M E M O R A N D U M

TO:	Evan Walsh | Lowell Regional Wastewater Utility (LRWWU)
FROM:	Jill Rossini, Matt Paragamian | Kleinfelder
DATE:	April 28, 2023
SUBJECT:	LRWWU Draft Consent Decree – 2022 Flow Data Analysis Technical Memo
CC:	Aaron Fox, Mark Young | Lowell Regional Wastewater Utility (LRWWU)
	Kate Goyette, Jason Lavoie | Kleinfelder; FILE

As part of the Draft Consent Decree dated September 19, 2022, EPA/MA DEP requires the City of Lowell to provide flow data and analysis of flows at the Lowell Regional Wastewater Utility's (LRWWU) treatment facility and for flows received from the Towns of Dracut, Chelmsford, Tewksbury, and Tyngsborough. This memorandum (memo) summarizes the following information for LRWWU and the member communities related to the 2022 wastewater flows: average daily flows, peak day flows, peak monthly (average) flows, and a breakdown of average daily infiltration and inflow, based on engineering analysis of flow data.

Background

LRWWU's Collection and Conveyance Sewer System

The Lowell Regional Wastewater Utility's (LRWWU) sewer system has 226 miles of sewer pipe comprised of portions of combined (approximately 52%) and separated (approximately 48%) sewers by linear foot dating back to the 1830s and largely developed from 1870s to the 1970s. The pipes range from 8-inch to 120-inch in diameter, with the majority of 36-inch in size or smaller. The sewer system is predominantly vitrified clay (VC), concrete, brick, and asbestos cement (AC) with the remaining materials including cast iron (CI), ductile iron (DI), and polyvinyl chloride (PVC). The system also includes six siphons (double or triple barrel), 5 miles of force main, 14 pump stations, nine combined sewer overflow (CSO) diversion structures, one siphon station, five intermunicipal flow meter stations, one flow control station, three permanent rain gauges and the Duck Island Wastewater Treatment Facility (DIWWTF). Additionally, there are six metering stations bordering the City that are not owned or operation by the LRWWU. The LRWWU collects and treats flows from the neighboring member communities of Tewksbury, Tyngsborough, Chelmsford, and Dracut utilizing Inter-Municipal Agreements (IMAs). **L**owell's wastewater collection and conveyance system is illustrated in **Figure 1**.

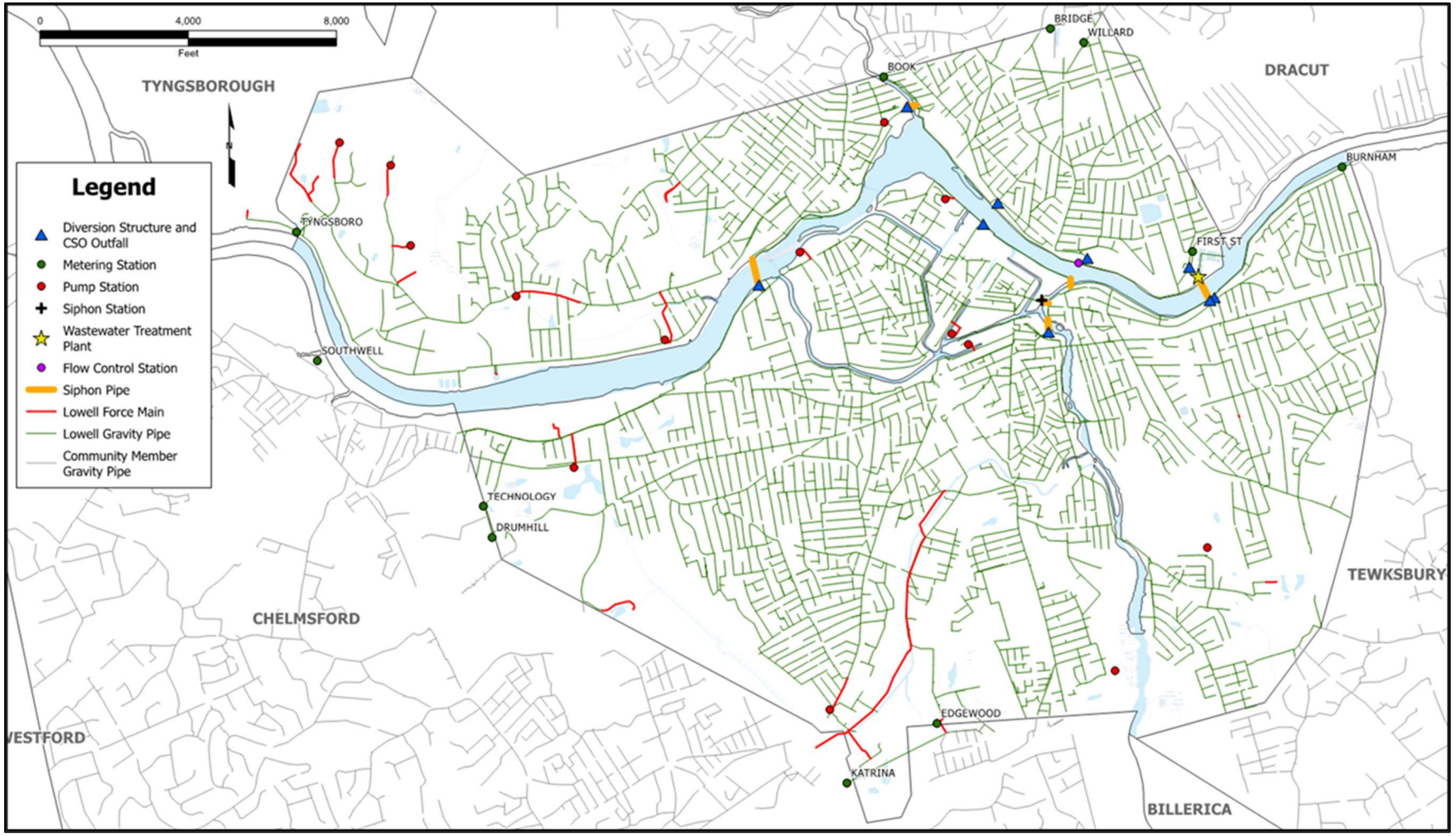

Figure 1: Lowell Collection and Conveyance System with Flow Meters

LRWWU's Member Communities Wastewater Collection and Conveyance Systems

Chelmsford has approximately 167 miles of polyvinyl chloride (PVC) and ductile iron (DI) sewer pipes estimated to be up to 40 years old (2021 Chelmsford I/I Plan). The majority of Chelmsford's wastewater flows are conveyed to the DIWWTF. Dracut has approximately 125 miles of sewer pipes ranging from 8-inch to 42-inch in diameter and consists of mostly PVC with some cross-country DI pipe and some larger concrete and asbestos cement (AC) pipe. All pipe is estimated to be 50 years old or newer. The majority of wastewater flows are conveyed to the DIWWTF, except for a portion of East Dracut conveyed to the Greater Lawrence Sewer District (GLSD) (2017/2018 Dracut I/I Reports). Tewksbury has approximately 158 miles of sewer pipe that is estimated to be 40 years old or newer (2018 Tewksbury I/I Report). The majority of Tewksbury flows are conveyed to the DIWWTF. Tyngsborough has approximately 22 miles of sewer pipe that is mostly AC or DI and is estimated to be 50 years old or newer. All flow is conveyed to the DIWWTF, predominantly via Dracut's system (2017 Tyngsborough I/I Report).

Flow Data Reporting Analysis

Data Sources

LRWWU and its member communities provided 2022 flow data from a collection of sources. Raw flow data for Dracut (Book Street, First Street, Willard Street meters), and Tewksbury (Burnham meter) was provided from LRWWU's Hach Claros website. Raw flow data for the DIWWTF influent was provided by the City directly. Kleinfelder utilized this five-minute interval flow data to analyze diurnal patterns to determine I/I and other parameters discussed herein. Flow meter locations are shown in **Figure 1.**

Chelmsford has five meters (Drum Hill, Edgewood, Katrina, Southwell, Technology) and Tyngsborough has one meter (on Pawtucket Blvd) recording wastewater flows discharging to LRWWU's system. Chelmsford and Tyngsborough provided handwritten flow data logs with cumulative flow values reported in gallons on a semi-weekly basis which Kleinfelder digitized in order to use for analysis. The data digitization involved converting cumulative flow in gallons to discrete flow in million gallons per day. This was done by subtracting the preceding recorded cumulative flow from the subsequent recorded flow and dividing by the number of days between the two recordings and dividing by one million. Kleinfelder then populated remaining data gaps from the intermitted data utilizing monthly average reported flows as a means for interpolation. Average daily flows were then calculated and subsequently compiled into monthly average flows to determine the peak monthly average flows. While Chelmsford and Tyngsborough's data did not provide enough granularity for comprehensive I/I analyses, the average day, peak day, and peak monthly average flows were calculated.

Figure 2 shows Lowell and its member community's gravity sewer systems. The Towns of Chelmsford, Dracut, and Tewksbury provided their geographic information systems (GIS) databases as their sewer systems directly influence Lowell's system at multiple locations. The Town of Tyngsborough provided record drawings for the small portion of sewer that directly ties into Lowell on Pawtucket Boulevard, for which Kleinfelder provided the inset on **Figure 2** from the Town's website depicting their online GIS sewer gravity pipes.

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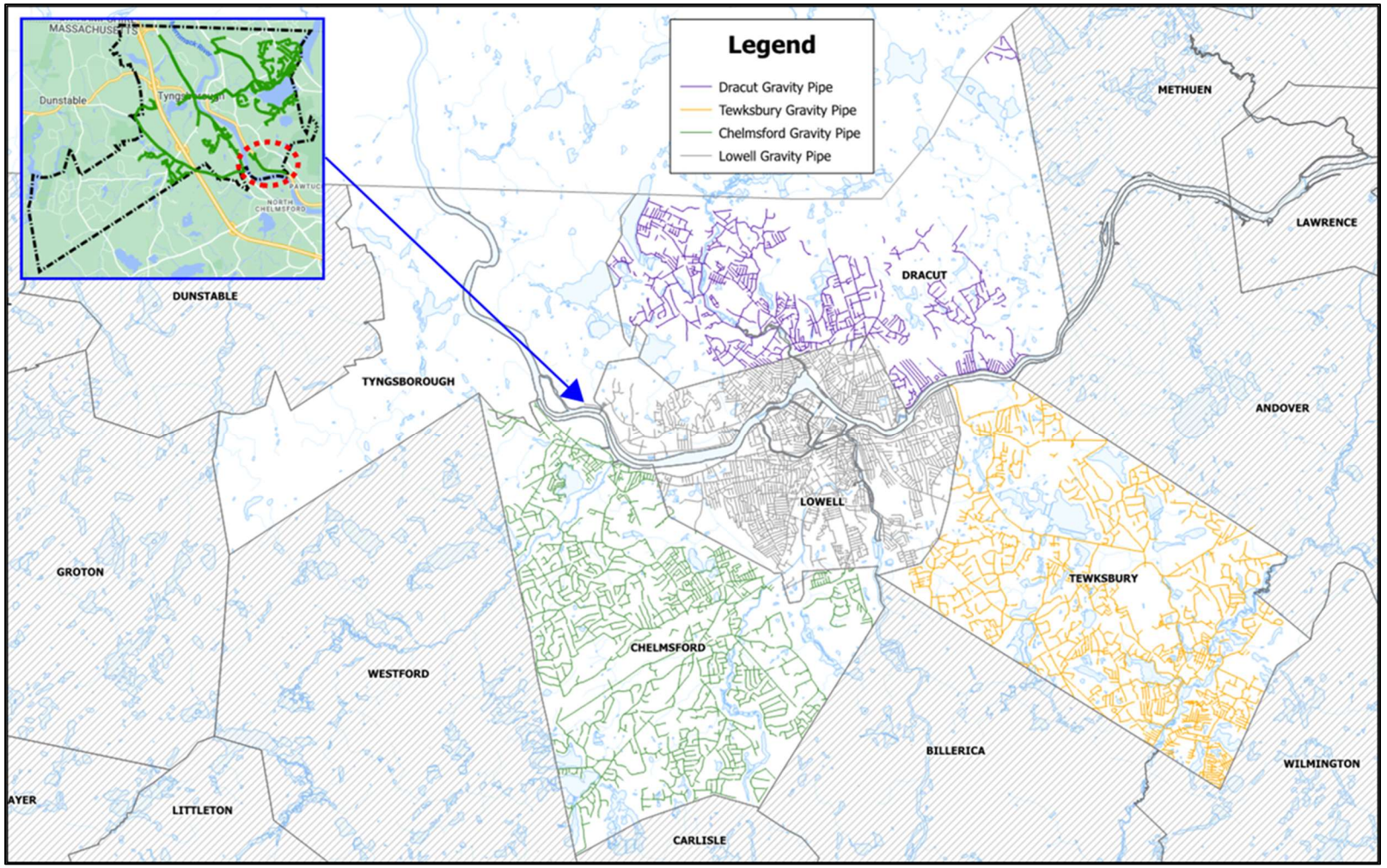

Figure 2: Wastewater Collection and Conveyance Systems of LRWWU and its Member Communities

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I/I Analysis Methodology

Given the variability in recorded flow frequency of the provided data, an I/I analysis was conducted solely for the DIWWTF, Dracut, and Tewksbury. With five-minute interval flow data and daily rainfall, average day I/I was able to be determined for the DIWWTF, Dracut, and Tewksbury. The Dracut meters and Tewksbury meter had several instances of missing logged data (particularly in high ground water periods) which created relatively small discrepancies in the data reported between **Table 1** and **Appendix A**. These missing values likely skew the average flows unfavorably by underrepresenting the observed flow but are reliable enough to yield effective results herein. Alternatively, with semi-weekly intermittent data, I/I was effectively indeterminate without the ability to evaluate diurnal patterns for Chelmsford and Tyngsborough. The three rain gauges (DIWWTF, Warren Street Pump Station, River's Edge Pump Station) located throughout Lowell were used to determine dry weather and wet weather periods. After determining these dry and wet weather periods, average daily flows, peak daily flows, peak monthly average flows, and average day I/I were calculated.

I/I analysis for the DIWWTF, Tewksbury, and Dracut were performed following MassDEP's 2017 Guidelines for Performing I/I Analyses and Sewer System Evaluation Surveys (SSES). The annual average infiltration was calculated by analyzing metered flow data for the entire year. Analyzing the infiltration for each month captures both the peak infiltration during high groundwater months along with the minimum infiltration during low groundwater months. Night-time flows (midnight to 6:00 AM) were averaged for three consecutive dry weather days per meter for each month and multiplied by a factor of 0.7 or 0.8 to determine the monthly average infiltration. At the DIWWTF, it is assumed that 30% of the nighttime minimum flows are attributed to sanitary flow from commercial and industrial users and a factor of 0.7 was utilized. For Tewksbury and Dracut, it is assumed 20% of the nighttime minimum flows are attributed to sanitary flow and a factor of 0.8 was utilized. Sanitary baseflow was determined by subtracting the infiltration from average daily dry weather flow utilizing the same consecutive dry-weather days. The 2022 average daily flow includes periods of dry and wet-weather, from which average daily I/I can be derived by subtracting the sanitary base flow.

Findings and Results

Chelmsford, Dracut, and Tewksbury were found to contribute average daily flows of 2.38 MGD, 2.37 MGD, and 1.95 MGD respectively. A small tributary area of Tyngsborough contributed 0.02 MGD to their direct connection along Pawtucket Boulevard. **Table 1** summarizes Lowell's DIWWTF and its member communities flow characteristics based on 2022 wastewater flows. Community Member flows were also totaled and subtracted from the DIWWTF's raw flows to provide isolated values specific to Lowell's contributions alone (designated as "solo").

Since Chelmsford and Tyngsborough flows are based on semi-weekly totals, I/I contributions could not be determined. Of the 6.7 MGD average daily flows conveyed to the DIWWTF from the member communities, at least 2.5 MGD are estimated to be I/I contributions from Dracut and Tewksbury. Monthly average dry-weather flows and monthly average infiltration for LRWWU, Dracut, and Tewksbury are provided in **Appendix A**. Inflow sources that consistently enter the system will be exhibited within these infiltration values, i.e. Humphrey's Brook and Billings Brook.

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Table 1: LRWWU and Member Communities 2022 Flow Characteristics

Flow Source	Parameter	MGD
Town of Chelmsford	AVG DAILY FLOW	2.38
	[1]AVG DAILY BASE SANITARY FLOW	N/A
	PEAK DAY FLOW	3.74
	PEAK MONTHLY AVG FLOW	2.77
	[1]AVG DAILY I/I	N/A
Town of Dracut	AVG DAILY FLOW	2.37
	AVG DAILY BASE SANITARY FLOW	1.22
	PEAK DAY FLOW	5.60
	PEAK MONTHLY AVG FLOW	3.00
	AVG DAILY I/I	1.15
Town of Tewksbury	AVG DAILY FLOW	1.95
	AVG DAILY BASE SANITARY FLOW	0.60
	PEAK DAY FLOW	9.89
	PEAK MONTHLY AVG FLOW	3.33
	AVG DAILY I/I	1.35
Town of Tyngsborough	AVG DAILY FLOW	0.02
	[1]AVG DAILY BASE SANITARY FLOW	N/A
	PEAK DAY FLOW	0.05
	PEAK MONTHLY AVG FLOW	0.03
	[1]AVG DAILY I/I	N/A
COMMUNITY MEMBERS TOTAL	AVG DAILY FLOW	6.73
	[1]AVG DAILY BASE SANITARY FLOW	N/A
	PEAK DAY FLOW	19.28
	PEAK MONTHLY AVG FLOW	9.13
	[1]AVG DAILY I/I	N/A
LRWWU DIWWTF (RAW)	AVG DAILY FLOW	28.98
	AVG DAILY BASE SANITARY FLOW	11.40
	PEAK DAY FLOW	130.70
	PEAK MONTHLY AVG FLOW	39.05
	AVG DAILY I/I	17.58
LRWWU DIWWTF (SOLO)	AVG DAILY FLOW	22.25
	AVG DAILY BASE SANITARY FLOW	7.17
	PEAK DAY FLOW	111.42
	PEAK MONTHLY AVG FLOW	29.92
	[2]AVG DAILY I/I	15.08

[1]Unable to determine parameter based on data provided
[2]Includes I/I contributions from Chelmsford and Tyngsborough

Kleinfelder will evaluate Lowell and its member communities flow characteristics in more detail through the LRWWU's City-wide Flow Monitoring Program, commencing in March 2023. The sixty-three meter program will allow for a more accurate I/I analysis as well as take into consideration specific locations of commercial and industrial users on a subarea basis, allowing for a more accurate baseline infiltration estimate, and in turn a more refined sanitary base flow volume.

APPENDIX A

LRWWU'S DIWWTF Influent Dry Weather Analysis						
Month	Monthly Total Rain (Inches)	Dry Weather Dates	*Average Daily Flow Parameters (MGD)			
			Raw	Night-time	Base Sanitary	Infiltration
Jan	2.12	1/12 - 1/14	27.90	23.21	11.66	16.25
Feb	3.54	2/10 - 2/12	39.44	30.57	18.04	21.40
Mar	2.42	3/28 - 3/30	33.68	29.17	13.26	20.42
Apr	3.31	4/23 - 4/25	31.99	27.31	12.87	19.12
May	2.36	5/6 - 5/8	28.89	24.32	11.87	17.02
Jun	3.38	6/12 - 6/14	25.38	21.04	10.65	14.73
Jul	3.79	7/9 - 7/11	22.58	18.76	9.45	13.13
Aug	1.20	8/12 - 8/14	21.30	17.57	9.00	12.30
Sep	9.04	9/9 - 9/11	22.28	18.32	9.46	12.82
Oct	5.68	10/9 - 10/11	21.46	16.96	9.58	11.87
Nov	2.70	11/4 - 11/6	23.13	18.39	10.25	12.88
Dec	5.24	12/9 - 12/11	25.94	21.72	10.74	15.20
		Average:	27.00	22.28	11.40	15.60

*includes Combined Community Member Contributions

Dracut (Book, First, Willard Meters Compiled) Dry Weather Analysis						
Month	Monthly Total Rain (Inches)	Dry Weather Dates	Average Daily Flow Parameters (MGD)			
			Raw	Night-time	Base Sanitary	Infiltration
Jan	2.12	1/12 - 1/14	2.56	1.76	1.15	1.41
Feb	3.54	2/10 - 2/12	3.15	2.18	1.41	1.74
Mar	2.42	3/28 - 3/30	2.97	2.23	1.18	1.79
Apr	3.31	4/23 - 4/25*	2.83	1.95	1.27	1.56
May	2.36	5/6 - 5/8	2.50	1.59	1.23	1.27
Jun	3.38	6/12 - 6/14	2.22	1.34	1.15	1.07
Jul	3.79	7/9 - 7/11	1.91	1.08	1.05	0.86
Aug	1.2	8/12 - 8/14	1.92	1.07	1.06	0.85
Sep	9.04	9/9 - 9/11	2.05	0.96	1.28	0.77
Oct	5.68	10/9 - 10/11	2.13	1.09	1.26	0.87
Nov	2.7	11/4 - 11/6	2.11	1.14	1.21	0.91
Dec	5.24	12/9 - 12/11	2.37	1.26	1.36	1.01
		Average:	2.39	1.47	1.22	1.18

*Used 4/28-4/30 for First Street due to reliable data availbility

Tewksbury (Burnham Meter) Dry Weather Analysis						
Month	Monthly Total Rain (Inches)	Dry Weather Dates	Average Daily Flow Parameters (MGD)			
			Raw	Night-time	Base Sanitary	Infiltration
Jan	2.12	1/12 - 1/14	2.20	2.09	0.53	1.67
Feb	3.54	2/10 - 2/12	3.39	3.10	0.91	2.48
Mar	2.42	3/28 - 3/30	2.55	2.39	0.64	1.91
Apr	3.31	4/23 - 4/25	2.46	2.14	0.75	1.71
May	2.36	5/6 - 5/8	2.00	1.66	0.67	1.33
Jun	3.38	6/12 - 6/14	1.63	1.39	0.52	1.11
Jul	3.79	7/9 - 7/11	1.54	1.30	0.50	1.04
Aug	1.20	8/12 - 8/14	1.42	1.16	0.49	0.93
Sep	9.04	9/9 - 9/11	1.42	1.14	0.51	0.91
Oct	5.68	10/9 - 10/11	1.52	1.17	0.58	0.94
Nov	2.70	11/4 - 11/6	1.57	1.22	0.59	0.98
Dec	5.24	12/9 - 12/11	1.54	1.34	0.46	1.07
		Average:	1.94	1.67	0.60	1.34