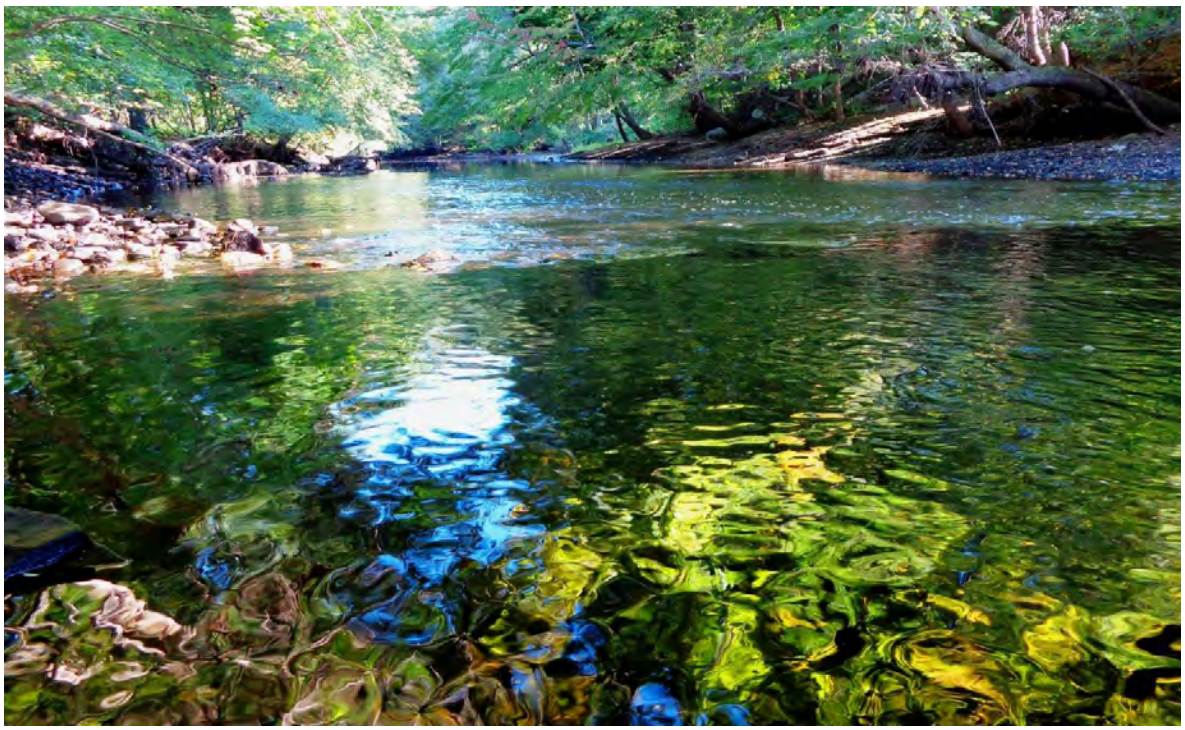
CONCORD RIVER WATERSHED
SMART MONITORING PROGRAM 2011-2013
TECHNICAL MEMORANDUM CN 418.0



Sudbury River, Framingham

Prepared By:
Therese Beaudoin
January 2016

Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
Matthew Beaton, Secretary
Massachusetts Department of Environmental Protection
Martin Suuberg, Commissioner
Bureau of Water Resources
Douglas Fine, Assistant Commissioner
Division of Watershed Management
Rebecca Weidman, Director
Watershed Planning Program
Kim Groff, Director

TABLE OF CONTENTS

LIST OF TABLES

Cover photo by Therese Beaudoin, MassDEP. September 25, 2013.
All photos in document taken by Therese Beaudoin. MassDEP. CERO.
SMART monitoring logo designed by Robert Kimball and Barbara Kimball.

LIST OF FIGURES

LIST OF LATIN NAMES

Latin Name	Common name	Latin Name	Common name
Agelaius phoeniceus	redwinged blackbird	*Lobelia canadensis*	cardinal flower
Anas platyrhynchos	mallard duck	*Myriophyllum* sp.	milfoil
Anatidae family	duck	*Peltandra virginica*	arrow arum
Ardea herodias	great blue heron	*Pontedaria cordata*	pickerelweed
Branta canadensis	Canada goose	*Potamogeton* sp.	pondweed
Cambaridae family	true crayfishes	*Potamogeton epihydrus*	ribbonleaf pondweed
Ceratophyllum demersum	coontail/hornwort	*Sagittaria* sp.	arrowhead
Culicidae family	mosquitoes	*Scirpus* sp.	sedges
Elodea sp.	waterweed	Unionidae family	freshwater mussels
Gramineae family	true grasses	*Vallisneria* sp.	eelgrass, tape grass or wild celery
Lemna sp.	duckweed	*Wolffia* sp.	watermeal
Lithobates clamitans	green frog		

LIST OF ACRONYMS

% sat	percent oxygen saturation
305(b)	Section 305(b), Clean Water Act
7Q10	lowest 7-day average streamflow that occurs, on average, once every 10 years
BWR	Bureau of Resource Protection
BWR	Bureau of Water Resources
ºC	degree Celsius
CERO	Central Regional Office
cfs	cubic feet per second
cond	specific conductivity
CSO	Combined Sewer Overflow
DO	dissolved oxygen
DWM	Division of Watershed Management
ºF	degree Fahrenheit
in/yr	inches per year
m	meter
MA	Massachusetts
MassDEP	Massachusetts Department of Environmental Protection
µS/cm	microsiemens per centimeter
mg/L	milligrams per liter
mi	mile
mi^2	square miles
NH_3-N	ammonia nitrogen
NO_3NO_2-N	nitrate-nitrite nitrogen
NTU	Nephelometric Turbidity Unit
NWS	National Weather Service
POR	Point of Record
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
SMART	Strategic Monitoring and Assessment for River basin Teams
SOP	Standard Operating Procedure
sp.	species
Ssolids	suspended solids
SU	Standard Unit
SuAsCo	Sudbury, Assabet, Concord
T	temperature
TDS	total dissolved solids
TMDL	Total Maximum Daily Load
TN	total nitrogen
TPhos	total phosphorus
turb	turbidity
USGS	United States Geological Survey
WES	Wall Experiment Station
WWTP	wastewater treatment plant

INTRODUCTION

The purpose of this technical memo is to present observations and data collected in the Strategic Monitoring and Assessment for River basin Teams (SMART) program in the SuAsCo River watershed from 2011 through 2013, highlighting how the program supports and augments programs of the Massachusetts Department of Environmental Protection (MassDEP) Bureau of Resource Protection (BRP, now the Bureau of Water Resources, BWR) Central Regional Office (CERO) and the Division of Watershed Management (DWM).

Overview of Monitoring Plan

Bimonthly water quality monitoring in the Concord Watershed began in March 2000. The sampling plan matrix for the 2011-2013 SMART monitoring program is presented in Table 1. The location of sampling stations is presented in Figure 1. Sampling components at all stations included:

- *in situ* measurements: dissolved oxygen (DO), percent oxygen saturation, pH, specific conductivity, temperature (T), depth and total dissolved solids (TDS);
- physical/chemical constituents: total alkalinity, chlorides, hardness, total suspended solids (TSS), turbidity;
- nutrients: ammonia-nitrogen (NH_3-N), nitrate-nitrite-nitrogen (NO_3_NO_2-N), total nitrogen (TN), and total phosphorus (TP);
- flow measurements (at existing USGS flow gaging stations); and
- general field observations.

Table 1 SuAsCo Basin SMART Sampling Summary – 2011 through 2013

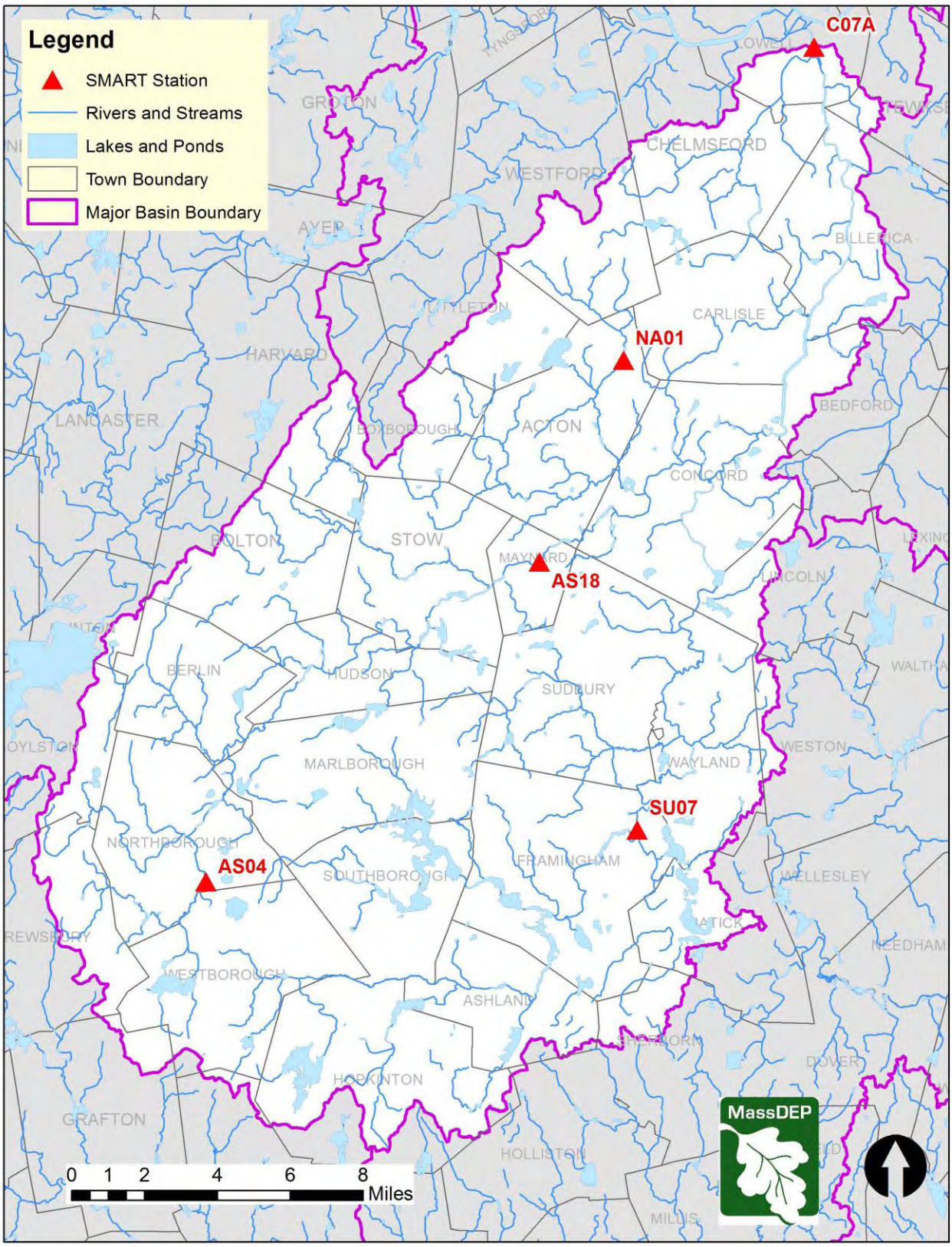
Location and Segment Numbers	Station Name	Station Type	Dates Sampled[1]
Assabet River @ School Street, Northborough MA82B-02	AS04	Impact	2011: 1/19/11, 3/15/11, 5/17/11, 7/20/11, 9/21/11, 11/16/11 2012: , 2/22/12, 4/11/12, 6/20/12, 8/22/12, 10/24/12 2013: 1/28/13, 3/20/13, 5/20/13, 8/28/13, 9/25/13
Assabet River @ USGS flow gaging station, State Roads 27/62, Maynard MA82B-05	AS18	Impact	
Nashoba Brook @ USGS flow gaging station, Wheeler Road, Acton MA82B-14	NA01	Impact	
Sudbury River @ USGS flow gaging station, Danforth Road, Framingham MA82A-03	SU07	Reference	
Concord River SW of Rogers Street, Lowell MA82A-08 (from 1/19/11 – 9/25/13)	CO7A	Boundary	

Hydrology

The Concord River Watershed has a total drainage area of 400 square miles (mi^2), entirely within the Commonwealth of Massachusetts (MA). It is comprised mainly of two subwatersheds, the Assabet and Sudbury, which is the basis of the basin's other name, the SuAsCo (Sudbury, Assabet, Concord). See SuAsCo Watershed Water Quality Assessment Report 2001 for further information (O'Brien-Clayton 2005).

The Assabet River, with a drainage area of 131 mi^2, begins at the outlet of the Assabet River Reservoir, or the "A1" site, in Westborough. From there, the river meanders approximately 31 miles (mi) through many dammed reaches until it joins the Sudbury River at Egg Rock in Concord, MA. The lower 4.4 mi were designated as Wild and Scenic by the U.S. Congress in 1999 (for further information on the Act of Congress that designated these areas, see Designation Of Sudbury, Assabet, And Concord Scenic And Recreational Rivers (USGPO 1999). Due to its highly impounded nature and the nutrient input from four major wastewater treatment plant (WWTP) discharges, the Assabet River exhibits problems associated with eutrophication.

Figure 1 MassDEP SMART Concord River Watershed Water Quality Station Locations



The Sudbury River, with a drainage area of 162 mi^2, flows approximately 28 mi from its headwaters at the outlet of Cedar Swamp Pond, Westborough to the Assabet River confluence. The upper watershed includes numerous large water supply reservoirs in Hopkinton, Southborough, Ashland and Framingham, which serve as emergency drinking water supplies. The river then flows through a large urbanized area in Framingham. North of the Danforth Street Bridge, the final 14.9 miles of the Sudbury have been designated as Wild and Scenic.

The Concord River drains an additional 107 mi^2 and flows approximately 15 mi to its junction with the Merrimack River in the City of Lowell. The upper 8 miles are federally designated Wild and Scenic. This part of the watershed is moderately to densely developed, with large areas of impervious surfaces throughout.

Quality Assurance/Quality Control

The quality assurance (QA) quality control (QC) project plan (QAPP) for the SMART program is presented in CN 012.1: *Strategic Monitoring and Assessment for River basin Teams Quality Assurance Project Plan* (Beaudoin 2008). The QAPP presents data quality objectives, quality assurance procedures, and other program-specific information. This technical memorandum will report deviations from the procedures described in the QAPP.

Aerial photos were obtained from Google Earth (2013a, 2013b, 2013c, 2013d, 2013e) at a height of approximately 4,000 feet (ft).

PROJECT OBJECTIVES

The primary water quality objectives of the SMART monitoring program are:

- Document baseline water quality by: providing information on low flow/event flow variation, seasonal variation and frequency of selected constituents; and establishing reference distributions of key constituents for ecoregion delineation and "clean water" sites;
- Estimate loads of detected water constituents at key locations by: quantifying nitrogen loadings to coastal waters; and calculating phosphorous loads upstream/downstream of representative land use areas;
- Define long term trends in water quality by: documenting improvements associated with major abatement projects; and identifying trends at least-impacted stations (that may result from factors such as acid precipitation and climate change);
- Assess attainment of water quality uses by: comparing existing water quality with water quality standards; and by assessing use support for the fishable/swimmable goal;
- Provide support for other programs by: determining reference distributions for ecoregion stations; conducting trend analysis for the 305(b) reports[1] and basin plans; quantifying nutrient loadings for load allocations (total maximum daily loads, or TMDLs); obtaining data on nonpoint source loadings for more intensive Year 2 sampling; providing guidance for volunteer monitoring; collecting data for development of statistically-based water quality standards and for improvement of Combined Sewer Overflow (CSO) and Stormwater policies; and developing a long-term database on conditions at key locations for the development of new programs and basic research.

As stated in the Introduction, this document presents observations and data collected in the SuAsCo Watershed under the SMART program from 2011-2013. An assessment of the data will be presented in future reports.

METHODS

Water quality sampling procedures are included in *Grab Collection Techniques for DWM Water Quality Sampling, Standard Operating Procedure* (MassDEP 1999b). Use of the *in situ* monitoring equipment followed procedures set forth in *CN 4.0 Water Quality Multi-probe Instrument Use, Standard Operating Procedure* (MassDEP 1999a). Physical/chemical and nutrient samples were analyzed at the Wall Experiment Station (WES), the MassDEP analytical laboratory located in Lawrence, Massachusetts. All samples were collected, transported, analyzed, and discarded according to chain-of-custody procedures.

In addition to the measurements and analytes noted above, field observations were recorded at each station on standardized field sheets, field notebooks, and photographs. Field observations included date/time, location, crewmembers, snow cover (when relevant), canopy cover, water odors, colors, sheens, foams, estimated river height and velocity, weather conditions, observed uses (e.g., boating), wildlife, aquatic algae and macrophytes, potential pollution sources, and unusual conditions. The number and type of samples were recorded, as well as the last set of *in situ* data collected. An aerial view and a photo depicting the upstream environs accompany each station description; see Figure 3 through Figure 11. A summary of field observations by station collected during this sampling period are presented in Table 2 through Table 6 following the station descriptions.

Each station selected for the SMART Monitoring program is described according to key characteristics associated with water quality at that location, as follows:

- Reference: a reference station is located in a stream segment that is minimally influenced by anthropogenic activities;
- Impact: an impact (or trend) station is located where several sources of pollution come together and can be used to calibrate a mass balance model, or where critical reactions take place such as at an oxygen sag point; and

[1] The 305(b) reports are the biannual reports to the U. S. Congress on water quality that are required under Section 305(b) of the Clean Water Act.

- Boundary: a boundary station is located at a pour point i.e., where water leaves a designated river basin, or at a state line.

Field sheets, raw data files, chain of custody forms, lab reports, and other metadata used in this report are managed and maintained by the MassDEP DWM in the Water Quality Access Database in Worcester, MA. The validation of the water quality data included data entry into DWM databases, data entry quality control checks, analysis for outliers, blank contamination, duplicates, precision, and holding time violations, followed by project level review (MassDEP 2005). The project coordinator, as identified in the QAPP for the SMART program (CN 012.2), reviews the data for reasonableness, completeness and acceptability (Beaudoin 2008).

STATION OBSERVATIONS

Station AS04 – Assabet River at School Street, Northborough, MA (river mile 27.803)

Figure 2 Google Earth view of Station AS04 area

Figure 3 Station AS04 upstream (9/25/2013)

Station AS04 is located on the Assabet River near the School Street Bridge in Northborough, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, this station was sampled 13 times, and access was gained from the bridge or from the shore upstream. When the abundance of poison ivy on the banks in this location prevented shoreline access, samples were collected from the bridge, center stream, with a sampling pole. When poison ivy was not an issue, sampling was conducted from a point upstream of the bridge, by wading in from the left bank. Both locations are representative of water quality conditions in this reach. Station AS04 serves as an impact station as it is located downstream of numerous point and nonpoint sources of pollution, as described below.

Land uses proximal to this station consist of residential and forested, including a Christmas tree farm (Figure 2) (Google Earth 2013a). The Westborough WWTP discharge is located 2.25 mi upstream. Nonpoint sources include roads, shopping districts, and other large expanses of impervious surfaces.

The river was approximately 30 ft wide at this site, typically less than 3 ft deep and roughly uniform across the channel throughout the year (Figure 3). Deciduous trees provided canopy cover over much of the streambed upstream of the bridge. The bottom consisted mainly of sand, with cobble and gravel, silt and mud.

During the growing season (approximately June through September), the channel was colonized with sparse to dense populations of emergent macrophytes, including *Elodea* sp. (waterweed), Gramineae family (grasses), *Peltandra virginica (*arrow arum), *Pontedaria cordata (*pickerelweed*), Potamogeton* sp. (pondweed), *P. epihydrus* (ribbonleaf pondweed), *Sagittaria* sp. (arrowhead), *Scirpus* sp. (sedges), *Vallisneria* sp. (eelgrass, tape grass, wild celery) and Wolffia sp. (watermeal). Periphyton was not present on 9 of the 13 dates sampled; when present, periphytic growth was most commonly composed of dense to very dense filamentous algae.

In addition to songbirds, the only wildlife observed in this stretch of river during SMART monitoring from 2011-2013 was *Branta canadensis* (Canada goose). Fishing line and bobbers were caught in shoreline tree branches, indicating that recreational fishing occurs in this area. In September 2011, a small platform was built on the eastern shore, upstream of the bridge, with a tether for a small boat.

In general, the water column at this station lacked trash, odor, foam, sheens and turbidity. Water color was typically clear or light yellow.

Field duplicates for the SMART program were collected at Station AS04 from 2001 through July 2011; from September 2011 through September 2013, duplicates were collected at Station AS18.

Station AS18 – Assabet River at Waltham Street, Maynard, MA (river mile 7.594)

Figure 4 Google Earth view of Station AS18

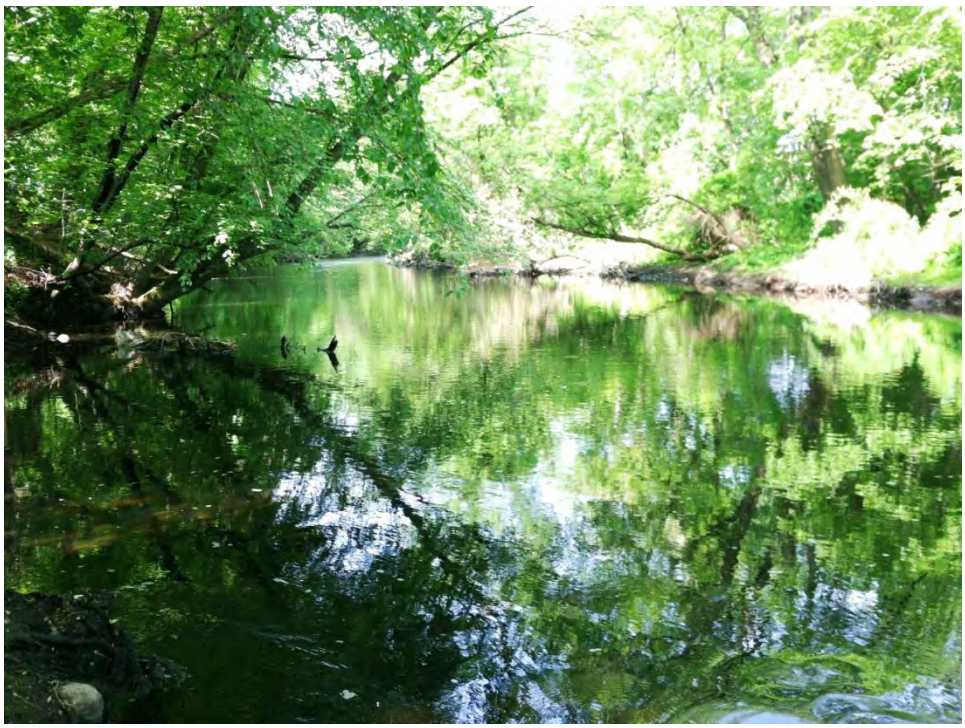


Figure 5 Station AS18 upstream (5/20/2013)

Station AS18 is located upstream of the Waltham Street Bridge (State Road or SR 27) in Maynard, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, the station was sampled 13 times, and access was gained from the eastern shore near the United States Geological Survey (USGS) flow gaging station. Samples were collected by wading in or with a sampling pole (when access to flowing water was difficult). Station AS18 serves as an impact station as it is located downstream of numerous point and nonpoint sources of pollution, as described below.

Land uses around this area include residential and commercial (Figure 4) (Google Earth 2013b). Upstream, the river flows through several hypereutrophic impoundments, and receives the discharges of three major WWTPs, including Marlborough Westerly and Hudson (as well as Westborough). Nonpoint sources include roads, shopping districts, and other large expanses of impervious surfaces.

The channel at this location was approximately 45 ft wide, with depths ranging from 1ft to unknown (too deep to wade), and heavily shaded (Figure 5). It was often difficult to see the bottom clearly due to solar reflection, turbidity and turbulence; in addition, bottom rocks were stained a dark brown/black color, and often covered in a dense growth of filamentous algae. As a result, the bottom composition was unobservable on most sampling dates (10 of 13). When visible, the bottom consisted of boulder, cobble, gravel, sand and silt.

Few aquatic macrophytes were observed at this station from 2011-2013; these included *Ceratophyllum demersum* (coontail, hornwort), Gramineae (grasses), *Lemna* sp. (duckweed), *Lobelia canadensis* (cardinal flower), *Myriophyllum* sp. (milfoil), *Potamogeton* sp. (pondweed) and *Wolffia* sp. (watermeal). In addition to songbirds, wildlife observed here included *Agelaius phoeniceus* (redwinged blackbird), *Anas platyrhynchos* (mallard ducks), Cambaridae (crayfish), *Lithobates clamitans* (green frog) and Unionidae (freshwater mussels). Periphyton was noted on 8 events (n=9; unobservable on 4 events); when visible, the most common forms were moderate to very dense populations of moss and/or filamentous algae.

The water column at this station ranged from clear to highly turbid; when visible, conditions were typically clear. The water color was clear on half of the sampling dates, and red or light yellow on the other half. Water odors were absent on half of monitoring events; musty, “eutrophic pond”, and effluent odors were also noted. Foam was present on most sampling events, usually sparse in coverage. Sheens were generally absent; pollen was observed on one event (9/21/2011). Trash was unobservable on most of dates; when visible, trash consisted of bricks, chunks of concrete and floatables.

Field duplicates for the SMART program were collected at Station AS04 from 2001 through July 2011; from September 2011 through September 2013, duplicates were collected at Station AS18.

Station NA01 – Nashoba Brook off Wheeler Lane, Acton, MA (river mile 4.305)

Figure 6 Google Earth view of NA01 area

Figure 7 Station NA01 upstream (6/20/2012)

Station NA01 is located on Nashoba Brook in Acton, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, the station was sampled 13 times, and access was gained from the eastern shore at the USGS flow gaging station near a footbridge in the Nashoba Brook Conservation Area. Samples were collected from center stream by wading in or with a sampling pole. Station NA01 was expected to represent reference conditions for the Concord watershed; however, water quality data have shown that it is an impact station, influenced by numerous point and nonpoint sources of pollution, as described below.

The station is located in the upper area of the Nashoba Brook watershed, and upstream land uses include light residential and industrial/commercial development and forest (Figure 6) (Google Earth 2013c). Robbins Mill Pond is located approximately 0.1 miles about Station NA01. Although there are no surface water municipal discharges upstream, there are numerous groundwater discharges of sewage. The closest is the Acton Retirement Community (approximately 350 ft from Nashoba Brook, and 2,400 ft upstream of the station).

The river channel was approximately 15 ft wide in this reach and heavily shaded (Figure 7). Although it was often difficult to determine the bottom composition due to solar reflection, the deep tannic color of the water column and bottom staining, the bottom (when visible) consisted mainly of cobble, gravel and sand. For the same reasons, it was often difficult to determine the presence or absence of periphyton; when visible, periphyton mainly consisted of moss. Trash was absent on all dates when the bottom was visible.

Aquatic macrophytes were largely absent from this stream segment; *Lobelia cardinalis* (cardinal flower) was observed on a single event (8/28/2013). Other than songbirds, wildlife was not observed in this area during this time period.

The water column was clear on most sampling events; when visible, turbidity was sparse to moderate. The water color was red on most sampling events. The water column typically lacked odor; although a petroleum odor was noted on 5 sampling events, the source appeared to be the sediments when disturbed by the sampling staff. Foam was absent on two-thirds of monitoring dates, and sparse on most other site visits. A pollen layer was observed on 6/20/2012; sheens were absent on all other dates.

Station SU07 – Sudbury River at Danforth Street, Framingham, MA (river mile 16.320)

Figure 8 Google Earth view of Station SU07 area

Figure 9 Station SU07 upstream (6/20/2012)

Station SU07 is located on the Sudbury River in the village of Saxonville, Framingham, MA within the Boston Basin ecoregion. From 2011-2013, the station was sampled 13 times, and access was gained from the western shore downstream of the historic Old Danforth Street Bridge (pedestrian traffic only) near the (modern) Danforth Street Bridge. Samples were collected from center stream by wading in or with a sampling pole. Both sites are considered to represent water quality in this reach. Station SU07 serves as a reference station, minimally influenced by anthropogenic activities.

The upper Sudbury watershed includes pristine riverine areas and large impoundments managed as emergency water supplies (Figure 8) (Google Earth 2011d). The river flows through the urbanized towns of Framingham and Natick, with dense residential and industrial/commercial development, roadways and a flood control project constructed by the U.S. Army Corps of Engineers in 1979 to alleviate flooding in the village of Saxonville.

Upstream of the Old Danforth Street Bridge, the river channel is approximately 75 ft wide, with depths ranging from approximately 0.5 ft to unknown (too deep to wade). The channel is open to the sky, except in the footprint of the two bridges (Figure 9). Downstream of the historic bridge, the channel is approximately 50 ft wide, 0.5 to 3 ft deep, with nearly complete canopy cover. The bottom consisted largely of cobble, gravel and sand. Periphyton was present on half of the sampling events; moss was the most common form observed (n=4), and moderate dark green filamentous algae and a sparse clear film were observed once. Aquatic macrophytes were sparse; those present included *Potamogeton* sp. (pondweed), *P. epihydrus* (ribbonleaf pondweed) and an unknown submergent. Waterfowl and other water-related birds included *Agelaius phoeniceus* (redwinged blackbird), Anatidae (duck family) and *Branta canadensis* (Canada goose). Mussels (Unionidae) and Culicidae (mosquitoes) were also noted.

On most sampling events, the water column was clear (without visible turbidity) and lacked odor, foam and sheens. Water color was typically clear or light yellow. Trash was present on all sampling dates, in both the riparian zone and the stream channel; items observed included broken glass, bricks, storm drain grate, catch basin cover, metals, floatables and miscellaneous unidentifiable objects.

Station CO7A – Concord River at Rogers Street, Lowell, MA (river mile 0.843)

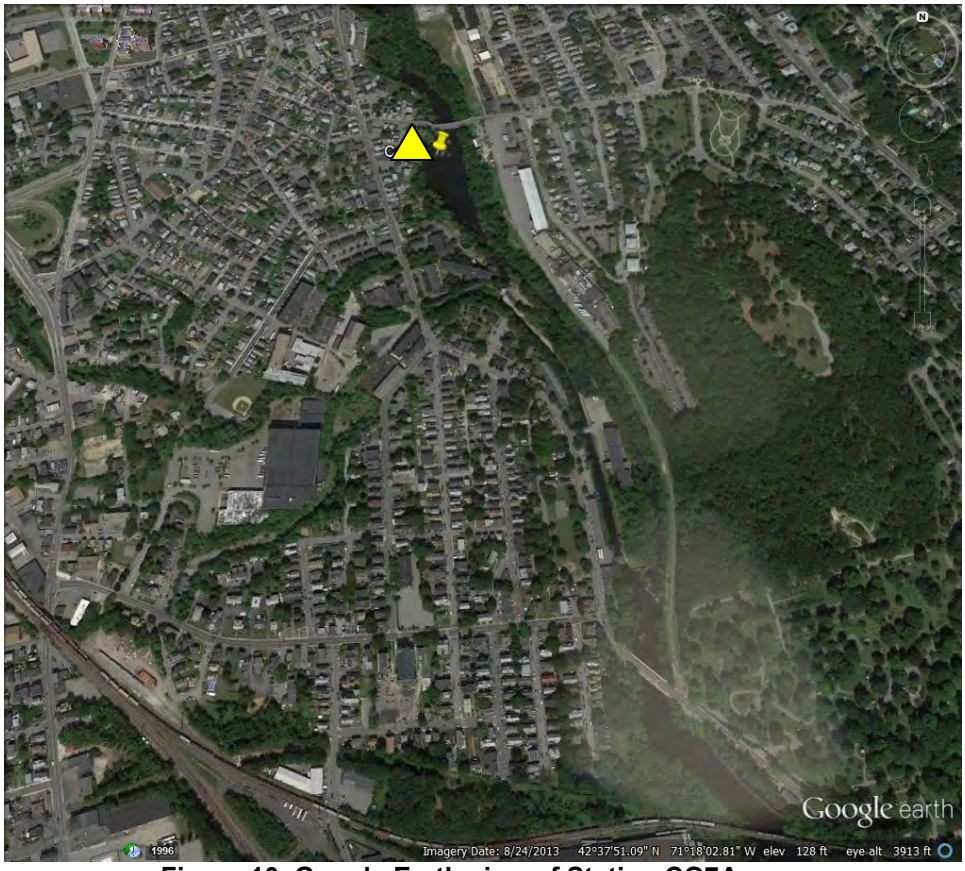


Figure 10 Google Earth view of Station CO7A area

Figure 11 Station CO7A upstream (9/25/2013)

Station CO7A is located on the lowest reach of the Concord River in Lowell, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, the station was sampled 12 times, and access was gained from the western shore approximately 20 ft upstream (south) of the Rogers Street Bridge. Samples were collected by wading in or with a sampling pole. Station CO7A serves as a boundary station, where the Concord River watershed enters the Merrimack River watershed.

The land use surrounding this stretch of river is the urbanized center of Lowell (Figure 10) (Google Earth 2011e). Numerous municipal discharges are located upstream, as well as large areas of impervious surfaces.

The river at Station CO7A is approximately 120 ft wide. Although shaded along some of the shoreline, most of the channel is open to the sky (Figure 11). The depth across the stream channel is unknown at both locations (too deep to wade). Visibility was often limited due to solar reflection, turbidity and turbulence. When visible (2 of 12 events), the stream bottom was composed largely of boulders, with cobble, gravel, sand and a layer of silt over all. Again, when the entire water column was visible (5 events, n=12), periphyton typically consisted of a filamentous algae or moss. No aquatic macrophytes were observed in this area from 2011-2013. Waterfowl noted at this station included Anatidae (duck family), *Branta canadensis* (Canada goose)*, Anas platyrhynchos* (mallard duck), and *Ardea herodias* (great blue heron*)*; "gulls" were also observed.

When visible, the water column at this station ranged from clear to highly turbid; in general, the river was moderately to highly turbid. Typically, the water color was red or light yellow and lacked odor and sheens. Foam was absent on half of the monitoring events; when present, foam coverage ranged from very sparse to moderate. The streambed was not visible on 9 of 12 events; when the bottom was visible (3 dates), minor to moderately dense trash was present, including metals, tires, shopping cart, scooter, unidentifiable items, and floatables.

As the last station sampled on each of the SuAsCo SMART Monitoring events, field blank samples were collected here.

Table 2 MassDEP SMART 2011 - 2013. Station AS04. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/19/2011	Sand	None	None	Clear	None	None	None	Clear	Wet
3/15/2011	Sand	None	None	Light yellow	None	None	None	Clear	Dry
5/17/2011	Cobble/sand	None	None	Red, slight	None	None	None	Clear	Wet
7/20/2011	Sand/silt	None	None	Light yellow	None	None	None	Clear	Dry
9/21/2011	Cobble/gravel/sand/silt	None	Moderate: moss	Light yellow	None	None	None	Clear	Dry
11/16/2011	Sand	None	None	Clear	None	Very sparse	None	Clear	Dry
2/22/2012	Sand/Mud	None	Dense: brown filamentous	Light yellow	None	None	None	Clear	Dry
4/11/2012	Unobservable	None	Dense: silt-covered filamentous	Clear	Effluent	None	None	Clear	Dry
6/20/2012	Cobble/gravel/sand/silt	None	None	Light yellow	Musty, slight	None	None	Moderate	Dry
8/22/2012	Cobble/gravel/sand/silt	Minor: beer can	None	Clear	Musty, slight	None	None	Clear	Dry
10/24/2012	Sand	None	Very dense: dark green filamentous; moderate brown film	Clear	None	None	None	Clear	Dry
1/28/2013	Sand	None	None	Clear	None	None	None	Clear	Dry
3/20/2013	Sand	None	None	Clear	None	None	None	Clear	Wet
5/20/2013	Unobservable	Unobservable	Unobservable; dense clear film on rocks where visible	Light yellow	Musty, slight	None	None	Clear	Dry
8/28/2013	Boulder/sand/silt	None	Moderate: moss	Clear	None	None	None	Clear	Dry
9/25/2013	Boulder/cobble/gravel/sand/silt	None	Sparse: moss	Clear	Musty, slight	None	None	Clear	Wet

-- : Not noted

Table 3 MassDEP SMART 2011 - 2013. Station AS18. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/19/2011	Unobservable	Unobservable	Unobservable	Clear	Effluent, strong	Sparse	None	Clear	Wet
3/15/2011	Unobservable	Unobservable	Unobservable; dark green filamentous on plants where visible	Clear	None	Sparse	None	Unobservable	Dry
5/17/2011	Unobservable	Unobservable	Unobservable	Unobservable	None	Moderate	None	Unobservable	Wet
7/20/2011	Unobservable	Trash	Dense: moss	Light yellow	Eutrophic pond, strong	Very sparse	None	Unobservable	Dry
9/21/2011	Boulder/cobble/gravel/sand/silt	Chunks of concrete, bricks	Sparse: moss	Red, slight	Musty	Sparse	Pollen	Moderate	Dry
11/16/2011	Unobservable	Unobservable; chunks of cement (where visible)	Unobservable	Red	Musty	Sparse	None	Clear	Dry
2/22/2012	Unobservable; dense periphyton	Unobservable; luxuriant filamentous algae	Very dense; bright green filamentous, "luxuriant"	Light yellow	None	Sparse	None	Clear	Dry
4/11/2012	Boulder/cobble/gravel/silt	Unobservable; chunks of cement (where visible)	Very dense: silt-covered filamentous, luxuriant	Light yellow	Eutrophic pond	None	None	Slight	Dry
6/20/2012	Boulder/cobble/gravel/sand/silt	Minor: cement chunks	Moderate: moss	Red	Musty, strong	Sparse	None	Moderate	Dry
8/22/2012	Unobservable; turbulence	Unobservable	Very dense: dark green filamentous	Clear	Eutrophic pond, strong	None	None	Unobservable	Dry
10/24/2012	Unobservable; bottom stained dark brown	Unobservable	Very dense: clear film	Clear	None	None	None	Clear	Dry
1/28/2013	Unobservable (solar reflection)	Unobservable	None	Clear	None	Sparse	None	Clear	Dry
3/20/2013	Unobservable	Minor: floatables, cement chunks	Moderate: bright green filamentous	Clear	None	Sparse	None	Clear	Wet
5/20/2013	Boulder/cobble/gravel/sand/silt	Chunks of concrete	Sparse green filamentous; dense moss	Unobservable	None	Moderate	None	Unobservable	Dry
8/28/2013	Boulder/cobble/gravel/sand/silt; stained	Chunks of concrete	Dense: moss	Clear	Eutrophic pond	None	None	Clear	Dry
9/25/2013	Boulder/cobble/gravel/sand/silt	Minor: cement chunks	Sparse: dark green filamentous; sparse moss	Clear	None	None	None	Clear	Wet
-- : Not noted									

Table 4 MassDEP SMART 2011 - 2013. Station NA01. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/19/2011	Unobservable	None	None	Clear	None	None	None	Clear	Wet
3/15/2011	Cobble/sand	None	Dense, moss	Red	Petroleum	Very sparse	None	Clear	Dry
5/17/2011	Unobservable	Unobservable	Unobservable	Red	None	Sparse	None	Unobservable	Wet
7/20/2011	Boulder/cobble/gravel/sand/silt	None	Moderate: moss	Red	Petroleum	None	None	Slight	Dry
9/21/2011	Unobservable	None	Sparse: moss	Red, deep	Petroleum (sediment release)	None	None	Slight	Dry
11/16/2011	Unobservable; bottom stained black	None	Sparse: moss	Red	None	None	None	Clear	Dry
2/22/2012	Cobble/gravel/sand	None	None	Red	None	None	None	Clear	Dry
4/11/2012	Boulder/cobble/gravel/sand/silt	None	None	Red	None	Sparse	None	Clear	Dry
6/20/2012	Unobservable	Unobservable	Unobservable	Red, deep	Petroleum, strong	None	Pollen	Moderate	Dry
8/22/2012	Unobservable	Unobservable	Unobservable	Red, deep	Musty, slight	Sparse	None	Unobservable	Dry
10/24/2012	Unobservable; bottom stained	None	None	Red	Petroleum (sediment release)	None	None	Clear	Dry
1/28/2013	Unobservable	Unobservable	Unobservable	Red	None	None	None	Clear	Dry
3/20/2013	Boulder/cobble/gravel/sand/silt	None	Moderate: moss	Red	None	Sparse	None	Clear	Wet
5/20/2013	Unobservable	None	Sparse: moss	Red	Musty, slight	None	Pollen, slight	Clear	Dry
8/28/2013	Unobservable	Unobservable	Unobservable	Red	Musty, slight	None	None	Slight	Dry
9/25/2013	Unobservable	Unobservable	Unobservable	Red	None	None	None	Clear	Wet
-- : Not noted									

Table 5 MassDEP SMART 2011 - 2013. Station SU07. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/19/2011	Cobble/grand/sand	Moderate: metals, broken glass	None	Clear	None	None	None	Clear	Wet
3/15/2011	Cobble/gravel/sand	Moderate	None	Light yellow	None	Sparse	None	Clear	Dry
5/17/2011	Unobservable	Moderate: broken "junk"	None	Brown	Musty	None	None	Moderate	Wet
7/20/2011	Cobble/gravel/sand/silt	Moderate: miscellaneous unidentifiable items, catch basin grate	None	Light yellow	None	Sparse	None	Clear	Dry
9/21/2011	Cobble/gravel/sand	Moderate: broken glass, metals, miscellaneous, bricks	None	Light yellow	Musty	None	None	Slight	Dry
11/16/2011	Cobble/gravel/sand	Minor: floatables, metals, miscellaneous unidentifiable objects	None	Red, slight	None	None	None	Clear	Dry
2/22/2012	Unobservable	Unobservable; broken glass, storm drain grate where visible	Unobservable	Light yellow	None	None	None	Unobservable	Dry
4/11/2012	Boulder/cobble/gravel/sand/silt	Moderate: broken glass, metals, floatables, unknown	Very dense: moss	Clear	Fishy - intermittent	None	None	Clear	Dry
6/20/2012	Cobble/gravel/sand	Moderate: broken glass, metals, miscellaneous unidentifiable objects	Sparse: moss	Red, slight/light yellow, slight	None	None	None	Slight	Dry
8/22/2012	Boulder/cobble/gravel/sand/silt; embedded	Moderate: broken glass, metals, miscellaneous	Sparse: moss	Clear	Musty	Sparse	None	Clear	Dry
10/24/2012	Cobble/gravel/sand	Moderate: broken metals, miscellaneous, bricks	Moderate: dark green filamentous; sparse clear film	Light yellow	None	None	None	Clear	Dry
1/28/2013	Cobble/gravel/sand/silt	Moderate: metals, miscellaneous	None	Clear	None	None	None	Clear	Dry
3/20/2013	Unobservable	Unobservable; moderate miscellaneous broken unidentifiable items where visible	Unobservable; none where visible	Clear	None	None	None	Clear	Wet
5/20/2013	Boulder/cobble/gravel/sand/silt	Moderate: miscellaneous pieces	Dense: green filamentous	Clear	None	None	None	Clear	Dry
8/28/2013	Boulder/cobble/gravel/sand	Minor: trash, most high and dry	Very dense: brown filamentous	Clear	None	None	None	Clear	Dry
9/25/2013	Boulder/cobble/gravel/sand/silt	Moderate: miscellaneous unidentifiable objects - most on banks	Sparse: green filamentous	Clear	None	None	None	Clear	Wet
-- : Not noted									

Table 6 MassDEP SMART 2011 - 2013. Station CO7A. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
1/19/2011 (CO7A)	Station not sampled; access/time issues								
3/15/2011	Unobservable	Unobservable	Unobservable	Light yellow	None	Moderate	None	Unobservable	Dry
5/17/2011	Unobservable	Unobservable	Unobservable	Light yellow	None	Sparse	None	Unobservable	Wet
7/20/2011	Boulder/cobble/gravel/sand/silt	Moderate: tires, shopping cart, unidentifiable "stuff", floatables	Moderate: moss, covered in silt	Red/light yellow	Eutrophic pond, strong	Moderate	None	Moderate	Dry
9/21/2011	Unobservable	Minor: unidentifiable items	Sparse: moss	Red	Musty	Moderate	None	Slight	Dry
11/16/2011	Unobservable	Unobservable	Unobservable	Red	None	Very sparse	None	Unobservable	Dry
2/22/2012	Unobservable	Unobservable	Unobservable; dense brown filamentous where visible	Light yellow	None	None	None	Unobservable	Dry
4/11/2012	Unobservable	Unobservable	Very dense olive green filamentous	Red, slight	Eutrophic pond	None	None	Moderate	Dry
6/20/2012	Unobservable	Unobservable	Unobservable	Brown/red	None	None	None	Highly murky	Dry
8/22/2012	Unobservable	Unobservable	Unobservable	Rusty	Fishy, eutrophic pond	None	None	Highly murky	Dry
10/24/2012	Unobservable (solar reflection)	Unobservable; broken pieces of "unidentifiable stuff" where visible	None	Light yellow	None	None	None	Clear	Dry
1/28/2013	Boulder/cobble/gravel/sand/silt	Moderate: floatables, metals, scooter, miscellaneous	Moderate: tan filamentous	Clear	None	None	None	Clear	Dry
3/20/2013	Unobservable	Unobservable	Unobservable	Unobservable	None	Sparse	None	Unobservable	Wet
5/20/2013	Unobservable	Unobservable; scooter where visible	Unobservable	Light yellow	None	None	Pollen	Moderate	Dry
8/28/2013	Boulder/coble/gravel/sand/silt	Moderate; covered in silt	Dense: brown filamentous	Red	Musty, slight	None	Pollen	Slight	Dry
9/25/2013	Unobservable	Moderate: miscellaneous unidentifiable objects	Very dense: brown filamentous	Brown	Musty, slight	Very sparse	None	Moderate	Wet
-- : Not noted									

SURVEY CONDITIONS

Stream discharge and precipitation data are used to determine hydrologic conditions and, consequently, if water quality surveys should be described as dry or wet weather events. Precipitation data were obtained from the National Oceanic and Atmospheric Administration (NOAA). The presence/absence of precipitation during the five days prior to each sampling event was based on the National Weather Service (NWS) data located on their website NOAA Climatological Data Publications (NOAA 2015). The weather stations closest to the Concord watershed are in Lowell, Reading and Worcester. Reading has the save average annual precipitation as most of the basin, while Worcester receives a greater volume and Lowell a smaller volume. Therefore, climatological data collected at Reading were utilized in this report. Overall, precipitation varies little across the watershed, which receives an average of 44 to 46 inches/year (in/yr) (Ostiguy et al 2010). The northern area, including Chelmsford, Lowell, and the northern sections of Westford and Billerica, receives 42 to 44 in/yr, while the southwest area, including portions of the towns of Bolton, Berlin, Northborough and Westborough, receives 46 to 48 in/yr.

During dry weather, trace amounts of precipitation may fall, but there is no measurable change in stream flow. The USGS operates five real time stream gaging stations in the Concord River Watershed near SMART stations:

- Assabet River at Maynard, MA (7/11/1941 to current)(USGS 2015a);
- Nashoba Brook near Acton, MA (7/26/1963 to current)(USGS 2015b);
- Sudbury River at Saxonville, MA (11/1/1979 to current) (USGS 2015c); and
- Concord River below River Meadow Brook at Lowell, MA (12/16/1936 to current)(USGS 2015d).

The mean streamflow values are from the USGS Concord River gage below River Meadow Brook, Lowell and are reported at USGS Daily Data at Concord River below River Meadow Brook, Lowell, MA (USGS 2015e). The monthly mean discharge data are found at USGS Monthly Data at Concord River below River Meadow Brook, Lowell, MA (USGS 2015f). The daily statistics data, based on 71-72 years of record are reported at USGS Mean Daily Statistics at Concord River below River Meadow Brook, Lowell, MA (USGS 2015g). .

Wet weather is determined to impact water quality when precipitation within a five-day antecedent period leads to more than a slight increase in stream discharge. Under dry weather conditions, trace amounts of precipitation may fall, but no measurable change in stream flow occurs. In addition to precipitation, discharge values were examined relative to the 7Q10 low flow (the lowest 7-day average streamflow that occurs, on average, once every 10 years) which is 32.2 cubic feet per second (cfs) at the USGS gaging station on the Concord River below River Meadow Brook in Lowell (Wandle and Fontaine 1984). At some of the SuAsCo flow gaging stations, precipitation-related stream fluctuations were difficult to distinguish from non-precipitation driven fluctuations on some events.

Table 7 through Table 11 present climate data used to determine wet weather/runoff or dry weather conditions for individual winter surveys (January – March). Table 12 through Table 13 present the precipitation and discharge data for each sampling event and the preceding 5-day period; these data were used to estimate hydrological conditions for each sampling event. When precipitation and discharge data were insufficient to determine wet or dry conditions, additional data consulted included maximum daily temperature, snowfall and snow on the ground.

January 19, 2011 – Over 5 in of snow (1.38 in as water) was recorded at the Reading, MA weather station on January 18-19, 2011. Discharge at area gages generally reflected this storm, as well as input from snowmelt (see Table 7). Data collected during this event reflect wet weather/runoff conditions. Air temperature during the sampling event ranged from 36 to 39 degrees Fahrenheit (°F) under overcast skies.

Table 7 Climate Conditions at Reading, MA from January 14-19, 2011

Parameter	Jan 14	Jan 15	Jan 16	Jan 17	Jan 18	Jan 19
Max Temperature (ºF)	25	30	37	24	39	39
Precipitation (inches as water)	0	T	0	0	1.38	0.26
Snowfall (inches)	0	T	0	0	5.2	1.0
Snow on the ground (inches)	20	17	15	15	18	16
Data obtained at NOAA Climatological Data Publications (NOAA 2015).						

March 15, 2011 – Over 0.67 in of precipitation was recorded at Reading between March 10-12, 2011. Discharge at area gages rose with this event, but decreased to pre-storm levels by March 14. Table 8 shows maximum daily temperatures well above freezing through this period, although snow on the ground remained at approximately 1 in (field observations note some areas with snow and patches of dry ground, and some areas with patches of snow only throughout the watershed). Data collected during this event dry weather conditions. Air temperature ranged from 31 to 47°F with cloud cover ranging from 15 to 100%.

Table 8 Climate Conditions at Reading, MA from March 10-15, 2011

Parameter	March 10	March 11	March 12	March 13	March 14	March 15
Max Temperature (ºF)	39	51	50	48	38	48
Precipitation (inches as water)	0.07	0.59	0.01	T	T	0
Snowfall (inches)	0	0	0	0	T	0
Snow on the ground (inches)	1	1	1	1	1	1
Data obtained at NOAA Climatological Data Publications (NOAA 2015).						

May 17, 2011 – Over 0.85 in rain fell on the area in the two days and the morning preceding this spring monitoring event (May 15-17). Discharge at area gages more than doubled during this period; discharge at the Concord River gage indicated several rapid fluctuations not associated with precipitation. Data reflect wet weather/runoff conditions. Air temperature ranged from 48 to 49°F with overcast skies and intermittent drizzle.

July 20, 2011 – Summer sampling in 2011 followed a relatively dry period (approximately 0.21 in of rain 2 days prior to monitoring activities). Discharge at the Assabet River at Maynard and Nashoba Brook at Acton gages steadily decreased in this period, while discharge at the Sudbury River at Saxonville and the Concord River at Lowell reflect non-precipitation based fluctuations. Field observations note river levels ranging from low to very low throughout the watershed. Data reflect dry weather conditions. Air temperature ranged from 68 to 84°F under sunny skies.

September 21, 2011 – A small amount of rain (0.14 in) fell the evening before this monitoring event. Discharge at all watershed gages steadily decreased in the preceding week. Data collected during this event reflect dry weather conditions. Air temperature ranged from 61 to 70°F under sunny skies.

November 16, 2011 – This mid-fall survey followed a week with only trace precipitation recorded at Reading (the half inch of rain measured on the sampling date fell after conclusion of monitoring activities). Discharge at area gages generally decreased from Nov. 10/12-16. Therefore, data reflect dry weather conditions. Air temperature ranged from 52 to 61°F and cloud cover from 20 to 100%.

February 22, 2012 – This winter sampling even followed a dry period, with scant precipitation recorded at Reading; see Table 9 for climate data. The discharge pattern at area gages generally decreased from February 17 through the sampling date. Field observations noted lower than normal water levels at all stations. Data collected on this date reflect dry weather conditions. Air temperature ranged from 35 to 55°F and skies ranged from mostly sunny to overcast.

Table 9 Climate Conditions at Reading, MA from February 17-22, 2012

Parameter	Feb 17	Feb 18	Feb 19	Feb 20	Feb 21	Feb 22
Max Temperature (ºF)	53	47	57	42	44	58
Precipitation (inches as water)	0.01	T	0	0	T	0
Snowfall (inches)	0	0	0	0	T	0
Snow on the ground (inches)	0	0	0	0	0	0
Data obtained at NOAA Climatological Data Publications (NOAA 2015).						

April 11, 2012 – A dry period proceeded this spring monitoring event (0.01 recorded on the sampling date fell after conclusion of monitoring activities). Overall, discharge at watershed gages decreased over the preceding week; although non-precipitation based fluctuations were observed at the Sudbury and Concord River gages, flows had returned to pre-event levels by April 11. Water levels at all stations continued to be low to very low. Data collected on this date reflect dry weather conditions. Air temperature ranged from 46 to 54°F under overcast skies.

June 20, 2012 – This late spring monitoring event followed a dry period, with no precipitation recorded at Reading in the preceding five days. Overall, discharge at area gages rose decreased steadily from June 14-20. Water levels at all stations continued to be lower than normal. Data collected during this event reflect dry weather conditions. Air temperature ranged from 74 to 90°F under clear skies.

August 22, 2012 –A storm brought 0.26 in to the area on August 17-18, followed by 4 days without measurable precipitation at Reading. Discharge at area gages generally reflected the precipitation pattern. Low to very low water levels were observed at all stations. Data reflect dry weather conditions. Air temperature ranged from 63 to 78°F under sunny skies.

October 24, 2012 – Over an inch of rain fell on the area on October 19-20, 2012 with no precipitation recorded at Reading from October 21-24. In general, discharge at area gages peaked on October 20-21, then decreased through monitoring activities to pre-storm levels. Data reflect dry weather conditions. Air temperature ranged from 52 to 57°F under overcast skies.

January 28, 2013 – Little precipitation was noted in the area in the five days preceding this winter monitoring event (1.2 in snow recorded on the sampling date fell after monitoring activities had concluded) (see Table 10). Discharge at area gages generally decreased throughout the week preceding this monitoring event. At stations throughout the watershed, water levels were lower than normal. Bare ground with patches of snow was noted throughout the watershed. Data collected during this event reflect dry weather conditions. Air temperature ranged from 25 to 30°F under overcast skies.

Table 10 Climate Conditions at Reading, MA from January 23-28, 2013

Parameter	Jan 23	Jan 24	Jan 25	Jan 26	Jan 27	Jan 28
Max Temperature (ºF)	17	19	24	25	30	30
Precipitation (inches as water)	0	0	T	0.01	0	0.15
Snowfall (inches)	0	0	T	0.1	0	1.2
Snow on the ground (inches)	T	0	T	0	0	1
Data obtained at NOAA Climatological Data Publications (NOAA 2015).						

March 20, 2013 – A late winter storm brought 13 inches of snow to the area from March 18-19, 2013 (2.01 in as water); see Table 11 for climate data from March 15-20, 2015. The discharge pattern varied at area gages. At the Assabet River, Maynard, flow decreased steadily from March 14-18, then remained at that level through March 20. At the Nashoba Brook, Acton and the Sudbury River, Saxonville, flow also decreased through March 18, then increased through March 20. Mean daily discharge at the Concord River gage varied little over the week prior this sampling event. Table 8 shows maximum daily temperatures above freezing through this period, and snow on the ground decreased 3 in from March 19-20. Field observations note that water levels at area stations were normal to high, up from low in January. Data collected during this event wet weather/runoff conditions. Air temperature ranged from 30 to 42°F and cloud cover from 0 to 70%.

Table 11 Climate Conditions at Reading, MA from March 15-20, 2013

Parameter	March 15	March 16	March 17	March 18	March 19	March 20
Max Temperature (ºF)	39	39	39	38	34	37
Precipitation (inches as water)	0	0	0	0.08	1.33	0
Snowfall (inches)	0	0	0	0.8	12.2	0
Snow on the ground (inches)	T	T	0	1	9	6
Data obtained at NOAA Climatological Data Publications (NOAA 2015).						

May 20, 2013 – A small storm brought 0.17 in rain to the area from May 19-20, 2013; however, discharge did not rise with precipitation. The water level at all stations had returned to lower than normal. Data collected on this date reflect dry weather conditions. Air temperature ranged from 60 to 70°F and skies from 10 to 100% cloud cover.

August 28, 2013 – Minimal precipitation fell in the area in the 5-day preceding this summer monitoring event (0.01 in). The discharge pattern varied between watershed gages from August 23-28. Discharge at the Assabet River gages (Hudson, Maynard) rose from August 27-28; fell at the Nashoba Brook (Acton) and Concord River (Lowell);

and varied little at the Sudbury River (Saxonville). Water levels at all stations remained at lower than normal. Based on precipitation, discharge at Nashoba Brook and the Concord River, and consistently low water levels throughout the watershed, data collected on this date reflect dry weather conditions. Air temperature ranged from 68 to 82°F under sunny to mostly sunny skies.

September 25, 2013 – A storm brought 0.74 in rain to the area 3 days before this early fall monitoring event (9/22/2013). Discharge at most watershed gages rose with the precipitation input, then decreased but not to pre-storm levels before the survey. Data collected during this event reflect wet weather/runoff conditions. Air temperature ranged from 50 to 60°F under sunny to mostly sunny skies.

Table 12 SuAsCo Basin Precipitation Data Summary 2011-2013							
Survey Dates	**5 Days Prior ***	**4 Days Prior**	**3 Days Prior**	**2 Days Prior**	**1 Day Prior****	**Sample Date**	**Wet/Dry Conditions*****
1/19/2011	0	T	0	0	1.38	0.26	Wet
3/15/2011	0.07	0.59	0.01	T	T	0	Dry
5/17/2011	0	0	T	0.55	0.21	0.09	Wet
7/20/2011	0	0	0	0.21	0	0	Dry
9/21/2011	0.04	0	0	0	0	0.14	Dry
11/16/2011	T	0	0	0	T	0.51	Dry
2/22/2012	0.01	T	0	0	T	0	Dry
4/11/2012	0	0	T	0	0	0.01	Dry
6/20/2012	0	0	0	0	0	0	Dry
8/22/2012	0.12	0.14	0	0	T	0	Dry
10/24/2012	0.14	0.97	0	0	0	0	Dry
1/28/2013	0	0	T	0.01	0	0.15	Dry
3/20/2013	0	0	0	0.08	1.33	0	Wet
5/20/2013	T	0	0	0	0.14	0.03	Dry
8/28/2013	0	0	0	0.01	T	0	Dry
9/25/2013	0	0	0.74	0	0	0	Wet

*Unofficial data from the National Weather Service station in Reading, MA and reported at NOAA Climatological Data Publications (NOAA 2015); all data in inches of water.

**T= trace amount

*** Based on precipitation, streamflow and other relevant data.

Table 13 Discharge at the Concord River below River Meadow Brook, Lowell, MA 2011-2013								
Survey Dates	**5 Days Prior**	**4 Days Prior**	**3 Days Prior**	**2 Days Prior**	**1 Day Prior**	**Sample Date**	**Monthly Mean**	**POR*** Mean**
1/19/2011	374	412	394	359	339	374	421.6	683
3/15/2011	2,830	3,000	3,110	3,120	3,090	3,000	2,229	1,180
5/17/2011	706	678	646	652	700	773	859.7	858
7/20/2011	190	176	155	144	113	163	283.1	221
9/21/2011	1,300	1,170	1,060	957	878	806	1,150	265
11/16/2011	1,120	1,130	1,120	1,090	1,040	1,000	1,196	556
2/22/2012	587	585	587	589	585	577	758.0	859
4/11/2012	363	349	341	335	329	299	499.0	1,450
6/20/2012	517	487	450	385	340	300	454.4	513
8/22/2012	416	475	452	419	399	334	208.9	267
10/24/2012	207	325	377	370	336	297	264.4	402
1/28/2013	546	506	423	380	333	310	613.7	895
3/20/2013	1,980	2,000	1,970	1,920	1,880	1,850	1,665	1,340
5/20/2013	421	394	352	327	287	266	396.7	831
8/28/2013	99	95	89	87	81	80	240.3	225
9/25/2013	137	120	136	134	137	128	156.4	293

*Gage # 01099500 data found at Daily Data for the Concord River below River Meadow Brook, Lowell, MA; all data approved for publication (USGS 2015e).

**Daily statistics based on mean values of the point of record from 10/1/1936 – 9/30/2008 (USGS 2015g).

7Q10 = 32.2 cfs @ USGS gaging station, Concord River below River Meadow Brook at Lowell, MA (Wandle and Fontaine 1984).

RESULTS AND QUALITY ASSURANCE/QUALITY CONTROL

The results of SMART monitoring conducted in the SuAsCo watershed from 2011 through 2013 are included below. Table 14 through Table 18 present *in-situ* multiprobe readings, including temperature, pH, dissolved oxygen, percent oxygen saturation, depth, specific conductivity, and total dissolved solids. Table 19 through Table 23 contain nutrient (ammonia-nitrogen, nitrate-nitrite nitrogen, total nitrogen and total phosphorus), chlorides, hardness, total alkalinity, total suspended solids and turbidity data. Most results are expressed as milligrams per liter (mg/L). Exceptions include: depth in meters (m); temperature in degrees Celsius (ºC); pH in Standard Units (SU); conductivity in microsiemens per centimeter (µS/cm); dissolved oxygen saturation in percent (%); and turbidity, in Nephelometric Turbidity Units (NTU).

Field sheets, field notebooks, chain of custody forms, raw and electronic data files, lab reports and other metadata are maintained by DWM. Detailed information regarding the data validation process is explained in the separate document, *CN 56.2. Standard Operating Procedure. Data Validation and Usability* (MassDEP 2005). Specific validation criteria used for 2011-2013 data include, but are not limited to conformance to the SMART Monitoring Quality Assurance Project Plan (Beaudoin 2008) and with DWM standard operating procedures (SOPs), precision, accuracy, representativeness, holding times, sample preservation, frequency of field QC samples, contamination of field blanks, stability of multiprobe readings and documentation. The following data qualifiers were applied as needed:

Multiprobe data qualifiers:

** = Missing data.
-- = No data.
= Censored data (data that have been discarded for some reason).
c = Greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard.
i = Inaccurate readings from multiprobe likely.
m = Method not followed; one or more protocols contained in the DWM Multi-probe SOP not followed.
r = Data not representative of actual field conditions.
s = Field sheet recorded data were used to accept data, not data electronically recorded in the Multi-probe surveyor unit, due to operator error or equipment failure.
u = Unstable readings.

Laboratory sample data qualifiers:

** = Missing data.
-- = No data.
= Censored data (data that have been discarded for some reason).
[ ] = A result reported inside brackets has been censored, but is shown for informational purposes.
b = Blank contamination in lab reagent blanks and/or field blank samples.
d = Precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP.
e = Not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for *E. coli* bacteria is greater than fecal coliform bacteria.
h = Holding time violation (usually indicating possible bias low).
j = 'Estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the reporting detection limit (RDL) and greater than the method detection limit (MDL) (RDL > x > MDL). Also used to note where values have been reported at levels less than the MDL.
m = Method SOP not followed, only partially implemented or not implemented at all, due to complications with sample matrix (e.g. sediment in sample, floc formation), lab error (e.g. cross-contamination between samples), additional steps taken by the lab to deal with matrix complications, lost/unanalyzed samples, and missing data.

Table 14 MassDEP SMART 2011-2013. Station AS04. *In Situ* Multiprobe Data.

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/19/2011	SM-3456	8:50 AM	0.3	3.1	6.6	777	505	11.9	89
3/15/2011	SM-3528	8:14 AM	0.7	3.1	6.5	458	298	12.1	90
5/17/2011	SM-3600	8:26 AM	0.3	12.6	6.7	436	283	##i	##i
7/20/2011	SM-3672	8:27 AM	0.2	21.4	7.0	1110	721	6.1	69
9/21/2011	SM-3743	8:15 AM	0.4	15.9	7.0	679	441	7.8	79
11/16/2011	SM-3815	8:07 AM	0.7	10.7	6.9	370	240	10.0	90
2/22/2012	SM-3887	8:12 AM	0.6	4.7	7.0	606	394	11.0	86
4/11/2012	SM-3959	8:04 AM	##i	10.8	7.0	894	581	8.7i	79i
6/20/2012	SM-4031	8:02 AM	##i	19.0	7.0	810	527	6.5	70
8/22/2012	SM-4103	8:22 AM	##i	20.5	7.1	1246	810	5.6i	63i
10/24/2012	SM-4175	7:58 AM	##i	14.5	7.1	1050	682	5.9	58
1/28/2013	SM-4248	8:43 AM	0.0i	2.1	6.9	795	517	11.3i	82i
3/20/2013	SM-4319	8:11 AM	0.0i	1.9	6.8	655	426	12.8i	92i
5/20/2013	SM-4379	8:10 AM	##i	16.1	7.3	902	586	8.1	82
8/28/2013	SM-4421	8:22 AM	0.0i	20.8	7.3	1047	681	6.8	76
9/25/2013	SM-4451	8:11 AM	0.0i	15.0	7.1	999	649	8.0	80

Table 15 MassDEP SMART 2011-2013. Station AS18. *In Situ* Multiprobe Data.

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/19/2011	SM-3460	10:51 AM	0.3	0.3	6.9	675	439	14.9	103
3/15/2011	SM-3532	10:21 AM	0.6	3.2	6.6	367	239	14.1	106
5/17/2011	SM-3604	10:45 AM	0.3	13.1	6.9	426	277	##i	##i
7/20/2011	SM-3676	10:13 AM	0.2	25.6	7.6	641	417	7.4	91
9/21/2011	SM-3748	10:04 AM	0.3	16.4	7.2	438	285	9.7	100
11/16/2011	SM-3820	10:03 AM	0.5	10.6	7.1	332u	215u	11.6	104
2/22/2012	SM-3892	10:15 AM	0.3	4.3	7.6	409	266	14.1	108
4/11/2012	SM-3964	10:01 AM	##i	11.1	8.0	495	322	12.7i	116i
6/20/2012	SM-4036	9:46 AM	##i	22.3	7.5	423	275	8.6	99
8/22/2012	SM-4108	10:10 AM	##i	23.6	7.5	452	293	8.0i	95i
10/24/2012	SM-4180	9:52 AM	##i	12.9	7.4	605	393	9.9	93
1/28/2013	SM-4252	10:29 AM	0.0i	0.6	7.3	579	376	14.7i	103i
3/20/2013	SM-4324	10:21 AM	0.0i	1.4	7.0	463	301	14.1i	100i
5/20/2013	SM-4384	10:02 AM	##i	18.8	7.5	547	355	9.7	104
8/28/2013	SM-4426	10:12 AM	##i	23.5	7.9	671	436	8.0	95
9/25/2013	SM-4456	9:58 AM	0.0i	16.5	7.5	673	438	9.5	97

Table 16 MassDEP SMART 2011-2013. Station NA01. *In Situ* Multiprobe Data.

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/19/2011	SM-3462	11:33 AM	0.3	0.1	6.4	507	330	12.1	83
3/15/2011	SM-3534	10:56 AM	0.8	1.2	6.4	383	249	14.1	100
5/17/2011	SM-3606	11:26 AM	0.5	11.0	6.5	426	277	##i	##i
7/20/2011	SM-3678	10:50 AM	0.4	22.7	6.8	536	349	6.0	70
9/21/2011	SM-3750	10:38 AM	0.5	13.8	6.7	487	317	8.5	83
11/16/2011	SM-3822	10:44 AM	0.6	10.9	6.7	383	249	9.7	88
2/22/2012	SM-3894	11:08 AM	0.4	2.8	6.9	413	269	12.5	93
4/11/2012	SM-3966	10:40 AM	##i	10.0	7.0	425	276	11.7i	104i
6/20/2012	SM-4038	10:23 AM	##i	19.6	6.8	416	271	7.4	81
8/22/2012	SM-4110	11:00 AM	##i	20.7	6.8	537	349	6.6i	74i
10/24/2012	SM-4182	10:26 AM	##i	11.2	6.6	528	343	8.6	79
1/28/2013	SM-4254	11:18 AM	0.0i	0.3	6.6	613	399	12.2i	84i
3/20/2013	SM-4326	11:10 AM	0.0i	0.4	6.6	516	335	13.1i	91i
5/20/2013	SM-4386	10:40 AM	0.0i	16.5	6.8	577	375	8.6	88
8/28/2013	SM-4428	10:54 AM	##i	21.0	6.9	387	251	7.3	82
9/25/2013	SM-4458	10:34 AM	0.0i	13.2	6.7	531	345	9.0	86

Table 17 MassDEP SMART 2011-2013. Station SU07. *In Situ* Multiprobe Data.

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/19/2011	SM-3458	10:01 AM	0.2	0.6	7.1	684u	444u	14.7	103
3/15/2011	SM-3530	9:41 AM	1.1	3.3	6.8	472	307	14.8	111
5/17/2011	SM-3602	9:48 AM	0.3	13.7	6.9	465	302	##i	##i
7/20/2011	SM-3674	9:26 AM	0.5	25.6	7.2	458	298	7.9	97
9/21/2011	SM-3745	9:25 AM	0.4	17.8	7.2	382	248	9.6	101
11/16/2011	SM-3817	9:18 AM	0.3	10.6	7.1	381	248	11.9	107
2/22/2012	SM-3889	9:19 AM	0.4	4.0	7.3	387	251	13.4	102
4/11/2012	SM-3961	9:11 AM	##i	11.1	7.3	443	288	11.7i	106ii
6/20/2012	SM-4033	9:00 AM	##i	21.0	7.2	473	308	8.4	95
8/22/2012	SM-4105	9:22 AM	##i	22.6	7.2	442	287	8.2i	95i
10/24/2012	SM-4177	9:05 AM	##i	13.2	7.2	433	282	10.2	97
1/28/2013	SM-4250	9:48 AM	0.0i	0.8	7.2	508	330	14.1i	99i
3/20/2013	SM-4321	9:29 AM	0.0i	2.0	7.1	698	454	14.1i	102i
5/20/2013	SM-4381	9:17 AM	##i	18.2	7.2	610	396	9.7	103
8/28/2013	SM-4423	9:26 AM	##i	21.7	7.3	595	387	8.1	92
9/25/2013	SM-4453	9:14 AM	0.0i	15.4	7.0	596	388	9.3	93

Table 18 MassDEP SMART 2011-2013. Station CO7A. *In Situ* Multiprobe Data.

Date	OWMID	Time	Depth	Temp	pH	Cond@ 25C	TDS	DO	SAT
		(24hr)	(m)	(C)	(SU)	(us/cm)	(mg/l)	(mg/l)	(%)
1/19/2011	SM-3465	12:30 PM	**	**	**	**	**	**	**
3/15/2011	SM-3537	11:48 AM	0.8	2.7	6.5	382	248	14.3	106
5/17/2011	SM-3609	12:26 PM	0.3	13.7	6.8	470	305	##i	##i
7/20/2011	SM-3681	11:47 AM	0.3	26.8	7.4	613	399	7.7	96
9/21/2011	SM-3753	11:22 AM	0.6	17.0	6.7	397	258	8.3	85
11/16/2011	SM-3825	11:30 AM	0.7	10.1	6.9	383	249	11.7	104
2/22/2012	SM-3897	12:00 PM	0.4	4.4	7.2	431	280	13.6	105
4/11/2012	SM-3969	11:20 AM	##i	11.0	7.4	480	312	12.6i	114i
6/20/2012	SM-4041	11:11 AM	##i	##m,u	##i,m,u	##i,m,u	##i,m,u	##i,m,u	##i,m,u
8/22/2012	SM-4113	12:08 PM	##i	25.1	8.4	425	276	9.6i	116i
10/24/2012	SM-4185	11:10 AM	##i	13.6	7.1	490	318	9.6	92
1/28/2013	SM-4257	11:58 AM	0.0i	0.3	7.0	564	367	14.4i	100i
3/20/2013	SM-4329	12:35 PM	0.0i	2.5	7.0	587	382	13.7i	101i
5/20/2013	SM-4389	11:25 AM	0.0i	18.6	7.2	567	368	9.5	102
8/28/2013	SM-4431	11:37 AM	##i	25.0	7.4	576	375	8.2	99
9/25/2013	SM-4461	11:30 AM	0.0i	17.6	7.5	522u	339u	9.9	103

Table 19 MassDEP SMART 2011-2013. Station AS04. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/19/2011	SM-3454	8:40	23	110	190	>2419.6	5.4	2.6	8.0	0.14	6.8	0.20
3/15/2011	SM-3526	8:00	16	63	110	21	2.6d	1.5	2.0	0.15	1.3	0.040
5/17/2011	SM-3598	8:15	26	76	110	435	6.5	2.6	2.0	0.35	1.2	0.10
7/20/2011	SM-3670	8:16	49	190	270	276	2.4	1.7	11.0	0.04	9.7	0.18
9/21/2011	SM-3742	8:10	45	120	170	65	1.5	1.6	4.1	0.05	2.7	0.26
11/16/2011	SM-3814	8:00	26	61	78	13	2.2	1.4	1.7	<0.04	1.2	0.072
2/22/2012	SM-3886	7:50	40	99	140	2	2.0	1.3	3.3	<0.04	2.9	0.11
4/11/2012	SM-3958	7:55	60	160	190	19	2.4	##h	10.0d	0.04	9.2	0.035
6/20/2012	SM-4030	7:55	67	150	180	121	3.5	2.2b	5.1	0.05	4.6	0.048
8/22/2012	SM-4102	8:10	70	260	250	121d	##h	1.4	6.6	<0.02	5.5	0.040
10/24/2012	SM-4174	7:45	89	210	240	75	2.4	0.8	8.2b	<0.10	7.9	0.036
1/28/2013	SM-4246	8:20 AM	50	120	180	54	3.0	1.6	6.0	0.05	4.7	0.042
3/20/2013	SM-4318	8:00 AM	22	81	170	18	1.9	1.2	1.9	0.03	1.4	0.078
5/20/2013	SM-4378	8:10 AM	73	160	200	130	6.0	2.7	5.3	0.12	4.4	0.070
8/28/2013	SM-4420	8:15 AM	80	180b	##h	345	1.8d	1.1d	5.5	##h	##h	0.034
9/25/2013	SM-4450	8:02 AM	75	180	210	185	<1.0	0.8	8.0	0.02	8.1	0.022

Table 20 MassDEP SMART 2011-2013. Station AS18. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/19/2011	SM-3459	10:42	20	74	160	108	2.6	2.3	3.7	0.32	3.2	0.055
3/15/2011	SM-3531	10:10	9	41	90	291	1.9	1.3	1.1	0.09	0.74	0.029
5/17/2011	SM-3603	10:35	22	61	100	613	11	3.0	1.5	0.09	0.93	0.076
7/20/2011	SM-3675	10:00	41	83	160	613	6.7	3.6	1.5	0.07	0.79	0.082
9/21/2011	SM-3746	9:58	17d	60	110	178	3.1	2.0	1.6	0.04	1.1	0.062
11/16/2011	SM-3818	9:56	19	50	84	105	16	8.6d	1.3	0.02d	0.93	0.051
2/22/2012	SM-3890	10:00	22	57	94	49	1.7	1.5	1.7	<0.02	1.4	0.032
4/11/2012	SM-3962	9:44	30	67	110	488	5.7	##h	##d	0.02	1.9	0.028d
6/20/2012	SM-4034	12:04	31	57	99	687	5.2	3.2b	1.5	0.04	0.95	0.071
8/22/2012	SM-4106	10:05	33	63	93	##d	##h	1.6	1.2	<0.02	0.73	0.063
10/24/2012	SM-4178	9:39	48	90	140	548	1.4	1.1	2.5b	0.06	2.5	0.031
1/28/2013	SM-4251	10:20 AM	29	77	130	75	1.5	1.7	2.7	48	2.0	0.030
3/20/2013	SM-4322	10:12 AM	10d	51	120	36	1.1d	1.1	1.1	0.02	0.89	0.025
5/20/2013	SM-4382	9:57 AM	30	72	120	48	3.4d	1.8	1.8	<0.02	1.2	0.051
8/28/2013	SM-4424	10:06 AM	47	89b	##h	435	##d	##d	1.2	0.05h	##h	0.041
9/25/2013	SM-4454	9:48 AM	48	96	160	387	<1.0	5.0	2.2	##	1.8	0.048d

Table 21 MassDEP SMART 2011-2013. Station NA01. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/19/2011	SM-3461	11:23	22	75	110	15	<1.0	1.6	1.9	0.80j	0.84	0.020
3/15/2011	SM-3533	10:45	8	44	94	17	<1.0	0.6	1.1	0.17	0.68	0.017
5/17/2011	SM-3605	11:18	16	54	100	461	3.2	1.9	0.94	0.13	0.22	0.044
7/20/2011	SM-3677	10:42	30	75	130	29	4.3	1.8	0.82	0.02	0.42	0.038
9/21/2011	SM-3749	10:32	25	71	130	55	2.4	1.5	1.5	0.06	0.95	0.032
11/16/2011	SM-3821	10:40	18	50	94	21	2.6	1.3	1.1	0.16	0.49	0.027
2/22/2012	SM-3893	10:50	20	56	98	9	2.0	1.7	1.4	0.47	0.73	0.021
4/11/2012	SM-3965	10:33	23	62	100	12	2.5	##h	1.1d	0.14	0.64	0.025
6/20/2012	SM-4037	10:12	25	59	100	64	5.0	4.0b	1.4	0.10	0.76	0.065
8/22/2012	SM-4109	10:50	25	81	140	62d	##h	2.8	0.80	0.04	0.18	0.058
10/24/2012	SM-4181	10:17	20	76	140	23	2.0	1.4	0.78b	0.05	0.19	0.034
1/28/2013	SM-4253	11:15 AM	50	87	120	11	<1.0	1.7	2.0	0.63	1.1	0.021
3/20/2013	SM-4325	11:05 AM	13	57	140	5	<1.0	0.8	1.1	0.18	0.66	0.013
5/20/2013	SM-4385	10:35 AM	25	75	140	58	8.7	3.8	1.3	0.25	0.52	0.068
8/28/2013	SM-4427	10:47 AM	28	75b	##h	89	13d	4.5d	1.9	##h	##h	0.22
9/25/2013	SM-4457	10:26 AM	21	79	130	44	24	4.0	1.4	0.04	0.57	0.13

Table 22 MassDEP SMART 2011-2013. Station SU07. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/19/2011	SM-3457	9:54	19	61	170	91	2.0	2.0	0.75	0.06	0.44	0.016
3/15/2011	SM-3529	9:30	11	44	120	29	1.5	1.2	0.76	0.04	0.49	0.014
5/17/2011	SM-3601	9:35	17	50	120	199	18	1.9	0.67	0.07	0.26	0.027
7/20/2011	SM-3673	9:17	18	47	110	365	2.3	1.6	0.43	0.02	0.07	0.026
9/21/2011	SM-3744	9:17	16	45	110	54	2.2	1.4	0.57	0.03	0.20	0.024
11/16/2011	SM-3816	9:14	15	41	97	38	1.6	1.9	0.63	0.03	0.29	0.021
2/22/2012	SM-3888	9:05	17	45	98	4	2.8	1.4	0.70	<0.02	0.44	0.019
4/11/2012	SM-3960	9:00	19	50	110	4	2.0	##h	0.58d	0.03	0.28	0.013
6/20/2012	SM-4032	8:52	25	53	120	45	1.9	2.0b	0.65	0.05	0.26	0.028
8/22/2012	SM-4104	9:13	24	49	110	16d	##h	1.3	0.48	0.03	0.13	0.019
10/24/2012	SM-4176	8:55	25	50	110	13	1.8	1.2	0.49b	0.02	0.14	0.018
1/28/2013	SM-4249	9:44 AM	25	61	120	30	1.5	1.6	0.86	<0.02	0.57	0.013
3/20/2013	SM-4320	9:22 AM	20	47	200	30	2.8	1.6	0.69	0.02	0.45	0.014
5/20/2013	SM-4380	9:15 AM	23	63	150	20	2.3	1.4	0.65	0.06	0.24	0.021
8/28/2013	SM-4422	9:22 AM	31	71b	**	72	4.3d	1.4d	**	**	**	**
9/25/2013	SM-4452	9:05 AM	30	73	160	27	1.6	1.3	0.49	<0.02	0.21	0.013

Table 23 MassDEP SMART 2011-2013. Station CO7A. Chemistry Data.

Date	OWMID	Time	Alkalinity	Hardness	Chloride	E_coli	Ssolids	Turb	TN	NH3-N	NO3-NO2-N	TPhos
		(24hr)	(mg/l)	(mg/l)	(mg/l)	(MPN/100ml)	(mg/l)	(NTU)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
1/19/2011	SM-3463	**	**	**	**	**	**	**	**	**	**	**
3/15/2011	SM-3535	11:37	8	39	94	45	3.5	1.6	1.0	0.06	0.67	0.028
5/17/2011	SM-3607	12:16	23	58	110	308	8.3	2.1	1.1	0.06	0.57	0.054
7/20/2011	SM-3679	11:32	33	77	140	980	11	5.1	1.6	0.04	0.93	0.076
9/21/2011	SM-3751	11:15	24	52	100	308	5.8	2.4	0.95	0.04	0.41	0.058
11/16/2011	SM-3823	11:25	20	49	92	86	3.8	1.8	0.89	0.02	0.50	0.034
2/22/2012	SM-3895	11:48	21	54	100	38	1.8	1.5	1.3	<0.02	0.99	0.029
4/11/2012	SM-3967	11:15	27	61	110	25	7.2	##h	1.5d	0.02	1.0	0.041
6/20/2012	SM-4039	11:02	29	57	110	105	9.0	4.8b	1.3	0.04	0.64	0.072
8/22/2012	SM-4111	11:59	30	57	92	148d	##h	4.6	1.0	<0.02	0.35	0.070
10/24/2012	SM-4183	11:00	32	68	120	142	7.5	3.2	1.4b	0.03	0.99	0.044
1/28/2013	SM-4255	11:52 AM	27	71	130	57	1.2	1.4	1.7	0.03	1.3	0.034
3/20/2013	SM-4327	12:28 PM	15	50	160	20	2.3	1.4	0.82	0.04	0.52	0.021
5/20/2013	SM-4387	11:18 AM	30	71	130	99	7.3	1.7	1.4	0.09	0.78	0.056
8/28/2013	SM-4429	11:34 AM	32	71b	##h	613	4.4d	2.4d	1.4	##h	##h	0.039
9/25/2013	SM-4459	11:25 AM	33	75	130	115	18	6.6	1.7	0.05	1.1	0.065

REFERENCES

Beaudoin, T. 2008 (unpublished). *CN 012.1: Strategic Monitoring and Assessment for River basin Teams Quality Assurance Project Plan. 2008-2012.* Massachusetts Department of Environmental Protection. Central Regional Office. Worcester, MA.

Google Earth. 2013a. "AS04". 42º18'00.20"N and 71º38'12.05"W. Imagery August 24, 2013. Retrieved August 21, 2014.

Google Earth. 2013b. "AS18". 42º25'47.98"N and 71º27'20.35"W. Imagery August 24, 2013. Retrieved August 21, 2014.

Google Earth. 2013c. "NA01". 42º31'04.03"N and 71º24'12.37"W. Imagery August 24, 2013. Retrieved August 21, 2014.

Google Earth. 2013d. "SU07". 42º19'22.85"N and 71º24'16.02"W. Imagery August 24, 2013. Retrieved August 21, 2014.

Google Earth. 2013e. "CO7A". 42º38'10.77"N and 71º18'08.17"W. Imagery August 24, 2013. Retrieved August 21, 2014.

MassDEP. 2005. *CN 56.2. Standard Operating Procedure. Data Validation and Usability.* Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

MassDEP. 1999a. *CN 4.0 Water Quality Multi-probe Instrument Use, Standard Operating Procedure.* Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

MassDEP. 1999b. *Grab Collection Techniques for DWM Water Quality Sampling, Standard Operating Procedure.* Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA.

NOAA. 2015 [online]. *Climatological Data Publications. Massachusetts.* NOAA Satellite and Information Service. National Climatic Data Center. Image and Publications System. Retrieved September 2, 2015. Available at http://www.ncdc.noaa.gov/IPS/cd/cd.html;jsessionid=1CB121D95499F2E6677D736184136915?_page=0&jsessionid=1CB121D95499F2E6677D736184136915&state=MA&_target1=Next+%3E

O'Brien-Clayton, Katie A. 2005 [online]. *CN 92.0: SuAsCo Watershed 2001 Water Quality Assessment Report. 2001.* Report 82-AC-1. August 2005. Massachusetts Department of Environmental Protection. Division of Watershed Management. Retrieved September 2, 2015. Available at http://www.mass.gov/eea/docs/dep/water/resources/71wqar09/82wqar1.pdf.

Ostiguy, Lance J., Weiskel, Peter K. and Stacey A. Archfield. 2010 [Online]. *Average Annual Precipitation, in Inches, for Massachusetts as Computed over the Period 1971-2000 Using the Parameter-Elevation Regressions on Independent Slopes (PRISM) Model. Appendix 1, Figure 1-2.* Retrieved September 2, 2015. Available at http://pubs.usgs.gov/sir/2009/5227/pdf/Appendix/sir2009-5227_appendix1_fig2.pdf

USGPO. 9 April, 1999. Public Law 106–20. Sudbury, Assabet and Concord Wild and Scenic River Act. 106th Congress. United States Government Printing Office. Washington, DC. Retrieved September 2, 2015. Available at http://www.gpo.gov/fdsys/pkg/PLAW-106publ20/pdf/PLAW-106publ20.pdf.

USGS. 2015a [online]. *National Water Interface System: Web Interface. USGS 01097000 Assabet River at Maynard, MA*. Provisional data subject to revision. Period of record July 11, 1941 to current. United States Geological Survey. Retrieved September 2, 2015. Available at http://waterdata.usgs.gov/ma/nwis/dv/?site_no=01097000&PARAmeter_cd=00060,00065.

USGS. 2015b [online]. *National Water Interface System: Web Interface. USGS* 01097300 *Nashoba Brook Near Acton, MA*. Provisional data subject to revision. Period of record July 26, 1963 to current. United States Geological Survey. Retrieved September 2, 2015. Available at http://waterdata.usgs.gov/ma/nwis/dv/?site_no=01097300&PARAmeter_cd=00060,00065.

USGS. 2015c [online]. *National Water Interface System: Web Interface. USGS 01098530 Sudbury River at Saxonville, MA*. Provisional data subject to revision. Period of record November 1, 1979 to current. United States Geological Survey. Retrieved September 2, 2015. Available at http://waterdata.usgs.gov/ma/nwis/dv/?site_no=01098530&PARAmeter_cd=00060,00065.

USGS. 2015d [online]. *National Water Interface System: Web Interface. USGS 01099500 Concord River below River Meadow Brook at Lowell, MA*. Provisional data subject to revision. Period of record December 16, 1936 to current. United States Geological Survey. Retrieved September 2, 2015. Available at http://waterdata.usgs.gov/ma/nwis/uv/?site_no=01099500&agency_cd=USGS.

USGS. 2015e [online]. Daily data at the USGS Concord River gage below River Meadow Brook, Lowell (USGS station number 01099500). Retrieved February 18, 2015. Available at http://waterdata.usgs.gov/nwis/dv/?site_no=01099500&agency_cd=USGS&referred_module=sw

USGS. 2015f [online]. Monthly data at the USGS Concord River gage below River Meadow Brook, Lowell (USGS station number 01099500). Retrieved September 2, 2015. Available at http://waterdata.usgs.gov/nwis/monthly/?referred_module=sw&site_no=01099500&por_01099500_1=1267274,00060,1,1936-12,2014-12&format=html_table&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list

USGS. 2015f[online]. Mean streamflow values based on 71-72 years of record at the USGS Concord River gage below River Meadow Brook, Lowell (USGS station number 01099500). Point of record daily statistics based on data collected from 10/1/1936 – 9/30/2008. Retrieved September 2, 2015. Available at http://waterdata.usgs.gov/nwis/dvstat/?referred_module=sw&site_no=01099500&por_01099500_1=1267274,00060,1,1936-12-16,2008-03-17&start_dt=1936-12-16&end_dt=2007-12-31&format=html_table&stat_cds=mean_va&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=parameter_selection_list

Wandle, S. W. and Fontaine, R.A.. 1984 [Online]. *Gazetteer of Hydrologic Characteristics of Streams in Massachusetts-Coastal River Basins of the North Shore and Massachusetts Bay*. Water-Resources Investigations Report 84-4284. United States Geological Survey. Retrieved September 2, 2015. Available at http://pubs.er.usgs.gov/publication/wri844284.