

**2019 Knickerbocker Lakes Withdrawal
Permit
L-16707-2B-D-M
Annual Report**

Submitted by

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I PURPOSE STATEMENT –

2019 marked the eleventh year of routine use of Knickerbocker Lake located in Boothbay, Maine as permitted in Knickerbocker Lakes Withdrawal Permit L-16707-2B-D-M (hereafter “the permit”) and as authorized by the 120th Maine Legislature L.D. 1442 *An Act to Create the Boothbay Region Water District*. The Boothbay Region Water District (hereafter “the district”) uses Knickerbocker Lake to meet its public safety and public health responsibilities to the population of the Boothbay peninsula. The district withdrew 44,436,300 gallons from Knickerbocker Lake. This report is designed to be an update and companion to the 2008 report submitted to the Maine Department of Environmental Protection (MDEP) 31 December 2008.

II RAINFALL DATA –

Overview of Data Collection - The Boothbay Region Water District records rainfall at the Adams Pond Treatment Plant, located at 182 Adams Pond Road, Boothbay, 43° 53' 21.83"N/69° 38' 02.73" W by using a Davis Industries Vantage Pro2™ (previously described). The district has developed a database tracking multiple weather parameters and allows the data from this station be tracked on the internet at - <http://www.wunderground.com/q/zmw:04537.1.99999>. Data recorded is kept on secured servers with regular backup protocols.

Permit Requirements – The permit requires the district to keep precipitation data. Reported here is rainfall data from December 2018 through November 2019.

Rainfall Data and Analysis During 2019 the Boothbay Region Water District Weather Station recorded 185-days with measurable precipitation recorded of which 79-days measured 0.1 inches of rain or greater within the 24-hour period, 30-days measured 0.5 inches of rain or greater within the 24-hour period and 9-days with one-inch or more precipitation recorded. The high 24-hour period accumulation amount occurred on 11 July 2019 with 1.83-inches of rainfall recorded. The average rainfall events in 24-hours equaled 0.30 inches of precipitation with the median dramatically less at 0.15 inches. During the 2019 pumping season, rainfall amounts were 108.56% of normal. Table 1 & Table 2 list the precipitation for the season (See Appendix A-*Daily Rainfall*; Appendix B -*Total Monthly Rainfall*).

III WITHDRAWAL DATA –

Overview of Withdrawal Data - For the purposes of this report, the withdrawal year is 1 December 2018 through 30 November 2019 which allows the preparation of this report with current data within the time constraints of the permit. During this period the district withdrew a total of 44,436,300 gallons from Knickerbocker Lake and 152,815,700 gallons from Adams Pond. Knickerbocker Lake contributed 22.53% of the water necessary for the district to meet the fire protection and health needs of the peninsula. See Appendix C *Boothbay Region Water District Source Water Usage*.

The district again opted to withdraw from Knickerbocker during peak season to offset the negative drawdown on Adams Pond and use Knickerbocker Lake while it was still relatively easy to treat. The district continues to monitor water quality.

Withdrawal operations began on 16 July 2019 and concluding on 2 September 2019.

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Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall
12/1/2018	0.04	3/29/2019	0.05	6/20/2019	1.51	10/23/2019	1.18
12/2/2018	0.67	3/30/2019	0.02	6/21/2019	0.02	10/25/2019	0.18
12/11/2018	0.01	3/31/2019	0.15	6/22/2019	0.31	10/27/2019	1.25
12/16/2018	0.21	4/2/2019	0.19	6/25/2019	0.87	10/28/2019	0.01
12/17/2018	0.06	4/3/2019	0.08	6/29/2019	0.70	10/30/2019	0.22
12/21/2018	0.99	4/4/2019	0.01	6/30/2019	0.41	10/31/2019	0.69
12/22/2018	0.02	4/5/2019	0.12	7/6/2019	0.26	11/5/2019	0.48
12/28/2018	0.63	4/7/2019	0.03	7/11/2019	1.83	11/7/2019	0.37
12/31/2018	0.06	4/8/2019	0.56	7/12/2019	0.25	11/11/2019	0.16
1/1/2019	0.01	4/9/2019	0.12	7/17/2019	0.02	11/12/2019	0.02
1/2/2019	0.03	4/12/2019	0.04	7/22/2019	0.35	11/14/2019	0.04
1/3/2019	0.23	4/13/2019	0.13	7/23/2019	0.04	11/15/2019	0.01
1/5/2019	0.21	4/14/2019	0.17	8/7/2019	0.75	11/18/2019	0.31
1/7/2019	0.15	4/15/2019	0.41	8/8/2019	0.28	11/19/2019	0.04
1/8/2019	0.23	4/18/2019	0.04	8/18/2019	0.49	11/20/2019	0.06
1/9/2019	0.22	4/20/2019	0.09	8/21/2019	0.54	11/21/2019	0.02
1/22/2019	0.08	4/21/2019	0.06	8/28/2019	1.62	11/22/2019	0.17
1/23/2019	0.21	4/22/2019	1.18	8/29/2019	0.02	11/24/2019	0.65
1/24/2019	0.82	4/23/2019	0.38	9/2/2019	0.11	11/26/2019	0.01
1/29/2019	0.46	4/26/2019	0.83	9/6/2019	0.08	11/27/2019	1.10
1/30/2019	0.01	4/27/2019	0.11	9/7/2019	0.26	11/28/2019	0.01
2/3/2019	0.05	5/1/2019	0.41	9/10/2019	0.12		
2/6/2019	0.14	5/3/2019	0.34	9/11/2019	0.03		
2/7/2019	0.05	5/7/2019	0.07	9/14/2019	0.01		
2/8/2019	0.06	5/9/2019	0.03	9/15/2019	0.01		
2/12/2019	0.88	5/10/2019	0.34	9/23/2019	0.02		
2/15/2019	0.31	5/13/2019	0.27	9/24/2019	0.09		
2/18/2019	0.01	5/14/2019	0.13	9/26/2019	0.29		
2/20/2019	0.16	5/17/2019	0.03	9/30/2019	0.02		
2/22/2019	0.01	5/19/2019	0.75	10/1/2019	0.47		
2/24/2019	1.44	5/20/2019	0.13	10/2/2019	0.02		
2/25/2019	0.01	5/23/2019	0.22	10/3/2019	0.05		
3/2/2019	0.11	5/25/2019	0.19	10/4/2019	0.02		
3/3/2019	0.34	5/28/2019	0.73	10/6/2019	0.01		
3/4/2019	0.12	6/2/2019	0.06	10/7/2019	0.74		
3/10/2019	0.91	6/4/2019	0.11	10/11/2019	0.02		
3/13/2019	0.11	6/5/2019	0.46	10/12/2019	0.06		
3/15/2019	0.16	6/6/2019	0.10	10/14/2019	0.01		
3/21/2019	0.04	6/11/2019	0.69	10/16/2019	0.96		
3/22/2019	0.56	6/13/2019	0.72	10/17/2019	0.25		
3/23/2019	0.01	6/14/2019	0.02	10/22/2019	1.10		

Month	Rainfall	Normal	% of Normal
April	4.55	4.10	110.98%
May	3.64	3.70	98.38%
June	5.98	3.60	166.11%
July	2.75	3.00	91.67%
August	3.70	3.30	112.12%
September	1.04	3.00	34.67%
October	7.24	3.80	190.53%
November	3.45	5.30	65.09%
TOTAL	32.35	29.8	108.56%

Date	Flow	Date	Flow	Date	Flow	Date	Flow
16-Jul-19	0.1294	29-Jul-19	1.0446	11-Aug-19	0.9316	24-Aug-19	0.9240
17-Jul-19	0.8373	30-Jul-19	0.9250	12-Aug-19	0.9694	25-Aug-19	0.8879
18-Jul-19	0.9706	31-Jul-19	1.0164	13-Aug-19	0.8337	26-Aug-19	0.8443
19-Jul-19	0.9046	1-Aug-19	1.0451	14-Aug-19	1.046	27-Aug-19	0.8297
20-Jul-19	1.0395	2-Aug-19	1.0810	15-Aug-19	0.939	28-Aug-19	0.7686
21-Jul-19	0.9596	3-Aug-19	1.1700	16-Aug-19	0.9986	29-Aug-19	0.7411
22-Jul-19	0.7890	4-Aug-19	1.0090	17-Aug-19	0.8929	30-Aug-19	0.8269
23-Jul-19	0.8279	5-Aug-19	1.0513	18-Aug-19	0.9479	31-Aug-19	0.8810
24-Jul-19	0.8460	6-Aug-19	1.0288	19-Aug-19	0.7757	1-Sep-19	0.9714
25-Jul-19	0.8614	7-Aug-19	0.9409	20-Aug-19	0.9104	2-Sep-19	0.7221
26-Jul-19	1.0831	8-Aug-19	0.8418	21-Aug-19	0.7797		
27-Jul-19	0.9857	9-Aug-19	0.9187	22-Aug-19	0.8195		
28-Jul-19	1.0546	10-Aug-19	1.0037	23-Aug-19	0.8299		

Withdrawal Metering Equipment and Maintenance – All 8” Krohne Optiflux Electromagnetic Flow Meter’s received annual calibration and maintenance by Sullivan & Associates, East Boothbay, Maine and were found to be in proper operating condition.

IV **KNICKERBOCKER LAKE AND CAMPBELL CREEK LEVEL MONITORING -**

Background - As required per the permit the Boothbay Region Water District maintained water level measurements at both a culvert located on Barters Island Road along Campbell Creek (43° 52’ 28.47”N, 69° 38’ 50.54”W), the sole discharge of Knickerbocker Lake and at the Knickerbocker Lake Intake location (43° 52’ 51.64”N, 69° 38’ 49.83”W) on a weekly basis. The measurements procedures included the use of staff gauge, Flo-Mate model 2000 portable flow meter, yardstick and stationary mounted ultrasonic level meter with data logger. 2017 saw no change in either equipment or procedures as outlined in the 2008 report.

The elevation benchmarks needed to compare data were established by Leighton and Associates of Boothbay, Maine (registered surveyors) with elevations reported to the North American Vertical Datum, 1988 (NAVD).

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Description of Knickerbocker Lake Monitoring Procedure – The majority of the daily/hourly data was obtained through the ultrasonic water level monitoring unit installed at the Knickerbocker Lake Intake. Periodically, district personnel would take staff gauge readings and compare those readings to ultrasonic readings at the same time. These readings would then be added together to give the distance between the known benchmark, (9.87ft. NAVD) and the ultrasonic unit. This information was reviewed to ensure the unit was in place on the vertical plane so that the values recorded could be used to translate the ultrasonic information into a value NAVD. Using this information the lake level NAVD can be calculated with a high degree of accuracy by the following equation: $4.1654 \text{ (ft)} - \text{Ultrasonic reading (ft)} + 9.87 \text{ (ft)} = \text{lake elevation NAVD}$. See *Table 4 2019 Ultrasonic Calibration Data*.

Date	Staff Gauge Reading (ft)	Ultrasonic Reading (ft)	Combined Total	Knickerbocker Staff Gauge Elevation NAVD
5-May-19	2.79	1.3781	4.1681	2.79
12-May-19	2.45	1.7437	4.1937	2.45
19-May-19	2.44	1.6959	4.1359	2.44
2-Jun-19	2.62	1.5075	4.1275	2.62
6-Jun-19	2.81	1.3416	4.1516	2.81
14-Jun-19	2.82	1.3162	4.1362	2.82
21-Jun-19	2.64	1.4934	4.1334	2.64
30-Jun-19	2.86	1.3134	4.1734	2.86
8-Jul-19	3.06	1.1109	4.1709	3.06
15-Jul-19	2.82	1.3697	4.1897	2.82
22-Jul-19	2.78	1.3669	4.1469	2.78
29-Jul-19	2.36	1.8169	4.1769	2.36
4-Aug-19	1.70	2.1487	3.8487	1.70
12-Aug-19	1.46	2.6269	4.0869	1.46
19-Aug-19	1.23	2.8069	4.0369	1.23
25-Aug-19	1.08	2.9616	4.0416	1.08
1-Sep-19	0.98	3.0825	4.0625	0.98
9-Sep-19	0.90	3.1106	4.0106	0.90
16-Sep-19	0.86	3.1387	3.9987	0.86
22-Sep-19	0.80	3.2034	4.0034	0.80
29-Sep-19	0.78	3.1978	3.9778	0.78
7-Oct-19	0.78	3.1472	3.9272	0.78

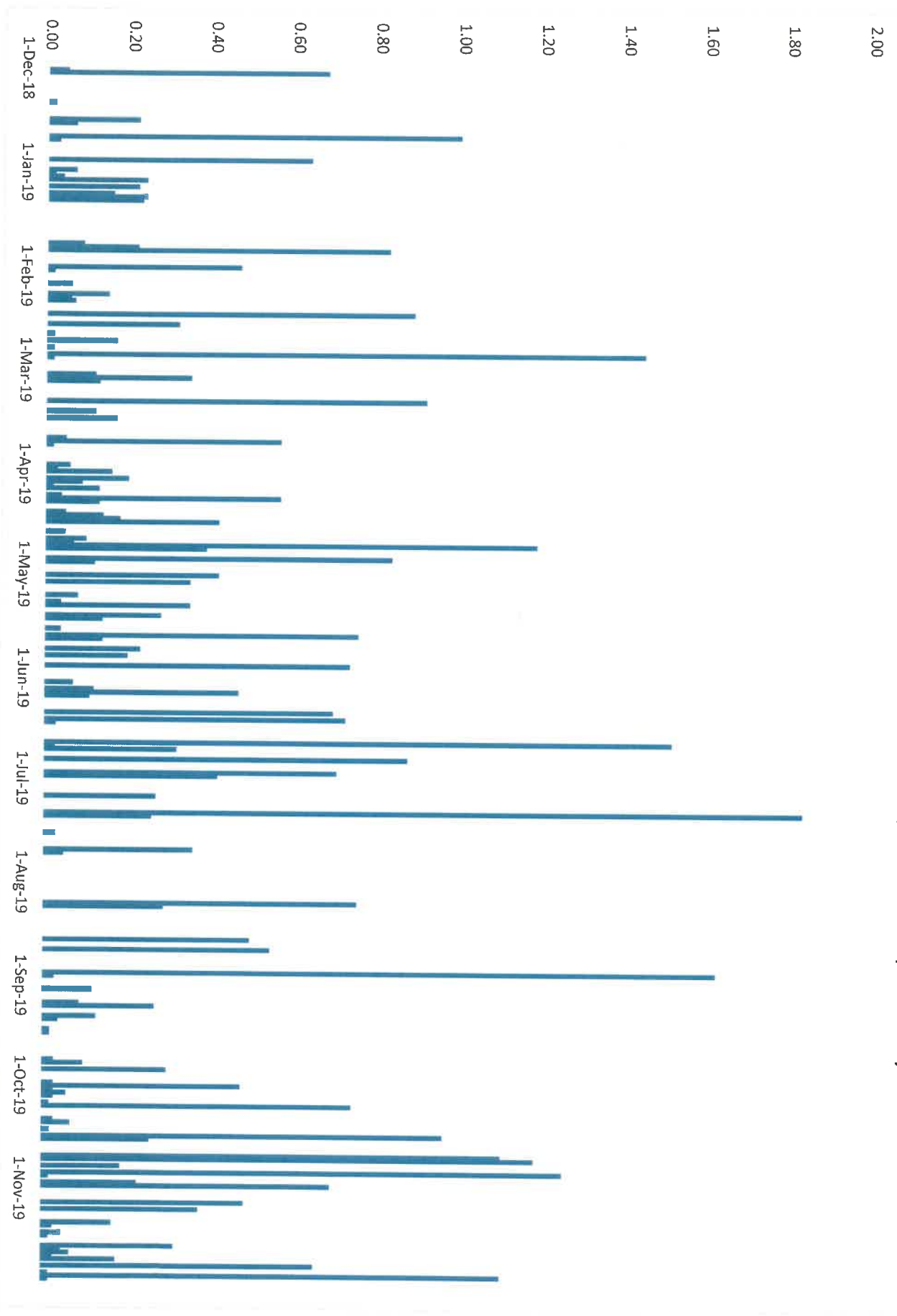
Water Level Measurement Campbell Creek - Campbell Creek water level is measured on the discharge side of culvert traversing the Barters Island Road in Boothbay. The method used is a yardstick measuring the water level from top dead center of the culvert. This level can easily be translated to water level NAVD in that the culvert invert was surveyed by Leighton and Associates in 2003 and found to be 9.09 ft. NAVD. Campbell Creek water level observations Are recorded in *Table 5 - 2019 Campbell Creek Water Level*

Date	Flooded Culvert (ft)	Campbell Creek Elevation NAVD (ft)	Date	Flooded Culvert (ft)	Campbell Creek Elevation NAVD (ft)
5-May-19	2.1042	11.1942	25-Aug-19	1.2083	10.2983
12-May-19	1.7083	10.7983	1-Sep-19	1.2292	10.3192
19-May-19	1.5417	10.6317	9-Sep-19	1.2083	10.2983
2-Jun-19	1.5417	10.6317	16-Sep-19	1.1458	10.2358
6-Jun-19	1.9792	11.0692	22-Sep-19	1.0417	10.1317
14-Jun-19	1.7917	10.8817	29-Sep-19	1.0417	10.1317
21-Jun-19	1.8750	10.9650	7-Oct-19	1.1250	10.2150
30-Jun-19	1.8333	10.9233			
8-Jul-19	1.8542	10.9442			
15-Jul-19	1.8750	10.9650			
22-Jul-19	1.8025	10.8925			
29-Jul-19	1.5625	10.6525			
4-Aug-19	1.4167	10.5067			
12-Aug-19	1.2917	10.3817			
19-Aug-19	1.2917	10.3817			

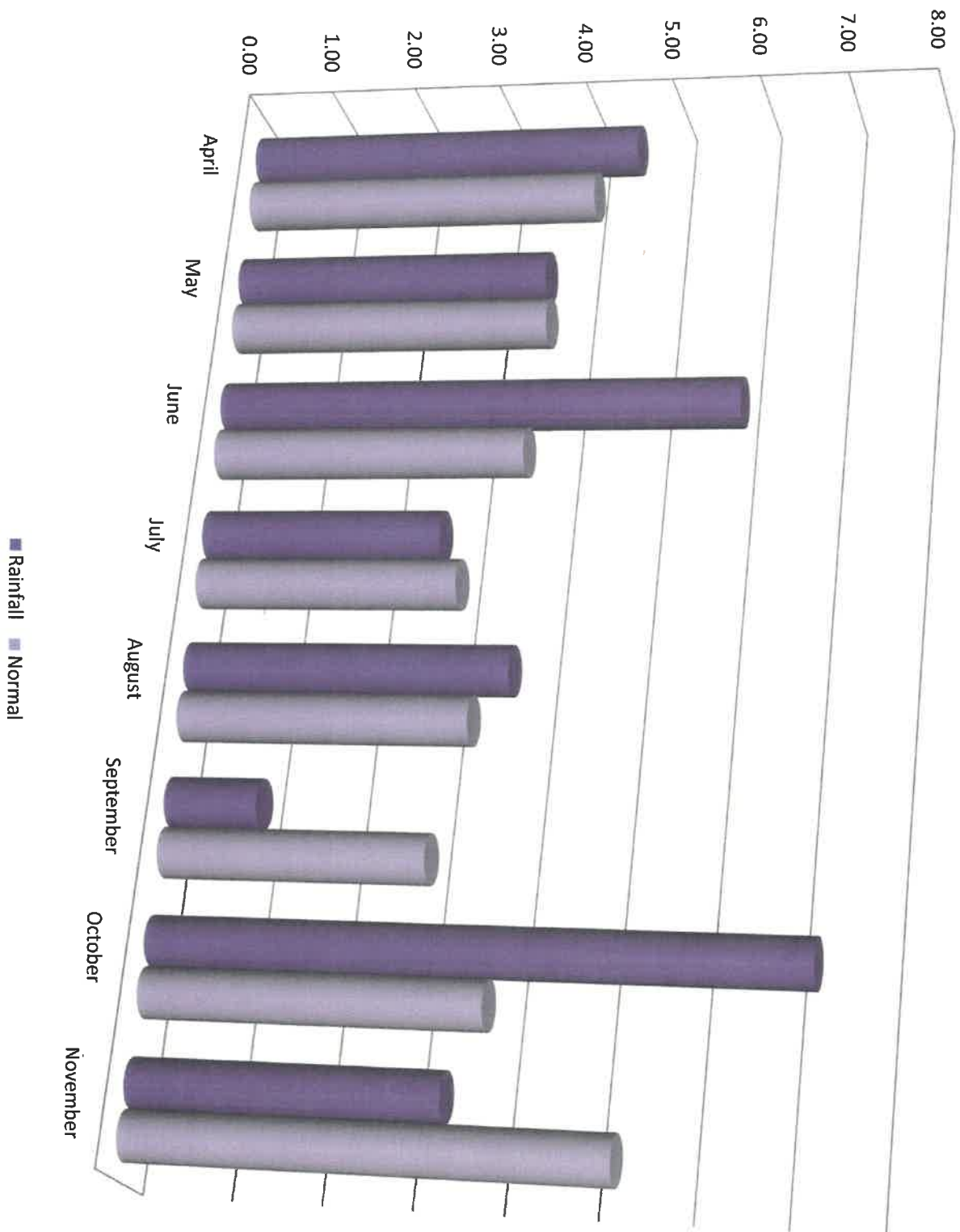
Flow Measurement of Campbell Creek - Flow measurement on Campbell Creek is accomplished by using a Marsh McBirney, Flo-Mate Model 2000 portable flow meter (see Appendix J *Flo-Mate Portable Flow meter Specifications*). This instrument is an industry standard with self-diagnostic logic program and is accurate +/- 0.05 ft/sec. The probe is inserted into the flooded culvert dead center and measures the velocity of the water. This information is taken to the district office with the depth of the wetted area of the culvert, overall size of the culvert and the velocity of the water moving through the culvert is entered into the manufacturers software which calculates flow using Manning's Equation, $Q=VA$. *Table 6, 2019 Campbell Creek Water Level* is a listing of the flow rate of Knickerbocker Lake discharge. See Appendix E- *2019 Knickerbocker Lake Discharge (MGD)*.

Table 6 2019 Knickerbocker Lake Discharge (mgd)					
Date	Velocity (fps)	Daily Discharge (mgd)	Date	Velocity (fps)	Daily Discharge (mgd)
5-May-19	2.66	9.1058	25-Aug-19	0.00	0.0000
12-May-19	1.32	3.5467	1-Sep-19	0.00	0.0000
19-May-19	0.52	1.2298	9-Sep-19	0.00	0.0000
2-Jun-19	0.66	1.6142	16-Sep-19	0.00	0.0000
6-Jun-19	0.47	1.1116	22-Sep-19	0.00	0.0000
14-Jun-19	2.29	7.3218	29-Sep-19	0.00	0.0000
21-Jun-19	1.40	3.9847	7-Oct-19	0.00	0.0000
30-Jun-19	1.61	4.8360			
8-Jul-19	1.30	3.8028			
15-Jul-19	1.06	3.1424			
22-Jul-19	0.96	2.8836			
29-Jul-19	0.81	2.3215			
4-Aug-19	0.45	1.0824			
12-Aug-19	0.09	0.1911			
19-Aug-19	0.02	0.0376			

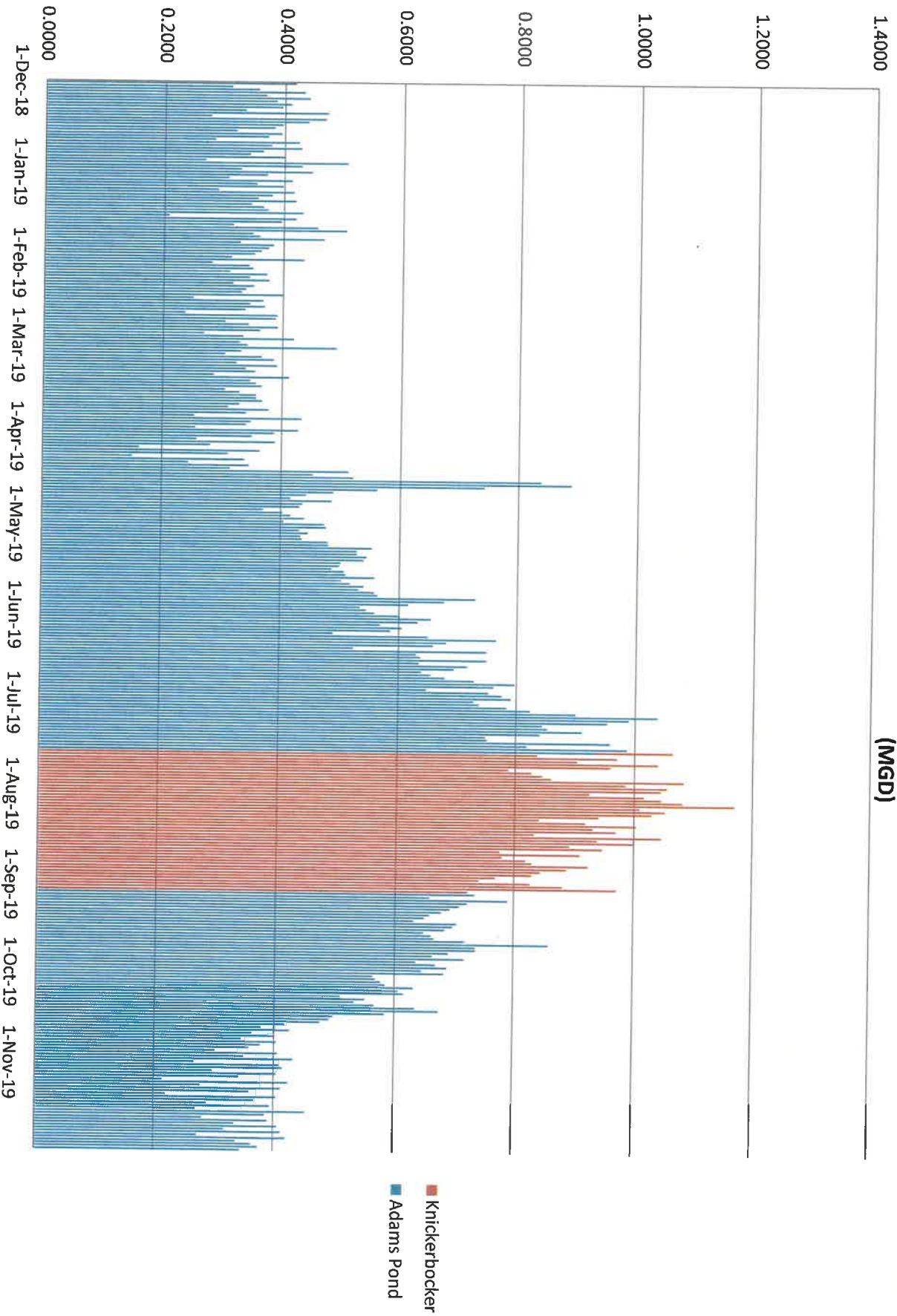
Appendix A - 2019 24-Hour Rainfall Equivalent (inches)



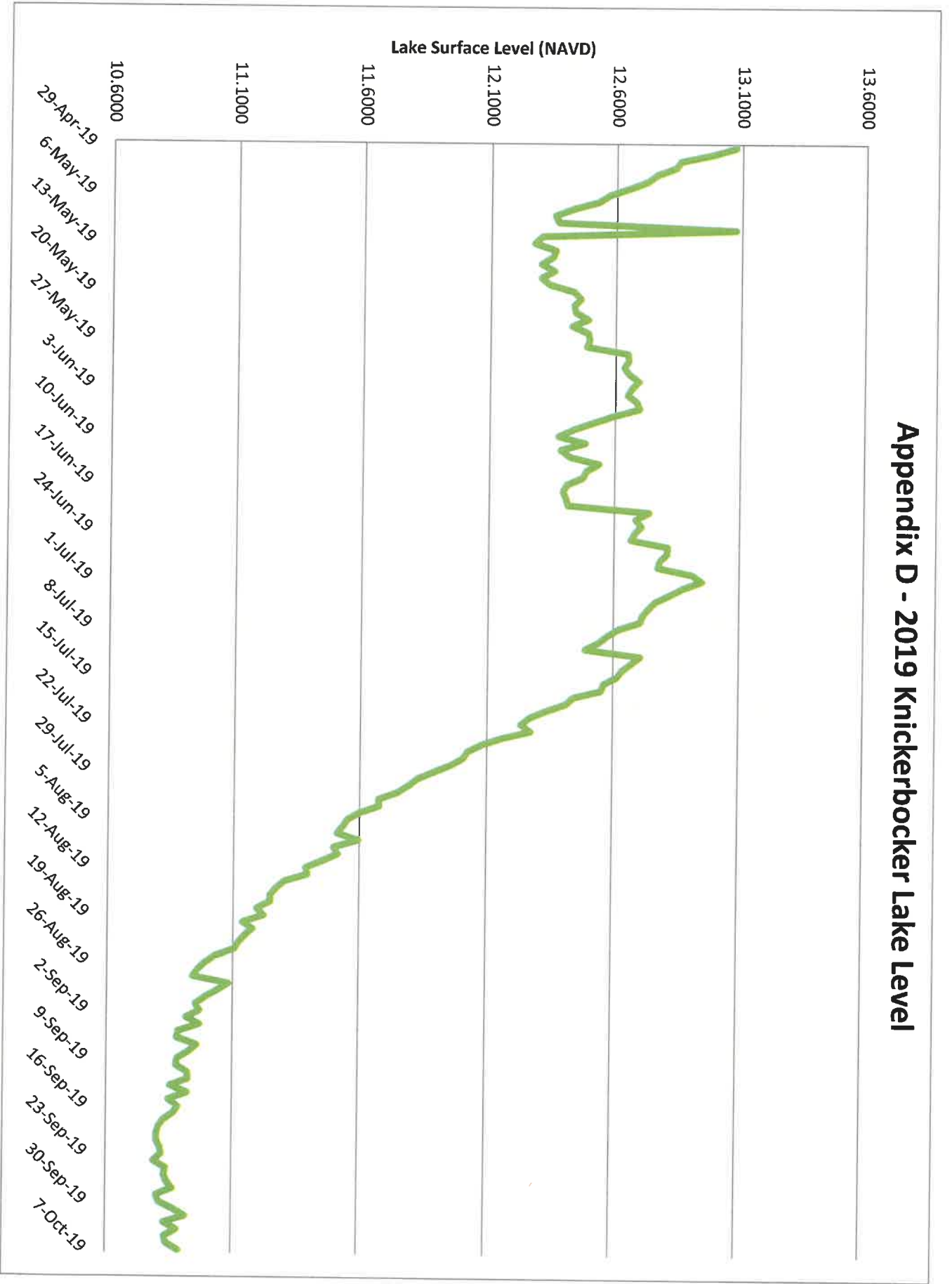
Appendix B - 2019 Monthly Rainfall (inches)



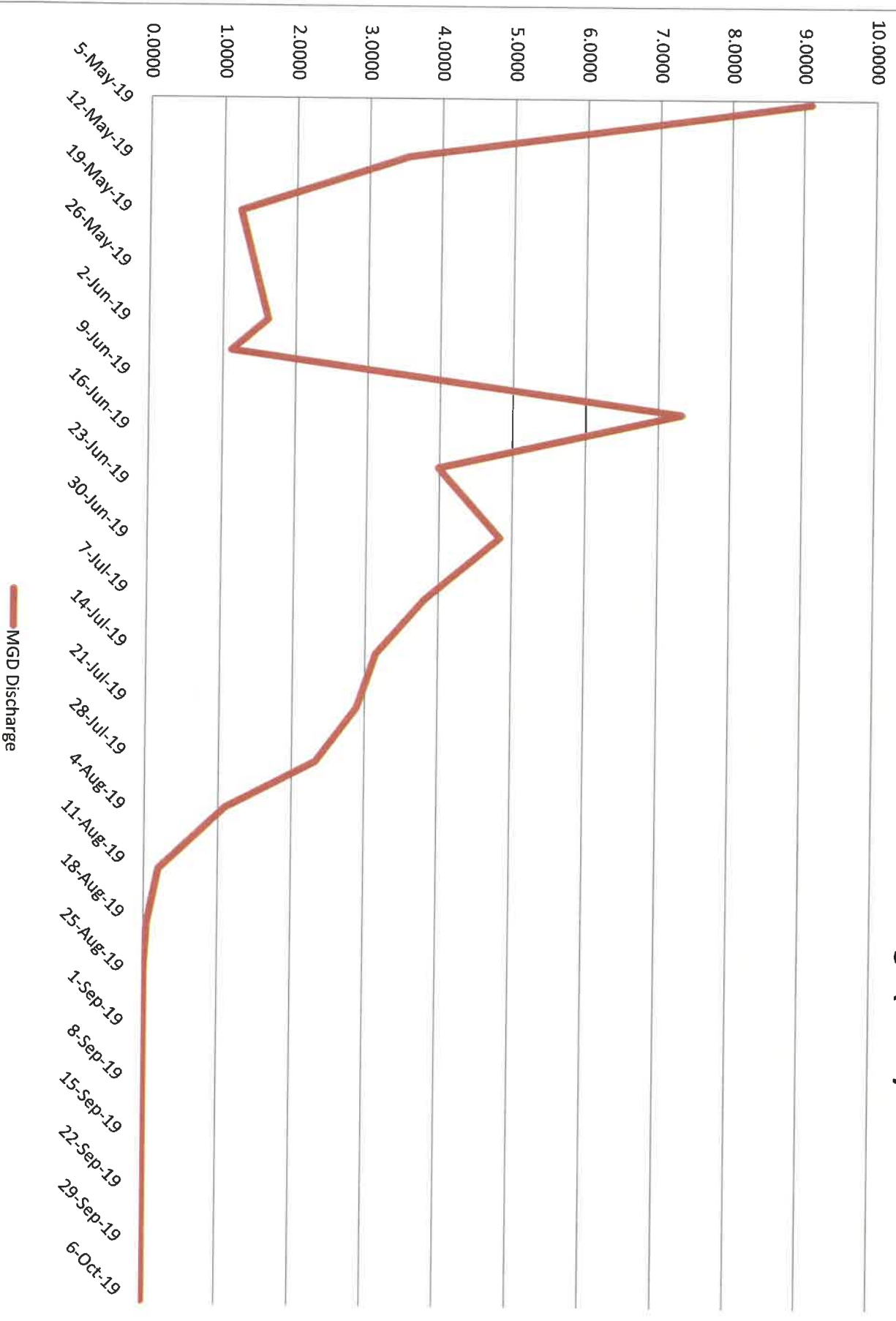
Appendix C - 2019 Boothbay Region Water District Source Water Usage (MGD)



Appendix D - 2019 Knickerbocker Lake Level



Appendix E - 2019 Knickerbocker Lake Discharge (MGD)



Appendix F - 2019 Knickerbocker Lake vs. Campbell Creek Water Level Elevation (NAVD) (ft)

