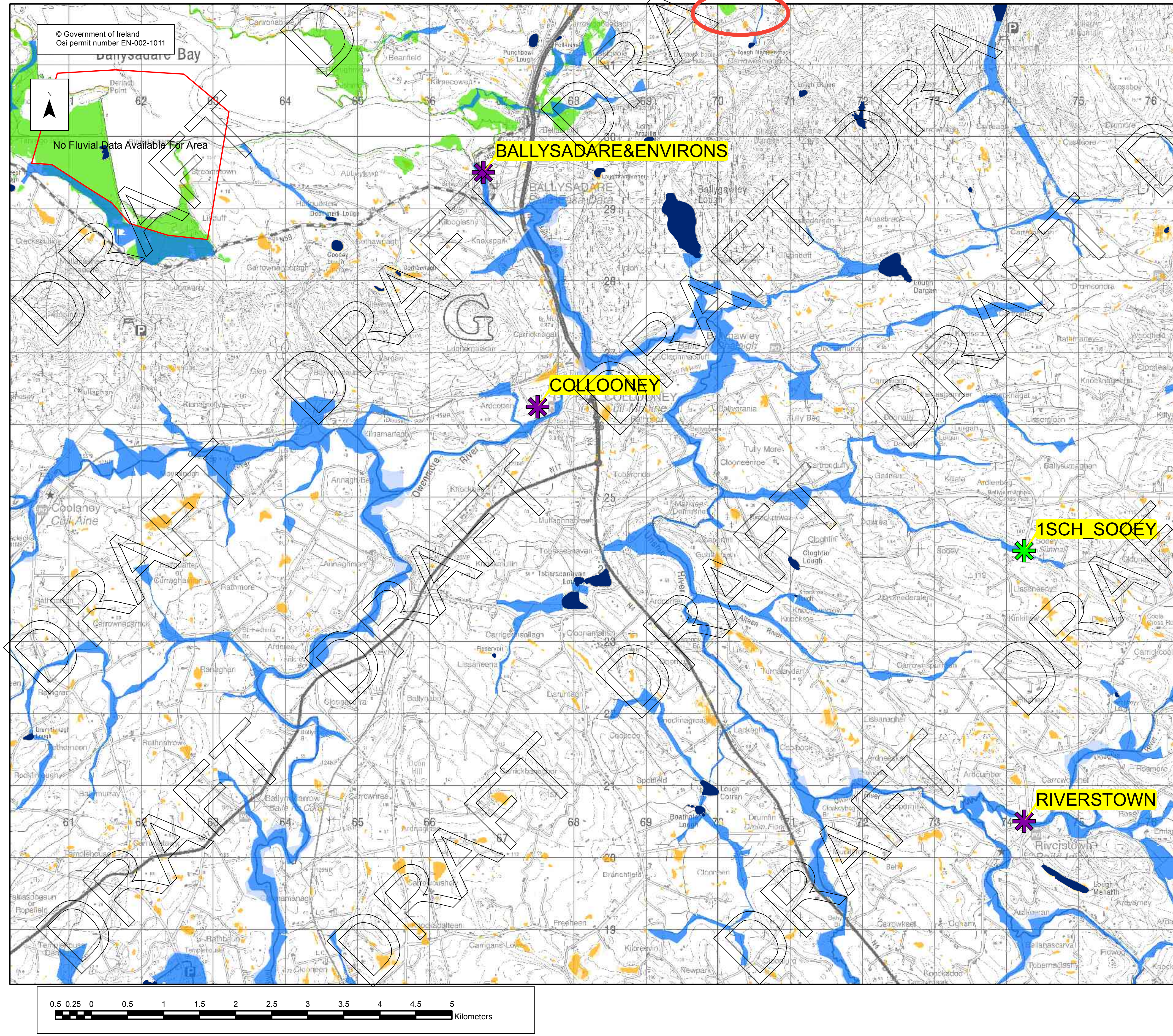
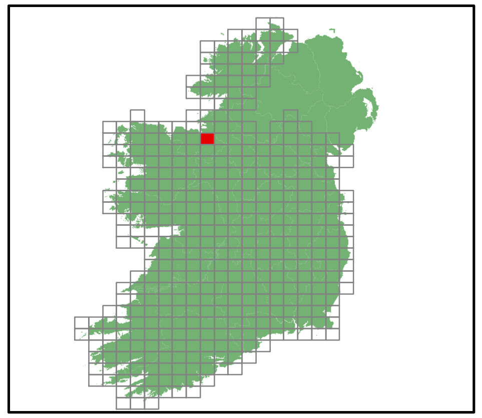
APPENDIX 7-7 PRELIMINARY FLOOD RISK ASSESSMENT MAPS



Location Plan :



Legend:

Flood Extents

- Fluvial - Indicative 1% AEP (100-yr) Event
- Fluvial - Extreme Event
- Coastal - Indicative 0.5% AEP (200-yr) Event
- Coastal - Extreme Event
- Pluvial - Indicative 1% AEP (100-yr) Event
- Pluvial - Extreme Event
- Groundwater Flood Extents
- Lakes / Turloughs

PFRA Outcomes

- Probable Area for Further Assesment
- Possible Area for Further Assesment

Important User Note:

The flood extents shown on these maps are based on broad-scale simple analysis and may not be accurate for a specific location. Information on the purpose, development and limitations of these maps is available in the relevant reports (see www.cfram.ie). Users should seek professional advice if they intend to rely on the maps in any way.

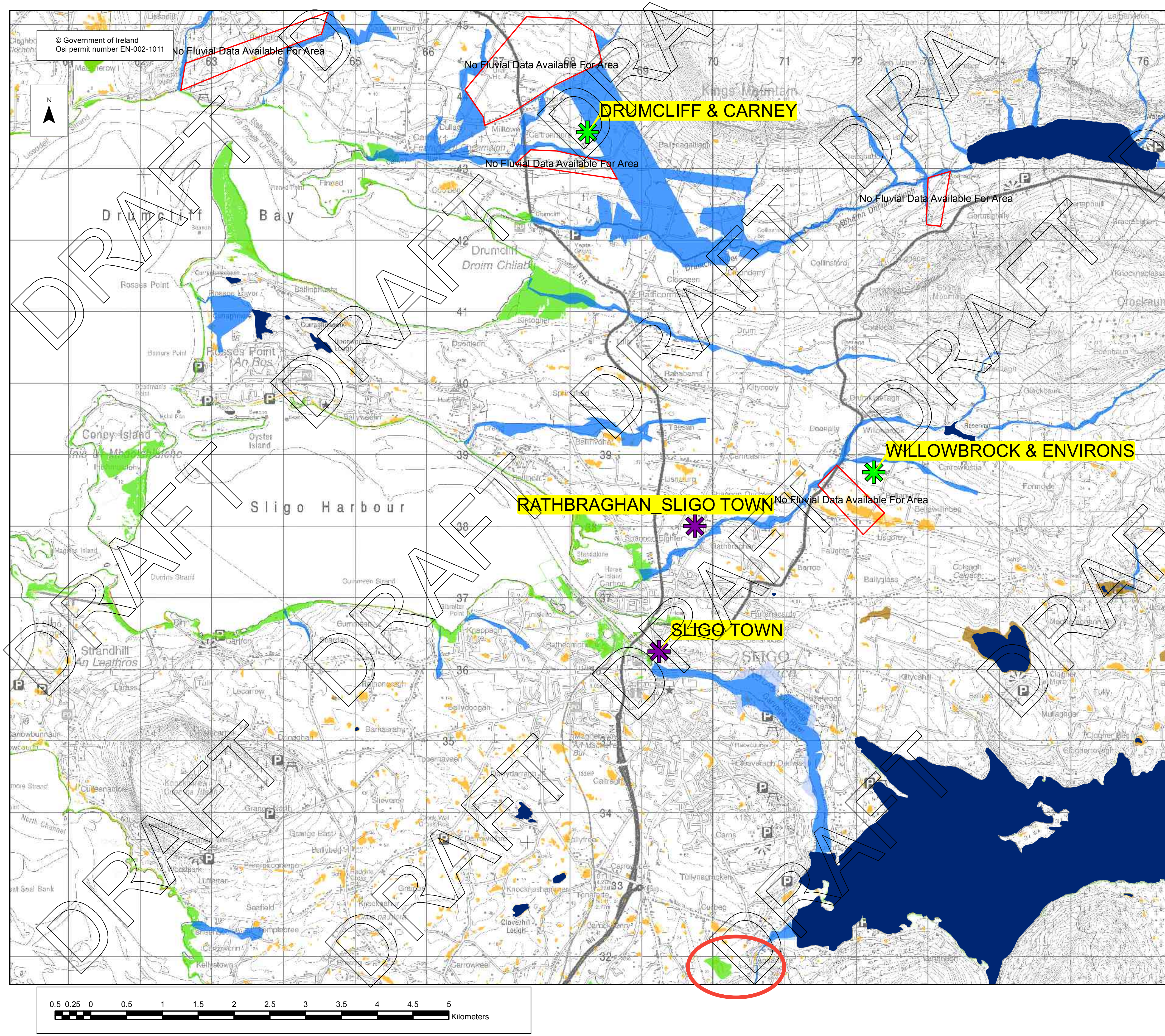
If you believe that the maps are inaccurate in some way please forward full details by contacting the OPW (refer to PFRA Information leaflets or 'Have Your Say' on www.cfram.ie).

Office of Public Works
Jonathon Swift Street
Trim
Co Meath
Ireland

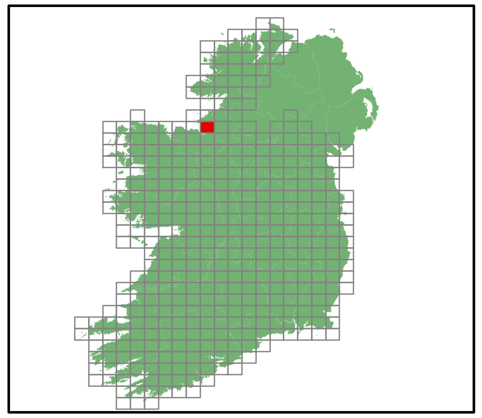
Project :
PRELIMINARY FLOOD RISK ASSESMENT (PFRA)

Map :
PFRA Indicative extents and outcomes
- Draft for Consultation

Figure By :	PJW	Date :	July2011
Checked By :	MA	Date :	July 2011
Figure No. :	2019 / MAP / 351 / A	Revision	0
Drawing Scale :	1:50,000	Plot Scale :	1:1 @ A3



Location Plan :



Legend:

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- Fluvial - Extreme Event
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- Coastal - Extreme Event
- Pluvial - Indicative 1% AEP (100-yr) Event
- Pluvial - Extreme Event
- Groundwater Flood Extents
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Office of Public Works
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Figure No. : 2019 / MAP / 368 / A	Revision 0
Drawing Scale : 1:50,000	Plot Scale : 1:1 @ A3

APPENDIX 7-8 SITE PHOTOGRAPHS

Plate 7-1: Quarry floor dry, pumping ongoing (12/7/2017)

Plate 7-2: Quarry floor flooded, no pumping (24/5/2018)

Plate 7-3: Eastern part of application site (note ponding due to heavy rainfall)

Plate 7-4: Eastern part of application site (note ponding due to heavy rainfall)

Plate 7-5: Typical profile of shallow depth to bedrock, with thin weathered zone at the top of rock (access road into quarry)

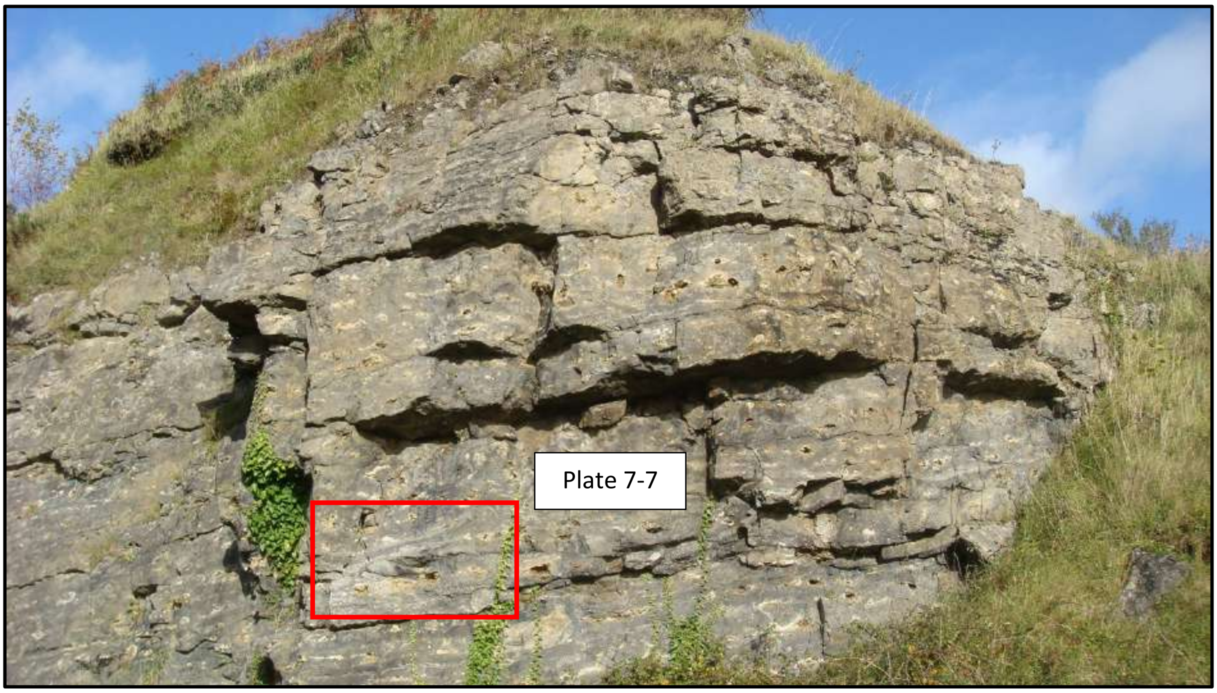


Plate 7-6: Weathered section of massive limestone beds showing infilled cavities (replaced colonial coral fossils) delineating bedding

Plate 7-7: Close-up of Plate 7-6 showing colonial corals (weathered and unweathered)

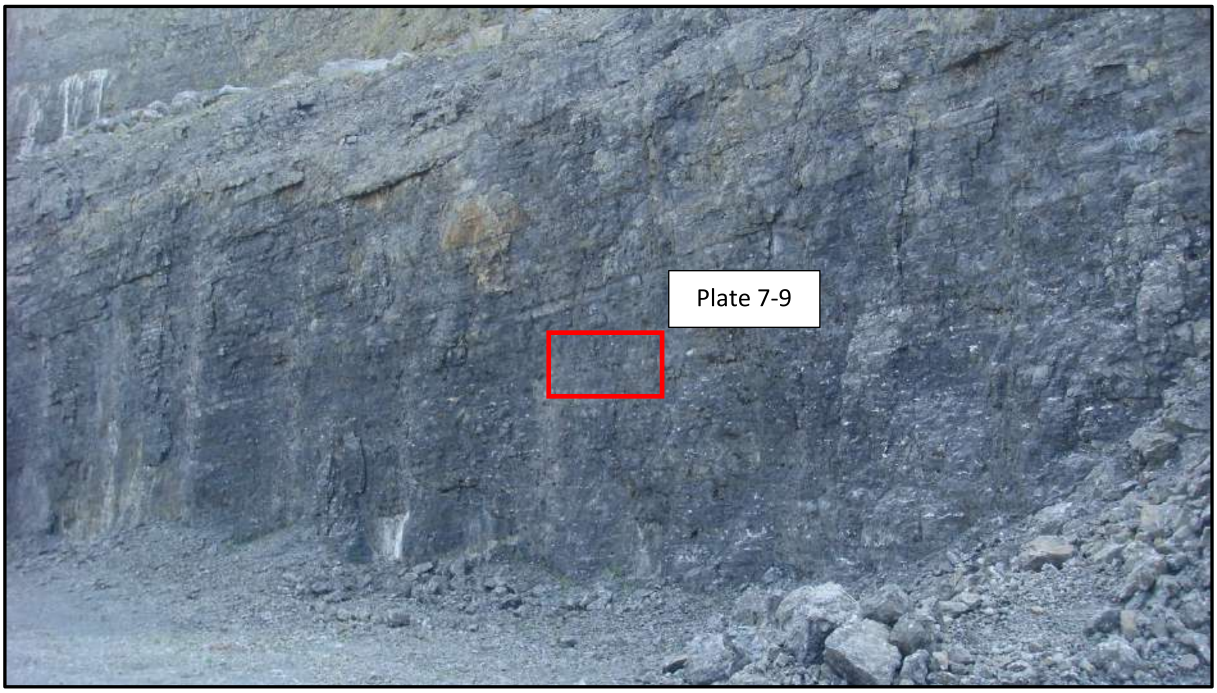


Plate 7-8: Massive limestone beds with weathered 'vuggy' cavities delineating bedding

Plate 7-9: Close-up of Plate 7-12 showing weathered 'vuggy' cavities, unconnected

Plate 7-10: Location of only deep weathered zone noted in quarry

Plate 7-11: Localised weathered zone at base of quarry, the only deep weathered zone noted, preferential weathering of particularly fossiliferous area in limestone (no conduits)

Plate 7-12: Close-up of Plate 7-11

Plate 7-13: Close-up of Plate 7-12 (note weathering of pockets of colonial coral fossils)

Plate 7-14: Large sub-vertical fault in east of quarry

Plate 7-15: Groundwater inflows at northwest corner of quarry (shallow entry but cascading down face, leaving staining/calcium-carbonate deposits)

Plate 7-16: Groundwater inflows from epikarst at northwest corner of quarry (photographed from above Plate 7-15 location)

Plate 7-17: Same location as Plate 7-16 in dry spell, inflow zones denoted by calcium-carbonate deposits

Plate 7-18: Groundwater inflows from epikarst at northeast corner of quarry

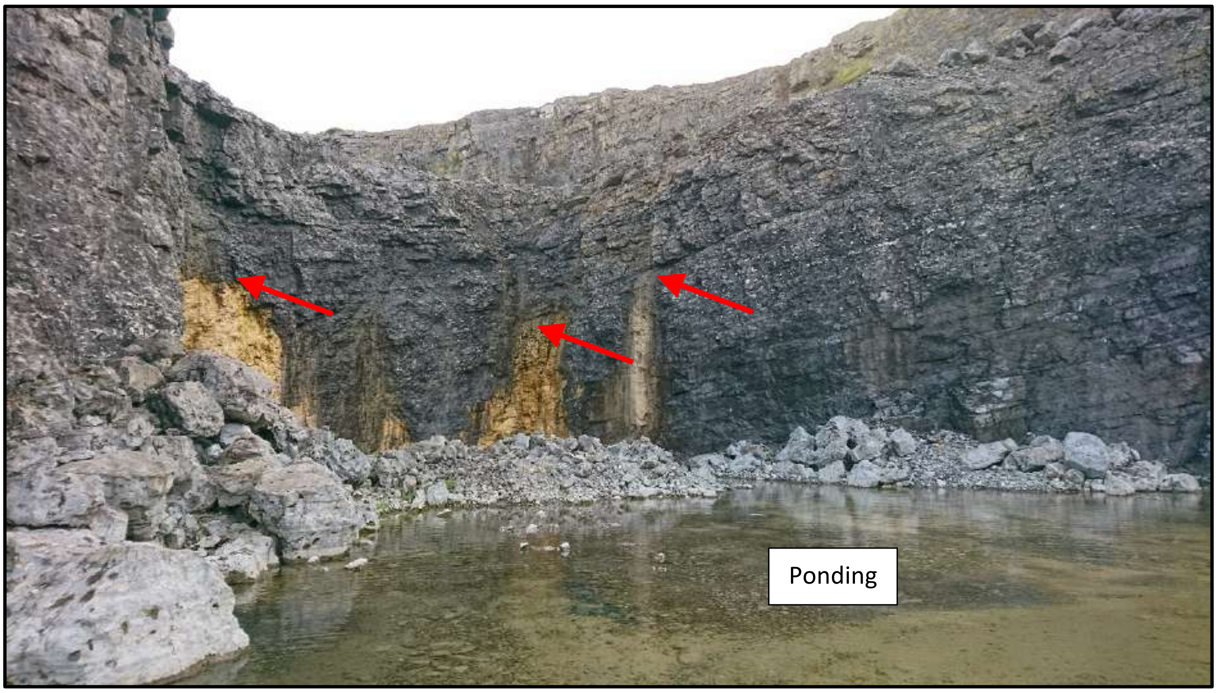


Plate 7-19: Same location as Plate 7-18 from different angle

Plate 7-20: Groundwater inflows at southwest corner of quarry (epikarst higher up face)

Plate 7-21: Groundwater inflow on quarry floor, elongate along quarry wall (rising of groundwater flow along bedding planes)

APPENDIX 7-9 DISCHARGED WATER SAMPLES

Discharged Water Samples (all available)

Cemex/Golders Samples:

	Units	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge	Discharge			Emission Limit Value
		02/07/2007	26/08/2008	30/07/2009	31/08/2009	30/10/2009	26/02/2010	30/04/2010	31/05/2010	30/06/2010	30/07/2010	27/08/2010	02/09/2010	19/04/2011			
Temperature	°C	10.9	9.9	-	-	-	-	-	-	-	-	-	-	11.1			20
pH	-	7.2	7.7	-	-	-	-	-	-	-	-	-	8.08	8.24			6 - 9
Biological Oxygen Demand	mg/l O_2	< 2	2	4	8	1	< 1	4	4	4	2	4	2	< 1			2
Total Ammonia	mg/l N	0.049	0.008	0.008	0.008	< 0.008	< 0.008	< 0.008	0.09	0.025	0.008	< 0.008	0.33	0.02			0.1
Total Suspended Solids	mg/l	< 2	5	60	1	1.5	1.3	< 1	2.8	2	5	< 1	15	< 10			25
Molybdate Reactive Phosphorus (MRP)	mg/l P	< 0.002	0.02	< 0.01	0.07	0.1	0.03	0.12	0.08	0.07	< 0.01	0.14	< 0.019	< 0.005			0.05
Total Phosphorus	mg/l P	0.05	0.05	-	-	-	-	-	-	-	-	-	-	-			2
Sulphates	mg/l	37	24	-	-	-	-	-	-	-	-	-	51.3	47.6			200
Hydrocarbons (EPH)	mg/l	< 0.02	< 0.001	-	-	-	-	-	-	-	-	-	< 0.01	< 10			1

TMS Samples:

	Units	Discharge (W)	Discharge (E)	Discharge (W)	Discharge (E)	Discharge (W)	Discharge (E)	Discharge (W)	Discharge (E)	Discharge (W)	Discharge (E)	Discharge (W)	Discharge (E)	Discharge (W)	Discharge (W)	Discharge (W)	Emission Limit Value
		22/02/2016	22/02/2016	31/03/2016	31/03/2016	19/04/2016	19/04/2016	06/05/2016	06/05/2016	15/06/2016	15/06/2016	30/01/2018	30/01/2018	27/02/2018	27/03/2018	23/04/2018	
Temperature	°C	-	-	-	-	-	-	-	-	-	-	7.1	7.3	3.3	8.4	11.9	20
pH	-	8	8	8.1	8.1	8.14	8.18	8.12	8.19	8.23	8.24	7.96	7.9	8.39	8.18	8.03	6 - 9
Biological Oxygen Demand	mg/l O_2	< 2	< 2	< 2	< 2	2.24	< 2	3.55	3.43	21.9	11.9	< 1	< 1	< 2	< 1	< 1	2
Total Ammonia	mg/l N	0.04	0.04	0.03	0.03	0.02	0.02	< 0.41	< 0.41	< 0.41	< 0.41	< 0.02	< 0.02	< 0.02	< 0.02	0.02	0.1
Total Suspended Solids	mg/l	< 3	< 3	10.3	< 3	< 3	< 3	3.1	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	25
Orthophosphate	mg/l P	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.02	< 0.02	< 0.02	< 0.02	0.02	0.05
Total Phosphorus	mg/l P	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	2
Sulphates	mg/l	23.5	25.6	25.6	25.1	29	28	29.5	28.7	31.6	29.9	24	24.6	3	3.8	2.5	200
Hydrocarbons (TPH)	mg/l	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.5	< 0.5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	1

TMS Samples (cont.):

	Units	Discharge (W)	Discharge (W)	Discharge (W)	Discharge (W)	Discharge (W)	Discharge (W)	Discharge (W)	Discharge (W)	Discharge (W)	Discharge (W)	Discharge (W)	Discharge (W)				Emission Limit Value
		27/08/2018	06/11/2018	07/01/2019	28/03/2019	26/08/2020	16/09/2020	13/10/2020	03/11/2020	14/12/2020	06/01/2021	02/02/2021	10/03/2021				
Temperature	°C	14.8	8.9	8.8	9.8	13.9	13.7	13.7	12.1	6.1	4.5	4.1	9.2				20
pH	-	8.65	7.38	8.51	7.89	8.41	8.55	8.33	8.51	7.95	8.49	8.19	7.93				6 - 9
Biological Oxygen Demand	mg/l O_2	< 1	< 1	< 1	< 1	2	2	6	< 1	< 1	< 2	2.4	< 2				2
Total Ammonia	mg/l N	0.03	< 0.02	< 0.02	0.31	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02				0.1
Total Suspended Solids	mg/l	< 3	< 3	< 3	14.6	< 3	7.2	< 3	< 3	4	< 3	4.8	3.5				25
Orthophosphate	mg/l P	< 0.02	0.2	< 0.02	< 0.02	< 0.02	0.06	0.03	< 0.02	< 0.02	< 0.02	<0.02	<0.02				0.05
Total Phosphorus	mg/l P	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.02	< 0.02	< 0.05	< 0.05				2
Sulphates	mg/l	< 2	35.7	25.8	15.3	20.3	24.8	31.4	25.9	-	-	-	-				200
Hydrocarbons (TPH)	mg/l	< 0.01	< 0.01	< 0.01	-	< 0.01	0.013	< 0.01	< 0.01	-	-	-	-				1

Notes:

1. Trade Effluent Discharge Licence DL(W)139 (issued 9/12/2011)
2. All TMS Environment samples are grab samples/all previous samples assumed to be grab samples
3. Two discharge pipes at discharge point: W - West bank, E - East bank
4. Condition 2.1.3 of the licence: for discrete sampling, no grab sample shall exceed 1.2 times the Emission Limit Value (other than pH and temperature)
5. Condition 3.4 of licence: discharge will not cause receiving water to exceed limits in the Surface Water Regulations

Concentration shaded where ELV exceeded

tms environment ltd

APPENDIX 7-10 GROUNDWATER SAMPLES

Groundwater Samples

	Parameter	Units	MW1					MW2					MW3					MW4					MW5		
			08/02/2018	19/04/2018	28/08/2018	05/02/2019	06/10/2020	08/02/2018	19/04/2018	28/08/2018	05/02/2019	06/10/2020	08/02/2018	19/04/2018	28/08/2018	05/02/2019	06/10/2020	08/02/2018	19/04/2018	28/08/2018	05/02/2019	06/10/2020	08/02/2018	19/04/2018	28/08/2018
Field	Temperature	°C	9.1	9.9	11.3	9.7	11.0	9.5	10.8	-	10.1	11.3	9.0	10.8	11.8	9.9	11.5	8.6	10.3	11.6	10.2	11.2	9.7	10.4	11.7
Field	Conductivity (field)	µS/cm @ 25°C	379	-	360	398	620	896	815	-	420	645	887	760	844	399	637	830	460	656	440	642	645	669	676
Field	pH	-	8.01	8.11	7.74	7.31	7.43	7.18	7.17	-	7.45	7.38	7.13	7.09	7.05	7.38	7.28	7.22	7.35	7.13	7.07	7.80	7.33	7.40	7.44
Field	Dissolved Oxygen [1]	% sat	88.7	90.1	86.5	98.4	89.6	66.2	70.5	-	96.3	87.2	41.0	53.6	76.5	97.2	83.9	76.8	79.7	62.5	96.7	82.9	71.4	69.7	72.1
Field	Dissolved Oxygen [1]	mg/l O_2	8.79	9.07	8.59	10.88	8.87	6.51	7.41	-	10.72	8.55	4.06	5.45	7.42	10.77	8.42	7.67	7.86	6.07	10.76	8.16	7.07	6.84	7.35
Whole Sample	Conductivity (lab) [2]	µS/cm @ 25°C	373	348	366	383	616	888	914	-	427	639	883	-	836	383	638	820	479	655	443	638	633	703	679
Whole Sample	Total Suspended Solids [3]	mg/l	50.3	114	39.9	4.9	8.4	278	78.6	-	12	< 3	149	> 200	27	23.2	7	84.8	186	43	7.6	< 3	180	70.1	93.6
Whole Sample	Turbidity [3]	NTU	65.3	76.8	0.4	7.1	0.65	143	101	-	0.23	3.92	22.4	14.3	0.48	0.61	1.21	140	80.3	0.42	0.22	0.78	31.9	47.3	96
Whole Sample	Biological Oxygen Demand	mg/l O_2	< 2	< 2	< 2	< 2	2	< 2	< 2	-	< 2	2.3	3.51	< 2	< 2	< 2	2.2	< 2	< 2	< 2	< 2	2.5	3.34	< 2	< 2
Whole Sample	Total Organic Carbon	mg/l	4.2	3.7	3.9	3.9	< 0.3	1.8	0.6	-	2	< 0.3	0.5	< 0.3	0.9	0.9	1.7	0.4	<0.3	1	1.2	4.2	0.7	0.5	0.8
Whole Sample	Total Alkalinity	mg/l $CaCO_3$	171	160	174	182	-	378	428	-	198	-	344	430	410	192	-	366	218	328	216	-	254	330	318
Major Constituents	Calcium	mg/l	55.5	53.4	57.1	51.2	87.9	149	137	-	61.3	87.5	85.7	125	134	53.8	87.2	123	75.6	120	65.9	72.9	73.4	98.5	111
Major Constituents	Magnesium	mg/l	12	12.5	11.7	10.6	16.7	24.1	26.4	-	10.9	16.8	24.5	24.2	25.6	11	17.6	28.1	10.8	13.5	10.6	20.2	20.5	26.7	31.9
Major Constituents	Sodium	mg/l	7.7	7.08	6.98	7	16.8	10	11.8	-	5.98	17.4	10.3	10.8	13.2	6.18	19.9	9.68	6.48	6.08	5.8	31.3	9.13	9.39	11.9
Major Constituents	Potassium	mg/l	0.59	0.62	0.84	0.72	1.12	2.17	1.65	-	0.66	1.16	2.34	1.69	2.58	0.73	1.27	0.62	1.03	1.63	0.6	1.84	1.34	0.65	1.27
Major Constituents	Bicarbonate	mg/l	209	195	212	222	-	461	522	-	242	-	420	525	500	234	-	447	266	400	264	-	310	403	388
Major Constituents	Chloride	mg/l	18.4	9.43	11.5	16.5	40	27.8	29.3	-	15.5	39.5	25.3	25.3	29	15	41	16.9	7.94	6.5	13.5	74	18.9	15.4	17.5
Major Constituents	Sulphate	mg/l	3.54	6.3	7.6	7.74	14.1	1.17	5.94	-	10.7	16.8	9.63	22.1	22.9	0.93	19.4	28.8	26.7	27.6	15	31.4	15.1	43.1	26.4
Minor Constituents	Fluoride	mg/l	0.09	1.27	0.19	0.08	0.19	0.07	0.23	-	0.22	0.18	0.22	0.32	0.33	0.09	0.17	0.59	0.14	0.35	0.33	0.17	0.79	0.14	0.45
Minor Constituents	Nitrate	mg/l NO_3	1.76	3.74	1.86	2.23	< 4.43	7.66	11.2	-	1.02	< 4.43	5.5	7.97	2.58	2.08	< 4.43	7.62	2.99	3.79	< 1	< 4.43	3.58	1.83	< 1
Minor Constituents	Nitrite	mg/l N	0.006	0.005	0.004	0.013	< 0.002	0.015	0.004	-	< 0.002	< 0.002	0.002	0.003	0.006	0.007	< 0.002	0.024	0.008	0.008	0.006	< 0.002	0.002	0.004	0.004
Minor Constituents	Total Ammonia	mg/l N	< 0.02	0.03	< 0.02	< 0.02	< 0.02	0.09	0.02	-	< 0.02	< 0.02	< 0.02	0.04	< 0.02	< 0.02	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	< 0.02	0.02	< 0.02
Minor Constituents	Total Nitrogen	mg/l N	< 1	< 1	2.4	2.3	< 1	< 1	2.7	-	1	< 1	< 1	1.9	2.1	2.5	< 1	< 1	< 1	3.1	2.8	< 1	< 1	< 1	0.5
Minor Constituents	Orthophosphate	mg/l P	< 0.02	< 0.02	< 0.02	0.02	< 0.02	< 0.02	0.02	-	0.04	< 0.02	< 0.02	0.02	< 0.02	0.04	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Minor Constituents	Total Phosphorus	mg/l P	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	0.12	< 0.12	-	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12
Minor Constituents	Iron (Dissolved) [4]	mg/l	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	-	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23
Minor Constituents	Manganese (Dissolved) [4]	mg/l	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.013	0.01	-	< 0.007	< 0.007	0.046	< 0.007	0.149	< 0.007	< 0.007	< 0.007	< 0.007	0.008	< 0.007	0.007	0.012	< 0.007	0.008
Trace Metals	Aluminium (Dissolved) [4]	µg/l	< 100	< 100	< 100	< 100	< 100	< 100	< 100	-	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
Trace Metals	Arsenic (Dissolved) [4]	µg/l	< 1	< 1	-	< 1	0.38	< 1	< 1	-	< 1	0.32	< 1	< 1	-	< 1	0.31	1.2	< 1	-	< 1	1.1	1.2	< 1	-
Trace Metals	Boron (Dissolved) [4]	µg/l	< 230	< 230	< 230	< 230	< 230	< 230	< 230	-	< 230	640	< 230	< 230	< 230	< 230	< 230	< 230	240	< 230	< 230	< 230	< 230	< 230	< 230
Trace Metals	Cadmium (Dissolved) [4]	µg/l	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	-	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6
Trace Metals	Chromium (Dissolved) [4]	µg/l	< 2	< 2	< 2	< 2	< 2	< 2	< 2	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Trace Metals	Copper (Dissolved) [4]	µg/l	< 9	< 9	< 9	< 9	10	< 9	< 9	-	< 9	11	< 9	< 9	< 9	< 9	20	< 9	< 9	< 9	< 9	< 9	15	< 9	< 9
Trace Metals	Lead (Dissolved) [4]	µg/l	< 6	< 6	< 6	< 6	< 6	< 6	< 6	-	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6
Trace Metals	Mercury (Dissolved) [4]	µg/l	< 0.01	< 0.01	0.31	< 0.2	< 0.01	< 0.01	< 0.01	-	< 0.2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.2	< 0.01	< 0.01	< 0.01	0.12	< 0.2	< 0.01	< 0.01	0.01	< 0.01
Trace Metals	Nickel (Dissolved) [4]	µg/l	< 3	< 3	< 3	< 3	< 3	9	5	-	< 3	< 3	8	3	8	< 3	< 3	22	8	7	< 3	< 3	19	< 3	4
Trace Metals	Selenium (Dissolved) [4]	µg/l	< 0.8	< 0.8	< 0.8	< 0.8	< 0.6	< 0.8	< 0.8	-	1.42	< 0.6	2.8	0.86	2.41	< 0.8	< 0.6	1.71	0.99	< 0.8	1.76	0.76	< 0.8	< 0.8	< 0.8
Trace Metals	Zinc (Dissolved) [4]	µg/l	< 18	30	< 18	< 18	< 18	< 18	70	-	< 18	< 18	< 18	30	44	< 18	20	< 18	40	< 18	< 18	< 18	21	< 18	< 18
Hydrocarb	Total Petroleum Hydrocarbons	µg/l	< 10	< 10	< 10	< 10	< 100	< 10	< 10	-	< 10	< 10	< 10	< 10	< 10	< 10	< 100	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Hydrocarb	Volatile Organic Compounds	µg/l	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Hydrocarb	Polycyclic Aromatic Hydrocarbons	µg/l	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	-	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1
Micro	Total Coliforms	mpn/100ml	166	> 2420	> 2420	79	2	0	24	-	131	12	24	104	> 2420	68	9	0	7	1414	2	162	1	36	> 2420
Micro	Faecal Coliforms	mpn/100ml	112	687	416	88	1	6	10	-	190	6	25	89	276	108	1	1	5	921	2	83	1	96	14
Micro	*E. coli*	mpn/100ml	42	4	173	25	0	0	12	-	34	1	21	5	345	30	0	0	0	1046	0	73	1	0	4

Notes:

1. Dissolved Oxygen measured in bucket, indicative only
2. Conductivity (lab) converted to 25°C reference temperature assuming 2%/°C
3. Elevated Total Suspended Solids and Turbidity related to sampling method (bailer), not representative of mobile levels
4. Iron, Manganese and Trace Metals filtered on site using 0.45µm filter and preserved with nitric acid
5. European Union Environmental Objectives (Groundwater)(Amendment) Regulations 2016 (S.I. No. 366 of 2016)
6. European Union (Drinking Water) Regulations 2014 (S.I. No. 122 of 2014)
7. Corrected to 25°C
8. No Abnormal Change
9. Converted to mg/l N

Concentration shaded where threshold/limit value exceeded

Groundwater Samples

		MW6					MW7					MW8					MW9					MW10c					
05/02/2019	06/10/2020	08/02/2018	19/04/2018	28/08/2018	05/02/2019	06/10/2020	08/02/2018	19/04/2018	28/08/2018	05/02/2019	06/10/2020	08/02/2018	19/04/2018	28/08/2018	05/02/2019	06/10/2020	08/02/2018	19/04/2018	28/08/2018	05/02/2019	07/10/2020	08/02/2018	19/04/2018	28/08/2018	05/02/2019	06/10/2020	08/02/2018
9.6	11.2	9.9	10.6	11.8	9.5	11.2	10.2	10.9	11.7	10.1	11.1	9.5	10.4	11.2	10.0	11.0	9.3	10.1	11.2	10.4	11.4	10.0	10.8	11.4	9.9	11.0	9.6
594	655	641	643	684	620	661	1142	397	688	640	673	676	481	795	455	660	756	663	786	707	762	576	373	542	666	663	910
7.51	7.19	7.40	7.42	7.37	7.60	7.65	7.11	7.02	7.39	7.55	7.57	7.15	7.21	7.23	7.11	7.80	7.31	7.39	7.23	7.01	8.01	7.35	7.38	7.21	7.39	7.09	7.17
93.7	84.1	68.7	70.3	75.4	86.5	85.7	80.6	85.8	68.5	82.1	83.1	66.1	72.5	73.6	87.5	84.7	58.2	55.4	90.6	44.2	90.3	77.5	82.6	55.2	65.7	92.4	80.2
10.44	8.25	6.92	7.02	7.48	9.70	8.38	7.99	8.64	6.82	9.08	8.32	6.42	7.50	7.45	9.78	8.52	5.72	5.53	8.97	4.97	8.91	7.62	8.31	5.17	7.43	9.07	8.18
630	645	635	575	684	-	646	1122	450	691	638	648	677	507	739	443	642	792	754	749	733	756	572	391	548	634	649	869
81.5	< 3	313	> 200	491	10.9	7.7	227	35	560	144	< 3	83.6	49.7	237	< 3	4.8	101	32.6	1921	22.5	151	< 3	35	654	70	4.3	228
2.5	1.58	104	72.3	369	0.57	8.23	77.1	101.4	340	1.05	1.66	87.4	92.3	311	0.4	0.36	59.4	62.7	718	3.21	5.33	1.74	1.34	296	2.9	0.1	563
< 2	< 2	3.98	< 2	2.2	2.31	< 2	< 2	< 2	< 2	10.32	< 2	3.93	< 2	< 2	< 2	2.3	2.85	< 2	4.22	< 2	9.1	< 2	< 2	< 2	9.9	< 2	< 2
0.6	3.3	0.8	1.2	0.6	0.7	< 0.3	1.2	1.5	1.5	1	< 0.3	1.15	0.9	1.2	< 0.3	3.2	2.7	3.8	2.2	2.4	8.4	< 0.3	< 0.3	< 0.3	< 0.3	5.1	1.4
294	-	274	296	322	370	-	330	218	322	308	-	304	244	338	214	-	286	328	332	326	-	286	178	262	302	-	336
90.5	111	115	101	159	100	117	200	72.2	172	89.5	114	123	83.2	139	67.1	83.1	117	109	378	109	116	95.7	58.2	193	88.4	114	135
18.2	15.3	28.9	27.6	58.7	20.9	15.9	61.5	10.6	64.3	20.2	15.7	15	11.8	29	10.8	23.3	20.5	20.3	39	19.8	18.6	11.5	11.3	52	20.2	15.6	22.9
9.24	5.82	6.56	9.44	10.7	9.3	5.84	12.2	6.5	9.9	10.2	6.16	9.67	7.01	12.6	5.7	35.9	27.7	21.5	29	17	16.9	7.37	7.08	9.51	9.96	5.78	18.4
1.48	0.64	0.78	0.68	1.53	3.65	0.67	0.8	0.83	1	5.84	0.66	1.17	1.1	1.41	0.58	2.12	5.11	3.15	4.32	1.07	7.19	0.53	0.74	1.16	7.34	0.66	1.59
359	-	334	361	393	451	-	403	266	393	376	-	371	298	412	261	-	349	400	405	359	-	349	217	320	332	-	410
15.5	18.5	15.4	14.9	21	14	16.5	15.9	9.93	18	17.5	15.5	18.4	8.93	19	14.5	71	54.1	41.2	38.5	30	50	17.4	12.9	17.7	16.5	16	45.2
18.3	7.16	18	33.5	34.7	23.5	5.68	308	18.3	50.6	2.55	3.48	10.7	25.9	45.8	9.5	33.6	19.5	29	51.3	8.43	47.9	< 2.0	12.2	18.2	19	7.99	16.8
0.85	0.16	0.15	0.26	0.17	0.87	0.16	0.06	0.32	0.12	0.71	0.16	0.18	0.54	1	0.35	0.15	0.10	0.11	0.18	0.05	0.12	0.15	0.17	0.23	0.69	0.18	0.09
4.78	< 4.43	< 1	2.99	< 1	4.73	< 4.43	< 1	4.97	< 1	3.76	< 4.43	2.56	4.67	1.12	3.85	< 4.43	9.46	4.9	3.53	1.75	< 4.43	2.3	3.35	4.28	4.21	< 4.43	7.34
0.011	< 0.002	0.002	0.006	0.003	0.022	< 0.002	0.006	0.008	0.002	0.031	< 0.002	0.014	0.005	0.005	0.02	< 0.002	0.006	0.004	0.004	0.022	< 0.002	0.002	0.005	0.002	0.027	< 0.002	0.032
0.09	< 0.02	0.04	0.03	< 0.02	0.09	< 0.02	< 0.02	0.03	< 0.02	0.16	0.03	0.26	0.04	< 0.02	< 0.02	< 0.02	< 0.02	0.05	0.15	< 0.02	0.3	< 0.02	0.03	< 0.02	0.08	< 0.02	0.06
1.3	< 1	< 1	< 1	2.3	4.1	< 1	< 1	1.2	1.3	2.9	< 1	< 1	1.1	1	1.9	< 1	< 1	1.2	2.1	2.4	1.09	< 1	< 1	2.5	3	< 1	< 1
< 0.02	0.02	< 0.02	0.04	< 0.02	0.05	0.02	< 0.02	0.03	< 0.02	0.05	< 0.02	< 0.02	0.03	< 0.02	0.02	0.02	< 0.02	< 0.02	< 0.02	0.02	0.29	< 0.02	< 0.02	< 0.02	0.04	0.03	< 0.02
< 0.12	< 0.12	< 0.12	< 0.12	0.29	< 0.12	< 0.12	< 0.12	< 0.12	0.13	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	0.20	< 0.12	< 1.2	< 0.12	0.26	< 0.12	< 0.12	0.3	< 0.12	< 0.12	0.27
< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	0.67	< 0.23	0.35	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23
< 0.007	< 0.007	0.027	0.01	0.007	0.008	< 0.007	0.513	< 0.007	0.056	0.017	< 0.007	0.008	< 0.007	< 0.007	< 0.007	0.01	< 0.007	0.335	0.463	0.435	< 0.007	< 0.007	< 0.007	< 0.007	0.019	< 0.007	0.058
< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100
1.3	0.37	< 1	6.2	-	1.8	0.3	4.3	< 1	-	2.6	0.32	< 1	< 1	-	< 1	1.1	< 1	< 1	-	< 1	0.32	< 1	< 1	-	2.6	0.32	1.3
< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	470	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	410	< 230
< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6
< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	2	< 2	< 2	< 2	< 2	< 2
< 9	10	< 9	< 9	< 9	< 9	9	< 9	< 9	< 9	< 9	10	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	19	< 9	< 9	< 9	< 9	10	< 9
< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6
< 0.2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.2	< 0.01	< 0.01	< 0.01	0.03	< 0.2	< 0.01	0.01	< 0.01	< 0.01	< 0.2	0.03	< 0.01	< 0.01	0.04	< 0.2	< 0.01	0.04
16	< 3	12	11	10	15	< 3	127	< 3	4	14	< 3	8	7	16	3	4	7	11	12	12	< 3	5	4	11	14	< 3	7
< 0.8	< 0.6	< 0.8	< 0.8	< 0.8	< 0.8	< 0.6	< 0.8	< 0.8	< 0.8	< 0.8	< 0.6	< 0.8	< 0.8	1.07	2.48	0.89	< 0.8	< 0.8	< 0.8	< 0.8	< 0.6	< 0.8	< 0.8	0.88	< 0.8	< 0.6	1.26
< 18	< 18	< 18	60	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	30	< 18	< 18	< 18	60	70	< 18	< 18	< 18	< 18	30	< 18	< 18	< 18	< 18
< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1
0	6	29	40	689	1	13	0	114	> 2420	57	4	4	0	3	1	98	10	0	1	43	548	0	122	214	25	8	57
0	5	21	47	133	0	3	2	276	> 2420	46	5	15	2	1	2	53	4	0	0	56	5	0	138	5	25	0	29
0	1	4	0	73	1	0	0	0	0	10	0	4	0	3	0	41	5	0	0	24	3	0	1	1	12	3	13

Groundwater Samples

MW11				MW12	MW13	MW14	MW15	MW16	MW17	MW18	MW19	MW20	MW21	MW22	MW23	MW24	MW25	Old Well	Groundwater Threshold Values [5]	Drinking Water Parametric Values [6]
19/04/2018	28/08/2018	05/02/2019	06/10/2020	06/10/2020	06/10/2020	06/10/2020	07/10/2020	07/10/2020	07/10/2020	06/10/2020	06/10/2020	07/10/2020	07/10/2020	07/10/2020	07/10/2020	07/10/2020	07/10/2020	07/10/2020		
10.3	11.7	11.0	11.1	11.4	11.6	11.3	11.6	11.5	11.5	11.0	11.3	11.3	11.5	11.6	11.6	11.4	11.5	11.2	-	-
315	823	440	641	632	609	634	335	352	373	644	652	702	551	761	344	502	274	738	800 - 1875	2750 [7]
7.22	7.25	7.27	7.33	7.08	7.16	7.14	7.12	7.08	7.33	7.31	7.23	7.24	7.17	7.14	7.18	7.18	7.21	7.46	-	≥ 6.5 and ≤ 9.5
83.8	58.2	87.7	86.8	80.8	80.7	81.2	81.5	80.5	79.3	76.8	76.6	83.3	81.9	82.9	79.3	75.5	73.3	91.2	-	-
8.37	5.71	9.74	8.72	8.02	8.02	8.14	8.18	8.02	7.96	7.62	7.59	8.26	8.13	8.17	7.19	7.18	7.22	9.07	-	-
348	813	397	638	638	616	639	310	311	352	636	639	684	542	743	344	504	274	735	800 - 1875	2750 [7]
20.1	393	78.4	8.4	5.2	64.7	6	2490	127	12021	< 3	< 3	1632	850	5072	14219	9067	392	36.7	-	-
415	657	16.9	0.82	1.68	1.76	0.98	177	47.4	198	1.9	2.42	103	29.4	24.9	283	140	128	7.71	-	NAC [8]
< 2	< 2	< 2	2.5	2.4	2.1	2	2.3	< 2	< 2	< 2	< 2	9.5	11	< 2	2.4	2.3	< 2	3.1	-	-
2	1.7	1.2	3.8	4.8	2.8	6.6	5.1	4.5	9.3	4.5	7.3	2.9	17	6.8	4.7	< 0.3	0.3	1.1	-	NAC [8]
158	382	174	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
50.2	129	57.9	92.4	69	72.4	71.6	-	36.7	-	112	84.7	-	97.2	102	-	-	101	109	-	-
10.7	28.4	10.8	17.4	19.2	20.1	19.9	-	9	-	15.4	18.3	-	25.4	28.3	-	-	19.2	19.7	-	-
6.6	13.2	6.5	17.7	30	31.6	30.8	22.8	30.7	29.6	6.04	22.1	12.9	13.6	22.4	36.4	< 6.0	6.88	20.6	-	200
0.58	1.45	0.67	1.17	1.75	1.83	1.8	6.67	9.94	-	0.64	1.38	6.78	-	-	-	-	2.75	4.29	-	-
193	466	191	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.4	30	16.2	51	64	65	60.5	39	19.5	21	16	25.5	26	26	18	18.7	28.5	13.5	44.5	24 - 187.5	250
5.48	40	13.72	22.9	26.4	31.7	29.2	14.2	64.5	-	5.55	10.4	47.1	10.9	-	-	20.6	19.4	27.5	187.5	250
0.12	0.3	0.17	0.17	0.17	0.34	0.2	0.24	0.17	0.2	0.16	0.14	0.14	0.15	0.14	0.17	0.14	0.18	0.16	-	1.5
1.77	1.35	1.56	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	37.5	50
0.003	0.002	0.009	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.41	0.23	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.21	< 0.002	< 0.002	< 0.002	0.114 [9]	0.152 [9]
0.04	< 0.02	0.02	< 0.02	< 0.02	< 0.02	0.02	0.29	0.1	0.18	< 0.02	< 0.02	0.06	4.1	0.04	0.17	0.04	0.04	0.16	0.065 - 0.175	0.23 [9]
< 1	0.8	1.4	< 1	< 1	< 1	< 1	< 1	< 1	3.81	< 1	< 1	< 1	5.62	1.03	1.16	< 1	< 1	< 1	-	-
< 0.02	0.04	0.09	< 0.02	0.02	< 0.02	< 0.02	1.48	0.1	1.49	0.03	< 0.02	0.43	1.03	3.2	9.3	6.6	0.19	0.07	0.035	-
< 0.12	0.8	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	1.53	< 0.12	< 0.12	< 0.12	< 0.12	2.19	0.2	0.23	3.81	3.67	0.17	< 0.12	-	-
< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	< 0.23	-	0.2
< 0.007	< 0.007	< 0.007	< 0.007	0.01	< 0.007	0.009	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	-	0.05
< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	150	200
< 1	-	< 1	0.32	1.1	1.1	1.2	0.33	0.32	0.36	0.29	0.3	0.31	0.31	0.32	0.33	0.35	0.36	0.36	7.5	10
< 230	< 230	< 230	< 230	< 230	840	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	-	1000
< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	-	5
< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	37.5	50
< 9	< 9	< 9	19	< 9	< 9	< 9	19	19	19	14	10	20	19	18	18	21	19	19	-	2000
< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6	7.5	10
< 0.01	< 0.01	< 0.2	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.15	0.01	< 0.01	0.75	1
< 3	3	< 3	< 3	4	4	4	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	-	20
< 0.8	< 0.8	1.03	< 0.6	0.84	0.94	0.83	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	-	10
< 18	< 18	< 18	20	< 18	< 18	< 18	20	20	20	< 18	< 18	< 18	20	20	< 18	20	< 18	18	75	-
< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 40	< 10	< 10	< 10	< 10	< 20	7.5	-
< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	-
< 0.1	< 0.1	< 0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.075	0.1
205	313	228	30	65	50	93	> 2420	435	80	6	3	> 2420	0	1986	> 2420	1203	13	122	-	0
99	120	172	1	10	11	15	12	26	31	0	0	649	0	76	29	3	3	5	-	-
0	240	61	6	4	7	8	6	24	31	1	0	117	0	96	981	0	0	1	-	0

tms environment ltd

APPENDIX 7-11 SURFACE WATER SAMPLES

Surface Water Samples

	Parameter	Units	Upstream of Infilled Area (Off-Site) [16]				Downstream of Infilled Area (Off-Site) [16]				Upstream											
			26/08/2020	16/09/2020	13/10/2020	03/11/2020	26/08/2020	16/09/2020	13/10/2020	03/11/2020	30/01/2018	27/02/2018	27/03/2018	23/04/2018	27/08/2018	06/11/2018	07/01/2019	28/03/2019	26/08/2020	16/09/2020	29/09/2020	13/10/2020
Field	Temperature	°C	14.3	15.2	13	8.1	14.4	15.3	13.1	8.2	6.3	3.9	8.7	11.6	13	9.1	8.7	10.2	14.5	15.6	13.6	12.9
	Conductivity (field)	µS/cm @ 25°C	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	557	212	209	151	231	232	421	ND [3]	ND [3]	ND [3]	ND [3]
	pH	-	7.26	7.19	7.01	7.01	7.21	7.17	7.06	7.02	7.72	8.21	7.32	7.81	7.24	7.62	7.31	7.65	7.2	7.25	7.18	7.06
	Dissolved Oxygen	% sat	92.1	99.6	91.7	93.7	92.3	99.4	92	94.1	93.8	102.5	95.7	95.6	91.7	92.6	65.1	89.3	91.8	92.3	97.2	92.6
	Dissolved Oxygen	mg/l O_2	9.21	9.76	9.06	9.34	9.25	9.7	9.08	9.42	11.57	13.15	11.14	11.78	9.08	9.07	6.68	10.06	9.15	9.27	9.2	9.2
Whole Sample	Conductivity (lab) [1]	µS/cm @ 25°C	54	143	228	244	51	139	228	237	405	551	209	299	158	240	235	428	179	330	-	226
	Total Suspended Solids	mg/l	< 3	3.9	3.7	4	< 3	4.9	5.9	< 3	< 3	< 3	3.1	< 3	< 3	24.5	< 3	< 3	< 3	3.8	-	< 3
	Turbidity	NTU	0.68	0.98	1.46	0.66	0.98	1.03	1.18	0.36	1.4	1	0.98	2.09	0.98	5.38	1.88	0.87	1.52	1.26	-	3.41
	Biological Oxygen Demand	mg/l O_2	3	1	3	< 1	4	2	3	< 1	1	< 2	4	< 1	2	< 1	< 1	< 1	4	1	1	3
	Total Organic Carbon	mg/l	20	1.9	1.5	5.8	2.1	14.5	2.6	13.4	0.45	4	8.4	6.2	2.6	11.7	6.3	3.5	2.1	1.1	-	10.8
	Total Hardness	mg/l $CaCO_3$	-	-	-	-	-	-	-	-	169	217	66.5	112	54.8	85.8	88.1	199	-	-	-	-
Major Constit	Calcium	mg/l	-	-	-	-	-	-	-	-	50.9	68.2	19.7	34.7	17.5	27.1	27.7	62.8	-	-	-	-
	Magnesium	mg/l	-	-	-	-	-	-	-	-	10.2	11.4	4.2	6.1	2.7	4.4	4.6	10.3	-	-	-	-
	Chloride	mg/l	8.5	13.5	32	22	8	14.5	31	20	33.2	41.2	24	23.5	13	24.5	19	30.5	10.5	18.5	-	31
	Sulphate	mg/l	9.8	8.9	< 2	3.6	11.8	8.7	< 2	2.6	3.05	< 2	< 2	< 2	5.9	5.6	4.3	< 2	8.4	9.9	-	< 2
Minor Constituents	Nitrate	mg/l NO_3	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	< 4.43	4.76	5.38	3.69	3	1.1	2.6	< 3.10	25.52	5.4	4.56	-	< 4.43
	Nitrite	mg/l N	0.008	0.004	< 0.002	< 0.002	0.008	0.003	< 0.002	< 0.002	0.006	0.008	0.004	0.003	0.008	0.004	< 0.08	< 0.08	0.003	0.005	-	< 0.002
	Total Ammonia	mg/l N	< 0.02	< 0.02	0.04	< 0.02	0.04	< 0.02	0.05	< 0.02	0.03	0.03	0.03	0.05	0.05	< 0.02	0.03	0.34	0.04	0.05	-	0.04
	Total Nitrogen	mg/l N	0.29	0.16	< 1	< 0.5	0.37	0.21	1.03	< 0.5	1.4	< 1	< 1	< 1	1.2	< 1	3.5	0.7	0.11	0.29	-	< 1
	Orthophosphate	mg/l P	< 0.02	0.05	0.02	< 0.02	< 0.02	0.04	0.03	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.05	< 0.02	0.04	< 0.02	0.06	0.02	0.02
	Total Phosphorus	mg/l P	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12
Trace Metals	Aluminium (Total)	µg/l	400	200	100	< 100	400	200	100	< 100	< 100	< 100	< 100	< 100	200	100	100	< 100	200	100	-	100
	Arsenic (Total)	µg/l	0.4	0.39	0.48	0.35	0.36	0.36	0.47	0.34	< 1	< 1	< 2	< 1	< 1	< 1	< 1	< 1	0.68	0.73	-	0.45
	Boron (Total)	µg/l	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	330	< 230	< 230	< 230	< 230	< 230	< 230	< 230	-	< 230
	Cadmium (Dissolved) [2]	µg/l	< 0.02	< 0.02	< 0.02	< 0.6	< 0.02	< 0.02	< 0.02	< 0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.02	< 0.02	-	< 0.02
	Chromium (Total)	µg/l	< 2	4	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	4	-	< 2
	Copper (Total)	µg/l	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	10	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	-	< 9
	Lead (Dissolved) [2]	µg/l	0.52	< 0.3	< 0.3	< 0.3	0.63	< 0.3	< 0.3	< 0.3	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 0.3	< 0.3	-	< 0.3
	Mercury (Dissolved) [2]	µg/l	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-	< 0.01
	Nickel (Dissolved) [2]	µg/l	< 3	< 3	< 3	< 3	< 3	5	< 3	< 3	< 3	< 3	17	< 3	< 3	< 3	< 3	< 3	< 3	< 3	-	< 3
	Selenium (Total)	µg/l	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.6	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.6	< 0.6	-	< 0.6
	Zinc (Total)	µg/l	< 18	20	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	-	< 18
Hydrocarb	Total Petroleum Hydrocarbons	µg/l	< 40	< 100	< 40	< 40	< 40	< 100	< 40	< 40	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	< 40	< 40	-	< 40
	Volatile Organic Compounds	µg/l	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	< 1
	Polycyclic Aromatic Hydrocarbons	µg/l	-	-	-	-	-	-	-	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.02	-	-	-	-
Micro	Total Coliforms	mpn/100ml	-	-	-	-	-	-	-	-	345	238	50 cfu/100ml	167	> 2420	921	2420	59	-	-	-	-
	Faecal Coliforms	mpn/100ml	602	88	308	> 2420	1300	82	308	> 2420	64	40	172	129	411	131	1203	36	1733	328	-	1120
	E. coli	mpn/100ml	214	3	133	488	185	14	361	411	32	26	50 cfu/100ml	119	214	115	106	21	411	365	-	411

Notes:

1. Conductivity (lab) converted to 25°C reference temperature assuming 2%/°C
2. Surface Water EQS's for Cadmium, Lead, Mercury and Nickel refer to dissolved concentrations
3. Not Detected (fieldmeter malfunction)
4. Discharge from the West stream bank (W) or East stream bank (E); note discharge from east bank ceased after January 2018 so only one sample taken
5. European Communities Environmental Objective (Surface Waters) Regulations 2009 (S.I. No. 272 of 2009), European Union Environmental Objectives (Surface Waters)(Amendment) Regulation 2015 (S.I. No. 386 of 2015)
6. European Communities (Quality of Salmonid Waters) Regulations 1988 (S.I. No. 293 of 1988)
7. European Union (Drinking Water) Regulations 2014 (S.I. No. 122 of 2014)
8. Surface Water EQS for 'Good' status
9. For Cadmium, EQS depends on water hardness
10. Annual Average (AA) and Maximum Allowable Concentration (MAC)
11. For Copper and Zinc, lower value applies for water hardness <100mg/l $CaCO_3$ and higher value applies for water hardness >100mg/l $CaCO_3$
12. Temperature must also not exceed 21.5°C, or 10°C from 1 November to 30 April where species which need cold water for reproduction are present
13. Converted to mg/l N
14. Corrected to 25°C
15. No Abnormal Change
16. Infilled area (now developed) surrounding Lough Nameenbrack upstream of site and operated by third party
17. Sampling locations provided on Figure 7-2

Concentration shaded where standard/limit value exceeded

Surface Water Samples

						Discharge (W) [4]																Discharge (E) [4]	
03/11/2020	24/11/2020	14/12/2020	06/01/2021	02/02/2021	10/03/2021	30/01/2018	27/02/2018	27/03/2018	23/04/2018	27/08/2018	06/11/2018	07/01/2019	28/03/2019	26/08/2020	16/09/2020	13/10/2020	03/11/2020	14/12/2020	06/01/2021	02/02/2021	10/03/2021	30/01/2018	30/01/2018
9.7	6.3	6.9	4.3	6.2	7.2	7.1	3.3	8.4	11.9	14.8	8.9	8.8	9.8	13.9	13.7	13.7	12.1	6.1	4.5	4.1	9.2	7.3	6.8
ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	630	654	697	548	711	686	763	585	507	551	651	672	582	667	731	692	660	430
7.01	7.05	7.1	7.03	7.09	7.12	7.96	8.39	8.18	8.03	8.65	7.38	8.51	7.89	8.41	8.55	8.33	8.51	7.95	8.49	8.19	7.93	7.9	7.78
93.6	91.7	-	-	-	98.4	99.3	109.5	101	100.7	99.7	98.7	98.6	103.4	101.6	102.7	102.6	102.6	-	-	-	103.6	100.2	94.6
9.42	9.17	-	-	-	9.97	12.03	14.71	11.92	12.16	9.82	9.91	9.79	11.74	10.15	10.23	10.29	10.32	-	-	-	11.71	12.06	11.52
265	-	-	-	-	-	591	614	580	662	662	669	693	584	620	649	634	626	-	-	-	-	648	425
23.9	-	7.1	4	14	13	< 3	< 3	< 3	< 3	< 3	< 3	< 3	14.6	< 3	7.2	< 3	< 3	4	< 3	4.8	3.5	< 3	3.5
11.8	-	-	-	-	-	0.53	0.84	0.72	1.02	0.21	0.35	0.63	0.74	0.57	0.44	0.58	0.68	-	-	-	-	0.32	0.87
< 1	1.2	< 1	< 2	2.2	2	< 1	< 2	< 1	< 1	< 1	< 1	< 1	< 1	2	2	6	< 1	< 1	< 2	2.4	< 2	< 1	< 1
0.5	-	-	-	-	-	< 0.3	3	< 0.3	< 0.3	1	2.2	4.3	1.9	2.1	3.3	1.1	3.7	-	-	-	-	< 0.3	0.4
-	-	-	-	-	-	248	277	285	259	251	275	288	263	-	-	-	-	-	-	-	-	278	174
-	-	-	-	-	-	72.5	81.7	80.6	71.4	66.4	77.8	82	76.5	-	-	-	-	-	-	-	-	80.9	52.2
-	-	-	-	-	-	16.4	17.8	20.4	19.6	20.7	19.6	20.3	17.5	-	-	-	-	-	-	-	-	18.4	10.7
23	-	-	-	-	-	38.7	43.7	56.5	59	16.5	4.5	57.5	47.5	59	58.5	60.5	47	-	-	-	-	41.2	30.8
4.1	-	-	-	-	-	24	3	3.8	2.5	< 2	35.7	25.8	15.3	20.3	24.8	31.4	25.9	-	-	-	-	24.6	4.34
< 4.43	-	-	-	-	-	6.53	6.54	7.05	2.84	1.87	2.87	3.1	12.05	< 4.43	< 4.43	< 4.43	< 4.43	-	-	-	-	6.98	4.89
< 0.002	-	< 0.002	< 0.002	< 0.002	0.01	0.007	0.003	0.003	0.005	0.006	0.004	< 0.08	< 0.08	< 0.002	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.003	0.006
0.06	-	0.06	0.06	< 0.02	0.03	< 0.02	< 0.02	< 0.02	0.02	0.03	< 0.02	< 0.02	0.31	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02
0.7	-	-	-	-	-	1	< 1	1.5	< 1.0	1.1	< 1	1.45	1	< 0.1	0.16	< 1	< 0.5	-	-	-	-	1	< 1
< 0.02	< 0.02	< 0.02	< 0.02	0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02	< 0.02	0.2	< 0.02	< 0.02	< 0.02	0.06	0.03	< 0.02	< 0.02	< 0.02	<0.02	<0.02	< 0.02	< 0.02
< 0.12	0.02	< 0.02	0.2	0.05	< 0.05	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.02	< 0.02	< 0.05	< 0.05	< 0.12	< 0.12
100	-	-	-	-	-	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	< 100	-	-	-	-	< 100	< 100
0.41	-	-	-	-	-	< 1	< 1	< 1	< 1	1.6	< 1	< 1	< 1	1.1	0.99	1.1	0.76	-	-	-	-	< 1	< 1
< 230	-	-	-	-	-	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	-	-	-	-	< 230	< 230
< 0.6	-	-	-	-	-	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.02	< 0.02	< 0.02	< 0.6	-	-	-	-	< 0.5	< 0.5
< 2	-	-	-	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	-	-	-	-	< 2	< 2
< 9	-	-	-	-	-	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	-	-	-	-	< 9	< 9
< 1	-	-	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 0.3	< 0.3	< 0.3	< 0.3	-	-	-	-	< 1	< 1
< 0.01	-	-	-	-	-	0.015	< 0.01	< 0.01	< 0.01	< 0.01	0.077	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-	-	-	-	< 0.01	< 0.01
< 3	-	-	-	-	-	5	6	6	4	5	< 3	4	8	3	3	10	5	-	-	-	-	7	< 3
< 0.6	-	-	-	-	-	1.45	1.2	1.21	1.3	1.26	1.1	1.37	1.05	1.1	1.2	0.88	1.4	-	-	-	-	1.07	< 0.8
< 18	-	-	-	-	-	< 18	< 18	< 18	< 18	< 18	40	< 18	< 18	< 18	< 18	< 18	< 18	-	-	-	-	< 18	< 18
< 40	-	-	-	-	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	< 10	13	< 10	< 10	-	-	-	-	< 10	< 10
< 1	-	-	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	-	-	-	< 1	< 1
-	-	-	-	-	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.01	-	-	-	-	-	-	-	-	< 0.1	< 0.1
-	-	-	-	-	-	17	178	0 cfu/100ml	15	231	63	173	8	-	-	-	-	-	-	-	-	20	132
201	-	-	-	-	-	3	32	0	3	19	9	1	6	36	0	20	3	-	-	-	-	3	23
88	-	-	-	-	-	1	82	0 cfu/100ml	1	6	4	0	1	4	1	4	5	-	-	-	-	1	24

Surface Water Samples

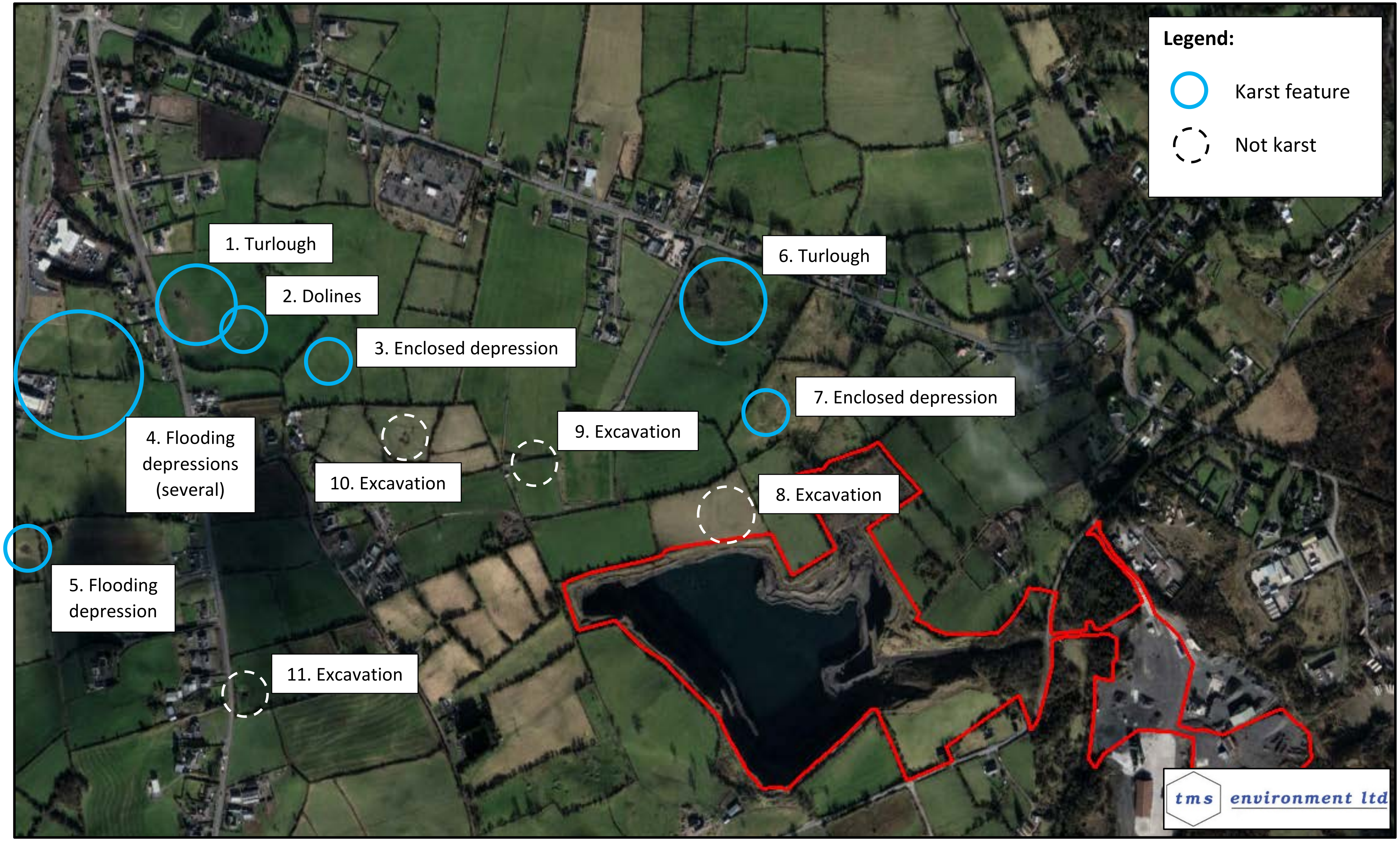
Downstream																	Bridge before Lough						
27/02/2018	27/03/2018	23/04/2018	27/08/2018	06/11/2018	07/01/2019	28/03/2019	26/08/2020	16/09/2020	29/09/2020	13/10/2020	03/11/2020	24/11/2020	14/12/2020	06/01/2021	02/02/2021	10/03/2021	30/01/2018	27/02/2018	27/03/2018	23/04/2018	27/08/2018	06/11/2018	07/01/2019
3.5	8.8	11.8	13.3	8.6	9	10.1	14.1	15.8	13.4	13.2	8.7	6.8	6.5	4.4	5.7	7.8	6.8	4	8.3	11.7	13.6	8.9	9
630	441	415	272	421	490	544	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	427	638	449	499	295	438	ND [3]
8.23	7.96	7.85	7.79	7.31	7.62	7.79	7.65	7.72	7.58	7.39	7.5	7.86	7.26	7.72	7.38	7.37	7.74	8.21	8.1	7.87	8.15	7.38	7.7
102.1	99	95.7	95.6	93.6	87.8	99.3	96.1	97.7	98.7	95.8	95.9	98.6	-	-	-	99.6	96.2	114	97.3	97	96.7	91.7	85.8
13.35	11.51	11.91	9.27	9.41	8.69	11.18	9.35	9.48	9.41	9.41	9.62	9.97	-	-	-	10.31	11.7	15.36	11.41	11.99	9.72	9.16	8.62
620	436	559	271	436	488	542	254	525	-	330	326	-	-	-	-	-	424	629	458	551	282	432	491
3	3.5	3.2	< 3	5.5	< 3	< 3	3.1	6.9	-	< 3	11.5	-	7	5.1	4.4	9.3	< 3	3	4.4	3.7	< 3	< 3	< 3
0.66	0.91	2.48	0.73	0.79	1.38	0.86	1.68	1.58	-	1.28	20.1	-	-	-	-	-	1.59	0.66	1.21	1.65	0.34	1.35	3.24
< 2	< 1	< 1	< 1	1	< 1	< 1	2	3	1	1	< 1	2.1	< 1	< 2	2.1	2	< 1	< 2	2	< 1	< 1	< 1	< 1
2.6	5.9	3.2	1.9	9.4	4.7	1.5	10.4	2.7	-	2.2	< 0.3	-	-	-	-	-	0.8	2.4	6	3.9	2	7.4	5.2
261	161	215	95.3	162	188	243	-	-	-	-	-	-	-	-	-	-	165	267	167	211	92.9	170	206
77.8	46.2	60.5	27.3	47.6	54.2	71.8	-	-	-	-	-	-	-	-	-	-	49.8	80.2	47.9	59.6	26.8	50.3	59.8
16.1	11.2	15.6	6.6	10.6	12.7	15.4	-	-	-	-	-	-	-	-	-	-	9.9	16.3	11.6	15.2	6.3	10.8	13.7
44.2	39	47.5	26	43	42.2	41	24	44.5	-	45	27	-	-	-	-	-	30.8	43.7	42.7	45.9	27.5	43	42.5
28.4	24.3	22.7	4.5	3.3	2.6	9.6	13.3	25.4	-	10.3	8.75	-	-	-	-	-	5.75	30	27.3	24.2	4	3.9	4.7
6.34	7.11	4.07	1.25	2	< 3.10	17.19	< 4.43	4.7	-	< 4.43	< 4.43	-	-	-	-	-	5.08	6.26	7.01	4.05	1.54	2.2	< 3.10
0.004	0.003	0.003	0.007	0.006	< 0.08	< 0.08	0.006	0.012	-	< 0.002	< 0.002	-	< 0.002	< 0.002	< 0.002	< 0.002	0.008	0.005	0.005	0.004	0.008	0.008	< 0.08
< 0.02	0.02	0.04	0.03	< 0.02	< 0.02	0.34	0.03	0.05	-	0.03	0.04	-	0.06	0.02	< 0.02	0.03	0.02	0.2	0.04	0.03	0.03	< 0.02	< 0.02
5.1	4.6	3.2	< 1	< 1	0.5	1	0.79	0.53	-	< 1	0.66	-	-	-	-	-	2.1	< 1	1.5	< 1	< 1	< 1	1.3
< 0.02	< 0.02	0.02	< 0.02	0.06	< 0.02	< 0.02	< 0.02	0.02	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02	0.03	< 0.02	0.07	< 0.02
< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	0.21	< 0.12	< 0.12	< 0.02	0.05	< 0.02	< 0.05	< 0.05	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12
< 100	< 100	< 100	200	< 100	< 100	< 100	300	100	-	100	100	-	-	-	-	-	< 100	< 100	< 100	< 100	200	< 100	< 100
< 1	< 2	< 1	< 1	< 1	< 1	< 1	0.9	1.2	-	0.61	0.45	-	-	-	-	-	< 1	< 1	< 2	< 1	< 1	< 1	< 1
< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	-	< 230	< 230	-	-	-	-	-	< 230	< 230	< 230	< 230	< 230	< 230	< 230
< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.02	< 0.02	-	< 0.02	< 0.6	-	-	-	-	-	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
< 2	< 2	< 2	< 2	< 2	2	2	< 2	< 2	-	< 2	< 2	-	-	-	-	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2
< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	-	< 9	< 9	-	-	-	-	-	< 9	< 9	< 9	< 9	< 9	< 9	< 9
< 1	< 1	< 1	< 1	< 1	< 1	< 1	0.4	< 0.3	-	< 0.3	< 0.3	-	-	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1
< 0.01	< 0.01	< 0.01	< 0.01	0.2	< 0.01	< 0.01	< 0.01	< 0.01	-	< 0.01	< 0.01	-	-	-	-	-	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
< 3	< 3	6	< 3	4	125	< 3	< 3	3	-	< 3	< 3	-	-	-	-	-	< 3	3	< 3	5	4	< 3	4
< 0.8	< 0.8	1.07	< 0.8	< 0.8	0.92	< 0.8	< 0.6	0.84	-	< 0.6	< 0.6	-	-	-	-	-	< 0.8	1.09	1.22	1.06	< 0.8	< 0.8	0.96
< 18	< 18	< 18	< 18	< 18	< 18	50	30	90	-	< 18	< 18	-	-	-	-	-	< 18	< 18	< 18	< 18	< 18	< 18	< 18
< 10	< 10	< 10	< 10	< 10	< 10	-	< 40	< 40	-	< 40	< 40	-	-	-	-	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10
< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	< 1	< 1	-	-	-	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1
< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.02	-	-	-	-	-	-	-	-	-	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
68	60 cfu/100ml	67	> 2420	435	579	19	-	-	-	-	-	-	-	-	-	-	240	68	30 cfu/100ml	137	792	461	> 2420
21	70	40	249	135	192	20	2420	344	-	184	238	-	-	-	-	-	39	21	46	22	249	86	579
15	60 cfu/100ml	58	144	74	27	4	770	317	-	121	50	-	-	-	-	-	32	13	30 cfu/100ml	43	101	44	55

Surface Water Samples

Gill						Lough Gill (Dooney Rock)												Surface Water Environmental Quality Standards [5]	Salmonid Water Quality Standard [6]	Drinking Water Parametric Value [7]
28/03/2019	26/08/2020	16/09/2020	13/10/2020	03/11/2020	24/11/2020	30/01/2018	27/02/2018	27/03/2018	23/04/2018	27/08/2018	06/11/2018	07/01/2019	28/03/2019	26/08/2020	16/09/2020	13/10/2020	03/11/2020			
10.2	14.3	15.5	13	7.8	6.2	6.3	4.2	6.9	9.9	14.7	8.7	6.3	9.5	14.6	15.5	13.3	10.1	≤ 1.5 rise outside mixing zone	≤ 1.5 rise outside mixing zone [12]	-
516	ND [3]	ND [3]	ND [3]	ND [3]	ND [3]	177.6	210	201	205	201	ND [3]	227	209	ND [3]	ND [3]	ND [3]	ND [3]	-	-	2750 [14]
7.91	7.3	7.29	7.25	7.04	7.1	7.81	8.17	8.11	7.9	8.18	8.22	8.09	7.77	8.11	8.2	8.07	8.07	> 6 and < 9 (hard water)	≥ 6 and ≤ 9	≥ 6.5 and ≤ 9.5
101	94.2	95.7	93.8	95.1	93.3	95	110.1	102.8	96	95.2	94.1	91.6	100.1	97.1	97.5	98.9	96.7	> 80% and < 120% (95%ile)	-	-
11.35	9.37	9.32	9.27	9.6	9.28	11.76	13.05	12.45	11.83	9.43	9.47	9.07	11.45	9.68	9.72	9.72	9.72	-	50% ≥ 9	-
540	272	542	349	334	-	180	210	195	209	194	141	204	210	235	218	221	211	-	-	2750 [14]
< 3	< 3	3	< 3	3.2	-	< 3	< 3	13.4	< 3	< 3	< 3	< 3	< 3	< 3	3.8	< 3	6	-	≤ 25	-
0.88	1.24	0.72	3.82	0.56	-	0.86	0.65	0.98	0.81	0.28	0.59	2.25	0.91	0.98	0.93	0.29	0.42	-	-	NAC [15]
< 1	13	2	2	< 1	1.5	< 1	< 2	< 1	< 1	< 1	2	< 1	< 1	3	1	1	< 1	≤ 1.5 (mean) or ≤ 2.6 (95%ile) [8]	≤ 5	-
1.8	3.4	8	1.3	< 0.3	-	1.1	6.8	8.7	6.2	4.2	12.4	5.9	6.9	< 0.3	13.1	0.5	< 0.3	-	-	NAC [15]
251	-	-	-	-	-	57.1	78.2	70.9	77.6	67.5	43.8	71.8	87.1	-	-	-	-	-	-	-
74.6	-	-	-	-	-	18.1	25.7	23.1	25.3	21.9	13.4	23.3	28.6	-	-	-	-	-	-	-
15.8	-	-	-	-	-	2.9	3.4	3.2	3.5	3.1	2.5	3.3	3.8	-	-	-	-	-	-	-
43	24	47.5	42	29	-	20.8	17.4	19	19.5	15.8	22	18	22.5	17.5	15.5	30	14	-	-	250
< 2	3.9	35.5	10.8	8.8	-	< 2	5.4	< 2	< 2	< 2	2.3	4	3.1	2.3	5.2	3.2	4.4	-	-	250
18.69	< 4.43	< 4.43	< 4.43	< 4.43	-	4.43	2.78	5.27	2.95	1.62	1.2	< 3.10	< 4.43	4.65	6.51	< 4.43	< 4.43	-	-	50
< 0.08	0.005	< 0.002	< 0.002	< 0.002	-	0.002	0.006	0.004	0.004	0.004	0.01	< 0.08	< 0.08	< 0.002	0.003	< 0.002	< 0.002	-	0.015 [13]	0.152 [13]
0.32	0.03	0.02	0.05	0.03	-	< 0.02	< 0.02	0.02	0.03	0.02	< 0.02	< 0.02	0.29	0.02	< 0.02	0.03	< 0.02	≤ 0.065 (mean) or ≤ 0.14 (95%ile) [8]	0.778 [13]	0.23 [13]
1	0.6	0.11	< 1	< 0.5	-	1.7	< 1	1.2	< 1	< 1	< 1	1	0.6	0.43	0.76	< 1	< 0.5	-	-	-
0.02	< 0.02	0.04	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	0.03	< 0.02	< 0.02	≤ 0.035 (mean) or ≤ 0.075 (95%ile) [8]	-	-
< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.02	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	< 0.12	-	-	-
< 100	200	< 100	< 100	< 100	-	< 100	< 100	< 100	< 100	< 100	100	100	< 100	< 100	< 100	< 100	< 100	-	-	200
< 1	0.75	1	0.55	0.47	-	< 1	< 1	< 2	< 1	< 1	< 1	< 1	< 1	0.46	0.36	0.35	0.39	25 (AA)	-	10
< 230	< 230	< 230	< 230	< 230	-	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	< 230	-	-	1000
< 0.5	< 0.02	< 0.02	< 0.02	< 0.6	-	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.02	< 0.02	< 0.02	< 0.6	0.09 - 0.25 (AA), 0.6 - 1.5 (MAC) [9]	-	5
< 2	< 2	< 2	< 2	< 2	-	< 2	< 2	< 2	< 2	< 2	< 2	5	3	< 2	< 2	< 2	< 2	4.7 (AA), 32 (MAC) [10]	-	50
< 9	< 9	< 9	< 9	< 9	-	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	< 9	5 or 30 [11]	22 or 40 [11]	2000
< 1	0.31	< 0.3	< 0.3	< 0.3	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 0.3	< 0.3	< 0.3	< 0.3	14 (MAC)	-	10
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	-	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05 (AA), 0.07 (MAC)	-	1
5	< 3	< 3	< 3	< 3	-	< 3	< 3	6	< 3	< 3	< 3	< 3	< 3	< 3	4	< 3	< 3	20 (AA)	-	20
< 0.8	< 0.6	0.67	< 0.6	< 0.6	-	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.8	< 0.6	< 0.6	< 0.6	< 0.6	-	-	10
30	< 18	< 18	< 18	< 18	-	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	< 18	50 or 100 [11]	200 or 300 [11]	-
-	< 40	< 20	< 40	< 40	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	-	< 20	< 20	< 40	< 40	-	-	-
< 1	< 1	< 1	< 1	< 1	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	-	-
< 0.02	-	-	-	-	-	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.04	-	-	-	-	-	-	0.1
91	-	-	-	-	-	57	41	0 cfu/100ml	21	> 2420	1414	378	4	-	-	-	-	-	-	0
27	1300	214	206	214	-	22	9	0	9	459	25	4	3	33	12	31	16	-	-	-
17	411	96	108	44	-	5	4	0 cfu/100ml	12	26	24	4	1	16	5	8	4	-	-	0

tms environment ltd

APPENDIX 7-12 KARST FEATURE SURVEY



Karst Feature Survey Map (Google Earth)

Feature No.	1
Feature Type	Turlough (probable)
ITM Coordinates	569255, 832372
Source	Google Earth (December 2006):
	
	Google Earth (March 2020):
	
Additional Information	Area identified in GSI Groundwater Flooding Data Viewer as historically flooded by groundwater, subject of recent study by SCC/OPW

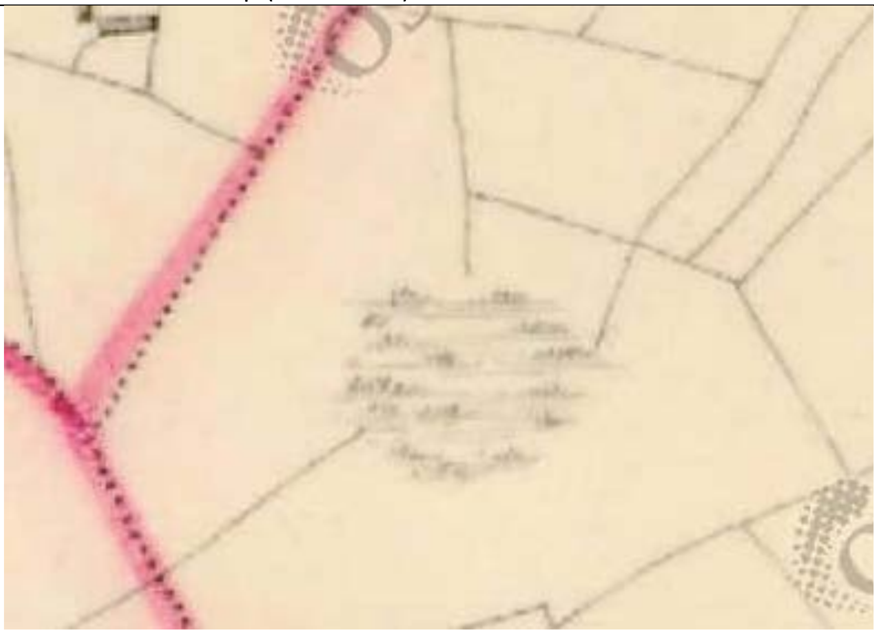
Feature No.	2
Feature Type	Dolines
ITM Coordinates	569255, 832371
Source	Google Earth (December 2006):
	
	Google Earth (March 2020):
	
Additional Information	Dolines flooded, connect to turlough when in flood

Feature No.	3
Feature Type	Enclosed depression
ITM Coordinates	569384, 832315
Source	Google Earth (December 2006):
	
	Google Earth (March 2020):
	
Additional Information	Small circular surface depression visible in aerial photographs, surface water ponding (or groundwater) when wet

Feature No.	4
Feature Type	Flooding depressions (several – one example highlighted)
ITM Coordinates	568978, 832326
Source	Google Earth (December 2006):
	
	Google Earth (March 2020):
	
Additional Information	Several circular/oval depressions in this low-lying area, surface water ponding (or groundwater) when wet, subject of recent study by SCC/OPW

Feature No.	5
Feature Type	Flooding depression
ITM Coordinates	568906, 832030
Source	Google Earth (February 2021):
	
	
Additional Information	Small circular surface depression visible in aerial photographs, surface water ponding (or groundwater) when wet, suggestion from aerial photographs of central hole (estavelle?)

Feature No.	6
Feature Type	Turlough (probable)
ITM Coordinates	570007, 832404
Source	Google Earth (December 2006):
	
	Google Earth (March 2020):
	
Additional Information	Area identified in GSI Groundwater Flooding Data Viewer as historically flooded by groundwater, subject of recent study by SCC/OPW

Feature No.	7
Feature Type	Enclosed depression
ITM Coordinates	570074, 832235
Source	Google Earth (December 2006):
	
	OSI Historical 6” Map (1837-1842):
	
Additional Information	Small elongate depression visible in aerial photographs, c. 25m x 10m, surface water ponding (or groundwater) when wet, possible ephemeral spring draining to low-lying wet area (artificially drained)

Feature No.	8
Feature Type	Excavation (assumed)
ITM Coordinates	569990, 832089
Source	Google Earth (December 2006):
	
	OSI MapGenie Imagery (2013-2018):
	
Additional Information	Two small surface depressions visible in aerial photographs, one elongate (c. 28m x 15m), one circular (c. 17m diameter), geophysical surveying across this field did not identify features in bedrock therefore assumed to be shallow excavations in overburden (not karst related)

<table>
<tr><td>Feature No.</td><td>9</td></tr>
<tr><td>Feature Type</td><td>Excavation (assumed)</td></tr>
<tr><td>ITM Coordinates</td><td>569716, 832144</td></tr>
<tr><td>Source</td><td>Google Earth (December 2006):</td></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td>Google Earth (February 2021):</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Additional Information</td><td>Small surface depression visible in aerial photographs, elongate (c. 26m x 15m), assumed to be shallow excavation in overburden (not karst related), now covered with new GAA pitch</td></tr>
</table>

Feature No.	10
Feature Type	Excavation (assumed)
ITM Coordinates	569506, 832195
Source	Google Earth (December 2006):
	
	Google Earth (February 2021):
	
Additional Information	Small surface depression visible in aerial photographs, circular (c. 25m diameter), assumed to be shallow excavation in overburden (not karst related)

Feature No.	11
Feature Type	Excavation (assumed)
ITM Coordinates	569254, 831800
Source	OSI Digital Globe 2011-2013:
	
	OSI MapGenie Imagery (2013-2018):
	
	Google Earth (February 2021):
	
Additional Information	Small surface depression visible in aerial photographs, elongate (c. 38m x 18m), assumed to be shallow excavation in overburden (not karst related)

APPENDIX 7-13 GROUNDWATER BODY DESCRIPTIONS (GSI)

Carrowmore East GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
35 Sligo/Leitrim Co. Co.'s.	**Rivers**: Bonet, Garavoge, Diffreen **Lakes**:, Gill, Anelteen, Doon, Colgagh, Black, Keelogyboy, Stramore	Cummeen Strand / Drumcliff Bay (000627), Colgagh Lough (001658), Lough Gill (001976).	58

Topography		The GWB occupies an area around L. Gill. The land surface is characterised by an upland area to the east which slopes toward L. Gill and the coast. Elevations range from 10-435 mAOD. The GWB is bounded to the south and east by the Dromahair GWB and L. Gill. The northern and western boundaries are topographic highs which act as surface water catchment divides. Figure 1 illustrates the location and boundaries.
Geology and Aquifers	**Aquifer categories**	**Rk^c:** Regionally important karstified aquifer dominated by conduit flow. The 'c' signifies conduit flow.
	Main aquifer lithologies	Dinantian Pure Bedded Limestones
	Key structures	The GWB is located to the north of the Ox Mountain Inlier. A major NE-SW trending fault (Ox Mountains-Pettigoe Fault) bounds the southern side of the GWB. A syncline runs through the GWB with the rocks on both limbs dipping approximately 5^o. A steep normal fault trending almost E-W belonging to the Cuilcagh-Manorhamilton-Rosses point fault zone cuts into the GWB just north of the Sligo-Manohamilton road.
	Key properties	Karstification is widespread throughout, and recorded features include swallow holes, caves and springs. Caves are particularly prevalent north of L. Gill. Yield data are sparse, there is 1 "good" (100-400 m^3/d) well present. Drilling carried out in the early 1970's by the GSI to locate high yielding wells was unsuccessful (Daly, 1975). Transmissivities are expected to variable, ranging from 1 to greater than 2000 m^2/d. Storativity is likely to be low - approximately 0.01-0.02. A tracer test was carried out in the neighbouring Carrowmore West GWB (Higgins, 1987). No groundwater velocities are reported but are expected to be in the order of 20-50 m/hr. General flow directions are likely to be to the west and north west under hydraulic gradients that are expected to be greater than 0.0005 on the low lying areas and greater than 0.005 on the upland areas.
	Thickness	Most groundwater flow is likely to be in an epikarstic layer a couple of metres thick and in a zone of interconnected solutionally-enlarged fissures and conduits that extends approximately 30 m below this. Deeper inflows can occur in areas associated with faults or dolomitisation.
Overlying Strata	**Lithologies**	Data are available for the western 2/3 of the GWB. Till is the dominant subsoil type.
	Thickness	Data are sparse, with thickness between 0-10 m. Rock outcrops are distributed on the upland areas.
	% area aquifer near surface	*[Information to be added at a later date]*
	Vulnerability	*[Information to be added at a later date]*
Recharge	**Main recharge mechanisms**	Both point and diffuse recharge occur. Diffuse recharge occurs via rainfall percolating through permeable subsoil and rock outcrops. Point recharge to the underlying aquifer occurs by means of swallow holes and caves. There are no surface outlets from the smaller lakes within the GWB, and it is assumed that there is recharge to the underlying aquifer.
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	**Large springs and high yielding wells (m^3/d)**	None identified
	Main discharge mechanisms	The main discharges are to springs, streams, rivers and lakes.
	Hydrochemical Signature	The groundwater is likely to have $CaHCO_3$ signature. Data from the adjoining Carrowmore West GWB is given below for six samples. Alkalinity (mg/l as $CaCO_3$): 113-163. Total Hardness (mg/l): 302-430. Conductivity (μS/cm): 580-725.

Groundwater Flow Paths	These rocks are generally devoid of intergranular permeability. Groundwater flows through fissures, faults, joints and bedding planes. In pure bedded limestones these openings are enlarged by karstification which significantly enhances the permeability of the rock. Karstification can be accentuated along structural features such as fold axes and faults. Groundwater flow through karst areas is extremely complex and difficult to predict. As flow pathways are often determined by discrete conduits, actual flow directions will not necessarily be perpendicular to the assumed water table contours. Groundwater can flow across surface water catchment divides and beneath surface water channels as evidenced by a tracer test carried out in the Carrowmore area by Higgins (1987). Flow velocities can be rapid and variable, both spatially and temporally. Rapid groundwater flow velocities indicate that a large proportion of groundwater flow takes place in enlarged conduit systems. Overall groundwater flow will be towards L. Gill, but the karstified nature of the bedrock means that locally, groundwater flow directions can be highly variable.
Groundwater & Surface water interactions	Generally, there is a high degree of interconnection between groundwater and surface water in karstified limestone areas. The karst features represent the close interaction between surface water and groundwater. Any contamination of surface water is rapidly transported into the groundwater system, and vice versa.

Conceptual model

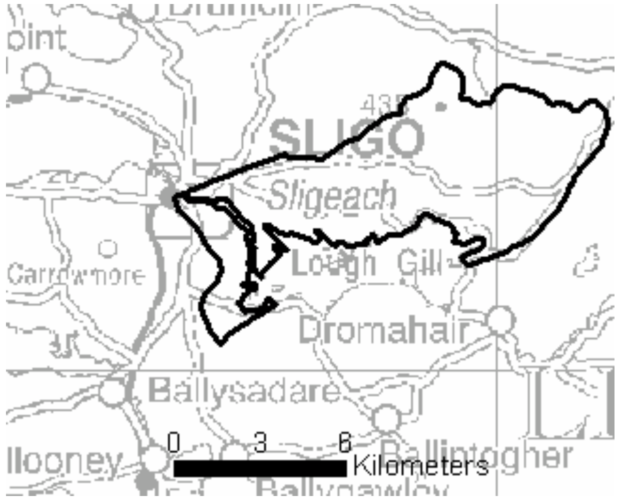
- The GWB occupies an area around L. Gill. The land surface is characterised by an upland area to the east which slopes toward L. Gill and the coast. Elevations range from 10-435 mAOD.
- The GWB is bounded to the south and east by the Dromahair GWB and L. Gill. The northern and western boundaries are topographic highs which act as surface water catchment divides.
- The aquifer is a Regionally important karstified aquifer (**Rk**^{c}).
- Several karst features are recorded, most notably caves.
- Transmissivities are expected to be variable, ranging from 1 to greater than 2000 m^2/d. Storativity is likely to be in the range of 1-2%.
- Most groundwater flux is likely to be in the upper part of the aquifer.
- Till is the dominant subsoil type.
- Recharge occurs via point and diffuse mechanisms. Point recharge to the underlying aquifer occurs by means of swallow holes.
- The main discharges are to springs, streams, rivers and lakes.
- The groundwater has a calcium bicarbonate signature.
- There is a high degree of interconnection between groundwater and surface water.

Attachments	Table 1 and Figure 1.
Instrumentation	**Stream gauge:** None **EPA Water Level Monitoring boreholes:** None **EPA Representative Monitoring points:** None
Information Sources	Daly, E. (1975) *Report on the groundwater potential of the area around Sligo town*. Geological Survey of Ireland. Higgins, T. (1987) *An Assessment of the Impact of Human activity on groundwater quality in th eCarrowmore area of County Sligo*. BSc thesis. Sligo Regional Technical College. MacDermot, C.V. Long C.B. and Harney S.J (1996) *Geology of Sligo-Leitrim: A geological description of Sligo, Leitrim and adjoining parts of Cavan, Fermanagh, Mayo and Roscommon, to accompany bedrock geology 1:100,000 scale map, Sheet 7, Sligo - Leitrim*. With contributions from K. Carlingbold, G. Stanley, D. Daly and R. Meehan. Geological Survey of Ireland, 100pp. Thorn, R., Drew, D. and Coxon, C. (1990). *The Hydrology and Caves of the Geevagh and Bricklieve Karsts, Co. Sligo. Irish Geography* 23(2) (1990) 120-135. Geographical Society of Ireland, Dublin. Thorn, R. (1987). The Geevagh Karst. *Irish Speleology*. Journal of the Speleological Union of Ireland. Vol. 4 No. 1 1987. Thorn, R., Doyle, M., Henry, H. (1986). *The Groundwater Resources of South County Sligo – A Preliminary Appraisal*. Sligo Regional Techincal College. Report Number 86/1. ISBN 0 948870 01 X.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae.

Table 1. List of Rock units in GWB

Abbeytown Limestone (BSab)	Crinoidal Calcarenite	Dinantian Pure Bedded Limestones	Rkc
Ballyshannon Limestone Formation (BS)	Pale grey calcarenite limestone	Dinantian Pure Bedded Limestones	Rkc
Dartry Limestone Formation (DA)	Dark fine-grained cherty limestone	Dinantian Pure Bedded Limestone	Rkc

Figure 1 Location and boundaries of GWB.



Carrowmore West GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
35 Sligo Co. Co.	**Rivers**: Ballysodare. **Lakes**: Pollanima, Punchbowl, Cloverhill, Corhawnagh, Cooney, Doonyneill.	Ballysadare Bay (000622), Corhawnagh Lough (001902)	37

Topography		The GWB occupies an area on the eastern side of Ballysadare Bay. The GWB includes an area that includes Ballysadare due its proximity and similar aquifer properties. The land surface is generally low lying apart from Knocknarea, a hill on the northwestern side of the GWB. Elevations range from 0-327 mAOD. The GWB is bounded to the west by the coast. The northern and southern boundaries are the poor aquifers of the Collooney and Strandhill GWB's. Figure 1 illustrates the location and boundaries. Surface drainage is minimal, with some streams located to the southern side of the GWB.
Geology and Aquifers	**Aquifer categories**	**Rk^c:** Regionally important karstified aquifer dominated by conduit flow. The 'c' signifies conduit flow.
	Main aquifer lithologies	Dinantian Pure Bedded Limestones, Dinantian Pure Unbedded Limestones.
	Key structures	The GWB is located to the north of the Ox Mountain Inlier. A major NE-SW trending fault (Ox Mountains-Pettigoe Fault) bounds the southern side of the GWB. A syncline runs through the GWB with the rocks on both limbs dipping approximately 5^o.
	Key properties	Karstification is widespread, and recorded features include swallow holes and springs. Drilling carried out in the early 1970's by the GSI to locate high yielding wells was unsuccessful (Daly, 1975). However, spring yields (Tobernaveen and Carrowgobadh) are estimated to be in the order of 30,000 m^3/d in total (Higgins, 1987). Transmissivities are expected to be variable, ranging from 1 to greater than 2000 m^2/d. Storativity is expected to be low - approximately 0.01-0.02. Positive traces are reported between the Tonesfortes sink and the Tobernaveen and Carrowgobadh springs (Higgins, 1987). However, no groundwater velocities are reported but are expected to be in the order of 20-50 m/hr. General flow directions are likely to be to the north and west under hydraulic gradients that are expected to be greater than 0.0005.
	Thickness	Most groundwater is likely to be in an epikarstic layer a couple of metres thick and in a zone of interconnected solutionally-enlarged fissures and conduits that extends approximately 30 m below this. Deeper inflows can occur in areas associated with faults or dolomitisation.
Overlying Strata	**Lithologies**	Till is the dominant subsoil type.
	Thickness	Data are sparse (n=3) and indicate that the thickness are less than 3 m.
	% area aquifer near surface	*[Information to be added at a later date]*
	Vulnerability	*[Information to be added at a later date]*
Recharge	**Main recharge mechanisms**	Both point and diffuse recharge occur. Diffuse recharge occurs via rainfall percolating through permeable subsoil and rock outcrops. Point recharge to the underlying aquifer occurs by means of swallow holes.
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	**Large springs and high yielding wells (m^3/d)**	Tobernaveen and Carrowgobadh springs are estimated to yield in the order of 30,000 m^3/d (Higgins, 1987).
	Main discharge mechanisms	The main discharges are to springs, streams, rivers and lakes.
	Hydrochemical Signature	The groundwater is very hard and has $CaHCO_3$ signature. Higgins (1987) carried out water sampling and the results for selected parameters are given below for six samples. Elevated chloride indicate that the groundwater is brackish (Higgins, 1987). Alkalinity (mg/l as $CaCO_3$): 113-163. Total Hardness (mg/l): 302-430. Conductivity (μS/cm): 580-725. Chloride (mg/l): 24-35.

Groundwater Flow Paths	These rocks are generally devoid of intergranular permeability. Groundwater flows through fissures, faults, joints and bedding planes. In pure bedded limestones these openings are enlarged by karstification which significantly enhances the permeability of the rock. Karstification can be accentuated along structural features such as fold axes and faults. Groundwater flow through karst areas is extremely complex and difficult to predict. As flow pathways are often determined by discrete conduits, actual flow directions will not necessarily be perpendicular to the assumed water table contours. Groundwater can flow across surface water catchment divides and beneath surface water channels. A tracer test carried out by Higgins (1987) illustrates that the positive trace from Tonafortes sink to Carrowgobadh spring crosses a surface water catchment. Flow velocities can be rapid and variable, both spatially and temporally. Rapid groundwater flow velocities indicate that a large proportion of groundwater flow takes place in enlarged conduit systems. Flow path lengths can be up to a several kilometres in length. Overall groundwater flow will be towards the rivers and lakes, generally to the west toward L. Gill, but the karstified nature of the bedrock means that locally, groundwater flow directions can be highly variable.
Groundwater & Surface water interactions	Generally, there is a high degree of interconnection between groundwater and surface water in karstified limestone areas. The karst features represent the close interaction between surface water and groundwater. Any contamination of surface water is rapidly transported into the groundwater system, and vice versa.

Conceptual model

- The GWB occupies an area on the eastern side of Ballysadare Bay. The GWB includes an area that includes Ballysadare due its proximity and similar aquifer properties. The land surface is generally low lying apart from Knocknarea, a hill on the northwestern side of the GWB. Elevations range from 0-327 mAOD.
- The GWB is bounded to the west by the coast. The northern and southern boundaries are the poor aquifers of the Collooney and Strandhill GWB's.
- The aquifer is a Regionally important karstified aquifer (**Rk**^{c}).
- Several karst features are recorded.
- Transmissivities are expected to be variable, ranging from 1 to greater than 2000 m^2/d. Storativity is likely to be in the range of 1-2%.
- Most groundwater flux is likely to be in the upper part of the aquifer.
- Till is the dominant subsoil type.
- Recharge occurs via point and diffuse mechanisms. Point recharge to the underlying aquifer occurs by means of swallow holes.
- The main discharges are to springs, streams, rivers and lakes.
- The groundwater has a calcium bicarbonate signature.
- There is a high degree of interconnection between groundwater and surface water.

Attachments	Table 1 and Figure 1.
Instrumentation	**Stream gauge:** 35039, 35040, 35041. **EPA Water Level Monitoring boreholes:** None **EPA Representative Monitoring points:** None
Information Sources	Daly, E. (1975) *Report on the groundwater potential of the area around Sligo town*. Geological Survey of Ireland. Higgins, T. (1987) *An Assessment of the Impact of Human activity on groundwater quality in the Carrowmore area of County Sligo*. BSc thesis. Sligo Regional Technical College. MacDermot, C.V. Long C.B. and Harney S.J (1996) *Geology of Sligo-Leitrim: A geological description of Sligo, Leitrim and adjoining parts of Cavan, Fermanagh, Mayo and Roscommon, to accompany bedrock geology 1:100,000 scale map, Sheet 7, Sligo - Leitrim*. With contributions from K. Carlingbold, G. Stanley, D. Daly and R. Meehan. Geological Survey of Ireland, 100pp. Thorn, R., Drew, D. and Coxon, C. (1990). *The Hydrology and Caves of the Geevagh and Bricklieve Karsts, Co. Sligo. Irish Geography* 23(2) (1990) 120-135. Geographical Society of Ireland, Dublin. Thorn, R. (1987). The Geevagh Karst. *Irish Speleology*. Journal of the Speleological Union of Ireland. Vol. 4 No. 1 1987. Thorn, R., Doyle, M., Henry, H. (1986). *The Groundwater Resources of South County Sligo – A Preliminary Appraisal*. Sligo Regional Techincal College. Report Number 86/1. ISBN 0 948870 01 X.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae.

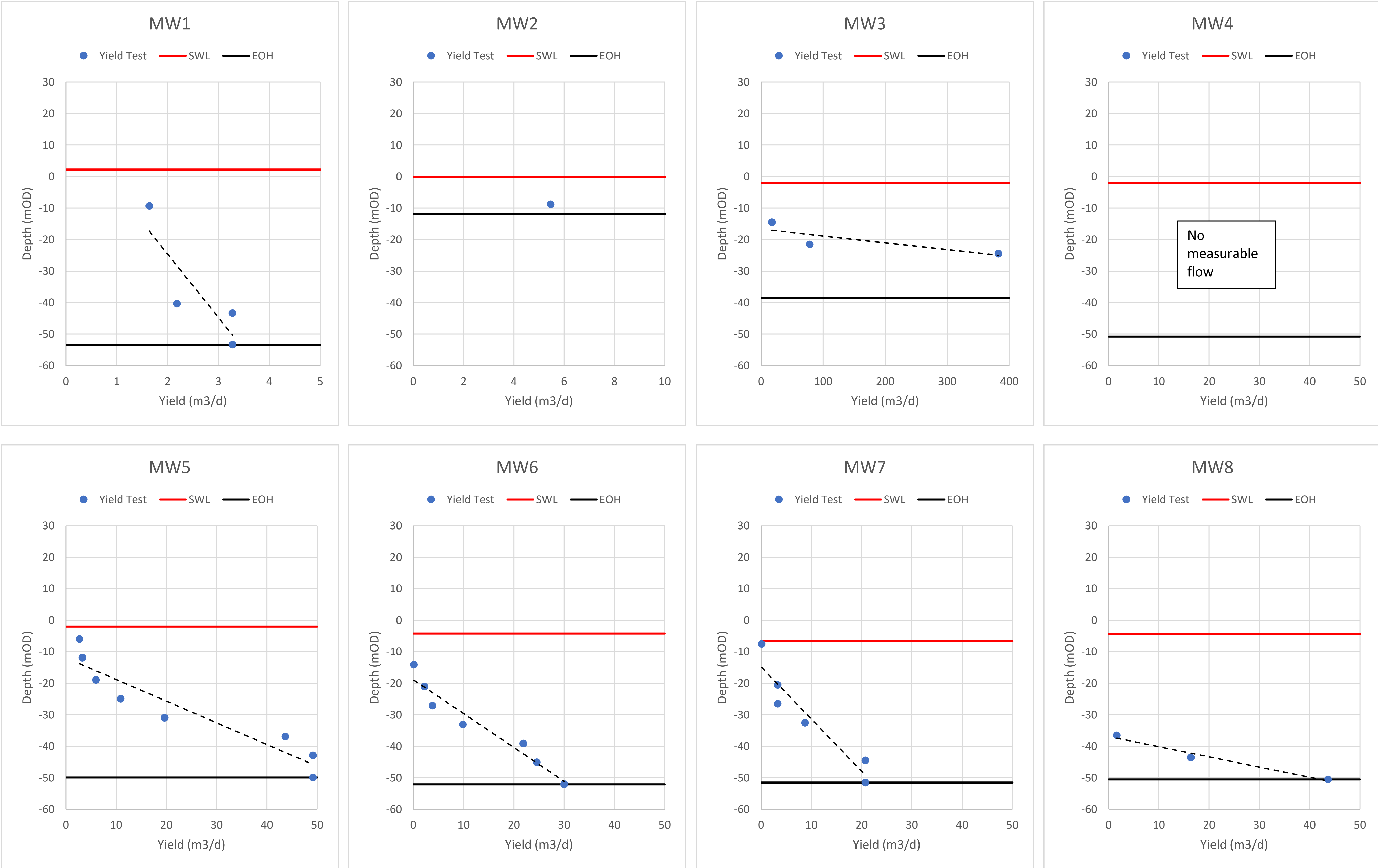
Table 1. Rock units in GWB.

Rock unit name and code	Description	Rock unit group	Aquifer Classification
Dartry Limestone Formation (DA)	Dark fine-grained cherty limestone	Dinantian Pure Bedded Limestone	Rkc
Dartry Limestone Formation and Mudbank Limestone	Dark fine-grained cherty limestone	Dinantian Pure Unbedded Limestone	Rkc

Figure 1 Location and Boundaries of GWB.

APPENDIX 7-14 YIELD TEST RESULTS

Yield Test Results



SWL - Static Water Level
EOH - End of Hole

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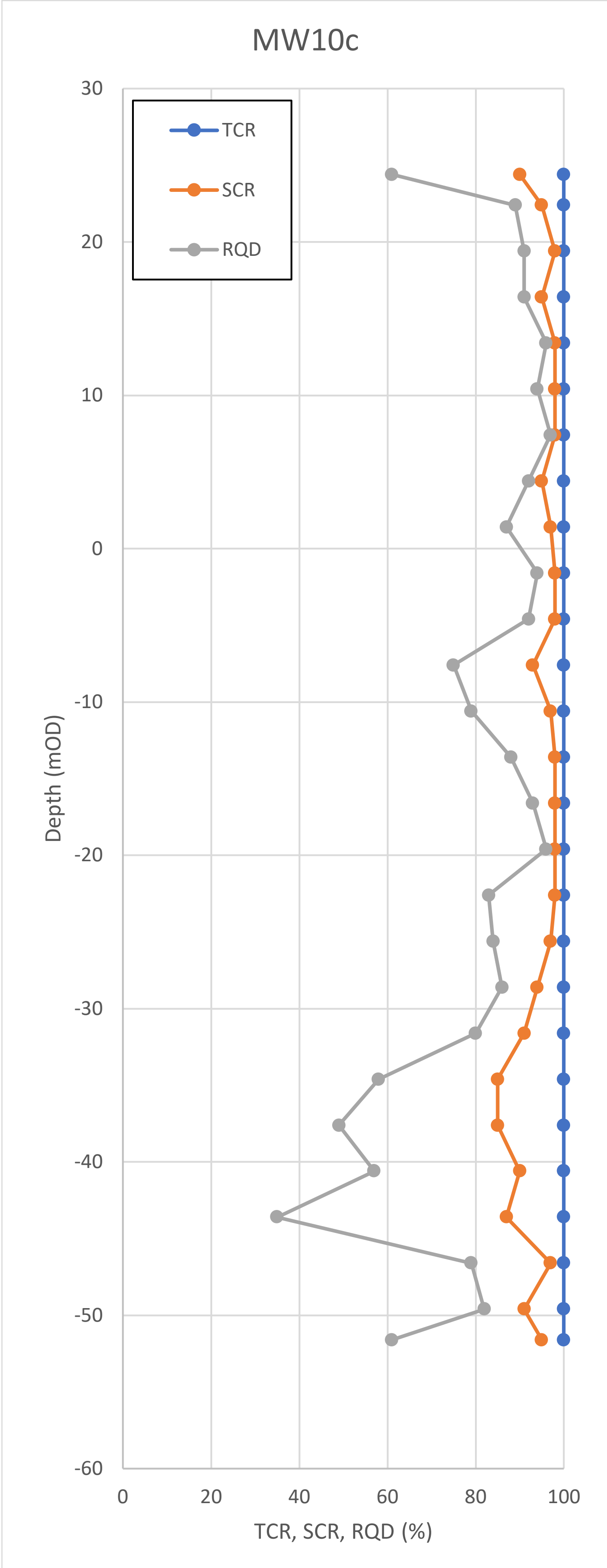
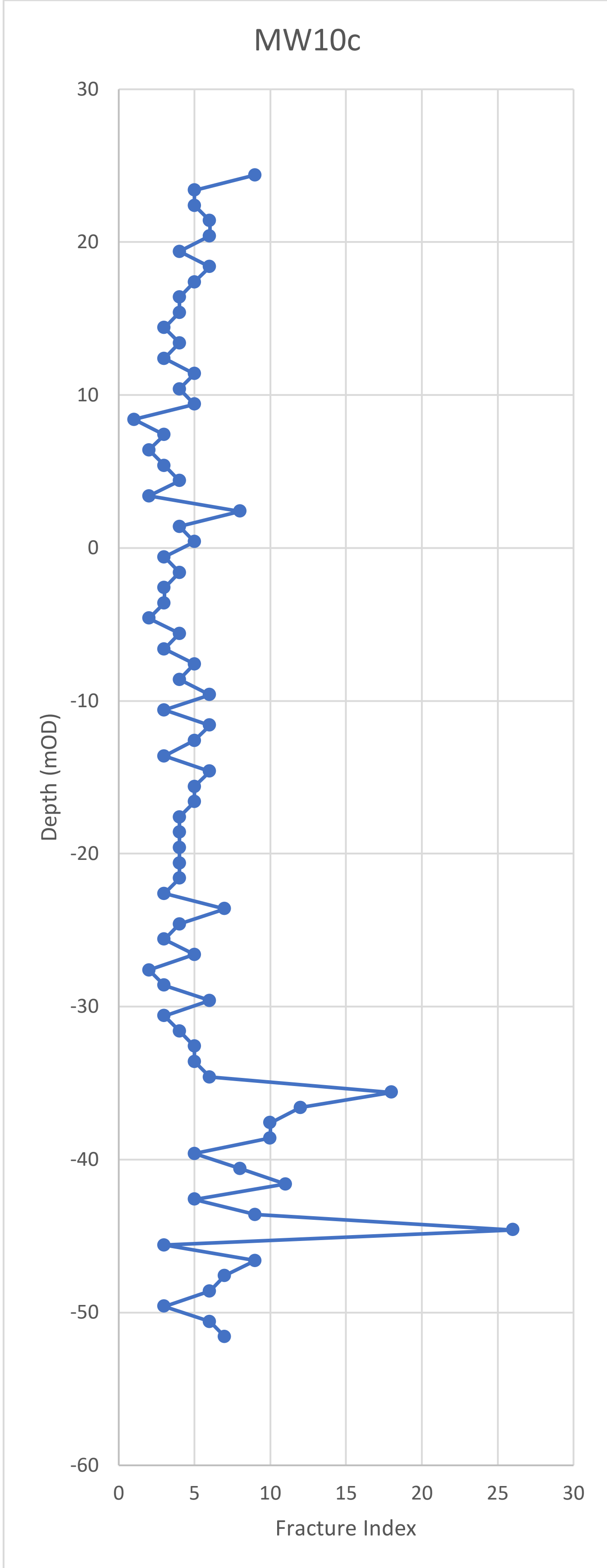
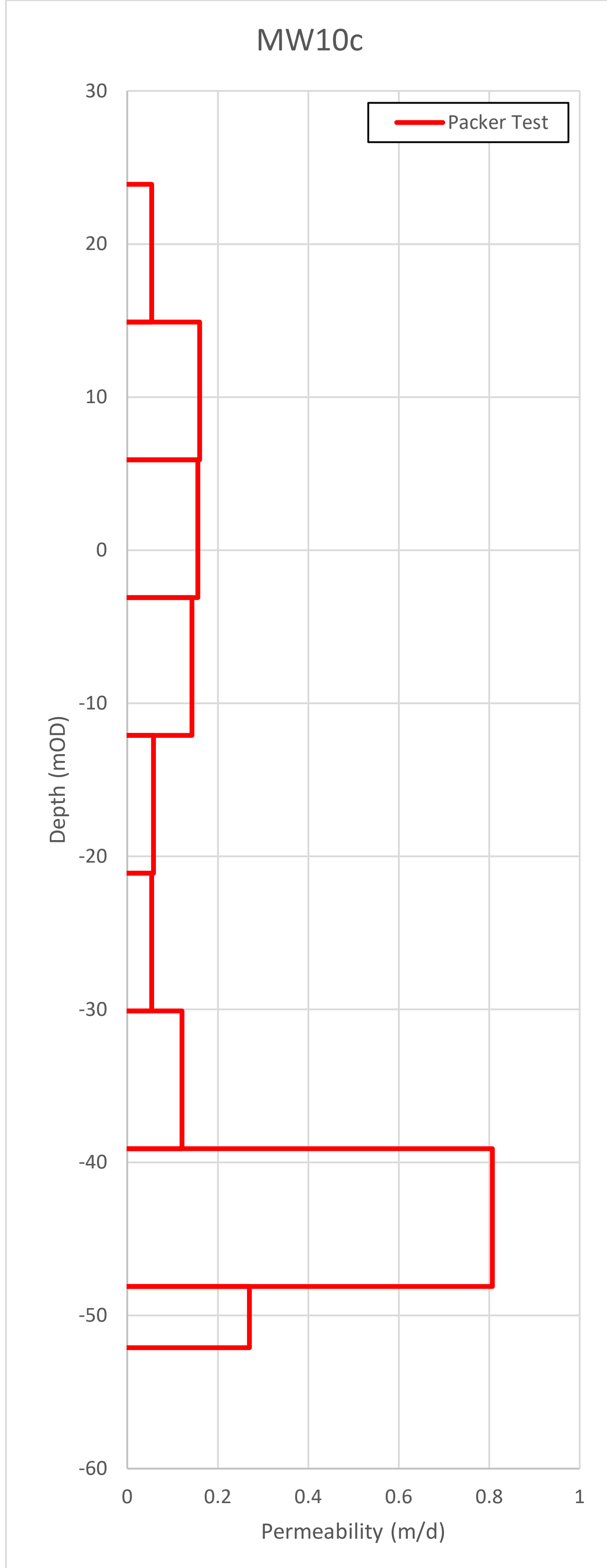
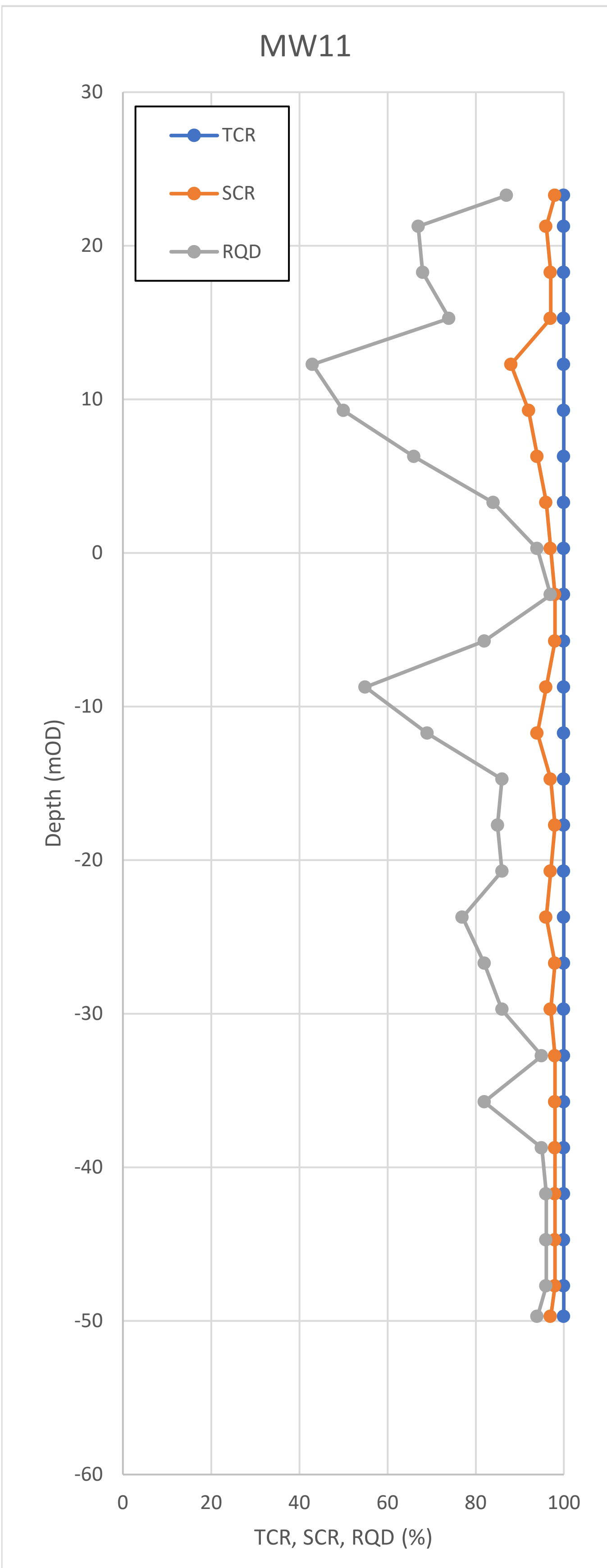
APPENDIX 7-15 COREHOLE RESULTS

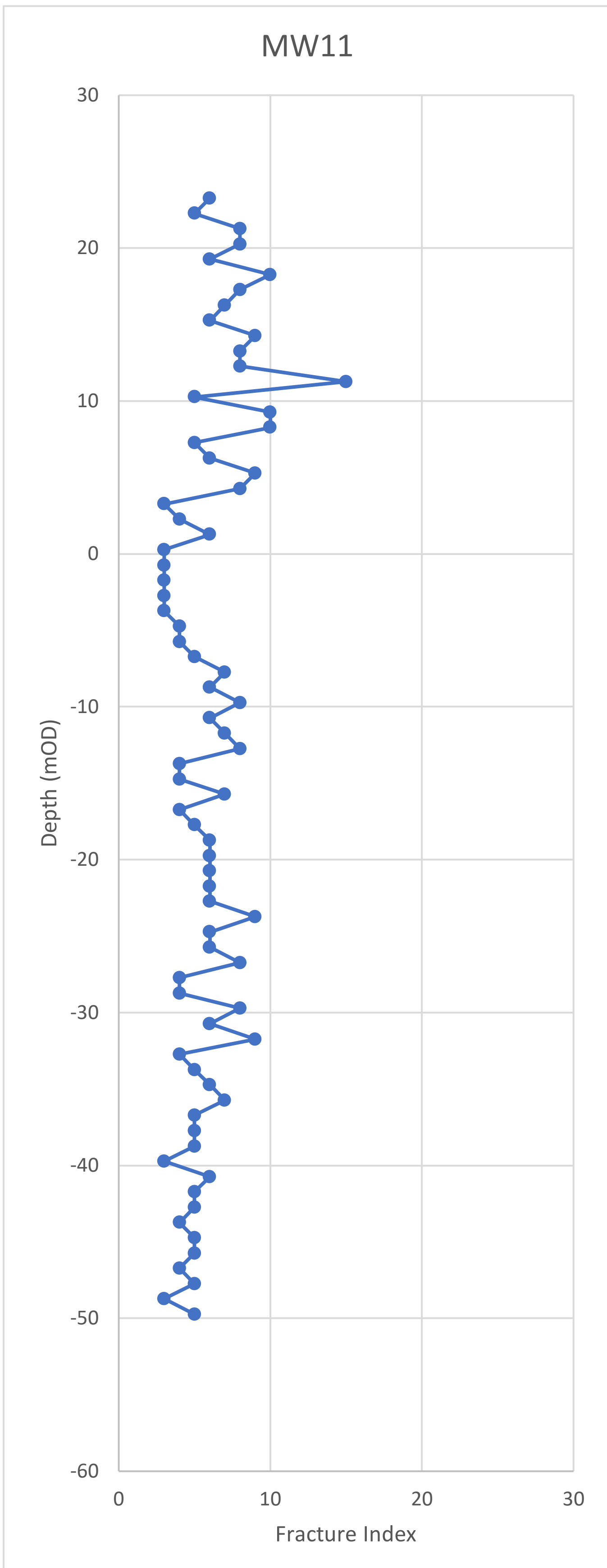
Corehole Results

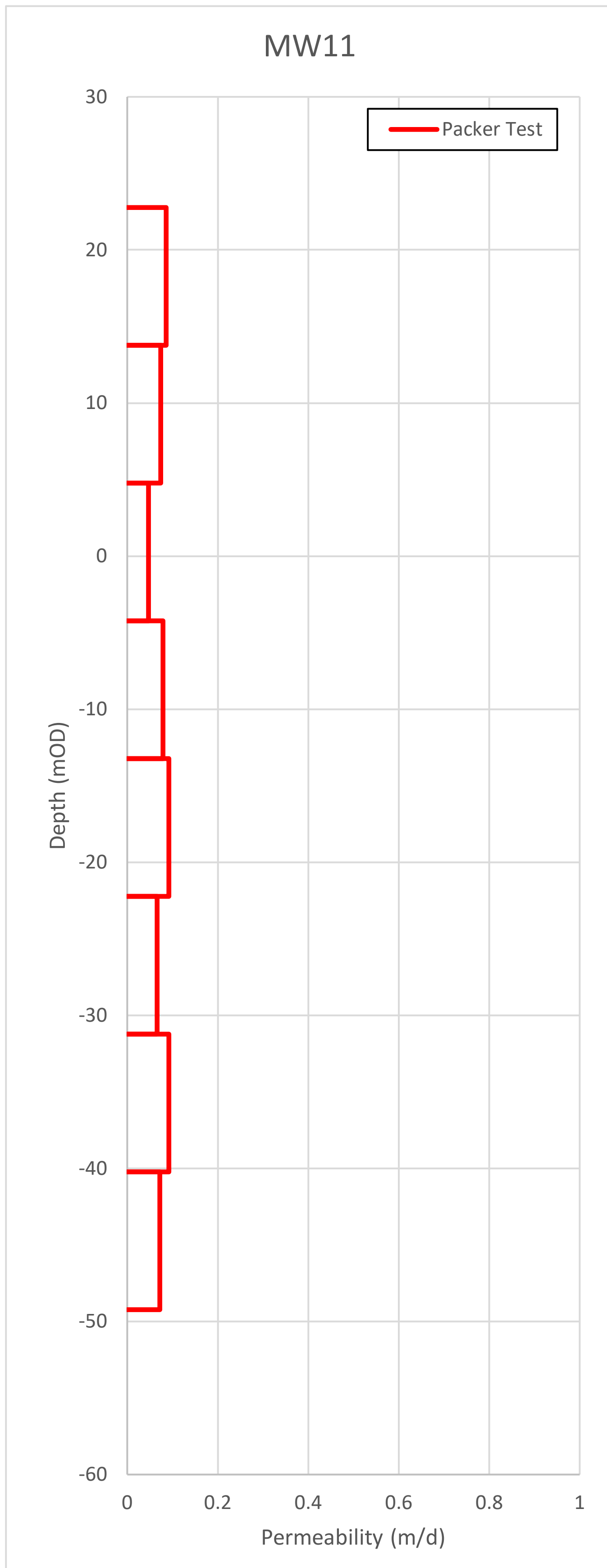












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PACKER TEST RESULTS

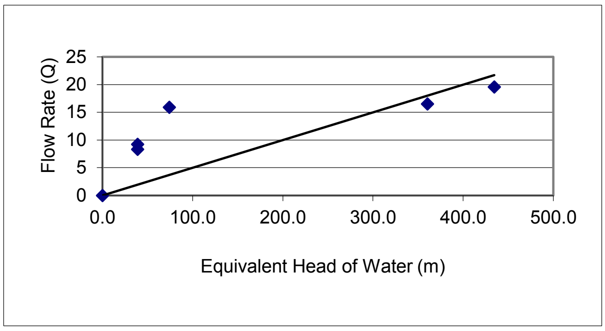
Contract:	Aghamore	Top of test section (m bgl)	4
Client:	Lagan	Bottom of test section (m bgl)	13
Engineer:	TMS Environmental	Centre of test section (m bgl)	8.5
Borehole:	**MW 10c**	Length of test section (m bgl)	9
Bh. size:	NQ	Pressure gauge height (m agl)	0.2
Date:	18/07/2017	Initial depth to G.W. (m bgl)	3.7
Packer Type:	Single	Packer inflation pressure (psi)	290

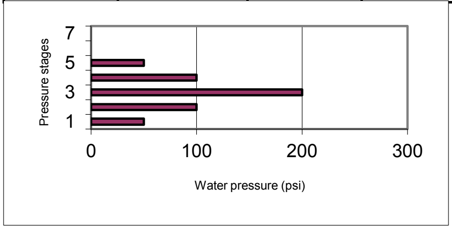
1. Site Records

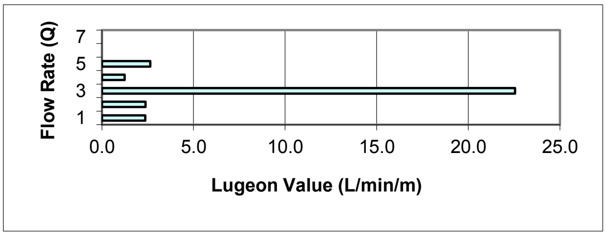
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	8375	8415	8458	8500	40	43	42	125
2	100	8521	8599	8679	8760	78	80	81	239
3	200	8676	8773	8872	8970	97	99	98	294
4	100	8982	9065	9147	9230	83	82	83	248
5	50	9241	9286	9333	9380	45	47	47	139

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	39.1	8.3	*2.4*
2	74.3	15.9	*2.4*
3	434.5	19.6	*22.6*
4	360.4	16.5	*1.2*
5	39.1	9.3	*2.6*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 6.24L

k (m/sec) 6.24E-07

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 10c
Bh. size: NQ
Date: 19/07/2017
Packer Type: Single

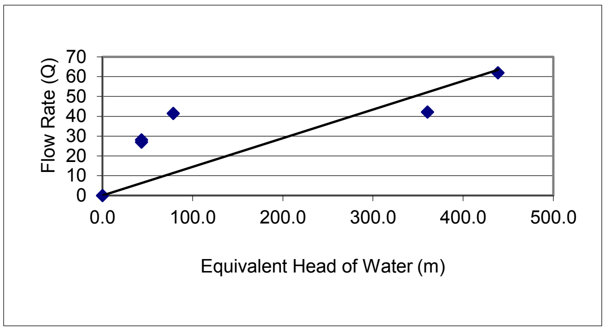
Top of test section (m bgl)	13
Bottom of test section (m bgl)	22
Centre of test section (m bgl)	17.5
Length of test section (m bgl)	9
Pressure gauge height (m agl)	0.2
Initial depth to G.W. (m bgl)	7.8
Packer inflation pressure (psi)	290

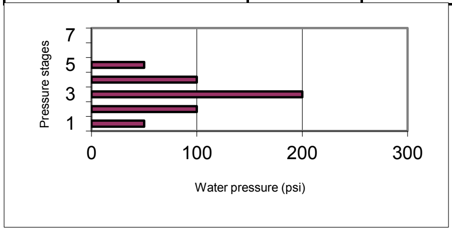
1. Site Records

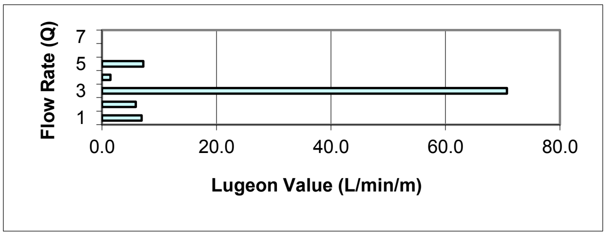
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	400	532	667	804	132	135	137	404
2	100	820	1025	1233	1443	205	208	210	623
3	200	1460	1767	2080	2391	307	313	311	931
4	100	2410	2621	2831	3042	211	210	211	632
5	50	3060	3202	3342	3482	142	140	140	422

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	43.2	26.9	*6.9*
2	78.4	41.5	*5.9*
3	438.6	62.1	*70.8*
4	360.4	42.1	*1.5*
5	43.2	28.1	*7.2*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 18.46L

k (m/sec) 1.85E-06

PACKER TEST RESULTS

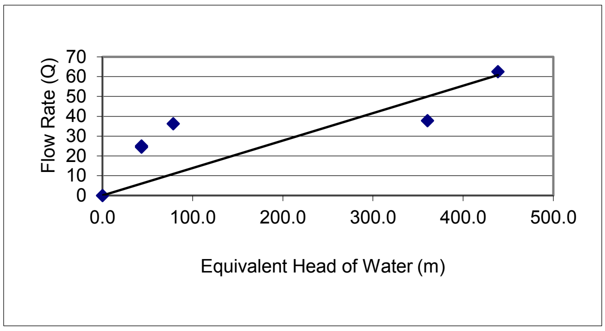
Contract:	Aghamore	Top of test section (m bgl)	22
Client:	Lagan	Bottom of test section (m bgl)	31
Engineer:	TMS Environmental	Centre of test section (m bgl)	26.5
Borehole:	**MW 10c**	Length of test section (m bgl)	9
Bh. size:	NQ	Pressure gauge height (m agl)	0.2
Date:	19/07/2017	Initial depth to G.W. (m bgl)	7.8
Packer Type:	Single	Packer inflation pressure (psi)	290

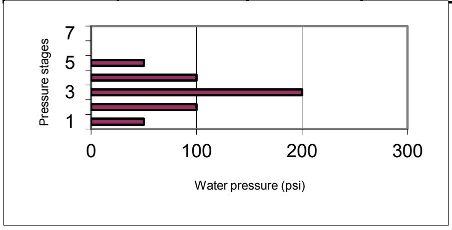
1. Site Records

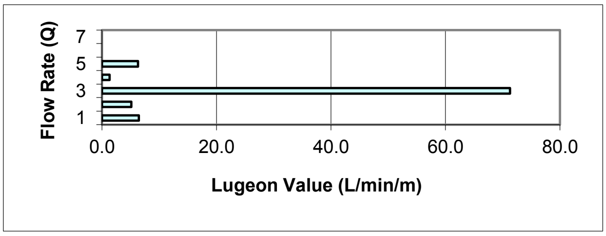
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	390	510	633	766	120	123	133	376
2	100	790	972	1153	1335	182	181	182	545
3	200	1350	1660	1975	2288	310	315	313	938
4	100	2300	2488	2678	2867	188	190	189	567
5	50	2880	3003	3126	3248	123	123	122	368

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	43.2	25.1	*6.4*
2	78.4	36.3	*5.1*
3	438.6	62.5	*71.3*
4	360.4	37.8	*1.3*
5	43.2	24.5	*6.3*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 18.08L

k (m/sec) 1.81E-06

PACKER TEST RESULTS

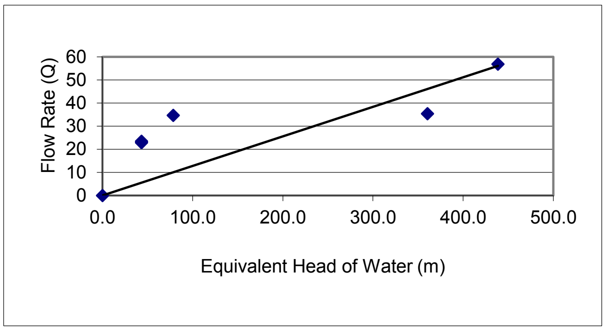
Contract:	Aghamore	Top of test section (m bgl)	31
Client:	Lagan	Bottom of test section (m bgl)	40
Engineer:	TMS Environmental	Centre of test section (m bgl)	35.5
Borehole:	**MW 10c**	Length of test section (m bgl)	9
Bh. size:	NQ	Pressure gauge height (m agl)	0.2
Date:	20/07/2017	Initial depth to G.W. (m bgl)	7.8
Packer Type:	Single	Packer inflation pressure (psi)	290

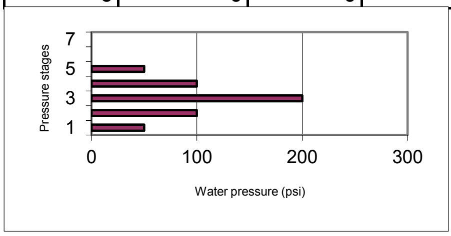
1. Site Records

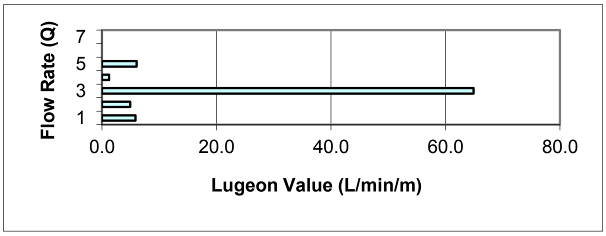
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	3260	3372	3487	3603	112	115	116	343
2	100	3615	3787	3962	4136	172	175	174	521
3	200	4145	4428	4714	4999	283	286	285	854
4	100	5010	5185	5364	5542	175	179	178	532
5	50	5550	5669	5786	5903	119	117	117	353

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	43.2	22.9	*5.9*
2	78.4	34.7	*4.9*
3	438.6	56.9	*64.9*
4	360.4	35.5	*1.3*
5	43.2	23.5	*6.1*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 16.62L

k (m/sec) 1.66E-06

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 10c
Bh. size: NQ
Date: 20/07/2017
Packer Type: Single

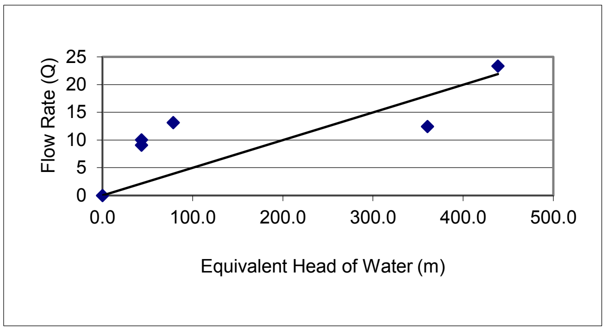
Top of test section (m bgl)	40
Bottom of test section (m bgl)	49
Centre of test section (m bgl)	44.5
Length of test section (m bgl)	9
Pressure gauge height (m agl)	0.2
Initial depth to G.W. (m bgl)	7.8
Packer inflation pressure (psi)	290

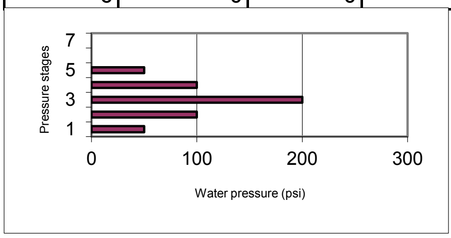
1. Site Records

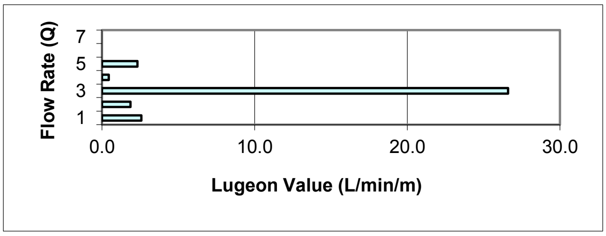
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	5920	5970	6021	6071	50	51	50	151
2	100	6080	6147	6212	6277	67	65	65	197
3	200	6285	6401	6519	6635	116	118	116	350
4	100	6640	6704	6766	6827	64	62	61	187
5	50	6835	6881	6926	6971	46	45	45	136

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	43.2	10.1	*2.6*
2	78.4	13.1	*1.9*
3	438.6	23.3	*26.6*
4	360.4	12.5	*0.4*
5	43.2	9.1	*2.3*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 6.76L

k (m/sec) 6.76E-07

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 10c
Bh. size: NQ
Date: 20/07/2017
Packer Type: Single

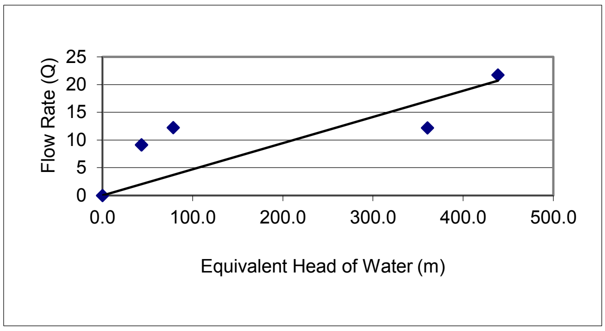
Top of test section (m bgl)	49
Bottom of test section (m bgl)	58
Centre of test section (m bgl)	53.5
Length of test section (m bgl)	9
Pressure gauge height (m agl)	0.2
Initial depth to G.W. (m bgl)	7.8
Packer inflation pressure (psi)	290

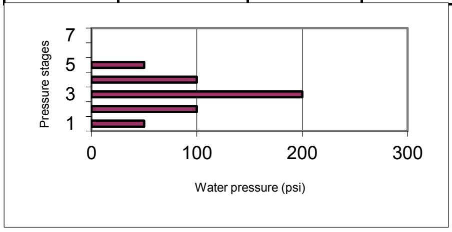
1. Site Records

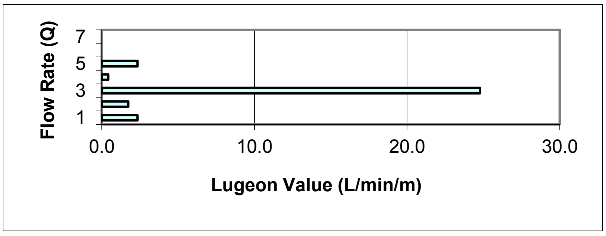
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	6990	7037	7082	7127	47	45	45	137
2	100	7140	7203	7264	7324	63	61	60	184
3	200	7350	7457	7567	7676	107	110	109	326
4	100	7690	7751	7813	7873	61	62	60	183
5	50	7890	7936	7981	8027	46	45	46	137

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	43.2	9.1	*2.3*
2	78.4	12.3	*1.7*
3	438.6	21.7	*24.8*
4	360.4	12.2	*0.4*
5	43.2	9.1	*2.3*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 6.30L

k (m/sec) 6.30E-07

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 10c
Bh. size: NQ
Date: 21/07/2017
Packer Type: Single

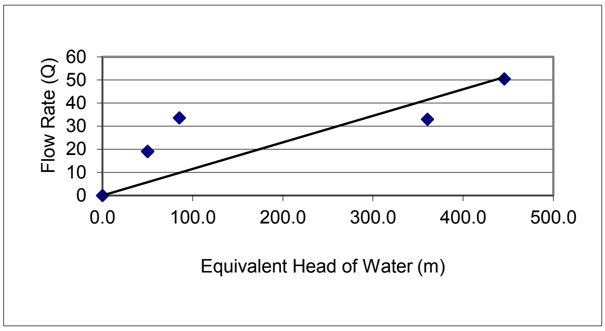
Top of test section (m bgl)	58
Bottom of test section (m bgl)	67
Centre of test section (m bgl)	62.4
Length of test section (m bgl)	9
Pressure gauge height (m agl)	0.2
Initial depth to G.W. (m bgl)	14.7
Packer inflation pressure (psi)	290

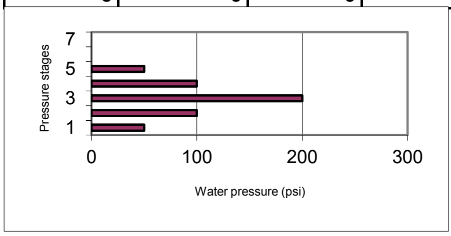
1. Site Records

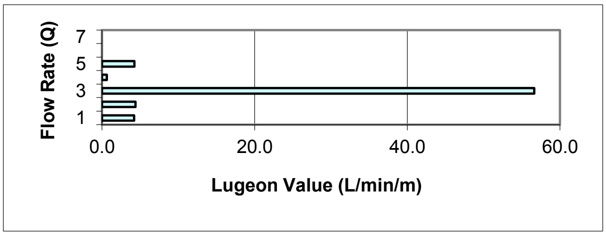
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	8050	8146	8241	8336	96	95	95	286
2	100	8345	8515	8683	8850	170	168	167	505
3	200	8870	9121	9374	9627	251	253	253	757
4	100	9640	9805	9971	10135	165	166	164	495
5	50	80140	80234	80331	80427	94	97	96	287

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	50.1	19.1	*4.2*
2	85.3	33.7	*4.4*
3	445.5	50.5	*56.6*
4	360.4	33.0	*0.6*
5	50.1	19.1	*4.2*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 14.00L

k (m/sec) 1.40E-06

PACKER TEST RESULTS

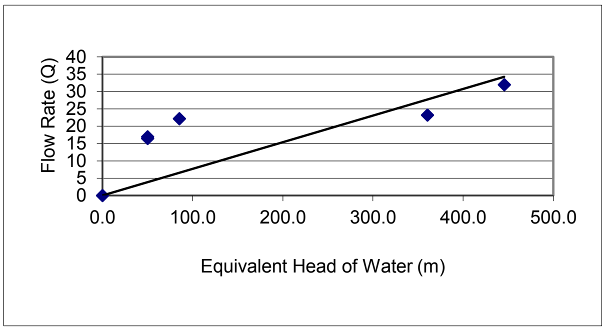
Contract:	Aghamore	Top of test section (m bgl)	67
Client:	Lagan	Bottom of test section (m bgl)	76
Engineer:	TMS Environmental	Centre of test section (m bgl)	71.5
Borehole:	**MW 10c**	Length of test section (m bgl)	9
Bh. size:	NQ	Pressure gauge height (m agl)	0.2
Date:	21/07/2017	Initial depth to G.W. (m bgl)	14.7
Packer Type:	Single	Packer inflation pressure (psi)	290

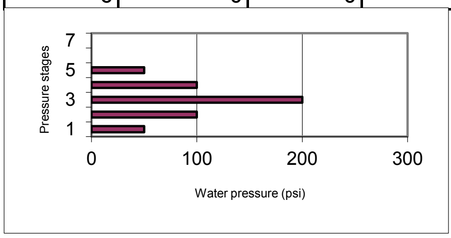
1. Site Records

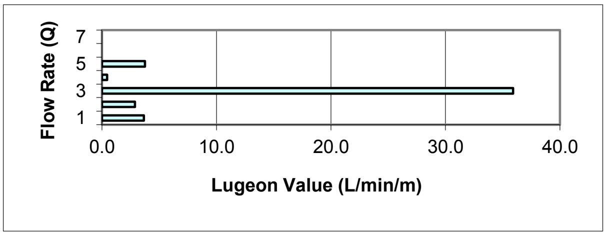
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	520	603	684	767	83	81	83	247
2	100	770	879	990	1103	109	111	113	333
3	200	1120	1277	1437	1600	157	160	163	480
4	100	1620	1737	1852	1968	117	115	116	348
5	50	1980	2065	2149	2234	85	84	85	254

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	50.1	16.5	*3.7*
2	85.3	22.2	*2.9*
3	445.5	32.0	*35.9*
4	360.4	23.2	*0.4*
5	50.1	16.9	*3.8*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used:	9.34L
k (m/sec)	9.34E-06

PACKER TEST RESULTS

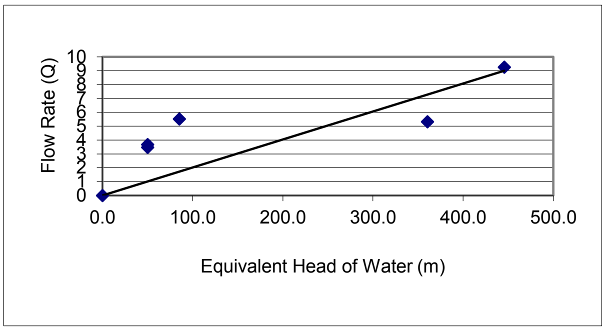
Contract:	Aghamore	Top of test section (m bgl)	76
Client:	Lagan	Bottom of test section (m bgl)	80
Engineer:	TMS Environmental	Centre of test section (m bgl)	78
Borehole:	**MW 10c**	Length of test section (m bgl)	4
Bh. size:	NQ	Pressure gauge height (m agl)	0.2
Date:	21/07/2017	Initial depth to G.W. (m bgl)	14.7
Packer Type:	Single	Packer inflation pressure (psi)	290

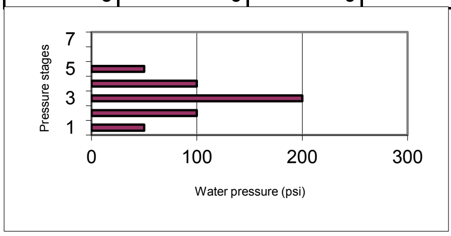
1. Site Records

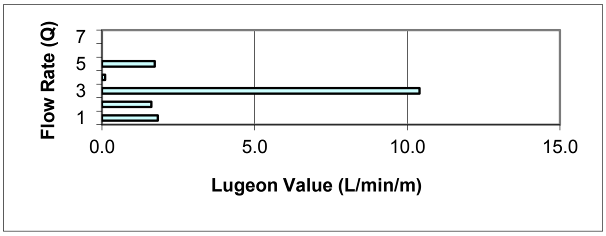
Pressure stage	Water pressure (psi)	Flow meter readings start	5 min	10 min	15 min	Water taken over time period (litres) 0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	2250	2267	2286	2305	17	19	19	55
2	100	2310	2338	2365	2393	28	27	28	83
3	200	2400	2445	2492	2539	45	47	47	139
4	100	2550	2577	2603	2630	27	26	27	80
5	50	2640	2658	2675	2692	18	17	17	52

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	50.1	3.7	*1.8*
2	85.3	5.5	*1.6*
3	445.5	9.3	*10.4*
4	360.4	5.3	*0.1*
5	50.1	3.5	*1.7*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 3.12L

k (m/sec) 3.12E-06

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 11
Bh. size: NQ
Date: 10/08/2017
Packer Type: Single

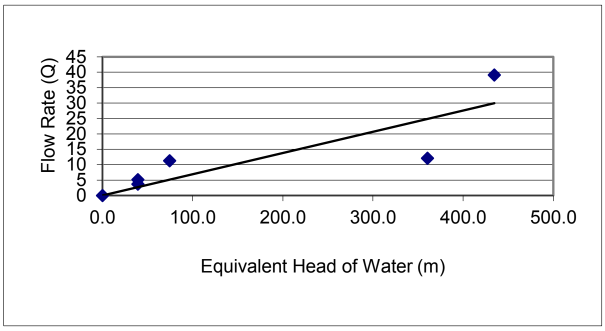
Top of test section (m bgl)	7
Bottom of test section (m bgl)	16
Centre of test section (m bgl)	11.5
Length of test section (m bgl)	9
Pressure gauge height (m agl)	0.2
Initial depth to G.W. (m bgl)	3.8
Packer inflation pressure (psi)	290

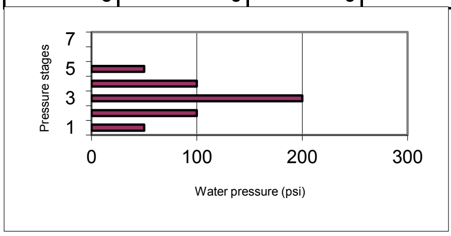
1. Site Records

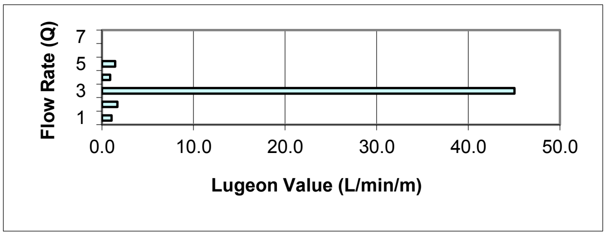
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	2700	2719	2737	2756	19	18	19	56
2	100	2760	2816	2873	2929	56	57	56	169
3	200	2940	3137	3332	3527	197	195	195	587
4	100	3535	3596	3656	3717	61	60	61	182
5	50	3730	3757	3782	3807	27	25	25	77

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	39.2	3.7	*1.1*
2	74.4	11.3	*1.7*
3	434.6	39.1	*45.0*
4	360.4	12.1	*0.9*
5	39.2	5.1	*1.5*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 10.04L

k (m/sec) 1.00E-06

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 11
Bh. size: NQ
Date: 10/08/2017
Packer Type: Single

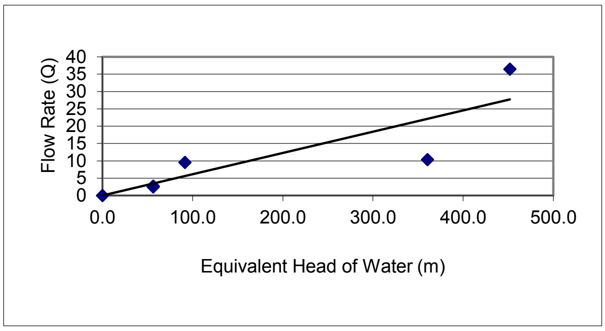
Top of test section (m bgl) 16
Bottom of test section (m bgl) 25
Centre of test section (m bgl) 20.5
Length of test section (m bgl) 9
Pressure gauge height (m agl) 0.2
Initial depth to G.W. (m bgl) 21
Packer inflation pressure (psi) 290

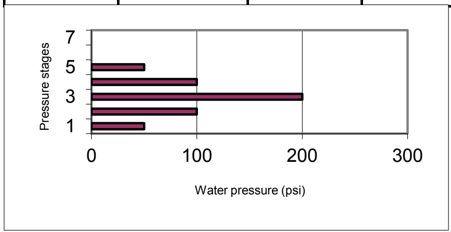
1. Site Records

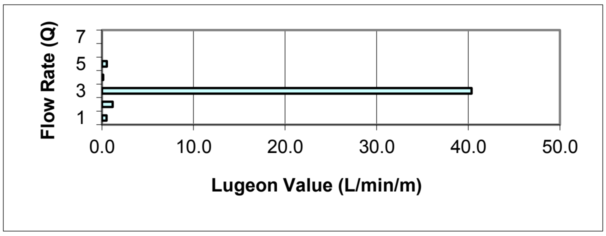
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	3830	3842	3855	3868	12	13	13	38
2	100	3880	3927	3976	4024	47	49	48	144
3	200	4035	4218	4400	4582	183	182	182	547
4	100	4595	4644	4692	4751	49	48	59	156
5	50	4760	4774	4788	4801	14	14	13	41

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	56.4	2.5	*0.5*
2	91.6	9.6	*1.2*
3	451.8	36.5	*40.4*
4	360.4	10.4	*0.1*
5	56.4	2.7	*0.5*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 8.54L

k (m/sec) 8.54E-07

PACKER TEST RESULTS

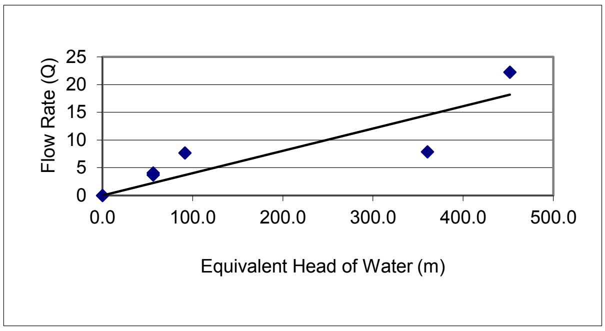
Contract:	Aghamore	Top of test section (m bgl)	25
Client:	Lagan	Bottom of test section (m bgl)	34
Engineer:	TMS Environmental	Centre of test section (m bgl)	29.5
Borehole:	**MW 11**	Length of test section (m bgl)	9
Bh. size:	NQ	Pressure gauge height (m agl)	0.2
Date:	11/08/2017	Initial depth to G.W. (m bgl)	21
Packer Type:	Single	Packer inflation pressure (psi)	290

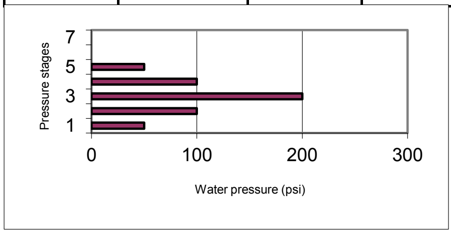
1. Site Records

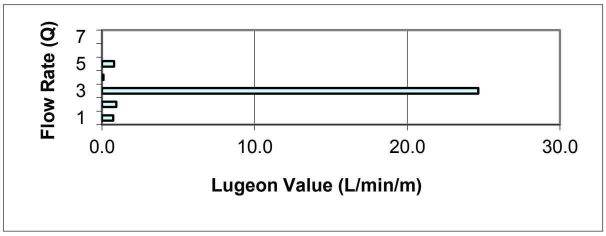
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	4830	4848	4867	4886	18	19	19	56
2	100	4895	4933	4971	5010	38	38	39	115
3	200	5020	5130	5241	5354	110	111	113	334
4	100	5360	5399	5439	5478	39	40	39	118
5	50	5480	5499	5520	5541	19	21	21	61

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	56.4	3.7	*0.7*
2	91.6	7.7	*0.9*
3	451.8	22.3	*24.6*
4	360.4	7.9	*0.1*
5	56.4	4.1	*0.8*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 5.42L

k (m/sec) 5.42E-07

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 11
Bh. size: NQ
Date: 11/08/2017
Packer Type: Single

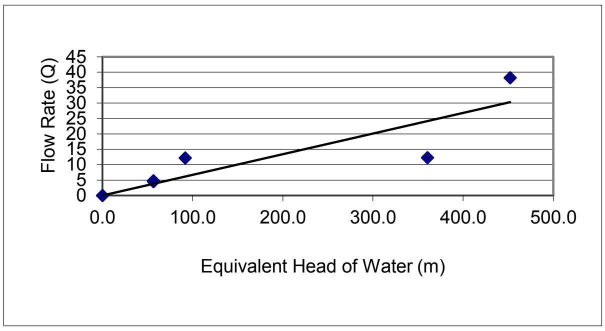
Top of test section (m bgl)	34
Bottom of test section (m bgl)	43
Centre of test section (m bgl)	38.5
Length of test section (m bgl)	9
Pressure gauge height (m agl)	0.2
Initial depth to G.W. (m bgl)	21.2
Packer inflation pressure (psi)	290

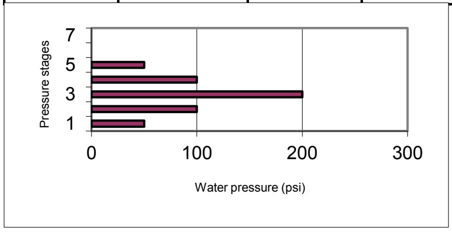
1. Site Records

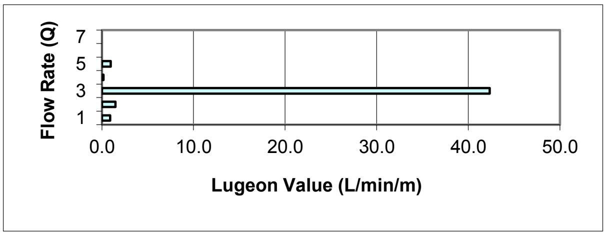
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	5560	5581	5604	5628	21	23	24	68
2	100	5640	5699	5760	5823	59	61	63	183
3	200	5835	6032	6221	6409	197	189	188	574
4	100	6420	6481	6543	6605	61	62	62	185
5	50	6620	6643	6668	6692	23	25	24	72

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	56.6	4.5	*0.9*
2	91.8	12.2	*1.5*
3	452.0	38.3	*42.3*
4	360.4	12.3	*0.2*
5	56.6	4.8	*0.9*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 9.16L

k (m/sec) 9.16E-07

PACKER TEST RESULTS

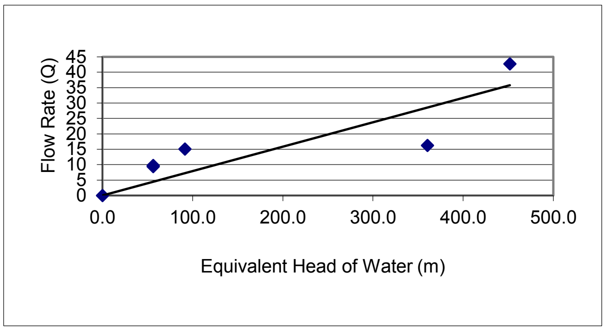
Contract:	Aghamore	Top of test section (m bgl)	43
Client:	Lagan	Bottom of test section (m bgl)	52
Engineer:	TMS Environmental	Centre of test section (m bgl)	47.5
Borehole:	**MW 11**	Length of test section (m bgl)	9
Bh. size:	NQ	Pressure gauge height (m agl)	0.2
Date:	14/08/2017	Initial depth to G.W. (m bgl)	21
Packer Type:	Single	Packer inflation pressure (psi)	290

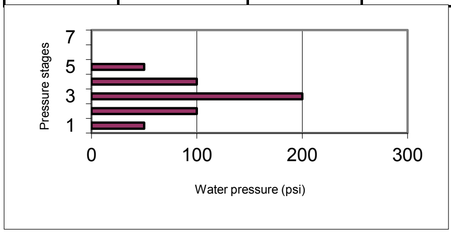
1. Site Records

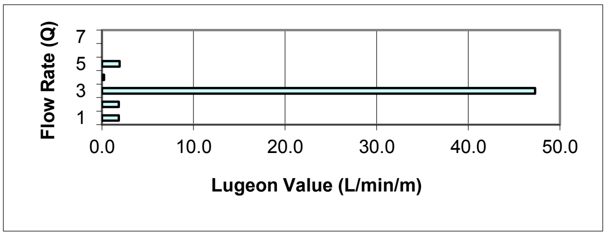
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	6705	6751	6799	6846	46	48	47	141
2	100	6855	6928	7003	7081	73	75	78	226
3	200	7100	7312	7526	7741	212	214	215	641
4	100	7750	7831	7919	7994	81	88	75	244
5	50	8005	8054	8102	8151	49	48	49	146

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	56.4	9.4	*1.9*
2	91.6	15.1	*1.8*
3	451.8	42.7	*47.3*
4	360.4	16.3	*0.2*
5	56.4	9.7	*1.9*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 10.62L

k (m/sec) 1.06E-06

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 11
Bh. size: NQ
Date: 14/08/2017
Packer Type: Single

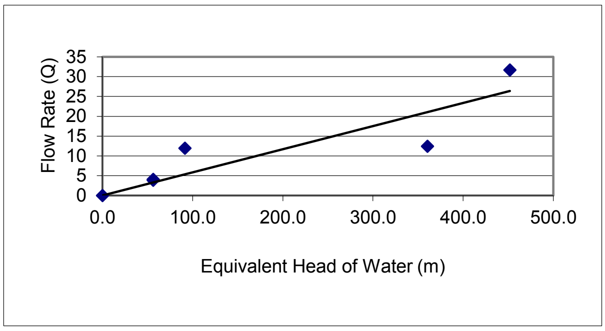
Top of test section (m bgl)	52
Bottom of test section (m bgl)	61
Centre of test section (m bgl)	56.5
Length of test section (m bgl)	9
Pressure gauge height (m agl)	0.2
Initial depth to G.W. (m bgl)	21
Packer inflation pressure (psi)	290

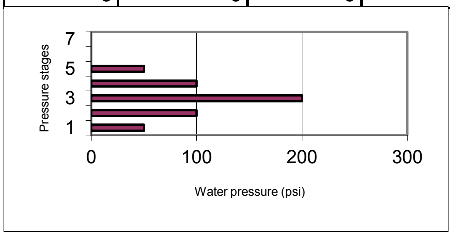
1. Site Records

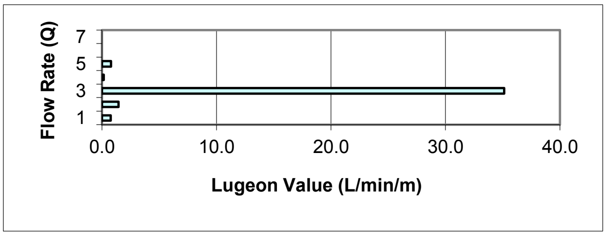
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	8170	8189	8209	8228	19	20	19	58
2	100	8240	8299	8359	8419	59	60	60	179
3	200	8430	8587	8746	8906	157	159	160	476
4	100	8920	8983	9045	9107	63	62	62	187
5	50	9130	9151	9171	9191	21	20	20	61

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	56.4	3.9	*0.8*
2	91.6	11.9	*1.4*
3	451.8	31.7	*35.1*
4	360.4	12.5	*0.2*
5	56.4	4.1	*0.8*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 7.66L

k (m/sec) 7.66E-07

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 11
Bh. size: NQ
Date: 15/08/2017
Packer Type: Single

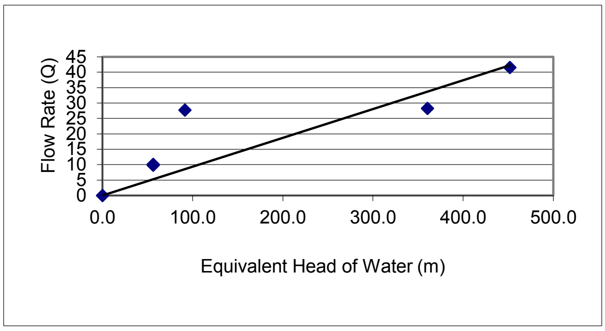
Top of test section (m bgl)	61
Bottom of test section (m bgl)	70
Centre of test section (m bgl)	65.5
Length of test section (m bgl)	9
Pressure gauge height (m agl)	0.2
Initial depth to G.W. (m bgl)	21
Packer inflation pressure (psi)	290

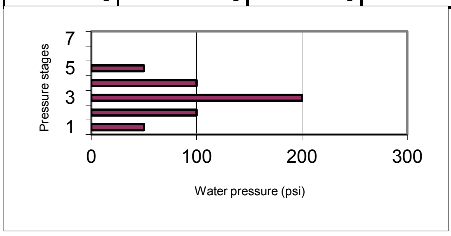
1. Site Records

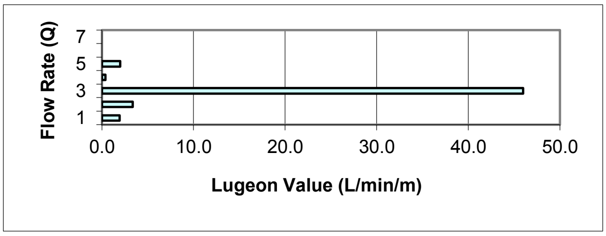
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	9200	9248	9297	9348	48	49	51	148
2	100	9360	9497	9636	9776	137	139	140	416
3	200	9785	9991	10200	10408	206	209	208	623
4	100	90418	90559	90701	90842	141	142	141	424
5	50	90730	90780	90831	90882	50	51	51	152

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	56.4	9.9	*1.9*
2	91.6	27.7	*3.4*
3	451.8	41.5	*46.0*
4	360.4	28.3	*0.4*
5	56.4	10.1	*2.0*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 10.74L

k (m/sec) 1.07E-06

PACKER TEST RESULTS

Contract: Aghamore
Client: Lagan
Engineer: TMS Environmental
Borehole: MW 11
Bh. size: NQ
Date: 15/08/2017
Packer Type: Single

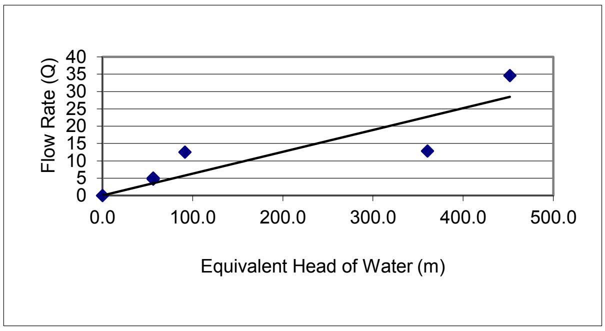
Top of test section (m bgl)	70
Bottom of test section (m bgl)	79
Centre of test section (m bgl)	74.5
Length of test section (m bgl)	9
Pressure gauge height (m agl)	0.2
Initial depth to G.W. (m bgl)	21
Packer inflation pressure (psi)	290

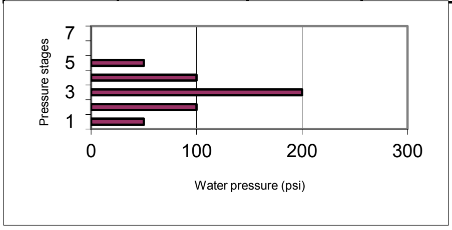
1. Site Records

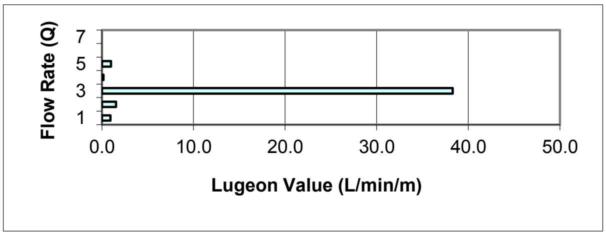
Pressure stage	Water pressure (psi)	Flow meter readings				Water taken over time period (litres)			
		start	5 min	10 min	15 min	0-5 min	5-10 min	10-15 min	0-15 min litres
1	50	895	918	942	966	23	24	24	71
2	100	980	1043	1105	1168	63	62	63	188
3	200	1180	1352	1526	1699	172	174	173	519
4	100	1710	1775	1839	1903	65	64	64	193
5	50	1920	1946	1971	1996	26	25	25	76

2. Calculations

Pressure stage	Equiv. head of water (m)	Flow rate (Q) l/min	Stage Lugeon Value l/min/m
1	56.4	4.7	*0.9*
2	91.6	12.5	*1.5*
3	451.8	34.6	*38.3*
4	360.4	12.9	*0.2*
5	56.4	5.1	*1.0*
6	0	0	0







3. Permeability (k) analysis

Mean Lugeon Value Used: 8.38L

k (m/sec) 8.38E-07

APPENDIX 7-16 WATER BALANCE

Quarry Water Balance - January to April 2021

Quarry Water Balance:

Start Date	26/01/2021	
End Date	09/04/2021	
Days	73	
Water Level 26/01/2021 (mOD)	-15.4	Water level measured by APEX Geophysics
Water Level 09/04/2021 (mOD)	-18.9	Water level measured by Hydro-G
Fall (m)	3.5	
Rainfall (mm)	256.8	Markree data
Potential Evapotranspiration (mm)	72.3	Finner data
Evaporation (mm)	104	Finner data
Pumping Rate (m3/d)	2,722	Assumed average of 31.5l/s
Stormwater Catchment to Quarry (m2)	125,000	Estimated
Quarry Lake Area Only (m2)	46,000	Estimated
Epikarst Drainage Area to Quarry (m2)	116,300	Estimated
Deeper Groundwater Inflows (m3/d)	*56.5*	*Estimated by iteration*

Recharge to Epikarst:

Rainfall (mm)	256.8	
Potential Evapotranspiration (mm)	72.3	
Actual Evapotranspiration (mm)	68.685	Assumed 95% of PE
Effective Rainfall (mm)	188.115	
Recharge Coefficient (%)	40	High Vulnerability: moderate permeability subsoils overlain by poorly drained soils
Recharge (mm)	75.246	
Recharge - deeper percolation (mm)	67.7214	Assumed 10% of recharge percolates deeper

Inputs:

Rainfall on Quarry Lake (m3)	11,813	
Runoff to Quarry Lake (m3)	17,244	Assumed runoff coefficient of 0.85
Epikarst Drainage to Quarry Lake (m3)	7,876	
Deeper Groundwater Inflows (m3)	4,125	
Total Inputs (m3)	41,057	Estimated by above

Outputs:

Pumping (m3)	198,706	
Evaporation from quarry lake (m3)	3,349	Evaporation from lake at 70% of pan data
Total Outputs (m3)	202,055	

Change in Storage:

Decrease (m3)	161,000	

Outputs - Storage = Inputs

Total Outputs (m3)	202,055	
Decrease in Storage (m3)	161,000	
Total Inputs (m3)	41,055	Calculated from Outputs minus Storage

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APPENDIX 7-17 GROUNDWATER LEVELS

Groundwater Levels - Manual Measurement

mbtoc:

	12/07/2017	23/08/2017	28/08/2017	07/09/2017	08/02/2018	26/03/2018	30/03/2018	11/04/2018	19/04/2018	16/05/2018	29/05/2018	01/06/2018	10/07/2018	07/11/2018	29/01/2019	02/05/2019	23/08/2019	22/07/2020	06/10/2020
MW1	34.410	18.610	23.350	25.140	17.220	25.040	24.950	23.515	21.485	24.800	25.285	25.390	26.515	16.365	16.670	-	25.870	9.230	8.990
MW2	27.600	c. 12.58 - 13.18	c. 15.00	c. 17.00 - 25.00	c. 14.99	Dry	Dry	26.715	26.320	27.215	Dry	Dry	Dry	21.450	21.300	25.710	24.340	21.225	22.670
MW3	30.495	30.455	30.470	30.470	30.475	30.500	30.500	30.510	30.565	30.315	30.525	30.545	30.505	30.505	30.560	29.985	30.615	28.420	29.550
MW4	35.040	30.000	30.465	31.730	29.550	34.340	33.110	30.350	30.320	33.595	34.225	34.390	35.340	30.010	33.265	34.560	35.380	32.055	35.170
MW5	35.335	34.660	34.455	34.530	29.990	32.495	32.580	32.800	33.945	33.105	33.155	33.190	34.040	33.475	32.350	33.555	35.755	33.295	34.770
MW6	34.680	33.650	33.660	33.935	26.255	31.310	31.470	31.860	32.005	32.240	32.255	32.315	33.235	32.570	30.695	32.750	32.855	32.415	32.540
MW7	38.555	37.415	37.500	37.810	32.355	35.495	35.560	35.760	35.935	36.075	36.055	36.075	36.895	36.505	35.350	35.350	37.210	35.900	35.680
MW8	35.520	31.140	31.280	32.430	30.625	33.920	33.760	31.065	31.090	34.050	34.625	34.885	35.675	29.055	30.795	35.390	36.100	33.105	35.850
MW9	14.880	14.580	14.655	14.680	14.070	14.670	14.640	14.640	14.610	14.700	14.710	14.745	14.655	11.315	14.315	14.485	15.015	14.655	-
MW10c	-	c. 7.21	c. 7.99	36.070	c. 12.27	33.960	34.015	33.870	15.565	34.565	34.560	34.550	34.975	28.500	21.740	33.980	35.200	33.450	35.150
MW11	-	c. 13.58	c. 14.50	c. 19.00	c. 13.20	35.565	c. 26.00	c. 27.00	35.650	35.560	35.545	35.570	35.565	35.470	35.385	35.105	35.650	32.210	35.320
Old Well	-	-	4.170	4.520	5.975	7.210	6.580	4.195	6.120	6.305	6.400	6.950	Dry	4.145	4.280	5.660	7.985	5.450	-
MW12																			15.060
MW13																			5.740
MW14																			7.240
MW15																			-
MW16																			-
MW17																			-
MW18																			34.750
MW19																			21.400
MW20																			-
MW21																			-
MW22																			-
MW23																			-
MW24																			-
MW25																			-

mOD:

	12/07/2017	23/08/2017	28/08/2017	07/09/2017	08/02/2018	26/03/2018	30/03/2018	11/04/2018	19/04/2018	16/05/2018	29/05/2018	01/06/2018	10/07/2018	07/11/2018	29/01/2019	02/05/2019	23/08/2019	22/07/2020	06/10/2020
MW1	-6.888	8.912	4.172	2.382	10.302	2.482	2.572	4.007	6.037	2.722	2.237	2.132	1.007	11.157	10.852	-	1.652	18.292	18.532
MW2	0.590	-	-	-	-	Dry	Dry	1.475	1.870	0.975	Dry	Dry	Dry	6.740	6.890	2.480	3.850	6.965	5.520
MW3	-1.937	-1.897	-1.912	-1.912	-1.917	-1.942	-1.942	-1.952	-2.007	-1.757	-1.967	-1.987	-1.947	-1.947	-2.002	-1.427	-2.057	0.138	-0.992
MW4	-5.758	-0.718	-1.183	-2.448	-0.268	-5.058	-3.828	-1.068	-1.038	-4.313	-4.943	-5.108	-6.058	-0.728	-3.983	-5.278	-6.098	-2.773	-5.888
MW5	-4.190	-3.515	-3.310	-3.385	1.155	-1.350	-1.435	-1.655	-2.800	-1.960	-2.010	-2.045	-2.895	-2.330	-1.205	-2.410	-4.610	-2.150	-3.625
MW6	-6.670	-5.640	-5.650	-5.925	1.755	-3.300	-3.460	-3.850	-3.995	-4.230	-4.245	-4.305	-5.225	-4.560	-2.685	-4.740	-4.845	-4.405	-4.530
MW7	-9.142	-8.002	-8.087	-8.397	-2.942	-6.082	-6.147	-6.347	-6.522	-6.662	-6.642	-6.662	-7.482	-7.092	-5.937	-5.937	-7.797	-6.487	-6.267
MW8	-5.268	-0.888	-1.028	-2.178	-0.373	-3.668	-3.508	-0.813	-0.838	-3.798	-4.373	-4.633	-5.423	1.197	-0.543	-5.138	-5.848	-2.853	-5.598
MW9	-1.372	-1.072	-1.147	-1.172	-0.562	-1.162	-1.132	-1.132	-1.102	-1.192	-1.202	-1.237	-1.147	2.193	-0.807	-0.977	-1.507	-1.147	-
MW10c	-	-	-	-7.085	-	-4.975	-5.030	-4.885	13.420	-5.580	-5.575	-5.565	-5.990	0.485	7.245	-4.995	-6.215	-4.465	-6.165
MW11	-	-	-	-	-	-4.716	-	-	-4.801	-4.711	-4.696	-4.721	-4.716	-4.621	-4.536	-4.256	-4.801	-1.361	-4.471
Old Well	-	-	8.004	7.654	6.199	4.964	5.594	7.979	6.054	5.869	5.774	5.224	Dry	8.029	7.894	6.514	4.189	6.724	-
MW12																			-3.758
MW13																			6.968
MW14																			5.052
MW15																			-
MW16																			-
MW17																			-
MW18																			-4.842
MW19																			8.471
MW20																			-
MW21																			-
MW22																			-
MW23																			-
MW24																			-
MW25																			-

Groundwater Levels - Manual Measurement

mbtoc:

	07/10/2020	15/10/2020	23/10/2020	30/10/2020	13/11/2020	30/11/2020	04/12/2020	21/12/2020	09/03/2021
MW1	-	8.960	-	6.305	6.380	-	-	8.870	8.865
MW2	-	22.450	-	-	-	19.180	21.360	20.935	24.350
MW3	-	29.380	-	30.470	30.470	30.505	31.785	28.345	30.600
MW4	-	29.940	-	28.520	29.025	29.690	29.120	33.790	29.915
MW5	-	31.700	-	30.030	29.300	29.050	30.855	30.230	30.140
MW6	-	29.830	-	25.410	24.445	27.075	29.135	27.935	27.445
MW7	-	34.460	-	32.195	31.530	31.490	31.545	33.555	32.635
MW8	-	35.620	-	30.015	30.010	30.335	29.865	35.790	30.745
MW9	14.950	14.310	-	13.550	13.505	13.835	13.990	14.030	14.530
MW10c	-	21.290	-	-	11.160	-	-	19.585	31.215
MW11	-	35.270	-	-	33.560	33.180	34.425	33.870	34.620
Old Well	7.460	4.170	4.160	4.160	4.160	4.225	4.105	4.150	-
MW12	-	13.520	12.990	12.910	12.395	12.280	13.480	12.155	12.530
MW13	-	8.770	6.300	5.520	5.480	5.565	5.515	5.515	6.475
MW14	-	4.970	3.540	3.660	3.675	4.320	3.580	3.700	5.925
MW15	5.100	5.960	-	4.750	4.390	4.570	4.880	5.000	5.500
MW16	4.980	4.610	-	3.590	3.330	3.330	3.575	3.745	4.505
MW17	5.560	-	-	6.100	5.690	5.515	5.550	5.580	-
MW18	-	34.450	-	31.780	31.105	31.150	31.280	33.950	32.475
MW19	-	21.040	-	15.050	16.870	18.980	20.535	19.765	21.355
MW20	4.180	4.140	-	3.575	3.190	3.070	3.135	3.210	3.630
MW21	2.320	2.180	-	1.590	1.355	1.280	1.270	1.355	2.030
MW22	7.720	7.620	-	6.530	6.425	6.505	6.795	6.945	-
MW23	1.570	1.720	-	1.260	0.930	0.735	0.700	0.610	0.630
MW24	3.660	3.470	-	2.540	2.200	2.275	2.390	2.560	3.150
MW25	4.910	3.750	-	3.120	2.790	2.680	2.765	2.820	3.330

mOD:

	07/10/2020	15/10/2020	23/10/2020	30/10/2020	13/11/2020	30/11/2020	04/12/2020	21/12/2020	09/03/2021
MW1	-	18.562	-	21.217	21.142	-	-	18.652	18.657
MW2	-	5.740	-	-	-	9.010	6.830	7.255	3.840
MW3	-	-0.822	-	-1.912	-1.912	-1.947	-3.227	0.213	-2.042
MW4	-	-0.658	-	0.762	0.257	-0.408	0.162	-4.508	-0.633
MW5	-	-0.555	-	1.115	1.845	2.095	0.290	0.915	1.005
MW6	-	-1.820	-	2.600	3.565	0.935	-1.125	0.075	0.565
MW7	-	-5.047	-	-2.782	-2.117	-2.077	-2.132	-4.142	-3.222
MW8	-	-5.368	-	0.237	0.242	-0.083	0.387	-5.538	-0.493
MW9	-1.442	-0.802	-	-0.042	0.003	-0.327	-0.482	-0.522	-1.022
MW10c	-	7.695	-	-	17.825	-	-	9.400	-2.230
MW11	-	-4.421	-	-	-2.711	-2.331	-3.576	-3.021	-3.771
Old Well	4.714	8.004	8.014	8.014	8.014	7.949	8.069	8.024	-
MW12	-	-2.218	-1.688	-1.608	-1.093	-0.978	-2.178	-0.853	-1.228
MW13	-	3.938	6.408	7.188	7.228	7.143	7.193	7.193	6.233
MW14	-	7.322	8.752	8.632	8.617	7.972	8.712	8.592	6.367
MW15	9.153	8.293	-	9.503	9.863	9.683	9.373	9.253	8.753
MW16	8.459	8.829	-	9.849	10.109	10.109	9.864	9.694	8.934
MW17	11.808	-	-	11.268	11.678	11.853	11.818	11.788	-
MW18	-	-4.542	-	-1.872	-1.197	-1.242	-1.372	-4.042	-2.567
MW19	-	8.831	-	14.821	13.001	10.891	9.336	10.106	8.516
MW20	8.204	8.244	-	8.809	9.194	9.314	9.249	9.174	8.754
MW21	8.942	9.082	-	9.672	9.907	9.982	9.992	9.907	9.232
MW22	9.317	9.417	-	10.507	10.612	10.532	10.242	10.092	-
MW23	9.994	9.844	-	10.304	10.634	10.829	10.864	10.954	10.934
MW24	7.782	7.972	-	8.902	9.242	9.167	9.052	8.882	8.292
MW25	7.092	8.252	-	8.882	9.212	9.322	9.237	9.182	8.672

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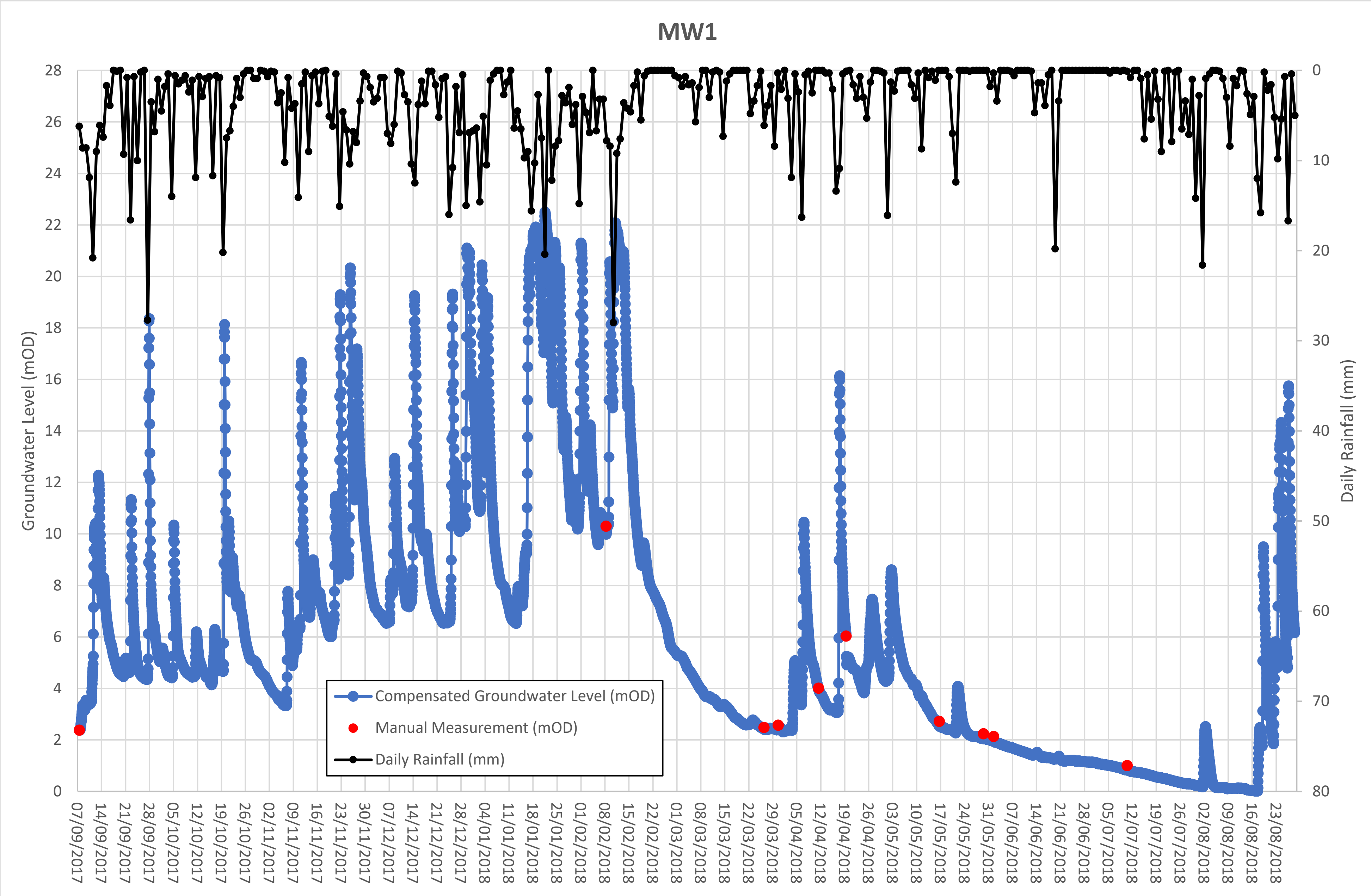
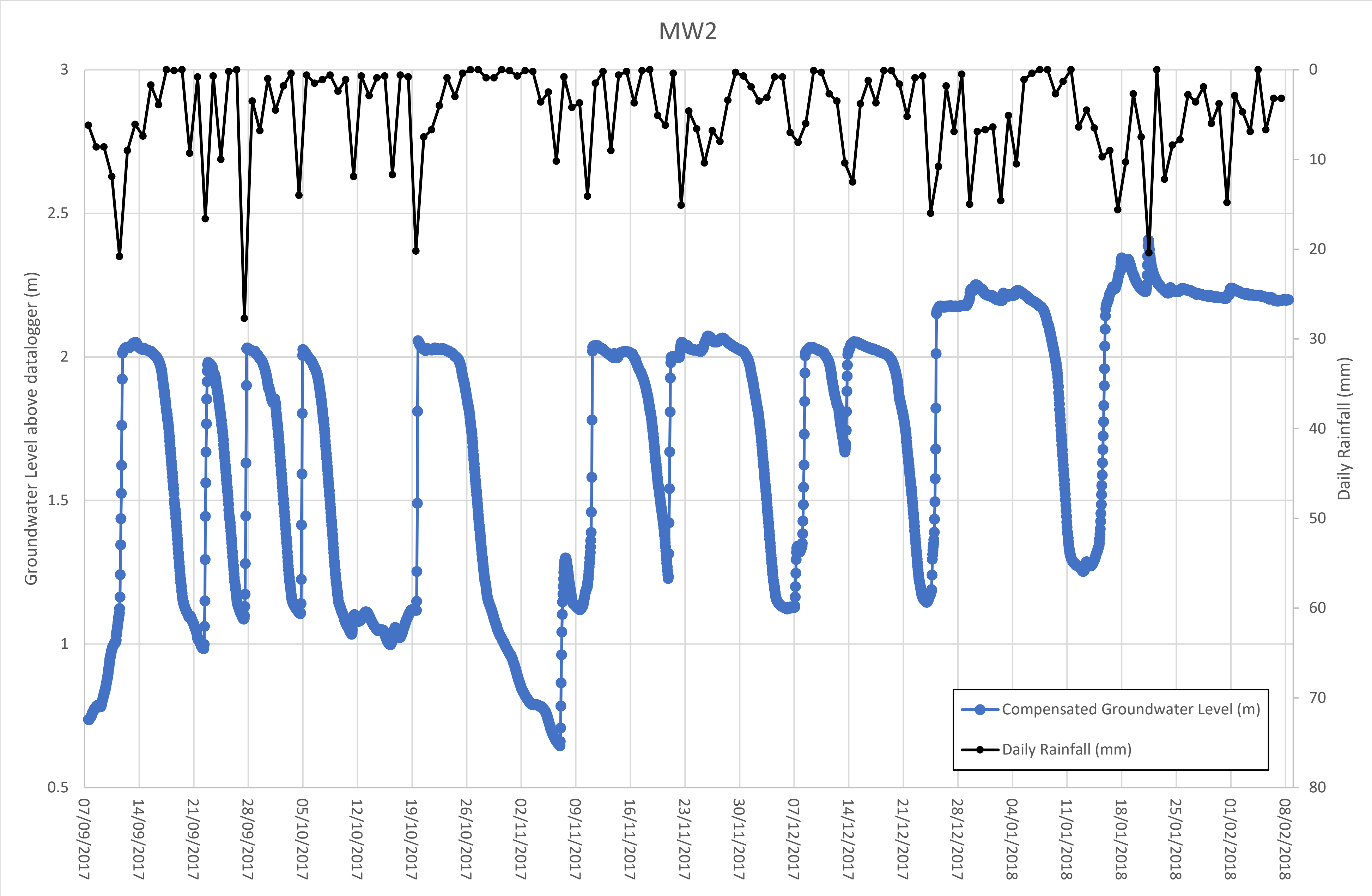
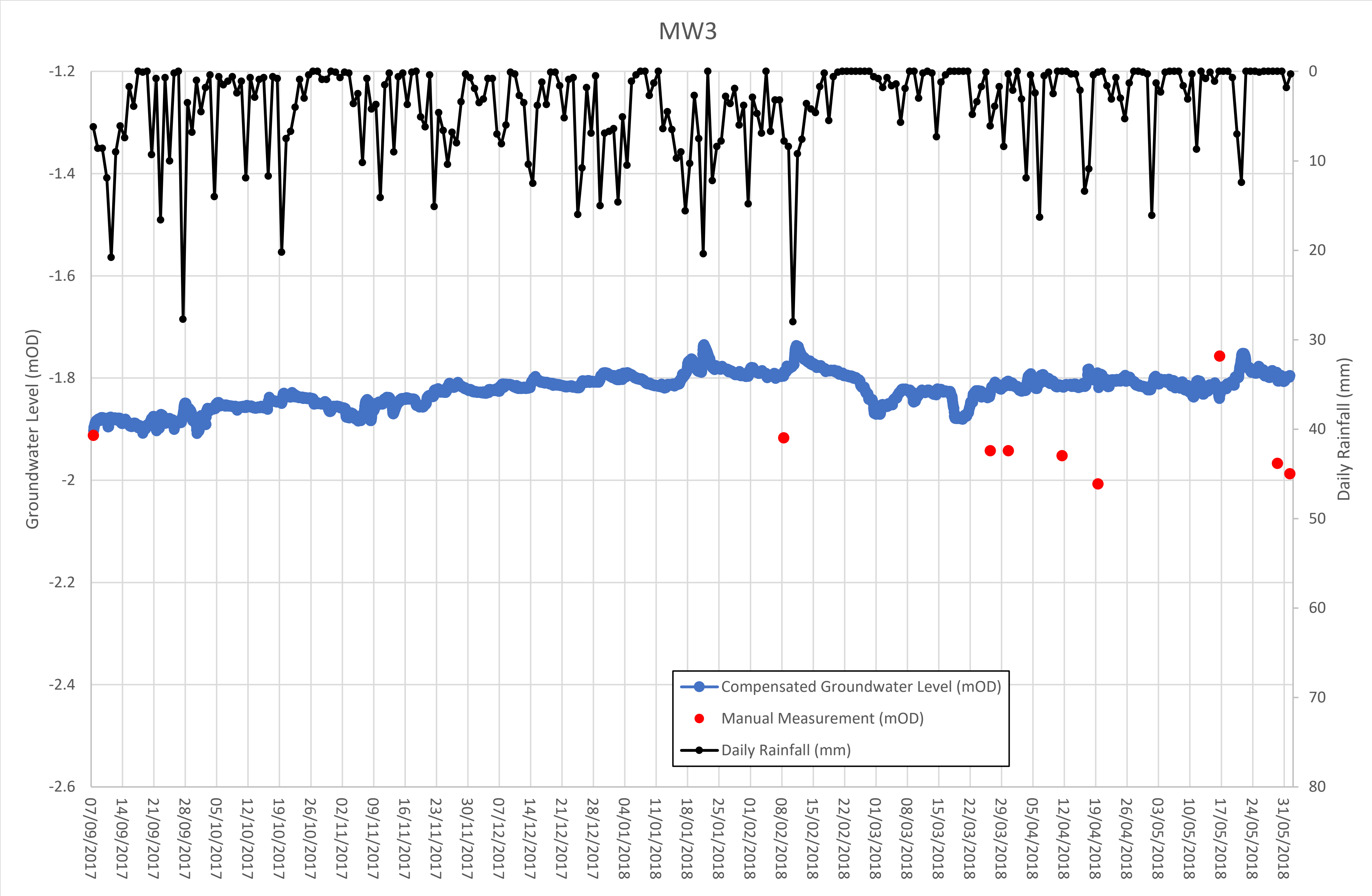
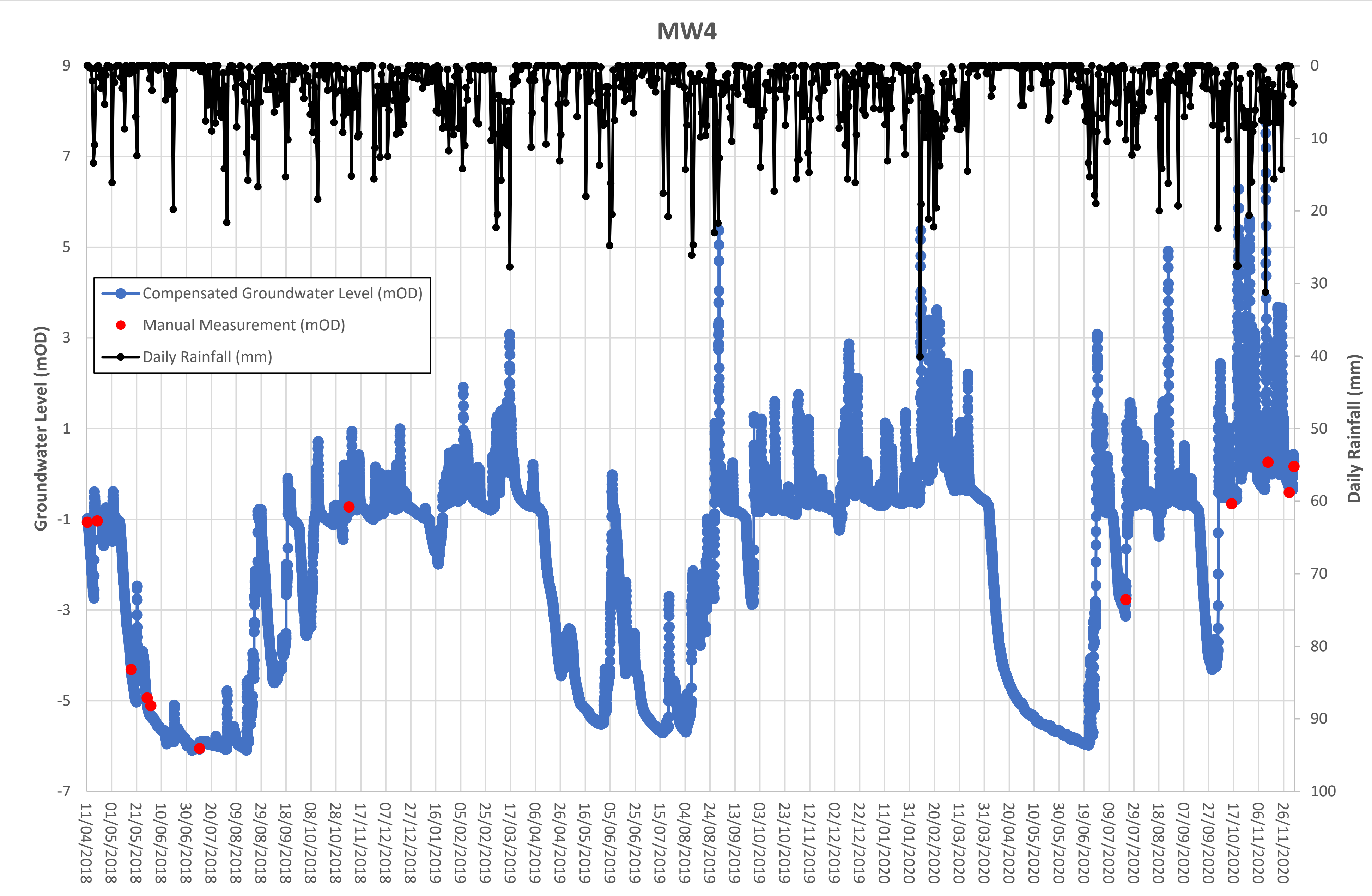


MW1
Groundwater Level (mOD)
Daily Rainfall (mm)
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
80
07/09/2017
14/09/2017
21/09/2017
28/09/2017
05/10/2017
12/10/2017
19/10/2017
26/10/2017
02/11/2017
09/11/2017
16/11/2017
23/11/2017
30/11/2017
07/12/2017
14/12/2017
21/12/2017
28/12/2017
04/01/2018
11/01/2018
18/01/2018
25/01/2018
01/02/2018
08/02/2018
15/02/2018
22/02/2018
01/03/2018
08/03/2018
15/03/2018
22/03/2018
29/03/2018
05/04/2018
12/04/2018
19/04/2018
26/04/2018
03/05/2018
10/05/2018
17/05/2018
24/05/2018
31/05/2018
07/06/2018
14/06/2018
21/06/2018
28/06/2018
05/07/2018
12/07/2018
19/07/2018
26/07/2018
02/08/2018
09/08/2018
16/08/2018
23/08/2018

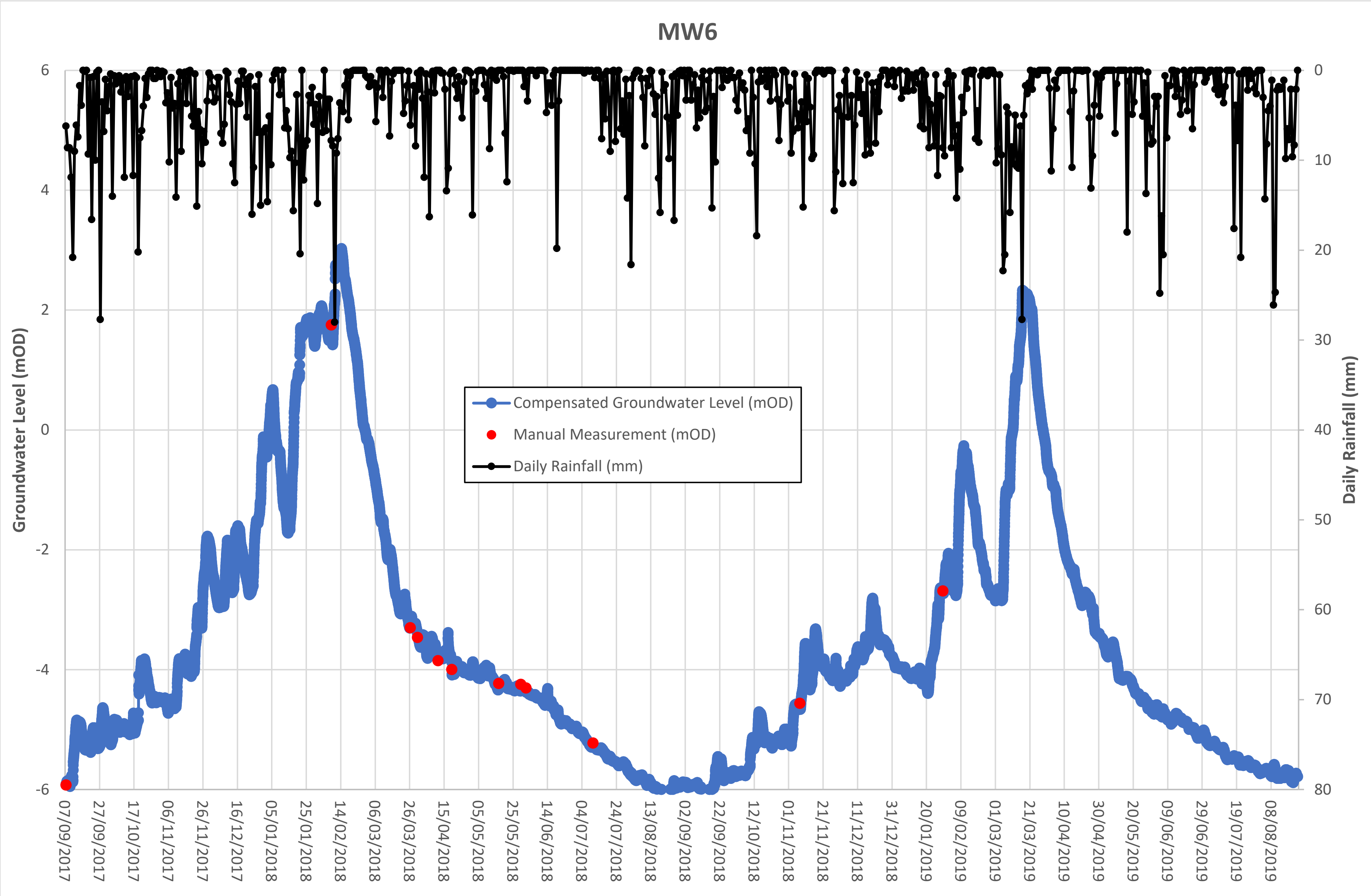

MW2
Groundwater Level above datalogger (m)
Daily Rainfall (mm)
3
2.5
2
1.5
1
0.5
0
10
20
30
40
50
60
70
80
07/09/2017
14/09/2017
21/09/2017
28/09/2017
05/10/2017
12/10/2017
19/10/2017
26/10/2017
02/11/2017
09/11/2017
16/11/2017
23/11/2017
30/11/2017
07/12/2017
14/12/2017
21/12/2017
28/12/2017
04/01/2018
11/01/2018
18/01/2018
25/01/2018
01/02/2018
08/02/2018
Compensated Groundwater Level (m)
Daily Rainfall (mm)



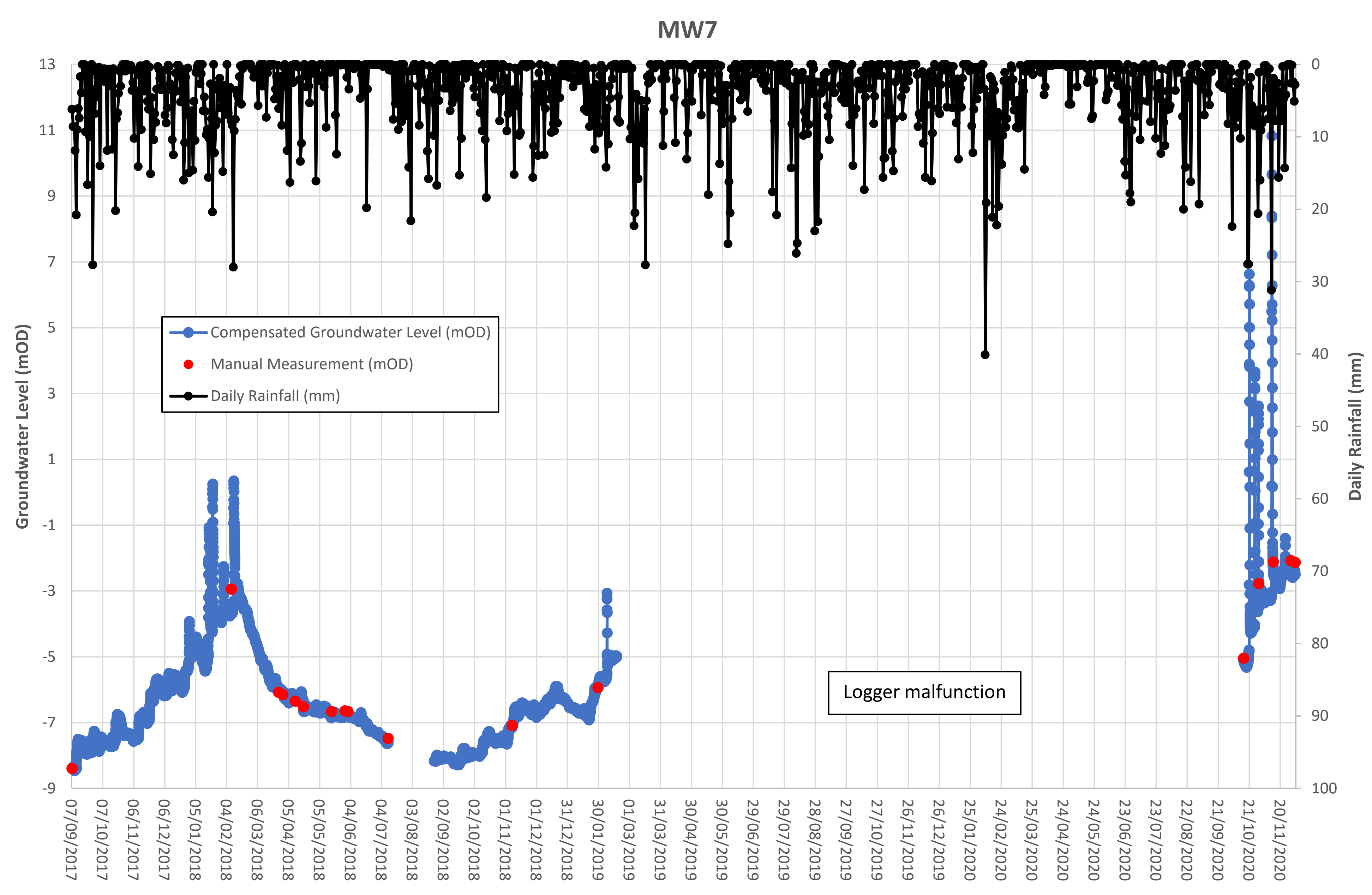
MW3
Groundwater Level (mOD)
Daily Rainfall (mm)
-1.2
-1.4
-1.6
-1.8
-2
-2.2
-2.4
-2.6
0
10
20
30
40
50
60
70
80
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)
07/09/2017
14/09/2017
21/09/2017
28/09/2017
05/10/2017
12/10/2017
19/10/2017
26/10/2017
02/11/2017
09/11/2017
16/11/2017
23/11/2017
30/11/2017
07/12/2017
14/12/2017
21/12/2017
28/12/2017
04/01/2018
11/01/2018
18/01/2018
25/01/2018
01/02/2018
08/02/2018
15/02/2018
22/02/2018
01/03/2018
08/03/2018
15/03/2018
22/03/2018
29/03/2018
05/04/2018
12/04/2018
19/04/2018
26/04/2018
03/05/2018
10/05/2018
17/05/2018
24/05/2018
31/05/2018

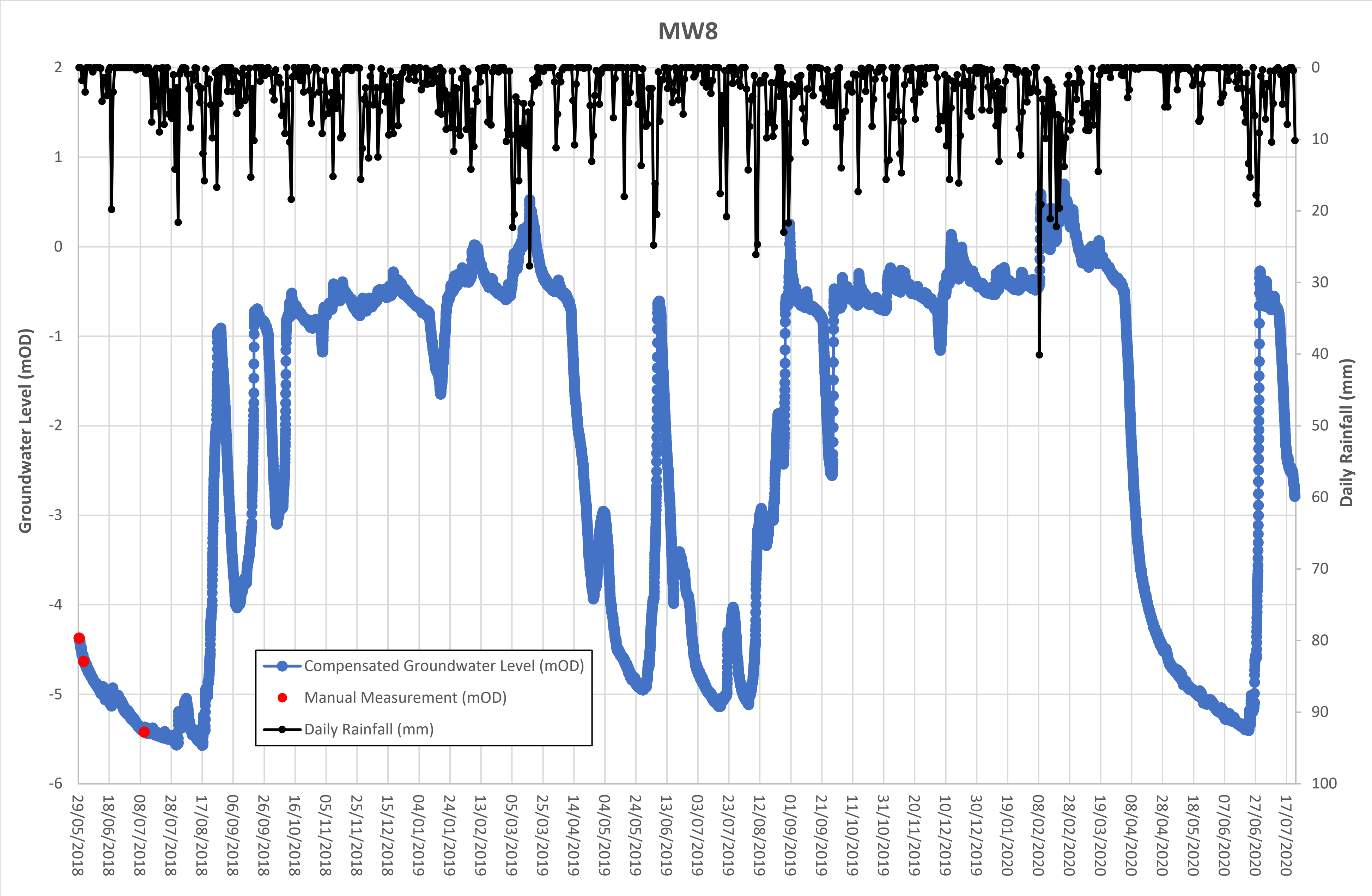


MW4
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)
Groundwater Level (mOD)
Daily Rainfall (mm)
9
7
5
3
1
-1
-3
-5
-7
0
10
20
30
40
50
60
70
80
90
100
11/04/2018
01/05/2018
21/05/2018
10/06/2018
30/06/2018
20/07/2018
09/08/2018
29/08/2018
18/09/2018
08/10/2018
28/10/2018
17/11/2018
07/12/2018
27/12/2018
16/01/2019
05/02/2019
25/02/2019
17/03/2019
06/04/2019
26/04/2019
16/05/2019
05/06/2019
25/06/2019
15/07/2019
04/08/2019
24/08/2019
13/09/2019
03/10/2019
23/10/2019
12/11/2019
02/12/2019
22/12/2019
11/01/2020
31/01/2020
20/02/2020
11/03/2020
31/03/2020
20/04/2020
10/05/2020
30/05/2020
19/06/2020
09/07/2020
29/07/2020
18/08/2020
07/09/2020
27/09/2020
17/10/2020
06/11/2020
26/11/2020

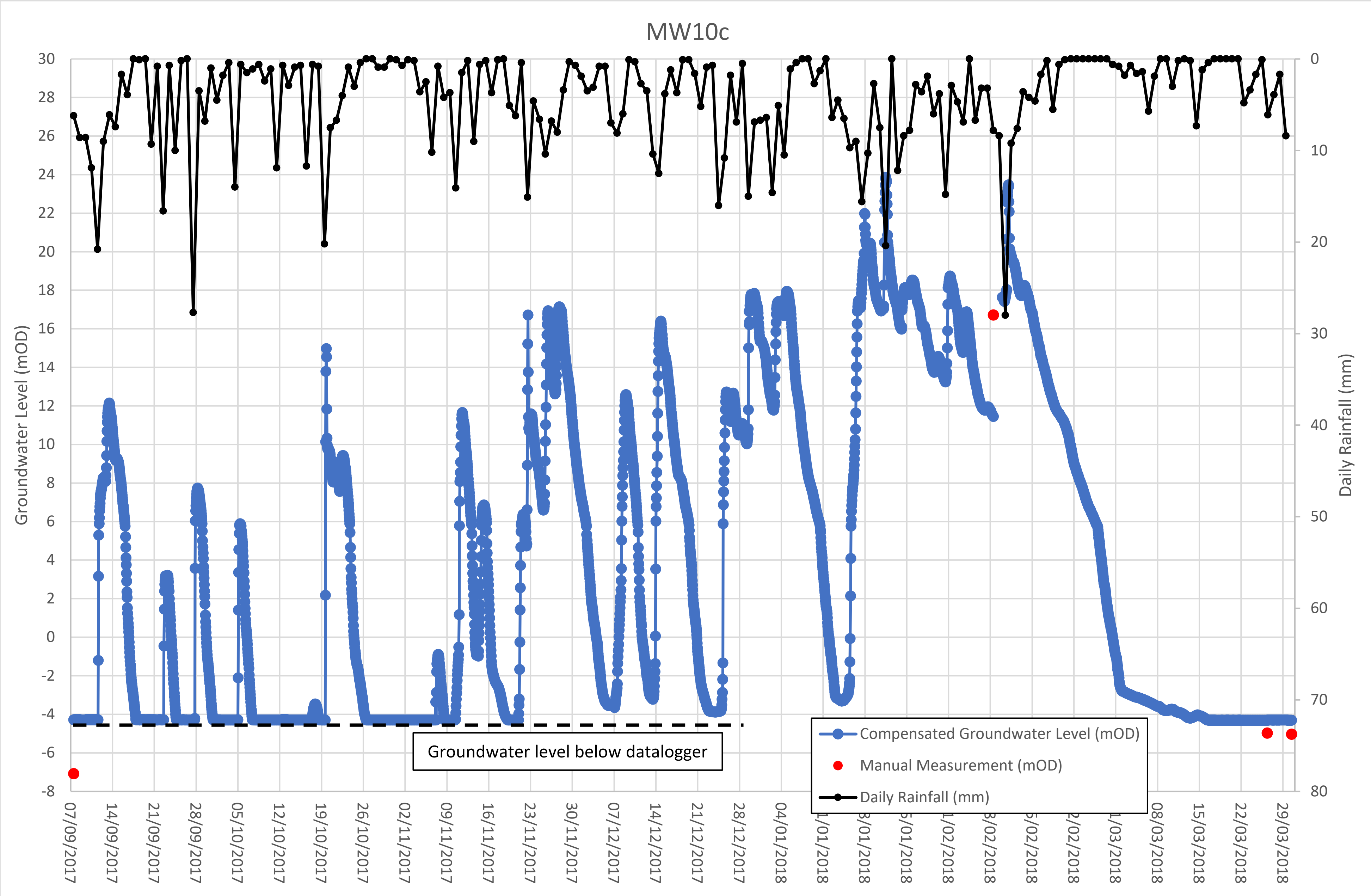


MW6
Groundwater Level (mOD)
Daily Rainfall (mm)
6
4
2
0
-2
-4
-6
0
10
20
30
40
50
60
70
80
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)
07/09/2017
27/09/2017
17/10/2017
06/11/2017
26/11/2017
16/12/2017
05/01/2018
25/01/2018
14/02/2018
06/03/2018
26/03/2018
15/04/2018
05/05/2018
25/05/2018
14/06/2018
04/07/2018
24/07/2018
13/08/2018
02/09/2018
22/09/2018
12/10/2018
01/11/2018
21/11/2018
11/12/2018
31/12/2018
20/01/2019
09/02/2019
01/03/2019
21/03/2019
10/04/2019
30/04/2019
20/05/2019
09/06/2019
29/06/2019
19/07/2019
08/08/2019

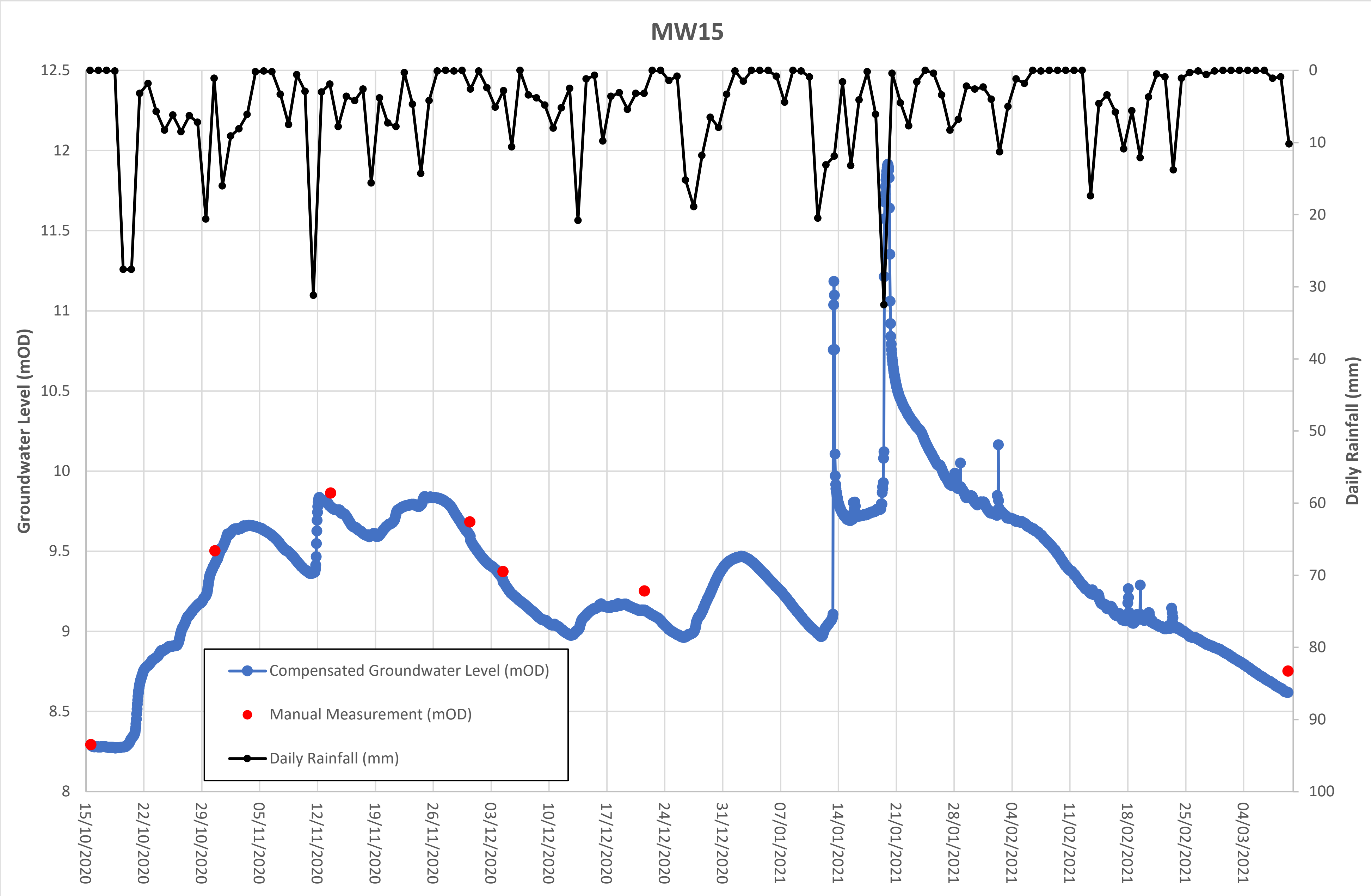

MW7
Groundwater Level (mOD)
Daily Rainfall (mm)
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)
Logger malfunction
13
11
9
7
5
3
1
-1
-3
-5
-7
-9
0
10
20
30
40
50
60
70
80
90
100
07/09/2017
07/10/2017
06/11/2017
06/12/2017
05/01/2018
04/02/2018
06/03/2018
05/04/2018
05/05/2018
04/06/2018
04/07/2018
03/08/2018
02/09/2018
02/10/2018
01/11/2018
01/12/2018
31/12/2018
30/01/2019
01/03/2019
31/03/2019
30/04/2019
30/05/2019
29/06/2019
29/07/2019
28/08/2019
27/09/2019
27/10/2019
26/11/2019
26/12/2019
25/01/2020
24/02/2020
25/03/2020
24/04/2020
24/05/2020
23/06/2020
23/07/2020
22/08/2020
21/09/2020
21/10/2020
20/11/2020

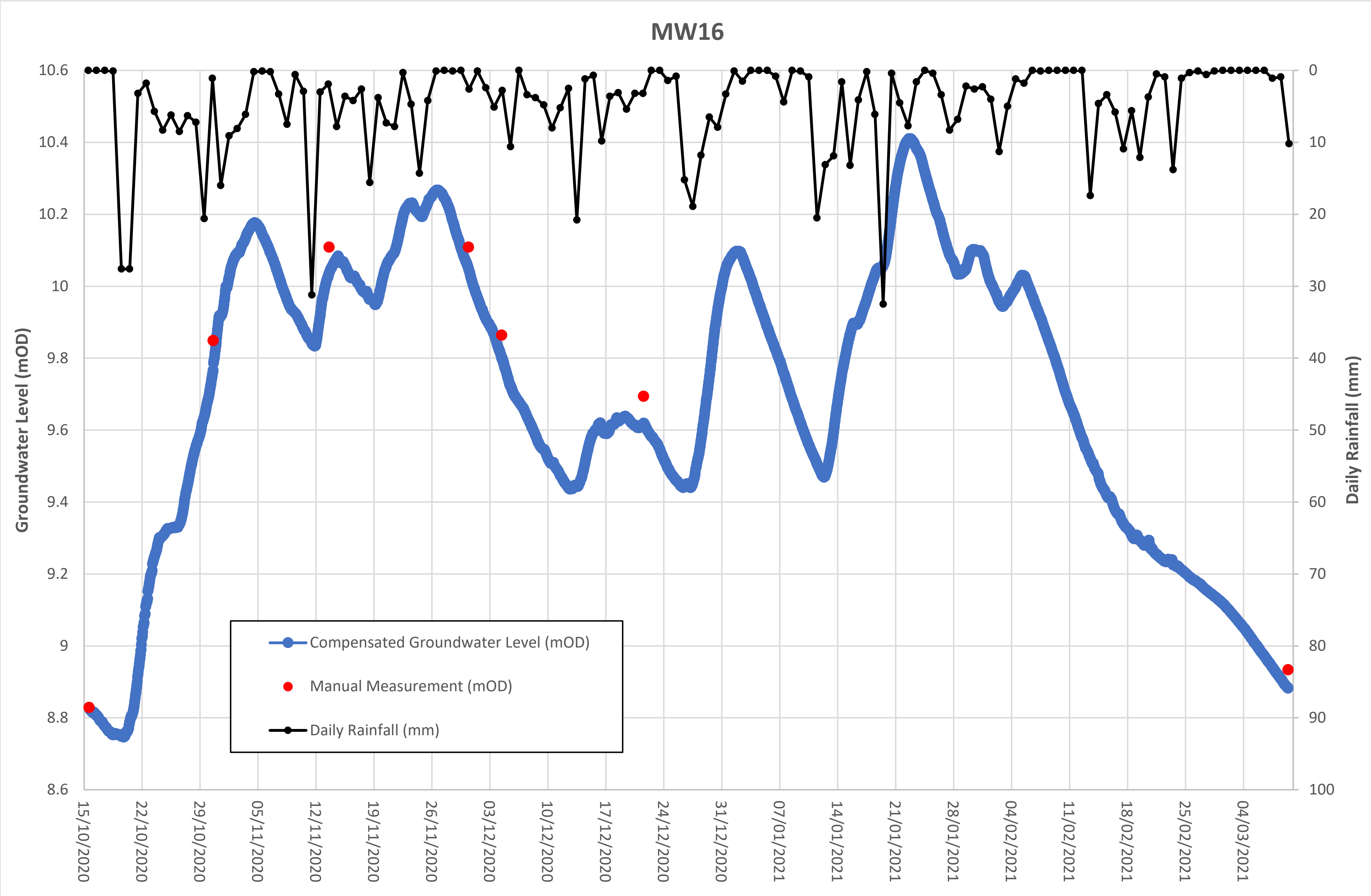


MW8
Groundwater Level (mOD)
Daily Rainfall (mm)
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)
2
1
0
-1
-2
-3
-4
-5
-6
0
10
20
30
40
50
60
70
80
90
100
29/05/2018
18/06/2018
08/07/2018
28/07/2018
17/08/2018
06/09/2018
26/09/2018
16/10/2018
05/11/2018
25/11/2018
15/12/2018
04/01/2019
24/01/2019
13/02/2019
05/03/2019
25/03/2019
14/04/2019
04/05/2019
24/05/2019
13/06/2019
03/07/2019
23/07/2019
12/08/2019
01/09/2019
21/09/2019
11/10/2019
31/10/2019
20/11/2019
10/12/2019
30/12/2019
19/01/2020
08/02/2020
28/02/2020
19/03/2020
08/04/2020
28/04/2020
18/05/2020
07/06/2020
27/06/2020
17/07/2020

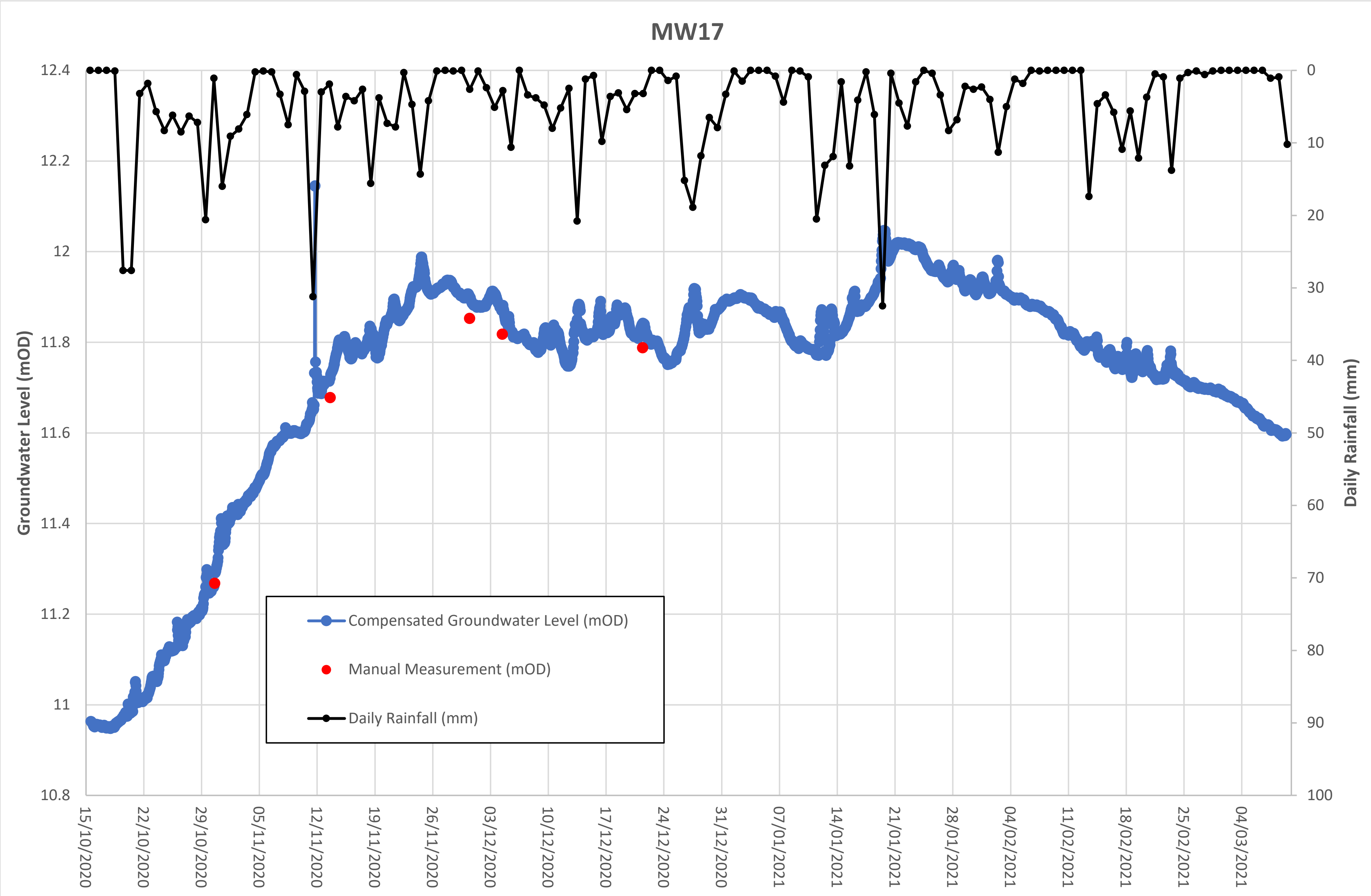


MW10c
Groundwater Level (mOD)
Daily Rainfall (mm)
Groundwater level below datalogger
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)

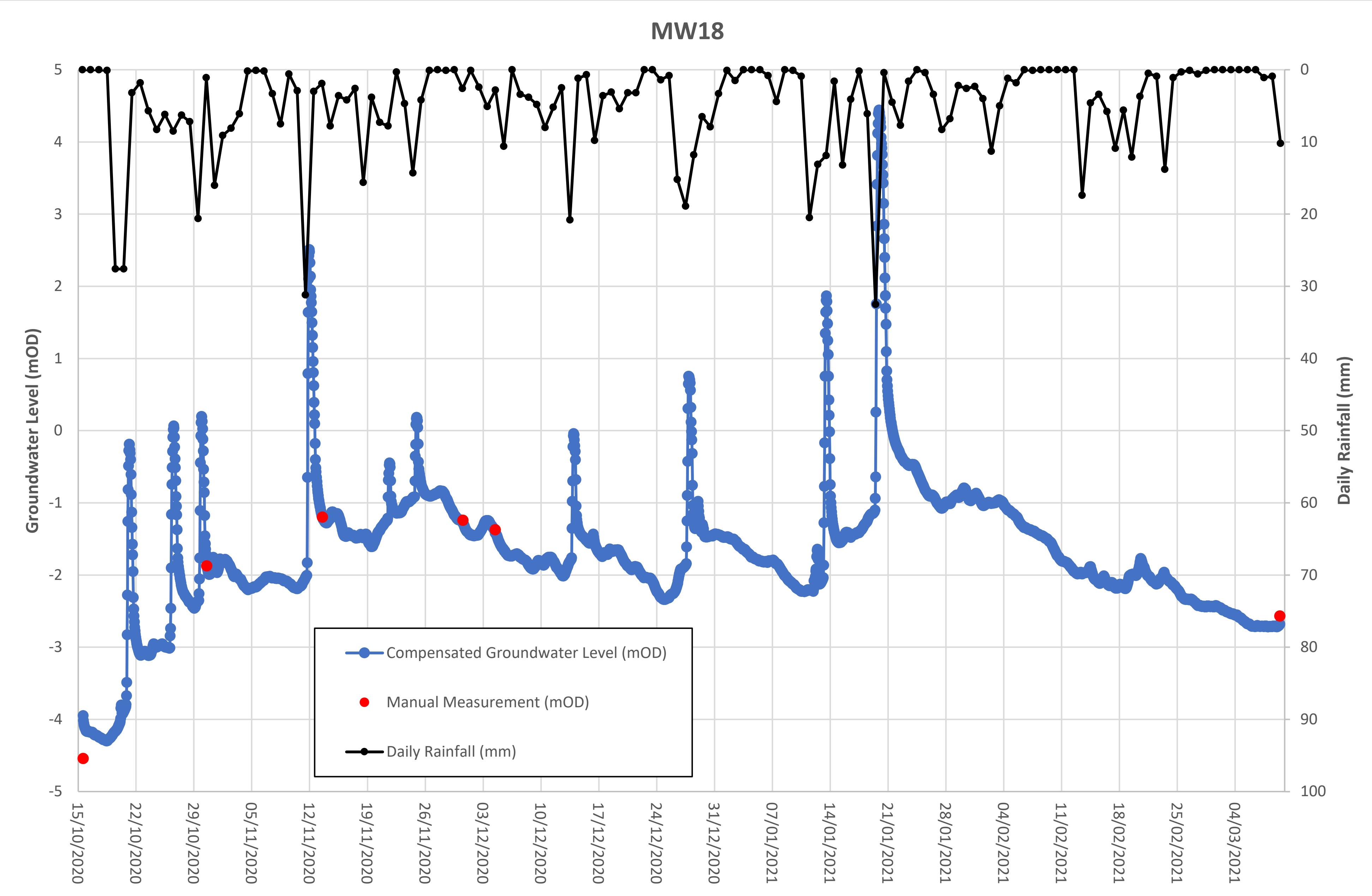

MW15
Groundwater Level (mOD)
Daily Rainfall (mm)
12.5
12
11.5
11
10.5
10
9.5
9
8.5
8
0
10
20
30
40
50
60
70
80
90
100
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021



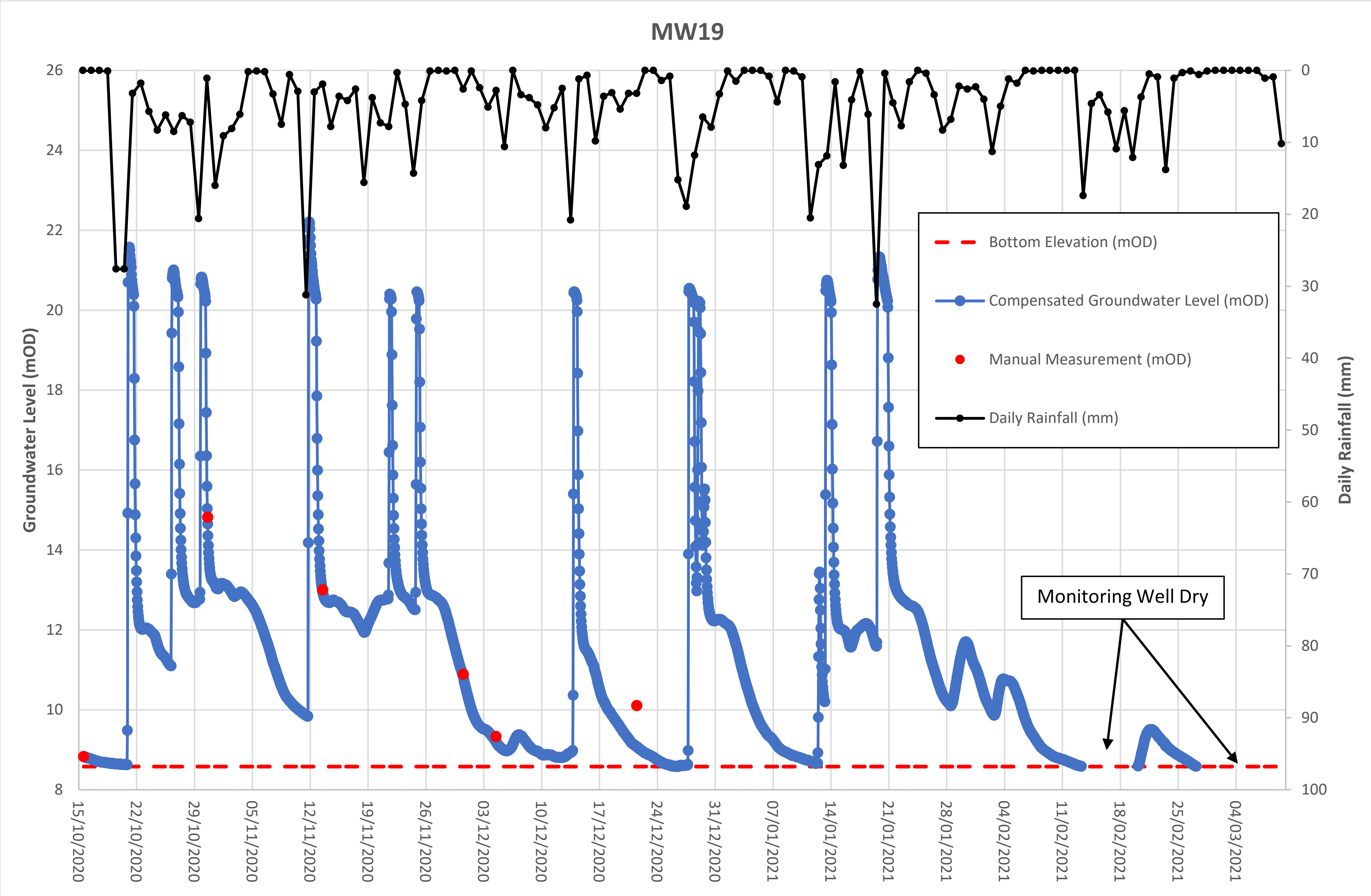
MW16
Groundwater Level (mOD)
Daily Rainfall (mm)
10.6
10.4
10.2
10
9.8
9.6
9.4
9.2
9
8.8
8.6
0
10
20
30
40
50
60
70
80
90
100
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)



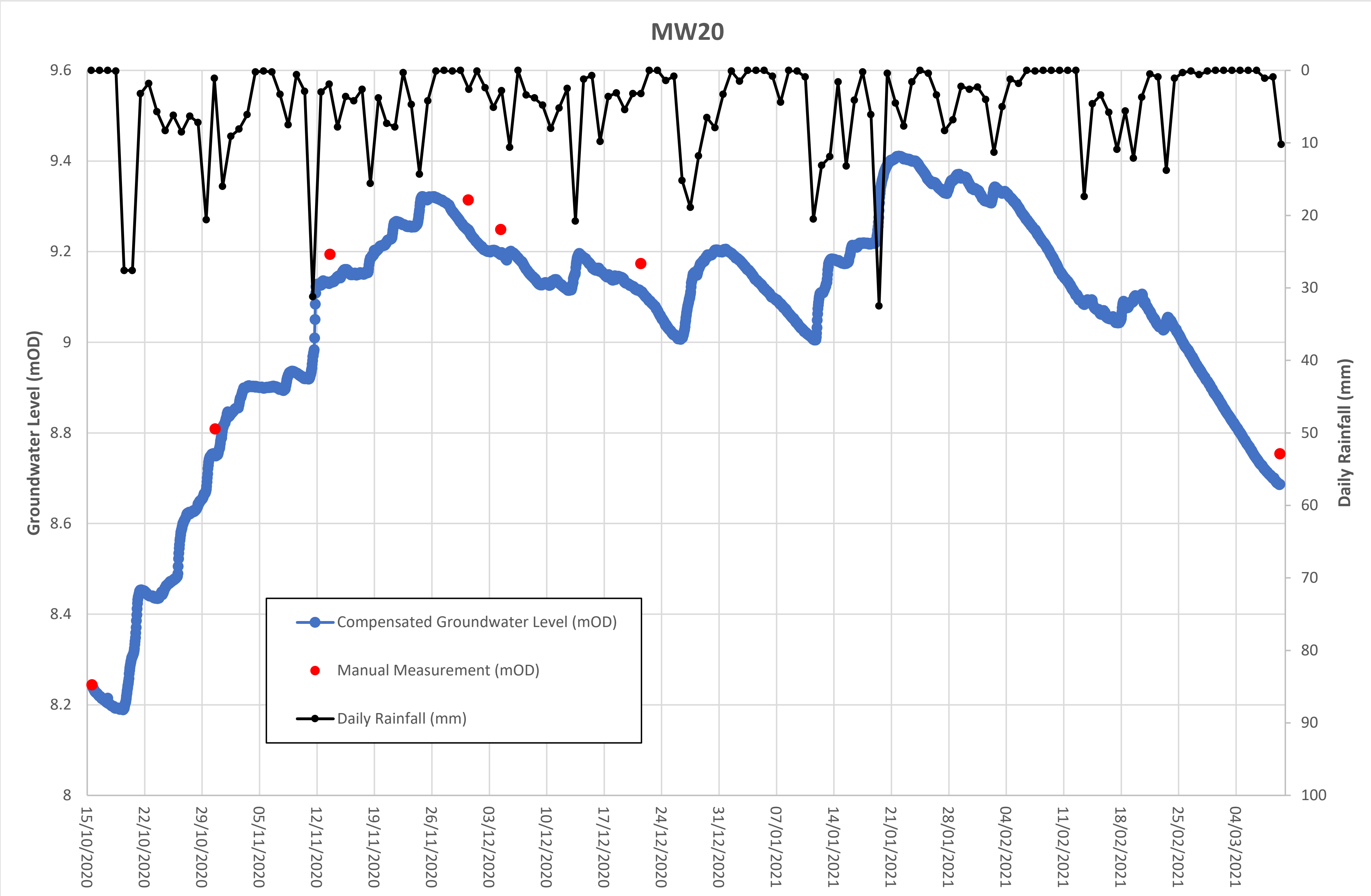
MW17
Groundwater Level (mOD)
Daily Rainfall (mm)
12.4
12.2
12
11.8
11.6
11.4
11.2
11
10.8
0
10
20
30
40
50
60
70
80
90
100
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)

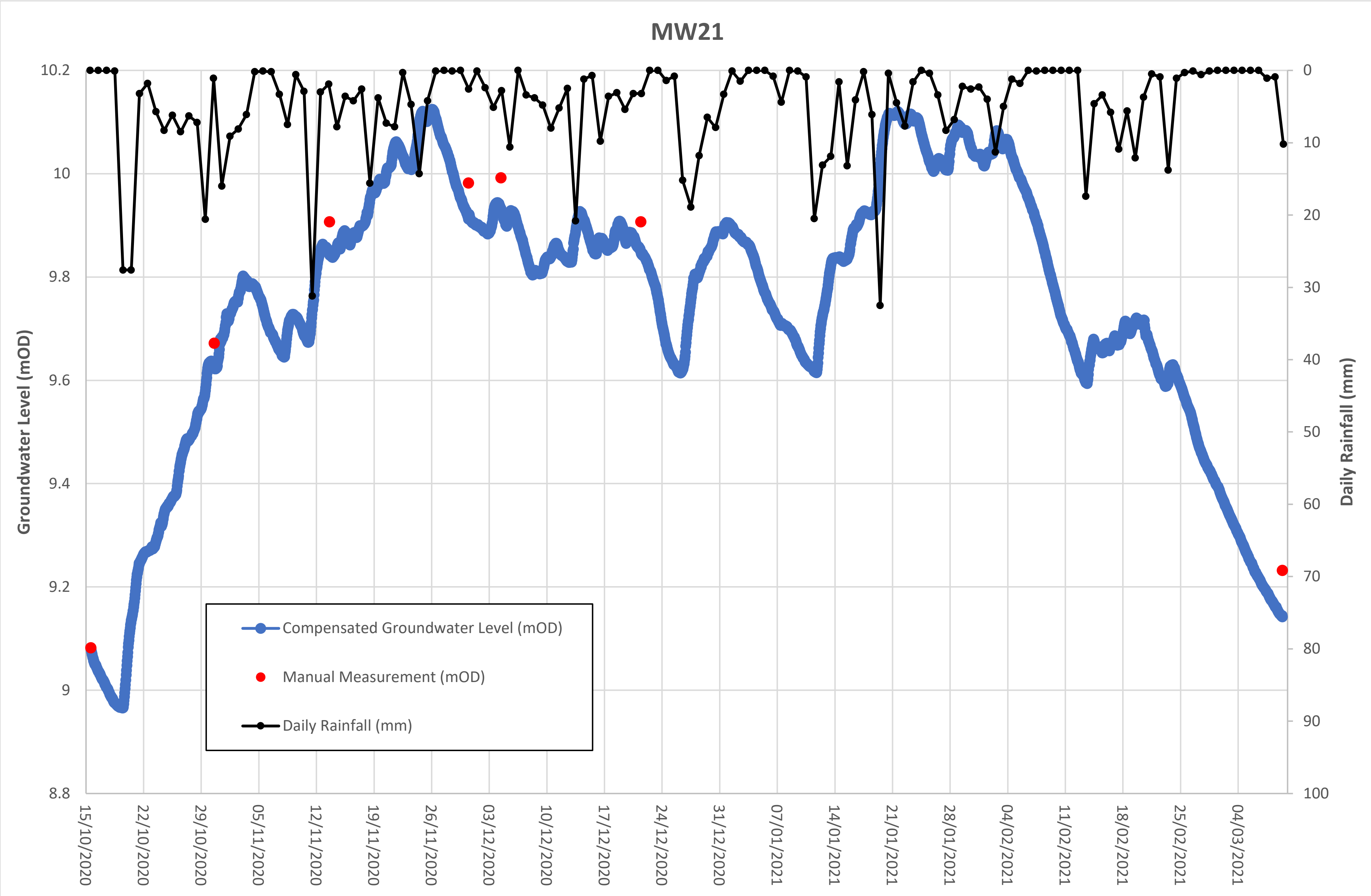


MW18
Groundwater Level (mOD)
Daily Rainfall (mm)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
10
20
30
40
50
60
70
80
90
100
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)

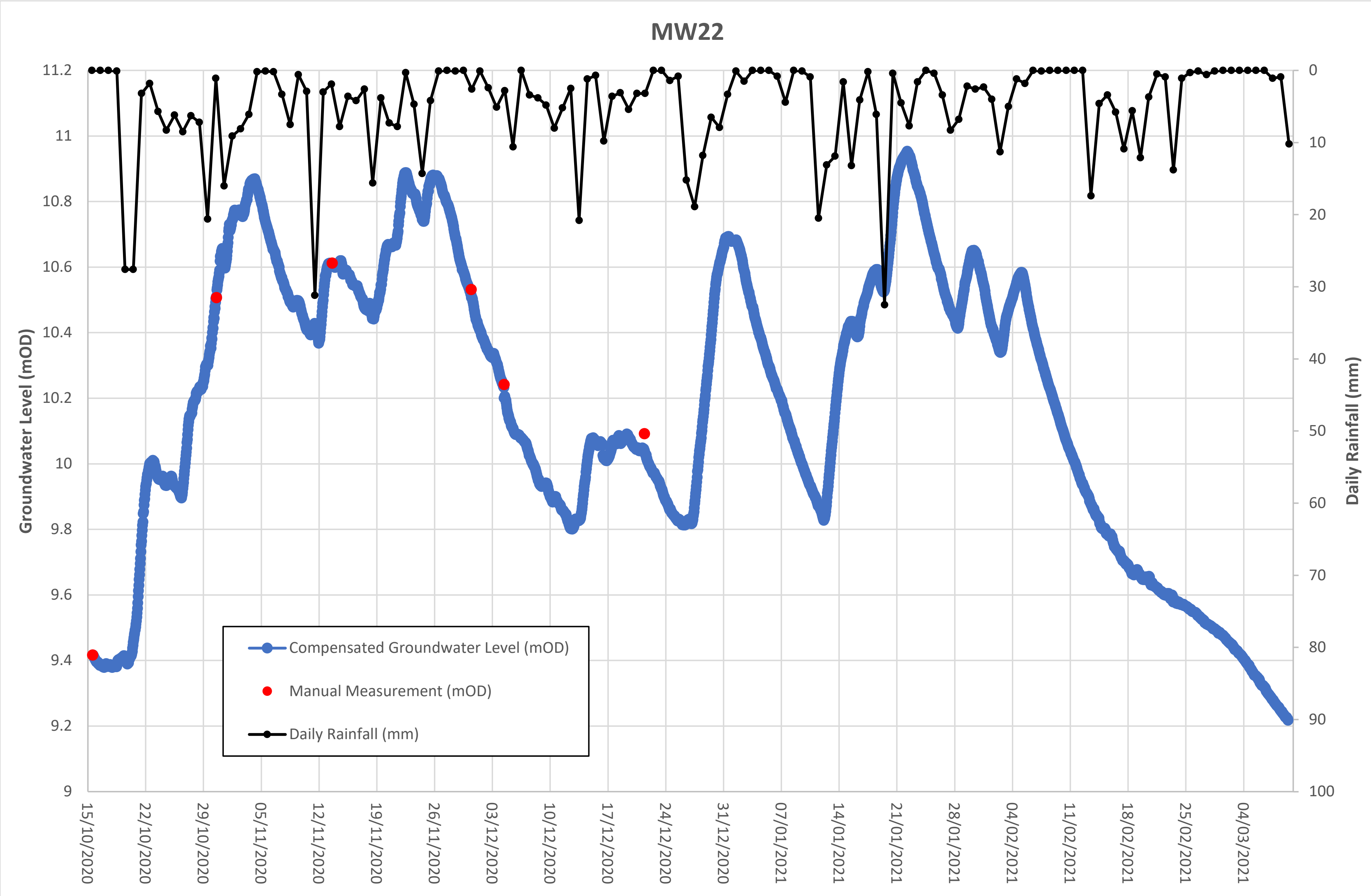


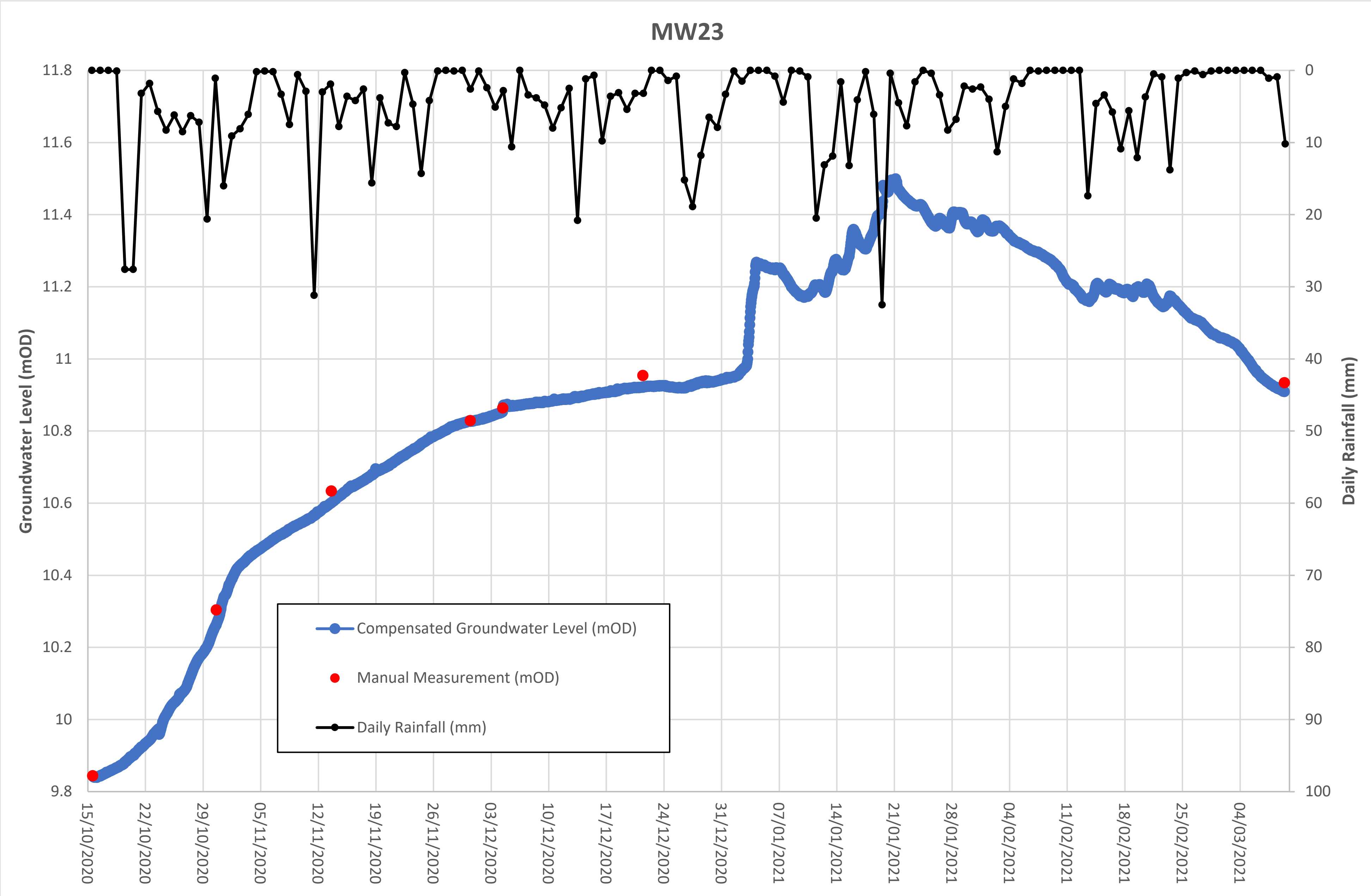
MW19
Groundwater Level (mOD)
Daily Rainfall (mm)
26
24
22
20
18
16
14
12
10
8
0
10
20
30
40
50
60
70
80
90
100
Bottom Elevation (mOD)
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)
Monitoring Well Dry
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021


MW20
Groundwater Level (mOD)
Daily Rainfall (mm)
9.6
9.4
9.2
9
8.8
8.6
8.4
8.2
8
0
10
20
30
40
50
60
70
80
90
100
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)

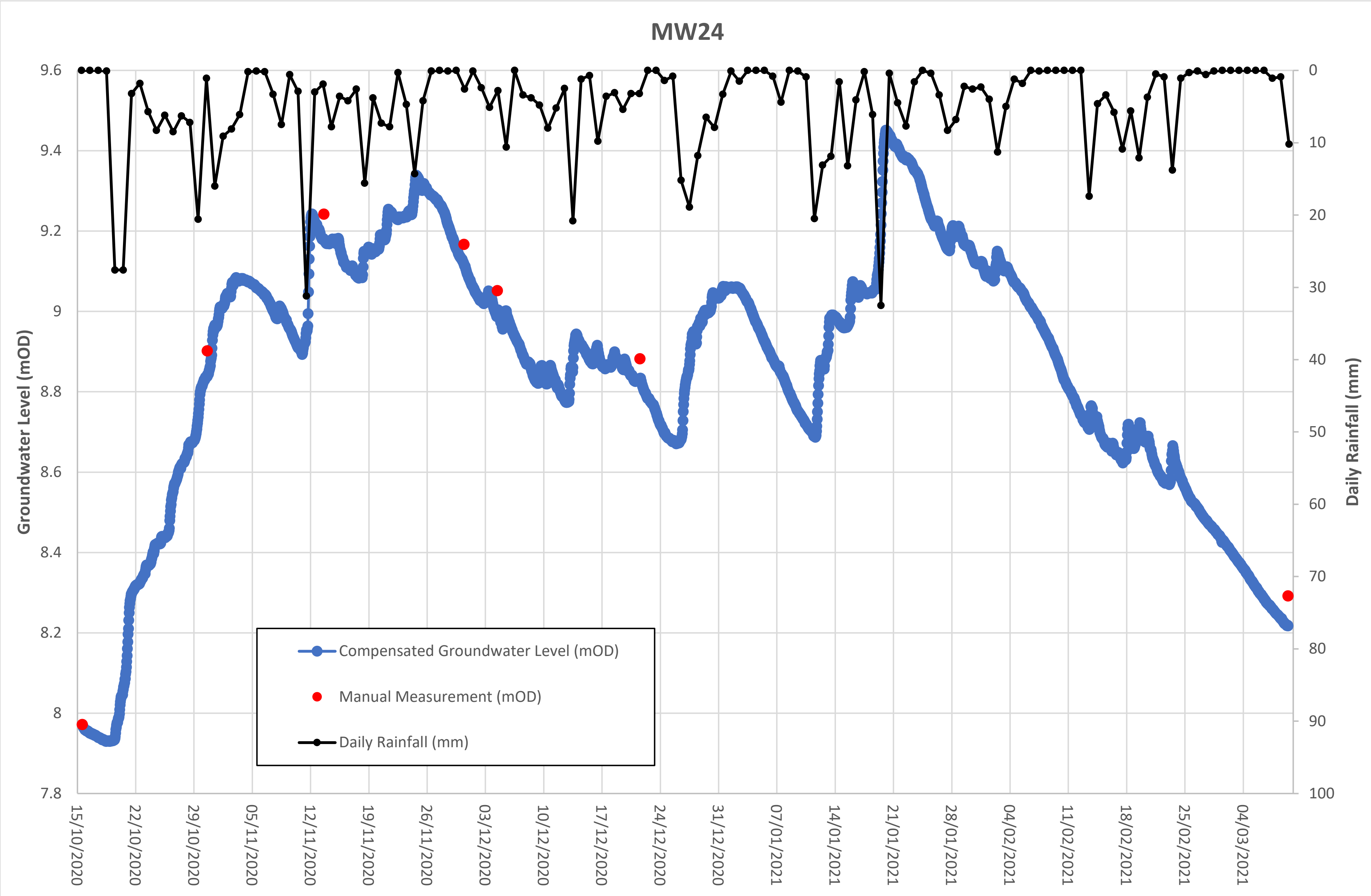


MW21
Groundwater Level (mOD)
Daily Rainfall (mm)
10.2
10
9.8
9.6
9.4
9.2
9
8.8
0
10
20
30
40
50
60
70
80
90
100
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)

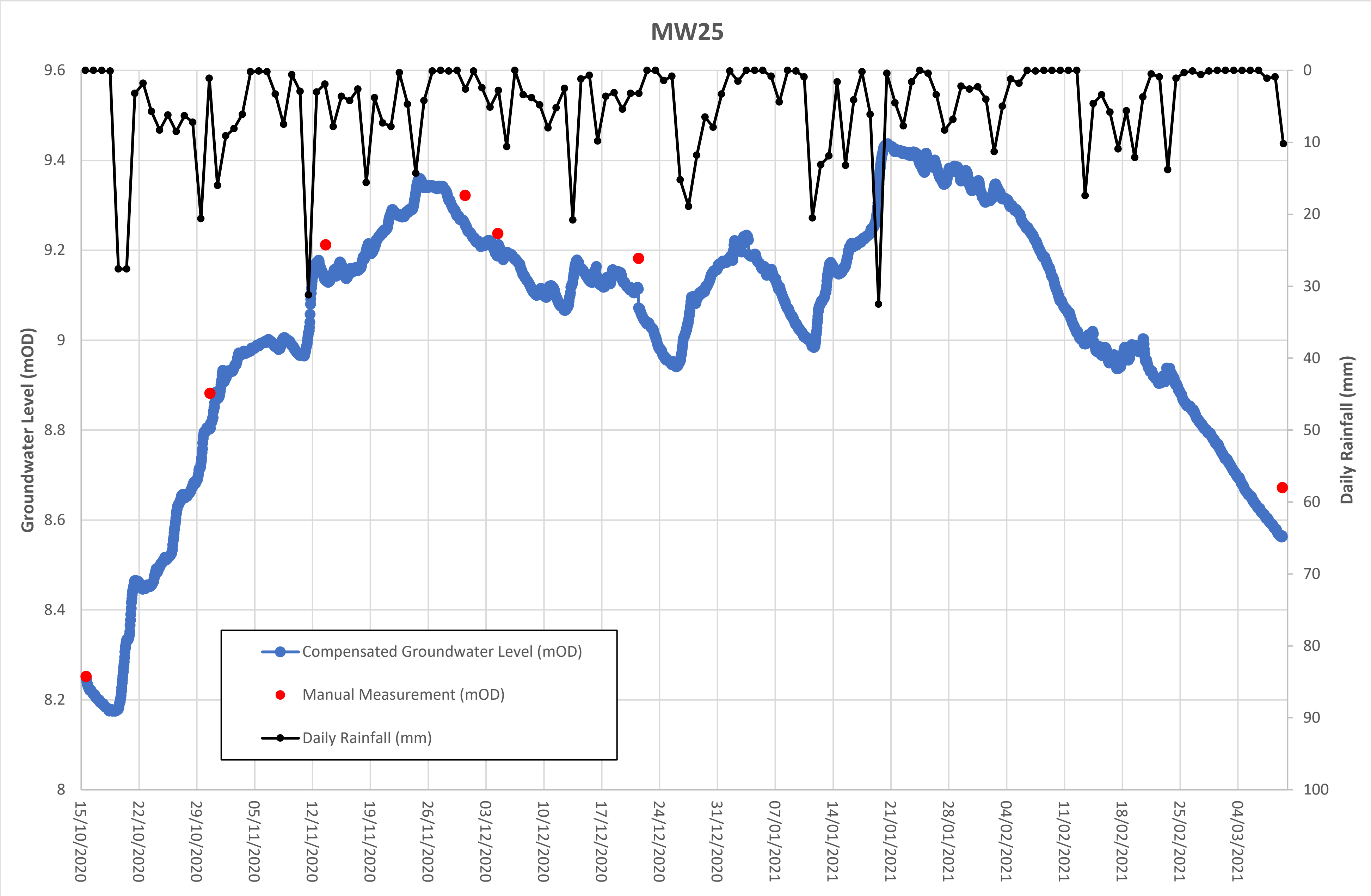

MW22
Groundwater Level (mOD)
Daily Rainfall (mm)
11.2
11
10.8
10.6
10.4
10.2
10
9.8
9.6
9.4
9.2
9
0
10
20
30
40
50
60
70
80
90
100
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021



MW23
Groundwater Level (mOD)
Daily Rainfall (mm)
11.8
11.6
11.4
11.2
11
10.8
10.6
10.4
10.2
10
9.8
0
10
20
30
40
50
60
70
80
90
100
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)



MW24
Groundwater Level (mOD)
Daily Rainfall (mm)
9.6
9.4
9.2
9
8.8
8.6
8.4
8.2
8
7.8
0
10
20
30
40
50
60
70
80
90
100
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)



MW25
Groundwater Level (mOD)
Daily Rainfall (mm)
9.6
9.4
9.2
9
8.8
8.6
8.4
8.2
8
0
10
20
30
40
50
60
70
80
90
100
15/10/2020
22/10/2020
29/10/2020
05/11/2020
12/11/2020
19/11/2020
26/11/2020
03/12/2020
10/12/2020
17/12/2020
24/12/2020
31/12/2020
07/01/2021
14/01/2021
21/01/2021
28/01/2021
04/02/2021
11/02/2021
18/02/2021
25/02/2021
04/03/2021
Compensated Groundwater Level (mOD)
Manual Measurement (mOD)
Daily Rainfall (mm)

APPENDIX 7-18 ASSESSMENT TABLES (EPA & NRA)

The EPA (2017) descriptive criteria integrated into the impact assessment presented are presented in Table 7-1 to Table 7-5, below.

Table 7-1

Quality of Effects EPA (2017)

Quality	Description
Positive	A change which improves the quality of the environment
Neutral	No change, or a change that is imperceptible (within normal bounds of variation or within the margin of forecasting error)
Negative/Adverse	A change which reduces the quality of the environment

Table 7-2

Extent & Context of Effects EPA (2017)

Extent & Context	Description
Extent	Describe the size of the area, the number of sites, and the proportion of a population affected by an effect
Context	Describe whether the extent, duration, or frequency will conform or contrast with established (baseline) conditions

Table 7-3

Probability of Effects EPA (2017)

Probability	Description
Likely	The effects that can reasonably be expected to occur because of the planned project if all mitigation measures are properly implemented
Unlikely	The effects that can reasonably be expected not to occur because of the planned project if all mitigation measures are properly implemented

Table 7-4

Duration & Frequency of Effects EPA (2017)

Duration & Frequency	Description
Momentary	Effects lasting from seconds to minutes

Brief	Effects lasting less than a day
Temporary	Effects lasting less than a year
Short-term	Effects lasting one to seven years
Medium-term	Effects lasting seven to fifteen years
Long-term	Effects lasting fifteen to sixty years
Permanent	Effects lasting over sixty years
Reversible	Effects that can be undone, for example through remediation or restoration
Frequency	Describe how often the effect will occur (once, rarely, occasionally, frequently, constantly – or hourly, daily, weekly, monthly, annually)

Table 7-5

Types of Effects EPA (2017)

Type	Description
Indirect (Secondary)	Impacts on the environment which are not a direct result of the project, often produced away from the project site or because of a complex path
Cumulative	The addition of many minor or significant effects, including effects of other projects, to create larger, more significant effects
'Do-Nothing'	The environment as it would be in the future should the project not be carried out
'Worst-Case'	The effects arising from a project in the case where mitigation measures substantially fail
Indeterminable	When the full consequences of a change in the environment cannot be described
Irreversible	When the character, distinctiveness, diversity or reproductive capacity of an environment is permanently lost
Residual	The degree of environmental change that will occur after the proposed mitigation measures have taken effect
Synergistic	Where the resultant effect is of greater significance than the sum of its constituents

The assessment of the significance of potential effects on the water environment follows the guidelines provided by the Institute of Geologists of Ireland (2013), which recommend the approach taken by the National Roads Authority (NRA, 2008). Tables 7-6 to 7-10 present the NRA (2008) Framework Tables.

Table 7-6

Importance of Hydrological Features (NRA, 2008)

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale	River, wetland or surface water body ecosystem protected by EU legislation (e.g. 'European sites' designated under the Habitats Regulations or 'Salmonid waters' designated pursuant to the European Communities (Quality of Salmonid Waters) Regulations, 1988.
Very High	Attribute has a high quality or value on a regional or national scale	River, wetland or surface water body ecosystem protected by national legislation (e.g. NHA status). Regionally important potable water source supplying >2,500 homes. Quality Class A (Biotic Index Q4, Q5). Flood plain protecting more than 50 residential or commercial properties from flooding. Nationally important amenity site for wide range of leisure activities.
High	Attribute has a high quality or value on a local scale	Salmon fishery. Locally important potable water source supplying >1,000 homes. Quality Class B (Biotic Index Q3-4). Floodplain protecting between 5 and 50 residential or commercial properties from flooding. Locally important amenity site for wide range of leisure activities.
Medium	Attribute has a medium quality or value on a local scale	Coarse fishery. Local potable water source supplying >50 homes. Quality Class C (Biotic Index Q3, Q2-3). Floodplain protecting between 1 and 5 residential or commercial properties from flooding.
Low	Attribute has a low quality or value on a local scale	Locally important amenity site for small range of leisure activities. Local potable water source supplying <50 homes. Quality Class D (Biotic Index Q2, Q1). Floodplain protecting 1 residential or commercial property from flooding. Amenity site used by small numbers of local people.

Table 7-7

Importance of Hydrogeological Features (NRA, 2008)

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale	Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation (e.g. SAC or SPA status).
Very High	Attribute has a high quality or value on a regional or national scale	Regionally Important Aquifer with multiple wellfields. Groundwater supports river, wetland or surface water body ecosystem protected by national legislation (e.g. NHA status). Regionally important potable water source supplying >2,500 homes. Inner source protection area for regionally important potable water source.
High	Attribute has a high quality or value on a local scale	Regionally Important Aquifer. Groundwater provides large proportion of baseflow to local rivers. Locally important potable water source supplying >1,000 homes. Outer source protection area for regionally important potable water source. Inner source protection area for locally important water source.
Medium	Attribute has a medium quality or value on a local scale	Locally Important Aquifer. Potable water source supplying >50 homes. Outer source protection area for locally important water source.
Low	Attribute has a low quality or value on a local scale	Poor Bedrock Aquifer. Potable water source supplying <50 homes.

Table 7-8

Magnitude of Impact on Hydrological Features (NRA, 2008)

Magnitude of Impact	Criteria	Typical Examples
Large Adverse	Results in loss of attribute and/or quality and integrity of attribute	Loss or extensive change to a waterbody or water dependent habitat. Increase in predicted peak flood level >100mm. Extensive loss of fishery. Calculated risk of serious pollution incident >2% annually. Extensive reduction in amenity value.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Increase in predicted peak flood level >50mm. Partial loss of fishery. Calculated risk of serious pollution incident >1% annually. Partial reduction in amenity value.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Increase in predicted peak flood level of >10mm. Minor loss of fishery. Calculated risk of serious pollution incident >0.5% annually. Slight reduction in amenity value.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	Negligible change in predicted peak flood level. Calculated risk of serious pollution incident <0.5% annually.
Minor Beneficial	Results in minor improvement of attribute quality	Reduction in predicted peak flood level >10mm. Calculated reduction in pollution risk of 50% or more where existing risk is <1% annually.
Moderate Beneficial	Results in moderate improvement of attribute quality	Reduction in predicted peak flood level >50mm. Calculated reduction in pollution risk of 50% or more where existing risk is >1% annually.
Major Beneficial	Results in major improvement of attribute quality	Reduction in predicted peak flood level >100mm.

Table 7-9

Magnitude of Impact on Hydrogeological Features (NRA, 2008)

Magnitude of Impact	Criteria	Typical Examples
Large Adverse	Results in loss of attribute and/or quality and integrity of attribute	Removal of large proportion of aquifer. Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems. Potential high risk of pollution to groundwater from routine runoff. Calculated risk of serious pollution incident >2% annually.
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Removal of moderate proportion of aquifer. Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems. Potential medium risk of pollution to groundwater from routine runoff. Calculated risk of serious pollution incident >1% annually.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Removal of small proportion of aquifer. Changes to aquifer or unsaturated zone resulting in minor change to existing water supply springs and wells, river baseflow or ecosystems. Potential low risk of pollution to groundwater from routine runoff. Calculated risk of serious pollution incident >0.5% annually.
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	Calculated risk of serious pollution incident <0.5% annually.

Table 7-10

Significance of Impact on Hydrological/Hydrogeological Features (NRA, 2008)

Importance of Attribute	Magnitude of Impact			
	Negligible	Small Adverse	Moderate Adverse	Large Adverse
Extremely High	Imperceptible	Significant	Profound	Profound
Very High	Imperceptible	Significant/ Moderate	Profound/ Significant	Profound
High	Imperceptible	Moderate/ Slight	Significant/ Moderate	Profound/ Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight/ Moderate

APPENDIX 7-19 SETTLEMENT LAGOON DETAILS

Settlement Lagoon Details

1. Design Settling Velocity

Parameter	Symbol	Value	Units	Notes
Diameter of particle	d	4.0×10^{-6}	m	Mid-range for fine silt
Density of settling particle	ϱ_p	2600	kg/m^3	
Density of water	ϱ_w	1000	kg/m^3	
Dynamic viscosity of water	μ	1.307×10^{-3}	kg/m.s	At 10 degrees Celcius
Acceleration due to gravity	g	9.81	m/s^2	

Settling Velocity (from Stokes Law)	V_s	1.067×10^{-5}	m/s	
Design Settling Velocity	V_s	1.0×10^{-5}	m/s	

Stokes Law:

$$V_s = \frac{g(\rho_s - \rho_w)d^2}{18\mu}$$

where
V_s = terminal settling velocity of the solid particle
g = gravitational acceleration
ρ_s = density of settling particle
ρ_w = density of water
d = diameter of particle
μ = dynamic viscosity

2. Design Flow Rate

Parameter	Symbol	Value	Units	Notes
Maximum discharge rate	Q	0.0405	m^3/s	As per discharge licence
Groundwater inflows	Q	0.0122	m^3/s	At final quarry depth of -50moD
Maximum excess discharge rate	Q	0.0283	m^3/s	Maximum rate available for storm water pumping
Design Flow Rate	Q_{max}	0.0283	m^3/s	

3. Surface Area Required

Parameter	Symbol	Value	Units	Notes
Surface Area	A	2830	m^2	Surface Area Required = Design Flow Rate/Settling Velocity

Notes:

1. Settlement lagoon to have standing water depth of 1.5m
2. Settlement lagoon to have freeboard of 0.5m
3. Settlement lagoon base/sides to be lined to prevent leakage

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APPENDIX 7-20 RADIUS OF INFLUENCE & GROUNDWATER INFLOWS ESTIMATES

Estimated Radius of Influence

Sichardt's Empirical Equation:

Sichardt's Empirical Equation:

$$R_o = C(H - h_w)\sqrt{(k)}$$

Where:

C is a constant (usually 3000)

H-h_w is drawdown at the excavation (m)

k is permeability (m/s)

Equivalent Well radius is 160m (match on aerial photo for lower bench)

1. Existing Situation (floor at -21mOD)

			Notes:
C	3000	-	Constant
H-h_w	27.5	m	Annual average
k	1.25 E-6	m/s	Packer tests
R_0 (beyond Equivalent Well)	92	m	Excludes Equivalent Well radius
R_0	252	m	Includes Equivalent Well radius

2. Bench at -34.5mOD

			Notes:
C	3000	-	Constant
H-h_w	41	m	Annual average
k	1.25 E-6	m/s	Packer tests
R_0 (beyond Equivalent Well)	138	m	Excludes Equivalent Well radius
R_0	298	m	Includes Equivalent Well radius

3. Bench at -50mOD

			Notes:
C	3000	-	Constant
H-h_w	56.5	m	Annual average
k	1.25 E-6	m/s	Packer tests
R_0 (beyond Equivalent Well)	190	m	Excludes Equivalent Well radius
R_0	350	m	Includes Equivalent Well radius

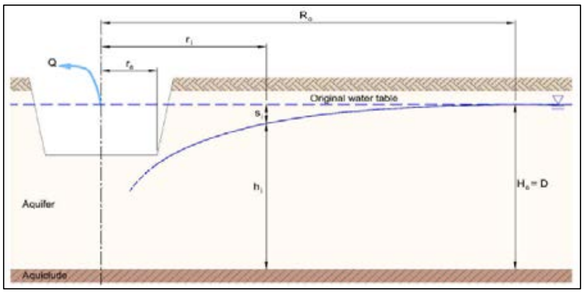
Radius of Influence and Groundwater Inflows

Iterative Method (Combined Thiem-Dupuit Equation & Rate-of-Recharge Method):

Existing Situation (floor at -21mOD):

1. Recharge Estimate:

			Notes:
Annual Rainfall (AR)	1,260	mm/yr	Annual mean at Markree Castle (Met Eireann)
Potential Evapotranspiration (PE)	509	mm/yr	Average of annual mean at Finner Camp and Knock Airport (Met Eireann)
Actual Evapotranspiration (AE)	484	mm/yr	Taken as 95% of PE
Effective Rainfall (ER)	776	mm/yr	AR - AE
Recharge Coefficient (rc)	90	%	Upper end estimate for thin moderately permeable overburden
Recharge (R)	698	mm/yr	ER x rc



2. Inputs:

			Notes:
k	0.108	m/d	Packer tests
H	27.5	m	Groundwater head above quarry floor outside zone of influence (annual average)
h_w	0	m	Groundwater head above quarry floor at quarry face
r_e	160	m	Equivalent Well radius, visual match on aerial photo for lower bench
R	0.0019123	m/d	Recharge per day (annual average)

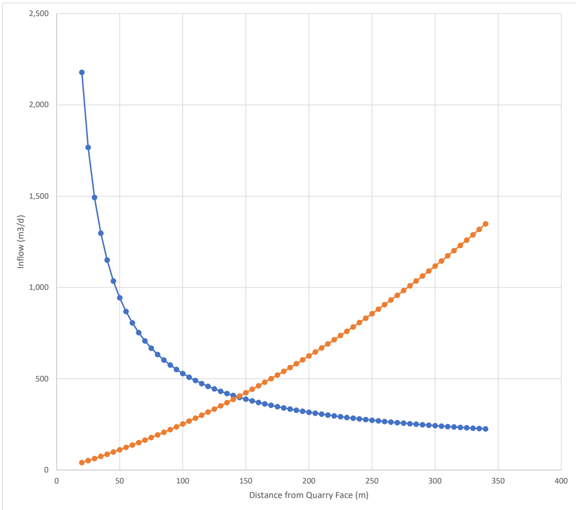
Thiem-Dupuit Equation:

$$Q = \frac{\pi k\left(H^2 - h_w^2\right)}{\ln\left[R_o / r_e\right]}$$

Assumptions:
- the aquifer is unconfined
- the aquifer has infinite areal extent
- the aquifer is homogeneous, and of uniform thickness
- there is only a small water table gradient
- groundwater flow is horizontal
- the pumping rate is constant
- the aquifer is fully penetrated
- the flow is in steady state
- the Dupuit assumptions are satisfied

3. Radius of Influence & Groundwater Inflows Estimate:

Distance from Quarry Face (m)	R_0 (m)	$Q_{groundwater\ inflows}$	$Q_{recharge}$
20	180	2178.49	40.85
25	185	1767.36	51.82
30	190	1493.10	63.08
35	195	1297.05	74.65
40	200	1149.89	86.51
45	205	1035.32	98.68
50	210	943.57	111.14
55	215	868.43	123.91
60	220	805.74	136.98
65	225	752.62	150.34
70	230	707.04	164.01
75	235	667.49	177.98
80	240	632.83	192.25
85	245	602.20	206.82
90	250	574.94	221.69
95	255	550.52	236.86
100	260	528.50	252.33
105	265	508.55	268.10
110	270	490.38	284.17
115	275	473.76	300.54
120	280	458.51	317.21
125	285	444.45	334.18
130	290	431.46	351.45
135	295	419.40	369.03
140	300	408.19	386.90
145	305	397.73	405.07
150	310	387.95	423.55
155	315	378.79	442.32
160	320	370.18	461.40
165	325	362.08	480.77
170	330	354.45	500.45
175	335	347.23	520.42
180	340	340.41	540.70
185	345	333.94	561.28
190	350	327.80	582.15
195	355	321.97	603.33
200	360	316.41	624.81
205	365	311.12	646.59
210	370	306.07	668.66
215	375	301.25	691.04
220	380	296.64	713.72
225	385	292.22	736.70
230	390	287.99	759.98
235	395	283.93	783.56
240	400	280.03	807.44
245	405	276.29	831.62
250	410	272.68	856.11
255	415	269.21	880.89
260	420	265.87	905.97
265	425	262.65	931.35
270	430	259.55	957.04
275	435	256.55	983.02
280	440	253.65	1009.30
285	445	250.85	1035.89
290	450	248.13	1062.77
295	455	245.51	1089.96
300	460	242.97	1117.44
305	465	240.51	1145.23
310	470	238.12	1173.32
315	475	235.81	1201.70
320	480	233.56	1230.39
325	485	231.38	1259.38
330	490	229.26	1288.66
335	495	227.19	1318.25
340	500	225.19	1348.14



For the Existing Situation:

R_0 (from Quarry Centre)	**303**	**m**
R_0 (from Quarry Face)	**143**	**m**
$Q_{groundwater\ inflows}$	**402**	**m^3/d**
$Q_{groundwater\ inflows}$	**4.7**	**l/s**

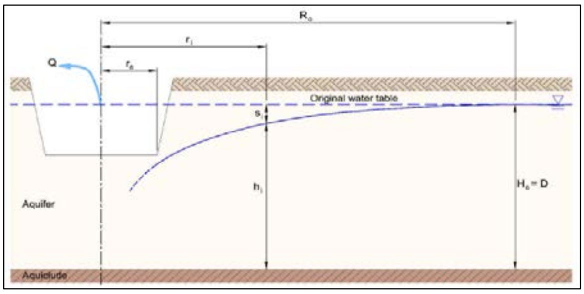
Radius of Influence and Groundwater Inflows

Iterative Method (Combined Thiem-Dupuit Equation & Rate-of-Recharge Method):

Bench at -34.5mOD:

1. Recharge Estimate:

			Notes:
Annual Rainfall (AR)	1,260	mm/yr	Annual mean at Markree Castle (Met Eireann)
Potential Evapotranspiration (PE)	509	mm/yr	Average of annual mean at Finner Camp and Knock Airport (Met Eireann)
Actual Evapotranspiration (AE)	484	mm/yr	Taken as 95% of PE
Effective Rainfall (ER)	776	mm/yr	AR - AE
Recharge Coefficient (rc)	90	%	Upper end estimate for thin moderately permeable overburden
Recharge (R)	698	mm/yr	ER x rc



2. Inputs:

			Notes:
k	0.108	m/d	Packer tests
H	41	m	Groundwater head above quarry floor outside zone of influence (annual average)
h_w	0	m	Groundwater head above quarry floor at quarry face
r_e	160	m	Equivalent Well radius, visual match on aerial photo for lower bench
R	0.0019123	m/d	Recharge per day (annual average)

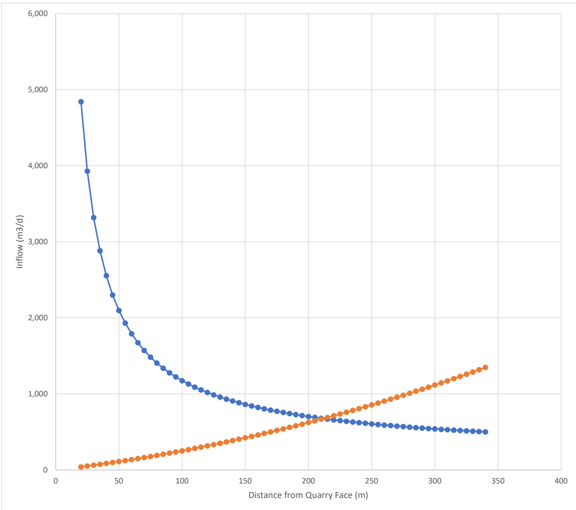
Thiem-Dupuit Equation:

$$Q = \frac{\pi k\left(H^2 - h_w^2\right)}{\ln\left[R_o / r_e\right]}$$

Assumptions:
- the aquifer is unconfined
- the aquifer has infinite areal extent
- the aquifer is homogeneous, and of uniform thickness
- there is only a small water table gradient
- groundwater flow is horizontal
- the pumping rate is constant
- the aquifer is fully penetrated
- the flow is in steady state
- the Dupuit assumptions are satisfied

3. Radius of Influence & Groundwater Inflows Estimate:

Distance from Quarry Face (m)	R_0 (m)	$Q_{groundwater\ inflows}$	$Q_{recharge}$
20	180	4842.38	40.85
25	185	3928.52	51.82
30	190	3318.88	63.08
35	195	2883.09	74.65
40	200	2555.98	86.51
45	205	2301.32	98.68
50	210	2097.39	111.14
55	215	1930.35	123.91
60	220	1791.00	136.98
65	225	1672.94	150.34
70	230	1571.62	164.01
75	235	1483.70	177.98
80	240	1406.66	192.25
85	245	1338.58	206.82
90	250	1277.99	221.69
95	255	1223.69	236.86
100	260	1174.75	252.33
105	265	1130.40	268.10
110	270	1090.02	284.17
115	275	1053.09	300.54
120	280	1019.18	317.21
125	285	987.93	334.18
130	290	959.04	351.45
135	295	932.25	369.03
140	300	907.32	386.90
145	305	884.07	405.07
150	310	862.34	423.55
155	315	841.97	442.32
160	320	822.84	461.40
165	325	804.84	480.77
170	330	787.86	500.45
175	335	771.83	520.42
180	340	756.66	540.70
185	345	742.28	561.28
190	350	728.64	582.15
195	355	715.67	603.33
200	360	703.33	624.81
205	365	691.56	646.59
210	370	680.34	668.66
215	375	669.62	691.04
220	380	659.37	713.72
225	385	649.55	736.70
230	390	640.14	759.98
235	395	631.12	783.56
240	400	622.46	807.44
245	405	614.13	831.62
250	410	606.12	856.11
255	415	598.41	880.89
260	420	590.99	905.97
265	425	583.83	931.35
270	430	576.92	957.04
275	435	570.25	983.02
280	440	563.81	1009.30
285	445	557.58	1035.89
290	450	551.56	1062.77
295	455	545.72	1089.96
300	460	540.08	1117.44
305	465	534.60	1145.23
310	470	529.30	1173.32
315	475	524.15	1201.70
320	480	519.15	1230.39
325	485	514.30	1259.38
330	490	509.59	1288.66
335	495	505.01	1318.25
340	500	500.56	1348.14



For Proposed Bench at -34.5mOD:

R_0 (from Quarry Centre)	**371**	**m**
R_0 (from Quarry Face)	**211**	**m**
$Q_{groundwater\ inflows}$	**678**	**m^3/d**
$Q_{groundwater\ inflows}$	**7.8**	**l/s**

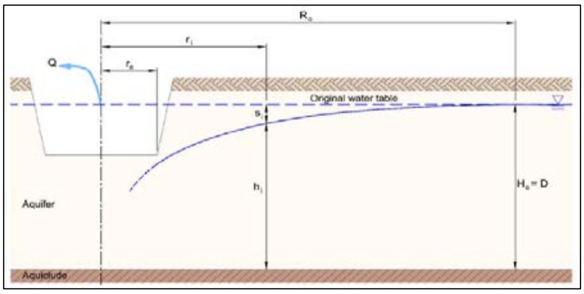
Radius of Influence and Groundwater Inflows

Iterative Method (Combined Thiem-Dupuit Equation & Rate-of-Recharge Method):

Bench at -50mOD:

1. Recharge Estimate:

			Notes:
Annual Rainfall (AR)	1,260	mm/yr	Annual mean at Markree Castle (Met Eireann)
Potential Evapotranspiration (PE)	509	mm/yr	Average of annual mean at Finner Camp and Knock Airport (Met Eireann)
Actual Evapotranspiration (AE)	484	mm/yr	Taken as 95% of PE
Effective Rainfall (ER)	776	mm/yr	AR - AE
Recharge Coefficient (rc)	90	%	Upper end estimate for thin moderately permeable overburden
Recharge (R)	698	mm/yr	ER x rc



2. Inputs:

			Notes:
k	0.108	m/d	Packer tests
H	56.5	m	Groundwater head above quarry floor outside zone of influence (annual average)
h_w	0	m	Groundwater head above quarry floor at quarry face
r_e	160	m	Equivalent Well radius, visual match on aerial photo for lower bench
R	0.0019123	m/d	Recharge per day (annual average)

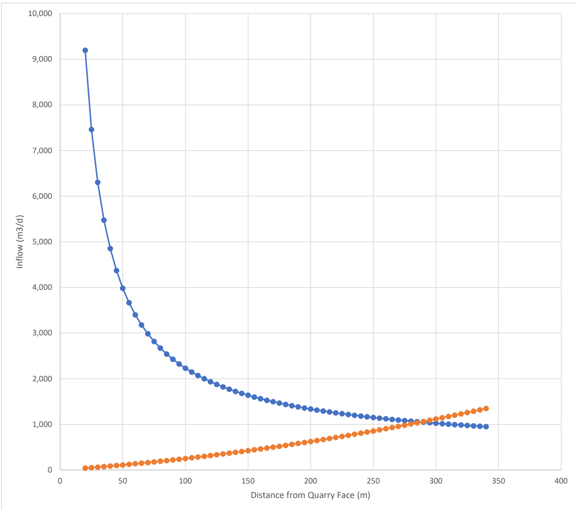
Thiem-Dupuit Equation:

$$Q = \frac{\pi k\left(H^2 - h_w^2\right)}{\ln\left[R_o / r_e\right]}$$

Assumptions:
- the aquifer is unconfined
- the aquifer has infinite areal extent
- the aquifer is homogeneous, and of uniform thickness
- there is only a small water table gradient
- groundwater flow is horizontal
- the pumping rate is constant
- the aquifer is fully penetrated
- the flow is in steady state
- the Dupuit assumptions are satisfied

3. Radius of Influence & Groundwater Inflows Estimate:

Distance from Quarry Face (m)	R_0 (m)	$Q_{groundwater\ inflows}$	$Q_{recharge}$
20	180	9195.76	40.85
25	185	7460.32	51.82
30	190	6302.61	63.08
35	195	5475.05	74.65
40	200	4853.85	86.51
45	205	4370.25	98.68
50	210	3982.97	111.14
55	215	3665.77	123.91
60	220	3401.14	136.98
65	225	3176.94	150.34
70	230	2984.54	164.01
75	235	2817.56	177.98
80	240	2671.27	192.25
85	245	2542.00	206.82
90	250	2426.92	221.69
95	255	2323.81	236.86
100	260	2230.87	252.33
105	265	2146.65	268.10
110	270	2069.96	284.17
115	275	1999.83	300.54
120	280	1935.44	317.21
125	285	1876.11	334.18
130	290	1821.24	351.45
135	295	1770.35	369.03
140	300	1723.02	386.90
145	305	1678.87	405.07
150	310	1637.60	423.55
155	315	1598.92	442.32
160	320	1562.59	461.40
165	325	1528.40	480.77
170	330	1496.17	500.45
175	335	1465.72	520.42
180	340	1436.91	540.70
185	345	1409.61	561.28
190	350	1383.70	582.15
195	355	1359.07	603.33
200	360	1335.63	624.81
205	365	1313.29	646.59
210	370	1291.98	668.66
215	375	1271.62	691.04
220	380	1252.15	713.72
225	385	1233.51	736.70
230	390	1215.64	759.98
235	395	1198.51	783.56
240	400	1182.05	807.44
245	405	1166.24	831.62
250	410	1151.04	856.11
255	415	1136.40	880.89
260	420	1122.29	905.97
265	425	1108.70	931.35
270	430	1095.58	957.04
275	435	1082.92	983.02
280	440	1070.68	1009.30
285	445	1058.86	1035.89
290	450	1047.42	1062.77
295	455	1036.34	1089.96
300	460	1025.62	1117.44
305	465	1015.22	1145.23
310	470	1005.15	1173.32
315	475	995.37	1201.70
320	480	985.88	1230.39
325	485	976.67	1259.38
330	490	967.72	1288.66
335	495	959.02	1318.25
340	500	950.56	1348.14



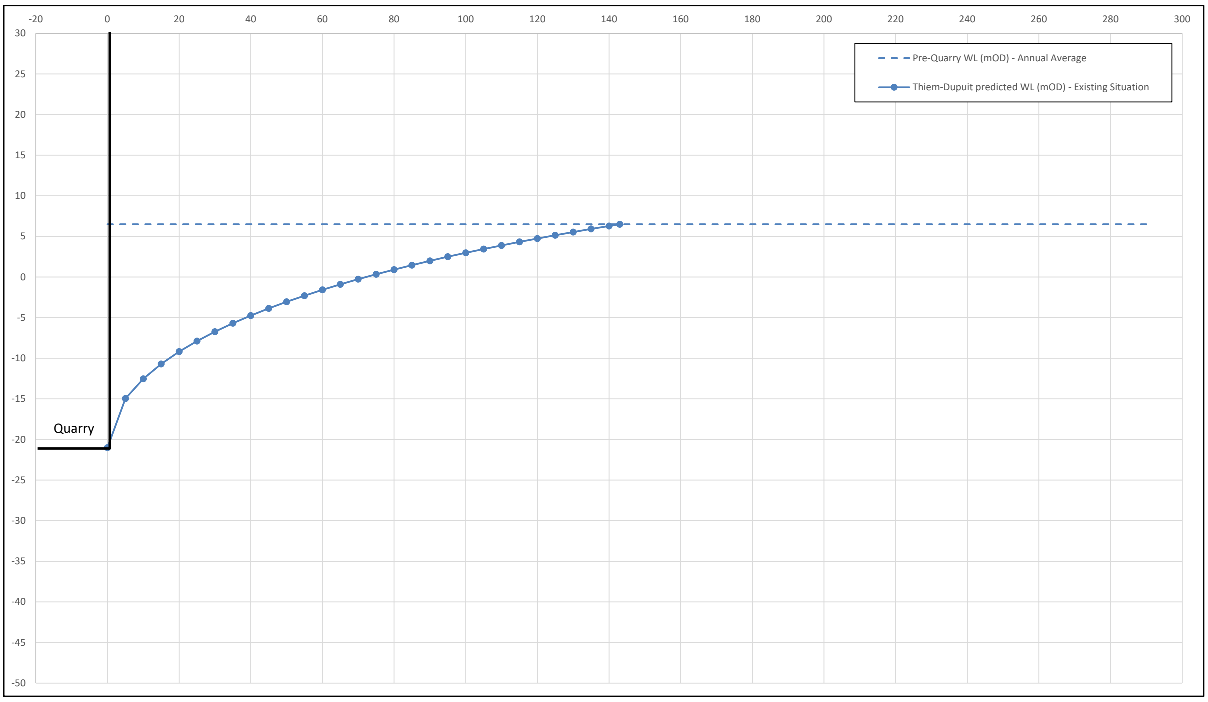
For Proposed Bench at -50mOD:

R_0 (from Quarry Centre)	446	m
R_0 (from Quarry Face)	286	m
$Q_{groundwater\ inflows}$	1057	m^3/d
$Q_{groundwater\ inflows}$	12.2	l/s

Drawdown Profile (Existing Situation)

Hydraulic Conductivity	K	0.108	m/d
Radius of Influence	R_0	303	m
Effective Radius of Quarry	r_e	160	m
Quarry Floor Level		-21	mOD
Aquifer Base		-21	mOD
Height of Water Table at Radius of Influence		6.5	mOD
Height of Water Table at Quarry Floor		-21	mOD
Head at boundary	H	27.5	m
Head at radius of interest	h_w	0	m
Drawdown at Quarry Face	s	27.5	m
Total flow into excavation	Q	401.826	m^3/d
	Q	4.7	l/s

R_0 (m)	Distance from Quarry Face (m)	Head (m)	Thiem-Dupuit predicted WL (mOD) - Existing Situation	Pre-Quarry WL (mOD) - Annual Average
160	0	0.00	-21.00	6.5
165	5	6.04	-14.96	6.5
170	10	8.47	-12.53	6.5
175	15	10.30	-10.70	6.5
180	20	11.81	-9.19	6.5
185	25	13.11	-7.89	6.5
190	30	14.27	-6.73	6.5
195	35	15.31	-5.69	6.5
200	40	16.26	-4.74	6.5
205	45	17.13	-3.87	6.5
210	50	17.95	-3.05	6.5
215	55	18.71	-2.29	6.5
220	60	19.42	-1.58	6.5
225	65	20.09	-0.91	6.5
230	70	20.73	-0.27	6.5
235	75	21.34	0.34	6.5
240	80	21.91	0.91	6.5
245	85	22.46	1.46	6.5
250	90	22.99	1.99	6.5
255	95	23.49	2.49	6.5
260	100	23.98	2.98	6.5
265	105	24.44	3.44	6.5
270	110	24.89	3.89	6.5
275	115	25.33	4.33	6.5
280	120	25.74	4.74	6.5
285	125	26.15	5.15	6.5
290	130	26.54	5.54	6.5
295	135	26.92	5.92	6.5
300	140	27.28	6.28	6.5
303	143	27.50	6.50	6.5
310	150			6.5
315	155			6.5
320	160			6.5
325	165			6.5
330	170			6.5
335	175			6.5
340	180			6.5
345	185			6.5
350	190			6.5
355	195			6.5
360	200			6.5
365	205			6.5
370	210			6.5
375	215			6.5
380	220			6.5
385	225			6.5
390	230			6.5
395	235			6.5
400	240			6.5
405	245			6.5
410	250			6.5
415	255			6.5
420	260			6.5
425	265			6.5
430	270			6.5
435	275			6.5
440	280			6.5
445	285			6.5
450	290			6.5



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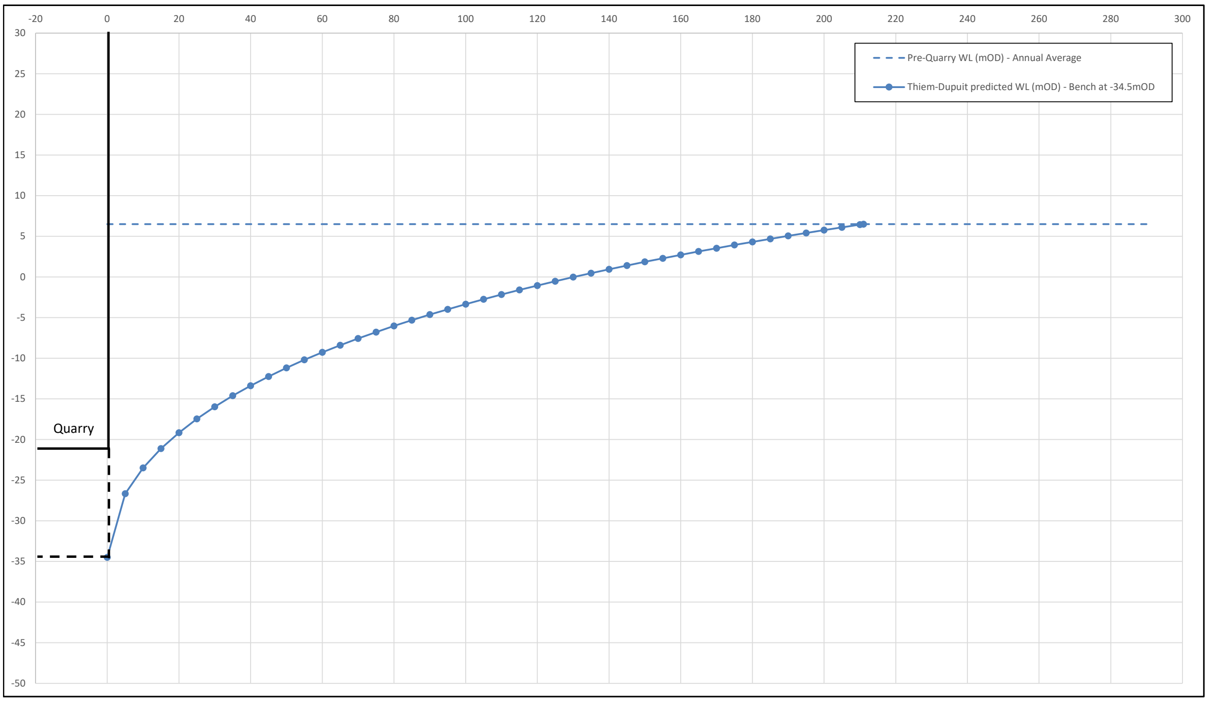
Drawdown Profile (Bench at -34.5mOD)

Hydraulic Conductivity	K	0.108	m/d
Radius of Influence	R_0	371	m
Effective Radius of Quarry	r_e	160	m
Quarry Floor Level		-34.5	mOD
Aquifer Base		-34.5	mOD
Height of Water Table at Radius of Influence		6.5	mOD
Height of Water Table at Quarry Floor		-34.5	mOD
Head at boundary	H	41	m
Head at radius of interest	h_w	0	m
Drawdown at Quarry Face	s	41	m
Total flow into excavation	Q	678.158	m^3/d
	Q	7.8	l/s

R_0 (m)	Distance from Quarry Face (m)	Head (m)	Thiem-Dupuit predicted WL (mOD) - Bench at -34.5mOD	Pre-Quarry WL (mOD) - Annual Average
160	0	0.00	-34.50	6.5
165	5	7.84	-26.66	6.5
170	10	11.01	-23.49	6.5
175	15	13.38	-21.12	6.5
180	20	15.34	-19.16	6.5
185	25	17.03	-17.47	6.5
190	30	18.53	-15.97	6.5
195	35	19.88	-14.62	6.5
200	40	21.12	-13.38	6.5
205	45	22.26	-12.24	6.5
210	50	23.31	-11.19	6.5
215	55	24.30	-10.20	6.5
220	60	25.23	-9.27	6.5
225	65	26.10	-8.40	6.5
230	70	26.93	-7.57	6.5
235	75	27.72	-6.78	6.5
240	80	28.47	-6.03	6.5
245	85	29.18	-5.32	6.5
250	90	29.87	-4.63	6.5
255	95	30.52	-3.98	6.5
260	100	31.15	-3.35	6.5
265	105	31.76	-2.74	6.5
270	110	32.34	-2.16	6.5
275	115	32.90	-1.60	6.5
280	120	33.44	-1.06	6.5
285	125	33.97	-0.53	6.5
290	130	34.48	-0.02	6.5
295	135	34.97	0.47	6.5
300	140	35.45	0.95	6.5
305	145	35.91	1.41	6.5
310	150	36.36	1.86	6.5
315	155	36.80	2.30	6.5
320	160	37.22	2.72	6.5
325	165	37.64	3.14	6.5
330	170	38.04	3.54	6.5
335	175	38.43	3.93	6.5
340	180	38.81	4.31	6.5
345	185	39.19	4.69	6.5
350	190	39.55	5.05	6.5
355	195	39.91	5.41	6.5
360	200	40.26	5.76	6.5
365	205	40.60	6.10	6.5
370	210	40.93	6.43	6.5
371	211	41.00	6.50	6.5
380	220			6.5
385	225			6.5
390	230			6.5
395	235			6.5
400	240			6.5
405	245			6.5
410	250			6.5
415	255			6.5
420	260			6.5
425	265			6.5
430	270			6.5
435	275			6.5
440	280			6.5
445	285			6.5
450	290			6.5



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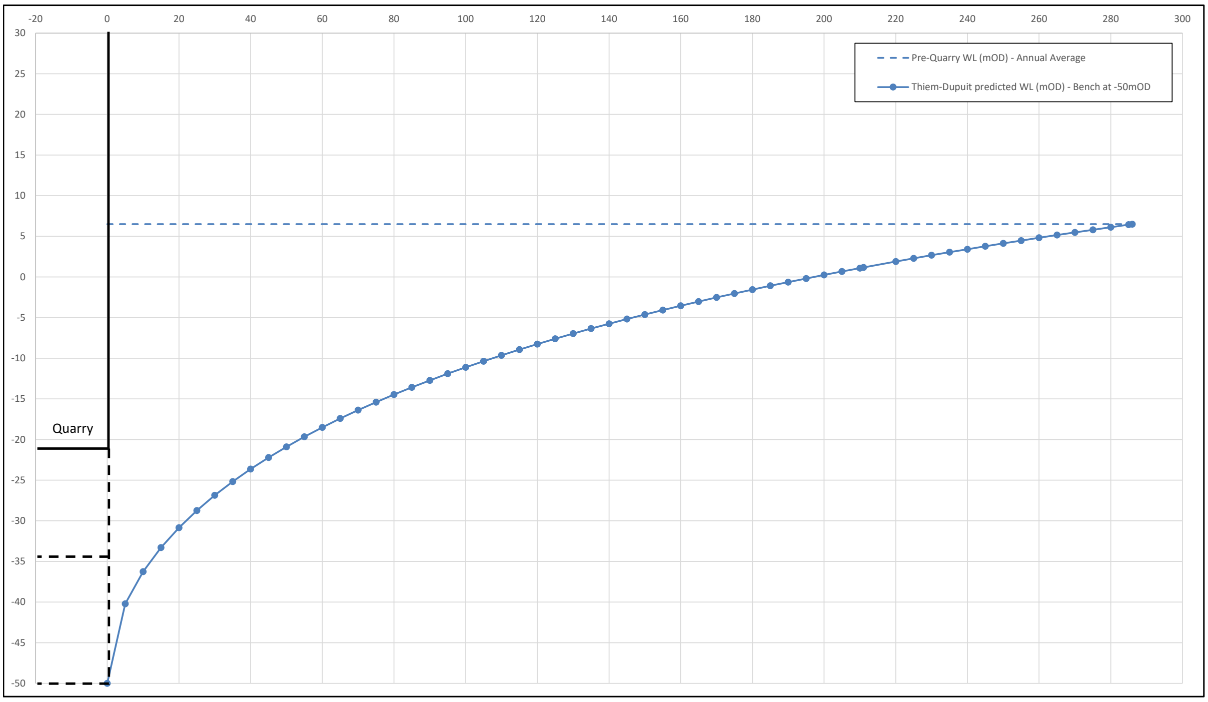
Drawdown Profile (Bench at -50mOD)

Hydraulic Conductivity	K	0.108	m/d
Radius of Influence	R_0	446	m
Effective Radius of Quarry	r_e	160	m
Quarry Floor Level		-50	mOD
Aquifer Base		-50	mOD
Height of Water Table at Radius of Influence		6.5	mOD
Height of Water Table at Quarry Floor		-50	mOD
Head at boundary	H	56.5	m
Head at radius of interest	h_w	0	m
Drawdown at Quarry Face	s	56.5	m
Total flow into excavation	Q	1056.538	m^3/d
	Q	12.2	l/s

R_0 (m)	Distance from Quarry Face (m)	Head (m)	Thiem-Dupuit predicted WL (mOD) - Bench at -50mOD	Pre-Quarry WL (mOD) - Annual Average
160	0	0.00	-50.00	6.5
165	5	9.79	-40.21	6.5
170	10	13.74	-36.26	6.5
175	15	16.70	-33.30	6.5
180	20	19.15	-30.85	6.5
185	25	21.26	-28.74	6.5
190	30	23.13	-26.87	6.5
195	35	24.82	-25.18	6.5
200	40	26.36	-23.64	6.5
205	45	27.78	-22.22	6.5
210	50	29.10	-20.90	6.5
215	55	30.33	-19.67	6.5
220	60	31.49	-18.51	6.5
225	65	32.58	-17.42	6.5
230	70	33.62	-16.38	6.5
235	75	34.60	-15.40	6.5
240	80	35.53	-14.47	6.5
245	85	36.43	-13.57	6.5
250	90	37.28	-12.72	6.5
255	95	38.10	-11.90	6.5
260	100	38.88	-11.12	6.5
265	105	39.64	-10.36	6.5
270	110	40.37	-9.63	6.5
275	115	41.07	-8.93	6.5
280	120	41.74	-8.26	6.5
285	125	42.40	-7.60	6.5
290	130	43.03	-6.97	6.5
295	135	43.65	-6.35	6.5
300	140	44.24	-5.76	6.5
305	145	44.82	-5.18	6.5
310	150	45.38	-4.62	6.5
315	155	45.93	-4.07	6.5
320	160	46.46	-3.54	6.5
325	165	46.98	-3.02	6.5
330	170	47.48	-2.52	6.5
335	175	47.97	-2.03	6.5
340	180	48.45	-1.55	6.5
345	185	48.91	-1.09	6.5
350	190	49.37	-0.63	6.5
355	195	49.82	-0.18	6.5
360	200	50.25	0.25	6.5
365	205	50.68	0.68	6.5
370	210	51.09	1.09	6.5
371	211	51.18	1.18	6.5
380	220	51.90	1.90	6.5
385	225	52.29	2.29	6.5
390	230	52.67	2.67	6.5
395	235	53.05	3.05	6.5
400	240	53.42	3.42	6.5
405	245	53.78	3.78	6.5
410	250	54.13	4.13	6.5
415	255	54.48	4.48	6.5
420	260	54.82	4.82	6.5
425	265	55.15	5.15	6.5
430	270	55.48	5.48	6.5
435	275	55.81	5.81	6.5
440	280	56.13	6.13	6.5
445	285	56.44	6.44	6.5
446	286	56.50	6.50	6.5



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