APPENDIX 3C – SURFACE WATER MONITORING DATA

Summary of 2017 Surface Water Monitoring Results

SW Monitoring Point	EC (µS/cm)			pH			SO4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	279.0	5380.0	2392.3	7.00	8.30	7.58	45.0	1790.0	787.0	4.4	1970.0	600.9
CC2	5470.0	8230.0	6306.0	7.70	8.30	7.99	1700.0	3170.0	2145.0	0.6	15.8	4.1
CC3	4100.0	4990.0	4520.0	8.30	8.50	8.40	1490.0	1920.0	1688.0	0.6	1.8	1.2
WIL (U)*	-	-	-	-	-	-	-	-	-	-	-	-
WIL (U2)	1360.0	3890.0	2851.7	5.40	8.00	6.58	13.0	121.0	20.9	2.4	70.8	20.9
WIL (PC)*	-	-	-	-	-	-	-	-	-	-	-	-
WIL (NC)	230.0	411.0	313.2	6.80	8.30	7.27	10.0	85.0	48.1	0.2	15.2	3.7
WIL (D)	248.0	1480.0	493.5	7.30	7.80	7.55	7.0	87.0	46.4	2.2	5.6	3.8
WIL (D2)	256.0	650.0	386.8	7.30	7.90	7.53	2.0	83.0	47.7	1.7	31.9	10.3
WOL1	336.0	1490.0	872.4	8.10	8.60	8.25	19.0	184.0	97.2	0.9	6.1	2.9
WOL2	1800.0	2950.0	2133.6	7.40	8.00	7.82	184.0	440.0	304.2	0.4	21.1	3.2

Notes:. mg/L = micrograms per litre. mS/cm= microSiemens per centimetre. NTU = nephelometric turbidity units. *Dry

Summary of 2016 Surface Water Monitoring Results

SW Monitoring Point	EC (µS/cm)			pH			SO_4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	170.0	4470.0	2802.9	7.10	7.90	7.41	28.0	1710.0	978.9	4.6	6270.0	936.0
CC2	3020.0	7540.0	5036.3	7.50	8.00	7.84	920.0	2940.0	1738.8	0.5	26.4	5.0
CC3	80.0	4860.0	2771.7	7.40	8.40	8.18	8.0	1920.0	972.5	0.7	126.0	25.1
WIL (U)	520.0	950.0	632.0	6.20	7.40	6.94	13.0	83.0	36.8	5.8	43.5	21.2
WIL (U2)	440.0	4420.0	2140.0	6.50	7.60	7.04	14.0	102.0	34.8	3.3	153.0	34.8
WIL (PC)	260.0	1340.0	682.0	6.90	7.40	7.16	7.0	48.0	28.6	9.7	64.6	38.3
WIL (NC)	240.0	1650.0	560.8	7.10	7.80	7.39	8.0	265.0	64.5	8.6	201.0	54.2
WIL (D)	580.0	3030.0	1189.2	6.80	8.00	7.46	12.0	603.0	165.5	1.2	39.4	10.0
WIL (D2)	390.0	1840.0	796.1	6.90	8.10	7.50	9.0	466.0	159.1	3.9	323.0	43.8
WOL1	780.0	2220.0	1226.3	7.80	8.30	8.11	104.0	475.0	205.8	1.3	11.2	5.0
WOL2	740.0	3160.0	1693.3	7.20	8.00	7.56	97.0	650.0	303.1	0.9	70.7	15.3
SGC_1*	0	0	0	0	0	0	0	0	0	0	0	0

Notes:. mg/L = micrograms per litre. mS/cm= microSiemens per centimetre. NTU = nephelometric turbidity units. *Dry

Summary of 2015 Surface Water Monitoring Results

SW Monitoring Point	EC (µS/cm)			pH			SO_4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	120.0	4380.0	2316.3	6.60	7.80	7.31	13.0	1660.0	237.7	3.3	13000.0	3415.4
CC2	350.0	5970.0	3591.4	7.30	7.90	7.67	1400.0	2290.0	1977.8	0.4	20.8	4.7
CC3	150.0	5130.0	2220.0	7.00	8.40	7.93	17.0	2100.0	946.0	1.2	359.0	93.7
WIL (U)	1650.0	7550.0	4306.7	4.80	6.80	5.93	38.0	146.0	99.0	7.4	263.0	77.0
WIL (U2)	790.0	5580.0	3353.8	5.60	7.40	6.71	22.0	118.0	41.9	1.5	158.0	41.9
WIL (PC)*	1170.0	6100.0	3256.3	6.80	7.90	7.23	3.0	42.0	16.0	1.8	222.0	90.4
WIL (NC)	410.0	3960.0	1987.1	6.60	7.80	7.31	4.0	106.0	43.0	1.2	1440.0	284.5
WIL (D)	340.0	5880.0	2713.0	7.10	8.10	7.67	29.0	607.0	253.2	2.6	363.0	63.1
WIL (D2)	500.0	6520.0	2457.5	7.50	8.20	7.73	16.0	693.0	148.4	7.5	557.0	113.2
WOL1	160.0	5540.0	2223.0	7.50	8.20	7.96	208.0	956.0	445.8	1.1	61.8	13.3
WOL2	400.0	5550.0	1830.0	7.30	7.80	7.54	262.0	822.0	532.8	0.6	486.0	53.9

Notes:. mg/L = micrograms per litre. mS/cm= micro Siemens per centimetre. NTU = nephelometric turbidity units.

Summary of 2014 Surface Water Monitoring Results

SW Monitoring Point	EC (µS/cm)			pH			SO_4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	610.0	5430.0	2055.7	7.10	9.20	8.00	120.0	1880.0	785.0	2.3	352.0	91.3
CC2	160.0	6590.0	4944.0	6.90	7.80	7.44	85.0	2520.0	1733.5	0.2	151.0	16.4
CC3	400.0	5260.0	3522.5	7.60	8.00	7.80	23.0	2100.0	1380.8	1.1	346.0	96.0
WIL (U)	980.0	1540.0	1260.0	6.00	7.10	6.55	70.0	174.0	122.0	3.2	30.0	16.6
WIL (U2)	1340.0	5970.0	2886.0	6.30	7.40	6.78	10.0	110.0	50.1	4.5	290.0	50.1
WIL (PC)	-	-	-	-	-	-	-	-	-	-	-	-
WIL (NC)	310.0	790.0	445.0	7.00	7.40	7.25	6.0	96.0	27.0	1.8	2410.0	664.4
WIL (D)	1520.0	6010.0	3728.3	6.90	8.40	7.68	205.0	1680.0	634.8	1.0	26.8	6.6
WIL (D2)	780.0	7550.0	3756.0	7.00	8.70	8.02	120.0	1670.0	932.4	0.8	42.7	11.7
WOL1	1870.0	3680.0	2582.5	7.00	8.90	8.13	434.0	1120.0	635.6	1.2	18.6	3.8
WOL2	1670.0	4060.0	2779.2	7.20	7.80	7.46	452.0	842.0	589.9	0.6	69.7	16.1

Notes:. mg/L = micrograms per litre. mS/cm= microSiemens per centimetre. NTU = nephelometric turbidity units. * Indicates no sample available during the schedule monitoring programme.

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Summary of 2013 Surface Water Monitoring Results

SW Monitoring Point	EC (µS/cm)			pH			SO_4 (mg/L)			Turbidity (NTU)		
	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
CC1	3150.0	5710.0	4568.5	6.9	8.2	7.9	828.0	3160.0	1647.0	0.4	1770	169.6
CC2	4380.0	6070.0	5040.0	7.4	8.1	7.7	1610.0	3110.0	2040.0	0.2	2.6	0.9
CC3	225.0	4890.0	3130.6	7.8	8.2	8.0	94.0	2270.0	1454.1	0.8	360.0	59.4
WIL (U)	448.0	1390.0	1065.0	6.5	7.0	6.8	7.0	63.0	38.1	1.5	74.5	26.5
WIL (U2)	413.0	4620.0	2165.5	6.3	7.6	6.7	4.0	89.0	47.4	6.1	473.0	62.8
WIL (PC)	395.0	1730.0	1158.0	6.7	7.1	6.9	31.0	186.0	93.8	5.2	148.0	47.6
WIL (NC)	340.0	930.0	510.0	7.4	7.9	7.7	5.0	140.0	59.6	2.2	4000	941.5
WIL (D)	1656.0	4200.0	2942.6	7.8	8.8	8.1	216.0	822.0	475.2	1.4	59.1	9.3
WIL (D2)	1500.0	4950.0	3051.6	7.8	8.1	7.9	217.0	1360.0	646.7	1.2	21.8	7.0
WOL1	1180.0	2710.0	1982.3	8.1	8.7	8.4	326.0	675.0	464.8	0.6	8.9	3.0
WOL2	1460.0	3150.0	2153.9	7.3	8.3	7.9	286.0	793.0	487.7	0.6	14.9	6.0

2017 Results for Surface Water Monitoring

Sample No.	Sample Location	Sampling Date	Electrical Conductivity (Field Reading) µS/cm	pH - Field pH Unit	Sulphate mg/L	Turbidity NTU
ME1700094001	CC_1	19-Jan-2017				
ME1700094002	CC_2	19-Jan-2017				
ME1700094003	CC_3	19-Jan-2017				
ME1700094004	WIL_U	19-Jan-2017				
ME1700094005	WIL_U2	19-Jan-2017	3460	6.4	63	70.8
ME1700094006	WIL_NC	19-Jan-2017	290	7.5	12	8.4
ME1700094007	WIL_PC	19-Jan-2017				
ME1700094008	WIL_D	19-Jan-2017	1480	7.7	21	4.7
ME1700094009	WIL_D2	19-Jan-2017	520	7.8	11	10.9
ME1700094010	WOL_1	19-Jan-2017	1490	8.4	116	0.9
ME1700094011	WOL_2	19-Jan-2017	2260	7.8	184	2.7
ME1700094012	SGC_1	19-Jan-2017				
ME1700094013	30M_U_CC1	19-Jan-2017				
ME1700223001	CC_1	15-Feb-2017				
ME1700223002	CC_2	15-Feb-2017				
ME1700223003	CC_3	15-Feb-2017				
ME1700223004	WIL_U	15-Feb-2017				
ME1700223005	WIL_U2	15-Feb-2017	3890	5.4	107	37

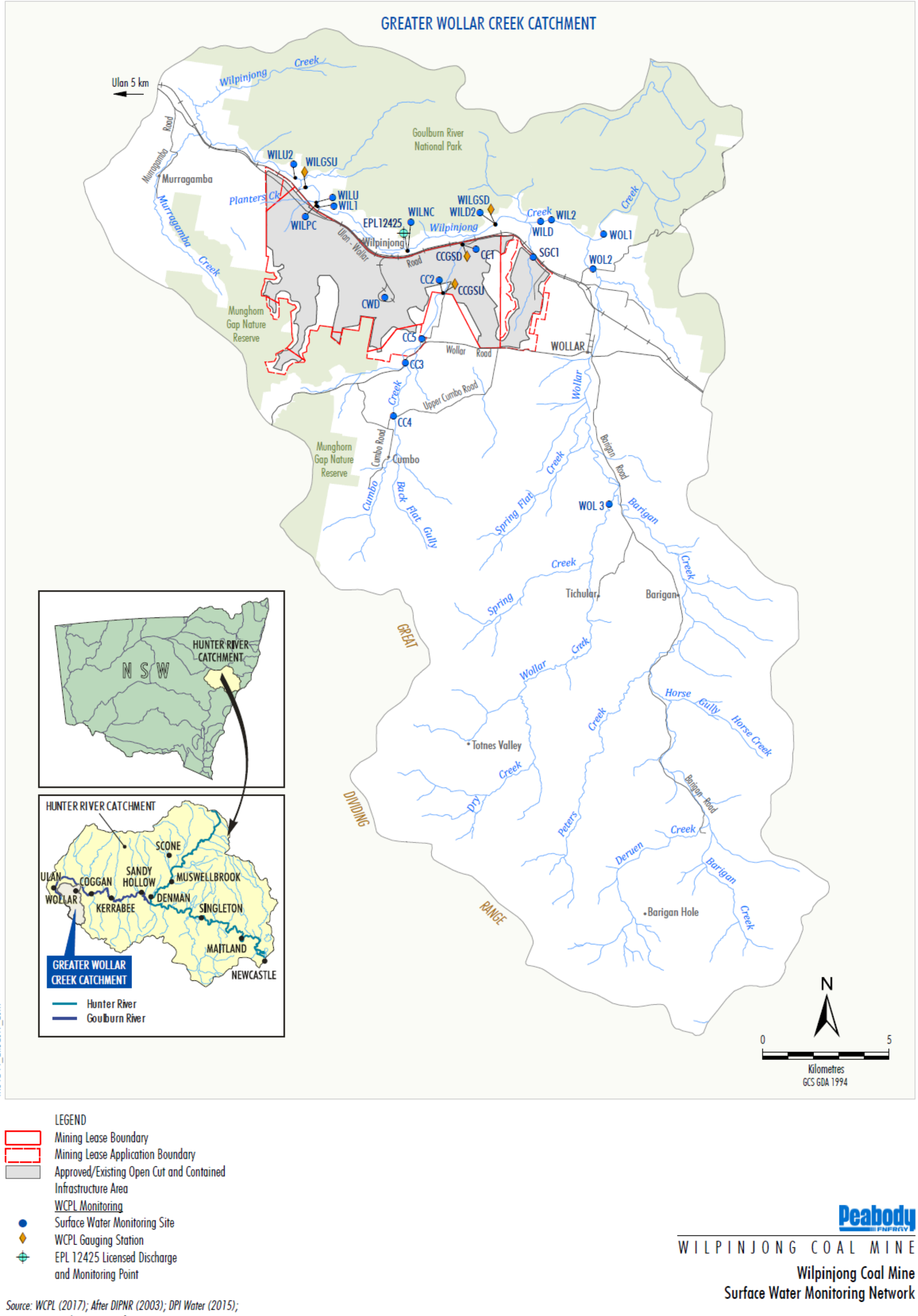
ME1700223006	WIL_NC	15-Feb-2017	300	7.1	12	4.9
ME1700223007	WIL_PC	15-Feb-2017				
ME1700223008	WIL_D	15-Feb-2017				
ME1700223009	WIL_D2	15-Feb-2017	650	7.4	<10	31.9
ME1700223010	WOL_1	15-Feb-2017	1240	8.4	19	1.1
ME1700223011	WOL_2	15-Feb-2017				
ME1700223012	SGC_1	15-Feb-2017				
ME1700223013	30M_U_CC1	15-Feb-2017				
ME1700399001	CC_1	21-Mar-2017	450	7.3	53	398
ME1700399002	CC_2	21-Mar-2017	6990	7.8	2150	10.4
ME1700399003	CC_3	21-Mar-2017				
ME1700399004	WIL_U	21-Mar-2017				
ME1700399005	WIL_U2	21-Mar-2017	3880	6.5	57	32.4
ME1700399006	WIL_NC	21-Mar-2017	370	7.4	82	1.2
ME1700399007	WIL_PC	21-Mar-2017				
ME1700399008	WIL_D	21-Mar-2017	900	7.6	7	4.8
ME1700399009	WIL_D2	21-Mar-2017	520	7.6	2	13.3
ME1700399010	WOL_1	21-Mar-2017	960	8.6	31	2.1
ME1700399011	WOL_2	21-Mar-2017	2950	8	216	21.1
ME1700399012	SGC_1	21-Mar-2017				
ME1700399013	30M_U_CC1	21-Mar-2017				
ME1700578001	CC_1	21-Apr-2017				
ME1700578002	CC_2	21-Apr-2017	5470	7.9	1920	2.4
ME1700578003	CC_3	21-Apr-2017	4100	8.5	1500	1.8
ME1700578004	WIL_U	21-Apr-2017				
ME1700578005	WIL_U2	21-Apr-2017	3090	7	87	4.4
ME1700578006	WIL_NC	21-Apr-2017	230	7.6	10	2.6
ME1700578007	WIL_PC	21-Apr-2017				
ME1700578008	WIL_D	21-Apr-2017	500	7.5	63	2.2
ME1700578009	WIL_D2	21-Apr-2017	450	7.4	77	5.4
ME1700578010	WOL_1	21-Apr-2017	1290	8.2	184	2.2
ME1700578011	WOL_2	21-Apr-2017	1850	7.7	304	1.2
ME1700578012	SGC_1	21-Apr-2017				
ME1700578013	30M_U_CC1	21-Apr-2017				
ME1700692001	CC_1	17-May-2017				
ME1700692002	CC_2	17-May-2017	5940	7.9	1720	1
ME1700692003	CC_3	17-May-2017	4990	8.3	1750	1
ME1700692004	WIL_U	17-May-2017				
ME1700692005	WIL_U2	17-May-2017	3080	7.2	89	8.5
ME1700692006	WIL_NC	17-May-2017	330	7.2	51	4.7
ME1700692007	WIL_PC	17-May-2017				
ME1700692008	WIL_D	17-May-2017	330	7.5	47	4.7
ME1700692009	WIL_D2	17-May-2017	310	7.4	48	2.8
ME1700692010	WOL_1	17-May-2017	920	8.2	139	2.9

ME1700692011	WOL_2	17-May-2017	2060	7.8	292	1.1
ME1700692012	SGC_1	17-May-2017				
ME1700692013	30M_U_CC1	17-May-2017				
ME1700825001	CC_1	15-Jun-2017	3460	7.7	1260	31.3
ME1700825002	CC_2	15-Jun-2017	5830	7.9	2190	0.6
ME1700825003	CC_3	15-Jun-2017	4640	8.4	1920	0.6
ME1700825004	WIL_U	15-Jun-2017				
ME1700825005	WIL_U2	15-Jun-2017	1570	7.2	121	3.2
ME1700825006	WIL_NC	15-Jun-2017	410	7.1	80	2.6
ME1700825007	WIL_PC	15-Jun-2017				
ME1700825008	WIL_D	15-Jun-2017	390	7.5	73	2.2
ME1700825009	WIL_D2	15-Jun-2017	390	7.4	81	1.7
ME1700825010	WOL_1	15-Jun-2017	940	8.2	175	1.3
ME1700825011	WOL_2	15-Jun-2017	1820	7.9	346	0.8
ME1700825012	SGC_1	15-Jun-2017				
ME1700825013	30M_U_CC1	15-Jun-2017				
ME1700998001	CC_1	20-Jul-2017				
ME1700998002	CC_2	20-Jul-2017	5900	8	2010	1
ME1700998003	CC_3	20-Jul-2017	4560	8.4	1780	1.8
ME1700998004	WIL_U	20-Jul-2017				
ME1700998005	WIL_U2	20-Jul-2017	1490	6.3	90	5.5
ME1700998006	WIL_NC	20-Jul-2017	285	7.2	58	15.2
ME1700998007	WIL_PC	20-Jul-2017				
ME1700998008	WIL_D	20-Jul-2017	283	7.6	50	3.3
ME1700998009	WIL_D2	20-Jul-2017	266	7.6	50	2.4
ME1700998010	WOL_1	20-Jul-2017	688	8.2	99	1.9
ME1700998011	WOL_2	20-Jul-2017	1830	8	330	0.5
ME1700998012	SGC_1	20-Jul-2017				
ME1700998013	30M_U_CC1	20-Jul-2017				
ME1701133001	CC_1	17-Aug-2017	5380	8.3	1790	4.4
ME1701133002	CC_2	17-Aug-2017	5600	8	1750	1.3
ME1701133003	CC_3	17-Aug-2017	4310	8.4	1490	0.8
ME1701133004	WIL_U	17-Aug-2017				
ME1701133005	WIL_U2	17-Aug-2017	1360	6.8	86	2.4
ME1701133006	WIL_NC	17-Aug-2017	290	6.8	35	0.5
ME1701133007	WIL_PC	17-Aug-2017				
ME1701133008	WIL_D	17-Aug-2017	286	7.8	35	3.9
ME1701133009	WIL_D2	17-Aug-2017	256	7.9	33	2.9
ME1701133010	WOL_1	17-Aug-2017	611	8.1	88	3.2
ME1701133011	WOL_2	17-Aug-2017	1800	8	313	0.4
ME1701133012	SGC_1	17-Aug-2017				
ME1701133013	30M_U_CC1	17-Aug-2017				
ME1701281001	CC_1	19-Sep-2017				
ME1701281002	CC_2	19-Sep-2017	5850	8.2	1950	1.9

ME1701281003	CC_3	19-Sep-2017				
ME1701281004	WIL_U	19-Sep-2017				
ME1701281005	WIL_U2	19-Sep-2017	2380	6.3	102	7.4
ME1701281006	WIL_NC	19-Sep-2017	233	6.8	42	0.9
ME1701281007	WIL_PC	19-Sep-2017				
ME1701281008	WIL_D	19-Sep-2017	248	7.3	41	3.1
ME1701281009	WIL_D2	19-Sep-2017	267	7.4	47	7.7
ME1701281010	WOL_1	19-Sep-2017	508	8.1	83	5.4
ME1701281011	WOL_2	19-Sep-2017	2060	8	334	0.7
ME1701281012	SGC_1	19-Sep-2017				
ME1701281013	30M_U_CC1	19-Sep-2017				
ME1701406001	CC_1	13-Oct-2017				
ME1701406002	CC_2	13-Oct-2017	6370	8.2	1700	1.2
ME1701406003	CC_3	13-Oct-2017				
ME1701406004	WIL_U	13-Oct-2017				
ME1701406005	WIL_U2	13-Oct-2017	3070	6.3	98	31.2
ME1701406006	WIL_NC	13-Oct-2017	300	6.9	48	0.2
ME1701406007	WIL_PC	13-Oct-2017				
ME1701406008	WIL_D	13-Oct-2017	309	7.5	44	3.7
ME1701406009	WIL_D2	13-Oct-2017	291	7.3	43	12.4
ME1701406010	WOL_1	13-Oct-2017	613	8.2	85	4.9
ME1701406011	WOL_2	13-Oct-2017	2350	7.9	319	1.3
ME1701406012	SGC_1	13-Oct-2017				
ME1701406013	30M_U_CC1	13-Oct-2017				
ME1701559001	CC_1	14-Nov-2017				
ME1701559002	CC_2	14-Nov-2017	8230	7.7	3170	15.8
ME1701559003	CC_3	14-Nov-2017				
ME1701559004	WIL_U	14-Nov-2017				
ME1701559005	WIL_U2	14-Nov-2017	3720	5.5	89	40.6
ME1701559006	WIL_NC	14-Nov-2017	309	7.3	62	2.7
ME1701559007	WIL_PC	14-Nov-2017				
ME1701559008	WIL_D	14-Nov-2017	297	7.3	42	5.6
ME1701559009	WIL_D2	14-Nov-2017	308	7.4	50	26.9
ME1701559010	WOL_1	14-Nov-2017	336	8.2	50	6.1
ME1701559011	WOL_2	14-Nov-2017	2580	7.4	440	4.3
ME1701559012	SGC_1	14-Nov-2017				
ME1701559013	30M_U_CC1	14-Nov-2017				
ME1701721001	CC_1	13-Dec-2017	279	7	45	1970
ME1701721002	CC_2	13-Dec-2017	6880	8.3	2890	5.2
ME1701721003	CC_3	13-Dec-2017				
ME1701721004	WIL_U	13-Dec-2017				
ME1701721005	WIL_U2	13-Dec-2017	3230	8	13	7.1
ME1701721006	WIL_NC	13-Dec-2017	411	8.3	85	0.4
ME1701721007	WIL_PC	13-Dec-2017				

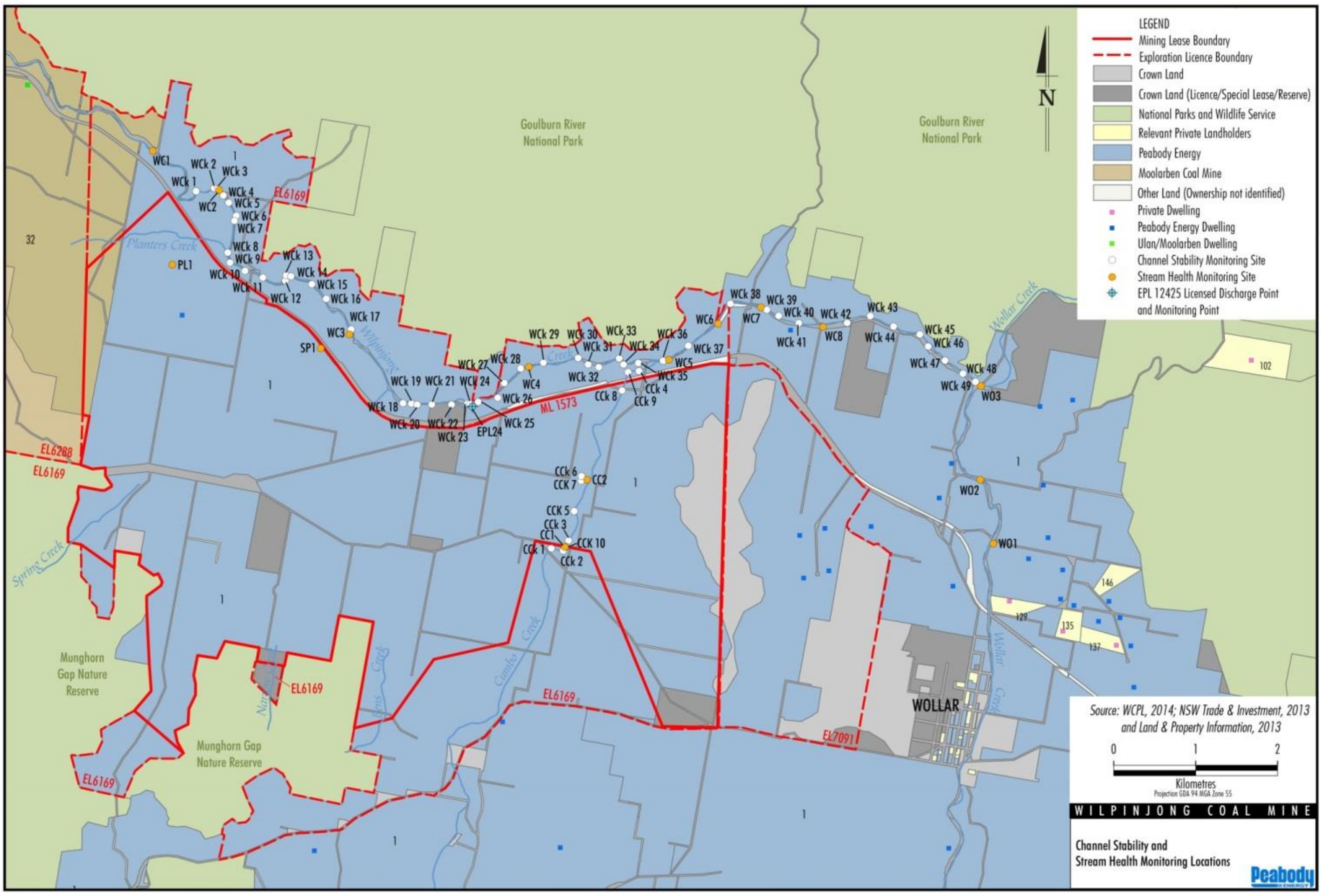
ME1701721008	WIL_D	13-Dec-2017	406	7.7	87	3.4
ME1701721009	WIL_D2	13-Dec-2017	413	7.8	83	5.3
ME1701721010	WOL_1	13-Dec-2017	418	8.2	76	5.2
ME1701721011	WOL_2	13-Dec-2017	1910	7.5	268	1.4
ME1701721012	SGC_1	13-Dec-2017				
ME1701721013	30M_U_CC1	13-Dec-2017				

Surface Water Monitoring Locations

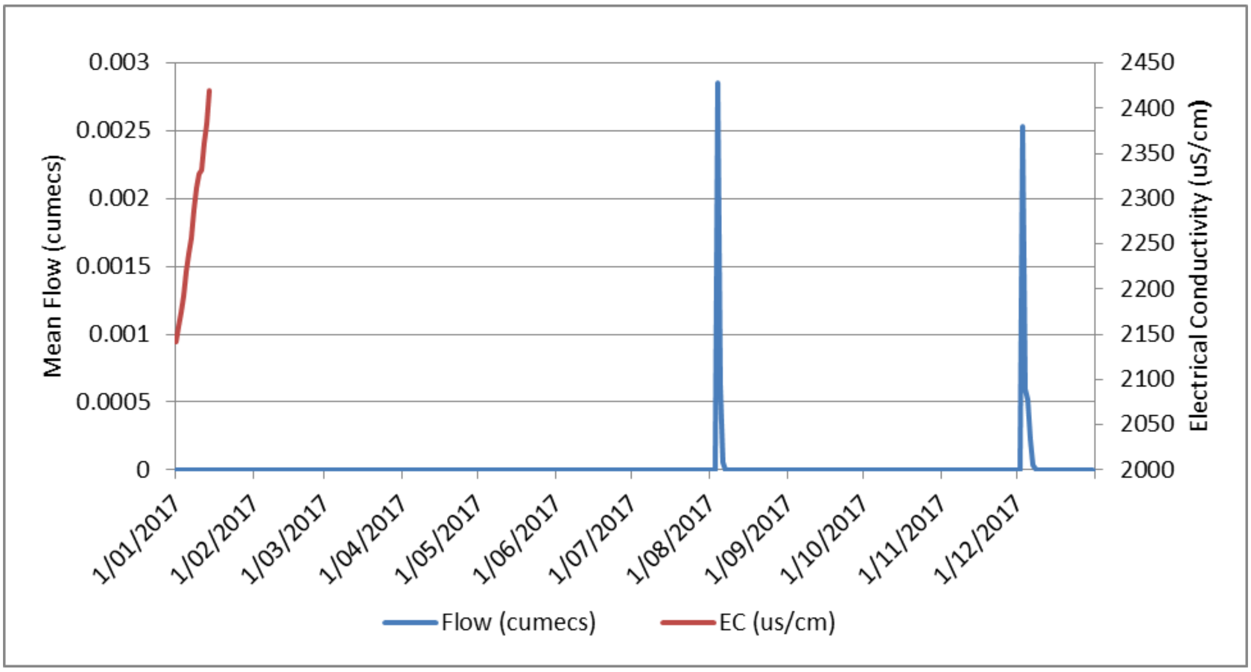


Source: WCPL (2017); After DIPNR (2003); DPI Water (2015); NSW Land & Property Information (2013)

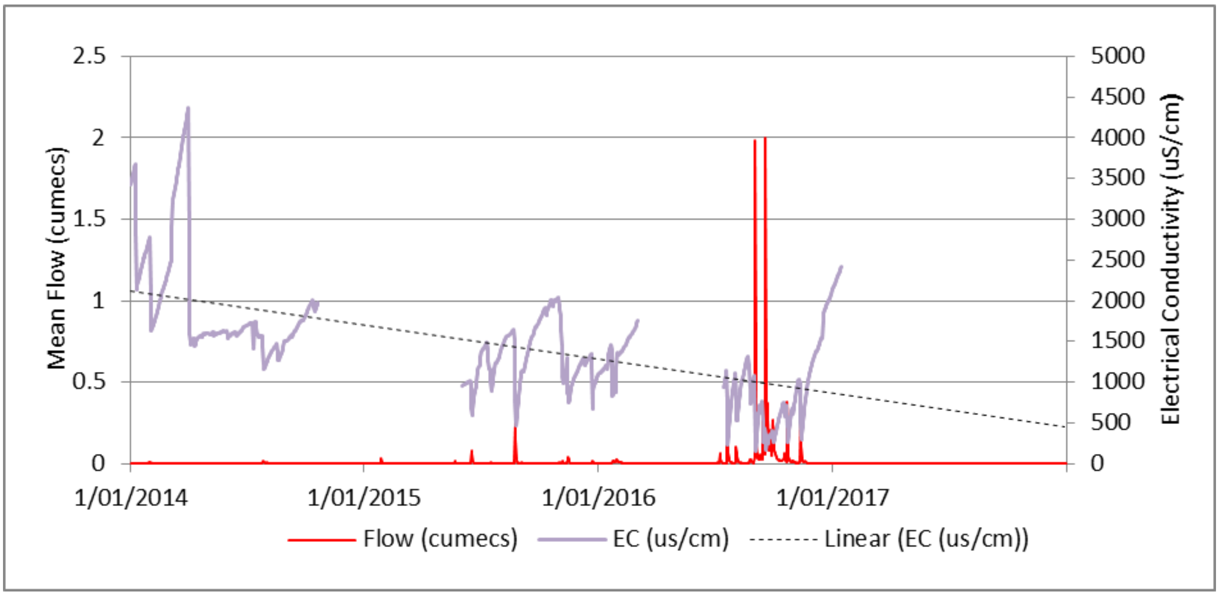
Channel Stability & Stream Health Monitoring Locations



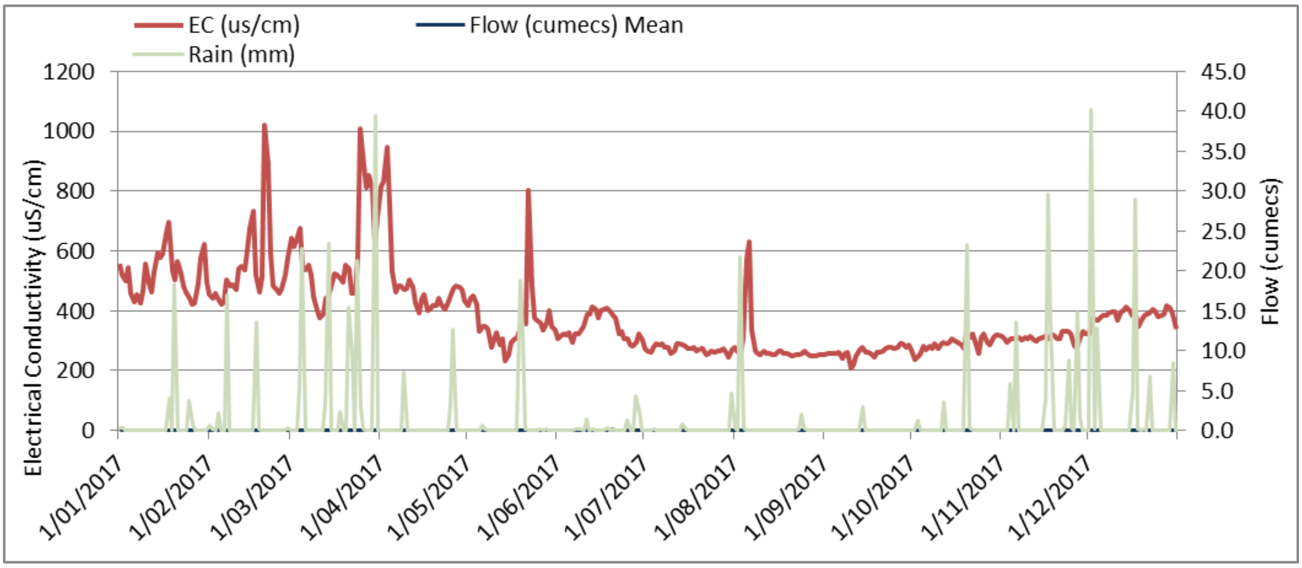
2017 Wilpinjong Creek Upstream Gauging Station



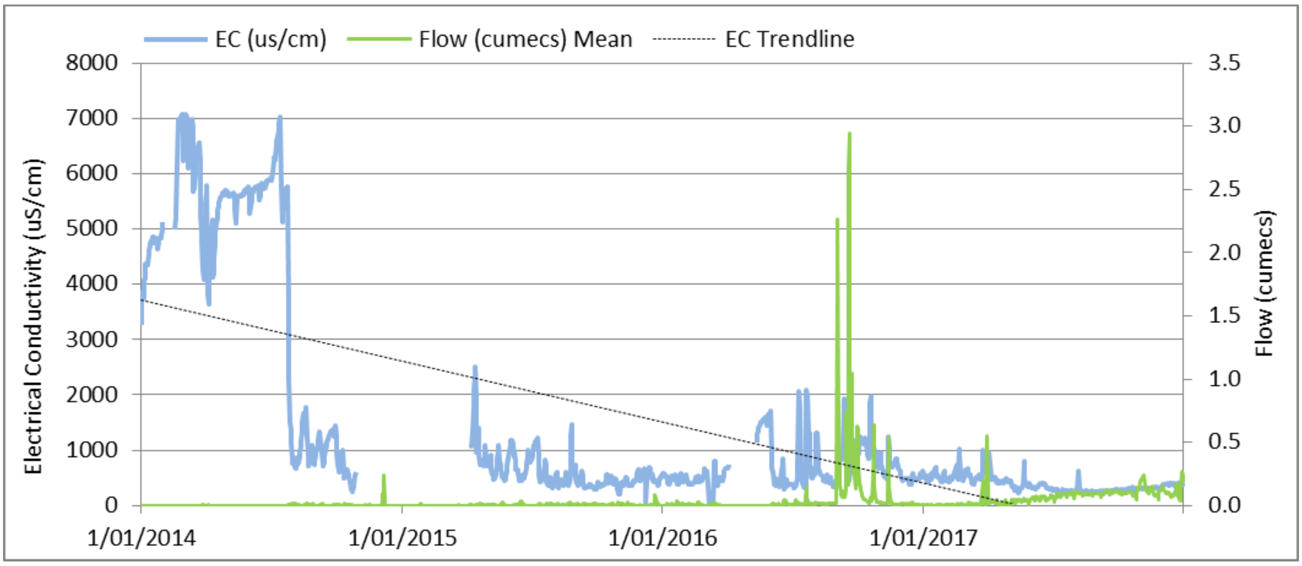
2014-2017 Wilpinjong Creek Upstream Gauging Station



2017 Wilpinjong Creek Downstream Gauging Station

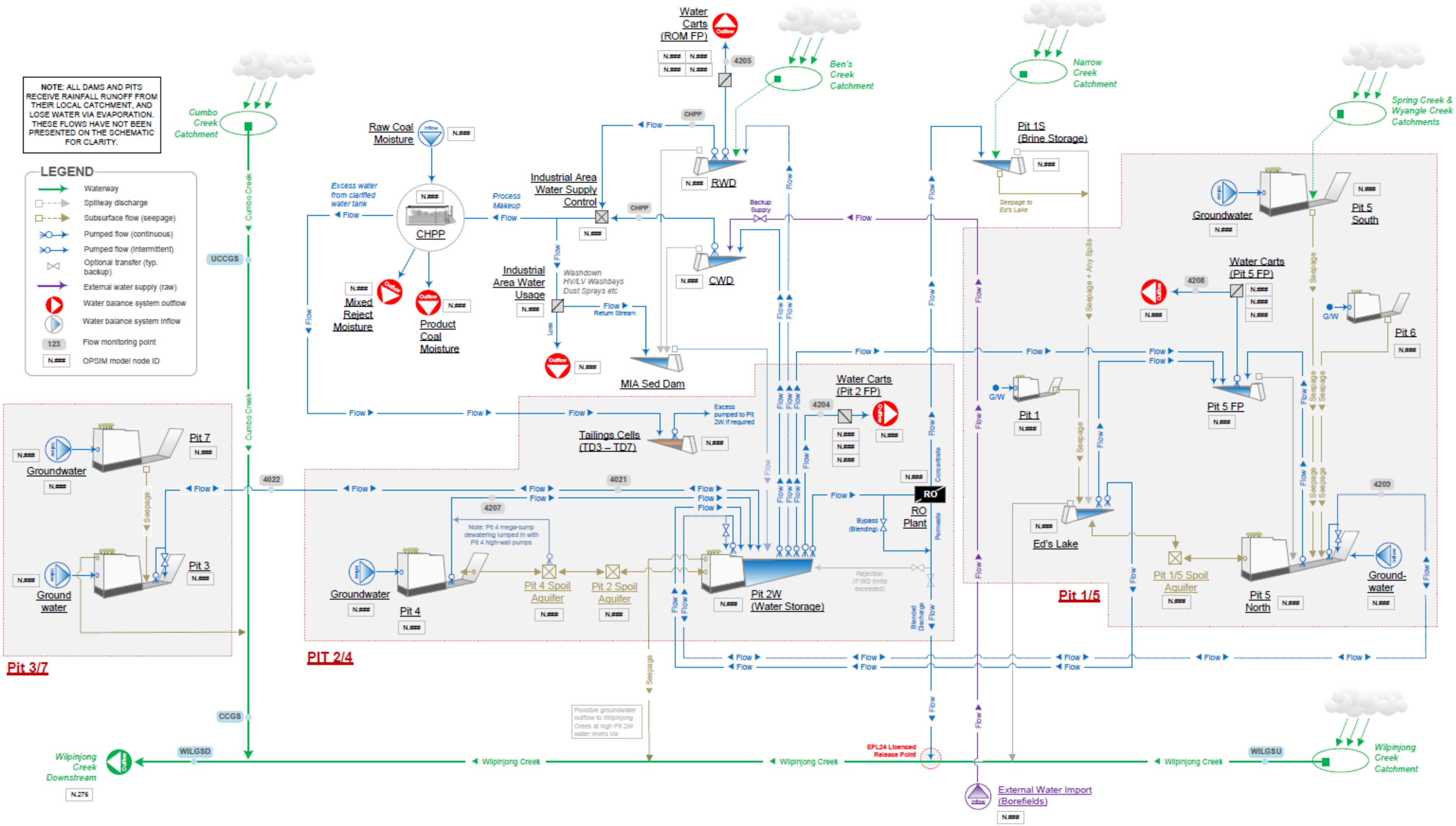


2014-2016 Wilpinjong Creek Downstream Gauging Station



OPSIM Schematic: Major Components of the WCPL Water Management System

Wilpinjong Coal Pty Ltd - 2016 Water Balance Model Update
Baseline OPSIM Model Setup - 31 Mar 2017



Water Management
Perfromance Measures

A summary of the water management performance measures was undertaken by WCPL as they related to the Development Consent SSD-6764 (i.e. 19 September to 31 December 2017)

Assessment of Water Management Performance Measures

Feature	Performance Measure	Complied with Performance Measure (Yes/No)	Comments/Actions
General	Maintain separation between clean, dirty and mine water management systems. Minimise the use of clean water on site. Design, install, operation and maintain water management systems in a proper and efficient manager.	Yes	Refer to Site Water Balance (Section 7.7) Refer to Estimate Groundwater Take (Section 7.2) Refer to Surface Water Results (Section 7.6)
Clean water diversion and storage infrastructure	Maximise as far as reasonable and feasible the diversion of clean water around disturbed areas on site.	Yes	Refer to Erosion and Sediment Control (Section 7.5)
Sediment dams	Design, install and/or maintain sediment dams to ensure no discharges to surface waters, except in accordance with an EPL or in accordance with Section 120 of the POEO Act.	Yes	Refer to Erosion and Sediment Control (Section 7.5) Refer to Water Treatment Facility (Section 7.8)
Mine water storages	Design, install and/or maintain mine water storage infrastructure to ensure no discharge of untreated mine water off-site. Discharge treated mine water in accordance with an EPL or in accordance with Section 120 of the POEO Act.	Yes	Refer to Site Water Balance (Section 7.7) Refer to Surface Water Results (Section 7.6) Refer to Water Treatment Facility (Section 7.8)
Wilpinjong, Cumbo and Wollar Creeks	No greater impact than predicted for the development for water flow and quality.	Yes	Refer to Surface Water Results (Section 7.6) Refer to Stream Health (Section 7.9)

Feature	Performance Measure	Complied with Performance Measure (Yes/No)	Comments/Actions
Aquatic, riparian and groundwater dependent ecosystems	Negligible environmental consequences beyond those predicted for the development.	Yes	Refer to Surface Water Results (Section 7.6) Refer to Stream Health (Section 7.9)
Flood mitigation measures*	Ensure all open cut pits, CHPP, coal stockpiles and main mine facilities areas exclude flows for all flood events up to and including the 1 in 100 year ARI. All final voids designed to exclude all flood events up to include the PMF event.	Yes	The Wilpinjong Coal Mine open cuts are located outside the extent of flooding from Wilpinjong Creek in the 1 in 1,000 AEP design flood. Flood mitigation works for open cut infrastructure in the vicinity of Cumbo Creek are already being implemented at the Wilpinjong Coal Mine and have been designed to a 1 in 100 AEP flood protection (WRM Water and Environment, 2015).
Overburden, CHPP Reject and Tailings	Design, install and maintain emplacements to prevent or minimise the migration of pollutants due to seepage.	Yes	Waste rock emplacements and coal reject management in accordance with the MOP
Chemical and hydrocarbon storage	Chemical and hydrocarbon products to be stored in bunded areas or structures in accordance with relevant Australian Standards.	Yes	Chemical and hydrocarbon products stored in bunded areas in accordance with relevant Australian Standards

Notes:* Consistent with Condition 29, Schedule 3 of Development Consent (SSD-6764), WCPL have maintained all open cut pits, CHPP, coal stockpiles and main mine facilities areas so that they exclude flows for all flood events up to and including the 1 in 100 year ARI. The final voids would be designed to exclude all flood events up to the probable maximum flood.

Creek Stability Monitoring Reports

Wilpinjong Coal Mine

2017 Channel Stability Monitoring Report

Prepared for
Wilpinjong Coal Pty Ltd

21 March 2018

DOCUMENT TRACKING

Item	Detail
Project Name	WCPL Channel Stability Monitoring
Project Number	17MUD-6723
Project Manager	Kalya Abbey Mudgee Office 02 4302 1238 / 0410 503 959 / kalyaa@ecoaus.com.au
Prepared by	Justin Russell, Cassandra Holt
Reviewed by	Mark Southwell, Kalya Abbey
Approved by	Daniel Magdi
Status	Final
Version Number	1
Last saved on	8 April 2018
Cover photo	Clockwise from top: Site WCk9, WCk18, cattle at WCk49 (credit: T. Kelly)

This report should be cited as 'Eco Logical Australia 2018. *Wilpinjong Coal Mine – 2017 Channel Stability Monitoring Report*. Prepared for Wilpinjong Coal Pty Ltd.'

ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Wilpinjong Coal Pty Ltd.

Contents

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Abbreviations

Abbreviation	Description
BEHI	Bank Erosion Hazard Index
ELA	Eco Logical Australia
NP	National Park
SWMMP	Surface Water Management and Monitoring Plan
WCPL	Wilpinjong Coal Pty Ltd

Summary of key findings

Channel stability monitoring was undertaken during spring 2017 to provide a qualitative assessment of natural regeneration of creek banks within the Wilpinjong Mine and surrounds. Fifty-nine permanent survey sites were monitored along Wilpinjong and Cumbo Creeks. Indicators include improved creek bank stability, reduction in erosional areas and improved riparian zones within the Wilpinjong Creek catchment. Condition of the creeks at monitoring sites ranged from moderately unstable to highly stable. Cumbo Creek has less cases of significant erosion that Wilpinjong Creek, however the riparian habitat at sites on Cumbo Creek is poor.

Comparison of 2017 monitoring data to 2016 data found that stability rating has either improved or stayed the same at most sites between 2016 and 2017, but vegetation cover has decreased. Reduced vegetation cover may be attributed to low rainfall in 2017, however degraded vegetation may continue to improve bank stability through the retention of root systems. Variation in stability ratings may have also been influenced by different observers between years.

Review of photographic records from channel stability surveys undertaken since 2011 indicates that Wilpinjong Creek remains a highly degraded creek as a result of past (pre-mining) land management practices, however there are areas of natural regeneration occurring that are related to stock access restriction from the riparian corridors. Cumbo Creek continues to lack structure and riparian features however it remains relatively stable. There is no visible evidence that mining within the vicinity of the creeks or discharge of water from the mine has resulted in creek bed lowering or increased erosion.

Mining activities do not appear to be accelerating natural erosional processes at Wilpinjong or Cumbo Creeks. Despite this, rehabilitation should to be undertaken to prevent creek lowering or further increases in erosion. Where possible this should be achieved through soft landscaping techniques (tree and shrub planting) and non-intrusive mitigation (loose rock check dams or pegged hay bales/coir logs) rather than reshaping of the creek profile.

1 Introduction

Eco Logical Australia (ELA) was engaged by Wilpinjong Coal Pty Ltd (WCPL) to undertake annual monitoring of channel stability along Wilpinjong and Cumbo Creeks. Channel stability monitoring is required to satisfy Schedule 3, Condition 32 (e) of WCPL's Project Approval (05-0021), and the channel stability monitoring criteria detailed in Section 4 of the Wilpinjong Surface Water Management and Monitoring Plan (SWMMP).

This report details the findings from the 2017 monitoring program and provides a comparison of the regeneration progress of both Wilpinjong and Cumbo Creeks against previous monitoring conducted since 2010.

1.1 Background

A baseline channel stability assessment of Wilpinjong and Cumbo Creeks was undertaken in 2005 as part of the Environmental Impact Statement for the Wilpinjong Coal Project (WCPL, 2005) to characterise the existing condition of the Wilpinjong and Cumbo creek stream channels prior to mining. The Wilpinjong Creek survey included 49 sites and extended 12.5 km from the upstream gauging station to the confluence with Wollar Creek to the east. The Cumbo Creek survey included 10 sites and extended 3 km from the southern boundary of Mining Lease 1573 north to the confluence with Wilpinjong Creek.

A series of permanent monitoring points were established to allow for subsequent long-term channel stability monitoring. Parameters of each monitoring point include:

- Transect sites
- Photo sites
- Waterholes
- Start and end points of creek reaches
- Confluences
- Any other features of interest.

The baseline surveys concluded both Wilpinjong and Cumbo Creeks have been affected by pre-mining land management practices dominated by sheep and cattle grazing. These land management practices involved the clearing of riparian vegetation on both creeks to maximize grazing areas and stock access to drinking water. The clearing of this vegetation is assumed to have contributed significantly to bank instability. Disturbance from burrowing animals, both native and pest, is also likely to have contributed to instability.

Subsequent annual surveys have been undertaken to assess the ongoing stability of the Wilpinjong and Cumbo Creeks during mining. Barnson (2016) developed a proforma to assist in the assessment of creek stability at each survey location and to enable comparisons to be made between annual survey periods.

1.2 Objectives

The channel stability monitoring program aims to provide qualitative measures of stream bed and bank erosion and channel instability along Wilpinjong and Cumbo Creeks. The 2017 assessment was undertaken as a qualitative assessment to review natural regeneration of the creeks. This includes improved creek bank stability, reduction in erosional areas and improved riparian zones within the Wilpinjong Creek catchment.

The key objectives of the 2017 channel stability monitoring program are to:

- Measure and evaluate erosional or depositional features of the creek banks
- Record the details of permanent monitoring sites with written descriptions and photographs
- Assess the stability of Wilpinjong and Cumbo Creeks using a rapid assessment methodology
- Compare visual channel stability at each of the permanent monitoring sites against previous monitoring records.

2 Methodology

2.1 Field survey - stability & comparative assessment

The field survey was conducted by ELA Senior River Scientist and geomorphologist Mark Southwell and ecologist Tomas Kelly between 21 and 24 November 2017.

A total of 59 (49 on Wilpinjong Creek and 10 on Cumbo Creek) permanent survey locations were surveyed (Figure 2-1). Surveys involved walking along the designated reach of each creek and completing the Bank Erosion Hazard Index (BEHI) assessment datasheet. BEHI assessment involves scoring a site on eight quantitative categories outlined below and in **Appendix A**.

The eight indicators of channel stability that were used to evaluate erosion at each site include:

- Bank Height (m)
- Bank Angle (°)
- Percentage of Bank Height with a Bank Angle Greater than 80°
- Evidence of Mass Wasting (% of Bank)
- Unconsolidated Material (% of Bank)
- Streambank Protection (% of Streambank covered by plant roots, vegetation, logs, branches, rocks etc
- Established Beneficial Riparian Woody - Vegetation Cover
- Stream Curvature Descriptor.

The channel stability indicators produce an Activity Rating that classifies each location from ‘Very Unstable’, indicating the drainage line is very actively eroding, to ‘Very Stable’, indicating the drainage line is very stable and likely to be in original form. This enables any deterioration to be detected over time.

Field notes and photographs were taken to allow qualitative assessment through comparisons between monitoring periods. This process included written site descriptions using the previous monitoring report (Barnson 2017) to make comparisons *in situ*, as well as taking upstream, downstream and across stream photographs at each of the permanent survey sites. Site descriptions are provided in **Section 3** and copies of site photos will be provided to WCPL in digital format. Comparison of the 2017 monitoring sites to 2011 – 2016 monitoring photographs has been made by referring to previous reports prepared by Barnson (2017).

2.2 Rainfall and flood analysis

Previous WCPL channel stability monitoring reports have included an analysis of rainfall Intensity-Frequency-Duration (IFD) and exceedance likelihood, with its effect on erosion (Barnson 2017). It was determined that due to generally low rainfall received during 2017 and the absence of highly significant erosion at the survey sites, IFD and exceedance analysis would not be conducted for the purposes of this report.

Figure 2-1: Survey locations

3 Results

The results of the channel stability monitoring are presented below in Table 3-1 and **Table 3-2**. Site descriptions and comparison notes can be found in **Table 3-3**.

Table 3-1: Stability – Bank erosion hazard index (BEHI) for Wilpinjong Creek.

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	Scoring								Total	Rating
				1	2	3	4	5	6	7	8		
WCk1	L	4	10	5	2	5	0	2.5	2.5	7.5	5	29.5	Mod Stable
WCk2	R	3.5	9	5	2	5	2.5	2.5	7.5	10	0	34.5	Mod Stable
WCk3	L	3	12	5	2	2.5	5	7.5	10	12.5	5	49.5	Unstable
WCk4	L	3.5	7	5	4	7.5	7.5	7.5	12.5	12.5	0	56.5	Mod Unstable
WCk5	L	3	7	5	2	2.5	2.5	2.5	7.5	7.5	0	29.5	Mod Stable
WCk6	L	4	8	5	2	2.5	2.5	2.5	2.5	10	2.5	29.5	Mod Stable
WCk7	L	2.5	6	2.5	2	2.5	2.5	2.5	2.5	10	0	24.5	Highly Stable
WCk8	L	5	12	7.5	2	0	2.5	5	7.5	15	2.5	42	Stable
WCk9	R	2	9	0	2	7.5	5	5	7.5	12.5	2.5	42	Stable
WCk10	R	2	15	2.5	0	0	0	2.5	2.5	10	2.5	20	Highly Stable
WCk11	R	1.5	18	0	0	0	0	2.5	2.5	10	2.5	17.5	Highly Stable
WCk12	R	2	12	2.5	2	0	0	0	2.5	12.5	5	24.5	Highly Stable
WCk13	L	3	8	5	2	0	0	5	7.5	10	5	34.5	Mod Stable
WCk14	L	1.8	7	2.5	2	0	0	2.5	2.5	12.5	0	22	Highly Stable

Site	Bank	Bank	Bank	Scoring								Total	Rating
WCk15	L	1.8	6	2.5	2	2.5	2.5	2.5	7.5	10	2.5	32	Mod Stable
WCk16	L	2	7	2.5	2	5	2.5	7.5	7.5	7.5	0	34.5	Mod Stable
WCk17	R	1.8	4	2.5	2	0	0	2.5	2.5	15	2.5	27	Mod Stable
WCk18	R	2.5	5	2.5	2	5	2.5	2.5	5	15	2.5	37	Stable
WCk19	L	2	4	2.5	2	5	5	5	7.5	15	0	42	Stable
WCk20	L	1.8	5	2.5	2	2.5	2.5	2.5	2.5	15	0	29.5	Mod Stable
WCk21	R	1.3	5	0	2	2.5	2.5	2.5	2.5	15	0	27	Mod Stable
WCk22	R	1.8	8	2.5	2	0	2.5	5	7.5	15	2.5	37	Stable
WCk23	R	2.5	12	2.5	2	0	0	7.5	10	15	5	42	Stable
WCk24	R	1.7	10	2.5	0	2.5	5	7.5	12.5	15	2.5	47.5	Unstable
WCk25	L	1.7	7	2.5	2	2.5	7.5	5	10	15	2.5	47	Unstable
WCk26	L	3.5	10	5	2	5	5	5	10	15	2.5	49.5	Unstable
WCk27	R	2.8	5	2.5	6	7.5	5	5	10	15	2.5	53.5	Unstable
WCk28	L	2.5	5	2.5	2	5	5	5	7.5	15	2.5	44.5	Stable
WCk29	L	3.6	8	5	2	5	5	2.5	7.5	15	2.5	44.5	Stable
WCk30	R	2.8	12	2.5	2	0	2.5	2.5	2.5	15	2.5	29.5	Mod Stable
WCk31	R	3	6	2.5	4	5	5	7.5	10	15	2.5	51.5	Unstable
WCk32	R	3.2	8	5	4	7.5	5	7.5	10	15	2.5	56.5	Mod Unstable

Site	Bank	Bank	Bank	Scoring								Total	Rating
WCk33	L	3.2	6	5	4	7.5	5	7.5	10	10	5	54	Unstable
WCk34	R	2.4	6	2.5	4	5	5	7.5	7.5	15	5	51.5	Unstable
WCk35	R	2.2	13	2.5	2	0	2.5	5	2.5	15	2.5	32	Mod Stable
WCk36	R	2	15	2.5	2	0	2.5	2.5	2.5	15	2.5	29.5	Mod Stable
WCk37	R	2	10	2.5	2	2.5	2.5	7.5	10	15	2.5	44.5	Stable
WCk38	L	3.1	6	5	2	2.5	2.5	5	7.5	10	5	39.5	Stable
WCk39	L	3.2	7	5	4	2.5	5	10	7.5	15	2.5	51.5	Unstable
WCk40	R	3.2	14	5	2	0	5	10	10	15	0	47	Unstable
WCk41	R	2.8	8	2.5	2	2.5	2.5	2.5	7.5	15	0	34.5	Mod Stable
WCk42	R	3.8	6	5	4	5	7.5	10	10	12.5	2.5	56.5	Mod Unstable
WCk43	L	3.1	5	5	4	5	2.5	5	7.5	15	2.5	46.5	Unstable
WCk44	R	1.7	3	2.5	2	2.5	2.5	5	2.5	15	2.5	34.5	Mod Stable
WCk45	L	3.2	7	5	2	2.5	5	5	7.5	10	5	42	Stable
WCk46	R	2.2	5	2.5	4	5	2.5	5	2.5	10	2.5	34	Mod Stable
WCk47	R	2.2	6	2.5	2	2.5	2.5	2.5	7.5	15	0	34.5	Mod Stable
WCk48	L	2.7	8	2.5	2	2.5	5	5	7.5	12.5	2.5	39.5	Stable
WCk49	L	3.8	10	5	5	2.5	2.5	5	7.5	12.5	2.5	42.5	Stable

Table 3-2: Stability – Bank erosion hazard index (BEHI) for Cumbo Creek.

Site	Bank (L/R)	Bank Height (m)	Bank Face Length	Scoring								Total	Rating
				1	2	3	4	5	6	7	8		
CCk1	R	1.8	10	2.5	0	0	0	0	0	15	0	17.5	Highly Stable
CCk2	R	1.3	8	0	2	2.5	5	5	7.5	15	5	42	Stable
CCk3	L	0.4	2	0	0	0	0	0	0	15	2.5	17.5	Highly Stable
CCk4	R	1	13	0	0	0	0	0	0	15	2.5	17.5	Highly Stable
CCk5	R	0.5	8	0	0	0	0	2.5	2.5	15	2.5	22.5	Highly Stable
CCk6	R	1.8	10	2.5	2	0	0	0	0	15	2.5	22	Highly Stable
CCk7	R	0.8	2	0	4	5	2.5	0	2.5	15	5	34	Mod Stable
CCk8	L	2	15	2.5	0	0	0	0	0	15	2.5	20	Highly Stable
CCk9	L	0.7	2	0	2	2.5	2.5	0	0	15	2.5	24.5	Highly Stable
CCk10	L	0.7	4	0	2	2.5	2.5	0	0	15	2.5	24.5	Highly Stable

Table 3-3: Site descriptions

Site	Upstream	Downstream
WCk1	- Limited vegetation cover on bed and banks - Localised erosion along stock tracks - Erosion evident on left bank	- Vegetation cover still acceptable but showing evidence of grazing by stock as well as cattle tracks - Bedrock exposed in creek bed
WCk2	- Reasonable vegetation cover, Phragmites has died back, and replaced by native and exotic grasses and herbs - Localised erosion along stock tracks	- Vegetation cover is moderate, but actively grazed - High leaf litter cover - Minor Blackberry present
WCk3	- Short vegetation cover of native and exotic grasses and herbs - Localised erosion along stock tracks	- Good instream cover of native and exotic grasses and herbs - Left-hand bank actively eroding - Low vegetation cover on left-hand bank
WCk4	- Native and exotic grasses and herbs on channel bed have been grazed - Right bank stable except for stock tracks - Left bank unstable – significant bank collapse and down cutting	- Fresh bank collapse & erosion on left-hand bank - Right-hand bank looks in good order below the fence - Stock impacting on stability of creek
WCk5	- Eucalypts growing in the channel bed - Wombat burrows on right bank - Active gully cutting on left bank	- Good cover of vegetation and logs on right-hand bank - Left bank has reasonable cover of grass/herbs/shrubs
WCk6	- Stock tracks on both banks - Gahnia and shrubs growing on left bank - Good litter cover in creek bed	- Wombat burrow on right-hand bank - Small amount of Blackberry - Good canopy regeneration - Good cover of leaf litter
WCk7	- Wombat burrows in right bank - Good cover of vegetation and debris on both banks	- Good Large Woody Debris (LWD) cover on right-hand bank - Good vegetation growth on both banks - Phragmites has dried up and mostly died

Site	Upstream	Downstream
WCk8	- Original site surveyed - Good vegetation cover in channel bed – predominantly Phragmites - Wombat burrows on both banks - Some debris accumulation in channel	- Assessed at old site location - Animal tracks, wombat burrows on left-hand bank and bare patches on steep banks
WCk9	- Original site surveyed - Good vegetation cover in channel bed and left bank - Right bank steep and bare in some places	- Assessed at old site - Steep eroded banks on right-hand bank - Phragmites in channel - Rabbit and Wombat burrows on left-hand bank
WCk10	- Banks well vegetated with grasses, herbs and rushes - Wombat burrows in left bank	- Reasonable vegetation cover in channels and on banks - Bare soil on steep sections of right-hand bank - Left-hand bank is stable
WCk11	- Increased Wombat activity on bench on right bank - Generally good ground cover	- Reasonably well vegetated - Wombat burrows on right-hand bank bench
WCk12	- Good vegetation cover on banks - Some minor Casuarina regrowth on left bank - Blackberry noted	- Patterson's Curse no longer evident - Good vegetation cover on both banks - LWD, litter and wombat burrows on right-hand bank bench
WCk13	- Wombat burrows noted on left bank - Some bare exposed areas on left bank - Blackberry noted	- Some undercutting on left-hand bank downstream of reach - Pig digging evident on left-hand bank
WCk14	- Wombat burrows in right bank - Pig digging in channel - Some debris in channel	- Wombat burrows on both banks - Pig digging in channel bed - Blackberry evident

Site	Upstream	Downstream
WCk15	- Wombat burrows in both banks - Good vegetation cover on right bank, moderate on left bank - Some leaf litter accumulation in channel	- Good vegetation growth on right-hand bank
WCk16	- Sand/gravel accumulation in channel - Good vegetation cover on right bank, moderate on left bank	- Sand/gravel deposits in channel - Right-hand bank has good vegetation cover, and left-hand bank has moderate vegetation cover
WCk17	- Well vegetated banks – Phragmites - Sand/gravel accumulations in channel with some iron staining - Animal tracks present - Wombat burrows in left bank	- Thick covering of Phragmites - Animal tracks crossing the creek - Sand/gravel substrate in channel
WCk18	- Wombat burrows in both banks - Reasonably good vegetation cover of grasses/ruches in channel and on banks	- Wombat burrows in both banks - Mass wasting evident on right-hand bank - Good vegetation cover downstream
WCk19	- Good vegetation cover of grasses/rushes in channel bed and banks - Some animal tracks on left bank	- Good vegetation cover in channel and on right-hand bank - Some mass wasting on top of left-hand bank
WCk20	- Bank and channel well vegetated - Some erosion on left bank - A few Saffron Thistles, but limited Patterson's Curse	- Channel and banks well-vegetated with Phragmites and Lomandra - Minor active erosion still evident
WCk21	- Good vegetation cover in channel and on right bank - Some bare exposed areas on left bank - Debris build up in channel	- Good vegetation growth in channel and right-hand bank - Erosion on left-hand bank - Some weed species

Site	Upstream	Downstream
WCk22	- Good vegetation cover in channel and of left bank - Wombat burrows in left bank - Erosion on right bank	- Wombat burrows in left-hand bank - Erosion evident on right-hand bank - Good vegetation cover in channel and left-hand bank - No riparian tree cover
WCk23	- Good in channel vegetation cover - Bare exposed patches on both banks at top and mid bank	- Good vegetation cover in channel - Significant bare soil on both banks - Blackberry growing in channel
WCk24	- Good cover of Lomandra on left bank - Some bare exposed patches with animal tracks on right bank - Wombat and rabbit burrows present on left bank	- Good vegetation cover in channel (Typha) - Good vegetation cover on left-hand bank with the exception of animal tracks - Bare soil patches on right-hand bank, downstream of Cumbo Ck confluence
WCk25	- Left bank actively eroding - Bank vegetation dominated by thistle spp. - No riparian zone	- Significant bare soil patches with notching erosion occurring - Some gullying erosion starting to form on left-hand bank
WCk26	- Vegetation instream and on left bank remains similar to 2016 - Exposed areas on top of left bank - Right bank remains stable - Some wombat and rabbit burrows in top of left bank - Blackberry noted	- No salt crusting evident - Some active erosion downstream - Wombat burrows on top of left-hand bank
WCk27	- Right bank has moderate vegetation cover - In channel vegetation remains similar to 2016	- Active erosion evident (rill and notching)
WCk28	- Reasonable vegetation cover in channel and on right bank - Bare sections present on left bank	- Good cover of vegetation in channel and on both banks

Site	Upstream	Downstream
WCk29	- Good vegetation cover in channel and on right bank - Left bank not as steep and good cover of grass cover than downstream	- Good vegetation cover in channel and right-hand bank - Wombat burrows present - Top half of left-hand bank very steep and actively eroding, some notching present
WCk30	- Increase in vegetation cover on right bank - Blackberry noted on left bank - Wombat burrows in both banks - Good general regeneration on both banks	- Gully forming on right-hand bank on downstream end of reach - Bare soil exposed on right-hand bank at downstream end of reach
WCk31	- Instream vegetation remains similar to 2016 - Right bank has degraded from 2016 – bare soil predominant - No salt crystallisation evident	- Stable instream vegetation - Right-hand bank has increased soil exposure compared to 2015 levels - Some minor gullying evident on right-hand bank
WCk32	- Good cover of in channel vegetation - Left bank showing signs of erosion - Wombat burrows in right bank	- Right-hand bank is steep but well vegetated - Gullying appears to be stabilised with addition of rock battering
WCk33	- Good cover of grasses in channel and on right bank - Areas of active erosion evident on left bank - Wombat burrows in both banks - Tree cover present on left bank but little ground cover	- Good vegetation cover in channel and right-hand bank - Wombat burrows on both banks - Left-hand bank steep, bare and actively eroding - Tree cover moderate, but no groundcover on left-hand bank - LWD on left-hand bank
WCk34	- In channel vegetation cover remains high - Right bank stable but some wombat burrows - Active erosion on face of left bank	- Right-hand bank actively eroding and several bare animal tracks

Site	Upstream	Downstream
WCk35	- Instream vegetation cover remains high - Lower section of left bank remains stable and well vegetation, however some block failure is evident on top of left bank - Right bank showing an increase in exposure from 2016	- Right-hand bank has improved in vegetation cover
WCk36	- Right bank similar to 2016 but grazed - Left bank remains steeply slowed and concave - Top of left bank still steep, showing signs of erosion - Good grass cover in channel and lower banks	- Slumping still occurring on right-hand bank - Some undercutting and exposed bare soil at downstream end of left-hand bank - Good grass cover in channel and lower banks
WCk37	- Left bank remains well vegetated (grazed) and stable. - Some Wombat burrows in left bank - Increase in cover of bare areas on right bank since 2016 - Stock tracks causing bare areas on right bank	- Wombat burrows on left-hand bank - Right-hand bank groundcover appears to have deteriorated with increased bare soil - Stock tracks evident on right-hand bank
WCk38	- Instream vegetation remains similar though grazed - Wombat burrows on left bank - Stock tracks causing localised erosion on both banks - Both banks have reasonable vegetation cover though grazed	- Stock access causing localised erosion - Good vegetation cover in channel and on banks, however it is being actively grazed
WCk39	- Right bank well vegetated and stable - Left bank showing signs of gully development - Wombat burrows on both banks	- Right-hand bank well vegetated, but left-hand bank actively eroding with steep bare upper-bank - Minor gullying forming on left-hand bank
WCk40	- Good vegetation cover in channel though grazed - Left bank stable and well vegetated - Bare patches of exposed bank still present on right bank – similar to 2016	- Creek bed remains well vegetated and stable but actively grazed

Site	Upstream	Downstream
WCk41	- Creek bed well vegetated - Left bank has good vegetation cover - Right bank has exposed soil, bedrock and erosion is active - Stock tracks in left bank	- Creek bed and left-hand bank well vegetated and stable - Right-hand bank is steep and still actively eroding
WCk42	- Creek bed well vegetated - Upstream end of right bank appears to be more vegetated than 2016 - Downstream end of right bank still eroding significantly - Gully developing on right bank Upstream of large tree - Some debris in channel - Suggest rehabilitation activities at this site	- Channel remains well vegetated but actively grazed - Wombat burrows on left-hand bank
WCk43	- Overall better vegetation cover than in 2015 - Some unstable sections on left bank, but generally acceptable - Good vegetation cover on right bank albeit grazed	- Blackberry present - Vegetation cover good and stable but actively grazed - Left-hand bank has minor bare soil exposure downstream of reach
WCk44	- Still good vegetation cover overall, but grazed - Wombat activity in left bank	- Vegetation cover good and stable but actively grazed - Good level of debris and litter in stream an on lower banks - Carp present
WCk45	- Channel well vegetated - Both banks stable and vegetated, though some minor exposure around stock tracks and vegetation has been grazed	- Good and stable vegetation as per previous years - Minor localised erosion caused by stock access on left-hand bank
WCk46	- Channel well vegetated - Both banks stable and well vegetated though grazed	- Good and stable vegetation but actively grazed - Left-hand bank remains stable, right-hand bank has minor exposed steep sections vulnerable to erosion

Site	Upstream	Downstream
WCk47	- Instream vegetation cover remains good, though some impact of grazing noted below fence - Banks are steep but stable - Pig seen	- Stock causing localised erosion - Good level of debris and litter in stream an on lower banks
WCk48	- Increase of in channel vegetation of right bank bar - Left bank steep but stable apart from around animal tracks and wombat burrows - Right bank stabilised by rock cover	- Site continues to stabilise with increased groundcover on right-hand bank - Good debris in channel
WCk49	- Good cover of grasses on channel and on right bank - Left bank showing signs of stock tracks and localised erosion - Vegetation has been heavily grazed	- Vegetation cover good in channel and right-hand bank - Left-hand bank steep but presently stable - Localised erosion caused by stock access - Wombat burrows on right-hand bank
CCk1	- Site remains well vegetated and stable - Mid and upper parts of right bank dominated by Saffron Thistle - No tree cover	- Good cover and stable with increased groundcover on right-hand bank however, strong exotic cover on banks
CCk2	- Good vegetation cover in channel and of left bank - Evidence of erosion on mid and upper sections of right bank - Some debris in channel	- Good vegetation cover and stable in channel and left-hand bank - Some bare soil and bed rock exposure on right-hand bank
CCk3	- Water pooled upstream of crossing - Good grass, herb and rush cover in channel and on banks - Some minor soil exposure on right bank	- Good vegetation cover and stable - Strong exotic cover on banks
CCk4	- Good groundcover in channel and on both banks - Some animal tracks on right bank	- Site remains stable - Good and stable vegetation cover
CCk5	- Site remains well vegetated and stable - Some bare ground on upper right bank	- Site remains stable

Site	Upstream	Downstream
CCk6	- Area well vegetated - Some Eucalypt regrowth on right bank - Leaf litter build up on top of right bank	- Pooling continues in downstream section of reach - Remains well vegetated and stable - Some canopy regen present
CCk7	- Good cover of grasses in channel and on left bank - Some minor erosion on face of right bank - Some bare bank noted low of left bank near pool	- Good and stable groundcover in channel and right-hand bank - Minor erosion on left-hand bank on downstream end of reach
CCk8	- Good vegetation cover in channel and on both banks - Very limited riparian zone apart from groundcover	- Site remains stable with good vegetation cover
CCk9	- Site remains well vegetated and stable - Saffron Thistle prevalent on both banks	- Site remains stable with good vegetation cover
CCk10	- Site remains well vegetated in channel and on both banks - Very limited riparian zone apart from groundcover	- Site remains stable with good vegetation cover - Wombat burrows on left-hand bank - Strong exotic cover

Figure 3-1: Active erosion points assessed in 2017

4 Discussion and Recommendations

Of the 49 sites surveyed along Wilpinjong Creek, five were highly stable, 17 moderately stable, 13 stable, 11 unstable and three moderately unstable (**Table 3-1**). The lowest scoring sites were WCk4, WCk32 and WCk42, showing a high degree of wasting of the bank, and a low percentage of streambank protection and vegetation cover.

The north-west section of Wilpinjong Creek (incorporating sites WCk1-8) contains good areas of natural regeneration with overall moderate to good riparian habitat present. At the time of survey, there was abundant birdlife occupying the canopy and shrub layer, including the threatened species Dusky Woodswallow, Little Lorikeet and Brown Treecreeper.

Scattered Priority Weeds through this section of the creek include Blackberry (*Rosa fruiticosa*) at sites WCk2, WCk6, WCk12, WCk13, WCk14, WCk30 and WCk43.

Active erosion points were observed along the creek, displaying lateral erosion caused primarily by cleared adjacent paddocks (**Figure 3-1**). There were no signs of ongoing downstream erosion. Bank instability along Wilpinjong Creek appeared to be related to cattle accessing the riparian zone. Photos of each erosion point and suggested remediation actions are included in **Table 4-3**.

Of the ten sites surveyed along Cumbo Creek, eight were highly stable, one moderately stable and one stable (**Table 3-2**). Overall, the riparian health remains poor due to historical clearing and agricultural use. However, bank stability remains generally high, due to low banks slopes and heights. No active erosion points were identified along Cumbo Creek.

4.1 Multi-year comparisons

Previous monitoring data was limited to the Barnson (2017) report and the original project EIS (WCPL 2005). The EIS concluded that both Wilpinjong and Cumbo Creeks were affected by pre-mining land management practices dominated by sheep and cattle grazing, resulting in erosion and general creek bank instability at numerous points. The Barnson report allowed for direct comparison of 2016 monitoring data and comparison of photo records from 2011 onwards (as the photos were not available separately to ELA, the Barnson report should be reviewed in conjunction with this section).

4.1.1 Site stability scores

Site stability score comparisons are provided in **Table 4-1** for 2016 and 2017 monitoring for Wilpinjong Creek, and **Table 4-2** for Cumbo Creek. At many sites, vegetation cover in the channel and on the bank was noted to have decreased since 2016. However, despite the decrease in vegetation cover, site stability has slightly increased since the 2016 monitoring. The vegetation cover decrease may be attributed to lower rainfall and hence streamflow in 2017, although deep rooted trees and shrubs, and vegetation with surface dieback retaining root structure and sub-ground components (e.g. rhizomes and tubers) will continue to contribute to site stability. The lack of rainfall, while being detrimental to plant health, also reduces erosional processes. It is also possible that observer variation has contributed to the difference in stability scores between 2016 and 2017.

Table 4-1: Wilpinjong Creek site stability scores 2016 – 2017 comparison

Site	2016 Total	2017 Rating	Difference	Site	2016 Total	2017 Rating	Difference
WCk1	Stable	Mod Stable	Improved	WCk31	Unstable	Unstable	Same
WCk2	Stable	Mod Stable	Improved	WCk32	Mod Unstable	Mod Unstable	Same
WCk3	Unstable	Unstable	Same	WCk33	Mod Unstable	Unstable	Improved
WCk4	Highly Unstable	Mod Unstable	Improved	WCk34	Unstable	Unstable	Same
WCk5	Stable	Mod Stable	Improved	WCk35	Stable	Mod Stable	Improved
WCk6	Stable	Mod Stable	Improved	WCk36	Stable	Mod Stable	Improved
WCk7	Mod Stable	Highly Stable	Improved	WCk37	Stable	Stable	Same
WCk8	Stable	Stable	Same	WCk38	Stable	Stable	Same
WCk9	Unstable	Stable	Improved	WCk39	Stable	Unstable	Degraded
WCk10	Highly Stable	Highly Stable	Same	WCk40	Unstable	Unstable	Same
WCk11	Mod Stable	Highly Stable	Improved	WCk41	Stable	Mod Stable	Improved
WCk12	Mod Stable	Highly Stable	Improved	WCk42	Highly Unstable	Mod Unstable	Improved
WCk13	Stable	Mod Stable	Improved	WCk43	No Access	Unstable	
WCk14	Stable	Highly Stable	Improved	WCk44	Stable	Mod Stable	Improved
WCk15	Stable	Mod Stable	Improved	WCk45	Stable	Stable	Same
WCk16	Highly Stable	Mod Stable	Degraded	WCk46	Stable	Mod Stable	Improved
WCk17	Mod Stable	Mod Stable	Same	WCk47	Stable	Mod Stable	Improved
WCk18	Stable	Stable	Same	WCk48	Stable	Stable	Same
WCk19	Unstable	Stable	Improved	WCk49	Stable	Stable	Same
WCk20	Unstable	Mod Stable	Improved				
WCk21	Unstable	Mod Stable	Improved				
WCk22	Mod Unstable	Stable	Degraded				
WCk23	Mod Unstable	Stable	Degraded				
WCk24	Unstable	Unstable	Same				
WCk25	Unstable	Unstable	Same				
WCk26	Unstable	Unstable	Same				
WCk27	Stable	Unstable	Degraded				
WCk28	Unstable	Stable	Improved				
WCk29	Unstable	Stable	Improved				
WCk30	Stable	Mod Stable	Improved				

Table 4-2: Cumbo Creek site stability score 2016 – 2017 comparison

Site	2016 Total	2017 Rating	Difference
CCK1	Highly Stable	Highly Stable	Same
CCK2	Mod Stable	Stable	Improved
CCK3	Mod Stable	Highly Stable	Improved
CCK4	Highly Stable	Highly Stable	Improved
CCK5	Mod Stable	Highly Stable	Improved
CCK6	Mod Stable	Highly Stable	Improved
CCK7	No Access	Mod Stable	
CCK8	Highly Stable	Highly Stable	Same
CCK9	Highly Stable	Highly Stable	Same
CCK10	Highly Stable	Highly Stable	Same

4.1.2 Photographic comparisons

Photographic comparisons made between the Barnson (2017) report photo records and the 2017 data indicate that there has been little change or improvement in erosive sites. Most notable differences appear to be related to vegetation cover which may be attributed to seasonal conditions and variations. Management actions do not appear to have been employed with the exception of fencing off livestock at some (but not all) sites.

4.2 Erosion points

Table 4-3 provides a photo log of the erosion points along Wilpinjong Creek which suffer from moderate to severe erosional process and/or poor riparian health as a result of past land management. These sites were identified as having moderate to severe erosion and/or poor riparian structure and should be prioritised for remediation works. These sites should continue to be monitored to assess the progress and success of remediation works.

Revegetation and remediation methods are discussed below in **Section 4.3.**

Table 4-3: Stability – Areas requiring remediation works

Erosion point	Image	Suggested works

Erosion point	Image	Suggested works
E2 (768469, 6422527)		Revegetation (**Section 4.3)**
E3 (768558, 6422432)		Revegetation; Check dams (**Section 4.3**).
E4 (768614, 6422382)		Check dams (**Section 4.3**).

Erosion point	Image	Suggested works
E6 (772166, 6420287)		Revegetation; Check dams (**Section 4.3**).
E11 (771670, 6419956)		Revegetation and mulching (**Section 4.3**).
WCk24 (771555, 6419882)		Revegetation and mulching (**Section 4.3**).

Erosion point	Image	Suggested works
E12 (773579, 6420397)		Revegetation; Check wall (**Section 4.3**).
E9 (773397, 6420376)		Revegetation (**Section 4.3**).
E8 (773014, 6420339)		Continue to monitor change

Erosion point	Image	Suggested works
E7 (772431, 6420352)		Continue to monitor change
E10 (773772, 6420328)		Continue to monitor change

4.3 Revegetation and remediation

Re-establishment of riparian corridors along the creek systems will provide a sustainable long-term solution to current instability problems and that stabilisation efforts should prioritise the erosion points surveyed along Wilpinjong Creek. It is recommended that revegetation of trees and shrubs is implemented along the sections of Wilpinjong and Cumbo Creeks with unstable banks to improve stability. Revegetation efforts should extend to a distance equal to the height of the eroded bank, allowing space for the bank to partially erode whilst the trees establish. Other recommended remediation efforts include applying mulch to the bank to assist stabilisation until plants establish, and installation of loose rock or hay bale check dams to reduce water flow. Where possible the use of non-biodegradable sediment fencing should be avoided.

4.4 Domestic animals

Exclusion of cattle from areas of potential natural regeneration and unstable sites should be a priority. Locations with evidence of cattle presence generally correlated with increased erosion. The added pressure from grazing and hoof damage will only be detrimental to potential natural regeneration and bank stabilising processes. The installation of fences parallel to the creeks will allow pasture areas with low potential for natural regeneration and erosion to be grazed for the immediate future provided the grazier conducts weed control and pasture management works to maintain the site.

5 Conclusion

The stability and physical health of both Wilpinjong and Cumbo Creeks are characteristic of ephemeral systems in agricultural landscapes consistent with other creeks in surrounding location and history, as evidenced by the following:

- Due to low rainfall, no recent downstream erosion is evident and overall susceptibility of the creeks to downstream erosion is low.
- Active lateral erosion is evident, creating lateral gully-erosion at several locations. This has formed due to high velocity runoff from adjacent cleared paddocks occurring at right angles to the creek line.
- There are several instances where cattle access is contributing to bank instability and reducing in-stream vegetation.
- Feral Pigs are active within the riparian zone of both creeks and should be managed.

Erosion and bank stability within the Wilpinjong and Cumbo Creeks is more likely to be directly linked to historic agricultural practices within the riparian zone than mining activities at Wilpinjong Mine. Additionally, mining activities do not appear to be accelerating natural erosional processes. Despite this, rehabilitation works need to be undertaken to prevent creek lowering or an increase in erosion. Where possible this should be achieved through soft landscaping techniques (tree and shrub planting) and non-intrusive mitigation (loose rock check dams or pegged hay bales/coir logs) rather than reshaping of the creek profile.

Surveys undertaken since 2010 have found that the Wilpinjong Creek remains a highly degraded creek as a result of past land management practices, however there are areas of natural regeneration occurring that are related to stock access restriction from the riparian corridors. Cumbo Creek continues to lack structure and riparian features however it remains relatively stable. There is no visible evidence that mining within the vicinity of the creeks or discharge of water from the mine has resulted in creek bed lowering or increased erosion.

6 References

Abernathy B, and Rutherford I.D. 1999. *Guidelines for Stabling Stream Banks with Riparian Vegetation,* Cooperative Research Centre for Catchment Hydrology, technical report 99/10.

Barnson 2017. *Wilpinjong and Cumbo Creek Stability Assessment, 2016*, prepared for Wilpinjong Coal Mine

CSIRO 2009. *Australian Soil and Land Survey Field Handbook – 3rd Edition,* CSIRO Publishing, Collingwood, Victoria

Wilpinjong Coal Pty Limited 2005. *Wilpinjong Coal Project Environmental Impact Statement*, prepared by Resource Strategies Pty Ltd for Wilpinjong Coal Pty Limited

Appendix A : BEHI Assessment Scoring

Category	Measure	Score
1. Bank Height (m)	0 - 1.5	0
	1.5-3	2.5
	3-4.5	5
	4.5-6	7.5
	6+	10
2. Bank Angle (°)	0-20	0
	21-60	2
	61-80	4
	81-90	6
	91-120	8
	> 120	10
3. Percentage of Bank Height with a Bank Angle Greater than 80°	0-10	0
	11-25	2.5
	26-50	5
	51-75	7.5
	76-100	10
4. Evidence of Mass Wasting (% of Bank)	0-10	0
	11-25	2.5
	26-50	5
	51-75	7.5
	76-100	10
5. Unconsolidated Material (% of Bank)	0-10	0
	11-25	2.5
	26-50	5
	51-75	7.5
	76-100	10
6. Streambank Protection (% of Streambank covered by plant roots, vegetation, logs, branches, rocks etc	0-10	15
	11-25	12.5
	26-50	10
	51-70	7.5
	70-90	2.5
	90-100	0
7. Established Beneficial Riparian Woody - Vegetation Cover	0-10	15
	11-25	12.5
	26-50	10
	51-70	7.5
	70-90	2.5
	90-100	0
8. Stream Curvature Descriptor	Meander	5
	Shallow Curve	2.5
	Straight	0
Totals	Highly Stable	0-25
	Mod Stable	26-35
	Stable	36-45
	Unstable	46-55
	Mod Unstable	56-65
	Highly Unstable	66-85

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DATE:	29 March 2018
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	Wilpinjong Coal Pty Ltd Peabody Energy Australia Locked Bag 2005, Mudgee NSW 2850
FROM:	Dr Derek Yates, Adam Skorulis, Maxime Philibert
RE:	Wilpinjong Coal Mine – Surface Water Analysis
OUR REF:	WIL014 – Report HS2018/17

INTRODUCTION

This letter report contains the analysis and information required for the review of flow and water quality trends at Wilpinjong Creek near Wilpinjong Coal Mine. It serves as a supplementary document to the review of hydrogeological data conducted by HydroSimulations for the 2017 Annual Review and 2016-17 Water Year Licensing Audit. This report is presented in two sections and addresses the following requests:

1. Cause-and-effect analysis of data from the Wilpinjong Creek upstream (WILGSU), and Wilpinjong Creek downstream (WILGSD) gauging stations, including a trend analysis in respect to the long-term rainfall trend, discharge from the reverse osmosis treatment plant (Licensed Discharge and Monitoring Point EPL12425) and flow from the Cumbo Creek upstream (CCGSU) gauging station.
2. Assessment of the data in relation to the flow trigger as proposed by Gilbert and Associates (2013)

The report consists of commentary on the cause-and-effect analysis and trigger level assessment, with the inclusion of supporting figures.

Note on the trend analysis

The trend analysis within this report has been conducted for both flow/ discharge and rainfall by assessing monthly data, the monthly deviation from the mean, and the cumulative monthly deviation from the mean. The deviation from the mean and cumulative deviation from the mean are useful tools the evaluate temporal correlation of rainfall with surface or groundwater levels. Short-term variability is filtered out, allowing for the display of longer-term trends. Where a cumulative deviation from the mean curve rises, above average conditions are indicated, a declining trend indicates below average conditions. These trends are calculated in the following way.

1. Mean monthly rainfall/ streamflow is calculated from all monthly rainfall/streamflow values (i.e. average rainfall for January)
2. Monthly deviation from the mean is calculated between the monthly mean rainfall/streamflow value and the value for a particular month.
3. Cumulative monthly deviation from the mean is determined for each month for the duration of monitoring at each site.

Cumulative deviation from the mean curves are also referred to as residual mass curves within this report

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1 REVIEW OF SURFACE WATER DATA

1.1 Flow Review

The following section assesses daily data from three continuous surface water monitoring gauges, two on Wilpinjong Creek, WILGSU and WILGSD, and one on Cumbo Creek, CCGSU, in conjunction with discharge data from the reverse osmosis treatment plant Licensed Discharge and Monitoring Point, EPL 12425. Supplementary assessment of the long term, monthly trends of the same sites can be found below in **Section 1.1.3 - Trend Analysis**.

The locations of the gauges on Wilpinjong Creek are shown in Error! Reference source not found. The upstream site, WILGSU, is located northwest of Wilpinjong Coal Mine, WILGSD is northeast of Wilpinjong Coal Mine, downstream of the reverse osmosis treatment plant discharge site (RO Plant) and downstream of the confluence of Wilpinjong and Cumbo Creek. The Cumbo Creek upstream gauging station CCGSU is located near bore GWa5, ~400 m to the East of Pit 2 and ~800m upstream of active mining at Pit4. Flow/ discharge, electrical conductivity, and pH are all measured and presented against the rainfall trend from the local rainfall station (Wollar, 062032).

Both Wilpinjong Creek gauging stations have been recording since January 2012, the catchment area to the upstream site (WILGSU) is 86km^2 while the downstream site has a catchment area of 216km^2. The RO Plant has been discharging treated wastewater upstream of WILGSD since June 2012, and CCGSU on Cumbo Creek has been recording data since August 2015.

Flows at both gauges, upstream (WILGSU) and downstream (WILGSD), show correlation with the long-term rainfall trend, with a decline from 2012 to July 2014 (**Figure 2**). Flows at both gauges have been less than 0.001 cumecs (<100 m^3/d) 50% of the time since early 2013 and for most of 2014. As this occurs at both gauges, with the rainfall trend during that period declining consistently, climate rather than mining is the primary cause of the low flow conditions. Flows at both gauges respond to the minor increase in the rainfall trend in 2015 and respond strongly to the large peak in late 2016, with peak flow rates ~0.5 and ~1 cumecs for the WILGSU and WILGSD gauging stations respectively. From January 2017 to December 2017, the rainfall trend declines, indicating below average conditions. This period of lower then average rainfall is likely responsible for the low, and no-flow conditions at WILGSU.

Correlation between the flows at the two gauges is high, with essentially a 1:1 relationship until about April-June 2012. Following the beginning of discharge from the RO Plant, flows at WILGSD are consistently higher than those at WILGSU. The change in proportionality is suggestive of the influence of the RO plant discharge above WILGSD (RO Plant discharges shown in yellow on **Figure 2**). This influence is best demonstrated during 2017, when low rainfall conditions have resulted in no flow at WILGSU, but WILGSD shows a near-perfect match with RO Plant discharge rates.

The Cumbo Creek gauging station (CCGSU), which begins monitoring in August 2015 is also displayed in **Figure 2.** Peaks in flow match the peaks in both the rainfall trend and the two Wilpinjong Creek gauging stations. Flow is maintained during most of the period of below average rainfall in 2017. It is important to note the logarithmic scale used to display the flows in **Figure 2**. During 2017, CCGSU has an average flow of around 0.001 cumecs, around 1% of the flow rate observed in Wilpinjong Creek as caused by RO Plant discharge (0.1 cumecs).

Table 1 presents the calculated daily mean discharge from RO Plant and flows at WILGSU, WILGSD and CCGSU for each water year since 2012

Table 1 Calculated daily mean discharge and flow (cumecs) at the monitoring locations along the Wilpinjong and Cumbo Creeks since water year 2012-13

Monitoring Location	Water Years – Average Daily Flow (cumecs)				
	2012-13	2013-14	2014-15	2015-16	2016-17
RO Plant	0.006	0.001	0.004	0.006	0.02
GS-U	0.014	0.0007	0.0012	0.0027	0.032
GS-D	0.03	0.0024	0.0041	0.0052	0.068
CCGS-U	No data				0.0071

1.1.2 Trigger Analysis

A flow trigger was proposed by Gilbert and Associates (2013) to monitor losses along Wilpinjong Creek where its course is adjacent to the mine. The trigger was deemed to have failed, i.e. further investigation is necessary, where:

[average daily flow at GS-D] < F x [average daily flow at GS-U]

where factor F = (1 – 0.11) x ([catchment area GS-D] / [catchment area GS-U]) = 2.16.

This rule is designed to check if the average loss of flow from upstream to downstream, allowing for the increased catchment size, is <=11%, as predicted in the original EIS (WCPL, 2005). A check on flow for the period July-2016 to June-2017 inclusive, has been made. Mean daily flow at WILGSU was 0.032 cumecs, leading to a trigger level of 0.069 cumecs. Mean daily flow at WILGSD was 0.0794 cumecs. According to the flow trigger further investigation is not required. (See table 1).

The influence of the RO Plant on flows at WILGSD, particularly those observed during 2017 likely render this method for assessing flow trigger exceedance invalid. The higher flows experienced at WILGSD are no longer related to the increased catchment size, and flow loss from upstream to downstream can no longer be accurately determined using the Gilbert and Associates (2013) method.

1.1.3 Trend Analysis

The trend analysis conducted on flow from WILGSU, WILSGD, CCGSU, discharge from the RO Plant and rainfall from the Wollar station has helped to confirm and clarify the relationships between stream flow, rainfall and discharge at two watercourses near Wilpinjong Coal Mine.

Figure 3 (CCGSU), **Figure 4** (WILGSU), and **Figure 5** (WILGSU) present monthly flow, deviation from the monthly mean, and cumulative deviation from the monthly mean in comparison with available data from either streamflow, rainfall, or discharge that may have some influence on recorded flow at a particular gauging station. Trends from CCGSU (**Figure 3**) and WILGSU (**Figure 4**) are assessed only against the trends from the Wollar rainfall station as they are upstream of the discharge plant and the confluence of any other assessed streams. WILGSD (**Figure 5**) is assessed against the rainfall trend as well as the discharge trends from the RO Plant and flow trends from both the WILGSU and CCGSU gauging stations. Water from any of these sources can influence the flow recorded at WILGSD.

As identified in the initial flow review CCGSU shows a good relationship with the rainfall trend (**Figure 3**). In the upper chart, peaks in monthly rainfall above 120 mm result in a strong increase in the monthly average flow rate recorded at the gauging station. Flow is sometimes maintained in periods of low monthly rainfall (observed during 2017), which may indicate some contribution of baseflow from groundwater in Cumbo Creek. Months with below average rainfall, indicated by values less than zero in the middle chart also correlate well with periods of below average flow in Cumbo Creek. The cumulative rainfall trend in the bottom chart (**Figure 3**) also shows a good match with the cumulative monthly deviation from mean flow trend at CCGSU. At the beginning of monitoring, below average flow is occurring CCGSU, correlating with the end of a recession in the rainfall trend that occurred from mid-2012 to mid-2015. The following peak in the rainfall trend in late 2016 and subsequent decline through 2017 are both well matched by the trend at CCGSU. The trend analysis indicates that flow at the upstream station of Cumbo Creek is strongly related to rainfall conditions, but also that baseflow from groundwater contributes to the recorded flow.

Similar trends between rainfall and flow are observed for WILGSU (**Figure 4**) to those seen at CCGSU. However, WILGSU frequently reports no flow in periods of low monthly rainfall, indicating that baseflow is a smaller component of flow. An excellent correlation between the long-term rainfall trend and the cumulative deviation from mean monthly flow for WILGSU is shown in the bottom chart of **Figure 4**. The flow trend is observed to decline for the period of below average rainfall from mid-2012 to mid-2015.

Figure 5 used to analyse the flow trends at WILGSD displays monthly rainfall and deviation from monthly average rainfall as bar charts to allow for clearer analysis of all potential components of flow at WILGSD. As stated in the above flow review, early observations of flow comparing WILGSU and WILGSD show an excellent match before RO Plant discharge begins, resulting in the maintenance of flow at WILGSD when discharge is occurring despite periods of low monthly rainfall. A period in early 2013 where there is zero discharge from the RO Plant shows the maintenance of flow at WILGSD while no flow is recorded at WILGSU. This may indicate a component of flow at WILGSD comes from baseflow, it may also indicate the influence of flow from a tributary such as Cumbo Creek that is also influence by baseflow. The influence of the RO Plant discharge on flow at WILGSD, particularly in 2017 becomes very clear in **Figure 5**. Prior to the significant (x10) increase in RO Plant discharge in 2017, flow at WILGSD showed a good correlation with the long-term rainfall trend. In 2017, the declining rainfall trend has shown no influence on flow at WILGSD. Instead, the increasing discharge trend from the RO Plant has become the major contributor to flow.

1.2 Water Quality Review

Water quality is monitored at WILGSU, WILGSD and CCGS-U, with the sondes measuring EC, pH (and temperature, which is not shown here). When water levels decline in dry periods, sondes may be 'banked' or capped to protect the instrument. These periods are marked on the EC and pH charts in **Figure 2**.

1.2.1 Electrical Conductivity Trends (EC)

Trends in Electrical Conductivity (EC) are a mirror of the flow and rainfall trends, and the daily EC data at each station are highly correlated to the flow data. In early periods, EC is consistently higher at WILGSD than at WILGSU. The usual pattern of higher EC at WILGSD is suggestive of a naturally higher baseflow index at WILGSD (groundwater being typically more saline than runoff) than at WILGSU. During late 2013 and early 2014, the EC pattern reverses, which is probably due to a much greater proportion of flow at GS-D being from the RO plant, which is less saline than the natural dry-weather EC of Wilpinjong Creek, which is shown at WILGSU. This pattern is for the remainder of the monitoring with higher EC value at WILGSU generally higher than at WILGSD before the EC recordings stopped at WILGSU due to low flow in early 2017.

EC at the Cumbo Creek gauging station (CCGSU) is generally much higher than recorded for Wilpinjong Creek during the period it has been recording data (Aug 2015-Dec2017) (**Figure 2**). However, the values at an average of around 5000 µS/cm are close to those recorded at WILGSD prior to the start of fresh water discharge from the RO Plant. It is likely that Cumbo Creek also has a higher baseflow index than sites further upstream in Wilpinjong Creek, with stream flow being sourced from saline Permian Groundwater. Declines in the EC at CCGSU are associated with periods of elevated rainfall when fresher surface water runoff would be the dominant source of flow within Cumbo Creek.

An increase in EC peaking at around 2000 µS/cm is recorded at WILGSD from mid to late 2016. These are associated with periods of high rainfall and high streamflow recorded at all gauging stations. It is likely that this increase is caused by elevated flow rates from Cumbo Creek. While EC from CCGSU declines to near fresh during the flow peak, during the recession, EC is observed to increase rapidly while the flow rate is still elevated, resulting in an EC higher than WILGSU and RO Plant discharge. EC at WILGSU increases to 2000 µS/cm in Jan 2017 before monitoring stops due the capping of sondes associated with low flow, while the increase in water being discharged from the RO plant in 2017 maintains low EC readings at WILGSD. While EC at CCGSU is elevated during 2017 observations, as was mentioned earlier, the daily flow rate is frequently around 1% of the flow recorded for WILGSU, meaning the influence of elevated EC in Cumbo Creek would be minimal.

1.2.2 pH Trends

pH at CCGSU is consistent for the entire monitoring period at a level of 7.7, it shows no correlation with rainfall or streamflow trends.

pH at both gauging stations on Wilpinjong Creek and appears to be correlated to the long-term trend in rainfall and flow. However, it also shows a response to short-term variation in flow and does exhibit signals depending on the source of the water in the river. For example, during storm events (e.g. March 2012, July-2012) pH is shown to decline sharply by about 0.5-1 pH unit, before recovering over a period of weeks, back to the baseline of about 7 (upstream) and 7.5-8 (downstream). The two main periods for which the pH trends deviate from their ‘baseline pattern’ are January 2013 and April-June 2013. During both periods the water quality sonde at WILGSU is capped due to low water levels at the site (i.e. not monitoring). However, it is clear that across each period, in-stream pH responds to the low flow conditions. In the first of these periods, pH at WILGSU declines to 6.2 and then recovers to over 7-7.5 within two months. pH at WILGSD appears unaffected at this time. In the second period pH at WILGSD declines to about 7, in response to a marked decline in flow and recovers to almost 8 by June, while at WILGSU the pH falls to 6.5 in May 2013, with a slow recovery back to pH 7 over a period of 5 months. From Jan 2014 to Dec 2017, pH values at both stations seem to decrease after periods of low-flow (Jul 2014, Apr 2015, Jun 2016), and a relatively more acidic environment at WILGSU than at WILGSD is observable.

Overall, during the last four water years, pH levels at both gauging stations are within the ANZECC and ARMCANZ (2000) default trigger values of 6.5-8.0. Exceptions occur in January 2015 and March 2016 with pH values of 8.8 and 9.8. These spikes may be the results of the sondes being exposed to air when near to no-flow conditions were recorded, resulting in unreliable pH values. The sharp decrease in EC seen above from July 2014 also occurs for pH from April 2015 where a decrease of 0.5 pH unit is seen. It is likely that the measured decline in pH is due to natural processes which can lead to saline groundwaters or groundwater discharge in creeks hosting chemical changes such as conversion of sulphates to sulphides, leading to acid generation. Such processes are not necessarily mining-related, but can be exacerbated by human activities, such as land clearing or water demand (e.g. irrigation, potable supply, mining).

2 CONCLUSIONS

The pH and EC values recorded at the Wilpinjong Creek site, even those around pH 6 or EC of 7,000 µS/cm, are consistent with those reported in Gilbert and Associates (2013). Gilbert and Associates (2013) concluded that pH, EC (and other parameters) recorded in Wilpinjong Creek did not show any discernible changes due to mining. The water quality parameters for EC and pH at the Cumbo Creek site are also within the parameters reported in Gilbert and Associates (2013) and do not indicate changes due to mining.

Two pronounced periods of below average rainfall associated with no-flow conditions at WILGSU make the assessment of a possible mining effect, that is discernible from climatic influence, difficult without more detailed analysis. This assessment indicates the current trends at WILGSU are likely caused by periods of below average rainfall.

The identification of a mining effect on stream flow at WILGSD is not possible without isolating the contribution of RO Plant discharge from rainfall derived flow. This has not been done in this assessment.

No mining impact on stream flow is apparent at the upstream site on Cumbo Creek.

3 RECOMMENDATIONS

If required, HydroSimulations recommends the development of a new trigger level that can determine flow loss due to Wilpinjong Coal Mine independent of RO Plant discharge.

4 REFERENCES

Gilbert and Associates, 2013. *Wilpinjong Coal Mine Modification* [5] – *Surface Water Assessment*. Report for Wilpinjong Coal Pty Ltd. Available at: http://www.peabodyenergy.com/mm/files/Operations/Australia/Wilpinjong/MOD%205/Appendix%20D%20-%20Surface%20Water%20Assessment.pdf

WCPL, 2017. *Wilpinjong Coal - Surface Water Management Plan.* August 2017. Document number: WI-ENV-MNP-0040

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Figures

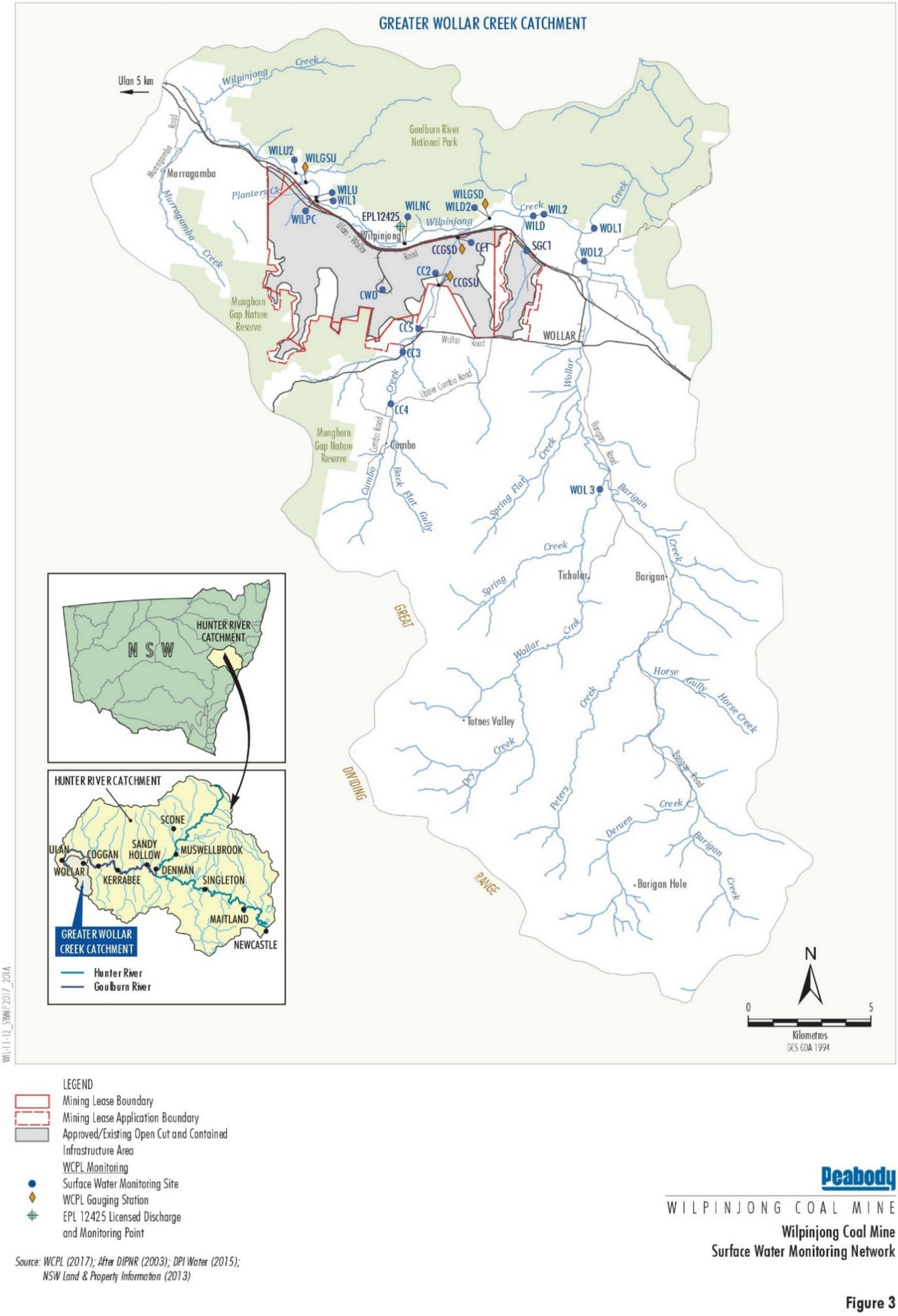

Figure 1 Wilpinjong Coal Mine – Surface Water Monitoring Network (WCPL, 2017)

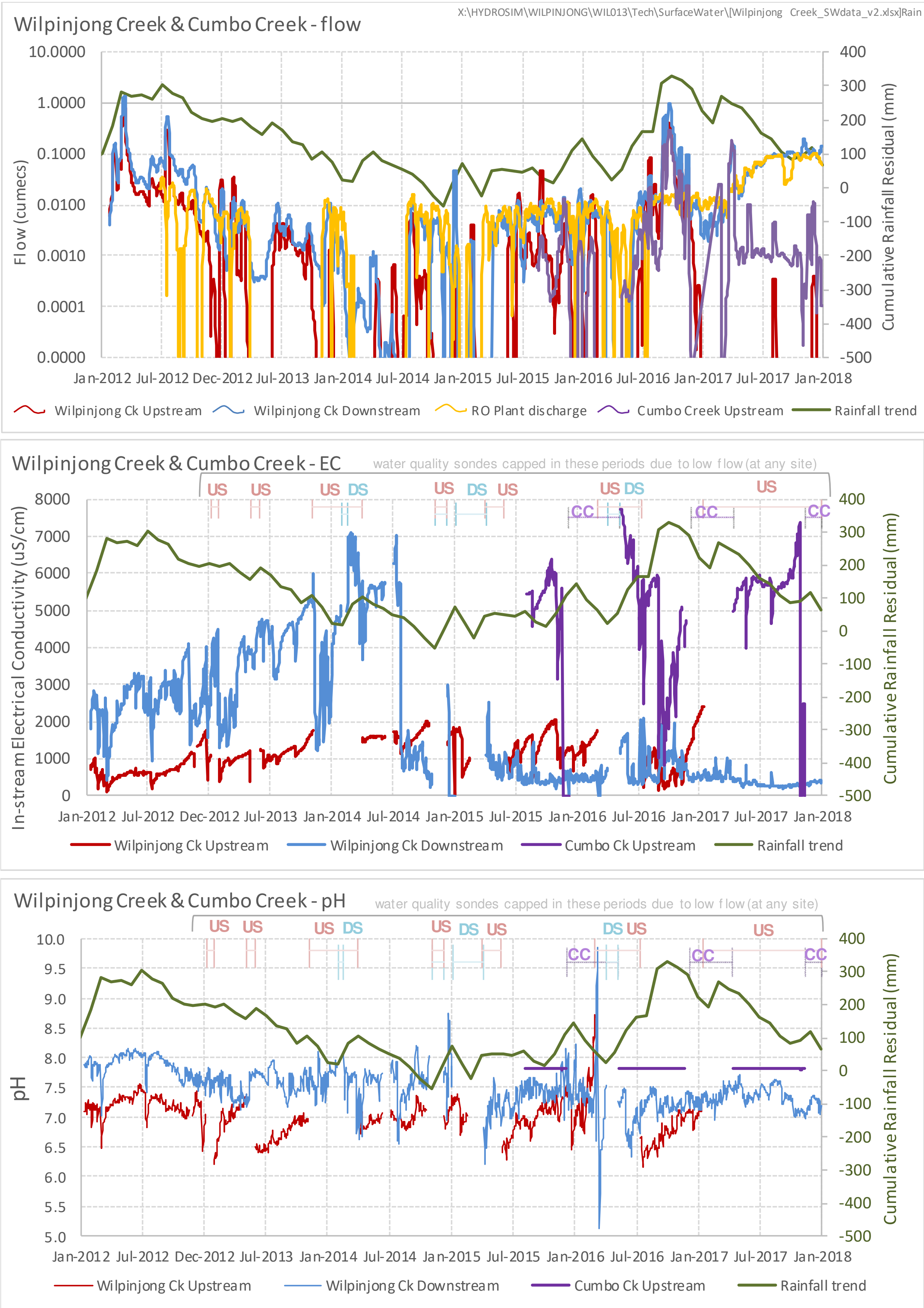

Figure 2 Summary of assessed surface sites near Wilpinjong Coal Mine

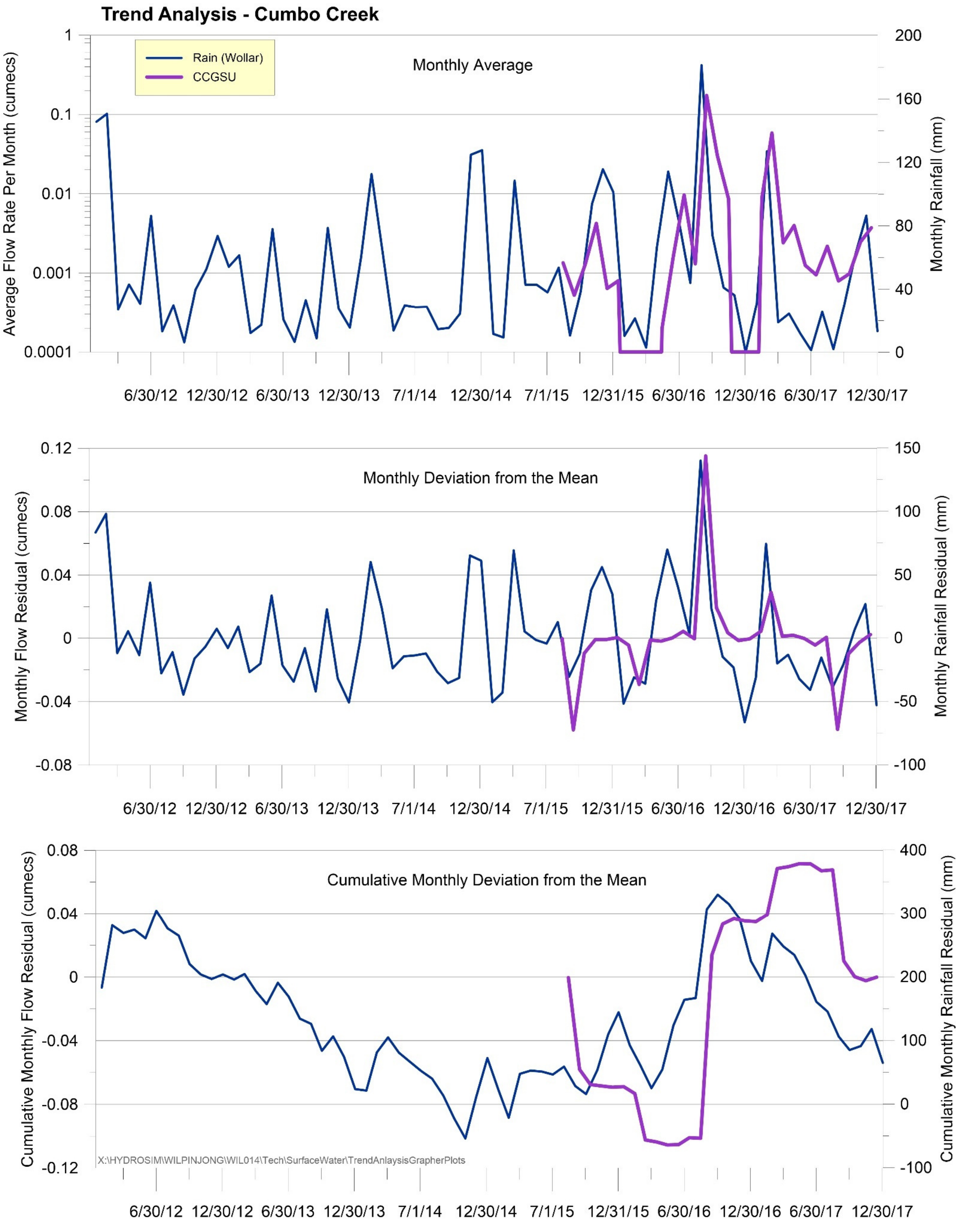

Figure 3 Summary of the Trend Analysis on Cumbo Creek Upstream gauging station (CCGSU)

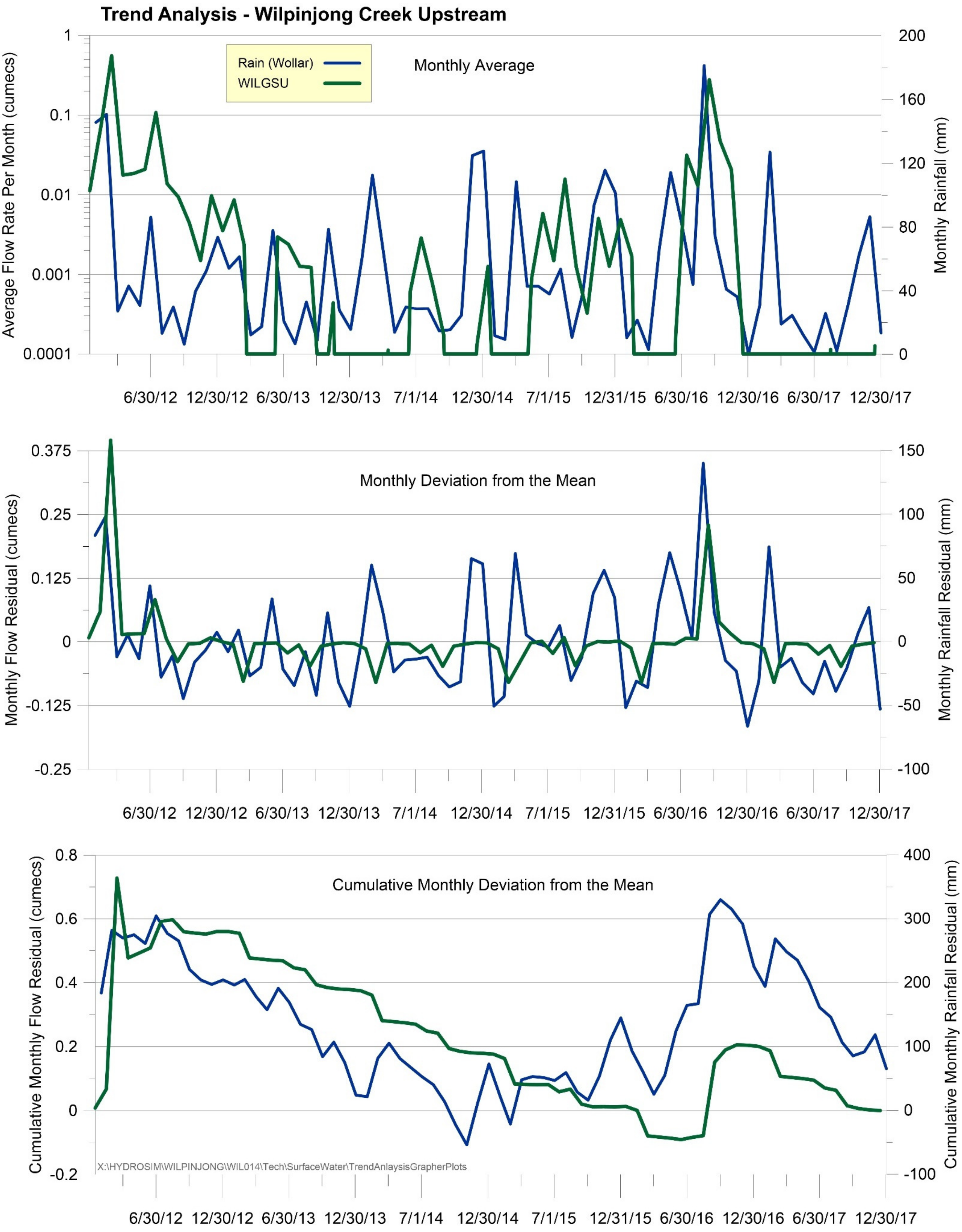

Figure 4Summary of the Trend Analysis on Wilpinjong Creek Upstream gauging station (WILGSU)

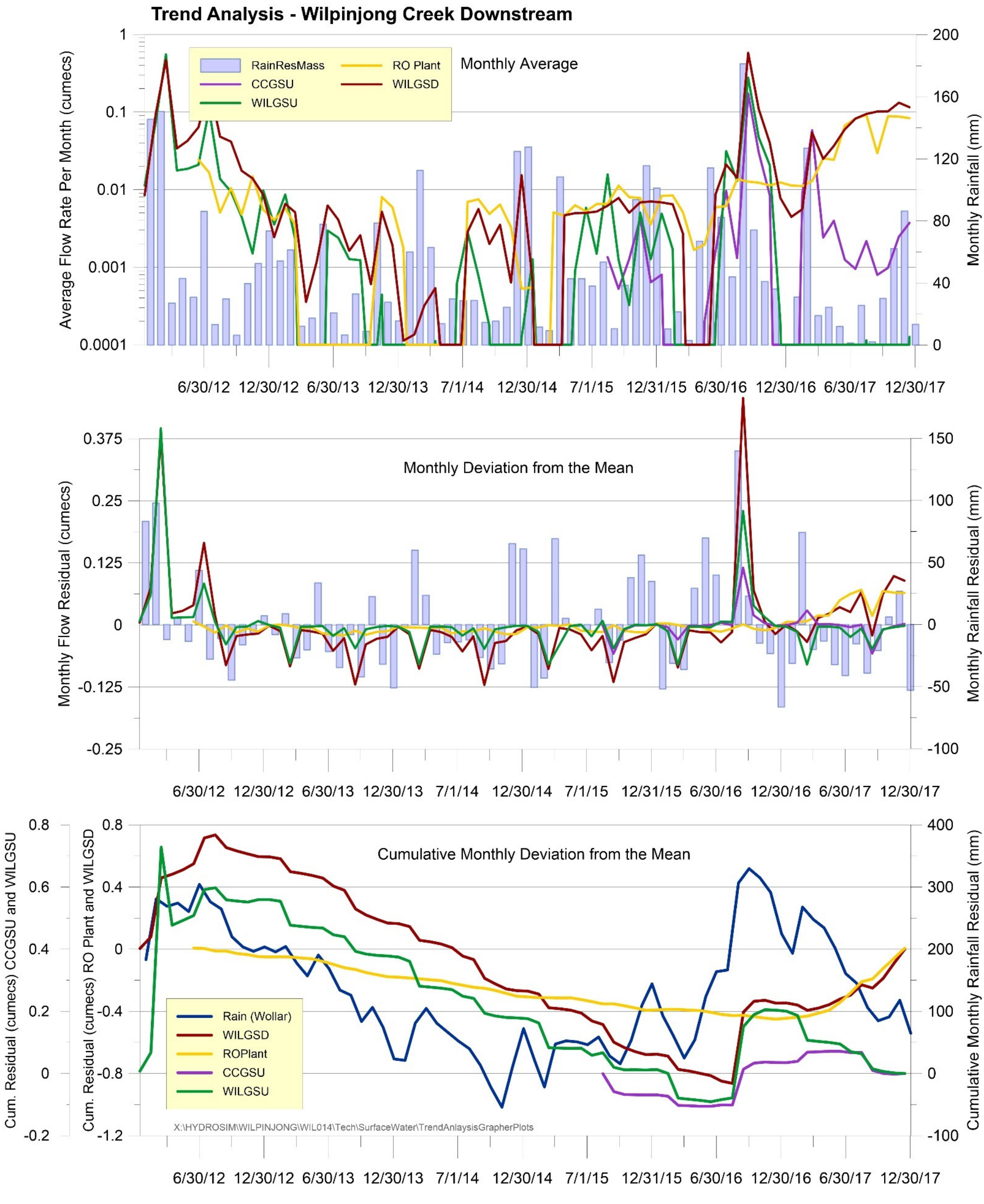

Figure 5 Summary of the Trend Analysis on Wilpinjong Creek Downstream gauging station (WILGSD)

wrm water + environment

Memorandum

Date	9 March 2018	Pages	9
Attention	Kieren Bennetts		
Company	Wilpinjong Coal Pty Ltd		
Job No.	1052-08-B		
Subject	Wilpinjong Mine – Site Water Balance for 2017 Annual Review		

Dear Kieren,

As requested by Wilpinjong Coal Pty Ltd (WCPL), WRM Water & Environment Pty Ltd (WRM) have prepared a site water balance for the Wilpinjong Mine to support WCPL's 2017 Annual Review.

The water balance has been derived based on monitoring data recorded by WCPL, supplemented with calculated values produced using the calibrated WCPL water balance software model (OPSIM). Annual volumes are listed in Table 1 for the July 2016 to June 2017 reporting period. Supporting information has been provided in sub-sections following the table.

Table 1: Wilpinjong Site Water Balance – July 2016 to June 2017 (Inclusive)

	Item	Vol. (ML)	Basis
Inflows	Groundwater into pits	1,009	Inferred (Section 2)
	Rainfall and runoff captured	3,436	Estimated (Section 3)
	Sub-total	4,445	
Outflows	Evaporation	788	Estimated (Section 3)
	Seepage	0	Inferred (Section 2)
	Discharge from WTF[1]	640	Measured (Section 4)
	Haul road dust suppression	600	Measured (Section 5)
	CHPP[2] and MIA losses[3]	912	Combination of measurement and estimation (Section 6)
	Sub-total	2,940	
Change in volume (increase in inventory)		1,505	Combination of measurement and estimation (Section 7)

Notes:
1. WTF denotes water treatment facility
2. CHPP denotes coal handling and processing plant
3. MIA denotes mine industrial area (includes vehicle wash bays, washdown pads etc)

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Memorandum

Supporting Information

Section 1: Wilpinjong OPSIM Model

Background: WCPL maintain a water balance simulation model for the Wilpinjong Mine using the OPSIM simulation software. Prior to this study, the Wilpinjong OPSIM model was most recently updated in early 2017 (Hatch, 2017) based on 2016 site conditions.

Model Schematic: An indicative schematic of the Wilpinjong water management system, as modelled in OPSIM, has been provided for reference in Attachment A.

Model Update & Calibration Results: In preparation of this water balance, WRM has updated the OPSIM model based on 2017 topographic survey and water monitoring data. The model update included a calibration exercise, in which selected model parameters were adjusted to align modelled estimates of site water inventory volume with historically measured values. The calibration exercise covered the four-year period between January 2014 to December 2017. Results of the calibration to combined site inventory are presented in Figure 1. Note the combined site inventory comprises of Pit 2W, Pit 1S, RWD, CWD, Pit 5N and Pit 3N.

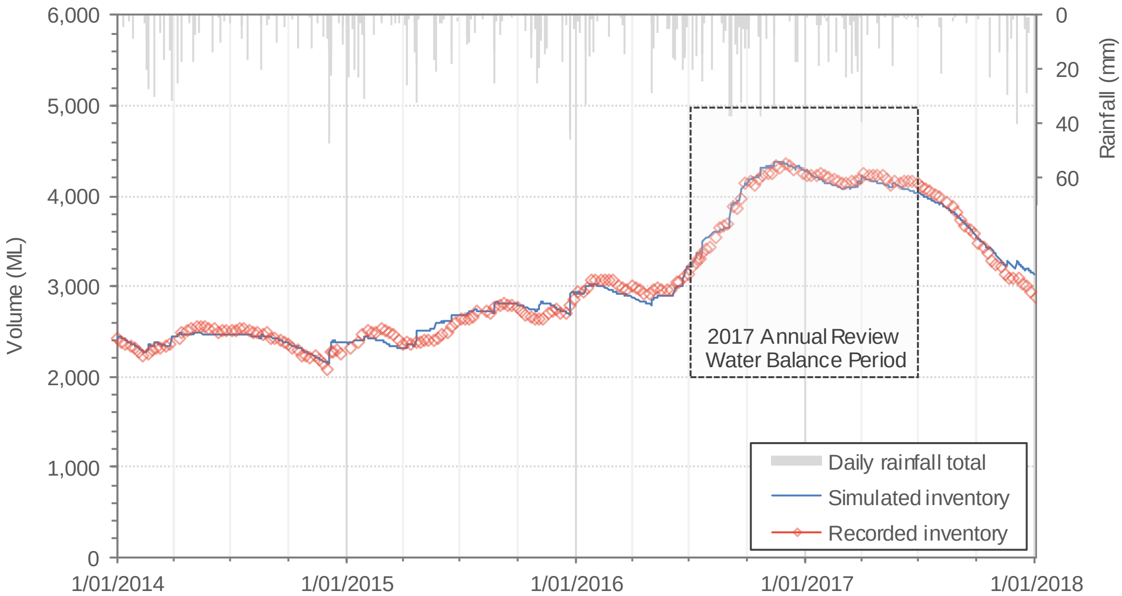

Figure 1: OPSIM Calibration – Simulated vs Measured Combined Site Inventory

Review of Figure 1 shows that the model simulated inventory is well aligned with the historical inventory data. Key flow streams, or model parameters, inferred or adjusted as part of this exercise include: 1) groundwater inflow rates; 2) catchment yield parameters and 3) spoil aquifer porosities. These are discussed further in following sections.

Section 2: Groundwater & Seepage

Groundwater Inflows: Net groundwater inflow rates have been inferred as part of the model calibration exercise. Modelling has assumed that net inflow rates are held constant over each calendar year. The following inflow rates have been inferred (note that inflow rates are net of any highwall evaporation or run-of-mine (ROM) coal moisture entrainment):

- 2014: 3.51 ML/d
- 2015: 3.29 ML/d
- 2016: 3.17 ML/d
- 2017: 2.36 ML/d

Seepage losses: Unmetered steady-state loss streams in any water balance model typically include evaporation, groundwater inflow and seepage. In the Wilpinjong OPSIM, evaporation is accounted for (see Section 3), and the combined influence of groundwater inflow and seepage (i.e. the net groundwater inflow) has been inferred as part of the model calibration exercise. The calibration inferred a positive net groundwater inflow to the water management system, which is consistent with groundwater modelling predictions documented in the 2017 Wilpinjong Annual Review Groundwater Analysis (Hydrosimulation, 2017). The water balance has assumed that the net groundwater inflow stream is comprised wholly of groundwater interception in the open cut voids, with no seepage outflow. The rationale supporting this assumption is as follows: 1) aquifers adjacent to open cut voids are understood to have been depressurised and as such any flow should be toward the voids; 2) seepage from pits or dams holding water is expected to drain back toward the mine water management system via preferential pathways (e.g. Pit 2W seepage will flow toward the depressurised Pit 4 void, Pit 1S seepage will flow towards the depressurised Pit 5 void).

Spoil aquifers: In-pit spoil dumps are porous and may transmit or store water under certain conditions. Spoil aquifer storage has been modelled adjacent to Pit 5N, and between Pit 2W and Pit 4. These areas are recharged or drained depending on the water level in the adjacent open cut void. Spoil aquifer storage capacities have been determined based on dump geometry and assuming a nominal spoil porosity of 20% (iteratively adjusted as part of model calibration). The model also simulates drainage of water from upslope pits to their respective downslope pits (i.e. Pit 5S to Pit 5N) through the interconnecting spoil aquifer (see schematic in Attachment A).

Section 3: Rainfall, Runoff & Evaporation

Rainfall: Rainfall inputs to the water balance have been based on data recorded by the site automated weather station (AWS) which is located within the rail loop (near the Clean Water Dam - see CWD location in Attachment B1/B2).

Evaporation (atmospheric): Evaporative losses from storages within the water balance model have been estimated based on daily evaporation depths and wetted surface areas. Evaporation depths have been sourced from the SILO Data Drill service (Morton Lake Evaporation). No adjustment factors have been applied to open cut pits (which are relatively shallow) or catchment areas. Wetted surface areas are calculated for each storage within the OPSIM model on a daily basis, using level-area-volume tables based on bathymetric survey or computer analysis of topographic survey data.

Evaporation (forced): WCPL operate a system of spray fans along the eastern bank of the Pit 2W water storage. These sprays propel water droplets into the atmosphere above the Pit 2W water surface in an attempt to increase evaporative losses from Pit 2W. Water losses have been estimated at 0.25 ML/d based on a spray rate of 1 ML/d and a recirculation factor of 75%, consistent with previous investigations (Hatch, 2017). The system has been in effect since January 2017. The water loss associated with these sprays during the July 2016 to June 2017 water balance period has been estimated at 45 ML.

Evaporation (total): The evaporation flow stream listed in the July 2016 to June 2017 water balance (Table 1) is the sum of atmospheric and forced evaporation.

Runoff: Catchment runoff is estimated within the Wilpinjong OPSIM using the Australian Water Balance Model (AWBM). The AWBM is a saturation overflow flow model which uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a water balance approach. Different AWBM parameters are defined for each land use type within the mine catchment. Catchment and Land Use maps are provided in Attachment B. Calibrated AWBM parameters are summarised in Table 2. Refer to Boughton (2003) for additional information regarding the AWBM.

Table 2: Calibrated AWBM Parameters

Parameter		Natural	Rehab	Spoil	High Runoff[1]
Partial Areas	A1	0.134	0.134	0.134	1.0
	A2	0.433	0.433	0.433	-
	A3	0.433	0.433	0.433	-
Soil Storage	S1	17.6 mm	13.2 mm	9.2 mm	15.0 mm
	S2	182.6 mm	136.9 mm	95.1 mm	-
	S3	366.2 mm	274.3 mm	190.7 mm	-
Surface Lag	Ks	0.50	0.50	0.50	0.00
Baseflow Index	BFI	0.80	0.97	0.97	0.00
Baseflow Lag	Kb	0.97	0.80	0.80	0.00
Avg. Storage	Savg	239.9 mm	179.8 mm	125.0 mm	15.0 mm
Avg. Yield[2]	R	4.5%	5.7%	8.0%	32.9%

Notes:

1. Hardstand, roads, pits, cleared, coal stockpiles and tailings all use this parameter set
2. Not a model parameter, calculated based on 129 years of SILO Data Drill climate data

Section 4: Discharge from WTF

Description: The WTF comprises two separate reverse osmosis (RO) treatment plants located immediately east of Pit 2W. Both plants receive a feed water stream from Pit 2W, and produce a low salinity permeate stream and a concentrate stream. The permeate stream is blended with small quantities of Pit 2W water and then discharged into Wilpinjong Creek in accordance with the site's environmental protection license (EPL No. 12425). The concentrate stream is recirculated into the water management system (either Pit 2W, Pit 1S or the RWD).

Discharge volumes: The volume of water discharged to Wilpinjong Creek via the WTF is measured and recorded by WCPL on a continuous basis. The water balance has been based on these measured volumes.

Section 5: Dust Suppression on Haul Roads

Description: A fleet of water carts extract water from the mine water management system via one of three fill points and apply to heavy and light vehicle roads to minimise dust lift-off. Fill points are located at Pit 2W, Pit 5, and the RWD.

Measurement: Water usage at each fill point is metered. Each water cart is also fitted with a global positioning system (GPS) transponder which automatically records the number of times each truck passes within a certain distance of a fill point. This 'trip count' data can be used to estimate water usage based on each trucks water holding capacity. The water balance has been based on metered fill point flow volumes, supplemented with trip count-based water usage estimates during any periods where the meters were temporarily offline. Measured usage rates have been factored by 0.90 to allow for over-filling (factor based on past experience at similar sites).

Section 6: CHPP and MIA Losses

CHPP water usage: Water is used in the CHPP to separate saleable coal from ROM impurities. The CHPP is supplied with mine water extracted from the CWD and RWD. Loss streams include moisture entrained within the product coal (railed offsite) and reject material stream (dumped in-pit). It is noted that the CHPP process was modified in 2015 to include a tailings belt filter press, which considerably reduced the plant's net water makeup requirement.

MIA water usage: Heavy and light vehicle wash bays, and washdown pads are located within the mine industrial area, adjacent to the CHPP. These areas are supplied with water extracted from the CWD and RWD, using the same infrastructure used to supply the CHPP. It is understood that excess water recovered from these activities is collected in drains which convey water back to the mine water management system (i.e. Pit 2W).

Measurement: WCPL measures the volume of water extracted from the CWD and RWD to supply the combined CHPP and MIA demands. CHPP and MIA offtakes are not individually metered. The total volume of water extracted from the CWD and RWD during the July 2016 to June 2017 water balance period was measured to be 1,592 ML.

Estimation of net losses: Net CHPP water losses were estimated through a water and solids mass balance, based on measured wash plant feed and product tonnages, and moisture contents documented as part of previous water balance investigations (Hatch, 2017). For the July 2016 to June 2017 water balance period, net CHPP water losses were estimated at approximately 812 ML. The residual 780 ML is understood to comprise MIA water usage (wash bays, washdown pads etc) and any water recovered from the CHPP process and not recirculated within the plant. The water balance has allowed for a nominal loss of 100 ML/yr for these activities, selected based on past experience at similar operations. As a result, of the 1,592 ML extracted from the CWD and RWD, approximately 912 ML is assumed to be lost, and 680 ML is recovered.

Section 7: Change in Volume

Surface water inventory: The change in volume over the July 2016 to June 2017 water balance period has been estimated based on historical water level data recorded by WCPL. Water levels have been converted to estimates of volume, using level-area-volume tables derived based on bathymetric survey or computer analysis of topographic survey data. The combined site volume at the start of July 2016 was 3,175 ML. The combined site volume at the end of June 2017 was

4,115 ML (note these totals exclude estimates of water stored in spoil aquifers). This represents a volume change (gain) of 940 ML.

Spoil aquifer storage: During the July 2016 to June 2017 period, water accumulated within Pit 5N, resulting in saturation of the adjacent in-pit spoil aquifer (see Section 2 'Groundwater, Seepage and Spoil Aquifers': spoil aquifers). Additional water is also expected to have accumulated in the in-pit spoil aquifer adjacent to Pit 2W, driven by an increase in the Pit 2W water level. The change in spoil aquifer inventory over the July 2016 to June 2017 period has been estimated at approximately 565 ML using the OPSIM model.

Total inventory change: The combined inventory change over the July 2016 to June 2017 water balance period is estimated at approximately 1,505 ML, calculated as the sum of the surface and spoil aquifer storage fluxes.

Closing

We trust that this advice satisfies WCPL's immediate requirements. Please do not hesitate to contact WRM if you have any questions or comments in relation to the content of this document.

For and on behalf of

WRM Water & Environment Pty Ltd

Gavin Rootsey

Senior Engineer

References:

Boughton, 2003	*'The Australian water balance model'*, October 2003.
Hatch, 2017	*'Report – Baseline OPSIM Model Setup'* H352411-00000-228-230-0001 Rev 0, Hatch Pty Ltd, April 2017.
EPA, 2017	*'Environmental Protection License – License 12425'*, New South Wales Environmental Protection Agency, January 2017.
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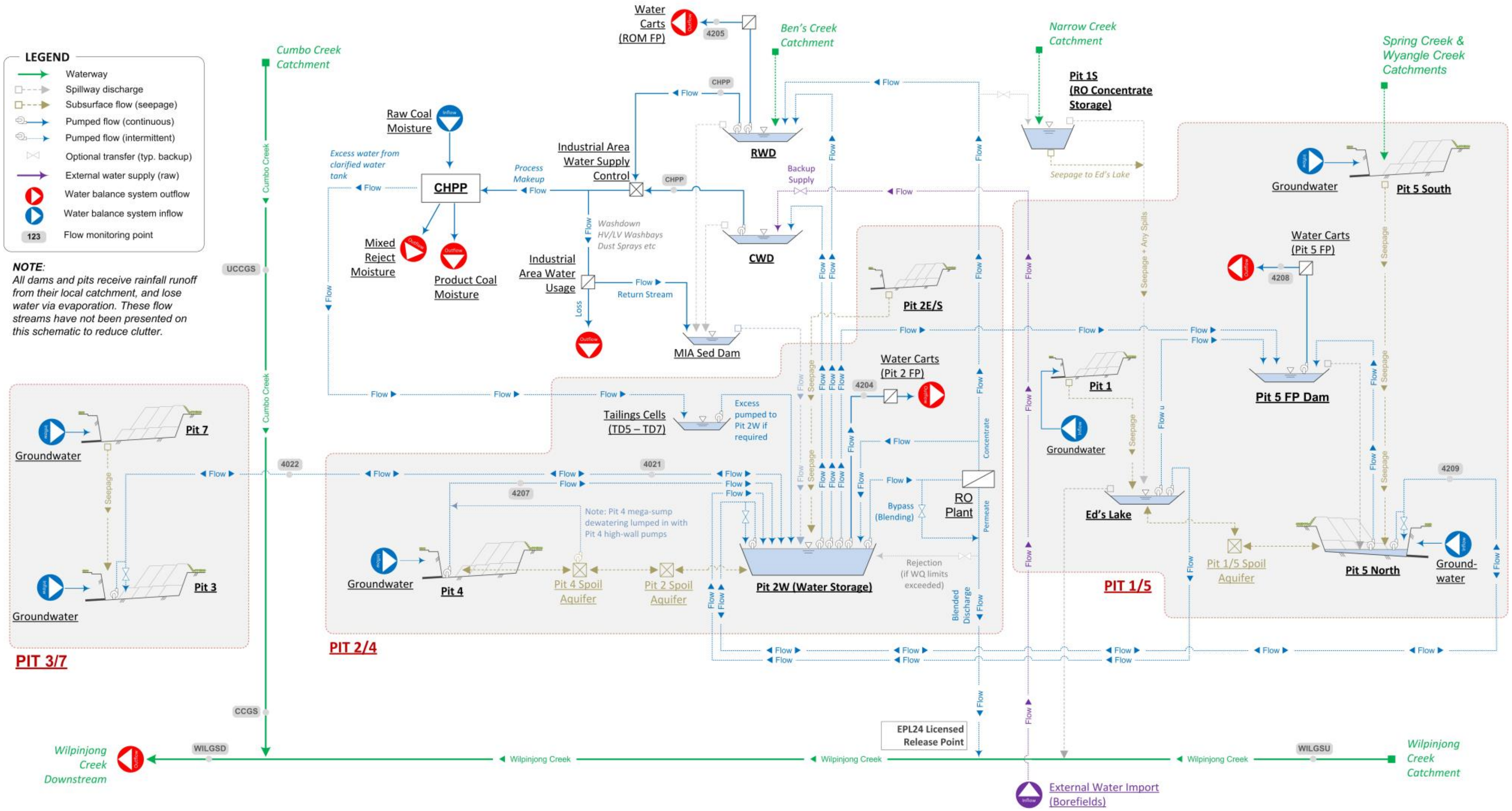
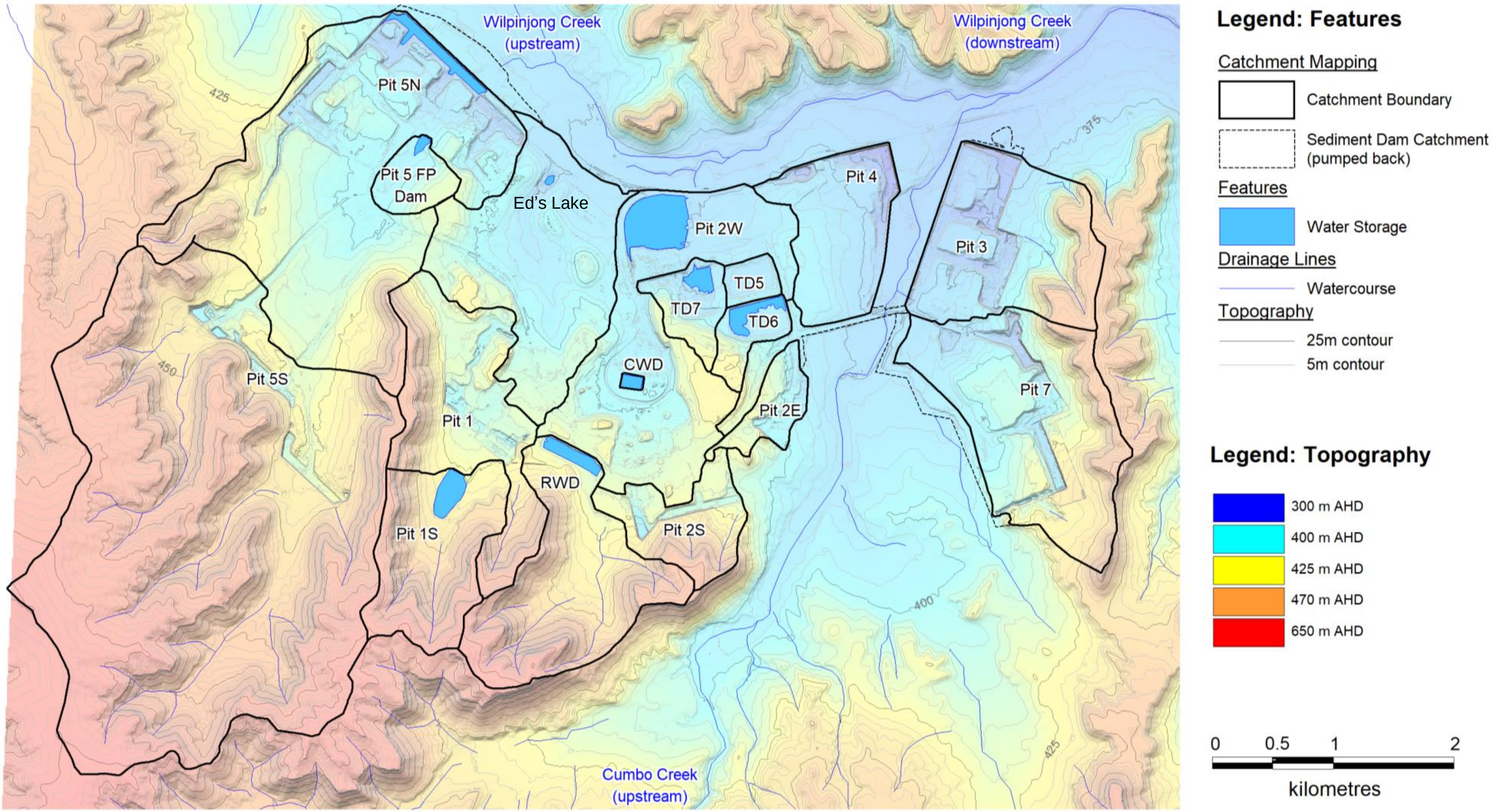
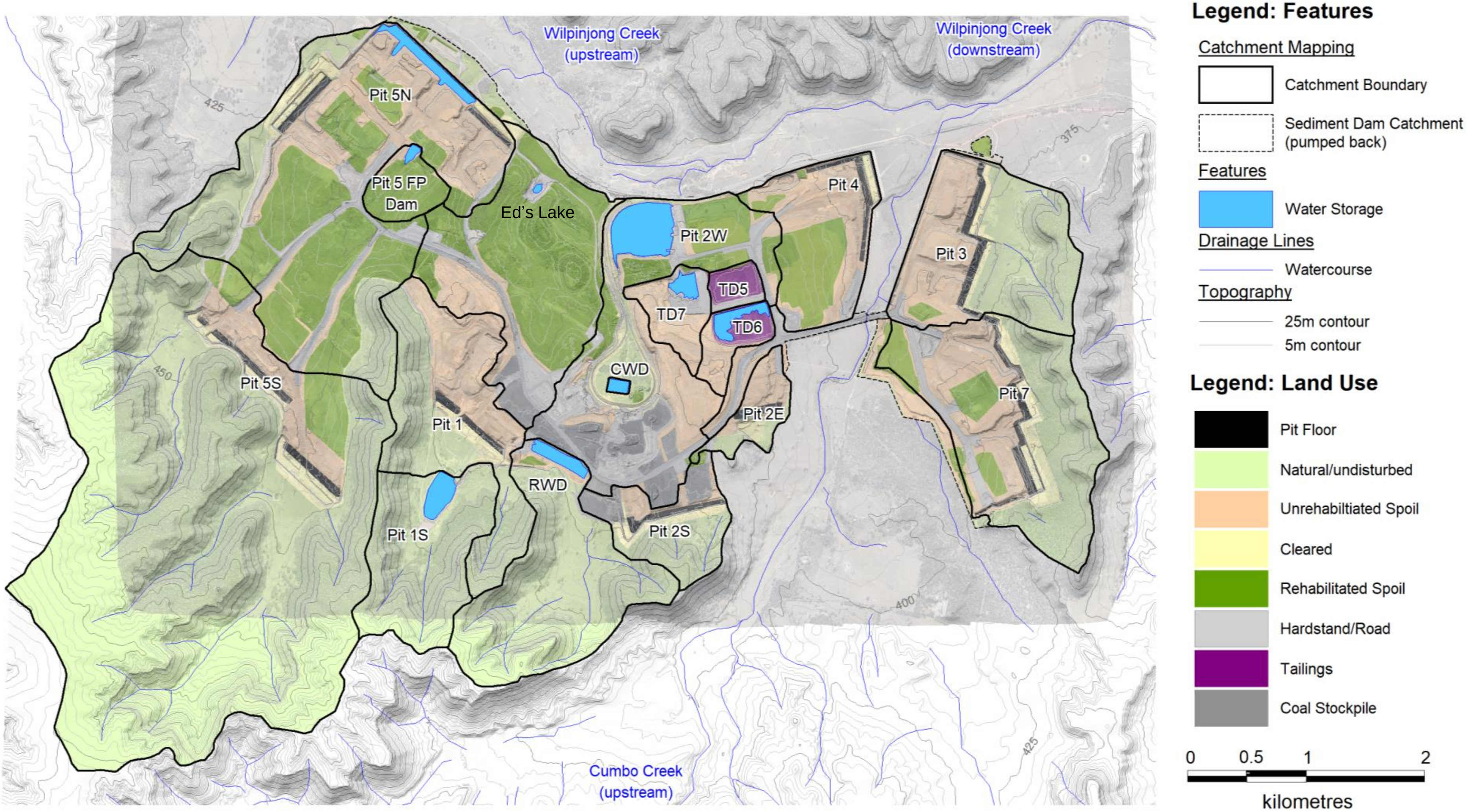


Attachment A: Wilpinjong OPSIM Model Schematic



Attachment B1: Wilpinjong Catchment Plan (2017 Site Conditions)



Attachment B2: Wilpinjong Land Use Plan (2017 Site Conditions)