# TOHICKON CREEK

# BUCKS COUNTY

**WATER QUALITY STANDARDS REVIEW**

**STREAM EVALUATION REPORT**

**Segment: Main Stem,**
**Lake Nockamixon Dam to Mouth**
**Stream Code: 03110**
**Drainage List: E**



**WATER QUALITY MONITORING SECTION** (MJL)
**DIVISION OF WATER QUALITY**
**BUREAU OF CLEAN WATER**
**DEPARTMENT OF ENVIRONMENTAL PROTECTION**

**2019**

## INTRODUCTION

The Department of Environmental Protection (DEP) conducted an evaluation of Tohickon Creek from Lake Nockamixon Dam to its mouth in response to a petition from Marion and Neil Kyde on behalf of the Tinicum Conservancy that was accepted for study by the Environmental Quality Board (EQB) on September 19, 1995. The petition requests this lower mainstem portion be redesignated to Exceptional Value (EV) from Lake Nockamixon Dam to the mouth. With the exception of the Warm Water Fishes, Migratory Fishes (WWF, MF) designation of Deep Run, the lower Tohickon Creek basin is currently designated Cold Water Fishes, Migratory Fishes (CWF, MF).

The stream redesignation process begins with an evaluation of the "existing uses" and the "designated uses" of a stream. "Existing uses" are water uses actually attained in the waterbody. When existing uses are determined, the stream is protected for those uses through permit or approval actions taken by the DEP. "Designated uses" are water uses identified in regulations that protect a waterbody. Candidates for stream redesignation may be identified by the DEP based on routine waterbody investigations, or based on requests initiated by other agencies or from the general public through a rulemaking petition to the state Environmental Quality Board (EQB).

The initial field survey in response to the petition was completed January 1997 and a report recommending the the lower Tohickon Creek basin be redesignated from CWF to Trout Stocking (TSF) was completed May 1997. The report was incorporated into a proposed regulatory package but was removed from the package and the recommendation did not make it to final rulemaking due in part to objections by the petitioners and stakeholders. The lower Tohickon Creek mainstem was surveyed for the second time in May 2000, subsequent to the DEP's revised Antidegradation Regulations. A draft report based on the findings was forwarded to the petitioners and stakeholders in March 2001. The draft report recommended the lower Tohickon Creek basin be redesignated from CWF to Warm Water Fishes (WWF) due to the warm instream summer temperatures and the predominance of warm water fish species in the basin. The petitioners and others rejected this recommendation and the report was not incorporated into a regulatory package.

Subsequent to the second report the DEP met with the petitioners and discussed the potential for the lower Tohickon Creek basin to meet the High Quality criterion at § 93.4b (a)(1)(i), "The water has long-term water quality, based on at least one year of data which exceeds levels….at least 99% of the time…"

The petitioners contracted Princeton Hydro to collect the long-term water quality data, which took place November 2005 through December 2006. The DEP also collected additional water quality and biological data in 2008, 2010 and again from 2012-2014 as part of other methods development and assessment efforts. Components of this evaluation are based on data collected from 1997 through 2014.

## GENERAL WATERSHED DESCRIPTION

Tohickon Creek is a freestone tributary to the Delaware River. The petitioned mainstem originates at Lake Nockamixon Dam in Nockamixon and Bedminster Townships, Bucks County and flows southeast through Tinicum and Plumstead Townships until it empties into the Delaware River (Figure 1). The entire Tohickon Creek basin has a drainage area of 114 square miles that includes Lake Nockamixon and its tributaries. The candidate mainstem segment is approximately 11.2 miles long, which is characterized by relatively flat topography with some gently rolling hills of low relief.

The current land use of the petitioned area (Nockamixon Dam to the mouth) is a mixture of agricultural (37%), forest (48%), urban/developed (4%), and wetland/water/transitional (11%). Ralph Stover State Park occupies approximately 45 acres within the watershed. A section of this park contains High Rocks - an argillite cliff rising approximately 200 feet above the streambed that is heavily used by rock climbers. Tohickon Valley Park occupies approximately 606 acres. A small portion of the 5,283-acre Nockamixon State Park is located within the portion of the basin under study. Sentinel Rock, a 25-foot pinnacle of red shale and siltstone, is an outstanding geological feature of Pennsylvania that is located within Nockamixon State Park downstream of Nockamixon Dam. The lower end of Tohickon Creek passes through the Delaware Canal State Park before emptying into the Delaware River.

## WATER QUALITY AND USES

### Surface Water

Water chemistry data was collected by Princeton Hydro from November 2005 through December 2006 and by the DEP from February 2008 through October 2008 and March 2012 through November 2014. The Princeton Hydro sampling effort was conducted at three locations on Tohickon Creek mainstem (Table 1, Figure 1). Water quality monitoring consisted of grab water chemistry samples and in-situ measurements (water temperature, pH, specific conductance, dissolved oxygen) using a multi-probe water quality meter. The Princeton Hydro results indicated that water quality in the Tohickon Creek mainstem did not always meet applicable water quality standards - specifically for temperature and pH (Figures 2, 7 & 10; Tables 2 & 3).

The DEP collected continuous instream monitoring (hereafter referred to as CIM) data at two locations on Tohickon Creek in 2008, at two locations in 2012 and 2013, and again at one station in 2014 (Table 1, Figure 1). CIM involves the deployment of equipment that collects water quality data at established intervals for a period of time. Most instream monitoring configurations include at least four parameters: water temperature, specific conductance, pH, and dissolved oxygen data. These data are valuable for a variety of purposes including but not limited to, characterizing baseline physicochemical stream conditions, describing seasonal and diel fluctuations, and documenting potential violations to water quality criteria. A detailed CIM report for Tohickon Creek is available on the DEP's website.

The DEP's initial CIM effort was conducted from February 2008 through October 2008 at two locations on the Tohickon Creek mainstem (Table 1, Figure 1). Water quality monitoring consisted of deploying continuous data loggers to monitor water temperature and pH. The data loggers recorded these parameters every four hours throughout the specified monitoring period and were periodically cleaned, downloaded, and calibrated to insure proper function. The results indicate that water quality in the Tohickon Creek mainstem does not meet §93.7 CWF, TSF, or WWF temperature criteria or pH criteria 99% of the time (Figures 3, 4 & 8).

Subsequent the DEP's 2008 CIM effort, it has been determined that Nockamixon Dam may not have been meeting its conservation release due to inoperable release valves. This may have resulted in significantly reduced flows and a subsequent reduced ability for Tohickon Creek to naturally assimilate elevated summer air tempertures.

CIM was again implemented on Tohickon Creek mainstem at 2TC from April 2012 through September 2013 and at 13TC from March 2013 through December 2014 (Table 1, Figure 1). The CIM effort at 13TC from 2013 through 2014 was accompanied by additional water chemistry sampling. Data loggers at 2TC collected water temperature data every 15 minutes. Data loggers at 13TC collected water temperature, specific conductance, pH, and dissolved oxygen data every 30 minutes throughout the specified period.

### Aquatic Biota

The indigenous aquatic community is an excellent indicator of long-term conditions and is used as a measure of water quality. DEP staff collected habitat and benthic macroinvertebrate data in the Tohickon Creek basin in January 1997, on the mainstem in May 2000 and again on the mainstem in April 2010. DEP and PFBC staff collected fish data at various locations within the Tohickon Creek basin on May 1977, June 1981, May 1992, September 1999, July 2009, July 2013, and August 2014.

**Habitat.** Habitat data collected in January 1997, May 2000 and April 2010 indicated that all stations scored suboptimal except for one tributary station, which received a marginal score. The lowest scoring habitat parameters were vegetative disruptive pressure and riparian vegetative zone width.

**Benthos.** Benthic macroinvertebrate samples were collected in January 1997 and, as a result of changes to reference station selection procedures, again in May 2000 from two stations using the DEP's Rapid Bioassessment Protocols (RBP) benthic sampling methodology, which is a modification of EPA's Rapid Bioassessment Protocols (RPBs; Plafkin et al. 1989, Barbour et al. 1999). The DEP also collected benthic macroinvertebrates from two Tohickon Creek mainstem stations as part of the DEP's routine surface water monitoring effort in 2010. The overall results of these three surveys indicated that the Tohickon Creek biological samples were generally dominated by pollution-tolerant taxa. While pollution-sensitive taxa were collected - such as some mayflies and caddisflies, they were present in lower numbers and at limited locations in the petitioned area. In addition, stoneflies - another pollution sensitive group, were very poorly represented and generally rare (Tables 4 & 5).

**Fish.** The PFBC surveyed the fish population in portions of the basin in May 1977, June 1981 and May 1992 documenting the presence of 21 species. The DEP surveyed one station on Tohickon Creek in September 1996 and two stations in January 1997; documenting the presence of 14 species. The DEP, along with the PFBC sampled an additional station in July 2009 as part of the DEP's Fish Index of Biotic Integrity (IBI) sampling protocol development. The DEP also sampled the same 2009 station in July 2013 and again in August 2014 as part of the protocol development effort (Table 6). The DEP's Fish IBI sampling in 2009, 2013 and 2014 was a semi-quantitative survey while the data from earlier DEP and PFBC surveys simply documented presence or absence of particular species. All surveys documented the presence of a relatively healthy fish community, most with abundant populations of American eel and some with the presence of stocked trout (Table 6). Blueback herring have been documented in the lower mainstem by the PFBC as a result of a fishing regulation violation. American eel and blueback herring are migratory fish species. Stocked trout were most likely a result of the PFBC's in-season stocking efforts. None of the fish surveys were able to document the presence of a naturally reproducing Salmonidae community or other flora and fauna indigenous to a cold water habitat.

PFBC's in-season stocking efforts occur on the lower mainstem of Tohickon Creek each spring. PFBC does not stock trout in Lake Nockamixon and other tributaries in the Tohickon Creek basin above Nockamixon Dam.

## BIOLOGICAL USE QUALIFICATIONS

The biological use qualifying criteria applied to the petitioned area were the DEP's integrated benthic macroinvertebrate scoring tests described at 25 Pa. Code § 93.4b(a)(2)(i)(A) and § 93.4b(b)(1)(v). Selected benthic macroinvertebrate community metrics from petitioned sites were compared to those from reference streams with a comparable drainage area (Table 7). Stations sampled in 1997 were collected prior to the DEP's revised Antidegradation Regulations and were not used to evaluate the biological use qualifying criteria. Stations 2TC and 18TC, collected in May 2000, were compared to a reference station on French Creek (1FC) in Chester County (Table 1 & 7). Stations 3TC and 17TC, collected in April 2010, were compared to a station on Kettle Creek (1KC) in Clinton County (Table 1 & 7). The stations on French Creek and Kettle Creek were used as references because both are freestone streams and have similar drainage areas to the candidate stations. In addition, both French Creek and Kettle Creek have served as EV reference streams in several other DEP surveys. The comparisons were done using the following metrics that were selected as being indicative of community health: taxa richness, modified EPT index, modified Hilsenhoff Biotic Index, percent dominant taxon, and percent modified mayflies.

Based on these five metrics, candidate stations had Biological Condition Scores (BCS) that ranged from 10% (17TC) to 50% (18TC) (Table 7). As a result, these candidate stations do not meet the 83% comparison standard required to qualify as High Quality Waters (§ 93.4b(a)(2)(i)(A)) or the 92% comparison standard required to qualify as Exceptional Value Waters (§ 93.4b(b)(1)(v)).

## WATER CHEMISTRY CRITERIA ASSESSMENT

Pursuant to the biological criteria scores not meeting the 83% and 92% comparison standards, water quality monitoring was conducted from November 2005 through December 2006 on behalf of the petitioners by Princeton Hydro on the mainstem in order to apply the DEP's water chemistry HQ criterion at §93.4b(a)(1). The application of this antidegradation chemistry qualifier requires at least one year of water quality data, which exceeds the water quality criteria in § 93.7 at least 99% of the time for the water quality parameters found at §93.4b(a)(1)(i) (dissolved oxygen, iron, dissolved copper, temperature, aluminum, dissolved nickel, dissolved cadmium, pH, dissolved arsenic, ammonia nitrogen, dissolved lead, and dissolved zinc). The Princeton Hydro sampling at stations 3TC, 13TC and 18TC (Figure 1, Table 1) characterized Tohickon Creek as meeting water quality in §93.7 at least 99% of the time with the exception of temperature and pH (Figures 2, 7 & 10; Tables 2 & 3).

The DEP's CIM effort was conducted from February 2008 through October 2008 at stations 7TC and 17TC targeting temperature and pH (Figure 1, Table 1). The purpose of the CIM was to increase the frequency that these parameters were originally measured in order to confirm that the sampling regiment employed by Princeton Hydro had accurately characterized these two water quality parameters for Tohickon Creek. The results indicate that Tohickon Creek is not meeting pH criteria in § 93.7 at least 99% of the time (Figure 8). The results also indicate that Tohickon Creek is not meeting CWF or Trout Stocking (TSF) temperature criteria in § 93.7 99% of the time. Temperatures recorded at station 7TC indicate that Tohickon Creek meets CWF criteria approximately 32% of the time and TSF approximately 76% of the time (Figure 3). Temperatures recorded at station 17TC indicate that Tohickon Creek meets CWF criteria approximately 53% of the time and TSF approximately 79% of the time (Figure 4).

Since the DEP's 2008 CIM effort, it has been determined that Nockamixon Dam may not have not meeting its conservation release due to inoperable release valves. This may have resulted in significantly reduced flows and a subsequent reduced ability for Tohickon Creek to naturally assimilate elevated summer air temperatures. CIM was again implemented on Tohickon Creek mainstem at 2TC, just downstream of Nockamixon Dam, from April 2012 through September 2013 and at 13TC from March 2012 through December 2014 (Table 1, Figure 1). Data loggers at 2TC collected water temperature data every 15 minutes. Data loggers at 13TC collected water temperature data every 15 minutes from March 2012 through August 2012 and water temperature, specific conductance, pH, and dissolved oxygen data every 30 minutes from March 2013 through December 2014. The CIM data indicates that pH and dissolved oxygen at 13TC meet pH and dissolved oxygen criteria in 25 Pa. Code § 93.7 99% of the time (Figures 9 & 11).

Temperatures recorded at station 2TC from April 2012 through December 2012 indicate that Tohickon Creek meets CWF criteria approximately 48% of the time and TSF criteria approximately 88% of the time. Temperatures recorded at station 2TC from January 2013 through September 2013 indicate that Tohickon Creek meets CWF criteria approximately 53% of the time and TSF approximately 82% of the time (Figure 5). Temperatures recorded at station 17TC from March 2012

through August 2012 indicate that Tohickon Creek meets CWF criteria approximately 13% of the time and TSF criteria approximately 53% of the time. Temperatures recorded at station 17TC from March 2013 through December 2013 indicate that Tohickon Creek meets CWF criteria approximately 51% of the time and TSF criteria approximately 80% of the time. Temperatures recorded at station 17TC from February 2014 through November 2014 indicate that Tohickon Creek meets CWF criteria approximately 49% of the time and TSF criteria approximately 87% of the time (Figure 6). CIM data collected from 2012 through 2014 do not meet CWF or TSF temperature criteria in 25 Pa. Code § 93.7 99% of the time.

## ADDITIONAL EXCEPTIONAL VALUE WATERS QUALIFYING CRITERIA

Based on petitioner information suggesting that certain EV regulatory criteria may apply, the DEP evaluated additional antidegradation criteria listed in 25 Pa. Code § 93.4b(b). These EV criteria include:

A. The water is an outstanding National, State, regional or local resource water [§ 93.4b(b)(1)(iii) – see Appendix A[1]];

B. The water is a surface water of exceptional recreational significance [§ 93.4b(b)(1)(iv) – see Appendix A[2]].

C. The water is a surface water of exceptional ecological significance [§ 93.4b(b)(2) – see Appendix A[3]].

### A. Waters qualifying as EV as outstanding National, State, regional or local resource waters under § 93.4b(b)(1)(iii):

The outstanding resource waters EV criterion may be applied to the petitioned waters if, as a prerequisite, the waters have an HQ designation or HQ existing use. No waters within petitioned area have an HQ designation or HQ existing use.

### B. Waters Qualifying as EV as Surface Water of Exceptional Recreational Significance under § 93.4b(b)(1)(iv):

The exceptional recreational waters criterion may be applied to the petitioned waters if, as a prerequisite, the waters have an HQ designation or HQ existing use. No waters within petitioned area have an HQ designation or HQ existing use.

### C. Waters Qualifying as EV as Surface Waters of Exceptional Ecological Significance under § 93.4b (b)(2):

Information gathered for the Pennsylvania Natural Heritage Program and reported in County Natural Areas Inventories for Bucks County did not identify any statewide or local ecological community types

within the Tohickon Creek watershed that would satisfy the "*exceptional ecological significance*" requirement of this EV criterion.

## PUBLIC RESPONSE AND PARTICIPATION SUMMARY

The DEP provided public notice of this redesignation evaluation and requested technical data from the general public through publication in the Pennsylvania Bulletin on April 22, 2000 (30 Pa.B 2071). A similar notice was also published in the Philadelphia Inquirer on April 21, 2000. In addition, Bedminster, East Rockhill, Haycock, Hilltown, Milford, Nockamixon, Plumstead, Richland, Springfield, Tinicum, and West Rockhill townships were notified of the redesignation evaluation in a letter dated April 19, 2000.

The Tinicum Conservancy provided a report prepared by the Heritage Conservancy in December 2008, "*Lower Tohickon Creek Exceptional Value Petition Background Documentation*" that provided updated information to be considered in evaluating Tohickon Creek. The data provided by the petitioner was reviewed in the context of satisfying the EV qualifying criteria.

In June 2013, the Delaware Riverkeeper Network and the Tinicum Conservancy provided a report published by the National Park Service and the National Wild and Scenic Rivers Program entitled, "*Delaware River Basin, National and Scenic River Values.*" The report identifies Tohickon Creek as part of the Wild and Scenic Rivers system that meets all five outstandingly remarkable values (ORVs). The five ORVs include: cultural, ecological, geological, recreational, and scenic. Federal designation of the lower Tohickon Creek as a scenic river is important for the management of this surface water, but it does not meet the DEP's special protection criteria at § 93.4b.

In July 2014, the Delaware Riverkeeper Network and the Tinicum Conservancy provided the report, "*Tohickon Creek Low Flow Hydrology Analysis Report*", prepared by Princeton Hydro. The report evaluated the hydrology of Tohickon Creek downstream of Nockomixon Dam before and after the repair to the dam's release valve. The report concluded that the repair resulted in an increased volume of discharge that should maintain cooler temperatures throughout the summer months.

An additional report prepared by Princeton Hydro was submitted to the DEP in January 2016 by the Delaware Riverkeeper Network. The report, "*Temperature Evaluation for Tohickon Creek"*, characterized a water temperature study of Tohickon Creek. The evaluation included temperature data from ten locations through the lower Tohickon Creek basin. According to the report, data from two of the ten locations meet WWF temperature criteria in 25 Pa. Code § 93.7 100% of the time. The two locations were on tributaries and not on the Tohickon Creek mainstem. In addition, the data collected at these locations represented approximately one single month of data. According to the report, there were no stations on Tohickon Creek that met WWF criteria in § 93.7 99% of the time.

In addition to the January 2016 Princeton Hydro report, the Tinicum Conservancy also submitted additional information pertaining to EV qualifying criteria. The additional information was reviewed and considered as part of the DEP's evaluation.

## DESIGNATED USE REVIEW

The petitioners have requested that the designated use of the lower Tohickon Creek basin below the Nockamixon Lake Dam be changed from its current CWF, MF designation to EV. However, the results of the biological and chemical data from several survey efforts determined that the existing aquatic life use of this section of Tohickon Creek mainstem is Trout Stocking, Migratory Fishes (TSF, MF) - a less restrictive use. DEP and PFBC surveys have documented the maintenance and propagation of fish species which are indigenous to a warm water habitat, and in addition populations of at least one migratory fish species and the presence of stocked trout. Stocked trout are a result of PFBC in-season stocking efforts, and stocked trout were documented through at least July. The presence of the described fish community meets the TSF, MF description at 25 Pa. Code §93.3. Neither the DEP nor PFBC was able to document the presence of a naturally reproducing Salmonidae (trout) community or other flora and fauna indigenous to a cold water habitat as described by 25 Pa. Code § 93.3. In order to redesignate a stream to a less restrictive use, the DEP must conduct a use attainability analysis that satisfies the demonstrations required by 25 Pa. Code § 93.4(b) (*Less restrictive uses)* and *§* 93.4(c) (*Redesignation of water)*.

**Use Attainability Analysis Requirements.** Section § 93.4(b) states that "less restrictive uses than those currently designated for particular waters listed in § § 93.9a—93.9z may be adopted when it is demonstrated that:

- the designated use is more restrictive than the existing use,
- the use cannot be attained by implementing effluent limits required under sections 301(b) and 306 of the Federal Clean Water Act (33 U.S.C.A. § § 1311(b) and 1316) [*pertains to point source discharges*] or implementing cost-effective and reasonable BMPs for nonpoint source control,
- and one or more of the following conditions exist:
  (1) Naturally occurring pollutant concentrations (natural quality) prevent the attainment of the use.
  (2) Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met.
  (3) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place.
  (4) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate the modification in a way that would result in the attainment of the use.
  (5) Physical conditions related to the natural features of the waterbody, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life uses.

(6) Controls more stringent than those required by sections 301(b) and 306 of the Federal Clean Water Act would result in substantial and widespread economic and social impact."

Further, Section § 93.4(c) states that "Waters considered for redesignation may not be redesignated to less restrictive uses than the existing uses."

**Use Attainability Analysis Summary.** In order to properly evaluate less restrictive uses than those designated for Tohickon Creek, the DEP has conducted the following use attainability analysis to determine the appropriateness of the original CWF designated use as required by § 93.4(b):

- An evaluation of uses actually attained on or after November 28, 1975,
- An evaluation of point sources and nonpoint sources to determine if effluent limits and BMPs will result in attainment of the designated use,
- A determination of whether any of the six conditions (§ 93.4(b)1-6) is applicable.

**Uses Actually Attained.** As part of this redesignation evaluation, information known to the DEP was reviewed to determine, to the best extent practical, whether the CWF designated use is supported by "existing use" conditions that may have been present at the time of the original designation. "Existing uses", as defined in 25 Pa. Code §93.1, are "*Those uses actually attained in the waterbody on or after November 28, 1975, whether or not they are included in the water quality standards*."

The designated use of Tohickon Creek was first described as TSF in the 1971 Sanitary Water Board Rulemaking, which lists, "*All tributaries to Delaware River from Pidcock Creek to Durham Creek inclusive – Exceptions to Standard Water Use List, Add 1.4 Trout (Stocking only)*." The TSF designated use was maintained through the October 1976 Rulemaking and until the October 1979 Rulemaking when Tohickon Creek basin from its source to Nockamixon Dam remained designated as TSF and the remaining portion of the basin downstream of Nockamixon Dam (with the exception of Deep Run being designated as WWF) was redesignated as CWF. Nockamixon Dam was completed in 1973 with the ability to release water to Tohickon Creek via bottom (cold water) and surface (spillway) releases. Originally, it was intended that bottom, cold water would be released to promote a cold water fishery on the Tohickon Creek mainstem below the dam. However, this would have required a significant drawdown of Lake Nockamixon that would limit its recreational use. PFBC performs in-season trout stocking on the mainstem below Nockamixon Dam. There is no indication that any potential for a cold water aquatic community exists or had existed within the Tohickon Creek basin downstream of Nockamixon Dam

Historic and recent data, including fish data for the lower Tohickon Creek mainstem, show that the CWF "designated use is more restrictive than the (TSF) existing use" – a demonstration required by § 93.4(b).

**Point and Nonpoint Source Evaluation**. There are currently 165 active water management permits issued in the basin that include 90 non-municipal and 7 municipal sewage treatment surface water or land application permits, 25 industrial stormwater discharges, 10 industrial waste water

discharges, and 33 pesticide application permits. There are currently no heated discharges within the Tohickon Creek basin that would contribute to increased surface water temperatures.

The land use throughout the entire Tohickon Creek basin is approximately 49% forested, 29% agricultural, 16% developed, and 6% water/wetlands/other; which highlights the potential for implementation of BMPs for nonpoint source control. It has been demonstrated that successful agricultural BMP implementation can improve water quality primarily through the reduction of nutrients and sediment entering waterways. The reduction of surface water temperature is identified as a secondary benefit of specific agricultural BMPs (Tetra Tech, Inc. 2017). However, it has been demonstrated that reduced riparian areas can significantly alter instream thermal regimes and affect cold water aquatic communities (Jones et al. 2006). Stormwater BMPs, typically associated with urban land use areas have been shown to have a greater effect on reducing instream temperatures (Jones 2010, Kieser et al. 2003). While nonpoint source BMPs would improve water quality and potentially decrease instream temperatures there is no indication that any potential for a cold water aquatic community exists or has existed within the Tohickon Creek basin downstream of Nockamixon Dam.

***Less Restrictive Use* Conditions.** The Less Restrictive Use conditions found at 25 Pa. Code §93.4(b) were reviewed in the context of the DEP's TSF existing use determination. Of the six listed, §93.4(b)(4) is applicable to the Tohickon Creek mainstem:

§93.4(b)(4) "*Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the waterbody to its original condition or to operate the modification in a way that would result in the attainment of the use*".

The presence of Nockamixon Dam has altered the natural flow dynamic of Tohickon Creek and its tributaries. Discharge from the dam is regulated to provide a recreational use on Lake Nockamixon supported by sustained water levels that allow for boating and other lake activities. The discharge is also regulated to provide a whitewater release in March and a second one in November for whitewater boating enthusiasts. A conservation release of approximately 11 cfs has been imposed to maintain adequate flow on Tohickon Creek downstream of Lake Nockamixon. For periods throughout the 2008 data collection effort instream discharge was documented below the 11 cfs conservation release for multiple periods including June 27, 2008 – July 14, 2008 and August 7, 2008 – September 6, 2008 with minimum discharge as low as 2.8 cfs (Figure 12). There were no periods below the conservation release subsequent to the Nockamixon Dam release valve repair during 2012 – 2014 with the exception of two partial day periods in late November 2014 (Figures 13 – 15).

Additional increases in cool water discharges from a bottom discharge release of Nockamixon Dam could possibly reduce surface water temperatures. The DEP's most recent lake survey profile data, collected in August 2016, indicates that cold water is available at depths from Lake Nockamixon. The profile data also indicates that this cold water is anoxic or lacking dissolved oxgen, and it would not be protective of any aquatic life use if it were to be discharged to Tohickon Creek (Table 8, Figures 16 & 17). Therefore, while there is the potential to release cool water to just below Nockamixon Dam, the

consequences of releasing this anoxic water would have a significant impact to the aquatic community of Tohickon Creek.

This use attainability analysis determined that the designated aquatic life use CWF is more restrictive than the TSF existing aquatic life use.

**RECOMMENDATION**

Based on applicable regulatory definitions and requirements of §93.4b, the benthic macroinvertebrate and fish data, and the current trout stocking regime maintained by the PFBC, the DEP recommends that Tohickon Creek mainstem from Nockamixon Dam to the mouth be redesignated Trout Stocking, Migratory Fishes (TSF, MF). This recommendation affects 11.2 stream miles and does not meet the EV designation sought in the petition.

## APPENDIX A

[1]Definition at § 93.1: *Outstanding National, State, regional or local resource water*—A surface water for which a National or State government Agency has adopted water quality protective measures in a resource management plan, or regional or local governments have adopted coordinated water quality protective measures[4] along a watershed corridor.

[2] Definition at § 93.1: *Surface water of exceptional recreational significance*—A surface water which provides a water-based, water quality-dependent recreational opportunity (such as fishing for species with limited distribution) because there are only a limited number of naturally occurring areas and waterbodies across the State where the activity is available or feasible.

[3] Definition at § 93.1: *Surface water of exceptional ecological significance*—A surface water which is important, unique or sensitive ecologically, but whose water quality as measured by traditional parameters (for example, chemical, physical or biological) may not be particularly high, or whose character cannot be adequately described by these parameters. These waters include:

(i) Thermal springs.

(ii) Wetlands which are exceptional value wetlands under § 105.17(1) (relating to wetlands).

[4] Definition at § 93.1: *Coordinated water quality protective measures*—

(i) Legally binding sound land use water quality protective measures coupled with an interest in real estate which expressly provide long-term water quality protection of a watershed corridor.

(ii) Sound land use water quality protective measure include: surface or ground water protection zones, enhanced stormwater management measures, wetland protection zones or other measures which provide extraordinary water quality protection.

(iii) Real estate interests include:

(A) Fee interests.
(B) Conservation easements.
(C) Government owned riparian parks or natural areas
(D) Other interests in land which enhance water quality in a watershed corridor area.

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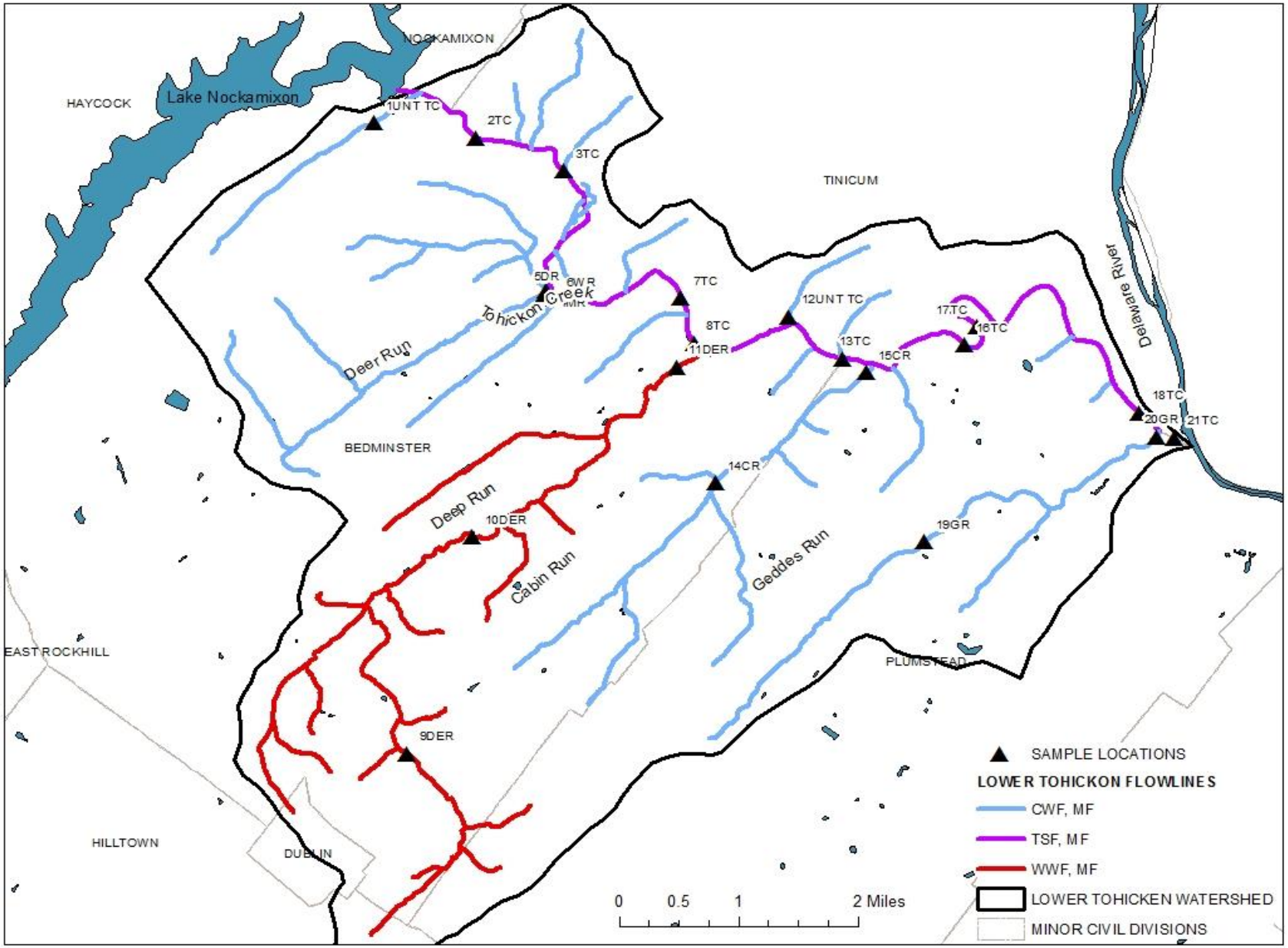


Figure 1. Lower Tohickon Creek basin - station locations

Table 1. Lower Tohickon Creek Station Locations 1977 – 2014

| STATION | LOCATION |
|---|---|
| **1UNT TC** | Unnamed Tributary (03153), approximately 640 meters upstream of mouth.<br>Bedminister Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>Lat: 40º 27' 56" Long: 75º 11' 24" |
| **2TC** | Tohickon Creek (03110), just upstream of SR 1014.<br>Bedminister and Tinicum Townships, Bucks County<br>DEP macroinvertebrate survey May 2000<br>DEP continuous instream monitoring 2012 & 2013<br>Lat: 40º 27' 48" Long: 75º 10' 25" |
| **3TC** | Tohickon Creek (03110), approximately 20 meters upstream of Farm School Road.<br>Bedminster Township, Bucks County<br>PFBC fish survey May 1977<br>Princeton Hydro water chemistry 2005-2006<br>DEP macroinvertebrate survey April 2010<br>Lat: 40º 27' 30" Long: 75º 09' 35" |
| **4MR** | Mink Run (03145), approximetaly 45 meters upstream of mouth.<br>Bedminster Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>Lat: 40º 26' 36" Long: 75º 09' 47" |
| **5DR** | Deer Run (03142), just upstream of TR 418.<br>Bedminster Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>PFBC fish survey September 1999<br>Lat: 40º 26' 35" Long: 75º 09' 49" |
| **6WR** | Wolf Run (03141), approximately 75 meters upstream of mouth.<br>Bedminster Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>PFBC fish survey September 1999<br>Lat: 40º 26' 32" Long: 75º 09' 45" |
| **7TC** | Tohickon Creek (03110), approximately 730 meters upstream of Randts Mill Road.<br>Tinicum Township, Bucks County<br>DEP continuous instream monitoring 2008<br>Lat: 40º 26' 31" Long: 75º 08' 31" |
| **8TC** | Tohickon Creek (03110), just upstream of TR 417.<br>Tinicum and Bedminster Townships, Bucks County<br>DEP macroinvertebrate survey January 1997<br>Lat: 40° 26' 10" Long: 75° 08' 25" |
| **9DER** | Deep Run (03125), just upstream of SR 4023.<br>Bedminister Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>Lat: 40° 23' 06" Long: 75° 11' 17" |

Table 1 continued. Lower Tohickon Creek Station Locations 1977 – 2014

| STATION | LOCATION |
|---|---|
| **10DER** | Deep Run (03125), just downstream of SR 4091.<br>Bedminister Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>Lat: 40° 24' 45" Long: 75° 10' 35" |
| **11DER** | Deep Run (03125), approximately 75 meters upstream of SR 611.<br>Bedminister Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>PFBC fish survey September 1999<br>Lat: 40° 26' 00" Long: 75° 08' 35" |
| **12UNT TC** | Unnamed Tributary (03124), approximately 60 meters upstream of mouth.<br>Tinicum Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>Lat: 40° 26' 21" Long: 75° 07' 31" |
| **13TC** | Tohickon Creek (03110), near Pipersville, along Covered Bridge Road, and approximately 50 meters downstream of USGS Gaging Station.<br>Bedminster Township, Bucks County<br>Princeton Hydro water chemistry 2005-2006<br>DEP fish survey July 2009, July 2013 & August 2014<br>DEP continuous instream monitoring 2012, 2013 & 2014<br>Lat: 40° 26' 01" Long: 75° 06' 59" |
| **14CR** | Cabin Run (03116), just upstream SR 413.<br>Bedminster Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>Lat: 40º 25' 06" Long: 75º 08' 15" |
| **15CR** | Cabin Run (03116), approximately 140 meters upstream of mouth.<br>Plumstead Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>Lat: 40º 25' 55" Long: 75º 06' 47" |
| **16TC** | Tohickon Creek (03110), approximately 400 meters upstream of SR 32.<br>Tinicum Township, Bucks County<br>DEP fish survey September 1996<br>DEP macroinvertebrate survey January 1997<br>Lat: 40º 25' 32" Long: 75º 04' 11" |
| **17TC** | Tohickon Creek (03110), approximately 500 meters downstream of abandon Stover Park Road crossing.<br>Tinicum Township, Bucks County<br>PFBC fish survey May 1977<br>DEP continuous instream monitoring 2008<br>DEP macroinvertebrate survey April 2010<br>Lat: 40º 26' 13" Long: 75º 05' 42" |

Table 1 continued. Lower Tohickon Creek Station Locations 1977 – 2014

| STATION | LOCATION |
|---|---|
| **18TC** | Tohickon Creek (03110), approximately 400 meters upstream of SR 32.<br>Tinicum Township, Bucks County<br>Princeton Hydro water chemistry 2005-2006<br>DEP macroinvertebrate survey May 2000<br>Lat: 40º 25' 32" Long: 75º 04' 11" |
| **19GR** | Geddes Run (03111), just upstream of SR 1003.<br>Plumstead Township, Bucks County<br>DEP macroinvertebrate survey January 1997<br>Lat: 40º 24' 36" Long: 75 º 06' 18" |
| **20GR** | Geddes Run (03111), approximately 55 meters upstream of mouth.<br>Plumstead Township, Bucks County<br>PFBC fish survey May 1992<br>DEP macroinvertebrate survey and fish survey January 1997<br>Lat: 40º 25' 21" Long: 75 º 04' 02" |
| **21TC** | Tohickon Creek (03110), approximately 30 meters upstream of SR 1010.<br>Tinicum Township, Bucks County<br>DEP macroinvertebrate and fish survey January 1997<br>Lat: 40º 26' 05" Long: 75º 05' 50" |
| **1FC** | French Creek (01548), just upstream of Coventryville Road.<br>South Coventry Township, Chester County<br>DEP macroinvertebrate and fish survey May 2000<br>Lat: 40º 10' 16" Long: 75º 41' 25" |
| **1KC** | Kettle Creek (23661), approximately 50 meters downstream of Leidy pipeline crossing.<br>Leidy Township, Clinton County<br>DEP macroinvertebrate and fish survey April 2010<br>Lat: 41º 24' 08" Long: 77º 55' 14" |

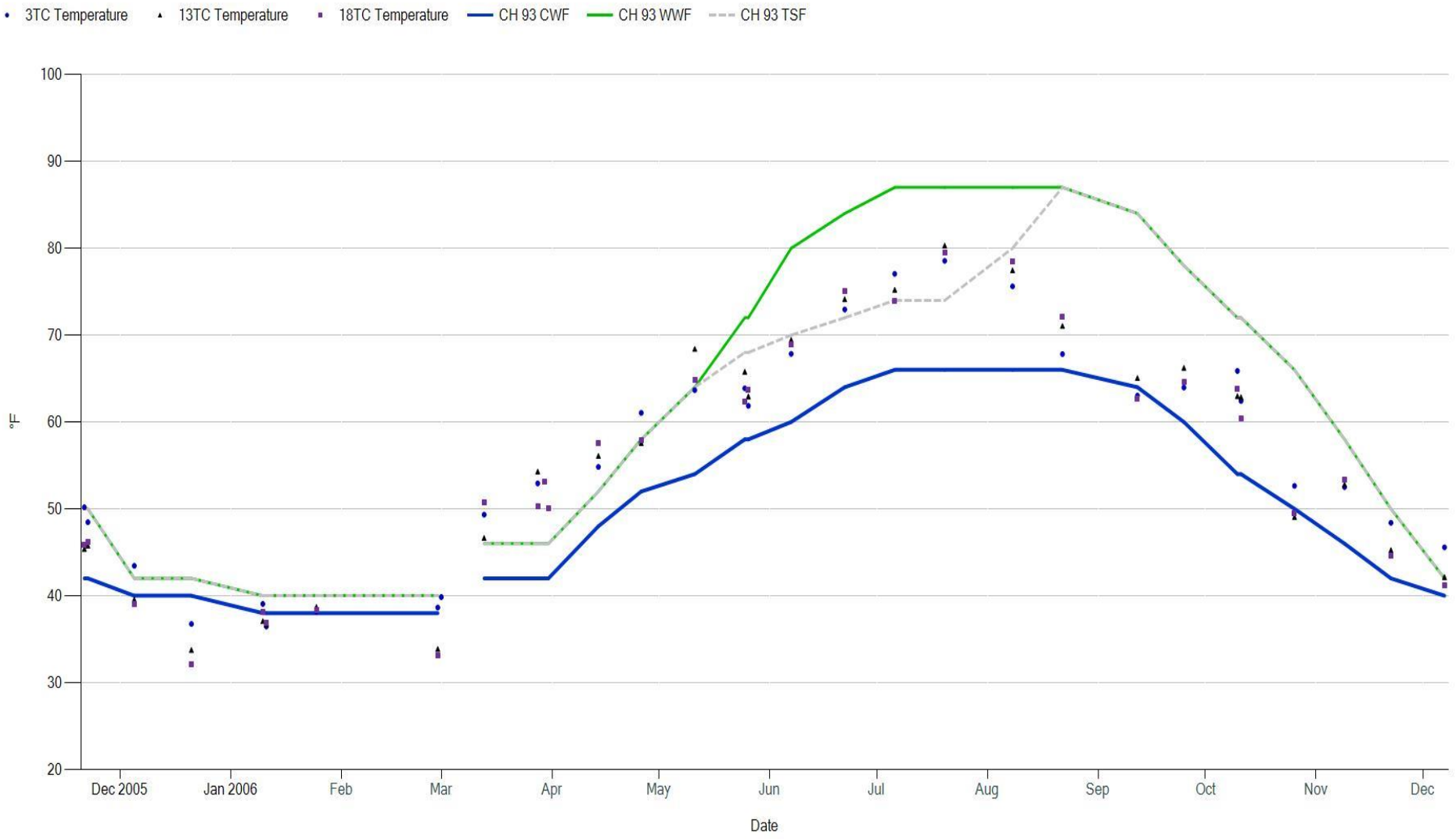


Figure 2. Princeton Hydro discrete temperatures compared to CWF, TSF and WWF temperature criteria November 2005 – December 2006. During this period 3TC meets CWF temperature criteria 8%, TSF 63% and WWF 83%. 13TC meets CWF 17%, TSF 67% and WWF 83%.18TC meets CWF 13%, TSF 70% and WWF 83%.

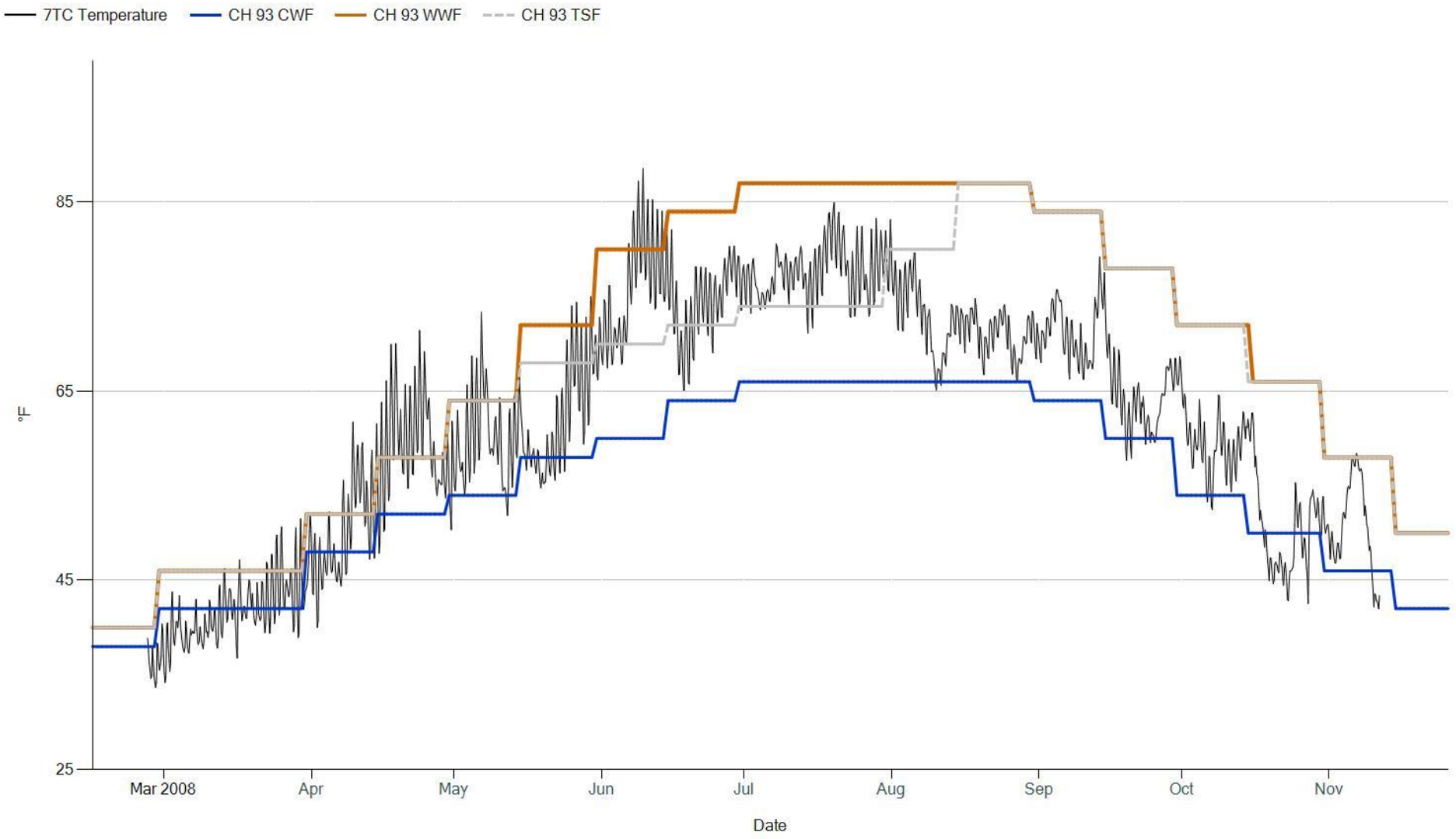


Figure 3. PA DEP CIM temperatures at 7TC compared to CWF, TSF and WWF temperature criteria March 2008 – November 2008. During this period 7TC meets CWF temperature criteria 32%, TSF 76% and WWF 92%.

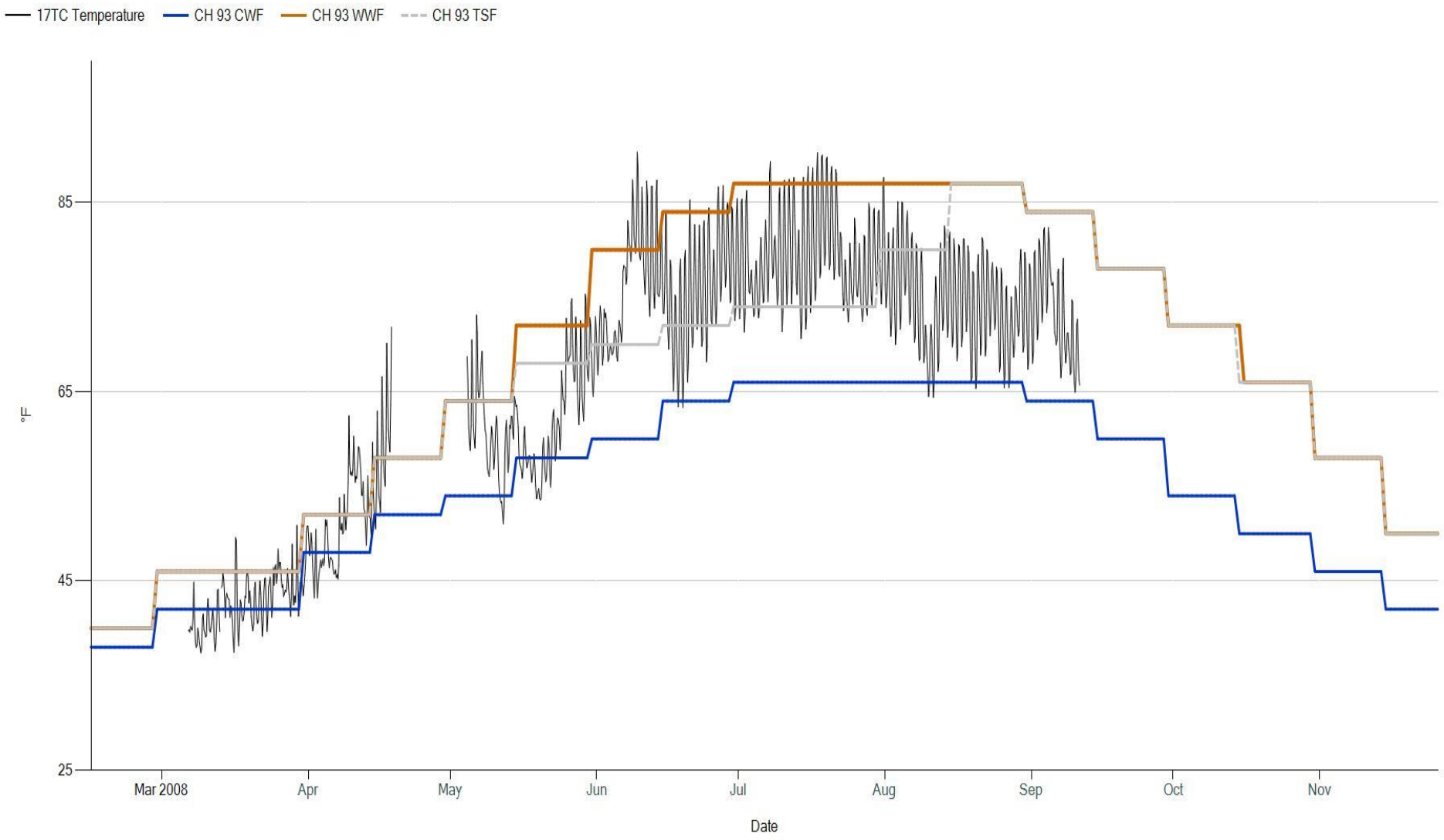


Figure 4. PA DEP CIM temperatures at 17TC compared to CWF, TSF and WWF temperature criteria March 2008 – September 2008. During this period 17TC meets CWF temperature criteria 53%, TSF 79% and WWF 94%.

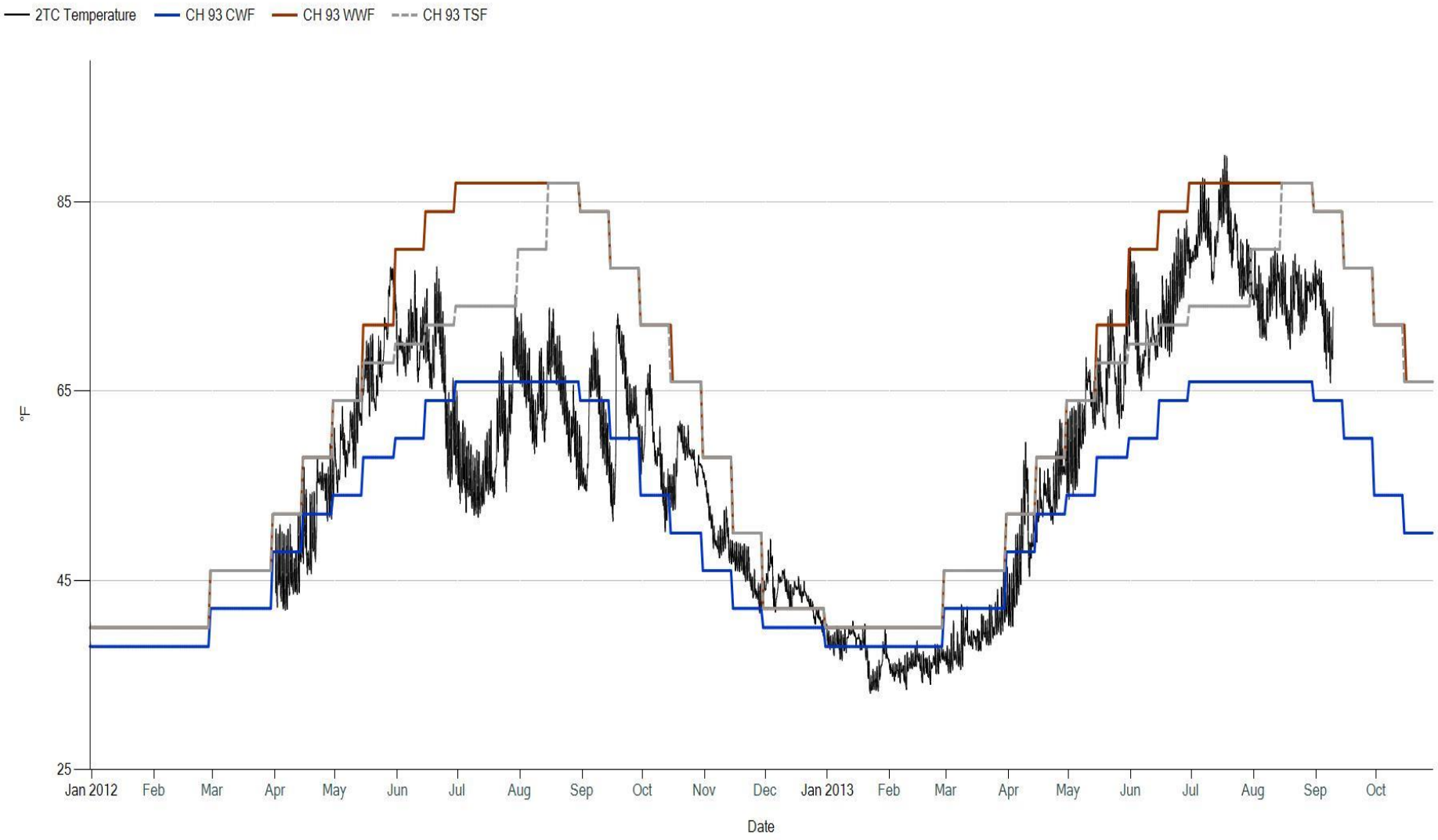


Figure 5. PA DEP CIM temperatures at 2TC compared to CWF, TSF and WWF temperature criteria April 2012 – September 2013. During the period April 2012 – December 2012 2TC meets CWF temperature criteria 48%, TSF 88% and WWF 92%. During the period January 2013 – September 2013 2TC meets CWF temperature criteria 53%, TSF 82% and WWF 97%

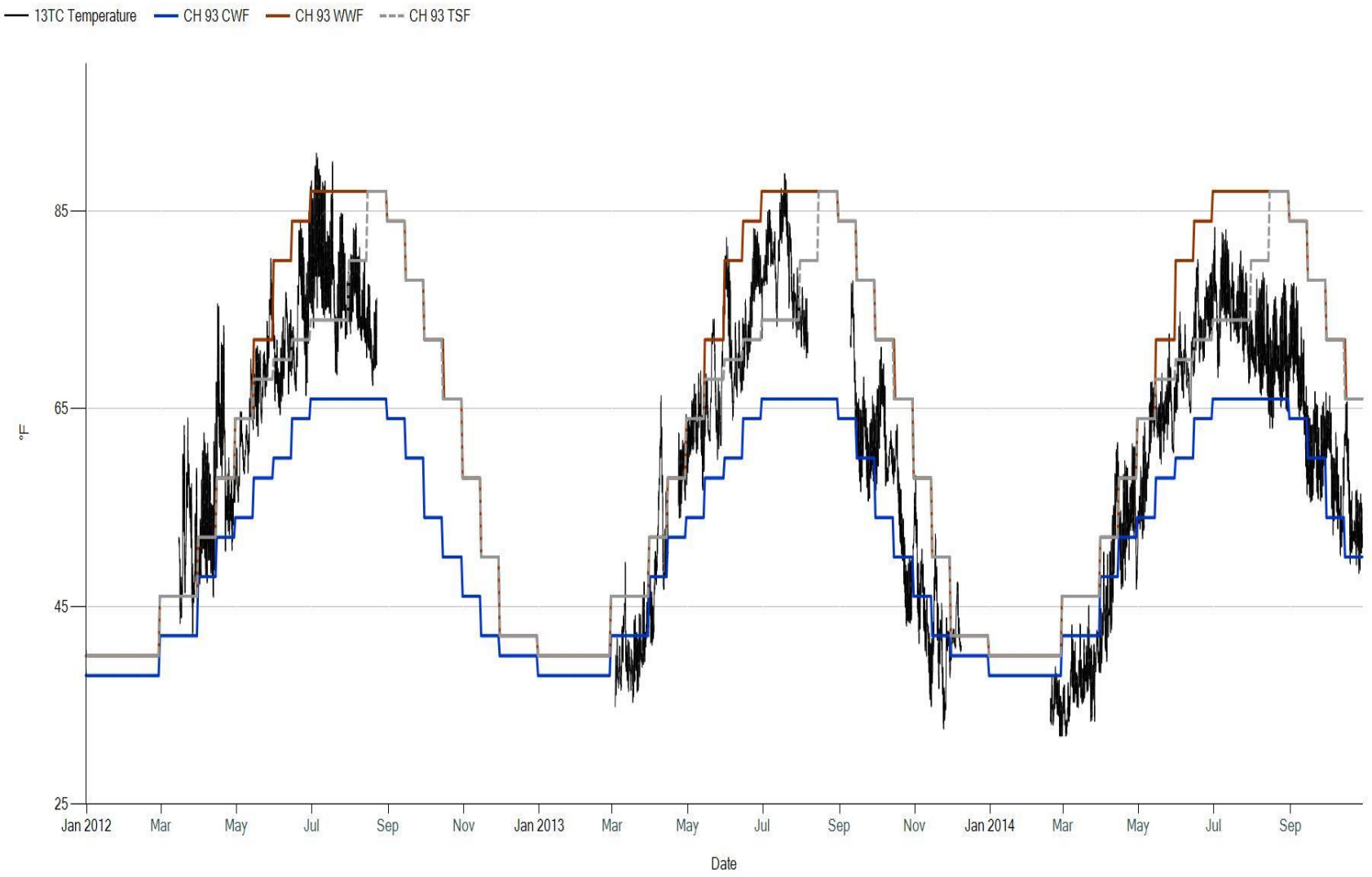


Figure 6. PA DEP CIM temperatures at 13TC compared to CWF, TSF and WWF temperature criteria March 2012 – November 2014. During the period March 2012 – August 2012 13TC meets CWF temperature critera 13% of the time, TSF 53%, and WWF 79%. During the period March 2013 – December 2013 13TC meets CWF temperature criteria 51%, TSF 80% and WWF 94%. During the period February 2014 – November 2014 13TC meets CWF temperature criteria 49%, TSF 87% and WWF 98%.

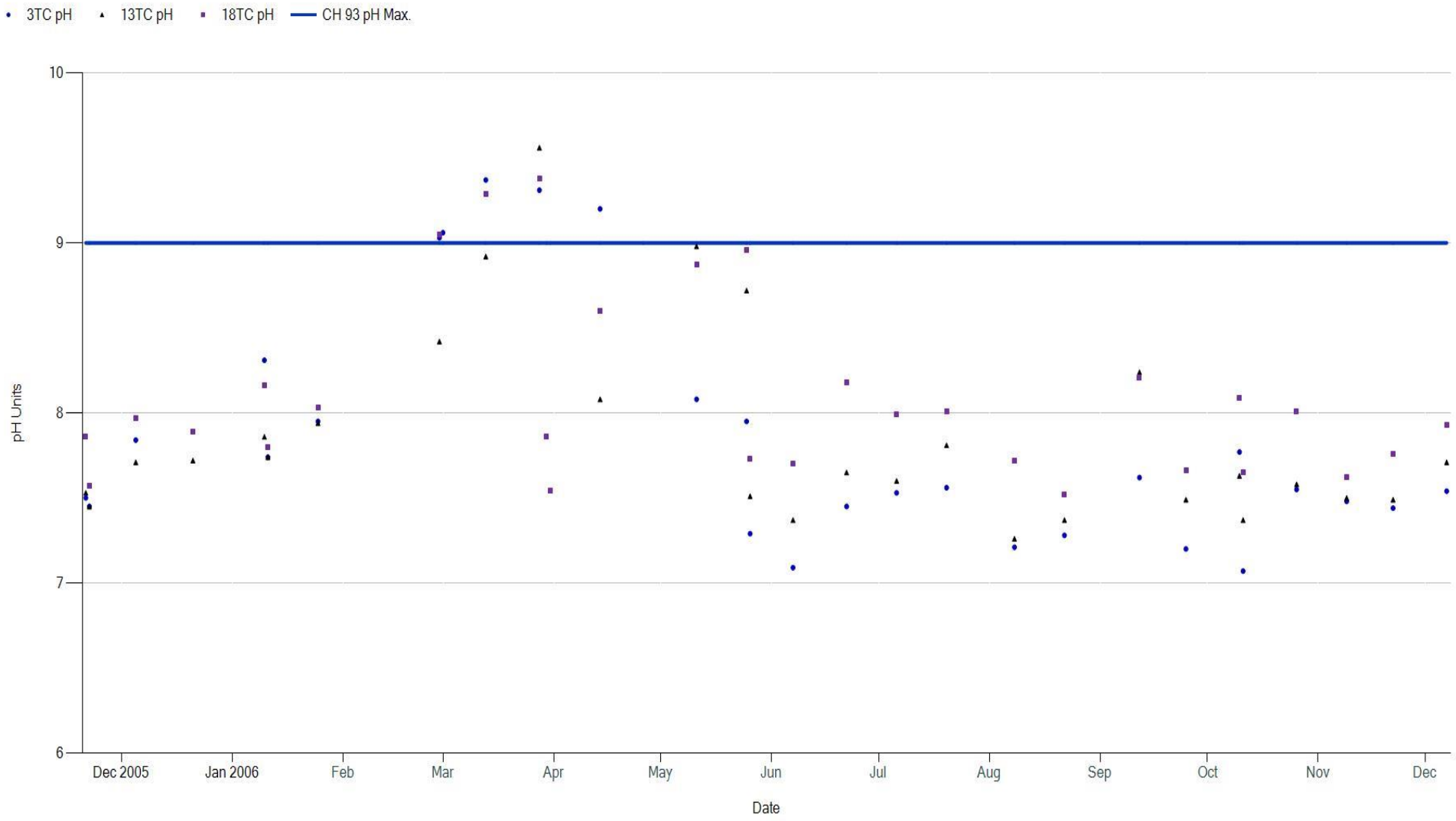


Figure 7. Princeton Hydro discrete pH compared to criteria maximum November 2005 – December 2006. During this period 3TC is below maximum 86%, 13TC 91% and 18TC 87%.

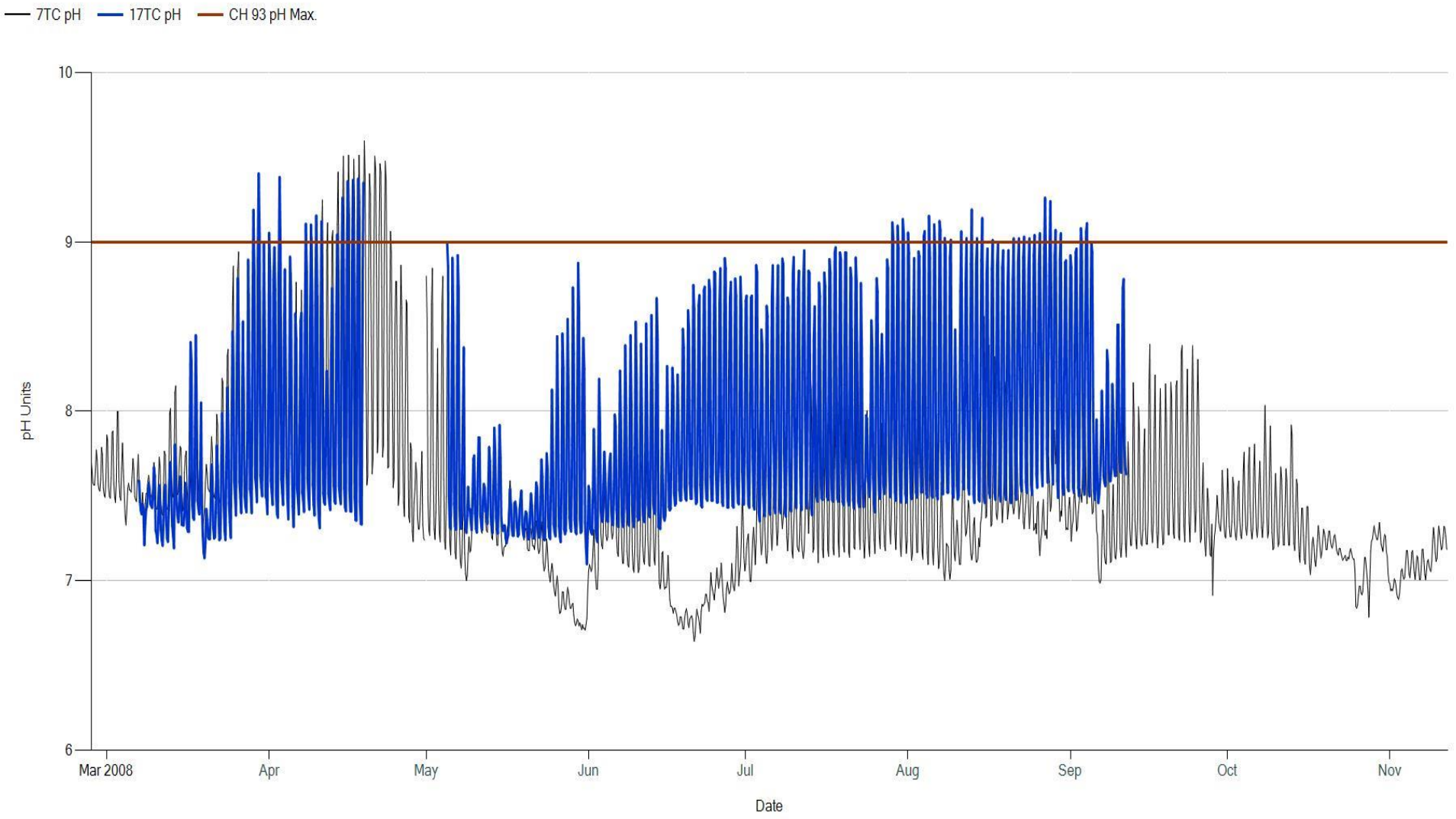


Figure 8. PA DEP CIM pH at 7TC March 2008 – November 2008 and 17TC March 2008 – September 2008 compared to pH criteria maximum. During this period stations 7TC and 17TC are below maximum criteria 98% of the time.

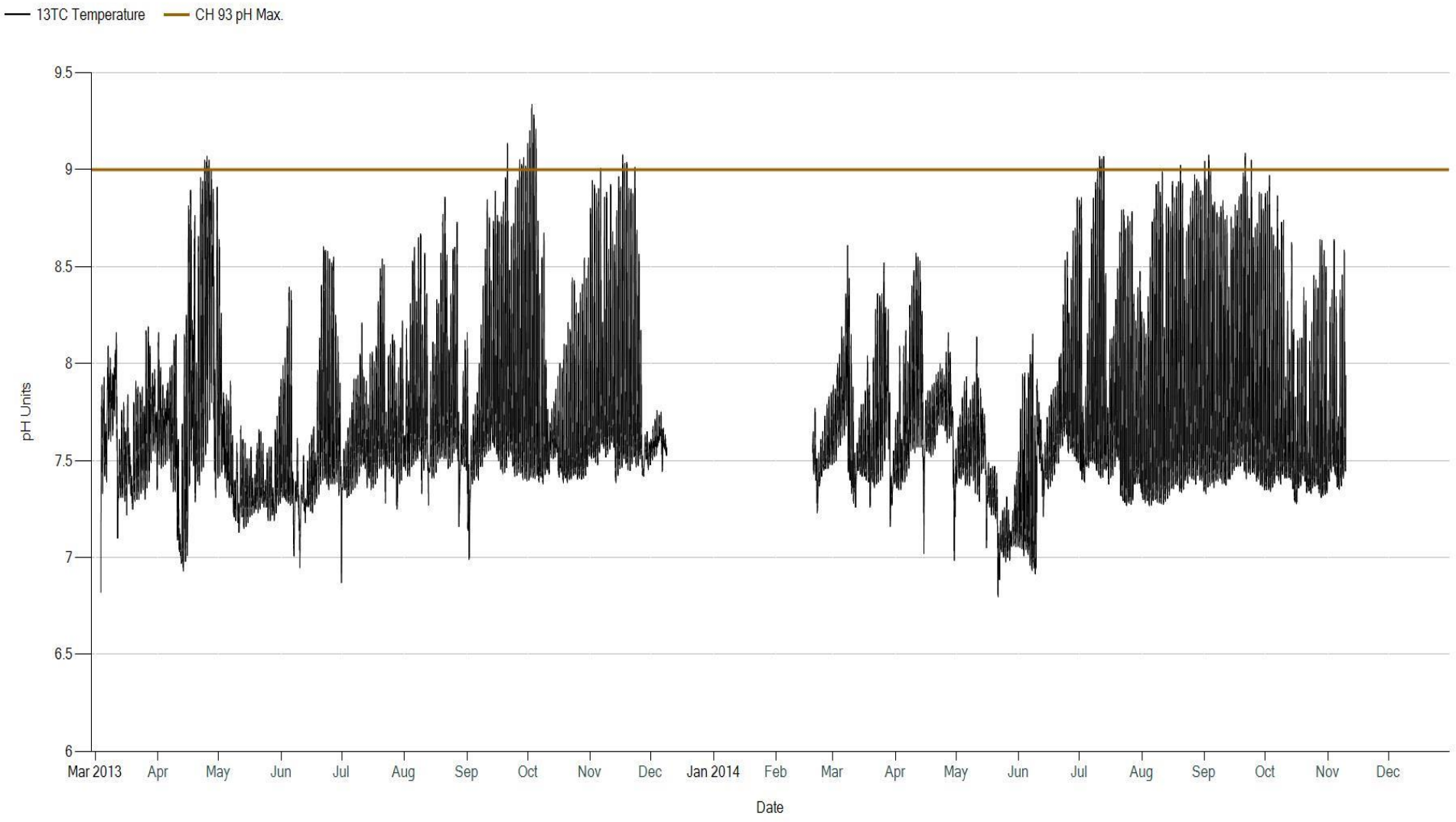


Figure 9. PA DEP CIM pH at 13TC compared to pH criteria maximum March 2013 – November 2014. During the period March 2013 – December 2013 13TC is below maximum and meets criteria 99%. During the period February 2014 – November 2014 13TC is below maximum and meets criteria 99%.

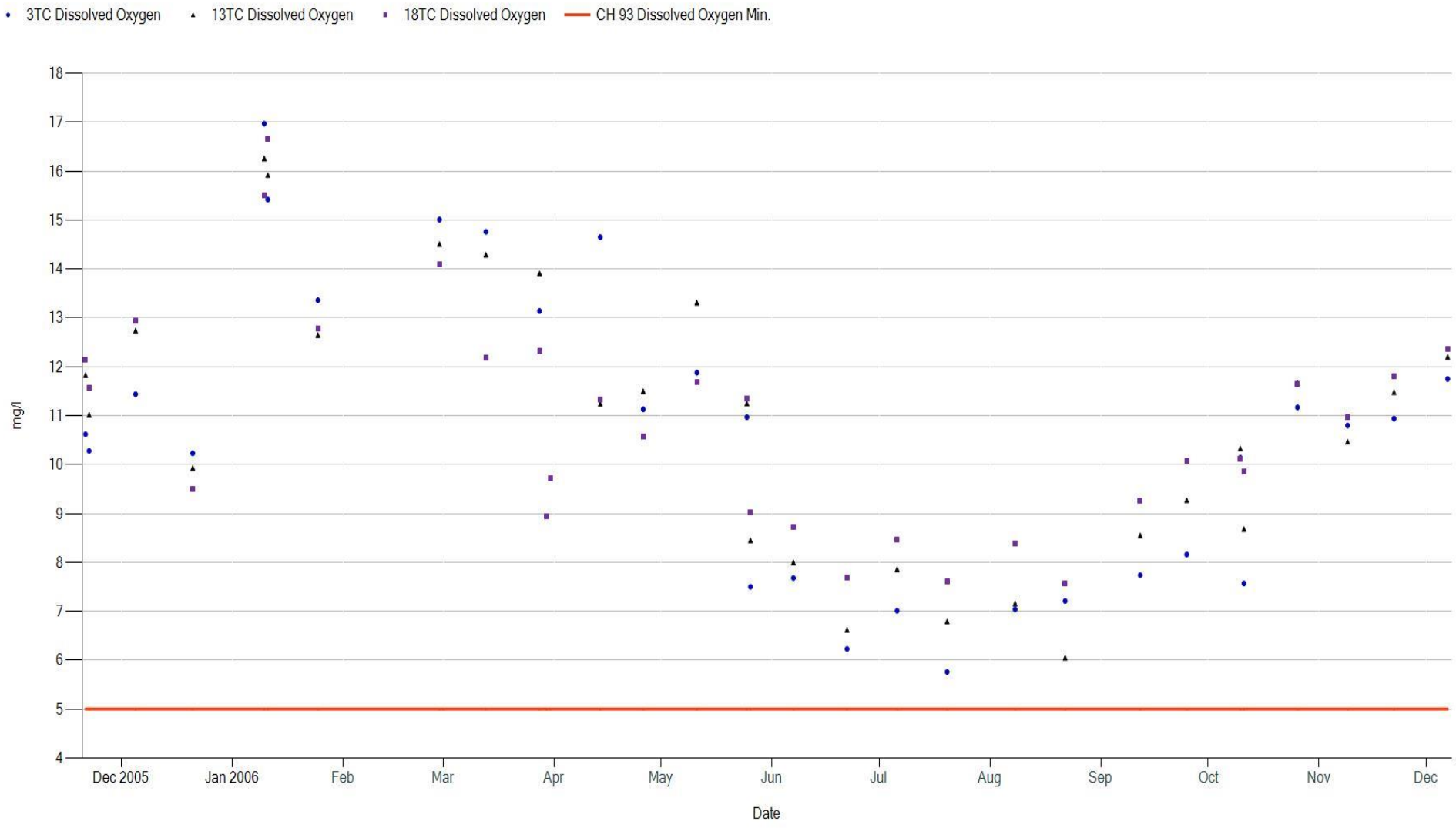


Figure 10. Princeton Hydro discrete dissolved oxygen compared to criteria November 2005 – December 2006. All three stations were above criteria minimum 100% of the time.

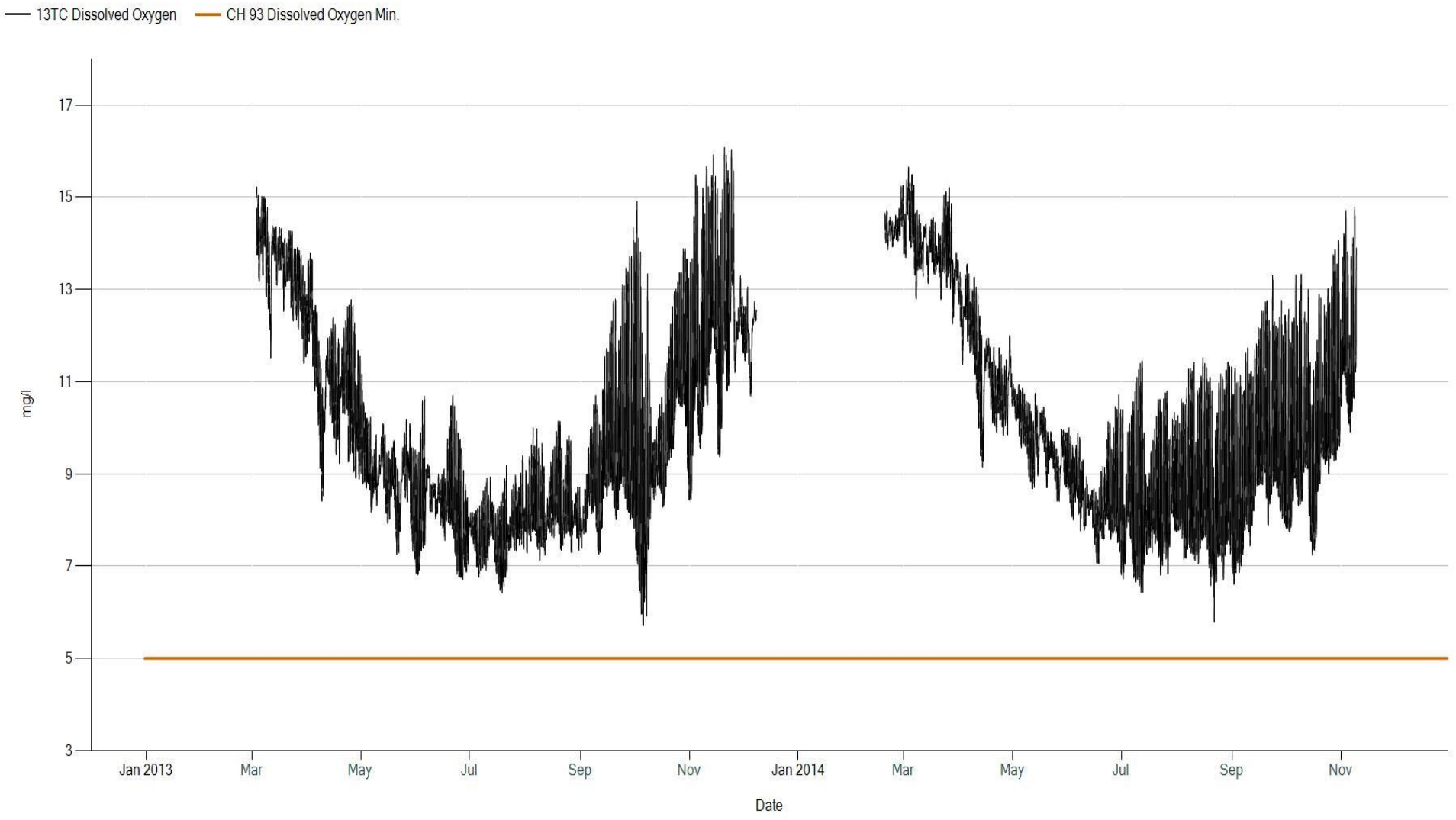


Figure 11. PA DEP CIM dissolved oxygen at 13TC compared to criteria minimum March 2013 – November 2014. During the period 13TC is above the minimum 100% of the time.

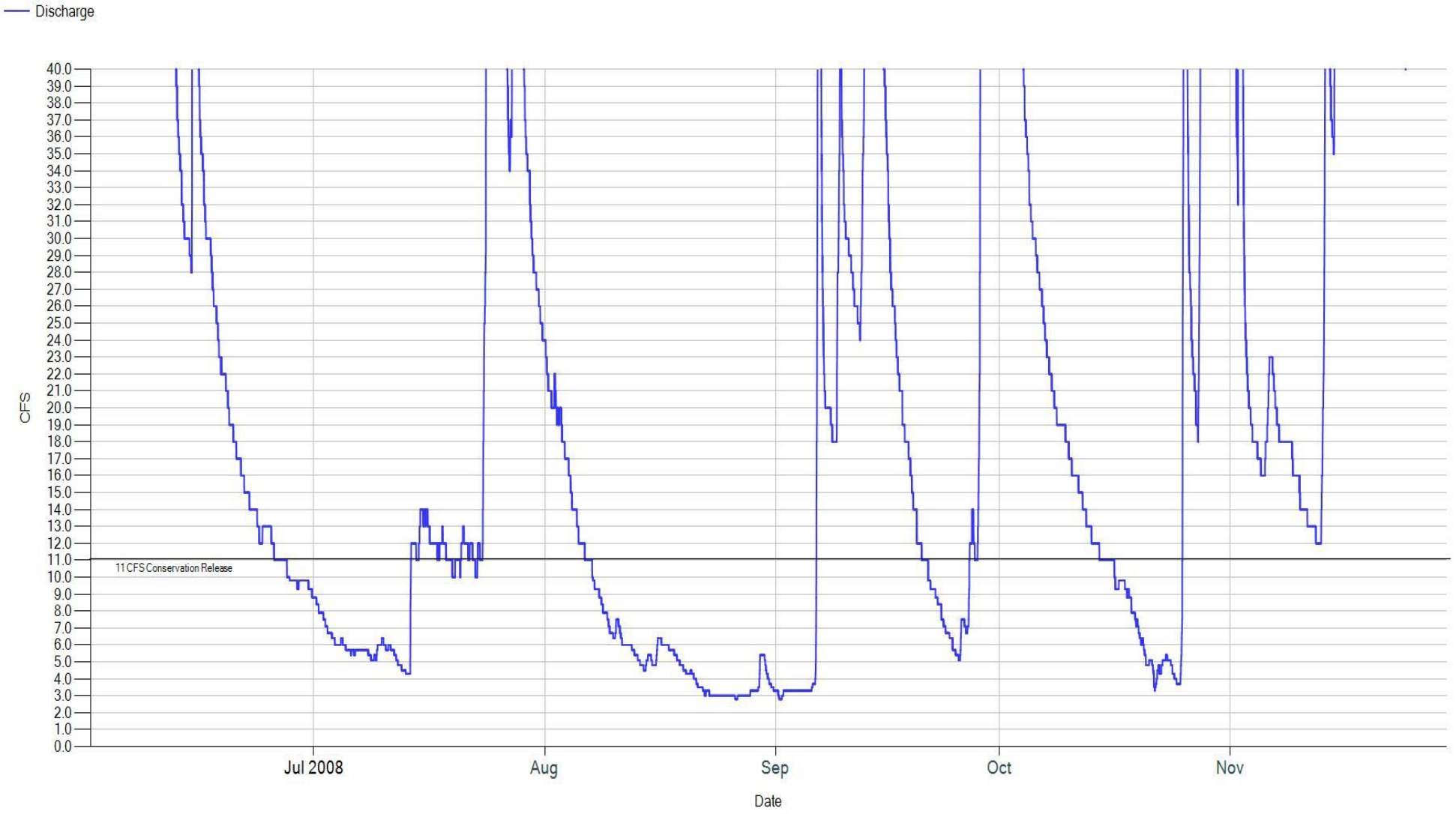


Figure 12. USGS Discharge at 13TC June 2008 – November 2008.

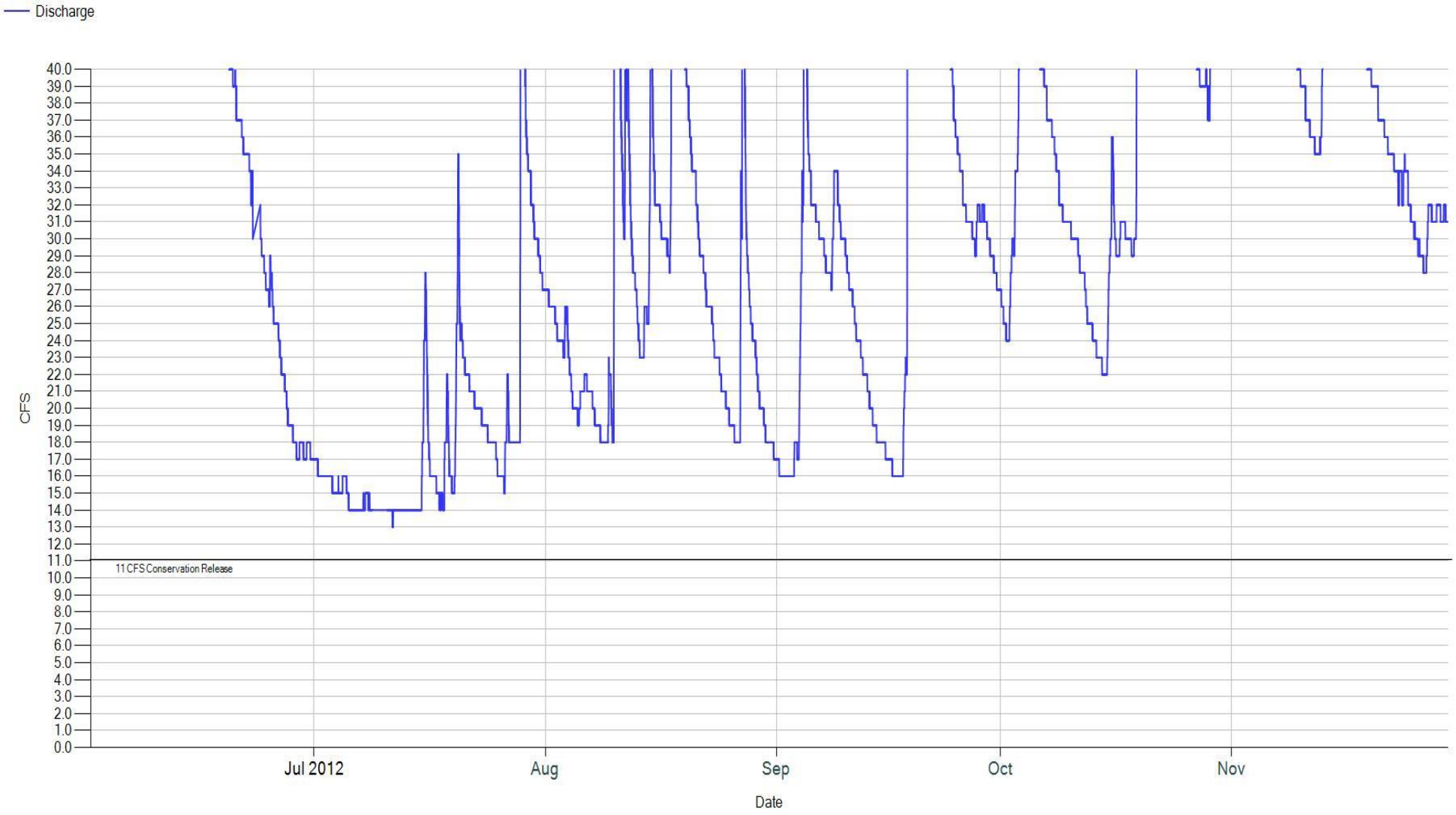


Figure 13. USGS Discharge at 13TC June 2012 – November 2012.

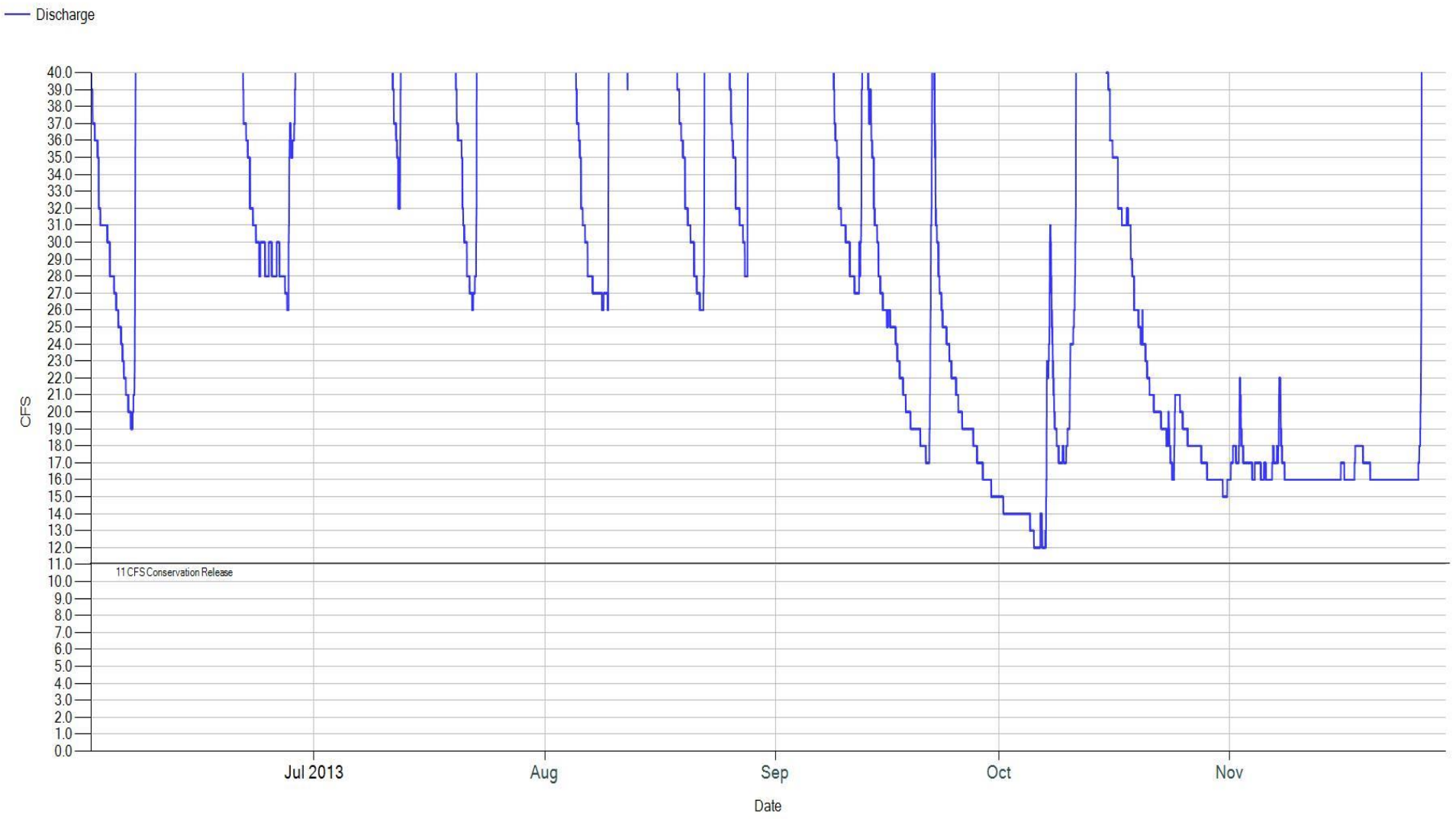


Figure 14. USGS Discharge at 13TC June 2013 – November 2013.

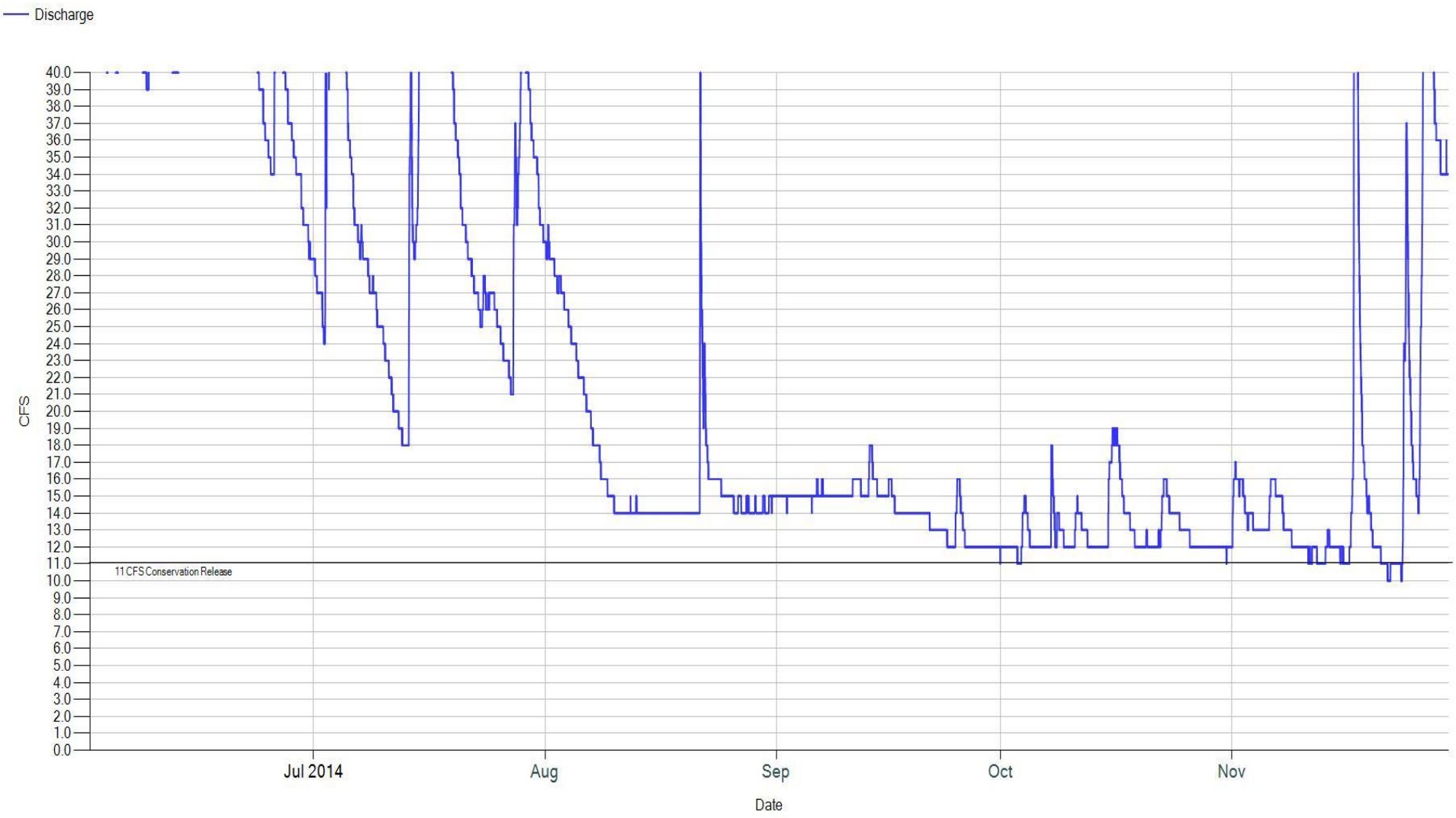


Figure 15. USGS Discharge at 13TC June 2014 – November 2014.

Table 2 Water chemistry (Al, As, Cu, Fe, Pb, Ni, Zn) data collected by Princeton Hydro November 2005 – December 2006 and PA DEP January 1997. Measurements with "<" indicate concentrations below the reporting limit.

| | STATION | Aluminum (total) µg/L | Arsenic (total) µg/L | Cadmium (dissolved) µg/L | Copper (dissolved) µg/L | Iron (total) µg/L | Lead (dissolved) µg/L | Nickel (dissolved) µg/L | Zinc (dissolved) µg/L |
|---|---|---|---|---|---|---|---|---|---|
| Acute Toxicity (*assuming 50 mg/L hardness, if necessary) | | 750 | 340 | 1.03* | 7* | - | 30* | 260* | 66* |
| Chronic Toxicity (*assuming 50 mg/L hardness, if necessary) | | - | 150 | 0.15* | 5* | 1500 | 1.2* | 29* | 65* |
| PADEP Data (6 - 10 January 1997) | 2TC | 554 | <4.0 | <0.2 | <4.0 | 543 | <1.0 | <4.0 | <5.0 |
| | 8TC | 363 | <4.0 | <0.2 | <4.0 | 521 | <1.0 | <4.0 | <5.0 |
| | 16TC | 373 | <4.0 | <0.2 | <4.0 | 444 | <1.0 | <4.0 | <5.0 |
| | 21TC | 352 | <4.0 | <0.2 | <4.0 | | <1.0 | <4.0 | <5.0 |
| Princeton Hydro Data | | | | | | | | | |
| 11/5/2005 | 3TC | 82.7 | 0.27 | <0.074 | 1.4 | 217 | <0.026 | 0.6 | 3.5 |
| 11/5/2005 | 3TC - duplicate | 83.4 | 0.18 | <0.074 | 1.4 | 220 | <0.026 | 0.56 | 1.5 |
| 11/5/2005 | 13TC | 88.1 | 0.42 | <0.074 | 1.4 | 188 | 0.23 | 0.56 | 2.1 |
| | 13TC - reanalysis of lead | | | | | | 0.14 | | |
| 11/5/2005 | 18TC | 78.9 | 0.21 | <0.074 | 1.3 | 164 | <0.026 | 0.49 | 1.9 |
| 11/21/2005 | 3TC | 69.4 | 0.39 | <0.074 | 1.5 | 175 | 0.047 | 0.75 | 7.1 |
| 11/21/2005 | 13TC | 74 | <0.12 | <0.074 | 1.5 | 153 | 0.06 | 0.73 | 5.6 |
| 11/21/2005 | 18TC | 88.7 | 0.23 | <0.074 | 1.6 | 145 | 0.078 | 0.7 | 3.5 |
| 1/10/2006 | 3TC | 117 | <0.12 | <0.074 | 1.5 | 181 | 0.092 | 0.74 | 10.8 |
| 1/10/2006 | 13TC | 99.8 | <0.12 | <0.074 | 1.5 | 145 | 0.092 | 0.69 | 3.1 |
| 1/10/2006 | 18TC | 95 | 0.22 | <0.074 | 1.5 | 128 | 0.098 | 0.67 | 5.2 |
| 1/25/2006 | 3TC | 253 | <0.12 | <0.074 | 1.5 | 307 | 0.064 | 0.67 | 2.1 |
| 1/25/2006 | 13TC | 266 | <0.12 | <0.074 | 1.6 | 306 | 0.063 | 0.6 | 3.6 |
| 1/25/2006 | 13TC - duplicate | 259 | <0.12 | <0.074 | 1.6 | 303 | 0.074 | 0.63 | 1.2 |
| 1/25/2006 | 18TC | 254 | <0.12 | <0.074 | 1.5 | 293 | 0.068 | 0.56 | 2.2 |
| 2/28/2006 | 3TC | 244 | <0.12 | <0.074 | 2.4 | 281 | 0.094 | 0.71 | 2.1 |
| 2/28/2006 | 13TC | 184 | 0.47 | <0.074 | 1.9 | 195 | 0.088 | 0.73 | 1.8 |
| 2/28/2006 | 18TC | 157 | <0.12 | <0.074 | 1.6 | 159 | 0.081 | 0.71 | 2.3 |
| 3/13/2006 | 3TC | 110 | 0.75 | <0.074 | 1.5 | 140 | 0.069 | 0.47 | 2.3 |
| 3/13/2006 | 13TC | 108 | 0.62 | <0.074 | 1.6 | 125 | 0.058 | 0.46 | 3.3 |
| 3/13/2006 | 18TC | 77.2 | 0.74 | <0.074 | 1.5 | 88 | 0.072 | 0.42 | 3 |

Table 2 cont. Water chemistry (Al, As, Cu, Fe, Pb, Ni, Zn) data collected by Princeton Hydro November 2005 – December 2006 and PA DEP January 1997. Measurements with "<" indicate concentrations below the reporting limit.

| | **STATION** | **Aluminum** (total) µg/L | **Arsenic** (total) µg/L | **Cadmium** (dissolved) µg/L | **Copper** (dissolved) µg/L | **Iron** (total) µg/L | **Lead** (dissolved) µg/L | **Nickel** (dissolved) µg/L | **Zinc** (dissolved) µg/L |
|---|---|---|---|---|---|---|---|---|---|
| Acute Toxicity (*assuming 50 mg/L hardness, if necessary) | | 750 | 340 | 1.03* | 7* | - | 30* | 260* | 66* |
| Chronic Toxicity (*assuming 50 mg/L hardness, if necessary) | | - | 150 | 0.15* | 5* | 1500 | 1.2* | 29* | 65* |
| Princeton Hydro Data | | | | | | | | | |
| 3/28/2006 | 3TC | 72.1 | 0.71 | <0.074 | 1.8 | 137 | 0.065 | 0.7 | 3.8 |
| 3/28/2006 | 13TC | 50.6 | 0.79 | <0.074 | 1.7 | 104 | 0.049 | 0.66 | 9.6 |
| 3/28/2006 | 18TC | 26.6 | 0.88 | <0.074 | 1.6 | 46.3 | 0.038 | 0.58 | 6 |
| 3/28/2006 | 18TC - duplicate | 26 | 0.38 | <0.074 | 1.6 | 44.9 | 0.06 | 0.55 | 4.5 |
| 4/14/2006 | 3TC | 77.6 | 0.74 | <0.074 | 1.7 | 140 | 0.029 | 1.4 | 2.4 |
| 4/14/2006 | 13TC | 163 | 0.74 | <0.074 | 1.5 | 122 | <0.026 | 0.53 | 2.6 |
| 4/14/2006 | 18TC | 37.2 | 0.38 | <0.074 | 1.6 | 66.6 | <0.026 | 0.83 | 5.7 |
| 4/26/2006 | 3TC | 92.2 | <.12 | <0.074 | 1.4 | 165 | 0.066 | 0.42 | 0.9 |
| 4/26/2006 | 13TC | 116 | 0.4 | <0.074 | 1.5 | 174 | 0.084 | 0.41 | 1.2 |
| 4/26/2006 | 18TC | 126 | 0.25 | <0.074 | 1.4 | 172 | 0.062 | 0.39 | 1.2 |
| 5/11/2006 | 3TC | 31.4 | 0.24 | <0.074 | 1.4 | 104 | <0.026 | 0.48 | 3.5 |
| 5/11/2006 | 3TC - duplicate | 34.7 | 0.52 | <0.074 | 1.5 | 108 | <0.026 | 0.54 | 2.4 |
| 5/11/2006 | 13TC | 25 | 0.33 | <0.074 | 1.6 | 76.6 | <0.026 | 0.53 | 3.3 |
| 5/11/2006 | 18TC | 13.8 | 0.25 | <0.074 | 1.6 | 24 | <0.026 | 0.47 | 3.2 |
| 5/25/2006 | 3TC | 46.1 | 0.24 | <0.074 | 1.6 | 103 | 0.092 | 0.5 | 3 |
| 5/25/2006 | 13TC | 48.9 | 0.37 | <0.074 | 1.7 | 97.3 | 0.10 | 0.54 | 2.7 |
| 5/25/2006 | 18TC | 33.7 | 0.32 | <0.074 | 1.6 | 60 | 0.098 | 0.48 | 2.5 |
| 6/7/2006 | 3TC | 103 | 0.89 | <0.074 | 2.3 | 145 | 0.3 | 0.88 | 7.7 |
| | 3TC - reanalysis for lead | | | | | | 0.11 | | |
| 6/7/2006 | 13TC | 105 | 0.85 | <0.074 | 2.4 | 124 | 0.29 | 1.2 | 8.2 |
| | 13TC - reanalysis for lead | | | | | | 0.11 | | |
| 6/7/2006 | 18TC | 72.4 | 0.39 | <0.074 | 2.2 | 76.5 | 0.97 | 1.1 | 6.2 |
| | 18TC - reanalysis for lead | | | | | | 0.083 | | |

Table 2 cont. Water chemistry (Al, As, Cu, Fe, Pb, Ni, Zn) data collected by Princeton Hydro November 2005 – December 2006 and PA DEP January 1997. Measurements with "<" indicate concentrations below the reporting limit.

| | STATION | Aluminum (total) µg/L | Arsenic (total) µg/L | Cadmium (dissolved) µg/L | Copper (dissolved) µg/L | Iron (total) µg/L | Lead (dissolved) µg/L | Nickel (dissolved) µg/L | Zinc (dissolved) µg/L |
|---|---|---|---|---|---|---|---|---|---|
| Acute Toxicity (*assuming 50 mg/L hardness, if necessary) | | 750 | 340 | 1.03* | 7* | - | 30* | 260* | 66* |
| Chronic Toxicity (*assuming 50 mg/L hardness, if necessary) | | - | 150 | 0.15* | 5* | 1500 | 1.2* | 29* | 65* |
| Princeton Hydro Data | | | | | | | | | |
| 6/22/2006 | 3TC | 28.6 | 1 | <0.074 | 1.7 | 92.6 | 0.084 | 0.54 | 5.7 |
| 6/22/2006 | 13TC | 38.5 | 1.5 | <0.074 | 2.2 | 85.5 | 0.11 | 0.7 | 10.1 |
| 6/22/2006 | 13TC - duplicate | 38.2 | 3.7 | <0.074 | 2.3 | 83.8 | 0.098 | 0.62 | 7.4 |
| 6/22/2006 | 18TC | 16.1 | 2.3 | <0.074 | 2 | 35.4 | 0.078 | 0.61 | 3.8 |
| 7/6/2006 | 3TC | 192 | 1 | <0.074 | 2.5 | 229 | 0.46 | 0.71 | 3 |
| | 3TC - reanalysis for lead | | | | | | 0.20 | | |
| 7/6/2006 | 13TC | 166 | 0.7 | <0.074 | 2.5 | 222 | 0.98 | 0.63 | 3.1 |
| | 13TC - reanalysis for lead | | | | | | 0.19 | | |
| 7/6/2006 | 18TC | 121 | 0.7 | <0.074 | 2.5 | 168 | 0.17 | 0.58 | 3.8 |
| | 18TC - reanalysis for lead | | | | | | 0.19 | | |
| 7/20/2006 | 3TC | 62.4 | 0.35 | <0.074 | 2.3 | 126 | 0.11 | 0.88 | 3.8 |
| 7/20/2006 | 13TC | 40.3 | 0.58 | <0.074 | 2.4 | 73.3 | 0.12 | 0.91 | 3.5 |
| 7/20/2006 | 18TC | 16 | 0.77 | <0.074 | 2 | 23.6 | 0.084 | 0.66 | 3 |
| 8/8/2006 | 3TC | 23.7 | 0.67 | <0.074 | 1.9 | 168 | 0.11 | 0.57 | 6.1 |
| 8/8/2006 | 13TC | 67.1 | 0.5 | <0.074 | 2 | 108 | 0.14 | 0.56 | 4.2 |
| 8/8/2006 | 18TC | 20.6 | 0.34 | <0.074 | 1.6 | 26.9 | 0.062 | 0.48 | 3.8 |
| 8/8/2006 | 18TC - duplicate | 23.6 | 0.3 | <0.074 | 1.9 | 27 | 0.065 | 0.52 | 4.6 |
| 8/22/2006 | 3TC | 18.3 | 0.19 | <0.074 | 1 | 374 | 0.055 | 0.44 | 6.5 |
| | 3TC - reanalysis for total iron | | | | | 198 | | | |
| 8/22/2006 | 13TC | 27.8 | <0.12 | <0.074 | 1.5 | 35.5 | 0.065 | 0.52 | 4.7 |
| | 13TC - reanalysis for total iron | | | | | 120 | | | |
| 8/22/2006 | 18TC | 17.2 | 0.19 | <0.074 | 1.3 | <6.2 | 0.031 | 0.42 | 17.8 |
| | 18TC - reanalysis for total iron | | | | | 37.4 | | | |

Table 2 cont. Water chemistry (Al, As, Cu, Fe, Pb, Ni, Zn) data collected by Princeton Hydro November 2005 – December 2006 and PA DEP January 1997. Measurements with "<" indicate concentrations below the reporting limit.

| | STATION | Aluminum (total) µg/L | Arsenic (total) µg/L | Cadmium (dissolved) µg/L | Copper (dissolved) µg/L | Iron (total) µg/L | Lead (dissolved) µg/L | Nickel (dissolved) µg/L | Zinc (dissolved) µg/L |
|---|---|---|---|---|---|---|---|---|---|
| Acute Toxicity (*assuming 50 mg/L hardness, if necessary) | | 750 | 340 | 1.03* | 7* | - | 30* | 260* | 66* |
| Chronic Toxicity (*assuming 50 mg/L hardness, if necessary) | | - | 150 | 0.15* | 5* | 1500 | 1.2* | 29* | 65* |
| Princeton Hydro Data | | | | | | | | | |
| 9/12/2006 | 3TC | 34.2 | 0.91 | <0.074 | 1.7 | 218 | 0.11 | 0.75 | 6 |
| 9/12/2006 | 13TC | 47 | 0.95 | <0.074 | 1.8 | 157 | 0.094 | 0.72 | 4.6 |
| 9/12/2006 | 18TC | 18 | 0.58 | <0.074 | 1.7 | 57.3 | 0.094 | 0.65 | 8.5 |
| 9/25/2006 | 3TC | 35 | 0.6 | <0.074 | 1.6 | 301 | 0.083 | 0.66 | 1.8 |
| 9/25/2006 | 3TC - duplicate | 34.9 | 0.51 | <0.074 | 1.5 | 279 | 0.046 | 0.64 | 1.7 |
| 9/25/2006 | 13TC | 42.7 | 0.19 | <0.074 | 1.7 | 183 | 0.05 | 0.56 | 2.5 |
| 9/25/2006 | 18TC | 21 | 0.4 | <0.074 | 1.7 | 89.9 | 0.037 | 0.6 | 1.8 |
| 10/11/2006 | 3TC | 26.6 | 1 | <0.074 | 1.9 | 295 | <0.026 | 0.73 | 5.4 |
| 10/11/2006 | 13TC | 30.6 | 0.26 | <0.074 | 1.9 | 189 | <0.026 | 0.7 | 6.2 |
| 10/11/2006 | 18TC | 24.6 | 0.26 | <0.074 | 3.5 | 114 | <0.026 | 0.61 | 6.1 |
| 10/27/2006 | 3TC | 31.8 | 0.18 | <0.074 | 1.2 | 338 | <0.026 | 0.57 | 4.9 |
| 10/27/2006 | 13TC | 34.8 | <0.12 | <0.074 | 1.3 | 198 | <0.026 | 0.53 | 4.6 |
| 10/27/2006 | 18TC | 25.6 | 0.4 | <0.074 | 1.4 | 165 | <0.026 | 0.47 | 4.9 |
| 11/9/2006 | 3TC | 211 | 0.68 | <0.074 | 1.6 | 397 | 0.11 | 0.96 | 5 |
| 11/9/2006 | 13TC | 247 | 0.16 | <0.074 | 1.7 | 477 | 0.12 | 0.96 | 4.9 |
| 11/9/2006 | 13TC - duplicate | 480 | 0.36 | <0.074 | 2 | 768 | 0.13 | 1 | 10.4 |
| 11/9/2006 | 18TC | 296 | 0.33 | <0.074 | 1.7 | 535 | 0.12 | 0.91 | 6 |
| 11/22/2006 | 3TC | 91.7 | <0.12 | <0.074 | 1.7 | 282 | 0.048 | 0.94 | 23.9 |
| 11/22/2006 | 13TC | 85 | 0.26 | <0.074 | 1.7 | 240 | 0.037 | 0.84 | 14.7 |
| 11/22/2006 | 18TC | 73 | 0.14 | <0.074 | 1.6 | 184 | <0.026 | 0.74 | 10.5 |
| 12/7/2006 | 3TC | 87 | <0.12 | <0.074 | 1.7 | 284 | 0.27 | 0.84 | 5.8 |
| 12/7/2006 | 13TC | 84.1 | <0.12 | <0.074 | 1.5 | 214 | 0.23 | 0.7 | 4.6 |
| 12/7/2006 | 18TC | 79 | <0.12 | <0.074 | 1.6 | 178 | 0.15 | 0.76 | 6.9 |

Table 3. Water chemistry ($NH_3$, $NH_4$, $NO_3$, $NO_4$, P, Hardness) data collected by Princeton Hydro November 2005 – December 2006 and PA DEP January 1997. Measurements with "<" indicate concentrations below the reporting limit.

| | STATION | Ammonia + Ammonium Nitrogen mg/L | Nitrate + Nitrite Nitrogen mg/L | Total Phosphorus mg/L | Hardness mg/L | *Ammonia + Ammonium Nitrogen: Criteria Max | *Ammonia + Ammonium Nitrogen: Criteria 30-day Avg |
|---|---|---|---|---|---|---|---|
| PADEP Data (6 - 10 January 1997) | 2TC | 0.05 | 0.351 | 0.03 | 36 | 24.100 | 4.90 |
| | 8TC | 0.05 | 0.5 | 0.03 | 31 | 24.900 | 5.20 |
| | 16TC | <0.02 | 0.8 | 0.03 | 50 | 23.100 | 4.60 |
| | 21TC | <0.02 | 0.66 | 0.02 | 44 | 24.100 | 4.90 |
| Princeton Hydro Data | | | | | | | |
| 11/21/2005 | 3TC | <0.049 | 0.49 | <0.044 | 52 | 12.300 | 3.00 |
| 11/21/2005 | 13TC | <0.049 | 0.88 | <0.044 | 52 | 11.900 | 3.00 |
| 11/21/2005 | 18TC | <0.049 | 0.87 | <0.044 | 54 | 7.100 | 1.90 |
| 1/25/2006 | 3TC | 0.077 | 0.46 | <0.044 | 52 | 6.000 | 1.50 |
| 1/25/2006 | 13TC | 0.14 | 0.72 | <0.044 | 56 | 6.100 | 1.60 |
| 1/25/2006 | 13TC - duplicate | 0.061 | 0.71 | <0.044 | 54 | 6.100 | 1.60 |
| 1/25/2006 | 18TC | 0.15 | 0.74 | <0.044 | 70 | 5.200 | 1.30 |
| 2/28/2006 | 3TC | <0.01 | 0.29 | 0.04 | 50 | 0.700 | 0.20 |
| 2/28/2006 | 13TC | <0.01 | 0.39 | 0.01 | 60 | 2.400 | 0.50 |
| 2/28/2006 | 18TC | <0.01 | 0.45 | <0.01 | 56 | 0.700 | 0.10 |
| 3/13/2006 | 3TC | <0.01 | 0.28 | 0.04 | 55.4 | 0.400 | 0.10 |
| 3/13/2006 | 13TC | <0.01 | 0.567 | 0.04 | 57.4 | 0.900 | 0.20 |
| 3/13/2006 | 18TC | <0.01 | 0.536 | 0.03 | 57.4 | 0.400 | 0.10 |
| 3/28/2006 | 3TC | <0.01 | 0.295 | 0.03 | 61 | 0.400 | 0.10 |
| 3/28/2006 | 13TC | <0.01 | 0.876 | 0.02 | 79 | 0.300 | 0.10 |
| 3/28/2006 | 18TC | <0.01 | 0.377 | 0.01 | 79 | 0.400 | 0.10 |
| 3/28/2006 | 18TC - duplicate | <0.01 | 0.467 | 0.03 | 79 | 0.400 | 0.10 |
| 4/14/2006 | 3TC | 0.02 | 0.437 | 0.03 | 56.6 | 0.400 | 0.10 |
| 4/14/2006 | 13TC | 0.02 | 0.447 | 0.05 | 66.7 | 3.600 | 0.90 |
| 4/14/2006 | 18TC | 0.01 | 0.255 | 0.03 | 60.6 | 1.200 | 0.30 |
| 5/11/2006 | 3TC | 0.02 | 0.407 | 0.09 | 56.6 | 2.700 | 0.70 |
| 5/11/2006 | 3TC - duplicate | 0.03 | 0.456 | 0.09 | 58.6 | 2.700 | 0.70 |
| 5/11/2006 | 13TC | 0.02 | 0.276 | 0.06 | 64.6 | 0.400 | 0.10 |
| 5/11/2006 | 18TC | <0.01 | 0.124 | 0.07 | 72.7 | 0.600 | 0.10 |

* Calculated based on formulas at §93.7

Table 3 cont. Water chemistry ($NH_3$, $NH_4$, $NO_3$, $NO_4$, P, Hardness) data collected by Princeton Hydro November 2005 – December 2006 and PA DEP January 1997. Measurements with "<" indicate concentrations below the reporting limit.

| | STATION | Ammonia + Ammonium Nitrogen mg/L | Nitrate + Nitrite Nitrogen mg/L | Total Phosphorus mg/L | Hardness mg/L | *Ammonia + Ammonium Nitrogen: Criteria Max | *Ammonia + Ammonium Nitrogen: Criteria 30-day Avg |
|---|---|---|---|---|---|---|---|
| Princeton Hydro Data | | | | | | | |
| 5/25/2006 | 3TC | 0.01 | 0.494 | 0.04 | 58.3 | 3.400 | 0.90 |
| 5/25/2006 | 13TC | 0.01 | 0.495 | 0.06 | 66 | 0.700 | 0.20 |
| 5/25/2006 | 18TC | <0.01 | 0.28 | 0.05 | 64.1 | 0.500 | 0.10 |
| 6/7/2006 | 3TC | <0.01 | 0.606 | 0.03 | 59.2 | 9.100 | 1.80 |
| 6/7/2006 | 13TC | <0.01 | 0.626 | 0.04 | 61.2 | 6.500 | 1.50 |
| 6/7/2006 | 18TC | <0.01 | 0.564 | 0.03 | 61.2 | 4.200 | 1.20 |
| 6/22/2006 | 3TC | <0.01 | 0.712 | 0.05 | 63.2 | 5.100 | 1.20 |
| 6/22/2006 | 13TC | <0.01 | 0.745 | 0.07 | 65.3 | 3.700 | 1.00 |
| 6/22/2006 | 13TC - duplicate | <0.01 | 0.727 | 0.08 | 65.3 | 3.700 | 1.00 |
| 6/22/2006 | 18TC | <0.01 | 0.465 | 0.09 | 65.3 | 1.400 | 0.30 |
| 7/6/2006 | 3TC | <0.01 | 0.302 | 0.06 | 48 | 3.900 | 1.00 |
| 7/6/2006 | 13TC | 0.01 | 0.693 | 0.08 | 48 | 3.800 | 1.00 |
| 7/6/2006 | 18TC | <0.01 | 0.667 | 0.07 | 50 | 2.100 | 0.50 |
| 7/20/2006 | 3TC | <0.01 | 0.193 | 0.05 | 51 | 3.600 | 0.90 |
| 7/20/2006 | 13TC | <0.01 | 0.292 | 0.06 | 55 | 2.300 | 0.60 |
| 7/20/2006 | 18TC | 0.01 | 0.25 | 0.05 | 57 | 1.700 | 0.40 |
| 8/8/2006 | 3TC | 0.04 | 0.247 | 0.04 | 60 | 6.000 | 1.30 |
| 8/8/2006 | 13TC | 0.04 | 0.264 | 0.03 | 60 | 5.300 | 1.10 |
| 8/8/2006 | 18TC | 0.02 | 0.203 | 0.05 | 58 | 2.800 | 0.80 |
| 8/8/2006 | 18TC - duplicate | 0.02 | 0.203 | 0.04 | 58 | 2.800 | 0.80 |
| 8/22/2006 | 3TC | <0.01 | 0.364 | 0.02 | 64.6 | 7.700 | 1.60 |
| 8/22/2006 | 13TC | 0.02 | 0.09 | <0.01 | 74.7 | 6.100 | 1.40 |
| 8/22/2006 | 18TC | 0.01 | 0.16 | <0.01 | 72.7 | 4.800 | 1.20 |
| 9/12/2006 | 3TC | <0.01 | 0.09 | 0.03 | 67.3 | 6 | 1.60 |
| 9/12/2006 | 13TC | <0.01 | 0.14 | 0.05 | 63.4 | 1.900 | 0.40 |
| 9/12/2006 | 18TC | 0.01 | 0.12 | 0.05 | 59.4 | 2.200 | 0.50 |

* Calculated based on formulas at §93.7

Table 3 cont. Water chemistry ($NH_3$, $NH_4$, $NO_3$, $NO_4$, P, Hardness) data collected by Princeton Hydro November 2005 – December 2006 and PA DEP January 1997. Measurements with "<" indicate concentrations below the reporting limit.

| | STATION | Ammonia + Ammonium Nitrogen mg/L | Nitrate + Nitrite Nitrogen mg/L | Total Phosphorus mg/L | Hardness mg/L | *Ammonia + Ammonium Nitrogen: Criteria Max | *Ammonia + Ammonium Nitrogen: Criteria 30-day Avg |
|---|---|---|---|---|---|---|---|
| Princeton Hydro Data | | | | | | | |
| 9/25/2006 | 3TC | <0.01 | 0.283 | 0.04 | 57.0 | 9.7 | 2.00 |
| 9/25/2006 | 3TC - duplicate | <0.01 | 0.27 | 0.05 | 55.0 | 9.7 | 2.00 |
| 9/25/2006 | 13TC | 0.01 | 0.27 | 0.03 | 65.0 | 6.400 | 1.50 |
| 9/25/2006 | 18TC | <0.01 | 0.302 | 0.02 | 65.0 | 5.3 | 1.50 |
| 10/11/2006 | 3TC | <0.01 | 0.39 | 0.07 | 55.4 | 11.6 | 2.30 |
| 10/11/2006 | 13TC | <0.01 | 0.194 | 0.04 | 65.3 | 8.5 | 1.90 |
| 10/11/2006 | 18TC | <0.01 | 0.292 | 0.04 | 63.4 | 6.4 | 1.80 |
| 11/9/2006 | 3TC | 0.04 | 0.259 | 0.02 | 53.5 | 11.400 | 2.80 |
| 11/9/2006 | 13TC | 0.19 | 0.329 | <0.01 | 53.5 | 11.000 | 2.70 |
| 11/9/2006 | 13TC - duplicate | 0.19 | 0.32 | <0.01 | 53.5 | 11.000 | 2.70 |
| 11/9/2006 | 18TC | 0.23 | 0.308 | <0.01 | 50.5 | 9.100 | 2.50 |
| 11/22/2006 | 3TC | 0.03 | 0.456 | 0.04 | 51.5 | 13.400 | 3.10 |
| 11/22/2006 | 13TC | 0.01 | 0.694 | 0.04 | 55.4 | 12.600 | 3.10 |
| 11/22/2006 | 18TC | 0.01 | 0.584 | 0.04 | 57.4 | 8.400 | 2.40 |
| 12/7/2006 | 3TC | 0.01 | 0.575 | 0.04 | 49.5 | 11.700 | 3.00 |
| 12/7/2006 | 13TC | 0.01 | 0.804 | 0.03 | 55.4 | 9.100 | 2.60 |
| 12/7/2006 | 18TC | 0.07 | 0.673 | 0.03 | 55.4 | 6.200 | 1.60 |

* Calculated based on formulas at §93.7

Table 4. 1997 & 2000 Benthic Macroinvertebrate Data

| TAXA | | STATIONS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2TC[1] | 5DR[2] | 8TC[2] | 10DER[2] | 11DER[2] | 15CR[2] | 16TC[2] | 18TC[1] | 20GR[2] | 21TC[2] | 1FC[1] |
| Ephemeroptera (mayflies) | | | | | | | | | | | | |
| Ameletidae | ***Ameletus*** | | | | | | | | | 2 | | |
| Baetidae | ***Acentrella*** | 1 | | 1 | 2 | | | 4 | 2 | | 7 | 1 |
| | ***Baetis*** | | | 6 | | | | 9 | 9 | | | 1 |
| Caenidae | ***Caenis*** | 1 | 26 | 1 | 5 | | | 6 | 2 | | 1 | |
| Ephemerellidae | ***Ephemerella*** | | | | | 2 | | | 1 | | | 102 |
| | ***Drunella*** | | | | | | | | | | | 35 |
| | ***Dannella*** | | | | | | | | | | | 1 |
| | ***Serratella*** | 1 | | 1 | | | | 1 | 2 | | 2 | 1 |
| Heptageniidae | ***Stenacron*** | 1 | 8 | | | | | 1 | 1 | | 1 | |
| | ***Stenonema*** | 1 | 3 | | 2 | 3 | | 4 | 4 | | 1 | 6 |
| Isonychiidae | ***Isonychia*** | | | | 1 | 1 | | | | | | 7 |
| Plecoptera (stoneflies) | | | | | | | | | | | | |
| Capniidae | ***Allocapnia*** | | 13 | | 26 | 7 | 33 | | | 73 | | |
| Nemouridae sp. | | | 2 | | | | | | | | | |
| | ***Amphinemoura*** | | | | | | | 1 | | | | |
| | ***Prostoia*** | | | | 8 | | 5 | | | | | |
| Perlidae | ***Acroneuria*** | | | | | | | | | | | 4 |
| | ***Paragnetina*** | | | | | | | | | | | 1 |
| | ***Perlesta*** | 3 | | 8 | | | | 3 | 5 | | 3 | 1 |
| Taeniopterygidae | ***Taeniopteryx*** | | | | | | | | | | | |
| Tricoptera (caddisflies) | | | | | | | | | | | | |
| Glossosomatidae | ***Glossosoma*** | | | | | | | | | | | 1 |
| Hydropsychidae | ***Cheumatopsyche*** | | 2 | 2 | 16 | 5 | 1 | 8 | 3 | | 4 | 22 |
| | ***Hydropsyche*** | 1 | 1 | | | 3 | | 3 | 2 | | 3 | 2 |
| Lepidostomatidae | ***Lepidostoma*** | 1 | | | | | | | | | | |
| Limnephilidae | ***Apatania*** | | | | | | | | 1 | | 1 | |
| Philopotamidae | ***Chimarra*** | 10 | | 14 | 1 | 10 | | 5 | 7 | | 3 | |
| Rhyacophilidae | ***Rhyacophila*** | | | | | | | | | | | 1 |
| Uenoidae | ***Neophylax*** | | | | | | | | | 1 | | |

Table 4 cont. 1997 & 2000 Benthic Macroinvertebrate Data

| TAXA | | STATIONS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2TC[1] | 5DR[2] | 8TC[2] | 10DER[2] | 11DER[2] | 15CR[2] | 16TC[2] | 18TC[1] | 20GR[2] | 21TC[2] | 1FC[1] |
| Diptera (true flies) | | | | | | | | | | | | |
| Simuliidae | ***Prosimulium*** | | 4 | | 10 | 35 | 59 | | | 48 | | |
| | ***Simulium*** | 7 | | 38 | 17 | | 2 | 2 | 6 | | 2 | 10 |
| Tipulidae | ***Hexatoma*** | | | | | | | | | | | |
| | ***Tipula*** | | 1 | | | | 1 | | | | | |
| Ceratopogonidae | | | | | | | | | | | 1 | |
| Chironomidae | | 4 | 15 | 7 | 18 | 6 | 5 | 51 | 85 | 3 | 55 | 6 |
| Misc. Insect Taxa | | | | | | | | | | | | |
| Corydalidae | ***Corydalus*** | | | | | 2 | | | | | | 1 |
| Sialidae | ***Sialis*** | | 3 | | | | | | | | | |
| Gomphidae | ***Lanthus*** | 1 | | | | | | | | | | |
| | ***Stylogomphus*** | | | | | | | | | | | 2 |
| Coenagrionidae | ***Argia*** | | 3 | 2 | | 1 | | | 2 | | | |
| Dytiscidae | | | | | | | | 1 | | | | |
| Elmidae | ***Optioservus*** | | | 2 | | 1 | | | 5 | | 7 | 1 |
| | ***Stenelmis*** | 22 | 10 | 25 | 1 | 3 | | 7 | 19 | | 13 | |
| Hydrophilidae | ***Berosus*** | | 1 | | | | | | | | | |
| Psephenidae | ***Psephenus*** | 25 | 4 | 9 | 2 | 10 | | | 5 | | 8 | 6 |
| Non-Insect Taxa | | | | | | | | | | | | |
| Planariidae | | 3 | | | | 11 | | | 1 | | | |
| Oligochaeta | | 1 | 1 | | | | 1 | 1 | 5 | 1 | 6 | |
| Asellidae | ***Caecidotea*** | 13 | | | | | | 4 | | | | |
| Gammaridae | ***Gammarus*** | 103 | 13 | 10 | | 14 | | 26 | 32 | | 20 | |
| Cragonyctidae | ***Cranygonyx*** | | | | 1 | | | 1 | | | | |
| Physidae | | | | | | | | 3 | 1 | | 1 | |
| Pleuroceridae | | | | | | | | | | | 1 | 1 |
| Sphaeriidae | | | 3 | | | 2 | | 1 | | | | |
| Corbicula | | 1 | | 1 | | | | | | | | |
| **Richness** | | 19 | 18 | 15 | 14 | 17 | 8 | 21 | 22 | 6 | 20 | 22 |
| **Total Number Individuals** | | 200 | 113 | 127 | 110 | 116 | 107 | 142 | 200 | 128 | 140 | 213 |

[1] Surveyed May 2000
[2] Surveyed January 1997

Table 5. 2010 Benthic Macroinvertebrate Data

| TAXA | | STATIONS | | |
|---|---|---|---|---|
| | | 3TC | 17TC | 1KC |
| Ephemeroptera (mayflies) | | | | |
| Baetidae | ***Acentrella*** | 3 | 5 | 5 |
| | ***Baetis*** | 3 | 95 | |
| | ***Heterocloeon*** | | 3 | |
| | ***Plauditus*** | | 3 | |
| Ephemerellidae | ***Drunella*** | | | 22 |
| | ***Ephemerella*** | 1 | | 32 |
| | ***Eurylophella*** | | | 3 |
| | ***Serratella*** | 19 | 4 | 8 |
| Heptageniidae | ***Epeorus*** | | | 5 |
| | ***Leucrocuta*** | | | 7 |
| | ***Stenacron*** | 1 | 1 | 1 |
| | ***Maccaffertium*** | 20 | 3 | 8 |
| Isonychiidae | ***Isonychia*** | | | 11 |
| Plecoptera (stoneflies) | | | | |
| Leuctridae | ***Leuctra*** | | | 2 |
| Perlidae | ***Agnetina*** | | 10 | |
| | ***Paragnetina*** | | | 1 |
| | ***Acroneuria*** | | | 5 |
| | ***Perlesta*** | 5 | | |
| Nemouridae | ***Amphinemura*** | | | 1 |
| Tricoptera (caddisflies) | | | | |
| Hydropsychidae | ***Diplectrona*** | | | 2 |
| | ***Ceratopsyche*** | | 1 | 5 |
| | ***Cheumatopsyche*** | 8 | 2 | 9 |
| | ***Hydropsyche*** | 3 | | |
| Lepidostomatidae | ***Lepidostoma*** | 1 | 5 | |
| Philopotamidae | ***Chimarra*** | 15 | 1 | 5 |
| Polycentropodidae | ***Polycentropus*** | | 1 | |
| Rhyacophilidae | ***Rhyacophila*** | | | 1 |
| Uenoidae | ***Neophylax*** | | | 1 |
| Diptera (true flies) | | | | |
| Ceratopogonidae | ***Probezzia*** | | | 1 |
| Chironomidae | | 29 | 18 | 23 |
| Empididae | ***Clinocera*** | | | 3 |
| | ***Hemerodromia*** | | | 1 |
| Simuliidae | ***Prosimulium*** | 2 | | |
| | ***Simulium*** | 18 | | 3 |

Table 5 cont. 2010 Benthic Macroinvertebrate Data

| TAXA | | STATIONS | | |
|---|---|---|---|---|
| | | 3TC | 17TC | KC |
| Misc. Insect Taxa | | | | |
| Coenagrionidae | ***Argia*** | 4 | 3 | |
| Elmidae | ***Optioservus*** | 3 | 1 | 1 |
| | ***Oulimnius*** | | | 3 |
| | ***Promoresia*** | | | 11 |
| | ***Stenelmis*** | 33 | 34 | 4 |
| Psephenidae | ***Psephenus*** | 16 | 1 | 1 |
| Non-Insect Taxa | | | | |
| Ancylidae | ***Ancylidae*** | 2 | | |
| Corbiculidae | ***Corbiculidae*** | 1 | | |
| Physidae | ***Physidae*** | 1 | | |
| Hirudinea | | 1 | | |
| Oligochaeta | | 1 | | |
| Crangonyctidae | ***Crangonyx*** | 1 | | |
| Gammaridae | ***Gammarus*** | 13 | 9 | |
| Hyalellidae | ***Hyalella*** | | 1 | |
| Asellidae | ***Caecidotea*** | 1 | | |
| **Richness** | | 26 | 20 | 30 |
| **Total number of individuals** | | 205 | 201 | 185 |

Table 6. Lower Tohickon Creek Basin Fish Data 1977 – 2014

| SCIENTIFIC NAME | COMMON NAME | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 13TC[1] | 13TC[1] | 13TC[2] | 13TC[3] | 3TC[4] | 5DR[5] | 6WR[5] | 11DER[5] | 16TC[6] | 17TC[7] | 20GR[8] | 21TC[9] |
| **Anguillidae** | | | | | | | | | | | | | |
| *Anguilla rostrata* | American eel | 438 | 260 | 146 | 198 | X | X | | X | X | X | | X |
| **Catostomidae** | | | | | | | | | | | | | |
| *Catostomus commersonii* | White sucker | | 13 | 6 | 39 | X | X | X | X | | X | X | X |
| *Erimyzon oblongus* | Creek chubsucker | | 11 | 1 | 14 | | X | X | X | | | | |
| *Hypentelium nigricans* | Nothern hog sucker | 17 | 16 | 9 | 23 | | | | | | | | |
| **Centrarchidae** | | | | | | | | | | | | | |
| *Ambloplites rupestris* | Rock bass | 9 | 5 | 2 | 3 | X | X | | | | X | | |
| *Lepomis auritus* | Redbreast sunfish | 115 | 215 | 117 | 365 | X | X | X | X | X | | | |
| *Lepomis cyanellus* | Green sunfish | 2 | 3 | 1 | 4 | | X | | X | X | | | |
| *Lepomis gibbosus* | Pumpkinseed | 1 | 14 | | 13 | | X | X | X | X | | | |
| *Lepomis macrochirus* | Bluegill | 10 | 25 | 8 | 28 | | X | | X | X | X | | |
| *Micropterus dolomieu* | Smallmouth bass | 5 | 11 | 5 | 13 | X | X | | X | X | | | |
| *Micropterus salmoides* | Largemouth bass | | 7 | | 7 | | X | | | X | | | |
| **Clupeidae** | | | | | | | | | | | | | |
| *Dorosoma cepedianum* | Gizzard shad | 1 | | 1 | | | | | | | | | |
| **Cyprinidae** | | | | | | | | | | | | | |
| *Cyprinus carpio* | Common carp | 3 | 3 | 8 | 3 | | X | | | X | | | |
| *Notropis amoenus* | Comely Shiner | | | 1 | 6 | | | | | | | | |
| *Cyprinella analostana* | Satinfin shiner | 97 | 153 | 22 | 103 | | | | | | | | |
| *Cyprinella spiloptera* | Spotfin shiner | 17 | 11 | | | | X | | | | X | | |
| *Notropis hudsonius* | Spottail Shiner | | | 7 | 13 | | | | | | X | X | |
| *Notemigonus crysoleucas* | Golden Shiner | | | | | | | X | | | | | |
| *Exoglossum maxillingua* | Cutlips minnow | 11 | 21 | | 28 | | | | | X | X | | |
| *Luxilus cornutus* | Common shiner | 6 | 17 | 32 | 132 | | X | | X | | | | |
| *Rhinichthys atratulus* | Blacknose dace | | 3 | | 15 | | X | | | | X | X | |
| *Rhinichthys cataractae* | Longnose dace | | | | 31 | | | | | | X | | X |
| *Semotilus corporalis* | Fallfish | | | 1 | | | | | | X | | X | |
| *Semotilus atromaculatus* | Creek chub | 7 | 6 | 6 | 40 | | X | | | | | X | |
| **Esocidae** | | | | | | | | | | | | | |
| *Esox niger* | Chain pickerel | 1 | 1 | | 4 | | | | | X | | | |

Table 6 cont. Lower Tohickon Creek Basin Fish Data 1977 – 2014

| SCIENTIFIC NAME | COMMON NAME | STATIONS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 13TC[1] | 13TC[1] | 13TC[2] | 13TC[3] | 3TC[4] | 5DR[5] | 6WR[5] | 11DER[5] | 16TC[6] | 17TC[7] | 20GR[8] | 21TC[9] |
| **Fundulidae** | | | | | | | | | | | | | |
| *Fundulus diaphanous* | Eastern banded killifish | 19 | 18 | 1 | 30 | | X | X | X | | X | | |
| **Ictaluridae** | | | | | | | | | | | | | |
| *Ictalurus natalis* | Yellow bullhead | 2 | 1 | | | | X | | X | | | | |
| *Ictalurus nebulosus* | Brown bullhead | | | | 1 | | | | X | X | | | |
| *Ictalurus punctatus* | Channel catfish | | | 1 | | | | | | X | | | |
| *Ictalurus catus* | White catfish | | | | | | | | | X | | | |
| *Noturus insignis* | Margined madtom | 6 | 6 | 5 | 88 | | | | | | X | | |
| **Percidae** | | | | | | | | | | | | | |
| *Etheostoma olmstedi* | Tessellated darter | 20 | 39 | 7 | 118 | | X | | | | X | | X |
| **Salmonidae** | | | | | | | | | | | | | |
| *Oncorhynchus mykiss* | Rainbow trout (stocked) | 1 | 1 | | | | | | | | | | |
| *Salmo trutta* | Brown trout (stocked) | 2 | | | | | | | | X | | | |

[1] 13TC = DEP Fish IBI survey and duplicate station, quantitative, July 2009
[2] 13TC = DEP Fish IBI survey, quantitative, July 2013
[3] 13TC = DEP Fish IBI survey, quantitative, August 2014
[4] 3TC = PFBC survey, presence/absence, May 1977
[5] 5DR, 6WR & 11DER = PFBC survey, presence/absence, September 1999
[6] 16TC = DEP survey, presence/absence, September 1996
[7] 17TC = PFBC survey, presence/absence May 1977
[8] 20GR = PFBC survey, presence/absence, May 1992; and
= DEP survey, presence/absence, January 1997
[9] 21TC = DEP survey, presence/absence, January 1997

Table 7. Tohickon Creek Candidate Reference Comparision May 2000 & 2010

| 2000 | CANDIDATE STATIONS | | REF |
|---|---|---|---|
| METRIC | 2TC | 18TC | 1FC |
| 1. TAXA RICHNESS | 19 | 22 | 22 |
| Cand/Ref (%) | 86 | 100 | xxx |
| Biol. Cond. Score | 8 | 8 | 8 |
| 2. MOD. EPT INDEX | 7 | 8 | 12 |
| Cand/Ref (%) | 58 | 67 | xxx |
| Biol. Cond. Score | 2 | 4 | 8 |
| 3. MOD. HBI | 4.45 | 5.32 | 2.68 |
| Cand-Ref | 1.77 | 2.64 | xxx |
| Biol. Cond. Score | 0 | 0 | 8 |
| 4. % DOMINANT TAXA | 51.5 | 42.5 | 47 |
| Cand-Ref | 4.5 | -4.5 | xxx |
| Biol. Cond. Score | 8 | 8 | 8 |
| 5. % MOD. MAYFLIES | 2 | 5 | 72.3 |
| Ref-Cand | 70.3 | 67.3 | xxx |
| Biol. Cond. Score | 0 | 0 | 8 |
| TOTAL BIOLOGICAL CONDITION SCORE | 18 | 20 | 40 |
| % COMPARABILITY TO REFERENCE | **45** | **50** | |

| 2010 | CANDIDATE STATIONS | | REF |
|---|---|---|---|
| METRIC | 3TC | 17TC | 1KC |
| 1. TAXA RICHNESS | 26 | 20 | 30 |
| Cand/Ref (%) | 87 | 67 | xxx |
| Biol. Cond. Score | 8 | 3 | 8 |
| 2. MOD. EPT INDEX | 8 | 9 | 18 |
| Cand/Ref (%) | 44 | 50 | xxx |
| Biol. Cond. Score | 0 | 1 | 8 |
| 3. MOD. HBI | 4.55 | 5.11 | 2.85 |
| Cand-Ref | 1.70 | 2.26 | xxx |
| Biol. Cond. Score | 0 | 0 | 8 |
| 4. % DOMINANT TAXA | 16.09 | 47.26 | 17.29 |
| Cand-Ref | -1.2 | 29.97 | xxx |
| Biol. Cond. Score | 8 | 8 | 8 |
| 5. % MOD. MAYFLIES | 21.46 | 9.45 | 55.13 |
| Ref-Cand | 33.67 | 45.68 | xxx |
| Biol. Cond. Score | 0 | 0 | 8 |
| TOTAL BIOLOGICAL CONDITION SCORE | 18 | 4 | 40 |
| % COMPARABILITY TO REFERENCE | **45** | **10** | |

Table 8. Lake Nockamixon Profile Data August 2016

| Depth meters | Temperature °C | Temperature °F | Dissolved Oxygen (mg/l) |
|---|---|---|---|
| 0 | 30.00 | 86.00 | 9.00 |
| 1 | 29.95 | 85.91 | 9.01 |
| 2 | 29.07 | 84.33 | 6.89 |
| 3 | 28.26 | 82.87 | 5.96 |
| 4 | 27.26 | 81.07 | 3.66* |
| 5 | 25.28 | 77.50 | 0.40* |
| 6 | 22.99 | 73.38 | 0.17* |
| 7 | 17.45 | 63.41 | 0.10* |
| 8 | 14.10 | 57.38 | 0.12* |
| 9 | 12.88 | 55.18 | 0.08* |
| 10 | 11.99 | 53.58 | 0.05* |
| 11 | 11.35 | 52.43 | 0.07* |
| 12 | 10.71 | 51.28 | 0.07* |
| 13 | 10.41 | 50.74 | 0.08* |
| 14 | 10.18 | 50.32 | 0.06* |
| 15 | 10.02 | 50.04 | 0.05* |
| 16 | 9.87 | 49.77 | 0.01* |
| 17 | 9.75 | 49.55 | 0.00* |
| 18 | 9.67 | 49.41 | 0.00* |
| 19 | 9.44 | 48.99 | 0.00* |
| 20 | 9.29 | 48.72 | 0.00* |

* < 5.0 mg/L dissolved oxygen criteria at Pa. Code §93.7

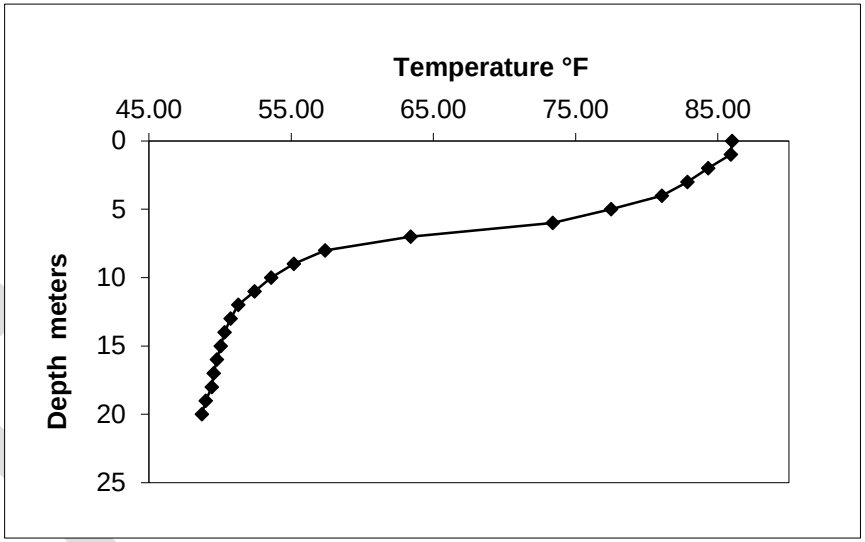


Figure 16. Lake Nockamixon Profile Data Temperature vs Depth

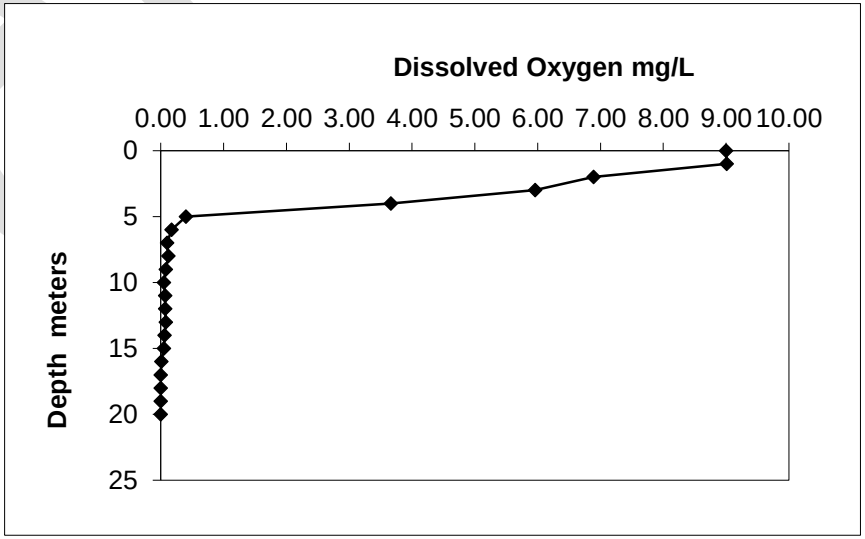


Figure 17. Lake Nockamixon Profile Data Dissolved Oxygen vs Depth