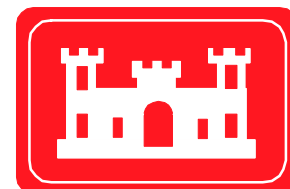


Merrimack River Watershed Assessment Study

Merrimack River Monitoring Report

Prepared for:

**New England District
U.S. Army Corps of
Engineers**



Sponsor Communities:

Manchester, NH
Nashua, NH
Lowell, MA
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Section 2

Dry-Weather Sampling Events

2.1 Introduction

Three dry-weather sampling events were conducted as part of the Merrimack River Watershed Assessment Study on the following dates:

- Dry Event 1: June 30, 2003
- Dry Event 2: August 20, 2003
- Dry Event 3: September 12, 2003

Additional detail on each dry-weather sampling event is provided below, including a summary of water quality sampling and flow monitoring activities; weather and streamflow conditions during and prior to the event; deviations from the approved QAPP during the field and analytical activities; a general data summary; and an analysis of data usability. Section 2-5 provides an overall assessment of the water quality data with respect to regulatory requirements. Data figures and tables showing the raw water quality results are provided in Appendix A and B, respectively.

2.2 Dry Event 1

2.2.1 Event Summary

The CDM Project Team conducted the first dry-weather sampling event on June 30, 2003. This event included sampling at 27 stations along the mainstem Merrimack River and at the mouth of 11 tributaries. In accordance with prescribed protocol, one bacteria grab sample was collected from the center of the river channel at each station. Additionally, one vertically-integrated, quarterpoint spatial composite sample was collected at each of the mainstem stations (with the exception of stations M028–downstream of Salisbury WWTP and M030–Shellfish bed, north bank, where single point vertical composite sample were collected) for all other parameters.

In the tributaries, one vertical composite sample was collected at the center of the channel for all parameters, with the exception of the bacteria samples. In some cases, the collection of single-point vertical composite samples at the tributaries was found to be infeasible due to logistics of the sampling locations. In these cases, a single point grab sample was collected from the center of the tributaries. In other cases it was determined that the sampling location was sufficiently well-mixed to warrant the collection of a grab sample rather vertical composite. Additional information is provided in Section 2.2.3, QAPP and Field Sampling Plan Deviations.

Surface water samples were analyzed for fecal coliform, *E. coli*, *Enterococcus* (marine waters only), chlorophyll-a, ammonia-N, nitrate, nitrite, total phosphorus, Total Kjeldahl Nitrogen (TKN), and 5- and 20-day Biochemical Oxygen Demand (BOD₅ and BOD₂₀) in accordance with Table 5–2a of the Field Sampling Plan, dated May 2003.

Table 2-12 summarizes the US EPA's nutrient guidance for lakes and streams in two US eco-regions. The EPA also provides guidance for lakes and reservoirs; however, these numbers have not been reprinted here.

Table 2-12: USEPA nutrient guidance for rivers and streams

Parameter	Region VIII	Region XIV
Total Phosphorus (mg/L)	0.01	0.03125
Total Nitrogen (mg/L)	0.38	0.71
Chlorophyll-a (µg/L)	0.63 ¹	3.75 ²
Turbidity (FTU/NTU)	1.30	3.04

¹Measured by Fluorometric method

²Measured by Spectrophotometric method

2.5.2 Analysis of Dry Weather Sampling Data

The following section provides an assessment of the dry-weather sampling data collected on the mainstem Merrimack River. The discussion is grouped by the following categories: bacteria results, nutrient results, dissolved oxygen and BOD results, *in situ* measurements, vertical dissolved oxygen and temperature profiles, and WWTP data.

Sample result matrices are provided in Tables 2-13 and 2-14 for the three dry weather sampling events. The matrices provide a summary of the attainment status at each station during the respective sampling events, with respect to state water quality standards for *E. coli*, fecal coliform, dissolved oxygen, temperature, and pH, as well as the USEPA guidance on Enterococcus.

Detailed data plots and data tables for the dry weather sampling data are provided in Appendix A and B, respectively. The plots show the sampling results for each constituent plotted versus the sampling station river mile. Sampling results for the tributary stations are provided as bar charts for comparison purposes. Data qualifiers, as discussed in previous sections, are provided in the data tables.

Table 2-13: Dry Event 1, 2, and 3 bacteria compliance matrix

Table 2-14: Dry Event 1, 2, and 3 in situ measurement compliance matrix

Bacteria Results

The sampling results from the three dry weather sampling events indicate that, in general, the mainstem Merrimack River is in compliance with the state and federal water quality standards for *E. coli* (NH), fecal coliform (MA), and *Enterococcus* (USEPA). Larger non-compliance issues were discovered in the tributaries.

Some general observations relating to the bacteria results are noted below. It is important to note that all observations are made based on a comparison of the single sample results for Dry Event 1, 2, and 3 with the geometric mean standards for Massachusetts and New Hampshire.

- The *E. coli* standard was met at all New Hampshire mainstem stations during each of the three sampling events, with the exception of M005 and M009 in Dry Event 1, located downstream of Manchester and Nashua, New Hampshire, respectively.
- Limited exceedances of the fecal coliform standard were observed in the Massachusetts portion of the Merrimack River during Dry Event 1 and 3, specifically at stations M024, M029, M030 (Dry Event 1) and M021 and M024 (Dry Event 3).
- Widespread exceedances of the fecal coliform standards were observed during the second dry-weather event between the Essex Dam and the shellfish bed/boat ramp in Newburyport (station M019 to M027). Additional exceedances were observed upstream at stations M015 and M016, located just downstream of Lowell. The maximum concentration observed was 400 col/100 mL at M016.
- The *Enterococcus* standard was not met at any of the tidally-influenced stations during the first dry-weather sampling event. Persistent problems were only observed at station M024, located downstream of Haverhill, Massachusetts during the second and third events.
- Exceedances of the New Hampshire *E. coli* standard were observed at tributary T003 (Souhegan River) during Dry Event 1 and 2, T004 (Nashua River) during Dry Event 2, and T005 (Salmon River) during all three dry-weather events. The concentrations at T005 ranged from 180 to 420 cfu/100 mL.
- Exceedances of the Massachusetts fecal coliform standard were observed at tributary stations T006 (Stony Brook) during Dry Event 2 and 3, T007 (Beaver Brook) during Dry Event 3, and T011 (Powwow River) during Dry Events 1 and 2. All concentrations were generally with 100 col/100 mL of the state standard.
- Exceedances of the Massachusetts fecal coliform standard were also observed at T009 (Spicket River) and T010 (Shawsheen River) during all three dry-weather

sampling events. Concentrations at T009 ranged from 8,000 to 11,200 col/100 mL, while concentrations at T010 ranged from 520 to 15,500 col/100 mL. Dry-weather concentrations of this magnitude indicate the potential for an illicit connection, broken pipe, or failing septic system.

Figures 2-4, 2-5, and 2-6 provide a summary of the range of Fecal coliform and E. coli concentrations observed at each monitoring station during the Dry-weather sampling events.



Figure 2-4: Dry Event 1 maximum event bacteria concentration

See Attachment

Figure 2-5: Dry Event 2 maximum event bacteria concentration



Figure 2-6: Dry Event 3 maximum event bacteria concentration

Nutrients

The following section provides an analysis of the nutrient data collected as part of the Merrimack River Watershed Assessment Study, including results for total phosphorus, nitrate/nitrite, ammonia-N, TKN, and Chlorophyll-a.

Some general observations relating to the nutrient results are provided below. Currently neither Massachusetts nor New Hampshire has state water quality regulations governing nutrient concentrations; however, as previously noted, the USEPA published a series of guidance documents regarding nutrient criteria. The guidance criteria provided in Table 2-12 will be used to generally compare the water quality data collected as part of this program.

- Total phosphorus concentrations on the mainstem Merrimack River ranged from 0.023 to 0.18 mg/L over the course of the three dry-weather sampling events. On the low end, the concentrations are below the USEPA guidance criteria for Region XIV.
- Total phosphorus concentrations in the tributaries ranged from 0.017 to 0.36 mg/L over the course of the three dry-weather sampling events. The highest concentrations were observed in the tributaries along the lower reaches of the Merrimack River (T007, T008, T009, T010, and T011).
- TKN results on the mainstem Merrimack River were generally less than 2.0 mg/L, with most below the detection limit of 1.0 mg/L. The exception was station M019 (downstream of Essex Dam) during Dry Event 2, which had a concentration of 4.2 mg/L.
- In general, the TKN results in the tributaries were below the respective reporting limits for all three dry-weather events. The exception was station T009 (Spicket River) during the second dry-weather sampling event, where a concentration of 72mg/L was observed. Due to the extremely elevated concentration, it is anticipated that this sample result is indicative of a non-representative sample taken in the Spicket River. Concentrations of this magnitude were not observed at this station during Dry Event 1 or 3. However, given the slightly elevated concentration observed in the mainstem Merrimack River at station M019 (downstream of Essex Dam) during Dry Event 2, as noted in the bullet above, the potential for the Spicket River as a potential source is likely.
- Ammonia-N results at the mainstem and tributary stations were generally below the reporting limit of 1.0mg/L for Dry Event 2 and 3; results from Dry Event 1 were rejected due to failure of the PE samples.

- Nitrite concentrations in the mainstem and tributaries were generally below the detection limit of 0.2 mg/L.
- Nitrate concentrations in the mainstem Merrimack River were generally below 0.35 mg/L during Dry Event 1 and 2. However, spikes above 1.0 mg/L were observed at station M016 and M026, located downstream of the Lowell and Amesbury WWTPs, respectively during these events. The concentrations in Dry Event 3 were generally higher than those measured during the first two events; large spikes were not observed.
- In general, nitrate concentrations in the tributaries were less than 0.5mg/L in three dry-weather sampling events.
- Dry-weather chlorophyll-a concentrations pointed to a potential algal growth problem in the mainstem Merrimack River. Concentrations during Dry Event 1 ranged from 3.4 to 42 µg/L and concentrations during Dry Event 3 ranged from 2.0 to 23.2 µg/L. Concentrations during Dry Event 2 were significantly lower (2.0 to 3.6µg/L), most likely due to the antecedent precipitation conditions during the month of August. The chlorophyll-a concentrations generally increased with increasing distance downstream. The concentrations observed in the River during Dry Event 1 and 3 were generally well above the national USEPA Nutrient Guidance provided in Table 2-12 (Note: Analysis was performed using fluorometric method).
- Similarly high chlorophyll-a concentrations were seen in the tributaries, where concentrations ranged from 2.0 to 29.9 µg/L over the course of the three dry-weather sampling events. During Dry Event 1, T011 (Powwow River) had the highest concentration at 29.9 µg/L. During Dry Event 2, T001 (Piscataquog River) had the highest concentration with 16.1 µg/L. During Dry Event 3, T008 had the highest concentration with 28.9 µg/L; however, station T001 (Piscataquog River), T007 (Beaver Brook), T010 (Shawsheen River), and T011 (Powwow River) all had concentration above 10 µg/L.

Dissolved Oxygen and BOD

The following section provides a brief summary of the *in situ* dissolved oxygen and BOD results for the three dry-weather sampling events; general observations are provided below. The results of continuous dissolved oxygen measurements upstream of the dams in Lowell and Manchester are provided in Section 5.

- The instantaneous, *in situ* dissolved oxygen measurements indicate that mainstem Merrimack River and tributaries are generally in compliance with the state water quality standards. Therefore, it appears that the algal problems discussed in the

nutrient section may not be having a significant impact on the dissolved oxygen levels in the watershed.

- A limited number of morning and afternoon diurnal dissolved oxygen and temperature measurements were made during the second and third dry-weather sampling events. As expected, the morning concentrations were typically lower than the afternoon values. In general, the difference between the morning and afternoon concentrations was less than 1.5 mg/L. Additionally, all morning measurements were above the Massachusetts and New Hampshire dissolved oxygen standard of 5.0 mg/L.
- BOD₅ concentrations in the mainstem Merrimack River during Dry Event 1, 2, and 3 were generally below the reporting limit of 2.0mg/L. However, values above 10mg/L were observed at stations M001, downstream of Hooksett Dam, and M024, downstream of Haverhill WWTP, during Dry Event 3.
- Similarly, BOD₅ concentrations in the tributaries were generally below the reporting limit of 2.0mg/L during the three dry-weather sampling events. A value above 4.0mg/L was observed station M001 during Dry Event 3.

***In situ* Measurements**

The following section provides a summary of the *in situ* temperature and pH measurements collected over the course of the three dry-weather sampling events. General observations are provided below.

- All *in situ* temperature measurements in the mainstem Merrimack River and tributaries were below the Massachusetts state water quality standard for warm water fisheries.
- All pH concentrations in the mainstem Merrimack River and tributaries were generally within the range of water quality standards for Massachusetts and New Hampshire.
- Turbidity measurements were made at a limited number of stations during the three dry-weather sampling events. The in-stream concentration generally ranged from -1.5 to 2.9 NTU during Dry Event 1, from -0.7 to 7.2 NTU during Dry Event 2, and from -1.1 to 0.7 during Dry Event 3. In general the turbidity concentrations tended to increase with increasing distance downstream.
- Secchi disk measurements were made at all locations (where feasible) during the three dry-weather sampling events. The Secchi measurements depths were generally highest in the upstream portions of the Study Area (i.e. north of Nashua, New Hampshire), typically ranging from six to 10 feet, indicating the greatest

clarity in that area. The depths decreased with increasing distance downstream, such that Secchi disk measurements between Nashua, New Hampshire and Haverhill, Massachusetts typically ranged from three to six feet. The Secchi disk depths were generally lowest during Dry Event 1, corresponding to the event with highest chlorophyll-a concentrations.

Vertical Dissolved Oxygen and Temperature Profiles

Vertical dissolved oxygen and temperature profiles were collected upstream of the Amoskeag, Pawtucket, and Essex Dams during Dry Event 2 and 3. Figures 2-7, 2-8, and 2-9 show the results of each vertical profile at the respective dams. The profiles cover the entire water column.

Decreases in the temperature and dissolved oxygen concentrations are observed with increased depth behind each of the dams during both Dry Event 2 and 3. However, the change with depth is generally most pronounced during the third dry-weather sampling event, which had the lowest flow conditions of the three events sampled. Despite this variation, all dissolved oxygen concentrations were above the minimum Massachusetts and New Hampshire standard of 5.0 mg/L.



Figure 2-7: Dissolved oxygen and temperature profiles upstream of Amoskeag Dam

See Attachment

Figure 2-8: Dissolved oxygen and temperature profiles upstream of Pawtucket Dam

See Attachment

Figure 2-9: Dissolved oxygen and temperature profiles upstream of Essex Dam

WWTP Data

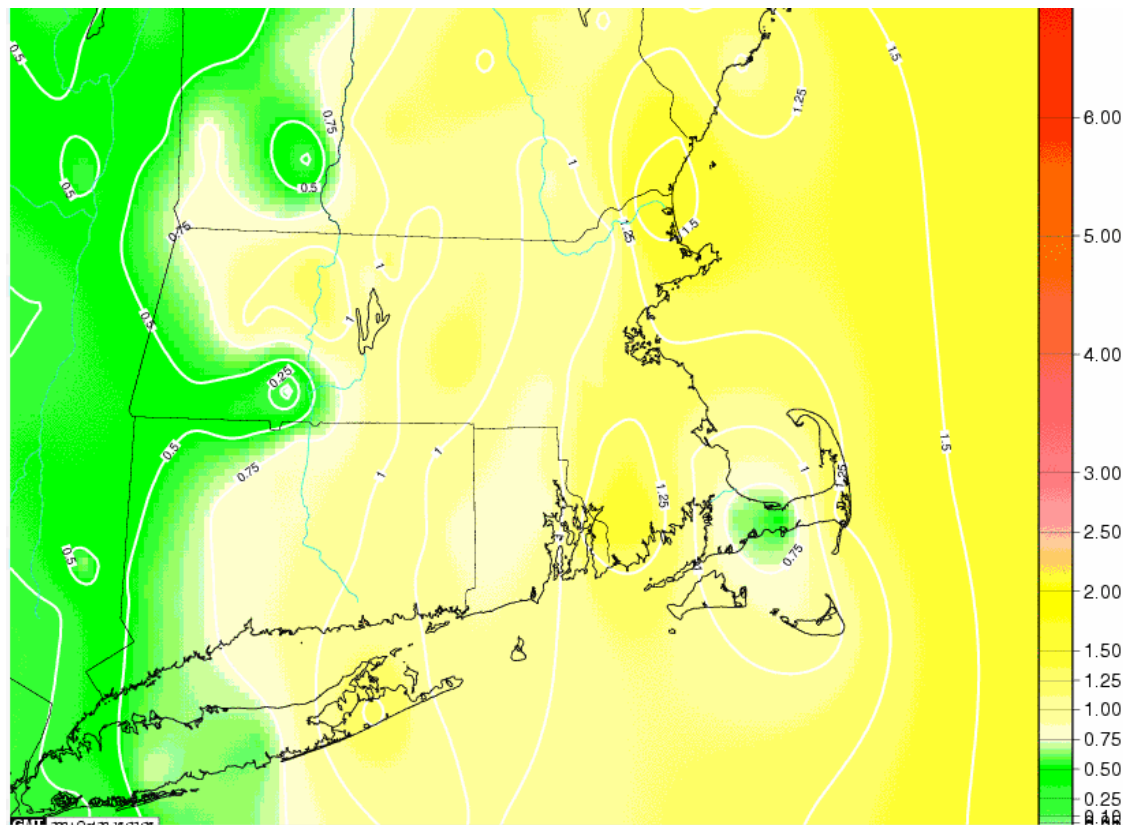
The WWTPs in the sponsor communities of Manchester and Nashua, New Hampshire; Lowell and Haverhill, Massachusetts; and the Greater Lawrence Sanitary District are required to monitor for the following water quality constituents on a daily basis:

- BOD₅
- pH
- Total Suspended Solids (TSS)
- Total Residual Chlorine
- E. coli (NH communities only)
- Fecal coliform (MA communities only)

Error! Reference source not found. provides a summary of the effluent discharge data from the WWTPs for the three days on which the dry-weather sampling events were performed. With the exception of the bacteria samples, the samples were collected as part of the laboratories 24-hour composite samples on the day of the three dry weather sampling events. As previously discussed, parameters typically not analyzed by the WWTPs were collected and analyzed by the CDM Project Team.

In general, the WWTPs are providing a high degree of control on total phosphorus concentrations in their effluent.

Table 2-15: WWTP effluent data for Dry Events 1, 2, and 3



(24-hour precipitation total in inches on October 16, 2004, from <http://www.erh.noaa.gov/>)

Figure 3-7: *Radar map of Wet Event 3 rainfall*

Streamflow

Figure 3-8 shows a summary of the streamflow conditions immediately before, during, and after Wet Event 3, as measured at the USGS gaging stations at Goff's Falls in Manchester, New Hampshire and in Lowell, Massachusetts.

The average daily flow over the course of the two-day sampling event at Goff's Falls was 3,200 cfs, slightly greater than the long-term average for the month of October, 3,033 cfs. The flow at Lowell averaged 4,530 cfs, slightly higher than the long-term October average of 4,152 cfs.