Broad Brook

Watershed Summary

WATERSHED DESCRIPTION AND MAPS

The Broad Brook watershed covers an area of approximately 10,099 acres in north central Connecticut (Figure 1). There are four municipalities located in the watershed, including East Windsor, Ellington, Somers, and Tolland, CT. The majority of the watershed lies in East Windsor and Ellington, CT.

The Broad Brook watershed includes two segments impaired for recreation due to elevated bacteria levels. These segments were assessed by Connecticut Department of Energy and Environmental Protection (CT DEEP) and included in the CT 2010 303(d) list of impaired waterbodies. Some segments in the watershed were currently unassessed as of the writing of this document. This does not suggest that there are no issues on these segments, but indicates a lack of current data to evaluate the segments as part of the assessment process. An excerpt of the Integrated Water Quality Report is included in Table 1 (CT DEEP, 2010).

Broad Brook (Segment 2) (CT4206-00_02) begins in the Shenipsit State Forest in Ellington just east of Route 83, flows westerly through developed and agricultural areas, passes the Ellington Airport, crosses the town line at East Windsor just west of Route 140, and ends at the inlet to Broad Brook Mill Pond. Broad Brook (Segment 1) (CT4206-00_01) continues west from the outlet of the pond near Route 191 to its outlet at the Scantic River in East Windsor (Figures 2 and 5).

Both impaired segments of Broad Brook have a water quality classification of A. Designated uses include potential drinking water supplies, habitat for fish and other aquatic life and wildlife, recreation, and industrial and agricultural water supply. These segments are impaired due to elevated bacteria concentrations, affecting the designated use of recreation. As there are no designated beaches in these segments of Broad Brook, the specific recreation impairment is for non-designated swimming and other water contact related activities.

Impaired Segment Facts

Impaired Segments:
1. Broad Brook (Segment 1) (CT4206-00_01)
2. Broad Brook (Segment 2) (CT4206-00_02)

Municipalities: East Windsor and Ellington

Impaired Segment Lengths (miles): 4206-00_01 (1.01), 4206-00_02 (9.01)

Water Quality Classifications: Class A

Designated Use Impairments: Recreation

Sub-regional Basin Name and Code: Broad Brook, 4206

Regional Basin: Scantic

Major Basin: Connecticut

Watershed Area (acres): 10,099

MS4 Applicable? Yes

Applicable Season: Recreation Season (May 1 to September 30)

Figure 1: Watershed location in Connecticut

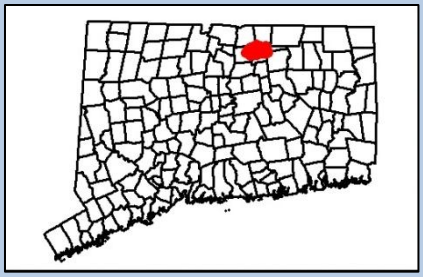


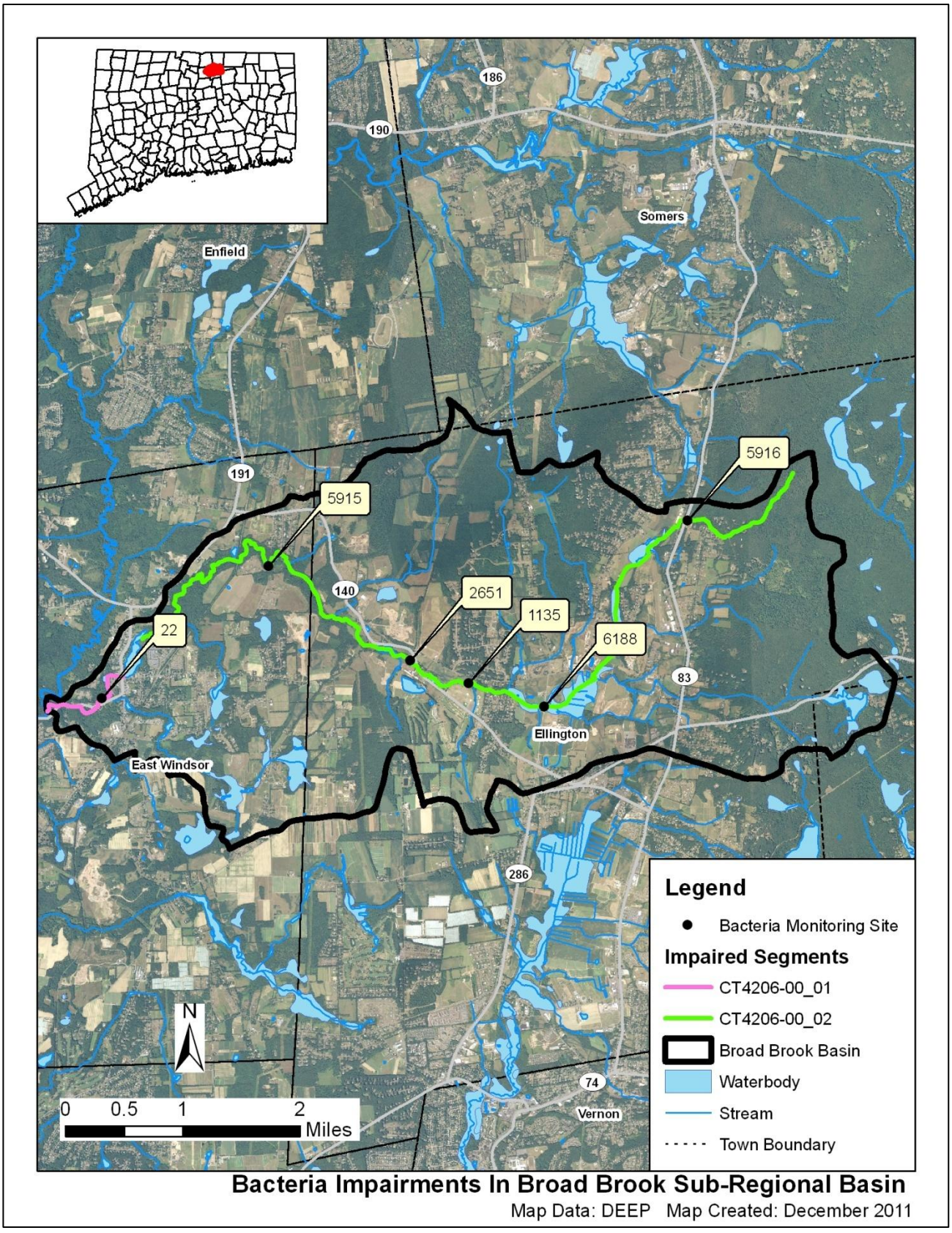
Table 1: Impaired segments and nearby waterbodies from the Connecticut 2010 Integrated Water Quality Report

Waterbody ID	Waterbody Name	Location	Miles	Aquatic Life	Recreation	Fish Consumption
CT4206-00_01	Broad Brook(East Windsor)-01	From mouth at Scantic River, US to Broad Brook Mill Pond, East Windsor, just US of Main Street (Route 191) crossing.	1.01	NOT	NOT	FULL
CT4206-00_02	Broad Brook (East Windsor-Ellington)-02	From Broad Brook Mill Pond inlet, East Windsor, US to headwaters, Ellington, just US of Shenipsit Forest Road crossing.	9.01	NOT	NOT	FULL

Shaded cells indicate impaired segment addressed in this TMDL

FULL = Designated Use Fully Supported
NOT = Designated Use Not Supported
U = Unassessed

Figure 2: GIS map featuring general information of the Broad Brook watershed at the sub-regional level (the location and name of each sampling station is indicated on each segment)



Land Use

Existing land use can affect the water quality of waterbodies within a watershed (USEPA, 2011c). Natural processes, such as soil infiltration of stormwater and plant uptake of water and nutrients, can occur in undeveloped portions of the watershed. As impervious surfaces (such as rooftops, roads, and sidewalks) increase within the watershed landscape from commercial, residential, and industrial development, the amount of stormwater runoff to waterbodies also increases. These waterbodies are negatively affected as increased pollutants from nutrients and bacteria from failing and insufficient septic systems, oil and grease from automobiles, and sediment from construction activities become entrained in this runoff. Agricultural land use activities, such as fertilizer application and manure from livestock, can also increase pollutants in nearby waterbodies (USEPA, 2011c).

As shown in Figures 3 and 4, the Broad Brook watershed consists of 40% forest, 33% agriculture, 25% urban, and 2% water. The majority of the watershed is forested, particularly in Shenipsit State Forest in Ellington. The area surrounding the impaired segments of Broad Brook is predominately a mix of agricultural and urban land uses (Figure 4).

Figure 3: Land use within the Broad Brook watershed

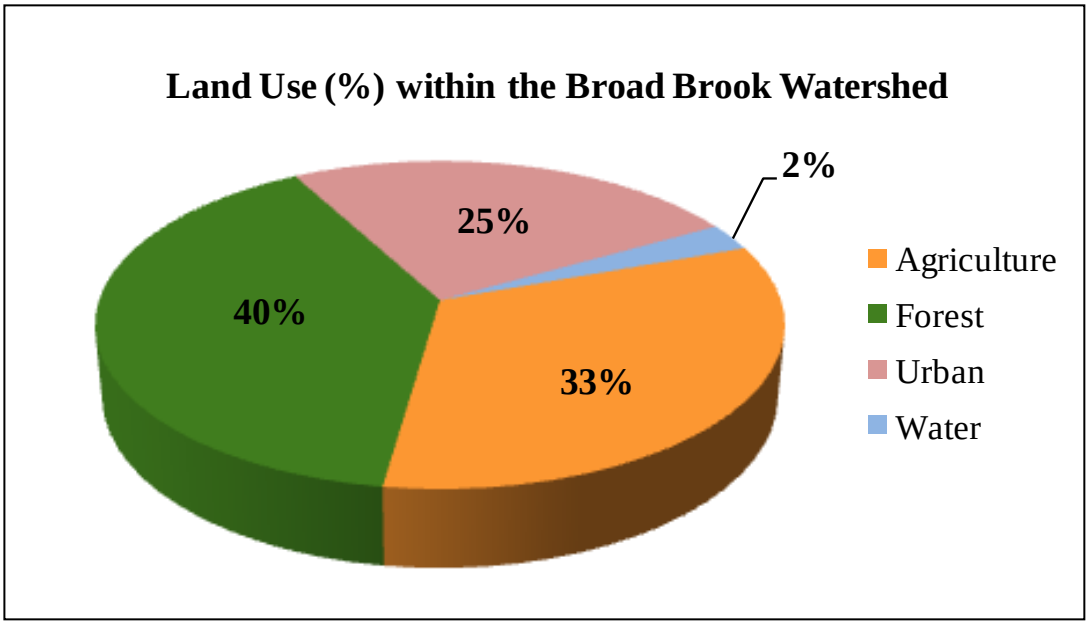
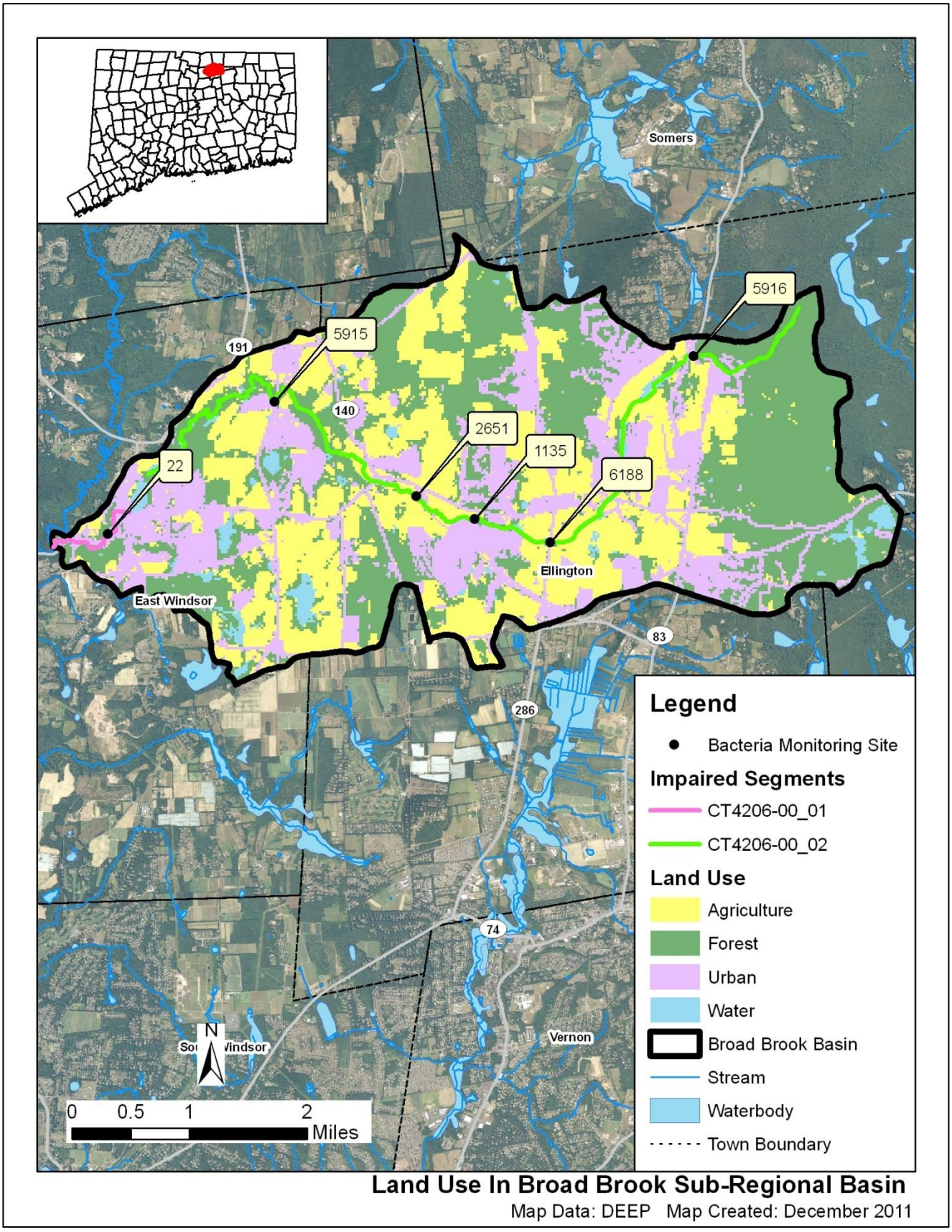


Figure 4: GIS map featuring land use for the Broad Brook watershed at the sub-regional level



WHY IS A TMDL NEEDED?

E. coli is the indicator bacteria used for comparison with the CT State criteria in the CT Water Quality Standards (WQS) (CTDEEP, 2011). All data results are from CT DEEP, USGS, Bureau of Aquaculture, or volunteer monitoring efforts at stations located on the impaired segments.

Table 2: Sampling station location description for impaired segments in the Broad Brook watershed (stations organized downstream to upstream)

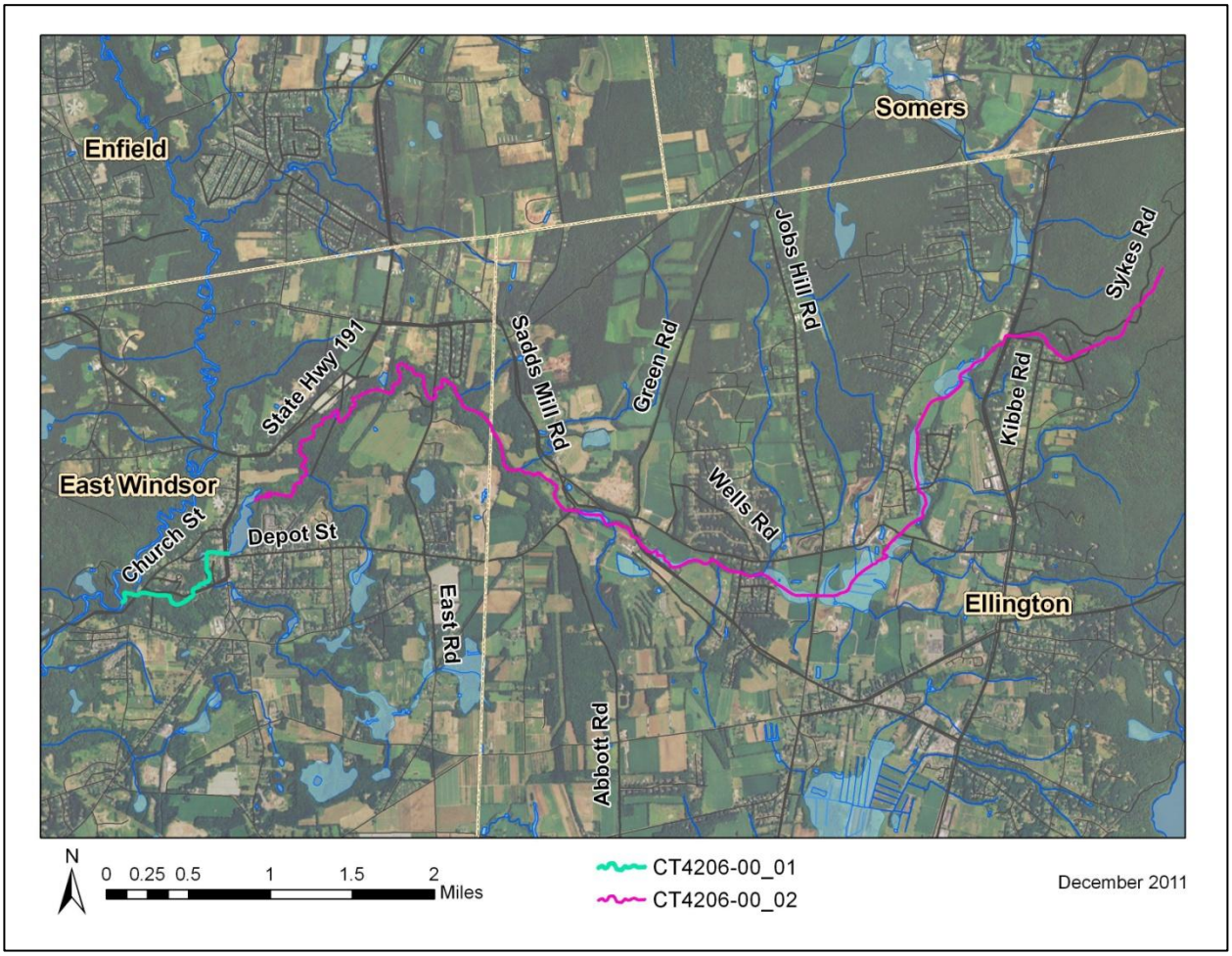
Waterbody ID	Waterbody Name	Station	Station Description	Municipality	Latitude	Longitude
CT4206-00_01	Broad Brook	22	USGS gage at Route 191	East Windsor	41.914658	-72.548967
CT4206-00_02	Broad Brook	5915	at East Road crossing	East Windsor	41.930886	-72.521363
CT4206-00_02	Broad Brook	2651	Broad Brook Road	Ellington	41.943600	-73.112900
CT4206-00_02	Broad Brook	1135	Behind town athletic fields in Brookside Park	Ellington	41.916389	-72.488333
CT4206-00_02	Broad Brook	6188	Job Hill Road Crossing	Ellington	41.913450	-72.475870
CT4206-00_02	Broad Brook	5916	at junction of Shenipsit Forest Rd and Kibbe Rd	Ellington	41.936367	-72.452082

The two impaired segments on Broad Brook (CT4206-00_01 and CT4206-00_02) are Class A freshwater rivers (Figure 5). Their applicable designated uses are potential drinking water supply, habitat for fish and other aquatic life and wildlife, recreation, and industrial and agricultural water supply. Water quality analyses were conducted using data from one sampling location on Broad Brook (Segment 1) (Station 22) and five sampling locations on Broad Brook (Segment 2) (Stations 5915, 2651, 1135, 6188, 5916) from 2009- 2010 (Table 2).

The water quality criteria for *E. coli*, along with bacteria sampling results from 2009-2010, are presented in Tables 8 and 9. For Broad Brook (Segment 1), the annual geometric mean exceeded the WQS for *E. coli* at Station 22 in 2009 and 2010. Single sample values for this station also exceeded the WQS for *E. coli* on multiple dates during the sampling period. For Broad Brook (Segment 2), the annual geometric mean value exceeded the WQS for *E. coli* during at all stations during each sample year except at Station 2651 in 2010 and Station 5916 in 2009. Single sample values for all stations exceeded the WQS for *E. coli* on multiple dates during the sampling period, with some values exceeding 24,000 colonies/100 mL.

To aid in identifying possible bacteria sources, the geometric mean was also calculated for each station for wet-weather and dry-weather sampling days, where appropriate (Tables 8 and 9). For Broad Brook (Segment 1), geometric mean values at Station 22 exceeded the WQS for *E. coli* during both wet and dry-weather. For Broad Brook (Segment 2), geometric mean values exceeded the WQS for *E. coli* during wet-weather at Stations 5915, 1135, and 5916 and during dry-weather at Stations 5915, 1135, and 6188.

Figure 5: Aerial map of Broad Brook (Segments 1 and 2)



Due to the elevated bacteria measurements presented in Tables 8 and 9, these impaired segments did not meet CT's bacteria WQS, were identified as impaired, and were placed on the CT List of Waterbodies Not Meeting Water Quality Standards, also known as the CT 303(d) Impaired Waters List. The Clean Water Act requires that all 303(d) listed waters undergo a TMDL assessment that describes the impairments and identifies the measures needed to restore water quality. The goal is for all waterbodies to comply with State WQS.

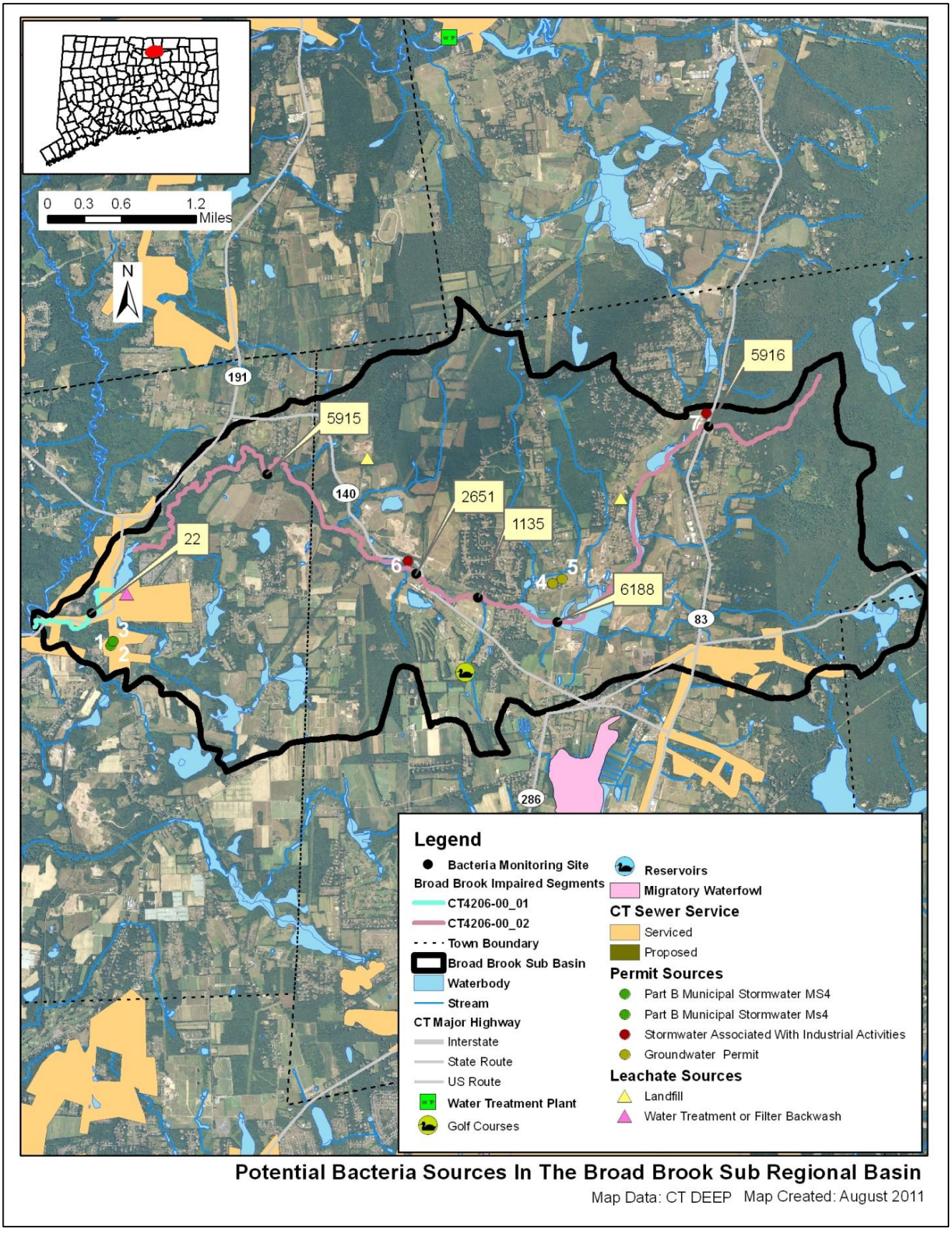
POTENTIAL BACTERIA SOURCES

Potential sources of indicator bacteria in a watershed include point and non-point sources, such as stormwater runoff, agriculture, sanitary sewer overflows (collection system failures), illicit discharges, and inappropriate discharges to the waterbody. Potential sources that have been tentatively identified in the watershed based on land use (Figures 3 and 4) and a collection of local information for the impaired waterbody is presented in Table 3 and Figure 6. However, the list of potential sources is general in nature and should not be considered comprehensive. There may be other sources not listed here that contribute to the observed water quality impairment in the study segments. Further monitoring and investigation will confirm listed sources and discover additional ones. Some segments in this watershed are currently listed as unassessed by CT DEEP procedures. This does not suggest that there are no potential issues on this segment, but indicates a lack of current data to evaluate the segment as part of the assessment process. For some segments, there are data from permitted sources, and CT DEEP recommends that any elevated concentrations found from those permitted sources be addressed through voluntary reduction measures. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement these TMDLs.

Table 3: Potential bacteria sources in the Broad Brook watershed

Impaired Segment	Permit Source	Illicit Discharge	CSO/SSO Issue	Failing Septic System	Agricultural Activity	Stormwater Runoff	Nuisance Wildlife	Other
Broad Brook CT4206-00_01	x	x		x	x	x	x	x
Broad Brook CT4206-00_02	x	x		x	x	x	x	x

Figure 6: Potential sources in the Broad Brook watershed at the sub-regional level



The potential sources map for the impaired basin was developed after thorough analysis of available data sets. If information is not displayed in the map, then no sources were discovered during the analysis. The following is the list of potential sources that were evaluated: problems with migratory waterfowl, golf course locations, reservoirs, proposed and existing sewer service, cattle farms, poultry farms, permitted sources of bacteria loading (surface water discharge, MS4 permit, industrial stormwater, commercial stormwater, groundwater permits, and construction related stormwater), and leachate and discharge sources (agricultural waste, CSOs, failing septic systems, landfills, large septic tank leach fields, septage lagoons, sewage treatment plants, and water treatment or filter backwash).

Point Sources

Permitted sources within the watershed that could potentially contribute to the bacteria loading are identified in Table 4. This table includes permit types that may or may not be present in the impaired watershed. A list of active permits in the watershed is included in Table 5. Additional investigation and monitoring could reveal the presence of additional discharges in the watershed.

Table 4: General categories list of other permitted discharges

Permit Code	Permit Description Type	Number in watershed
CT	Surface Water Discharges	0
GPL	Discharge of Swimming Pool Wastewater	0
GSC	Stormwater Discharge Associated with Commercial Activity	0
GSI	Stormwater Associated with Industrial Activity	2
GSM	Part B Municipal Stormwater MS4	2
GSN	Stormwater Registration – Construction	0
LF	Groundwater Permit (Landfill)	0
UI	Underground Injection	2

Permitted Sources

As shown in Table 5, there are multiple permitted discharges in the Broad Brook watershed. Bacteria data are currently not available for any of the permitted discharges in the watershed. Since the MS4 permits are not targeted to a specific location, but the geographic area of the regulated municipality, there is no one accurate location on the map to display the location of these permits. One dot will be displayed at the geographic center of the municipality as a reference point. Sometimes this location falls outside of the targeted watershed and therefore the MS4 permit will not be displayed in the Potential Sources Map. Using the municipal border as a guideline will show which areas of an affected watershed are covered by an MS4 permit.

Table 5: Permitted facilities within the Broad Brook watershed

Town	Client	Permit ID	Permit Type	Site Name/Address	Map #
East Windsor	Town Of East Windsor	GSM000053	Part B Municipal Stormwater MS4	East Windsor, Town Of	1
Ellington	Gpt Highmeadow, Grove Properties	UI0000045	Groundwater Permit	Septicwtr High Meadows Apts	4
Ellington	Gpt Highmeadow, Grove Properties	UI0000045	Groundwater Permit	Gpt Highmeadow	5
Ellington	Town of Ellington	GSM000059	Part B Municipal Stormwater MS4	Ellington, Town of	NA
Ellington	First Student, Inc.	GSI002213	Stormwater Associated With Industrial Activities	First Student, Inc. #20686	7
Ellington	Powder Hill Sand & Gravel, L.L.C.	GSI001454	Stormwater Associated With Industrial Activities	Powder Hill Sand & Gravel Ellington Pit	6

Municipal Stormwater Permitted Sources

Per the EPA Phase II Stormwater rule all municipal storm sewer systems (MS4s) operators located within US Census Bureau Urbanized Areas (UAs) must be covered under MS4 permits regulated by the appropriate State agency. There is an EPA waiver process that municipalities can apply for to not participate in the MS4 program. In Connecticut, EPA has granted such waivers to 19 municipalities. All participating municipalities within UAs in Connecticut are currently regulated under MS4 permits by CT DEEP staff in the MS4 program.

The US Census Bureau defines a UA as a densely settled area that has a census population of at least 50,000. A UA generally consists of a geographic core of block groups or blocks that exceeds the 50,000 people threshold and has a population density of at least 1,000 people per square mile. The UA will also include adjacent block groups and blocks with at least 500 people per square mile. A UA consists of all or part of one or more incorporated places and/or census designated places, and may include additional territory outside of any place. (67 FR 11663)

For the 2000 Census a new geographic entity was created to supplement the UA blocks of land. This created a block known as an Urban Cluster (UC) and is slightly different than the UA. The definition of a UC is a densely settled area that has a census population of 2,500 to 49,999. A UC generally consists of a geographic core of block groups or blocks that have a population density of at least 1,000 people per square mile, and adjacent block groups and blocks with at least 500 people per square mile. A UC consists of all or part of one or more incorporated places and/or census designated places; such a place(s) together with adjacent territory; or territory outside of any place. The major difference is the total population cap of 49,999 people for a UC compared to >50,000 people for a UA. (67 FR 11663)

While it is possible that CT DEEP will be expanding the reach of the MS4 program to include UC municipalities in the near future they are not currently under the permit. However, the GIS layers used to create the MS4 maps in this Statewide TMDL did include both UA and UC blocks. This factor creates some municipalities that appear to be within an MS4 program that are not currently regulated through an MS4 permit. This oversight can explain a municipality that is at least partially shaded grey in the maps and there are no active MS4 reporting materials or information included in the appropriate appendix. While these areas are not technically in the MS4 permit program, they are still considered urban by the

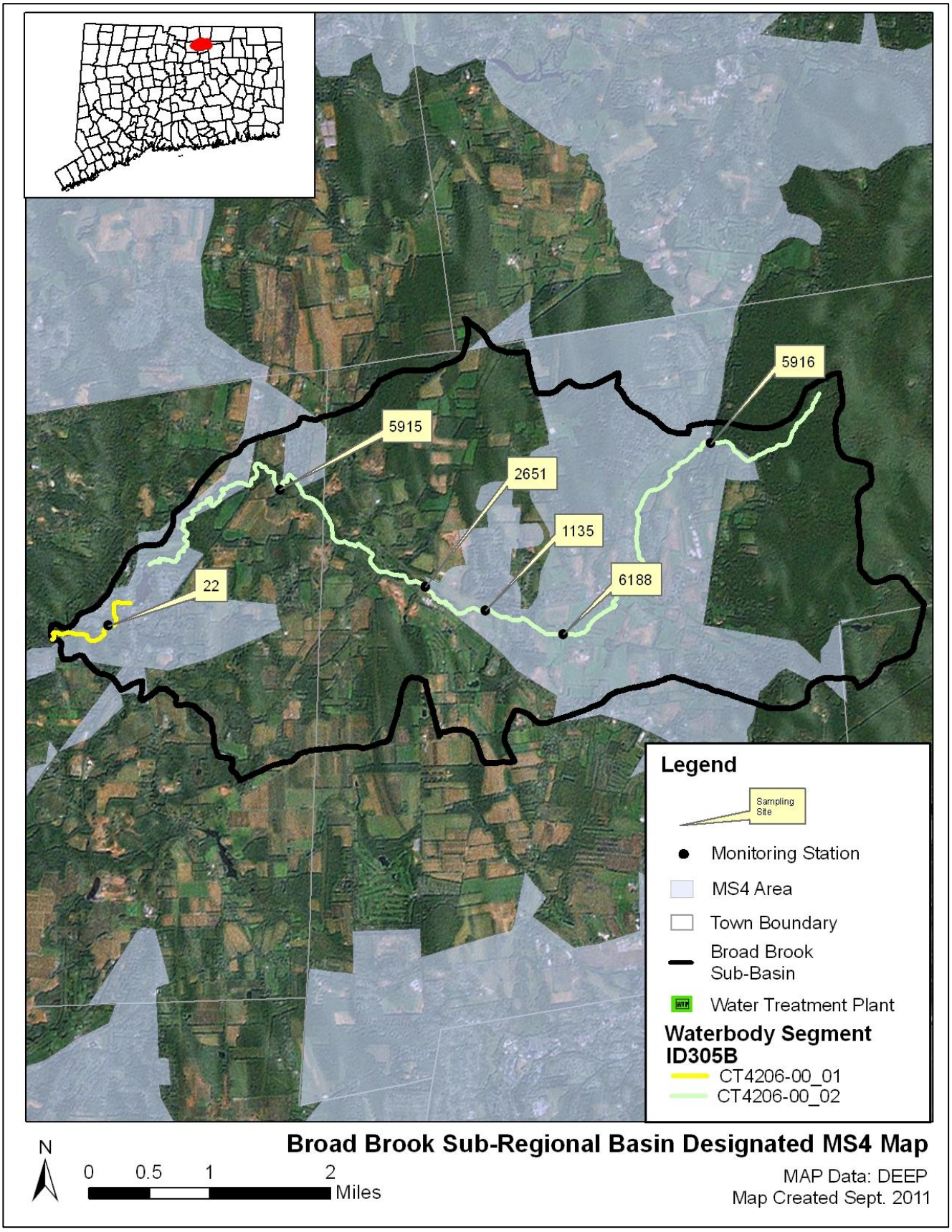
cluster definition above and are likely to contribute similar stormwater discharges to affected waterbodies covered in this TMDL.

As previously noted, EPA can grant a waiver to a municipality to preclude their inclusion in the MS4 permit program. One reason a waiver could be granted is a municipality with a total population less than 1000 people, even if the municipality was located in a UA. There are 19 municipalities in Connecticut that have received waivers, this list is: Andover, Bozrah, Canterbury, Coventry, East Hampton, Franklin, Haddam, Killingworth, Litchfield, Lyme, New Hartford, Plainfield, Preston, Salem, Sherman, Sprague, Stafford, Washington, and Woodstock. There will be no MS4 reporting documents from these towns even if they are displayed in an MS4 area in the maps of this document.

The list of US Census UCs is defined by geographic regions and is named for those regions, not necessarily by following municipal borders. In Connecticut, the list of UCs includes blocks in the following Census Bureau regions: Colchester, Danielson, Lake Pocotopaug, Plainfield, Stafford, Storrs, Torrington, Willimantic, Winsted, and the border area with Westerly, RI (67 FR 11663). Any MS4 maps showing these municipalities may show grey areas that are not currently regulated by the CT DEEP MS4 permit program.

The impaired segments of the Broad Brook watershed are located within the Towns of East Windsor and Ellington. Both municipalities have designated urban areas, as defined by the U.S. Census Bureau and are required to comply with the General Permit for the Discharge of Stormwater from Small Municipal Storm Sewer Systems (MS4 permit) issued by the Connecticut Department of Energy and Environmental Protection (DEEP) and some of the areas surrounding the impaired segments are located in these urban areas (Figure 7). This general permit is only applicable to municipalities that are identified in Appendix A of the MS4 permit that contain designated urban areas and discharge stormwater via a separate storm sewer system to surface waters of the State. The permit requires municipalities to develop a Stormwater Management Plan (SMP) to reduce the discharge of pollutants as well as to protect water quality. The MS4 permit is discussed further in the "TMDL Implementation Guidance" section of the core TMDL document. Additional information regarding stormwater management and the MS4 permit can be obtained on CT DEEP's website (http://www.ct.gov/dep/cwp/view.asp?a=2721&q=325702&depNav_GID=1654).

Figure 7: MS4 areas of the Broad Brook watershed



Non-point Sources

Non-point source pollution (NPS) comes from many diffuse sources and is more difficult to identify and control. NPS pollution is often associated with land-use practices. Examples of NPS that can contribute bacteria to surface waters include insufficient septic systems, pet and wildlife waste, agriculture, and contact recreation (swimming or wading). Potential sources of NPS within the Broad Brook watershed are described below. The Broad Brook Watershed Based Plan (2010) describes many of these sources in greater detail (http://www.ct.gov/dep/lib/dep/water/watershed_management/wm_plans/broadbrook/broad_brook_wbp.pdf).

Agricultural Activities

Agricultural operations are an important economic activity and landscape feature in many areas of the State. Runoff from agricultural fields may contain pollutants such as bacteria and nutrients (USEPA, 2011a). This runoff can include pollutants from farm practices such as storing manure, allowing livestock to wade in nearby waterbodies, applying fertilizer, and reducing the width of vegetated buffer along the shoreline. Agricultural land use makes up 33% of the Broad Brook watershed. Multiple agricultural fields and large livestock farms are located along and upstream of the impaired segments and are a likely source of bacteria to Broad Brook. The Broad Brook Watershed Based Plan (2010) identified agricultural operations, including intensive animal feeding operations, as a major source of bacteria to Broad Brook.

Wildlife and Domestic Animal Waste

Wildlife and domestic animals within the Broad Brook watershed represent another potential source of bacteria. With the construction of roads and drainage systems, these wastes may no longer be retained on the landscape, but instead may be conveyed via stormwater to the nearest surface water. These physical land alterations can exacerbate the impact of natural sources on water quality (USEPA, 2001). As the majority of the watershed is undeveloped, particularly in the upper portions of the watershed, wildlife waste is a potential source of bacteria to Broad Brook. The Broad Brook Watershed Based Plan (2010) identified wildlife in the upper reaches of Broad Brook and waterfowl in the lower reaches, particularly near Broad Brook Mill Pond, as major sources of bacterial contamination.

The Rolling Meadows Country Club is located within the Broad Brook watershed near Broad Brook (Segment 2) (Figure 6). Geese and other waterfowl are known to congregate in open areas including recreational fields, agricultural cropfields, and golf courses. In addition to creating a nuisance, large numbers of geese can also create unsanitary conditions on the grassed areas and cause water quality problems due to bacterial contamination associated with their droppings. Large populations of geese can also lead to habitat destruction as a result of overgrazing on wetland and riparian plants.

The watershed is also characterized by residential development and much of this development is located near the impaired segments. According to the Broad Brook Watershed Based Plan (2010), there are approximately 934 licensed dogs in the Broad Brook watershed. Waste from domestic animals, such as dogs, may also be contributing to bacteria concentrations in Broad Brook.

Illicit Discharges and Insufficient Septic Systems

As shown in Figure 6, the majority of the Broad Brook watershed relies on onsite wastewater treatment systems, such as septic systems. Properly managed septic systems and leach fields have the ability to effectively remove bacteria from waste. If systems are not maintained, waste will not be adequately

treated and may result in bacteria reaching nearby surface and ground water. In Connecticut, local health directors or health districts are responsible for keeping track of any reported insufficient or failing septic systems in a specific municipality. The Towns of Ellington and East Windsor do not have specific health directors and are part of the North Central Health District (http://www.ncdhd.org/).

A small portion of the watershed near the intersection of Routes 83 and 140 and west of the Broad Brook Mill Pond outlet around Broad Brook (Segment 1) relies on the municipal sanitary sewer system. Sewer system leaks and other illicit discharges can contribute bacteria to nearby surface waters and have been listed as a potential source of bacteria in the Broad Brook Watershed Based Plan (2010).

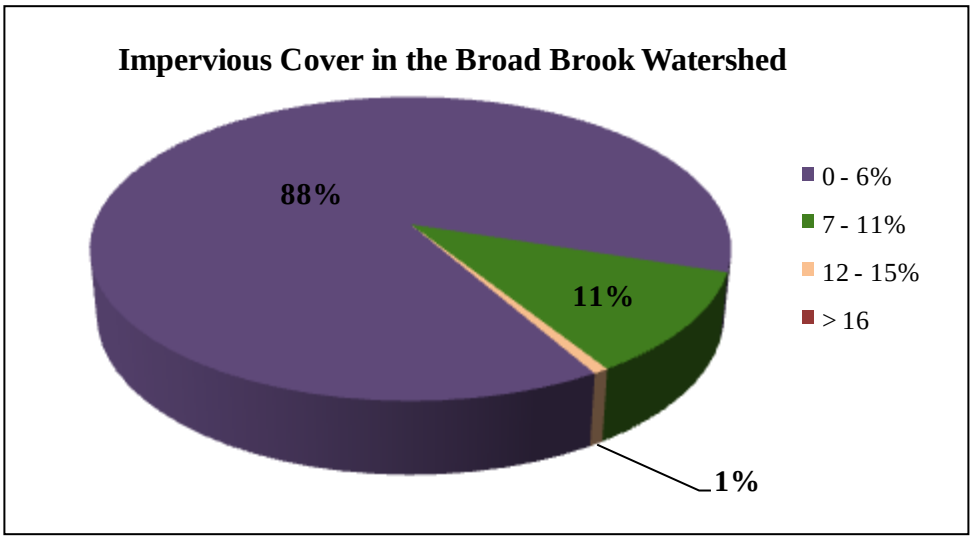
High geometric means during dry-weather may indicate the presence of insufficient septic systems or other illicit discharges. As shown in Tables 8 and 9, the geometric mean for dry weather exceeded the WQS at four stations along Broad Brook (Segment 1) (Station 22) and Broad Brook (Segment 2) (Stations 5915, 1135, and 6188). The area near Station 22 is serviced by the municipal sanitary sewer system and may be receiving bacteria from leaks in the system or other illicit discharges to the brook. As the areas around stations in Broad Brook (Segment 2) are not serviced by the municipal sanitary sewer system, bacteria from insufficient septic systems may be a source of impairment in these sections of the brook.

Stormwater Runoff from Developed Areas

Approximately 25% of the Broad Brook watershed is developed (Figure 3). Urban areas are often characterized by impervious cover, or surface areas such as roofs and roads that force water to run off land surfaces rather than infiltrate into the soil. Studies have shown a link between increasing impervious cover and degrading water quality conditions in a watershed (CWP, 2003). In one study, researchers correlated the amount of fecal coliform to the percent of impervious cover in a watershed (Mallin *et al.*, 2000).

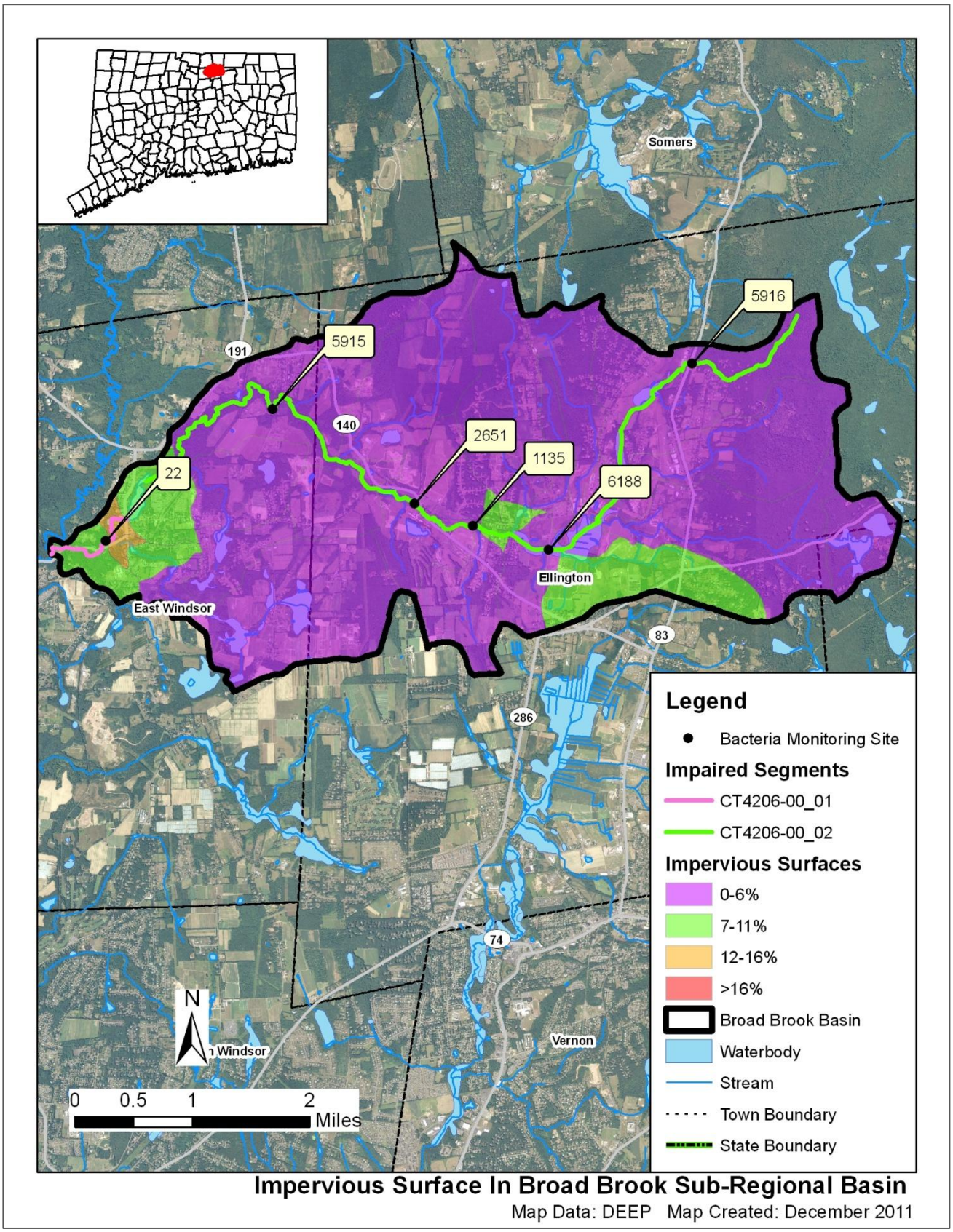
The majority of the Broad Brook watershed has less than 6% impervious surfaces (Figures 8 and 9). However, portions of the watershed near the lower portion of the watershed have a higher percentage of impervious cover (Figure 9). In particular, the area surrounding Broad Brook (Segment 1) has an impervious cover of 7-11% with some areas of 12-15%, indicating that stormwater runoff may be a source of bacteria (Figure 9).

Figure 8: Range of impervious cover (%) in the Bruce Brook watershed



High geometric means during wet-weather may indicate that stormwater runoff is contributing to the bacterial impairment in a river. As shown in Tables 8 and 9, the geometric mean for wet weather exceeded the WQS at four stations along Broad Brook (Segment 1) (Station 22) and Broad Brook (Segment 2) (Stations 5915, 1135, and 5916). The area around Station 22 is heavily developed (Figure 9), and is likely receiving bacteria from stormwater runoff. Broad Brook (Segment 2) is also likely receiving bacteria from stormwater runoff, particularly near Stations 5915, 1135, and 5916.

Figure 9: Impervious cover (%) for the Broad Brook sub-regional watershed



Additional Sources

As shown in Figure 6, the CRRA Ellington Landfill on Sadds Mill Road and a water treatment of backwash filter area near Broad Brook Mill Pond have been identified as potential sources of bacteria to Broad Brook Segments 1 and 2. There may be other sources not listed here or identified in Figure 6 that contribute to the observed water quality impairment in the Broad Brook watershed. Further monitoring and investigation will confirm the listed sources and discover additional ones. More detailed evaluation of potential sources is expected to become available as activities are conducted to implement this TMDL.

Land Use/Landscape

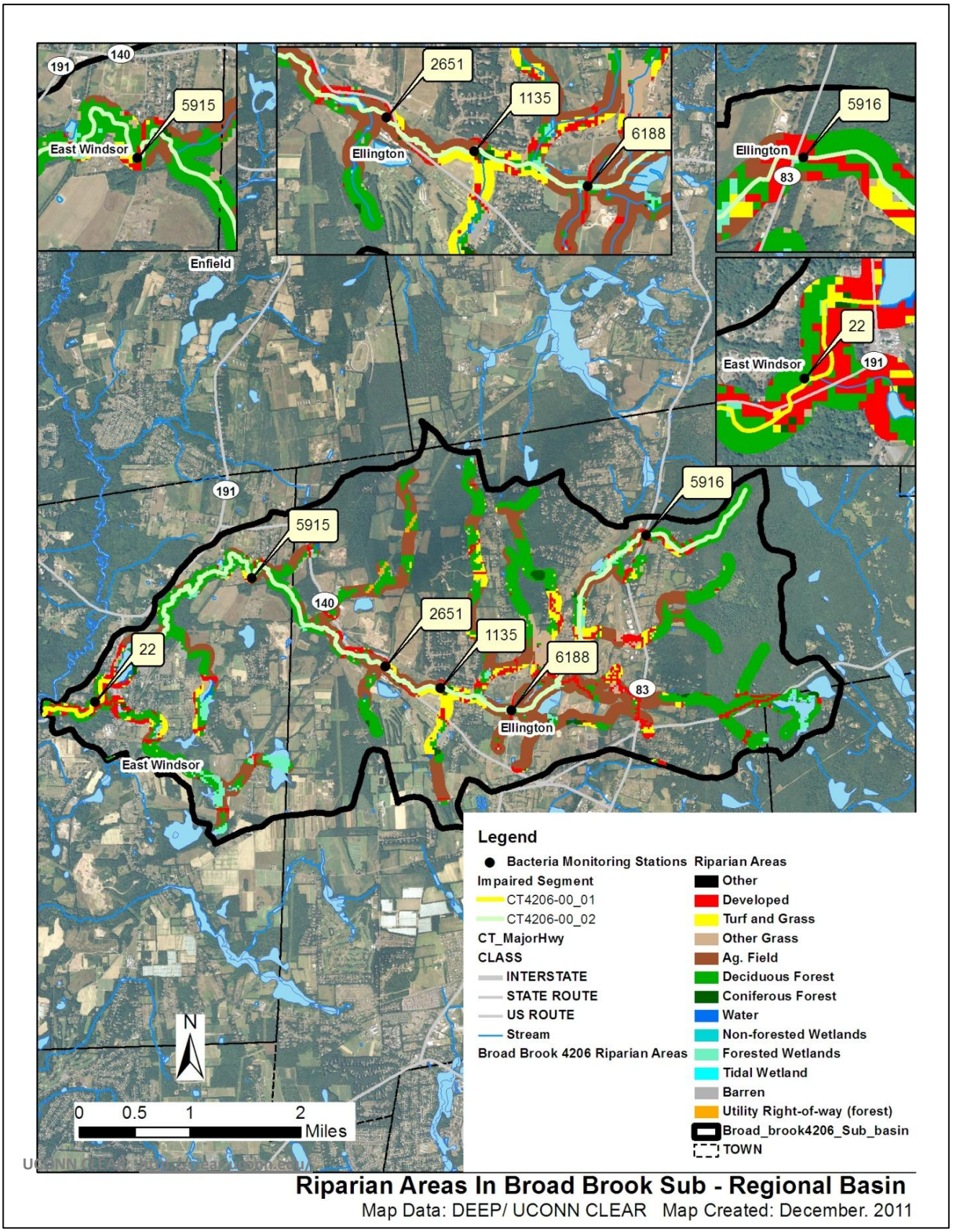
Riparian Buffer Zones

The riparian buffer zone is the area of land located immediately adjacent to streams, lakes, or other surface waters. The boundary of the riparian zone and the adjoining uplands is gradual and not always well-defined. However, riparian zones differ from uplands because of high levels of soil moisture, frequent flooding, and the unique assemblage of plant and animal communities found there. Through the interaction of their soils, hydrology, and vegetation, natural riparian areas influence water quality as contaminants are taken up into plant tissues, adsorbed onto soil particles, or modified by soil organisms. Any change to the natural riparian buffer zone can reduce the effectiveness of the natural buffer and has the potential to contribute to water quality impairment (USEPA, 2011b).

The CLEAR program at UCONN has created streamside buffer layers for the entire State of Connecticut (http://clear.uconn.edu/), which have been used in this TMDL. Analyzing this information can reveal potential sources and implementation opportunities at a localized level. The land use directly adjacent to a waterbody can have direct impacts on water quality from surface runoff sources.

The riparian zones for the impaired segments of Broad Brook are characterized by a mix of agricultural, forested, and urban areas (Figure 10). Riparian areas of Broad Brook (Segment 2) generally have more agricultural and forested areas, while the riparian areas of Broad Brook (Segment 1) are more developed. As previously noted, if not properly treated, runoff from agricultural fields may contain pollutants such as bacteria and nutrients. Developed areas within the riparian zone also contribute pollutants such as bacteria to the waterbody since the natural riparian buffer is not available to treat runoff.

Figure 10: Riparian buffer zone information for the Broad Brook watershed



CURRENT MANAGEMENT ACTIVITIES

The Towns of East Windsor and Ellington have developed and implemented programs to protect water quality from bacterial contamination. In 2010, the Broad Brook Watershed Based Plan was completed (USDA, 2010). This document outlines current actions in the watershed and recommends future actions necessary to maintain or improve water quality.

As indicated previously, portions of Ellington and East Windsor within the watershed are regulated under the MS4 program. The MS4 General Permit is required for any municipality with urbanized areas that initiates, creates, originates or maintains any discharge of stormwater from a storm sewer system to waters of the State. The MS4 permit requires towns to design a Stormwater Management Plan (SMP) to reduce the discharge of pollutants in stormwater to improve water quality. The plan must address the following 6 minimum measures:

1. Public Education and Outreach.
2. Public Involvement/Participation.
3. Illicit discharge detection and elimination.
4. Construction site stormwater runoff control.
5. Post-construction stormwater management in the new development and redevelopment.
6. Pollution prevention/good housekeeping for municipal operations.

Each municipality is also required to submit an annual update outlining the steps they are taking to meet the six minimum measures. All updates that address bacterial contamination in the watershed are summarized in Tables 6 and 7.

Table 6: Summary of MS4 requirement updates related to the reduction of bacterial contamination from East Windsor, CT (Permit # GSM000053)

Minimum Measure	East Windsor Annual Report (2010)
Public Outreach and Education	1) In the process of forming a Stormwater Management Committee to complete required tasks. 2) Stormwater management information has been added to the City website.
Public Involvement and Participation	1) Completed storm drain marking on ¼ of town storm drains (Eagle Scouts). 2) Completed annual river clean-up day (American Heritage River Committee).
Illicit Discharge Detection and Elimination	1) Currently mapping outfalls. 2) Continued annual sampling of six stormwater outfalls.
Construction Site Stormwater Runoff Control	1) Continued compliance with existing guidelines
Post Construction Stormwater Management	1) Continued compliance with existing guidelines
Pollution Prevention and Good Housekeeping	1) Completed annual catch basin cleaning. 2) Completed annual street sweeping program. 3) Purchased a new JetVac truck.

Table 7: Summary of MS4 requirement updates related to the reduction of bacterial contamination from Ellington, CT (Permit # GSM000059)

Minimum Measure	Ellington Annual Report Update (2010)
Public Outreach and Education	No updates
Public Involvement and Participation	No updates
Illicit Discharge Detection and Elimination	No updates
Construction Site Stormwater Runoff Control	1) Reviewed land use regulations to meet requirements of MS4 permit and Erosion and Sedimentation guidelines.
Post Construction Stormwater management	1) Reviewed land use regulations to meet requirements of MS4 permit and Erosion and Sedimentation guidelines. 2) Developed post-construction ordinance. 3) Developed a program to fund long-term maintenance of BMPs
Pollution Prevention and Good Housekeeping	1) All town-owned streets swept annually. 2) All town-owned catch basins inspected and cleaned as needed.

RECOMMENDED NEXT STEPS

East Windsor and Ellington have developed and implemented programs to protect water quality from bacterial contamination. Future mitigative activities are necessary to ensure the long-term protection of Broad Brook and have been prioritized below. Some of these actions are provided in more detail in the 2010 Broad Brook Watershed Based Plan (USDA, 2010).

1) Continue monitoring of permitted sources.

Further monitoring will provide information essential to better locate, understand, and reduce pollution sources. If any current monitoring is not done with appropriate bacterial indicator based on the receiving water, then a recommended change during the next permit reissuance is to include the appropriate indicator species. If facility monitoring indicates elevated bacteria, then implementation of permit required, and voluntary measures to identify and reduce sources of bacterial contamination at the facility are an additional recommendation. Regular monitoring should be established for all permitted sources to ensure compliance with permit requirements and to determine if current requirements are adequate or if additional measures are necessary for water quality protection.

Section 6(k) of the MS4 General Permit requires a municipality to modify their Stormwater Management Plan to implement the TMDL within four months of TMDL approval by EPA if stormwater within the municipality contributes pollutant(s) in excess of the allocation established by the TMDL. For discharges to impaired waterbodies, the municipality must assess and modify the six minimum measures of its plan, if necessary, to meet TMDL standards. Particular focus should be placed on the following plan components: public education, illicit discharge detection and elimination, stormwater structures cleaning, and the repair, upgrade, or retrofit of storm sewer structures. The goal of these modifications is to establish a program that improves water quality consistent with TMDL requirements. Modifications to the Stormwater Management Plan in response to TMDL development should be submitted to the Stormwater Program of DEEP for review and approval.

Table 8 details the appropriate bacteria criteria for use as waste load allocations established by this TMDL for use as water quality targets by permittees as permits are renewed and updated, within the Broad Brook watershed.

For any municipality subject to an MS4 permit and affected by a TMDL, the permit requires a modification of the SMP to include BMPs that address the included impairment. In the case of bacteria related impairments municipal BMPs could include: implementation or improvement to existing nuisance wildlife programs, septic system monitoring programs, any additional measures that can be added to the required illicit discharge detection and elimination (IDDE) programs, and increased street sweeping above basic permit requirements. Any non-MS4 municipalities can implement these same types of initiatives in effort to reduce bacteria source loading to impaired waterways.

Any facilities that discharge non-MS4 regulated stormwater should update their Pollution Prevention Plan to reflect BMPs that can reduce bacteria loading to the receiving waterway. These BMPs could include nuisance wildlife control programs and any installations that increase surface infiltration to reduce overall stormwater volumes. Facilities that are regulated under the Commercial Activities Stormwater Permit should report any updates to their SMP in their summary documentation submitted to DEEP.

Table 8. Bacteria (e.coli) TMDLs, WLAs, and LAs for Recreational Use

		Instantaneous *E. coli* (#/100mL)						Geometric Mean *E. coli* (#/100mL)	
Class	**Bacteria Source**	**WLA[6]**			**LA[6]**			**WLA[6]**	**LA[6]**
	Recreational Use	**1**	**2**	**3**	**1**	**2**	**3**	**All**	**All**
A	Non-Stormwater NPDES	0	0	0				0	
	CSOs	0	0	0				0	
	SSOs	0	0	0				0	
	Illicit sewer connection	0	0	0				0	
	Leaking sewer lines	0	0	0				0	
	Stormwater (MS4s)	235[7]	410[7]	576[7]				126[7]	
	Stormwater (non-MS4)				235[7]	410[7]	576[7]		126[7]
	Wildlife direct discharge				235[7]	410[7]	576[7]		126[7]
	Human or domestic animal direct discharge[5]				235	410	576		126

(1) **Designated Swimming.** Procedures for monitoring and closure of bathing areas by State and Local Health Authorities are specified in: Guidelines for Monitoring Bathing Waters and Closure Protocol, adopted jointly by the Department of Environmental Protections and the Department of Public Health. May 1989. Revised April 2003 and updated December 2008.

(2) **Non-Designated Swimming.** Includes areas otherwise suitable for swimming but which have not been designated by State or Local authorities as bathing areas, waters which support tubing, water skiing, or other recreational activities where full body contact is likely.

(3) **All Other Recreational Uses.**

(4) Criteria for the protection of recreational uses in Class B waters do not apply when disinfection of sewage treatment plant effluents is not required consistent with Standard 23. (Class B surface waters located north of Interstate Highway I-95 and downstream of a sewage treatment plant providing seasonal disinfection May 1 through October 1, as authorized by the Commissioner.)

(5) Human direct discharge = swimmers

(6) Unless otherwise required by statute or regulation, compliance with this TMDL will be based on ambient concentrations and not end-of-pipe bacteria concentrations

(7) Replace numeric value with "natural levels" if only source is naturally occurring wildlife. Natural is defined as the biological, chemical and physical conditions and communities that occur within the environment which are unaffected or minimally affected by human influences (CT DEEP 2011a). Sections 2.2.2 and 6.2.7 of this Core Document deal with BMPs and delineating type of wildlife inputs.

2) Ensure there are sufficient buffers on agricultural lands in the Broad Brook watershed.

The 2010 Broad Brook Watershed Based Plan made specific recommendations to reduce the impacts of agricultural runoff on water quality (USDA, 2010). The plan offered watershed-wide recommendations for agricultural operations and recommends focusing on agricultural lands classified as pasture, cultivated lands, and operations with barns, feeding areas, and manure storage areas. These lands have a greater potential for contributing bacteria to Broad Brook. Recommendations included:

- Ensure that there are sufficient waste storage facilities on all agricultural operations, particularly those located near Broad Brook;
- Install fences and/or vegetated buffers along waterways to restrict livestock and other farm animal access to streams and wetlands and filter pollutants through vegetation;
- Evaluate the timing and application rate of manure fertilizers to ensure minimal fertilizer is applied during a period of no rain;
- Ensure that all horse farms in the watershed have Comprehensive Conservation Plans; and

- Provide educational materials to agricultural operators about water quality impacts and suggested BMPs.

3) Evaluate municipal programs regarding animal waste.

The 2010 Broad Brook Watershed Based Plan made specific recommendations to reduce the impacts of animal runoff on water quality (USDA, 2010). The plan offered watershed-wide recommendations for managing wildlife and domestic animals waste in the Broad Brook watershed. Recommendations included:

- Develop dog walking areas;
- Establish pet waste collection stations; and
- Establish vegetated buffers along waterbodies to limit access of wildlife and discourage the congregation of geese on the shore (particularly Broad Brook Mill Pond and East Windsor Park on Reservoir Road).

Any education and outreach program in the watershed should highlight the importance of not feeding waterfowl and wildlife and managing waste from horses, dogs, and other pets. The towns and residents can take measures to minimize waterfowl-related impacts such as allowing tall, coarse vegetation to grow in the riparian areas of the impaired segments that are frequented by waterfowl. Waterfowl, especially grazers like geese, prefer easy access to water. Maintaining an uncut vegetated buffer along the shore will make the habitat less desirable to geese and encourage migration. In addition, any educational program should emphasize that feeding waterfowl, such as ducks, geese, and swans, may contribute to water quality impairments in the Broad Brook watershed and can harm human health and the environment.

Animal wastes should be disposed of away from any waterbody or storm drain system. BMPs effective at reducing the impact of animal waste on water quality include installing signage, providing pet waste receptacles in high-uses areas, enacting ordinances requiring the clean-up of pet waste, and targeting educational and outreach programs in problem areas.

4) Develop a system to monitor septic systems.

Most residents of the Broad Brook watershed rely on septic systems. If not already in place, all municipalities within the watershed should establish a program to ensure that existing septic systems are properly operated and maintained. For instance, communities can create an inventory of existing septic systems through mandatory inspections. Inspections help encourage proper maintenance and identify failed and sub-standard systems. Policies that govern the eventual replacement of the sub-standard systems within a reasonable timeframe could also be adopted. Municipalities can also develop programs to assist citizens with the replacement and repair of older and failing systems.

5) Implement a program to evaluate the sanitary sewer system.

A small portion of the Broad Brook watershed relies on a municipal sewer system (Figure 6), particularly residents near Broad Brook (Segment 1). East Windsor has already been conducting annual water quality sampling at six stormwater outfalls and is currently mapping all town outfalls. It is important for East Windsor and Ellington to develop and/or expand a program to evaluate its sanitary sewer system and reduce leaks and overflows. This program should include periodic inspections of the sewer line.

6) Identify areas in the Broad Brook watershed to implement Best Management Practices (BMPs) to control stormwater runoff.

As noted previously, 25% of the Broad Brook watershed is considered urban and the municipalities within the watershed are MS4 communities regulated by the MS4 program. Although most of the watershed has an impervious cover less than 6%, the impaired segments are located near developed areas. As such, stormwater runoff is likely contributing bacteria to Broad Brook.

The 2010 Broad Brook Watershed Based Plan made specific recommendations to reduce the impacts of stormwater runoff on water quality (USDA, 2010). The plan offered watershed-wide recommendations for managing stormwater runoff in the Broad Brook watershed. Recommendations included:

- Ensure that annual vacuum-assisted street sweeping occurs on all streets in the watershed (East Windsor has since purchased a new JetVac truck);
- Ensure there is regular maintenance of all catch basins throughout the watershed;
- Insert catch basin filters throughout the watershed, with focus on the area near Broad Brook Mill Pond;
- Install catch basin filters on all catch basins throughout the watershed; and
- Install detention basins or stormwater wetlands around Broad Brook Mill Pond.

To identify other specific areas that are contributing bacteria to the impaired segments, East Windsor and Ellington should continue to conduct wet-weather sampling at stormwater outfalls that discharge directly to the Broad Brook watershed. To treat stormwater runoff, East Windsor and Ellington should identify areas along the river to install BMPs designed to encourage stormwater to infiltrate into the ground before entering the waterbodies. These BMPs would disconnect impervious areas and reduce pollutant loads to the river. More detailed information and BMP recommendations can be found in the core TMDL document.

BACTERIA DATA AND PERCENT REDUCTIONS TO MEET THE TMDL

Table 9: Broad Brook (Segment 1) Bacteria Data

Waterbody ID: CT4206-00_01

Characteristics: Freshwater, Class A, Potential Public Drinking Water Supply, Habitat for Fish and other Aquatic Life and Wildlife, Recreation, and Industrial and Agricultural Water Supply

Impairment: Recreation (*E. coli bacteria)*

Water Quality Criteria for E. coli:

Geometric Mean: 126 colonies/100 mL

Single Sample: 410 colonies/100 mL

Percent Reduction to meet TMDL:

Geometric Mean: **92%**

Single Sample: **98%**

Data: 2009-2010 from CT DEEP targeted sampling efforts, 2012 TMDL Cycle

Single sample *E. coli* data (colonies/100 mL) from Station 22 on Broad Brook (Segment 1) with annual geometric means calculated

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
22	Upstream of USGS gauge at Route 191 crossing	10/22/2009	340	dry	**1630* (92%)**
22	Upstream of USGS gauge at Route 191 crossing	10/27/2009	9800	dry	
22	Upstream of USGS gauge at Route 191 crossing	10/28/2009	1300	wet	

Single sample *E. coli* data (colonies/100 mL) from Station 22 on Broad Brook (Segment 1) with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
22	Upstream of USGS gauge at Route 191 crossing	6/3/2010	11000	wet	1239
22	Upstream of USGS gauge at Route 191 crossing	6/10/2010	400	wet	
22	Upstream of USGS gauge at Route 191 crossing	6/15/2010	3500	dry	
22	Upstream of USGS gauge at Route 191 crossing	6/17/2010	310	dry	
22	Upstream of USGS gauge at Route 191 crossing	6/24/2010	2000	wet	
22	Upstream of USGS gauge at Route 191 crossing	6/29/2010	420	dry	
22	Upstream of USGS gauge at Route 191 crossing	7/8/2010	340	dry	
22	Upstream of USGS gauge at Route 191 crossing	7/15/2010	960	wet	
22	Upstream of USGS gauge at Route 191 crossing	7/22/2010	670	dry	
22	Upstream of USGS gauge at Route 191 crossing	7/29/2010	1700†	dry	
22	Upstream of USGS gauge at Route 191 crossing	8/3/2010	1200	dry	
22	Upstream of USGS gauge at Route 191 crossing	8/5/2010	1900	wet	
22	Upstream of USGS gauge at Route 191 crossing	8/12/2010	1100	dry	
22	Upstream of USGS gauge at Route 191 crossing	8/19/2010	1400	dry	
22	Upstream of USGS gauge at Route 191 crossing	8/26/2010	1100	dry	
22	Upstream of USGS gauge at Route 191 crossing	9/2/2010	2000	dry	
22	Upstream of USGS gauge at Route 191 crossing	9/9/2010	560	dry	
22	Upstream of USGS gauge at Route 191 crossing	9/15/2010	1300	dry	
22	Upstream of USGS gauge at Route 191 crossing	9/20/2010	860	dry	
22	Upstream of USGS gauge at Route 191 crossing	9/23/2010	740	dry	
22	Upstream of USGS gauge at Route 191 crossing	9/30/2010	**17000* (98%)**	wet	

Shaded cells indicate an exceedance of water quality criteria

†**Average of two duplicate samples**

***Indicates single sample and geometric mean values used to calculate the percent reduction**

Wet and dry weather *E. coli* geometric mean (colonies/100 mL) values for Station 22 on Broad Brook (Segment 1)

Station Name	Station Location	Years Sampled	Number of Samples		Geometric Mean		
			Wet	Dry	All	Wet	Dry
22	Upstream of USGS gauge at Route 191 crossing	2009-2010	7	18	1296	2314	1035

Shaded cells indicate an exceedance of water quality criteria

Weather condition determined from rain gage at the Hartford Bradley International Airport

Table 10: Broad Brook (Segment 2) Bacteria Data

Waterbody ID: CT4206-00_02

Characteristics: Freshwater, Class A, Potential Public Drinking Water Supply, Habitat for Fish and other Aquatic Life and Wildlife, Recreation, Navigation, and Industrial and Agricultural Water Supply

Impairment: Recreation (*E. coli bacteria)*

Water Quality Criteria for E. coli:

Geometric Mean: 126 colonies/100 mL

Single Sample: 410 colonies/100 mL

Percent Reduction to meet TMDL:

Geometric Mean: **89%**

Single Sample: **98%**

Data: 2009 – 2010 from CT DEEP targeted sampling efforts, 2012 TMDL Cycle

Single sample *E. coli* data (colonies/100 mL) from all monitoring stations on Broad Brook (Segment 2) with annual geometric means calculated

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
5915	Downstream at East Road crossing	10/22/2009	52	dry	231
5915	Downstream at East Road crossing	10/27/2009	550	dry	
5915	Downstream at East Road crossing	10/28/2009	430	wet	

Single sample *E. coli* data (colonies/100 mL) from all monitoring stations on Broad Brook (Segment 2) with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/Dry	Geomean
5915	Downstream at East Road crossing	6/3/2010	2600	wet	388
5915	Downstream at East Road crossing	6/10/2010	840	wet	
5915	Downstream at East Road crossing	6/15/2010	1500	dry	
5915	Downstream at East Road crossing	6/17/2010	540	dry	
5915	Downstream at East Road crossing	6/24/2010	930	wet	
5915	Downstream at East Road crossing	6/29/2010	320	dry	
5915	Downstream at East Road crossing	7/8/2010	340†	dry	
5915	Downstream at East Road crossing	7/15/2010	540	wet	
5915	Downstream at East Road crossing	7/22/2010	170	dry	
5915	Downstream at East Road crossing	7/29/2010	350	dry	
5915	Downstream at East Road crossing	8/3/2010	200	dry	
5915	Downstream at East Road crossing	8/5/2010	440	wet	
5915	Downstream at East Road crossing	8/12/2010	86	dry	
5915	Downstream at East Road crossing	8/19/2010	130†	dry	
5915	Downstream at East Road crossing	8/26/2010	132†	dry	
5915	Downstream at East Road crossing	9/2/2010	110	dry	
5915	Downstream at East Road crossing	9/9/2010	110	dry	
5915	Downstream at East Road crossing	9/15/2010	270	dry	
5915	Downstream at East Road crossing	9/20/2010	230	dry	
5915	Downstream at East Road crossing	9/23/2010	170	dry	
5915	Downstream at East Road crossing	9/30/2010	**24001* (98%)**	wet	
2651	Broad Brook Road crossing	9/15/2010	52	dry	67
2651	Broad Brook Road crossing	9/20/2010	86	dry	
1135	Behind town athletic fields in Brookside Park	10/22/2009	52	dry	**1144* (89%)**
1135	Behind town athletic fields in Brookside Park	10/27/2009	1200	dry	
1135	Behind town athletic fields in Brookside Park	10/28/2009	24000	wet	

Single sample *E. coli* data (colonies/100 mL) from all monitoring stations on the Broad Brook (Segment 2) with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/ Dry	Geomean
1135	Behind town athletic fields in Brookside Park	6/3/2010	4100	wet	853
1135	Behind town athletic fields in Brookside Park	6/10/2010	1500	wet	
1135	Behind town athletic fields in Brookside Park	6/15/2010	2900	dry	
1135	Behind town athletic fields in Brookside Park	6/17/2010	3300	dry	
1135	Behind town athletic fields in Brookside Park	6/24/2010	1800	wet	
1135	Behind town athletic fields in Brookside Park	6/29/2010	580	dry	
1135	Behind town athletic fields in Brookside Park	7/8/2010	400	dry	
1135	Behind town athletic fields in Brookside Park	7/15/2010	1100	wet	
1135	Behind town athletic fields in Brookside Park	7/22/2010	420	dry	
1135	Behind town athletic fields in Brookside Park	7/29/2010	740	dry	
1135	Behind town athletic fields in Brookside Park	8/3/2010	350	dry	
1135	Behind town athletic fields in Brookside Park	8/5/2010	1400	wet	
1135	Behind town athletic fields in Brookside Park	8/12/2010	335†	dry	
1135	Behind town athletic fields in Brookside Park	8/19/2010	350	dry	
1135	Behind town athletic fields in Brookside Park	8/26/2010	360†	dry	
1135	Behind town athletic fields in Brookside Park	9/2/2010	770	dry	
1135	Behind town athletic fields in Brookside Park	9/9/2010	400	dry	
1135	Behind town athletic fields in Brookside Park	9/15/2010	460	dry	
1135	Behind town athletic fields in Brookside Park	9/20/2010	300	dry	
1135	Behind town athletic fields in Brookside Park	9/23/2010	200	dry	
1135	Behind town athletic fields in Brookside Park	9/30/2010	**24001* (98%)**	wet	
6188	Job Hill Road crossing	9/2/2010	520	dry	748
6188	Job Hill Road crossing	9/9/2010	1100	dry	
6188	Job Hill Road crossing	9/15/2010	1300	dry	
6188	Job Hill Road crossing	9/20/2010	420	dry	
5916	Upstream of Snipsic Forest Road and Kibbe Road junction	10/22/2009	10	dry	42
5916	Upstream of Snipsic Forest Road and Kibbe Road junction	10/27/2009	41	dry	
5916	Upstream of Snipsic Forest Road and Kibbe Road junction	10/28/2009	180	wet	

Single sample data from all monitoring stations on the Broad Brook (Segment 2) with annual geometric means calculated (continued)

Station Name	Station Location	Date	Results	Wet/ Dry	Geomean
5916	Upstream of Snipsic Forest Road and Kibbe Road	6/3/2010	52	wet	179
5916	Upstream of Snipsic Forest Road and Kibbe Road	6/10/2010	62	wet	
5916	Upstream of Snipsic Forest Road and Kibbe Road	6/15/2010	63	dry	
5916	Upstream of Snipsic Forest Road and Kibbe Road	6/17/2010	31	dry	
5916	Upstream of Snipsic Forest Road and Kibbe Road	6/24/2010	150	wet	
5916	Upstream of Snipsic Forest Road and Kibbe Road	6/29/2010	20	dry	
5916	Upstream of Snipsic Forest Road and Kibbe Road	7/15/2010	260	wet	
5916	Upstream of Snipsic Forest Road and Kibbe Road	7/29/2010	550	dry	
5916	Upstream of Snipsic Forest Road and Kibbe Road	8/5/2010	1400	wet	
5916	Upstream of Snipsic Forest Road and Kibbe Road	9/9/2010	135†	dry	
5916	Upstream of Snipsic Forest Road and Kibbe Road	9/15/2010	300	dry	
5916	Upstream of Snipsic Forest Road and Kibbe Road	9/23/2010	52	dry	
5916	Upstream of Snipsic Forest Road and Kibbe Road	9/30/2010	**24001* (98%)**	wet	

Shaded cells indicate an exceedance of water quality criteria

†Average of two duplicate samples

***Indicates single sample and geometric mean values used to calculate the percent reduction**

Wet and dry weather *E. coli* (colonies/100 mL) geometric mean values for all monitoring stations on Broad Brook (Segment 2)

Station Name	Station Location	Years Sampled	Number of Samples		Geometric Mean		
			Wet	Dry	All	Wet	Dry
5915	Downstream at East Road crossing	2009-2010	7	20	332	1258	209
2651	Broad Brook Road crossing	2010	0	2	67	NA	67
1135	Behind town athletic fields in Brookside Park	2009-2010	7	19	823	3718	472
6188	Job Hill Road crossing	2010	0	4	748	NA	748
5916	Upstream of Snipsic Forest Road and Kibbe Road junction	2009-2010	7	10	136	358	69

Shaded cells indicate an exceedance of water quality criteria

Weather condition determined from rain gage at the Hartford Bradley International Airport

REFERENCES

Costa, Joe (2011). Calculating Geometric Means. Buzzards Bay National Estuary Program. **Online**: http://www.buzzardsbay.org/geomean.htm

CTDEEP (2010). State of Connecticut Integrated Water Quality Report. **Online:** http://www.ct.gov/dep/lib/dep/water/water_quality_management/305b/ctiwqr10final.pdf

CTDEEP (2011). State of Connecticut Water Quality Standards. **Online:** http://www.ct.gov/dep/lib/dep/water/water_quality_standards/wqs_final_adopted_2_25_11.pdf

CWP (2003). Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection. **Online**: http://clear.uconn.edu/projects/tmdl/library/papers/Schueler_2003.pdf

Federal Register 67 (March 15, 2002) 11663-11670. Urban Area Criteria for Census 2000.

Mallin, M.A., K.E. Williams, E.C. Escham, R.P. Lowe (2000). Effect of Human Development on Bacteriological Water Quality in Coastal Wetlands. Ecological Applications 10: 1047-1056.

USDA and NRCS (2010). Broad Brook Watershed Report. **Online:** http://www.ct.gov/dep/lib/dep/water/watershed_management/wm_plans/broadbrook/broad_brook_wbp.pdf

USEPA (2001). Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water. **Online**: http://www.epa.gov/safewater/sourcewater/pubs/fs_swpp_petwaste.pdf.

USEPA (2011a). Managing Nonpoint Source Pollution from Agriculture. **Online:** http://water.epa.gov/polwaste/nps/outreach/point6.cfm

USEPA (2011b). Riparian Zone and Stream Restoration. **Online:** http://epa.gov/ada/eco/riparian.html

USEPA (2011c). Land Use Impacts on Water. **Online:** http://epa.gov/greenkit/toolwq.htm