Merrimack River Watershed
2004 Water Quality Technical Memorandum

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Prepared by:
Katie O'Brien-Clayton
With final edits by Arthur S. Johnson

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Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Ian Bowles, Secretary
Department of Environmental Protection
Arleen O'Donnell, Acting Commissioner
Bureau of Resource Protection
Glenn Haas, Acting Assistant Commissioner
Division of Watershed Management
Glenn Haas, Director

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Introduction

The watershed assessment process in Massachusetts is carried out on a 5-year cycle. In Year One, the Massachusetts Department of Environmental Protection Division of Watershed Management (DWM) coordinates with watershed groups, gathers background information and begins to compile sampling needs for streams, rivers, ponds and lakes in pre-determined watersheds. During Year Two of the cycle, sampling sites and parameters are finalized and sampling is conducted. In Year Three, the finalized data are used for assessment reporting to comply with Section 305b of the Clean Water Act (CWA). Implementation of specific projects or programs to address water quality problems, and post-project evaluation are conducted in Year Four and Year Five, respectively.

As part of the DWM Year Two monitoring in 2004, the Division of Watershed Management's Assessment Monitoring Program was charged with increasing, both temporally and spatially, the percent coverage of assessed surface waters in the Commonwealth. Specifically, emphasis was placed on monitoring waters currently "unassessed" (i.e., there are no data) or "not assessed" (i.e., historical data exist but are greater than five years old). As part of the 2004 watershed assessments, biological monitoring, bacteria sampling, and habitat assessments were conducted to evaluate the biological health and recreational use status of various portions of the Merrimack River Watershed. Water quality surveys were performed at 24 sites in the Merrimack River Watershed and included measuring *in situ* parameters (e.g., dissolved oxygen, temperature, pH, specific conductance) and collecting grab samples for bacteria analysis. This technical memorandum is designed to present final DWM-generated water quality monitoring data for use in watershed assessment reports and for reporting data to outside groups. The biological and habitat assessment data will be presented in a separate technical memorandum.

Project Objectives

The main objectives of monitoring in the Merrimack River Watershed were: (a) to determine the biological health and recreational status of "unassessed" and "not assessed" rivers/streams within the watershed by conducting assessments based on biological (aquatic macroinvertebrates, fish, periphyton, bacteria) communities; and (b) to identify problem stream segments so that efforts can be focused on developing or modifying NPDES and Water Management Act permits, stormwater management, and control of other nonpoint source (NPS) pollution (MassDEP 2004a). Biological assessments were supplemented with a habitat assessment and *in situ* water quality measurements (including dissolved oxygen, percent saturation, temperature, pH, depth, and specific conductivity) to evaluate water quality and habitat quality at each study site. The 2004 DWM monitoring efforts also included fecal coliform and *E. coli* bacteria sampling at all biomonitoring stations. Bacteria data will provide information used in making assessments of the *Primary and Secondary Contact Recreation* uses.

Methods

Twenty-four stations (Figure 1) in the Merrimack River Watershed were selected for monitoring in 2004. Sampling station descriptions are provided in Table 1. Additional information pertaining to station location (including detailed station maps), rationale, objectives, and sampling methods is available in *Quality Assurance Project Plan 2004 Surface Water Quality Monitoring and Assessment CN 177.0 (*MassDEP 2004a) and *2004 Biological Monitoring and Habitat Assessment QAPP* (MassDEP 2004b). During the summer, low-flow months of July, August and September dissolved oxygen (DO), percent DO saturation, pH, conductivity, temperature, and total dissolved solids were measured *in situ* during pre-dawn hours using multi-probe units.

Between May and September wade-in grab samples were also collected monthly (n=5) from the 24 stations and sent to the Senator William X. Wall Experiment Station (WES) in Lawrence, MA where they were analyzed for *E. coli* and fecal coliform bacteria. The analytical methods, associated detection limits and project data quality objectives for water sample analyses at WES and DWM are provided in Table 2.

QA/QC decisions were imposed on the data following the guidelines of the DWM working SOP *Data Validation and Usability Standard Operating Procedure* (MassDEP 2005). Details pertaining to data validation are available in the *2004 Data Validation Report* (MassDEP 2006). It should be noted that when the multi-probe depths are reported as less than 0.1 m, they are automatically qualified as potentially in error (e.g., depth not calibrated by field crews). Additionally, if zero and/or negative depth readings occur more than once per survey date, then all negative/zero depth data are censored, and all other depth data for that survey are qualified [indicating that erroneous depth readings were not recognized in the field and that corrective action (field calibration of the depth sensor) was not taken, i.e., that all positive readings may be in error.]

Field sheets, raw data files, chain-of-custody forms, lab reports, and other metadata used in this report are stored and maintained by DWM in project files and the Water Quality Database in Worcester, MA.

Table 1. Massachusetts Department of Environmental Protection Division of Watershed Management 2004 Merrimack River Watershed Water Quality Sampling Station Descriptions.

Waterbody	Station ID#	Site Description
Unnamed Tributary	AR01	unnamed tributary to Johnson Creek, locally known as Argilla Brook, west off Baldwin Terrace approximately 1400 feet upstream/east of Main Street crossing, Groveland
Unnamed Tributary	ABR01	unnamed tributary to Powwow River, approximately 50 feet upstream/northeast of R Street, Amesbury
Powwow River	PO01	approximately 550 feet downstream/east of Route 150 (approximately 225 feet downstream of Amesbury electrical substation but upstream of discharge pipe directly across from 35 Mill Street), Amesbury
Back River	ABR02	Clinton Street crossing, Amesbury
East Meadow River	EA01	Thompson Road crossing, Haverhill
Johnson Creek	JC03	Center Street crossing, Groveland
Little River	LR01	Downstream/south at Winter Street crossing, Haverhill
Creek Brook	CR01	West Lowell Avenue crossing, Haverhill
Bare Meadow Brook	BMB01A	Renfrew Street crossing, Methuen
Bartlett Brook	BA01	Route 113 (North Lowell Street) crossing, Methuen
Fish Brook	FI01	River Road crossing, Andover
Trull Brook	TB02	Approximately 230 feet downstream/north of River Road, Tewskbury
Richardson Brook	RBR01	Methuen Street crossing, Dracut
Trout Brook	TRB02	Kenwood Road crossing, Dracut
Peppermint Brook	PE01	Lakeview Avenue crossing, Dracut
Black Brook	BB05	Westford Street crossing, Lowell
Tadmuck Brook	TA01	Lowell Road crossing, Westford
Bennetts Brook	BE01	Willow Road crossing, Ayer
Deep Brook	DBR05	Ledge Road crossing, Chelmsford
Lawrence Brook	LWB02	Approximately 130 feet downstream/south of Sherburne Avenue, Tyngsborough
Bridge Meadow Brook	BR01	Downstream/northeast of the unnamed school access road crossing north off Westford Avenue between the localities of Hayward Corner and Swan Corner, Tyngsborough
Salmon Brook	SA01	Ridge Road crossing, Nashua, New Hampshire
Joint Grass Brook	JG01	Downstream/east of Main Street crossing (below confluence of unnamed tributary), Dunstable
Martins Pond Brook	MRB01	Approximately 180 feet downstream from washed out culvert crossing of Loomis Lane, Groton

Figure 1. Massachusetts Department of Environmental Protection Division of Watershed Management 2004 Water Quality Monitoring Station Locations in the Merrimack River Watershed.

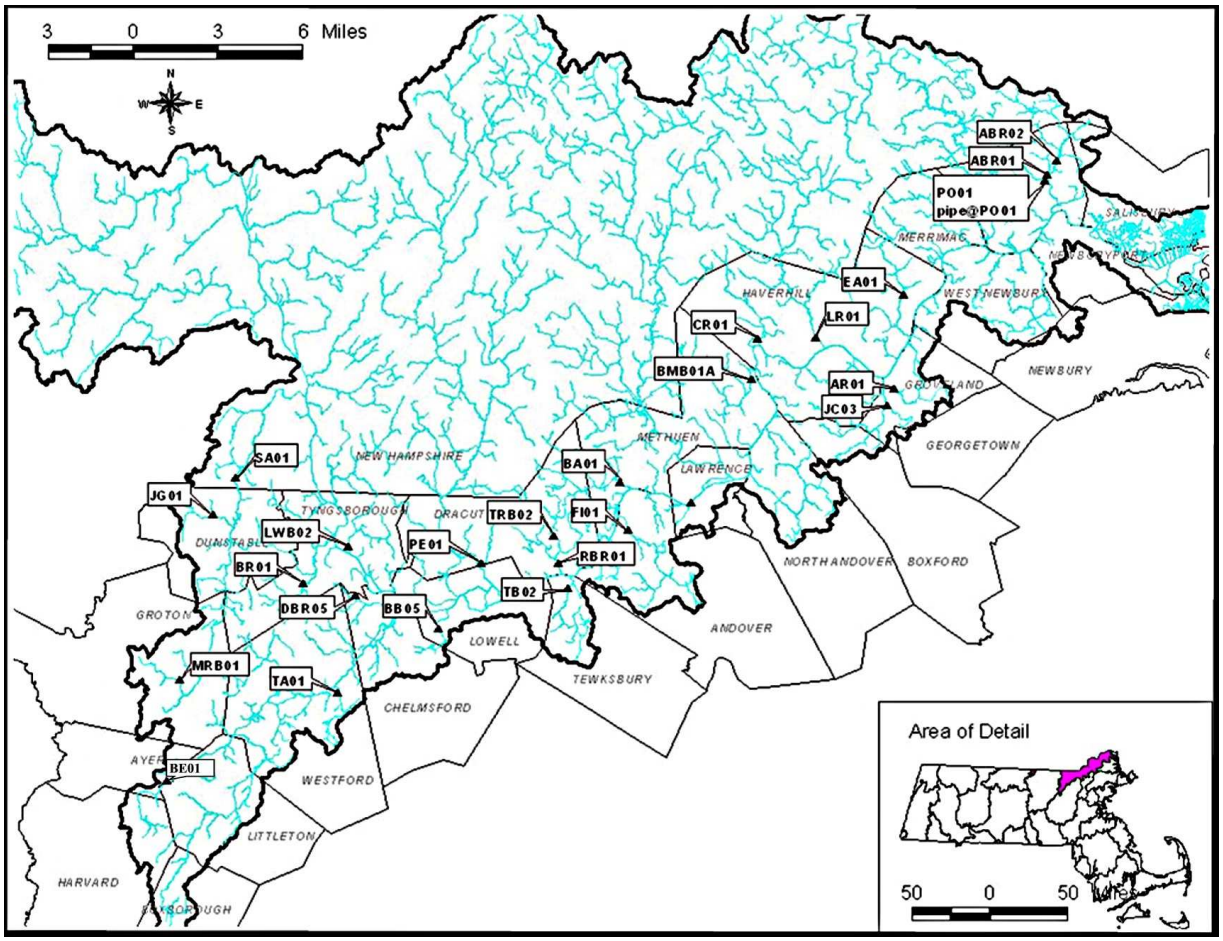


Table 2. Analytical Methods & MDLs for 2004 Merrimack River Watershed Water Quality Analytes

Water Quality Analyte	Method *	MDL **	RDL **
Hydrolab® Multiprobe Series 3 & 4	DWM SOP (CN 4.2)	NA	NA
YSI 600 XLM	DWM SOP (CN 4.2)	NA	NA
Fecal Coliform ***	SM 9222D	6 CFU/100mls	6 CFU/100mls
E. coli ***	EPA 1603 (also modified 1103.1)	6 CFU/100mls	6 CFU/100mls

***** = "Methods for Chemical Analysis of Water and Wastes", Environmental Protection Agency, Environmental Monitoring Systems Laboratory – Cincinnati (EMSL-CI), EPA-600/4-79-020, Revised March 1983 and 1979 where applicable; Standard Methods, Examination of Water and Wastewater, 20th edition

** = WES typically reports results down to the MDL with a qualifier.

*** = 6 CFUs/100 ml was the practical RDL for WES, as no results were reported below 6 (these were reported as "<6")

NA = Not Applicable

Survey Conditions

To fulfill 305(b) assessment guidance, precipitation (NOAA undated) and stream discharge (Socolow et al. 2005) data were analyzed to estimate hydrological conditions during the 2004 water quality sampling events in the Merrimack River Watershed. This review was conducted to estimate streamflow conditions in relation to the 7-day, 10-year (7Q10) low flow. Additionally, this review was used to determine whether fecal coliform bacteria data were representative of "wet" or "dry weather" sampling conditions. A sample is considered to be collected during dry weather when there has been no precipitation (<0.1 inch) on the sampling day and three days prior. Wet weather is defined as a precipitation event, generally greater than 0.25 inches of rain, on the sampling date that results in a subsequent increase in streamflow. Given limited resources, sampling the first flush (first 1 hour of a rain event forecast to produce 0.25 inches of precipitation) was not possible.

There is one United States Geological Survey (USGS) stream gauge (#01100000) on the main stem Merrimack River. It is situated on the right bank of the river, 1,100 ft. downstream from the Concord River at Lowell. The daily discharge includes water released from 210 mi^2 in basins of the Sudbury and Nashua Rivers and Lake Cochituate. Flows are regulated by power plants, by Franklin Falls Reservoir since 1942, and by Squam, Newfound, Winnipesaukee, Winnisquam, and other lakes and reservoirs upstream (in New Hampshire). The total drainage area above this gauge is 4,635 mi^2. Because the DWM 2004 Merrimack surveys entailed sampling only tributaries in Massachusetts, discharge data from the Lowell gauge was not deemed representative of flow conditions in the much smaller watersheds of the tributary streams. A real-time gauge on the Spicket River near Methuen (#01100561) is operated for flood forecasting and warning purposes. The USGS states that low-flow discharges below 200 cubic feet per second are not generally available due to variable backwater effects from downstream dam operation (USGS 2005a). Therefore, data from this gauge were also considered unacceptable for assessing survey conditions.

Although managed separately from the main stem Merrimack by the MassDEP's Watershed Planning Program, the Shawsheen Watershed is tributary to the Merrimack River and lies entirely within the boundaries of Massachusetts. Furthermore, its 78 mi^2 watershed, while still larger than most, more closely approximates the drainage areas of those tributary streams monitored in 2004. Therefore, discharge data from the Shawsheen River gauge in Wilmington was considered more representative of the local flow conditions in neighboring watersheds.

Survey conditions are described below for each sampling event. Precipitation (Table 3) and stream discharge (Table 4) data were reviewed for a minimum of five days leading up to each sampling date in an effort to determine whether survey conditions were more representative of dry or wet-weather conditions (Figure 2). No drought advisories were issued in 2004; USGS reports that streamflows were normal to above normal during July, August, and September 2004 (USGS 2005b).

2 June 2004: Sampling crews reported overcast skies with temperatures between 50 and 60°F. On the day of sampling 0.02 inches of rain fell at the Lawrence Airport. One day prior to sampling (1 June) 0.22 inches of rain was recorded at the airport. Streamflows in the Shawsheen River near Wilmington (Gauge #01100600) decreased from a high of 88 cfs on 29 May to 40 cfs on the day of sampling. Flows were near the May monthly average streamflow of 59.7 cfs (Socolow et al. 2005). Since streamflows did not respond to the rain event (i.e., increase), samples collected during this survey will be interpreted as being representative of **dry weather conditions**.

23 June 2004: The sun was shining on field crews during this bacteria survey in mid-June; air temperatures were estimated to be between 70-80°F. At the Lawrence Airport the rain gauge was generally dry with rain fall totaling 0.08 inches five days prior to sampling and 0.03 inches falling the day before sampling (Table 3). Streamflows at the USGS gauge continued to generally decrease from the 2 June survey. The daily mean flow value five days prior to sampling was 33 cfs. Stream flow increased to 42 cfs the next day but then steadily decreased to 13 cfs on 23 June. Flow on the sampling date was six times greater than 7Q10 and four times lower than the period-of-record mean discharge for June (Table 4). Bacteria samples collected on 23 June were considered representative of **dry weather**.

8 July 2004: A total of 1.52 inches of rain were reported for 8 July. Pre-dawn crews reported clear to mostly cloudy skies during the multi-probe survey. Later sampling crews reported that their day began with overcast skies and occasional drizzle. The Spicket River gauge is equipped with a rain gauge. Hourly precipitation data from the gauge **showed that precipitation began around 2200 hours, long after sampling** was completed (USGS 2005c). The Shawsheen River exhibited steadily declining daily mean flow values from 3 July (11 cfs) to 8 July (5.9 cfs) despite a minimal amount (0.05 inches) of precipitation on 5 July. Since the rain event on the 8th occurred after crews were finished sampling, samples collected on this date will be interpreted as being representative **of dry-weather conditions**.

18 August 2004: Field crews during the pre-dawn survey reported drizzle while samplers reported mostly cloudy skies during the bacteria survey. Precipitation was recorded at Lawrence on each of the five days preceding the survey (Table 3) totaling 1.44 inches. It is also important to note that on 12 August, 2.44 inches of rain was recorded at Lawrence as well. The mean daily discharge at the Shawsheen River Gauge on 12 August was 4.9 cfs, a value that was nearing the provisional 7Q10 statistic (i.e., 2.3 cfs). Due to the rain, however, daily mean flow increased dramatically to 52 cfs on 13 August, and increased again to 168 cfs on the day after that. While flows gradually declined from 14 August to 18 August, the mean flow on the 18th was still approximately 14 times higher than the week before and three times higher than the mean monthly value for the period of record (i.e., 23.3 cfs). Data from samples collected on the 18th will be interpreted as being indicative of **wet-weather conditions**.

9 September 2004: Field crews reported rain at the beginning of the final Merrimack survey in September. However, by the end of the survey, crews reported only overcast skies. No precipitation fell at Lawrence between 4 September and 7 September. On 8 September, 0.20 inches were measured in the gauge and 1.17 inches of rain was reported for the sampling date (9 September). Streamflows decreased slightly each day between 4 September and 7 September (19-14 cfs) but doubled on the 9th (28 cfs) in response to the rain event. Daily mean flow values continued to increase to a maximum of 66 cfs on 11 September. Since field crews reported collecting in rainy weather, and stream discharge was twice that of the previous day, bacteria samples collected on 9 September 2004 are considered representative of **wet-weather conditions.**

Table 3. Provisional precipitation data summaries for MassDEP DWM bacteria surveys obtained from the NOAA website http://www.erh.noaa.gov/box/dailystns.shtml for Lawrence, MA (NOAA undated).

Merrimack River Bacteria Survey
Precipitation Data Summary (reported in inches of rain)

Survey Dates	5 Days Prior	4 Days Prior	3 Days Prior	2 Days Prior	1 Day Prior	Sample Date
Lawrence						
6/2/2004	0.4	0.00	0.00	T*	0.22	0.02
6/23/2004	0.08	T	0.00	0.00	0.03	0.00
7/8/2004	0.00	0.00	0.05	0.00	0.00	1.52
8/18/2004	0.48	T	0.66	0.29	0.01	0.00
9/9/2004	0.00	0.00	0.00	0.00	0.20	1.17

* trace amount of precipitation noted

Table 4. USGS gauge data summary for the 2004 MassDEP DWM Merrimack River Watershed surveys (Socolow et al. 2005).

Merrimack River Watershed Surveys
USGS Discharge Data Summary (reported in cfs)

Survey Dates	5 Days Prior	4 Days Prior	3 Days Prior	2 Days Prior	1 Day Prior	Sample Date	Monthly Mean	POR* Monthly Mean
Shawsheen River near Wilmington, MA. (Provisional 7Q10 = 2.306 cfs, USGS 1998) Gauge #01100600								
6/2/2004	79	88	80	61	46	40	59.7**	63.7**
6/23/2004	33	42	36	26	16	13	25.9	49.8
7/8/2004	11	10	8.0	7.8	6.8	5.9	32.3	24.8
8/18/2004	52	168	135	101	88	68	52.5	23.3
9/9/2004	19	17	15	14	14	28	52.3	21.8

* Period of Record
** Statistics for May, 2004 discharge data

Figure 2. Streamflow versus precipitation in the Merrimack River Watershed. Streamflow from USGS Gauge #01100600 (Shawsheen River) and precipitation data from Lawrence, MA.

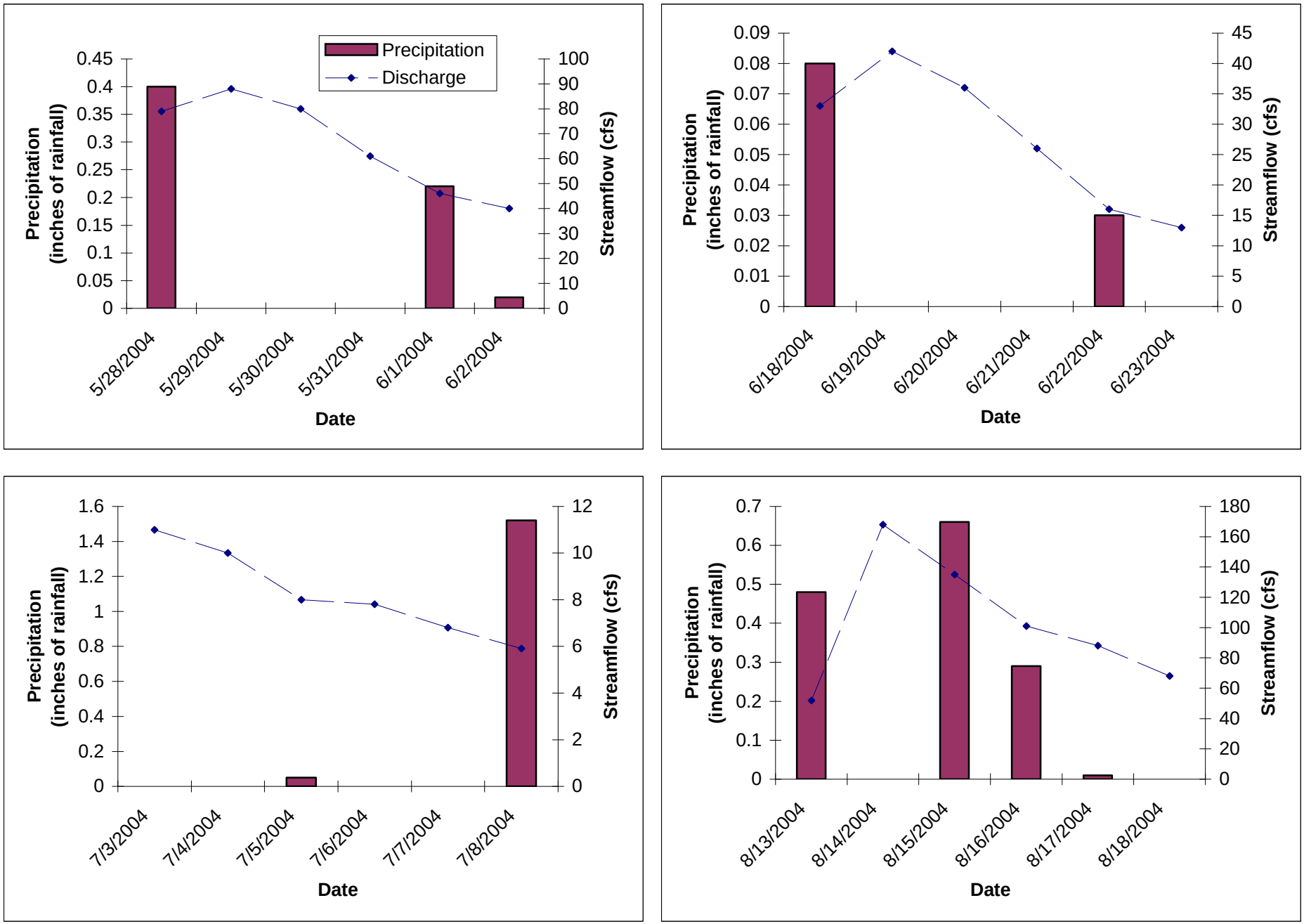
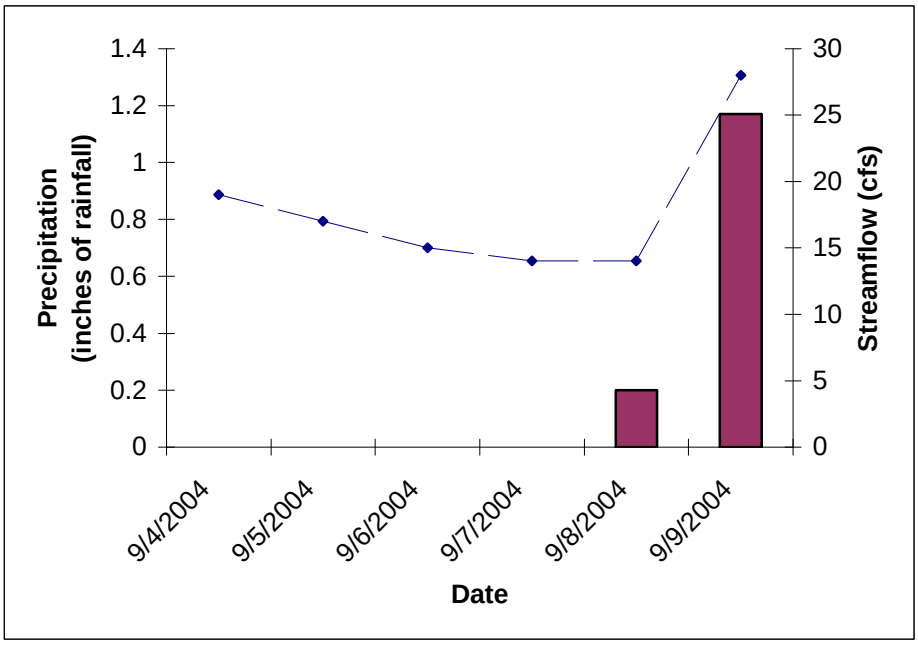


Figure 2 (continued). Streamflow versus precipitation in the Merrimack River Watershed. Streamflow from USGS Gauge #01100600 (Shawsheen River) and precipitation data from Lawrence, MA.



Station Observations

Station BE01- Bennetts Brook- Willow Road crossing, Ayer.

Bennetts Brook originates to the north of Route 2 and west of Shaker Road in Harvard. The brook flows in a northeasterly direction for approximately one half mile before making a 180 degree bend to the north. The brook flows north for one mile to the Harvard/Ayer town line. It again takes a 180-degree turn, enters Shaker Millpond, and flows in an east/northeasterly direction for another 2.2 miles, before finally discharging to Spectacle Pond. The contributing drainage area to Bennetts Brook is 4.6 mi^2. Land use throughout the drainage area is 52% forest, 19% residential, 11% open land, 4% transportation, and 4% agricultural.

Field crews parked in a commercial lot adjacent to the brook. Access to Station BE01 was gained downstream from the Willow Road bridge by walking down a trail on the right bank. Samples were collected from the center of the brook. The light yellow/tan water was slightly to moderately turbid throughout the sampling season. The water was odorless. A floating scum was reported on two occasions (2 June and 18 August). Trash was observed in localized areas. Moderate brown film and filamentous algae were present on the rocky substrates as early as June and continued through September. Substrates were a mix of cobble, gravel, and sand. Potential pollution sources noted by the sampling teams included road runoff and runoff from the parking lot.

Station MRB01- Martins Pond Brook, approximately 180 feet downstream from washed out culvert crossing of Loomis Lane, Groton.

Martins Pond Brook emerges as the outlet of Martins Pond in Groton. The brook flows for 2.3 miles in a southeasterly direction to Lost Lake. The drainage area is two square miles. Forty-one percent of the land use within the drainage area is forest, 19% is residential, and 18% is agricultural. Field crews accessed

Station MRB01 by driving to the end of Loomis Lane in Groton and walking down a trail to a wooden footbridge. Samples were collected center stream. The water in Martins Pond Brook varied from clear to light yellow/tan in color and was slightly to moderately turbid. Sparse aquatic macrophytes (*Sparganium*, *Lemna*, and *Wolffia*) were observed in the brook. Additionally, filamentous, film, and floc algae were documented at various densities throughout the sampling season. Substrates in Martins Pond Brook were cobble, gravel, and sand. No scums, trash, or other objectionable deposits were viewed by field crews. The crews noted that dirt bikes frequently cross the brook resulting in minimal erosion.

Station JG01- Joint Grass Brook- downstream/east of Main Street crossing, Dunstable

Joint Grass Brook rises to the north of Pleasant Street (Route 113) and to the west of Hauk Swamp in Dunstable. The brook flows north for about 1.1 miles. It turns to the east and skirts around Hound Meadow Hill- a distance of about 0.6 miles. Joint Grass Brook then flows in an east/southeasterly direction for 1.3 miles, through a small unnamed pond, before confluencing with Salmon Brook. The sampling location was approximately 30 feet downstream from Main Street. A small unnamed tributary discharges to Joint Grass Brook downstream from Main Street on the left bank. The sampling station was also located downstream from this tributary. Samples were collected from center stream. The water was reddish in color from tannins. With the exception of the 23 June survey where the water was slightly turbid due to wind, the water in Joint Grass Brook was free from turbidity. There were no odors, scums, or other aesthetically objectionable deposits. Sand dominated the substrate composition but coarse gravel and boulder provided some stable habitat for invertebrates. Sparse brown film algae was reported on the rocks in June, July, and August. The drainage area of Joint Grass Brook is three square miles. Land use within the drainage area is 62% forest, 12% agriculture, 11% residential, and 9% open land. Land use within the riparian zone surrounding the sampling station is forest, although a crop field is located less than 0.1 miles upstream. Field crews identified road runoff as a potential pollution source. Additionally, they were concerned with the sediment inputs from no apparent source. A small farm pond (0.01 mi^2) impounds the unnamed tributary 0.2 miles upstream from Joint Grass Brook. Depending upon the outlet control strategies (if any), this pond could contribute to the sedimentation in Joint Grass Brook.

Station SA01- Salmon Brook- Ridge Road crossing, Nashua, New Hampshire

Salmon Brook forms as the outlet of Lower Massapoag Pond, near Route 113 in Dunstable. The brook flows north into New Hampshire. From the pond to the state line, the brook flows a distance of 2.8 miles. The sampling station was located downstream from Ridge Road in Nashua, New Hampshire. Samples were collected from the right bank. There is no canopy cover at the sampling station. The water in Salmon Brook was odorless, slightly turbid, and light yellow to tan in color. The aquatic macrophyte *Sparganium* and thin film algae were observed in Salmon Brook. Substrates at this sampling location were a mix of sand, boulder, cobble, and gravel. Foam was observed in July and August. No scums or trash were reported. Potential pollution sources included road runoff. A quarry/mine is located along the left bank at the state line. The Massachusetts portion of the drainage area is 22.5 mi^2. Land use within the drainage area is 59% forest, 18% residential, and 7% agriculture. Land use in the riparian zone is mostly forest.

Station LWB02- Lawrence Brook- approximately 130 feet downstream/south of Sherburne Avenue, Tyngsborough

Lawrence Brook, a second-order tributary to the Merrimack River begins to the west of Jefferson Drive in Tyngsborough. The brook flows southwest through the locality of Norris Corner, under Lawndale Road, and Sherburne Avenue, before emptying into the Merrimack River 0.8 miles downstream from the Tyngsborough Bridge. The brook is 2.5 miles long. The drainage area of Lawrence Brook is 3.4 mi^2 and includes Althea and Mascuppic lakes. Land use in the watershed is 40% residential, 37% forest, 45% agriculture, and 4% wetlands. The sampling station was located downstream from Sherburne Avenue. A golf course is located less than 150 feet from the left bank. Water clarity varied from clear to slightly turbid. The color of the water in Lawrence Brook was reported by crews to generally be light yellow/tan, however, during the 23 June survey it was grayish. The water never emitted any objectionable odors. Substrates were a mix of cobble, sand, coarse gravel, and boulder. A sparse stand of Arrow arum

(*Peltandra)* was noted. Thin film algae covered 25-50% of the rock substrates in the riffle areas. There were no aesthetically objectionable conditions found within 100 meters of the sampling reach

Station BR01- Bridge Meadow Brook- Downstream/northeast of the unnamed school access road crossing north off Westford Avenue between the localities of Hayward Corner and Swan Corner, Tyngsborough

Bridge Meadow Brook is an approximately 4 mile-long stream that originates to the north of Chestnut Road and west of the locality of Fredericks Corner. The stream flows in a west/northwest direction to Flint Pond. Two former gravel pits adjacent to the brook have been reclaimed. The gravel pit to the north is now the site of an elementary school, while the one to the south has been converted to residential subdivisions. The sampling station was located downstream from the school access road. Samples were collected from center stream. Approximately 95 feet upstream from the road a large beaver dam creates an approximately 2.5 acre impoundment of the brook. Downstream from the road, the culvert creates a large pool and then a riffle area. There was little to no canopy cover shading the brook, visual estimates of percent open sky ranged from 80-100% open. The water was a reddish/light yellow/tan color. During both July surveys and the August bacteria survey the water was described as having an organic odor. During the August pre-dawn survey the water smelled of sulfides. The stream was almost always turbid, but in varying degrees—on 23 June and 18 August the water was slightly turbid, on 8 July and 17 August it was moderately turbid and on 7 July and 9 September it was highly turbid. During the other surveys there was either no turbidity (i.e., clear) or clarity was unobservable due to darkness (i.e., predawn surveys). Algae and periphyton abounded at this station. Floating clumps of blue green algae were documented in the slow moving areas of the brook during the 23 June survey. Moderate to very dense filamentous, film, and floc periphyton were documented during the 8 July, 18 August, and/or 9 September surveys. Freshwater sponges were also observed in Bridge Meadow Brook. Trash, debris and other objectionable deposits were absent from this sampling station. Potential pollution sources include road runoff and runoff from lawns (school athletic fields, nearby houses). The drainage area, upstream from the sampling location is 3.2mi^2. Land use within the upstream drainage area is 57% forest, 35% residential, and 4% open land.

Station TA01- Tadmuck Brook- Lowell Road crossing, Westford

Tadmuck Brook emerges from Tadmuck Swamp just north of Main Street in Westford and flows north for a relatively short distance (0.9 miles) before confluencing with Stony Brook. Land use within the 1.9 mi^2 drainage area of Tadmuck Brook is 42% residential, 33 % forest, and 14% open land. The sampling station was located upstream from Lowell Road in Westford. Samples were collected from the center of the stream. The riparian area surrounding the sampling site was forested and included a mix of shrubs, herbaceous plants, and trees. Canopy cover was visually estimated to be 70-100% open. Sand was the dominant substrate but coarse gravel, mud, silt, and cobble were also encountered. Periphyton coverage varied throughout the sampling season but filamentous, thin film, and loose floc varieties were documented. The water was stained from tannins originating in the wetlands as evidenced by sampling crew reports of reddish, brownish, and light yellow/tan water color. The water was odorless with the exception of the August pre-dawn survey where the water smelled musty. Clarity in Tadmuck Brook varied from clear to moderately turbid. There were no scums, sheens, trash, or other objectionable deposits in Tadmuck Brook. Road runoff was the only potential pollution source identified by field crews.

Station DBR05- Deep Brook- Ledge Road crossing, Chelmsford.

The headwaters to Deep Brook are located in a wetland, east of Route 3 and north of Dunstable Road (Make Peace Road) near the Tyngsborough/Westford/Chelmsford town lines. After flowing in a southeast/ east direction for 2.9 miles, Deep Brook empties into the Merrimack River, about one mile downstream from Tyngs Island. The sampling station was located downstream from Ledge Road. It is important to note that data collected from this sampling station would not reflect any water quality impacts associated with Swains Pond or the urbanized area of North Chelmsford 0.4 miles downstream. The sampling station is surrounded by forest with an herbaceous understory (see inset to the right). Percent open sky was visually estimated to be between 50 and 80%. The color of the water varied from reddish to light yellow/tan. The water smelled musty during the 8 July and 9 September surveys and was slightly to moderately turbid throughout the sampling season. At the sampling station, substrates were coarse gravel, cobble, and sand. Thin film algae covered less than 25% of the rocky surfaces. There were no scums, sheens, trash, or debris at the sampling station. The drainage area upstream from the sampling station is 0.5 mi^2 while the entire Deep Brook drainage area is 2.5 mi^2. Land use in the area upstream from the sampling location is 56% forest, 21% residential, 11% wetlands, and 7% transportation. Land use throughout the entire watershed is 51% forest, 24% residential, 7% transportation, and 7% industrial.

View off end of Marguerite Road, Chelmsford (downstream from Swains Pond)

Sedimentation is a major problem in the lower portion of this stream. Sampling crews were frequently stopped by civilians and told that sand from the Route 3 construction was washing into the brook (Fiorentino personal communication 15 December 2005). Fish population crews gave this reach a score of 10 out of 20 due to sedimentation (Maietta 2004). Pictometry images reviewed in the preparation of this technical memorandum show that the brook is channelized downstream from Swains Pond and large sand bars have filled in the center of the channel (see inset to the left). An unnamed tributary flows under Route 3 and discharges to Deep Brook just downstream from the sampling station. A quarry is located to the west of Route 3 at the headwaters to this unnamed tributary.

Station BB05- Black Brook, Westford Street crossing, Lowell

Black Brook originates in a golf course north of Route 3 in Lowell. The Middlesex Canal ends as the headwaters to Black Brook. The brook flows in a northwesterly direction under Westford Street and into an unnamed pond. The brook then flows past Hadley Field and into two additional unnamed ponds. From the downstream-most pond Black Brook apparently flows underground for the remaining distance to the Merrimack River. The brook is 1.5 miles long and drains an area of 3.3 square miles. Land use within the drainage area is 52% residential, 17% forest, 11% open land, and 10% industrial. The sampling station was accessed by parking in a commercial lot –"Amy's Hair designs" – on the west side of the Westford Street bridge. Field crews crossed over the bridge and collected samples on the right bank, upstream from the bridge. Substrates in the vicinity of the sampling location consisted of sand, coarse gravel, and boulder. Percent open sky was visually estimated to be between 5 and 40%. Thin film periphyton was observed covering less than 25% of the rocky substrates during the June and July surveys. Loose floc periphyton was observed on the bottom of the pools during the August survey. There were no other reports of periphyton, however, it is important to note that the water clarity in Black Brook was described as moderately turbid to highly turbid/murky throughout the sampling season. The water was light yellow/tan in color. Field crews reported some type of aesthetically objectionable conditions (floating scums, trash, duckweed, pollen/dust blankets with coarse particulate matter, flocculent masses) on every survey. Shoreline erosion was noted on the right bank from adjacent yards. Potential pollution sources identified by field crews included garbage dumping, lawns, and road runoff.

Station PO01- Powwow River, approximately 550 feet downstream/east of Route 150 (approximately 225 feet downstream of Amesbury electrical substation but upstream of discharge pipe directly across from 35 Mill Street), Amesbury
Station pipe at PO01- flowing storm water pipe

The Massachusetts portion of the Powwow River begins as the outlet of Tuxbury Pond at the South Hampton, New Hampshire/Merrimac, Massachusetts border. The river meanders in a generally east direction, crosses back into New Hampshire before returning to Massachusetts. The river is impounded to form Lake Gardner. After spilling over the dam, the river continues to meander through the center of Amesbury, flows under Route 110 and Route 495, and meets the Merrimack River, just east of the Amesbury Wastewater Treatment Plant. The sampling station was accessed by walking through a field across from 35 Mill Street. A storm drain discharges on the right bank. Water quality samples were taken upstream from this discharge. The water was generally clear from turbidity except during August when it was slightly to moderately turbid. The water was light yellow/tan in color. On two surveys (July bacteria and August bacteria) the water smelled musty. Substrates in the sampling reach were boulder and cobble. Thin film periphyton covered 25-50% of the rocky substrates. Percent open sky was visually estimated to be between 40 and 60%. Field crews noted no foams or scums or other objectionable deposits. The left bank of the river is channelized for a short distance by a concrete block retaining wall. Downstream from the sampling station, the river widens and the gradient lessens. An unnamed tributary (sometimes referred to as the Back River) confluences with the Powwow approximately 600 feet downstream from the sampling station. The entire drainage area upstream from Station PO01 is 50.2 square miles. Land use within the 6.5 square miles portion in Massachusetts is 40% forest, 20% residential, and 17% agricultural. Commercial and industrial uses abut the riverbanks for 1000 feet upstream from the sampling station.

Samples were also collected from the pipe for bacterial analysis. Data from the pipe station were censored for the July and August surveys as field crews collected the sample from the pool of water under the pipe, rather than from the actual flow from the pipe. Data from the pipe indicated high concentrations of fecal coliform and *E. coli* bacteria during the first two surveys and the last survey. The Northeast Regional Office (NERO) of MassDEP was notified of the elevated counts.

Station ABR01- Unnamed tributary to Powwow River, approximately 50 feet upstream/northeast of R Street, Amesbury

This unnamed tributary originates as the outlet of Clarks Pond and flows 0.4 miles to the Powwow River. The sampling station was located approximately 400 feet downstream from Clarks Pond. The station was accessed via R Street. The R Street bridge was closed to traffic. Crews walked down a steep bank upstream from the bridge. The samples were collected from the right bank upstream from antiquated storm drains. Substrates in the sampling reach were cobble, boulder, and coarse gravel. Thin film periphyton covered between 25 and 50% of the rocky substrates. Percent open sky was estimated to be 25-60%. The water was odorless. Water color varied from clear to brownish to grayish to light yellow/tan. Water clarity varied from slightly turbid to clear. Field crews observed trash and debris at the station on every sampling trip. No scums were observed. Both banks are very steep with a high potential for erosion. Land use in the stream corridor immediately upstream from the sampling station includes high- to medium-density residential, commercial, and industrial. The drainage area upstream from the sampling station is 7.5 square miles and includes areas in New Hampshire, as well as the drainage area for Station ABR02.

Station ABR02- Back River, Clinton Street crossing, Amesbury

The Back River originates in a wetland in South Hampton, New Hampshire. The Massachusetts portion of the river is 2.7 miles long. The river flows around Beech Hill in Amesbury and then flows in a generally southwestern direction into Clark's Pond. The river receives flow from Lucy Brook and two unnamed tributaries. Station ABR02 was located approximately 2400 feet upstream from Clark's Pond at Clinton Street. The bridge abutments are armored with riprap. Field crews walked down the riprap upstream from the bridge on the left bank. Samples were taken close to the left bank or from center stream, depending upon water levels. The water was generally brownish to light yellow/tan in color and moderately turbid. The water generally was free from odors. No scums or other objectionable deposits were observed. Substrates in the sampling reach included mud, sand, silt, boulder, cobble, and coarse gravel. Thin film, filamentous, and loose floc periphyton were observed on various occasions throughout the sampling period. Vegetation in the riparian zone included understory shrubs that provided some canopy cover over the stream (percent open sky was estimated between 50 and 100%). The drainage area upstream from Station ABR02 is 6.4 square miles and includes area in New Hampshire. Land use within the Massachusetts portion of the drainage area is 42% forest, 27% agriculture, and 22% residential.

Station EA01- East Meadow River, Thompson Road crossing, Haverhill

The East Meadow River originates as the outlet from Neal Pond on the Merrimac/Haverhill corporate boundary. The river flows in a southeasterly direction, passing under routes 110 and 495, and under Thompson Road before entering Millvale Reservoir. A large portion of the riparian zone is contiguous wetland. The sampling station (EA01) was located in the Meadow Brook Conservation Area. Thompson Road was really a dirt path through the conservation area and was not accessible by car. Field crews parked at the gated entrance to the conservation area and walked approximately 0.1 miles to the bridge. Samples were collected upstream from the bridge from the right bank. Beaver were active in the vicinity of the sampling station; field crews observed black corrugated pipes from a beaver exclusion device and a dam under the Thompson Road bridge. Percent open sky was estimated to be between 50 and 90%. It was difficult to determine the substrate composition as the water was deep and dark tannin stained in color. The water was also slightly turbid. No objectionable conditions (i.e., scums, trash, odors) were observed by sampling personnel. The upstream drainage area is approximately seven square miles. Land use in the drainage area is 54% forest, 18% residential, and 11% agricultural.

Station AR01- Unnamed Tributary, unnamed tributary to Johnson Creek, locally known as Argilla Brook, west off Baldwin Terrace approximately 1400 feet upstream/east of Main Street crossing, Groveland

The headwaters of this unnamed tributary, locally known as Argilla Brook, begin in a wetland in Crane Pond Wildlife Management Area in Groveland. The brook flows north and east for 3.5 miles before it reaches Johnson Brook. The sampling station was located off Baldwin Terrace. Field crews walked down

a path and followed the railroad tracks for about 0.03 miles to an all-terrain-vehicle (ATV) trail. They then followed the trail to an old/makeshift footbridge over the brook. Samples were collected upstream from the "bridge" in the center of the stream. The water in this unnamed brook was light yellow/tan in color and free from turbidity. Substrates were cobble, bedrock, and coarse gravel. Thin film and filamentous periphyton covered <50% of the cobble substrates during the June survey. Loose floc was observed on the cobble substrates during the July survey. Only thin film periphyton was seen on the cobble during the August survey. Percent open sky was estimated to range from 5 to 15%. Trash, debris, floating scums, and water odors were not found in this stream. Shoreline erosion was evident throughout the sampling reach due in large part to the ATVs crossing the brook. The drainage area upstream from the sampling point is 1.9 square miles. Land use within the drainage area is 55% forest, 30% residential, and 6% open land.

Station JC03- Johnson Creek, Center Street crossing, Groveland

According to the Massachusetts Stream And Rivers Inventory System (SARIS) Johnson Creek originates as the outlet to Johnson Pond. [USGS quadrangles indicate that the creek originates in a wetland south of Salem Street and West of Route 97.] The creek flows due north from Johnson Pond for 1.3 miles to the Merrimack River. The sampling station was located downstream from Center Street. Percent open sky at the sampling station was estimated to be between 50 and 100%. Approximately ten feet downstream from the road, the creek is completely shaded by overhanging vegetation. Cobble, coarse gravel, and sand comprised the substrates in the sampling reach. Periphyton (thin film and filamentous) was observed to cover <50% of the cobble substrates and was concentrated in the areas where sunlight penetrated the canopy (e.g., close to the road). The water was clear and colorless and was not malodorous. This little creek was aesthetically pleasing with no objectionable deposits or floating scums. The drainage area of Johnson Creek is 9.5 square miles. Land use within the drainage area is 48% forest, 21% residential, and 10% agricultural. Land use within the buffer zone upstream from the sampling station is open land, residential, and forest.

Station FI01- Fish Brook, River Road crossing, Andover

The headwaters of Fish Brook lie in a wetland north of Route 133 in Andover. The brook flows in a northeast direction, passing under interstate routes 93 and 495 on its way to the Merrimack River. For much of its 4.1-mile length, Fish Brook is bordered by wetlands. The Massachusetts Highway Department maintains a salt storage shed for treating the highways in winter months at the Route 495/Route 93 cloverleaf interchange. The Fish Brook Initiative task force conducted monitoring in the brook for 30 months between 2004 and 2006 and found elevated chloride levels. The task force solicited bids to conduct a salt balance study and hopes to positively identify the source(s) (Wacker 2006). DWM conducted sampling in Fish Brook downstream from River Road in Andover. Field crews parked on Launching Road and then walked back to the bridge. Samples were collected from the left bank close to the bridge abutment. Substrates at the sampling location consisted of cobble and coarse gravel. Percent open sky was estimated to be between 50 and 80%. The water was slightly turbid and light yellow/tan in color. The water exhibited no odor, nor were there scums floating on the surface. Trash and debris was absent from this sampling reach. Runoff from River Road is eroding the left bank at the bridge. The drainage area upstream from the sampling station is 5.9 square miles. Land use within the drainage area is 46% forest, 27% residential, 6% open land, and 6% wetlands.

Station TB02- Trull Brook, approximately 230 feet downstream/north of River Road, Tewskbury

Trull Brook also originates in a wetland. This wetland is located north of Route 495 and borders Great Swamp in Tewksbury. Trull Brook flows north for approximately two miles to meet the Merrimack River. The drainage area upstream from the sampling station is 4.4 square miles. Land use within the drainage area is 35% residential, 29% forest, and 11% open land. Station TB02 was located near the 10^{th} fairway of the Trull Brook Golf Course. The station was upstream from a small dam and downstream from a chain link fence that marks the property boundary of the golf course. A section of pipe leads from the impoundment to a manmade pond that the golf course uses for irrigation purposes. The pool the samples were collected from was quite deep, averaging about four feet, and as such, bacteria samples were often collected from the left bank. *In situ* measurements were obtained by deploying a multiprobe unit for

approximately 48 hours in the pool about one foot off of the bottom. The purpose of this effort was to gather data during worst-case conditions (i.e., pre-dawn) when the golf course was closed and access to the station was prohibited. The water in Trull Brook varied in clarity from clear to highly turbid, but was generally slightly turbid. The odorless water was light yellow/tan in color. Substrates in the brook consisted of boulder and cobble, however due to the depth of the pool, it was difficult to ascertain if additional substrate types were present. The depth of the water also impeded observations of periphyton, although field crews did find filamentous periphyton during the July survey. Percent open sky estimates ranged between 40 and 80%. Aesthetically objectionable conditions were rarely observed in the brook. The irrigation pond frequently was covered with duckweed and algal mats, which occasionally made their way to the brook via the pipe. Geese were ever-present and their droppings were prevalent in the vicinity of the sampling station.

Station PE01- Peppermint Brook, Lakeview Avenue crossing, Dracut

The headwaters of Peppermint Brook can be found in a small, unnamed pond west of Route 38 near the Pelham, New Hampshire/Dracut, Massachusetts border. The brook flows south through an impoundment, through a wetland, and into the center of Dracut. It continues to flow south, passing under Route 113, before turning west and draining into the main stem Merrimack River. The sampling station was located in an urbanized area of Dracut. Field crews parked their vehicles in a shopping plaza, crossed over the Lakeview Avenue bridge and accessed the brook upstream from the bridge on river right. Crews had to scale down a steep, eroding bank to gain access to the water. Across from the sampling station was another steep bank that was fenced off from an adjacent yard and the shopping plaza parking area. However, this fence did not prevent illegal dumping- trash, plastic bags, a metal bed frame, tires, and wooden boards, all found their way into the center of the stream. Surprisingly, the water was not malodorous. Water clarity varied from clear to moderately turbid. This turbidity was most often documented during rain events. Substrates in Peppermint Brook upstream from Lakeview Avenue consisted of cobble, sand, and coarse gravel. Film periphyton was observed covering <50% of the cobble substrates. Percent open sky varied from 20 to 40%. Storm drains were located in the middle of the Lakeview Avenue bridge and were observed to contain stagnant standing water during the June survey. A smell of natural gas always permeated the air at the bridge. The brook was carried under Lakeview Avenue through two round, corrugated culverts. The drainage area upstream from the sampling station is 1.7 square miles. Land use within the drainage area is 41% residential, 31% forest, and 7% agricultural while in the buffer zone immediately upstream from the sampling station land use is mostly high-density residential.

Station TRB02- Trout Brook, Kenwood Road crossing, Dracut

Trout Brook begins in Dracut to the west of Jones Avenue and east of the power lines. The brook flows in a southwesterly direction for 2.6 miles then empties into Richardson Brook. The sampling station was located upstream from Kenwood Road in Dracut. Samples were collected from center stream. The water was light yellow/tan in color and free from turbidity and odors. Substrates in the sampling reach were composed of boulder, cobble, and sand. Estimates of percent open sky ranged between 5 and 10%. No objectionable scums, trash, debris, or deposits were observed. The drainage area upstream from Station TRB02 is 1.2 square miles. Land use within the drainage area is 46% forest, 26% agriculture, and 15% open land.

Station RBR01- Richardson Brook, Methuen Street crossing, Dracut

Richardson Brook originates at the outlet of a small, unnamed pond, just south of Route 113 (Broadway Street) in Dracut. It then flows in a southeasterly direction into another small, unnamed pond. Trout Brook flows are added to Richardson Brook in this pond. The brook then flows out of the pond and into the Merrimack River. The total length of Richardson Brook is 2.3 miles. Station RBR01 was located upstream from the Methuen Street bridge. The brook flows under the road through a concrete box culvert. During the course of the surveys, the Town of Dracut installed a sewer line under Richardson Brook. They accomplished this by installing a coffer dam and rerouting the water. They had installed similar sewer lines under other brooks that go through town (e.g., Peppermint and Trout brooks). The sampling station was located downstream from this activity. The brook was moderately filled (50%) with aquatic

macrophytes including *Typha sp, Sparganium sp., Polygonum sp., Pontederia sp.,* and *Peltandra sp.* Additionally, thin film and filamentous periphyton were observed growing epiphytically on the macrophytes and on boulder/cobble substrates. Percent open sky was visually estimated to be 100%. The water was clear to light yellow/tan in color. On two occasions (August and September bacteria surveys) the water was slightly turbid. There were no scums, algal mats, trash, or other debris encountered during the sampling events. The drainage area upstream from Station RBR02 (including all of the Trout Brook drainage area) is 4.2 square miles. Land use within the drainage area is 45% forest, 21% residential, 18% agriculture, and 12% open land.

Station BA01- Bartlett Brook, Route 113 (North Lowell Street) crossing, Methuen

Bartlett Brook begins at the New Hampshire/Massachusetts border, just north of Island Pond Road in Dracut. The brook flows generally in a westerly direction and receives inputs from six unnamed tributaries. The brook is impounded between Route 113 and Route 110 to form Mill Pond. Mill Pond empties into the Merrimack River. Upstream from Route 113, Bartlett Brook is braided. The braid comes together just under the Route 113 bridge. Samples were collected from center stream, 20 feet downstream from the bridge abutments. Sparse areas (two individual plants) of the aquatic macrophyte *Pontederia cordata* were observed growing near the right bank. Substrates in the sampling reach included boulder, cobble, coarse gravel, and sand. During the August bacteria survey, silt covered the substrates, however, it was washed away by the September survey. Percent open sky estimates varied widely between field crews and ranged from 5 to 60%. There were no aesthetically objectionable conditions observed within the brook. Yard waste and litter covered the path leading to the brook, close to the road. The drainage area upstream from Station BA01 is 6.7square miles. Land use within the drainage area is 44% forest, 30% residential, and 9% agriculture.

Station BMB01A- Bare Meadow Brook, Renfrew Street crossing, Methuen

Bare Meadow Brook begins north of Bare Meadow Street in Methuen. The brook flows in a northwest direction for 0.8 miles. After passing under Oak Street, the brook turns and flows due east for approximately 0.5 miles. After it flows under Route 213, the brook parallels Route 495 and flows in a northeasterly direction for about 1.8 miles before confluencing with the Merrimack River. Station BMB01A was located roughly 0.5 miles upstream from the confluence. Field crews accessed the station by parking before the Renfrew Road bridge then walking downstream about 30 feet to an area flagged by the survey coordinator on the right bank. Beaver were active at this site and numerous trees had been felled. Substrates at the sampling location were cobble, sand, and coarse gravel. Percent open sky was visually estimated to be between 50 and 80%. Thin film periphyton covered less than 25% of the cobble substrates. The water was observed to be slightly turbid and grayish in color during the July bacteria survey. For the remainder of the surveys water color varied from clear to light yellow/tan and visual instream turbidity varied from none (i.e., clear) to slightly turbid. No floating scums, trash, debris, or other objectionable conditions were found in Bare Meadow Brook. Both the left and right banks were undercut. During the June bacteria survey, the sampling crew encountered a sea lamprey. The drainage area upstream from Station BMB01A is seven square miles. Land use within the drainage area is 39% forest, 36% residential, and 9% open land.

Station CR01- Creek Brook, West Lowell Avenue crossing, Haverhill

Creek Brook flows from the outlet of Crystal Lake to the Merrimack River, a distance of 2.3 miles. Station CR01 was located upstream from West Lowell Avenue in Haverhill. The station was accessed through private property at 574 West Lowell Avenue. Field crews walked down the steep right embankment and collected samples from the center of the stream, about 10 feet upstream from the bridge. Substrates in Creek Brook at the sampling reach consisted of cobble, boulder, and coarse gravel. The water was generally clear and colorless. However, during the September bacteria survey the water was brownish in color and highly turbid/murky. Creek Brook was aesthetically pleasing with no scums, trash, debris or other deposits. The drainage area upstream from the sampling station is 5.6 square miles. Land use within the drainage area is 39% forest, 27% residential, 12% open land, and 10% agriculture.

Station LR01- Little River, Winter Street crossing, Haverhill

The Little River commences at the Haverhill, Massachusetts/New Hampshire state line and is formed by the confluence of three streams. The Little River flows in a southeasterly direction, receiving flow from Fishin Brook and two unnamed tributaries, before passing under Route 495. The brook then receives flow from Snows Brook. The river flows directly through downtown Haverhill. Just upstream from Winter Street the Little River is dammed for manufacturing uses. The sampling station was located approximately 30 feet downstream from the road (~150 feet downstream from the dam) and was closer to the right bank than center stream. The station was accessed via walking down an eroded path leading down from the road/adjacent parking lot. Downstream from the sampling station, the stream disappears, presumably it is culverted underground and discharges to the Merrimack River. The entire drainage area upstream from the sampling location, including a large area in New Hampshire, is 28.3 square miles. The Massachusetts portion is 7.8 square miles. Land use within the Massachuestts portion is 37% forest, 35% residential, 9% open land, and 7% agriculture. Interestingly, the buffer zones upstream and downstream from the sampling station are commercial, industrial, and transportation uses.

This stream suffered the fate of a typical urban stream. The left bank was channelized with concrete blocks. The water was light yellow/tan to grayish to brownish in color. The river was usually slightly turbid; during the July predawn, and August and September bacteria surveys the river was moderately turbid. Often odors were noted including untreated sewage, chlorine, musty basement, and a chemical smell similar to creosote, but it was difficult to discern whether the water or the air had the odor due to the re-aeration over the dam. Two sparse stands of *Pontederia* were noted near the left shoreline. Substrates in the sampling reach were boulder, cobble, coarse gravel, and sand. Brown foam, presumed to be natural, was observed on most of the surveys. An oil sheen was noted during the August bacteria survey. It appeared that the sheen originated from the sediments. The sheen appeared and then moved downstream, but did not cover the entire width of the river and mostly hugged the right bank. Garbage including shopping carts, a scooter, plastic bags, tires, and bicycles blanketed the streambed. A large (3-4 foot) concrete outfall pipe was noted to be flowing downstream from the sampling station on the right bank. Another storm drain coming from the carwash on the left bank was not seen discharging.

Water Quality Data

All MassDEP DWM water quality data are managed and maintained in the *Water Quality Data Access Database.* Tables 5 – 8 below are 2004 data exports for the Merrimack River Watershed. The procedures used to accept, accept with qualification or censor data are based on the DWM SOP for data validation and usability (MassDEP 2005), and are in addition to separate quality assurance activities and laboratory validation steps undertaken by WES. Data validation procedures for 2004 data are described further in Appendix 1. Data qualifiers are listed at the bottom of each page and in Appendix 2.

Table 5. 2004 MassDEP DWM Merrimack River Watershed *In situ* Multi-probe Data.

Unnamed Tributary
Unique_ID: W1209 Station: AR01, Mile Point: 0.473
Description: [unnamed tributary to Johnson Creek, locally known as Argilla Brook, west off Baldwin Terrace approximately 1400 feet upstream/east of Main Street crossing, Groveland]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0075	04:03	0.4	21.8	7.3	369	240	6.9	79
08/17/04	84-0131	04:49	0.1 i	17.3	7.3 c	302	193	8.1 u	85 u
09/08/04	84-0187	04:04	0.2	18.4	7.4 c	366	234	7.6 u	81 u

Unnamed Tributary
Unique_ID: W1196 Station: ABR01, Mile Point: 0.345
Description: [unnamed tributary to Powwow River, approximately 50 feet upstream/northeast of R Street, Amesbury]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0072	02:13	0.5	22.8	7.5	223	145	7.9	92
08/17/04	84-0128	02:27	0.1 i	19.0	7.3 c	211	135	6.9	75
09/08/04	84-0184	02:18	0.2	20.5	7.5 c	247	158	7.8 u	87 u

POWWOW RIVER (Saris: 8450300)
Unique_ID: W1198 Station: PO01, Mile Point: 1.553
Description: [approximately 550 feet downstream/east of Route 150 (approximately 225 feet downstream of Amesbury electrical substation but upstream of discharge pipe directly across from 35 Mill Street), Amesbury]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0071	01:51	0.6	22.9	7.4	175	114	8.4	98
08/17/04	84-0127	01:49	0.9	22.4	7.7 c	176	113	8.3	96
09/08/04	84-0183	01:57	0.2	21.5	7.6 c	163	104	8.5	97

BACK RIVER (Saris: 8450325)
Unique_ID: W1212 Station: ABR02, Mile Point: 0.442
Description: [Clinton Street crossing, Amesbury]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0073(Pooled)	02:35	0.9 r	20.2 r	7.2 r	192 r	125 r	6.2 ru	69 ru
08/17/04	84-0129	02:56	0.4	18.5	7.3 c	191	122	7.6 u	82 u
09/08/04	84-0185	02:37	0.3	18.3	7.3 c	203	130	6.8 u	72 u

" i " = inaccurate readings from Multi-probe <u>likely</u>; may be due to significant pre-survey calibration problems, post-survey checks outside typical acceptance ranges for the low ionic and deionized water checks, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses. Where documentation on unit pre-calibration is lacking, but SOPs at the time of sampling dictated pre-calibration prior to use, then data are considered <u>potentially</u> inaccurate.

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

" c " = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for <u>conductivity</u> (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or <u>turbidity</u> (>10, 20 or 40 NTU). It can also be used for <u>TDS and Salinity</u> calculations based on qualified ("c") conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading).

" r " = data not representative of actual field conditions.

EAST MEADOW RIVER (Saris: 8450525)
Unique_ID: W1213 Station: EA01, Mile Point: 0.112
Description: [Thompson Road crossing, Haverhill]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0074	03:30	1.1	20.7	6.6	314	204	1.8	20
08/17/04	84-0130	03:59	0.6	18.7	6.6	273	175	1.7	18
09/08/04	84-0186	03:33	0.4	17.9 u	6.4	362	232	0.2 u	2 u

JOHNSON CREEK (Saris: 8450550)
Unique_ID: W1197 Station: JC03, Mile Point: 0.957
Description: [Center Street crossing, Groveland]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0076	04:25	0.4	15.5	7.2 u	292	190	8.9	89
08/17/04	84-0132	05:18	0.2	17.1	7.3 c	238	152	8.1 u	85 u
09/08/04	84-0188	04:25	0.3	17.3	7.3 c	263	168	8.1	85

LITTLE RIVER (Saris: 8450575)
Unique_ID: W1210 Station: LR01, Mile Point: 0.441
Description: [downstream/south at Winter Street crossing, Haverhill]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0070	05:13	0.3	21.3	7.1 c	424	271	7.8	90
08/17/04	84-0126	04:21	0.2	19.5	7.1	294	191	8.7	95
09/08/04	84-0182	04:37	0.1 i	20.0	7.2	475	309	8.5	93

CREEK BROOK (Saris: 8450700)
Unique_ID: W1203 Station: CR01, Mile Point: 0.154
Description: [West Lowell Avenue crossing, Haverhill]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0069	04:52	0.2	19.6	7.3 c	522	334	7.8	87
08/17/04	84-0125	03:57	0.2	18.3	7.1	400	260	8.3	89
09/08/04	84-0181	04:12	0.2	17.7	7.2	624	406	8.7	92

BARE MEADOW BROOK (Saris: 8450750)
Unique_ID: W1195 Station: BMB01A, Mile Point: 0.596
Description: [Renfrew Street crossing, Methuen]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0068	04:33	0.2	23.5	7.1 c	739 c	473 c	5.2 u	62 u
08/17/04	84-0124	03:36	0.2	18.6	6.9	370	241	6.5 u	70 u
09/08/04	84-0180	03:50	0.2	20.4	7.0	472	307	6.9	77

BARTLETT BROOK (Saris: 8450875)
Unique_ID: W1202 Station: BA01, Mile Point: 0.009
Description: [Route 113 (North Lowell Street) crossing, Methuen]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0067	03:55	0.3	20.9	6.9 c	263	168	6.8	78
08/17/04	84-0122	03:01	0.2 m	18.5 m	6.9 m	319 m	208 m	7.7 m	82 m
09/08/04	84-0178	03:16	0.1 i	18.5	7.1	383	249	7.9	85

" i " = inaccurate readings from Multi-probe likely; may be due to significant pre-survey calibration problems, post-survey checks outside typical acceptance ranges for the low ionic and deionized water checks, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses. Where documentation on unit pre-calibration is lacking, but SOPs at the time of sampling dictated pre-calibration prior to use, then data are considered potentially inaccurate.

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

" c " = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for conductivity (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or turbidity (>10, 20 or 40 NTU). It can also be used for TDS and Salinity calculations based on qualified ("c") conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading).

" m " = method not followed; one or more protocols contained in the DWM Multi-probe SOP not followed, i.e. operator error (eg. less than 3 readings per station (rivers) or per depth (lakes), or instrument failure not allowing method to be implemented.

FISH BROOK (Saris: 8450950)
Unique_ID: W1206 Station: FI01, Mile Point: 0.641
Description: [River Road crossing, Andover]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0063	01:43	0.3	22.7	6.6	929 c	595 c	1.9 u	23 u
08/17/04	84-0118	01:13	0.3 m	19.5 m	6.3 m	822 cm	534 cm	1.2 mu	13 mu
09/08/04	84-0174	01:24	0.3	19.0	6.4	573	372	1.3	14

TRULL BROOK (Saris: 8451000)
Unique_ID: W1194 Station: TB02, Mile Point: 0.548
Description: [approximately 230 feet downstream/north of River Road, Tewksbury]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
09/09/04	84-0198	09:37	0.6 m	18.0 m	6.5 mu	242 m	158 m	8.1 mu	85 mu

RICHARDSON BROOK (Saris: 8451025)
Unique_ID: W1192 Station: RBR01, Mile Point: 0.351
Description: [Methuen Street crossing, Dracut]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0086(Pooled)	03:26	0.3 r	22.6 r	7.1 cr	361 r	231 r	6.0 r	71 r
08/17/04	84-0123	02:31	0.2	19.4	6.8	296	192	5.6	61
09/08/04	84-0179	02:46	0.1 i	19.1	7.0	392	255	7.6	82

TROUT BROOK (Saris: 8451050)
Unique_ID: W1193 Station: TRB02, Mile Point: 1.058
Description: [Kenwood Road crossing, Dracut]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0066	03:04	0.1 i	17.2	7.0 c	286	183	7.8	82
08/17/04	84-0121	02:12	0.2	17.2	6.8	365	238	7.7	80
09/08/04	84-0177	02:24	0.1 i	17.0	6.9 u	287	187	7.9 u	82 u

PEPPERMINT BROOK (Saris: 8451100)
Unique_ID: W1211 Station: PE01, Mile Point: 0.178
Description: [Lakeview Avenue crossing, Dracut]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0065	02:28	0.1 i	21.2	7.1 c	751 c	481 c	4.1	48
08/17/04	84-0120	01:45	0.2	19.0	7.2	644	418	6.5	70
09/08/04	84-0176	01:57	0.1 i	19.5	7.1 u	764 c	497 c	6.1	67

BLACK BROOK (Saris: 8451175)
Unique_ID: W1191 Station: BB05, Mile Point: 0.977
Description: [Westford Street crossing, Lowell]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0085	05:59	0.4	19.7	6.7	1,003 c	652 c	5.7	63
08/17/04	84-0141	05:42	0.3	17.3	6.7	878 c	571 c	6.5	68
09/08/04	84-0197	05:01	0.2	19.1	6.7	950 c	617 c	6.0	65

" i " = inaccurate readings from Multi-probe likely; may be due to significant pre-survey calibration problems, post-survey checks outside typical acceptance ranges for the low ionic and deionized water checks, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses. Where documentation on unit pre-calibration is lacking, but SOPs at the time of sampling dictated pre-calibration prior to use, then data are considered potentially inaccurate.

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

" c " = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for conductivity (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or turbidity (>10, 20 or 40 NTU). It can also be used for TDS and Salinity calculations based on qualified ("c") conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading).

" r " = data not representative of actual field conditions.

" m " = method not followed; one or more protocols contained in the DWM Multi-probe SOP not followed, i.e. operator error (eg. less than 3 readings per station (rivers) or per depth (lakes), or instrument failure not allowing method to be implemented.

TADMUCK BROOK (Saris: 8451325)
Unique_ID: W1201 Station: TA01, Mile Point: 0.316
Description: [Lowell Road crossing, Westford]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0083	05:05	0.2	21.0	7.1 u	625	406	8.0	89
08/17/04	84-0139	04:47	0.3	17.8	7.0	573	372	9.2	97
09/08/04	84-0195	04:06	0.2	17.5	6.8	448	291	8.3	87

BENNETTS BROOK (Saris: 8451525)
Unique_ID: W1200 Station: BE01, Mile Point: 0.997
Description: [Willow Road crossing, Ayer]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0077	01:48	0.2	21.2	6.9	391	254	6.5	73
08/17/04	84-0133	01:16	0.2	17.9	6.9	323	210	8.2	87
09/08/04	84-0189	01:14	0.2	18.4	6.8	316	205	7.4	79

DEEP BROOK (Saris: 8451550)
Unique_ID: W1190 Station: DBR05, Mile Point: 1.747
Description: [Ledge Road crossing, Chelmsford]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0084	05:33	0.5	19.0	6.7	522	340	7.2	78
08/17/04	84-0140	05:16	0.5	16.9	6.7	513	333	7.9	82
09/08/04	84-0196	04:34	0.4	17.8	6.7	607	394	7.8	82

LAWRENCE BROOK (Saris: 8451600)
Unique_ID: W1189 Station: LWB02, Mile Point: 0.235
Description: [approximately 130 feet downstream/south of Sherburne Avenue, Tyngsborough]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0081	04:07	0.3	24.7	7.0	518	336	6.8	82
08/17/04	84-0137	03:57	0.3	20.6	6.9	495	322	7.7	86
09/08/04	84-0193	03:16	0.2	19.9	6.7	463	301	6.2	68

BRIDGE MEADOW BROOK (Saris: 8451625)
Unique_ID: W1207 Station: BR01, Mile Point: 1.524
Description: [downstream/northeast of the unnamed school access road crossing north off Westford Avenue between the localities of Hayward Corner and Swan Corner, Tyngsborough]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0082	04:36	0.2	21.8	6.4	350	228	3.9	44
08/17/04	84-0138	04:21	0.2	20.1	6.5	345	224	5.2	58
09/08/04	84-0194	03:40	0.2	19.4	6.2	333	216	3.1	34

SALMON BROOK (Saris: 8451675)
Unique_ID: W1199 Station: SA01, Mile Point: -0.525
Description: [Ridge Road crossing, Nashua, New Hampshire]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0080	03:35	0.5	21.7	6.8	236	153	5.6	64
08/17/04	84-0136	03:29	0.6	19.3	6.8	248	161	5.6	61
09/08/04	84-0192	02:45	0.4	19.8	6.7	257	167	4.6	51

JOINT GRASS BROOK (Saris: 8451700)
Unique_ID: W1208 Station: JG01, Mile Point: 1.058
Description: [downstream/east of Main Street crossing (below confluence of unnamed tributary), Dunstable]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0079	03:03	0.2	21.2	6.8	232	151	5.6	63
08/17/04	84-0135	02:58	0.2	18.4	6.9	213 u	138 u	6.5	69
09/08/04	84-0191	02:20	0.2	19.5	6.8	144	94.0	5.1	56

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

MARTINS POND BROOK (Saris: 8451825)
Unique_ID: W1188 Station: MRB01, Mile Point: 0.375
Description: [approximately 180 feet downstream from washed out culvert crossing of Loomis Lane, Groton]

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25℃	TDS	DO	SAT
		(24hr)	(m)	(℃)	(SU)	(uS/cm)	(mg/L)	(mg/L)	(%)
07/07/04	84-0078	02:23	0.3	21.9 u	7.0	290	189	5.2	59
08/17/04	84-0134	01:59	0.3	18.1	6.9	261	170	5.9	62
09/08/04	84-0190	01:43	0.2	18.1	6.9	277	180	5.9	62

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly variable water quality conditions, etc.

Table 6. 2004 MassDEP DWM Merrimack River Watershed Bacteria Data.

Unnamed Tributary
Unique_ID: W1209 Station: AR01, Mile Point: 0.473
Description: [unnamed tributary to Johnson Creek, locally known as Argilla Brook, west off Baldwin Terrace approximately 1400 feet upstream/east of Main Street crossing, Groveland]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0016	--	11:30	45 e	71 e
6/23/2004	84-0047	--	11:05	20 e	33 e
7/8/2004	84-0102	--	11:48	20	20
8/18/2004	84-0158	--	11:15	110 e	140 e
9/9/2004	84-0215	--	11:15	5600 d	3600

Unnamed Tributary
Unique_ID: W1196 Station: ABR01, Mile Point: 0.345
Description: [unnamed tributary to Powwow River, approximately 50 feet upstream/northeast of R Street, Amesbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0013	--	09:05	650	440
6/23/2004	84-0044	--	09:15	320	190
7/8/2004	84-0099	--	**	90 p	84 p
8/18/2004	84-0155	--	09:35	130	84
9/9/2004	84-0212	--	09:50	3800 dej	13000 e

POWWOW RIVER (Saris: 8450300)
Unique_ID: W1198 Station: PO01, Mile Point: 1.553
Description: [approximately 550 feet downstream/east of Route 150 (approximately 225 feet downstream of Amesbury electrical substation but upstream of discharge pipe directly across from 35 Mill Street), Amesbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0012	--	08:45	110 e	150 e
6/23/2004	84-0043	--	09:00	250	200
7/8/2004	84-0098	--	**	420 e	550 e
8/18/2004	84-0153	--	09:15	800 e	850 e
9/9/2004	84-0210	--	09:30	3400 d	3000

Pipe/Discharge to POWWOW RIVER (Saris: 8450300)
Unique_ID: W1204 Station: pipe@PO01, Mile Point: 0.001
Description: [on right bank directly across from 35 Mill Street (approximately 6 feet downstream of Station PO01), Amesbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0020	--	08:50	>40000	>40000
6/23/2004	84-0051	--	09:05	49000	45000
7/8/2004	84-0106	--	**	## r	## r
8/18/2004	84-0154	--	09:20	## r	## r
9/9/2004	84-0211	--	09:35	22000 d	7400

" -- " = No data (i.e., data not taken/not required)
" ** " = Missing data (i.e., data that should have been reported)
" ## " = Censored data (i.e., data that has been discarded for some reason)
" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.
" p " = Samples not preserved per SOP or analytical method requirements
" j " = 'estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.
" r " = Samples collected may not be representative of actual field conditions, including the possibility of "outlier" data and flow-limited conditions (e.g., pooled)

BACK RIVER (Saris: 8450325)
Unique_ID: W1212 Station: ABR02, Mile Point: 0.442
Description: [Clinton Street crossing, Amesbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0014	--	10:45	410	390
6/23/2004	84-0045	--	09:30	250 e	290 e
7/7/2004	84-0073(Pooled)	--	02:40	--	--
7/8/2004	84-0100	--	10:05	350 e	480 e
8/18/2004	84-0156	--	09:53	230 e	350 e
9/9/2004	84-0213	--	10:00	6800 dej	25000 e

EAST MEADOW RIVER (Saris: 8450525)
Unique_ID: W1213 Station: EA01, Mile Point: 0.112
Description: [Thompson Road crossing, Haverhill]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0015	--	10:10	65 e	84 e
6/23/2004	84-0046	--	10:30	150	130
7/8/2004	84-0101	--	11:20	110 e	150 e
8/18/2004	84-0157	--	10:30	32 e	77 e
9/9/2004	84-0214	--	10:45	190 de	270 e

JOHNSON CREEK (Saris: 8450550)
Unique_ID: W1197 Station: JC03, Mile Point: 0.957
Description: [Center Street crossing, Groveland]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0017	84-0018	11:55	77	65
6/2/2004	84-0018	84-0017	12:00	90 e	97 e
6/23/2004	84-0048	84-0049	11:20	32 e	110 e
6/23/2004	84-0049	84-0048	11:25	65	52
7/8/2004	84-0103	84-0104	12:05	1200 dep	1800 ep
7/8/2004	84-0104	84-0103	12:05	600 dep	1000 ep
8/18/2004	84-0159	84-0160	11:35	93 e	100 e
8/18/2004	84-0160	84-0159	11:35	71 e	110 e
9/9/2004	84-0216	84-0217	11:25	3400 d	2200
9/9/2004	84-0217	84-0216	11:30	1000 de	1800 e

LITTLE RIVER (Saris: 8450575)
Unique_ID: W1210 Station: LR01, Mile Point: 0.441
Description: [downstream/south at Winter Street crossing, Haverhill]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0011	--	11:30	250 e	310 e
6/23/2004	84-0042	--	11:20	3800	160
7/8/2004	84-0097	--	11:53	270	270
8/18/2004	84-0150	84-0151	11:20	330	200
8/18/2004	84-0151	84-0150	11:20	240	210
9/9/2004	84-0207	84-0208	11:35	4000 de	5400 e
9/9/2004	84-0208	84-0207	11:35	9600 d	6600

" -- " = No data (i.e., data not taken/not required)
" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.
" p " = Samples not preserved per SOP or analytical method requirements
" j " = 'estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.

CREEK BROOK (Saris: 8450700)
Unique_ID: W1203 Station: CR01, Mile Point: 0.154
Description: [West Lowell Avenue crossing, Haverhill]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0010	--	11:15	160	130
6/23/2004	84-0041	--	11:05	200 e	270 e
7/8/2004	84-0096	--	11:35	230	210
8/18/2004	84-0149	--	11:05	45	45
9/9/2004	84-0206	--	11:22	13000 d	12000

BARE MEADOW BROOK (Saris: 8450750)
Unique_ID: W1195 Station: BMB01A, Mile Point: 0.596
Description: [Renfrew Street crossing, Methuen]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0009	--	11:00	210	120
6/23/2004	84-0040	--	10:55	210	190
7/8/2004	84-0095	--	11:25	270	250
8/18/2004	84-0148	--	10:55	130	100
9/9/2004	84-0205	--	11:12	9800 d	6200

BARTLETT BROOK (Saris: 8450875)
Unique_ID: W1202 Station: BA01, Mile Point: 0.009
Description: [Route 113 (North Lowell Street) crossing, Methuen]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0008	--	10:25	200	150
6/23/2004	84-0039	--	10:22	880 e	1000 e
7/8/2004	84-0094	--	11:00	150	140
8/18/2004	84-0147	--	10:28	170 e	230 e
9/9/2004	84-0203	--	10:48	800 de	1000 e

FISH BROOK (Saris: 8450950)
Unique_ID: W1206 Station: FI01, Mile Point: 0.641
Description: [River Road crossing, Andover]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0001	--	08:35	250	200
6/23/2004	84-0032	--	08:37	150	97
7/8/2004	84-0087	--	08:45	52 e	58 e
8/18/2004	84-0142	--	08:41	270	270
9/9/2004	84-0199	--	09:15	190 de	370 e

TRULL BROOK (Saris: 8451000)
Unique_ID: W1194 Station: TB02, Mile Point: 0.548
Description: [approximately 230 feet downstream/north of River Road, Tewksbury]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0002	--	08:55	200	150
6/23/2004	84-0033	--	09:03	710	540
7/8/2004	84-0088	--	09:20	480	450
8/18/2004	84-0143	--	09:05	400	320
9/9/2004	84-0200	--	09:35	21000 d	19000

" -- " = No data (i.e., data not taken/not required)
" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.

RICHARDSON BROOK (Saris: 8451025)
Unique_ID: W1192 Station: RBR01, Mile Point: 0.351
Description: [Methuen Street crossing, Dracut]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0007	--	10:00	71 e	97 e
6/23/2004	84-0038	--	10:00	40	27
7/7/2004	84-0086(Pooled)	--	03:30	--	--
7/8/2004	84-0093	--	10:40	400	200
8/18/2004	84-0146	--	10:08	52	32
9/9/2004	84-0204	--	10:32	1800 dej	6600 e

TROUT BROOK (Saris: 8451050)
Unique_ID: W1193 Station: TRB02, Mile Point: 1.058
Description: [Kenwood Road crossing, Dracut]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0006	--	09:45	58 e	77 e
6/23/2004	84-0037	--	09:50	84 e	100 e
7/8/2004	84-0092	--	10:25	510	500
8/18/2004	84-0145	--	09:57	140 e	230 e
9/9/2004	84-0202	--	10:25	8800 d	6200

PEPPERMINT BROOK (Saris: 8451100)
Unique_ID: W1211 Station: PE01, Mile Point: 0.178
Description: [Lakeview Avenue crossing, Dracut]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0003	84-0004	09:30	310	220
6/2/2004	84-0004	84-0003	09:30	290	270
6/23/2004	84-0034	84-0035	09:27	1800 e	2400 e
6/23/2004	84-0035	84-0034	09:27	1400 e	2800 e
7/8/2004	84-0089	84-0090	09:50	380 e	410 e
7/8/2004	84-0090	84-0089	09:50	470	420
8/18/2004	84-0144	--	09:36	490 e	690 e
9/9/2004	84-0201	--	10:08	4800 de	7400 e

BLACK BROOK (Saris: 8451175)
Unique_ID: W1191 Station: BB05, Mile Point: 0.977
Description: [Westford Street crossing, Lowell]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0029	84-0030	11:55	97	52 d
6/2/2004	84-0030	84-0029	11:55	130	130 d
6/23/2004	84-0060	84-0061	12:15	160 e	170 e
6/23/2004	84-0061	84-0060	12:15	130	110
7/8/2004	84-0115	84-0116	11:32	620 e	700 e
7/8/2004	84-0116	84-0115	11:32	700 e	740 e
8/18/2004	84-0170	84-0171	11:36	210	170
8/18/2004	84-0171	84-0170	11:36	290	140
9/9/2004	84-0227	84-0228	10:55	6200	2400
9/9/2004	84-0228	84-0227	10:55	5000	3800

" -- " = No data (i.e., data not taken/not required)
" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.
" j " = 'estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.

TADMUCK BROOK (Saris: 8451325)
Unique_ID: W1201 Station: TA01, Mile Point: 0.316
Description: [Lowell Road crossing, Westford]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0027	--	10:55	150 e	210 e
6/23/2004	84-0058	--	11:32	280 e	350 e
7/8/2004	84-0113	--	10:47	1400	600
8/18/2004	84-0168	--	10:48	250	190
9/9/2004	84-0225	--	10:20	4200 e	5200 e

BENNETTS BROOK (Saris: 8451525)
Unique_ID: W1200 Station: BE01, Mile Point: 0.997
Description: [Willow Road crossing, Ayer]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0021	--	08:25	330	250
6/23/2004	84-0052	--	08:25	240	230
7/8/2004	84-0107	--	08:25	190 e	210 e
8/18/2004	84-0162	--	08:20	290	240
9/9/2004	84-0219	--	08:40	3600	3400

DEEP BROOK (Saris: 8451550)
Unique_ID: W1190 Station: DBR05, Mile Point: 1.747
Description: [Ledge Road crossing, Chelmsford]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0028	--	11:30	120 e	130 e
6/23/2004	84-0059	--	11:58	200	140
7/8/2004	84-0114	--	11:06	150 e	180 e
8/18/2004	84-0169	--	11:10	270 e	380 e
9/9/2004	84-0226	--	10:39	4000 e	5200 e

LAWRENCE BROOK (Saris: 8451600)
Unique_ID: W1189 Station: LWB02, Mile Point: 0.235
Description: [approximately 130 feet downstream/south of Sherburne Avenue, Tyngsborough]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0025	--	10:05	210	170
6/23/2004	84-0056	--	10:10	13 e	45 e
7/8/2004	84-0111	--	10:05	71 e	84 e
8/18/2004	84-0166	--	10:07	84	71
9/9/2004	84-0223	--	09:52	250	220

BRIDGE MEADOW BROOK (Saris: 8451625)
Unique_ID: W1207 Station: BR01, Mile Point: 1.524
Description: [downstream/northeast of the unnamed school access road crossing north off Westford Avenue between the localities of Hayward Corner and Swan Corner, Tyngsborough]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0026	--	10:30	73 e	87 e
6/23/2004	84-0057	--	11:10	71	52
7/8/2004	84-0112	--	10:25	<6	6
8/18/2004	84-0167	--	10:21	19 e	45 e
9/9/2004	84-0224	--	10:06	200 e	270 e

" -- " = No data (i.e., data not taken/not required)
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.

SALMON BROOK (Saris: 8451675)
Unique_ID: W1199 Station: SA01, Mile Point: -0.525
Description: [Ridge Road crossing, Nashua, New Hampshire]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0024	--	09:45	26	26
6/23/2004	84-0055	--	09:50	120	71
7/8/2004	84-0110	--	09:36	19 e	52 e
8/18/2004	84-0165	--	09:43	52 e	77 e
9/9/2004	84-0222	--	09:35	350 e	500 e

JOINT GRASS BROOK (Saris: 8451700)
Unique_ID: W1208 Station: JG01, Mile Point: 1.058
Description: [downstream/east of Main Street crossing (below confluence of unnamed tributary), Dunstable]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0023	--	09:25	52	19
6/23/2004	84-0054	--	09:35	27 e	80 e
7/8/2004	84-0109	--	09:22	47	47
8/18/2004	84-0164	--	09:12	13 e	52 e
9/9/2004	84-0221	--	09:23	1600	600

MARTINS POND BROOK (Saris: 8451825)
Unique_ID: W1188 Station: MRB01, Mile Point: 0.375
Description: [approximately 180 feet downstream from washed out culvert crossing of Loomis Lane, Groton]

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0022	--	08:50	150	110
6/23/2004	84-0053	--	08:50	39 e	65 e
7/8/2004	84-0108	--	08:53	19	19
8/18/2004	84-0163	--	08:45	77 e	84 e
9/9/2004	84-0220	--	09:00	290	230

" -- " = No data (i.e., data not taken/not required)
" e " = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.

Quality Control Data

Table 7. 2004 MassDEP DWM Merrimack River Watershed Field Blank Data.

Date	OWMID	QAQC	Time	Fecal	E.coli
			(24hr)	CFU/100ml	CFU/100ml
6/2/2004	84-0019	Blank	11:50	<7	<7
6/23/2004	84-0050	Blank	11:30	<6	<6
7/8/2004	84-0105	Blank	12:10	<6	<6
8/18/2004	84-0161	Blank	11:35	<6	<6
9/9/2004	84-0218	Blank	11:35	<6	<6
8/18/2004	84-0152	Blank	11:31	<6	<6
9/9/2004	84-0209	Blank	11:42	<6 d	<6
6/2/2004	84-0005	Blank	09:35	<7	<7
6/23/2004	84-0036	Blank	09:53	<6	<6
7/8/2004	84-0091	Blank	09:55	<6	<6
6/2/2004	84-0031	Blank	12:00	<7	<7
6/23/2004	84-0062	Blank	12:15	<6	<6
7/8/2004	84-0117	Blank	11:32	<6	<6
8/18/2004	84-0172	Blank	11:45	<6	<6
9/9/2004	84-0229	Blank	10:51	<6	<6

" d " = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.

Table 8. 2004 MassDEP DWM Merrimack River Watershed Field Duplicate Data.

JOHNSON CREEK (Saris: 8450550)
Unique_ID: W1197 Station: JC03, Mile Point: 0.957
Description: [Center Street crossing, Groveland]

Date	OWMID	QAQC	Time	Log10(Fecal)	Log10(E.coli)
			(24hr)	CFU/100mL	CFU/100mL
06/02/04	84-0017	84-0018	11:55	1.886	1.813
06/02/04	84-0018	84-0017	12:00	1.954	1.987
Relative	*Percent*	*Difference*		*3.5%*	*9.2%*
06/23/04	84-0048	84-0049	11:20	1.505	2.041
06/23/04	84-0049	84-0048	11:25	1.813	1.716
Relative	*Percent*	*Difference*		*18.6%*	*17.3%*
07/08/04	84-0103	84-0104	12:05	3.079	3.255
07/08/04	84-0104	84-0103	12:05	2.778	3.000
Relative	*Percent*	*Difference*		*10.3%*	*8.2%*
08/18/04	84-0159	84-0160	11:35	1.968	2.000
08/18/04	84-0160	84-0159	11:35	1.851	2.041
Relative	*Percent*	*Difference*		*6.1%*	*2.0%*
09/09/04	84-0216	84-0217	11:25	3.531	3.342
09/09/04	84-0217	84-0216	11:30	3.000	3.255
Relative	*Percent*	*Difference*		*16.3%*	*2.6%*

LITTLE RIVER (Saris: 8450575)
Unique_ID: W1210 Station: LR01, Mile Point: 0.441
Description: [downstream/south at Winter Street crossing, Haverhill]

Date	OWMID	QAQC	Time	Log10(Fecal)	Log10(E.coli)
			(24hr)	CFU/100mL	CFU/100mL
08/18/04	84-0150	84-0151	11:20	2.519	2.301
08/18/04	84-0151	84-0150	11:20	2.380	2.322
Relative	*Percent*	*Difference*		*5.6%*	*0.9%*
09/09/04	84-0207	84-0208	11:35	3.602	3.732
09/09/04	84-0208	84-0207	11:35	3.982	3.820
Relative	*Percent*	*Difference*		*10.0%*	*2.3%*

PEPPERMINT BROOK (Saris: 8451100)
Unique_ID: W1211 Station: PE01, Mile Point: 0.178
Description: [Lakeview Avenue crossing, Dracut]

Date	OWMID	QAQC	Time	Log10(Fecal)	Log10(E.coli)
			(24hr)	CFU/100mL	CFU/100mL
06/02/04	84-0003	84-0004	09:30	2.491	2.342
06/02/04	84-0004	84-0003	09:30	2.462	2.431
Relative	*Percent*	*Difference*		*1.2%*	*3.7%*
06/23/04	84-0034	84-0035	09:27	3.255	3.380
06/23/04	84-0035	84-0034	09:27	3.146	3.447
Relative	*Percent*	*Difference*		*3.4%*	*2.0%*
07/08/04	84-0089	84-0090	09:50	2.580	2.613
07/08/04	84-0090	84-0089	09:50	2.672	2.623
Relative	*Percent*	*Difference*		*3.5%*	*0.4%*

BLACK BROOK (Saris: 8451175)
Unique_ID: W1191 Station: BB05, Mile Point: 0.977
Description: [Westford Street crossing, Lowell]

Date	OWMID	QAQC	Time	Log10(Fecal)	Log10(E.coli)
			(24hr)	CFU/100mL	CFU/100mL
06/02/04	84-0029	84-0030	11:55	1.987	1.716
06/02/04	84-0030	84-0029	11:55	2.114	2.114
Relative	*Percent*	*Difference*		*6.2%*	*20.8%*
06/23/04	84-0060	84-0061	12:15	2.204	2.230
06/23/04	84-0061	84-0060	12:15	2.114	2.041
Relative	*Percent*	*Difference*		*4.2%*	*8.9%*
07/08/04	84-0115	84-0116	11:32	2.792	2.845
07/08/04	84-0116	84-0115	11:32	2.845	2.869
Relative	*Percent*	*Difference*		*1.9%*	*0.8%*
08/18/04	84-0170	84-0171	11:36	2.322	2.230
08/18/04	84-0171	84-0170	11:36	2.462	2.146
Relative	*Percent*	*Difference*		*5.9%*	*3.9%*
09/09/04	84-0227	84-0228	10:55	3.792	3.380
09/09/04	84-0228	84-0227	10:55	3.699	3.580
Relative	*Percent*	*Difference*		*2.5%*	*5.7%*

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Appendix 1

Data Validation Procedures
Merrimack Watershed 2004 Water Quality Survey

Selected Excerpts from:
Data Validation Report for Year 2004 Project Data (CN 265.0)

October, 2006

Massachusetts Department of Environmental Protection
Division of Watershed Management

4.0 2004 *In-Situ* Multiprobe Data

4.1 QA/QC Objectives and Criteria for 2004 *In-Situ* Multi-probe Data

Trained DWM staff members (and their designees) conducted *in-situ* measurements using Hydrolab® Series 3/4 and YSI 6000 Series multi-probe instruments. These simultaneously measure dissolved oxygen, temperature, pH, conductivity, and depth, and provide calculated estimates for total dissolved solids and % oxygen saturation.

To ensure the quality of the data, the following QA/QC steps were taken before, during and after use:

- Pre-Survey Calibration and Check: Standard pre-survey calibration of each unit was conducted in accordance with the DWM SOP (CN 4.2). After the instrument was calibrated and before the instrument was released to field staff, an instrument check using both a low ionic standard and filtered de-ionized water was performed. The purpose of this check is to make sure that the instrument is providing stable readings as the waters in Massachusetts are typically of low ionic strength. If the instrument failed acceptance criteria, it was not released to field staff until the source of error was identified and corrected.

- Post-Survey Check: A standard post survey check of each unit was performed in accordance with the DWM SOP. Upon return to the lab, a visual inspection was performed to identify any physical damage that may have occurred in the field. The calibration of the unit was then checked against both a low ionic standard and filtered de-ionized water. The results of the post survey calibration check were compared to the pre-calibration results. If visual damage was observed and/or post calibration acceptance criteria were not achieved, the source of error was investigated and data collected in the field may have been subject to qualification or censoring.

- Data Reduction: The Multi-probe Coordinator, QC Analyst and Database Manager reviewed the multi-probe data for problems associated with instability, instrument malfunction, operator error and aberrant trends. If any of these conditions were detected, the data was investigated and may have been recommended for censoring. The Database Manager electronically tagged all data recommended for censoring in the database. Measured data were also evaluated for the following:

• **Consistency with the SOP** (specifically, the requirement for three (minimum)-five (preferred) sequential readings one-minute-apart at appropriate depths, proper field use, etc.).

• **Accuracy and precision** of readings, as assessed through review of pre-survey calibration/check and post-survey check data, field notes for any information on faulty operation and/or unusual field conditions, and accuracy checks.

• **Representativeness** of data (review of fieldsheets and notes for any information that might indicate non-representativeness; eg. not taken at the deep hole).

• Check for **"outliers" or unreasonable data**, based on best professional judgement. Outliers are identified and flagged for scrutiny. For lake depth profiles, more leeway is given to apparently unstable multi-probe data, given that thermal stratification can cause rapid, natural changes in parameters within the thermocline.

• Multi-probe record **acceptance criteria**: Within each set of records for individual OWMID #s, automatically accept the final line of data for each depth where the change in depth from the previous accepted-record-depth is greater than 0.2 meters, subject to review and change by the multiprobe review team.

• The criterion used in 2004 to accept, qualify or censor **Conductivity (and the dependent, calculated estimates for TDS and Salinity)** readings was based on exceedance of the calibration standard concentration. For exceedances greater than two times the standard, the conductivity reading was typically censored. Readings above the calibration standard were qualified whenever the reading was less than two times the calibration standard. NOTE: In cases where readings fell far below the calibration standard concentration (e.g., measured value of 100 uS/cm using 6668 calibration standard), no censoring or qualification was imposed.

• For **D.O.** values less than 0.2 mg/l, 2004 data were accepted without qualification and reported as "<0.2". Similarly for % saturation, values less than 2% were accepted without qualification and reported as "<2%".

• For all parameters taken at the same location and whose range for 3-5 successive readings fluctuated beyond the range (+/-) of probe accuracy, the data was typically qualified or censored (depending on the degree of fluctuation) with "u" (**unstable**). Data exhibiting significant, continuous movement in one direction and that did not appear to reach equilibrium was also qualified or censored.

• For instances **where temperature has been censored, data for Conductivity, pH and D.O. are typically qualified.** (readings for Conductivity, pH and dissolved oxygen are internally-corrected for temperature; conductivity is temperature-compensated to 25 deg. C, D.O. readings are adjusted about 5% per degree C to account for changes in oxygen solubility and membrane permeability, and pH is compensated for electrode effects due to variable sample temperatures.) In cases where temperature has only been qualified, no qualification of data for conductivity, pH and D.O. is imposed.

• Depth criteria:

General Depth Criteria: Apply to each OWMID# for lakes and rivers

- Clearly erroneous readings due to faulty depth sensor: Censor (i)
- Negative and zero depth readings: Censor (i); (likely in error)
- 0.1 m depth readings: Qualify (i); (potentially in error)
- 0.2 and greater depth readings: Accept without qualification; (likely accurate)

Specific Depth Criteria: Apply to entirety of depth data for survey date

- If zero and/or negative depth readings occur more than once per survey date, censor all negative/zero depth data, and qualify all other depth data for that survey (indicates that erroneous depth readings were not recognized in the field and that corrective action (field calibration of the depth sensor) was not taken, ie. that all positive readings may be in error.)

5.0 2004 Discrete Water Sample Data

5.1 QA/QC Objectives and Criteria for 2004 Discrete Water Sample Data

The collection and analysis of discrete water samples in 2004 followed the DWM Standard Operating Procedures and lab analyte-specific SOPs. The majority of river samples were taken via the manual grab and basket sampler techniques (where ambient water enters the sample bottle directly). For Lakes, the samples were taken using the Van Dorn thief-type sampler at depth and manually for epilimnetic "surface" samples.

For river sampling, field quality control samples consisted of approx. 10% ambient blanks and 10% field duplicates (i.e., separate, co-located (side-by-side), simultaneous field duplicates). For lakes, equipment blanks and sequential duplicates were taken using a Van Dorn apparatus.

Using the following criteria, as well as other considerations and input from data reviewers, individual datum were either:
Accepted
Accepted with qualification, or
Censored

In cases where poor quality control (e.g., blank/cross contamination, lab accuracy) affected batched analyses or entire surveys, censoring/qualification decisions were applied to groups of samples (e.g., a specific crew's samples, a specific survey's samples or all samples from a specific batch analysis).

Criteria for acceptance of discrete water quality sample data were as follows:

- For simplicity, samples that were **"lost", "missing", "spilled" and "not analyzed"** were denoted using the 'm' (method not followed) qualifier and ** symbol.

- **Sampling/Analysis Holding Time**: Each analyte has a standard holding time that has been established to ensure sample/analysis integrity. Refer to DWM Standard Operating Procedure CN# 1.2 for a complete listing. If the standard holding time was exceeded, this criterion is violated and the data may be censored, depending on the extent of exceedance. For minor exceedances (e.g., < than 20% of the holding time), the data is typically qualified ("h" for minor holding time violation).

- **Quality Control Sample Frequency**: At a minimum, one field blank and one replicate must be collected for every ten samples by any given sampling crew on any given date. If less than 10% blanks and replicates were collected, the data are typically qualified with "f". If blanks were omitted and duplicates taken, typically no data are qualified, as long as there are no documented historical problems for the survey-specific samplers or station locations with regard to field contamination. If blanks were taken but duplicates were not, the data may be qualified with "f". Typically, no censoring of data takes place for insufficient QC sample frequencies only.

- **Field Blanks:** Field blanks were prepared at the DWM Worcester Laboratory. Reagent grade water was transported into the field in a sample container where it was transferred into a different sample container directly or via a sampling device (equipment blank) using the same methods as for its corresponding field sample (e.g., blank samples were preserved in the same way). All blanks were submitted to the WES laboratory "blind". If the field blank results were greater than the MDL (indicating potential sampling error, airborne contaminants, dirty equipment, etc.), the data may be censored or qualified, depending on extent and other factors. Programmatically, DWM does not correct sample results by subtracting blank concentrations.

- **Field Replicates:** In 2004, field duplicate samples for rivers were taken as co-located, simultaneous duplicates. As a result, these duplicate results include any spatial, natural variability present between side-by-side samples (which should be minimal in most cases where site selection has accounted for

uniform mixing). Duplicate lake samples were sequential and therefore also include any temporal variability. Samples were submitted to WES laboratory "blind".
Results were compared to specific criteria contained in a 2004 QAPP document. If the criteria are not met, the sample/duplicate data may be censored or qualified, depending on extent of exceedance and other factors. Arguably, very poor precision of field duplicate samples reflects poor reproducibility for entire surveys and/or analytical batch runs, and should result in censoring or qualification of the entire survey/batch data. Decisions related to poor precision for entire surveys/batchs were made on a case-by-case basis.

- Results of **Field and/or Lab Audits** and Miscellaneous Survey Information: If, based on the results of field evaluation of implementation of field sampling SOPs, samples are deemed to have been taken incorrectly or to not represent station conditions at the time of sampling, then individual or survey-based sample results may be qualified or censored. Likewise, the results of QC audits of lab(s) analytical accuracy (and precision) for specific parameters are evaluated. If results indicate poor accuracy or repeatability, batch run data may be qualified or censored. In addition, information from survey personnel regarding sample integrity and representativeness may lead to decisions to qualify or censor data.

- **Laboratory assessment of analytical precision and accuracy:** The WES Laboratory is solely responsible for the administration of its Quality Assurance Program and Standard Operating Procedures. WES staff release discrete water sample data when their established QA/QC criteria have been met. When the following criteria cannot be met, data are qualified using appropriate qualifiers:

• Low Calibration Standards – Checks the stability of the instrument's calibration curve; analyzes the *accuracy* of an instrument's calibration within a 5% range.

• Reference Standards – Generally, a second source standard (a standard different from the calibration stock standard) that analyzes the method *accuracy.*

• Laboratory Reagent Blank/Method Blank (LRB) – Reagent grade water (de-ionized) extracted with every sample set used to ensure that the system is free of target analytes (< MDL) and to assess potential blank contamination.

• Duplicate Sample – Measures the *precision* (as Relative Percent Difference or RPD) of the analytical process. The acceptable laboratory %RPD range is typically ≤ 25%. For bacteria, duplicate data are evaluated based the range of logged values.

• Spike Sample (Laboratory Fortified Blank - LFB, Laboratory Fortified Matrix - LFM)– Measures the *accuracy* (% Recovery) of an analytical method. The acceptable laboratory % recovery range is typically between 80 – 120% for LFB samples and 70 –130% for LFM discrete water samples.

2004 Field and Lab Audit Results

Field Audits – Due to limited time and resources, only one (1) field audit was performed by DWM's QC Analyst in 2004. This review for adherence to field protocols was conducted on 9/16/04 for a fish population survey. Survey included one DWM crew lead and two trained seasonal interns. Habitat scoring sheets were filled out by the crew lead and QC analyst to estimate general precision of scoring. This audit indicated acceptable staff performance, did not impact validation of survey sample results, and did not result in any corrective actions.

Appendix 2

2004 Data Symbols and qualifiers
Merrimack Watershed 2004 Water Quality Survey

Selected Excerpts from:
Data Validation Report for Year 2004 Project Data (CN 265.0)

October, 2006

Massachusetts Department of Environmental Protection
Division of Watershed Management

The following data qualifiers or symbols are used in the MADEP/DWM WQD database for qualified and censored water quality and multi-probe data. Decisions regarding censoring vs. qualification for specific, problematic data are made based on a thorough review of all pertinent information related to the data.

General Symbols (applicable to all types):

" ## " = Censored data (i.e., data that has been discarded for some reason). *NOTE: Prior to 2001 data, "**" denoted either censored or missing data.*

" ** " = Missing data (i.e., data that should have been reported). See NOTE above.

" -- " = No data (i.e., data not taken/not required)

* = Analysis performed by Laboratory OTHER than DEP's Wall Experiment Station (WES)

[ ] = A result reported inside brackets has been "censored", but is shown for informational purposes (e.g., high blank results).

Multi-probe-specific Qualifiers:

" i " = inaccurate readings from Multi-probe likely; may be due to significant pre-survey calibration problems, post-survey checks outside typical acceptance ranges for the low ionic and deionized water checks, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses. Where documentation on unit pre-calibration is lacking, but SOPs at the time of sampling dictated pre-calibration prior to use, then data are considered potentially inaccurate.

Qualification Criteria for Depth (i):

General Depth Criteria: Apply to each OWMID#

- Clearly erroneous readings due to faulty depth sensor: Censor (i)
- Negative and zero depth readings: Censor (i); (likely in error)
- 0.1 m depth readings: Qualify (i); (potentially in error)
- 0.2 and greater depth readings: Accept without qualification; (likely accurate)

Specific Depth Criteria: Apply to entirety of depth data for survey date

- If zero and/or negative depth readings occur more than once per survey date, censor all negative/zero depth data, and qualify all other depth data for that survey (indicates that erroneous depth readings were not recognized in the field and that corrective action (field calibration of the depth sensor) was not taken, ie. that all positive readings may be in error.)

“ m ” = method not followed; one or more protocols contained in the DWM Multi-probe SOP not followed, ie. operator error (eg. less than 3 readings per station (rivers) or per depth (lakes), or instrument failure not allowing method to be implemented.

“ s ” = field sheet recorded data were used to accept data, not data electronically recorded in the Multi-probe surveyor unit, due to operator error or equipment failure.

“ u ” = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly-variable water quality conditions, etc. See Section 4.1 for acceptance criteria.

“ c ” = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for conductivity (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or turbidity (>10, 20 or 40 NTU). It can also be used for TDS and Salinity calculations based on qualified (“c”) conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading). See Section 4.1 for acceptance criteria.

“ r ” = data not representative of actual field conditions.

“ ? ” = Light interference on Turbidity sensor (Hydrolab error message). Data is typically censored.

Sample-Specific Qualifiers:

“ a ” = accuracy as estimated at WES Lab via matrix spikes, PT sample recoveries, internal check standards and lab-fortified blanks did not meet project data quality objectives identified for program or in QAPP.

“ b ” = blank Contamination in lab reagant blanks and/or field blank samples (indicating possible bias high and false positives).

“ d ” = precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.

“ e ” = not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.

“ f ” = frequency of quality control duplicates did not meet data quality objectives identified for program or in QAPP.

“ h ” = holding time violation (usually indicating possible bias low)

“ j ” = ‘estimated’ value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the ‘reporting’ limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.

“ m ” = method SOP not followed, only partially implemented or not implemented at all, due to complications with sample matrix (eg. sediment in sample, floc formation), lab error (eg. cross-contamination between samples), additional steps taken by the lab to deal with matrix complications, lost/unanalyzed samples, and missing data.

“ p ” = samples not preserved per SOP or analytical method requirements.

“ r ” = samples collected may not be representative of actual field conditions, including the possibility of “outlier” data and flow-limited conditions (e.g., pooled).

Misc. abbrev./symbols:

TY= tygon tubing
AF= ambient field blank
VD= van dorn bottle