Memorandum

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28 May 2018

To Aaron Clifton
From Gonzalo Jimenez

Subject Camden Gas Project- FY17/18 Six-monthly monitoring update – April 2018

Dear Aaron,

This memo presents the updated hydrographs for the Menangle Park and Glenlee groundwater monitoring bores to April 2018, and the water quality results for the April 2018 sampling event. Results are presented for samples from monitoring bores MPMB01 and MPMB02 taken on 12 April 2018. Monitoring bores GLMB03, MPMB03, and MPMB04 were re-sampled on 24 April 2018 to include dissolved methane analysis.

Key observations for this monitoring period (October 2017 to April 2018) are as follows:

- water levels at the Menangle Park monitoring bores were relatively stable with MPMB02, MPMB03, and MPMB04 showing a slight increase in response to the rainfall events in March 2018;
- water levels at the Glenlee monitoring bore GLMB03 remain stable; and
- the Vibrating Wire Piezometer (VWP) sensors at GLMB01 and GLMB02 have stabilised at low piezometric pressure head levels compared with pressures observed from the former standpipe monitoring bores prior to conversion to VWPs. This data is not considered representative of formation pressures. It is possible that during the conversion of the monitoring bores to VWP's the grout did not fully penetrate the gravel pack of the former standpipe monitoring bore creating an unnatural pressure gradient adjacent to the piezometer and bore wall. The gravel pack has a much higher hydraulic conductivity (K) (both horizontal and vertical K) than the grouted VWP sensor and the surrounding formation. In this case the higher vertical gradient in the gravel pack may be responsible for reducing horizontal pressure on the sensor hence the observed pressure difference. Although the absolute pressure values post-VWP installation are not representative of formation pressures, the trends in the data are and are therefore still useful.

The groundwater quality results will be analysed and discussed in the next annual monitoring report.

Figures A.1 – A.4: Individual hydrographs for the Menangle Park and Glenlee sites

Figures A.5: Nested hydrographs for the Menangle Park and Glenlee sites

Table A.1: Water quality results for April 2018

Yours sincerely

Gonzalo Jimenez
Hydrogeologist

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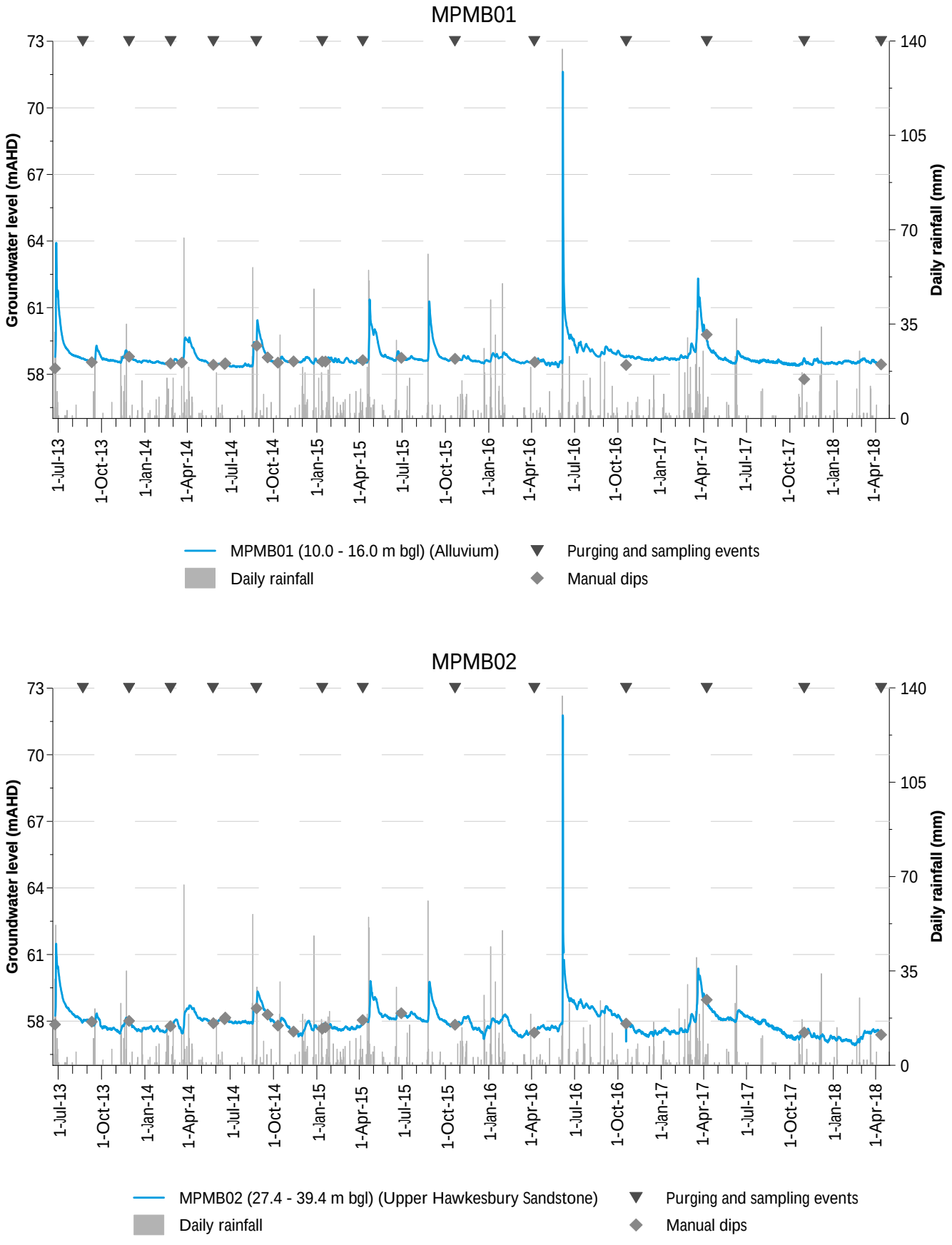
Reviewed: JD



MPMB01 and MPMB02 hydrographs

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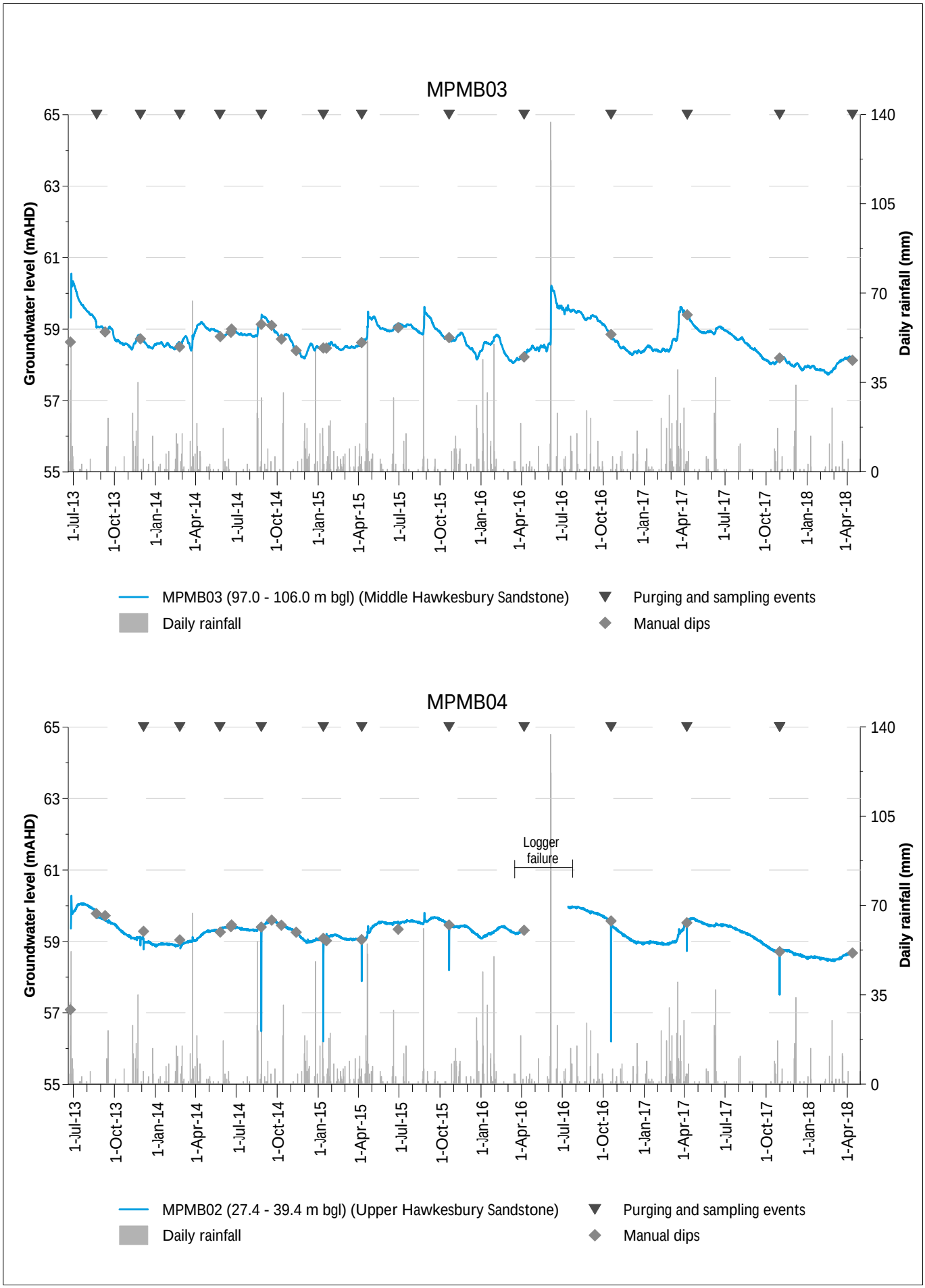
Figure A.1



MPMB03 and MPMB04 hydrographs

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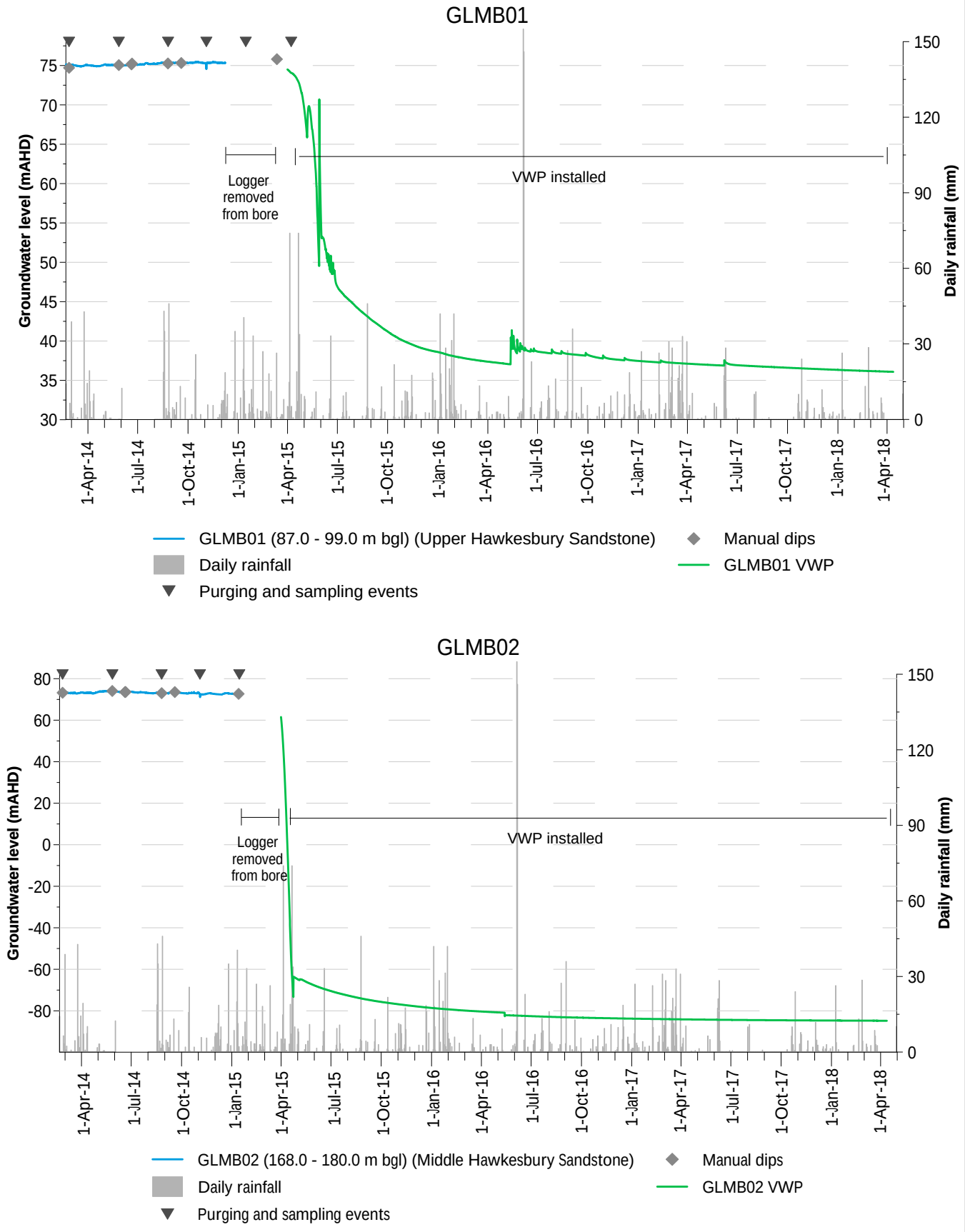
Figure A.2



Although the absolute piezometric pressure values at GLMB01 and GLMB02 post-VWP installation are not representative of formation pressures, the trends in the data are and are therefore still useful.

GLMB01 and GLMB02 hydrographs

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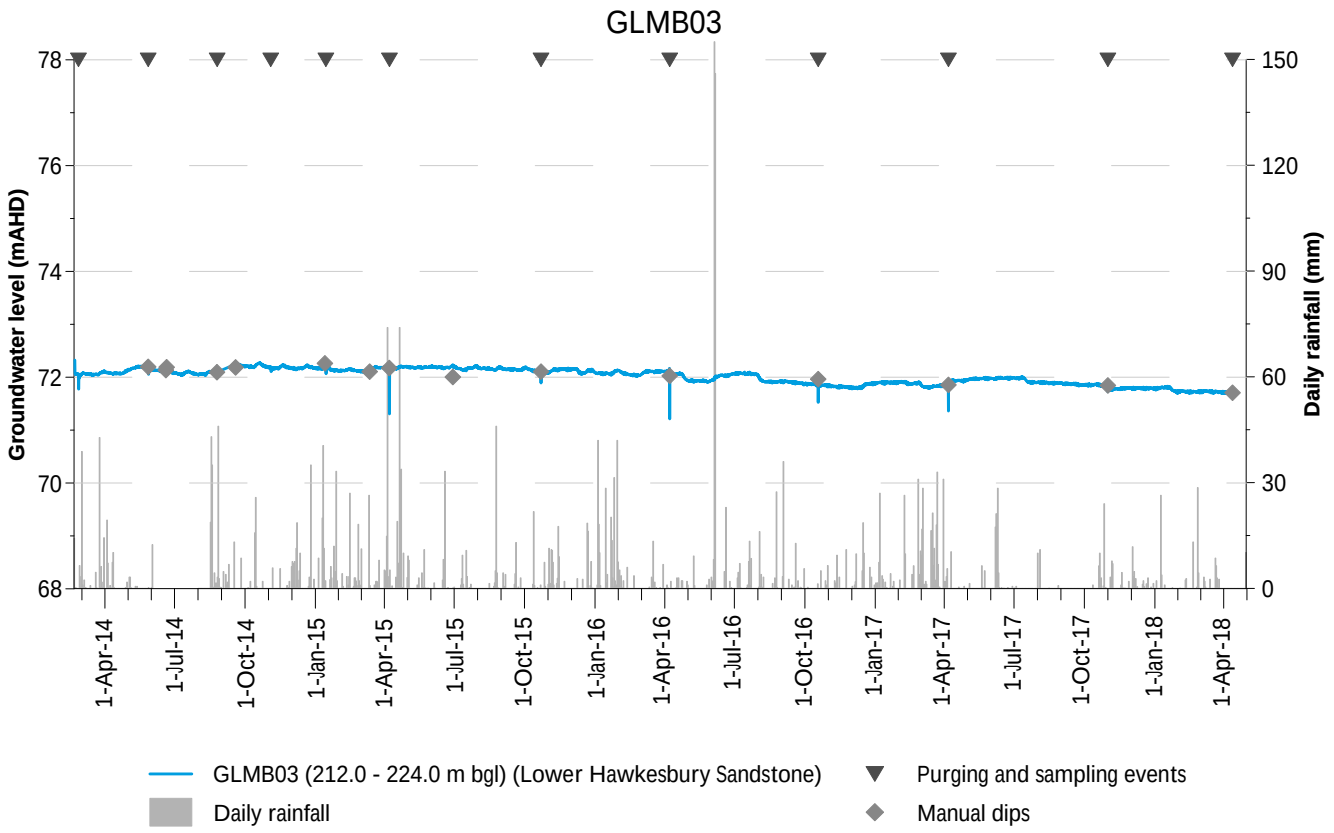
Figure A.3



GLMB03 hydrograph

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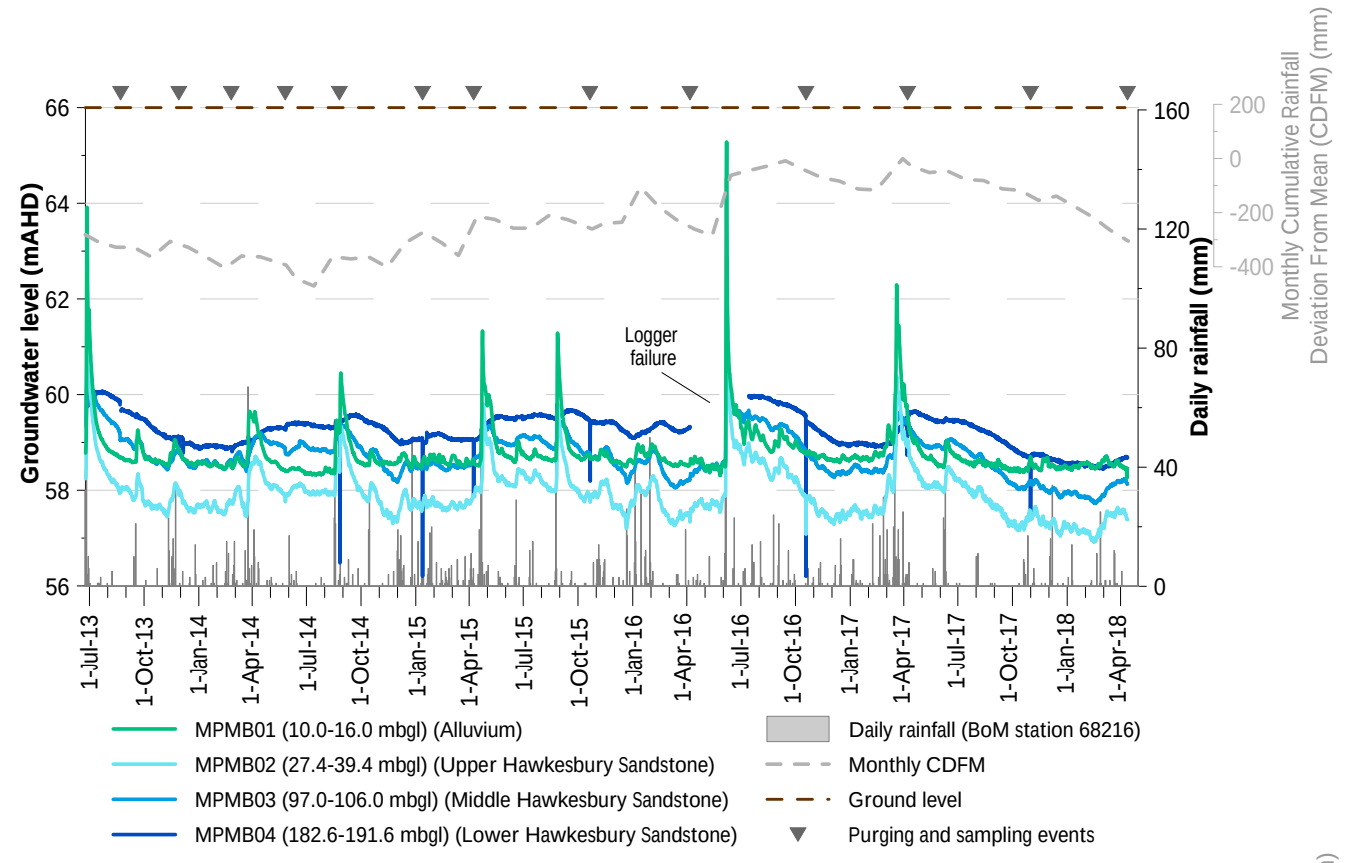
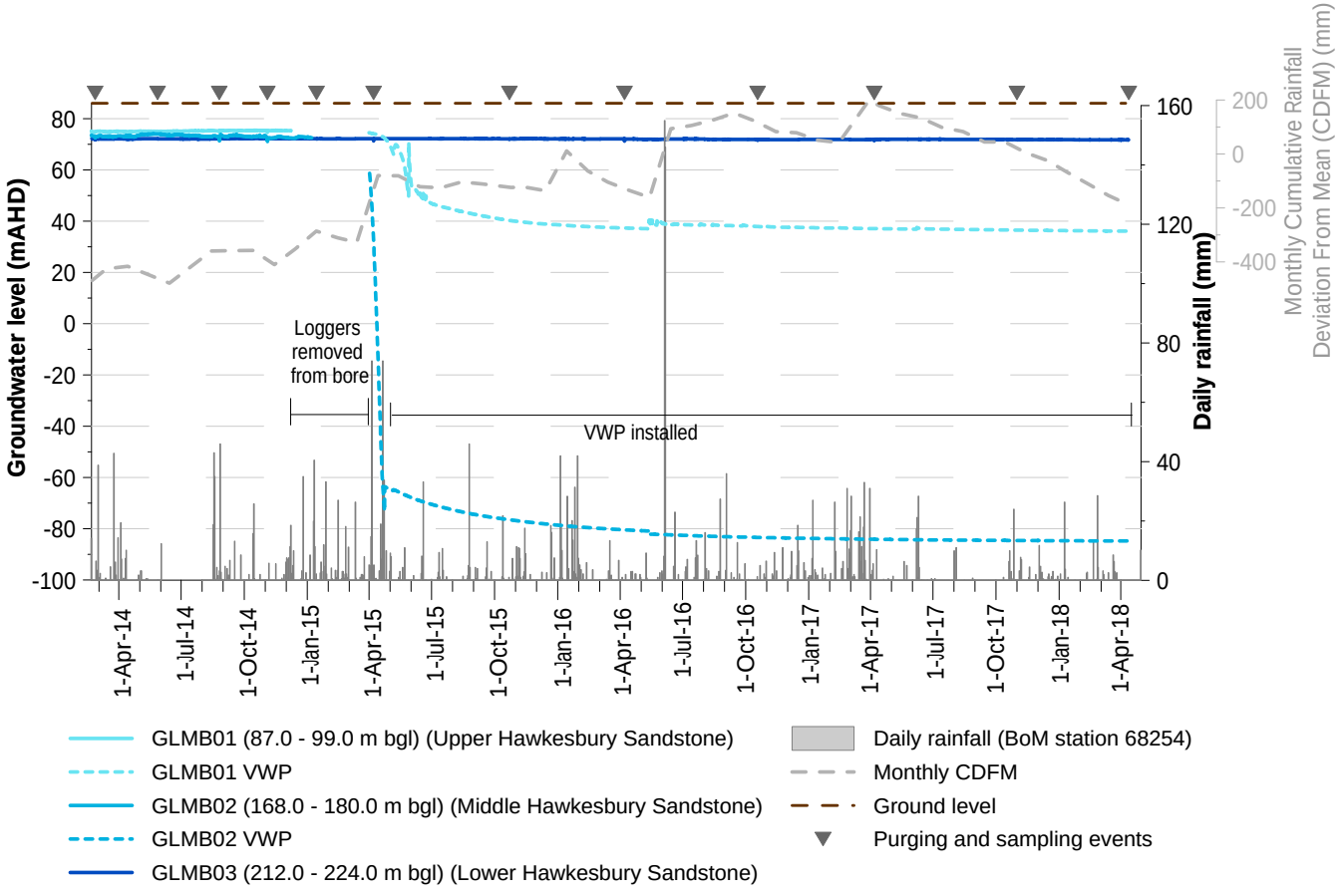
Figure A.4





Although the absolute piezometric pressure values at GLMB01 and GLMB02 post-VWP installation are not representative of formation pressures, the trends in the data are and are therefore still useful.

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MPMB and GLMB hydrographs

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Figure A.5

Table A.1 Water quality results May 2018

		Field ID	12/04/2018	12/04/2018	24/04/2018	24/04/2018	24/04/2018
		Date	MPMB01	MPMB02	MPMB03	MPMB04	GLMB03
		Water level (mbgl)	8.755	9.74	8.845	8.235	14.73
	Units	EQL					
Field parameters							
Dissolved Oxygen	mg/L		8.37	2.65	0.5	1.66	0.95
pH (field)	pH units		3.47	5.69	7.4	8.8	7.42
Electrical conductivity (field)	uS/cm		780	810	1080	612	4812
Electrical conductivity (lab)	µS/cm	1	803	824	1110	649	5140
Temp (Field)	°C		23.78	22.43	19.8	22.2	21.6
Dissolved oxygen (field)	%		101	30.8	5.5	19.2	10.9
Total dissolved solids (field)	mg/L		0.518	0.552	702	397	3127
Total dissolved solids (lab)	mg/L	10	528	470	560	290	3010
Suspended solids	mg/L	5	121	662	7	<5	8
Redox (field)	mV		131	-47.5	-97.4	-110.2	-89.8
Laboratory analytes							
Alkalinity (Hydroxide) as CaCO3	mg/L	1	<1	<1	<1	<1	<1
Carbonate Alkalinity-mg CaCO3/L	mg/L	1	<1	<1	<1	100	<1
Bicarbonate Alkalinity-mg CaCO3/L	mg/L	1	17	172	467	74	1,830
Alkalinity (total) as CaCO3	mg/L	1	17	172	467	173	1,830
Sulfate as SO4 - Turbidimetric	mg/L	1	3	5	<10	<1	<10
Chloride	mg/L	1	252	171	70	80	680
Calcium	mg/L	1	11	31	89	3	161
Magnesium	mg/L	1	19	29	23	<1	69
Sodium	mg/L	1	110	91	112	121	908
Potassium	mg/L	1	1	3	13	7	36
Reactive Silica	mg/L	0.05	15.9	10.4	8.79	6.42	13.6
Fluoride	mg/L	0.1	<0.1	0.1	0.1	0.7	0.1
Bromide	mg/L	0.01	0.535	0.32	0.134	0.176	0.079
Cyanide Total	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Dissolved metals							
Aluminium	mg/L	0.01	0.02	<0.01	<0.01	<0.01	<0.01
Antimony	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	<0.001	0.006	0.004	0.003	0.01
Barium	mg/L	0.001	0.55	0.464	3.04	0.464	19.7
Beryllium	mg/L	0.001	0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Bromine	mg/L	0.1	0.5	0.3	0.1	0.1	1.5
Cadmium	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	0.041	0.004	0.001	<0.001	<0.001
Copper	mg/L	0.001	0.006	0.002	<0.001	<0.001	<0.001
Iron	mg/L	0.05	0.18	4.02	2.11	<0.05	1.61
Lead	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.001	0.47	0.192	0.045	0.001	0.036
Mercury	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	0.007	<0.001
Nickel	mg/L	0.001	0.016	0.002	0.001	<0.001	0.001
Selenium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	0.112	0.39	0.86	0.106	4.83
Uranium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.046	0.011	<0.005	0.011	1.18
Nutrients							
Ammonia (as N)	mg/L	0.01	<0.01	0.11	1	0.81	3.1
Nitrite (as N)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate (as N)	mg/L	0.01	0.35	0.01	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.01	0.35	0.01	<0.01	<0.01	<0.01
Total phosphorus	mg/L	0.01	0.03	0.22	0.02	0.01	<0.01
Reactive phosphorus (as P)	mg/L	0.01	<0.01	<0.01	<0.01	0.01	0.01
Total organic carbon	mg/L	1	<1	2	<1	4	4
Dissolved gases							
Methane	mg/L	0.01	0.013	1.03	37.8	29.5	27.4
Ethane	mg/L	0.01	<0.01	<0.01	0.01	<0.01	0.128
Ethene	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propane	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Propene	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Butene	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Butane	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenolic compounds							
Phenol	µg/L	1	<1	<1	<1	<1	<1
2-chlorophenol	µg/L	1	<1	<1	<1	<1	<1
2-methylphenol	µg/L	1	<1	<1	<1	<1	<1
3-&4-methylphenol	µg/L	2	<2	<2	<2	<2	<2
2-nitrophenol	µg/L	1	<1	<1	<1	<1	<1
2,4-dimethylphenol	µg/L	1	<1	<1	<1	<1	<1
2,4-dichlorophenol	µg/L	1	<1	<1	<1	<1	<1
2,6-dichlorophenol	µg/L	1	<1	<1	<1	<1	<1
4-chloro-3-methylphenol	µg/L	1	<1	<1	<1	<1	<1
2,4,6-trichlorophenol	µg/L	1	<1	<1	<1	<1	<1
2,4,5-trichlorophenol	µg/L	1	<1	<1	<1	<1	<1
Pentachlorophenol	µg/L	2	<2	<2	<2	<2	<2
Polycyclic aromatic hydrocarb							
Acenaphthene	µg/L	1	<1	<1	<1	<1	<1
Acenaphthylene	µg/L	1	<1	<1	<1	<1	<1
Fluorene	µg/L	1	<1	<1	<1	<1	<1
Phenanthrene	µg/L	1	<1	<1	<1	<1	<1
Anthracene	µg/L	1	<1	<1	<1	<1	<1
Fluoranthene	µg/L	1	<1	<1	<1	<1	<1
Pyrene	µg/L	1	<1	<1	<1	<1	<1
Benz(a)anthracene	µg/L	1	<1	<1	<1	<1	<1
Chrysene	µg/L	1	<1	<1	<1	<1	<1
Benzo(k)fluoranthene	µg/L	1	<1	<1	<1	<1	<1
Benzo(b&j)fluoranthene	µg/L	1	<1	<1	<1	<1	<1
Benzo(a) pyrene	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc (Zero)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1,2,3-c,d)pyrene	µg/L	1	<1	<1	<1	<1	<1
Dibenz(a,h)anthracene	µg/L	1	<1	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	1	<1	<1	<1	<1	<1
PAHs (Sum of total)	µg/L	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total petroleum hydrocarbons							
C 6 - C 9 Fraction	µg/L	20	<20	<20	<20	40	160
C10 - C14 Fraction	µg/L	50	<50	<50	<50	<50	<50
C15 - C28 Fraction	µg/L	100	<100	<100	<100	<100	<100
C29 - C36 Fraction	µg/L	50	<50	<50	<50	<50	<50
TPH+C10 - C36 (Sum of total)	µg/L	50	<50	<50	<50	<50	<50
Total recoverable hydrocarbons							
C6-C10 fraction	µg/L	20	<20	<20	<20	40	150
C6 - C10 fraction minus BTEX	µg/L	20	<20	<20	<20	<20	40
C10 - C16 fraction	µg/L	100	<100	<100	<100	<100	<100
TRH >C10-C16 less Naphthalene (F2)	µg/L	100	<100	<100	<100	<100	<100
C16 - C34 fraction	µg/L	100	<100	<100	<100	<100	<100
C34 - C40 fraction	µg/L	100	<100	<100	<100	<100	<100
C10 - C40 fraction (Sum)	µg/L	100	<100	<100	<100	<100	<100
Aromatic hydrocarbons							
Benzene	µg/L	1	<1	<1	<1	<1	<1
Toluene	µg/L	2	<2	<2	<2	31	115
Ethylbenzene	µg/L	2	<2	<2	<2	<2	<2
Xylene (m & p)	µg/L	2	<2	<2	<2	<2	<2
Xylene (o)	µg/L	2	<2	<2	<2	<2	<2
Xylene Total	µg/L	2	<2	<2	<2	<2	<2
Total BTEX	µg/L	1	<1	<1	<1	31	115
Naphthalene	µg/L	1	<1	<1	<1	<1	<1
Additional analytes							
Ionic Balance	%	0.01	4.07	2.42	1.02	1.07	1.47
Cations Total	meq/L	0.01	6.92	7.97	11.5	5.59	54.1
pH (Lab)	pH_Units	0.01	5.81	6.83	7.5	9.56	7.65
Anions Total	meq/L	0.01	7.51	8.36	11.3	5.71	55.7

Note: mbgl - metres below ground level; EQL - laboratory estimated quantitation limit