20/3/14	
					By	Date	Time	Storage Location*		
AGE13	–	–	W	P	ACP	20/3/14	↓	esky	✓	TNT
RT5	–	–	↓	↓	↓	↓	10:35am	↓	✓	Mudgee
RT1	–	–	↓	↓	↓	↓	↓	↓	✓	20/3/14
RT2	–	D49	↓	↓	↓	↓	↓	↓	✓ ✓	

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PO: 113412

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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong, NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: ACP Date: –	☑ Envirolab 14/4/14 &	
					By	Date	Time	Storage Location*	Date: 16/4/14	
BY0016	–	–	W	P	ACP	13/4/14	1:40 pm	esky	✓	TNT Mudgee 14/4/14
BY0014	–	–					2:55pm		✓	
A01-S	–	–					4:02pm		✓	
BY0015	–	–				↓	4:20pm		✓	
RT4	–	–				14/4/14	7:00am		✓	
RT2	–	–							✓	
RT3	–	–					↓		✓	
A20	–	–					8:35pm		✓	
A06-D	–	–					↓		✓	
AGE08	–	D50					10:20am		✓✓	
A14	–	–					11:50am		✓	
A09	–	–					↓		✓	
RT1	–	–					12:55pm		✓	
RT5	–	–					1:40pm		✓	
RT5F	–	–				↓	1:45pm		✓	
A13	–	–				15/4/14	7:40am		✓	16/4/14
B3-S	–	–					↓		✓	
B3-D	–	–					10:30am		✓	
A15	–	–					11:15am		✓	
AGE10	–	–	↓	↓	↓	↓	12:30pm	↓	✓	

Default containers for soil: glass = clear 125/250 mL with teflon liner, plastic =press seal bag
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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong, NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: ALP Date: –	☑ envirolab	
					By	Date	Time	Storage Location*	Date: 16/4/14	
A02-S	–	–	W	P	ALP	15/4/14	2:00pm	Esky	✓	16/4/14
AGE13	–	–	↓	↓	↓	↓	2:40pm	↓	✓	
A12	–	–	↓	↓	↓	↓	3:45pm	↓	✓	
A18	–	–	↓	↓	↓	16/4/14	7:45am	↓	✓	
SW4	–	–	↓	↓	↓	↓	10:25am	↓		

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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong, NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: ALP Date: 19/5/14 to	☑ envirolab	
					By	Date	Time	Storage Location*	Date: 20/5/14	
BY0016	-	-	W	P	ACP	19/5/14	1:20pm	Esky	✓	TNT Mudgee 20/5/14
A01-S	-	-	↓	↓	↓	↓	2:45pm	↓	✓	
BY0015	-	-					2:55pm		✓	
AGE08	-	D51					4:05pm		✓✓	
SW4	-	-				20/5/14	7:30am		✓	
BY0014	-	-				↓	8:40am		✓	
A14	-	-					10:15am		✓	
A13	-	-					11:05am		✓	
A09	-	-					11:40am		✓	
A06-D	-	-					12:50pm		✓	
AGE10	-	-				21/5/14	7:55am		✓	TNT Mudgee 22/5/14
B3-D	-	-				↓	9:25am		✓	
B3-S	-	-					10:30am		✓	
AGE13	-	-					12:20pm		✓	
A15	-	-					11:20am		✓	
A18	-	-					1:30pm		✓	
A12	-	-					2:30pm		✓	
A02-D	-	-					4:00pm		✓	
A20	-	-				22/5/14	10:30am		✓	
RTS	-	-								

Default containers for soil: glass = clear 125/250 mL with teflon liner, plastic =press seal bag
*Default storage: Glass containers in fridge, plastic containers shelved, all water samples in fridge

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CHAIN OF CUSTODY FIELD SHEET

Client: Cockatoo Coal
Project: Groundwater / Surface Water Monitoring Project No: 49761.03
Location: Bylong, NSW

Field								DP Office	Despatch	Notes
Sample ID	Depth (m)	Duplicate/ Replicate Sample	Sample Type S-soil W-water	Container Type G-glass P-plastic	Sampling			Received by: ALP Date: 22/5/14	☑ Envirolab	
					By	Date	Time	Storage Location*	Date: 22/5/14	
RT6	-	-	W	P	ALP	22/5/14	11:50am	esky	✓	TNT Mudgee 22/5/14
RT3	-	-	↓	↓	↓	↓	12:15pm	↓	✓	
RT2	-	-	↓	↓	↓	↓	12:30pm	↓	✓	
RT1	-	-	↓	↓	↓	↓	1:00pm	↓	✓	

Default containers for soil: glass = clear 125/250 mL with teflon liner, plastic =press seal bag
*Default storage: Glass containers in fridge, plastic containers shelved, all water samples in fridge

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: [redacted]/111238
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	faecal Coliforms	Phosphorus Total + Metals (16)			TCLP	Notes
BY0014	13.1.14	W	1	✓	✓	✓	✓	✓	✓	✓	✓								Al PQL:
BY0015	14.1.14		2	✓	✓	✓	✓	✓	✓	✓	✓								0.005 mg/L
BY0016	13.1.14		3	✓	✓	✓	✓	✓	✓	✓	✓								
A01-S	14.1.14		4	✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
A09	14.1.14		5	✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
A13	13.1.14		6	✓	✓	✓	✓	✓	✓	✓	✓								
A14	14.1.14		7	✓	✓	✓	✓	✓	✓	✓	✓								
AGE08	13.1.14		8	✓	✓	✓	✓	✓	✓	✓	✓								
SW4	14.1.14		9	✓	✓	✓	✓	✓	✓	✓	✓								
RT1	14.1.14		10	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
RT4	14.1.14	↓	11	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
PQL (S)		mg/kg																	
PQL (W)		mg/L																	

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 103498
Date Received: 15/01
Time Received: 8:30
Received by:
Temp: [✓ Cool]/Ambient
Cooling: [✓ Ice]/Icepack
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): As Cd Cr Cu Pb Zn Hg Ni [✓ Other] Al Ba Be Co Fe Mn V Se
Date relinquished: 14.1.14
Total number of samples in container: 11
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature: STS
Date: 15/01 Lab Ref:

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

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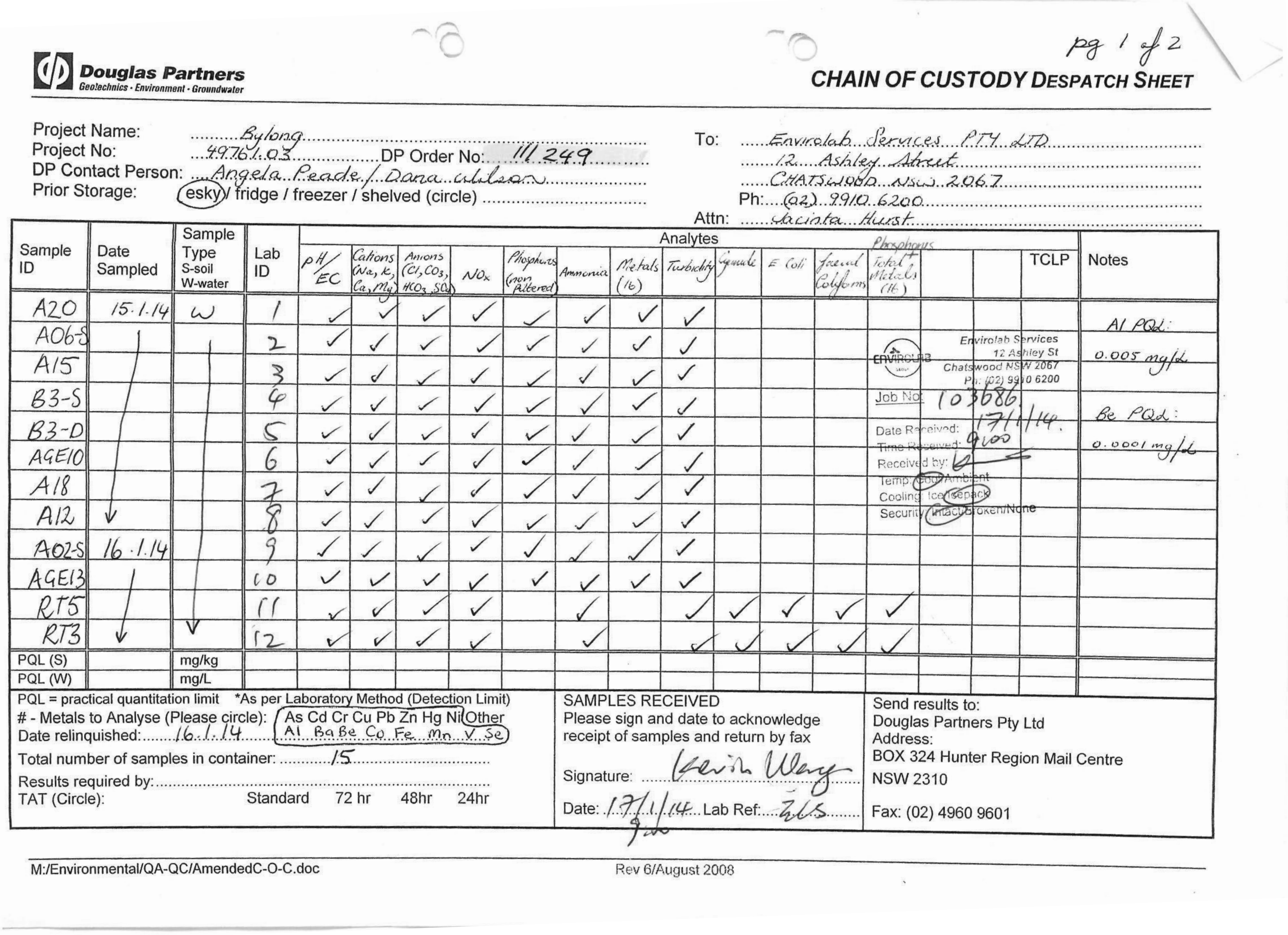

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 111 249
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes: pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	Faecal Coliforms	Phosphorus Total + Metals (16)			TCLP	Notes
A20	15.1.14	W	1	✓	✓	✓	✓	✓	✓	✓	✓								
A06-S			2	✓	✓	✓	✓	✓	✓	✓	✓								Al PQL:
A15			3	✓	✓	✓	✓	✓	✓	✓	✓								0.005 mg/L
B3-S			4	✓	✓	✓	✓	✓	✓	✓	✓								
B3-D			5	✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
AGE10			6	✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
A18			7	✓	✓	✓	✓	✓	✓	✓	✓								
A12	↓		8	✓	✓	✓	✓	✓	✓	✓	✓								
A02-S	16.1.14		9	✓	✓	✓	✓	✓	✓	✓	✓								
AGE13			10	✓	✓	✓	✓	✓	✓	✓	✓								
RT5			11	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
RT3	↓	↓	12	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
PQL (S)		mg/kg																	
PQL (W)		mg/L																	

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 103686.
Date Received: 17/1/14.
Time Received: 9:00
Received by:
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 16.1.14
Total number of samples in container: 15
Results required by:
TAT (Circle): Standard 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature: Kevin Wang
Date: 17/1/14 Lab Ref: ZLS
9:00

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 111249
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)
CD 3686

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	faecal Coliforms	Phosphorus + Total Metals (16)			TCLP	Notes
RT2	16.1.14	W	13	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				Al PQL:
																			0.005 mg/L
D44	15.1.14	W	14	✓	✓	✓	✓	✓	✓	✓	✓								
D45	16.1.14	W	15	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				Be PQL:
																			0.0001 mg/L
PQL (S)		mg/kg																	
PQL (W)		mg/L																	

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
\# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 16.1.14
Total number of samples in container: 15
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature: Kevin Wong
Date 17/1/14 9:00 Lab Ref: ELS

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 112998
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E. Coli	Faecal Coliforms	Phosphorus Total + Metals (16)			TCLP	Notes
RT2	18/2/14	W	1	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				Al PQL:
RT3	"		2	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				0.005 mg/L
RT4	"		3	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
SW4	17/2/14		4	✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
A01-S	17/2/14		5	✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
A06-S	18/2/14		6	✓	✓	✓	✓	✓	✓	✓	✓								
A09			7	✓	✓	✓	✓	✓	✓	✓	✓								Quote
A13			8	✓	✓	✓	✓	✓	✓	✓	✓								14SY018
A14			9	✓	✓	✓	✓	✓	✓	✓	✓								
A20			10	✓	✓	✓	✓	✓	✓	✓	✓								
AGE08	↓		11	✓	✓	✓	✓	✓	✓	✓	✓								
BY0015	17/2/14	↓	12	✓	✓	✓	✓	✓	✓	✓	✓								
PQL (S)		mg/kg																	
PQL (W)		mg/L																	

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
\# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni] [✓ Other] Al Ba Be Co Fe Mn V Se
Date relinquished: 18/2/14
Total number of samples in container: 12
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: 19/02 Lab Ref: 105282

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

ENVIROLAB GROUP
Envirolab Service
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 105282
Date Received: 19/02
Time Received: 8:55
Received by:
Temp: [✓ Cool]/Ambient
Cooling: [✓ Ice]/Icepack
Security: [✓ Intact]/Broken/None

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 112998
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

	Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes														TCLP	Notes
					pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E. Coli	Faecal Coliforms	Phosphorus Total + Metals (16)				
1	RT1	20/2/14	W	1	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				Al PQL:
2	RT5	"		2	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				0.005 mg/L
3	BY0014	19/2/14		3	✓	✓	✓	✓	✓	✓	✓	✓								
4	BY0016			4	✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
5	AGE10			5	✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
6	A15			6	✓	✓	✓	✓	✓	✓	✓	✓								
7	B3D			7	✓	✓	✓	✓	✓	✓	✓	✓								Quote
8	B3S			8	✓	✓	✓	✓	✓	✓	✓	✓								14SY018
9	A12	↓		9	✓	✓	✓	✓	✓	✓	✓	✓								
10	A18	20/2/14		10	✓	✓	✓	✓	✓	✓	✓	✓								
11	AGE13			11	✓	✓	✓	✓	✓	✓	✓	✓								
12	A02-S	↓		12	✓	✓	✓	✓	✓	✓	✓	✓								
	PQL (S)		mg/kg																	
	PQL (W)		mg/L																	

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 105433
Date Received: 21/2/14
Time Received: 10:50.
Received by: JYH
Temp: [✓ Cool]/Ambient 5.2
Cooling: [✓ Ice]/Icepack
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni] [✓ Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 20/2/14
Total number of samples in container: 14
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: 21/2/14 Lab Ref: 105433

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: M2998
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

	Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID 105433	Analytes														TCLP	Notes
					pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	faecal Coliforms	Phosphorus + Total Metals (16)				
13	D46	19/2/14	W	13	✓	✓	✓	✓	✓	✓	✓	✓								Al PQL:
14	D47	20/2/14	↓	14	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				0.005 mg/L
																				Be PQL:
																				0.0001 mg/L
																				Quote
																				14SY018
	PQL (S)		mg/kg																	
	PQL (W)		mg/L																	

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni] [✓ Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 20/2/14
Total number of samples in container: 14
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: 21/2/14 Lab Ref: 105433

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 113386
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

	Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	Faecal Coliforms	Phosphorus + Total Metals (16)			TCLP	Notes
1	BY0014	17/3/14	W		✓	✓	✓	✓	✓	✓	✓	✓								
2	BY0016	"	↓		✓	✓	✓	✓	✓	✓	✓	✓								Al PQL:
3	A01-S	18/3/14			✓	✓	✓	✓	✓	✓	✓	✓								0.005 mg/L
4	BY0015	↓			✓	✓	✓	✓	✓	✓	✓	✓								
5	A13				✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
6	A14				✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
7	A09				✓	✓	✓	✓	✓	✓	✓	✓								
8	AGE08				✓	✓	✓	✓	✓	✓	✓	✓								Quote
9	RT3	↓	↓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				14SY018
	PQL (S)		mg/kg																	
	PQL (W)		mg/L																	

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 106730
Date Received: 19/3
Time Received: 10am
Received by: PH
Temp: [✓ Cool]/Ambient
Cooling: [✓ Ice]/Icepack
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni] [✓ Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 18/3/14
Total number of samples in container: 9
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: 19/3 Lab Ref:

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 113386
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

	Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes														TCLP	Notes
					pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	faecal Coliforms	Phosphorus + Total Metals (16)				
1	SW4	19/3/14	W		✓	✓	✓	✓	✓	✓	✓	✓								Al PQL:
2	A20	↓	↓		✓	✓	✓	✓	✓	✓	✓	✓								0.005 mg/L
3	A06-S				✓	✓	✓	✓	✓	✓	✓	✓								
4	AGE10				✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
5	A15				✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
6	B3-D				✓	✓	✓	✓	✓	✓	✓	✓								
7	B3-S				✓	✓	✓	✓	✓	✓	✓	✓								Quote
8	A02-S				✓	✓	✓	✓	✓	✓	✓	✓								14SY018
9	A12	↓			✓	✓	✓	✓	✓	✓	✓	✓								
10	RT4	20/3/14			✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
11	A18	↓			✓	✓	✓	✓	✓	✓	✓	✓								
12	AGE13	↓	↓		✓	✓	✓	✓	✓	✓	✓	✓								
	PQL (S)		mg/kg																	
	PQL (W)		mg/L																	

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 106867
Date Received: 21/3
Time Received: 8:00
Received by: MT
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni] [✓ Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 20/3/14
Total number of samples in container: 17
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: 21/3 Lab Ref:

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

pg 2 of 2

Douglas Partners
Geotechnics · Environment · Groundwater

CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 113386
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	Faecal Coliforms	Phosphorus Total + Metals (16)			TCLP	Notes
13 RT5	20/3/14	W		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				Al PQL:
14 RT1	↓	↓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				0.005 mg/L
15 RT2				✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
16 * D48				✓	✓	✓	✓	✓	✓	✓	✓	~~✓~~	~~✓~~	~~✓~~	~~✓~~	All.			Be PQL:
17 D49	↓	↓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				0.0001 mg/L
																			Quote
																			14SY018
PQL (S)		mg/kg																	
PQL (W)		mg/L																	

Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
ENVIROLAB GROUP
Job No: 106867
Date Received: 21/3
Time Received: 9:00
Received by: MT
Temp: [✓ Cool]/Ambient
Cooling: Ice/[✓ Icepack]
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 20/3/14
Total number of samples in container: 17
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: 21/3 Lab Ref:

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

pg 1 of 2

Douglas Partners
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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 113412
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

	Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes														TCLP	Notes
					pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	faecal Coliforms	Total Metals (16) + Phosphorus				
1	BY0016	13/4/14	W		✓	✓	✓	✓	✓	✓	✓	✓								Al PQL:
2	BY0014				✓	✓	✓	✓	✓	✓	✓	✓								0.005 mg/L
3	A01-S				✓	✓	✓	✓	✓	✓	✓	✓								
4	BY0015	↓			✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
5	A20	14/4/14			✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
6	A06-D				✓	✓	✓	✓	✓	✓	✓	✓								
7	AGE08				✓	✓	✓	✓	✓	✓	✓	✓								Quote
8	A14				✓	✓	✓	✓	✓	✓	✓	✓								14SY018
9	A09				✓	✓	✓	✓	✓	✓	✓	✓								
10	RT1				✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
11	RT2				✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
12	RT3	↓	↓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
	PQL (S)		mg/kg																	
	PQL (W)		mg/L																	

ENVIROLAB GROUP
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 108220
Date Received: 15.4.14
Time Received: 900
Received by: TA
Temp: [✓ Cool]/Ambient
Cooling: [✓ Ice]/Icepack
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 14/4/14
Total number of samples in container: 16
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: 15.4.14 Lab Ref: 108220

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

3 x 60mL HNO3 RT4 received - discarded.

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 113412
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes														TCLP	Notes
				pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	Faecal Coliforms	Phosphorus Total + Metals (16)				
13 RT4	14/4/14	W		✓	✓	✓	✓	×	✓		✓	✓	✓	✓	✓				Al PQL:
14 RT5	↓	↓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				0.005 mg/L
15 RT5F				✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
16 D50				✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
																			0.0001 mg/L
																			Quote
																			14SY018
PQL (S)		mg/kg																	
PQL (W)		mg/L																	

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): As Cd Cr Cu Pb Zn Hg Ni [✓ Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 14/4/14
Total number of samples in container: 16
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax

Signature:

Date: 15/4/14 Lab Ref: 108220

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310

Fax: (02) 4960 9601

Douglas Partners
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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 113412
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

	Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	Faecal Coliforms	Phosphorus Total + Metals (16)			TCLP	Notes
1	A13	15/4/14	W		✓	✓	✓	✓	✓	✓	✓	✓								Al PQL:
2	B3-S	↓	↓		✓	✓	✓	✓	✓	✓	✓	✓								0.005 mg/L
3	B3-D				✓	✓	✓	✓	✓	✓	✓	✓								
4	A15				✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
5	AGE10				✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
6	A02-S				✓	✓	✓	✓	✓	✓	✓	✓								
7	AGE13				✓	✓	✓	✓	✓	✓	✓	✓								Quote
8	A12				✓	✓	✓	✓	✓	✓	✓	✓								14SY018
9	A18				✓	✓	✓	✓	✓	✓	✓	✓								
10	SW4	↓	↓		✓	✓	✓	✓	✓	✓	✓	✓								
	PQL (S)		mg/kg																	
	PQL (W)		mg/L																	

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 108392
Date Received: 17.4.14
Time Received: 900
Received by: JA
Temp: [✓ Cool]/Ambient
Cooling: [✓ Ice]/Icepack
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni] [✓ Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 16/4/14
Total number of samples in container: 10
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: 17.4.14 Lab Ref:

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 115052
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	faecal Coliforms	Phosphorus + Total Metals (16)			TCLP	Notes
BY0016	19/5/14	W	1	✓	✓	✓	✓	✓	✓	✓	✓								
A01-S	↓		2	✓	✓	✓	✓	✓	✓	✓	✓								Al PQL:
BY0015			3	✓	✓	✓	✓	✓	✓	✓	✓								0.005 mg/L
AGE08	↓		4	✓	✓	✓	✓	✓	✓	✓	✓								
SW4	20/5/14		5	✓	✓	✓	✓	✓	✓	✓	✓								Be PQL:
BY0014	↓		6	✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
A14			7	✓	✓	✓	✓	✓	✓	✓	✓								
A13			8	✓	✓	✓	✓	✓	✓	✓	✓								Quote
A09			9	✓	✓	✓	✓	✓	✓	✓	✓								14SY018
A06-D	↓		10	✓	✓	✓	✓	✓	✓	✓	✓								
D51	19/5/14		11	✓	✓	✓	✓	✓	✓	✓	✓								11 x GW/SW
																			Suite
PQL (S)		mg/kg																	0 x Drinking Water Suite
PQL (W)		mg/L																	

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 110170
Date Received: 21.05.14
Time Received: 8.00
Received by: Lina
Temp: [✓ Cool]/Ambient
Cooling: [✓ Ice]/Icepack
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni] [✓ Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 20/5/14
Total number of samples in container: 11
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: 21.05.14 Lab Ref: 110170

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

pg 1 of 2

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 115052
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes: pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO3, HCO3, SO4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	Faecal Coliforms	Phosphorus + Total Metals (16)			TCLP	Notes
RT6	22/5/14	w	1	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
RT3	↓	↓	2	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				Al PQL:
RT2			3	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				0.005 mg/L
RT1			4	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				
RT5			5	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓				Be PQL:
AGE10	21/5/14		6	✓	✓	✓	✓	✓	✓	✓	✓								0.0001 mg/L
B3-D	↓		7	✓	✓	✓	✓	✓	✓	✓	✓								
B3-S			8	✓	✓	✓	✓	✓	✓	✓	✓								Quote
AGE13			9	✓	✓	✓	✓	✓	✓	✓	✓								14S7018
A15			10	✓	✓	✓	✓	✓	✓	✓	✓								
A18			11	✓	✓	✓	✓	✓	✓	✓	✓								
A12	↓	↓	12	✓	✓	✓	✓	✓	✓	✓	✓								
PQL (S)		mg/kg																	
PQL (W)		mg/L																	

ENVIROLAB
Envirolab Services
12 Ashley St
Chatswood NSW 2067
Ph: (02) 9910 6200
Job No: 110321
Date Received: 23.05.14
Time Received: 8.00
Received by: Lora
Temp: [✓ Cool]/Ambient 8.1°
Cooling: [✓ Ice]/Icepack
Security: [✓ Intact]/Broken/None

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni] [✓ Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 22/5/14
Total number of samples in container: 14
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax
Signature:
Date: ~~23~~ 23.05.14 Lab Ref: 110321

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310
Fax: (02) 4960 9601

pg 2 of 2

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CHAIN OF CUSTODY DESPATCH SHEET

Project Name: Bylong
Project No: 49761.03 DP Order No: 115052
DP Contact Person: Angela Peade / Dana Wilson
Prior Storage: [✓ esky] / fridge / freezer / shelved (circle)

To: Envirolab Services PTY LTD
12 Ashley Street
CHATSWOOD NSW 2067
Ph: (02) 9910 6200
Attn: Jacinta Hurst

Sample ID	Date Sampled	Sample Type S-soil W-water	Lab ID	Analytes pH/EC	Cations (Na, K, Ca, Mg)	Anions (Cl, CO_3, HCO_3, SO_4)	NOx	Phosphorus (non filtered)	Ammonia	Metals (16)	Turbidity	Cyanide	E Coli	Faecal Coliforms	Phosphorus Total + Metals (16)			TCLP	Notes
A02-D	21/5/14	W	13	✓	✓	✓	✓	✓	✓	✓	✓								
A20	22/5/14	"	14	✓	✓	✓	✓	✓	✓	✓	✓								Al PQL:
																			0.005 mg/L
																			Be PQL:
																			0.0001 mg/L
																			Quote
																			14SY018
PQL (S)		mg/kg																	
PQL (W)		mg/L																	

PQL = practical quantitation limit *As per Laboratory Method (Detection Limit)
# - Metals to Analyse (Please circle): [✓ As Cd Cr Cu Pb Zn Hg Ni] [✓ Other Al Ba Be Co Fe Mn V Se]
Date relinquished: 22/5/14
Total number of samples in container: 14
Results required by:
TAT (Circle): [✓ Standard] 72 hr 48hr 24hr

SAMPLES RECEIVED
Please sign and date to acknowledge receipt of samples and return by fax

Signature:

Date: Lab Ref:

Send results to:
Douglas Partners Pty Ltd
Address:
BOX 324 Hunter Region Mail Centre
NSW 2310

Fax: (02) 4960 9601

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Rev 6/August 2008

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client:

Douglas Partners Newcastle	ph: 4960 9600
Box 324 Hunter Region Mail Centre	Fax: 4960 9601
Newcastle NSW 2310	

Attention: Angela Peade, Dana Wilson

Sample log in details:

Your reference:	**49761.03, Bylong**
Envirolab Reference:	**103498**
Date received:	15/01/14
Date results expected to be reported:	**22/01/14**

Samples received in appropriate condition for analysis:	YES
No. of samples provided	11 Waters
Turnaround time requested:	Standard
Temperature on receipt (°C)	1.8
Cooling Method:	Ice
Sampling Date Provided:	

Comments:

Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples.

Contact details:

Please direct any queries to Aileen Hie or Jacinta Hurst
ph: 02 9910 6200 fax: 02 9910 6201
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client:

Douglas Partners Newcastle	ph: 4960 9600
Box 324 Hunter Region Mail Centre	Fax: 4960 9601
Newcastle NSW 2310	

Attention: Angela Peade, Dana Wilson

Sample log in details:

Your reference:	**49761.03, Bylong**
Envirolab Reference:	**103686**
Date received:	17/01/2014
Date results expected to be reported:	**28/01/14**

Samples received in appropriate condition for analysis:	YES
No. of samples provided	15 Waters
Turnaround time requested:	Standard
Temperature on receipt (°C)	6.6
Cooling Method:	Ice
Sampling Date Provided:	

Comments:

Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples.

Contact details:

Please direct any queries to Aileen Hie or Jacinta Hurst
ph: 02 9910 6200 fax: 02 9910 6201
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client:

Douglas Partners Newcastle	ph: 4960 9600
Box 324 Hunter Region Mail Centre	Fax: 4960 9601
Newcastle NSW 2310	

Attention: Angela Peade, Dana Wilson

Sample log in details:

Your reference:	**49761.03, Bylong**
Envirolab Reference:	**105282**
Date received:	19/02/14
Date results expected to be reported:	**26/02/14**

Samples received in appropriate condition for analysis:	YES
No. of samples provided	12 Waters
Turnaround time requested:	Standard
Temperature on receipt (°C)	1.4
Cooling Method:	Ice
Sampling Date Provided:	

Comments:

Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples.

Contact details:

Please direct any queries to Aileen Hie or Jacinta Hurst
ph: 02 9910 6200 fax: 02 9910 6201
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client:

Douglas Partners Newcastle
Box 324 Hunter Region Mail Centre
Newcastle NSW 2310

ph: 4960 9600
Fax: 4960 9601

Attention: Angela Peade, Dana Wilson

Sample log in details:

Your reference:	**49761.03, Bylong**
Envirolab Reference:	**105433**
Date received:	19/02/14
Date results expected to be reported:	**4/03/14**

Samples received in appropriate condition for analysis:	YES
No. of samples provided	14 Waters
Turnaround time requested:	Standard
Temperature on receipt (°C)	5.2
Cooling Method:	Ice
Sampling Date Provided:	

Comments:

Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples.

Contact details:

Please direct any queries to Aileen Hie or Jacinta Hurst
ph: 02 9910 6200 fax: 02 9910 6201
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client:

Douglas Partners Newcastle	ph: 4960 9600
Box 324 Hunter Region Mail Centre	Fax: 4960 9601
Newcastle NSW 2310	

Attention: Angela Peade, Dana Wilson

Sample log in details:

Your reference:	**49761.03, Bylong**
Envirolab Reference:	**106730**
Date received:	19/03/14
Date results expected to be reported:	**26/03/14**

Samples received in appropriate condition for analysis:	YES
No. of samples provided	9 Waters
Turnaround time requested:	Standard
Temperature on receipt (°C)	8.0
Cooling Method:	Ice
Sampling Date Provided:	

Comments:

Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples.

Contact details:

Please direct any queries to Aileen Hie or Jacinta Hurst
ph: 02 9910 6200 fax: 02 9910 6201
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au

ENVIROLAB SERVICES

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client:

Douglas Partners Newcastle	ph: 4960 9600
Box 324 Hunter Region Mail Centre	Fax: 4960 9601
Newcastle NSW 2310	

Attention: Angela Peade, Dana Wilson

Sample log in details:

Your reference:	**49761.03, Bylong**
Envirolab Reference:	**106867**
Date received:	21/03/14
Date results expected to be reported:	**28/03/14**

Samples received in appropriate condition for analysis:	YES
No. of samples provided	17 Waters
Turnaround time requested:	Standard
Temperature on receipt (°C)	4.7
Cooling Method:	Ice Pack
Sampling Date Provided:	

Comments:

Samples will be held for 1 month for water samples and 2 months for soil samples from date of receipt of samples.

no micro jar for D48

Contact details:

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ph: 02 9910 6200 fax: 02 9910 6201
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au

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SAMPLE RECEIPT ADVICE

Client:

Douglas Partners Newcastle	ph: 4960 9600
Box 324 Hunter Region Mail Centre	Fax: 4960 9601
Newcastle NSW 2310	

Attention: Angela Peade, Dana Wilson

Sample log in details:

Your reference:	**49761.03, Bylong**
Envirolab Reference:	**108220**
Date received:	15/04/2014
Date results expected to be reported:	**24/04/14**

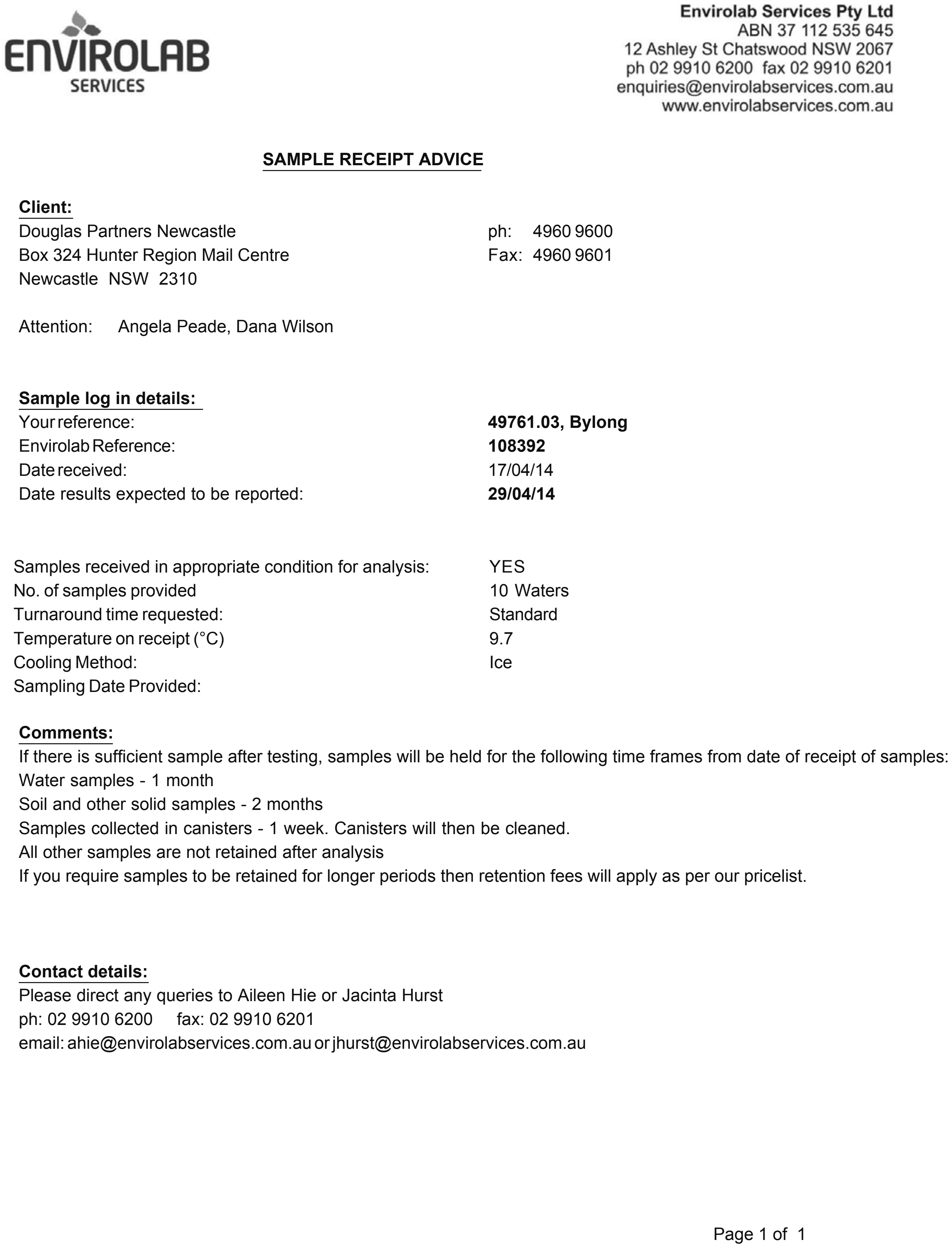
Samples received in appropriate condition for analysis:	YES
No. of samples provided	16 Waters
Turnaround time requested:	Standard
Temperature on receipt (°C)	12.0
Cooling Method:	Ice Pack
Sampling Date Provided:	

Comments:

If there is sufficient sample after testing, samples will be held for the following time frames from date of receipt of samples:
Water samples - 1 month
Soil and other solid samples - 2 months
Samples collected in canisters - 1 week. Canisters will then be cleaned.
All other samples are not retained after analysis
If you require samples to be retained for longer periods then retention fees will apply as per our pricelist.

Contact details:

Please direct any queries to Aileen Hie or Jacinta Hurst
ph: 02 9910 6200 fax: 02 9910 6201
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au



Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
enquiries@envirolabservices.com.au
www.envirolabservices.com.au

SAMPLE RECEIPT ADVICE

Client:
Douglas Partners Newcastle ph: 4960 9600
Box 324 Hunter Region Mail Centre Fax: 4960 9601
Newcastle NSW 2310

Attention: Angela Peade, Dana Wilson

Sample log in details:
Your reference: **49761.03, Bylong**
Envirolab Reference: **108392**
Date received: 17/04/14
Date results expected to be reported: **29/04/14**

Samples received in appropriate condition for analysis: YES
No. of samples provided 10 Waters
Turnaround time requested: Standard
Temperature on receipt (°C) 9.7
Cooling Method: Ice
Sampling Date Provided:

Comments:
If there is sufficient sample after testing, samples will be held for the following time frames from date of receipt of samples:
Water samples - 1 month
Soil and other solid samples - 2 months
Samples collected in canisters - 1 week. Canisters will then be cleaned.
All other samples are not retained after analysis
If you require samples to be retained for longer periods then retention fees will apply as per our pricelist.

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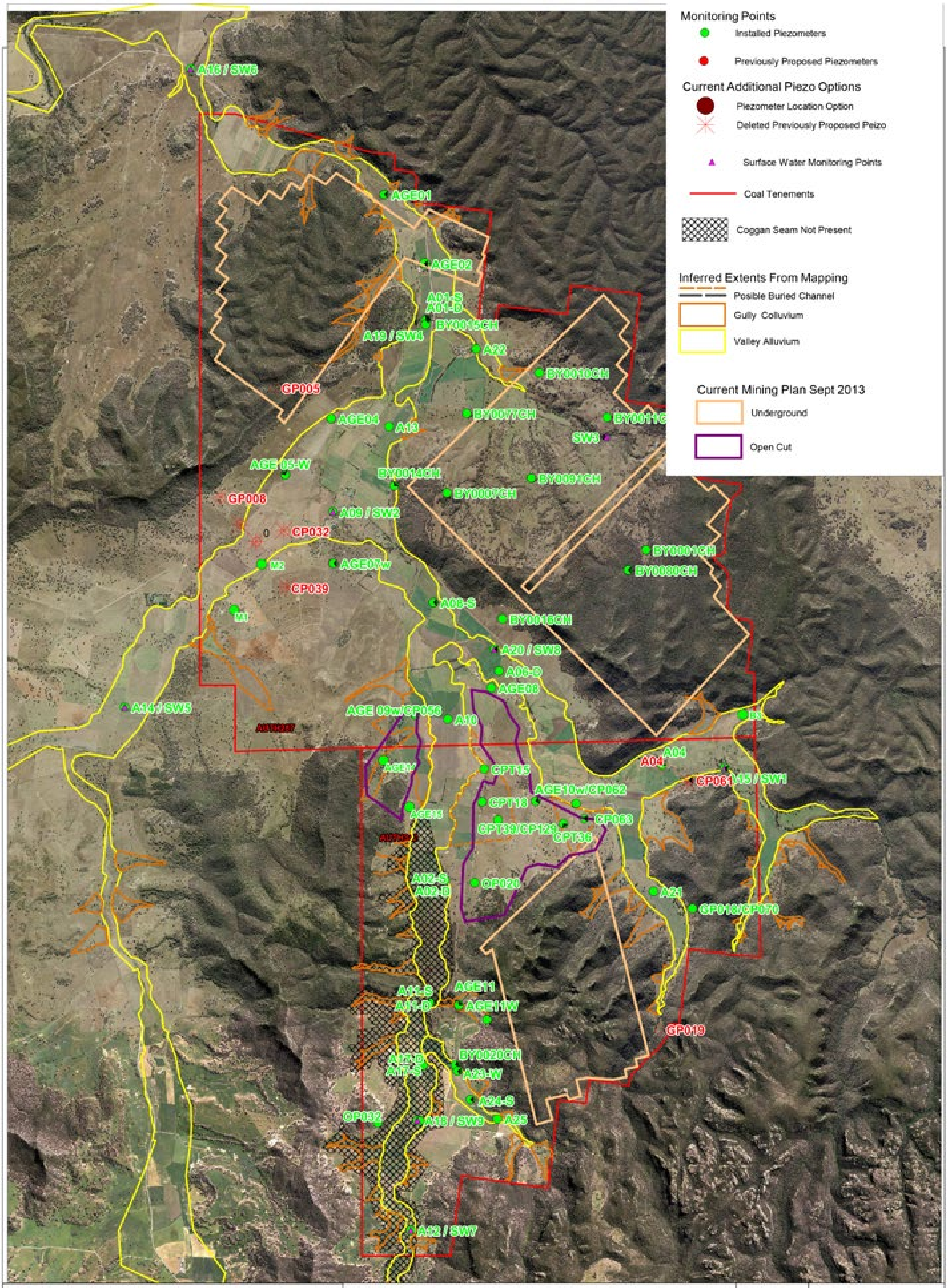
email: ahie@envirolabservices.com.au or jhurst@envirolabservices.com.au

Appendix E

Drawing 1 – Piezometer Installation Status



Douglas Partners
Geotechnics / Environment / Groundwater

TITLE: Piezometer Installation Status
Proposed Coal Mine
Bylong, Central Western NSW

OFFICE: Newcastle
DRAWN BY: DEW
DATE: 28.01.14

CLIENT: Cockatoo Coal Limited
PROJECT No: 49761.03
DRAWING No: 1
REVISION: 6
SCALE: 1:50,000 @ A3

Appendix C

Bore Surveying Results

Point ID	Easting	Northing	RL	Code	Comments
406120	235445	6404474	317.59	Bore	Borehole with windmill
406122	235460	6404322	320.61	Bore	Borehole with wind mill
406133	233998	6403144	328.27	Bore	Dia150 bore with pressure pump for house
406193	233580	6403979	313.19	Bore	Old windmill at top of metal bore dia150
406195	230457	6403923	300.59	Bore	Dia210 metal bore with windmill
406198	229875	6404628	294.33	Bore	Dia200 steel bore with windmill
406210	231079	6406594	292.14	Bore	Dia150 steel bore, equipped
1605209	230203	6414141	240.25	Bore	Western edge of 150 steel bore
3005027A	235031	6405606	303.92	Bore	Top of dia 150 steel bore
406136	232464	6405451	288.55	Bore hole	Government monitoring bore (blue)
406218	230240	6404918	292.46	Bore hole	Government monitoring bore
406125	235518	6405200	305.96	Well	Well with broken windmill
406150	230342	6405338	287.84	Well	S/e corner wooden well 1.1 x 1.1m
406181	229534	6408923	263.33	Well	Corner 1.3 x 1.2 square concrete well
406182	229535	6408922	263.35	Well	Corner 1.3 x 1.2 square concrete well
406183	229536	6408922	263.34	Well	Corner 1.3 x 1.2 square concrete well
406184	229535	6408923	263.33	Well	Corner 1.3 x 1.2 square concrete well
406194	232474	6405357	288.53	Well	Dia1050 concrete liner with old windmill
406196	230274	6404445	296.78	Well	Dia1220 concrete well with shed
406197	230133	6404536	295.57	Well	Dia1100 concrete well with bore pump
406199	229911	6404926	292.78	Well	Dia1240 concrete well with windmill & pump
406205	230313	6405339	289.77	Well	Dia1200 concrete well
406206	230383	6405803	284.33	Well	Dia1240 concrete well, no structure
406207	230731	6406104	282.49	Well	Dia1240 concrete well, no structure
406208	230278	6406241	281.82	Well	Dia1240 concrete well, no structure
406209	230388	6406436	280.41	Well	Dia1240 concrete well, with pump
406211	230357	6407117	275.53	Well	Dia920 concrete well, feeds crop circle irrigation
406212	230250	6407794	270.88	Well	Dia1240 concrete well, with pump

Point ID	Easting	Northing	RL	Code	Comments
406213	230320	6407962	271.38	Well	Dia1240 concrete well, with pump
406214	230145	6408124	269.23	Well	Dia1240 concrete well, equipped
406215	230086	6408260	267.75	Well	Dia1240 concrete well, equipped
406216	229215	6409381	263.23	Well	Dia900 concrete well, not used
406217	229213	6409397	261.95	Well	Dia1100 concrete well, not equipped
506108	229761	6398796	341.42	Well	Centre dia1040 concrete well, not equipped
506109	229757	6398799	340.77	Well	Centre 1.1 x 1.1m wooden well, equipped
506116	230168	6400522	325.95	Well	Wooden well with windmill, not used
506117	230111	6401203	321.22	Well	Old 1.1 x 1.1m wooden well, old windmill not used
506118A	229947	6401632	318.32	Well	Dai1240 concrete well. Equipped.
506120	230156	6402333	312.79	Well	Eastern edge dia950 concrete well, equipped
506154A	229689	6409239	261.02	Well	Dia2000, round timber well. Equipped
606112A	229494	6412106	250.18	Well	Dia 1240 concrete well not equipped
1106202	231661	6407062	278.85	Well	Old well 1.1 x 1.1 metres, timber collapsed. Not used. Windmill
1605123	228950	6410171	259.52	Well	Dia1400 concrete well
1605171	229451	6411607	251.74	Well	Dia1350 concrete well
1605234	229412	6411627	251.02	Well	Dia1350 concrete well
1605237	229917	6412463	246.99	Well	Dia1170 concrete well (leaning)
1605240	229893	6412462	246.35	Well	Dia1520 concrete well
1605243	229906	6412479	247.38	Well	Dia1370 concrete well in yard
1605246	230017	6413687	243.16	Well	Dia150 bore at ground level
1605249	229918	6414173	241.19	Well	Dia1350 concrete well
1605252	229935	6414159	241.17	Well	Dia1200 concrete well. (at shed)
1605255	229637	6414579	239.96	Well	Dia1530 concrete well
1605258	230301	6414189	239.88	Well	Dia 1350 concrete well
1605261	230375	6413623	244.36	Well	Dia1350 concrete well with Davey pump
1605264	230312	6413625	244.09	Well	Dia1200 concrete well

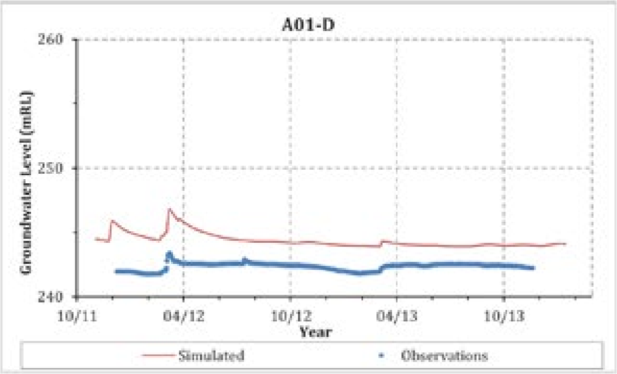
Point ID	Easting	Northing	RL	Code	Comments
1605300	228793	6410252	259.29	Well	Dia1350 concrete well, mesh on top
1605301	229342	6410640	254.23	Well	Dia1350 concrete well
1605302	229098	6411021	253.47	Well	Dia1240 concrete well
1605303	229629	6411252	251.26	Well	Dia1350 concrete well (shed)
3005005	231819	6406930	279.29	Well	N/e 2 x 2 metre wooded well
3005007	232197	6406877	281.42	Well	North side of 1.1 x 1.1 wooded well
3005009	231829	6406587	281.02	Well	N/e corner (1.3 x 1.3m wooden well & bore at leaky dam
3005010	231828	6406586	281.03	Well	N/w corner (1.3 x 1.3m wooden well and bore at leaky dam
3005011	232122	6406120	284.97	Well	Centre of old well fallen in with windmill
3005001A	231366	6407230	276.52	Well	S/e corner wooden well 1.1 x 1.1m
3005014A	233361	6405731	291.91	Well	Dia700 plastic lined well
3005016A	233850	6405593	296.00	Well	Top of dia1050 concrete well liner and windmill
3005018A	234581	6406402	300.33	Well	Top of dia1100 concrete well with windmill
3005020A	233101	6405553	291.90	Well	Dia1240 concrete well with pump
3005022A	233028	6405333	293.44	Well	Dia1500 concrete well with pump
3005028A	235225	6405512	303.69	Well	Dia1200 concrete well, leaning
2305121	228806	6410724	256.29	Well	Dia1350 concrete well
406158	230465	6406251	281.50	Windmill	Western leg of tripod (1.1 x 1.1 wooden well, old windmill, no pump)
406159	230466	6406253	281.53	Windmill	Northern leg of tripod (1.1 x 1.1 wooden well, old windmill, no pump)
406160	230467	6406251	281.23	Windmill	Eastern leg of tripod (1.1 x 1.1 wooden well, old windmill, no pump)
506127	230399	6402498	310.35	Windmill	Windmill leg over old well
506128	230402	6402498	310.27	Windmill	Windmill leg over old well
506129	230400	6402499	310.41	Windmill	Windmill leg over old well
606102	231939	6399509	375.07	Windmill	Western edge of 1.1 x 1.1m wooden well
3005012	231922	6405889	284.44	Windmill	N/e leg of windmill at old well fallen in
3005013	231920	6405888	284.65	Windmill	S/w leg of windmill

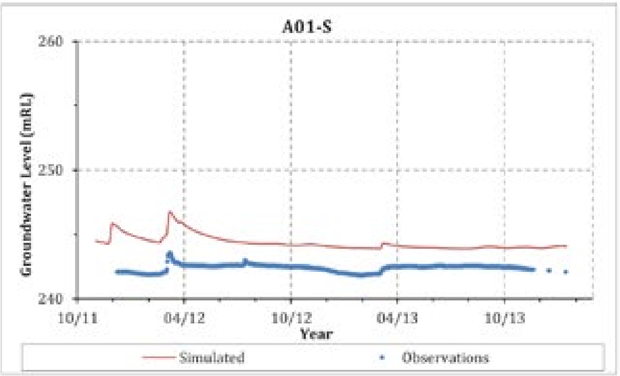
Point ID	Easting	Northing	RL	Code	Comments
3005024	234927	6405775	302.00	Windmill	N/e corner - top of windmill leg
3005025	234927	6405773	302.04	Windmill	S/w corner - top of windmill leg - old timber well
3005003A	231429	6406858	285.79	Windmill	Either side of windmill at base, bore down 0.75 to top of pipe

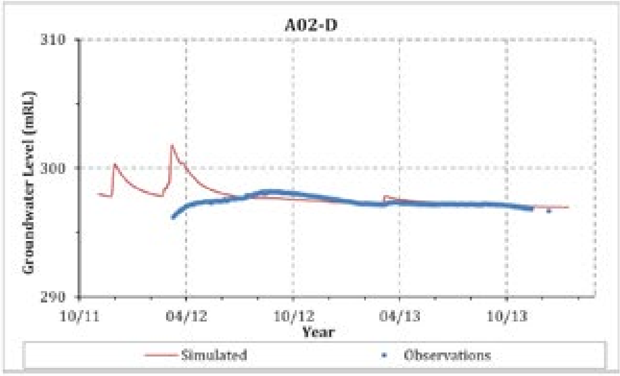
Appendix D

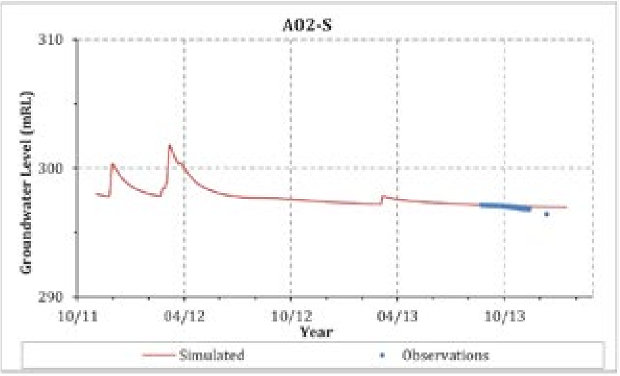
Calibration and Hydrographs

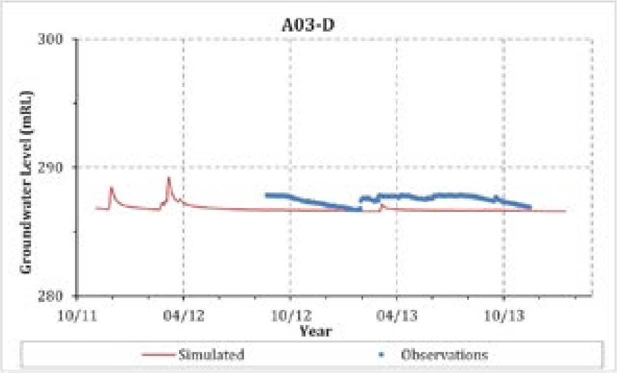
Calibration Hydrographs

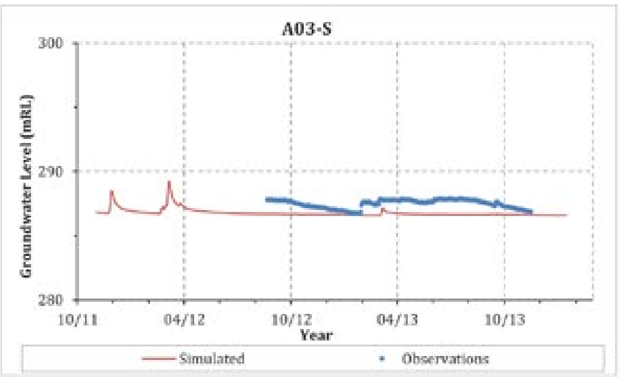


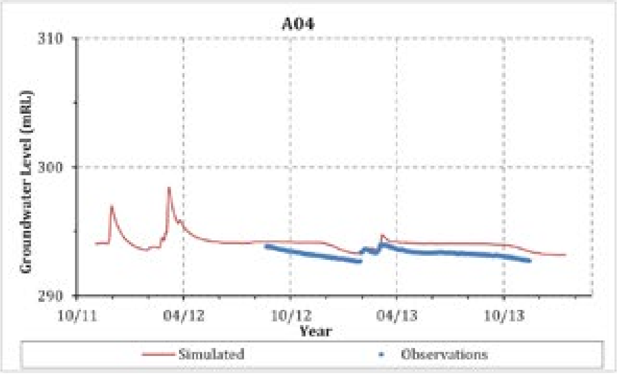


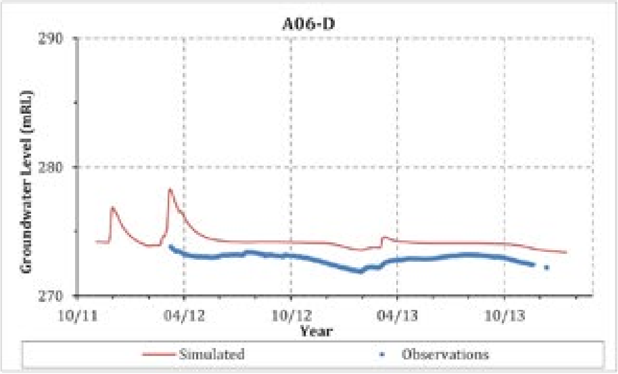


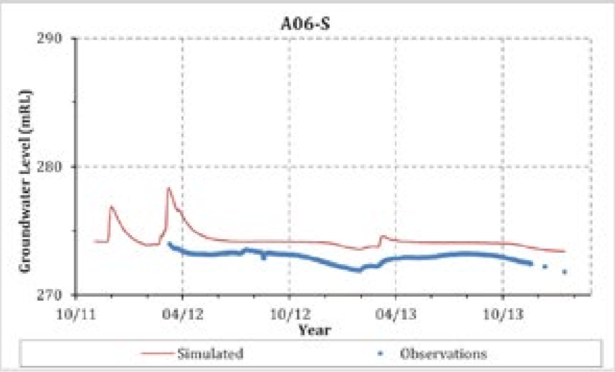








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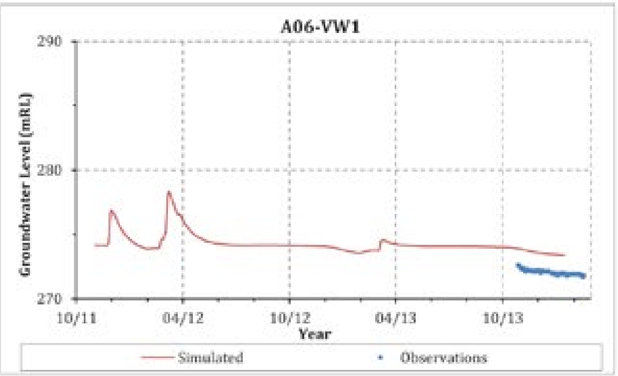
280
270
Groundwater Level (mRL)
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations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270
Groundwater Level (mRL)
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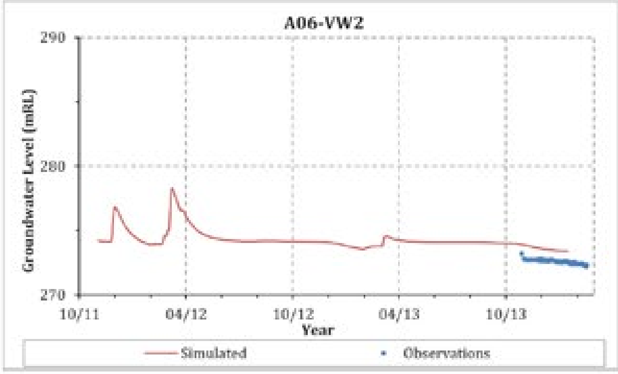
04/12
10/12
04/13
10/13
Year
Simulated
Observations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280
270
Groundwater Level (mRL)
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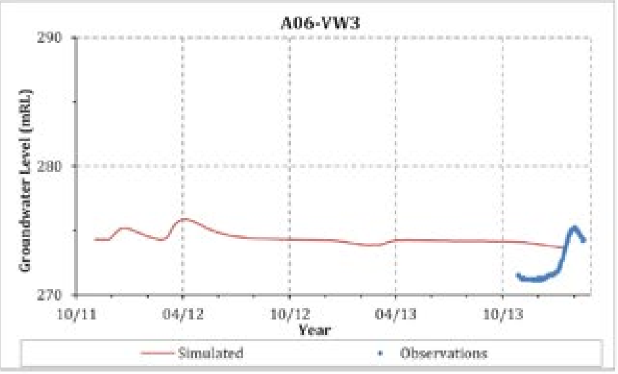
04/12
10/12
04/13
10/13
Year
Simulated
Observations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270
Groundwater Level (mRL)
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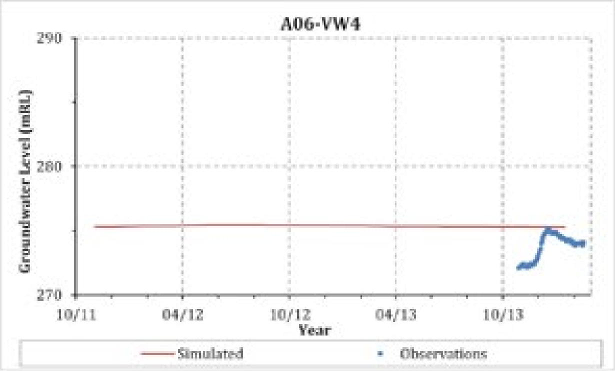
04/12
10/12
04/13
10/13
Year
Simulated
Observations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270
Groundwater Level (mRL)
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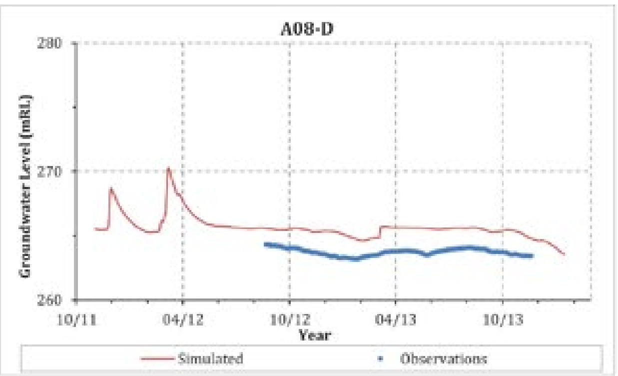
04/12
10/12
04/13
10/13
Year
Simulated
Observations


A08-D
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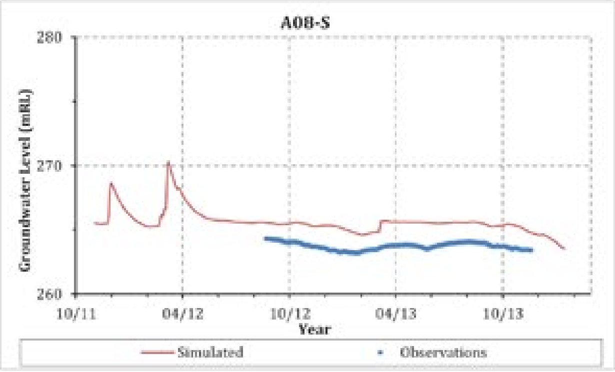
270
260
Groundwater Level (mRL)
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations


A08-S
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270
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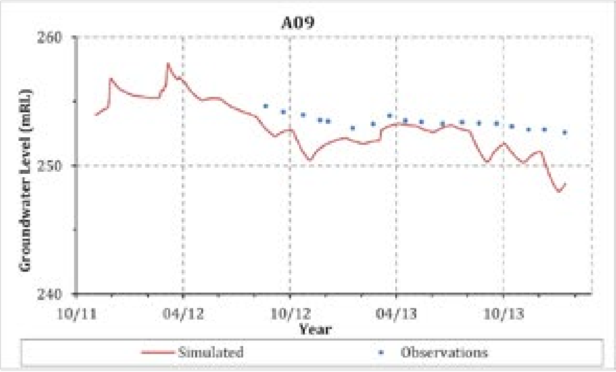
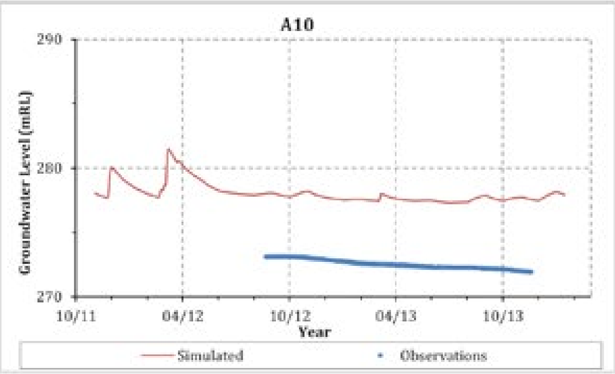
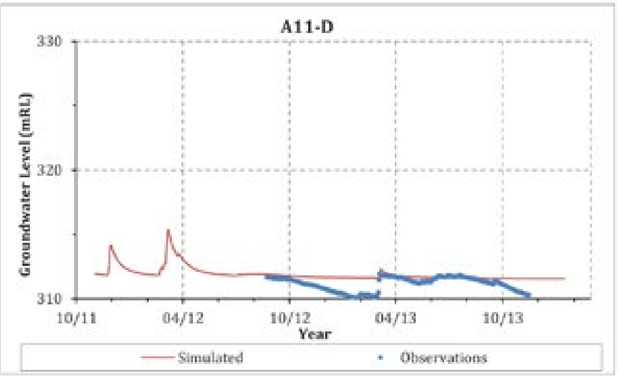
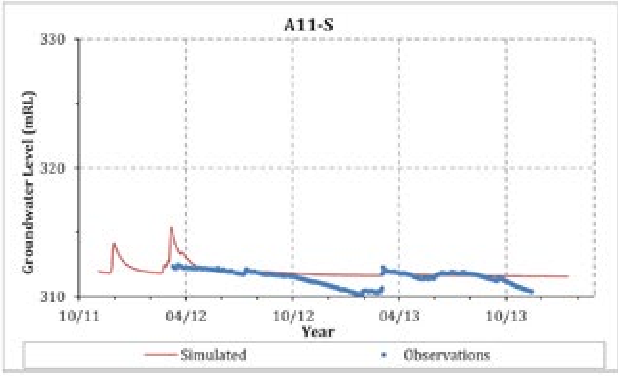
Groundwater Level (mRL)
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations

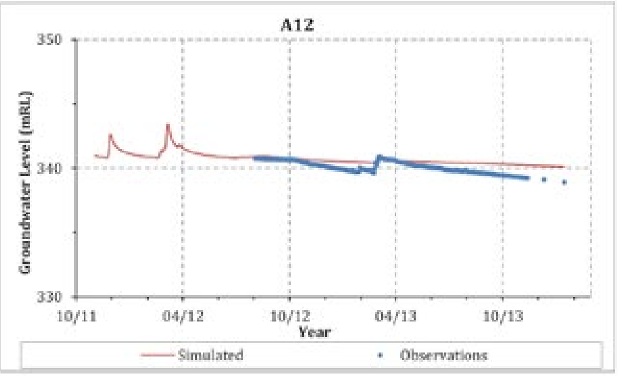

A09
260
250
240
Groundwater Level (mRL)
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations

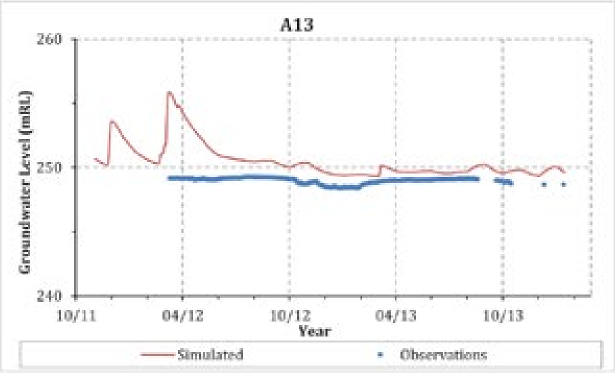
Calibration Hydrographs

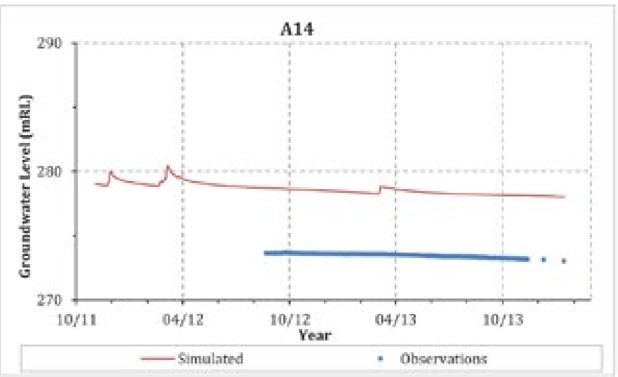


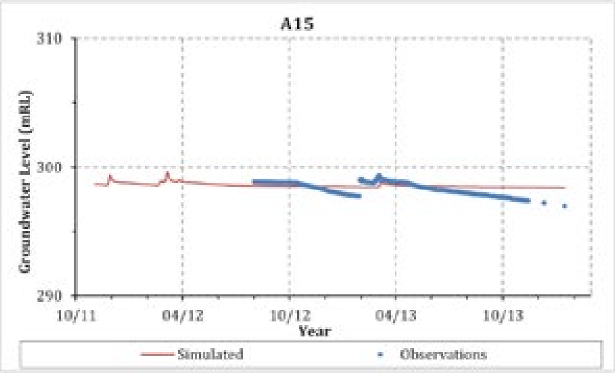


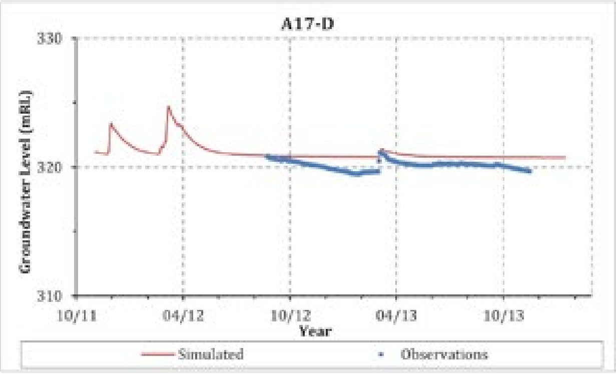




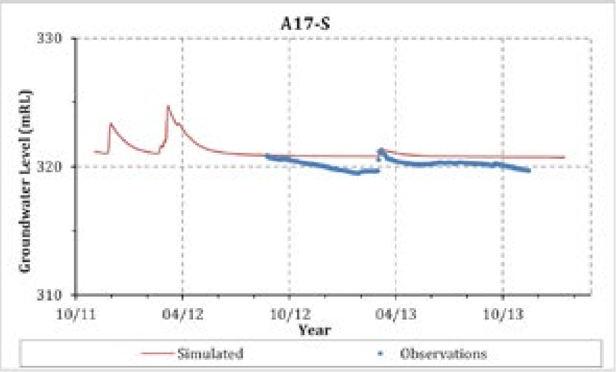


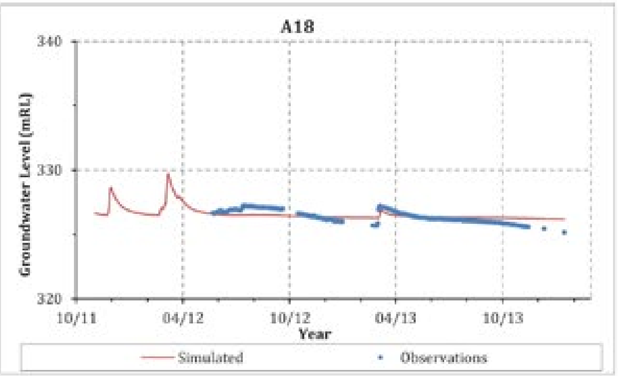


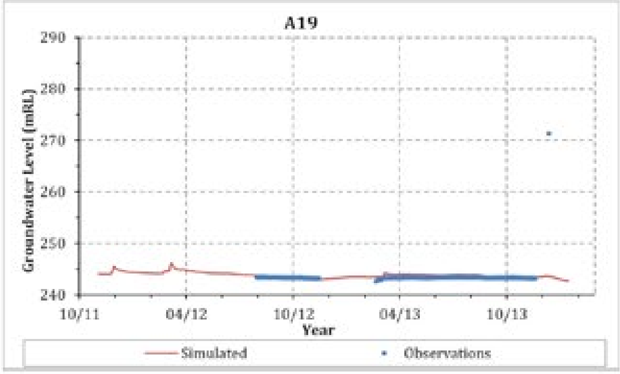


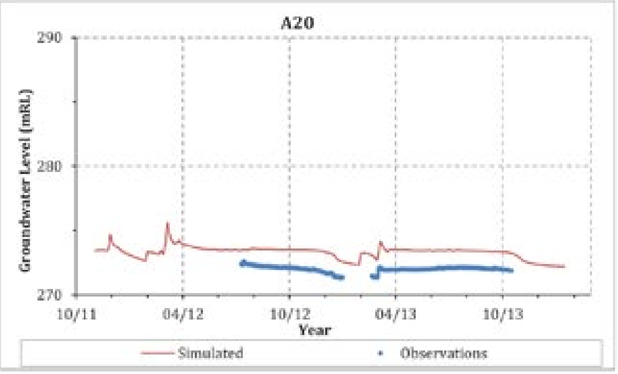


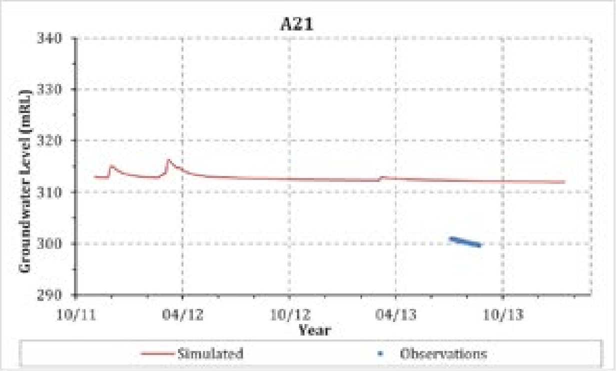
Calibration Hydrographs

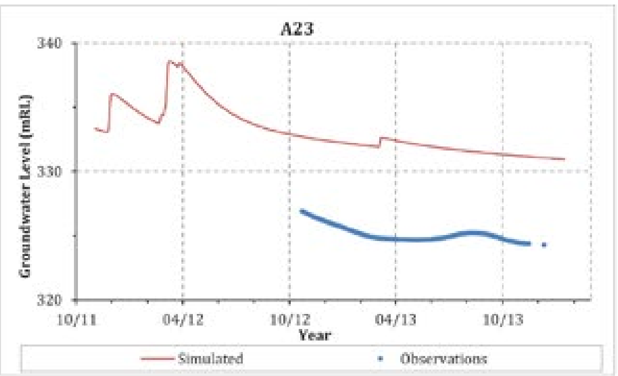


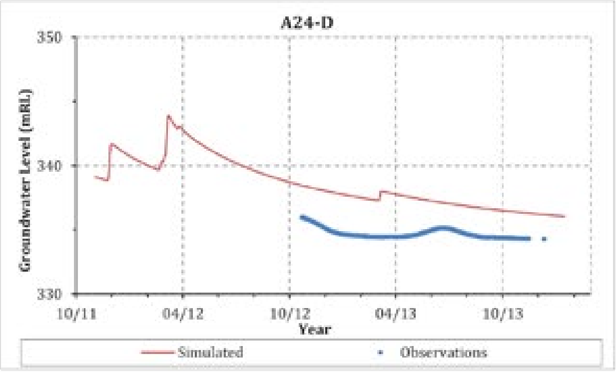




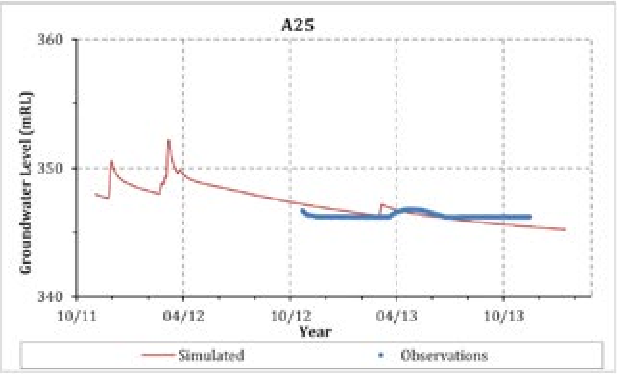


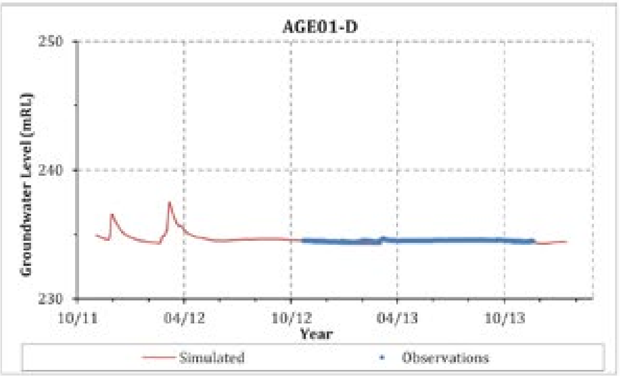


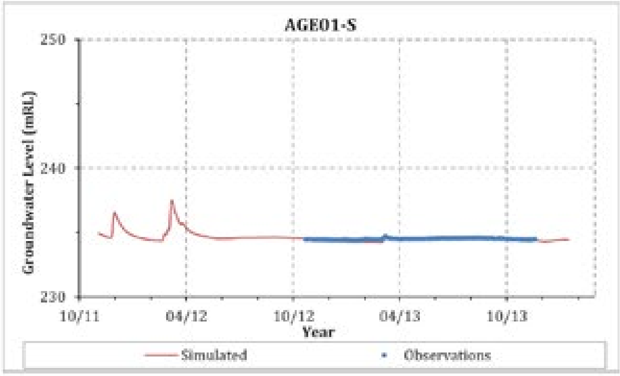


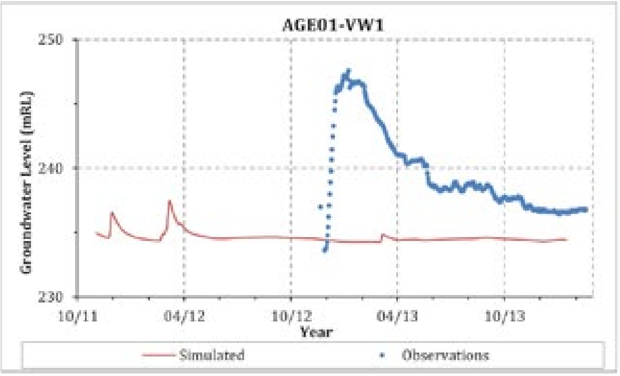


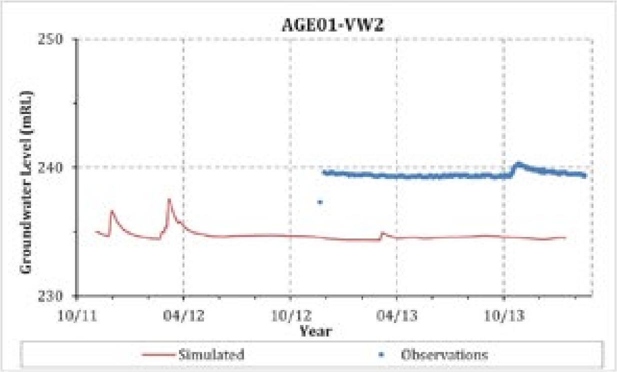
Calibration Hydrographs

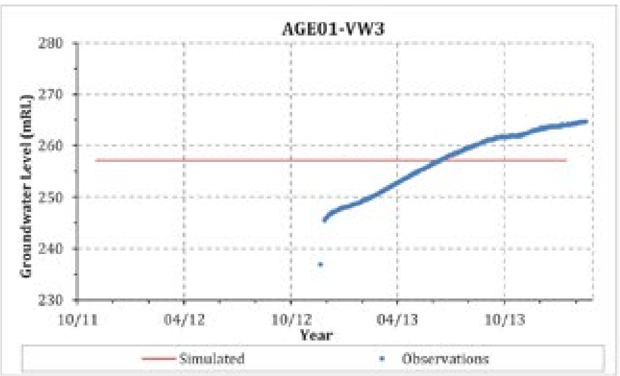


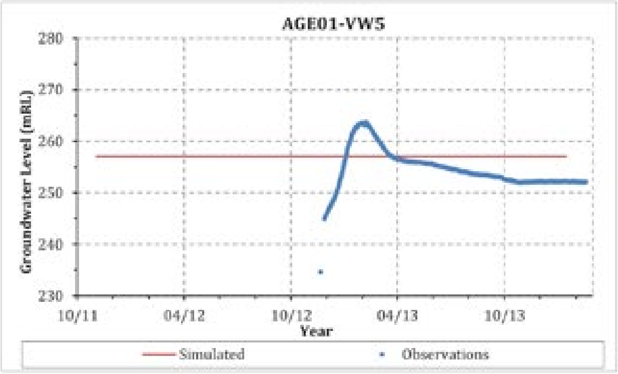




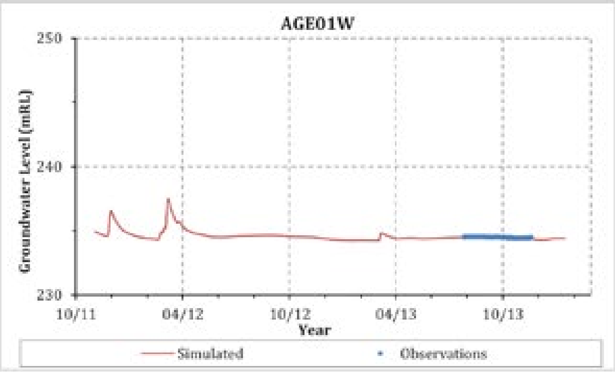


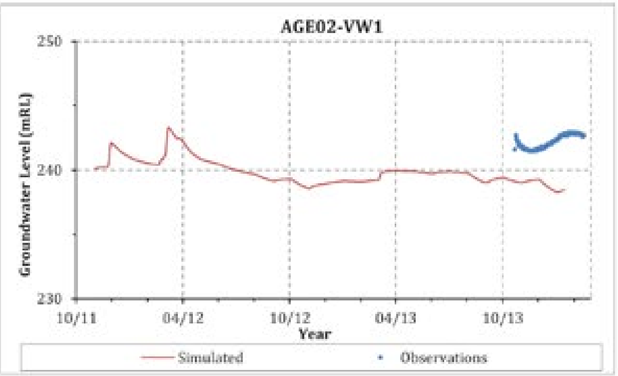


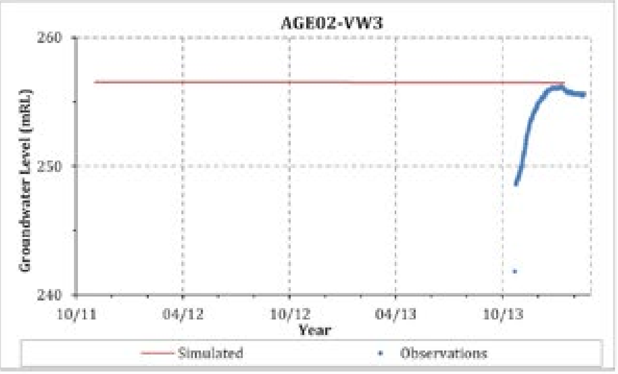


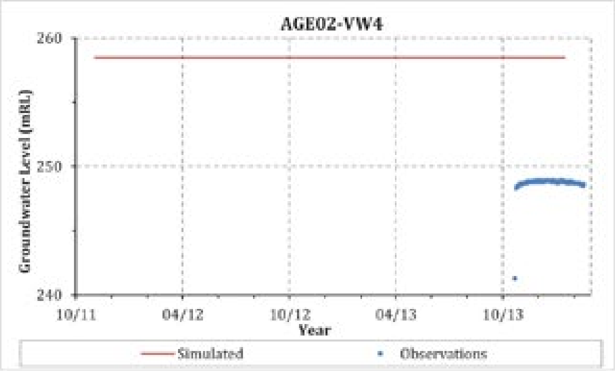


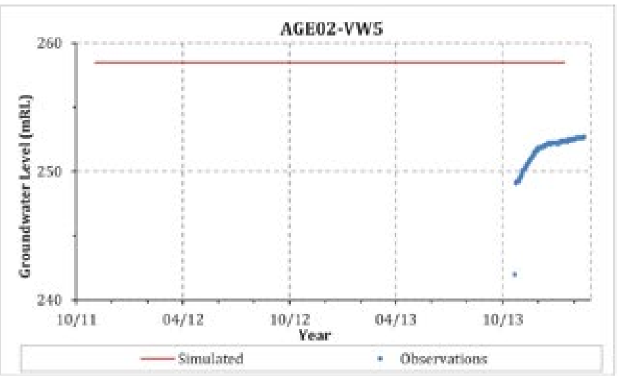
Calibration Hydrographs

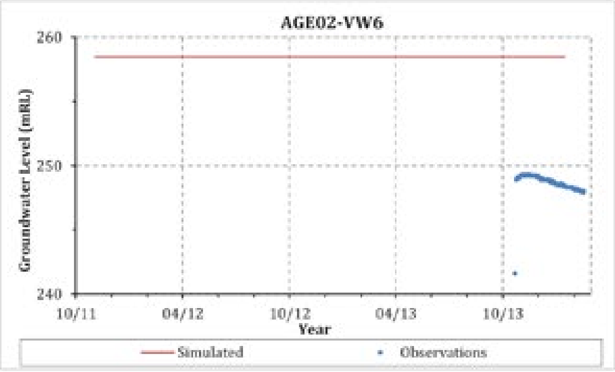


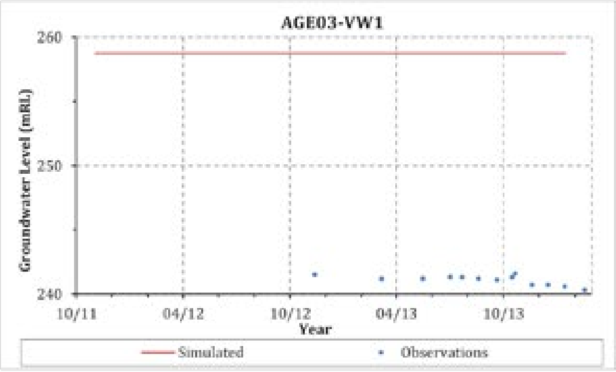


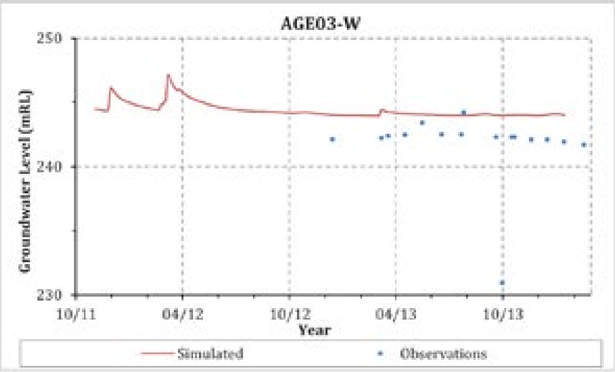


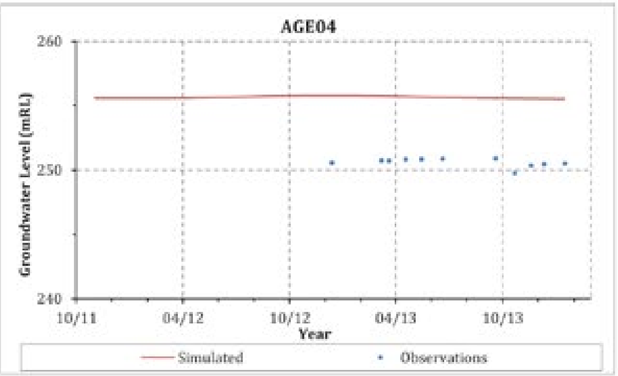


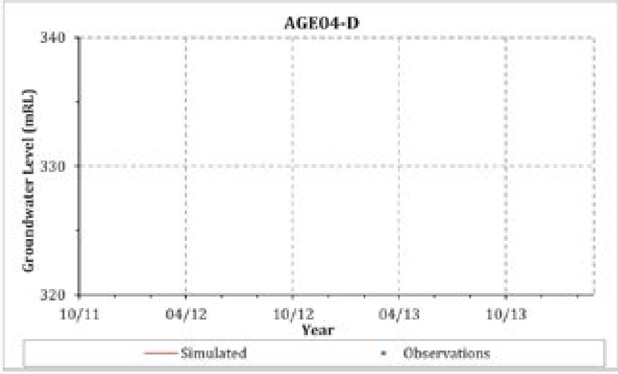







AGE03-W
Groundwater Level (mRL)
250
240
230
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations


AGE04
Groundwater Level (mRL)
260
250
240
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations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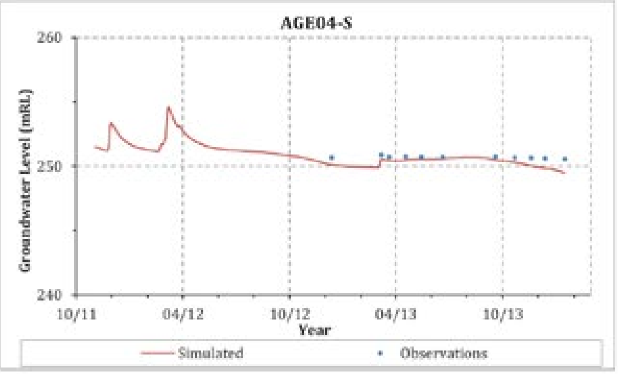
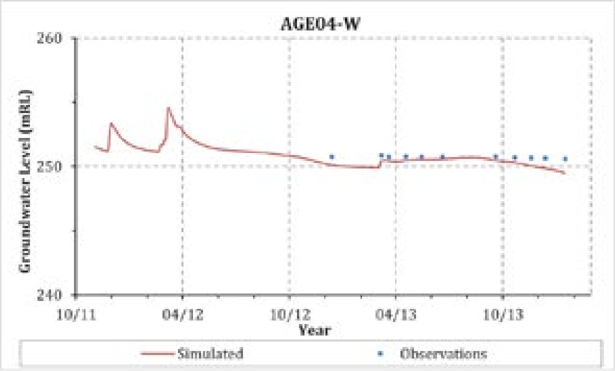
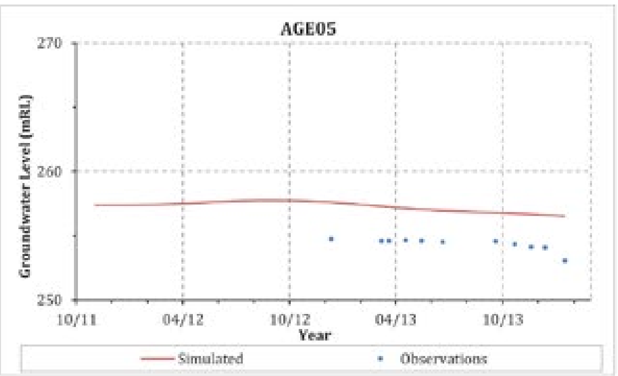
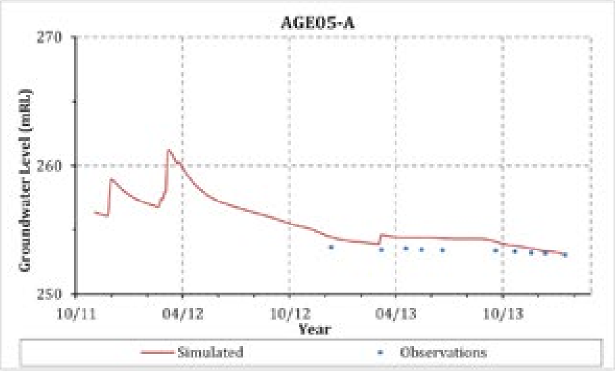
Groundwater Level (mRL)
340
330
320
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations


AGE04-S
Groundwater Level (mRL)
260
250
240
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations


AGE04-W
Groundwater Level (mRL)
260
250
240
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations


AGE05
Groundwater Level (mRL)
270
260
250
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations


AGE05-A
Groundwater Level (mRL)
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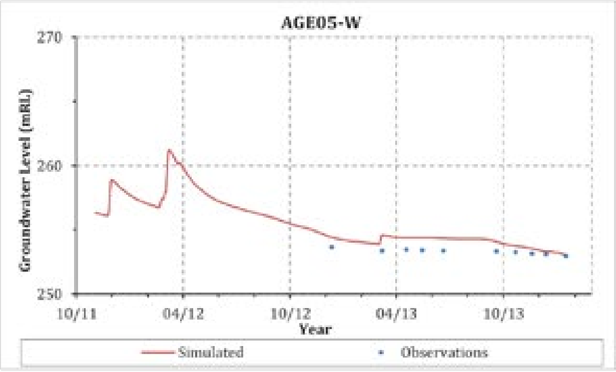
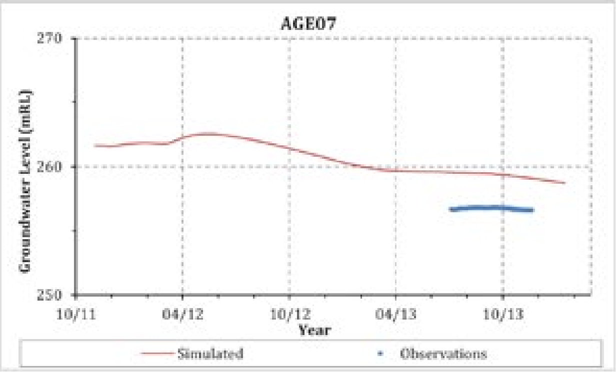
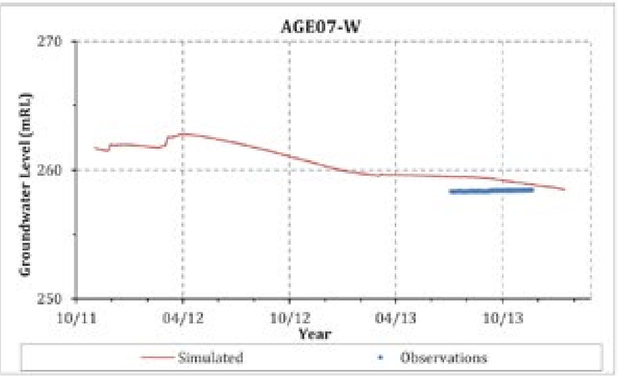
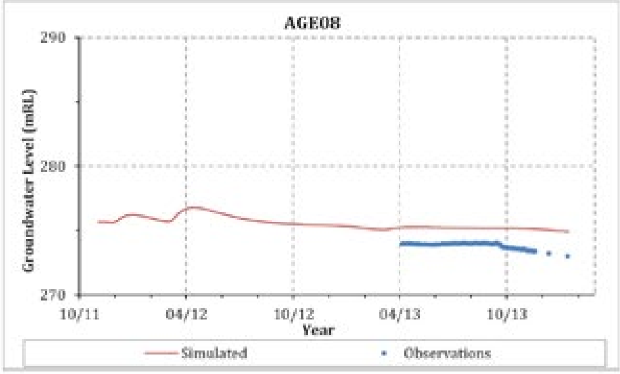
250
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations

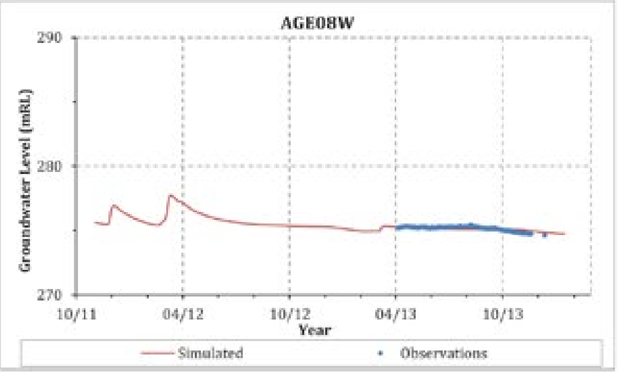

AGE05-W
Groundwater Level (mRL)
270
260
250
10/11
04/12
10/12
04/13
10/13
Year
Simulated
Observations

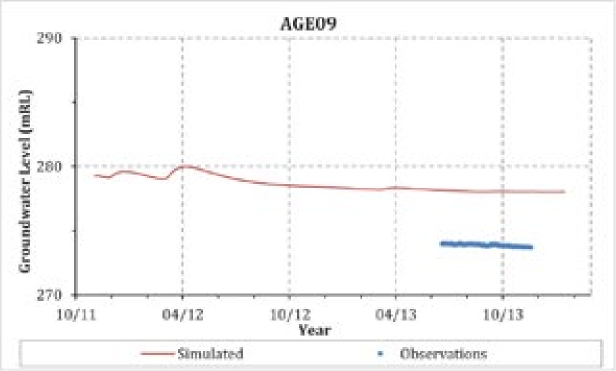
Calibration Hydrographs

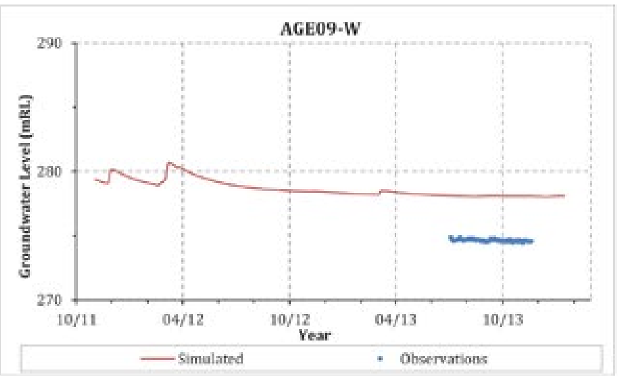


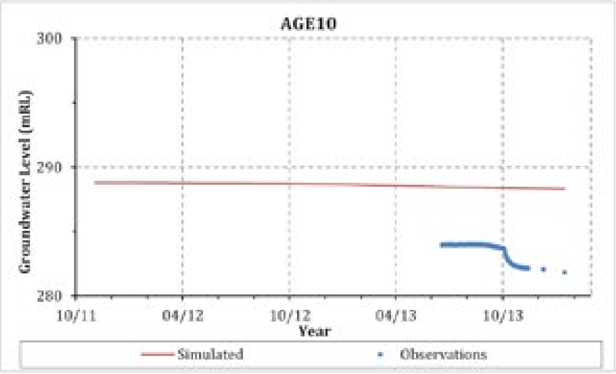


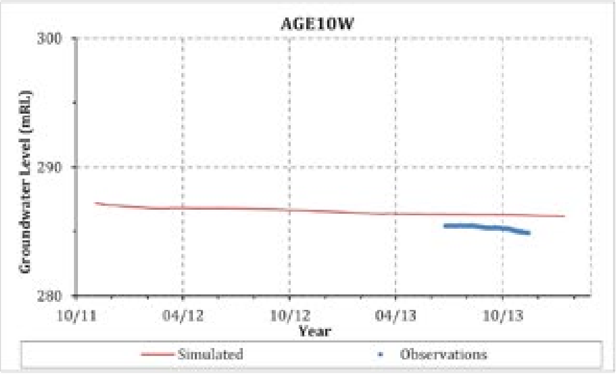




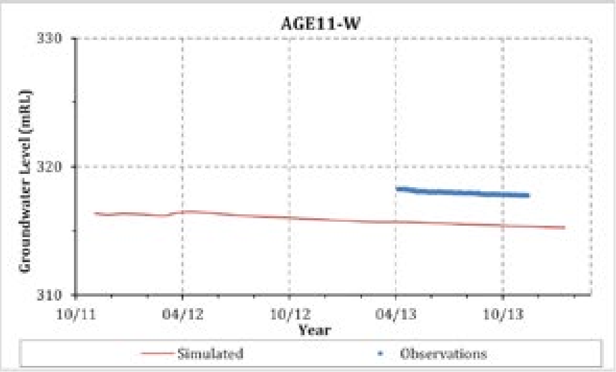


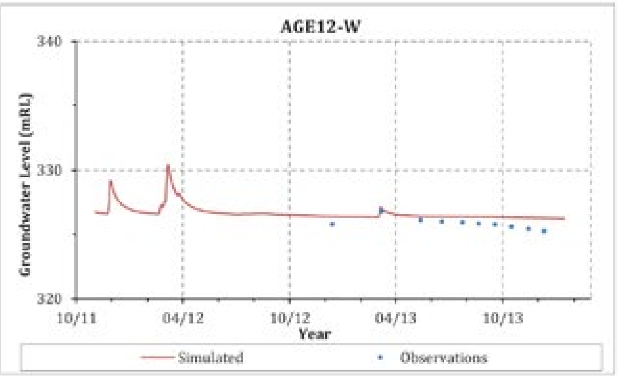


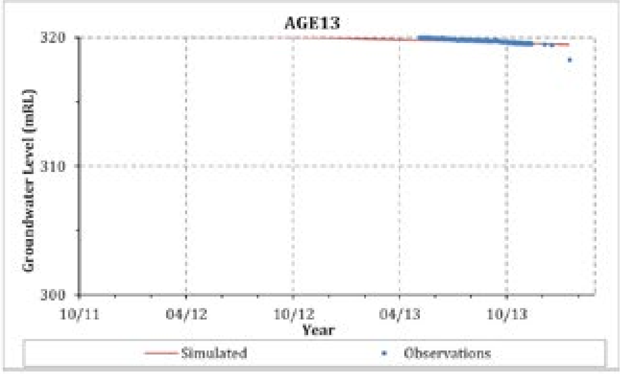


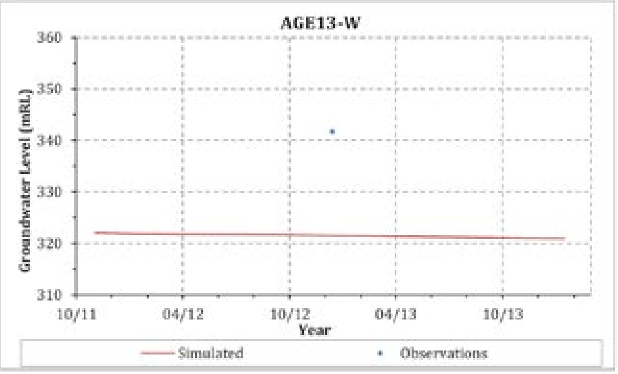


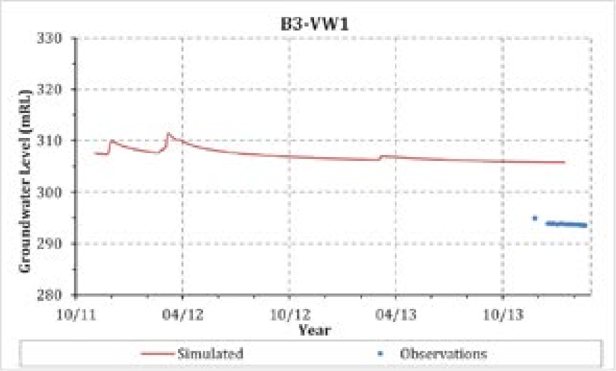
Calibration Hydrographs

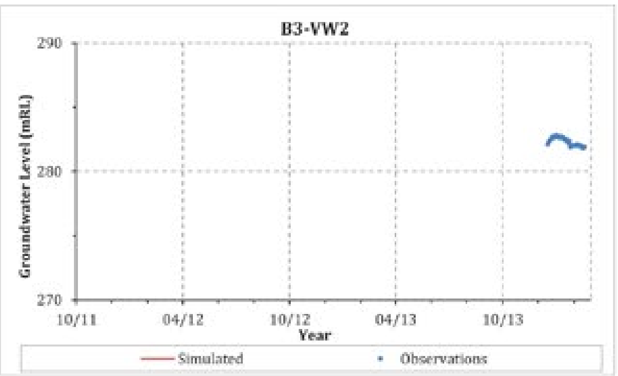


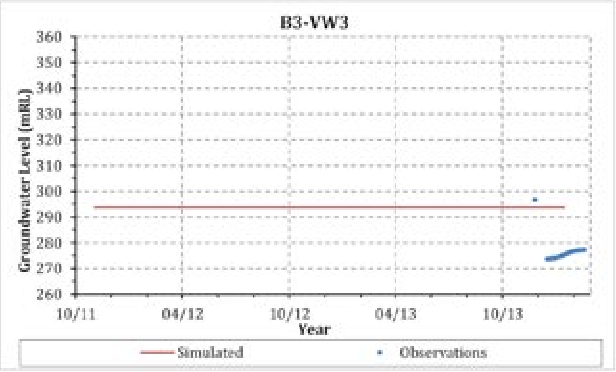


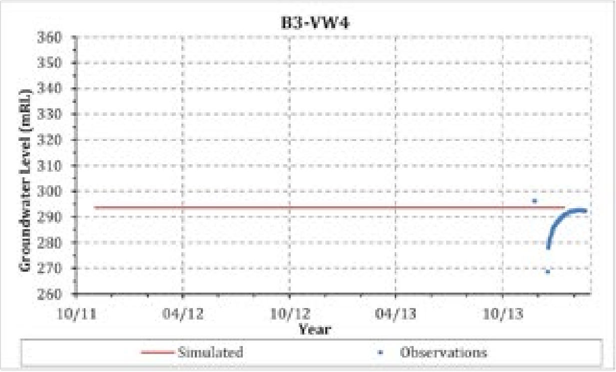




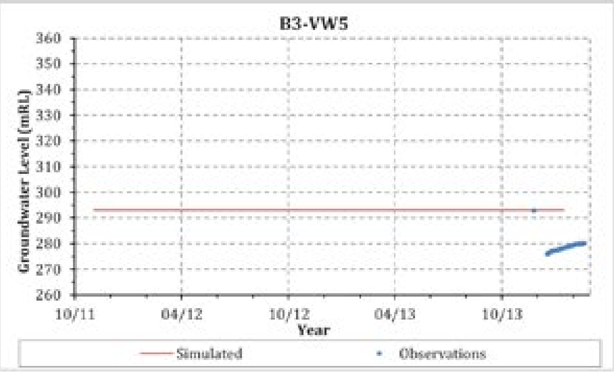


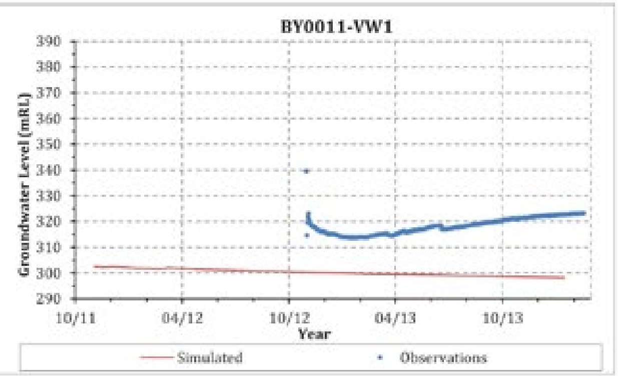


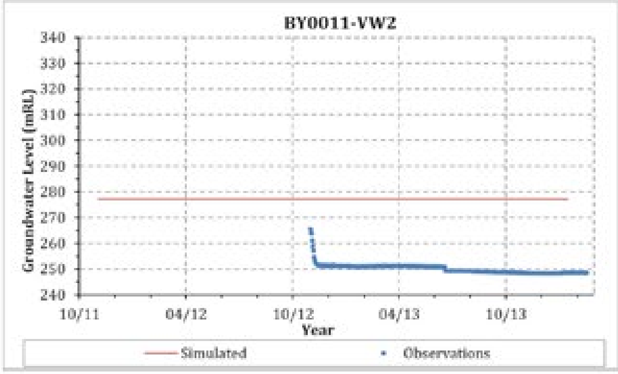


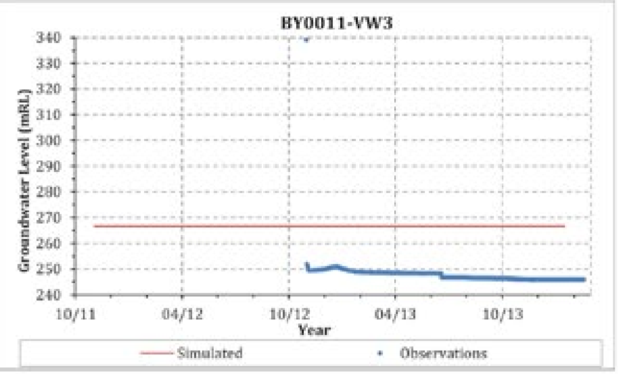


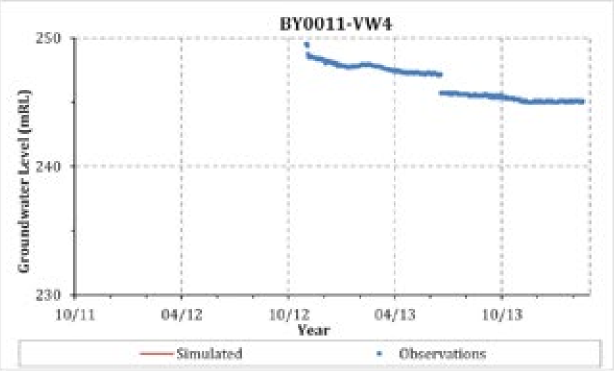
Calibration Hydrographs

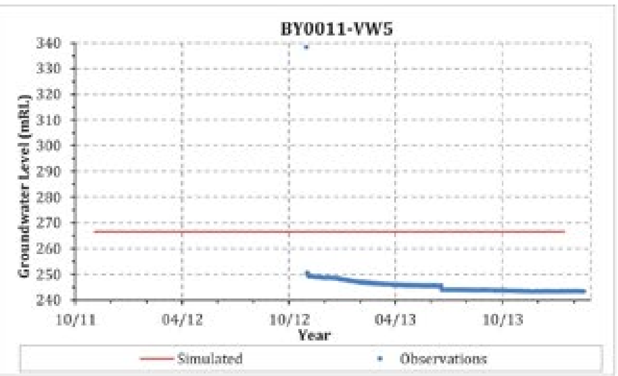


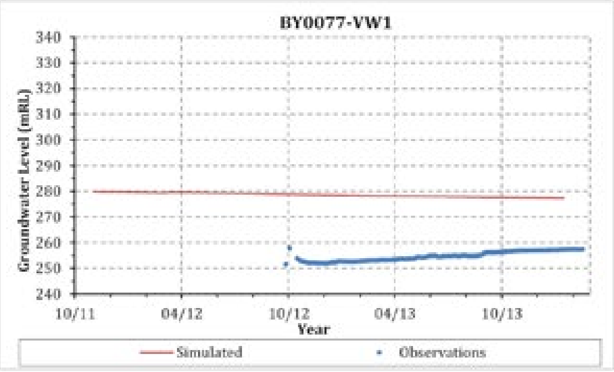


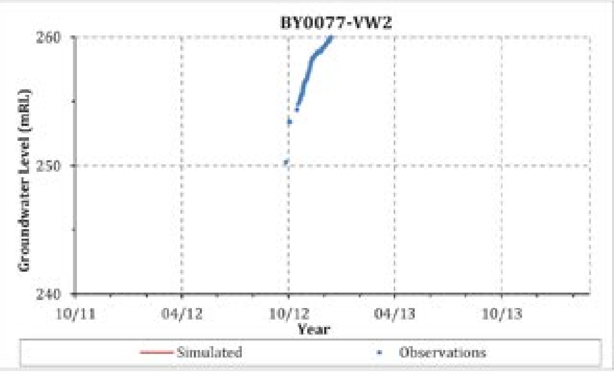




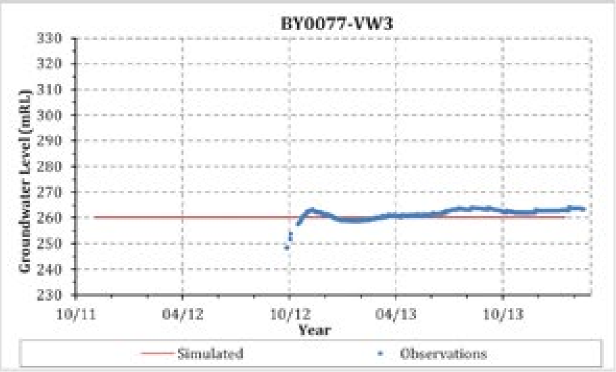


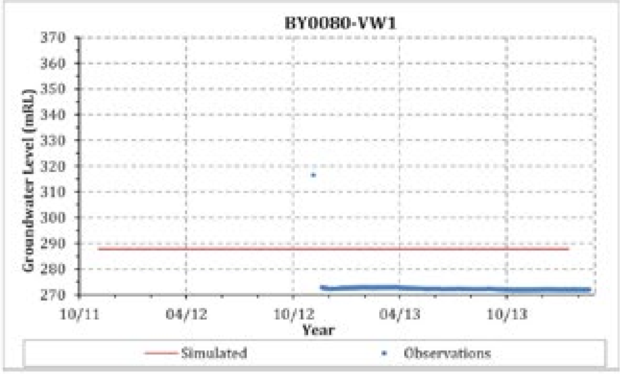


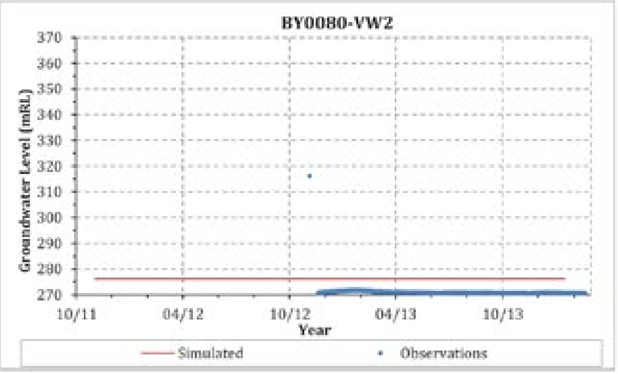


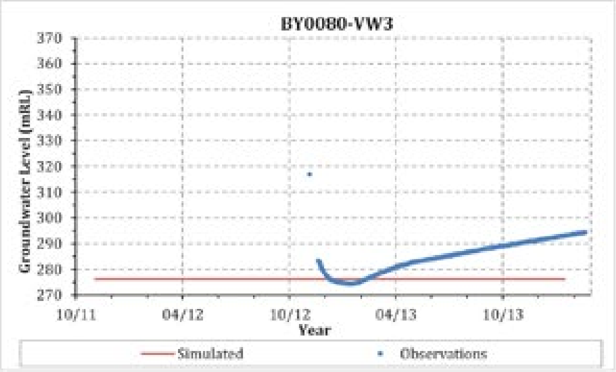


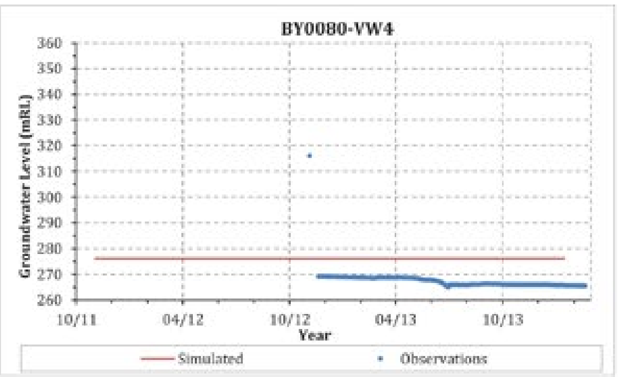
Calibration Hydrographs

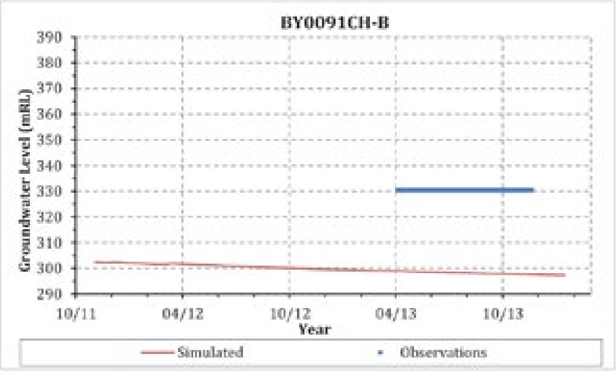


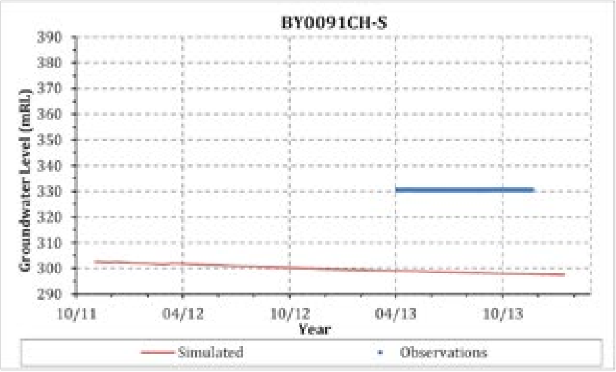




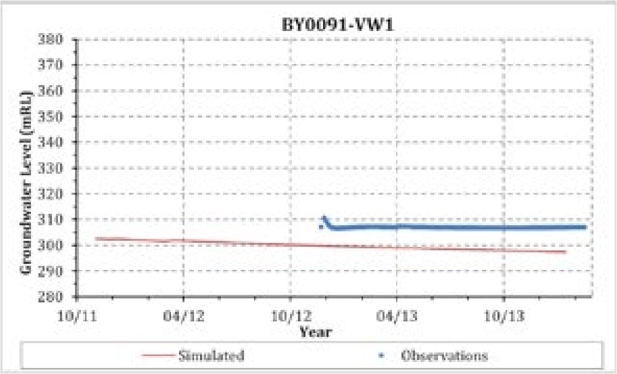


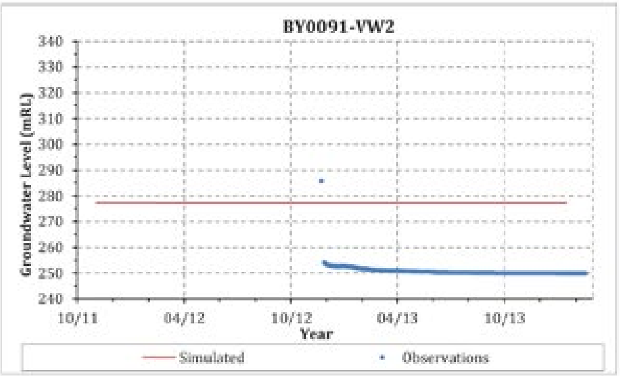


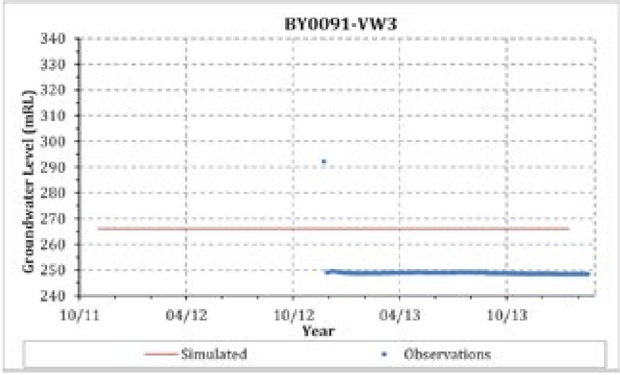


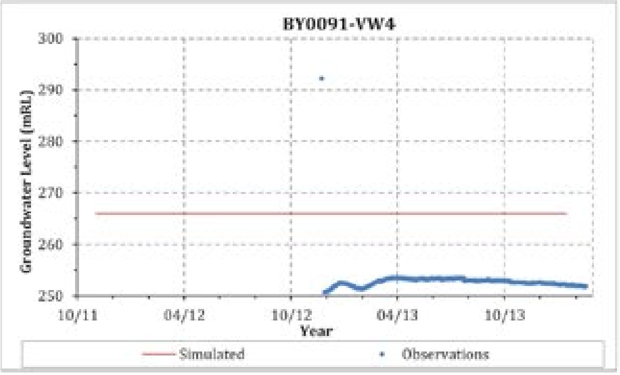


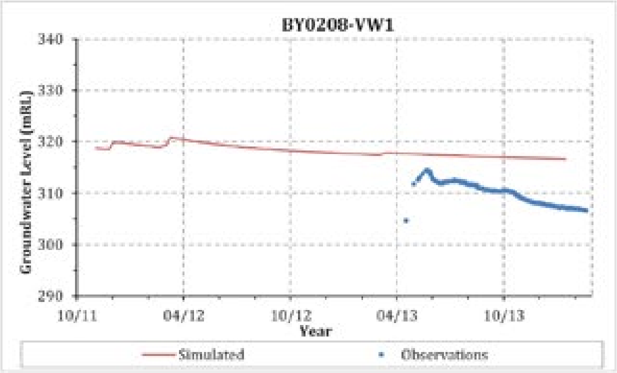
Calibration Hydrographs

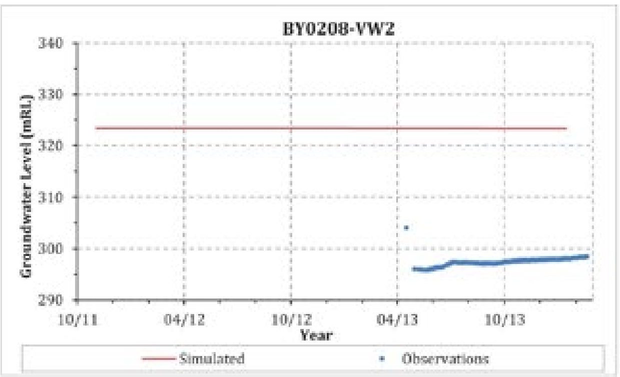


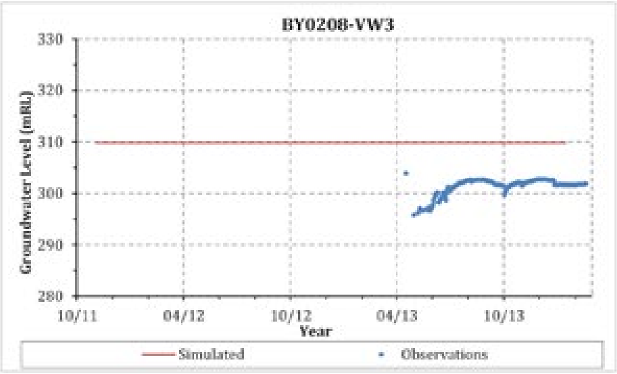


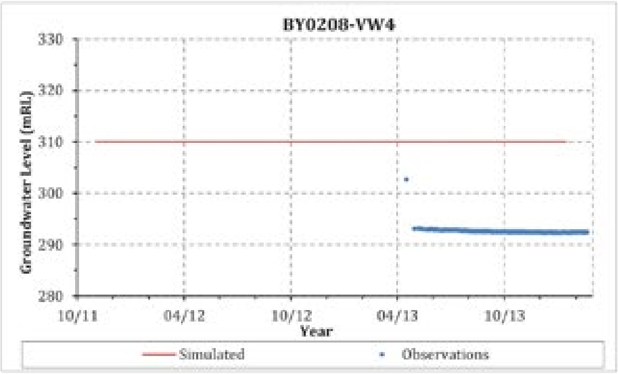




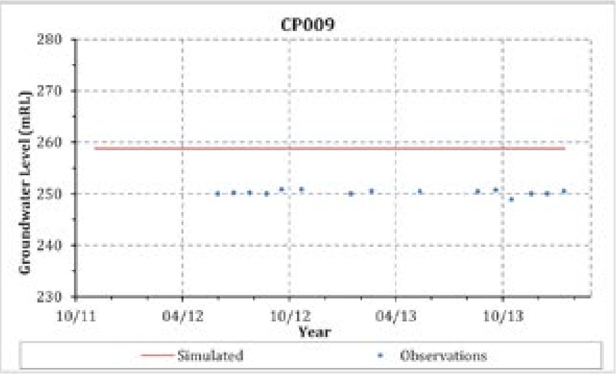


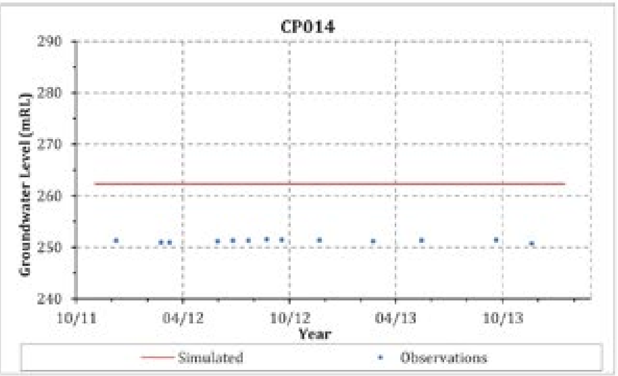


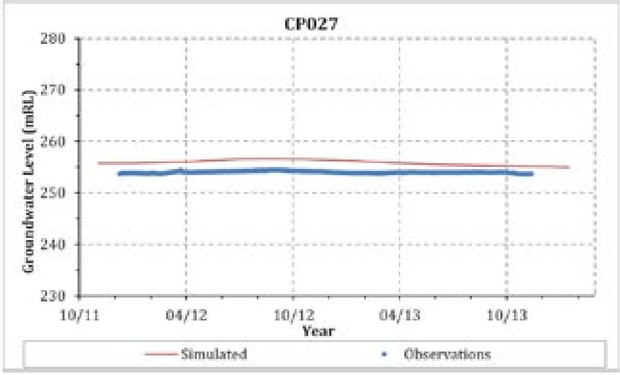


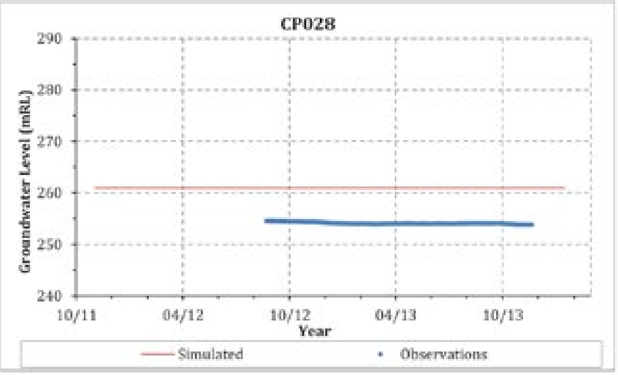


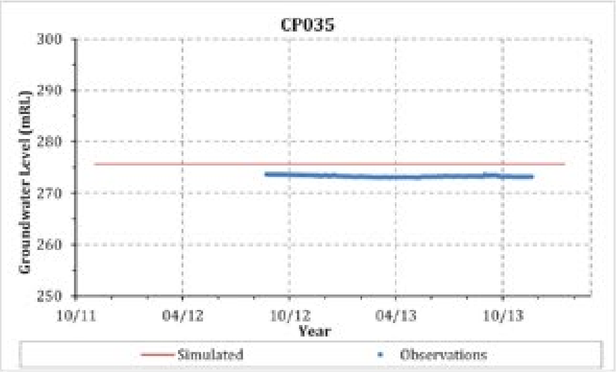
Calibration Hydrographs

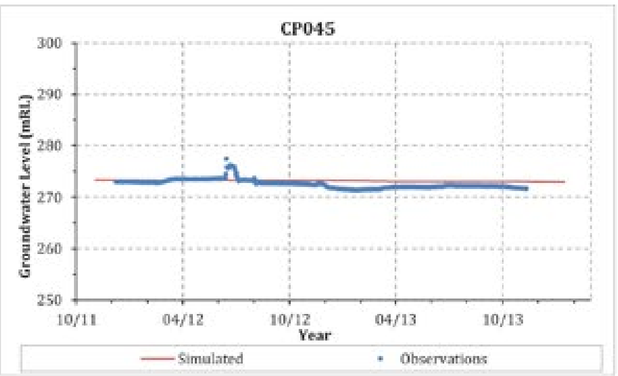


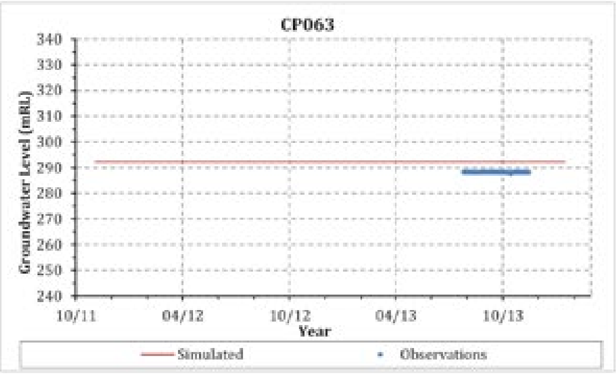


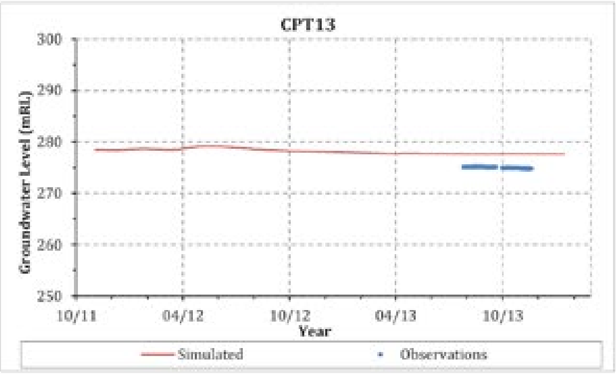




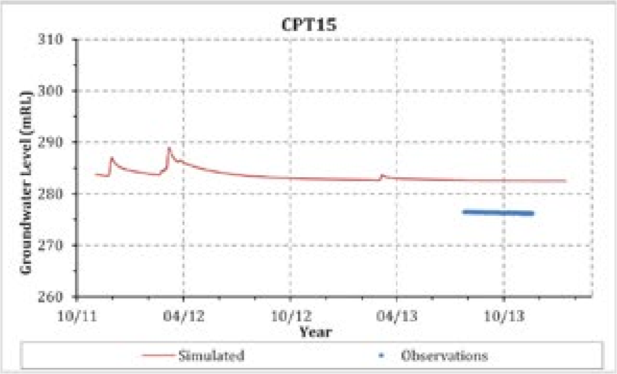


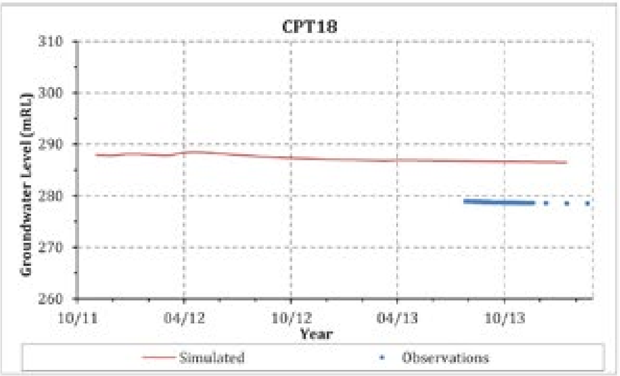


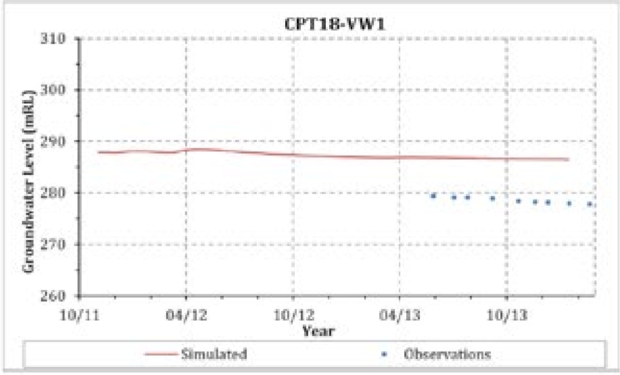


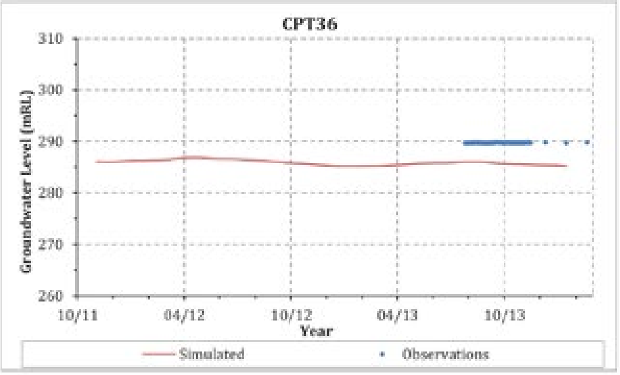


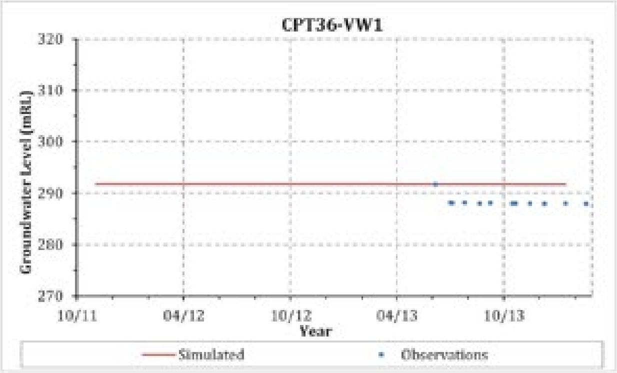
Calibration Hydrographs

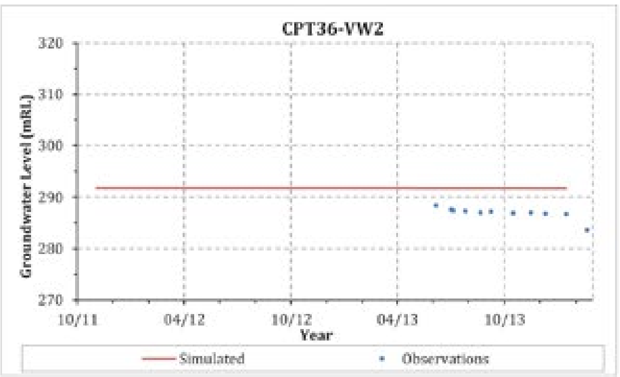


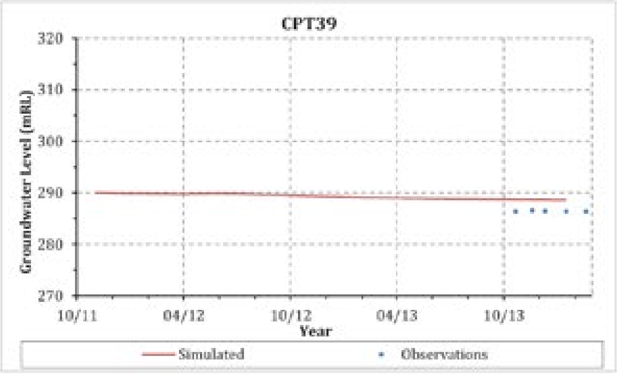


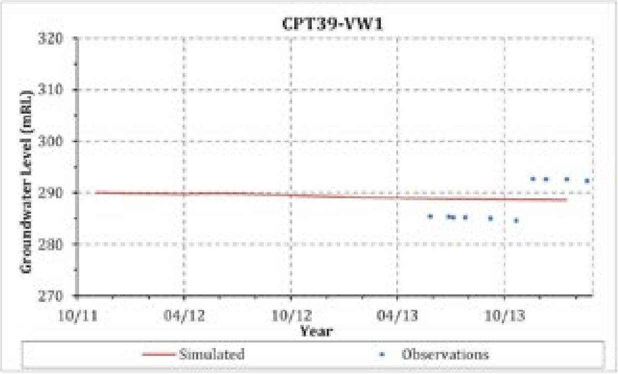




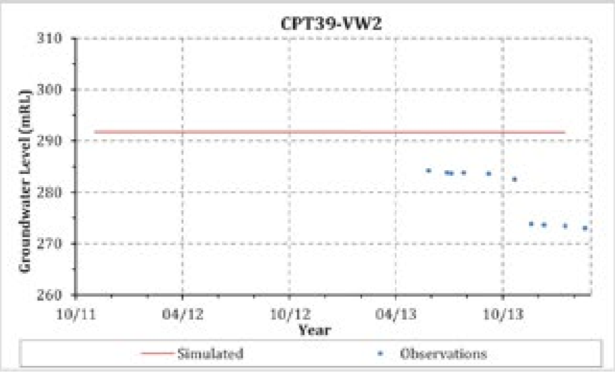


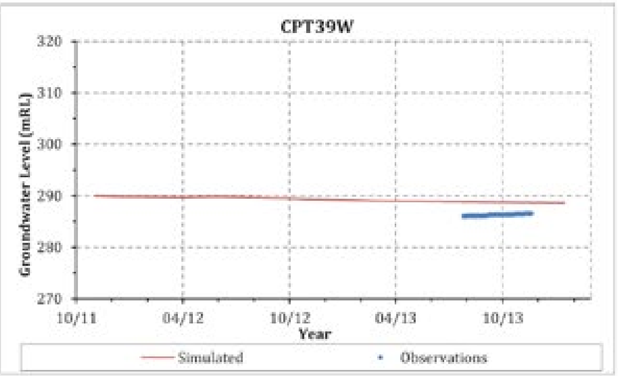


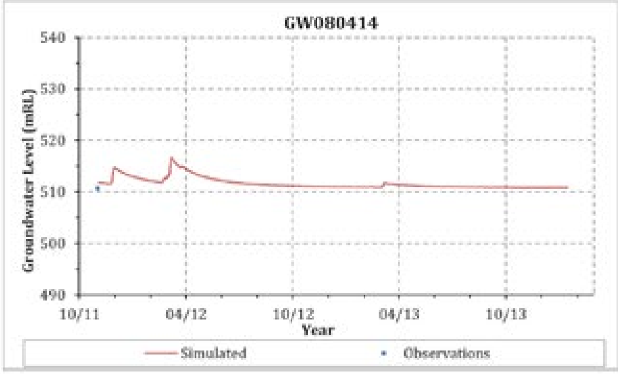


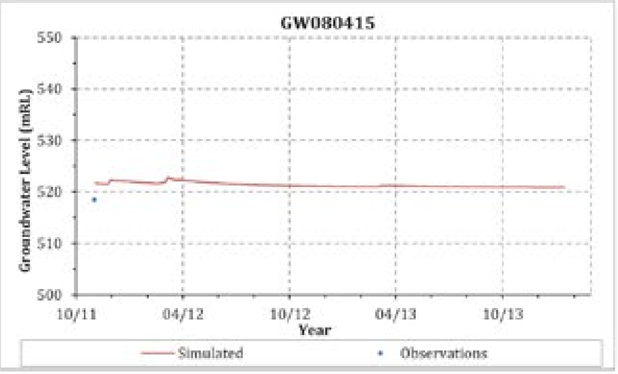


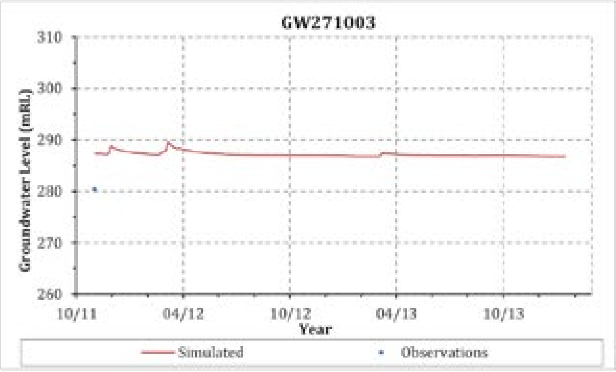
Calibration Hydrographs



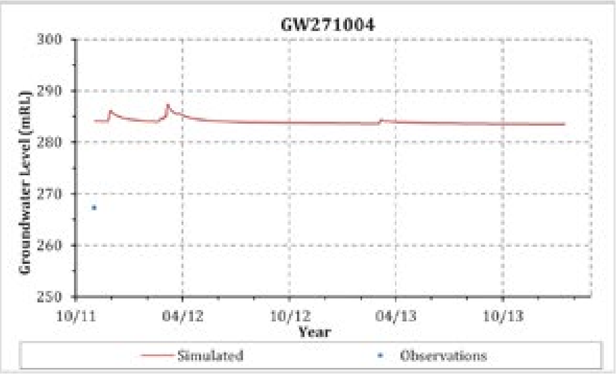


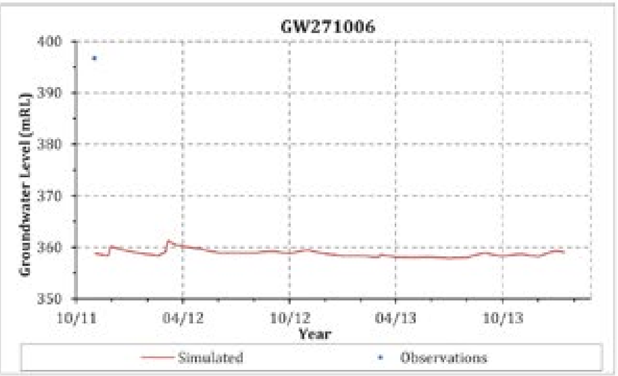


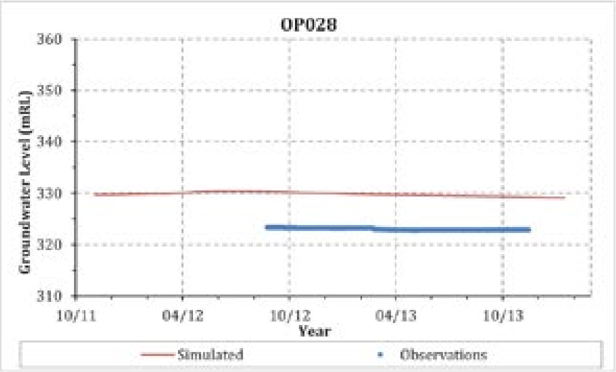


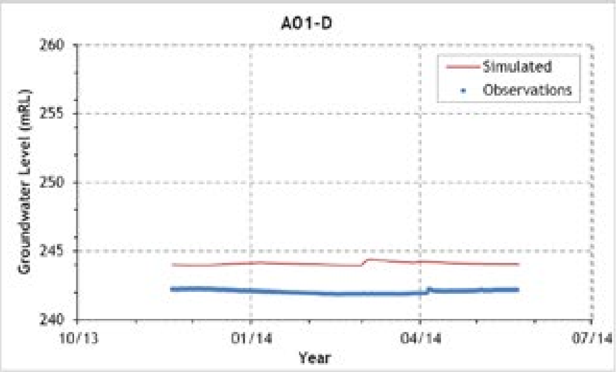


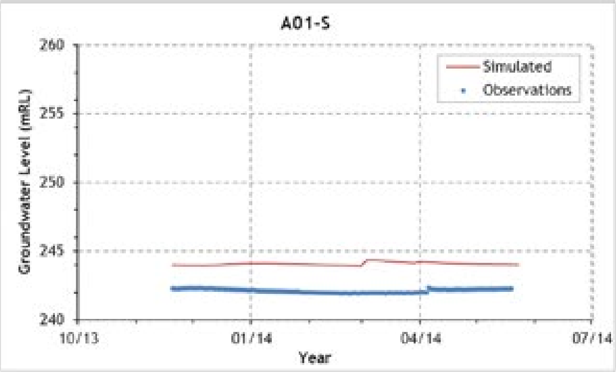
Calibration Hydrographs

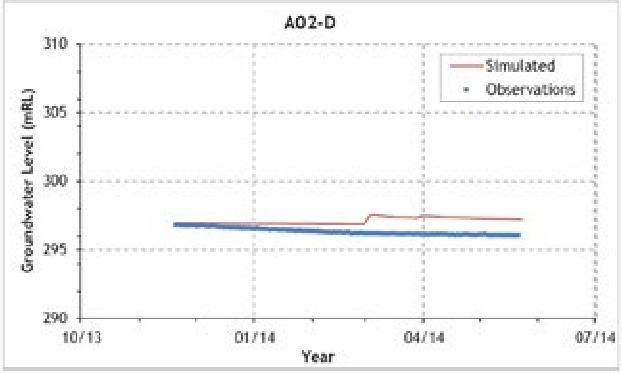


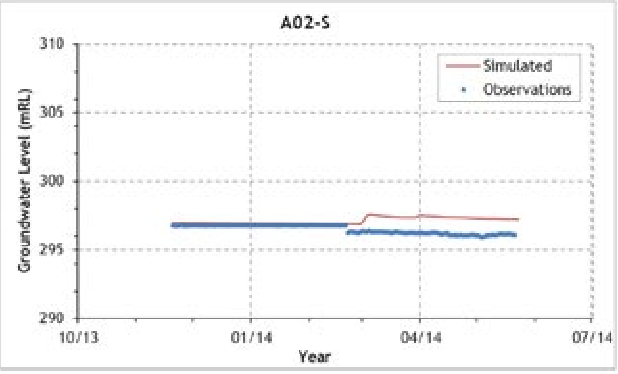


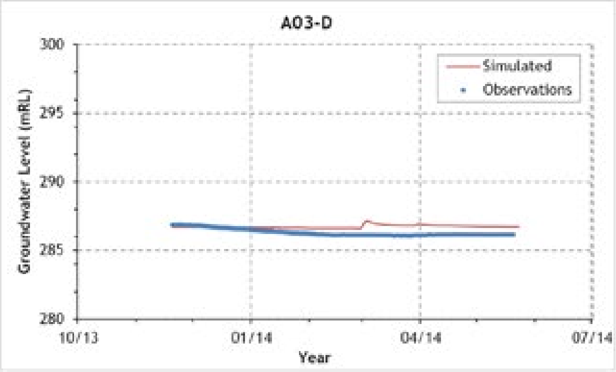


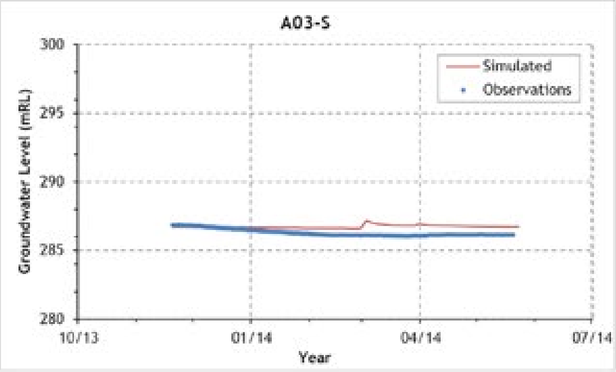

A01-D

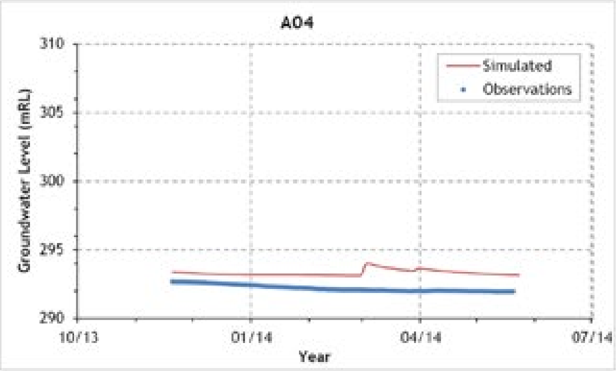

A01-S

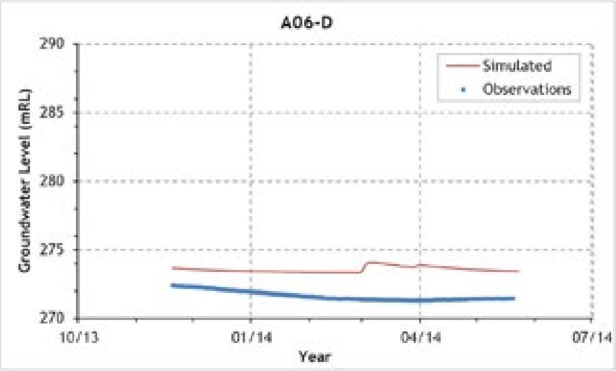

A02-D

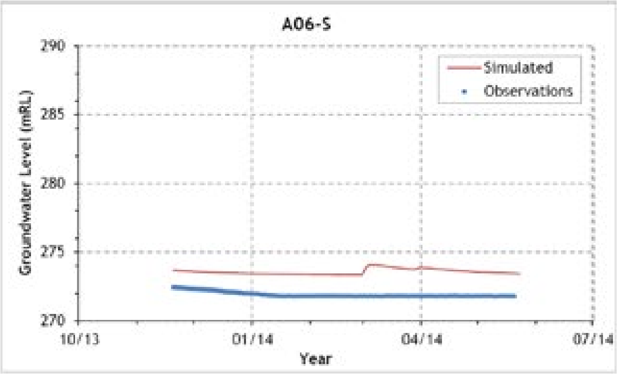

A02-S

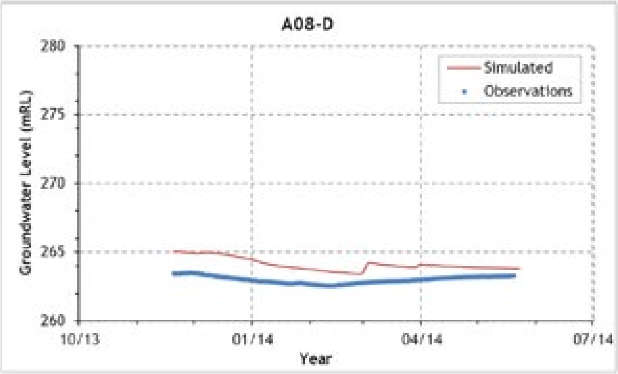

A03-D

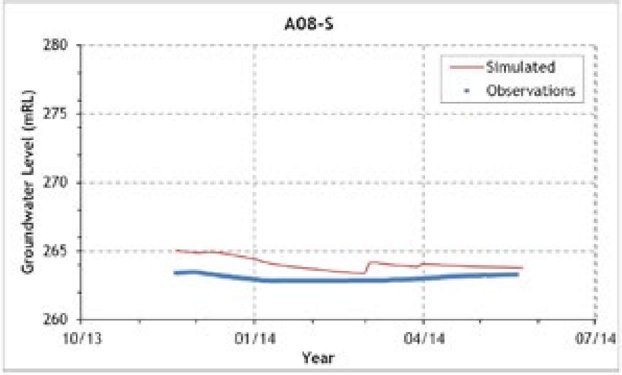

A03-S

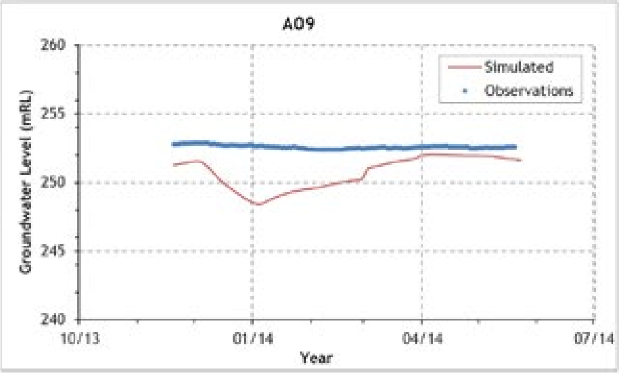

A04

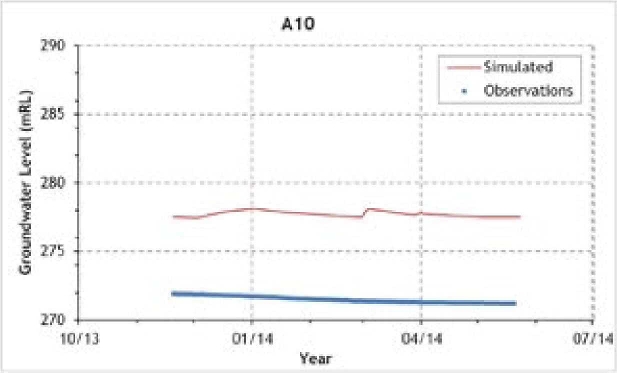

A06-D

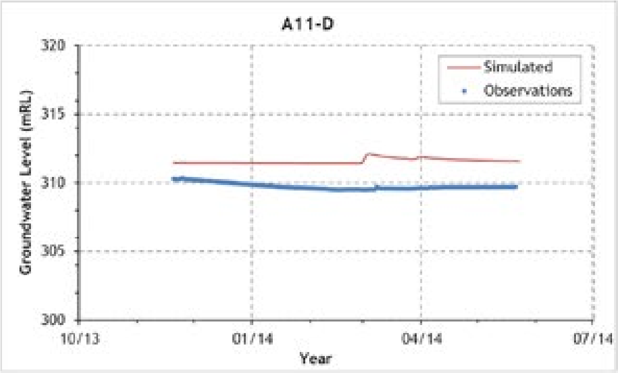

A06-S
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations

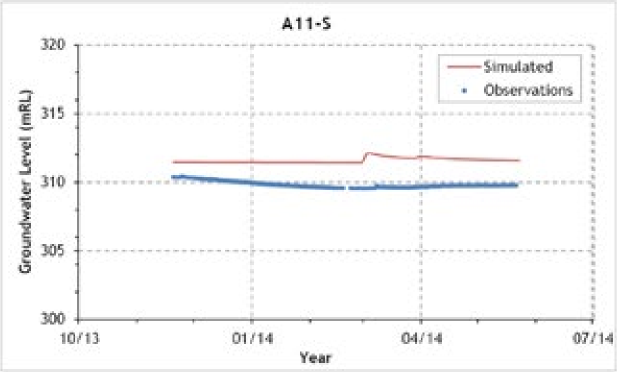

A08-D
Groundwater Level (mRL)
280
275
270
265
260
10/13
01/14
04/14
07/14
Year
Simulated
Observations

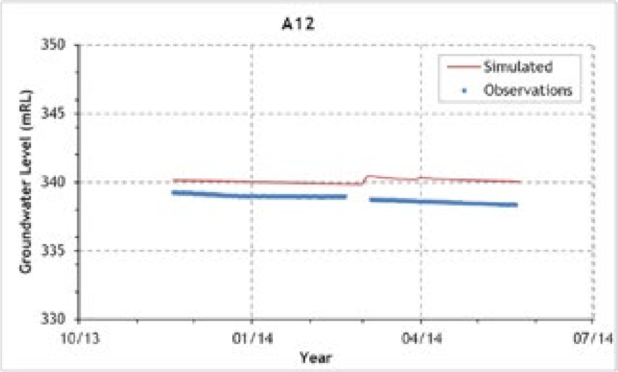

A08-S
Groundwater Level (mRL)
280
275
270
265
260
10/13
01/14
04/14
07/14
Year
Simulated
Observations

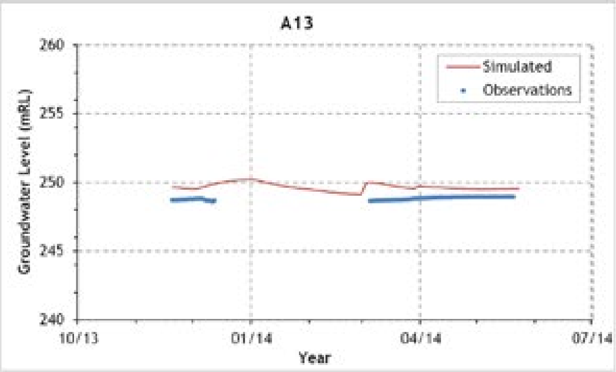

A09
Groundwater Level (mRL)
260
255
250
245
240
10/13
01/14
04/14
07/14
Year
Simulated
Observations

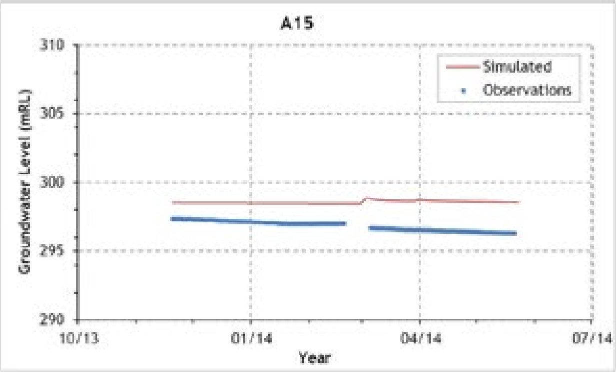

A10
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations

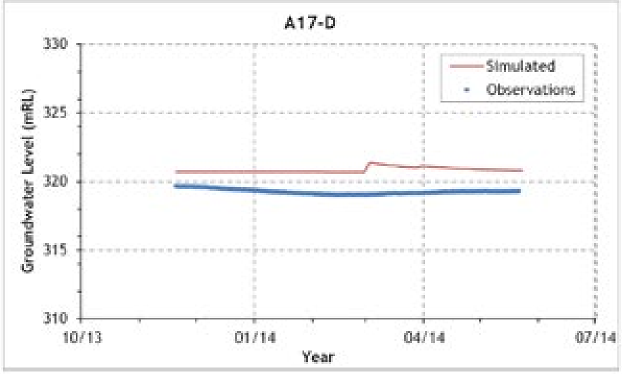

A11-D
Groundwater Level (mRL)
320
315
310
305
300
10/13
01/14
04/14
07/14
Year
Simulated
Observations

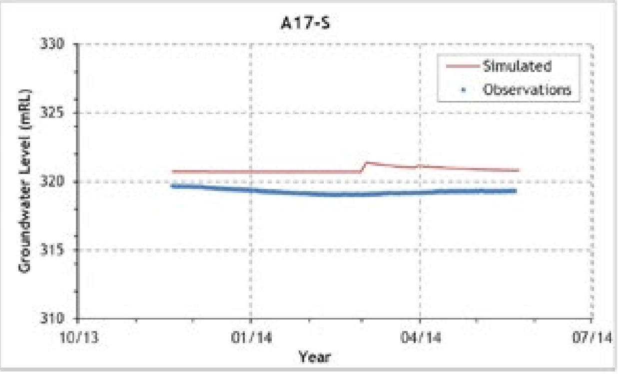

A11-S
Groundwater Level (mRL)
320
315
310
305
300
10/13
01/14
04/14
07/14
Year
Simulated
Observations

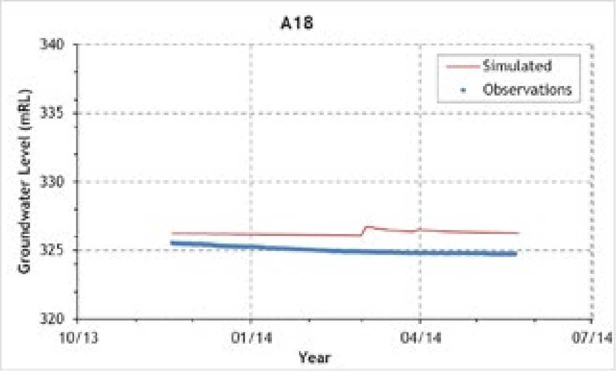

A12
Groundwater Level (mRL)
350
345
340
335
330
10/13
01/14
04/14
07/14
Year
Simulated
Observations

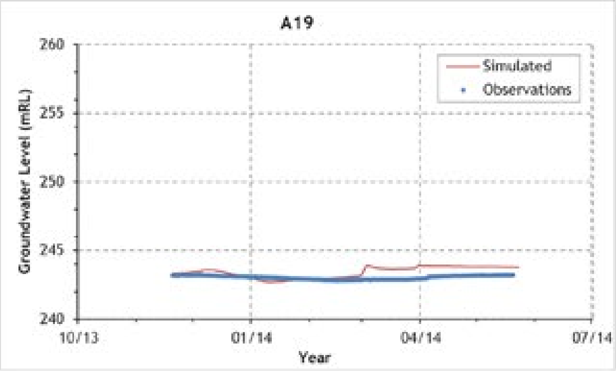

A13
Groundwater Level (mRL)
260
255
250
245
240
10/13
01/14
04/14
07/14
Year
Simulated
Observations

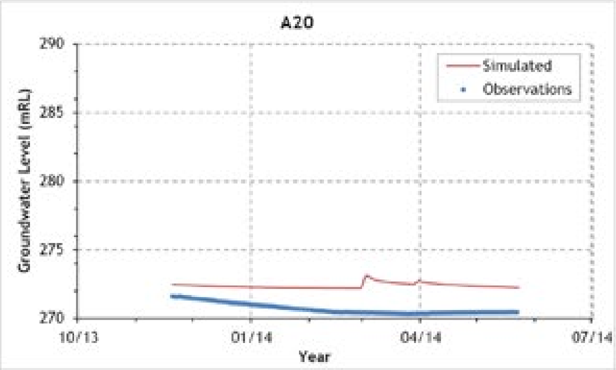

A15
Groundwater Level (mRL)
310
305
300
295
290
10/13
01/14
04/14
07/14
Year
Simulated
Observations

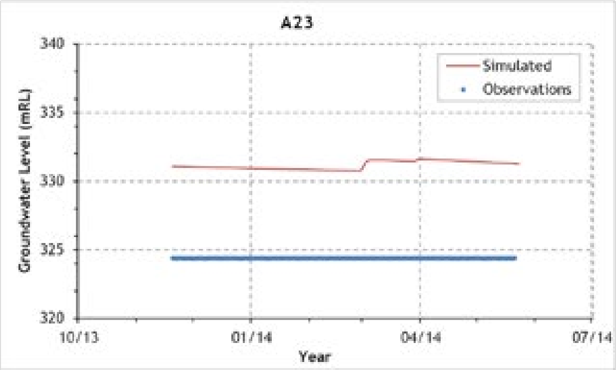

A17-D
Groundwater Level (mRL)
330
325
320
315
310
10/13
01/14
04/14
07/14
Year
Simulated
Observations


A17-S
Groundwater Level (mRL)
330
325
320
315
310
10/13
01/14
04/14
07/14
Year
Simulated
Observations

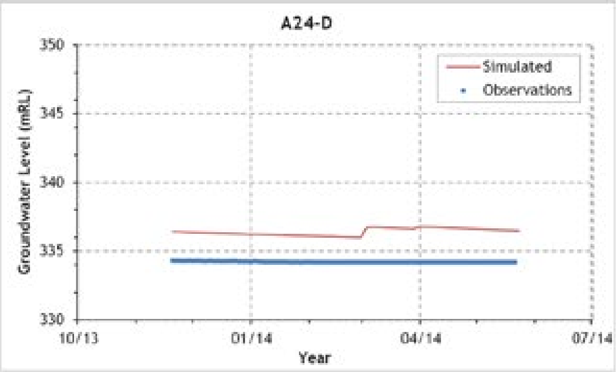

A18
Groundwater Level (mRL)
340
335
330
325
320
10/13
01/14
04/14
07/14
Year
Simulated
Observations

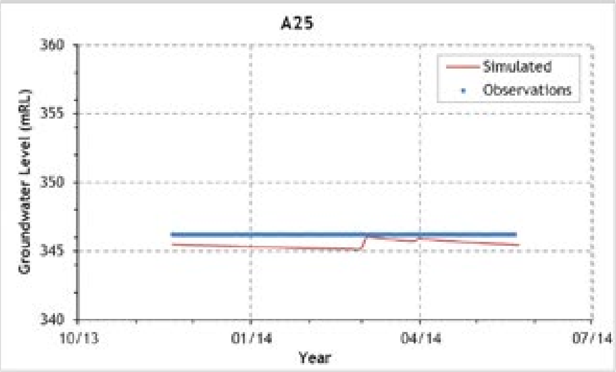

A19
Groundwater Level (mRL)
260
255
250
245
240
10/13
01/14
04/14
07/14
Year
Simulated
Observations

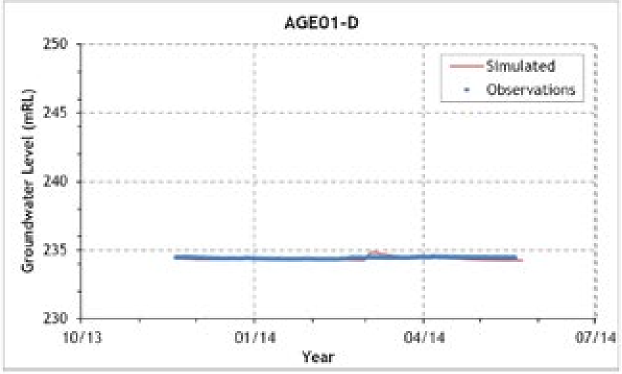

A20
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations

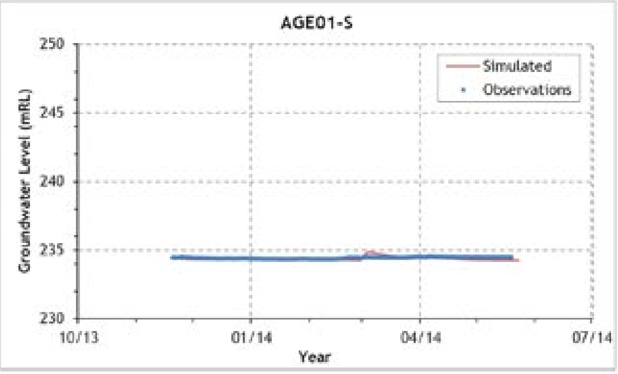

A23
Groundwater Level (mRL)
340
335
330
325
320
10/13
01/14
04/14
07/14
Year
Simulated
Observations

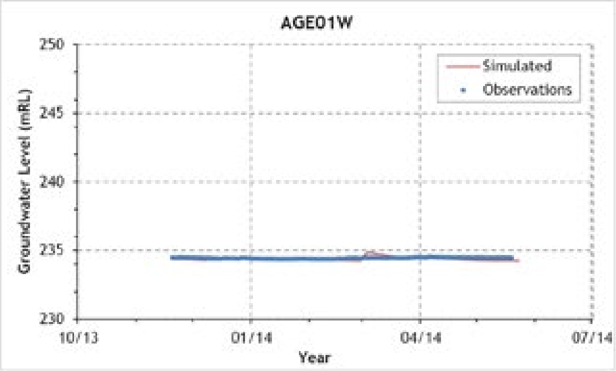
Appendix 3

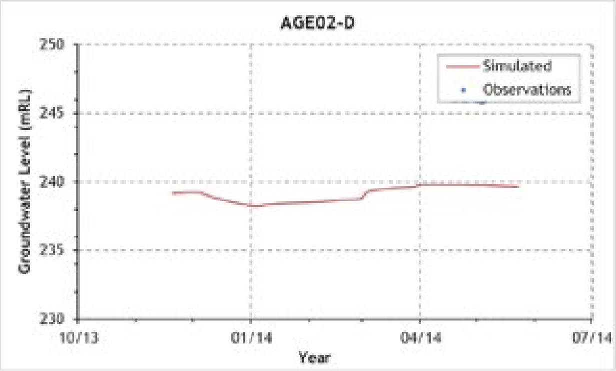

A24-D
350
345
340
335
330
Groundwater Level (mRL)
10/13
01/14
04/14
07/14
Year
Simulated
Observations

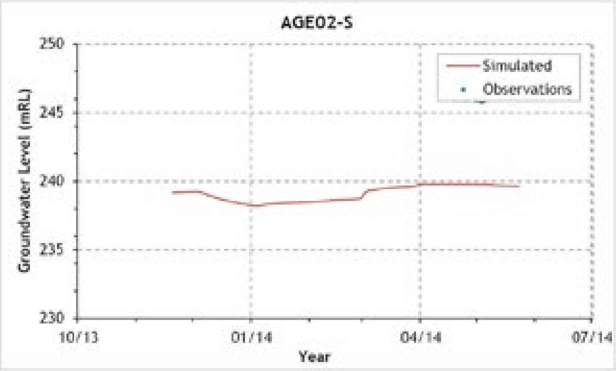

A25
360
355
350
345
340
Groundwater Level (mRL)
10/13
01/14
04/14
07/14
Year
Simulated
Observations

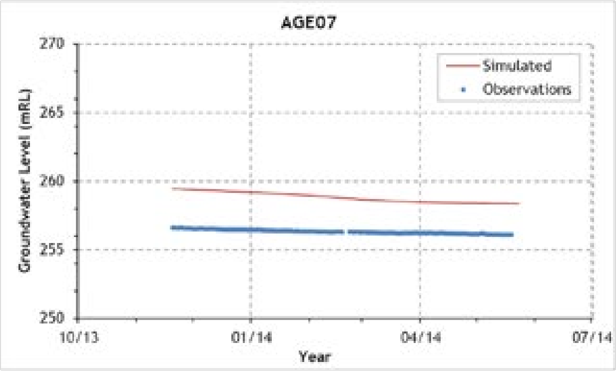

AGE01-D
250
245
240
235
230
Groundwater Level (mRL)
10/13
01/14
04/14
07/14
Year
Simulated
Observations

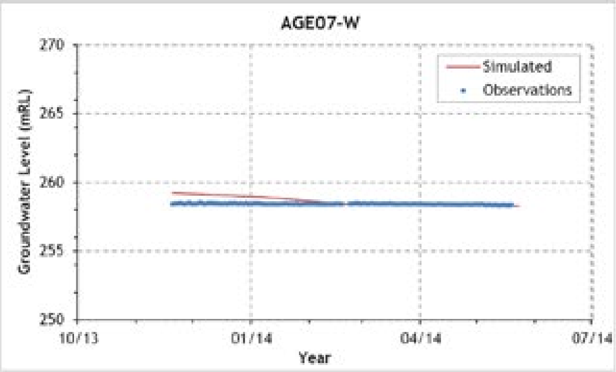

AGE01-S
250
245
240
235
230
Groundwater Level (mRL)
10/13
01/14
04/14
07/14
Year
Simulated
Observations

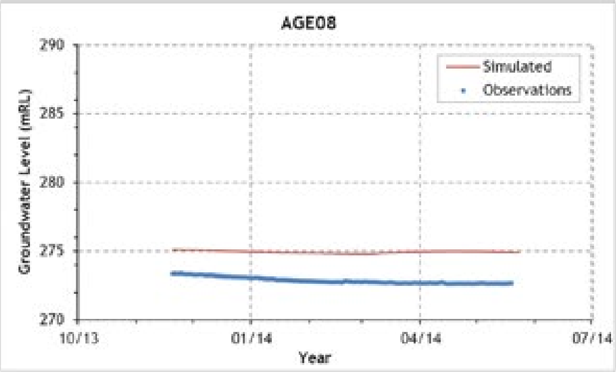

AGE01W
250
245
240
235
230
Groundwater Level (mRL)
10/13
01/14
04/14
07/14
Year
Simulated
Observations

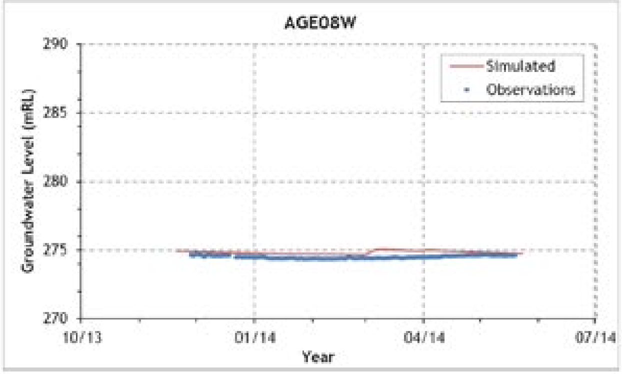

AGE02-D
250
245
240
235
230
Groundwater Level (mRL)
10/13
01/14
04/14
07/14
Year
Simulated
Observations

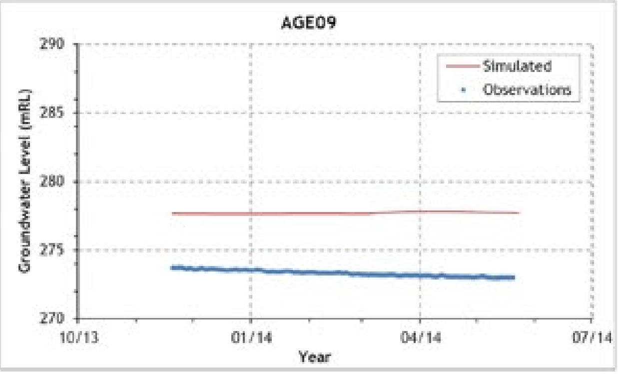

AGE02-S
250
245
240
235
230
Groundwater Level (mRL)
10/13
01/14
04/14
07/14
Year
Simulated
Observations

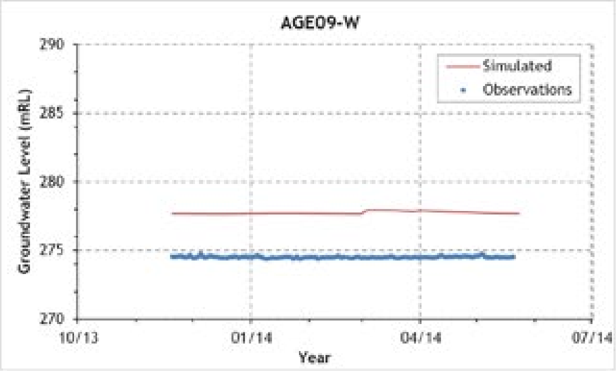

AGE07
270
265
260
255
250
Groundwater Level (mRL)
10/13
01/14
04/14
07/14
Year
Simulated
Observations

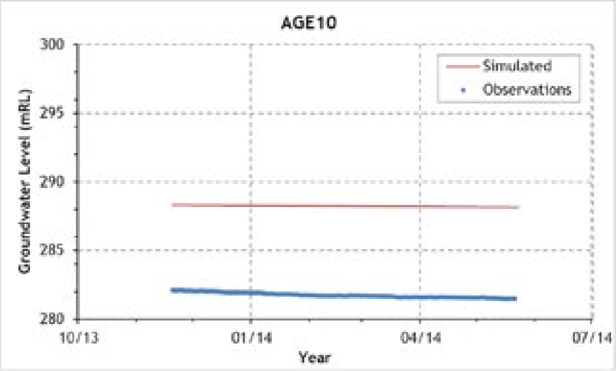

AGE07-W
Groundwater Level (mRL)
270
265
260
255
250
10/13
01/14
04/14
07/14
Year
Simulated
Observations

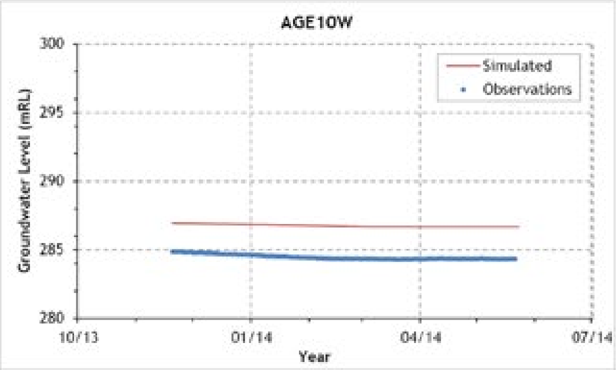

AGE08
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations

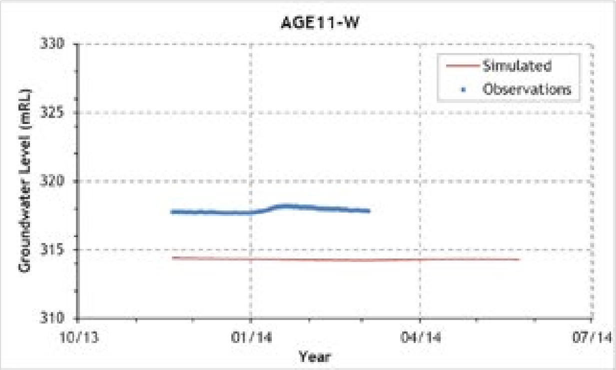

AGE08W
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations


AGE09
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations

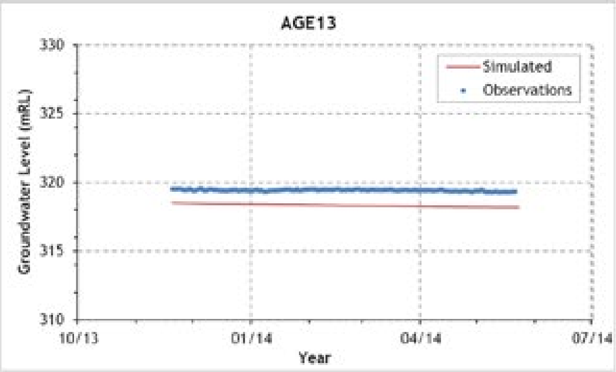

AGE09-W
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations

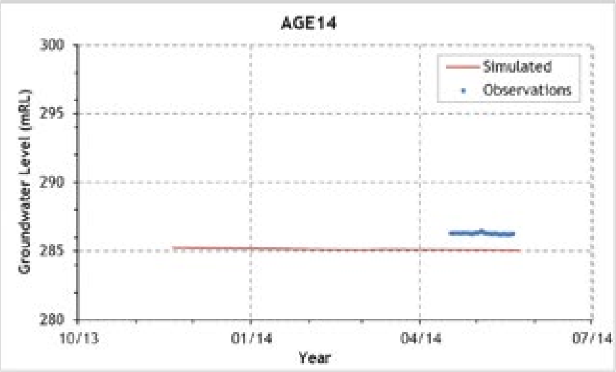

AGE10
Groundwater Level (mRL)
300
295
290
285
280
10/13
01/14
04/14
07/14
Year
Simulated
Observations

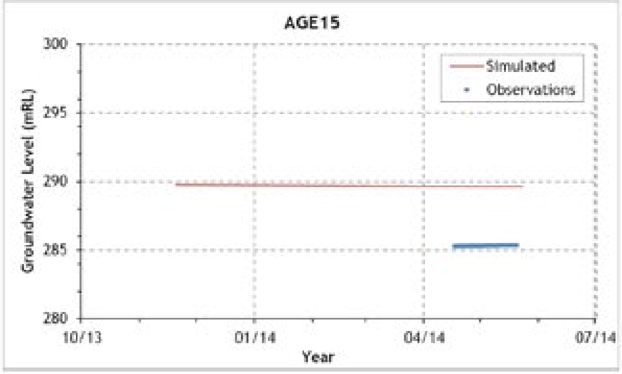

AGE10W
Groundwater Level (mRL)
300
295
290
285
280
10/13
01/14
04/14
07/14
Year
Simulated
Observations

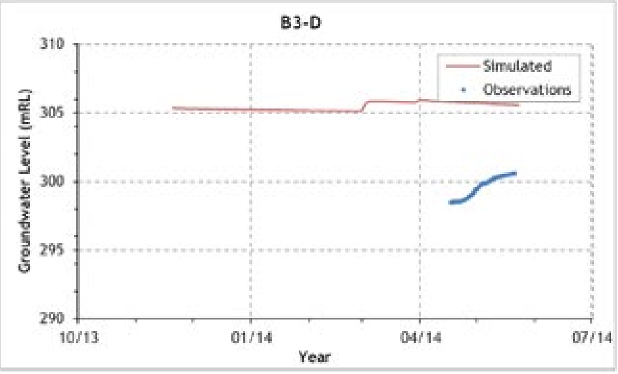

AGE11-W
Groundwater Level (mRL)
330
325
320
315
310
10/13
01/14
04/14
07/14
Year
Simulated
Observations

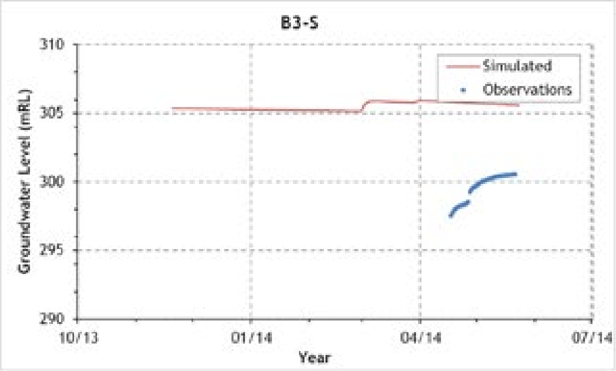
Appendix 3

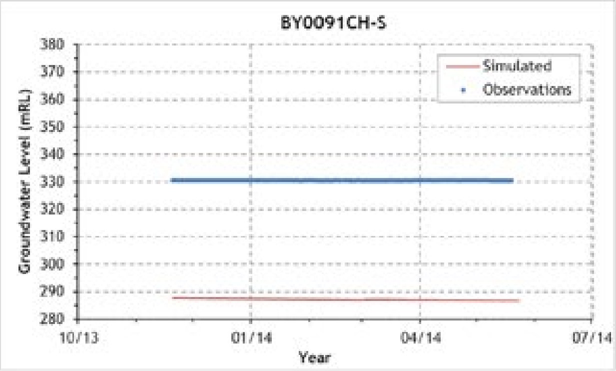

AGE13
Simulated
Observations
Groundwater Level (mRL)
330
325
320
315
310
10/13
01/14
04/14
07/14
Year

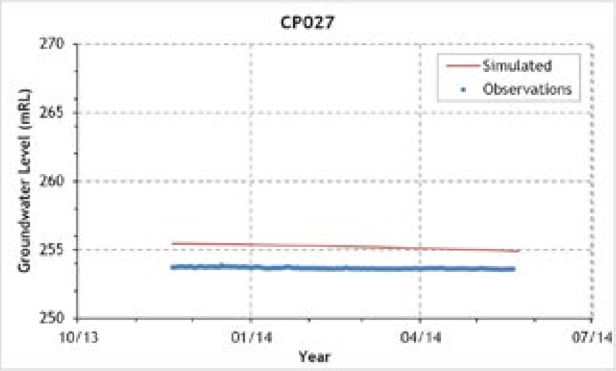

AGE14
Simulated
Observations
Groundwater Level (mRL)
300
295
290
285
280
10/13
01/14
04/14
07/14
Year

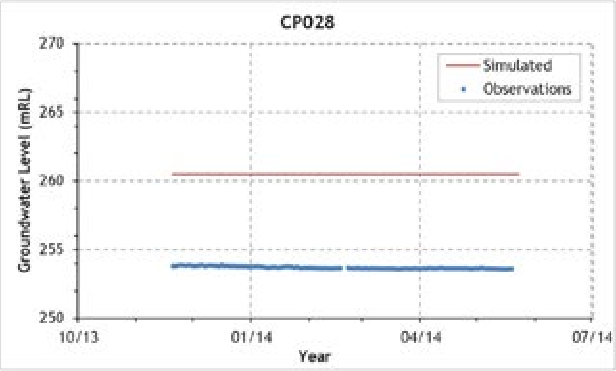

AGE15
Simulated
Observations
Groundwater Level (mRL)
300
295
290
285
280
10/13
01/14
04/14
07/14
Year


B3-D
Simulated
Observations
Groundwater Level (mRL)
310
305
300
295
290
10/13
01/14
04/14
07/14
Year

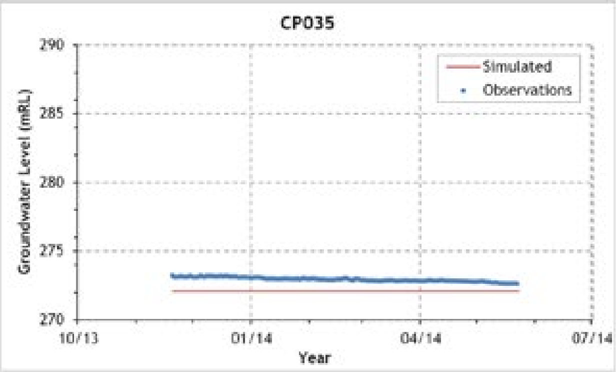

B3-S
Simulated
Observations
Groundwater Level (mRL)
310
305
300
295
290
10/13
01/14
04/14
07/14
Year

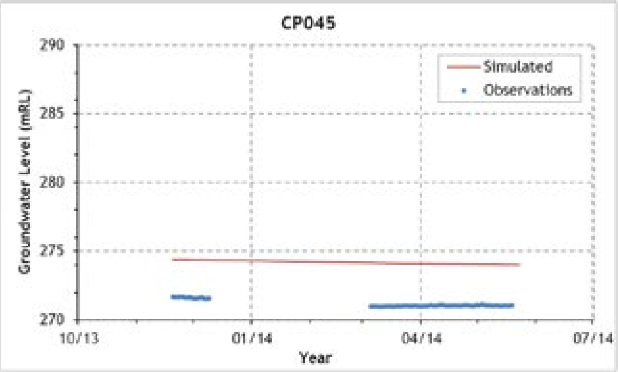

BY0091CH-S
Simulated
Observations
Groundwater Level (mRL)
380
370
360
350
340
330
320
310
300
290
280
10/13
01/14
04/14
07/14
Year

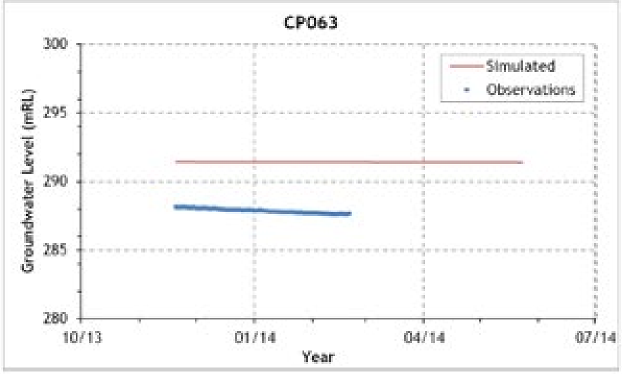

CP027
Simulated
Observations
Groundwater Level (mRL)
270
265
260
255
250
10/13
01/14
04/14
07/14
Year

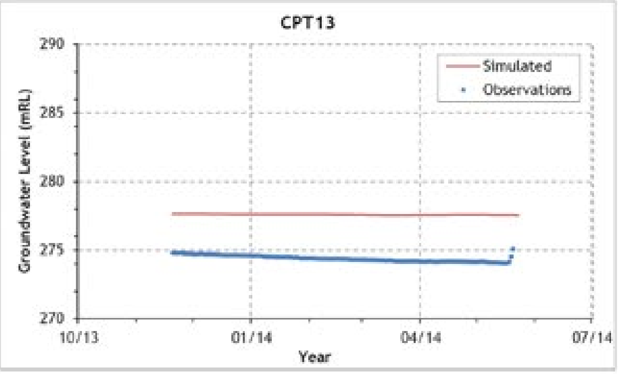

CP028
Simulated
Observations
Groundwater Level (mRL)
270
265
260
255
250
10/13
01/14
04/14
07/14
Year

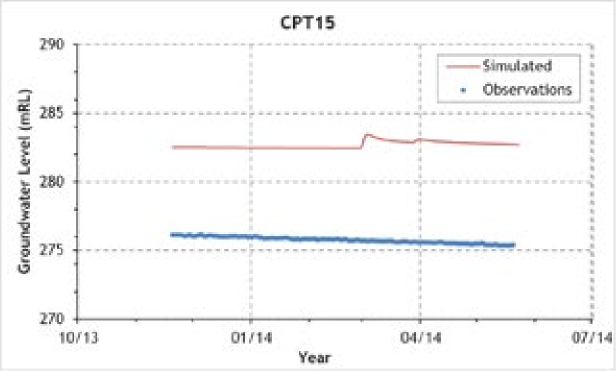
Appendix 3

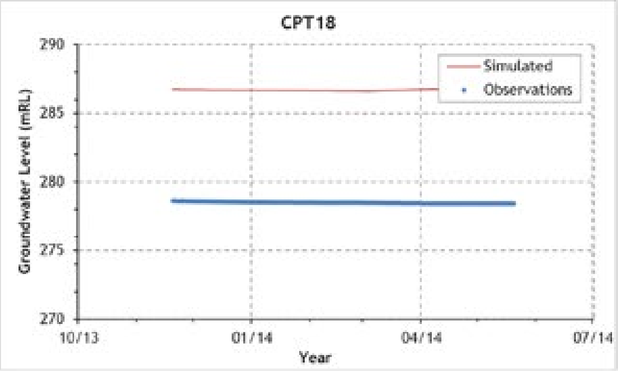

CP035
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations

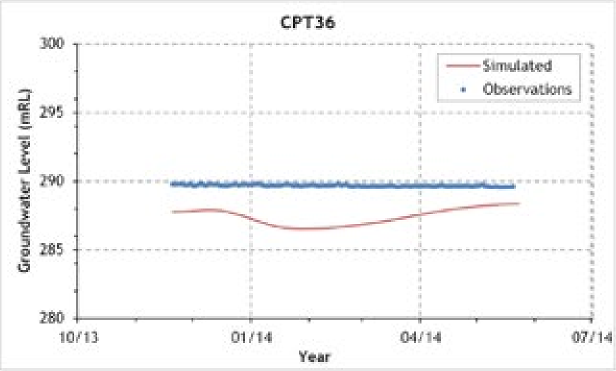

CP045
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations

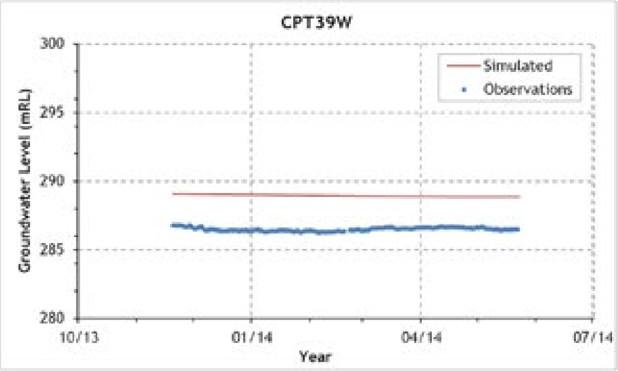

CP063
Groundwater Level (mRL)
300
295
290
285
280
10/13
01/14
04/14
07/14
Year
Simulated
Observations

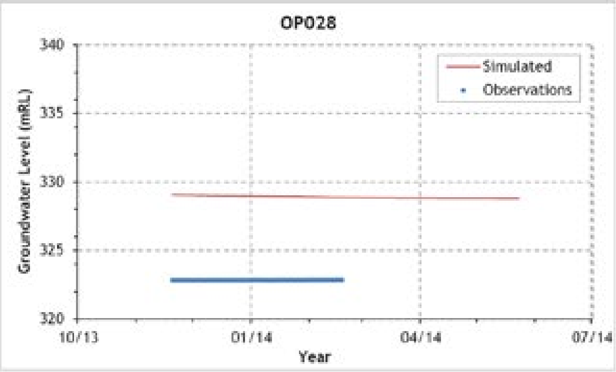

CPT13
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations


CPT15
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations


CPT18
Groundwater Level (mRL)
290
285
280
275
270
10/13
01/14
04/14
07/14
Year
Simulated
Observations


CPT36
Groundwater Level (mRL)
300
295
290
285
280
10/13
01/14
04/14
07/14
Year
Simulated
Observations


CPT39W
Groundwater Level (mRL)
300
295
290
285
280
10/13
01/14
04/14
07/14
Year
Simulated
Observations


OP028
Groundwater Level (mRL)
340
335
330
325
320
10/13
01/14
04/14
07/14
Year
Simulated
Observations

Appendix E

Van Genuchten Parameters Literature Review

Tested Sample	alpha m-1	n (beta)	Rs	Source
Hygiene sandstone	0.79	10.4	0.153	van Genuchten, 1980
Touchet silt loam	0.5	7.09	0.19	van Genuchten, 1980
silt loam	0.423	2.06	0.131	van Genuchten, 1980
Guelph loam - drying	1.15	2.03	0.218	van Genuchten, 1980
Guelph loam - wetting	2	2.76	0.218	van Genuchten, 1980
Beit Netofa Clay	0.152	1.17		van Genuchten, 1980
Weldt silty clay loam	1.73	61.54	0.116	van Genuchten, Nielsen, 1985
Weldt silty clay loam	1.36	5.45	0.159	van Genuchten, Nielsen, 1985
Weldt silty clay loam	1.43	5.87	0.155	van Genuchten, Nielsen, 1985
Weldt silty clay loam	1.72		0.116	van Genuchten, Nielsen, 1985
Touchet Silt loam	3.13	3.98	0.081	van Genuchten, Nielsen, 1985
Touchet Silt loam	2.78	3.59	0.102	van Genuchten, Nielsen, 1985
Touchet Silt loam	3.12	3.98	0.082	van Genuchten, Nielsen, 1985
Touchet Silt loam	3.77		0.018	van Genuchten, Nielsen, 1985
GE No2 sand	2.27	4.11	0.091	van Genuchten, Nielsen, 1985
GE No2 sand	3.64	5.05	0.057	van Genuchten, Nielsen, 1985
GE No2 sand	3.82	4.51	0	van Genuchten, Nielsen, 1985
GE No2 sand	4.62		0	van Genuchten, Nielsen, 1985
Sarpy Loam	1.27	1.14	0.051	van Genuchten, Nielsen, 1985
Sarpy Loam	2.79	1.6	0.032	van Genuchten, Nielsen, 1985
Sarpy Loam	3.93	2.45	0.012	van Genuchten, Nielsen, 1985
Sarpy Loam	4.44		0	van Genuchten, Nielsen, 1985
Bandelier Tuff	143.3	1.506	0.05	Kool, Parker, van Genuchten, 1986
Topsoil B1 - coarse textured	1.69	1.83		Vosten, van Genuchten, 1988
Topsoil B2 - coarse textured	2.03	1.52		Vosten, van Genuchten, 1988
Topsoil B3 - coarse textured	2.9	1.44		Vosten, van Genuchten, 1988
Topsoil B4 - coarse textured	1.57	1.58		Vosten, van Genuchten, 1988
Subsoil 01	5.51	2.43		Vosten, van Genuchten, 1988
Subsoil 02	2.01	2.05		Vosten, van Genuchten, 1988
Subsoil 03	27.8	1.75		Vosten, van Genuchten, 1988
Subsoil 04	1.54	1.82		Vosten, van Genuchten, 1988
Topsoil B7 - medium texture	3.47	1.27		Vosten, van Genuchten, 1988
Topsoil B8 - medium texture	6.24	1.25		Vosten, van Genuchten, 1988
Topsoil B9 - medium texture	5.36	1.15		Vosten, van Genuchten, 1988
Subsoil 08	3.16	1.32		Vosten, van Genuchten, 1988
Subsoil 09	4.24	1.28		Vosten, van Genuchten, 1988
Subsoil 10	4	1.21		Vosten, van Genuchten, 1988
Topsoil B10 - fine textured	13.3	1.12		Vosten, van Genuchten, 1988
Topsoil B11 - fine textured	13.8	1.12		Vosten, van Genuchten, 1988
Topsoil B12 - fine textured	14.1	1.108		Vosten, van Genuchten, 1988
Subsoil 011	5.1	1.13		Vosten, van Genuchten, 1988
Subsoil 012	6.02	1.14		Vosten, van Genuchten, 1988
Subsoil 013	7.4	1.08		Vosten, van Genuchten, 1988
Silt Loam GE 3	0.414	2.15	0.139	van Genuchten, Leij, 1989

Tested Sample	**alpha m-1**	**n (beta)**	**Rs**	**Source**
Yolo Light Clay K(WC)	2.793	1.71	0.205	van Genuchten, Leij, 1989
Yolo Light Clay K(H)	2.793	1.71	0.205	van Genuchten, Leij, 1989
Hygiene Sandstone	0.562	3.27	0	van Genuchten, Leij, 1989
Lambcrg Clay	14	1.93	0	van Genuchten, Leij, 1989
Beit Netofa Clay Soil	0.156	1.17	0	van Genuchten, Leij, 1989
Shiohot Silty Clay		1.17	0	van Genuchten, Leij, 1989
silt Columbia	1.45	1.85	0.146	van Genuchten, Leij, 1989
Silt Mont Cenis	1.03	1.34	0	van Genuchten, Leij, 1989
Slate Dust	0.981	6.75	0	van Genuchten, Leij, 1989
Weld Silty Clay Loam	1.36	5.45	0.159	van Genuchten, Leij, 1989
Rideau Clay Loam, Wetting	6.61	1.89	0.279	van Genuchten, Leij, 1989
Rideau Clay Loam, Drying	1.77	3.18	0.29	van Genuchten, Leij, 1989
Caribou Silt Loam, Drying	0.845	1.29	0	van Genuchten, Leij, 1989
Caribou Silt Loam, Wetting	14	1.09	0	van Genuchten, Leij, 1989
Grenville Silt Loam, Wetting	6.3	1.24	0.013	van Genuchten, Leij, 1989
Grenville Silt Loam, Drying	1.12	1.23	0	van Genuchten, Leij, 1989
Touchet Silt Loam	1.04	5.78	0.183	van Genuchten, Leij, 1989
Gilat Loam	2.91	1.47	0	van Genuchten, Leij, 1989
Pachapa Loam	0.829	1.62	0	van Genuchten, Leij, 1989
Adelanto Loam	0.71	1.26	0	van Genuchten, Leij, 1989
Indio Loam	0.847	1.6	0	van Genuchten, Leij, 1989
Guclph Loam	2.75	1.27	0	van Genuchten, Leij, 1989
Guclph Loam	2.71	2.62	0.236	van Genuchten, Leij, 1989
Rubicon Sandy Loam	0.972	2.18	0	van Genuchten, Leij, 1989
Rubicon Sandy Loam	14.7	1.28	0	van Genuchten, Leij, 1989
Pachapa Fme Sandy Clay	1.94	1.45	0	van Genuchten, Leij, 1989
Gilat Sandy Loam	1.03	1.48	0	van Genuchten, Leij, 1989
Plainfield Sand (210-250 pm)	2.36	12.3	0	van Genuchten, Leij, 1989
Plainfield Sand (210-250 gm)	3.87	4.48	0	van Genuchten, Leij, 1989
Plainfield Sand (177-210 pm)	2.07	10.11	0	van Genuchten, Leij, 1989
Plainfield Sand (177-210 pm)	3.28	6.23	0.022	van Genuchten, Leij, 1989
Plainfield Sand (149-177 pm)	1.73	7.8	0	van Genuchten, Leij, 1989
Plainfield Sand (149-177 pm)	2.72	6.69	0.025	van Genuchten, Leij, 1989
Plainfield Sand (l25-149 pm)	1.45	10.6	0	van Genuchten, Leij, 1989
Plainfield Sand (125-149 urn)	2.3	5.18	0	van Genuchten, Leij, 1989
Fracture media	10	2	0	Gerke, van Genuchten, 1993
matrix media	0.5	1.5	0.10526	Gerke, van Genuchten, 1993

van Genuchten (1980) "*A Closed-form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils*" Soil Sci. Soc. Am. J., vol. 44, 1980

van Genuchten and Nielsen (1985) "*On describing and predicting hydraulic properties of unsaturated soils*", Annales Geophysicae, 1985, 3,5, 615-628

Kool, Parker and van Genuchten (1986) "*Parameter estimation for unsaturated flow and transport models - a review*" Journal of Hydrology, 91 (1987) 255-293 255

Vosten, van Genuchten (1988) "*Using Texture and Other Soil Properties to Predict the Unsaturated Soil Hydraulic Functions*" DIVISION S-6-SOIL AND WATER MANAGEMENT AND CONSERVATION Soil Sci. Soc. Am. J. 52:1762-1770 (1988)

van Genuchten, Leij (1989) "*1989 - van Genuchten, Leij - Indirect methods for estimating the hydraulic properties of unsaturated soils*" Proceedings of the International Workshop on Indirect Methods for Estimating the Hydraulic Properties of Unsaturated Soils Riverside, California, October 11-13, 1989

Gerke, van Genuchten (1993) "*A dual porosity model for simulating the preferential movement of water in structured porous media*" Water Resources Research Vol 29 305-319, February 1993

Simunek, van Genuchten (1997) "*Estimating unsaturated soil hydraulic properties from multiple tension disc infiltrometer data*" Soil Science Vol 162, No. 6 June 1997

Appendix F

Numerical Model – Sensitivity & Uncertainty Analysis

F1 Predictive sensitivity and uncertainty analysis

The uncertainty in the model predictions was assessed using a traditional sensitivity analysis where model inputs were changed individually to assess the impact upon the predictions. A more complex Monte Carlo style uncertainty analysis was also undertaken where numerous model inputs were changed at the same time. The sections below describe the results of the methodology applied to the sensitivity and uncertainty analyses, and the results of these analyses.

F1.1 Sensitivity analysis methodology

F1.1.1 Base case

The sensitivity analysis assumed a higher demand for makeup water than the base case model presented within the main body of this report. Refinement of the site water balance reduced the demand for dust suppression water, which was proposed to be partly extracted from the sites bore field. The base case represented in the main body of this report reduced the pumping from the bore field to reflect this change, however it was decided to leave the sensitivity and uncertainty analyses unchanged to ensure a conservative approach to assessing impacts. Figure F1 shows base case in the main body of the report (base case 1) and the version with higher demand for makeup water used in the sensitivity and uncertainty analyses (base case 2).

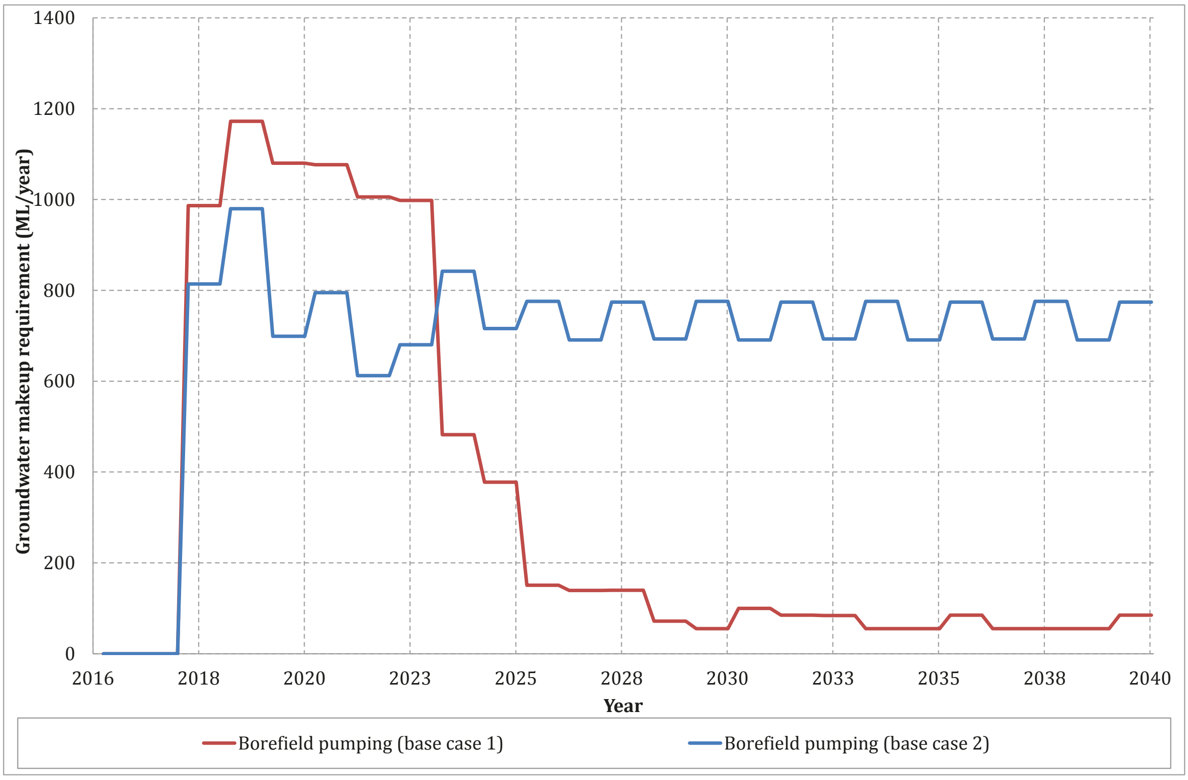


Figure F 1 Bore field requirements (Base case version 2)

Irrigation return to the aquifers was also represented slightly differently in the base case version 2 used for the sensitivity/uncertainty analyses. Base case version 2 simulated an area of 185 Ha of irrigated land on KEPCO properties, which was later refined to 97 Ha in base case 1 based on the results of the EIS agricultural assessment (see Section 9.2.2). As mining progressed, the base case version 2 used in the sensitivity analyses reduced agricultural pumping from KEPCO owned land to 15% of the rates adopted in the calibrated model. Similarly enhanced irrigation recharge was also reduced to 15% of the values adopted in the calibrated model.

Although base case version 2 varies from the base case presented in Section 10, the sensitivity of the model in relation to changes from base case 2 still provide a valid comparison with base case 1. This is because agricultural pumping, irrigation returns, and bore field pumping cause minor cumulative impacts when compared with the mining induced drawdown and subsequent changes to groundwater flow.

F1.1.2 Scenarios

A traditional sensitivity analysis assessed the response of the model predictions to changes in the model input parameters. The objective of the sensitivity analysis was to rank the input parameters in terms of their influence on the predicted results. The sensitivity analysis assessed the impact of varying:

- climatic conditions:
    - historic rainfall records were used to represent above average, below average and average conditions;
    - irrigation returns were removed; and
    - river leakage that recharges the aquifer was removed.
- hydraulic parameters, including hydraulic conductivity, storativity, river bed conductance, spoil parameters, drains and connective cracking;
- unsaturated zone parameters (alpha, beta, residual saturation, Brooks Corey exponent, and upstream weighting); and
- representation of the mining process by leaving all drain cells active for the mine life.

The scenario where drains remained active for the mine life is termed the ‘extreme scenario’ as it is proposed to fully backfill the open cut after 10 years, and seal off underground mine panels as mining progresses.

All sensitivity models ran with acceptable numerical percent discrepancies and were compared against the base case 2 discussed above. Sections below outline the methodology adopted for each of the scenarios.

F1.1.3 Climate scenario

A sensitivity analysis was carried out to assess the response of the model to varying climatic conditions. Historical rainfall trends and the CRD were examined to identify periods in history when rainfall was on a monthly basis typically above average, below average or similar to the average. Figure F 2 shows the Wollar Gauge annual rainfall data and CRD, and the three periods of rainfall data selected to be used to assess the sensitivity of the model predictions to rainfall recharge.

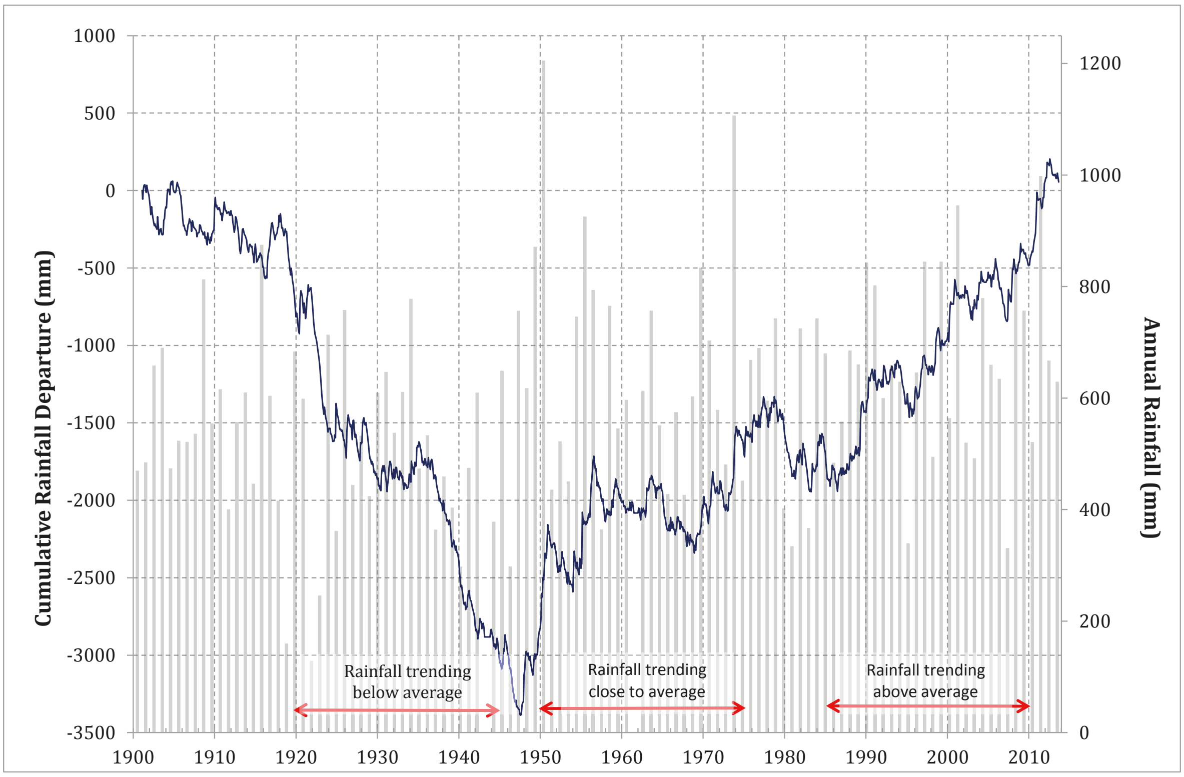


Figure F 2 Historic climate sensitivity scenarios

Three model runs were conducted using recharge rates calculated from the historical rainfall records for the above periods. In addition the recharge rates in the base case model were also adjusted by factors to further assess the influence of climate variability on the impacts. Table F 1 summarises the data used in the sensitivity scenarios.

Table F 1 Summary of climate sensitivity analysis scenarios

Sensitivity scenario	Rainfall data	River flow and height	Mine makeup water
Rainfall trending above average (Wet)	1985 to 2010	Estimated by WRM using rainfall runoff model and 1985 to 2010 rainfall data	Determined by WRM using water balance model and 1985 to 2010 rainfall data.
Rainfall trending at the average (Average)	1950 to 1975	Estimated by WRM using rainfall runoff model and 1950 to 1975 rainfall data	Determined by WRM using water balance model and 1950 to 1975 rainfall data.
Rainfall trending below average (Dry)	1920 to 1945	Estimated by WRM using rainfall runoff model and 1920 to 1945 rainfall data	Determined by WRM using water balance model and 1920 to 1945 rainfall data.
Recharge+/ Recharge-	base case model adjusted in the alluvium ± 100% and other stratigraphy ± 0.5 to 1 orders of magnitude	Base case 2 unchanged	Base case 2 unchanged
Extreme scenario (drains active for entire mine life)	Base case 1 and no irrigation returns	No leakage into aquifer, only discharge from aquifer	Base case 1

The recharge rates for each scenario were calculated using the soil-moisture bucket model described in Section 7.4. The daily recharge rates calculated with this model were summed, and applied to the model in quarterly stress periods. Figure F 3 presents the effective recharge rate applied to the base case 2 and the three climate scenarios.

Figure F 3 highlights the uniform nature of rainfall recharge in the base case model, and the natural variability that using the historical data introduces to the sensitivity scenarios. This figure also suggests that visually there appears to be less rainfall recharge during the above average rainfall scenario. Figure F 4 shows the CRD, the cumulative rainfall recharge and the estimated make up water requirements for the three scenarios. It confirms that the recharge on a cumulative basis is generally lower for the scenario where the rainfall was trending above the monthly average (wet scenario). This highlights that the fact that the groundwater recharge rate is not directly linked to the monthly rainfall total, but is also influenced by the antecedent moisture in the soil profile and the frequency of rainfall events. For example three days of 20 mm rainfall per day will generate more recharge than one day of 60mm because more deep drainage can occur as sufficient time elapses to allow the soil profile to 'wet up'.

The duration and frequency of rainfall events also influences the volume of make-up water required by the Project, rather than simply the monthly total rainfall. In contrast to groundwater recharge, more runoff is generated by the high intensity rainfall events that do not promote wetting up of the soil profile and groundwater recharge. Figure F 4 shows that the scenario when rainfall is trending below average has periods where make up water demands are relatively low, because the rainfall events are of sufficient intensity and duration to generate runoff to the mine water circuit and reduce demand based on the historical rainfall records.

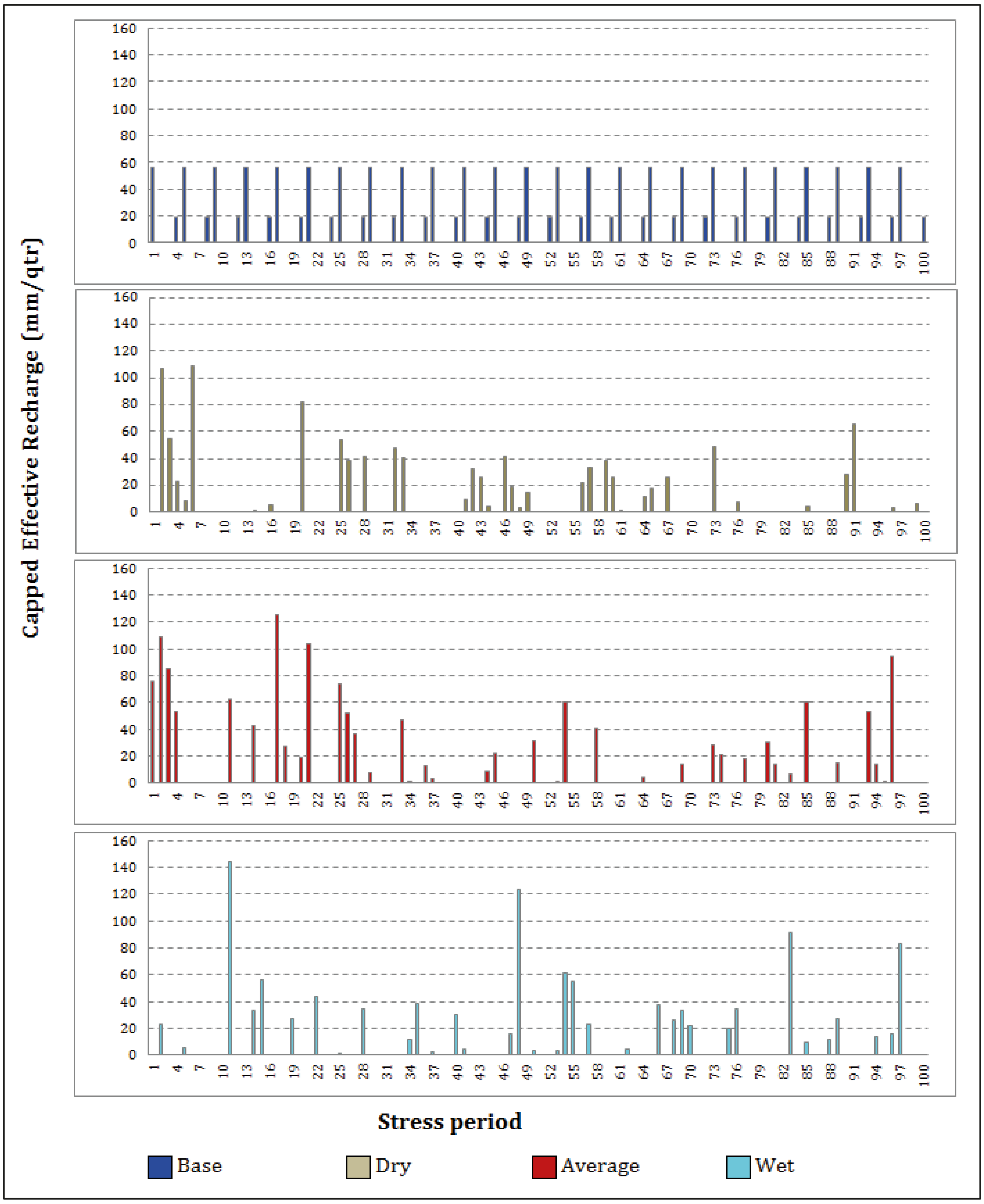


Figure F 3 **Climate sensitivity of recharge rates**

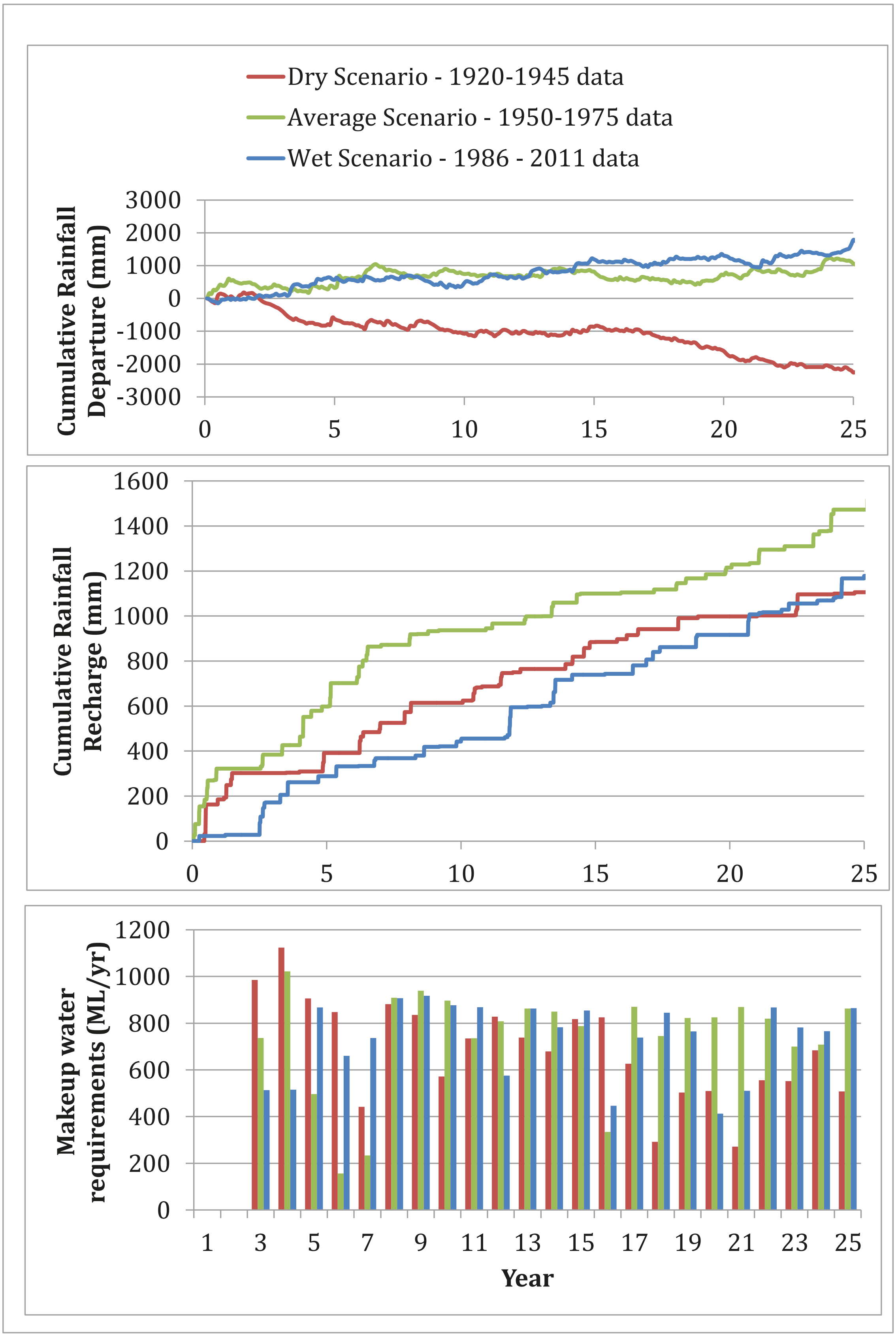


Figure F 4 CRD, cumulative recharge and make up water for sensitivity scenarios

The base case model 2 used average river stage heights and looped these levels over the 25 year project life, similar to rainfall recharge. The stage heights for the wet, dry and average rainfall sensitivity scenarios were based on stream flows simulated at gauges SW8, SW9, and SW4 by a rainfall runoff model developed by WRM. The flow volumes were converted to an average river stage height based on the relationship between baseflow and stage height. Figure F 5 presents the simulated river stage heights applied to SW8 (Bylong River), for the predictive climate scenarios.

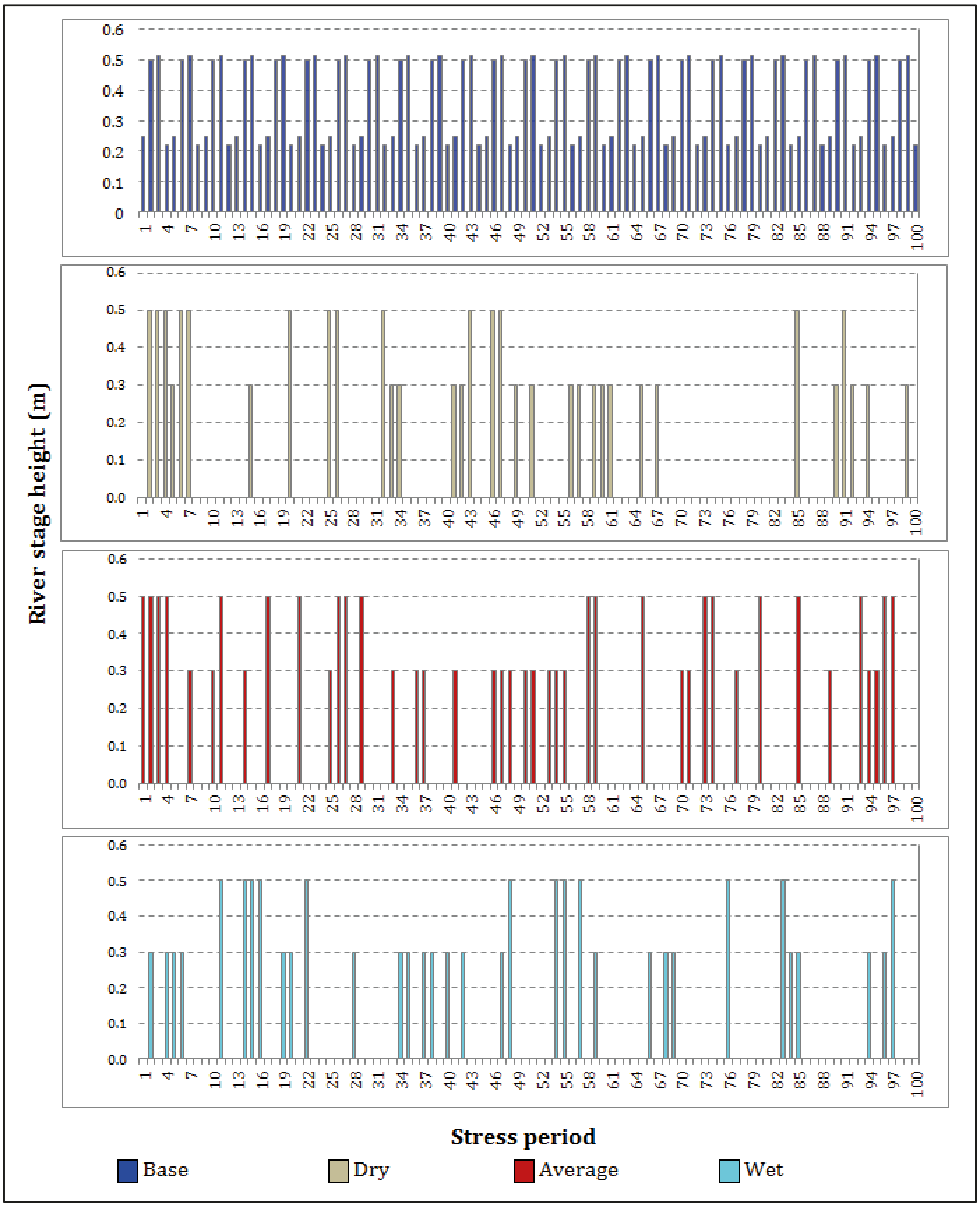


Figure F 5 Climate sensitivity of river stage heights (Bylong River)

Again, Figure F 5 highlights the uniform nature of stream flow in the base case model, and the natural variability that using the historical data introduces to the sensitivity scenarios. For example, the 'Dry scenario' contains periods of several years where there is no baseflow or leakage within the Bylong River. Interestingly, the average climate scenario has a more consistent rainfall for longer durations, and therefore shows more consistent streamflow compared to the wet climate scenario.

F1.1.4 Hydraulic properties

The sensitivity analysis also assessed the sensitivity response of the model for varying hydraulic properties. The hydraulic properties were adjusted to encompass the range of uncertainty in key parameters. Table F 2 below summarises the changes made to the model to assess the sensitivity of the hydraulic properties.

Table F 2 Summary of hydraulic properties sensitivity analysis

Sensitivity scenario	Parameters	Description
K+/K-	hydraulic conductivity (horizontal and vertical)	alluvium ± 0.5 order of magnitude (mag) x base case, all other stratigraphy ± 1 mag x base case
S+/S-	specific yield and specific storage	Alluvium, weathered material and tertiary basalt SY ± 100% base case, all other stratigraphy SY ± 0.5 mag x base case Alluvium, weathered material and tertiary basalt SS ± 0.5 mag x base case, all other stratigraphy ± 1 x mag base case
Spoil+ /Spoil-	hydraulic conductivity (horizontal and vertical)	spoil ± 1 mag x base case
	specific yield	spoil ± 0.25 mag x base case
	specific storage	spoil ± 1 mag x base case
	recharge rate	spoil ± 0.5 mag x base case
Riv+/Riv-	vertical bed conductance	river bed ± 1 mag. x base case
Drain on	-	drains representing mining active throughout mine life – no spoil
Cracking+/ Cracking-	goafed vertical hydraulic conductivity	± 1 mag x base case

F1.1.5 Unsaturated zone parameters

As discussed previously, SURFACT has three options to solve the equations for variably saturated water flow in the unsaturated zone. These are the pseudo-soil function, the van Genuchten algorithm, and the Brooks and Corey model. A sensitivity analysis was carried out to assess the response of the model predictions to changes in the unsaturated zone simulation method and parameters.

MODFLOW USG's equivalent to the pseudo-soil function, known as 'upstream weighting' was also explored. The 'upstream weighting' function sets the conductance between a dry cell and the adjoining wet cell to zero. This allows MODFLOW to keep a dry cell active while not allowing water to flow out of a dry cell (see Figure F 6). Recharge bypasses dry cells and is added to storage in the highest 'wet' cell.

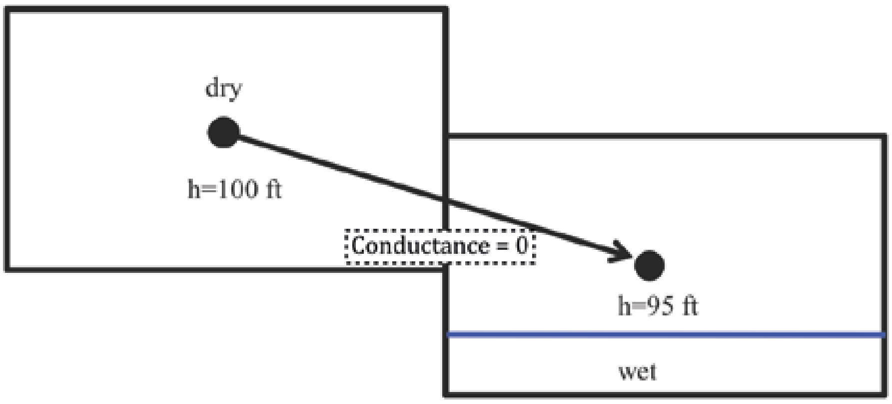


Figure F 6 Example of upstream weighting correction (from MODLOW-NWT manual)

To make use of the upstream weighting function, the model was converted to be compatible with MODFLOW-USG. To aid model convergence and model run times, the model was converted to a Voronoi unstructured mesh, with pinching out of 'wrapped' layers. Table F 3 details the scenarios run to assess the sensitivity of the unsaturated zone representation.

Table F 3 Summary of unsaturated zone sensitivity analysis

Sensitivity scenario	Unit	Alpha (m-1)	Beta (-)	Residual saturation (%)	Brooks Corey exponent
Base case van Genuchten model	Alluvium	0.02	7.0	1.0	N/A
	Colluvium	0.02	7.0	1.0	N/A
	Basalt	0.02	5.0	0.2	N/A
	Weathered Permian (Layer 1-3)	0.02	5.0	1.0	N/A
	Interburden (Layer 4)	0.02	5.0	1.0	N/A
	Interburden (Layer 5,7,9,10)	0.02	5.0	0.2	N/A
	Coal	0.02	5.0	0.2	N/A
Pseudo soil function	All units	N/A	N/A	N/A (implied by specific yield)	N/A
Brooks-Corey and van Genuchten (Scenario 1) (medium alpha, low beta and residual saturation)	Alluvium	1.0	1.9	1.0	2.0
	Colluvium	1.0	1.9	1.0	2.0
	Basalt	0.3	1.9	0.2	2.0
	Weathered Permian (Layer 1-3)	0.5	1.2	1.0	2.0
	Interburden (Layer 4)	0.3	1.2	1.0	2.0
	Interburden (Layer 5,7,9,10)	0.3	1.2	0.2	2.0
	Coal	0.3	1.2	0.2	2.0

Sensitivity scenario	Unit	Alpha (m-1)	Beta (-)	Residual saturation (%)	Brooks Corey exponent
Brooks-Corey and van Genuchten (Scenario 2) (medium alpha and beta and high residual saturation)	Alluvium	1.0	1.9	5.0	2.0
	Colluvium	1.0	1.9	5.0	2.0
	Basalt	0.3	1.9	5.0	2.0
	Weathered Permian (Layer 1-3)	0.5	2.0	5.0	2.0
	Interburden (Layer 4)	0.3	2.0	5.0	2.0
	Interburden (Layer 5,7,9,10)	0.3	2.0	5.0	2.0
	Coal	0.3	2.0	5.0	2.0
Brooks-Corey and van Genuchten high alpha, beta and residual saturation (Scenario 3)	Alluvium	10.0	2.0	5.0	2.0
	Colluvium	10.0	2.0	5.0	2.0
	Basalt	1.0	2.0	5.0	2.0
	Weathered Permian (Layer 1-3)	2.0	2.0	5.0	2.0
	Interburden (Layer 4)	1.0	2.0	5.0	2.0
	Interburden (Layer 5,7,9,10)	1.0	2.0	5.0	2.0
	Coal	1.0	2.0	5.0	2.0
Upstream weighting	All units	N/A	N/A	N/A (implied by specific yield)	N/A

The Bylong groundwater model (both base case 1 and 2) used the van Genuchten algorithm to predict the relationship between unsaturated zone hydraulic conductivity and water saturation/retention. To explore the unsaturated parameters effectively, the Brooks and Corey algorithm was used for relative hydraulic conductivity and the van Genuchten algorithm for water retention. This was a necessity, as when using van Genuchten algorithm, increasing the values used for alpha reduced the relative hydraulic conductivity[7] to very low values, resulting in mounding of water levels and the model failing to converge.

Figure F 7 shows the relationship between unsaturated hydraulic conductivity and matric suction in the groundwater model for the three sensitivity scenarios using the van Genuchten / Brooks-Corey algorithms.

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[7] ratio of the unsaturated and saturated hydraulic conductivity

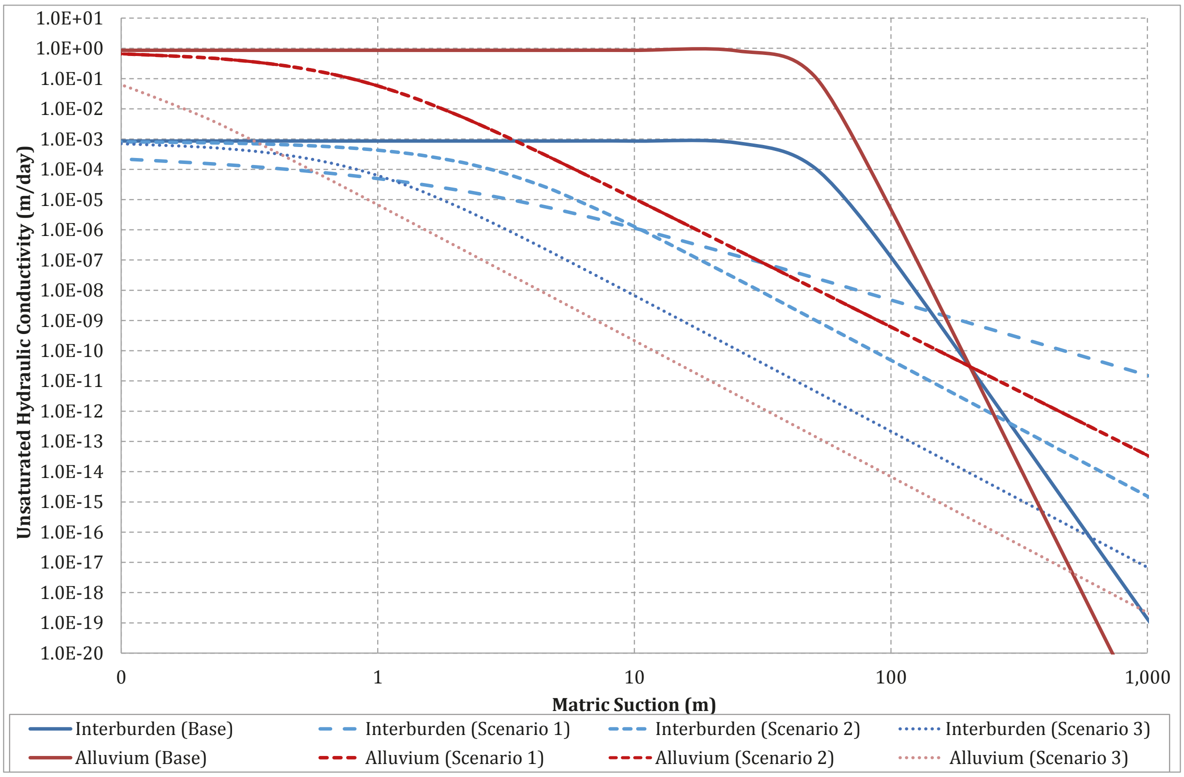

Figure F 7 Unsaturated hydraulic conductivity vs. matric suction

The figure demonstrates the base case model has the highest relative hydraulic conductivity at matric suction heads occurring in the Bylong groundwater model, which is considered a conservative approach to predictive modelling.

Figure F 8 presents the relationship between unsaturated water content and matric suction in the groundwater model using the van Genuchten algorithm.

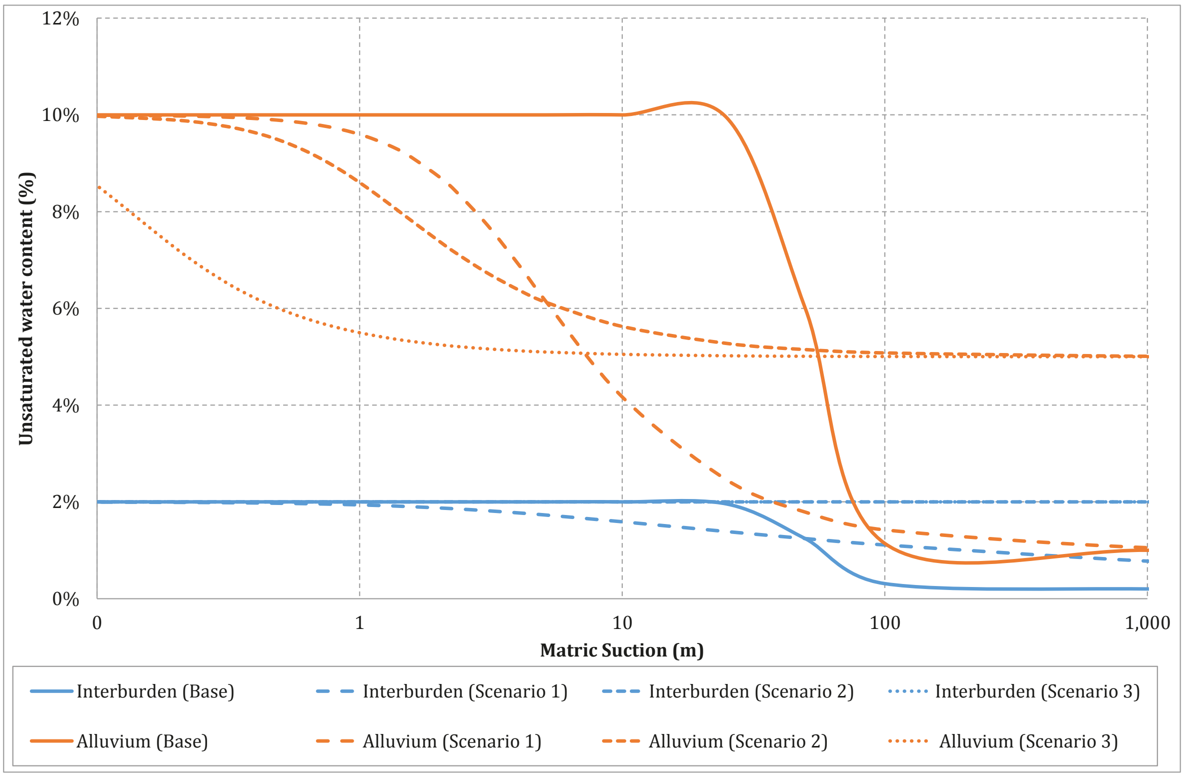

Figure F 8 Unsaturated water content vs. matric suction

The results show that the base case retains slightly more water as unsaturated storage at higher matric suction values than the sensitivity scenarios.

The pseudo-soil function was attempted in the Bylong model sensitivity analysis, however, the model failed to converge. This was likely due to the large number of unsaturated cells in the upper layers of the groundwater model (i.e. overlying the underground mining areas), coupled with the relatively low recharge rates assigned to the model cells in areas of high relief creating a high matric suction.

To overcome convergence errors, the Bylong groundwater model was converted to a MODFLOW-USG compatible model, to utilise the upstream weighting function, which is the equivalent of the pseudo-soil function.

The pseudo-soil/upstream weighting functions do not simulate transmission of groundwater through the unsaturated zone, as relative hydraulic conductivity is reduced to 0 m/day when the cell becomes dry. It simulates a linear hydraulic conductivity saturation curve according to the saturated thickness of the model cell. This approach does not require the uncertain input parameters of the van Genuchten algorithm, but it is not considered a conservative approach for open cut mining. This is because there is potential for depressurisation through the unsaturated zone to be retarded by the hydraulic conductivity of 0 m/day when the cell becomes dry. Therefore using this approach requires confidence in the thickness of the saturated model cells surrounding the proposed mining areas.

F1.2 Uncertainty analysis methodology

F1.2.1 Introduction

This section assesses the uncertainty of the model predictions to natural variability in the calibrated parameters. Analysis of the uncertainty of model outputs is referred to as "uncertainty analysis". Model calibration does not necessarily result in a unique set of parameter values, especially if the model employs a number of parameters to simulate system complexity. Typically, groundwater models employ numerous levels of simplification and assumptions, in order to represent reality. Therefore, a number of issues may arise, including:

(i) adequacy in representing naturally complex processes;
(ii) gaps in our understanding of the hydrogeological system process; and
(iii) measurement 'noise' in observed aquifer measurements.

A calibration-constrained Monte Carlo method was used for predictive uncertainty analysis to generate variable model parameter sets. To ensure the model remained calibrated, the results from the models were then compared against observed data, accounting for natural errors associated with observed data (i.e. measurement error). This process aims to replicate the projection of the null-space between the parameters and observations in the groundwater model, although it does not implicitly project the null-space (zero vector gradient) from the covariance matrix. This analysis allows more model 'de-calibration' and permits parameters to extend past the calibration bounds (dependant on the calibrated 'mean'). The results from this analysis are far more conservative than a 'textbook' null-space analysis, which normalises and re-calibrates the random data set, reducing the departure of the predictions from the calibrated model.

It should be noted that the calibration-constrained Monte Carlo analysis was carried out on the MODFLOW-USG version of the groundwater model (base case version 2), employing the upstream weighting function. This approach removes the unsaturated zone from the simulation. The USG model was not as well calibrated as the SURFACT model, and did not perform well simulating landholder pumping using the WEL package. Landholder pumping was removed from the simulation, although this had very little cumulative effect on the impacts. Pumping from the bore field had to be reduced to 60% of the Project requirements (base case version 2), and whilst this created differences in heads and flows locally around the bore field, on a regional scale the influence of this was not considered significant.

F1.2.2 Methodology

During the pre-calibration stage, appropriate bounds were established for each parameter set, based on observed data, textbook sources (if necessary) and best knowledge. These bounds could represent, for example, the 95th confidence interval of field hydraulic testing data, or one-magnitude variability in specific storage as suggested from similar hydrostratigraphic units in the region. The groundwater model was manually calibrated using these conceptual bounds as parameter limits then set in the automated calibration software, (e.g. PEST).

Model calibration does not necessarily produce a unique set of parameter values, therefore model predictions can vary with a 'calibrated' parameter set. The analysis of the variability in these predictions is known as a calibration-constrained Monte Carlo approach.

Given large variability in the expected range of hydraulic parameters required to create a groundwater model, it is assumed that the predictive results will be subject to a similar level of uncertainty (although the level of uncertainty depends on the type of prediction).

In this study, predictive uncertainty analysis was applied to the steady state, transient calibration, and predictive groundwater models, which was calibrated to a measurement dataset. This dataset was selected to best represent the groundwater response to seasonal and mining induced stresses on the system from years 2011 to 2014. These parameter sets were 'realised' using a stochastic random number generator, using an adopted set of parameter statistical properties to best represent the observed and/or estimated range.

The randomised realised fields represent the possible variability of the parameter dataset that leads to variability in model predictions. A higher level of 'de-calibration' of the model occurred when compared to a null space approach. This however was considered a conservative approach likely to overestimate the uncertainty and therefore preferable for a greenfield EIS.

Randomised parameter sets were generated by allowing random heterogeneity on a cell-by-cell basis, to better represent the type of aquifer variability that exists in the real world. Each spatial parameter field was generated using a cell-by-cell stochastic field generator. Cell-by-cell variability of parameters also assumed a log-normal prior probability distribution, with means corresponding to optimised parameter values and a variogram sill (upper bound) corresponding to the assumed parameter variance.

200 realised parameter sets were explored for the calibration model, bounded by the 95% confidence intervals from the expected calibrated parameter bounds used in PEST. The rejection of these parameter sets was determined by ranking the objective function (i.e. Phi) from the steady state and transient calibration simulation for each realisation. Realisations that exceeded the calibrated objective function by more than 25% were rejected from the predictive calibration analysis, which was determined from the spread of the Phi results and subsequent levels of de-calibration. Of the 200 realised parameter sets, 157 fell within the acceptable calibrated objective function. The suite of 157 realisations was used to predict the degree of uncertainty within the model outputs, and computing the statistical probabilities of the results (e.g. groundwater drawdown) from all model runs.

F1.2.3 Application of uncertainty analysis

F1.2.3.1 Variable parameters

All hydraulic parameters explored in the automatic calibration were explored in the analysis, including horizontal hydraulic conductivity, specific storage, specific yield, groundwater recharge, and riverbed conductance.

The original calibration process employed layer-wide parameters to represent aquifer hydraulic properties for the undisturbed rock, spoil and underground longwall areas. Thus, these parameters were replaced with spatially varying fields to replicate cell-by-cell variability across the model domain.

The reduction of hydraulic conductivity with depth below surface was represented using an exponential decline function determined from measurement data (refer Section 5.5 of the main report). To introduce a variability of hydraulic parameters, the observed decline of horizontal hydraulic conductivity with depth was honoured, however a multiplier array changing the calculated hydraulic conductivity value was applied. The multiplier array adjusted the calculated horizontal hydraulic conductivity of the coal seam by a value of 1 order of magnitude of the calibrated parameter interval.

Cell-by cell groundwater recharge rates from diffuse rainfall were also included in the uncertainty analyses, using the random-generated multiplication fields. Realised fields representing daily recharge rates were generated for the regolith and alluvial zones, using bounds utilised in the automated calibration process.

F1.2.3.2 Generating random fields

The covariance matrix C(**k**) represents information on hydraulic properties available from outside of the calibration process, and represents "expert knowledge" in the model parameterisation process. The hydraulic parameters within the C(**k**) matrix were set realistic bounds based on the "expert knowledge". The uncertainty of the predictions made by an un-calibrated model is a function of C(**k**).

Information used to assemble the components of the C(**k**) matrix for random parameter generation is presented in Table F 4 to Table F 9. All parameters and standard deviations were converted to log values given the relationship between parameter and model output is likely to approach linearity. Note, the exponential variogram range in kilometres applied to realised parameter fields was based on expected structural variances in the model (e.g. 2000 m).

Within Table F 4 to Table F 9, the calculation of standard deviation of each parameter was based on the assumption that the parameter has a normal distribution and parameter bounds represent the 95% confidence limit. Variance, or the multiplying range applied to the random number generator, is the square of the standard deviation. The mean represents the calibrated value attained from automated PEST calibration, which best replicates the calibrated parameter set. It should be noted the vertical hydraulic conductivity is a maintained factor of the realised horizontal field.

Table F 4 Horizontal hydraulic conductivity cell-by-cell field generation statistics

Parameter Zone	Parameter Name	Mean (m/day)	Standard Deviation ($\log_{10}$)	Variance ($\log_{10}$)	"a" of Exponential Variogram (m)
1	alluv1	2.70E+00	0.500	0.25	2000
2	alluv2	4.72E+00	0.500	0.25	2000
3	colluv	4.60E-01	0.500	0.25	2000
4	int4	1.50E-03	0.500	0.25	2000
5	int5	3.64E-04	0.500	0.25	2000
7	int7	1.50E-03	0.500	0.25	2000
9	marr	1.63E-03	0.500	0.25	2000
10	int10	1.87E-04	0.500	0.25	2000
11	bas	1.10E+00	0.500	0.25	2000
12	volc	1.49E-03	0.500	0.25	2000
13	weath	2.41E-01	0.500	0.25	2000
1a	Spoil	1.00E+00	0.445	0.20	2000
2a	TSF	1.00E-02	0.500	0.25	2000

Table F 5 Coal seam conductance multiplier for cell-by-cell field generation statistics

Parameter Zone	Parameter Name	Mean	Standard Deviation ($\log_{10}$)	Variance ($\log_{10}$)	“a” of Exponential Variogram (m)
1	Coal Seam	1.00	0.5	0.25	2000

Table F 6 Specific yield for cell-by-cell field generation statistics

Parameter Zone	Parameter Name	Mean	Standard Deviation ($\log_{10}$)	Variance ($\log_{10}$)	“a” of Exponential Variogram (m)
1	alluv1	9.81E-02	0.325	0.11	2000
2	alluv2	8.55E-02	0.325	0.11	2000
3	colluv	8.24E-02	0.325	0.11	2000
4	int4	2.22E-02	0.425	0.18	2000
5	int5	3.08E-02	0.425	0.18	2000
7	int7	1.62E-02	0.349	0.12	2000
9	marr	7.56E-03	0.425	0.18	2000
10	int10	2.07E-02	0.349	0.12	2000
11	bas	1.24E-02	0.425	0.18	2000
12	volc	7.31E-03	0.425	0.18	2000
13	weath	5.00E-02	0.305	0.09	2000
1a	Spoil	9.62E-03	0.425	0.18	2000
2a	TSF	1.00E-01	0.325	0.11	2000

Table F 7 Specific storage for cell-by-cell field generation statistics

Parameter Zone	Parameter Name	Mean (m^{-1})	Standard Deviation ($\log_{10}$)	Variance ($\log_{10}$)	“a” of Exponential Variogram (m)
1	alluv1	5.00E-03	0.500	0.25	2000
2	alluv2	1.00E-03	0.500	0.25	2000
3	colluv	2.00E-05	0.500	0.25	2000
4	int4	1.63E-05	0.500	0.25	2000
5	int5	2.31E-06	0.500	0.25	2000
7	int7	2.28E-05	0.500	0.25	2000
9	marr	7.60E-05	0.500	0.25	2000
10	int10	2.00E-04	0.500	0.25	2000
11	bas	1.31E-05	0.500	0.25	2000

Parameter Zone	Parameter Name	Mean (m^{-1})	Standard Deviation (log_{10})	Variance (log_{10})	"a" of Exponential Variogram (m)
12	volc	7.06E-06	0.500	0.25	2000
13	weath	1.52E-05	0.500	0.25	2000
1a	Spoil	1.57E-05	0.500	0.25	2000
2a	TSF	2.00E-04	0.500	0.25	2000

Table F 8 Recharge factor for cell-by-cell field generation statistics

Parameter Zone	Parameter Name	Mean (%)	Standard Deviation (log_{10})	Variance (log_{10})	"a" of Exponential Variogram (m)
1	rch01	1.40E+01	0.325	0.11	2000
2	rch02	2.79E+00	0.325	0.11	2000
3	rch03	9.00E+00	0.750	0.56	2000
4	rch04	9.64E-01	0.750	0.56	2000
5	rch05	1.00E-03	0.750	0.56	2000
1a	rch01tr	1.00E+02	0.075	0.006	2000
2a	rch02tr	4.77E+00	0.325	0.11	2000
3a	rch03tr	5.00E+01	0.575	0.33	2000
4a	rch04tr	1.20E-01	0.750	0.56	2000
5a	rch05tr	9.25E-01	0.750	0.56	2000
6a	irrig	2.70E-01	0.287	0.08	2000

Table F 9 Vertical riverbed conductivity for cell-by-cell field generation statistics

Parameter Zone	Parameter Name	Mean (m/day)	Standard Deviation (log_{10})	Variance (log_{10})	"a" of Exponential Variogram (m)
1	riv1	1.00E-01	0.500	0.25	2000
2	riv2	1.37E-01	0.500	0.25	2000
3	riv3	7.22E-01	0.500	0.25	2000
4	riv4	1.00E+00	0.500	0.25	2000
5	riv5	1.60E-01	0.500	0.25	2000

F1.2.3.3 Application

Two hundred randomised realisations were generated with FIELDGEN using the parameters listed in above. The realised fields were transferred to Voronoi cells compatible with the MODFLOW USG model. All 200 realisations were tested using PEST, and the objective function (sum of squared residuals) from each run was examined. The calibrated objective function[8] (Phi) was determined as 67,657 m^2, and a suitable cut off for "de-calibration" was set to be 125% of the calibrated Phi (i.e. 85,000 m^2). 157 realisations meet these criteria, and 43 realisations were rejected from further analysis. Of these 157 realisations, a total of 32 simulations failed to converge (or failed to converge in a timely manner), meaning that the combination of varied parameters e.g. high recharge and low hydraulic parameters, caused numerical instability.

Figure F 9 shows a sample of the 157 realisations for the hydraulic conductivity.

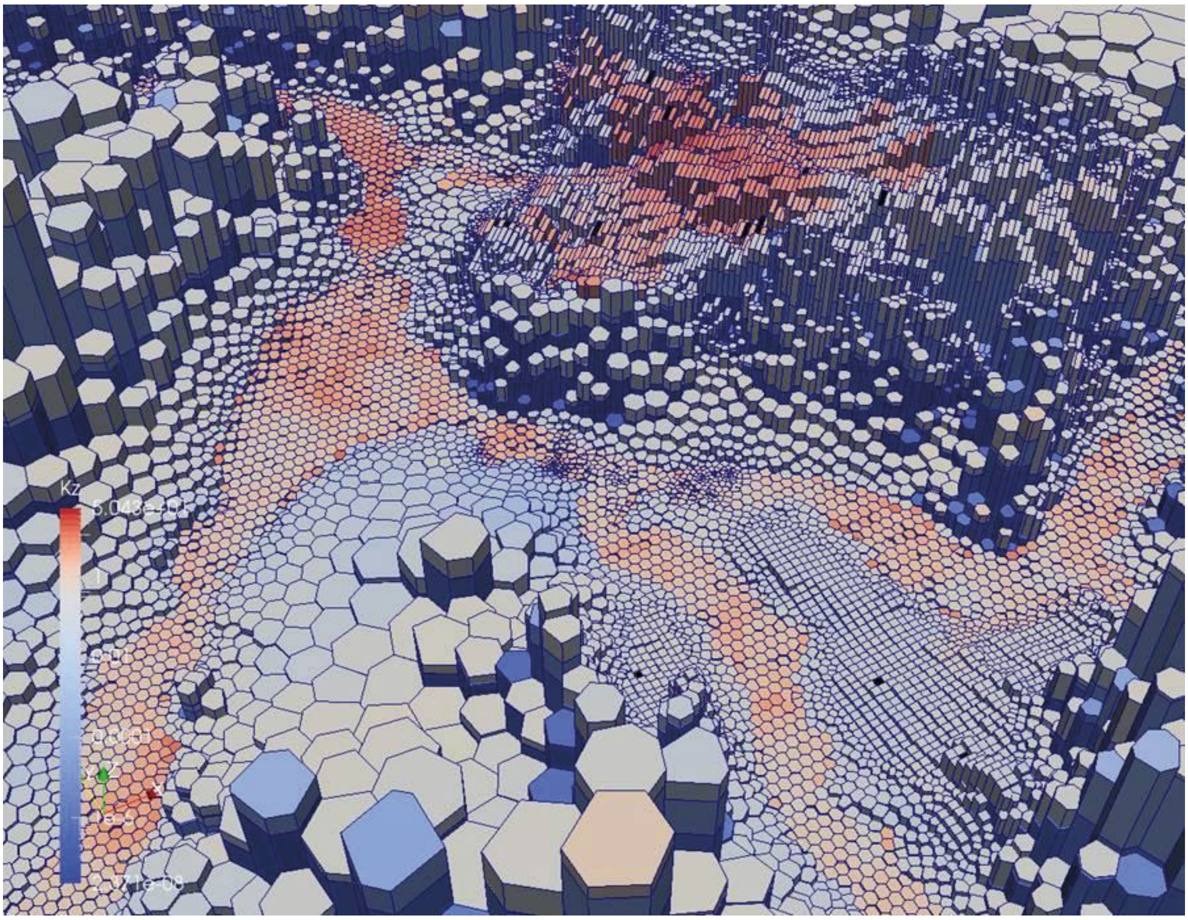

Figure F 9 Realized example of horizontal hydraulic conductivity (looking north through project area)

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[8] The initial model calibration Phi used for uncertainty analysis.

Figure F 10 shows the results from the calibration uncertainty analysis (Realisations), as well as the calibrated and cut-off levels for the objective function (Phi).

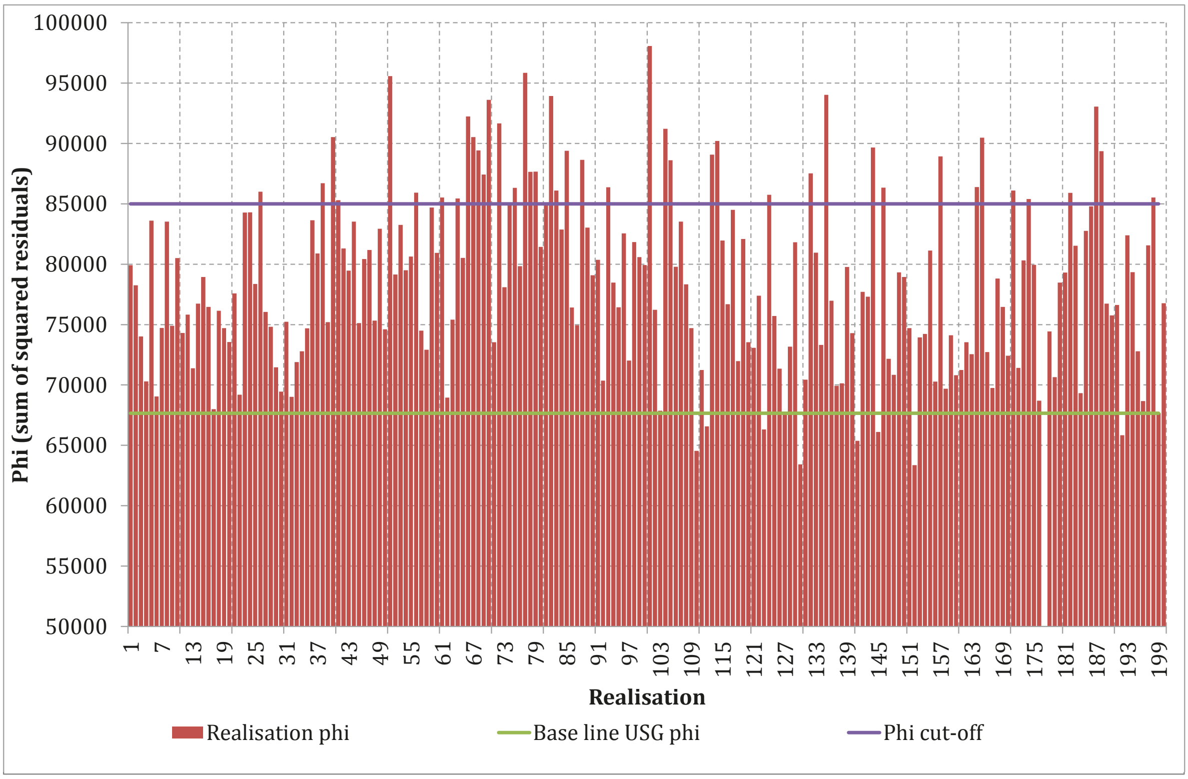


Figure F 10 Ranking of objective function (phi) from calibration runs

The results of the uncertainty are presented with the results for unsaturated zone within Section F2.3.

F2 Sensitivity and uncertainty analysis results

The sections below describe the results of the sensitivity analyses.

F2.1 Climate scenario

F2.1.1 Predicted mine seepage rates

Figure F 11 shows the sensitivity of the predicted seepage rate into the mining areas, to changes in rainfall recharge and stream flow conditions. Note the seepage rate to the mining areas is based on the inflow at the end of each stress period, not the weighted average of all time steps as reported in Section 10.4 of the main report.

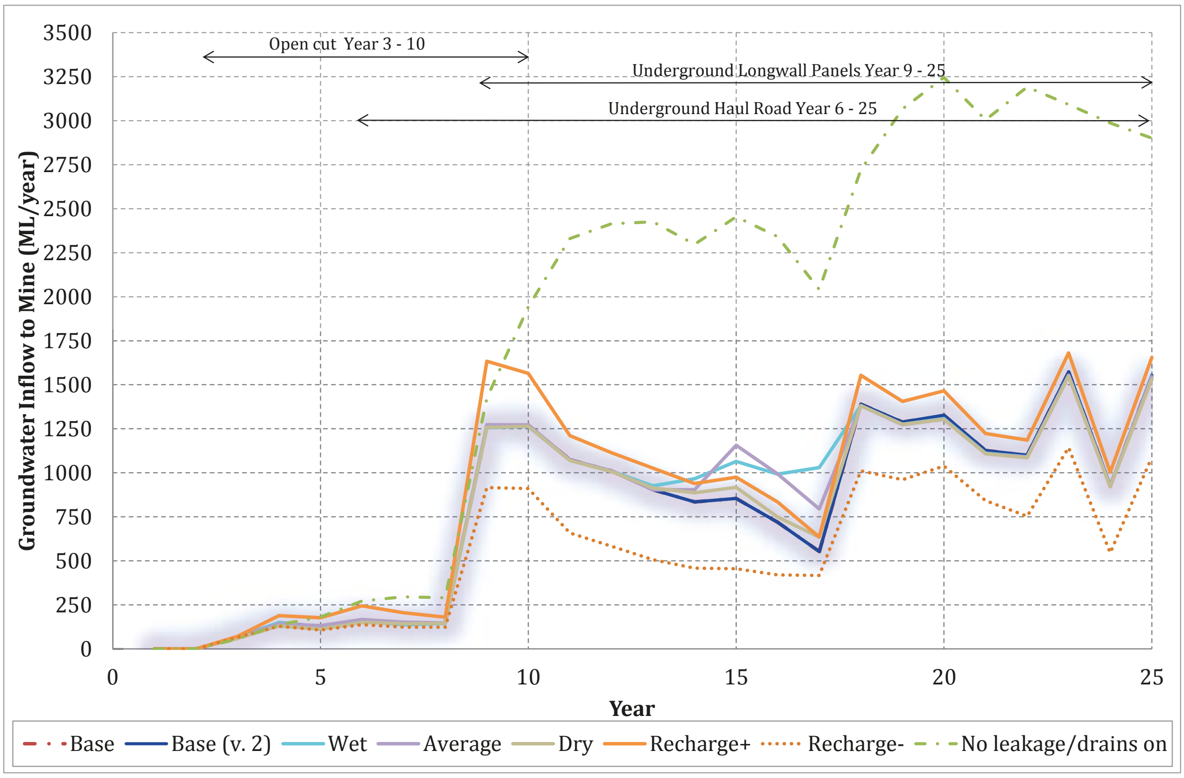


Figure F 11 Climate sensitivity of mining area inflow

Figure F 11 indicates the predicted rate of seepage into the mines does not vary significantly in response to climatic conditions (dry/average/wet conditions). This is expected, as periods of high or low rainfall typically change groundwater levels in the order of 1 m to 2 m, and this does not significantly change steep hydraulic gradients around the mining areas.

When irrigation recharge and river leakage are removed from the model for 25 years, and the mine drains are left on for the entire mine life, groundwater inflow rates increase, particularly during the underground mine life and are roughly double the base case.

The seepage rate to the mining areas was most sensitive to the more extreme changes to recharge (alluvium ± 100% base case, other stratigraphy ± 0.5 to 1 mag x base case), but seepage rate did not change proportionally in response to the changes in recharge.

F2.1.2 Alluvial aquifer system

A key model prediction is the water take from the alluvial aquifers due to mining. Figure F 12 presents the sensitivity of the predicted water take to climate variability.

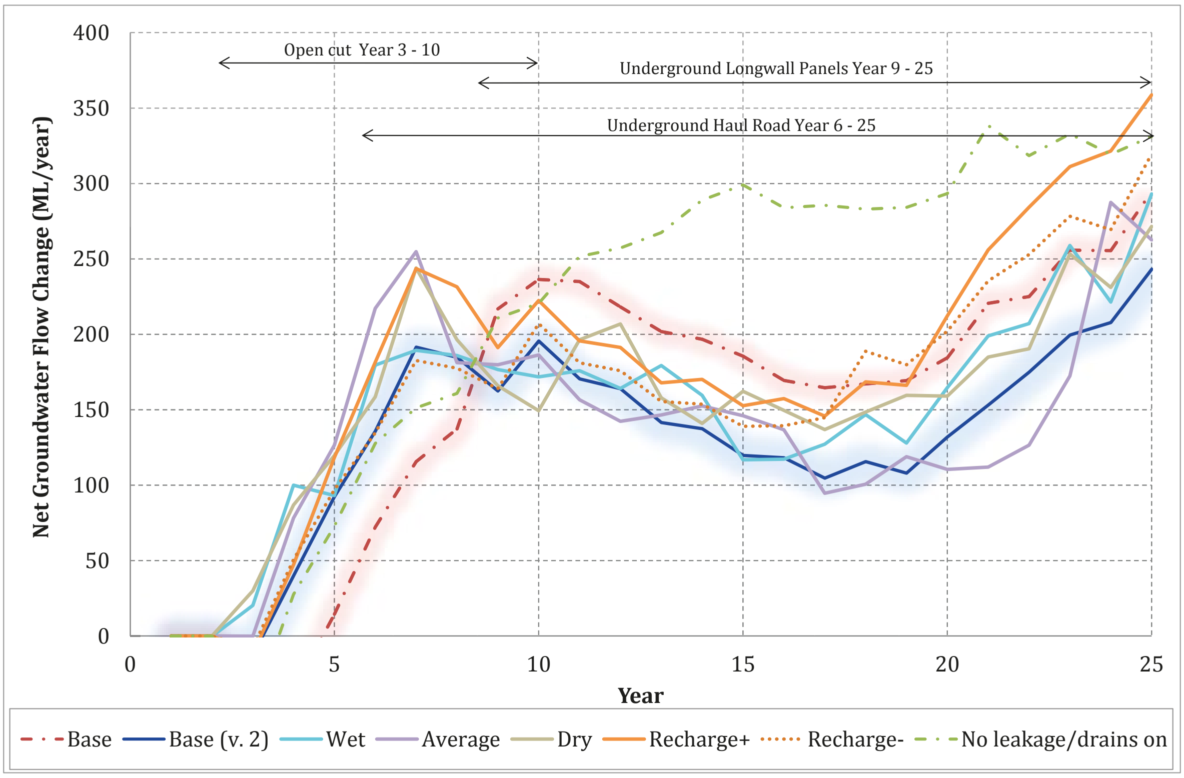


Figure F 12 Climate sensitivity of Permian to alluvial flow change

Figure F 12 demonstrates the 'water take' from alluvium is not sensitive to changes in recharge rates. Again, this is expected, as periods of high or low rainfall typically change groundwater levels in the order of 1 m to 2 m, and this does not result in significant changes to steep hydraulic gradients around the mining areas. It should be noted that the reduced recharge scenario (Recharge -) had convergence issues, resulting in a markedly different solution, which explains why the results deviate from the base case.

When leakage and irrigation recharge are removed, and drains are left on, more Permian groundwater is intercepted compared with the base case, resulting in more 'water take'. This is because of enhanced depressurisation primarily caused by leaving the drains on for longer than realistically proposed.

Figure F 12 also shows that the 'water take' from the alluvium due to the Project is slightly offset between base case 1 and base case 2. This is because there this a large makeup water requirement during years 3 to 8 in base case 1.

F2.1.3 Bylong River baseflow

Figure F 13 presents the simulated change to river baseflow in Bylong River for each of the climate scenarios. In the figure, negative flows indicate a net reduction in flow from the aquifer to the river, (i.e. baseflow /gaining conditions).

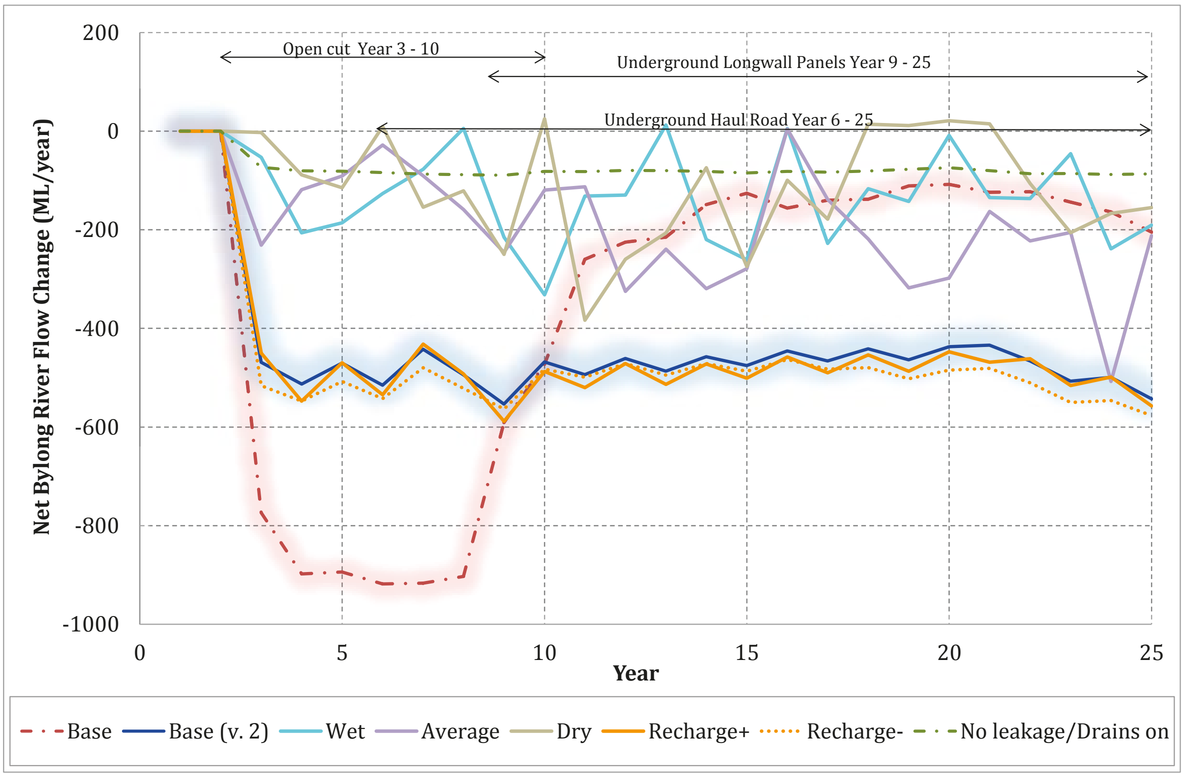


Figure F 13 Climate sensitivity of river baseflow change (Bylong River)

Figure F 13 shows less loss of baseflow for the climate scenarios of wet, dry and average rainfall conditions, compared with the base case. This is largely due to the base case assuming perennial flow within defined sections of the Bylong River (and therefore more interaction with groundwater); whilst the three climate scenarios represent more variable ephemeral flow dependent on rainfall events, and all have periods where leakage from the river to the aquifer cannot occur. This results in less 'water take' in the climate scenarios than the base case, because there is less leakage between the groundwater table and the river. The sensitivity analysis therefore demonstrates that the base case provides a conservative estimate of the water take from the rivers and streams.

Similar to the dry climate scenario, the scenario in which river leakage and irrigation recharge are removed shows much lower flow changes than both base cases and the climate scenarios. This is because river leakage is removed for the entirety of the predictive simulation, meaning there is much less water available to leak from the river to the aquifer.

F2.1.4 Zone of depressurisation and impact on water users

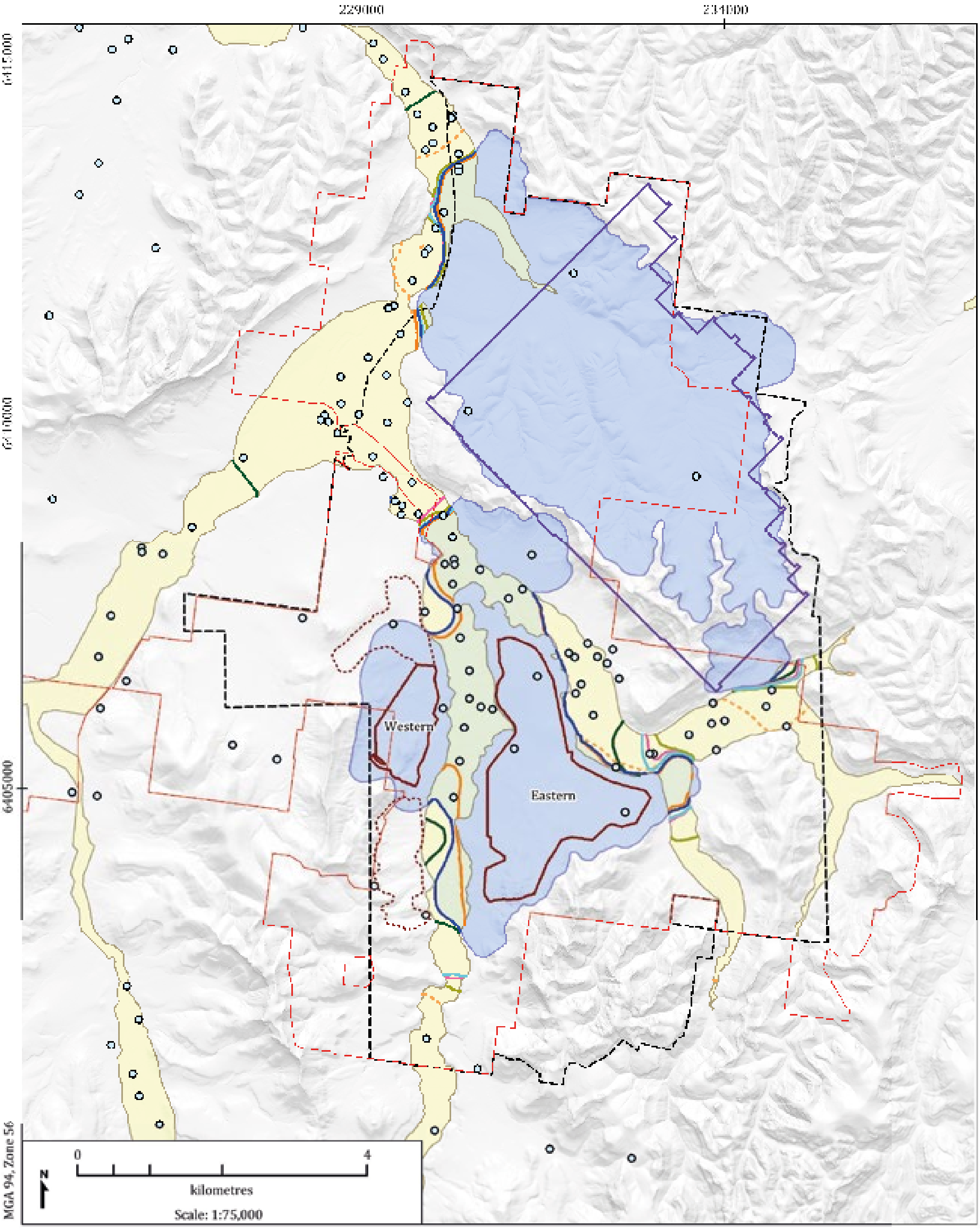
The sensitivity analysis assessed the changes to the zone of depressurisation in the alluvium and the Coggan coal seam. Figure F 14 and Figure F 15 show the sensitivity of predicted maximum groundwater drawdown during mining to changes in the model, for the alluvium (Layer 2) and the Coggan coal seam (Layer 8) respectively.

Figure F 14 shows drawdown in the alluvium depends on the proximity to the opencut and underground mining areas. West of the proposed longwall mining area, all climate scenarios have little impact on the extent of drawdown within the alluvium. In contrast, the drawdown becomes more extensive within the alluvium to the east of the Eastern Mining Area extending across the flood plain. The drawdown also extends further upstream within Lee Creek for the wet, dry and average scenarios when compared to the base case. The analysis highlights that periods of drought that are not represented in the base case can result in periods of more extensive drawdown, however despite this the drawdown remains largely within the land owned by the proponent and does not increase drawdown in any private bores.

It is important to note that although the wet climate scenarios represents a 25 year period of higher rainfall than the base case, maximum drawdown can extend further than the base case if mining coincides with a particularly dry year in the wet scenario. For example, the dry period between stress period 86 to 93 in the wet climate scenario shows very little rainfall recharge, and therefore no streambed leakage.

Figure F 15 shows the drawdown within the Coggan seam is relatively insensitive to the climate scenarios. The influence of climate is most evident where the seams are relatively shallow, with the influence of climate becoming insignificant with depth, as would be expected.

The zone of depressurisation is most extensive when leakage and irrigation recharge are removed, and drains are left active. This scenario does result in a drawdown of greater than 0.5 m in seven private bores, with one bore reporting a drawdown over the 2 m limit specified within the AIP. It should be noted this outcome is considered improbable because it is proposed to progressively backfill the open cut (with exception of Eastern void area) after 10 years, and seal off underground mine panels as mining progresses.



LEGEND:

- Underground Extraction Area
- Open Cut Mining Area
- Overburden Emplacement Area
- Project boundary
- Quaternary alluvium
- Land ownership - KEPCO Bylong Australia
- ○ Registered bore

Climate sensitivity
1m drawdown contour

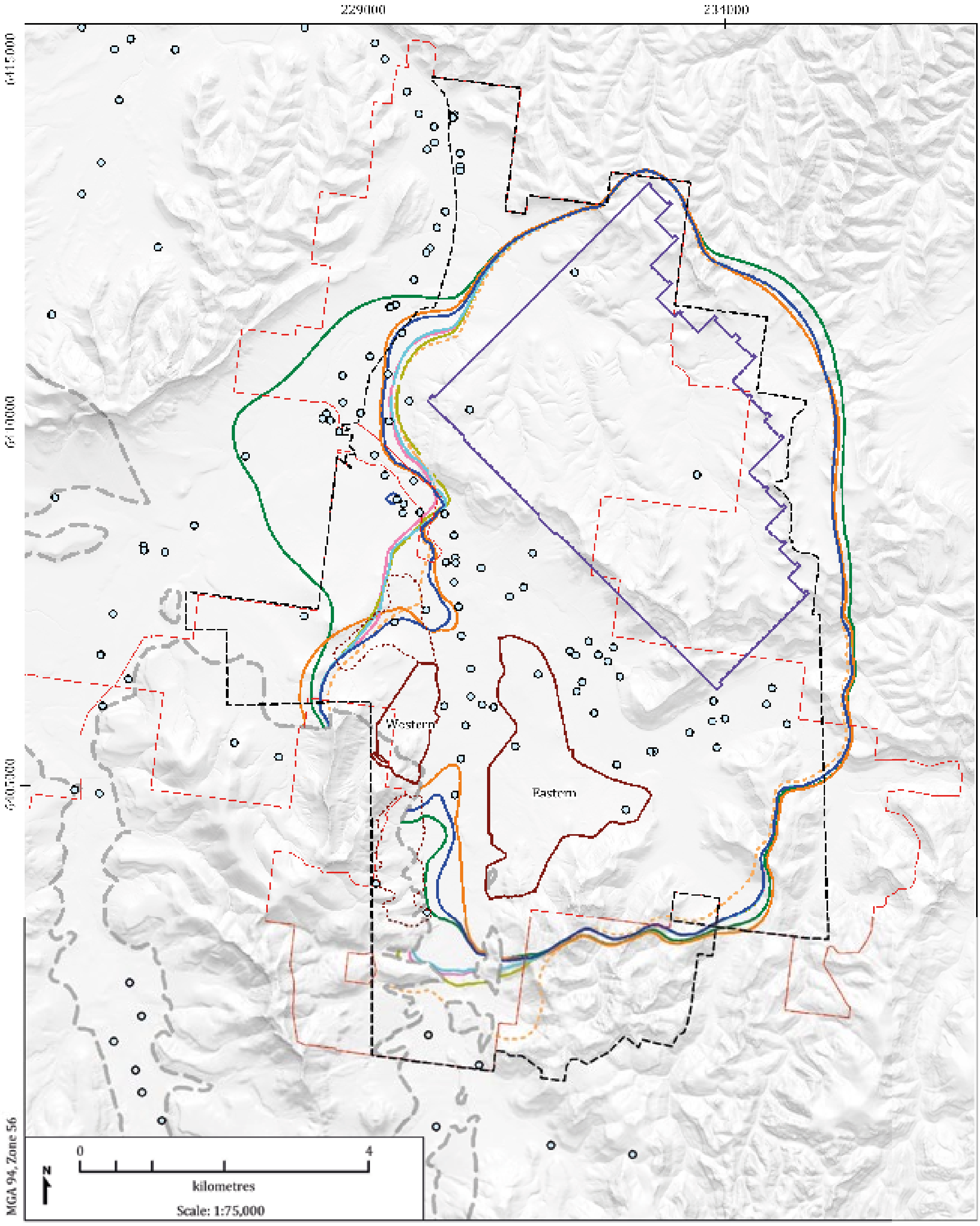
- Base
- Wet
- Average
- Dry
- Recharge +
- Recharge -
- Drain on
- Base - indicative only (outside extent of alluvium)

Bylong Coal Project (G1606)

Climate sensitivity of maximum groundwater drawdown - alluvium

DATE: 11/5/2015

FIGURE No: **F.14**



Bylong Coal Project (G1606)

Climate sensitivity of maximum groundwater drawdown - Coggan Seam

DATE:
11/5/2015

FIGURE No:
F.15

F2.1.5 Water licensing

Figure F 16 shows the water take from the alluvial water sources for the dry climate scenario, which is comprised of interception of water due to mining and pumping from the proposed bore field for makeup water.

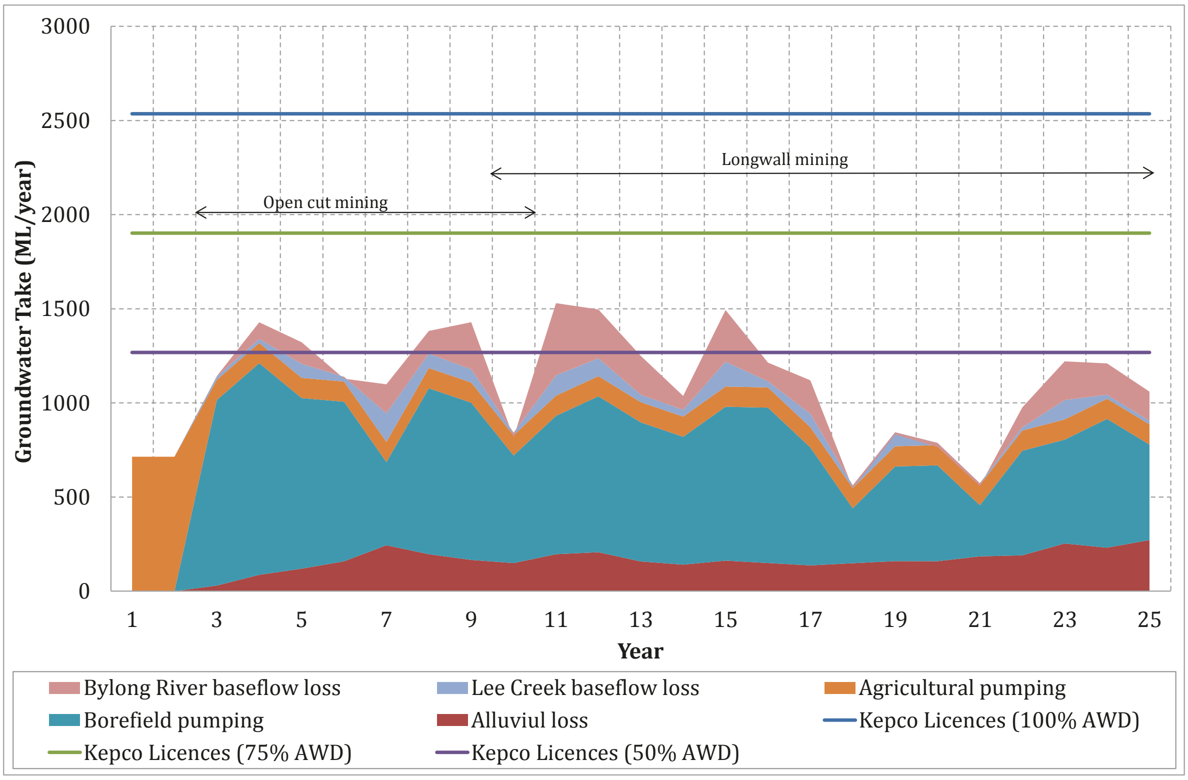


Figure F 16 'Water take' from alluvium (Dry climate scenario)

The results show that the dry climate scenario produces lower groundwater take from the alluvial water sources. This is because there is less groundwater interaction between surface water/groundwater and the mining area.

Figure F 17 and Figure F 18 show the water take from the alluvial water sources from the average and wet climate conditions, respectively.

Similar to the dry climate scenarios, total groundwater take from the alluvial aquifer system is lower than the base case, which is primarily due to the fact the interaction with the Bylong River is lower in the climate scenarios. These results show that the base case represents an extremely conservative approach to assessing the changes to baseflow and leakage caused by mining and bore field induced depressurisation.

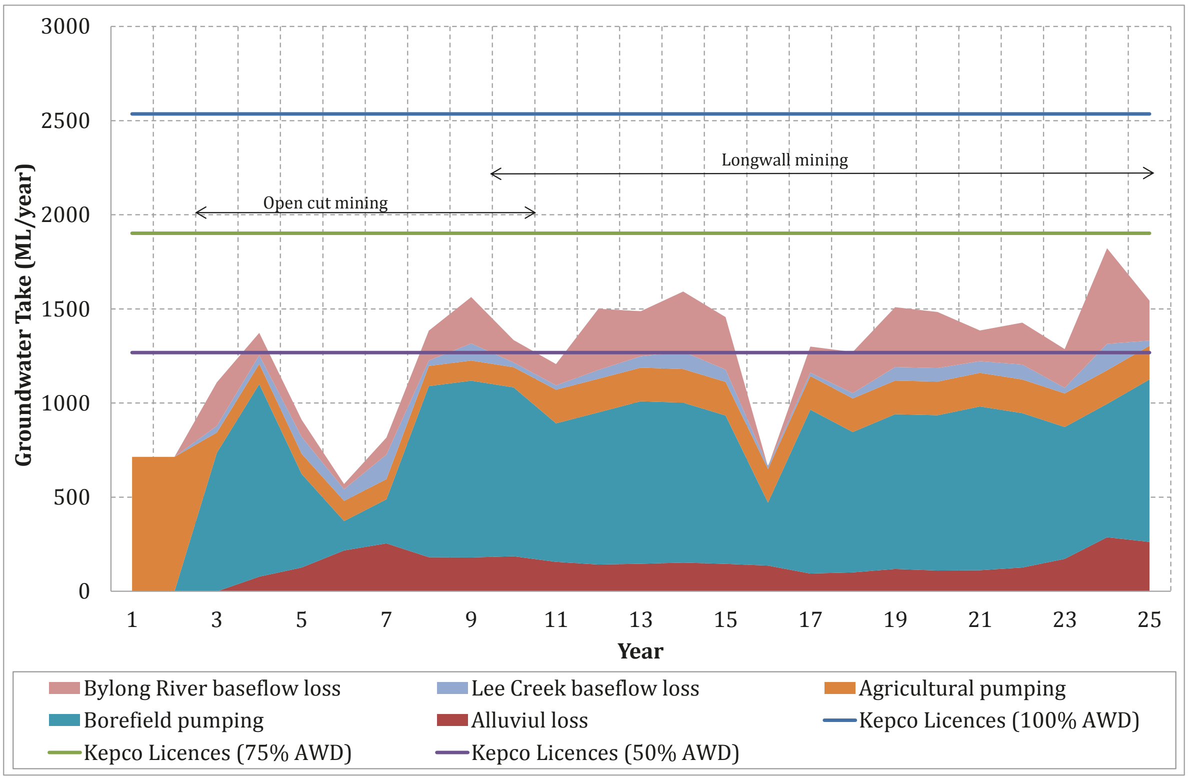


Figure F 17 Water take from alluvium (Average climate scenario)

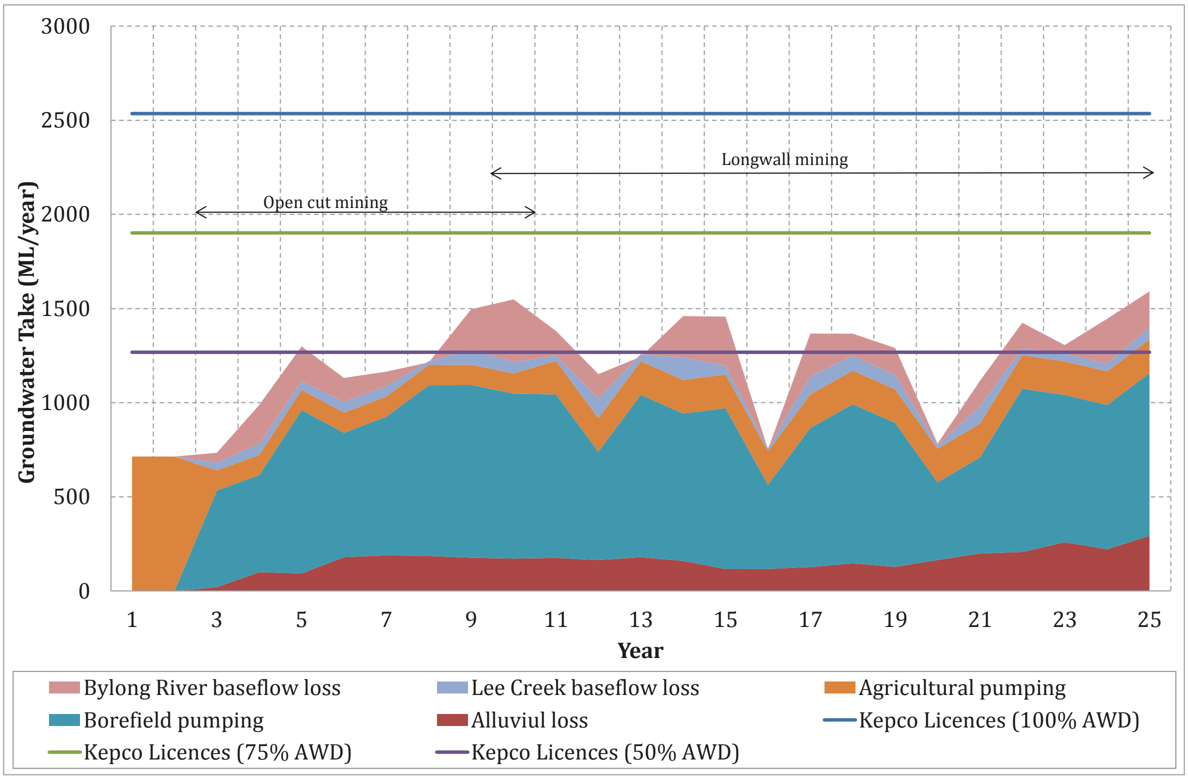


Figure F 18 Water take from alluvium (Wet climate scenario)

When river leakage and enhanced irrigation are removed, and drains remain active on for the life of the Project, 'water take' from the alluvium is similar to the base case presented in Section 10. Figure F 19 shows the licencing requirements during the extreme climate scenario.

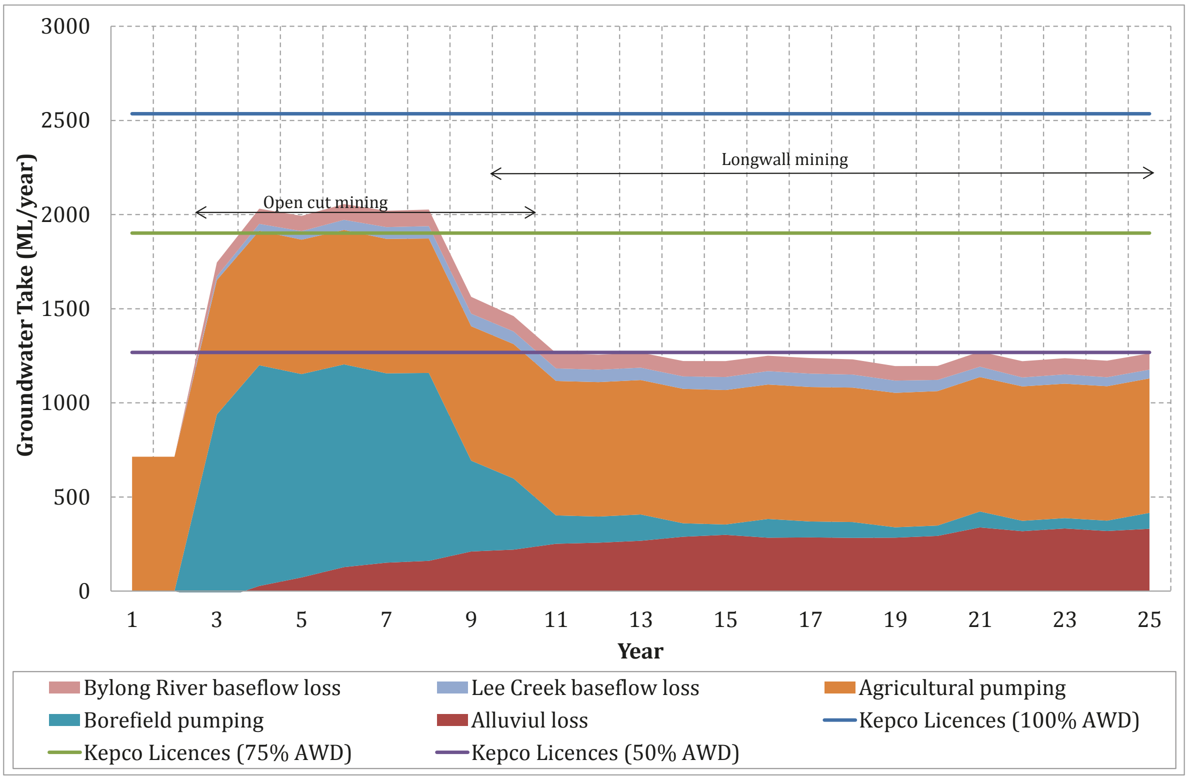


Figure F 19 Water take from alluvium (No leakage scenario)

F2.1.6 Bore field requirements

Abstraction from the bore field was simulated using the fractured well package, which automatically 'throttles' back groundwater pumping according to the available head within the bore. For the base case, the volumes of water removed from the bore field during each stress period were inspected, and additional bores were added until the 'make up' requirements were met.

It should be noted the bore field was unable to pump the required 1st percentile 'make up' water requirement from years 3 to 12 due to the limited saturated thickness within the alluvial aquifer. Figure F 20 presents the bore field water budgets from the extreme scenario along with the 1st percentile and median make-up water requirements.

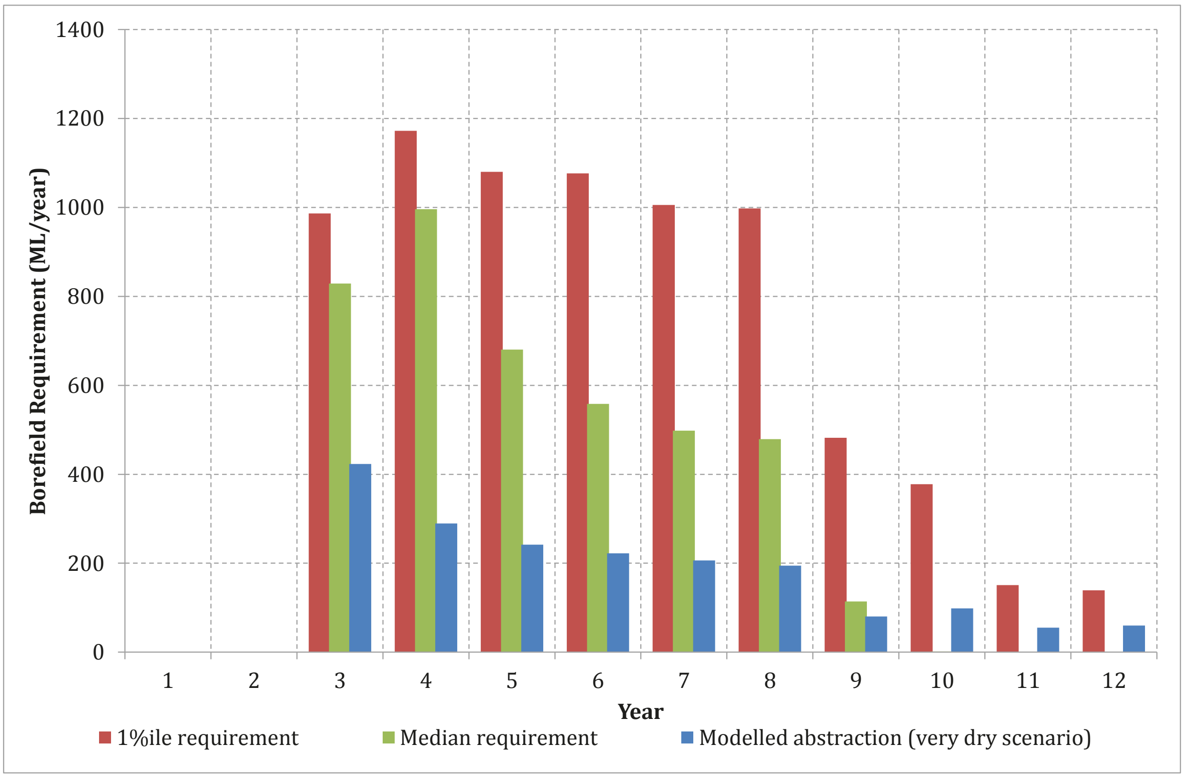


Figure F 20 Bore field abstraction vs. required volumes

The results show that the very dry climate model failed to meet the make-up water requirements for both the 1st percentile and median. During year 4 the bore field was 883 ML short of the 1st percentile requirement and 706 ML short of the median. To meet bore field requirements during these years, it is anticipated that the proposed bore field needs to expand by a further 25 to 31 bores. It should be noted that whilst this is an extreme scenario, it is considered improbable but remains possible. Section 13.6 describes the proposed design of the bore field, and measures to mitigate impacts during periods of extreme drought.

F2.2 Hydraulic properties

The sensitivity analysis also assessed the response of the model to varying hydraulic properties. The hydraulic properties were adjusted to encompass the range of uncertainty in key parameters.

Sections below describe the sensitivity of the predicted mine seepage rates, groundwater/surface take and the zone of drawdown to changes in the saturated zone parameters. The RMS performance of each of the sensitivity runs to demonstrate whether the scenarios are still calibrated are presented in Section F2.4. The results from scenarios that departed excessively from the base case model have limited confidence.

F2.2.1 Predicted mine seepage rates

Figure F 21 shows the sensitivity of the predicted seepage rate to changing the hydraulic parameters in the model.

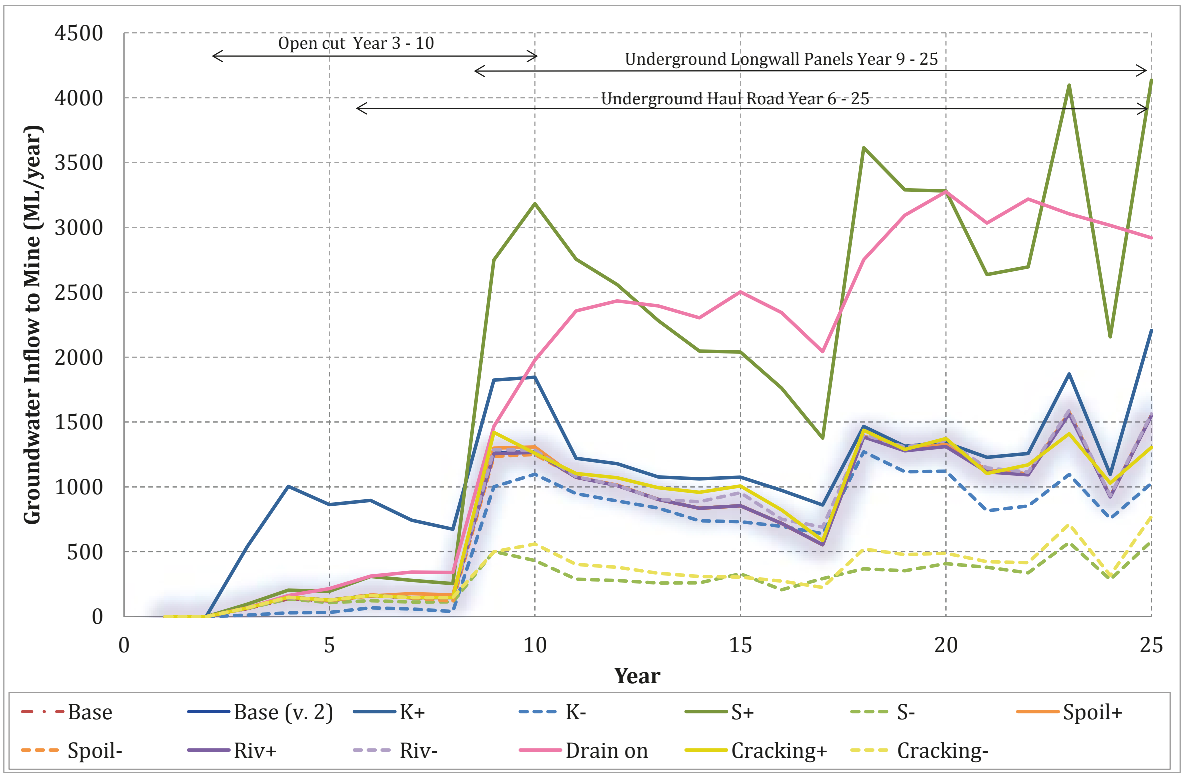


Figure F 21 Hydraulic parameter sensitivity of mining area inflow

The seepage rate was most sensitive to the adopted specific storage value, with an order of magnitude increase to the Permian units, resulting in a doubling of the seepage rate. Decreasing the storage had a similar effect, reducing predicted seepage rates to approximately 50% of the base case model.

The base case model represented mining with advancing drain cells, and gradually removed these drains and allowed flow of groundwater into previously mined areas if hydraulic gradients promoted this. A sensitivity scenario kept the drain cells active across the entire mine footprint, meaning all groundwater seepage was captured during the mine life even in mined out longwall panels and backfilled open cut pits. As expected, this scenario resulted in a gradually increasing rate of seepage to the mining areas over the mine life, with seepage about double the base case model. The scenario where drains were left on ('Drain on' in graphs) does not simulate the emplacement of spoil until the completion of the open cut, resulting in slightly higher groundwater inflows during open cut mining due to a larger drain footprint. This scenario also assumes the longwall panels are completely dewatered for the entire mine life. This does not replicate reality, as the mine plan requires the emplacement of overburden and goafing of each longwall panel as the longwall mine progresses. Therefore, it is impossible to keep every square meter of the mining footprint fully drained.

The mine seepage rate was relatively insensitive to horizontal and vertical hydraulic conductivity, and the leakage through the river beds, with results generally aligning closely to the base case. The exception was for the period of open cut mining where increases in the horizontal and vertical hydraulic conductivity resulted in the predicted rate of seepage being more than double the predicted seepage rate for the base case.

Reducing the vertical hydraulic conductivity of the fractured zone reduced predicted seepage rates to approximately 50% of the base case model. Interestingly, mining seepage recorded at the last time step of each period using a higher vertical conductivity in the fracture zone was similar to the base case. The weighted average of inflow from all time steps would show greater disparity.

F2.2.2 *Alluvial aquifer system*

A key model prediction is the water take from the alluvial aquifers due to mining. Figure F 22 presents the sensitivity of the predicted water take from the alluvial due to changes in hydraulic parameters.

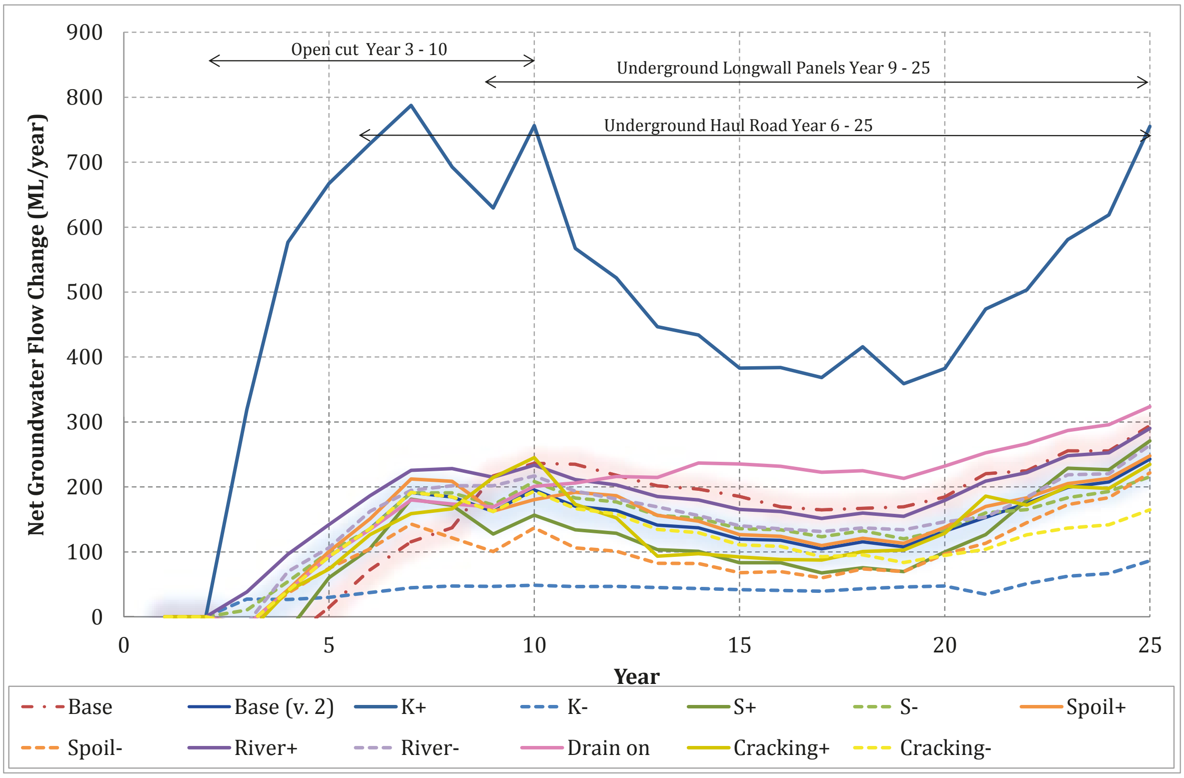


Figure F 22 Hydraulic parameter sensitivity of Permian to alluvial flow change

Figure F 22 demonstrates that the reduced transfer from the Permian to the alluvium is most sensitive to horizontal and vertical hydraulic conductivity, and is relatively insensitive to all other changes to the undisturbed strata. This is because changing the hydraulic conductivity increases the connectivity between the depressurised Permian formation and the adjacent alluvial system.

F2.2.3 *Bylong River baseflow*

Figure F 23 presents the sensitivity of the changes to the Bylong River surface water/ groundwater flow to changes in hydraulic properties.

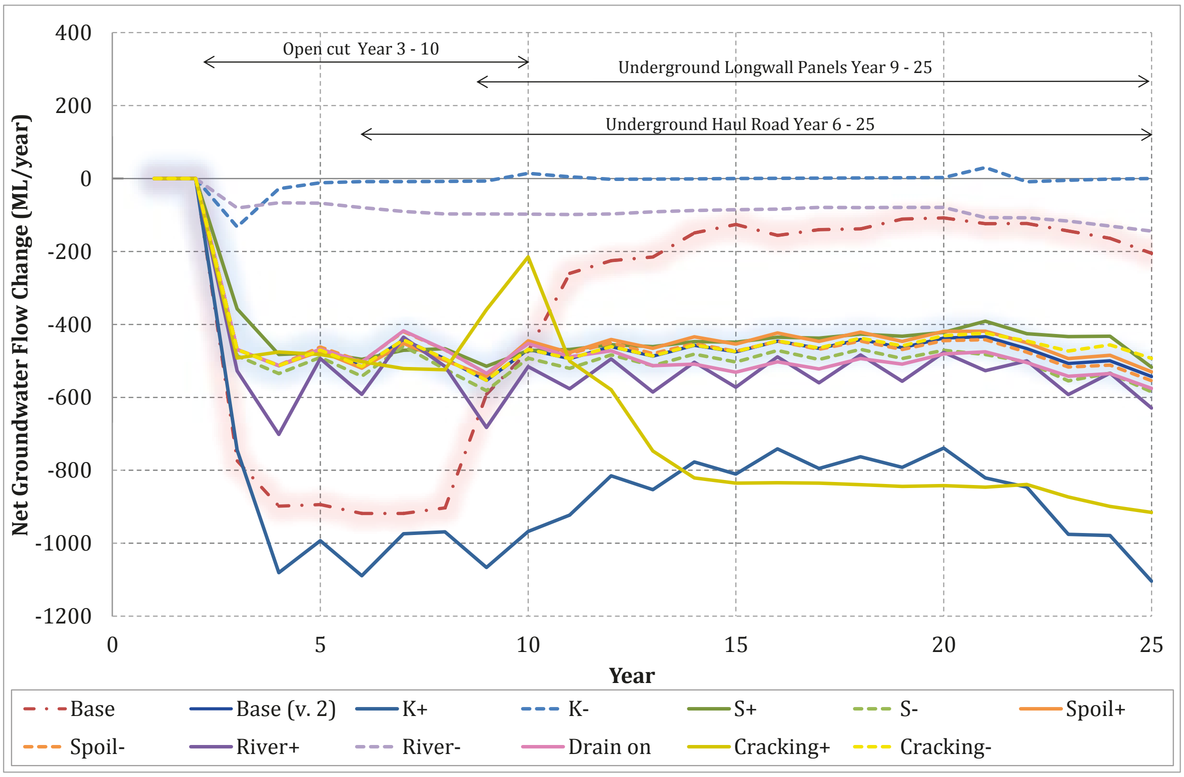


Figure F 23 Hydraulic parameter sensitivity of Bylong River baseflow

Figure F 23 demonstrates that the volume of baseflow removed from the Bylong River is most sensitive to hydraulic conductivity of the undisturbed strata and the fractured zone above the longwall mining area. As discussed previously, this is because changing the hydraulic conductivity increases the connectivity between the depressurised Permian formation and the adjacent alluvial system, which is directly connected to the Bylong River. When the hydraulic conductivity of the undisturbed strata and the river bed is reduced, the water take from the Bylong River also reduces by four to five times lower than the base case.

The results also show that the magnitude of the baseflow loss is relatively insensitive to all other changes to the properties of the undisturbed strata.

F2.2.4 Zone of depressurisation and impact on water users

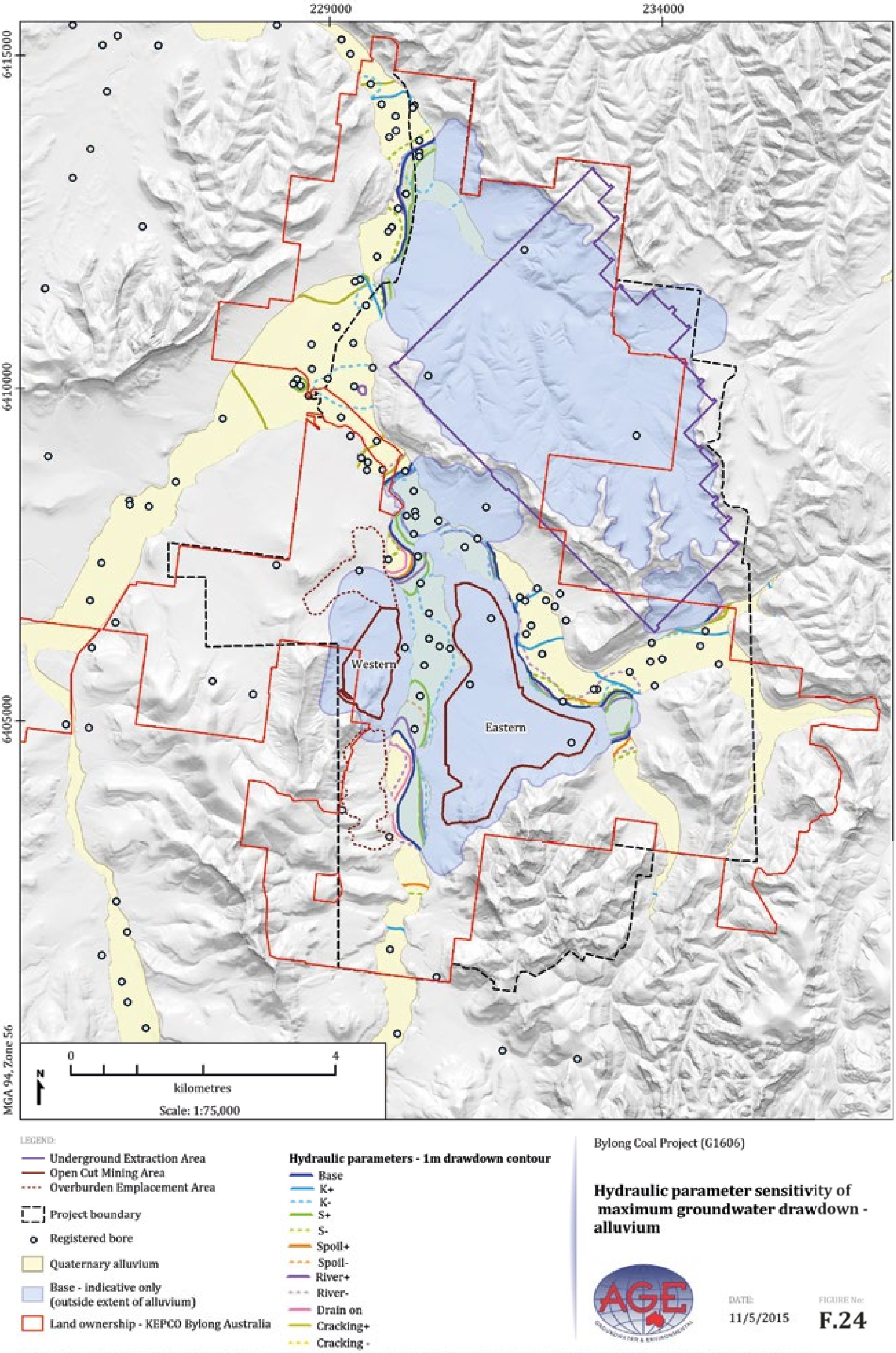
The sensitivity analysis assessed the changes to the zone of depressurisation in the alluvium and the Coggan coal seam. Figure F 24 and Figure F 25 show the sensitivity of predicted groundwater drawdown to changes in the hydraulic properties for the alluvium (Layer 2) and the Coggan Coal seam (Layer 8) respectively.

Figure F 24 illustrates drawdown within the alluvium becomes more extensive when hydraulic conductivity is increased in the undisturbed strata and in the fractured zone above the longwall mining area. Reducing specific storage also increases the drawdown. The drawdown generally remains within the land owned by the proponent, except for the scenarios where the vertical hydraulic conductivity of the fracture zone is increased and the specific storage is reduced. This results in two private bores located on land outside the area presently owned by the proponent potentially experiencing drawdown in excess of 2 m. Table F 10 summarises the private bores where the maximum drawdown during mining is predicted to exceed 2 m under this sensitivity scenario.

Table F 10 Private bores with predicted drawdown exceeding 2 m

Work No.	Easting (mGDA94Z56)	Northing (mGDA94Z56)	Property Name	Type	Base	Base (version 2)	Cracking+ (version 2)
GW021881	229139	6409593	Tinka Tong	Well	0.00	0.29	2.88
GW047394	228525	6410070	Eagle Hill, Jarvet	Well	0.00	0.00	2.05

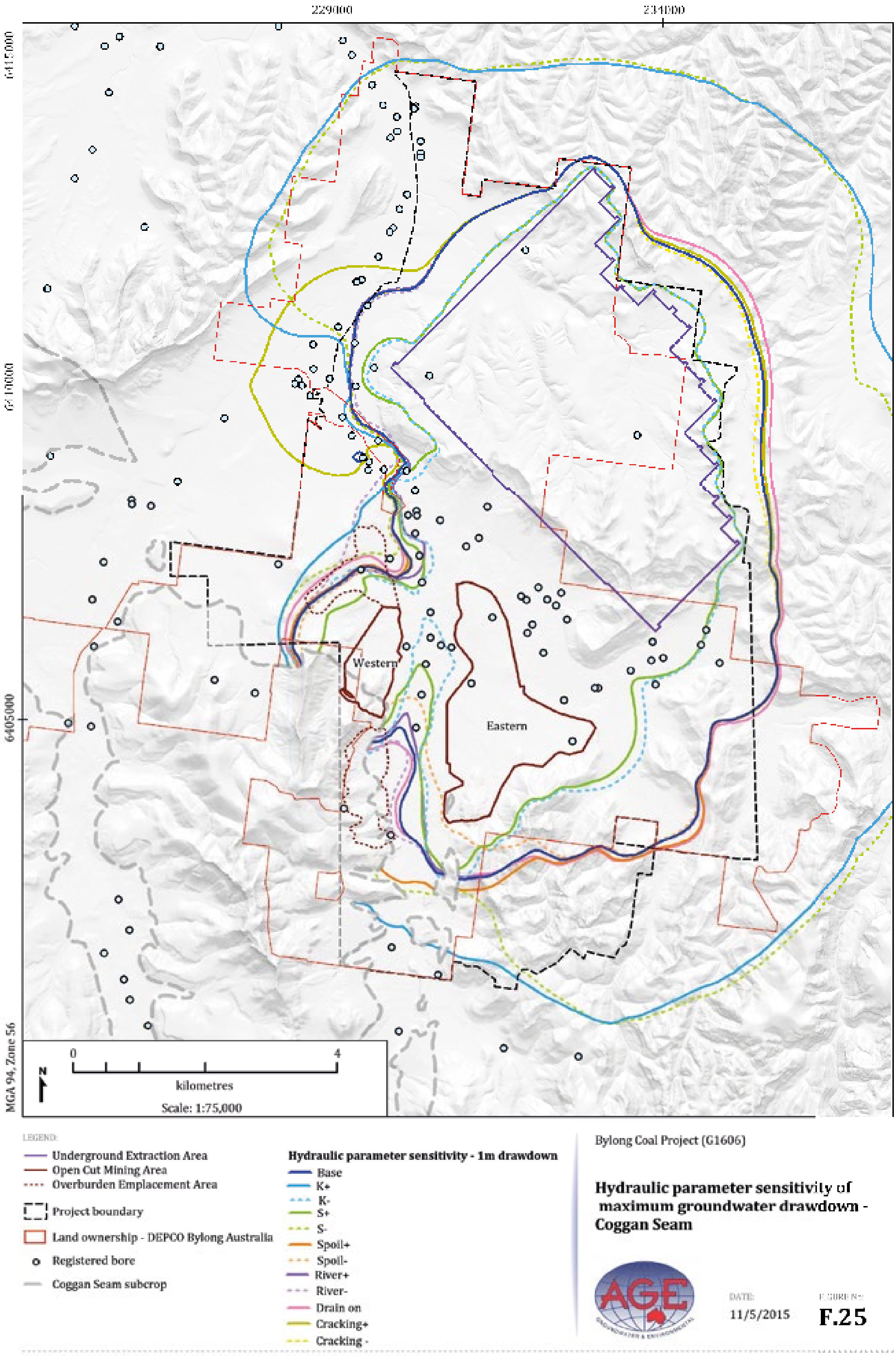
Figure F 26 and Figure F 27 show a cross-section through the model at the completion of the open cut and underground mine areas where the drains cells are active for the mine life. Similar to the base case, the sections shows that the mining areas are completely desaturated, and only small areas above the underground roads display very low levels of saturation.



Bylong Coal Project (G1606)

Hydraulic parameter sensitivity of maximum groundwater drawdown - alluvium

F.24

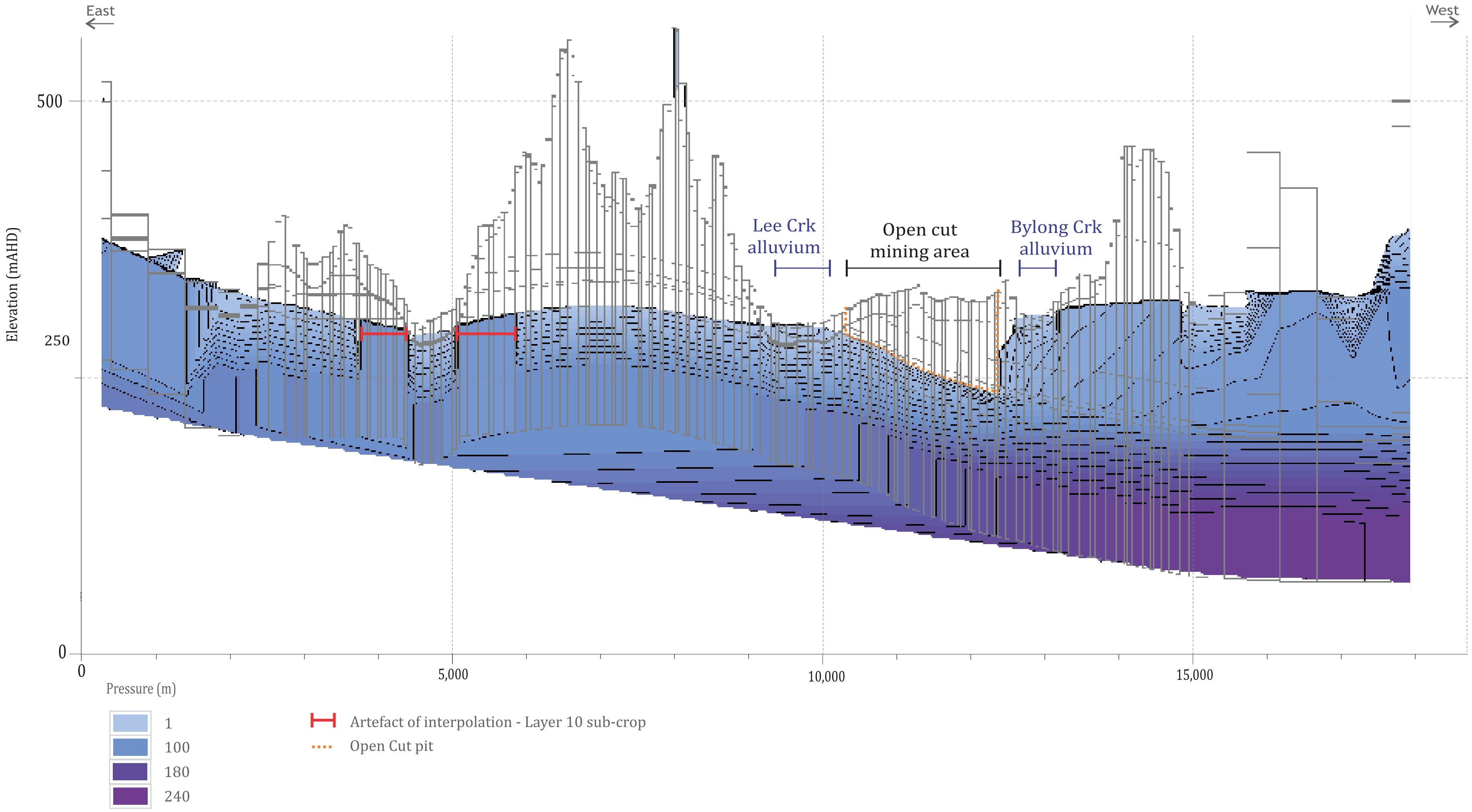


Bylong Coal Project (G1606)

Hydraulic parameter sensitivity of maximum groundwater drawdown - Coggan Seam

DATE: 11/5/2015

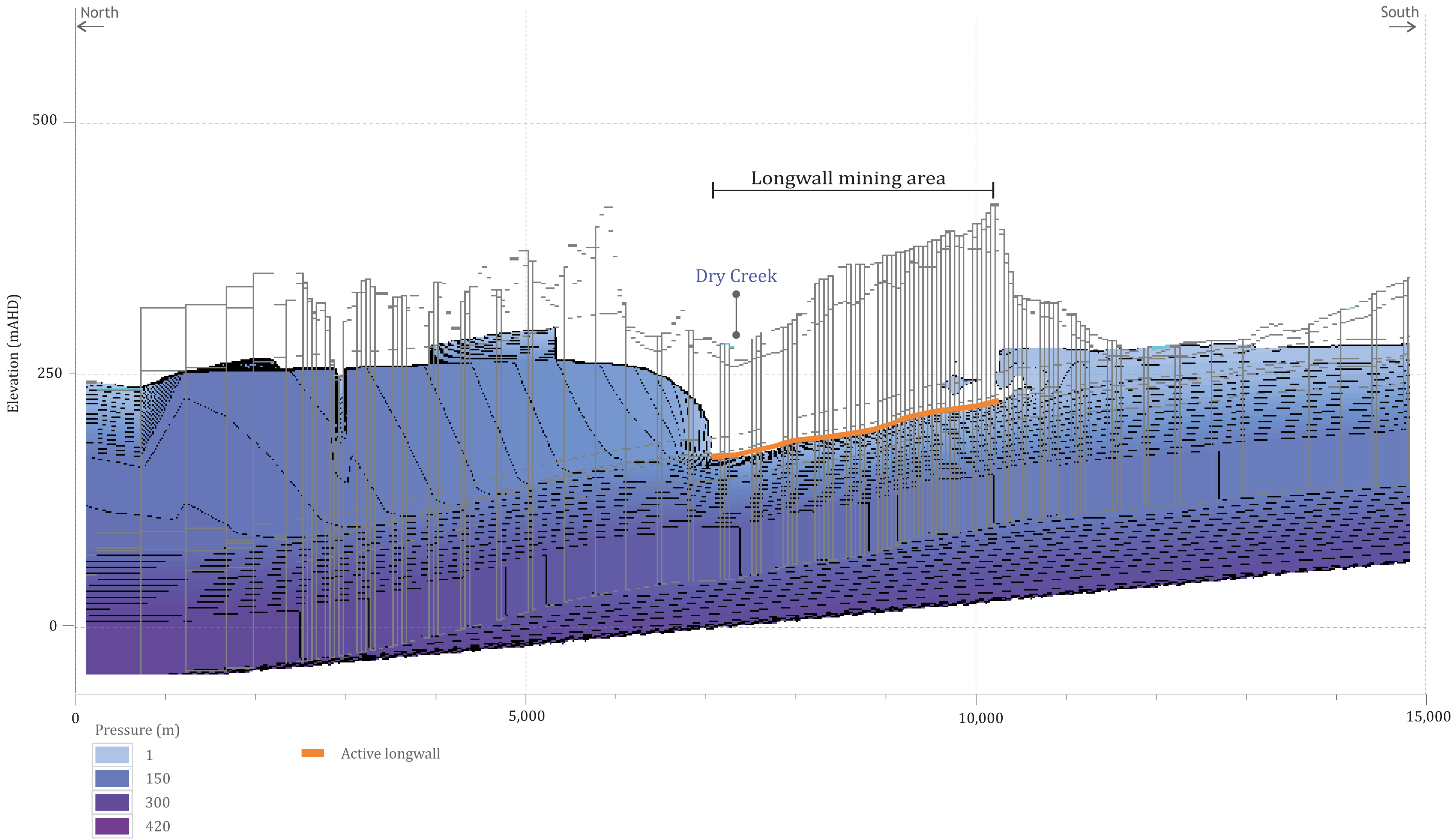
FIGURE No: **F.25**



Cross section of pressure at end of open cut (Year 10) – Drain active scenario

Figure F.26

Bylong Coal Project (G1606)



Cross section of pressure at end of underground (year 25) – Drain active scenario

Figure F.27

Bylong Coal Project (G1606)

F2.3 Unsaturated zone parameters

The sections below present the sensitivity of the predicted mine seepage rates, water take and the zone of depressurisation to changes in the methodology representing flow within the unsaturated zone. The calibration-constrained Monte Carlo uncertainty analysis simulated the unsaturated zone using 'upstream weighing'.

F2.3.1 Predicted seepage rates

Figure F 28 shows the sensitivity of the predicted seepage rate to changes in unsaturated zone parameters. It should be noted that Figure F 28 presents inflows to the mining areas at the end of each stress period.

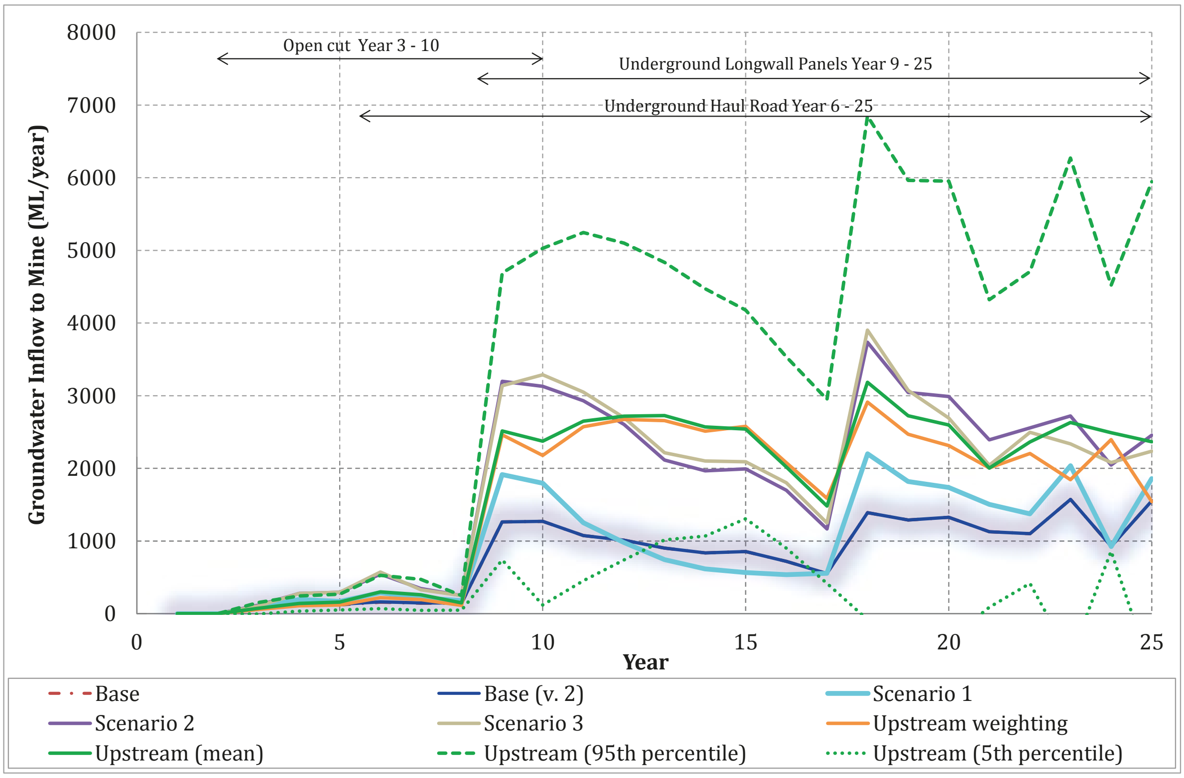


Figure F 28 Sensitivity of predicted mining area inflow to unsaturated zone method and parameters

The seepage rate was most sensitive to increases in values adopted for alpha and residual saturation, resulting in maximum seepage rates of 3,904 ML/year. This is because more water enters the longwall mine from unsaturated storage within the fractured zone from layers 1 to 8 in the groundwater model using the Van Genuchten method.

Predicted seepage to the mining areas from using the upstream weighting option effectively doubled the amount of groundwater inflow during underground mining, with the 95th percentile being four times higher. This was because more water is not routed through the unsaturated cells, but is directed moved to the drain cells. In addition to changing the method, representing the flow within the unsaturated zone the uncertainty analysis also varied all of the model parameters including recharge and hydraulic properties. The 95th percentile prediction therefore represents the extremes in the dataset.

F2.3.2 Alluvial aquifer system

A key model prediction is the water take from the alluvial aquifers due to mining. Figure F 29 presents the sensitivity of the predicted water take to changes in the unsaturated zone parameters.

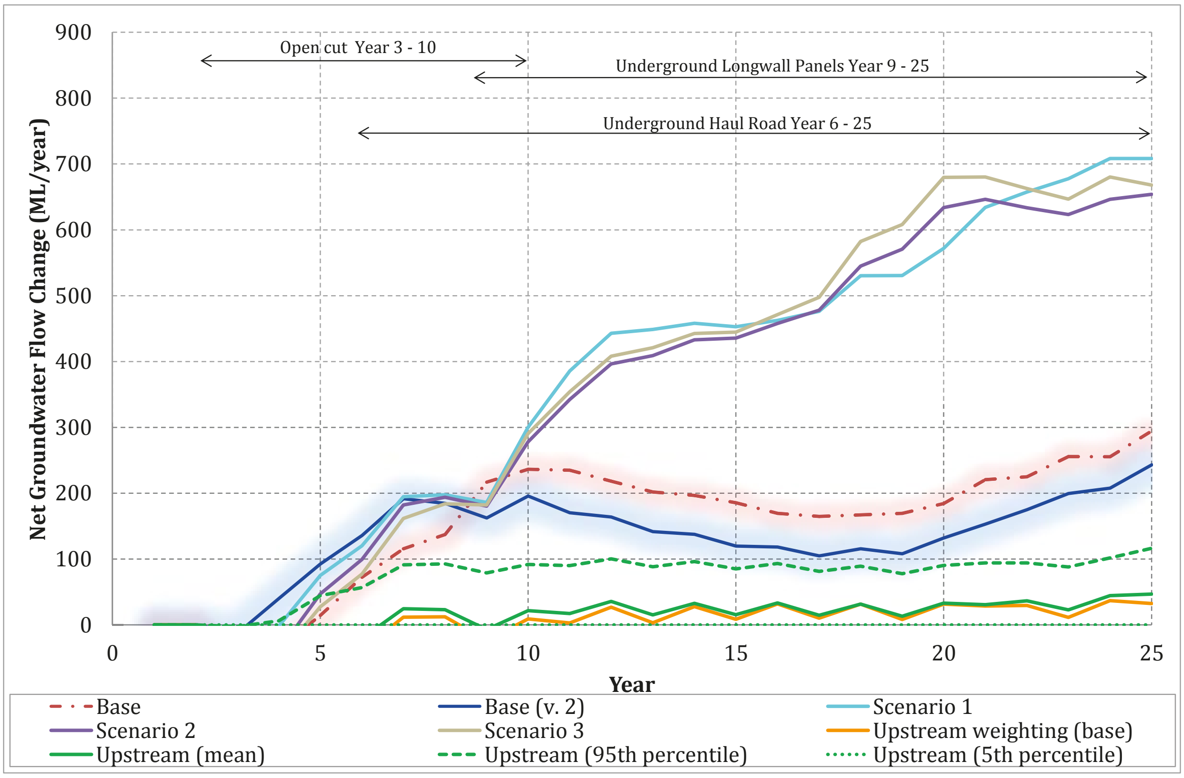


Figure F 29 Sensitivity of predicted Permian to alluvial flow change to unsaturated zone method and parameters

Figure F 29 demonstrates that the 'water take' from the alluvium is sensitive to changes in alpha and beta and the nature of the mining, i.e. open cut or underground mining. 'Water take' from the alluvium during open cut mining is less sensitive to the vadose zone parameters, and slightly less than the base case. This is due to the decreased relative hydraulic conductivity within the unsaturated zone between the drain cells and the alluvium that occurs when using the upstream weighting method. In contrast changing the vadose zone parameters in the longwall mining area results in a larger 'water take'. This occurs because a larger volume of water is routed from the fractured zone into the underground mining area with steeper hydraulic gradients.

Results from the upstream weighting scenario show the conservatism of the base case model to alluvial impacts. Due to the lack of connection through the unsaturated zone using upstream weighting, the model predicts very little impact to the alluvial aquifer system, reaching a maximum impact of 37 ML/year during year 24.

F2.3.3 Bylong River baseflow

Figure F 30 presents the simulated change to river base flow in the Bylong River due to changes in the unsaturated zone parameters. Figure F 30 shows that baseflow from the alluvium to the Bylong River is largely insensitive to changes in the vadose zone parameters in the initial ten years of mining (i.e. period of open cut mining operations and initial development of underground mining area). In the final stages of mining, the predicted baseflow from alluvium to the Bylong River is most sensitive to Scenario 1 (refer to F1.1.5) . This is because the underground removes more groundwater storage and depressurises the alluvium, which conversely reduces the interaction between the model river cells and the groundwater system.

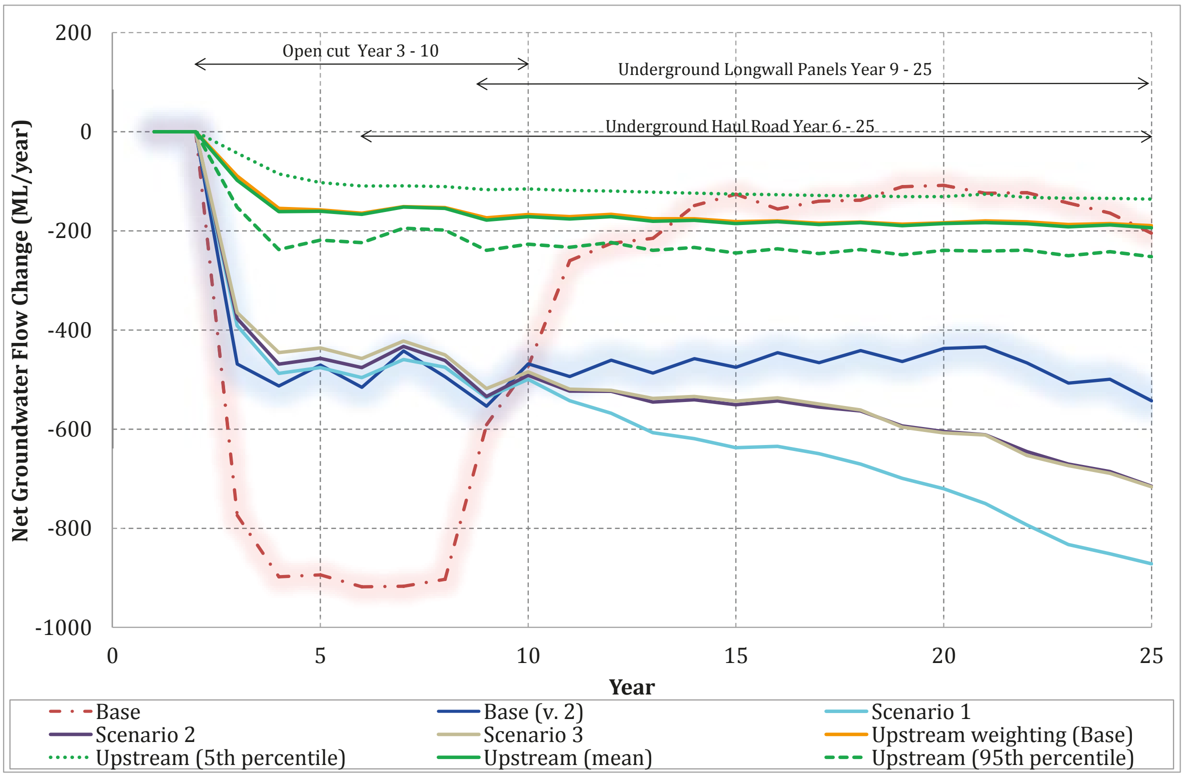


Figure F 30 Sensitivity of predicted river flow change (Bylong River) to unsaturated zone method and parameters

Results from the upstream weighting scenario highlight the conservatism of the base case model to impacts on the Bylong River. The model predicts a maximum reduction of 189 ML/year in baseflow caused by underground mining, which is due to the lack of hydraulic connection through the unsaturated zone using the upstream weighting option.

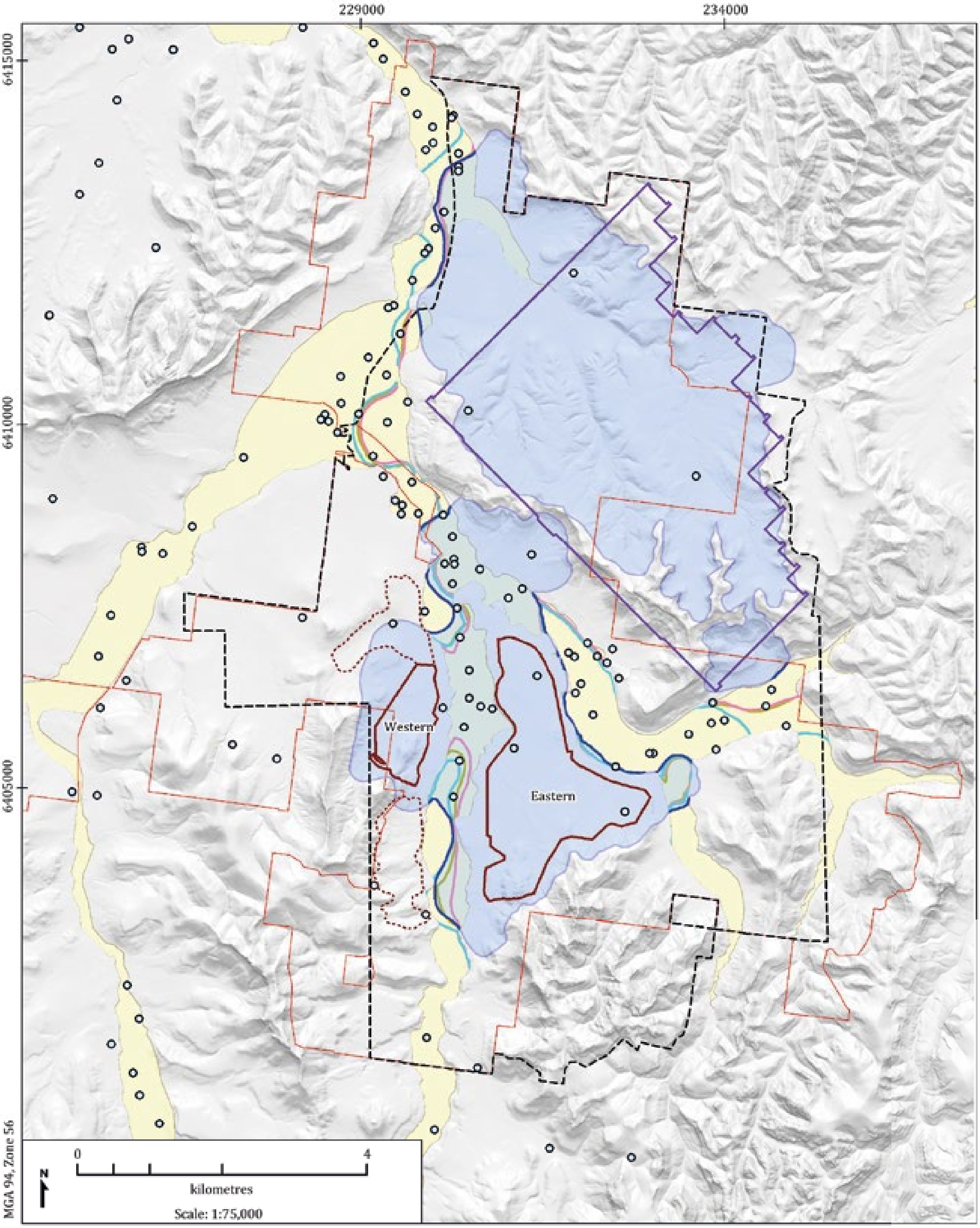
F2.3.4 Zone of depressurisation and impact on water users

The sensitivity analysis assessed the changes to the zone of depressurisation in the alluvium and the Coggan coal seam. Figure F 31 and Figure F 32 show the sensitivity of predicted maximum groundwater drawdown to changes in the vadose zone parameters for the alluvium (Layer 2) and Coggan coal seam (Layer 8) respectively.

As discussed previously, decreases to the unsaturated hydraulic conductivity surrounding the open cut mine causes less drawdown during years 3 to 10 in all sensitivity scenarios. Figure F 31 shows drawdowns reduce up to 900 m proximal to the open cut. Conversely, changes to the vadose zone parameters whilst longwall mining is active results in alluvial drawdown propagating marginally further than the base case. Figure F 31 shows the 1 m drawdown contour extends a 2.2 km from the northern longwall panel for the base case, and 2.4 km when the unsaturated hydraulic conductivity is decreased and residual storage is low (Scenario 1).

Drawdown in the Coggan seam is less sensitive to changes to the vadose zone parameters. Figure F 32 shows that the maximum extent of groundwater drawdown in the Coggan seam extends a maximum of 400 m from the base case. This is because the Coggan seam is saturated over the majority of the Project area, and therefore has less interaction with the unsaturated zone algorithms.

Groundwater drawdown in the alluvium using the upstream weighting function is greatly reduced from the base case model. This is because the conductance term reduces to zero where the alluvium is unsaturated preventing flow of water. Maximum drawdowns greater than 1 m are typically limited to the fringes of the alluvium adjacent to the mining areas. No groundwater users are predicted to experience measurable drawdown at their bores.



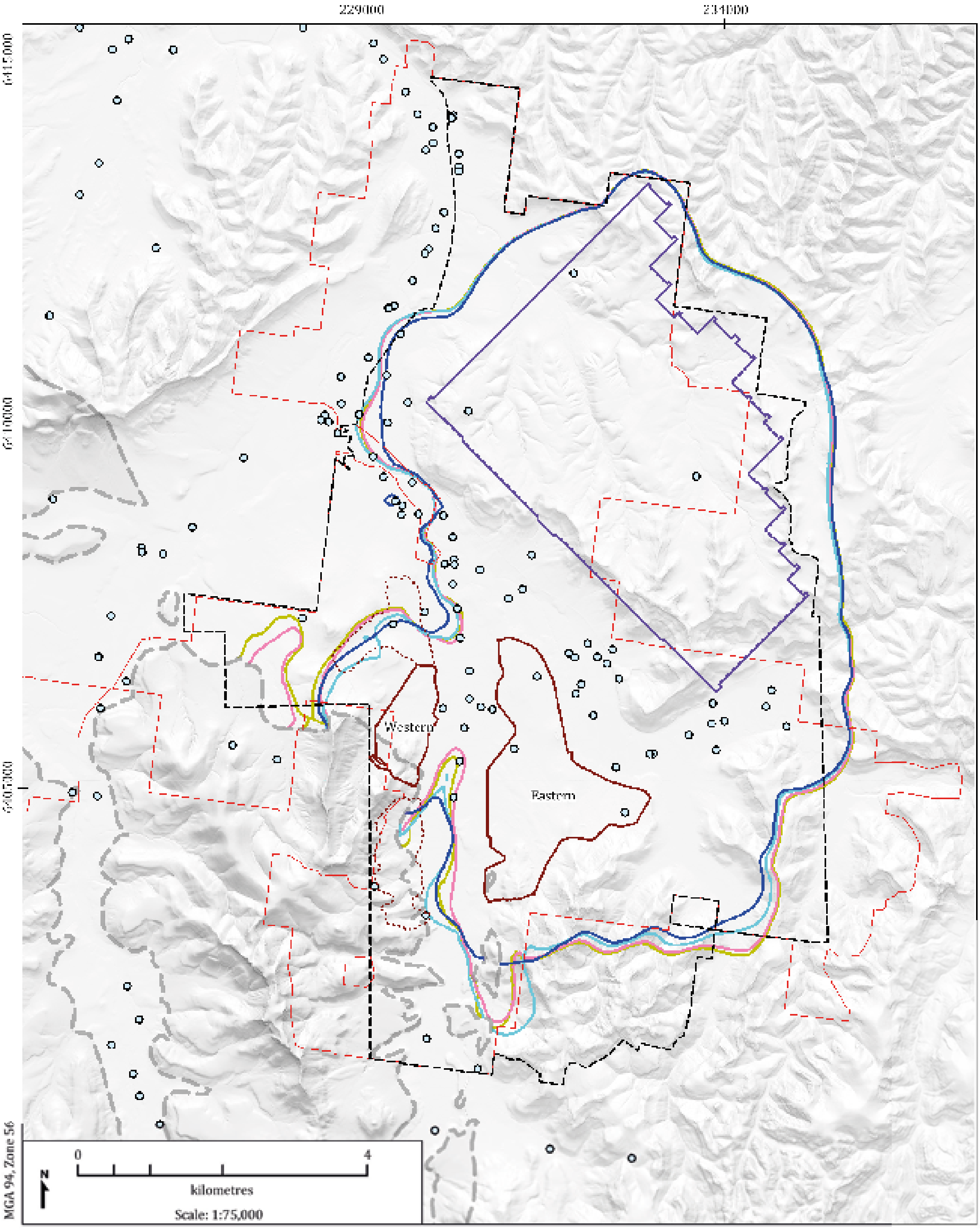
Bylong Coal Project (G1606)

Unsaturated zone parameter sensitivity of maximum groundwater drawdown - alluvium

AGE GROUNDWATER & ENVIRONMENTAL

DATE: 11/5/2015

FIGURE No: **F.31**



LEGEND:

- Underground Extraction Area
- Open Cut Mining Area
- Overburden Emplacement Area
- Project boundary
- Land ownership - KEPCO Bylong Australia
- Registered bore
- Coggan Seam subcrop

Unsaturated zone parameter sensitivity
1 m drawdown contour

- Base
- BC
- BC+
- BC + high alpha

Bylong Coal Project (G1606)

Unsaturated zone parameter sensitivity of maximum groundwater drawdown - Coggan Seam

DATE:
11/5/2015

FIGURE No:
F.32

F2.4 Sensitivity analysis summary

Table F 11 shows how changing the model parameters influences the overall model error as represented by the SRMS, Bylong River baseflow loss, changes to alluvial flow and seepage to mining areas.

Table F 11 Summary results of sensitivity analysis

Scenario	Steady State SRMS (%)	Transient SRMS (%)	Max Bylong River Baseflow Loss (ML/year)	Max Alluvial Change (ML/year)	Max mine seepage (ML/year)
Base	3.11	3.52	-918	295	1574
Base (version 2)	3.14	3.56	-553	243	1574
Hydraulic Conductivity +*	4.08	4.80	-1104	787	2205
Hydraulic Conductivity -*	6.84	6.98	-132	86	1270
Storage +*	3.14	3.54	-517	271	4137
Storage –*	3.14	3.60	-585	216	580
Recharge +*	5.33	5.82	-589	359	1681
Recharge -*	5.64	4.75	-577	320	1143
River bed conductivity +*	3.12	3.55	-702	290	1565
River bed conductivity -*	3.23	3.60	-144	264	1592
Spoil +*	-	-	-543	248	1575
Spoil -*	-	-	-554	222	1574
Cracking +*	-	-	-915	245	1436
Cracking -*	-	-	-553	194	771
Drains on*	-	-	-575	324	3276
Dry climate*	-	-	-383	272	1548
Average climate*	-	-	-508	287	1553
Wet climate*	-	-	-332	293	1555
No leakage/irrig./drains on	-	-	-89	338	3246
vG Scenario 1*	3.07	3.43	-872	708	2202
vG Scenario 2*	4.19	4.72	-715	654	3737
vG Scenario 3*	4.70	5.22	-716	680	3904
Upstream weighting*	5.71	5.75	-189	37	2911

Note ** Model based on version 2 base case*

The results show that changes to the hydraulic conductivity in the saturated zone (Hydraulic Conductivity +) has the largest impact on the Bylong River alluvium. The model is also sensitive to changes in storage (both saturated and unsaturated), which can increase maximum predicted groundwater seepage into the underground mining area by almost two times compared to the base case.

The results indicate that the base case model is a conservative tool for assessing the Project impacts from the open cut mining area during the mine life. In contrast more extreme impacts than predicted by the base case are predicted for the underground mining area when the vadose zone properties were changed. The three sensitivity scenarios run using the van Genuchten algorithm completely depressurise the aquifers above the longwall mining area; however, the matric suction surface (unsaturated groundwater level) for all layers lowers close to the level of longwall mining. This creates a steep gradient between the saturated alluvium and the unsaturated weathered Permian in layers 1 and 2, which unrealistically displaces water from the alluvium. This is an extremely conservative approach.

The Murray Darling Basin Modelling Guidelines (MDBC, 2000) recommends classifying sensitivity by the resultant changes to the model calibration and predictions. The four sensitivity types are as follows:

- Type I: Insignificant changes to calibration and prediction;
- Type II: Significant changes to calibration – insignificant changes to predictions;
- Type III: Significant changes to calibration – significant changes to predictions; and
- Type IV: Insignificant changes to calibration – significant changes to predictions.

Types I and II are of no concern as these sensitivities have an insignificant impact on model predictions. Type III is only of concern for un-calibrated models. Types I to III are of no concern for the current assessment, as the model developed for the Project is a well calibrated and is a high complexity model.

Type IV is classed as 'a cause for concern' as non-uniqueness in a model input might allow a range of valid calibrations but the choice of value impacts significantly on a prediction (Middlemis, 2000).

Using the modelling data the model input parameters are classified as:

Hydraulic conductivity:	Type II – III
Storage:	Type I – III
Recharge:	Type II – III
Unsaturated parameters:	Type I – III

There are no Type IV 'cause for concern' outcomes from the sensitivity analysis providing confidence in the level of risk for an adverse impact.