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**Date:** June 1, 2017

**Subject:** Evaluation of the Plymouth Water System – Water Supply vs. Water Demands  
Plymouth, MA

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## INTRODUCTION

This memorandum summarizes Environmental Partners' review of the Town of Plymouth's water system, which was conducted to evaluate the capacity of the Town's current water supplies to meet ongoing and future demands. The Town has a limited number of supply wells available to it, together with defined withdrawal permits for the system under the Massachusetts Water Management Act, and therefore needs to understand the ability of the existing system to supply water in the face of significant residential and commercial development pressures.

As building and development progresses in Plymouth, there needs to be a coordinated balance between the available water supply and the approval of new services. With the assistance of the Plymouth Water Division, Environmental Partners Group compiled and analyzed existing water supply capacity and average and maximum day water demands to determine how much water is available for the impending development.

## WATER SUPPLY SOURCES

Currently, water for the Town originates from twelve wells at a total of ten groundwater sources: Bradford Wells, Savery Pond (also known as John Holmes Well), Wannos Pond, Ship Pond, Ellisville, Lout Pond, South Pond Wells 1 & 2, Federal Furnace, North Plymouth, and Darby Pond. The distribution system has six service zones: Bradford, Cedarville, Manomet, Pine Hills, Plymouth Center, and West Plymouth as shown on Attachment 1: Water Supply Sources. Table 1 categorizes each source by its service zone. The Pine Hills zone is a boosted service zone, and does not have a dedicated source.

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**Table 1 – Summary of Sources**

Service Zone	Source	Installation Date	Depth (ft)
Bradford	Bradford Well	1972	166
	Bradford Replacement Well	2010	80
Cedarville	Savery Pond Well	2002	116
Manomet	Wannos Pond Well	2011	101
	Ship Pond Well	1968	100
	Ellisville Well	1980	136
Plymouth Center	Lout Pond Well	2009	52
	South Pond Well 1	1995	140
	South Pond Well 2	1995	105
West Plymouth	Federal Furnace Well	1972	80
	North Plymouth Well	1973	120
	Darby Pond Well	1990	90

## **WATER MANAGEMENT ACT WITHDRAWAL PERMIT**

In the Commonwealth of Massachusetts, all withdrawals of water for public water consumption greater than 100,000 gpd must either be registered or permitted based on the requirements of the Water Management Act (310 CMR 36.00) and M.G.L c. 21G. The Town currently holds a permit with a withdrawal limit of 6.36 MGD (2321.4 MGY). The Town does not have registered sources.

The Town's sources are located within the South Coastal Basin and the Buzzards Bay Basin. Plymouth is permitted to withdraw a daily average of 6.36 million gallons per day (MGD) from the South Coastal Basin and a daily average of 1.59 MGD from the Buzzards Bay Basin; however, the combined daily average withdrawal must not exceed 6.36 MGD. Exceeding the Registered and Permitted withdrawal volumes by more than 100,000 gpd would result in violation of the Water Management Act. A summary of the permitted wells is provided below in Table 2.



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**Table 2 – WMA Authorized Withdrawals**

Basin	Wells	Volume Authorized
South Coastal	Bradford Well, Bradford Replacement Well, Ellisville Well, Lout Pond Well, North Plymouth Well, Savery Pond Well, Ship Pond Well, South Pond Well #1, South Pond Well #2, Wannos Pond Well	6.36 MGD (2321.4 MGY)
Buzzards Bay	Darby Pond Well, Federal Furnace Well	1.59 MGD (580.35 MGY)
<b>Not-to-Exceed Withdrawal Volume</b>		<b>6.36 MGD (2321.4 MGY)</b>

The Town is currently in the process of renewing its WMA permit. The Water Needs Forecast generated by the Department of Conservation and Recreation proposes to reduce the Authorized Withdrawal Volume to 4.87 MGD. However, the Town has petitioned to maintain the current Authorized Withdrawal Volume of 6.36 MGD due to seasonal demand fluctuations, projected population growth, and management of the service zones.

Plymouth must operate within the standards of its current permit, including compliance with the residential gallons per capita day (RGPCD) water use of 80 gallons per day or less, and not exceeding the unaccounted for water (UAW) of 15 percent or less. When the permit is renewed, these standards are expected to be lowered to 65 RGPCD and 10 percent UAW, respectively.

Under the existing WMA permit there are a series of water use restrictions and requirements, including water conservation, unaccounted for water performance, residential gallons per capita per day, seasonal limits on non-essential outdoor water use, coldwater fishery resource protection, minimization, and mitigation. Historically, the Town implements a voluntary water use restriction for nonessential outdoor water from May 1<sup>st</sup> to September 30<sup>th</sup>. During the drought conditions in 2016, the Water Division was faced with increased summer demands, mechanical failure at one well supply and limited use of water supplies due to the WMA restrictions. A water ban was necessary to maintain storage capacity and meet demands for water use and firefighting.

## AVERAGE DAY DEMAND

Average day demand (ADD) is the average volume of water pumped into the distribution system in a year, calculated by dividing total volume pumped in one year by 365 days. This metric is used as a baseline for determining the adequacy of water supply sources. Water consumption for the past four years (2013 through 2016) was provided to Environmental Partners by the Town of Plymouth Water Division, and is summarized in Table 3. Based on the information available, the Town's average water production from 2013 to 2016 was approximately 4.35 MGD or 1,592 million gallons each year.



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**Table 3 – Annual Water Consumption**

Year	Total Annual Production (MG)	Average Day Demand (MG)
2013	1,560.81	4.27
2014	1,615.05	4.41
2015	1,603.42	4.38
2016	1,589.49	4.33
<b>4-Year Average</b>	<b>1,592.19</b>	<b>4.35</b>

## MAXIMUM DAY DEMAND

Maximum day demand (MDD) is the largest 24-hour demand during the course of a calendar year and is an essential component used in the evaluation of pumping facilities. Comparing periods of maximum consumption to the capabilities of supply sources is critical to ensure that storage tank levels remain adequate and system pressures stay within acceptable ranges.

Maximum day demand is typically expressed as a ratio of the average day demand. This ratio varies based on the characteristics of the individual community. Water systems with low density, residential communities have relatively large fluctuations; conversely, highly industrialized, densely populated communities are generally not subject to significant seasonal fluctuations and have a smaller maximum day demand ratio. The Water System serves a mix of residential, commercial, and industrial customers.

A summary of MDD relative to ADD between the years of 2013 to 2016 is presented in Table 4. A review of the data shown in Table 4 indicates that the average MDD is 8.07 MGD and the average ratio of MDD to ADD is 1.86. This average ratio is similar to other southeastern Massachusetts systems with mixed residential, commercial and industrial customers.

**Table 4 – Maximum Day Water Consumption**

Year	Average Daily Demand (MGD)	Maximum Day Demand (MGD)	MDD/ADD Ratio
2013	4.27	7.82	1.83
2014	4.41	7.90	1.79
2015	4.38	8.12	1.85
2016	4.33	8.44	1.95
<b>4-Year Average</b>	<b>4.35</b>	<b>8.07</b>	<b>1.86</b>

## RESIDENTIAL WATER USE

The Town has an average water use of approximately 71 residential gallons per capita per day (RGPCD) and a residential percentage of metered water use of 72 percent, which are tabulated in



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Table 5 based on historical Annual Statistics Report (ASR) data. Residential water use for the months of October through March was assessed using the winter population provided in the ASR data. Similarly, for the months of April through September the summer population was used. Based on Plymouth's current WMA permit this is within the allowable RGPCD of 80. However, it is anticipated that when the permit is renewed, the allowable RGPCD will be reduced to 65 in accordance with typical WMA permit requirements.

**Table 5 – Residential Per-Capita Water Use**

<b>Year</b>	<b>Residential Metered Water Sales (MG)</b>	<b>Percent of Total Metered Water Sales</b>	<b>Residential Summer Population Served</b>	<b>Residential Winter Population Served</b>	<b>Residential Per-Capita Water Use (RGPCD)</b>
2013	1045.98	76%	38,633	38,350	76
2014	970.85	69%	38,248	37,969	71
2015	1008.87	73%	38,970	38,692	72
2016	948.18	72%	40,362	39,189	67
<b>4-year Average</b>		<b>72%</b>			<b>71</b>

While 71 residential gallons per capita per day is a representative average, actual usage is seasonally affected and changes throughout the year. Table 6 and Figure 1 illustrate the monthly residential usage based on 2013 to 2016 ASR data.



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**Table 6 – Monthly Residential Water Demand Summary (2013 – 2016)**

Month	Avg. Residential Per-Capita Water Usage (gallons/day)
January	54.2
February	55.2
March	55.1
April	58.0
May	78.3
June	94.6
July	104.7
August	96.0
September	81.9
October	63.3
November	55.9
December	57.9

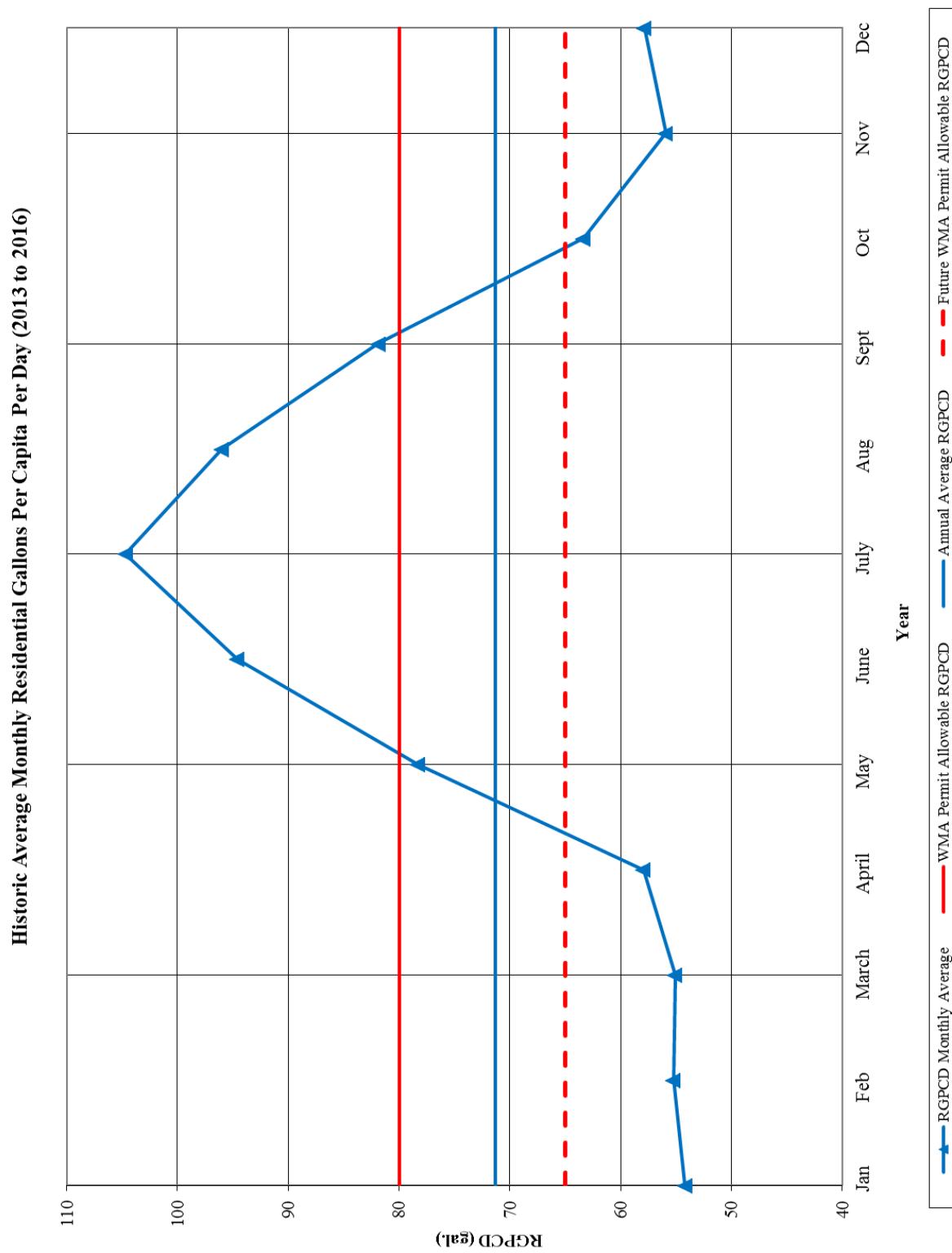


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**Figure 1**



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## UNACCOUNTED FOR WATER

Unaccounted for water (UAW) is the difference between the finished water pumped from the pump stations or treatment plants and the reported metered water usage. The volume of UAW includes water use that is not quantified for firefighting, water main leaks and breaks, system flushing, and any meter inaccuracies. The residential meter replacement program that recently began should help in reducing UAW for meters that were under registering. ASR data from 2013 to 2016 shows an average of 12 percent unaccounted for water, as shown in Table 7. Based on Plymouth's current WMA permit this percentage is within the allowable UAW of 15 percent. However, it is anticipated that when the permit is renewed the allowable UAW will be reduced to 10 percent in accordance with typical WMA permit requirements.

**Table 7 – Unaccounted for Water Loss (2013 – 2016)**

Year	Finished Water Produced (MG)	Total Metered Water Sales (MG)	Authorized Unaccounted for Water Loss (MG)	Unaccounted for Water Loss (MG)	Percent Unaccounted for Water Loss
2013	1557.29	1381.33	25.73	150.23	9.6%
2014	1609.28	1400.27	17.52	191.49	11.9%
2015	1598.49	1376.92	17.80	203.76	12.7%
2016	1583.46	1324.85	39.32	219.29	13.8%
<b>4-Year Average</b>				<b>191.19</b>	<b>12%</b>

## WATER DEMAND ASSESSMENT

The water distribution system consists of six pressure service zones, namely: Bradford, Cedarville, Manomet, Pine Hills, Plymouth Center, and West Plymouth. Billing information was provided for 2013 through 2015 metered water usage. Environmental Partners geocoded the provided billing information and assigned a pressure zone to each account. Table 8 presents the total metered water usage for 2015 by service zone. The 2015 data is representative of current conditions, based on available information provided by the Town to date. A review of the information presented in this table suggests that the majority of the Town's water use occurs in the Plymouth Center, West Plymouth, and Manomet service zones.



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**Table 8 – Demand by Service Zone**

Service Zone	2015 Metered Water Usage (MGY)	Percent of Total Demand
West Plymouth	458.92	33%
Plymouth Center	348.76	25%
Manomet	334.22	24%
Bradford	129.71	9%
Cedarville	87.02	6%
Pine Hills	18.30	1%
<b>Total</b>	<b>1,376.92</b>	<b>100%</b>

## WATER SUPPLY ASSESSMENT

This section of the memorandum summarizes the capacity of Plymouth's existing water supply sources and their ability to satisfy existing water demands within the community.

### WATER SUPPLY CAPACITY

Adequacy of supply was evaluated based upon the ability of supply capacity to meet maximum-day demand. The supply capacity was examined in several ways including typical pumping rate, firm capacity, and safe yield.

Well capacity is expressed in the following ways:

*DEP Approved Rate* – This is the 24-hour pumping rate approved by DEP as part of the source approval process or Zone II delineation. This is typically the safe yield of the well but may be lower due to contamination or other circumstances.

*Safe Yield* – Defined by MassDEP as, “the maximum dependable withdrawals that can be made continuously from a water source including ground or surface water during a period of years in which the probable driest period or period of greatest water deficiency is likely to occur; provided, however, that such dependability is relative and is a function of storage and drought probability.”

*Design Capacity* – DEP allows the design of well pumps to be up to 150% of the approved rate with the provision that the approved daily volume is not exceeded.

*Current Operational Capacity* – Actual pumping rates vary based on well condition, pump equipment, hydraulics, water quality, and other factors. Operational capacity is based on discussions with water system operators and performance tests conducted by experienced well drillers.

*Firm Capacity* – The system capacity based on the lesser of the safe yield, design capacity, and current operational capacity with the largest single source out of service.

A summary of the Town's water supply sources is provided in Table 9 and shown graphically in Figure 2. South Pond Well 2 is currently the Town's largest source, and its capacity was excluded from the Firm Capacity calculation.



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**Table 9 – Well Capacities**

Service Zone	Source	Safe Yield (MGD)	Design Capacity (MGD)	Current Operational Capacity (MGD)	Firm Capacity (MGD)
Bradford	Bradford Well	1.51 <sup>1</sup>	1.01	1.30	1.30
	Bradford Replacement Well		1.01		
Cedarville	Savery Pond Well	1.50	1.73	1.30	1.30
Manomet	Wannos Pond Well	0.94	1.01	0.72	0.72
	Ship Pond Well	0.86	0.94	0.50 <sup>2</sup>	0.50
	Ellisville Well	1.12	1.08	0.94 <sup>2</sup>	0.94
Plymouth Center	Lout Pond Well	0.72	0.50	0.36	0.36
	South Pond Well 1	1.12	1.30	3.10	1.12
	South Pond Well 2	1.50	1.44		-
West Plymouth	Federal Furnace Well	0.79	0.72	0.50 <sup>3</sup>	0.50
	North Plymouth Well	1.53	1.58	1.30 <sup>4</sup>	1.30
	Darby Pond Well	0.80 <sup>5</sup>	1.20	1.48	0.20 <sup>6</sup>
<b>Total</b>		<b>6.36<sup>7</sup></b>	<b>13.51</b>	<b>11.48</b>	<b>8.24</b>

1. The Bradford wells have a combined safe yield of 1.51 MGD, for any pumping combination.
2. Ship Pond and Ellisville well withdrawals are limited due to proximity and cast iron transmission main.
3. Federal Furnace Well withdrawals are limited due to manganese concentrations.
4. North Plymouth Well withdrawals are limited by sodium concentrations.
5. Darby Pond Well is permitted for 0.80 MGD as a monthly average, therefore withdrawals shall not exceed 0.80 MGD for any consecutive 30 days.
6. During the pond level restriction pumping is limited to a maximum of 4 hours per day; 0.20 MGD is based on the approximate 2016 pumping rates when the pond level restriction was in effect.
7. Not-to-exceed average day withdrawal limit per WMA Permit

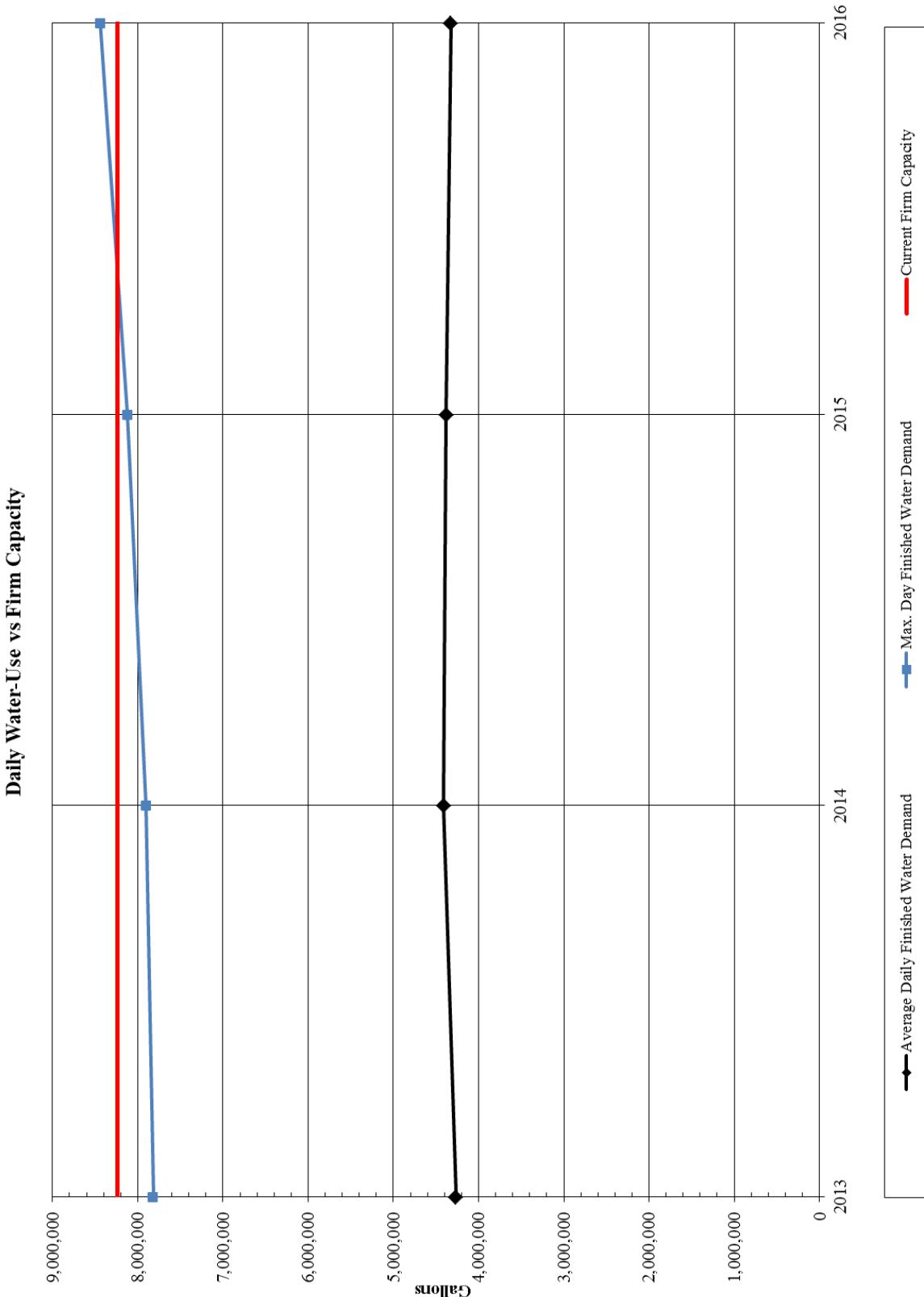


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**Figure 2**



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A review of the table above suggests that the existing firm capacity, 8.24 MGD, is sufficient to meet the 4-year average maximum day demand of 8.07 MG. However, the Water System effectively operates as two independent systems as depicted in Attachment 2: Water System Service Zones. To the north, operators can typically move water between the Bradford, Plymouth Center, West Plymouth, and Pine Hills service zones. To the east, operators can move water between the Cedarville and Manomet service zones. The two regions are separated by a permanently closed pressure reducing valve. Therefore it is important to assess the firm capacity under these restrictions.

Based on the percentage of water use in each zone presented in Table 8, the maximum day demand can be estimated for each service area. The average day demand was calculated by evenly distributing the Authorized Unaccounted for Water Loss and the Unaccounted for Water Loss. The maximum day demand was then calculated using the MDD/ADD ratio.

Table 10 presents the firm capacity of the northern service zones, and Table 11 presents the average and maximum day demands of the northern service zones.

**Table 10 – Northern Service Zones Well Capacities**

Service Zone	Source	Safe Yield (MGD)	Design Capacity (MGD)	Current Operational Capacity (MGD)	Firm Capacity (MGD)
Bradford	Bradford Well	1.51 <sup>1</sup>	1.01	1.30	1.30
	Bradford Replacement Well		1.01		
Plymouth Center	Lout Pond Well	0.72	0.50	0.36	0.36
	South Pond Well 1	1.12	1.30	3.10	1.12
	South Pond Well 2	1.50	1.44		-
West Plymouth	Federal Furnace Well	0.79	0.72	0.50 <sup>2</sup>	0.50
	North Plymouth Well	1.53	1.58	1.30 <sup>3</sup>	1.30
	Darby Pond Well	0.80 <sup>4</sup>	1.20	1.48	0.20 <sup>5</sup>
<b>Total</b>			<b>8.76</b>	<b>8.03</b>	<b>4.78</b>

1. The Bradford wells have a combined safe yield of 1.51 MGD, for any pumping combination.
2. Federal Furnace Well withdrawals are limited due to manganese concentrations.
3. North Plymouth Well withdrawals are limited by sodium concentrations.
4. Darby Pond Well is permitted for 0.80 MGD as a monthly average, therefore withdrawals shall not exceed 0.80 MGD for any consecutive 30 days.
5. During the pond level restriction pumping is limited to a maximum of 4 hours per day; 0.20 MGD is based on the approximate 2016 pumping rates when the pond level restriction was in effect.



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**Table 11 – Northern Service Zones Demand**

Service Zone	2015 Metered Water Usage (MGY)	Average Day Demand (MGD)	Maximum Day Demand (MGD)
Bradford	129.71	0.41	0.77
Pine Hills	18.30	0.06	0.11
Plymouth Center	348.76	1.11	2.06
West Plymouth	458.92	1.46	2.71
<b>Total</b>		<b>3.04</b>	<b>5.64</b>

A review of Table 10 and Table 11 shows that under existing conditions there is sufficient firm capacity to meet the average day demands. However, there is insufficient capacity to meet the maximum day demands under existing conditions in the northern service zones. Further, there are operational limits on the Bradford Wells, Federal Furnace, North Plymouth, and Darby Pond, as discussed in the Operational Restrictions section, which stress the available water supply.

Table 12 presents the firm capacity of the eastern service zones, and Table 13 presents the average and maximum day demands of the eastern service zones.

**Table 12 – Eastern Service Zones Well Capacities**

Service Zone	Source	Safe Yield (MGD)	Design Capacity (MGD)	Current Operational Capacity (MGD)	Firm Capacity (MGD)
Cedarville	Savery Pond Well	1.50	1.73	1.30	-
Manomet	Wannos Pond Well	0.94	1.01	0.72	0.72
	Ship Pond Well	0.86	0.94	0.50 <sup>1</sup>	0.50
	Ellisville Well	1.12	1.08	0.94 <sup>1</sup>	0.94
<b>Total</b>			<b>4.75</b>	<b>3.46</b>	<b>2.16</b>

1. Ship Pond and Ellisville well withdrawals are limited due to proximity and cast iron transmission main.

**Table 13 – Eastern Service Zones Demand**

Service Zone	2015 Metered Water Usage (MGY)	Average Day Demand (MGD)	Maximum Day Demand (MGD)
Cedarville	87.02	0.28	0.51
Manomet	334.22	1.06	1.97
<b>Total</b>		<b>1.34</b>	<b>2.48</b>



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A review of Table 12 and Table 13 shows that under existing conditions there is sufficient firm capacity to meet the average day demands. However, there is insufficient capacity to meet the maximum day demands under existing conditions in the eastern service zones. Further, there are operational limits on the Ship Pond and Ellisville due to their close proximity, as discussed in the Operational Restrictions section, which stress the available water supply.

By assessing the capacity of the water system in two separate zones based on the physical and operational limitations of the system, it is evident that there is insufficient capacity to meet the maximum day demand. The results of this analysis are summarized in Table 14, below.

**Table 14 – Capacity Deficit**

	<b>Firm Capacity (MGD)</b>	<b>Maximum Day Demand (MGD)</b>	<b>Surplus Capacity (MGD)</b>
Northern Service Zones	4.78	5.64	-0.86
Eastern Service Zones	2.16	2.48	-0.32

## OPERATIONAL RESTRICTIONS

There are operational limits on specific sources within Plymouth's system, described below.

*Bradford and Bradford Replacement Wells* – The average daily withdrawals may not exceed 1.51 MGD from the two Bradford Wells; the wells may be used in any combination. In addition, pumping at the Bradford Well is limited by high iron and manganese levels, which clog the well screen.

*Darby Pond Well* – The maximum monthly withdrawal may not exceed 0.80 MGD for any consecutive 30 day period. In addition, when water in Darby Pond drops below 121.5 feet (NGVD 1929 datum), the WMA permit requires the Town to limit pumping at the facility to no more than 4 hours per day. In 2016, the pond was below 121.5 feet for 6 months in a row.

*Federal Furnace Well* – Manganese levels are elevated at the well; the Town currently utilizes sequestering to stabilize the manganese.

*North Plymouth Well* – Sodium and chloride levels are elevated at the well presumably due to roadway deicing constituents, based on a water quality analysis performed by Environmental Partners in December 2014.

*Ship Pond and Ellisville Wells* – Reduced capacity due to proximity and tuberculated cast iron transmission main.

## AVAILABLE CAPACITY FOR DEVELOPMENT

The analysis of water system supply and demand shows that there is currently a deficit of 0.86 MGD in the northern service zones, and a deficit of 0.32 MGD in the eastern service zones during maximum day demand. If firm capacity is assessed with the largest source online, i.e. the current operational capacity, there would be an excess capacity of 0.58 MGD in the Northern Service Zones, and an excess capacity of 0.97 MGD in the Eastern Service Zones to meet the maximum day demand. However, this approach is not recommended as a planning mechanism because it assumes that each source is 100 percent reliable, which has not been the case for Plymouth or many public water suppliers with aging infrastructure.



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Chapter 2 of MassDEP's Guidelines for Public Water Systems states that a distribution system shall be designed for the maximum day demand. In addition, AWWA Manual M31 Distribution System Requirements for Fire Protection states that a distribution system is considered reliable if it can meet required fire flows, when the largest pump is out of service, while maintaining the maximum daily demand rate. System expansion and adding additional services to the existing system will create a greater capacity deficit during maximum day demand conditions and reduce the reliability of Plymouth's fire protection.

In conclusion, there is no redundant capacity during maximum-day demands; therefore, there is no available capacity for development at this time without a reduction in current water use during the summer peak use periods.

## FUTURE WATER SYSTEM IMPROVEMENTS

The Town is in the process of developing two additional sources and a water system expansion project, expected to be completed by 2020. The preliminary results suggest that a future production well at the Forges Field Site may have a withdrawal rate of up to 1 MGD, and that a production well at the 200 Acre Site may have a withdrawal rate of up to 2 MGD. Results from recent water sampling continue to indicate excellent water quality at both locations. The addition of these two sources will provide redundancy and reduce the stress on existing sources.

Further, the water system expansion will provide connectivity between the northern service zones and the eastern service zones with the addition of approximately 14 miles of pipe and three valve control stations. This connectivity will provide for more flexibility in moving water through the system during maximum demands and in the event of an emergency. The proposed wells are remote from the existing service area, so transmission mains are needed in order to connect these water supplies and storage tank to the system. This area of Town has generally higher elevations than the existing service areas; therefore, a new pressure zone needs to be created to adequately serve the expansion area.

Again, adequacy of supply capacity to meet maximum day demand must be assessed for the existing demands and those created by the expansion project. Based on ASR data from 2013 to 2016, an average of 16 new residential services were added to the existing service zones per year. In addition, 93 percent of the estimated 325 services added by the expansion project are expected to be residential. According to the United States Census Bureau, the average household size for the Town of Plymouth is approximately 2.55 people, based on data from 2011 to 2015. From this information, the residential water consumption is projected for the year 2020, when the expansion project is complete, using the average RGPCD of 71.33, and average MDD to ADD ratio of 1.86. Using the historic average water use for other usage categories including commercial, agricultural, industrial and municipal/institutional, the average and maximum day demands are projected. Table 15 presents the projected annual water production and estimated average and maximum day demands for the year 2020.

**Table 15 – Projected Maximum Day Water Consumption**

Year	Total Annual Production (MG)	Average Daily Demand (MGD)	Average MDD/ADD Ratio	Maximum Day Demand (MGD)
2020	1,603.34	4.38	1.86	8.13



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The expansion project will provide connectivity between the six existing pressure zones; therefore the firm capacity of the system may be assessed as a whole, rather than as two independent systems. A summary of the Town's current and projected water supply sources is provided in Table 16. When developed, the proposed 200 Acres Well will be the Town's largest source, and its capacity was excluded from the Firm Capacity calculation.

**Table 16 – Projected Well Capacities**

Service Zone	Source	Safe Yield (MGD)	Design Capacity (MGD)	Current Operational Capacity (MGD)	Firm Capacity (MGD)
Bradford	Bradford Well	1.51 <sup>1</sup>	1.01	1.30	1.30
	Bradford Replacement Well		1.01		
Cedarville	Savery Pond Well	1.50	1.73	1.30	1.30
Manomet	Wannos Pond Well	0.94	1.01	0.72	0.72
	Ship Pond Well	0.86	0.94	0.50 <sup>2</sup>	0.50
	Ellisville Well	1.12	1.08	0.94 <sup>2</sup>	0.94
Plymouth Center	Lout Pond Well	0.72	0.50	0.36	0.36
	South Pond Well 1	1.12	1.30	3.10	1.12
	South Pond Well 2	1.50	1.44		1.44
West Plymouth	Federal Furnace Well	0.79	0.72	0.50 <sup>3</sup>	0.50
	North Plymouth Well	1.53	1.58	1.30 <sup>4</sup>	1.30
	Darby Pond Well	0.80 <sup>5</sup>	1.20	1.48	0.20 <sup>6</sup>
Projected Sources	Forges Field Well	1.00	1.00	1.00	1.00
	200 Acres Well	2.00	2.00	2.00	-
<b>Total</b>		<b>6.36<sup>7</sup></b>	<b>16.51</b>	<b>14.48</b>	<b>10.68</b>

1. The Bradford wells have a combined safe yield of 1.51 MGD, for any pumping combination.
2. Ship Pond and Ellisville well withdrawals are limited due to proximity and cast iron transmission main.
3. Federal Furnace Well withdrawals are limited due to manganese concentrations.
4. North Plymouth Well withdrawals are limited by sodium concentrations.
5. Darby Pond Well is permitted for 0.80 MGD as a monthly average, therefore withdrawals shall not exceed 0.80 MGD for any consecutive 30 days.
6. During the pond level restriction pumping is limited to a maximum of 4 hours per day; 0.20 MGD is based on the approximate 2016 pumping rates when the pond level restriction was in effect.
7. Not-to-exceed average day withdrawal limit per WMA Permit

A review of Table 15 and Table 16 projects there will be sufficient firm capacity to meet both the average and maximum day demands, with available capacity for expansion. The results of this analysis are summarized in Table 17, below.



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**Table 17 – Projected Excess Capacity**

	<b>Projected Firm Capacity (MGD)</b>	<b>Projected Maximum Day Demand (MGD)</b>	<b>Projected Surplus Capacity (MGD)</b>
Plymouth Water System, 2020	10.68	8.13	2.54

A review of Table 17 above demonstrates that, following construction of the expansion project, in 2020 there will be an estimated surplus capacity of 2.54 MGD available for future development in the Town. Assuming residential percentage of metered water use continues at 72 percent, the average RGPCD of 71.33, and average MDD to ADD ratio of 1.86, the maximum service population can be calculated such that the maximum day demand is equal to the firm capacity, and the average day demand does not exceed the WMA not-to-exceed withdrawal volume of 6.36 MGD. This equates to a total service population of approximately 50,435 people, or the addition of 10,175 people to the summer 2016 service population.

## **RECOMMENDATIONS**

It is strongly recommended that, if development is to continue, the Water Division will need to strictly enforce water use restrictions, including non-essential outdoor water use. Restrictions for non-essential outdoor water use should be in place from May 1<sup>st</sup> to September 30<sup>th</sup> and limit use to two days per week, before 9 a.m. and after 5 p.m.

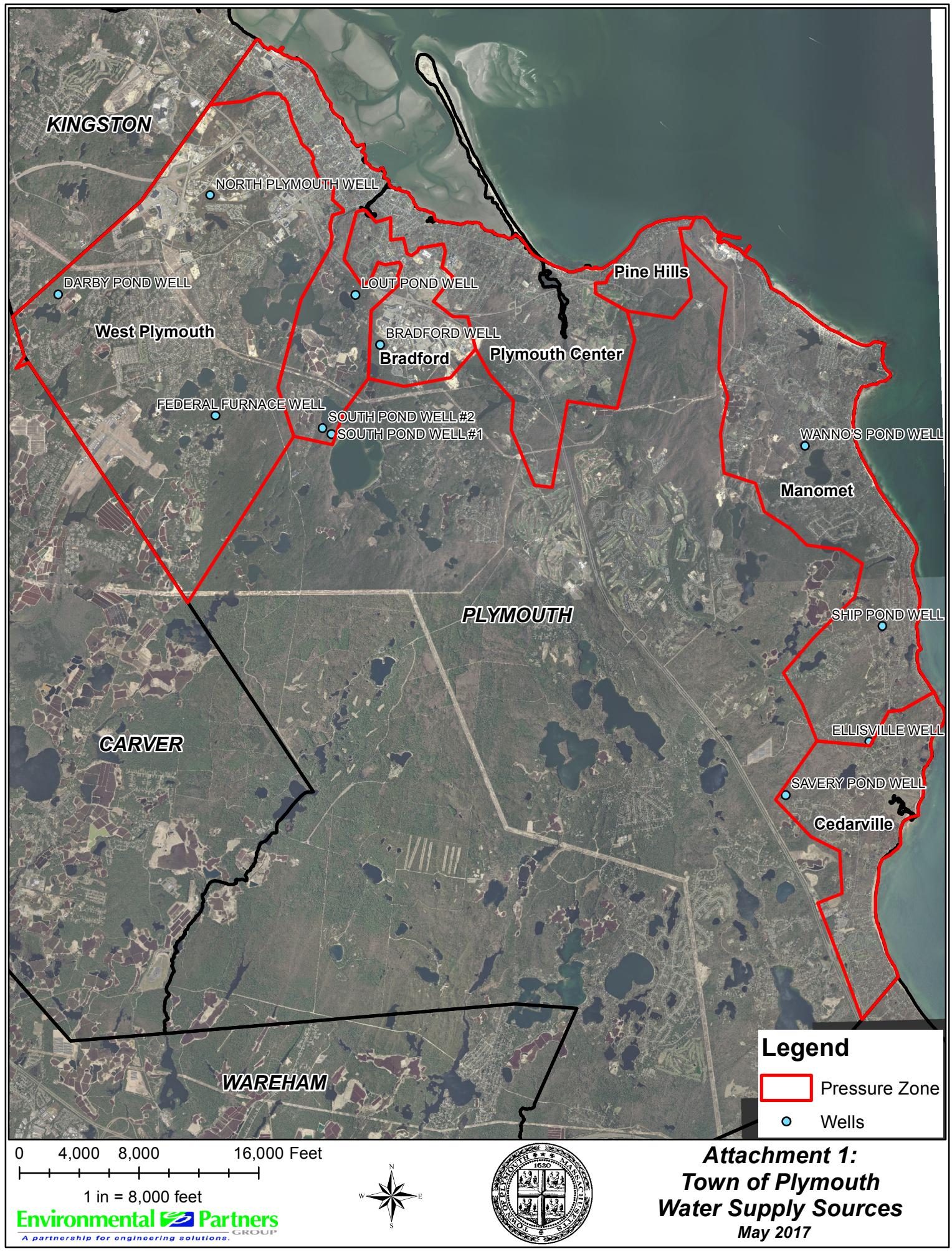
Additional work can be performed to minimize unaccounted for water through leak detection. The current water management act permit requires a full leak detection survey of the entire water system once every three years. Consideration should be made to budget more frequent surveys in the West Plymouth, Plymouth Center and Manomet pressure zones with particular attention to the West Plymouth service zone. This pressure zone has the single highest water supply deficiency and would benefit most with reduction of unaccounted-for water.

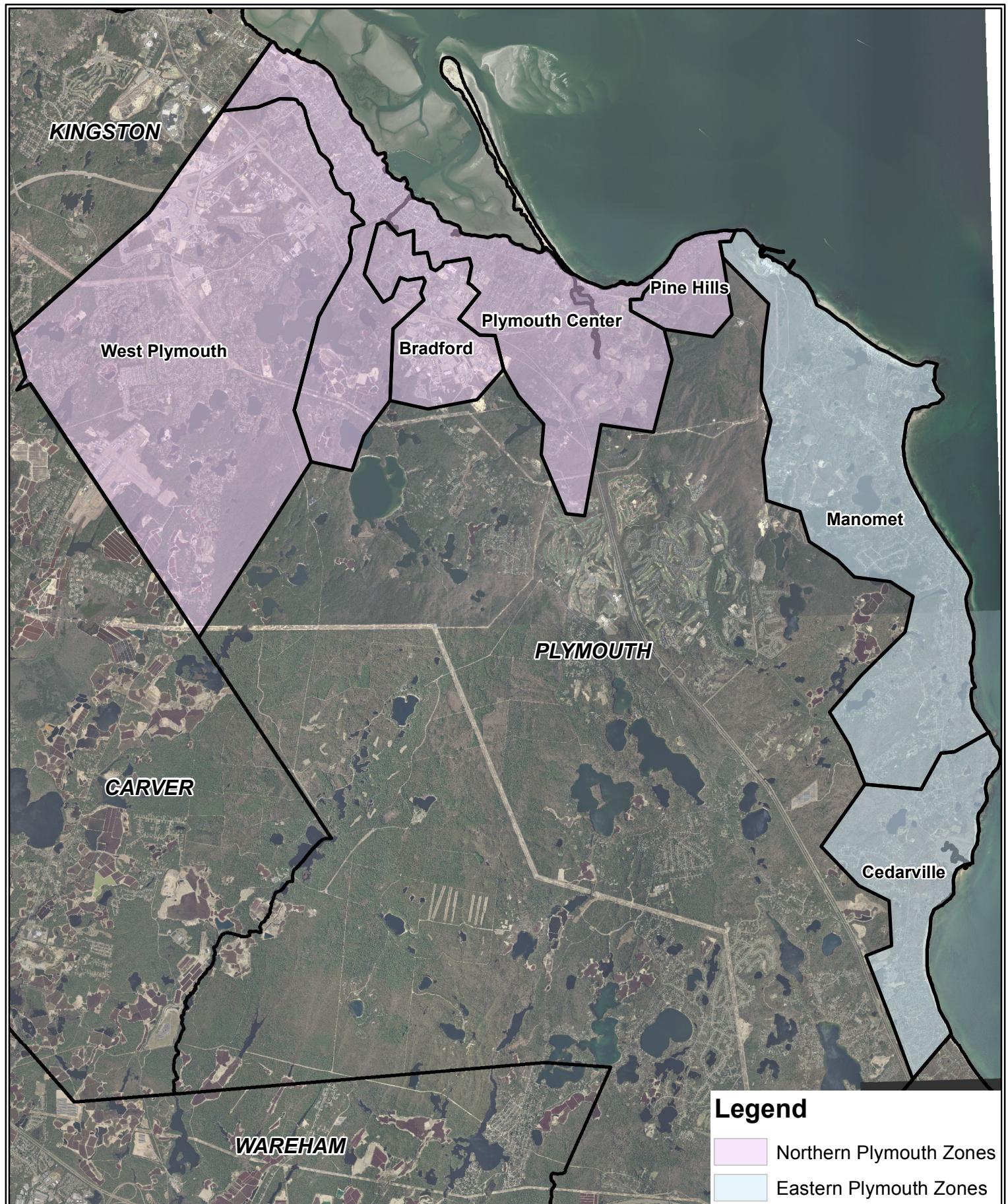
Any new development proposed should look to minimize its water use through water saving devices. Options for water saving devices include water-less urinals and low-flow shower heads. In addition, the DPW could expand its current public outreach on providing water-saving devices and rain barrels to the consumers to increase public awareness of water conservation.

Lastly, a targeted water audit program could be developed for the Town's top fifteen water users. Site visits can be performed to survey each facility and discuss water use practices with each user to educate them on water usage and the potential for water savings.

Review of the data throughout this analysis has reiterated our past recommendation to proceed with a full update of a Water System Master Plan. The scope of the master plan would include population and water demand projections for the next twenty years. This analysis has identified the current weaknesses and vulnerabilities that exists with water supply capacity, the full master plan update can look to plan for future weaknesses to stay ahead of the curve and help plan for future growth.



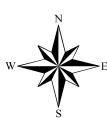




0 4,000 8,000 16,000 Feet

1 in = 8,000 feet

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**Attachment 2:**  
**Town of Plymouth**  
**Water System Service Zones**  
**May 2017**