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NPS Proj. # 07-04e

Morgan Brook Watershed Based Plan

Barkhamsted, New Hartford and Winchester, CT
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Prepared by the
Northwest Conservation District
www.conservect.org/northwest

Northwest Conservation District

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Executive Summary

Morgan Brook is listed as a Category 5 impaired waterbody on Connecticut's List of Impaired Waters according to the reporting requirements for Section 303(d) of the Federal Clean Water Act. In the case of Morgan Brook, high concentrations of *Escherichia coli* (*E. coli*) bacteria have impaired most of the stream for recreational use. While regular water quality sampling has revealed this issue, the source(s) of this impairment has not been identified. Therefore, a team of environmental scientists from the Northwest Conservation District (NCD) walked all the streams and tributaries of the watershed performing visual inspections of stream corridor health. Failing septic systems can cause high bacteria counts, but none were identified. Large areas of impervious surface (over 30 acres) in the upper watershed were surveyed and no stormwater quality or quantity treatment measures were identified. NCD has identified uncontrolled stormwater runoff from these large areas of impervious surface - associated primarily with commercial development - as the most likely source of *E. coli* bacteria as well as other water quality degrading nonpoint source pollutants impacting Morgan Brook. A series of Low Impact Development (LID) style retrofits are recommended to minimize the negative impacts of impervious surfaces. In addition, an agricultural operation close to a major tributary was noted which may also be contributing bacteria. NCD will encourage the farm manager to seek assistance from the USDA Natural Resource Conservation Service to address potential issues.

Watershed Description

Morgan Brook flows north from West Hill Pond in New Hartford, then East along State Route 44 through Barkhamsted before emptying into the West Branch of the Farmington River near Century Wood Working on Route 181, just south of the village of Pleasant Valley in Barkhamsted. The headwaters of Morgan Brook are West Hill Pond in New Hartford, and Mallory Brook which drains a section of Winchester along its southeastern border with Barkhamsted. The headwaters of the Morgan Brook Watershed begin at an elevation of 950 feet above mean sea level and empty to the Farmington River, approximately 450 feet above mean sea level. An elevation change of 500 feet occurs over 3 miles meaning Morgan Brook has a moderately steep stream gradient of 3%.

The flow energy created by the moderate stream gradient allows Morgan Brook to be very efficient at carrying sediments down its steam corridor and into the Farmington River. This was confirmed by the lack of sediment deposition noted throughout the watershed.

Figure 1. Typical Streamflow of Morgan Brook

The Morgan Brook Watershed, identified by the Connecticut Department of Energy & Environmental Protection (CT DEEP) as Subregional Basin #4305, is approximately 3 miles long and 4 miles wide at its greatest point. Morgan Brook watershed is nested within the Farmington Regional Basin (#43) which lies within the Connecticut River Major Basin (#4). The watershed is comprised of approximately 5,800 acres which is drained by approximately 9 miles of perennial streams, including the tributaries and the main stem of Morgan Brook. Greater than 80% of the watershed lies within the town of Barkhamsted. See Table 1 for additional data for Morgan Brook watershed.

Table 1
Background Data for Morgan Brook Watershed

Morgan Brook Subregional Basin #	4305
Farmington Regional Basin #	43
Connecticut River Major Basin #	4
Local Basin Size	5,800 acres / 9 square miles
Main Stem Stream Length	3.1 miles
Perennial Stream Density	1.1 miles of stream per square mile
State Highway Length (44, 318 and 181)	3 miles
Local Road Length	25 miles
Road Density	3 miles of road per square mile
Road Stream Crossings	32

Land use/land cover within the Morgan Brook watershed is mostly forested with a large area of commercial development within the Winchester headwater region. The remaining non commercial areas are characterized by forest or low density residential cover types with a few small agricultural operations. Watershed percentage of land use/land cover types are summarized in Table 2.

Table 2
Current Land Use / Cover Classifications in the Morgan Brook Watershed
(depicted as a percent of the watershed / approximate acres)

Low Density Residential	7.1% / 412 ac	Pasture	3.0% / 17 ac
Medium Density Residential	1.9% / 110 ac	Bare Ground	0.6% / 35 ac
High Density Residential	0.6% / 35 ac	Open Water	5.0% / 290 ac
Commercial Development	1.2 % / 70 ac	Wetland	2.6% / 151 ac
Industrial	0.1% / 6.0 ac	Forested	73.2% / 4245 ac
Institutional	0.1% / 6.0	Transportation	0.6 % / 35 ac
Turf & Grass	4.6% / 266 ac		

For many years the Farmington River Watershed Association (FRWA) has been performing regular bacteria sampling in Morgan Brook. This regular sampling has revealed steady increases in bacteria concentrations, placing three out of four segments of this watercourse on the List of Waterbodies Not

Meeting Water Quality Standards which has been developed by CT DEEP as required by Section 303(d) of the Federal Clean Water Act (CT DEEP, 2010) (See Appendix E). This list is also known as Connecticut's Impaired Waters List. For details on Morgan Brook see the Assessment Results and Impaired Waters List in the 2010 State of CT Integrated Water Quality Report (CT DEEP, 2010). (See Appendices D and E) Connecticut's Impaired Waters List states the source of the impairments as "unknown".

One way to address water quality problems is to assess the entire watershed and create a United States Environmental Protection Agency (EPA)-approved watershed based plan. This document can then be used to help guide the towns and other stakeholders through a series of priorities that should be addressed in order to remove this stream from Connecticut's Impaired Waters List. These priorities could include increased sampling to narrow down locations of water quality degrading pollutants, retrofitting existing outdated stormwater infrastructure, and rigorous review of development or redevelopment projects that are proposed in the watershed. The overarching goal is to identify and carry out any and all opportunities to reverse the steady increase of water quality degrading pollutants being added to surface water.

Funded in part by the Connecticut Department of Energy & Environmental Protection through a United States Environmental Protection Agency Clean Water Act§319 Nonpoint Source Grant, Northwest Conservation District (NCD) conducted a visual track down survey of the entire Morgan Brook watershed to identify conditions responsible for high bacteria concentrations causing the impairment. The goal of the track down survey was to collect information on all the potential sources of impairment, and design a watershed based plan to layout recommendations to eliminate the sources of bacteria. The next step would be to implement proposed solutions in an effort to have the stream removed from Connecticut's Impaired Waters List. Table 1 and 2 summarize watershed statistics and defining characteristics needed to complete an abbreviated nine-element EPA watershed based plan for Morgan Brook.

US EPA Nine Elements of the Morgan Brook Watershed-Based Plan.

This plan is organized according to the methodology of an abbreviated nine-element EPA watershed based plan for Morgan Brook. The purpose of the plan is to identify the source(s) of the impairment using a qualitative assessment of information gathered by a track down survey. The information gathered during the visual assessment can then be translated into action items that will be used to focus efforts directly on addressing problem area(s).

In addition, a simple pollutant loading model has been employed as a screening tool to identify areas with the largest pollutant loads relative to the size of the land use/land cover types. This can be used to set up a framework that interested parties can use to select the best approaches for addressing potential sources of water quality impairments.

EPA Element One: Impairment

Water Quality Status

The Farmington River Watershed Association (FRWA) has been performing bacteria sampling (including *E. coli*) throughout the Morgan Brook Watershed since 2004. The most recent bacteria sampling took place in July of 2011. The Farmington Valley Health District (FVHD) has also been performing regular *E. coli* sampling at West Hill Pond at two bathing beaches. There are a total of twelve bacteria sampling locations on Morgan Brook (MB), Mallory Brook (ML) and one of its tributaries (Mltrib), and West Hill Pond (WHP). (See Table 3) A map of the Morgan Brook watershed with bacteria sampling locations is included with this Watershed Based Plan. (See Attachment – Interactive Watershed Map) Appendix A contains the results of bacteria sampling in the Morgan Brook Watershed.

Table 3
Bacteria Sampling Locations
(sampling results are included in Appendix A)

Location ID	Location Description	Sampling Organization
MB-1	B. Sullak Road Stream Crossing, 500 Feet East of W. West Hill Road, Barkhamsted	FRWA
MB-1.1	B. Sullak Road Tributary to Morgan Brook, Barkhamsted	FRWA
MB-2	East West Hill Rd Bridge at Rte 44, Barkhamsted	FRWA
MB-3	Rt 181 Stream Crossing, 400 feet from confluence with Farmington River, Barkhamsted	FRWA
ML-1	Forest behind Ledgebrook Plaza, Barkhamsted	FRWA
ML-1.9	100 Feet upstream of ML-2; above beaver dam, Barkhamsted	FRWA
ML-2	Southwest corner of Mallory Brook Plaza, Barkhamsted	FRWA
ML-3	Southeast corner of Mallory Brook Plaza, Barkhamsted	FRWA
Mltrib-4	East side of Mallory Brook Plaza, Barkhamsted	FRWA
ML-5	Rte 44 Stream Crossing in local basin # 4305-02-2-R1	FRWA
WHP-1	Brodie Park Beach at West Hill Pond, New Hartford	FVHD
WHP-2	Dillon Beach at West Hill Pond, New Hartford	FVHD

Morgan Brook is listed as a Category 5 impaired waterway on Connecticut's List of Impaired Waters according to the reporting requirements for Section 303(d) of the Federal Clean Water Act. Category 5 waters have at least one designated use that cannot be supported and the creation of a Total Maximum Daily Load (TMDL) is needed. In the case of Morgan Brook, the high concentrations of *E. coli* bacteria have impaired three out of four segments of the stream for recreational use.

E. coli concentrations in Morgan Brook regularly exceed the safe threshold for human contact. However, these exceedances are borderline. According to CT DEEP Water Quality Standards, *E. coli* recreational criteria is the geometric mean of samples taken over a 30-day period which needs to be less than 126

Colony Forming Units (CFU) /100 ml, with no sample testing higher than 576 CFU/100 ml for recreational uses other than swimming (CT DEEP, 2011). For designated and non-designated swimming areas, the single sample maximums are 235 CFU /100 ml and 410 CFU /100 ml, respectively. (See Appendix F for Water Quality Criteria for Bacterial Indicators of Sanitary Quality) *E. coli* concentrations in the Morgan Brook watershed have regularly exceeded the geometric mean standard. However, the 576 CFU/100 ml maximum was never exceeded (see Appendix A for sampled bacteria concentrations). Currently, the source of this impairment has not been definitely determined. However, non-point source pollution in uncontrolled stormwater runoff from large impervious surfaces associated primarily with commercial developments high in the watershed is a likely contributing factor.

These large areas of impervious surface are located along a commercially developed stretch of Route 44 in Winchester and Barkhamsted which drain to Mallory Brook, a major tributary of Morgan Brook. Although Mallory Brook has been assessed, it is not listed as impaired. (See Appendix D and Attached – Interactive Watershed Map) This information is a little deceiving, however, because Mallory Brook has not been assessed specifically for recreational use and *E. coli*. Therefore, it is possible that Mallory Brook is actually impaired but sufficient data has not been collected to substantiate this theory. Because FRWA has collected samples showing high bacteria concentrations adjacent to these commercially developed areas, NCD strongly suspects that they are a significant source contributing to the downstream impairment in Morgan Brook. As a result, most of this Watershed Based Plan focuses on this section of the watershed.

Another anomaly is the impairment of the segment of Morgan Brook which is located between the West Hill Pond dam outlet and its confluence with Mallory Brook. (See Appendix E and Attached - Interactive Watershed Map) Morgan Brook originates from West Hill Pond, and regular water quality sampling by FVHD at bathing beaches at either end of this pond have not revealed any water quality problems. In addition, a recent stormwater runoff survey conducted on behalf of West Hill Pond Association by Lenard Engineering, Inc., observes that existing water quality in the pond is excellent and the goal is to maintain or improve these conditions (LEI, 2011). CT DEEP assessment of West Hill Pond shows it to be fully supporting for all uses, including recreational use. (See Appendix D) For these reasons, it appears unlikely that West Hill Pond is contributing to the impairment of the segment of Morgan Brook that flows out of it. Although there is a small cluster of residential and commercial development at the head of Morgan Brook near the lake, NCD did not observe any activities or issues that would necessarily lead to downstream impairment. The rest of this segment of Morgan Brook is mostly forested and undeveloped. (See Figure 1) As NCD's field investigations did not reveal any obvious sources impacting water quality in this stream segment, further investigation of this area is recommended.

Finally, the segment of Morgan Brook that stretches between its confluence with Mallory Brook, downstream to where East West Hill Road crosses it, is also not listed as impaired. (See Appendix E and Attached - Interactive Watershed Map) However, as with Mallory Brook, this segment of Morgan Brook has not been assessed for recreational use and *E. coli*. (See Appendix D) This section is downstream of an impaired segment of Morgan Brook, downstream of Mallory Brook which NCD suspects as being impaired, and just upstream of two contiguous and impaired segments of Morgan Brook. Therefore, it is highly possible that this "unimpaired" segment is also impaired but there currently is not enough data to support this hypothesis.

Identification of Impairment Sources Using Track Down Survey Method

After reviewing existing water quality information, NCD undertook a Track Down Survey to identify potential sources of bacterial impairment as well as other situations that might be impacting water quality. This visual survey of Morgan Brook and its tributaries was conducted in September of 2010 following the methods described in an US EPA approved Track Down Survey Methodology. A more detailed description of the Track Down Survey which utilized the Center for Watershed Protection's Unified Stream Assessment Method Manual #10 is described below. Site impacts were assessed for all potential nonpoint pollution sources observed during the field survey. No water chemistry testing was performed as part of the Track Down Survey. However, the location of bacteria samplings and concentration results collected and analyzed by the Farmington River Watershed Association and the Farmington Valley Health District (Appendix A) have been incorporated into the watershed assessment.

The Track Down Survey was conducted throughout the Morgan Brook Watershed according to a modified version of the Unified Stream Assessment (USA) method developed for small urban watersheds by the Center for Watershed Protection (CWP, 2005). The USA is a protocol for a stream walk assessment that systematically evaluates conditions of stream channels to identify improvement opportunities, including storm water retrofits, stream restoration, riparian management and discharge prevention. The USA method consists of four steps:

1) Pre-field Preparation;
2) Stream Corridor Assessment;
3) Quality Control; and
4) Data Evaluation/Interpretation.

NCD conducted the Track Down Survey of Morgan Brook according to these steps, as follows:

1. Pre-field Preparation:

Prior to conducting the surveys, the field team was established and trained, supplies gathered and organized, survey reaches defined, field maps generated, assessment routes and schedules planned, and the public/streamside landowners notified about the surveys. Aerial photos from 2004, topographic maps, and existing data about known problem areas were reviewed to assist in defining survey reaches of uniform character and to familiarize field staff with the area to be surveyed. The watershed contains 11 local basins or sub-watershed areas (identified on accompanying map). The field survey data sheets are identified and organized according to the local basin identification number (e.g., 4305-00-3-R2). District staff also worked with municipal officials in planning and conducting the surveys. Their local knowledge and experience were beneficial in the identification of stream impairments and their sources.

2. Stream Corridor Assessment:

A team of two staff conducted the field surveys. The surveys were conducted in September of 2010 when water flows were slower and water levels lower, making it safe to walk in the stream channel. Surveys were also conducted during dry weather to eliminate the possibility that a rain event might: wash away algae, obscure the presence of aquatic vegetation or otherwise make it difficult to determine normal conditions pertaining to water level, color, odor and turbidity.

Field assessment forms were used to document conditions, problems, and possible restoration/improvement actions. Eight "Impact Assessment Forms" were used to record specific

information about the condition and restorability of individual problem sites identified along the stream corridor. These include: Storm Water Outfalls, Severe Erosion, Impacted Buffers, Utility Impacts, Trash and Debris, Stream Crossings, Channel Modification, and Miscellaneous Impacts. These forms contain questions that collect field data that is important to evaluating pollution source problems, which could include bacteria. Photographs were archived with each survey form to document the condition of the stream at the assessed location. A map of the survey locations with their associated survey data sheets and photos are included in the watershed map on the CD attached to this report. (See Attachment – Interactive Watershed Map)

3. Quality Control:
Field team responsibilities were divided with one member focused on the impact assessment field survey data sheet and the other taking photos and recording GPS locations. The field team walked in an up-stream direction but turned and faced downstream when determining right/left bank issues. Individual impact sites were mapped and photographed as they were encountered, and impact assessment forms completed and ID numbers assigned. Survey data locations and characteristics were compiled in Appendix B. Data was entered immediately after fieldwork was completed, and spot checked by the QA manager. Field team members reviewed draft stream corridor maps with site impact assessment locations to identify inaccuracies in data entry and fill any gaps in stream corridor coverage.

4. Data Evaluation/Interpretation:
Stream Crossings/Stormwater Outfalls - Most of the survey sheets describe the many road crossings in the watershed (Figure 2). Stream crossing survey sheets were completed for thirty-two locations throughout the Morgan Brook watershed (Table 4). All of the stream crossings were stable. However, most had stormwater runoff directly entering the stream from stormwater outfall pipes or by sheet flow. While no one stream crossing stood out as a problem source, collectively, untreated runoff from these locations is likely altering the water quality in Morgan Brook. After reviewing all the potential sources of bacteria and water quality degrading pollutants, stream crossing were assigned a low priority as compared to the problem areas identified by both through visual inspections and the pollutant loading analysis describe below.


Figure 2 West Hill Road Structured Stream Crossing

Table 4 Field Survey Data Sheets Collected			
ID	Impact Sheet	Sheet Description	No. Completed
SC	Stream Crossing	Culvert, Bridge or Dam	32
OT	Stormwater Outfalls	Outfall into watercourse	8

Agricultural Activities - During the field investigation of the watershed, a small agricultural/livestock operation was noted on Route 44 in the middle of local basin # 4304-02-2-R1. The property was posted so the field team did not walk it. Agricultural operations have the potential to contribute high levels of bacteria to surface water through stormwater runoff.

Impervious Surfaces - Impairment of water quality in a watershed is often caused by uncontrolled stormwater runoff from impervious surfaces. The upper reaches of the Morgan Brook watershed has many acres of impervious surfaces abutting the stream. Most of these expanses of impervious surfaces are associated with commercial and/or transportation-related development. Through land use/land cover analysis as well as field review, NCD identified five key locations where large areas of contiguous impervious surface have no stormwater quality or quantity management measures. In other words, there are no structures that renovate stormwater runoff or even detain and meter it slowly into the surrounding wetlands. Trackdown Field Survey Data Sheets were not created for these large areas of contiguous impervious surfaces because of the lack of a stormwater management system that could be evaluated. The five areas identified and the approximate impervious cover associated with each are as follows:

Green Ridge Condominiums and Former KFC Restaurant, Winchester		~2 acres
Ledge Brook Plaza, Winchester		~11.4 acres
State Commuter Parking Lot, Barkhamsted		~1 acre
Mallory Brook Plaza, Barkhamsted		~11.6 acres
Car Dealership, Barkhamsted		~4 acres
	Total	~30 acres

The close proximity of these developed areas to Morgan and Mallory Brooks allows stormwater runoff to enter the watercourse directly without any renovation. (See Attachment – Interactive Watershed Map and identified Areas of Concern; Also, see Figures 3, 4 and 5).

The Center for Watershed Protection (CWP) published a research monograph that comprehensively reviews the available scientific data on the impacts of urbanization and impervious surfaces on small streams (Thomas Schueler and Heather K. Holland, 2002). The negative impacts that impervious surfaces can have on waterbodies are generally classified according to four broad categories which look at changes associated with hydrologic, physical, water quality and/or biological indicators. More than 225 research studies were assessed to document the adverse impact of urbanization and impervious surfaces on one or more of these key indicators. In general, most research was focused on smaller watersheds, with drainage areas ranging from a few hundred acres up to ten square miles (Morgan Brook Watershed is 9 sq/mi). One conclusion extracted from the research review is that surface water quality starts to significantly degrade as impervious surface coverage increases in a watershed. Significant impacts occur when impervious cover reaches 10% and above. Currently, impervious surface cover within the entire Morgan Brook Watershed is well below 10%. However, a majority of the large expanses of impervious surfaces with no stormwater controls are within a few feet of the stream, and are concentrated in a headwater region. Therefore, based on the visual inspection of the entire watershed, non-point source pollution from these impervious surfaces is most likely a significant source of the bacteria that is impairing Morgan Brook.

West Hill Pond Storm Water Runoff Survey

The track down survey for the Morgan Brook watershed did not include an assessment of West Hill Pond and its associated watershed. A detailed study was conducted by Lenard Engineering, Inc. for the West Hill Pond Association entitled West Hill Pond Storm Water Runoff Survey (LEI, 2011). This document also contains recommendations for stormwater management (See Appendix C). As discussed previously, NCD does not suspect West Hill Pond of contributing to downstream impairment. (Note – The West Hill Pond Storm Water Survey was funded in part by the CT DEEP through a U.S. EPA CWA Sec. 319 Nonpoint Source Grant to the Connecticut Federation of Lakes under a small grants program for Connecticut lake associations.)

EPA Element Two: Load Reduction

As described previously, the area most likely contributing the largest bacteria loads, relative to the size of the land use category, are the expanses of impervious surfaces associated primarily with commercial and transportation-related development in the upper watershed of the Morgan Brook. These same impervious areas are probably also contributing nonpoint source pollutants such as nutrients and metals that may be degrading the water quality of Morgan Brook, as well.

Bacteria - Unfortunately, at the present time, there is no consistent data documenting the concentrations of *E. coli* generated by different land use/land cover types in the research literature. Therefore, it was not possible to include this information in the pollutant loading calculations described below. However, *E. coli* research, to date, indicates that uncontrolled stormwater runoff from commercial development sites and local/state roadways is often a large source of bacteria contamination in open water systems (Tufford D. and Marshall W., December 2002). The average concentration of *Fecal coliform* bacteria in urban runoff situations is 1,500 col/ml. Although you can not directly extrapolate *E. coli* concentrations from *Fecal coliform* concentrations, it is safe to assume that *E. coli* concentrations would also increase as impervious surfaces areas increase. Since the upper portion of the Morgan Brook watershed has approximately 30 acres of contiguous impervious surfaces that feed directly into Mallory Brook (a major tributary of Morgan Brook), and there are no stormwater quality controls managing runoff from these locations, these areas are likely a significant source of bacteria. Because there is currently no stormwater renovation occurring, any improvements in stormwater management will reduce bacteria loading to the Morgan Brook Watershed.

Other Nonpoint Source Pollutants – NCD also conducted a pollutant loading analysis to better understand other sources of nonpoint pollution in the watershed. The following protocol was used to calculate pollutant loads entering Morgan Brook. Using the calculated areas in Table 1, it is possible to determine the pollutant contribution of each land use/land cover category by using The Simple Method developed by Tom Schueler, 1987, as follows:

The Simple Method:
$L=0.226(P)(Pj)(Rv)(C)(A)$ where:

L = Pollutant loads to adjacent water resources in pounds
P = Annual rainfall depth (inches)
Pj = Factor to correct for rain events with no runoff

Rv =Runoff coefficient to correct for fraction of rainfall that turns to runoff
I = Impervious coverage where present (acres)
C = Concentration of pollutant (mg/l)
A = Acres of the watershed in specific land use land cover category
0.229= Conversion Factor

The following pollutants were chosen for modeling because of their known adverse impacts to water quality:

1) Total Suspended Solids (TSS)
2) Total Phosphorus
3) Total Nitrogen
4) Zinc
5) Total Petroleum Hydrocarbons TPH
6) Dissolved Nitrogen

Each land use/land cover category contributes different pollutant concentrations (C) to stormwater runoff. Data was gleaned from the resources listed below and included in Table 5.

Table 5
Pollutant Load Contribution "C" for each Land Use / Land Cover Type
(pollutant concentration contained in runoff mg/l)

	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	60	0.38	2.1	0.16	0.5	0.51
Medium Density Residential	60	0.3	2.1	0.18	1.25	0.344
High Density Residential	60	.3	2.1	0.22	1.5	0.344
Commercial Development	58	0.25	2.6	0.15	3.0	0.324
Industrial Development	50	0.23	2.1	0.17	3.0	0.324
Institutional Development	58	0.27	2.1	0.67	3.0	0.521
Transportation	99	0.25	2.3	0.15	3.0	0.375
Turf and Grass	357	1.0	2.92	0	0	.215
Pasture	145	0.38	2.2	0	0	0.65
Forest	90	0.10	1.5	0	0	0.215
Wetlands	0	0.38	1..5	0	0	0
Bare Ground	1000	0.38	1.5	0	0	0

1) National Stormwater Quality Database (NSQD), version 1.1-9/4/05 by Maestre &Pitt
2) National Urban Runoff Program (NURP), 1983
3) University of New Hampshire Stormwater Center

Using the information in Table 5, pollutant load analyses were calculated. The results of these calculations are captured in the Table 6 and Table 7.

Table 6
Pollutant Loading to Morgan Brook Watershed by Land Use / Land Cover Type
(annual contribution in pounds)

	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	59,466	376	2,081	160	496	505
Medium Density Residential	26,168	131	916	77	545	150
High Density Residential	10,496	52	367	38	262	60
Commercial Development	36,864	159	1,652	99	1,908	206
Industrial Development	3,318	9	87	28	124	24
Institutional Development	2,246	10	77	7	116	20
Transportation	18,133	46	421	29	549	69
Turf and Grass	49,068	137	401	0	0	30
Pasture	13,161	34	200	0	0	59
Forest	197,924	219	3,298	0	0	473
Wetlands	0	29	116	0	0	59
Bare Ground	5705	2	8	0	0	0
Total	422,549	1,204	9,624	438	4,000	1,655

Table 7
Pollutant Loading to Morgan Brook Watershed by Land Use / Land Cover Type
(percent contribution)

	TSS	TP	TN	Zn	TPH	DIN
Low Density Residential	14.1%	31.2%	21.6%	36.5%	12.4%	30.5%
Medium Density Residential	6.2%	10.9%	9.5%	17.6%	13.6%	9.1%
High Density Residential	2.5%	4.3%	3.8%	8.7%	6.6%	3.6%
Commercial Development	8.7%	13.2%	17.2%	22.6%	47.7%	12.4%
Industrial Development	0.8%	0.7%	0.9%	6.4%	3.1%	1.5%
Institutional Development	0.5%	0.8%	0.8%	1.6%	2.9%	1.2%
Transportation	4.3%	3.8%	4.4%	6.6%	13.7%	4.2%
Turf and Grass	11.6%	11.4%	4.2%	0.0%	0.0%	1.8%
Pasture	3.1%	2.8%	2.1%	0.0%	0.0%	3.6%
Forest	46.8%	18.2%	34.3%	0.0%	0.0%	28.6%
Wetlands	0.0%	2.4%	1.2%	0.0%	0.0%	3.6%
Bare Ground	1.4%	0.2%	0.1%	0.0%	0.0%	0.0%
Total	100%	100%	100%	100%	100%	100%

Commercial development only makes up 1.2% of the total watershed yet, proportionately it contributes a significant amount - 13.2% and 17.2% - of the total phosphorus and nitrogen load to the watershed. (See highlighted text in Table 7) As described previously, it is reasonable to predict that the commercially developed areas are also generating high concentrations of bacteria (Tufford D. and Marshall W., December 2002). This loading analysis of land use/land cover types directed our approach to focus on stormwater management of the large expanses of impervious surface associated primarily with commercial development. Because there is currently no stormwater renovation occurring, any improvements in stormwater management will reduce nutrient and metal loadings, and most likely bacteria loading as well, to the Morgan Brook Watershed.

West Hill Pond Storm Water Runoff Survey

The West Hill Pond Storm Water Survey (LEI, 2011) documents and ranks locations around West Hill Pond that contribute to pollutant loads. This document ranks stormwater infrastructure retrofits that would work best to reduce pollutant loads to the pond. (See Appendix C).

EPA Element Three: Management Measures

This section primarily focuses on impervious surfaces since these are suspected of being the primary sources of bacteria and other nonpoint source pollutants. Most of the large scale commercial development as well as transportation infrastructure - and associated expanses of impervious surface - within the Morgan Brook watershed were built before the concepts and strategies of Low Impact Development (LID) were common practice. Since the commercial and other developed areas are tightly grouped in one section of the watershed, it would be most efficient to start water quality management efforts in these locations.

Bacteria removal efficiencies of LID structures as well as traditional stormwater management structures are variable and tough to predict. However, one particular journal article advises that the best management practices for reducing bacteria concentrations in runoff are bio-retention structures and stormwater retention ponds (Stormwater, May 2008). The key to effective bacteria reduction in stormwater is to pass it through structures that retain water which allows for one or more of the following processes to occur:

- Photo-degradation by sunlight
- Microbial predation
- Filtration through soils or sediments that contain a high organic component
- Sedimentation
- Creation of an anaerobic environment

Gravel Wetlands do not fall into the category of bio-retention structures or stormwater management ponds but also provide the above mentioned elements that have been proven to increase *E. coli* die off rates. The processes listed above are also very efficient at removing most other pollutants generated by impervious surfaces.

Although bacteria removal efficiencies are difficult to predict, load reduction efficiencies for other types of nonpoint source pollutants, using different types of LID stormwater management structures have been well documented. (See Table 8) These stormwater water management structures should also reduce bacteria concentrations because they incorporate one or more of the processes described previously.

Table 8
Stormwater Quality and Quantity Management Structures
Pollutant Removal Efficiency Rate (*% removal*)

	Total Suspended Solids	Total Phosphorus	Total Nitrogen	Zinc	Copper	Total Petroleum Hydro-carbons	Total Dissolved Nitrogen	Source
Bioretention / Rain Garden	99	5	29	99	97	58	29	UNHS C07
Vegetated Swale	60	0	0	88	0	67	0	UNHS C07
Tree Box Filter	96	0	37	96	0	88	37	UNHS C07
Pond / Wetland System	71	56	19	56	59	0	40	NPRD 07
Extended Detention Wetland	69	39	56	0	0	4	35	NPRD 07
Surface Sand Filter	87	59	32	80	49	98	0	NPRD 07
Grass Filter Strip	68	29	0	45	42	0	0	NPRD 07
Infiltration Trench	0	90	42	0	0	0	82	NPRD 07
Gravel Wetland	99	55	99	99	99	99	99	UNHS C07
Porous Asphalt	99	38	0	96	0	99	0	UNHS C07

Sources: University of New Hampshire Stormwater Center – 2007 Annual Report (UNHSC07)
National Pollutant Removal Database, Version 3, 2007 (NPRD07)

As described previously, five areas in the upper watershed most likely contribute significant bacteria and other nonpoint source pollutant loads to Morgan Brook. Management measures recommended for each of these five areas are as follows:

<u>Green Ridge Condominiums and the former KFC Restaurant</u> (Winchester) - In this location, approximately 2 acres of impervious surface drains directly to Mallory Brook via a rip-rap channel with no visible control technology at the outlet (Figure 3).

Fig- 3 Green Ridge Condominium and Former KFC Restaurant

Given the space constraints, there are a limited choice of stormwater management retrofits that would be effective in this developed area. Stormwater management strategies could be dispersed throughout the development to cumulatively renovate stormwater so that end of pipe discharges would have reduced pollutant loads.

Stormwater management practices appropriate for use throughout the condominium development and KFC include underground sand filters, infiltration trenches and bioretention areas. These measures are commonly used when space is limited.

Ledgebrook Plaza (Winchester) - Ledgebrook Plaza contains approximately 11.4 acres of contiguous impervious surfaces that drain directly to Mallory Brook (Figure 4). Currently there is no stormwater quality or quantity management of runoff from this area. The health of Mallory Brook – and subsequently Morgan Brook - would benefit greatly if runoff from this commercial development were routed through a properly sized gravel wetland or extended detention wetland.

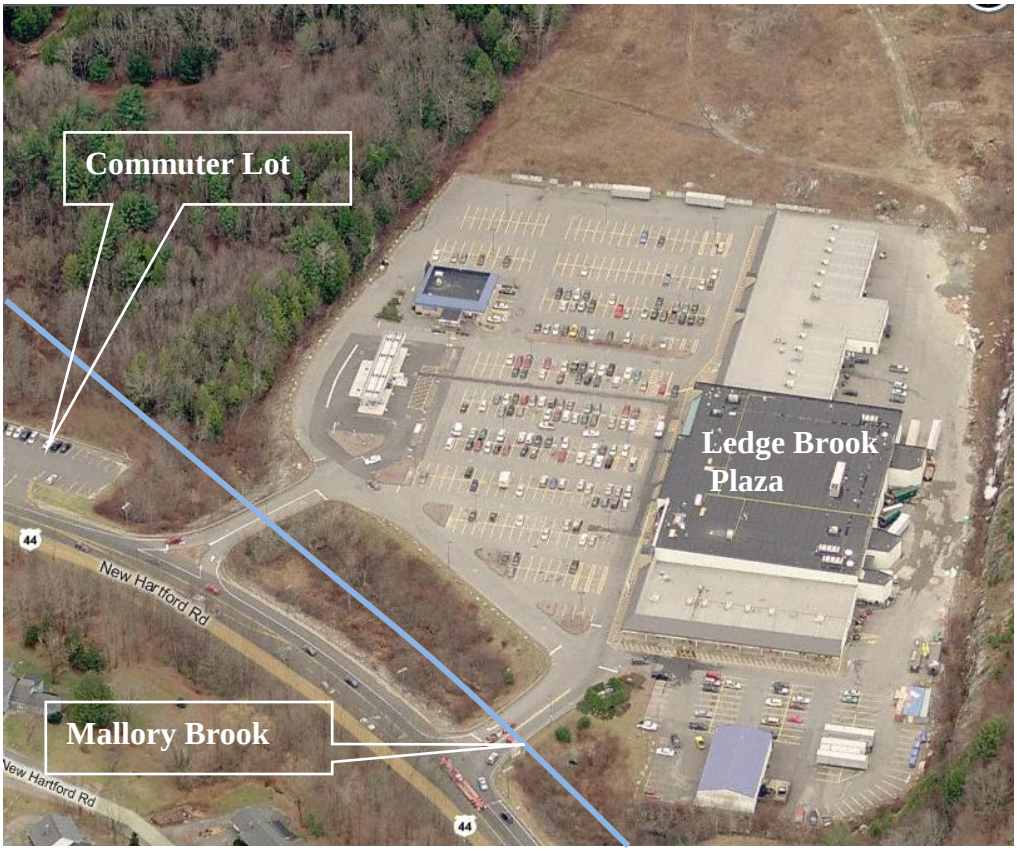

Figure 4 – Ledge Brook Plaza and State Commuter Parking Lot

State Commuter Parking Lot (Barkhamsted) - The State Commuter Parking Lot adjacent to Ledgebrook Plaza is almost 1 acre of pavement with no stormwater management measures (Figure 4). A simple bioretention measure or infiltration trench structure would help protect the water quality in Mallory Brook.

Mallory Brook Plaza (Barkhamsted) - Mallory Brook Plaza on Route 44 contains approximately 11.6 acres of contiguous impervious surfaces that drain directly to Mallory Brook (Figure 5). Currently there is no stormwater quality or quantity management in this area. It is recommended that runoff from this commercial development be routed through a properly sized gravel wetland or extended detention wetland. However, it may be necessary to use the combination of a smaller sized gravel wetland and extended detention wetland in a treatment train, given the extremely flat nature of the site.

In addition, the stream has been ditched between the Mallory Brook Plaza parking area and Route 44. Water quality would be improved if this portion of Mallory Brook could be returned to a more naturalized channel with meanders, pools and riffles. The ability for a stream to buffer against pollutant loading is greatly reduced when a stream is not allowed a more natural morphology. In other words, streams with a series of natural meanders pools and riffles, creating a diverse habitat for plants and animals, is better equipped to handle and renovate pollutant loads. Restoring stream morphology is an important retrofit consideration for this area.

Figure 5 Commercial Development and Car Dealership

Car Dealership (Barkhamsted) - A car dealership on the south side of Route 44 roughly opposite the Mallory Brook Plaza has 4 acres of contiguous impervious surfaces that drain directly to Mallory Brook (Figure 5). Stormwater quality management structure(s) are needed to treat stormwater runoff from the parking area and roof. Treatment systems could include a bio retention area, sand filter and perimeter bioswale. To minimize pollutants loads from generalized sheetflow, a filter strip should be combined with reestablishment of a riparian buffer.

Agriculture - To make sure the previously described agricultural operation is not or will not become a significant source of bacteria, NCD will approach the farm manager with assistance through a Conservation Technical Assistance Grant that is administered through the United States Department of Agriculture – Natural Resource Conservation Service USDA-NRCS.

West Hill Pond Storm Water Runoff Survey

As described previously, the West Hill Pond Storm Water Survey (LEI, 2011) contains recommendations for stormwater infrastructure retrofits that would work best to reduce pollutant loads to the pond. (See Appendix C).

Future Development - NCD also will continue to review development and re-development projects in the watershed to ensure the latest water quality management techniques are being employed. This will protect and improve the water quality in the Morgan Brook Watershed.

EPA Element Four: Technical and Financial Assistance

The approximate costs associated with design, permitting and construction of the stormwater structures discussed in the preceding section are as follows:

Greenridge Condominiums and Former KFC

See discussion under EPA Element Three – Management Measures. A more detailed assessment of stormwater management opportunities is needed to identify the most effective measures that would work on these challenging properties.

Ledge Brook Plaza

The University of New Hampshire just completed construction of a 1 acre Gravel Wetland that services 11 acres of impervious surfaces at a shopping plaza. The cost of constructing this 1 acre Gravel Wetland was over $200,000. Given that Ledge Brook Plaza also encompasses approximately 11 acres of impervious surface, NCD assumes that a gravel wetland retrofit for this area would also need to be at least one acre in size, and the cost would be approximately the same.

State Commuter Parking Lot

Installation cost of a bioretention structure would be approximately $20,000, and an infiltration trench would cost $30,000. A feasibility study would be needed to determine what the site conditions are, and which of these structures would be the most effective at treating stormwater at this site.

Mallory Brook Plaza

Similar to Ledge Brook Plaza, Mallory Brook Plaza would need a 1 acre Gravel Wetland installed for a cost of approximately $200,000. An alternative that may be cheaper to install would be an Extended Detention Wetland. The cost of a one acre Extended Detention Wetland would be approximately $150,000. It is difficult to estimate the cost of recreating a natural stream channel. However, this practice could be expensive, but efficiencies could be incorporated while implementing the recommended structures above.

Car Dealership

Stormwater quality management structure(s) to treat stormwater runoff from the parking area and roof could include any combination from the list below:

1) a bioretention area ($35,000)
2) a sand filter ($50,000)
3) a perimeter bioswale ($15,000)

Meanwhile, regrading and creating a vegetated filter strip in combination with a riparian buffer along Mallory Brook could be installed at a cost of approximately $30,000. This is assuming a 30 foot wide filter strip running for 150 feet along the stream bank.

Overall, the installation of the proper stormwater treatment infrastructure and reestablishment of a more natural stream channel in the upper Morgan Brook watershed could exceed $1,000,000. Funding and in kind services to design, permit and construct stormwater treatment structures in the upper Morgan Brook Watershed will need to originate from a number of private and public sources. These could include:

1) Commercial Property Owners
2) Towns of Winchester and Barkhamsted
3) Farmington River Coordinating Committee
4) Farmington River Watershed Association
5) Northwest Conservation District
6) Small Town Economic Assistance Program (STEAP) Grant
7) EPA Section §319 of the Clean Water Act Grant

Many of the entities listed above will need to be stakeholders along with NCD in implementing this Watershed Based Plan.

West Hill Pond Storm Water Runoff Survey

The West Hill Pond Survey (LEI, 2011) describes the cost associated with each stormwater retrofit recommendation. All the recommendations made in the survey would reduce pollutant loads to the pond, and protect and improve downstream water quality in Morgan Brook. (See Appendix C).

EPA Element Five: Public Information and Education

NCD has presented the results of the Watershed Based Plan to both the Town of Winchester Inland Wetland Commission and the Planning and Zoning Commission. NCD has also met with the First Selectman and Land use Administrator from the Towns of New Hartford and Barkhamsted to discuss the results of the Morgan Brook Watershed Based Plan (WBP). NCD will also provide each town with a hard copy and digital copy of the final Watershed Based Plan and map. NCD plans to continue working with the towns and other watershed stakeholders to facilitate small group brainstorming sessions to coordinate implementation of the Watershed Based Plan. Participation from Federal, State, municipal, non-profit and private sector entities will all be needed to achieve water quality improvement goals.

EPA Element Six and Seven: Implementation Schedule and Cost

In the grid below, projects have been ranked from highest to lowest priority, according to the greatest potential to reduce pollutant loading. The ranking was accomplished by looking at the amount of impervious surface that lacked water quality treatment and the ease of installing stormwater retrofits.

Project Priority Rank	Retrofit Installation and Estimated Cost	Proposed Time Frame: BMP research, project design, permitting and implementation
1. Ledge Brook Plaza	Gravel Wetland or Extended Detention Wetland ($200,000 to $250,000)	2 years
2. Mallory Brook Plaza	Gravel Wetland and/or Extended Detention Wetland ($200,000 and/or $150,000) Stream Morphology Repair (Cost unknown)	2 years
3. Car Dealership	1) Bioretention Area ($35,000) 2) Sand Filter ($50,000) 3) Perimeter Bioswale ($15,000) 4) Riparian Buffer & Filter Strip ($30,000)	1.5 years
4. State Commuter Parking Lot	Bioretention ($20,000 or Infiltration Trench, $30,000)	0.5 years
5. Green Ridge Condominiums / KFC Restaurant	Bioretention ($20,000 each) Infiltration Trenches ($30,000 each) Sand Filter ($50,00)	To Be Determined

Time estimates regarding the above proposed projects take into account the need for: more detailed site investigation, refinement of structure selection, property owner permission, engineered design, permitting and construction. Actual start date of implementation on any of these proposed measures will depend on developing cooperative relationships with property owners and other stakeholders, and raising adequate funds.

EPA Elements Eight and Nine: Milestones and Monitoring

Performance of stormwater management structures to treat runoff from all the impervious surfaces in the upper water will be measured by stream water quality monitoring. The Farmington River Watershed Association plans to continue sampling for bacteria from April through November at their established

sampling locations. In addition, Farmington Valley Health District will continue to sample West Hill Pond public swimming areas. Continued sampling for bacteria throughout the watershed will indicate if retrofit installations are effective. As discussed previously, the bacteria concentrations that trigger the impairment are borderline exceedances. Therefore, if any one of the problem areas is addressed, there is the potential that bacteria levels will drop to levels that would allow Morgan Brook and Mallory Brook to be removed from the Impaired Waters List.

Conclusion

After walking the entire watershed and performing visual inspections of all the stream channels and riparian corridors, NCD concluded that large areas of impervious surface associated primarily with dense commercial development in the upper watershed is the dominant factor contributing to the bacteria impairment of Morgan Brook. The fact that these large commercial developments are in the headwaters of the watershed makes management of stormwater a high priority. Degrading water quality and altering runoff volumes in the upper watershed can amplify problems throughout a watershed. Given the complete lack of stormwater management in this developed area, any stormwater improvements will bring measurable reductions in bacteria, nutrients and other nonpoint source pollutant loads. Managing stormwater will also reduce erosion throughout the watershed which will also improve water quality. NCD looks forward to working with the property owners, Towns of Barkhamsted and Winchester, and other stakeholder to address these important water quality management issues in the Morgan Brook watershed.

APPENDICES
Appendix A – Morgan Brook Bacteria Sampling Locations and Results
Appendix B – Track Down Survey Field Data Sheets with Photos (referenced on interactive map)
Appendix C – West Hill Pond Water Runoff Survey
Appendix D – 305(b) Assessment Results for Morgan Brook and Mallory Brook from 2010 Connecticut Integrated Water Quality Report
Appendix E – 303(d) Impaired Water Listings for Morgan and Mallory Brook from 2010 Connecticut Integrated Water Quality Report
Appendix F – Water Quality Criteria for Bacterial Indicators of Sanitary Quality – From 2011 Connecticut Water Quality Standards
Attachment – Interactive Watershed Map – Morgan Brook Impaired Watershed Study Area Map

Any comments or questions regarding this plan should be directed to the
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