New York City Department of Environmental Protection

Bureau of Water Supply

Stream Management Program
Planning for Stream Feature Inventories and Water Quality Stream Project Site Selection

June 2019

Prepared in accordance with Section 4.6 of the NYSDOH 2017 Filtration Avoidance Determination

NYC Environmental Protection

Prepared by: DEP, Bureau of Water Supply

1. Introduction

The 2017 Filtration Avoidance Determination (FAD) requires the New York City Department of Environmental Protection (DEP) Stream Management Program (SMP) to complete 24 water quality stream projects (WQSPs) based on stream feature inventories (SFIs) that support project prioritization. The FAD further requires DEP to submit basin specific reports outlining the water quality basis for stream project site selection and prioritizing main stem and/or sub-basins for stream feature inventories (SFIs); this report fulfills the latter FAD requirement.

1.1 Water Quality and Stream Management

High-magnitude runoff events can deliver elevated suspended-sediment loads of silt and clay to New York City's West of Hudson reservoirs originating from stream channel erosion into glacial geologic source material (Nagle, Fahey, Ritchie, & Woodbury, 2007). Suspended-sediment is the source of turbidity in Catskill Mountain streams and it is the water quality impairment that has been mitigated at some sites at low to moderate flows through stream stability restoration practices (Siemion, McHale, & Davis, 2016; DEP, 2019a).

WQSPs focus on suspended-sediment reduction as the primary approach to reducing turbidity and secondarily, decreasing nutrient transport to reservoirs (specifically total phosphorus, or TP) where loading is attributable to stream processes. DEP reviewed its watershed water quality monitoring data to evaluate its potential to inform where the SMP should focus SFI assessments and WQSP implementation. It is important to note that the water quality monitoring program is not designed for this purpose. DEP maintains 55 stream monitoring stations West of Hudson that include fixed-frequency (monthly to weekly) turbidity and TP measurements (Figure 1). Fixed-frequency sampling does not fully capture water quality impacts from storm events, as high-flow events are not necessarily represented in the monitoring data statistics. Consequently, the reported data may not be a comprehensive accounting of turbidity or TP for a given basin or sub-basin due to the limitations of the sampling frequency. However, the sampling program is sufficient for its designed purpose to track trends and spatial variations in water quality conditions.

Figure 2 depicts the range of monitored turbidity values for West of Hudson reservoirs during the period 2007-2017. Turbidity is obviously a water quality concern in the Schoharie and Ashokan basins, where elevated turbidity levels reflect the fluvial geomorphic erosional contact with glacial legacy sediments. For this reason, the preponderance of stream projects to reduce turbidity have been constructed in the Schoharie and Ashokan basins since the inception of the SMP, and these basins will likely continue to be the focus of future turbidity reduction projects.

Nutrients, particularly TP, can also be associated with suspended-sediment, especially in agricultural regions such as the West Branch Delaware River basin where fertilizer-sourced nutrients are stored in former or current floodplain soils (Ross, et al., 2019). Figure 3 shows the range of monitored TP values in the West of Hudson reservoirs during the period 2007-2017. Although Cannonsville Reservoir has the highest levels of monitored TP, the median 2017 value falls below the 20 μgL^{-1} NYSDEC ambient water quality guidance value. TP measured in Schoharie Reservoir is also elevated, but with rare exception remains below the 20 μgL^{-1} threshold. TP includes both particulate and dissolved forms of phosphorus arising from both point and nonpoint sources. DEP uses reservoir TP concentrations in determining whether a basin has a “phosphorus restricted” status; currently none of the West of Hudson reservoirs are phosphorus restricted (DEP, 2018).

DEP and its SMP partners recognize that on a case-by-case basis, water quality concerns may be tied to a non-erosion process and/or constituents other than suspended-sediment that require an approach other than stream restoration. While the vast majority of projects are expected to address suspended-sediment through stream restoration, it is possible that DEP may nominate a WQSP that targets other water quality concerns where there is a compelling case.

DEP and its SMP partners use a combination of assessment methods to identify stream reaches that contribute to turbidity or potentially TP. Methods include reviewing available water quality monitoring data, conducting GIS analyses, field mapping of stream channel conditions through SFIs, and monitoring rates of stream bank erosion. SFIs map stream bank and streambed erosion, including information on bank and bed geology. DEP and its SMP partners use this information to identify potential turbidity-generating stream reaches, evaluate and prioritize these reaches for potential treatment, and nominate WQSPs to fulfill DEP’s FAD requirements. To date, two of the 24 FAD-mandated WQSPs have been completed and eight other projects have been approved by NYSDOH (Table 1).

1.2 Basin Meetings

In May and June 2018, DEP met individually with the SMP partners to review the process for prioritizing SFIs and identifying potential WQSPs. DEP presented relevant water quality monitoring data for each basin, and meeting participants discussed whether these data could inform SFI and stream project selection. For some basins, DEP’s stream water quality monitoring stations were deemed sufficient to identify the sub-basins for SFIs (Schoharie, Ashokan, Pepacton) while in other basins the available monitoring stations are not fully sufficient to inform sub-basin selection (Rondout, Neversink, Cannonsville). Each meeting concluded with a general strategy for SFI and project selection. The subsequent sections of this report present brief summaries of basin turbidity and TP conditions, SFI status and planning, and WQSP planning.

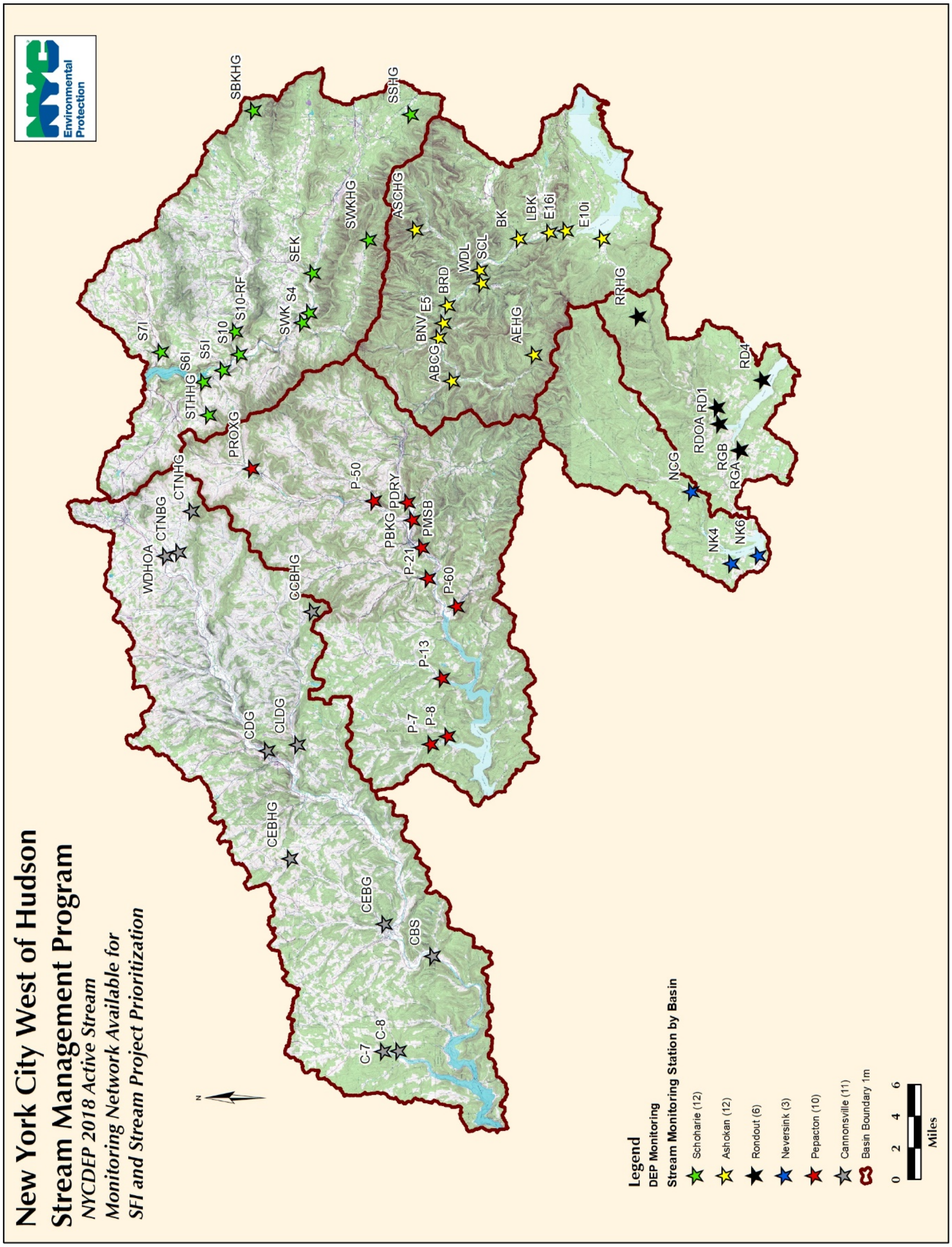

Figure 1. DEP water quality monitoring stream stations that can inform SFI and WQSP planning.

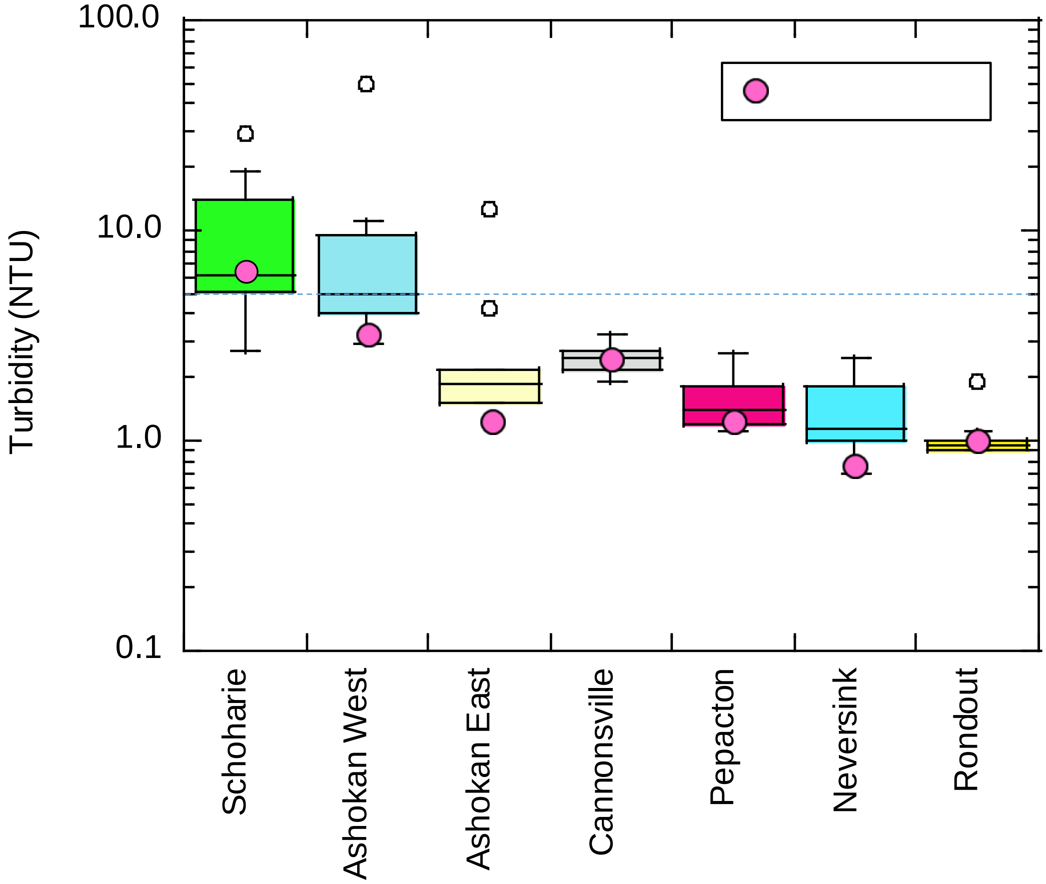

Figure 2. Annual median turbidity in West of Hudson reservoirs (2007-2017) with the 2017 values displayed as a solid dot. The dashed line represents the standard (5 NTU) for source waters as a reference.

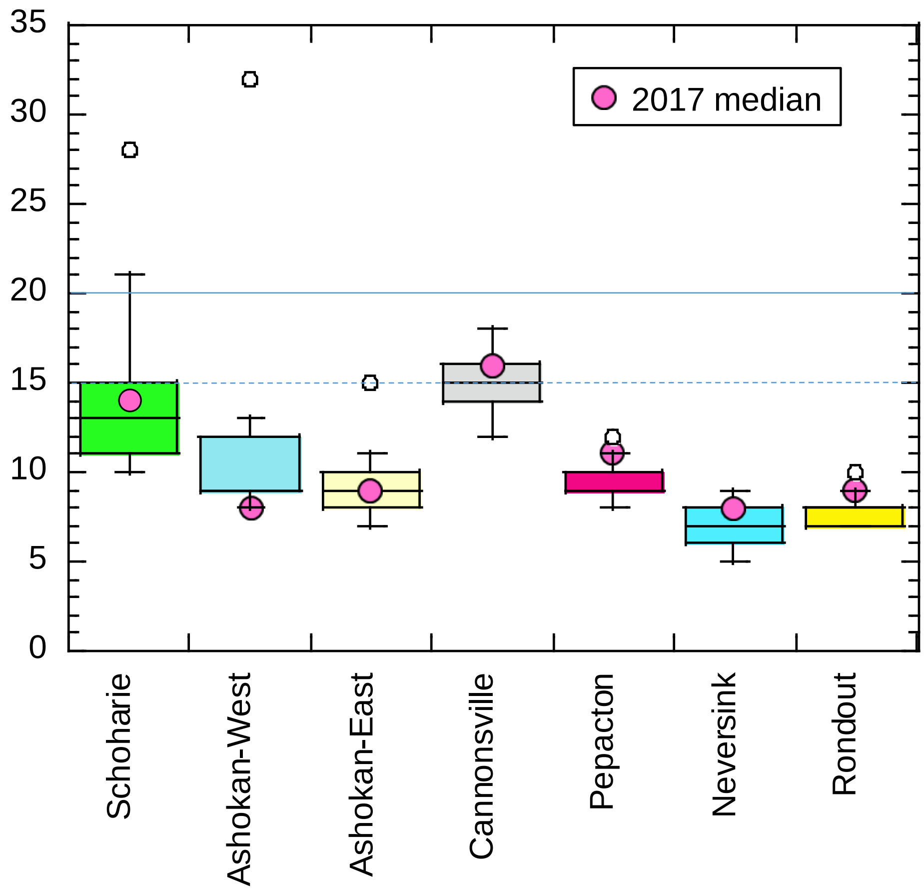

Figure 3. Annual median total phosphorus (TP) in West of Hudson reservoirs (2017 vs. 2007-2016) with the 2017 75th percentile values displayed as a solid dot. The horizontal dashed line at 15 μg L^{-1} refers to the NYC Total Maximum Daily Load (TMDL) guidance value for source waters. The horizontal solid line at 20 μg L^{-1} refers to the NYSDEC ambient water quality guidance value for reservoirs other than source waters.

Table 1. Status of WQSPs towards fulfillment of the 2017 FAD requirement.

Project Name	Status	Length (feet)	Basin
Batavia Kill at Kastanis	Completed	3,800	Schoharie
Bush Kill at Watson Hollow	Completed	250	Ashokan
Batavia Kill at Red Falls Phase 1	Approved	2,700	Schoharie
Batavia Kill at Red Falls Phase 2	Approved	4,400	Schoharie
West Branch Neversink River at Clothes Pool	Approved	800	Neversink
Hillslope Stabilization at Bull Run	Approved	300	Pepacton
East Kill at Colgate Lake Road	Approved	680	Schoharie
Warner Creek at Mile 1.2	Approved	540	Ashokan
Warner Creek at Mile 1.5	Approved	560	Ashokan
Stony Clove Creek above Jansen Road	Approved	1,600	Ashokan

2. Schoharie Basin

2.1 Water Quality Monitoring

With respect to stream management and reservoir operations, turbidity continues to be the primary water quality concern in the Schoharie basin (Figure 2). Figure 4 shows locally weighted scatterplot smoothing (LOWESS) trend lines of monthly monitored turbidity and TP for Schoharie Creek above the Schoharie Reservoir from 1993 to 2014. The plot shows that following the repeat high magnitude flooding of 2010-2011, turbidity levels in the Schoharie basin increased and remained elevated, reflecting the stream geomorphic response of increased erosional contact with suspended sediment sources in the basin. While TP is relatively elevated in the Schoharie basin, it is not explicitly targeted as a contaminant of concern by the Schoharie Basin SMP. It is understood that some portion of TP is associated with soils eroded from former or current agricultural floodplains and stream banks in the Schoharie basin. Therefore, targeting assessments and stream projects to reduce suspended-sediment is expected to have some additional benefit in reducing TP.

There are 12 DEP water quality monitoring stations in the Schoharie basin that have routine monthly sampling of turbidity and TP (Figure 1). Schoharie Creek and the three largest tributaries (East Kill, West Kill and Batavia Kill) are monitored routinely. Bear Kill and Manor Kill, which flow directly into the reservoir, are also monitored. In 2018, DEP resumed upstream/downstream turbidity monitoring of the Red Falls reach of Batavia Kill. Provisional results support the conclusion reached by past storm event monitoring and observation by Greene County Soil and Water Conservation District (GCSWCD) that the Red Falls reach is the most significant source of both chronic and acute turbidity on Batavia Kill and probably in the entire Schoharie basin. As described below, a two-phase WQSP is currently under design for the Red Falls reach. The pre-construction and post-construction monitoring that DEP has set up will help measure the potential turbidity reduction efficacy of this project.

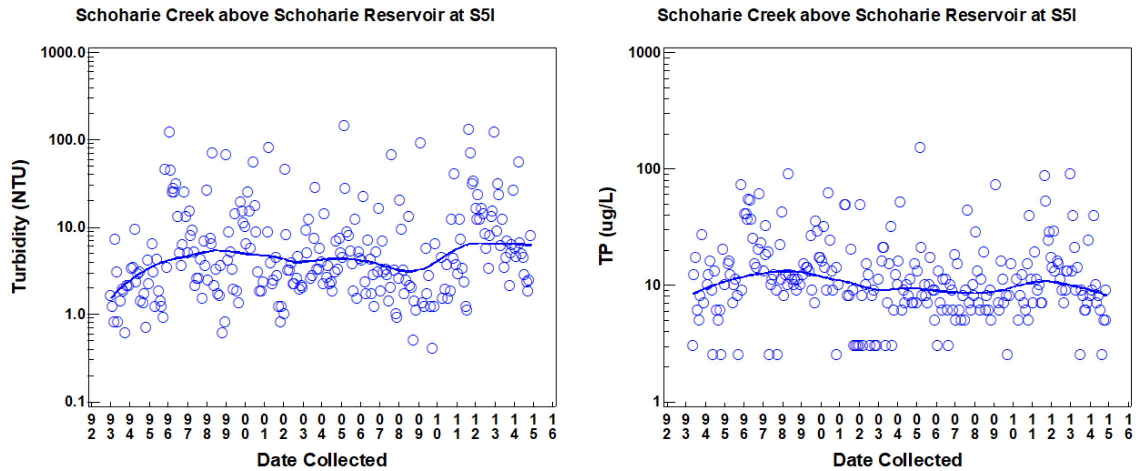

Figure 4. Turbidity and total phosphorous (TP) temporal trends for Schoharie Creek above Schoharie Reservoir for the period 1993-2014. Each blue circle represents the first sample collected in a given month. LOWESS curves (blue line) were fit to the data using a smooth factor of 30% to visually describe both the long-term and intermediate data patterns. Trend statistics were performed on the data after it was adjusted for flow (DEP, 2016).

2.2 Stream Feature Inventories

GCSWCD has a robust stream corridor assessment and monitoring program as reported annually in the Schoharie Basin SMP Action Plans. GCSWCD has completed multiple SFIs in the Schoharie basin since 1997 (Table 2) covering all higher order streams. DEP water quality monitoring data generally supported GCSWCD's recent selection of the Batavia Kill and West Kill for repeat SFIs. The 2019-2021 Action Plan includes a repeat SFI for the East Kill and a new SFI for the Sawmill Creek in 2019. A total of four of the required six SFIs will be completed in the period 2018-2019. Plans for future SFIs will be described in subsequent Action Plans.

Table 2. Completed SFIs in the Schoharie basin.

Stream	DEP Monitored Sub-Basin (Station) [1]	Year Completed
Batavia Kill	Batavia Kill (S10)	1996; 2003; 2017
West Kill	West Kill (SWK)	2004; 2005; 2018
Schoharie Creek	Schoharie Creek (S5i)	2006
East Kill	East Kill (SEK)	2006
Manor Kill	Manor Kill (S7i)	2008
Mad Brook	Batavia Kill (S10-RF)	2009
North Settlement Creek	Batavia Kill (S10)	2009
Furnace Creek	Batavia Kill (S10)	2009
Red Falls Creek	Batavia Kill (S10)	2009
Huntersfield Creek	Schoharie Creek (S5i)	2016
Little West Kill	Schoharie Creek (S5i)	2016
Red Kill	Schoharie Creek (S4)	2016
Gooseberry Creek	Schoharie Creek (S4)	2018

[1] Refers to the closest stream monitoring station that would include the assessed stream.

2.3 Water Quality Stream Projects

All WQSPs in the Schoharie basin have been and will continue to focus on reducing turbidity contributions from eroding reaches identified by SFIs. GCSWCD is scheduled to construct a WQSP on the East Kill at Colgate Lake Road in 2019. This is a site where active channel erosion has triggered long-lasting contact with glacial sediment that produces turbid streamflow following high magnitude events. GCSWCD is also progressing the design of a two-phase approach to restoring channel stability and turbidity reduction for the Red Falls reach on the Batavia Kill.

3. Ashokan Basin

3.1 Water Quality Monitoring

With respect to stream management, turbidity continues to be the primary water quality concern in the Ashokan basin (Figure 2). Figure 5 shows LOWESS trend lines of monthly monitored turbidity and TP for Esopus Creek above the Ashokan Reservoir from 1993 to 2014. The plot shows that following the high magnitude flooding of 2010-2011, turbidity levels in the Ashokan basin increased and remained elevated through 2014, reflecting the stream geomorphic response of increased erosional contact with suspended-sediment sources. This pattern is evident in response to earlier extreme hydrologic conditions (e.g. April 2005 flooding). TP does not seem to exist at elevated levels in the reservoir and the Ashokan Watershed Stream Management Program (AWSMP) does not currently target TP as a contaminant of concern (Figures 3 and 5).

There are 12 DEP water quality monitoring stream stations in the Ashokan basin that have routine monthly sampling of turbidity and TP. The Esopus Creek and most of the main tributaries are monitored, in addition to the Bush Kill which flows directly into Ashokan Reservoir (Figure 1). In addition to DEP's water quality data, the Ashokan basin is extensively monitored as part of a 10-year turbidity monitoring research project conducted by USGS and DEP. The monitoring for the first two years identified the sub-basins contributing the most turbidity in the Esopus Creek basin using the 14 sub-basin turbidity monitoring stations (DEP, 2019a). Woodland Creek is currently the highest turbidity producing sub-basin, followed by Beaver Kill, Birch Creek, Stony Clove Creek and Broadstreet Hollow for the period 2016-2018.

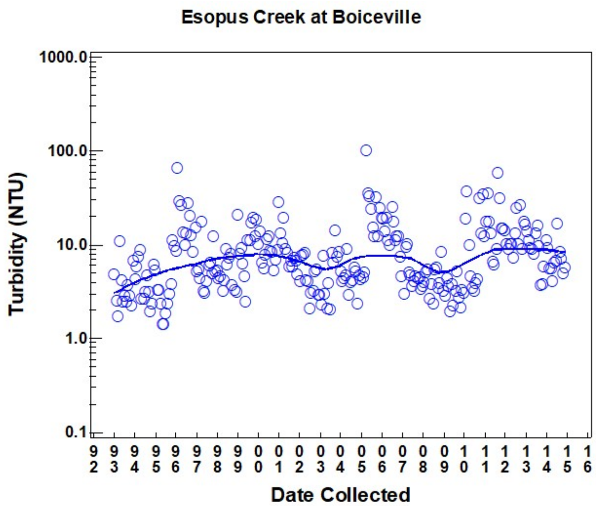

Figure 5. Turbidity and total phosphorous (TP) temporal trends for Esopus Creek above Ashokan Reservoir for the period 1993-2014. Each blue circle represents the monthly median from weekly surveys rather than the first survey of the month. LOWESS curves (blue line) were fit to the data using a smooth factor of 30% to visually describe both the long-term and intermediate data patterns. Trend statistics were performed on the data after it was adjusted for flow (DEP, 2016).

3.2 Stream Feature Inventories

The AWSMP has a robust stream corridor assessment and monitoring program as reported annually in the AWSMP Action Plans. Ulster County SWCD (UCSWCD) and DEP have completed multiple SFIs in the Ashokan basin since 2001 covering most higher order streams, including repeat assessments of turbidity-generating streams (Table 3). All streams monitored by DEP for water quality have been assessed using SFI methods at least once. In 2018, UCSWCD completed SFIs for two Esopus Creek headwater tributary streams (Hatchery Hollow and Lost Clove Creek) and DEP completed a repeat SFI of the Stony Clove Creek as part of the 10-year Turbidity/Suspended-Sediment Monitoring Study. In 2019, UCSWCD will complete a repeat SFI for the Esopus Creek headwater reaches that were last assessed in 2005. As part of the Upper Esopus Creek Turbidity/Suspended-Sediment Study, DEP will complete repeat SFIs for Stony Clove tributary streams (Warner Creek, Ox Clove Creek, Hollow Tree Brook, and Myrtle

Brook) in 2019. UCSWCD plans to complete future SFIs for at least six additional Esopus Creek tributary streams in 2020-2021.

Table 3. Completed SFIs in the Ashokan basin.

Stream	DEP Monitored Sub-Basin (Station) [1]	Year Completed
Broadstreet Hollow	Broadstreet Hollow (BRD)	2001
Stony Clove Creek	Stony Clove (SCL)	2001; 2013; 2018
Esopus Creek	Esopus Creek (E16i)	2006
Woodland Creek	Woodland Creek (WDL)	2008; 2015
Beaver Kill	Beaver Kill (BK)	2010
Warner Creek	Stony Clove (SCL)	2010; 2011; 2012; 2015
Birch Creek	Birch Creek (ABCG)	2012
Bush Kill	Bush Kill (E10i)	2012
Bushnellsville Creek	Bushnellsville Creek (BNV)	2013
Stony Clove Tributaries	Stony Clove (SCL)	2015
Maltby Hollow Brook	Bush Kill (E10i)	2015
Little Beaver Kill	Little Beaver Kill (LBK)	2017
Hatchery Hollow, Lost Clove	Esopus Creek (E5)	2018

[1] Refers to the closest stream monitoring station that would include the assessed stream.

3.3 Water Quality Stream Projects

Stream restoration projects in the Ashokan basin have been and will continue to focus on reducing turbidity contributions from eroding reaches (DEP, 2019b). UCSWCD plans to construct three WQSPs in the Stony Clove sub-basin between 2020 and 2021 (DEP, 2019c). These project sites were selected using USGS turbidity monitoring data. DEP anticipates that UCSWCD will continue to use the SFI methods and turbidity monitoring data to identify future WQSPs.

4. Rondout Basin

4.1 Water Quality Monitoring

With respect to stream management, turbidity and TP potentially associated with stream bank erosion are not water quality concerns in the Rondout basin (Figures 2 and 3). Figure 6 shows LOWESS trend lines of monthly monitored turbidity and TP for the Rondout Creek above Rondout Reservoir from 1993 to 2014. The plots show that Rondout Creek and its tributary streams are, with rare exception, below levels of concern. Although this basin has also experienced geomorphic response in stream channel erosion following high magnitude flooding, there is generally limited contact with the suspended-sediment geologic sources that can produce sustained high turbidity levels.

There are six DEP water quality monitoring stations in the Rondout basin that have routine monthly sampling of turbidity and TP (Figure 1). The current monitoring is limited to the Rondout Creek, Chestnut Creek and two smaller streams (Trout Creek and Sugarloaf Brook) that enter the reservoir directly.

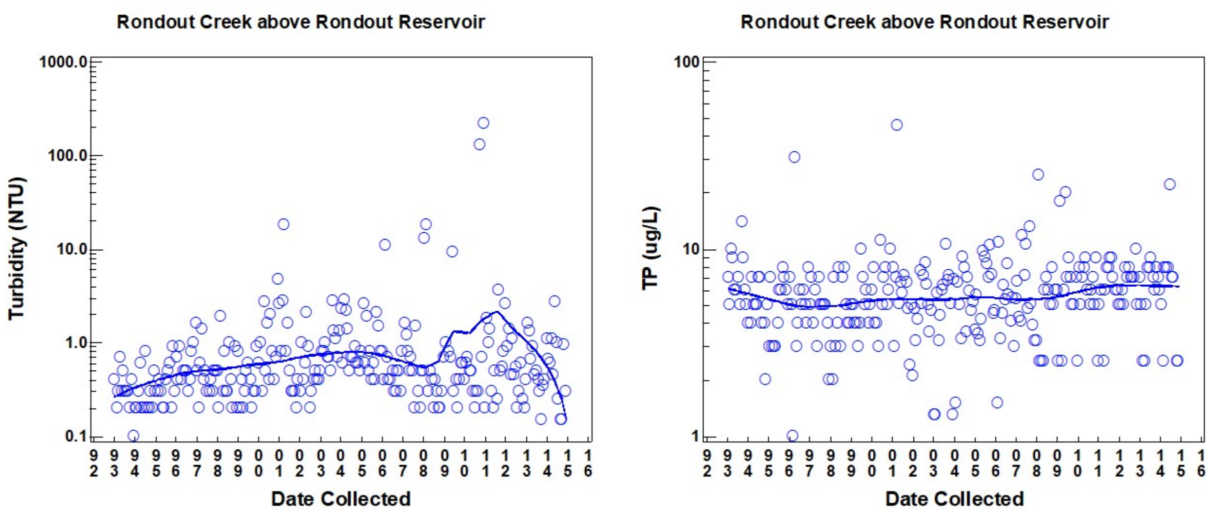

Figure 6. Turbidity and total phosphorous (TP) temporal trends for the Rondout Creek above Rondout Reservoir for the period 1993–2014. Each blue circle represents the first sample collected in a given month. LOWESS curves (blue line) were fit to the data using a smooth factor of 30% to visually describe both the long-term and intermediate data patterns. Trend statistics were performed on the data after it was adjusted for flow (DEP, 2016).

4.2 Stream Feature Inventories

The Rondout Neversink Stream Program (RNSP) has completed five SFIs in the Rondout basin since 2001 (Table 4). All DEP water quality monitored streams have been assessed. The 2019-2021 RNSP Action Plan includes a list of planned SFIs for the Rondout basin: a repeat SFI of Rondout Creek in 2019 and new SFIs for Rondout tributaries Stone Cabin Brook, Bear Hole Brook, and Molls Brook.

Table 4. Completed SFIs in the Rondout basin.

Stream	DEP Monitored Sub-Basin (Station) [1]	Year Completed
Chestnut Creek	Chestnut Creek (RGB)	2001-2002
Rondout Creek	Rondout Creek (RDOA)	2008-2009
Sugar Loaf Brook	Sugar Loaf Brook (RD1)	2017
Trout Creek	Trout Creek (RD4)	2017
Conklin Brook	N/A	2017

[1] Refers to the closest stream monitoring station that would include the assessed stream. If the stream flows directly to the reservoir without a downstream station that is noted as N/A.

4.3 Water Quality Stream Projects

As of 2019 there are no designated WQSPs completed in the Rondout basin that explicitly address turbidity or TP. Given the relative low turbidity conditions in this basin, turbidity reduction projects have not been a priority; however, future SFI efforts may find sections of stream that would benefit from some level of treatment that could help reduce future sediment loading that can impair water quality.

5. Neversink Basin

5.1 Water Quality Monitoring

With respect to stream management, turbidity and TP potentially associated with stream bank erosion have not historically been water quality concerns in the Neversink basin (Figures 2 and 3). Figure 7 shows LOWESS trend lines of monthly monitored turbidity and TP for Neversink River above the Neversink Reservoir from 1993 to 2014. The turbidity plot shows that the Neversink River system has seen an increase in sampled turbidity since 2010; however, the values are still comparatively low. Although this basin has experienced stream channel erosion following high magnitude flooding, there is generally limited contact with the suspended-sediment geologic sources that can produce sustained high turbidity levels. As discussed below, past SFIs and bank erosion monitoring assessments completed by RNSP have found several sites that do have chronic mass wasting that include suspended-sediment geologic sources that can lead to episodic event-based turbidity. This is a basin that is potentially prone to degraded water quality if bank erosion into the glacially-sourced fine sediment increases in response to high magnitude floods.

There are three DEP water quality monitoring stations in the Neversink basin that have routine monthly sampling of turbidity and TP (Figure 1). The current monitoring is limited to the

Neversink River above the reservoir and two small streams that flow directly into the reservoir (Aden and Kramer Brooks).

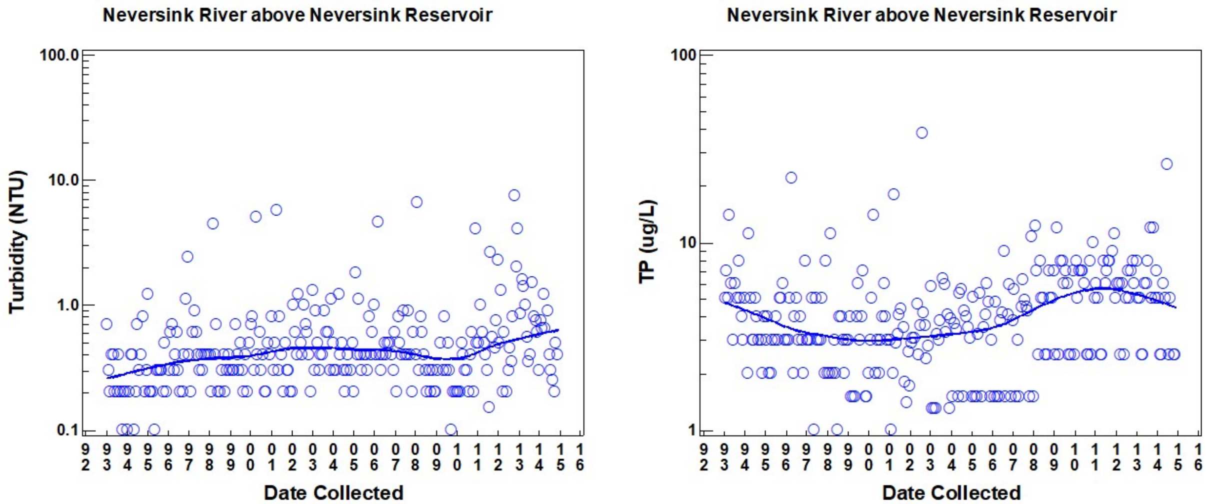

Figure 7. Turbidity and total phosphorous (TP) temporal trends for Neversink River above Neversink Reservoir for the period 1993–2014. Each blue circle represents the first sample collected in a given month. LOWESS curves (blue line) were fit to the data using a smooth factor of 30% to visually describe both the long-term and intermediate data patterns. Trend statistics were performed on the data after it was adjusted for flow (DEP, 2016).

5.2 Stream Feature Inventories

The RNSP has a robust stream corridor assessment and monitoring program as reported annually in the RNSP Action Plans and in the Stream Management Plan developed for streams in the Neversink basin. The RNSP has completed 12 SFIs in the Neversink basin since 2010 (Table 5). The limited water quality monitoring is not sufficient to inform where the RNSP will focus future SFI and water quality project efforts; therefore, the RNSP strategy is to perform repeat SFIs of the main streams as needed, and to assess smaller tributaries previously unassessed. The current RNSP Action Plan includes a list of planned SFIs for the Neversink basin: repeat SFIs for High Falls Brook and Pigeon Brook.

The RNSP has also developed a network of bank erosion monitoring sites identified in SFI efforts in the Neversink basin that are prioritized based on size and potential sediment contribution to the stream. Recent stream projects were selected from this prioritized list of bank erosion monitoring sites.

Table 5. Completed stream feature inventories in the Neversink Reservoir basin.

Stream	DEP Monitored Sub-Basin and Station [1]	Year Completed
Neversink mainstem	Neversink River (NCG)	2010-2011
East Branch of the Neversink	Neversink River (NCG)	2010-2011
West Branch of the Neversink	Neversink River (NCG)	2010-2011
Pigeon Brook	Neversink River (NCG)	2014
Biscuit Brook	Neversink River (NCG)	2014
Shelter Creek	Neversink River (NCG)	2015
High Falls Brook	Neversink River (NCG)	2015
Fall Brook	Neversink River (NCG)	2015
Tray Mill Brook	Neversink River (NCG)	2015
Flat Brook	Neversink River (NCG)	2015
Erts Brook	Neversink River (NCG)	2015

[1] Refers to the closest stream monitoring station that would include the assessed stream

5.3 Water Quality Stream Projects

Neversink basin WQSPs will focus on reducing stream channel erosion that can potentially lead to localized sources of excess sediment supply and turbidity. Given the relatively low turbidity conditions in this basin, turbidity reduction projects have not been a long-standing priority as they are in the Ashokan and Schoharie basins; however, since 2011, there has been an observed increase in erosional contact with glacial sediment sources that can episodically increase turbidity. The planned 2019 WQSP on the West Branch Neversink River at Clothes Pool is designed to remove erosional contact with a mass-wasting hillslope that is the largest turbidity source currently monitored in that sub-basin. Future SFI efforts may find bank erosion sites that can be added to the monitoring list for inclusion in the treatment prioritization process.

6. Pepacton Basin

6.1 Water Quality Monitoring

With respect to stream management, turbidity and TP potentially associated with stream bank erosion have not been priority water quality concerns in the Pepacton basin (Figures 2 and 3). Figure 8 shows LOWESS trend lines of monthly monitored turbidity and TP for the East Branch Delaware River (EBDR) above Pepacton Reservoir from 1993 to 2014. The turbidity plot illustrates that the EBDR system has not seen an increase in sampled turbidity through the monitoring period and that values are generally between 1.0 and 2.0 NTU. This indicates that though there is stream erosion in the basin, there is generally limited contact with the suspended-sediment geologic sources that can produce sustained high turbidity levels. TP values are trending from higher to lower values at the basin scale and it is not known what percentage of the TP may be associated with stream bank erosion.

There are 10 DEP water quality monitoring stations in the Pepacton basin that have routine monthly sampling of turbidity and TP (Figure 1). EBDR and most of the main tributaries are monitored, in addition to four tributary streams that flow directly into Pepacton Reservoir.

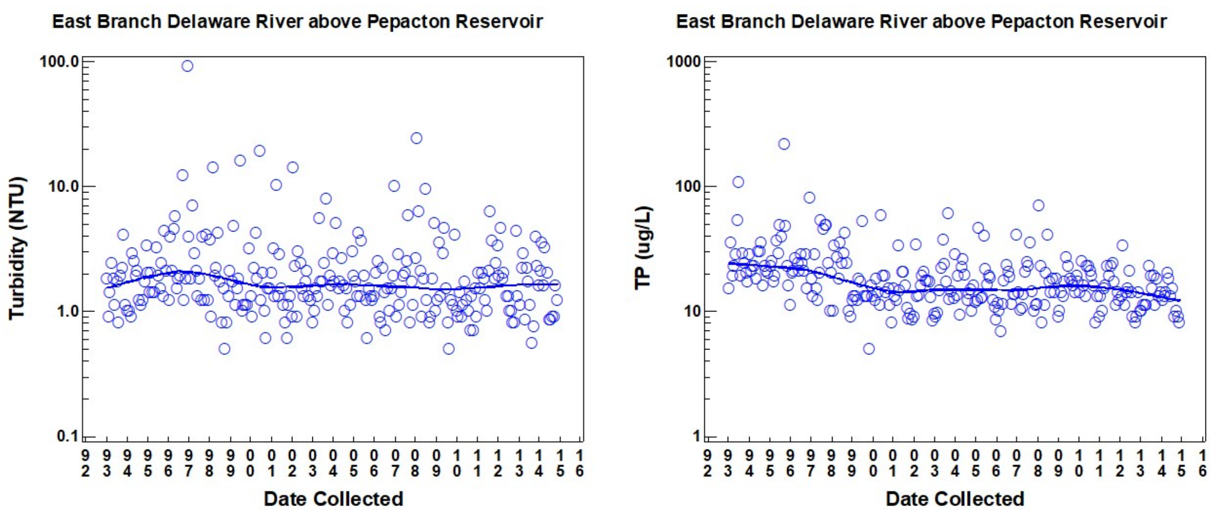

Figure 8. Turbidity and total phosphorous (TP) temporal trends for East Branch Delaware River above Pepacton Reservoir for the period 1993–2014. Each blue circle represents the first sample collected in a given month. LOWESS curves (blue line) were fit to the data using a smooth factor of 30% to visually describe both the long-term and intermediate data patterns. Trend statistics were performed on the data after it was adjusted for flow (DEP, 2016).

6.2 Stream Feature Inventories

The Delaware Watershed Stream Corridor Management Program has recently resumed SFIs following a multi-year focus on flood response and stream stabilization. Unlike other basins, which used GPS field-based assessments for all assessed streams, SFI efforts in the Delaware basins prior to 2017 included a mix of remote-sensed assessments, helicopter-based video assessments, and GPS field-based methods. Volume II of the EBDR Stream Corridor Management Plan developed for multiple streams in the Pepacton basin provides the SFI results (Table 6). In 2018, Delaware County SWCD (DCSWCD) completed an SFI for the Little Red Kill, a tributary to EBDR. The 2019-2020 Action Plan for the East and West Branches of the Delaware River includes a planned SFI of Huntley Hollow on the north side of the Pepacton Reservoir for 2019.

Table 6. Completed SFIs in the Pepacton basin.

Stream	DEP Monitored Sub-Basin (Station) [1]	Year Completed
Dry Brook	Dry Brook (PDRY)	2005-2006
Tremper Kill	Tremper Kill (P-13)	2005-2006
Bush Kill	Bush Kill (PBKG)	2005-2006
Batavia Kill	Batavia Kill (P-50)	2005-2006
Platte Kill	Platte Kill (P-21)	2005-2006
East Branch Delaware River	EBDR (PMSB and PROXG)	2005-2006
Terry Clove	Terry Clove (P-7)	2005-2006
Fall Clove	Fall Clove (P-8)	2005-2006
Mill Brook	Mill Brook (P-60)	2005-2006
Little Red Kill	EBDR (PMSB)	2018

[1] Refers to the closest stream monitoring station that would include the assessed stream.

6.3 Water Quality Stream Projects

Pepacton basin WQSPs will focus on reducing stream channel erosion that can potentially protect against increases in turbidity. Given the relatively low turbidity conditions in this basin, turbidity reduction projects have not been a priority relative to the Ashokan and Schoharie basins, although DCSWCD has implemented several stream projects addressing erosion. A WQSP on Bull Run, a tributary stream to the EBDR, is currently under design; the project will mitigate a stream erosion triggered hillslope mass failure in glacial till that episodically creates turbidity. Future SFI efforts may find sections of stream that would benefit from some level of treatment that could help reduce future suspended-sediment loading that can impair water quality.

7. Cannonsville Basin

7.1 Water Quality Monitoring

The Cannonsville Reservoir continues to have the highest TP levels of all West of Hudson reservoirs (Figure 3); it also has the third highest levels of turbidity although it remains below the 5 NTU source waters standard as shown in Figure 2. With respect to stream management, suspended-sediment loading potentially associated with stream bank erosion have been water quality concerns in the Cannonsville basin. TP has been a water quality concern for NYC mitigated through improved WWTPs and agricultural BMPs (DEP, 2016). Figure 9 shows LOWESS trend lines of monthly monitored turbidity and TP for the West Branch Delaware River (WBDR) above Cannonsville Reservoir from 1993 to 2014. The turbidity plot shows that the WBDR system has seen a minor decrease in sampled turbidity through the monitoring period. This indicates that though there is stream erosion in the basin, there is generally limited contact with the suspended-sediment geologic sources that can produce sustained high turbidity levels. TP values are also trending from higher to lower values at the basin scale; it is not known what percentage of the TP may be associated with stream bank erosion.

There are 11 DEP water quality monitoring stations in the Cannonsville basin that have routine monthly sampling of turbidity and TP (Figure 1). WBDR is monitored at three mainstem locations, three main tributaries to WBDR (East Brook, Little Delaware River, and Town Brook) along with three headwater sites (Wolf Creek, Coulter Brook, and upper Town Brook). Two streams (Loomis Brook and Trout Creek) that flow directly into Cannonsville Reservoir are also monitored.

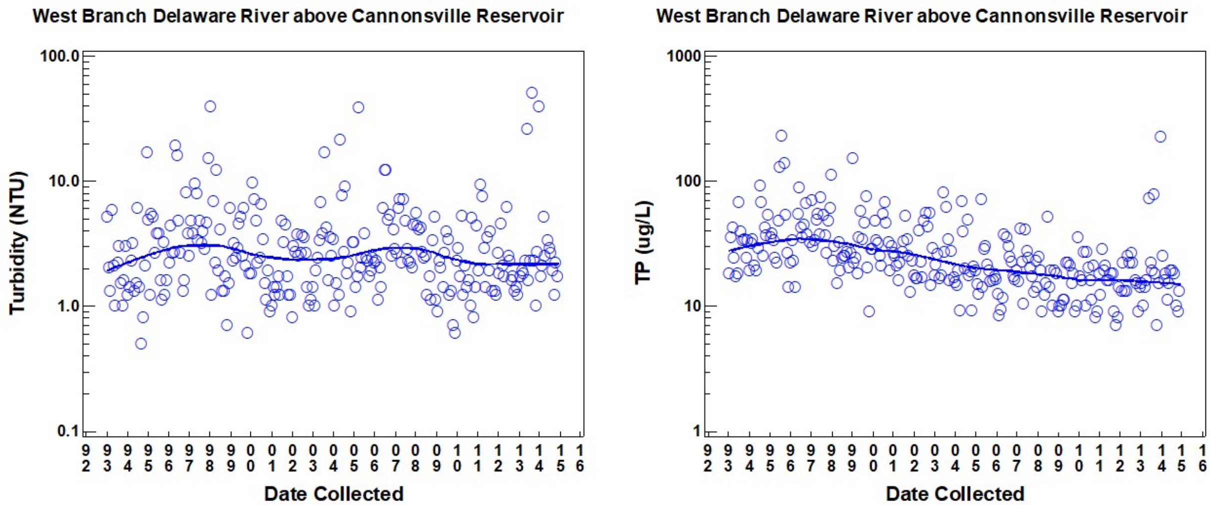

Figure 9. Turbidity and total phosphorous (TP) temporal trends for West Branch Delaware River above Cannonsville Reservoir for the period 1993–2014. Each blue circle represents the first sample collected in a given month. LOWESS curves (blue line) were fit to the data using a smooth factor of 30% to visually describe both the long-term and intermediate data patterns. Trend statistics were performed on the data after it was adjusted for flow (DEP, 2016).

7.2 Stream Feature Inventories

In 2017, the Delaware Watershed Stream Corridor Management Program resumed SFIs following a multi-year focus on flood response and stream stabilization. The results of pre-2017 SFIs are described in Section 6 of the WBDR Stream Corridor Management Plan developed for multiple streams in the Cannonsville basin and in the Third Brook Watershed Management Plan (as summarized in Table 7). In 2017, DCSWCD completed an SFI for Steele Brook and a small tributary to Elk Creek, which flows into the WBDR upstream of Delhi. The 2019-2020 Action Plan for the East and West Branches of the Delaware River does not reference a planned SFI for a Cannonsville basin stream in 2019.

According to DCSWCD, turbidity and TP are the priority pollutants that will guide SFI and WQSP selection in the Cannonsville basin. DEP's water quality monitoring network can provide some guidance using the three monitoring stations on the WBDR to help identify the segments of the river (and corresponding sub-basins) that may yield the most turbidity and/or TP. A supplemental assessment by DCSWCD will measure and map TP concentrations in representative streamside soils in conjunction with a review of available aerial imagery to identify eroding stream reaches that may disproportionately contribute TP through bank erosion. DCSWCD will use subsequent field-based SFIs to obtain additional data to prioritize erosion sites for potential treatment.

Table 7. Completed SFIs in the Cannonsville basin.

Stream	DEP Monitored Sub-Basin (Station) [1]	Year Completed
West Branch Delaware River	WBDR (CBS, CDG, WDHOA)	2002-2004
Town Brook	Town Brook (CTNBG)	2003
Third Brook	WBDR (CBS)	2013
Steele Brook	WBDR (CBS)	2017
Elk Creek Tributary	WBDR (CDG)	2017

[1] Refers to the closest stream monitoring station that would include the assessed stream.

7.3 Water Quality Stream Projects

Projects to reduce turbidity or TP in the Cannonsville basin include stream bank stabilization projects to mitigate erosion into streams adjacent to agricultural land. The 2016 More Farm Project on the WBDR is an example of a WQSP designed to reduce stream bank erosion that could also protect against entrainment of TP-bound in sediments.

DCSWCD plans to pursue WQSPs that explicitly intend to reduce TP and suspended-sediment loading from stream bank erosion in current or former agricultural settings. Utilizing the methods outlined in Section 7.2, DCSWCD will prioritize eroding reaches of stream channel for treatment with stabilization practices. Additionally, DCSWCD will continue assessing other priority tributaries to identify and prioritize stream and bank instabilities for treatment.

8. Conclusion

The density and distribution of DEP's water quality monitoring stations varies greatly throughout the West of Hudson watershed. In all cases, monitoring is generally at a fixed frequency with some exceptions, and therefore does not sufficiently represent storm event impacts on water quality. Despite this limitation, DEP was able to use basin-scale data to focus discussion on water quality status and trends for turbidity and TP, and facilitate each basin's SFI and WQSP prioritization approach. DEP will continue to share new data on turbidity and TP levels with its SMP partners to help inform ongoing SFI selection, and SFIs will continue to be the primary tool for assessing stream impacts on water quality and in selecting WQSPs.

9. References

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