New York City Department of Environmental Protection
Bureau of Water Supply

Exploring the Potential for Additional
East of Hudson Riparian Buffer Protection Programs

September 2018

Prepared in accordance with Section 4.2 of the NYSDOH
2017 Filtration Avoidance Determination

Prepared by: DEP, Bureau of Water Supply

1. Introduction and Background

The 2017 Filtration Avoidance Determination (FAD) requires the New York City Department of Environmental Protection (DEP) to submit a report that evaluates the need, opportunities, and options for enhancing riparian buffer protection efforts in the Kensico and East of Hudson (EOH) FAD basins, including but not limited to, establishing a riparian acquisition program for these basins, either through the City's existing programs or another entity. DEP is also required to report on the metrics used as part of the evaluation. For purposes of this report, the term "EOH FAD basins" refers to the following six basins[1]: Kensico, West Branch, Boyd Corners, Croton Falls, Cross River, and Lake Gleneida. Under normal operating conditions, Kensico, West Branch and Boyd Corners function as part of the Catskill/Delaware supply; the other basins are rarely used as part of the Catskill/Delaware supply.

The protection of riparian buffers has always been a component of DEP's Long-Term Watershed Protection Strategy. Beginning with the 2007 FAD, DEP consolidated reporting on the many programs that protect buffers under a new Riparian Buffer Protection Program heading. The 2007 FAD committed the City to continue riparian buffer protection efforts through existing programs while initiating select program enhancements such as voluntary landowner agreements, education and training, and the development of riparian planting plans.

Currently, DEP funds riparian buffer protection efforts through the Watershed Agricultural Program (including the federal Conservation Reserve Enhancement Program, or CREP), Watershed Forestry Program, Stream Management Program (including the Catskill Streams Buffer Initiative, or CSBI), and Wetlands Protection Program; with the exception of the Stream Management Program, all of these efforts have spanned both the West of Hudson (WOH) and EOH watersheds. DEP's Land Acquisition Program (LAP) has permanently protected thousands of acres of buffers and hundreds of miles of streams in both the WOH and EOH watersheds through acquisition of fee simple land and conservation easements; more recently, the LAP-funded pilot Streamside Acquisition Program (SAP) has further protected riparian buffers in the WOH watershed. DEP also supports Regulatory Programs that protect EOH riparian buffers, in addition to the EOH Nonpoint Source Pollution Control Program and the Kensico Water Quality Control Program that further protect water quality in the EOH watershed. Pursuant to the 2017 FAD, DEP and its partners are currently exploring a riparian buffer pilot partnership between CREP and CSBI in the WOH watershed.

As summarized above, DEP has demonstrated a longstanding commitment to the establishment and protection of riparian buffers through programs and activities in both the WOH and EOH watersheds. In developing this report, DEP has taken the approach of conducting a needs assessment that considers the status of existing buffers and programs, as well as the water quality basis for designing new programs. DEP is mindful about the costs of developing new programs in relation to the potential benefits that might be achieved, especially in light of the significant investments already made in protecting water quality in the EOH FAD basins, and considering that several riparian buffer pilot programs are already underway in the WOH

1 Small portions of the Cross River (10%) and Kensico (6%) Basins extend into Connecticut; these areas are not included in this analysis.

watershed and not yet fully evaluated (such as the CREP/CSBI partnership and SAP).

In terms of metrics used to evaluate program options, DEP considered the following: (1) the amount and relative proportion of riparian buffers in various FAD basins; (2) the current ownership or "protected" status of these riparian buffers; (3) the current land cover of these riparian buffers; (4) a summary of selected water quality parameters for specific EOH FAD basins; and (5) the presence of existing programs, partnerships and other protection measures for maintaining or enhancing riparian buffers in the EOH watershed. DEP has also drawn on its extensive field knowledge of land use patterns and activities in the EOH watershed to assess whether current protection efforts are sufficient given total City investments overall.

2. A Primer on Riparian Buffers

Riparian buffers are portions of terrestrial ecosystem that directly affect or are affected by adjacent aquatic environment such as streams, rivers, lakes, and wetlands. Riparian zones typically comprise a small percentage of the landscape, often less than one percent, yet they perform a large number of ecological functions when compared to most upland habitats (USDA Forest Service 1988, McShane and White 2013). Although the re-establishment of forested ecosystems is typically a goal of riparian buffer protection programs, other vegetation cover types, such as shrub or herbaceous communities, also contribute to the water quality functions and ecosystem services provided by riparian buffers.

Riparian buffers have a well-documented influence on water quality in streams through direct and indirect functions and processes. Vegetated buffers can mitigate the transport of nutrients, chemicals, and sediment to stream channels by enhancing the infiltration and retention rates of surface runoff (Bharati et al. 2002). Aboveground plant biomass and litter can slow surface flows, and plant roots can create soil pores that enhance infiltration of runoff along with the deposition of sediments and sediment-bound chemicals and nutrients in the riparian zone; these nutrients and chemicals can be assimilated into plant tissue or transformed and immobilized by soil microbes. Similarly, when riparian zones intercept floodwaters, vegetation can enhance the deposition of entrained sediments and the infiltration of chemicals and nutrients in floodwater. For example, Brunet et al. (1994) examined the retention capacity of a floodplain and riparian zone during two flood events, finding that the floodplain and riparian zone retained 10-20% of the sediment and particulate nitrogen that were carried into the reach in floodwater.

Riparian vegetation helps to stabilize streambanks and minimize the release of sediment, nutrients, and chemicals into streams. Aboveground biomass and plant litter stabilize the soil surface while plant roots enhance soil cohesion, helping to reduce turbidity and nutrient inputs. As a macronutrient, nitrogen (N) is generally in high demand by plants, and forested riparian buffers can mitigate its transport to surface water through uptake, microbial immobilization, and denitrification. The potential for N removal in riparian zones ranges widely across studies based on soil type, buffer width, and flow path (Vidon and Hill 2004, reviewed in Mayer et al. 2007), as well as through time (Groffman et al. 2009).

Processes involved in the transport of phosphorus (P) to waterbodies include stormwater runoff, direct inputs from wastewater treatment plants and failing septic systems, desorption

from sediments, microbial breakdown of organic material such as leaf litter and animal waste, and land disturbances such as clear cutting and construction projects. Excessive inputs of P can increase biological productivity in surface waters, which can affect drinking water quality and treatment costs. Vegetated riparian buffers can directly mitigate the amount of P reaching surface water from upland sources through uptake of some forms, retaining particulate P in runoff, and stabilizing streambanks to prevent P stored in soil from eroding. The main process through which riparian zones are thought to mitigate P is by retaining particulate P (Hoffman et al. 2008). The amount of P removed by riparian systems can vary widely; for example, Cooper and Gilliam (1987) reported that 50% of P in runoff was removed by riparian vegetation, while Lowrance et al. (1984) found a 30% retention rate; retention rates vary through time (Vidon et al. 2010).

If fecal coliform is suspended in runoff, buffers may facilitate the infiltration and absorption of fecal coliform to soil or organic matter by contributing to infiltration rates and retention (Tate et al. 2004; grass filter strips were used as model system). Vegetated buffers may reduce the use of reservoirs by some types of waterbirds during some seasons, but in other seasons buffers may provide habitat and increase waterbird use (Traut and Hostetler 2004).

Few studies have investigated the potential for riparian buffers to reduce the amount of sodium and chloride that reach watercourses. Although plants can uptake sodium and chloride (Bastviken et al. 2007, Lovett et al. 2005), the magnitude of uptake is likely minimal compared to inputs. As an anion, chloride is not significantly retained in soils and tends to leach directly to groundwater and ultimately surface water. It is unlikely that riparian buffers directly mitigate the amount of sodium and chloride that reach surface water from road salt applications. Similarly, few studies have examined the potential for riparian buffers to retain or mitigate heavy metals, even though some plants can uptake and sequester some heavy metals. For example, in a floodplain forest, Hupp et al. (1993) found lead, nickel, copper and zinc in plant tissues and soil. Pesticides in runoff can also be mitigated by vegetated buffers, such as removal through plant uptake (Paterson and Schnoor 1992). In addition, Mudd et al. (1995) found that soils within a forested buffer were more effective at removing atrazine than soils from grass or corn covers.

There is evidence that vegetated riparian buffers can enhance in-stream processing of nutrients. Most studies have focused on the mechanisms through which streams transform and process P and N. Organic matter in forested buffers assists with nitrate immobilization and removal in stream channels through microbial processing and facilitating uptake by stream organisms. Organic matter enables denitrification and microbial uptake of nitrate by serving as a carbon source, slowing flows, and increasing residence time (Mulholland 1992, Mayer et al. 2003, Bernhardt et al. 2005). However, the magnitude of in-stream nitrate processing varies by season and flow, with greater nitrate attenuation capacity in small headwater streams (Mulholland and Hill 1997, reviewed in Ranalli and Macalady 2010). The magnitude of in-stream nitrate removal through denitrification is likely relatively minor, while the amount immobilized by microbes and other organisms is likely greater (Peterson et al. 2001). For example, Mulholland (2004) found that uptake and microbial immobilization removed 20% of the nitrate that annually entered a forest stream.

3. Characterizing Buffers in the EOH FAD Basins

To assess existing riparian buffer conditions in the six EOH FAD basins[2], DEP conducted a GIS analysis to characterize these basins based on size, stream length, and associated buffer area. DEP also analyzed the ownership of riparian buffers, grouping land ownership patterns into a "protected" category (property owned by the City, State, land trust, or a municipality) or "privately-owned" category. Finally, DEP grouped riparian buffer land cover into three broad categories of (1) forested/vegetated, (2) lawn/soil, and (3) impervious that were further analyzed by ownership as part of DEP's evaluation metrics.

For the purpose of this report, a riparian buffer is defined as the area within 300 feet of a watercourse, which includes streams and rivers but excludes reservoirs, ponds, and lakes.[3] This definition comports with the 1997 Watershed Memorandum of Agreement (MOA) and all FADs and Water Supply Permits issued to the City since 1997.

Basin and Buffer Areas

Table 1 provides a summary of all FAD basins watershed-wide (WOH and EOH), depicting overall basin size, length of streams, and area within 300-foot riparian buffers. With respect to the City's entire watershed, the EOH FAD basins combined represent only 6% of total size and a similarly small fraction of total stream length (7%) and riparian buffer areas (7%).

Table 1. Comparative summary of all FAD basins in the City's WOH and EOH watersheds.

	Overall Basin Size		Total Stream Miles		Riparian Buffers	
	Acres	% Total	Miles	% Total	Acres	% Total
Cannonsville	291,013	27%	931	24%	61,078	24%
Pepacton	235,346	22%	807	20%	52,204	20%
Schoharie	201,658	19%	813	21%	53,113	21%
Ashokan	163,198	15%	628	16%	40,247	16%
Rondout	60,813	6%	239	6%	15,783	6%
Neversink	59,240	6%	269	7%	16,961	7%
Total WOH	1,011,268	94%	3,688	93%	239,387	93%
Cross River	19,092	2%	82	2%	5,605	2%
Boyd Corners	14,276	1%	58	1%	3,914	1%
West Branch	12,696	1%	57	1%	3,774	1%
Croton Falls	10,351	1%	36	1%	2,469	1%
Kensico	8,420	1%	27	1%	1,963	1%
Lake Gleneida	409	0%	1	0%	40	0%
Total EOH	65,244	6%	261	7%	17,765	7%
Grand Totals	1,076,512	100%	3,949	100%	257,152	100%

2 In considering all available tools for analysis of riparian buffers, DEP reviewed the Statewide Riparian Assessment Tool (SRAT) which is available to the public at http://www.nynhp.org/treesfortribsny. DEP determined that its proprietary GIS system offers higher resolution, more comprehensive coverage of layers, and easier manipulation of data, so SRAT was not used for the analyses in this report.

3 Watershed statistics, including hydrography, are derived through GIS analysis of DEP's local-resolution National Hydrography Dataset (NHD) accepted by the USGS as the official hydrography dataset for the NYC Watershed.

Within the EOH FAD basins (65,244 acres), 17,765 acres (27%) are within 300 feet of watercourses that total 262 miles in length. Although Table 1 lists basins in order of size, it is important to note that size can be independent of importance based on contribution to the water supply. For example, Cross River is the largest of the six EOH FAD basins, but typically is operated as part of the filtered Croton system; Kensico is fifth in size but serves the most important EOH role in its capacity as the terminal basin for the entire unfiltered Catskill/Delaware system and also during certain conditions for portions of the Croton system (including Cross River and Croton Falls). The basin surrounding Lake Gleneida represents 0.6% of the combined surface areas of the six EOH FAD basins, and it similarly contributes virtually no stream length or acreage of stream buffers relative to overall totals.

Buffer Ownership and Protected Status

Table 2 compares ownership of riparian buffers based on "protected" versus "privately-owned" status across all FAD basins in the WOH and EOH watersheds. For the six EOH FAD basins, the average percent protected is very high (40%) and it is noteworthy that this overall percentage exceeds the level of protection in the WOH FAD basins (34%). In fact, the largest WOH basin, Cannonsville, has the smallest proportion of protected buffers at 20%.

For the EOH FAD basins, the West Branch Basin contains the highest proportion of protected buffers at 54% overall, which is up from roughly 3% in 1997 as a result of DEP's land acquisition efforts. Of the remaining basins, the four largest (Cross River, Boyd Corners, Croton Falls and Kensico) range between 25% and 48% protected, while Lake Gleneida contains the smallest proportion protected at 9%. However, it should be noted that Lake Gleneida represents the smallest basin in total area and also the smallest acreage of riparian buffers; its 40 acres of riparian buffers represent 0.2% of all riparian buffers in the six EOH FAD basins.

Table 2. Land ownership ("protected") status of riparian buffers for all FAD basins.

Basin	Total Buffer Acres	Acres Protected	% Basin Protected	Acres Privately-owned	% Basin Privately-owned
Boyd Corners	3,914	1,895	48%	2,019	52%
Cross River	5,605	1,771	32%	3,834	68%
Croton Falls	2,469	616	25%	1,853	75%
Kensico	1,963	803	41%	1,160	59%
Lake Gleneida	40	4	9%	37	91%
West Branch	3,774	2,033	54%	1,741	46%
Total EOH	17,765	7,138	40%	10,680	60%
Ashokan	40,247	22,647	56%	17,600	44%
Cannonsville	61,078	12,058	20%	49,020	80%
Neversink	16,961	9,634	57%	7,327	43%
Pepacton	52,204	14,441	28%	37,764	72%
Rondout	15,783	7,636	48%	8,147	52%
Schoharie	53,113	15,814	30%	37,299	70%
Total WOH	239,387	82,231	34%	157,156	66%

Land Cover

The data presented in Tables 3a, 3b and 3c demonstrate that riparian buffers throughout the EOH and WOH watersheds are largely in a forested/vegetated state, regardless of ownership. Table 3a depicts that 89% of all buffer acreage in the EOH FAD basins is forested/vegetated, compared to 94% in the WOH FAD basins. Table 3b depicts riparian buffer land cover for only those lands that are categorized as protected status (owned by the City, State, land trust, or a municipality), while Table 3b depicts riparian buffer land cover for only privately-owned lands. It is noteworthy, albeit not surprising, that 99% of all riparian buffers on protected lands are already forested/vegetated throughout all FAD basins in the WOH and EOH watersheds.

As shown in Table 3c, roughly 83% of the privately-owned riparian buffers in the EOH FAD basins is forested/vegetated, while 8% is lawn/soil and 9% is impervious. The Boyd Corners Basin contains the highest levels of forested/vegetated buffers under private ownership (89%), followed closely by Cross River (86%) and West Branch (85%). The basin with the lowest percentage of privately-owned forested/vegetated buffers, excluding Lake Gleneida, is Kensico (73%); although not depicted in Table 3c, it is worth noting that 87% of privately-owned buffers within the Upper Kensico sub-basin is covered by forest/vegetation.

For all six EOH FAD basins, the percentage of lawn/soil land cover in privately-owned buffers is relatively low, averaging just 8%. Many of these areas are likely dedicated to uses that require lawn/soil land cover such as septic leach fields, recreational fields, or golf courses which may not be available for riparian buffer planting opportunities. The privately-owned riparian buffers in the Kensico Basin contain an average of 13% lawn/soil, most of which is attributable to small house lots and ballfields. For comparison, riparian buffers in the WOH FAD basins contain an average of 5% lawn/soil cover, with little variation between basins.

Table 3a. Land cover on 300-foot riparian buffers for all FAD basins.

Basin	Total Buffer Acres	Forested/Vegetated		Impervious		Lawn/Soil	
		Acres	% Total	Acres	% Total	Acres	% Total
Boyd Corners	3,914	3,684	94%	132	3%	99	3%
Cross River	5,605	5,057	90%	271	5%	276	5%
Croton Falls	2,469	2,036	82%	242	10%	191	8%
Kensico	1,963	1,618	82%	174	9%	170	9%
Lake Gleneida	40	26	64%	8	19%	7	17%
West Branch	3,774	3,483	92%	153	4%	139	4%
Total EOH	17,765	15,903	89%	980	6%	883	5%
Ashokan	40,247	38,200	95%	1,126	3%	921	2%
Cannonsville	61,078	56,123	92%	2,483	4%	2,472	4%
Neversink	16,961	16,546	98%	217	1%	199	1%
Pepacton	52,204	48,367	93%	1,923	4%	1,915	4%
Rondout	15,783	15,024	95%	369	2%	389	2%
Schoharie	53,113	49,621	93%	1,755	3%	1,736	3%
Total WOH	239,387	223,881	94%	7,873	3%	7,632	3%

Table 3b. Land cover on 300-foot riparian buffers that are "protected" for all FAD basins.

Basin	Total Buffer Acres	Forested/Vegetated		Impervious		Lawn/Soil	
		Acres	% Total	Acres	% Total	Acres	% Total
Boyd Corners	1,895	1,883	99%	8	0%	5	0%
Cross River	1,771	1,750	99%	10	1%	11	1%
Croton Falls	616	601	98%	8	1%	7	1%
Kensico	803	776	97%	11	1%	16	2%
Lake Gleneida	4	4	96%	0	3%	0	0%
West Branch	2,033	2,010	99%	13	1%	10	0%
Total EOH	7,123	7,025	99%	50	1%	47	1%
Ashokan	22,647	22,494	99%	106	0%	47	0%
Cannonsville	12,058	11,821	98%	129	1%	108	1%
Neversink	9,634	9,590	100%	28	0%	17	0%
Pepacton	14,441	14,196	98%	130	1%	115	1%
Rondout	7,636	7,581	99%	28	0%	28	0%
Schoharie	15,814	15,688	99%	91	1%	36	0%
Total WOH	82,231	81,369	99%	511	1%	350	0%

Table 3c. Land cover on 300-foot riparian buffers that are "privately-owned" for all FAD basins.

Basin	Total Buffer Acres	Forested/Vegetated		Impervious		Lawn/Soil	
		Acres	% Total	Acres	% Total	Acres	% Total
Boyd Corners	2,019	1,801	89%	124	6%	94	5%
Cross River	3,834	3,307	86%	261	7%	266	7%
Croton Falls	1,853	1,434	77%	234	13%	185	10%
Kensico	1,160	842	73%	163	14%	155	13%
Lake Gleneida	37	22	61%	7	20%	7	19%
West Branch	1,741	1,472	85%	140	8%	129	7%
Total EOH	10,643	8,878	83%	929	9%	836	8%
Ashokan	17,600	15,706	89%	1,020	6%	874	5%
Cannonsville	49,020	44,301	90%	2,354	5%	2,364	5%
Neversink	7,327	6,957	95%	189	3%	182	2%
Pepacton	37,764	34,171	90%	1,793	5%	1,800	5%
Rondout	8,147	7,443	91%	342	4%	362	4%
Schoharie	37,299	33,933	91%	1,665	4%	1,701	5%
Total WOH	157,156	142,512	91%	7,362	5%	7,282	5%

Table 4 characterizes impervious land cover within 300-foot riparian buffers in all FAD basins. For the six EOH FAD basins, the majority of impervious land cover (79%) is in the form of transportation structures such as roads, highways, airports, or parking lots, while the remaining 21% is buildings. By comparison, 86% of the impervious land cover in the WOH FAD basins is in the form of transportation structures while 14% is buildings. For just privately-owned buffers in the EOH FAD basins (Table 3c), the percent of impervious land cover is consistently low, with an overall average of 9%. While impervious levels are somewhat higher in

the Kensico Basin (14%) and Croton Falls Basin (13%), the development features driving these levels seem to be related more to transportation.

Table 4. Impervious land cover categories within all riparian buffers in all FAD basins, including "protected" status and "privately-owned" status.

Basin	Total Buffer Acres	Buildings		Roads		Other Impervious*		Total Impervious	
		Acres	% Total	Acres	% Total	Acres	% Total	Acres	% Total
Boyd Corners	3,914	20	15%	77	58%	35	27%	132	3%
Cross River	5,605	55	20%	127	47%	90	33%	271	5%
Croton Falls	2,469	51	21%	98	40%	93	38%	242	10%
Kensico	1,963	51	29%	73	42%	50	29%	174	9%
Lake Gleneida	40	2	25%	5	63%	1	13%	8	20%
West Branch	3,774	27	18%	84	55%	41	27%	153	4%
Total EOH	17,765	206	21%	464	47%	310	32%	980	6%
Ashokan	40,247	173	15%	589	52%	364	32%	1,126	3%
Cannonsville	61,078	343	14%	1,311	53%	829	33%	2,483	4%
Neversink	16,961	21	10%	129	59%	67	31%	217	1%
Pepacton	52,204	233	12%	1,067	56%	623	32%	1,923	4%
Rondout	15,783	47	13%	217	59%	105	28%	369	2%
Schoharie	53,113	253	14%	931	53%	572	33%	1,755	3%
Total WOH	239,387	1,070	14%	4,244	54%	2,559	33%	7,873	3%

* Parking lots, sidewalks, driveways, unimproved roads, or other pavement.

Wetlands and Deepwater Habitat

As shown in Table 5, riparian buffers in the six EOH FAD basins contain 4,283 acres of wetlands and deepwater habitat, 54% of which (2,332 acres) are on private lands. Roughly 23% of all EOH riparian buffers are wetlands or deepwater habitat, compared to just 4% in the WOH FAD basins. This is consistent with National Wetland Inventory mapping, which shows greater coverage by wetlands throughout the EOH watershed (6%) compared to the WOH watershed (1%) (DEP 2009). Overall, the acreage of EOH riparian buffers represents only 7% of all buffers found throughout the City's entire watershed, yet they contain 29% of all wetlands and deepwater habitat within those buffers.

Table 5. Wetlands and Deepwater Habitat (DWH) in riparian buffers in all FAD basins.

Basin	All 300-foot Riparian Buffers			Privately-owned Buffers		
	Total Buffer (Acres)	Wetlands and DWH (Acres)	% of Total Buffer	Private Buffers (Acres)	Wetlands and DWH (Acres)	% of Private Buffer
Boyd Corners	4,090	1,246	30%	2,144	624	29%
Cross River	5,759	1,547	27%	3,967	988	25%
Croton Falls	2,528	492	19%	1,886	307	16%
Kensico	2,013	212	11%	1,185	58	5%
Lake Gleneida	42	8	29%	37	0	0%
West Branch	3,893	778	20%	1,801	355	20%
Total EOH	18,326	4,283	23%	11,019	2,332	21%

Ashokan	41,101	1,527	4%	18,021	811	5%
Cannonsville	62,871	3,593	6%	50,244	2,935	6%
Neversink	17,243	509	3%	7,446	239	3%
Pepacton	53,235	1,840	3%	38,099	1,373	4%
Rondout	16,011	439	3%	8,251	178	2%
Schoharie	54,550	2,764	5%	38,116	2,020	5%
Total WOH	245,011	10,672	4%	160,177	7,556	5%
Grand Total	263,337	14,955	6%	171,196	9,888	6%

Note: Total buffer acreage and privately-owned buffer acreage both include open water wetlands and deepwater habitat; therefore these figures are slightly larger than the buffer acreage described in previous tables.

4. Characterizing Water Quality in the EOH FAD Basins

To determine whether there are water quality issues that may be addressed through additional riparian buffer programs, DEP analyzed 2010-2017 water quality data from fourteen streams that are routinely monitored in the EOH FAD basins (Figure 1). It should be noted that these data were collected as part of DEP's routine watershed water quality monitoring program, and were not specifically designed to address the potential water quality benefits of a riparian buffer program. The analytes selected for examination include those considered to be the most important for the City's water supply; these include turbidity and fecal coliform bacteria (to maintain compliance with the Surface Water Treatment Rule), phosphorus and nitrogen (to control nutrients and eutrophication), and conductivity and chloride (these have been trending higher primarily due to road salt practices).

Eight of the sampled streams are located in the Kensico Basin (sites MB-1, N12, N5-1, WHIP, BG9, E9, E10, and E11) and six are distributed among Boyd Corners (site WESTBR7), West Branch (sites GYPSYTR1, HORSEPD12, LONGPD1), Croton Falls (site MIKE2) and Cross River (site CROSS2). In general, only the largest streams are sampled within each basin, together representing approximately 50% of the total drainage area in each basin. Samples are typically collected monthly from January to December. Storm events are not specifically sampled, so the results presented in this report are generally reflective of baseflow conditions.

Water quality results from 2010-2017 are discussed in the following pages. The number of samples per site are provided in each figure beneath each boxplot. Where appropriate, reference lines representing water quality benchmarks are provided on the plots for each figure; the stream site WESTBR7 is the first boxplot presented since this site is considered a reference or control basin based on the least amount of development of the EOH FAD basins.

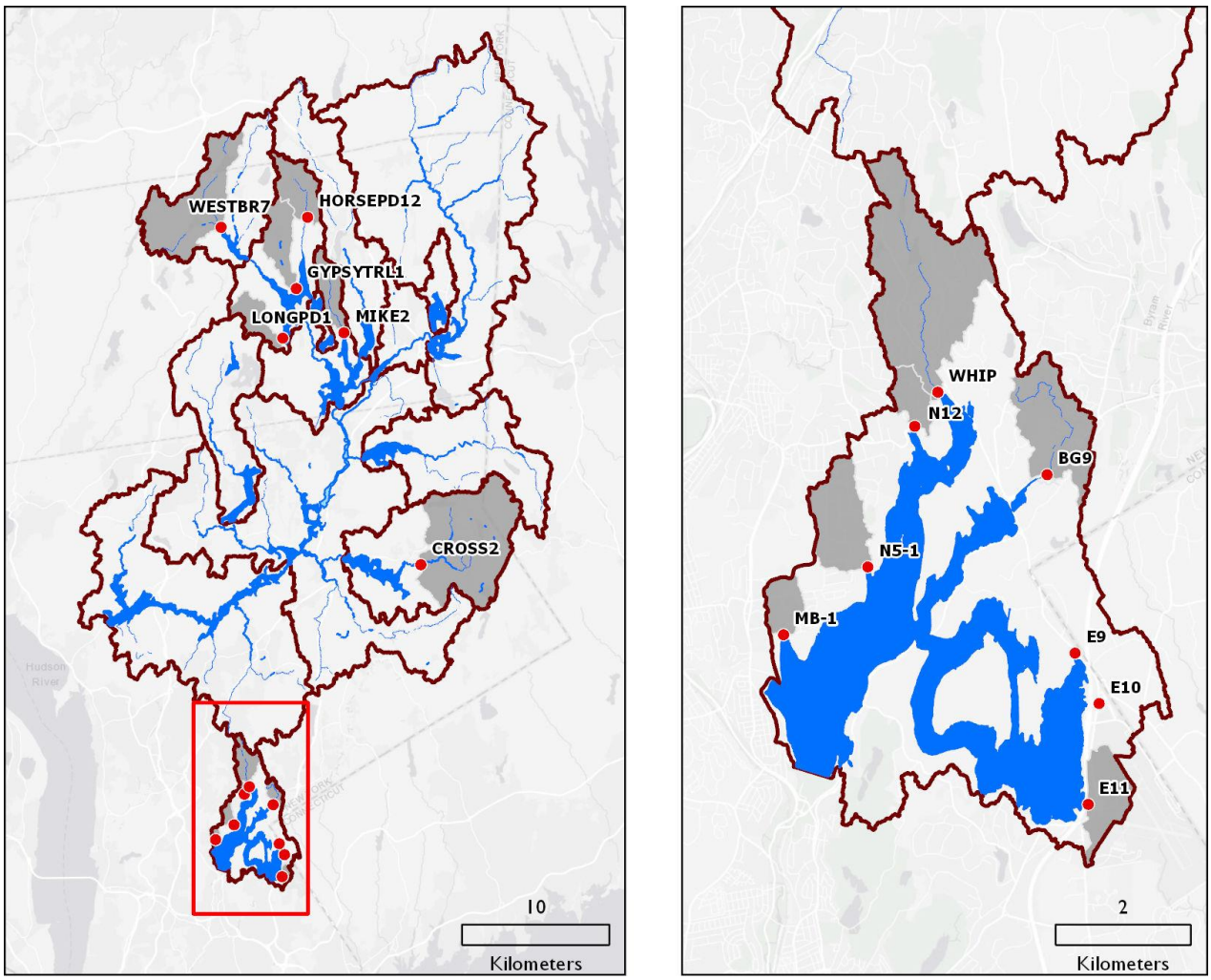

Figure 1. Streams in the EOH FAD basins with water quality monitoring sites identified; Kensico Basin is enlarged in the right hand panel.

Phosphorus

Total phosphorus (TP) results for EOH FAD streams are provided in Figure 2. Median TP concentrations ranged from 14 µg L^{-1} at the reference site WESTBR7 to 55 µg L^{-1} at Kensico stream site N5-1. All stream sites displayed higher TP concentrations compared to the reference site with median TP at five streams (i.e. BG9, E11, MB-1, MIKE2 and N5-1) doubling the median TP at WESTBR7. TP results at the Kensico stream sites were elevated despite 29-73% removal efficiencies from BMPs located upstream (DEP 2007). TP increases have been observed in EOH streams and reservoirs in recent years, but to date the source of the increase has not been identified (DEP 2017, DEP 2018). It is worth noting that fertilizers have become less of a source in the EOH watershed starting with a 2009 Westchester County ban (effective date of January 2011) on fertilizers containing phosphorus and also fertilizer applications within 20 feet of a waterbody absent a vegetated buffer. New York State has since expanded this law to the entire state with certain exceptions for agricultural lands and turf application (NEIWPCC 2011).

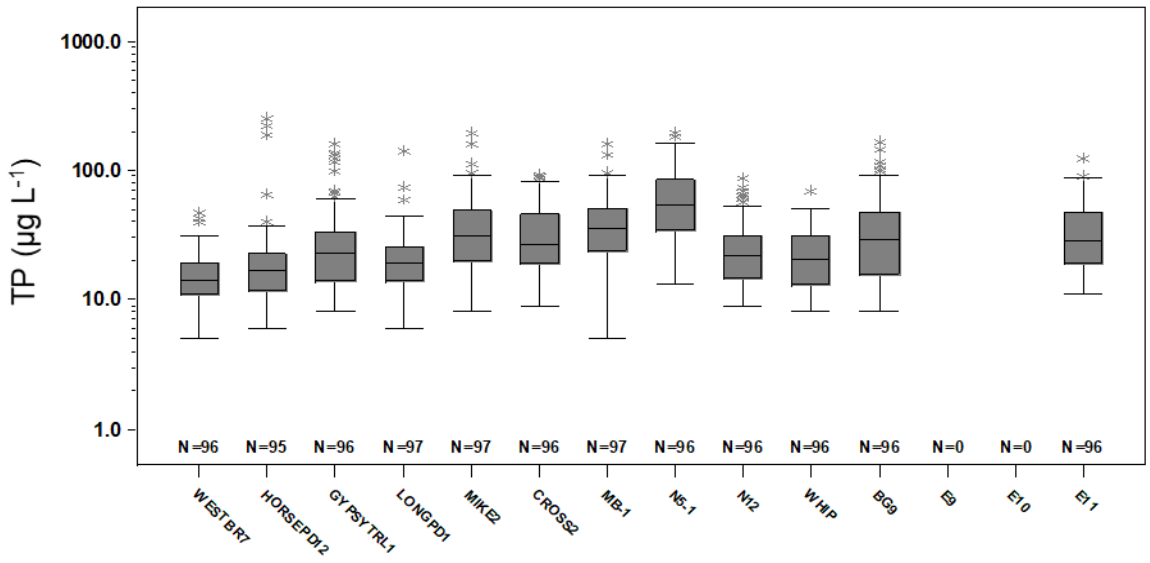

Figure 2. Total phosphorus (TP) results for streams in the EOH FAD basins (2010-2017).

Fecal coliform

Fecal coliform results for the EOH FAD streams are provided in Figure 3. The red line at 200 coliforms 100 mL^{-1} indicates the New York State water quality health-based standard for fecal coliforms in surface waters based on the average of a minimum of five samples per month (NYSDEC Surface WQ 6NYCRR parts 701-703). Median concentrations ranged from 20 coliforms 100 mL^{-1} to 140 coliforms 100 mL^{-1}, well below the 200 coliform 100 mL^{-1} benchmark. However, all stream sites have exceeded the benchmark on multiple occasions. Compared to the reference site WESTBR7, fecal coliforms were especially elevated at Croton Falls stream site MIKE2 and Kensico stream sites MB-1, N12, and N5-1.

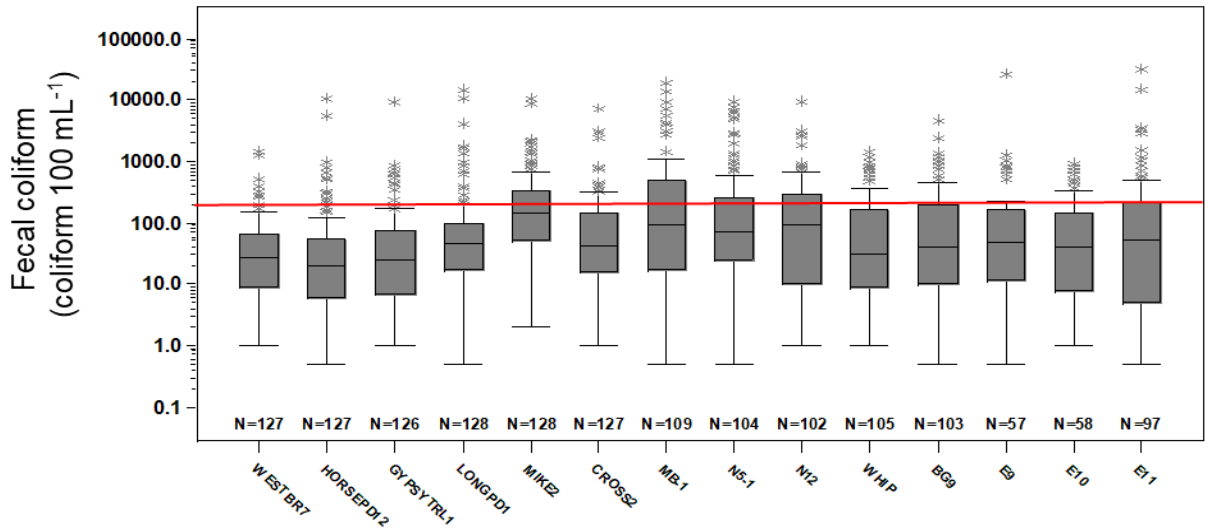

Figure 3. Fecal coliform results for streams in the EOH FAD basins (2010-2017).

Turbidity

Turbidity is influenced by both inorganic and organic particulates suspended in the water column. Elevated turbidity can have negative effects on aquatic life and plant growth, macroinvertebrate abundance and diversity, and it can inhibit the ability of fish to locate prey (Oregon DEQ 2014). Turbidity can also interfere with drinking water disinfection processes, requiring increased or modified treatment requirements (World Health Organization 2017).

Elevated turbidity may result from a number of sources/processes such as streambank erosion and stormwater runoff. Important factors influencing turbidity levels in runoff include storm intensity and duration, surficial geology, season, antecedent conditions and the amount of impervious surface in the basin. High flows from storms or snowmelt can also cause bottom sediments in streams to become re-suspended, resulting in increased turbidity.

Turbidity results are provided in Figure 4. Median turbidity levels appear to range from 0.8 to 3.9 NTU among all the streams, only occasionally exceeding 10 NTU. The highest baseflow turbidities occurred in Kensico streams sampled at MB-1, N5-1, BG9 and E11. These streams are very small and contribute minimal water to Kensico Reservoir, which receives more than 98% of its volume from water diverted from the WOH system (DEP 2014).

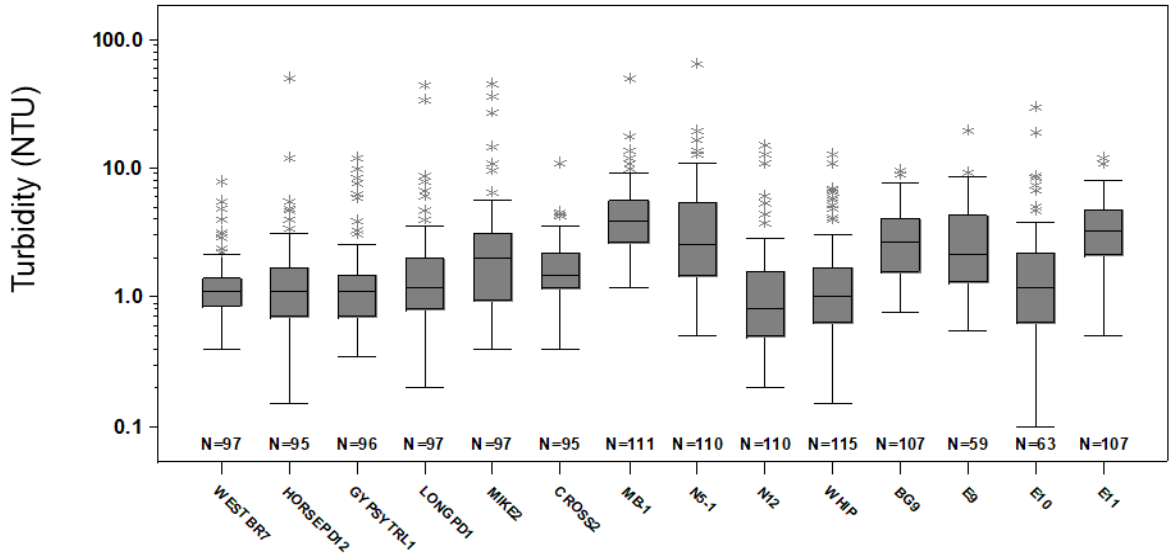

Figure 4. Turbidity results for streams in the EOH FAD basins (2010-2017).

Nitrogen

Nitrate results for EOH FAD basin streams are provided in Figure 5. The solid red line at 10 mg L^{-1} represents the New York State water quality health based standard for nitrate in surface waters (NYSDEC Surface WQ 6NYCRR parts 701-703). The dashed blue line at 1.5 mg L^{-1} identifies the single sample maximum nitrate benchmark as per NYC anti-degradation rules and regulations (DEP 2010). Median nitrate ranged from 0.025 mg L^{-1} to 2.705 mg L^{-1} in the EOH FAD basin streams. Nitrate in most streams exceeded the reference site at WESTBR7 by at

least a factor of ten. The highest concentrations occur at MIKE2 where nearly all samples collected since 2010 exceeded the single sample benchmark of 1.5 mg L^{-1}. A small number of excursions were also apparent at three Kensico streams sampled at N5-1, N12, and WHIP. Nitrate at MIKE2 also exceeded the New York State health based standard of 10 mg L^{-1} on four occasions. One potential point source, the Carmel wastewater treatment plant, is located approximately one mile upstream of sample site MIKE2. Nitrate monitoring is not required on the Carmel plant's SPDES permit, so its nitrate contribution is unknown.

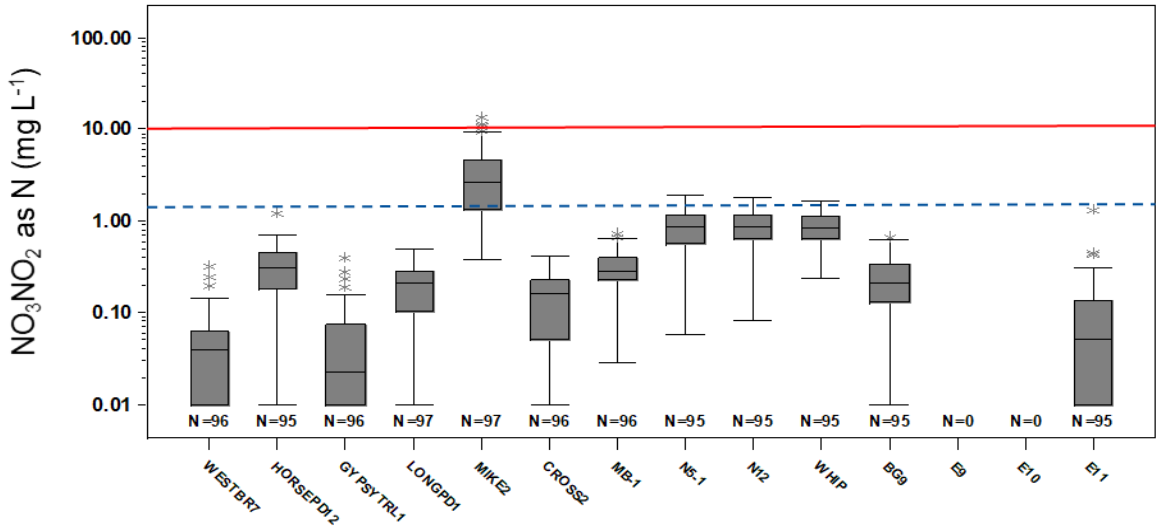

Figure 5. Nitrate (NO3NO2 as N) results for streams in the EOH FAD basins (2010-2017).

Specific Conductivity and Chloride

Chloride results for EOH FAD basins are provided in Figure 6. The solid red line at 250 mg L^{-1} represents the New York State water quality health based standard for chloride in surface waters (NYSDEC Surface WQ 6NYCRR parts 701-703). Above 250 mg L^{-1}, New York State considers water non-potable based on research showing that consumers considered the water too salty to drink. The dashed blue line at 100 mg L^{-1} identifies the single sample maximum chloride benchmark as per New York City anti-degradation rules and regulations (DEP 2010). Low road density sites WESTBR7 and CROSS2 were the only sites well under the New York City single sample maximum benchmark at 100 mg L^{-1}. Sites which commonly exceeded the benchmark included MIKE2, MB-1 and BG9. These sites as well as N5-1 and N12 also exceeded the NYS health-based benchmark of 250 mg L^{-1} on at least one occasion during the 2010-2017 period.

For many basins in both the EOH and WOH watersheds, there is a trend toward higher specific conductivity; this is associated with increasing concentrations of chloride and sodium resulting from the use of road salt and to a much lesser degree from water softeners. Elevated chloride concentrations are commonly observed in regions that use road salt deicers. Increasing chloride trends have been observed in all EOH reservoirs including the FAD basins (Van Dreason 2011) and streams (Heisig 2000, Mayfield 2010); these trends are highly correlated to road density (Heisig 2000, Van Dreason 2011). In the absence of roads, elevated chloride levels

have been associated with septic effluent in the EOH basins (Heisig 2000).

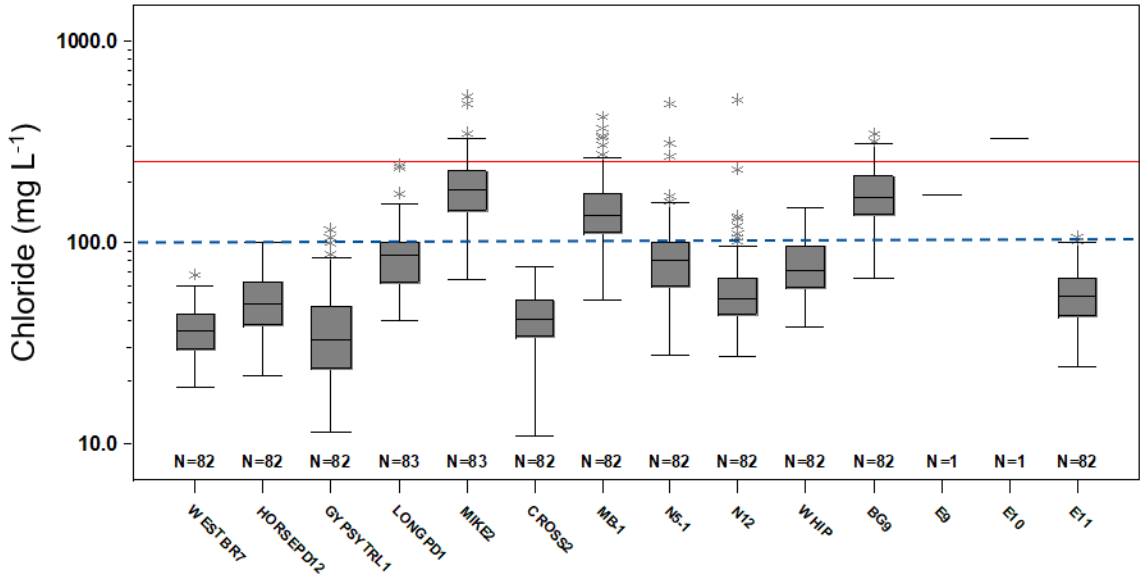

Figure 6. Chloride results for streams in the EOH FAD basins (2010-2017).

5. Existing Buffer Protection Programs

A comprehensive regulatory framework exists at every level of government to ensure protection of streams and riparian buffers throughout the EOH FAD basins. In addition, several voluntary programs exist to protect and restore riparian buffers, and to reduce pollutant loadings from human activities that impact water quality and/or buffer functions.

New York State Protection of Waters

New York State preserves and protects lakes, ponds, rivers and streams through Article 15 (Title 5) of the Environmental Conservation Law (ECL). NYSDEC created the Protection of Waters Regulatory Program to implement this policy (6 CRR-NY 701). All waters of the State have a classification and standard designation based on the existing or expected best usage of each water or waterway segment. The classification AA or A is assigned to waters used as a source of drinking water. Classification B indicates a best usage for swimming and other contact recreation. Classification C is for waters supporting fisheries and suitable for non-contact activities. Classification D, the lowest classification standard, reflects a best usage for fishing. Waters with classifications A, B, and C may also have a standard of (T), indicating that it may support a trout population, or (TS), indicating that it may support trout spawning. Special requirements apply to these waters and a Protection of Waters Permit is required for disturbing the bed or banks of a stream with a classification of AA, A, B, C(T) or C(TS). Disturbance may be temporary or permanent in nature, and some examples of activities requiring this permit are placement of structures in or across a stream, fill placement for bank stabilization or to isolate a work area, excavations for gravel removal or as part of a construction activity, and lowering stream banks to establish a stream crossing.

Wetland Protection

As the majority of wetlands are associated with streams, riparian buffers contain higher wetland coverage as compared to the entire watershed, which conveys protection through federal, State and municipal wetland regulations (DEP 2009). Riparian buffers in the EOH watershed enjoy higher regulatory protection compared to WOH buffers, given their significantly higher percent coverage by wetlands (24%) as compared to WOH (4%).

Wetlands are protected federally under Section 404 of the Clean Water Act which prohibits discharge of dredge or fill into waters of the United States without a permit from the US Army Corps of Engineers. Wetlands and waters in the EOH watershed have stronger federal regulatory oversight than those in the WOH watershed given their designation as Critical Resource Waters, meaning that many more activities require pre-construction notification or individual rather than nationwide permits.

In New York State, freshwater wetlands are regulated under the Freshwater Wetlands Act, Article 24 of the ECL (6NYCRR Part 663). Under this Act, NYSDEC regulates activities in freshwater wetlands and 100-foot adjacent areas to prevent or minimize impairment of wetland functions. Almost any activity which may adversely impact the natural values of these wetlands or adjacent areas is regulated. For example, activities requiring a permit include construction of buildings, roadways, septic systems, bulkheads, dikes, or dams; placement of fill, excavation, or grading; modification, expansion, or extensive restoration of existing structures; drainage, except for agriculture; and the application of pesticides. While the scope of the Freshwater Wetlands Act is generally limited to wetlands that are 12.4 acres and larger, EOH basins receive a higher level of protection given that nearly 80% of mapped wetland acreage is State-regulated, compared to 38% WOH (DEP 2018). State-regulated wetlands cover 18% of EOH riparian buffers, as compared to 1.4% of WOH buffers.

Protections by Town Ordinances

Wetlands and riparian buffers are protected through local municipal ordinances. It should be noted that only one municipality in the WOH watershed (Woodstock) has enacted wetland regulations, whereas all towns in the EOH FAD basins regulate activities within wetlands, watercourses, and their adjacent areas; these regulations vary by town and are generally between 50-150 feet adjacent to streams and wetlands, with most towns enacting limitations of at least 100 feet. In this regard, riparian buffers on all EOH perennial streams and most intermittent streams can be considered protected both temporally (ordinances are likely to be strengthened over time) and rigorously (restrictions on activities are likely to be strictly enforced).

Some towns regulate activities adjacent to and within even the smallest of watercourses. All EOH watershed towns specify activities that are permitted in watercourses and buffers “as of right,” such as recreational activities, operation of existing water control structures, maintenance of existing lawns and landscaping, and public health and emergency activities. Several towns allow limited grazing and clearing of vegetation, but towns that allow these activities also impose limitations on the number of domesticated animals and/or the size and amount of clearing that can occur without a permit. Most activities not allowed “as of right” require a permit. Some

towns have a two-tiered permitting process whereby "simple" activities may be permitted by administrative permit or approved by a wetlands or building inspector; these activities generally involve minor work in the buffer or waterbody. Grading limitations are found in many towns, constrained by amount of disturbance or fill, or by the equipment needed to accomplish the activity. More complex and larger scope activities generally require full review by a Wetlands Commission, Planning Board or other town entity and generally require detailed plans to be submitted for review. Each ordinance includes details of the application process and materials that must be submitted for review. While it is understood that protection levels provided by a subjective review process can vary in effectiveness, the degree of detail included in each ordinance suggest that EOH watershed towns play an important role in maintaining the integrity of their respective waterbodies and riparian buffers.

Kensico and EOH Nonpoint Source Pollution Control Programs

Although not specifically focused on riparian buffer protection, DEP's Kensico Water Quality Control Program and EOH Nonpoint Source Pollution Control Program are intended to reduce inputs of pathogens and nutrients from sanitary sewers, septic systems, and stormwater throughout the EOH FAD basins. These programs are noted in this report due to their contributions to pollutant loading reductions that enter riparian buffers, and to document the City's significant investment in water quality protection throughout the EOH FAD basins. Since 2011, for example, DEP has funded the design and installation of dozens of stormwater retrofit projects that are monitored by NYSDEC and projected to have reduced total phosphorus loads in stormwater runoff by 436 kg/year at a cost of $30 million (Belyea and Fitzpatrick, 2015).

The EOH Nonpoint Source Pollution Control Program includes active DEP involvement in project reviews; inspection and maintenance of stormwater facilities; inspection of sanitary sewers; and funding to support planning for community wastewater solutions, design and construction of stormwater retrofits, and an expanded septic system repair program. Pursuant to the 2017 FAD, DEP is required to invest more than $25 million to support and expand these programs throughout the EOH FAD basins. DEP similarly supports the Kensico Water Quality Control Program through funding and implementation of numerous stormwater and wastewater projects, including completion of a shoreline stabilization project at Kensico Reservoir's Shaft 18 site and the continuation of wildlife scat surveys around the reservoir prior to storm events.

Municipal Separate Storm Sewer Systems (MS4) Program

The MS4 Program is implemented by NYSDEC in the EOH watershed to control the inflow of pollutants such as oil, litter, animal waste, fertilizers, pesticides and sediment into storm sewers, drainage ditches and roadside swales. Through the MS4 permit process, regulated municipalities are required to develop and fully implement stormwater programs, which must contain appropriate management practices in the following minimum control measure (MCM) categories: (1) Public Education and Outreach; (2) Public Involvement and Participation; (3) Illicit Discharge Detection and Elimination; (4) Construction Site Runoff Control; (5) Post-construction Runoff Control; and (6) Pollution Prevention/Good Housekeeping. Each of these MCM categories include elements that protect environmentally sensitive areas such as wetlands and stream buffers. For example, new development and redevelopment projects offer an

opportunity to implement structural and non-structural stormwater runoff controls to reduce the amount of pollutants entering watercourses; good planning and design is a cost-effective approach to minimizing pollutants in post-construction stormwater discharges.

The MS4 program requires municipalities to consider smart growth principles, natural resource protection, impervious area reduction, maintaining natural hydrologic conditions in developments, and riparian buffer setback distances for streams and wetlands. Reducing overland flow from impervious surfaces and directing runoff into vegetated areas helps to restore natural stream flows and protect stream habitat and water quality. Perhaps most importantly, the MS4 program requires that EOH watershed municipalities implement retrofit projects to restore environmentally sensitive or degraded areas. One of the most common types of EOH retrofits are channel stabilization projects that revegetate and restore stream corridors and buffers.

New York State Pollutant Discharge Elimination System (SPDES) Program

Article 17 of New York State's ECL authorized creation of the State Pollutant Discharge Elimination System (SPDES) program to maintain New York's waters with reasonable standards of purity. The SPDES program is designed to eliminate pollution and maintain the highest quality of water consistent with public health, public enjoyment, and protection and propagation of fish and wildlife. New York's SPDES program is approved by the USEPA for the control of surface wastewater and stormwater discharges in accordance with the Clean Water Act; the SPDES program also controls point source discharges to groundwater as well as surface waters.[4]

With regard to wastewater treatment plants covered by the SPDES program in the EOH watershed, DEP funds the improvement of facilities to prevent degradation and contamination of watercourses. To ensure these plants are operated and maintained in accordance with the limits and conditions established in their SPDES permits, DEP performs quarterly inspections of all wastewater treatment facilities in the watershed and conducts regular monitoring of effluent through a field sampling program. DEP uses these sampling results to assist plant operators or to initiate enforcement actions through NYSDEC as appropriate. DEP also regulates phosphorus loading to streams and reservoirs by prohibiting the construction of new surface discharging plants in phosphorus-restricted basins and by investing considerable funds to support mandated upgrading of wastewater treatment plants.

Concerning the State's stormwater SPDES program, DEP incorporates by reference in its New York City Watershed Rules and Regulations the latest General Permit for Stormwater Discharges from Construction Activity which includes standards for the design and construction of facilities that control stormwater runoff during and after construction. DEP regulations often exceed State standards to ensure no increases in pollutant loading or runoff volume to surface waters. DEP also reviews and approves stormwater pollution prevention plans for certain land development activities, performs weekly compliance inspections of all active construction sites, and pursues enforcement actions as necessary to ensure regulatory compliance. DEP works cooperatively to alert EOH watershed municipalities and NYSDEC of unauthorized stream or

4 From NYSDEC website listed in bibliography.

wetland incursions and projects that disturb over 5,000 square feet, as those activities require special review under the stormwater SPDES program.

New York City Watershed Rules and Regulations (WRR)

As noted above, DEP has the authority to regulate certain activities on both private and publicly-owned land within various limiting distances of surface water features as defined in the WRR, including watercourses, wetlands, controlled lakes, reservoir stems and reservoirs. The WRR are intended to reduce, modify, eliminate or control activities that typically result in tree or vegetation removal, soil disturbance, soil compaction and grade changes (conditions which tend to degrade surface waters and riparian buffers). The setback distances in the WRR restrict these activities to areas beyond the established buffers, thereby serving to minimize the inherent risks associated with pollution events such as the discharge of untreated sewage and spills of petroleum products. Relevant setback distances contained in the WRR include:

- Aboveground and underground storage tanks are prohibited within 100 feet of watercourses and State-regulated wetlands, and prohibited within 500 feet of reservoirs, reservoir stems and controlled lakes.
- Subsurface disposal areas for wastewater treatment plants are prohibited within 100 feet of watercourses and State-regulated wetlands, and prohibited within 500 feet of reservoirs, reservoir stems and controlled lakes.
- No portion of a septic system may be installed within 100 feet of a watercourse or State-regulated wetland, or within 300 feet of a reservoir, reservoir stem or controlled lake.
- Impervious surfaces are generally prohibited within 100 feet of watercourses and State-regulated wetlands and within 300 feet of reservoirs, reservoir stems and controlled lakes. Where culverts, bridges or crossings of watercourses require DEP review and approval, DEP requires certain control measures and applies special conditions to ensure construction will not have adverse impacts on water quality.
- Junkyards and other solid waste management facilities are prohibited within 250 feet of watercourses and State-regulated wetlands, and within 1,000 feet of reservoirs, reservoir stems and controlled lakes.
- Where construction activities require DEP review and approval of a stormwater pollution prevention plan, DEP directs applicants to avoid soil disturbance, particularly in proximity to surface water features, by requiring certain control measures and applying special conditions so that temporary cover materials are in place throughout construction so that soils are permanently stabilized to achieve a uniform, perennial vegetative cover with a density of 80% percent over the entire disturbed surface.

As a result, DEP's WRRs provide strong levels of protection within 100 feet of watercourses, with additional protection against certain activities beyond that distance in some areas; these protections are further supported by local municipal ordinances that severely restrict wetland disturbance and tree-cutting in the 14 towns that overlap the six EOH FAD basins.

Lower Hudson Partnership for Regional Invasive Species Management (PRISM)

With a growing list of invasive species impacting the health, diversity, and geographic extent of more native species every year, harmful impacts on riparian buffer functions, and therefore stream health and water quality, are expected to continue. The Lower Hudson PRISM was created to protect biodiversity and ecosystems of the Lower Hudson region through partnerships and collaborations that focus on controlling the introduction, spread, and harmful impact of invasive species. Funded by NYSDEC and hosted by the NY-NJ Trail Conference, this partnership covers all of the EOH FAD basins and serves to educate the public about methods that can be used to control invasive species. Invasive vines in particular are deemed to be detrimental to watercourses, and the NYSDEC advisory document *Managing Invasive Plants in Riparian Areas* strongly suggests that controlling and removing invasive vines may improve water quality. The document notes that invasive vines often strangle and kill trees, including native trees and shrubs that are planted, which can lead to stream bank erosion, nutrient loading, increased stream exposure to sunlight and warmer stream temperatures, decreased biodiversity, and a disturbed site where additional invasive species may become established.

Watershed Agricultural Program and CREP

The Watershed Agricultural Program assists farmers in the EOH watershed with reducing agricultural runoff and protecting riparian buffers. The program develops Whole Farm Plans that are tailored to each farm and provide a framework for implementing BMPs that are protective of streams and water quality. Twelve farms in the EOH FAD basins are currently enrolled in the Watershed Agricultural Program, and several of these farms have implemented riparian buffer BMPs such as livestock exclusion fencing around streams, vegetative plantings, and streambank stabilization practices.

In addition, the entire EOH watershed is covered under the New York State CREP Agreement that was signed in 2003; CREP provides opportunities for farmers to enter into 10-15 year contracts with the USDA to retire streamside buffers used for crops or pasture and to establish and maintain vegetative covers in these areas. To date, no farms in the EOH FAD basins have enrolled in the New York State CREP. In general, EOH farmers have not been enticed to enroll due to the scarcity of available farmland and the high costs of land/taxes.

Croton Trees for Tribs Program

The Croton Trees for Tribs Program is funded by DEP and implemented through the Watershed Agricultural Council (WAC) Forestry Program. The program was launched in 2010 as a pilot collaboration with the NYSDEC Hudson River Estuary Program and expanded in 2011 to the entire EOH watershed following an evaluation of ten pilot projects that planted 4.5 acres of riparian buffers. Through July 2018, the Croton Trees for Program has completed 60 projects that represent 8.5 acres of riparian buffers along 7,822 linear feet of streams; twelve of these projects (0.89 acres, 1,244 linear feet of streams) were completed in FAD basins. The 2017 FAD requires that priority for these riparian planting projects be given to the EOH FAD basins and explicitly the Kensico, West Branch and Boyd Corners Basins.

Land Acquisition Program

DEP's Land Acquisition Program (LAP) is currently able to buy land that is important for water quality protection in the Kensico, West Branch and Boyd Corners Basins. To date, the City has acquired 11,991 acres of land in these three FAD basins through fee simple acquisitions and DEP conservation easements, in addition to 91 acres in the Cross River Basin that are also under a DEP easement. The LAP has increased City holdings in the Kensico Basin by 17%, from 1,907 acres in 1997 to 2,234 acres today; in the West Branch and Boyd Corner Basins, City holdings have increased by more than 1,500%, from 603 acres in 1997 to 9,757 acres today. These latter statistics include two West Branch/Boyd Corners properties that under contract totaling 380 acres, which include 176 acres of stream buffers and 66 acres of wetlands. These properties are among a diminishing number of large holdings in private hands that are still available following the City's successful acquisition efforts over the past two decades.

6. Conclusions and Potential Opportunities

The review and analysis included in this report demonstrates that (1) vegetated riparian buffers are a predominate land cover throughout the EOH FAD basins; (2) local town and county regulations are much stronger EOH than WOH, essentially enhancing federal, State, and City regulations that protect vegetated buffers; (3) voluntary programs are available to landowners who wish to maintain or enhance buffer protections on their properties, and (4) water quality remains good in the EOH FAD basins, though not without isolated instances that continue to be addressed through the City's investments in its Long-Term Watershed Protection Strategy.

Water Quality Status

A review of the routine long-term water quality monitoring data does not indicate a new riparian buffer program would provide significant (or measureable) water quality benefits. In the case of phosphorus, the exact cause, scope and potential impacts of the upward water quality trends are not well characterized, and the subject basins are already heavily forested within both protected and privately-owned buffers. In addition to the various programs that help to control phosphorus, the WRR require DEP to determine which reservoirs are phosphorus-restricted. For the six EOH FAD basins, this designation currently applies to Cross River, Croton Falls, and Lake Gleneida and essentially provides another layer of regulatory protection in these basins.

Only one site exceeded New York State health-based standards for nitrate, and this exceedance is likely due to releases from a wastewater treatment plant located upstream from the monitoring site; direct-to-stream releases offer no opportunity for infiltration or treatment by buffers, and research suggests it is unlikely that increased in-stream processing would mitigate the magnitude of nitrate inputs from a wastewater treatment plant. With regard to limited fecal coliform exceedances, the buffers in these basins are already protected and vegetated at relatively high levels. Similarly with turbidity, DEP has already constructed a variety of BMPs including retention ponds and one wetland on four of the seven monitored streams in the Kensico basin; these BMPs have helped to reduce turbidity during storm flows (DEP 2007). With respect to higher conductivity trends, sodium and chloride are unlikely to be bound or stored in soil or plants, so it is unlikely that enhancing forested buffers would mitigate these constituents.

Restoration/Revegetation

The vast majority of buffers throughout the EOH FAD basins are heavily forested on protected or privately-owned lands. Enhancing restoration on the small areas of privately-owned buffers that are not well vegetated may not be efficient or cost-effective. Sixty percent of EOH buffers are on privately-owned land and 83% of this acreage is vegetated. The 8% of privately-owned lands under the lawn/soil land cover is highly dispersed throughout the basins under myriad ownership and likely serving recreational fields and septic fields that are not suitable for enhanced vegetative cover; the remaining 9% is covered by impervious surfaces that are essentially untreatable due to roads, buildings and other permanent features. Thus the marginal benefits for water quality and public health protection are likely to be small or non-existent.

DEP continues to support existing programs that help revegetate riparian buffers, such as the Watershed Agricultural Program and Croton Trees for Tribs; for the latter program, DEP will work with the WAC Forestry Program to explore ways to improve landowner participation in the EOH FAD basins pursuant to the 2017 FAD. Given the potential future impacts of invasive species on the health and functions of riparian buffers, DEP is willing to explore opportunities for educating landowners in the EOH FAD basins about the benefits and options for reducing invasive species in vegetated buffers through collaboration with the Lower Hudson PRISM.

Land Acquisition

After considering whether a new acquisition program focused on stream buffers is needed for the EOH FAD basins, DEP has concluded that such a program would not be feasible or effective for several reasons. First, as the metrics in this report indicate, overall levels of protected riparian buffers are already high – 83% of privately-owned buffer land is currently vegetated, with 9% impervious and the remaining 8% lawn/soil. This latter category would be the main focus of any efforts to improve cover type, but is likely in land uses (septic fields, recreational fields, etc.) that would not be amenable or useful to acquisition. The marginal benefit of developing a new acquisition program for this category appears low, particularly when DEP's Land Acquisition Program already exists to buy land that is deemed important to own for water quality protection purposes in the Kensico, West Branch and Boyd Corners Basins.

Secondly, many small lots in the EOH watershed are already built out with residential or commercial improvements, and stream buffers within such parcels enjoy significant measures of protection as discussed in this report, including limits or prohibitions on impervious surfaces and clearing of trees and vegetation. Local ordinances generally prohibit small parcels from further subdivision, limiting the City's ability to acquire marginal areas; perhaps more importantly, these local ordinances reduce certain development threats and risks to water quality.

Since the City will continue pursuing for acquisition large compelling properties with significant streams and buffer features in the Kensico, West Branch and Boyd Corners Basins, DEP does not believe there is benefit to creating a new acquisition program which would serve the three EOH FAD basins that are not routinely operated as part of the Catskill/Delaware system (Lake Gleneida, Cross River and Croton Falls).

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