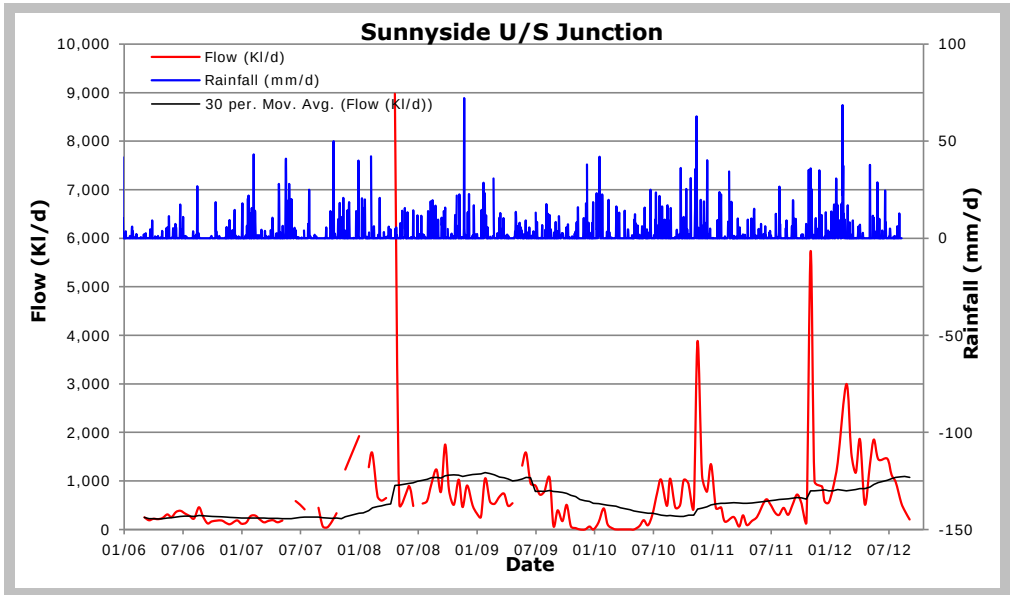
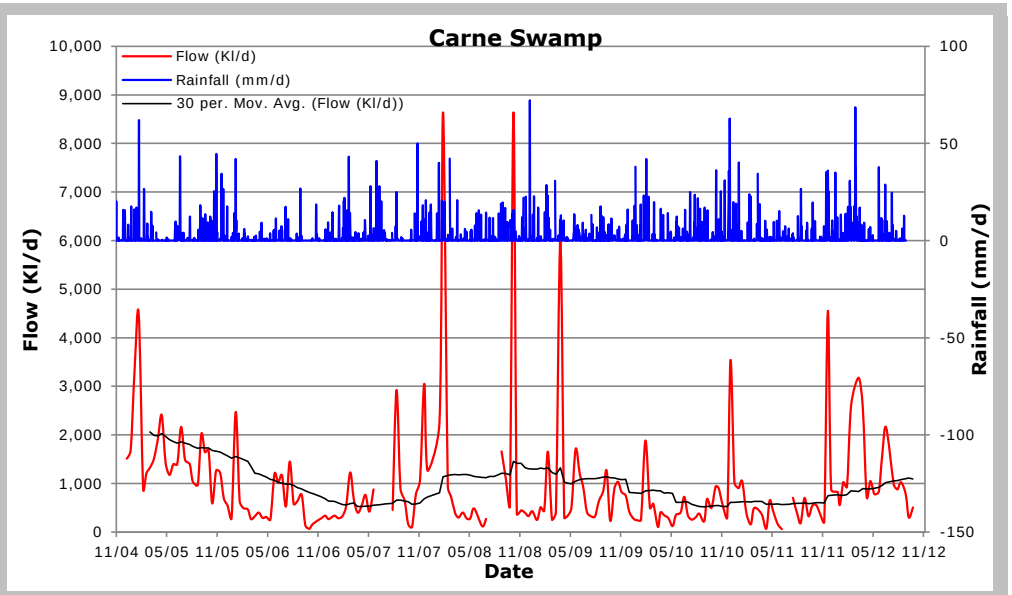
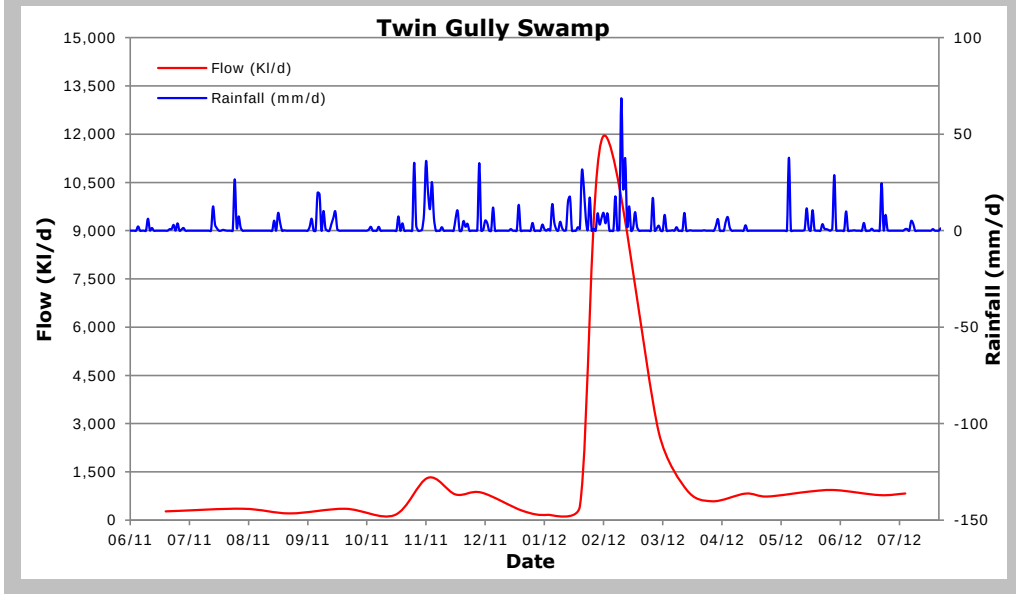
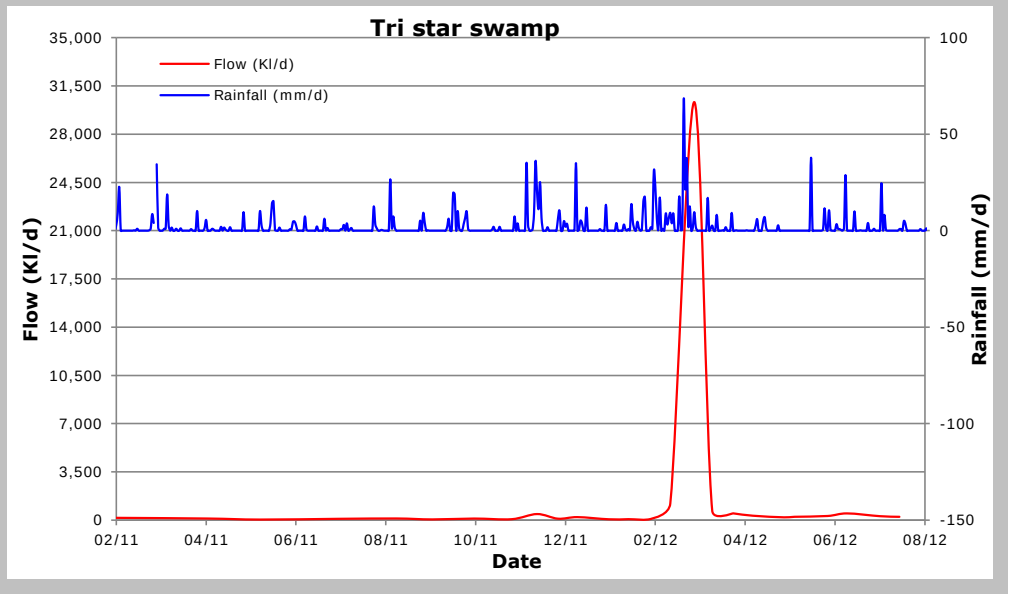
APPENDIX A:
OBSERVED DISCHARGE AND STREAMFLOWS





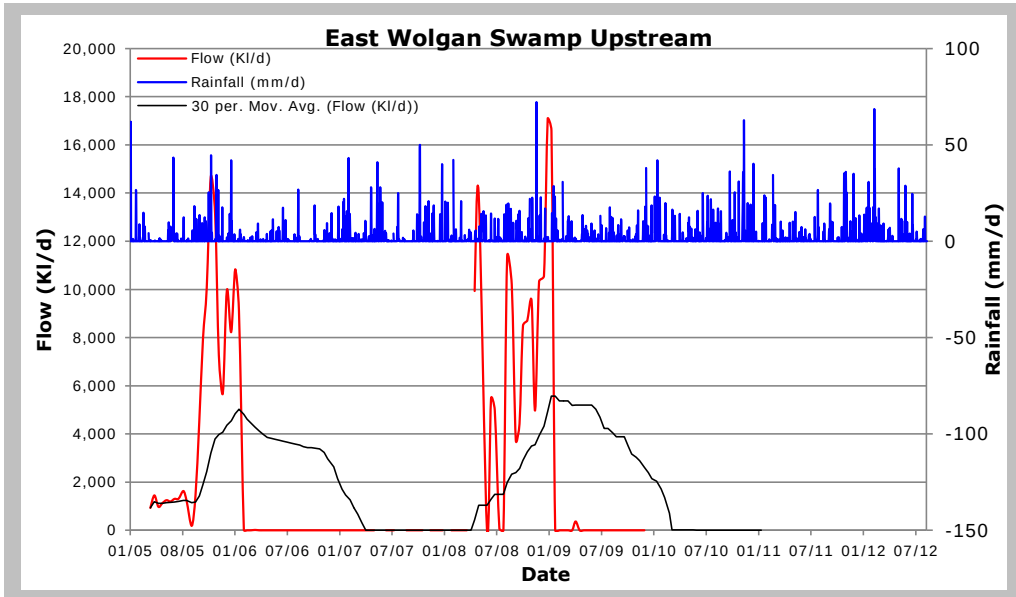


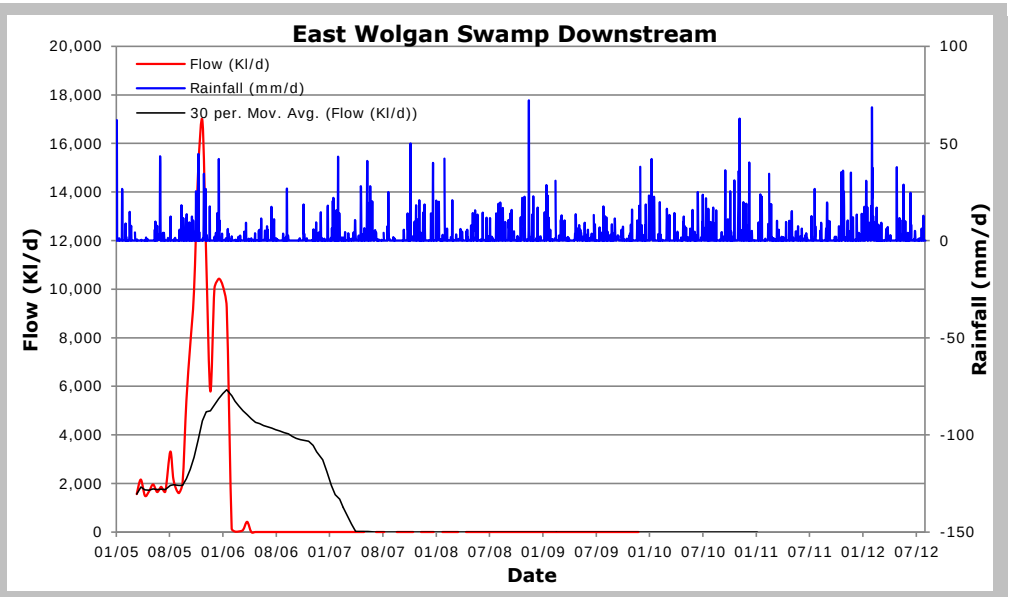


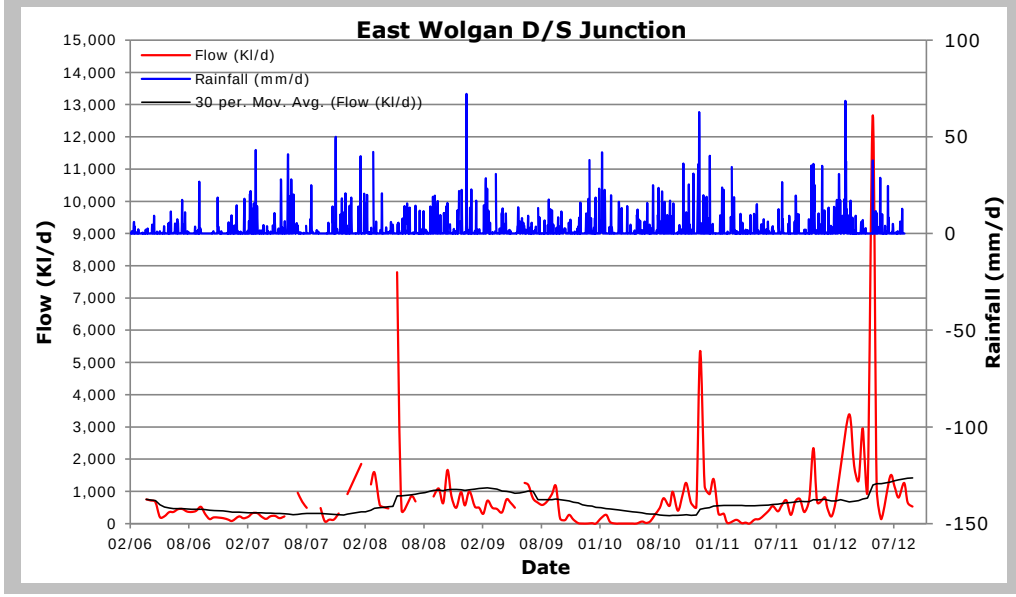
RPS Aquaterra

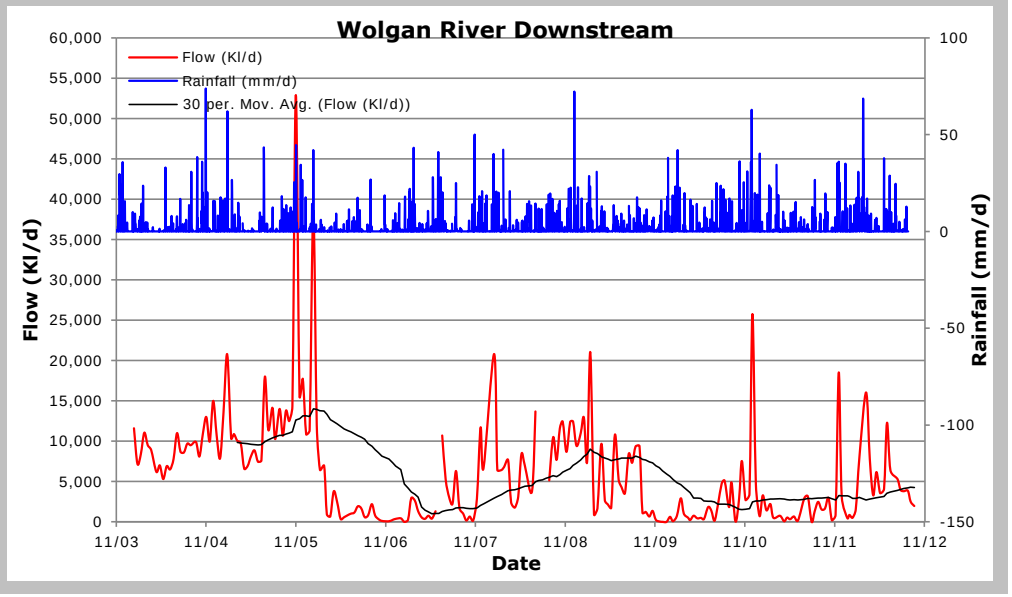
SURFACE WATER FLOWS AND RAINFALL FIGURE A.01

F:\Jobs\Other Offices\Sydney\S187_S188\300\360 Analysis\AP\AP Flow Analysis\[APPENDIX A 01 TO 05_swamps creeks rivers flows.xls]Figure_01

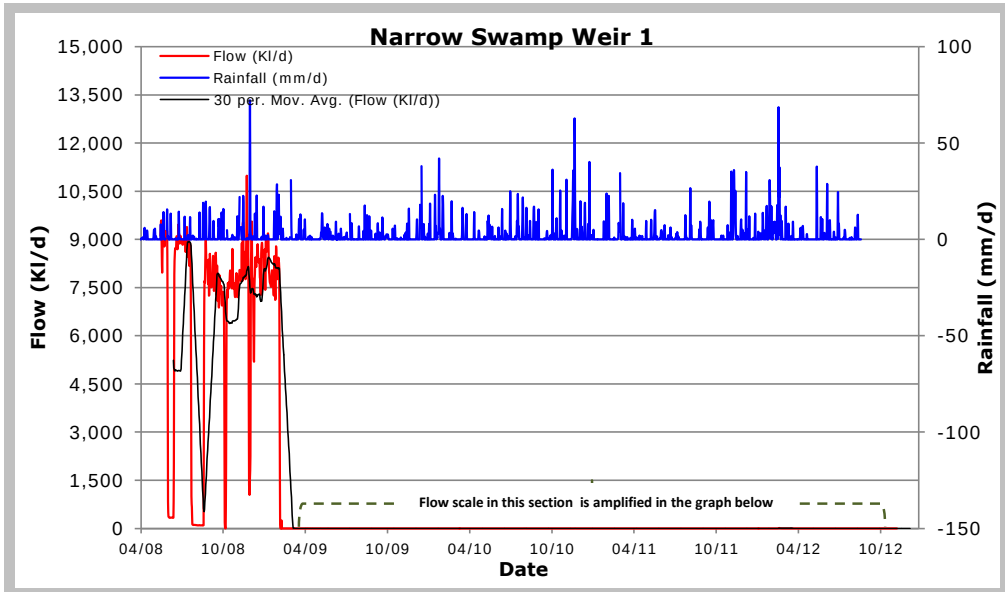


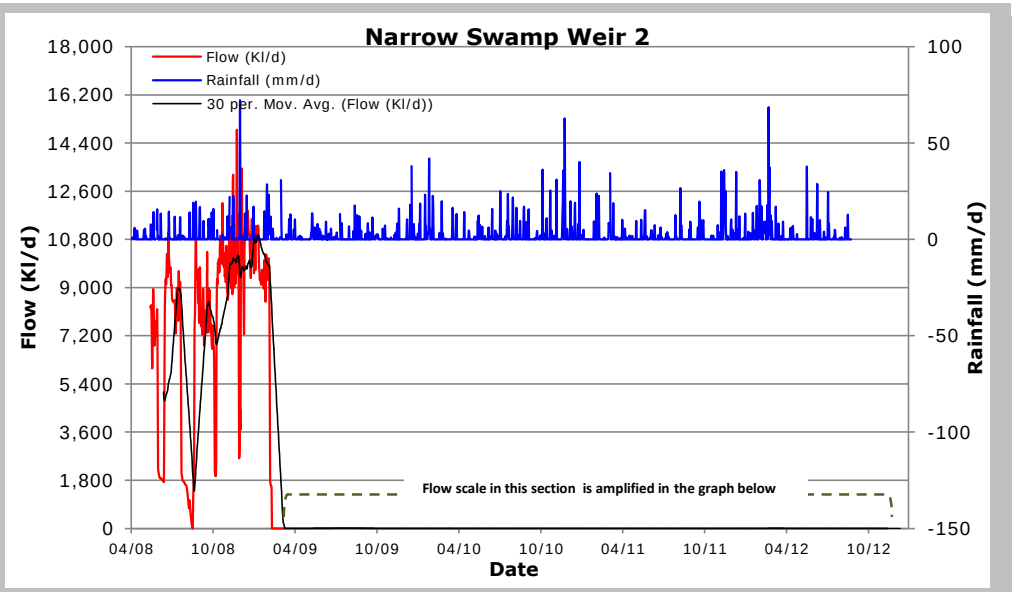


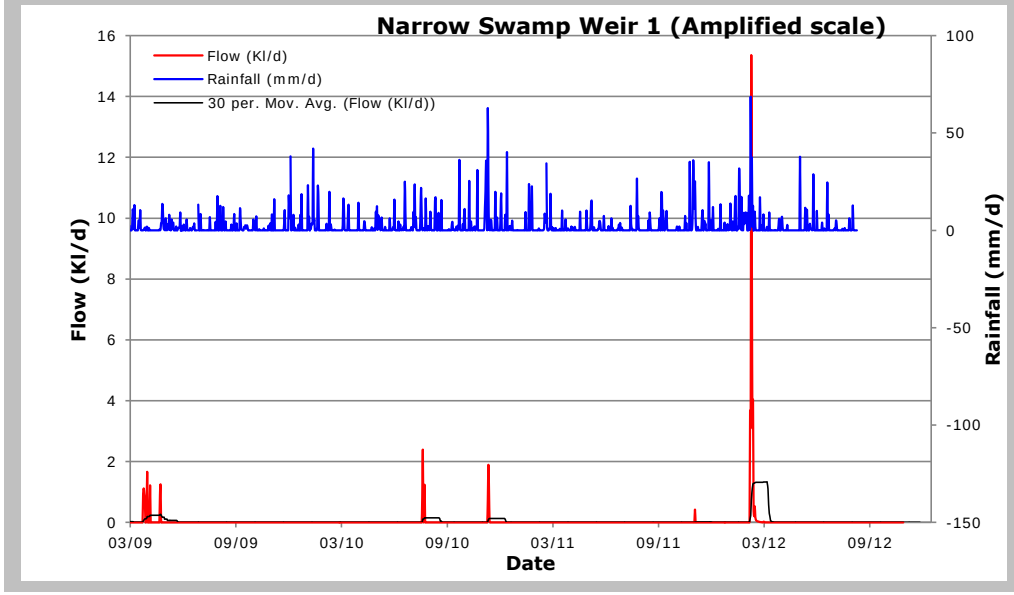


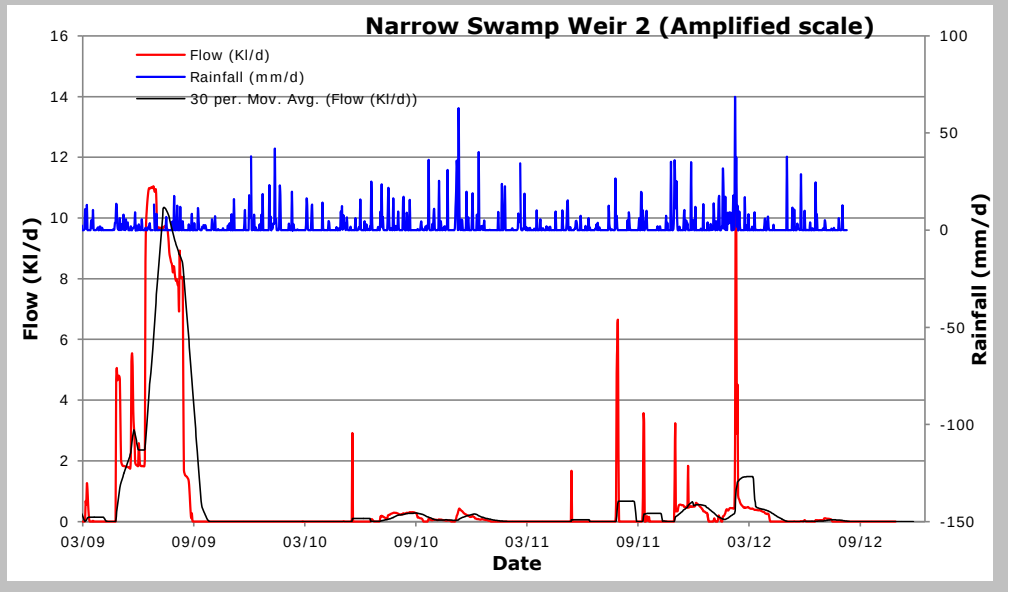


F:\Jobs\Other Offices\Sydney\S187_S188\300\360 Analysis\AP\AP Flow Analysis\[APPENDIX A 01 TO 05_swamps creeks rivers flows.xls]Figure_02





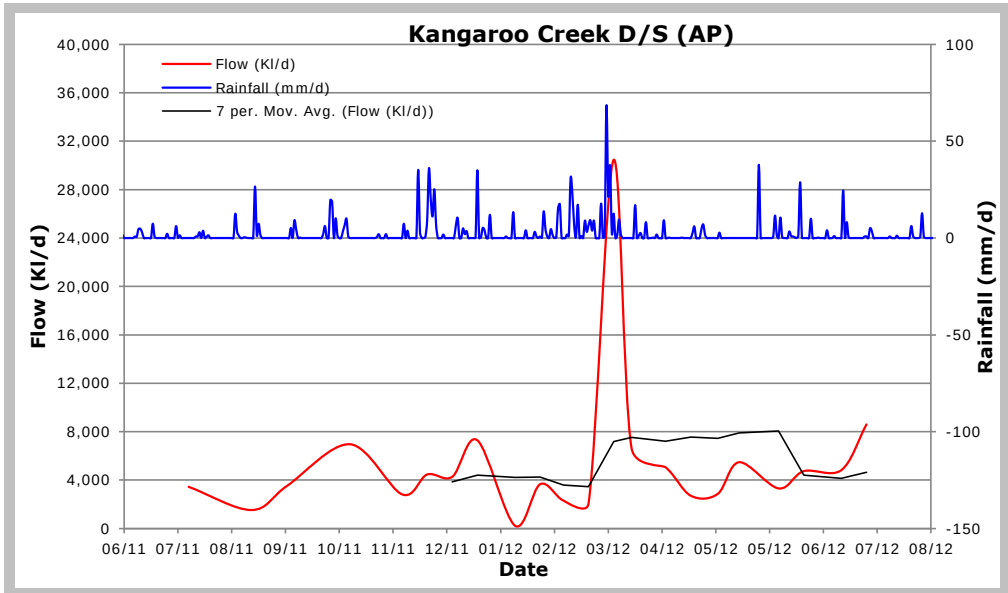


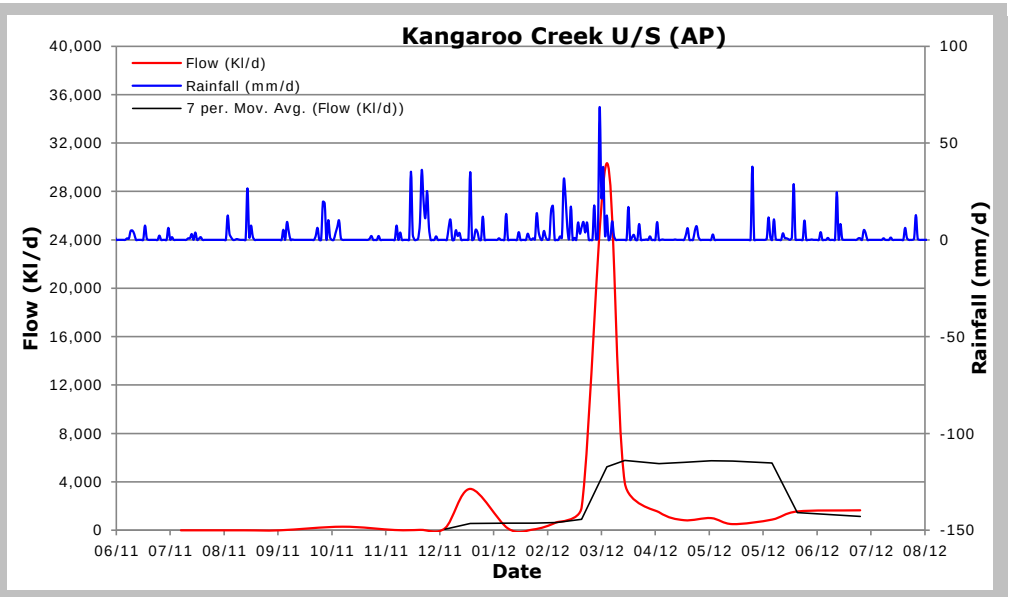


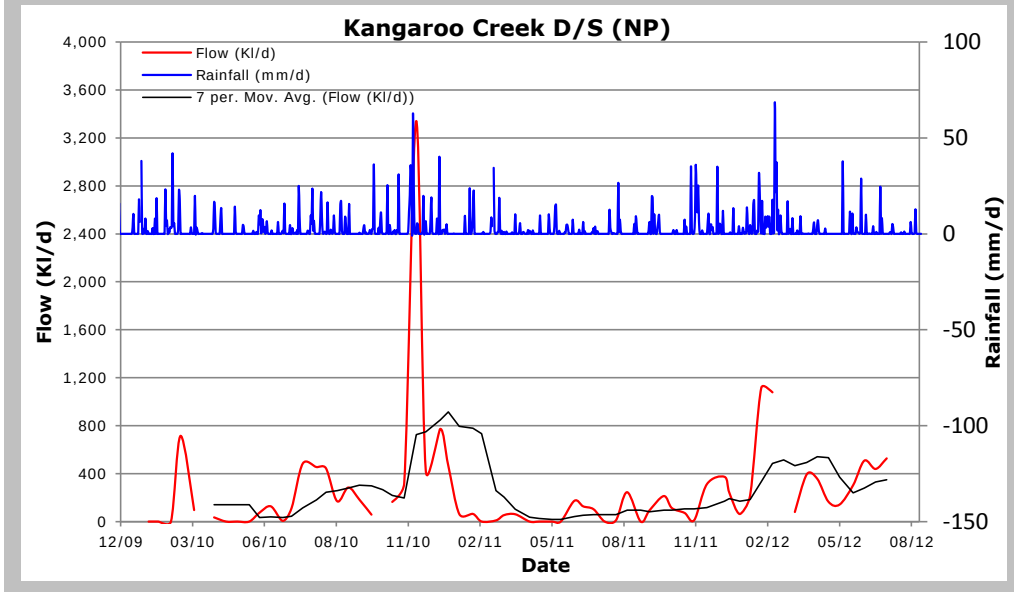
RPS Aquaterra

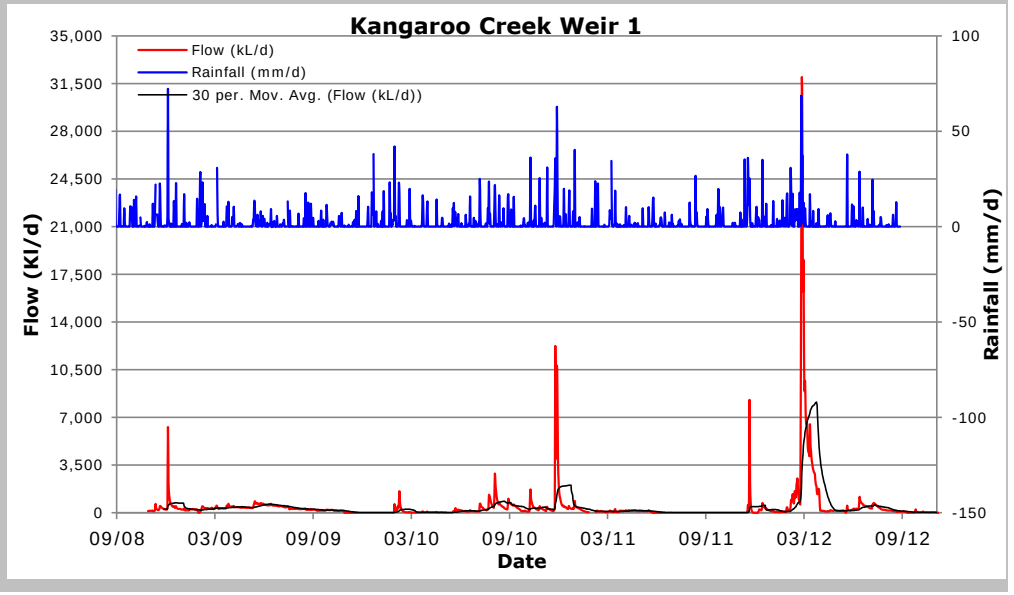
SURFACE WATER FLOWS AND RAINFALL FIGURE A.03

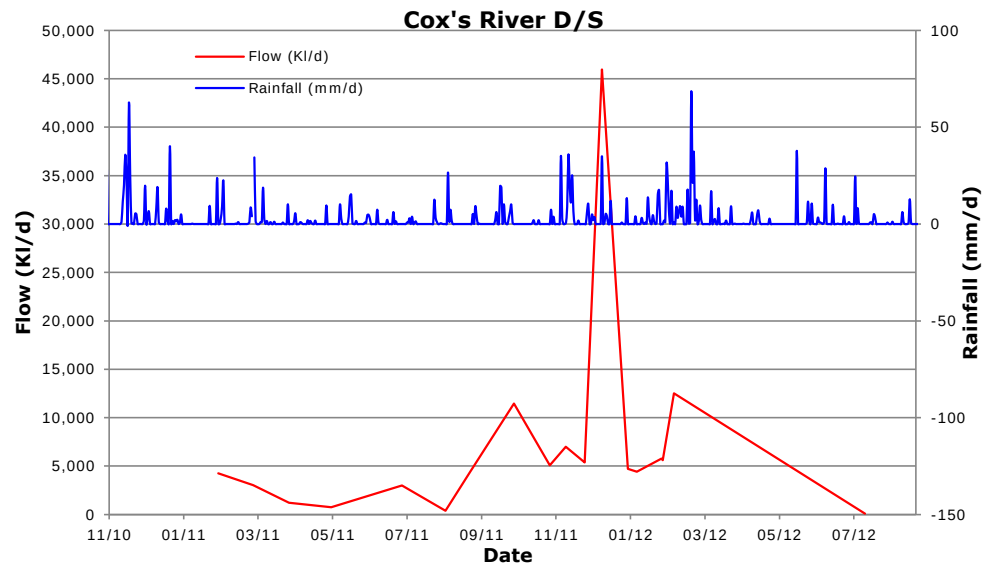
F:\Jobs\Other Offices\Sydney\S187_S188\300\360 Analysis\AP\AP Flow Analysis\[APPENDIX A 01 TO 05_swamps creeks rivers flows.xls]Figure_03

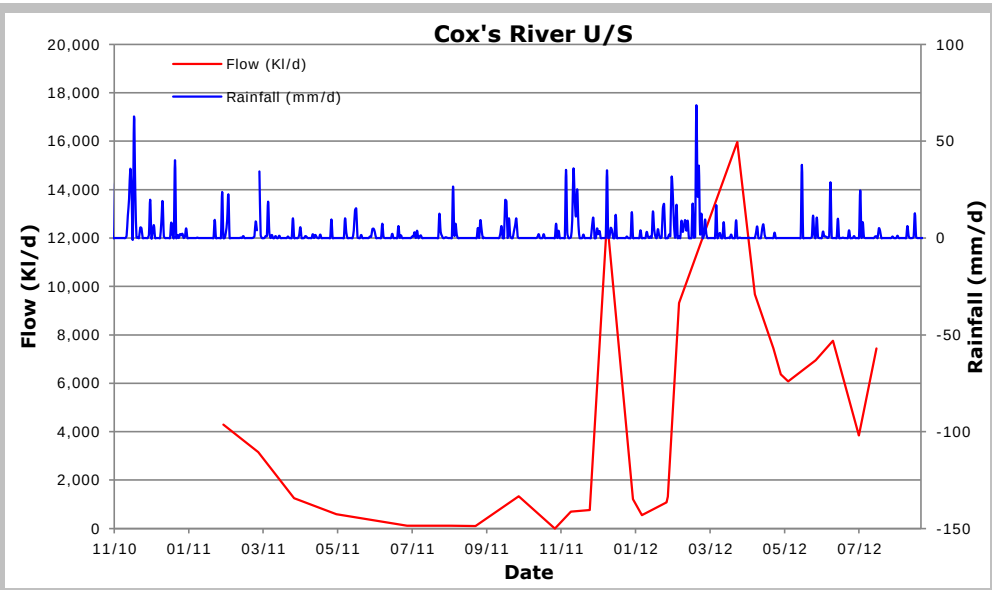

Kangaroo Creek D/S (AP)
Flow (Kl/d)
Rainfall (mm/d)
7 per. Mov. Avg. (Flow (Kl/d))
Flow (Kl/d)
Rainfall (mm/d)
Date

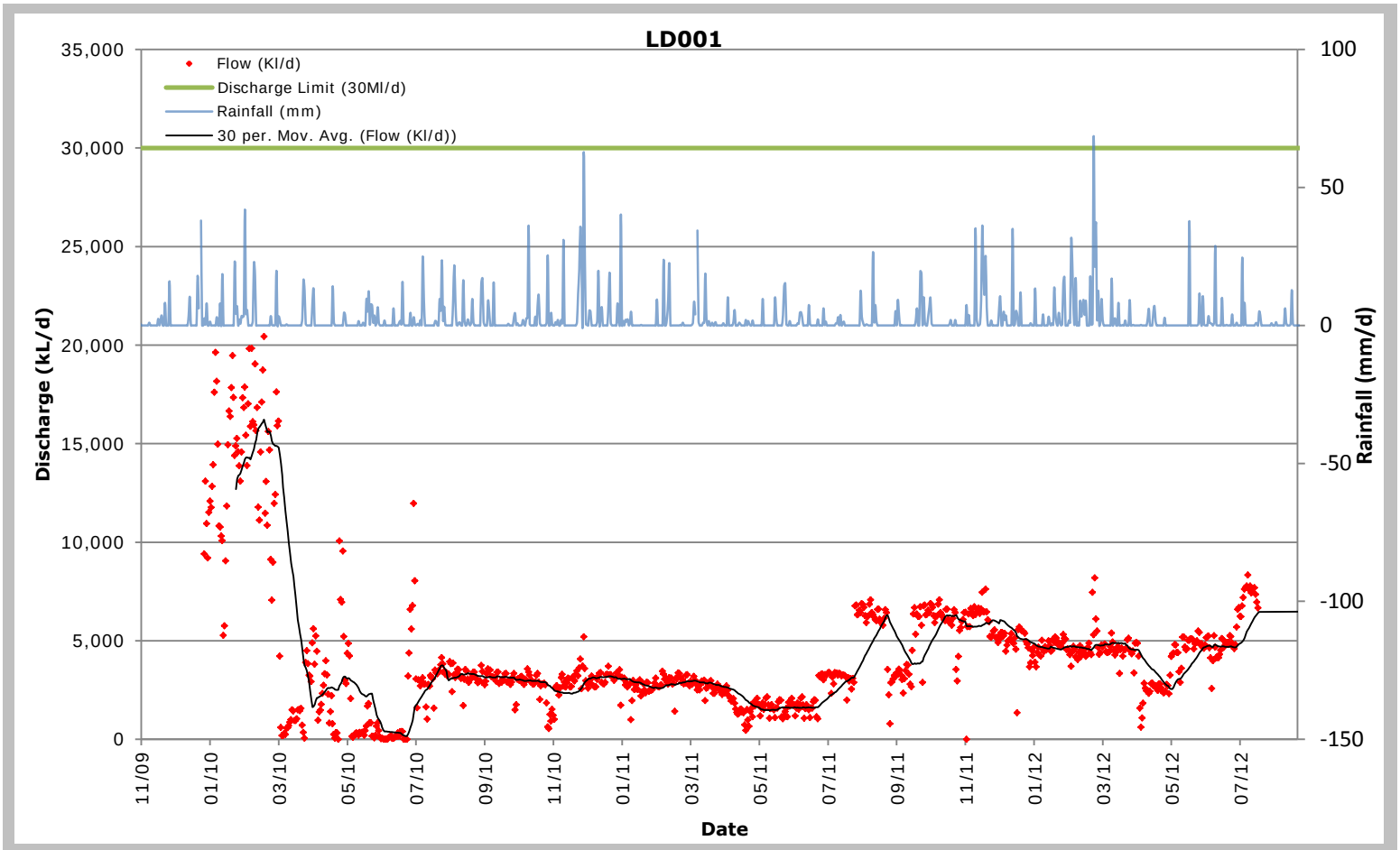

Kangaroo Creek U/S (AP)
Flow (Kl/d)
Rainfall (mm/d)
7 per. Mov. Avg. (Flow (Kl/d))
Flow (Kl/d)
Rainfall (mm/d)
Date

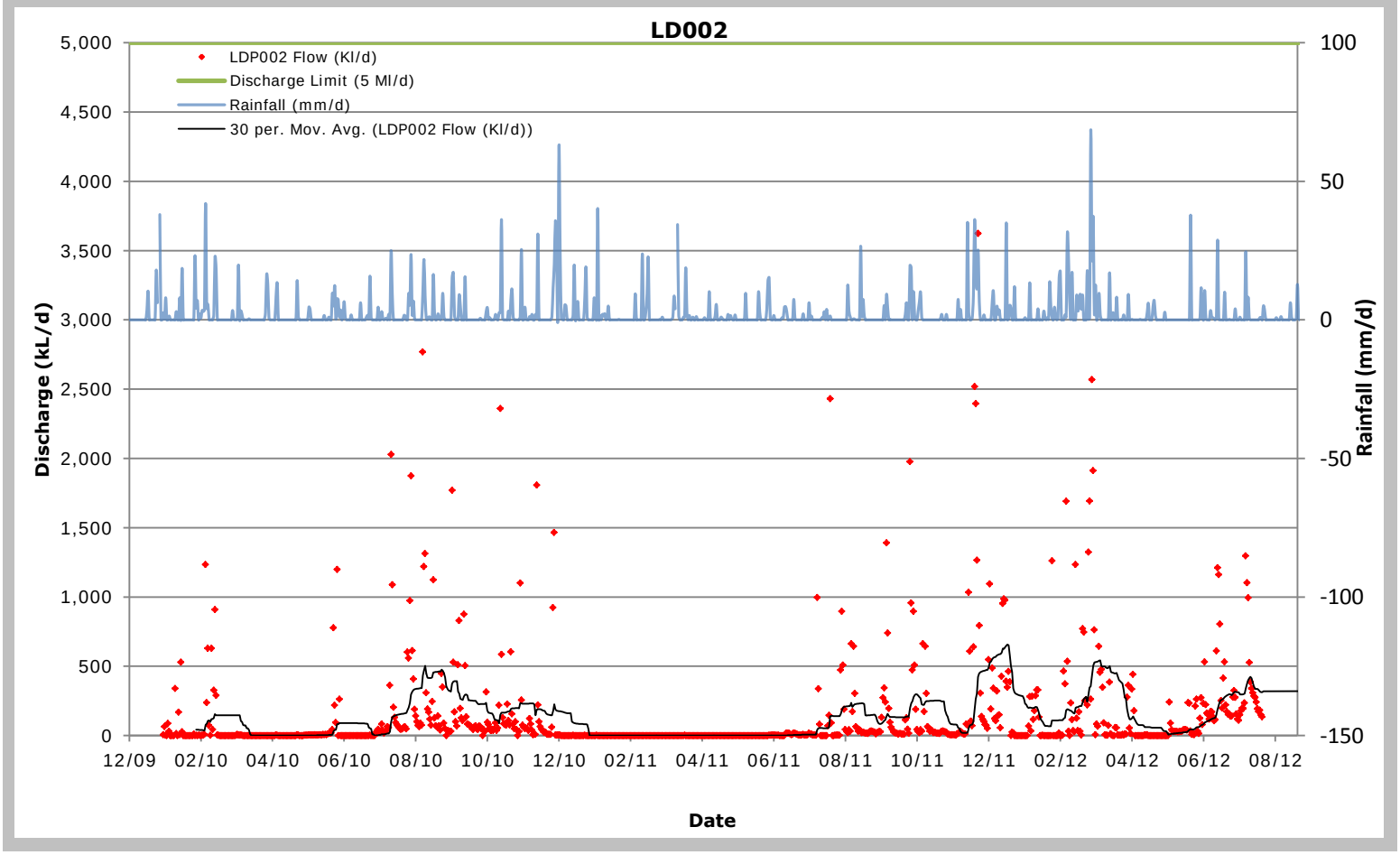

Kangaroo Creek D/S (NP)
Flow (Kl/d)
Rainfall (mm/d)
7 per. Mov. Avg. (Flow (Kl/d))
Flow (Kl/d)
Rainfall (mm/d)
Date


Kangaroo Creek Weir 1
Flow (kL/d)
Rainfall (mm/d)
30 per. Mov. Avg. (Flow (kL/d))
Flow (Kl/d)
Rainfall (mm/d)
Date


Cox's River D/S
Flow (Kl/d)
Rainfall (mm/d)
Flow (Kl/d)
Rainfall (mm/d)
Date
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100
50
0
-50
-100
-150
11/10
01/11
03/11
05/11
07/11
09/11
11/11
01/12
03/12
05/12
07/12


Cox's River U/S
Flow (Kl/d)
Rainfall (mm/d)
Flow (Kl/d)
Rainfall (mm/d)
Date
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
100
50
0
-50
-100
-150
11/10
01/11
03/11
05/11
07/11
09/11
11/11
01/12
03/12
05/12
07/12



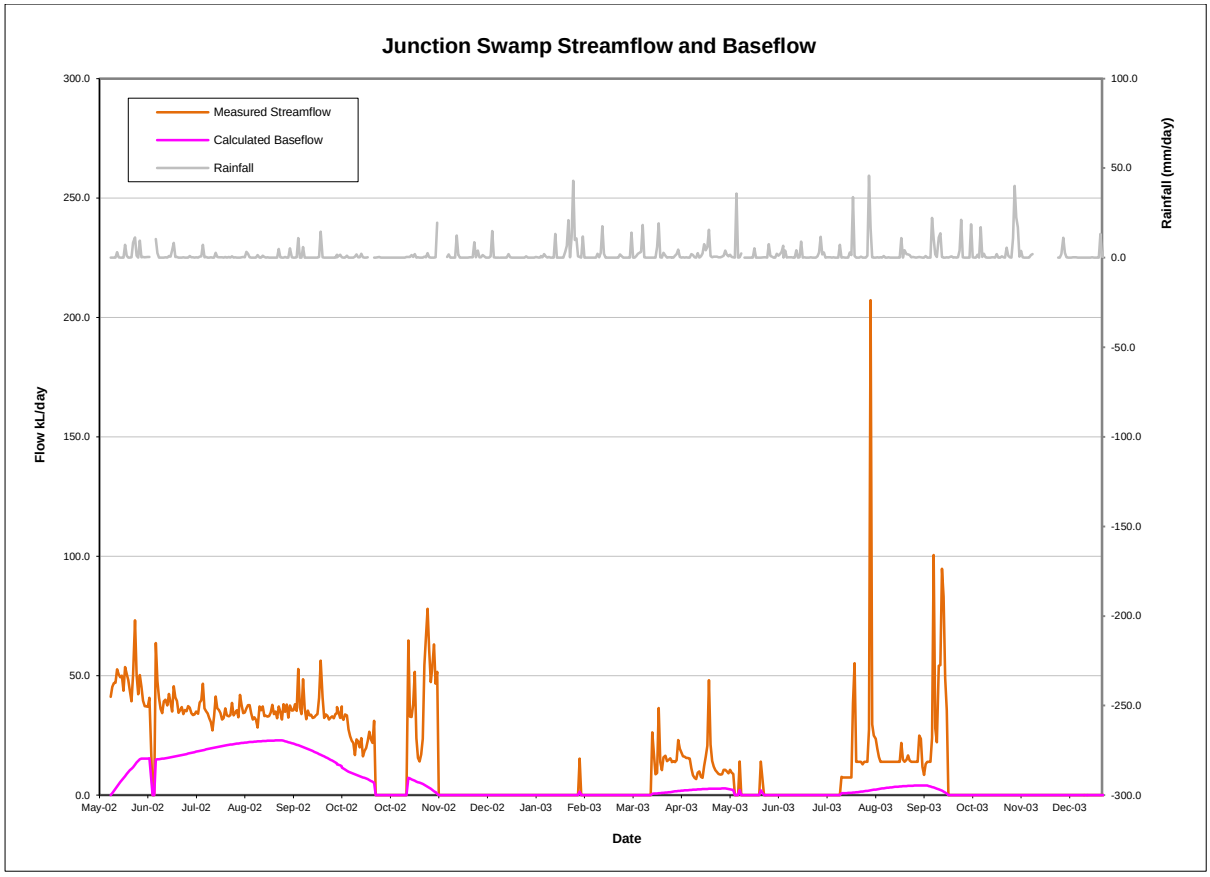


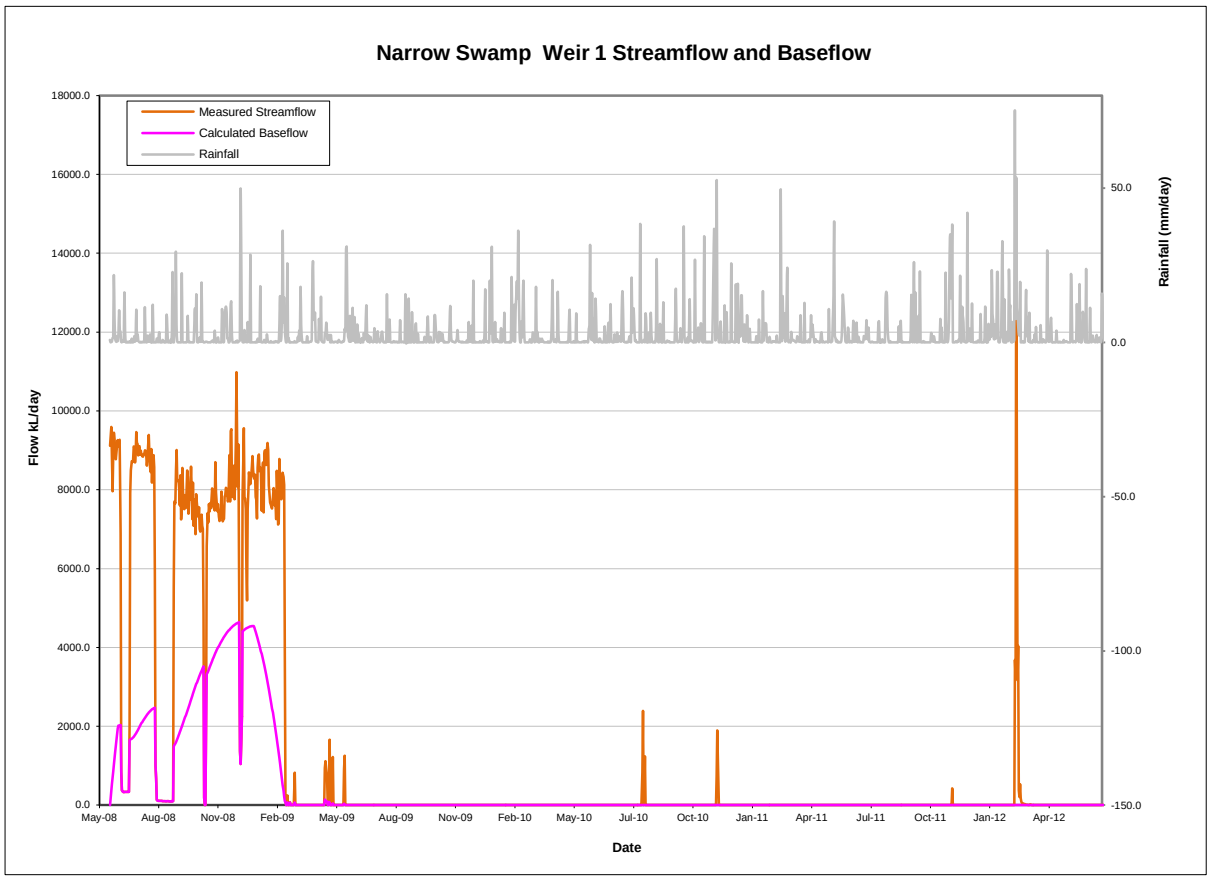
RPS Aquaterra

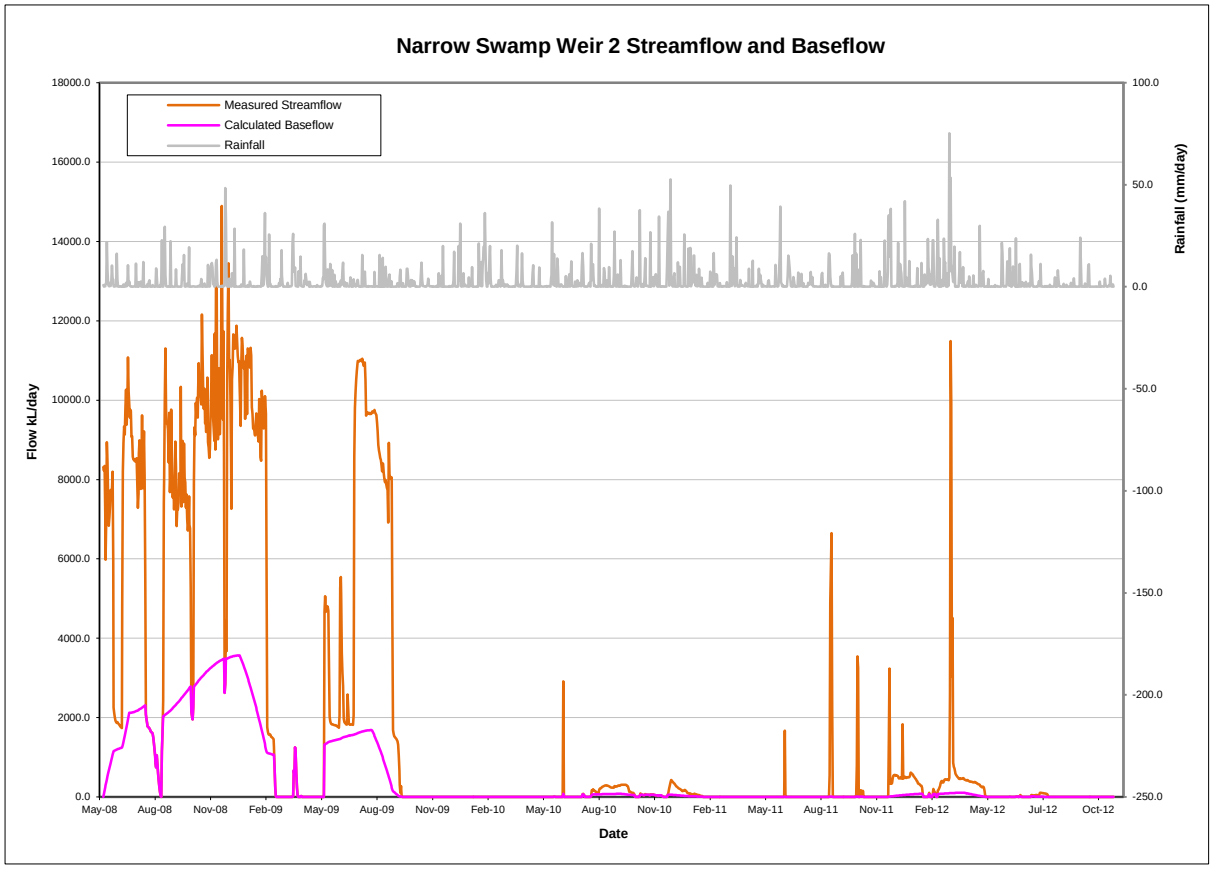
ANGUS PLACE LDP FLOWS FIGURE A.06

F:\Jobs\Other Offices\Sydney\S187_S188\300\360 Analysis\AP\AP Flow Analysis\[APPENDIX A 06 TO 72 _ LDPs.xls]Figure_06

APPENDIX B:
CALCULATED BASEFLOW SEPARATION


Junction Swamp Streamflow and Baseflow
Measured Streamflow
Calculated Baseflow
Rainfall
Flow kL/day
Rainfall (mm/day)
Date
300.0
250.0
200.0
150.0
100.0
50.0
0.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
-200.0
-250.0
-300.0
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Oct-02
Nov-02
Dec-02
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03
Aug-03
Sep-03
Oct-03
Nov-03
Dec-03


Narrow Swamp Weir 1 Streamflow and Baseflow
Measured Streamflow
Calculated Baseflow
Rainfall
Flow kL/day
Rainfall (mm/day)
Date
18000.0
16000.0
14000.0
12000.0
10000.0
8000.0
6000.0
4000.0
2000.0
0.0
50.0
0.0
-50.0
-100.0
-150.0
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
May-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12


Narrow Swamp Weir 2 Streamflow and Baseflow
Measured Streamflow
Calculated Baseflow
Rainfall
Flow kL/day
Rainfall (mm/day)
Date
18000.0
16000.0
14000.0
12000.0
10000.0
8000.0
6000.0
4000.0
2000.0
0.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
-200.0
-250.0
May-08
Aug-08
Nov-08
Feb-09
May-09
Aug-09
Nov-09
Feb-10
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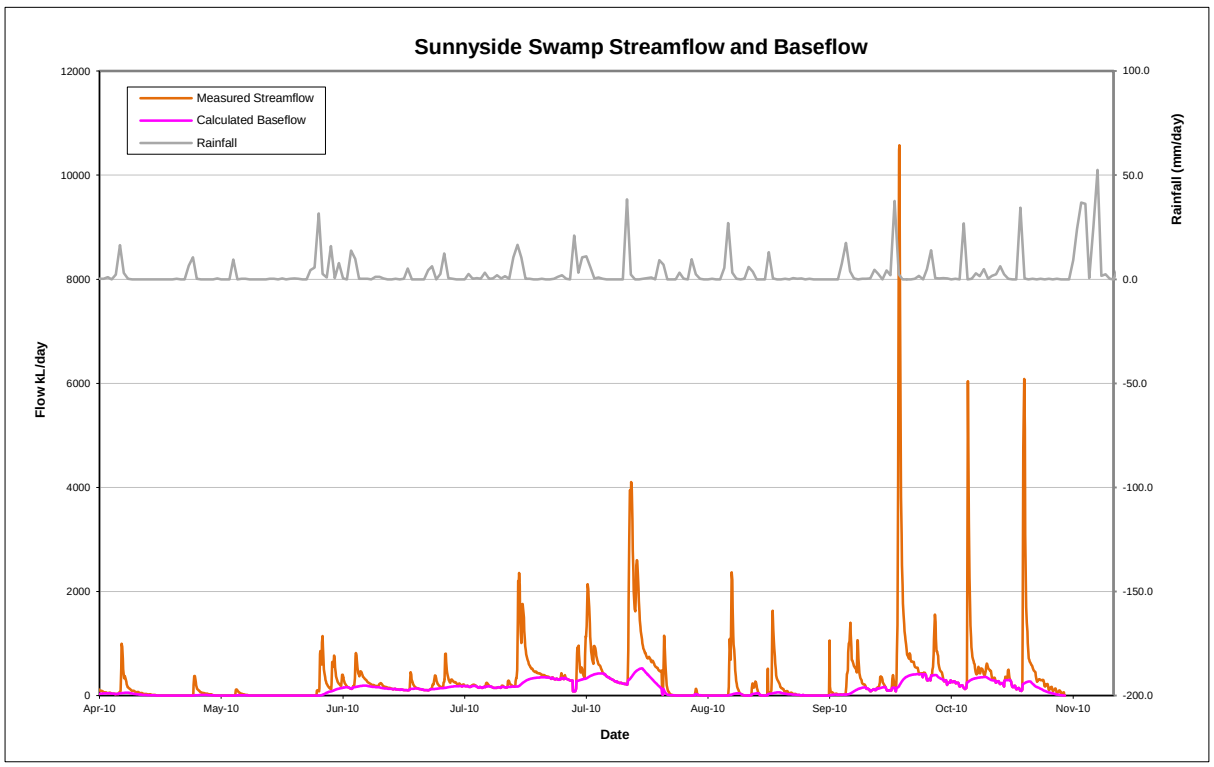
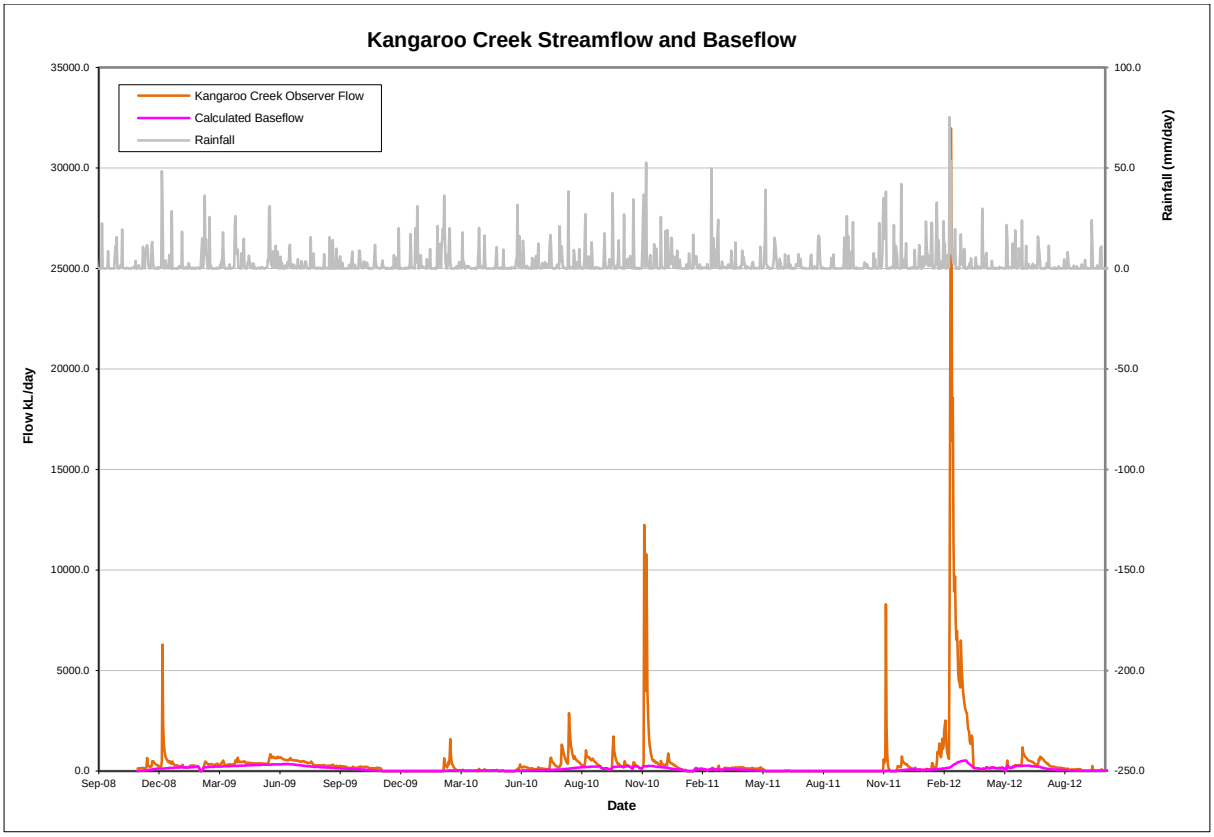
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Jul-12
Oct-12

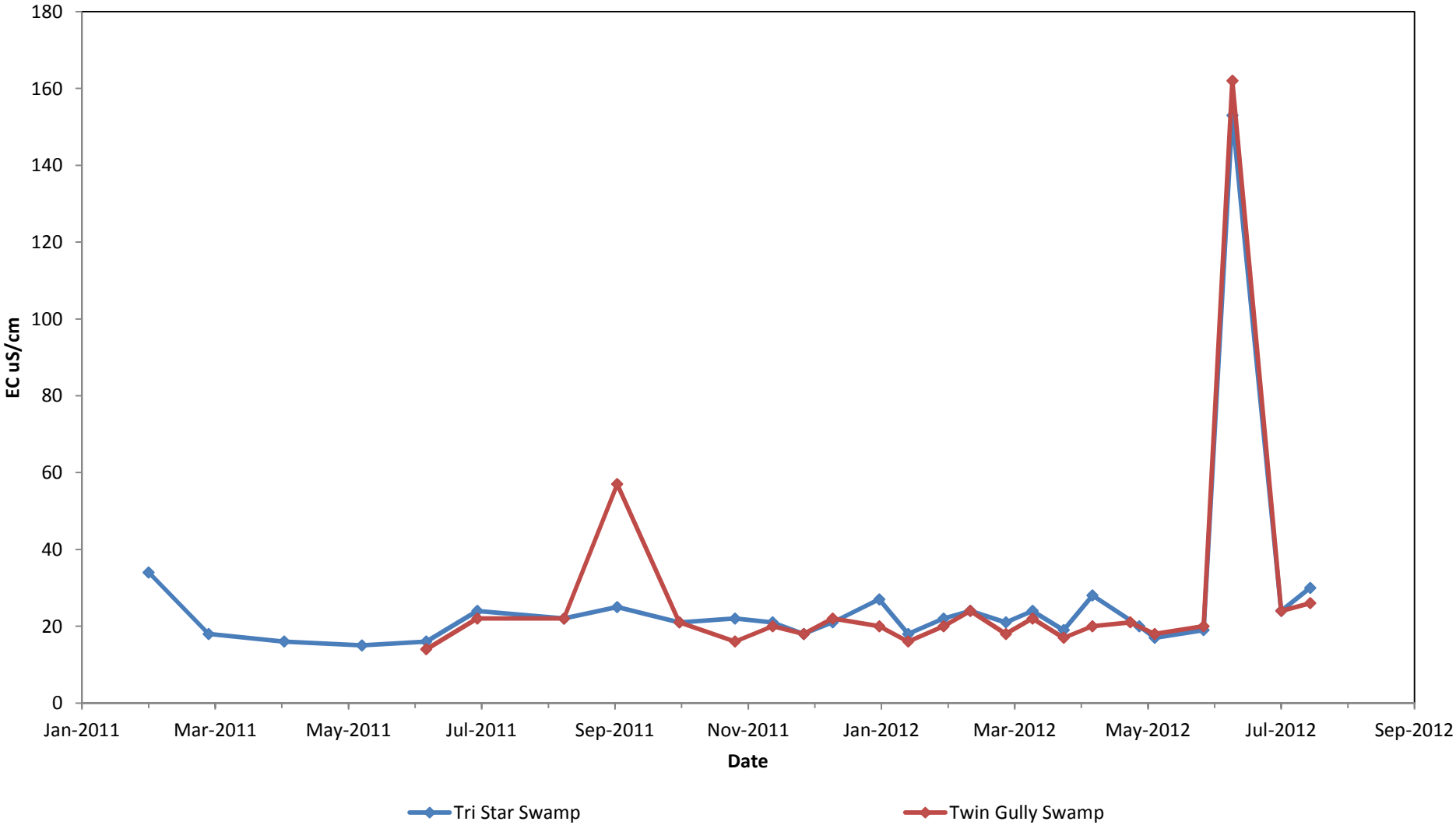

Sunnyside Swamp Streamflow and Baseflow
Measured Streamflow
Calculated Baseflow
Rainfall
Flow kL/day
Rainfall (mm/day)
Date
12000
10000
8000
6000
4000
2000
0
100.0
50.0
0.0
-50.0
-100.0
-150.0
-200.0
Apr-10
May-10
Jun-10
Jul-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10


Kangaroo Creek Streamflow and Baseflow
Kangaroo Creek Observer Flow
Calculated Baseflow
Rainfall
Flow kL/day
Rainfall (mm/day)
35000.0
30000.0
25000.0
20000.0
15000.0
10000.0
5000.0
0.0
100.0
50.0
0.0
-50.0
-100.0
-150.0
-200.0
-250.0
Sep-08
Dec-08
Mar-09
Jun-09
Sep-09
Dec-09
Mar-10
Jun-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11
Feb-12
May-12
Aug-12
Date

APPENDIX C:
WATER QUALITY STATISTICAL SUMMARY AND PLOTS

Sample Name	Statistics	pH	TSS	TDS	Ec (uS/cm)	Oil & Grease	Manganese Filt (mg/L)	Iron Filt (mg/L)	Turbidity (NTU)	Aluminium Filt (mg/L)	Arsenic Filt (mg/L)	Barium Filt (mg/L)	Boron Filt (mg/L)	Cadmium Filt (mg/L)	Calcium	Chromium Filtered (mg/L)	Chloride	Cobalt Filt (mg/L)	Copper Filt (mg/L)	Cyanide Total	Lead Filt (mg/L)	Magnesium	Nickel Filt (mg/L)	Potassium	Selenium Filt (mg/L)	Silver Filt (mg/L)	Sodium	Total Sulphur (Sulphate)	Uranium Filt	Zinc Filt (mg/L)	Nitrogen (Ammonia) (mg/L)	Nitrite as N (mg/L)	Nitrate as N (mg/L)	Nitrate + Nitrite (mg/L)	Total Nitrogen as N (mg/L)	Total Phosphorous	Carbonate Alkalinity (mg/L)	Bicarbonate Alkalinity (mg/L)	Hydroxide Alkalinity (mg/L)	Total Alkalinity (mg/L)	Total Hardness as CaCO3	Total Fluoride
LDP001	Min	7.28	1	518	695	5	0.0040	0.0500	2	0.0010	0.0010	0.0620	0.0500	0.0001	9.00	0.0010	5		0.00100	0.0040	0.0010	7.00	0.0030	21.00	0.0100	0.0010	190.00	41.90	0.0010	0.0160	0.0100	0.01	0.01	0.01	0.20	0.01	1.00	363.00	1.00	394.00	60	0.00
	Median	7.93	4	682	1010	5	0.0310	0.0500	11	0.0200	0.0010	0.0910	0.0700	0.0001	21.00	0.0010	8		0.00200	0.0040	0.0010	12.00	0.0040	29.00	0.0100	0.0010	225.00	69.00	0.0020	0.0460	0.0500	0.01	0.64	0.63	1.00	0.01	31.00	495.00	1.00	507.00	109	1.00
	Mean	8.03	5	764	989	5	0.0355	0.0719	14	0.0350	0.0017	0.0921	0.0727	0.0002	21.48	0.0010	8		0.00659	0.0040	0.0010	11.85	0.0037	28.56	0.0100	0.0010	226.00	68.12	0.0024	0.0493	0.1252	0.02	0.66	0.66	1.11	0.06	30.59	482.56	1.00	511.89	104	0.90
	Max	8.88	41	2950	1270	6	0.0850	0.3000	37	0.3000	0.0130	0.1290	0.1000	0.0007	30.00	0.0010	11		0.05200	0.0040	0.0010	17.00	0.0050	34.00	0.0100	0.0010	264.00	92.00	0.0030	0.1440	1.0000	0.29	2.70	2.70	4.20	1.20	104.00	605.00	1.00	646.00	141	1.20
	20th percentile	7.75	2	646	837	5	0.0100	0.0500	5	0.0100	0.0010	0.0740	0.0600	0.0001	19.00	0.0010	8		0.00100	0.0040	0.0010	9.00	0.0030	25.20	0.0100	0.0010	209.20	56.00	0.0020	0.0380	0.0160	0.01	0.40	0.43	0.80	0.01	1.00	420.80	1.00	471.20	87	0.90
	80th percentile	8.38	7	735	1120	5	0.0610	0.0800	21	0.0400	0.0020	0.1060	0.0800	0.0001	25.00	0.0010	9		0.00480	0.0040	0.0010	14.80	0.0040	32.00	0.0100	0.0010	244.20	82.00	0.0030	0.0560	0.2000	0.01	0.80	0.73	1.20	0.03	46.40	535.80	1.00	557.40	122	1.10
	90th percentile	8.55	9	750	1160	5	0.0710	0.1000	32	0.0560	0.0020	0.1120	0.0800	0.0002	26.00	0.0010	10		0.02000	0.0040	0.0010	15.00	0.0040	33.00	0.0100	0.0010	251.00	85.00	0.0030	0.0640	0.2520	0.01	0.83	0.82	1.42	0.06	62.00	556.80	1.00	567.20	123	1.13
	Sample Count	75	59	26	53	53	31	31	26	28	29	31	26	30	27	1	31		27	24	30	27	30	27	3	3	27	31	31	31	29	25	25	29	29	28	27	27	27	27	26	28
LDP002	Min	6.88	2	14	171	5	0.0060	0.0500	6	0.0100	0.0010	0.0001	0.0500	0.0001	17.00	0.0010	7		0.00100	0.0040	0.0010	3.00	0.0010	6.00	0.0100	0.0010	16.00	11.10	0.0010	0.0080	0.0100	0.01	0.01	0.01	0.10	0.01	1.00	49.00	1.00	49.00	55	0.00
	Median	7.83	12	222	314	5	0.0460	0.0550	33	0.0500	0.0010	0.0570	0.0500	0.0001	24.00	0.0010	14		0.00300	0.0040	0.0010	5.00	0.0040	9.00	0.0100	0.0010	38.50	32.00	0.0010	0.0270	0.0200	0.01	0.02	0.03	0.60	0.02	1.00	120.00	1.00	120.00	80	0.26
	Mean	7.90	30	215	370	5	0.1169	0.0938	81	0.0916	0.0011	0.0598	0.0500	0.0010	25.27	0.0010	14		0.00487	0.0041	0.0012	5.18	0.0066	9.14	0.0100	0.0010	38.18	38.84	0.0010	0.0297	0.0733	0.01	0.14	0.13	1.28	0.09	1.14	114.23	1.00	114.45	83	0.32
	Max	9.12	238	382	1930	10	1.0800	0.3500	668	0.5900	0.0020	0.1430	0.0500	0.0146	46.00	0.0010	26		0.02700	0.0060	0.0050	7.00	0.0750	13.00	0.0100	0.0010	58.00	119.00	0.0020	0.0690	0.8900	0.04	1.29	1.29	8.00	0.60	4.00	171.00	1.00	171.00	144	1.10
	20th percentile	7.56	6	158	262	5	0.0220	0.0500	15	0.0100	0.0010	0.0414	0.0500	0.0001	20.40	0.0010	11		0.00200	0.0040	0.0010	4.00	0.0030	8.00	0.0100	0.0010	30.00	23.00	0.0010	0.0172	0.0100	0.01	0.01	0.01	0.40	0.01	1.00	91.40	1.00	91.40	70	0.20
	80th percentile	8.35	35	296	379	5	0.1360	0.1400	106	0.1440	0.0010	0.0744	0.0500	0.0006	28.00	0.0010	16		0.00660	0.0040	0.0010	6.00	0.0058	10.80	0.0100	0.0010	44.80	44.00	0.0010	0.0428	0.0480	0.01	0.11	0.11	1.50	0.12	1.00	125.00	1.00	125.80	96	0.30
	90th percentile	8.41	84	330	413	5	0.2655	0.1800	233	0.1780	0.0010	0.0949	0.0500	0.0023	30.90	0.0010	18		0.00780	0.0040	0.0010	6.90	0.0064	11.00	0.0100	0.0010	53.40	66.20	0.0010	0.0496	0.1340	0.01	0.48	0.31	2.64	0.23	1.00	158.80	1.00	159.10	100	0.60
	Sample Count	79	80	24	42	41	26	26	75	25	25	28	22	27	22	2	26		23	23	27	22	27	22	3	3	22	25	28	22	27	23	23	27	27	27	22	22	22	22	22	26
LDP003	Min	6.61	0	16	59	5	0.0010	0.0500	1	0.0020	0.0010	0.0090	0.0500	0.0001	5.00	0.0010	3		0.00100	0.0040	0.0010	1.00	0.0010	2.00	0.0100	0.0010	7.00	8.00	0.0010	0.0050	0.0100	0.01	0.01	0.01	0.01	0.01	1.00	1.00	1.00	1.00	17	0.00
	Median	7.31	7	166	201	5	0.0210	0.0600	31	0.0100	0.0010	0.0180	0.1000	0.0001	14.00	0.0010	9		0.00200	0.0040	0.0010	9.00	0.0020	10.00	0.0100	0.0010	15.00	50.00	0.0010	0.0130	0.0200	0.01	0.03	0.04	0.30	0.02	1.00	40.00	1.00	40.00	70	0.20
	Mean	7.47	26	155	209	5	0.0354	0.1012	84	0.0781	0.0010	0.0251	0.0992	0.0202	12.60	0.0010	9		0.00336	0.0040	0.0013	6.96	0.0028	10.45	0.0100	0.0010	18.22	49.14	0.0010	0.0165	0.0529	0.01	0.21	0.22	0.79	0.05	1.00	45.96	1.00	45.96	60	0.26
	Max	8.58	191	278	1171	6	0.2940	0.7900	668	1.0400	0.0010	0.1780	0.1800	1.1800	18.00	0.0010	23		0.02800	0.0040	0.0080	12.00	0.0110	110.00	0.0100	0.0010	44.00	78.00	0.0010	0.0650	1.0900	0.04	1.75	1.75	9.00	0.28	1.00	89.00	1.00	89.00	94	1.10
	20th percentile	7.11	1	98	125	5	0.0060	0.0500	2	0.0100	0.0010	0.0140	0.0500	0.0001	8.00	0.0010	7		0.00100	0.0040	0.0010	2.80	0.0010	4.00	0.0100	0.0010	13.00	33.00	0.0010	0.0070	0.0100	0.01	0.01	0.01	0.10	0.01	1.00	29.80	1.00	29.80	32	0.10
	80th percentile	7.93	33	201	262	5	0.0504	0.1020	100	0.0600	0.0010	0.0294	0.1500	0.0001	16.00	0.0010	11		0.00400	0.0040	0.0010	10.20	0.0040	12.00	0.0100	0.0010	17.80	70.00	0.0010	0.0224	0.0400	0.01	0.28	0.33	1.08	0.10	1.00	63.20	1.00	63.20	84	0.30
	90th percentile	8.23	94	236	274	5	0.0708	0.1630	268	0.1600	0.0010	0.0372	0.1600	0.0004	17.00	0.0010	12		0.00580	0.0040	0.0020	11.00	0.0050	13.00	0.0100	0.0010	36.00	72.00	0.0010	0.0292	0.0700	0.01	0.76	0.81	1.40	0.18	1.00	80.60	1.00	80.60	88	0.44
	Sample Count	77	77	60	77	70	60	60	75	56	57	59	49	59	55	1	59		53	45	59	55	59	55	3	4	55	58	59	59	62	58	58	62	62	62	55	55	55	55	55	60
Cox's Far U/S	Min	5.34	1	44	70	5	0.0900	0.2900	3	0.0200	0.0010	0.0140	0.0500	0.0001	3.00	0.0010	5		0.00200	0.0040	0.0010	2.00	0.0010	3.00			3.00	4.00	0.0010	0.0050	0.0100	0.01	0.01	0.01	0.20	0.01	1.00	4.00	1.00	4.00	16	0.10
	Median	6.24	3	75	98	5	0.1850	0.5200	13	0.0300	0.0010	0.0210	0.0500	0.0001	5.00	0.0010	7		0.00250	0.0040	0.0010	3.00	0.0010	3.00			4.00	12.00	0.0010	0.0100	0.0100	0.01	0.01	0.01	0.40	0.05	1.00	20.00	1.00	20.00	25	0.10
	Mean	6.12	6	82	102	5	0.4303	2.0656	13	0.0338	0.0010	0.0259	0.0500	0.0002	5.89	0.0010	7		0.00300	0.0040	0.0013	3.11	0.0013	3.33			4.56	11.11	0.0010	0.0110	0.0200	0.02	0.08	0.08	0.36	0.08	1.00	24.33	1.00	24.33	28	0.18
	Max	6.76	15	182	128	5	1.1000	7.8600	30	0.0600	0.0010	0.0420	0.0500	0.0005	9.00	0.0010	11		0.00600	0.0040	0.0020	5.00	0.0020	4.00			6.00	20.00	0.0010	0.0170	0.0500	0.06	0.36	0.36	0.60	0.25	1.00	44.00	1.00	44.00	43	0.50
	20th percentile	5.55	2	59	89	5	0.1328	0.3780	6	0.0240	0.0010	0.0168	0.0500	0.0001	4.60	0.0010	6		0.00200	0.0040	0.0010	2.00	0.0010	3.00			4.00	5.00	0.0010	0.0086	0.0100	0.01	0.01	0.01	0.20	0.02	1.00	15.40	1.00	15.40	20	0.10
	80th percentile	6.54	14	83	120	5	0.9158	3.7840	20	0.0420	0.0010	0.0380	0.0500	0.0001	8.40	0.0010	7		0.00360	0.0040	0.0016	4.00	0.0016	4.00			5.40	16.80	0.0010	0.0144	0.0300	0.01	0.14	0.14	0.48	0.12	1.00	40.60	1.00	40.60	37	0.22
	Sample Count	9	9	9	9	8	9	9	9	8	8	8	7	8	9	1	9		8	6	8	9	8	9			9	9	8	9	9	9	9	9	9	9	9	9	9	9	9	9
Cox's U/S	Min	5.98	1	40	63	5	0.0020	0.1000	2	0.0200	0.0010	0.0001	0.0500	0.0001	3.00	0.0010	5		0.00100	0.0040	0.0010	2.00	0.0010	4.00			4.00	7.00	0.0010	0.0050	0.0100	0.01	0.01	0.01	0.10	0.01	1.00	9.00	1.00	9.00	18	0.10
	Median	6.74	3	100	107	5	0.1150	0.2550	11	0.0400	0.0010	0.0265	0.0500	0.0001	7.00	0.0010	7		0.00250	0.0040	0.0010	4.50	0.0010	5.00			6.00	16.50	0.0010	0.0125	0.0100	0.01	0.02	0.03	0.20	0.01	1.00	20.50	1.00	20.50	39	0.10
	Mean	6.77	17	129	128	5	0.3618	0.4107	27	0.0657	0.0010	0.0316	0.0500	0.0004	7.36	0.0010	7		0.00788	0.0040	0.0023	4.64	0.0036	5.14			10.57	23.70	0.0010	0.0205	0.0243	0.01	0.07	0.08	0.65	0.06	1.79	38.46	1.00	39.89	38	0.19
	Max	7.82	422	683	372	5	4.4500	2.7800	391	0.4200	0.0010	0.0980	0.0500	0.0040	14.00	0.0010	9		0.11200	0.0040	0.0380	8.00	0.0620	18.00			134.00	74.00	0.0010	0.0960	0.2200	0.04	0.54	0.54	9.00	0.70	23.00	299.00	1.00	322.00	68	1.00
	20th percentile	6.36	1	67	92	5	0.0428	0.1480	5	0.0300	0.0010	0.0204	0.0500	0.0001	4.00	0.0010	6		0.00100	0.0040	0.0010	3.00	0.0010	4.00			5.00	12.00	0.0010	0.0088	0.0100	0.01	0.01	0.01	0.20	0.01	1.00	11.40	1.00	11.40	22	0.10
	80th percentile	7.07	8	127	166	5	0.2716	0.5060	24	0.0660	0.0010	0.0360	0.0500	0.0002	10.00	0.0010	8		0.00500	0.0040	0.0010	6.00	0.0020	5.00			7.00	41.20	0.0010	0.0288	0.0200	0.01	0.05	0.12	0.56	0.06	1.00	40.60	1.00	40.60	50	0.10
	Sample Count	34	34	28	34	33	30	30	29	28	28	28	23	28	28	2	28		24	25	28	28	28	28			28	30	28	30	28	28	28	28	28	28	28	28	28	28	28	27
Cox's D/S	Min	6.69	1	62	53	5	0.0040	0.0060	2	0.0200	0.0010	0.0001	0.0500	0.0001	4.00	0.0010	6		0.00100	0.0040	0.0010	2.00	0.0010	4.00			6.00	7.00	0.0010	0.0050	0.0100	0.01	0.01	0.01	0.10	0.01	1.00	16.00	1.00	16.00	21	0.10
	Median	8.03	4	348	513	5	0.0120	0.1900	9	0.0450	0.0010	0.0380	0.0500	0.0001	11.00	0.0010	9		0.00200	0.0040	0.0010	7.00	0.0020	15.00			98.50	36.50	0.0010	0.0110	0.0100	0.01	0.07	0.08	0.55	0.02	1.00	228.00	1.00	235.50	56	0.40
	Mean	7.96	10	349	548	5	0.0235	0.2942	20	0.0823	0.0010	0.0408	0.0514	0.0006	12.03	0.0010	9		0.00488	0.0040	0.0011	7.00	0.0032	15.43			103.33	36.93	0.0011	0.0163	0.0503	0.01	0.98	0.98	1.69	0.06	12.93	233.50	1.00	245.83	59	0.43
	Max	8.53	117	660	1030	12	0.1420	1.5400	162	0.4700	0.0010	0.0730	0.0700	0.0070	22.00	0.0010	14		0.04000	0.0040	0.0040	13.00	0.0290	28.00			213.00	72.00	0.0020	0.0740	0.3100	0.04	25.50	25.50	26.00	0.40	58.00	447.00	1.00	487.00	108	0.90
	20th percentile	7.76	1	229	315	5	0.0078	0.1080	4	0.0200	0.0010	0.0338	0.0500	0.0001	9.00	0.0010	7		0.00100	0.0040	0.0010	5.80	0.0010	10.00			57.20	23.80	0.0010	0.0080	0.0100	0.01	0.05	0.05	0.40	0.01	1.00	139.20	1.00	139.20	47	0.16
	80th percentile	8.22	9	460	818	5	0.0260	0.3720	14	0.1000	0.0010	0.0542	0.0500	0.0001	15.20	0.0010	10		0.00500	0.0040	0.0010	8.00	0.0024	20.20			150.40	50.40	0.0010	0.0218	0.0400	0.01	0.19	0.19	0.82	0.07	27.20	326.00	1.00	349.00	71	0.70
	Sample Count	44	44	30	44	42	35	35	31	30	30	30	22	30	30	2	30		26	24	30	30	29	30			30	30	30	32	30	30	30	30	30	30	30	30	30	30	30	29
Lambs Creek	Min	4.88	1	18	69	5	0.1660	0.1800	1	0.1000	0.0010	0.0420	0.0500	0.0001	1.00	0.0010	6		0.00100	0.0040	0.0010	2.00	0.0010	3.00			5.00	14.00	0.0010	0.0140	0.0100	0.01	0.01	0.01	0.10	0.01	1.00	3.00	1.00	3.00	8	0.10
	Median	5.46	1	57	99	5	0.5100	6.9200	2	0.1000	0.0010	0.0615	0.0500	0.0001	1.00	0.0010	6		0.00200	0.0040	0.0010	2.00	0.0020	4.00			5.00	14.00	0.0010	0.0220	0.0100	0.01	0.01	0.01	0.10	0.02	1.00	12.00	1.00	12.00	12	0.10
	Mean	5.41	2	53	203	5	0.4859	6.2756	4	0.1111	0.0010	0.0606	0.0500	0.0001	1.22	0.0010	7		0.00300	0.0040	0.0010	2.56	0.0019	4.44			5.67	14.56	0.0010	0.0213	0.0189	0.01	0.09	0.09	0.23	0.05	1.00	13.44	1.00	13.44	12	0.11
	Max	5.83	7	104	1040	5	0.7500	13.1000	13	0.2000	0.0010	0.0800	0.0500	0.0001	2.00	0.0010	8		0.00900	0.0040	0.0010	4.00	0.0030	6.00			7.00	16.00	0.0010	0.0270	0.0700	0.03	0.70	0.70	1.10	0.21	1.00	26.00	1.00	26.00	19	0.20
	20th percentile	5.09	1	27	81	5	0.3804	2.4880	1	0.1000	0.0010	0.0544	0.0500	0.0001	1.00	0.0010	6		0.00140	0.0040	0.0010	2.00	0.0014	4.00			5.00	14.00	0.0010	0.0162	0.0100	0.01	0.01	0.01	0.10	0.02	1.00	8.60	1.00	8.60	8	0.10
	80th percentile	5.72	4	73	125	5	0.5844	9.6480	5	0.1000	0.0010	0.0656	0.0500	0.0001	1.40	0.0010	7		0.00360	0.0040	0.0010	3.00	0.0020	5.40			6.40	15.00	0.0010	0.0264	0.0200	0.01	0.01	0.01	0.20	0.06	1.00	19.80	1.00	19.80	16	0.10
	Sample Count	9	9	9	9	8	9	9	9	9	8	8	7	8	9	1	9		8	6	8	9	8	9			9	9	8	9	9	9	9	9	9	9	9	9	9	9	9	9
Kangaroo Ck D/S (AP)	Min	7.33	2	68	93	5	0.0110	0.0500	5	0.0100	0.0010	0.0320	0.0500	0.0001	4.00	0.0010	7		0.00100	0.0040	0.0010	2.00	0.0010	6.00			29.00	15.00	0.0010	0.0080	0.0100	0.01	0.01	0.01	0.20	0.01	1.00	61.00	1.00	61.00	18	0.00
	Median	8.35	5	556	770	5	0.0340	0.1400	14	0.0400	0.0010	0.0810	0.0600	0.0001	18.00	0.0010	9		0.00200	0.0040	0.0010	10.00	0.0030	25.00			200.00	60.00	0.0020	0.0255	0.0200	0.01	0.45	0.51	0.90	0.01	31.00	404.00	1.00	441.00	88	0.85
	Mean	8.26	6	525	751	5	0.0681	0.4303	15	0.0656	0.0011	0.0783	0.0632	0.0001	17.42	0.0010	9		0.00439	0.0040	0.0010	9.59	0.0030	23.63			183.96	59.48	0.0021	0.0349	0.0791	0.02	0.45	0.48	0.92	0.07	28.56	392.48	1.00	420.74	84	0.75
	Max	8.89	20	702	1130	5	0.5540	4.7900	50	0.4300	0.0020	0.1050	0.1000	0.0005	25.00	0.0010	12		0.02800	0.0040	0.0010	15.00	0.0040	31.00			247.00	141.00	0.0040	0.1540	0.8000	0.13	0.74	0.74	3.00	1.20	83.00	506.00	1.00	535.00	116	1.10
	20th percentile	8.08	3	433	592	5	0.0180	0.0700	7	0.0200	0.0010	0.0630	0.0520	0.0001	14.00	0.0010	8		0.00100	0.0040	0.0010	7.20	0.0030	20.00			158.80	44.20	0.0020	0.0180	0.0100	0.01	0.31	0.33	0.60	0.01	1.00	357.60	1.00	362.80	66	0.60
	80th percentile	8.53	8	654	982	5	0.0810	0.5500	20	0.0780	0.0010	0.0936	0.0700	0.0001	21.00	0.0010	10		0.00460	0.0040	0.0010	12.00	0.0040	28.00			210.40	72.60	0.0030	0.0402	0.0920	0.01	0.65	0.66	1.04	0.03	49.60	457.20	1.00	495.00	101	1.00
	Sample Count	40	40	27	40	38	31	31	28	27	27	27	22	27	26	1	27		23	21	27	27	27	27			27	27	27	30	23	23	23	23	24	23	27	27	27	27	27	22
Kangaroo Ck D/S (NP)	Min	4.31			21		0.0190	0.0170		0.0300	0.0010	0.0550	0.0600						0.00300		0.0040		0.0050						0.0010	0.0230												
	Median	5.64			30		0.0350	0.2500		0.0300	0.0075	0.0550	0.0600						0.00300		0.0040		0.0050						0.0010	0.0230												
	Mean	5.61			31		0.0413	0.2829		0.0300	0.0075	0.0550	0.0600						0.00300		0.0040		0.0050						0.0010	0.0230												
	Max	6.58			123		0.1100	0.8200		0.0300	0.0140	0.0550	0.0600						0.00300		0.0040		0.0050						0.0010	0.0230												
	20th percentile	5.36			24		0.0250	0.1200		0.0300	0.0036	0.0550	0.0600						0.00300		0.0040		0.0050						0.0010	0.0230												
	80th percentile	5.91			33		0.0580	0.4460		0.0300	0.0114	0.0550	0.0600						0.00300		0.0040		0.0050						0.0010	0.0230												
	Sample Count	60			58		56	58		1	2	1	1						1		1		1						1	1												
Kangaro Ck U/S	Min	4.44	1	11	37	5	0.0130	0.2000	1	0.0400	0.0010	0.0130	0.0500	0.0001	1.00	0.0010	6		0.00100	0.0040	0.0010	1.00	0.0010	1.00			5.00	1.00	0.0010	0.0040	0.0100	0.01	0.01	0.01	0.10	0.01	1.00	1.00	1.00	1.00	1	0.10
	Median	6.32	5	67	65	5	0.1040	1.5500	8	0.1200	0.0010	0.0250	0.0500	0.0001	1.00	0.0010	10		0.00200	0.0040	0.0010	1.00	0.0010	2.00			8.00	1.00	0.0010	0.0130	0.0100	0.01	0.01	0.01	0.50	0.02	1.00	13.00	1.00	13.00	9	0.10
	Mean	6.27	7	66	102	5	0.2760	3.2752	16	0.1415	0.0010	0.0290	0.0500	0.0002	1.50	0.0010	10		0.00596	0.0042	0.0010	1.52	0.0016	1.78			7.59	5.64	0.0010	0.0164	0.0364	0.01	0.11	0.11	1.13	0.05	1.00	14.44	1.00	14.44	9	0.18
	Max	7.14	29	164	818	13	1.6800	18.8000	99	0.5000	0.0020	0.1010	0.0500	0.0028	3.00	0.0010	15		0.03800	0.0080	0.0010	4.00	0.0030	3.00			16.00	82.20	0.0010	0.1000	0.2200	0.04	0.89	0.89	13.00	0.60	1.00	46.00	1.00	46.00	29	1.10
	20th percentile	5.82	2	34	46	5	0.0508	0.5480	4	0.0700	0.0010	0.0154	0.0500	0.0001	1.00	0.0010	8		0.00100	0.0040	0.0010	1.00	0.0010	1.00			6.00	1.00	0.0010	0.0086	0.0100	0.01	0.01	0.01	0.40	0.01	1.00	6.00	1.00	6.00	5	0.10
	80th percentile	6.77	9	88	86	5	0.4538	5.1740	20	0.1780	0.0010	0.0352	0.0500	0.0001	2.00	0.0010	11		0.00760	0.0040	0.0010	2.00	0.0020	2.00			8.80	4.20	0.0010	0.0190	0.0300	0.01	0.04	0.04	0.82	0.05	1.00	20.00	1.00	20.00	13	0.10
	Sample Count	38	35	27	38	35	33	33	28	27	27	27	22	27	26	1	27		23	23	27	27	27	27			27	30	27	29	25	25	25	25	25	25	27	27	27	27	27	24
KC/CR Confluence	Min	6.10	1	1	45	5	0.0060	0.0500	2	0.0100	0.0010	0.0170	0.0500	0.0001	3.00		6		0.00100	0.0040	0.0010	2.00	0.0010	4.00			4.00	7.00	0.0010	0.0100	0.0100	0.01	0.01	0.01	0.10	0.01	1.00	9.00	1.00	9.00	16	0.10
	Median	8.50	3	611	699	5	0.0155	0.1100	8	0.0300	0.0010	0.0675	0.0600	0.0001	18.00		8		0.00300	0.0040	0.0010	8.50	0.0030	24.00			192.50	59.00	0.0020	0.0195	0.0150	0.01	0.32	0.32	0.70	0.02	29.50	382.00	1.00	417.00	77	0.80
	Mean	8.26	3	511	682	5	0.0205	0.3288	11	0.0692	0.0011	0.0673	0.0590	0.0003	16.24		9		0.00876	0.0040	0.0011	8.88	0.0028	21.65			166.50	56.08	0.0019	0.0223	0.0281	0.01	0.35	0.35	0.89	0.06	28.73	336.73	1.00	370.38	77	0.60
	Max	9.00	7	725	1200	5	0.0650	2.5800	47	0.3400	0.0020	0.1010	0.0800	0.0027	24.00		12		0.07400	0.0040	0.0030	16.00	0.0040	32.00			258.00	132.00	0.0030	0.0540	0.0800	0.01	1.64	1.64	4.00	0.38	78.00	509.00	1.00	575.00	116	1.10
	20th percentile	8.11	1	366	387	5	0.0090	0.0700	4	0.0200	0.0010	0.0540	0.0500	0.0001	13.00		8		0.00200	0.0040	0.0010	7.00	0.0020	18.00			140.00	36.00	0.0010	0.0140	0.0100	0.01	0.01	0.01	0.40	0.01	1.00	282.00	1.00	312.00	65	0.10
	80th percentile	8.65	4	654	1040	5	0.0230	0.5600	17	0.0800	0.0010	0.0880	0.0620	0.0002	20.00		10		0.00600	0.0040	0.0010	12.00	0.0040	27.00			216.00	70.00	0.0020	0.0280	0.0400	0.01	0.51	0.51	1.00	0.04	44.00	435.00	1.00	479.00	99	0.92
	Sample Count	26	26	26	26	26	26	26	26	26	26	26	20	26	25		26		21	21	26	26	26	26			26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	25
Tri Star Swamp	Min	4.74	2	9	15	5	0.0010	0.0200	1	0.0600	0.0010	0.0020	0.0500	0.0001	1.0000		4		0.00010	0.0040	0.0010	1.00	0.00	1.00			2.00	1.00	0.0010	0.0010	0.0100	0.0100	0.01	0.01	0.10	0.01	1	1	1	1.00	1	0.1
	Median	5.64	5	35	21	5	0.0065	0.2200	6	0.1000	0.0010	0.0060	0.0500	0.0001	1.0000		5		0.00200	0.0040	0.0010	1.00	0.00	1.00			3.00	1.00	0.0010	0.0080	0.0100	0.0100	0.01	0.01	0.20	0.01	1	1	1	1.00	1	0.1
	Mean	5.63	6	38	27	5	0.0080	0.2530	8	0.1185	0.0029	0.0074	0.0509	0.0021	1.0000		5		0.00457	0.0040	0.0015	1.00	0.00	1.00			2.93	1.19	0.0010	0.0114	0.0252	0.0104	1.47	1.53	1.98	0.03	1	2	1	2.00	1	0.108333
	Max	6.44	22	86	153	5	0.0250	0.7700	46	0.2500	0.0500	0.0200	0.0690	0.0440	1.0000		6		0.02100	0.0040	0.0130	1.00	0.01	1.00			3.00	6.00	0.0010	0.0340	0.1400	0.0200	32.20	32.2	32.40	0.12	1	6	1	6.00	1	0.2
	20th percentile	5.21	3	22	18	5	0.0050	0.1680	3	0.0720	0.0010	0.0050	0.0500	0.0001	1.0000		5		0.00100	0.0040	0.0010	1.00	0.00	1.00			3.00	1.00	0.0010	0.0060	0.0100	0.0100	0.01	0.01	0.10	0.01	1	1	1	1.00	1	0.1
	80th percentile	6.03	9	51	25	5	0.0100	0.3100	10	0.1540	0.0010	0.0100	0.0500	0.0001	1.0000		5		0.00760	0.0040	0.0010	1.00	0.00	1.00			3.00	1.00	0.0010	0.0140	0.0200	0.0100	0.03	0.034	0.48	0.034	1	3	1	3.00	1	0.1
	Sample Count	27	26	27	27	26	26	27	26	27	27	27	21	26	26		27		23	21	27	27	27	27			27	27	27	26	25	25	25	24	24	24	27	27	27	27	27	24
Twin Gully Swamp	Min	4.68	1	1	14	5	0.0010	0.0100	1	0.0400	0.0010	0.0020	0.0500	0.0001	1.00		4		0.00010	0.0040	0.0010	1.0000	0.0010	1.00			2.00	1.00	0.0010	0.0010	0.0100	0.01	0.01	0.01	0.10	0.01	1.00	1.00	1.00	1.00	1	0.10
	Median	5.57	4	36	20	5	0.0105	0.2800	6	0.0800	0.0010	0.0070	0.0500	0.0001	1.00		5		0.00300	0.0040	0.0010	1.0000	0.0010	1.00			3.00	1.00	0.0010	0.0100	0.0200	0.01	0.01	0.01	0.20	0.02	1.00	2.00	1.00	2.00	1	0.10
	Mean	5.63	8	57	28	5	0.0128	0.2683	10	0.0926	0.0010	0.0078	0.0500	0.0001	1.00		5		0.00443	0.0040	0.0209	1.0000	0.0015	1.00			3.04	1.04	0.0010	0.0145	0.1319	0.01	0.10	0.11	0.37	0.04	1.09	3.48	1.00	3.61	1	0.20
	Max	6.81	39	412	162	5	0.0330	0.6200	50	0.2800	0.0010	0.0240	0.0500	0.0003	1.00		6		0.02000	0.0040	0.4450	1.0000	0.0110	1.00			4.00	2.00	0.0010	0.0530	1.1800	0.03	1.81	1.81	1.90	0.26	3.00	13.00	1.00	13.00	1	1.00
	20th percentile	5.16	3	25	18	5	0.0092	0.2000	3	0.0540	0.0010	0.0060	0.0500	0.0001	1.00		4		0.00100	0.0040	0.0010	1.0000	0.0010	1.00			3.00	1.00	0.0010	0.0050	0.0100	0.01	0.01	0.01	0.10	0.01	1.00	1.40	1.00	1.40	1	0.10
	80th percentile	6.12	11	62	23	5	0.0158	0.3060	11	0.1100	0.0010	0.0090	0.0500	0.0001	1.00		5		0.00540	0.0040	0.0016	1.0000	0.0010	1.00			3.00	1.00	0.0010	0.0180	0.0300	0.01	0.02	0.02	0.40	0.04	1.00	5.60	1.00	5.60	1	0.20
	Sample Count	23	22	23	23	22	22	23	23	23	23	23	17	22	23		23		19	15	23	23	23	23			23	23	23	22	21	21	21	20	20	20	23	23	23	23	23	21

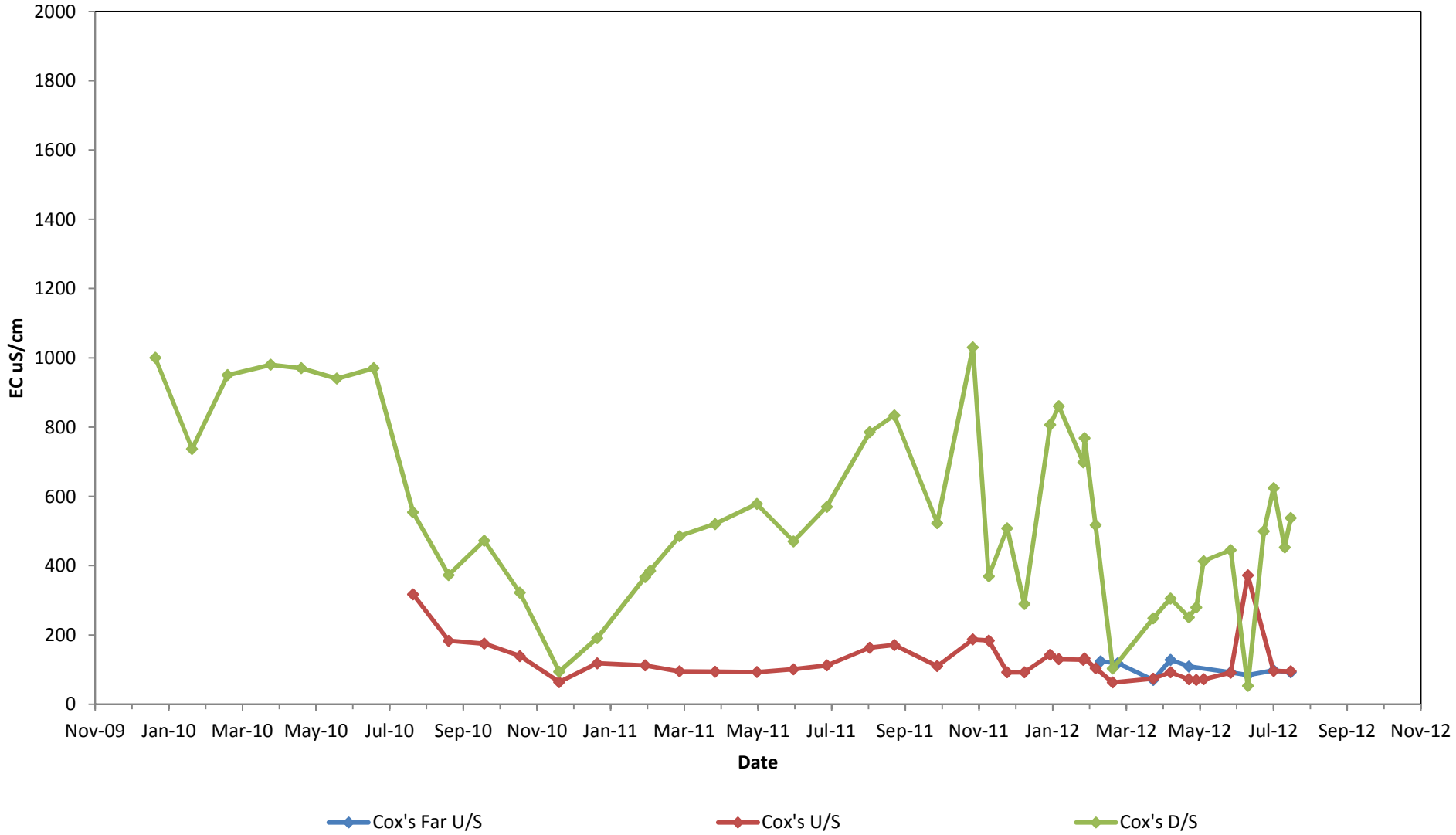
Note: values marked in brown colour denote exceedence for the selected trigger value, either ANZECC/ARMCANZ (2000) or EPL3607 as defined in Section 4.



RPS Aquaterra

App. C- Figure 1

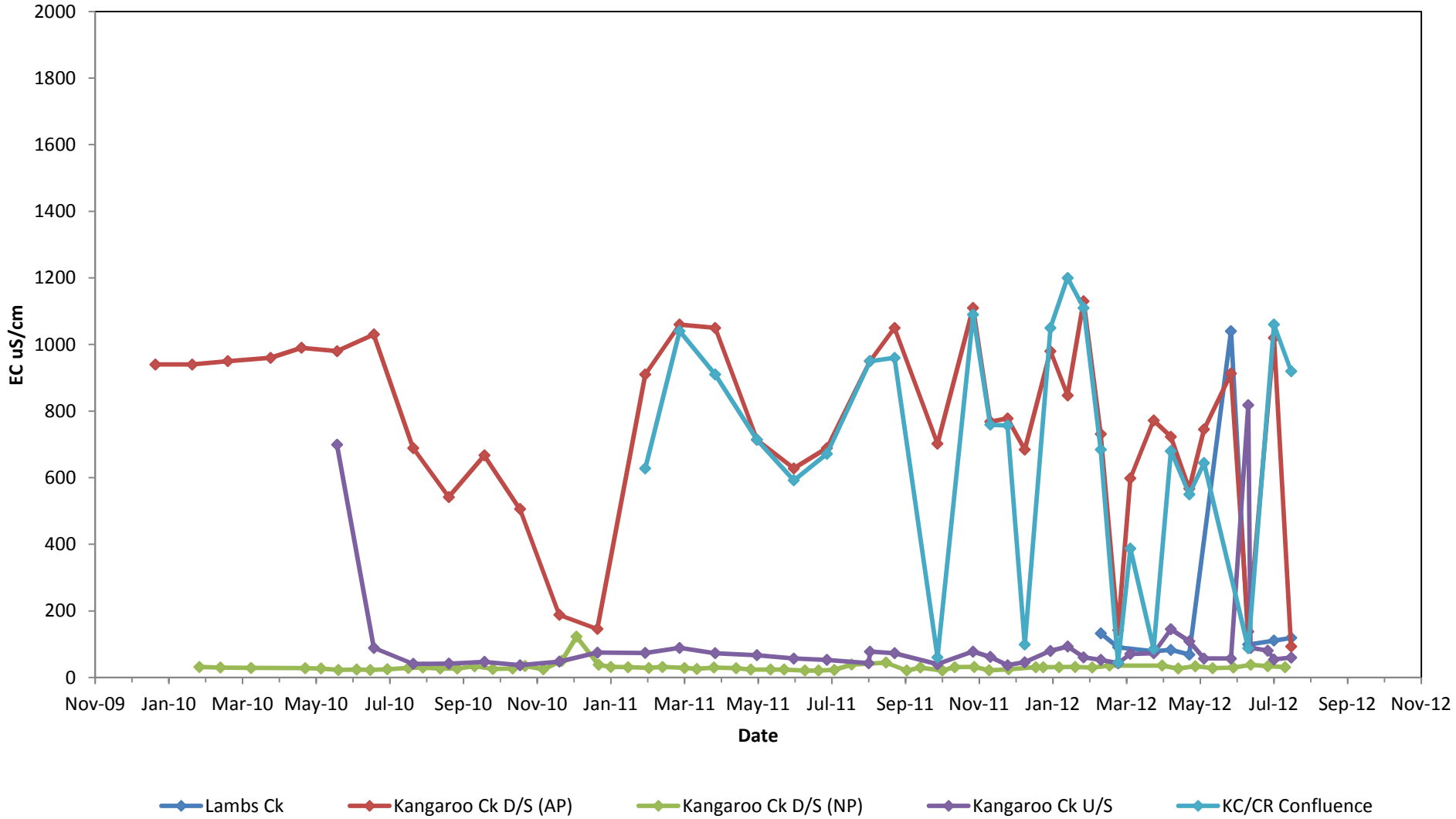
Rivers Salinity



RPS Aquaterra

App. C - Figure 2

Creeks Salinity



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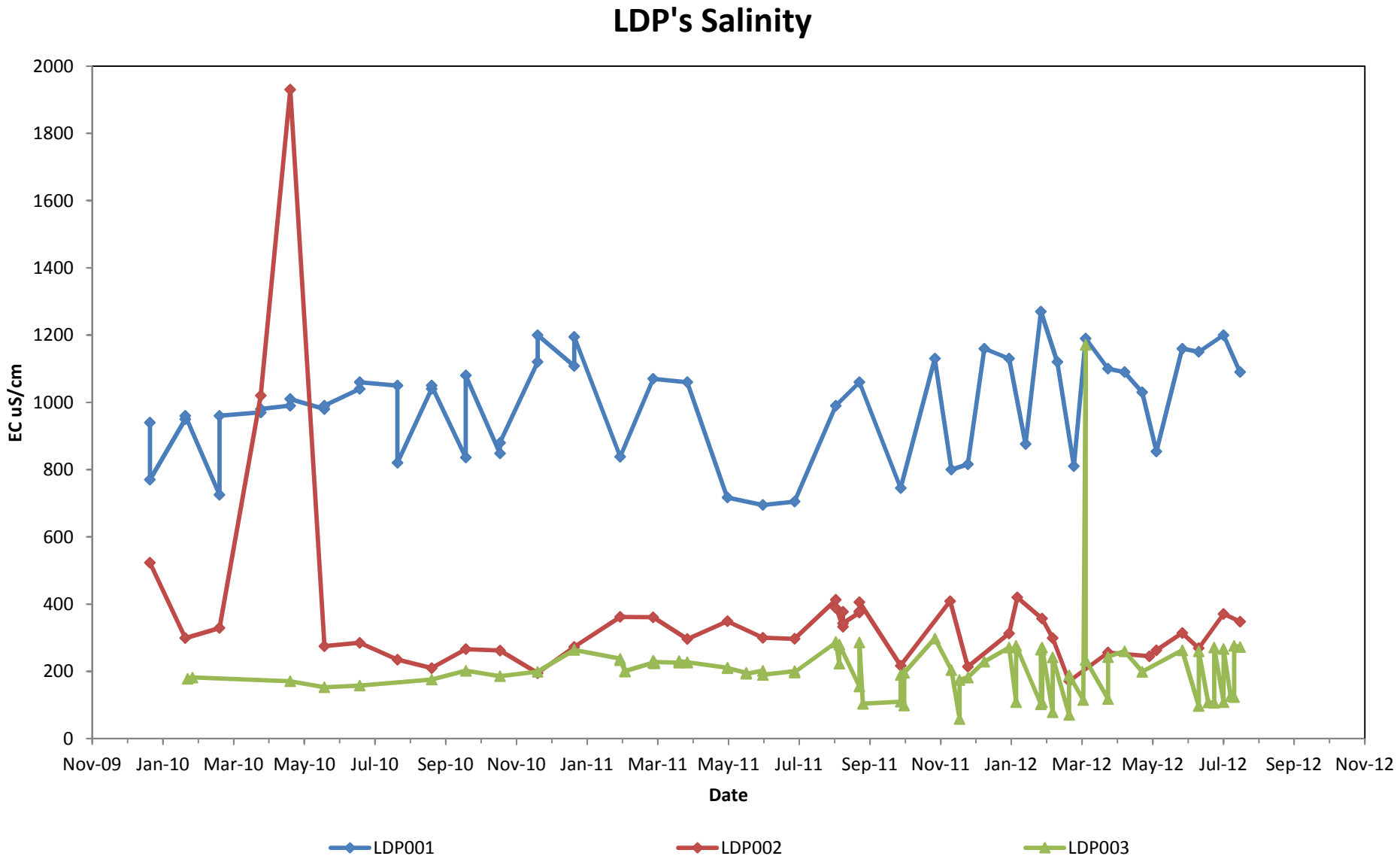
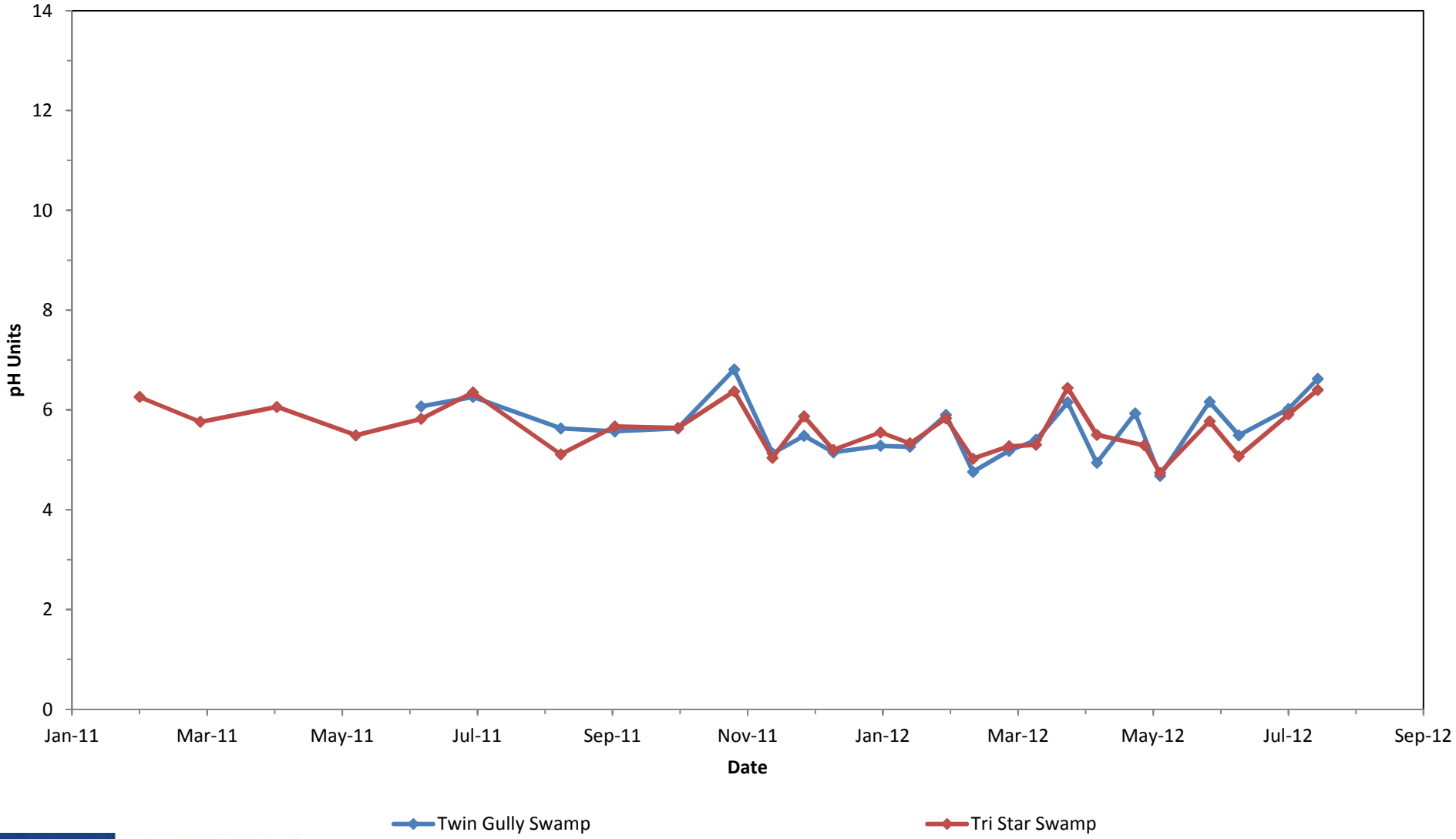
App. C - Figure 3



RPS Aquaterra

App. C - Figure 4

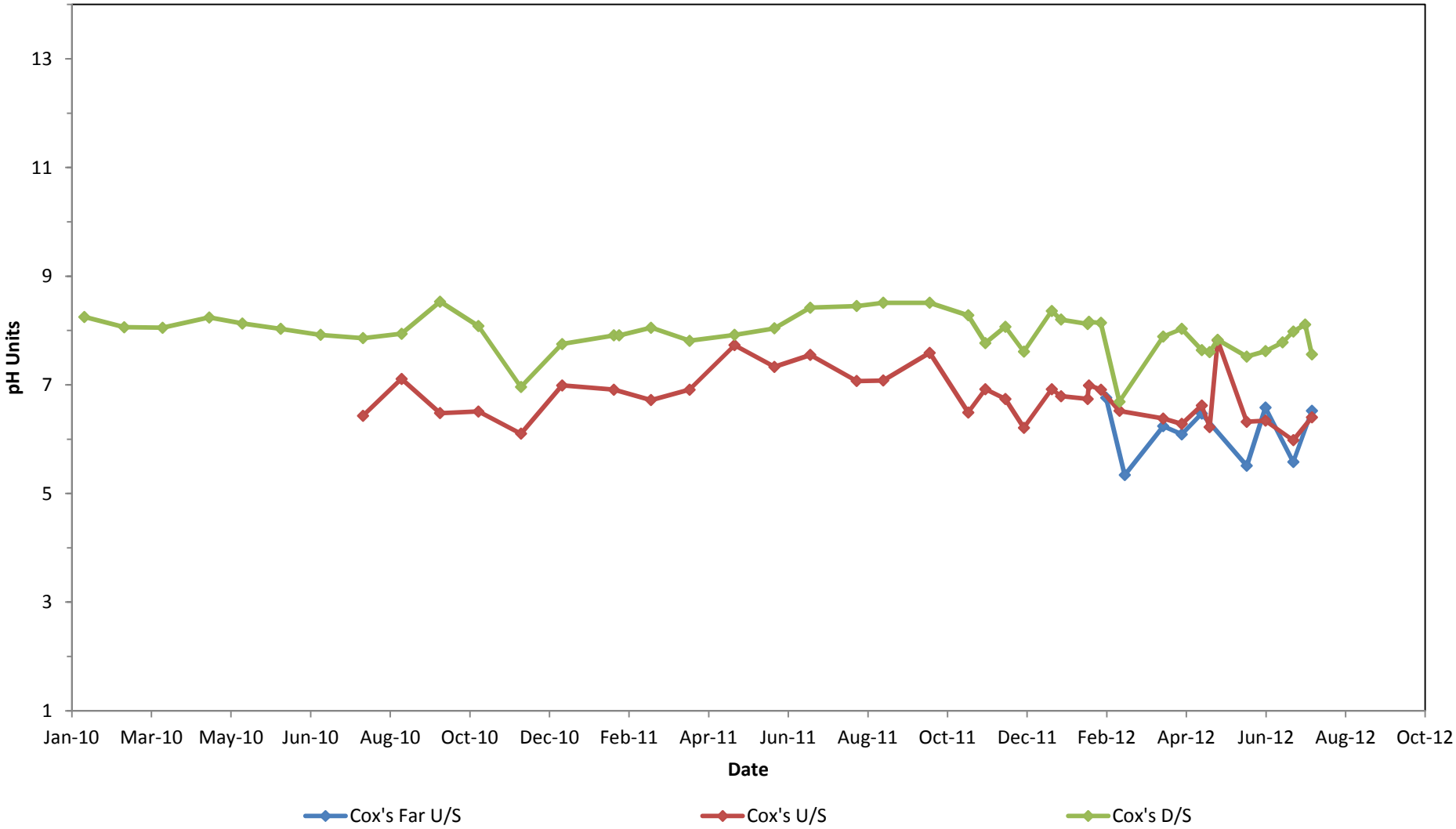
Swamps pH



RPS Aquaterra

App. C - Figure 5

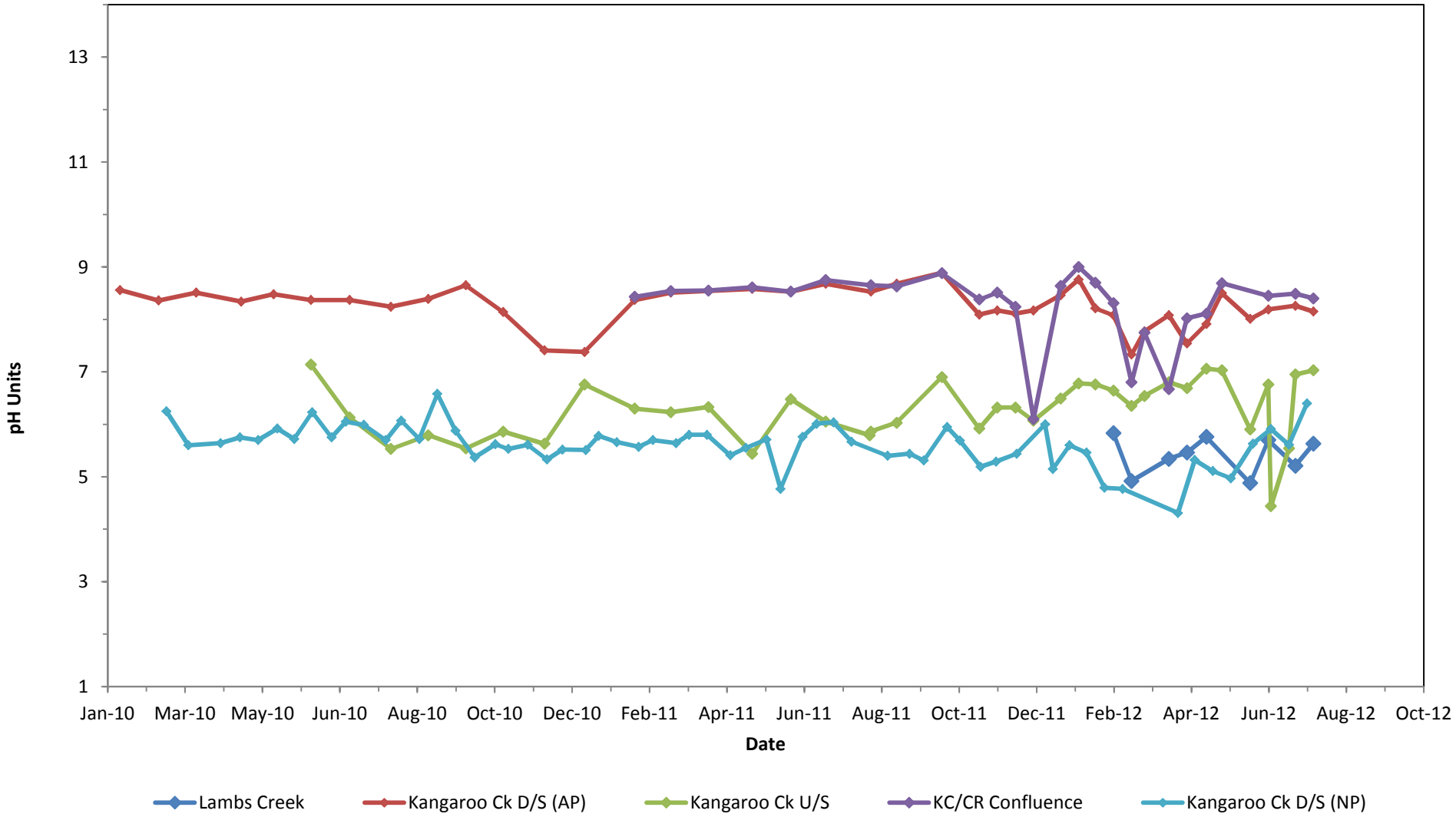
Rivers pH



RPS Aquaterra

App. C - Figure 6

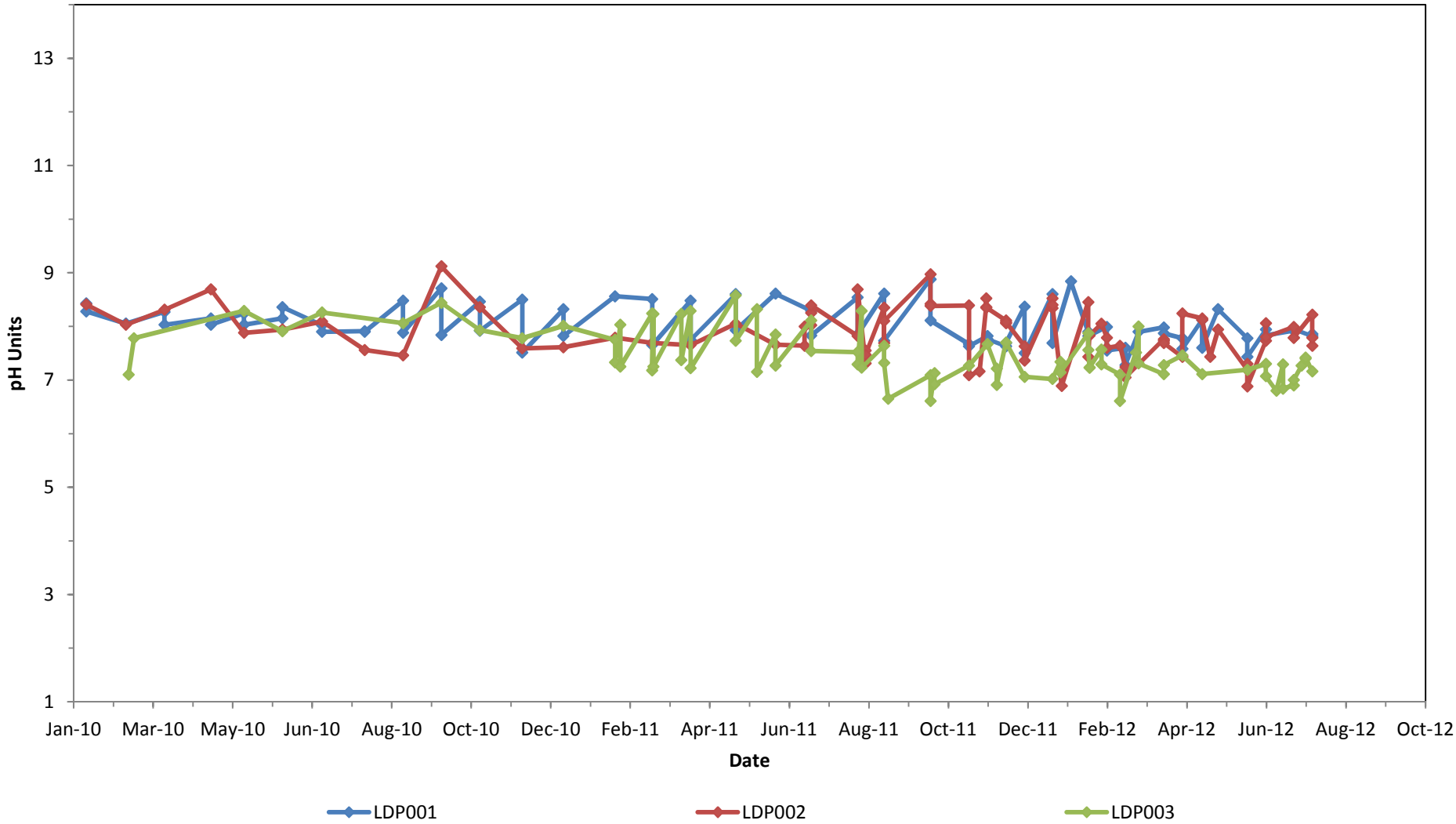
Creeks pH



RPS Aquaterra

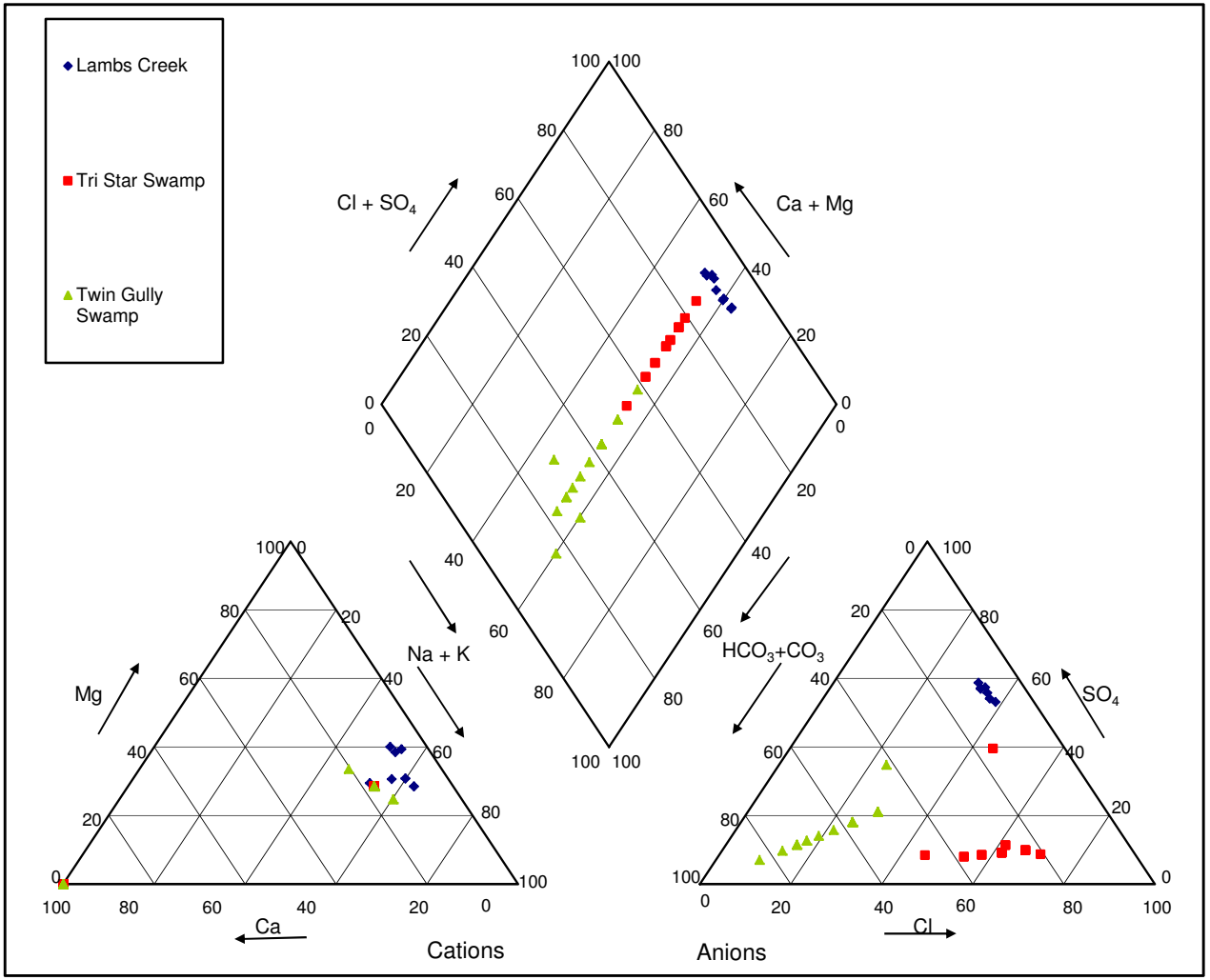
App. C - Figure 7

Licensed Discharge Points

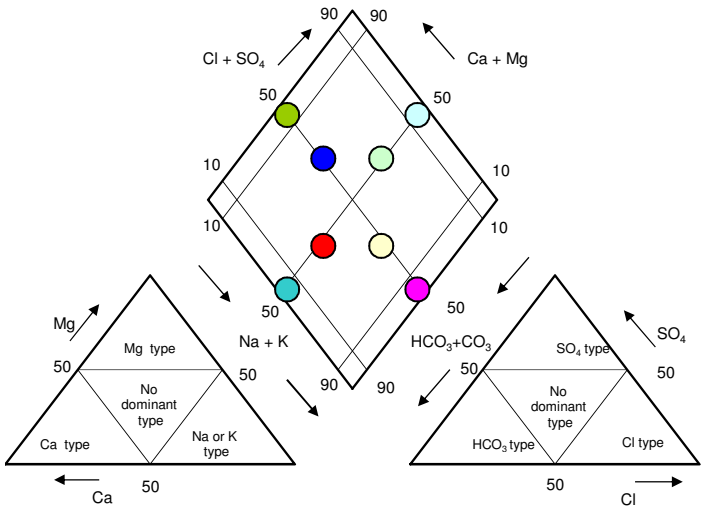


RPS Aquaterra

App. C - Figure 8



WATER TYPE CATEGORISATION



WATER TYPE SUB-FIELDS

- Ca + Mg, Na + K type
- Ca + Mg type
- HCO_3, Cl + SO_4 type
- HCO_3 + CO_3 type
- Na + K, Ca + Mg type
- Na + K type
- Cl + SO_4, HCO_3 type
- Cl + SO_4 type

RPS Aquaterra

Piper Diagram

App. C
Figure 9

Date: 18/02/13

F:\Jobs\S63\300\Water quality

Project: Springvale Colliery
Project No: S188C
Description: Surface Water Assessment
Client: Centennial Coal

HydroCHEM 2.0

APPENDIX D:
WATER BALANCE ASSESSMENT

Centennial Coal

GHD

Angus Place Mine Extension Project

Water and Salt Balance Assessment

Centennial Angus Place Pty Ltd

November 2013

Executive Summary

Angus Place Colliery is an underground coal mine owned and operated by Centennial Angus Place Pty Ltd. The Angus Place Colliery pit top, comprising the underground mine entry and surface facilities, are located approximately 15 km north-west of the City of Lithgow and is accessed via an entrance from Wolgan Road. Centennial Angus Place Pty Ltd proposes to continue its mining operations using longwall mining methods and to extend its mining area to the east of its existing operations. The proposed project, the Angus Place Mine Extension Project, will extend the mine life by up to 25 years.

A Water and Salt Balance Assessment has been developed for the Project to quantify the existing and proposed water and salt budgets such that the potential impacts of the Project may be assessed in accordance with the *Director General's Environmental Assessment Requirements* for the Project.

The water and salt balance was developed based on information provided by Angus Place Colliery regarding current operations and water management, as well as meteorological data and groundwater inflows predicted from hydrogeological modelling (CSIRO; 2013). The existing conditions were based on site conditions in the year 2013. The model developed for existing conditions was modified to represent the proposed conditions for the water cycle as a result of the Project. Amendments to the model to represent the proposed conditions were associated with the management of the expected increase in volume of mine water make due to extraction of the proposed workings. The reported results for the proposed conditions were based on predicted site conditions in 2030, when groundwater inflows into the underground workings are at their predicted peak.

Angus Place Colliery, along with Springvale Mine, transfers excess groundwater not used to meet operational requirements to the Springvale-Delta Water Transfer Scheme (SDWTS). Currently, the capacity of the SDWTS is 30 ML/day however this will be upgraded to 50 ML/day in the future. The assessment of the water management system included an evaluation of transfers occurring with the current SDWTS capacity compared with an upgraded SDWTS capacity.

For existing conditions in 2013, the largest source of water and salt were associated with groundwater inflows into the underground workings. On average, groundwater inflows account for approximately 97% (3,154 ML) of all water and 99% (1,690 tonnes) of all salt inflows into the Angus Place Colliery water management system, followed by direct rainfall and runoff to surface storages and potable water.

Water predicted to be transferred to the SDWTS represents on average 72% (2,355 ML) of all water and 74% (1,262 tonnes) of all salt outputs from the site under existing conditions. The second and third largest annual water and salt outputs from the system on average are predicted to be discharges through LDP001, representing 22% (732 ML) of water and 22% (384 tonnes) of salt, and discharges through LDP002, representing 3% (106 ML) of water and 3% (55 tonnes) of salt outflows from the Angus Place Colliery water management system.

The proposed conditions at Angus Place Colliery were based on site conditions in 2030, when mine water make into the underground workings is predicted to peak. Amendments to the model to represent the proposed conditions were associated with the management of the expected increase in volume of mine water make due to extraction of the proposed workings.

For proposed conditions in 2030, the largest source of water and salt will continue to be associated with groundwater inflows into the active underground workings. On average, modelled groundwater inflows account for approximately 99% (10,541 ML) of all water and 99% (5,650 tonnes) of all salt inflows into the Angus Place Colliery water management system, followed by direct rainfall and runoff to surface storages and potable water.

Water predicted to be transferred to the SDWTS represents on average 91% (9,742 ML) of all water and 92% (5,222 tonnes) of all salt outputs from the site under proposed conditions. Discharges through LDP001 and LDP002 are not expected to change as a result of the proposed Project in 2030.

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Table Index

Figure Index

Appendices

Glossary

48 Cut Through Dam	Underground storage dam located within the 48 Cut Through Area.
900 District	Underground storage area located underground 900 mining area.
930 Dam	Underground storage dam located within the 930 Cut Through.
940 Dewatering Bore	Existing dewatering bore within Longwall 940.
Baseflow	The component of streamflow that originates from groundwater.
Bore	A constructed connection between the surface and a source of underground water that enables the underground water to be transferred to the surface either naturally or through artificial means.
Catchment	The land area draining through the main stream and tributary streams to a particular location.
Clean catchment areas	Catchments in which there are no exposed or disturbed surfaces containing coal or mined carbonaceous material.
Clean water	Water on the premises that has not come into physical contact with coal, mined carbonaceous material or disturbed surface areas.
Coal Handling Plant	A facility where coal is screened and prepared for transport off-site.
Cut Through	Underground mine access ways between the development headings. They occur at regular intervals along the development headings.
Depression storage	The volume of water that is contained in natural depressions in the land surface.
Dewatering	Transfer of water from the underground mine workings to the surface or other underground areas.
Dirty catchment areas	Catchments in which coal or mined carbonaceous materials are present or areas where the topsoil has been disturbed.
Dirty water	Water on the premises that has come into physical contact with coal, mined carbonaceous materials or otherwise contains elevated sediment load.
Discharge	Quantity of water per unit of time flowing in a stream, for example cubic meters per second or megalitres per day.
Electrical conductivity	A measure of concentration of dissolved salts in water.
Ephemeral	Stream that is usually dry, but may contain water for rare and irregular periods, usually after significant rain.
Evapotranspiration	The loss of water from soil by evaporation and from plant surfaces by transpiration.
Groundwater	Water in a saturated zone, stratum or aquifer beneath the surface of the land.
Infiltration	Natural flow of surface water through ground surfaces as a result of rainfall events.
Licensed discharge point	A location where Angus Place Colliery discharges water in accordance with conditions stipulated within the site Environment Protection Licence issued under the NSW *Protection of the Environment Operations Act 1997*.

Lithgow seam	Deepest coal horizon of the Permian Age Illawarra Coal Measures, with an average depth of 380 m.
Longwall	Longwall mining is a form of underground coal mining where a block of coal is mined using a longwall shearer. The longwall mining method is supported by roadway development, mined using a continuous miner unit.
Oil/Water Separator	Device designed to separate oil and suspended solids from water.
Pan factor	Reduction factor applied to measured pan evaporation to simulate evaporation from natural water bodies and surface water storages.
Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
Potable water	Water of a quality suitable for drinking.
Recharge	Inflow of water from surrounding strata into underground workings through infiltration. This can be as a result of rainfall events or from surrounding aquifers.
Run of mine coal	Raw or unprocessed coal.
SILO	An enhanced climate data bank based on historical climate data from 1889 provided by the Bureau of Meteorology. Records are mainly based on observed data, with interpolation where there are data gaps.
Springvale Coal Services Site	Site currently used for stockpiling and processing of run of mine coal from Springvale Mine but proposed to be upgraded, as part of the Centennial Western Coal Services Project, to increase coal throughput at the site and to provide the coal handling logistics predominantly for both Angus Place Colliery and Springvale Mine.
Springvale-Delta Water Transfer Scheme	Subterranean pipeline network which transfers extracted groundwater using boreholes from Angus Place Colliery and Springvale Mine to Wallerawang Power Station for consumption at the cooling towers or discharge into Coxs River.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.

Abbreviations

APE Bores	Angus Place East Dewatering Bores
AWBM	Australian Water Balance Model
BOM	Bureau of Meteorology
BS	Baseflow storage
Centennial	Centennial Coal Company Limited
Centennial Angus Place	Centennial Angus Place Pty Ltd
CHP	Coal Handling Plant
EC	Electrical conductivity
EPL	Environment Protection Licence
GHD	GHD Pty Ltd
kL	Kilolitres
kL/day	Kilolitres per day
km	Kilometres
L/s	Litres per second
LDP	Licensed Discharge Point
m	Metres
ML	Megalitres, equivalent to 10^6 litres
ML/day	Megalitres per day
ML/yr	Megalitres per year
mm	Millimetres
Mtpa	Million tonnes per annum
ROM	Run of Mine
SDWTS	Springvale-Delta Water Transfer Scheme
SS	Surface storage
SSD	State Significant Development
t/day	Tonnes per day
t/yr	Tonnes per year
µS/cm	Microsiemens per centimetre

1. Introduction

Angus Place Colliery is an underground coal mine owned and operated by Centennial Angus Place Pty Ltd (Centennial Angus Place), a wholly owned subsidiary of Centennial Coal Company Limited (Centennial). The mine entry and surface facilities are located approximately 15 km north-west of the City of Lithgow as shown on Figure 1-1 and are accessed via an entrance from Wolgan Road.

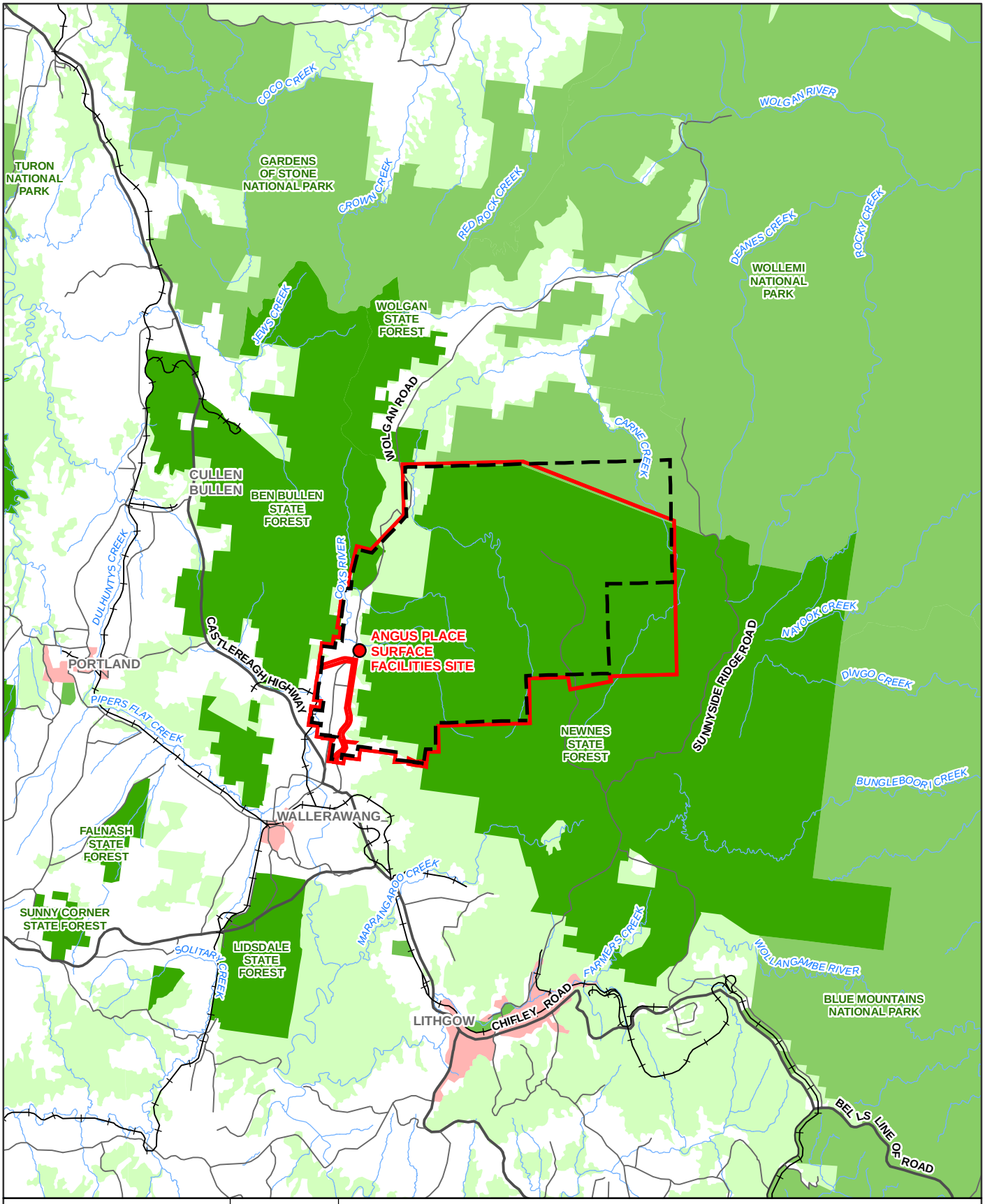
Centennial Angus Place is seeking approval for the Angus Place Mine Extension Project (the Project) based on resource modelling within the Angus Place Colliery Holding Boundary. This involves a continuation of current mining practices through longwall extraction methods which would extend the mine life by up to 25 years. The Project will continue to use existing surface and underground facilities at Angus Place Colliery. New facilities and modifications to existing facilities are required to support the Project. The proposed new facilities will assist with the provision of appropriate underground mine ventilation as well as mine dewatering and ancillary support such as power.

The Project is a State Significant Development (SSD 5602) in accordance with Clause 8 and Schedule 1 (Item 5) of *State Environmental Planning Policy (State and Regional Development) 2011*. As such, Centennial Angus Place is seeking approval under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979*.

1.1 Project Overview and Description

Centennial Angus Place proposes to extend its mining operations using longwall mining methods. The Project will:

- Continue to extract up to 4 million tonnes per annum (Mtpa) of run of mine (ROM) coal from the Lithgow Seam underlying the Project Application Area.
- Develop underground access headings and roadways from the current mining area to the east to allow access to the proposed mining area.
- Undertake secondary extraction by retreat longwall mining for the proposed longwall panels LW1001 to LW1019.
- Continue to use the existing ancillary surface facilities at the Angus Place Colliery pit top.
- Continue to manage the handling of ROM coal through a crusher and screening plant at the Angus Place Colliery pit top and the subsequent loading of the coal onto the existing road haulage trucks for despatch to off-site locations.
- Continue to operate and maintain the existing ancillary surface infrastructure for ventilation, electricity, water, materials supply and communications at the Angus Place Colliery pit top and on Newnes Plateau.
- Install and operate seven additional dewatering borehole facilities on Newnes Plateau and the associated power and pipeline infrastructure.
- Upgrade and extend the existing access tracks from Sunnyside Ridge Road to the dewatering borehole facilities.
- Install and operate water transfer boreholes and pipeline infrastructure at the existing Ventilation Facility site (APC-VS2).
- Construct and operate a downcast ventilation shaft (APC-VS3) and upgrade the existing access track to the proposed facility from Sunnyside Ridge Road.



1:200,000 for A4

0 1 2 4 6

Kilometers

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Angus Place Holding Boundary
- Project Application Area
- Waterway
- Existing Rail
- Principal Road
- Secondary Road
- Minor Road
- Built Up Area
- Nature Conservation
- State Forest
- Forest Or Shrub

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	R.Towner
CHECKED	T. Davies
APPROVED	S. Callander
SCALE	refer to scalebar

Angus Place Mine Extension Project
Water and Salt Balance Assessment

Locality Plan

Centennial Angus Place

DATE 9/10/2013

Figure 1-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2216599\Water Balance Assessment\2216599_AP_WSBA_001_LocalityPlan_B.mxd

- Manage mine inflows using a combination of direct water transfer to the Wallerawang Power Station, via the Springvale-Delta Water Transfer Scheme (SDWTS) and discharge through Angus Place Colliery's licensed discharge point LDP001 and Springvale Mine's LDP009.
- Continue to undertake existing and initiate new environmental monitoring programs.
- Continue to operate 24 hours per day, seven days per week.
- Continue to provide employment to a full time workforce of up to 225 persons and 75 contractors.
- Progressively rehabilitate disturbed areas at infrastructure sites no longer required for mining operations.
- Undertake life-of-mine rehabilitation at the Angus Place Colliery pit top and the Newnes Plateau infrastructure disturbance areas to create final landforms commensurate with the surrounding areas and the relevant zonings of the respective areas.
- Transfer the operational management of coal processing and distribution infrastructure to the proposed Centennial Western Coal Services Project.

1.2 Study Area

The Study Area for this Water and Salt Balance Assessment encompasses the Project Application Area identified on Figure 1-1. The assessment has given consideration to the overall water management system associated with Angus Place Colliery and includes water transfers associated with:

- Existing mining activities.
- Proposed mining activities.
- Surface operations.

1.3 Report Objectives and Scope

The Water and Salt Balance Assessment has been developed to:

- Quantify the water and salt budget in relation to the surface water, process water usage and groundwater management systems for existing operations.
- Provide an assessment of the changes to water transfers, water discharges, the frequency of discharges and wastewater volumes that may occur as a result of the proposed future operations.
- Document the most likely (average annual values) of the water and salt transfers within the Angus Place Colliery operations.
- Document the variability of the likely (annual values) of the water and salt transfers within the Angus Place Colliery operations.

The objective of the Water and Salt Balance Assessment is to address the water resources components of the *Director General's Environmental Assessment Requirements* for the Project as listed in Table 1-1. This requires a detailed assessment of the potential impacts of the Project on the water and salt balance of the site. The water and salt budget of the SDWTS is also considered in the Water and Salt Balance Assessment, including transfers from Springvale Mine into the SDWTS.

Table 1-1 Director General's Requirements

Director General's Requirements	Where Addressed in this Report
A detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply and transfer infrastructure and water storage structures.	Sections 2, 3, 4 and 5.

The scope of work for the Water and Salt Balance Assessment included:

- Review and collation of data relating to Angus Place Colliery.
- Establish an understanding of the water management system at the site.
- Develop a GoldSim water and salt balance model for the site that could assess conditions under various rainfall patterns. The model was developed initially to represent the existing conditions and appropriately modified to represent conditions upon implementation of the Project.
- Compare the existing and proposed water and salt balances of Angus Place Colliery with consideration of implications of the Project.

1.4 Related Projects

Springvale Mine is an underground coal mine located approximately 6 km south of Angus Place Colliery. Springvale Mine is seeking approval to extend its mining operations using longwall mining methods and extract up to 4.5 Mtpa of ROM coal as part of the Springvale Mine Extension Project (Golder Associates; 2013). Groundwater inflows into the underground workings at both Springvale Mine and Angus Place Colliery are transferred to the SDWTS, which is a subterranean pipeline network providing water to Wallerawang Power Station. Mine water from Springvale Mine is taken as priority, with the remaining capacity supplied by mine water from Angus Place Colliery. Section 2.2.2 provides more detail about the operation of the SDWTS.

Springvale Coal Services is a coal processing facility located approximately 5 km west of Angus Place Colliery. The facility currently receives coal from Springvale Mine and provides coal storage, handling and processing functions. As part of the Western Coal Services Project, it is proposed to upgrade the facility and to provide operational management of coal processing and distribution infrastructure primarily for Angus Place Colliery and Springvale Mine. The project will separate the transport and logistics function from the source mines.

1.5 Overview of Site Operations

1.5.1 Existing Operations

Angus Place Colliery commenced longwall operations in 1979, after being developed as an extension of the Newcom Mine bord and pillar operations at Kerosene Vale. Currently, Angus Place Colliery has approval to extract 4 Mtpa of ROM coal from the Lithgow Seam using longwall mining methods. The ROM coal production in 2012 totalled 3.7 Mtpa, with coal distributed to Mount Piper and Wallerawang Power Stations.

Water management at Angus Place Colliery involves the separation of clean and dirty water and the treatment of dirty water prior to discharge through licensed discharge points (LDPs). Groundwater is pumped from the underground workings to the surface for transfer to Wallerawang Power Station using the SDWTS or discharge through LDP001.

Relevant surface site features and associated operations at Angus Place Colliery are provided on Figure 1-2. The main site features at Angus Place Colliery include:

- Administration building and portable offices on the pit top site.
- Coal processing at the Coal Handling Plant (CHP).
- Coal stockpile area.
- Visitor and employee car parking areas.
- Various workshops, service buildings and material storage sheds.
- Personnel and materials drift for access to the underground workings.
- Coal conveyor drift and coal conveyor drive to transport coal from the underground workings to the surface.
- Mine dewatering infrastructure.
- Water management facilities including various surface storages and both clean and dirty water diversion drains.
- Licensed discharge points.
- Sewage processing through the on-site treatment system and maturation pond.
- Ventilation system providing air to the underground mine workings located at the pit top.
- Power supply infrastructure.

1.5.2 Future Operations

The Project involves the continuation of mining operations using longwall mining methods and the extension of the mining area to the east of the current workings. Centennial Angus Place is seeking approval to continue extracting coal at a rate of up to 4 Mtpa. The Project is expected to commence in 2016 and extend the mine life by up to 25 years

Although the Project will continue to use existing surface and underground facilities at Angus Place Colliery, new facilities and modifications to existing facilities are required to support the Project. The proposed new facilities will assist in providing adequate underground mine ventilation in accordance with Clause 13(h) of the *Coal Mine and Safety Regulation 2006* as well as mine dewatering and ancillary support such as power.

The extraction of coal is predicted to increase the rate of mine water make into the underground workings. Modifications to the water management system at Angus Place Colliery are limited to the management of increased groundwater inflows. The existing and proposed water management systems at Angus Place Colliery are described in further detail in Section 2.

1.5.3 Environment Protection Licence

Environment Protection Licences (EPLs) are issued by the NSW Environment Protection Authority under the *Protection of the Environment Operations Act 1997*. Licence conditions relate to pollution prevention and monitoring and can control the air, noise, water and waste impacts of an activity. Angus Place Colliery's EPL 467 includes both volumetric and concentration limits for the discharge of water off-site.

Angus Place Colliery's LDPs are indicated on Figure 1-3 and include:

- LDP001 – Discharge of mine water make and runoff into Kangaroo Creek through wetlands.

- LDP002 – Discharge of surface water from the Angus Place Colliery surface facilities into the Coxs River through settling ponds.
- LDP003 – Located at the Kerosene Vale site (not considered in this assessment).
- LDP005 – Discharge of treated sewage effluent from Angus Place Colliery via a spray irrigation network to a designated irrigation utilisation area.

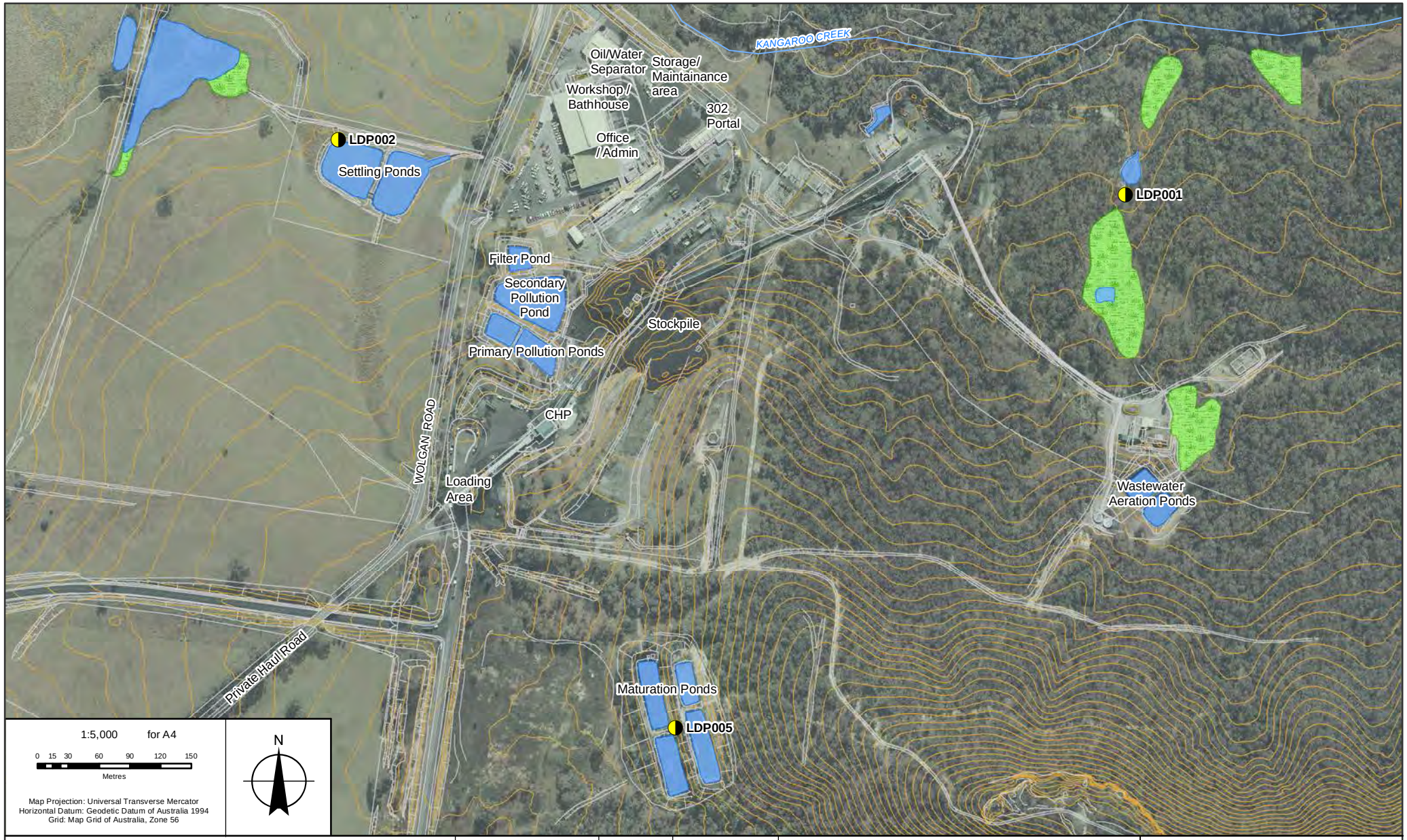
LDP003 at the Kerosene Vale site is not considered in this assessment as Centennial are currently revising this area to be managed by the proposed Centennial Western Coal Services Project.

1.6 Site Hydrology

The Project Application Area lies on the border of the Coxs River catchment and the Wolgan River catchment. Both catchments are part of the Greater Hawkesbury/Nepean catchment, which ultimately contributes to the Hawkesbury River and Broken Bay.

The pit top area is located within the Coxs River catchment, which flows in a southerly direction. The 940 Dewatering Bore site located on the Newnes Plateau is located within the Wolgan River catchment. The underground workings are located below both the Coxs River catchment and the Wolgan River catchment. LDP001, LDP002, LDP003 and LDP005 are all located within the Coxs River catchment.

Angus Place Colliery does not extract water from any natural watercourse, however does discharge both mine water and runoff into Kangaroo Creek and the Coxs River through LDP001 and LDP002 at the pit top.



LEGEND

- Pollution Control Structure
- Pollution Control Wetland
- Licenced Discharge Point
- Infrastructure
- Waterway
- Contour

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	R.Towner
CHECKED	T. Davies
APPROVED	S. Callander
SCALE	refer to scalebar

Angus Place Mine Extension Project
Water and Salt Balance Assessment

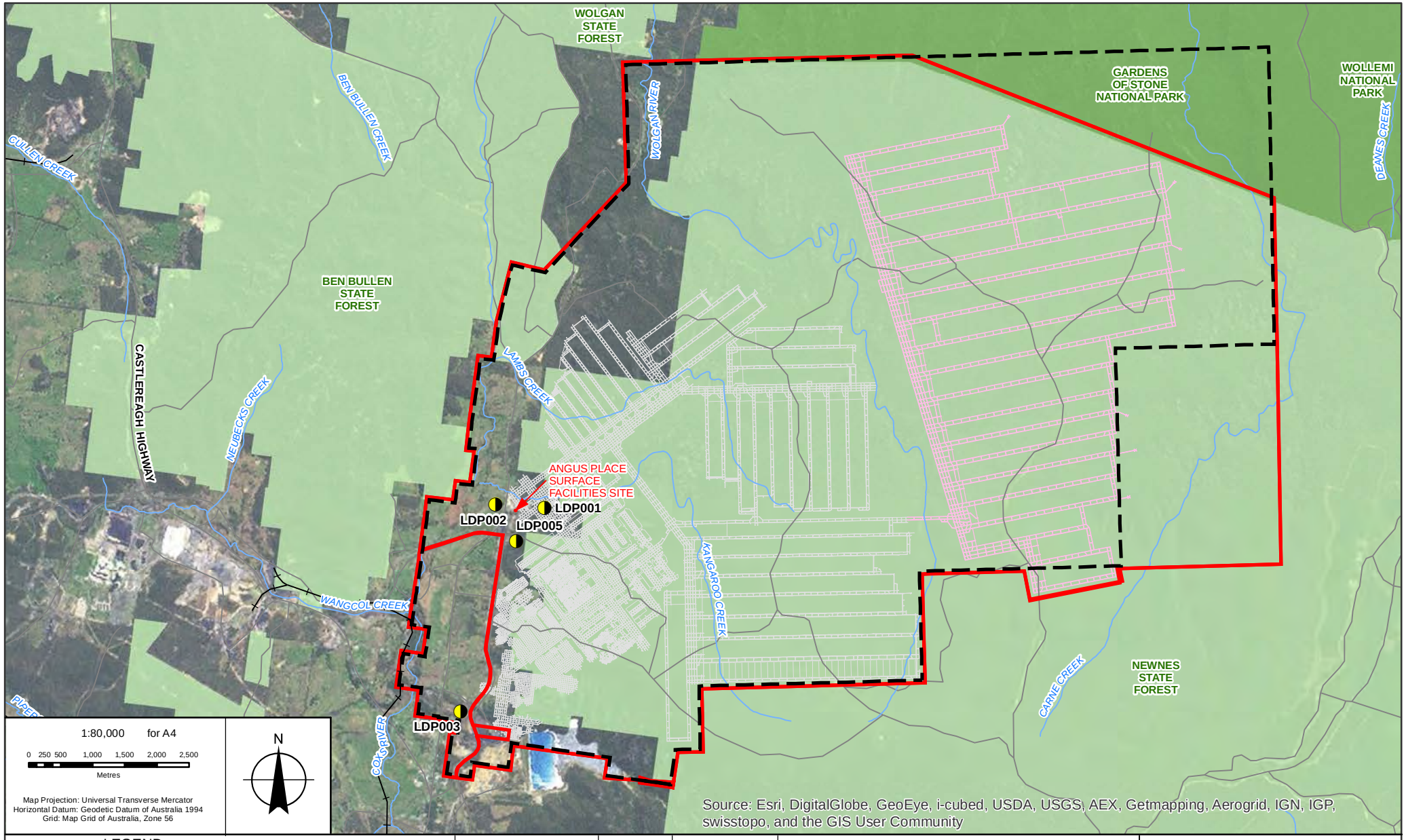
Location of Site Features

Centennial Angus Place

DATE 8/10/2013

Figure 1-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2216599\Water Balance Assessment\2216599_AP_WSBA_002_SiteFeatures_B.mxd



LEGEND

- Licenced Discharge Point
- Surface Facilities Area
- Project Application Area
- Angus Place Holding Boundary
- Existing/Approved Workings
- Proposed Workings
- Waterway
- Road
- Existing Rail
- Nature Conservation
- State Forest

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	R.Towner
CHECKED	T. Davies
APPROVED	S. Callander
SCALE	refer to scalebar

Angus Place Mine Extension Project
Water and Salt Balance Assessment

Licensed Discharge Point Locations

Centennial Angus Place

DATE 10/10/2013

Figure 1-3

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2216599\Water Balance Assessment\2216599_AP_WSBA_003_LicencedDischargePoints_B.mxd

2. Water Management

The water management system at Angus Place Colliery is comprised of surface, potable, waste and underground elements. The primary objective of water management at Angus Place Colliery is the separation of clean and dirty water and the effective management of water through collection, treatment and discharge.

2.1 Existing Operations

A schematic of the overall water management system at Angus Place Colliery is provided in Figure 2-1. The water cycle at the mine is represented in Figure 2-2 and Figure 2-3.

2.1.1 Surface Water System

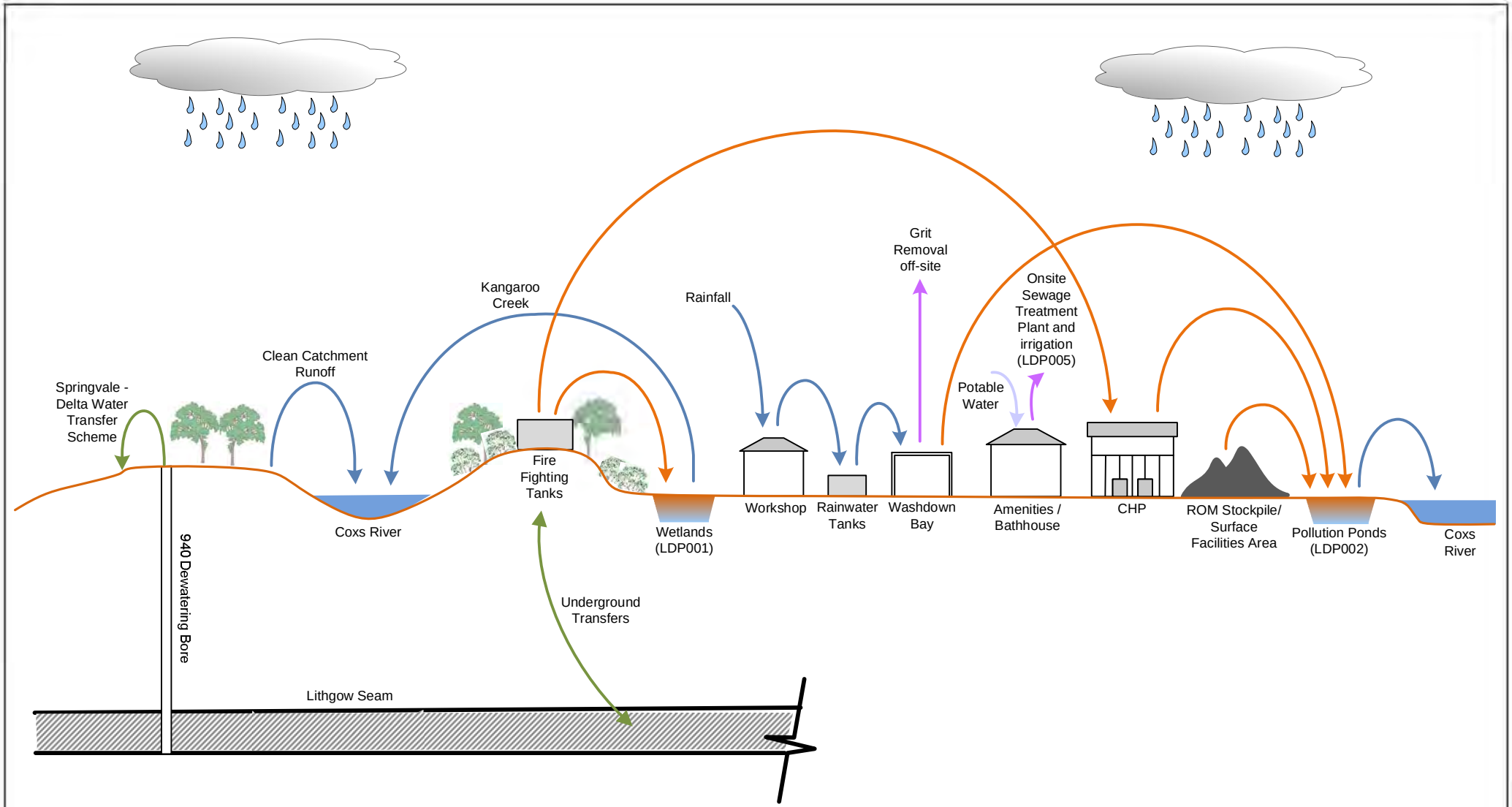
The surface water system consists of runoff contributing to surface water storages at Angus Place Colliery. The surface water storages present are the Primary, Secondary and Filter Ponds (Pollution Ponds), Settling Ponds and the LDP001 Wetlands. The primary functions of the surface water system are as pollution control structures and to store water harvested from the site. Figure 2-4 shows the catchments contributing to the Angus Place Colliery pit top. The clean and dirty water diversions in place at the pit top are provided on Figure 2-5 and Figure 2-6.

The inputs to the surface water system under existing conditions consist of:

- Direct rainfall onto storages.
- Runoff from the contributing catchment as a result of rainfall.
- Transfer of groundwater from the underground workings to the Fire Fighting Tanks at the pit top and the 940 Dewatering Bore for transfer to the SDWTS.
- Harvesting of water from the workshop roof into the Rainwater Tanks.
- Moisture of ROM coal transported to the surface from underground.

The outputs from the surface water system under existing conditions consist of:

- Evaporation from water storages.
- Discharges through LDP001 from the Fire Fighting Tanks and clean catchment runoff into Kangaroo Creek.
- Discharges through LDP002 from the Settling Ponds into the Coxs River.
- Removal of water off-site from the Grit Trap by a contractor.
- Transfer of water to the underground water system for mining processes.
- Evaporation of in situ coal moisture in the coal stockpiles.



Dirty Water
Clean Water
Underground Water
Potable Water
Waste Water

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Angus Place Mine Extension Project
Water and Salt Balance Assessment

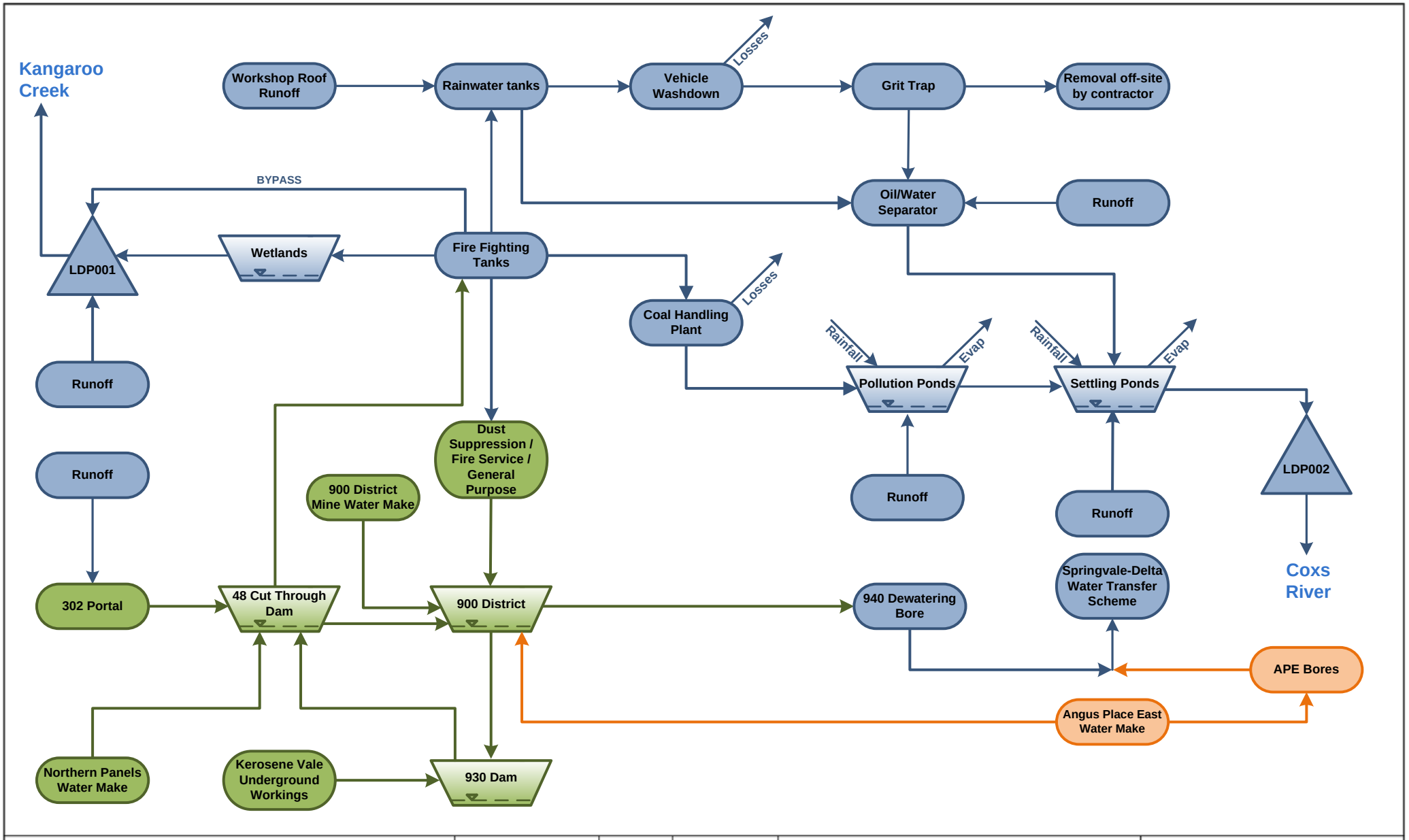
Overall Water Management Schematic

Centennial Angus Place

DATE October 2013

Figure 2-1

G:\22\16599\Visio\2216599_AP_FIG2-1_Angus Overall Water Management Schematic.vsd



LOCATION	Angus Place
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Angus Place Mine Extension Project
Water and Salt Balance Assessment

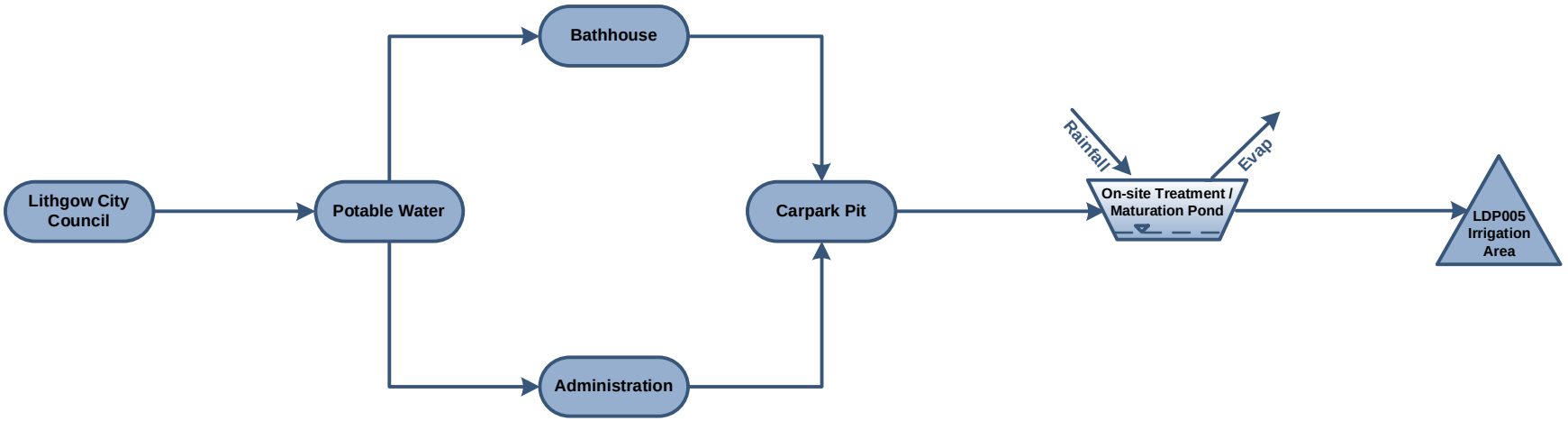
Water Cycle Schematic
Existing and Proposed Conditions

Centennial Coal

DATE Oct 2013

Figure 2-2

G:\22\16599\Visio\2216599_AP_FIG2-2_Angus Place_Existing_Proposed Water_Schematic.vsd



Surface Water Transfers

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Angus Place Mine Extension Project
Water and Salt Balance Assessment

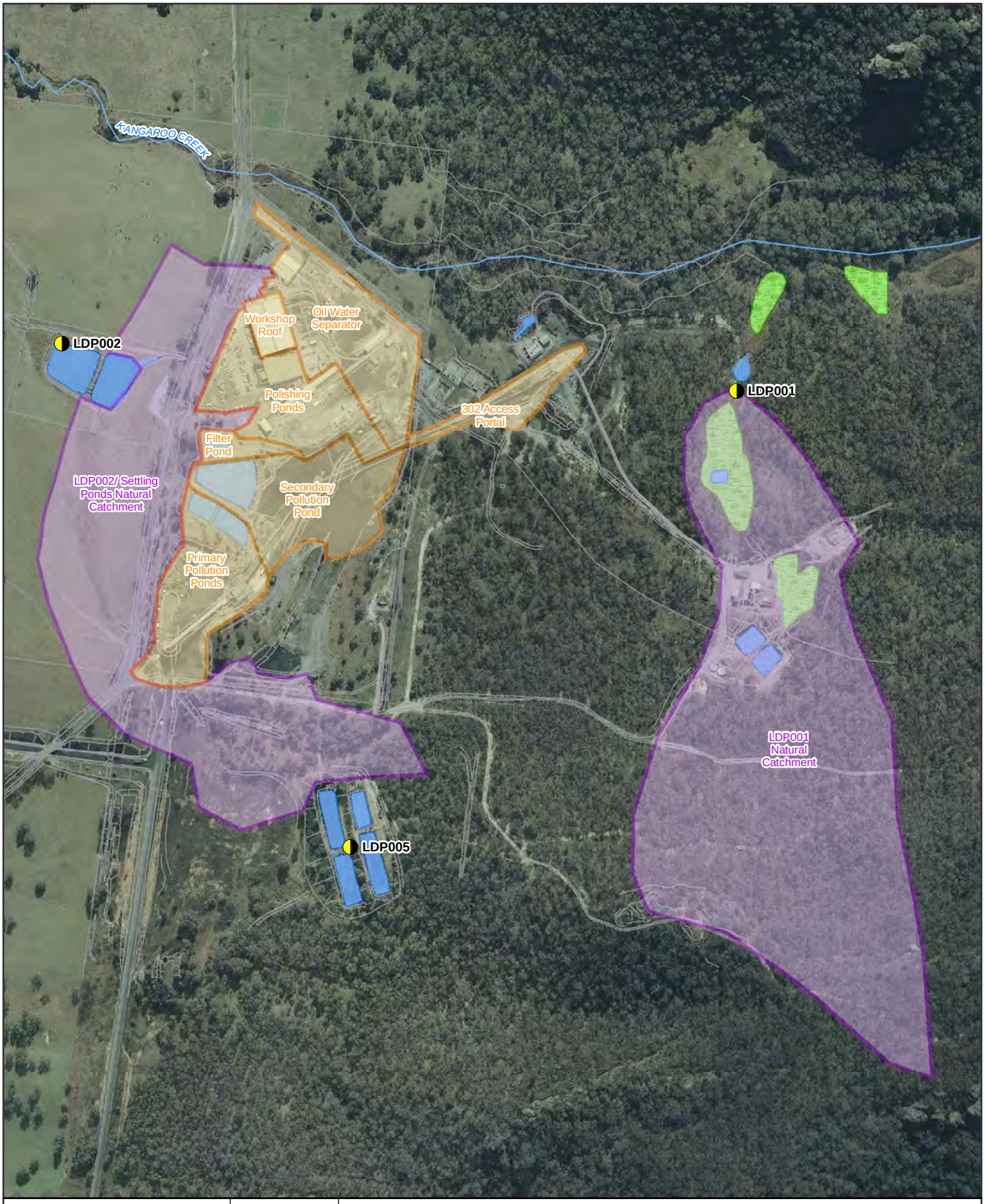
Potable Water Cycle Schematic
Existing and Proposed Conditions

Centennial Angus Place

DATE October 2013

Figure 2-3

G:\22\16599\Visio\2216599_AP_FIG2-4_Angus Potable Water Cycle Schematic Existing and Proposed.vsd



1:6,000 for A4

0 30 60 120 180

Meters

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Licensed Discharge Point
- Site Catchment
- LDP Natural Catchment
- Pollution Control Structure
- Pollution Control Wetland
- Infrastructure
- Waterway

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	R.Towner
CHECKED	T. Davies
APPROVED	S. Callander
SCALE	refer to scalebar

Angus Place Mine Extension Project
Water and Salt Balance Assessment

Pit Top Area Catchments

Centennial Angus Place

DATE 8/10/2013

Figure 2-4

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2216599\Water Balance Assessment\2216599_AP_WSBA_004_SurfaceFacilitiesSiteCatchments_B.mxd

LEGEND

- Clean Water Surface Diversion
- Clean Water Pipe Diversion
- Pollution Control Wetland
- Pollution Control Structure
- Infrastructure
- Waterway
- Licensed Discharge Point

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	R.Towner
CHECKED	T. Davies
APPROVED	S. Callander
SCALE	refer to scalebar

Angus Place Mine Extension Project
Water and Salt Balance Assessment

Pit Top Area
Clean Water Diversions

Centennial Angus Place

DATE 8/10/2013

Figure 2-5

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2216599\Water Balance Assessment\2216599_AP_WSBA_005_CleanWaterDiversions_B.mxd

1:4,000 for A4

0 15 30 60 90 120

Metres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Dirty Water Diversions
- Pollution Control Wetland
- Pollution Control Structure
- Infrastructure
- Waterway
- Licensed Discharge Point

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	R.Towner
CHECKED	T. Davies
APPROVED	S. Callander
SCALE	refer to scalebar

Angus Place Mine Extension Project
Water and Salt Balance Assessment

Pit Top Area
Dirty Water Diversions

Centennial Angus Place

DATE 8/10/2013

Figure 2-6

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Angus Place\2216599\Water Balance Assessment\2216599_AP_WSBA_006_DirtyWaterDiversions_B.mxd

2.1.2 Potable and Wastewater Systems

The potable and wastewater systems are a component of the surface water system at Angus Place Colliery.

The inputs to the potable and wastewater system under existing conditions consist of potable water provided to the administration and bathhouse buildings from Lithgow City Council.

The outputs from the potable and wastewater systems consist of grey water and sewage from the administration and bathhouse buildings directed to the Maturation Ponds before disposal via spray irrigation through LDP005.

2.1.3 Underground Water System

Mining at Angus Place Colliery intersects the Lithgow Seam. Groundwater inflows into the underground workings are primarily extracted by the 940 Dewatering Bore, located on the Newnes Plateau. This water is extracted using submersible pumps from the low point in the mine to the surface where it is transferred into the SDWTS. Some water is also extracted from the underground workings through the in-seam water management system. It is then directed to the groundwater collection system at the Surface Facilities Site, where it is transferred to the Fire Fighting Tanks for use in mining associated activities as process water. Any excess mine water that is not transferred to the SDWTS or used as process water is discharged through LDP001 via the Fire Fighting Tanks.

The inputs to the underground water system under existing conditions consist of:

- Natural recharge of the active underground workings.
- Natural recharge of the old underground workings.
- Runoff from the contributing catchment into the 302 Access Portal.
- Transfer of water from the Fire Fighting Tanks to the underground workings.
- In situ moisture in the extracted coal.

The outputs from the underground water system under existing conditions consist of:

- Extraction of water from the 940 Dewatering Bore transferred to the SDWTS.
- Transfer from the underground workings (48 Cut Through Dam) to the Fire Fighting Tanks.
- Moisture of the ROM coal transported to the surface from underground.
- Unrecoverable water used for dust suppression and other mining related activities.

2.2 Future Operations

Modifications to the water management system associated with the proposed Project are generally limited to management of mine water make from the proposed Angus Place East workings.

No modifications will be made to the existing surface water system or potable and wastewater systems.

2.2.1 Groundwater Inflows

The predicted increase in groundwater make will be discharged into the SDWTS via the 940 Dewatering Bore and the Angus Place East Dewatering Bores (APE Bores). Any excess mine water will be discharged through LDP001 via the Fire Fighting Tanks into Kangaroo Creek. Process water for underground operations will continue to be sourced from the underground using the in-seam water management system and stored in the Fire Fighting Tanks prior to use.

2.2.2 Springvale-Delta Water Transfer Scheme

The SDWTS receives excess water (groundwater not used to meet operational requirements or discharged through LDPs) from both Angus Place Colliery and Springvale Mine for transfer to Delta Electricity's Wallerawang Power Station to be used in their cooling towers or to Springvale Mine's LDP009. Transfers from Springvale Mine take priority, with the remaining capacity of the SDWTS supplied by transfers from Angus Place Colliery.

Currently Delta Electricity has a contract with Springvale Coal to receive a maximum of 30 ML/day of water through the SDWTS, which is expected to continue into the future. This transfer to Wallerawang Power Station significantly reduces the quantity of water that would otherwise be discharged via LDPs. The Water and Salt Balance Assessment considers transfers from both Angus Place Colliery and Springvale Mine to the SDWTS.

The hydrogeological model (CSIRO; 2013) developed for Angus Place Colliery and Springvale Mine predicts increased groundwater inflows associated with the proposed longwalls as part of the mine extension projects at both Angus Place Colliery and Springvale Mine. The cumulative predicted groundwater make from both sites will exceed the current capacity of the SDWTS. For this reason, the capacity of the SDWTS will be increased through a duplication of the existing pipeline network to a maximum capacity of 50 ML/day to accommodate increased inflows from Angus Place Colliery into the SDWTS.

In the unlikely event that the Springvale Mine Extension Project (Golder Associates; 2013) is not approved, all mine water make from Angus Place Colliery is expected to be discharged through LDP001 into Kangaroo Creek.

3. Data

The development of the water and salt balance for the existing and proposed operations at Angus Place Colliery involved the collation and interpretation of data and operational processes from various sources. The purpose of this section is to outline the data and assumptions used in developing the water balance model.

Note the data used for the water and salt balance model for Springvale Mine is provided in *Springvale Mine Extension Project: Water and Salt Balance Assessment* (GHD; 2013).

3.1 Extent of Water Balance Models

The water and salt balance for Angus Place Colliery has been developed to include the surface infrastructure and mining operations within the Project Application Area as well as the SDWTS, including transfers from Springvale Mine to the SDWTS.

3.2 Data Sources

Data and site operational information has been made available by Angus Place Colliery for this assessment. This information was provided during earlier development of the water balance, as well as from information sourced at the December 2012 site visit. From this provided information, input data for the water balance was derived. The sources of data for the water balance are shown in Table 3-1.

Table 3-1 Data Sources

Item	Comment
General operational data	Provided by Angus Place Colliery
Areas of water storages	Provided by Angus Place Colliery/obtained from GIS
Catchment areas	Derived from topographic information
Maximum water transfer rates	Provided by Angus Place Colliery
CHP water usage	Provided by Angus Place Colliery
Storage capacities	Provided by Angus Place Colliery
Underground water usage	Provided by Angus Place Colliery/Estimated from metered data
Site potable water demand	Provided by Angus Place Colliery
Building usage rates	Provided by Angus Place Colliery
Vehicle Washdown Bay usage rates	Provided by Angus Place Colliery
Drainage infrastructure information	Provided by Angus Place Colliery
Pumping rules and rates	Provided by Angus Place Colliery
Groundwater inflows into underground workings	Existing conditions – pumping data Proposed conditions – CSIRO (2013)

Item	Comment
Salt concentration of rainfall and coal-contact runoff	Based on typical values for similar sites and literature
Salt concentration of clean catchment runoff and mine water make	Based on 2012 recorded water quality data

3.3 Site-Specific Data

3.3.1 General Operational Data

Operational data and site infrastructure information relating to water management at Angus Place Colliery was used to develop the water and salt balance model. This site-specific information was used as input to the model (i.e. modelling parameters) and is presented in Table 3-2. Water storage information is presented in Table 3-3.

Table 3-2 Model Parameter Data

Category	Parameter	Input
Mine operations	Hours of operation	Coal produced 24 hours per day, seven days per week (mining operations cease on 36 days per year)
Potable water demand	Administration building	2.5 ML/yr
	Bathhouse[1]	25.5 ML/yr
Mining support operations	ROM coal moisture content	8%
	CHP demand[1]	3 L/s
	Losses from CHP[1]	20%
	Underground process demand[1]	8.3 L/s
	Vehicle washdown demand	6.5 kL/day
	Losses from vehicle washdown	50%
	Removal of water off-site from the Grit Trap	1.1 kL/day

Category	Parameter	Input
Salinity data	Electrical conductivity of rainfall	30 µS/cm
	Electrical conductivity of clean catchment runoff	70 µS/cm
	Electrical conductivity of coal-contact runoff	895 µS/cm
	Electrical conductivity of groundwater inflows into underground workings	800 µS/cm

[1] *Production day is equivalent to 329 days/year*

Table 3-3 Surface Water Management Structures (Excluding Wastewater)

Location	Capacity (ML)
Primary Pollution Ponds	1.9
Secondary Pollution Pond	2.2
Filter Pond	1.2
Settling Ponds	7.5
LDP001 Dams and Wetlands	5.0
Fire Fighting Tanks	0.2
Rainwater Tanks	0.3

3.3.2 Mine Water Make Data

Mine water make is a critical component of the water and salt budget at Angus Place Colliery. It was assumed that current groundwater inflows into the underground workings at Angus Place Colliery were 100 L/s, based on average pumping rates. The groundwater inflows into the underground workings for proposed conditions provided by CSIRO (2013) and incorporated into the water and salt balance are provided in Figure 3-1.

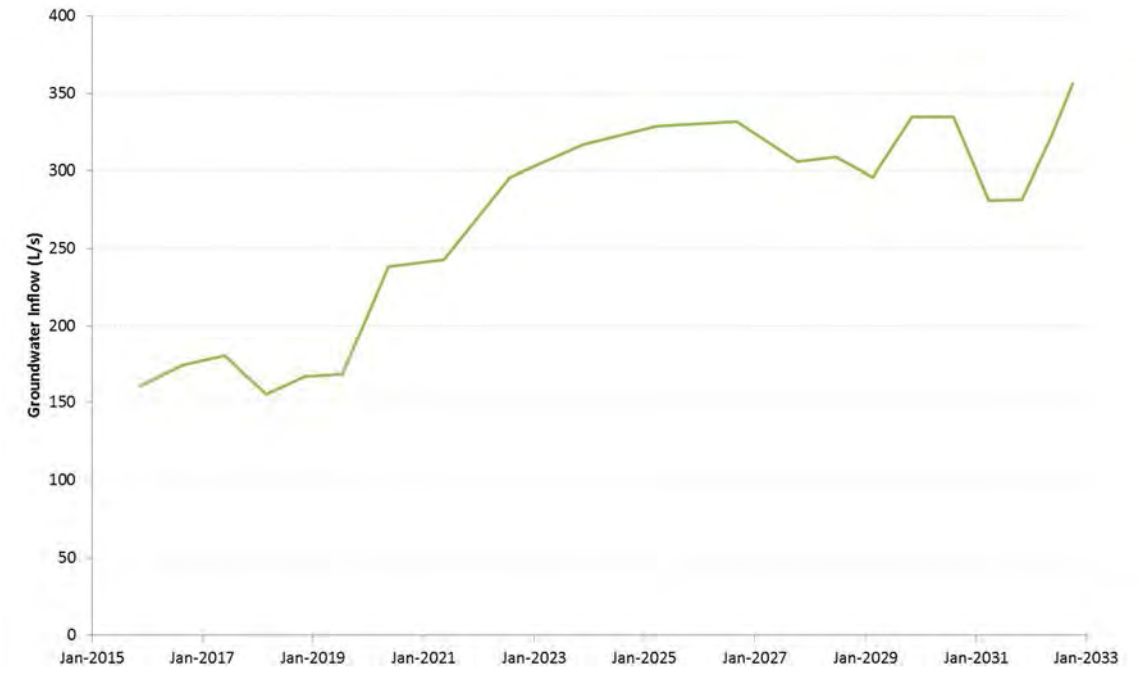


Figure 3-1 Predicted Groundwater Inflows into the Underground Workings (CSIRO; 2013)

As shown in Figure 3-1, groundwater inflows into the mine are expected to peak in 2032 at approximately 356 L/s.

3.3.3 Operational Conditions for Water Transfers

A number of operational conditions were determined from information provided by Angus Place Colliery for incorporation into the water and salt balance model. The operating rules adopted for the analysis of water transfers are provided in Appendix A. It should be noted that transfers between storages relevant to rainfall, runoff, evaporation and overflows were given priority, with pumped transfers only occurring after the priority transfers had taken place. With respect to the SDWTS, transfers from Springvale Mine are given priority over transfers from Angus Place Colliery.

3.3.4 Topography

The topographic information used in establishing catchment areas included the site survey information provided by Centennial Angus Place and Land and Property Information contours for the area.

3.4 Environmental Data

3.4.1 Rainfall

For the purposes of this Water and Salt Balance Assessment, daily rainfall data was obtained as SILO Patched Point Data from the Queensland Climate Change Centre of Excellence. SILO Patched Point Data is based on historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' with interpolations from nearby stations. For this assessment SILO data was obtained for BOM Lithgow (Birdwood St) Station (station number 63224) which is located approximately 15 km south-east of the Angus Place Colliery pit top. The period of data used in this assessment extended from January 1901 through to December 2012 (112 years of data) and is provided in Figure 3-2.

The statistics for the rainfall data set for BOM Lithgow (Birdwood St) Station are:

- Minimum annual rainfall – 450 mm in 1944.
- Average annual rainfall – 852 mm.
- Median annual rainfall – 846 mm.
- Maximum annual rainfall – 1,616 mm in 1950.

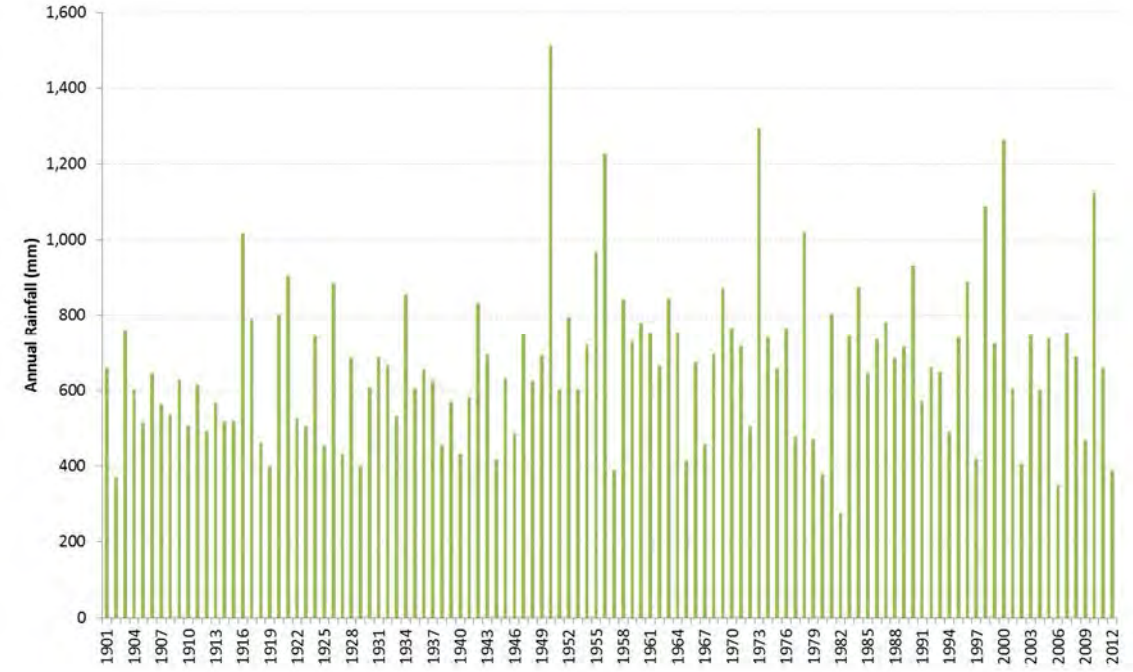


Figure 3-2 Annual Rainfall for BOM Lithgow (Birdwood St) Station

The monthly rainfall statistics were also determined for the period of record from the BOM Lithgow (Birdwood St) Station and are provided in Figure 3-3. The average monthly rainfall was observed to vary from a low of approximately 56 mm in September to a high of approximately 91 mm in January. Figure 3-3 shows a significant variation in the maximum recorded monthly rainfall with the maximum monthly value being approximately 374 mm in August and the lowest monthly value being approximately 150 mm in May. The minimum monthly rainfalls are less than 10 mm for all months.

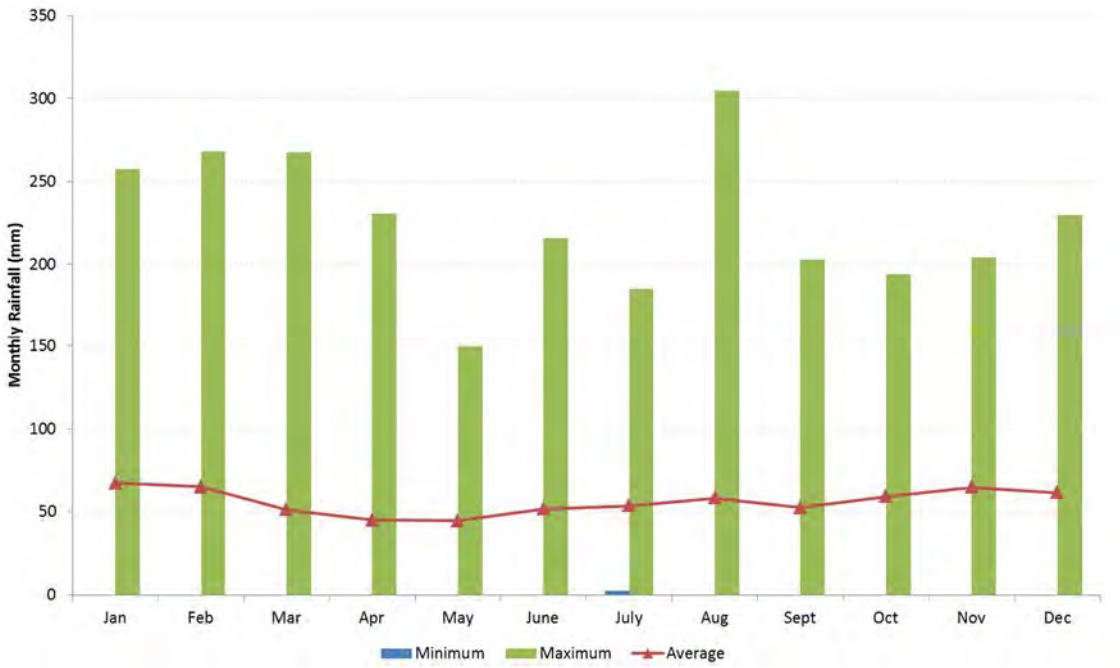


Figure 3-3 Monthly Rainfall Statistics for BOM Lithgow (Birdwood St) Station

An analysis of the rainfall data was undertaken to enable an understanding of the likely rainfall patterns at the site. For various intervals of daily rainfall, the average number of days per year which have rainfall within each interval are presented in Figure 3-4, with non-rainfall days (less than 0.1 mm) excluded. The figure also presents the cumulative days per year as a percentage against the same rainfall intervals. The average number of non-rainfall days (less than 0.1 mm) per year is approximately 229, which is approximately 63% of days in a year.

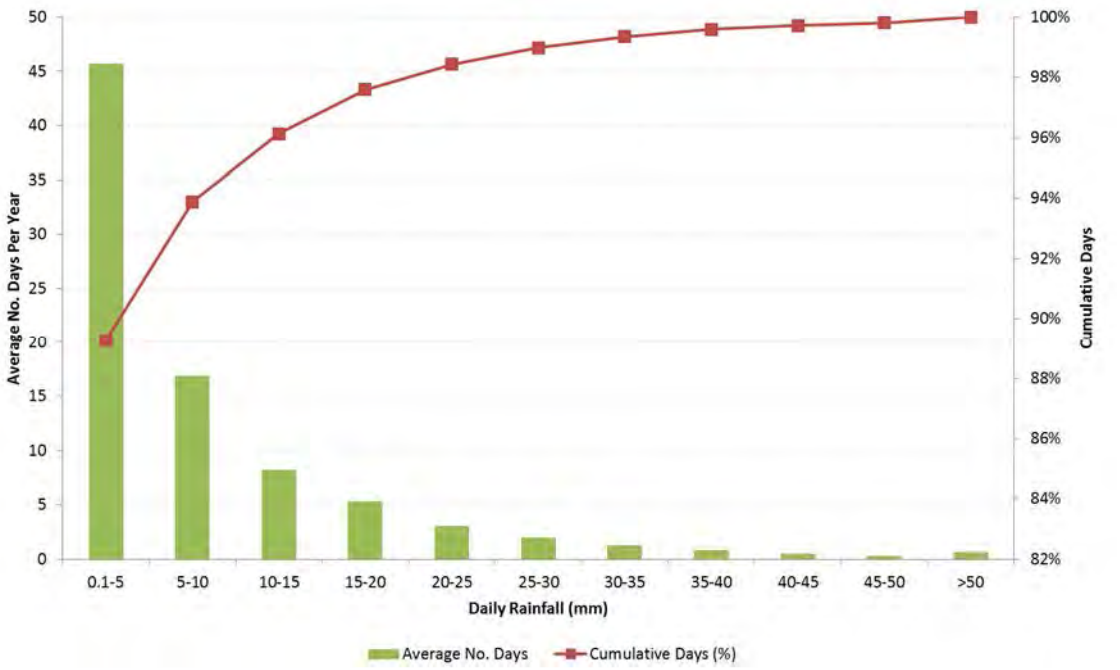


Figure 3-4 Frequency of Daily Rainfall Depths

3.4.2 Evaporation

Information provided at the closest BOM station which records evaporation, the BOM Bathurst Agricultural Station (station number 63005) was reviewed and average monthly evaporation

rates were determined for input into the water balance. The average daily evaporation rates adopted for the water and salt balance are presented in Figure 3-5.

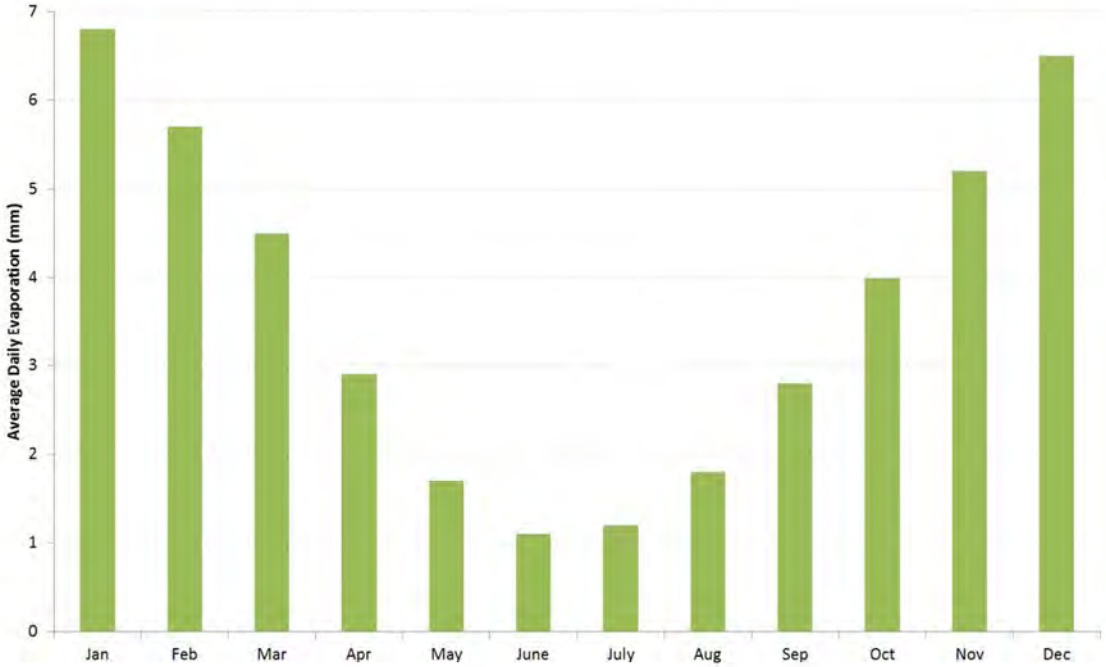


Figure 3-5 Average Daily Evaporation Rates from BOM Bathurst Agricultural Station

3.4.3 Hydrological Model Data

To estimate the runoff contributing to the water storages at Angus Place Colliery, the Australian Water Balance Model (AWBM) was incorporated within the wider water balance model. The AWBM was adopted as the most suitable model as it is widely used throughout Australia, has been verified through comparison with large amounts of recorded streamflow data, and literature is available to assist in estimating input parameters based on recorded streamflow data (Boughton and Chiew; 2003). Another advantage of the AWBM model is the consideration of soil moisture retention when determining runoff.

The AWBM is a catchment water balance model that calculates runoff from rainfall after allowing for relevant losses and storage. As seen in Figure 3-6 the model consists of three storage elements (with surface areas A_1, A_2 and A_3) representing elements such as infiltration into the soil. The definition of model parameters is provided in Table 3-4. Rainfall initially enters these storages, and once a storage element is full any additional rainfall is considered to be excess rainfall. Of this excess rainfall a proportion is routed to the groundwater/baseflow storage (BS) while the remainder is routed to the surface storage (SS). The discharge from the groundwater storage and surface storage is estimated as a proportion of the volume of the storages at the end of each day. The total daily runoff is equal to the combined volume of water discharged from these two storages.

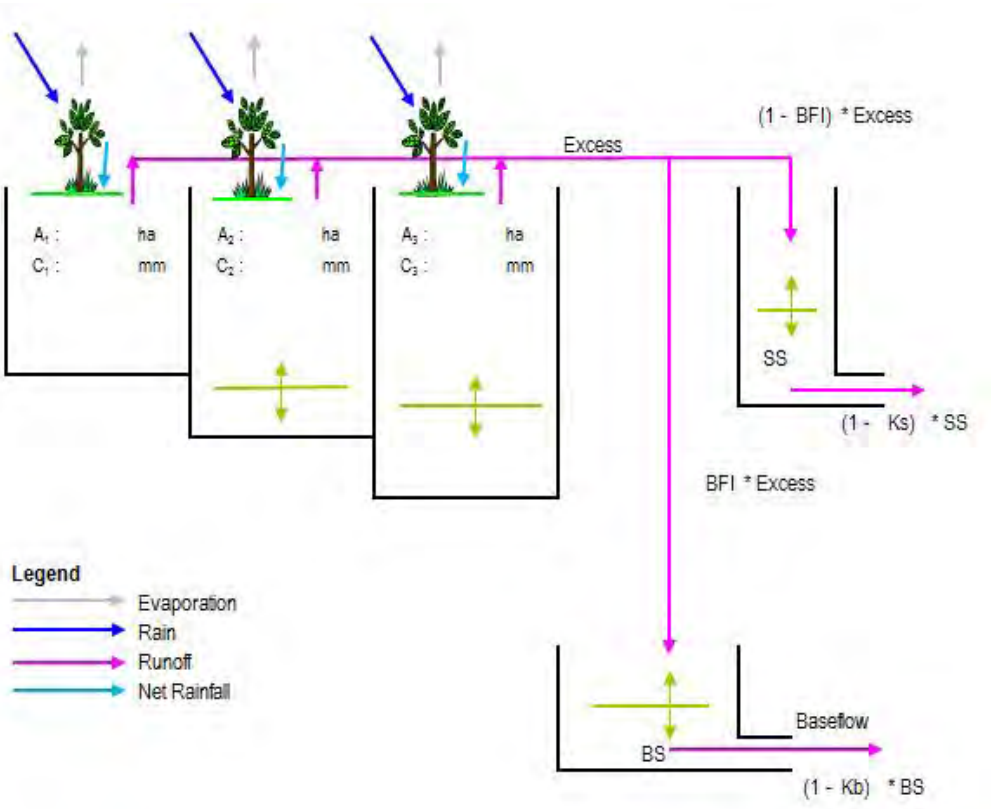


Figure 3-6 Australian Water Balance Model (AWBM) Representation

The relevant site catchments were divided into two areas representing bushland/vegetation and impervious areas. The two areas were modelled with a different set of AWBM parameters. The AWBM parameters adopted for the Water Balance Assessment are presented in Table 3-4.

The parameters for bushland/vegetated areas were determined based on available literature where historical streamflow data had been used to provide recommendations on parameter selection. The nearest location for which

The nearest location for which AWBM model parameters had been determined by Boughton and Chiew (2003) was Coxs River, located approximately 5 km south-west of the Angus Place Colliery Surface Facilities Site. The recommended parameters relating to baseflow were adjusted to reflect the ephemeral nature of drainage lines adjacent to the sites.

The impervious areas were modelled without infiltration into the soil and without surface storage or baseflow storage. Only one storage was assigned a non-zero capacity. This storage represents depression storage of 7 mm for impervious areas. The baseflow parameters were adjusted to reflect no baseflow as the relevant site catchments are not typically large enough to generate baseflow.

The runoff for each relevant catchment was then calculated by scaling the runoff depth to reflect the sub catchment impervious and pervious areas.

Table 3-4 AWBM Parameters

Parameter	Description	Bushland / Vegetation Areas Adopted Value	Impervious Areas Adopted Value
A_1, A_2, A_3	The partial areas of the overall catchment contributing to storages 1, 2 and 3 respectively.	8.1, 82.3, 164.6	7.0, 0.1, 0.1
C_1, C_2, C_3	The capacity of storages 1, 2 and 3 respectively (mm).	0.0	0.0
BFI	The proportion of excess rainfall flowing to the baseflow.	Calculated	Calculated
Excess	Excess from storages C_1, C_2 and C_3.	(1-BFI) x Excess	(1-BFI) x Excess
SS	Surface storage recharge.	BFI x Excess	BFI x Excess
BS	Baseflow storage recharge.	N/A	N/A
Kb	The proportion of the volume of the baseflow storage remaining in the storage at the end of each day. Not applicable for these catchments as there is no baseflow component.	0.5	0.0
Ks	The proportion of the surface flow storage remaining in the storage at the end of each day.	0.5	0.0

4. Modelling Representation

4.1 Water Balance

The modelling software used to represent the Angus Place Colliery water balance was GoldSim Version 10.5 (GoldSim Technology; 2011). This software is a graphical object orientated system for simulating either static or dynamic systems. It is like a 'visual spreadsheet' that allows the visual creation and manipulation of data and equations representing system behaviour.

Simulation, in this context, is defined as a process of creating a model of an existing or proposed system (such as a mine water management system) in order to identify and understand the factors that control the system performance or predict (forecast) the future behaviour of the system under varying input conditions and operational decisions.

The model was created by representing the site water cycle as a series of elements, each containing pre-set rules and data, that were linked together to simulate the interaction of these elements within the water cycle. The water cycle was simulated over time in GoldSim and selected outputs from the modelled system were statistically summarised.

4.1.1 Time Steps and Simulation Timeline

The GoldSim model simulated the Project water cycle from current conditions in 2013 to the end of the projected extraction in 2032 (inclusive) using daily time steps. Daily time steps were used for the modelling as daily rainfall data was the shortest period of data available and changes in operational conditions are typically made on a daily (or shorter) basis.

4.1.2 Probabilistic Modelling

To assess the impact of rainfall on the site, the water balance modelling was completed by applying 112 different rainfall patterns over the simulation timeline (2013 to 2032 inclusive). To complete this, the simulation timeline was modelled for 112 'realisations', where each realisation represented a single model run from 2013 to 2032. The only variation between realisations was that each realisation modelled a different continuous historical rainfall pattern.

The 112 realisations were applied as the historical rainfall data extended from January 1901 to December 2012 (refer Section 3.4.1), which represents 112 years of complete rainfall data available. The 112 years of rainfall data provides 112 rainfall patterns as the seasonality in rainfall is maintained for each model run, e.g. the 1st January in the model was simulated with 1st January historical rainfall data. For each realisation, a continuous pattern of historical rainfall was applied over the simulation timeline. Where the end of the continuous historical rainfall record was reached in a realisation, the rainfall looped back to the start of the rainfall record. A graphical explanation of the rainfall simulation process is provided in Figure 4-1.

The above repetition process provided 112 values of each simulated element in the model, for each day of the simulation timeline. Each extraction, discharge or transfer was then statistically assessed to provide estimates of the average, 10th percentile and 90th percentile annual totals for each year over the simulation timeline.

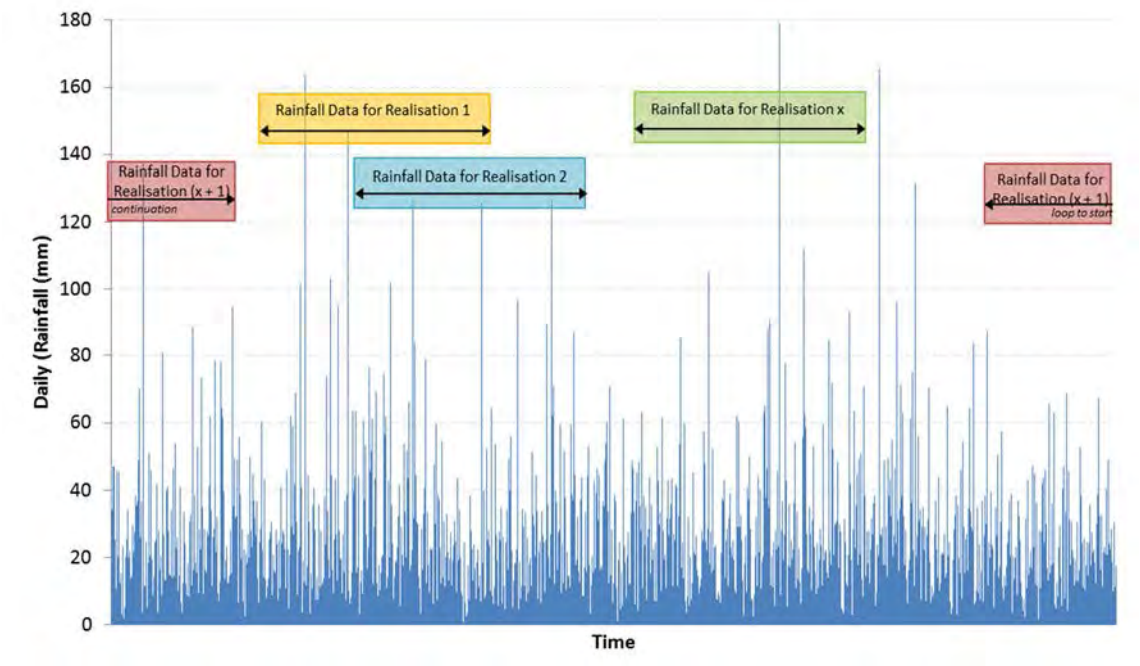


Figure 4-1 Rainfall Simulation Conceptualisation

4.1.3 GoldSim Representation

Existing Operations

The water cycle for existing operations at Angus Place Colliery is represented in Figure 2-2 and Figure 2-3. This was modelled in GoldSim with existing conditions based on site conditions in the year 2013.

To undertake the modelling the following simplifications were incorporated:

- Transfer rates were modelled using daily time steps. In reality, transfer rates are determined during the day on an 'as needs' basis and may apply over periods smaller than a day.
- The rate of delivery of water to the administration and bathhouse buildings was input at constant rates. This was determined from average annual data obtained from Angus Place Colliery. In reality, the demand for water in the administration and bathhouse buildings varies daily.
- Operating rules/conditions were established within the model in accordance with advice from Angus Place Colliery.
- Rainfall and runoff are represented in daily time steps and therefore short duration, high intensity events are not accurately represented by the model. In reality, more overflows from the surface water storages may occur than represented by the water balance model.
- The rate of delivery of process water to the underground workings was based on the average pumping rate over a short period of time. In reality, the demand for process water varies daily based on underground activities.

Proposed Operations

The GoldSim water balance model developed for existing conditions was modified to represent the proposed conditions for the water cycle as a result of the Project. The Project was assumed to commence in 2016 and continue until the projected end of extraction in 2032. Amendments to the model to represent the proposed conditions were associated with the management of the

expected increase in volume of mine water make due to extraction of the proposed Angus Place East workings.

The predicted transfers for the water management system under proposed conditions are based on the predicted site conditions in 2030. This year was selected as it is when mine water make into the underground workings is predicted to peak and the water management system will be the most different compared to existing conditions. The distribution of water over the Project life is also presented for critical elements of the Angus Place Colliery water management system.

Springvale-Delta Water Transfer Scheme

As the water budget of Angus Place Colliery, Springvale Mine and the SDWTS are interrelated, the transfer of mine water make into the SDWTS has been assessed collectively for Angus Place Colliery and Springvale Mine. The critical point in time for the Project and the Springvale Mine Extension Project (Golder Associates; 2013) in terms of water management is when the combined mine water make from both sites is greatest. Based on the results by CSIRO (2013), the maximum mine water make from both sites is predicted to occur in 2024.

The assessment of transfers to the SDWTS included evaluation of transfers occurring with the current SDWTS capacity of 30 ML/day and the upgraded SDWTS capacity of 50 ML/day. The upgrade to the capacity of the SDWTS was assumed to occur when the combined mine water make from both Angus Place Colliery and Springvale Mine transferred to the SDWTS is predicted to exceed the current capacity of the SDWTS.

The future management of the SDWTS has been assessed in the *Springvale Mine Extension Project: Water and Salt Balance Assessment* (GHD; 2013) and the *Springvale Mine Extension Project: Surface Water Impact Assessment* (RPS; 2013) for the Springvale Mine Extension Project.

4.2 Salt Balance

The salt balance was developed as an extension of the water balance model, with expected concentrations of salt applied to water inflows into the system. Transfers of the resulting salt loads were modelled throughout the site. The mass and concentration of salt within particular storages was established such that a mass balance was achieved after allowing for salt discharged via extraction and overflows.

Inflows of water into the system were assigned a specific concentration of salt depending on the source of the water (as shown in Table 3-2). The concentration values were based upon recorded water quality data and typical concentration values for similar sites, usually provided in units of µS/cm. A conversion factor of 0.67 was used to convert salinity data in µS/cm to mg/L as recommended by the Queensland Department of Natural Resources and Water (DNRW, 2007).

Salt transfers for both the existing and proposed scenarios were simulated in parallel with the water balance model. Extractions and overflows from each storage assumed instantaneous mixing. Modifications for the proposed salt balance to represent proposed conditions were the same as the modifications for the water balance.

4.3 Model Verification

To verify the results of the water balance, outputs of the model were compared to available monitored data supplied by Angus Place Colliery. As LDP001 is the main discharge location of the water management cycle at the site, it was considered to be a suitable monitoring location to verify the modelling outputs. A comparison of the recorded and modelled discharges was undertaken in order to assist in the calibration of the water balance model.

Discharges through LDP001 predicted by the model were found to be reasonably consistent with recorded discharges. From around September 2012, LDP001 discharges decrease steadily from approximately 6 ML/day to a negligible volume in late April 2012. Recorded extractions from the 940 Dewatering Bore increased by approximately the same volume over this period. Both transfers were replicated in the water balance model results.

As the results from the water balance model were comparable to the recorded discharges through LDP001, it was determined that the results generated by the model were a reasonable representation of the water management system.

Salt outputs from the salt balance model were comparable to recorded water quality monitoring data across the site, including data for clean water catchments and mine water transfers.

It is recommended that LDP001 discharges continue to be recorded and the model verified further when additional data is available as the Project progresses.

5. Modelling Results

5.1 Interpretation of Results

5.1.1 Water Balance

The water management system for Angus Place Colliery was modelled for the projected life of the mine, extending from the present (2013) through to the predicted end of extraction (2032). The water management system was simulated using a historic time series of daily rainfall data extending over 112 years. A total of 112 simulations were applied to this timeline with each simulation modelling a different rainfall pattern (refer Section 4.1). As a result, for each year of mining 112 annual totals were available for each transfer element within the water management system thereby representing a wide range of possible rainfall conditions.

The results presented in Section 5.2 show the average annual transfer volumes (along with 10th percentile and 90th percentile values) for the water management elements at Angus Place Colliery for both existing and proposed conditions. The results presented for proposed conditions consider transfers occurring with the current capacity of the SDWTS (30 ML/day) and the upgraded capacity (50 ML/day). The results provide an indication of the possible range of volumes expected under proposed conditions.

The 10th percentile represents the value at which 10% of the modelled outputs were less than this value. Similarly, the 90th percentile represents the value at which 90% of the modelled outputs were less than this value. The 10th percentile and 90th percentile values have been used (rather than absolute minimum and maximum values) to remove the impact of skewing by infrequent to extreme wet and dry conditions.

5.1.2 Salt Balance

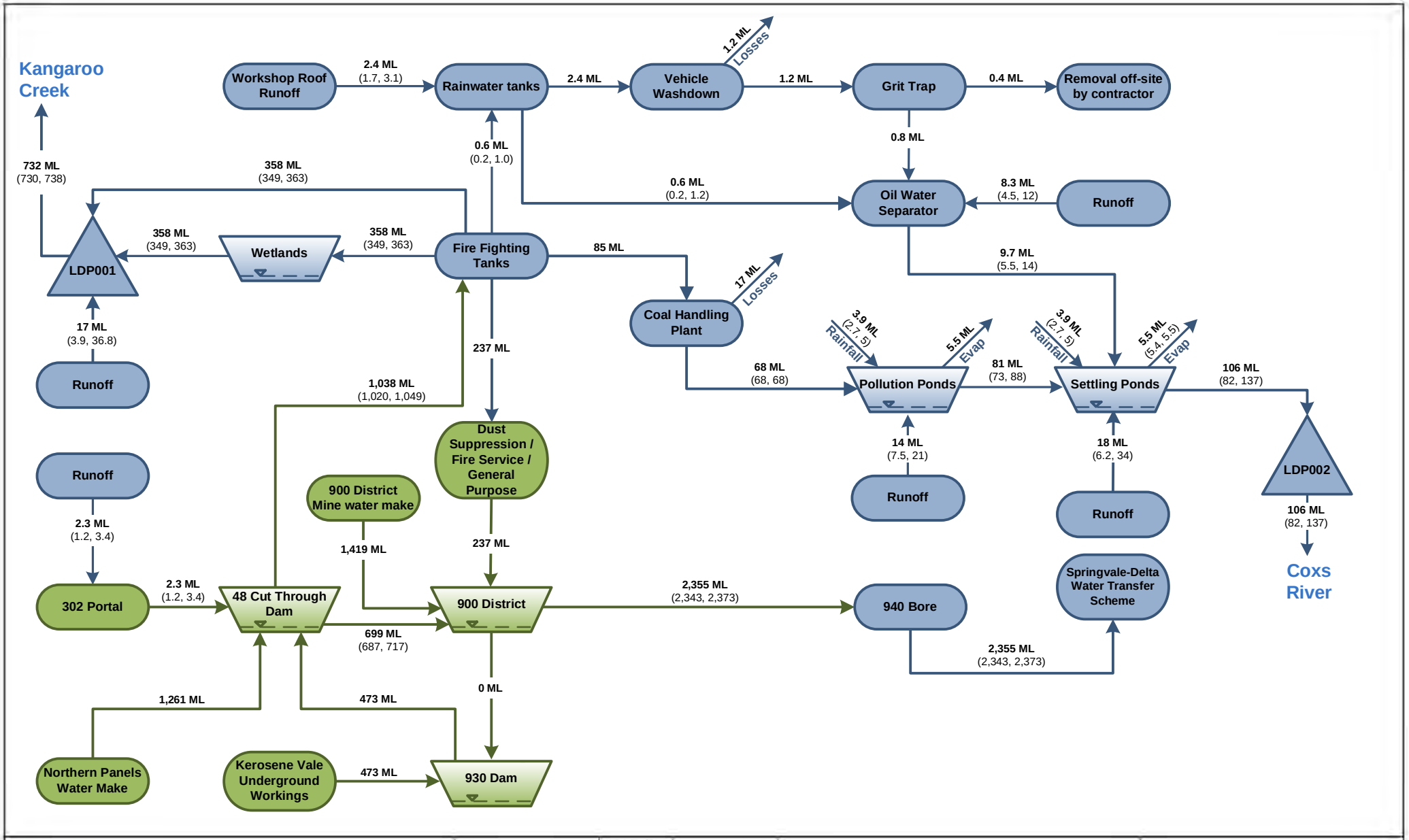
Similar to the water balance, the salt modelling provided 112 possible annual totals of salt transfers for each transfer element. The results presented in Section 5.3 show the average annual salt transfer volumes (along with 10th percentile and 90th percentile values) for the water management elements at Angus Place Colliery for both existing and proposed conditions. In addition to the salt transfer quantities, the average electrical conductivity (EC) of each transfer is also displayed on the figures.

5.2 Water Balance Results

The predicted values for existing and proposed conditions for each of the water transfers associated with Angus Place Colliery are provided in Figure 5-1 and Figure 5-2 respectively. Figure 5-3 shows the predicted transfers for the potable water cycle, which is expected to remain unchanged from existing to proposed conditions. As discussed in Section 5.1, the results present the annual transfers between the water management elements of the site as well as an indication of the range of values expected due to possible variations in rainfall.

The results presented for the proposed conditions are based on the predicted site conditions in 2030. This year was selected as it is when mine water make into the underground workings are predicted to peak and the water management system will be the most different compared to the existing conditions.

It should be noted that mine water make into the underground workings are predicted to vary over time, in accordance with projected mine water make shown in Figure 3-1.



LOCATION	Angus Place
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Angus Place Mine Extension Project
Water and Salt Balance Assessment

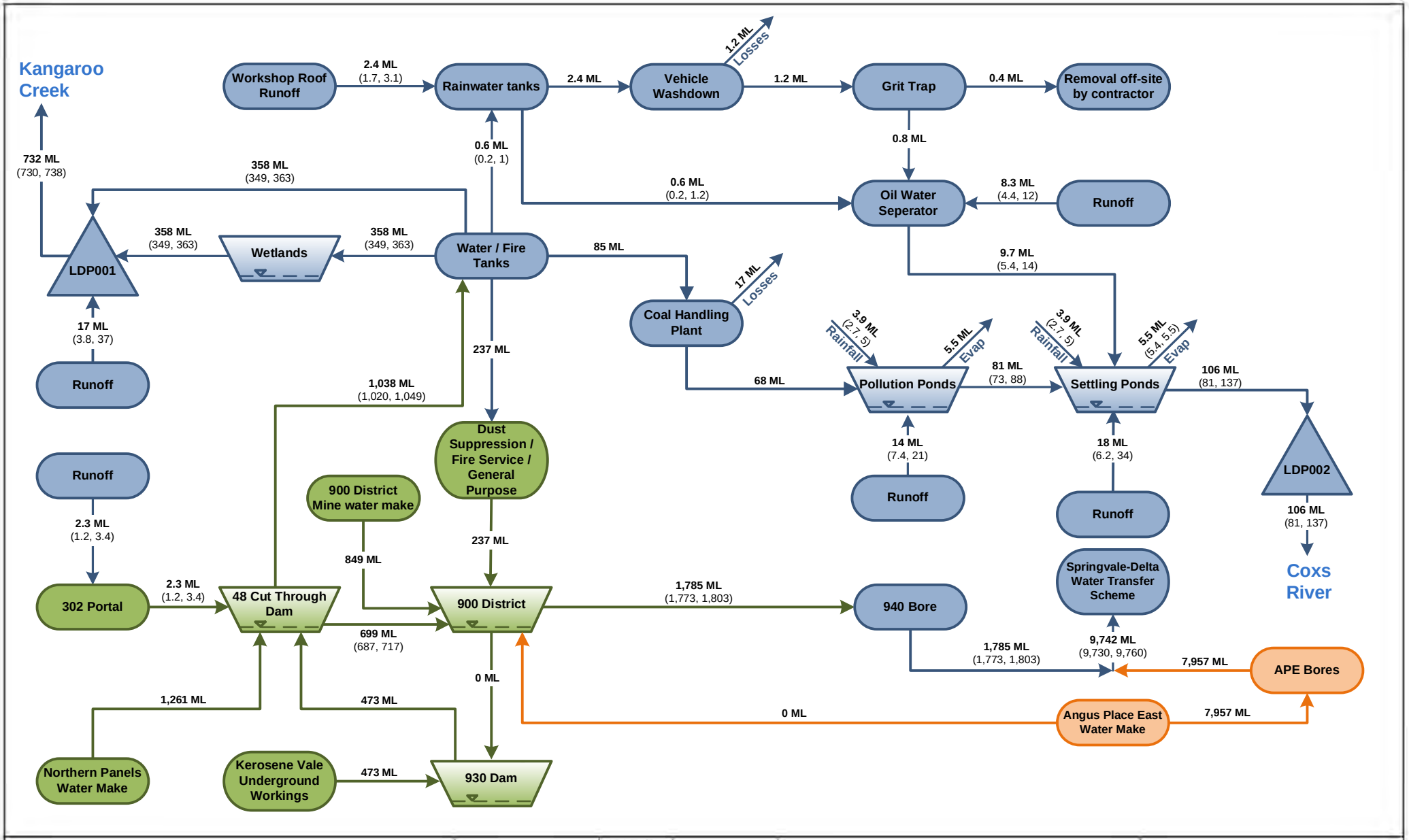
Annual Water Transfers
Existing Conditions (2013)

Centennial Coal

DATE Nov 2013

Figure 5-1

G:\22\16599\Visio\2216599_AP_FIG5-1_Angus Place_Existing_Water_Schematic_Numbered.vsd



LOCATION	Angus Place
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Angus Place Mine Extension Project
Water and Salt Balance Assessment

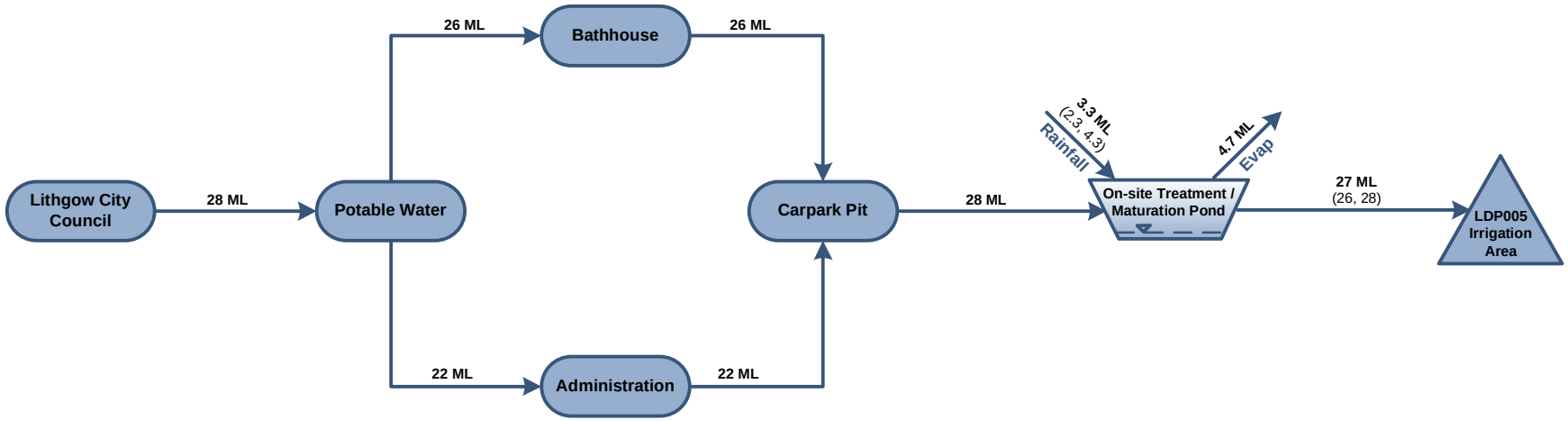
Annual Water Transfers
Proposed Conditions (2030)

Centennial Coal

DATE Nov 2013

Figure 5-2

G:\22\16599\Visio\2216599_AP_FIG5-2_Angus Place_Proposed_Water_Schematic_Numbered.vsd



LEGEND

Surface Water Transfer

Storage

XXML Mean ML/y

(XX-XX) 10th, 90th Percentile ML/y

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Angus Place Mine Extension Project
Water and Salt Balance Assessment

Potable Water Cycle Transfers
Existing and Proposed Conditions

Centennial Angus Place

DATE Oct 2013

Figure 5-3

G:\22\16599\Visio\2216599_AP_FIG5-3_Angus Annual Potable Water Transfers Existing and Proposed Conditions_Numbered.vsd

A summary of the average inputs and outputs of the Angus Place Colliery water management system for the existing (2013) and proposed (2030) conditions is presented in Table 5-1.

Table 5-1 Summary of Average Predicted Water Inputs and Outputs

	Existing Conditions (2013) (ML/yr)	Proposed Conditions (2030) (ML/yr)
INPUTS		
Direct rainfall onto storages and catchment runoff	72.7	72.7
External potable water supply	28.0	28.0
Groundwater inflows into underground workings	3,153.6	10,540.5
TOTAL INPUTS	**3,254**	**10,641**
OUTPUTS		
Evaporation	15.6	15.6
Discharge through LDP001	732.1	732.1
Discharge through LDP002	106.3	106.3
Discharge through LDP005	26.6	26.6
Transfer to SDWTS	2,354.9	9,741.8
Removal of water off-site from the Grit Trap	0.4	0.4
Losses from CHP	17.1	17.1
Losses from vehicle washdown	1.2	1.2
TOTAL OUTPUTS	**3,254**	**10,641**
CHANGE IN STORAGE		
Surface water storages	0.0	0.0
Underground water storages	0.0	0.0
TOTAL CHANGE IN STORAGE	**0**	**0**
BALANCE		
Inputs – Outputs – Change in storage	0	0

As seen in Table 5-1, the largest source of water into the Angus Place Colliery water management system is the inflow of groundwater into the underground workings. The predicted annual mine water make under existing conditions in 2013 is 3,154 ML. The greatest change to the system under proposed conditions is the increase in groundwater make into the proposed mining areas, which is estimated to increase by approximately 7,387 ML to a total of 10,541 ML in 2030.

Under existing conditions, the predicted average annual discharges from Angus Place Colliery in 2013 are 2,355 ML (average 6.5 ML/day) to the SDWTS, 732 ML (average 2.0 ML/day) through LDP001 and 106 ML (average 0.3 ML/day) through LDP002.

For the proposed conditions at Angus Place Colliery in 2030, discharges through LDP001 and LDP002 are not expected to change. Transfers to the SDWTS are predicted to increase by 7,387 ML to a total of 9,742 ML (average 26.7 ML/day).

For the potable water management system, under both existing and proposed conditions approximately 28 ML/yr is expected to be sourced from Lithgow City Council potable water system. It is predicted that approximately 27 ML/yr will be disposed of through the on-site treatment system and LDP005 irrigation area.

The majority of in situ moisture associated with the extracted coal is expected to be lost from the system through evaporation in the stockpiles, with the remainder transported off-site associated with product coal. Therefore, the in situ moisture associated with extracted coal does not impact significantly on other elements of the water management system.

The results of the water balance indicate that Angus Place has a surplus of water under both existing and proposed conditions. As mine water is used to supply water to mining associated activities, extended periods of low rainfall are not likely to affect the availability of water to supply mining operations.

5.2.1 Transfers to SDWTS

The total transfer rate of water to the SDWTS from both Springvale Mine and Angus Place Colliery is dependent on the management of mine water make at both sites. Currently, the capacity of the SDWTS is 30 ML/day however this will be upgraded to 50 ML/day in the future. From the SDWTS, water is either transferred to Wallerawang Power Station or discharged through LDP009 at Springvale Mine. Figure 5-4 presents the predicted average annual transfers from Angus Place Colliery to the SDWTS for both the current SDWTS capacity of 30 ML/day and the upgraded SDWTS capacity of 50 ML/day. Appendix B provides the predicted average daily transfers to the SDWTS.

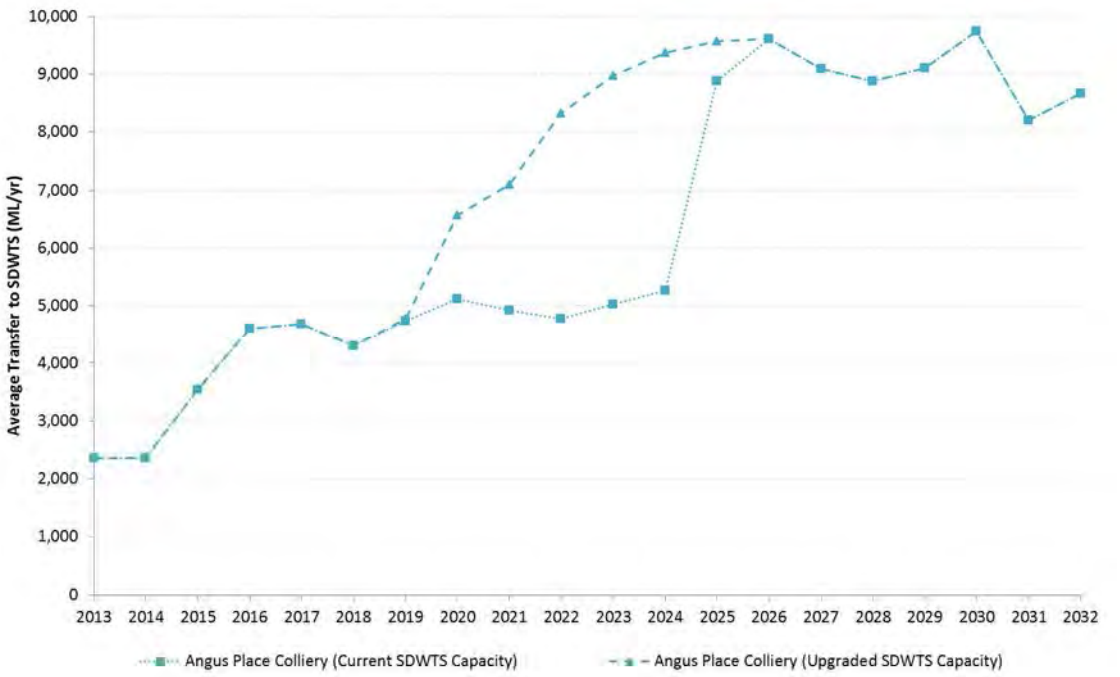


Figure 5-4 Predicted Annual Average Transfers to the SDWTS

As seen in Figure 5-4, an average of approximately 2,355 ML (6.5 ML/day) of mine water make is predicted to be transferred from Angus Place Colliery to the SDWTS in 2013 under existing conditions. The greatest average annual transfer to the SDWTS is predicted to be approximately 9,742 ML (average 26.7 ML/day), occurring in 2030.

If the SDWTS were to remain at the current capacity of 30 ML/day, the combined transfer from Springvale Mine and Angus Place Colliery is predicted to reach the maximum SDWTS capacity from approximately January 2020 until the end of February 2025. During this time, it is predicted that approximately 52% to 70% of mine water make from Angus Place Colliery is transferred to the SDWTS. The remaining mine water make is expected to be discharged through LDP001. After February 2025, transfer of mine water make from the Springvale Mine dewatering bores to the SDWTS cease and Angus Place Colliery is predicted to transfer all mine water make to the SDWTS.

For the upgraded SDWTS capacity of 50 ML/day, transfers to the SDWTS from Springvale Mine and Angus Place Colliery are not predicted to reach the maximum capacity. Similar to the results presented for a 30 ML/day SDWTS capacity, only Angus Place Colliery is expected to contribute to the SDWTS after Springvale Mine ceases transfers to the SDWTS in February 2025.

5.2.2 Predicted LDP001 Discharges

Figure 5-5 presents the time series of predicted annual discharges through LDP001. The time series of predicted daily LDP001 discharges is presented in Appendix B.

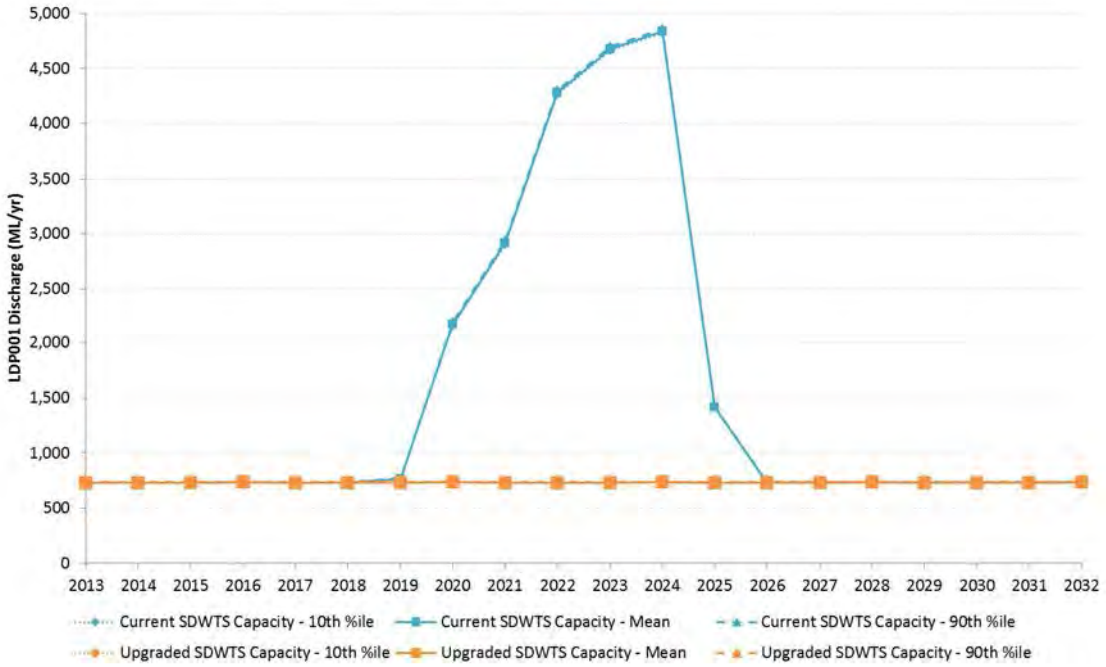


Figure 5-5 Predicted Annual LDP001 Discharges

Mine water make from Angus Place Colliery not transferred to the SDWTS is directed through LDP001 for discharge into Kangaroo Creek. The current water management system limits discharges through LDP001 to approximately 2 ML/day by transferring the bulk of mine water make to the SDWTS. Compared to transfers from Angus Place Colliery to the SDWTS presented in Figure 5-4, discharges through LDP001 are relatively minor. Under existing conditions, discharges are predicted to be an average of approximately 732 ML/yr (average 2.0 ML/day). The modelling results indicate that the EPL limit of 2 ML/day is exceeded for less than 0.03% of days for 2013. There is slight variation in the discharges modelled through LDP001, which are attributable to the variation in runoff from catchments contributing to LDP001 due to the wide range of possible rainfall conditions modelled.

If the SDWTS were to remain at the current capacity of 30 ML/day, the scheme is predicted to reach maximum capacity from approximately January 2020 until the end of February 2025, as discussed in Section 5.2.1. During this time, mine water make not transferred to the SDWTS is discharged through LDP001 continuously. The average annual flows through LDP001 are expected to peak at approximately 4,836 ML (average 13.2 ML/day) in 2024, as seen in Figure 5-5, and will exceed the current EPL limit of 2 ML/day. The maximum daily LDP001 discharge modelled was approximately 27.6 ML/day, occurring in 2024.

For the upgraded SDWTS capacity of 50 ML/day, no mine water make in addition to current transfers is expected to be discharged through LDP001. The proposed Project is not predicted to impact on the magnitude or frequency of discharges through LDP001. The flows through LDP001 are predicted to remain unchanged from existing conditions, with an annual average discharge of approximately 732 ML/yr comprised of mine water make and runoff from the upstream catchment.

Note in the unlikely event that the Springvale Mine Extension Project (Golder Associates; 2013) is not approved, all mine water make from Angus Place Colliery is expected to be discharged through LDP001 into Kangaroo Creek.

5.2.3 Predicted LDP002 Discharges

Figure 5-6 presents the time series of predicted annual discharges through LDP002. The average annual discharge under existing conditions was predicted to be approximately 106 ML/yr (average 0.3 ML/day) and is not expected to change as a result of the Project.

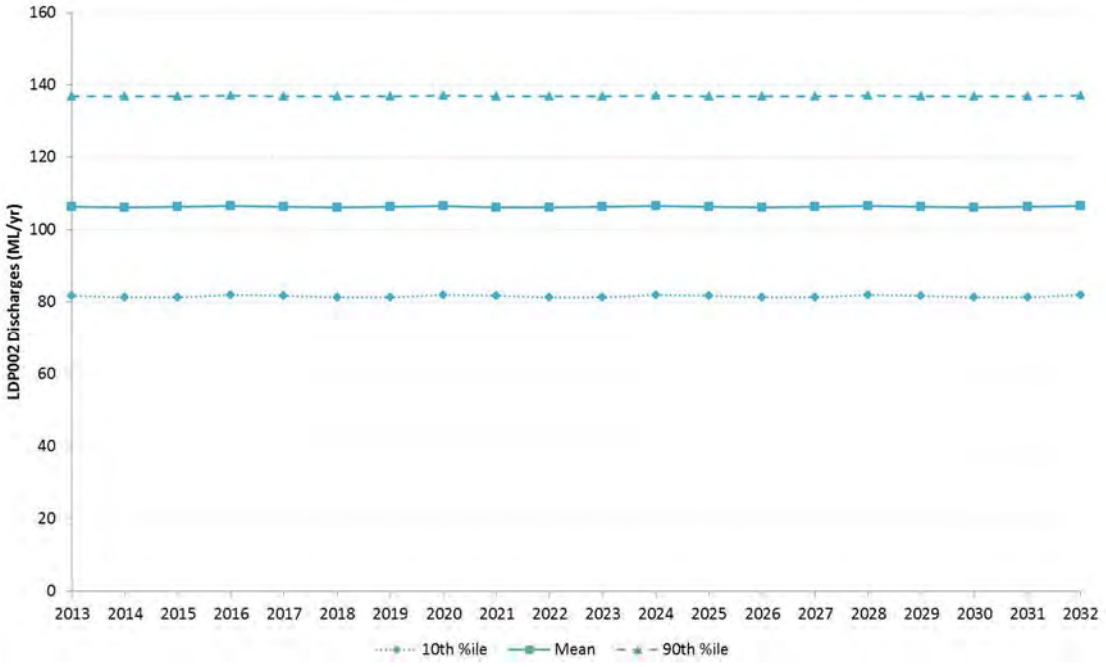


Figure 5-6 Predicted Annual LDP002 Discharges

The time series of predicted daily LDP002 discharges is presented in Appendix B. A seasonal pattern can be seen in the daily time series of discharges, corresponding to the pattern found in the rainfall and evaporation data, as discussed in Section 3.4.

The percentiles of the range of daily flow rates predicted to pass through LDP002 under existing and proposed conditions are presented in Figure 5-7. For clarity, the results are shown on a single graph with a logarithmic y-axis scale and the 5 ML/day volumetric limit imposed on LDP002 by EPL 467.

The results indicate that the proposed Project does not impact on the magnitude or frequency of discharges through LDP002. The EPL limit of 5 ML/day is exceeded for less than 0.3% of days.

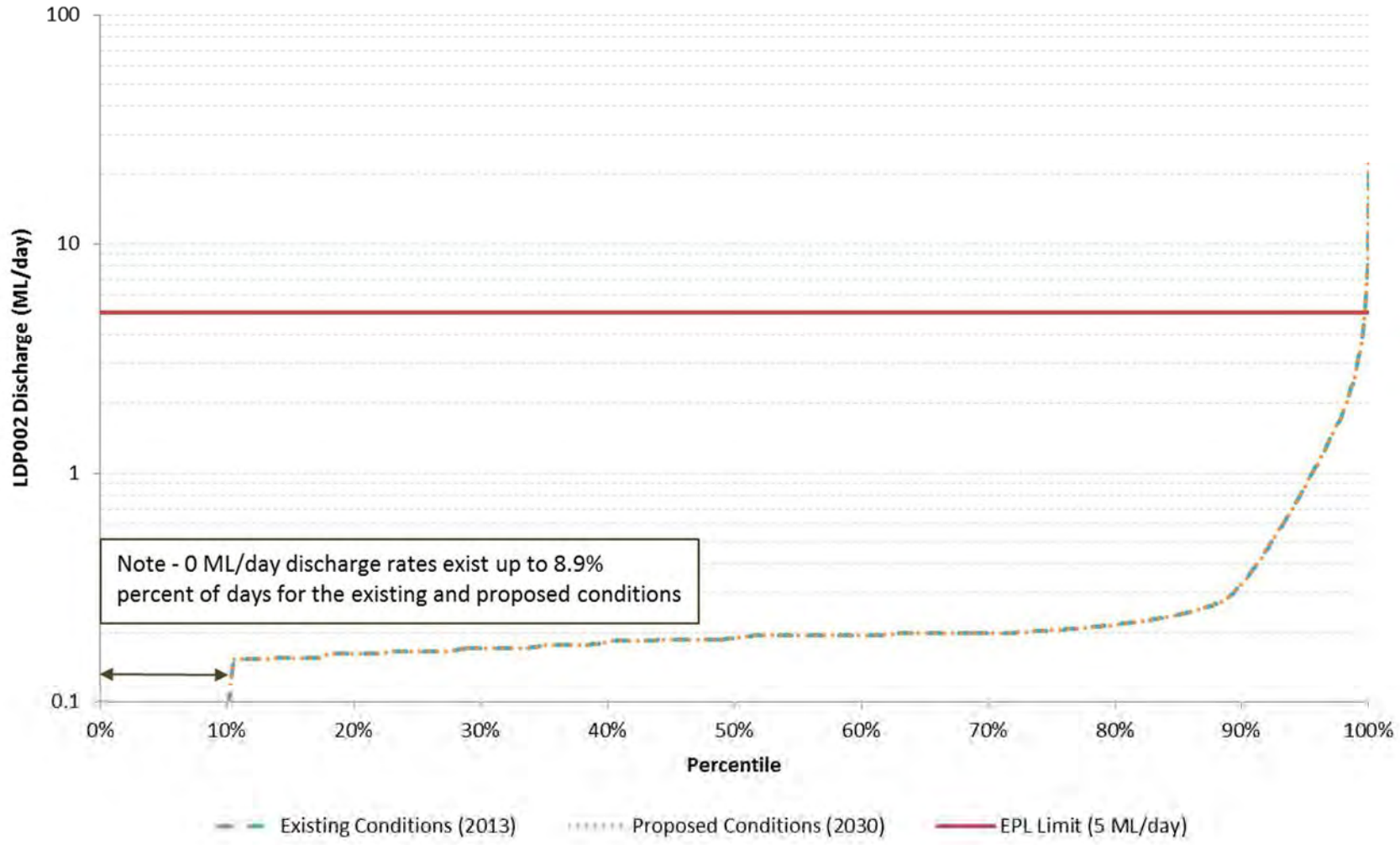


Figure 5-7 LDP002 Daily Flow Percentiles

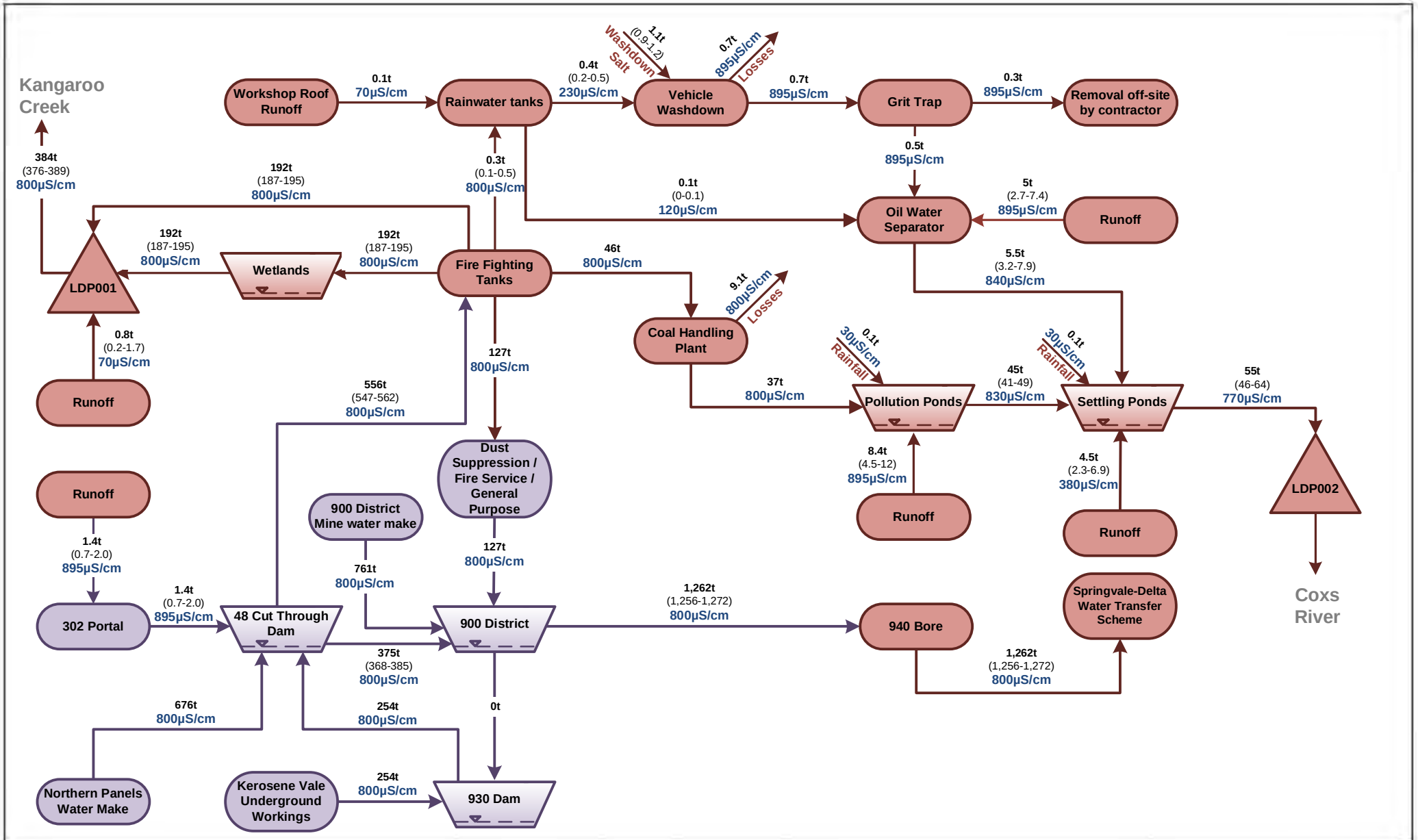
5.3 Salt Balance Results

The predicted values for existing and proposed conditions for each of the salt transfers associated with Angus Place Colliery are provided in Figure 5-8 and Figure 5-9 respectively. As discussed in Section 5.1, the results present the average annual transfers between the water management elements of the site as well as an indication of the range of values expected due to possible variations in rainfall. In addition to the salt transfer quantities, the predicted average salt concentration is also displayed on the figures.

A summary of the salt inputs and outputs of the Angus Place Colliery water management system for the existing and proposed conditions is presented in Table 5-2.

Table 5-2 Summary of Average Predicted Salt Inputs and Outputs

	Existing Conditions (2013) (t/yr)	Proposed Conditions (2030) (t/yr)
INPUTS		
Direct rainfall onto storages and catchment runoff	20.3	20.3
Vehicle washdown addition	1.1	1.1
Groundwater inflows into underground workings	1,690.3	5,649.7
TOTAL INPUTS	**1,712**	**5,671**
OUTPUTS		
Discharge through LDP001	384.1	384.1
Discharge through LDP002	55.1	55.1
Transfer to SDWTS	1,262.4	5,221.7
Removal of grit off-site	0.3	0.3
Vehicle washdown losses	0.7	0.7
CHP losses	9.1	9.1
TOTAL OUTPUTS	**1,712**	**5,671**
CHANGE IN STORAGE		
Surface water storages	0.0	0.0
Underground water storages	0.0	0.0
TOTAL CHANGE IN STORAGE	**0**	**0**
BALANCE		
Inputs – Outputs – Change in storage	0	0



LEGEND

- Surface Salt Transfer
- Underground Salt Transfer
- Storage

XXt (XX-XX) XXµS/cm — Mean t/y, 10th, 90th Percentile t/y, Mean Salinity

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Angus Place Mine Extension Project
Water and Salt Balance Assessment

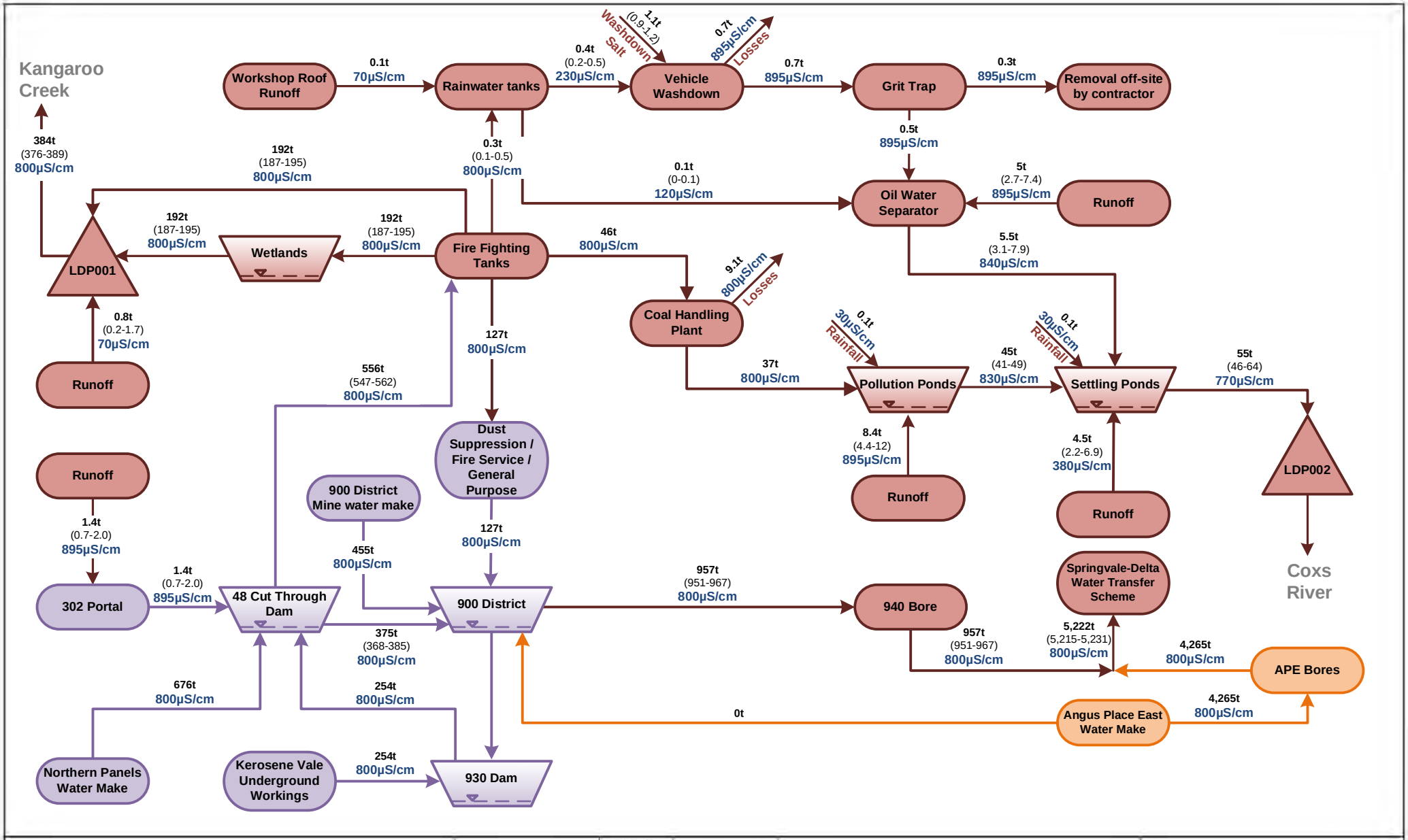
Annual Salt Transfers
Existing Conditions (2013)

Centennial Coal

DATE Nov 2013

Figure 5-8

G:\22\16599\Visio\2216599_AP_FIG5-8_Angus Place_Existing_Salt_Schematic_Numbered.vsd



LEGEND

- Surface Salt Transfer
- Underground Salt Transfer
- Proposed Salt Transfer
- Storage
- XXt (XX-XX) XXµS/cm — Mean t/y, 10th, 90th Percentile t/y, Mean Salinity

LOCATION	Angus Place
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Angus Place Mine Extension Project
Water and Salt Balance Assessment

Annual Salt Transfers
Proposed Conditions (2030)

Centennial Coal

DATE Nov 2013

Figure 5-9

G:\22\16599\Visio\2216599_AP_FIG5-9_Angus Place_Proposed_Salt_Schematic_Numbered.vsd

As seen in Table 5-2, the largest source of salt into the Angus Place Colliery water management system is the inflow of groundwater into the underground workings. The predicted annual salt mass associated with mine water make under existing conditions in 2013 is 1,690 tonnes. The greatest change to the system under proposed conditions is the increase in salt associated with groundwater make, which is estimated to increase by approximately 3,959 tonnes of salt to 5,650 tonnes.

Under existing conditions in 2013, the predicted annual average mass of salt discharged from Angus Place Colliery in 2013 is 1,262 tonnes (average 3.5 t/day) at a concentration of 800 µS/cm to the SDWTS, 384 tonnes (average 1.1 t/day) at a concentration of 780 µS/cm through LDP001 and 55 tonnes (average 0.15 t/day) at a concentration of 770 µS/cm through LDP002

For the proposed conditions at Angus Place Colliery in 2030, discharges of salt through LDP001 and LDP002 are not expected to change. Salt transfers to the SDWTS are predicted to increase to 5,222 tonnes (average 14.3 t/day) at a concentration of 800 µS/cm.

5.3.1 Transfers to SDWTS

Figure 5-10 presents the predicted average EC of transfers from Angus Place Colliery to the SDWTS.

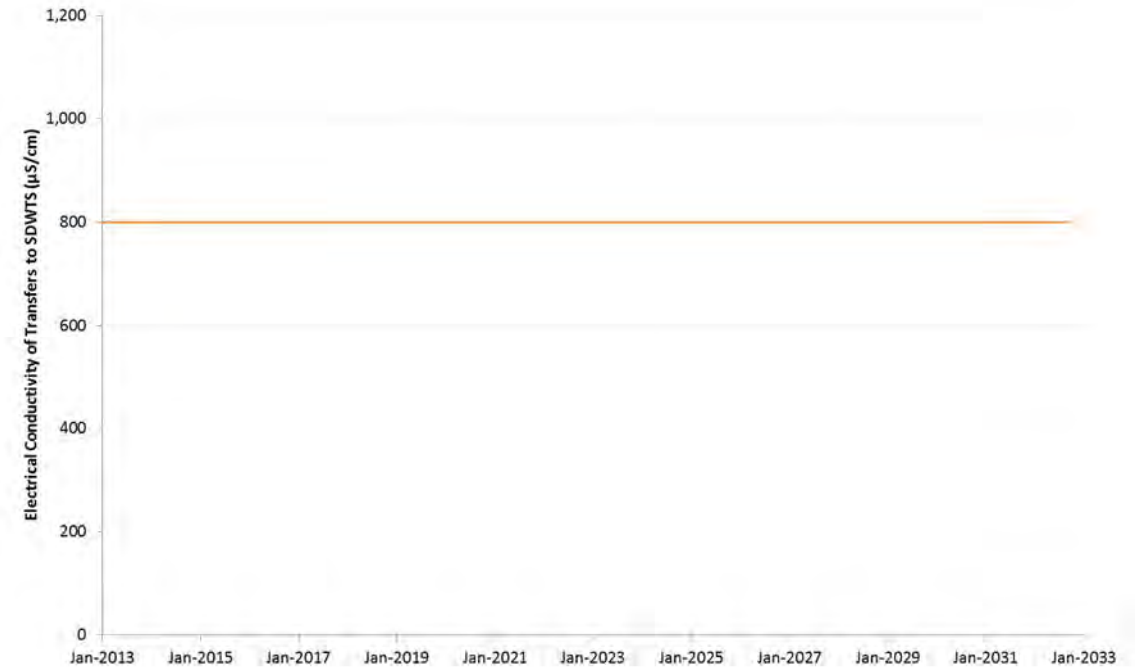


Figure 5-10 Predicted Average Electrical Conductivity of Transfers to the SDWTS

An average EC of approximately 800 µS/cm is expected for mine water make transferred to the SDWTS. The EC modelled does not vary over time or for the current SDWTS capacity compared to the potential upgraded capacity.

5.3.2 Predicted LDP001 Discharges

Figure 5-11 presents the time series of the predicted EC of discharges through LDP001. As discussed in 5.2.2, the bulk of transfers through LDP001 are expected to be comprised of mine water make, with runoff from the upstream catchment contributing a small portion.

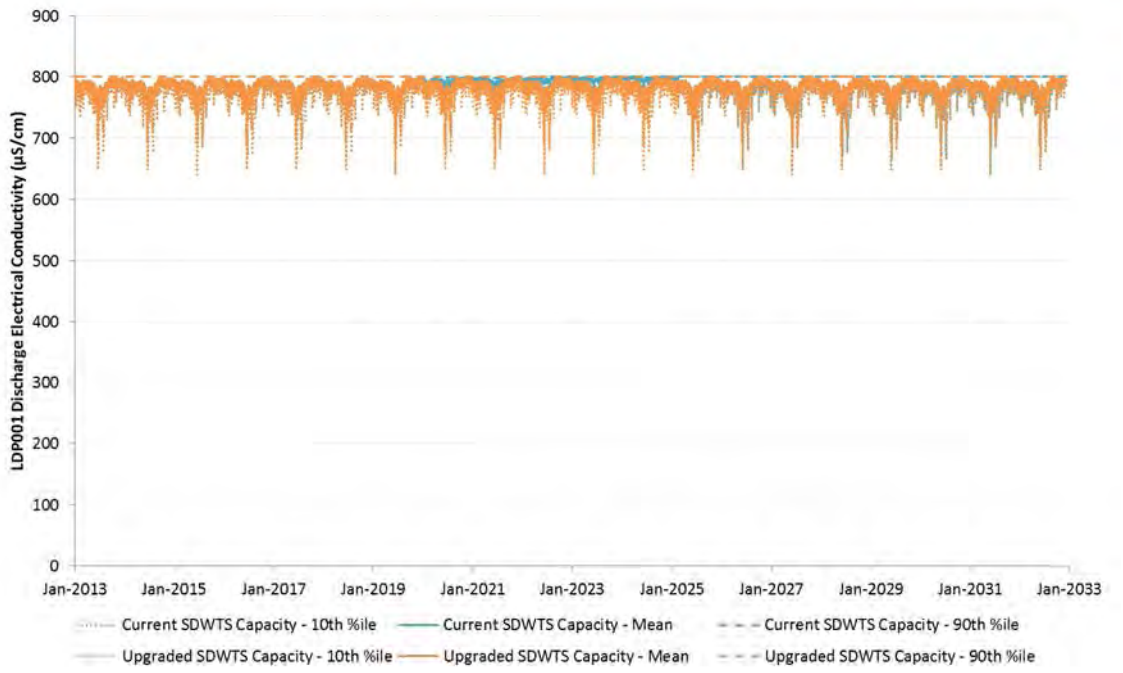


Figure 5-11 Predicted Electrical Conductivity of LDP001 Discharges

The average EC of discharges through LDP001 was predicted to range between approximately 780 µS/cm and 800 µS/cm. Variability is present in the salinity of LDP001 discharges due to runoff periodically diluting the EC of mine water make continuously passing through LDP001. A seasonal pattern in salinity is also present in Figure 5-11, corresponding to the pattern found in rainfall and evaporation data, as discussed in Section 3.4.

5.3.3 Predicted LDP002 Discharges

Figure 5-12 presents the time series of the predicted daily EC of discharges through LDP002.

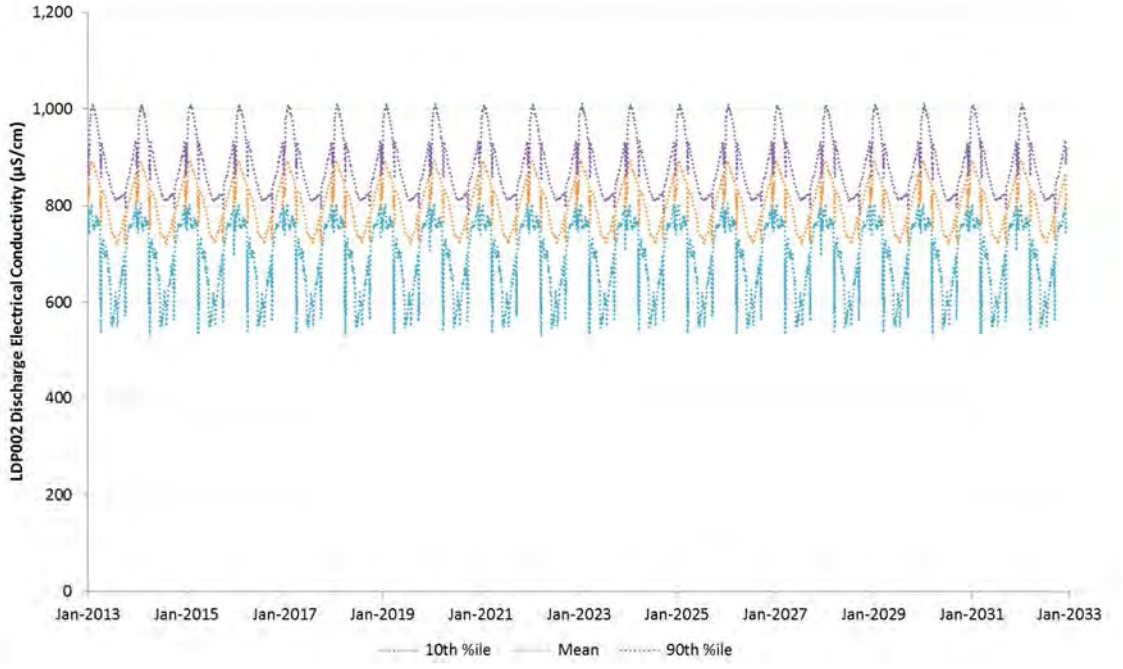


Figure 5-12 Predicted Electrical Conductivity of LDP002 Discharges

The average EC of discharges under existing conditions was predicted to be approximately 800 µS/cm, as the bulk of water passing through LDP002 from the Settling Ponds is expected to be comprised of mine water make recirculated through the water management system. Similar to the daily discharges of water through LDP002, a seasonal pattern can be seen in the daily time series of salinity presented in Figure 5-12.

5.4 Qualifications on Predictions

Predicted water transfers are based upon a mix of data. Typical data sources for model construction and verification included:

- Relatively reliable data:
  - SILO rainfall data.
  - BOM evaporation data.
  - Surface catchment areas based on topographic maps.
  - Annual potable water demands.
  - Metered pumping data for water transfers.
- Less reliable data:
  - Runoff rates for impervious and natural catchments.
  - Estimates of some storage capacities.
  - Estimates of future rates of mine water make.

As a result of the items listed within the 'less reliable data' category there is likely to be a risk that the accuracy of the model estimations is somewhat limited. It is therefore suggested that the individual predictions given herein should be considered reliable to ±30% until more site data is gathered. Additional data will allow refinement of the data sources and model predictions.

It should also be noted that the adoption of historical rainfall and evaporation data within the detailed water balance model, does not include the potential impacts of climate change.

6. Summary

The Water and Salt Balance Assessment considers the overall water management system associated with Angus Place Colliery and the impacts of the Project in assessing future conditions. The assessment has been undertaken to quantify the existing and proposed water and salt budgets such that potential impacts of the Project may be assessed.

The water and salt balance for the existing conditions was developed based on information provided by Angus Place Colliery regarding current operations and water management, as well as other sourced data such as meteorological data.

The existing conditions model was then amended to incorporate modifications corresponding to the Project. The full duration of the Project was modelled with 112 different rainfall patterns to assess the possible impacts of the Project on the water and salt balances at Angus Place Colliery. The 112 rainfall patterns each comprised the historic time series of 112 years of daily rainfall data, with each pattern using a different starting year within the time series.

Angus Place Colliery, along with Springvale Mine, transfers excess groundwater not used to meet operational requirements to the SDWTS. Currently, the capacity of the SDWTS is 30 ML/day however this will be upgraded to 50 ML/day in the future. The assessment of the water management system included an evaluation of transfers occurring with the current SDWTS capacity compared with an upgraded SDWTS capacity.

For existing conditions in 2013, the largest source of water and salt were associated with groundwater inflows into the underground workings. On average, groundwater inflows account for approximately 97% (3,154 ML) of all water and 99% (1,690 tonnes) of all salt inflows into the Angus Place Colliery water management system, followed by direct rainfall and runoff to surface storages and potable water.

Water predicted to be transferred to the SDWTS represents on average 72% (2,355 ML) of all water and 74% (1,262 tonnes) of all salt outputs from the site under existing conditions. The second and third largest annual water and salt outputs from the system on average are predicted to be discharges through LDP001, representing 22% (732 ML) of water and 22% (384 tonnes) of salt, and discharges through LDP002, representing 3% (106 ML) of water and 3% (55 tonnes) of salt outflows from the Angus Place Colliery water management system.

The proposed conditions at Angus Place Colliery were based on site conditions in 2030, when mine water make into the underground workings is predicted to peak. Amendments to the model to represent the proposed conditions were associated with the management of the expected increase in volume of mine water make due to extraction of the proposed workings.

For proposed conditions in 2030, the largest source of water and salt will continue to be associated with groundwater inflows into the active underground workings. On average, modelled groundwater inflows account for approximately 99% (10,541 ML) of all water and 99% (5,650 tonnes) of all salt inflows into the Angus Place Colliery water management system, followed by direct rainfall and runoff to surface storages and potable water.

Water predicted to be transferred to the SDWTS represents on average 91% (9,742 ML) of all water and 92% (5,222 tonnes) of all salt outputs from the site under proposed conditions. Discharges through LDP001 and LDP002 are not expected to change as a result of the proposed Project in 2030.

7. References

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Appendices

Appendix A – Operational Conditions

Table A-1 Operational Conditions for Water Transfers

Feature	Comment
Administration building	Inflows from: • Potable water from Lithgow City Council (demands everyday). Outflows to: • Discharges excess water to the Carpark Pit.
Bathhouse building	Inflows from: • Potable water from Lithgow City Council (demands only on production days). Outflows to: • Discharges excess water to the Carpark Pit.
Carpark Pit	Inflows from: • Discharges from administration and bathhouse buildings. • Runoff from carpark. Outflows to: • Discharges to on-site wastewater treatment and Maturation Pond.
Maturation Ponds	Inflows from: • Discharges from Carpark Pit. Outflows to: • Losses due to evaporation. • Overflows are applied to the irrigation area.
Fire Fighting Tanks	Inflows from: • Receives water pumped from 48 Cut Through Dam. Outflows to: • Pumped transfers to the underground operations. • Pumped transfers to the CHP. • Pumped transfers water to Rainwater Tanks when volume in tanks is less than 20% of capacity and will continue until volume is greater than 80% of capacity. • Overflows to the LDP001 Dam and Wetlands.
LDP001	Inflows from: • Fire Fighting Tanks overflows (approximately 50% of overflows are directed through a series of wetlands with the remainder diverted around the wetlands). • Runoff from the natural upstream catchment.

Feature	Comment
Rainwater Tanks	Inflows from: • Rainwater from workshop roof. • Pumped transfers from Fire Fighting Tanks. Outflows to: • Transfers to the vehicle washdown.
Vehicle Washdown	Inflows from: • Transfers from the Rainwater Tanks. Outflows to: • Discharges runoff to the Grit Trap.
Grit Trap	Inflows from: • Receives water from the vehicle washdown. Outflows to: • Removal of grit by contractor. • Pumped transfers to the Oil/Water Separator.
Oil/Water Separator	Inflows from: • Pumped transfers from the Grit Trap. • Runoff from external catchment. • Overflows from the Rainwater Tanks. Outflows to: • Overflows to the Settling Ponds.
Primary Pollution Pond	Inflows from: • Runoff from the CHP. • Runoff from external catchment. Outflows to: • Overflows to Secondary Pollution Pond.
Secondary Pollution Pond	Inflows from: • Overflows from Primary Pollution Pond. • Runoff from external catchment. Outflows to: • Overflows to the Filter Pond.
Filter Pond	Inflows from: • Overflows from Secondary Pollution Pond. • Runoff from external catchment. Outflows to: • Overflows to the Settling Ponds.

Feature	Comment
Settling Ponds	Inflows from: • Overflows from Filter Pond and Oil/Water Separator. • Runoff from external catchment. Outflows to: • Overflows to LDP002.
900 District	Inflows from: • Receives 900 District mine water make. • Receives transfers from 48 Cut Through Dam. • Receives Angus Place East mine water make that is not able to be transferred to SDWTS. • Receives process water from the Fire Fighting Tanks. Outflows to: • Discharges to the SDWTS via 940 Dewatering Bore. • Remainder of flows are directed to the 930 Dam.
930 Dam	Inflows from: • Receives water from Kerosene Vale underground workings. • Receives transfers from 900 District. Outflows to: • Transfers water to the 48 Cut Through Dam.
48 Cut Through Dam	Inflows from: • Dirty water runoff into the 302 Portal. • Northern Panels mine water make. • Transfers from 930 Dam. Outflows to: • Transfers to Fire Fighting Tanks. • Transfers to 900 District.
Springvale-Delta Water Transfer Scheme	Inflows from: • Pumped transfers from Springvale Mine. • Transfers from the 940 Dewatering Bore. • Transfers from the APE Bores. Outflows to: • Pumped transfers to Wallerawang Power Station. • Discharge through LDP009 at Springvale Mine.

Appendix B – Additional Modelling Results

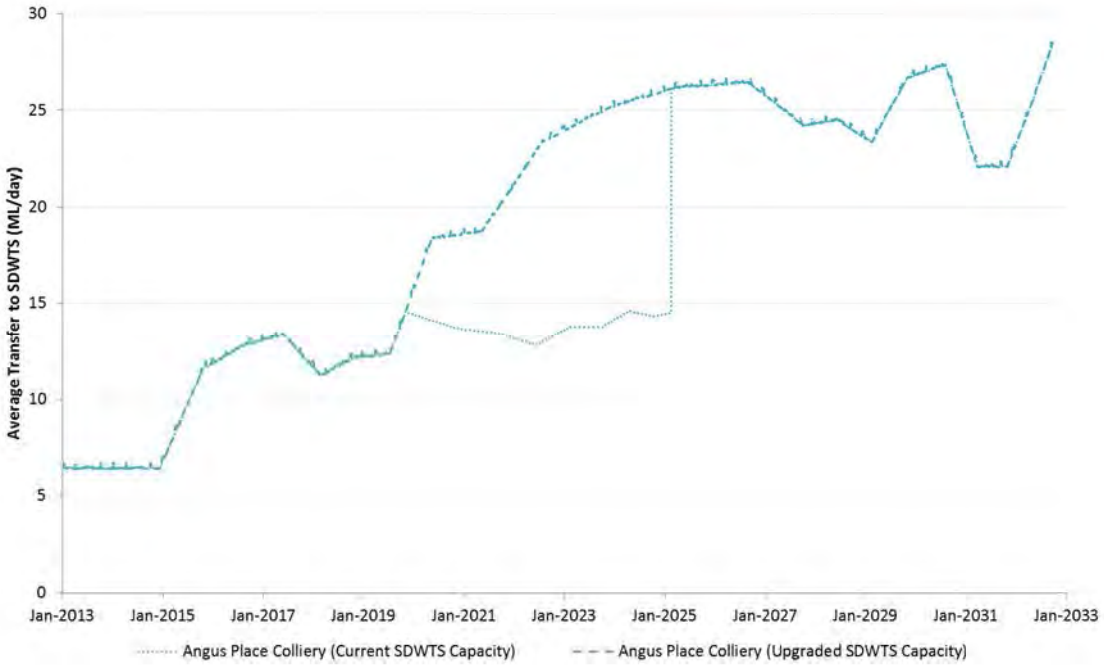

Figure B-1 Predicted Daily Average Transfers to the SDWTS

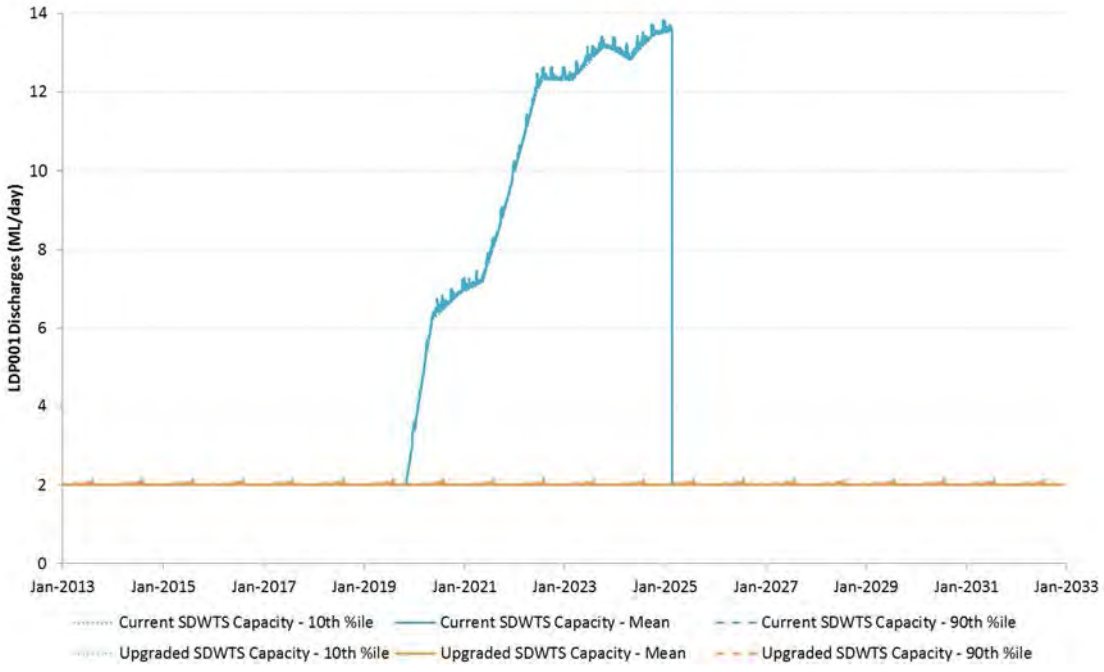

Figure B-2 Predicted Daily LDP001 Discharges

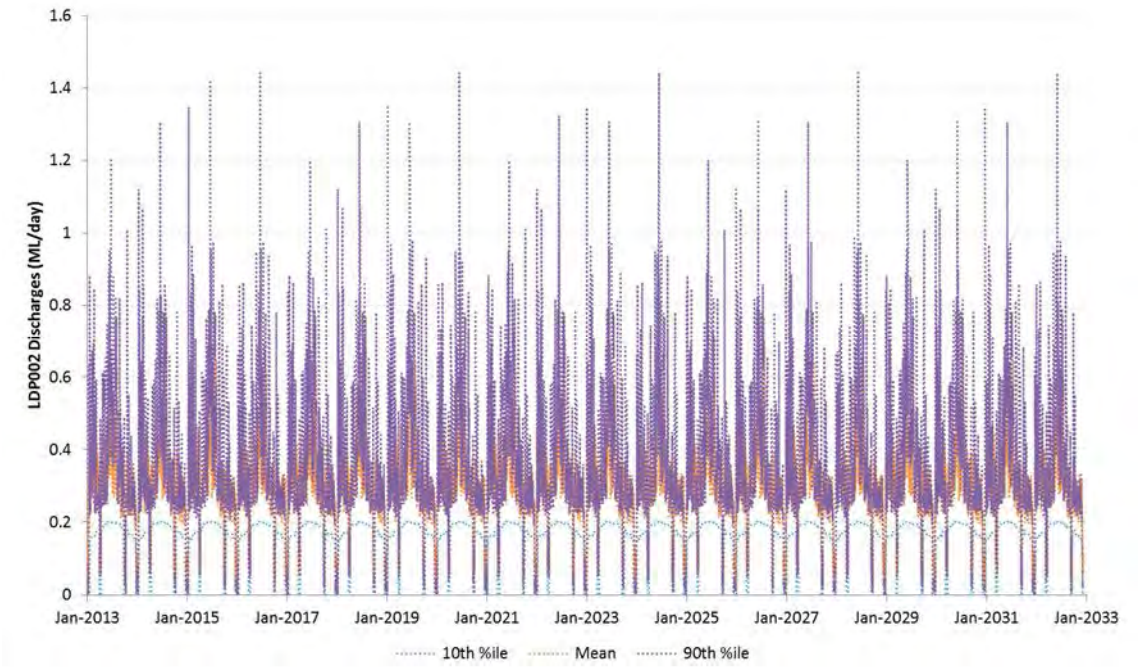

Figure B-3 Predicted Daily LDP002 Discharges

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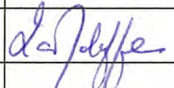
Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	S. Callander T. Davies	I. Joliffe		S. Gray		09/10/13
1	S. Callander T. Davies	I. Joliffe		S. Gray		06/11/13

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APPENDIX E:
REGIONAL WATER BALANCE ASSESSMENT

Centennial Coal

Western Coalfield Water Balance

Centennial Coal

November 2013

Executive Summary

Overview

Centennial Coal (Centennial) is currently in the process of planning extensions to its coal mining and handling operations in the Western Coalfield, to be developed over the next 25 years. As part of this process, Centennial wishes to understand the potential cumulative impact of current and future operations on the regional water balance by considering the cumulative water inputs and outputs of both Centennial and non-Centennial coal mining operations in the region. GHD Pty Ltd (GHD) was engaged by Centennial to develop this regional water balance and identify interactions with the relevant surface water and groundwater Water Sharing Plans (WSPs) as well as compare current and future discharges with Centennial's Environment Protection Licence (EPL) limits.

Centennial currently has four operating mines located between Lithgow and Kandos (Angus Place Colliery, Charbon Colliery, Clarence Colliery and Springvale Mine). Centennial also owns and operates the Western Coal Services and Lidsdale Siding sites, which includes coal handling, processing and transport facilities, and manages several non-operating sites within the Western Coalfield including Airly Mine, Lamberts Gully, and Ivanhoe.

Water Sources

Under Section 50 of the WM Act, the Study Area for the assessment is regulated by four WSPs. Two are for groundwater and two for surface water. The two groundwater WSPs covering the Study Area are the Greater Metropolitan Region (GMR) and the NSW Murray Darling Basin (MDB) porous rock groundwater sources. The two surface water WSPs covering the Study Area are the Greater Metropolitan Region Unregulated River Water Sources (GMRU water sources) and the Macquarie Bogan Unregulated and Alluvial Water Sources (MBUA water sources).Each WSP consists of several water sources which are regulated by a water extraction entitlement. Overall, the assessed sites interact with eight water sources, including:

- Sydney Basin Coxs River Groundwater Source (GMR WSP).
- Sydney Basin Richmond Groundwater Source (GMR WSP).
- Sydney Basin North Groundwater Source (GMR WSP).
- Sydney Basin MDB Groundwater Source (MDB WSP).
- Upper Nepean and Upstream Warragamba Surface Water Source (GMRU WSP).
- Hawkesbury and Lower Nepean Rivers Water Source (GMRU WSP).
- Turon Crudine River Water Source (MBUA WSP).
- Upper Cudgegong River Water Source (MBUA WSP).

Assessment

The licensed extractions and discharges associated with the water sources listed above were determined by water balance modelling. With regard to extractions, the water balance assessment was limited to considering the licensed extractions, i.e. those regulated by Water Access Licences (WALs). With regard to discharges, this water balance assessment is limited to considering the licensed discharges, i.e. those regulated by EPLs and defined as LDPs. The harvesting and use of runoff at each site was not considered by this assessment, unless the flows contribute to a LDP.

Groundwater extraction for this study is defined as the removal of groundwater from a groundwater source or aquifer, either via direct removal for use via a production bore or via incidental flow of groundwater from the aquifer into the mine workings during and after mining.

Where hydrogeological modelling had been undertaken, extractions from groundwater sources were estimated conceptually from existing information. For other sites, groundwater extraction was conceptually derived from available information or a conceptual hydrogeological model was developed. Predictions for LDP discharges were estimated from detailed site water balance models where possible. Otherwise, information incorporated into the model was derived from existing water balance reports or conceptual models developed with the appropriate level of detail to simulate any anticipated response of extractions and discharges to rainfall conditions.

The regional water balance model incorporated predicted groundwater extractions and site operation data for a simulation timeline of 25 years (2013 to 2038). Probabilistic modelling, using the Monte Carlo simulation method, estimated the range of possible outcomes as a result of rainfall variation. The water balance modelling estimated the range of predicted licensed extractions and discharges over the simulation timeline for each site and water source.

Outcomes

The cumulative impact of the coal mining industry in the Western Coalfield was quantified by the outcomes of water balance modelling undertaken for Centennial operated coal mines, other identified coal mines and power generation activities undertaken in the Study Area.

Current total extractions from all groundwater sources are estimated to be approximately 18,000 ML/yr, of which 15,000 ML/yr is extracted by Centennial operated mine sites. Peak extraction from all groundwater sources is predicted to occur in 2024 at a rate of approximately 28,600 ML/yr. Extraction of ground water from Centennial sites is also predicted to peak in 2024 at 25,600 ML/yr. By the end of the assessment period in 2038 groundwater extractions across all sites is largely attributed by Centennial sites at a rate of 13,500 ML/yr.

The cumulative impact on each groundwater source was estimated to vary according to the mining operations extracting from each source. Some sources are expected to undergo significant increases in extraction rates over the first half over the assessment period, whilst extraction from other sources are to decrease over time or peak in the middle of the assessment period.

The total licensed discharge from the sites assessed is predicted to peak at approximately 17,500 ML/yr in 2016. After 2016 until the end of the assessment period licensed discharges are expected to decrease as the number of active mining operations decreases with time.

The cumulative impact on each surface water source also varies according to the mining operations discharging into each source. The licensed discharge from each source is predicted to peak at different times throughout the assessment period but discharges to all sources are predicted to significantly decrease by the end of the assessment period.

No licensing shortfalls were identified for volumetric discharges through LDPs with respect to groundwater discharges. It is recommended however that the adequacy of LDP volumetric discharges is completed on a site by site basis to include the interaction of site water cycles and catchment runoff.

The assessment demonstrated that licensed discharges into the Upper Nepean and Upstream Warragamba Water Source contribute to a significant proportion of the water extracted for power generation by Delta Electricity. The supply of water from Springvale Mine and Angus Place Colliery via the SDWTS also supply a significant volume of water to Delta Electricity.

The outcomes from the assessment indicate that there are no expected sustained increases to pollution loads from current operations.

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Glossary

Alluvial	Pertaining to material, such as sand or silt, deposited by running water.
Aquifer	Under the *Water Management Act 2000* an aquifer is a geological structure or formation, or an artificial landfill, that is permeated with water or is capable of being permeated with water. For the purposes of this study, an aquifer also includes flooded mine workings in equilibrium with the surrounding strata and perched aquifers recharged directly from rainfall infiltration.
Aquifer interference	The *Water Management Act 2000* defines an aquifer interference activity as that which involves any of the following: • The penetration of an aquifer. • The interference with water in an aquifer. • The obstruction of the flow of water in an aquifer. • The taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations. • The disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.
Ash	A major by-product of coal fuelled electricity generation. Bottom ash is collected from the bottom of the boilers while fly ash is an inert mineral matter collected in a dust collection plant.
Bord and pillar	A mining system whereby coal is extracted leaving pillars of untouched coal to support the strata above.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Brackish water	Water that has more salinity than fresh water, but not as much as seawater. Typically containing between 0.5 and 30 grams of dissolved slat per litre of water.
Catchment	The land area draining through the main stream and tributary streams to a particular location.
Coal handling and preparation plant	A facility where coal is washed, screened and prepared for transport off site.
Coal preparation plant	A facility where coal is screened and prepared for transport off site.
Depression storage	The volume of water that must be filled prior to the generation of runoff for a particular land use
Dewatering	The removal or pumping of water from an above or below ground storage, including the mine water within the water collection system of mine workings. Water removed from mine workings is regarded as dewatering unless the workings are flooded and at equilibrium with the surrounding strata (in which case the removal is considered groundwater extraction).
Discharge	Quantity of water per unit of time flowing in a stream, for example cubic meters per second or megalitres per day.
Electrical conductivity	A measure of the concentration of dissolved salts in water.

Ephemeral	Stream that is usually dry, but may contain water for rare and irregular periods, usually after significant rain.
Fracture	Cracks within the ground strata, either natural or resulting from underground mining works.
Groundwater	Water in a saturated zone, stratum or aquifer beneath the surface of the land.
Groundwater extraction	For the purposes of this study, groundwater extraction has been defined as the removal of groundwater from a groundwater source or aquifer, either via direct removal for use via a production bore or via incidental flow of groundwater from the aquifer into the mine workings during and after mining. Groundwater extraction includes the pumping of underground water from flooded mine workings in equilibrium with the surrounding strata as well as the removal of water from perched aquifers recharged directly from rainfall infiltration.
Guideline	Numerical value or narrative statement that provides appropriate guidance for a designated water use or impact.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks.
Hydrology	The study of rainfall and surface runoff processes.
Infiltration	The downward movement of water into soil and rock. It is largely governed by the structural condition of the soil, the nature of the soil surface (including presence of vegetation) and the antecedent moisture content of the soil.
Interburden	The strata between coal seams.
Licenced Discharge Point	A location where the premises discharge water in accordance with conditions stipulated within the site Environment Protection Licence.
Long-term average annual extraction limit	An estimated sustainable extraction limit for a groundwater source, based on the proportion of annual rainfall recharge that may sustainably be released for use.
Longwall mining	Underground coal mining where a block of coal is mined using a longwall shearer, supported by roadway development that is created using a continuous miner unit.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.
Meteorology	The science concerned with the processes and phenomena of the atmosphere, especially as a means of forecasting the weather.
Outcrop	Where the bedrock is exposed at the ground surface.
Overburden	The strata between the recoverable topsoil and the upper coal seam.
Pan factor	Reduction factor applied to measured pan evaporation to simulate evaporation from natural water bodies and surface water storages.
Partial extraction	A continuous miner system of mining whereby some of the coal pillars in a panel, or parts thereof, are systematically extracted.
Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.

pH	Value measure used to represent the acidity or alkalinity of an aqueous solution. A value of 7 is applied to a water that is neither acidic or alkaline. A value less than 7 represents an acidic condition.
Potable water	Water of a quality suitable for drinking.
Reach	Defined section of a stream with a uniform character and behaviour.
Recharge	Inflow of water from surrounding strata into underground mine workings via infiltration. This can be as a result of rainfall events or from surrounding aquifers.
Reject	The by-product resulting from the processing of coal, including rock and coal material that is out of sale specifications.
Runoff	Amount of rainfall that ends up as streamflow.
Run of mine	Raw coal production (unprocessed).
SILO	An enhanced climate data bank based on historical climate data from 1889 provided by the Bureau of Meteorology. Records are mainly based on observed data, with interpolation where there are data gaps.
Strata	Geological layers below the ground surface.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	Representation of the features and configuration of land surfaces.
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.
Unassigned water	The difference between the average long-term sustainable extraction limit for a water source and the actual total entitlement within that water source at any point in time. Unassigned water may be released via a Controlled Allocation Order.
Underground water	Water stored in underground aquifers. During the mining process a proportion of this water is released and managed by the underground settling and pumping system.
Water allocation	Total annual volume of water attributed to a share component of a water source. Usually one share equals 1 ML/yr.
Water entitlement	Total annual volume of water available for extraction from a water source by a licence holder.
Water Sharing Plan	A legal document prepared under the *Water Management Act 2000* that establishes rules for sharing water between the environmental needs of the river or aquifer and water users and also different types of water use.

Abbreviations

ANZECC	Australia New Zealand Environment Conservation Council
AWBM	Australian Water Balance Model
Banpu	Banpu Public Company Limited
BOM	Bureau of Meteorology
BS	Baseflow storage
Centennial	Centennial Coal Company Limited
Centennial Airly	Centennial Airly Coal Pty Ltd
Centennial Angus Place	Centennial Angus Place Pty Ltd
Centennial Springvale	Centennial Springvale Pty Ltd
Charbon Coal	Charbon Coal Pty Ltd
CHPP	Coal handling and preparation plant
Coalpac	Coalpac Pty Ltd
CPP	Coal preparation plant
EC	Electrical conductivity
Enhance Place	Enhance Place Pty Ltd
EPL	Environment Protection Licence
GHD	GHD Pty Ltd
GMR	Greater Metropolitan Region
GMRU water sources	Greater Metropolitan Region Unregulated River Water Sources
ha	Hectares
HMTV	Hardness-modified trigger value
Ivanhoe Coal	Ivanhoe Coal Pty Ltd
km	Kilometres
L/s	Litres per second
LDP	Licenced Discharge Point
LTAAEL	Long-term average annual extraction limit
m	Metres
m/day	Metres per day
m/s	Metres per second
MBUA water sources	Macquarie Bogan Unregulated and Alluvial Water Sources
MDB	Murray Darling Basin
mg/L	Milligrams per litre

ML	Megalitres
ML/day	Megalitres per day
ML/Unit Share/yr	Megalitres per Unit Share per year
ML/yr	Megalitres per year
mm	Millimetres
Mtpa	Million tonnes per annum
NOW	NSW Office of Water
NTU	Nephelometric turbidity unit
POEO Act	Protection of the Environment Operations Act 1997
REA	Reject emplacement area
ROM	Run of mine
SDWTS	Springvale-Delta Water Transfer Scheme
Springvale SK Kores	Springvale SK Kores Pty Ltd
SS	Surface storage
SSTV	Site-specific trigger value
TSS	Total suspended solids
USGS	United States Geological Survey
VWP	Vibrating wire piezometer
WAL	Water Access Licence
WM Act	Water Management Act 2000
WSP	Water Sharing Plan
WTP	Water Treatment Plant
µS/cm	Microsiemens per centimetre

1. Introduction

1.1 Background

Centennial Coal Company Limited (Centennial) is a wholly owned subsidiary of Banpu Public Company Limited (Banpu), who purchased Centennial in 2010. Centennial is a coal mining and marketing company supplying thermal and coking coal to the domestic and export markets. The company is a major fuel supplier to the NSW energy industry, fuelling approximately 46% of the State's coal-fired electricity.

Centennial is one of the major coal mine operators within the Western Coalfield of NSW, located along the western edge of the Sydney Basin. Coal mining has been carried out in the Western Coalfield for about 150 years and currently the area produces mostly thermal grade coal for local coal-fired power stations. Centennial currently has four operating mines located between Lithgow and Kandos (Angus Place Colliery, Charbon Colliery, Clarence Colliery and Springvale Mine). Centennial also owns and operates the Western Coal Services and Lidsdale Siding sites, which includes coal handling, processing and transport facilities, and manages several non-operating sites within the Western Coalfield including Airly Mine (placed in care and maintenance in 2013), Lamberts Gully (rehabilitation project) and Ivanhoe (rehabilitation project). The regional locality of Centennial's existing operations is shown in Figure 1-1.

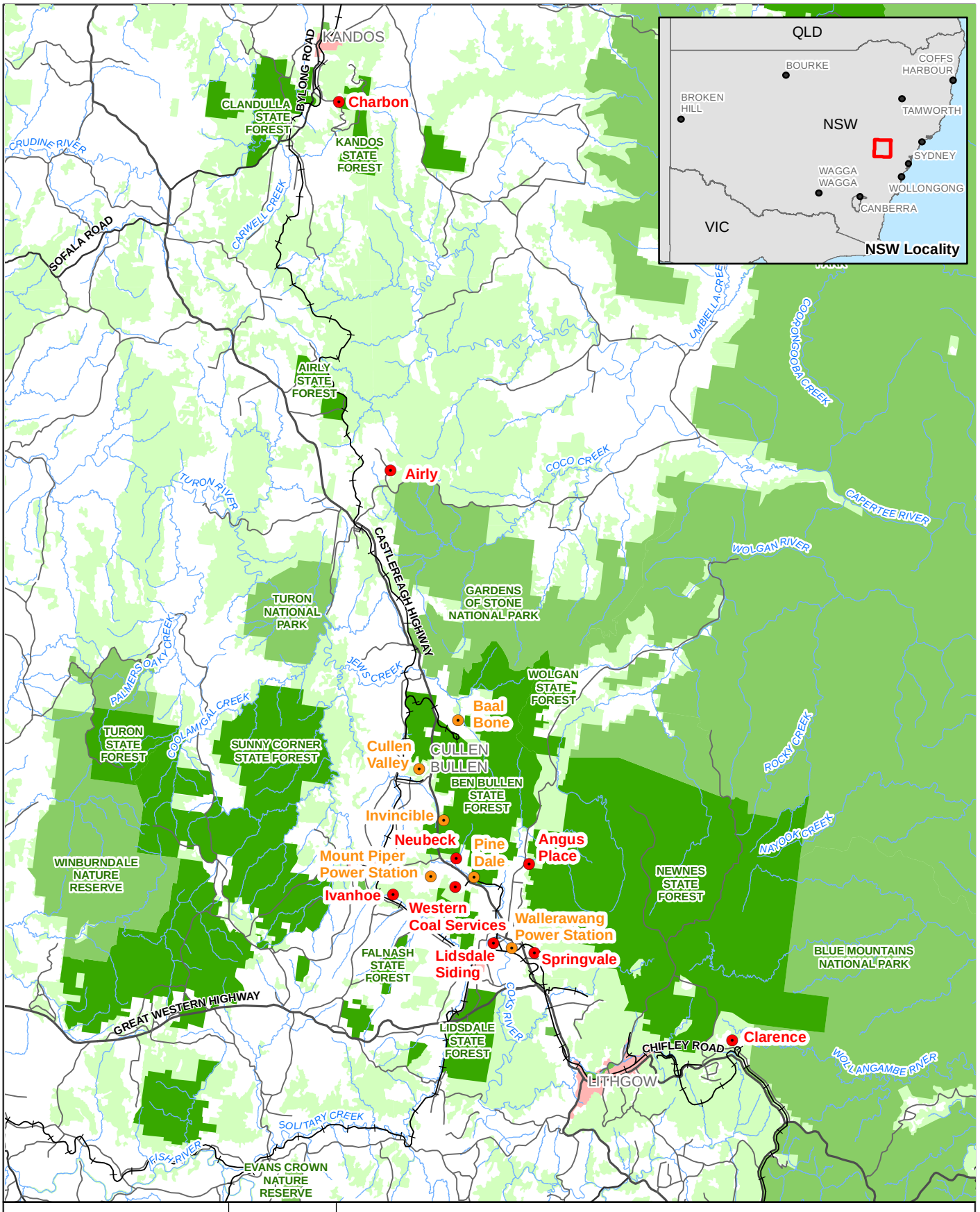
Centennial is currently in the process of planning extensions to its coal mining and handling operations in the Western Coalfield, to be developed over the next 25 years. As part of this process, Centennial wishes to understand the potential cumulative impact of current and future operations on the regional water balance by considering the cumulative water inputs and outputs of both Centennial and non-Centennial coal mining operations in the region. GHD Pty Ltd (GHD) was engaged by Centennial to develop this regional water balance and identify interactions with the relevant surface water and groundwater Water Sharing Plans (WSPs) as well as compare current and future discharges with Centennial's Environment Protection Licence (EPL) limits.

1.2 Purpose of this Document

The purpose of the regional water balance is provide context to the cumulative impacts of coal mining with respect to water demands and distribution in the Western Coalfield (South) over the next 25 years. This document is to support site-specific surface water and groundwater impact assessments prepared for proposed Centennial mining projects in the Study Area.

1.3 Study Area

The Study Area for the regional water balance assessment has been defined by the surface and underground footprint of existing and future mining and power generation operations in the Western Coalfield (South). Generally, this area extends from Kandos in the north to Lithgow in the south and from the Blue Mountains and Wollemi National Parks in the east to the western edge of the Sydney Basin in the west. The Study Area boundary is shown in Figure 1-2. The Study Area has been divided into a Northern Study Area and Southern Study Area.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Existing Rail
- Dual Carriageway
- Principal Road
- Secondary Road
- Minor Road
- Waterway
- Waterbody
- Built Up Area
- Nature Conservation
- State Forest
- Forest Or Shrub

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

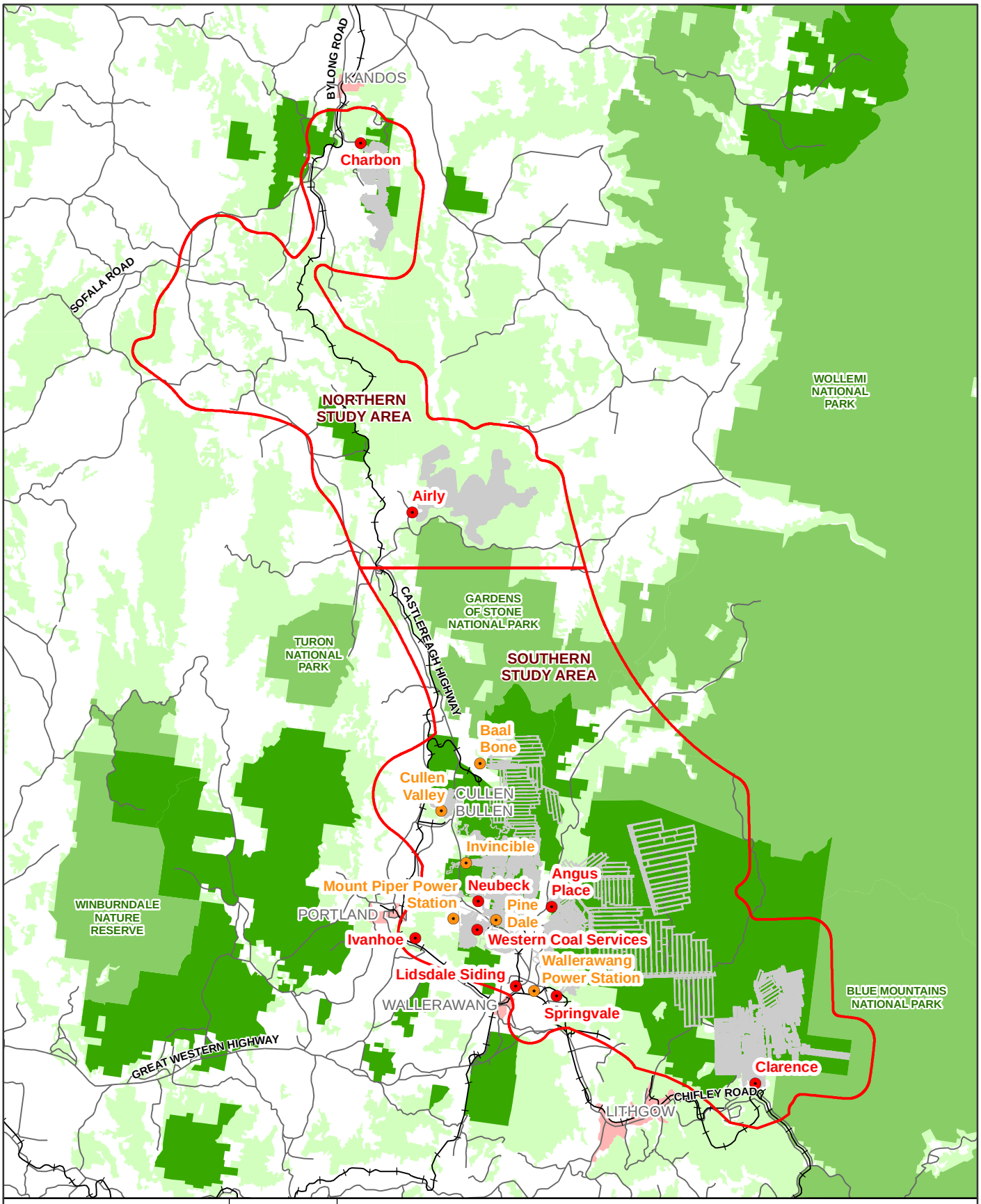
Western Coalfield Locality

Centennial Coal

DATE 2/08/2013

Figure 1-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB001_Locality_0.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Study Area
- Mine Workings
- Roads
- Existing Rail
- Built Up Area
- Nature Conservation
- State Forest
- Forest Or Shrub

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

Study Area

Centennial Coal

DATE 2/08/2013

Figure 1-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB002_StudyArea_0.mxd

1.4 Objectives of the Regional Water Balance

The objectives of the regional water balance assessment have been defined as follows:

- Assess the cumulative impact of the coal mining industry in the Western Coalfield with respect to licensed water extractions and licensed discharges between 2013 and 2038.
- Quantify the annual cumulative licensed water take and water discharge by Centennial owned sites throughout the Western Coalfield for each year between 2013 and 2038 and assess the outcomes with respect to relevant WSP and EPL requirements.
- Quantify the annual cumulative licensed water take and water discharge by other identified coal mining operations in the Western Coalfield for each year between 2013 and 2038.
- Identify potential Water Access Licence (WAL) or EPL volumetric limit shortfalls that may exist for each Centennial-owned site over the modelling period.
- Identify potential water quality issues arising from cumulative discharges to waterways by Centennial-owned sites.
- Inform Centennial's regional water management strategy for the Western Coalfield.

1.5 Scope of Works

The following tasks have been undertaken to develop the regional water balance:

- Review existing relevant information that is available for Centennial-owned sites and non-Centennial sites. The surface sites that have been incorporated into the regional water balance are considered to be the major water users within the Study Area. The locations of these sites are shown in Figure 1-1.
- Collate existing spatial data (including mine plans, geology, waterways and catchments, WSP boundaries and topography data) into ArcGIS geodatabases.
- Review legislative context and clarify water licensing rules under the applicable WSPs.
- Develop water cycle schematics for modelled sites, including the underground workings associated with each site and the WSP water sources that interact with each site.
- Develop a regional scale water cycle schematic that shows water transfers between modelled sites as well as between WSP water sources and modelled sites.
- Represent the regional scale water cycle and site water cycles in a GoldSim regional water balance model, utilising existing water balance models and reports where possible.
- Determine groundwater seepage rates into existing and future mine workings (underground and open cut) throughout the Study Area over the period 2013 to 2038 (utilising existing hydrogeological modelling where possible), including the extraction from each WSP groundwater source, and input into the GoldSim model.
- Run the regional water balance model to quantify the cumulative water take of each assessed site from each WSP water source and cumulative discharge to each WSP water source via Licensed Discharge Points (LDPs) over the period 2013 to 2038.
- Run the regional water balance model to quantify the cumulative water take from each WSP water source from mining operations and electricity generators and cumulative discharge to each WSP water source via LDPs over the period 2013 to 2038.
- Assess predicted water take and water discharge rates against WSP and EPL requirements to identify potential licensing shortfalls for Centennial sites between 2013 and 2038.

- Prepare a regional water balance report to document the assessment undertaken, the assumptions and limitations, and the results and recommendations.

1.6 Assumptions and Limitations

1.6.1 Extent of the Water Balance Assessment

This water balance assessment of the Western Coalfield considers the cumulative impact of coal mining and associated operations (i.e. power generation) in the Western Coalfield on licensed water extractions and discharges. The sites assessed are limited to those listed in Table 1-1, which were determined in consultation with Centennial as the known coal mining and associated operations occurring over the next 25 year period. Other industries or water users in the region have therefore not been considered in this assessment.

Table 1-1 Sites Incorporated into the Regional Water Balance Model

Site	Owner	Site Details	Status
Airly Mine	Centennial Airly	Underground Coal Mine	Care and maintenance and Project
Angus Place Colliery	Centennial Springvale / SK Kores	Underground coal mine	Operational and Project
Baal Bone Colliery	Oakbridge (Glencore Xstrata) / Sumitomo	Underground and open cut coal mine	Care and maintenance
Charbon Colliery	Centennial / SK Energy	Underground and open cut coal mine	Operational
Clarence Colliery	Centennial / SK Energy	Underground coal mine	Operational
Coalpac Consolidation Project	Coalpac	Underground and open cut coal mine	Care and maintenance
Ivanhoe No. 2 Colliery	Ivanhoe Coal	Former underground and open cut coal mine	Rehabilitation
Ivanhoe North Rehabilitation Project	Ivanhoe Coal	Former underground and open cut coal mine	Rehabilitation
Lidsdale Siding	Ivanhoe Coal	Rail loading	Operational and Project
Mount Piper Power Station	Delta Electricity	Power station	Operational
Neubeck Project	Centennial Springvale / SK Kores	Proposed open cut coal mine	Project
Pine Dale Coal Mine	Enhance Place	Open cut coal mine	Operational
Springvale Mine	Centennial Springvale / Springvale SK Kores	Underground coal mine	Operational and Project

Site	Owner	Site Details	Status
Western Coal Services	Centennial Springvale / Springvale SK Kores	Coal processing and handling; former open cut coal mine	Operational and Project (rehabilitation at Lamberts Gully)
Wallerawang Power Station	Delta Electricity	Power station	Operational

The future status of projects pending approval cannot be confirmed and is therefore a limitation of the results presented in this report.

For old underground workings in the region that are not part of the current water management system for a site, it has been assumed that these underground water storages are at equilibrium with the adjacent aquifer. Therefore, it is assumed there is no extraction from groundwater sources for these underground storages.

With regard to extractions, this water balance assessment is limited to considering the licensed extractions, i.e. those regulated by WALs. With regard to discharges, this water balance assessment is limited to considering the licensed discharges, i.e. those regulated by EPLs and defined as LDPs. The harvesting and use of runoff at each site has not been considered by this assessment, unless the flows contribute to a LDP.

The extraction from surface water sources for individual mine sites was not determined in this assessment. Surface water extractions for mine sites are dependent on consultation with NOW on a site-by-site basis. The impacts of variations to surface water runoff regimes and collection have not been considered by this assessment.

Potable water supply and wastewater discharges from sites have also been excluded by this assessment as sites do not require licences for the supply of potable water and wastewater discharges (although licensed) do not contribute to surface water sources as generating runoff from these activities is typically not permitted.

1.6.2 Availability of Information

In developing the water balance for the Western Coalfield region, information relating to the water cycle at each site has been drawn upon from a range of sources. For some sites where detailed site information was available, GHD has developed detailed representations of the water cycle in the modelling software. For other sites GHD has drawn upon the information presented in previously completed water balance reports and surface water assessments.

Where GHD has not developed a modelled representation of an individual site, information and data relating to these sites has been determined from reviewing available information. Particularly for non-Centennial sites, this data is typically limited to publicly available information. GHD has endeavoured to interpret information presented in these reports as accurately as possible in the modelling undertaken but cannot be responsible for inaccuracies due to misleading or absent information in the reports reviewed.

1.6.3 Timing of Operations

The commencement of mining operations and the cessation of operations have an impact on the assessment of licensing requirements undertaken. If project timelines change from the timelines assumed for this assessment, the recommended licensing requirements may be impacted.

1.6.4 Trading of Water Access Licences

This assessment assumes WAL licences will be traded freely between Centennial sites within WSP water sources to meet project water demands of different mining operations. These trades are subject to applicable local impact management restrictions which have not been considered by this assessment.

1.6.5 Climate Change

The impacts of climate change have not been considered by this assessment. The assessment period extends for a 25 year period from 2013 to 2038 and any potential impacts of climate change over this time period are unlikely to affect the outcomes from the water balance for the following reasons:

- The outcomes from modelling has been presented as a range of possible values (10th percentile, mean and 90th percentile). The variation due to climate change is likely to be within the variation of values presented.
- Primary drivers to for the regional modelling are changes to groundwater extractions and the distribution of this water over the simulation timeline. The impacts of climate change on groundwater over such a timescale are insignificant due to limited correlation between inflows into underground workings and rainfall.
- The inputs into the modelling for some sites are adopted from other reports which were derived from models GHD has not had access to. Incorporating the impacts on climate change was not possible without access to the models.

2. Legislation and Policy

This section provides an overview of the legislation, policies and guidelines relevant to this regional water balance assessment.

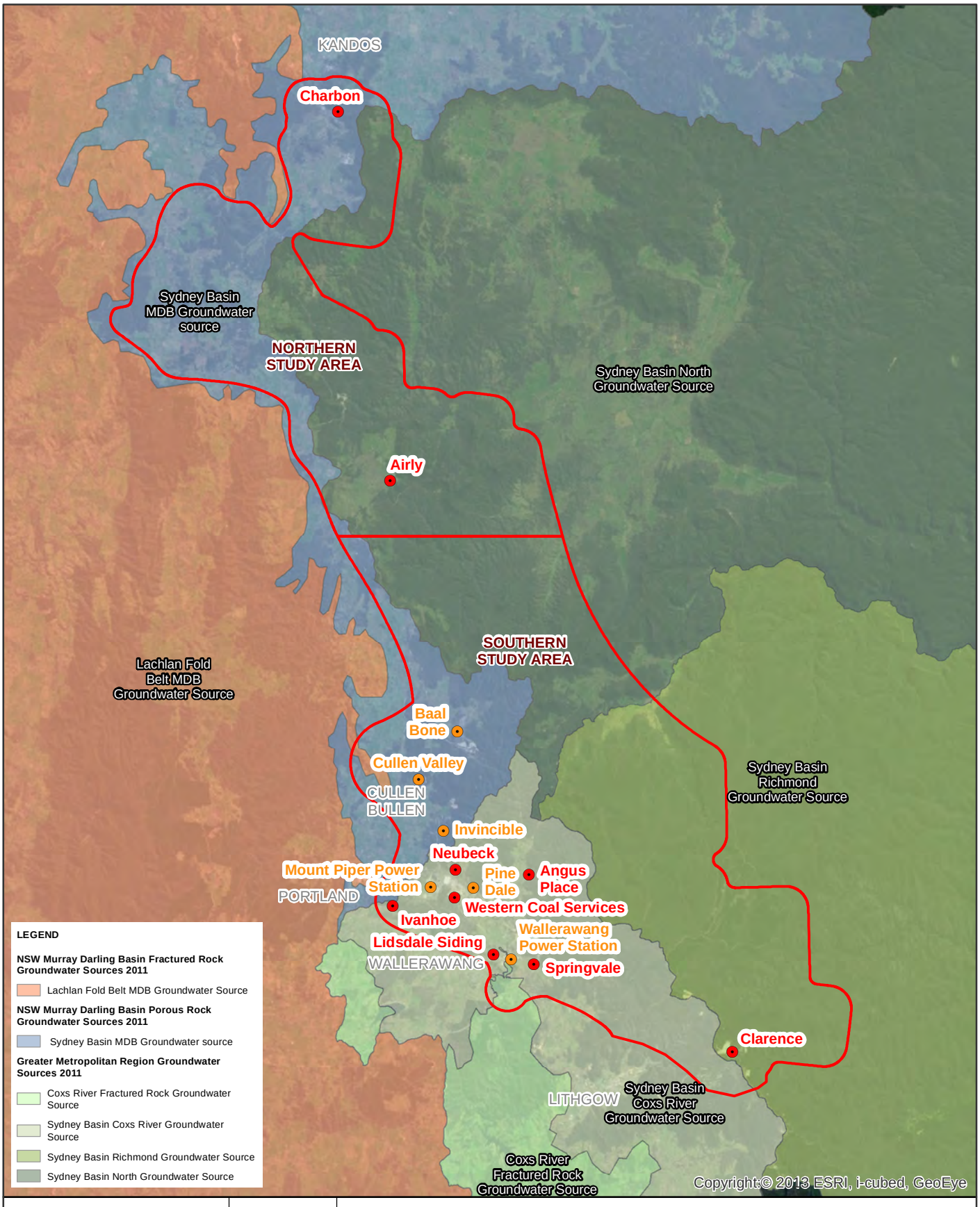
2.1 Water Management Act 2000

The *Water Management Act 2000* (WM Act), administered by NSW Office of Water (NOW), is intended to ensure that water resources are conserved and properly managed for sustainable use benefitting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions.

An amendment to the WM Act (Section 60I) came into effect on 1 March 2013. This amendment provides that it is an offence for a person without an access licence to take, remove or divert water from a water source or relocate water from one part of an aquifer to another part of an aquifer in the course of carrying out a mining activity. Various activities are captured by the provisions of the amendment including mining, mineral exploration and petroleum exploration.

The Study Area is regulated by four WSPs made under Section 50 of the WM Act. Two are for groundwater and two for surface water. The two groundwater WSPs covering the Study Area are the Greater Metropolitan Region (GMR) and the NSW Murray Darling Basin (MDB) porous rock groundwater sources. The two surface water WSPs covering the Study Area are the Greater Metropolitan Region Unregulated River Water Sources (GMRU water sources) and the Macquarie Bogan Unregulated and Alluvial Water Sources (MBUA water sources).

The boundaries of the applicable groundwater and surface water WSPs are shown in Figure 2-1 and Figure 2-2 and are outlined in the following sections.



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Study Area

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

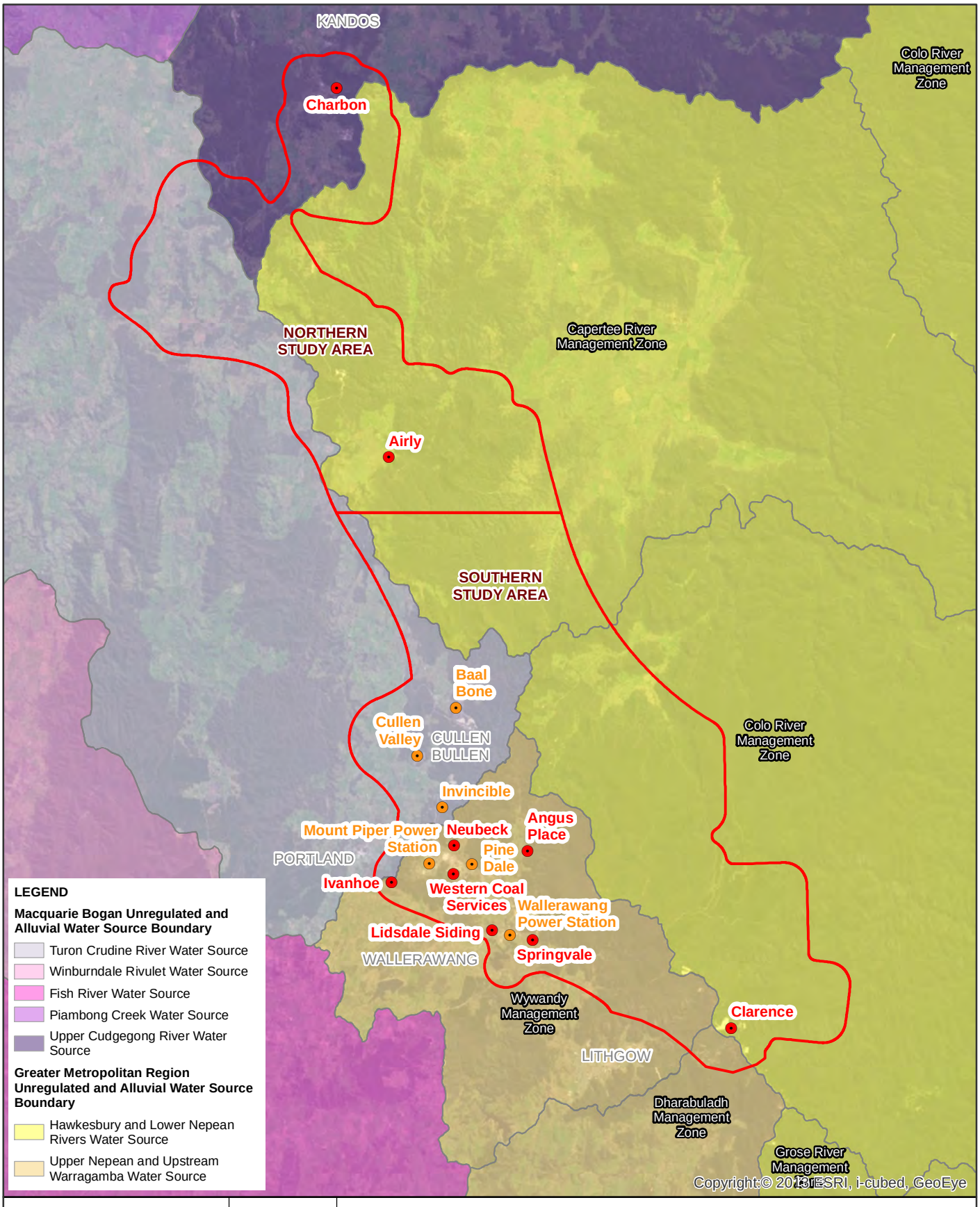
Groundwater WSP Boundaries

Centennial Coal

DATE 2/08/2013

Figure 2-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB003_Groundwater_Boundary_0.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Study Area

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

Surface Water WSP Boundaries

Centennial Coal

DATE 2/08/2013

Figure 2-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB005_SurfaceWater_Boundary_A.mxd

2.1.1 Greater Metropolitan Region Groundwater Sources

The WSP for the GMR groundwater sources covers 13 groundwater sources on the east coast of NSW. Table 2-1 identifies the water extraction entitlement for each of the sources within the GMR groundwater sources at the commencement of the WSP (July 2011), based on existing groundwater extraction licences under the *Water Act 1912*, and the long-term average annual extraction limit (LTAAEL). The LTAAEL is an estimated sustainable extraction limit for each of the groundwater sources, based on the proportion of annual rainfall recharge that may sustainably be released for use.

Table 2-1 GMR Groundwater Source Extraction Entitlement and Limit

Groundwater Source	Entitlement (ML/Unit Share/yr)	LTAAEL (ML/yr)
Botany Sands	11,156	14,684
Maroota Tertiary Sands	189	645
Metropolitan Coastal Sands	1,409	27,206
Sydney Basin North	**557**	**19,682**
Sydney Basin Richmond	**15,923**	**21,103**
Sydney Basin Central	2,592	45,915
Sydney Basin Blue Mountains	138	7,039
Sydney Basin Nepean	16,294	99,568
Sydney Basin South	2,880	69,892
Hawkesbury Alluvium	1,019	2,456
Sydney Basin Coxs River	**6,926**	**17,108**
Goulbourn Fractured Rock	3,151	53,074
Coxs River Fractured Rock	114	6,806

** Correct at the time of commencement of the WSP (July 2011)

There are embargoes on applications being made for new commercial licenses in the Botany Sands and Sydney Basin Blue Mountains groundwater sources, as well as orders applying under Section 324 of the WM Act that restrict water extraction in these groundwater sources.

Three GMR groundwater sources fall within the Study Area:

1. Sydney Basin North.
2. Sydney Basin Richmond.
3. Sydney Basin Coxs River.

The Southern Study Area borders the Coxs River Fractured Rock groundwater source; however, it is considered that current and future mining operations do not intercept this source. Old workings within this source are considered to be at equilibrium with the groundwater environment and not extracting from the source.

Each source provides rules on:

- Access.
- Managing water allocation accounts.
- Granting and amending water supply works approvals.
- Rules for the use of water supply works approvals.
- Limits to availability of water.
- Trading rules.

Rules are standard for access, managing water allocation accounts, access licences, water supply works approvals, availability of water and trading rules. Note that for each source, the trading rules state that inputs into groundwater sources are not permitted.

There is some variation across the source rules for granting and amending water supply works approvals; more specifically these rules vary for the distance between which water supply works can be granted or amended from existing bores or rules for replacement groundwater works. In other cases specific rules apply for site specific features, for example the Sydney Basin Coxs River Groundwater Source and Sydney Basin North Groundwater Source outline rules for groundwater dependent culturally significant sites.

For a comprehensive list of the groundwater source rules refer to Table A–1, Table A–2 and Table A–3 in Appendix A.

2.1.2 Murray-Darling Basin Porous Rock Groundwater Sources

The NSW MDB porous rock groundwater sources are located within the NSW portion of the MDB. The outcropped and buried groundwater sources within the plan cover a total area of approximately 12,078,000 ha. There are four groundwater sources within the plan. Existing bore depths range from 20 m to 200 m with most bores being less than 60 m deep. Groundwater quality may limit its potential use.

The water extraction entitlement for each of the sources within the MDB porous rock groundwater sources and the LTAAEL is identified in Table 2-2.

Table 2-2 Current MDB Groundwater Sources Extraction Entitlement and Limit

Groundwater Source	Entitlement (ML/Unit Share/yr)	LTAAEL (ML/yr)
Gunnedah-Oxley Basin MDB	16,309	199,893
Oaklands Basin	0	N/A
Sydney Basin MDB	**2,657**	**60,443**
Western Murray Porous Rock	21,780	530,486

As the Oaklands Basin groundwater source is entirely buried, it does not have an LTAAEL. A small amount (0.002% of the total storage capacity) of extraction from the groundwater source is instead allowed from the storage component.

There is only one set of groundwater source rules applicable for the Study Area; that being the Sydney Basin MDB Groundwater Source rules.

This set of rules provides guidance on:

- Limits to the availability of water.
- Access rules.
- Rules for granting and amending water supply works approvals.
- Trading rules.

For a comprehensive list of source rules, please refer to Table A–4 in Appendix A. As for the GMR groundwater sources, the trading of water into the Sydney Basin MDB Porous Rock Groundwater Source is not permitted.

2.1.3 Greater Metropolitan Region Unregulated River Water Sources

The GMRU water sources WSP covers an area of approximately 3,250,000 ha. The WSP covers six water sources which are made up of 87 management zones. The water extraction entitlement and active licences within the GMRU water sources are identified in Table 2-3.

Table 2-3 Current GMRU Water Sources Extraction Entitlement and Licences

Water Source	Entitlement (ML/yr)	Number of Licences
Shoalhaven River	362,270	185
Illawarra Rivers	3,045	105
Upper Nepean and Upstream Warragamba	**669,520**	**411**
Hawkesbury and Lower Nepean	**120,532**	**1,395**
Southern Sydney Rivers	35,341	63
Northern Sydney Rivers	1,865	49

Detailed long-term water use is not available in the unregulated rivers since there is not yet broad scale metering in these water sources. However all surface water licences with an entitlement of greater than 10 ML across the catchment of the Hawkesbury and Nepean Rivers will be metered.

Two water source rules are applicable for the GMRU water sources within this Study Area. These rules provide guidance on:

- Access rules – providing specific access rules for the varying licence classes (A Class to C Class).
- Trading rules – providing specific management strategies for into and within the management zone. In all cases conversion to a high flow access licence is not permitted.

These rules are provided for the Wywandy River Management Zone (Upper Nepean and Upstream Warramgamba Water Source) and the Colo River and Capertree River Management Zones (Hawkesbury and Lower Nepean Water Source).

For details on source rules, particularly extraction and trading rules specific to each zone please refer to Table A–5 and Table A–6 in Appendix A.

2.1.4 Macquarie Bogan Unregulated and Alluvial Water Sources

The area covered by the MBUA water sources WSP covers both the Macquarie and Bogan Catchments containing 30 unregulated water sources covering an area of 7,400,000 ha, as well as four alluvial groundwater sources. The MBUA water sources plan area is shown in Figure 2-2. The water extraction entitlement and active licences within the MBUA water sources are outlined in Table 2-4.

Table 2-4 MBUA Water Sources Extraction Entitlement and Licences

Water Source	Entitlement (ML/yr)	Number of Licences
Unregulated Water Sources		
Backwater Boggy Cowal	4,449	20
Bell River	7,878	108
Bulbodney Grahway Creek	7,795	47
Burrendong Dam Tributaries	579	13
Campbells River	2,116	57
Coolbaggie Creek	470	4
Cooyal Wialdra Creek	820	29
Ewenmar Creek	1299	15
Fish River	18,080	49
Goolma Creek	0	0
Lawsons Creek	1499	32
Little River	2,347	37
Lower Bogan River	42,844	57
Lower Macquarie River	51,934	33
Lower Talbragar River	1,701	14
Macquarie River above Burrendong	25,611	107
Marra Creek	374.5	18
Marthaguy Creek	4,458	44
Maryvale Geurie Creek	737	5
Molong Creek	5,598	122
Piambong Creek	974	14
Pipeclay Creek	426	14
Queen Charlottes Vale Evans Plains Creek	1908	54
Summerhill Creek	12,228	96

Water Source	Entitlement (ML/yr)	Number of Licences
Turon Crudine River	**328**	**15**
Upper Bogan River	2,821	39
Upper Cudgegong River	**6,462**	**49**
Upper Talbragar River	382	9
Wambangalong Whylandra Creek	169	5
Winburdale Rivulet	1,636	30
Alluvial Groundwater Sources		
Bell alluvial	4,362	51
Cudgegong alluvial	13,595	78
Talbragar alluvial	5,812	26
Upper Macquarie alluvial	32,648	136

Two water source rules exist for the MBUA water sources located within the Study Area:

1. Turon Crudine River.
2. Upper Cudgegong River.

These rules provide guidance on:

- Access rules – including 'cease to pump' limits and reference points.
- Trading rules.

In general, the access rules and trading rules are identical across sites. In both cases, no trading is permitted into the water source with trades only permitted within the water source, subject to assessment. Further 'cease to pump' and trading rules apply to the Rylstone Dam, covered by the Upper Cudgegong River Water Source.

For details on source rules, particularly the rules specific to the Upper Cudgegong River Water Source, please refer to Table A–7 and Table A–8 in Appendix A.

2.1.5 Additional Groundwater Entitlements

An application can be made for a water access licence if a person has acquired the right to apply for the licence under a controlled allocation order. A controlled allocation order was made 31 May 2013 under Section 65 of the WM Act. This controlled allocation order was made to provide a limited number of aquifer access licences to groundwater sources that previously had unassigned water.

The additional entitlements applicable to the relevant groundwater sources are outlined in Table 2-5.

Table 2-5 Additional Groundwater Entitlements

Groundwater Source	Entitlement (ML/yr)
Coxs River Fractured Rock Groundwater Source	325
Sydney Basin Coxs River Groundwater Source	337
Sydney Basin Murray-Darling Basin Groundwater Source	2,882
Sydney Basin North Groundwater Source	920
Sydney Basin Richmond Groundwater Source	176

2.2 Protection of the Environment Operations Act 1997

The objectives of the *Protection of the Environment Operations Act 1997* (POEO Act) are to protect, restore and enhance the quality of the environment. Some of the mechanisms that can be applied under the POEO Act to achieve these objectives include reduction of pollution at source and monitoring and reporting of environmental quality.

EPLs issued under the POEO Act are a means by which the impact on the environment is regulated where a scheduled activity is conducted. Table 4-1 lists the EPLs for each location in the Western Coalfield and relevant licence discharge information.

2.3 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy was finalised in September 2012 and clarifies the water licensing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining activities.

This Policy outlines the water licensing requirements under the *Water Act 1912* and WM Act and identifies that the Policy does not exempt an activity from the requirement to obtain an EPL under the POEO Act. A water licence is required whether water is taken for consumptive use or whether it is taken incidentally by the aquifer interference activity (such as groundwater filling a void) even where that water is not being used consumptively as part of the activity's operation. Under the WM Act, a water licence gives its holder a share of the total entitlement available for extraction from the groundwater source. The water access licence must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times. Sufficient access licences must be held to account for all water taken from a groundwater or surface water source as a result of an aquifer interference activity, both for the life of the activity and after the activity has ceased. Where the WSP provides for unassigned water in a water source (i.e. the total entitlement is less than the LTAAEL), a controlled allocation order may be made under Section 65 of the WM Act to release more water.

Many mining operations continue to take water from groundwater sources after operations have ceased. This take of water continues until an aquifer system reaches equilibrium and must be licensed.

The Policy also identifies the assessment process for aquifer interference activities including the minimum environmental impact considerations for various water sources including alluvial and porous and fractured rock.

Many aspects of this Policy will be given legal effect in the future through an Aquifer Interference Regulation. Stage 1 of the Aquifer Interference Regulation commenced on 30 June 2011.

3. Existing Environment

3.1 Landform/Topography

The Western Coalfield Study Area lies on the western slopes of the north-south oriented sandstone ridgeline of the Great Dividing Range, to the west of the Wollemi and Blue Mountains National Parks. The Study Area consists primarily of undulating hills and mountain tops, with some low lying areas.

The region is surrounded by state recognised forests and reserves, including the Turon State Forest and Winburndale Nature Reserve to the west, and the Wolgan State Forest and Newnes State Forest to the east. The region to the north of the study area consists primarily of forest/ shrub. These low-lying areas have been cleared of natural vegetation for agricultural, commercial and industrial purposes, including coal and shale mining, forestry and power generation. Other surrounding land use includes the Mount Piper and Wallerawang Power Stations. Nearby residential areas include Lithgow and Wallerawang to the south and Portland and Cullen Bullen to the west. The township of Kandos is located to the north of the Study Area.

3.2 Surface Water

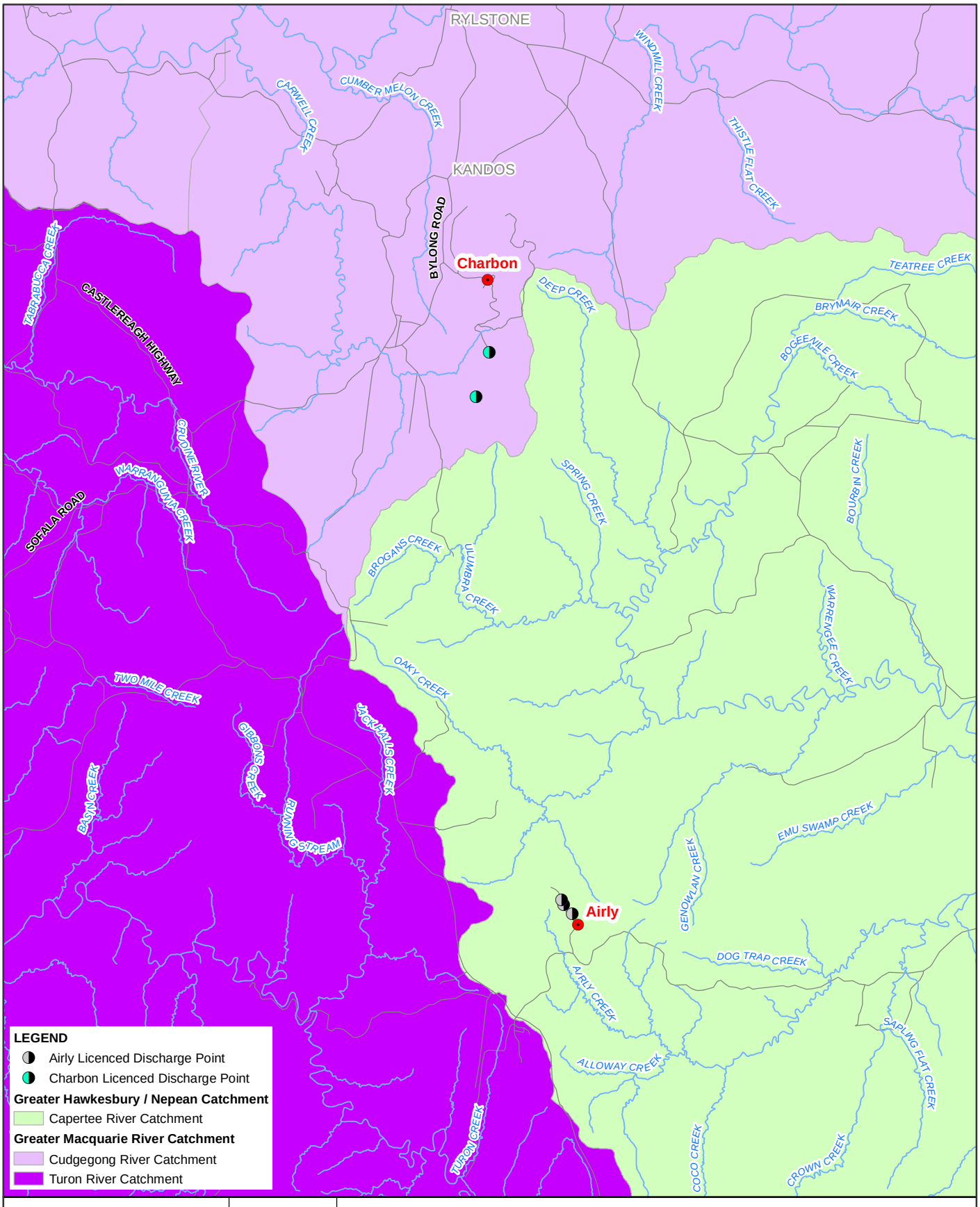
The Study Area encompasses two primary water catchment areas: the Greater Macquarie River Catchment, which is within the MDB, and the Greater Hawkesbury/Nepean Catchment. Figure 3-1 and Figure 3-2 indicate the catchment areas, Centennial and non-Centennial sites and locality of LDPs within the Northern Study Area and Southern Study Area respectively.

The Greater Macquarie River Catchment is located in central NSW, west of the Great Dividing Range. The Macquarie River originates in the Great Dividing Range south of Bathurst and is formed by the junction of the Fish River and Campbells River. The river flows in a north-west direction for approximately 960 km until it joins the Barwon River. Major tributaries of the Greater Macquarie River Catchment include Fish River, Turon River, Crudine River and Cudgegong River.

The Greater Macquarie River Catchment comprises three smaller catchments in the Study Area: Cudgegong River Catchment, Fish River Catchment and Turon River Catchment. Charbon Colliery is located within the Cudgegong River Catchment, and Baal Bone Colliery, the Coalpac Consolidation Project and Ivanhoe North Rehabilitation Project are located within the Turon River Catchment.

The Greater Hawkesbury/Nepean catchment is one of the largest coastal basins in NSW. Over 70% of the catchment consists of mountainous terrain. The Nepean River headwaters rise approximately 100 km south of Sydney and flows north. The Hawkesbury River is formed by the confluence of the Nepean River and Grouse River and flows in a north-east direction. Major tributaries of the Greater Hawkesbury/Nepean Catchment include Coxs River, Colo River, McDonald River and Warragamba River.

The Greater Hawkesbury/Nepean Catchment comprises five smaller catchments in the Study Area: Capertee River Catchment, Coxs River Catchment, Wollangambe River Catchment, Wolgan River Catchment and Grose River Catchment. Airly Mine is located within the Capertee River Catchment and Clarence Colliery is located in the Wollangambe River Catchment. The remaining Centennial and non-Centennial sites (Angus Place Colliery, Ivanhoe No. 2 Colliery, Lidsdale Siding, Mount Piper Power Station, Neubeck Project, Pine Dale Coal Mine, Springvale Mine, Western Coal Services and Wallerawang Power Station) are all located within the Coxs River Catchment.



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0 0.75 1.5 3 4.5 6

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Waterway
- Road

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

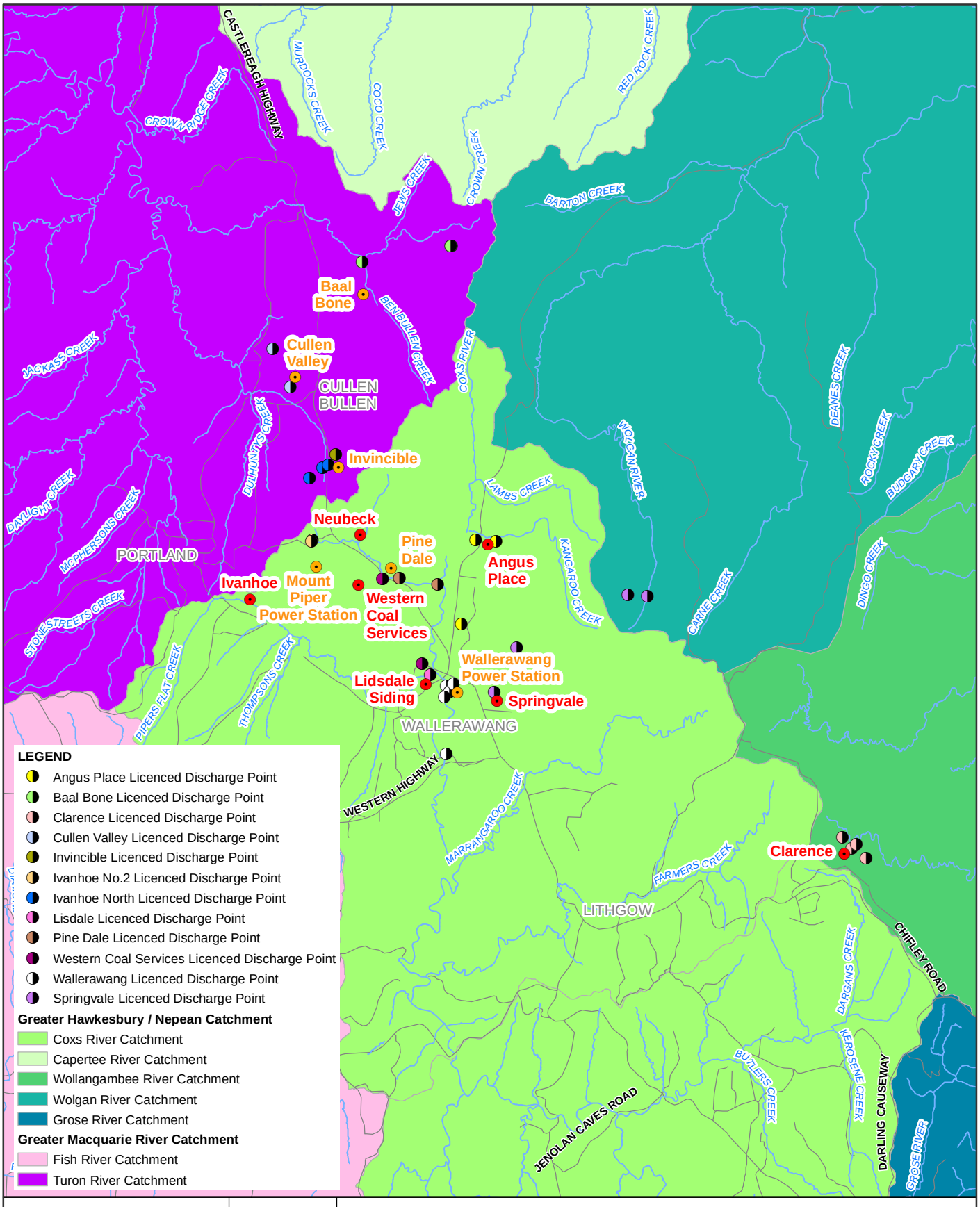
Northern Study Area
Surface Water Catchments

Centennial Coal

DATE 2/08/2013

Figure 3-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB007_Northern_SWCatchments_A.mxd



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0 0.75 1.5 3 4.5 6

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Road
- Waterway

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

Southern Study Area
Surface Water Catchments

Centennial Coal

DATE 7/11/2013

Figure 3-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB008_Southern_SWCatchments_A.mxd

3.3 Geology

The Study Area is geologically located on the western edge of the Sydney Basin. The stratigraphy of the region consists of material from the Tertiary, Triassic and Permian periods.

The Sydney Basin is characterised by coal, shale and sandstone sedimentary beds of Permo-Carboniferous age. These form the gently dipping beds of the Illawarra Coal Measures, capped by shale and sandstone from the Wiannamatta and Narabeen Group (Triassic Period) and Basalt from the Tertiary period.

Directly below the Illawarra Coal Measures lies the silty, coaly sedimentary rocks of the Nile Subgroup and sandy siltstone of the Berry Siltsone.

Basement rocks of western Sydney are folded Palaeozoic metamorphosed rocks of the Lachlan Fold Belt, Late Carboniferous granites and Early Permian Rhylstone Volcanics.

There are seven identified coal seams within this region, listed in descending stratigraphical order as follows:

- Katoomba Seam.
- Middle River Seam.
- Moolarben Seam.
- Upper Irondale Seam.
- Irondale Seam.
- Lidsdale Seam.
- Lithgow Seam.

Seismic activity has been noted along the Coxs River Lineament Fault Zone, a 250 m wide, north-south trending graben structure which follows the valley of Coxs River.

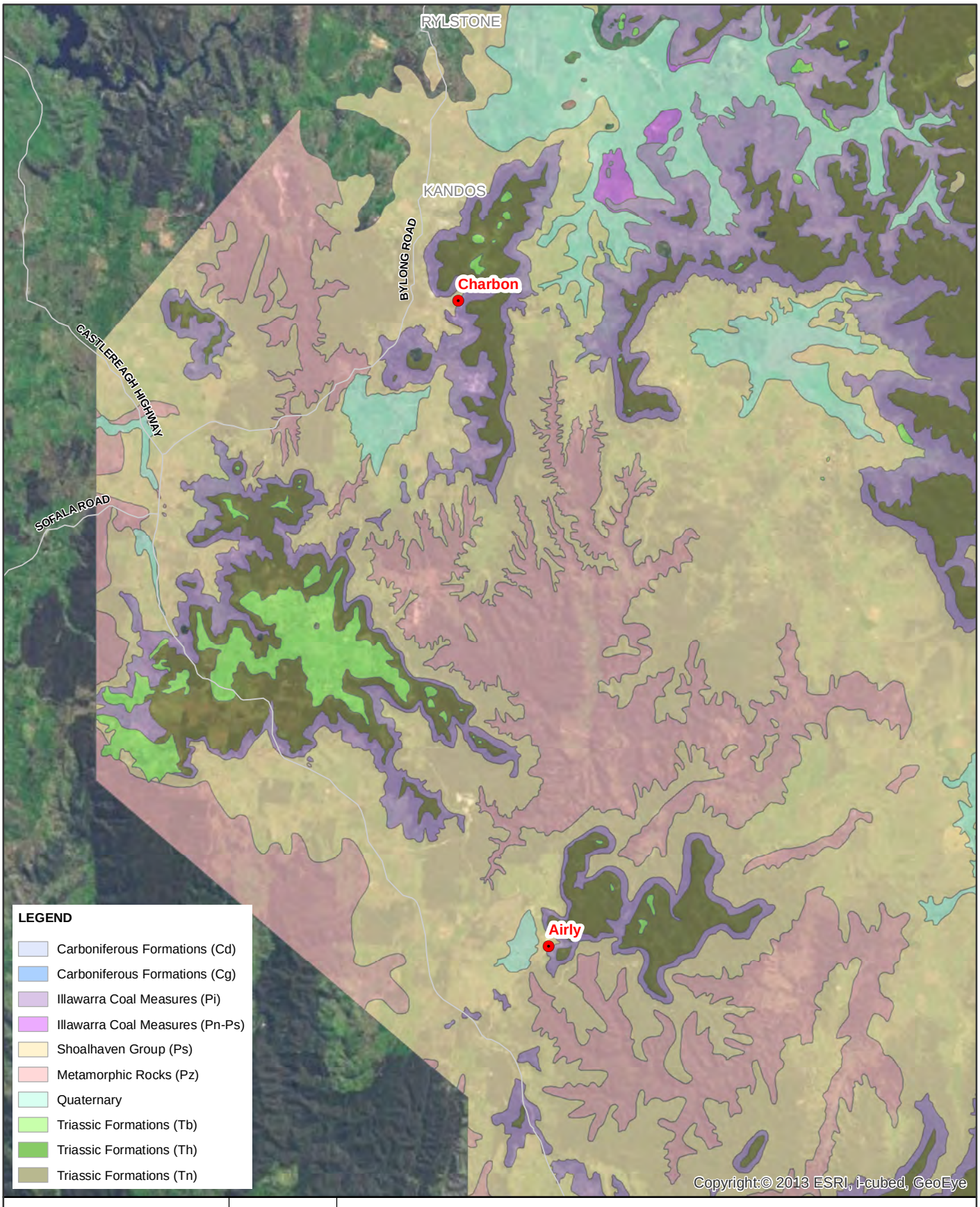
Geological maps for the Northern and Southern study area are shown in Figure 3-3 and Figure 3-4.

3.4 Hydrogeology

3.4.1 Aquifers

The groundwater system surrounding the project area consists of four aquifer systems, including:

- Quaternary alluvium.
- Triassic overburden sediments (sandstone) of the Narrabeen Group.
- Coal seams within the Permian Illawarra Coal Measures, separated by Permian interburden sediments (functioning as aquitards).
- Underlying Marrangaroo (sandstone/conglomerate) Formation.



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0 0.5 1 2 3 4

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Road

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

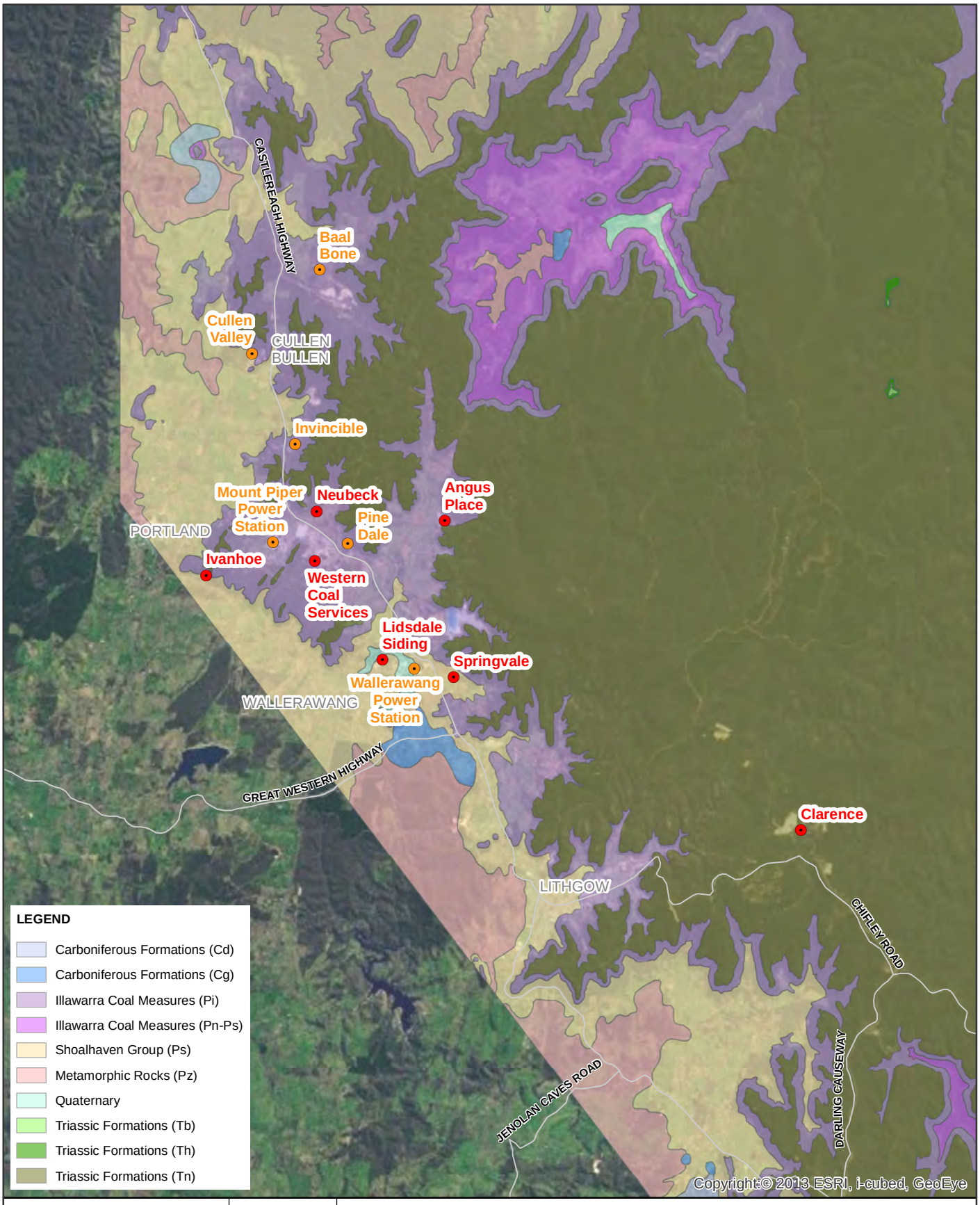
Northern Study Area Geological Map

Centennial Coal

DATE 2/08/2013

Figure 3-3

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB009_NorthernCoalOutcropLocations_A.mxd



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0 0.5 1 2 3 4

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Road

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

Southern Study Area Geological Map

Centennial Coal

DATE 2/08/2013

Figure 3-4

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The properties of each of these groundwater systems is summarised in Table 3-1.

Table 3-1 Aquifer Properties

Aquifer	Description
Quaternary Alluvium Aquifers	Saturated zones are laterally discontinuous and occur in isolated pockets. Perched groundwater present in unconsolidated sands, silts and peat. Generally isolated and of minimal thickness.
Triassic Overburden Sediment Aquifers	Water-bearing zones within the Narrabeen Group. Complex with perched water tables and semi-confined, separated by relatively impermeable claystone layers. Porosity: • Primary: Low flow inter-granular. • Secondary: Higher flow, fractures, bedding partings and fissures.
Permian Coal Measure Aquifers	Overburden/interburden sandstones, siltstones and mudstones (primarily coal seams). Porosity: • Primary: Limited primary porosity (tightly consolidated geological layers). • Secondary: greater due to jointing and localised faulting. Weathered profile. Largely unsaturated.
Permian Marrangaroo Formation Aquifer	Thickness from 2 m to 6 m. Dominantly quartzose in composition grading from granular sandstone to pebble conglomerate. Likely hydraulic conductivity expected to range from 0.05 m/day to 0.5 m/day. Recharge through direct rainfall infiltration and local runoff into outcrop in low-lying areas. Flow north-east and discharges at outcrop areas.

3.4.2 Groundwater Quality

Groundwater quality assessments have been made in respect to Australia New Zealand Environment Conservation Council (ANZECC) criteria and environmental value.

Groundwater present in the Permian aquifers is slightly acidic and of fresh to brackish quality. Within the Lithgow Coal Seam, groundwater is near neutral ranging from a slightly alkaline pH of 6.6 to slightly acidic pH of 7.2.

Assessments of the groundwater in the Permian aquifers have revealed concentrations of iron and manganese that exceed Australian Drinking Water Guideline values and the ANZECC guidelines for irrigation. Due to slightly elevated zinc concentrations, the groundwater at some locations within this region is also considered unsuitable for aquatic ecosystems. It is likely these elevated concentrations are a result of the pre-existing local conditions and are not attributable to mining activities.

4. Site Overviews

4.1 Individual Site Summaries

A brief overview of the mining and power generation operations that have been included in this regional water balance is given in this section.

Figure 4-1 and Figure 4-2 show the location of each site and its associated mine workings (both current and future) with respect to the groundwater sources that are intercepted in the Northern Study Area and Southern Study Area respectively. The majority of mine workings are within the Sydney Basin Coxs River and Sydney Basin Richmond Groundwater Sources.

4.1.1 Centennial Sites

Airly Mine

Airly Mine is an underground coal mine located near Capertee Village, approximately 40 km north-west of Lithgow. Centennial Airly Coal Pty Ltd (Centennial Airly) acquired Airly Mine in 1997, with coal production commencing in 2009. Airly Mine has approval to produce up to 1.8 million tonnes per annum (Mtpa) of run of mine (ROM) coal, which is transported by rail to Port Kembla for the export market. Airly Mine moved to a care and maintenance phase in January 2013, during which mining operations have ceased.

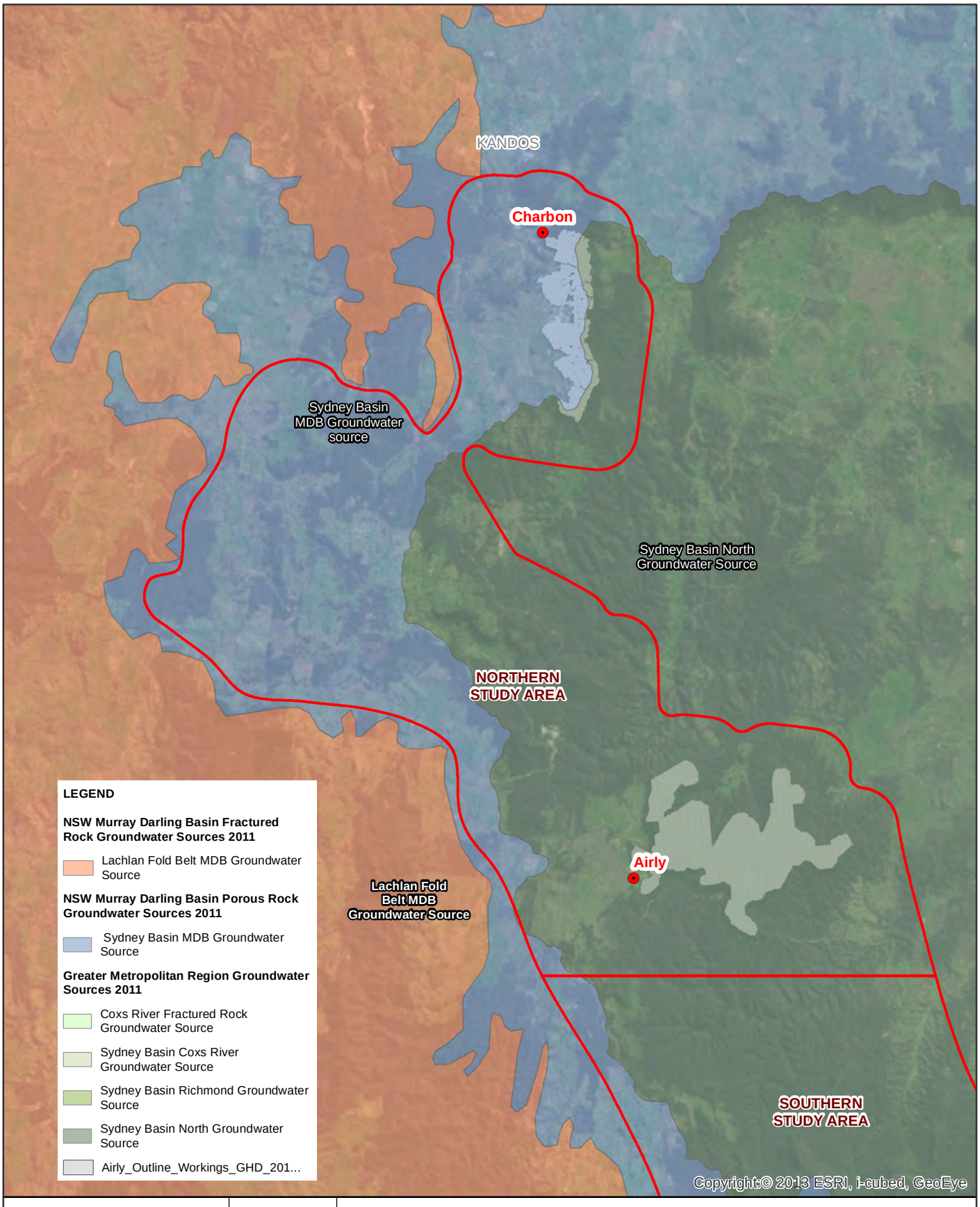
Centennial Airly is currently seeking approval to extend mining operations employing a range of partial extraction mining methods. As part of the project, Centennial Airly proposes to construct a coal preparation plant (CPP) and life-of-mine reject emplacement area (REA).

Water is required at Airly Mine for underground mining activities, coal processing and dust suppression and is supplied by surface water storages and supplemented by a production bore. All groundwater extraction at Airly Mine (via the production bore and the flow of groundwater into the mine workings) is from the Sydney Basin North Groundwater Source. Licensed water discharges from Airly Mine are within the Airly Creek catchment, in the Hawkesbury and Lower Nepean Rivers Water Source (Capertee River Management Zone).

Angus Place Colliery

Angus Place Colliery is an underground coal mine located approximately 5 km north of Lidsdale and approximately 15 km north-west of Lithgow. The colliery is managed by Centennial Angus Place Pty Ltd (Centennial Angus Place) under a joint venture arrangement between Centennial Springvale Pty Ltd (Centennial Springvale) and Springvale SK Kores Pty Ltd (Springvale SK Kores). Angus Place Colliery commenced production in 1979 and currently has approval to produce up to 4 Mtpa of ROM coal. Coal is delivered by overland conveyor and trucks on dedicated private haul roads to Mount Piper and Wallerawang Power Stations.

Angus Place Colliery is currently seeking approval for the continuation of longwall mining to the east of the current workings. The construction and operation of a new private haul road is being proposed as part of the Western Coal Services Project (outlined in this Section). This haul road will enable coal from Angus Place Colliery to be transported to the Western Coal Services site for processing and distribution.



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0 0.5 1 2 3 4

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Study Area
- Mine Workings

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

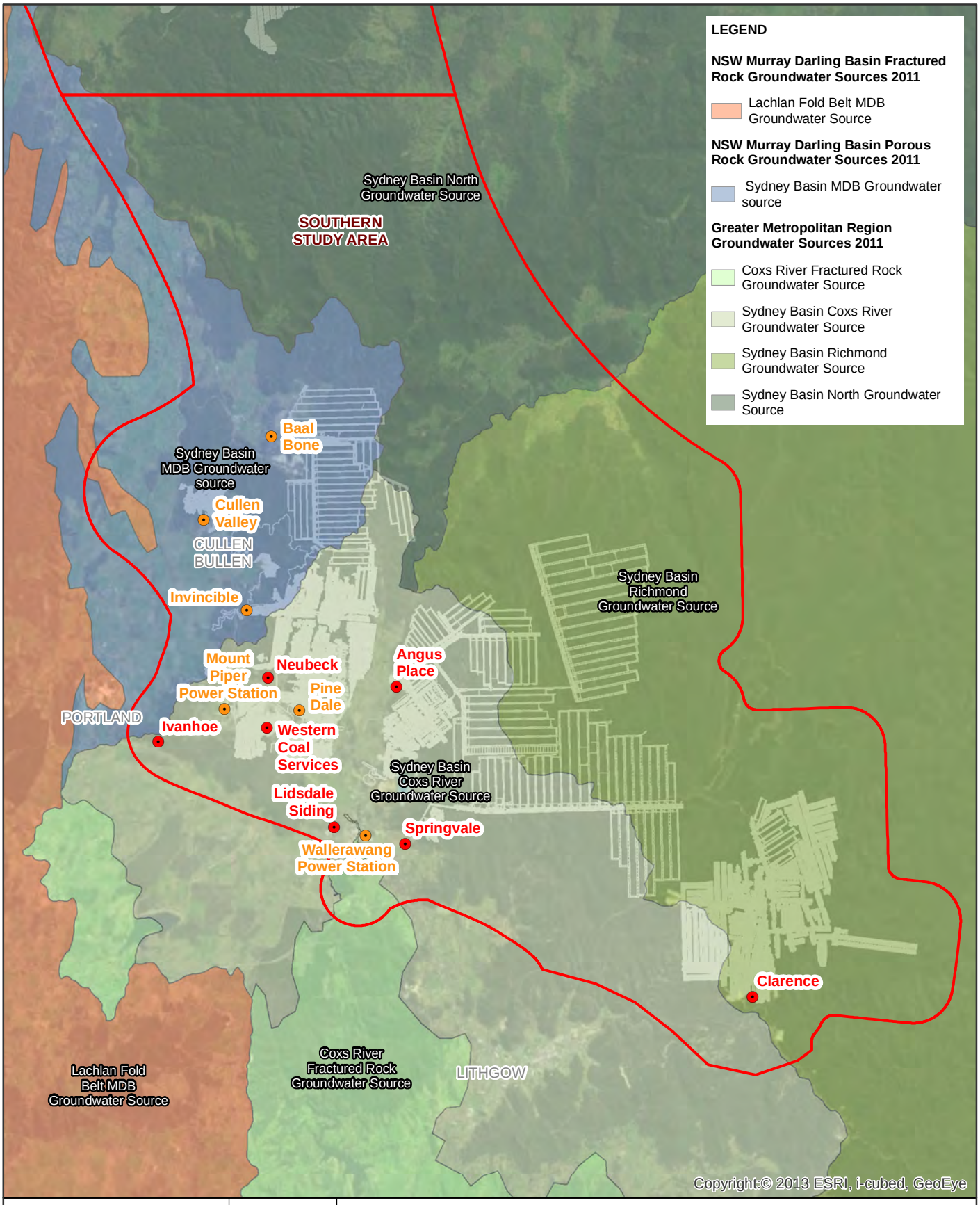
Northern Study Area Groundwater Source Boundaries with Mine Workings

Centennial Coal

DATE 8/11/2013

Figure 4-1

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\2216761_WB004_GroundwaterBoundary_MineWorkings_0.mxd



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Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Study Area
- Mine Workings

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

Southern Study Area Groundwater Source Boundaries with Mine Workings

Centennial Coal

DATE 2/08/2013

Figure 4-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB004a_SouthernGroundwaterBoundary_MineWorkings_0.mxd

Water is required at Angus Place Colliery for underground mining activities, dust suppression and washdown and is supplied by surface water storages. There is groundwater extraction from the Sydney Basin Richmond and Sydney Basin Coxs River groundwater sources into the underground workings by incidental inflow due to the aquifer interference. This water is transferred from the underground workings to the Springvale-Delta Water Transfer Scheme (SDWTS), which transfers water to Wallerawang Power Station. The SDWTS also receives water from Springvale Mine. Excess water is discharged through LDPs, located within the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone).

Charbon Colliery

Charbon Colliery is an underground and open cut mine located approximately 1 km south of Charbon and approximately 88 km north-west of Lithgow. Charbon Colliery is owned and operated by Charbon Coal Pty Ltd (Charbon Coal), a joint venture between Centennial (95% share) and SK Networks Resources Australia Pty Ltd (5% share). Operations at Charbon Colliery commenced in the 1920s and supplied coal to the Charbon Cement Works. The colliery was upgraded in 1985 to include a rail loop and coal handling and preparation plant (CHPP) and the production rate increased to produce washed coal for export. Open cut mining commenced at the site in 1996. Charbon Colliery currently has approval to produce up to 1.5 Mtpa of ROM coal employing bord and pillar underground and open cut mining methods. Coal is transported to Port Kembla by rail for export. Site infrastructure includes a CHPP and REA. It is expected that Charbon Coal will surrender all existing development consents in 2013 and enter a care and maintenance phase (Charbon 2012 AMER).

Water is required at Charbon Colliery for underground mining activities, coal processing and dust suppression and is supplied by surface water storages and supplemented by a production bore. Groundwater inflow into the workings is minimal. Natural recharge of the active underground workings occurs intermittently following extended rainfall periods. Groundwater extraction at Charbon Colliery (via the production bore and the flow of groundwater into the mine workings) is from the Sydney MDB Groundwater Source. Licensed water discharges are within the Upper Cudgegong River Water Source.

Clarence Colliery

Clarence Colliery is an underground coal mine located approximately 10 km north-east of Lithgow. The colliery is owned and operated by Clarence Colliery Pty Ltd, a joint venture between Centennial (85% share) and SK Energy Australia Pty Ltd (15% share). Coal production commenced at Clarence Colliery in 1979 and currently there is approval to extract 3 Mtpa of ROM coal using bord and pillar mining methods. Clarence Colliery surface infrastructure includes a rail loading facility, CHPP, REA and water treatment plant. It is expected that Clarence Colliery will seek approval for the construction of a new REA during 2013.

Water is required at Clarence Colliery for underground mining activities, coal processing and dust suppression and is supplied by surface water storages via the water treatment plant. There is groundwater extraction from the Sydney Basin Richmond and Sydney Basin Coxs River groundwater sources into the underground workings by incidental inflow due to aquifer interference. This water is pumped to the surface for treatment and discharge off-site through a LDP. All LDPs at Clarence Colliery are located within the Hawkesbury and Lower Nepean Rivers Water Source (Colo River Management Zone).

Ivanhoe No. 2 Colliery

Ivanhoe No. 2 Colliery is a former underground coal mine owned by Ivanhoe Coal Pty Ltd (Ivanhoe Coal) located approximately 2.5 km east of Portland and approximately 20 km north-west of Lithgow. Mining commenced at Ivanhoe No. 2 Colliery in the 1940s. In 2005 the site was placed on care and maintenance and no mining activities have occurred since.

Surface water runoff from contributing catchments is collected in several surface water storages that overflow through a single LDP (located within the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone)) or is discharged underground. No groundwater is extracted at this site.

Ivanhoe North Rehabilitation Project

The Ivanhoe North Rehabilitation Project is a former open cut mining operation located approximately 2 km north of Ivanhoe No. 2 Colliery and approximately 22 km north-west of Lithgow. Ivanhoe Coal commenced operations in 2009 to rehabilitate the abandoned Cullen Main West open cut and concurrently recover coal remaining between the high wall of the open cut mine and the underground workings of Ivanhoe No. 2 Colliery. Mining operations were completed in 2012 with rehabilitation of the site continuing.

Surface water runoff from contributing catchments is collected in several surface water storages that overflow through LDPs located within the Turon Crudine River Water Source. No groundwater is extracted at this site.

Lidsdale Siding

Lidsdale Siding is a coal storage and rail loading facility located near Wallerawang and approximately 12 km north-west of Lithgow. Ivanhoe Coal owns and operates the facility, which has operated since 1974. Coal is delivered by overland conveyor from Springvale Mine via Western Coal Services and transported by rail to Port Kembla and Port of Newcastle for export. Approval was granted for the Lidsdale Siding Upgrade Project in May 2013, which will improve operational efficiency with an automated train loading process and increase throughput capacity to approximately 6.3 Mtpa of product coal.

Water is required at Lidsdale Siding for dust suppression and washdown and is supplied by surface water storages and supplemented by a production bore. Groundwater extraction at Lidsdale Siding is from the Sydney Basin Coxs River Groundwater Source. It is expected that discharges through the single LDP, located within the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone), will be minimal.

Neubeck Project

The Neubeck Project is a proposed open cut mine located approximately 7 km north of Wallerawang and approximately 18 km north-west of Lithgow. The project area has a history of underground mining activities extending over the last century. Centennial Angus Place is currently seeking approval to develop the Neubeck Project. It is proposed to extract coal using open cut mining methods to produce up to 1.2 Mtpa of ROM coal. All coal will be transported to Mount Piper and Wallerawang Power Stations or to Western Coal Services using the private haul road network.

Water will be required for dust suppression and washdown, which will be supplied by surface water storages. Groundwater extraction from old adjacent underground workings and via groundwater inflows into the open cut pits will come from the Sydney Basin Coxs River Groundwater Source. Any LDPs that may be established will be located within the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone).

Springvale Mine

Springvale Mine is an underground coal mine located approximately 15 km north-west of Lithgow. The mine is managed by Centennial Springvale under a joint venture arrangement between Centennial Springvale and Springvale SK Kores. Springvale Mine commenced mining operations in 1995 and currently has approval to extract up to 3.4 Mtpa of ROM coal. Coal is delivered by overland conveyor to Western Coal Services for further processing or directly to Mount Piper and Wallerawang Power Stations.

Springvale Mine is currently seeking approval to extend its mining operations using longwall mining methods. It is also proposed to integrate Springvale Mine's coal processing and distribution network into Western Coal Services operations.

Water is required at Springvale Mine for underground mining activities, dust suppression and washdown and is supplied by surface water storages. There is groundwater extraction from the Sydney Basin Richmond and Sydney Basin Coxs River groundwater sources into the underground workings by incidental inflow due to the aquifer interference. This water is transferred from the underground workings to the SDWTS, which transfers water to Wallerawang Power Station. The SDWTS also receives water from Angus Place Colliery. Excess water is discharged through LDPs located within the Hawkesbury and Lower Nepean Rivers Water Source (Colo River Management Zone) and the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone).

Western Coal Services

Western Coal Services is a coal processing facility located approximately 18 km north of Lithgow. The Western Coal Services site is an existing approved facility within the Springvale Mine development consent. The facility currently receives coal from Springvale Mine by overland conveyor and provides coal storage, handling and processing functions. Coal is then transported by overland conveyor to Mount Piper Power Station or Lidsdale Siding. The site has a long history of mining and includes the Lamberts Gully open cut mine and Kerosene Vale mine.

Centennial is currently seeking approval to upgrade the Western Coal Services facility, link the site to Angus Place Colliery and separate the transport and logistics function of the facility from the source mines. The project will also increase the total coal handling capacity of the site to up to 9.5 Mtpa of ROM coal.

Water is required at Western Coal Services for coal processing, dust suppression and washdown and is sourced from surface water storages. Treated excess water is discharged through a single LDP located within the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone). There is minor groundwater extraction from the Sydney Basin Coxs River Groundwater Source due to incidental flows of water from the old Western Main workings into surface dams.

4.1.2 Non-Centennial Sites

Baal Bone Colliery

Baal Bone Colliery is a former open cut and underground coal mine located approximately 3 km north-west of Cullen Bullen and approximately 25 km north-west of Lithgow. The site is operated by Wallerawang Collieries Ltd, a company owned by Oakbridge Pty Ltd (95% share) and Sumitomo Pty Ltd (5% share). Glencore Xstrata has a 78% share in Oakbridge Pty Ltd. Mining commenced at Baal Bone Colliery in 1983. Underground mining operations ceased in 2011 and the site was placed on care and maintenance. From 2012 Baal Bone Colliery has been used as a training facility for Glencore Xstrata employees.

There is groundwater extraction from the Sydney Basin MDB and Sydney Basin Coxs River groundwater sources into the underground workings by incidental inflow due to the aquifer interference. The majority of this water is transferred from the underground workings via dewatering bores and discharged through LDPs located within the Turon Crudine River Water Source.

Coalpac Consolidation Project

Coalpac Pty Ltd (Coalpac) owns and operate Cullen Valley Mine and Invincible Colliery located near Cullen Bullen approximately 25 km north-west of Lithgow. Coalpac is currently seeking approval to consolidate and extend mining operations and manage both sites under a single development consent (the Coalpac Consolidation Project).

Cullen Valley Mine is an open cut coal mine that commenced mining operations in the late 1800s. A range of open cut and underground mining operations have been undertaken over the last century. Cullen Valley Mine currently has approval to extract up to 1 Mtpa of ROM coal. Coal is transported by trucks on public roads and private haul roads to Mount Piper Power Station or to the Invincible Colliery CPP for further processing.

Invincible Colliery is an open cut coal mine that commenced mining operations in 1901 with an underground operation. Open cut mining at the site has occurred since 1998. Invincible Colliery currently has approval to extract up to 1.2 Mtpa of ROM coal. Product coal is transported by trucks on public roads and private haul roads to Mount Piper and Wallerawang Power Stations or other domestic destinations.

Mining activities were suspended at Cullen Valley Mine in 2012 and at Invincible Colliery in March 2013. It is expected that both mines will remain on care and maintenance until the application for the Coalpac Consolidation Project has been determined.

The Coalpac Consolidation Project involves the consolidation and extension of the existing Cullen Valley Mine and Invincible Colliery operations to produce up to 3.5 Mtpa of ROM coal. The project also involves the integration of the water management systems at both sites into a single system. Water will be required for coal processing and dust suppression, which will be supplied by surface water sources and supplemented by groundwater from underground workings.

Groundwater extracted from old flooded underground workings (Invincible, Old Invincible and Old Tyldesley) comes from the Sydney Basin MDB and Sydney Basin Coxs River groundwater sources. Excess water will be discharged through LDPs located within the Turon Crudine River Water Source.

Mount Piper Power Station

Mount Piper Power Station is owned and operated by Delta Electricity and is located approximately 17 km north-west of Lithgow. The power station was commissioned in 1993 and currently comprises two coal-fired generating units. Mount Piper and Wallerawang Power Stations are the greatest surface water users within the Study Area, due to the volume amount of water that is evaporated during the cooling process.

Water required for the operation of Mount Piper Power Station is supplied from the Coxs River via Thompsons Creek Dam and is supplemented by the Fish River Water Supply Scheme. No groundwater is supplied to the facility. Surface water runoff from contributing catchments is directed through an LDP located within the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone) and is expected to be minimal.

Pine Dale Coal Mine

Pine Dale Coal Mine is an open cut coal mine located approximately 5 km north of Wallerawang and 15 km north-west of Lithgow. The mine is owned and operated by Enhance Place Pty Ltd (Enhance Place), which is owned by Energy Australia. Coal production commenced at Pine Dale Coal Mine in 2006 and establishment works within the Yarraboldy Extension Area commenced in 2011. Pine Dale Coal Mine currently has approval to extract 0.35 Mtpa of ROM coal using open cut mining methods. Product coal is delivered to the Mount Piper Power Station by trucks on private haul roads. Enhance Place is currently seeking approval to extend mining operations and increase coal extraction to 2 Mtpa of ROM coal.

Water is required at Pine Dale Coal Mine for dust suppression and is supplied by surface water storages. Groundwater extracted from old flooded underground workings comes from the Sydney Basin Coxs River groundwater sources. Excess water not utilised on-site will be treated as necessary and either transferred to Delta Electricity or discharged through an LDP located within the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone).

Wallerawang Power Station

Wallerawang Power Station is owned and operated by Delta Electricity and is located approximately 15 km north-west of Lithgow. The power station was commissioned in 1957 and currently comprises two coal-fired generating units. Mount Piper and Wallerawang Power Stations are the greatest surface water users within the Study Area, due to the volume amount of water that is evaporated during the cooling process.

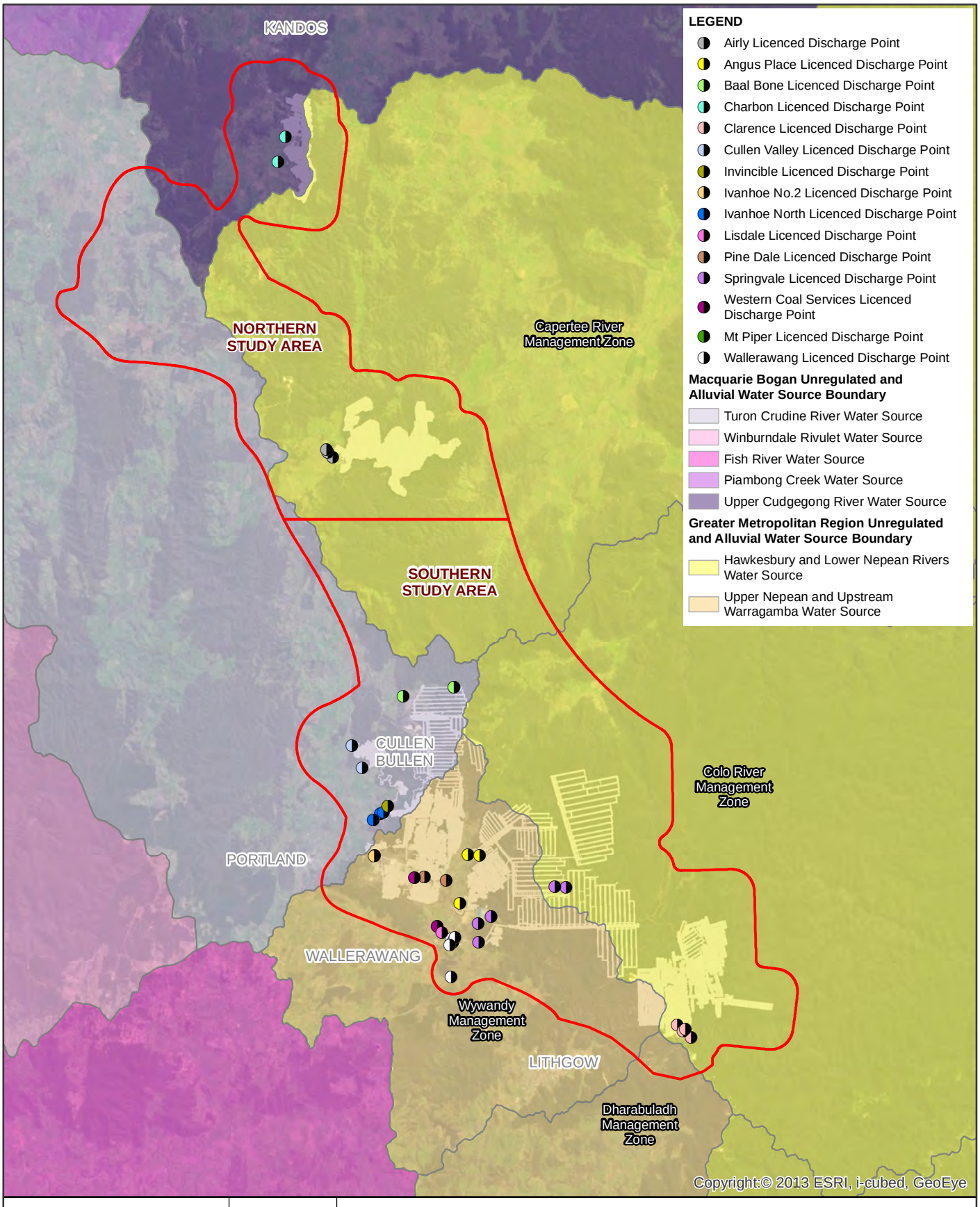
Water required for the operation of Wallerawang Power Station is supplied by the SDWTS, which transfers groundwater make from Angus Place Colliery and Springvale Mine. Currently Wallerawang Power Station has a contract with Springvale Coal to receive a maximum of 30 ML/day of water through the SDWTS, which is expected to continue into the future. Additional water is supplied from the Coxs River via Lake Wallace and is supplemented by the Fish River Water Supply Scheme. No groundwater is supplied to the facility. Surface water runoff from contributing catchments is directed through LDPs located within the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone) and is expected to be minimal.

4.2 Licences

4.2.1 Environment Protection Licences

Each currently operating site operates under an EPL which specifies conditions under which water is to be discharged from each site. LDPs are the defined locations for such discharges and have been used as the reference point for discharges to be modelled for the regional water balance. Figure 4-3 shows the location of each existing LDP with respect to the surface water sources that are intersected by the Study Area.

Table 4-1 below summarises the licence conditions for LDPs for each site. The regional water balance identifies whether any Centennial site may have a shortfall over the next 25 years in the volumetric limit for any of the LDPs compared to the water that needs to be discharged.



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0 1.25 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

Study Area

Mine Workings

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

Surface Water Source Boundaries and Current LDP Locations

Centennial Coal

DATE 7/11/2013

Figure 4-3

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB006_SurfaceWaterBoundary_LDP_A.mxd

Table 4-1 Environment Protection Licences

Location	Licence No.	EPA ID	Discharge point	Discharge Point Name	Monitoring		Licence Discharge Limits per Day	Creek Catchment
					Water Quality	Volume		
Airly Mine	12374	1	Y	LDP 1	During discharge: EC; O&G; pH and TSS	–	100 ML	Airly Creek
		7	Y	LDP 2		–	No limit specified	
		8	Y	LDP 3		–		
Angus Place Colliery	467	1	Y	LDP001	EC; O&G; pH and TSS	Y	2 ML	Kangaroo Creek
		2	Y	LDP002		Y	5 ML	Coxs River
		3	Y	LDP003		–	No limit specified	
		5	Y	LDP005	–	–		
Baal Bone Colliery	765	2	–	LDP2	BOD; faecal coliforms; TN; O&G; pH; TP; TSS	–	Not applicable	–
		11	Y	LDP1	EC; O&G; pH; sulfate; Fe (total); TSS	–	No limit specified	Ben Bullen Creek
		12	–	WMP1		–	Not applicable	–
		17	Y	LDP3		–	No limit specified	Baal Bone Creek
		18	Y	LDP6		–	12 ML	
Charbon Colliery	528	1	Y	LDP1	EC; O&G; pH and TSS	–	No limit specified	Carwell Creek / Rileys Creek
		2	Y	LDP2		Y	5 ML	Rileys Creek
		3	Y	LDP3		Y		Rileys Creek
Clarence Colliery	726	1	Y	LDP1	As; B; Cd; chloride; Cr (Hex); Cu; Fe (filt); Mn (filt); fluoride; Pb; Hg; O&G; pH; Se; Ag; sulfate; TSS; Zn	–	No limit specified	–
		2	Y	LDP2		Y	25 ML	Wollangambe River
		3	Y	LDP3		–	No limit specified	

Location	Licence No.	EPA ID	Discharge point	Discharge Point Name	Monitoring		Licence Discharge Limits per Day	Creek Catchment
					Water Quality	Volume		
		4	Y	LDP4		–		
Coalpac Consolidation Project	10341 (Cullen Valley Mine)	1	Y	–	EC; O&G; pH; Fe (total); Mn (total); TSS	–	No limit specified	–
		4	Y	–		–		–
	1095 (Invincible Colliery)	2	Y	LDP002	O&G; pH; TSS	–	No limit specified	–
Ivanhoe No. 2 Colliery	631	2	Y	LDP3	Fe (filt); O&G; pH; TSS	–	No limit specified	–
		4	–	–	O&G; pH	–	Not applicable	–
Ivanhoe North Rehabilitation Project	13063	1	Y	LDP001	EC; O&G; pH; TSS	–	No limit specified	Hunts Creek
		2	Y	LDP002	EC; O&G; pH; TSS	–		Cullen Creek
		6	Y	LDP006	EC; O&G; pH; TSS	–		Cullen Creek
Lidsdale Siding	5129	4	Y		EC; O&G; pH; TSS	–	No limit specified	Coxs River
Mount Piper Power Station	13007	1	Y	EPA ID 1	EC; TSS; pH	Y	No limit specified	Wangcol Creek
Neubeck Project	No Licence							
Pine Dale Coal Mine	4911	2	–	–	EC; Fe (filt); pH; sulfate; TSS; turbidity	–	Not applicable	–
		3	–	–		–		–
		4	Y	–	EC; Fe (filt); O&G; pH; sulfate; TSS; turbidity	–	No limit specified	Wangcol Creek
		5	Y	–		–		Wangcol Creek
		13	Y	–		Y		Wangcol Creek
		14	–	–	EC; Fe (filt); pH; sulfate; TSS; turbidity	–	Not applicable	Coxs River

Location	Licence No.	EPA ID	Discharge point	Discharge Point Name	Monitoring		Licence Discharge Limits per Day	Creek Catchment
					Water Quality	Volume		
Springvale Mine	3607	1	Y	LDP001	EC; Fe (filt); Mn (filt); O&G; pH; TSS; Zn (total)	Y	10 ML	Springvale Creek/ Coxs River
		2	Y	LDP002	–	–	No limit specified	Coxs River
		4	Y	LDP004	EC; Fe (filt); Mn (filt) O&G; pH; temp; TSS; turbidity	Y	15 ML	Wolgan River
		5	Y	LDP005		Y	15 ML	Wolgan River
		9	Y	LDP009	Al (filt); Al (total); As; B; EC; Cu; fluoride; Fe (filt); Mn (filt); Ni; O&G; pH; TSS; turbidity; Zn; Zn (total)	Y	30 ML	–
		10	Y	LDP010	Al (filt); Al (total); As; B; EC; Cu; fluoride; Fe (filt); Mn (filt); Ni; O&G; pH; TSS; turbidity; Zn; Zn (total)	Y	No limit specified	–
Western Coal Services		6	Y	LDP006	EC; Fe (filt); Mn (filt) O&G; pH; total hardness; TSS; Zn (total)	Y	10 ML	Wangcol Creek
		7	Y	LDP007	EC; pH; TSS	–	No limit specified	Coxs River
Wallerawang Power Station	766	1	Y	EPA ID 1	Al (filt); Al (total); As (total); B; Cu (filt); Cu (total); EC; Fluoride; Ni; pH; Se; sulfate; Zn (filt); Zn (total)	Y	210 ML	Coxs River
		3	Y	EPA ID 3	B; EC; Fe (filt) Mn (filt); fluoride; pH; Se; Sulfate; TSS	Y	No limit specified	Coxs River
		4	Y	EPA ID 4	Al (filt); Al (total); As; B; Cu (filt); Cu (total); EC; fluoride; Ni; pH; Se; sulfate; TSS; turbidity; Zn (filt); Zn (total)	Y	105 ML	Coxs River
		5	Y	EPA ID 5	EC; O&G; pH; TSS	–	No limit specified	Coxs River

Location	Licence No.	EPA ID	Discharge point	Discharge Point Name	Monitoring		Licence Discharge Limits per Day	Creek Catchment
					Water Quality	Volume		
		7	–	EPA ID 7	Al (filt); Al (total); As (total); B; Cu (total); EC; fluoride; Ni (total); pH; Se; sulfate; Zn (total)	–	Not applicable	–
		8	–	EPA ID 8	Al (filt); Al (total); As (total); B; Cu (total); EC; fluoride; Ni (total); pH; Se; sulfate; Zn (total)	–	Not applicable	–
		18	Y	EPA ID 18	EC; O&G; pH; TSS	Y	No limit specified	Coxs River
		21	Y	EPA 21	Al (filt); Al (total); As (total); B; Cu (filt); Cu (total); EC; fluoride; Ni; pH; sulfate; TSS; Zn (filt); Zn (total)	–	105 ML	Coxs River
		22	–	WX13	Al (filt); Al (total); As (total); B; Cu (total); EC; fluoride; Ni (total); pH; Se; sulfate; Zn (total)	–	Not applicable	–
		23	–	Cox 4	Al (filt); Al (total); As (total); B; Cu (total); EC; fluoride; Ni (total); pH; Se; sulfate; Zn (total)	–	Not applicable	–

4.2.2 Water Access Licences

The existing groundwater extraction licences held by each Centennial site within the Study Area are listed in Table 4-2. The licensed bore locations are shown in Figure 4-3. The majority of existing groundwater extraction licences held by coal mining operations in the Study Area were obtained under Part 5 of the *Water Act 1912* prior to the commencement of the WSPs and have not as yet been converted into WALs. These extraction volumes were accounted for by NOW in the calculation of existing entitlements for each groundwater source as presented in Table 2-1 and Table 2-2.

The total groundwater entitlement currently held by Centennial operations within the Study Area is 21,891.5 ML/year (approximately 60 ML/day). This entitlement is divided into the four groundwater sources as follows:

- Sydney Basin Coxs River Groundwater Source: 6,594.5 ML/yr.
- Sydney Basin Richmond Groundwater Source: 15,104 ML/yr.
- Sydney Basin North Groundwater Source: 278 ML/yr.
- Sydney Basin MDB Groundwater Source: 35 ML/yr.

The existing groundwater extraction licences held by each non-Centennial site within the Study Area are listed in Table 4-3. The majority of these licences are located within the Sydney Basin MDB Groundwater Source.

Monitoring bore licences have not been included in Table 4-2 and Table 4-3 because they do not have a volumetric allocation.

Table 4-2 Existing Groundwater Extraction Licences – Centennial Sites

Site	Current Licence No.	Bore Name	Groundwater Extraction Volume (ML/yr)	Groundwater Source	Additional Information
Airly Mine	WAL24386 (volume) 10BL603503 (bore work)	AM2B / AM2B-1	278	Sydney Basin North	Replaced *Water Act 1912* licence number 10BL603503.
Angus Place Colliery	10BL601851	Bore 940	2523	Sydney Basin Richmond	Issued under *Water Act 1912*. Expiry extended to July 2014.
	10BL601838	Collector System (AP)	2701	Sydney Basin Coxs River	Issued under *Water Act 1912*. Expiry extended to July 2014.
Charbon Colliery	WAL27890	PB2/PB3	35	Sydney Basin MDB	Replaced *Water Act 1912* licence numbers 80BL244068, 80BL244069 and 80BL244070.

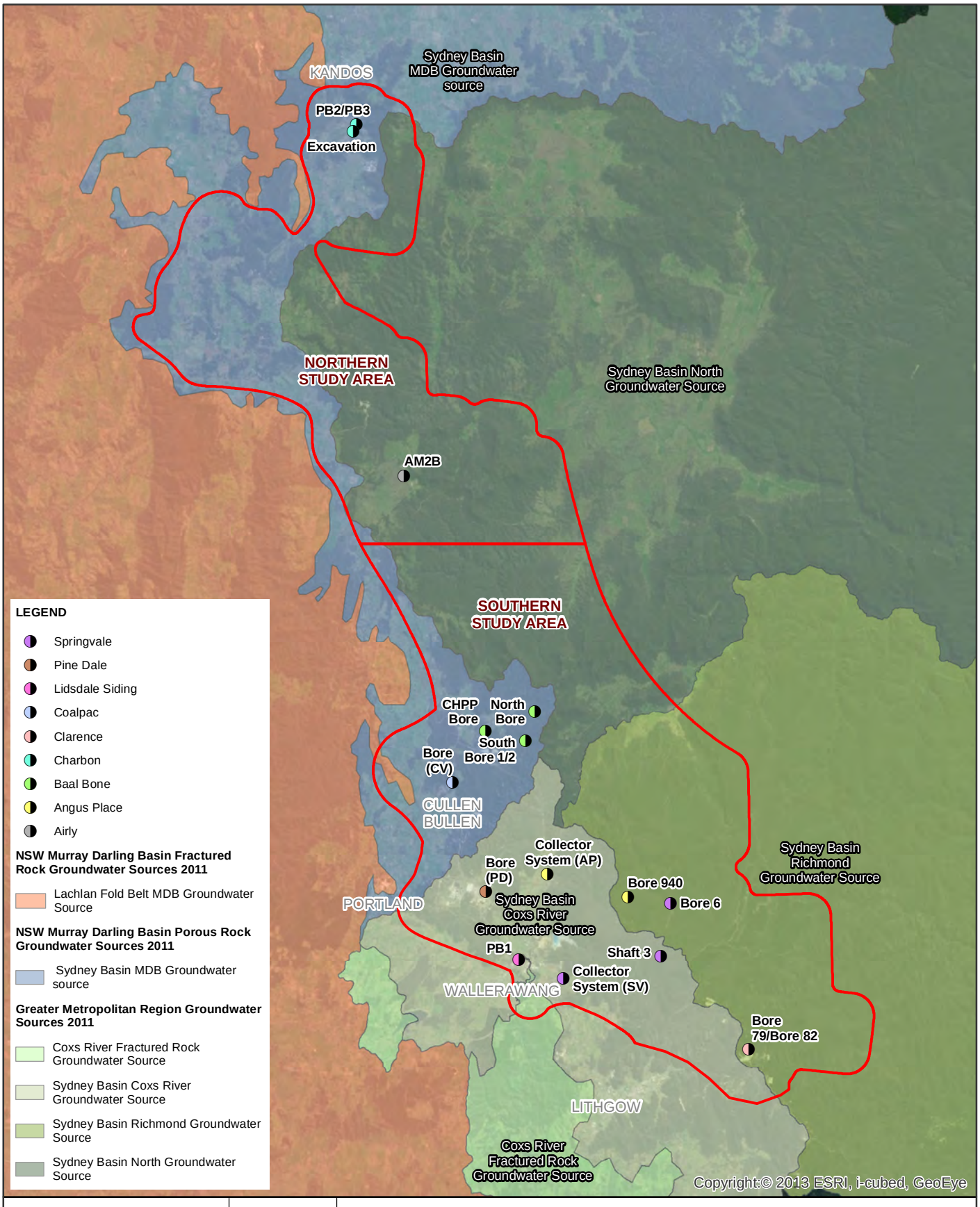
Site	Current Licence No.	Bore Name	Groundwater Extraction Volume (ML/yr)	Groundwater Source	Additional Information
	80BL243771	Excavation	5	Sydney Basin MDB	Valid in perpetuity under *Water Act 1912*. Allows for the extraction of groundwater seepage into workings.
Clarence Colliery	10BL165054	Bore 79	4100	Sydney Basin Richmond	Issued under *Water Act 1912*. Expired August 2011 (renewal application in progress).
	10BL165053	Bore 82	2523	Sydney Basin Richmond	Issued under *Water Act 1912*. Expired August 2011 (renewal application in progress).
Lidsdale Siding	10WA116403	PB1	8.5	Sydney Basin Coxs River	Issued under *Water Act 1912*.
Springvale Mine	10BL603519	Bore 6	5958	Sydney Basin Richmond	Issued under *Water Act 1912*. Expires February 2015.
	10BL601863	Shaft 3	3300	Sydney Basin Coxs River	Issued under *Water Act 1912*. Expired September 2012.
	10BL602017	Collector System (SV)	585	Sydney Basin Coxs River	Issued under *Water Act 1912*. Expired September 2012.

Table 4-3 Existing Groundwater Extraction Licences – Non-Centennial Sites

Site	Current Licence No.	Bore Name	Groundwater Extraction Volume (ML/yr)	Groundwater Source	Additional Information
Baal Bone Colliery	WAL27887	CHPP Bore	750	Sydney Basin MDB	Replaced existing *Water Act 1912* licences in 2012.
	80BL236132	South Bore 1	NI	Sydney Basin MDB	Issued under *Water Act 1912*.

Site	Current Licence No.	Bore Name	Groundwater Extraction Volume (ML/yr)	Groundwater Source	Additional Information
	80BL236134	South Bore 2	NI	Sydney Basin MDB	Issued under *Water Act 1912*.
	80BL239077	North Bore	NI	Sydney Basin MDB	Issued under *Water Act 1912*. Expires June 2016.
Coalpac Consolidation Project	80BL244942	Bore (CV)	NI	Sydney Basin MDB	Issued under *Water Act 1912*. Expires July 2015.
Pine Dale Coal Mine	10BL604181	Bore (PD)	200	Sydney Basin Coxs River	Issued under *Water Act 1912*.

NI = no publically available information



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0 1.25 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

Study Area

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

Groundwater Source Boundaries and Existing Licensed Bores

Centennial Coal

DATE 8/11/2013

Figure 4-4

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\2216761_WB014_GroundwaterBoundary_LicencedBores_A.mxd

5. Water Quality

The water quality at LDPs located at Centennial Coal sites within the Study Area is reported in this section to highlight existing water quality issues at LDPs and potential future water quality issues.

5.1 Summary of Water Quality Issues at Operating Sites

Water quality assessments have previously been undertaken at each of the operating Centennial Coal sites. The most recent assessments and water quality reports at each site have been reviewed by GHD to summarise the current water quality issues at each LDP.

Table 5-1 lists the water quality analytes that have exceeded trigger values at each operating Centennial site within the Study Area. In most cases, site-specific trigger values (SSTVs) have been developed for these sites, based on ANZECC/ARMCANZ (2000) default trigger values and upstream or reference site concentrations. Only those LDPs where at least one exceedance has been reported since January 2012 are included in Table 5-1. The water quality assessment reports reviewed for each site is included in the table.

Table 5-1 Existing Water Quality Exceedances at Centennial LDPs

Site	LDP	Exceedance Parameter(s)	Concentration Range	Creek Catchment	Source Document
Angus Place Colliery	LDP001	EC, Turbidity	EC: up to 1,204 µS/cm (2012); turbidity: up to 36 NTU	Kangaroo Creek/Coxs River	AEMR 2012; RPS (2013)
	LDP002	TSS, EC, Turbidity	TSS: up to 135 mg/L (2012); EC: up to 432 µS/cm; turbidity: up to 261 NTU	Coxs River	
	LDP003	Turbidity	Turbidity: up to 156 NTU	Coxs River	
Charbon Colliery	LDP 2	EC	EC: up to 1,460 µS/cm	Rileys Creek	AEMR 2012; GHD (2012)
Clarence Colliery	LDP2	TSS	TSS: up to 46 mg/L (March 2012)	Wollangambe River	AEMR 2012
	LDP3	pH, TSS, Cd (filt), Cu, Mn, Zn	pH: 5.4 (min); TSS: up to 38 mg/L; Cd (filt): up to 0.0013 mg/L; Cu: up to 0.02 mg/L; Mn: up to 2.2 mg/L; Zn: up to 2.57 mg/ L	Wollangambe River	

Site	LDP	Exceedance Parameter(s)	Concentration Range	Creek Catchment	Source Document
Lidsdale Siding	LDP004	Cd, Cu	Cd: <0.0001 mg/L – 0.0003 mg/L (Aug 2012); Cu: up to 0.025 mg/L (Aug 2012)	Coxs River	RPS (2012)
Springvale Mine	LDP001	pH; EC	pH: 3.15-8.64 (2012); EC: 344-1680 µS/cm (2012)	Springvale Creek/Coxs River	AEMR 2012; RPS (2013)
Western Coal Services (Lamberts Gully)	LDP006	EC, Ni (filt), Zn (filt)	EC: 110-2660 µS/cm; Ni: 0.045-0.433 mg/L; Zn: 0.072-0.494 mg/L	Wangcol/Coxs River	GHD (2012)

The most common exceedances at existing operating sites are in pH, EC, TSS and turbidity. The main dissolved metal exceedances are at Clarence Colliery LDP3, Lidsdale Siding LDP4 and Western Coal Services LDP6 and involve cadmium, copper, manganese, nickel and/or zinc. The majority of elevated metal concentrations are discharged to the Coxs River catchment, although exceedances have also been reported in the Wollangambe River catchment. The majority of elevated EC levels are also being discharged into the Coxs River catchment.

5.2 Summary of Water Quality Issues at Other Centennial Sites

The water quality at other Centennial sites with LDPs is discussed in this section. The quality of the water that may be discharged from the Neubeck Project site at some point in the future is unknown and has not been addressed here.

5.2.1 Airly Mine

LDP001 is the primary discharge location for Airly Mine. Discharges through LDP001 occurred during February and March 2012. The pH measurements during this discharge reported a range of 7.9 to 8.9 pH units and an EC of between 555 µS/cm and 750 µS/cm, indicating a slightly alkaline and fresh water. These values of pH and EC exceeded ANZECC/ARMCANZ (2000) default trigger values. Total suspended solids (TSS) and oil and grease concentrations were all below the EPL limit of 50 mg/L and 10 mg/L, respectively.

LDP002 and LDP003 are located at the spillways of the 7 ML Dam and the Train Loader Dam respectively. Overflows from these locations occur only very occasionally and monthly monitoring is conducted at both locations.

5.2.2 Ivanhoe No. 2 Colliery

With the exception of May 2012, no discharges were released at Ivanhoe No. 2 Colliery during April 2012 through February 2013. There were no exceedences reported from the discharge in May 2012.

5.2.3 Ivanhoe North Rehabilitation Project

Surface water at Ivanhoe North is monitored at LDP001, LDP002 and LDP006. These LDPs were monitored monthly for pH, TSS, EC and oil and grease. Since March 2012, few discharges have been released from Sediment Dams 1, 2 and 3.

In February 2012 discharges occurred from Sediment Dam 1 (LDP001), and in August 2012 discharges occurred from Sediment Dams 1, 2 (LDP002) and 3 (LDP006). No exceedences were reported as a result of these discharges.

6. Modelling Methodology

6.1 Site Water Cycle Representation

This section provides an overview on the general modelling methodology for all sites. Further information regarding site specific data and assumptions is provided in Section 7.3. A representation of the water cycle for each Centennial site is provided as a schematic in Appendix C.

6.1.1 Modelling Representation

The model used to represent the inputs and outputs from each site over time was GoldSim Version 10.50 (GoldSim Technology, 2011). This software is a graphical object orientated system for simulating either static or dynamic systems. It is like a 'visual spreadsheet' that allows one to visually create and manipulate data and equations.

GoldSim was used as the platform for data from all sites to be entered into. All the sites were simulated over time in GoldSim which statistically summarised selected outputs from the modelled systems.

Time Steps and Simulation Timeline

The GoldSim model simulated conditions for all identified sites from current conditions, 2013, to 2038 (inclusive) using daily time steps. Daily time steps were used for the modelling because daily rainfall data was the shortest period of data available and changes in operational conditions are typically made on a daily (or shorter) basis.

Probabilistic Modelling

To assess the impact of rainfall on the modelled sites, the water balance modelling was completed by applying 112 different rainfall patterns over the simulation timeline (2013 to 2038 inclusive). To complete this, the simulation timeline was modelled for 112 'realisations', where each realisation represented a single model run from 2013 to 2038. The only variation between realisations was that each realisation modelled a different continuous historical rainfall pattern.

The 112 realisations were applied because, as described in Section 7.1.1, the historical rainfall data extended from January 1901 to December 2012 and represents 112 years of complete rainfall data available. The 112 years of rainfall data can provide only 112 rainfall patterns as the seasonality in rainfall is maintained for each model run, e.g. the 1 January in the model was simulated with 1 January historical rainfall data. For each realisation, a continuous pattern of historical rainfall would be applied over the simulation timeline. Where the end of the continuous historical rainfall record was reached throughout a realisation, the rainfall would loop back to the start of the rainfall record. A graphical explanation of the rainfall simulation process is provided in Figure 6-1.

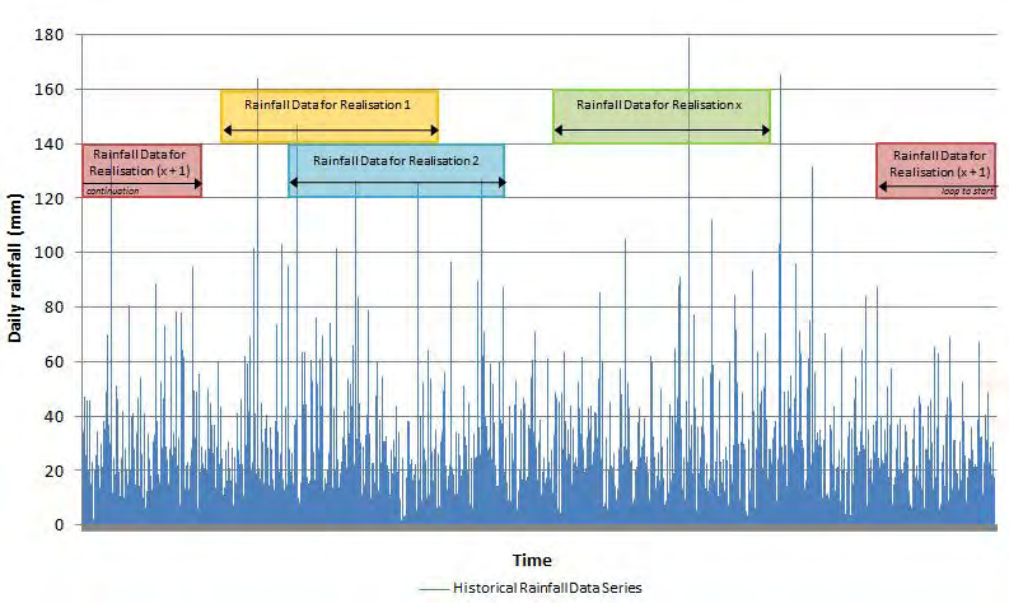


Figure 6-1 Rainfall Simulation Conceptualisation

The above repetition process provided 112 values for each simulated element in the model, for each day of the simulation timeline. Each extraction, discharge or transfer was then statistically assessed to provide estimates of the mean, 10th percentile and 90th percentile annual totals for each year over the simulation timeline.

6.1.2 Key Variables

The variables that were reported on were associated with the major extractions to and discharges from each site. If applicable, the following variables were incorporated into the modelling of each site over the simulation timeline:

- Extractions from groundwater sources.
- Extractions from surface water sources (typically waterways and not including harvesting runoff by dirty water collection systems).
- Discharges from sites through LDPs into surface water systems.

6.1.3 Available Information

The available information associated with the water cycle at each site was categorised into one of the following data sources:

- Case 1 – Sites for which GHD had previously completed a detailed water balance.
- Case 2 – Sites for which a water balance has been completed by others and the water balance report was available.
- Case 3 – Sites for which no relevant water balance has been completed previously.

Case 1

For sites which GHD had previously completed a water balance model, GHD was able to directly incorporate the entire detailed water balance into the regional water balance model. The key variables (as detailed in Section 6.1.2) were then referenced from the relevant model elements.

Case 2

For sites where only a water balance report was available, GHD reviewed the available information and interpreted what relevant data was to be included into the water balance model. For these sites, GHD did not model the water cycle, but directly input the relevant data presented in the reports into the GoldSim regional water balance model.

Where the key variables provided in the reports varied with annual or daily rainfall totals, this variation was included in the GoldSim model such that the appropriate extraction or discharge value was simulated by the model depending on the annual or daily rainfall being simulated.

Section 6.4 describes the methodology for modelling rainfall over the simulation timeline.

Case 3

For sites where an appropriate water balance has not been previously completed, GHD developed a water balance model in GoldSim. Information for these sites was based on the review of available information and the provision of information from Centennial. Such models were developed so that the appropriate level of detail was included to simulate any anticipated response of extractions and discharges to rainfall conditions.

6.2 Water Balance Modelling Assumptions

6.2.1 Application of Externally Derived Data

For sites where a water balance model was not available and information was derived from available reports, information was typically provided in terms of an annual discharge per annual percentile rainfall for various phases of the operational timeline. For incorporation into the regional water balance model, this data was interpreted so that values could be provided for daily time steps for any given rainfall year.

Interpolation between Operational Phases

Where estimates were provided for extractions and discharges of a site that varied along the simulation timeline to simulate changes in operational phases with time, values between the provided dates were linearly interpolated between the values provided. The values provided were assumed to be appropriate for the 1st of January for the applicable year.

Interpolation between Annual Percentile Rainfall Years

Where estimates were provided for extractions and discharges of a site for various annual rainfall percentile years, values for the percentiles not provided were estimated by either a log or linear interpolation. A log interpolation was applied to extractions and discharges that were determined to be predominantly influenced by variations in rainfall. Linear interpolations were applied extractions and discharges predominately influenced by dewatering or groundwater inflow rates. For data sets where the dominant influence was not known a comparison was conducted on the available data to assess whether a log or linear fit was most appropriate.

As annual values were typically provided for sites and the model was simulated using daily time steps, the daily values were scaled down from the annual value determined for the annual rainfall for the respective calendar year.

6.2.2 Rehabilitation and Closure

After the assumed active mining phase, it was assumed that each site then commenced a rehabilitation phase. Typically, rehabilitation was assumed to continue over a seven year period. Over the rehabilitation phase it was assumed that disturbed areas would be progressively rehabilitated and diverted away from the LDP catchments, thereby decreasing the discharge through these locations over time progressively to nil. The discharge from LDPs was assumed to scale down linearly over the rehabilitation phase from the final year of operations.

6.3 Hydrogeological Modelling

Extractions from groundwater sources are one of the key inputs into the regional water balance model and were derived separately from GoldSim on a site by site basis. The hydrogeological modelling method that was adopted by GHD to estimate extractions from groundwater sources depended on the amount of information currently available for a particular site and the modelling that has already been undertaken by GHD or others. In most cases, groundwater extraction volumes were estimated conceptually from existing information rather than building a new regional hydrogeological model.

For the purposes of this study, groundwater extraction has been defined as the removal of groundwater from a groundwater source or aquifer, either via direct removal for use via a production bore or via incidental flow of groundwater from the aquifer into the mine workings during and after mining. Groundwater extraction includes the pumping of underground water from flooded mine workings in equilibrium with the surrounding strata as well as the removal of water from perched aquifers recharged directly from rainfall infiltration.

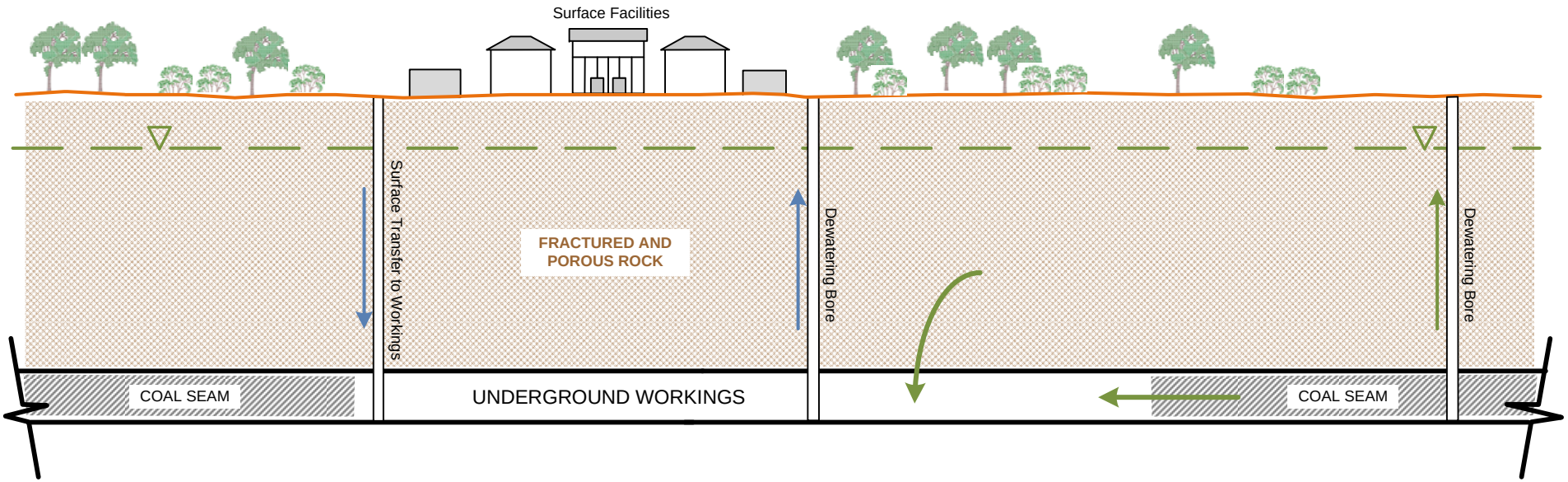
The removal of water from the collection system within mine workings is regarded as dewatering and is considered to be an operational transfer of water at a mining operation rather than the extraction from a groundwater source. In the same way, the transfer of mine water into mine workings for operational or water storage purposes is also considered to be an operational transfer of water and not an injection into a groundwater source.

The definitions of groundwater extraction, dewatering and operational transfers are shown schematically in Figure 6-2 and Figure 6-3.

The following methodologies were adopted to estimated extractions from groundwater sources. At sites where there are no current or future groundwater extractions (Ivanhoe No. 2 Colliery, Ivanhoe North Rehabilitation Project, Wallerawang Power Station and Mount Piper Power Station), hydrogeological calculations were not undertaken.

6.3.1 Case 1 – Existing Hydrogeological Assessment (Model)

For the majority of sites with groundwater extractions (Clarence Colliery, Angus Place Colliery, Springvale Mine, Lidsdale Siding, Western Coal Services, Airly Mine and Pine Dale Coal Mine) a site hydrogeological model had been developed in the past by GHD or others to predict current and future inflow (or extraction) of groundwater into the mine workings. Most hydrogeological models have been developed in a version of MODFLOW, a three-dimensional finite difference groundwater flow model from the United States Geological Survey (USGS) and one of the industry standard codes for numerical groundwater modelling. The exceptions are the hydrogeological models for Angus Place Colliery and Springvale Mine, which were developed by CSIRO using their in-house model COSFLOW.



Extraction from Groundwater Source

Operational Transfer of Mine Water

LOCATION	Regional
SEAM	NA
DRAWN	SM
CHECKED	SG
APPROVED	SG
SCALE	NTS

Western Coalfield Water Balance

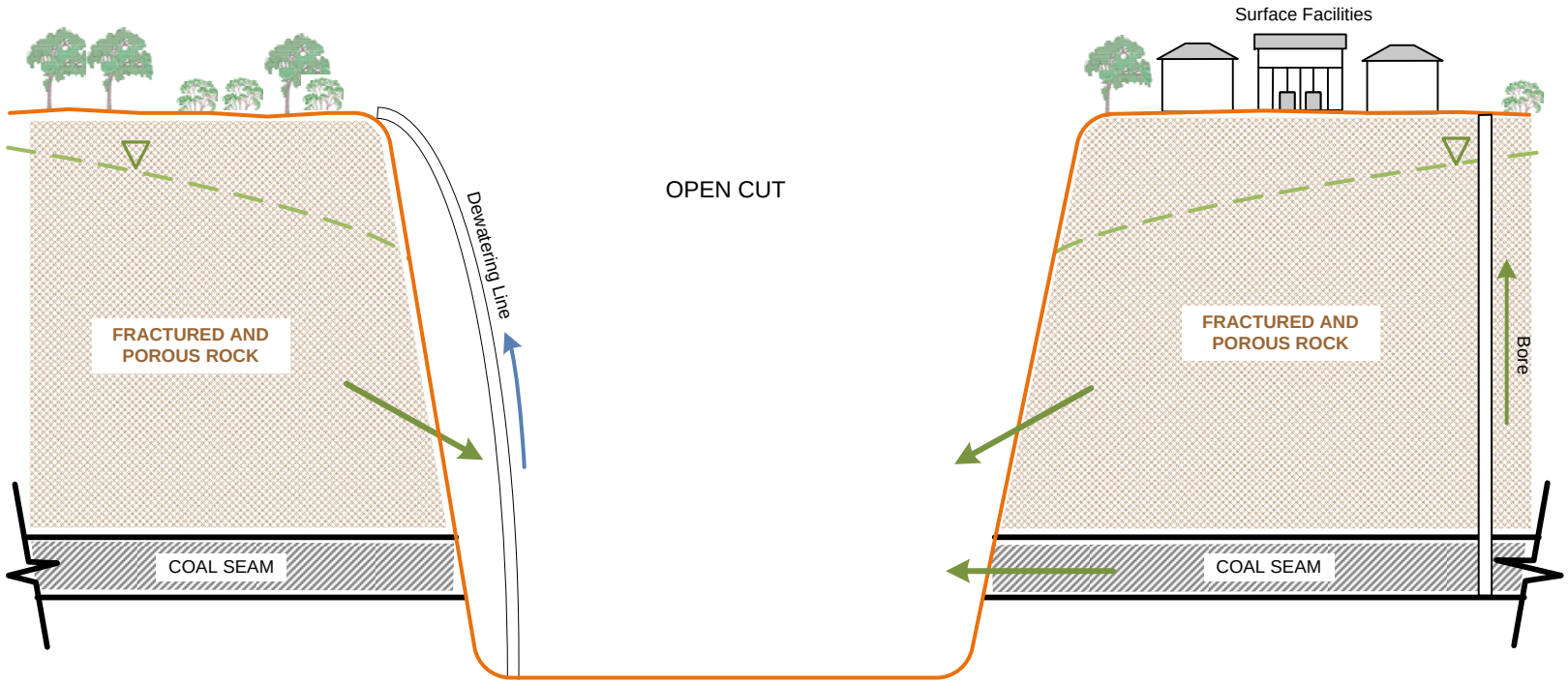
Aquifer Interception by Underground Mine Workings

Centennial Coal

DATE Aug 2013

Figure 6-2

G:\22\16761\Visios\Report2Visios\2216761_FIG6-2_AquiferInterceptionbyUndergroundMineWorkings.vsd



Extraction from Groundwater Source

Operational Transfer of Mine Water

LOCATION	Regional
SEAM	NA
DRAWN	SM
CHECKED	SG
APPROVED	SG
SCALE	NTS

Western Coalfield Water Balance

Aquifer Interception by Open Cut Operations

Centennial Coal

DATE Aug 2013

Figure 6-3

G:\22\16761\Visios\Report2Visios\2216761_FIG6-3_AquiferInterceptionbyOpenCutMine.vsd

In the case where models had been developed for the full period between 2013 and 2038 (Angus Place Colliery, Springvale Mine, Lidsdale Siding and Western Coal Services), predicted annual groundwater extraction volumes over this period were input directly into GoldSim, although the extractions were proportioned conceptually according to groundwater sources if they came from multiple sources. The method used to proportion the extractions between groundwater sources is described in Section 6.3.4.

In the case where a site hydrogeological model had previously been developed but it did not run over the full period from 2013 to 2038, either additional numerical modelling was undertaken by GHD (Airly Mine) or the existing hydrogeological model predictions were used and extrapolated linearly according to the local hydrogeological environment and available mine plans (Clarence Colliery and Pine Dale Mine), Predicted total groundwater extractions were also proportioned between the relevant groundwater sources.

6.3.2 Case 2 – Existing Hydrogeological Assessment (No model)

For those sites with no hydrogeological model, estimates of groundwater extraction were based on the mine water balance models and/or recorded dewatering rates. This method was used for Baal Bone Colliery, Charbon Colliery and the Coalpac Consolidation Project. Groundwater extraction at these sites is linked to site water demands, rainfall infiltration into old mine workings and the regional flow of groundwater between old workings.

6.3.3 Case 3 – No Existing Hydrogeological Assessment

For the Neubeck Project, the site has not been developed and does not have an existing site hydrological model. A conceptual site hydrogeological model was developed. A six layer uncalibrated MODFLOW hydrogeological model was developed to estimate the inflow of groundwater (primarily from old workings) into the proposed open cut pits under a range of groundwater recharge conditions. The Wallerawang and Ivanhoe underground workings were incorporated into the model.

6.3.4 Proportioning Between Groundwater Sources

The total predicted groundwater extraction by mine workings at each site was proportioned between the intercepted groundwater sources by assigning the predicted extraction for each year between 2013 and 2038 to the groundwater source in which the active workings were operating during that year.

Water volumes taken from groundwater extraction bores were not proportioned; the predicted extraction was assigned to the groundwater source in which the bore is located.

The majority of the existing groundwater extraction entitlement for Angus Place Colliery, Clarence Colliery and Springvale Mine is within the Sydney Basin Richmond Groundwater Source because the licensed bores for these sites are predominantly located within the Sydney Basin Richmond boundary. These bores are actually only transferring water that has already been incidentally extracted from the groundwater sources as a result of underground mining. While some of this extraction is from the Sydney Basin Richmond Groundwater Source, a large proportion also comes from the Sydney Basin Coxs River Groundwater Source since at least half of the underground mine footprints at these sites (particularly at Springvale Mine and Angus Place Colliery) are located within this groundwater source.

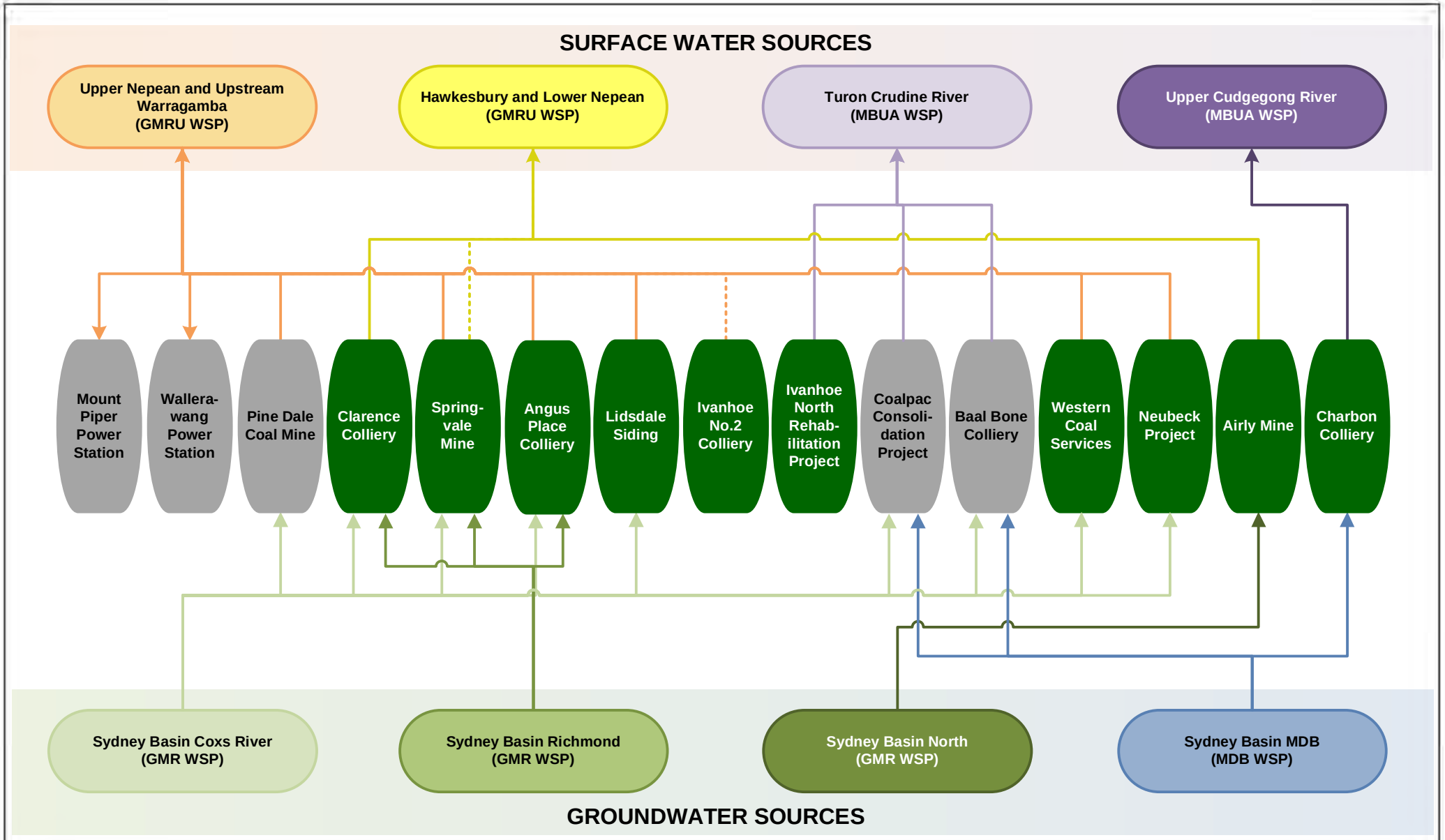
6.4 Regional Water Balance Conceptualisation

Each modelled extraction and discharge was assigned to a groundwater or surface water source as defined by the WSPs. Figure 4-1 and Figure 4-3 presents the location of mine workings and LDPs in relation to groundwater and surface water sources respectively. Typically, extractions (with the exception of Mount Piper and Wallerawang Power Stations) occur from groundwater sources, due to the interaction of mine workings with aquifers, and discharges feed into surface water sources via LDPs. Some sites interact with several groundwater and surface water sources due to their site extending over several water source boundaries.

The conceptual chart of the potential interactions of each site with the respective groundwater and surface water sources is provided in Figure 6-4. A schematic of the water transfers between Centennial sites in the region is provided in Figure 6-5.

As described in Section 6.1.1, all sites were assessed over the simulation timeline (2013 to 2038). The outputs for the key variables at each site were then aggregated so that the total annual extractions and discharges from the site were categorised by source and further aggregated to determine the distribution of total extractions and discharges by site over time.

The key variables were grouped further such that the extractions and discharges across sites were aggregated by the water source being drawn from or discharged to. This enabled an assessment of the operations across the study area by water source.



Extraction/Discharge

No Discharge

Centennial

Non-Centennial

LOCATION	Regional
SEAM	NA
DRAWN	SM
CHECKED	SC
APPROVED	SG
SCALE	NTS

Western Coalfield Water Balance

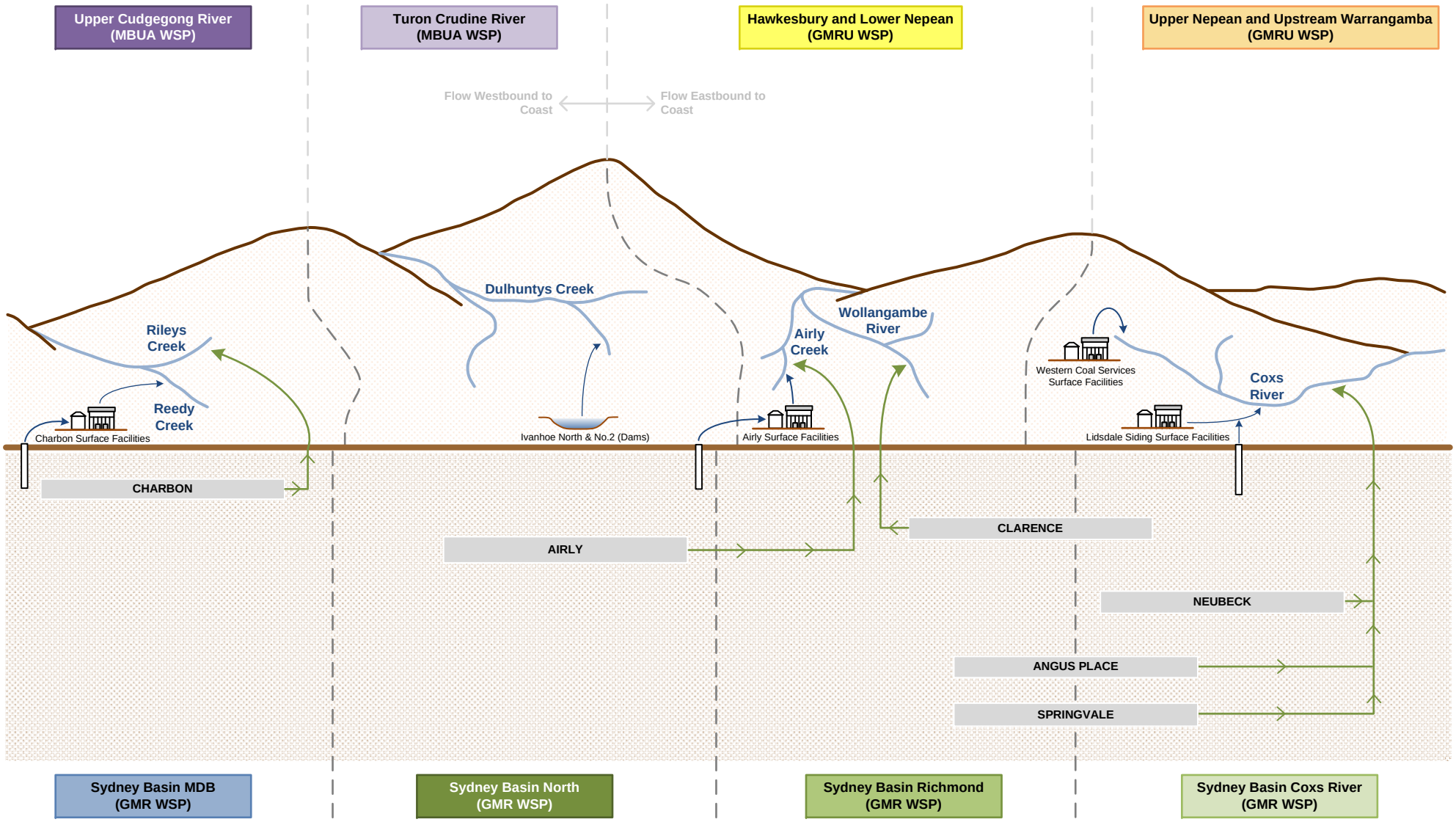
Western Coalfield Interactions between Water Sharing Plans

Centennial Coal

DATE Nov 2013

Figure 6-4

G:\22\16761\Visios\Report2Visios\2216761_FIG6-4_Regional Water Sharing Schematic.vsd



LOCATION	Regional
SEAM	NA
DRAWN	SM
CHECKED	SG
APPROVED	SG
SCALE	NTS

Western Coalfield Water Balance

Centennial Regional Water Transfers

Centennial Coal

DATE Aug 2013

Figure 6-5

G:\22\16761\Visios\Report2Visios\2216761_FIG6-5_RegionalWaterTransfers.vsd

6.5 Hydrologic Modelling

In order to estimate the runoff contributing to the water storages, the Australian Water Balance Model (AWBM) was incorporated within the wider GoldSim model.

The AWBM model was adopted as the most suitable model as it is widely used throughout Australia, has been verified through comparison with large amounts of recorded streamflow data, and literature is available to assist in estimating input parameters based on recorded streamflow data (Boughton and Chiew, 2003). Another advantage of the AWBM model is the consideration of soil moisture retention when determining runoff.

The AWBM model is a catchment water balance model that calculates runoff from rainfall after allowing for relevant losses and storage. As seen in Figure 6-6 the model consists of three storage elements (with surface areas A_1, A_2 and A_3) representing elements such as infiltration into the soil. The definition of model parameters is provided in Table 7-1. Rainfall initially enters these storages, and once a storage element is full any additional rainfall is considered to be excess rainfall. Of this excess rainfall a proportion is routed to the groundwater/baseflow storage (BS) while the remainder is routed to the surface storage (SS). The discharge from the groundwater storage and surface storage is estimated as a proportion of the volume of the storages at the end of each day. The total daily runoff is equal to the combined volume of water discharged from these two storages.

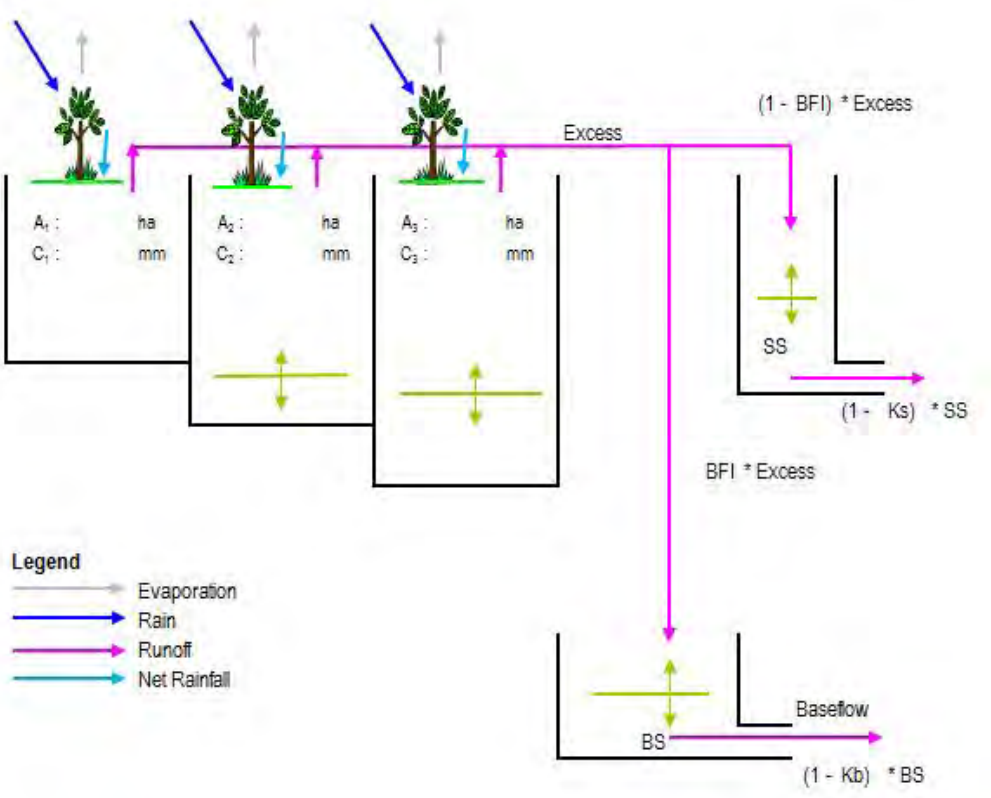


Figure 6-6 AWBM Model Representation

The relevant site catchments were divided into areas representing bushland/vegetation, impervious areas, disturbed/compacted areas and spoil. These areas were modelled with a different set of AWBM parameters. The parameters for bushland/vegetated areas were determined based on available literature where historical streamflow data had been used to provide recommendations on parameter selection.

7. Data

7.1 Regional Data

7.1.1 Rainfall

Rainfall data from a number of Bureau of Meteorology (BOM) stations was assessed. The rainfall was found to vary significantly between the Northern Study Area and Southern Study Area, due to the large area covered by the Study Area. Rainfall data from two BOM stations was used in the regional water balance to assess the Northern Study Area and Southern Study Area. The rainfall data was chosen based on the length and quality of the data record and proximity to the sites assessed.

For this assessment, daily rainfall data was obtained as SILO Patched Point Data from the Queensland Climate Change Centre of Excellence. SILO Patched Point Data is based on historical data from a particular BOM station with missing data 'patched in' with interpolations from nearby stations.

Northern Study Area

For the Northern Study Area, SILO data was obtained for BOM Ilford (Warragunyah) Station (station number 62031), which is located approximately 29 km north-west of Airly Mine and 21 km south-west of Charbon Colliery.

The period of rainfall data extended from January 1901 to December 2012 and is summarised as annual totals in Figure 7-1. The statistics for this rainfall set are:

- Minimum annual rainfall – 277 mm in 1982.
- Average annual rainfall – 672 mm.
- Median annual rainfall – 659 mm.
- Maximum annual rainfall – 1,513 mm in 1950.

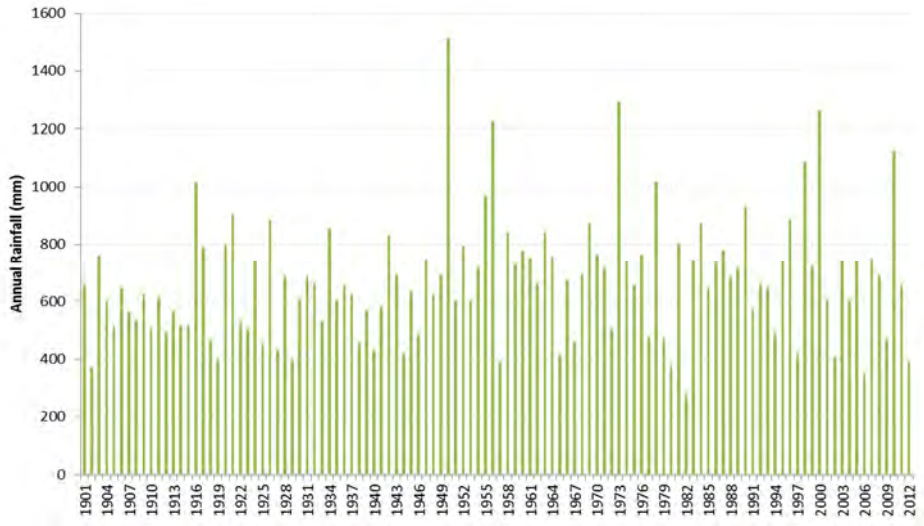


Figure 7-1 Annual Rainfall Adopted for the Northern Study Area

The monthly rainfall statistics were also determined for the period of record from the Ilford (Warragunyah) BOM station and selected statistics are provided in Figure 7-2.

The average monthly rainfalls were observed to vary from a low of approximately 45 mm in May to a high of approximately 67 mm in January. Figure 7-2 shows a significant variation in the maximum recorded monthly rainfalls with the maximum value being approximately 304 mm in August and the lowest monthly value of approximately 150 mm in May. Minimum monthly rainfall values for all months were 0 mm, except for July with 2 mm.

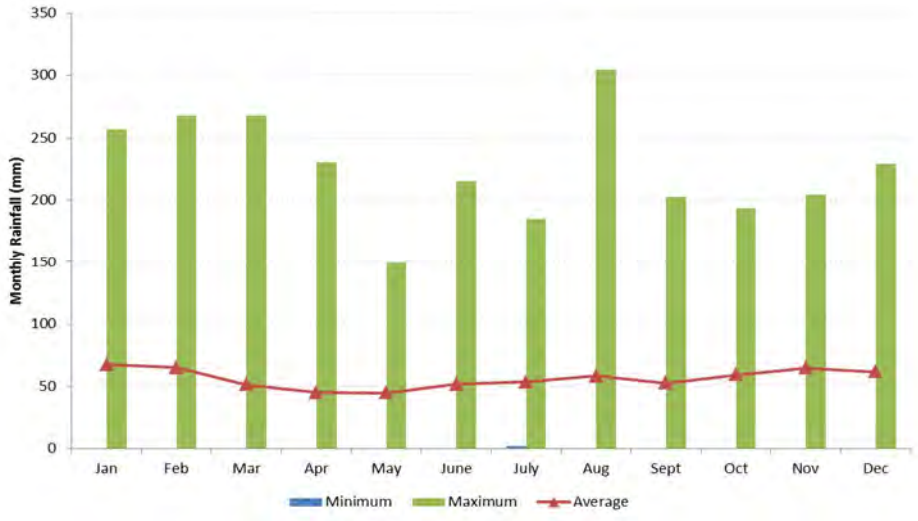


Figure 7-2 Monthly Rainfall Statistics for Ilford (Warragunyah) Station

An analysis of the rainfall data was undertaken to enable an understanding of the likely rainfall patterns for the Northern Study Area. For various intervals of daily rainfall, the average number of days per year which have rainfall within each interval are presented in Figure 7-3, with non-rainfall days (less than 0.1 mm) excluded. The figure also presents the cumulative days per year as a percentage against the same rainfall intervals. The average number of non-rainfall days (less than 0.1 mm) per year is approximately 280, which is approximately 77% of days in a year.

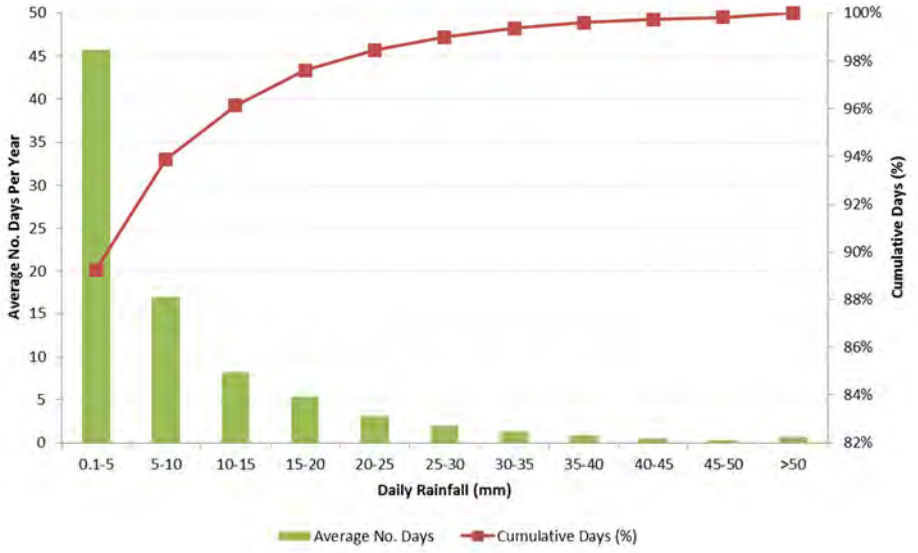


Figure 7-3 Number of Rain Days of Various Magnitudes (greater than 0.1 mm) for Ilford (Warragunyah) Station

As shown in Figure 7-3, 13% of days per year (or 46 days) receive between 0.1 and 5 mm of rainfall. Daily rainfall depths are greater than 10 mm approximately 6% of the time (or 22 days per year) on average, with approximately 1% of days in the year (or five days) receiving greater than 25 mm of rain.

A comparison of average monthly rainfall recorded at the Ilford (Warragunyah) BOM station and the corresponding SILO Patched Point Data is presented in Figure 7-4. The figure indicates that the interpolated SILO data reasonably represents the historical recorded rainfall at the BOM station.

Figure 7-4 Comparison of Average Monthly Rainfall Data from Ilford (Warragunyah) BOM Station and SILO Patched Point Data

Southern Study Area

For the Southern Study Area, SILO data was obtained for BOM Lithgow (Birdwood St) Station (station number 63224), which is located in Lithgow.

The period of rainfall data extended from January 1901 to December 2012 and is summarised as annual totals in Figure 7-5. The statistics for this rainfall set are:

- Minimum annual rainfall – 450 mm in 1944.
- Average annual rainfall – 852 mm.
- Median annual rainfall – 846 mm.
- Maximum annual rainfall – 1,616 mm in 1950.

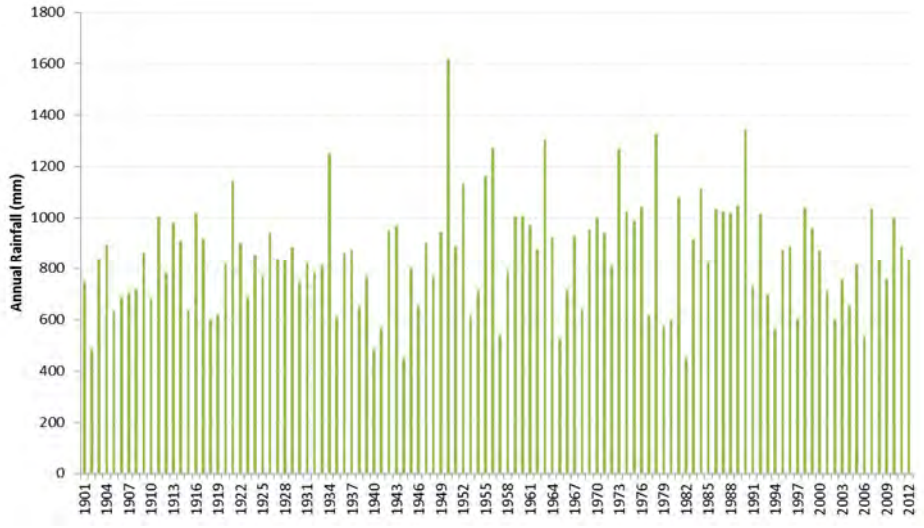


Figure 7-5 Annual Rainfall Adopted for Southern Study Area

The monthly rainfall statistics were also determined for the period of record from the Lithgow (Birdwood St) BOM station and selected statistics are provided in Figure 7-6.

The average monthly rainfalls were observed to vary from a low of approximately 56 mm in September to a high of approximately 91 mm in January. Figure 7-6 shows a significant variation in the maximum recorded monthly rainfalls with the maximum value being approximately 374 mm in August and the lowest monthly value of approximately 158 mm in September.

Figure 7-6 Monthly Rainfall Statistics for Lithgow (Birdwood St) Station

An analysis of the rainfall data to enable an understanding of the likely rainfall patterns was also undertaken for the Southern Study Area. For various intervals of daily rainfall, the average number of days per year which have rainfall within each interval are presented in Figure 7-7, with non-rainfall days (less than 0.1 mm) excluded. The figure also presents the cumulative days per year as a percentage against the same rainfall intervals. The average number of non-rainfall days (less than 0.1 mm) per year is approximately 229, which is approximately 63% of days in a year.

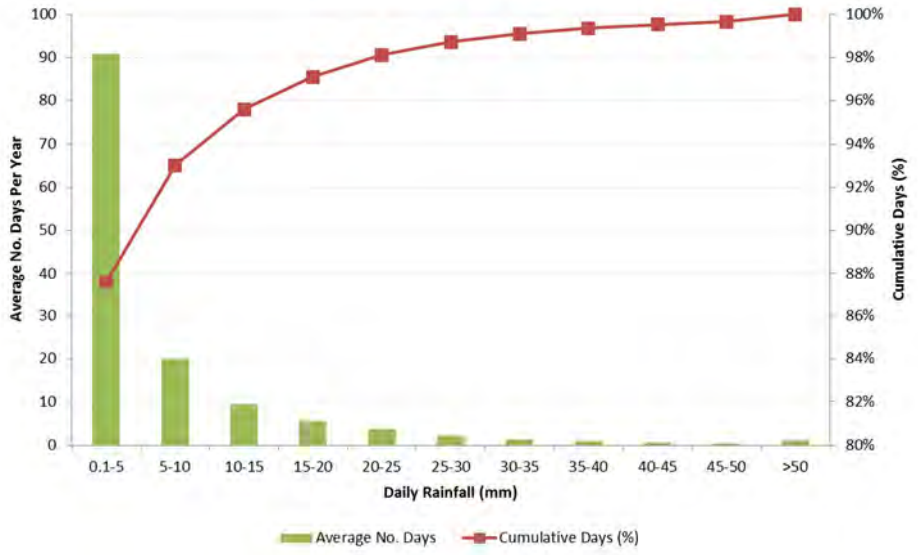


Figure 7-7 Number of Rain Days of Various Magnitudes (greater than 0.1 mm) for Lithgow (Birdwood St) Station

As shown in Figure 7-7, 25% of days per year (or 91 days) receive between 0.1 and 5 mm of rainfall. Daily rainfall depths are greater than 10 mm approximately 7% of the time (or 25 days per year) on average, with approximately 2% of days in the year (or seven days) receiving greater than 25 mm of rain.

A comparison of average monthly rainfall recorded at the Lithgow (Birdwood St) BOM station and the corresponding SILO Patched Point Data is presented in Figure 7-8. The figure indicates that the interpolated SILO data reasonably represents the historical recorded rainfall and the BOM station.

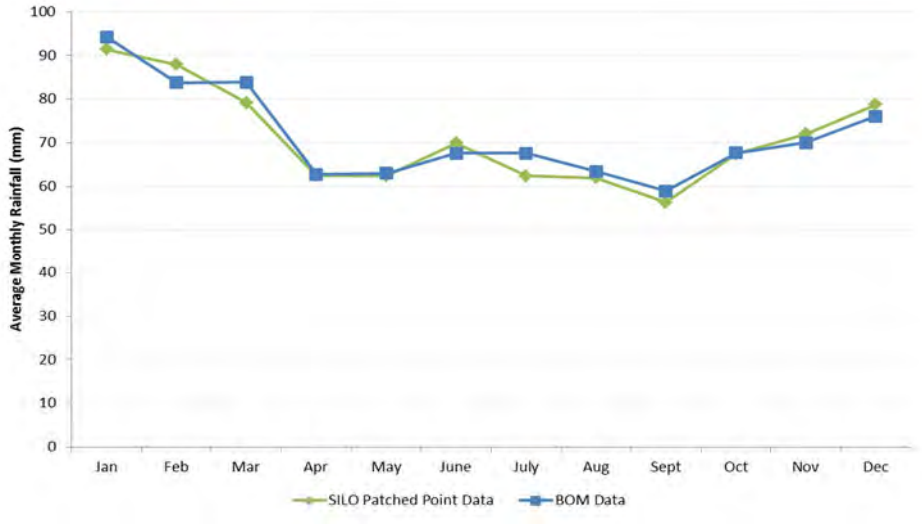


Figure 7-8 Comparison of Average Monthly Rainfall Data from Lithgow (Birdwood St) BOM Station and SILO Patched Point Data

7.1.2 Evaporation

Information provided at the closest BOM site which records evaporation, Bathurst Agricultural Station (station number 63005), was reviewed and average monthly evaporation rates determined for input to the water balance. The average daily evaporation adopted for the water balance is presented in Figure 7-9.

Figure 7-9 Average Daily Evaporation Each Month from Bathurst Agricultural Station

A pan factor of 0.9 was applied to the daily evaporation rates to simulate the evaporation of water from surface water storages. Evapotranspiration factors were applied in the hydrologic model to simulate evapotranspiration losses from impervious and vegetated catchments.

7.1.3 Hydrologic Model Data

For the Northern Study Area, the nearest location for which AWBM model parameters had been determined by Boughton and Chiew (2003) was Capertee River, located 25 km east of Airly Mine and 38 km south-east of Charbon Colliery. For the Southern Study Area, the nearest location was Coxs River, located 31 km south of Lithgow. The recommended parameters relating to baseflow were adjusted to reflect the ephemeral nature of drainage lines adjacent to the sites.

The impervious areas were modelled without infiltration into the soil and without surface storage or baseflow storage. Only one storage was assigned a non-zero capacity. This storage represents depression storage of 7 mm for impervious areas. The baseflow parameters were adjusted to reflect no baseflow as the relevant site catchments are typically not large enough to generate baseflow.

The runoff for each relevant catchment was then calculated by scaling the runoff depth to reflect the sub catchment impervious and pervious areas.

A description of AWBM parameters is provided in Table 7-1. The AWBM parameters adopted in the GoldSim model is shown in Table 7-2.

Table 7-1 Description of AWBM Parameters

Parameter	Description
A_1, A_2, A_3	The partial areas of the overall catchment contributing to storages 1, 2 and 3 respectively
C_1, C_2, C_3	The capacity of storages 1, 2 and 3 respectively (mm)
BFI	The proportion of excess rainfall flowing to the baseflow
Excess	Excess from storages C_1, C_2 and C_3
SS	Surface Storage Recharge
BS	Baseflow Storage Recharge
Kb	The proportion of the volume of the baseflow storage remaining in the storage at the end of each day. Not applicable for these catchments as there is no baseflow component
Ks	The proportion of the surface flow storage remaining in the storage at the end of each day

Table 7-2 AWBM Parameters Adopted

Parameter	Bushland/Vegetation Areas			Impervious Areas		Disturbed/Compacted Areas			Spoil Areas
	Northern Study Area	Southern Study Area	Neubeck Project	Northern/Southern Study Area	Neubeck Project	Northern Study Area	Southern Study Area	Neubeck Project	Neubeck Projecy
A_1, A_2, A_3	0.134, 0.433, 0.433	0.134, 0.433, 0.433	0.134, 0.433, 0.433	1.0, 0.0, 0.0	1.0, 0.0, 0.0	0.134, 0.433, 0.433	0.134, 0.433, 0.433	0.134, 0.433, 0.433	0.2, 0.8, 0.0
C_1, C_2, C_3	18.0, 182.88, 365.76 ($C_{average}$ = 240)	8.1, 82.296, 164.592 ($C_{average}$ = 108)	7.125, 72.39, 144.78 ($C_{average}$ = 95)	7.0, 0.0, 0.0	5.0, 0.0, 0.0	7.0, 14.0, 30.0	7.0, 18.0, 36.0	7.0, 14.0, 30.0	10.0, 150.0, 0.0
BFI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Excess	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated
SS	(1-BFI) x Excess	(1-BFI) x Excess	(1-BFI) x Excess	(1-BFI) x Excess	(1-BFI) x Excess	(1-BFI) x Excess	(1-BFI) x Excess	(1-BFI) x Excess	(1-BFI) x Excess
BS	BFI x Excess	BFI x Excess	BFI x Excess	BFI x Excess	BFI x Excess	BFI x Excess	BFI x Excess	BFI x Excess	BFI x Excess
Kb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ks	0.5	0.5	0.35	0.0	0.0	0.5	0.5	0.2	0.2

7.2 Operational Timelines

The water balance model simulates the conditions at each site from 2013 to 2038. As the operational conditions at each site were not specifically available for all sites over this timeframe, several assumptions have been made with respect to each site's operational phases over this time. A summary of the assumed operational phases for each site is provided in Appendix D.

7.3 Detailed Site Data

7.3.1 Airly Mine

Airly Mine is currently operating under care and maintenance and Centennial Airly is seeking approval to extend mining operations employing a range of partial extraction mining methods. As part of the project, Centennial Airly proposes to construct a CPP and life-of-mine REA. To model the mining activities which may occur under existing conditions, the water balance was based on existing site conditions assuming maximum extraction of 1.8 Mtpa of ROM coal.

GHD has developed a detailed site water balance for the site in GoldSim which simulated the complete water cycle at the site. The water balance assumed the site would commence operations of the proposed extension project in 2015 and continue for a period of 17 years (Briefing Paper, 2012).

Underground mining undertaken as part of the proposed extension project is expected to produce groundwater inflows in the order of up to 0.5 ML/day. These estimates were made using the existing Airly Mine hydrogeological model (GHD, 2013a). This is a MODFLOW three-dimensional numerical model. The model was updated using the new mine plan for Airly Mine and calibrated for groundwater head under steady state conditions (by manually altering the hydraulic conductivity of the hydrogeological units and/or rainfall recharge) with vibrating wire piezometer (VWP) data recorded in 2012 and 2013. The transient model was run using annual stress periods and monthly time steps between 2013 and 2038, using a rainfall recharge of 2% of average rainfall (derived from the steady state calibration). It was assumed that the mine workings would remain fully drained throughout the operational phase of mining.

Water demands of the site are expected to be supplemented by extraction from a groundwater bore. The current volumetric licence for this bore is WAL 24386 and the bore work licence is 10BL603503. Both of these withdrawals (mine inflow and groundwater bore) were considered an extraction from the Sydney Basin North Groundwater Source.

The Airly mine site is located in the upper reaches of the Capertee River catchment and so overflows from LDPs at the site will discharge into the Hawkesbury and Lower Nepean Surface Water Source.

It should be noted that as the project is in a concept phase, water cycle estimates are preliminary and extraction and discharge volumes are subject to change.

7.3.2 Angus Place Colliery

Angus Place Colliery is currently seeking approval for the continuation of longwall mining to the east of the current workings.

GHD has developed a detailed site water balance for the site in GoldSim which simulated the complete water cycle at the site. The water balance assumed the site would commence operations of the proposed extension project by 2016 and continue until 2032 (CSIRO, 2013).

There is groundwater extraction into the underground workings, which is transferred through an in-seam water management system. Groundwater extraction volumes over the life of mine were predicted by CSIRO using the COSFLOW geomechanical/hydrogeological model (CSIRO, 2013). Additional water is also transferred via a dewatering bore. The underground workings at Angus Place Colliery extend over two groundwater sources and therefore inflows in the mine workings extract from both the Sydney Basin Coxs River Groundwater Source and the Sydney Basin Richmond Groundwater Source. The predicted groundwater extraction volumes were proportioned between these groundwater sources as described in Section 6.3.4. Groundwater extraction from the 900 District and Northern Panels was split equally between the Sydney Basin Coxs River and Sydney Basin Richmond groundwater sources. All extraction by the proposed Angus Place East workings will come from the Sydney Basin Richmond Groundwater Source.

Groundwater extraction is transferred to the Wallerawang Power Station via the SDWTS, which also receives water from Angus Place Colliery. It has been assumed that transfers to the SDWTS from Angus Place Colliery will cease in 2032 with mining activities.

Angus Place Colliery has LDPs located in the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone). Excess water is regularly discharged through LDPs in the Upper Nepean and Upstream Warragamba Water Source.

Springvale-Delta Water Transfer Scheme

The SDWTS receives excess groundwater from both Angus Place Colliery and Springvale Mine for transfer to Wallerawang Power Station or to Springvale Mine's LDP009. Transfers from Springvale Mine take priority, with the remaining capacity of the SDWTS supplied by transfers from Angus Place Colliery.

It is expected that groundwater extraction in the underground mine workings at both Angus Place Colliery and Springvale Mine will increase due to the proposed mining extension. The cumulative predicted groundwater make is predicted to exceed the current capacity of the SDWTS. For this reason, the capacity of the SDWTS will be increased through a duplication of the existing pipeline network to a maximum capacity of 50 ML/day to accommodate increased inflows from Angus Place Colliery into the SDWTS.

The assessment of transfers to the SDWTS from Angus Place Colliery and Springvale Mine included an evaluation of transfers occurring with the current SDWTS capacity of 30 ML/day and the upgraded SDWTS capacity of 50 ML/day.

7.3.3 Baal Bone Colliery

Underground mining operations at Baal Bone Colliery ceased in 2011 and the site was placed on care and maintenance and from 2012 Baal Bone Colliery has been used as a training facility for Glencore Xstrata employees.

An existing water balance model was not available for Baal Bone Colliery. An understanding of site water management was developed from the review of the following documents:

- AECOM, 2009, *Continued Operations at Baal Bone Colliery – Mine Water Balance (prepared for the Environmental Assessment for the mining of Longwalls 29 to 31).*
- The Wallerawang Collieries Ltd, 2013, *2012 Annual Environmental Management Report, Baal Bone Colliery.*

- Water source extractions undertaken at Baal Bone Colliery are associated with interception by the underground workings. The workings are dewatered whilst underground mining training activities are being undertaken. The underground workings at Baal Bone Colliery extend into two WSPs and extract from two groundwater sources – the Sydney Basin MDB Groundwater Source and the Sydney Basin Coxs River Groundwater Source.
- The reported volume of water transferred from the underground workings in 2012 was used to estimate total groundwater extraction at Baal Bone until the end of the current approval in December 2014. From this time, it was assumed that groundwater extraction will reduce uniformly over time as it is allowed to accumulate within the underground workings. It was assumed that groundwater extraction will reduce to 365 ML/year by 2038, which is understood to reflect the rate of groundwater movement between old flooded workings in the region.
- The predicted groundwater extraction volumes between 2013 and 2038 were proportioned between the two groundwater sources as described in Section 6.3.4.

There are three current LDPs at the Baal Bone which frequently discharge into the Turon Crudine River Water Source. LDP001 discharges into Ben Bullen Creek are reportedly runoff based with an average annual discharge of 135 ML/yr and median annual discharge of 118 ML/yr. These values were then extrapolated to provide annual runoff values for all modelled rainfall years using annual runoff ratios derived as a proportion of the mean for runoff modelled for typical disturbed catchments. The extrapolation estimated the following annual runoff values in Table 7-3 for a range of annual percentile rainfall years.

Table 7-3 Annual Estimated Runoff values derived for LDP001 Baal Bone Colliery

Annual Rainfall Percentile	Annual Estimated Runoff (ML/yr)
1%	28.7
10%	53.7
30%	90.9
50%	125.5
70%	162.1
90%	225.4
99%	348.0

Although the estimated median runoff reported in the water balance report (AECOM, 2009) was approximately 8 ML/yr less than the value estimated by extrapolating from the mean using typical runoff ratios, the values in Table 7-3 were considered appropriate. The runoff values determined in Table 7-3 were applied to the model and scaled down from year 2014 due to assumed rehabilitation.

Discharges through LDP003 and LDP006 were modelled as a product of dewatering the underground workings.

It has been assumed that underground mining training activities may continue at the site until the end of the current approved mining lease in 2022. For the purposes of modelling the water cycle it was assumed that dewatering of the underground workings would continue until 2022, and that rehabilitation of the surface areas would commence in 2014.

7.3.4 Charbon Colliery

Charbon Colliery currently has approval to produce up to 1.5 Mtpa of ROM coal employing bord and pillar underground and open cut mining methods. It is expected that Charbon Coal will surrender all existing development consents in 2013 and enter a care and maintenance phase (Charbon Coal, 2012).

GHD has developed a detailed site water balance for the site in GoldSim which simulated the complete water cycle at the site. The water balance assumed the site would cease active mining operations by the end of 2013 and continue in care and maintenance whilst rehabilitation activities continue for the following seven years.

Groundwater is intercepted at Charbon Colliery by underground mining activities, resulting in the extraction of perched groundwater, and via the production bore. Both extractions are from the Sydney Basin MDB Groundwater Source. The extraction of perched groundwater has been assumed to continue for the entire simulation timeline and varies with rainfall. Therefore the water balance model has been used to predict groundwater extraction volumes.

Excess water from the site is discharged through LDPs located in the Upper Cudgegong River Water Source. As the rehabilitation phase has been assumed to last seven years, LDP discharges from the Charbon site will cease from 2021.

7.3.5 Clarence Colliery

GHD has developed a detailed site water balance for the site in GoldSim which simulated the complete water cycle at Clarence Colliery. The water balance assumed the site would continue underground mining until 2027 which is the end of the sites current mining approval.

There is groundwater extraction into the underground workings, from both the Sydney Basin Coxs River Groundwater Source and the Sydney Basin Richmond Groundwater Source. The existing hydrogeological model for Clarence Colliery (GHD, 2011) was used to predict future groundwater extractions. Run 6 of the transient model was used to predict groundwater extractions between 2013 and 2016 because this simulation was found to best fit the most recent underground water pumping data for Clarence. The Best Case model output curve was then extrapolated at an increasing rate of 0.5 ML/day per year up to 2026 (the average rate of increase between 2010 and 2016), after which time the extraction was assumed to decrease at a rate of 0.5 ML/day per year.

The predicted groundwater extraction volumes between 2013 and 2038 were proportioned between the two groundwater sources as described in Section 6.3.4.

Groundwater extractions into the workings are pumped to the surface for treatment and discharged off-site through an LDP in the Hawkesbury and Lower Nepean Rivers Water Source. Other discharges through LDPs at Clarence are a result of overflows from the surface water collection system.

7.3.6 Coalpac Consolidation Project

Coalpac is currently seeking approval to consolidate and extend mining operations and manage both sites under a single development consent, known as the Coalpac Consolidation Project.

The existing water balance model for the Coalpac Consolidation Project was not provided for this study. An understanding of site water management was developed from the review of the following documents:

- WRM, 2011, *Surface Water Impact Assessment for Coalpac Consolidation Project*.
- Hansen Bailey, 2013, *Coalpac Consolidation Project Preferred Project Report*.

Mining activities were suspended at Cullen Valley Mine in 2012 and at Invincible Colliery in March 2013. It is expected that both mines will remain on care and maintenance until the application for the Coalpac Consolidation Project has been determined. For modelling purposes it was assumed operations for the proposed project will commence in 2015 and cease in 2035 once the 21 year mine life has expired.

Groundwater is extracted from underground workings for the supply of water for the CHPP and dust suppression activities. Groundwater is currently withdrawn from the Old Tyldesley workings and in the future the Invincible and Old Invincible workings will be drawn upon to supplement the water demands of the site. These workings are considered to be flooded and at equilibrium with the adjacent aquifer and therefore removal of water from them are considered to be groundwater extraction. The Old Tyldesley workings are located within the Sydney Basin MDB Groundwater Source while the Invincible and Old Invincible workings are located in both the Sydney Basin Coxs River and Sydney Basin MDB Groundwater Sources.

Water will be discharged from site via three LDPs, all located in the Turon Crudine River Water Source: LDP001, LDP002 and LDP004. The estimates for extraction from the underground workings and discharges from the LDPs were derived from values presented in the *Surface Water Impact Assessment for Coalpac Consolidation Project* (WRM, 2011). Groundwater extractions from the Invincible/Old Invincible workings were split equally between the Sydney Basin Coxs River and Sydney Basin MDB groundwater sources.

Following submission of the original environmental assessment the consolidation project, characteristics of the project were amended from the original project description. Changes to the project include: the removal of the sand extraction component, removal of the Hillcroft mining area and the reduction of mining footprint area. All of these changes to the project have the potential to alter the water extraction and discharge volumes predicted for the project, however, GHD are unable to quantify the impact of these changes. Therefore, modelling for the Coalpac Consolidation Project does not consider amendments to the project following the initial environmental assessment submission.

For the existing (2013) conditions, the values presented (WRM, 2011) assume the site is in its final year of operations before the consolidation project commences. In reality, the Coalpac Consolidation Project is currently in a care and maintenance phase. To reflect this amendment to the existing conditions the estimated demand (150 ML/yr) was removed from the extractions provided for the first year. Where the extraction for the year was less than 150 ML/yr the remaining, the difference was added to the discharge at LDP001 as it was assumed this water would otherwise have been extracted from the surface water dams which discharge through LDP001.

The assumed extraction and discharge volumes are provided in Table 7-4 , alongside the original existing condition volumes (WRM, 2011).

Table 7-4 Extraction and Discharge Volumes

Extraction / Discharge	Annual Rainfall Percentile	Original Existing Conditions	Adopted Existing Conditions	Future Operations (Year 2)	Future Operations (Year 8)	Future Operations (Year 14)	Future Operations (Year 20)
		ML/yr	ML/yr	ML/yr	ML/yr	ML/yr	ML/yr
Extractions from UG Workings	1%	146	0	465	512	451	453
	20%	81	0	353	354	276	295
	50%	19	0	206	223	158	188
	80%	0	0	69	86	30	45
	99%	0	0	0	0	0	0
LDP001 Discharges	1%	0	4	0	0	0	0
	20%	0	69	0	0	0	0
	50%	35	166	0	0	7.5	5
	80%	138	288	100	110	125	125
	99%	530	680	540	550	550	550
LDP002 Discharges	1%	0	0	0	0	0	0
	20%	0	0	0	0	0	0
	50%	0	0	0	0	0	0
	80%	0	0	0	0	0	0
	99%	0	0	0	290	350	290
LDP004 Discharges	1%	0	0	0	0	0	0
	20%	0	0	0	0	0	0
	50%	3	3	0	0	0	0
	80%	160	160	85	90	90	92
	99%	670	670	480	490	490	510

7.3.7 Ivanhoe No. 2 Colliery

In 2005 Ivanhoe No. 2 Colliery was placed on care and maintenance and no mining activities have occurred since. Surface water runoff from contributing catchments is collected in several surface water storages that overflow through a single LDP or is discharged underground.

No water is actively extracted from any water sources at the site, including groundwater or surface water. Currently the surface water collected at the site is discharged underground into previously mined underground workings. Water is not currently discharged to surface water sources via an LDP and therefore no discharges have been included in the water balance modelling for this site. Therefore, Ivanhoe No. 2 Colliery has been assumed to have no net impact on the water balance of the Western Coalfield.

7.3.8 Ivanhoe North Rehabilitation Project

Mining operations were completed at the Ivanhoe North site in 2012 and rehabilitation of the site is continuing since the closure.

A simple water balance model was developed for the site which simulated the collection of runoff from disturbed catchment areas and the subsequent discharge of surface water from water storages. Water storage volumes and catchment areas to the surface water storages were delineated from the *Ivanhoe North Rehabilitation Project: Revised Site Water Management Plan, Revision 3* (GHD, 2010).

The modelling assumed that rehabilitation commenced in 2013 and therefore discharges through the LDPs at the site would reduce until 2019 when rehabilitation is completed.

7.3.9 Lidsdale Siding

Lidsdale Siding is a coal storage and rail loading facility. Water is required at Lidsdale Siding for dust suppression and washdown and is supplied by surface water storages and supplemented by a production bore.

Extraction volumes from the licensed bore and discharges from LDP004 under normal operating conditions were adopted from the *Lidsdale Siding Upgrade Project – Surface Water Assessment* (RPS, 2012). The only amendment that has been made to the data presented in the report is that water reportedly sourced from Pipers Flat Creek has been assumed to be sourced from the production bore as extractions from the creek no longer occur.

The information in Table 7-5 was incorporated into the water balance model.

Table 7-5 Daily Extraction and Discharge Rates adopted for Lidsdale Siding (Normal Conditions)

Daily Rainfall Percentile	Production Bore Extraction	Discharge from LDP004
5%	0.014 ML/day	0.000 ML/day
10%	0.014 ML/day	0.000 ML/day
50%	0.018 ML/day	0.000 ML/day
70%	0.018 ML/day	0.000 ML/day
90%	0.018 ML/day	0.002 ML/day

It was assumed that construction activities for an upgrade to the facilities at Lidsdale Siding will be undertaken in 2014. For this year only, dewatering is required to be undertaken at a rate of 1.4 ML/yr as indicated by the *Lidsdale Siding Upgrade Project – Groundwater Assessment* (RPS, 2012). Groundwater extractions occur from the Sydney Basin Coxs River Groundwater Source and surface water discharges enter the Upper Nepean and Upstream Warragamba Surface Water Source.

7.3.10 Mount Piper Power Station

Water required for the operation of Mount Piper Power Station is supplied from the Coxs River via Thompsons Creek Dam and is supplemented by the Fish River Water Supply Scheme. The most detailed information available to GHD regarding the extraction and discharge of water at Mount Piper Power Station was obtained from the following documents:

- *Delta Electricity Western – Water Management Licence Annual Compliance Report 2005-2006*, Parsons Brinkerhoff, 2006.
- *Delta Electricity Western – Water Management Licence Annual Compliance Report 2006-2007*, Delta Electricity, 2007.
- *Delta Electricity Western – Water Management Licence Annual Compliance Report 2007-2008*, Delta Electricity, 2008.
- *Delta Electricity Western – Water Management Licence Annual Compliance Report 2008-2009*, Delta Electricity, 2009.
- *Delta Electricity Water Management Licence*, NSW Office of Water, 2009.

An estimate of Mount Piper Power Station's net annual extractions was determined from the annual compliance reports listed above. A comparison was undertaken of the annual extraction volumes from the Fish River Water Supply Scheme and the Coxs River with annual rainfall totals to determine whether there was a correlation between annual rainfall and the volumes of extraction from each source. Over the four years of data available, a correlation between annual was not evident and therefore the average extraction volume from each water source was applied to the modelling.

The following average annual extractions were reported:

- 12,600 ML/yr from the Coxs River (Upper Nepean and Upstream Warragamba Surface Water Source).
- 1,600 ML/yr from the Fish River Water Supply Scheme (Fish River Surface Water Source).

It should be noted that variations in these extractions from each water source typically vary from year to year; however, the total volume extracted by Mount Piper Power Station was consistently reported to be approximately 14,200 ML/yr.

It was assumed that the water demand is sourced from the Coxs River and the Fish River Water Supply Scheme in the proportion of 90% / 10%. This proposed was derived from the average annual extractions presented above.

It should be noted that these assumptions have been made by GHD and in reality the sources of water to Mount Piper Power Station would be determined by the interaction of other factors including the availability and quality of water in each source which has not been considered here.

Although LDPs are listed for Mount Piper Power Station, limited information was available on the volumetric discharges from the site. Discharges from LDP001 have been reported as mostly generated by stormwater runoff and not expected to be significant in relation to other discharges entering the Coxs River catchment.

7.3.11 Neubeck Project

GHD has developed a detailed site water balance for the Neubeck site in GoldSim which simulated the proposed water cycle at the site. The water balance assumed the site would commence mining in 2015 and continue for a period of 11 years.

The proposed Neubeck open cut mine will require dewatering of existing flooded underground workings in the first few years of operation. It has been assumed that dewatering of the workings for the first two years of the project will be at a rate of 5 ML/day. Following this, inflows to the pit will continue for the duration of the project. The dewatering and pit inflows have been considered to be extractions from the Sydney Basin Coxs River Groundwater Source. As outlined in Section 6.3.3, a six layered MODFLOW numerical model was developed to predict inflows over time into the open cut pits.

Dewatered water and excess water collected in the surface water management system will be discharged through several LDPs into the Upper Nepean and Upstream Warragamba Surface Water Source. Detailed water balance modelling of indicative catchments and site conditions over the proposed mine life has been completed to provide estimates of the response of the site to varying rainfall conditions.

It should be noted that as the project is in a concept phase, water cycle estimates are preliminary and extraction and discharge volumes are subject to change.

7.3.12 Pine Dale Coal Mine

Establishment works in the Yarraboldy Extension Area of Pine Dale Coal Mine commenced in 2011. Pine Dale Coal Mine currently has approval to extract 0.35 Mtpa of ROM coal using open cut mining methods and is currently seeking approval to extend mining operations and increase coal extraction to 2 Mtpa of ROM coal as part of Stage 2 of the Yarraboldy Extension Project.

An existing water balance model was not available for Pine Dale Mine. An understanding of site water management was developed from the review of the following documents:

- R.W. Corkery & Co., 2011, *Water Management Plan for the Pine Dale Coal Mine (Including the Yarraboldy Extension).*
- R.W. Corkery & Co., 2011, *Documentation Supporting an Application for Director-Generals Requirements for the Pine Dale Coal Mine Stage 2 Extension*.

Pine Dale Coal Mine is currently operating in its final year of the Stage 1 Extension Project and it has been assumed the site will enter care and maintenance for the year 2014. Modelling assumed that the proposed Stage 2 Extension Project will commence operations in 2015 and operate for 15 years, after which the site will enter a rehabilitation phase.

Groundwater currently enters the open cut pit at a rate of approximately 7.4 ML/yr, based on hydrogeological modelling undertaken for the Stage 1 Yarraboldy Extension (Aquaterra Consulting, 2010). When the Stage 2 Extension Project commences it has been assumed that groundwater will be extracted from old underground workings at the site at a rate of 10 ML/day for a period of three and a half years. After this time groundwater extraction will continue at an estimated rate of 1 ML/day (corresponding to the approximate regional groundwater flow between old underground workings) and seepage into the open cut will cease. All groundwater extraction at the Pine Dale site comes from the Sydney Basin Coxs River Groundwater Source.

It was assumed that current excess water from the site is discharge via LDP004 into the Wallerawang underground workings. As this is a temporary underground storage these discharges do not contribute to the water source. With commencement of the Stage 2 Extension, it has been assumed extracted water will be discharged via LDP013 into Wangcol Creek, part of the Upper Nepean and Upstream Warragamba Surface Water Source.

7.3.13 Springvale Mine

Springvale Mine is currently seeking approval for the continuation of longwall mining to the east of the current workings.

GHD has developed a detailed site water balance for the site in GoldSim which simulated the complete water cycle at the site. The water balance assumed the site would commence operations of the proposed extension project by 2016 and continue until 2025 (CSIRO, 2013).

There is groundwater extraction into the underground workings, which is transferred through an in-seam water management system. Groundwater extraction volumes over the life of mine were predicted by CSIRO using the COSFLOW geomechanical/hydrogeological model (CSIRO, 2013). Additional water is also transferred via a dewatering bore. The underground workings at Springvale extract from both the Sydney Basin Coxs River Groundwater Source and the Sydney Basin Richmond Groundwater Source. The predicted groundwater extraction volumes were proportioned between these groundwater sources as described in Section 6.3.4.

Groundwater extraction is transferred to the Wallerawang Power Station via the SDWTS, which also receives water from Angus Place Colliery. It has been assumed that transfers to the SDWTS from Springvale Mine will cease in 2025 with mining activities. Currently Wallerawang Power Station has a contract with Springvale Coal to receive a maximum of 30 ML/day of water through the SDWTS, which is expected to continue into the future. Transfers to the SDWTS in excess of 30 ML/day are expected to be discharged via LDP009 into the Coxs River.

Springvale Mine has LDPs located in both the Hawkesbury and Lower Nepean Rivers Water Source (Colo River Management Zone) and the Upper Nepean and Upstream Warragamba Water Source (Wywandy Management Zone). The LDPs located in the Hawkesbury and Lower Nepean Rivers Water Source is an emergency discharge location only and therefore discharges to this water source have not been included in the water balance modelling or reporting. Excess water is regularly discharged through LDPs in the Upper Nepean and Upstream Warragamba Water Source.

As discussed in Section 7.3.2, the assessment of transfers to the SDWTS from Angus Place Colliery and Springvale Mine included an evaluation of transfers occurring with the current SDWTS capacity of 30 ML/day and the upgraded SDWTS capacity of 50 ML/day.

7.3.14 Wallerawang Power Station

Water required for the operation of Wallerawang Power Station is supplied from the Coxs River (via Lake Wallace and Lake Lyell), the SDWTS and supplemented by the Fish River Water Supply Scheme. The most detailed information available to GHD regarding the extraction and discharge of water at Wallerawang Power Station was obtained from the following documents:

- *Delta Electricity Western – Water Management Licence Annual Compliance Report 2005-2006*, Parsons Brinkerhoff, 2006.
- *Delta Electricity Western – Water Management Licence Annual Compliance Report 2006-2007*, Delta Electricity, 2007.
- *Delta Electricity Western – Water Management Licence Annual Compliance Report 2007-2008*, Delta Electricity, 2008.
- *Delta Electricity Western – Water Management Licence Annual Compliance Report 2008-2009*, Delta Electricity, 2009.
- *Delta Electricity Water Management Licence*, NSW Office of Water, 2009.

An estimate of Wallerawang Power Station's net annual extractions was determined from the annual compliance reports listed above. A comparison was undertaken of the annual extraction volumes from the Fish River Water Supply Scheme and the Coxs River with annual rainfall totals to determine whether there was a correlation between annual rainfall and the volumes of extraction from each source. Over the four years of data available, a correlation between annual totals was not evident and therefore the average extraction volume from each water source was applied to the modelling.

The following average annual extractions were assumed from the Coxs River and Fish River Water Supply Scheme:

- 2,260 ML/yr from the Coxs River (Upper Nepean and Upstream Warragamba Surface Water Source).
- 3,220 ML/yr from the Fish River Water Supply Scheme (Fish River Surface Water Source).

Available data indicates that Wallerawang Power Station demanded between 9,000 ML/yr and 11,000 ML/yr between 2005 and 2009 and the remaining demand was provided by the SDWTS. For the purposes of this assessment an annual demand of 11,000 ML/yr has been assumed.

The following assumptions were made when modelling the sources of water to meet Wallerawang Power Station demands:

- The demand for water at the Wallerawang Power Station was 11,000 ML/yr for the simulation timeline.
- All water transferred to the SDWTS up to 11,000 ML/yr was received by Wallerawang Power Station.
- Where the volume transferred by SDWTS was less than 11,000 ML/yr, the remaining demand was sourced by extractions from the Coxs River and Fish River Water Supply Scheme at a proportion of 40% / 60% respectively (based on the average annual extraction above).

It should be noted that these assumptions have been made by GHD and in reality the sources of water to Wallerawang Power Station would be determined by the interaction of other factors including the availability and quality of water in each source which has not been considered here.

Although LDPs are listed for Wallerawang Power Station, limited information was available on the volumetric discharges from the site. Discharges from LDP003 (Sawyers Swamp Creek Ash Dam) are listed in the Annual Compliance Reports listed above. Although it is stated that the discharge through this point is related to runoff, a correlation did not exist between the annual discharges through LDP003 and annual rainfall totals.

The average annual discharge through LDP003 was reported as approximately 400 ML/yr and therefore this value has been applied to the modelling for all rainfall conditions over the simulation timeline. Other than discharges from LDP003, no discharges from either Delta Electricity operations have been included in this assessment.

7.3.15 Western Coal Services

Centennial is currently seeking approval to upgrade the Western Coal Services facility, link the site to Angus Place Colliery and separate the transport and logistics function of the facility from the source mines.

Modelling assumed the current operation continues until 2015 when the proposed upgrade commences.

An existing water balance model was not available for Western Coal Services. An understanding of site water management was developed from the review of the *Centennial Western Coal Services Project – Water Balance & Surface Water Impact Assessment* (RPS, 2013).

At the Western Coal Services Site (Lamberts Gully), the only groundwater source extraction is seepage of groundwater from the Western Main workings into dams. The assumed value adopted for modelling for current and future conditions is 0.2 ML/day from the Sydney Basin Coxs River Groundwater Source.

Similarly, at the Western Coal Services Site (Lamberts Gully), there is only one surface water discharge location reported. LDP006 flows into Wangcol Creek and subsequently discharges into the Upper Nepean and Upstream Warragamba Surface Water Source.

Discharge volumes through LDP006 adopted for the modelling (RPS, 2013) are presented in Table 7-6.

Table 7-6 Discharge Volumes through LDP006

Daily Rainfall Statistic	Current Discharge LDP006 (ML/day)	Future Discharge LDP006 (ML/day)
Daily Average	1.479	1.329
Daily Maximum	220.888	208.180
Daily Minimum	0.000	0.000
5 %ile	0.027	0.027
10 %ile	0.052	0.043
20 %ile	0.110	0.075
30 %ile	0.183	0.115
40 %ile	0.274	0.174
50 %ile	0.404	0.278
70 %ile	0.962	0.717
90 %ile	3.252	2.796
95 %ile	5.685	5.247
98 %ile	10.959	10.639

8. Modelling Results

8.1 Interpretation of Results

8.1.1 Percentiles

The water management timeline was simulated using a historic time series of daily rainfall data extending over 112 years. A total of 112 simulations were applied to this timeline with each simulation modelling a different rainfall pattern (refer Section 6.1.1). As a result, for each year of mining 112 annual totals were available for each transfer element within the water management system thereby representing a wide range of possible rainfall conditions.

The 10th percentile represents the value at which 10% of the modelled outputs were less than this value. Similarly, the 90th percentile represents the value at which 90% of the modelled outputs were less than this value. The 10th and 90th percentile values have been used (rather than minimum and maximum values) to remove the impact of skewing by infrequent to extreme wet and dry conditions. The mean value for all rainfall conditions has also been provided.

8.1.2 Annualised Outputs

The results presented have been annualised per calendar year. That is, the daily values for each calendar year have been aggregated and the subsequent results are presented in graphical form.

8.1.3 Extraction/Discharge Graphs

Outputs from each site have been developed which summarise the annual licensed extractions and discharges by groundwater/surface water source from each site over the simulation timeline. The net extraction/discharge of each site is also provided which is equal to the estimated discharges through LDPs minus the estimated extractions. This provides an indication of the net water consumption of each site and the net withdrawal/addition of water removed from the water cycle on a site by site basis.

The estimated licensed extractions and discharges for each site were aggregated to provide total estimated annual licensed water extraction/ discharge for each water source of sites in the Western Coalfield (South). Results are provided for Centennial sites and total for all sites (i.e. Centennial plus non-Centennial sites assessed).

8.2 Individual Site Results

The estimated annual licensed extractions and discharges for each groundwater and surface water source for each site are provided in Appendix C. The following three graphs are provided for each site:

- Licensed extraction by source.
- Licensed discharges by source.
- Net extraction/discharge.

For Angus Place Colliery and Springvale Mine, two sets of graphs are provided for the Upper Nepean and Upstream Warragamba Water Source which reflect results for transfers occurring with the current SDWTS capacity of 30 ML/day and the upgraded SDWTS capacity of 50 ML/day.

The information in these graphs was aggregated into the results by water source provided in Section 8.3 and used to provide recommendations for current and future licensing requirements provided in Section 8.4

8.3 Water Source Results

8.3.1 Extractions from Groundwater Sources

The estimated annual extractions of coal mining operations in the Western Coalfield (South) from groundwater sources over the next 25 years are presented in Figure 8-1 to Figure 8-5. Each figure presents the contribution of Centennial's operations as well as the contribution of all assessed sites in the Western Coalfield against the total entitlements for the water source and Centennial's current licensed entitlement. For reference these graphs are also provided in Figure 8-2.

It should be noted that in Figure 8-3 and Figure 8-4, values are presented only for Centennial sites as no other assessed sites have been identified extracting from the respective water source.

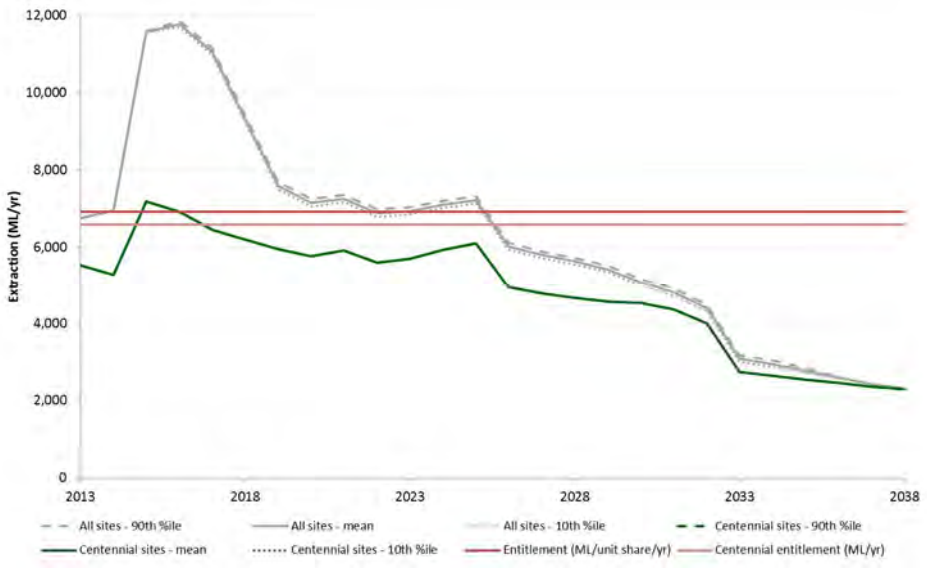
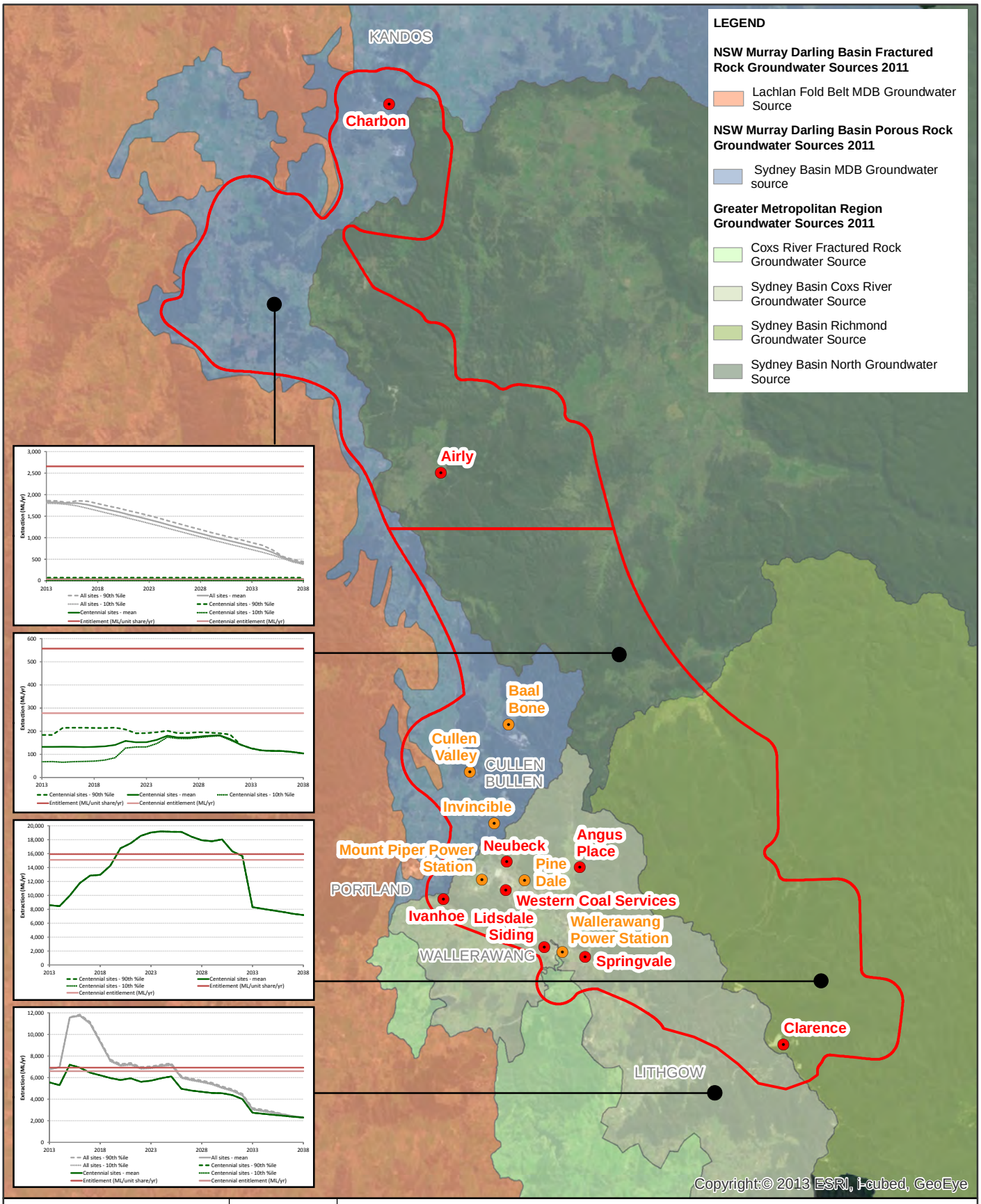


Figure 8-1 Sydney Basin Coxs River Groundwater Source – Estimated Aggregate Extractions

As shown in Figure 8-1, Centennial currently has adequate WAL volumes for the current estimated extractions from the Sydney Basin Coxs River Groundwater Source. For a period between 2014 and 2017, Centennial is predicted to extract more from the groundwater source than the current available licence volumes.



1:350,000 for A4

0 1.25 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Study Area

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

Estimated Extractions by Groundwater Source

Centennial Coal

DATE 7/11/2013

Figure 8-2

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\Report2\2216761_WB011_ExtractionsDischarges_GW_B.mxd

Figure 8-3 Sydney Basin Richmond Groundwater Source – Estimated Aggregate Extractions

Figure 8-3 shows that Centennial currently has an excess of WAL volumes for the Sydney Basin Richmond Groundwater Source until approximately 2020. After this time Centennial require additional WAL volumes for the source to meet their predicted groundwater extractions and the current volume of licences available are not sufficient to meet these predictions.

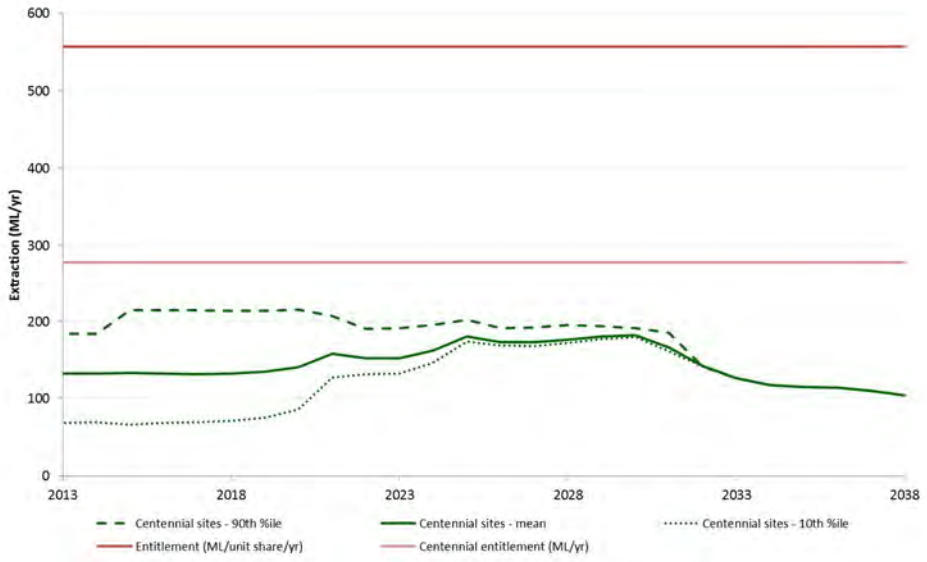


Figure 8-4 Sydney Basin North Groundwater Source – Estimated Aggregate Extractions

As shown in Figure 8-4, Centennial currently has adequate WAL volumes for the Sydney Basin North Groundwater Source and is expected to continue to be sufficient in the future.

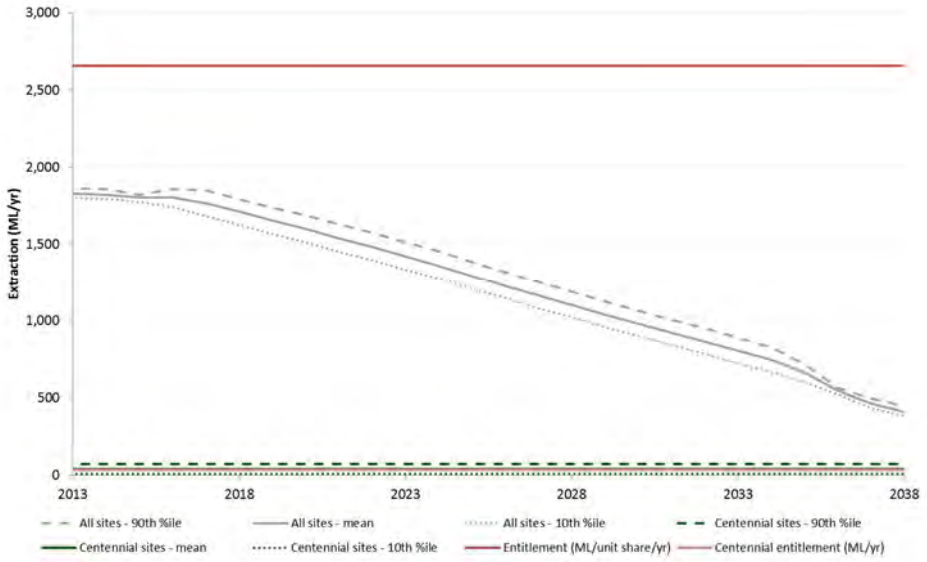


Figure 8-5 Porous Rock Sydney Basin MDB Groundwater Source – Estimated Aggregate Extractions

Figure 8-5 shows that Centennial's current licence entitlement in the Sydney Basin MDB Porous Rock Groundwater Source should be sufficient for most years leading into the future. Results show that the predicted 90th percentile groundwater extractions at Charbon Colliery exceed the current licence entitlement. Variations in the predicted extraction estimates are due to the interaction of rainfall with groundwater interception at Charbon Colliery.

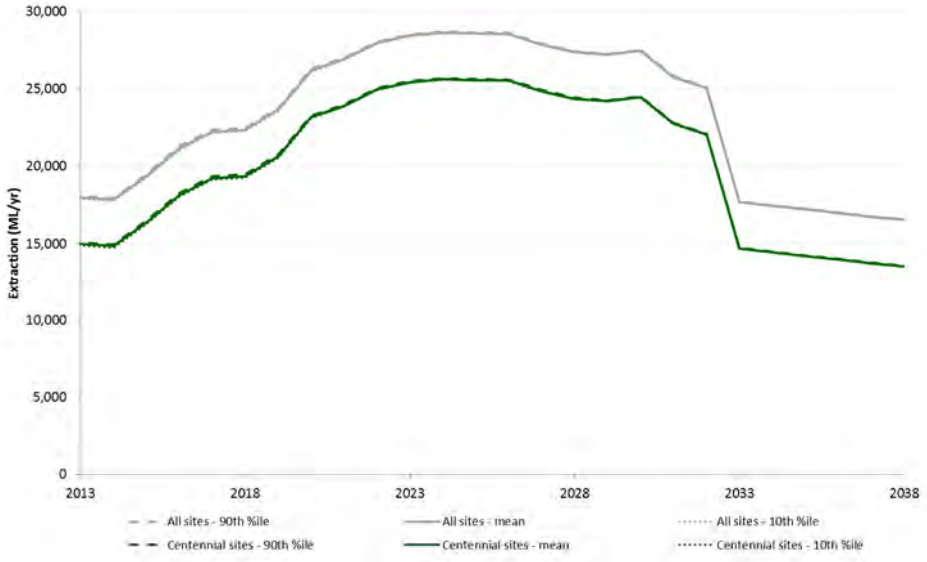


Figure 8-6 Total Extractions from Groundwater Sources

As shown in Figure 8-6, current total extractions from all groundwater sources are estimated to be approximately 18,000 ML/yr, of which 15,000 ML/yr is extracted by Centennial-operated mine sites.

Peak extraction from all groundwater sources is predicted to occur in 2024 at a rate of approximately 28,600 ML/yr. Extraction of groundwater from Centennial sites is also predicted to peak in 2024 at 25,600 ML/yr. By the end of the assessment period in 2038 groundwater extractions across all sites is largely attributed by Centennial sites at a rate of 13,500 ML/yr.

8.3.2 Discharges to Surface Water Sources

The estimated annual discharges of coal mining operations in the Western Coalfield (South) to surface water sources over the next 25 years are presented in Figure 8-7 to Figure 8-11. Each figure presents the contribution of Centennial's operations as well as the contribution of all assessed sites in the Western Coalfield. For reference these graphs are also provided in Figure 8-8.

The information presented in these figures provides an indication of the distribution of extracted groundwater to surface water sources. It should be noted when reviewing these figures that catchment runoff to the LDPs contribute to the discharge and therefore estimates provided are not completely related to groundwater extractions.

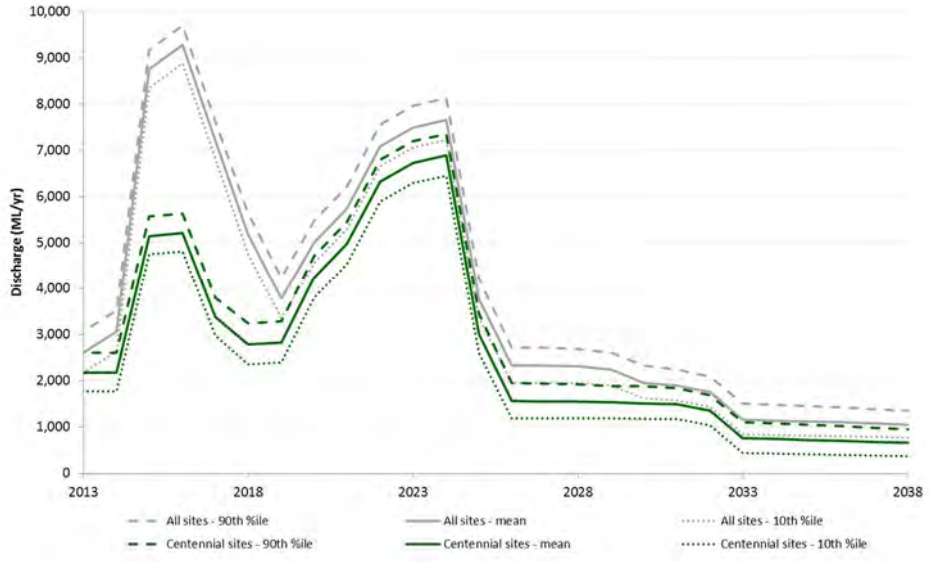
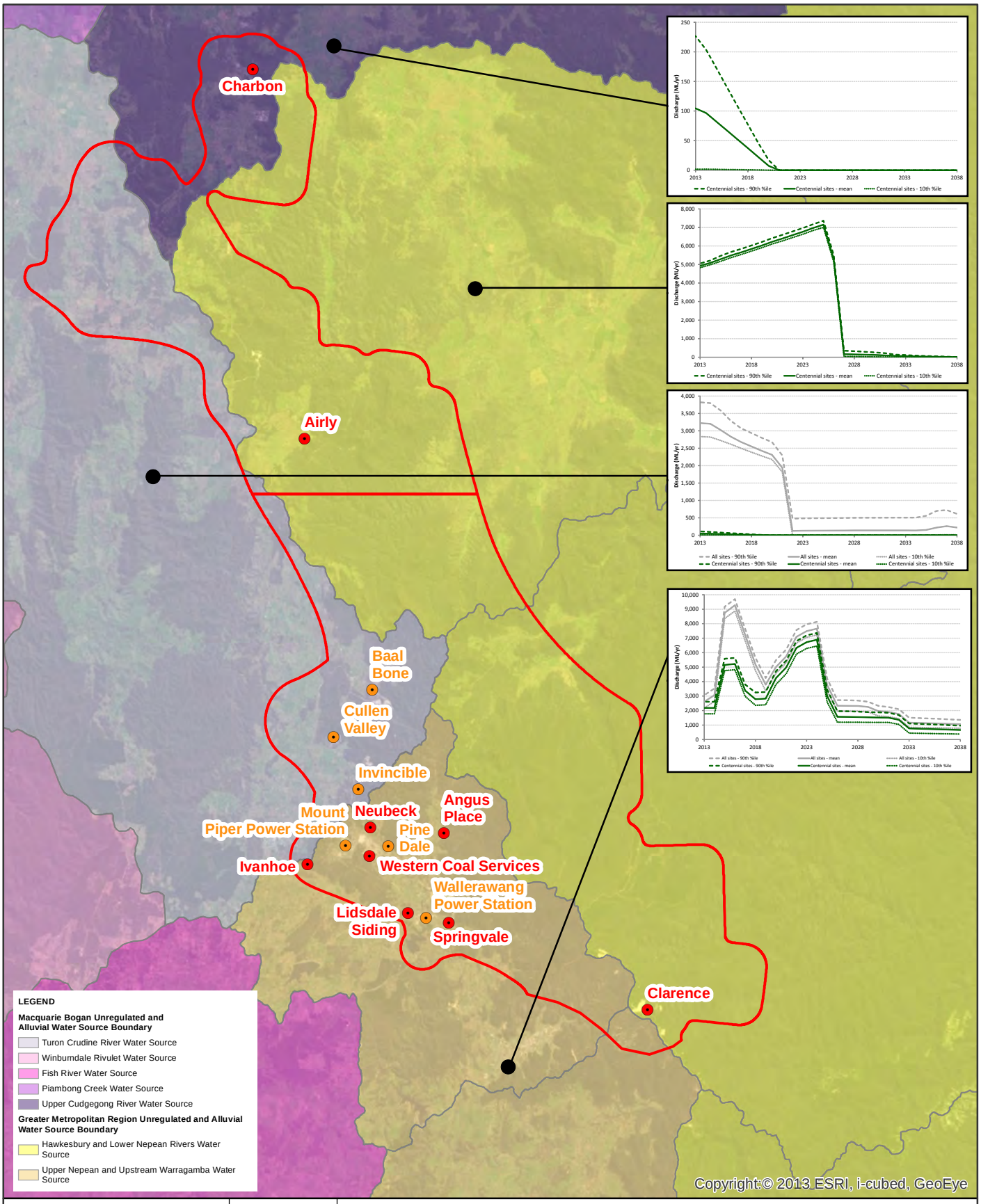


Figure 8-7 Upper Nepean and Upstream Warragamba Water Source – Estimated Aggregate Discharges

As seen in Figure 8-7, discharges to the Upper Nepean and Upstream Warragamba Water Source decrease significantly from 2026, which is attributed to the assumed cessation of mining operations at Springvale Mine. Discharges to this water source are not predicted to vary with capacity of the SDWTS, as transfers in excess of the 30 ML/day taken up by Wallerawang Power Station are assumed to be discharged through a LDP at either Angus Place Colliery or Springvale Mine. Both LDPs discharge into the Upper Nepean and Upstream Warragamba Water Source. Further results showing the impact of the two options for the SDWTS are presented in the individual site results in Appendix C.



1:350,000 for A4

0 1.25 2.5 5 7.5 10

Kilometres

Map Projection: Universal Transverse Mercator
Horizontal Datum: Geodetic Datum of Australia 1994
Grid: Map Grid of Australia, Zone 56

N

LEGEND

- Centennial Site Location
- Non Centennial Site Location
- Study Area

LOCATION	-
SEAM	NA
DRAWN	F.Mackay
CHECKED	T.Morton
APPROVED	S.Gray
SCALE	Refer to scalebar

Western Coalfield Water Balance

Estimated Discharges by Surface Water Source

Centennial Coal

DATE 7/11/2013

Figure 8-8

GIS Filename: G:\22\0105001\GIS\Maps\Deliverables\Western\Regional\2216761\WesternCoal_WaterBalance\2216761_WB012_ExtractionsDischarges_SW_B.mxd

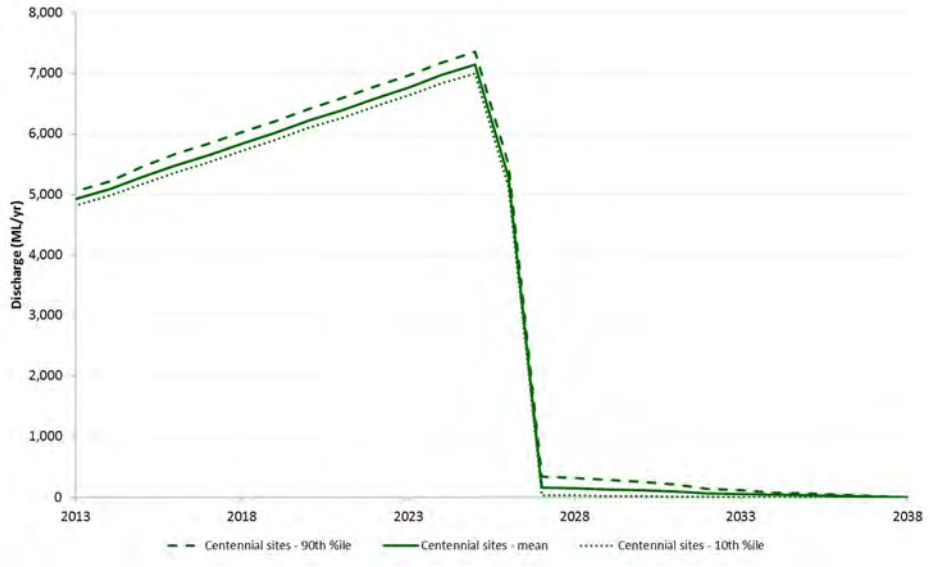


Figure 8-9 Hawkesbury and Lower Nepean Water Source – Estimated Aggregate Discharges

It should be noted that in Figure 8-9 values are presented only for Centennial sites as no other assessed sites have been identified discharging to the Hawkesbury and Lower Nepean Water Source. Figure 8-9 indicates that discharges into the Hawkesbury and Lower Nepean Water Source are predicted to significantly decrease from 2027, this is attributed to the assumed closure of Clarence Colliery from this date and subsequent cessation of mine water discharge.

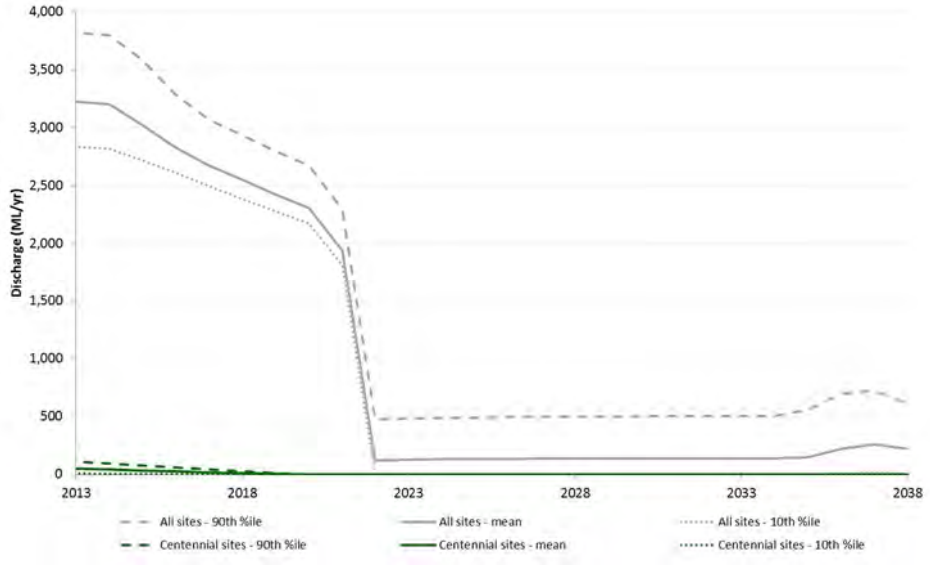


Figure 8-10 Turon Crudine River Water Source – Estimated Aggregate Discharges

Figure 8-10 shows that the total assessed discharges into the Turon Crudine River Water Source are predicated to significantly decrease following the cessation of operations at Baal Bone Colliery in 2022. The contribution of Centennial sites to the water source is predicted to be minimal.

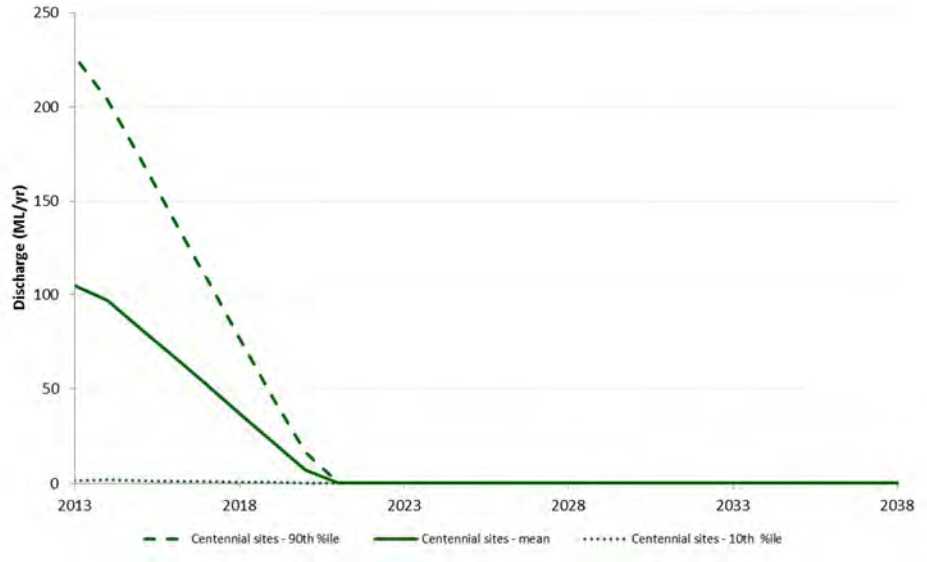


Figure 8-11 Upper Cudgegong River Water Source – Estimated Aggregate Discharges

It should be noted that in Figure 8-11 values are presented only for Centennial sites as no other assessed sites have been identified as discharging to the Upper Cudgegong River Water Source. Discharges to the water source are predicted to decrease as a result of the assumed rehabilitation and closure of Charbon Colliery. The contribution of Centennial sites to the water source is predicted to be minimal.

The total estimated licensed discharges to all assessed surface water sources is presented in Figure 8-12.

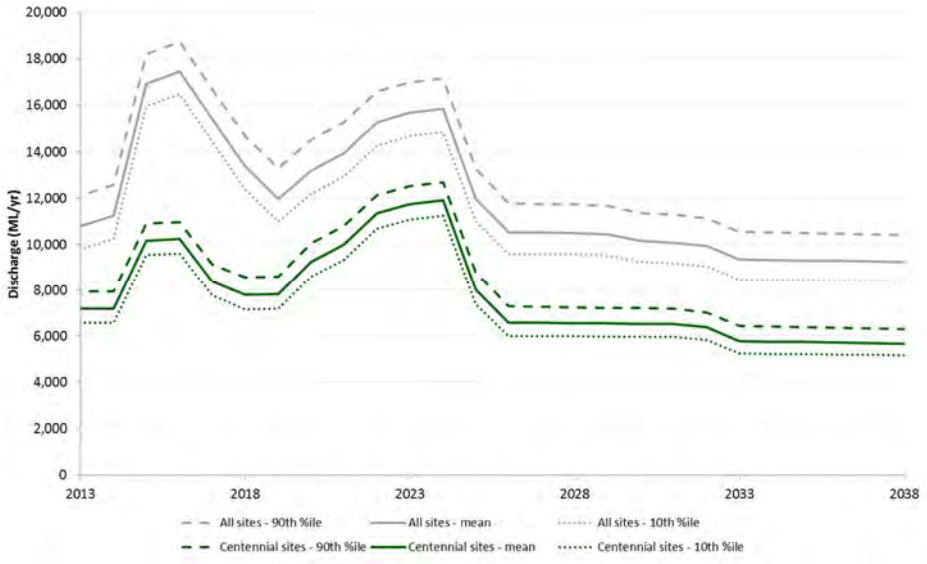


Figure 8-12 Total Discharges to Surface Water Sources

As shown in Figure 8-12, the current total discharges to all assessed surface water sources is estimated to be approximately 10,800 ML/yr, of which approximately 7,200 ML/yr is discharged by Centennial-operated mine sites.

Peak discharge to all water sources is predicted to occur in 2016 at a rate of approximately 17,500 ML/yr. Discharge from Centennial sites is predicted to peak in 2024 at 11,900 ML/yr, corresponding with the peak in extraction of groundwater from Centennial sites. By the end of the assessment period in 2038, discharges across Centennial sites are predicted to occur at a rate of 5,700 ML/yr.

8.3.3 Extractions from Surface Water

The major surface water extractions that occur within the Study Area are associated with Delta Electricity's operations. Wallerawang and Mount Piper Power Stations withdraw substantial volumes of water from the Coxs River (Upper Nepean and Upstream Warragamba Water Source) and the Fish River Water Supply Scheme in addition to mine water transferred from Angus Place Colliery and Springvale Mine. The point of extraction from the Coxs River is downstream of all mine sites that discharge into the Upper Nepean and Upstream Warragamba Water Source. Therefore the availability of water in the Coxs River for Delta Electricity's operations are affected by the discharges by the assessed mine sites into the water source.

Figure 8-13 show the predicted average volumes of water extracted by Delta Electricity.

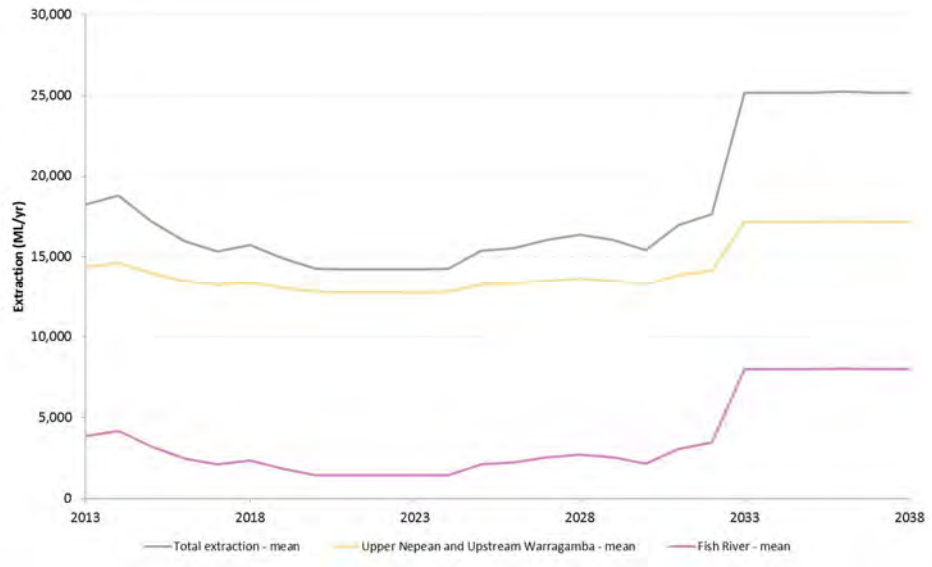


Figure 8-13 Delta Electricity Extractions from Surface Water Sources

As shown in Figure 8-13, the estimated average withdrawal from the Coxs River by Delta Electricity is 14,400 ML/yr in 2013 and is expected to decrease to 12,800 ML/yr by 2020. The total contribution of assessed mining operations into the Coxs River catchment (part of the Upper Nepean and Upstream Warragamba Water Source), as shown in Figure 8-7, is predicted to be significantly less than the extractions from the Coxs River by Delta Electricity. The discharge into the Coxs River catchment from all assessed mining operations is predicted to be between 1,100 ML/yr and 9,300 ML/yr. Natural catchment runoff also contributes to the Coxs River; however, as demonstrated above, mine water discharges contribute to a significant proportion of the water extracted for power generation by Delta Electricity.

As mentioned in Section 1.6.1, the extraction of surface water for individual mine sites was not determined in this assessment. Surface water extractions for mine sites are typically minor compared to groundwater extractions and licensing of these extractions is dependent on consultation with NOW on a site by site basis.

8.4 Licensing Overview of Centennial Sites

8.4.1 Water Access Licences

An assessment of the outcomes from the assessments for individual sites and water sources was undertaken to compare the current and predicted Water Access Licensing requirements for each Centennial site and also at a water source level. The outcomes from the assessment are summarised in Table 8-1.

Table 8-1 documents the current extraction licence for each site and was aggregated to provide the current aggregated extraction licence volumes for each water source. The current estimated extraction for each site is provided such that a comparison between the current WAL owned by Centennial are sufficient for current operations.

The predicted peak WAL requirement and the estimated year the peak will occur is provided for each site (by source). The purpose of providing the date of the predicted peak is to give an indication of when in time the individual site would require the peak volume in WAL.

The recommended WAL requirement for each source is also provided in Table 8-1, which provides an indication of the maximum WAL volume Centennial would need to purchase to meet the predicted water extraction requirements between 2013 and 2038. The recommended WAL requirement for each source is not necessarily equal to the sum of all the individual site peaks, as the interaction of timing of the peaks is considered and the maximum extraction from the entire source over the simulation timeline was used to predict this recommended WAL requirement. The WAL requirement by source has been considered as WAL can be traded within water sources (not between water sources) and it has been assumed that Centennial will trade water licences between the Centennial sites. The estimation of the recommended WAL requirement was determined as the 90th percentile requirement (if the extractions are affected by rainfall) for the year of the peak, rounded to the nearest 50 ML.

The additional WAL recommended for each source is the difference between the current WAL owned by Centennial and the recommended WAL requirement for each source.

8.4.2 LDP Volumetric Limits

An assessment of the outcomes from the assessments for individual sites was undertaken to compare the current and predicted LDP volumetric discharge limits for each Centennial site. The outcomes from the assessment are summarised in Table 8-2.

Table 8-2 documents each actively discharging LDP at each Centennial site in the Western Coalfield (South) and the current maximum volumetric discharge limit. An indication of the recommended volumetric limit required to meet future groundwater discharges is provided for each applicable site. The recommended volumetric requirement does not take into consideration runoff or surface water discharges from each LDP.

Where LDPs discharge primarily due to catchment runoff, a recommended volumetric discharge volume is not provided and ‘rainfall based’ is noted. For LDPs where both runoff and groundwater extractions contribute to the LDP discharge, an indication of the required volumetric limit to meet the maximum groundwater extraction rates is provided with a side note ‘in addition to rainfall based discharges’.

The assessment determined that there were no identifiable licensing shortfalls for volumetric discharges through LDPs with respect to groundwater discharges. It is recommended however that the adequacy of LDP volumetric discharges is completed on a site by site basis to include the interaction of site water cycles and catchment runoff.

Table 8-1 Summary of Centennial Western Coalfield WAL Requirements

Water Source	Site	Current WAL for Site (ML/yr)	Current WAL for Source (ML/yr)	Current Estimated Extraction (2013)	Peak WAL Requirement (ML/yr)	Date of Peak (Year)	Recommended WAL Requirement for Source (ML/yr)	Additional WAL Recommended for Source (ML/yr)
Sydney Basin Coxs River (GMR WSP)	Clarence Colliery	-	6,594.5	580	1,750	2026	7,190	595.5
	Springvale Mine	3,885		3,070	3,100	2013		
	Angus Place Colliery	2,701		1,800	1,800	2013		
	Lidsdale Siding	8.5		5.8	7.2	2014		
	Western Coal Services	-		73	73	2013-2038		
	Neubeck Project	-		0	1,600	2016		
Sydney Basin Richmond (GMR WSP)	Clarence Colliery	6,623	15,104	5,200	6,350	2026	19,200	4,096
	Springvale Mine	5,958		2,050	5,100	2021		
	Angus Place Colliery	2,523		1,350	9,700	2033		
Sydney Basin North (GMR WSP)	Airly Mine	278	278	150	200	2015-2021	200	0

Water Source	Site	Current WAL for Site (ML/yr)	Current WAL for Source (ML/yr)	Current Estimated Extraction (2013)	Peak WAL Requirement (ML/yr)	Date of Peak (Year)	Recommended WAL Requirement for Source (ML/yr)	Additional WAL Recommended for Source (ML/yr)
Sydney Basin MDB (MDB WSP)	Charbon Colliery	35	35	70	70	2013-2038	70	35

Table 8-2 Summary of LDP Requirements

Site	Current LDP Name	Current LDP Volumetric Limit (ML/day)	Recommended Volumetric Limit to Meet Future Groundwater Discharges (ML/day)
Airly Mine	LDP1	100	Rainfall based
	LDP2	No limit specified	Rainfall based
	LDP3	No limit specified	Rainfall based
Angus Place Colliery	LDP001	2	2 (in addition to rainfall based discharges)
	LDP002	5	Rainfall based
Charbon Colliery	LDP2	5	Rainfall based
	LDP3	5	Rainfall based
Clarence Colliery	LDP2	25	15 (in addition to rainfall based discharges)
	LDP3	No limit specified	Rainfall based
	LDP4	No limit specified	Rainfall based

Site	Current LDP Name	Current LDP Volumetric Limit (ML/day)	Recommended Volumetric Limit to Meet Future Groundwater Discharges (ML/day)
Ivanhoe North Rehabilitation Project	LDP001	No limit specified	Rainfall based
	LDP002	No limit specified	Rainfall based
	LDP006	No limit specified	Rainfall based
Lidsdale Siding	LDP4	No limit specified	Rainfall based
Neubeck Project	No Current LDP	No licence	6 (in addition to rainfall based discharges)
Springvale Mine	LDP001	10	2 (in addition to rainfall based discharges)
Western Coal Services	LDP003	No limit specified	Rainfall based
	LDP006	10	Rainfall based

*Future Kerosene Vale LDP003 assumed to be under Western Coal Services EPL

9. Conclusions

The cumulative impact of the coal mining industry in the Western Coalfield (South) has been quantified by the outcomes of water balance modelling undertaken for Centennial operated coal mines, other identified coal mines and power generation activities undertaken in the Study Area.

Current total extractions from all groundwater sources are estimated to be approximately 18,000 ML/yr, of which 15,000 ML/yr is extracted by Centennial operated mine sites. Peak extraction from all groundwater sources is predicted to occur in 2024 at a rate of approximately 28,600 ML/yr. Extraction of ground water from Centennial sites is also predicted to peak in 2024 at 25,600 ML/yr. By the end of the assessment period in 2038 groundwater extractions across all sites is largely attributed by Centennial sites at a rate of 13,500 ML/yr.

The cumulative impact on each groundwater source was estimated to vary according to the mining operations extracting from each source. Some sources are expected to undergo significant increases in extraction rates over the first half over the assessment period, whilst extraction from other sources are to decrease over time or peak in the middle of the assessment period.

The peak extractions estimated for each groundwater source enabled a recommended additional WAL requirement for Centennial to be determined for each groundwater source. The recommended additional WAL requirement for each source varied between 0 ML/yr and 4,096 ML/yr. It should be noted however, that these recommendations are heavily dependent on the timing of mining operations over the assessment period.

The total licensed discharge from the sites assessed is predicted to peak at approximately 17,500 ML/yr in 2016. After 2016 until the end of the assessment period licensed discharges are expected to decrease as the number of active mining operations decreases with time.

The cumulative impact on each surface water source also varies according to the mining operations discharging into each source. The licensed discharge from each source is predicted to peak at different times throughout the assessment period but discharges to all sources are predicted to significantly decrease by the end of the assessment period.

The peak discharges estimated for each surface water source enabled a comparison of the current and predicted LDP volumetric discharge limits for each Centennial site, based on future predicted groundwater extraction rates only. No licensing shortfalls were identified for volumetric discharges through LDPs with respect to groundwater discharges. It is recommended however that the adequacy of LDP volumetric discharges is completed on a site-by-site basis to include the interaction of site water cycles and catchment runoff.

The assessment demonstrated that licensed discharges into the Upper Nepean and Upstream Warragamba Water Source contribute to a significant proportion of the water extracted for power generation by Delta Electricity. The supply of water from Springvale Mine and Angus Place Colliery via the SDWTS also supply a significant volume of water to Delta Electricity.

The outcomes from the assessment indicate that there are no expected sustained increases to pollution loads from current operations.

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Appendices

Appendix A – Water Sharing Plan Rules

Table A–1 Greater Metropolitan Region Groundwater Source Rules: Sydney Basin North

Sydney Basin North Groundwater Source	
1. Access Rules	
1.1 Granting of access licences	• Granting of licences may be considered for commercial access licences under a controlled allocation order made in relation to any unassigned water in this water source.
2. Rules for Managing Water Allocation Accounts	
2.1 Carryover	• Up to 10 percent entitlement allowed. *Carryover is not allowed for domestic and stock, major utility, local water utility or specific purpose access licences.*
3. Rules for Managing Access Licences	
3.1 Managing surface and groundwater connectivity	• From year seven of the plan, for areas adjoining unregulated water sources (i.e. river and creeks), existing works within 40 metres of the top of the high bank of a river or creek, except existing works for, local water utility, town water supply, food safety or essential dairy care purposes, will have conditions which establish: - The flow class of the river established under the water sharing plan for the corresponding unregulated water source, or - In the absence of a flow class, visible flow in the river at the closest point of the water supply works to the river. • These distances and rules may be varied for an applicant if the work is drilled into the underlying parent material and the slotted intervals of the works commences deeper than 30 metres or no minimal impact on base flows in the stream can be demonstrated. • For major utility and local water utility access licences these rules apply to new water supply works from plan commencement.
4. Rules for Granting and Amending Water Supply Works Approvals	
4.1 To minimise interference between neighbouring water supply works	• No water supply works (bores) to be granted or amended within the following distances of existing bores: - 400 metres of an aquifer access licence bore or another land holding, or - 100 metres from a basic landholder rights bore on another landholding, or - 50 metres from a property boundary (unless written consent from neighbour), or - 1,000 metres from a local or major utility bore, or - 200 metres from a NSW Office of Water monitoring bore (unless written consent from NSW Office of Water). *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*

Sydney Basin North Groundwater Source	
4.2 To protect bores located near contamination	• No water supply works (bores) are to be granted or amended within: - 250 metres of contamination as identified within the plan, or - 250 metres to 500 metres of contamination as identified within the plan unless no drawdown of water will occur within 250 metres of the contamination source, or - a distance greater than 500 metres of contamination as identified within the plan if necessary to protect the water source, the environment or public health and safety. *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
4.3 Protection of water quality	• To minimise the impact on water quality from saline interception in the shale aquifers overlaying Sydney basin sandstone, the bore being used to take groundwater must be constructed with pressure cement to seal off the shale aquifer as specified by the Minister.
4.4 To protect bores located near sensitive environmental areas	• No water supply works (bores) to be granted or amended within the following distances of high priority Groundwater Dependent Ecosystems (GDEs) (non Karst) as identified within the plan: - 100 metres for bores used solely for extracting basic landholder rights, or - 200 meters for bores used for all other aquifer access licences. • The above distance restrictions for the location of works from high priority GDEs do not apply where GDE is a high priority endangered ecological vegetation community and the work is constructed and maintained using impermeable pressure cement plug from the surface of the land to a minimum depth of 30 metres. • No water supply works (bores) are to be located within the following distances from these identified features: - 500 metres high priority karst environment GDEs, or - a distance greater than 500 metres of a high priority karst environment GDE if the Minister is satisfied that the work is likely to cause drawdown at the perimeter of the high priority karst GDE, or - 40 metres of a river or stream or lagoon (third order or above), - 40 metres of a first or second order stream, unless drilled into underlying parent material and slotted intervals commence deeper than 30 metres (30 metres may be amended if demonstrate minimal impact on base flows in the stream), or - 100 metres from the top of an escarpment. *The plan lists circumstance in which these distance rules may be varied and exemptions from these rules.*
4.5 To protect groundwater dependent culturally significant sites	• No water supply works (bores) to be granted or amended within the following distances of groundwater dependent cultural significant sites as identified within the plan: - 100 metres for bores used for extracting for basic landholder rights, or - 200 metres for bores used for all other aquifer access licences *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*

Sydney Basin North Groundwater Source	
4.6 Rules for replacement groundwater works	• A replacement groundwater work must be constructed to take water from the same water source as the existing bore and to a depth specified by the Minister.
	• A replacement work must be located within: - 20 metres of an existing bore, or - If the existing bore is located within 40 metres of the high bank of a river the replacement work must be located within: (a) 20 metres of an existing bore but no closer to the high bank of the river or a distance greater if the Minister is satisfied that it will result in no greater impact. • Replacement works may be at a greater distance than 20 metres if the minister is satisfied that doing so will result in no greater impact on the groundwater source and its dependent ecosystem. • The replacement work must not have a greater internal diameter or excavation footprint than the existing work unless it is no longer manufactured. If no longer manufactured the internal diameter of the replacement work must be no greater than 110 percent of the existing work.
5. Rules for the Use of Water Supply Works Approvals	
5.1 To manage bores located near contaminated sites	• The maximum amount of water that can be taken in any one year from an existing work within 500 metres of a contamination source is equal to the sum of the share component of the access licence nominating that work at commencement of the plan.
5.2 To manage the use of bores within restricted distances	• The maximum amount of water that can be taken in any one year from an existing work within the restricted distances to minimise interference between works, protect sensitive environmental areas and groundwater dependent culturally significant sites is equal to the sum of the share component of the access licence nominating that work at the commencement of the plan.
5.3 To manage the impacts of extraction	• The Minister may impose restrictions on the rate and timing of extraction of water from a water supply work to mitigate the impacts of extraction.
6. Limits to the Availability of Water	
6.1 Available Water Determinations (AWDs)	• 100 percent stock and domestic, local and major utilities and specific purpose access licences. • One megalitre/unit of share aquifer access licences. *AWD for aquifer access licenses may be reduced in response to a growth in use.*
7. Trading Rules	
7.1 INTO water source	• Not permitted.
7.2 WITHIN water source	• Permitted, subject to local impact assessment.

Sydney Basin North Groundwater Source	
7.3 Conversion to another category of licence	• Not permitted.

Table A-2 Greater Metropolitan Region Groundwater Source Rules: Sydney Basin Richmond

Sydney Basin Richmond Groundwater Source	
1. Access Rules	
1.1 Granting of access licences	• Access licences may be considered for commercial access licences under a controlled allocation order made in relation to any unassigned water in this water source.
2. Rules for Managing Water Allocation Accounts	
2.1 Carryover	• Up to 10 percent entitlement allowed. *Carryover is not allowed for domestic and stock, major utility, local water utility or specific purpose access licences.*
3. Rules for Managing Access Licences	
3.1 Managing surface and groundwater connectivity	• From year seven of the plan, for areas adjoining unregulated water sources (i.e. rivers and creeks), existing works within 40 metres of the top of the high bank of a river or creek, except existing works for, local water utility, town water supply, food safety or essential dairy care purposes, will have conditions which establish: - The flow class of the river established under the water sharing plan for the corresponding unregulated water source, or - In the absence of a flow class, visible flow in the river at the closest point of the water supply works to the river. • These distances and rule may be varied for the applicant if the work is drilled into the underlying parent material and the slotted intervals with the works commences deeper than 30 meteres or no minimal impact on base flows in the stream can be demonstrated. • For major utility and local water utility access licences these rules apply to new water supply works from plan commencement.
4. Rules for Granting and Amending Water Supply Works Approvals	
4.1 To minimise interference between neighbouring water supply works	• No water supply works (bores) to be granted or amended within the following distances of existing bores: - 400 metres from an aquifer access licence bore on another landholding, or - 100 metres from a basic landholder rights bore on another landholding, or - 50 metres from a property boundary (unless written consent from neighbour), or - 1,000 metres from a local or major water utility bore, or - 200 metres from a NSW Office of Water monitoring bore (unless written consent from NSW Office of Water). *The plan lists circumstances in which these distance rules may be varied and exemption for these rules.*

Sydney Basin Richmond Groundwater Source	
4.2 To protect bored located near contamination	• No water supply works (bores) are to be granted or amended within: - 250 metres of contamination as identified within the plan, or - 250 metres to 500 metres of contamination as identified within the plan unless no drawdown of water will occur within 250 metres of the contamination source, or - a distance greater than 500 metres of contamination as identified within the plan if necessary to protect the water source, the environment or public health and safety. *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
4.3 To protect water quality	• To minimise the impact on water quality from saline interception in the shale aquifers overlaying Sydney basin sandstone, the bore being used to take groundwater must be constructed with pressure cement to seal off the shale aquifer as specified by the Minister.
4.4 To protect bores located near sensitive environmental areas	• No water supply works (bores) to be granted or amended within the following distances of high priority Groundwater Dependent Ecosystems (GDEs) (non Karst) as identified within the plan: - 100 metres for bores used solely for extracting basic landholder rights, or - 200 meters for bores used for all other aquifer access licences. • The above distance restrictions for the location of works from high priority GDEs do not apply where GDE is a high priority endangered ecological vegetation community and the work is constructed and maintained using impermeable pressure cement plug from the surface of the land to a minimum depth of 30 metres. • No water supply works (bores) are to be located within the following distances from these identified features: - 500 metres high priority karst environment GDEs, or - a distance greater than 500 metres of a high priority karst environment GDE if the Minister is satisfied that the work is likely to cause drawdown at the perimeter of the high priority karst GDE, or - 40 metres of a river or stream or lagoon (third order or above), - 40 metres of a first or second order stream, unless drilled into underlying parent material and slotted intervals commence deeper than 30 metres (30 metres may be amended if demonstrate minimal impact on base flows in the stream), or - 100 metres from the top of an escarpment. *The plan lists circumstance in which these distance rules may be varied and exemptions from these rules.*
4.5 To protect groundwater dependent culturally significant sites	• No water supply works (bores) to be granted or amended within the following distances of groundwater dependent cultural significant sites as identified within the plan: - 100 metres for bores used for extracting for basic landholder rights, or - 200 metres for bores used for all other aquifer access licences *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*

Sydney Basin Richmond Groundwater Source	
4.6 Rules for replacement groundwater works	• A replacement groundwater work must be constructed to take water from the same water source as the existing bore and to a depth specified by the Minister. • A replacement work must be located within: - 20 metres of an existing bore, or - If the existing bore is located within 40 metres of the high bank of a river the replacement work must be located within: (a) 20 metres of an existing bore but no closer to the high bank of the river or a distance greater if the Minister is satisfied that it will result in no greater impact. • Replacement works may be at a greater distance than 20 metres if the minister is satisfied that doing so will result in no greater impact on the groundwater source and its dependent ecosystem. • The replacement work must not have a greater internal diameter or excavation footprint than the existing work unless it is no longer manufactured. If no longer manufactured the internal diameter of the replacement work must be no greater than 110 percent of the existing work.
5. Rules for the Use of Water Supply Works Approvals	
5.1 To manage bores located near contaminated sites	• The maximum amount of water that can be taken in any one year from an existing work within 500 metres of a contamination source is equal to the sum of the share component of the access licence nominating that work at commencement of the plan.
5.2 To manage the use of bores within restricted distances	• The maximum amount of water that can be taken in any one year from an existing work within the restricted distances to minimise interference between works, protect sensitive environmental areas and groundwater dependent culturally significant sites is equal to the sum of the share component of the access licence nominating that work at the commencement of the plan.
5.3 To manage the impacts of extraction	• The Minister may impose restrictions on the rate and timing of extraction of water from a water supply work to mitigate the impacts of extraction.
6. Limits to the Availability of Water	
6.1 Available Water Determinations (AWDs)	• 100 percent stock and domestic, local and major utilities and specific purpose access licences. • One megalitre/unit of share aquifer access licences. *AWD for aquifer access licenses may be reduced in response to a growth in use.*
7. Trading Rules	
INTO groundwater source	• Not permitted.
WITHIN groundwater source	• Permitted subject to local impact assessment.

Sydney Basin Richmond Groundwater Source	
Conversion to another category of access licence	• Not permitted.

Table A-3 Greater Metropolitan Region Groundwater Source Rules: Sydney Basin Coxs River

Sydney Basin Coxs River Groundwater Source	
1. Access Rules	
1.1 Granting of access licences	• Granting of licences may be considered for commercial access licences under a controlled allocation order made in relation to any unassigned water in this water source.
2. Rules for Managing Water Allocation Accounts	
2.1 Carryover	• Up to 10 percent entitlement allowed. *Carryover is not allowed for domestic and stock, major utility, local water utility or specific purpose access licences.*
3. Rules for Managing Access Licences	
3.1 Managing surface and groundwater connectivity	• From year seven of the plan, for areas adjoining unregulated water sources (i.e. river and creeks), existing works within 40 metres of the top of the high bank of a river or creek, except existing works for, local water utility, town water supply, food safety or essential dairy care purposes, will have conditions which establish: - The flow class of the river established under the water sharing plan for the corresponding unregulated water source, or - In the absence of a flow class, visible flow in the river at the closest point of the water supply works to the river. • These distances and rules may be varied for an applicant if the work is drilled into the underlying parent material and the slotted intervals of the works commences deeper than 30 metres or no minimal impact on base flows in the stream can be demonstrated. • For major utility and local water utility access licences these rules apply to new water supply works from plan commencement.

Sydney Basin Coxs River Groundwater Source	
4. Rules for Granting and Amending Water Supply Works Approvals	
4.1 To minimise interference between neighbouring water supply works	• No water supply works (bores) to be granted or amended within the following distances of existing bores: - 400 metres of an aquifer access licence bore or another land holding, or - 100 metres from a basic landholder rights bore on another landholding, or - 50 meteres from a property boundary (unless written consent from neighbour), or - 1,000 metres from a local or major utility bore, or - 200 metres from a NSW Office of Water monitoring bore (unless written consent from NSW Office of Water). *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
4.2 To protect bores near located contamination	• No water supply works (bores) are to be granted or amended within: - 250 metres of contamination as identified within the plan, or - 250 metres to 500 metres of contamination as identified within the plan unless no drawdown of water will occur within 250 metres of the contamination source, or - a distance greater than 500 metres of contamination as identified within the plan if necessary to protect the water source, the environment or public health and safety. *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
4.3 Protection of water quality	• To minimise the impact on water quality from saline interception in the shale aquifers overlaying Sydney basin sandstone, the bore being used to take groundwater must be constructed with pressure cement to seal off the shale aquifer as specified by the Minister.
4.4 To protect bored located near sensitive environmental areas	• No water supply works (bores) to be granted or amended within the following distances of high priority Groundwater Dependent Ecosystems (GDEs) (non Karst) as identified within the plan: - 100 metres for bores used solely for extracting basic landholder rights, or - 200 meters for bores used for all other aquifer access licences. • The above distance restrictions for the location of works from high priority GDEs do not apply where GDE is a high priority endangered ecological vegetation community and the work is constructed and maintained using impermeable pressure cement plug from the surface of the land to a minimum depth of 30 metres.

Sydney Basin Coxs River Groundwater Source	
	• No water supply works (bores) are to be located within the following distances from these identified features: - 500 metres high priority karst environment GDEs, or - a distance greater than 500 metres of a high priority karst environment GDE if the Minister is satisfied that the work is likely to cause drawdown at the perimeter of the high priority karst GDE, or - 40 metres of a river or stream or lagoon (third order or above), - 40 metres of a first or second order stream, unless drilled into underlying parent material and slotted intervals commence deeper than 30 metres (30 metres may be amended if demonstrate minimal impact on base flows in the stream), or - 100 metres from the top of an escarpment. *The plan lists circumstance in which these distance rules may be varied and exemptions from these rules.*
4.5 To protect groundwater dependent culturally significant sites	• No water supply works (bores) to be granted or amended within the following distances of groundwater dependent cultural significant sites as identified within the plan: - 100 metres for bores used for extracting for basic landholder rights, or - 200 metres for bores used for all other aquifer access licences *The plan lists circumstances in which these distance rules may be varied and exemptions from these rules.*
4.6 Rules for replacement groundwater works	• A replacement groundwater work must be constructed to take water from the same water source as the existing bore and to a depth specified by the Minister. • A replacement work must be located within: - 20 metres of an existing bore, or - If the existing bore is located within 40 metres of the high bank of a river the replacement work must be located within: (a) 20 metres of an existing bore but no closer to the high bank of the river or a distance greater if the Minister is satisfied that it will result in no greater impact. • Replacement works may be at a greater distance than 20 metres if the minister is satisfied that doing so will result in no greater impact on the groundwater source and its dependent ecosystem. • The replacement work must not have a greater internal diameter or excavation footprint than the existing work unless it is no longer manufactured. If no longer manufactured the internal diameter of the replacement work must be no greater than 110 percent of the existing work.
5. Rules for the Use of Water Supply Works Approvals	
5.1 To manage bores located near contaminated sites	• The maximum amount of water that can be taken in any one year from an existing work within 500 metres of a contamination source is equal to the sum of the share component of the access licence nominating that work at commencement of the plan.

Sydney Basin Coxs River Groundwater Source	
5.2 To manage the use of bores within restricted distances	• The maximum amount of water that can be taken in any one year from an existing work within the restricted distances to minimise interference between works, protect sensitive environmental areas and groundwater dependent culturally significant sites is equal to the sum of the share component of the access licence nominating that work at the commencement of the plan.
5.3 To manage the impacts of extraction	• The Minister may impose restrictions on the rate and timing of extraction of water from a water supply work to mitigate the impacts of extraction.
6. Limits to the Availability of Water	
6.1 Available Water Determinations (AWDs)	• 100 percent stock and domestic, local and major utilities and specific purpose access licences. • One megalitre/unit of share aquifer access licences. *AWD for aquifer access licenses may be reduced in response to a growth in use.*
7. Trading Rules	
7.1 INTO water source	• Not permitted.
7.2 WITHIN water source	• Permitted, subject to local impact assessment.
7.3 Conversion to another category of licence	• Not permitted.

Table A-4 MDB Groundwater Source Rules

Sydney Basin MDB Groundwater Source	
1. Limits to the Availability of Water	
1.1 Assessment of average annual extraction against the long-term average annual extraction limit	• Growth in extractions will be assessed against the long-term average annual extraction limit over a three year period with a five percent tolerance. • Assessments will commence in fourth year of the plan. • Assessment of groundwater storage extraction limit will commence in the second year after the first supplementary (storage) access licence is granted.
1.2 Available water determinations (AWDs)	• Available water determinations will be made at the commencement of each water year for: - Stock and domestic, local and major water utilities and specific purpose access licences – 100 percent of share component. - Supplementary water (storage) access licences – 100 percent of share component. - Aquifer access licences – 1 megalitre / unit of share or lower amount as a result of a growth in extraction response.

Sydney Basin MDB Groundwater Source	
2. Access Rules	
2.1 Granting of access licences	• Granting of new water access licences may be considered for the following categories: - Local water utility, major water utility, domestic and stock and town water supply. *These are specific purpose access licences in clause 19 of the Water Management (General) Regulation 2011.* - Supplementary water (storage) access licences. *These access licences may only be granted if the Minister is satisfied that there is insufficient unassigned water to make further controlled allocation orders.* - Aquifer (Aboriginal cultural) up to 10 megalitres a year. • Granting of water access licences may also be considered as part of a controlled allocation order made in relation to any unassigned water in this water source. ***Note:*** *Prior to any controlled allocation being made there must be consideration of maximum volumes representing the total share components of access licences in the water source, future priority requirements, including basic landholder rights and specific purpose access licences and exemptions that do not require and access licence.*
2.2 Carryover	• Up to 25 percent of entitlement can be carried over. *No carryover is allowed for domestic and stock, local water utility or special purpose access licences.*
2.3 Take limit	• The maximum amount of water permitted to be taken in any one water year is the water allocation accrued in the water access account for that water year including carryover from the previous year, adjusted for allocation assignments out of or into individual accounts.
3. Rules for Granting and Amending Water Supply Works Approvals	
3.1 To minimise interference between neighbouring water supply works	• Water supply works (bores) are not to be granted or amended within the following distances of existing bores: - 400 metres of an aquifer access bore on another landholding. - 100 metres from a basic landholder rights bore on another landholding. - 500 metres from a local or major water utility access licence bore. - 200 meters from an Office of Water monitoring bore. - 200 metres from a property boundary. *The plan lists circumstances in which these distance conditions may be varied and exemptions from these rules.*

Sydney Basin MDB Groundwater Source	
3.2 To protect bores located near contamination	• Water supply works (bores) are not to be granted or amended within: - 250 metres of contamination identified within the plan - Between 250 metres and 500 metres of contamination as identified within the plan unless no drawdown of water will occur within 250 metres of the contamination. - A distance greater than 500 metres of contamination as identified within the plan if necessary to protect the water source, the environment or public health or safety. *The plan lists circumstances in which these distance conditions may be varied and exemptions from these rules.*
3.3 To protect bores located near sensitive environmental receivers	• Water supply works (bores) used soley for extracting basic landholder rights are not to be granted or amended within: - 100 metres of a high priority GDE listed in the plan. - 40 metres of the top of a river or stream. • Bores not used solely for extracting basic landholder rights are not to be granted or amended within: - 200 metres of high priority GDE listed in the plan. - Greater than 200 metres of high priority GDE listed in the plan if the bore is likely to cause drawdown at the perimeter of any high priority GDE listed in the plan. - 500 metres from a high priority karst or escarpment. - 40 meters from the top of a high bank of a river or stream. *The plan lists circumstances in which these distance conditions may be varied and exemptions to these rules.*
3.4 To protect groundwater dependent culturally significant sites	• Water supply works (bores) are not to be granted or amended within the following distances of groundwater dependent cultural significant sites: - 100 metres for basic landholder rights bores - 200 metres for bores not used solely for extracting basic landholder rights. *The plan lists circumstances in which these distance conditions may be varied and exemptions from these rules.*
4. Rules for Granting and Amending Water Supply Works Approvals	
4.1 To manage the use of existing bores within restricted distances	• Existing water supply works (bores) can continue extraction of groundwater with the maximum annual amount extracted equivalent to the shares nominated at the commencement of the plan within: - 500 metres of contamination listed in the plan. - Any of the distance restrictions listed above.

Sydney Basin MDB Groundwater Source	
4.2 To manage local impacts	• The Minister may prohibit or restrict the taking of water from a water source in order to manage local impacts in groundwater sources, where required to: - Maintain or protect water levels in an aquifer. - Maintain, protect or improve the quality of water in an aquifer. - Prevent land subsidence or compaction in an aquifer. - Protect GDEs. - Maintain pressure or to ensure pressure recovery in an aquifer.
5. Trading Rules	
5.1 INTO groundwater source	• Not permitted.
5.2 WITHIN groundwater source	• Permitted. - Subject to any applicable local impact management restrictions.
5.3 Conversion to another category of access licence	• Not permitted. - Except those allowed under the Minister's Access Licence Dealing Principles
5.4 Between states	• Not permitted.

Table A-5 GMRU Water Source Rules: Wywandy River

Wywandy River Management Zone (Upper Nepean and Upstream Warragamba Water Source)	
1. Access Rules	
1.1 Licence classes	• A class: Users must cease to pump when flows are at or less than 2 megalitres per day. - Users may commence to pump when flows are greater than 4 megalitres per day. • B class: Users must cease to pump when flows are at or less than 6 megalitres per day. • C class: Users must cease to pump when flows are at or less than 14 megalitres per day.
1.2 Daily flow sharing	• From year six of the plan daily flow sharing will be introduced for A, B and C class. The total daily extraction limit is set at four megalitres per day for A class, eight megalitres per day for B class and 15 megalitres per day for C class. This is the volume of water that is available for sharing between licensed extractors. • Initial assessment of these volumes to different categories of access licences in A class is as follows: - 0.01 megalitres per day to domestic and stock access licences - 3.99 megalitres to unregulated river access licences • Initial assessment of these volumes to different categories of

Wywandy River Management Zone (Upper Nepean and Upstream Warragamba Water Source)	
	access licences in B class is as follows: - 0.01 megalitres per day to domestic and stock licences - 4.99 megalitres per day to unregulated river access licences • Initial assessment of these volumes to different categories of access licences in C class is as follows: - 0.01 megalitres per day to domestic and stock access licences - 9.99 megalitres per day to unregulated river access licences • Unassigned water in B class of three megalitres per day and in C class of five megalitres per day may be assigned as a result of a new licence application or a variation to an existing local water utility access licence.
1.3 Reference point	• Coxs River at Wallerawang Power Station (flow gauge 212054)
2. Trading Rules	
INTO management zone	• Not permitted.
WITHIN management zone	• Permitted, subject to assessment.
Conversion to High Flow Access Licence	• Not permitted.

Table A-6 GMRU Water Source Rules: Colo River and Capertee River

Colo River and Capertee River Management Zones (Hawkesbury and Lower Nepean water source)	
1. Lagoon Rules	
1.1 Trading onto a lagoon from a river	• Not permitted.
1.2 Application for new works on a lagoon	• Not permitted.
Capertee River Management Zone	
2. Access Rules	
2.1 Licence class	• A class: Users must cease to pump when flows are at or less than two megalitres per day. - Users may commence to pump when flows have exceeded two megalistres per day for a period of up to 24 hours. • B class: Users must cease to pump when flows are less than or equal to 11 megalitres per day.

Colo River and Capertee River Management Zones (Hawkesbury and Lower Nepean water source)	
2.2 Reference point	• Carpertee River at Glen Davis (flow gauge 212018).
3. Trading Rules	
3.1 INTO management zone	• Not permitted into the hydrological catchment of Crown Creek within the management zone. • Not permitted if the trade will increase the total licensed entitlement for the zone. • Not permitted into or above reaches declared a 'wild river'.
3.2 WITHIN management zone	• Not permitted into the hydrological catchment of the Crown Creek within the management zone. • Not permitted into or above the reaches declared a "wild river", permitted elsewhere subject to assessment. • Permitted elsewhere, subject to assessment.
3.3 Conversion to High Flow Access Licence	• Not permitted.
Colo River Management Zone	
4. Access Rules	
4.1 Licence class	• A class: Users must cease to pump when flows are at or less than 24 megalitres per day. - Users may commence to pump when flows have exceeded 24 megalitres per day for a period of 24 hours. *Note: the cease to pump may be amended to 45 megalitres per day (90th percentile) based on further studies.* • B class: Users must cease to pump when flows are at or less than 244 megalitres per day.
4.2 Reference point	• Colo River at Upper Colo (flow gauge 212290).
5. Trading Rules	
5.1 INTO management zone	• No permitted if the trade will increase the total licensed entitlement for the zone. Not permitted into or above reaches declared a 'wild river'.
5.2 WITHIN management zone	• Not permitted into or above reaches declared a 'wild river', permitted elsewhere subject to assessment.
5.3 Conversion to High Flow Access Licence	• Not permitted.

Table A-7 MBUA Water Source Rules: Turon Crudine River

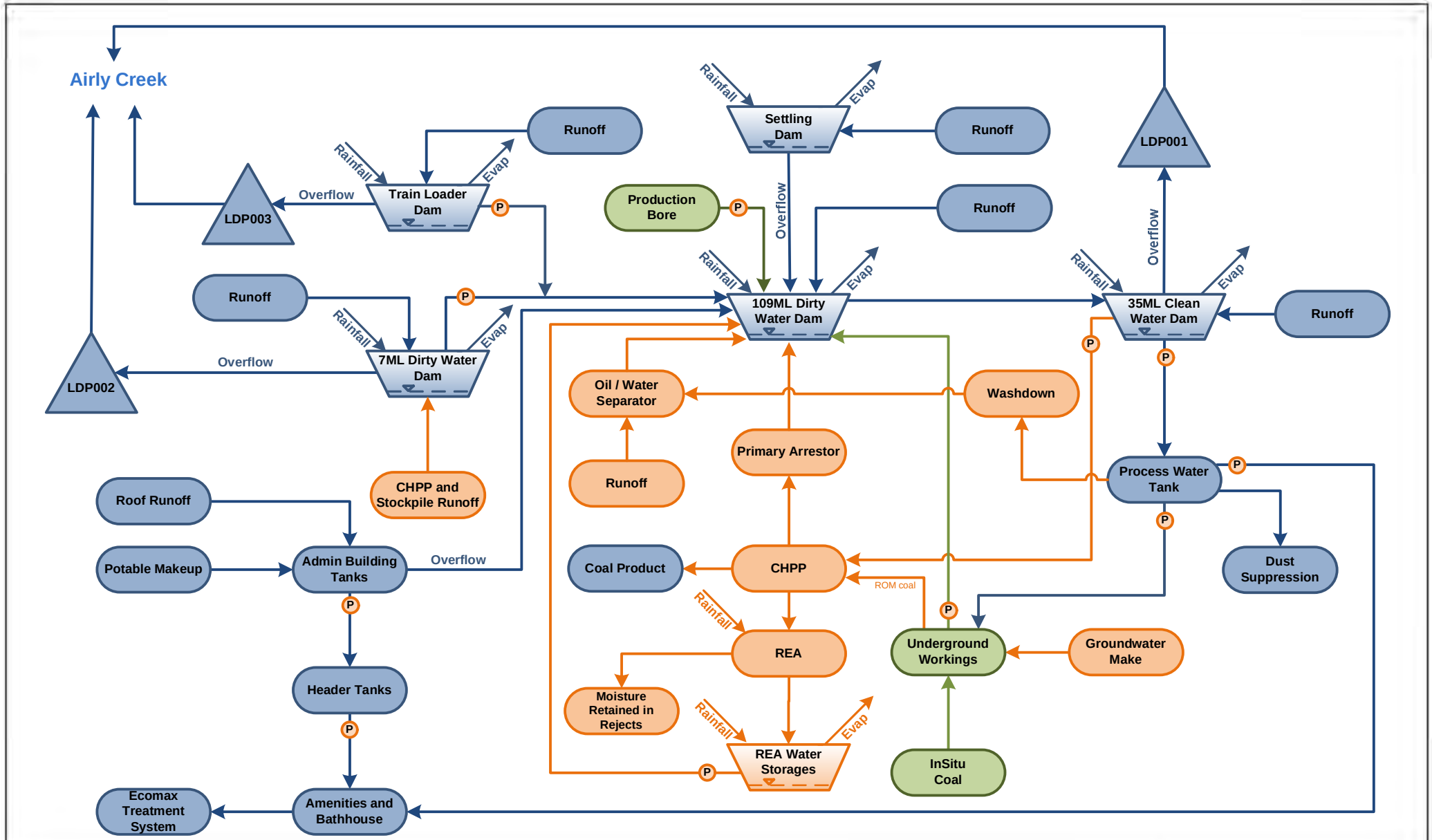
Turon Crudine River Water Source	
1. Access Rules	
1.1 Cease to pump	• Pumping is not permitted from natural pools when the water level in the pool is lower than its full capacity. ***Note:*** *'Full capacity' can be approximated by the pool water level at the point where there is no visible flow into and out of that pool.* ***Note:*** *Natural pools include in-river pools found within the channels of rivers and creek and off-river pools located on flood runners, floodplains and effluents e.g. lakes, lagoons and billabongs.* ***Note:*** *For pump sites not within a natural pool, the cease to pump rule is when there is no visible flow at that pump site.*
1.2 Reference point	• Individual natural pool.
Note: *these access rules do not apply:* • *If the existing Water Act 1912 entitlement had more stringent access licence conditions. These existing conditions will be carried forward under the plan, or* • *To major water utility, local water utility or unregulated river (town water supply) access licences, or* • *To water taken for domestic consumption by stock and domestic access licences, or* • *For the first five years of the plan to water taken for stock watering by stock and domestic access licences, or* • *To water taken from existing dams (any existing licence conditions associated with a dam will be carried forward under the plan).*	
2. Trading Rules	
2.1 INTO water source	• Not permitted.
2.2 WITHIN water source	• Trades permitted within water source, subject to assessment.

Table A-8 MBUA Water Source Rules: Upper Cudgegong River

Upper Cudgegong River Water Source	
1. Access Rules	
1.1 Cease to pump	• Pumping is not permitted from natural pools when the water level in the pool is lower than its full capacity. ***Note:*** *Licences on Rylstone Dam must cease pumping when the pool is at or below 1.22 metres from the top of the spillway.* ***Note:*** *'Full capacity' can be approximated by the pool water level at the point where there is no visible flow into and out of that pool.* ***Note:*** *Natural pools include in-river pools found within the channels of rivers and creeks and off-river pools located on flood runners, floodplains and effluents e.g. lakes, lagoons and billabongs.* ***Note:*** *For pump sites not within a natural pool, the cease to pump rule is when there is no visible flow at that pump site.*
1.2 Reference point	• Individual natural pool

Upper Cudgegong River Water Source	
Note: these access rules do not apply: • *If the existing Water Act 1912 entitlement had more stringent access licence conditions. These existing conditions will be carried forward under the plan, or* • *To major water utility, local water utility or unregulated river (town water supply) access licences, or* • *To water taken for domestic consumption by stock and domestic access licences, or* • *For the first five years of the plan to water taken for stock watering by stock and domestic access licences, or* • *To water taken from existing dams (any existing licence conditions associated with a dam will be carried forward under the plan).*	
2. Trading Rules	
2.1 INTO water source	• Not permitted.
2.2 WITHIN water source	• Trades permitted within water source, subject to assessment, but not permitted into the pool created by Rylstone Dam.

Appendix B – Site Schematics



LEGEND

- Surface Water Transfer
- Underground Water Transfer
- Proposed Water Transfer
- Storage
- Pump

LOCATION	Airly
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Western Coalfield Water Balance

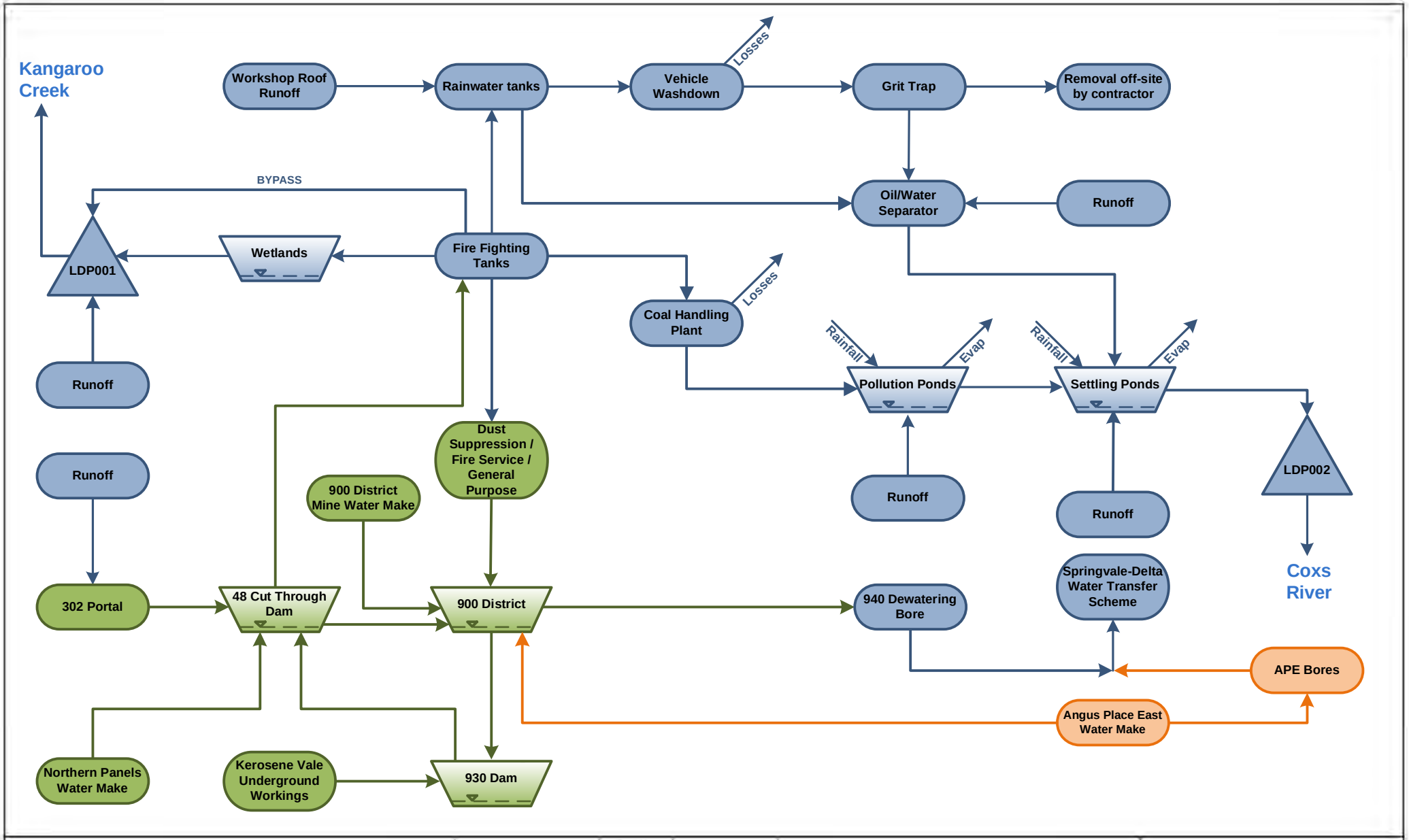
Airly Mine
Water Cycle Schematic

Centennial Airly

DATE Nov 2013

Figure B-1

G:\22\16761\Visios\Report2Visios\FigureB1_Airly Water Cycle Schematic.vsd



LOCATION	Angus Place
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Western Coalfield Water Balance

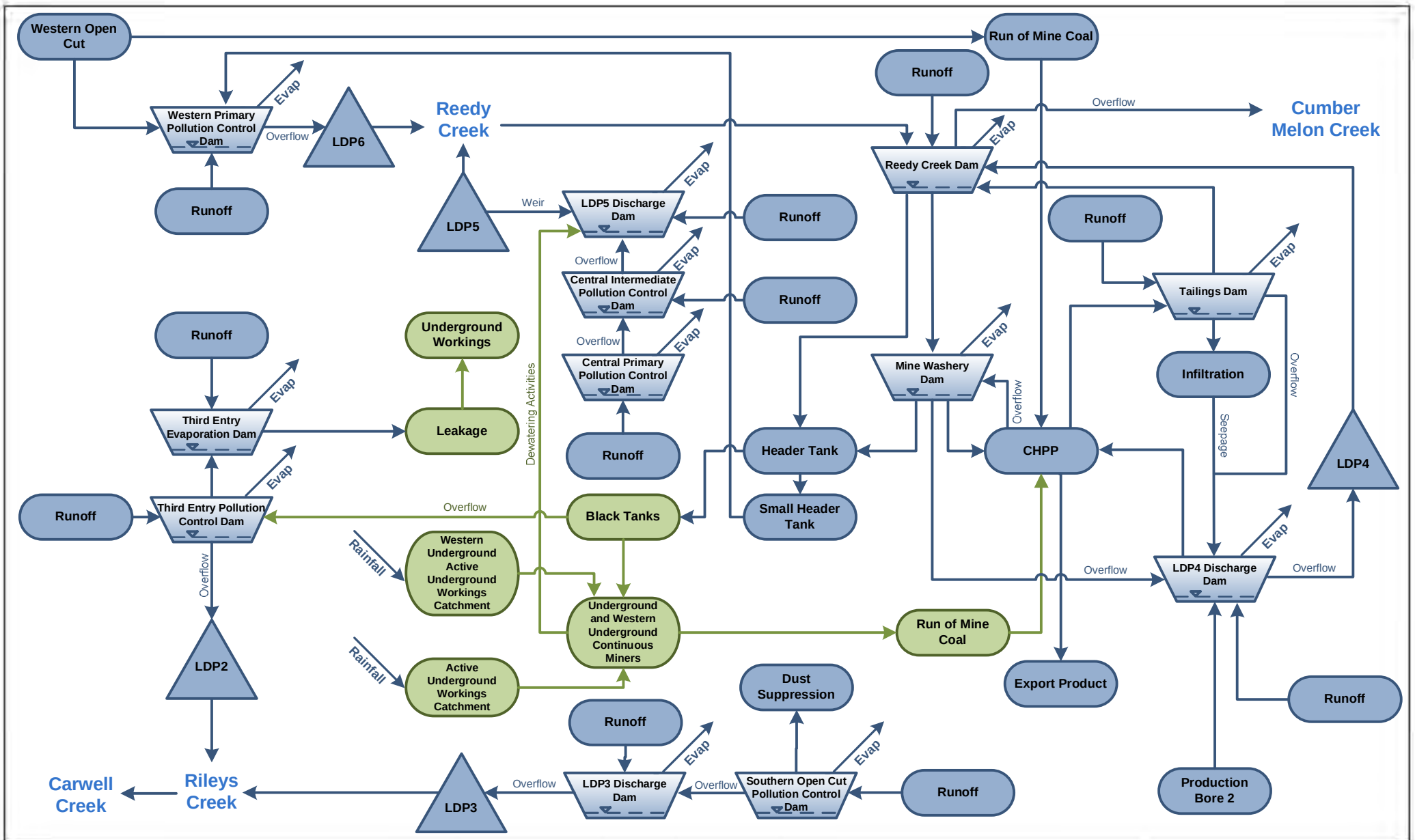
Angus Place Colliery
Water Cycle Schematic

Centennial Coal

DATE Nov 2013

Figure B-2

G:\22\16761\Visios\Report2Visios\FigureB2_Angus Place Water Cycle Schematic.vsd



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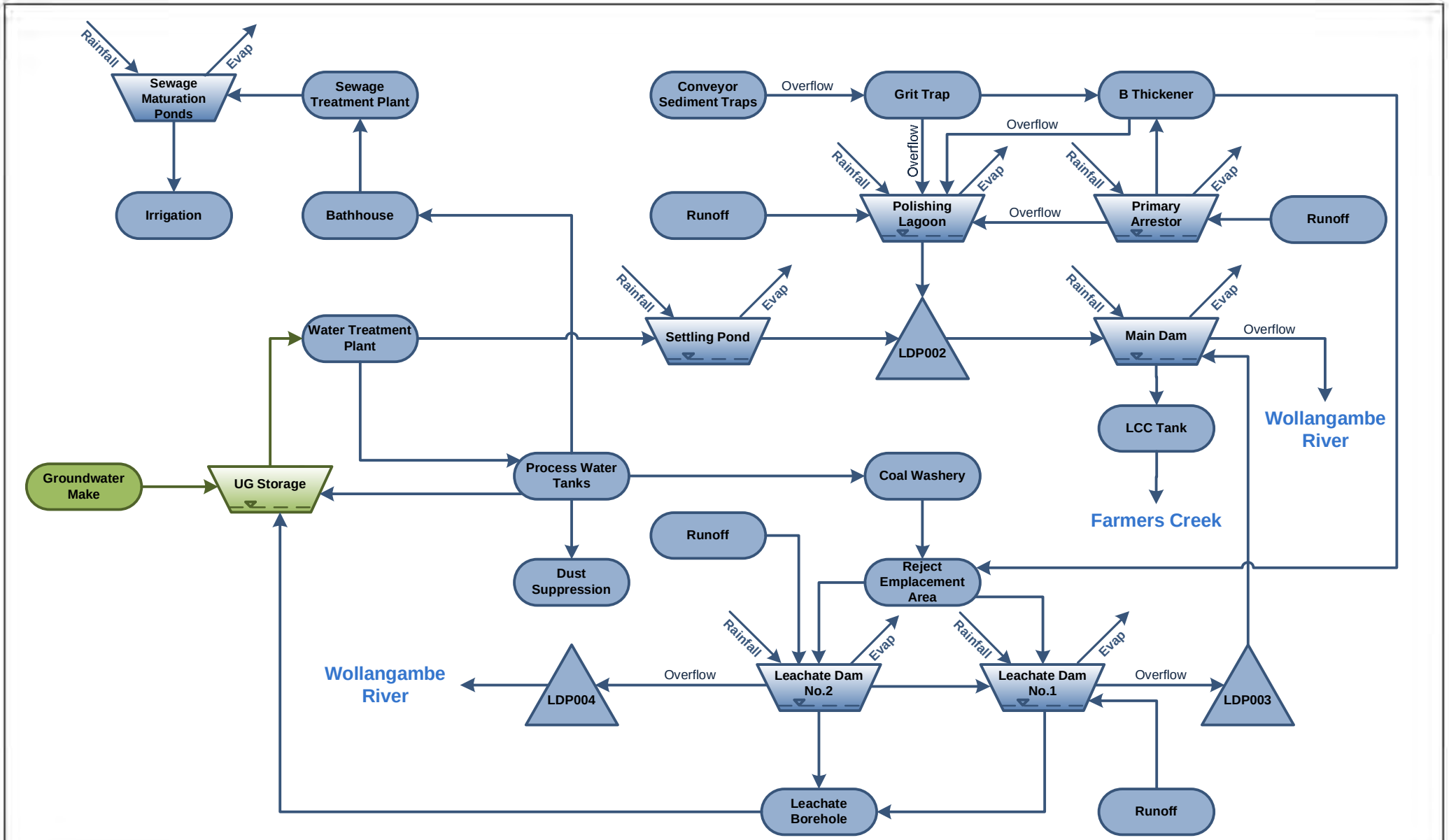


LEGEND

Surface Water Transfer

Underground Water Transfer

Storage

LOCATION	Clarence
SEAM	Lithgow
DRAWN	SM
CHECKED	SC
APPROVED	SG
SCALE	NTS

Western Coalfield Water Balance

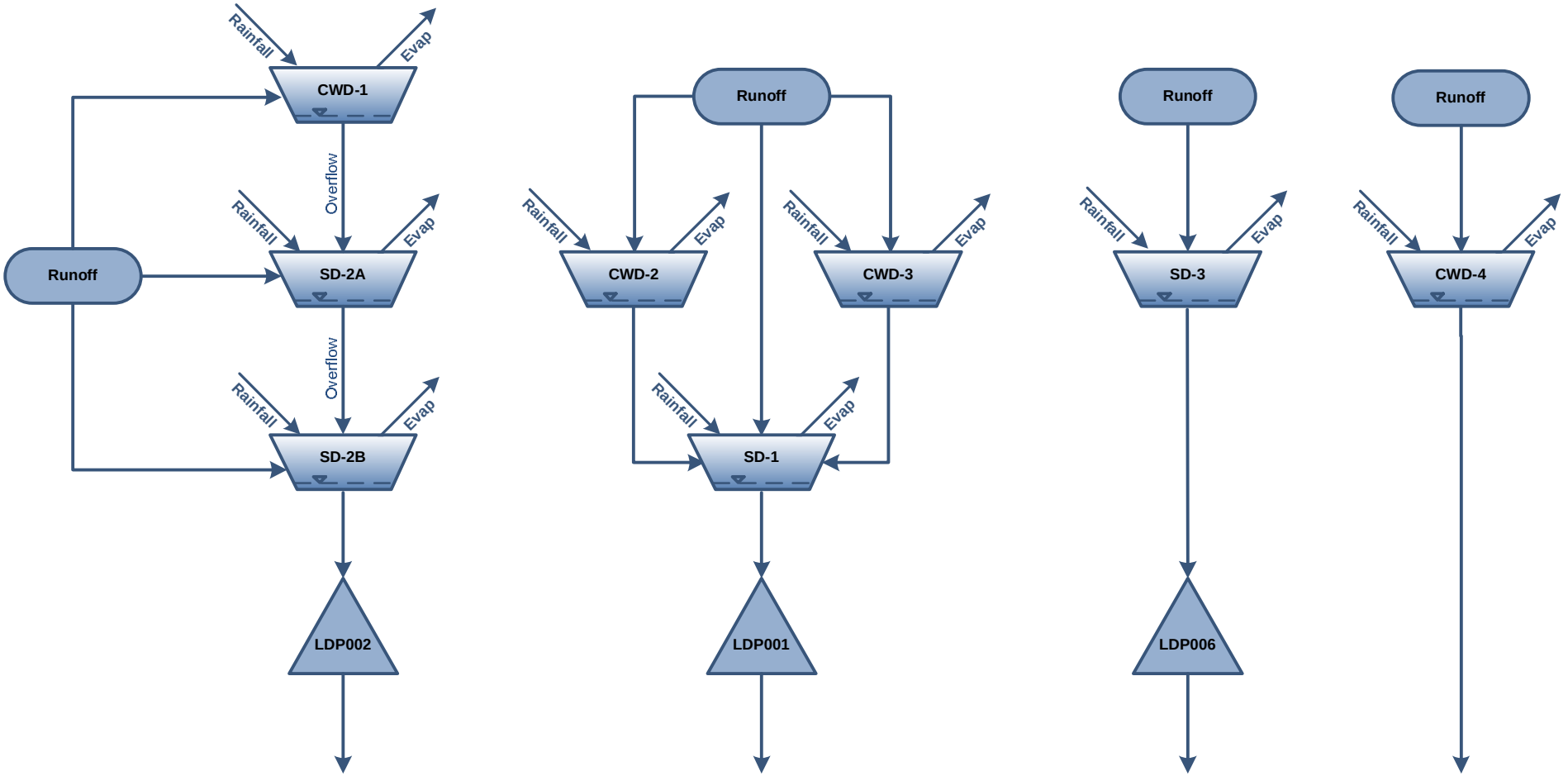
Clarence Colliery
Water Cycle Schematic

Centennial Coal

DATE Nov 2013

Figure B-4

G:\22\16761\Visios\Report2Visios\FigureB4_Clarence Water Cycle Schematic.vsd



LEGEND

Surface Water Transfer

Underground Water Transfer

Storage

LOCATION	Ivanhoe North
SEAM	Lithgow
DRAWN	SM
CHECKED	SC
APPROVED	SG
SCALE	NTS

Western Coalfield Water Balance

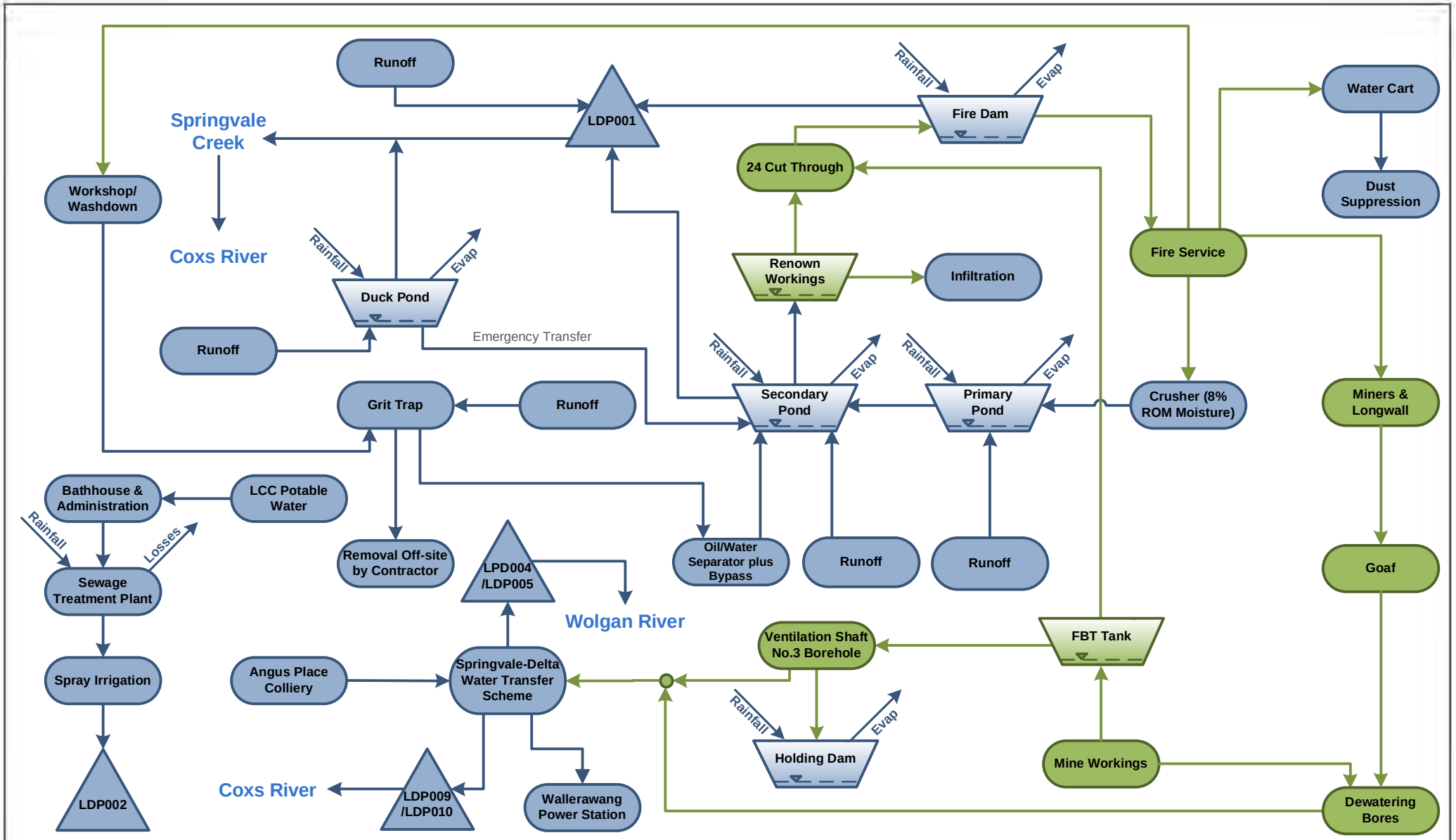
Ivanhoe North
Water Cycle Schematic

Centennial Coal

DATE Nov 2013

Figure B-5

G:\22\16761\Visios\Report2Visios\FigureB5_Ivanhoe North Water Cycle Schematic.vsd



LEGEND

Surface Water Transfer

Underground Water Transfer

Storage

LOCATION	Springvale
SEAM	Lithgow
DRAWN	SM
CHECKED	TD
APPROVED	SC
SCALE	NTS

Western Coalfield Water Balance

Springvale Mine
Water Cycle Schematic

Centennial Coal

DATE Nov 2013

Figure B-6

G:\22\16761\Visios\Report2Visios\FigureB6_Springvale Water Cycle Schematic.vsd

Appendix C – Individual Site Results

Centennial Sites

Airly Mine

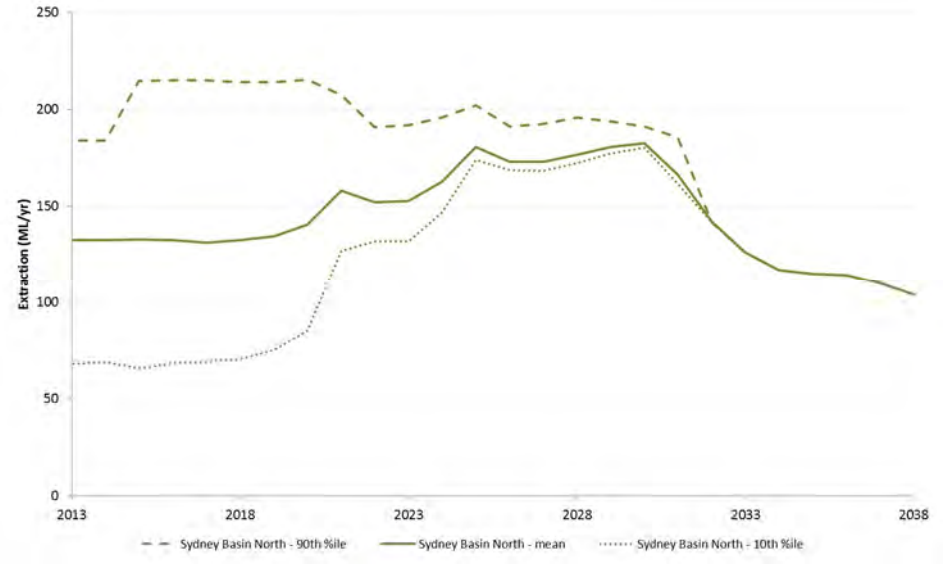


Figure C-1 Airly Mine – Groundwater Extraction by Water Source

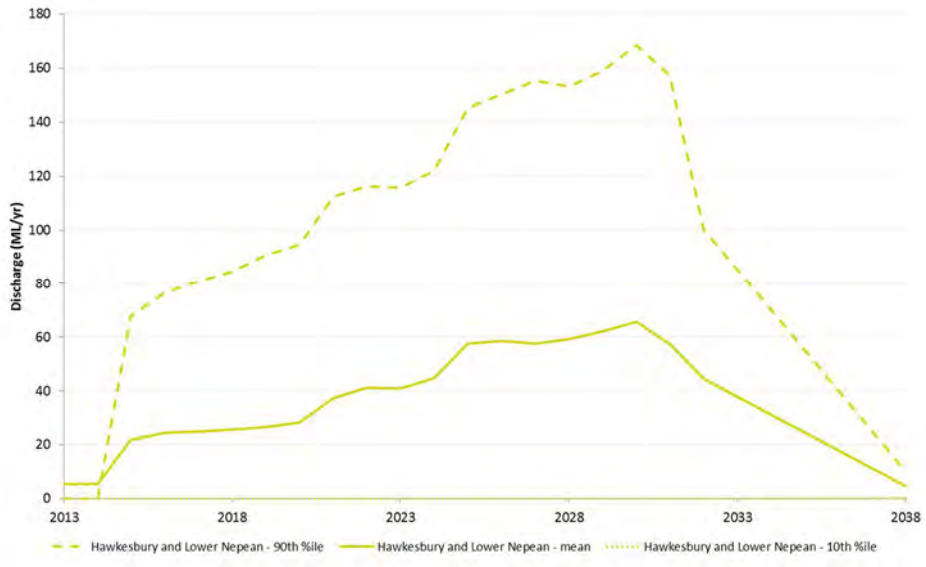


Figure C-2 Airly Mine – Surface Water Discharge by Water Source

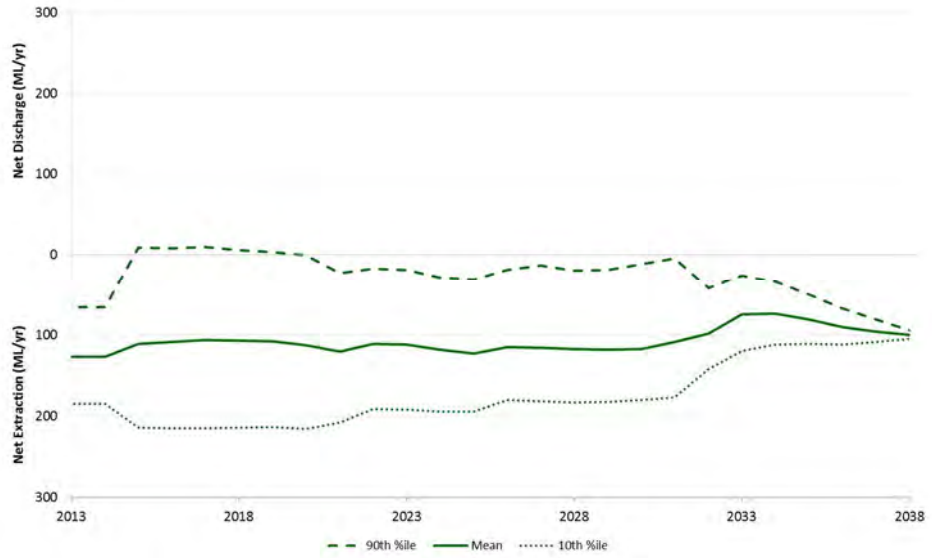


Figure C-3 Airly Mine – Net Extraction/Discharge (All Water Sources)

Angus Place Colliery

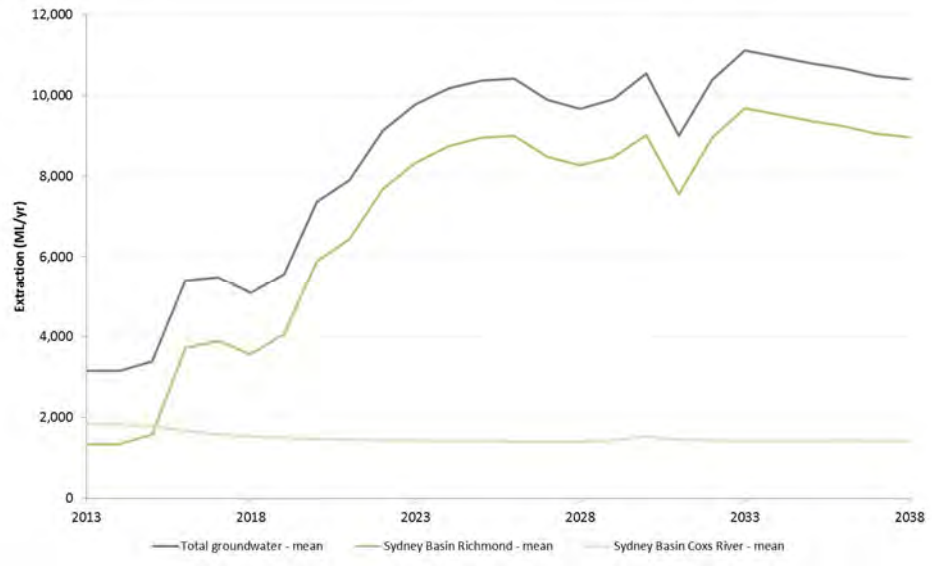


Figure C-4 Angus Place Colliery – Groundwater Extraction by Water Source

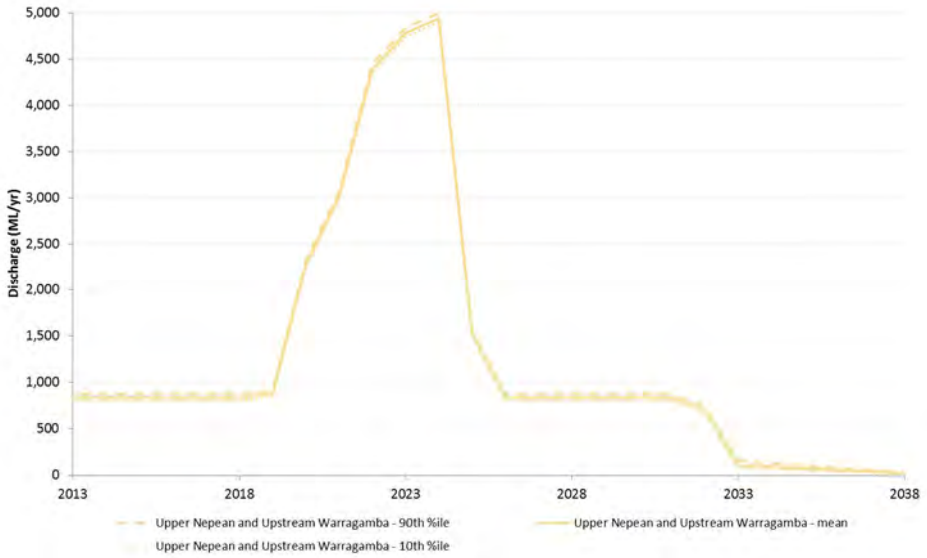


Figure C-5 Angus Place Colliery – Surface Water Discharges by Water Source (Current SDWTS Capacity)

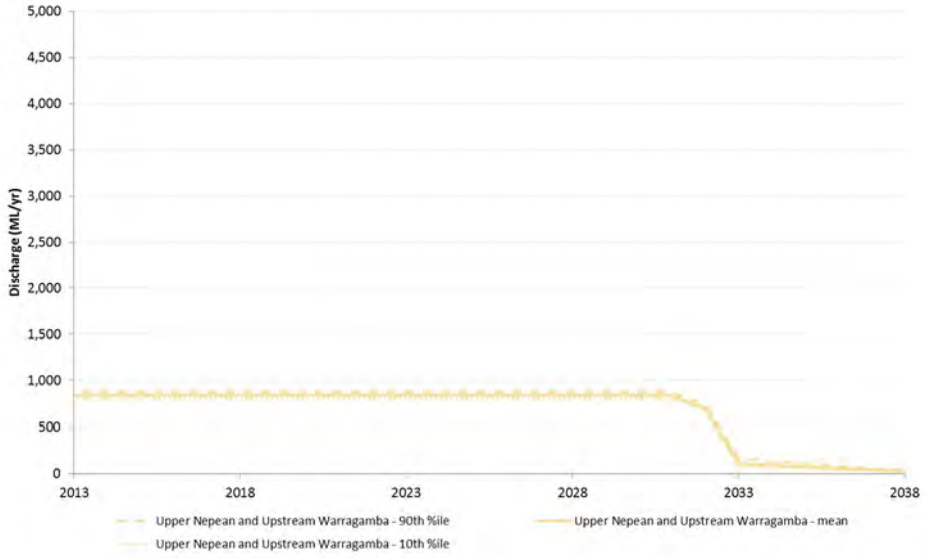


Figure C-6 Angus Place Colliery – Surface Water Discharges by Water Source (Upgraded SDWTS Capacity)

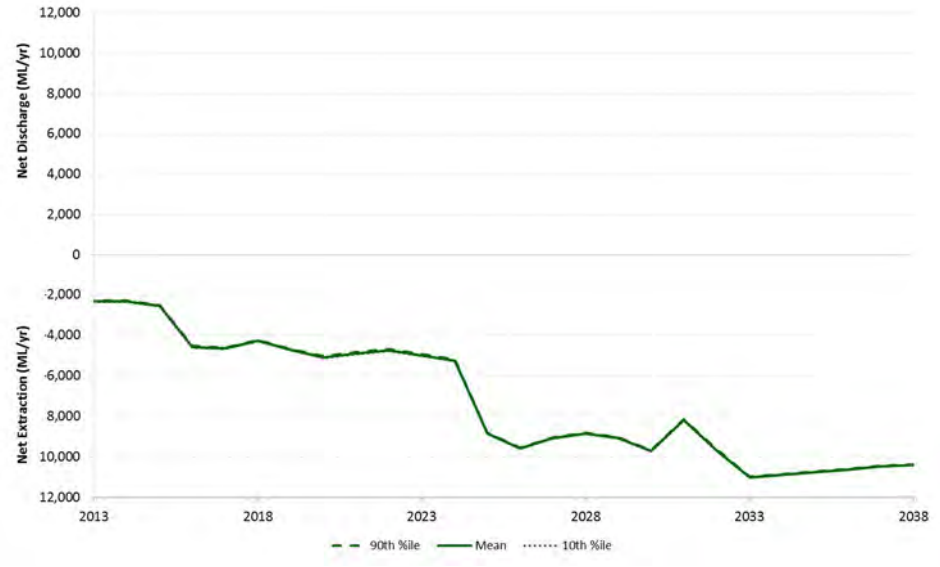


Figure C-7 Angus Place Colliery – Net Extraction/Discharge (All Water Sources; Current SDWTS Capacity)

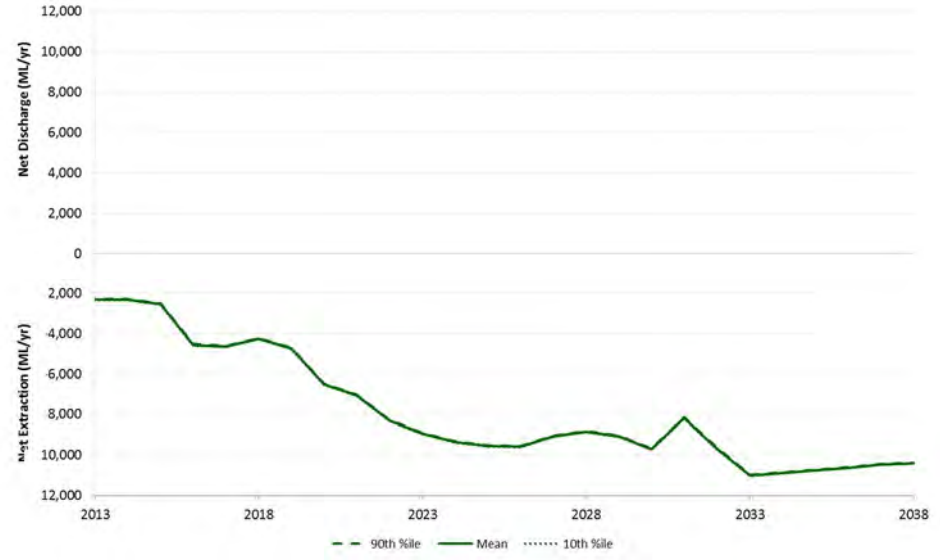


Figure C-8 Angus Place Colliery – Net Extraction/Discharge (All Water Sources; Upgraded SDWTS Capacity)

Charbon Colliery

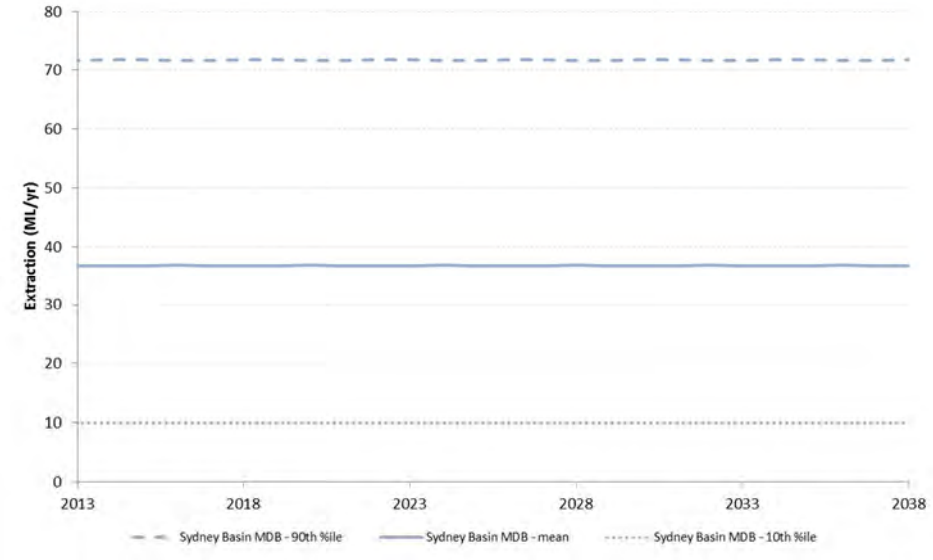


Figure C-9 Charbon Colliery – Groundwater Extraction by Water Source

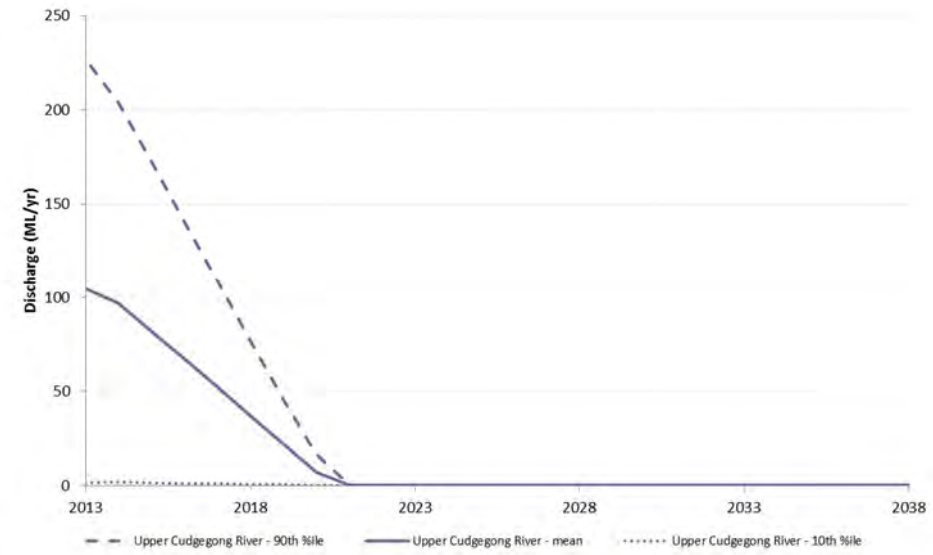


Figure C-10 Charbon Colliery – Surface Water Discharge by Water Source

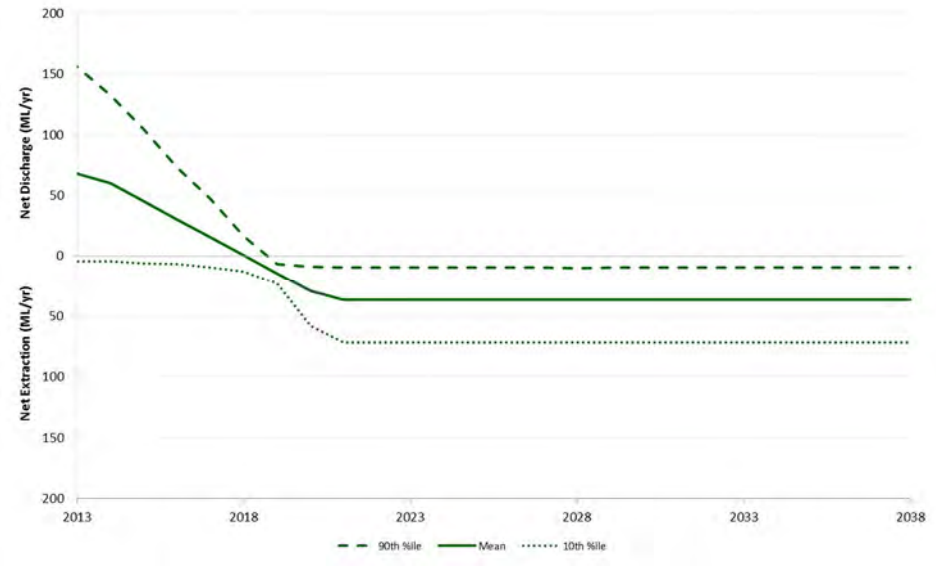


Figure C-11 Charbon Colliery – Net Extraction/Discharge (All Water Sources)

Clarence Colliery

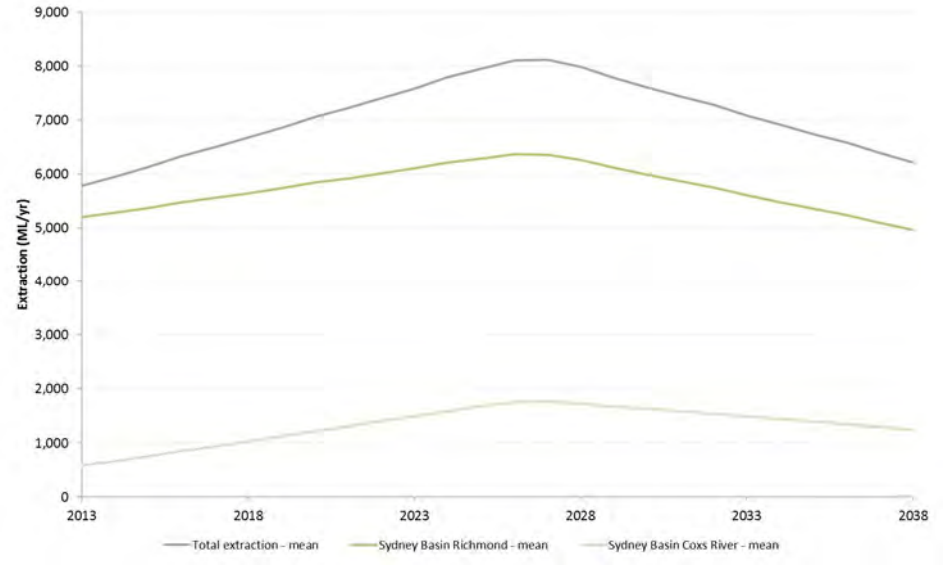


Figure C-12 Clarence Colliery – Groundwater Extraction by Water Source

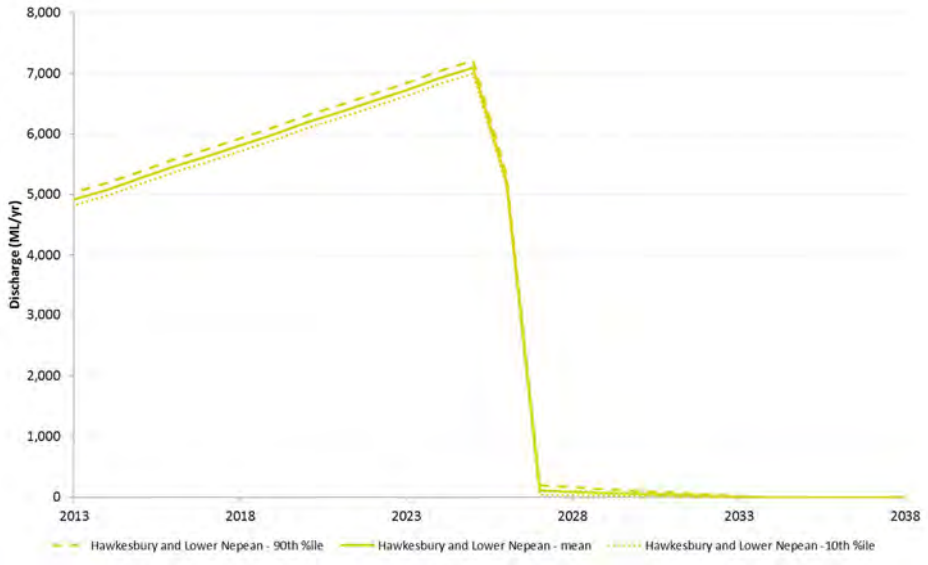


Figure C-13 Clarence Colliery – Surface Water Discharge by Water Source

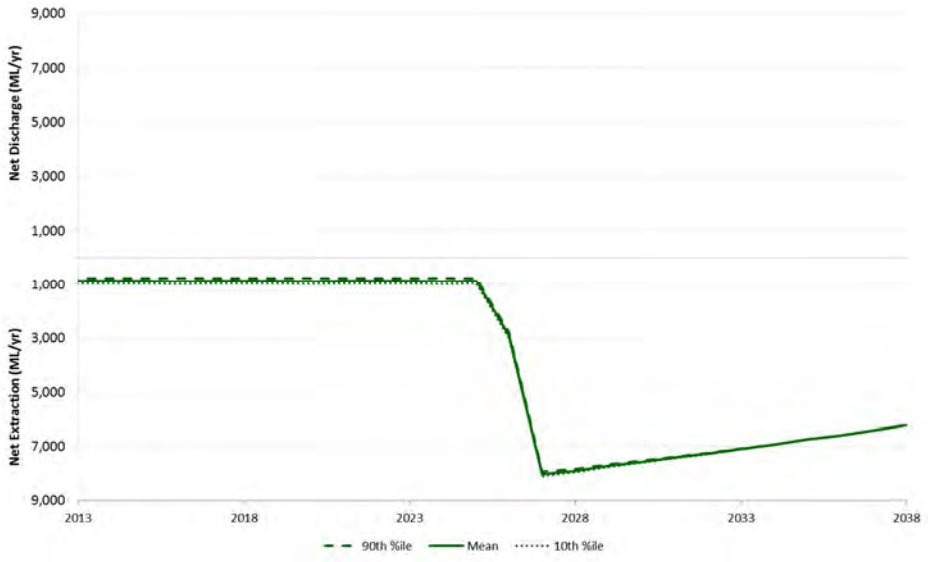


Figure C-14 Clarence Colliery – Net Extraction/Discharge (All Water Sources)

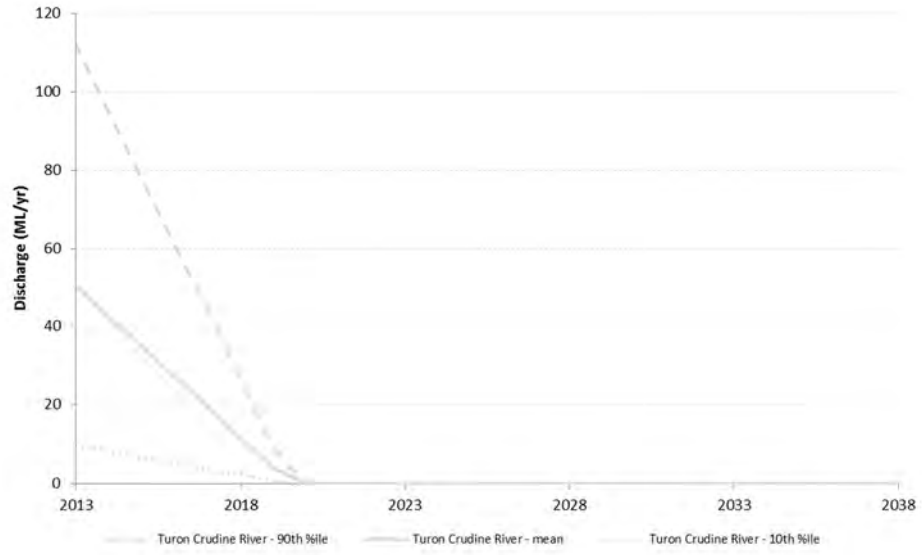


Figure C-15 Ivanhoe North Rehabilitation Project – Surface Water Discharge by Water Source

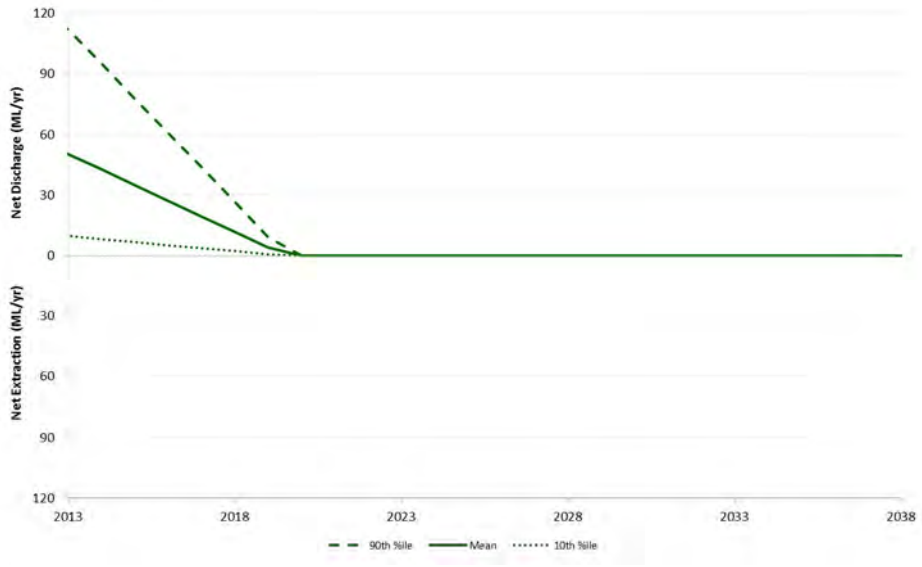


Figure C-16 Ivanhoe North Rehabilitation Project – Net Extraction/Discharge (All Water Sources)

Lidsdale Siding

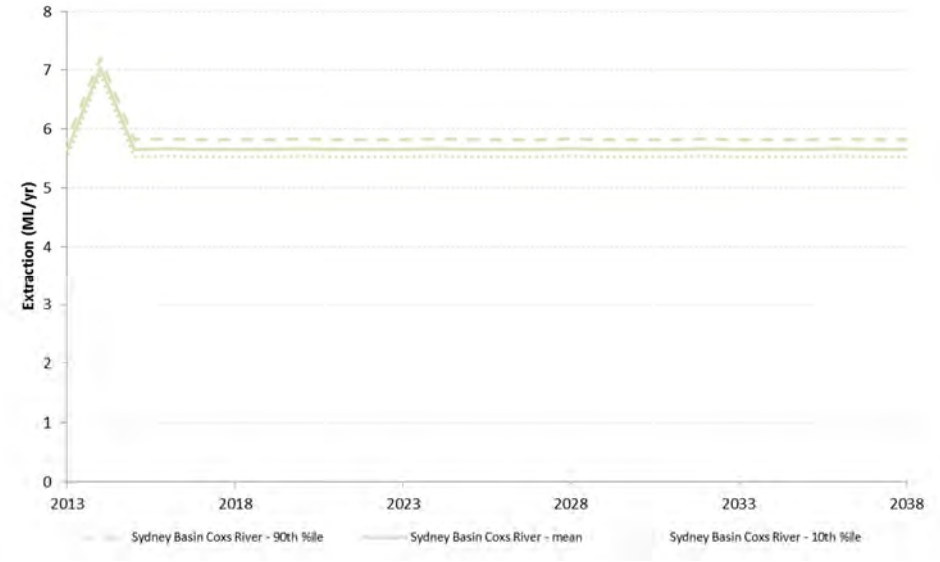


Figure C-17 Lidsdale Siding – Groundwater Extraction by Water Source

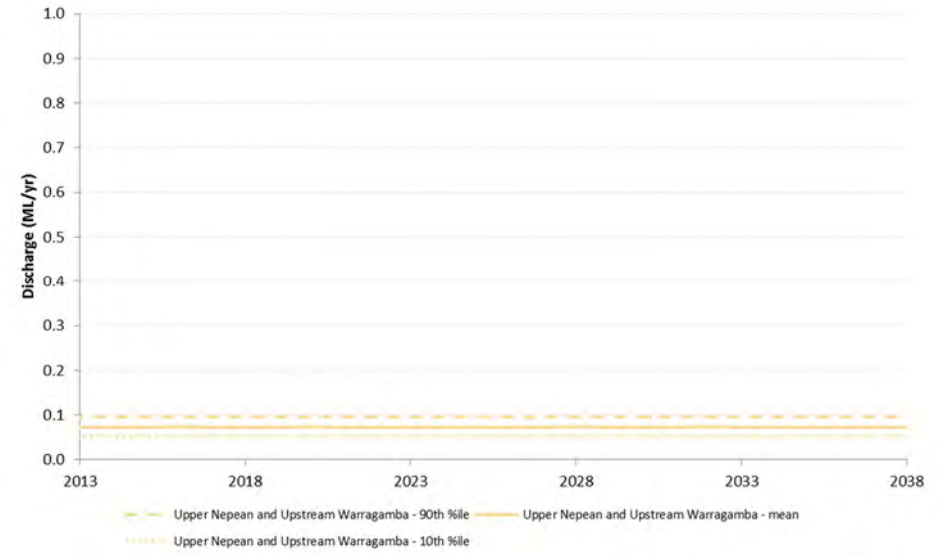


Figure C-18 Lidsdale Siding – Surface Water Discharge by Water Source

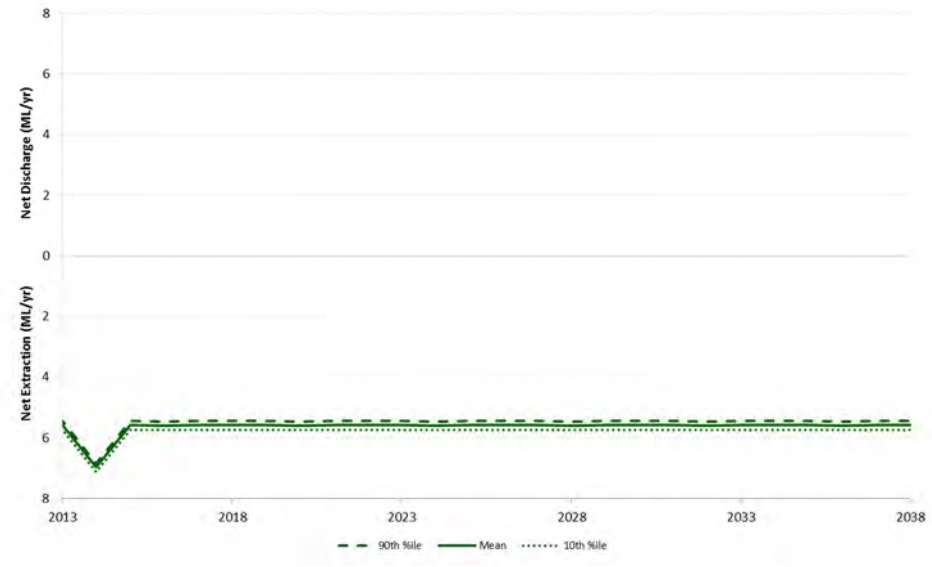


Figure C-19 Lidsdale Siding – Net Extraction/Discharge (All Water Sources)

Neubeck Project

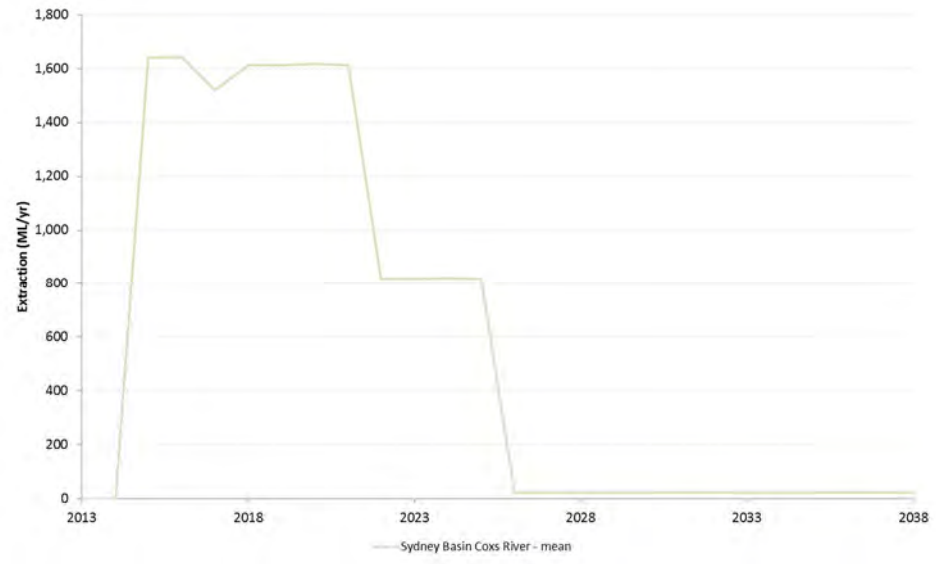


Figure C-20 Neubeck Project – Groundwater Extraction by Water Source

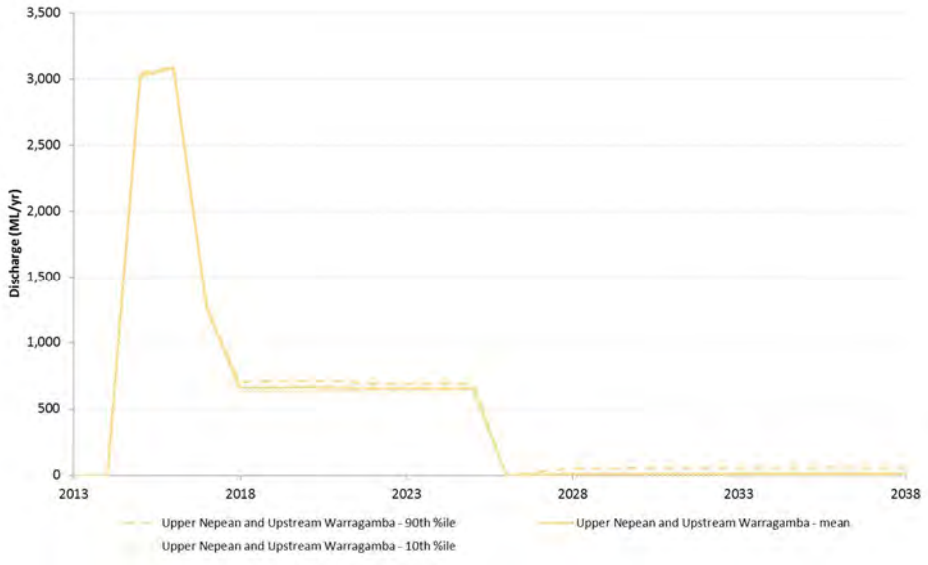


Figure C-21 Neubeck Project – Surface Water Discharge by Water Source

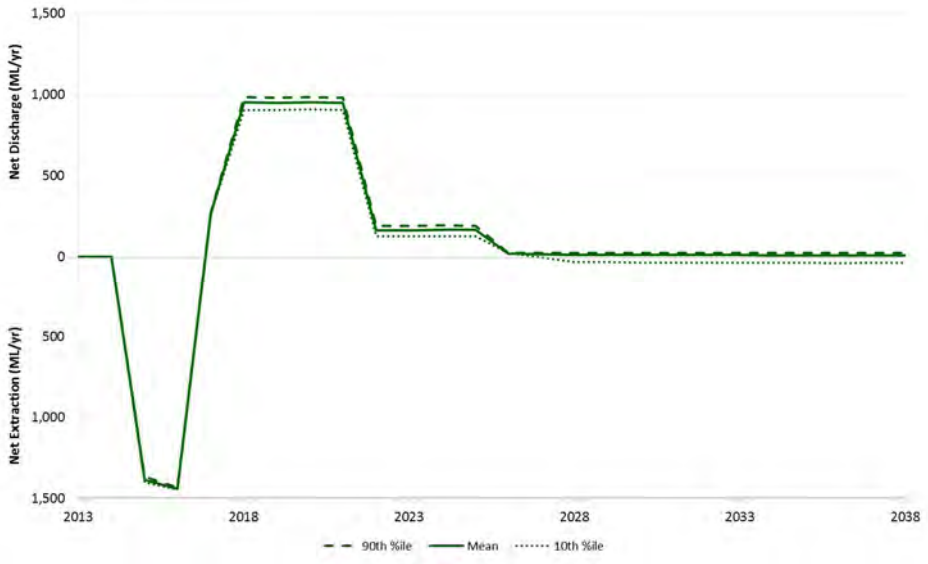


Figure C-22 Neubeck Project – Net Extraction/Discharge (All Water Sources)

Springvale Mine

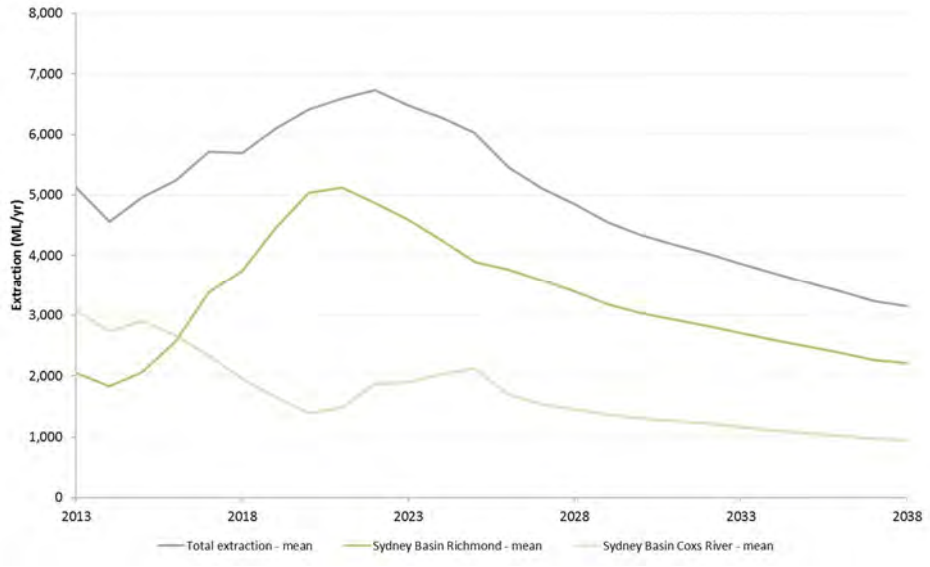


Figure C-23 Springvale Mine – Groundwater Extraction by Water Source

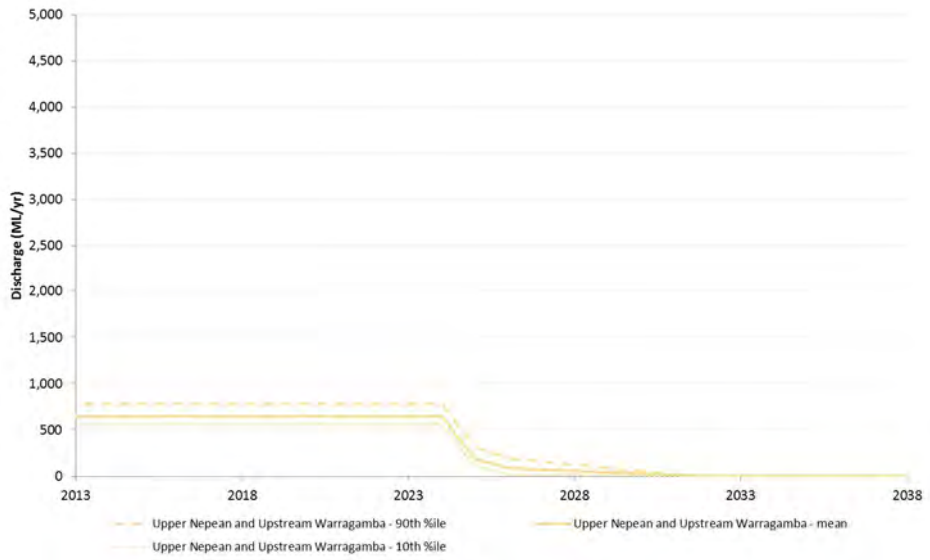


Figure C-24 Springvale Mine – Surface Water Discharge by Water Source (Current SDWTS Capacity)

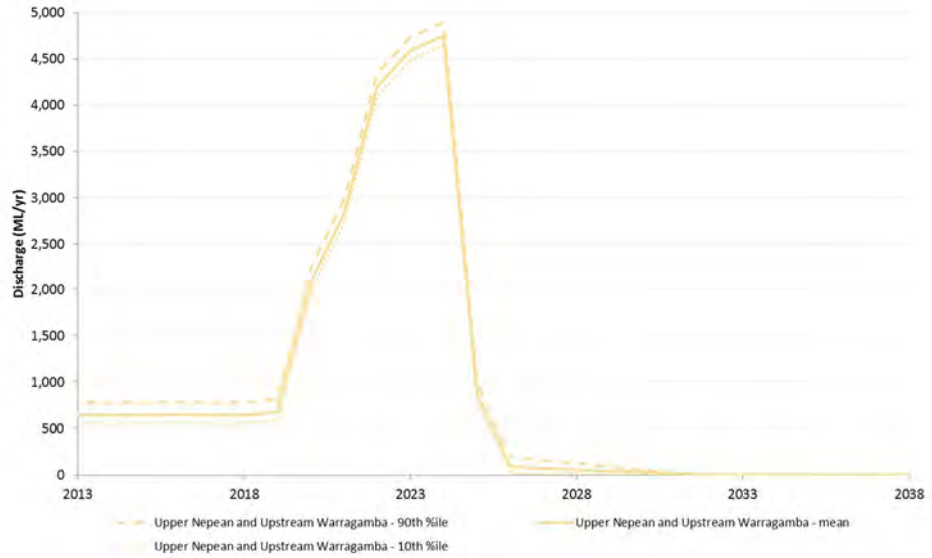


Figure C-25 Springvale Mine – Surface Water Discharge by Water Source (Upgraded SDWTS Capacity)

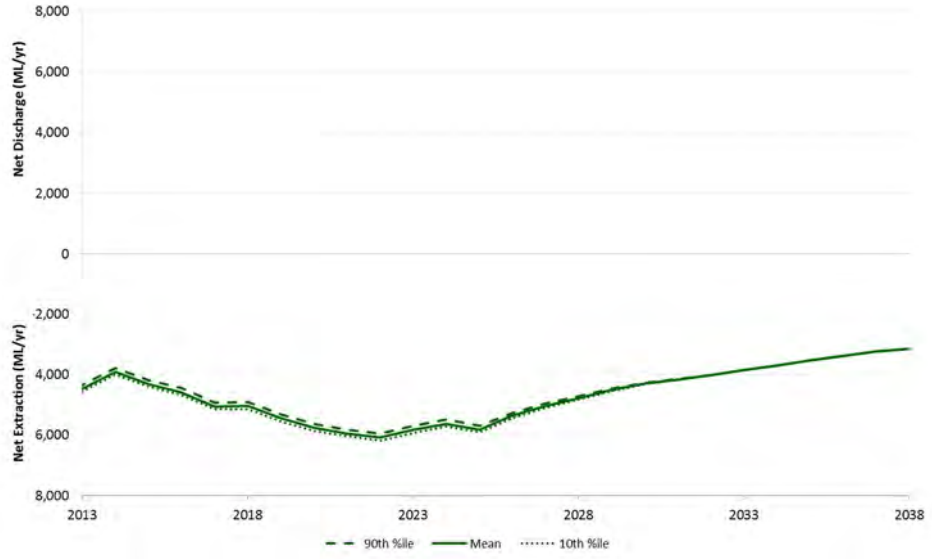


Figure C-26 Springvale Mine – Net Extraction/Discharge (All Water Sources; Current SDWTS Capacity)

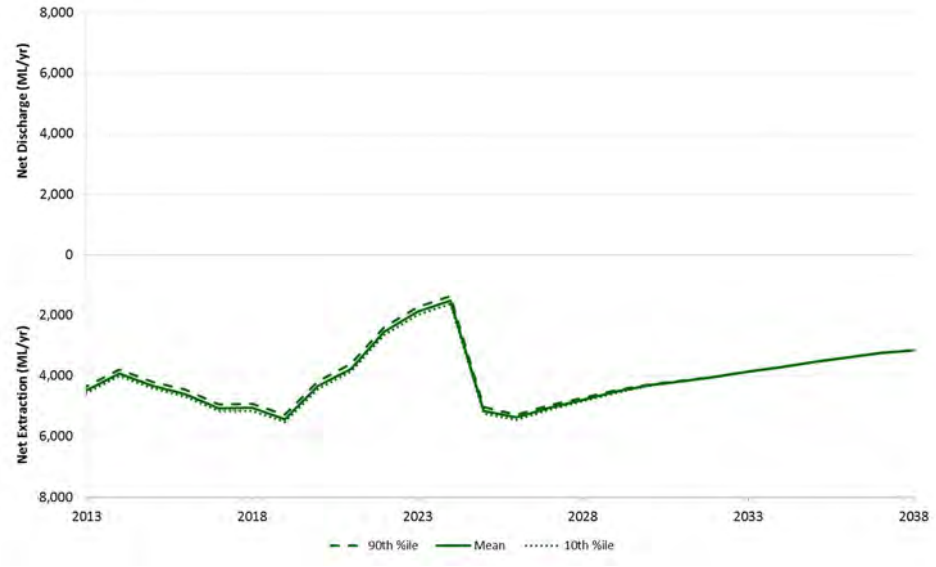


Figure C-27 Springvale Mine – Net Extraction/Discharge (All Water Sources; Upgraded SDWTS Capacity)

Western Coal Services

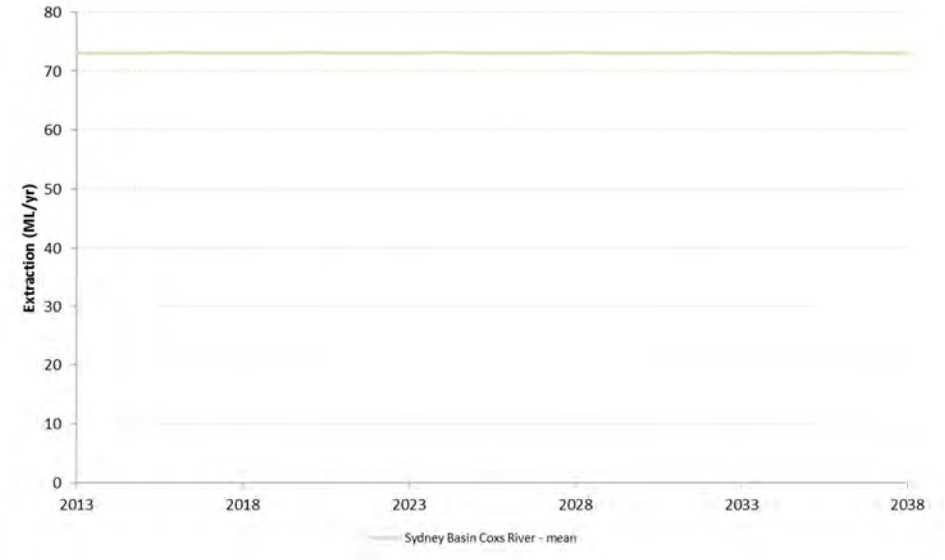


Figure C-28 Western Coal Services – Groundwater Extraction by Water Source

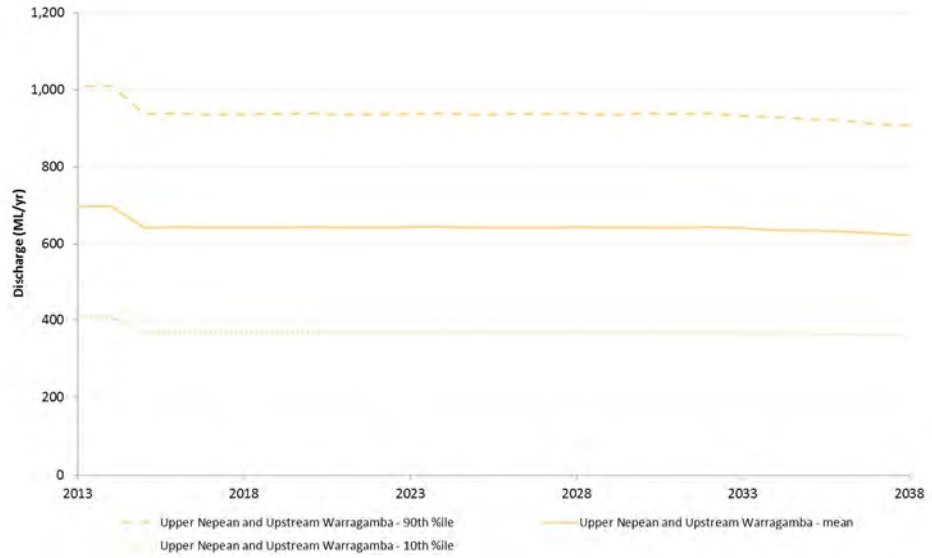


Figure C-29 Western Coal Services – Surface Water Discharge by Water Source

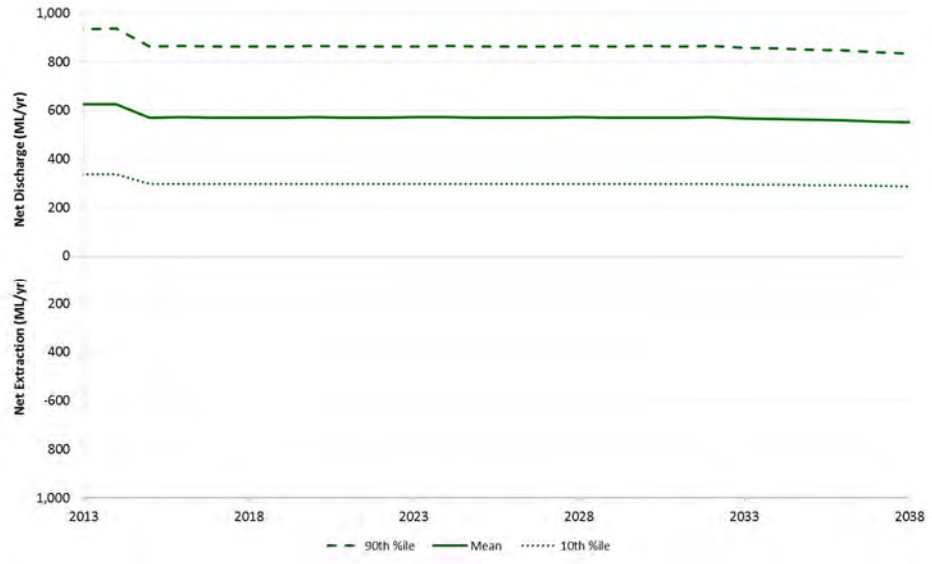


Figure C-30 Western Coal Services – Net Extraction/Discharge (All Water Sources)

Non-Centennial Sites

Baal Bone Colliery

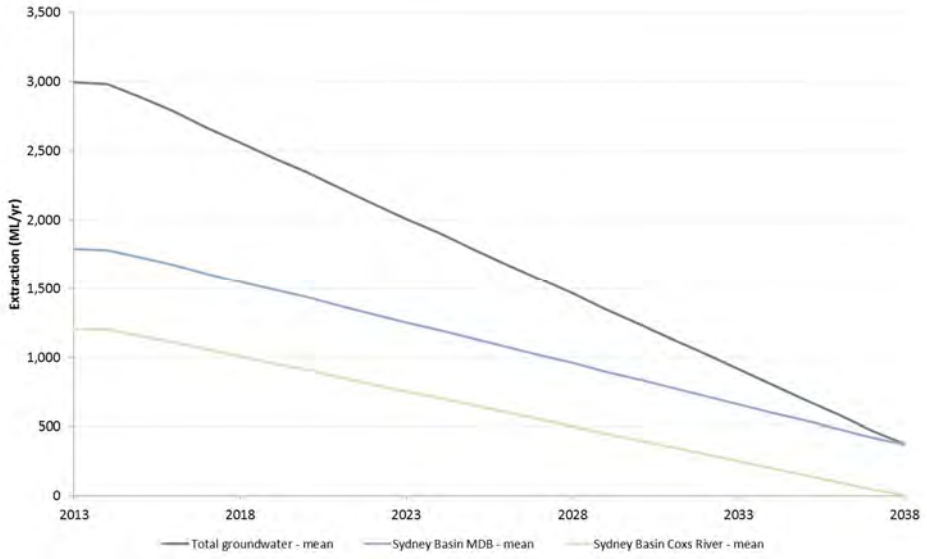


Figure C-31 Baal Bone Colliery – Groundwater Extraction by Water Source

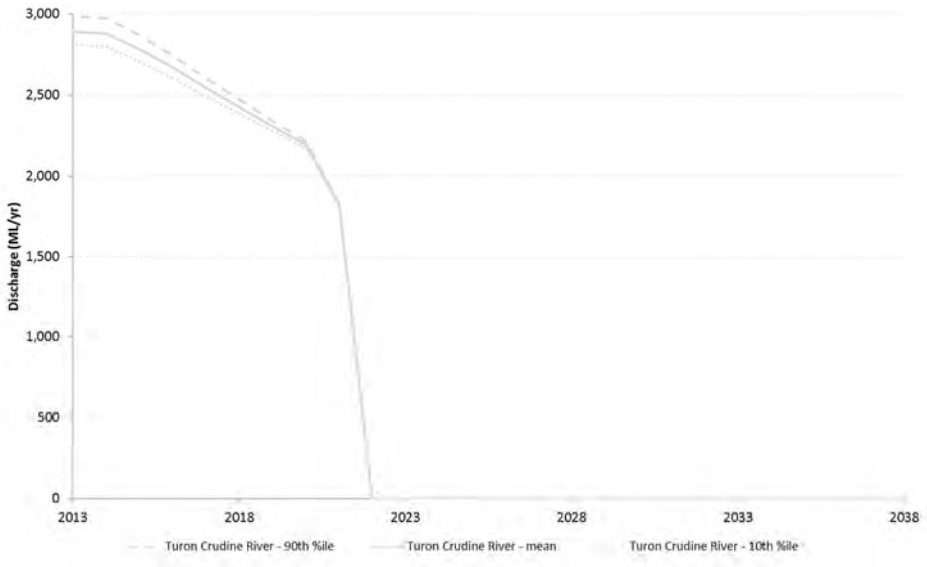


Figure C-32 Baal Bone Colliery – Surface Water Discharge by Water Source

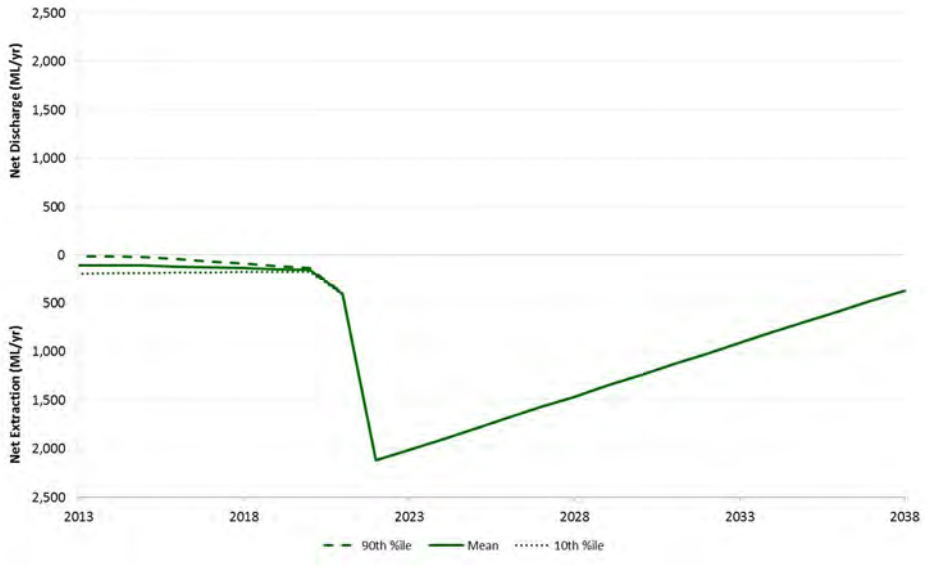


Figure C-33 Baal Bone Colliery – Net Extraction/Discharge (All Water Sources)

Coalpac Consolidation Project

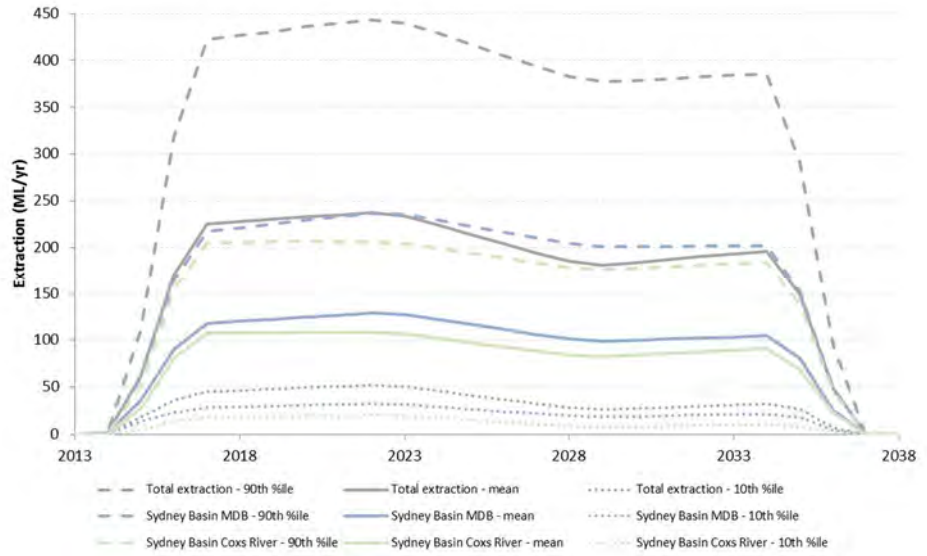


Figure C-34 Coalpac Consolidation Project – Groundwater Extraction by Water Source

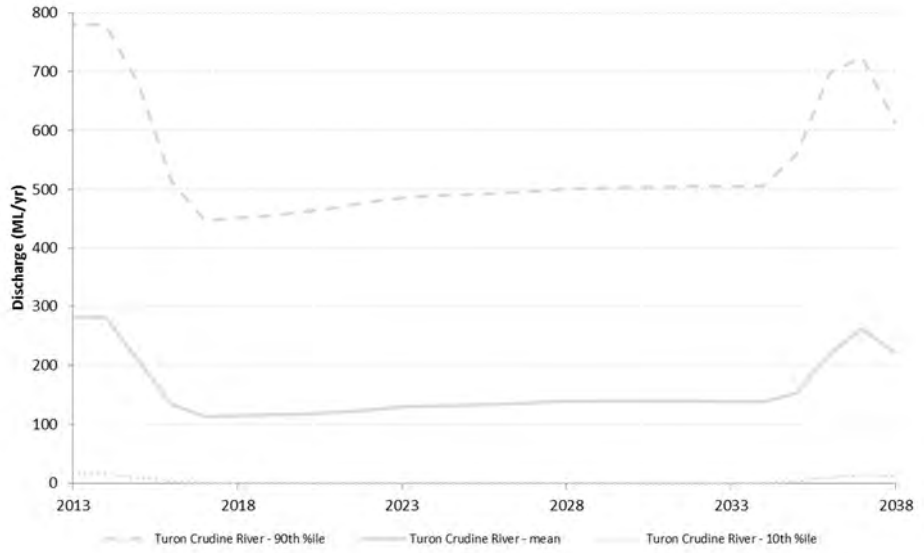


Figure C-35 Coalpac Consolidation Project – Surface Water Discharge by Water Source

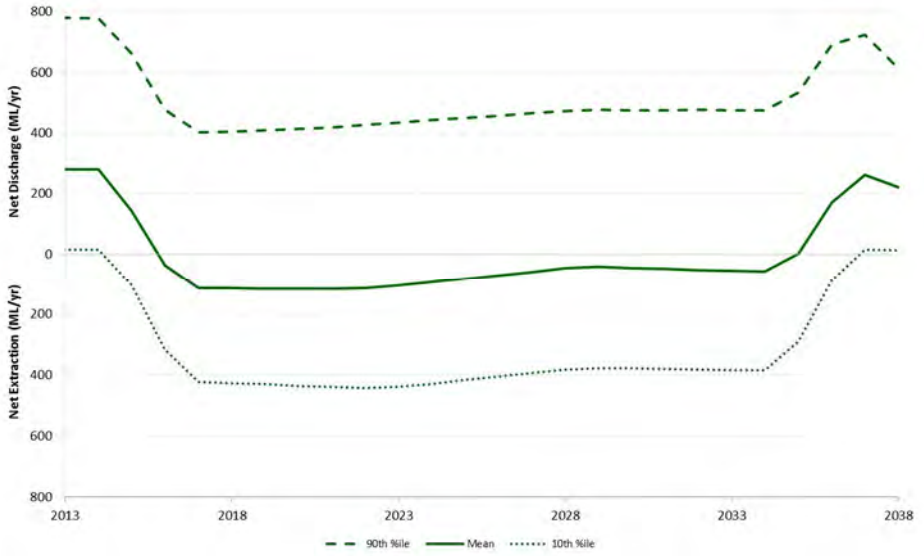


Figure C-36 Coalpac Consolidation Project – Net Extraction/Discharge (All Water Sources)

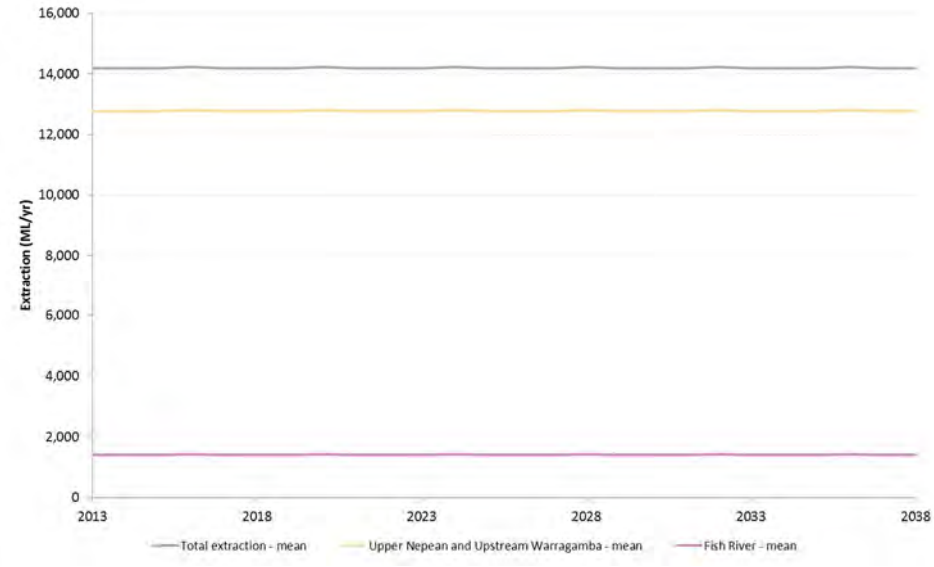


Figure C-37 Mount Piper Power Station – Surface Water Extraction by Water Source

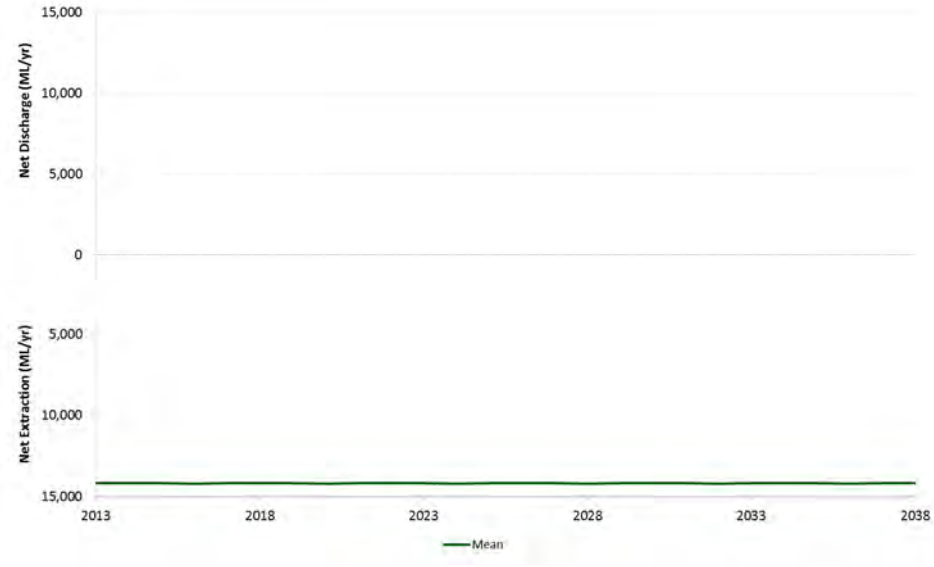


Figure C-38 Mount Piper Power Station – Net Extraction/Discharge (All Water Sources)

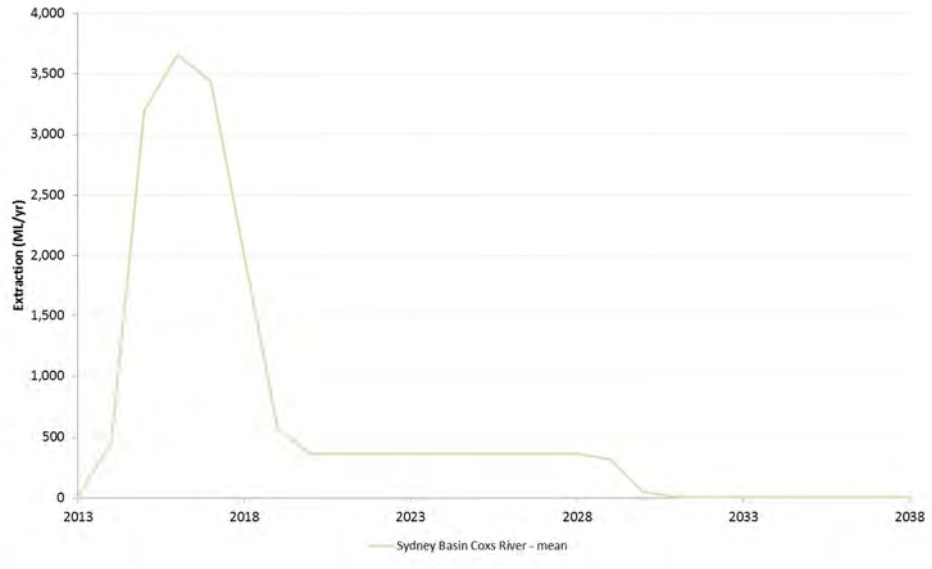


Figure C-39 Pine Dale Coal Mine – Groundwater Extraction by Water Source

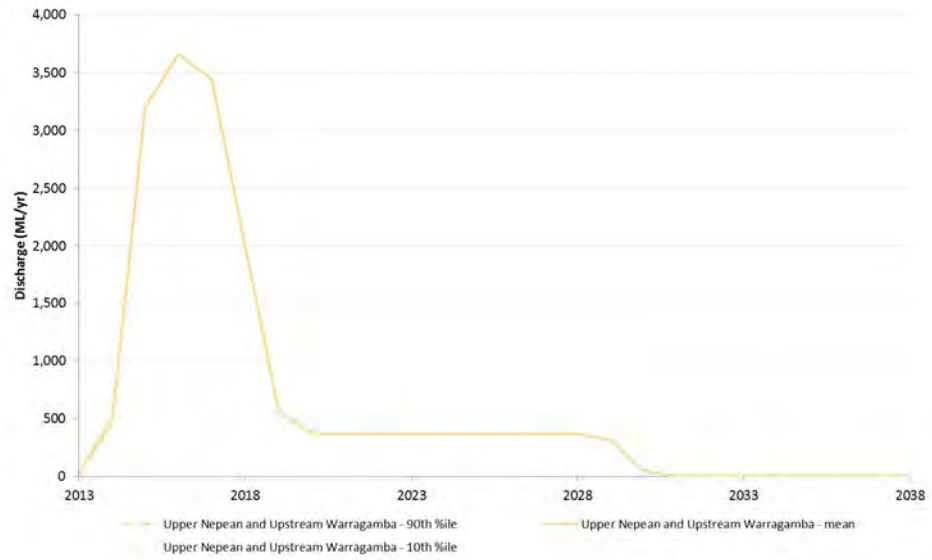


Figure C-40 Pine Dale Coal Mine – Surface Water Discharge by Water Source

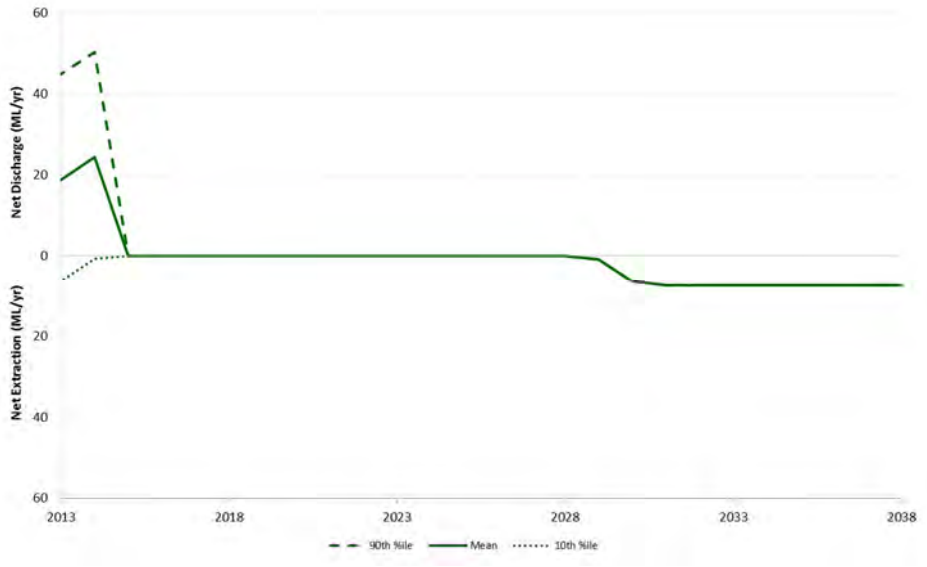


Figure C-41 Pine Dale Coal Mine – Net Extraction/Discharge (All Water Sources)

Wallerawang Power Station

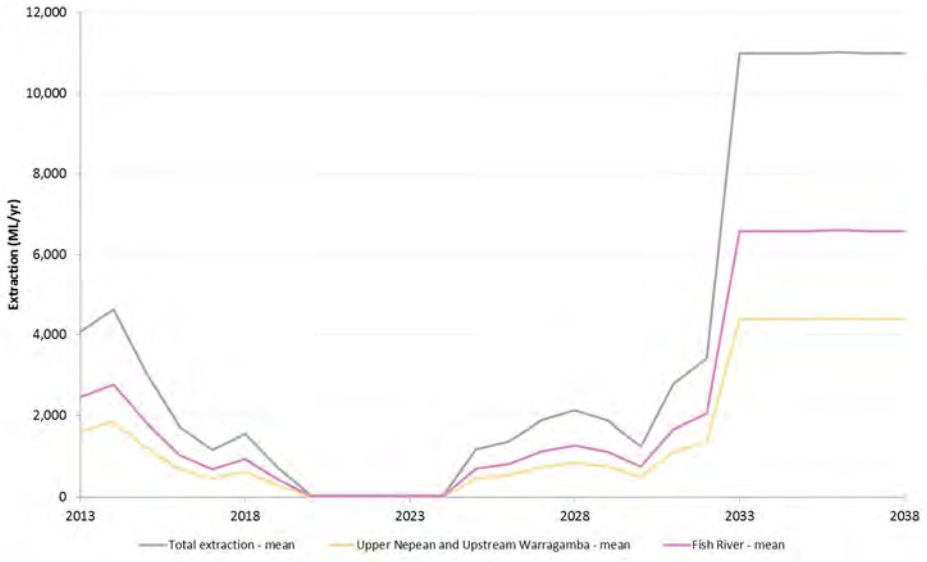


Figure C-42 Wallerawang Power Station – Surface Water Extraction by Water Source

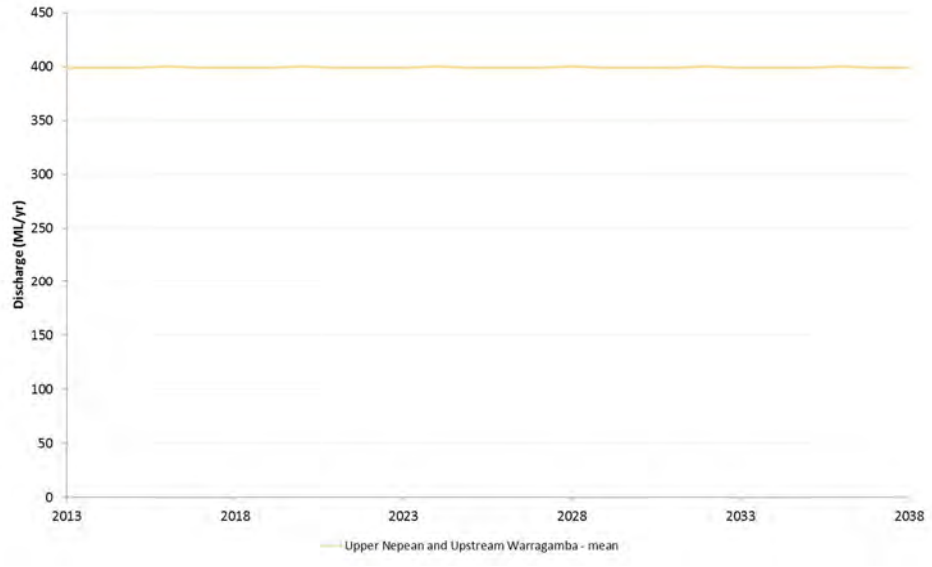


Figure C-43 Wallerawang Power Station – Surface Water Discharge by Water Source

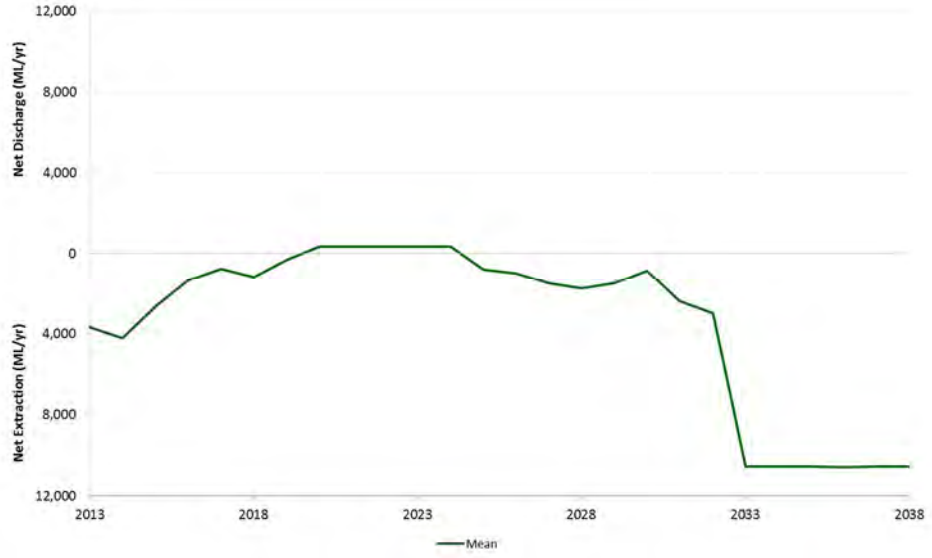


Figure C-44 Wallerawang Power Station – Net Extraction/Discharge (All Water Sources)

Appendix D – Operational Timeline

Operations Timeline

	Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Airly	Status	CM		Active Mining																	Rehab						
	Description			Proposed Mining																							
Angus Place	Status	Active Mining			Active Mining															Rehab						DWTS only
	Description	Current Approved Mining			Proposed Extension Project															Mine water to DWTS continues. Mine water to LDPs ceases. Taper runoff							
Baal Bone	Status	Training Site		Training Site - Surface Rehab starts																							
	Description	Dewatering		Dewatering continues (UG training) and LDP discharge tapers																							
Clarence	Status	Active Mining														Rehab											
	Description	Current approval														LDP discharges taper. Dewatering ceases.											
Coal Pac	Status	CM		Active Mining																							
	Description																										
Ivanhoe No. 2	Status																										
	Description																										
Ivanhoe North	Status	Rehab																									
	Description																										
Lidsdale Siding	Status	Regular Operations	Construction	Regular Operations																							
	Description		Extra dewatering																								
Mount Piper	Status	Regular Operations																									
	Description																										
Neubeck	Status			Active Mining											Rehab												
	Description			Proposed Mining																							
Pinedale	Status	Active Mining	CM	Active Mining															Rehab								
	Description	Last yr of Stage 1		Stage 2 Project																							
Springvale	Status	Active Mining			Active Mining										Rehab							DWTS only					
	Description	Current Approved Operations			Proposed Extension Project										DWTS continues, Mine water to LDPs cease, LDPs taper down												
Wallerawang	Status	Regular Operations																									
	Description																										
Western Coal Services	Status	Approved Operations		Proposed Operations																							
	Description																										

Active Mining | Care & Maintenance | Rehabilitation | Other | No Discharges or Extractions

GHD

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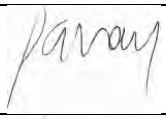
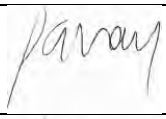
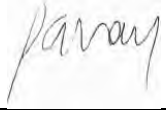
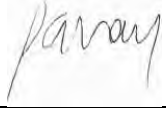
Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	S Callander	S Gray		S Gray		05/08/13
1	S Callander	S Gray		S Gray		08/11/13

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APPENDIX F:
SITE PHOTOGRAPHS

No 3 Ventilation shaft and dewatering bore

No 3 Ventilation shaft and dewatering bore

Operating dewatering bore

Operating dewatering bore

Operating dewatering bore

Operating Dewatering bore

Decommissioned dewatering bore

Narrow Swamp monitoring location

Narrow Swamp

Narrow Swamp

General view of Lidsdale Pasture meadows by the Cox River and Coal conveyor belt in the background

Cox River upstream Springvale Colliery

Wallerawang Power Station

Cox River by Wallerawang Power Station

Angus Place Colliery Coal Stockpile

Angus Place Colliery- Secondary pollution Pond

Angus Place Colliery- Secondary pollution Pond

Angus Place Colliery- Secondary pollution Pond

Filter pond

Drainage from Pollution ponds under car park and administration building

Primary pollution pond and Stockpile

Disturbed area around Stockpile

Coal crusher and storage silo

Drain from crusher to primary pollution ponds

Primary pollution ponds

Drain from crusher and primary pollution ponds

Coal loading area

Coal silo and loading area

Storage and warehouse area

Oil separator

Outlet from oil separator

Drain from Storage and parking area to Settling ponds

Culvert under the access road to Settling ponds

Chemical dosing unit upstream of Settling ponds

Drain to Settling ponds

Drain to Settling ponds

Settling ponds and LDP0002

Drain to Settling ponds and natural catchment around

Natural catchment draining to LDP0002

Settling ponds and LDP0002

Water sump near the underground mine main entrance and coal conveyor belt

Mine water make recirculation pipes

Water sump near the underground mine main entrance

Mine water make recirculation pipes

Fire / Water tanks

Fire / Water tanks

Aerating ponds

Aerating ponds

Wetlands at LDP0001

LDP0001

LDP0001

Water dilution at LDP0001

Water dilution at LDP0001