FRENCH AND QUINEBAUG RIVERS WATERSHED
SMART MONITORING PROGRAM 2011-2013
TECHNICAL MEMORANDUM CN 415.0

The Quinebaug River, Dudley/Webster

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Cover photo by Therese Beaudoin, MassDEP. 31 August 2011.
All photos in document taken by Therese Beaudoin. MassDEP. CERO.
SMART monitoring logo designed by Robert Kimball and Barbara Kimball.

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LIST OF LATIN NAMES

Latin Name	Common name	Latin Name	Common name
Anura order	frogs	*Micropterus dolomieu*	smallmouth bass
Carex sp.	sedge	*Myriophyllum* sp.	milfoil
Castor canadensis	North American beaver	Plecoptera order	stoneflies
Ceratophyllum demersum	coontail, hornwort	*Rana catesbeiana*	American bullfrog
Culicidae family	mosquitoes	*Rana clamitans*	green frog
Elodea canadensis	waterweed	*Sagittaria* sp.	arrowhead
Eutrochium sp.	Joe-pye weed	*Semotilus corporalis*	fallfish
Gramineae family	true grasses	Tipulidae family	crane flies
Lemna sp.	duckweed	Trichoptera order	caddisflies
Lobelia cardinalis	cardinal flower	*Vallisneria* sp.	eelgrass, tape grass
Lontra canadensis	North American river otter	*Wolffia* sp.	watermeal

LIST OF ACRONYMS

% sat	percent oxygen saturation
305(b)	Section 305(b), Clean Water Act
7Q10	the lowest 7-day average streamflow that occurs, on average, once every 10 years
BRP	Bureau of Resource Protection
BWR	Bureau of Water Resources
ºC	degree Celsius
CERO	Central Regional Office
CFR	Coldwater Fish Resource
cfs	cubic feet per second
cond	specific conductivity
CSO	Combined Sewer Overflow
CT	Connecticut
DO	dissolved oxygen
DWM	Division of Watershed Management
ºF	degree Fahrenheit
ft	feet
F/Q	French/Quinebaug
GPD	gallons per day
in	inch
m	meter
MA	Massachusetts
MassDEP	Massachusetts Department of Environmental Protection
MDL	method detection limit
MGD	million gallons per day
µS/cm	microsiemens per centimeter
mg/L	milligrams per liter
mi	mile
mi^2	square mile
NH_3-N	ammonia nitrogen
NOAA	National Oceanic and Atmospheric Administration
NO_3NO_2-N	nitrate-nitrite nitrogen
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Unit
NWS	National Weather Service
POR	Period of Record
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RDL	reporting detection limit
RI	Rhode Island
RPD	relative percent difference
SMART	Strategic Monitoring and Assessment for River basin Teams
SOP	standard operating procedure
SR	state road
SU	Standard Unit
Ssolids	suspended solids
Temp	temperature
TDS	total dissolved solids
TMDL	Total Maximum Daily Load
TN	total nitrogen
TPhos	total phosphorus
Turb	turbidity
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WES	Wall Experiment Station
WWTP	wastewater treatment plant

INTRODUCTION

The purpose of this technical memorandum is to present observations and data collected from 2011-2013 as part of the Strategic Monitoring and Assessment for River basin Teams (SMART) program in the F/Q watershed, 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 began in March 1999. The sampling plan matrix for the SMART monitoring program Years 2011-2013 is presented in Table 1; the location of sampling stations is presented in Figure 1**Error! Reference source not found.**. 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 French/Quinebaug Basin SMART Sampling Summary – 2011 through 2013

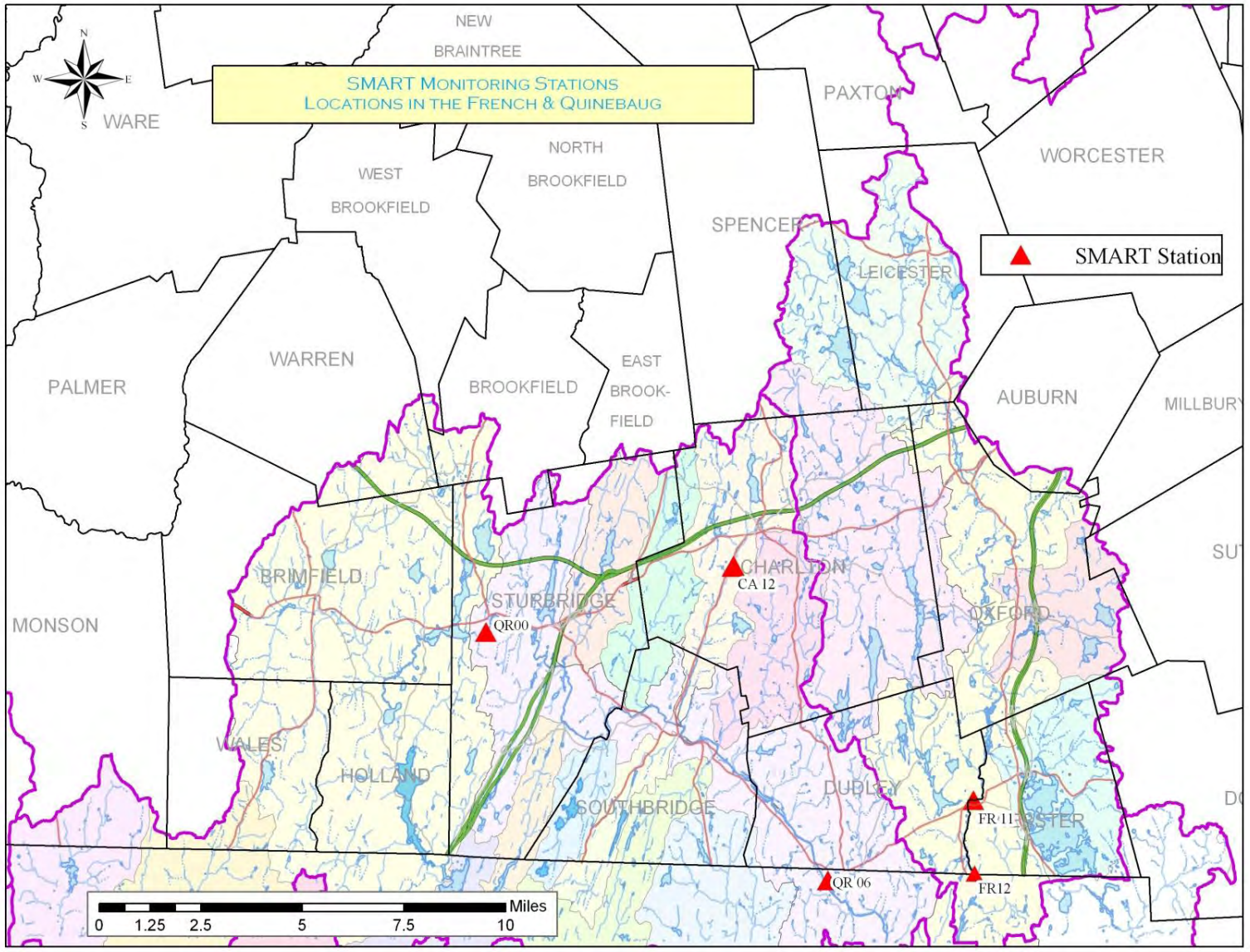
Location and Segment Numbers	Station Name	Station Type	Dates Sampled[1]
Quinebaug River @ Holland Road, Sturbridge MA41-01	QR00	Reference	2011: 3/23/11, 4/27/11, 6/22/11, 8/31/11. 10/26/11 2012: 1/25/12, 3/28/12, 5/29/12, 7/25/12, 9/26/12, 11/14/12 2013: 2/27/13, 4/24/13, 8/27/13[2], 9/23/13[2] [1]Sampling began in the French/Quinebaug Basin on 4/21/1999; the Cady Brook station (CA12) was added in 2/26/2003, and the French River at Perryville (FR12) on 2/24/2009. [2]Sampling was conducted at Station QR06, Quinebaug River at Quinebaug, CT only
Cady Brook at gas pipeline above upper Cady Brook crossing @ State Road (SR) 169, Charlton MA41-06	CA12	Impact	
Quinebaug River @ SR 197, Thompson, CT below MA41-04	QR06	Boundary	
French River @ Oxford Ave, Dudley MA42-05	FR11	Impact	
French River below Perryville Road, Webster, MA MA42-06	FR12	Impact	

Hydrology

The French/Quinebaug (F/Q) watershed, part of the Thames River Basin, lies in the south-central part of Massachusetts (MA). The Thames has a total drainage area of 1,474 square miles (mi^2), of which 251 mi^2 are in MA, 61 mi^2 in Rhode Island (RI) and 1,162 mi^2 in Connecticut (CT, USACE 2015). In Massachusetts, the Thames Basin is comprised mostly of the Quinebaug River and its major tributary, the French River. For a detailed description of the Quinebaug River Watershed, see French and Quinebaug Rivers Watershed Water Quality Assessment Report 2004 - 2008 (MassDEP 2009).

The Quinebaug River flows approximately 76 miles (mi) from its beginning, either at the outlet of Goodall's Pond (also known as Little Massapoag Pond) or Mashapaug Lake (although Mashapaug Lake normally drains south to

Figure 1 MassDEP SMART French/Quinebaug Rivers Watershed Water Quality Station Locations



Bigelow Brook and the Shetucket Watershed, it sometimes flows to the north, and the Quinebaug Watershed). The 28-mi segment of the Quinebaug River and its associated watershed within Massachusetts encompasses all or part of 14 towns. The river is characterized by long runs and three large impoundments (Hamilton Reservoir, East Brimfield Lake and West Dudley Pond) as well as several smaller ones. Numerous dams remain on the mainstem, including two United States Army Corps of Engineers (USACE) flood control projects, East Brimfield and Westville Lakes; these operate in a run-of-river mode under normal conditions. There are also two hydropower projects: the Old Sturbridge Village Project, Sturbridge; and the West Dudley Project, Dudley.

Annual precipitation ranges from 48 to 50 inches (in) over most of the watershed, with a section in the south-central to southeast area along the CT border averaging 50 to 52 in (Ostiguy et al 2010).

Massachusetts tributaries of the Quinebaug River include the Mill, Hobbs, McKinstry, Cady, Breakneck, Hamant, Hatchet, Cohasse, Lebanon and McIntyre Pond brooks. Coldwater Fish Resources (CFR) have been identified on twenty-three tributaries to the Quinebaug River (including Hamant, Hatchet, and McKinstry Brooks), but not the mainstem itself (MassDFG 2015).

The French River flows approximately 26 mi from its beginning at the outlet of Greenville Pond, Leicester to its junction with the Quinebaug. The French River watershed within Massachusetts encompasses all or part of 10 towns. The river is characterized by long runs and numerous impoundments (Rochdale, Texas, and Perryville ponds, as well as a large, unnamed impoundment above North Village, Webster). The Hodges Village flood control project is a dry bed reservoir on the mainstem, and typically operates in a run-of-river mode. The Buffumville Lake project on the Little River maintains a large recreational pool (186 acres); it is operated in a run-of-river mode under most conditions. Annual precipitation ranges from 48 to 50 in over most of the watershed, with a small area averaging 50 to 52 in located on the Connecticut border in Webster and Dudley (Ostiguy et al 2010).

The French River is the largest tributary to the Quinebaug River in MA, joining the mainstem in Thompson, CT. Tributaries of the French River in Massachusetts include the Little River, Lowes and Mill Brooks, and a number of smaller streams. The French River from the North Oxford Dam upstream of Clara Barton Road, Oxford, to the dam at North Village, Webster/Dudley is designated as a coldwater fishery; Wellington Brook and an unnamed tributary have also been identified as CFRs (MassDFG 2015).

Quality Assurance/Quality Control

The quality assurance/control (QA/QC) plan for the SMART program is presented in CN 012.1*: Quality Assurance Project Plan* [QAPP] *Strategic Monitoring and Assessment for River basin Teams (SMART) (Blackstone, Chicopee, Concord, French/Quinebaug, Millers, and Nashua Watersheds) 2008-2012* (Beaudoin 2008). The QAPP presents data quality objectives, quality assurance procedures, and other program-specific information.

Aerial photos were obtained from Google Earth (2015a, 2015b, 2015c, 2015d, 2015e) 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 French and Quinebaug Rivers 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 as photographs. Field observations included date/time, location, crewmembers, snow cover, canopy cover, water odors, colors, sheens, foams, estimated river height and velocity, weather conditions, observed uses, wildlife, aquatic algae and macrophytes, potential pollution sources, and unusual conditions. Number and type of samples were recorded, as well as the last set of *in situ* data collected. A summary of field observations by station collected during this sampling period are presented in Table 2 through Table 5 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 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
- Boundary: a boundary station is located at a pour point i.e., where water leaves a designated river basin, or at a state line.

[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.

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 QR00 – Quinebaug River at Holland Road, Sturbridge, MA (river mile 15.202)

Figure 2 Google Earth view of Station QR00 area

Figure 3 Station QR00 upstream (9/26/2012)

Station QR00 is located on the Quinebaug River in Sturbridge, MA within the Lower Worcester Plateau ecoregion. From 2011-2013, the station was sampled 13 times, and access was gained from the southern shore upstream of the Holland Road Bridge. Samples were collected by wading to flowing water. Station QR00 serves as a reference station, minimally influenced by anthropogenic activities.

Land uses near this station included forest, rural residential, and roadways (Figure 2; Google Earth 2015a). The large recreational pool at the relatively shallow East Brimfield flood control project (420 acres at typical pool height) also influences water quality at this station. No municipal National Pollutant Discharge Elimination System (NPDES) discharges are located upstream (design flow greater than 1 million gallons per day, or MGD), nor are there any large water withdrawals (greater than 100,000 gallons per day, or GPD).

The river is a riffle in this area, approximately 55 feet (ft) wide and typically 1 to 4 ft deep (Figure 3). Deciduous and evergreen trees provided shade along the banks, and the canopy covered most of the channel above the sample collection site. However, a tornado carved a path adjacent to the river in this reach on 6/1/2011; the reduction in forested bank opened this previously heavily shaded area to sunlight (see Figure 4). Observation of the water column and benthic environment was affected by turbulence and solar reflection. When visible, the bottom was mostly boulder, cobble and gravel, with little sand.

Aquatic macrophytes observed at Station QR00 included *Carex* sp. (sedge), *Ceratophyllum demersum* (coontail, hornwort), *Elodea canadensis* (waterweed), *Eutrochium* sp. (Joe-pye weed), Graminae (grasses), *Lobelia cardinalis* (cardinal flower) and *Myriophyllum* sp. (milfoil). Periphyton, when present and/or visible, ranged from sparse to very dense. Periphyton density ranged from sparse to very dense, when visible, and consisted most often of dense to very dense moss; filamentous algae were observed on 3 of 13 events, and a loose green floc on one event.

Wildlife observed at Station QR00 from 2011-2013 includes North American beaver (*Castor canadensis*), North American river otter (*Lontra canadensis*), smallmouth bass (*Micropterus dolomieu*), green frog (*Rana clamitans)* and various songbirds. Aquatic insects included Culicidae (mosquitoes) and Plecoptera (stoneflies).

On most events, the water column was clear, red, with a sparse coverage of foam, and lacking in odor, sheens and trash.

Figure 4 Station QR00 Tornado (6/1/2011) damage along southern bank of channel 9/26/2012

Station CA12 – Cady Brook at Southbridge Road (State Road/SR-169), Charlton, MA (river mile 3.268)

Figure 5 Google Earth view of Station CA12 area

Figure 6 Station CA12 upstream (8/31/2011)

Station CA12 is located on Cady Brook in Charlton, 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 western shore at the downstream edge of the gas pipeline transmission corridor, north of the upstream-most of the two Cady Brook bridges on Southbridge Road (SR-169). Samples were collected by wading to flowing water or, when the flow was too high and/or fast, from shore with a sampling pole. Station CA12 serves as an impact station as it is located downstream of numerous point and nonpoint sources of pollution, as described below.

Upstream land uses include forest, residential, commercial, and roadways (Figure 5; Google Earth 2015b). The Charlton Wastewater Treatment Plant (WWTP), a major municipal NPDES discharge, is located approximately 4.8 mi upstream; there are no large water withdrawals.

The river at this location is a run, approximately 12 ft wide and 1 to 3 ft deep. The shoreline is shaded by complete canopy cover up- and downstream of the gas pipeline transmission corridor, which is maintained to minimize woody vegetation (Figure 6). Observation of the water column and benthic environment was affected by turbulence and solar reflection. The stream bottom consisted mainly of a mixture of boulder, cobble, gravel, and sand. Periphyton was noted on most sampling events, most frequently as moss; filamentous (2 events) and film algae (4 events) were also noted. When present, aquatic macrophytes were sparse, and limited to members of the Gramineae family (grass) and *Vallisneria* sp. (eelgrass). Aquatic and other organisms noted here included Anura order (frogs), Culicidae family (mosquitoes), exuviae from the Plecoptera order (stonefly), songbirds and immature fish.

On most events, the water column was clear in both color and clarity, with very sparse to sparse foam, and lacking odors, sheens and trash.

Figure 7 Station CA12 Water column at sampling location 9/26/2012

Station QR06 – Quinebaug River at Old Turnpike Road (SR-197), Thompson, CT (river mile -0.373)[2]

Figure 8 Google Earth view of Station QR06 area

Figure 9 Station QR06 upstream (9/26/2012)

[2] River mile calculation begins at the Massachusetts state boundary; as this station is below the state boundary, the river mile is a negative value.

Station QR06 is located on the Quinebaug River in Thompson, CT, within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, the station was sampled 15 times, and access was gained from the western shore upstream (north) of the Old Turnpike Road (SR-197) Bridge. Samples were collected by wading to flowing water or, when the flow was too high and/or fast, from shore with a sampling pole. Station QR06 serves as a boundary station, representing water quality in the Quinebaug River as it enters the State of Connecticut.

Upstream land uses include forest, residential, industrial, commercial, and roadways (Figure 8; Google Earth 2015c). An upstream hydropower project at West Dudley Pond impacts this reach. The Southbridge WWTP, a major municipal NPDES discharge, is located 4.7 mi upstream. A large water withdrawal is located upstream at the American Optical facility, and includes the permitted withdrawal for the Millennium power plant (Charlton).

The river is a run in this area; the channel is approximately 65 ft wide and shaded along the channel edges (Figure 9). Banks were undercut throughout the site area. Observation of the water column and benthic environment was affected by turbulence and solar reflection. When visible, the bottom consisted mainly of boulder, cobble, gravel and sand. Periphyton was observed on approximately half of the sampling events when habitat was visible, and included film, algae and moss. No aquatic macrophytes were observed near this station during this time period. Aquatic and other life included *Micropterus dolomieu* (smallmouth bass), exuviae from the Plecoptera order (stoneflies), *Rana catesbeiana* (American bullfrog), *Semotilus corporalis* (fallfish), Tipulidae family (crane fly), cases from the Trichoptera order (caddisflies) and songbirds.

When visible, the water column was typically clear in clarity and color, with minor trash and sparse foam, and lacking odors and sheens.

Figure 10 Station QR06 Water column at sampling location 7/25/2012

Station FR11 – French River near Oxford Ave, Webster, MA (river mile 2.106)

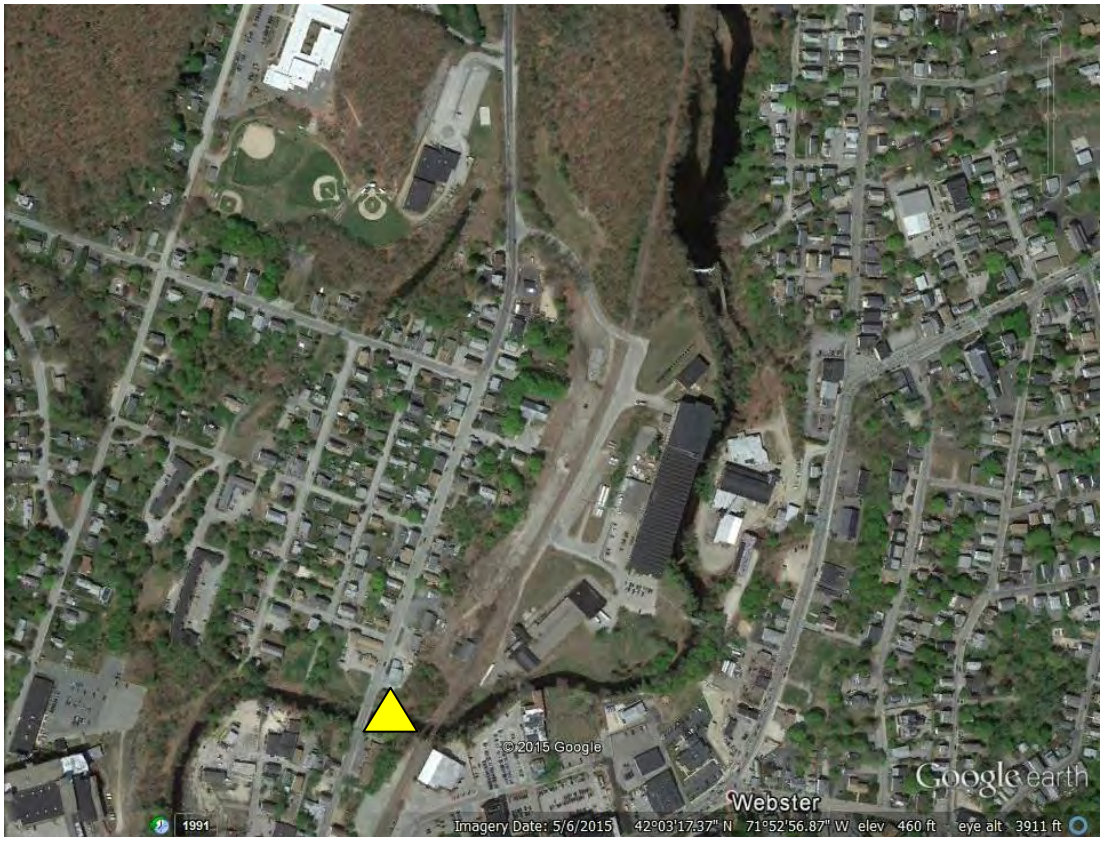


Figure 11 Google Earth view of Station FR11 area

Figure 12 Station FR11 upstream (9/26/2012)

Station FR11 is located on the French River in Dudley, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013 the station was sampled 12 times; on 2/27/2013, access was unsafe in this reach due to steep icy banks. The river was sampled from the northern shore upstream of the Oxford Ave Bridge. Samples were collected by wading to flowing water or, when the flow was too high and/or fast, from shore with a sampling pole. Station FR11 serves as an impact station as it is located downstream of numerous point and nonpoint sources of pollution, as described below.

Land uses near and upstream of this station include forest, residential, commercial and industrial; an upstream hydropower project impacts the river in this reach (Figure 11; Google Earth 2015d). The nearest upstream municipal NPDES discharge is approximately 13.5 mi. above this site. Station FR11 is within the Zone II of four large water supply wells for the town of Dudley.

The river is a run in this area, approximately 40 ft wide, and the channel is typically too deep to wade (Figure 12). Trees provide shade over most of the stream corridor. Turbulence and solar reflection prevented observation of the water column and benthic environment on all but one event ((9/26/2012). On this date, the bottom consisted of boulder, cobble, gravel, sand and silt. *Sagittaria* sp. (arrowhead), an emergent plant, was the only aquatic macrophyte noted at this station during this time period; submergent vegetation may have been present, but unobservable. Periphytic growth was present on the 2 sampling events when the water column was observable, and included filamentous and film algae. Other aquatic life included *Micropterus dolomieu* (smallmouth bass), exuviae of the Plecoptera order (stonefly) and songbirds.

Typically, the water column was yellow, with very sparse to sparse foam, and lacking in odors and sheens. Turbidity was observable on less than half of the monitoring dates, and ranged from clear to slightly turbid. Observations of trash were limited by turbulence and solar reflection on most dates; however, floatables were noted on 7 events. Other trash items included shopping carts, broken glass, metal and miscellaneous items.

Figure 13 Station FR11 Water column at sampling location 9/26/2012

Station FR12 – French River below Perryville Road, Webster, MA (river mile 0.020)

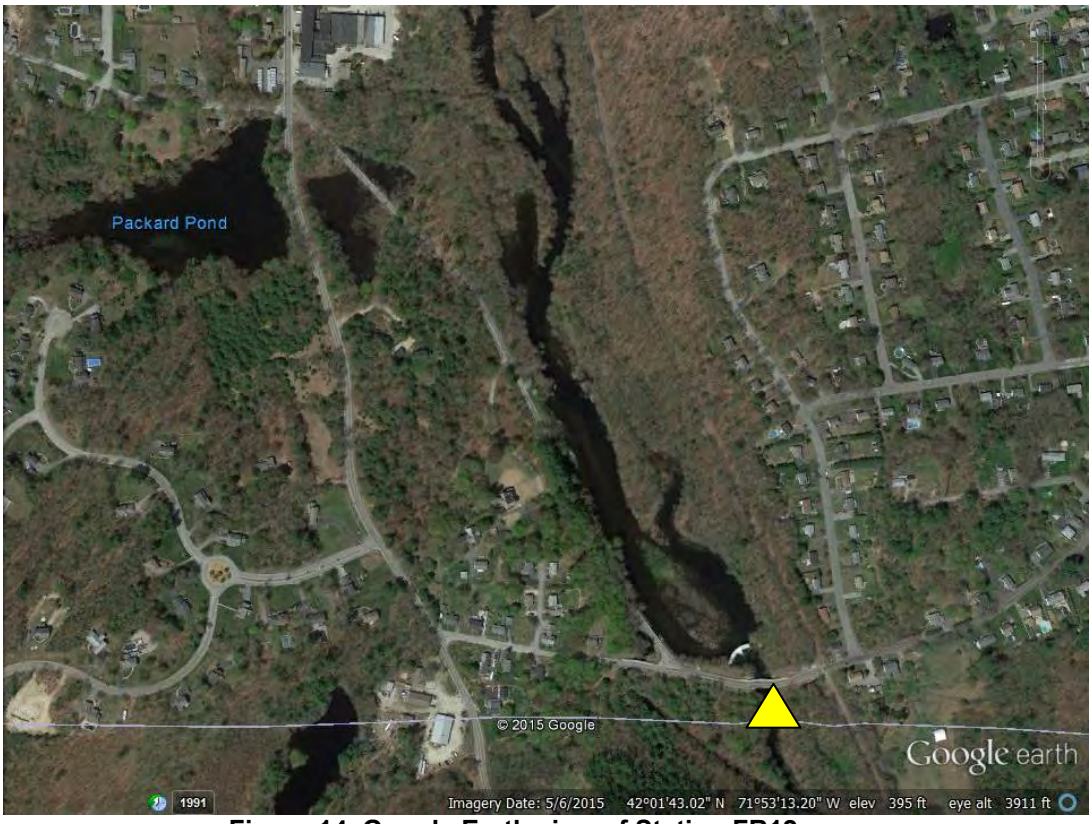


Figure 14 Google Earth view of Station FR12 area

Figure 15 Station FR12 upstream (9/26/2012)

Station FR12 is located on the French River in Webster, within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, Station FR12 was sampled 13 times. The river was accessed from the eastern shore downstream of the Perryville Road Bridge. Samples were collected by wading to flowing water or from shore with a sampling pole. Station FR12 serves as a boundary station, representing water quality in the Quinebaug River as it enters the State of Connecticut.

Land uses near and upstream of this station include forest, residential, urban, commercial and industrial. An active rail line is adjacent to the river on the east (Figure 14; Google Earth 2015e). The town of Webster NPDES discharge is approximately one mile upstream, as well as five water supply wells for the town of Dudley.

The river is a run in this area, approximately 40 ft wide, and typically too deep to wade (Figure 15). Although trees provide shade over most of the channel near the sample site, the shallow, 7-acre (approximate) Perryville Pond impoundment is located approximately 200 feet upstream. Observation of the water column and benthic environment was affected by turbulence and solar reflection on 10 of the 13 sampling events; bottom staining also affected observations. When visible, the bottom consisted mainly of boulder, cobble, gravel, sand and silt. Aquatic macrophytes observed in this location included members of the Gramineae family (grasses), *Lemna* sp. (duckweed), *Myriophyllum* sp. (milfoil), *Vallisneria* sp. (eelgrass) and *Wolffia* sp. (water meal). Wildlife included songbirds, which were noted on most sampling dates, and a frog (order Anura), noted on 9/26/2012.

When visible, the water column was typically clear in color, with minor trash and moderate foam, and absent of odors and sheens. Water clarity was clear or slightly turbid on the 6 dates that the water column was observable.

Figure 16 Station FR12 Water column at sampling location 4/24/2013

Table 2 MassDEP SMART 2011 - 2013. Station QR00. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/23/2011	Unobservable	Unobservable	Unobservable	Light yellow	None	Sparse	None	Unobservable	Wet
4/27/2011	Unobservable	Unobservable	Unobservable; dense: moss, where visible	Clear	None	Sparse	None	Unobservable	Dry
6/22/2011	Unobservable	Unobservable	Very dense: moss	Red	None	Sparse	None	Unobservable	Dry
8/31/2011	Unobservable	Minor: floatables	Filamentous	Clear	None	Sparse	None	Slight	Wet - TS Irene
10/26/2011	Unobservable	Unobservable	Unobservable; sparse: moss, where visible	Red	None	Sparse	None	Unobservable	Dry
1/25/2012	Unobservable	Unobservable	Unobservable; very dense moss, olive green loose floc where visible	Red, slight	None	Sparse	None	Clear	Wet
3/28/2012	Boulder/cobble/gravel/sand	None	Dense: moss	Red	Eutrophic pond	Sparse	None	Clear	Dry
5/29/2012	Boulder/cobble/gravel/sand	None	Very dense: dark green filamentous on moss; very dense moss	Red	Fishy, eutrophic pond	Sparse	None	Slight	Dry
7/25/2012	Boulder/cobble/gravel/sand	None	Moderate: moss	Red	Eutrophic pond	None	None	Clear	Dry
9/26/2012	Boulder/cobble/gravel/sand/silt	None	Sparse: blue-green filamentous; sparse moss	Red, slight	None	None	None	Clear	Dry
11/14/2012	Boulder/cobble/gravel/sand/silt	None	Dense: moss	Red, slight	None	None	None	Clear	Wet
2/27/2013	Unobservable	None	None	Clear	None	Sparse	None	Clear	Wet
4/24/2013	Boulder/cobble/gravel/sand	None	Dense: moss	Clear	None	Sparse	None	Clear	Dry
-- : Data not available									

Table 3 MassDEP SMART 2011 - 2013. Station CA12. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/23/2011	Cobble/gravel/sand	None	Dense: moss	Clear	None	Very sparse	None	Clear	Wet
4/27/2011	Cobble/gravel/sand	None	Sparse: dark green film	Light yellow	None	Moderate	None	Clear	Dry
6/22/2011	Boulder/cobble/gravel/sand/silt	Minor, single golf ball	None	Clear	None	Very sparse	None	Clear	Dry
8/31/2011	Boulver/cobble/gravel/sand	None	Sparse: moss	Clear	None	Sparse	None	Clear	Wet - TS Irene
10/26/2011	Boulder/cobble/gravel/sand; embedded	Minor: newspaper	Sparse: moss	Red	None	Sparse	None	Clear	Dry
1/25/2012	Cobble/gravel/sand	None	Sparse: bright green filamentous; dense moss	Light yellow	None	Very sparse	None	Clear	Wet
3/28/2012	Boulder/cobble/gravel/sand; highly embedded	None	Sparse: moss	Light yellow	None	Very sparse	None	Clear	Dry
5/29/2012	Boulder/cobble/gravel/sand; embedded	None	Very dense: dark green film	Light yellow	None	Sparse	None	Clear	Dry
7/25/2012	Boulder/cobble/gravel/sand/silt	None	Very dense: brown film; moss, sparse	Light yellow	None	None	None	Slight, milky	Dry
9/26/2012	Boulder/cobble/gravel/sand/silt	None	Moderate: dark green/brown film; sparse moss	Clear	None	Very sparse	None	Clear	Dry
11/14/2012	Unobservable	None	Sparse: moss	Clear	None	Sparse	None	Clear	Wet
2/27/2013	Unobservable	None	None	Clear	None	Sparse	None	Clear	Wet
4/24/2013	Boulder/cobble/gravel/sand; highly embedded	None	Dense: bright green filamentous; dense moss	Clear	None	Very sparse	None	Clear	Dry

-- : Data not available

Table 4 MassDEP SMART 2011 - 2013. Station QR06. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/23/2011	Unobservable	Unobservable	Unobservable	Red	None	Sparse	None	Unobservable	Wet
4/27/2011	Unobservable	Unobservable	Unobservable	Clear	None	Sparse	None	Unobservable	Dry
6/22/2011	Boulder/cobble/gravell/sand	None	None	Clear	None	Sparse	None	Clear	Dry
8/31/2011	Unobservable	Unobservable	Unobservable	Red	Musty, eutrophic pond	Sparse	None	Clear	Wet - TS Irene
10/26/2011	Unobservable	Unobservable	Unobservable	Red	None	Sparse	None	Unobservable	Dry
1/25/2012	Unobservable	Unobservable	Unobservable	Light yellow	None	Sparse	None	Unobservable	Wet
3/28/2012	Boulder/cobble/gravel/sand	Minor: floatables	None	Red	None	Sparse	None	Clear	Dry
5/29/2012	Cobble/gravel/sand; embedded	Sparse: bicycle tires	Moderate: dark green film; sparse: moss	Red, slight	None	Moderate	None	Slight	Dry
7/25/2012	Boulder/cobble/gravel/sand; embedded	None	Moderate: clear film	Clear	None	None	None	Clear	Dry
9/26/2012	Boulder/cobble/gravel/sand; embedded	None	Sparse: clear film	Clear	None	Moderate	None	Clear	Dry
11/14/2012	Unobservable	Unobservable; trash: floatables, where visible	Unobservable	Light yellow	None	Sparse	None	Clear	Wet
2/27/2013	Unobservable	Minor: broken pieces of unknown items	None	Clear	None	Moderate	None	Clear	Wet
4/24/2013	Boulder/cobble/gravel/sand; highly embedded	Minor: floatables	None	Clear	None	Sparse	None	Clear	Dry

-- : Data not available

Table 5 MassDEP SMART 2011 - 2013. Station FR11. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/23/2011	Unobservable	Unobservable; floatables where	Unobservable	Clear	None	Sparse	None	Unobservable	Wet
4/27/2011	Unobservable	Unobservable; floatables where	Unobservable	Light yellow	None	Moderate	None	Unobservable	Dry
6/22/2011	Unobservable	Unobservable; floatables where	Unobservable	Light yellow	None	Moderate	None	Unobservable	Dry
8/31/2011	Unobservable	Unobservable	Unobservable	Red	Musty, eutrophic pond	Sparse	None	Slight	Wet - TS Irene
10/26/2011	Unobservable	Unobservable; floatables, shopping card where visible	Unobservable	Red	None	Sparse	None	Unobservable	Dry
1/25/2012	Unobservable	Unobservable; broken glass, shopping cart where visible	Unobservable	Light yellow	None	Very sparse	None	Unobservable	Wet
3/28/2012	Unobservable	Floatables	Unobservable	Light yellow	None	Sparse	None	Unobservable	Dry
5/29/2012	Unobservable	Unobservable	Unobservable	Red, slight	Eutrophic pond, strong	Moderate	None	Slight	Dry
7/25/2012	Unobservable	Moderate: floatables, shopping carts, unidentifiable metals, misc. items	Moderate: filamentous, covered in silt	Light yellow; red, slight	None	Moderate	None	Slight, milky	Dry
9/26/2012	Boulder/cobble/gravel/sand/silt	Minor: shopping cart(s), floatables	Sparse: blue-green filamentous; very dense brown film, covered in silt	Clear	Eutrophic pond	Sparse	None	Clear	Dry
11/14/2012	Unobservable	Unobservable	Unobservable	Light yellow	None	Sparse	None	Unobservable	Wet
2/27/2013	Station not sampled on this date; not accessible due to icy, steep banks								
4/24/2013	Unobservable	Unobservable; metal items where visible	Unobservable	Clear	None	Sparse	None	Clear	Dry
-- : Data not available									

Table 6 MassDEP SMART 2011 - 2013. Station FR12. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/23/2011	Unobservable	Unobservable	Unobservable	Clear	None	Moderate	None	Unobservable	Wet
4/27/2011	Unobservable	Unobservable	Unobservable; sparse: moss where visible	Light yellow	Effluent	Dense	None	Unobservable	Dry
6/22/2011	Boulder/cobble/gravel/sand	Minor: broken glass, floatables	Very dense: moss	Light yellow	None	Moderate	None	Clear	Dry
8/31/2011	Unobservable	Unobservable	Unobservable	Red	None	Moderate	None	Slight	Wet - TS Irene
10/26/2011	Unobservable	Unobservable	Unobservable	Red	Effluent, slight	Moderate	None	Unobservable	Dry
1/25/2012	Unobservable	Unobservable	Unobservable; sparse bright green filamentous where visible	Red	None	Moderate/dense	None	Unobservable	Wet
3/28/2012	Unobservable; bottom stained	Minor: beer cans, floatables	Unobservable	Light yellow	None	Sparse	None	Unobservable	Dry
5/29/2012	Unobservable	Unobservable	Unobservable; moderate: moss where visible	Red, slight	Effluent, slight	Dense	None	Slight	Dry
7/25/2012	Boulder/cobble/gravel/sand/silt	Minor: floatables	Sparse: clear film	Light yellow; red, slight	None	None	None	Slight, milky	Dry
9/26/2012	Boulder/cobble/gravel/sand/silt	Minor: plastic chair, beer can(s)	Unobservable (covered in silt); sparse moss where visible	Clear	Fishy	Sparse	None	Clear	Dry
11/14/2012	Unobservable	Unobservable	Unobservable; moderate: moss where visible	Light yellow	None	Moderate	None	Unobservable	Wet
2/27/2013	Unobservable	Unobservable	Unobservable	Clear	None	Moderate	None	Unobservable	Wet
4/24/2013	Boulder/cobble/gravel/sand/silt	None	Moderate: moss	Clear	Effluent	Moderate	None	Clear	Dry
-- : Data not available									

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-influenced events. Precipitation data for each monitoring event 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 station closest to the French/Quinebaug watershed sampling stations is located in Southbridge, MA; precipitation data collected here were utilized in this report. However, temperature data were not available, therefore data collected at the Worcester station were utilized. Precipitation ranges from 48 to 50 inches (in) throughout most of the basin in Massachusetts; a small area ranges from 50 to 52 inches in the south-central area along the CT border (Ostiguy et al 2010).

During dry weather, trace amounts of precipitation may fall, but there is no measurable change in stream flow. The United States Geological Survey (USGS) operates four real time stream gaging stations in the French/ Quinebaug Watershed that are applicable to this water quality data set, as shown below:

- Quinebaug River below East Brimfield Dam at Fiskdale, MA (USGS 2015a)
- Quinebaug River below Westville Dam near Southbridge, MA (USGS 2015b)
- Quinebaug River at Quinebaug, CT (USGS 2015c) and
- French River at Webster, MA (USGS 2012d).

Discharge data (in cubic feet per second, or cfs) from the stations in Massachusetts can be accessed at Daily Data for Massachusetts: Stage and Streamflow (USGS 2015e) and for Connecticut at Daily Data for Connecticut: Stage and Streamflow (USGS 2015f). Discharge data at the French River/Webster gaging station are not available online for this time period

The period of record (POR) mean streamflow values are the mean of daily mean values for each day for 82-83 years of record at the USGS Quinebaug River gage at Quinebaug, CT (USGS station number 01124000). These daily means are reported at Daily mean data (USGS 2015g). The monthly mean discharges are found at Monthly mean data (USGS 2015h).

Wet weather is defined as precipitation within a five-day antecedent period that leads to more than a slight increase in stream discharge at the four stations listed above. Under dry weather conditions, trace amounts of precipitation may fall, but no measurable change in stream flow occurs. All of the French/Quinebaug Watershed gaging stations were affected by flow manipulation and were difficult to distinguish from precipitation-related fluctuations on some dates.

Precipitation and discharge data as well as field observations were used to determine if samples were impacted by surface water runoff. Table 10 (precipitation) and Table 11 (stream discharge) report survey conditions during each sampling event. Precipitation data utilized in this tech memo were reported at the Southbridge, MA National Weather Service (NWS) station. Discharge data were collected at the USGS stream gaging station on the Quinebaug River in Quinebaug, CT. Low flows were compared to the 7Q10 flow (the lowest 7-day average streamflow that occurs, on average, once every 10 years) at the Quinebaug River, Quinebaug, CT (16.640 cfs) (USGS 2015i); the 7Q10 at the French River upstream of the Webster-Dudley WWTP is 14.8 cfs (USGS 2015j). Air temperature was recorded at each station in degrees Fahrenheit (ºF).

March 23, 2011 – This early spring sampling event followed a storm that brought 0.32 in to the area (as recorded at the Southbridge weather station) on March 22 (1.5 in as snow); for climate information, see Table 7. Overall, discharge at all watershed gages varied little from March 19-23, (decreasing steadily at Quinebaug River at Quinebaug, CT) remaining well above the mean daily discharge on all dates (based on 35 years of record). The maximum daily temperature on March 22 was 29 °F and 33°F on the sampling date, while the measured snow on the ground decreased from 2 to 0 in. Field observations note water levels at all stations were 0.5-3+ feet above normal for this time of year. Based on snowfall, snow on the ground, maximum daily temperature and field observations, water quality on this date reflects wet weather/snowmelt conditions. Air temperature ranged from 31 to 34 ºF under overcast skies. Trees and shrubs were not yet in bud at the Quinebaug River watershed stations, while buds were just beginning to form at those in the French River watershed.

Table 7 Climate Conditions at Southbridge, MA from March 18-21, 2011

Parameter	Mar 18	Mar 19	Mar 20	Mar 21	Mar 22	Mar 23
Max Temperature (ºF) [1,2]	64	47	44	33	39	33
Precipitation (in as water)	0	0	0	0	0.32	0
Snowfall (in)	0	0	0	0	1.5	0
Snow on the ground (in)	0	0	0	0	2	0

[1]Data from the Southbridge weather station are available at NOAA Climatological Data Publications (NOAA 2015).
[2]Temperature data were not available for the Southbridge station; data from the Worcester station are reported.

April 27, 2011 – In the 5-day period preceding this spring monitoring event, 0.67 in of rainfall was recorded at Southbridge, most of which fell on 4/23-24 (0.61 in). The pattern of discharge varied at area gages; at the Quinebaug River at East Brimfield gage, discharge remained steady at approximately 350 cfs from April 23-27, which may indicate flow management activities at the East Brimfield flood control project dam. At the Quinebaug River gages at Westville and Quinebaug CT, discharge decreased slowly and steadily during this period. At the French River at Webster gage, flows rose slightly from April 23-24, and remained at approximately 400 cfs on April 25. Then several rapid flow fluctuations occurred through April 27, which may indicate hydropower operations upstream. Water levels ranged from normal (Quinebaug River at Sturbridge, Cady Brook at Charlton) to 3+ft above normal (Quinebaug River, Quinebaug CT). Based on the precipitation, discharge pattern and water level at most stations, water quality data collected on this date reflect dry weather conditions. Air temperature ranged from 66 to 72ºF throughout monitoring activities. Although the sky was mostly sunny at Station CA12 (<5% cloud cover), skies were overcast at most stations (with drizzle at Station QR06, Quinebaug River at Quinebaug CT). In the Quinebaug River watershed, trees and shrubs were beginning to bud; in the French River watershed, buds were fully formed and leaves were beginning to emerge.

June 22, 2011 – This summer event followed a three-day dry period with generally decreasing discharge and normal to low water levels throughout the watershed. Field observations note drizzle/rain fell at two of five stations, although no precipitation was recorded on this date at the Southbridge Airport NWS station. Based on precipitation and discharge data, water quality on this date reflects dry conditions. Air temperature ranged from 68 to 72ºF with overcast skies and intermittent drizzle developing to rain by the end of monitoring activities.

August 31, 2011 – Tropical storm Irene dropped 5.8 in on the area on August 28-29; discharge at area rose and remained well above the median daily flow at all watershed gages through August 31. Water quality data reflect wet weather/runoff conditions. Air temperature ranged from 64 to 76°F under sunny to partly sunny skies.

October 26, 2011 – Fall sampling in 2005 was conducted within a dry period, with only 0.03 in precipitation recorded at Southbridge from October 21-26. Overall, discharge at watershed gages decreased during this period (several rapid fluctuations were reported at the Quinebaug River at Quinebaug, CT gage). Water quality data collected on this event reflect dry weather conditions. Air temperature increased from 44 to 47°F with overcast skies and intermittent fog and drizzle. Most deciduous leaves had changed color and many were down.

January 25, 2012 – Storms on January 20, 22 and 24 brought over 0.57 in of precipitation to the area (4+ in as snow); for climate details, see Table 8. The maximum daily temperatures from January 23-25 were above freezing (36 to 50ºF). Discharge at the Quinebaug River at East Brimfield fell steadily from January 18-24, then rose through monitoring activities on January 25; a similar pattern was seen at the Quinebaug River at Westfield. Discharge patterns at the Quinebaug River at Quinebaug, CT and the French River at Webster showed several rapid flow fluctuations, possibly associated with hydropower operations. Water quality data reflect wet weather/ snowmelt conditions. Air temperature ranged from 34 to 38ºF; cloud cover rose from 5% to overcast during monitoring activities.

Table 8 Climate Conditions at Southbridge, MA from January 20-25, 2012

Parameter	Jan 20	Jan 21	Jan 22	Jan 23	Jan 24	Jan 25
Max Temperature (ºF) [1,2]	27	17	28	47	50	36
Precipitation (inches as water)	0.15	T	0.21	0	0.21	0
Snowfall (inches)	2.0	T	2.0	0	0	0
Snow on the ground (inches)	2	2	4	4	0	0

[1]Data from the Southbridge weather station are available at NOAA Climatological Data Publications (NOAA 2015).
[2]Temperature data were not available for the Southbridge station; data from the Worcester station are reported.

March 28, 2012 – This early spring event followed a relatively dry period (0.08 in total precipitation from March 23-28)), with, in general, steadily decreasing discharge at area gages. Water quality data on this date reflect dry weather conditions. Air temperature data were unavailable on this date; overcast skies were accompanied by intermittent rain by the last station. Deciduous tree and shrubs were beginning to bud throughout the watershed.

May 29, 2012 – This mid-spring monitoring event followed a dry period, with no precipitation recorded at the Southbridge climate station from May 24-29. Discharge at area gages decreased during this period. Water quality data reflect dry weather conditions. Air temperature ranged from 70 to 77ºF under sunny and hazy skies. Deciduous trees and shrubs were in full foliage throughout the watershed.

July 25, 2012 – Small storms brought 0.26 in of precipitation to the area from July 20-25. In general, discharge at area gages was low and varied little in this time period (rapid fluctuations were evident at the French River at Webster). Water quality data reflect dry weather conditions. Air temperature ranged from 68 to 75ºF with sunny skies developing to mostly cloudy by the end of monitoring activities.

September 26, 2012 – This early fall monitoring event was preceded by a storm that brought 0.27 in rain to the area on September 23-24. In general, discharge at area gages rose on September 23, then fell below pre-storm levels. Field observations depict low water levels throughout the watershed. Water quality data reflect dry weather conditions. Air temperature ranged from 60 to 67ºF under overcast skies; occasional sprinkles were observed at the second station only (Cady Brook). Deciduous trees and shrubs were beginning to change color; most leaves were still on the branches.

November 14, 2012 – An overnight storm brought 0.30 in precipitation to the area on November 13-14 (as recorded at Southbridge); discharge rose with the input (rapid fluctuations were seen at the Quinebaug River at Quinebaug CT). Water quality data reflect wet weather/runoff weather conditions. The air temperature ranged from 37 to 47ºF under sunny skies. Foliage had changed and most leaves were down in the watershed.

February 27, 2013 – This winter sampling event followed several storms, including an overnight event that brought 0.45 in rain and snow to the area (1.2 in as snow); snow on the ground increased from 2 to 4 in (for climate data, see Table 9). Discharge at area gages generally increased from February 24-27 (rapid fluctuations were seen at the Quinebaug River at Quinebaug, CT). Water quality data reflect wet weather/runoff conditions. Air temperature ranged from 40 to 43ºF with light rain/rain.

Table 9 Climate Conditions at Southbridge, MA from February 22-27, 2013

Parameter	Feb 22	Feb 23	Feb 24	Feb 25	Feb 26	Feb 27
Max Temperature (ºF) [1,2]	36	33	32	35	38	38
Precipitation (inches as water)	0	0	0.51	0.13	0	0.45
Snowfall (inches)	0	0	0	1.0	0	1.2
Snow on the ground (inches)	3	3	2	2	2	4

[1]Data from the Southbridge weather station are available at NOAA Climatological Data Publications (NOAA 2015).
[2]Temperature data were not available for the Southbridge station; data from the Worcester station are reported.

April 24, 2013 – A storm event on April 20 brought 0.47 in precipitation to the area, which was followed by a dry period. Discharge at area gages generally decreased from April 20-24 (rapid fluctuations were reported at the

Quinebaug River at Quinebaug CT gage). Water quality data reflect dry weather conditions. Air temperature ranged from 49 to 61ºF with overcast skies clearing to sunny by mid-monitoring activities. Deciduous trees and shrubs ranged from beginning to bud to flowering.

August 27, 2013 – On this date, only station QR06, Quinebaug River at Quinebaug, CT was sampled. An overnight storm brought 1.05 in of precipitation to the area; discharge at this gage rose. Water quality data reflect wet weather/runoff conditions for this event. The air temperature was 69ºF under overcast skies.

September 23, 2013 – On this date, only station QR06, Quinebaug River at Quinebaug, CT was sampled. This early autumn monitoring event was preceded by a storm that brought 0.66 in precipitation to the area from September 22-23; discharge at this gage rose with the input. Water quality data reflect wet weather/runoff conditions. Air temperature was 55ºF under sunny skies. Deciduous trees and shrubs were just beginning to change color.

Table 10 French/Quinebaug Basin Precipitation Data Summary 2011-2013*							
Survey Dates	**5 Days**	**4 Days**	**3 Days**	**2 Days**	**1 Day**	**Sample**	**Wet/Dry****
3/23/2011	0	0	0	0	0.32	0	Wet
4/27/2011	0	0.07	0.54	0	0.06	0	Dry
6/22/2011	0	0.61	0	0	0	0	Dry
8/31/2011	0.98	0	2.55	3.25	0	0	Wet
10/26/2011	0	0	0	0	0.03	0	Dry
1/25/2012	0.15	T	0.21	0	0.21	0	Wet
3/28/2012	0	0	0.02	0.06	0	0	Dry
5/29/2012	0	0	0	0	0	0	Dry
7/25/2012	0	0.08	0	0.02	0.14	0.02	Dry
9/26/2012	0	0	0.21	0.06	0	0	Dry
11/14/2012	0.10	0	0	0	0.04	0.26	Wet
2/27/20163	0	0	0.51	0.13	0	0.45	Wet
4/24/2013	0	0.47	0	0	0	T	Dry
8/27/2013***	0	0	0	0	0	1.05	Wet
9/23/2013***	0	0	0	0	0.31	0.35	Wet

*Official data from the National Weather Service station in Southbridge, MA available at NOAA Climatological Data Publications (NOAA 2015); data reported in inches.
**Based on precipitation, streamflow and other relevant data.
***Only Station QR06 was sampled on these dates.

Table 11 USGS Flow Data Summary Discharge for Quinebaug River at Quinebaug, CT 2011-2013*								
Survey Dates	**5 Days**	**4 days**	**3 Days**	**2 Days**	**1 Day**	**Sample**	**Monthly****	**Daily*****
3/23/2011	1,630	1,570	1,430	1,350	1,330	1,260	1,280	629
4/27/2011	637	592	626	562	526	499	574.2	438
6/22/2011	310	335	274	230	202	200	319.5	176
8/31/2011	324	390	2,460	2,260	1,160	838	409.6	81
10/26/2011	712	628	590	522	459	445	533.4	199
1/25/2012	313	298	326[e]	304	403	370	401.4	417
3/28/2012	178	160	148	142	129	129	218.7	590
5/29/2012	139	130	123	114	96	95	190.2	238
7/25/2012	35	31	31	31	31	29	40.5	132
9/26/2012	76	68	69	59	51	46	59.4	119
11/14/2012	163	161	170	187	225	208	171.1	249
2/27/20163	259	237	328	366	348	597	334.2	393
4/24/2013	196	224	200	189	180	158	237.2	445
8/27/2013***	46	50	38	38	36	46	77.0	82
9/23/2013***	60	55	52	49	70	80	80.6	167

*Gage # 0112400 data found at Daily mean discharge Quinebaug River at Quinebaug CT (USGS 2015c); data reported in cfs; all data were approved for publication; processing and review completed.
**Mean of monthly mean discharge (cfs) based on data collected from 10/1/1931 to 9/30/2010 found at Monthly mean discharge Quinebaug River at Quinebaug CT (USGS 2015h)
***POR= Period of Record, means of daily mean discharge values based on data collected from 10/1/1931 to 9/30/2014 found at Mean of daily mean values at Quinebaug River, Quinebaug, CT (USGS 2015g)
7Q10 = 16.640 cfs @ USGS gaging station, Quinebaug River near Quinebaug, CT (USGS 2015c).

RESULTS AND QUALITY ASSURANCE/QUALITY CONTROL

The results of SMART monitoring conducted in the French/Quinebaug watershed from 2011 through 2013 are included below. *In situ* multiprobe readings, including temperature, pH, dissolved oxygen, percent oxygen saturation, depth, specific conductivity, and total dissolved solids, are presented for each station in Table 12 through Table 16. Nutrient and chemistry data are presented in Table 17 through Table 21. 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 data files, lab reports and other metadata are maintained by the Massachusetts Department of Environmental Protection (MassDEP) Bureau of Resource Protection (BRP) CEntral Regional Office (CERO) in Worcester, MA and data are stored electronically in the Division of Watershed Management's (DWM) water quality database. 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 2005-2010 data include, but are not limited to: conformance to the SMART Monitoring Quality Assurance Project Plan (Beaudoin 2008) and 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 Relative Percent Difference, or 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 are 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 12 MassDEP SMART 2011-2013. Station QR00. *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)	(%)
3/23/2011	SM-3503	8:14 AM	0.4	4.0	5.7u	97	63	12.5	95
4/27/2011	SM-3575	8:33 AM	0.2	14.8	6.6	107	69	9.9	98
6/22/2011	SM-3647	8:17 AM	0.3	22.7	6.4	115i	75i	8.2	95
8/31/2011	SM-3719	8:26 AM	0.3	20.6	6.2	72	46	7.2	81
10/26/2011	SM-3791	8:18 AM	0.3	10.8	6.6	86	56	11.3	102
1/25/2012	SM-3863	8:36 AM	0.3	1.5	5.9	92	59	13.4	97
3/28/2012	SM-3935	8:23 AM	##i	10.1	6.9	114	74	11.5	103
5/29/2012	SM-4007	8:24 AM	##i	23.7	7.0	107	70	7.7	91
7/25/2012	SM-4079	8:14 AM	##i	24.0	7.0	118	77	7.2	85
9/26/2012	SM-4151	8:14 AM	##i	18.1	6.9	114	74	8.8	94
11/14/2012	SM-4223	8:17 AM	##i	6.9	6.8	118	77	12.5	103
2/27/2013	SM-4295	8:02 AM	0.0i	2.0	6.6	116	75	14.2	103
4/24/2013	SM-4367	8:55 AM	##i	11.5	7.0	118	77	11.0	101

Table 13 MassDEP SMART 2011-2013. Station CA12. *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)	(%)
3/23/2011	SM-3505	8:47 AM	0.3	2.8	6.8	280	182	14.0	104
4/27/2011	SM-3577	9:14 AM	0.2	14.3	7.3	294	191	10.2u	100u
6/22/2011	SM-3649	9:12 AM	0.3	19.9	6.9	337i	219i	8.8	96
8/31/2011	SM-3721	9:12 AM	0.3	19.3	7.1	185	118	8.8	97
10/26/2011	SM-3793	8:55 AM	0.3	10.9	7.2	168	109	11.3	103
1/25/2012	SM-3865	9:51 AM	0.2	2.5	6.7	344	220	13.3	99
3/28/2012	SM-3937	9:20 AM	##i	6.0	7.1	394	256	12.7	102
5/29/2012	SM-4009	9:07 AM	##i	20.1	7.3	373	243	8.6	95
7/25/2012	SM-4081	9:08 AM	##i	18.2	7.4	537	349	9.3	99
9/26/2012	SM-4153	8:52 AM	##i	14.2	7.3	472	307	9.9	97
11/14/2012	SM-4225	9:09 AM	##i	6.0	7.1	293	191	13.1	105
2/27/2013	SM-4297	8:37 AM	0.0i	1.8	7.0	1088	707	14.6	105
4/24/2013	SM-4369	9:31 AM	##i	8.7	7.7	474	308	13.4	116

Table 14 MassDEP SMART 2011-2013. Station QR06. *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)	(%)
3/23/2011	SM-3507	9:23 AM	0.8	3.7	6.5	129u	84u	14.0	106
4/27/2011	SM-3579	9:46 AM	0.4	15.9	6.9	175	114	10.2u	103u
6/22/2011	SM-3651	9:49 AM	0.4	22.1	7.0	191i	124i	8.3	95
8/31/2011	SM-3723	9:48 AM	0.8	19.5	6.8	116	74	9.0	99
10/26/2011	SM-3795	9:33 AM	0.3	10.5	7.1	141u	92u	11.5	103
1/25/2012	SM-3867	10:28 AM	0.4	1.9	6.9	170	109	13.5	98
3/28/2012	SM-3939	9:55 AM	##	8.4	7.2	203	132	12.2	104
5/29/2012	SM-4011	9:46 AM	##	23.3	7.3	196	127	8.6	101
7/25/2012	SM-4083	9:51 AM	##	22.4	7.5	342	222	8.5	99
9/26/2012	SM-4155	9:36 AM	##	16.1	7.4	245	159	9.9	101
11/14/2012	SM-4227	9:44 AM	##	7.4	7.1	211	137	12.7	105
2/27/2013	SM-4299	9:21 AM	0.0	2.0	7.0	239	155	14.6	106
4/24/2013	SM-4371	10:13 AM	##	10.5	7.2	218	142	12.1	109
8/27/2013	SM-4419	10:54 AM	##	21.8	7.4	301	196	8.7	99
9/23/2013	SM-4437	11:21 AM	0.0	17.4	7.3	227	148	9.8	103

Table 15 MassDEP SMART 2011-2013. Station FR11. *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)	(%)
3/23/2011	SM-3513	10:37 AM	0.6	3.7	6.4	154u	100u	14.0	106
4/27/2011	SM-3585	10:52 AM	0.3	16.4	6.8	166	108	9.9	101
6/22/2011	SM-3657	11:03 AM	0.7	23.0	6.9	192i	125i	8.2	95
8/31/2011	SM-3729	10:58 AM	1.3	21.1	6.6	123	79	8.3	94
10/26/2011	SM-3801	10:57 AM	0.7	11.0	6.8	150	98	10.8	98
1/25/2012	SM-3873	11:45 AM	0.7	2.5	6.7	185	118	13.1	97
3/28/2012	SM-3945	11:15 AM	##i	8.9	7.2	203	132	12.0	103
5/29/2012	SM-4017	10:58 AM	##i	23.9	7.0	200	130	8.0	95
7/25/2012	SM-4089	11:06 AM	##i	23.1	7.1	236	153	7.9	92
9/26/2012	SM-4161	10:43 AM	##i	16.8	7.2	225	147	9.5	98
11/14/2012	SM-4233	11:02 AM	##i	7.8	6.8	171	111	12.1	102
2/27/2013	SM-4305	10:20 AM	**	**	**	**	**	**	**
4/24/2013	SM-4377	11:31 AM	##i	10.7	7.0	215	140	11.4	103

Table 16 MassDEP SMART 2011-2013. Station FR12. *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)	(%)
3/23/2011	SM-3511	10:10 AM	0.6	3.8	6.5	161	105	14.1	107
4/27/2011	SM-3583	10:23 AM	0.4	16.5	6.9	177	115	10.1	103
6/22/2011	SM-3655	10:36 AM	0.4	22.5	7.0	215i	140i	8.5	98
8/31/2011	SM-3727	10:28 AM	1.1	21.0	6.8	132	85	8.7	99
10/26/2011	SM-3799	10:24 AM	0.3	11.2	7.0	167	109	11.4	103
1/25/2012	SM-3871	11:16 AM	0.6	2.8	6.8	199	128	13.2	99
3/28/2012	SM-3943	10:39 AM	##i	8.8	7.2	220	143	12.0	103
5/29/2012	SM-4015	10:34 AM	##i	23.4	7.1	218	142	8.1	95
7/25/2012	SM-4087	10:35 AM	##i	23.0	7.0	323	210	7.5	87
9/26/2012	SM-4159	10:17 AM	##i	16.7	7.1	268	174	9.1	94
11/14/2012	SM-4231	10:21 AM	##i	8.0	7.0	186	121	12.4	105
2/27/2013	SM-4303	10:00 AM	0.0i	2.7	7.0	524	341	14.5	107
4/24/2013	SM-4375	11:01 AM	##i	10.8	7.1	230	149	11.6	105

Table 17 MassDEP SMART 2011-2013. Station QR00. 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)
3/23/2011	SM-3502	7:55	4	14	18	4	<1.0	0.9	0.27	<0.02	0.12	0.008
4/27/2011	SM-3574	8:17	6	15	21	5	<1.0	0.7	0.18a	<0.02	<0.02	0.008
6/22/2011	SM-3646	8:10	**	19	20	5	2.8	**	0.34	0.02	<0.02	0.021
8/31/2011	SM-3718	8:22	7	13	13	122	1.9	2.5	0.41	0.03	<0.02	0.024
10/26/2011	SM-3790	8:15	18	15	15	11	1.3	2.2	0.27	0.02	0.05	0.014
1/25/2012	SM-3862	8:16	7	17	16	1	1.6	0.9	0.30	<0.02	0.19	0.007
3/28/2012	SM-3934	8:10	8	20	20	<1	1.9	1.2b	0.25	<0.02	0.04	0.011
5/29/2012	SM-4006	8:15	12	19	18	2	2.2	1.3b	0.30	0.02	<0.02	0.017
7/25/2012	SM-4078	8:06	13	20	21	47	3.7h	2.3b	0.41	0.03	0.05	0.023
9/26/2012	SM-4150	8:05	12	22	20	26	<1.0	1.2	0.29	<0.02	<0.02	0.012
11/14/2012	SM-4222	8:05	9	20	23	3	1.2	1.3b	0.25	<0.02	0.02	0.011
2/27/2013	SM-4294	7:55 AM	7	18	21	8	<1.0	1.0	0.28	<0.02	0.13	0.008
4/24/2013	SM-4366	8:45 AM	7	18	22	2	2.0	0.8	0.18	<0.02	<0.02	0.009

Table 18 MassDEP SMART 2011-2013. Station CA12. 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)
3/23/2011	SM-3504	8:38	7	28	68	16	<1.0	0.8	0.29	0.04	0.42	0.005
4/27/2011	SM-3576	9:07	10	31	72	2	2.1	1.1	0.62	0.04	0.32	0.012
6/22/2011	SM-3648	9:05	**	38	83	118	2.2	**	1.2	0.06	0.82	0.033
8/31/2011	SM-3720	9:05	11	26	39	93	2.8	2.0	0.61	0.02	0.24	0.026
10/26/2011	SM-3792	8:50	18	26	33	8	<1.0	2.1	0.58	0.04	0.24	0.018
1/25/2012	SM-3864	9:38	12	34	91	47	1.9	1.2	0.78	0.04	0.55	0.014
3/28/2012	SM-3936	9:15	17	41	95	5	5.1	1.1b	1.2	0.08	0.89	0.011
5/29/2012	SM-4008	9:00	20	41	87	135	2.5	1.3b	2.3	0.08	1.7	0.024
7/25/2012	SM-4080	8:55	27	59	130	488	18h	14.0b	2.8	<0.02	2.2	0.053
9/26/2012	SM-4152	8:45	27	57	110	37	1.2	0.8	4.3h	<0.05	3.9	0.015
11/14/2012	SM-4224	8:57	17	38	69	24	1.0	1.5b	0.54	0.02	0.26	0.012
2/27/2013	SM-4296	8:30 AM	11	51	280	35	4.3	3.6	0.76	0.04	0.56	0.021
4/24/2013	SM-4368	9:21 AM	10	40	130	23	2.0	0.9	0.58	<0.02	0.40	0.019

Table 19 MassDEP SMART 2011-2013. Station QR06. 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)
3/23/2011	SM-3506	9:11	5	17	26	26	2.8	1.1	0.33	0.04	0.16	0.013
4/27/2011	SM-3578	9:40	6	22	40	40	2.4	1.1	0.32	<0.02	0.11	0.013
6/22/2011	SM-3650	9:42	**	26	40	40	2.4	**	0.56	0.04	0.20	0.027
8/31/2011	SM-3722	9:42	8	19	23	23	4.5	2.4	0.51	0.04	0.11	0.029
10/26/2011	SM-3794	9:27	11	21	27	27	2.6	2.0	0.41	<0.02	0.16	0.018
1/25/2012	SM-3866	10:21	7	24	37	37	1.7	1.2	0.42	0.02	0.25	0.011
3/28/2012	SM-3938	9:48	12	29	**	**	2.0	1.4b	**	**	**	**
5/29/2012	SM-4010	9:38	15	28	39	39	2.7	1.4b	0.65	<0.02	0.33	0.024
7/25/2012	SM-4082	9:39	23	48	71	71	2.6h	2.1b	0.90	<0.02	0.56	0.025
9/26/2012	SM-4154	9:24	18	39	49	49	1.1	1.2	0.70	<0.02	0.41	0.014
11/14/2012	SM-4226	9:41	13	31	45	45	1.9	1.8b	0.53	<0.02	0.24	0.017
2/27/2013	SM-4298	9:14 AM	8	27	56	345	2.3	1.5	0.52	0.09	0.28	0.013
4/24/2013	SM-4370	10:01 AM	10	27	48	20	1.8	1.3	0.37	0.02	0.15	0.013
8/27/2013	SM-4416	10:45 AM	--	--	61	>2419.6	--	--	0.87	0.10	0.57	0.024
9/23/2013	SM-4434	11:27 AM	--	--	##h	435	--	--	0.83h	##h	##h	0.022h

Table 20 MassDEP SMART 2011-2013. Station FR11. 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)
3/23/2011	SM-3512	10:30	7	21	34	2	1.8	0.9	0.50	0.02	0.29	0.013
4/27/2011	SM-3584	10:45	8	23	37	14	1.5	0.9	0.42	0.03	0.16	0.013
6/22/2011	SM-3656	10:54		27	41	40	1.4		0.59	0.05	0.19	0.026
8/31/2011	SM-3728	10:54	9	19	25	96	3.1	1.1	0.47	0.02	0.05	0.027
10/26/2011	SM-3800	10:49	11	23	30	24	<1.0	1.3	0.51	<0.02	0.19	0.017
1/25/2012	SM-3872	11:35	10	26	42	26	2.6	1.3	0.65	0.04	0.41	0.012
3/28/2012	SM-3944	11:10	14	31	43	30	1.6	2.0b	0.62	<0.02	0.35	0.017
5/29/2012	SM-4016	10:52	17	30	41	35	1.3	1.6b	0.63	0.04	0.26	0.026
7/25/2012	SM-4088	10:59	23	42	50	228	7.3h	2.3b	0.58	0.04	0.21	0.026
9/26/2012	SM-4160	10:37	21	41	47	57	1.2	0.8	0.51	<0.02	0.22	0.012
11/14/2012	SM-4232	10:53	13	26	36	28	1.6	1.0b	0.43	<0.02	0.16	0.012
2/27/2013	SM-4304	**	**	**	**	**	**	**	**	**	**	**
4/24/2013	SM-4376	11:23 AM	12	30	48	21	1.9	0.9	0.49	<0.02	0.22	0.014

Table 21 MassDEP SMART 2011-2013. Station FR12. 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)
3/23/2011	SM-3508	10:00	6	22	34	80	2.1d	1.0	0.29	0.03	0.38	0.009
4/27/2011	SM-3580	10:15	9	25	39	28d	1.4	0.9	0.60	0.02	0.35	0.014
6/22/2011	SM-3652	10:25		33	45	54	1.4d		1.3	0.04d	0.91	0.029
8/31/2011	SM-3724	10:18	10	21	27	166	4.7	1.5	0.56	0.03d	0.12	0.031
10/26/2011	SM-3796	10:12	13	27	34	57	<1.0	1.3	0.83	<0.02	0.53	0.017
1/25/2012	SM-3868	11:07	11	29	45	105	2.0	1.3	0.90	0.03	0.65	0.017
3/28/2012	SM-3940	10:35	16	36	43	31	1.6d	1.9b,d	1.3	<0.02	1.0	0.017
5/29/2012	SM-4012	10:22	18	34	43	140	2.0	1.7b	1.2	0.04	0.83	0.030
7/25/2012	SM-4084	10:25	30	60	58	488	2.1d,h	1.8b	3.1	0.04	2.5	0.027
9/26/2012	SM-4156	10:13	26	51	51	144	1.1	0.9	1.8	0.02	1.5	0.018
11/14/2012	SM-4228	10:12	15	30	38	192	1.4	1.1b	0.74	<0.02	0.43	0.022
2/27/2013	SM-4300	9:55 AM	10	36	140	53	5.9	4.0	0.83	0.02	0.57	0.025
4/24/2013	SM-4372	10:42 AM	13	34	51	20	1.5	1.0	0.90	0.02	0.63	0.015

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