EPA's Annual Water Quality Report on the Lower Charles River 2006

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Prepared By

US EPA

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Background

In 1995, the U.S. Environmental Protection Agency - New England (EPA) established the Clean Charles Initiative to restore the lower Charles River (from Watertown to Boston harbor) to a swimmable and fishable condition by Earth Day in the year 2005. The initiative incorporated a comprehensive approach for improving water quality through: Combined Sewer Overflow (CSO) controls, illicit sanitary connection removals, stormwater management, public outreach, education, monitoring, enforcement, technical assistance, and the development of a Total Maximum Daily Load (TMDL) to address nutrient impacts for the Lower Charles.

Introduction

In 1998, EPA's Office of Environmental Measurement and Evaluation (OEME) initiated the Clean Charles Core Monitoring Program. The purpose of the program was to track water quality improvements in the lower Charles River and to identify where further pollution reductions or remediation actions were necessary to meet the Clean Charles Initiative goals. The program was designed to sample during the summer months coinciding with peak recreational uses.

The target date for achieving swimmable and fishable conditions was originally Earth Day 2005. Although, the Clean Charles initiative has achieved significant improvements in water quality during the past twelve years, water quality still needs improvements. The Lower Charles continues to suffer from nutrient enrichment and sections of the river continue to exceed bacteria standards.

In 2005, EPA modified the monitoring program to reflect changes in the initiative and existing trends in water quality conditions. Beginning in 2005, the monitoring program was changed to monitor key parameters during dry weather conditions at seven trend stations (Figure 4). These stations were a subset of the original twelve Core Monitoring Program stations. The modified program, which began in 2005, now measures field parameters (temperature, DO, pH, specific conductance, salinity, turbidity, Secchi disk transparency, chlorophyll, and transmissivity) and samples for fecal coliform, E.coli, total phosphorus, ortho-phosphate, and Chlorophyll a on each of the monthly sampling events. On August 3, 2006, an additional sampling event was added to measure depth profiles at selected stations for temperature, specific conductance, DO and pH during warm afternoon conditions (Figure 5).

In 2006, additional monitoring was conducted to assess water quality and sediment conditions at Havey Beach in West Roxbury. Havey Beach has been identified by the Charles River Watershed Association (CRWA) as a potential swimming area. The beach, which includes a former bath house, was historically used as a swimming area. During the summer of 2006 field parameters and bacteria were measured and the results are presented in this report. On June 1, 2006, sediment samples were collected at Havey Beach and these data will be presented in a separate report.

Discussion of Results

The summary below reflects the EPA water quality monitoring data collected during 2006 and compares these data with previous EPA monitoring data collected from 1998 to 2005.

In addition to point source and non-point source pollutant loadings, water quality was influenced by yearly fluctuations in weather and river flows, making short-term trends difficult to determine. The weather conditions and river flow

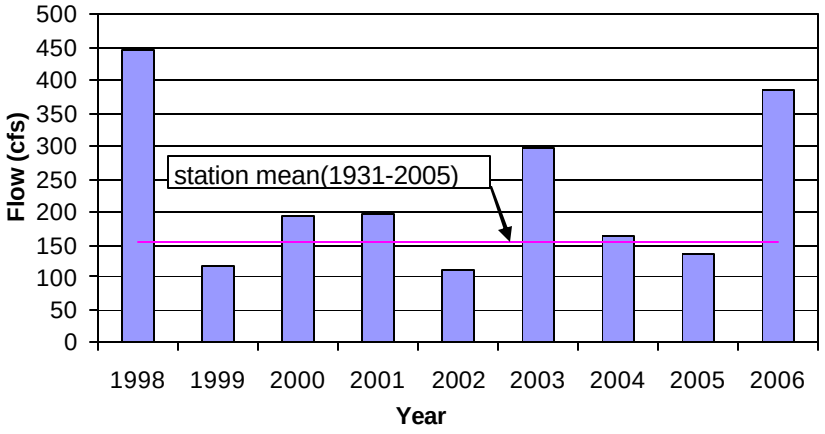

Figure 1: June - September Mean Monthly Stream Flow at the USGS Gaging Station in Waltham, MA (2006 data are provisional)

affect the transport of pollutants in the watershed. The flow data collected at the Waltham USGS gaging station revealed that in 2006, the mean monthly summer (June - September) flow was higher than the average mean monthly summer flow (June – September from 1931 – 2005). Except for 1998, the 2006 mean summer flow was higher than all previous years since 1998 (Figure 1). The high summer mean flow was mainly attributed to the high flows recorded in June. The monthly mean flow for June 2006 was approximately four times as high as the June monthly mean from 1931 to 2005. The monthly mean for July 2006 was approximately twice as high as the July monthly mean from 1931 to 2005. August and September were very close to the monthly means from 1931 to 2005.

When comparing the 2006 data to the past eight years of data, the following conclusions can be made. The majority of the time, the best water quality occurred near the mouth of the River (downstream of the Longfellow Bridge; CRBL11, & CRBL12). This part of the river met the swimming standards more often than any other part of the lower Charles River. However, in previous years, bacteria concentrations were also lower at the stations between the Mass Ave. Bridge and the Longfellow Bridge (CRBL07 and CRBLA8). In 2006, these stations recorded elevated bacteria concentrations.

A significant algae bloom was detected during EPA's August 9 sampling event. One of the key causes of algae blooms is excess nutrients. EPA and the state of Massachusetts are finalizing a Total Maximum Daily Load (TMDL) for nutrients. The TMDL establishes the amount of nutrients that the lower Charles can receive and still maintain its designated use as a recreational water body. The TMDL will be used by agencies to develop cleanup tools to address the excess nutrients flowing into the River.

Clarity

Water clarity was directly measured in the field using a Secchi disk. The greatest clarity was measured near the mouth of the River which has been a trend observed from the previous eight years of data collection (EPA 2006). On October 17, the greatest clarity was measured at all stations (Figure 2). Both stations downstream from the Longfellow Bridge (CRBL11 & CRBL12) met the Massachusetts Department of Environmental Protection primary contact (swimming) use support criterion of greater than or equal to 1.2 meters during all sampling events. The increased clarity measured near the mouth of the River is associated with the wider and deeper part of the lower Charles. This deeper and wider section of the River allows for more settling to occur (with little resuspension), the process where solids in the water drop out of the water column and are deposited on the river bottom. This settling out process leads to less suspended particles and generally to better water clarity.

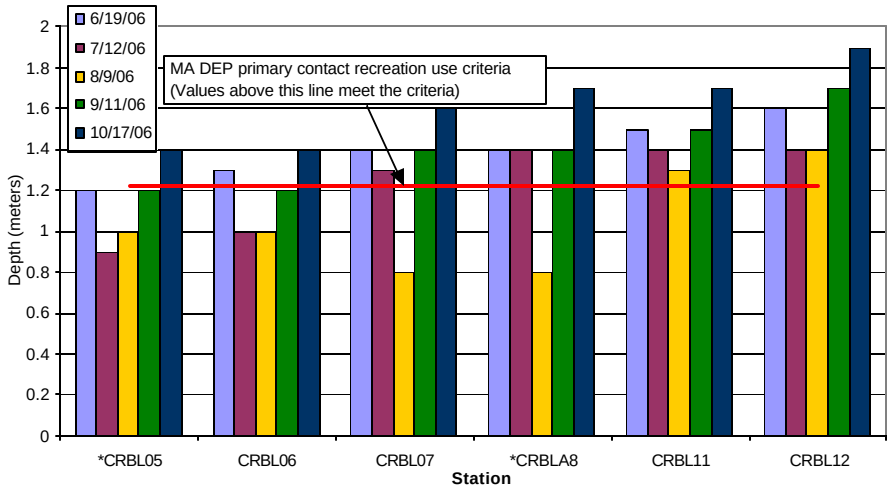

Figure 2: 2006 Clarity - Secchi Disk Measurments

Based on the Secchi disk transparency dry weather data collected over the last nine years, the most downstream station (upstream of the Railroad Bridge; CRBL12) met the MA DEP primary contact use criterion approximately 85% of the time, while the station at Magazine beach (CRBL05) met the criterion 20% of the time.

The lowest clarity was measured on August 9 at the station downstream of the Mass Ave. Bridge and at the Esplanade (CRBL07 and CRBLA8 respectively).
On this date, these stations also recorded the highest Chlorophyll a values (117 ug/L and 98 ug/L for stations CRBL07 and CRBLA8 respectively). These values indicated a significant algae bloom that occurred in parts of the lower Charles River. The seasonal (June 1- October 31) chlorophyll a target established in the Draft TMDL report for nutrients in the lower Charles River Basin is 10 ug/L (MADEP, et al. 2007). A grab sample collected

in the old locks, (between stations CRBL11 and CRBL12) where the algae were piling up, had a chlorophyll a concentration of 1,450 ug/L. A sample collected here was sent to the MA DEP for additional testing. The MA DEP identified the primary alga species as a cyanobacterium; *Microcystis flos-aquae* and measured a cell count of 1,022,857 cells/ml (Beskenis, 2006). MA DPH later issued a health advisory for the river based on these data.

Transmissivity and turbidity are other measurements of water clarity, but unlike Secchi disk transparency, these measurements are independent of external light. Transmissivity and turbidity measurements use their own light source to measure the scattering and absorption of light as it passes through the water column. High transmissivity or low turbidity correlates with high clarity. The lowest transmissivity and the highest turbidity were measured on August 9 at the station downstream of the Mass Ave. Bridge (CRBL07). On this date, stations CRBL07 and CRBLA8 recorded the lowest Secchi disk reading.

Bacteria

In 2006, the calculated dry weather E.coli geometric means met the swimming standard[1] at three (CRBL05, CRBL11, & CRBL12) of the seven locations. The highest geometric mean (199 cfu/100 ml) was at the station downstream of the Mass Ave. Bridge (CRBL07), the lowest geometric mean (39 cfu/100 ml) and was upstream of the Railroad Bridge (CRBL12). Ten samples (29% of all samples) exceeded the individual E.coli sample criterion[1].

Bacteria concentrations were generally lower near the mouth of the River (downstream of the Longfellow Bridge; (CRBL11, & CRBL12)). This is a consistent trend, over the previous eight years of data collection. However in previous years, lower concentrations were also measured at the section of the river between Mass Ave and the Longfellow Bridge (CRBL07 & CRBLA8). For unknown reasons these stations recorded higher bacteria levels in 2006 compared to previous years. The station down stream of the Mass Ave. Bridge (CRBL07) recorded the highest dry weather fecal coliform geometric mean of all nine years of monitoring (Figure 3). The station located off the Esplanade (CRBLA8) recorded the highest fecal coliform geometric mean of all the past five years of monitoring this location.

The area from station CRBL07 - CRBL12 is the most heavily recreated part of the River. This area contains the MIT (Massachusetts Institute of Technology) Sailing Pavilion and Community Boating where much sailing, kayaking, windsurfing, and occasional contact with the water occurs.

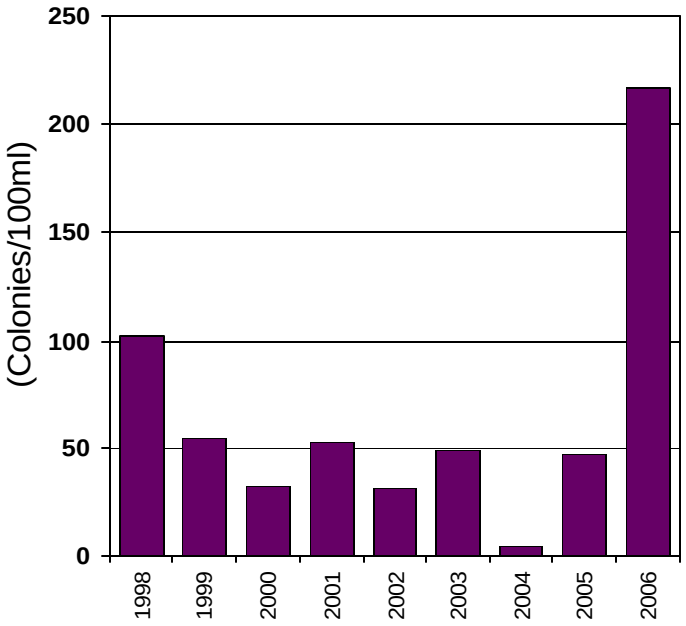

Figure 3: Fecal Coliform Dry Weather Geometric Means at Station CRBL07
(Note: Between 1998 and 2004 some of the geometric means were calculated using less than 5 data points.)

1 The Massachusetts Surface Water Quality Standards for Class B waters and the Massachusetts Minimum Standards for Bathing Beaches for E. coli using a single sample is ≤ 235 colonies /100ml for a geometric mean it is ≤ 126 colonies/100ml and is based on a geometric mean of the most recent five samples collected within the same bathing season or a six month period.

Table 1: Massachusetts Freshwater Bacteria Criteria

Indicator Organism	MA DEP Surface Water Quality Standards (314 CMR 4.00) and water quality guidelines and MA DPH Minimum Standards for Bathing Beaches (105 CMR 445)	
	Primary contact	Secondary contact
E. coli	Individual sample ≤235 colonies/100ml Geometric mean of ≤126 col/100ml (within bathing season or previous 6 months)	NA
Enterococci	Individual sample ≤61 colonies/100ml and a Geometric mean of ≤33 col/100ml (within bathing season or previous 6 months)	NA
Fecal coliform	a geometric mean ≤200 col/100ml for ≥5 samples ≤400/100ml for not more than 10 % of the samples ≤400 col/100ml for <5 samples	a geometric mean ≤1000 col/100ml for ≥5 samples ≤2000/100ml for not more than 10 % of the samples ≤2000 col/100ml for <5 samples

Previous criteria (no longer a state standard)

NA = Not applicable

Dissolved Oxygen (DO), pH and Temperature

Dissolved Oxygen (DO) is required for a healthy ecosystem as fish and other aquatic organisms require DO for survival. No values above the Massachusetts DO criterion[1] were measured in the surface water during any of the sampling events. Although no below surface (depth) DO results were reported for 2006, previous depth profiles revealed that water quality bottom conditions downstream of the BU Bridge were anoxic and failed to meet state DO criterion[1] (EPA 2006).

The pH of an aquatic system is an important parameter in evaluating toxicity as high acidity (a low pH) can convert insoluble metal sulfides to soluble forms, which increases the bioavailability. A high pH can also cause ammonia toxicity (FISRWG 1998). The surface measurements exceeded the upper range of the Massachusetts pH criterion on two of the five sampling events (August 9 and September 11) for at total of 6 exceedences or approximately 17% of all field measurements. The highest of these exceedences (8.8) occurred on August 9 at the stations downstream of the Mass Ave Bridge and off the Esplande (CRBL07 and CRBLA8). These elevated values were most likely caused by the algae bloom that occurred on this date.

Temperature is a crucial factor in maintaining a natural ecosystem as changes in the temperature can alter the existing or natural aquatic community (EPA 1986). Temperature also governs many biochemical and physiological processes in cold-blooded aquatic organisms (such as fish and the organisms they feed on). Increased temperature decreases the oxygen solubility in water and this can exacerbate the impact of oxygen-demanding waste. The surface measurements from the five dry weather sampling events exceeded the temperature criterion[1] once on August 9 at the station between the Longfellow Bridge and Old Dam (CRBL07). This station out of all the stations is the most influenced by the Mirant Kendall power plant thermal discharge. All of the measurements from the five dry weather sampling events occurred in the morning when water temperatures have generally not reached their peak daily values.

During the afternoon sampling event on August 3, all surface measurements exceeded the temperature criterion[1] at all of the five stations monitored (Figure 5). The highest temperature (38.6°C) was measured 1.3 meters below the waters surface near the discharge of the Kendall Station NPDES (National Pollutant Discharge Elimination System) non contact-cooling water discharge (Table A-3 in the Appendix). All of the temperature violations were likely influenced by the Mirant Kendal NPDES thermal discharge.

1 The Massachusetts Surface Water Quality Standards for Class B water for DO is ≥ 5 mg/l, for pH is in the range of 6.5 through 8.3, and for temperature is ≤ 28.3°C (83°F).

Table 2: Massachusetts Class B Surface Water Quality Standards and Guidelines for Warm Waters

Parameter	MA Surface Water Quality Standards (314 CMR 4.00) and Guidelines
Dissolved oxygen	$\geq$ 5 mg/l
Temperature	$\leq$ 83°F (28.3°C) and change 3°F (1.7°C) in Lakes, change 5°F (2.8°C) in Rivers
pH	Between 6.5 and 8.3
Bacteria	See Table 1
Secchi disk depth	Lakes $\geq$ 1.2 meters (for primary contact recreation use support)
Solids	Narrative and TSS $\leq$ 25.0 mg/l (for aquatic life use support)
Color and turbidity	Narrative Standard
Nutrients	Narrative "Control of Eutrophication" Site Specific

Phosphorus

Elevated levels of nutrients in the water can lead to excessive growth of algae and other instream plants. This can cause nuisance conditions, reduced oxygen in the water during times of respiration, and algae blooms that can be harmful to animals or people in contact with water. Phosphorus is the most significant nutrient in this system. Elevated phosphorus concentrations at many of the sampling stations indicated highly eutrophic conditions.

The highest total phosphorus concentrations were recorded at most of the stations during the July sampling event. These high phosphorus values may have helped trigger the significant algae bloom that occurred in August. All of total phosphorus sample results exceeded the EPA recommended Ambient Water Quality Criterion (AWQC) for Rivers and Streams[1] and the EPA recommended criterion for lakes and reservoirs[2] (EPA, 2001).

There appears to be a decreasing trend in phosphorus levels at most of the stations over the past nine years. A longitudinal analysis conducted on the data from 1998-2005 using the dry weather yearly means shows there to be a significant rate of reduction (Rate ~ -.0081/year) (Heltshe).

In 2002, additional samples were collected at selected stations from various depths to support the development of a water quality model for the Total Maximum Daily Load (TMDL). The results from this sampling showed elevated concentrations of total phosphorus, ortho-phosphorous, total kjeldahl nitrogen, and ammonia below the pycnocline. The concentrations measured below the pycnocline where significantly higher than concentrations measured above the pycnocline and in the surface water (EPA, 2003). The pycnocline is the interface between water of different densities. It is primarily caused in the Charles River by the salt water wedge that occurs on the bottom of the river near the mouth.

Havey Beach Water Quality

In 2006, a new location was sampled at the site of the old Havey Beach in West Roxbury, Massachusetts. EPA and the Charles River Watershed Association worked jointly to collect samples at this location. To help characterize water quality at this site and influences immediate upstream, a location was also sampled at a CRWA monthly sampling location (534S), located upstream of Havey Beach at the Route 109 Bridge in

1 The EPA recommended total phosphorus criterion for rivers and stream in ecoregion XIV subecoregion 59 is 0.0237 mg/L.
2 The EPA recommended total phosphorus criterion for lakes and reservoirs in ecoregion XIV subecoregion 59 is 0.008 mg/L.

Dedham. In the spring of 2006, a sediment study was initiated by EPA at the Havey Beach location. These data will be presented in a separate report.

The results from the six dry weather sampling events at Havey Beach were all less than the MA individual sample criterion[1] for E.coli. The dry weather geometric mean at Havey Beach (46 colonies/100ml) was less the state geometric mean criterion[1]. The dry weather E.coli results from the Route 9 Bridge (534S) were similar to the results from Havey Beach, indicating there were no significant dry weather sources of bacteria between these locations.

One wet weather sampling event was conducted on June 8. The results from this sampling event at Havey Beach and the Route 9 Bridge showed elevated E.coli concentrations which exceeded the Massachusetts individual sampling criterion[1].

Other field measurements collected during the sampling events did not exceed the Massachusetts criteria for dissolved oxygen, pH, or temperature. For all the water quality sampling results collected at Havey Beach refer to Table A-2 in the Appendix.

Data Usability

Quality control criteria were established to insure data quality. Criteria were specified for holding times, sample preservation, and precision and accuracy goals. The quality control requirements for this project were documented in the Project Work/QA Plan – Clean Charles River Clean 2005 – 2010 Water Quality Study dated June 7, 2005. Laboratory generated data that did not meet laboratory quality control parameters or concentrations that were less than the associated reporting limit were reported as estimated values. All estimated data were identified with a swung dash (~) preceding the value. The holding times specified in the Project Work/QA Plan were met for all samples. All data that did not meet field or collection quality control parameters are described below.

Instruments used in the field to measure temperature, DO, pH, specific conductance, salinity, turbidity, and transmissivity were calibrated prior to sampling and verified after use. Field instrument monitoring data that did not meet all the established quality control criteria were not presented in this report and are summarized below.

Dissolved oxygen data collected during the depth profile sampling on August 3 were not reported, since these data did not meet the post calibration criteria. Field instrument data from Havey Beach on 6/8/06, 6/15/06, 9/11/06, and 10/17/06 were collected by the Charles River Watershed Association (CRWA) using their equipment and protocols. EPA did not verify the accuracy of these data. All other field instrument data in this report were collected by EPA and met the required quality control criteria.

Duplicate field measurements (temperature, DO, pH, specific conductance, salinity, turbidity, and transmissivity) were collected during each of the main sampling events. No duplicate field measurements were collected at Havey Beach. The Project Work/QA Plan did not specify Relative Percent Difference (RPD) goals between the regular and duplicate samples for any of these measurements. All calculated RPDs between the regular and duplicate field samples were less than 12%. None of the field measurement data were qualified based on duplicate sampling results.

All Secchi disk measurements collected during October 17 and one measurement made at station CRBL12 on July 12 were conducted without the use of the viewing scope. These values were identified with an asterisk (*) following the value. The use of the scope eliminates some of the interference from waves and glare and generally Secchi disk values would be higher with use of a scope.

1 The Massachusetts Surface Water Quality Standards for Class B waters and the Massachusetts Minimum Standards for Bathing Beaches for E. coli using a single sample is $\leq$ 235 colonies /100ml for a geometric mean it is $\leq$ 126 colonies/100ml and is based on a geometric mean of the most recent five samples collected within the same bathing season or a six month period.

Field duplicate samples were collected during each of the six main sampling events and during three of the seven Havey Beach sampling events to evaluate sampling and analytical precision. Except for bacteria, during one sampling event, all of the field duplicate samples met the precision quality control goals established in the Project Work/QA Plan. On June 19, the duplicate samples for fecal coliform and E.coli did not meet the quality control criteria established in the Project Work/QA Plan. Since, both duplicate and regular samples exceeded the water quality criteria used in this report and all samples were with in the same magnitude, the use of these data were not limited in this report.

A trip blank was used to evaluate any contamination caused by: the sample container, sample preservation, sampling method, transportation to the laboratory, and/or laboratory processing. The trip blank (CRBL00) collected on June 19 for chemistry analysis showed no contamination and all values were reported as "ND" (non detect). Therefore, none of the presented data were limited because of any of the field quality control (duplicates and blank) samples collected.

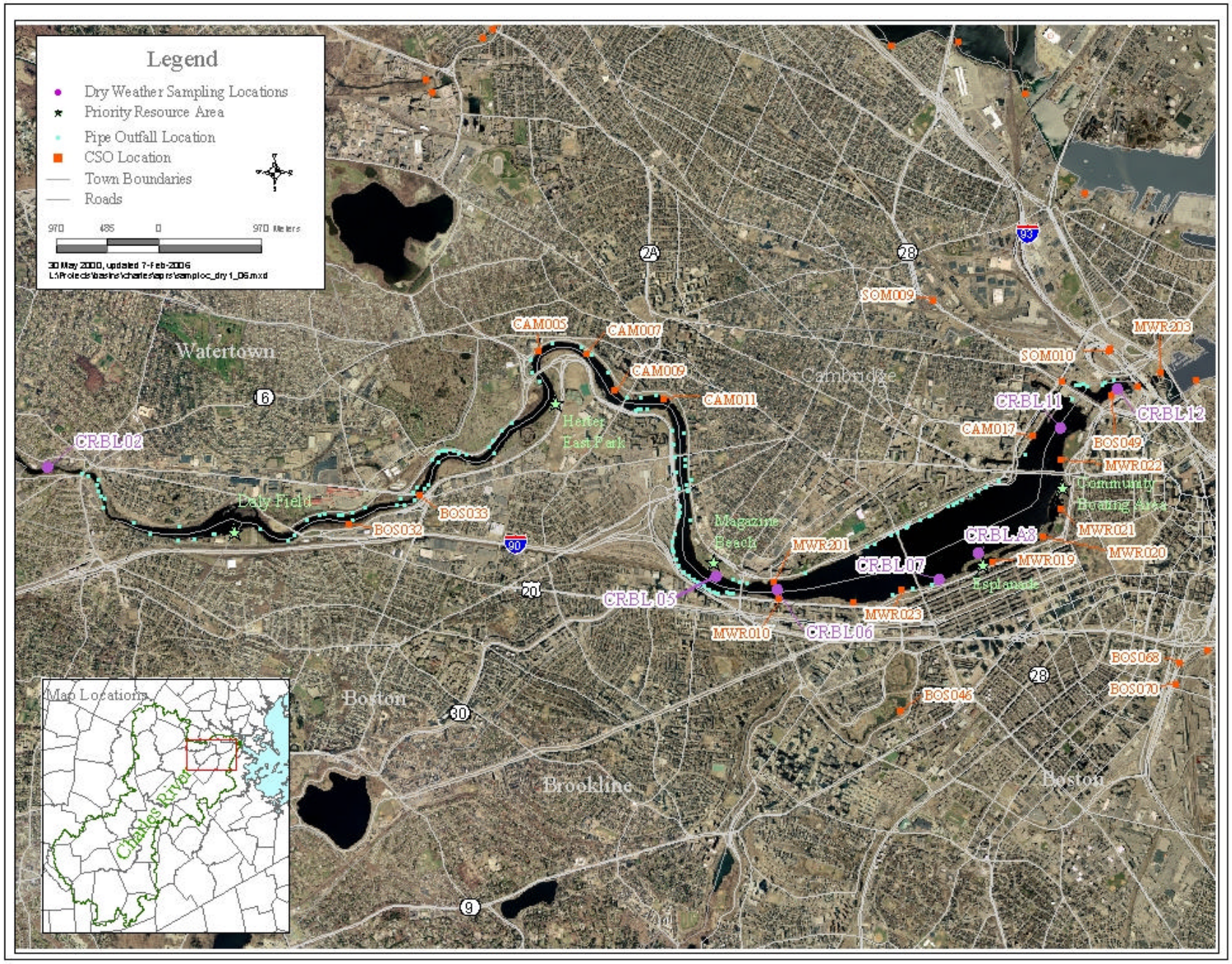

Figure 4: EPA Charles River Dry Weather Trend Station Locations

Figure 5: Locations of EPA Charles River Water Chemistry Profiles Collected on August 3, 2006

References

Beskenis, J.L, Massachusetts Department of Environmental Protection. 2006. Personal Communication

Breault, R.F, United States Geological Service. 2001. Personal Communication.

Breault, R.F., Barlow, L.K., Reisig, K.D., Parker, G.W., 2000. Spatial Distribution, Temporal Variability, and Chemistry of the Salt Wedge in the Lower Charles River, Massachusetts, June 1998 to July 1999. United States Geological Service. Water-Resources Investigation Report 00-4124

Eleria, A., Charles River Watershed Association. 2006. Personal Communication

Federal Interagency Stream Restoration Working Group. 1998. Stream Corridor Restoration Principles, Processes, and Practices. EPA841_R_98_900

Heltshe, J., United States Environmental Protection Agency, Office of Research and Development. 2006. Personal Communication

Massachusetts Department of Environmental Protection, Division of Watershed Management. 1998. Commonwealth of Massachusetts Summary of Water Quality Report.

Massachusetts Department of Environmental Protection, United States Environmental Protection Agency, New England Region, Tetra Tech, Inc. 2007. Draft Total Maximum Daily Load for Nutrients in the Lower Charles River Basin, Massachusetts CN 301.0.

New England Water Pollution Control Commission and ENSR International. 2000. Collection and Evaluation of Ambient Nutrient Data for Lakes, Ponds, and Reservoirs in New England – Data Synthesis Report. Final Report. June 2000.

United States Environmental Protection Agency. 2001. Ambient Water Quality Criteria Recommendations – Lakes and Reservoirs in Nutrient Ecoregion XIV. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-822-B-01-011

United States Environmental Protection Agency. 2000. Ambient Water Quality Criteria Recommendations – Rivers and Streams in Nutrient Ecoregion XIV. U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA-822-B-00-022

United States Environmental Protection Agency. 1996. Charles River Shoreline Survey. U. S. Environmental Protection Agency, Office of Environmental Measurement and Evaluation, Region I

United States Environmental Protection Agency. 2003. Clean Charles 2005 Water Quality Report, 2002 Core Monitoring Program. U. S. Environmental Protection Agency, Office of Environmental Measurement and Evaluation, Region I

United States Environmental Protection Agency. 2005. Clean Charles 2005 Water Quality Report, 2004 Core Monitoring Program. U. S. Environmental Protection Agency, Office of Environmental Measurement and Evaluation, Region I

United States Environmental Protection Agency. 2006. EPA's Annual Water Quality Report on the Lower Charles River 2005. U. S. Environmental Protection Agency, Office of Environmental Measurement and Evaluation, Region I

United States Environmental Protection Agency. 1994. Water Quality Standards Handbook - Second Edition. U.S. Environmental Protection Agency, Water Quality Standards Branch, Washington, DC. EPA-823-B-94-005a

Table A-1 EPA Charles River Annual Monitoring Data - 2006

Station	Time	Temp (Deg C)	Sp Cond. (uS/cm)	Salinity (ppth)	DO (%)	DO (mg/l)	pH	Turbidity (NTU)	Sonde (in-situ) Chlorophyll (ug/L)	Secchi (meters)	Transmissivity (%)	Fecal coliform (cfu/100ml)	E.coli (cfu/100ml)	Chlorophyll a (ug/L)	Orthophosphate as P (ug/L)	Total Phosphorus (ug/L)
Results from 6/19/06 Dry Weather Sampling																
CRBL02	11:50 AM	23.8	276	NA	96.3	8.1	6.9	3	8.5	NA	54	520	520	7	17	69
CRBL05	10:20 AM	24.6	287	NA	95.6	8.0	6.9	2	11.8	1.2	55	380	380	11	15	63
CRBL06	10:05 AM	24.2	288	NA	91.1	7.6	6.9	3	10.2	1.3	54	420	400	6	17	69
CRBL07	9:45 AM	24.0	293	NA	90.1	7.6	6.9	2	12.9	1.4	56	955	955	9	17	69
CRBLA8	9:30 AM	23.5	296	NA	86.3	7.3	6.8	3	11.9	1.4	53	937	937	11	19	74
CRBL11	9:10 AM	24.4	294	NA	90.4	7.6	6.9	2	10.5	1.5	59	410	410	10	16	61
CRBL12	8:40 AM	24.2	389	NA	91.1	7.6	7.0	1	12.4	1.6	60	220	200	11	15	65
CRBL07 (dup)	9:45 AM	23.9	293	NA	89.9	7.6	6.9	2	12.6	1.4	56	568	532	8	16	65
CRBL00	5:50 AM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND(4)	ND(4)	ND(2)	ND(5)	ND(5)
Results from 7/12/06 Dry Weather Sampling																
CRBL02	11:35 AM	25.3	376	0.18	92.8	7.6	7.1	1	10	NA	66	NA	360	8	13	76
CRBL05	10:10 AM	25.6	370	0.18	98.6	8.1	7.2	3	23.1	0.9	44	224	224	32	6	NA
CRBL06	9:50 AM	25.9	374	0.18	96	7.8	7.1	3	24.3	1	46	96	88	27	ND(5)	83
CRBL07	9:30 AM	25.8	419	0.2	74.7	6.1	7.0	2	8.9	1.3	62	204	184	5	26	96
CRBLA8	9:15 AM	25.5	409	0.19	78.4	6.4	7.0	1	8.9	1.4	63	176	176	6	23	91
CRBL11	8:50 AM	27.9	481	0.23	78.6	6.2	7.0	1	8	1.4	65	55	36	5	29	90
CRBL12	8:30 AM	27.3	552	0.26	77.4	6.1	7.1	1	8	1.4*	66	42	30	4	30	95
CRBLA8 (dup)	9:15 AM	25.5	408	0.19	78.6	6.4	7.0	1	9.1	1.4	63	196	184	6	23	98
Results from 8/9/06 Dry Weather Sampling																
CRBL02	11:45 AM	24.8	533	0.26	76	6.3	7.1	2	5	NA	81	11	11	ND(2)	12	45
CRBL05	10:25 AM	26.3	532	0.26	86.8	7.0	7.2	5	11.7	1.0	45	ND(4)	ND(4)	14	7	72
CRBL06	10:05 AM	26.1	605	0.29	74.9	6.1	7.1	5	10.3	1.0	49	120	112	15	9	90
CRBL07	9:45 AM	26.6	871	0.43	147.6	11.8	8.8	26	17.6	0.8	43	1189	1189	117	ND(5)	76
CRBLA8	9:30 AM	26.9	949	0.46	141.4	11.3	8.8	16	15.5	0.8	51	350	350	98	ND(5)	74
CRBL11	9:05 AM	28.7	1101	0.54	126.1	9.7	8.3	8	12.5	1.3	58	33	33	41	ND(5)	49
CRBL12	8:31 AM	27.7	1237	0.61	121.8	9.5	8.2	8	12.1	1.4	58	19	19	44	ND(5)	48
Old locks	8:50 AM	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,450	NA	NA
CRBL06 (dup)	10:05 AM	26.1	605	0.29	73.6	6.0	7.1	5	10.5	1.1	48	116	104	15	9	71
Results from 9/11/06 Dry Weather Sampling																
CRBL02	11:35 AM	19.9	477	0.23	88.5	8.1	7.2	1	4.6	NA	82	188	188	3	7	37
CRBL05	10:10 AM	20.7	506	0.24	95.3	8.5	7.2	4	13.1	1.2	52	78	75	18	ND(5)	56
CRBL06	9:55 AM	20.8	524	0.25	94.2	8.4	7.3	5	10.9	1.2	50	267	265	19	ND(5)	51
CRBL07	9:35 AM	20.8	925	0.46	120.1	10.7	8.6	4	14	1.4	59	19	14	38	ND(5)	30
CRBLA8	9:25 AM	20.9	924	0.46	119	10.6	8.6	4	14.4	1.4	61	22	22	37	ND(5)	31
CRBL11	8:45 AM	21.8	1010	0.5	115.5	10.1	8.5	4	16.2	1.5	62	6	6	40	ND(5)	39
CRBL12	8:25 AM	22.0	1342	0.67	115.3	10.1	8.4	3	20.9	1.7	65	17	14	37	ND(5)	27
CRBL11 (Dup)	8:45 AM	21.7	1011	0.5	115.5	10.1	8.5	3	16.7	1.5	62	22	19	42	ND(5)	33
Results from 10/17/06 Dry Weather Sampling																
CRBL02	11:15 AM	12.1	444	NA	95.8	10.3	7.3	2	8.8	NA	71	136	136	10	ND(5)	31
CRBL05	9:50 AM	13.0	478	NA	97.7	10.3	7.5	2	21.2	1.4*	60	69	64	20	ND(5)	27
CRBL06	9:30 AM	13.2	543	NA	95.3	10.0	7.5	2	19.5	1.4*	60	80	72	16	~ND(5)	27
CRBL07	9:15 AM	14.0	1011	NA	86.2	8.9	7.4	2	13.1	1.6*	68	108	108	14	ND(5)	29
CRBLA8	9:05 AM	14.3	1169	NA	92.7	9.5	7.6	2	15.5	1.7*	68	83	83	18	ND(5)	31
CRBL11	8:50 AM	16.4	1314	NA	95.6	9.3	7.6	2	15.8	1.7*	67	84	84	18	ND(5)	29
CRBL12	8:25 AM	15.8	1517	NA	93.5	9.2	7.6	2	15.4	1.9*	69	58	58	17	ND(5)	26
CRBL06 (Dup)	9:30 AM	13.2	544	NA	95.3	10.0	7.5	2	20.1	1.4*	60	112	100	16	ND(5)	27

Note:
ND = not detected above the associated detection limit
NA = not available
~ = estimated data
* = At station CRBL12 on 7/12/06 and at all stations on 10/17/07 Secchi disk measurements were performed without a scope, which deviates from the standard protocol.

Table A-2 Havey Beach Water Quality Sampling Result

Station	Date	Time	Conditions Dry o rWet	Temp (Deg C)	Sp Cond. (uS/cm)	Salinity (ppth)	DO (%)	DO (mg/l)	pH	Turbidity (NTU)	Sonde (in-situ) Chlorophyll (ug/L)	Fecal coliform (cfu/100ml)	E.coli (cfu/100ml)
534S	06/08/06	11:15 AM	Wet	14.9	188.1	0.09	66.5	6.66	6.4	NA	NA	960	740
HAV1	06/08/06	11:55 AM	Wet	14.9	199.6	0.09	68	6.81	6.3	NA	NA	740	680
534S	06/15/06	10:31 AM	Dry	18.7	200.2	0.09	61.2	5.66	6.4	NA	NA	58	66
HAV1	06/15/06	11:08 AM	Dry	18.7	204	0.09	59.6	5.52	6.4	NA	NA	88	96
534S	06/20/06	10:22 AM	Dry	24.5	241	NA	71.5	5.9	6.8	2.8	9.2	96	76
HAV1	06/20/06	11:00 AM	Dry	24.2	261	0.12	74.2	6.2	6.7	3.8	9.7	148	148
HAV1	07/18/06	7:15 AM	Dry	NA	NA	NA	NA	NA	NA	NA	NA	92	86
534S	07/26/06	10:15 AM	Dry	25.4	371	0.2	85.5	7.0	7.1	1.9	14.9	162	NA
HAV1	07/26/06	11:10 AM	Dry	25.3	378	0.2	94.7	7.7	7.1	3.1	14.2	266	NA
534S	08/09/06	11:30 AM	Dry	NA	NA	NA	NA	NA	NA	NA	NA	14	14
HAV1	08/09/06	11:50 AM	Dry	NA	NA	NA	NA	NA	NA	NA	NA	6	6
HAV1 (dup)	08/09/06	11:50 AM	Dry	NA	NA	NA	NA	NA	NA	NA	NA	14	14
534S	09/11/06	10:50 AM	Dry	18.3	376.2	0.53	74	7.06	7.5	NA	NA	33	33
HAV1	09/11/06	11:15 AM	Dry	18.7	378.2	0.02	85.6	8.1	7.4	NA	NA	47	47
HAV1(dup)	09/11/06	11:17 AM	Dry	NA	NA	NA	NA	NA	NA	NA	NA	25	25
534S	10/17/06	10:48 AM	Dry	10.2	365.4	0.18	81.5	9.26	7.1	NA	NA	36	25
HAV1	10/17/06	10:28 AM	Dry	10.3	371	0.18	82	9.3	7.1	NA	NA	39	30
HAV1(dup)	10/17/06	10:28 AM	Dry	NA	NA	NA	NA	NA	NA	NA	NA	28	28

Notes:
Samples collected on 6/15/06, 7/18/06 were analyzed by Alpha Analytical Laboratories, all other samples were analyzed at EPA's New Regional Laboratory
Field Chemistry data collected on 6/8/06, 6/15/06, 9/11/06, and 10/17/06 were collected by the Charles River Watershed Association (CRWA) using their equipment and protocols
Field Chemistry data collected on 6/20/06 and 7/26/06 were collected by the EPA using EPA equipment and protocols
All bacteria samples were collected by CRWA or CRWA and EPA

Table A-3 EPA Charles River Water Chemistry Profiles Collected On August 3, 2006

	Time (hours)	Depth (m)	Temp (°C)	SpCond (us/cm)	pH	GPS Location	Station Location	Total Depth (m)
Station 1								
	15:30	Surface	28.7	702	7.2	42deg. 21' 10.958" N	Mid-channel and upstream of Harvard Bridge.	5
	15:40	0.5	28.7	702	7.2	71deg. 05' 55.309" W		
	15:49	1	28.7	702	7.2			
	15:52	2	28.1	690	7.1			
	15:56	3	27.6	748	7.0			
	16:01	4	25.9	863	6.7			
	16:07	4.7	24.2	727	6.7			
Station 2								
	16:27	Surface	30.2	757	8.0	42deg. 21' 32.157" N	Mid-channel and upstream of Longfellow Bridge.	4.5
	16:31	0.5	30.1	755	8.0	71deg. 04' 49.790" W		
	19:47	1	30.0	770	7.5			
	16:34	2	29.8	744	7.8			
	16:38	3	28.8	708	7.4			
	16:44	4	28.4	784	7.3			
	16:54	4.3	27.1	2797	7.0			
Intake								
	17:07	Surface	30.6	780	7.8	42deg. 21' 43.925" N	Mouth of the intake canal.	1.5
	17:10	0.5	30.6	780	7.8	71deg. 04' 41.739" W		
	17:12	1	30.6	780	7.8			
Discharge								
	17:38	Surface	35.5	793	7.5	42deg. 21' 46.734" N	North side and downstream from intake 150m.	1.5
	17:42	0.5	37.0	808	7.5	71deg. 04' 40.039" W		
	17:45	1	38.1	810	7.5			
	17:50	1.3	38.6	817	7.4			
Station 4								
	18:58	Surface	30.8	802	7.7	42deg. 21' 48.652" N	Downstream of Longfellow Bridge	8.5
	19:01	0.5	30.8	801	7.7	71deg. 04' 26.530" W		
	19:06	1	30.7	797	7.6			
	19:12	2	29.6	772	7.5			
	19:15	3	28.9	762	7.4			
	19:18	4	28.2	1479	7.2			
	19:21	5	22.9	24517	7.1			
	19:24	6	18.7	32885	7.0			
	19:27	7	17.4	33505	7.1			
	19:28	8	18.0	34196	7.2			

Note

Data collected by Mathew Arvanites and Jonathon Merritt (reviewed by Tom Faber)

Station 1 GPS data was collected on August 3, 2006 and post processed

Station 2 GPS data was collected instantaneously on August 3, 2006

All other stations were navigated to using previous collected coordinates - GPS data from 2005

All presented data met post calibration criteria, DO data did not meet post calibration criteria and are not presented