Maine Statewide Bacteria TMDL:2013 Freshwater Addendum

Appendix A: Duck Brook Bacteria Sampling Project Reports

Report #: DEPLW-1254
August, 2013

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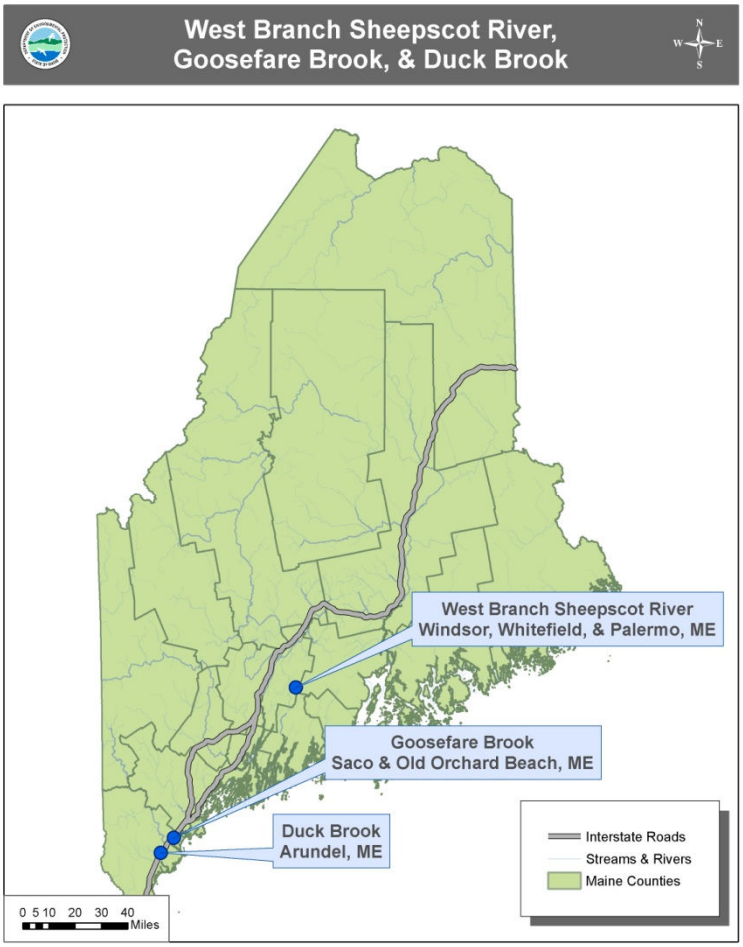

Maine Department of Environmental Protection - Created by: KNemmer, August 2013 - Data Sources: MEGIS, MDEP

Prepared for:

US EPA New England, Region 1

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
17 State House Station | Augusta, Maine 04330-0017

Restoration of Streams Impaired by NPS Bacteria

2012 Data Report
Duck Brook - Arundel, Maine

Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333

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ABSTRACT

The quality of Maine's surface waters, including rivers and streams, is assessed by a number of criteria including designated uses, dissolved oxygen, habitat, aquatic life, and bacteria. Based on these criteria, rivers and streams are assigned a Class of AA, A, B, or C. In freshwaters, the U.S. Environmental Protection Agency (EPA) recommends *Escherichia coli* as the best indicator of health risks associated with recreational waters. *E. coli* is used because it is naturally found in the intestines of all warm-blooded animals and indicates contamination from human, domestic animal, or wildlife fecal waste. A subset of Maine streams impaired by *E. coli* has been selected for study in the Restoration of Streams Impaired by NPS Bacteria project with the goals of: identifying the source of contamination, removal of those sources, and restoration in the form of removal of the stream from Maine's list of impaired waters. Duck Brook was added to the study in 2011. Wetland watersheds were added this year to characterize *E. coli* in natural systems, to assess the impact of wetland bacteria counts on the downstream receiving waters, and to understand what portion of an impaired system might have a natural signature. This year's survey continues to indicate bacterial impairment of Duck Brook with human-sources contributing a significant amount of contamination in some areas. This report outlines suggested actions for addressing potential sources which will improve water quality on Duck Brook and the Kennebunk River into which it flows.

INTRODUCTION TO DUCK BROOK

Duck Brook is a Class B stream situated in the town of Arundel in York County, Maine (Figure 1). The lower main stem flows for 0.31 miles before it empties into the Kennebunk River. The Duck Brook watershed drains approximately 6.64 square miles of the greater Piscataqua-Presumpscot-Saco watershed. In addition to the main stem, five tributaries are included in this discussion.

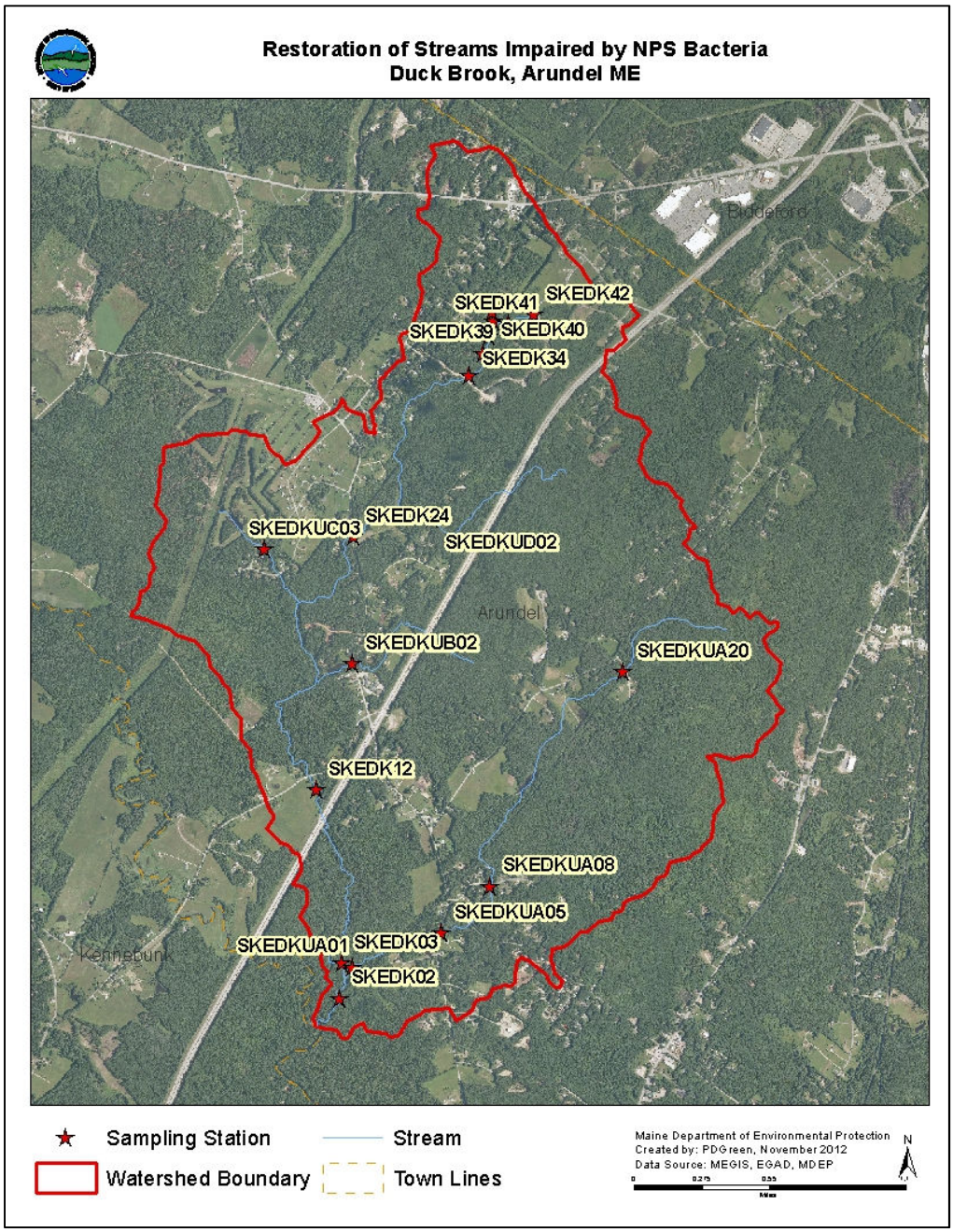

Figure 1. Duck Brook flows through a mixed landscape.

The Duck Brook watershed is primarily defined by natural drainage divides resulting from topography and elevation contours. Watershed drainage is also subject to development, land use, and impervious surface. The Duck Brook watershed has 6.0% impervious surface nested within a land cover mosaic of: 7.6% development including developed open spaces; 72.1% coniferous, deciduous, or mixed forest vegetation; 7.1% agriculture characterized as pastures, crops, or blueberry fields; 3.3% wetland cover; and 9.9% classified as other with herbaceous plants and shrubs (Figure 2).

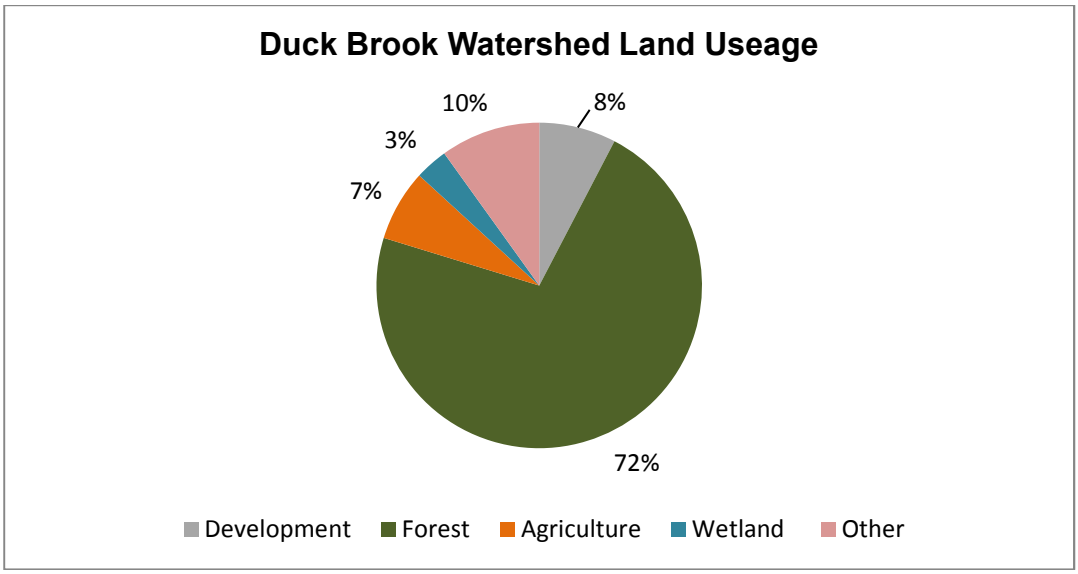

Figure 2. Forest covers the majority of the Duck Brook watershed.

Class B streams in Maine must meet water quality goals for designated uses, habitat characterization, dissolved oxygen content, and numbers of Escherichia coli bacteria. Additionally, discharges into Class B waters must support the aquatic species and biological community that naturally occur there. Duck Brook's waters must meet a geometric mean standard (calculated average) of no more than 64 MPN/100 mL of bacteria from human and domestic animal origin, and an instantaneous criteria (one-time reading) of no more than 236 MPN/100 mL *E. coli*; both criteria must be met to attain Maine Water Quality Standard (WQS) in regard to bacteria.

Duck Brook has not been listed in the Maine DEP Integrated Water Quality Monitoring and Assessment Reports, nor was it included in the Maine Statewide Bacteria TMDL report which was approved by the U.S. Environmental Protection Agency (EPA) in 2009. Its receiving waters, the Kennebunk River, is listed however, so Duck Brook was added to the Restoration of Streams Impaired by Non-Point Source Bacteria project with the same goals as the project: to identify sources of bacteria, eliminate the problems, and document improvement in water quality that will restore the Kennebunk River and remove it from the 303(d) list of impaired waters.

METHODS

Sampling stations were established to achieve representative sampling of the watershed (Figure 3) The downstream location (SKEDK02) on the Eastern Trail was close to the downstream site

sampled last year (SKEDK01; this location was more easily accessed but determined to be close enough for good comparison. Upstream, most sites had been established in 2011 with few exceptions. Station codes were assigned according to DEP river mile conventions to reflect specific points along Duck Brook and its tributaries. For example, SKEDKUA20 reflects 2.0 miles (20) upstream on unnamed tributary A (UA) which flows into Duck Brook (DK), then the Kennebunk River (KE) and then into the southern (S) extent of the Gulf of Maine.

The extensive sampling plan presented the opportunity to partner with Maine DEP's Volunteer River Monitoring Program (VRMP). VRMP volunteers sampled the lower watershed and Tributary A while DEP staff sampled the watershed upstream of and including SKEDK12 on Downing Road. An investigation of the upper segment of Duck Brook revealed that a mapped section of the main stem was actually a tributary; a new station was established at a culvert (SKEDK42) that fed the upper main stem of the brook.

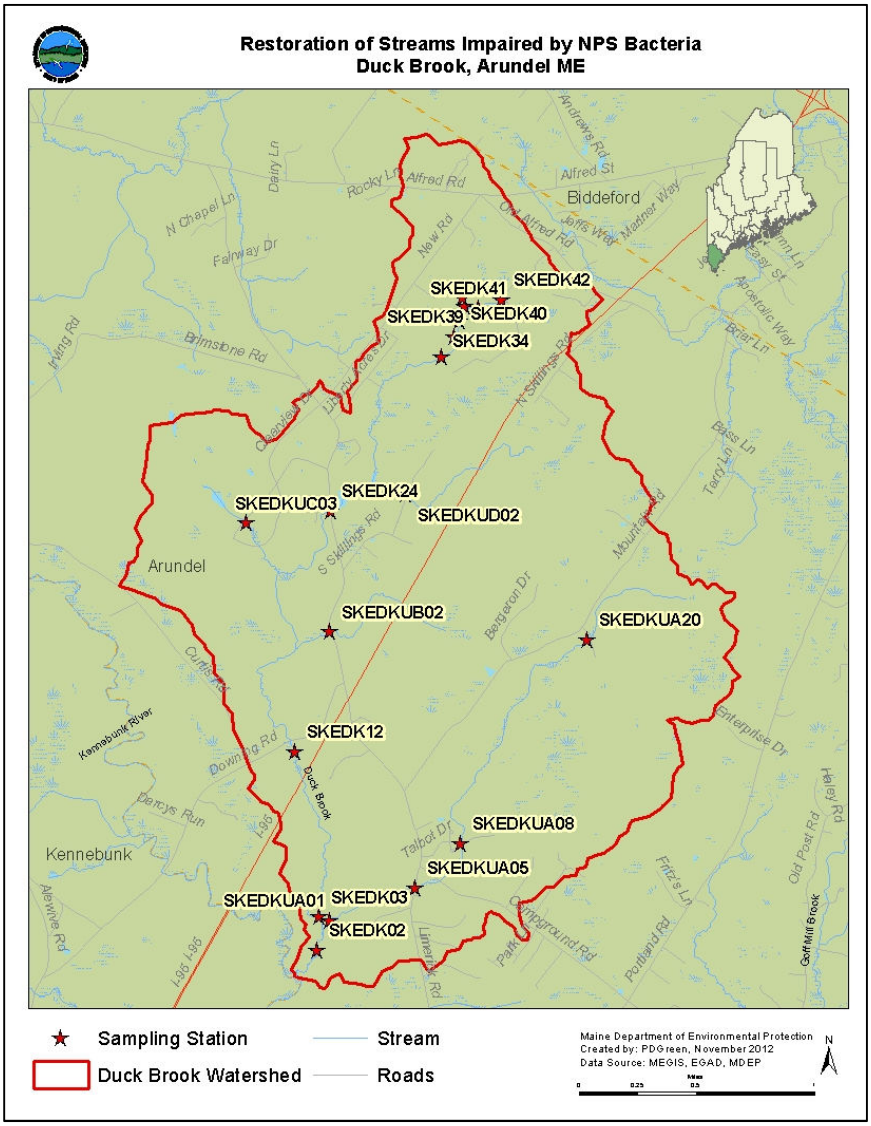

Figure 3. Extensive sampling of the Duck Brook watershed involved two sampling teams in 2012.

Geographic coordinates were verified using either a Garmin Etrex or a Garmin GPSmap 76CSx hand held GPS unit (Table1). Photographs were taken using a Canon Powershot A2200 pocket camera.

Table 1. Geographic coordinates and description of sampling stations ensures consistent monitoring over time.

StreamName	SiteCode	Description	Town	UTM_X	UTM_Y	Lat	Long
Duck Brook	SKEDK02	downstream of Eastern Trail where bridge crosses brook	Arundel	375337	4809419	-70.5402	43.4273
Duck Brook	SKEDK03	upstream of Eastern Trail, west of trib A	Arundel	375353	4809645	-70.5400	43.4293
Duck Brook	SKEDK12	downstream of Downing Rd	Arundel	375187	4810774	-70.5423	43.4395
Duck Brook	SKEDK24	upstream of Limerick Rd	Arundel	375428	4812419	-70.5397	43.4543
Duck Brook	SKEDK34	upstream of unpaved road at south end of Bartlett Farms	Arundel	376185	4813466	-70.5306	43.4639
Duck Brook	SKEDK39		Arundel	376270	4813609	-70.5296	43.4652
Duck Brook	SKEDK40		Arundel	376307	4813717	-70.5292	43.4661
Duck Brook	SKEDK41		Arundel	376441	4813802	-70.5275	43.4669
Duck Brook	SKEDK42	downstream culvert just past entrance to Bartlett Farms	Arundel	376599	4813860	-70.5256	43.4675
Duck Brook Tributary A	SKEDKUA01		Arundel	375421	4809620	-70.5392	43.4291
Duck Brook Tributary A	SKEDKUA05		Arundel	376004	4809843	-70.5320	43.4312
Duck Brook Tributary A	SKEDKUA08		Arundel	376316	4810147	-70.5282	43.4340
Duck Brook Tributary A	SKEDKUA20		Arundel	377184	4811538	-70.5178	43.4467
Duck Brook Tributary B	SKEDKUB02		Arundel	375425	4811592	-70.5396	43.4469
Duck Brook Tributary C	SKEDKUC03		Arundel	374851	4812335	-70.5468	43.4535
Duck Brook Tributary D	SKEDKUD02		Arundel	375941	4812532	-70.5334	43.4554
Duck Brook Tributary E	SKEDKUE00		Arundel	376343	4813813	-70.5287	43.4670
Duck Brook Tributary E	SKEDKUE01		Arundel	376332	4813876	-70.5289	43.4676

Precipitation data was obtained through Weather Underground for the Sanford, Maine station KSFM. Rainfall was noted as either base flow or storm flow. Base flow conditions are defined as precipitation less than 0.1" during the 24 hours prior to sampling, and storm flow conditions are defined as precipitation 0.1" or greater during the 24 hours prior to sampling.

Meters were used to collect water quality data. An ECtester Plus conductivity pen was used to assess water temperature (°C) and conductivity (µS/cm). A Hach 30d ODO meter was used to measure dissolved oxygen concentration (mg/L), dissolved oxygen saturation (%), water temperature (°C), and to verify the time of data collection (EST). Conductivity was averaged for each station. Conductivity was also assessed as a deviation from the mean of a system so that, in areas of high conductivity due to road treatments or geologic influences, hot spots could be isolated from an otherwise subtle signature.

Water samples were collected from May through September with the goal of including equal base flow and storm flow samples. Routine samples were collected at established stations. From a representative flow, water samples were collected in 100 mL sealed, sterile IDEXX

bottles. The water samples were maintained on ice or ice pack in a cooler for no more than eight hours before delivery to the laboratory. Samples were processed using the IDEXX method at the DEP Biological Laboratory or by a different method at the Health and Environmental Testing Laboratory (HETL); both labs are located in Augusta, Maine. At the DEP lab, samples were treated with Colilert, incubated for 24 hours ± 2 hours, and read as MPN/100 mL (Most Probable Number in a 100 mL sample).

Water samples for optical brightener tests were collected in clean bottles at two sampling stations, SGSBR01 and SGSBRUC03. Samples were maintained in a dark container during transport to DEP's Southern Maine Regional Office in Portland where Maine Healthy Beaches staff processed them, using fluorometric methods. Results were reported in ug/L units. Optical brightener values were averaged for each station. Optical brighteners were also assessed as a deviation from the mean of a system so that, in urban areas with generally high optical brightener values, hot spots could be isolated from an otherwise subtle signature.

Water samples to test for pharmaceutical products were collected in amber glass jars provided by EPA Region 1. Samples were maintained in a cool, dark environment until they were transferred to EPA personnel for transport to and analysis in their laboratories. Results were reported in ng/L units.

RESULTS

More than a dozen sampling stations were regularly surveyed by two teams from May through September in 2012. Six stations in the lower watershed were visited by Maine Volunteer River Monitor Program (VRMP) volunteers; data from their season are forthcoming and not fully discussed in this report. Maine DEP sampled seven stations in the upper watershed; this report highlights those results. In addition to these routinely surveyed stations, exploratory sampling was conducted to assess the impaired upstream segment of Duck Brook in the Bartlett Farms development.

In the upper watershed, a total of four base flow and two storm flow events were sampled. All precipitation data was obtained for the weather station KSFM at Sanford, Maine and recorded as inches of rainfall for the day of sampling, for the previous 24 hours, and for the previous 48 hours.

A geometric mean calculation was used to summarize *E. coli* bacteria instantaneous results (Table 2). The overall main stem geometric mean of 103 MPN/100 mL exceeded Water Quality Standards. The downstream sampling station at SKEDK02 on the Eastern Trail had a geometric mean of 83 MPN/100 mL and two of the six instantaneous values exceeded WQS. The station at Bartlett Farms, SKEDK34, did not attain WQS; it had the highest geometric mean of 625 MPN/100 mL and an exceedance of six of the seven instantaneous values. Tributary A and Tributary B both exceeded geometric mean and instantaneous WQS. Tributary C attained the geometric mean, but exceeded one of the six instantaneous values during storm flow. Tributary E is the tributary previously mapped as the upper main stem.

Table 2. Results of 2012 E. coli bacteria sampling on Duck Brook including the a) the main stem b), the tributaries, c) the upper watershed at Bartlett Farms, and d) tributary A. SF=Storm Flow and BF=Base Flow. Red instantaneous values exceed WQS. Green geometric means meet standards, yellow slightly exceeds standards, orange exceeds standards, and red indicates an extreme exceedance of standards. NS = Not Sampled and - indicates lack of data at the time this report was drafted.

2.a. Duck Brook main stem bacteria results for 2012.

DUCK BROOK MAIN STEM E. COLI ALL CONDITIONS	Eastern Trail SKEDK02	Limerick Rd SKEDK03	Downing Rd SKEDK12	Limerick Rd SKEDK24	Bartlett Farms SKEDK34	Bartlett Farms SKEDK42	Day Geomean	Overall
Flow & Date								
SF: 05/17/2012	54.8	90.6	NS	67.7	488.4	NS	113	
SF: 06/13/2012	366.0	249.0	NS	NS	NS	NS	302	
BF: 06/19/2012	-	-	23.3	43.7	461.1	14.8	51	
BF: 07/5/2012	435.0	727.0	NS	NS	NS	NS	562	
BF: 07/23/2012	-	-	76.3	1.0	26.5	NS	13	
SF: 07/24/2012	64.0	28.0	NS	NS	NS	NS	42	
SF: 08/13/2012	-	-	88.2	298.7	1299.7	62.7	215	
BF: 08/14/2012	111.0	46.0	NS	NS	NS	NS	71	
BF: 08/21/2012	-	-	25.6	115.3	816.4	23.1	86	
BF: 08/27/2012	13.0	9.0	NS	NS	NS	NS	11	
SF: 08/29/2012	111.9	-	NS	NS	2419.6	NS	520	
SF: 09/05/2012	-	-	920.8	1986.3	2419.6	727.0	1339	
BF: 09/11/2012	24.0	14.0	NS	NS	NS	NS	18	
								103
Geometric Mean	83	60	82	77	625	63		

2.b. Duck Brook bacteria results for tributaries for 2012.

DUCK BROOK TRIBUTARIES E. COLI BASE FLOW	Trib A SKEDKUA	Trib B SKEDKUB02	Trib C SKEDKUC03	Trib D SKEDKUD02	Trib E SKEDKUE01
Flow & Date					
BF: 06/19/2012	-	66.3	21.8	51.2	NS
BF: 07/5/2012	431.75	NS	NS	NS	NS
BF: 07/23/2012	-	52.0	5.2	17.3	NS
BF: 08/14/2012	357.00	NS	NS	NS	NS
BF: 08/21/2012	-	71.2	68.3	29.4	218.7
BF: 08/27/2012	113.75	NS	NS	NS	NS
BF: 09/11/2012	96.75	NS	NS	NS	NS
Average	250	63	32	33	219

2.c. Duck Brook at Bartlett Farms

DUCK BROOK AT BARTLETT FARMS E. COLI ALL CONDITIONS Flow & Date	SKEDK38.5	SKEDK39	SKEDK40	SKEDK41.25	SKEDK41.5	SKEDK42-ds	Day Average
SF: 05/17/2012	NS	NS	NS	NS	NS	NS	
SF: 06/13/2012	NS	NS	NS	NS	NS	NS	
BF: 06/19/2012	NS	NS	NS	NS	NS	NS	
BF: 07/5/2012	NS	NS	NS	NS	NS	NS	
BF: 07/23/2012	NS	NS	NS	107.6	39.3	NS	73
SF: 07/24/2012	NS	NS	NS	NS	NS	NS	
SF: 08/13/2012	NS	NS	NS	686.7	488.4	NS	588
BF: 08/14/2012	NS	NS	NS	NS	NS	NS	
BF: 08/21/2012	770.1	980.4	228.2	61.3	73.3	NS	423
BF: 08/27/2012	NS	NS	NS	NS	NS	NS	
SF: 08/29/2012	NS	NS	NS	NS	NS	NS	
SF: 09/05/2012	NS	NS	228.2	NS	344.8	816.4	463
BF: 09/11/2012	NS	NS	NS	NS	NS	NS	
Average	770	980	228	285	236	816	

2.d. E. coli bacteria at Tributary A of Duck Brook.

DUCK BROOK TRIBUTARY A E. COLI ALL CONDITIONS Flow & Date	Eastern Trail SKEDKUA01	Limerick Rd SKEDKUA05	Talbot Drive SKEDKUA08	Hidden Meadows SKEDKUA20	Day Geomean	Overall
SF: 05/17/2012	75.4	57.3	60.5	22.6	49	
SF: 06/13/2012	816.0	260.0	1300.0	1046.0	733	
BF: 06/19/2012	-	-	-	-		
BF: 07/5/2012	99.0	488.0	1046.0	94.0	263	
BF: 07/23/2012	-	-	-	-		
SF: 07/24/2012	31.0	816.0	517.0	256.0	241	
SF: 08/13/2012	-	-	-	-		
BF: 08/14/2012	114.0	921.0	214.0	179.0	252	
BF: 08/21/2012	-	-	-	-		
BF: 08/27/2012	10.0	365.0	10.0	70.0	40	
SF: 08/29/2012	-	-	-	613.1	613	
SF: 09/05/2012	-	-	-	-		
BF: 09/11/2012	5.0	152.0	86.0	144.0	55	
						151
Geometric Mean	52	314	186	168		

Conductivity was calculated as an average for each sampling station in the upper watershed - data was not yet available from the lower watershed sampling efforts (Table 3). The station at SKEDK12 on Downing Road had the lowest conductivity value of199 µS/cm. At the routinely sampled main stem stations, the highest conductivity was at the Limerick Road station, SKEDK24, at 248 µS/cm.

Table 3. Conductivity was high at all sampling stations in the upper watershed of Duck Brook.

DUCK BROOK UPPER MAIN STEM CONDUCTIVITY	Downing Rd SKEDK12	Limerick Rd SKEDK24	Bartlett Farms SKEDK34	Bartlett Farms SKEDK42
Date & Flow	µS/cm	µS/cm	µS/cm	µS/cm
SF: 5/17/2012	NS	142	147	NS
BF: 6/19/2012	135	164	147	233
BF: 7/23/2012	232	280	322	NF
SF: 8/13/2012	274	309	245	203
BF: 8/21/2012	223	289	256	249
BF: 8/29/2012	NS	NS	240	NS
SF: 9/5/2012	130	303	213	188
Average	199	248	224	218

Conductivity values were assessed based on their deviation from a system mean, using an average of all available Duck Brook main stem conductivity values to establish a system mean (Table 4). The stations upstream of the Bartlett Farms station SKEDK34 were all higher than the Duck Brook system.

Table 4. Assessment of conductivity based on a deviation from a system mean revealed relatively higher values in the upper watershed, in the Bartlett Farms area.

Duck Brook main stem - Conductivity	Conductivity (µS/cm)	Deviation from System Mean
SKEDK01	101	-106
SKEDK02	180	-28
SKEDK03	120	-87
SKEDK12	199	-8
SKEDK24	248	41
SKEDK34	237	30
SKEDK39	215	8
SKEDK41.25	252	45
SKEDK41.5	297	90
SKEDK42	218	11
System Mean (Duck Brook main stem)	207	

Optical brightener samples were assessed based on their deviation from a system mean, using an average of all Duck Brook optical brightener values to establish a system mean (Table 5). A deviation from the mean of Duck Brook main stem optical brighteners was also calculated to see if there were tributaries that had locally higher levels, and a separate analysis of the upper stations upstream of SKEDK34 was conducted. Results varied, but the highest values seemed to be at SKEDK42, the newly established upstream site at the entrance to Bartlett Farms.

Table 5. Optical brighteners were detected in highest amounts at Bartlett Farms station SKEDK42.

Duck Brook main stem - Optical Brighteners	OB (ug/L)	Deviation from System Mean
SKEDK12	130.75	-16.49
SKEDK24	150.88	3.63
SKEDK34	131.80	-15.44
SKEDK42	175.50	28.26
System Mean (Duck Brook main stem)	147	

Duck Brook tributaries - Optical Brighteners	OB (ug/L)	Deviation from System Mean
SKEDKUA	119.75	-27.49
SKEDKUB02	153.20	5.96
SKEDKUC03	97.80	-49.44
SKEDKUD02	137.20	-10.04
System Mean (Duck Brook main stem)	147	

Source tracking of pharmaceutical products was conducted during the August 2012 EPA assessment of small streams (Table 6). Most pharmaceuticals were detected at all three stations with the highest values seen at Bartlett Farms station SKEDK34. Acetaminophen is a pain medication, atenolol is prescribed for high blood pressure, caffeine is found in coffee and tea, carbamazepine is prescribed for seizures and mood disorders, cotinine is a metabolite of nicotine (not from cigarette butts), 1,7-dimethylxanthine is a metabolite of caffeine, and metropolol is prescribed to treat high blood pressure and some heart conditions..

Table 6. Pharmaceutical levels highest at Bartlett Farms SKEDK34, though other stations also had elevated levels (Surf = surfactants, Acet = Acetaminophen, Aten = Atenolol, Caff = Caffeine, Carb = Carbamazepine, Coti = Cotinne, 1,7-dim = 1,7-dimethylxanthine, Metr = Metropolol. BF = Base Flow. RL = Reporting Limit. ND = Not Detected).

Duck Brook - Pharmaceuticals ng/L							
SiteCode	Acet RL 2.0 ng/L	Atenl RL 2.0 ng/L	Caff RL 4.0 ng/L	Carb RL 0.4 ng/L	Coti RL 0.4 ng/L	1,7-dim RL 2.0 ng/L	Metr RL 2.0 ng/L
SKEDK02	ND	ND	15	ND	1.7	15	ND
SKEDK34	2.2	1.3	230	1	9.7	21	2.8
SKEDKUA 20	ND	ND	4.20	1.40	0.77	1.10	ND

DISCUSSION

Sampling protocol was followed for all sampling events. Most samples were collected in the morning or early afternoon with four base and two storm flows represented. Additional sampling during storm flow conditions could yield a better understanding of the source of bacterial contamination. More extensive tracking with pharmaceuticals could also help to further connect bacteria to human sources.

In general, this year's bacteria results were consistent with previous results. Duck Brook exceeded Maine Water Quality Standards for instantaneous and geometric mean criteria for *E. coli* bacteria. Contamination appears to be related to hot spots with Tributary A and Bartlett Farms being the most impaired locations.

Since fecal coliform bacteria live in the intestines of humans and other warm-blooded animals, its detection in natural waters warrants investigation into the source and route of contamination.[1] Potential human sources include: failing septic systems or faulty sewer connections, wastewater treatment plants, 'accidents' during swimming, overboard discharges from boats, or combined sewer overflows (CSO). Potential sources from other warm-blooded animals include: manure, livestock near or in the stream, pet waste, birds, or other wildlife.

There are human sources of Duck Brook's bacteria to be considered. While there are no municipal sewer systems or combined sewer overflows in the area, there are a number of residences with private subsurface wastewater disposal systems. The waters are not conducive to boating, and there are no beaches or likely areas for swimming or water-based recreation, but there were fishermen seen at the small pond at the Downing Rd station, SKEDK12. The most likely potential human source of *E. coli* seems to be a failing septic system in proximity to the stream.

There are some farms and farm fields in the watershed that could contribute manure runoff or place livestock near, or in, the stream channel. There are nearby residences that could be a source of pet waste from cats, dogs, or other domestic animals. The woodlands and wetlands along the stream corridor and in the upland watershed could support a diverse and abundant population of birds and wildlife that may contribute to bacteria, either directly or indirectly through surface runoff of fecal material.

E. coli bacteria survive longer in moist, muddy waters[2]. Natural habitat along the stream channel and adjacent uplands can influence water quality and the presence *of E. coli* bacteria. Duck Brook has 6.0% impervious surfaces in the watershed that, when in close proximity to the stream, could facilitate storm runoff of pollutants, including bacteria, from upland areas into the waters.

The watershed has 72.1% forest cover and there may be small localized patches of timber harvesting; trees intercept rainfall, lessen its impact on the soil below, and maintain cooler temperatures of the soils, ground cover, and waters. Clearing trees and vegetation near the stream channel can results in increased turbidity and temperatures. This could boost bacterial colonization and result in elevated *E. coli* counts.

In Maine, conductivity in natural freshwater systems is usually less than 100 µS/cm. Elevated conductivity values can be related to geology, or they can indicate contamination from industrial processes, road chloride treatments, or sewage. The generally high conductivity throughout the

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[1] Bacteria and Water Quality, Chapter 2. USEPA Available from:
.http://www.usawaterquality.org/volunteer/ecoli/june2008manual/chpt2_ecoli.pdf. Accessed 29 Sept 2012.
[2] Bacteria and Water Quality. Available from:
http://www.usawaterquality.org/volunteer/ecoli/june2008manual/chpt2_ecoli.pdf

watershed is likely a result of road chloride treatments, but the relatively high values - based on deviation from the system's average - in the upper watershed Bartlett Brook development suggests a potential human-source of inorganic ions from wastewater.

There has been discussion about whether wetlands serve as a sink or source for *E. coli* bacteria. The Duck Brook watershed has 3.3% wetland cover, and this may contribute to fluctuations in *E. coli* counts but the wetland component of this study suggests only a minimal impact. A more thorough analysis is necessary to make a definitive determination.

The high *E. coli* bacteria paired with optical brighteners, pharmaceutical products, and the relatively high conductivity suggests a strong likelihood of human-sourced contamination at Bartlett Farms in the upper watershed and Tributary A that flows near the Eastern Trail. Human sources cannot be ruled out at other locations. While contributions from natural wildlife may be present, this influence is probably minimal.

RECOMMENDATIONS

Restoration of bacterially impaired stream systems begins with a thorough assessment of potential contamination sources for each known location of high bacteria, understanding that there may be a unique suite of human, domestic animal, or wildlife sources at particular points along a stream or river and that upstream contamination can impact downstream locations.

A systematic investigation of contaminated sites will either reveal a direct human source that can be remediated, suggest human activities that may exacerbate natural wildlife influences, or substantiate that bacterial contamination is solely from wildlife sources and natural processes. Recommendations include:

- Investigate private septic systems for malfunctions. A GIS overlay of tax maps with bacteria results has identified suspect properties. Conducting sanitary surveys of the stream to document pipes, waste matter, or other indications of human fecal material or discharges and using dye tests, smoke tests, or cameras, to explore subsurface systems could lead to major sources of contamination. One place to begin is the large tract of land upgradient and to the west of the upper reach of Duck Brook upstream of SKEDK34. Residences along Tributary A near the Eastern Trail are also suspect.
- Assess the impact of domestic animal waste. The Eastern Trail intersects the stream in several locations where runoff containing domestic animal waste could flow into the stream. Horses have been seen in the Laura Lane neighborhood, and that area could be surveyed for drainage ditches leading into the stream channel from pastures and barns. Upgradient and to the west of the upper reach of Duck Brook, the vegetation signature on aerial images shows some discontinuity with the surrounding landscape, and a clearing with a small pond may host a farm of some sort.
- Evaluate expansive open areas in the watershed that could impact segments of the stream. Impervious surfaces such as large parking lots, dense residential development, or roadways facilitate urban runoff that may contain pet waste and other surface

pollutants. Large parks and trail systems with grass and herbaceous cover off minimal filtration of storm runoff, and timber harvesting can introduce soil sediments into the stream.

The Kennebunk River has a documented history of *E. coli* bacterial contamination that has been traced to Duck Brook where hot spots have been identified as potential sources of bacteria from humans and domestic animals, and perhaps some small contribution from wildlife. Elimination of the problem can be accomplished by determination of the most likely source, the route of entry, and implementing structural improvements or behavioral changes to remove the sources. Although the stream has not been listed on the 303(d) list of impaired waters, it does affect general water quality in the receiving waters of the Kennebunk River.

2011 Data Report
Duck Brook - Arundel, Maine

Prepared by Heather Stukas
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1. Background

1.1. Kennebunk River

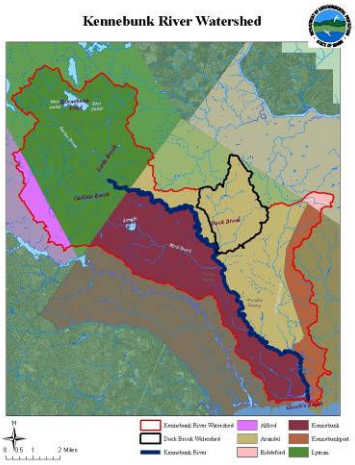


Figure 1.1: A map of the Kennebunk River watershed and surrounding towns.

The Kennebunk River is a Class B river located in York Country and it has a length of 17.6 miles and a watershed area of 38 square miles (see Figure 1.1). It originates at the confluence of Lords Brook and Carlisle Brook in Lyman and flows southwest through the towns of Arundel, Kennebunk and Kennebunkport before emptying into the Gooch's Beach. Located in in the Piscataqua River Watershed, the Kennebunk River is listed for "bacteria-only" impairment as specified in Maine's 2004 305(b) report, and remains on the updated 2010 list.[3] The bacterial contamination is listed as nonpoint source pollution and is widespread throughout the watershed[4].

In 2010, the Kennebunk River was sampled for macroinvertebrates and attained class B standards. This indicated the river is otherwise relatively healthy and is a great prospect for removal from Maine's 303d list of impaired waters,

The Maine Department of Environmental Protection (DEP) partnered with the Maine Healthy Beaches Program (MHB), who has monitored portions of the watershed extensively. The objective of the partnership is to assist MHB's efforts to clean Gooch's Beach by reducing bacteria load contributed from the Kennebunk River. Widespread bacterial contamination is difficult to address and requires breaking the watershed into subwatersheds that can be examined individually to identify potential sources. The subwatershed analysis is the most logical approach to identify and resolve bacterial sources. In 2008, MHB screened Duck Brook, a freshwater tributary in Arundel, and observed elevated bacteria counts; as a result DEP decided to follow up. DEP expanded efforts with strategic sampling to determine the extent of bacterial contamination.

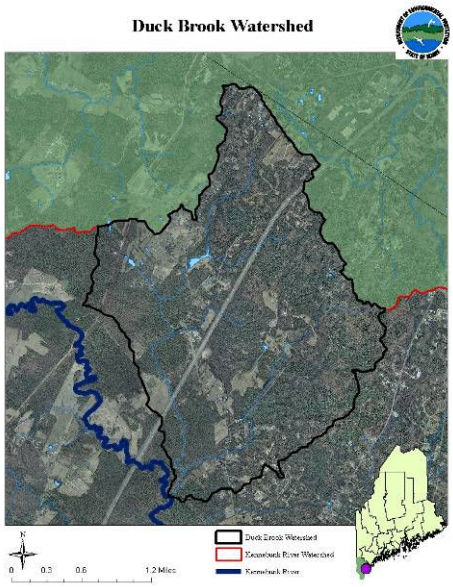


Figure 1.2: An aerial photo map of Duck Brook watershed boundary.

1.2. Duck Brook

Duck Brook is a Class B stream located in Arundel with a

[3] State of Maine, Department of Environmental Protection. (2008). *2008 Integrated Water Quality Monitoring and Assessment Report.*
[4] MHB KRW Special Study Data

length of 4.2 miles and a watershed area of 5.0 square miles (see Figure 1.2). The watershed is dominated by forested land (78%) and the remaining watershed is comprised agricultural and developed land, and wetlands. (see Figure 1.3).

2. Method

In 2008, MHB sampled three sites on Duck Brook: the mouth just before entering the Kennebunk River; the unnamed tributary off Limerick Rd. near the intersection of Campground Rd.; and below the Davis Pond outlet. In 2011, DEP took over those sampling stations and expanded throughout the watershed (see Table 1.1 and Figure 1.4). The Eastern Trail sampling station (SKEDK01) is equivalent of the MHB site at mouth and will be referred to as the original sampling station.

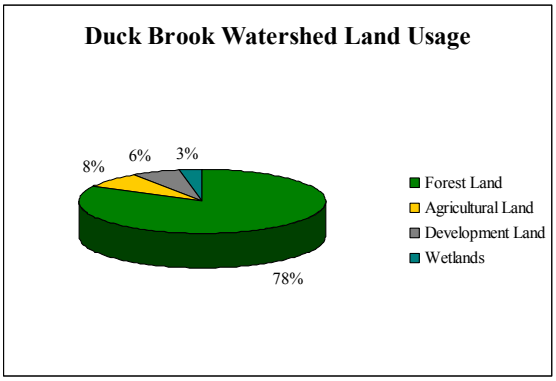
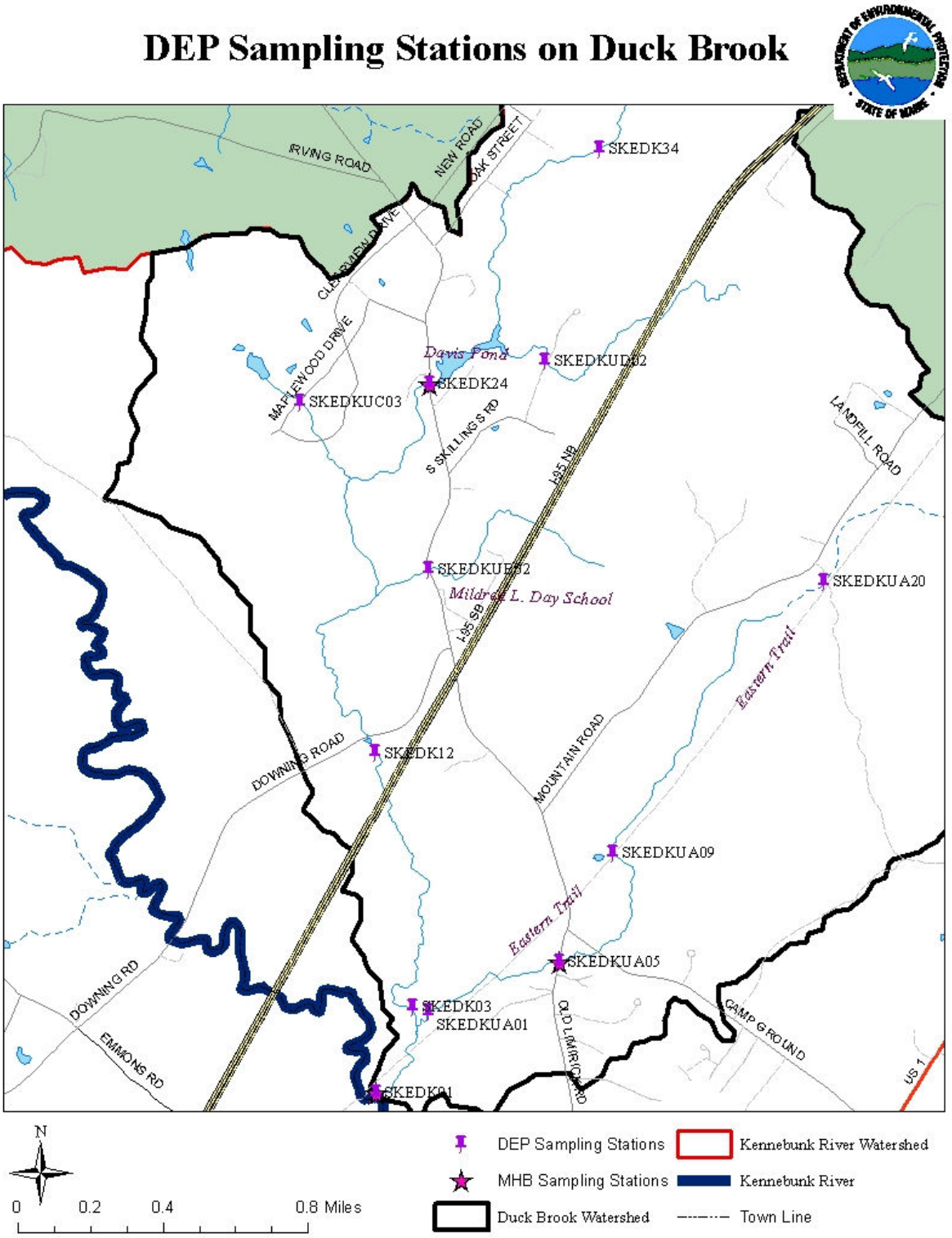


Figure 1.3: Watershed land usage specific to Duck Brook

Table 1.1: Below is a list of the sampling stations on Duck Brook with a description of their locations.

Segment Name	Site Code	Description of Locations
Duck Brook	SKEDK01*	Eastern Trail; Enter South on the Eastern Trail off Old Limerick Rd. walk down the trail (~0.75mi or 1.18Km), just before the bridge crossing of the Kennebunk River. At the beginning of the curve railing [on the left] before the bridge, walk down towards the brook in the northeast angle (~40m)
Duck Brook	SKEDK03	Eastern Trail; Enter South on the Eastern Trail off Old Limerick Rd walk down the trail (~0.50mi or 0.80Km), just before the bridge crossing of Duck Brook. Walk into the woods heading upstream (~0.10mi or 0.15Km), follow the brook until it branches (the main branch is the branch that is more "vertical". [sample above where Tributary A enters]
Duck Brook	SKEDK12	Downing Rd; Drive (0.36mi or 0.58Km) down Downing Rd, until Duck Brook crosses the road. Sample downstream about ~171ft or 52m below the pool.
Duck Brook	SKEDK24*	Limerick Rd; Sample upstream where Davis Pond drains into Duck Brook.
Duck Brook	SKEDK34	Bartlett Farms; Turn left on Tamrox Dr. into Bartlett Farm Subdivision off Old Alfred Rd. drive to the end of the pave road and turn right (~2.0mi or 1.50Km). Sample upstream just above the pool.
Duck Brook-Unnamed Tributary	SKEDKUA01	Eastern Trail; Enter North on the Eastern Trail off Old Limerick Rd. walk down the trail (~0.50mi or 0.80Km), just before the bridge crossing of Duck Brook. Walk into the woods heading upstream (~0.10mi or 0.15Km), follow the brook until it branches (Tributary A is the branch that is more "Horizontal").
Duck Brook-Unnamed Tributary	SKEDKUA05*	Limerick Rd; From the intersection of Campground Rd and Old Limerick Rd, turn left and drive (~0.13mi or 0.22Km). Sample upstream of Old Limerick Rd (~30ft or 9m above Skyview Acres Dr)
Duck Brook-Unnamed Tributary	SKEDKUA09	Eastern Trail; Enter the Eastern Trail off Old Limerick Rd. walk up the trail (0.20mi or 0.33Km) until Tributary A crosses the trail. Sample upstream.
Duck Brook-Unnamed Tributary	SKEDKUA20	Hidden Meadows; Drive (1.05mi or 1.69Km) on Mountain Rd. (coming from Old Limerick Rd) then turn right onto Hidden Meadows. Sample downstream (~36ft or 11m).
Duck Brook-Unnamed Tributary	SKEDKUB02	Limerick Rd; About (~0.10mi or 0.10Km) pass Mildred L Day School exit driveway; park on the left-hand side of road next to hydrant. Sample upstream about (~15ft or 4m).
Duck Brook-Unnamed Tributary	SKEDKUC03	Maplewood Dr; Drive (0.50mi or 0.75Km) down Maplewood Dr. go straight thru the stop sign (four-way). Sample downstream.
Duck Brook-Unnamed Tributary	SKEDKUD02	Laura Ln; Drive (~0.30mi or 0.45Km) on South Stillings Rd then turn left onto Laura Ln. Drive down (~0.20mi or 0.30Km) where Tributary C crosses. Sample downstream (~15ft or 4m).
The descriptions of locations are a supplementary resource; and should be used with a map of the watershed when locating the sampling stations.		
* Originally Maine Healthy Beaches Program sampling stations.		

Figure 1.4: Maine Department of Environmental Protection sampling stations on Duck Brook.



3. Data

The geometric mean for Duck Brook at the original sampling station is 208/100mL, and does not attain Maine geometric mean water quality standards (64/100mL). A compilation of the sampling stations yields an overall geometric mean of 128/100mL. The Hidden Meadows (SKEDKUA20) sampling station and the Barlett Farm (SKEDK34) sampling station had the highest geometric means, at 349/100mL and 348/100mL respectively. The Maplewood Dr. (SKEDKUC03) sampling station had the lowest geometric mean of 69/100mL. None of the sampling stations attain Maine's geometric mean quality standard (64/100mL).

Table 1.2: Below is a table summary of the 2011 bacteria counts on Duck Brook. The original sampling station Eastern Trail (SKEDK01) is outlined in purple.

2011 Bacteria Results Summary of Duck Brook

	SKEDK01: Eastern Trail (MPN/100mL)	SKEDK03: Eastern Trail (MPN/100mL)	SKEDK12: Downing Rd. (MPN/100mL)	SKEDK24: Limerick Rd. (MPN/100mL)	SKEDK34: Bartlett Farms (MPN/100mL)	SKEDKUA01: Eastern Trail (MPN/100mL)	SKEDKUA05: Limerick Rd. (MPN/100mL)	SKEDKUA09: Eastern Trail (MPN/100mL)	SKEDKUA20: Hidden Meadows (MPN/100mL)	SKEDKUB02: Limerick Rd. (MPN/100mL)	SKEDKUC03: Maplewood Dr. (MPN/100mL)	SKEDKUD02: Laura Ln. (MPN/100mL)	Overall (MPN/100mL)
Date & Flow													
SF: May 18th	138	NS	236	TE	NS	236	308	291	135	161	53	27	
BF: June 16th	124	143	236	517	NS	59	65	36	84	59	33	76	
BF: July 12th	130	102	130	161	1427	79	238	15	1046	326	236	66	
BF: August 4th	169	76	36	39	345	121	155	24	579	105	32	41	
BF: August 31st	140	68	80	102	131	96	162	115	269	126	46	313	
SF: September 8th	1553	1733	2420	1203	228	2420	2420	2420	980	488	179	488	
Geometric Mean	208	167	192	209	348	177	257	101	349	165	69	97	128

BF = Base Flow Sample; SF = Base Flow Sample; NF = No Flow; NS = Not Sampled; TE = Testing Error

Red = Extremely Exceed Standards; Orange = Significantly Exceed Standards; Yellow = Slightly Exceed Standards; Green = Complying with Standards

Figure 1.5: Below is a graph summary of the 2011 bacteria counts on Duck Brook. The original sampling station Eastern Trail (SKEDK01) is in the bottom left hand corner of the graph.

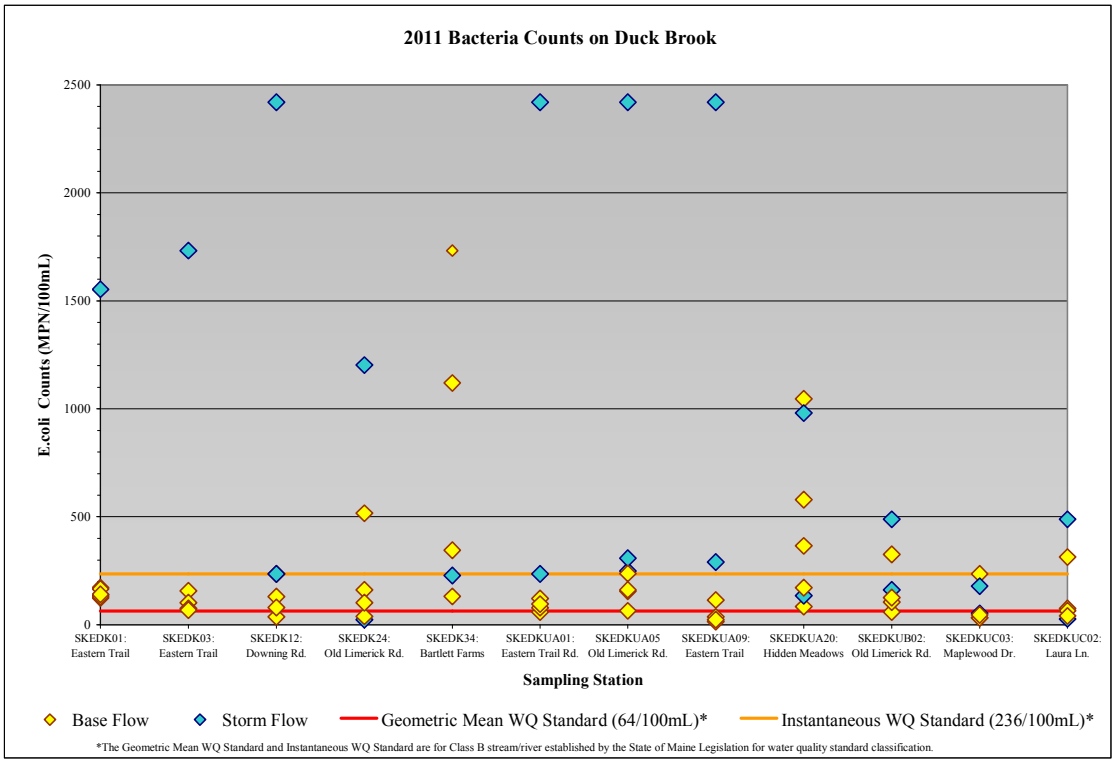
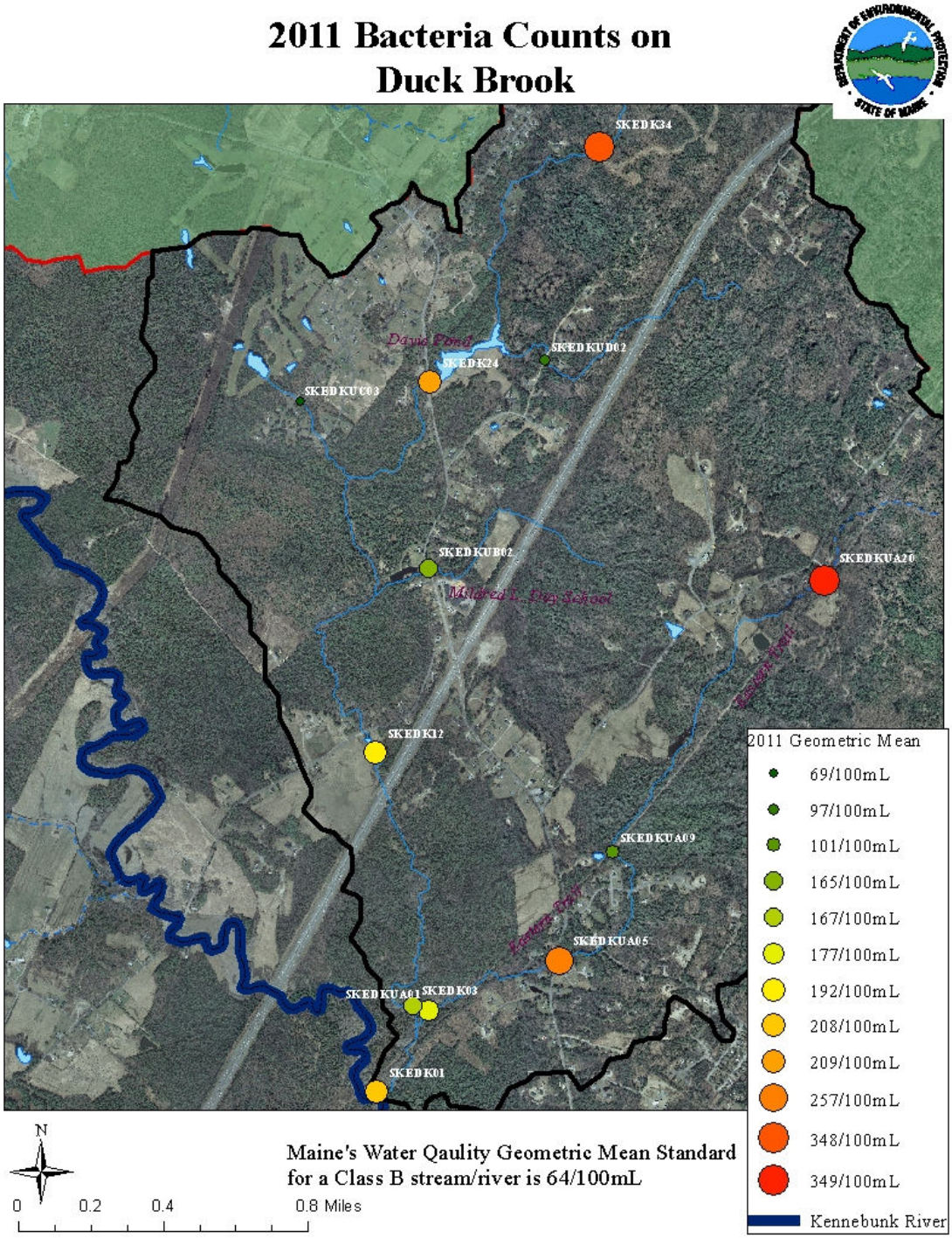


Figure 1.6: A visual representation of the 2011 bacteria counts on Duck Brook.[5]



[5] Please note the legend represents the geometric mean at each sampling station in order from non-attainment to attainment for a Class B stream/river.

4. Discussion

The results of 2011 DEP bacteria sampling on Duck Brook are better than the screening results Maine Healthy Beaches Program (MHB) had found in 2008. The majority of the samples collected in 2011 were base flow samples. This allowed the capability to determine whether or not the bacteria contamination was originating from a wet source, such as illicit discharges[6], or a dry source, such as fecal runoff. In Duck Brook's case, both illicit discharges and fecal contamination are causing the bacteria contamination.

There are three major sources: agricultural runoff and domestic animal fecal contamination, malfunctioning septic systems, and wildlife fecal contamination. Of the twelve sampling stations on the brook, two are influenced by agricultural runoff and/or domestic animals with a possible third; three are influenced by malfunctioning septic systems; three are influenced by wildlife with a possible fourth; and two remain unknown. Additionally, the bacteria contamination is restricted to discrete sections of the watershed, as defined by, its four unnamed tributaries. (The unnamed tributaries will be referred as Tributary A, B, C, or D – with Tributary A being the farthest downstream in the watershed and Tributary D being the farthest upstream in watershed) (see Figure 1.4 or Figure 1.6).

For a southern Maine costal town, Arundel has a considerable amount of agricultural land at 8 %. There are three sampling stations in close proximity to agricultural lands: one on the main stem (Downing Rd (SKEDK12), one on Tributary A (Eastern Trail (SKEDKUA09) and one on Tributary B (Limerick Rd (SKEDKUB02). The Downing Rd site (SKEDK12) is directly below a farm, while the Eastern Trail (SKEDKUA09) and Limerick Rd (SKEDKUB02) are influenced by farms to a lesser extent. Results from all three sampling stations indicate that agricultural runoff is contributing to bacteria contamination of Duck Brook.

The bacteria counts at the Downing Rd (SKEDK12) sampling station point to runoff from the farm. It is the closest sampling station of the three to any farms and had the highest geometric mean of the three with 192/100mL. The Eastern Trail (SKEDKUA09) sampling station suggests the farm upstream has good management practices but could improve during storm events. The only times that the station exceeded Maine's instantaneous water quality standard (236 MPN/100mL) was during storms. However, there is a large span of forest between the station and the farm, therefore the bacteria counts being observed may be a combination of wildlife and agricultural runoff. Further investigation needs to be done to determine the direct source for the Eastern Trail (SKEDKUA09) sampling station.

Similarly, the Limerick Rd (SKEDKUB02) sampling station needs additional investigation to determine the source of the bacteria. Tributary B drains a wetland, an agricultural field and is in close proximately to a school. There are too many variables to pinpoint a single source; although agricultural runoff is the most logical explanation during storms, the few "high" bacteria spikes during low flow may indicate an illicit discharge (see Table 1.2).

Agricultural runoff is not the only contributing factor to the bacteria contamination, malfunctioning septic systems are also contributor. There are at least three different portions of the watershed that are affected by malfunctioning systems.

[6] Illicit discharges are leaks or connection failures of sewage pipes.

Figure 1.7. A picture of water with the "grayish water" appearance near Limerick Rd (SKEDKUA05) sampling station.

The portion closest to the mouth of Duck Brook is Tributary A. While sampling during both storms events, water with a "grayish water" appearance was observed near the Limerick Rd (SKEDKUA05) sampling station (see Figure 1.7). There are a few houses to the right (while looking upstream from the road) of the station on Skyview Acres Dr., as well as the small subdivision just above the station on Talbot Dr. Both are candidates for sanitary surveys. The bacteria contamination in this portion of the watershed is confined to this particular stream segment; limiting the scope of work. The Eastern Trail (SKEDKUA09) sampling station is directly above the subdivision and attains water quality standards. However, farther up on Tributary A, malfunctioning systems were detected at Hidden Meadows. There are few houses on Hidden Meadows that are above the Hidden Meadows (SKEDKUA20) sampling station and after that it is a forested area. Sanitary surveys and additional investigation will be needed in the area.

Barlett Farms subdivision should also be included in the sanitary surveys. The elevated bacteria counts during base flow indicate there are malfunctioning systems in the subdivision. There are only a dozen or so homes in the newly developed subdivision and existing problems should be fixed before it becomes any larger. Other than the Barlett Farm subdivision and the two portions of Tributary A, the current data suggests that no other malfunctioning systems in the watershed at this time.

The only remaining contributor to the bacterial contamination is wildlife, and there are at least three to four sampling stations that suggest a heavy presence. The Eastern Trail sampling stations (SKEDK03 and SKEDKUA01) are in a heavily wood area with no homes close by and deer and raccoon tracks were observed during every site visit. Field surveys of Tributary A, until it crosses Limerick Rd, revealed no human influences, however, a half mile upstream there may be malfunctioning septic systems. It is difficult to distinguish between the malfunctioning system and wildlife influences. Malfunctioning septic systems have at least a half mile influence.[7]

The sampling stations on Tributary C and Tributary D also indicate wildlife presence; both stations are just slightly above Maine's geometric mean water quality standard (64 MPN/100mL): 69/100mL for Tributary C and 97/100mL for Tributary D. Tributary C never exceeded Maine's instantaneous water quality standard (236 MPN/100mL) during the sampling season. Tributary D only exceeded the instantaneous standard twice; once during storm event and once during a base flow, however that was a couple days after Tropical Storm Irene. Tropical Storm Irene dropped almost two inches of rain in two days (which is rare) and seemed to affect the streams for a longer period than a typical storm. The DEP did try not to collect during Irene because it was considered an abnormal event, but Tributary D's exceedance of the instantaneous standard, days after the event, suggests Irene was still influencing the watershed.

The bacteria counts observed at both the Eastern Trail samplings stations (SKEDK03 and SKEDKUA01) and the sampling stations on Tributary C and Tributary D are consistent with wildlife sources found in other locations. If wildlife is the cause, then the sampling station is not violating Maine water quality standards; Maine water quality standards for Class B stream/river

[7] For additional information on malfunctioning septic systems influences a half mile see Section 3. Currier Brook.

states "E.coli of human and domestic animal origin shall not to exceed a geometric mean of 64/100mL or an instantaneous level of 236/100mL." The human influence in the drainage areas must be ruled out before elevated bacteria levels can be attributed to wildlife.

5. Conclusion

Duck Brook should be placed on the Maine List of Impaired Waters, 303d list. Arundel needs to identify and resolve the malfunctioning septic systems. The Department of Agriculture should inspect and advise the farms for good management practices and that would improve runoff quality. The potential for Duck Brook to meet water quality standards is high. Restoring Duck Brook would also improve the water quality of the Kennebunk River which remains bacterially impaired.

6. Recommendations

- Conducted sanitary surveys on:
    - Skyview Acres Dr.
    - Talbot Dr.
    - Hidden Meadows
    - Barlett Farms

- Investigate and inspect agricultural practices on:
    - Downing Rd.
    - Mountain Rd.

- Monitor more storm flows:
    - Assess both agricultural/domestic animal runoff and wildlife runoff.

- Monitor more dry flows:
    - Assess the watershed for additional malfunctioning septic system in watershed.

- Conduct public outreach and education on the Eastern Trail the importance of properly disposing of dog and horse waste.
    - On several occasion dog waste was observed on the trail.
    - Hoof-prints were also observed on the trail.