NASHUA RIVER WATERSHED
SMART MONITORING PROGRAM 2011-2013

Technical Memorandum CN 417.0

The Squannacook River, Groton/Shirley

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Cover photo by Therese Beaudoin, MassDEP. September 24, 2013
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
Agelaius phoeniceus	red-winged blackbird	*Lontra canadensis*	North American river otter
Anas platyrhynchos	mallard duck	*Myriophyllum* sp.	milfoil
Anatidae family	ducks	*Nerodia sipedon*	Northern water snake
Ardea herodias	great blue heron	*Peltandra virginica*	arrow arum
Branta canadensis	Canada goose	*Potamogeton* sp.	pondweed
Cambaridae family	freshwater crayfishes	*Potamogeton crispus*	curly-leaf pondweed
Ceratophyllum demersum	coontail	*Sagittaria* sp.	arrowhead
Charadrius vociferus	killdeer	Strigiformes order	owls
Cygnus olor	mute swan	Tricoptera order	caddisflies
Elodea canadensis	waterweed	Unionoida order	freshwater mussel
Gramineae family	true grasses	*Vallisneria* sp.	American eelgrass
Icterus galbula	Baltimore oriole	*Wolffia* sp.	watermeal
Lemna sp.	duckweed	Zygoptera order	damselflies
Lithobates catesbeianus	American bullfrog		

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
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
CSO	Combined Sewer Overflow
DO	dissolved oxygen
DWM	Division of Watershed Management
ºF	degree Fahrenheit
GPD	gallons per day
HSPF	Hydrological Simulation Program - FORTRAN
in	inch
m	meter
MassDEP	Massachusetts Department of Environmental Protection
µS/cm	microsiemen per centimeter
MDL	method detection limit
MGD	million gallons per day
mg/L	milligrams per liter
mi	mile
mi^2	square mile
NH_3-N	ammonia nitrogen
NO_3NO_2-N	nitrate-nitrite nitrogen
NPDES	National Pollutant Discharge Elimination System
NRWA	Nashua River Watershed Association
NTU	Nephelometric Turbidity Unit
NWR	National Wildlife Refuge
NWS	National Weather Service
POR	point of record
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RDL	reporting detection limit
RPD	relative percent difference
SMART	Strategic Monitoring and Assessment for River basin Teams
SOP	standard operating procedure
SR	State Road
SSolids	suspended solids
STP	sewage treatment plant
SU	Standard Unit
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
WPP	Watershed Planning Program
WWTF	wastewater treatment facility
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 Nashua 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 SMART monitoring began in the Nashua watershed in 1998 as part of a cooperative effort between MassDEP CERO and the DWM Watershed Planning Program (WPP), as well as the Nashua River Watershed Association (NRWA); regular bimonthly water quality monitoring began in March 1999. Data collected provided the basis for HSPF modeling and the draft 2007 Nashua Watershed Total Maximum Daily Load (TMDL). 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. 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.

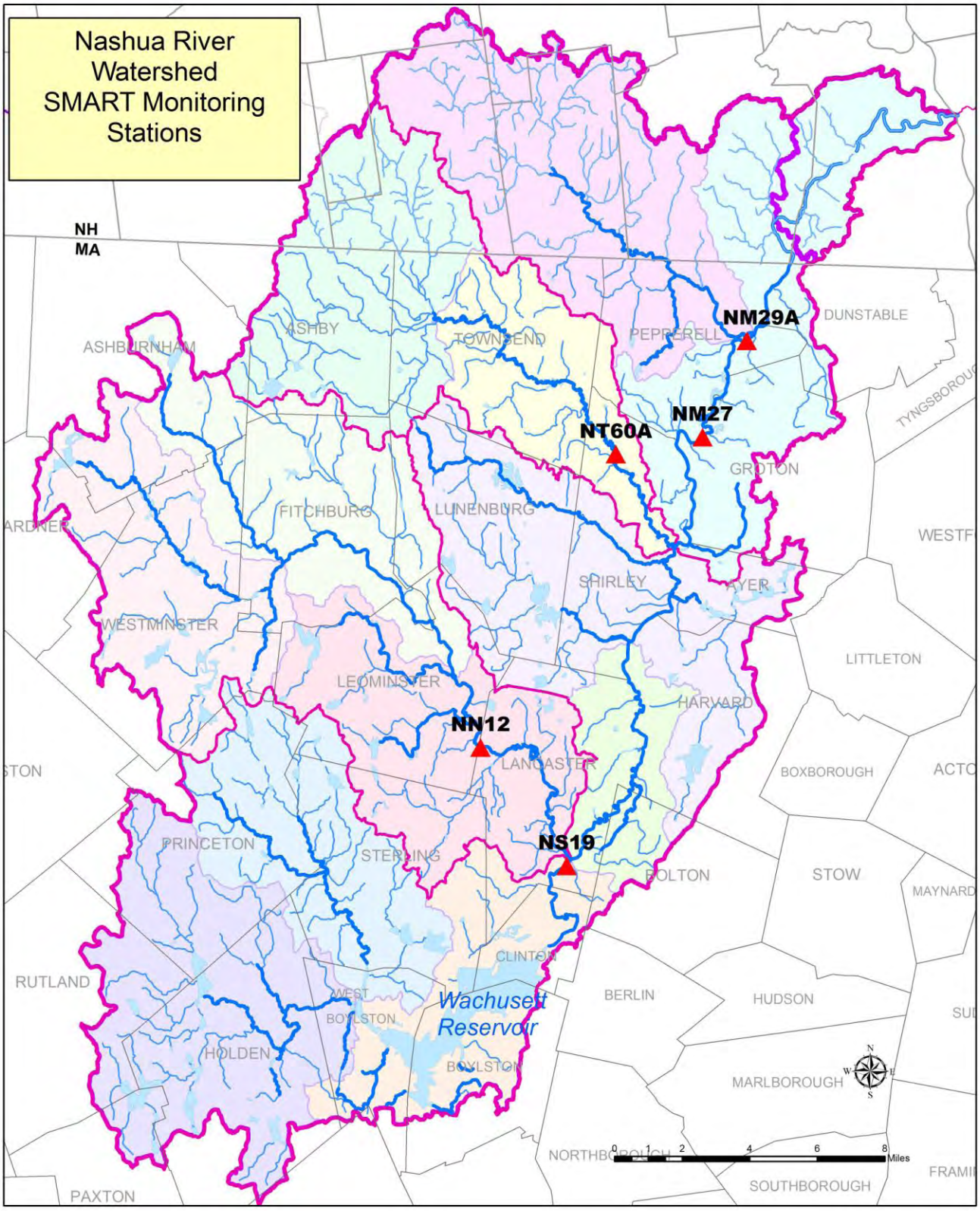
Table 1 Nashua Basin SMART Sampling Summary – 2011 through 2013

Location and Segment Numbers	Station Name	Station Type	Dates Sampled[1]
North Nashua River @ Old North Main Street, Lancaster MA81-04	NN12	Impact	2011: 3/9/11, 4/25/11, 6/15/11, 8/24/11, 10/19/11 2012: 1/18/12, 3/20/12, 5/22/12, 7/18/12, 9/19/12, 11/7/12 2013: 3/6/13, 4/17/13, 5/29/13, 9/24/13 [1]The SMART Monitoring program began in the Nashua basin in May 1998.
Nashua River "South Branch" @ Atherton Bridge, Bolton Road, Lancaster MA81-09	NS19	Impact	
Nashua River at canoe launch, South Road State Road (SR) 119, Pepperell MA81-06	NM27	Impact	
Nashua River at former trestle site downstream of covered bridge, Mill Street, Pepperell MA81-07	NM29A	Boundary	
Squannacook River west of Candace Lane, Groton MA81-18	NT60A	Reference	

Hydrology

The Nashua River, a major tributary of the Merrimack River, flows approximately 41.6 miles (mi) from its beginning at the outlet of Lancaster Millpond in Clinton. Its watershed lies in both Massachusetts and New Hampshire. Of the total drainage area of 530 square miles (mi^2), most lies within Massachusetts and encompasses all or part of 3 cities and 21 towns. For an in-depth description of the watershed, see Nashua River Watershed Water Quality Assessment Report

Figure 1 MassDEP SMART Nashua River Watershed Water Quality Station Locations



2003 (MassDEP 2008). The river is characterized by long runs and large impoundments on the mainstem, and upstream, on the North and South Branches. Four dams remain on the mainstem, including the Pepperell Paper Company Dam behind which lies Pepperell Pond, a 296-acre impoundment. In addition, the Ice House Dam in Ayer impounds 137 acres. Annual precipitation ranges from 48 to 50 inches (in) over most of the watershed, with a section in the northeast corner of the watershed averaging 46 to 48 in, and a smaller region around Mt. Wachusett receiving 50 to 52 in; more information can be found at Average Annual Precipitation For Massachusetts (Ostiguy et al 2014).

Major Massachusetts tributaries of the Nashua River include the North Nashua, Squannacook, and Nissitissit Rivers.

The quality assurance (QA) project plan (QAPP) for the SMART program is presented in CN 012.1*: Quality Assurance Project Plan 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 (2014a, 2014b, 2014c, 2014d, 2014e) 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 (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 Nashua 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. An aerial view and a photo depicting the upstream environs accompany each station description; see Figure 2 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 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).

The SMART monitoring program was terminated in 2013, and the Nashua watershed was only sampled four times that year.

STATION OBSERVATIONS

Station NN12 – North Nashua River at old North Main Street, Lancaster, MA (river mile 7.415)

Figure 2 Google Earth view of Station NN12 area

Figure 3 Station NN12 upstream – I-190 Bridges (9/24/2013)

Station NN12 is located on the North Branch of the Nashua River in Lancaster, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011 through 2013, Station NN12 was sampled 15 times. The river was accessed from the southern shore downstream of the I-190 bridges. Samples were collected by wading to flowing water or by sampling pole. Station NN12 serves as an impact station as it is located downstream of numerous point and nonpoint sources of pollution, as described below.

Land uses near this station included urban, forest, residential, and major roadways (Figure 2; Google Earth 2014a). Three major municipal National Pollutant Discharge Elimination System (NPDES) discharges are located upstream (design flow greater than 1 million gallons per day, or MGD), including the Fitchburg West (taken off-line in February 2010 but the permit is still active), Fitchburg East, and Leominster wastewater treatment plants (WWTP); the latter two are the largest and most complex facilities in the watershed. This segment of the river also contains numerous combined sewer overflows (CSO) which, with the WWTP discharges, define downstream water quality. Numerous large water withdrawals are located upstream (greater than 100,000 gallons per day, or GPD), including private and municipal drinking water supplies and industries.

The river is a run in this area, approximately 72 feet wide, and typically 3 to 5 feet deep (Figure 3). Deciduous and evergreen trees provided shade along the banks, but the canopy did not extend over the channel. The bottom was mostly gravel and sand, with bedrock, boulder, cobble and silt also present. Periodic high flows and channel scouring resulted in minimal habitat for rooted vegetation; the only aquatic macrophytes observed at Station NN12 between 2011 and 2013 were true grasses (family Graminae). Periphyton was observed on half of the sampling dates in this period (n=12), and consisted of filamentous algae, algal film, floc and moss.

Aquatic and semi-aquatic wildlife were reported infrequently at Station NN12. Small fish (species unknown), crayfish (family Cambaridae), and a duck (family Anatidae), were observed once. A tentative sighting of North American river otter (*Lontra canadensis*) was made on June 15, 2011. Songbirds were often present as well.

The water column in this reach was turbid on most events (80%), ranging from slightly to highly turbid/murky; clear conditions were only observed on 3 dates. Water color was typically light yellow/tan/brown, with few observations of clear or grey. On two-thirds of the sampling events, the water column lacked on odor; when noted, odors included effluent or musty. Foam was present on nearly half of the sampling dates, mostly very sparse in density. Sheens were only seen twice, and included a slight milky film and pollen. Trash was noted in the stream bed on numerous events, usually minor in quantity; items included miscellaneous floatables and a tire.

Station NS19 – Nashua River at Bolton Road, Lancaster, MA (river mile 27.201)

Figure 4 Google Earth view of Station NS19 area

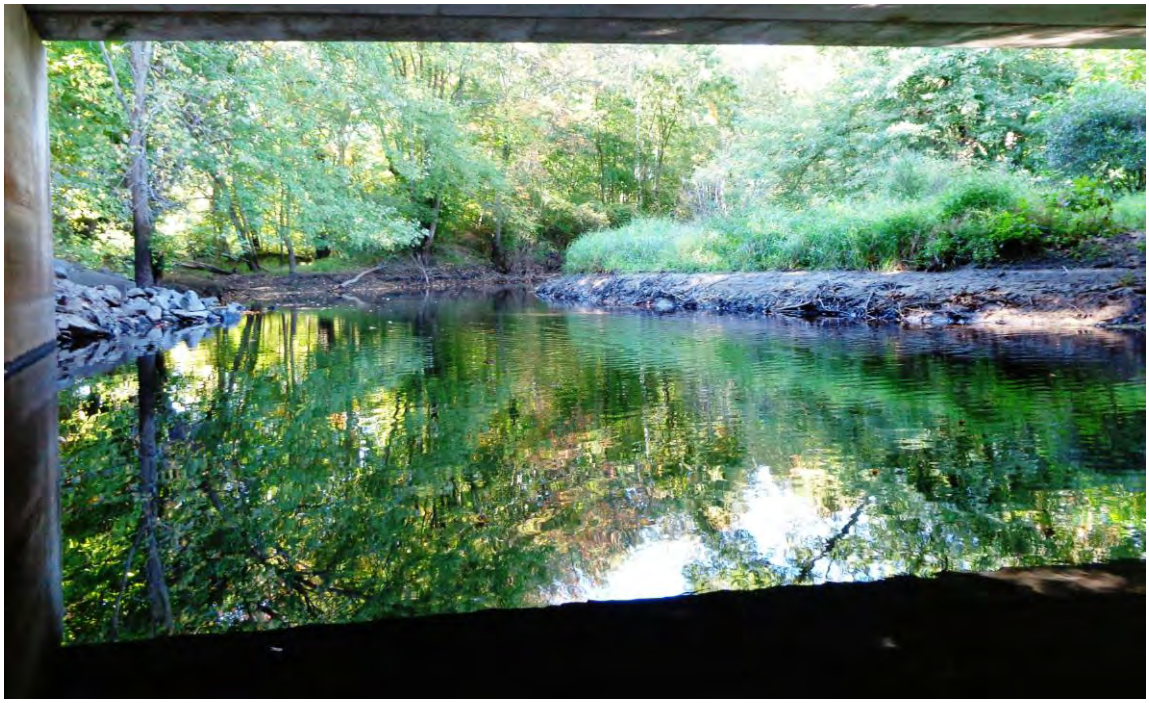


Figure 5 Station NS19 upstream (9/24/2013)

Station NS19 is located on the Nashua River in Lancaster, within the Southern New England Coastal Plains and Hills ecoregion. From 2011 through 2013, Station NS19 was sampled 15 times. The river was accessed from two locations during this time frame, depending on flow conditions: the eastern shore downstream of the Bolton Road Bridge; and the western shore downstream of the Atherton Bridge (3/9/2011 only). Both locations are considered to represent conditions in this area. Samples were collected by wading to flowing water or by sampling pole. Station NS19 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 agriculture, forest and residential, as well as a large surface water supply and an urbanized area (Figure 4; Google Earth 2014b). The 4,135-acre Wachusett Reservoir is part of the water supply for the Metropolitan Boston area; for more information on the management of Wachusett Reservoir, see Wachusett Watershed (MWRA 2014), MA DCR Annual Water Quality Reports (MA DCR 2014a) and Wachusett Tributaries Water Quality 1998-2007 for water quality information on the headwater streams of Wachusett Reservoir (MA DCR 2010). At the base of the Reservoir lies Lancaster Millpond, whose outlet is the beginning of the Nashua River (also known as the "South Branch" of the Nashua River). Municipal NPDES discharges above Station NS19 include the MWRA-Clinton STP.

The river at Station NS19 is a run, approximately 32 feet wide and shaded along its shores with deciduous trees and shrubs (Figure 5). The stream bottom consisted of a mixture of boulder, cobble, gravel and sand, with a large sand bar located along the western shore that extends northward 60-70 feet from the Bolton Road Bridge. Periphyton was absent on 11 of 15 events (unobservable on the other 4 events). Aquatic macrophytes were typically absent from the stream channel; the only plants observed were true grasses (family Gramineae) along the stream edge, on one event (10/19/2011). Wildlife noted here included mallard ducks (*Anas platyrhynchos)*, killdeer (*Charadrius vociferus*), Baltimore oriole (*Icterus galbula*) as well as many other bird species (no other water birds); freshwater mussels (order Unionoida) and fish (species unknown), 6-7 in length.

The water column at Station NS19 was turbid on more than half of the sampling dates in this period, and typically described as slight (6 of 8 events); clear conditions were noted 6 times. The water column was described as free of color on 73% of events; color, when observed, was usually light yellow/tan/brown. The river here typically lacked odor, with musty noted once (5/22/2013). Foam was observed once (8/24/2011); sheens were never observed during this time frame. Minor levels of trash were present on 3 events and included wooden planks, "miscellaneous unidentifiable objects, and floatables.

Station NT60A – Squannacook River near Candice Lane, Groton, MA (river mile 4.708)

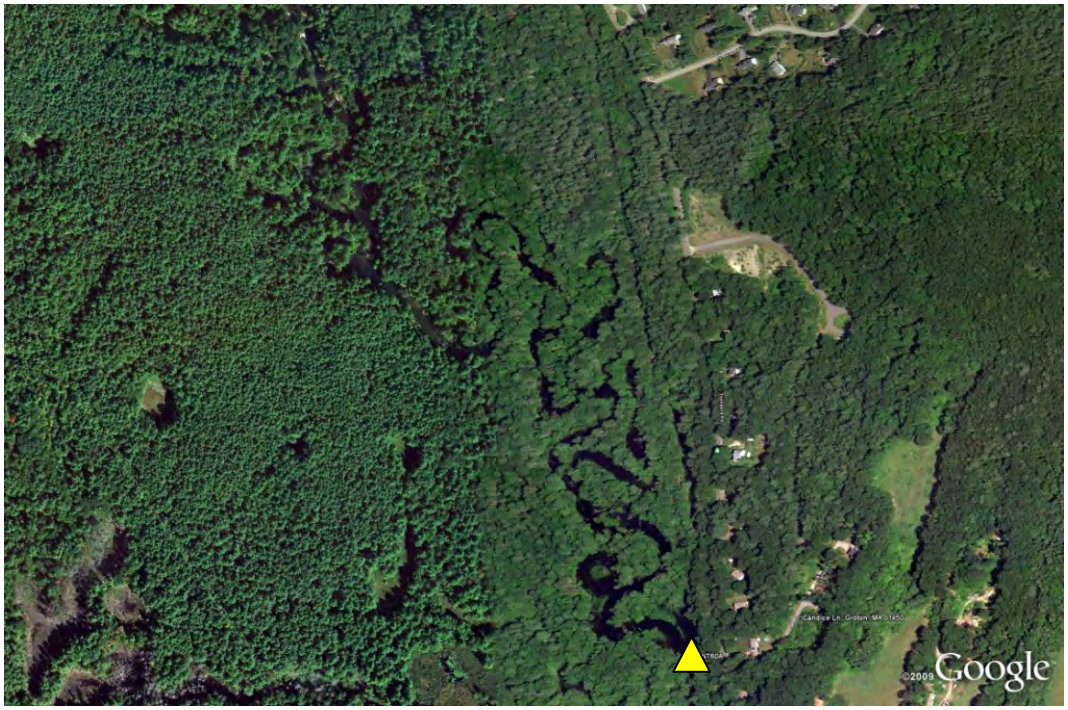


Figure 6 Google Earth view of Station NT60A area

Figure 7 Station NT60A upstream (9/24/2013)

Station NT60A is located on the Squannacook River in Groton, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011 through 2013, Station NT60A was sampled 15 times. The river was accessed from the eastern shore near Townsend Road, approximately opposite Candice Lane. Samples were collected by wading in or with a sampling pole. Station NT60A serves as a reference station, minimally impacted by anthropogenic activities.

Land uses near and upstream of this station include forest and sparse residential development; a downstream dam often impounds the river throughout this reach (Figure 6; Google Earth 2014c). The Squannacook River is a designated Coldwater Fish Resource (CFR; MassDFG 2015). There were no major municipal NPDES discharges (>1 MGD) or water withdrawals (>100,000 GPD) upstream of this station.

The river is a run near Station NT60A, approximately 60 to 75 feet wide, and the channel is typically too deep to wade (Figure 7). Trees provide shade along the stream corridor edges only; the channel is almost entirely open to the sun. Banks are undercut throughout the area. The bottom consisted mainly of gravel and sand (when visible), as well as occasional traces of silt. No aquatic macrophytes or periphyton were observed near the sampling point, although numerous plants were observed upstream. Aquatic wildlife noted here included red-winged blackbird (*Agelaius phoeniceus*), Canada goose *(Branta canadensis*), American bullfrog *(Lithobates catesbeianus*), Northern water snake (*Nerodia sipedon*), owl (order Strigiformes), and small fish (species unknown). Songbirds were often present.

The station was characterized by a lack of color, odor, foam, trash and periphyton. A slight pollen blanket was the only sheen observed from 2011-2013 (5/22/2012). Water color was clear on more than half of the monitoring dates; on most of the remaining events, the color was described as red.

Station NM27 – Nashua River at Nod Road, Groton, MA (river mile 7.426)

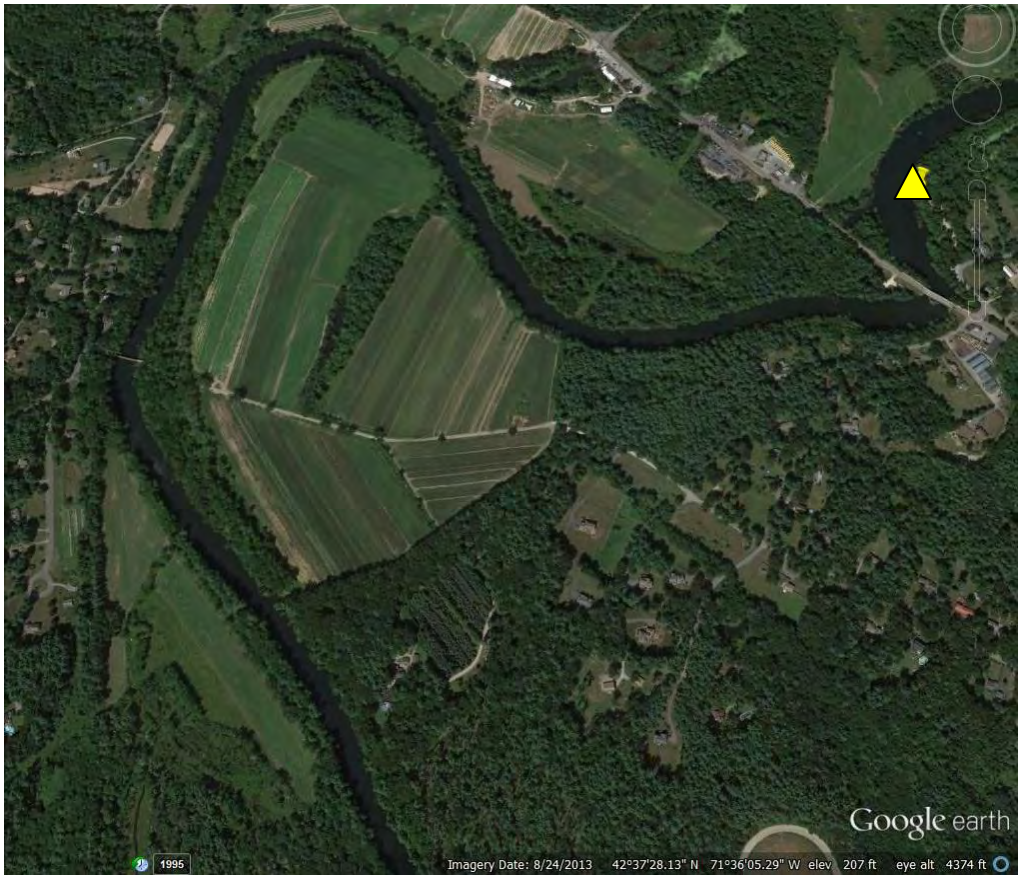


Figure 8 Google Earth view of Station NM27 area

Figure 9 Station NM27 upstream (9/24/2013)

Station NM27 (formerly INLTPEPPD) is located on the Nashua River in Groton, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011 through 2013, Station NM27 was sampled 14 times; on 3/9/2011, the river was inaccessible due to bank-to-bank ice coverage. The river was accessed from the eastern shore downstream (north) of the Rte 119 Bridge at the Groton boat launch. Samples were collected by wading in and/or with a sampling pole. Station NM27 serves as an impact station as it is located downstream of major point and nonpoint sources of pollution, as described below.

Land uses near and upstream of this station include agriculture, forest, and sparse residential (Figure 8; Google Earth 2014d). The Oxbow National Wildlife Refuge (NWR) abuts an 8-mile stretch of the Nashua River above this sampling site; more information can be found at Oxbow National Wildlife Refuge (USFWS 2014). Upstream municipal NPDES discharges (below Station NS19) include the Ayer WWTP and the Groton School (minor); a large groundwater discharge system is located near the Nashua River at Devens (design flow 3 MGD). There are no large water withdrawals (>100,000 GPD) near the river in this stretch.

The river is a run in this area, ranging from 110 to 200 feet wide and too deep to wade across (Figure 9). Trees provide shade along the stream corridor edges only; the channel is almost entirely open to the sun. Stream banks were undercut. The bottom mainly consisted of mud, gravel, sand and silt. Aquatic macrophyte growth was sparse, and included coontail (*Ceratophyllum demersum*), waterweed (*Elodea canadensis*), true grasses (family Graminae), duckweed (*Lemna* sp.), arrow arum (*Peltandra virginica*), curly-leaf pondweed (*Potamogeton crispus*), pondweed (*Potamogeton* sp.), arrowhead (*Sagittaria* sp.), American eelgrass (*Vallisneria* sp.), and watermeal (*Wolffia* sp.). Sparse periphytic growth was noted on two events (n= 14), and consisted of green filamentous algae, algal film or floc.

Wildlife observed included mallard duck (*Anas platyrhynchos*), great blue heron (*Ardea herodias),* mute swan *(Cygnus olor),* freshwater mussels (order Unionoida), and unidentified songbirds. Small fish (species unknown) were also observed, as well as a fish nest near the boat ramp.

The water column at Station NM27 was typically clear (12, n=14), and lacked trash, periphyton, color, odor, foams and sheens. Canoers, kayakers and other boaters were infrequently observed, as well as fishermen.

Field blank samples were collected here throughout this monitoring period.

Station NM29A – Nashua River near Groton Street, Pepperell, MA (river mile 2.917)

Figure 10 Google Earth view of Station NM29A area

Figure 11 Station NM29A upstream (9/24/2013)

Station NM29A is located on the Nashua River in Pepperell, MA within the Southern New England Coastal Plains and Hills ecoregion. From 2011-2013, Station NM29A was sampled 15 times, and access was gained from the southern shore at the former railroad trestle, downstream of the historic Groton Street covered bridge. Samples were collected by wading in or with a sampling pole. Station NM29A serves as a boundary station, reflecting water quality in the Nashua River as it enters the state of New Hampshire approximately 3 miles downstream.

Land uses near and upstream of this station include agriculture, forest, and sparse residential, as well as the town center of Pepperell (Figure 10; Google Earth 2014e). Most of the river corridor between Station NM27 and NM29A lies within the Pepperell Pond impoundment, its length approximately 4.1 miles. A hydropower facility is located below Pepperell Pond. There are no NPDES municipal discharges or large water withdrawals (>100,000 GPD) near the river in this stretch (the Pepperell wastewater treatment facility, or WWTF, discharge is located downstream of this station).

The river is a run near Station NM29A, approximately 85 feet wide and typically too deep to wade across (Figure 11). Trees provide shade along the stream corridor edges only; the channel is almost entirely open to the sun. Stream banks were undercut. Numerous deadfalls were noted in this segment. The water column and bottom were often unobservable due to solar reflection and turbulence, which reduced the ability to observe substrate, trash, periphyton, macrophyton and turbidity. When visible, the bottom consisted of boulder, cobble, gravel, sand, silt and mud, and the wood and metal debris from the trestle that once spanned the river. Aquatic macrophyte growth included an unidentified submergent, tentatively identified as coontail (*Ceratophyllum demersum*), true grasses (family Graminae), duckweed (*Lemna* sp.), milfoil (*Myriophyllum* sp.), curly-leaf pondweed (*Potamogeton crispus*), pondweed (*Potamogeton* sp.), watermeal (*Wolffia* sp.) and an unknown submergent. Periphytic growth was present on most events (n=15, completely unobservable on 6), and the types of periphyton included moss, algal film, and filamentous algae, in densities ranging from sparse to dense. Wildlife noted at the station included ducks (family Anatidae), adult caddisflies (order Tricoptera), damselflies (suborder Zygoptera), and unidentified songbirds and fish.

The water column ranged from clear (10 events) to slightly turbid (5 events). The color was clear on most events (11, n=15). The water at this site lacked odor on nearly half of the sampling dates (7, n=15); “eutrophic pond” was noted on most of the other dates. Very sparse to sparse foam was present on more than half of the monitoring efforts (9, n=15). Sheens were never observed at this station during this time frame. Wood, steel ties, cables and other debris from the railroad trestle formerly located here were a constant presence. Other trash was described as consisting of telephone poles, floatables, lawn chairs, plastic sheeting, broken glass, beer cans and bottle caps, and miscellaneous unidentifiable objects.

Table 2 MassDEP SMART 2011 - 2013. Station NN12. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/9/2011	Unobservable	Unobservable; moderate, floatables where visible	Unobservable	Dark tan	None	None	None	Highly turbid/murky	Wet
4/25/2011	Unobservable	Unobservable; minor, floatables where visible	Unobservable; sparse, dark green filamentous where visible	Clear	Effluent, strong	Very sparse	None	Slight	Wet
6/15/2011	Bedrock/cobble/gravel/sand/silt	None	Moderate, green filamentous	Clear	Musty, faint	Very sparse	None	Slight	Wet
8/24/2011	Bedrock/cobble/gravel/sand/silt	Minor, tire	Moderate, green floc	Light yellow	Effluent	Moderate	None	Slight	Dry
10/19/2011	Unobservable	None	None	Light yellow	None	Very sparse	None	Slight	Wet
1/18/2012	Unobservable	None	None	Light yellow	None	None	None	Slight	Wet
3/20/2012	Unobservable	None	Sparse, dark tan filamentous	Brown	None	Sparse	None	Slight	Dry
5/22/2012	Bedrock/cobble/gravel/sand/silt	None	None	Dark tan	None	None	None	Slight	Dry
7/18/2012	Bedrock/cobble/gravel/sand	None	Dense, bright green film; dense moss	Grey	None	None	Milky film on surface, slight	Slight	Dry
9/19/2012	Unobservable	Unobservable	Unobservable	Brown	None	None	None	Highly turbid/murky	Wet
11/7/2012	Bedrock/cobble/gravel/sand/silt	Unobservable	Dense: clear film	Clear	Musty, slight	None	None	Clear	Dry
3/6/2013	Bedrock/cobble/gravel/sand/silt	None	None	Clear	None	Very sparse	None	Clear	Dry
4/17/2013	Bedrock/cobble/gravel/sand/silt	None	None	Clear	None	Very sparse	None	Slight	Dry
5/22/2013	Unobservable	Unobservable	Unobservable	Brown	None	None	Pollen, moderate	Highly turbid/murky	Wet
9/24/2013	Bedrock/boulder/cobble/gravel/sand/silt	Minor, tire	None	Clear	Effluent, slight	None	None	Clear	Wet
-- : Not noted									

Table 3 MassDEP SMART 2011 - 2013. Station NS19. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/9/2011	Unobservable	Unobservable; minor, floatables where visible	Unobservable	Light yellow	None	None	None	Moderate	Wet
4/25/2011	Unobservable	None	Unobservable	Clear	None	None	None	Unobservable	Wet
6/15/2011	Cobble/gravel/sand	None	None	Clear	None	None	None	Clear	Wet
8/24/2011	Cobble/gravel/sand/silt	None	None	Clear	None	Very sparse	None	Slight	Dry
10/19/2011	Unobservable	None	None	Light yellow	None	None	None	Slight	Wet
1/18/2012	Unobservable	Unobservable	None	Clear	None	None	None	Clear	Wet
3/20/2012	Boulder/cobble/gravel/sand/silt	None	None	Clear	None	None	None	Clear	Dry
5/22/2012	Cobble/gravel/sand/silt	None	None	Dark tan	None	None	None	Slight	Dry
7/18/2012	Cobble/sand	None	None	Clear	None	None	None	Clear	Dry
9/19/2012	Unobservable	Unobservable	Unobservable	Brown	None	None	None	Highly turbid/murky	Wet
11/7/2012	Boulder/cobble/sand/silt	None	None	Clear	None	None	None	Clear	Dry
3/6/2013	Boulder/cobble/gravel/sand/silt	Minor: planks	None	Clear	None	None	None	Slight	Dry
4/17/2013	Unobservable	Minor: miscellaneous unidentifiable objects	None	Clear	None	None	None	Slight	Dry
5/22/2013	Unobservable	Unobservable	Unobservable	Clear	Musty, slight	None	None	Slight	Wet
9/24/2013	Boulder/cobble/gravel/sand/silt	None	None	Clear	None	None	None	Clear	Wet
-- : Not noted									

Table 4 MassDEP SMART 2011 - 2013. Station NT60A. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/9/2011	Unobservable	None	Unobservable	Light yellow	None	None	None	Unobservable	Wet
4/25/2011	Gravel/sand	None	None	Clear	None	None	None	Clear	Wet
6/15/2011	Gravel/sand/silt	None	None	Red, slight	None	None	None	Clear	Wet
8/24/2011	Gravel/sand	None	None	Clear	None	None	None	Clear	Dry
10/19/2011	Gravel/sand	None	None	Red, slight	None	None	None	Clear	Wet
1/18/2012	Cobble/gravel/sand	None	None	Clear	None	None	None	Clear	Wet
3/20/2012	Gravel/sand	None	None	Clear	None	None	None	Clear	Dry
5/22/2012	Gravel/sand/silt	None	None	Red, slight	None	None	Pollen, slight	Clear	Dry
7/18/2012	Gravel/sand	None	None	Light yellow	None	None	None	Clear	Dry
9/19/2012	Gravel/sand/silt	None	None	Clear	None	None	None	Clear	Wet
11/7/2012	Gravel/sand/silt	None	None	Clear	None	None	None	Clear	Dry
3/6/2013	Cobble/gravel/sand/silt	None	None	Clear	None	None	None	Clear	Dry
4/17/2013	Gravel/sand/silt	None	None	Clear	None	None	None	Clear	Dry
5/22/2013	Gravel/sand	None	None	Red, slight	None	None	None	Clear	Wet
9/24/2013	Gravel/sand	None	None	Clear	None	None	None	Clear	Wet

-- : Not noted

Table 5 MassDEP SMART 2011 - 2013. Station NM27. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/9/2011	Station not sampled on this date; not accessible due to snow/ice								
4/25/2011	Gravel/sand/silt	None	None	Clear	None	None	None	Clear	Wet
6/15/2011	Gravel/sand/silt	None	Sparse green floc	Light yellow	Eutrophic pond, slight	None	None	Slight	Wet
8/24/2011	Gravel/sand/silt	None	None	Light yellow	Eutrophic pond	None	None	Clear	Dry
10/19/2011	Gravel/sand/silt	None	None	Red, slight	Musty	None	None	Clear	Wet
1/18/2012	Gravel/sand	None	None	Clear	None	None	None	Clear	Wet
3/20/2012	Gravel/sand/silt	Minor: beer can	None	Clear	None	None	None	Clear	Dry
5/22/2012	Gravel/sand/silt	None	None	Light yellow	Eutrophic pond	None	Pollen, slight	Slight	Dry
7/18/2012	Gravel/sand	None	None	Light yellow	None	None	None	Clear	Dry
9/19/2012	Gravel/sand/silt	None	Sparse: green filamentous; sparse geen film	Clear	None	Moderate	None	Clear	Wet
11/7/2012	Unobservable	Unobservable	None	Clear	None	None	None	Clear	Dry
3/6/2013	Gravel/sand/silt	Minor: floatables	None	Clear	None	None	None	Clear	Dry
4/17/2013	Gravel/sand/silt	Minor: can (beer)	None	Clear	None	None	None	Clear	Dry
5/22/2013	Gravel/sand/silt	Minor: beer can flip top	None	Clear	None	None	None	Clear	Wet
9/24/2013	Gravel/sand/silt/mud	None	None	Clear	None	None	None	Clear	Wet
-- : Not noted									

Table 6 MassDEP SMART 2011 - 2013. Station NM29A. Summary of Observations.

Survey Dates	Substrate	Trash	Periphyton	Color	Odor	Foam	Sheen	Turbidity	Wet/Dry Conditions
3/9/2011	Unobservable	Unobservable	Unobservable	Light yellow	None	Sparse to moderate	None	Slight	Wet
4/25/2011	Unobservable	Floatables	Moderate, moss	Clear	None	Sparse	None	Clear	Wet
6/15/2011	Unobservable	Minor: trestle remnants, broken glass, floatables, miscellaneous	Unobservable	Clear	Eutrophic pond, strong	Sparse	None	Slight	Wet
8/24/2011	Boulder/gravel/sand/silt	Minor: trestle remnants, beer can, lawn chairs, plastic sheeting	None	Clear	Eutrophic pond, strong; musty, slight	Very sparse	None	Clear	Dry
10/19/2011	Gravel/sand/silt	Bridge/trestle remnants	None	Red, slight	Musty	None	None	Clear	Wet
1/18/2012	Unobservable	Unobservable	None	Clear	None	None	None	Clear	Wet
3/20/2012	Unobservable	Unobservable; lawn chair, floatables, telephone poles, broken glass where visible	Sparse, moss	Clear	None	None	None	Clear	Dry
5/22/2012	Unobservable	Unobservable; broken glass, lawn chair, trestle stumps where visible	Unobservable; dense dark green film, sparse moss where visible	Light yellow	Eutrophic pond	Sparse	None	Slight	Dry
7/18/2012	Boulder/cobble/gravel/sand	Minor: miscellaneous, broken glass, broken chairs, trestle remnants, telephone pole	Sparse, clear film	Clear	Eutrophic pond	None	None	Clear	Dry
9/19/2012	Unobservable	Trestle remnants, floatables, miscellaneous unknown objects	Dense, dark green film	Clear	Eutrophic pond, strong	Sparse	None	Clear	Wet
11/7/2012	Unobservable	Unobservable	Unobservable	Clear	None	Sparse	None	Clear	Dry
3/6/2013	Unobservable	Trestle abutments, floatables	Unobservable	Clear	None	Sparse	None	Clear	Dry
4/17/2013	Unobservable	Minor: beer cans, floatables, trestle pilings; miscellaneous unidentifiable items	Unobservable	Green, slight	None	Sparse	None	Slight	Dry
5/22/2013	Unobservable	Unobservable; minor, trestle remnants, floatables where visible	Unobservable	Clear	Eutrophic pond, strong	Sparse	None	Slight	Wet
9/24/2013	Unobservable	Unobservable; trestle remnants, broken glass where visible	Unobservable; olive green filamentous algae where visible	Clear	Eutrophic pond	None	None	Clear	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-influenced events. Precipitation data for each monitoring event were obtained from the National Oceanic and Atmospheric Administration (NOAA), and are shown in Table 10. 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 Nashua watershed is located in Ashburnham, MA; data collected here were utilized in this report. Annual precipitation ranges from 46 to 48 inches (in) on the northeastern portion of the watershed, and 48 to 50 in on the rest; in a small area centered approximately on Mount Wachusett, the range is from 50 to 52 in (Ostiguy et al 2014).

The United States Geological Survey (USGS) operates four real time stream gaging stations in the Nashua River Watershed that are applicable to this water quality data set, as shown below:

- North Nashua River near Leominster, MA (USGS 2014a)
- Nashua River 0.4 mi Upstream Rte 110 at Clinton, MA (USGS 2014b)
- Squannacook River near West Groton, MA (USGS 2014c) and
- Nashua River at East Pepperell, MA (USGS 2014d).

Discharge data were obtained at Daily Data for Massachusetts: Stage and Streamflow; see Table 11 (USGS 2014e).

The period of record (POR) mean streamflow values are the mean of daily mean values for each day for the 63-64 years of record at the USGS Squannacook River gage at West Groton, MA (USGS station number 01096000), recorded in cubic feet per second (cfs). The daily mean data are reported at USGS Surface water daily statistics for Massachusetts (USGS 2011f). The monthly and annual mean discharges are found at USGS Surface water monthly statistics for Massachusetts (monthly, USGS 2014g) and USGS Surface water annual statistics for Massachusetts (annual, USGS 2014h).

Wet weather is defined as precipitation within a five-day antecedent period that 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. At some of the Nashua Watershed flow gaging stations, flow fluctuations not related to precipitation events were seen, particularly at the Nashua River gages in Clinton and East Pepperell.

Flows considered representative of background conditions were based on discharge data recorded at the USGS gaging station on the Squannacook River near West Groton, which is 0.1 mi downstream of the SMART reference station for the Nashua watershed (Station NT60A). Low flows were compared to the 7Q10 flow (the lowest 7-day average streamflow that occurs, on average, once every 10 years) at that location, which is 6.525 cfs (Ries 1999). When precipitation and discharge data were not sufficient to determine wet or dry conditions, additional data were utilized e.g., maximum daily temperature (in degrees Fahrenheit, or ºF), snowfall, snow on the ground, visual clarity and specific conductivity.

March 9, 2011 – A late winter storm on March 6-8, 2011 brought approximately 3 in of rain to the area (trace amount as snow); see Table 7 for local climate data. Maximum daily temperature ranged from 24 to 48 °F from March 4-9, and snow on the ground decreased from 21 to 11 in during this period. Mean daily discharge at the Squannacook River gage rose from March 5 to March 8 then fell through the monitoring survey, but not to pre-storm flows. Data collected during this event reflect wet weather/snowmelt conditions. Air temperature measured in the field during the survey ranged from 30 to 35ºF under cloudy skies. Station NM27 was inaccessible due to unsafe conditions.

Table 7 Climate Conditions at Ashburnham, MA from March 4-9, 2011

Parameter	Mar 4	Mar 5	Mar 6	Mar 7	Mar 8	Mar 9
Max Temperature (ºF)	24	34	48	47	34	40
Precipitation (in, as water)	0	T	0.02	2.90	0.05	0
Snowfall (in)	0	T	0	0	T	0
Snow on the ground (in)	21	21	18	12	11	11
Data obtained at NOAA Climatological Data Publications (NOAA 2015).						

April 25, 2011 – A storm that began on April 23, 2011 and ended after monitoring activities on April 25th brought over 0.6 in rain to the area. Discharge at the Squannacook River gage generally reflected the precipitation pattern. Data collected

during this event reflect wet weather/runoff conditions. Air temperature ranged from 55 to 58°F under cloudy skies with intermittent sprinkles.

June 15, 2011 – Over one inch of rain fell in the five days preceding this monitoring event; discharge at the Squannacook River gage generally reflected the precipitation pattern, and did not return to pre-storm levels prior to monitoring activities. Data reflect wet weather/runoff weather conditions. Air temperature ranged from 63 to 76°F; cloud cover was 90% at the beginning of the survey, diminishing to 20% by the last station.

August 24, 2011 – This summer survey followed a storm that brought approximately 0.5 in to the area on August 22, 2011; however, precipitation in the area was patchy, as rain measured at Worcester for this event was less than 0.1 in. Flow at the Squannacook gage decreased from August 17 through August 24, while the discharge pattern at the other watershed gages included non-natural fluctuations (i.e., not associated with precipitation). Data collected during this event reflect dry weather conditions. Air temperature ranged from 65 to 82°F; cloud cover varied from 30 to 90%.

October 19, 2011 – A wet period preceded this fall survey, with approximately 1.65 in of rain measured at Ashburnham from October 14-17, 2011. In general, discharge rose at area gages from October 14-15 then decreased, but not to pre-storm flows. Data reflect wet weather/runoff conditions. Air temperature ranged from 51 to 54°F under overcast skies, with occasional drizzle. Foliage was partly to mostly changed and down.

January 18, 2012 – From January 13-18, 2012, 5.2 in snow fell on the area (0.86 in as water); see Table 8 for local climate data for this time period. The maximum daily temperature was below freezing on 4 of the 6 days in this period. Snow on the ground decreased from 5 to 4 in on the survey date. In general, discharge rose from January 16-18 at the North Nashua and Squannacook River gages; however, discharge at the other watershed gages showed numerous fluctuations not reflective of either precipitation or snowmelt in the week preceding this event. Data collected during this event reflect wet weather/runoff conditions. Air temperature ranged from 33 to 35°F; and cloud cover from 20 to 60%.

Table 8 Climate Conditions at Ashburnham, MA from January 13-18, 2011

Parameter	Jan 13	Jan 14	Jan 15	Jan 16	Jan 17	Jan 18
Max Temperature (ºF)	34	30	36	27	10	30
Precipitation (in, as water)	0.50	0.15	0	0	0.12	0.09
Snowfall (in)	3.0	0.6	0	0	1.6	0
Snow on the ground (in)	5	4	4	4	5	4
Data obtained at NOAA Climatological Data Publications (NOAA 2015).						

March 20, 2012 – A late winter storm brought approximately a quarter of an inch of rain to Ashburnham on March 16-17, 2012. Discharge generally decreased from March 14 through monitoring activities, although non-natural fluctuations were seen at the Nashua River gage at East Pepperell. Data collected on this date reflect dry weather conditions. Air temperature ranged from 47 to 62°F under sunny skies.

May 22, 2012 – This spring monitoring event took place near the beginning of a small storm that brought 0.1 in of rain to the area on this date. In general, discharge at watershed gages decreased from May 17-22; the discharge pattern at the Nashua River gages in Clinton and East Pepperell indicated possible flow manipulation. Water quality data collected on this date reflect dry weather conditions. Air temperature ranged from 61 to 64ºF; skies were overcast, with precipitation noted at most stations, ranging in intensity from drizzle to light rain.

July 18, 2012 – This summer survey fell within a dry period, with little precipitation noted in the previous five days (Σ=0.03 in). Discharge on the Squannacook River steadily decreased over the week before this event; discharge at the other watershed gages reflected non-precipitation related fluctuations. Data collected on this date reflect dry conditions. Air temperature ranged from 77 to 88ºF and cloud cover from 40 to 100%.

September 19, 2012 – This late summer event occurred within a storm that brought over an inch of rain to the area on this date. The field record notes heavy rain over the previous night. In general, discharge at area gages peaked in the morning prior to the survey, then fell rapidly (not to pre-storm levels before the end of the survey); non-precipitation fluctuations were observed at the Nashua River gage in East Pepperell. Water quality data collected on this date reflect wet weather/runoff conditions. Air temperature ranged from 55 to 62°F; cloudy skies cleared by the last station.

November 7, 2012 – This mid-fall survey followed a 5-day period with no precipitation measured at the Ashburnham weather station. Discharge decreased steadily at watershed gages from November 2-7, 2012 (the Nashua River at Clinton remained at 10-11 cfs). The data collected on this event reflect dry weather conditions. Air temperature ranged from 32 to 40°F under cloudy skies.

March 6, 2013 – Over half an inch of snow fell in the area between March 3-6, 2013 (0.03+ in as water); see Table 9 for local climate data. The maximum daily temperature was above freezing in the five days up to and including this late winter survey; however, the amount of snow measured on the ground at Ashburnham did not diminish in this period (if snowmelt occurred, it may have been offset by the fresh snow that accumulated during this time). The North Nashua and Squannacook River gages show a steadily decreasing discharge from March 1 through mid-day March 6th, with an increase at the North Nashua site beginning at approximately 10 am (the discharge pattern at the Nashua River gages in Clinton and Pepperell indicated non-natural flow fluctuations). Field observations note: visual turbidity was low to very low at all stations; the specific conductivity ranged from 133 to 338 µS/cm; odors were absent at all stations; and the water level was low at those stations where discharge did not indicate non-natural conditions (the North Nashua and the Squannacook Rivers). Based on the discharge data at these two stations, water quality data on this date reflect dry weather conditions. Air temperature ranged from 33 to 39ºF; snow falling at the beginning of the survey developed to rain and sleet by the end.

Table 9 Climate Conditions at Ashburnham, MA from March 1-6, 2013

Parameter	March 1	March 2	March 3	March 4	March 5	March 6
Max Temperature (ºF)	39	36	36	34	34	40
Precipitation (in, as water)	T	0	T	0.01	T	0.02
Snowfall (in)	T	0	T	0.3	T	0.3
Snow on the ground (in)	14	14	14	14	14	14
Data obtained at NOAA Climatological Data Publications (NOAA 2015).						

April 17, 2013 –A storm brought 0.6 in rain to the area on April 12-13, 2013; although a small amount of rain fell on this date (0.04 in), it was after the conclusion of the survey. Discharge at the North Nashua, Nashua (at Pepperell) and Squannacook River gages peaked on April 13, then fell steadily through April 17, with generally level flows observed at the Nashua River at Clinton gage. Water quality data on this date reflect dry conditions. Air temperature ranged from 44 to 54ºF under sunny skies.

May 22, 2013 – This late spring survey followed an overnight storm that brought 0.85 in rain to the area. Streamflow at all watershed gages rose rapidly shortly after midnight on November 22, 2013 (rapid fluctuations at the Nashua River gage in East Pepperell indicate flow manipulation). Data from this survey reflect wet weather/runoff conditions. Air temperature ranged from 56 to 60ºF under cloudy skies.

September 24, 2013 – A storm on September 22 brought nearly an inch of rain to the area; discharge at area gages rose with the input. Water quality data reflect wet weather/runoff conditions. Air temperature ranged from 48 to 56ºF under sunny skies.

Table 10 Nashua Basin Precipitation Data Summary 2011-2013 at Ashburnham, MA							
Survey Dates	**5 Days**	**4 Days**	**3 Days**	**2 Days**	**1 Day**	**Sample**	**Wet/Dry**
3/9/2011	0	T	0.02	2.90	0.05	0	Wet**
4/25/2011	0.30	0.02	0	0.06	0.52	0.03	Wet
6/15/2011	0.40	0.05	0.53	0.03	0.02	0.10	Wet
8/24/2011	0	T	0	0.46	0	0	Dry
10/19/2011	0.35	1.18	0.05	0.07	0	0	Wet
1/18/2012	0.50	0.15	0	0	0.12	0.09	Wet
3/20/2012	0	0.02	0.24	0	0	0	Dry
5/22/2012	0.31	0	0	0	0	0.10	Dry
7/18/2012	0	0	0	0.03	0	0	Dry
9/19/2012	0	0.03	0	0	0	1.01	Wet
11/7/2012	0	0	0	0	0	0	Dry
3/6/2013	T	0	T	0.01	T	0.02	Dry
4/17/2013	0.02	0.57	0	0	0	0.04	Dry
5/22/2013	0	0	0	0.13	0	0.85	Wet
9/24/2013	0	0	0	0.95	0	0	Wet

*Data expressed as inches of precipitation (as water); official data from the National Weather Service station in Ashburnham, MA available at NOAA Climatological Data Publications (NOAA 2015)

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

T = trace amount; an amount too small to measure

Table 11 USGS Flow Data Summary Discharge (cfs) 2011-2013 at Squannacook River, Groton								
Survey Dates	**5 Days**	**4 days**	**3 Days**	**2 Days**	**1 Day**	**Sample***	**Monthly****	**Daily*****
3/9/2011	118 [e]	118	165	1,200	1,720	683	427.4	199
4/25/2011	296	258	211	197	274	244	234.1	219
6/15/2011	77	87	130	128	105	94	117.7	107
8/24/2011	45	38	32	29	26	27	68.4	24
10/19/2011	193	296	240	175	147	135	218.4	94
1/18/2012	123	129	100 [e]	92 [e]	102	120	150.5	59
3/20/2012	157	145	150	145	135	125	137.2	265
5/22/2012	197	168	129	106	92	92	119.8	140
7/18/2012	17	17	16	16	15	14	19.3	33
9/19/2012	10 [p]	69.5 [p]	10 [p]	8.5 [p]	8.2 [p]	20 [p]	N/A	33
11/7/2012	170	123	99	85	77	72	73.8	82
3/6/2013	279	212	173	153	138	136	194.8	171
4/17/2013	305	356	327	245	197	172	207.7	316
5/22/2013	32	31	28	26	24	22	91.8	140
9/24/2013	17	16	15	20	25	22	21.7	37

*Gage # 01096500 data found at Daily Data at Squannacook River near West Groton, MA (USGS 2014c)

**Mean of monthly mean discharge (cfs) based on data collected from 10/1/1949 to 9/30/2013, found at USGS Surface water monthly statistics for Massachusetts (USGS 2014g)

***POR= Period of Record, mean of daily mean discharge based on data collected from 10/1/1949 to 9/30/2013, found at USGS Surface water daily statistics for Massachusetts (USGS 2014f)

[e] = Value has been estimated

[p] = Provisional data subject to revision

N/A = Data not available

7Q10 = 6.525 cfs @ USGS gaging station, Squannacook River near West Groton, MA (Ries 1999)

RESULTS AND QUALITY ASSURANCE/QUALITY CONTROL

The results of SMART monitoring conducted in the Nashua 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 (% sat); 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) Division of Watershed Management Watershed Planning Program 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 2011-2013 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 quality control (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, 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 NN12. *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)	(%)
3/9/2011	SM-3480	8:38 AM	1.0	1.1	6.5	234	152	15.1	107
4/25/2011	SM-3552	8:31 AM	0.9	11.4	6.8	230	150	10.1	93
6/15/2011	SM-3624	9:07 AM	0.7	15.6	6.7	365	237	9.0	90
8/24/2011	SM-3696	8:44 AM	0.6	19.1	7.0	464	301	9.3i	100i
10/19/2011	SM-3768	8:18 AM	0.1	12.4	6.9	228	148	10.4	98
1/18/2012	SM-3840	8:25 AM	0.3	2.3	6.8	487	317	12.8	94
3/20/2012	SM-3912	8:19 AM	##i	10.7	6.8	257	167	10.6i	96i
5/22/2012	SM-3984	8:21 AM	##i	16.7	6.8	##i	##i	8.7	89
7/18/2012	SM-4056	8:06 AM	##i	24.4	7.2	587	382	6.4	76
9/19/2012	SM-4128	8:24 AM	##i	19.1	7.0	244	159	7.9	86
11/7/2012	SM-4200	8:34 AM	##i	5.8	6.8c	285c	185c	12.4	99
3/6/2013	SM-4272	8:18 AM	0.0i	3.4	7.0	338	220	##i	##i
4/17/2013	SM-4344	7:58 AM	0.0i	10.1	6.7	237	154	11.5	102
5/22/2013	SM-4404	8:18 AM	##i	15.8	6.9	275	179	8.7	88
9/24/2013	SM-4440	8:41 AM	0.0i	13.9	7.0	425	276	9.6	93

Table 13 MassDEP SMART 2011-2013. Station NS19. *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)	(%)
3/9/2011	SM-3482	9:22 AM	1.8	2.0	6.8	272	177	0.3r,u	<2r,u
4/25/2011	SM-3554	9:15 AM	1.7	8.6	6.9	154	100	11.5	98
6/15/2011	SM-3626	9:50 AM	0.7	13.9	6.5	151	98	10.2	98
8/24/2011	SM-3698	9:25 AM	0.8	16.4	6.6	126	82	10.5i	107i
10/19/2011	SM-3770	8:54 AM	0.8	14.1	6.9	138	90	9.7	94
1/18/2012	SM-3842	9:01 AM	1.0	2.4	6.9	157	102	12.9	94
3/20/2012	SM-3914	8:59 AM	##i	6.3	6.9	136	88	12.7i	103i
5/22/2012	SM-3986	8:59 AM	##i	13.2	6.9	##i	##i	10.2	97
7/18/2012	SM-4058	8:48 AM	##i	18.7	6.8	120	78	8.9	96
9/19/2012	SM-4130	9:04 AM	##i	17.8	6.9	215	140	7.6	81
11/7/2012	SM-4202	9:22 AM	##i	7.1	6.9c	208c	135c	11.2	92
3/6/2013	SM-4274	8:56 AM	0.0i	2.6	7.0	163	106	##i	##i
4/17/2013	SM-4346	8:35 AM	0.0i	10.8	7.0	288	187	10.4	94
5/22/2013	SM-4406	9:31 AM	##i	15.7	7.1	249	162	8.5	85
9/24/2013	SM-4442	9:36 AM	0.0i	13.2	7.0	325	211	9.3	88

Table 14 MassDEP SMART 2011-2013. Station NT60A. *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)	(%)
3/9/2011	SM-3484	10:31 AM	0.5	0.4	5.8	105	68	14.7	102
4/25/2011	SM-3556	10:18 AM	0.6	10.4	6.2	117	76	10.9	98
6/15/2011	SM-3628	10:53 AM	0.7	15.8	6.3	142	92	9.0	91
8/24/2011	SM-3700	10:41 AM	0.9	19.9	6.3	181	118	7.8i	86i
10/19/2011	SM-3772	9:51 AM	0.7	11.4	6.4	115	74	9.6	88
1/18/2012	SM-3844	10:10 AM	0.6	0.9	6.4	140	91	13.0	91
3/20/2012	SM-3916	10:04 AM	##i	10.6	6.5	114	74	10.9i	98i
5/22/2012	SM-3988	10:05 AM	##i	17.2	6.5	##i	##i	8.3	86
7/18/2012	SM-4060	10:01 AM	##i	25.2	6.5	193	126	5.5	67
9/19/2012	SM-4132	10:10 AM	##i	16.5	6.5	206	134	6.8	70
11/7/2012	SM-4204	10:38 AM	##i	5.3	6.4c	137c	89c	11.8	93
3/6/2013	SM-4276	9:58 AM	0.0i	1.8	6.4	133	87	##i	##i
4/17/2013	SM-4348	9:39 AM	0.0i	9.8	6.4	115	75	11.4	101
5/22/2013	SM-4408	10:41 AM	##i	16.9	6.6	174	113	8.5	88
9/24/2013	SM-4444	10:54 AM	0.0i	14.8	6.5	189	123	7.8	77

Table 15 MassDEP SMART 2011-2013. Station NM27. *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)	(%)
3/9/2011	SM-3489	11:25 AM	**	**	**	**	**	**	**
4/25/2011	SM-3561	11:28 AM	0.2	10.8	6.8	190	124	10.8u	98u
6/15/2011	SM-3633	12:03 PM	0.9	16.7	6.8	224	146	9.1	94
8/24/2011	SM-3705	11:49 AM	0.5	22.0	6.8	238	155	8.5i	97i
10/19/2011	SM-3777	10:27 AM	0.7	12.9	6.8	184	120	9.1	87
1/18/2012	SM-3846	10:50 AM	0.4	1.5	6.8	223	145	13.2	94
3/20/2012	SM-3918	10:31 AM	##i	10.1	6.9	191	124	11.3i	100i
5/22/2012	SM-3990	10:33 AM	##i	17.8	6.8	##i	##i	7.9	83
7/18/2012	SM-4065	11:10 AM	##i	24.8	6.9	243	158	7.5	91
9/19/2012	SM-4137	10:45 AM	##i	18.1	7.0	391	254	7.3	77
11/7/2012	SM-4209	11:08 AM	##i	6.9	6.9c	220c	143c	11.3	93
3/6/2013	SM-4278	10:25 AM	0.0i	3.1	6.8	259	169	##i	##i
4/17/2013	SM-4350	10:02 AM	0.0i	10.6	6.8	213	138	11.1	100
5/22/2013	SM-4410	11:09 AM	##i	18.2	6.9	310	202	7.6	81
9/24/2013	SM-4446	11:36 AM	0.0i	16.3	6.9	354	230	8.3	84

Table 16 MassDEP SMART 2011-2013. Station NM29A. *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)	(%)
3/9/2011	SM-3489	11:25 AM	**	**	**	**	**	**	**
4/25/2011	SM-3561	11:28 AM	0.2	10.8	6.8	190	124	10.8u	98u
6/15/2011	SM-3633	12:03 PM	0.9	16.7	6.8	224	146	9.1	94
8/24/2011	SM-3705	11:49 AM	0.5	22.0	6.8	238	155	8.5i	97i
10/19/2011	SM-3777	10:27 AM	0.7	12.9	6.8	184	120	9.1	87
1/18/2012	SM-3849	11:24 AM	0.6	0.8	6.9	220	143	13.4	94
3/20/2012	SM-3921	10:59 AM	##i	9.7	6.9	189	123	12.1i	106i
5/22/2012	SM-3993	11:01 AM	##i	18.5	6.8	##i	##i	7.8	83
7/18/2012	SM-4062	10:39 AM	##i	25.9	7.1	255	166	7.5	92
9/19/2012	SM-4134	11:17 AM	##i	18.6	7.2	355	231	8.0	86
11/7/2012	SM-4206	11:35 AM	##i	7.3	7.0c	208c	135c	12.3	102
3/6/2013	SM-4281	10:49 AM	0.0i	2.8	6.9	270	175	##i	##i
4/17/2013	SM-4353	10:27 AM	0.0i	10.1	6.9	202	131	11.8	105
5/22/2013	SM-4413	11:40 AM	##i	18.5	7.0	301	196	8.2	87
9/24/2013	SM-4449	12:06 PM	0.0i	16.7	7.1	294	191	10.0	103

Table 17 MassDEP SMART 2011-2013. Station NN12. 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)
3/9/2011	SM-3478	8:17	6	22	53	1990	15	4.2	1.1	0.17	0.56	0.050
4/25/2011	SM-3550	8:14	11	26	51	921	3.6	1.5	0.97	0.10	0.63	0.026
6/15/2011	SM-3622	8:50	28	45	76	1990	4.2d	2.4	2.7	0.10	1.9	0.070
8/24/2011	SM-3694	8:36	33	53	90	166	3.1	2.0	5.7	<0.10	4.8	0.14
10/19/2011	SM-3766	8:10	14	28	48	365b	11d	2.0h	1.5	0.04	1.2	0.046
1/18/2012	SM-3838	8:05	16	36	120	**	6.8d	3.5	2.1	0.08	1.6	0.056
3/20/2012	SM-3910	8:10	16	30	52	313	4.0	1.7b	1.7b	0.04	1.3	0.036b
5/22/2012	SM-3982	8:05	21	35	59	435	5.8	1.9	2.7	0.06	2.2	0.058
7/18/2012	SM-4054	7:48	58	69	110	179	5.0	2.3b	9.1	0.25	7.8	0.11
9/19/2012	SM-4126	8:10	23	30	44	>2419.6	19	8.3	3.1	0.32	1.6	0.19
11/7/2012	SM-4198	8:20	21	37	54	219	2.4	1.3b	2.2	0.06d	1.8	0.040
3/6/2013	SM-4270	8:10 AM	13	33	77	48	2.1	1.3	1.7	0.12	1.2	0.030
4/17/2015	SM-4342	7:50 AM	10	24	52	68	4.0	1.5	1.2	0.30	0.69	0.023
5/29/2015	SM-4402	8:10 AM	16	31	58	>2419.6	42	11.0	3.3	0.84	1.1	0.22
9/24/2015	SM-4438	8:35 AM	35	64	85	365	2.9	1.6	4.8	0.06	4.5	0.049

Table 18 MassDEP SMART 2011-2013. Station NS19. 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)
3/9/2011	SM-3481	9:13 AM	21	40	55	>2419.6	4.8	3.0	1.8	0.23	1.1	0.086
4/25/2011	SM-3553	9:05 AM	10	22	31	111	2.2	1.1	0.70	<0.02	0.52	0.037
6/15/2011	SM-3625	9:45 AM	8	21	27	121	3.9	1.0	0.66	0.02	0.46	0.027
8/24/2011	SM-3697	9:17 AM	7	19	24	152	4.6	1.1	0.76	<0.02	0.52	0.021
10/19/2011	SM-3769	8:50 AM	10	20	26	36b	3.3	0.9h	0.58	0.03	0.38	0.021
1/18/2012	SM-3841	8:54 AM	10	22	30	**	2.1	0.8	0.68	<0.02	0.48	0.039
3/20/2012	SM-3913	8:45 AM	9	20	23	12	1.8	1.0b	0.60b	<0.02	0.43	0.038b
5/22/2012	SM-3985	8:55 AM	10	19	24	69	4.1	0.8	0.53	<0.02	0.38	0.017
7/18/2012	SM-4057	8:40 AM	9	17	21	53	2.9	1.0b	0.84	<0.02	0.61	0.027
9/19/2012	SM-4129	8:54 AM	22	40	38	>2419.6	5.1	5.5	2.5	0.04	2.1	0.078
11/7/2012	SM-4201	9:06 AM	23	38	36	119	2.5	1.6b	1.6	0.04	1.4	0.044
3/6/2013	SM-4273	8:48 AM	11	23	27	46	6.5	1.9	0.90	0.02	0.68	0.054
4/17/2015	SM-4345	8:58 AM	31	43	52	46	3.0	1.6	2.6	<0.02	2.1	0.082
5/29/2015	SM-4405	9:23 AM	29	35	42	1730	15	6.0	2.4	0.17	1.9	0.14
9/24/2015	SM-4441	9:15 AM	41	48	52	387	1.0	1.2	4.6	0.03	4.7	0.038

Table 19 MassDEP SMART 2011-2013. Station NT60A 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)
3/9/2011	SM-3483	10:20	2	10	21	22	4.5	2.3	0.45	0.04	0.17	0.023
4/25/2011	SM-3555	10:09	5	12	25	19	1.3	0.9	0.34	<0.02	0.15	0.010
6/15/2011	SM-3627	10:43	8	16	30	89	2.1	1.6	0.56	0.02	0.23	0.020
8/24/2011	SM-3699	10:35	8	21	42	98	5.1	1.2	0.57	0.02	0.27	0.016
10/19/2011	SM-3771	9:50	6	13	25	22b	1.7	1.2h	0.45	<0.02	0.18	0.018
1/18/2012	SM-3843	10:01	7	16	27		2.0	0.8	0.59	0.02	0.46	0.007
3/20/2012	SM-3915	9:55	5	13	22	10	1.4	1.3b	0.43b	<0.02	0.26	0.010b
5/22/2012	SM-3987	9:56	7	14	25	65	2.6	1.7	0.49	0.03	0.26	0.018
7/18/2012	SM-4059	9:45	12	21	43	22	1.4	1.3b	0.62	<0.02	0.29	0.017
9/19/2012	SM-4131	10:02	12	23	47	291	1.7	1.2	0.52	0.03	0.29	0.013
11/7/2012	SM-4203	10:29	6	16	27	13	1.2	1.0b	0.54	0.03	0.27	0.013
3/6/2013	SM-4275	9:52 AM	4	14	23	7	<1.0	0.7	0.41	0.02	0.30	0.009
4/17/2015	SM-4347	9:30 AM	6	12	25	8	1.4	0.8	0.34	<0.02	0.17	0.010
5/29/2015	SM-4407	10:32 AM	9	18	37	313	4.4	1.8	0.68	0.05	0.43	0.021
9/24/2015	SM-4443	10:45 AM	10	23	40	61	1.3	1.4	0.57	<0.02	0.45	0.010

Table 20 MassDEP SMART 2011-2013. Station NM27. 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)
3/9/2011	SM-3487	**	**	**	**	**	**	**	**	**	**	**
4/25/2011	SM-3559	11:17	11	25	40	98	<1.0	1.2	0.66	0.07	0.37	0.023
6/15/2011	SM-3631	11:53	17	31	44	124	2.0	1.8	0.99	0.05	0.66	0.041
8/24/2011	SM-3703	11:10	19	33	49	62	<1.0	1.4	1.4	0.05	0.96	0.044
10/19/2011	SM-3775	10:20	17	28	36	36b	1.4	1.6h	0.79	0.03	0.52	0.028
1/18/2012	SM-3845	10:43	18	33	44	**	2.1	1.3	1.2	0.07	0.87	0.027
3/20/2012	SM-3917	10:18	14	27	37	17	1.3	1.7b	0.84b	0.05	0.59	0.022b
5/22/2012	SM-3989	10:26	17	27	36	40	3.4	1.8	0.99	0.07	0.66	0.039
7/18/2012	SM-4061	11:00	23	35	46	77	1.3	1.9b	1.4	0.03	1.1	0.033
9/19/2012	SM-4135	10:34	44	62	74	84	1.1	1.1	2.2	0.14	1.7	0.028
11/7/2012	SM-4207	10:57	20	34	42	33	1.4	1.7b	1.1	0.05	0.72	0.027
3/6/2013	SM-4277	10:16 AM	15	32	54	15	3.9	2.0	0.98	0.06	0.74	0.028
4/17/2015	SM-4351	9:55 AM	12	24	44	13	1.7	1.1	0.70	0.08	0.41	0.019
5/29/2015	SM-4411	11:02 AM	25	43	62	154	3.4	2.9	1.6	0.13	1.1	0.045
9/24/2015	SM-4445	11:30 AM	34	61	69	86	2.4	2.2	2.3	0.08	1.9	0.032

Table 21 MassDEP SMART 2011-2013. Station NM29A. 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)
3/9/2011	SM-3485	10:55	5	17	33	435	16	7.1	0.82	0.11	0.32	0.092
4/25/2011	SM-3557	10:45	12	26	41	365	2.5	1.6	0.75	0.08	0.43	0.024
6/15/2011	SM-3629	11:23	18	32	48	108	1.8	1.6	1.1	0.07	0.76	0.042
8/24/2011	SM-3701	11:32	19	34	49	28	1.8	1.0	1.0	0.03	0.70	0.034
10/19/2011	SM-3773	12:45	15	26	35	91b	1.1	1.3h	0.74	0.04	0.43	0.029
1/18/2012	SM-3847	11:15	17	32	42	**	1.7	1.3	1.0	0.06	0.79	0.023
3/20/2012	SM-3919	12:45	14	28	38	23	1.2	1.1b	0.81b	0.04	0.54	0.020b
5/22/2012	SM-3991	11:05	16	27	35	27	3.0	2.0	0.98	0.07	0.57	0.043
7/18/2012	SM-4063	10:27	25	36	51	194	1.3	1.3b	1.2	0.04	0.79	0.035
9/19/2012	SM-4133	11:09	40	54	72	117	<1.0	0.4	1.7	0.04	1.4	0.017
11/7/2012	SM-4205	11:28	19	32	40	21	1.5	1.4b	0.99	0.05	0.61	0.030
3/6/2013	SM-4279	10:42 AM	15	32	57	26	1.0	1.3	0.99	0.08	0.74	0.022
4/17/2015	SM-4351	10:20 AM	12	26	46	11	1.7	1.1	0.79	0.13	0.47	0.018
5/29/2015	SM-4411	11:31 AM	24	41	60	67	5.9	2.3	1.5	0.10	0.97	0.050
9/24/2015	SM-4447	11:55 AM	29	49	56	36	2.4	1.0	1.0	<0.02	0.76	0.021

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