APPENDIX 3C – SURFACE WATER MONITORING DATA

Summary of 2016 Results for Surface Water Monitoring

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	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 Results for Surface Water Monitoring

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
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 2014 Results of Surface Water Monitoring

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.

Summary of 2013 Results of Surface Water Monitoring

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

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

2016 Results for Surface Water Monitoring

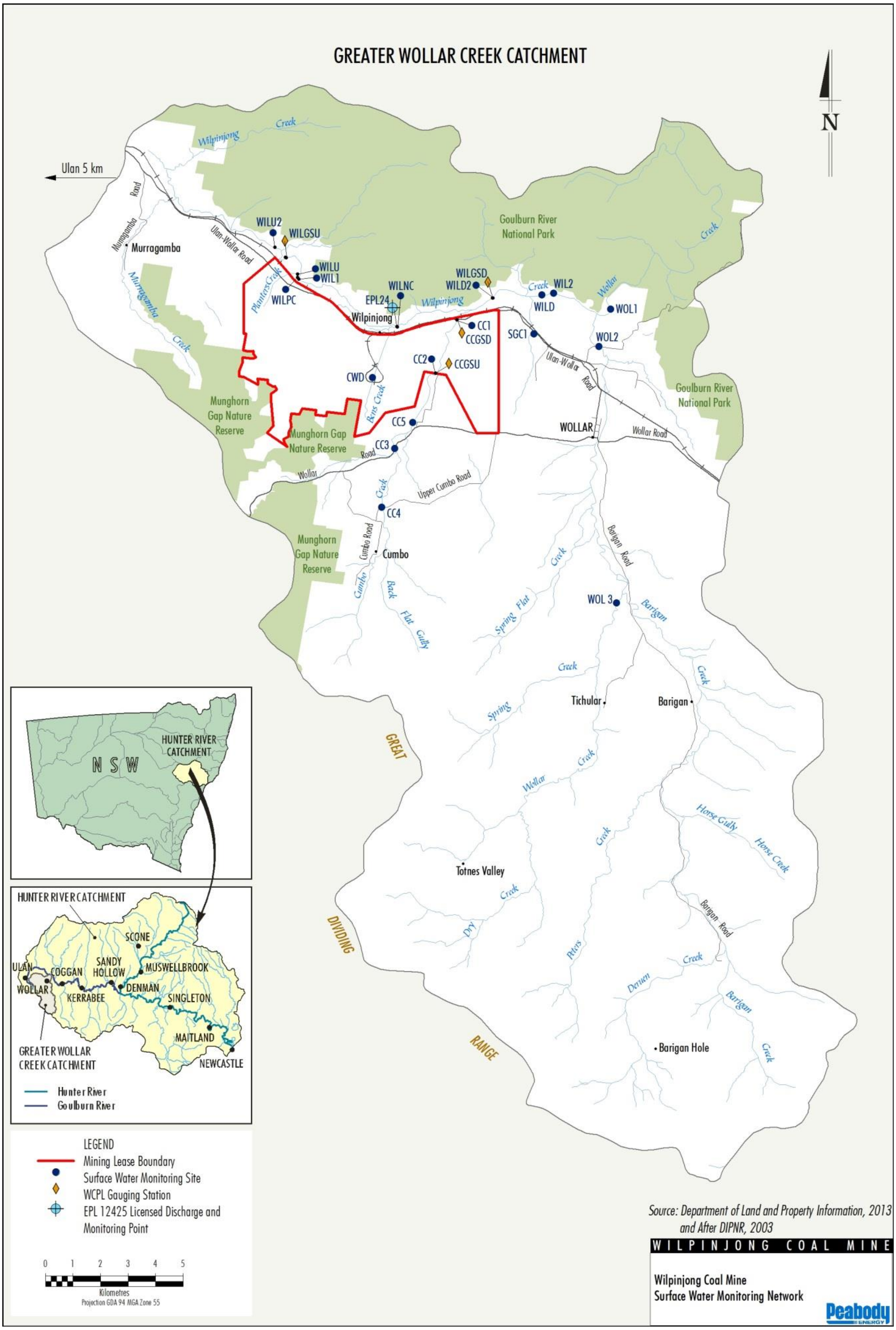
Sample No.	Sample Location	Sampling Date	Electrical Conductivity (Non Compensated) µS/cm	pH - Lab pH Unit	Sulfate mg/L	Turbidity NTU
ME1600071001	CC_1	15-Jan-2016	170	7.4	28	6270
ME1600071002	CC_2	15-Jan-2016	5440	7.5	1720	26.4
ME1600071003	CC_3	15-Jan-2016	80	7.4	8	126
ME1600071004	WIL_U	15-Jan-2016				
ME1600071005	WIL_U2	15-Jan-2016	1700	7.6	14	7.2
ME1600071006	WIL_NC	15-Jan-2016	440	7.3	63	132
ME1600071007	WIL_PC	15-Jan-2016				
ME1600071008	WIL_D	15-Jan-2016	700	7.4	76	39.4
ME1600071009	WIL_D2	15-Jan-2016	510	7.6	62	323
ME1600071010	WOL_1	15-Jan-2016	1330	8.1	211	9.3
ME1600071011	WOL_2	15-Jan-2016	2670	7.2	484	43.4
ME1600071012	SGC_1	15-Jan-2016				
ME1600071013	30M_U_CC1	15-Jan-2016				
ME1600248001	CC_1	22-Feb-2016	730	7.1	164	230
ME1600248002	CC_2	22-Feb-2016				
ME1600248003	CC_3	22-Feb-2016				
ME1600248004	WIL_U	22-Feb-2016				
ME1600248005	WIL_U2	22-Feb-2016				
ME1600248006	WIL_NC	22-Feb-2016	840	7.6	146	201
ME1600248007	WIL_PC	22-Feb-2016				
ME1600248008	WIL_D	22-Feb-2016	640	7.5	43	11
ME1600248009	WIL_D2	22-Feb-2016	430	8.1	11	4.5
ME1600248010	WOL_1	22-Feb-2016	1140	8.3	104	4.6
ME1600248011	WOL_2	22-Feb-2016	3160	7.7	650	70.7
ME1600248012	SGC_1	22-Feb-2016				
ME1600248013	30M_U_CC1	22-Feb-2016				
ME1600399001	CC_1	23-Mar-2016				
ME1600399002	CC_2	23-Mar-2016				
ME1600399003	CC_3	23-Mar-2016				
ME1600399004	WIL_U	23-Mar-2016				
ME1600399005	WIL_U2	23-Mar-2016	4420	7.1	30	26.1
ME1600399006	WIL_NC	23-Mar-2016	270	7.1	15	38.8
ME1600399007	WIL_PC	23-Mar-2016				
ME1600399008	WIL_D	23-Mar-2016	970	6.8	179	1.3
ME1600399009	WIL_D2	23-Mar-2016	460	6.9	103	15.5
ME1600399010	WOL_1	23-Mar-2016				
ME1600399011	WOL_2	23-Mar-2016				
ME1600399012	SGC_1	23-Mar-2016				
ME1600399013	30M_U_CC1	23-Mar-2016				
ME1600547001	CC_1	21-Apr-2016				
ME1600547002	CC_2	21-Apr-2016				
ME1600547003	CC_3	21-Apr-2016				
ME1600547004	WIL_U	21-Apr-2016				
ME1600547005	WIL_U2	21-Apr-2016	4010	7	20	53.1
ME1600547006	WIL_NC	21-Apr-2016				

Sample No.	Sample Location	Sampling Date	Electrical Conductivity (Non Compensated) µS/cm	pH - Lab pH Unit	Sulfate mg/L	Turbidity NTU
ME1600547007	WIL_PC	21-Apr-2016				
ME1600547008	WIL_D	21-Apr-2016	1830	8	137	4.4
ME1600547009	WIL_D2	21-Apr-2016				
ME1600547010	WOL_1	21-Apr-2016				
ME1600547011	WOL_2	21-Apr-2016				
ME1600547012	SGC_1	21-Apr-2016				
ME1600547013	30M_U_CC1	21-Apr-2016				
ME1600691001	CC_1	19-May-2016				
ME1600691002	CC_2	19-May-2016	7540	7.9	2940	4.6
ME1600691003	CC_3	19-May-2016				
ME1600691004	WIL_U	19-May-2016				
ME1600691005	WIL_U2	19-May-2016	3410	6.5	72	153
ME1600691006	WIL_NC	19-May-2016				
ME1600691007	WIL_PC	19-May-2016				
ME1600691008	WIL_D	19-May-2016	3030	7.5	161	5.1
ME1600691009	WIL_D2	19-May-2016				
ME1600691010	WOL_1	19-May-2016				
ME1600691011	WOL_2	19-May-2016				
ME1600691012	SGC_1	19-May-2016				
ME1600691013	30M_U_CC1	19-May-2016				
ME1600834001	CC_1	16-Jun-2016				
ME1600834002	CC_2	16-Jun-2016	6450	7.8	2370	0.5
ME1600834003	CC_3	16-Jun-2016				
ME1600834004	WIL_U	16-Jun-2016				
ME1600834005	WIL_U2	16-Jun-2016	2600	6.6	102	36.8
ME1600834006	WIL_NC	16-Jun-2016	278	7.6	8	90.2
ME1600834007	WIL_PC	16-Jun-2016				
ME1600834008	WIL_D	16-Jun-2016	720	7.2	112	21.7
ME1600834009	WIL_D2	16-Jun-2016	601	7.3	184	20.1
ME1600834010	WOL_1	16-Jun-2016	2220	8	475	2.9
ME1600834011	WOL_2	16-Jun-2016	2340	7.4	531	1
ME1600834012	SGC_1	16-Jun-2016				
ME1600834013	30M_U_CC1	16-Jun-2016				
ME1601014001	CC_1	25-Jul-2016	3340	7.3	1230	5.1
ME1601014002	CC_2	25-Jul-2016	4690	7.9	1560	0.8
ME1601014003	CC_3	25-Jul-2016	3950	8.3	1450	1.2
ME1601014004	WIL_U	25-Jul-2016	570	6.2	45	38.3
ME1601014005	WIL_U2	26-Jul-2016			65	18.1
ME1601014006	WIL_NC	25-Jul-2016	240	7.1	13	10
ME1601014007	WIL_PC	25-Jul-2016	450	6.9	32	33.2
ME1601014008	WIL_D	25-Jul-2016	1420	7.1	340	3
ME1601014009	WIL_D2	25-Jul-2016	1380	7.1	343	8.2
ME1601014010	WOL_1	25-Jul-2016	780	7.8	135	11.2
ME1601014011	WOL_2	25-Jul-2016	740	7.2	115	11.4
ME1601014012	SGC_1	25-Jul-2016				
ME1601014013	30M_U_CC1	25-Jul-2016	3370	7.4	1240	3.6

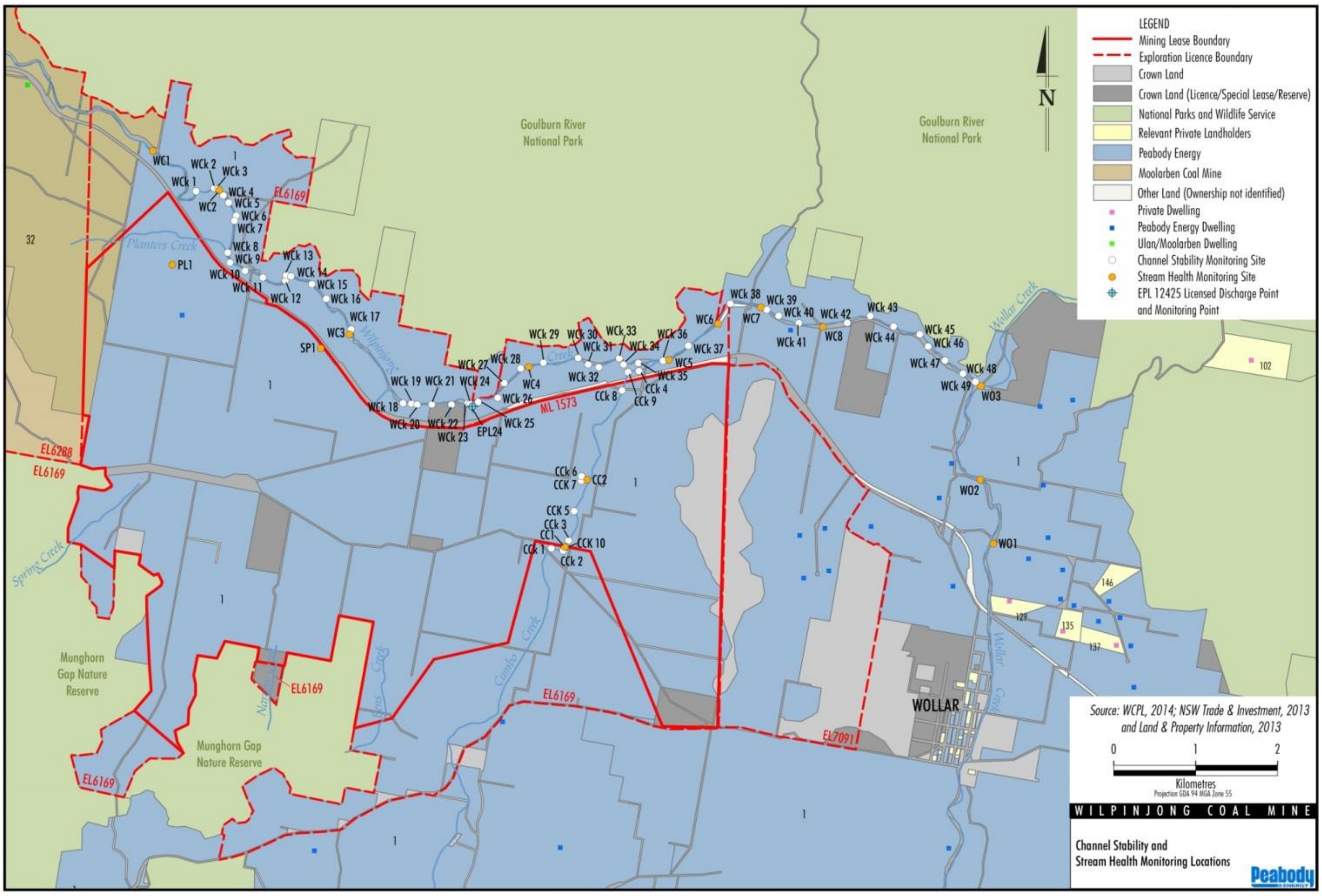
Sample No.	Sample Location	Sampling Date	Electrical Conductivity (Non Compensated) µS/cm	pH - Lab pH Unit	Sulfate mg/L	Turbidity NTU
ME1601158001	CC_1	18-Aug-2016	4470	7.4	1710	32.2
ME1601158002	CC_2	18-Aug-2016	5880	8	2050	1.3
ME1601158003	CC_3	18-Aug-2016	4860	8.4	1920	1.4
ME1601158004	WIL_U	18-Aug-2016	950	6.7	83	5.8
ME1601158005	WIL_U2	18-Aug-2016	1180	6.6	94	3.3
ME1601158006	WIL_NC	18-Aug-2016	240	7.4	10	19.7
ME1601158007	WIL_PC	18-Aug-2016	820	7	48	61.1
ME1601158008	WIL_D	18-Aug-2016	580	7.7	89	4.5
ME1601158009	WIL_D2	18-Aug-2016	510	7.8	84	8.6
ME1601158010	WOL_1	18-Aug-2016	1530	8.2	321	1.5
ME1601158011	WOL_2	18-Aug-2016	1900	7.6	408	1.2
ME1601158012	SGC_1	18-Aug-2016				
ME1601158013	30M_U_CC1	18-Aug-2016				
ME1601289001	CC_1	14-Sep-2016	3560	7.5	1230	4.6
ME1601289002	CC_2	14-Sep-2016	3020	7.8	920	4.8
ME1601289003	CC_3	14-Sep-2016	2690	8.2	877	20
ME1601289004	WIL_U	14-Sep-2016	520	7.2	27	43.5
ME1601289005	WIL_U2	14-Sep-2016	440	7.1	18	44
ME1601289006	WIL_NC	14-Sep-2016	1650	7.4	265	20.2
ME1601289007	WIL_PC	14-Sep-2016	260	7.4	11	64.6
ME1601289008	WIL_D	14-Sep-2016	750	7.5	136	24.2
ME1601289009	WIL_D2	14-Sep-2016	1140	7.5	244	44.5
ME1601289010	WOL_1	14-Sep-2016	930	8	143	5.8
ME1601289011	WOL_2	14-Sep-2016	840	7.7	120	4.9
ME1601289012	SGC_1	14-Sep-2016				
ME1601289013	30M_U_CC1	14-Sep-2016	3510	7.4	1200	3.4
ME1601466001	CC_1	19-Oct-2016	3700	7.9	1270	5.3
ME1601466002	CC_2	19-Oct-2016	3400	7.9	1120	0.7
ME1601466003	CC_3	19-Oct-2016	2300	8.4	699	0.7
ME1601466004	WIL_U	19-Oct-2016	570	7.4	16	8.8
ME1601466005	WIL_U2	19-Oct-2016	660	7.5	23	6.2
ME1601466006	WIL_NC	19-Oct-2016	760	7.3	67	10.7
ME1601466007	WIL_PC	19-Oct-2016	1340	7.3	45	9.7
ME1601466008	WIL_D	19-Oct-2016	2190	7.6	603	2.6
ME1601466009	WIL_D2	19-Oct-2016	1840	7.5	466	5.5
ME1601466010	WOL_1	19-Oct-2016	920	8.2	142	3.6
ME1601466011	WOL_2	19-Oct-2016	790	8	97	2.1
ME1601466012	SGC_1	19-Oct-2016				
ME1601466013	30M_U_CC1	19-Oct-2016	3740	8	1230	6.2
ME1601619001	CC_1	17-Nov-2016	3650	7.3	1220	5.1
ME1601619002	CC_2	17-Nov-2016	3870	7.9	1230	1
ME1601619003	CC_3	17-Nov-2016	2750	8.4	881	1
ME1601619004	WIL_U	17-Nov-2016	550	7.2	13	9.6
ME1601619005	WIL_U2	17-Nov-2016	820	7.3	32	5.8
ME1601619006	WIL_NC	17-Nov-2016	570	7.3	47	10.9
ME1601619007	WIL_PC	17-Nov-2016	540	7.2	7	22.9

Sample No.	Sample Location	Sampling Date	Electrical Conductivity (Non Compensated) µS/cm	pH - Lab pH Unit	Sulfate mg/L	Turbidity NTU
ME1601619008	WIL_D	17-Nov-2016	790	7.5	98	1.2
ME1601619009	WIL_D2	17-Nov-2016	700	7.4	85	3.9
ME1601619010	WOL_1	21-Nov-2016	960	8.3	115	1.3
ME1601619011	WOL_2	21-Nov-2016	990	7.6	118	0.9
ME1601619012	SGC_1	17-Nov-2016				
ME1601619013	30M_U_CC1	17-Nov-2016				
ME1601767001	CC_1	15-Dec-2016				
ME1601767002	CC_2	15-Dec-2016				
ME1601767003	CC_3	15-Dec-2016				
ME1601767004	WIL_U	15-Dec-2016				
ME1601767005	WIL_U2	15-Dec-2016	2160	7.1	43	12.3
ME1601767006	WIL_NC	15-Dec-2016	320	7.8	11	8.6
ME1601767007	WIL_PC	15-Dec-2016				
ME1601767008	WIL_D	15-Dec-2016	650	7.7	12	1.5
ME1601767009	WIL_D2	15-Dec-2016	390	7.8	9	4.4
ME1601767010	WOL_1	15-Dec-2016	1190	8.2	94	2.6
ME1601767011	WOL_2	15-Dec-2016	1810	7.6	205	2.0
ME1601767012	SGC_1	15-Dec-2016				

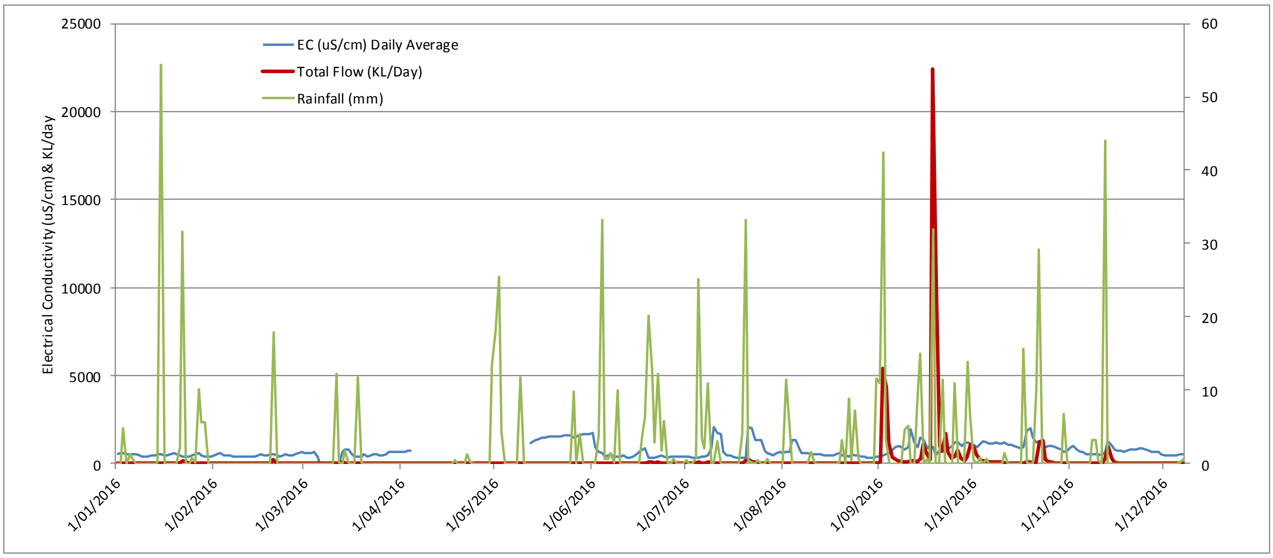
Surface Water Monitoring Locations



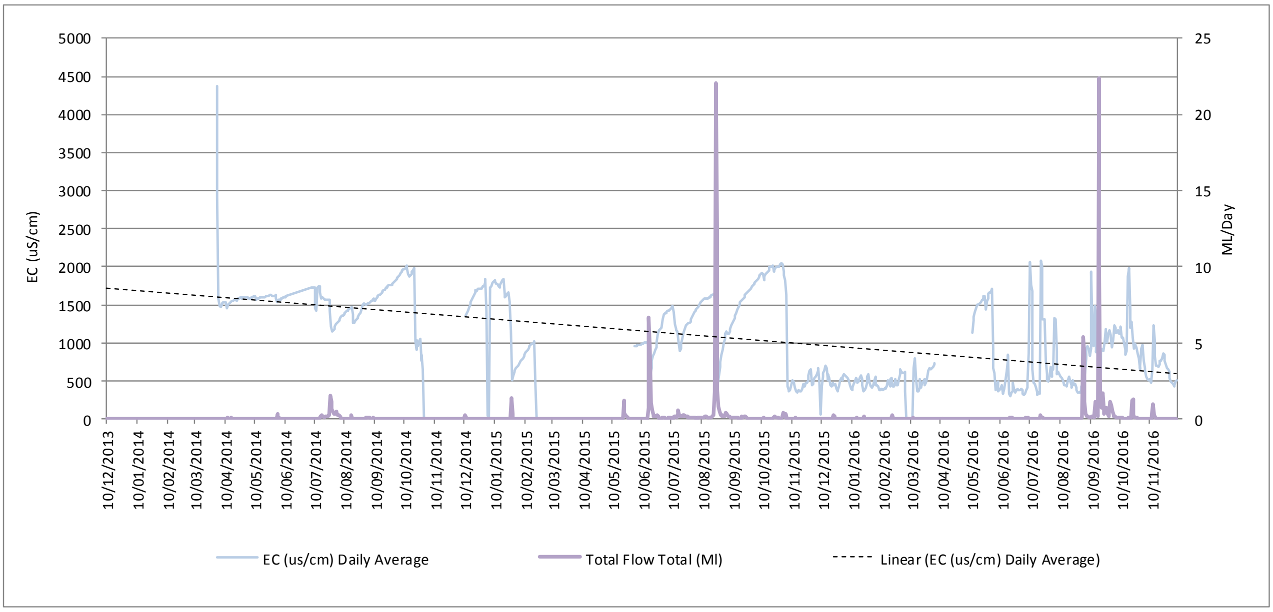
Channel Stability & Stream Health Monitoring Locations



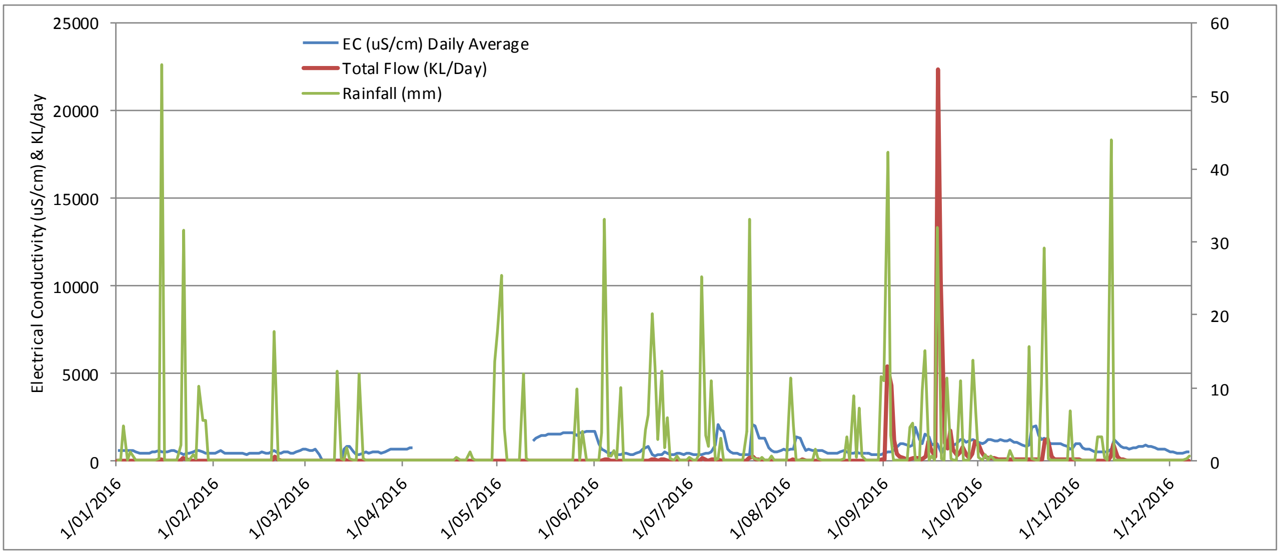
2016 Wilpinjong Creek Upstream Gauging Station



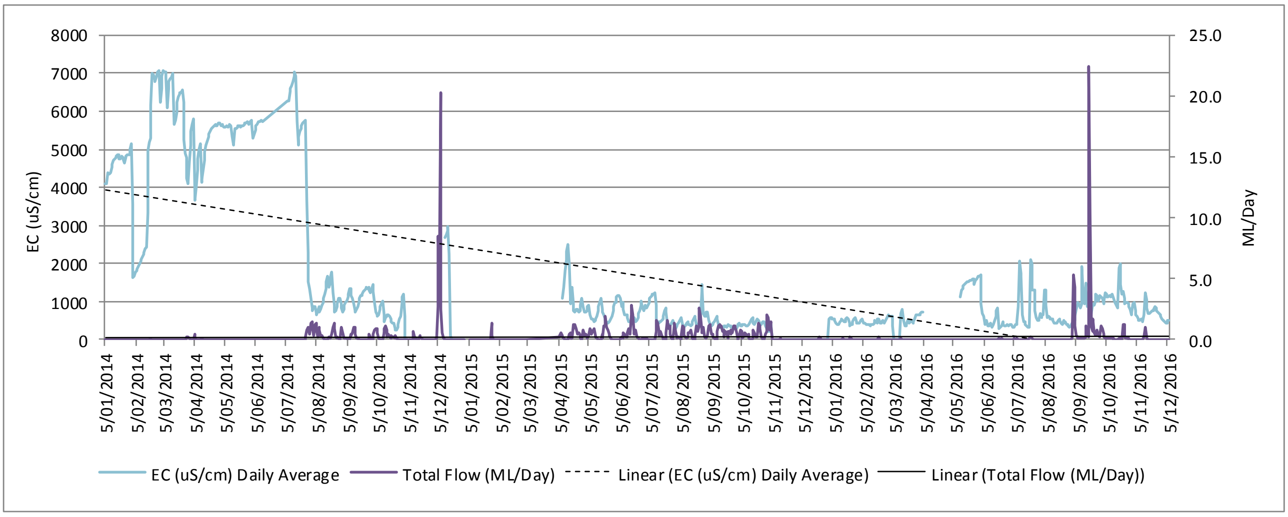
2014-2016 Wilpinjong Creek Upstream Gauging Station



2016 Wilpinjong Creek Downstream Gauging Station

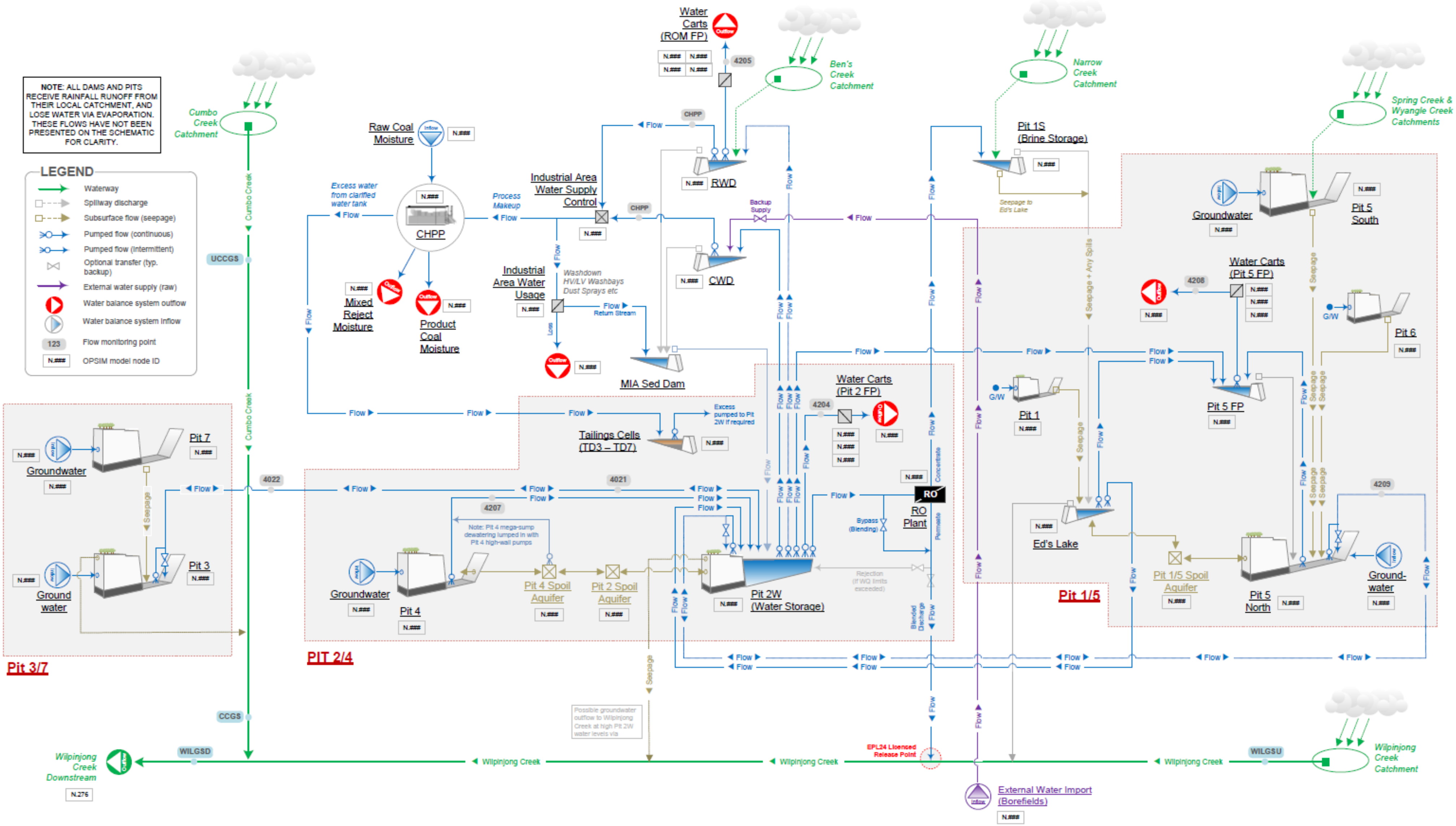


2014-2016 Wilpinjong Creek Downstream Gauging Station



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



Creek Stability Monitoring Reports

Wilpinjong & Cumbo Creek Stability Assessment, 2016

Wilpinjong Coal Mine

For: Ian Flood

structural engineering
project management
residential design
civil engineering
registered surveyors
commercial design
geotechnical engineering
town planning
graphic representations
environmental drilling
construction management
mechanical engineering
industrial design
environmental consulting
nata accredited
testing laboratory
electrical engineering
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Mar-17
(Our Reference: 26081_E02_Final)

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DOCUMENT TRACKING

ITEM	DETAILS
Project Name & Number	Wilpinjong and Cumbo Creek Stability Assessment 2016 # 26081
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Report Preparation	Kristy Bennetts
Peer Reviewed	Natalie Richards
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ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

Wilpinjong Coal Proprietary Limited (WCPL) commissioned Barnson Pty Ltd (Barnson) in November 2016 to undertake the annual stability assessment of Wilpinjong and Cumbo Creeks. The 2016 assessment was undertaken as a qualitative assessment to review natural regeneration of the creek. This includes improved creek bank stability, reduction in erosional areas and improved riparian zones within the Wilpinjong Creek catchment.

This report provides details on the fieldwork undertaken in 2016, and compares Wilpinjong and Cumbo Creeks with the previous assessment in 2015, 2014, and 2011.

1.1 Project Overview

Wilpinjong Coal Mine is situated in the Central Tablelands of NSW. It is located in the Mid-Western Regional Council Local Government Area, approximately 40 km north-east of Mudgee, near the Village of Wollar. The mine is located at the headwaters of the Goulburn River catchment, which is a major tributary of the Hunter River. The mine is wholly owned and operated by Peabody Energy Ltd.

The basis of this report is to satisfy Schedule 3, Condition 32 (e) of Project Approval (05-0021), together with the Channel Stability Monitoring Programme as outlined in Section 7 of the site Surface Water Management and Monitoring Plan. The plan states that *'the channel stability monitoring programme aims to provide qualitative measures of stream bed and bank erosion and channel instability along Wilpinjong and Cumbo Creeks.'* Monitoring details are provided in the plan and are largely based on obtaining cross sectional and longitudinal survey data and making comparisons in relation to change over time. This is with the exception of point four which states '*Photographs and written descriptions "of each site will be also undertaken, focusing on evidence of erosion and exposed soils'*.

This Environmental Stability Assessment builds on previous surveys undertaken by Barnson, for qualitative comparative purposes.

1.2 Project Objectives

There are two main objective of this assessment. They are:

- Assess the stability of Wilpinjong and Cumbo Creeks using a rapid assessment methodology, which was refined in 2013.
- Compare visual channel stability at each of the pre-selected sites against a previous survey undertaken in 2015, 2014, and 2011.

The visual assessment relies upon the established GPS photographic points previously determined, where possible.

1.3 Project Background

During 2007 permanent survey locations were selected by Peabody Energy. These survey locations are generally in use today. Updated site localities are identified in **Figure 1**. These points are located along 13km of Wilpinjong Creek – from the upstream gauging station in the west, to the confluence with the Goulburn River in the east, and 3km of Cumbo Creek, adjacent to the minesite. Barnson has undertaken qualitative monitoring of this creek annually from 2010-2016. However, comparisons for this year are provided to years 2011, 2014 and 2015.

Wilpinjong Creek is located within the Greater Wollar catchment area. The dominant non-mining land use within and around the project area is cattle and sheep grazing with some intermittent cropping (fodder crops). Cumbo Creek drains into Wilpinjong Creek approximately 4km upstream of the confluence of Wilpinjong Creek and Wollar Creek. Both creeks suffer moderate to severe erosion and poor riparian health as a result of past practises. The Environmental Impact Statement (EIS) undertaken for the Wilpinjong Coal project described Wilpinjong Creek in Table 3.4 of Section 3.2.2 of the EIS as being a- *well incised channel (3-4m deep). Varies significantly including dry areas, semi-permanent soaks, pools and riffle sequences and swampy areas with extensive areas of reed growth along the creek bed. Severely impacted by grazing of livestock and kangaroos. Vegetation on the banks and overbank areas is predominantly grass with occasional trees and little riparian vegetation.* Cumbo Creek was described as - *Upper parts of the creek drain through low-lying marshes with stream bank and stream bed erosion. Heavily modified by land clearing and grazing. Little riparian vegetation.*

The Aquatic Ecosystem Assessment undertaken by Bio-Analysis for the EIS (Appendix AH) states in HD7 that *in general, the aquatic habitats were found to be in very poor condition and generally reflected the degraded nature of the immediate catchments.* This report indicates that *stock exclusion, weed control and establishment of vegetation in the riparian areas would lead to improved habitats for aquatic biota.*

A comprehensive surface water assessment was also undertaken by Resource Strategies in 2005 as part of the EIS. The assessment found that runoff (total catchment yield) is a small percentage of rainfall, and that baseflow (comprising both deeper groundwater and interflow/underflow) is estimated to account for some 40% of total flow. It was predicted that the Project has the potential to reduce flows in Wilpinjong Creek by up to 11%, as a result of a reduction in overland flow from the Project catchment and indirectly through reductions in the rate of groundwater discharge to the creek. This should, in general terms, reduce baseflow induced erosion, such as sheeting.

Mitigation measures suggested in the EIS include the enhancement of riparian vegetation in sections of Wilpinjong and Cumbo Creeks. These enhancement works are expected to have a positive impact on the in-stream ecology of Wilpinjong and Cumbo Creeks. In terms of channel stability, enhancement works would also allow for improved creek stability and reduced erosion of the creek beds and banks.

Surface waters within the project area were re-assessed by Gilbert and Associates Pty Ltd in 2013 as part of the s75W modification to the current conditions of consent. No creek stability issues or recommendations were raised in this assessment.

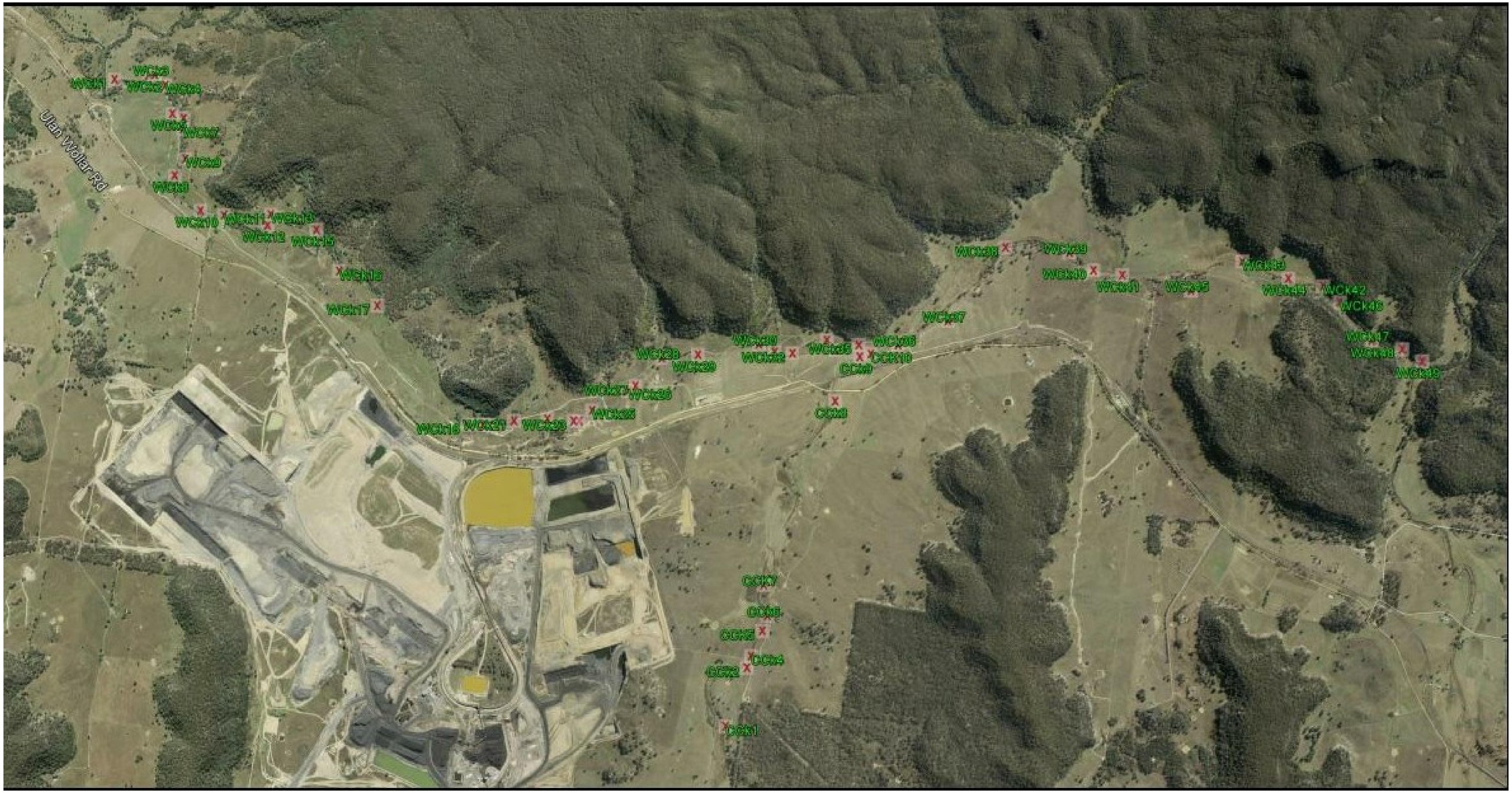
Over the past several years the creek has been subject to periods of drought and flooding. To date, no rehabilitation control sites along any other local creeks have been established or utilised for comparative purposes, nor has an historical assessment based on old aerial photographs been undertaken.

1.4 Report Limitations

It is not within the scope of this stability monitoring project to undertake extensive creek analysis in terms of the following forms of assessment. WCPL may consider undertaking one or all of these assessments in the future. Assessments not included in this project including, but not limited to:

- Geophysical Survey, including assessment of subsurface conditions
- Cross Sectional Analysis utilising accurate survey instrumentation and
- LiDAR (Light Detection and Ranging) Analysis.

No permanent marker/survey pegs have been installed along either of the creeks for ongoing monitoring purposes.



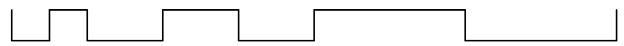


FIGURE 1 – WILPINJOG CREEK AND CUMBO CREEK SURVEY LOCATIONS

SCALE: 1 : 30,000

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Client:	WILPINGJONG COAL MINE
Project:	WILPINJONG CREEK
Drawing Title:	FIGURE 1 - WILPINJONG CREEK AND CUMBO CREEK SURVEY LOCATIONS
Design:	.
Drawn:	CP
Check:	KB
QA:	KB
Drawing Sheet	A3 - Scales as noted
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Amendment	
Sheet	01 of
Drawing Number	26081-A01
Revision	A

2.0 METHODOLOGY

2.1 Rainfall and Flood Analysis

The intensity and amount of rainfall can result in flooding and thus influence erosion by way of scouring, slumping and surface destabilisation within rural creeks. The amount of erosion is influenced by vegetation cover, topography, climatic factors and soil characteristics. The rate of soil erosion is influenced by the erosivity - the amount of rainfall and precipitation intensity.

IFD stands for Intensity-Frequency-Duration, of rainfall. The processes of determining IFD is known as frequency analysis, is an important part of hydrological design procedures. An IFD table for the Wilpinjong catchment was generated using the Bureau of Meteorology's (BoM) '2016 Rainfall IFD Data System', available at:

http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016

Rainfall data for 2016 was provided by WCPL. Rainfall data was collected from the WCPL Meteorology Station and provided to Barnson in 15 minute and hourly increments, as well as daily totals. This data was examined in consultation with the IFD table to determine the ARI (average recurrence interval) or rarity of rainfall events over the 12-month period to determine if any rainfall events would impact creek stability or erosion.

2.2 Field Survey - Stability & Comparative Assessment

To satisfy the project objectives, a field survey was undertaken by Kristy Bennetts (Environmental Scientist) and Ellissa Harris (Graduate Environmental Engineer) in December 2016. This involved walking each creek from the creek headwater to its confluence. Photographs of each site (upstream, downstream) were taken for comparative purposes, a field proforma was completed and any signs of bed lowering or erosion were identified and recorded. The pre-selected monitoring points are illustrated in **Figure 1,** and were found using survey GPS instrumentation. For the 2016 survey, the same proforma updated in 2013 was utilised. This updated proforma was refined using a number of sources, including:

- CSIRO Ephemeral Assessment Methodology;
- Australian Soil and Land Survey Field Handbook (2009);
- Heeren, D.M et al (2012) *Using Rapid Geomorphic Assessments to Assess Streambank Stability in Oklahoma Ozark Streams*, American Society of Agriculture and Biological Engineers.

The field proforma is contained at **Appendix A**, with a summary of results located in Section 3. A Bank Erosion Hazard Index (BEHI), as proposed by Heeren et al, was also completed for each site and updated where required in 2015.

3.0 RESULTS

3.1 Rainfall and Flood Analysis

IFD tables and graphs were produced via the BoM 2016 Rainfall IFD Data System for:

- **Frequent and Infrequent events** - **Table 1 and Graph 1,** with the annual exceedance probability (AEP) provided as a percentage;
- **Very Frequent events - Table 2 and Graph**, with AEP expressed as the number of times an event is likely to occur or be exceeded within any given year.

Table 1 : Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP) , Frequent and Infrequent events

		Annual Exceedance Probability (AEP)						
Duration	Duration in min	63.20%	50%#	20%*	10%	5%	2%	1%
15 min	15	12.1	13.5	17.8	20.8	23.9	28.3	31.8
1 hour	60	20.3	22.5	29.6	34.6	39.7	46.4	51.7
24 hour	1440	52.2	58.3	78.8	93.7	109	132	152

Note:

The 50% AEP IFD **does not** correspond to the 2-year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.

* The 20% AEP IFD **does not** correspond to the 5-year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

Table 2 : Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP), Very Frequent Events

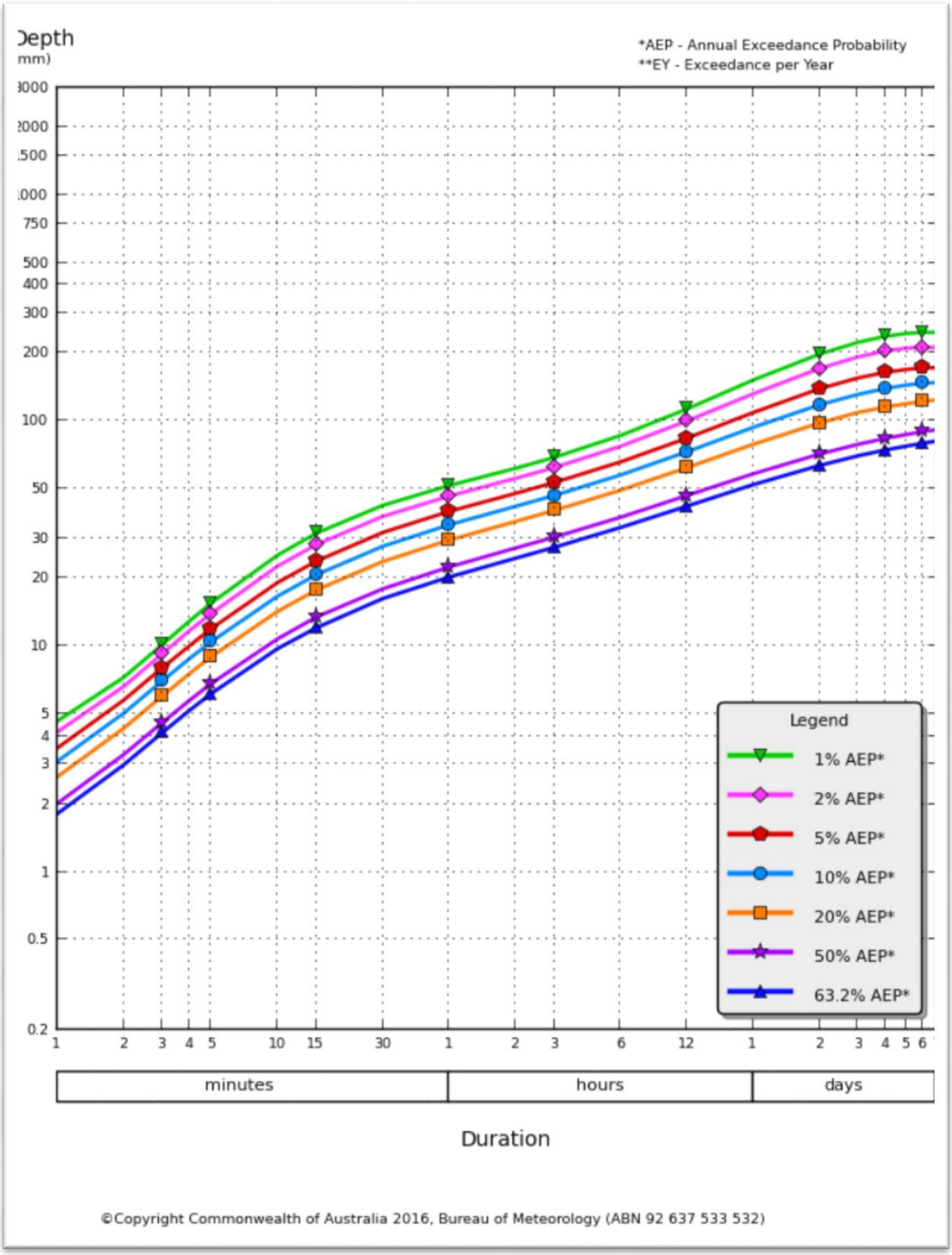
		Exceedance per Year (EY)							
Duration	Duration in min	12EY	6EY	4EY	3EY	2EY	1EY	0.5EY#	0.2EY*
15 min	15	4.52	5.36	6.84	7.91	9.44	12.1	14.9	18.1
1 hour	60	8.42	9.74	12	13.7	16.1	20.3	25	30.2
24 hour	1440	22.2	25.6	31.5	35.7	41.7	52.2	64.8	80.4

Note:

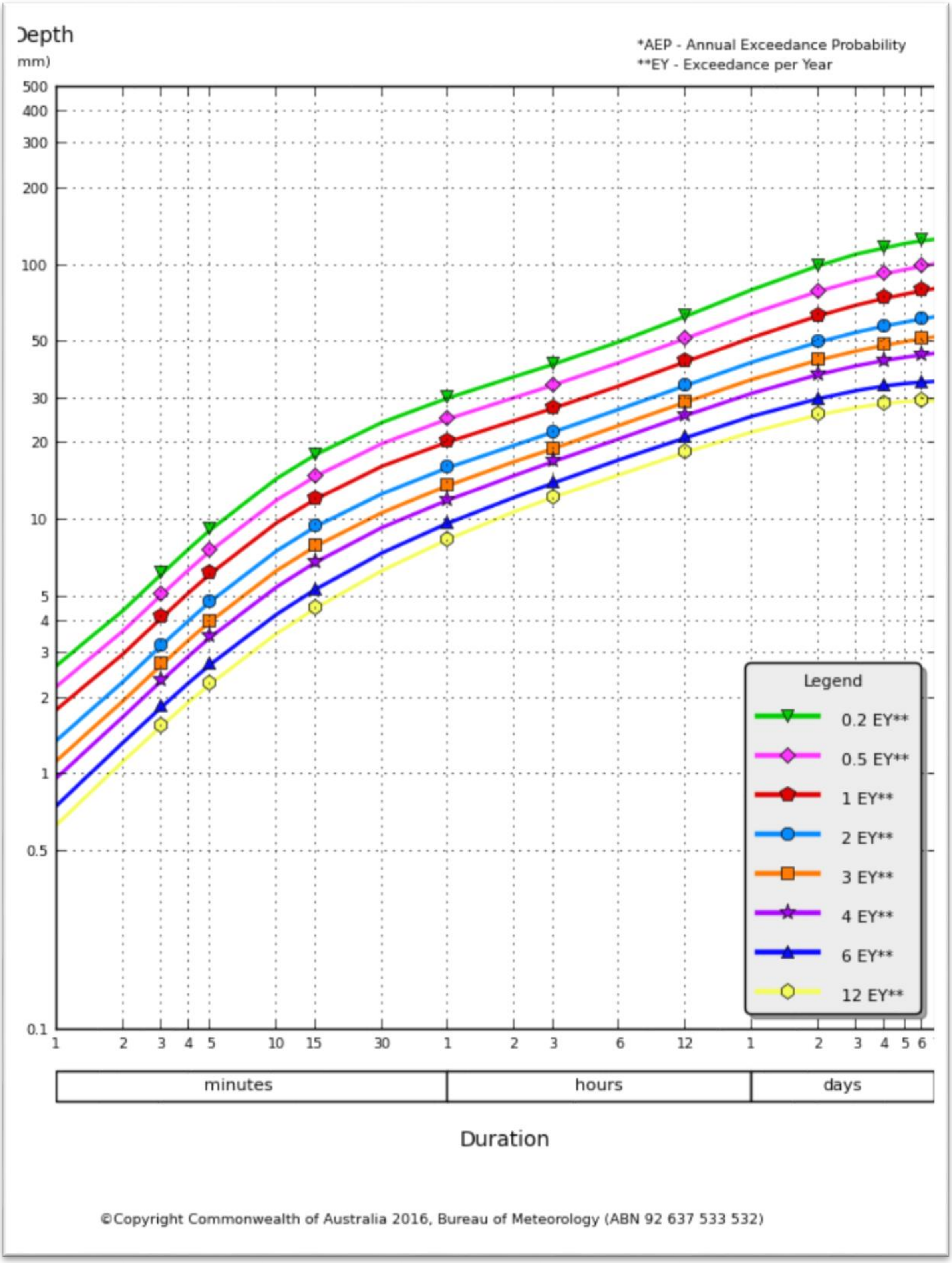
The 0.5 EY design rainfall corresponds to the 2-year Average Recurrence Interval (ARI) IFD **not** the 50% AEP IFD.

* The 0.2 EY design rainfall corresponds to the 5-year Average Recurrence Interval (ARI) IFD **not** the 20% AEP IFD.

Graph 1 - Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP), Frequent and Infrequent events



Graph 2 : Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP), Very Frequent Events



The current (2012) total catchment area of Wilpinjong creek upstream of the Project Area (from the upstream gauging station) was calculated to be $81km^2$, with the downstream catchment calculated to be $175km^2$ (Gilberts & Associates, 2013). The Cumbo Creek catchment area (upstream of the confluence with Wilpinjong Creek) was reported to be $70km^2$. Both Creeks are ephemeral in nature, meaning flow is limited to after prolonged rainfall or heavy storm events.

Unfortunately, information relating to velocities of flow versus scouring potential of soils within each of these creeks is somewhat limited. It is generally accepted that a well vegetated creek bank and bed will not scour during a minor storm event (i.e. 1 in 5 year ARI storm event).

Appendix B provides rainfall data as provided by WCPL for the reporting period as recorded from the WCPL meteorological station in the 24-hour period 9am-9am. Rainfall data was provided in daily, hourly and 15 minute increments. The total rainfall for the reporting period 1 January 2016 -31 December 2016 was calculated to be 815.6mm. This is greater than the previous several reporting periods (1 January -31 December), which recorded a total of 761.6mm, 683mm, 496.2mm, 629.2mm in 2015, 2014, 2013, and 2012 respectively.

On inspection of the available 15-minute rainfall data for 2016, with respect to rainfall depth for durations, exceedance per year, and annual exceedance probabilities, the following is noted:

- 22/1/16 – One 5% AEP was recorded (22mm between 5:15-5:30pm);
- 2/5/16 – One 10% AEP was recorded (20.8mm between 7:30-7:45pm);
- 22/10/16 – One 50% AEP was recorded (13.2mm between 4:00-4:15am);
- There were 10 events recorded above the 12 exceedances per year for 15-minute rainfall durations. Of these two were above the 1 in 5 year ARI of 18.1mm in 15minutes. The rest corresponds to less than a 1 in 2 year ARI.

On inspection of the available hourly rainfall data for 2016, with respect to rainfall depth for durations, exceedance per year, and annual exceedance probabilities, the following is noted:

- 22/1/16 – One 20-50% AEP was recorded (27mm between 4:00-5:00pm);
- 2/5/16 and 22/10/16 – both recorded 63.2% AEP with 22.6mm (6:00pm-7:00pm) and 23.6mm (4:00am-5:00am) respectively;
- One rainfall event was above the 2 year ARI of 25mm - 22/1/16 (27mm between 4:00am-5:00am);
- Two other rainfall events were above the one expected exceedance per year limit of 20.3mm (23.6mm on 2/5/16 between 6:00pm-7pm and 22.6mm on 22/10/16 between 4:00am-5:00am);
- There was a total of eight rainfall events that fell above the 12 exceedance events per year figure of 8.42mm in one hour.

On inspection of the available daily rainfall data for 2016, with respect to rainfall depth for durations, exceedance per year, and annual exceedance probabilities, the following is noted:

- Of the 108 days' rain fell at WC - 1 rainfall event corresponded to between a 1 and 2 year ARI (15/1/16, 54.4mm was recorded);
- 10 events were recorded within the 12 expected exceedances for the year (greater than 22.2mm in 24hours) of which 8 were greater than the expected 6 expected exceedance events for the year, and 3 were greater than the expected 2 exceedances per year (15/1/17, 2/9/17 and 12/11/17).

All other rainfall events were within or under a rating less than a 1 in 1 year storm event.

Although the rainfall total for the 2016 reporting period exceeded the annual average of 653mm (as per Bureau of Meteorology), there was only two 15-minute rainfall events that exceeded the 1 in 5-year storm ARI. Therefore, it is likely that the reporting period did generate some local scouring in the area over the year.

3.2 Field Survey - Stability Results

3.2.1 Wilpinjong Creek

Creek bank stability during low flow is, in areas, continuing to improve along much of the Wilpinjong Creek. **Table 3** provides BEHI results for the creek. Destocking along much of the creek, as well as fencing out riparian areas, continues to allow for natural regeneration to occur. Seven sites improved stability from the previous reporting period- scoring an improved 'stable' from 'unstable' (Sites – 18, 27, 36, 37, 39 and 44). One site improved from 'moderately unstable' to 'unstable' (Site 26), and one site scored a reduced stability score from 'stable' to unstable (Site 3). Of the 48 sites assessed along Wilpinjong Creek in 2016, 29 scored within the 'stable' to 'moderately stable' range. This is improved from 23 in the previous reporting period. This reporting period 19 sites scored within the 'unstable' to 'moderately unstable' range, which is a reduction from 25 last year. The creek bed still remains largely obscured by in-stream vegetation, particularly in the upper reaches. However, there was an increase in flora species growth in the lower reaches, due to recent rainfall. There is little evidence of bed erosion, bed lowering, knickpoints and sediment deposition along much of the creek. Instream species diversity also remains low, with minimal snags and habitat features.

There remain visible areas of bank erosional features along the length of the creek – including large areas of undercutting, sheet wash and gullying, however groundcover continues to improve. **Figure 2** identifies the areas at greatest risk of erosion and instability. The upper banks are subject to high erosional potential during high flows or flooding.

Riparian health along much of the creek continues to remain poor. This is the result of a floristic profile being dominated by grasses. Tree and shrub layers are largely absent along most of the creek. Noxious weed species such as blackberry, various thistle species and prickly pear still exist in pockets along the length of the creek.

3.2.2 Cumbo Creek

Creek Stability along Cumbo Creek remains stable for the length of the creek surveyed. **Table 4** provides BEHI results for the creek. No sites were assessed as being within the unstable classification, however an area of instability was noted near site 8. This creek continues to lack species diversity and structural diversity. It possesses low banks with moderate to low slopes. Banks are largely stable as a result of a high degree of groundcover. Erosional features continue to remain minimal. The creek bed is largely obscured by in stream vegetation, which is again dominated by one species. Riparian health along the creek remains largely poor. This is the result of a floristic profile being dominated by grasses and a tree and shrub layer being largely absent along the creek. As a result of the low slopes and high ground cover, Cumbo creek remains largely stable. Site 7 was excluded from the assessed due to mining in the area.

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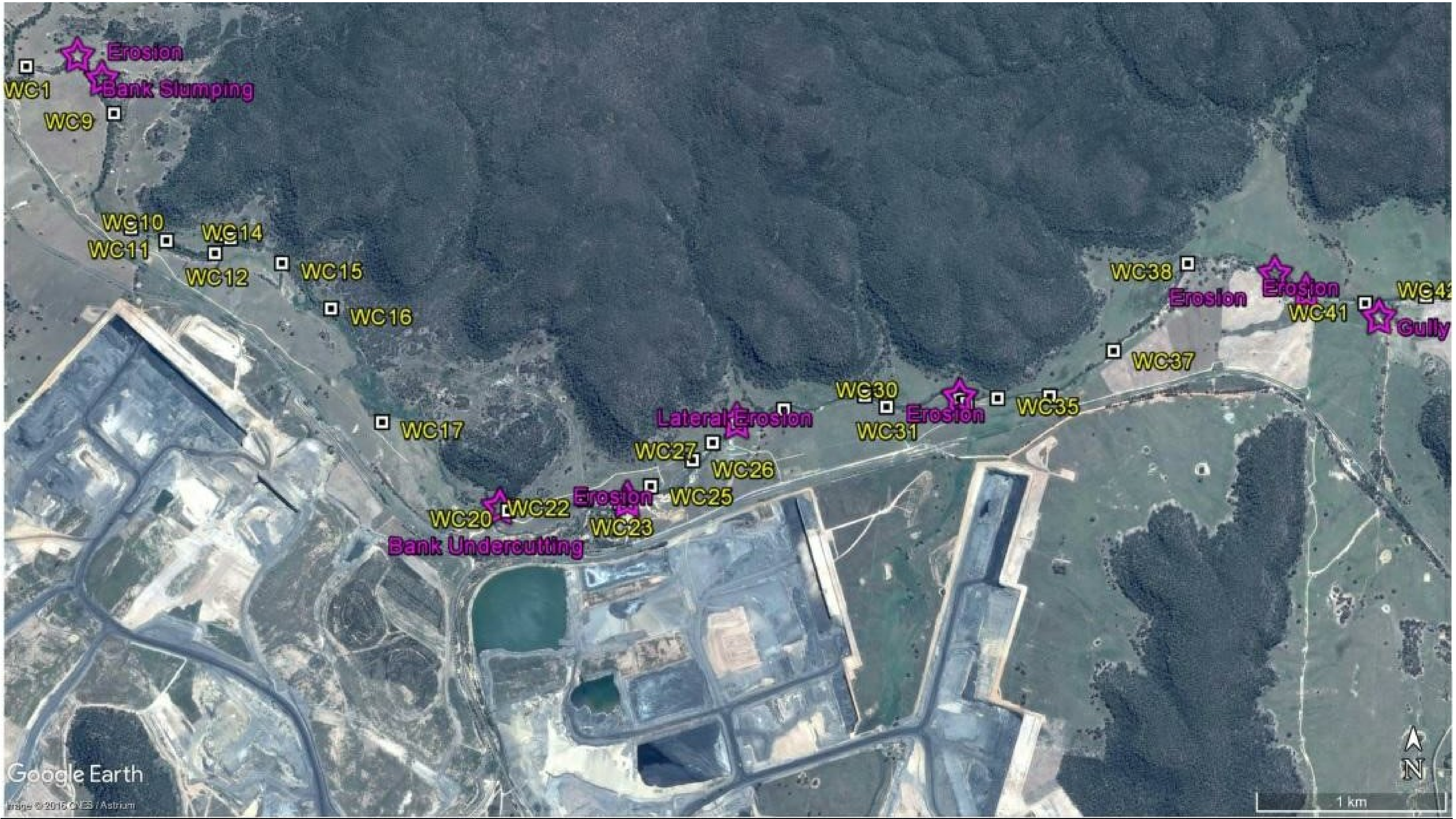

FIGURE 2 - SITE LAYOUT

SCALE: 1 : 200

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Client: WILPINGJONG COAL MINE

Project: WILPINGJONG CREEK

Drawing Title: FIGURE 2 - WILPINJONG CREEK - EROSION LOCATIONS

Design: .
Drawn: CP
Check: KB
QA: KB
Drawing Sheet
A3 - Scales as noted

Rev Date Amendment

Sheet 02 of

Drawing Number 26081-A02

Revision A

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

Site Number									
Questions	1	2	3	4	5	6	7	8	9
1	5	7.5	7.5	7.5	7.5	7.5	7.5	5	5
2	2	4	4	6	2	4	2	2	4
3	7.5	2.5	7.5	7.5	5	7.5	2.5	5	2.5
4	5	7.5	7.5	10	2.5	5	5	2.5	5
5	2.5	5	5	10	2.5	5	2.5	2.5	5
6	7.5	12.5	7.5	12.5	2.5	2.5	2.5	7.5	10
7	7.5	10	7.5	12.5	10	12.5	10	12.5	12.5
8	2.5	0	2.5	0	0	0	0	0	2.5
Total	39.5	44	46.5	66	32	44	32	37	46.5
Rating	Stable	Stable	Unstable	Highly Unstable	Stable	Stable	Mod Stable	Stable	Unstable
Site Number									
Questions	10	11	12	13	14	15	16	17	18
1	2.5	5	2.5	2.5	2.5	10	0	0	5
2	2	2	2	2	4	4	0	0	2
3	0	2.5	0	2.5	5	2.5	0	2.5	2.5
4	0	2.5	2.5	5	2.5	2.5	0	2.5	5
5	2.5	2.5	2.5	5	2.5	5	0	10	2.5
6	2.5	2.5	7.5	10	10	7.5	2.5	2.5	10
7	12.5	12.5	12.5	10	12.5	10	15	15	15
8	0	0	5	5	0	0	0	0	0
Total	22	29.5	34.5	42	39	41.5	17.5	32.5	44
Rating	Highly Stable	Mod Stable	Mod Stable	Stable	Stable	Stable	Highly Stable	Mod Stable	Stable

Site Number									
Questions	19	20	21	22	23	24	25	26	27
1	2.5	2.5	2.5	5	5	5	5	7.5	7.5
2	6	6	6	4	4	2	6	4	4
3	10	10	7.5	0	2.5	2.5	5	5	5
4	5	5	7.5	7.5	7.5	5	7.5	7.5	2.5
5	2.5	2.5	7.5	7.5	10	7.5	7.5	7.5	2.5
6	12.5	12.5	10	15	12.5	10	10	10	10
7	12.5	12.5	12.5	15	15	15	15	15	15
8	0	0	0	2.5	5	2.5	0	2.5	2.5
Total	51	51	53.5	56.5	61.5	49.5	55	55	44
Rating	Unstable	Unstable	Unstable	Mod Unstable	Mod Unstable	Unstable	Unstable	Unstable	Stable

Site Number									
Questions	28	29	30	31	32	33	34	35	36
1	7.5	7.5	7.5	5	7.5	7.5	7.5	5	7.5
2	6	6	4	4	6	6	4	4	4
3	7.5	7.5	2.5	5	7.5	7.5	5	7.5	2.5
4	5	5	5	5	5	7.5	5	5	5
5	5	5	2.5	7.5	7.5	7.5	5	2.5	2.5
6	10	10	7.5	10	10	12.5	10	2.5	7.5
7	15	15	10	15	15	10	15	15	15
8	2.5	2.5	2.5	0	0	2.5	2.5	2.5	0
Total	58.5	58.5	41.5	51.5	58.5	61	54	44	44
Rating	Unstable	Unstable	Stable	Unstable	Mod Unstable	Mod Unstable	Unstable	Stable	Stable

Site Number									
Questions	37	38	39	40	41	42	43	44	45
1	7.5	10	2.5	5	2.5	10	No Access	2.5	5
2	6	2	6	4	4	6		6	4
3	7.5	2.5	10	5	2.5	10		10	5
4	2.5	2.5	2.5	5	2.5	7.5		2.5	2.5
5	2.5	2.5	2.5	7.5	2.5	7.5		2.5	2.5
6	2.5	10	2.5	12.5	7.5	12.5		2.5	7.5
7	15	10	15	15	15	12.5		15	10
8	0	2.5	2.5	0	0	0		0	2.5
Total	43.5	42	43.5	54	36.5	66		41	39
Rating	Stable	Stable	Stable	Unstable	Stable	Highly Unstable		Stable	Stable

Site Number				
Questions	46	47	48	49
1	5	5	5	7.5
2	6	6	4	6
3	7.5	7.5	5	5
4	0	7.5	5	7.5
5	2.5	5	5	2.5
6	7.5	2.5	7.5	2.5
7	7.5	15	15	12.5
8	2.5	0	0	2.5
Total	38.5	48.5	46.5	46
Rating	Stable	Stable	Stable	Stable

Table 4: Stability - Bank erosion hazard index (BEHI) for Cumbo Creek

Questions	1	2	3	4	5	6	7	8	9	10
1	2.5	0	2.5	2.5	5	2.5	Not assessed	2.5	2.5	0
2	2	2	2	2	2	6		2	2	2
3	0	2.5	2.5	0	2.5	7.5		0	2.5	0
4	0	2.5	0	0	0	0		0	0	0
5	0	2.5	0	0	2.5	0		0	0	0
6	0	7.5	2.5	0	2.2	2.5		0	0	0
7	15	15	15	15	15	15		15	15	15
8	0	2.5	5	2.5	2.5	0		2.5	2.5	0
Total	19.5	34.5	29.5	22	31.7	33.5		22	24.5	17
Rating	Highly Stable	Mod Stable	Mod Stable	Highly Stable	Mod stable	Mod Stable		Highly Stable	Highly Stable	Highly Stable

3.3 Comparative Results

Appendix C (upstream) and **D (downstream)** provides a comparison of site photographs from the December 2011 survey, to September 2014 and December 2015 and 2016 for Wilpinjong and Cumbo Creeks. Most notably, differences relate to changes in in-stream flora abundance, groundcover and general groundcover health as a result of a lack of rainfall over the past several years.

4.0 RECOMMENDATIONS & CONCLUSIONS

4.1 Remediation Areas

Figure 2 identifies areas of notable bank slumping and erosion. Table 5 provides a photo log of these areas of concern that could be considered in future bank remedial works. These areas suffer moderate to severe erosion and poor riparian health as a result of past practises. It is suggested that WCPL consider some form of remedial works during the next reporting period.

4.2 Weed Control

There are a number of areas along Wilpinjong Creek suffering from weed infestations – including blackberry, thistle and prickly pear. The following provides an overview of locations that eradication works should be considered:

- Blackberry was noted near Wilpinong Creek Sites - 3,4, 6,7,11,14,15,16,27,38,39;
- Prickly Pear was noted – 35 and between 46-47;
- Scotch Thistles and other varieties were noted – 15, 19, 20,21, 22 25, 29, 37,
- Patterson's Curse was noted – 12, 18, 21, 22,
- Bathurst Burr – 34 and 38;

4.3 Pest Animal Control

A fox was observed during the survey around sites 7. Several rabbits and rabbit holes were noted around sites 23, 26, 27, 36 and 37. Appropriate controls in accordance with WCPL Feral Animal control procedures should be undertaken during the next reporting period to reduce the incidence of nuisance animals.

4.4 Potential Asbestos

At the old house located near Site 40 – a pile of sheeting remains and it is recommended that it be investigated as potentially containing asbestos by an appropriately qualified occupational hygienist /contaminated sites investigator.

Table 5: Suggested Remediation Areas

Reference Point	Photograph	Suggested Works
768469E 6422527N		• Bank stabilisation works – reshaping/battering • Revegetation • Continue to de-stock

Reference Point	Photograph	Suggested Works
768558E 6422432N	 	• Bank stabilisation works * Fence repairs; – reshaping/battering Revegetation * Continue to de-stock

Reference Point	Photograph	Suggested Works
768614E 6422382N		• Bank stabilisation works – reshaping/battering • Revegetation • Continue to de-stock

Reference Point	Photograph	Suggested Works
7551554E 6419884N	 	• Bank stabilisation works – reshaping/battering • Revegetation • Continue to de-stock

Reference Point	Photograph	Suggested Works
772166E 6420287N		• Bank stabilisation works – reshaping/battering • Revegetation • Continue to de-stock

Reference Point	Photograph	Suggested Works
772431E 6420352N		• Bank stabilisation works – reshaping/battering • Revegetation • Continue to de-stock

Reference Point	Photograph	Suggested Works
773014E 6420339N		• Bank stabilisation works – reshaping/battering • Revegetation • Continue to de-stock

Reference Point	Photograph	Suggested Works
773397E 6420376N		• Bank stabilisation works – reshaping/battering • Revegetation • Continue to de-stock

Reference Point	Photograph	Suggested Works
773772E 6420328N		• Bank stabilisation works – reshaping/battering • Revegetation • Continue to de-stock

4.5 Other Recommendations

The following dot points provide recommendations for continued assessment and ongoing improvement of Wilpinjong and Cumbo Creeks:

- Stability monitoring during low flow should continue for both creeks. It is suggested that panoramic photographs be considered in future sampling rounds;
- Cross sectional analysis is recommended to be undertaken every 3-5 years. This should be undertaken by survey instrumentation such as GNSS equipment with a base and rover unit. This equipment holds accuracies of approximately 30mm in x, y and z coordinates, making it reliable for future cross-sectional comparisons;
- Consideration should be given to installation of permanent coloured wooden survey pegs on the high bank to enable ease of site location;
- Consideration of the installation of erosion pins at some or all survey points should be given. These pins are surveyed in and bench marked with cross sectional analysis of the creek undertaken. Ongoing surveys will identify qualitatively bank erosion and widening, as well as areas of deposition;
- Continued works to improve the riparian zone of Wilpinjong creek should be considered in future site remediation works, in consultation with the NSW Department of Primary Industries (DPI) – Fisheries, to determine the need for a Part 7 Fisheries permit for instream works;
- Incorporation of bank soil testing at random locations, including aggregate stability testing – which involves dispensability and solidity calculations;
- Best Practise Management of weeds in areas along both creeks – sightings of blackberry, prickly pear, Bathurst Burr and several other noxious weeds were noted during the survey; and
- Best Practise Management of pest animals should continue within WCPL lands, including around the creeks;
- Continued Best Practise Management of stock around watercourses should continue.

4.6 Conclusion

This report provides WCPL with a stability assessment and photographic survey for future comparative purposes relating to ongoing monitoring of erosion, remediation and stability of both creeks. There is currently no visible indication that mining within the vicinity of the creek has resulted in any creek bed lowering or increased erosion, beyond natural occurrence.

5.0 REFERENCES

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Heeren D.M, Mittelstet A.R, Fox G.A, Storm D.E, Al-Madhhachi T, Midgley T.L, Stringer A.F, Stunkel K.B and Tejral R.D (2012), *Using Rapid Geomorphic Assessments to Assess Streambank Stability in Oklahoma Ozark Streams,* American Society of Agricultural and Biological Engineers Vol. 55 (3) 957-968.

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Appendix A

Field Sheet Proforma

Stability Rating - Using Critical Bank

Circle - Left Bank Right Bank

Bank Height - ________m Bank Face, length - _________m

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

Appendix B

WCPL Rainfall Data

Wilpinjong 24 Hour Rainfall Data												
Day	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
1	0	0	0	0	17.8	0	0.4	0	11	0.4	0	0
2	0	0	0	0	25.4	0	0	11.4	42.4	0	0	0
3	4.8	0	0	0	4.4	3.8	0	4.8	3.4	0.8	0	0
4	0	0	0	0	0	33.2	0.8	0	0	0	0	0
5	1.2	0	0	0	0	0.6	25.2	0	0	0.6	0	0
6	0.6	0	0	0	0	0.6	3.4	0	0	0	0	0.2
7	0	0	0	0	0	1.4	2	0	0	0	0	0.6
8	0	0	0	0	0	0.2	11	0	0	0	3.2	0
9	0	0	0	0	11.8	10	0	0	4.6	0	3.2	0
10	0	0	0	0	0.2	0	0.2	1.6	5.2	0	0.4	0
11	0	0	12.2	0	0	0	3	0.2	0	1.4	0	0
12	0	0	0.2	0	0	0	0	0	0	0	44	0
13	0	0	0	0	0	0	0	0	9.6	0	0	0
14	0.2	0	1.8	0	0	0	0	0	15	0	0	0
15	54.4	0	0.2	0	0	0	0	0	0	0	0	8.4
16	0	0	0	0	0	0	0	0	0.6	0	0	19
17	0	0	0	0	0	4.2	0	0	0	15.6	0	0.8
18	0	0	11.8	0.4	0	6.2	0	0	32	0.2	0	0
19	0	0	0.2	0	0	20.2	4	0.2	0.2	0	0	0
20	0	17.8	0	0	0	12.8	33.2	3.2	0	0	0	0
21	2.2	0	0	0	0	2.8	0.4	0	11.4	10.4	0	0
22	31.6	0	0	1.2	0	12.2	0.2	8.8	0.2	29.2	0	0
23	0	0	0	0.2	0	1.8	0	0.4	0	0.2	0	0
24	0	0	0	0	0	5.8	0.4	7.2	0	0	0	0.8
25	0.8	0	0	0	0	0.2	0	0.6	11	0	0	0.2
26	0.2	0	0	0	9.8	0	0	0	0	0	0	0
27	10.2	0	0	0	0	0.6	0.6	0	0	0	0	0
28	5.6	0	0	0	4	0	0	0	0	0	0	0
29	5.6	0	0	0	0	0	0	0	13.8	0	0	0
30	0		0	13.6	0	0	0	0	6.8	6.8	0	0
31	0		0		0		0	11.6		0.2		0
Total	**117.4**	**17.8**	**26.4**	**15.4**	**73.4**	**116.6**	**84.8**	**50**	**167.2**	**65.8**	**50.8**	**30**
C.Total	117.4	135.2	161.6	177	250.4	367	451.8	501.8	669	734.8	785.6	815.6

Wilpinjong Coal Hourly Rainfall Data - 1 Jan 16-31 Dec 16											
Date	Rain	Date	Rain	Date	Rain	Date	Rain	Date	Rain	Date	Rain
22/01/2016 17:00	27	29/09/2016 8:00	2.2	21/01/2016 20:00	1	20/07/2016 4:00	0.6	19/03/2016 7:00	0.2	5/10/2016 1:00	0.2
2/05/2016 19:00	23.6	15/12/2016 22:00	2.2	27/01/2016 16:00	1	20/07/2016 13:00	0.6	18/04/2016 9:00	0.2	11/10/2016 1:00	0.2
22/10/2016 5:00	22.6	15/01/2016 11:00	2	22/04/2016 15:00	1	20/07/2016 15:00	0.6	18/04/2016 13:00	0.2	11/10/2016 14:00	0.2
12/11/2016 2:00	18.4	11/03/2016 19:00	2	30/04/2016 7:00	1	20/07/2016 16:00	0.6	22/04/2016 16:00	0.2	17/10/2016 5:00	0.2
20/02/2016 14:00	17.6	30/04/2016 11:00	2	1/05/2016 4:00	1	3/08/2016 3:00	0.6	23/04/2016 7:00	0.2	17/10/2016 14:00	0.2
15/01/2016 3:00	11.2	1/05/2016 7:00	2	28/05/2016 7:00	1	22/08/2016 20:00	0.6	1/05/2016 8:00	0.2	18/10/2016 13:00	0.2
1/05/2016 5:00	10.6	18/06/2016 4:00	2	4/06/2016 0:00	1	24/08/2016 8:00	0.6	2/05/2016 15:00	0.2	22/10/2016 4:00	0.2
4/06/2016 18:00	9.4	5/07/2016 1:00	2	4/06/2016 14:00	1	24/08/2016 9:00	0.6	3/05/2016 1:00	0.2	22/10/2016 11:00	0.2
5/07/2016 0:00	8.2	2/08/2016 20:00	2	17/06/2016 13:00	1	24/08/2016 14:00	0.6	9/05/2016 5:00	0.2	23/10/2016 11:00	0.2
5/07/2016 5:00	8.2	3/08/2016 1:00	2	19/06/2016 16:00	1	1/09/2016 19:00	0.6	9/05/2016 15:00	0.2	30/10/2016 16:00	0.2
15/01/2016 5:00	7	2/09/2016 13:00	2	19/06/2016 18:00	1	3/09/2016 2:00	0.6	9/05/2016 16:00	0.2	30/10/2016 21:00	0.2
20/07/2016 9:00	7	21/09/2016 12:00	2	20/06/2016 7:00	1	3/09/2016 4:00	0.6	9/05/2016 22:00	0.2	31/10/2016 13:00	0.2
18/09/2016 15:00	6.8	30/10/2016 17:00	2	20/06/2016 11:00	1	14/09/2016 16:00	0.6	10/05/2016 18:00	0.2	10/11/2016 7:00	0.2
12/11/2016 3:00	6.6	12/11/2016 5:00	2	20/06/2016 14:00	1	21/09/2016 23:00	0.6	26/05/2016 5:00	0.2	12/11/2016 12:00	0.2
19/06/2016 17:00	6.4	3/01/2016 18:00	1.8	23/06/2016 23:00	1	30/10/2016 15:00	0.6	26/05/2016 20:00	0.2	6/12/2016 22:00	0.2
12/11/2016 7:00	6.2	15/01/2016 1:00	1.8	5/07/2016 18:00	1	9/11/2016 16:00	0.6	28/05/2016 5:00	0.2	7/12/2016 0:00	0.2
15/01/2016 4:00	6	27/01/2016 12:00	1.8	20/07/2016 5:00	1	16/12/2016 16:00	0.6	3/06/2016 8:00	0.2	7/12/2016 1:00	0.2
20/07/2016 10:00	6	28/01/2016 4:00	1.8	24/08/2016 18:00	1	5/01/2016 12:00	0.4	4/06/2016 2:00	0.2	7/12/2016 4:00	0.2
18/03/2016 16:00	5.8	30/04/2016 8:00	1.8	2/09/2016 12:00	1	6/01/2016 0:00	0.4	4/06/2016 11:00	0.2	12/12/2016 11:00	0.2
11/03/2016 18:00	5.6	3/05/2016 0:00	1.8	14/09/2016 4:00	1	22/01/2016 14:00	0.4	4/06/2016 13:00	0.2	15/12/2016 9:00	0.2
21/10/2016 19:00	5.6	26/05/2016 7:00	1.8	18/09/2016 7:00	1	14/03/2016 10:00	0.4	4/06/2016 16:00	0.2	15/12/2016 10:00	0.2
15/01/2016 2:00	5	20/07/2016 1:00	1.8	21/09/2016 5:00	1	14/03/2016 11:00	0.4	5/06/2016 8:00	0.2	15/12/2016 19:00	0.2
30/04/2016 10:00	5	2/08/2016 18:00	1.8	21/09/2016 13:00	1	14/03/2016 13:00	0.4	7/06/2016 5:00	0.2	16/12/2016 1:00	0.2
13/09/2016 19:00	5	2/08/2016 19:00	1.8	25/09/2016 2:00	1	14/03/2016 21:00	0.4	7/06/2016 11:00	0.2	16/12/2016 8:00	0.2
14/09/2016 18:00	5	2/08/2016 22:00	1.8	29/09/2016 7:00	1	9/05/2016 3:00	0.4	7/06/2016 20:00	0.2	16/12/2016 17:00	0.2
18/09/2016 14:00	5	3/08/2016 0:00	1.8	11/10/2016 3:00	1	9/05/2016 4:00	0.4	7/06/2016 21:00	0.2	16/12/2016 18:00	0.2
18/09/2016 10:00	4.8	22/08/2016 14:00	1.8	9/11/2016 14:00	1	9/05/2016 14:00	0.4	7/06/2016 22:00	0.2	16/12/2016 19:00	0.2
15/01/2016 0:00	4.4	31/08/2016 12:00	1.8	16/12/2016 9:00	1	26/05/2016 21:00	0.4	8/06/2016 1:00	0.2	17/12/2016 1:00	0.2
2/09/2016 9:00	4.4	1/09/2016 21:00	1.8	16/12/2016 13:00	1	28/05/2016 12:00	0.4	9/06/2016 3:00	0.2	17/12/2016 4:00	0.2
31/08/2016 13:00	4.2	2/09/2016 23:00	1.8	25/01/2016 19:00	0.8	4/06/2016 3:00	0.4	9/06/2016 10:00	0.2	25/12/2016 4:00	0.2
1/09/2016 22:00	4.2	9/09/2016 21:00	1.8	18/03/2016 11:00	0.8	4/06/2016 15:00	0.4	17/06/2016 16:00	0.2		
18/03/2016 12:00	4	10/09/2016 1:00	1.8	26/05/2016 3:00	0.8	4/06/2016 17:00	0.4	17/06/2016 19:00	0.2		
9/06/2016 9:00	4	14/09/2016 1:00	1.8	3/06/2016 11:00	0.8	4/06/2016 20:00	0.4	18/06/2016 1:00	0.2		
20/07/2016 7:00	4	14/09/2016 2:00	1.8	3/06/2016 12:00	0.8	4/06/2016 22:00	0.4	18/06/2016 10:00	0.2		
2/09/2016 1:00	4	25/09/2016 7:00	1.8	3/06/2016 13:00	0.8	7/06/2016 19:00	0.4	19/06/2016 19:00	0.2		
18/09/2016 12:00	4	30/09/2016 12:00	1.8	4/06/2016 10:00	0.8	17/06/2016 11:00	0.4	20/06/2016 2:00	0.2		
21/10/2016 21:00	4	17/10/2016 7:00	1.8	4/06/2016 12:00	0.8	17/06/2016 22:00	0.4	20/06/2016 8:00	0.2		
16/12/2016 4:00	4	17/10/2016 9:00	1.8	4/06/2016 19:00	0.8	18/06/2016 0:00	0.4	20/06/2016 9:00	0.2		
30/04/2016 9:00	3.8	17/10/2016 12:00	1.8	4/06/2016 21:00	0.8	18/06/2016 9:00	0.4	20/06/2016 10:00	0.2		
9/05/2016 12:00	3.8	2/05/2016 20:00	1.6	9/06/2016 2:00	0.8	19/06/2016 5:00	0.4	20/06/2016 22:00	0.2		
2/09/2016 10:00	3.8	3/05/2016 7:00	1.6	18/06/2016 3:00	0.8	20/06/2016 20:00	0.4	20/06/2016 23:00	0.2		
22/10/2016 7:00	3.6	9/05/2016 10:00	1.6	19/06/2016 9:00	0.8	21/06/2016 21:00	0.4	22/06/2016 11:00	0.2		
28/01/2016 5:00	3.4	18/06/2016 2:00	1.6	19/06/2016 15:00	0.8	24/06/2016 15:00	0.4	23/06/2016 18:00	0.2		
8/07/2016 11:00	3.4	22/06/2016 1:00	1.6	20/06/2016 15:00	0.8	24/06/2016 17:00	0.4	24/06/2016 0:00	0.2		
2/09/2016 14:00	3.4	22/06/2016 4:00	1.6	20/06/2016 16:00	0.8	24/06/2016 21:00	0.4	24/06/2016 4:00	0.2		
9/05/2016 11:00	3.2	8/07/2016 12:00	1.6	20/06/2016 17:00	0.8	27/06/2016 4:00	0.4	24/06/2016 8:00	0.2		
26/05/2016 9:00	3.2	2/08/2016 21:00	1.6	20/06/2016 18:00	0.8	1/07/2016 4:00	0.4	24/06/2016 18:00	0.2		
4/06/2016 4:00	3.2	10/08/2016 17:00	1.6	20/06/2016 19:00	0.8	8/07/2016 7:00	0.4	24/06/2016 22:00	0.2		
19/06/2016 13:00	3.2	24/08/2016 15:00	1.6	22/06/2016 5:00	0.8	11/07/2016 20:00	0.4	25/06/2016 13:00	0.2		

Wilpinjong Coal - 15 minute Rainfall Data 1 Jan 2016-31-Dec 2017

StatDate	Rainfall	StatDate	Rainfall	StatDate	Rainfall	StatDate	Rainfall	StatDate	Rainfall	StatDate	Rainfall	StatDate	Rainfall	StatDate	Rainfall	StatDate	Rainfall		
22/01/2016 17:30	22	29/01/2016 12:00	1.4	29/09/2016 6:15	1	2/09/2016 13:45	0.8	2/08/2016 21:00	0.6	27/01/2016 16:30	0.4	11/07/2016 19:45	0.4	21/09/2016 7:30	0.4	1/05/2016 8:00	0.2	19/06/2016 12:15	0.2
2/05/2016 19:45	20.8	11/03/2016 18:45	1.4	29/09/2016 8:00	1	2/09/2016 14:30	0.8	2/08/2016 21:15	0.6	29/01/2016 12:30	0.4	11/07/2016 21:45	0.4	21/09/2016 10:00	0.4	2/05/2016 15:45	0.2	19/06/2016 14:15	0.2
22/10/2016 4:15	13.2	30/04/2016 10:15	1.4	29/09/2016 11:15	1	2/09/2016 15:00	0.8	2/08/2016 22:00	0.6	29/01/2016 12:45	0.4	19/07/2016 16:00	0.4	21/09/2016 23:00	0.4	2/05/2016 20:45	0.2	19/06/2016 15:45	0.2
12/11/2016 1:30	11.8	30/04/2016 10:45	1.4	17/10/2016 8:45	1	2/09/2016 23:45	0.8	3/08/2016 1:45	0.6	11/03/2016 20:15	0.4	19/07/2016 16:15	0.4	25/09/2016 1:45	0.4	3/05/2016 1:45	0.2	19/06/2016 19:00	0.2
20/02/2016 14:15	9	1/05/2016 6:15	1.4	17/10/2016 9:30	1	3/09/2016 0:15	0.8	10/08/2016 17:30	0.6	14/03/2016 10:45	0.4	20/07/2016 4:15	0.4	25/09/2016 2:30	0.4	3/05/2016 6:15	0.2	20/06/2016 2:00	0.2
20/02/2016 14:00	8.6	2/05/2016 20:00	1.4	17/10/2016 10:45	1	9/09/2016 17:45	0.8	22/08/2016 13:15	0.6	14/03/2016 11:00	0.4	20/07/2016 5:30	0.4	25/09/2016 5:15	0.4	3/05/2016 6:30	0.2	20/06/2016 7:00	0.2
15/01/2016 3:45	5.6	19/06/2016 17:15	1.4	21/10/2016 20:15	1	14/09/2016 0:15	0.8	22/08/2016 13:45	0.6	14/03/2016 21:00	0.4	20/07/2016 5:45	0.4	29/09/2016 5:45	0.4	9/05/2016 4:00	0.2	20/06/2016 8:15	0.2
21/10/2016 18:15	5.6	5/07/2016 1:30	1.4	22/10/2016 4:45	1	14/09/2016 17:45	0.8	24/08/2016 8:45	0.6	18/03/2016 8:45	0.4	20/07/2016 6:15	0.4	29/09/2016 8:30	0.4	9/05/2016 4:15	0.2	20/06/2016 9:00	0.2
4/06/2016 18:30	5.2	20/07/2016 7:15	1.4	30/10/2016 16:45	1	14/09/2016 18:15	0.8	31/08/2016 10:30	0.6	30/04/2016 8:30	0.4	20/07/2016 7:45	0.4	29/09/2016 11:30	0.4	9/05/2016 5:00	0.2	20/06/2016 10:45	0.2
12/11/2016 1:15	5	20/07/2016 9:30	1.4	30/10/2016 17:30	1	18/09/2016 10:45	0.8	31/08/2016 11:15	0.6	30/04/2016 11:30	0.4	20/07/2016 13:45	0.4	30/09/2016 10:00	0.4	9/05/2016 10:45	0.2	20/06/2016 11:15	0.2
22/10/2016 4:00	4.4	31/08/2016 13:30	1.4	12/11/2016 2:15	1	18/09/2016 11:45	0.8	31/08/2016 11:45	0.6	30/04/2016 11:45	0.4	20/07/2016 15:45	0.4	30/09/2016 11:00	0.4	9/05/2016 13:00	0.2	20/06/2016 12:45	0.2
18/03/2016 16:00	4	31/08/2016 14:15	1.4	12/11/2016 3:00	1	18/09/2016 12:00	0.8	31/08/2016 12:30	0.6	1/05/2016 6:45	0.4	20/07/2016 16:00	0.4	30/09/2016 12:30	0.4	9/05/2016 13:30	0.2	20/06/2016 13:45	0.2
22/10/2016 4:30	4	2/09/2016 1:45	1.4	12/11/2016 4:30	1	18/09/2016 14:00	0.8	31/08/2016 14:30	0.6	3/05/2016 7:00	0.4	23/07/2016 2:15	0.4	30/09/2016 14:30	0.4	9/05/2016 13:45	0.2	20/06/2016 14:00	0.2
1/05/2016 5:00	3.8	2/09/2016 5:00	1.4	12/12/2016 2:00	1	21/09/2016 9:45	0.8	1/09/2016 21:30	0.6	3/05/2016 7:30	0.4	2/08/2016 14:45	0.4	3/10/2016 11:30	0.4	9/05/2016 15:15	0.2	20/06/2016 14:15	0.2
12/11/2016 6:00	3.8	2/09/2016 10:30	1.4	15/12/2016 23:00	1	21/09/2016 11:15	0.8	2/09/2016 1:15	0.6	9/05/2016 3:00	0.4	2/08/2016 18:30	0.4	4/10/2016 23:00	0.4	9/05/2016 16:45	0.2	20/06/2016 14:45	0.2
18/09/2016 15:15	3.4	18/09/2016 13:00	1.4	16/12/2016 4:30	1	21/09/2016 12:15	0.8	2/09/2016 4:45	0.6	9/05/2016 10:00	0.4	2/08/2016 19:00	0.4	11/10/2016 2:30	0.4	9/05/2016 22:00	0.2	20/06/2016 15:00	0.2
15/01/2016 5:45	3.2	21/10/2016 20:45	1.4	16/12/2016 5:15	1	21/09/2016 13:00	0.8	2/09/2016 6:00	0.6	9/05/2016 10:30	0.4	2/08/2016 19:30	0.4	11/10/2016 2:45	0.4	10/05/2016 18:30	0.2	20/06/2016 15:15	0.2
8/11/2016 15:15	3.2	12/11/2016 1:45	1.4	16/12/2016 14:15	1	29/09/2016 6:45	0.8	2/09/2016 7:30	0.6	9/05/2016 14:00	0.4	2/08/2016 19:45	0.4	17/10/2016 14:45	0.4	26/05/2016 3:00	0.2	20/06/2016 15:30	0.2
15/01/2016 4:00	3	12/11/2016 6:15	1.4	15/01/2016 10:00	0.8	30/09/2016 11:15	0.8	2/09/2016 12:45	0.6	26/05/2016 4:30	0.4	2/08/2016 20:00	0.4	21/10/2016 21:00	0.4	26/05/2016 4:00	0.2	20/06/2016 15:45	0.2
18/03/2016 12:15	3	15/01/2016 8:30	1.2	21/01/2016 19:30	0.8	30/09/2016 12:00	0.8	2/09/2016 13:15	0.6	26/05/2016 8:45	0.4	2/08/2016 22:15	0.4	22/10/2016 5:00	0.4	26/05/2016 5:30	0.2	20/06/2016 16:00	0.2
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5/07/2016 5:15	3	29/01/2016 11:45	1.2	27/01/2016 11:15	0.8	22/10/2016 6:00	0.8	9/09/2016 23:45	0.6	26/05/2016 10:15	0.4	2/08/2016 22:45	0.4	22/10/2016 8:15	0.4	26/05/2016 20:45	0.2	20/06/2016 17:15	0.2
12/11/2016 4:45	3	3/05/2016 0:45	1.2	27/01/2016 12:45	0.8	30/10/2016 16:15	0.8	10/09/2016 1:15	0.6	26/05/2016 10:30	0.4	2/08/2016 23:15	0.4	22/10/2016 8:45	0.4	28/05/2016 5:45	0.2	20/06/2016 17:45	0.2
22/01/2016 17:15	2.8	9/05/2016 12:15	1.2	27/01/2016 13:30	0.8	12/11/2016 5:45	0.8	10/09/2016 1:45	0.6	26/05/2016 21:00	0.4	3/08/2016 3:30	0.4	30/10/2016 14:45	0.4	28/05/2016 12:00	0.2	20/06/2016 18:00	0.2
1/05/2016 5:15	2.8	4/06/2016 9:15	1.2	27/01/2016 15:00	0.8	15/12/2016 22:00	0.8	10/09/2016 2:00	0.6	28/05/2016 6:00	0.4	20/08/2016 0:45	0.4	9/11/2016 14:00	0.4	28/05/2016 12:45	0.2	20/06/2016 18:15	0.2
2/05/2016 19:30	2.8	9/06/2016 9:15	1.2	27/01/2016 15:30	0.8	16/12/2016 4:15	0.8	13/09/2016 19:30	0.6	28/05/2016 7:30	0.4	20/08/2016 3:00	0.4	9/11/2016 14:30	0.4	28/05/2016 13:15	0.2	20/06/2016 19:00	0.2
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5/07/2016 0:15	2.6	19/06/2016 13:00	1.2	29/01/2016 11:30	0.8	3/01/2016 17:00	0.6	13/09/2016 22:00	0.6	3/06/2016 11:45	0.4	22/08/2016 12:30	0.4	12/11/2016 6:45	0.4	3/06/2016 10:00	0.2	20/06/2016 20:15	0.2
5/07/2016 5:45	2.6	24/06/2016 14:45	1.2	29/01/2016 12:15	0.8	3/01/2016 17:15	0.6	14/09/2016 1:15	0.6	3/06/2016 12:00	0.4	22/08/2016 12:45	0.4	15/12/2016 8:30	0.4	3/06/2016 10:15	0.2	20/06/2016 20:45	0.2
13/09/2016 19:15	2.6	5/07/2016 17:15	1.2	18/03/2016 8:30	0.8	3/01/2016 17:45	0.6	14/09/2016 1:45	0.6	3/06/2016 23:45	0.4	22/08/2016 13:00	0.4	15/12/2016 21:30	0.4	3/06/2016 10:30	0.2	20/06/2016 21:45	0.2
15/01/2016 2:15	2.4	7/07/2016 17:00	1.2	18/03/2016 11:45	0.8	3/01/2016 18:30	0.6	14/09/2016 2:15	0.6	4/06/2016 7:15	0.4	22/08/2016 14:15	0.4	15/12/2016 22:30	0.4	3/06/2016 11:15	0.2	20/06/2016 22:15	0.2
15/01/2016 3:15	2.4	20/07/2016 11:00	1.2	30/04/2016 7:45	0.8	15/01/2016 1:45	0.6	14/09/2016 2:45	0.6	4/06/2016 7:45	0.4	22/08/2016 14:30	0.4	15/12/2016 22:45	0.4	3/06/2016 11:30	0.2	20/06/2016 23:30	0.2
11/03/2016 17:45	2.4	1/09/2016 22:30	1.2	1/05/2016 4:45	0.8	15/01/2016 2:00	0.6	14/09/2016 4:30	0.6	4/06/2016 8:00	0.4	22/08/2016 16:00	0.4	15/12/2016 23:15	0.4	3/06/2016 12:15	0.2	21/06/2016 0:45	0.2
19/06/2016 17:00	2.4	1/09/2016 22:45	1.2	3/05/2016 7:15	0.8	15/01/2016 9:00	0.6	18/09/2016 7:15	0.6	4/06/2016 8:45	0.4	22/08/2016 20:30	0.4	16/12/2016 0:15	0.4	3/06/2016 12:45	0.2	21/06/2016 2:45	0.2
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15/01/2016 0:45	2.2	2/09/2016 0:15	1.2	9/05/2016 11:30	0.8	15/01/2016 10:30	0.6	18/09/2016 14:15	0.6	4/06/2016 12:00	0.4	23/08/2016 14:00	0.4	16/12/2016 2:00	0.4	4/06/2016 0:15	0.2	21/06/2016 21:45	0.2
15/01/2016 5:30	2.2	2/09/2016 7:00	1.2	9/05/2016 12:30	0.8	15/01/2016 11:00	0.6	18/09/2016 15:30	0.6	4/06/2016 12:30	0.4	24/08/2016 9:00	0.4	16/12/2016 9:00	0.4	4/06/2016 0:45	0.2	21/06/2016 22:00	0.2
1/05/2016 5:30	2.2	2/09/2016 9:15	1.2	26/05/2016 7:00	0.8	15/01/2016 11:15	0.6	18/09/2016 16:00	0.6	4/06/2016 15:15	0.4	24/08/2016 14:45	0.4	16/12/2016 9:15	0.4	4/06/2016 1:15	0.2	21/06/2016 22:15	0.2
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14/09/2016 18:45	2.2	2/09/2016 14:00	1.2	26/05/2016 8:30	0.8	22/01/2016 18:30	0.6	18/09/2016 19:45	0.6	4/06/2016 21:30	0.4	24/08/2016 16:30	0.4	16/12/2016 13:00	0.4	4/06/2016 1:45	0.2	21/06/2016 23:15	0.2
12/11/2016 2:00	2.2	9/09/2016 21:00	1.2	26/05/2016 9:00	0.8	25/01/2016 19:15	0.6	21/09/2016 5:30	0.6	9/06/2016 7:45	0.4	25/08/2016 3:30	0.4	16/12/2016 14:30	0.4	4/06/2016 2:00	0.2	22/06/2016 0:00	0.2
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11/03/2016 18:15	2	18/09/2016 14:30	1.2	28/05/2016 6:30	0.8	27/01/2016 14:30	0.6	21/09/2016 10:15	0.6	9/06/2016 11:00	0.4	1/09/2016 20:30	0.4	24/12/2016 22:15	0.4	4/06/2016 3:45	0.2	22/06/2016 0:45	0.2
4/06/2016 18:15	2	17/10/2016 7:15	1.2	3/06/2016 13:15	0.8	28/01/2016 4:45	0.6	21/09/2016 11:30	0.6	17/06/2016 11:15	0.4	1/09/2016 23:15	0.4	3/01/2016 16:45	0.2	4/06/2016 8:15	0.2	22/06/2016 4:30	0.2
5/07/2016 0:30	2	17/10/2016 7:30	1.2	4/06/2016 4:30	0.8	11/03/2016 18:00	0.6	21/09/2016 12:00	0.6	17/06/2016 13:30	0.4	1/09/2016 23:45	0.4	3/01/2016 19:00	0.2	4/06/2016 8:30	0.2	22/06/2016 4:45	0.2
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20/07/2016 9:00	2	22/10/2016 6:30	1.2	4/06/2016 5:30	0.8	30/04/2016 8:00	0.6	25/09/2016 5:00	0.6	17/06/2016 22:15	0.4	2/09/2016 0:45	0.4	5/01/2016 23:30	0.2	4/06/2016 10:45	0.2	22/06/2016 5:15	0.2
20/07/2016 10:00	2	30/10/2016 17:15	1.2	4/06/2016 6:15	0.8	30/04/2016 8:45	0.6	25/09/2016 5:30	0.6	18/06/2016 0:15	0.4	2/09/2016 2:15	0.4	6/01/2016 0:00	0.2	4/06/2016 11:30	0.2	22/06/2016 6:00	0.2
14/09/2016 18:00	2	15/01/2016 1:00	1	4/06/2016 6:30	0.8	30/04/2016 10:00	0.6	25/09/2016 7:00	0.6	18/06/2016 2:30	0.4	2/09/2016 2:30	0.4	6/01/2016 0:30	0.2	4/06/2016 13:30	0.2	22/06/2016 6:15	0.2
18/09/2016 10:15	2	15/01/2016 2:30	1	4/06/2016 7:00	0.8	1/05/2016 6:30	0.6	29/09/2016 7:00	0.6	18/06/2016 3:15	0.4	2/09/2016 3:45	0.4	6/01/2016 8:00	0.2	4/06/2016 14:30	0.2	22/06/2016 6:30	0.2
29/09/2016 10:30	2	15/01/2016 2:45	1	4/06/2016 7:30	0.8	1/05/2016 7:00	0.6	29/09/2016 8:15	0.6	18/06/2016 4:00	0.4	2/09/2016 4:30	0.4	14/01/2016 23:45	0.2	4/06/2016 16:30	0.2	22/06/2016 7:45	0.2
12/11/2016 2:30	2	15/01/2016 4:15	1	4/06/2016 14:45	0.8	3/05/2016 0:30	0.6	29/09/2016 9:00	0.6	18/06/2016 4:30	0.4	2/09/2016 5:15	0.4	15/01/2016 0:15	0.2	4/06/2016 17:15	0.2	22/06/2016 11:00	0.2
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22/01/2016 17:45	1.8	15/01/2016 7:00	1	9/06/2016 8:00	0.8	9/05/2016 17:00	0.6	30/09/2016 11:30	0.6	19/06/2016 6:30	0.4	2/09/2016 6:15	0.4	15/01/2016 8:15	0.2	4/06/2016 19:30	0.2	23/06/2016 23:15	0.2
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18/03/2016 16:15	1.8	22/01/2016 18:15	1	9/06/2016 9:45	0.8	28/05/2016 7:00	0.6	17/10/2016 7:00	0.6	19/06/2016 10:15	0.4	2/09/2016 8:15	0.4	22/01/2016 18:45	0.2	4/06/2016 21:15	0.2	24/06/2016 8:45	0.2
1/05/2016 5:45	1.8	27/01/2016 11:45	1	18/06/2016 2:15	0.8	4/06/2016 0:00	0.6	17/10/2016 8:30	0.6	19/06/2016 10:30	0.4	2/09/2016 9:00	0.4	22/01/2016 19:30	0.2	4/06/2016 21:45	0.2	24/06/2016 10:15	0.2
9/05/2016 12:00	1.8	28/01/2016 5:00	1	19/06/2016 12:45	0.8	4/06/2016 4:15	0.6	17/10/2016 11:45	0.6	19/06/2016 11:00	0.4	2/09/2016 10:15	0.4	25/01/2016 19:30	0.2	4/06/2016 22:00	0.2	24/06/2016 15:00	0.2
20/07/2016 9:15	1.8	28/01/2016 5:15	1	19/06/2016 14:00	0.8	4/06/2016 5:15	0.6	30/10/2016 17:00	0.6	19/06/2016 13:45	0.4	2/09/2016 10:45	0.4	26/01/2016 11:30	0.2	4/06/2016 22:15	0.2	24/06/2016 15:45	0.2
20/07/2016 9:45	1.8	18/03/2016 12:00	1	20/06/2016 7:45	0.8	4/06/2016 5:45	0.6	30/10/2016 18:30	0.6	19/06/2016 14:45	0.4	2/09/2016 11:15	0.4	27/01/2016 12:15	0.2	5/06/2016 6:00	0.2	24/06/2016 17:15	0.2
20/07/2016 10:15	1.8	30/04/2016 9:00	1	20/06/2016 11:45	0.8	4/06/2016 6:00	0.6	9/11/2016 13:00	0.6	20/06/2016 12:30	0.4	2/09/2016 11:30	0.4	27/01/2016 12:30	0.2	5/06/2016 6:30	0.2	24/06/2016 17:45	0.2
2/09/2016 1:30	1.8	30/04/2016 11:00	1	20/06/2016 12:00	0.8	4/06/2016 9:00	0.6	9/11/2016 13:45	0.6	20/06/2016 13:30	0.4	2/09/2016 13:00	0.4	27/01/2016 13:00	0.2	5/06/2016 8:00	0.2	24/06/2016 18:45	0.2
18/09/2016 15:00	1.8	1/05/2016 7:15	1	22/06/2016 3:15	0.8	4/06/2016 9:30	0.6	12/11/2016 4:15	0.6	20/06/2016 14:30	0.4	2/09/2016 14:45	0.4	27/01/2016 13:15	0.2	6/06/2016 22:00	0.2	24/06/2016 21:00	0.2
25/09/2016 6:00	1.8	9/05/2016 11:45	1	22/06/2016 8:00	0.8	4/06/2016 18:00	0.6	12/11/2016 5:15	0.6	20/06/2016 16:30	0.4	2/09/2016 15:15	0.4	27/01/2016 13:45	0.2	6/06/2016 22:15	0.2	24/06/2016 21:30	0.2
25/09/2016 6:15	1.8	26/05/2016 9:30	1	24/06/2016 16:00	0.8	9/06/2016 8:15	0.6	15/12/2016 18:30	0.6	20/06/2016 17:00	0.4	2/09/2016 15:30	0.4	27/01/2016 14:00	0.2	6/06/2016 22:30	0.2	24/06/2016 22:30	0.2
17/10/2016 10:30	1.8	4/06/2016 4:00	1	5/07/2016 18:15	0.8	17/06/2016 13:45	0.6	15/12/2016 21:00	0.6	20/06/2016 18:45	0.4	2/09/2016 18:30	0.4	27/01/2016 14:15	0.2	7/06/2016 5:30	0.2	25/06/2016 13:15	0.2
12/11/2016 5:00	1.8	4/06/2016 5:00	1	8/07/2016 8:45	0.8	18/06/2016 4:15	0.6	15/12/2016 22:15	0.6	20/06/2016 19:30	0.4	2/09/2016 19:30	0.4	27/01/2016 15:45	0.2	7/06/2016 11:00	0.2	27/06/2016 4:15	0.2

16/12/2016 14:00	1.8	17/06/2016 14:00	1	8/07/2016 10:30	0.8	18/06/2016 4:45	0.6	15/12/2016 23:30	0.6	20/06/2016 21:30	0.4	3/09/2016 0:00	0.4	27/01/2016 16:45	0.2	7/06/2016 19:15	0.2	27/06/2016 4:45	0.2
15/01/2016 0:30	1.6	19/06/2016 13:15	1	8/07/2016 12:15	0.8	19/06/2016 7:00	0.6	15/12/2016 23:45	0.6	21/06/2016 0:30	0.4	3/09/2016 0:30	0.4	27/01/2016 17:00	0.2	7/06/2016 19:30	0.2	27/06/2016 7:45	0.2
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4/06/2016 18:45	1.6	20/06/2016 12:15	1	20/07/2016 0:45	0.8	20/06/2016 13:00	0.6	16/12/2016 15:30	0.6	22/06/2016 1:15	0.4	9/09/2016 20:45	0.4	28/01/2016 6:00	0.2	8/06/2016 1:30	0.2	5/07/2016 6:15	0.2
19/06/2016 17:45	1.6	22/06/2016 2:45	1	20/07/2016 2:30	0.8	22/06/2016 2:15	0.6	16/12/2016 15:45	0.6	22/06/2016 1:30	0.4	10/09/2016 0:45	0.4	28/01/2016 14:15	0.2	9/06/2016 3:00	0.2	5/07/2016 7:45	0.2
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2/09/2016 6:45	1.6	8/07/2016 10:45	1	20/07/2016 6:30	0.8	22/06/2016 3:45	0.6	3/01/2016 18:00	0.4	22/06/2016 2:00	0.4	13/09/2016 20:00	0.4	29/01/2016 13:30	0.2	9/06/2016 7:00	0.2	5/07/2016 18:45	0.2
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18/09/2016 10:30	1.6	3/08/2016 1:00	1	3/08/2016 0:30	0.8	4/07/2016 23:45	0.6	5/01/2016 23:45	0.4	23/06/2016 20:15	0.4	14/09/2016 2:30	0.4	14/03/2016 13:00	0.2	17/06/2016 15:30	0.2	6/07/2016 4:45	0.2
18/09/2016 12:45	1.6	10/08/2016 17:15	1	3/08/2016 0:45	0.8	5/07/2016 0:45	0.6	15/01/2016 0:00	0.4	23/06/2016 23:00	0.4	14/09/2016 3:15	0.4	14/03/2016 13:15	0.2	17/06/2016 16:45	0.2	6/07/2016 5:15	0.2
18/09/2016 16:15	1.6	20/08/2016 0:15	1	20/08/2016 0:30	0.8	5/07/2016 6:45	0.6	15/01/2016 6:15	0.4	23/06/2016 23:45	0.4	14/09/2016 11:30	0.4	14/03/2016 16:30	0.2	17/06/2016 19:15	0.2	6/07/2016 9:00	0.2
29/09/2016 6:30	1.6	31/08/2016 13:00	1	22/08/2016 13:30	0.8	8/07/2016 10:00	0.6	15/01/2016 7:30	0.4	24/06/2016 10:30	0.4	14/09/2016 16:00	0.4	15/03/2016 7:30	0.2	18/06/2016 1:00	0.2	6/07/2016 13:30	0.2
29/09/2016 11:00	1.6	31/08/2016 13:45	1	22/08/2016 14:00	0.8	8/07/2016 10:15	0.6	15/01/2016 9:45	0.4	24/06/2016 16:15	0.4	16/09/2016 7:00	0.4	19/03/2016 7:30	0.2	18/06/2016 2:00	0.2	6/07/2016 13:45	0.2
17/10/2016 6:45	1.6	1/09/2016 22:15	1	22/08/2016 19:15	0.8	8/07/2016 12:00	0.6	15/01/2016 10:45	0.4	1/07/2016 4:45	0.4	18/09/2016 8:00	0.4	18/04/2016 9:15	0.2	18/06/2016 2:45	0.2	6/07/2016 16:00	0.2
21/10/2016 20:30	1.6	2/09/2016 6:30	1	24/08/2016 15:45	0.8	19/07/2016 16:30	0.6	15/01/2016 11:30	0.4	5/07/2016 1:45	0.4	18/09/2016 8:15	0.4	18/04/2016 13:15	0.2	18/06/2016 3:00	0.2	6/07/2016 19:00	0.2
22/10/2016 6:15	1.6	2/09/2016 8:30	1	24/08/2016 17:45	0.8	20/07/2016 0:00	0.6	15/01/2016 11:45	0.4	5/07/2016 5:00	0.4	18/09/2016 8:30	0.4	22/04/2016 15:00	0.2	18/06/2016 3:30	0.2	6/07/2016 19:30	0.2
12/11/2016 1:00	1.6	2/09/2016 8:45	1	24/08/2016 18:00	0.8	20/07/2016 1:00	0.6	21/01/2016 19:45	0.4	5/07/2016 6:30	0.4	18/09/2016 9:15	0.4	22/04/2016 15:30	0.2	18/06/2016 5:15	0.2	6/07/2016 20:00	0.2
12/11/2016 2:45	1.6	2/09/2016 14:15	1	31/08/2016 12:15	0.8	20/07/2016 1:15	0.6	21/01/2016 20:00	0.4	5/07/2016 17:00	0.4	18/09/2016 10:00	0.4	22/04/2016 16:00	0.2	18/06/2016 10:00	0.2	6/07/2016 20:15	0.2
16/12/2016 4:45	1.6	2/09/2016 23:30	1	31/08/2016 13:15	0.8	20/07/2016 1:30	0.6	22/01/2016 0:00	0.4	5/07/2016 17:30	0.4	18/09/2016 13:30	0.4	23/04/2016 7:30	0.2	19/06/2016 5:30	0.2	6/07/2016 20:30	0.2
16/12/2016 5:00	1.6	14/09/2016 0:45	1	31/08/2016 14:00	0.8	20/07/2016 2:15	0.6	22/01/2016 6:15	0.4	5/07/2016 19:15	0.4	21/09/2016 5:45	0.4	30/04/2016 7:30	0.2	19/06/2016 5:45	0.2	6/07/2016 21:15	0.2
15/01/2016 3:00	1.4	18/09/2016 11:00	1	1/09/2016 20:45	0.8	20/07/2016 10:30	0.6	22/01/2016 14:15	0.4	6/07/2016 13:00	0.4	21/09/2016 6:00	0.4	30/04/2016 8:15	0.2	19/06/2016 9:00	0.2	7/07/2016 5:45	0.2
15/01/2016 5:15	1.4	18/09/2016 12:30	1	1/09/2016 21:15	0.8	2/08/2016 14:30	0.6	22/01/2016 17:00	0.4	6/07/2016 19:45	0.4	21/09/2016 6:15	0.4	30/04/2016 9:30	0.2	19/06/2016 9:30	0.2	7/07/2016 8:00	0.2
15/01/2016 6:00	1.4	18/09/2016 15:45	1	1/09/2016 22:00	0.8	2/08/2016 18:45	0.6	22/01/2016 18:00	0.4	8/07/2016 8:30	0.4	21/09/2016 6:45	0.4	30/04/2016 11:15	0.2	19/06/2016 10:00	0.2	7/07/2016 16:45	0.2
15/01/2016 7:15	1.4	25/09/2016 5:45	1	1/09/2016 23:30	0.8	2/08/2016 19:15	0.6	27/01/2016 11:30	0.4	8/07/2016 9:45	0.4	21/09/2016 7:00	0.4	1/05/2016 4:30	0.2	19/06/2016 10:45	0.2	7/07/2016 17:15	0.2
15/01/2016 8:45	1.4	25/09/2016 6:30	1	2/09/2016 0:00	0.8	2/08/2016 20:15	0.6	27/01/2016 14:45	0.4	8/07/2016 11:30	0.4	21/09/2016 7:15	0.4	1/05/2016 7:30	0.2	19/06/2016 11:30	0.2	8/07/2016 5:45	0.2
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								27/01/2016 16:00	0.4									8/07/2016 7:30	0.2

17/10/2016 8:00	3.2	2/09/2016 11:00	1.6	22/06/2016 7:00	0.8	19/07/2016 20:00	0.4	27/06/2016 7:00	0.2		
8/11/2016 16:00	3.2	2/09/2016 15:00	1.6	22/06/2016 8:00	0.8	20/07/2016 3:00	0.4	5/07/2016 2:00	0.2		
16/12/2016 14:00	3.2	3/09/2016 0:00	1.6	4/07/2016 23:00	0.8	20/07/2016 14:00	0.4	5/07/2016 7:00	0.2		
29/01/2016 12:00	3	13/09/2016 23:00	1.6	5/07/2016 19:00	0.8	23/07/2016 2:00	0.4	5/07/2016 20:00	0.2		
4/06/2016 5:00	3	17/10/2016 13:00	1.6	6/07/2016 13:00	0.8	2/08/2016 15:00	0.4	6/07/2016 0:00	0.2		
8/07/2016 10:00	3	9/11/2016 15:00	1.6	6/07/2016 19:00	0.8	3/08/2016 2:00	0.4	6/07/2016 4:00	0.2		
20/07/2016 0:00	3	22/01/2016 0:00	1.4	8/07/2016 9:00	0.8	20/08/2016 3:00	0.4	6/07/2016 5:00	0.2		
20/07/2016 11:00	3	27/01/2016 13:00	1.4	11/07/2016 17:00	0.8	22/08/2016 16:00	0.4	6/07/2016 9:00	0.2		
18/09/2016 16:00	3	27/01/2016 14:00	1.4	11/07/2016 21:00	0.8	22/08/2016 22:00	0.4	6/07/2016 16:00	0.2		
29/09/2016 11:00	3	9/06/2016 7:00	1.4	19/07/2016 15:00	0.8	23/08/2016 0:00	0.4	6/07/2016 21:00	0.2		
17/10/2016 11:00	3	17/06/2016 14:00	1.4	2/08/2016 23:00	0.8	23/08/2016 14:00	0.4	7/07/2016 5:00	0.2		
30/10/2016 18:00	3	19/06/2016 14:00	1.4	24/08/2016 16:00	0.8	24/08/2016 5:00	0.4	7/07/2016 8:00	0.2		
15/01/2016 7:00	2.8	7/07/2016 17:00	1.4	31/08/2016 10:00	0.8	25/08/2016 3:00	0.4	7/07/2016 16:00	0.2		
15/01/2016 8:00	2.8	8/07/2016 8:00	1.4	2/09/2016 3:00	0.8	31/08/2016 18:00	0.4	8/07/2016 5:00	0.2		
15/01/2016 10:00	2.8	19/07/2016 16:00	1.4	9/09/2016 23:00	0.8	2/09/2016 18:00	0.4	10/07/2016 0:00	0.2		
31/08/2016 14:00	2.8	19/07/2016 19:00	1.4	10/09/2016 2:00	0.8	2/09/2016 19:00	0.4	11/07/2016 16:00	0.2		
1/09/2016 23:00	2.8	22/08/2016 12:00	1.4	13/09/2016 21:00	0.8	3/09/2016 1:00	0.4	11/07/2016 18:00	0.2		
2/09/2016 0:00	2.8	31/08/2016 11:00	1.4	13/09/2016 22:00	0.8	9/09/2016 20:00	0.4	20/07/2016 8:00	0.2		
2/09/2016 8:00	2.8	1/09/2016 20:00	1.4	14/09/2016 3:00	0.8	14/09/2016 11:00	0.4	20/07/2016 12:00	0.2		
29/09/2016 10:00	2.8	2/09/2016 4:00	1.4	14/09/2016 17:00	0.8	16/09/2016 7:00	0.4	21/07/2016 15:00	0.2		
12/11/2016 4:00	2.8	9/09/2016 17:00	1.4	18/09/2016 9:00	0.8	25/09/2016 1:00	0.4	22/07/2016 13:00	0.2		
16/12/2016 5:00	2.8	13/09/2016 20:00	1.4	18/09/2016 19:00	0.8	29/09/2016 5:00	0.4	27/07/2016 5:00	0.2		
15/01/2016 9:00	2.6	18/09/2016 8:00	1.4	29/09/2016 9:00	0.8	30/09/2016 13:00	0.4	27/07/2016 12:00	0.2		
9/06/2016 8:00	2.6	21/09/2016 7:00	1.4	30/10/2016 19:00	0.8	30/09/2016 14:00	0.4	11/08/2016 8:00	0.2		
2/09/2016 5:00	2.6	21/09/2016 9:00	1.4	15/12/2016 18:00	0.8	3/10/2016 12:00	0.4	19/08/2016 23:00	0.2		
14/09/2016 0:00	2.6	21/09/2016 11:00	1.4	24/12/2016 22:00	0.8	5/10/2016 0:00	0.4	20/08/2016 1:00	0.2		
25/09/2016 5:00	2.6	17/10/2016 10:00	1.4	3/01/2016 19:00	0.6	17/10/2016 15:00	0.4	20/08/2016 2:00	0.2		
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11/03/2016 17:00	2.4	15/12/2016 21:00	1.4	9/05/2016 13:00	0.6	21/10/2016 22:00	0.4	22/08/2016 17:00	0.2		
4/06/2016 7:00	2.4	21/01/2016 19:00	1.2	9/05/2016 17:00	0.6	22/10/2016 8:00	0.4	22/08/2016 21:00	0.2		
4/06/2016 9:00	2.4	18/03/2016 8:00	1.2	26/05/2016 4:00	0.6	22/10/2016 10:00	0.4	24/08/2016 19:00	0.2		
20/06/2016 12:00	2.4	26/05/2016 8:00	1.2	28/05/2016 13:00	0.6	12/11/2016 8:00	0.4	25/08/2016 13:00	0.2		
22/06/2016 2:00	2.4	26/05/2016 10:00	1.2	3/06/2016 10:00	0.6	15/12/2016 8:00	0.4	31/08/2016 17:00	0.2		
22/06/2016 3:00	2.4	4/06/2016 8:00	1.2	3/06/2016 23:00	0.6	15/12/2016 20:00	0.4	1/09/2016 12:00	0.2		
20/07/2016 2:00	2.4	19/06/2016 10:00	1.2	4/06/2016 1:00	0.6	16/12/2016 3:00	0.4	2/09/2016 16:00	0.2		
20/08/2016 0:00	2.4	19/06/2016 11:00	1.2	6/06/2016 22:00	0.6	17/12/2016 3:00	0.4	2/09/2016 20:00	0.2		
22/08/2016 13:00	2.4	19/06/2016 12:00	1.2	9/06/2016 11:00	0.6	3/01/2016 16:00	0.2	3/09/2016 7:00	0.2		
2/09/2016 7:00	2.4	20/06/2016 13:00	1.2	17/06/2016 15:00	0.6	5/01/2016 7:00	0.2	9/09/2016 19:00	0.2		
10/09/2016 0:00	2.4	24/06/2016 14:00	1.2	18/06/2016 5:00	0.6	6/01/2016 8:00	0.2	10/09/2016 3:00	0.2		
30/09/2016 11:00	2.4	24/06/2016 16:00	1.2	19/06/2016 7:00	0.6	14/01/2016 23:00	0.2	16/09/2016 3:00	0.2		
3/01/2016 17:00	2.2	2/08/2016 14:00	1.2	20/06/2016 21:00	0.6	15/01/2016 17:00	0.2	19/09/2016 3:00	0.2		
22/01/2016 18:00	2.2	22/08/2016 19:00	1.2	21/06/2016 0:00	0.6	22/01/2016 19:00	0.2	22/09/2016 1:00	0.2		
27/01/2016 11:00	2.2	24/08/2016 17:00	1.2	21/06/2016 2:00	0.6	26/01/2016 11:00	0.2	25/09/2016 4:00	0.2		
27/01/2016 15:00	2.2	2/09/2016 2:00	1.2	21/06/2016 22:00	0.6	27/01/2016 17:00	0.2	25/09/2016 16:00	0.2		
29/01/2016 11:00	2.2	21/09/2016 10:00	1.2	21/06/2016 23:00	0.6	28/01/2016 14:00	0.2	30/09/2016 8:00	0.2		
11/03/2016 20:00	2.2	30/09/2016 10:00	1.2	22/06/2016 0:00	0.6	29/01/2016 13:00	0.2	30/09/2016 15:00	0.2		
5/07/2016 17:00	2.2	12/12/2016 2:00	1.2	23/06/2016 20:00	0.6	29/01/2016 17:00	0.2	30/09/2016 17:00	0.2		
18/09/2016 11:00	2.2	16/12/2016 0:00	1.2	24/06/2016 10:00	0.6	20/02/2016 17:00	0.2	1/10/2016 4:00	0.2		
18/09/2016 13:00	2.2	16/12/2016 2:00	1.2	24/06/2016 19:00	0.6	12/03/2016 2:00	0.2	1/10/2016 14:00	0.2		
		16/12/2016 12:00	1.2	6/07/2016 20:00	0.6	14/03/2016 16:00	0.2	3/10/2016 9:00	0.2		
		16/12/2016 15:00	1.2	11/07/2016 19:00	0.6	15/03/2016 7:00	0.2	3/10/2016 11:00	0.2		

Appendix C

Photo Comparison Upstream

Wilpinjong Creek Photo Comparison Upstream December 2011, September 2014, December 2015 and December 2016

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
1					• Increased exposure of bedrock along the banks • Increase in active channel creek width; • Increased sediment deposition midstream • Increase debris on creek bank
2					• An increase in in-stream growth between 2015 to 2016; • Blackberry noted in the area; • Groundcover stabilised; • Increased leaf litter; • Several wombat holes noted.
3					• Bank stabilisation between 2015-2016. Fair surface coverage; • Increased growth and regeneration of instream flora; • Site remains similar between 2015-2016.
4					• Continued erosion of the right bank – soil exposure; • Left banks stabilising; • Increased flora health instream; • Blackberry noted in the area.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
5					• Right bank stabilising with good bank ground coverage. • Left bank increased soil exposure and erosion over the past few years; • Instream plant growth - similar; • Active channel reamain similar.
6					• Increase shrub growth left bank • A reduction in in stream flora growth; • Reduction in active channel width; • Increase in in stream debris; • Blackberry noted. • Several trees have fallen into the creek bed.
7					• Left bank stabilising; • Right bank stable; • Blackberry noted; • Fox noted; • Similar site to previous year.
8					• Site moved due to access issues; • New site – sediment deposition but stable.
9					• Site moved due to access issues; • New site – sediment and debris deposition but stable.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
10					• Low banks – good ground coverage and stable; • Increased woody debris instream; • Upstream bed staining noted. • Similar to previous year; • Blackberry noted.
11					• Increase in instream flora growth; • Reduction in the active channel; • Site similar to previous year. • Blackberry noted.
12					• Large amount of Patterson's Curse noted in the area; • Increase in instream debris; • Site similar to previous year.
13					• Scotch thistles noted; • Wombats noted in the area; • Increase in debris; • Banks stabilising; • Site similar to last year
14					• Site similar to previous year; • Banks relatively stable; • Blackberry present; • Patterson's curse noted. • Evidence of wombats.

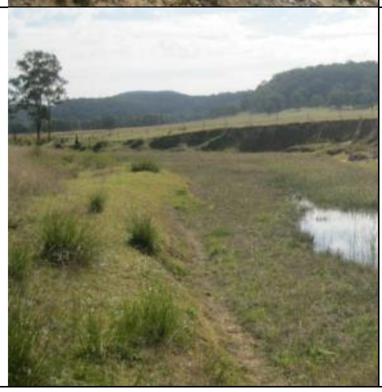
Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
15					• Site similar to previous year; • Increase in instream flora growth. • Banks relatively stable – excellent ground coverage. • Scotch thistles noted; • Blackberry present; • Evidence of wombats.
16					• Dense instream vegetation; • Both banks stable – excellent ground coverage; • Scotch thistles note; • Blackberry noted; • Some minor bed deposition at the location.
17					• Slightly different location as a result of access difficulties; • Site well vegetated – instream and on minor banks; • Little to no riparian zone.
18					• Increased in instream flora health; • Pooling in the area; • Banks well vegetated; • Left bank erosion noted; • Dominated by weed species – Scotch Thistles and Patterson's Curse • Little to no riparian zone.
19					• 2015 slightly different location; • Increase in instream health – compared to 2014; • Pooling in the area; • Banks well vegetated; • Left bank erosion noted; • Dominated by weed species – Scotch Thistles and Patterson's Curse • Little to no riparian zone.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
20					• Pooling in the area; • Banks well vegetated; • Left bank erosion noted; • Dominated by weed species – Scotch Thistles and Patterson's Curse • Little to no riparian zone.
21					• Reduction in healthy instream flora; • Dominated by weed species – Scotch Thistles and Patterson's Curse • Sediment deposition instream noted • Little to no riparian zone.
22					• Reduction in instream flora; • Continued bleaching of exposed soils on the right bank face; • Left bank remains stable however increase in exposure; • Reduction of the active channel; • Little to no riparian zone.
23					• Instream vegetation remains similar to last year; • Left bank exposure reduced – increase in groundcover; • Continued bleaching of exposed soils on the bank faces; • Reduction of the active channel; • Little to no riparian zone; • Rabbits noted in the area.
24					• Instream vegetation remains similar to last year; • Left bank exposure reduced – increase in groundcover; • Continued bleaching of exposed soils on the bank faces; • Reduction of the active channel; • Little to no riparian zone.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
25					• Instream vegetation remains similar; • Increased bank stability left bank – reduction in exposed soils and increase in vegetation cover; • Right bank remain similar; • Bank vegetation – dominated by thistle species; • No ripararian zone.
26					• Instream vegetation – remains similar; • Left bank stabilization and exposure – remains similar to last year; • Bleaching and salt crusting continued to be evident on the left top bank; • Right bank – remain stable; • Blackberry noted; • Rabbits noted; • No riparian zone.
27					• Instream vegetation – remains similar; • Left bank stabilization and exposure – remains similar to last year; • Bleaching and salt crusting continued to be evident on the left top bank; • Right bank – remain stable; • Blackberry noted; • Rabbits noted; • No riparian zone.
28					• Reduction in instream vegetation; • Ponding in the area; • Sediment deposition noted; • Left bank – increase in soil exposure; • Right bank – lateral erosion – similar to last year. Little to no riparian zone.
29					• Site remains similar to last year; • Site is dominated by weed species – thistles; • Little to no riparian zone.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
30					• Instream vegetation remains similar; • Bank stability remain similar – with good vegetation coverage; • Blackberry noted on both banks; • Wombats also noted. • Good general regeneration in the riparian areas as a result of destocking.
31					• Instream vegetation remains similar; • Reduction in soil exposure on the right bank; • Salt crystallisation continues to be apparent on the right bank in exposed areas; • Left bank stable and well vegetated; • Little to no riparian zone.
32					• Instream vegetation remains high; • Continued exposure, regression and erosion of the left bank; • Little to no riparian zone.
33					• Instream vegetation remains high; • Continued exposure, regression and erosion of the left bank in some areas; • Right bank remains similar; • Little to no riparian zone.
34					• Instream vegetation remain high and similar to previous years; • Right bank remains stable and well vegetated; • Reduction in left bank soil exposure as a result of an increase in surface cover; • Site remains similar; • Little to no riparian zone.

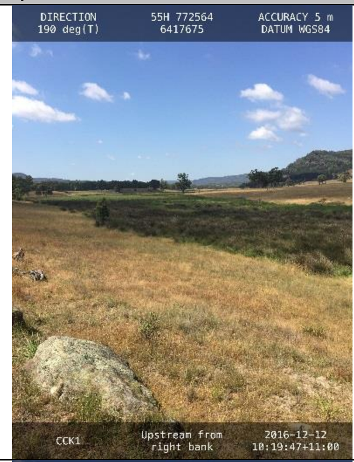
Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
35					• Instream vegetation remain high and similar to previous years; • Right bank remains stable and well vegetated; • Reduction in left bank soil exposure as a result of an increase in surface cover; • Site remains similar; • Prickly pear noted in the vicinity of the site. • Little to no riparian zone.
36					• Instream vegetation remains similar; • Reduction in right bank soil expsoure due to an increase in vegetation coverage; • Left bank similar – steeply sloped and concave; • Rabbits noted in the area • No riparian zone.
37					• Instream vegetation remains similar; • Left bank remains well vegetated and stable; • Reduction in right bank exposure due to an increase in vegetation cover; • Weed species dominate – thistles; • Rabbits noted in the area; • Little to no riparian zone.
38					• Instream vegetation remains similar; • Left bank remains well vegetated and stable; • Reduction in right bank exposure due to an increase in vegetation cover; • Weed species dominate – thistles; • Blackberry noted in the area. • Little to no riparian zone.
39	No Access - Private property				• Site remains similar to last year; • Creek bed is well vegetated with little to no exposure of the creek bed; • Both banks are well vegetated; • Blackberry noted close to the site; • Wombats noted on site; • Stock noted within the area; • Little to no riparian zone.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
40	No Access - Private property				• Creek bed remains well vegetated with little to no exposure of the creek bed; • Left bank is stable and well vegetated; • Reduction in soil exposure and sheet erosion on the right bank due to an increase in ground cover. • No riparian zone.
41	No Access - Private property		No Access – Private property		• Creek bed is well vegetated with little to no exposure of the creek bed; • Left bank is well vegetated; • Right bank suffering from minor soil exposure and erosion; • Lack of riparian zone on both banks; • Evidence of stock in the creek bed.
42					• Creek bed is well vegetated, some pooling in the area; • Left bank is stable and well vegetated; • Reduction in soil exposure, erosion and regretation of the right bank, due to an increase in ground cover and leaf litter; • An increase in undercutting of the inner right bank; • Lack of riparian zone on both banks.
43				No Access	• No comparison 2016.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
44			No Access – Private property		• Increase in instream vegetation coverage since 2014; • The right bank is stable and well vegetated; • The left bank is stabilizing as a result on increased vegetation coverage; • Minimal riparian zone.
45					• Creek bed well vegetated; • Both banks are stable and well vegetated. • Minimal riparian zone.
46					• Creek bed well vegetated; • Both banks are stable and well vegetated. • Minimal riparian zone.
47					• Instream vegetation remains similar; • Site continues to stabilise; • Minimal riparian zone.

Site	Upstream December 2011	Upstream December 2014	Upstream December 2015	Upstream December 2016	Main Comparison
48					• Instream vegetation remains similar; • Site continues to stabilise; • Minimal riparian zone.
49					• Reduction in instream vegetation; • Instream vegetation remains similar; • Site continues to stabilise; • Minimal riparian zone. .

Cumbo Creek Photo Comparison Upstream 2011, 2014, 2015 & 2016

Site	Upstream December 2011	Upstream September 2014	Upstream December 2015	Upstream December 2016	Main Comparison
1					• Reduction in 'green' groundcover within the creek bed and on the creek bank faces between 2015 to 2016. • Site remain well vegetated with groundcover and stable. • No riparian zone.
2					• Reduction in 'green' groundcover within the creek bed and on the creek bank faces between 2015 to 2016. • Site remain well vegetated with groundcover and stable. • No riparian zone.
3					• Pooling remains visible in this area. • Reduction in 'green' groundcover within the creek bed and on the creek bank faces between 2015 to 2016. • Site remain well vegetated with groundcover and stable. • No riparian zone.

4					• Site remain well vegetated with groundcover and stable. • No riparian zone.
5					• Site remain well vegetated with groundcover and stable. • No riparian zone.
6					• Site remain well vegetated with groundcover and stable. • No riparian zone. •
7		Missing due to construction		No Access	• No comparisons

8					• Site remain well vegetated with groundcover and stable. • No riparian zone.
9					• Site remain well vegetated with groundcover and stable. • No riparian zone.
10					• Site remain well vegetated with groundcover and stable. • No riparian zone.

Appendix D

Photo Comparison Downstream

Wilpinjong Creek Photo Comparison Downstream December 2011, September 2014, December 2015 and December 2016

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
1					• A reduction in instream plant growth; • An increase in green plant growth on the creek bank faces and in the riparian zone; • Stabilisation of bank erosion – banks well vegetated.
2					• An increase in in-stream growth between 2015 to 2016; • Blackberry noted in the area; • Groundcover stabilised; • Increased leaf litter; • Several wombat holes noted.
3					• Pooling instream and reduced flora growth and regeneration between 2015 and 2016; • Continued bleaching of exposed soils within the bank faces;
4					• Continued bank collapse – increased soil exposure; • Left banks stabilising; • Increased flora health instream; • Blackberry noted in the area.
5					• Right bank stabilising with good bank ground coverage. • Left bank increased soil exposure and erosion over the past few years; • Instream plant growth - similar; • Active channel reamain similar.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
6					• Increase shrub growth left bank. • A reduction in in stream flora growth; • Reduction in active channel width; • Increase in in stream debris; • Blackberry noted.
7					• Left bank stabilising; • Right bank stable; • Blackberry noted; • Fox noted; • Similar site to previous year.
8					• Site moved due to access issues; • New site – sediment deposition but stable.
9					• Site moved due to access issues; • New site – sediment and debris deposition but stable.
10					• Similar to previous year. • Blackberry noted.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
11					• Low banks – good ground coverage and stable; • Increased woody debris instream; • Site similar to previous year; • Blackberry noted.
12					• Large amount of Patterson's Curse noted in the area; • Increase in instream debris; • Site similar to previous year.
13					• Scotch thistles noted; • Wombats noted in the area; • Increase in debris; • Banks stabilising; • Site similar to last year.
14					• Site similar to previous year; • Banks relatively stable; • Blackberry present; • Patterson's curse noted. • Evidence of wombats.
15					• Site similar to previous year; • Increase in instream flora growth. • Banks relatively stable – excellent ground coverage. • Scotch thistles noted; • Blackberry present; • Evidence of wombats.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
16					• Both banks stable – excellent ground coverage; • Scotch thistles note; • Blackberry noted; • Sediment deposition within the bed at this location.
17					• Slightly different location as a result of access difficulties; • Site well vegetated – instream and on minor banks; • Little to no riparian zone.
18					• 2015 slightly different location; • Increased in instream flora health; • Pooling in the area; • Banks well vegetated; • Left bank erosion noted; • Dominated by weed species – Scotch Thistles and Patterson's Curse • Little to no riparian zone.
19					• 2015 slightly different location; • Increase in instream health – compared to 2014; • Pooling in the area; • Banks well vegetated; • Left bank erosion noted; • Dominated by weed species – Scotch Thistles and Patterson's Curse • Little to no riparian zone.
20					• Pooling in the area; • Banks well vegetated; • Left bank erosion noted; • Dominated by weed species – Scotch Thistles and Patterson's Curse • Little to no riparian zone.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
21					• Reduction in healthy instream flora; • Left bank lateral erosion and bleaching– similar to last year; • Dominated by weed species – Scotch Thistles and Patterson's Curse; • Sediment deposition instream noted • Little to no riparian zone.
22					• Dominated by weed species – Scotch Thistles and Patterson's Curse; • Left bank lateral erosion and bleaching– similar to last year; • Well vegetated; • Little to no riparian zone; • Rabbits noted in the area; • Similar to last year.
23					• Reduction in instream flora; • Continued bleaching of exposed soils on the right bank face; • Left bank remains stable however increase in exposure; • Reduction of the active channel; • Little to no riparian zone.
24					• Reduction in healthy instream flora; • Increased bleaching of exposed soils on the right bank face; • An increase in sheet erosion of the right bank; • Left bank remains stable; • Reduction of the active channel; • Little to no riparian zone.
25					• Instream vegetation remains similar; • Increased bank stability left bank – reduction in exposed soils and increase in vegetation cover; • Right bank remain similar; • Bank vegetation – dominated by thistle species; • Little to no ripairan zone.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
26					• Instream vegetation – remains similar; • Left bank stabilization and exposure – remains similar to last year; • Bleaching and salt crusting continued to be evident on the left top bank; • Right bank – remain stable; • Blackberry noted; • Rabbits noted; • No riparian zone.
27					• Instream vegetation – remains similar; • Left bank stabilization and exposure – remains similar to last year; • Bleaching and salt crusting continued to be evident on the left top bank; • Right bank – remain stable; • Blackberry noted; • Rabbits noted; • No riparian zone.
28					• Reduction in instream vegetation; • Ponding in the area; • Sediment deposition noted; • Left bank – increase in soil exposure; • Right bank – lateral erosion – similar to last year. • Little to no riparian zone.
29					• Site remains similar to last year; • Site is dominated by weed species – thistles; • Erosion of the left bank continues as a result of with a lack of groundcover and steep slope; • Little to no riparian zone.
30					• Instream vegetation remains similar; • Bank stability remain similar – with good vegetation coverage; • Blackberry noted on both banks; • Wombats also noted. • Good general regeneration in the riparian areas as a result of destocking.

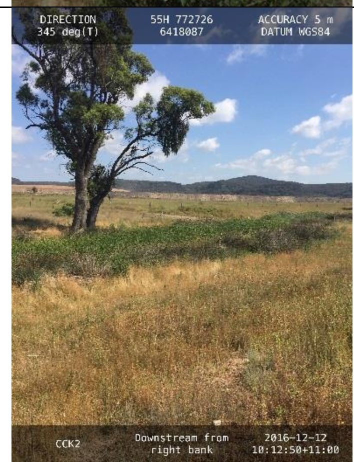
Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
31					• Instream vegetation remains similar; • Reduction in soil exposure on the right bank; • Salt crystallisation continues to be apparent on the right bank in exposed areas; • Left bank stable; • Little to no riparian zone.
32					• Instream vegetation remains high; • Continued exposure, regression and erosion of the left bank in some areas; • Little to no riparian zone.
33					• Instream vegetation remains high; • Continued exposure, regression and erosion of the left bank in some areas; • Little to no riparian zone.
34					• Instream vegetation remain high and similar to previous years; • Right bank remains stable and well vegetated; • Reduction in left bank soil exposure as a result of an increase in surface cover; • Site remains similar; • Little to no riparian zone.
35					• Instream vegetation remain high and similar to previous years; • Right bank remains stable and well vegetated; • Reduction in left bank soil exposure as a result of an increase in surface cover; • Site remains similar; • Prickly pear noted in the vicinity of the site. • Little to no riparian zone.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
36					• Instream vegetation remains similar; • Right bank remain well vegetated and stable, however some slumping noted; • Reduction is soil exposure of the left bank as a result of increased vegetation coverage; • Rabbits noted in the area; • No riparian zone.
37					• Instream vegetation remains similar; • Left bank remains well vegetated and stable; • Reduction in right bank exposure due to an increase in vegetation cover; • Weed species dominate – thistles; • Rabbits noted in the area; • Little to no riparian zone.
38					• Instream vegetation remains similar; • Left bank remains well vegetated and stable; • Reduction in right bank exposure due to an increase in vegetation cover; • Weed species dominate – thistles; • Blackberry noted in the area. • Little to no riparian zone.
39	No Access - Private property				• Site remains similar to last year; • Creek bed remains well vegetated with little to no exposure of the creek bed; • Both banks are well vegetated; • Blackberry noted close to the site; • Wombats noted on site; • Stock noted within the area; • Little to no riparian zone
40	No Access - Private property				• Creek bed remains well vegetated with little to no exposure of the creek bed; • Left bank is stable and well vegetated; • Reduction in soil exposure and sheet erosion on the right bank due to an increase in ground cover. • No riparian zone.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
41	No Access - Private property		No Access – Private property		• Creek bed is well vegetated with little to no exposure of the creek bed; • Left bank is well vegetated; • Right bank suffering from minor soil exposure and erosion; • Lack of riparian zone on both banks; • Evidence of stock in the creek bed.
42					• Creek bed is well vegetated, some pooling in the area; • Left bank is stable and well vegetated; • Increase in soil exposure, erosion and regretation of the right bank; • An increase in undercutting of the inner right bank; • Lack of riparian zone on both banks.
43				No Access	• No comparison 2016.
44			No Access – Private property		• Increase in instream vegetation coverage since 2014; • Both banks are stable and well vegetated. • Minimal riparian zone.
45					• Creek bed well vegetated; • Both banks are stable and well vegetated. • Minimal riparian zone.

Site	Downstream December 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
46					• Creek bed is well vegetated with little to no exposure of the creek bed; • Both banks are well vegetated and stable; • Site continues to stabilise.
47					• Instream vegetation remains similar; • Site continues to stabilise; • Minimal riparian zone.
48					• Reduction in instream vegetation coverage; • Site continues to stabilise; • Minimal riparian zone.
49					• Reduction in instream vegetation; • Instream vegetation remains similar; • Site continues to stabilise; • Minimal riparian zone.

Cumbo Creek Photo Comparison Downstream 2011, 2014, 2015 & 2016

Site	Downstream January 2011	Downstream September 2014	Downstream December 2015	Downstream December 2016	Main Comparisons
1					• Reduction in 'green' groundcover within the creek bed and on the creek ba • Site remain well vegetated with groundcover and stable. • No riparian zone.
2					• Reduction in 'green' groundcover within the creek bed and on the creek ba • Site remain well vegetated with groundcover and stable. • No riparian zone.
3					• Some pooling in the area – increase in bed exposure. • Site remain well vegetated with groundcover and stable. • No riparian zone.

4					• Site remain well vegetated with groundcover and stable. • No riparian zone.
5					• Site remain well vegetated with groundcover and stable. • No riparian zone.
6					• Some pooling in the local area. • Site remain well vegetated with groundcover and stable. • No riparian zone.
7	Removed from survey due to works in area.			No Access	• No comparisons

<table>
<tr><td>8</td><td></td><td></td><td></td><td></td><td>Site remain well vegetated with groundcover and stable.
No riparian zone.</td></tr>
<tr><td>9</td><td></td><td></td><td></td><td></td><td>Site remain well vegetated with groundcover and stable.
No riparian zone.</td></tr>
<tr><td>10</td><td></td><td></td><td></td><td></td><td>Pooling in local area. Reduction in groundcover, within the creek bed noted
Site remain well vegetated with groundcover and stable.
No riparian zone.</td></tr>
</table>

Report

Baseline OPSIM Model Setup

H352411-00000-228-230-0001

2017-04-07	0	Approved for Use	G. Rootsey	J. Heaslop	J. Heaslop	Not Required
DATE	REV.	STATUS	PREPARED BY	CHECKED BY	APPROVED BY	APPROVED BY
				Discipline Lead	Functional Manager	Client

Executive Summary

As part of ongoing water management, Wilpinjong Coal Pty Ltd (WCPL) have engaged Hatch Pty Ltd (Hatch) to develop an operational water balance model for the Wilpinjong mine using the OPSIM simulation software. At a high level, the project has entailed a review of historical data to define the Wilpinjong water management system (WMS) in terms of where and how water is generated, used, lost and stored. This understanding has been leveraged to develop and verify a water balance simulation model which is suitable for on-going planning, infrastructure sizing and operational decision making.

This report documents the acquisition and review of historical WMS data, and development and verification of the Wilpinjong OPSIM model. The intent of this report is to: **1)** document the basis of the Wilpinjong OPSIM model, and to serve as a platform that future planning studies can build upon, **2)** outline recommendations for further monitoring and/or studies that will allow the accuracy of the Wilpinjong OPSIM model to be improved, and **3)** satisfy the requirements of the Site Water Balance per Condition 30, Schedule 3 of Project Approval PA 05-0021 (refer to Section 11).

Current investigations have been undertaken to a level of detail sufficient to maintain a fair and reasonable appreciation of the hydrological characteristics for the Wilpinjong WMS. The OPSIM model was able to successfully reproduce the observed site water management system performance over the period January 2014 to January 2017, however it is noted that there remains some uncertainty associated with selected model parameters and assumptions, including: catchment yield parameters, groundwater inflow rates, spoil aquifer storage capacity and possible level-driven outflow mechanisms acting on Pit 2W and Pit 1S. Recommendations to address or account for these uncertainties have been listed in Table 10-1 of Section 10.3.4 (page 48) of this report. Recommendations generally entail:

- Incorporating sensitivity analysis, and scenario-appropriate model settings as part of future planning studies.
- Conducting further monitoring (particularly during the dewatering of Pit 5, and monitoring of electrical conductivity during the forthcoming river discharge campaign).
- Hydrogeological studies to investigate spoil storage characteristics, level-driven outflow mechanisms, and suitability of Pit 2W to store water above 370 mRL.
- Conducting further investigations to define the breakdown of the inferred 60 ML/mth water usage inferred as part of this study (refer Section 5.1.3). Investigations may include review of design information and/or additional metering (portable or permanent meters).
- On-going data collection and refinement of the OPSIM model.

Despite the uncertainties noted above, the model is considered to be well suited for planning studies, infrastructure sizing and operational decision making, provided these studies incorporate sensitivity analysis (as any robust study should). The next OPSIM update should be undertaken after completion of the next wet-season or sooner if any significant discrepancy or uncertainty between OPSIM simulation and actual system performance becomes apparent. It should be noted that the content of this report may be subject to revision with any future improved understanding of the operational and response characteristics of the Wilpinjong WMS.

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1. Introduction

The Wilpinjong Coal Mine (Wilpinjong) is an open cut thermal coal mine located approximately 40 kilometres (km) north-east of Mudgee, in the Western Coalfields of New South Wales (NSW). The mine is managed by Wilpinjong Coal Pty Ltd (WCPL), a subsidiary of Peabody Energy Australia Pty Limited (PEA).

As part of ongoing water management, WCPL have engaged Hatch Pty Ltd (Hatch) to develop an operational water balance model for the site using the OPSIM simulation software.

At a high level, the project has entailed a review of historical data to define the Wilpinjong water management system (WMS) in terms of where and how water is generated, used, lost and stored. This understanding has been leveraged to develop and verify a water balance simulation model, suitable for planning, infrastructure sizing and operational decision making.

The project scope of work is outlined in Hatch proposal 16-3641-BP-AU01-10001 (Revision 0, dated 26 July 2016), and includes:

1. Acquisition and review of historical WMS data;
2. OPSIM model development and verification;
3. Design model development and performance assessment;
4. Water inventory tracking tool development; and
5. Preparation of model documentation.

This report covers scope items 1, 2 and 5. Scope items 3 and 4 will be covered by a separate report(s).

The intent of this report is to document the basis of the Wilpinjong OPSIM model, and to serve as a platform that future planning studies (i.e. scope item 3) can build upon. This report also outlines recommendations for further monitoring and/or studies that will allow the accuracy of the Wilpinjong OPSIM model to be improved.

This report is also intended to satisfy the requirements of the Site Water Balance as required by Condition 30, Schedule 3 of Project Approval PA05-0021.

Key personnel involved with investigations to date have included:

Wilpinjong Coal Pty Ltd

- Kieren Bennetts, Environment and Community Manager

Peabody Energy Australia

- John Merritt, Senior Specialist – Environment & Water

Hatch Pty Ltd

- Gavin Rootsey, Water Engineer
- Jim Heaslop, Senior Water Engineer

2. Background

2.1 Operational Description

Wilpinjong is an open cut coal thermal coal mine located approximately 40 kilometres north-east of Mudgee, near the Village of Wollar, within the Mid-Western Regional Local Government Area, in central NSW. The mine is owned and operated by WCPL, a wholly owned subsidiary of PEA. The mine extracts run-of-mine (ROM) coal from the Ulan Seam or Moolarben Coal Member which is either processed on site at the Coal Handling and Preparation Plant (CHPP) or bypassed directly to product stockpiles. Current approvals permit production of up to 16 million tonnes per annum (Mtpa) of ROM coal and to rail 12.5 Mtpa[1] of product coal. Coal products are transported by rail on the existing Sandy Hollow Gulgong Railway to domestic energy generators and to the Port of Newcastle for export.[2]

The Wilpinjong mine has seven approved open cut mining areas, named Pit 1 through to Pit 7. Mining is currently undertaken in Pits 1, 2, 3, 4, 5 and 7. Open cut mining in Pit 6 is yet to commence, but is scheduled for 2017. Open cut mining of Pit 1, 2 and 5 has historically originated at a central point, and has progressed outward, forming a series of peripheral excavations separated by backfilled spoil. These sub-pits are defined based on their relative position within the associated main pit, i.e. Pit 5 South (Pit 5S), Pit 5 North (Pit 5N) etc.

The mine is located on the right bank of Wilpinjong Creek, which is incised into a valley between the sandstone plateaus of the Munghorn Gap Nature Reserve to the south, and the Goulburn River National Park to the north. The mine is located on the alluvial/colluvial flats associated with the gullies draining the southern escarpment. The valley flats have typical gradients toward Wilpinjong Creek of approximately 1 in 65 (1.5 percent). The escarpment rises approximately 100 m from the valley floor to elevations exceeding 450 m Australian Height Datum (mAHD) on the plateau. The sandstone plateaus are heavily forested. The valley flats in the nearby area are used for cattle and sheep grazing with intermittent cropping, principally for fodder.[3]

2.2 Approvals & Licenses

Mining operations at Wilpinjong are authorised under Project Approval (PA) 05-0021, which was originally granted in February 2006 and has since been modified on several occasions. The most recent approval, Modification 7, was granted on 11 August 2016.

The mine is also subject to conditions outlined in Environmental Protection License (EPL) No. 12425, which was most recently revised by the NSW Environmental Protection Agency (EPA) in February 2017.

[1] The production limit was temporarily increased from 12.5 Mtpa to 13.0 Mtpa during 2016, covered by PA 05-0021 Modification 7. Production limit reverted back to 12.5 Mtpa in 2017.

[2] Paragraph adapted from Resource Strategies Pty Ltd, 2015. *Wilpinjong Extension Project Environmental Impact Statement*. Document 00659084 Version A.

[3] Paragraph adapted from WRM Water & Environment, 2015. *Wilpinjong Extension Project Surface Water Assessment*. Doucment 1052-01-B9 Revision B9.

Mining operations are carried out upon Mining Lease (ML) 1573, in accordance with the Mining Operations Plan (MOP), a requirement of ML1573.

2.3 Wilpinjong Extension Project

In 2015, WCPL submitted a Development Application (DA) for the Wilpinjong Extension Project (WEP), which entails a continuation and extension of open cut mining operations beyond the extents approved under PA 05-0021. The WEP application was lodged with the NSW Department of Planning & Environment (DP&E) on 8 January 2016. As at quarter one (Q1) 2017, the WEP is currently proceeding through the final stages of the approval process. It is understood that if the WEP is approved, the mine would be granted a new Development Consent which would replace the existing PA 05-0021.

An Environmental Impact Statement (EIS) was prepared by Resource Strategies Pty Ltd (RS) on behalf of WCPL to support the WEP Development Application. The following studies were undertaken as part of the EIS, and have been referenced as part of the current water balance project:

- HydroSimulations: Groundwater Assessment (EIS Appendix C)
- WRM Water & Environment (WRM): Surface Water Assessment (EIS Appendix D)

The latter is considered particularly relevant as it entailed development of a water balance simulation model using the OPSIM simulation software, referred to herein as the WEP OPSIM. Current investigations have made reference to, or built upon, this earlier study where possible.

3. Water Management System

3.1 Overview

The Wilpinjong WMS comprises a network of dams interconnected via pumps/pipelines and drainage channels. The main objective of the WMS during wet periods is to minimise the risk of uncontrolled discharge of water to the receiving environment and to minimise the risk of pit inundation which may impact coal production. During dry periods, the main objective of the WMS is to ensure that adequate reserves are available to maintain water supply to industrial tasks. The majority of the systems water storage capacity is provided by Pit 2W, a former open cut mining pit located adjacent to Wilpinjong Creek. Other significant water storages include the Recycled Water Dam (RWD), Clean Water Dam (CWD) and Pit 1S. A locality plan has been provided in Figure 3-1.

As described in Section 2.1, open cut mining currently occurs in one of six pits (i.e. Pit 1, 2, 3, 4, 5, or 7). Review of deepest mined topographic data shows that historical mining has occurred within three distinct voids, which each share a common and continuous pit floor, and are divided from each other by an unmined in-situ rock barrier. These voids are referred to herein as **Pit 1/5** (containing Pits 5S, 5N, and 1), **Pit 2/4** (containing Pits 2W, 2S, and 4) and **Pit 3/7** (containing Pits 3 and 7). **Pit 1/5** and **Pit 2/4** feature a central overburden dump, which acts as a highly permeable aquifer. Water within each void passively drains down the dip of the former coal seam, collecting in either Pit 5N, Pit 4, or Pit 3 where it is then pumped to the Pit 2W hub water storage. Note that the **Pit 1/5**, **Pit 2/4** and **Pit 3/7** definitions are only used in the context of water management; these definitions do not align with mine planning terminology.

Water inflows to the WMS include rainfall, catchment runoff and groundwater interception. The mine has intersected several ephemeral creeks and these catchments now report to the WMS. At present, there are limited measures in place to divert clean catchment runoff away from the WMS (diversion drains, rehabilitation and discharge via sediment basins etc.). It is noted that Wilpinjong rehabilitation has not yet had sufficient time to mature to the extent that would allow runoff from these areas to be discharged off-site.

Water is used for dust suppression (road watering, stockpile sprays), wash down (washbays and vehicle wash stations) and for washing coal. The majority of water used for these applications is lost via evaporation or entrainment within railed product coal and waste rock dumps. The coal washing process formerly included a wet-tailings circuit, with tailings slurry pumped to a number of cells adjacent to Pit 2W for consolidation and water recovery (note that tailings was pumped into the northern end of Pit 1 prior to using the tailings cells). The process was modified in April 2015 to include a tailings belt filter press (BFP). Mixed reject is now disposed of within the overburden dumps and the tailings cells are in the process of being capped. One tailings cell will remain open to allow for the deposition of tailings slurry during periods in which the BFP is undergoing maintenance.

During periods of high water inventory, the site operates a reverse osmosis (RO) plant[4] and discharges a blend of permeate and Pit 2W water to the adjacent Wilpinjong Creek in

[4] Note that the RO plant is referred to as the Water Treatment Facility (WTF) in selected other documentation (e.g. approvals).

accordance with flow and water quality limits specified in EPL 12425. RO reject is pumped to Pit 1S. During periods of low water inventory (extended drought), the site may draw water from a network of bores in order to maintain supply to site water demands. Site also imports potable water which is used to supply amenities. Sewage is treated and disposed of via irrigation in accordance with EPL 12425. The potable water circuit has no functional influence on the performance of the WMS and is not discussed further in this study.

The following sub-sections summarise the physical characteristics of the Wilpinjong water management system, including water storage specifications and function, catchment and land use classification breakdown, and key transfer infrastructure specifications as incorporated in the model.

Figure 3-1: Locality Plan – Wilpinjong Mine

3.2 Water Storage Infrastructure and Voids

3.2.1 Function and Specifications

Summary specifications and brief functional descriptions for key water storages and voids within the Wilpinjong water management system have been provided in Table 3-1. Summary information includes location, full storage capacity levels and volumes, and catchment areas.

Infrastructure has been grouped based on function as one of the following:

- Water Storages: Infrastructure used for storing water that has come into contact with mining operations. Comprises surface ponds/dams and inactive mining pits used for bulk water storage.
- Tailings: dams or repurposed open cut mining pits used to store tailings waste. Note that tailings storage capacities have not been listed in the following tabulation, as available air space is not intentionally used for water storage.
- Mining Pits: open cut voids currently subject to active mining. Not used for water storage.

Table 3-1: Water Storage Infrastructure and Voids – Specifications and Function

Storage	Location GDA94 Zone 55		Catch Area (ha)	Full Storage Capacity		Functional Description
	Easting	Northing		(mRL)	(ML)	
Water Storages						
Pit 2 West	770,975	6,419,350	221.5	370.0*	2,276	Hub water storage, and primary buffer storage. Receives dewatering from mining and processing areas, and supplies water to industrial tasks as required. Feed water supply for the RO plant.
Pit 1 South	769,250	6,417,120	164.4	421.4	295	Stores reject from the RO plant.
Pit 5 Fill Point (FP) Dam	769,030	6,419,995	31.1	392.2	8	Water supply for dust suppression activities in the Pit 5 mining area. Water makeup from local mining area dewatering, or Pit 2W as a backup.
Clean Water Dam (CWD)	770,785	6,418,000	2.4	396.6	45	Water supply for CHPP/MIA area tasks. Water makeup from Pit 2W.
Recycled Water Dam (RWD)	770,270	6,417,430	199.5	412.6	295	Water supply for CHPP/MIA area tasks and to the ROM truck fill point. Water makeup from Pit 2W
Ed's Lake	770,085	6,419,690	218.4	375.3	110	Transfer dam located in backfilled Pit 1N void. Storage capacity includes basin to the north-east of the main void storage.
MIA Sediment Dam	770,570	6,417,820	- [5]	-	-	Sediment trap located near admin area. Intercepts sediments from water draining back to Pit 2W from the CHPP/MIA area.

[5] Catchment included within Pit 2W

Storage	Location GDA94 Zone 55		Catch Area (ha)	Full Storage Capacity		Functional Description
	Easting	Northing		(mRL)	(ML)	
Mining Pits						
Pit 5 South	767,835	6,418,265	1,029.1	n/a	n/a	Active mining pits.
Pit 5 North	769,130	6,420,620	363.6	n/a	n/a	
Pit 1	769,125	6,418,675	152.4	n/a	n/a	
Pit 2 South	771,330	6,416,985	50.7	n/a	n/a	
Pit 4	772,535	6,419,530	88.6	n/a	n/a	
Pit 3	773,518	6,419,490	230.9	n/a	n/a	
Pit 7	773,975	6,417,455	183.8	n/a	n/a	
Tailings Storages						
TD3	771,520	6,419,535	10.7	n/a	n/a	Inactive tailings storage facilities. TD3 capped. TD4 capping in progress.
TD4	771,525	6,419,300	29.1	n/a	n/a	
TD5	771,720	6,418,885	20.4	n/a	n/a	
TD6	771,785	6,418,580	31.1	n/a	n/a	
TD7	771,370	6,418,890	36.7	n/a	n/a	

Note: * recommended value

3.2.2 *Storage Characteristics*

Storage characteristics (level-area-volume relationships) have been defined based on the following information, provided by WCPL:

- Bathymetric Survey (Bruttour International Pty Ltd, 2014)[6] for Pit 2W, Pit1S, RWD and CWD.
- Stage data estimated by WCPL Technical Services[7] for active mining areas: Pit 5N, Pit 4 and Pit 3.
- 2016 surface topography[8] for all other water storages.
- 2016 deepest mined survey[9] used to estimate in-pit spoil dump volumes, for the purposes of estimating spoil aquifer storage characteristics (refer to Section 8.2)

Modelled level-area-volume profiles for all storages have been provided for reference in Appendix C.

3.2.3 *Storage Capacities*

3.2.3.1 *Water Storages*

Recommended full storage levels (FSL) are summarized in Table 3-2 with accompanying basis. It is recommended that these values be adopted for future water management modelling/planning studies.

[6] File reference: Wilpinjong Pond Survey Report October 2014.pdf
[7] File reference: Wilpinjong Water Storage - 2017.xlsx
[8] File reference: WILP16_MGA55_DSM_*.xyz
[9] File reference: g_floor_mined_out_aug2016.dxf

Storage capacities for mining pits and tailings cells have not been listed in Table 3-2, as storage of water within these structures is generally not part of standard operating procedures. Section 3.2.3.2 describes water storage within mining pits under non-standard conditions.

Table 3-2: Full Storage Level – Adopted Value and Basis – Water Storages

Storage	FSL (mRL)	Basis
Pit 2 West	370.0	Nominal 1.0 m offset below the level at which 'unaccounted for' outflows were inferred as part of the OPSIM model verification (refer section 10.3). Recommend further hydrogeological analysis be undertaken to determine whether adopting a higher FSL is possible.
Pit 1 South	421.5	Nominal 0.5 m offset below the level at which additional seepage flows to Ed's Lake were inferred as part of the OPSIM model verification. Note: seepage from Pit 1S at high water levels has been observed by operational personnel.
Pit 5 Fill Point (FP) Dam	392.2	Defined based on review of 2016 surface topography. Nominal level at which overflow to Pit 5N would occur.
Clean Water Dam	396.6	Maximum water level recorded in 2014 to 2017 historical water level survey. FSL defined as a maximum operating level rather than a spillway level. It is understood that this dam has no formally constructed spillway outlet.
Dirty Water Dam	412.6	Per WCPL water storage report tracking sheet. It is understood that this dam seeps to the CHPP area at high water levels, and water levels in the dam are managed to minimise the risk of this occurring. FSL defined as an operational level rather than a spillway level. It is understood that this dam has no formally constructed spillway outlet.
Ed's Lake	375.3	Defined based on review of 2016 surface topography. Nominal elevation at which overflow to Wilpinjong Creek would occur via a low point in adjacent road/rail.
MIA Sediment Dam	N/A	Not included within OPSIM model.

3.2.3.2 *Temporary Water Storage In-Pit*

In the event that total site water inventory exceeds the storage capacity of the WMS, excess water may be temporarily stored within one or more mining pits, until the inventory can be drawn down through evaporation, water usage and river discharge (via RO in accordance with EPL).

WCPL have advised that Pit 5N would be filled first in this scenario, followed by Pit 4, then Pit 3. Water storage in up-dip pits (i.e. Pit 5S, Pit 1, Pit 2S, Pit 7) is understood to be impossible, as these voids freely drain down the dip of the coal seam, through the in-pit spoil dumps, to their respective down-dip pits.

The maximum allowable volume to be held within each pit before triggering filling of the next pit in sequence should be defined on a scenario by scenario basis.

Maximum storage levels have been listed in Table 3-3. Levels have been estimated based on review of topographic data (e.g. overflow levels) with a nominal 5m freeboard accounting for wind-wave action and geotechnical/hydrogeological uncertainty. It is understood/expected that adopted fill levels would likely be well below the levels listed below, for operational reasons.

Table 3-3: Mining Pits – Overflow and Recommended Maximum Fill Levels

Pit	Level (mRL)		Notes
	Overflow	Max. Fill	
Pit 5N	374.0	369.0	Assumed hydraulic connection between Pit 5N and Ed's Lake. Pit 5N overflow level defined based on Ed's Lake overflow level. Note that current operational plans specify a maximum storage level of 360 mRL in this pit (level at Jan-17 was 361.6 mRL).
Pit 4N	371.5	366.5	Overflow level based on low point in northern end of Pit 4N high-wall. Note that low-point will reduce as mining progresses eastward.
Pit 3N	363.9	358.9	Overflow level based on low point on western side of Pit 3N void (adjacent to Cumbo Creek). Note that current operational plans specify a maximum storage level of 333mRL in this pit (maximum water level at Nov-16 was 338 mRL)

3.2.4 Catchment Breakdown

3.2.4.1 Watersheds

Catchment boundaries for water storages within the Wilpinjong mine have been delineated based on the most recent available topographic data and advice from operational personnel. Current catchment areas have been summarised in Table 3-1. Catchment maps and land use maps have been provided in Appendix B.

3.2.4.2 Land Use Classifications

Land use classifications have been determined based on Peabody ARO mapping and review of Dec-2015 satellite imagery[10].

Land use has been classified as one of the following categories:

- *Natural / undisturbed* – no disturbance, typically grass or brush.
- *Cleared / prestrip* – topsoil stripped land ahead of an advancing open-cut pit.
- *Roads / industrial / hardstand* – sealed or unsealed road or track, cleared and compacted earth or concrete (layout areas etc.).

[10] File reference: WPEOY_MGA55_35cm.ecw

- *Mining Pit*- open-cut void, classification typically refers to runoff properties for exposed coal face.
- *Spoil / overburden* – unrehabiliated spoil dumps, clear of vegetation,
- *Rehabilitated overburden* – dump areas that have been shaped and re-vegetated.
- *Tailings Area* – beach and other exposed tailings reject areas.

Land use data has been used to calculate catchment yield within the water balance model. Different land use classifications generally correspond with a unique catchment runoff model parameter set. Catchment yield is discussed further in Section 4.4.

A breakdown of land use type per water storage catchment area has been provided in Appendix B, in addition to catchment and land use plans.

3.2.4.3 Comparison against WEP

Catchment areas determined as part of the current project have been compared against design catchments listed in the WEP Surface Water Assessment (WRM, 2015) for the 2016 base case scenario. Total catchment reporting to the water management system was approximately 1,700ha in the WEP vs 3,100 ha estimated as part of the current project. The difference between the two catchment schedules is primarily associated with clean catchment diversion assumptions. The WEP assumed that an extensive network of bunds/drains/pipelines would be installed to divert large sections of upstream undisturbed catchment, and also rehabilitated catchments within the mine footprint. In practise, the implementation of such measures has been limited, and most upstream catchments are captured within the water management system.

3.2.5 Water Transfer Infrastructure

The Wilpinjong water transfer network comprises a mixture of fixed pump and pipeline infrastructure connections, supplemented with portable infrastructure that can be moved around for pit dewatering. The locality plan provided in Figure 3-1 shows the indicative pipeline network layout as at November 2015.

Water transfer capacities adopted as part of the Wilpinjong OPSIM model development have been summarised in Table 3-4. Note the following:

- Assumed no pumping from up-dip pits, i.e. Pit 5S, Pit 1, Pit 2S and Pit 7. These pits passively drain along the dip of the mined coal seam (either along the surface or through the highly permeable in-pit spoil dumps) to their respective down-dip pits.
- Water transfers from dams to industrial tasks are assumed to be constrained by demand, not by pump/pipeline capacity.
- Assumed no pumping from any tailings cells – water inflow to these areas is assumed to evaporate or seep to the underlying Pit 2/4 spoil aquifer.

Table 3-4: Water Transfer Infrastructure – Modelled Capacities

Category	Connection Points		Flow Capacity	
	Storage (From)	Directed (To)	L/s	ML/d
Pit Dewatering	Pit 5N	Pit 2W	180	15.5
	Pit 4	Pit 2W	185	16.0
	Pit 3N	Pit 2W	90	8.0
Mine Water Containment	Ed's Lake	Pit 5 FP Dam	100	8.6
	Ed's Lake	Pit 2W	100	8.6
	Pit 2W	Pit 5N	100	8.6
	Pit 2W	Pit 3N	90	8.0
Other	Pit 2W	CWD	100	8.6
	Pit 2W	RDW	100	8.6

4. Climate

4.1 Overview

Climatic influence on the Wilpinjong water management system is principally via catchment rainfall–runoff and evaporation (from wetted areas) and evapotranspiration [11] (from catchments). The Wilpinjong OPSIM has been configured to simulate system performance on the basis of long-term historical climate data. Historical data has been directly applied, based on the assumption that climatic conditions observed in the past, and captured in the data, are indicative of persistent local climatic trends. Historical data is therefore assumed to represent the range of potential conditions likely to be observed in the near future. Investigations have not included allowance for climate change effects at this stage.

Climatic data for the Wilpinjong site [12] has been sourced through the SILO Data Drill service [13]. The Data Drill service accesses grids of climate data interpolated from point observations by the Bureau of Meteorology (BoM), for any point in Australia. Sourced information includes daily resolution rainfall and evaporation data, for the 128 year period 1889 to present. This information has been processed and summarised in the following sub-sections.

WCPL have also provided rainfall data for the Jan-14 to Jan-17 period, recorded at the site automated weather station (AWS), located within the rail loop (near the CWD). Rainfall data recorded at nine neighbouring BoM rainfall gauges has also been sourced and used for reference. Site AWS and BoM rainfall data has been compared against Data Drill rainfall in Section 4.2.3.

4.2 Rainfall

4.2.1 Annual Rainfall (Data Drill)

Annual rainfall totals (calendar year) have been presented in Figure 4-1 on a percentile basis. Review of this information shows that annual rainfall varies between approximately 200 mm and 1,200 mm (~1,000 mm spread), with a median of 610 mm ± 178 mm. Approximately 60% of the data set falls within 1 standard deviation of the median.

Also shown for reference are calendar year rainfall totals for the five most recent years. Review shows that the recent 2016 rainfall was equivalent to a historical 82nd percentile.

[11] Evapotranspiration is the combined effect of two separate processes acting on a plant-soil system to convert liquid water to water vapour; it comprises evaporative losses from the exposed soil surfaces, and transpiration from the plant canopy.

[12] Reference coordinates -32.35S, 149.90E.

[13] SILO Data Drill service hosted by the State of Queensland (Department of Science, Information Technology and Innovation).

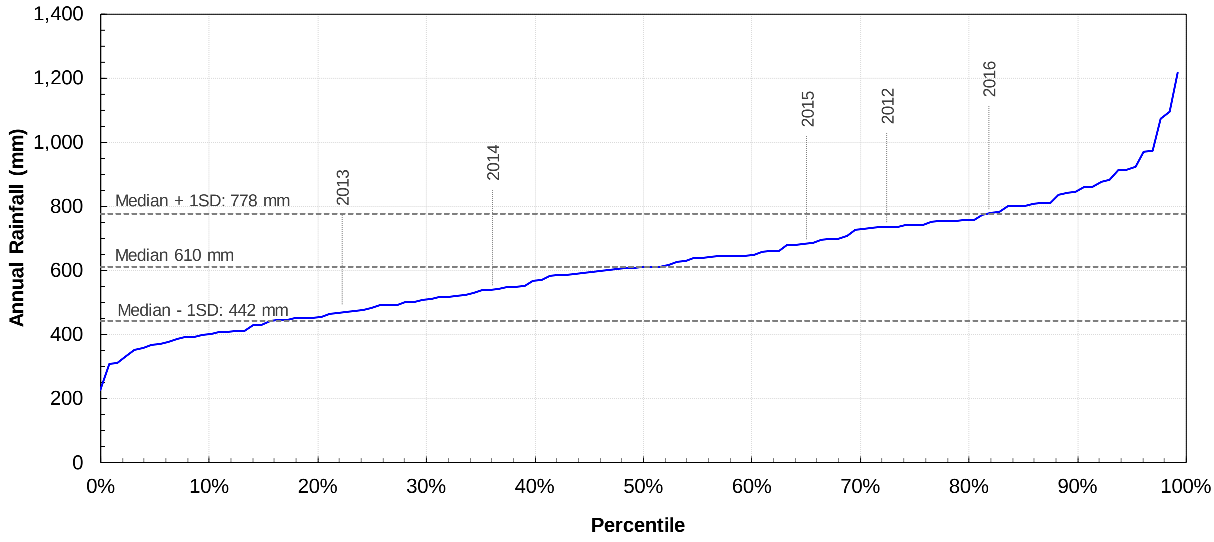

Figure 4-1: Annual Rainfall Percentiles – Data Drill 128 years

4.2.2 Rainfall Statistics (Data Drill)

The statistics for the long term Data Drill rainfall data are summarised in Table 4-1. Annual totals are for a calendar year January to December.

Table 4-1: Long Term Monthly Total Rainfall Statistics (mm)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	232	372	235	202	186	245	176	128	173	205	257	211	1,218
90th %	138	145	115	82	83	96	96	80	94	100	114	124	844
Median	62	47	40	34	33	36	40	40	36	48	53	51	610
10th %	14	5	4	4	5	10	10	11	12	9	11	13	402
Min	0	0	0	0	0	0	0	0	0	0	0	0	228
Mean	70	63	54	40	41	48	45	43	44	53	57	62	620
Std Dev	48	62	48	37	34	41	32	27	33	40	44	46	178
Count	129	129	128	128	128	128	128	128	128	128	128	128	128

4.2.3 SILO Rainfall vs Measured Data

SILO Data Drill rainfall data has been compared against data recorded at the Wilpinjong AWS and also at nine neighbouring BoM rainfall gauges. The intent of this exercise was to:

- Demonstrate that the SILO rainfall is comparable to local measurements, and is therefore an appropriate input time-series to the Wilpinjong OPSIM model; and
- Identify an appropriate measured rainfall data set to be used in the 2014-2017 OPSIM model verification.

Rainfall stations forming part of this review have been summarized in Table 4-2.

Table 4-2: Rainfall Stations Included in Review

Name	Source	Location		Distance* (km)
		Lat	Long	
Data Drill	SILO	-32.35	149.90	-
Wilpinjong AWS	WCPL	-32.34	149.88	-
062084: Budgee Budgee	BoM	-32.50	149.71	22
062102: Bylong	BoM	-32.52	150.08	28
062009: Cassilis	BoM	-32.00	149.99	38
062013: Gulgong	BoM	-32.36	149.53	32
062035: Leadville	BoM	-32.08	149.61	38
061287: Merriwa	BoM	-32.19	150.17	32
062021: Mudgee	BoM	-32.60	149.60	40
062036: Ulan Water	BoM	-32.28	149.74	13
062032: Wollar	BoM	-32.36	149.95	8

Note: * distance from Wilpinjong mine

Cumulative rainfall totals, resetting on a quarterly basis, have been presented in Figure 4-2. Site AWS and SILO rainfall data have been shown in black, using solid and dashed lines respectively. The dark blue coloured band shows the range of data recorded at BoM gauges within 20km of the mine, and the light blue band gauges within 30km. Gauges outside 30km are shown as faint blue lines.

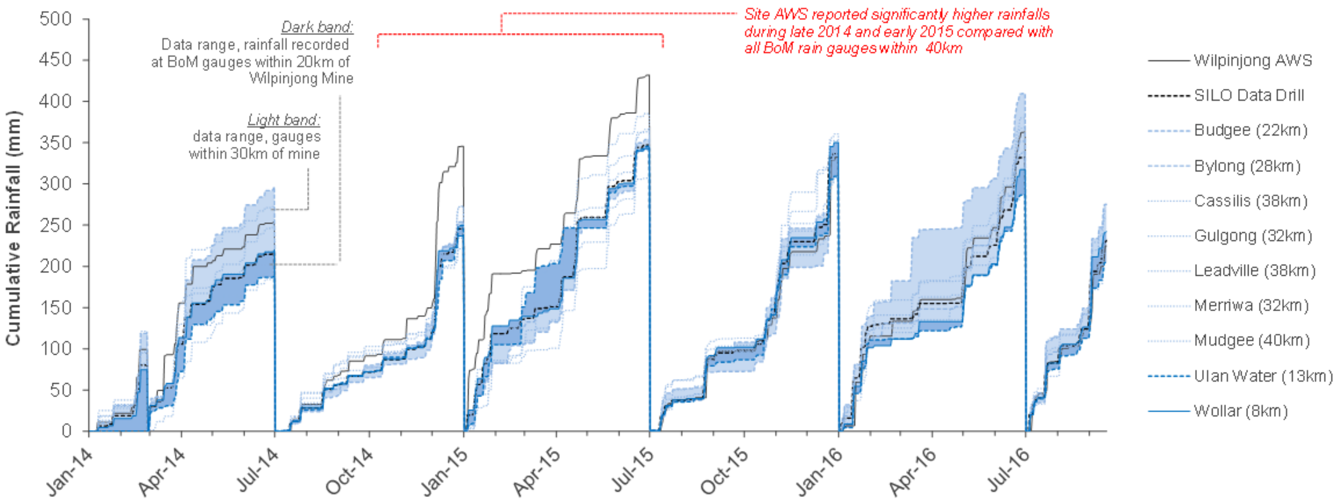

Figure 4-2: Cumulative Rainfall Totals – Quarterly Reset Interval

Review of Figure 4-2 shows the following:

- Cumulative rainfall reported by the site AWS was significantly higher than other gauges in the region prior to mid-2015. From July 2015 onward, data from the AWS appears to be more consistent with the other gauges. It is noted that the AWS appears to have been briefly taken offline at the end of February 2012 (possibly for maintenance).

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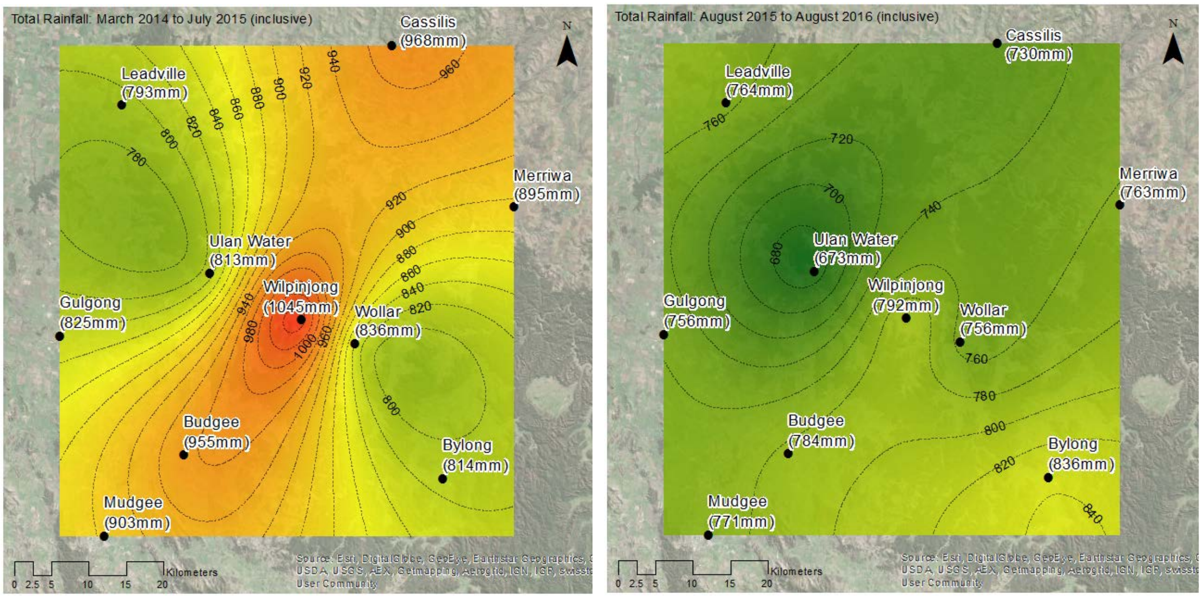
- SILO Data Drill rainfall totals generally consistent with BoM gauges throughout the review period.

The spatial variability of rainfall has been presented in Figure 4-3 for two periods; March 2014 to July 2015, and August 2015 to August 2016. This figure is intended to highlight the perceived discrepancy between the site AWS and surrounding gauges prior to July 2015.



Rainfall Totals: March 2014 to July 2015

Rainfall Totals: August 2015 to August 2016

Figure 4-3: Rainfall Spatial Variability – Pre and Post Jul 2015

Outcomes of the comparison of SILO Data Drill rainfall against data recorded at the Site AWS, and also at surrounding BoM rainfall gauges include:

- SILO Data Drill rainfall is consistent with rainfalls recorded at gauges in the study area, and is therefore considered to be an appropriate input time-series to the Wilpinjong OPSIM model.
- The accuracy of the site AWS rainfall data is questionable prior to mid 2015. Verification of the Wilpinjong OPSIM model has been undertaken using rainfall data recorded at the BoM Wollar gauge (the nearest measured rainfall data set).

4.3 Evaporation

Long term daily evaporation data for the Wilpinjong site has been sourced from the SILO Data Drill service. Morton lake (M_{lake}) evaporation has been used to estimate evaporation from the wet surface areas of surface storages.[14] For simplicity, the same time-series has also been used to estimate catchment evapotranspirative losses as it was found to be within 2% of the Morton Wet-Area evapotranspiration time-series. No adjustment factors have been applied to pits or catchment areas.

The statistics for the long term Data Drill M_{lake} evaporation data are summarised in Table 4-3.

Table 4-3: Long Term Monthly Total M_{lake} Evaporation Statistics (mm)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	230	192	164	109	68	45	53	85	124	166	205	233	1,553
90th %	216	175	152	100	63	42	50	76	112	158	186	212	1,485
Median	197	159	139	92	58	38	45	68	101	142	169	195	1,404
10th %	173	142	128	84	52	34	40	62	88	129	151	181	1,328
Min	155	123	110	68	45	29	36	58	71	114	137	150	1,282
Mean	195	160	139	92	57	38	45	69	100	143	169	195	1,403
Std Dev	16	13	10	7	5	3	4	6	10	11	13	14	58
Count	129	129	128	128	128	128	128	128	128	128	128	128	128

4.4 Catchment Yield

4.4.1 Overview

Accurate estimation of catchment yield hydrology is an important component of water management investigations. Catchment yield within the Wilpinjong OPSIM is simulated using the Australian Water Balance Model (AWBM). The AWBM is a saturation overland flow model which uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a water balance approach. The AWBM is widely accepted and commonly used within Australia[15].

4.4.2 Parameters

Different AWBM model parameters are defined for each land use type within the mine catchment. AWBM model parameters were initialised using values from the WEP surface water assessment (WRM, 2015), and optimised as part of the historical water balance model verification process (refer Section 10.3).

Changes to WEP model parameters include:

- Consolidated six land use parameter sets into four (simplification).

[14] Evaporation from shallow water lakes is calculated by Data Drill, on the basis of daily meteorological data (temperature, humidity, vapour pressure, etc.) as per procedures proposed by Morton (1983). Rates are typically lower than comparative Class A Pan evaporation, and are generally considered to be more appropriate for estimating losses from surface water storages.

[15] Refer to '*A Hydrograph-based Model for Estimating the Water Yield of Ungauged Catchments*' (Boughton, 1993) for further information.

- Standardised the distribution of soil storage capacity[16] (S_{avg}) between internal sub-storages in accordance with AWBM software vendor recommendations.
- Increased BFI (percent of runoff expressing as baseflow) and K_b (baseflow lag) parameters to attenuate runoff.
- Increased S_{avg} to reduce runoff volumes.

Adopted AWBM model parameters are summarised in Table 4-4.

Table 4-4: Wilpinjong OPSIM AWBM Parameters

Land Use Classification	AWBM Parameters									
	Partial Area			Soil Storage			K_s	Baseflow		S_{avg}
	A_1	A_2	A_3	S_1	S_2	S_3		K_b	BFI	
Natural / Undisturbed	0.134	0.433	0.433	14	145	289	0.5	0.97	0.8	190
Rehabilitated Spoil	0.134	0.433	0.433	11	114	229	0.5	0.97	0.5	150
Unrehabilitated Spoil	0.134	0.433	0.433	8	76	152	0.5	0.97	0.5	100
High Runoff*	1.0	-	-	12	-	-	0.0	-	0.0	12

Note: * Hardstand, Roads, Mining Pits, Cleared, and Tailings land use types share a common parameter set.

4.4.3 *Typical Runoff Coefficients*

A breakdown of AWBM calculated runoff coefficients are provided in Table 4-5 on a monthly and annual basis.

Table 4-5: Percent Runoff by AWBM Land Use (Avg 128 yr Long Term Simulation)

Item	Monthly average runoff co-efficient (%)												Annual average (%)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Natural	3.7	5.2	6.8	7.5	6.2	6.6	8.7	7.2	5.0	3.7	3.4	3.7	5.4
Rehab	4.4	6.4	8.5	9.2	7.6	8.3	11.1	9.2	6.3	4.6	4.2	4.5	6.7
Spoil	6.0	9.0	12.1	13.2	10.6	12.2	16.7	13.8	9.0	6.4	5.8	6.4	9.7
High Runoff	38.1	42.8	41.9	41.0	43.9	51.3	44.8	33.8	30.1	29.3	30.2	30.4	37.8

Note: * Hardstand, Roads, Mining Pits, Cleared, and Tailings land use types share a common parameter set.

4.4.4 *Additional Considerations*

The historical OPSIM model verification exercise encountered difficulty reproducing the observed inventory response during the wet winter of 2016 without resorting to the use of AWBM parameters which fall outside the range of parameter values used in other similar studies (refer model verification Section 10.3.3.1).

[16] This parameter generally represents the cumulative rainfall required to generate runoff from the majority of the catchment. Higher values of this parameter result in lower runoff volumes.

AWBM parameters were adjusted by a reasonable margin to reduce runoff volumes, and applied in union with an increase in spoil aquifer storage capacity and a level-driven outflow mechanism from Pit 2W. Further studies and monitoring have been recommended to reduce the uncertainty in all three of these areas. Should these studies minimise or rule out the influence of spoil aquifer storage or the level-driven outflow, then AWBM parameters will need to be revisited.

Recent studies being undertaken in parallel with the OPSIM model update project indicate that these catchments may behave more like shallow groundwater systems, rather than conventional catchments (additional info provided in next sub-section). Future water balance model updates may consider modelling upstream catchments as separate storages, which release water slowly into the mine whilst also being subjected to on-going/additional evapotranspiration losses. This may allow further reduction in runoff volumes (if required) without resorting to the use of unconventional AWBM parameters.

4.4.4.1 Upstream Catchment Description

The following points have been adapted from a preliminary waterway assessment report prepared by Alluvium in 2017 [17]; they describe the characteristics of the natural catchments upstream of the Wilpinjong mine.

- The waterways in the study area are predominantly classified as laterally unconfined, discontinuous channel, Valley fill systems. Despite this classification, the Valley fill systems through the study area do not appear to function like conventional Valley fill systems. There appears to be very little alluvium, or “fill” within the valley floor. The waterways traverse a broad valley floor with a substrate consisting of colluvium and in-situ weathered Permian bedrock.
- There is limited evidence of aquatic vegetation or surface water except within dams which had been excavated into the substrate to intercept shallow aquifer flows. There was limited evidence of channelization or gullying, which typically occurs in Valley fill systems which have been impacted by stock. The creeks which flow through the Wilpinjong mine area show limited evidence of regular surface flow. Within all valleys (excluding Cumbo Creek) there is minimal evidence of alluvial deposits within the valley floor or aquatic vegetation which is typical of swampy, discontinuous Valley fill watercourses.
- It is likely that the geology of the region results in high rates of infiltration and sub-surface flow. The fractured sandstone which forms the ridges and escarpments act as an elevated aquifer system. Rainfall captured in the floor surface at the base of the escarpments, or to deeper aquifers (i.e. Illawarra Coal Measures). Surface flow may occur following very heavy rainfall or in isolated locations where springs seep into the drainage line. However, with the existing (or pre-mine) vegetation characteristics the surface flow is unlikely to generate shear stress of stream power values which are able to scour a defined channel. These observations are supported by anecdotal evidence from mine staff and field observations.

[17] Alluvium, 2017. *Wilpinjong Coal Mine: Final Landform Drainage System Design – Preliminary Waterway Assessment*. Rev 3 dated 9 March 2017.

5. Site Water Usage

Water stored within the Wilpinjong WMS is beneficially re-used to supply various industrial tasks including: CHPP process water makeup, stockpile/conveyor dust suppression, heavy vehicle (HV) and light vehicle (LV) road dust suppression, HV/LV vehicle wash-bays and miscellaneous washdown. The following sub-sections describe industrial water usage as incorporated into the Wilpinjong OPSIM model.

5.1 CHPP and MIA Usage

5.1.1 Overview

Water is pumped from Pit 2W to the RWD and CWD. Water is then pumped from these dams into a distribution network which is used to supply water to the following tasks within the CHPP and MIA area:

- CHPP process water
- HV/LV wash bays
- MIA wash-down pads
- Coal handling/stockpile dust sprays
- Other miscellaneous MIA/CHPP tasks

Water supply from the RWD and CWD to the distribution network is metered, but the individual offtakes are not. The following sub-sections describe a process which has aimed to disaggregate the metered water usage between CHPP process water makeup and lumped other tasks.

5.1.2 CHPP Water Usage

5.1.2.1 Overview

Current investigations have estimated a water and solids mass balance for the Wilpinjong coal production process in order to estimate minimum process water makeup requirements.

The plant mass balance has been prepared based on the following information:

- Monthly bypass, CHPP feed, washed product and railed actual tonnages provided by WCPL [18] for the period January 2014 to January 2017.
- 2017 and 2018 production forecasts [19] (predicted tonnages – same streams as above).
- Moisture contents for the various material streams, based on information provided by WCPL, information contained in the WEP surface water assessment (WRM, 2015) and assumption
- A conceptual block flow of the coal washing process

[18] Monthly production summary spreadsheets: Jan-14 to Jan-17
[19] File reference: 2016-2018 summary.xlsx

5.1.2.2 *Tailings Circuit*

Prior to April 2015 the CHPP reject circuit comprised separate coarse and fine waste material streams. Coarse rejects were trucked and disposed of within in-pit overburden dumps, and fine tailings were pumped as a slurry to tailings cells adjacent to Pit 2W. The CHPP tailings circuit was modified in April 2015 to include a BFP, which dewaters the tailings stream and allows this material to be disposed of as a dry waste stream with the coarse reject. Any moisture bleed off from within the BFP process is captured and re-circulated to the clarified water tank. Excess water from the clarified water tank may be drained off by pumping water to the tailings cells via the old slurry pipelines.

5.1.2.3 *Block Flow and Operating Specifications*

A conceptual block flow of the coal production process has been prepared and presented in Figure 5-1. Note the positioning of the flow meters.

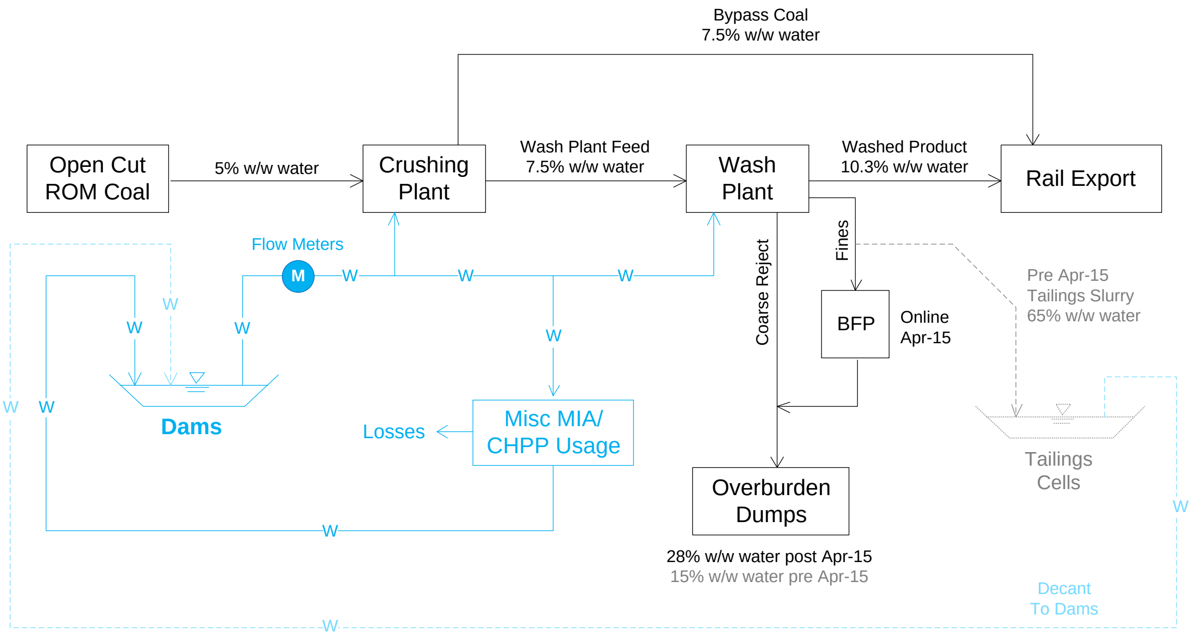


Figure 5-1: Wilpinjong Coal Washing Process Block Flow

Operating specifications adopted for the purposes of conducting a water and solids mass balance are summarized in Table 5-1.

Table 5-1: Summary CHPP Operational Parameters

Item	Stream	Value %	Basis
Moisture Contents (w/w water)	ROM	5.0	Study assumption
	Bypass Coal	7.5	Assumed same as CHPP feed
	CHPP Feed	7.5	Per WEP OPSIM (WRM, 2015)
	Product Coal	10.3	Per WEP OPSIM (WRM, 2015)
	Coarse Rejects (pre Apr-15)	15.0	Per WEP OPSIM (WRM, 2015)

Item	Stream	Value %	Basis
	Tailings Slurry (pre Apr-15)	65.0	Per WEP OPSIM (WRM, 2015)
	Mixed Reject (post Apr-15)	28.0	Per WCPL CHPP advice
Reject Split (pre Apr-15)	Percent as coarse reject	80.0	Inferred as part of balance
	Percent as fine tailings	20.0	Inferred as part of balance
	Percent as mixed reject	-	No mixed reject (pre-BFP)
Reject Split (post Apr-15)	Percent as coarse reject	-	All classed as mixed reject
	Percent as fine tailings	-	All classed as mixed reject
	Percent as mixed reject	100.0	All classed as mixed reject

5.1.2.4 *Material Throughput*

Historical and forecast material tonnages have been plotted in Figure 5-2. Monthly tonnages have been presented for a standardized moisture content of 7.5% w/w, for ease of comparison.

Review of Figure 5-2 gives the following:

- Historical production (railings) has remained relatively constant at around 1,000 tonnes per month (tpm) (± 200 tpm). Production is forecast to increase slightly in 2017 and 2018.
- Historical washplant feed followed a slight downward trend through 2014 and 2015. Washplant feed increased in 2016, and is forecast to increase further in 2017 and 2018 (note this is conditional upon approval of the WEP).
- Coal production is relatively evenly split between bypass coal and washed coal in both the historical and forecast datasets.
- Historical yield (railings/ROM) is approximately 90%, and washplant yield is approximately 74% across the 2014-2016 period.

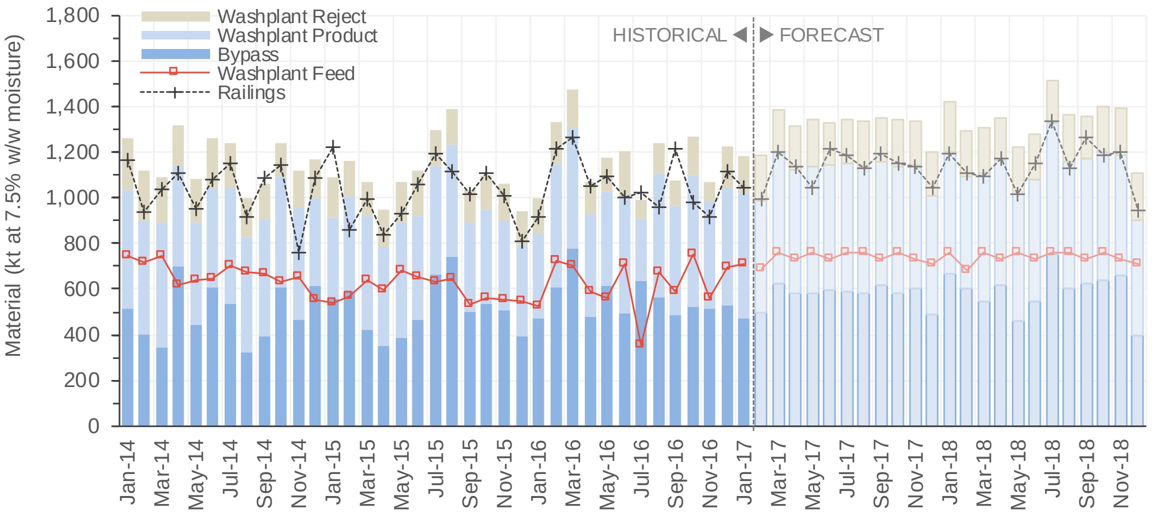


Figure 5-2: Historical and Forecast Production Data

5.1.2.5 Estimated Water Makeup

CHPP process water makeup has been calculated based on a water and solids mass balance. Generally, water makeup is calculated as the difference between the moisture entrained in the outbound material streams (product and reject) and the moisture entrained in the inbound streams (ROM).

Estimated process water makeup requirements have been presented in Figure 5-3 and compared against the metered water supply from the RWD and CWD to the water distribution network which supplies the CHPP (refer Figure 5-1). Washplant feed tonnages have also been presented for context.

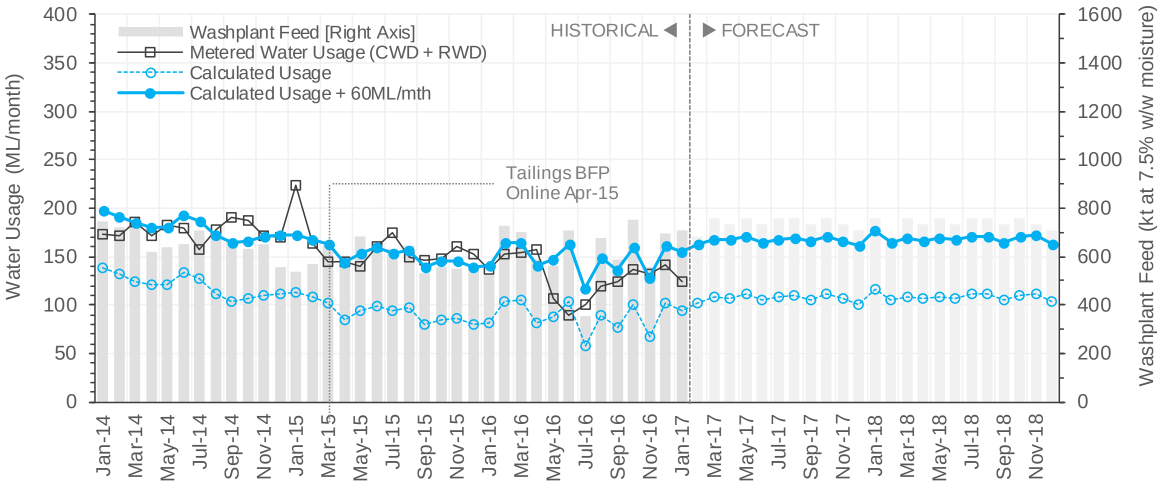


Figure 5-3: Estimated CHPP Water Usage vs Metered Data

Review of Figure 5-3 gives the following:

- Water supply to the CHPP followed a downward trend in 2014, consistent with CHPP ROM feed trends. Water usage reduced further post April 2015 following commissioning of the tailings BFP. Estimated water usage through late 2016 has been variable.
- Metered water supply from the RWD and CWD is approximately 60 ML/month higher than estimated CHPP water usage. This is relatively consistent throughout the historical period, with the exception of the latter half of 2016, where the difference appears to reduce at times. The 60 ML/month offset is understood to represent other water usage offtakes in the CHPP/MIA area.
- Estimated CHPP water usage is approximately 110 ML/month based on forecast production data. Note that since commissioning of the tailings BFP, effectively all water supplied to the CHPP is lost via entrainment within the product and mixed reject material streams.

The baseline Wilpinjong OPSIM model has been configured to model CHPP water usage as a net water loss from the WMS of 110 ML/month, sourced from the RWD and CWD.

5.1.3 *MIA and Misc. Usage*

Metered water supply from the RWD and CWD to the distribution network in the CHPP/MIA has been compared against estimated CHPP water usage in the preceding report section. The unaccounted for component of the RWD and CWD water supply was inferred at approximately 60 ML/month, which is understood to account for the following offtakes:

- HV/LV wash bays
- MIA wash-down pads
- Coal handling/stockpile dust sprays
- Other miscellaneous MIA/CHPP tasks (cleaning/hoses, clarifier tank overflow or bleed-off via old tailings lines).

A nominal 50% moisture loss has been assumed for the purposes of the Wilpinjong OPSIM water balance. The balance is assumed to returned to the WMS via Pit 2W. The loss is also assumed to remove water from the system (i.e. via evaporation) but not salt. The Wilpinjong OPSIM model thus simulates a 30 ML/month net loss of water from the WMS.

Further investigations to define the breakdown of the inferred 60 ML/mth water usage have not been undertaken as part of the current scope of work. It is recommended that this be explored further as part of the next model update.

5.2 Haul Road Dust Suppression

5.2.1 *Measured Water Usage*

Water is extracted from the Wilpinjong WMS and applied using water trucks over HV/LV roads to minimise dust lift-off. There are three fill points in operation: the ROM FP, Pit 2 FP and Pit 5 FP. All water truck fill points have been fitted with flow meters and data is recorded daily.

Site also operates a GPS logging system which maintains a count of how many times each truck has driven within a certain proximity of a fill point. Water usage is estimated by multiplying each individual trucks trip count by its respective water fill capacity. This approach tends to produce conservative estimates as a partial fill (top-up), or even a truck driving past a fill point, will be registered as a complete fill. ROM FP flow meter data overlaps with trip-based data between Jul-15 and Nov-15. This period has been used to define a scaling factor (0.45) which has been applied to all trip-based usage estimates.

Metered usage spans Dec-14 to Oct-16, comprising flow meter data where available, supplemented with scaled trip-based estimates. Usage prior to Dec-14 has been estimated using a sub-model which calculates application rates as a function of haul road area, evaporation and rainfall. Sub-model development is described in Section 5.2.2.

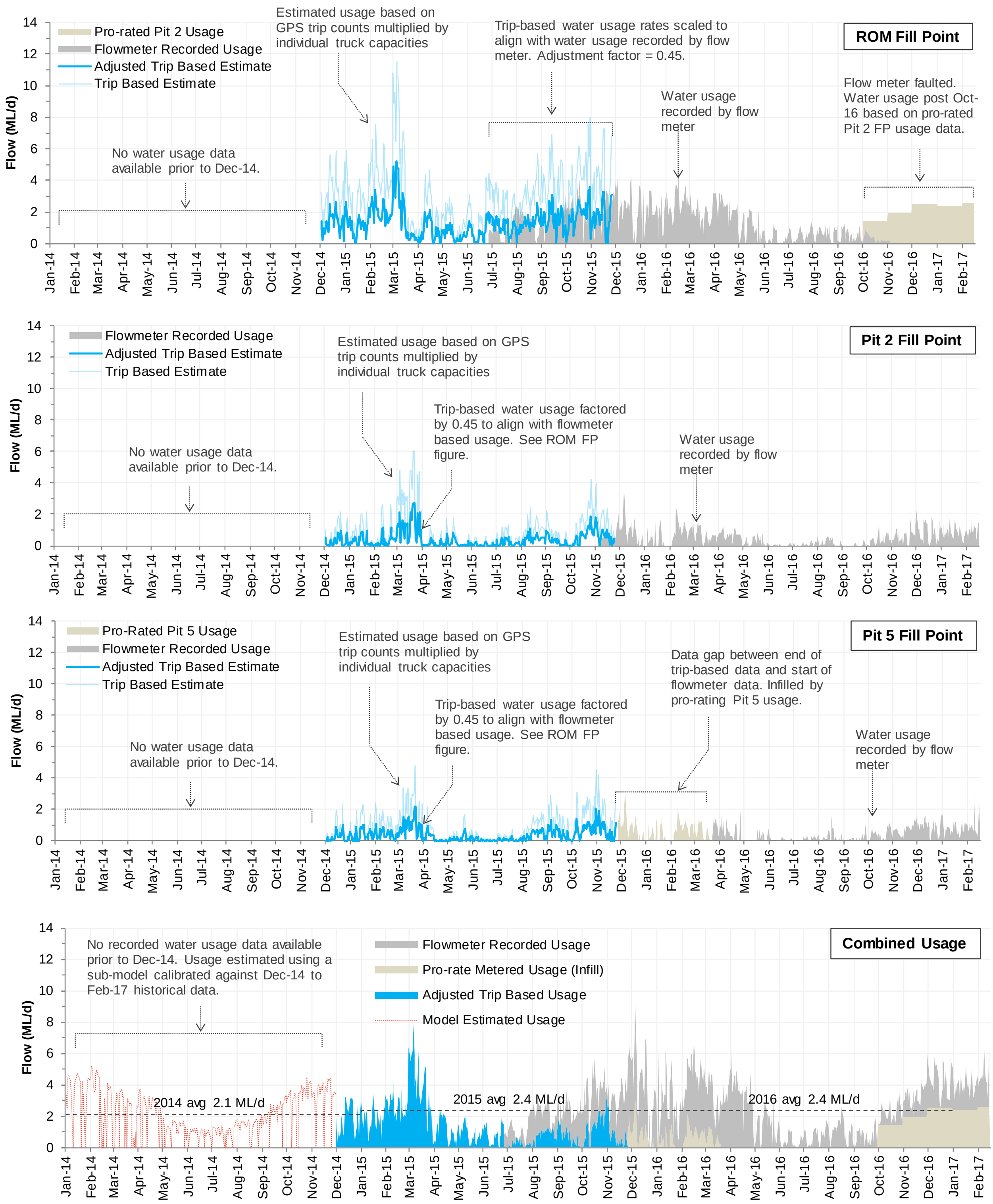


Figure 5-4: Historical Dust Suppression Water Usage

5.2.2 *Dust Suppression Sub-Model*

5.2.2.1 Sub-Model Development

A sub-model has been developed to dynamically calculate haul road dust suppression water usage in the Wilpinjong OPSIM model. The dust suppression sub-model accounts for seasonal variation and sensitivity to rainfall observed in the metered usage data.

Daily water application is calculated as a function of wetted haul road area, evaporation, and rainfall. Water is applied to offset daily evaporation from the wetted area. Evaporation rates are subject to monthly adjustment factors. Application is cancelled if rainfall exceeds a nominated minimum threshold. Monthly evaporation factors and the rainfall threshold have been adjusted to reproduce Dec-2014 to Jan-2017 historical water usage.

Predicted versus metered dust suppression usage has been presented in Figure 5-5.

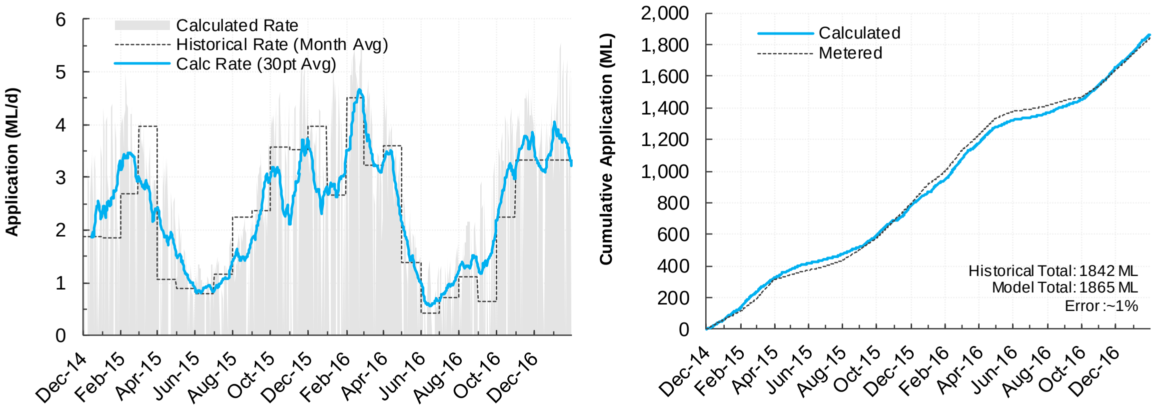


Figure 5-5: Dust Suppression – Predicted versus Metered Usage

Review of Figure 5-5 shows good agreement between the predicted and metered water usage rates. Note that water usage has been calculated based on:

- Haul road wetted area of 44 ha (per WEP surface water assessment),
- Rainfall threshold of 1.5 mm/d.

Evaporation adjustment factors have been summarised in Table 5-2.

Table 5-2: Dust-Suppression Model – Month Adjustment Factors

Month	Factor	Month	Factor
January	1.50	July	2.00
February	1.75	August	1.75
March	1.75	September	1.75
April	2.50	October	1.75
May	2.00	November	1.50
June	2.00	December	1.25

5.2.2.2 *Predicted Water Usage*

Water usage rates have been predicted using the dust suppression sub-model and 128 years of SILO data drill climate. The range of predicted usage rates has been presented in Figure 5-6 as a probability distribution. Jul-15 to Jan-17 metered usage has been superimposed for context. Usage statistics are summarised for reference in Table 5-3.

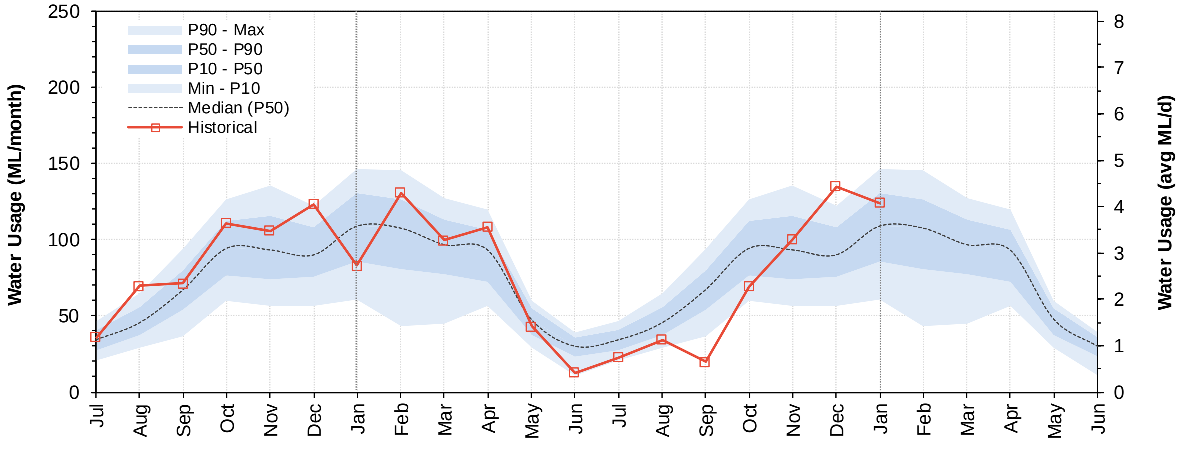


Figure 5-6: Predicted Dust Suppression Usage Rates

Table 5-3: Predicted Dust Suppression Usage Statistics (ML/month)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	147	146	127	119	60	39	46	65	94	126	135	122	1,058
90th %	130	126	113	106	55	35	41	56	79	113	115	108	982
Median	109	108	97	93	48	30	34	45	67	94	93	90	907
10th %	85	81	78	73	37	23	27	37	54	77	74	75	809
Min	60	44	45	57	29	11	21	29	36	60	57	56	722
Mean	109	105	95	91	47	29	34	46	67	94	95	91	904
Std Dev	18	19	15	13	7	5	5	7	11	14	16	14	69
Count	128	128	128	128	128	128	128	128	128	127	127	127	127

5.2.2.3 *Distribution*

Net water usage predicted by the dust suppression sub-model is apportioned to the various fill points based on proportional usage observed in 2016 historical usage data (see Figure 5-4). The adopted breakdown is as follows:

- ROM FP 62.6%
- Pit 2 FP 18.6%
- Pit 5 FP 18.8%

5.3 Water Destruction (Sprays)

WCPL operate a system of evaporator sprays which are located on the eastern bank of Pit 2W. There are currently 10 sprays in operation. Installation of the spray system commenced in late December 2016, and was completed in late January 2017.

Water supply to the spray system is unmetered, and has been estimated at approximately 1 ML/d. Net water losses have been estimated at 0.25ML/d assuming a 25% spray efficiency, which has been selected based on past experience with similar systems at other operations.

The Wilpinjong OPSIM has been configured to model a net 0.25 ML/d water extraction from Pit 2W. The outflow is assumed to remove no salt from Pit 2W. Operation of the spray system is assumed to cease if the combined inventory in the WMS reduced below a specified minimum threshold, which has been initially defined at 1,000 ML but should be confirmed on a scenario by scenario basis.

6. Reverse Osmosis Plant (River Discharge)

6.1 Overview

WCPL operate a RO water treatment plant, which is used to treat excess mine water, and discharge a blend of permeate and mine water to Wilpinjong Creek in accordance with conditions outlined in EPL 12425. License conditions prescribe a maximum release rate of 15 ML/d (recently increased from 5ML/d in January 2017 license amendment), a maximum release water electrical conductivity of 500 μS/cm, and a pH range between 6.5 and 8.5.

The existing RO plant (referred to as RO1), is located adjacent to Pit 2W as shown in Figure 3-1. Water is supplied to RO1 from Pit 2W (typ. 3,500 μS/cm EC), and then passes through a process of strainers, UF filters and RO membranes to produce a low EC permeate stream (typ. 180 μS/cm EC). The permeate stream is blended with a small amount of feed water prior to release to achieve a mixed EC closer to the 500 μS/cm limit prescribed in the EPL. The RO reject by-product is typically around 14,000 μS/cm EC and is pumped to Pit 1S. Some permeate is also used for RO1 back-flushing/cleaning. A conceptual schematic of the RO plant and river discharge process is presented in Figure 6-1.

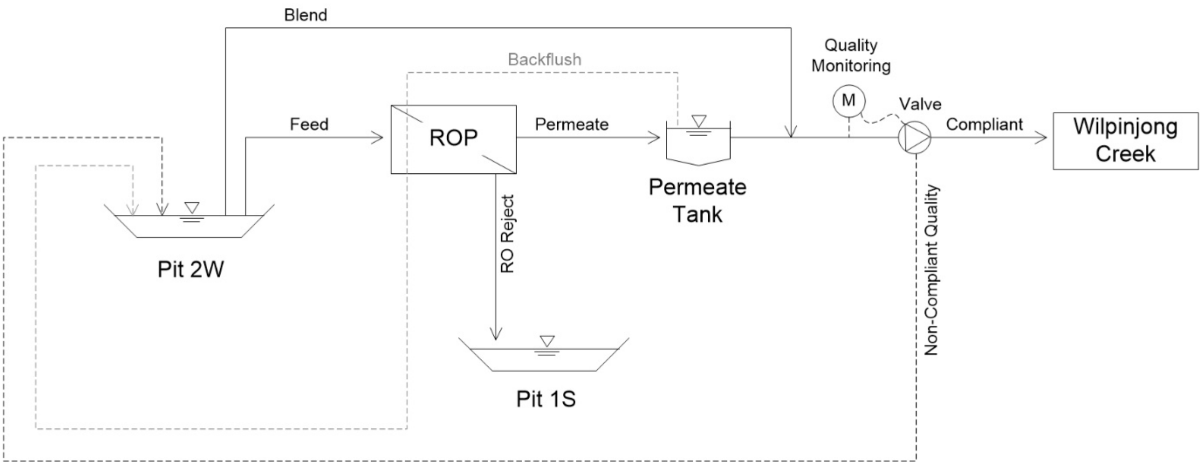


Figure 6-1: Conceptual Schematic – RO Plant and River Discharge Process

The design discharge capacity of RO1 is approximately 4 ML/d, however due to technical issues, the plant has historically operated at levels well below this. Technical issues are understood to relate to the feed water quality drifting out of specification (high turbidity during/post rainfall events). It is understood that upgrade works are currently underway to improve the performance of the existing plant, targeting completion in April 2017.

WCPL are also in the process of installing an additional RO plant adjacent to RO1. The second plant, referred to as RO2, comprises two separate modules, each nominally equivalent to the design capacity of the existing RO1. Module one and two are expected to be online in March and April 2017 respectively. Following completion of the RO1 upgrade project, and commissioning of both RO2 units, the net permeate production capacity is expected to be 9 ML/d (vs recent performance of 1ML/d).

6.2 Historical Performance

WCPL have provided copies of RO1 monthly performance reports prepared by IXOM, which contain metered permeate, blended discharge and reject volumes. This information has been collated and presented in Figure 6-2.

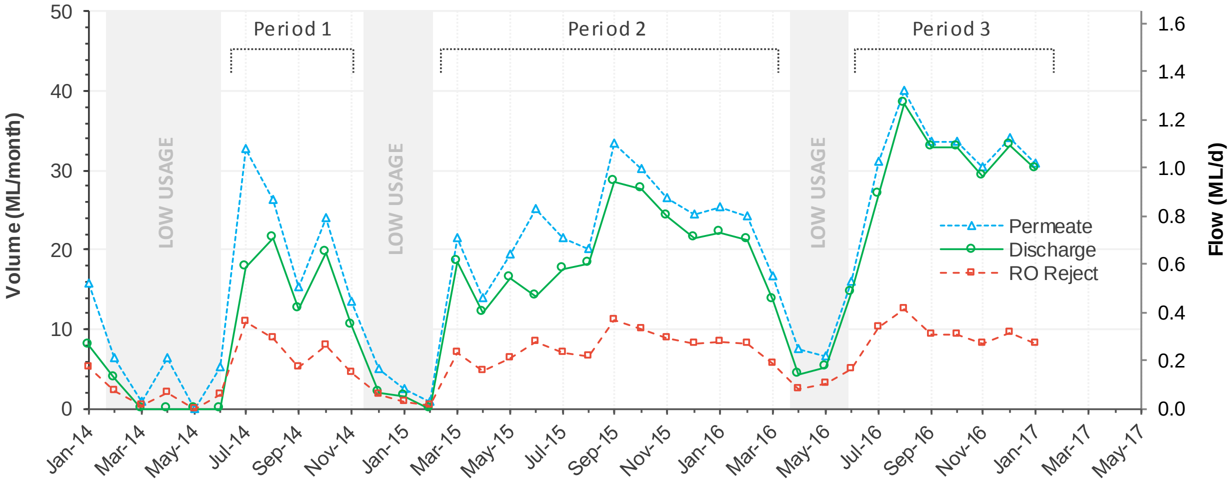


Figure 6-2: Historical RO Plant Performance

Review of Figure 6-2 gives the following:

- Three operational periods interspersed with periods of low RO plant usage.
- Usage characteristics during period one and period two are similar.
- Permeate production and river discharge are higher in period three, with a relatively minor corresponding increase in reject production (i.e. plant recovery has improved).

Recorded flow volumes presented in Figure 6-2 have been considered in conjunction with water quality monitoring data (refer Section 9) to estimate RO plant operating specifications for the three periods defined above. This process has been summarised in Table 6-1.

Table 6-1: Historical RO Plant Operating Specifications

Item	Units	Period 1	Period 2	Period 3
Period Start	-	Jul-14	Mar-15	Jul-16
Period End	-	Nov-14	Mar-16	Jan-17
Permeate Production (P)	ML/d	0.74	0.76	1.10
RO Reject (C)	ML/d	0.25	0.25	0.32
Plant Feed (F=P+C)	ML/d	0.98	1.02	1.41
Plant Recovery (R=P/F)	%	75	75	77.5
Feed Water EC	µS/cm	3,810	3,310	3,545
Permeate EC	µS/cm	180	180	180
Estimated Reject EC	µS/cm	14,700	12,690	15,170
Discharge EC	µS/cm	350	255	285

Item	Units	Period 1	Period 2	Period 3
Blended Discharge (D)	ML/d	0.54	0.65	1.05
Discharge % Permeate*	%	95.3	97.6	96.9
Discharge % Blend	%	4.68	2.40	3.12
Discharge Permeate (D_P)	ML/d	0.51	0.63	1.02
Discharge Blend (D_B=D-D_P)	ML/d	0.03	0.02	0.03
Residual Permeate (X=P-D_P)	ML/d	0.22	0.13	0.08

Note: * ratio of permeate to raw water = (EC_{raw} – $Ec_{discharge}$)/($EC_{discharge}$ – $EC_{permeate}$). Percent permeate calculated as 1/(ratio + 1).

Review of this information gives the following:

- Plant recovery has improved from 75% in period one and two, to 77.5% in period three.
- Discharge EC is typically well below the 500 µS/cm EC limit prescribed in the EPL. Recent releases have been at less than 300 µS/cm EC. The proportion of Pit 2W water being blended in with the discharge stream is very small.
- The residual permeate is the difference between the measured permeate produced by the RO plant, and the estimated permeate discharged to Wilpinjong Creek. This stream accounts for permeate used for backflush/cleaning, and also for any permeate that is returned to Pit 2W instead of being released (due to non-compliant water quality). The residual permeate volume has been reducing over time, and in period three accounts for approximately 7.3% of total permeate production.

6.3 Model Configuration

The OPSIM model verification exercise has modelled river discharge and transfer of reject to Pit 1S based on time-series data presented in Figure 6-2.

The baseline Wilpinjong OPSIM model to be used for future studies has been configured as follows, assuming RO1 only with performance improvements completed:

- RO plant capacity: 4 ML/d
- Permeate recovery: 75% of feed
- Permeate EC: 180 µS/cm EC
- Permeate to Pit 2W: 0.22 ML/d (7.3% of produced permeate, based on period three in Table 6-1)
- Reject EC: calculated in model based on feed water EC
- Discharge water EC: 300 µS/cm EC (per recent historical sampling)
- Blend water volume: calculated in model to achieve discharge water EC
- Assumed no reduction in RO recovery due to increasing feed water EC
- RO plants deactivated if the site inventory drops below 1000 ML.

Plant capacity and volumes generally scale by a factor of three if RO2 is assumed to be fully operational.

7. External Water Import

External water supply to the Wilpinjong mine has not been required in recent years, given the surplus of mine water in storage. However, the mine does have access to external water supplies, if required. These are outlined in the WEP surface water assessment (WRM, 2015):

- The mine water supply system includes a water supply borefield located to the north of the mine area. Five existing production bores have been developed to date and are licensed to each provide up to 110 ML annually (equivalent to 3.5 L/s if pumped continuously). Additional production bores may be established as required over the life of the mine.
- WCPL has an in principle agreement with the nearby Ulan Coal Mines Ltd to source excess water from this mining operation (by pipeline) if required in the future (subject to approval).

The Wilpinjong OPSIM model has been configured to import water from an external source if the combined mine water inventory falls below a specified minimum threshold (initially set at 500 ML). Water is assumed to be sourced from the borefield, and pumped into the Pit 2W hub water storage, where it is the pumped on to supply tasks as required.

Note also that Wilpinjong imports potable water to supply amenities. Sewage is treated and disposed of via irrigation. The potable water circuit has no functional influence on the performance of the WMS and is not discussed further in this study, nor is it included in the Wilpinjong OPSIM model.

8. Groundwater

8.1 Groundwater Inflows

8.1.1 Definition

For the purposes of this report, groundwater inflows are defined as waters reporting to the WMS from aquifers external to the current extent of disturbance. This generally includes seepage from coal seams and in-situ rock and alluvial aquifers, and water released from cracks and pores within coal and rock as it is broken as part of the mining process.

8.1.2 Previous Estimates

Previous estimates of groundwater inflow to the Wilpinjong mine include the following:

- **WEP EIS (2015)**: net groundwater inflow rates adopted as part of the WEP surface water assessment (WRM, 2015) were derived by applying highwall evaporative losses to gross inflow rates determined through hydrogeological modelling as part of the groundwater assessment (HydroSimulations, 2015).
- **PA 05-0021 Modification 6 EA, Groundwater Assessment (HydroSimulations, 2014)**: semi-quantitative assessment to estimate changes in gross groundwater inflow rates which were estimated using 3D groundwater modelling for the previous (Mod 5) mine plan.

Previous estimates have been summarised in Table 8-1. Rates are net inflows the WMS, after highwall evaporative losses have been accounted for. Gross inflow rates estimated as part of the 2014 HydroSimulations study have been equated to net estimates by applying per annum evaporative losses from the WEP surface water assessment. This is a coarse approximation but suitable for comparison purposes.

Table 8-1: Net Groundwater Inflows – Previous Studies

Year	WEP (2015)		Modification 6 (2014)	
	ML/d	ML/yr	ML/d	ML/yr
2014	2.85	1,040	4.43	1,616
2015	2.95	1,076	4.99	1,820
2016	2.52	921	3.94	1,439
2017	2.64	965	1.16	424
2018	2.42	883	2.09	762
2019	2.42	883	0.24	86

8.1.3 Inferred Estimates (This Study)

Groundwater inflow rates have been inferred as part of this study as part of the historical model verification exercise. Inflow rates were iteratively adjusted to align simulated mine water inventory trends during dry-periods with observed historical trends.

The following points reference the historical model verification (Section 10.3):

- Initial model settings involved use of similar catchment yield parameters to those adopted as part of the WEP study. Inferred groundwater inflow rates were estimated at approximately 2.9 ML/d between 2014 and 2016, which aligned well with the WEP values in Table 8-1. However, these catchment yield parameters appeared to over-estimate the catchment runoff response during the recent 2016 winter climate (which was wetter than any climate sequences reviewed as part of the WEP).
- In order to improve the modelled representation of the 2016 wet winter, catchment yield parameters were adjusted to produce less runoff across all rainfall events. The adjusted parameters improved the representation of the 2016 event, but resulted in gradual under-estimation of inventory through the 2014 to 2016 period. Increasing the inferred net groundwater inflow rate to 3.8 ML/d was found to re-align the simulated inventory with the observed data.

The inferred groundwater inflow rate of 3.8 ML/d has been apportioned as follows:

- **Pit 3/7**: 1.6 ML/d (inferred to reproduce metered Pit 3 dewatering volumes)
- **Pit 2/4**: 0.9 ML/d (assumption)
- **Pit 1/5**: 1.3 ML/d (assumption)

8.1.3.1 *Comparison Against Previous Estimates*

Groundwater inflow rates inferred as part of current investigations have been compared against previous estimates in Figure 8-1. Review of this figure shows that current estimates sit roughly between estimates developed as part of the WEP (2015) and Modification 6 (2014). The figure also highlights the fact that inflows were predicted to reduce from 2017 onward in the Modification 6 study, whereas in the WEP inflows remain relatively constant.

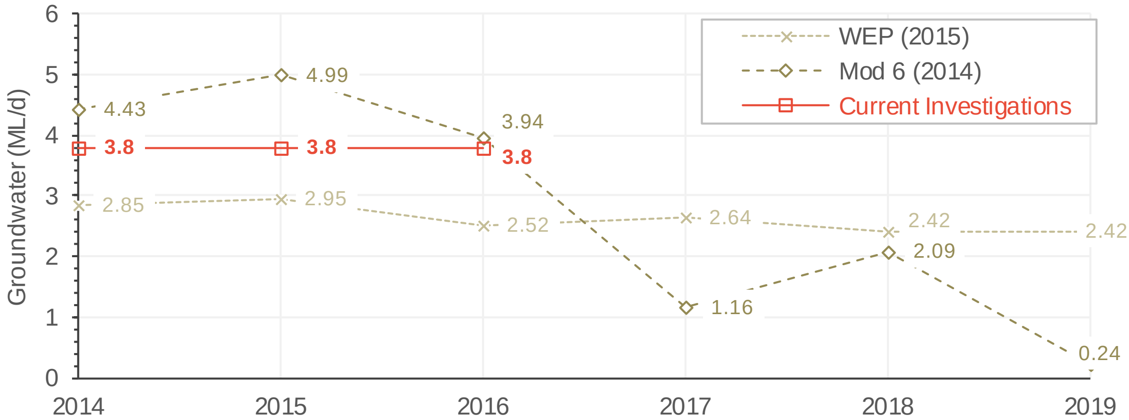


Figure 8-1: Inferred Groundwater Inflows vs Previous Estimates

8.1.4 *Model Configuration*

The historical OPSIM model verification has inferred an inflow rate of 3.8 ML/d.

This value has been retained in the baseline Wilpinjong OPSIM model as a starting point. However, given the apparent uncertainty associated with forward estimates of groundwater inflow, it is recommended that:

- Future studies select groundwater assumptions appropriate for the study at hand. For example, lower groundwater inflows may be more appropriate for studies concerned with water supply security, or where groundwater inflows would be of benefit (i.e. if RO reject is being mixed back into the WMS inventory).
- Future studies also include sensitivity analysis to test the impact of groundwater inflow variability on study outcomes.

The following items have not been included in the model, but are noted as areas for potential further study:

- Leakage from coal seams
- Dynamic reduction in groundwater inflow rates under high water conditions (e.g. backpressure effects)
- Event-based seepage inflows from Cumbo or Wilpinjong Creek

8.2 Spoil Aquifers

8.2.1 *Overview*

As described in Section 3.1, mining operations have extracted coal from three distinct voids, termed Pit 1/5, Pit 2/4 and Pit 3/7 (note these definitions are used in the context of discussing water management, and that they do not necessarily align with mine planning terminology). Voids are separated from each other by in-situ rock. Mining within Pit 1/5 and Pit 2/4 has generally originated at a central point and progressed outward, with some open-cuts mining up-dip (toward the south i.e. Pit 5S) and others mining down-dip (to the north, toward Wilpinjong Creek, i.e. Pit 5N).

In-pit spoil dumps have been formed within Pit 1/5 and Pit 2/4. These in-pit dumps are porous and highly permeable. The drainage characteristics of the spoil are such that up-dip pits (such as Pit 5S, Pit 1 and Pit 2S) do not need to be pumped out following rainfall events, as they freely drain down the dip of the coal (through the spoil) to the down-dip pits (i.e. Pit 5N and Pit 4). Pit 2W is also observed to seep at a high rate to Pit 4, through the interconnecting spoil dump, due to the high water level difference between these two areas.

Storage of water in-pit is expected to result in flow of water from the open water body into the adjoining spoil dump, forming a saturated zone within the spoil in which significant volumes of water may be stored. In the event in which a pit is filled with water, leakage to the adjoining spoil aquifer will prolong the filling process, and conversely, leakage from the aquifer will prolong the subsequent dewatering process.

8.2.2 *Extents*

Spoil aquifer extents have been estimated based on review of deepest mined topographic survey. Estimated extents based on 2016 mining progression have been presented in Figure 8-2. Two spoil aquifer extents have been marked within Pit 1/5 and Pit 2/4:

- Upper extents are based on the maximum possible fill levels (refer Table 3-3.
- Intermediate extents are based on estimated conditions at November 2016.

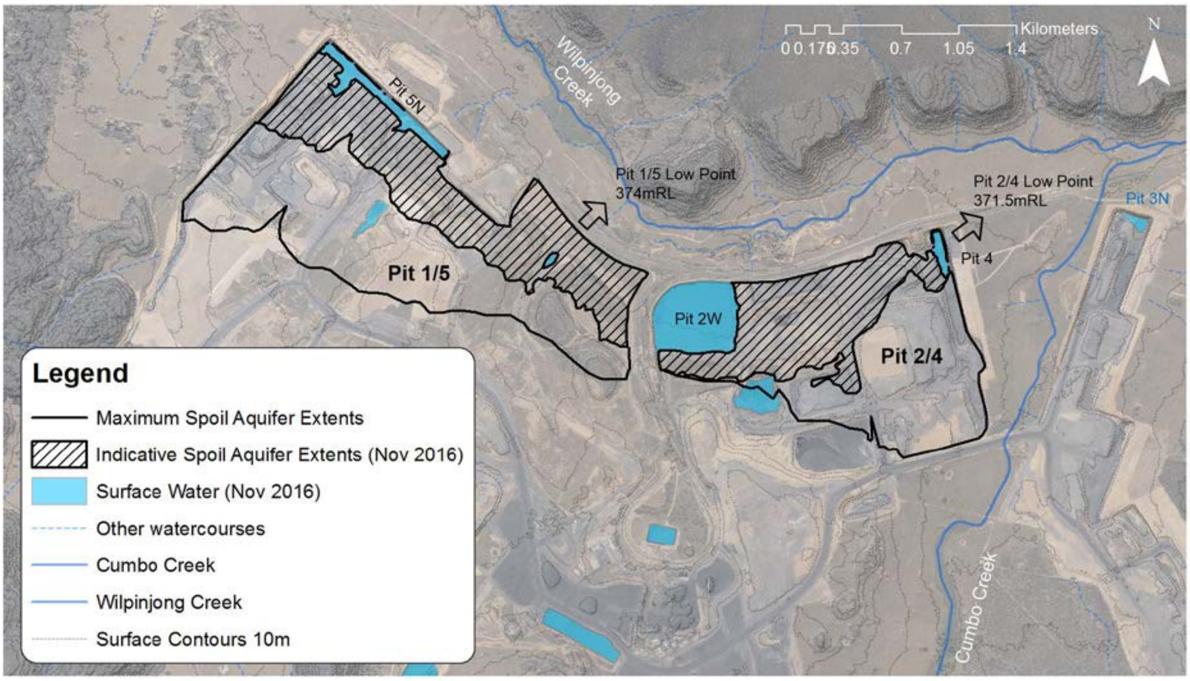


Figure 8-2: Indicative Spoil Aquifer Extents (Nov 2016 vs Potential)

8.2.3 *Storage Capacity*

Spoil aquifer storage capacity is a function of the spoil extent and the spoil porosity. The groundwater study undertaken as part of the WEP (HydroSimulations, 2015) assumed a nominal spoil aquifer storage of 20%.

Spoil aquifer storage characteristics were initially modelled based on this value in the 2014-2017 OPSIM model verification exercise (refer to Section 10.3). However, initial modelling results reported significant over-estimation of surface water inventory post June 2016. This period coincides with prolonged wet-weather, but also with the filling of Pit 5N to a level of 361.6 mRL, and presumably the saturation of the Pit 1/5 spoil aquifer. Catchment yield parameters were adjusted to counter the over-estimation, but additional measures were required to align the simulated inventory with actual historical data. One of the additional measures entailed increasing the porosity of the spoil aquifers to 30%. As a result, more water was modelled as being stored within the spoil aquifers, and less in the surface stores (improving the model agreement with the measured surface store inventory).

A high level literature review was undertaken to determine whether the increased value was supported by other studies. Findings have been summarised in Table 8-2. Review shows that the modelled value of 30% does fall within the range of values reported by other studies, but does seem to be within the upper end of this range. It is noted however that there remains considerable uncertainty in this regard, and further studies and modelling precautions are required until the accuracy of the model can be further improved. These include:

- Monitoring Pond 5 level and dewatering volumes as it is pumped down over the coming year, and try to back-calculate the volume of water that was stored in the spoil.
- Sensitivity analysis as part of future studies. Recommend testing reduced/nil spoil aquifer storage for studies concerned with containment. For studies commencing from current conditions, recommend testing a scenario in which no water is stored in the spoil at simulation start (particularly if this spoil water will be of benefit. e.g. dilution of RO reject).

It should also be noted that spoil aquifers are only modelled at a high level within the Wilpinjong OPSIM. The aquifer system is modelled as four discrete cells (each with a constant water level), rather than a continuous water table surface with smooth gradients such as in a typical 3D groundwater model. The porosity value of 30% is implicitly tied to the simplified Wilpinjong OPSIM model configuration, and is not necessarily reflective of actual values across the site. This parameter should not be used for any purpose other than the Wilpinjong OPSIM.

Table 8-2: Spoil Aquifer Porosity – Selected Reference Material

Paper	Title	Location	Notes
Hawkins 1998	Hydrogeologic Characteristics of Surface-Mine Spoil	Appalachian coalfields, USA.	Lab porosities of 25-36% for surface mine spoils, composed of mainly shale and sandstone (Wells et al, 1982). Lab measured values from a different location ranged from 41-48% with a mean of 44% (Mezga, 1973) Estimated porosities for cast spoil range between 14 and 25% (Cederstrom (1971). Estimated storage contents of 17 to 23% based on pumping tests (Rahn, 1976 reported in Moran et al. 1979). Estimated storage capacities ranging from 14 to 16% (Hawkins) based on slug and tracer tests, for a site 13 years post-reclamation.
Hawkins 2004	Predictability of Surface Mine Spoil Hydrologic Properties in the Appalachian Pateau	Appalachian coalfields, USA.	Porosity values of 16% and 23% have been recorded by field measurements in mine spoil in two separate coalfields (respectively, Rahn 1976 and Hawkins 1998)

Paper	Title	Location	Notes
Williams Kho 2013	Laboratory Geotechnical Characterisation of Scalped Coal Mine Spoil	Australian Coalfields	Lab sampled compaction testing of 19mm scalped spoil materials. Uncemented Jeebropilly weathered rock spoil. 42% porosity at maximum dry density (MDD). Cemented Mt Arthur 3 month old sandstone spoils. 30% porosity at MDD.
Wunsch et al 1996	Hydrogeology, Hydrogeochemistry, and Spoil Settlement at a large mine-spoil area in Eastern Kentucky: Star Fire Tract	Kentucky, USA	Calculations assumed 20% spoil porosity Reference to study by Diodato and Parizek (1994) which found that the porosity of mine spoil ranged from 30.1-57% in shallow, unsaturated boreholes.
Lindorff et al 1981	Hydrogeology of spoil at three abandoned surface mines in Illinois: preliminary results	Illinois, USA	Mezga (1973) investigated Ohio watershed, found average porosity of 44%.
Simmons et al 2015	Moisture conditions in mine spoil dumps	Bowen Basin, QLD Australia	Reference to ACARP project C20019 which tested two boreholse from 10 year old spoil at the QLD Bowen Basin Broadmeadow Mine. Porosity found to decrease from 40% near the surface to around 30% measured 80m below surface.

8.2.4 *Model Configuration*

Spoil aquifers have been modelled in the Wilpinjong OPSIM in accordance with the following:

- Spoil aquifers have been modelled adjacent to Pit 5N, below Ed's Lake, Pit 2W and Pit 4.
- Recharge and discharge occurs to balance water levels between the pit lake and the adjacent spoil aquifer. Rates of transfer are governed by head difference, but are typically in the order of 10ML/d-20ML/d when flowing (model assumption).
- Pit 2W spoil aquifer drainage to Pit 4 (via Pit 4 spoil aquifer) modelled at a constant rate of ~10ML/d.
- Storage characteristics have been modelled assuming 30% spoil porosity. Stage-storage characteristics have been provided for reference in Appendix C.
- Seepage from up-dip pits into spoil aquifers, and back out into down-dip pits.

9. Water Quality

Water quality sampling at Wilpinjong is undertaken at a number of locations with samples analysed for the standard suite of quality indicators. Water sample test results have been provided for selected locations extending as far back as 2014. Month average measurements of EC for selected surface water locations have been summarised in Table 9-2. Review of this information shows the following:

- Water circulating through the WMS is typically within the EC range of 3,000-4,000 μS/cm (see Pit 2W, CWD and RWD sampling).
- The EC within Pit 1S is higher, due to inflow of RO reject. Concentrations of salt within this storage appear to have been diluted with upstream clean catchment runoff (RO reject EC sampled at 14,000 μS/cm in Feb-17 vs. Pit 1S EC of around 6,000 μS/cm in Sep-16).
- The EC of the blended discharge stream to Wilpinjong Creek is typically less than 300 μS/cm vs the 500 μS/cm EC end-of-pipe limit specified in EPL 12425. This indicates there is potential to optimise the ratio of RO permeate to Pit 2W water within the discharge stream, to achieve increased discharge volumes.

The Wilpinjong OPSIM maintains a running account of salt mass in all water storages which is equated to, and reported as EC. Salt mass inflows are typically estimated by assigning salinity concentrations to runoff from various land use types, and to point water sources (e.g. groundwater, pipeline water).

Water quality model parameters were initially set in accordance with parameters developed as part of the WEP surface water assessment (WRM, 2015). The 2014-2017 model verification process confirmed that these parameters continued to produce reasonable estimates of EC in the circulating WMS inventory (based on Pit 2W data). As such, values from the WEP have been retained in the 2017 Wilpinjong OPSIM model. Adopted parameters are listed in Table 9-1.

Table 9-1: Adopted Salinity Generation Rates

Item	Salinity (EC) (μS/cm)
Catchment Runoff	
Natural / Undisturbed	1,600
Roads / Industrial / Hardstand / Pit	3,000
Spoil / Overburden / Cleared	2,500
Rehabilitated Overburden	2,000
Point Water Sources	
Groundwater	3,000
External Water Supply (eg. borefield)	3,000

Table 9-2: Average Electrical Conductivity (EC units: µS/cm) by Month and Sampling Location

Year	Mth	Dams							Pits				RO Plant				Other	Ref
		Pit 2W	Pit 1S	Pit 5 FP	CWD	RWD	Ed's Lake	MIA Sed D.	Pit 5	Pit 2-NB	Pit 4	Pit 3	Feed	Perm -eate	Dis-charge	RO Reject	Tails	Wilp. Ck. U/S
2014	Jan	3,660											3,940		370			
	Feb														373			
	Jul														366			1,660
	Aug														317	11,300		1,340
	Sep	3,810													298			
	Oct														356			
	Nov														403			
	Dec														347			1,260
2015	Jan														348			
	Feb									5,290								
	Mar	3,048								4,790					330		4,540	
	Apr	3,390	6,670		3,330	3,510	880		1,060	4,940	3,960				277		5,580	
	May														235			
	Jun		9,180*												277			580
	Jul									4,100					180			1,190
	Aug									4,620					236		4,510	440
	Sep	3,490	5,690	2,110	3,440	3,580		6,130	2,290		4,250	3,030			197			
	Oct			3.540						5,190					222			
	Nov														245			
	Dec									4,290					279			1,180
2016	Jan	3,280	5,770		3,470	3,440	2,210	2,850	2,330	4,940	3,640				279			1,090
	Feb														274			
	Mar														285			
2017	Jan	3,545																
	Feb													180		14,000		

Note: Wilpinjong Creek upstream water quality data filtered to exclude samples collected on days of zero flow.

10. Water Balance Model

10.1 Overview

The Wilpinjong OPSIM [20] has been designed to simulate the operation of all major components of the water management system, including: catchment runoff, water inventory fluctuation and overflow, pump and gravity transfers, industrial water extraction and return, climatic influence, groundwater inflow, open cut mine dewatering, discharge of water to Wilpinjong Creek (via the RO plant), and interaction with spoil aquifers. Key components of the Wilpinjong WMS are generally described and quantified in the preceding report sections.

10.2 Model Schematisation

A representative schematic of the Wilpinjong OPSIM model has been provided in Appendix A. Review of this figure shows the model is comprised of a collection of inter-connected nodes. Nodes represent key components of the water management system (dams, wash plant, pits, etc.). Functional specifications for various node types can be provided upon request.

10.3 Model Verification

10.3.1 Overview

WCPL have provided historical water level survey data for the period January 2014 to January 2017 [21]. This information has been used to verify the accuracy of the Wilpinjong OPSIM model. Model verification has focused specifically on reproducing the following:

- Combined water inventory in the WMS (primary verification objective).
- Inventory in individual storages: Pit 2W, Pit 1S, RWD, CWD, Pit 5N, Pit 4, Pit 3N.
- Cumulative pumping volumes from Pit 3N to Pit 2W.
- Water quality in Pit 2W (EC), which is considered to be generally indicative of water circulating through the WSM.

The objective of the exercise was to infer or establish key model inputs and parameters, and to demonstrate that the Wilpinjong OPSIM mode suitably replicates observed site inventory trends. An additional objective of the model verification exercise was to identify areas of model uncertainty, to guide future studies (e.g. sensitivity analysis requirements, monitoring programs etc).

[20] The OPSIM software is a general purpose simulation model for water resource systems. It is industry accepted, and primarily used for mine site water management applications throughout Australia.

[21] It is acknowledged that model verification is considered to have been achieved if observed system responses are replicated by the model over a minimum three year period that ideally encompasses three full wet-seasons.

10.3.2 Configuration

The following inflows and outflows were *hard-coded* into the model as time-series data:

- Water extraction from Pit 2W, the RWD and Pit 5 FP Dam for dust suppression (daily resolution data - modelled as per Figure 5-4).
- Extraction of water from the RWD and CWD to supply demands in the MIA/CHPP area, including the CHPP and misc MIA demands (daily resolution data – modelled as per metered stream in Figure 5-3).
- Return from miscellaneous CHPP/MIA area water usage stream. Assumed 50% return from 60 ML/month usage, resulting in 30 ML/month (1.0 ML/d) water return to the WMS via Pit 2W (per Section 5.1.3).
- Discharge of blended RO1 permeate and Pit 2W water to Wilpinjong Creek (monthly resolution data – modelled as per Figure 6-2).
- Transfer of RO1 reject from Pit 2W to Pit 1S (via RO1) (monthly resolution data – modelled as per Figure 6-2).
- Transfer of fine tailings slurry water to the tailings cells adjacent to Pit 2W, at rates calculated as part of the CHPP solids and water mass balance (refer Section 5.1.2). Transfer occurs until April 2015 (prior to Tailings BFP commissioning). Assumed 73% tailings water loss associated with matrix retention and evaporation, consistent with a previous study (Jacobs, 2010) [22].

The following processes were *simulated* within the model:

- Climatic influence: evaporation, evapotranspiration, direct rainfall and catchment runoff based on daily rainfall recorded at the BoM Wollar Gauge and SILO Data Drill evaporation data (refer to Section 4).
- Transfer of water between storages, pit dewatering etc (refer to Table 3-4).
- Seepage from up-dip pits into down-dip pits via spoil aquifers (e.g. Pit 5S seepage to Pit 5N).
- Saturation and drainage of spoil aquifers adjacent to open cut pits (spoil aquifers modelled adjacent to Pit 5N, Pit 2W and Pit 4 (refer to Section 8.2).

The following parameters were adjusted to improve the overall agreement between simulated and observed historical WMS performance:

- AWBM catchment yield parameters.
- Groundwater inflow rates
- Spoil aquifer storage capacities (porosities)
- Salt balance model parameters.
- Other inflow/outflow mechanisms (e.g. seepage).

[22] Jacobs (formerly SKM), January 2010. *Wilpinjong Coal – Site Water Management – Water Management Study.* Rev 0.

Other settings and configuration assumptions include:

- Groundwater inflow assumed to be constant across the historical simulation period (for simplicity).
- Catchment and land use information described in Section 3.2.4. Minor adjustments to catchment areas and land use classification applied in 2014 and 2015 simulation years to account for mine progression. Changes based on review of aerial photography included in annual environment monitoring reports (AEMRs) submitted by PEA.
- The timing and magnitude of selected (unmetered) water transfers has been iteratively adjusted where considered appropriate. These include pumped inflows and outflows from Pit 1S, timing of pumping from Pit 3N and Pit 5N, and pumping from Pit 2W to Pit 5N in late 2016.

10.3.3 Outcomes

10.3.3.1 Overall Verification

Model simulated volumes have been compared against historical measurements in Figure 10-1 for the period January 2014 to January 2017. Results have been plotted for the following items:

- Combined water inventory in the WMS (primary verification objective).
- Inventory in individual storages: Pit 2W, Pit 1S, RWD, CWD, Pit 5N, Pit 4, Pit 3N.
- Cumulative pumping volumes from Pit 3N to Pit 2W.

Model settings associated with these results include the following. Selection basis is described in the text following Figure 10-1.

- AWBM catchment yield parameters as per Table 4-4, which generally produce lower runoff estimates than parameters adopted as part of the WEP surface water assessment (WRM, 2015).
- Groundwater inflows modelled at a constant rate of 3.8 ML/d, which is higher than rates modelled in the WEP surface water assessment (WRM, 2015) but lower than rates estimates as part of a groundwater study prepared to support PA Modification 6 HydroSimulations, 2014) (refer to Figure 8-1).
- Spoil aquifer storage calculated assuming 30% spoil porosity, which is higher than the 20% adopted as part of the WEP groundwater study (HydroSimulations, 2015), however direct comparison is not necessarily applicable given differences in modelling approach (OPSIM models spoil aquifer storage at a much coarser resolution than a conventional groundwater model).
- An outflow mechanism assumed to operate as a function of the water level in Pit 2W. Outflows modelled at approximately 2-3 ML/d if Pit 2W water level exceeds 371 mRL.

A simulated water inventory has also been presented in Figure 10-1 for an alternate model configuration, for discussion purposes. Alternate results are shown using a grey dashed line. This alternate scenario is based on model settings more closely aligned with the WEP surface water study.

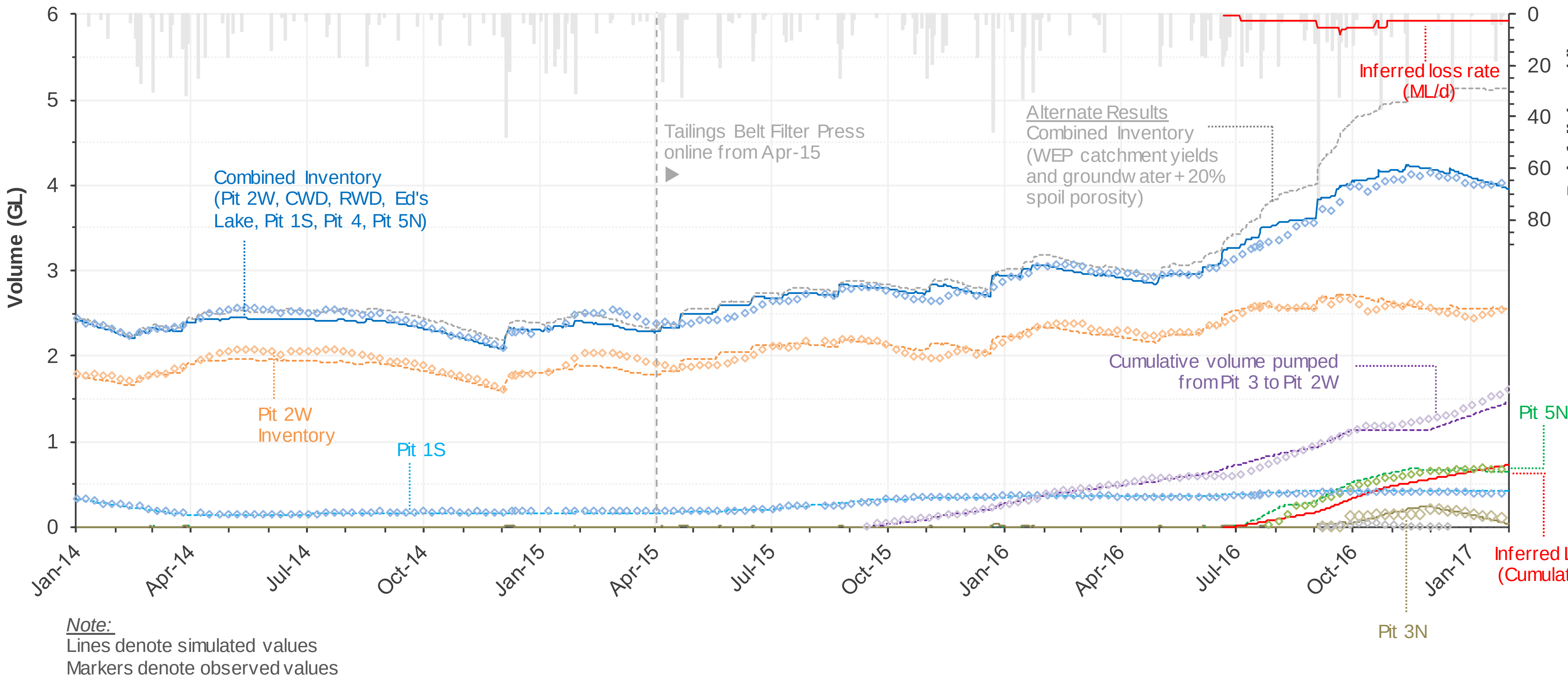


Figure 10-1: Model Verification Outcomes - Simulated vs Historical Volumes

Review of Figure 10-1 gives the following:

- A good overall representation of the combined historical surface water inventory within the WMS has been achieved using the Wilpinjong OPSIM across the 2014 to 2017 period.
- Similar agreement between simulated and observed inventory is achieved for individual water storages within the WMS.
- Cumulative pumped volumes from Pit 3 to Pit 2W are consistent with metered volumes. This has been achieved through a combination of catchment yield parameter adjustment, and a groundwater inflow to Pit 3 of 1.6 ML/d (note the balance of the 3.8 ML/d total groundwater inflow has been apportioned between Pit 4 and Pit 5N).

The alternate simulated WMS inventory (grey profile) has been presented for discussion purposes, and is considered relevant as it provides a basis for describing the process through which model parameters have been shifted to their current settings, from values aligned with the WEP (higher catchment yields, 2.9ML/d groundwater, 20% spoil porosity). Review of the grey profile shows that it achieves a similarly good agreement through between January 2014 and June 2016, but diverges from the observed inventory during the wet winter of 2016, ultimately over-estimating the inventory in storage by approximately 1 GL. Three (unmetered) variables are noted to come into effect in mid 2016:

- Significant winter rainfalls saturate catchments, prompting a higher conversion of rainfall to runoff (second and third of three AWBM sub-buckets reach capacity and begin generating runoff).
- Pit 5N is intentionally flooded, saturating the backfilled spoils within the Pit 5 void with an amount of water determined by the porosity of the spoil. The maximum water level reached in Pit 5N was recorded at 361.66 mRL.
- Pit 2W is filled to high water level, higher than anything reached prior to June 2016 (in the 2014-2017 data period). This may have triggered some level-driven outflow mechanisms (e.g. seepage to geological structures or coal seams). This could also represent a level-driven reduction in inflow rate (i.e. reduced groundwater inflow rates due to high water levels, e.g backpressure).

Based on consideration of the above, the following adjustments were made to model settings to resolve the over-estimation of inventory in the latter half of 2016. Listed in order of preference:

- AWBM catchment yield parameters were de-coupled from the WEP aligned values and adjusted to produce lower runoff. The upper limit for parameter adjustment was determined based on comparison against models reviewed/developed as part of previous Hatch studies.

- Groundwater inflows were increased from 2.9ML/d to 3.8ML/d to counteract a progressively growing under-estimation of inventory through 2014 to 2015, which arose following the change to catchment yield parameters described above.
- Increased spoil aquifer porosity from 20% to 30% (working within a parameter range determined based on review of published literature – refer Section 8.2.3). This effectively moved 350 ML of water from the surface inventory to the spoil aquifer inventory.
- A level-driven outflow was modelled from Pit 2W, initiated at 371 mRL (2,470 ML in Pit 2W). Outflow rate was modelled as a function of water depth above the threshold value, and were estimated at around 2-3 ML/d. Cumulative outflow via this mechanism was approximately 750 ML by the end of January 2017.

In summary, a combination of model parameters was identified that enabled the historical inventory to be matched within the model, however there remains a degree of uncertainty associated with each of the four items described in the points above. Recommendations to account for this uncertainty are summarised in Section 10.3.4.

10.3.3.2 Pit 1S Sub-Model

Model verification outcomes have been presented for Pit 1S in Figure 10-2. Volumes of reject pumped from RO1 have also been presented in this figure for context.

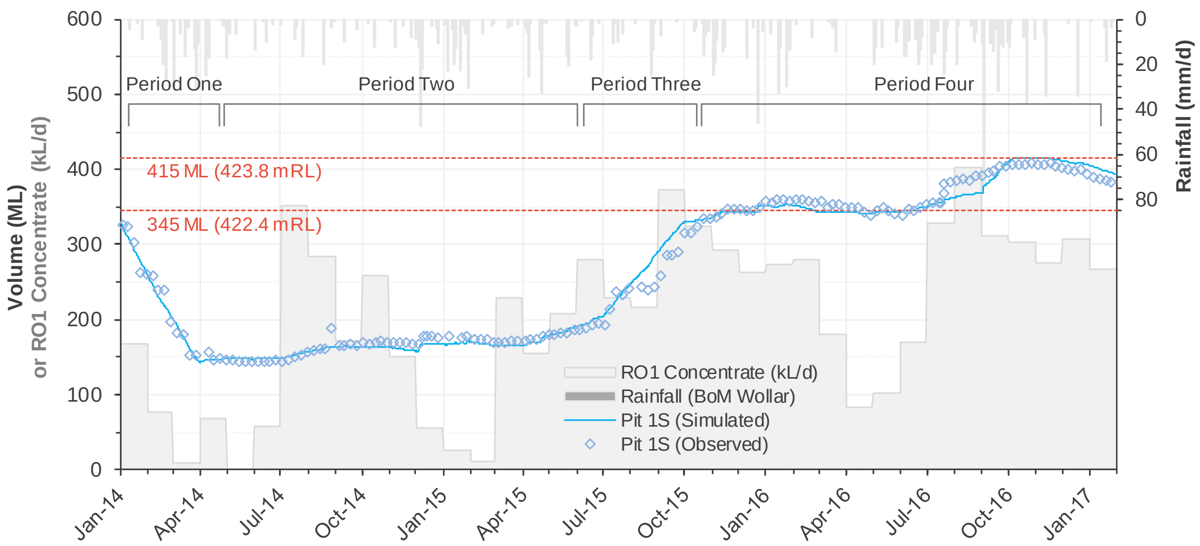


Figure 10-2: Pit 1S Sub-Model Verification

Review of Figure 10-2 shows that the model can reproduce the historical inventory recorded within this dam over the past three years, however this has required the implementation of the following assumptions/settings:

- <u>Period One</u>: Simulated 2.1 ML/d extraction from Pit 1S between 1/1/14 and 31/3/2014 (approx 185 ML total) to account for unmetered pumping to the RWD to supply CHPP and ROM FP water demands.

- Period Two: 1.0 mm/d seepage to Ed's Lake (or its underlying spoil aquifer) defined during this period. Outflow rates have been modelled throughout the entire simulation period. Seepage rate is equivalent to approximately 0.05 ML/d.
- Period Three: Rapid inventory increase in the absence of significant rainfall is indicative of an unmetered pumped inflow. Simulated 1.6 ML/d inflow to Pit 1S between 1/8/15 and 30/9/2015 (approx 95 ML total) to maintain agreement between simulated and observed inventories. Operational basis unconfirmed. Modelling has assumed the water was transferred from Pit 2W.
- Period Four: Additional 0.4 ML/d seepage to Ed's Lake modelled if water level exceeds 422.4mAHD (345ML). This was required to maintain agreement between simulated and observed inventories.

Overall outcomes of the Pit 1S sub-model verification include:

- Occurrence of unmetered pumped inflows and outflows.
- Apparent leakage to downstream storages or spoil aquifers within the WMS at high water levels.

The latter is supported by anecdotal evidence from site personnel (both Pit 1S and RWD have been observed to saturate the surrounding areas, including the CHPP area, if water levels are pushed too high).

10.3.3.3 *Water Quality (Pit 2W)*

Salt balance aspects of the Wilpinjong OPSIM have been verified by comparing simulated Pit 2W EC with respective water quality sampling data. Pit 2W is an ideal candidate for this exercise as it is indicative of water circulating through the WMS. Outcomes of the salt balance verification have been presented in Figure 10-3. Review of this figure shows that simulated EC is generally consistent with measured EC throughout the duration of the historical simulation. This supports the adopted salt balance parameters and assumptions incorporated into the Wilpinjong OPSIM.

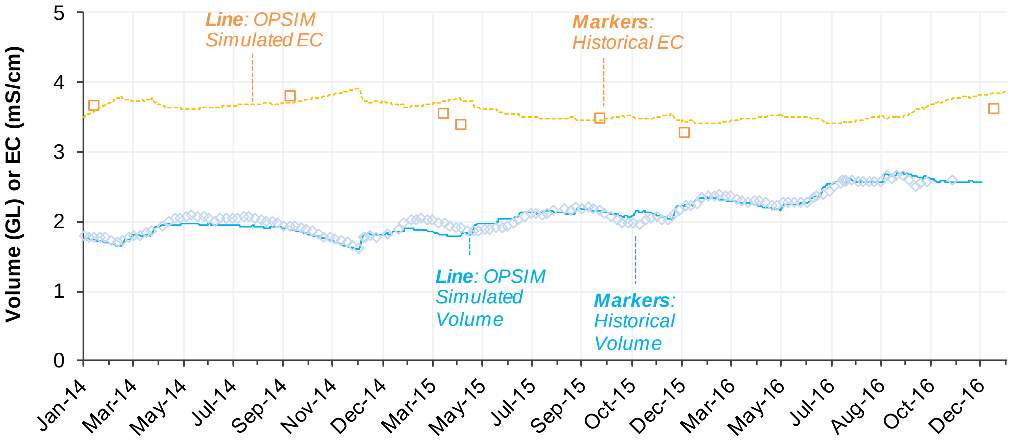


Figure 10-3: Simulated vs Observed Pit 2W Inventory and EC

10.3.4 Model Uncertainty

Key areas of model uncertainty identified as part of the model verification exercise have been summarized in Table 10-1 along with recommendations to account for this uncertainty as part of future studies or operational decisions.

Table 10-1: Model Uncertainty & Recommended Actions

Element	Recommendation
Catchment yield (AWBM parameters)	• Continue collecting monitoring data and revisit model verification in 6-12 months. • Re-adjust model parameters if estimates of groundwater, spoil porosity or level-driven outflow are improved. • Explore potential to model upstream valley fill catchments as 'storage' elements, rather than conventional catchments within OPSIM. Drainage through these storages could be subject to additional evapotranspiration losses as is slowly flows through the shallow surface aquifers of the colluvial valley floor. This could reduce catchment runoff further without resorting to using unconventional AWBM parameter sets.
Groundwater inflows	• Conduct investigations to disaggregate the 60 ML/mth MIA/CHPP area water usage, and estimate water returns for each individual usage stream. Increased accuracy in this area should improve the accuracy of the inferred groundwater inflow estimates. • Groundwater inflow rates are higher than values listed in the WEP. Consider adopted lower inflow rates for studies that are concerned with water supply security, or studies in which additional groundwater would be of benefit (e.g. diluting RO2 reject that is being pumped back into the circulating WMS inventory) .
Spoil porosity	• Continue collecting monitoring data and revisit model verification in 6-12 months. • Emphasise collection of Pit 5N water level and pumped dewatering data to back calculate spoil aquifer storage. • Include sensitivity analysis as part of future studies. Test reduced/nil spoil aquifer storage for studies concerned with containment. • For studies commencing from current conditions, recommend testing scenario in which no water is stored in the spoil at simulation start (particularly if this spoil water will be of benefit. e.g. dilution of RO reject)
Level-driven outflow from Pit 2W	• In future planning studies, model a maximum operating level in Pit 2W nominally 1 m below the level at which the level-driven outflow mechanism appears to be initiated (i.e. 1m below 371mRL). • Reduce the current water level in Pit 2W to the level described above, when practicable. • Engage a hydrogeologist to investigate whether a level-driven outflow from Pit 2W is probable, or whether there are any other risks associated with operating this storage above the level specified above.
Level-driven outflow from Pit 1S	• In future planning studies, model a maximum operating level in Pit 1S nominally 1 m below the level at which increased leakage is expected to occur (i.e. 1 m below 422.4 mRL). This is emphasized for any studies in which Pit 1S is to be used as a dedicated RO reject storage.
Water Quality	• Monitoring water quality in Pit 2W on a more frequent basis, at least monthly, particularly if RO reject is being recirculated back into the WMS.

10.4 Model Operating Rules

Representative operating rules that define the Wilpinjong OPSIM are summarised in Table 10-2. The operating rules should be taken as indicative and subject to future revision pending receipt of more detailed information regarding the physical specifications and operational philosophy of the WMS.

Table 10-2: Wilpinjong OPSIM Operating Rules

Item	Description	Operating Rules
1.0	**External Water Supply**	
1.1	External Water Supply	▪ Water imported from an external source to sustain mine water demands during prolonged drought periods. ▪ Import scheduled to maintain a minimum site inventory of approximately 500 ML. ▪ Inflow directed to Pit 2W. ▪ Supply rate modelled as unconstrained in order to estimate total import requirements.
2.0	**Supply to Demands**	
2.1	CHPP	▪ Modelled as a net water extraction of 110 ML/month (3.6 ML/d) sourced evenly between the CWD and RWD. ▪ Usage based on CHPP water balance and forecast production (refer Section 5.1.2.5). ▪ No return from demand since commissioning of tailings BFP.
2.2	Misc Industrial Area	▪ Modelled as a net water extraction of 60 ML/month (2.0 ML/d) sourced evenly between the CWD and RWD. ▪ Assumed 50% of usage is returned to Pit 2W. ▪ Loss component is assumed to remove water only, all salt is assumed to Pit 2W.
2.3	Dust Suppression	▪ Water usage calculated daily in model as a function of climate and application area. (Refer to Section 5.2.2) ▪ No dust suppression if rainfall exceeds 1.5 mm/d ▪ Demand supplied based on the following breakdown: o ROM FP (RWD) – 62.6% o Pit 2 FP (Pit 2W) – 18.6% o Pit 5 FP (Pit 5 FP Dam) – 18.8% ▪ No return from demand modelled
2.4	Evaporators	▪ Modelled as a net 0.25 ML/d loss from Pit 2W. ▪ Outflow stream assumed to be water only, no salt removed from Pit 2W.

Item	Description	Operating Rules
2.5	RO Plant	▪ Used to draw down mine water inventory. Operated if inventory in WMS exceeds 1,000 ML. ▪ Supplied from Pit 2W at 4 ML/d. ▪ Permeate recovery modelled as 75% of feed. No reduction in recovery modelled due to high feed water EC. ▪ Permeate EC modelled at 180 µS/cm. ▪ Nominal 0.22 ML/d (7.3% of permeate) returns to Pit 2W accounting for backflush/cleaning and non-compliant water rejection. ▪ RO reject EC modelled as a function of feed water EC based on salt mass balance. ▪ RO reject pumped to Pit 1S. If Pit 1S full, reject pumped to Pit 2W. ▪ Discharge water EC modelled at 300 µS/cm, achieved by adding Pit 2W water to the residual permeate stream (after backflush etc accounted for).
3.0	**Operation of Key Storages**	
3.1	*Water Storages*	
3.1.1	Pit 2W	▪ Primary hub mine water storage. ▪ Supplies makeup water to the following locations as required: o RWD and CWD o Pit 2 FP o Pit 5 FP Dam ▪ Receives pumped dewatering from Pit 5N, Pit 4 and Pit 3N. ▪ All inbound pumping is cancelled if inventory reaches 370.0 mRL (2,275 ML). ▪ Pumps to Pit 5N at 100 L/s (8.64 ML/d) if water level exceeds 370 mRL. If Pit 5N is full, Pit 2W pumps to Pit 4, and then to Pit 3 as a last resort. ▪ Seeps to Pit 4 via Pit 2/4 spoil aquifer. ▪ Supplies water to RO plant for treatment and discharge to Wilpinjong Creek under EPL 12425. ▪ Feed water for evaporator spray system. ▪ Exchanges water with adjacent Pit 2/4 spoil aquifer to maintain equalised water levels (exchanges water with Pit 2 half of spoil aquifer only). ▪ Level driven outflow (system loss) modelled if water level exceeds 371.0 mRL Outflow rate modelled as a function of water level above threshold level, rates typically less than 3 ML/d. Mechanism should be rarely triggered due to pumping rules defined above. ▪ No spillway overflows modelled.
3.1.2	RWD	▪ Mine water dam in the CHPP/MIA area. ▪ Supplies makeup water to the following locations as required: o CHPP process water makeup o MIA/CHPP misc water usage o ROM FP ▪ Sources water from Pit 2W to maintain water level at 412.7 mRL (300 ML). ▪ No spillway overflow modelled.

Item	Description	Operating Rules
3.1.3	CWD	▪ Mine water dam located north of CHPP/MIA, within the rail loop. ▪ Supplies makeup water to the following locations as required: o CHPP process water makeup o MIA/CHPP misc water usage ▪ Sources water from Pit 2W to maintain water level at 395.7 mRL (30 ML). ▪ No spillway overflow modelled.
3.1.4	Pit 1S	▪ RO reject storage dam. ▪ Receives pumped inflow of reject from RO1. ▪ Maximum operating level defined as 421.4 mRL (295 ML) to minimise seepage to downstream areas within the WMS. ▪ Constant seepage rate of 1 mm/d modelled. Seepage assumed to report to Pit 1/5 spoil aquifer. ▪ Additional seepage of 0.4 ML/d to Pit 1/5 spoil aquifer modelled if water level exceeds 422.4 mRL (345 ML).
3.1.5	Pit 5 FP Dam	▪ Water supply for Pit 5 FP. ▪ Receives pumped inflows from Pit 5N and Ed's Lake. ▪ Sources makeup water from Pit 2W to maintain a minimum water level of 391.5 mRL (3 ML). ▪ Spillway overflow to Pit 5N at 392.2 mRL (full storage volume 8.5 ML)
3.1.6	Ed's Lake	▪ Residual void left within backfilled and rehabilitated Pit 1N void. ▪ Supplies makeup water to Pit 5 FP Dam. ▪ Pumps excess water to Pit 2W at 100 L/s (8.64 ML/d) ▪ Seepage to underlying Pit 1/5 spoil aquifer modelled at 0.5 ML/d. ▪ Spillway overflow to Wilpinjong Creek at 375.3 mRL (storage capacity nominally 110 ML)
3.2	*Tailings Storage Facilities*	
3.2.1	All TD's	▪ Old tailings storage cells ▪ All receive local catchment runoff with no pumped inflows ▪ No pumped outflows modelled. Standing water left to evaporate, or seep to Pit 2/4 spoil aquifer (at an assumed rate of 2 mm/d).

Item	Description	Operating Rules
3.3	*Mining Pits*	
3.3.1	Pit 5N	▪ Pumps to Pit 5 FP Dam if it requires water. Excess water pumped to Pit 2W at 180 L/s (15.6 ML/d) unless receiving storage is above its maximum operating level. ▪ Maximum water level of 369 mRL modelled. If water level exceeds this threshold, pumping to Pit 2W will occur regardless of downstream inventory (this will triggering filling of next pit in sequence). ▪ Receives groundwater inflow of 1.3 ML/d (modelled via Pit 1/5 spoil aquifer). ▪ Exchanges water with adjacent Pit 1/5 spoil aquifer to maintain equalised water levels. ▪ Receives seepage from up-dip pits (Pit 5S, Pit 5 Strip 6 and Pit 1) via spoil aquifer.
3.3.2	Pit 5S	▪ Seepage to Pit 5N (via Pit 1/5 spoil aquifer) modelled as a depth loss rate of 300 mm/d. ▪ No pumped dewatering.
3.3.3	Pit 5 (Strip 6)	▪ Seepage to Pit 5N (via Pit 1/5 spoil aquifer) modelled as a depth loss rate of 300 mm/d. ▪ No pumped dewatering.
3.3.4	Pit 4	▪ Receives seepage from Pit 2W via Pit 2/4 spoil aquifer. ▪ Excess water pumped to Pit 2W at 160 L/s (14.0 ML/d) unless receiving storage is above its maximum operating level. ▪ Maximum water level of 366.5 mRL modelled. If water level exceeds this threshold, pumping to Pit 2W will occur regardless of downstream inventory (this will triggering filling of next pit in sequence). ▪ Receives groundwater inflow of 0.9 ML/d ▪ Exchanges water with adjacent Pit 2/4 spoil aquifer to maintain equalised water levels (exchanges water with Pit 4 half of spoil aquifer only).
3.3.5	Pit 1	▪ Seepage to Pit 1/5 spoil aquifer modelled as a depth loss rate of 300 mm/d. ▪ No pumped dewatering.
3.3.6	Pit 2S	▪ Seepage to Pit 2/4 spoil aquifer modelled as a depth loss rate of 300 mm/d. ▪ No pumped dewatering.
3.3.7	Pit 3	▪ Receives drainage from Pit 7. ▪ Excess water pumped to Pit 2W at 90 L/s (7.8 ML/d) unless receiving storage is above its maximum operating level. ▪ Maximum water level of 358.9 mRL modelled. If water level exceeds this threshold, pumping to Pit 2W will occur regardless of downstream inventory. ▪ Receives groundwater inflow of 1.6 ML/d
3.3.8	Pit 7	▪ Passively drains to Pit 3. ▪ No pumped dewatering.

Item	Description	Operating Rules
3.4	*Spoil Aquifers*	
3.4.1	Pit 1/5 Aquifer	▪ Modelled as two separate cells: Pit 5 spoil aquifer and Pit 1 spoil aquifer. ▪ Pit 5 spoil aquifer equalises with Pit 5N open cut above 352 mRL. ▪ Pit 5 spoil aquifer equalises with Pit 1 spoil aquifer above 354 mRL.
3.4.2	Pit 2/4 Aquifer	▪ Modelled as two separate cells: Pit 2 spoil aquifer and Pit 4 spoil aquifer. ▪ Pit 2 spoil aquifer equalises with Pit 2W open cut above 350.75 mRL. ▪ Pit 4 spoil aquifer equalises with Pit 4 open cut above 338 mRL. ▪ Pit 2 spoil aquifer seeps to Pit 4 spoil aquifer at a fixed rate of 10 ML/d (seepage calculation based on level difference cannot be modelled within OPSIM due to large head difference – i.e. unstable calculation).
4.0	**Other**	
4.1	Climate	▪ All water storages receive catchment runoff and lose water to evaporation.

10.5 Model Limitations

Climatic data (rainfall and evaporation), supply, demand and transfer volumes have been modelled as daily totals. The model assumes that daily data can be distributed over 24 hours. The model does not accurately represent events with durations less than 24 hours. For example, storm runoff events with durations less than 24 hours cannot be accurately accounted for using the Wilpinjong OPSIM.

The Wilpinjong OPSIM has been developed and calibrated with a focus on the water management system as a whole. Model accuracy is considered better for design applications of wider scope (e.g. site water balance) relative to studies of narrower focus (e.g. single dams). Although the model is well suited for undertaking smaller studies, inputs and controls should always be first understood and then modelled to a level of detail suitable to the task at hand.

11. Site Water Balance Reporting

Current investigations have prepared a historical water balance for the period July 2015 to June 2016 to satisfy the requirements of the Site Water Balance as required by Condition 30, Schedule 3 of Project Approval PA05-0021. Annual volumes and associated basis have been listed in Table 11-1.

Table 11-1: Wilpinjong Water Balance – July 2015 to June 2016

Item		Volume (ML)	Basis
Inflow	Groundwater into pits	1,387	Historical OPSIM model verification inferred net 3.8 ML/d groundwater inflow rate
	Rainfall and runoff captured	2,325	Simulated within Wilpinjong OPSIM model
	Sub-Total	**3,712**	
Outflow	Evaporation	654	Simulated within Wilpinjong OPSIM model
	Seepage	-	No seepage losses inferred as part of historical OPSIM model verification
	Discharge from WTF[23]	219	XOM monthly discharge summary reports (metered volumes)
	Dust suppression on haul roads	993	Metered data (combination of flowmeter and scaled trip-based usage estimates)
	CHPP	1,370	1,730 ML metered supply minus 360 ML return (50% of 60 ML/mth misc usage)
	Sub-total	**3,236**	
Change in volume (increase in inventory)		**476**	Surveyed inventory end Jun-16 (3,118ML). Inventory at start Jul-15 (2,642ML)

[23] Note that approval documentation refers to the RO plant as the water treatment facility (WTF).

12. Conclusions and Recommendations

Current investigations have been undertaken to a level of detail sufficient to maintain a fair and reasonable appreciation of the hydrological characteristics for the Wilpinjong water management system. This has been achieved through the collation and review of data recorded from 1 January 2014 to 31 January 2017.

Key outcomes from current investigations include:

- Improved understanding and capability to model the Wilpinojng water management system.
- GIS database of catchment areas, land use classifications georeferenced against aerial photography.
- Collated a database of level area volume characteristics for water storages, pits and spoil aquifers.
- Improved understanding and modelling of site water usage practises, including CHPP usage, MIA area usage, and dust suppression (including development of a sub-model to calculate dust suppression water usage based on prevailing climate)
- Verification of the Wilpinjong OPSIM and associated parameters against recorded water level data for the January 2014 to January 2017 period (greater than three years).
- Developed a baseline OPSIM model that can be used as a platform for future studies.

The OPSIM model was able to successfully reproduce the observed site water management system performance over the recent three year period, however it is noted that there remains some uncertainty associated with selected model parameters and assumptions, including: catchment yield parameters, groundwater inflow rates, spoil aquifer storage capacity and possible level-driven outflow mechanisms acting on Pit 2W and Pit 1S. Recommendations to address or account for these uncertainties have been listed in Table 10-1 of Section 10.3.4 (page 48). Recommendations generally entail:

- Incorporating sensitivity analysis, and scenario-appropriate model settings as part of future planning studies.
- Conducting further monitoring (particularly during the Pit 5N draw-down, and EC in Pit 2W on a regular basis if RO reject is being returned into the WMS).
- Hydrogeological studies to investigate spoil storage characteristics, level-driven outflow mechanisms, and suitability of Pit 2W to store water above 370 mRL.
- Conducting further investigations to define the breakdown of the inferred 60 ML/mth water usage inferred as part of this study (refer Section 5.1.3). Investigations may include review of design information and/or additional metering (portable or permanent meters).
- On-going data collection and refinement of the OPSIM model.

Despite the above, the model is considered to be well suited for planning studies, infrastructure sizing and operational decision making, provided these studies incorporate sensitivity analysis (as any robust study should).

The next OPSIM update should be undertaken after completion of the next wet-season or sooner if any significant discrepancy or uncertainty between OPSIM simulation and actual observation becomes apparent.

It should be noted that the content of this report may be subject to revision with any future improved understanding of the operational and response characteristics of the Wilpinjong water management system.

13. References

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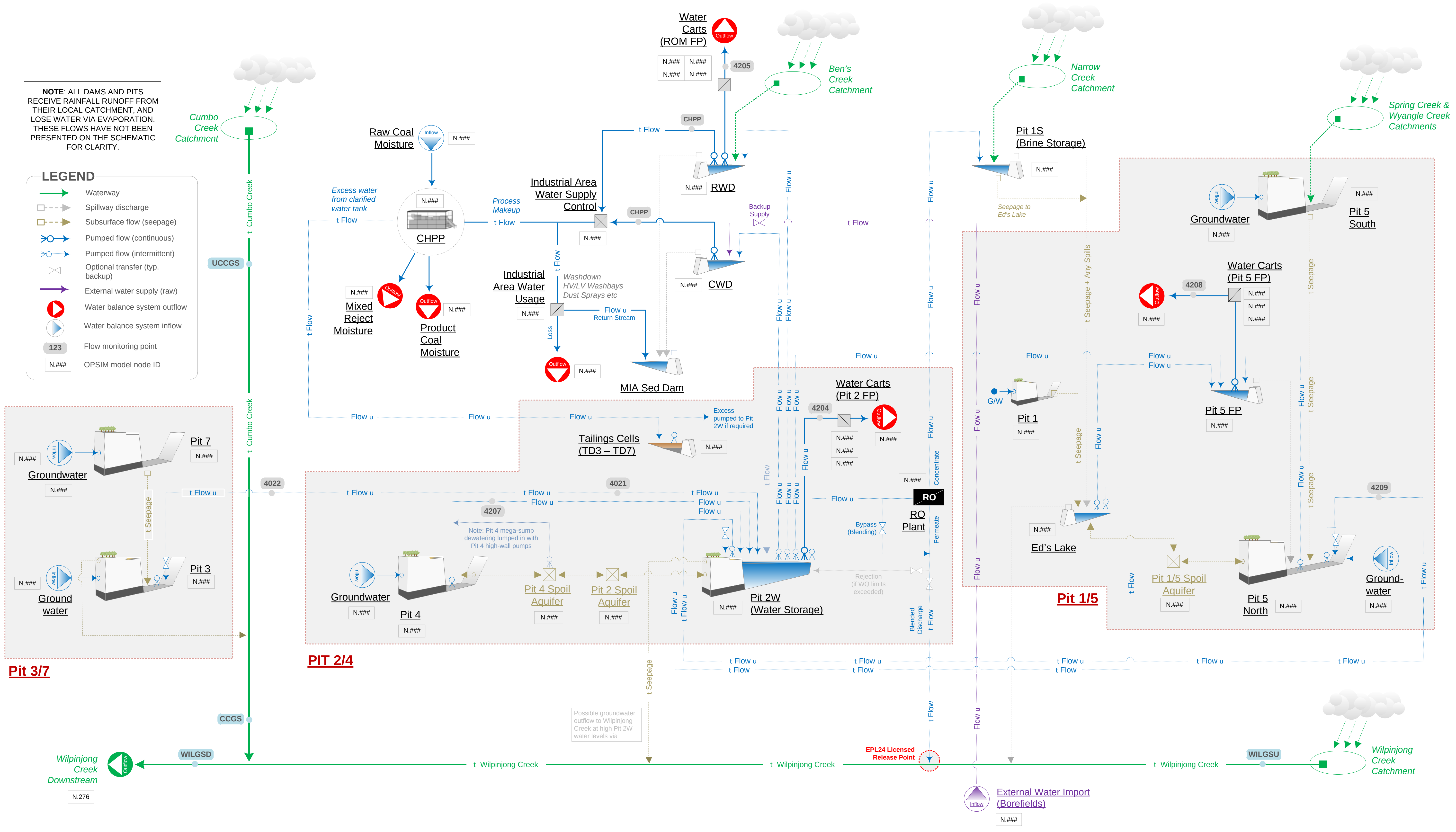
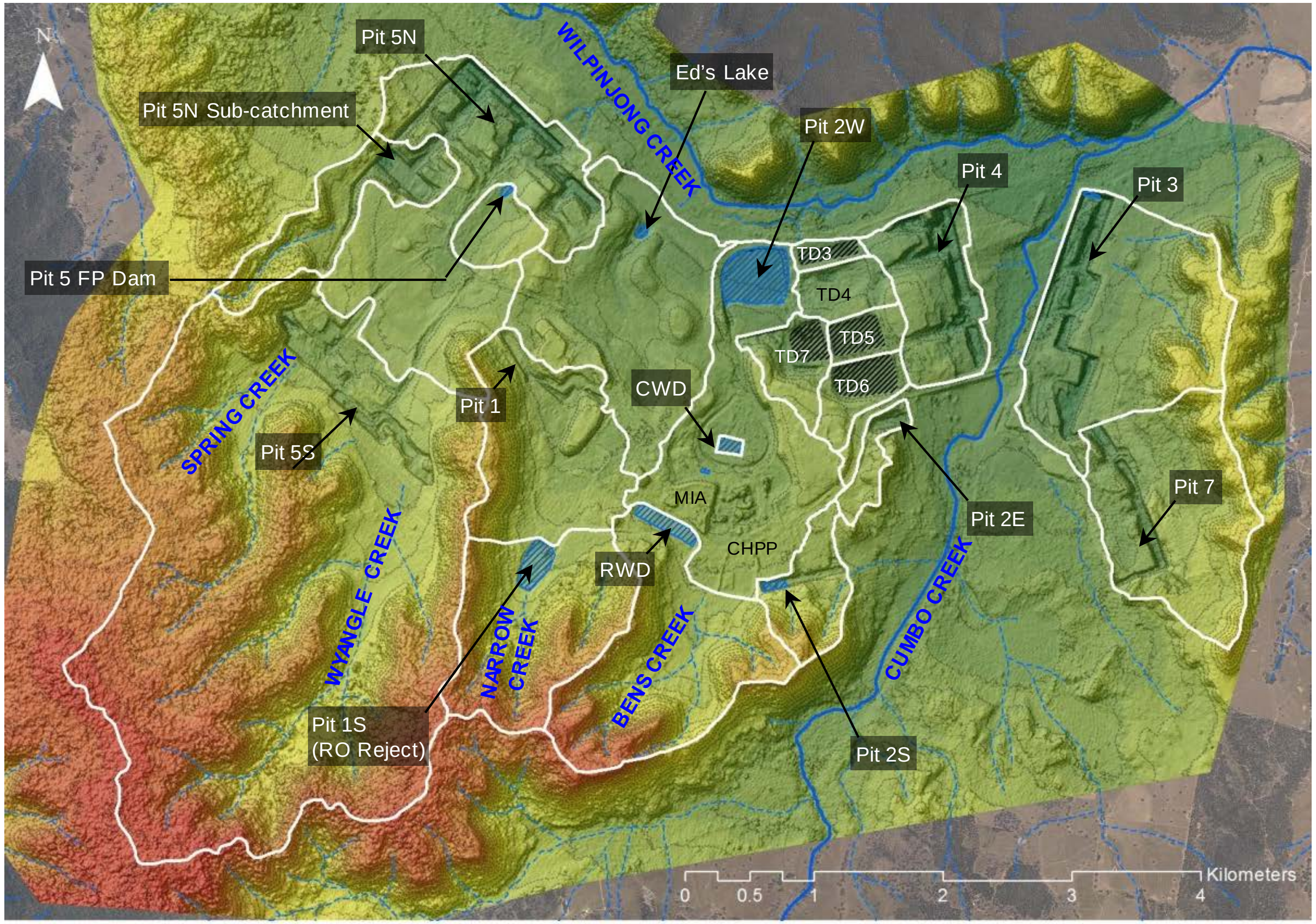
Appendix A
OPSIM Schematics

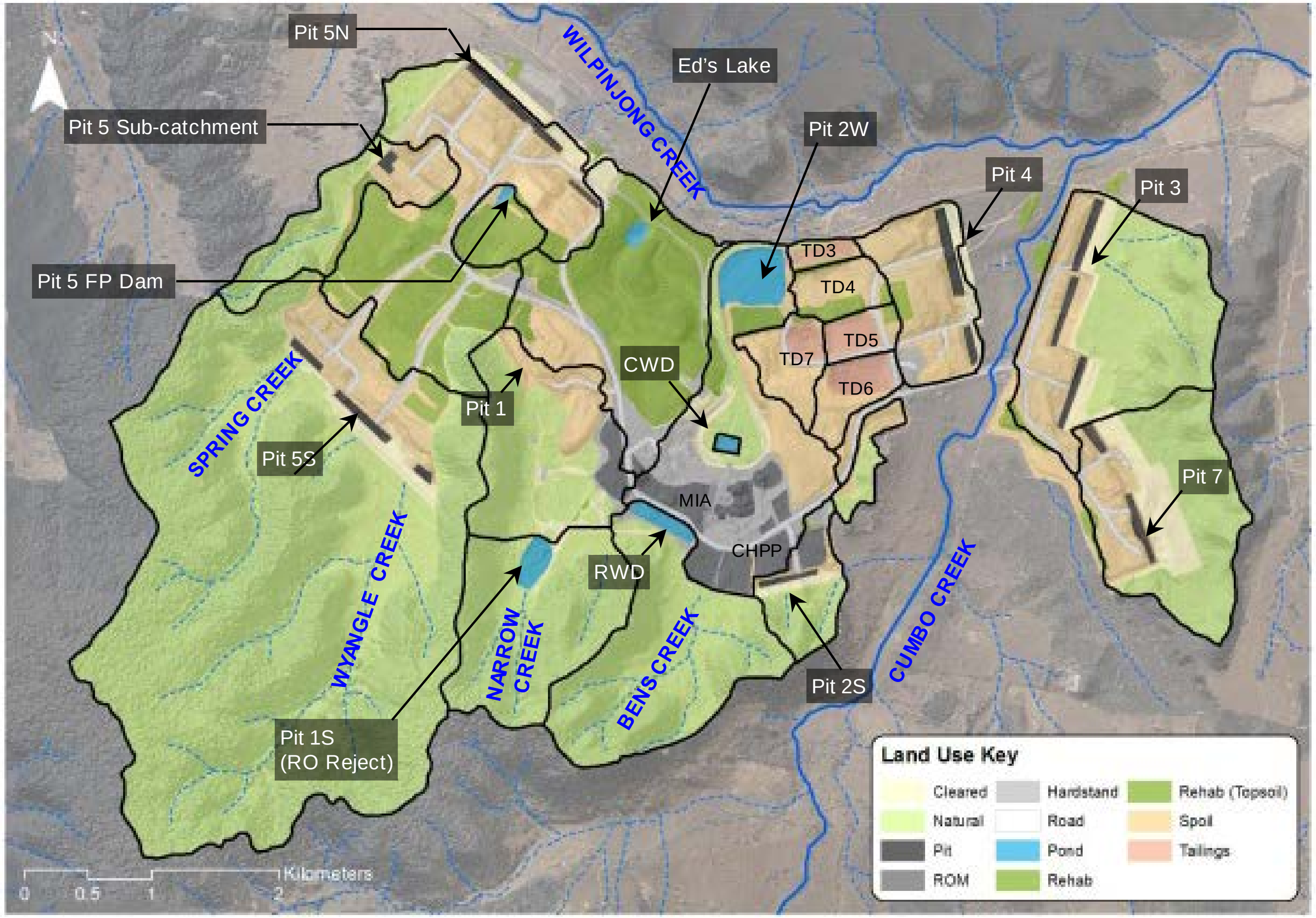

NOTE: ALL DAMS AND PITS RECEIVE RAINFALL RUNOFF FROM THEIR LOCAL CATCHMENT, AND LOSE WATER VIA EVAPORATION. THESE FLOWS HAVE NOT BEEN PRESENTED ON THE SCHEMATIC FOR CLARITY.
LEGEND
Waterway
Spillway discharge
Subsurface flow (seepage)
Pumped flow (continuous)
Pumped flow (intermittent)
Optional transfer (typ. backup)
External water supply (raw)
Water balance system outflow
Water balance system inflow
Flow monitoring point
OPSIM model node ID
Cumbo Creek Catchment
Raw Coal Moisture
CHPP
Mixed Reject Moisture
Product Coal Moisture
Industrial Area Water Supply Control
Industrial Area Water Usage
Washdown HV/LV Washbays Dust Sprays etc
MIA Sed Dam
Water Carts (ROM FP)
Ben's Creek Catchment
RWD
CWD
Narrow Creek Catchment
Pit 1S (Brine Storage)
Seepage to Ed's Lake
Spring Creek & Wyangle Creek Catchments
Groundwater
Pit 5 South
Water Carts (Pit 5 FP)
Pit 5 FP
Tailings Cells (TD3 – TD7)
Water Carts (Pit 2 FP)
RO Plant
Pit 1
Ed's Lake
Pit 7
Pit 3
Pit 3/7
Pit 4
Pit 4 Spoil Aquifer
Pit 2 Spoil Aquifer
Pit 2W (Water Storage)
PIT 2/4
Pit 1/5 Spoil Aquifer
Pit 5 North
Pit 1/5
Note: Pit 4 mega-sump dewatering lumped in with Pit 4 high-wall pumps
Possible groundwater outflow to Wilpinjong Creek at high Pit 2W water levels via
EPL24 Licensed Release Point
Wilpinjong Creek Downstream
Wilpinjong Creek
Wilpinjong Creek Catchment
External Water Import (Borefields)
UCCGS
CCGS
WILGSD
WILGSU
4022
4021
4207
4204
4205
4208
4209
N.276

Appendix B
Catchment & Land Use Data



Group	Storage	Catchment (ha)
Western	Ed's Lake	218.4
	Pit 1	152.4
	Pit 1S (Brine)	164.4
	Pit 5 FP Dam	31.1
	Pit 5 South	1,029.1
	Pit 5N	279.6
	Pit 5N Sub-catchment	84.0
	Sub-Total	*1,959.0*
Central	CWD	2.4
	Pit 2 East	19.9
	Pit 2 South	50.7
	Pit 2 West	221.5
	Pit 4	88.6
	RWD	199.5
	TD3	10.7
	TD4	29.1
	TD5	20.4
	TD6	31.10
	TD7	36.70
	Sub-Total	*710.6*
Eastern	Pit 3	230.9
	Pit 7	183.8
	Sub-Total	*414.7*
	Total	3084.2

Figure B1 – Surface Topography and Catchment Mapping



Land use area (ha) by 'Super Pit' grouping

Land Use	West	Central	East	ALL
Cleared	45.5	27.2	52.4	125.1
Hardstand	99.5	171.7	15.4	286.6
Natural	1,265.3	255.4	238.1	1,758.8
Pit	15,.6	9.9	15.5	41.0
Rehab	297.6	31.9	2.8	332.4
Spoil	235.5	179.0	90.4	505.0
Tailings	0	35.4	0	35.4

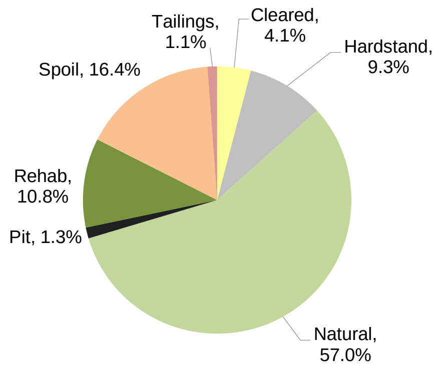


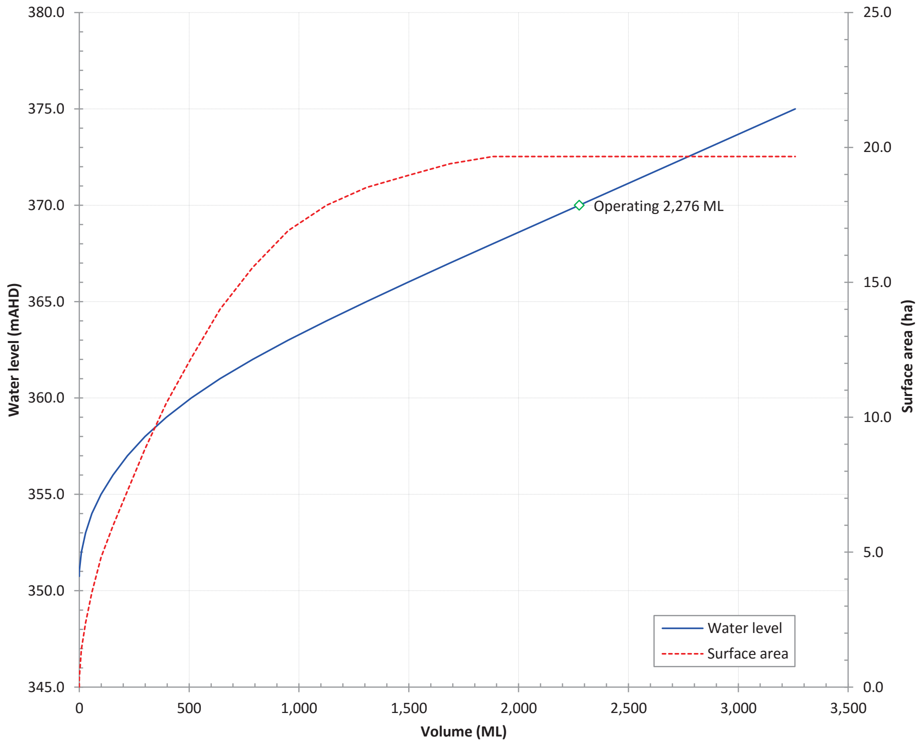
Figure B2 – Catchment and Land Use Mapping

Appendix C
Storage Characteristics

Wilpinjong Mine
Pit 2W

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating	370.0	2,276
Spillway		
Crest		

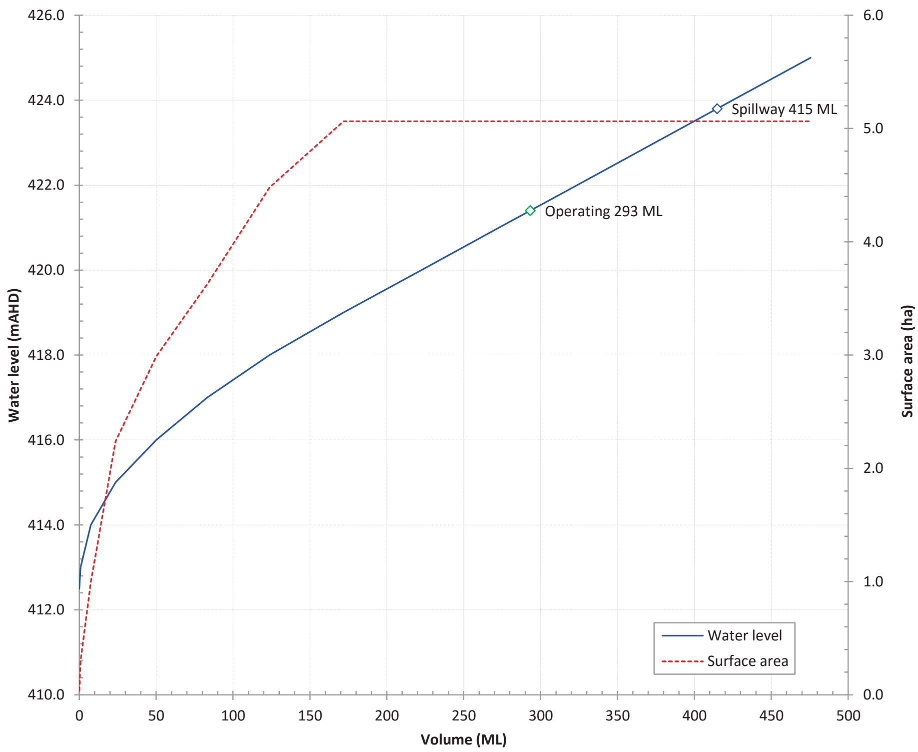
Level (mAHD)	Area (ha)	Volume (ML)
350.8	0.0	0.0
351.0	0.3	0.4
352.0	1.4	9.3
353.0	2.4	28.2
354.0	3.5	57.5
355.0	4.8	98.9
356.0	6.0	152.9
357.0	7.3	219.0
358.0	8.8	299.4
359.0	10.5	396.0
360.0	12.2	509.7
361.0	14.0	640.6
362.0	15.5	789.2
363.0	16.9	951.3
364.0	17.9	1,125.6
365.0	18.5	1,307.7
366.0	19.0	1,495.1
367.0	19.4	1,686.8
368.0	19.7	1,882.8
369.0	19.7	2,079.4
370.0	19.7	2,276.1
371.0	19.7	2,472.7
372.0	19.7	2,669.3
373.0	19.7	2,866.0
374.0	19.7	3,062.6
375.0	19.7	3,259.3



Wilpinjong Mine
Pit 1S

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating	421.4	293
Spillway	423.8	415
Crest		

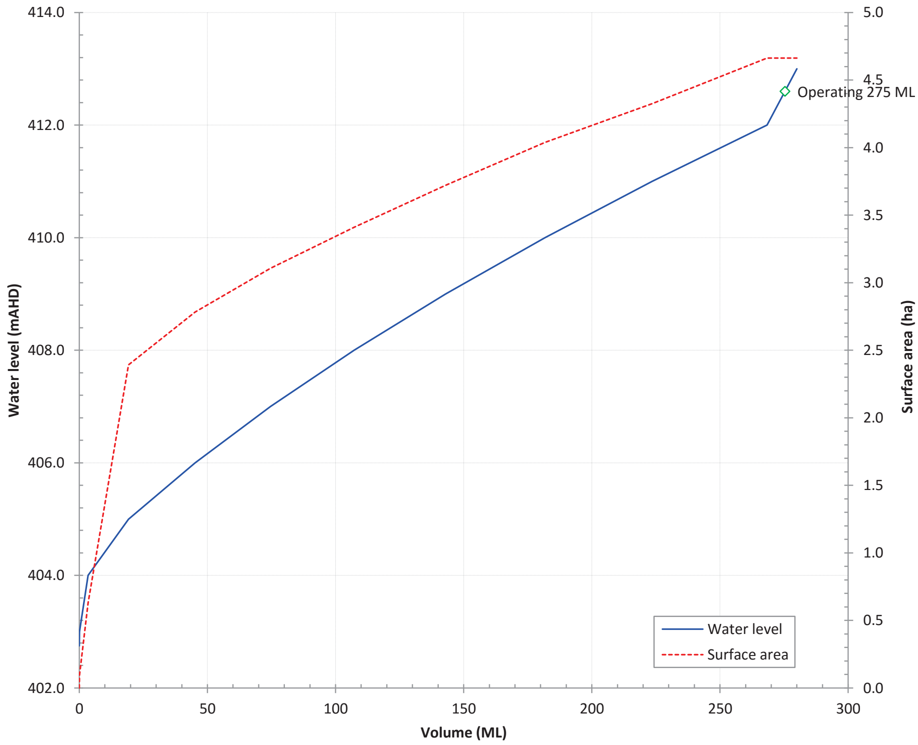
Level (mAHD)	Area (ha)	Volume (ML)
412.5	0.0	0.0
413.0	0.3	0.9
414.0	1.0	7.5
415.0	2.2	23.5
416.0	3.0	50.1
417.0	3.6	83.2
418.0	4.5	123.8
419.0	5.1	171.8
420.0	5.1	222.4
421.0	5.1	273.1
422.0	5.1	323.7
423.0	5.1	374.3
424.0	5.1	425.0
425.0	5.1	475.6



Wilpinjong Mine
Recycled Water Dam

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating	412.6	275
Spillway		
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
402.8	0.0	0.0
403.0	0.1	0.1
404.0	0.6	3.5
405.0	2.4	19.2
406.0	2.8	45.1
407.0	3.1	74.6
408.0	3.4	107.2
409.0	3.7	142.9
410.0	4.0	181.7
411.0	4.3	223.5
412.0	4.7	268.3
413.0	4.7	280.0



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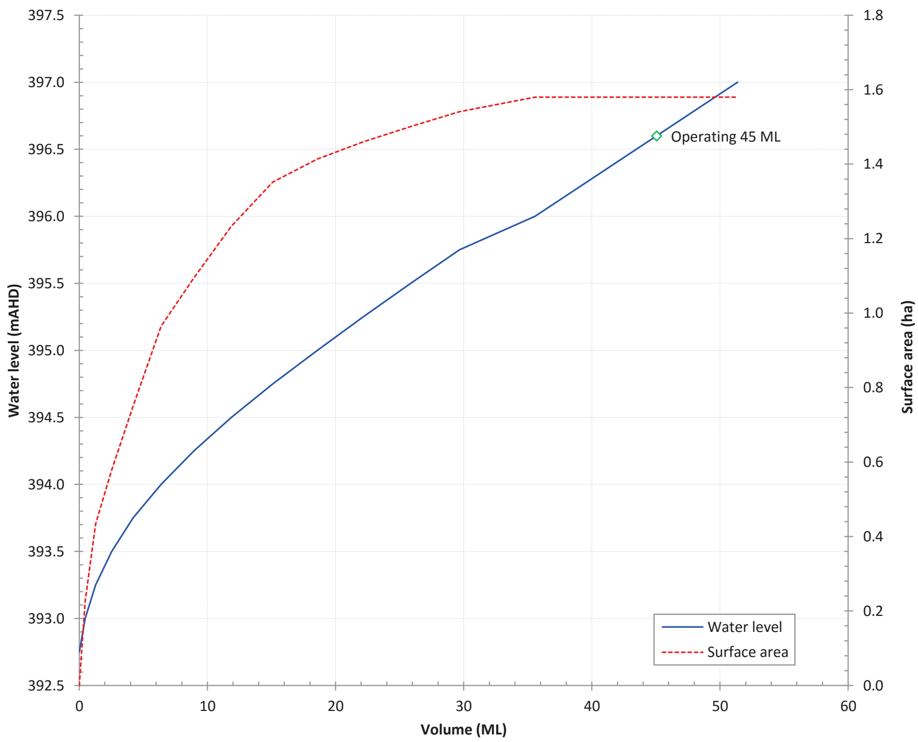
Wilpinjong Mine
Clean Water Dam

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating	396.6	45
Spillway		
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
392.8	0.0	0.0
393.0	0.2	0.5
393.3	0.4	1.3
393.5	0.6	2.5
393.8	0.8	4.2
394.0	1.0	6.4
394.3	1.1	9.0
394.5	1.2	11.9
394.8	1.4	15.1
395.0	1.4	18.6
395.3	1.5	22.2
395.5	1.5	25.9
395.8	1.5	29.7
396.0	1.6	35.6
397.0	1.6	51.4



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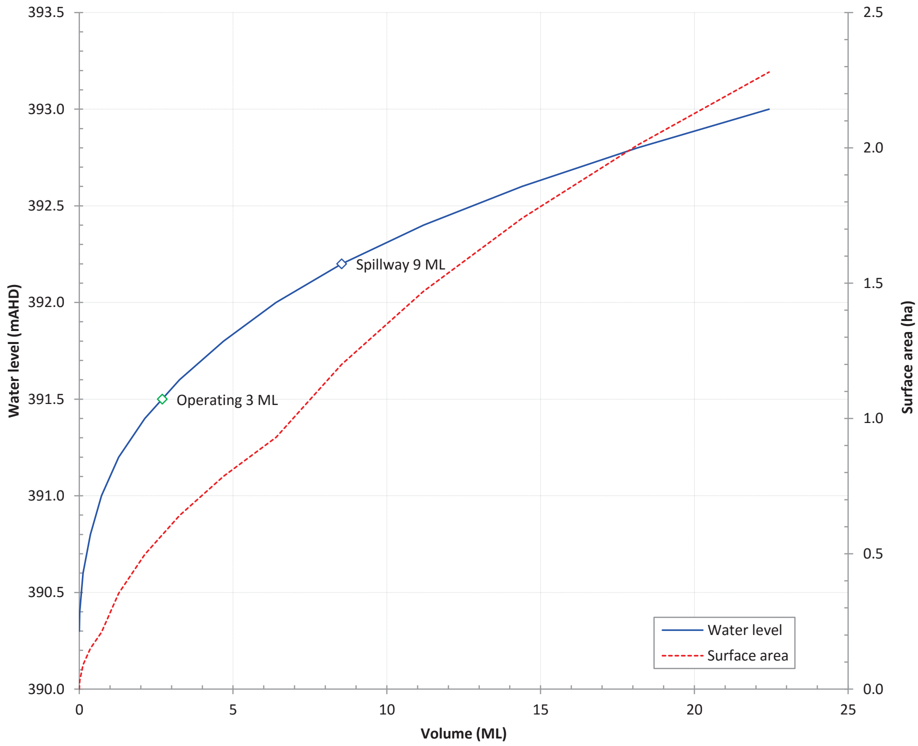
Wilpinjong Mine
Pit 5 FP Dam

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating	391.5	3
Spillway	392.2	9
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
390.3	0.0	0.0
390.4	0.0	0.0
390.6	0.1	0.1
390.8	0.2	0.4
391.0	0.2	0.7
391.2	0.4	1.3
391.4	0.5	2.1
391.6	0.6	3.3
391.8	0.8	4.7
392.0	0.9	6.4
392.2	1.2	8.5
392.4	1.5	11.2
392.6	1.7	14.4
392.8	2.0	18.2
393.0	2.3	22.4



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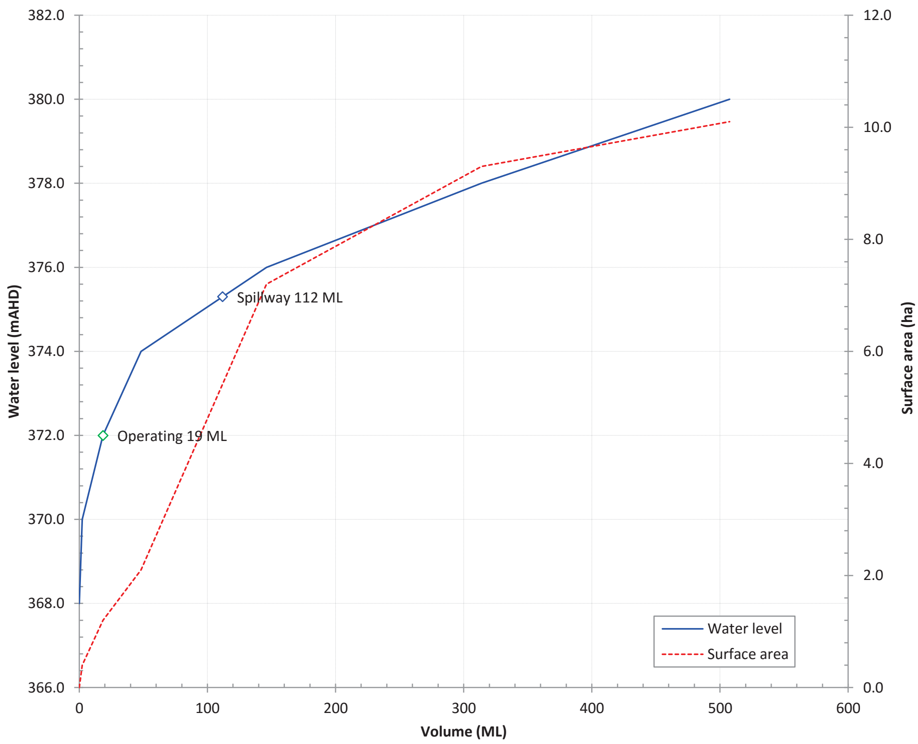
Wilpinjong Mine
Ed's Lake

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating	372.0	19
Spillway	375.3	112
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
368.0	0.0	0.0
370.0	0.4	2.2
372.0	1.2	18.5
374.0	2.1	48.2
376.0	7.2	146.1
378.0	9.3	313.8
380.0	10.1	507.5



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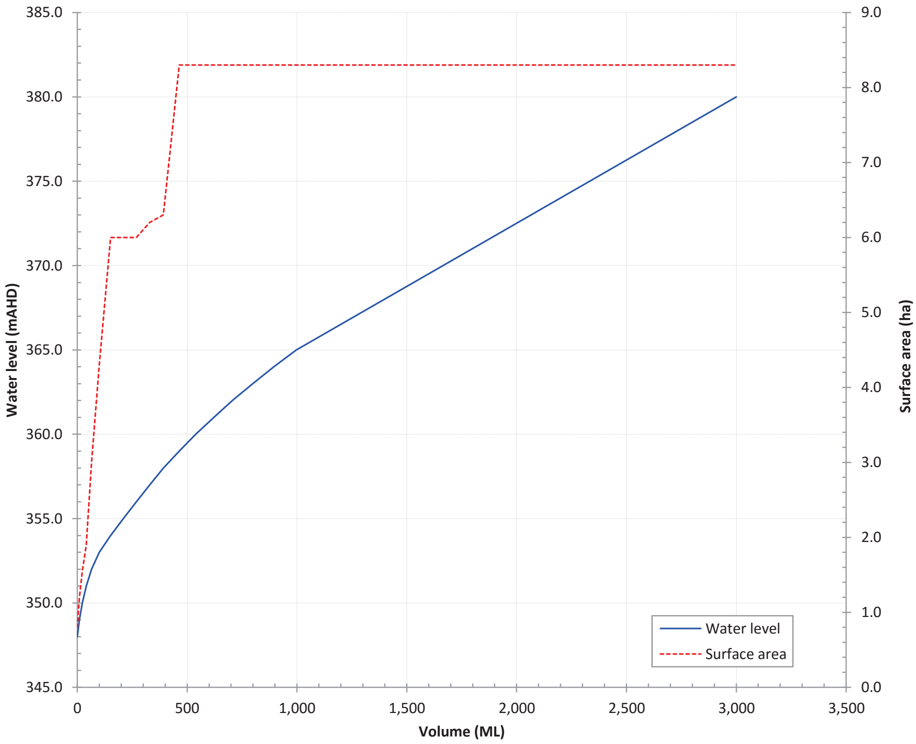
Wilpinjong Mine
Pit 5N

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

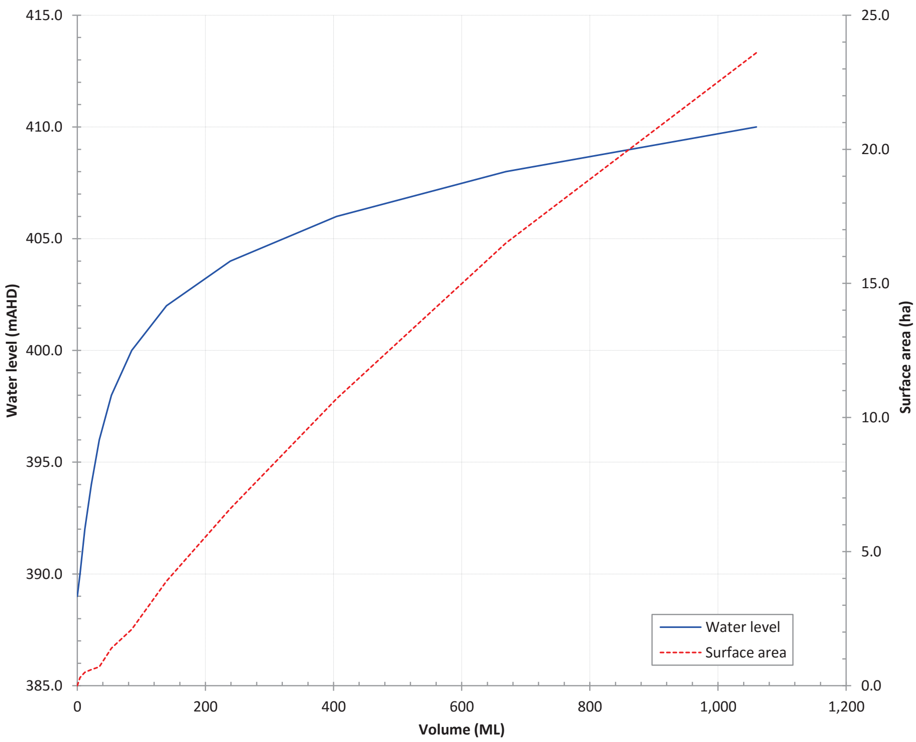
Level (mAHD)	Area (ha)	Volume (ML)
348.0	0.8	0.0
349.0	1.2	9.3
350.0	1.6	23.1
351.0	1.9	40.5
352.0	3.0	64.6
353.0	4.3	100.3
354.0	6.0	151.7
355.0	6.0	209.3
356.0	6.0	268.3
357.0	6.2	329.3
358.0	6.3	392.1
359.0	8.3	464.3
360.0	8.3	539.7
361.0	8.3	621.2
362.0	8.3	706.4
363.0	8.3	798.9
364.0	8.3	895.1
365.0	8.3	997.4
380.0	8.3	3,000.0



Wilpinjong Mine
Pit 5S

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

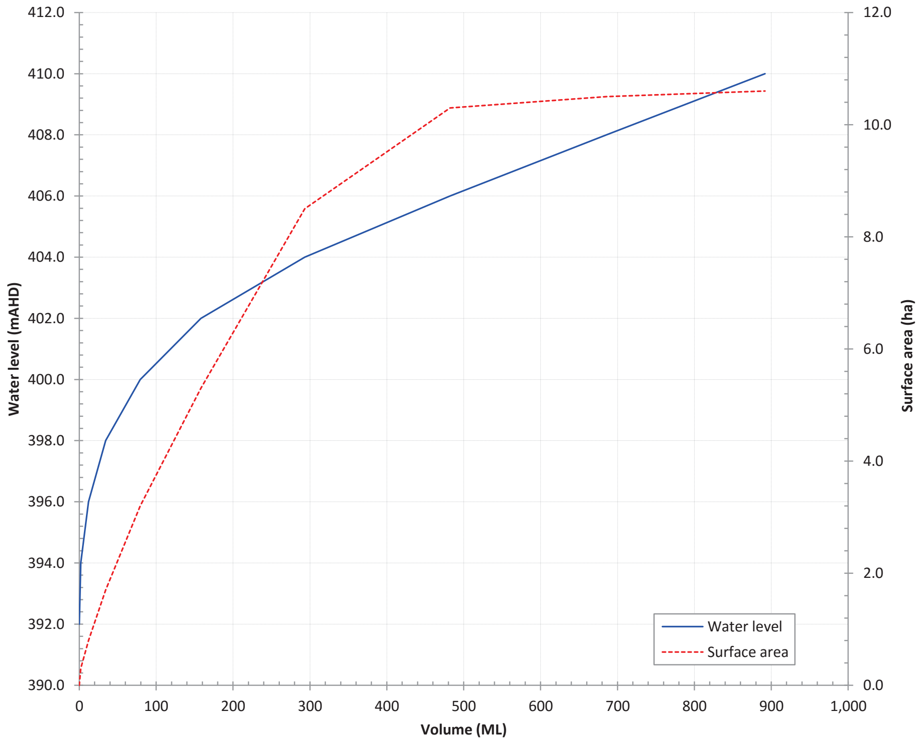
Level (mAHD)	Area (ha)	Volume (ML)
389.0	0.0	0.0
390.0	0.3	4.1
392.0	0.5	11.8
394.0	0.6	21.9
396.0	0.7	34.2
398.0	1.4	53.4
400.0	2.1	85.1
402.0	3.9	139.2
404.0	6.6	238.8
406.0	10.7	404.6
408.0	16.5	669.0
410.0	23.6	1,059.9



Wilpinjong Mine
Pit 1

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
392.0	0.0	0.0
394.0	0.3	2.0
396.0	0.8	12.0
398.0	1.7	34.3
400.0	3.2	79.1
402.0	5.3	158.3
404.0	8.5	293.2
406.0	10.3	482.3
408.0	10.5	686.0
410.0	10.6	891.9



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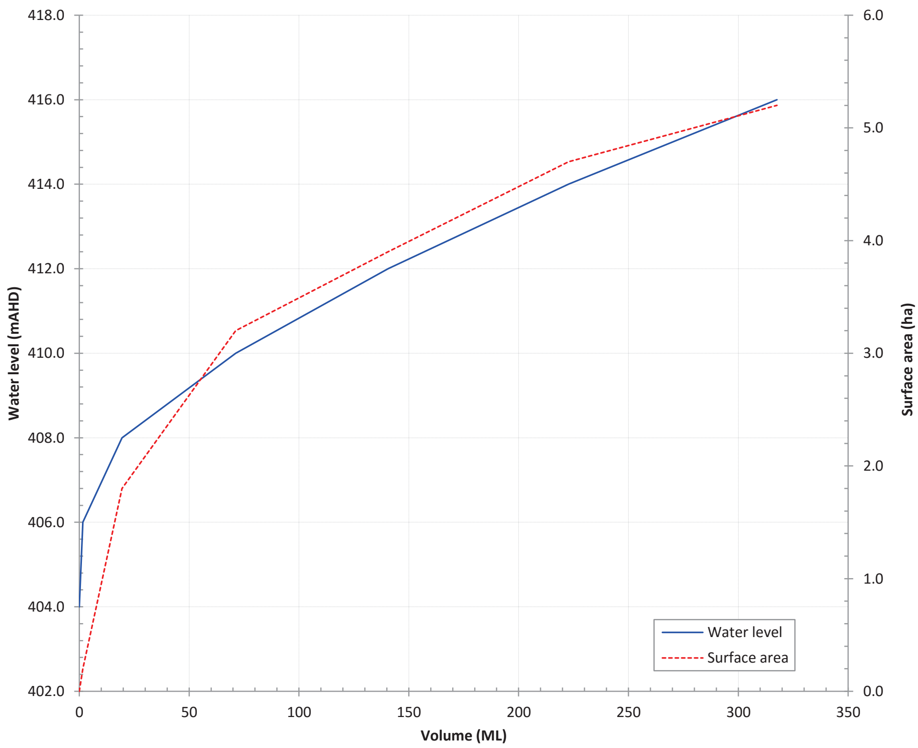
Wilpinjong Mine
Pit 2S

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
404.0	0.0	0.0
406.0	0.2	1.6
408.0	1.8	19.4
410.0	3.2	71.2
412.0	3.9	140.6
414.0	4.7	222.7
416.0	5.2	317.6



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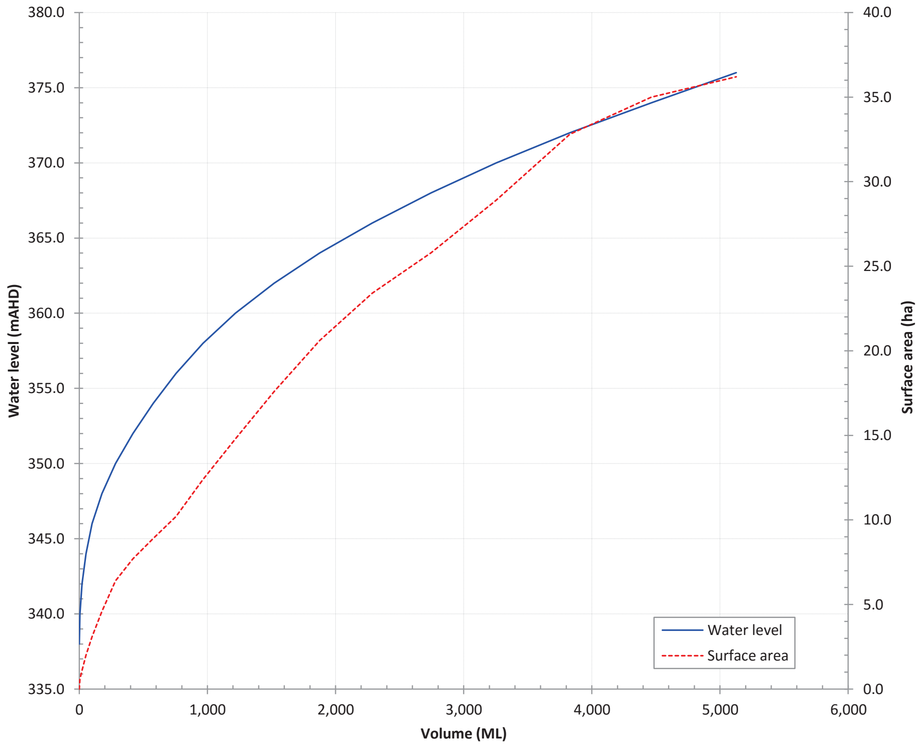
Wilpinjong Mine
Pit 4

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

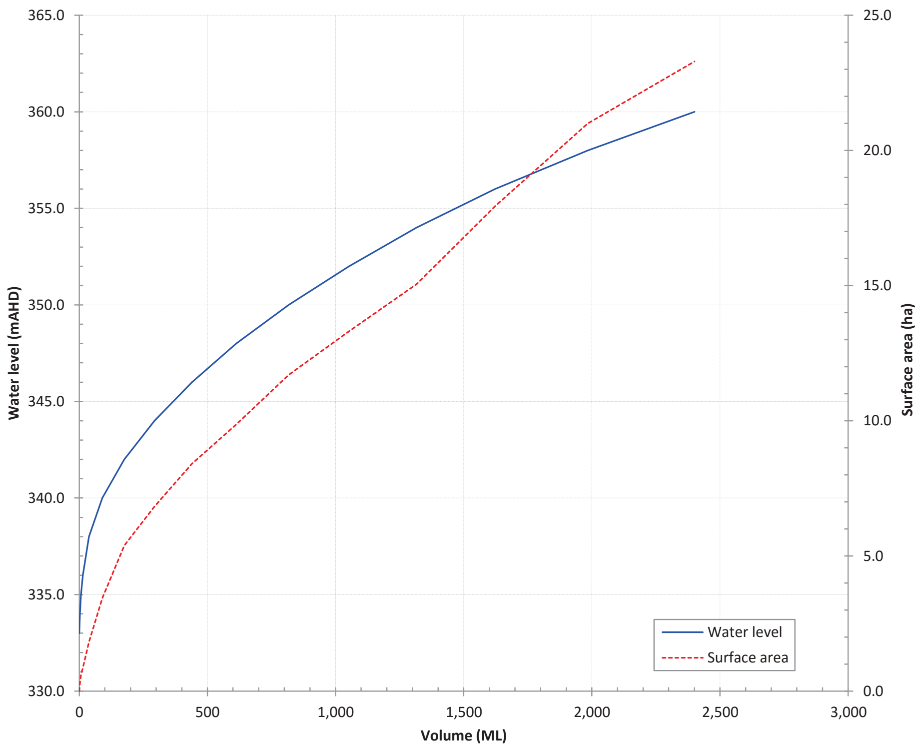
Level (mAHD)	Area (ha)	Volume (ML)
338.0	0.0	0.0
340.0	0.6	5.1
342.0	1.1	21.0
344.0	2.0	52.3
346.0	3.1	99.9
348.0	4.6	175.9
350.0	6.4	282.6
352.0	7.7	418.7
354.0	8.9	576.4
356.0	10.2	755.6
358.0	12.4	966.0
360.0	14.8	1,219.0
362.0	17.6	1,521.6
364.0	20.6	1,876.0
366.0	23.4	2,286.5
368.0	25.8	2,744.9
370.0	28.9	3,253.1
372.0	32.8	3,827.7
374.0	35.0	4,463.1
376.0	36.2	5,126.8



Wilpinjong Mine
Pit 3

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

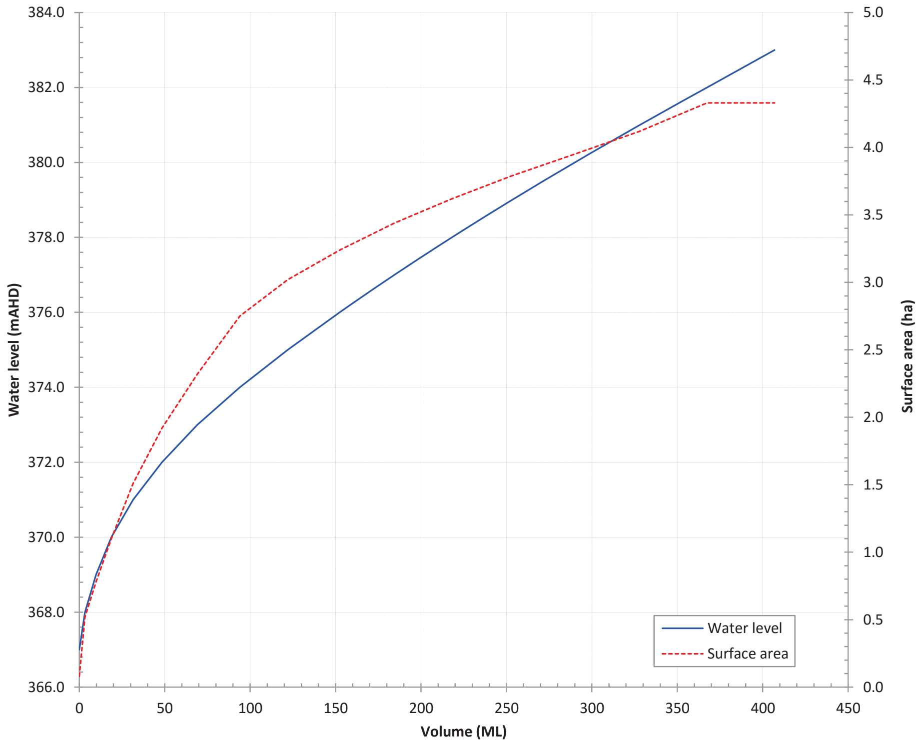
Level (mAHD)	Area (ha)	Volume (ML)
333.0	0.0	0.0
334.0	0.3	2.0
335.0	0.6	6.4
336.0	0.9	13.6
338.0	1.8	37.3
340.0	3.4	89.6
342.0	5.4	175.4
344.0	6.8	293.0
346.0	8.4	439.3
348.0	9.9	613.0
350.0	11.7	817.2
352.0	13.3	1,052.4
354.0	15.1	1,316.0
356.0	17.9	1,622.1
358.0	21.0	1,984.2
360.0	23.3	2,400.7



Wilpinjong Mine
Pit 7

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
367.0	0.1	0.0
368.0	0.5	3.3
369.0	0.8	9.9
370.0	1.1	18.8
371.0	1.5	31.5
372.0	1.9	48.4
373.0	2.3	69.1
374.0	2.8	94.0
375.0	3.0	122.1
376.0	3.2	152.4
377.0	3.4	184.5
378.0	3.6	218.2
379.0	3.8	253.3
380.0	4.0	289.9
381.0	4.1	327.9
382.0	4.3	367.4
383.0	4.3	406.9



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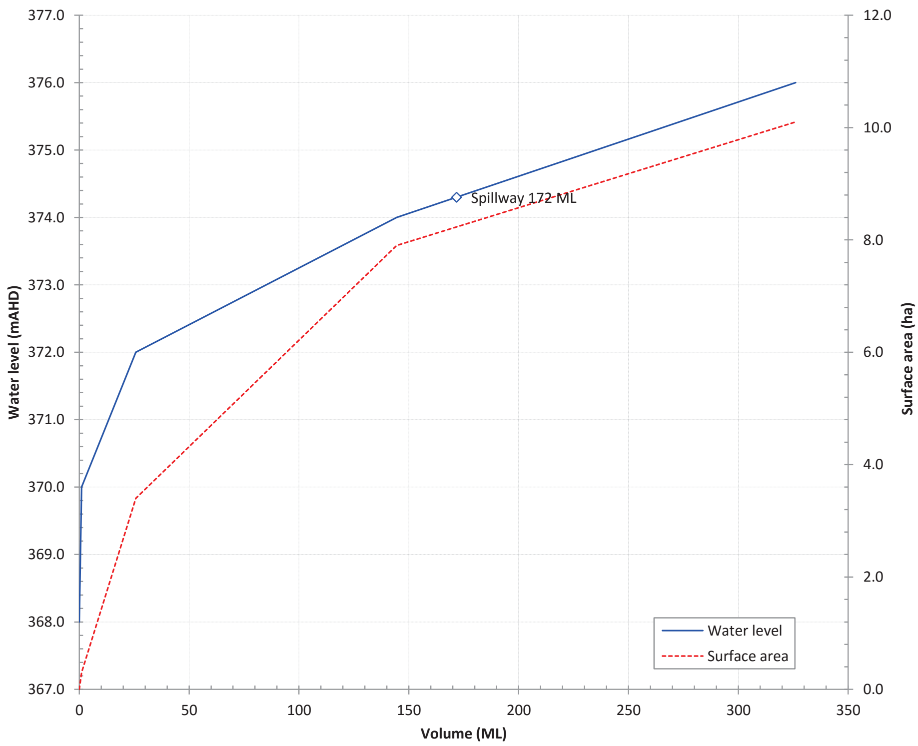
Wilpinjong Mine
TD4

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway	374.3	172
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
368.0	0.0	0.0
370.0	0.3	1.0
372.0	3.4	25.7
374.0	7.9	144.5
376.0	10.1	326.1



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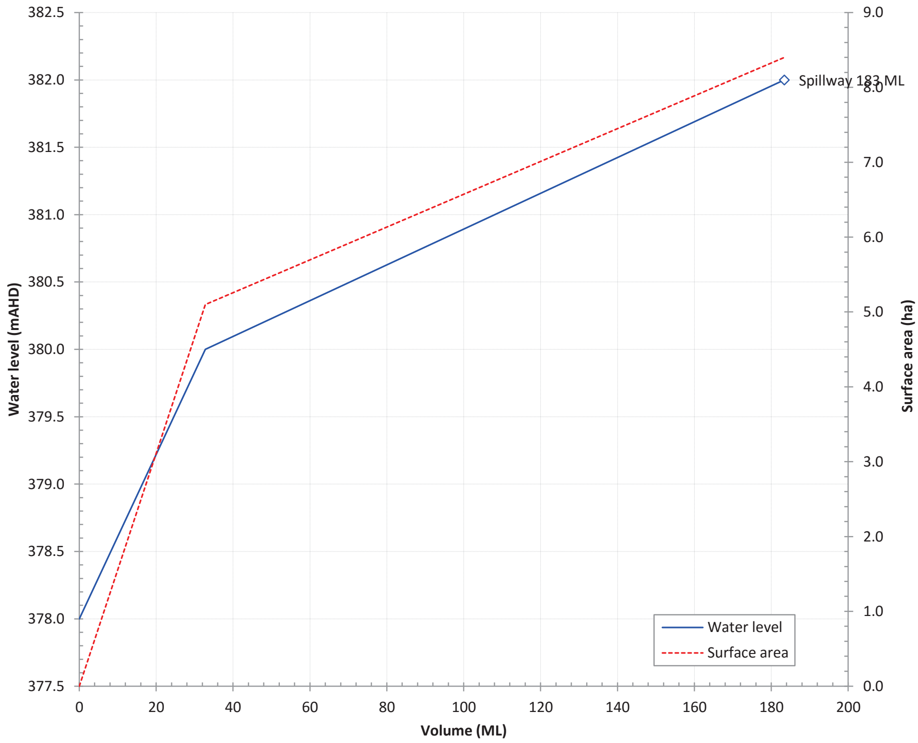
Wilpinjong Mine
TD4

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway Crest	382.0	183

Level (mAHD)	Area (ha)	Volume (ML)
378.0	0.0	0.0
380.0	5.1	32.8
382.0	8.4	183.4



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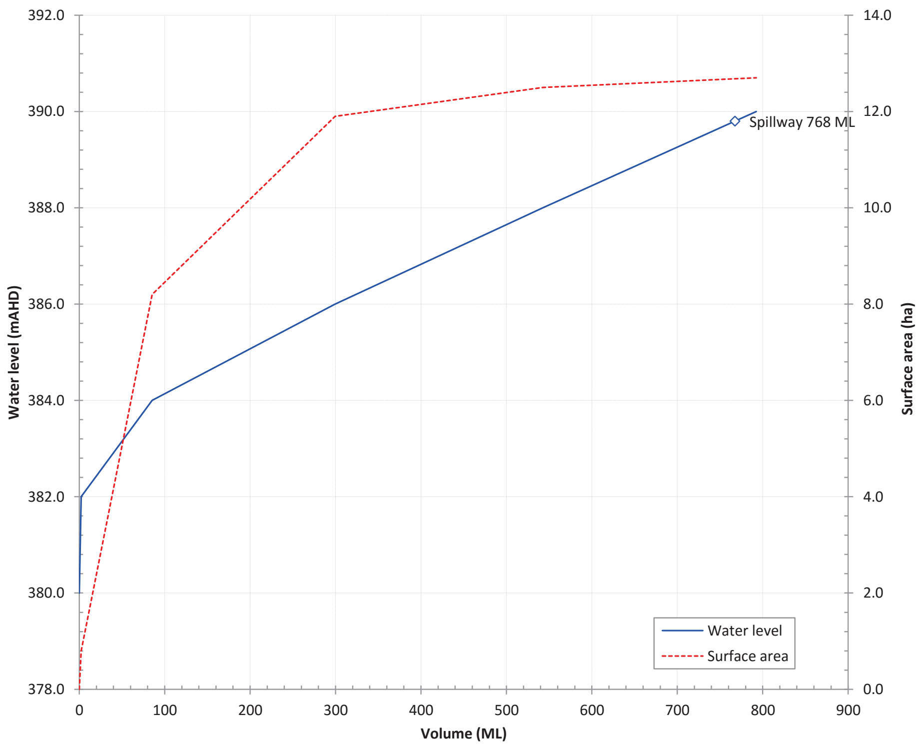
Wilpinjong Mine
TD6

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway Crest	389.8	768

Level (mAHD)	Area (ha)	Volume (ML)
380.0	0.0	0.0
382.0	0.8	2.2
384.0	8.2	85.2
386.0	11.9	299.5
388.0	12.5	542.6
390.0	12.7	792.5



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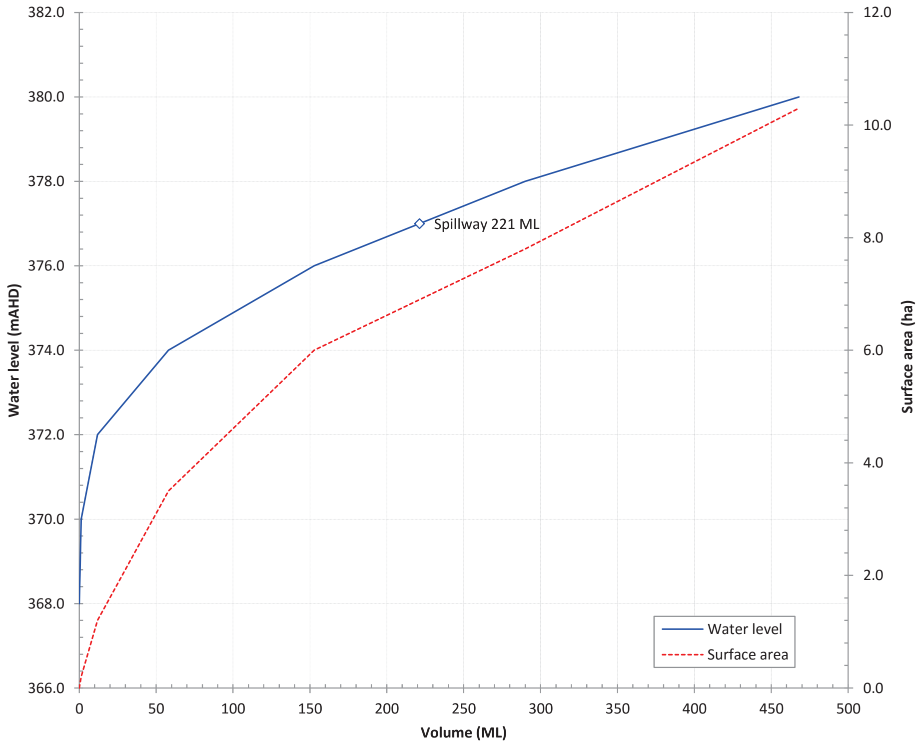
Wilpinjong Mine
TD7

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway	377.0	221
Crest		

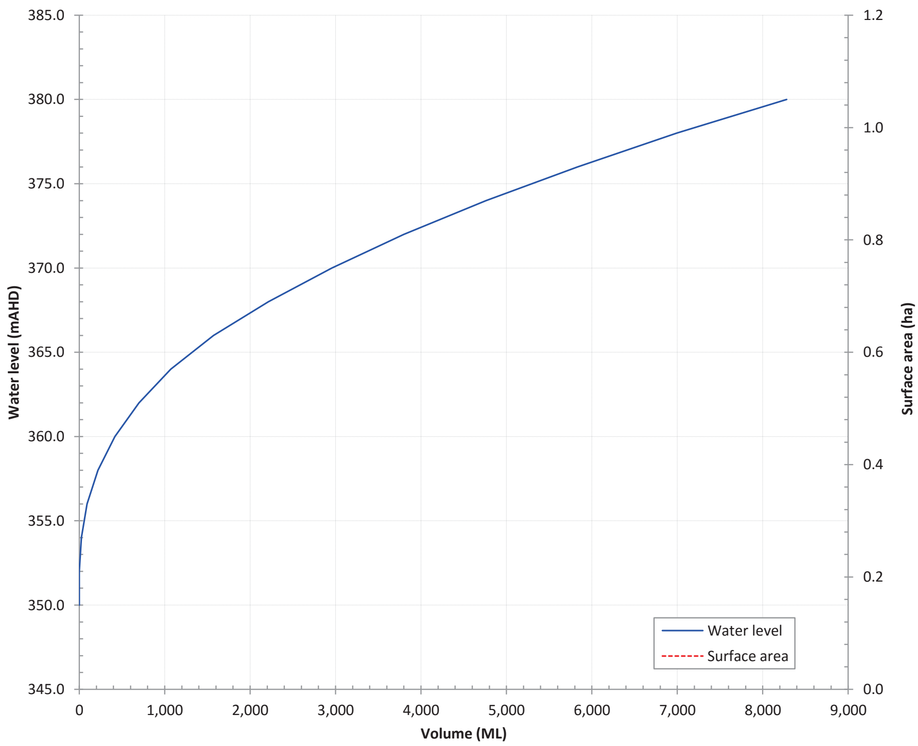
Level (mAHD)	Area (ha)	Volume (ML)
368.0	0.0	0.0
370.0	0.2	1.2
372.0	1.2	11.8
374.0	3.5	58.0
376.0	6.0	152.7
378.0	7.8	289.9
380.0	10.3	468.0



Wilpinjong Mine
Pit 5 Spoil Aquifer
30% Porosity

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

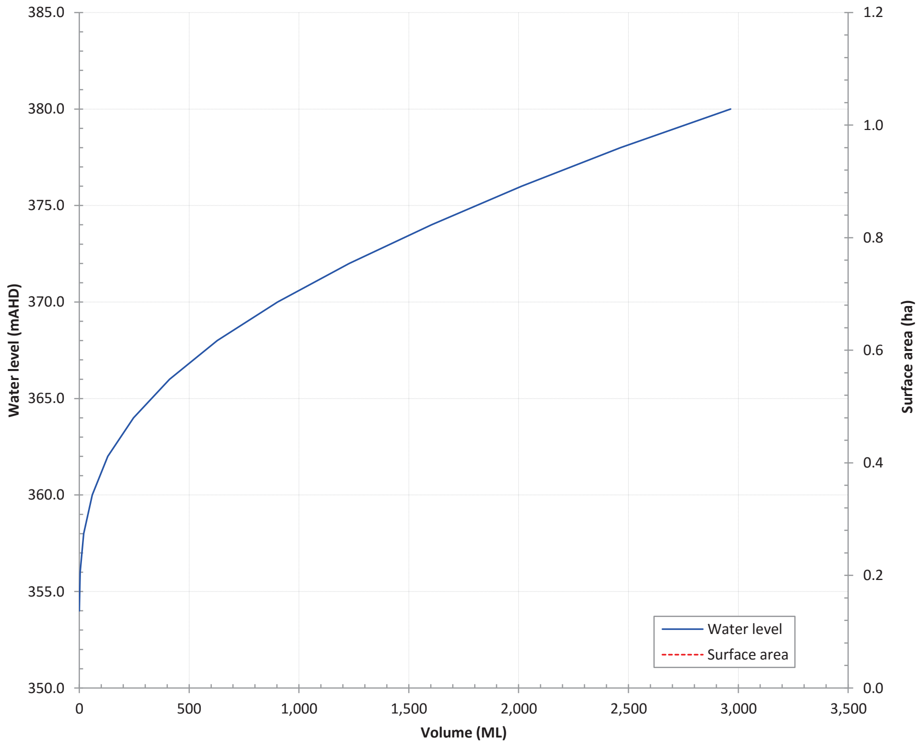
Level (mAHD)	Area (ha)	Volume (ML)
350.0		0.0
352.0		1.1
354.0		23.6
356.0		90.7
358.0		217.6
360.0		416.2
362.0		699.6
364.0		1,070.1
366.0		1,571.5
368.0		2,212.7
370.0		2,955.3
372.0		3,799.2
374.0		4,760.3
376.0		5,829.6
378.0		6,994.6
380.0		8,280.3



Wilpinjong Mine
Pit 1 Spoil Aquifer
30% Porosity

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
354.0		0.0
356.0		3.6
358.0		20.0
360.0		58.7
362.0		129.8
364.0		246.7
366.0		410.4
368.0		628.3
370.0		902.4
372.0		1,228.6
374.0		1,604.3
376.0		2,014.2
378.0		2,463.5
380.0		2,965.0



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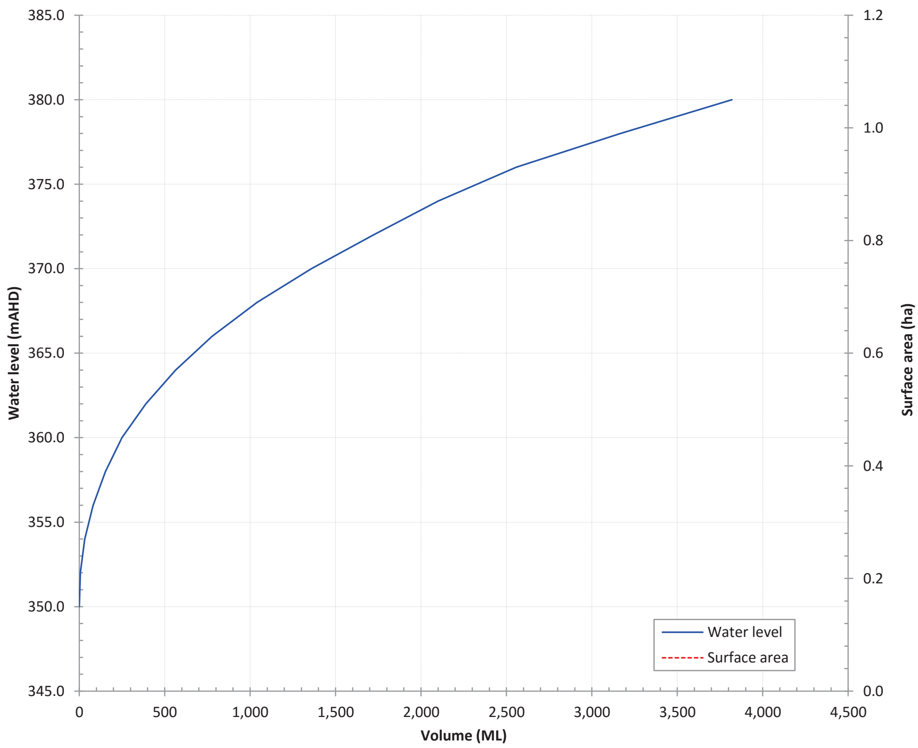
Wilpinjong Mine
Pit 2 Spoil Aquifer
30% Porosity

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
350.0		0.0
352.0		6.6
354.0		31.8
356.0		80.8
358.0		153.1
360.0		250.5
362.0		389.3
364.0		563.9
366.0		776.4
368.0		1,040.8
370.0		1,359.5
372.0		1,721.4
374.0		2,099.5
376.0		2,557.4
378.0		3,168.2
380.0		3,820.1



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Wilpinjong Mine

Pit 4 Spoil Aquifer

30% Porosity

Key levels	Level (mAHD)	Volume (ML)
Min operating		
Operating		
Spillway		
Crest		

Level (mAHD)	Area (ha)	Volume (ML)
330.0		0.0
332.0		0.0
334.0		0.4
336.0		11.9
338.0		47.3
340.0		113.5
342.0		215.7
344.0		384.5
346.0		638.2
348.0		1,002.3
350.0		1,487.9
352.0		2,105.0
354.0		2,840.1
356.0		3,695.6
358.0		4,687.9
360.0		5,845.1
362.0		7,137.9
364.0		8,549.1
366.0		10,086.4
368.0		11,727.9
370.0		13,447.5