IPSWICH RIVER WATERSHED ASSOCIATION

Connecting Communities from Source to Sea

RiverWatch Water Quality Volunteer Monitoring Program

The Ipswich River Watershed Association serves as the voice of the Ipswich River. Through outreach, education, monitoring,
and advocacy, we seek to connect the people, communities, and ecosystems integral to a healthy watershed.

2013 Annual Results Report

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Executive Summary

In 1997 the Ipswich River was listed as one of the 20 most threatened rivers in America. The level of threat to the Ipswich River was heightened in 2003 when it was ranked the third most endangered river in America by American Rivers, a national nonprofit, primarily due to low flow problems (American Rivers 1997 and 2003, IRWA 2003).

Much of the upper half of the River dried up or was reduced to isolated stagnant pools in the summers of 1995, 1997, 1999, 2001, 2002, 2003, and 2005. In 1999, the River experienced record low-flows in May, June, July and August. In 2000, the United States Geological Survey (USGS) completed a model of river flow that linked withdrawals for regional water supply with low flows in the Ipswich River. Major fish kills were also documented in 1995, 1997, 1999, 2002, and 2005.

Low flows continue to be a threat to the Ipswich River. In order to assess the health of the Ipswich River, the Ipswich River Watershed Association has maintained the RiverWatch Volunteer Water Quality Monitoring Program since 1997. Volunteers collect data monthly from March-December on weather conditions, rain in the last 48 hours, water color, water odor, water temperature, dissolved oxygen, velocity, depth, cross-sections and conductivity. Streamflow is also monitored at two sites in the upper watershed, where consistent flow data has been lacking. In 2013, volunteers monitored a total of 33 sites monthly from March to December. Two sites were monitored for streamflow by volunteers and 8 sites were sampled for benthic macroinvertebrates.

<u>Results</u>

The Ipswich River and many of its tributaries continue to show impairment for dissolved oxygen and flow and relative abundance of organisms. Dissolved oxygen (DO) is necessary for all forms of life that depend on the river. DO is influenced by many factors including flow and temperature. Dissolved oxygen levels below 5 mg/L create a stressful environment for fish and other aquatic organisms. Levels below 3 mg/L can be fatal to organisms that cannot move to areas of higher concentration. Large fish kills can result from DO levels that fall below 1-2 mg/L, even if those levels are present for only a few hours. Certain fish species, like brook trout, are especially sensitive to low DO.

Low DO conditions have been widespread and frequent since monitoring began in 1997. In 2013, 30% of the collected samples did not meet the state standard for dissolved oxygen concentration of 5 mg/L for class B waters. Figure 1 illustrates average summer dissolved oxygen concentration values at all sites. Sites located in the upper section of watershed continue to show a higher degree of impairment for dissolved oxygen than sites elsewhere.

All temperature samples met Massachusetts State Water Quality Standards. This indicates that temperatures are in an acceptable range along the Ipswich River. This may be an indicator of the importance that cool groundwater plays in providing the river's baseflow in summer. It is important to note that this measure does not consider the most extreme conditions as temperatures cannot be recorded when there is little (or no) water present in the river during extreme low flows. Also, monitoring is conducted in the morning, and may not represent the highest temperatures that occur in the course of that day or month.

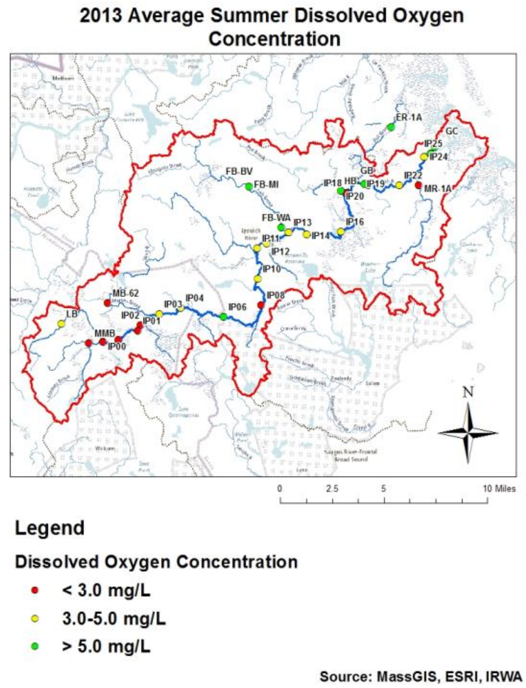


Figure 1. Average summer dissolved oxygen levels for 2013. Sites in red (< 3mg/L) represent a highly stressed environment for fish and other aquatic organisms.

There must be water in the river for most aquatic organisms to survive. The Ipswich River experiences significant periods of extreme low flow during many years. Withdrawals for drinking and irrigation water are the primary cause of unnaturally low flows in the Ipswich River (Armstrong 2001, Zarrielo and Ries 2000). While it might be expected that low flows occur seasonally, the low flows observed in the Ipswich River are about 1/10th of what might be considered "natural." Due to low flow, the Ipswich River is classified as highly stressed by the MA Water Resources Commission (2001) and impaired under section 303(d) of the Clean Water Act.

Streamflow gauges maintained by the United States Geological Survey (USGS) have recorded regular episodes of extended extreme low flow events since monitoring began in 1997. "Extreme low flow" is defined based on the USGS summer "ecological protection flow" (Horsley and Witten 2002), that "provides adequate habitat for the protection of fisheries" (Ibid). Extreme low flows were observed for 110 days in 2013, primarily during the summer and early fall.

Conductivity measures the ability of water to pass an electrical current resulting from the presence of dissolved solids (or salts) such as chloride, sulfate, sodium and calcium. Significant changes in conductivity can be an indicator that a discharge or some other source of pollution has entered the water. Rivers that can support healthy fisheries should be in the range of 150 to 500 µS/cm. In 2013, conductivity levels greater than 500 µS/cm were recorded at many sites, especially in the upper watershed. Elevated readings recorded in March and April may be the result of road-salt applications from the winter entering the river through spring runoff. Elevated readings during the summer may be an indicator of other sources such as septic systems.

Macroinvertebrate sampling indicates an absence of mayflies and frequent lack of stoneflies. These groups are the most sensitive to pollution and poor water quality conditions and their absence indicates long-term water quality issues at many sites. Many sites, especially in the upper watershed are dominated by amphipod crustaceans (scuds) which can thrive under poor water quality conditions.

Conclusion

The upper watershed continues to experience low dissolved oxygen levels, especially during the summer months, despite low flow conditions not being as severe as in years prior to 2006 when the town of Reading discontinued using wells adjacent to the Ipswich River. Martins Brook continues to experience severe low flows near active groundwater wells. Low flows impact the biological health of the watershed and a lack of abundance in macroinvertebrate groups sensitive to environmental stress indicate a moderate to severe degree of impairment at many sampling locations.

The primary cause of impairments in the Ipswich River watershed are low flow alterations due to water withdrawals and impervious surfaces contributing to stormwater runoff. Under these conditions, dissolved oxygen levels decrease below what is suitable to aquatic life such as fish and macroinvertebrates that are an important part of the aquatic food web.

Water has remained in the river year-round since Reading discontinued well use, showing that reductions in water withdrawals and water restrictions by towns can have a beneficial effect on the Ipswich River.

Our deepest thanks to our volunteers that have monitored on sunny and rainy days, in cold and heat and high and low river flows. Thank you for your considerable efforts and dedication to the Ipswich River!

Section 1: Overview of the RiverWatch Monitoring Program

1.1 Description

The Ipswich River Watershed Association has conducted the RiverWatch water quality monitoring program since 1997. The program enlists a group of volunteers to collect water quality data on the Ipswich River and its tributaries. The purpose of the program is to establish baseline data in order to identify and address impairments to water quality and quantity, as well as to promote awareness and stewardship of the river. The RiverWatch program expanded upon an earlier, informal water quality monitoring program that ran from 1988 – 1996. An EPA-approved Quality Assurance Project Plan (QAPP) was finalized in 1999 and most recently updated in 2013. The goal of the RiverWatch program is to provide high quality data regarding the health of the Ipswich River. This monitoring program has established a crucial baseline of water quality and biological data, which continues to enable IRWA to work with researchers and government officials to better manage the watershed and improve the condition of the Ipswich River.

The specific goals of regularly monitoring the Ipswich River and its tributaries include:

- Defining the baseline water quality conditions of the Ipswich River and key tributaries.
- Defining the range of dissolved oxygen concentrations, temperature and conductivity over the range of annual conditions in both mainstem and tributary locations.
- Determining the relative water level and flow at a variety of ungauged locations around the basin.
- To observe the River, habitat and wildlife, and report on observations.
- To identify pollution hotspots.
- To educate watershed residents about the river.
- To promote stewardship of the river.

Monitors collect data monthly on weather conditions, rain in the last 48 hours, water color, water odor, water temperature, dissolved oxygen, conductivity, velocity and depth. In addition, two streamflow monitoring stations were established in the upper watershed in 2012 in cooperation with the Mass. Division of Ecological Restoration. Volunteers read staff gages at these sites and the data are converted to a streamflow value from rating curves produced by DER staff.

The purpose of this report is to summarize data collected in 2013 by volunteers for the RiverWatch program. Specific site data are available in the appendix.

Data collected by IRWA will be reported to IRWA members, state agencies, interested organizations, and conservation commissions through reports and presentations on the collected data. Atypical data will be reported to the appropriate agencies. Atypical data include dissolved oxygen data that vary significantly from adjacent sites over one or more months. Extended periods of no flow or extremely low dissolved oxygen (less than 2 mg/L) are also considered extremely important and will be presented to state agencies. When dissolved oxygen levels fall below 2 mg/L the health of fish and other aquatic organisms can be severely impacted.

Section 2: An Introduction to the Ipswich River

The Ipswich River watershed is 155 square miles and includes all or part of 21 communities in northeastern Massachusetts. The topography of this Atlantic coastal plain basin is characterized by low relief, with an average grade of 3.1 feet per mile. The length of the river is a meandering 40 miles. The surficial geology of the region consists primarily of glacial till with stratified sand and gravel deposits covering about 43 percent of the basin and alluvial deposits covering about 3 percent of the basin. Extensive wetlands are present along the River and streams within the Ipswich River basin. These wetlands protect surrounding areas during flooding as well as positively affect the water quality of the River and streams in the basin.

This river system supplies water to more than 330,000 people and thousands of businesses, providing all or part of the water supply for 14 communities: Beverly, Danvers, Hamilton, Ipswich, Lynn, Lynnfield, Middleton, North Reading, Peabody, Salem, Topsfield, Wenham, and Wilmington.

In 1997 and again in 2003, American Rivers, a national nonprofit, recognized the Ipswich River as one of the most threatened or endangered rivers in America, primarily due to severe low flow problems (American Rivers 1997, 2003, IRWA 2003, Zarriello and Reis 2000). Much of the upper half of the River dried up or was reduced to isolated stagnant pools in the summers of 1995, 1997, 1999, 2001, 2002, 2003, and 2005. In 1999, the River experienced record low-flows in May, June, July and August. Major fish kills were documented in 1995, 1997, 1999, 2002, and 2005.

The primary causes of impairments in the Ipswich River watershed are low flow alterations from groundwater withdrawals and runoff from impervious surfaces. This results in a loss of groundwater that supports the baseflow of the river between precipitation events. Low flows have the effect of causing the river to heat more rapidly in the summer. Additional warming in the summer is caused by stormwater runoff directly entering the river from paved areas when runoff is typically much warmer than groundwater. Under these conditions, dissolved oxygen levels decrease below what is suitable to aquatic life such as fish and macroinvertebrates that are an important part of the aquatic food web.

Low flows in summer have been linked to ground water withdrawals, particularly in the upper watershed (Zarriello and Reis 2000). Additionally, the diversion of wastewater to treatment plants outside the watershed also significantly reduces flow (Ibid). Many sub-basins in the watershed experience severe flow depletion seasonally due to groundwater withdrawals and significant annual flow depletion due to surface water withdrawals (Weiskel, *et al*. 2009).

Low flow problems have resulted in the loss of flow dependent fish species that would otherwise occur in the Ipswich River (Armstrong et al. 2001). The study identified critical aquatic habitats and recommended minimum flows necessary to preserve those habitats. The Ipswich River Fisheries Restoration Task Group then developed recommendations to restore healthy fisheries to the Ipswich River (2002). These recommendations include maintaining flow over riffle areas, maintaining water to the channel margins and maintain seasonal flow variations near natural levels (Ibid).

Under the Massachusetts Surface Water Quality Standards (MA DEP 1996), most of the freshwater section of the Ipswich River is classified as a Class B water body and warm water fishery, except for public water supplies and certain tributaries (Table 1). The water quality goal for Class B waters is to be “fishable and swimmable” throughout the year. The tidal section of the river located downstream of the Ipswich Dam is classified as a class SA water body. Class SA water bodies are tidal waters intended to be fishable, swimmable, and safe for shell fishing. Table 2 details the water quality standards associated with these classifications.

The Massachusetts Department of Environmental Protection (MassDEP) monitors surface water quality and develops a plan to bring back into compliance those waters that do not meet standards. Under section 303d of the Clean Water Act, states are required to report a list of impaired waters and in the final 2012 list; all sections of the Ipswich River were designated as impaired (MassDEP, 2012) (figure 2). A watershed monitoring program on a 5 year rotating schedule is implemented by MassDEP to identify and rank impaired waterbodies. In the 2000 Water Quality Assessment Report for the Ipswich River watershed, 91% of the named river miles throughout the watershed were assessed and 53% of these were impaired for supporting healthy populations of aquatic life (Mass DEP, 2000).

The RiverWatch water quality monitoring program is an effort to provide high quality data on the health of the Ipswich River in order to make informed decisions about water management practices and monitor ongoing restoration efforts.

Our thanks to our volunteers that have monitored on sunny and rainy days, in cold and heat, and high and low river flows. Thank you for your considerable efforts and dedication to the Ipswich River!

Table 1. Massachusetts surface water classifications for the Ipswich River watershed and coastal drainage area (MassDEP, 2007).

BOUNDARY	MILE POINT	CLASS	OTHER RESTRICTIONS
Ipswich River			
Source to Salem Beverly Waterway Canal	41.1 - 16.4	B	Treated Water Supply, Warm Water, High Quality Water
Salem Beverly Waterway Canal to tidal portion	16.4 - 4.5	B	Warm Water, High Quality Water
Tidal portion and tributaries thereto	4.5 - 0.0	SA	Shellfishing (O)
Middleton Pond			
Source to outlet in Middleton and those tributaries thereto	-	A	Public Water Supply
Swan Pond			
Source to outlet in North Reading and those tributaries thereto	-	A	Public Water Supply
Mill Pond			
Source to outlet in Burlington and those tributaries thereto	-	A	Public Water Supply
Longham Reservoir			
Source to outlet in Wenham and those tributaries thereto	-	A	Public Water Supply
Wenham Lake			
Source to outlet in Wenham and those tributaries thereto	-	A	Public Water Supply
Putnamville Reservoir			
Source to outlet in Danvers and those tributaries thereto	-	A	Public Water Supply
Suntaug Lake			
Source to outlet in Lynn and Peabody and those tributaries thereto	-	A	Public Water Supply
Winona Pond			
Pond to outlet in Peabody and those tributaries thereto	-	A	Public Water Supply
Unnamed Reservoir (Emerson Brook Reservoir)			
Reservoir to outlet in Middleton and those tributaries thereto	-	A	**Public Water Supply**

Table 2. Massachusetts Department of Environmental Protection water quality standards (2007).

	Class B Standards	Class SA Standards
AQUATIC LIFE		
Dissolved Oxygen	5.0 mg/L *	6.0 mg/L
Temperature	83° F Max * (28.3° C)	85 F (29.4° C) Max, 80 F Average
pH	6.5 - 8.3	6.5 - 8.5
PRIMARY CONTACT RECREATION		
Fecal Coliform	200 / 100 mL geo. mean 10% <= 400 / 100 mL	200 / 100 mL geo. mean 10% <= 400 / 100 mL
SECONDARY CONTACT RECREATION		
Fecal Coliform	1000 / 100 mL geo. mean 10% <= 2000 / 100 mL	1000 / 100 mL geo. mean 10% <= 2000 / 100 mL
SHELLFISHERY		
Fecal Coliform	Not applicable	14 / 100 mL geo. mean 10% <= 43 / 100 mL
AESTHETICS		
Taste and Odor	None that are objectionable	None other than natural

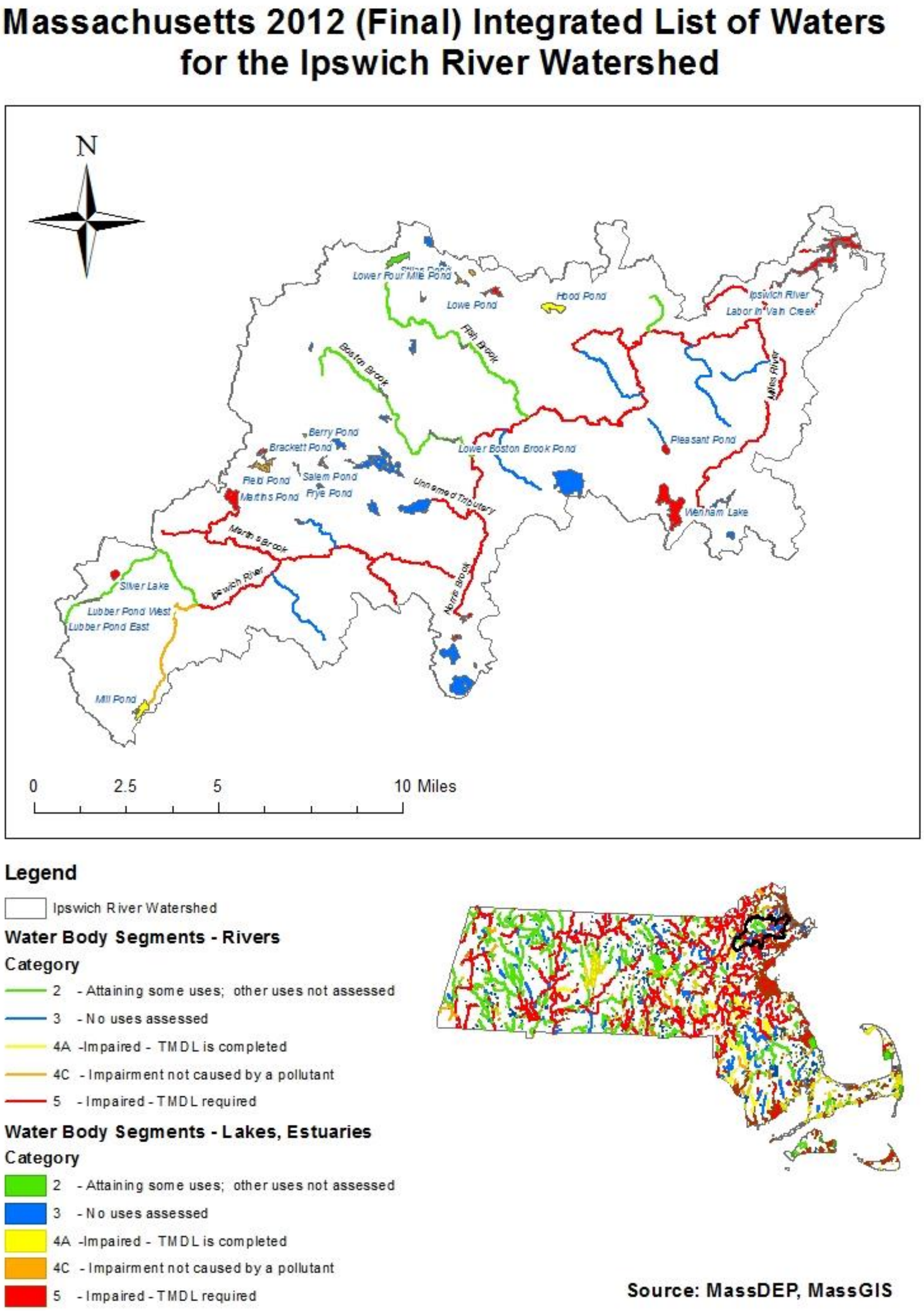
* Warm water fishery.

1314 CMR 4.05 (3) (b)1.b. states that Dissolved Oxygen “levels shall not be lowered below…60% of saturation in warm water fisheries due to a discharge.” This report will therefore assume 60% of saturation to be the Class B standard.

*In 2008, the State eliminated standards pertaining to DO% saturation. Values in this report are based on the previous standard of a minimum of 60% DO saturation and presented for comparison with previous years.

2314 CMR 4.05 (4)(a)1.b.states that Dissolved Oxygen “levels shall not be lowered below 75% of saturation due to a discharge.” This report will therefore assume 75% of saturation to be the Class SA standard.

Figure 2. **Final Massachusetts Year 2012 Integrated List of Waters (EEA, 2012).**



2.1 Program Description and Monitoring Methods

Monthly Water Quality Testing

As stated earlier, IRWA has conducted informal monitoring from 1988-1996. The RiverWatch program took its current form in 1997 and has been continuously monitoring the Ipswich River Watershed since this time. In order to best use our resources to gain an accurate picture of the Ipswich River, 10 tributary sites and 22 sites along the mainstem of the River from Wilmington to Ipswich, have been identified for monitoring once a month from March through December (figure 1, table 3). Both Fish Brook at Brookview Farm Rd. (FB-BV) and Greenwood Creek (GC) were discontinued in 2001.

The goal of the RiverWatch Program is to produce data of sufficient quality to be acceptable for its intended use and audience, for the following parameters:

1. Weather
    a. To determine if the collected data is related to weather conditions. Dissolved oxygen, water temperature, water color, water odor and velocity are affected by precipitation. Cloud cover and other climatic factors may also affect DO and temperature.
2. Rain in the last 48 hours
    a. To determine if the collected data is related to weather conditions. Dissolved oxygen, water temperature, water color, water odor and velocity are affected by precipitation.
3. Water Color
    a. To record any abnormal coloration of the water potentially indicating a pollution issue.
4. Water Clarity
    a. To record any abnormal sediment loading of the water potentially indicating a pollution issue.
5. Water Odor
    a. Assessment of potential pollution concerns.
6. Water Temperature:
    a. To determine if the MassDEP defined water quality standards are met
    b. To determine what wildlife the temperature of the river will support
    c. To investigate the relationship between low flow and temperature and
    d. To determine dissolved oxygen saturation levels
7. Dissolved Oxygen
    a. To determine if the MADEP defined water quality standards are met and
    b. To determine areas/periods of low DO
8. Flow
    a. To determine if flow present is able to support designated uses and habitat
    b. To establish timeline trend of baseline indices of velocity for each site to act as an indicator for flow, which cannot be measured within accuracy limits.
    c. Flow is calculated based on river cross-section, velocity and depth information.
    d. To determine flow on Martin's Brook and Ipswich River upstream of South Middleton USGS gage.
9. Conductivity
    a. To establish baseline conditions and potentially identify stormwater contributions to stream and river flow.

Volunteer monitors are responsible for monthly monitoring which takes place in the morning of the last Sunday of each month from March through December unless the date conflicts with a holiday, in which case, the previous or next Sunday will be chosen. All samples are collected between 8 am and 12:30 pm, except for the tidal locations, which are sampled within 1 hour of low tide closest to the 8 am to 12:30 pm time span. Sampling in the morning is extremely important because the lowest dissolved oxygen values are generally observed in the early morning. This is desirable, because low values have the most potential to affect the organisms living in the Ipswich River. As of the spring of 2006, sampling in January and February became optional. Historically, volunteers sampled during these months, but the River was often frozen and the data collected during these months was generally not used in management decisions.

Volunteers record information on weather, rain in the last 48 hours and river status (frozen or dry). Monitors then collect a grab sample using a bucket. While water is contained in the sampling bucket, observations of color, clarity and odor are made. Color is recorded as a range of pre-determined colors from Clear to Dark Tea. Clarity is recorded as the amount of turbidity in the water from a scale ranging from clear to highly turbid.

Water temperature is measured followed by a test for dissolved oxygen. Water Temperature is measured with H-B Enviro-Safe® Thermometers. Monitors are asked to round to the nearest 0.5 degrees Celsius.

Dissolved Oxygen (DO) is measured with a LaMotte Modified Winkler Method Test Kit. One drop of fluid from the direct reading titrator in the kit is approximately 0.4 mg/L. Thus, accuracy from the titrator is +/- 0.2 mg/L of dissolved oxygen. Results from DO kits were compared with results from other test kits or a dissolved oxygen meter, obtained by the trainer, with a goal of all sites being within 1mg/L of measure DO concentration. In addition, duplicate DO samples were taken at each site at least once during the monitoring year.

For DO, a percent saturation value is also calculated. This is a percentage of the DO measured in the water relative to the maximum DO water could theoretically hold at the testing water temperature (and elevation).

Depth is measured at a consistent location on the bridge with a weight attached to a decimal measuring tape. Cross-sections are taken at monitoring sites located at selected bridges twice each year. Monitors take depths at one to two foot increments across the channel. Monitors try to take 20 measurements across the bed of the channel. On the cross section data sheet, volunteers indicate at what location they measure depth each month. An approximate flow value can be calculated by adding the product of average velocity by each cross-sectional area.

Velocity is measured by dividing the average of three times that it takes an orange peel to travel a known distance (often the width of a bridge). If times are disparate, another three readings are taken.

Conductivity is measured at selected sites as an indicator of human impact from sources such as stormwater runoff. Ions from sources such as road salts and leaking septic systems increase conductivity which can negatively impact aquatic life. All nine tributary sites are monitored for conductivity since these may be expected to vary more than along the mainstem of the river where five sites are monitored to detect variations. This is done using an Oakton Eco Testr EC Low or Oakton ECTestr Low conductivity meter. The meter is first rinsed with deionized or distilled water. The meter is calibrated using 447 µSiemens/cm conductivity standard solution. The meter is rinsed again and placed in the sampling bucket to record the conductivity value.

As stated previously, data collected will be reported to IRWA members, state agencies, interested organizations, and conservation commissions through reports and presentations on the collected data. Atypical data will be reported to the appropriate agencies. Atypical data include dissolved oxygen data that vary significantly from adjacent sites over one or more months. Extended periods of no flow or extremely low dissolved oxygen (less than 2 mg/L) are also considered extremely important and will be presented to state agencies. (When dissolved oxygen levels fall below 2 mg/L the health of fish and other aquatic organisms can be severely impacted.)

For data to be reported to state agencies, a Quality Assurance Project Plan (QUAPP) is maintained with MassDEP and most recently updated for the period 2013-2015. The QUAPP requires all new and returning monitors to receive annual training, and an annual site audit of each volunteer. Prior to monitoring, new monitors receive a walk-through of the monitoring manual and hands-on training at a monitoring site. All new and returning monitors must attend an annual training that consists of an overview of the program and procedures followed by a collection and analysis of temperature, dissolved oxygen and conductivity samples for comparison with readings obtained by the Monitoring Project Coordinator. Records of data generated during this training as well as attendance records are retained by IRWA.

During the year, each site is audited by the Monitoring Project Coordinator. This consists of the observation of the volunteer by the auditor. Any errors in procedure are recorded on the project audit sheet and problems discussed and resolved with the volunteers.

Figure 3. RiverWatch monitoring sites and monitoring type. Detailed description on following page.

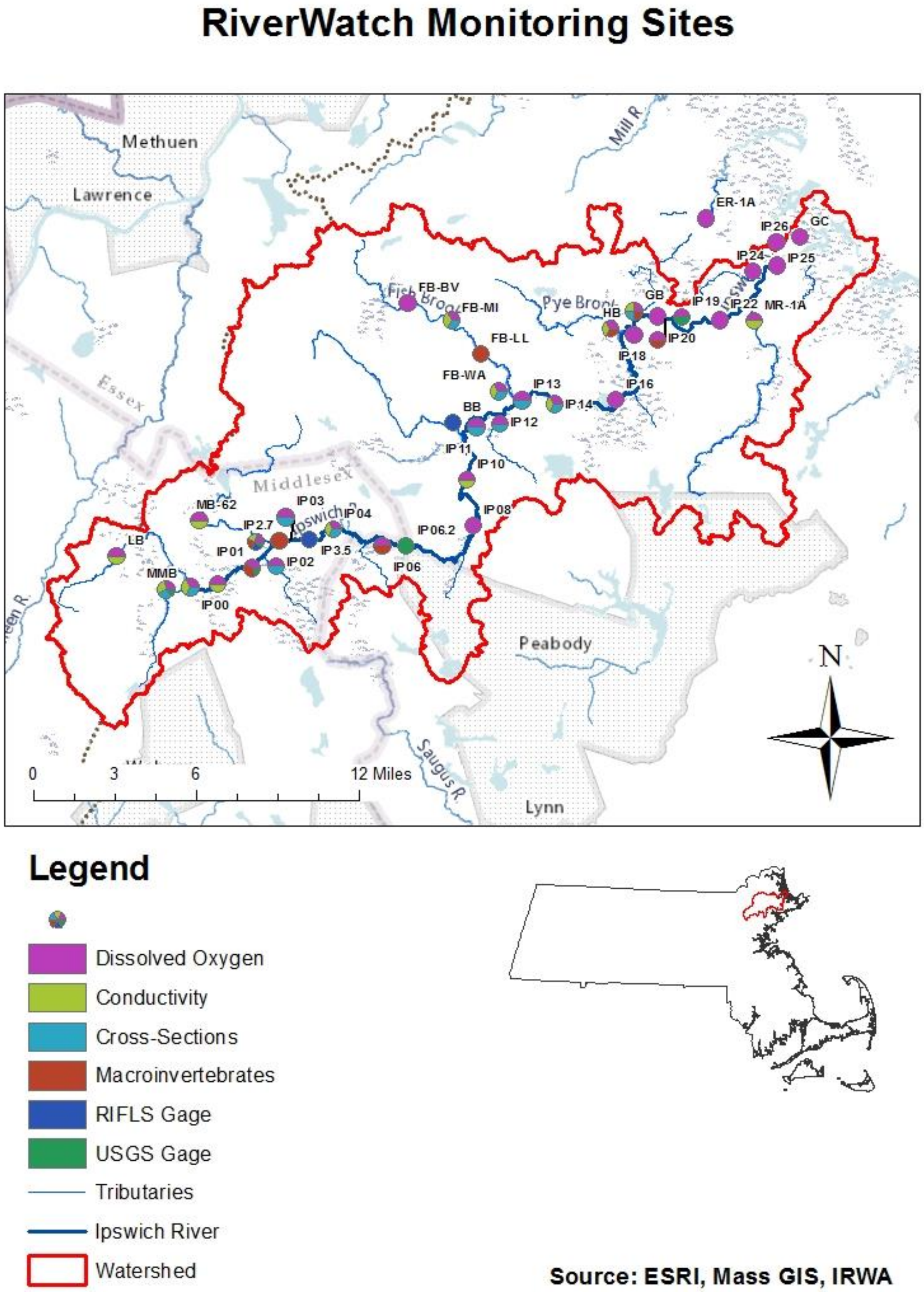


Table 3. Monitoring sites and parameters measured.

Site ID	Site Name	Stream	Town	Date Start	Dissolved Oxygen/ Temp	Conduc tivity	Cross-Sections	Macroinver -tebrates	RIFLS Discharge Gage	USGS Discharge Gage
BB	Boston Brook at Peabody Street	Boston Brook	Middleton	8/12					Yes	
ER-1A	Egypt River Rt. 1A	Egypt River	Ipswich	3/11	Yes					
FB-BV	Fish Brook at Brookview Road	Fish Brook	Boxford	1/97-01	Yes					
FB-LL	Fish Brook at Lockwood Lane	Fish Brook	Boxford	10/13				Yes		
FB-MI	Fish Brook at Middleton Road	Fish Brook	Boxford	3/99	Yes	Yes	Yes			
FB-WA	Fish Brook at Washington Street	Fish Brook	Topsfield	3/99	Yes	Yes	Yes			
GB	Gravelly Brook	Gravelly Brook	Ipswich	6/11	Yes	Yes		Yes		
GC	Greenwood Creek	Greenwood Creek	Ipswich	9/97-01	Yes					
HB	Howlett Brook at Ipswich Road	Howlett Brook	Topsfield	3/99	Yes	Yes		Yes		
IP00	Woburn Street Bridge	Ipswich River	Wilmington	1/97	Yes	Yes	Yes			
IP00.5	Reading Town Forest	Ipswich River	Reading	11/97	Yes	Yes				
IP01	Mill Street Bridge	Ipswich River	Reading	1/97	Yes			Yes		discontinued
IP02	Main Street (Rt. 28) Bridge	Ipswich River	Reading	1/97	Yes		Yes			
IP03	Central Street Bridge	Ipswich River	North Reading	1/97	Yes		Yes			
IP04	Washington St. (Rt. 62) Bridge	Ipswich River	North Reading	1/97	Yes	Yes	Yes			
IP06	Boston Street Bridge	Ipswich River	Middleton	1/97	Yes			Yes		
IP06.2	South Middleton Gage	Ipswich River	Middleton							Yes
IP08	Log Bridge Road	Ipswich River	Middleton	3/99	Yes					
IP10	Maple Street (Rt. 62) Bridge	Ipswich River	Middleton	1/97	Yes	Yes				
IP11	Peabody Street Bridge	Ipswich River	Middleton	1/97	Yes		Yes			
IP12	East Street (Thunder Bridge)	Ipswich River	Middleton	1/97	Yes		Yes			
IP13	Rowley Bridge Road	Ipswich River	Topsfield	1/97	Yes		Yes			
IP14	Salem Road Bridge	Ipswich River	Topsfield	1/97	Yes	Yes	Yes			
IP16	IRWS Canoe Launch	Ipswich River	Topsfield	1/97	Yes					
IP18	Asbury Street Bridge	Ipswich River	Topsfield	1/97	Yes					
IP19	Below Willowdale Dam	Ipswich River	Ipswich	1/97	Yes					Yes
IP19A	Above Willowdale Dam	Ipswich River	Ipswich	3/10	Yes					
IP2.7	Parish Park	Ipswich River	North Reading	10/99				Yes		
IP20	Winthrop Street Bridge	Ipswich River	Ipswich	1/97	Yes			Yes		
IP22	Mill Road Bridge	Ipswich River	Ipswich	1/97	Yes					
IP24	Ipswich Dam, County Rd. (Rt. 1A)	Ipswich River	Ipswich	1/97	Yes					
IP25	Green Street Bridge	Ipswich River	Ipswich	1/97	Yes					
IP26	Town Wharf, Water Street	Ipswich River	Ipswich	1/97	Yes					
IP3.5	Haverhill Street Bridge	Ipswich River	North Reading	6/12					Yes	

Site ID	Site Name	Stream	Town	Date Start	Dissolved Oxygen/ Temp	Conduc tivity	Cross-Sections	Macroinver -tebrates	RIFLS Discharge Gage	USGS Discharge Gage
LB	Lubbers Brook at Glen Road	Lubbers Brook	Wilmington	8/97	Yes	Yes				
MB-62	Martins Brook Salem Street (Route 62)	Martins Brook	Wilmington	1/11	Yes	Yes				
MB-PS	Martins Brook at Park Street	Martins Brook	North Reading	3/99	Yes	Yes		Yes	Yes	discontinued
MMB	Maple Meadow Brook at Wildwood Street	Maple Meadow Brook	Wilmington	8/97	Yes	Yes	Yes			discontinued
MR-1A	Miles River, County Road (Rt. 1A)	Miles River	Ipswich	3/99	Yes	Yes				

Streamflow Monitoring

Having adequate amounts of flowing water is essential for the health of rivers and streams. The Ipswich River has a history of flow alterations from water withdrawals, particularly in the upper watershed, so measuring streamflow is important to understanding low-flow impacts.

Two real-time streamflow gages are maintained by USGS on the Ipswich River in South Middleton and Ipswich that transmit real-time discharge data. These gages have recorded flow levels since the 1930's, as both a historical record of the river and vital source of real-time information needed to manage municipal water supplies. However, many sections of the river and streams in the watershed are not gaged.

In 2012, IRWA began a partnership with the Massachusetts Division of Ecological Restoration's (DER), River Instream Flow Stewards (RIFLS) Program to monitor streamflow at two sites in the upper watershed. The RIFLS program enables local groups to document streamflow on otherwise ungaged sections of rivers to investigate any signs of flow alteration, with the goal of restoring more natural flow patterns.

Two sites in the upper watershed were selected based on the need to monitor flow alterations in this area: Haverhill St. in North Reading, designated IP3.5, and Martins Brook at Park St., also in North Reading (figure 3). A new staff gage was installed on the bridge abutment at IP3.5 in June 2012. An existing staff gage that was part of a flow monitoring station maintained by USGS from 2007-2009 is now being used as the RIFLS gage on Martins Brook. Volunteers read staff gages at these sites on a regular basis and enter data to the RIFLS.com website where it is converted to a streamflow value in cubic feet per second (cfs) from rating curves maintained by the RIFLS staff.

Data are downloaded from the RIFLS and USGS websites for analysis. Individual gage data are compared by converting mean daily streamflow values from cfs to cubic feet per second per square mile (cfsm). The drainage area values needed for this conversion are obtained from either the USGS or RIFLS websites for each gage. Daily discharge values in cfsm are plotted together and compared. When normalized for area, flows at the RIFLS and USGS gages should be similar. Differences may indicate a flow alteration such as from groundwater pumping. Groundwater pumping records can be used to identify the source, which is the focus of ongoing work.

Section 3: Monthly Water Quality Testing

3.1 Monthly RiverWatch Monitoring Results by Parameter

Temperature

In 2013, all but one sample met the Class B standard or Class SA standard for maximum water temperature The Class B standard is a maximum of 28.5° Celsius (83°F); the Class SA standard is a maximum of 29.4° Celsius (85°F), and applies to the tidal sites of IP25, and IP26.

Temperature is an important measure of water quality, as temperatures higher than the natural observed range can reduce the amount of dissolved oxygen that the water can hold (more on dissolved oxygen in the next section). This can create a stressful environment for aquatic organisms. For example, some fish, like brook trout, cannot survive in warm water.

Annual Statistics

Table 3 is a summary of annual statistics for temperature. Temperature has exceeded the state standard only 5 times since 1997. This does not reflect the times the river has dried up and monitoring could not take place. Figure 4 is a comparison of average annual and maximum water temperature for 2013, while figure 5 illustrates long-term trends in water temperature.

Table 3: Annual temperature statistics for all sites.

Water Quality Parameter	Year	# Samples	Range	Average	Summer Average	Winter Average	#Samples Outside Class B/SA Standard
Water Temp	1997	201	-4 - 26	9.8	21.4	2.3	0
(degrees C)	1998	264	-1 - 32	12.7	21.4	6.6	1
	1999	315	-0.5 - 28	12.1	22.9	5.2	0
	2000	295	-5.6 - 25	11.3	20.4	4.2	0
	2001	265	-1 - 25.3	11.0	20.4	3.9	0
	2002	291	-2 - 25.5	10.0	20.2	3.7	0
	2003	237	0 - 29	12.3	21.5	5.7	1
	2004	247	-2 - 25	11.4	20.2	5.1	0
	2005	264	-2.5 - 34	11.0	21.3	2.9	2
	2006	268	-0.5 - 28	11.1	21.1	5.2	0
	2007	230	-1 - 26	12.8	21.7	5.8	0
	2008	225	-1 - 29	12.2	20.7	4.1	1
	2009	209	0-24	13.8	18.8	7.4	0
	2010	235	-1 - 27.5	13.7	22.1	5.5	0
	2011	228	0.1-26	12.6	20.0	4.8	0
	2012	287	0-30	13.3	22.2	7.0	1
	2013	239	0-26	14.6	21.8	4.9	0
	Entire Record	4300	-5.6 - 34	12.1	21.1	4.9	6

Figure 4. Maximum and Average Water Temperatures, by Site, 2013. The dashed line indicates the maximum temperature for class B (28.5°C) and Class SA waters (29.4°C).

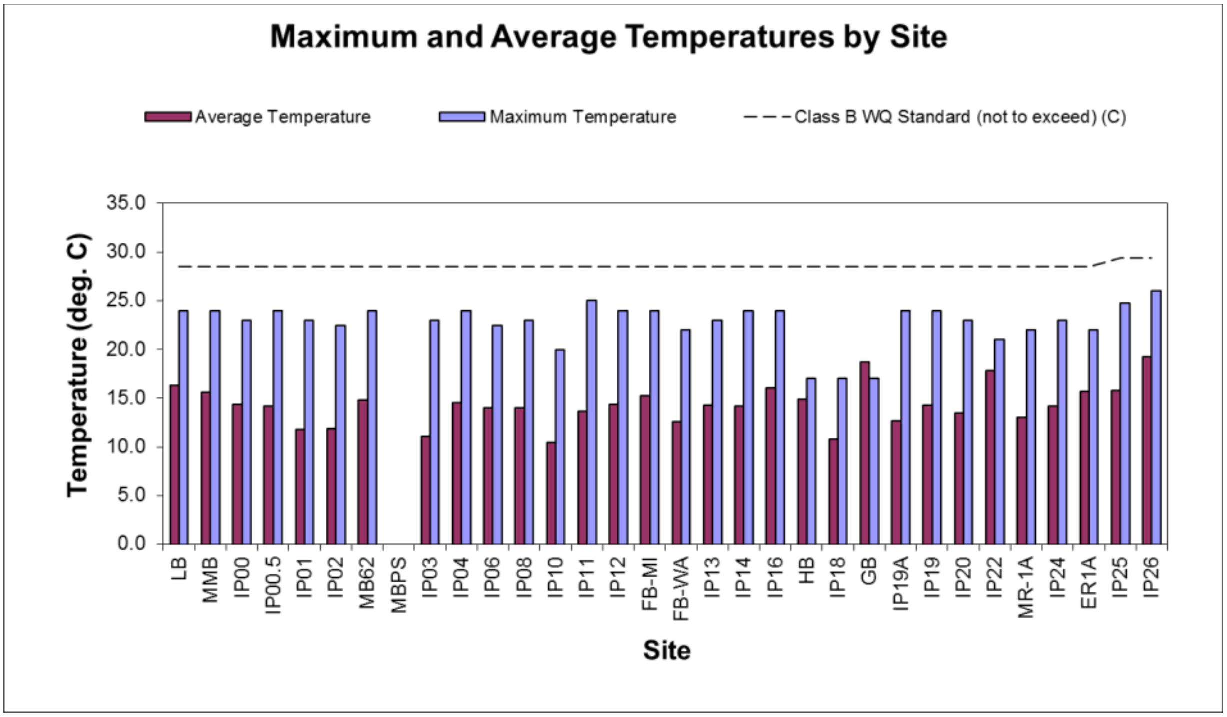
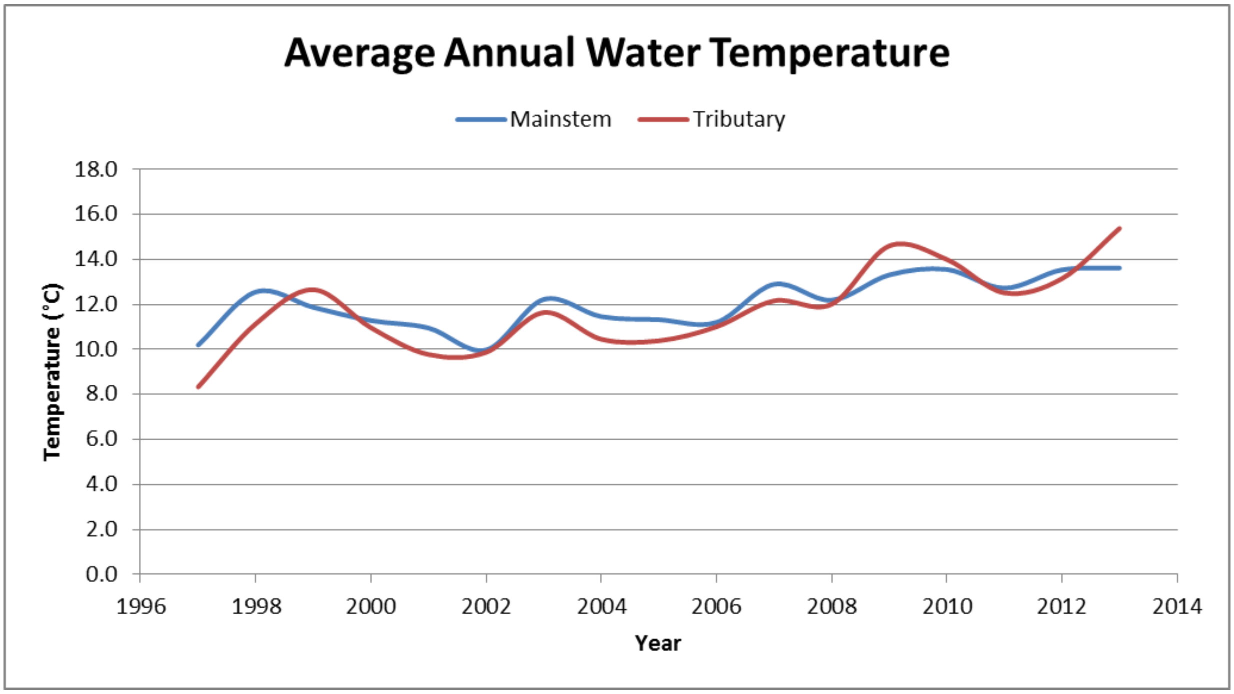


Figure 5. Comparison of average annual water temperature for mainstem and tributary monitoring sites.



General Findings

Water temperature readings met state standards throughout 2013 across the watershed (i.e., temperatures remained below the state standard maximum temperature). It is important to note that recorded temperatures are conservative, as temperatures are not recorded when there is no water present in the river during extreme low flows. Also, monitoring is conducted in the morning, and may not represent the highest temperatures that occur in the course of that day or month.

Long-term trends in the data suggest an increase in average annual water temperature. More analysis is required to determine a statistical significance to this trend. Tributary sites appear to show a higher rate of increase in more recent years. Tributaries would be expected to vary more than the mainstem, given that they are often shallower and more likely to show water temperature changes in response to changes in temperature in the atmosphere.

Dissolved Oxygen

The amount of dissolved oxygen (DO) in water depends on numerous factors, including the temperature of the water and the gas exchange across the air-water interface. DO can increase when water is at lower temperatures and in areas where there is turbulence in the water (e.g., riffles or rapids). Other primary factors affecting DO include oxygen production through photosynthesis and depletion through respiration and other oxygen-demanding processes. DO changes on a diurnal basis as well as seasonally, and is affected by cloud cover and other weather conditions. The most critical time for organisms is in the early morning hours on hot summer days when water temperatures are high, flows are low and photosynthesis has ceased producing oxygen since sunset. The interactions of factors affecting DO in the natural environment are quite complex, and a full exploration of this topic is beyond the scope of this report, but warrants further investigation.

Sampling was conducted during morning hours because DO is typically lowest at or just after dawn, so morning sampling is likely to capture relatively low DO. Therefore the values observed generally represent a more stressed condition than if the values were mid-day or later.

For dissolved oxygen concentration, the Class B standard requires a minimum of 5.0 mg/L; the Class SA standard is a minimum of 6.0 mg/L DO, and applies to the tidal sites of IP25, and IP26. For dissolved oxygen percent of saturation, 60% is considered the minimum for good water quality in class B waters and 75% in class SA waters. The state of Massachusetts no longer uses the standard for percent of saturation; however, we continue to monitor according to this figure.

Table 4 presents annual statistics for DO concentration and percent saturation for all sites monitored.

Annual Statistics

Table 4. Annual statistics for dissolved oxygen concentration and percent of saturation for all sites.

Water Quality Parameter	Year	# Samples	Range	Average	Summer Average	Winter Average	# Samples Outside Class B/SA Standard	% Violations(% of samples not meeting Standard)
Dissolved Oxygen	1997	110	1 - 14.4	7.9		9.1	13	12%
(mg/L)	1998	267	0 - 13	6.6	3.9	8.4	69	26%
	1999	318	0.4 - 14.8	7.5	5.0	9.1	50	16%
	2000	309	1 - 15.5	7.6	5.1	9.4	51	17%
	2001	278	0.2 - 16	7.3	4.6	9.1	61	22%
	2002	288	0.2 - 14.4	7.8	5.3	9.6	43	15%
	2003	234	0.1 - 12.4	6.5	3.8	8.2	64	27%
	2004	252	0 - 12.4	6.8	4.3	8.8	60	24%
	2005	270	0 - 13.2	6.9	4.4	8.8	62	23%
	2006	271	0.2 - 13.8	7.2	4.2	9.0	62	23%
	2007	231	0.6 - 16.2	6.4	4.9	7.8	67	29%
	2008	223	0.6 - 13.9	6.8	4.0	9.4	63	28%
	2009	210	0.8 - 12.7	6.2	4.4	8.0	60	29%
	2010	237	0-13.2	6.6	4.5	8.7	63	27%
	2011	210	0.6-12.6	7.2	5.0	7.2	46	22%
	2012	291	0.5-14	6.5	4.1	9.0	76	26%
	2013	244	0.1-13.4	6.2	4.0	8.3	73	30%
	Entire Record	4243	0 - 16.2	6.9	4.5	8.7	983	23%
DO % Saturation	1997	107	7.8 - 113.9	66.8		66.6	30	28%
(%)	1998	260	0 - 111.3	59.1	44.5	67.0	118	45%
	1999	308	4.4 - 101.7	67.3	57.9	71.5	102	33%
	2000	291	11.7 - 115.2	65.7	56.1	71.9	106	36%
	2001	258	2.1 - 116.3	62.6	51.7	67.8	108	42%
	2002	284	2.1 - 119.7	66.3	58.6	72.3	94	33%
	2003	232	0.7 - 99.2	58.4	43.1	65.5	110	47%
	2004	246	0-97.4	59.7	47.6	68.4	103	42%
	2005	264	6.7 - 115.9	59.7	50.2	65.3	119	45%
	2006	268	2.4 - 117.9	61.6	45.9	69.4	115	43%
	2007	224	6.2 - 123.6	58.7	54.6	60.5	112	50%
	2008	222	0 - 113.2	59.8	44.9	70.2	96*	43%
	2009	207	0 - 112.5	57.8	47.7	64.8	103*	50%
	2010	233	0-95.4	60.5	51.1	68.2	99*	42%
	2011	228	0-115	58.6	43.0	58.6	100*	43%
	2012	277	5.7-98.5	58.7	46.1	66.5	137*	36%
	2013	236	1.2-110	58.5	45.7	64.4	111*	42%
	Entire Record	4145	0 - 123.6	61.2	49.3	67.0	1117	27%

*In 2008, the State eliminated standards pertaining to DO% saturation. Number is based on previous standard of a minimum of 60% DO saturation and presented for comparison with previous years.

In 2013, 30% of all samples taken by volunteers did not meet the state standard of 5 mg/L for class B waters (73 of 244 samples). When calculating percent saturation of dissolved oxygen, 42% of these same samples fall below 60% saturation.

Site Statistics

Low DO conditions have been widespread and frequent during the past 17 years of monitoring. In 2013:

- Summer averages for 20 sites (out of 32) were less than 5.0 mg/L DO concentration. Nine sites had summer DO averages below 3.0 mg/L (figure 6).
- Annual averages for 5 (out of 32) sites were less than 5.0 mg/L DO concentration.
- Twenty seven sites out of 32 had a minimum DO concentration below 5.0 mg/L DO. Only 5 sites had minimum values above 5.0 mg/L.
- Values at one of the tidally influenced sites (IP25) fell below 6mg/L on three instances.
- 30% of the 244 samples for dissolved oxygen were below the standard for concentration (5 mg/L).

Figure 6 shows average and minimum dissolved oxygen concentration values for all sites in 2013, while figure 7 illustrates long-term trends in the data. Figure 8 shows the distribution of sites with low dissolved oxygen relative to river health.

The fact that DO levels were very low consistently over the past decade represents a significant impaired condition on the river, and indicates that many aquatic organisms are under high stress conditions. Many organisms may not likely survive during most summers.

Figure 6. Average annual and minimum dissolved oxygen concentration (mg/L) for all sites in 2013.

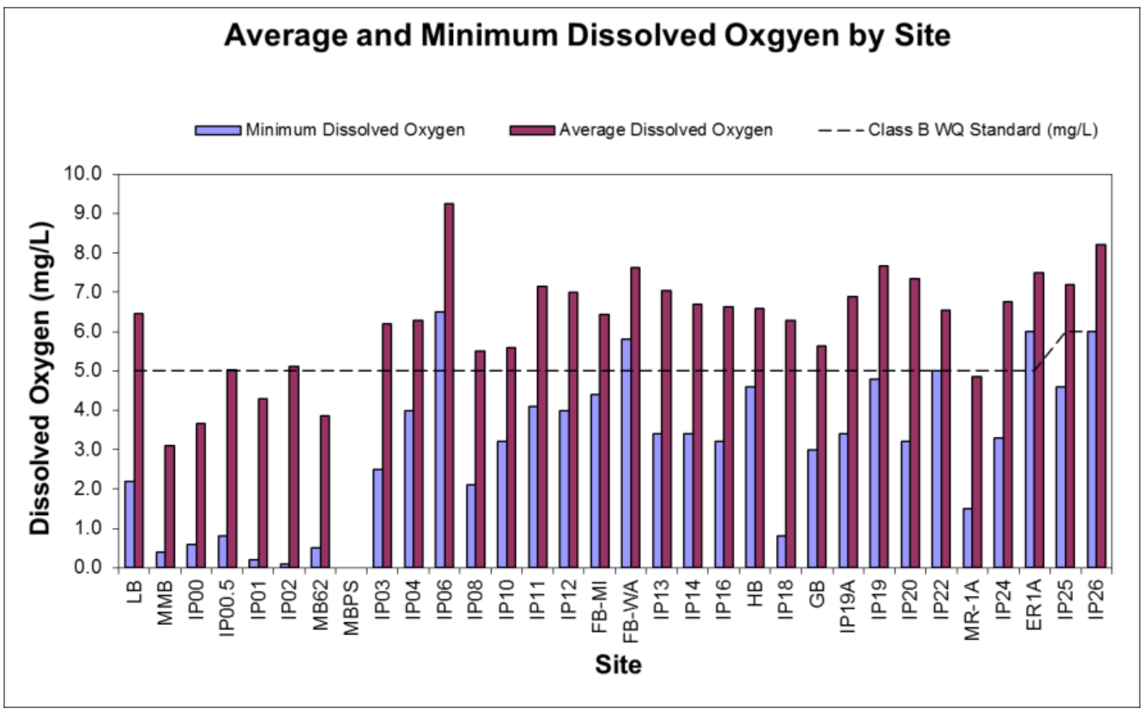


Figure 7. Comparison of trends in average annual dissolved oxygen concentration for mainstem and tributary sites.

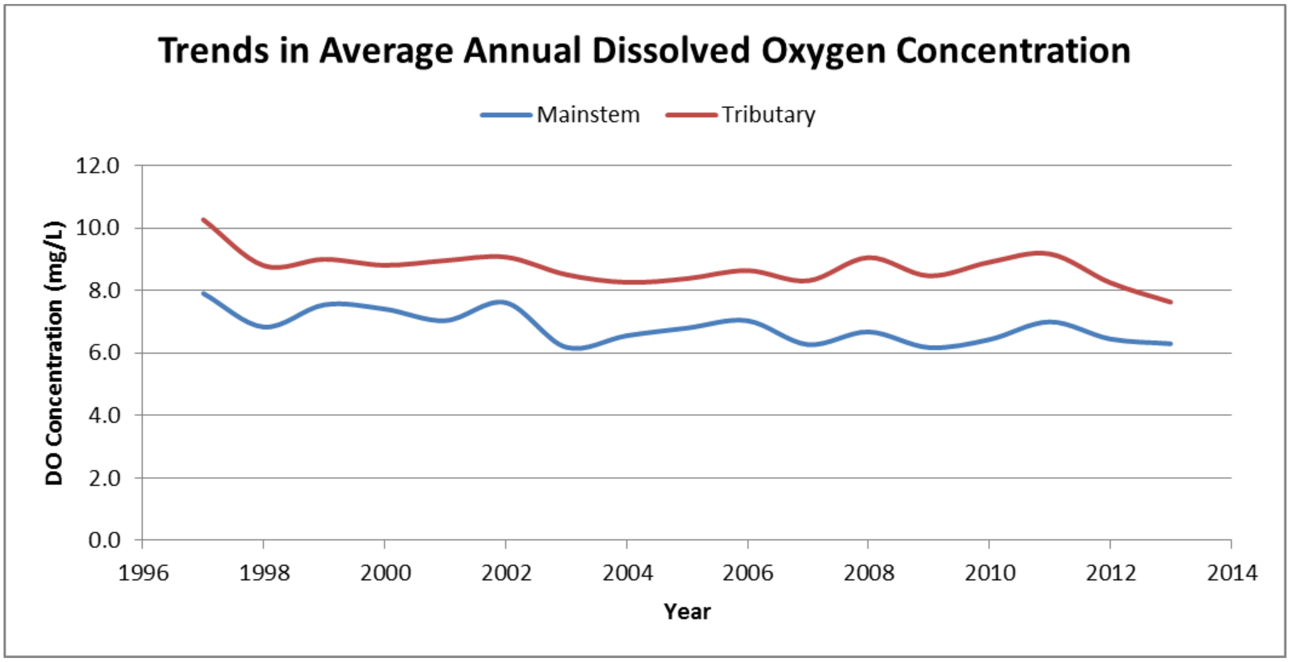
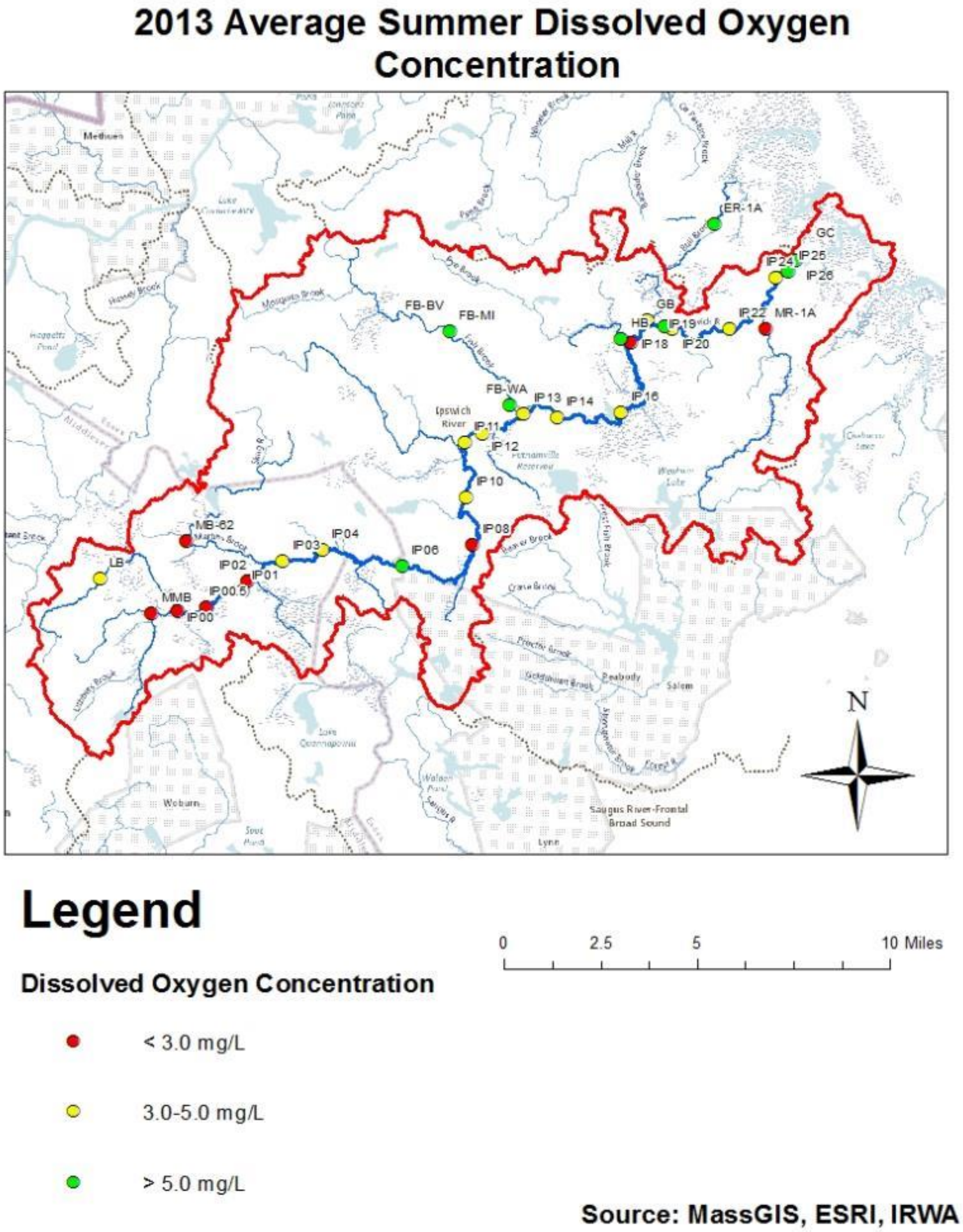


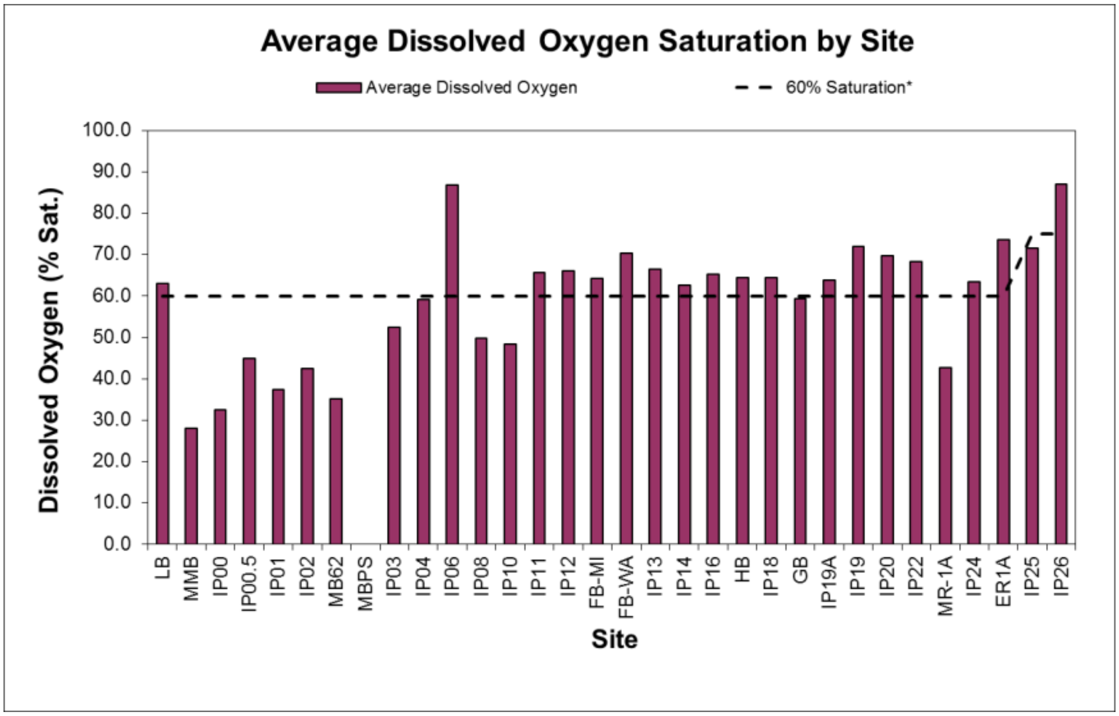
Figure 8. Average summer dissolved oxygen levels for 2012 and relative river health.



- **> 5mg/L (Class B), > 6mg/L (Class SA): Supports aquatic organisms.**
- **3-5 mg/L: organisms may become stressed.**
- **< 3mg/L: Mobile organisms will move to areas of higher DO and immobile organisms may die.**
  <0.5 mg/L Cannot support most aquatic life.

Dissolved oxygen, percent of saturation is defined as the amount of oxygen that can be absorbed by water at a given temperature. Colder water can absorb more oxygen than warmer water. The Commonwealth of Massachusetts discontinued use of a water quality standard for dissolved oxygen, percent of saturation in 2008, but the data are presented here for comparison with dissolved oxygen concentration (mg/L) measurements and for comparison with previous years. The previously used standard of 60% saturation can be used to confirm water oxygen depletion in the upper watershed. Most sites in the upper watershed did not achieve this level over the course of the year and especially in summer months when water temperatures are highest. Site statistics for dissolved oxygen, percent saturation are presented in table 4 and figure 9.

Figure 9. Average Dissolved Oxygen Percent Saturation Statistics for 2013.* The dashed line represents the minimum standard for class B waters (60%) and class SA waters (75%).



**In 2008, the state discontinued use of the 60% saturation standard for dissolved oxygen percent saturation. Values are presented here for comparison with previous years*.

General Findings

Dissolved oxygen (DO) is usually lowest at or shortly after dawn, and then increases during daylight hours. Sampling was conducted during morning hours, likely capturing lower DO than what occurs in the afternoon, and therefore the values observed represent the lower end of the daily DO fluctuation.

Frequent and prolonged low DO conditions represent a serious threat to aquatic organisms that are dependent on the river for survival. State standards represent a minimum condition that is protective of the health of aquatic organisms and the Ipswich River repeatedly and for extended periods of time does not meet those minimum standards. Fish kills were observed in 1995, 1997, 1999, 2002, and 2005.

Under natural conditions, DO varies considerably daily and seasonally, as well as in response to weather conditions and numerous other factors, so conclusively stating the causes of the extremely low DO documented on the Ipswich River is beyond the scope of this report. It might be expected that DO levels in the Ipswich River tend towards the lower end of that 5-10 mg/L healthy DO concentration range because of the relatively low gradient of the river and the presence of numerous wetlands and forest that contribute organic matter (like leaves) to the water. For example, sites IP08 and IP18 are both located downstream of wetlands. Both sites exhibit average summer DO levels lower than other surrounding sites (figures 6 and 8). However, the Ipswich River experiences DO levels that fall consistently lower than this natural range, and consistently lower than state standards for a healthy river.

A statistical investigation into the causes of low DO was conducted by IRWA in 2002, and indicated that variables most linked with DO levels are water temperature, river kilometer (how far upstream the site is), depth, and the previous 28-day rainfall amount (IRWA, 2002). While this study provides a first step towards better understanding of variation in DO in the Ipswich River, there remain a number of unanswered questions warranting further study. For example: what is the role of these variables and their interactions on DO levels; what are the causes of the observed changes in these variables; what is the extent and health of wetlands adjacent to the river; and, how can management actions and behavioral changes alleviate low DO levels in the river?

Long-term data suggests a possible trend in decreasing oxygen concentrations for both mainstem and tributary sites. Further analysis is required to validate any possible trend, but it is interesting that the mainstem is consistently lower than the tributaries. One explanation may be that while some tributaries, such as Fish Brook, have consistently higher oxygen concentrations, the mainstem has many sites where consistently lower oxygen concentrations are recorded.

Depth, Velocity and Streamflow

Depth and velocity are measured as rough indicators of channel coverage and flow at individual sites. Because depth is measured from the middle of the channel at most sites, generally it is an optimistic indicator of depth across the channel, since drying will typically occur first at the channel margins. There are, however, occasions when flow is too high to accurately measure depth (or velocity), such as during the flooding event in May of 2006 and March 2010. Conversely, velocity is a conservative indicator, since volunteers insert the floatable object only where there is noticeable current. Immeasurable velocities cannot be quantified.

Flow is an obvious and important measure of river health. Observations of a dry riverbed or very low flow associated with very small amounts of water in the river are indicative of a serious impairment. Unfortunately, numerous episodes of little or no flow have been documented for the Ipswich River.

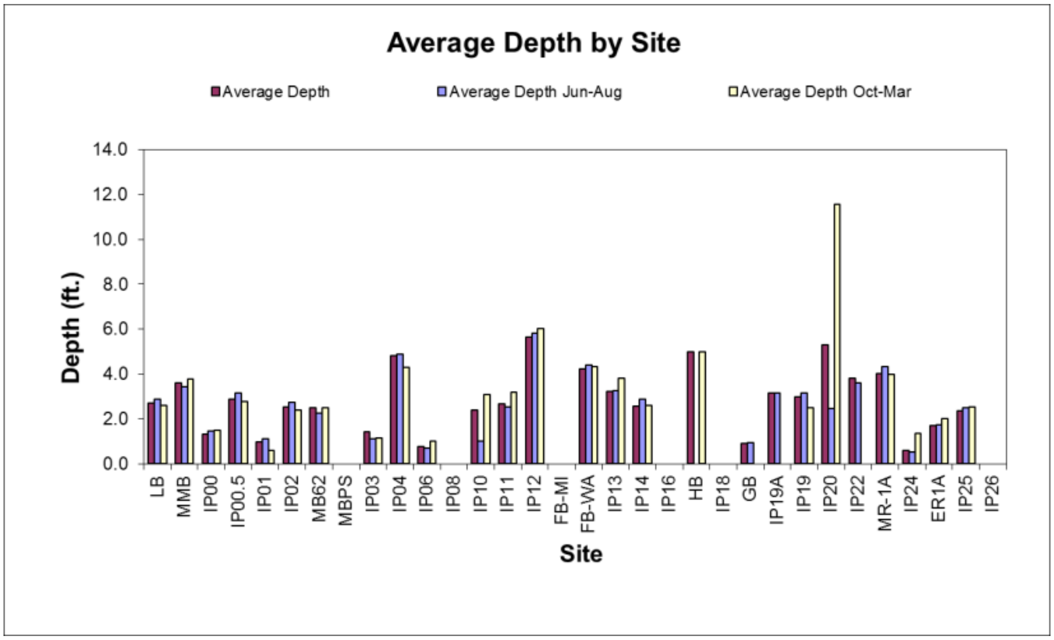
Site Statistics

In 2013, as in previous years, most sites recorded average water depths that were highest during the winter and lowest during the summer (table 5, figure 10).

Table 5. Annual statistics for depth and velocity for all sites.

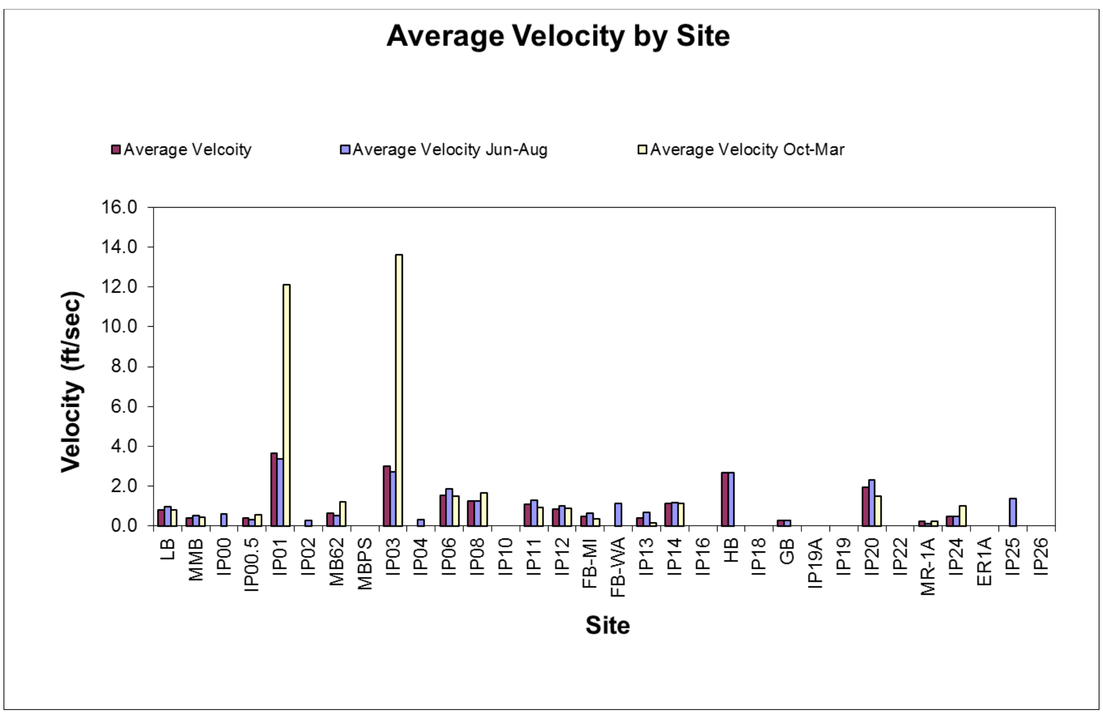
Water Quality Parameter	Year	# Samples	Range	Average	Summer Average	Winter Average
Depth (ft)	1997	183	0 - 10	3.0	2.0	3.3
	1998	261	0 -12.3	3.1	2.7	3.5
	1999	293	0 - 9.2	2.4	1.5	3.0
	2000	280	0 - 11.3	3.0	2.4	3.1
	2001	238	0 - 22	2.6	2.2	2.9
	2002	270	0 - 14.6	2.7	1.8	3.7
	2003	204	0 - 9.3	3.0	2.6	3.4
	2004	215	0.4 - 10	3.2	3.1	3.3
	2005	223	0 - 11	3.1	2.3	3.8
	2006	228	0.4 - 10.7	3.5	3.1	3.6
	2007					
	2008	187	0 - 16.6	1.7	1.9	1.8
	2009	168	0 - 35.5	2.0	1.5	2.1
	2010	150	0.1 - 35.1	2.1	1.6	2.2
	2011	211	0.2-8.5	3.4	3.0	3.4
	2012	237	0.2-6.4	2.4	2.1	2.4
	2013	190	0-18.6	3.0	2.7	4.7
	Entire Record	2395	0 - 22	2.9	2.4	3.3
Velocity (ft/s)	1997	185	0 -10.2	1.3	0.5	1.6
	1998	259	0 - 8.3	1.6	1.4	1.9
	1999	296	0 - 23.7	1.3	0.3	1.8
	2000	271	0 - 6.6	1.7	1.2	1.9
	2001	199	0 - 13	1.5	1.0	1.9
	2002	261	0 - 57.7	2.0	1.0	2.6
	2003	202	0 - 5.1	1.5	1.1	1.7
	2004	217	0 - 19.4	1.6	1.8	1.5
	2005	236	0 -15.9	1.5	0.5	2.4
	2006	240	0 - 9.8	1.7	1.4	1.8
	2007	150	0.1-8.3	1.5	0.8	0.8
	2008	208	0.4 - 9.7	3.4	3.3	3.8
	2009	184	0.5 - 10.7	3.3	3.4	3.6
	2010	180	0.2 - 8.7	3.3	3.1	3.6
	2011	175	0.1-10.0	1.7	1.0	1.7
	2012	174	0.1-4.4	1.0	0.8	1.1
	2013	140	0-4.0	1.1	1.2	0.4
	Entire Record	2366	0 - 57.7	1.6	1.0	1.9

Figure 10. Comparison of average annual, spring and summer water depths by site.



Water velocity is measured as an indicator of the amount of flow in the river. Monitors record the time it takes a floating object such as an orange peel to travel a known distance, usually the width of the bridge spanning the river or between two points along the bank. Only sites with a bridge or where it is convenient to do so will measure velocity. Water velocity is typically lowest in the upper watershed where there is a low gradient to the river and tributaries and surrounding wetlands (figure 11). Sites IP01 and IP03 are located at bridges where the channel width narrows, increasing water velocity during spring runoff events beyond what would be expected naturally.

Figure 11. Comparison of average annual, summer and winter water velocity by site.



The United States Geological Survey (USGS) maintains two real-time streamflow gauges on the Ipswich River. One is located near Boston St. in South Middleton and the other is located off Topsfield Rd., near Winthrop St. in Ipswich. Water depth or stage height is recorded and compared to a rating curve of flow measurements taken over time at high and low water levels. The result is a flow volume measured in cubic feet per second (cfs). The South Middleton and Ipswich gauges have been recording streamflow data since 1938 and 1930, respectively.

These gauges have recorded regular episodes of extended extreme low flow events over the past 17 years. “Extreme low flow” is defined by the USGS as a minimum summer “ecological protection flow” (Horsley and Witten 2002). This “ecological protection flow” is the flow that “provides adequate habitat for the protection of fisheries” (Ibid). The ecological protection flow is 0.42 cubic feet per second per square mile (cfsm).

Summer low flows at the Ipswich gauge are defined as flows lower than 52.5 cfs (calculated as 0.42 cfsm multiplied by the drainage area of 125 square miles). Summer low flows at the South Middleton gauge are defined as flows falling below 18.6 cfs (calculated as above, with a drainage area of 44.5 square miles).

In 2013, low flows were observed for almost four months, from July through much of October (figure 12).

Flows per unit area in cfsm for all gages should closely match; however differences are seen during periods of low flows from approximately September to December of 2013. In figure 12, the RIFLS gage at Haverhill St., which is about four miles upstream of the USGS gage at South Middleton shows higher flows beginning in late September and October. This difference is a possible indicator of groundwater withdrawals between these two sites.

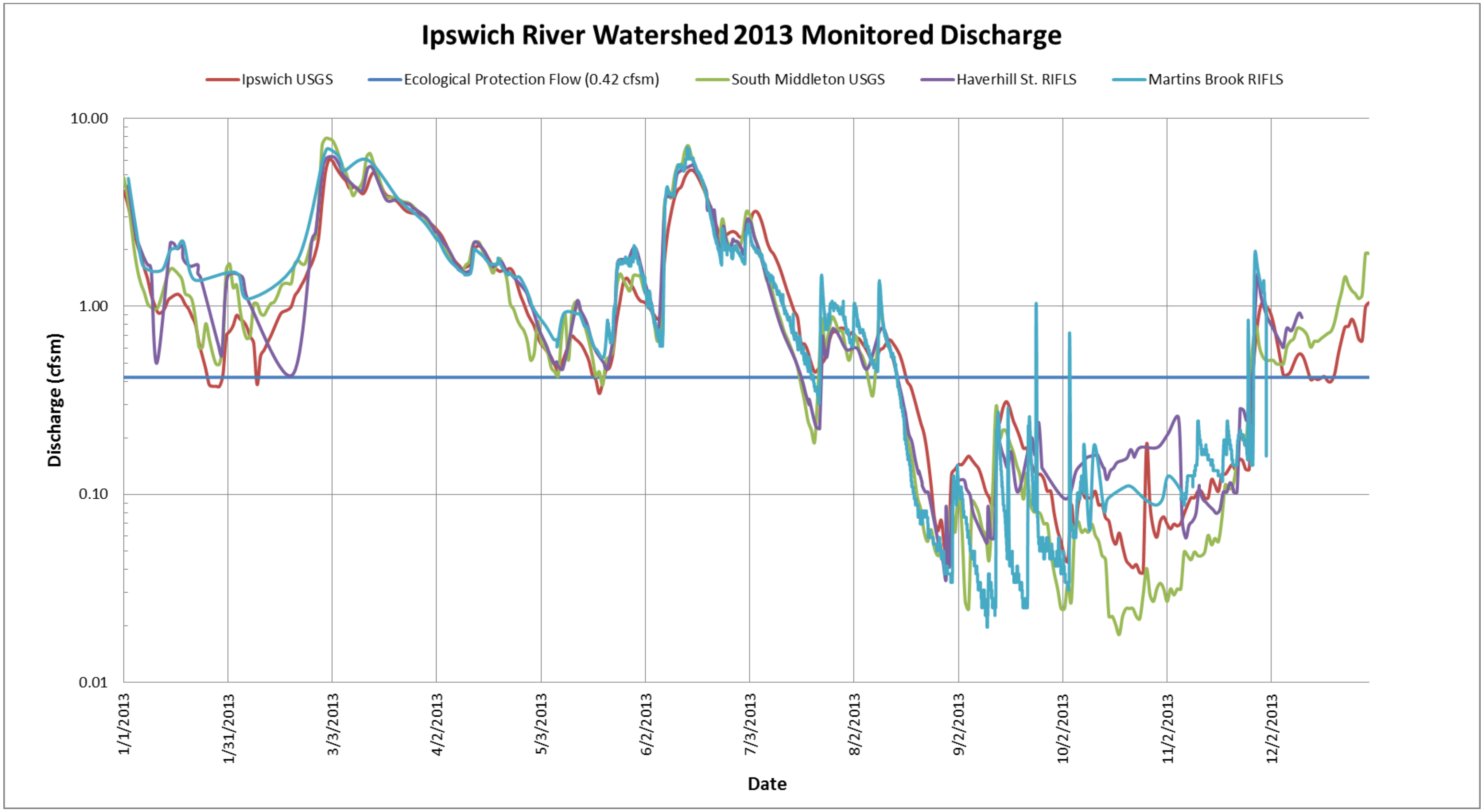
A water level logger was deployed at Martins Brook in the summer of 2013. The continuous data record shows episodes where sharp declines in flow occurred during September of 2013 following precipitation events (figure 12). The towns of Wilmington and North Reading both maintain groundwater wells adjacent to Martin’s Brook on the upper section of this sub-basin, although North Reading primarily receives water from Andover during the summer. These declines may be an indicator of water withdrawal activity and illustrate the rapid runoff that takes place in this sub-basin following a rain event compared to the other gage locations.

General Findings

Withdrawals for drinking water are the primary cause of unnaturally low flows in the Ipswich River (Armstrong 2001, Zarrielo and Ries 2000). While it might be expected that low flows occur seasonally, the low flows observed in the Ipswich River are about a 10th of what might be considered “natural.” Due to low flows, the Ipswich River is classified as highly stressed by the MA Water Resources Commission (2001) and impaired under section 303(d) of the Clean Water Act.

Flow monitoring data indicate that fluctuations and differences in flows are more pronounced below the established threshold of 0.42 cfsm. Further analysis is needed to determine the exact role that groundwater withdrawls and land cover may have in causing the observed changes. Having access to continuous data at the RIFLS gages will also be important to determine the statistical significance of the observed trends. Water level loggers will be used in 2014 at the Martins Brook and Haverhill St. locations.

Figure 12. 2013 Daily Mean discharge at USGS streamflow gauges in South Middleton and Ipswich MA and two RIFLS gages in North Reading, MA. The blue line indicates the minimum ecological protection flow. Soure: USGS and Mass Riverways.



Conductivity

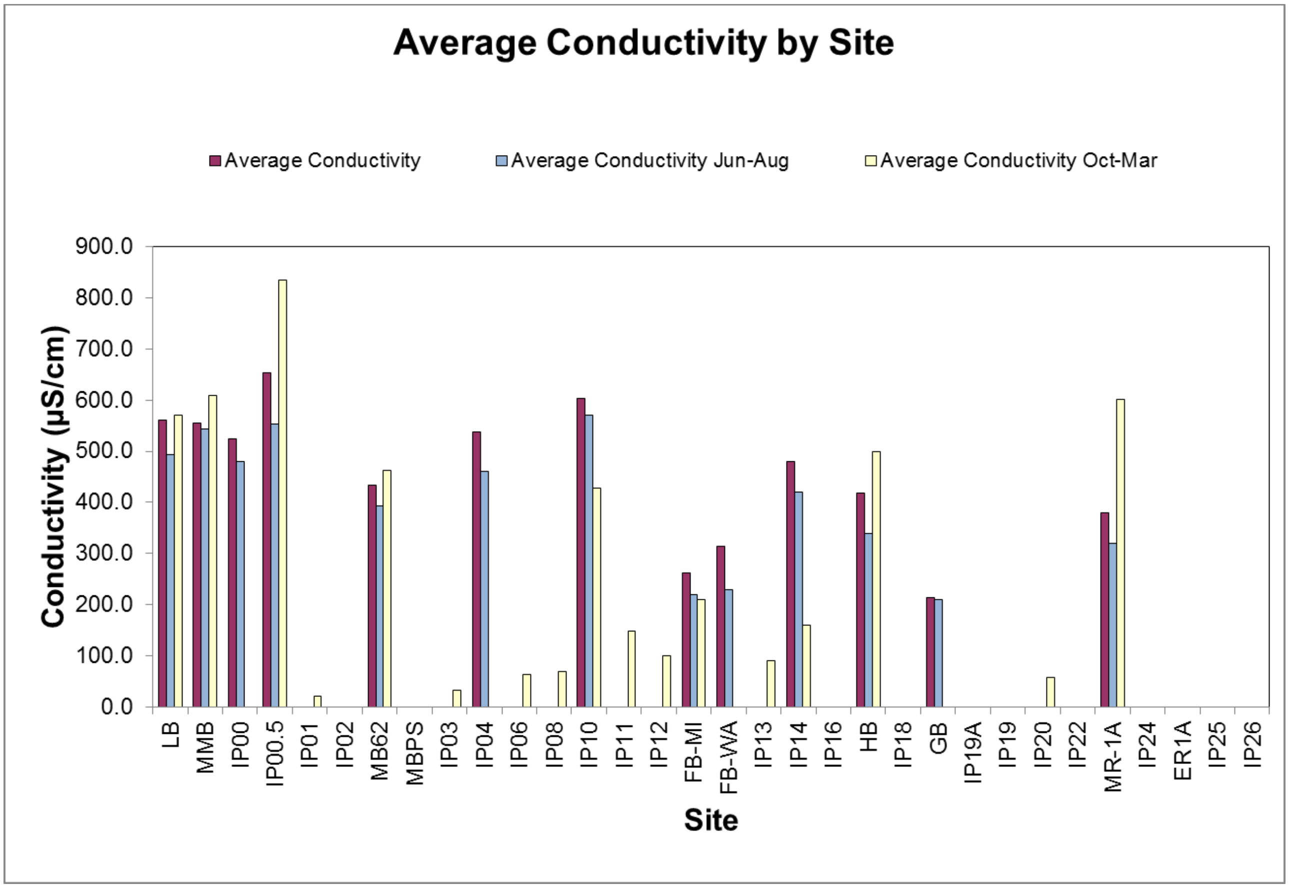
Conductivity measures the ability of water to pass an electrical current resulting from the presence of dissolved solids (or salts) such as chloride, sulfate, sodium and calcium, among others. Many factors can affect conductivity including local geology, rainfall, low flows and salt water concentrations in tidal areas. Most streams have a fairly constant range of conductivity under normal circumstances. Therefore, significant changes in conductivity can be an indicator that a discharge or some other source of pollution has entered the water. According to the EPA, the conductivity of rivers in the United States generally ranges from 50 to 1500 µS/cm (micro Siemens per centimeter). Rivers that can support healthy fisheries should be in the range of 150 to 500 µS/cm.

Conductivity was measured at 10 sites in 2013. Table 6 shows statistics of conductivity collected from 2007, when measurements began, through 2013. Figure 13 shows a comparison of average annual and summer conductivity for the sites monitored. Many sites show higher readings in the winter months, particularly in the upper watershed. Roadside salt applications are known to increase chloride concentrations at wellfields located in the Ipswich River Watershed in Wilmington, MA (Heath, et al., 2012). Elevated conductivity values are usually seen in the spring and readings at sites in the upper watershed are also likely due to the influx of road salts from spring runoff. These values are at or exceed those that are known to support healthy fisheries. Continuing to monitor conductivity will be important in determining how the effects of possible mitigation efforts might be observed at monitoring sites in the upper watershed.

Table 6. Statistics for Conductivity 2007-2013.

Water Quality Parameter	Year	Site	# Samples	Range	Average	Summer Average	Winter Average
Conductivity	2007	MMB		267 - 557	437		414
(µS/cm)		IP00		277 - 557	446	494	403
		IP04		297 - 607	487	472	537
		FB-MI		147 - 217	190		
	2008	MMB	9	197 - 517	376	354	340
		IP00	6	257 - 507	421	370	449
		IP04	6	47 - 447	343	440	292
		FB-MI	6	150 - 220	201	193	
	2009	MMB		420-480	447	430	
		IP00		280-480	404	400	
		IP04		320-510	428	410	495
	2010	IP04		250-641	486	583	284
	2011	MMB	7	330-540	465	475	468
		IP00	7	338-580	441	459	441
		MB-62	6	330-430	380	395	380
		MB-PS	3	440-560	507	560	480
		IP04	4	362-476	430	362	453
		FB-WA	8	180-380	256	280	256
		IP16	2	340-350	345		345
	2012	FB-WA	8	230-370	316	360	370
		GB	5	170-230	202	210	
		HB	1	300-300	300		
		IP00	10	390-580	480	503	490
		IP04	10	395-594	483	514	434
		IP10	6	400-530	493	477	
		IP14	10	330-490	417	420	450
		MB-62	9	400-580	442	420	495
		MB-PS	8	400-510	443	464	420
		MMB	10	350-610	471	530	440
		MR-1A	2	280-370	325		
		FB-MI	7	220-310	263	220	
		FB-WA	6	230-350	315	230	
		GB	5	200-220	214	210	
	2013	HB	5	310-510	418	340	490
		IP00	7	410-580	524	480	
		IP00.5	8	500-840	654	553	840
		IP04	7	442-688	538	462	534
		IP10	4	570-650	603	570	650
		IP14	8	350-560	480	420	560
		LB	7	430-760	560	493	
		MB-62	8	360-460	429	393	
		MB-PS					
		MMB	7	510-610	556	543	
		MR-1A	7	320-440	380	320	440

Figure 13. Annual and summer average conductivity by site. The conductivity range considered suitable for healthy fisheries is 150-500 µS/cm (micro Siemens per centimeter).



Color and Odor

The Ipswich River is a tea-like color naturally. This color is due primarily to dissolved organic carbon (e.g., tannins from leaves and plants). There is a lot of dissolved organic carbon in the Ipswich River due to the wetlands that drain into the river throughout the watershed.

Each month monitors noted the color and odor of the river on their data sheets in order to track changes or events where color changed significantly. Color was measured on a scale of 1 through 5: 1 (Clear), 2 (Very Light Tea), 3 (Light Tea), 4 (Tea), and 5 (Dark Tea). If a particular odor was noticed, this was noted on the data sheet. Most colors noted were in the Very Light Tea to Light Tea range. The river tended to be a light tea throughout the year.

Darker colors (tea to dark tea) were typically recorded in the summer months (July – August) and so may be associated with lower flow periods. However, in general it seems that there is no clear relationship between darker color and higher flow periods. Some sites were darker when it rained, some sites were variable, and some were lighter. It does seem, however, that darker colors were prevalent during summer months, and particularly associated with lower flows.

Habitat Observations

Each month monitors recorded wildlife and habitat observations. Often, the level of observation depended on monitor knowledge of birds, macroinvertebrates, fish, and other wildlife. Lists of birds and other wildlife seen are below.

Beaver activity was noted at sites IP01 and IP13. Fish activity was noted at IP10 and FB-MI.

Birds

American Red-Start
Bald Eagle
Baltimore Oriole
Barn Swallow
Belted Kingfisher
Blackbird
Black Ducks
Blue-Gray Gnatcatcher
Blue Jay
Brown Headed Cowbird
Canada Geese
Cardinals
Carolina Wren
Catbird
Cedar Waxwing
Chickadees
Chimney Swift
Common Yellowthroat
Coot
Copper's Hawk
Cowbird
Crows
Downy Woodpecker
Fish Crow
Flicker
Goldfinch
Grackles
Great Blue Herron
Green Heron
Hairy Woodpecker
Herring Gull
House Finch
House Sparrow
Hooded Merganser
Kingbird
Mallards
Mocking Bird
Mourning Dove
Orioles
Phoebe
Pigeons
Red-Bellied Woodpecker
Red-Tailed Hawk
Red-Winged Blackbirds
Ring-Necked Duck
Robins
Rough-Winged Swallows
Savanah Sparrow
Spotted Sandpiper
Song Sparrow
Starling
Swamp Sparrow
Tree Swallow
Tufted Titmouse
Turkey Vulture
Warbling Vireo
White Breasted Nuthatch
Willow Flycatcher
Wood Duck
Yellow-Rumped Warbler
Yellow Warble

Other Wildlife

Mammals: Beavers, Muskrat, Chipmunk

Reptiles and Amphibians: Frogs, Toads, Painted Turtle

Insects: Dragonflies, crickets

Plants

Loosestrife, duckweed, bittersweet, lily pads

Other Observations

Table 7. General observations made at RiverWatch sites throughout the year

Site ID	Date(s)	Observation
MMB	6/30, 8/25	Earthy odor and murky
IP00	3/24	River looks good!
IP00	7/28, 9/29	Metallic odor
IP00	10/27	River really low, odor slightly fishy
IP00.5	6/30, 7/28, 8/25, 9/29	Low flows due to beaver dam upstream
IP01	6/30	Oily sheen on water, orange color with particulates
IP01	9/29	Water covered with pale slime
IP01	10/27	Lots of trash, faintly septic odor downstream
MB-62	8/25, 9/29, 10/27	No flow over weir boards, dam observed 50 yds. Downstream
IP03	11/17	Beaver dam may be impairing DO
IP08	10/27 11/17	Beaver dam Break in beaver dam
IP10, IP11, IP12	Various dates	Beaver activity noted
IP22	7/28	Large tree down in river
IP24	8/25 9/24	River is low, lots of aquatic plants showing. Lots of trash around from Ipswich illuminates.

3.2 Quality Assurance/Quality Control

Quality Assurance Project Plan (QAPP)

A formal Quality Assurance Project Plan (QAPP) was updated and approved in April of 2013 for the RiverWatch Program by the Department of Environmental Protection (DEP) and the Office of Coastal Zone Management (CZM) and the.

As part of the Quality Assurance Project Plan (QAPP), both temperature and dissolved oxygen are evaluated for quality control purposes. Volunteers must attend an annual training and calibrate new chemicals for testing dissolved oxygen. Also, monitors undergo an annual site audit by the Program Coordinator from IRWA where values for dissolved oxygen and temperature obtained by the program manager are compared to the values obtained by the monitor. Monitors also perform a duplicate test for dissolved oxygen once each year.

Three training events were held in 2013 to accommodate the travel distances and increase the likelihood of full attendance. All monitors attended except for one site (IP25). Volunteers had not been found for sites IP10, FB-MI and MR-1A by the time of the training. Site MMB is covered by the same volunteers who also test IP00.

Table 7 shows results for dissolved oxygen and temperature calibration values at the annual training. A number of measurements for dissolved oxygen and temperature were outside the quality control limit of 1.0 mg/L dissolved oxygen or 1.0 °C. A digital YSI dissolved oxygen meter that had been calibrated at air saturation was used to produce the calibration value by the program coordinator, whereas the volunteers use Winkler Titration Kits. One possible source of discrepancy is the use of an additional cap that yields finer drops when fixed to the end of the titrator syringe supplied with the kit. Many were not clear on its function, so this was explained to all. Without the cap, larger single drops can result in a less accurate reading. Repeat measurements were not performed due to limited time.

Differences in temperature measurements were generally due to instances where the monitor measured at the later end of the training session allowing some time to pass from when the calibration value was obtained. The water sample had likely warmed, however a repeat calibration value was not taken at each instance. Each thermometer was in agreement when read at a similar time.

Comparison of field duplicate and audit DO and temperature readings are presented in table 8. Only 2 samples exceeded the 1 mg/L DO concentration and 1 sample exceeded the 1.0 °C difference levels specified in the 2013 QAPP. Field duplicates in table 9 met quality standards as defined in the 2013 QAPP, indicating that volunteer data are within quality assurance limits. Few sites recorded field duplicate values limiting the scope of this comparison; however, site audits indicate accurate measurements.

Table 8. 2013 training dissolved oxygen and temperature calibration values.

Site	Date	Attended training	DO monitor	DO Trainer	Differenc e	Acceptible	Action Taken	Temp Monitor	Temp Trainer	Difference	Acceptible	Action
LB	3/2/2013	x	10	11.6	1.6	no	shown use of titrator cap	5.0	2.6	2.4	no	measured later than others
MMB												
IP00	3/2/2013	x	10	11.6	1.6	no	shown use of titrator cap	2.5	2.6	0.1	yes	
IP00.5	3/2/2013	x	10	11.6	1.6	no	shown use of titrator cap	4.0	2.6	1.4	no	measured later than others
IP01	3/2/2013	x	10.6	11.6	1	yes		2.8	2.6	0.2	yes	
IP02	3/2/2013	x	10.7	11.6	0.9	yes		4.3	2.6	1.7	no	measured later than others
MB-PS	3/2/2013	x	10	11.6	1.6	no	shown use of titrator cap	3.0	2.6	0.4	yes	
MB-62	3/21/2013	x	10	10	0	yes						
IP03	3/2/2013	x	12.8	11.6	1.2	no	shown use of titrator cap	3.0	2.6	0.4	yes	
IP04	3/2/2013	x	12.3	11.6	0.7	yes		4.0	2.6	1.4	no	measured later than others
IP06	3/9/2013	x	12	11.2	0.8	yes		4.0	4.3	0.3	yes	
IP08	3/16/2013	x	11.1	9.5	1.6	no	shown use of titrator cap	7.0	7	0	yes	
IP10												
IP11	3/2/2013	x	10	11.6	1.6	no	shown use of titrator cap	4.0	2.6	1.4	no	measured later than others
IP12	3/9/2013	x	9.7	11.2	1.5	no	shown use of titrator cap	4.0	4.3	0.3	yes	
FB-WA	3/9/2014	x	10.4	11.2	0.8	yes		4.0	4.3	0.3	yes	
FB-MI												
IP13	3/16/2013	x	11.2	9.5	1.7	no	shown use of titrator cap	5.5	7	1.5	no	measured later than others
IP14	3/9/2013	x	10	11.2	1.2	no	shown use of titrator cap	4.0	4.3	0.3	yes	
IP16	3/9/2013	x	9.6	11.2	1.6	no	shown use of titrator cap	4.0	4.3	0.3	yes	
HB	3/9/2013	x	9.6	11.2	1.6	no	shown use of titrator cap	4.0	4.3	0.3	yes	
IP18	3/9/2013	x	10	11.2	1.2	no	shown use of titrator cap	5.5	4.3	1.2	no	measured later than others
GB	4/25/2013	x	8.4	9.2	0.8	yes		13.0	13.3	0.3	yes	
IP19/19A	3/16/2013	x	10.2	9.5	0.7	yes		5.0	4.3	0.7	yes	
IP20	3/16/2013	x	10.9	9.5	1.4	no	shown use of titrator cap	8.5	7	1.5	no	measured later than others
MR-1A												
IP24	3/16/2013	x	10	9.5	0.5	yes		5.5	7	1.5	no	measured later than others
ER-1A	3/16/2013	x	10.4	9.5	0.9	yes		6.0	7	1	yes	
IP25												
IP26	3/16/2013	x	9.8	9.5	0.3	yes		6.0	7	1	yes	

Table 9. 2013 site audit comparisons for dissolved oxygen and temperature readings.

Date	Auditor DO	Monitor DO	Difference	Acceptible	Action Taken	Method	Auditor Temp	Monitor Temp	Difference	Acceptible	Action Taken	Method
3/24/2013	10.6	10.8	0.2	yes		Winkler Titration Kit	3	4	1.0	yes		Thermometer
						Winkler Titration Kit			0.0	yes		Thermometer
3/24/2013	10.0	9.8	0.2	yes		Winkler Titration Kit	13.5	13	0.5	yes		Thermometer
4/28/2013	7.0	6.1	0.9	yes		Winkler Titration Kit	14	14	0.0	yes		Thermometer
5/19/2013	3.2	2.5	0.7	yes		Winkler Titration Kit	16	16	0.0	yes		Thermometer
5/19/2013	3.6	3.3	0.3	yes		Winkler Titration Kit	16	16.5	0.5	yes		Thermometer
5/19/2013	4.9	4.9	0.0	yes		Winkler Titration Kit	16	15	1.0	yes		Thermometer
4/28/2013	6.4	5.6	0.8	yes		Winkler Titration Kit	14.2	15	0.8	yes		Thermometer
4/28/2013	7.0	6.2	0.8	yes		Winkler Titration Kit			0.0	yes		Thermometer
						Winkler Titration Kit						Thermometer
7/28/2013	7.7	7.8	0.1	yes		Winkler Titration Kit	21.6	21	0.6	yes		Thermometer
6/30/2013	2.4	2.3	0.1	yes		Winkler Titration Kit	22.6	23	0.4	yes		Thermometer
						Winkler Titration Kit						Thermometer
8/25/2013	5.3	4.8	0.5	yes		Winkler Titration Kit	20.3	21	0.7	yes		Thermometer
7/28/2014	5.1	4.3	0.8	yes		Winkler Titration Kit	22.2	22.5	0.3	yes		Thermometer
9/29/2013	8.0	7.0	1.0	yes		Winkler Titration Kit	14	14	0.0	yes		Thermometer
8/25/2013	7.0	6.4	0.6	yes		Winkler Titration Kit	16.6	17	0.4	yes		Thermometer
7/28/2013	5.8	6.0	0.2	yes		Winkler Titration Kit	22.2	23	0.8	yes		Thermometer
8/25/2014	6.3	5.4	0.9	yes		Winkler Titration Kit	19	19	0.0	yes		Thermometer
8/25/2013	7.7	6.6	1.1	no	marginal difference	Winkler Titration Kit	21	21	0.0	yes		Thermometer
9/29/2013	7.2	7.4	0.2	yes		Winkler Titration Kit	14	13.5	0.5	yes		Thermometer
11/17/2013	9.2	9.7	0.5	yes		Winkler Titration Kit	4.5	6	1.5	no	rechecked OK at same time	Thermometer
11/17/2013	10.0	10.0	0.0	yes		Winkler Titration Kit	5	5	0.0	yes		Thermometer
10/27/2013	9.0	8.4	0.6	yes		Winkler Titration Kit	10	10	0.0	yes		Thermometer
10/27/2014	9.0	9.0	0.0	yes		Winkler Titration Kit	9	9	0.0	yes		Thermometer
11/17/2013	10.1	10.0	0.1	yes		Winkler Titration Kit	4	4	0.0	yes		Thermometer
11/17/2013	8.1	8.2	0.1	yes		Winkler Titration Kit	4	4.5	0.5	yes		Thermometer
10/27/2014	9.0	8.5	0.5	yes		Winkler Titration Kit	7	8	1.0	yes		Thermometer
11/17/2013	8.2	8.2	0.0	yes		Winkler Titration Kit	5.5	6	0.5	yes		Thermometer
10/27/2013	9.6	8.0	1.6	no	results not compared in the field	Winkler Titration Kit	12	11.5	0.5	yes		Thermometer
10/27/2014	8.8	8.9	0.1	yes		Winkler Titration Kit	12	12	0.0	yes		Thermometer

Table 10. 2013 field duplicate dissolved oxygen measurement

Site	Date	DO 1	DO 2	Difference	Acceptible	Action Taken
LB	7/28/2013	5.4	4.6	0.8	yes	
MMB	7/28/2013			-		
IP00	7/28/2013			-		
IP00.5	7/28/2013			-		
IP01	7/28/2013			-		
IP02	7/28/2013	2.2	2.4	0.2		
MB-PS	7/28/2013			-		
MB-62	7/28/2013	1.6	1.6	0.0		
IP03	7/28/2013	3.6	3.6	0.0	yes	
IP04	7/28/2013	4.6	4.4	0.2		
IP06	7/28/2013	7.8	6.8	1.0		
IP08	7/28/2013	2.1	2.2	0.1	yes	
IP10	7/28/2013			-		
IP11	7/28/2013			-		
IP12	7/28/2013	4.5	4.5	0.0		
FB-WA	7/28/2013			-		
FB-MI	7/28/2013			-		
IP13	7/28/2013	5.0	5.4	0.4	yes	
IP14	7/28/2013	5.4	5.2	0.2	yes	
IP16	7/28/2013			-		
HB	7/28/2013			-		
IP18	7/28/2013			-		
GB	7/28/2013			-		
IP19/19A	7/28/2013			-		
IP20	7/28/2013			-		
IP22	7/28/2013			-		
MR-1A	7/28/2013			-		
IP24	7/28/2013			-		
ER-1A	7/28/2013			-		
IP25	7/28/2013			-		
IP26	7/28/2013			-		

Volunteer Qualifications

Volunteer quality assurance is maintained in the following ways:

Volunteers attend one training annually, led by the Monitoring Coordinator. The training includes a review of all procedures in the RiverWatch Monitoring Manual and a discussion of any changes. In addition, the previous year's data are presented, calibrations conducted, and QA/QC standards discussed.

Monitors are audited at their sampling site once per year.

Volunteers take duplicate samples at their site once per year, and equipment, data analysis and data control are held to QA/QC standards.

Completeness

Table 10, below, summarizes the completeness of data collection for the 17-year period. Completeness is calculated as the number of samples taken in a year divided by the maximum number of samples it was possible to collect during that year. Our goal is to collect at least 80% of the total number of samples possible, and that goal was met for every year except 2003 and 2010. However, there is excellent completeness for all other years of monitoring, indicating the strength of volunteer commitment. In 2009, the bridge at site IP18 was out for construction, so monitoring was not possible for six months.

Table 11. Percent of Samples Collected per year, 1997 - 2013.

Year	Completeness
1997	86%
1998	90%
1999	92%
2000	89%
2001	83%
2002	89%
2003	76%
2004	81%
2005	88%
2006	91%
2007	82%
2008	83%
2009	78%
2010	73%
2011	85%
2012	87%
2013	82%

Section 4: Macroinvertebrate Monitoring

4.1 Benthic Macroinvertebrate Monitoring

Benthic macroinvertebrates (macros) are excellent indicator organisms of overall river health based on their preferences and tolerances for water quality. Different groups of macroinvertebrates exhibit a range of tolerances to environmental factors such as low flow, low dissolved oxygen, high suspended solids, temperature and toxics. For example, certain macros, such as mayfly or caddisfly larvae, can only thrive in waters with relatively high water quality. Other macros, such as the damselfly larvae, water boatmen and leeches, can tolerate relatively poor water quality conditions. By monitoring the number, richness and diversity of macroinvertebrates present at different locations in the watershed, it is possible to establish trends, which indicate the vitality of the Ipswich River's habitat and reinforce the water quality testing we do with information about how the ecology of the river is affected by areas of low flow or points in the river that have become pooled and stagnant.

Monitoring that began in 1997 concluded that significant effects from low flows were observable in the macroinvertebrate sampling and that the study should continue, however, monitoring stopped in 2002 and resumed in 2011. Eight sites were identified for monitoring. Six sites were originally selected in 1997, and two additional sites were added in 1999. Monitoring stopped in these same sites were samples in 2011 and 2012, while 1 more

All samples were collected from wadeable riffle areas using a kick-net according to the methodology of the River Watch Network Benthic Macroinvertebrate Monitoring Manual (River Watch Network, 1997).

In this method, one composite sample is collected from each sampling site. The composite sample consists of samples collected from four locations within a sampling area; two from fast moving areas (approximately 0.5 to 1.5 feet per second) and two from slow moving areas (1.5 to 2.5 feet per second). Four sites representative of the riffle area are chosen if there is no difference in velocity.

Samples are collected beginning from the most downstream location. The kick-net is held on the downstream side of a 50cm^2 quadrat while rocks are dislodged and rubbed using gloved hands to remove macroinvertebrates that then flow directly into the net. Rocks are placed into a sieve bucket. The rocks are rubbed once more and placed back into the stream. The net is emptied and rinsed into the sieve bucket. Once all 4 locations have been sampled, the contents are transferred to a plastic sample bottle or Ziplock bags, labeled and preserved with 90% denatured alcohol.

Specimens are later processed for classification. Using a sieve, the specimen containers are drained and the material is suspended in water in a shallow tray. Using forceps and a magnifying glass, specimens are separated from debris, placed into a specimen container and preserved with 90% denatured alcohol. Water is drained from the remaining material using a sieve, placed back in the sample container and preserved once more.

The specimens that were picked from the sample were classified using a clean, shallow, white tray with a numbered grid of 12 equal squares. The bottom of the tray is covered with water and the specimens are evenly distributed. A sub-sample of 100 organisms is selected by choosing ¼ of the tray (3 different squares) at random. Additional squares are selected if 100 organisms have not been picked. For the 2013 samples, the sub-samples were sorted to the order level only. Family level identification is planned for specimens collected in 2014. Identifications are made using picture keys found in the River Watch Manual (Dates and Byrne, 1997). Further identifications will be made using the key found in Freshwater Macroinvertebrates of Northeast North America (Peckarsky, et al., 1990). Specimens are stored according to site and order in specimen vials. The number of organisms in each order are recorded on a data collection sheet.

Once macroinvertebrates are identified, data are entered and the metrics outlined below are calculated according to Dates and Byrne (1997).

Percent Composition of Major Groups: The percent of the sample in selected major groups. Generally, mayflies, stoneflies and caddisflies should be well represented, if they are absent, there may be a problem at the site. Stoneflies as a group are the most sensitive to pollution from sewage and other organic materials. They are often the first to become absent from a stream and generally make up a low percentage of a given sample (5-10%). Mayflies generally make up a significant percent of a sample (20-40%) and are usually the next group to disappear if a stream is impacted. If neither mayflies nor stoneflies are present the stream may be considered moderately to seriously degraded. It is rare to find a sample with no caddisflies present as this organism is pollution tolerant. If a river or stream is dominated (greater than 50%) by worms or midges, the water body may be seriously impacted. Worms are in the class *Oligochaeta* and midges are in the family *Chironomidae*.

Percent composition of selected major groups compares the sites to a sample model community from Connecticut based on historical data collected by the Connecticut Department of Environmental Protection (1992). The model community consists of the following groups described in Dates and Byrne (1997).

38% *Ephemeroptera* (Mayflies)
5% *Plecoptera* (Stoneflies)
31% *Trichoptera* (Caddisflies)
10% *Coleoptera* (Beetles)
8% *Chironomidae* (Midges)
1% *Oligochaeta* (Worms)

7% other

Percent Model Affinity (Bode, 1991): This is a measure of the similarity of the sample to a model "non-impacted community" based on the Percent Composition of selected major groups. The same model group used to compare the percent composition of selected major groups is used in this calculation. Results are analyzed based on the following percent similarity:

>64% = non-impacted
50-64% = slightly impacted
35-49% = moderately impacted
<35% = severely impacted

Major Group Biotic Index: This is a coarse estimate of the pollution tolerance of the community based on estimated pollution tolerances of the major groups that make up the aquatic insect community. Each major group is assigned a pollution tolerance value from 0-10, with 0 being intolerant and 10 being the most tolerant. Results are analyzed based on the following scale:

0-3.75 = No Impairment
3.76-6.50 = Moderate Impairment
>6.50 = Severe Impairment

Habitat Assessments: Habitat Assessments measure physical characteristics to determine the quality of habitat for benthic macroinvertebrates. These characteristics include the percent of cobble substrate, current velocity, substrate embeddedness, composition of river bottom, the nature and extent of the riffles within the sampling area, bank and riparian vegetation coverage and overhead canopy coverage. This determination helps to account for how habitat conditions influence the number and types of macroinvertebrates found at a site. The maximum possible score attainable is 150. Ideally, the percent similarity to a reference site with relatively good habitat quality is calculated.

4.2 Benthic Macroinvertebrate Results

In 2013, seven sites were sampled for macroinvertebrates: IP01 (Mill St., Reading/North Reading), IP2.7 (Parish Park, North Reading), IP06 (Boston St., Middleton), FB-LL (Fish Brook, Lockwood Ln., Boxford), HB (Howlett Brook, Ipswich Rd., Topsfield), GB (Gravelly Brook, Willowdale State Forest, Ipswich) and IP20 (Winthrop St., Ipswich). All sites were sampled during October 18-22, 2013. Percent composition of selected major groups, percent model affinity and major group biotic index were calculated based on the total number of specimens counted within each order represented in a sub-sample. Habitat assessments were not determined in 2013; however, results from previous years are reported. Three of the sites sampled in 2013 have yet to be assessed and a complete assessment will occur in 2014.

Habitat Assessments

Habitat Assessments were determined for a number of sites in the past which show a range of conditions. Many of the parameters are subjective in nature and differences are likely the result of interpretations being made by different individuals. Many of the sites showing results have been relatively stable over time, so variations will need to be resolved with consistent annual measurements and quality control checks by the program manager. In general, sites IP20 on the Ipswich River in Ipswich, Howlett Brook in Topsfield and Fish Brook at Lockwood Lane in Boxford have consistently better habitat quality than other sites. Sites in the upper watershed including Martins Brook and IP2.7 on the Ipswich River on average have lower habitat quality (Table 11).

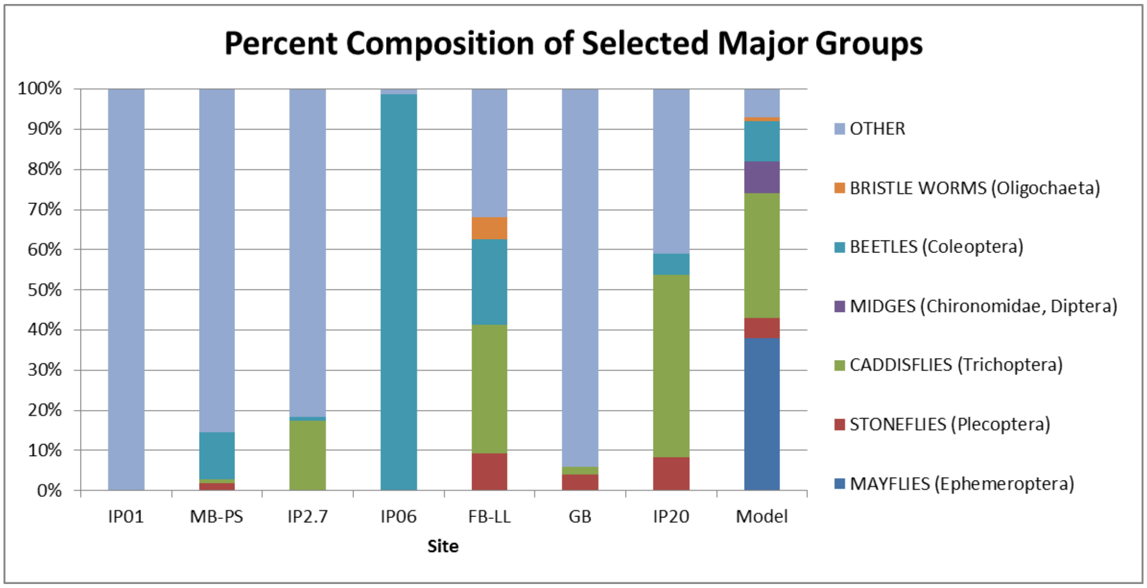
Table 12. Record of habitat assessments by site.

Habitat Assessments by Site											
Year	**FB-LL**	**FB-WA**	**GB**	**HB**	**IP01**	**IP02**	**IP06**	**IP08**	**IP2.7**	**IP20**	**MB-PS**
1997	95			97		67					75
1998	110			126							82
1999				127				97	103	102	86
2001	87			119		55		83	89	115	98
2002	116			80				83	90	87	71
2011											
2012											
2013											

Percent Composition of Selected Major Groups

Sites are compared to the model community described previously: 38% *Ephemeroptera* (Mayflies) 5% *Plecoptera* (Stoneflies) 31% *Trichoptera* (Caddisflies) 10% *Coleoptera* (Beetles) 8% *Chironomidae* (Midges) 1% *Oligochaeta* (Worms) 7% other. This comparison shows noticeable differences seen in figure 14. Mayflies were not present among the samples and it is also important to note that the category **"Other"** includes all *Amphipoda* (scud) families. Scuds are macroinvertebrates with extremely high pollution tolerance, and account for the majority of the percentages listed under **"Other"** at all sites. Fish Brook and site IP20 both occur in areas where good habitat quality is available and show relatively higher diversity than all other sites sampled.

Figure 14. Percent composition of major groups compared to a model community.



Percent Model Affinity

Percent model affinity is a measure of the similarity of the sample to the same model community used to compare the percent composition of selected major groups. A slight to moderate degree of impairment is shown by this metric in figure 15. Fish Brook and IP20 are indicated as non-impacted by this metric, in agreement with the composition of major groups relative to the reference site. Results vary over time as seen in table 12; however the same pattern is consistent of Fish Brook and IP20 showing greater similarity to the reference than other sites.

Figure 15. Percent model affinity in 2013 of sampling sites compared with a model community. The degree of similarity indicates the level of impact.

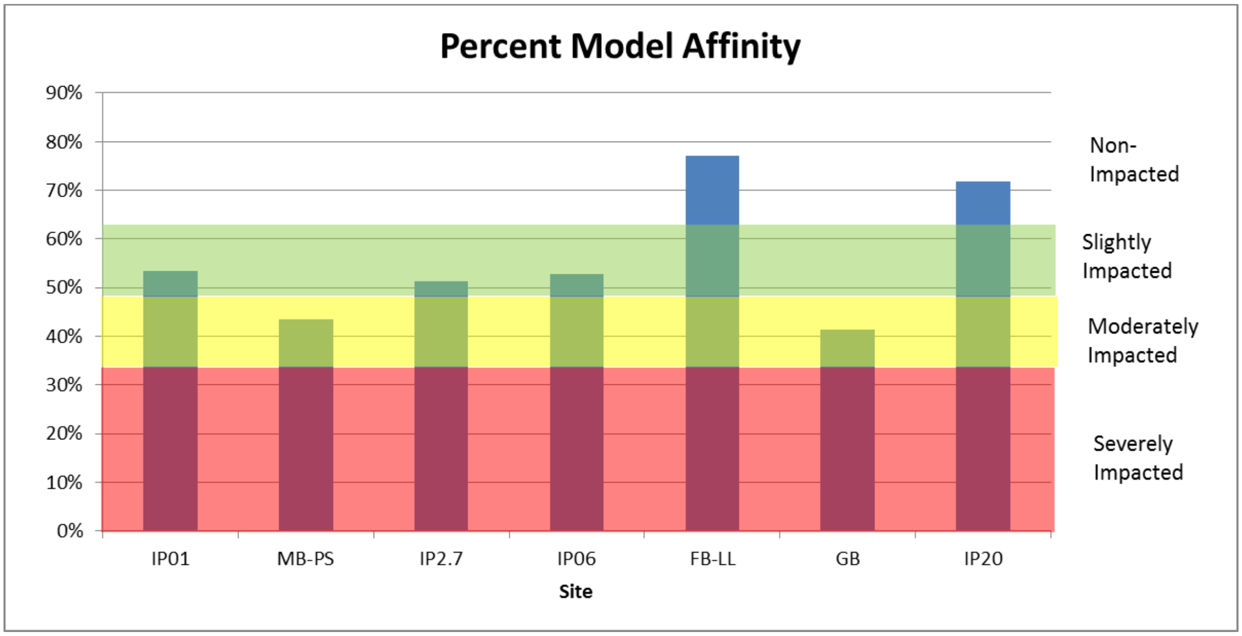


Table 13. Record of percent model affinity by site.

Percent Model Affinity by Site											
Year	**FB-LL**	**FB-WA**	**GB**	**HB**	**IP01**	**IP02**	**IP06**	**IP08**	**IP2.7**	**IP20**	**MB-PS**
1997	45%			48%		11%	20%			55%	49%
1998	53%			44%		16%	44%			49%	26%
1999				38%			17%	37%	17%	22%	28%
2001	27%			23%		10%	27%	20%	20%	32%	13%
2002	45%			21%			21%	23%	20%	31%	30%
2011			38%	41%						15%	
2012		24%	27%	29%				11%	6%	35%	16%
2013	77%		41%		54%		53%		51%	72%	43%

Major Group Biotic Index

Major group biotic index is a coarse measurement of the pollution tolerance of the sample classified to the order level. An increase in biotic index indicates an increase in the pollution tolerance of the community. A biotic index above 6.5 represents a severe impairment while values below 3.75 indicate little to no impairment. Intermediate impairments occur between these two values. According to this scale, the sites range from moderate to no impairment for all sites in 2013 (figure 16). Pollution tolerance values also vary over time and expected differences are not consistent (table 13).

Figure 16: Major group biotic index summary for macroinvertebrate monitoring sites.

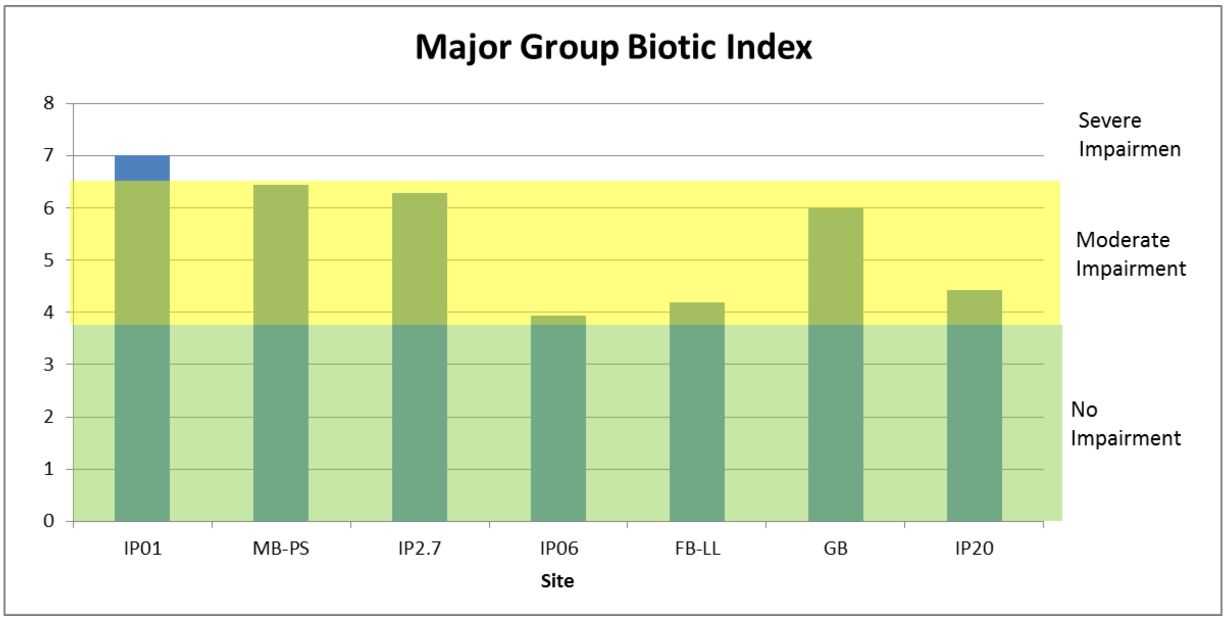


Table 14. Record of major group biotic index or pollution tolerance by site.

Major Group Biotic Index by Site											
Year	**FB-LL**	**FB-WA**	**GB**	**HB**	**IP01**	**IP02**	**IP06**	**IP08**	**IP2.7**	**IP20**	**MB-PS**
1997	4.3			4.0		5.6	6.5			4.8	4.1
1998	5.5			3.4		7.0	3.7			3.7	6.0
1999				4.6			2.3	4.0	3.7	2.6	4.3
2001	3.7			3.8		3.9	3.9	4.2	3.3	3.9	4.0
2002	4.1			3.8			5.3	5.2	4.6	3.9	5.1
2011			4.4	5.0						3.6	
2012		4.2	4.4	5.0				7.1	4.1	4.3	3.9
2013	4.2		6.0		7.0		3.9		6.3	4.4	6.4

General Findings

Without habitat assessments, a complete analysis cannot be made, however, the observed trends agree with water quality data where available.

At most sites, the absence of mayflies and frequent lack of stoneflies is notable. Stoneflies and mayflies, along with some types of caddisflies are the most sensitive groups and should be well represented in a sample as observed in the model comparison. Stoneflies are the most sensitive to pollution and the first to disappear when conditions in a stream decline. Why stoneflies are present at some sites while mayflies are absent is not known, but may be due to habitat conditions. The absence of stoneflies and mayflies at the locations and times samples were collected suggest long-term impairments in habitat and water quality occur at many sites throughout the watershed. The abundance of amphipod crustaceans indicates warm water and low oxygen conditions that this group is known to tolerate. With the exception of Gravelly Brook, all sites in the upper watershed, where low oxygen conditions are frequently recorded, show this pattern.

Further investigation is needed to better understand observed results. Achieving family level identification will be important to detect subtle changes by applying new metrics that are not possible when working at the order level. Habitat assessments will also be necessary to account for number and types of specimens seen at a site. In general, the upper watershed shows more signs of impairment, where low flows along with low oxygen and the impacts of increased development are expected to reduce habitat and water quality conditions.

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Section 6: References

American Rivers. 2003. Ipswich River. America's Most Endangered Rivers of 2003. pgs. 18-19. http://www.americanrivers.org/site/DocServer/meripswich.pdf?docID=676

Armstrong, D.S., T.A. Richards and G.W. Parker. 2001. Assessment of Habitat, Fish Communities, and Streamflow Requirements for Habitat Protection, Ipswich River, Massachusetts, 1989-99. USGS Water Resources Investigations Report 01-4161. http://pubs.usgs.gov/wri/wri01-4161/

Connecticut Department of Environmental Protection, January 1992. Cumulative Macroinvertebrate Taxa List, Water Management Bureau.

Dates, Geoff, and Byrne, Jack, 1997. Living Waters: Using Benthic Macroinvertebrates and Habitat to Assess Your River's Health, River Watch Network, Montpelier, Vt.

http://content.yudu.com/Library/A1xs36/LivingWaters/resources/index.htm?referrerUrl=http%3A%2F%2Fwww.rivernetwork.org%2Fresource-library%2Fonline-publications

Horsley and Witten, Inc. 2002. Ipswich River Watershed Management Plan.

http://ipswich-river.org/wp-content/uploads/2010/03/wap_ipswich_2003.pdf

Heath, D, and Morse, D. 2013. Road Salt Transport at Two Municipal Wellfields in Wilmington, Massachusetts. *New England Water Works Association, volume 127*(1), 1-23.

Ipswich River Fisheries Restoration Task Force. 2002. Ipswich River Fisheries Current Status and Restoration Approach. Ipswich River Watershed Association, Ipswich, Massachusetts.

http://ipswich-river.org/wp-content/uploads/2010/03/FishRestReport.pdf

Ipswich River Watershed Association. 2002. A multivariate regression analysis of dissolved oxygen in the Ipswich River mainstem. http://ipswich-river.org/wp-content/uploads/2010/03/do-final.pdf

Ipswich River Watershed Association. 2003. The State of the Ipswich River 2003.

http://ipswich-river.org/wp-content/uploads/2010/03/StateoftheRiver2003.pdf

MA Department of Conservation and Recreation Monthly Rainfall Composite Statistics. http://www.mass.gov/dcr/watersupply/rainfall/

MA Department of Environmental Protection. 2000. Ipswich River Watershed Water Quality Assessment Report.

http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/92wqar.pdf

MA Department of Environmental Protection. 2007. 314 CMR: Division of Water Pollution Control, 314 CMR 4.00: Massachusetts Surface Water Quality Standards. http://www.mass.gov/dep/service/regulations/314cmr04.pdf Accessed October 2012.

MA Department of Environmental Protection. 2001. Stressed Basins in Massachusetts http://www.mass.gov/eea/docs/eea/wrc/stressed-basins.pdf

MA Department of Environmental Protection. 2010. Massachusetts Year 2010 Integrated List of Waters Section 303d. USEPA Approved. http://www.mass.gov/dep/water/resources/10list6.pdf

(USGS) United States Geological Survey. Ipswich Flow Gauge Records.

http://waterdata.usgs.gov/ma/nwis/uv?site_no=01102000

(USGS) United States Geological Survey. South Middleton Flow Gauge Records. http://waterdata.usgs.gov/ma/nwis/uv?site_no=01101500

(USGS) United States Geological Survey. Wilmington Groundwater conditions. http://nwis.waterdata.usgs.gov/nwis/dv?referred_module=gw&site_no=423401071093801

Weiskel, Peter, K., Brandt, Sara, L., DeSimone, Leslie, A., Ostiguy, Lance, J., Archfield, Stacey, A. 2010. Indicators of Streamflow Alteration, Habitat Fragmentation, Impervious Cover, and Water Quality for Massachusetts Stream Basins USGS Scientific Investigations Report 2009-5272. http://pubs.usgs.gov/sir/2009/5272/pdf/sir2009-5272_text.pdf

Zarriello, P.J. and K.G. Reis. 2000. A Precipitation-Runoff Model for Analysis of the Effects of Water Withdrawals on Streamflow, Ipswich River Basin, Massachusetts. USGS Water Resources Investigation Report 00-4029. http://pubs.usgs.gov/wri/wri004029/whole_report.pdf

RiverWatch Data Appendices and Quality Assurance Project Plan (QAPP) available at:

http://www.ipswichriver.org/our-work/library/research/