

2173 Washington Street • Canton, MA 02021  
Phone 781-575-0354 • Fax 781-575-9971 • [www.neponset.org](http://www.neponset.org)

**Optical Brightener Survey of Three Streams  
in The Lower Neponset River Watershed:  
Pine Tree Brook, Mother Brook and Unquity Brook  
2009-2010**

By: William Guenther  
Environmental Scientist  
Neponset River Watershed Association  
2173 Washington St.  
Canton MA, 02031



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### ***Executive Summary***

During 2009 and the first half of 2010, the Neponset River Watershed Association conducted a pilot project using optical brightener testing at storm drain outfalls in an effort to identify potential illicit connections of sewage into storm drains and/or sanitary sewer overflows into storm drains. A total of 349 samples were collected at 88 outfalls representing both dry and wet weather. The survey covered Pine Tree Brook, Mother Brook and Unquity Brook in the municipalities of Milton, Dedham and Boston. A total of three suspected illicit connections were identified during the survey, in spite of the fact that previous surveys using conventional bacterial source tracking methods had not found similar problems. In addition, one suspected sanitary sewer overflow was identified through visual inspection without the use of optical brightener testing. Optical brightener surveys at storm drain outfalls were found to be an effective and relatively inexpensive complement to traditional outfall source tracking methods.

### ***Acknowledgements***

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## ***Introduction***

In 2009 the Neponset River Watershed Association (NepRWA) began a survey program along three brooks in the lower Neponset River watershed, Pine Tree Brook and Unquity Brook in the Town of Milton, MA and Mother Brook in the Town of Dedham and the City of Boston, MA. This pilot program was aimed at using new techniques in an attempt to locate and eliminate possible illicit connections discharging sewage into the stormwater conveyance systems along these brooks.

Earlier efforts in these three subwatersheds used conventional screening methods at outfalls for bacteria, ammonia and surfactants to look for sites with elevated levels of these contaminants. Under these earlier investigations outfalls with elevated levels of two or three of these parameters would have a high probability of having an illicit connection. This work yielded some results but it was clear that these streams were still experiencing poor water quality. It was thought that intermittent illicit connections or sanitary sewer overflows (SSOs) could be to blame for continued poor water quality results observed through NepRWA's Citizen's Water Monitoring Network (CWMN).

In order to determine if there were intermittent connections, NepRWA needed to come up with a sampling program that would be able to take composite or time lapse samples from outfalls rather than the grab samples that had been taken previously. After looking at several options, it was determined that an inexpensive, yet comprehensive way to conduct such a survey was to use optical brightener testing.

Optical brighteners (OBs) are a class of chemicals that are commonly added to laundry detergents and a variety of other products to make white colors appear brighter. Like surfactants, optical brighteners can be used to help distinguish between sewage related bacterial pollution (which generally also includes detergent waste) and animal or stormwater related sources of bacterial pollution.

There are no standards for acceptable levels of optical brighteners under the Massachusetts Surface Water Quality Standards. Tests for optical brighteners do not indicate a specific quantity of the chemicals, just the presence or absence of the chemicals.

Optical Brighteners are tested by placing an absorbent wad of untreated cotton in a stream or storm drain for a period of 3 to 10 days. If water containing optical brighteners is present, brighteners will attach to the cotton and can be detected by examining the cotton under an ultraviolet (UV) light. The particular advantage of testing for optical brighteners is that the long duration of the test has an increased probability of detecting intermittent sewer problems which are less likely to be detected by an instantaneous grab sample.

## ***Methods***

Sampling was conducted at outfalls along three brooks in the Neponset River Watershed, Pine Tree Brook, Mother Brook and Unquity Brook (Figure 1). Outfalls were first located using mapping provided by the Towns of Milton and Dedham and the City of Boston in paper as well as digital GIS compatible formats.

This section outlines preparation and procedures in detail for choosing the sampling device, sample collection and sample analysis. All procedures were adapted from the Optical Brightener Handbook created for Eight Towns and the Bay (Sargent and Castonguay 1998).

Essentially, a cotton pad, which has not been exposed to OBs, is placed in a location where water thought to contain OBs will pass over it for two to ten days. If OBs are present they will adhere to the pad and fluoresce under long wave ultraviolet (UV) light. If they are not present then the pad will not fluoresce.

The cotton sampling pads for this project were obtained from VWR (Catalog #: 21902-985) and were verified to contain no OBs prior to deployment.

### *Deployment*

With any sampling program it is important to choose the proper sampling device for the parameters you are studying before heading out to sample. Optical brightener sampling is no different. Most important for optical brightener sampling is making sure that the entirety of the cotton pad will be exposed to the OBs while it is deployed. There are generally two ways to accomplish this and in extreme cases adaptations may be required to deploy samplers effectively.

The device used almost exclusively during this study was a cage delivery system (Figure 10). For cage delivery, the sampling pad was placed between two flat wire mesh sheets in order to expose the maximum surface area of the cotton pad to the water. Each end of the cage was then closed with an elastic band or zip-tie to keep the pad firmly in place.

Once the pad was in place the cage was positioned in the area to be sampled, generally a foot or two inside the end of the outfall pipe, and anchored in some manner. Anchoring was primarily achieved by using a zip-tie to connect the wire cage to a steel block with sufficient weight to stay in the outfall. In certain circumstances other cage delivery systems were devised on a case by case basis depending on conditions at individual outfalls.

Disposable rubber or latex gloves were worn while deploying and retrieving optical brightener sampling devices and contact with clothing was avoided. Samplers were deployed inside of outfalls along the brooks and were placed in a dark area if at all possible as direct sunlight can degrade OBs.

### *Retrieval*

Cotton pads were left in place from two to ten days and retrieved thereafter. When retrieving samples disposable rubber or latex gloves were worn to avoid contamination of the samples.

First, the cotton pad was removed from the sampling device and rinsed in the receiving waters to

remove as much sediment as possible from the pad. Once the pad was rinsed, the excess water was squeezed out prior to labeling and storage.

After these procedures were completed a label was stapled to the pad that indicated the location of sampling, the date the pad was placed and the date the pad was retrieved. The label was constructed of manila folder or other stiff paper product that was tested to ensure it did not contain optical brighteners. All materials used for deployment, retrieval and labeling were verified under UV light prior to sampling to be sure that they did not contain optical brighteners.

Once the pads were retrieved, cleaned and labeled they were dried out. Pads were hung to dry on monofilament fishing line as it does not contain optical brighteners. The drying area was located where the pads would not come into contact with direct sunlight. After drying, the monofilament drying line was replaced entirely before more samples were hung.

### *Analysis*

There are three qualitative results in optical brightener testing: Positive, Negative, and Undetermined/Retest. When pads were finished drying they were individually analyzed for optical brighteners against a control cotton pad that had not been exposed to brighteners. Each pad, along with a control, was read under long wave Ultra Violet (UV) light in a dark viewing box (Sargent and Castonguay 1998).

A pad would very definitely glow (fluoresce) if it was positive. If it was negative it was dull and similar to the control pad. All other samples were undetermined or retests. As each pad was read it was placed in either the positive, negative, or retest pile. In some instances only a portion of the pad or simply the outer edge fluoresced after being exposed to OBs. Several factors are thought to cause this. For example, sedimentation on the pad can prevent OBs from being visible on portions of the pad. Also, the wire mesh of the cage used to deploy the sampling pads can prevent water from reaching the entirety of the pad as well. Regardless, as long as a portion of the pad fluoresced and one could explain why the remainder did not, it was considered positive. Since paper and cotton dust are so pervasive, it was common to see specks or spots of fluorescence on the sample or control pads. These were ignored and not considered indicative of a positive result.

There was never a borderline positive or a negative result. All borderline situations were categorized as undetermined.

## ***Results***

### *Pine Tree Brook*

A total of 153 samples were taken at 40 outfalls along Pine Tree Brook in Milton, MA (Figure 2). Only 12 of the 153 samples were positive for optical brighteners. There were six undetermined results. A total of six outfalls had at least one positive result and only two of the outfalls had repeated positive results (OF 24 and OF 175)(Table 1).

The two outfalls that had repeated positive results were OF 24 and OF 175. Both outfalls were discharging effluent regardless of whether it was a dry or wet weather sampling event. While both of these outfalls were flowing in both dry and wet weather there was little in the way of anecdotal or visual evidence of an illicit connection at either of these outfalls. On at least one occasion for each outfall odor emanating from the outfall was consistent with the smell of sewage, however this was not a common occurrence while sampling at these outfalls.

Outfall 65 had one positive result for optical brighteners that coincided with a wet weather sampling event. There was also discharge from the pipe at the time of retrieval, but no discharge during any of the other samplings. No other sampling results for this outfall yielded a positive result despite larger rainfall totals during deployment for the final wet weather sample collected at this outfall (Table 1).

Outfalls OF 70 and OF 72 each had one sample return a positive result for OBs. Outfall 70 had one positive result that occurred during a dry weather sampling event. Similar to OF 65, OF 72 had its one positive sample during wet weather and then a negative result during a later wet weather sampling that had larger precipitation totals. Neither outfall exhibited anecdotal evidence of an illicit connection for the duration of sampling at these locations.

OF 40 was the remaining outfall to have at least one positive result. The positive result came from a wet weather sampling. The next result for this outfall came back as negative despite heavier precipitation during deployment.

Outfalls 150 and 9A both exhibited flow during both wet and dry weather samplings yet neither outfall had a positive result for optical brighteners (Table 1).

Outfall 38 was found to have flow twice during sampler retrieval but was negative for optical brighteners (Table 1). Outfall 38 did however exhibit signs of an SSO after heavy rains in March of 2010 after all optical brightener sampling was completed for this outfall (Figures 5 and 6). A picture of the outfall in 2009 shows that while the outfall is releasing flow it is clear in color and there is no discoloration along the wall leading down to the stream prior to the possible SSO (Figure 5). In 2010, after significant rainfall in March a picture of the same outfall shows signs of having had a SSO at some time while the precipitation event was occurring or afterwards. The discharge appears to have become milky in color and there was significant staining along the wall leading to the stream where heavy algae growth and some floatables could be seen (Figure 6).

All other outfalls were found to be negative for optical brighteners regardless of whether they exhibited flow either at deployment or at the time of retrieval (Table 1).

### *Mother Brook*

A total of 152 samples were taken at 38 outfalls along Mother Brook in Dedham and Boston, MA (Table 2). Only four samples returned a positive result for optical brighteners during the sampling period. All of these samples were from the same outfall (OF 659)(Table 1). In addition to the positive results for optical brighteners this outfall also had at least one occasion where anecdotal evidence in the form of a slight smell of sewage was recorded as well.

Of the 38 outfalls sampled along Mother Brook there were eight outfalls that were shown to have flow or discharge at the time of retrieval (Table 2). Several of these outfalls were inundated with water from the brook so it was difficult to determine if they had their own discharge while others had a distinct discharge regardless of weather conditions at the time of deployment or retrieval.

Of these eight outfalls four were inundated with water from the stream and four had distinct flows of their own. Only OF 659 however, was found to have an odor or other anecdotal evidence pointing to an illicit connection somewhere in the drainage system. There were no undetermined results for any of the outfalls along Mother Brook during the sampling period.

Several outfalls along Mother Brook were unable to be located during this survey from documents and mapping acquired from the City of Boston and Town of Dedham.

### *Unquity Brook*

Sampling at outfalls discharging to Unquity Brook took place entirely during 2009. There were a total of 44 samples taken at 9 outfalls (Table 3). Of these 44 samples only five were determined to be positive for optical brighteners. Of the five positive results only one outfall had more than one positive result (OF U4)(Table 3). Eight samples were listed as Undetermined during the sampling period (Table 3).

Outfall U1B had a positive result for OBs once during a wet weather sampling event (Table 3). In addition, there were two undetermined results for this outfall. Outfall U5 also had one positive result for OBs. This positive result was also obtained during a wet weather sampling event. Negative results for this outfall occurred both before and after the positive result and both during wet weather samplings with higher precipitation totals.

Outfall U4 was the only outfall to have two positive results during the sampling period. In addition to the positive results there were also two undetermined results for this outfall. Outfall U4 is believed to be a privately owned pipe and not part of the Town's stormwater drainage system.

## ***Discussion and Recommendations***

### *Pine Tree Brook*

On Pine Tree Brook at least two outfalls are believed to have illicit connections due to consistent positive results for optical brighteners. These outfalls (OF 24 and OF 175) will be brought to the attention of the Town of Milton, who owns the outfalls. While no other chemical or biological parameters were used to confirm the presence of an illicit connection the combination of positive optical brightener results for the duration of the sampling period along with the anecdotal

evidence of foul odors at both of these outfalls should be sufficient evidence that an anthropogenic source within the drainage system is causing impairment to the water body.

In addition to these two outfalls, Outfall 38 will also be brought to the attention of the Town as an outfall that may require further investigation for a SSO. Despite negative results from the optical brightener sampling it is believed that an SSO has occurred at this outfall after the sampling was completed. During sampling in 2009 a picture was taken of the outfall for reference (Figure 5). After heavy rains in March of 2010 the stretch of stream containing OF 38 was revisited as part of an assessment of the brook after the precipitation event. A new picture was taken of the outfall due to discoloration of the wall leading to the brook and the evidence of floatables in the effluent (Figure 6). It is not known if the SSO is continuing or what specifically caused the SSO other than high volumes of rain water infiltrating into the sewer system. It is our hope that further investigation of this drainage system will find a cause and be able to eliminate this drainage area and outfall from further SSO events.

The outfalls along Pine Tree Brook having only one positive result for OBs will also be included in our report to the Town but it is not believed that serious problems exist at these locations. Outfalls 65, 72 and 40 all had one positive OB result during a wet weather event and negative results during a separate wet weather sampling with great precipitation totals. If the positive result had occurred due to an illicit connection or SSO there should have been either multiple positive results or positive results that occurred with the higher precipitation totals as well. The positive results from these locations could be from isolated events such as car washing.

Secondarily to problems at the aforementioned outfalls, it will also be brought to the attention of the Town that at a number of locations along Pine Tree Brook there is dumping of yard waste occurring (Figures 7, 8 and 9). Pictures taken in 2009 and 2010 indicate that along small portions of Pine Tree Brook some homeowners are using the area along the brook to dump yard waste in the form of brush and grass clippings with some regularity. It is our hope that these practices can be eliminated in the near future.

#### *Mother Brook*

Only one outfall (OF 659) along Mother Brook had repeated positive results for OBs. This outfall appears to be owned and maintained by the Boston Water and Sewer Commission (BWSC) rather than the Town of Dedham where mapping was originally obtained. According to the BWSC Stormwater Management Report (2009) this outfall, which is listed as 06C110, has had investigations for illicit connections completed. The results of this project will be brought to the attention of the BWSC and it is our hope that a reinvestigation of the outfall will occur. NepRWA has had a long, positive relationship with the BWSC when it comes to identifying and correcting illicit connections in the Neponset River watershed.

In addition to OF659, several more outfalls owned by the BWSC are under investigation along Mother Brook currently but none of these outfalls showed positive results for optical brighteners during this survey. One outfall (OF 189, listed as 04F189 by the BWSC) was positive for both ammonia and surfactants when sampled by the BWSC in the past but was negative for optical brighteners during this project. This outfall was noted on field data sheets to be inundated by the brook when sampling for this survey occurred which could have lead to a dilution of the optical

brighteners and the negative results. The drainage area for this outfall is currently under investigation by the BWSC as of March, 2009 (BWSC 2009).

While completing the survey for optical brighteners it was noticed that several of the mill ponds along Mother Brook appear to have large populations of Canada geese (*Branta canadensis*). It is unknown what the extent of these populations are and if they are resident populations that over winter at these locations or if they are migratory. It is also unknown if their populations are high enough to reach nuisance levels. Resident geese populations can have a negative impact on water quality in Massachusetts waterways should their population numbers increase to nuisance levels (Moore et al. 1998, Chaichana et al. 2010). With this in mind it may be important to monitor goose populations along these waterways going forward.

#### *Unquity Brook*

Although there were no outfalls that consistently had positive results for optical brighteners the survey did help to eliminate outfalls previously thought to have problems with intermittent illicit connections. As one of the goals of this survey it was believed that some outfalls along Unquity Brook had intermittent illicit connections or possible SSOs connected to the storm drain system. One of the few ways to test for such problems is to use optical brightener sampling since the samples themselves are of a more composite nature. One sampling had over two inches of precipitation during deployment which should have been a sufficient amount of precipitation to identify any regularly recurring SSOs that may have been connected to the system. There were no positive results during that particular sampling deployment at any of the outfalls sampled.

OF U4 did have two positive results for optical brighteners. This outfall does not appear to be a part of the Town's storm drain system. This outfall may be connected to a private residence. Further investigation is required to identify what this outfall may be connected to.

#### *Overall*

Despite the proportionately small number of samples having positive results for optical brighteners the use of optical brightener sampling as a survey tool was successful. Many of the same outfalls were sampled in 2007 and 2008 for bacteria, ammonia and surfactants and were found to be clean for those parameters. The fact that optical brightener sampling did yield positive results at outfalls that previously were thought to be free of illicit connections, points to their use as a successful strategy in addition to or in advance of conventional source tracking techniques.

The results from this survey suggest that using optical brightener sampling as a prescreening tool might be more effective than the typical use of ammonia, bacteria and surfactant parameters. Optical brightener sampling is less expensive than using the more typical chemical and biological indicators. In any screening program, especially those conducted by not for profit watershed groups or municipalities, cost is a major issue. If similar, or better, results can be obtained using optical brighteners at a lower cost then that should be the first survey type used when trying to locate illicit connections. Furthermore, optical brightener testing is clearly superior to simple visual outfall inspection and it is only slightly more expensive and time consuming. Also, the composite nature of the samples during both wet and dry weather sampling enables optical brightener sampling to potentially identify intermittent illicit connections where traditional techniques can not.

It should be noted that when using OBs to screen outfalls during wet weather events there is the possibility that samplers may become dislodged from the outfall due to increased flows during precipitation events. Several samplers during this survey were found at the base of outfalls if heavy rains had occurred during deployment. While it is thought that a dilution effect can occur with OBs at outfalls where the sampler is inundated with stream water throughout the sampling deployment several samples at OF 24 and OF 175 along Pine Tree Brook returned positive results even after the samplers had been dislodged into the stream. This suggests that once OBs have concentrated on the pads to the point where they fluoresce there is no longer a dilution effect should the sampler become dislodged.

While conducting this sampling it was learned that animal urine can cause false positive results. It is known that many rodents and mammals have urine that will fluoresce under the same long wave UV light that is used to analyze samples for OBs. It is important to thoroughly inspect sample pads for signs of these animals such as small hairs or tracks left near sampling locations. During analysis pads contaminated with animal urine will fluoresce similar to pads containing OBs however samples with urine contamination will not fluoresce across the whole pad. Typically pads exposed to animal urine will exhibit fluorescence in random portions of the pad. These samples were identified as undetermined results during this study when proper evidence of animals could be corroborated. Typically these animals mark the entrance to their den, where the pads were being placed. Pads thought to be contaminated by animal urine are believed to have been directly urinated on rather than urine from within the catchment system being washed over them. Animal urine within the catchment system should be sufficiently diluted during a wet weather event that it would not be in high enough concentrations to cause the pads to fluoresce.

It was our hope that using optical brightener testing would also help locate recurring SSOs. While we did appear to locate one SSO during this project it was not the direct result of OB sampling. This does not mean that SSOs can not be discovered using OB sampling techniques, merely that we did not find evidence of them during our efforts. The major concern is how much dilution the sewage would have gone through before it came in contact with the sampling pads and what concentration of sewage would be necessary to get a positive result for OBs. Further testing is required to make any determinations on the efficacy of OB sampling to detect SSOs.

In addition to locating potential collection systems with illicit connections an optical brightener program collects much of the same data as a more traditional chemical and biological screening. Outfalls are catalogued with GPS, the condition of the outfall is recorded, similar anecdotal information is recorded and outfalls with dry weather discharges are located. Many times those outfalls with dry weather discharges are the most likely candidates for illicit connections. Should an outfall have a dry weather discharge and accompanied positive optical brightener results this information alone may be sufficient to convince towns and other outfall owners that further screening and investigation should be done in these drainage areas.

## ***Literature Cited***

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## Tables

Table 1: Pine Tree Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
2	4/12/2010	4/15/2010	Negative	Dry
2	4/15/2010	4/19/2010	Negative	Wet
2	4/19/2010	4/22/2010	Negative	Dry
2	4/22/2010	4/27/2010	Negative	Wet
3	4/12/2010	4/15/2010	Negative	Dry
3	4/15/2010	4/19/2010	Negative	Wet
3	4/19/2010	4/22/2010	Negative	Dry
3	4/22/2010	4/27/2010	Negative	Wet
4	4/12/2010	4/15/2010	Negative	Dry
4	4/15/2010	4/19/2010	Negative	Wet
4	4/19/2010	4/22/2010	Negative	Dry
4	4/22/2010	4/27/2010	Negative	Wet
8	4/12/2010	4/15/2010	Negative	Dry
8	4/15/2010	4/19/2010	Negative	Wet
8	4/19/2010	4/22/2010	Negative	Dry
8	4/22/2010	4/27/2010	Negative	Wet
10	4/12/2010	4/15/2010	Negative	Dry
10	4/15/2010	4/19/2010	Negative	Wet
10	4/19/2010	4/22/2010	Negative	Dry
10	4/22/2010	4/27/2010	Negative	Wet
22	9/15/2009	9/18/2009	Negative	Dry
22	9/18/2009	9/30/2009	Negative	Wet
22	9/30/2009	10/8/2009	Negative	Wet
22	10/8/2009	10/13/2009	Negative	Wet
23	9/15/2009	9/18/2009	Negative	Dry
23	9/18/2009	9/30/2009	Negative	Wet
23	9/30/2009	10/8/2009	Negative	Wet
23	10/8/2009	10/13/2009	Negative	Wet
24	9/15/2009	9/18/2009	Positive	Dry
24	9/18/2009	9/30/2009	Positive	Wet
24	9/30/2009	10/8/2009	Positive	Wet
24	10/8/2009	10/13/2009	Positive	Wet
25	9/15/2009	9/18/2009	Negative	Dry
25	9/18/2009	9/30/2009	Negative	Wet
25	9/30/2009	10/8/2009	Negative	Wet
25	10/8/2009	10/13/2009	Negative	Wet

Table 1 (cont.): Pine Tree Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
34	9/15/2009	9/18/2009	Negative	Dry
34	9/18/2009	9/30/2009	Negative	Wet
34	9/30/2009	10/8/2009	Negative	Wet
34	10/8/2009	10/13/2009	Negative	Wet
36	9/15/2009	9/18/2009	Negative	Dry
36	9/18/2009	9/30/2009	Negative	Wet
36	9/30/2009	10/8/2009	Negative	Wet
36	10/8/2009	10/13/2009	Negative	Wet
37	9/15/2009	9/18/2009	Negative	Dry
37	9/18/2009	9/30/2009	Negative	Wet
37	9/30/2009	10/8/2009	Negative	Wet
37	10/8/2009	10/13/2009	Negative	Wet
38	8/19/2009	8/27/2009	Negative	Wet
38	8/27/2009	9/5/2009	Undetermined	Wet
38	9/5/2009	9/15/2009	Negative	Wet
40	8/19/2009	8/27/2009	Negative	Wet
40	8/27/2009	9/5/2009	Positive	Wet
40	9/5/2009	9/15/2009	Negative	Wet
42	8/19/2009	8/27/2009	Negative	Wet
42	8/27/2009	9/5/2009	Negative	Wet
42	9/5/2009	9/15/2009	Negative	Wet
43	8/19/2009	8/27/2009	Negative	Wet
43	8/27/2009	9/5/2009	Negative	Wet
43	9/5/2009	9/15/2009	Negative	Wet
44	8/19/2009	8/27/2009	Negative	Wet
44	8/27/2009	9/5/2009	Negative	Wet
44	9/5/2009	9/15/2009	Negative	Wet
45	9/15/2009	9/18/2009	Negative	Dry
45	9/18/2009	9/30/2009	Negative	Wet
45	9/30/2009	10/8/2009	Negative	Wet
45	10/8/2009	10/13/2009	Negative	Wet
46	9/15/2009	9/18/2009	Negative	Dry
46	9/18/2009	9/30/2009	Negative	Wet
46	9/30/2009	10/8/2009	Negative	Wet
46	10/8/2009	10/13/2009	Negative	Wet

Table 1 (cont.): Pine Tree Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
47	9/15/2009	9/18/2009	Negative	Dry
47	9/18/2009	9/30/2009	Negative	Wet
47	9/30/2009	10/8/2009	Undetermined	Wet
63	8/25/2009	9/1/2009	Negative	Wet
63	9/1/2009	9/5/2009	Negative	Dry
63	9/5/2009	9/10/2009	Negative	Dry
63	9/10/2009	9/15/2009	Negative	Wet
64	8/25/2009	9/1/2009	Undetermined	Wet
64	9/5/2009	9/10/2009	Negative	Dry
64	9/10/2009	9/15/2009	Negative	Wet
65	8/25/2009	9/1/2009	Positive	Wet
65	9/1/2009	9/5/2009	Negative	Dry
65	9/5/2009	9/10/2009	Negative	Dry
65	9/10/2009	9/15/2009	Negative	Wet
66	8/25/2009	9/1/2009	Negative	Wet
66	9/1/2009	9/5/2009	Negative	Dry
66	9/5/2009	9/10/2009	Negative	Dry
66	9/10/2009	9/15/2009	Negative	Wet
67	8/18/2009	8/25/2009	Negative	Wet
67	8/25/2009	9/1/2009	Negative	Wet
67	9/1/2009	9/5/2009	Negative	Dry
67	9/5/2009	9/10/2009	Negative	Dry
67	9/10/2009	9/15/2009	Negative	Wet
69	8/18/2009	8/25/2009	Undetermined	Wet
69	8/25/2009	9/1/2009	Negative	Wet
69	9/1/2009	9/5/2009	Undetermined	Dry
69	9/5/2009	9/10/2009	Negative	Dry
69	9/10/2009	9/15/2009	Negative	Wet
70	8/18/2009	8/25/2009	Negative	Wet
70	8/25/2009	9/1/2009	Negative	Wet
70	9/1/2009	9/5/2009	Positive	Dry
70	9/5/2009	9/10/2009	Negative	Dry
70	9/10/2009	9/15/2009	Negative	Wet
72	8/25/2009	9/1/2009	Positive	Wet
72	9/1/2009	9/5/2009	Negative	Dry
72	9/5/2009	9/10/2009	Negative	Dry
72	9/10/2009	9/15/2009	Negative	Wet

Table 1 (cont.): Pine Tree Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
140	4/12/2010	4/15/2010	Negative	Dry
140	4/15/2010	4/19/2010	Negative	Wet
140	4/19/2010	4/22/2010	Negative	Dry
140	4/22/2010	4/27/2010	Negative	Wet
150	4/12/2010	4/15/2010	Negative	Dry
150	4/15/2010	4/19/2010	Negative	Wet
150	4/19/2010	4/22/2010	Negative	Dry
150	4/22/2010	4/27/2010	Negative	Wet
175	9/15/2009	9/18/2009	Positive	Dry
175	9/18/2009	9/30/2009	Positive	Wet
175	9/30/2009	10/8/2009	Positive	Wet
175	10/8/2009	10/13/2009	Positive	Wet
176	9/15/2009	9/18/2009	Negative	Dry
176	9/18/2009	9/30/2009	Negative	Wet
176	9/30/2009	10/8/2009	Negative	Wet
176	10/8/2009	10/13/2009	Negative	Wet
35A	8/27/2009	9/5/2009	Negative	Wet
35A	9/5/2009	9/15/2009	Negative	Wet
41A	8/19/2009	8/27/2009	Negative	Wet
41A	8/27/2009	9/5/2009	Negative	Wet
41A	9/5/2009	9/15/2009	Negative	Wet
41B	8/19/2009	8/27/2009	Negative	Wet
41B	8/27/2009	9/5/2009	Negative	Wet
41B	9/5/2009	9/15/2009	Negative	Wet
41C	8/19/2009	8/27/2009	Negative	Wet
41C	8/27/2009	9/5/2009	Negative	Wet
41C	9/5/2009	9/15/2009	Negative	Wet
41D	8/19/2009	8/27/2009	Undetermined	Wet
41D	8/27/2009	9/5/2009	Negative	Wet
41D	9/5/2009	9/15/2009	Negative	Wet
72A	8/18/2009	8/25/2009	Negative	Wet
72A	8/25/2009	9/1/2009	Negative	Wet
72A	9/1/2009	9/5/2009	Negative	Dry
72A	9/5/2009	9/10/2009	Negative	Dry
72A	9/10/2009	9/15/2009	Negative	Wet

Table 1 (cont.): Pine Tree Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
9A	10/8/2009	10/13/2009	Negative	Wet
9A	4/12/2010	4/15/2010	Negative	Dry
9A	4/15/2010	4/19/2010	Negative	Wet
9A	4/19/2010	4/22/2010	Negative	Dry
9A	4/22/2010	4/27/2010	Negative	Wet
9B	10/8/2009	10/13/2009	Negative	Wet
9B	4/12/2010	4/15/2010	Negative	Dry
9B	4/15/2010	4/19/2010	Negative	Wet
9B	4/19/2010	4/22/2010	Negative	Dry
9B	4/22/2010	4/27/2010	Negative	Wet

Table 2: Mother Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
64	6/1/2010	6/4/2010	Negative	Wet
64	6/4/2010	6/7/2010	Negative	Wet
64	6/7/2010	6/10/2010	Negative	Wet
64	6/10/2010	6/14/2010	Negative	Wet
69	6/1/2010	6/4/2010	Negative	Wet
69	6/4/2010	6/7/2010	Negative	Wet
69	6/7/2010	6/10/2010	Negative	Wet
69	6/10/2010	6/14/2010	Negative	Wet
70	6/1/2010	6/4/2010	Negative	Wet
70	6/4/2010	6/7/2010	Negative	Wet
70	6/7/2010	6/10/2010	Negative	Wet
70	6/10/2010	6/14/2010	Negative	Wet
71	6/1/2010	6/4/2010	Negative	Wet
71	6/4/2010	6/7/2010	Negative	Wet
71	6/7/2010	6/10/2010	Negative	Wet
71	6/10/2010	6/14/2010	Negative	Wet
72	6/1/2010	6/4/2010	Negative	Wet
72	6/4/2010	6/7/2010	Negative	Wet
72	6/7/2010	6/10/2010	Negative	Wet
72	6/10/2010	6/14/2010	Negative	Wet
73	6/1/2010	6/4/2010	Negative	Wet
73	6/4/2010	6/7/2010	Negative	Wet
73	6/7/2010	6/10/2010	Negative	Wet
73	6/10/2010	6/14/2010	Negative	Wet
74	6/1/2010	6/4/2010	Negative	Wet
74	6/4/2010	6/7/2010	Negative	Wet
74	6/7/2010	6/10/2010	Negative	Wet
74	6/10/2010	6/14/2010	Negative	Wet
152	5/13/2010	5/18/2010	Negative	Dry
152	5/18/2010	5/20/2010	Negative	Wet
152	5/20/2010	5/24/2010	Negative	Dry
152	5/24/2010	5/28/2010	Negative	Wet
153	5/13/2010	5/18/2010	Negative	Dry
153	5/18/2010	5/20/2010	Negative	Wet
153	5/20/2010	5/24/2010	Negative	Dry
153	5/24/2010	5/28/2010	Negative	Wet

Table 2 (cont.): Mother Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
189	6/1/2010	6/4/2010	Negative	Wet
189	6/4/2010	6/7/2010	Negative	Wet
189	6/7/2010	6/10/2010	Negative	Wet
189	6/10/2010	6/14/2010	Negative	Wet
207	6/1/2010	6/4/2010	Negative	Wet
207	6/4/2010	6/7/2010	Negative	Wet
207	6/7/2010	6/10/2010	Negative	Wet
207	6/10/2010	6/14/2010	Negative	Wet
244	5/13/2010	5/18/2010	Negative	Dry
244	5/18/2010	5/20/2010	Negative	Wet
244	5/20/2010	5/24/2010	Negative	Dry
244	5/24/2010	5/28/2010	Negative	Wet
245	5/13/2010	5/18/2010	Negative	Dry
245	5/18/2010	5/20/2010	Negative	Wet
245	5/20/2010	5/24/2010	Negative	Dry
245	5/24/2010	5/28/2010	Negative	Wet
403	4/27/2010	4/30/2010	Negative	Wet
403	4/30/2010	5/3/2010	Negative	Dry
403	5/3/2010	5/7/2010	Negative	Dry
403	5/7/2010	5/10/2010	Negative	Wet
408	4/27/2010	4/30/2010	Negative	Wet
408	4/30/2010	5/3/2010	Negative	Dry
408	5/3/2010	5/7/2010	Negative	Dry
408	5/7/2010	5/10/2010	Negative	Wet
466	5/13/2010	5/18/2010	Negative	Dry
466	5/18/2010	5/20/2010	Negative	Wet
466	5/20/2010	5/24/2010	Negative	Dry
466	5/24/2010	5/28/2010	Negative	Wet
471	4/27/2010	4/30/2010	Negative	Wet
471	4/30/2010	5/3/2010	Negative	Dry
471	5/3/2010	5/7/2010	Negative	Dry
471	5/7/2010	5/10/2010	Negative	Wet
472	5/13/2010	5/18/2010	Negative	Dry
472	5/18/2010	5/20/2010	Negative	Wet
472	5/20/2010	5/24/2010	Negative	Dry
472	5/24/2010	5/28/2010	Negative	Wet

Table 2 (cont.): Mother Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
473	4/27/2010	4/30/2010	Negative	Wet
473	4/30/2010	5/3/2010	Negative	Dry
473	5/3/2010	5/7/2010	Negative	Dry
473	5/7/2010	5/10/2010	Negative	Wet
484	4/27/2010	4/30/2010	Negative	Wet
484	4/30/2010	5/3/2010	Negative	Dry
484	5/3/2010	5/7/2010	Negative	Dry
484	5/7/2010	5/10/2010	Negative	Wet
485	5/13/2010	5/18/2010	Negative	Dry
485	5/18/2010	5/20/2010	Negative	Wet
485	5/20/2010	5/24/2010	Negative	Dry
485	5/24/2010	5/28/2010	Negative	Wet
486	4/27/2010	4/30/2010	Negative	Wet
486	4/30/2010	5/3/2010	Negative	Dry
486	5/3/2010	5/7/2010	Negative	Dry
486	5/7/2010	5/10/2010	Negative	Wet
504	5/13/2010	5/18/2010	Negative	Dry
504	5/18/2010	5/20/2010	Negative	Wet
504	5/20/2010	5/24/2010	Negative	Dry
504	5/24/2010	5/28/2010	Negative	Wet
572	5/13/2010	5/18/2010	Negative	Dry
572	5/18/2010	5/20/2010	Negative	Wet
572	5/20/2010	5/24/2010	Negative	Dry
572	5/24/2010	5/28/2010	Negative	Wet
599	4/27/2010	4/30/2010	Negative	Wet
599	4/30/2010	5/3/2010	Negative	Dry
599	5/3/2010	5/7/2010	Negative	Dry
599	5/7/2010	5/10/2010	Negative	Wet
600	4/27/2010	4/30/2010	Negative	Wet
600	4/30/2010	5/3/2010	Negative	Dry
600	5/3/2010	5/7/2010	Negative	Dry
600	5/7/2010	5/10/2010	Negative	Wet
601	4/27/2010	4/30/2010	Negative	Wet
601	4/30/2010	5/3/2010	Negative	Dry
601	5/3/2010	5/7/2010	Negative	Dry
601	5/7/2010	5/10/2010	Negative	Wet

Table 2 (cont.): Mother Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
603	5/13/2010	5/18/2010	Negative	Dry
603	5/18/2010	5/20/2010	Negative	Wet
603	5/20/2010	5/24/2010	Negative	Dry
603	5/24/2010	5/28/2010	Negative	Wet
604	5/13/2010	5/18/2010	Negative	Dry
604	5/18/2010	5/20/2010	Negative	Wet
604	5/20/2010	5/24/2010	Negative	Dry
604	5/24/2010	5/28/2010	Negative	Wet
656	5/13/2010	5/18/2010	Negative	Dry
656	5/18/2010	5/20/2010	Negative	Wet
656	5/20/2010	5/24/2010	Negative	Dry
656	5/24/2010	5/28/2010	Negative	Wet
657	4/27/2010	4/30/2010	Negative	Wet
657	4/30/2010	5/3/2010	Negative	Dry
657	5/3/2010	5/7/2010	Negative	Dry
657	5/7/2010	5/10/2010	Negative	Wet
658	4/27/2010	4/30/2010	Negative	Wet
658	4/30/2010	5/3/2010	Negative	Dry
658	5/3/2010	5/7/2010	Negative	Dry
658	5/7/2010	5/10/2010	Negative	Wet
659	4/27/2010	4/30/2010	Positive	Wet
659	4/30/2010	5/3/2010	Positive	Dry
659	5/3/2010	5/7/2010	Positive	Dry
659	5/7/2010	5/10/2010	Positive	Wet
704	5/13/2010	5/18/2010	Negative	Dry
704	5/18/2010	5/20/2010	Negative	Wet
704	5/20/2010	5/24/2010	Negative	Dry
704	5/24/2010	5/28/2010	Negative	Wet
207A	6/1/2010	6/4/2010	Negative	Wet
207A	6/4/2010	6/7/2010	Negative	Wet
207A	6/7/2010	6/10/2010	Negative	Wet
207A	6/10/2010	6/14/2010	Negative	Wet
484A	4/27/2010	4/30/2010	Negative	Wet
484A	4/30/2010	5/3/2010	Negative	Dry
484A	5/3/2010	5/7/2010	Negative	Dry
484A	5/7/2010	5/10/2010	Negative	Wet

Table 2 (cont.): Mother Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
64A	6/1/2010	6/4/2010	Negative	Wet
64A	6/4/2010	6/7/2010	Negative	Wet
64A	6/7/2010	6/10/2010	Negative	Wet
64A	6/10/2010	6/14/2010	Negative	Wet
659A	4/27/2010	4/30/2010	Negative	Wet
659A	4/30/2010	5/3/2010	Negative	Dry
659A	5/3/2010	5/7/2010	Negative	Dry
659A	5/7/2010	5/10/2010	Negative	Wet

Table 3: Unquity Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
U1A	7/24/2009	7/30/2009	Negative	Wet
U1A	7/30/2009	8/3/2009	Negative	Wet
U1A	8/3/2009	8/6/2009	Negative	Dry
U1A	8/6/2009	8/13/2009	Undetermined	Wet
U1A	8/13/2009	8/18/2009	Undetermined	Wet
U1B	7/24/2009	7/30/2009	Positive	Wet
U1B	7/30/2009	8/3/2009	Negative	Wet
U1B	8/3/2009	8/6/2009	Negative	Dry
U1B	8/6/2009	8/13/2009	Undetermined	Wet
U1B	8/13/2009	8/18/2009	Undetermined	Wet
U2A	7/7/2009	7/24/2009	Negative	Wet
U2A	7/24/2009	7/30/2009	Negative	Wet
U2A	7/30/2009	8/3/2009	Negative	Wet
U2A	8/3/2009	8/6/2009	Negative	Dry
U2A	8/6/2009	8/13/2009	Negative	Wet
U2A	8/13/2009	8/18/2009	Negative	Wet
U2B	8/6/2009	8/13/2009	Negative	Wet
U2B	8/13/2009	8/18/2009	Negative	Wet
U3	7/7/2009	7/24/2009	Negative	Wet
U3	7/24/2009	7/30/2009	Negative	Wet
U3	7/30/2009	8/3/2009	Undetermined	Wet
U3	8/3/2009	8/6/2009	Negative	Dry
U3	8/6/2009	8/13/2009	Positive	Wet
U3	8/13/2009	8/18/2009	Undetermined	Wet
U4	7/24/2009	7/30/2009	Undetermined	Wet
U4	7/30/2009	8/3/2009	Undetermined	Wet
U4	8/3/2009	8/6/2009	Negative	Dry
U4	8/6/2009	8/13/2009	Positive	Wet
U4	8/13/2009	8/18/2009	Positive	Wet
U5	7/7/2009	7/24/2009	Negative	Wet
U5	7/24/2009	7/30/2009	Positive	Wet
U5	7/30/2009	8/3/2009	Negative	Wet
U5	8/3/2009	8/6/2009	Negative	Dry
U5	8/6/2009	8/13/2009	Negative	Wet
U5	8/13/2009	8/18/2009	Negative	Wet

Table 3 (cont.): Unquity Brook Optical Brightener Results

Outfall ID	Date Deployed	Date Retrieved	Analysis Result	Weather
U6	7/24/2009	7/30/2009	Negative	Wet
U6	7/30/2009	8/3/2009	Negative	Wet
U6	8/3/2009	8/6/2009	Negative	Dry
U6	8/6/2009	8/13/2009	Negative	Wet
U6	8/13/2009	8/18/2009	Negative	Wet
U7	7/30/2009	8/3/2009	Negative	Wet
U7	8/3/2009	8/6/2009	Negative	Dry
U7	8/6/2009	8/13/2009	Negative	Wet
U7	8/13/2009	8/18/2009	Negative	Wet

**Figures**

Figure 1: Optical Brightener Pilot Project study area

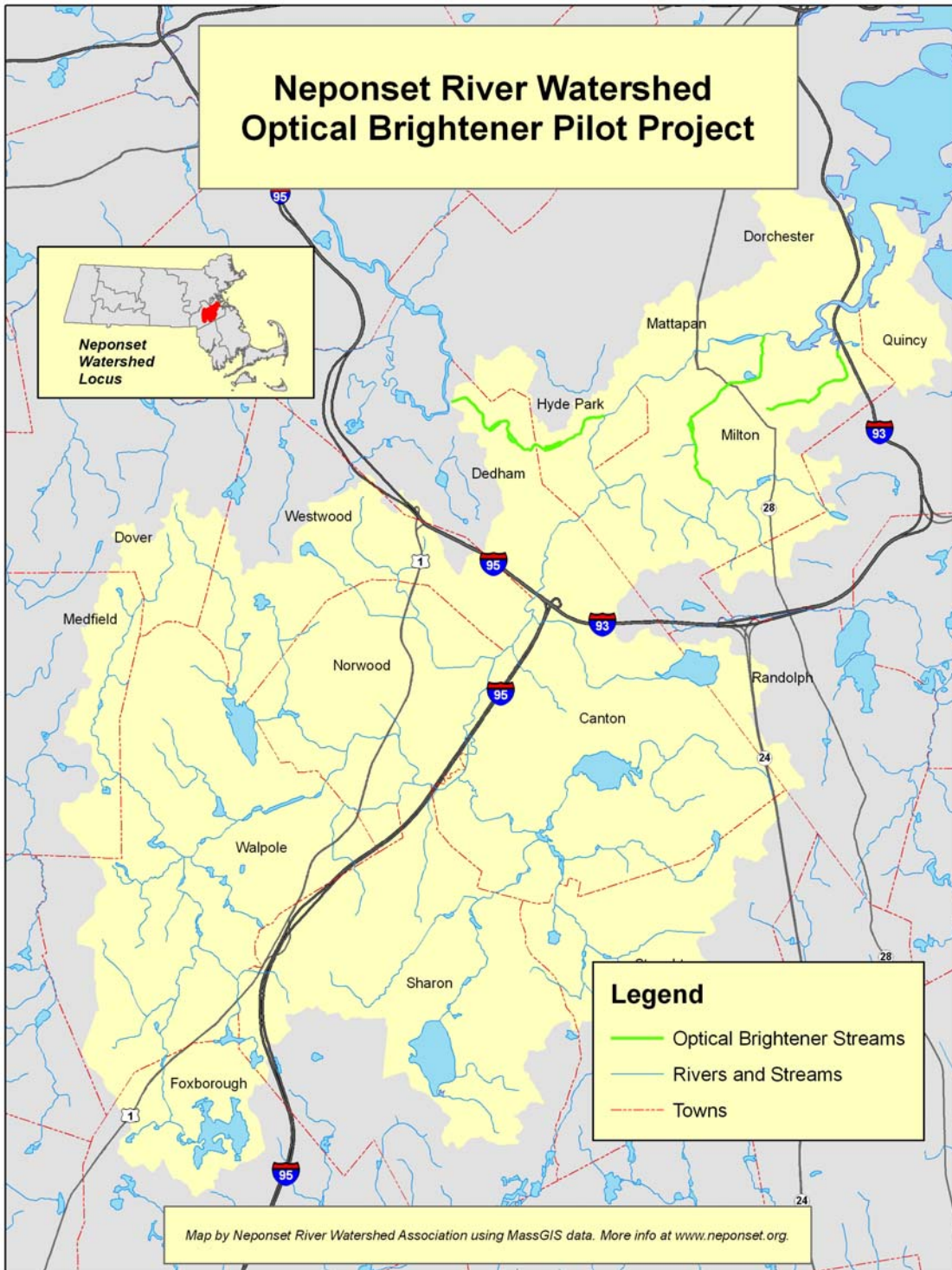


Figure 2: Sampling locations along Pine Tree Brook in Milton, MA.

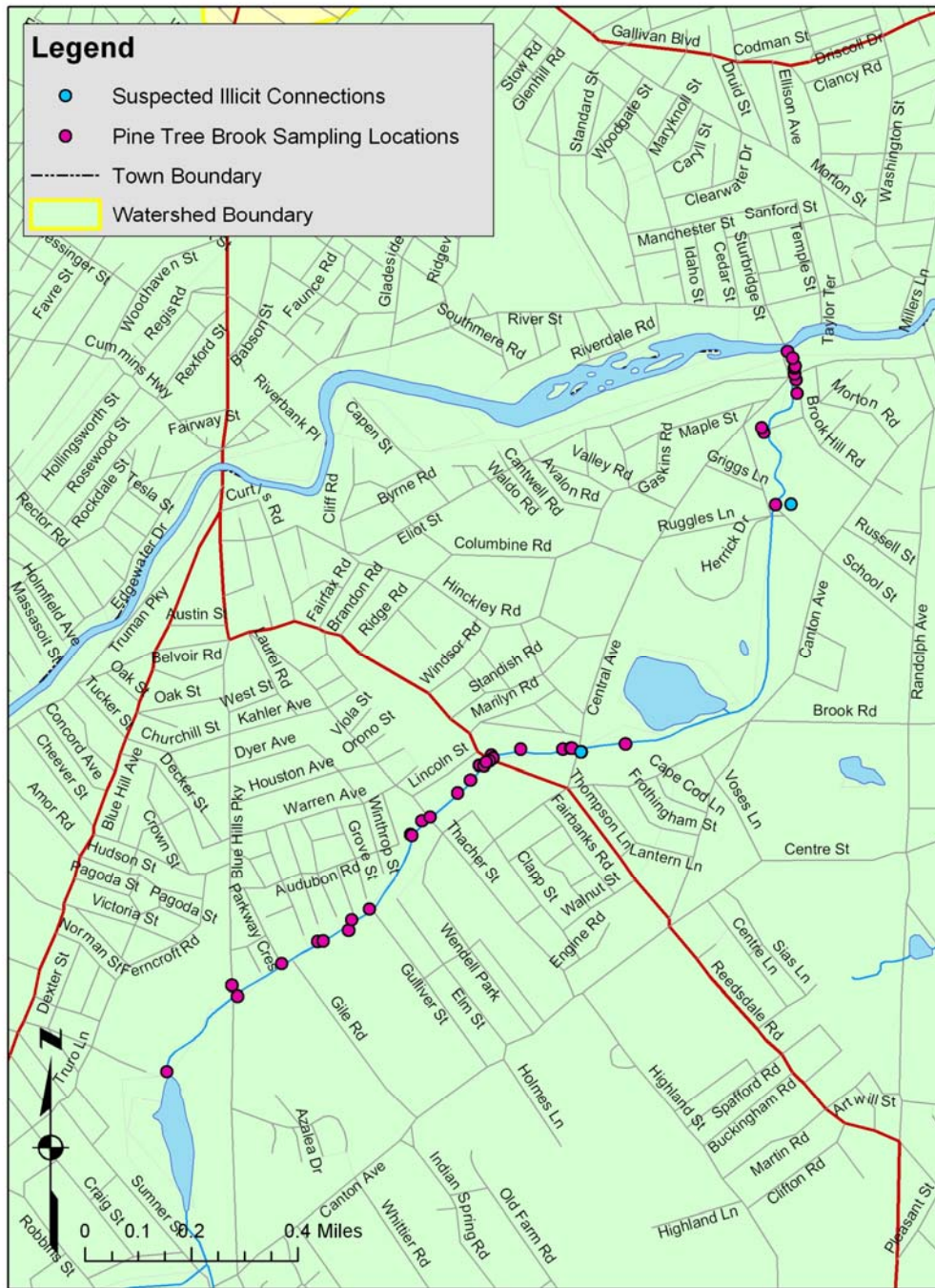


Figure 3: Sampling locations along Mother Brook in the Town of Dedham and the City of Boston, MA.

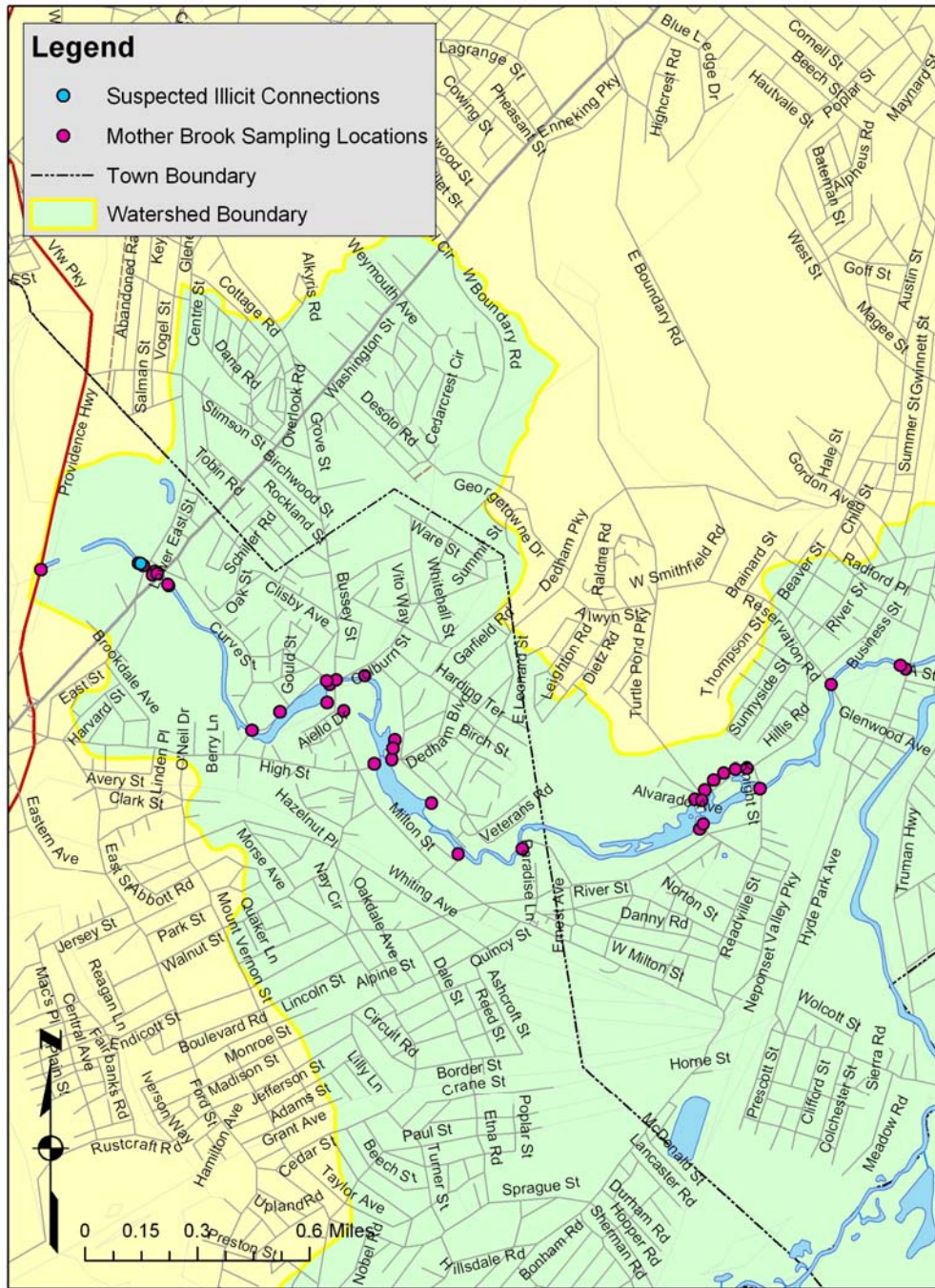


Figure 4: Sampling locations along Unquity Brook in the Town of Milton, MA. Discrepancies between sampling locations and the projected image of Unquity Brook could be attributed to the use of consumer grade handheld GPS equipment used to locate the outfalls as well as inaccuracies in the projected rivers data layer

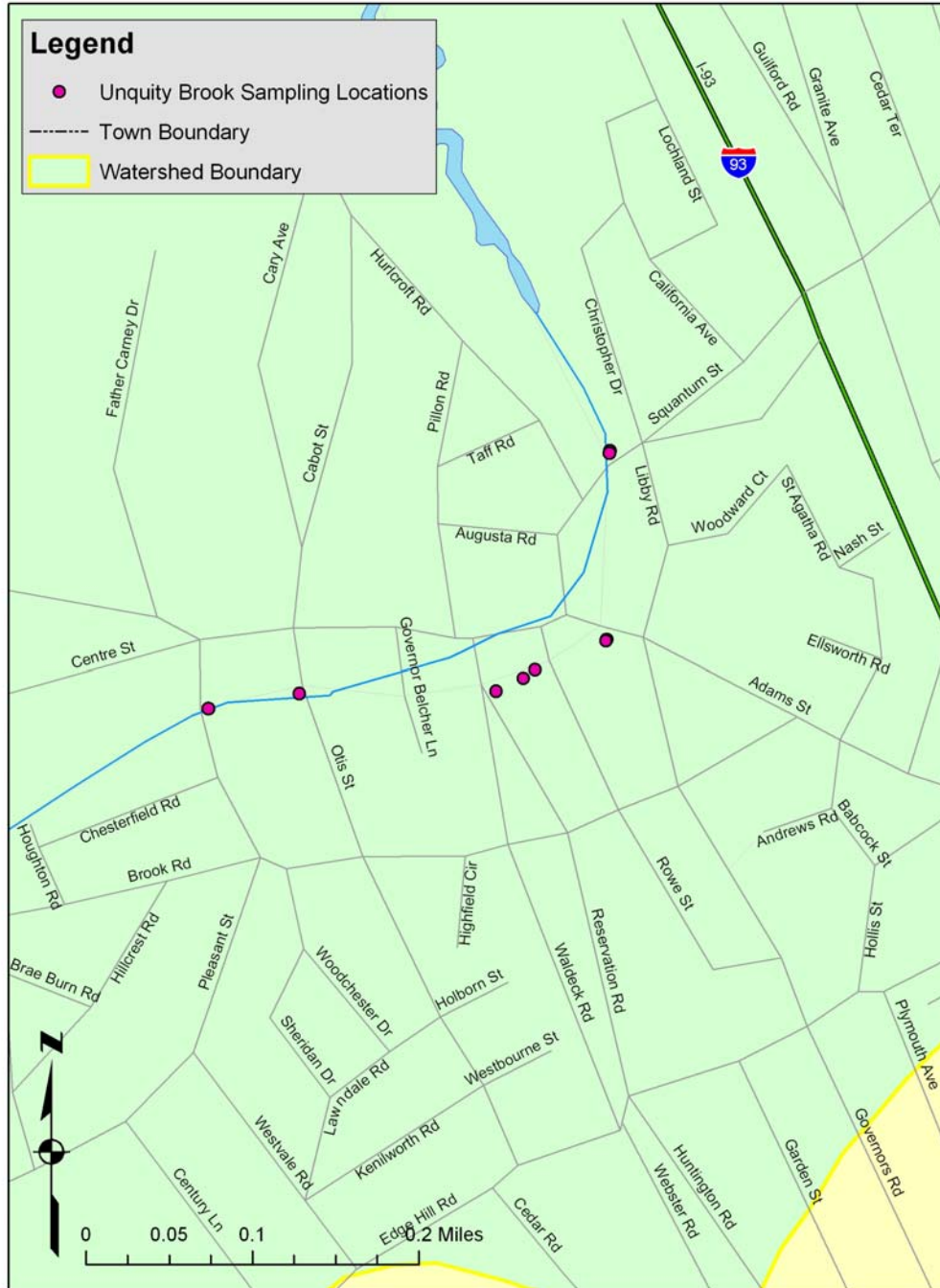


Figure 5: Outfall 38 along Pine Tree Brook. Picture taken in August of 2009.



Figure 6: Outfall 38 along Pine Tree Brook in Milton, MA. Picture taken in April of 2010.



Figure 7: Grass clippings dumped along the bank of Pine Tree Brook in Milton, MA, 2009.



Figure 8: Brush piles dumped along the banks of Pine Tree Brook in Milton, MA, 2010.



Figure 9: Yard waste dumped along the banks of Pine Tree Brook in Milton, MA, 2010.

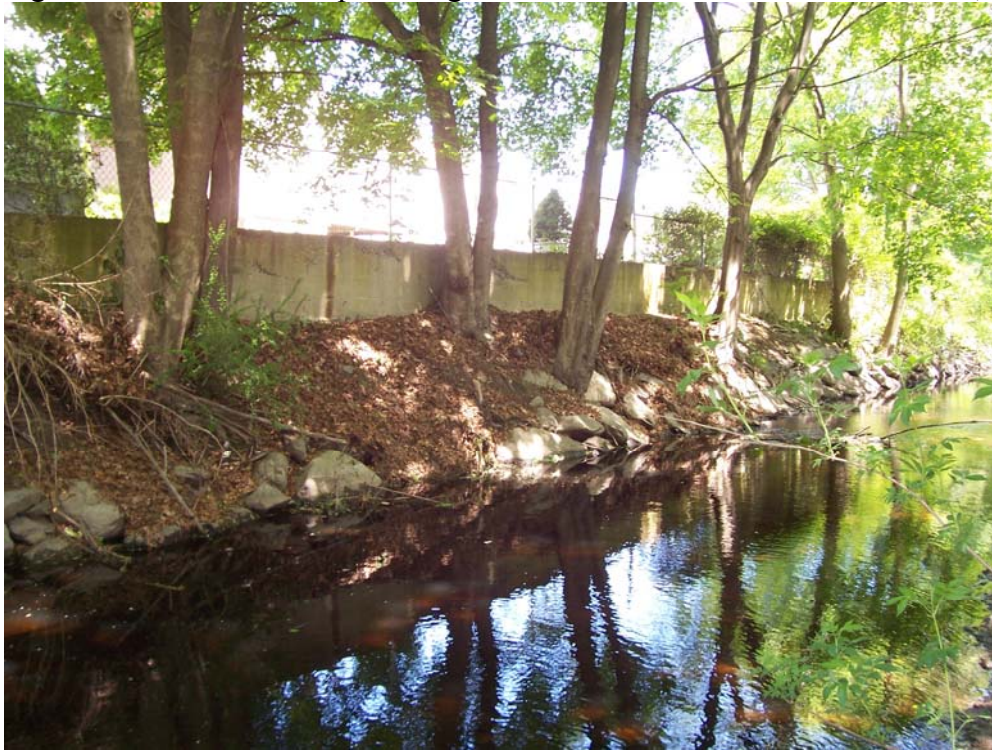


Figure 10: Optical Brightener cage sampling device with anchoring system attached.

