

I PURPOSE STATEMENT –

2015 marked the eight 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 45,023,100 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 2015 through November 2016.

Rainfall Data and Analysis During 2016 the Boothbay Region Water District Weather Station recorded 136-days with measurable precipitation recorded of which 60-days measured 0.1 inches of rain or greater within the 24-hour period, 24-days measured 0.5 inches of rain or greater within the 24-hour period and 7-days with one-inch or more precipitation recorded. The high 24 hour period accumulation amount occurred on 5 June 2016 2.20 inches of rainfall. The average rainfall events in 24-hours equaled 0.26 inches of precipitation with the median dramatically less at 0.09 inches. During the 2016 pumping season, rainfall amounts were 79.16% 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 2015 through 30 November 2016 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 50,003,200 gallons from Knickerbocker Lake and 151,856,000 gallons from Adams Pond. Knickerbocker Lake contributed 24.77% 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 were conducted in two sessions: session #1 beginning 25 July 2016 and concluding on 6 September 2016; session #2 beginning 18 October 2016, concluding 6 November 2016.

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Daily Precipitation Records 1 December 2015 through 30 November 2016 (inches)							
Date	Rainfall	Date	Rainfall	Date	Rainfall	Date	Rainfall
1-Dec-15	0.06	15-Mar-16	0.43	16-Jul-16	0.57	28-Oct-16	1.4
2-Dec-15	0.1	16-Mar-16	0.11	17-Jul-16	0.56	29-Oct-16	0.07
3-Dec-15	0.04	17-Mar-16	0.01	22-Jul-16	0.29	3-Nov-16	0.75
10-Dec-15	0.01	18-Mar-16	0.01	25-Jul-16	0.52	8-Nov-16	0.01
14-Dec-15	0.75	20-Mar-16	0.06	10-Aug-16	0.1	11-Nov-16	0.01
15-Dec-15	0.02	21-Mar-16	0.06	12-Aug-16	1.41	15-Nov-16	0.8
17-Dec-15	0.26	25-Mar-16	0.12	13-Aug-16	0.11	16-Nov-16	0.05
18-Dec-15	0.05	28-Mar-16	0.8	16-Aug-16	0.42	19-Nov-16	0.04
21-Dec-15	0.02	1-Apr-16	0.07	20-Aug-16	0.01	20-Nov-16	0.3
22-Dec-15	0.73	6-Apr-16	0.04	21-Aug-16	1.35	25-Nov-16	0.17
23-Dec-15	0.89	7-Apr-16	0.49	26-Aug-16	0.03	26-Nov-16	0.01
26-Dec-15	0.25	11-Apr-16	0.06	27-Aug-16	0.01	29-Nov-16	1.72
27-Dec-15	0.1	12-Apr-16	0.18	28-Aug-16	0.03	30-Nov-16	1.39
28-Dec-15	0.06	18-Apr-16	0.48	31-Aug-16	0.01		
29-Dec-15	0.09	19-Apr-16	0.02	4-Sep-16	0.02		
30-Dec-15	0.06	23-Apr-16	0.03	5-Sep-16	0.04		
9-Jan-16	0.04	26-Apr-16	0.32	11-Sep-16	0.13		
10-Jan-16	1.21	1-May-16	0.03	12-Sep-16	0.01		
12-Jan-16	0.28	2-May-16	0.8	14-Sep-16	0.06		
16-Jan-16	0.21	4-May-16	0.27	17-Sep-16	0.03		
18-Jan-16	0.02	5-May-16	0.09	18-Sep-16	0.17		
29-Jan-16	0.05	6-May-16	0.01	19-Sep-16	0.02		
3-Feb-16	0.97	8-May-16	0.13	20-Sep-16	0.01		
4-Feb-16	0.03	13-May-16	0.19	23-Sep-16	0.07		
5-Feb-16	0.1	15-May-16	0.02	26-Sep-16	0.12		
6-Feb-16	0.03	24-May-16	0.02	27-Sep-16	0.03		
8-Feb-16	0.02	25-May-16	0.01	1-Oct-16	0.36		
10-Feb-16	0.01	27-May-16	0.02	4-Oct-16	0.01		
11-Feb-16	0.01	30-May-16	0.02	5-Oct-16	0.01		
15-Feb-16	0.49	3-Jun-16	0.14	7-Oct-16	0.01		
16-Feb-16	0.34	5-Jun-16	2.21	8-Oct-16	0.15		
19-Feb-16	0.08	7-Jun-16	0.31	9-Oct-16	0.73		
20-Feb-16	0.04	12-Jun-16	0.04	10-Oct-16	0.01		
23-Feb-16	0.04	22-Jun-16	0.08	12-Oct-16	0.01		
24-Feb-16	0.86	27-Jun-16	0.17	13-Oct-16	0.04		
25-Feb-16	0.17	28-Jun-16	0.28	14-Oct-16	0.01		
1-Mar-16	0.43	29-Jun-16	0.25	15-Oct-16	0.01		
2-Mar-16	0.23	1-Jul-16	0.27	20-Oct-16	0.49		
7-Mar-16	0.08	9-Jul-16	0.19	21-Oct-16	0.63		
10-Mar-16	0.7	10-Jul-16	0.18	22-Oct-16	0.07		
14-Mar-16	0.03	14-Jul-16	0.16	27-Oct-16	0.62		

Table 2			
2016 Monthly Rainfall Data (inches)			
Month	Rainfall	Normal	% of Normal
April	1.69	4.1	41.22%
May	1.61	3.7	43.51%
June	3.48	3.6	96.67%
July	2.74	3	91.33%
August	3.48	3.3	105.45%
September	0.71	3	23.67%
October	4.63	3.8	121.84%
November	5.25	5.3	99.06%
TOTAL	23.59	29.8	79.16%

Table 3											
2016 Knickerbocker Daily Withdrawals (MGD)											
Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow	Date	Flow
7/25/16	0.1279	8/5/16	1.2022	8/16/16	0.9184	8/27/16	0.9954	10/18/16	0.1235	10/29/16	0.2729
7/26/16	0.8972	8/6/16	1.1426	8/17/16	0.878	8/28/16	0.9173	10/19/16	0.5641	10/30/16	0.2353
7/27/16	1.1779	8/7/16	1.2654	8/18/16	1.0057	8/29/16	0.8316	10/20/16	0.5127	10/31/16	0.3356
7/28/16	1.0883	8/8/16	1.1486	8/19/16	1.056	8/30/16	0.9142	10/21/16	0.3776	11/1/16	0.3059
7/29/16	1.0621	8/9/16	1.1864	8/20/16	1.0142	8/31/16	0.7514	10/22/16	0.2894	11/2/16	0.458
7/30/16	1.1667	8/10/16	0.9076	8/21/16	0.9456	9/1/16	0.8748	10/23/16	0.3814	11/3/16	0.2458
7/31/16	1.0612	8/11/16	1.1701	8/22/16	0.8072	9/2/16	0.9405	10/24/16	0.3672	11/4/16	0.3701
8/1/16	0.9924	8/12/16	1.0776	8/23/16	0.8605	9/3/16	1.0128	10/25/16	0.3179	11/5/16	0.3702
8/2/16	1.1861	8/13/16	0.9022	8/24/16	0.9166	9/4/16	0.9809	10/26/16	0.3162	11/6/16	0.3756
8/3/16	1.1745	8/14/16	1.0031	8/25/16	0.9825	9/5/16	0.8084	10/27/16	0.3027		
8/4/16	1.1857	8/15/16	0.9429	8/26/16	0.9263	9/6/16	0.7563	10/28/16	0.3178		

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. 2015 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: $4.2190 \text{ (ft)} - \text{Ultrasonic reading (ft)} + 9.87 \text{ (ft)} = \text{lake elevation NAVD}$. See *Table 4 2016 Ultrasonic Calibration Data*.

Date	Staff Gauge Reading (ft)	Ultrasonic Reading (ft)	Combined Total	Knickerbocker Staff Gauge Elevation NAVD
15-May-16	2.25	1.9575	4.2075	10.53
22-May-16	2.18	2.0109	4.1909	10.42
1-Jun-16	2.13	2.0953	4.2253	10.30
10-Jun-16	2.48	1.7719	4.2519	10.69
19-Jun-16	2.43	1.7775	4.2075	10.30
26-Jun-16	2.34	1.8591	4.1991	10.34
30-Jun-16	2.34	1.8872	4.2272	10.34
5-Jul-16	2.28	1.9266	4.2066	10.34
10-Jul-16	2.25	1.9322	4.1822	10.34
15-Jul-16	2.20	1.9912	4.1912	10.34
24-Jul-16	2.20	1.9928	4.1928	10.34
31-Jul-16	2.01	2.1712	4.1812	10.32
7-Aug-16	1.70	2.4553	4.1553	10.28
14-Aug-16	1.54	2.6044	4.1444	10.26
21-Aug-16	1.32	2.8237	4.1437	10.24
28-Aug-16	1.20	2.9194	4.1194	10.22
4-Sep-16	0.92	3.1697	4.0897	10.24
11-Sep-16	0.76	3.2934	4.0534	10.13
19-Sep-16	0.70	3.3525	4.0525	10.05
25-Sep-16	0.66	3.4397	4.0997	9.99
2-Oct-16	0.64	3.4116	4.0516	10.01
11-Oct-16	0.68	3.4116	4.0916	10.22
17-Oct-16	0.63	3.4312	4.0612	10.15
23-Oct-16	0.66	3.3694	4.0294	10.30
31-Oct-16	0.88	3.2203	4.1003	10.30
7-Nov-16	0.95	3.1528	4.1028	10.24

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 2016 Campbell Creek Water Level*.

Date	Flooded Culvert (ft)	Campbell Creek Elevation NAVD (ft)	Date	Flooded Culvert (ft)	Campbell Creek Elevation NAVD (ft)
15-May-16	1.4375	12.2098	28-Aug-16	1.1250	12.1838
22-May-16	1.3333	12.2011	4-Sep-16	1.1458	12.1855
1-Jun-16	1.2083	12.1907	11-Sep-16	1.0417	12.1768
10-Jun-16	1.6042	12.2237	19-Sep-16	0.9583	12.1699
19-Jun-16	1.2083	12.1907	25-Sep-16	0.8958	12.1647
26-Jun-16	1.2500	12.1942	2-Oct-16	0.9167	12.1664
30-Jun-16	1.2500	12.1942	11-Oct-16	1.1250	12.1838
5-Jul-16	1.2500	12.1942	17-Oct-16	1.0625	12.1785
10-Jul-16	1.2500	12.1942	23-Oct-16	1.2083	12.1907
15-Jul-16	1.2500	12.1942	31-Oct-16	1.2083	12.1907
24-Jul-16	1.2500	12.1942	7-Nov-16	1.1458	12.1855
31-Jul-16	1.2292	12.1924			
7-Aug-16	1.1875	12.1890			
14-Aug-16	1.1667	12.1872			
21-Aug-16	1.1458	12.1855			

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, 2016 Campbell Creek Water Level* is a listing of the flow rate of Knickerbocker Lake discharge. See Appendix E- 2015 *Knickerbocker Lake Discharge (MGD)*.

Table 6					
2016 Knickerbocker Lake Discharge (mgd)					
Date	Velocity (fps)	Daily Discharge (mgd)	Date	Velocity (fps)	Daily Discharge (mgd)
15-May-16	0.50	1.0816	28-Aug-16	0.00	0.0000
22-May-16	0.23	0.4512	4-Sep-16	0.00	0.0000
1-Jun-16	0.02	0.0345	11-Sep-16	0.00	0.0000
10-Jun-16	0.06	0.1492	19-Sep-16	0.00	0.0000
19-Jun-16	0.01	0.0172	25-Sep-16	0.00	0.0000
26-Jun-16	0.00	0.0000	2-Oct-16	0.00	0.0000
30-Jun-16	0.02	0.0360	11-Oct-16	0.00	0.0000
5-Jul-16	0.03	0.0541	17-Oct-16	0.00	0.0000
10-Jul-16	0.01	0.0180	23-Oct-16	0.01	0.0172
15-Jul-16	0.03	0.0541	31-Oct-16	0.02	0.0345
24-Jul-16	0.01	0.0180	7-Nov-16	0.00	0.0000
31-Jul-16	0.01	0.0176			
7-Aug-16	0.00	0.0000			
14-Aug-16	0.00	0.0000			
21-Aug-16	0.00	0.0000			