Lower Chicopee River Watershed Stormwater Assessment Project

Final Report
2014-02/604

June 30, 2017

Prepared By Pioneer Valley Planning Commission
Chicopee 4Rivers Watershed Council

For Massachusetts Department of Environmental Protection Bureau of Water Resources
and
U.S. Environmental Protection Agency, Region 1

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2015 through 2017

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Executive Summary

The Chicopee River begins at the confluence of the Ware and Quaboag Rivers and flows for 18 miles to join the Connecticut River. Like other "working" rivers that served the industrial age, the Chicopee River has been plagued by water quality problems. At its lowest point in history, it had 7 dams and received combined storm and sanitary flows from at least 43 outfalls.

While there have been vast improvements in water quality, the Chicopee River is still impaired along much of its lower reach for E coli (5.8 miles) and Fecal coliform (9.1 miles), according to the *2014 List of Integrated Waters*. Two of its tributaries—Poor Brook and Fuller Brook—are also impaired for E coli. Mass DEP has noted in past reports that the impairment is due in some locations to combined sewer flows, but also indicates that suspected sources include illicit connections and unspecified urban stormwater. On Abbey Brook, another tributary in this section, the recorded impairment is tied to Total Suspended Solids, but results from this study point to *E. coli* issues as well.

To abate combined sewer flows, communities along the river (Palmer, Ludlow, Chicopee, and Springfield) have invested millions of dollars and have together eliminated 31 combined sewer outfalls and nearly 140 million gallons of polluted flows annually. Palmer and Ludlow have eliminated all of their combined flow, while Chicopee and Springfield continue to work toward this goal.

The successes of reduced combined sewer flow merit continued documentation. But at the same time, it is important to understand the degree to which illicit connections and urban stormwater flow along the Chicopee River and its tributaries are contributing to the impairment.

The work of this Section 604b funded grant project yielded information to indicate that urban storm flows are contributing to this impairment. Key results from this grant show the following from dry and wet weather water quality sampling, source tracking, and preliminary stormwater BMP design recommendations:

<u>Water quality sampling: dry versus wet events (May – June 2016)</u>
Water quality results for the sampling during “dry” weather showed few problems relative to *E. coli*. The two exceptions were:

1. At the Main Street/Indian Orchard outfall (C04) where it became apparent that sewage was entering the storm line (subsequently reported and corrected by the City of Springfield and Springfield Water & Sewer Commission); and

2. The “dry” event on 6/7/16, which did not qualify as “wet” based on the study parameters (>0.1” within the previous 24 hours), but which was preceded by heavy rain 32 hours prior to sampling and yielded results that could be compared to what was seen for “wet” events in this study. As such, this event has been interpreted as a “wet” rather than “dry” event for purposes of results and analysis.

Despite some input of *E. coli* from the problem outfall at the Main Street/Indian Orchard outfall (C04) during the truly "dry" events on 5/10/16 and on 5/17/16, the mainstem instream location at the bottom of the system just upstream of Davitt Bridge (C09) did not show significant increased concentration of *E. coli* when compared to the instream location at the top of the system at the North Wilbraham Bridge(C01).

The "wet" weather event on 5/24/16 yielded results that seem to be most indicative of the impact of polluted urban storm flows from a "first flush." Volunteers collected samples just after a .23" storm event. Of the 17 sites sampled that morning, 13 showed elevated *E. coli* levels. Results at four of these locations were indicative of sewage, based on corresponding high results for ammonia and surfactants (CO4, PO2, PO3, and PO4). These sites were reported and addressed by the City of Springfield and Springfield Water & Sewer Commission. The other sites all had *E. coli* values indicating waters unsuitable for recreation - no boating or swimming (≥576 colonies/100 ml on a single sample).

The other "wet" weather events on 5/31/16, 6/7/16, 6/7/16, and 6/29/16 were caught some time after the storm and flows did not yield the dramatic results seen on 5/24/16. It did become apparent, however, that several sites were showing repeated levels of *E. coli* during storm flows that are concerning for recreational use of the river.

- The outfall of Abbey Brook at the Chicopee River (A01) showed elevated levels of *E. coli* bacteria during all four sampling events.
- In stream locations on Fuller Brook showed repeated problems with elevated *E. coli* during the wet sampling events, with the middle of the system site (F02) showing high hits during three sampling events and the upper (F01) and lower (F03) sites on the system showing high hits during two sampling events.
- The outfall at Grochmal Street (CO7) showed elevated bacteria on two occasions.
- The two instream sampling locations on lower Poor Brook (P03 and P04) showed elevated bacteria (unrelated to sewage) on one occasion, but had also indicated a problem related to sewage during the first wet event.

<u>Water quality sampling: source tracking (August – November 2016)</u>
Source tracking occurred on the four tributaries identified through wet weather sampling described above. Based on source tracking, Abbey Brook and Fuller Brook rose to the top as highest priority based on persistent elevated *E. coli* levels.

On Abbey Brook, PVPC conducted three rounds of source tracking during qualifying wet weather events. Results suggest that runoff carrying fecal matter from geese that congregate on lawns surrounding the Bemis Pond area is a problem. Another contributing factor could be beaver activity in the stretch of wetlands above Bemis Pond, where there is a large beaver dam that stretches from one bank of Abbey Brook to the other.

On Fuller Brook, C4RWC conducted three rounds of source tracking during qualifying wet weather events. Results suggest that the flow coming from the Moody Street area could be a cause of elevated bacteria levels in Fuller Brook. The size and complexity of this collection system make it a challenge to pinpoint a distinct source, so it could be an accumulation from

the whole system. It is unclear if a more probing study could pinpoint a distinct source. The Harris Pond spillway had one high hit, but it would likely need more study to better define if this area is an area needing BMPs as well.

Stormwater BMP recommendations (May 2017)

At Szot Park, engineering consultants for the project, Amec Foster Wheeler, in consultation with municipal officials, recommend addressing non-point source pollution primarily through source control (*i.e.*, discouraging of geese by transforming the landscape to be less attractive to waterfowl), and secondarily through structural BMPs (sediment forebay and bioretention swales). The serpentine nature of a bioswale allows potentially-impacted stormwater sheet flow from a large area to be captured, treated, filtered, and/or infiltrated prior to reaching the surface waters of the ponds. The sediment forebay will promote sediment removal prior to road runoff reaching the bioswale(s) and the ponds. Note that bioretention areas, sand filters, and tree boxes were not proposed at this location because drainage patterns do not flow to a central area, other than Upper and Lower Bemis Pond. Structural BMPs are not proposed within the ponds.

For the Moody/West/Holyoke Street drainage area to Fuller Brook, there is very little publically owned space aside from the roadway right of ways and a 10, 890-square-foot lot at the intersection of West and Holyoke streets. As such, the consulting engineers devised several stormwater BMPs, tied to catch basins with varying pretreatment and infiltration schemes depending on available right of way space. They also designed an infiltrating cul de sac for Helena Circle that can serve as a model for other cul de sacs throughout Town. For the vacant parcel at the corner of West and Holyoke streets, they recommend installation of two BMPs, one of which would route drainage from the intersection via a curb cut to a sediment forebay and swale system, and the other which would capture flow from West Street and route it through a sediment removal structure and then a chambered infiltration system.

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Introduction

Study area

The Chicopee River begins at the confluence of the Ware/Swift and Quaboag rivers and flows for 18 miles to join the Connecticut River. The Chicopee River is impaired along much of its length for E coli (5.8 miles) and Fecal coliform (9.1 miles), according to the *2014 List of Integrated Waters*. Two of its tributaries—Poor Brook (MA36-39) and Fuller Brook (MA36-41)—are also impaired for E coli. Mass DEP noted in past reports that the impairment is due in some locations to combined sewer flows, but also indicates that suspected sources include illicit connections and unspecified urban stormwater. On Abbey Brook, another tributary in this section of the Chicopee River, the recorded impairment is tied to Total Suspended Solids, but results from this study point to *E. coli* issues as well.

This 604b grant study focused on the lower Chicopee River, and its tributaries from the North Wilbraham Bridge in Ludlow to the Davitt Bridge in Chicopee, where impacts are greatest, but where there are dedicated efforts to reconnect with the River. Public regard and access to the river have been on the rise. In Ludlow, the Riverwalk is now fully completed in the Ludlow Mills section with benches, lights, and interpretive signage. Dog waste bag dispensers and trash receptacles have also been installed to prevent contaminated flow to the Chicopee River. The next phase of the Riverwalk, currently going into design, will connect Ludlow to Wilbraham.

The recently opened Riverwalk in the Ludlow Mills section leads people for a walk along the shore

of the Chicopee River and past remnants of industrial age infrastructure.

In Springfield, residents in the Indian Orchard section participated in an Urban Design Studio project led by UMass graduate students and the City's Department of Planning and Economic Development to re-envision their neighborhood. The resulting planning document from these workshops highlights the potential for local connections to the mill buildings along the Chicopee River, to recreation opportunities along the undeveloped portions of the river itself and the Ludlow Bridge "gateway" into the neighborhood. This plan with recommendations titled "Along the Chicopee River from the Mills to the Ludlow Bridge – Creating a Vision for Indian Orchard in Springfield, MA" can be reviewed at the Office of Planning and Economic Development.

In addition to the recently completed segment of the Riverwalk, the City of Chicopee is now in the early stages of planning a formal river access along the Chicopee River to provide paddlers an opportunity for recreation. C4RWC plans to partner with the City to help bring this effort to fruition. C4RWC is also working to establish a paddling trail on the Chicopee River from Red Bridge to Ludlow/Indian Orchard, with a guide map for the Indian Orchard area.

The watershed for the lower Chicopee River receives flow from at least 12 tributaries, draining large urban areas with extensive impervious cover. While there have been some important strides toward abating combined sewer flows to the river, the work to understand and address contaminated stormwater runoff has been much more limited. This project provides some critical first steps in the right direction.

Project goals and strategies

Through this 604b funded project, the Pioneer Valley Planning Commission and Chicopee 4Rivers Watershed Council had three primary objectives:

1. Identify to what degree urban stormwater is contributing to the bacteria impairments on the Chicopee River and its tributaries;

2. Locate sources of bacteria contamination within sub-watershed areas; and

3. Recommend appropriate action to initiate remediation (including preliminary structural BMP design where appropriate)

At the same time, the project also sought to:

- Contribute to ongoing and future assessments of whether bacterial contamination impairs the river's ability to support primary (and in some cases secondary) contact recreation
- Engage watershed residents, municipal officials, and other interested stakeholders in advancing improved water quality in the Chicopee River, Poor Brook, Abbey Brook, and Fuller Brook

These objectives have been consistent with recommendations for the Chicopee River in Mass DEP's *Nonpoint Source Action Strategy: Chicopee River Basin*, and in the Executive Office of Energy and Environmental Affairs' *Chicopee River 5-Year Watershed Action Plan*. The objectives also provide an important complement to the ongoing work to eliminate combined sewer overflows.

To meet these objectives, the project had six strategies:

1. Select water quality monitoring locations
2. Conduct 3 dry/3wet rounds of water quality sampling
3. Analyze water quality results to determine which drainage areas contribute higher bacteria levels than others
4. Map, investigate, and source track with sampling in subwatershed areas to identify possible sources of bacteria (non human derived)
5. Develop preliminary stormwater BMP designs and cost estimates for nonpoint source control at priority locations
6. Share results and promote better practices with local stakeholders

Project partners

For this project, the Pioneer Valley Planning Commission (PVPC) partnered with the municipalities of Chicopee, Ludlow, and Springfield, and the Connecticut River Watershed Council (now called the Connecticut River Conservancy), which served as an umbrella for partnering with the Chicopee 4Rivers Watershed Council. The project received matching funds from each of the municipalities in the form of in-kind staff time, and through the 16 local citizens who generously volunteered their time to help with water quality sampling from May to November 2016.

PVPC worked with the coordinator of C4RWC to organize and engage volunteers in the water quality investigation and other project activities toward rebuilding and revitalizing a watershed organization for the Chicopee River. The Connecticut River Conservancy's lab in Greenfield ran the analysis of E coli samples, using the U.S. EPA approved Colilert method.

Final products

There are six final products for this project. All are included within the pages of this report or the Appendixes.

A. Working maps showing existing storm and combined sewer infrastructure and sampling locations
B. MassDEP and EPA approved Quality Assurance Project Plan for water quality monitoring, including regular water quality monitoring locations with GPS coordinates
C. Water quality sampling results from 3 dry / 3 wet weather events
D. Source tracking water quality sampling results
E. Report on preliminary design and costs for stormwater BMP facilities at priority locations
F. Materials from public education and outreach

Project Approach

Study design

The water quality sampling work of this project sought to do the following:

- Produce data of known and documented quality, in support of state monitoring programs, and municipal infrastructure improvements as appropriate
- Determine where urbanized storm flow may be contributing to the *E. coli* impairment in the Chicopee River, and
- Locate sources of bacterial contamination within subwatershed areas and rank based on these contaminated flows.

As such the critical design elements of the study were: site selection, sampling during 3 dry and 3 wet weather events, and subwatershed investigations, including source tracking.

Site selection

The 17 sampling locations were identified based on mapping, site reconnaissance, and conversations with municipal officials, and key watershed stakeholders. Mapping included reviewing layers showing impervious areas and current stormwater and combined sewer outfalls. Conversations involved key municipal officials from Chicopee, Ludlow, and Springfield, and MassDEP staff. MassDEP sampling data for the Chicopee River and tributaries and site reconnaissance to evaluate access further informed site selection. It became clear that the terrain of the lower Chicopee River is tricky in many locations, with very steep slopes and dense vegetative growth, so accessibility became another major factor in site selection. In accordance with the study design, effort was made to ensure that selected sampling locations do not coincide with current CSO locations.

Final selection included 9 sampling locations along the Chicopee River mainstem and 8 sites along the major tributaries located in this lower reach of the river (Fuller, Poor, and Abbey brooks). Note that because the recorded impairment on Abbey Brook is tied to Total Suspended Solids and not *E. coli*, there was only one regular sampling site on Abbey Brook (where it flows into the Chicopee River).

On the tributaries, sites were selected based on three factors:

- distribution along the system, i.e., upper and middle reaches, proximity to developments and stormlines or near confluence with the mainstem;
- accessibility; and/or
- former MassDEP sampling location where there is E.coli data from either 2003, 2008 or both

On the mainstem of the Chicopee River, sites were selected based on their association with stormwater outfalls that drain large impervious areas. In some cases, stormwater outfalls are former CSO outfalls. There were also two instream locations on the mainstem: one at the top of the impaired segment at the North Wilbraham Bridge (CO1), and another near the bottom of the impaired section at the Davitt Bridge (CO9). These two in-stream locations on the

mainstem served as points of reference for each sampling event, providing understanding of overall water quality in the river as it enters and exits the study area.

Table 1 below identifies each site, the rationale for site selection, and previous data available associated with the location if available. Map 1 below shows the sampling locations.

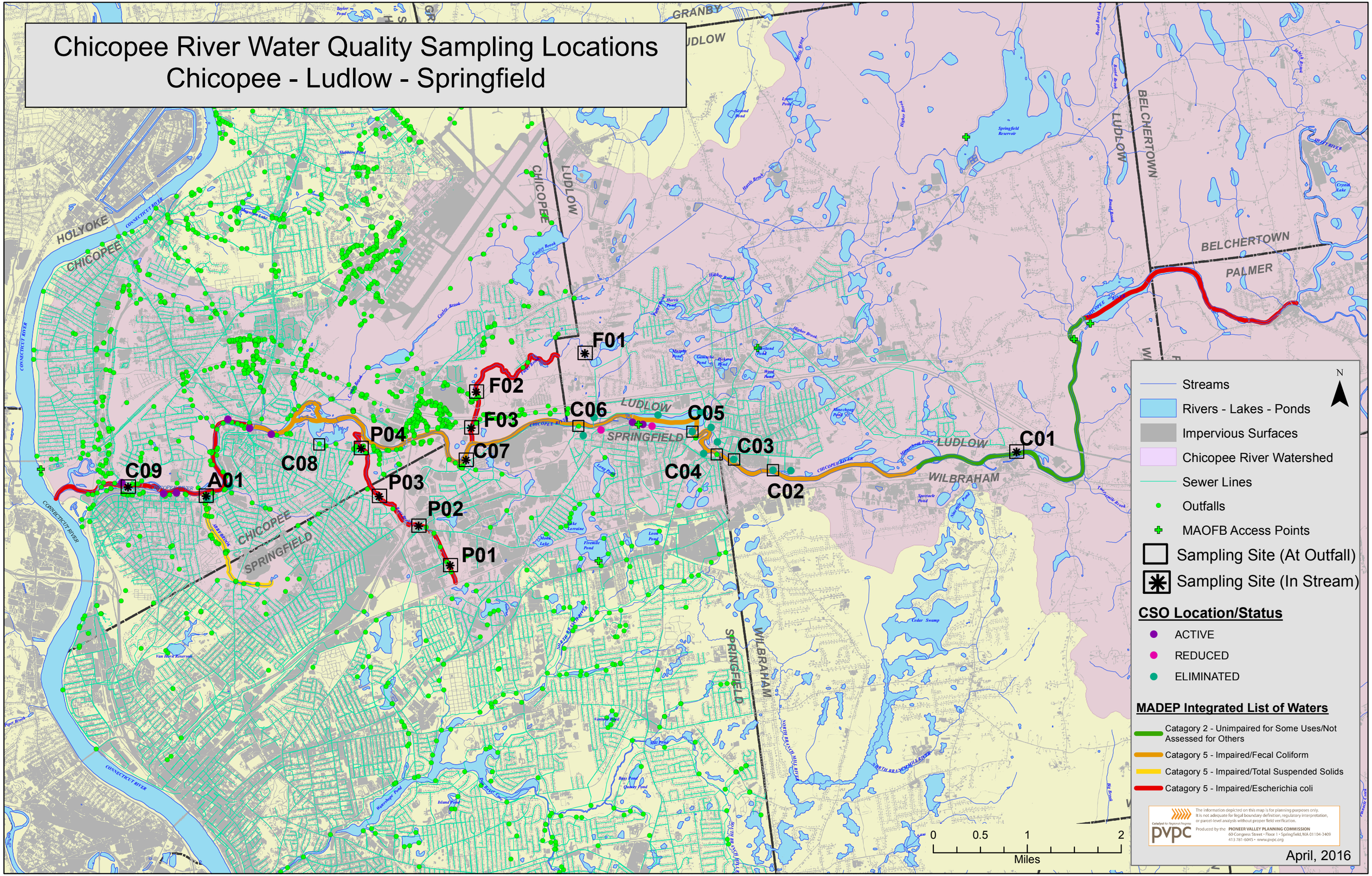
Outfall at Grochmal Avenue that delivers flow to the Chicopee River.

Table 1: Sampling Locations

Site ID	Site Location	Latitude	Longitude	Rationale for Site Selection	Previous Data
Fuller Brook					
F01	West St., Ludlow	42.17088	-72.51222	2003 MassDEP sampling site	2003=4,64,370-w, 110, 40, 800-w cfu/100mL ecoli
F02	Crossing with Lombard Road, Chicopee	42.16477	-72.53502	Middle reach site that is below Loomis Drive yet upgradient of landfill	
F03	Shawinigan Drive, Chicopee	42.15905	-72.53577	Near confluence with Chicopee River mainstem. Also, 2003 MassDEP sampling site.	2003 readings ranged from 14, 55, 450 (wet),160, 200, and 1120 (wet) cfu/100 mL E.coli.
Poor Brook					
P01	Near Realtor Assoc. of Pioneer Valley office at 221 Industry Ave., Springfield	42.13842	-72.54017	Upper reach	
P02	Cottage Street, Springfield (near Pride Facility before Tributary enters culvert)	42.14457	-72.5452	2008 MassDEP sampling site	2008= 96, >200, 120, 110, 200, 120 cfu/100mL - geomean = 135 DEP POB1.42
P03	Behind Price Street, Springfield	42.1488	-72.55485	below Page Blvd/291 Interchange	
P04	E. Main Street, Chicopee	42.15603	-72.55763	2003 and 2008 MassDEP sampling site; Near confluence with Chicopee River	2003 bac-t = 30, 49, 4200 (wet), 160, 200, 1880 (wet). No bac-t sampled in 2008.

Site ID	Site Location	Latitude	Longitude	Rationale for Site Selection	Previous Data
Abbey Brook					
A01	Mouth of Abbey Brook before enters Chicopee River (behind Chicopee Park and Rec. Dept.)	42.14936	-72.59082	Downstream of 2003 MassDEP sampling site (which was above Front St., near entrance to Szot Park, Chicopee)	2003 readings = 2, 72, 112, 30, 110, 10,000-w! cfu/100mL
Chicopee River - Mainstem					
CO1	North Wilbraham Bridge, Ludlow	42.1573	-72.42338	Reference, base line site; Former MassDEP sampling site	CH02B, 2008 geomean = 87 cfu; 2003=<2, 20, 32, 40, <10, 160 cfu
CO2	Ludlow Mills A (Dukes Street), Ludlow	42.15413	-72.47337	Stormwater outfall	
CO3	Ludlow Mills B (East Sewall Street), Ludlow	42.15577	-72.4819	Stormwater outfall	
CO4	Main Street, Indian Orchard/Springfield (southwest end of Ludlow Bridge)	42.15631	-72.485175	Stormwater outfall; City found trickle of flow during dry weather in	
CO5	Indian Leap St., Springfield	42.16023	-72.48982	Stormwater outfall	
CO6	Worcester St., Springfield	42.160592	-72.514914	Stormwater outfall; City found trickle of flow during dry weather in	
CO7	Grochmal St., Springfield	42.15455	-72.53785	Unnamed tributary that drains large urban area	
CO8	Behind 525 Main Street, Chicopee	42.157233	-72.567386	Stormwater outfall	
CO9	Davitt Bridge, Chicopee	42.150683	-72.605828	Instream reference location at end of study area	7 years of extensive data by PVPC; most recent years on CT River U.S. website

Chicopee River Water Quality Sampling Locations
Chicopee - Ludlow - Springfield



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Water quality sampling: dry versus wet weather events

The study entailed collecting grab samples during 3 dry and 3 wet weather events. Wet weather for this study was considered >0.1" of rain within the preceding 24 hours. This shorter time frame (as opposed to > 0.25 in 48 hours or >0.5 in 72 hours) was intended to capture the more immediate impacts of stormwater flowing off nearby surfaces into local streams and outfalls into the river.

Sampling Events - 2016

Tuesday, May 10 - dry
Tuesday, May 17 – dry
Tuesday, May 24 – wet
Tuesday, May 31 – wet
Tuesday, June 7 – dry
Wednesday, June 29 – wet

Sampling for the 3 dry and 3 wet weather events occurred between May 10 and June 29, 2016, with a trained crew of 16 volunteers. Volunteers collected river water samples to be analyzed for *E. coli*, surfactant, and ammonia (NH3). Volunteers also obtained air and water temperatures and recorded observations at each sampling site on field data sheets, including flow, odor, water color, signs of wildlife, and any other noteworthy observations during the time of sampling. MassDEP surface water quality standards provided comparative values for water temperature. Given that the Chicopee River is classified as Class B, warm water fishery, temperature shall not exceed 83˚F (28.3˚C).

Ammonia analysis was conducted in the field by volunteers using Hach brand ammonia test strips the results of which were compared with the color chart on the test strip bottle and recorded on the field data sheet. Based on the thresholds provided by EPA New England's Bacterial Source Tracking Protocol, color results indicating ≥1 mg/l indicate potential wastewater or washwater contamination, though .5 mg/l may provide an indication as well. As such, PVPC used the lower ammonia threshold in cross comparisons of *E. coli* and surfactant results.

Analysis of samples for surfactants was done at the PVPC office in Springfield using an MBAS (Methylene Blue Active Substances) test kit with a colorimeter. Results were recorded on the field data sheet.

Volunteer Alan Menard reaches to collect a sample at an outfall to the Chicopee River (C08). Getting to this site required permission to walk through the back yard of private property owner at 525 Main Street, Chicopee, and then steep climb down to River's edge.

Based on the thresholds provided by EPA New England's Bacterial Source Tracking Protocol, color results indicating ≥.25 mg/l indicates potential wastewater or washwater

contamination. As waste from the surfactant analysis is very acidic and considered hazardous, ampoules and liquid waste were collected in liter size amber bottles and disposed of when full through the City of Springfield Hazardous Waste Disposal Program.

Samples for *E. coli* analysis remained on ice and were transported to the Connecticut River Conservancy laboratory in Greenfield. *E. coli* is used as an indicator organism because it is easily cultured, and its presence in water in certain amounts indicates the possible presence of sewage. Results were compared against US EPA water quality standards for *E. coli* where waters are unsuitable for recreation - no boating or swimming if ≥576 colonies/100 ml on a single sample.

Where laboratory results indicated elevated *E. coli* colony levels (≥576 MPN/100 ml), PVPC analyzed samples for surfactants and compared *E. coli*, surfactant, and ammonia results to determine whether the source was anthropogenically derived. [Note that initially all samples were analyzed for surfactants in advance of receiving *E. coli* results from the lab, but it soon became apparent that chemical exposure during this analysis is problematic and a hooded vent and/or respirator could provide greater safety. The surfactant analysis had been promoted as part of a field test kit within the EPA Region 1's source tracking protocol, but exposure as well as the byproducts of this analysis (glass and a chemical reagent that is a hazardous waste) are a significant issue.]

As such, no surfactant analysis was performed during the 5th sampling round/a dry event (the analyst was feeling sick). Surfactant analysis was performed on all samples during the 6th round, but for all source tracking, surfactant analysis was limited to those samples showing elevated *E. coli* levels. This approach, which reduces human exposure and waste, is recommended for all such use of the protocol going forward. Note that this analysis was performed within the maximum holding time for surfactant analysis (48 hours).

Locations indicating anthropogenic sources of *E. coli* (where elevated *E. coli* levels were accompanied by samples that showed elevated ammonia and surfactant levels) were reported to local authorities.

Sites showing elevated levels of *E. coli* without corresponding elevated ammonia and surfactant levels were ranked and PVPC and C4RWC conducted multiple rounds of source tracking to identify the sources of *E. coli* to the extent possible. Note that the QAPP was adjusted based on the timing of source tracking. Originally, the QAPP had indicated that source tracking would be conducted within 48 hours of a sample collection that showed elevated *E. coli*. This did not prove practical, however, as the hits typically occurred during wet events and given the scarcity of rain, 48 hours were all dry events and very unlikely to yield useful findings.

Water quality sampling: source tracking

Where monitoring results showed elevated *E. coli* counts that exceeded water quality standards for recreation (no boating or swimming), PVPC staff referred to ammonia and surfactant test results. Where all of these parameters showed elevated levels, indicating

anthropogenic sources, PVPC alerted local officials (Department of Public Works and others) for further investigation. It is assumed that these results are indicative of an illicit discharge.

Once the dry versus wet weather events sampling was completed, PVPC and C4RWC staff examined results and ranked those locations showing the greatest frequency of elevated *E. coli* levels not associated with anthropogenic sources. PVPC prepared working maps of subwatershed areas to begin identifying best locations for source tracking relative to locations with elevated *E. coli* results. This work of source tracking strategy was further informed by meetings with city officials, MassDEP, and field and desktop mapping (for parcels and access) reconnaissance.

PVPC and C4RWC staff and two of the project volunteers tracked bacteria sources in these high ranking locations, bracketing the contributing area and then closing in on a source as best as possible. Samples were sent to the Connecticut River Conservancy laboratory for bacteria analysis. Samples were also analyzed for ammonia and surfactants to ensure that any elevated bacteria levels were not from anthropogenic/illicit discharge sources.

Locations identified through source tracking as persistent sources of elevated *E. coli* were flagged as priority project locations for stormwater best management facilities.

Preliminary BMP design

To examine the possibility of stormwater best management practices in addressing *E. coli* inputs at priority locations related to the Chicopee River, PVPC and C4RWC solicited quotes from 14 engineering firms. PVPC received responses from 3 firms (a response from a 4th firm came in after the deadline). PVPC used project funding to hire Amec Foster Wheeler, who teamed up with Wetland Strategies, Inc. Amec Foster Wheeler met with PVPC, C4RWC, and municipal officials to review results and then conducted site visits on April 11 and April 18, 2017.

Amec Foster Wheeler's analysis entailed a review of water quality results, information on existing drainage, soil infiltration characteristics, flood zones, and wetlands. Consultants also reviewed available right of way and other property available for the installation of stormwater Best Management Practices. They developed a summary of BMPs to reduce bacteria loading into the Chicopee River and tributaries (shown as Technical Memorandum #1 in the Appendixes) and talked with town officials about preferred options.

A final report took the form of Technical Memorandum #2, evaluating each site in terms of available space, hydrologic soil group, potential bacteria reduction, cost and other factors (i.e. depth to groundwater, permitting, flood zones). In this Memorandum (also included in the Appendixes) the Amec Foster Wheeler team also provides preliminary design, model pollutant reduction achieved by each BMP facility, and cost estimates for facilities at each of these locations.

Education and outreach

A strategic benefit of the project relates to the engagement and capacity building within the Chicopee 4Rivers Watershed Council. C4RWC is in its infancy and the opportunity

provided through this project offered an enhanced awareness to local residents of C4RWC‘s vision to serve the watershed protection needs of the area. In working with town and city departments, the project also began to spark awareness among municipal entities of C4RWC’s efforts.

Furthermore, the water quality sampling component of the project provided an excellent way to engage watershed residents. On April 28, 2016, PVPC and C4RWC held an event to talk about the Chicopee River, project objectives, and train 18 interested volunteers to collect samples for the 3 dry/3 wet weather events. As part of the training, volunteers were teamed up with one another based on interest in specific sampling locations. The team approach not only ensured greater safety for volunteers, but provided continuity throughout the 6 sampling events.

Education and outreach work also entailed placing project news and notices in local newspapers and holding two public events, one in Ludlow and the other in Chicopee to share and promote project results.

A fuller description of education and outreach activities is provided in the "Results" section of this report.

Results

Water quality sampling: dry vs. wet weather events

Dry weather events

Water quality results for the sampling during "dry" weather showed few problems relative to *E. coli*. The two exceptions were:

1. At the Main Street/Indian Orchard outfall (C04) where it became apparent that sewage was entering the storm line (subsequently reported and corrected by the City of Springfield and Springfield Water & Sewer Commission); and

2. The "dry" event on 6/7/16, which did not qualify as "wet" based on the study parameters (>0.1" within the previous 24 hours), but which was preceded by heavy rain 32 hours prior to sampling and yielded results that could be compared to what was seen for "wet" events in this study. As such, this event has been interpreted as a "wet" rather than "dry" event for purposes of results and analysis.

During "dry" events several outfalls had no flow, while others did have flow. See Table 2 below.

Despite some input of *E. coli* from the problem outfall at C04 during the truly "dry" events on 5/10/16 and on 5/17/16, the mainstem instream location at the bottom of the system (C09) did not show significant increased concentration of *E. coli* when compared to the instream location at the top of the system (C01).

Wet weather events

As noted above, the "dry" sampling event on 6/7/16 will be included here so that there are essentially four wet events in this study: 5/24/16, 5/31/16, 6/7/16, and 6/29/16.

Through the four wet events sampled, it is remarkable to note that despite contributing flows with elevated *E. coli* levels, the highest recorded *E. coli* level at the downstream location at C09 was 166.4 colonies of *E. coli* per 100 ml. This might suggest the possibility of attenuation, though this could also be due to the variability of sampling a large river like the Chicopee.

The "wet" weather event on 5/24/16 yielded results that seem to be most indicative of the impact of polluted urban storm flows from a "first flush." Volunteers collected samples just after a .23" storm event. Of the 17 sites sampled that morning, 13 showed elevated *E. coli* levels. See Table 3 below. Results at four of these locations were indicative of sewage, based on corresponding high results for ammonia and surfactants (CO4, PO2, PO3, PO4). These sites were reported and addressed by the City of Springfield and Springfield Water & Sewer Commission). The other sites all had *E. coli* values indicating waters unsuitable for recreation - no boating or swimming (≥576 colonies/100 ml on a single sample).

The other "wet" weather events on 5/31/16, 6/7/16, 6/7/16, and 6/29/16 were caught some time after the storm and flows did not yield the dramatic results seen on 5/24/16. It did become apparent, however, that several sites were showing repeated levels of *E. coli* during storm flows that are concerning for recreational use of the river.

- The outfall of Abbey Brook at the Chicopee River (A01) showed elevated levels of *E. coli* bacteria during all four sampling events.
- In stream locations on Fuller Brook showed repeated problems with elevated *E. coli* during the wet sampling events, with the middle of the system site (F02) showing high hits during three sampling events and the upper (F01) and lower (F03) sites on the system showing high hits during two sampling events.
- The outfall at Grochmal Street (CO7) showed elevated bacteria on two occasions.
- The two instream sampling locations on lower Poor Brook (P03 and P04) showed elevated bacteria (unrelated to sewage) on one occasion, but had also indicated a problem related to sewage during the first wet event.

Abbey Brook confluence with the Chicopee River. Just before it reaches this location, Abbey Brook spills out of a highly perched culvert.

Based on the number of times that samples from a given locations were analyzed with elevated *E. coli* levels, Abbey Brook, Fuller Brook, Grochmal, and Poor Brook were prioritized for source tracking. The outfall at the lower part of Ludlow Mills presented certain logistical challenges, with the need to pull manhole covers and getting local traffic details lined up, that it became a lower priority than the other identified locations.

Quality control

Please see Appendix B for summary of Quality control conducted under this study.

Table 2: Chicopee River Water Quality Sampling Results During 3 Dry Events

Site Name	Site ID	5/10/2016 - Dry				5/17 - Dry				6/7/16 - Dry (Note: Did not qualify as wet event, but heavy rain .72" 32 hours before sampling)			
Sites below are listed from upstream to downstream locations.		Ecoli MPN / 100ml Undiluted sample	Ammonia (NH3) mg/l	Surfactant mg/l	Water temp. degrees C	Ecoli MPN / 100ml Undiluted sample	Ammonia (NH3) mg/l	Surfactant mg/l	Water temp. degrees C	Ecoli MPN / 100ml Undiluted sample	Ammonia (NH3) mg/l	Surfactant mg/l	Water temp. degrees C
Threshold limit		≥576	≥.5	≥.25	28.3°	≥576	≥.5	≥.25	28.3°	≥576	≥.5	≥.25	28.3°
Chicopee River - North Wilbraham Bridge, Ludlow	CO1	37.9	0	0	12.5°	30.5	0.125	0	14°	235.9	0		21.5°
Chicopee River outfall - Dukes Street, Ludlow (Ludlow Mills A)	C02	No flow				No flow				No flow			
Chicopee River outfall - East Sewall Street, Ludlow (Ludlow Mills B)	C03	35.5	0.25	Not collected	12°	35.0	0	0.25	12°	44.1	0.25		19°
Chicopee River outfall - Main Street, Indian Orchard/Springfield	C04	No flow				>2419.6	3.0	0.25	10°	> 2419.6	6		not enough water
Chicopee River outfall - Indian Leap, Springfield	CO5	No flow				No flow				No flow			
Chicopee River outfall - Worcester Street, Springfield	CO6	No flow				275.5	0.25	0.25	8.5°	38.8	0.25		12.5°
Fuller Brook - West Street, Ludlow	FO1	133.3	0.25	0.125	11°	95.9	0	0	12°	488.4	0.4		19°
Fuller Brook - Lombard Road, Chicopee	FO2	62.4	0.25	0	11°	65.0	0.1	0	12°	866.4	0.25		19°
Fuller Brook - downstream of Shawinigan Drive, Chicopee	FO3	83.6	0.25	0	11°	68.3	0.25	0	12°	980.4	0.25		19°
Chicopee River outfall - Grochmal Street, Springfield	CO7	204.6	0.25	0.125	12°	325.5	0.25	0.125		> 2419.6	0.25		15.5°
Poor Brook - near Industry Avenue, Springfield	PO1	51.2	0.25	0.125	12.5°	37.9	0	0.125	14°	579.4	0.25		22°
Poor Brook - Cottage Street, Springfield	PO2	56.3	0.5	0.125	12°	49.5	1.0	0.125	11.5°	517.2	0.5		20°
Poor Brook - near Price Street, Springfield	PO3	24.1	0	0.25	10°	145.0	0.25	0	10°	461.1	1		16°
Poor Brook - East Main Street, Chicopee	PO4	36.4	0.25	0.25	8°	79.4	0	0	10°	365.4	0		15.5°
Chicopee River outfall - East Main Street, Chicopee	C08	32.3	0.25	0	10.5°	124.6	0.25	0.125	11°	461.1	0.5		14°
Chicopee River outfall - Abbey Brook	AO1	57.6	0.25	0	12.5°	63.1	0.3	0.125	14°	1986.3	0.15		21°
Chicopee River - Davitt Bridge, Chicopee	CO9	56.3	0.25	0	12.5°	86.2	0.25	0	14°	166.4	0.1		22°

Key			
	Results indicative of human waste/illicit discharge (E.coli, ammonia, and surfactant all elevated)	=	Mainstem instream location
	Results do not indicate human waste, but E. coli level exceeds threshold for recreation	=	Tributary instream location
	Ammonia or surfactant result elevated, but not connected to suite of three elevated parameters		

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Table 3: Chicopee River Water Quality Sampling Results During 3 Wet Events

Site Name	Site ID	5/24/16 - Wet .23" (caught just after storm)				5/31/16 - Wet .14"				6/7/16 - Dry (Note: Did not qualify as wet event, but heavy rain .72" 32 hours before sampling)				6/29/16 - Wet .21"			
Sites below are listed from upstream to downstream locations.		Ecoli MPN / 100ml Undiluted sample	Ammonia (NH3) mg/l	Surfactant mg/l	Water temp. degrees C	Ecoli MPN / 100ml Undiluted sample	Ammonia (NH3) mg/l	Surfactant mg/l	Water temp. degrees C	Ecoli MPN / 100ml Undiluted sample	Ammonia (NH3) mg/l	Surfactant mg/l	Water temp. degrees C	Ecoli MPN / 100ml Undiluted sample	Ammonia (NH3) mg/l	Surfactant mg/l	Water temp. degrees C
Threshold limit		≥576	≥.5	≥.25	28.3°	≥576	≥.5	≥.25	28.3°	≥576	≥.5	≥.25	28.3°	≥576	≥.5	≥.25	28.3°
Chicopee River - North Wilbraham Bridge, Ludlow	CO1	16.1	0.25	0	17.5	68.9	0	0.125	24	235.9	0		21.5°	20.1	0.125	0	22°
Chicopee River outfall - Dukes Street, Ludlow (Ludlow Mills A)	C02	105.4	0.25	0	17	No flow				No flow				No flow			
Chicopee River outfall - East Sewall Street, Ludlow (Ludlow Mills B)	C03	1884.8	0.25	0.25		34.5	0.125	0.25	14	44.1	0.25		19°	129.1	0.5	0	20°
Chicopee River outfall - Main Street, Indian Orchard/Springfield	C04	>2419.6	3	1.5	thermo meter broke	>2419.6	6	0.25	not enough water	> 2419.6	6		not enough water	> 2419.6	Not recorded	1	not enough water
Chicopee River outfall - Indian Leap, Springfield	CO5	>2419.6	0.25	0.125	14.5	No flow				No flow				No flow			
Chicopee River outfall - Worcester Street, Springfield	CO6	>2419.6	0.125	0.125	13.3	93.3	0.25	0.125	11.5	38.8	0.25		12.5°	248.1	0	0.125	14°
Fuller Brook - West Street, Ludlow	FO1	906.0	0	0.125	16	686.7	0	0.125	20	488.4	0.4		19°	365.4	0.25	0.125	19°
Fuller Brook - Lombard Road, Chicopee	FO2	1986.3	0.5	0.125	16	579.4	0.25	0.125	20	866.4	0.25		19°	325.5	0.4	0.125	20°
Fuller Brook - downstream of Shawinigan Drive, Chicopee	FO3	1732.9	0.25	0.125	16	344.8	0.25	0.125	20	980.4	0.25		19°	248.9	0.4	0.125	20°
Chicopee River outfall - Grochmal Street, Springfield	CO7	>2419.6	0	0	14.9	410.6	0.125	0.125	18	> 2419.6	0.25		15.5°	547.5	0.25	0	18.5°
Poor Brook - near Industry Avenue, Springfield	PO1	387.3	0	0.125	19	137.6	0.25	0.25	23	579.4	0.25		22°	101.0	0.25	0.25	22.5°
Poor Brook - Cottage Street, Springfield	PO2	1299.7	0.5	0.25	15.5	275.5	1	0.25	21	517.2	0.5		20°	387.3	1	0.25	20°
Poor Brook - near Price Street, Springfield	PO3	>2419.6	0.5	0.5	15	365.4	0.25	0.25	18	461.1	1		16°	1732.9	0	0.125	16.5°
Poor Brook - East Main Street, Chicopee	PO4	>2419.6	1	0.5	15	190.4	0	0.125	16	365.4	0		15.5°	727.0	0.25	0.125	16.5°
Chicopee River outfall - East Main Street, Chicopee	C08	>2419.6	0.25	0	14	64.4	0.25	0	13	461.1	0.5		14°	203.5	0.25	0.125	15°
Chicopee River outfall - Abbey Brook	AO1	2419.6	0.2	0.125	17	648.8	0.3	0.25	22	1986.3	0.15		21°	1203.3	0.2	0.25	23°
Chicopee River - Davitt Bridge, Chicopee	CO9	104.3	0.2	0	18	95.9	0.15	0	23	166.4	0.1		22°	83.9	0.25	0.125	24°

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Source Tracking

Abbey Brook

Abbey Brook is a tributary to the Chicopee River and the presence of geese in Szot Park, just upstream of the outfall sampled during the dry versus wet round of sampling, provided a suspected source for the detected bacteria problem. The results, however, were somewhat variable. As such, PVPC conducted three rounds of source tracking during qualifying wet weather events on Abbey Brook. These events were on 8/11/16, 10/10/16, and 11/16/16, and involved a total of seven different locations on the stream system. Sampling began at the downstream location and proceeded upstream during all source tracking sampling rounds.

During the first round on 8/11/16, 0.14" of rain fell, beginning at 10:58 a.m. and ending by 2 p.m. the previous day. Source tracking was done at four locations: the regular sampling site at the outfall of Abbey Brook to the Chicopee River (A01), and then three upstream locations. Two located within Szot Park-- below and at the top of Bemis Pond—and another further upstream on the south side of Armory Street. See Map 2 below for source tracking locations on Abbey Brook.

Results showed the two sites higher in the stream system (A01B and A01C) with *E. coli* values indicating waters unsuitable for recreation - no boating or swimming (≥576 colonies/100 ml on a single sample). The two lower sites (A01 and A01A) had elevated *E. coli* levels, but were lower than the ≥576 colonies/100 ml threshold. See Table 4 for sampling results.

Geese congregate along the shores of Bemis Pond in Szot Park, Chicopee.

The next round of source tracking on 10/10/16 was preceded by 0.37" of rainfall, with rain beginning at 10 a.m. the previous morning and ending at 5 p.m. in the evening. This round involved five sampling locations, including two sites aimed at bracketing a potential source upstream of the Armory Street site (A01C), which had the highest hit in the first round.

E. coli results from these upstream locations, including A01C, were below the threshold for water unsuitable for recreation. That was not the case at A01B, which again had *E. coli* levels above the study threshold. In this round, the site below lower Bemis Pond also had elevated *E. coli* levels. Together these sites suggest that the waste coming from the geese may indeed be a problem.

The third round on 11/16/16 was preceded by 0.35" of rainfall, with rain beginning at 1 p.m. the previous day and ending around 7 p.m. Another site, just above A01B was added and the *E. coli* levels in this location were extremely high (as was A01B once again), suggesting that runoff carrying fecal matter from the geese could be a problem as the adjacent hillside drains to this area just above the pond, but also to Bemis Pond itself. Another contributing factor here could be beaver activity in the stretch of wetlands above Bemis Pond, where there is a large beaver dam that stretches from one bank of Abbey Brook to the other.

While the Abbey Brook site at Mildred Avenue (A01E) did not show elevated E.coli levels, this upper part of the system is highly impacted from urbanized flows. Sampling at this site on 10/10/16, some 16 hours after a .37-inch storm, it is apparent that the real drama of what happens to this system occurs much closer to the storm event.

Abby Brook Monitoring Sites

CHICOPEE RIVER
FRONT STREET
ABBY BROOK
FAIRVIEW AVENUE
ARMORY DRIVE
BROADWAY AVENUE
LIBERTY STREET

AO1
AO1A
AO1B
AO1B2
AO1C
AO1D
AO1E

Abby Brook Watershed Bounds
Sampling Site
Sampling Site (At Outfall)
Outfalls
Storm Water Lines
Streams
Rivers - Lakes - Ponds
Impervious Surfaces

MADEP Integrated List of Waters

Catagory 5 - Impaired/Total Suspended Solids
Catagory 5 - Impaired/Escherichia coli

Land Use

Residential
Commercial
Indusrtrial
Agriculture
Forest
Other OpenSpace
WaterWetlands

N

0 200 400 600 800 Feet

Table 4: Abbey Brook Source Tracking

8/11/2016						10/10/2016					11/16/2016				
		.14 " of rain in preceeding 24 hrs.					*.37" of rain in preceeding 24 hrs.*					*.35" of rain in preceeding 24 hrs.*			
Site Name	**Site ID**	**8/11/2016 - Source Tracking .14" of rain in preceeding 24 hrs.**				**Site ID**	**10/10/2016 - Source Tracking .37" of rain in preceeding 24 hrs.**				**Site ID**	**11/16/2016 - Source Tracking .35" of rain in preceeding 24 hrs.**			
		Ecoli MPN / 100ml Undiluted sample	**Ammonia (NH3) mg/l**	**Surfactant mg/l**	**Water temp. degrees C**		**Ecoli MPN / 100ml Undiluted sample**	**Ammonia (NH3) mg/l**	**Surfactant mg/l**	**Water temp. degrees C**		**Ecoli MPN / 100ml Undiluted sample**	**Ammonia (NH3) mg/l**	**Surfactant mg/l**	**Water temp. degrees C**
Threshold limit		**≥576**	**≥.5**	**≥.25**	**28.3°**		**≥576**	**≥.5**	**≥.25**	**28.3°**		**≥576**	**≥.5**	**≥.25**	**28.3°**
Abbey Brook - outfall to Chicopee River	A01	248.9	0	0.125	24	A01					A01	131.4	0		7
Abbey Brook - below lower Bemis Pond dam	A01A	178.5	0	0.125	24	A01A	1119.9	0.25	0.125		A01A	435.2	0.125		
Abbey Brook - at upper dam inlet to Bemis Pond	A01B	547.5	0.25	0.125	25	A01B	866.4	0.25	0.20		A01B	920.8	0.125	0.125	
Abbey Brook - Just above upper dam											A01B2	>2,419.6	0.125	totally green - twice; too much sediment	
Abbey Brook - south side of Armory Street	A01C	920.8	0.25	0.125	19	A01C	435.2	0.25			A01C				
Abbey Brook - below Liberty Street						A01D	344.8	0.25			A01D				
Abbey Brook - end of Mildred Avenue						A01E	410.6	0.25			A01E				

Fuller Brook

While this study refers to the entire stream system as Fuller Brook based on USGS and MassDEP references, locally the upper reach of the stream in Ludlow is called Higher Brook.

Three source tracking events were conducted on 8/22/16, 9/29/16, and 11/16/16, and involved a total of 12 different locations on the stream system. This included sites sampled for dry versus wet sampling (FO1, FO2, FO3) and additional sites identified for source tracking high bacteria hits during wet events. See Map 3 below for locations.

For the first round on 8/22/16, 0.55 inches of rain fell between 10 PM the night before and ending at 2 AM. Sampling started at the lowest point in the watershed, F03, and proceeded upstream. Sampling began at 8:05 AM and concluded at 10:45 AM. Flow was strong at F03, water cloudy, clarity improved as samplers moved upstream. All storm drain outfalls in the upper watershed had stopped flowing when the area was sampled. Additional sites added on this round were FO1A, FO1B, FO1C, above FO1, then FO2A, FO2B, which checked sources between FO1 and FO2.

The results (see Table 5) point to high bacteria levels in the lower reaches of the stream. This condition began below the Massachusetts Avenue site as it approached West Street, with an uptick at the Sportsmans Club, which dropped within ¾ of a mile. Bacteria between F02A and F02 seem identical. A final rise in bacteria occurred between F02 and F03.

For the second round on 9/27/16, 0.54 inches of rain fell between 2 AM and 7 AM. Sampling started upstream and moved downstream, with the idea of catching the event in the upstream segment as soon as possible. Sampling began at 8:05 AM and concluded at 10:30 AM (at F03. Stream flow was good, but not visibly high.

The Moody Street storm outfall was flowing modestly, while the Massachusetts Avenue outfall had just a trickle of flow that was too low for a grab sample. New sites on this round included FO1B1 a stormwater interceptor outfall that drains the Moody/West/ and Holyoke streets area.

Results point to high bacteria in the upper reaches of the watershed and lower bacteria in the lower reach.

One possible factor in the higher bacteria levels below F01B1 could be beaver activity: A neighbor reported the possibility of a beaver dam and impoundment below the Helena Street outfall, but above the Massachusetts Avenue sampling site. There is also a wetland area and evidence of a beaver dam in the area above the Sportmans Club, which was somewhat flooded during the 9/29/16 sampling event.

Based on the previous two sampling events, where bacteria seemed higher below Massachuestts Avenue and before West Street, additional sites between Massachusetts Avenue and West Street were identified (FO1Ad, FO1Ab) to see if any input could be identified for the 11/16/16 sampling round. Nearby streets on the west side of the stream have septic systems and two storm drains.

Rainfall was 0.44 inches and fell mostly about 15 hours before the 11/16/16 sampling event, about 0.02" fell as sampling began. Sampling began upstream and proceeded downstream. Streamflow was good, but not particularly high. Flow ran clear. There was minor flow coming from the Moody outfall, so it was sampled at the confluence in the pool. The Massachusetts Avenue storm pipe had no flow though the concrete itself was wet.

Results showed bacteria levels exceeding the recreation limit ≥576 colonies/100 ml on a single sample at F01B1 (the Moody Street stormwater interceptor outfall) Otherwise, all other sites were below this threshold with the Sportsmen Club site being elevated at 235.9 colonies / 100 ml.

Grochmal Street outfall

The outfall at Grochmal Street, located east of Route 291 in Springfield, off Worcester Street, is actually a tributary known locally as Bircham Bend Brook. The Brook begins near the intersection of Cottage and Carando streets, flows northeast under Route 20, is impounded by several dams at Bircham Bend Ponds, flows northwest under Route 141 and passes a mobile home park before spilling into the Chicopee River.

During the first round on 8/11/16, 0.14" of rain fell, beginning at 10:58 a.m. and ending by 2 p.m. the previous day. Source tracking involved sampling at four locations: the regular sampling site at the outfall to the Chicopee River (C07) and in three upstream locations all related to the mobile home park on the north side of Route 141. See Map 4 below for source tracking locations on this system.

Results showed bacteria levels all below the 576 colonies/100 ml single sample threshold. While this system warrants further investigation in the future, source tracking at Abbey Brook and Fuller Brook became priorities based on the more elevated bacteria results in those locations. See Table 6 below.

Table 6: Grochmal Street Outfall Source Tracking

Site Name	Site ID	8/11/2016 - Source Tracking .14" of rain in preceding 24 hrs.			
		Ecoli MPN / 100ml Undiluted sample	Ammonia (NH3) mg/l	Surfactant mg/l	Water temp. degrees C
Threshold limit		**≥576**	**≥.5**	**≥.25**	**28.3º**
Grochmal Street - outfall at Chicopee River	C07	344.1	0	0.125	20.5
Grochmal - 100' upstream of culvert	C07A	186.0	0.125	0.125	20.1
Grochmal - end of 2nd Avenue	CO7B	156.5	0.125	0.125	20
Grochmal Street	C07C	151.5	0.25	0.125	20.9

Fuller Brook source Tracking Locations
Ludlow & Chicopee

Cooley Brook
Harris Pond
Cutler Brook
Fuller Brook
CHICOPEE RIVER
CHICOPEE
LUDLOW
SPRINGFIELD
SPORTS CLUB
HOLYOKE STREET
BURNETT ROAD
WEST STREET
MASSACHUSETTS TURNPIKE
RUSSELL STREET
SHAWINIGAN DRIVE
RIVER STREET
FRONT STREET
MAIN STREET
WORCESTER STREET
BERKSHIRE AVENUE
SPRINGFIELD EXPRESSWAY
TECHNOLOGY DRIVE
RAMP-SPRINGFIELD EXPY TO RT 90
RAMP-RT 90 TO SPRINGFIELD EXPY
RAMP-SPRINGFIELD EXPY TO RT 90

F01C
F01B
F01A
F01Ab
F01Ad
F01D
F01
F02B
F02A
F02
F03
C06
C07

N

Streams
Rivers - Lakes - Ponds
Impervious Surfaces
Storm Water & CSO Lines
Outfalls
MAOFB Access Points
Fuller Brook Watershed Bounds
Sampling Site (In Stream)
Sampling Site (At Outfall)

CSO Location/Status

- ACTIVE
- REDUCED
- ELIMINATED

MADEP Integrated List of Waters

- Catagory 2 - Unimpaired for Some Uses/Not Assessed for Others
- Catagory 5 - Impaired/Fecal Coliform
- Catagory 5 - Impaired/Total Suspended Solids
- Catagory 5 - Impaired/Escherichia coli

Land Use

- Residential
- Commercial
- Indusrtrial
- Agriculture
- Forest
- Other OpenSpace
- WaterWetlands

0 0.05 0.1 0.15 0.2 0.25
Miles

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November, 2016

Table 5: Fuller Brook Source Tracking

8/22/2016							9/27/2016						11/16/2016				
		.55" of rain in preceeding 24 hrs.						*.54" of rain in preceeding 24 hrs.*						*.35" of rain in preceeding 24 hrs.*			
Site Name	**Site ID**	**Ecoli MPN/ 100ml Undiluted sample**	**Ammonia (NH3) mg/l**	**Surfactant mg/l**	**Water temp. degrees C**		**Site ID**	**Ecoli MPN/ 100ml Undiluted sample**	**Ammonia (NH3) mg/l**	**Surfactant mg/l**	**Water temp. degrees C**		**Site ID**	**Ecoli MPN/ 100ml Undiluted sample**	**Ammonia (NH3) mg/l**	**Surfactant mg/l**	**Water temp. degrees C**
Threshold limit		**≥576**	**≥.5**	**≥.25**	**28.3°**			**≥576**	**≥.5**	**≥.25**	**28.3°**			**≥576**	**≥.5**	**≥.25**	**28.3°**
Fuller Brook, Shawwinigan Chicopee	F03	1553.1	0.2	0.125	21°		F03	579.4	.25 to .30	0.125	16		F03				
Fuller Brook, Lombard Rd Chicopee	F02	1046.2	0	0.125	21°		F02	648.8	No result indicated on field data sheet	0.125	15.5		F02	150	0		8.8
Fuller Brook - Loomis	F02A	1119.9	0	0.125	21°		F02A						F02A	148.3	0		8.6
Fuller Brook, Sportsmen Club	F02B	1986.3	0.1	0.125	21°		F02B	206.4	0.1		14.5		F02B	235.9	0		8.3
Fuller Brook, West St, Ludlow	F01	980.4	0.15	0.125	21°		F01						F01	95.9	0		8.7
Fuller Brook, North of Power and east of West Street							F01D	>2419.6	0.125	0.125	15		F01D				
Fuller Brook, end of Daisy Lane							FO1Ad						FO1Ad	88.2	0		8.5
Fuller Brook, Bruni Avenue							FO1Ab						FO1Ab	77.6	0		8.4
Fuller Brook, Mass Ave Ludlow	F01A	238.2	0.1		22°		F01A	1,413.60	0.125	0.125	2 field data sheets both labeled FO1B		F01A	81.60			
Fuller Brook - Moody							F01B1	>2419.6	0.125	0.125	17		F01B1	648.8	0	0.125	10
Fuller Brook - Helena	F01B	178.5	Not recorded on field data sheet		23°		F01B*	>2419.6	0.125	0.125	17		F01B	135.4	0		10.3
Fuller Brook - below Holyoke Street	F01C	156.5	0.1		24°		F01C						F01C				
								*Though 2 surfactant bottles labeled FO1B and assume one must have been FO1A, which was missing, both samples yielded same surfactants results.									

Grochmal Outfall
Source Tracking Locations
Springfield

CHICOPEE RIVER

CHICOPEE

SPRINGFIELD

MONSANTO AVENUE

MONSANTO ROAD

GROCHMAL AVENUE

FIRST AVENUE

SECOND AVENUE

FOURTH AVENUE

FIFTH AVENUE

SIXTH AVENUE

FIRST STREET

SECOND STREET

THIRD STREET

FOURTH STREET

C07

C07A

C07B

C07C

WORCESTER STREET

CADWELL DRIVE

RIO VISTA STREET

BIRCHAM STREET

GLEN ALBYN STREET

PAGE BOULEVARD

JIMMY COURT

SECOND STREET

CARLOS STREET

OBSERVER STREET

KENWAY DRIVE

BRAY STREET

JEAN DRIVE

TREMONT STREET

PARAMOUNT STREET

Streams

Rivers - Lakes - Ponds

Impervious Surfaces

Storm Water & CSO Lines

Outfalls

Sampling Site (In Stream)

Sampling Site (At Outfall)

CSO Location/Status

ACTIVE

REDUCED

ELIMINATED

MADEP Integrated List of Waters

Catagory 2 - Unimpaired for Some Uses/Not Assessed for Others

Catagory 5 - Impaired/Fecal Coliform

Catagory 5 - Impaired/Total Suspended Solids

Catagory 5 - Impaired/Escherichia coli

Land Use

Residential

Commercial

Indusrtrial

Agriculture

Forest

Other OpenSpace

WaterWetlands

0 100 200 300 400 500

Feet

N

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Poor Brook

Poor Brook has its origins just north of Bay Rd and along Industrial Ave with a small tributary from the Carando Conservation Area and flows in a northerly direction through an industrialized area of Springfield, the Delta Hills Conservation area, into Chicopee and then spills into the Chicopee River.

In source tracking on Poor Brook, three additional sites located between the original dry/wet sites were sampled to zero in on other possible contributing sources. The magnitude of this storm event was similar to the "wet" event sampled earlier in May when it appeared sewage was entering Poor Brook from where it flows near Cottage Street in Springfield at P02 down to P04 in Chicopee. See Map 5 for source tracking locations.

Results from this round of sampling showed far lower *E. coli* levels. High Ammonia levels can likely be explained by the location of P02 and P02A just downstream of the former City landfill. At P02, the sampler noted noxious fumes coming out of the culvert (through which Poor Brook travels). This was reported to Springfield City officials.

Table 7: Poor Brook Source Tracking

Site Name	Site ID	9/12/2016 - Source Tracking .27" of rain in preceding 24 hrs.			
		Ecoli MPN / 100ml Undiluted sample	Ammonia (NH3) mg/l	Surfactant mg/l	Water temp. degrees C
Threshold limit		**≥576**	**≥.5**	**≥.25**	**28.3º**
Poor Brook - outfall at Chicopee River	PO4	116.2	0		
Poor Brook - west of Robbins Road cul de sac	P04A	172.3	0.125		
Poor Brook - path from corner where Price and Anniversary streets meet	P03	129.6	0.25		
Poor Brook- off the corner where Stanley Street meets Fitzgerald Road (downstream of outfall in this area)	P03A	156.5	0.25		
Poor Brook - behind Pride (246 Cottage Street) at outlet of double culvert	P02	101.2	0.5		
Poor Brook - upstream and southeast of Cottage Street, just below landfill fencing	P02A	52.1	0.5		

Focus areas defined through source tracking

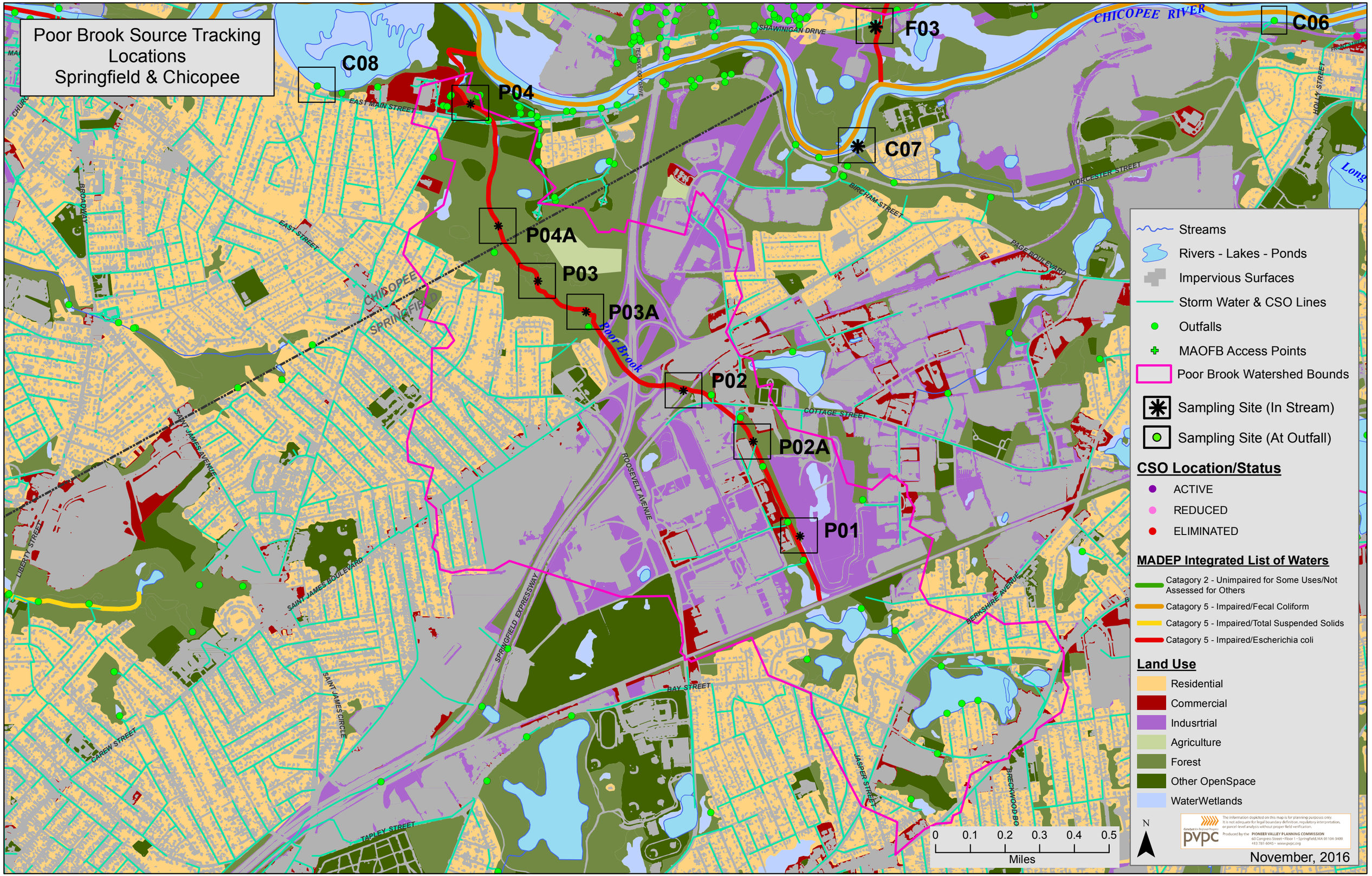
Wet weather source tracking presents significant challenges, with major variability based on the magnitude of a given wet weather event and the timing of sampling after a given wet weather event. River flow itself also presents a certain dynamic that can make it difficult to "nail down" an understanding of specific sources of contamination. What was observed in the 5/24/16 wet weather sampling event--where the study essentially captured a "first flush" and most locations showed extremely high levels of bacteria moving in tributaries and into the mainstem--is likely typical of what happens with storm flows from heavily urbanized areas. So the question for the water quality investigation became: Where are we seeing persistent evidence of bacteria contaminated flows based on a variety of wet weather events and a variety of sampling times?

The answers for this study, which in turn became the two focus areas are: Szot Park as it drains to Abbey Brook and the Moody/West/Holyoke Street area as it drains to the outfall on Fuller Brook. Even with a smaller source tracking storm event (0.14" in preceding 24 hours), Szot Park locations showed elevated bacteria when compared with source tracking locations on Poor Brook (0.27") and the Grochmal Street outfall locations (sampled following that same 0.14" storm event albeit an hour or so later in the morning). While the sampling on Fuller Brook occurred during larger wet events, the Moody/West/Holyoke Street outfall, had elevated bacteria for both source tracking samples taken at that location.

The focus area and storm system around Szot Park is fairly straightforward. There is some contribution of stormflow from the nearby neighborhood, a cemetery, and the park itself. The adjacent maintained grass areas of the park, which attract Canada geese, directly contribute storm runoff to the surface waters here. Two dams in the park along this reach of Abbey Brook, form upper and Lower Bemis Pond. See Map 6, which outlines this focus area.

The subwatershed area and storm system around the Moody/West/Holyoke Street outfall on Fuller Brook is more complicated. The drainage system in this area was developed in the 1980s as part of the Westover Industrial Park and includes commercial and residential properties. A subwatershed investigation during a high flow event indicates that storm runoff is coming from lower Moody and West streets (with little to no runoff from the upper drainage system). And unlike Szot Park, there does not seem to be one specific identifiable source of bacteria other than urbanized storm flow. (See Map 7 for an outline of this focus area and Appendix C for summary of the investigation.)

Poor Brook Source Tracking Locations Springfield & Chicopee



Abby Brook Szot Park Focus Area

CHICOPEE RIVER

FRONT STREET

AO1A

AO1B

AO1B2

ABBY BROOK

ARMORY DRIVE

ABBY BROOK

Abby Brook Watershed Bounds
Sampling Site
Sampling Site (At Outfall)
Outfalls
Storm Water Lines
Streams
Rivers - Lakes - Ponds
Impervious Surfaces

MADEP Integrated List of Waters

Catagory 5 - Impaired/Total Suspended Solids
Catagory 5 - Impaired/Escherichia coli

Land Use

Residential
Commercial
Indusrtrial
Agriculture
Forest
Other OpenSpace
WaterWetlands

N

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0 100 200 300 400 Feet

Fuller Brook Moody/West Street Focus Area

Focus Area
Sampling Site
Storm Water Lines
Streams
Rivers - Lakes - Ponds
Impervious Surfaces

Land Use
Residential
Commercial
Indusrtrial
Agriculture
Forest
Other OpenSpace
WaterWetlands

N

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0 100 200 300 400 Feet

STONYBROOK STREET
WESTOVER ROAD
RICHARD STREET
TANK FARM ROAD
MOODY STREET
SCOTT STREET
CLARK STREET
CONNIE AVENUE
CHARLES STREET
WEST STREET
HOLYOKE STREET
SKYRIDGE STREET
MICHAEL STREET
OVERLOOK DRIVE
KENDALL STREET
STANLEY STREET
KEITH CIRCLE
DEROCHE CIRCLE
LIBBY STREET
BARNA STREET
F01C
F01B
Fuller Brook
ATLANTIC STREET
NORTH ARTHUR STREET
ARNOLD STREET
ALFRED STREET
ALVIN STREET
ANDREW STREET
ARTHUR STREET
BRUNI AVENUE
GUERTIN AVENUE

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Preliminary BMP design

Constructed stormwater BMP facilities have been demonstrated effective in addressing bacteria through sedimentation, filtration, sorption, desiccation, predation, and photolysis. Note that BMPs recommended for this area were selected based on their ability to promote at least one of these processes. Sedimentation and filtration (via infiltration) were the most applicable processes given site conditions. Other BMPs which have been reported to be highly effective for addressing bacteria were considered impractical in most cases due to space limitations, depth to groundwater, layout of existing infrastructure, and other site-specific constraints. These BMPs include: bioretention, tree box filter, and sand filter facilities.[1]

At the Fuller Brook study area, a bioretention area was proposed at the Helena Circle location, where the constructability of this BMP appears to be feasible based on available data. A bioswale was proposed in a second, high visibility area. Design of the bioswale will likely not include an underdrain, so increased infiltration is probable, and the function of the bioswale will resemble a bioretention area. The remaining design in the Ludlow focus area feature BMPs proficient in sediment removal and infiltration (deep sump catch basins, sediment vaults, leaching catch basins, dry wells, and infiltration chambers). Based on soil survey data, BMPs are proposed in hydrologic soil groups A, B, and/or C.

Engineering consultant Amec Foster Wheeler worked with project partners, including municipal officials from Chicopee and Ludlow, to review BMP options for Szot Park on Abbey Brook and the Moody/West/Holyoke Street drainage area to Fuller Brook. The objective for Amec Foster Wheeler was to limit bacteria-impacted stormwater runoff in these two areas through conceptual (10%) design of suitable BMPs. They began the work by reviewing data, conducting site visits, and conferring with the existing project team. Out of this process, the consulting engineers produced Technical Memorandum #1, recommending stormwater best management practices for consideration by municipal officials, PVPC, and C4RWC. See Appendix D. Discussion of this memo helped to provide guidance for preliminary design. For the City of Chicopee, the major considerations have to do with the uncertain future of the dams and creating BMPs that would remain in place and look good regardless of the future scenario. For the Town of Ludlow, the major consideration was to ensure that BMPs not create a major maintenance burden. The resulting designs are responsive to these considerations.

At Szot Park, the consulting engineers prepared stormwater BMP preliminary designs with the existing dams in place and alternatively with both the Upper and Lower Bemis Pond dams removed. In addition to structural BMPs that limit contaminated runoff, the design includes landscaping to discourage geese from gathering. Recommended structural BMPs include a sediment forebay at the top of the hillside to reduce the velocity of waters draining from the nearby roadway, a bioswale that gradually winds its way from the top to bottom of the hillside where geese congregate. The idea is to use "cut" from the bioswale to create a "fill" area, essentially a berm, closer to the pond's edge that along with vegetation will serve to block the

[1] *Coastal Stormwater Management through Green Infrastructure: A Handbook for Municipalities*, December 2014, U.S. EPA, Office of Wetlands, Oceans and Watersheds National Estuary Program.

movement of geese from the pond to adjacent hillside. See Appendix E, which includes preliminary BMP design plans, costs, and pollutant removal capability for Szot Park.

At Szot Park addressing non-point source pollution is primarily addressed through source control (i.e., removal of geese by transforming the landscape to be less attractive to waterfowl), and secondarily through structural BMPs (sediment forebay and bioretention swales). Bioretention areas, sand filters, and tree boxes were not proposed at this location because drainage patterns do not flow to a central area, other than Upper and Lower Bemis Pond. Structural BMPs are not proposed within the ponds. The serpentine nature of a bioswale allows potentially-impacted stormwater sheet flow from a large area to be captured, treated, filtered, and/or infiltrated prior to reaching the surface waters of the ponds. The sediment forebay will promote sediment removal prior to road runoff reaching the bioswale(s) and the ponds.

For the Moody/West/Holyoke Street drainage area to Fuller Brook, there is very little publically owned space aside from the roadway right of ways and a 10, 890 square foot lot at the intersection of West and Holyoke streets. As such, the consulting engineers devised several stormwater BMPs, tied to catch basins with varying pretreatment and infiltration schemes depending on available right of way space. They also designed an infiltrating cul de sac for Helena Circle that can serve as a model for other cul de sacs throughout Town. For the vacant parcel at the corner of West and Holyoke streets, they recommended the installation of two BMPs, one of which would route drainage from the intersection via a curb cut to a sediment forebay and swale system, and the other which would capture flow from West Street and route it through a sediment removal structure and then a chambered infiltration system. See Appendix E, which includes preliminary BMP design plans, costs, and pollutant removal capability for Moody/West/Holyoke Street drainage area.

Table 7: Background Summary for Proposed BMP Sites

Background Issue	Fuller Brook	Szot Park / Abbey Brook
Soils	Several (see Attachment A in Appendix D)	Urban Land-Hinckley-Windsor association, 0-15% slopes
Hydrologic Soil Group	A, B, C - Site-specific determination required	A for Hinckley and Windsor and D for Urban Land - Site-specific determination required
Flood Zone	Site specific	Lower portions of bioswales within 100-year flood zone
Wetland	• Site-Specific • Resource Areas Along Fuller Brook • Possible Work in Buffer Zone	• Resource Areas Along Pond Edge • Possible Work in Buffer Zone • Isolated Wetland Area
Permitting	Possible Filing with Conservation Commission	Filing with Conservation Commission

Education and outreach

Throughout the course of the project, C4RWC promoted its partnership and provided updates on progress on its website. There were also several specific events associated with this project.

June 14, 2015 - C4RWC held its training for volunteers on its regular bacteria monitoring program. PVPC attended the training to announce the MassDEP 604b grant and promote the forthcoming source tracking program, describing site locations that were being identified and the draft study design.

Keith Davies of Chicopee 4Rivers Watershed Council talks with volunteers about collecting samples.

April 28, 2016 - A robust media outreach effort, starting in March, attracted 17 volunteers to a training program for source tracking at the Ludlow Public Library. See Appendix F for press release and articles. The evening program involved engaging volunteers in talking about their love for a special place on the Chicopee River, reviewing locations of sampling sites and organizing volunteers into teams based on interest in certain sites, a discussion of study objectives, review of equipment/sampling kits and handouts. Then the program moved outdoors with each team carrying their sampling kit to sample at a nearby outfall. Volunteers learned how to correctly grab bacteria and surfactant samples, take air and water temperature, record and note flow out of the outfall, and obtain and analyze a sample for ammonia using test strips.

June 3, 2017 - Two major outreach events were held, one in Chicopee at Szot Park and the other in Ludlow at the Boys and Girls Club. Displays reporting on project results and materials on actions were shared with people to begin a process of improved awareness of how stormwater can impact local waters. Both “home grown” and larger BMP information was ready to share.

Keith Davies of the Chicopee 4Rivers Watershed Council talks with Chicopee resident Roger O'Neil and project volunteer Nat Arai at the Szot Park public outreach event.

The event at Szot Park in Chicopee was situated in view of the area that could benefit from BMP actions as noted in the preliminary design report. The event was publicized broadly and the weather was good. A display highlighting the issue of stormwater, the study, results and actions was presented. Residents and park officials, as well as volunteers came by to hear about how water quality could be improved in local waters by both simple “home grown” and more designed projects. BMPs for the park could be clearly displayed as the problem lay before them. Those engaged seemed to voice appreciation for this work and new awareness of the issues.

The event in Ludlow was held at the Boys and Girls Club Community Center. Promotion of the event was posted on a number of town-wide web sites, as well as the local paper. The Club can be a busy location and some sporting events were in progress nearby. The same display was set up and a number of discussions with residents ensued. This location,

however, is at some distance from the Fuller Brook BMP area, which does not really offer any community space for an event. Engaging neighbors in the BMP area will take some greater effort going forward.

Turnout was modest at both June 3 events. PVPC and C4RWC talked about the importance of "piggybacking" onto larger community events in order to capture larger audiences. Possible events later in these season could be: Celebrate Ludlow, Chicopee Kielbasa Festival, and Chicopee Farmers Market. C4R will be looking to be at such events in the future and will incorporate this project where possible in our "service story" and education/outreach efforts.

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Conclusions and Lessons Learned

Water quality sampling (dry/wet weather)

1. Wet weather can produce flows from highly urbanized areas contaminated with bacteria when compared with dry weather. This is especially evident with sampling of a "first flush," which seems to have occurred with the 5/24/16 monitoring event when 0.23" of rain fell just before sampling began. It should be noted that there may be great variation too in the concentration of contaminants in this first flush, depending on how much time has passed since the previous rain event.

2. Locations that indicated repeated high levels of *E. coli* during storm flows that are concerning for recreational use of the river are:

- The outfall of Abbey Brook at the Chicopee River (A01) showed elevated levels of *E. coli* bacteria during all four sampling events.
- In stream locations on Fuller Brook showed repeated problems with elevated *E. coli* during the wet sampling events, with the middle of the system site (F02) showing high hits during three sampling events and the upper (F01) and lower (F03) sites on the system showing high hits during two sampling events.
- The outfall at Grochmal Street (CO7) showed elevated bacteria on two occasions.
- The two instream sampling locations on lower Poor Brook (P03 and P04) showed elevated bacteria (unrelated to sewage) on one occasion.
- The outfall at the lower part of Ludlow Mills (C03) had elevated bacteria on one occasion.

3. Illicit discharges may not be evident during dry weather events, especially if there is no flow in an outfall. On the 5/10/16 dry event, the Main Street, Indian Orchard outfall (C04) in Springfield, did not show any evidence of flow. The illicit discharge at this location only became apparent during the second dry sampling event and certainly during all the wet sampling events.

4. The EPA bacteria source tracking protocol seemed to prove effective in helping distinguish where there were locations impacted by human sewage/illicit connection to the storm system. EPA should perhaps consider revising the protocol so that there is some explicit mention that testing for surfactants be limited to those locations where analysis shows high bacteria levels. It should be noted too that the surfactant analysis must be conducted within 48-hours of sample collection. This refinement of the protocol would reduce hazardous waste and limit human exposure to the problem chemicals (propanol, chloroform, and sulfuric acid) used in analyzing samples for surfactants. Recommending a mask or ventilation system would also be a valuable addition to this protocol. There should be some thought about the use of this protocol in complying with the MS4 permit. How and where will municipalities be able to conduct this analysis? Do they have a facility where they can do this analysis? How will they collect and dispose of the waste generated from this analysis?

5. Despite what seemed to be highly contaminated flows coming from tributaries and outfalls, the Chicopee River mainstem appeared to have a diluting effect, with the bacteria results at the Davitt Bridge site (C09) indicating that waters even met the EPA standard of "acceptable for moderate full body contact recreation" (236-298 colonies/100ml). It would be good to pursue inquiry on the impacts of what are essentially "pulses" of contaminated flows through the tributaries.

6. For future sampling in highly urbanized locations, it may be worth reevaluating the timing of sampling relative to rainfall. These systems, given the surrounding impervious cover, are extremely flashy with storm flows moving through them at high volume and high velocity in a short period of time. Sampling that occurs within 6 or 12 hours rather than 24 hours could provide a better picture of just how impacted these systems are by the surrounding land uses. Mobilizing volunteers in this shorter time frame, however, could prove very difficult. Coordinating with lab services could also prove difficult.

7. It is believed that this study has yielded some good specifics that elaborate on exactly how to sample at an outfall and how to improve use of the EPA source tracking protocol. Going forward, this protocol will be further refined by PVPC for use in the region to help municipalities with MS4 permit compliance work.

Water quality sampling (source tracking) and subwatershed investigation

8. Those locations with persistent evidence of bacteria contaminated flows based on a variety of wet weather events and a variety of sampling times during source tracking are:

- Szot Park as it drains to Abbey Brook
- Moody/West/Holyoke Street area as it drains to the outfall on Fuller Brook

In the Szot Park subwatershed, there is some contribution of stormflow from the nearby neighborhood, a cemetery, and the park itself. Two dams in the park along this reach of Abbey Brook, form upper and Lower Bemis Pond. The adjacent maintained grass areas of the park, which attract Canada geese, directly contribute storm runoff to the surface waters here. There is also evidence of beaver activity upstream of the park with cut trees forming an extensive dam just below Armory Street.

The subwatershed area and storm system draining to the Moody/West/Holyoke Street outfall was developed in the 1980s as part of the Westover Industrial Park and includes commercial and residential properties. A subwatershed investigation during a high flow event indicates that storm runoff is coming from lower Moody and West streets (with apparently little to no runoff from the upper drainage system). And unlike Szot Park, there does not seem to be one specific identifiable source of bacteria other than urbanized storm flow.

It is important to note that at the writing of this final report, a large beaver dam was discovered in the area above Moody Street. The property owner and Town are taking action now to address this situation. This could explain why the field investigation found almost no flow in the upper reaches of the drainage system. The beaver dam was discovered when it

breached and sent flood waters into parking lots and buildings below. So while the beavers were likely not the source of bacteria in this study, flow at this point could carry higher bacteria levels with their dam having been breached.

9. Wet weather source tracking presented some serious logistical challenges given the unexpected combination of three factors:

- The source tracking phase of the study occurred in a severe drought period, presenting more limited opportunities to source track.
- Volunteers were unable to mobilize as readily as we had hoped. PVPC and C4RWC staff had the help of only two volunteers.
- Several wet weather events had to be passed over because the Connecticut River Conservancy lab did not have capacity to do the analysis. The lab is not staffed full time and they were at times at capacity in terms of the numbers of samples they could receive. It should be noted that the lab did try its utmost to accommodate later in the season when they expanded their capacity to run E.coli analysis and when staff came in on days off. Future source tracking projects ought to consider whether it makes sense to use another lab with greater availability so that wet weather opportunities are not lost.

10. Going forward, provided adequate funding, C4RWC could consider continued sampling at the Grochmal Street outfall (C07), the outfall locations at Ludlow Mills B (C03), Indian Leap (C05), and Worcester Street (C06), and possibly Poor Brook. More data over a longer period of time could help better characterize what may be occurring in these locations.

11. Fuller Brook results presented some interesting possible insights into what it means to catch a storm at different times of passage through the system. It appears each event caught the storm flow at different points of passage: 8/22 halfway through or more, 9/27 near the start, and 11/16 near the end. All of these were fairly good size storms occurring within 24 hours of sampling, but the concentrations of high bacteria levels within the sampling region are inverse for the first two events, and perhaps passed on the last (though not in the Moody outfall pool). Never the less, during two of these events, the Moody / West/ Holyoke Streets outfall had elevated *E. coli*.

12. Access to outfalls and the river itself can present significant challenges to source tracking. Despite the high hits on Fuller Brook lower in the system, which occurred twice each at F03 and F02, source tracking was hampered by several barriers. At F02, there are landfill operations to the east, west, and north. Looking upstream from F03, Fuller Brook is culverted under the Massachusetts Turnpike.

13. Future sampling might move further up into the Fuller Brook system, especially around Harris Pond. While Ludlow Public Works did not flag any major outfalls into Harris Pond for this project, it is likely that the residential area around it drains into the pond. The pond often shows signs of high nutrient conditions. Also, geese are present in the pond and adjoining land areas at times. Perhaps BMPs at Szot Park can inform what might be useful here for discouraging geese.

14. Despite the urbanization of the project area, it seems that wildlife have noticeable impacts on water quality in the stream systems. Future study could make use of microbial source tracking to help provide better understanding of which wildlife sources are having greater impacts: beaver vs. geese, etc. PVPC has been talking with a new faculty member in the Smith College Engineering Program, who is expert in microbial source tracking. There may be opportunities to do some targeted follow up this fall on Abbey Brook and Fuller Brook to enhance understanding about *E. coli* sources.

15. This project illustrates the challenge of outreach in beginning a process of sparking awareness of a seemingly hidden (but clear) problem and changing the prevailing culture of use to one of stewardship. The ever widening means of connecting to people of different ages (few young people responded on this project) make outreach even more challenging. Planning a future project of this sort may consider making outreach its central purpose and its science its compliment component.

Education and Outreach

The BMP recommendations and preliminary design plans coming out of this project are in and of themselves another important education and outreach tool. PVPC worked with municipal officials to explore the feasibility of submitting a 319 grant in this most recent round.

Through discussions, it became clear that despite the water quality issues in Szot Park, City of Chicopee officials would like to get a better handle on the future of the dams before investing in stormwater BMPs. In conversations with the Chicopee DPW Director and City Planner, there is an interest in revisiting the possibility of a 319 application for this work in next year's round.

Ludlow is just now hiring a new DPW Director as they have been without for at least one year. The Town Engineer who participated in project work is also very interested in working together starting next January or February to build support for submitting a 319 project for the Moody/West/Holyoke streets area. In the meantime, the Town Engineer has indicated that construction planning for Helena Circle, will incorporate the preliminary design for s stormwater BMP cul de sac. This has provided some good inspiration for a how a cul de sac can help to manage stormwater flows.