Walla Walla River Basin Fecal Coliform Bacteria, pH, and Dissolved Oxygen Total Maximum Daily Load

Supplemental Study

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Cover photo: Touchet River upstream of the Waitsburg Wastewater Treatment Plant.

Walla Walla River Basin
Fecal Coliform, pH, and Dissolved Oxygen
Total Maximum Daily Load Study

Supplemental Study

by

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Abstract

The Touchet River was included in the Walla Walla River basin total maximum daily load (TMDL) evaluations for fecal coliform bacteria, pH, and dissolved oxygen that were conducted in 2002 and later approved by the U.S. Environmental Protection Agency. The TMDLs recommended additional monitoring for specific areas in the Touchet River (Joy and Swanson, 2005; Joy et al., 2007). This supplemental study documents findings of the additional monitoring on the Touchet River.

The Washington State Department of Ecology (Ecology) monitored the effectiveness of ultraviolet (UV) disinfection on fecal coliform bacteria at the Dayton Wastewater Treatment Plant (WWTP) from May 2009 to October 2009. Two out of the six sample visits had fecal coliform concentrations above the permit limits. The results indicate inadequate disinfection at the plant.

Ecology conducted two synoptic surveys (July and August 2009) to verify nutrient levels in the Touchet River upstream and through the city of Dayton, and through the city of Waitsburg. The 2002 study appears to have over-estimated the background nutrient concentrations. Diffuse (nonpoint) nutrient sources were evident in the lower South and North Forks Touchet River. The 2002 and 2009 study data confirm earlier findings that the river system is nitrogen-limited. Nonpoint nutrient loads were apparent in the Touchet River in both the Dayton and Waitsburg areas.

During 2009, the Dayton WWTP discharged large nutrient loads to the Touchet River, which appear to be contributing to the eutrophic conditions in the river. Recommendations for the Dayton WWTP are consistent with the 2002 study.

The impacts of the groundwater nutrient transport from the wetland, at the Waitsburg WWTP, to the Touchet River were more difficult to determine. The Waitsburg WWTP nutrient loads appear to encourage eutrophic conditions downstream, and upgrading treatment should be considered. Additional monitoring is needed to provide more precise groundwater nutrient loading and its impact on the Touchet River.

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  - Karin Baldwin and Jon Jones, Water Quality Program, Eastern Regional Office.
  - Charles Pitz, Environmental Assessment Program, Headquarters.

Introduction

In 2002, the Washington State Department of Ecology (Ecology) conducted the Walla Walla River basin fecal coliform (FC) bacteria, pH, and dissolved oxygen (DO) total maximum daily load (TMDL) studies to address federal Clean Water Act 303(d) listings. One of the tributaries to the Walla Walla River that was monitored, and the waterbody of interest for this supplemental study, is the Touchet River. FC bacteria and nutrient load and wasteload allocations were determined to bring specific reaches of the Touchet River into compliance with water quality standards.

As a result of the 2002 FC TMDL (Joy and Swanson, 2005), additional monitoring of specific facilities and areas in the basin was recommended. One of the facilities was the Dayton Wastewater Treatment Plant (WWTP). Additional monitoring was necessary to ensure effective ultraviolet disinfection due to inconsistent FC results in effluent during the initial TMDL study. The FC NPDES permit limits for the Dayton WWTP are a weekly average of 400 cfu/100 mL and a monthly average of 200 cfu/100 mL.

As a result of the 2002 pH and DO TMDL (Joy et al., 2007), additional surface water and groundwater nutrient monitoring of the Touchet River, through the city of Waitsburg, was recommended to characterize possible groundwater transport from the Waitsburg WWTP. This possible groundwater nutrient transport may explain high levels of nutrients downstream of the Waitsburg WWTP that may affect pH and DO levels downstream. Ecology's Eastern Regional Office TMDL lead also requested further nutrient monitoring of the Touchet River, upstream and through the city of Dayton, to verify nutrient levels that also may affect pH and DO levels in the river.

The verification was requested because the results of the TMDL called for a significant reduction in nutrients from the Dayton WWTP. To comply with the reduction, Dayton WWTP would need to update its treatment or remove its discharge from the Touchet River during the growing season (May through October). Reference nutrient concentrations in the forested area above Dayton are needed to verify that nutrient wasteload allocations for the Dayton WWTP are correct.

Dayton Load and Wasteload Allocations

According to the TMDL (Joy et al., 2007), the load allocations for nutrients for all surface water and diffuse (nonpoint) inflows to the Touchet River are equivalent to background conditions estimated from the monitoring data as follows:

- All headwater and tributary surface water inputs are assigned a seasonal load allocation average of 18 μg/L for organic phosphorus, 55 μg/L for dissolved inorganic nitrogen (DIN), 39 μg/L for organic nitrogen, and 25 ugP/L for soluble reactive phosphorus (SRP). These allocations are based on estimated reductions of nonpoint sources in the North and South Fork Touchet River by one-third.

- Groundwater and nonpoint sources from the North and South Fork to river mile (RM) 34 are assigned a load allocation average of 205 ugN/L for DIN and 50 ugP/L for SRP based on estimated nonpoint inflows to the Touchet River to the mouth. Diffuse and groundwater inflows to the reaches of the Touchet River below RM 34 should be reduced as much as possible after examining possible natural and legacy sources of the nutrient loads.

The Dayton WWTP[1] nutrient wasteload allocations to the Touchet River from May through October are based on no net increase in pH downstream of the outfall and less than 0.2 mg/L decrease in DO after load allocations are met above Dayton (Joy et al., 2007). Modeled scenarios indicate that these wasteload allocations will have no effect under the current NPDES permit with a seasonal maximum discharge of 0.61 mgd and current upstream nutrient loads that have been reduced by one-third:

- 0.28 lb/day for DIN as nitrogen (sum of nitrate, nitrite, and ammonia as nitrogen).
- 0.20 lb/day for organic nitrogen as nitrogen.
- 0.13 lb/day for SRP as phosphorus.
- 0.09 lb/day for organic phosphorus as phosphorus.

Waitsburg Nutrient Sources

The TMDL states that nutrient sources in the Waitsburg reach of the Touchet River require further investigation. If the Waitsburg WWTP wetland system[2] is identified as a significant source of nutrients, preventing continuity between the wetland and river via groundwater will be necessary. There is no capacity in the Waitsburg reach from May through October for nutrients from the WWTP, abandoned landfill, or sources with an inactive permit (Joy et al., 2007).

Groundwater was monitored around the Waitsburg WWTP in 2009. This monitoring helped characterize the possible groundwater transport of nutrients from the Waitsburg WWTP or the old landfill to the Touchet River. An additional report, that addresses the groundwater monitoring, was submitted by Charles Pitz and Scott Tarbutton (2010).

[1] WA 002072-9.
[2] WA 004555-1.

Washington State Criteria

Table 1 displays the pH, DO, and temperature criteria for the study area. Note the change in DO minimum criteria for the Touchet River at RM 52.4.

Table 1. pH, DO, and temperature criteria for the 2009 study area.

Waterbody reaches	Aquatic Life Use	pH range (s.u.)	DO minimum (mg/L)	Temperature minimum (°C)
NF, WF, and SF Touchet Rivers.	Char Spawning and Rearing	6.5 - 8.5	9.5	12
Touchet River from the confluence of the NF and SF to RM 52.4 (latitude 46.3172, longitude -118.0000), and Coppei Creek.	Core Summer Habitat	6.5 - 8.5	9.5	16
Touchet River downstream of RM 52.4 (latitude 46.3172, longitude -118.0000).	Salmonid Spawning, Rearing, and Migration	6.5 - 8.5	8	17.5

NF - North Fork. WF - Wolf Fork. SF - South Fork.

Study Objectives

The objectives of this 2009 supplemental study were to address the following:

- The inconsistent FC results in Dayton WWTP effluent.
- The verification of nutrient levels in the Touchet River through Dayton.
- The possible groundwater transport of nutrients at the Waitsburg WWTP.

Methods

Field collection study methods were described in the *Supplemental Quality Assurance Project Plan: Walla Walla River basin Fecal Coliform and pH Total Maximum Daily Load Study* (Tarbutton, 2009).

Fecal Coliform

Ecology collected monthly side-by-side FC grab samples with Dayton WWTP staff from May to October 2009. Samples were collected at the end of the UV disinfection chamber before the effluent enters the discharge pipe. The samples were analyzed with each party's typical procedure. Ecology shipped their samples to Manchester Environmental Laboratory, and Dayton WWTP analyzed their samples in-house. Both labs use the same analytical technique, but their holding times are different. Both labs have been accredited by Ecology to provide credible FC data.

Dayton did not collect a side-by-side sample in July because the primary treatment plant operator was on vacation and the substitute operator was not thoroughly informed on the study.

The metric for determining the difference between the two methods is the same as the field replicate metric. It is described in *Replicate Precision for 12 TMDL Studies and Recommendations for Precision Measurement Quality Objectives for Water Quality Parameters* (Mathieu, 2006).

Nutrients

The surface water monitoring included two synoptic surveys during Touchet River baseflow conditions, one in July 2009 and the other in August 2009. Surface water parameters measured during the synoptic surveys are listed in Table 4. Instantaneous streamflow, temperature, pH, DO, and conductivity data were also collected at all sites.

The synoptic surveys included 19 sites (Table 2 and Figure 1) within the Dayton and Waitsburg study areas. Sites upstream of Dayton (North Fork Touchet River, Wolf Creek, and South Fork Touchet River) established nutrient reference conditions. Nutrient inputs were determined through Dayton and past the Dayton WWTP outfall (Touchet RM ~ 54 to 51). Sites were located above, through, and below Waitsburg (Touchet RM ~ 44 to 40) to determine possible changes in nutrient loads. Each synoptic survey site was visited once in the morning and once in the afternoon.

Additional data were collected to help determine the effects of nutrients on the Touchet River. Prior to the synoptic surveys, periphyton (chlorophyll-a) was sampled at four locations: upstream and downstream of the Dayton WWTP and Waitsburg WWTP. Hydrolabs were deployed for at least 24 hours at critical site locations to characterize diel fluctuations in pH, DO, conductivity, and temperature. Critical sites included upstream and downstream of WWTPs, the mouths of major tributaries to the Touchet River, and the North Fork and South Fork Touchet River reference sites (Table 3).

Table 2. Site list for the 2009 Touchet River synoptic surveys.

User Location ID	Location Name	Longitude	Latitude
32NFT-15.1	N Fork Touchet River along Forest Service Rd 64	-117.8062	46.1515
32NFT-04.9	N Fork Touchet River at Wolf Fork Rd	-117.8903	46.2710
32WFT-00.2	Wolf Fork Touchet River near confluence	-117.8953	46.2714
32NFT-00.0	N Fork Touchet River at S Fork confluence	-117.9592	46.3012
32SFT-08.8	S Fork Touchet River in Rainwater Wildlife Area	-117.9557	46.1924
32SFT-00.0	S Fork Touchet River at N Fork confluence	-117.9594	46.3010
32B130	Touchet River at Dayton	-117.9831	46.3184
32PAT-00.1	Patit Creek at Front St	-117.9836	46.3203
32TOU-52.2	Touchet River above Dayton WWTP outfall	-118.0036	46.3160
32DAY-WWTP	Dayton WWTP	-118.0024	46.3157
32TOU-52.1	Touchet River below Dayton WWTP outfall	-118.0048	46.3152
32TOU-51.2	Touchet River at Ward Rd	-118.0133	46.3012
32TOU-44.2	Touchet River at Hwy 12 in Waitsburg	-118.1512	46.2702
32TOU-43.5	Touchet River above Waitsburg WWTP lagoons	-118.1678	46.2726
32WAI-WWTP	Waitsburg WWTP	-118.1680	46.2704
32TOU-43.0	Touchet River at Coppei Creek confluence	-118.1746	46.2724
32COP-00.0	Coppei Creek at confluence, below WWTP lagoons	-118.1746	46.2722
32TOU-42.9	Touchet River below Coppei Creek confluence	-118.1762	46.2721
32B100	Touchet River at Bolles Rd	-118.2212	46.2741

Table 3. Continuous Hydrolab deployment sites.

User Location ID	Location Name	Longitude	Latitude
32NFT-15.1	N Fork Touchet River along Forest Service Rd 64	-117.8062	46.1515
32NFT-00.0	N Fork Touchet River at S Fork confluence	-117.9592	46.3012
32SFT-08.8	S Fork Touchet River in Rainwater Wildlife Area	-117.9557	46.1924
32SFT-00.0	S Fork Touchet River at N Fork confluence	-117.9594	46.3010
32TOU-52.2	Touchet River above Dayton WWTP outfall	-118.0036	46.3160
32TOU-52.1	Touchet River below Dayton WWTP outfall	-118.0048	46.3152
32TOU-43.5	Touchet River above Waitsburg WWTP lagoons	-118.1678	46.2726
32TOU-43.0	Touchet River at Coppei Creek confluence	-118.1746	46.2724
32COP-00.0	Coppei Creek at confluence, below WWTP lagoons	-118.1746	46.2722
32TOU-42.9	Touchet River below Coppei Creek confluence	-118.1762	46.2721

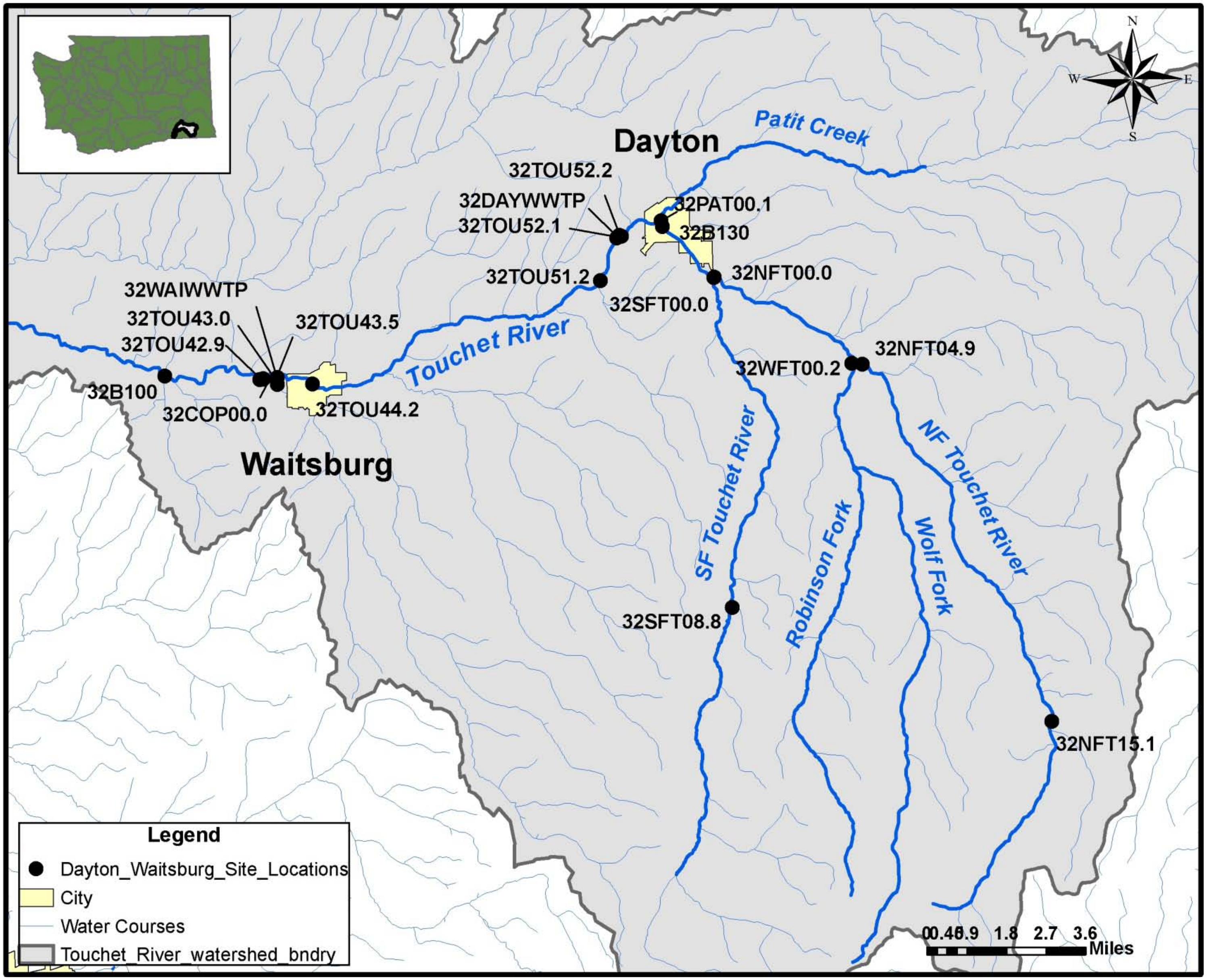


Figure 1. Sampling sites, 2009.

All samples were collected following procedures detailed in the supplemental Quality Assurance (QA) Project Plan (Tarbutton, 2009). Grab samples were collected with pre-cleaned containers supplied by Manchester Laboratory and described in their *Lab Users Manual* (MEL, 2008). Samples were collected under Environmental Assessment Program (EAP) standard operating procedures (Joy, 2006). Sample parameters, containers, volumes, preservation requirements, and holding times are summarized in the QA Project Plan.

QA/quality control (QC) followed procedures in the supplemental QA Project Plan (Tarbutton, 2009). Field replicates were taken simultaneously with site samples as duplicates. Field blanks were collected to ensure clean sample collection equipment and procedures.

Pre-calibrations and post-calibrations, described in the supplemental QA Project Plan (Tarbutton, 2009), were conducted for each Hydrolab meter. Hydrolab DO readings were checked and corrected with samples analyzed following the Winkler method (Azide-modification), SM 21st Edition (APHA, 2005). Hydrolab DO values were collected with luminescent DO (LDO) or clark cell DO probes.

Periphyton field sampling protocols were adapted from the U.S. Geological Survey protocols (Porter et al., 1993).

Table 4 summarizes parameter field blank and replicate sample frequency, reporting limits, and holding times. All samples for laboratory analysis were stored on ice and delivered to Manchester Laboratory within 24 hours of collection via Horizon Air and Manchester Laboratory courier. The field measurement methods followed EAP standard operating procedures (Swanson, 2007). Estimation of instantaneous flow measurements followed the Ecology protocol (Ecology, 2006).

After QA checks, data were entered into the Ecology Environmental Information Management (EIM) database and are available at the website www.ecy.wa.gov/eim/index.htm. Search User Study ID, SCTA0001.

Table 4. Field blank and replicate sample frequency, reporting limits, and holding times, 2009.

Parameter	Field Blanks	Field Replicates	Precision (relative standard deviation)	Required Reporting Limits (concentration units)	Holding Time
Fecal Coliform	N/A	1/run[1]	20% & 50%[1]	1 cfu/100 mL	24 hours
Chlorophyll a	N/A	1/10 samples	20%	0.05 µg/L	28 days after filtration
Total Organic Carbon	1/survey	1/10 samples	10%	1 mg/L	28 days
Dissolved Organic Carbon	1/survey	1/10 samples	10%	1 mg/L	28 days
Total Suspended Solids; TNVSS	1/survey	1/10 samples	15%	1 mg/L	7 days
Alkalinity	1/survey	1/10 samples	10%	5 mg/L	14 days
Chloride	1/survey	1/10 samples	5%	0.1 mg/L	28 days
Total Persulfate Nitrogen	1/survey	1/10 samples	10%	0.025 mg/L	28 days
Ammonia	1/survey	1/10 samples	10%	0.01 mg/L	28 days
Nitrate/Nitrite	1/survey	1/10 samples	10%	0.01 mg/L	28 days
Orthophosphate	1/survey	1/10 samples	10%	0.003 mg/L	48 hours
Total Phosphorus	1/survey	1/10 samples	10%	0.005 mg/L	28 days

[1] Two-tiered: 50% of replicates ≤ 20% RSD; 90% of replicates ≤ 50% RSD.
TNVSS: Total nonvolatile suspended solids.

Results

All laboratory and field data collected for this supplemental study are loaded into Ecology's EIM database. These data are available online from the Ecology website: www.ecy.wa.gov/eim/. Several query options are available. The User Study ID is "SCTA0001," and the Study Name is "Dayton and Waitsburg TMDL Fine-Tuning."

Quality Assurance

Data collected for this 2009 supplemental study were in compliance with Washington State law (RCW 90.48.585) and Ecology Water Quality Program Policy 1-11. The data collection followed standard data QA procedures. The data were also evaluated to determine whether data QA/QC objectives for the project were met. As a result, the data are credible and representative.

The majority of measurement methods and quality objectives were consistent with the original TMDL QA Project Plan (Swanson and Joy, 2002). Alterations and additions in 2009 to FC methods and quality objectives reflect recommendations made in *Replicate Precision for 12 TMDL Studies and Recommendations for Precision Measurement Quality Objectives for Water Quality Parameters* (Mathieu, 2006).

Laboratory

Manchester Laboratory prepared and submitted QA memos summarizing the QC procedures and results for sample transport and storage, sample holding times, and instrument calibration. The memo also included a QA summary of check standards, matrix spikes, method blanks (used to check for analytical bias), and laboratory splits (used to check for analytical precision).

All samples were received in good condition and were properly preserved, as necessary. The temperature of the shipping coolers was within the proper ranges for all sample shipments.

Manchester Laboratory analyzed all samples within the necessary holding time.

Overall, data quality for this project met laboratory QA/QC criteria as determined by Manchester Laboratory. The lab qualified rare individual exceptions as estimates with a "J" qualifier in the data tables. For the July synoptic survey, most of the ortho-phosphate samples had concentrations that were larger than the total phosphorus concentrations. This is acceptable as long as the ortho-phosphate concentrations are no greater than 20% larger than the total phosphorus concentrations. This condition indicates that all of the phosphorus present was ortho-phosphate (Momohara, 2010).

Analytical laboratory precision was determined by calculating a pooled relative standard deviation (%RSD) of laboratory split results. About 10% of the general chemistry samples were analyzed as laboratory split samples. For FC samples, a laboratory split sample was analyzed for each sampling effort, but there still were not enough samples taken to fulfill the requirements of the precision targets. However, Manchester Laboratory QA assessments indicate that the laboratory FC results are acceptable. The laboratory analytical precision and blank results were within QA targets for all parameters (Table 5). The laboratory blanks had no detections for all surveys.

Table 5. Laboratory precision and blank results.

Parameter	Target Precision %RSD		Average %RSD		Lab Blank[1]
Fecal Coliform[2]	50% ≤ 20%	90% ≤ 50%	67% ≤ 20%	100% ≤ 50%	< 1
Total Organic Carbon	10		2.16		< 1
Dissolved Organic Carbon	10		2.16		< 1
Total Suspended Solids	15		11.07		< 1
Alkalinity	10		0.43		< 5
Chloride	5		1.65		< 0.1
Total Persulfate Nitrogen	10		0.66		< 0.025
Ammonia Nitrogen	10		0.07		< 0.01
Nitrate & Nitrite Nitrogen	10		0.58		< 0.01
Orthophosphate P	10		0.67		< 0.003
Total Phosphorus	10		3.17		< 0.005
Chlorophyll a	20		1.24		< 0.1

[1]Lab blank concentrations were non-detect for all sample runs.
[2]Two-tiered: 50% of replicates ≤ 20% RSD; 90% of replicates ≤ 50% RSD.

Field

Field replicate samples (side-by-side duplicates) were collected for at least 10% of the total number of general chemistry samples and at every microbiology sampling in order to assess total precision (i.e., total variation) for field samples. The field replicate concentrations are located in Appendix A (Table A-1). A pooled %RSD was calculated for each parameter using field replicate results. The total precision represented by the pooled %RSD and blank results can be seen in Table 6. The laboratory blanks had no detections for all surveys.

As expected, %RSD for field replicates was higher than that for laboratory splits because %RSD is a measurement of total variability, including both field and analytical variability.

FC met the first part but not the second part of the %RSD criteria. This could be due to the low number of replicates. Though a field replicate was collected for every sampling, there were only 6 replicates; the %RSD targets for FC are recommended for a minimum of 10 replicates (Mathieu, 2006).

The FC samples (Table 8) appear to have been taken from a properly disinfected effluent or a not properly disinfected effluent, depending on the treatment at the time of sampling. The replicate pairs of the former category have concentrations less than 200 cfu/100 mL and have a pooled %RSD of 17.7%. The replicate pairs of the latter category have concentrations greater than 200 cfu/100 mL and have a pooled %RSD of 46.6%. The increased %RSD in the latter category may be due to the nature of FC colonies in water. The colonies in the disinfected effluent were most likely clumped and not homogenous through the water column.

Table 6. Total precision and blank results.

Parameter	Target Precision %RSD		Average %RSD		Field Blank[1]
Fecal Coliform[2]	50% ≤ 20%	90% ≤ 50%	50% ≤ 20%	67% ≤ 50%	< 1
Total Organic Carbon	10		4.71		< 1
Dissolved Organic Carbon	10		3.55		< 1
Total Suspended Solids	15		21.33		< 1
Alkalinity	10		0.68		< 5
Chloride	5		3.11		< 0.1
Total Persulfate Nitrogen	10		4.69		< 0.025
Ammonia Nitrogen	10		2.41		< 0.01
Nitrate & Nitrite Nitrogen	10		1.83		< 0.01
Orthophosphate P	10		4.14		< 0.003
Total Phosphorus	10		4.49		< 0.005

[1]Field blank concentrations were non-detect for all sample runs.
[2]Two-tiered: 50% of replicates ≤ 20% RSD; 90% of replicates ≤ 50% RSD.

Total suspended solids (TSS) also did not meet the target %RSD. All TSS concentrations replicated were below 10 mg/L where the %RSD has limited effectiveness for evaluation (Mathieu, 2006). This also could be due to only having 8 replicates for the calculation; the target is recommended for a minimum of 10 replicates. One of the 8 replicates had a %RSD of 61%, and this replicate is pulling the average %RSD up. If this replicate were removed, the %RSD becomes 15.71%, which nearly meets the target. Also, this replicate was taken at Coppei Creek which is very shallow, and streambed sediment could have been disturbed during the grab sample.

No field replicate was taken for chlorophyll-a, so a %RSD could not be calculated.

Field Measurements

Replicates were also measured for field measurements. The replicates were measured minutes after the initial site measurements using the same Hydrolab meter to ensure the initial site measurements were stable and representative. The precision was calculated from these replicates (Table 7).

Table 7. Field measurement precision.

Parameter	Target Precision %RSD	Average %RSD
Streamflow discharge	5	2.07
pH[1]	0.05 s.u.	0.02 s.u.
Temperature[1]	0.025 °C	0.21 °C
Dissolved Oxygen	5	1.05
Specific Conductivity	10	0.71

[1]As units of measure, not percentages.

All parameters met the target precision except temperature. The average measured difference was nearly an order of magnitude higher than the target, but the %RSD calculated for the temperature replicates was less than 1% (0.84). Also, 2 of these replicates were taken at 32TOU-52.1. This site was not far enough downstream of the Dayton WWTP effluent, so the water column was not completely mixed. If the replicates from this site were excluded, the average measured difference would become 0.08 °C. This indicates that the initial temperature target may be unrealistic for our method. The temperature data are acceptable for the intended use.

DO maximums at 32TOU-42.9 were based on the Hydrolab check measurements in the afternoon, not the continuous Hydrolab diel data. The Hydrolab LDO probe caps were allowing additional light from the sun to interfere with the DO readings in the afternoons at 32TOU-42.9. This is not an issue for DO minimums because the minimums were in the middle of the night, so no additional light is present for interference.

Hydrolab meter pre-calibration and post-calibration were performed. Quality assurance measurements were within acceptable target levels for a majority of the Hydrolab meters. Some qualification and rejection of data was needed. Hydrolab calibration data can be found in Appendix A (Table A-2).

Conclusion

Overall, the data collected by Ecology for this project met the data quality objectives. There was higher variability in the FC, TSS, and temperature data, but this is acceptable for the intended use. Based on the QA and QC review, the Ecology data are of good quality, properly qualified, and acceptable for use.

Replicates taken at 32TOU-52.1 were more variable than replicates taken at other sites for all parameters except total organic carbon (TOC) and TSS. This is most likely due to the incomplete mixing downstream of the Dayton WWTP effluent discharge. Data interpretation at 32TOU-52.1 will take the incomplete mixing into consideration.

Survey Results

Ecology successfully collected monthly side-by-side FC grab samples with Dayton WWTP staff from May to October 2009 except in July. The results of the FC samples are in Table 8.

Table 8. Fecal coliform results from the Dayton WWTP (site 32DAY-WWTP), 2009.

Date	Time	Ecology sample (cfu/100 mL)	WWTP sample (cfu/100 mL)	Ecology QA sample (cfu/100 mL)	Ecology sample qualifier	Ecology QA qualifier	RSD% for side-by-side samples
5/27/09	11:02	1	1	3			0.0
6/3/09	12:45	1	0	1		U	141.4
7/8/09	13:15	680	*	230			*
8/17/09	10:40	4300	1900	6000	J	J	54.7
9/16/09	12:20	25	3.33	25	U	U	108.2
10/7/09	12:15	3	8.33	3		U	66.5

*Dayton WWTP did not analyze a side-by-side FC sample for this month.

Ecology successfully collected synoptic survey nutrient data at the study locations in July and August 2009. Sites were sampled in the morning and afternoon for each survey.

Laboratory data for sites in the Dayton study area are in Appendix A (Tables A-3 and A-4). Field observation data for the same sites are in Tables A-5 and A-6.

Laboratory data for sites in the Waitsburg study area are in Appendix A (Tables A-7 and A-8). Field observation data for the same sites are in Tables A-9 and A-10.

Nutrient loads were calculated as the product of the streamflow discharge and parameter concentration. The loads have been converted to pounds per day (lbs/day). The nutrient load results for sites in the Dayton area are in Tables A-11 and A-12 of Appendix A. Loads calculated at 32TOU-52.1 are estimates due to the incomplete mixing downstream of the Dayton WWTP. The nutrient load results for sites in the Waitsburg area are in Tables A-13 and A-14.

Hydrolabs were deployed for a minimum of 24 hours at selected sites during the synoptic surveys in the Dayton and Waitsburg study areas. The Hydrolabs continuously recorded DO, pH, conductivity, and temperature. The graphical continuous results for the July 2009 survey are in Figures A-1 through A-10 in Appendix A. The graphical continuous results for the August 2009 survey are in Figures A-11 through A-20.

Tables 9 and 10 summarize the exceedances[3] of water quality criteria recorded by the deployed Hydrolabs for the July and August 2009 surveys.

[3] "Exceedance" indicates the results *do not meet* the water quality criteria.

Table 9. Number of exceedances of water quality criteria recorded by the deployed Hydrolabs, July 2009.

Site	Dissolved oxygen				pH				Temperature			
	Time of day[1]	Number of hours	Continuous readings	Percent of Total[2]	Time of day[1]	Number of hours	Continuous readings	Percent of Total[2]	Time of day[1]	Number of hours	Continuous readings	Percent of Total[2]
32NFT-15.1	1200 - 0600	25.75	103	66%	-	0.00	0	0%	1200 - 2100	8.25	33	21%
32NFT-00.0	0000 - 2359	39.00	156	100%	-	0.00	0	0%	0000 - 2359	39.00	156	100%
32SFT-08.8	0000 - 2359	38.75	155	100%	-	0.00	0	0%	0000 - 2359	38.75	155	100%
32SFT-00.0	0000 - 2359	38.75	155	100%	-	0.00	0	0%	0000 - 2359	38.75	155	100%
32TOU-52.2	1800 - 0300	13.75	55	35%	-	0.00	0	0%	1000 - 0100	21.50	86	55%
32TOU-52.1	1800 - 0600	22.75	91	58%	-	0.00	0	0%	1000 - 0100	21.25	85	54%
32TOU-43.5	1800 - 0700	23.50	94	60%	1300 - 1900	7.50	30	19%	0000 - 2359	39.00	156	100%
32TOU-43.0	1800 - 0700	23.25	93	60%	1100 - 2000	11.50	46	29%	0000 - 2359	39.00	156	100%
32COP-00.0	0000 - 2359	38.75	155	100%	-	0.00	0	0%	0000 - 2359	38.75	155	100%
32TOU-42.9	1800 - 0700	25.00	100	65%	1200 - 1900	9.75	39	25%	0000 - 2359	38.75	155	100%

[1] Approximate time range when most exceedances were observed.
[2] Percentage of the total continuous readings and/or time that had exceedances.

Table 10. Number of exceedances of water quality criteria recorded by the deployed Hydrolabs, August 2009.

Site	Dissolved oxygen				pH				Temperature			
	Time of day[1]	Number of hours	Continuous readings	Percent of Total[2]	Time of day[1]	Number of hours	Continuous readings	Percent of Total[2]	Time of day[1]	Number of hours	Continuous readings	Percent of Total[2]
32NFT-15.1	1300 - 0200	19.25	77	46%	-	0.00	0	0%	1500 - 1700	1.25	5	3%
32NFT-00.0	*	*	*	*	-	0.00	0	0%	0000 - 2359	41.50	166	100%
32SFT-08.8	0000 - 2359	40.25	161	100%	-	0.00	0	0%	0000 - 2359	40.25	161	100%
32SFT-00.0	1700 - 1000	32.50	130	79%	-	0.00	0	0%	0000 - 2359	41.25	165	100%
32TOU-52.2	2000 - 2300	4.50	18	11%	1200 - 1700	6.25	25	15%	1200 - 2100	14.50	58	34%
32TOU-52.1	1900 - 0100	11.25	45	27%	-	0.00	0	0%	1200 - 2100	13.50	54	33%
32TOU-43.5	1900 - 0100	9.75	39	26%	1100 - 2000	11.00	44	29%	1100 - 0100	19.50	78	52%
32TOU-43.0	1900 - 0700	23.00	92	62%	1100 - 2000	9.00	36	24%	1100 - 0200	20.25	81	55%
32COP-00.0	*	*	*	*	-	0.00	0	0%	1100 - 0500	26.75	107	72%
32TOU-42.9	1900 - 0500	17.50	70	47%	1100 - 2000	10.00	40	27%	1100 - 0200	20.75	83	56%

* No DO data due to probe malfunction.
[1] Approximate time range that most exceedances were observed.
[2] Percentage of the total continuous readings and/or time that had exceedances.

Discussion

Dayton WWTP Fecal Coliform

Samples collected in May, June, September and October showed nearly complete disinfection. July and August samples had FC concentrations far above the WWTP weekly and monthly permit limits (Ecology, 2005). The July samples were collected a week before the Dayton WWTP experienced a malfunction and wastewater bypassed treatment. The August sample was collected under normal operational conditions.

The number of side-by-side samples was too few to calculate a %RSD; however, the side-by-side samples were consistent in terms of general magnitude, given the variability of the method. The Dayton WWTP samples and the Ecology samples were elevated for the same sample visits. Both labs detected violations on August 17.

Touchet River Nutrients

Dayton

The nutrient reference conditions upstream of land-use impacts, also known as background conditions, were determined from samples taken up the North Fork, Wolf Fork, and South Fork Touchet River at 32NFT-15.1, 32WFT-00.2, and 32SFT-08.8, respectively (Tables A-3 and A-4). These sites are above most agricultural and residential development. However, large forest fires swept through upstream catchments twice since 2002. Some residences, recreational facilities, and range and forest harvesting activities are present upstream of some sites.

The most upstream site on the South Fork, 32SFT-08.8, had the lowest nitrate/nitrate concentrations, between 0.020 and 0.024 mg/L, and ortho-phosphate concentrations between 0.0296 and 0.0433 mg/L. The inorganic nutrient ratios were between 0.6 and 0.7 indicating a nitrogen-limiting condition. The site at the mouth of the South Fork (32SFT-00.0) had greatly increased nitrate/nitrite concentrations and reduced streamflow and phosphorus concentrations. Nitrate/nitrite loads increased by an order of magnitude while phosphorus loads decreased slightly. Rural development between the two sites is suspected of increasing the nutrient concentrations over the background condition. Average nitrate/nitrite concentrations and loads at SFT-00.0 in 2009 were twice those reported in 2002 (Table 11). Phosphorus concentrations and loads were similar in the two years.

Table 11. Estimated average nutrient concentrations and loads at sites in the upper forks of the Touchet River above Dayton in July and August of 2002 and 2009.

Site	Year	Q	NO2+NO3	OP	TP	NO2+NO3	OP	TP	N:P
		cfs	mg/L	mg/L	mg/L	lbs/day	lbs/day	lbs/day	ratio
32SFT-08.8	2009	5.2	0.022	0.037	0.034	0.6	1.0	0.9	0.6
32SFT-00.0		3.2	0.715	0.038	0.035	12.4	0.7	0.6	18.9
32NFT-15.1		11.4	0.271	0.036	0.032	16.7	2.2	2.0	7.6
32WFT-00.2		29.7	0.067	0.048	0.045	10.7	7.6	7.1	1.4
32NFT-00.0		51.6	0.127	0.046	0.044	35.3	12.8	12.3	2.8
32SFT-00.0	2002	5	0.281	0.036	0.046	6.1	0.9	1.1	7.7
32NFT-00.0		49	0.063	0.042	0.057	17	10.8	14.9	1.7

Q = Streamflow.
NO2+NO3 = Nitrate + nitrite.
OP = Ortho-phosphate.
TP = Total phosphorus.
N:P = Nitrogen:phosphorus.

Samples taken at 32NFT-15.1 had higher nitrate/nitrite concentrations than SFT-08.8, but similar ortho-phosphate concentrations. The inorganic nutrient ratios were between 6.1 and 9.1 indicating a possible phosphorus-limiting condition, different than the South Fork ratio indications. 32NFT-15.1 was located downstream of a ski resort, camping areas, and forest and range land that was affected by fire twice since the 2002 TMDL. Therefore 32NFT-15.1 may not be an appropriate site for assessing background conditions.

The site at the mouth of the North Fork (32NFT-00.0) had lower nitrate/nitrite concentrations compared to the site at RM 15.1 but a greater load due to increased streamflow (Table 11). Ortho-phosphate concentrations increased slightly and loads increased slightly more than would flow-proportionally be expected. Average July and August streamflows at NFT-00.0 were similar in 2002 and 2009. Phosphorus loads at the mouth were similar to the 2002 study, but nitrogen loads were more than double in 2009 than in 2002. This may be due to the fires and subsequent increase of nitrogen release in the watershed.

32SFT-08.8 did not have the land-use activities seen upstream of 32NFT-15.1, so the site is more appropriate for assessing background conditions. Background nutrient concentrations and ratios seen at 32SFT-08.8 are more like the U.S. Environmental Protection Agency (EPA) nutrient concentrations for the Blue Mountain eco-region than the Columbia Basin eco-region. This result is not entirely consistent with the 2002 study. In 2002, the estimated background nutrient concentrations were similar to the EPA nutrient concentrations for the Columbia Basin eco-region, and the nutrient ratios were more similar to the Blue Mountain eco-region (Joy et al., 2007). Therefore the 2002 study may have over-estimated the background nutrient concentrations. Nonpoint sources in the upper Touchet watershed may contribute more of a nutrient load than was recognized. Nitrogen sources are still the dominant stimulus of primary productivity.

The nitrogen and chloride loads at the mouth of the North Fork (32NFT-00.0) do not equal the loads measured upstream (32NFT-04.9 and 32WFT-00.2), so there may be a suspected nonpoint load from the reach between the confluence of the North Fork and Wolf Fork to the mouth.

As seen in Tables 9 and 10, diel Hydrolab data for the North Fork (32NFT-15.1 and 32NFT-00.0) recorded DO values less than the criteria of 9.5 mg/L in July and August. Figures A-1, A-2, A-11, and A-12 graphically display the diel Hydrolab data for 32NFT-15.1 and 32NFT-00.0. The DO probe at 32NFT-00.0 in August was not working properly and the values were rejected, but one of the Winkler titrations (grab samples) taken at that site in August was analyzed with DO at 9.05 mg/L. DO minimums were much lower, and diurnal curves had a larger range (low to high), at 32NFT-00.0 than at 32NFT-15.1 in July. This could be due to primary productivity and eutrophic conditions.

Diel Hydrolab data for the South Fork (32SFT-08.8 and 32SFT-00.0) show DO values less than the criteria of 9.5 mg/L in July and August (Table 9). Figures A-3, A-4, A-13, and A-14 graphically display the diel Hydrolab data for 32SFT-08.8 and 32SFT-00.0. The DO minimums were much lower at 32SFT-00.0 than at 32SFT-08.8 for both surveys. In July the DO minimum at 32SFT-08.8 was 7.52 mg/L and the minimum at 32SFT-00.0 was 6.56 mg/L. In August the DO minimum at 32SFT-08.8 was 7.97 mg/L and at 32SFT-00.0 was 6.84 mg/L. The diurnal curves at 32SFT-08.8 had a range (low to high) of 0.93 mg/L in July and 0.54 mg/L in August. The diurnal curves at 32SFT-00.0 had a range (low to high) of 2.37 mg/L in July and 3.5 mg/L in August. The difference in DO is likely due to primary productivity and eutrophic conditions downstream at 32SFT-00.0.

Figures 2 through 7 display the nitrogen, phosphorus, chloride loads, and streamflows for the Dayton area sites for the July and August 2009 surveys. Note the differences in scales between the July and August surveys.

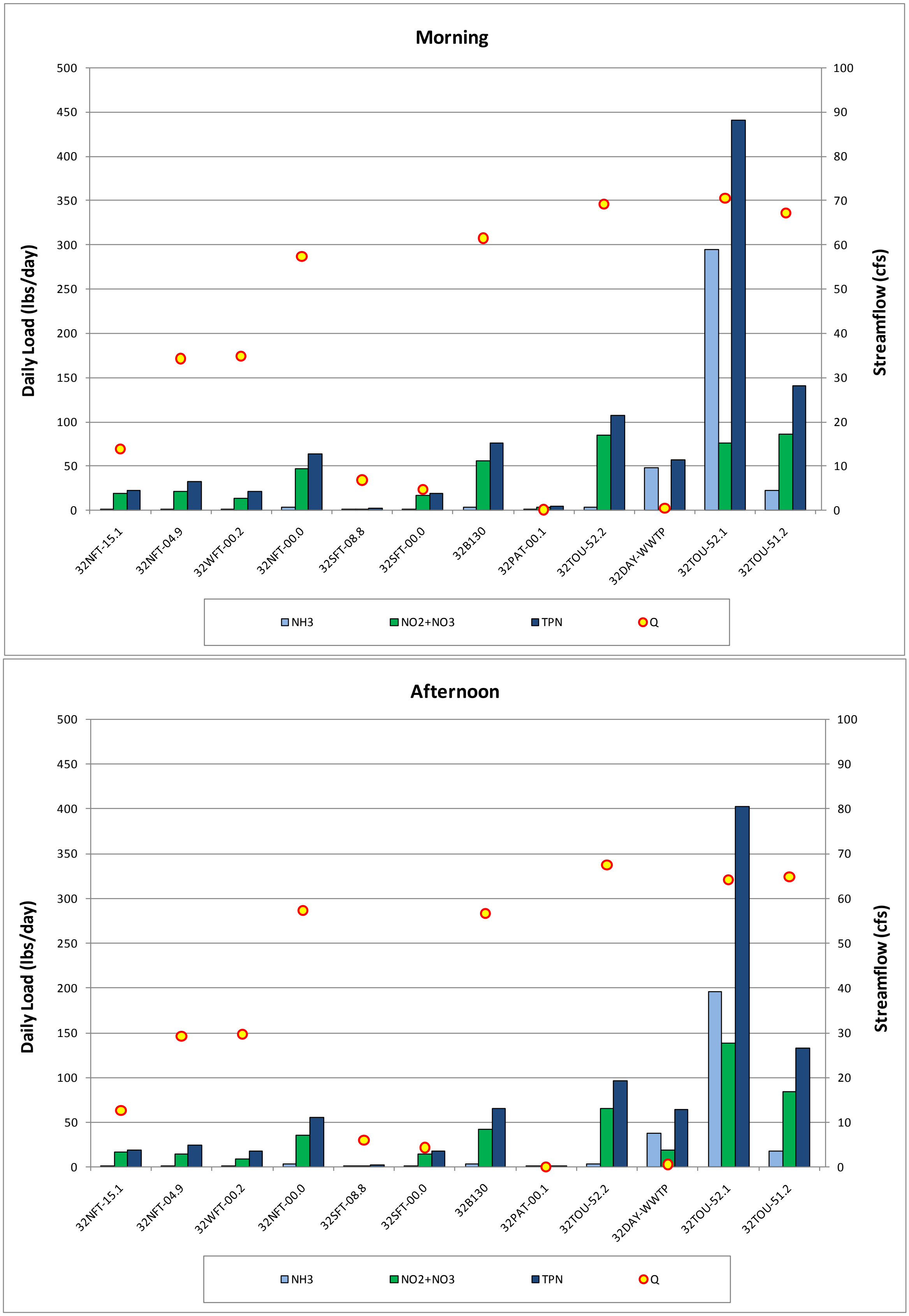
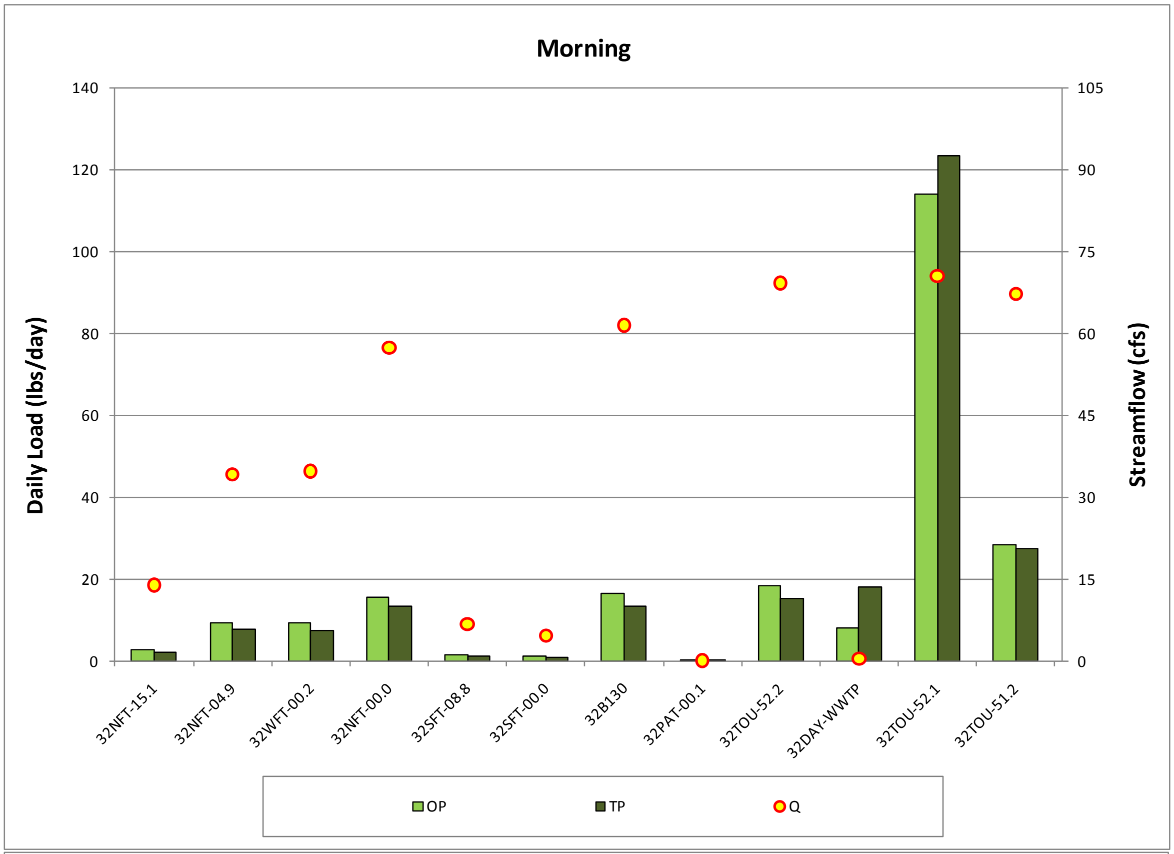


Figure 2. Nitrogen loads and streamflow for sites in the Dayton area, July 2009.



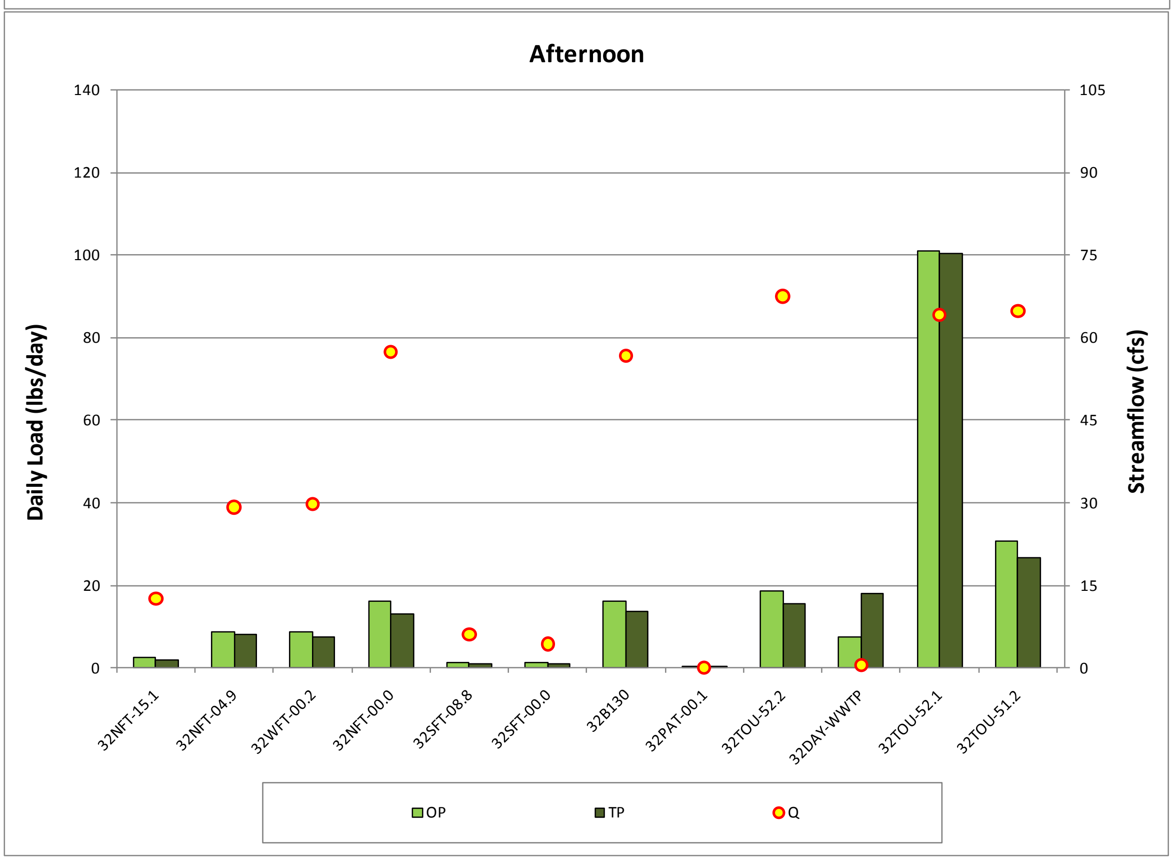


Figure 3. Phosphorus loads and streamflow for sites in the Dayton area, July 2009.

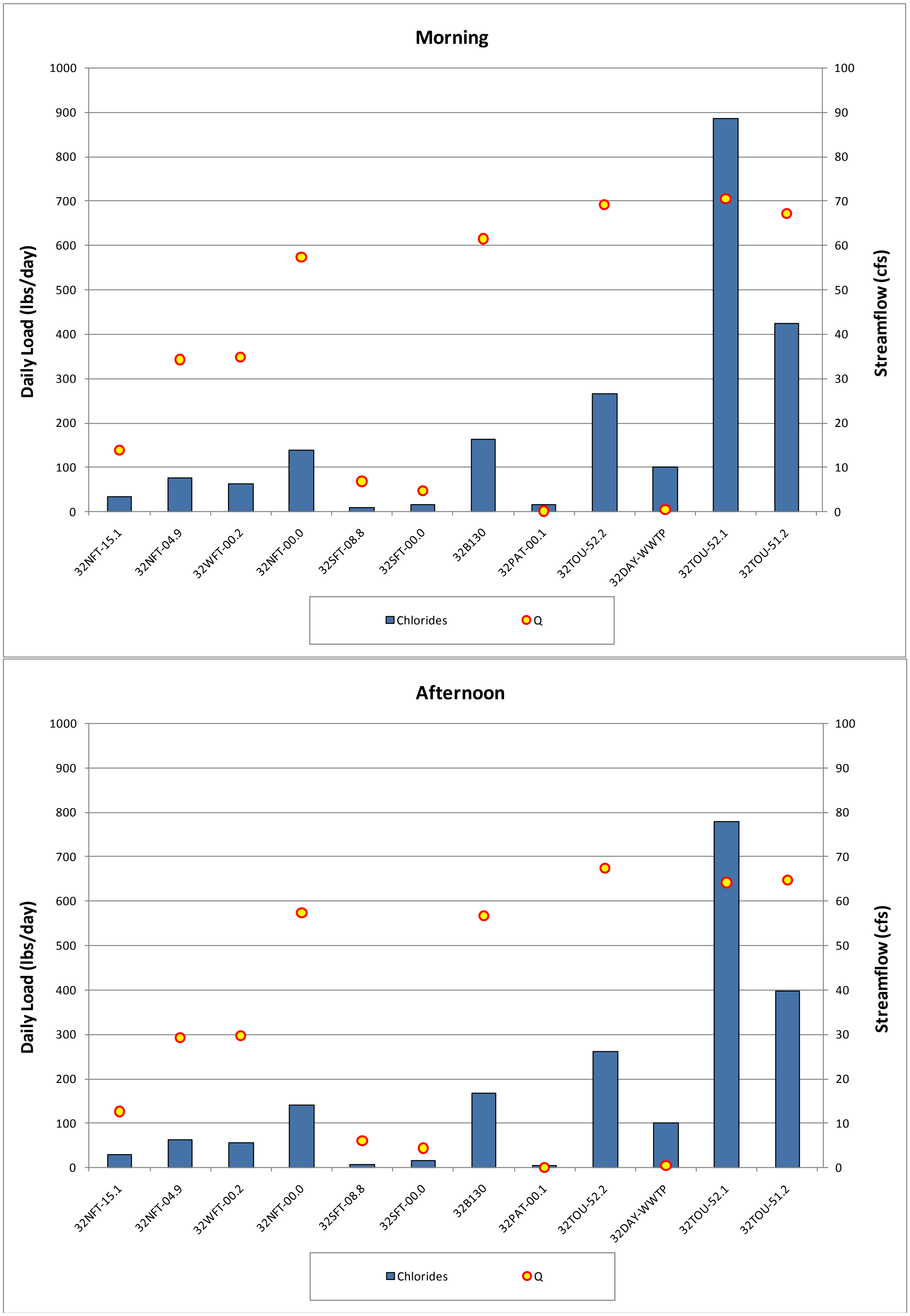


Figure 4. Chloride loads and streamflow for sites in the Dayton area, July 2009.

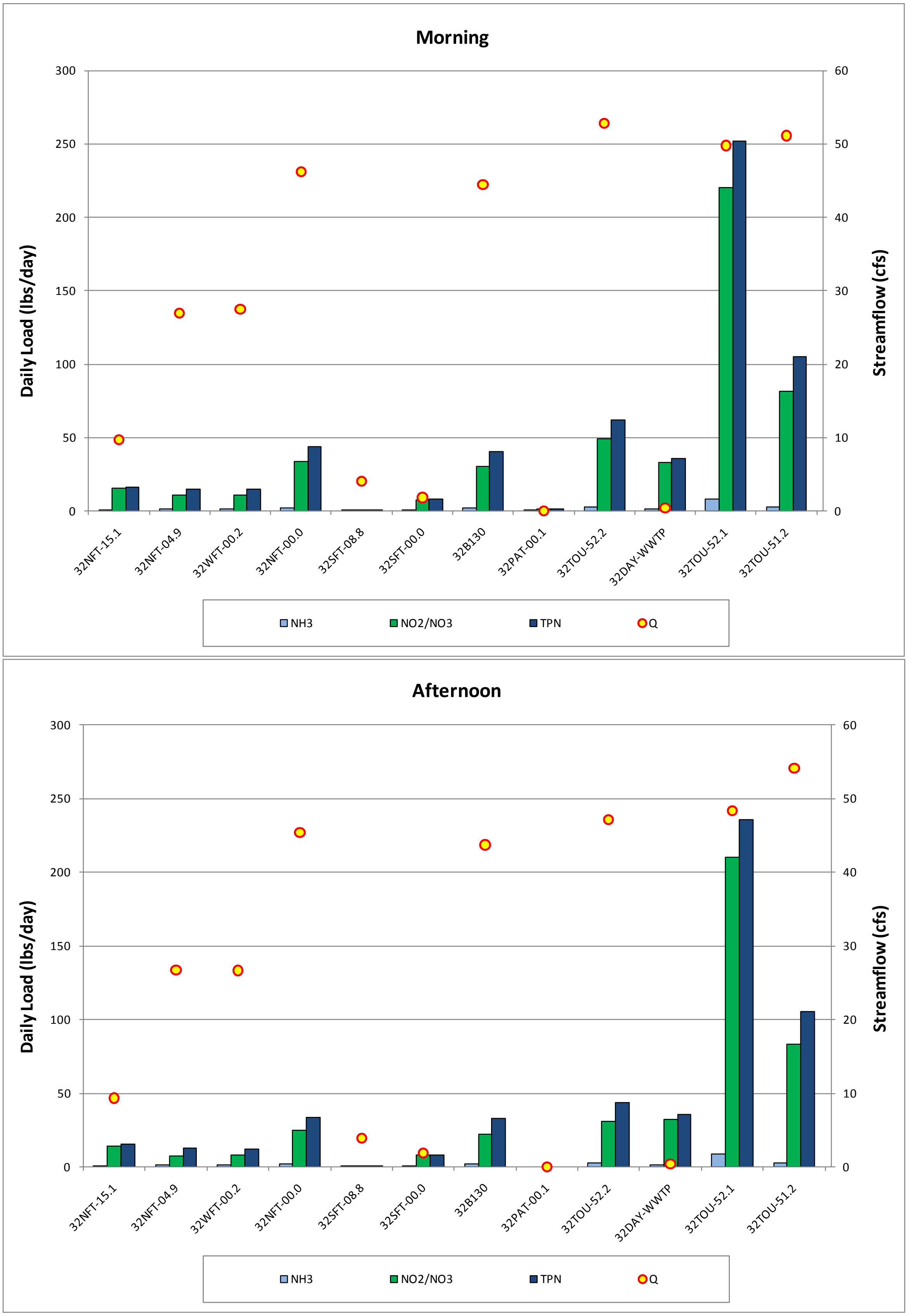


Figure 5. Nitrogen loads and streamflow for sites in the Dayton area, August 2009.

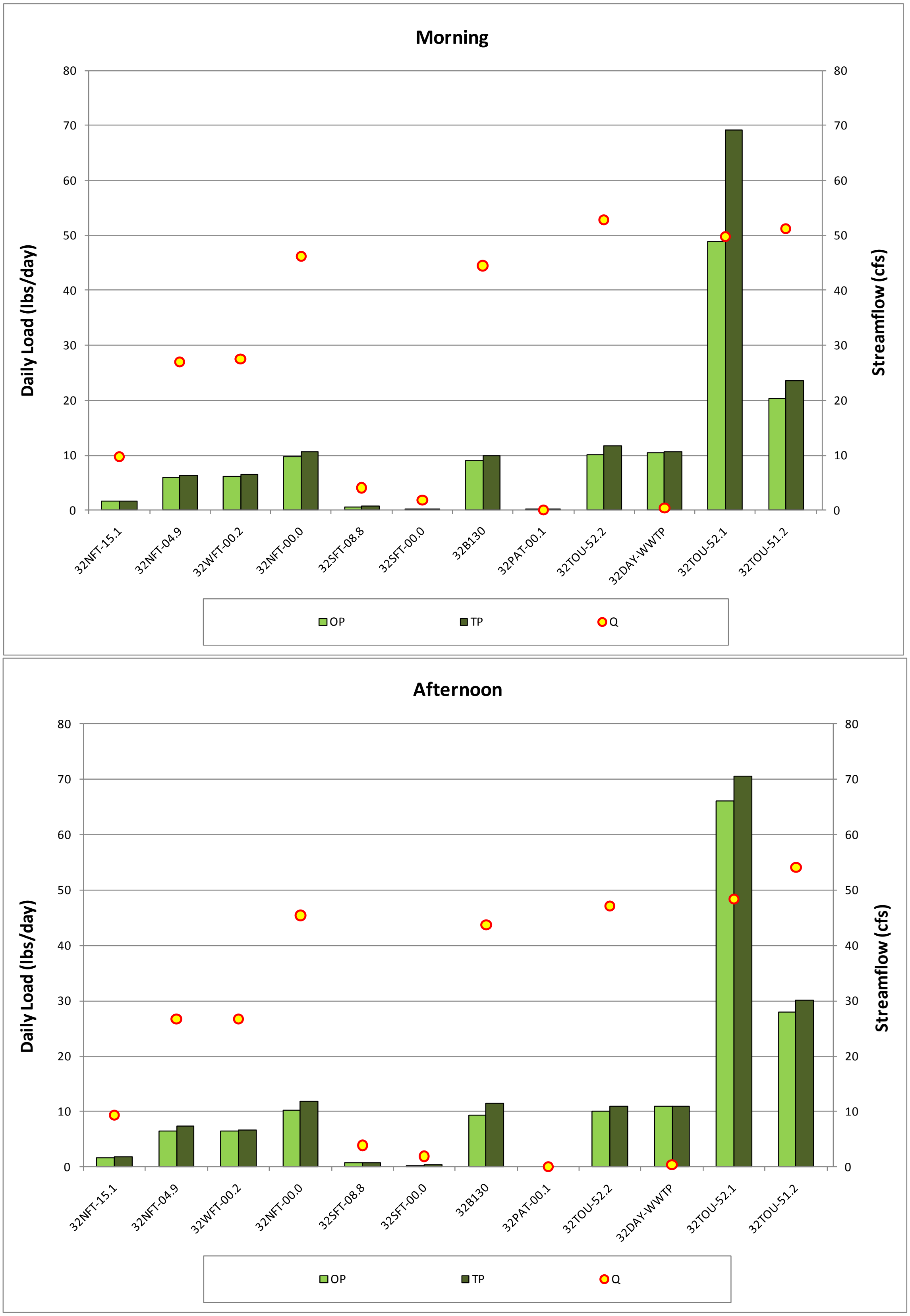


Figure 6. Phosphorus loads and streamflow for sites in the Dayton area, August 2009.

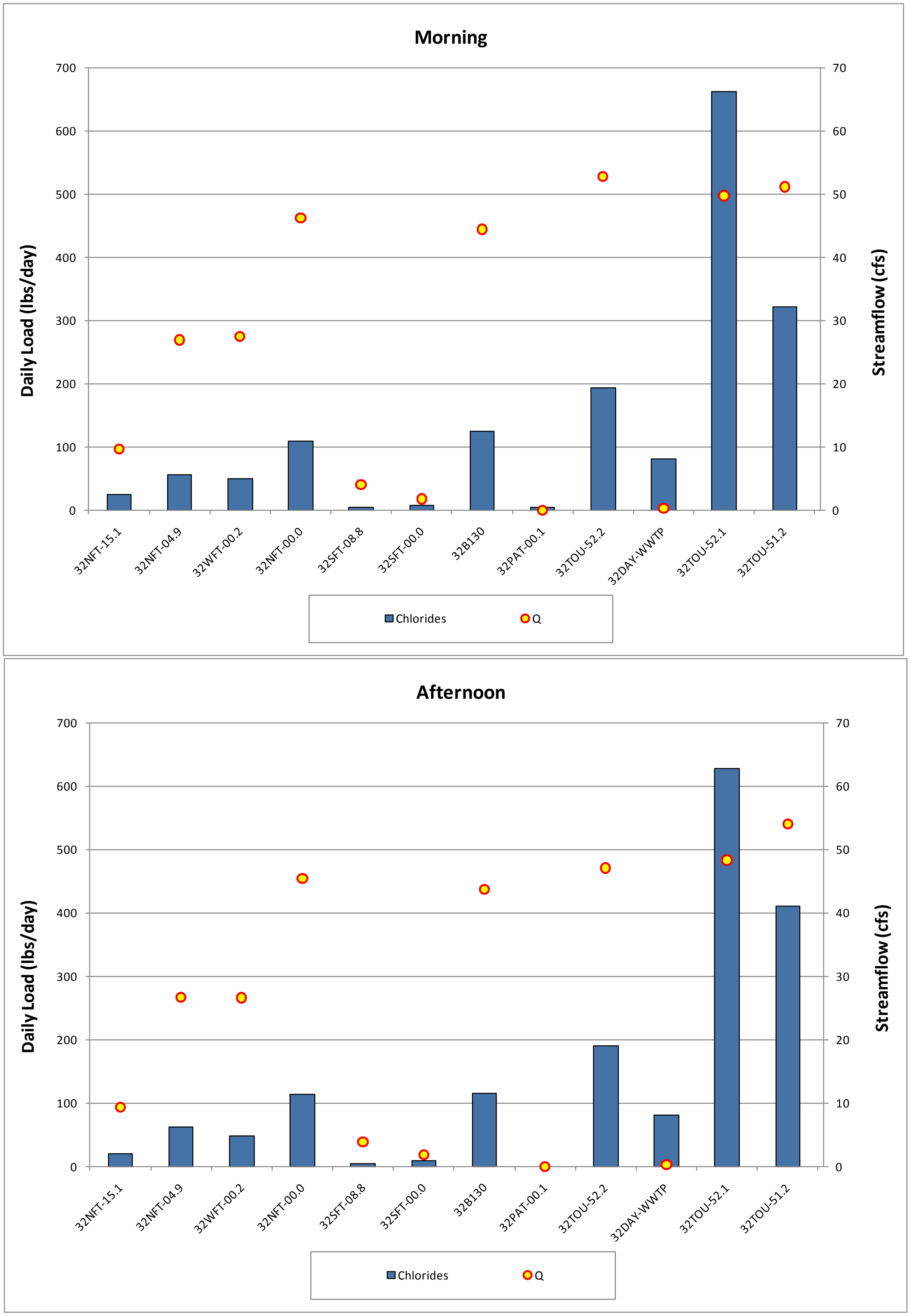


Figure 7. Chloride loads and streamflow for sites in the Dayton area, August 2009.

Nitrogen loads at 32B130 are less than the sum of the loads from the North Fork and South Fork in July and August (Table A-11 and A-12). This evident loss in nitrogen could be due to the uptake by aquatic plants with no additional nitrogen loads.

Nutrient loads increase at 32TOU-52.2 and are not explained by the input of Patit Creek alone. There appears to be an additional nonpoint load from 32B130 to 32TOU-52.2 (Table A-11 and A-12).

The Dayton WWTP was experiencing a malfunction during the July survey. The plant was discharging wastewater that bypassed treatment. As a result, the water quality of the discharge and the downstream reaches of the Touchet River were degraded (Table A-3). The pollution effects can especially be seen in the ammonia concentrations and loads from the WWTP discharge. The permit limit for ammonia concentration is 5 mg/L; this limit was clearly exceeded. The effects of the poorly treated effluent continued more than a mile downstream at 32TOU-51.2 and at 32TOU-44.2 where elevated nutrient concentrations and loads were observed.

The Dayton WWTP was not experiencing a bypass during the August survey. However, nutrient concentrations and loads indicate that the WWTP discharge is a significant source of nutrients (Table A-4). Nitrate/nitrite, ortho-phosphate, and total phosphorus concentrations were considerably high in August.

32TOU-52.1 was sampled only about 100 feet downstream of the Dayton WWTP effluent outfall, within the designated chronic mixing zone. The estimated loads were larger than could be expected from addition of the effluent to the river, so the effluent was not completely mixed at this site (Table A-11 and A-12).

There was an increase in chlorophyll biomass at 32TOU-52.1, relative to 32TOU-52.2, for both surveys. The difference in biomass from upstream to downstream in July was 140%, in August the difference was only 8%. Between July and August, the upstream biomass increased by 305% and the downstream increased by only 82%. This may indicate a biomass growth limitation.

The WWTP effluent discharge appears to increase chlorophyll biomass at a faster rate than sources upstream because the site below the effluent discharge reaches the growth limitation earlier in the year than the upstream site.

Some researchers consider nuisance periphyton biomass is reached at 100 - 200 mg/m^2 (Dodds and Welch, 2000). In August, both sites reached this level of growth.

The diel Hydrolab data show a DO minimum of 7.34 mg/L in July and 7.87 mg/L in August upstream of the WWTP discharge, and a DO minimum of 7.01 mg/L in July and 7.54 mg/L in August downstream of the WWTP discharge (Figures A-5, A-6, A-15, and A-16). The diurnal curve range (low to high) at 32TOU-52.2 was 2.24 mg/L in July and 2.44 mg/L in August. The diurnal curve range at 32TOU-52.1 was 2.35 mg/L in July and 2.59 mg/L in August. The chlorophyll biomass and diel Hydrolab analysis indicate increased periphyton productivity downstream of the WWTP discharge.

The DO minimum criterion in the Touchet River decreases from 9.5 to 8.0 mg/L just upstream of 32TOU-52.2. The diel Hydrolab data show that this DO minimum criterion is not met at all applicable sites. The diel Hydrolab data show the effect of cooling temperatures in offsetting increased respiration at night. This effect is seen with a linear increase in DO at night in the diel Hydrolab graphs.

Continuous Hydrolab pH readings show an increase in pH for the 32TOU-52.2 to 32TOU-52.1 reach during the July survey (Figures A-5 and A-6). The pH maximums do not exceed the 8.5 s.u. criteria in July. The August survey shows a decrease in the reach between 32TOU-52.2 and 32TOU-52.1 (Figures A-15 and A-16). The pH maximums at 32TOU-52.2 exceed the 8.5 s.u. criteria in August. The WWTP does not appear to have an effect on pH in the mixing zone because of the influence of lower pH in the effluent and biochemical reactions of the effluent and river water.

The August instantaneous pH measurements downstream of the mixing zone exceeded the criterion or showed the potential to do so. One mile downstream at 32TOU-51.2 the pH was 8.45 at 2 pm (Table A-6). Since pH values peak about an hour or two later, it is likely that the 8.5 criterion was exceeded at this site. This area is commonly called a recovery zone where organisms in the river are responding with increased biomass to useable nutrient components in a more dilute form than in the mixing zone. The pH measurement above Waitsburg at 32TOU-44.2 exceeded the criterion in the afternoon (Table A-10).

The large increase of nutrient loads seen at 32TOU-51.2 during the August survey are mostly explained by the nutrient loads from the Dayton WWTP discharge (Table A-12). In the afternoon there was an unaccounted-for increase in nutrient loads between 32TOU-52.2 and 32TOU-51.2, which indicates either a potential nonpoint load in the reach, or greater variability in effluent quality. This increase in load was not as apparent in the morning, so further investigation would be required to determine the existence of a nonpoint load between 32TOU-52.2 and 32TOU-51.2.

Waitsburg

The reach between the most downstream site in Dayton (32TOU-51.2) and the most upstream site in Waitsburg (32TOU-44.2) consistently shows a 5 to 7 cubic feet per second (cfs) decrease in streamflow (Tables A-7 and A-8). The reach had an increase in chloride loads in the morning for both the July and August surveys (Tables A-13 and A-14). This indicates a potential load from a nonpoint source within the reach. Carbon loads did not decrease with the streamflow, but instead carbon loads stayed constant or increased in some samples. July inorganic nitrogen (ammonia plus nitrate/nitrite) loads stayed fairly constant between the two sites. Phosphorus loads declined slightly. The nitrogen and phosphorus loads decreased considerably in August suggesting increased nutrient uptake and productivity in the reach. This decrease in nitrogen and phosphorus loads is not explained by the decrease in flow alone.

The July nitrogen concentrations and loads at 32TOU-51.2 were influenced by the bypass experienced at the Dayton WWTP, so the August survey was more heavily weighted in the nutrient data analysis for this reach. July ammonia concentrations and loads at 32TOU-44.2 were double those calculated in August. The large ammonia concentrations and loads at 32TOU-44.2 are most likely a result of the bypass event at the Dayton WWTP during the July survey. This reach is approximately 7 river miles, and finer resolution between sample sites should be used to further characterize sources along this reach.

Figures 8 through 13 display the nitrogen, phosphorus, and chloride loads as well as streamflows for the sites in the Waitsburg area for the July and August 2009 surveys. Note the differences in scales between July and August.

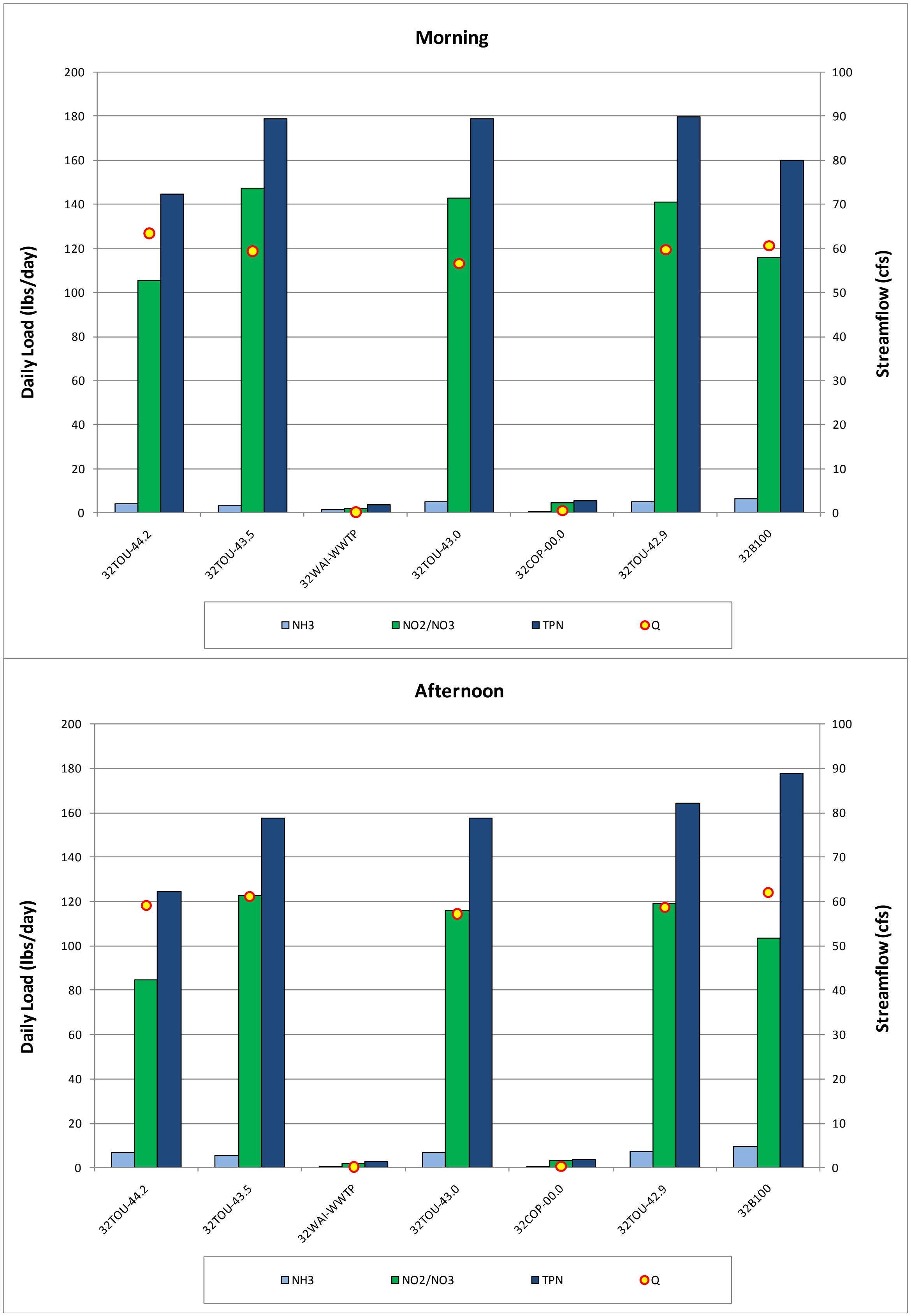


Figure 8. Nitrogen loads and streamflow for sites in the Waitsburg area, July 2009.

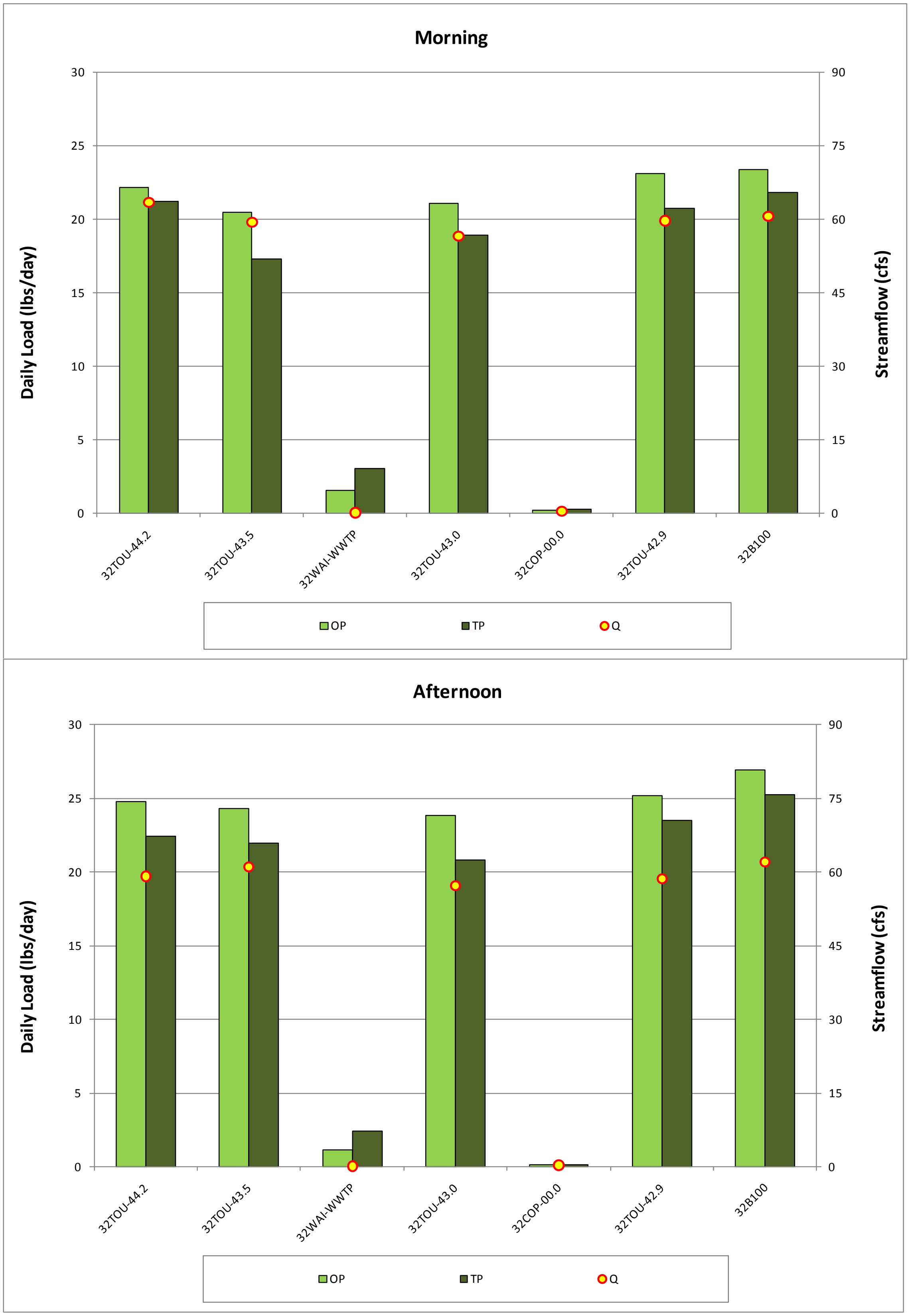
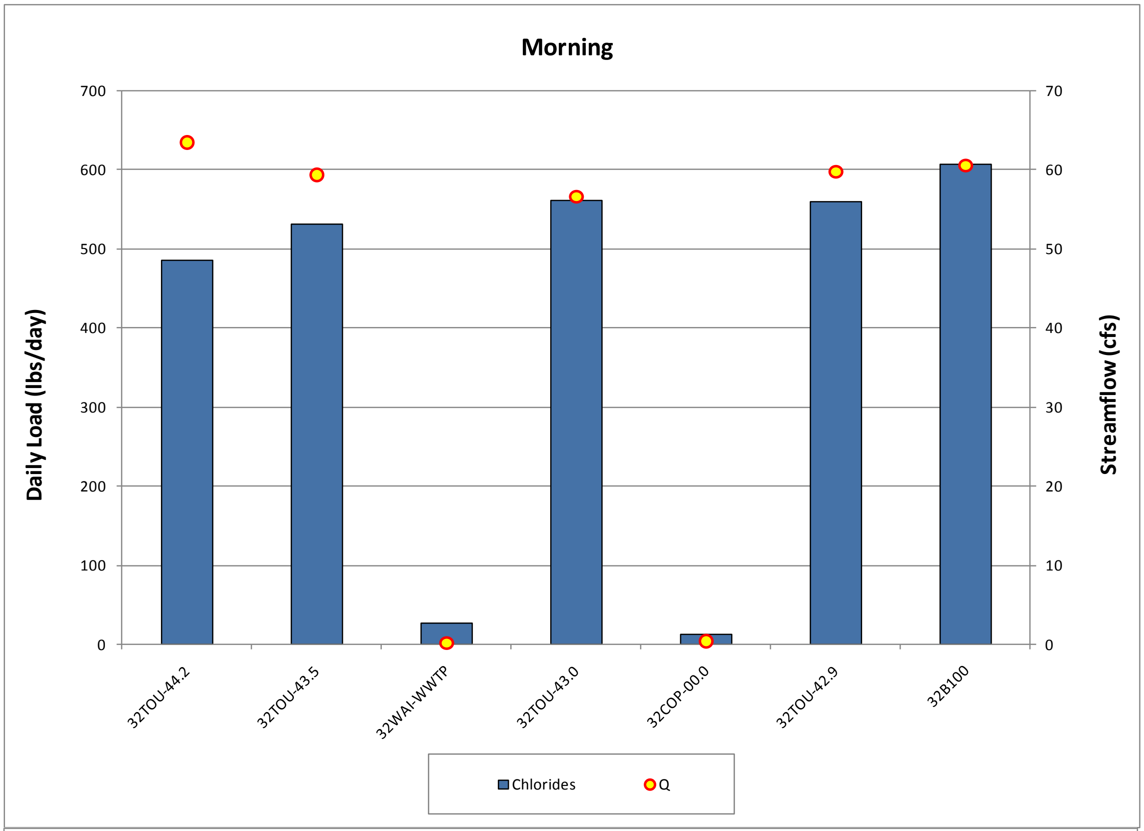


Figure 9. Phosphorus loads and streamflow for sites in the Waitsburg area, July 2009.



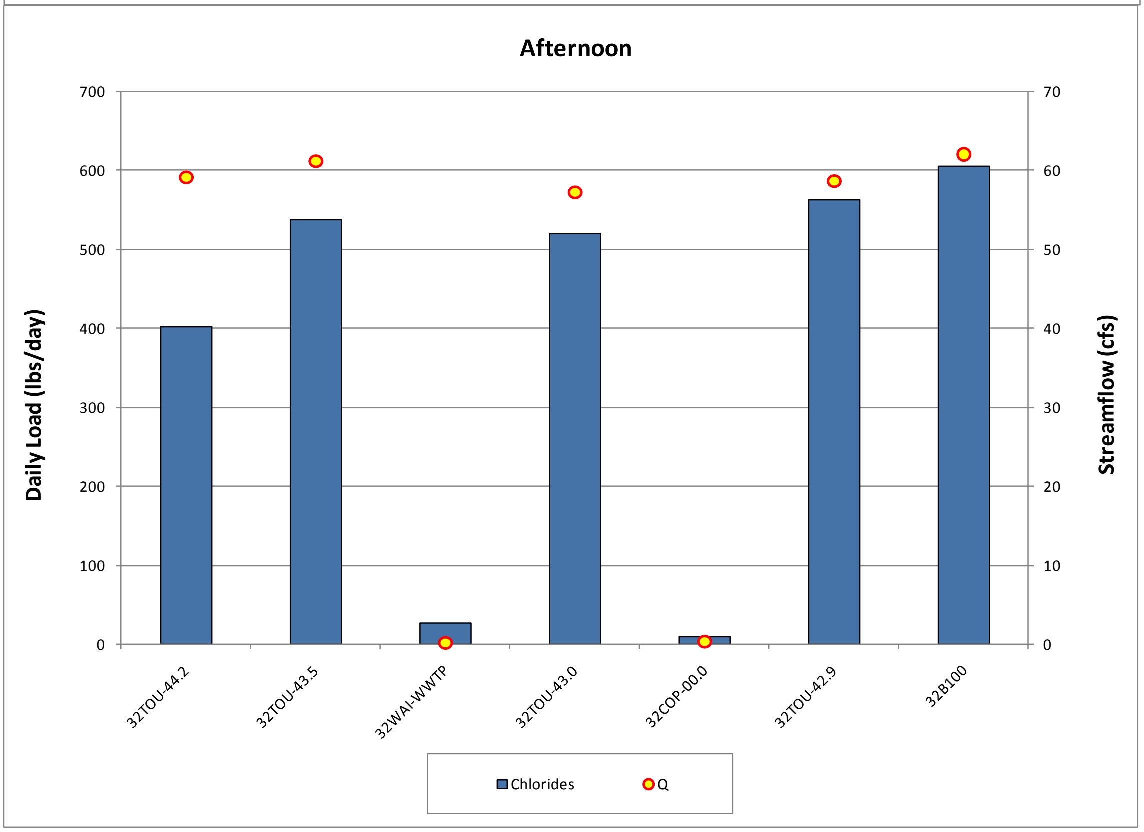


Figure 10. Chloride loads and streamflow for sites in the Waitsburg area, July 2009.

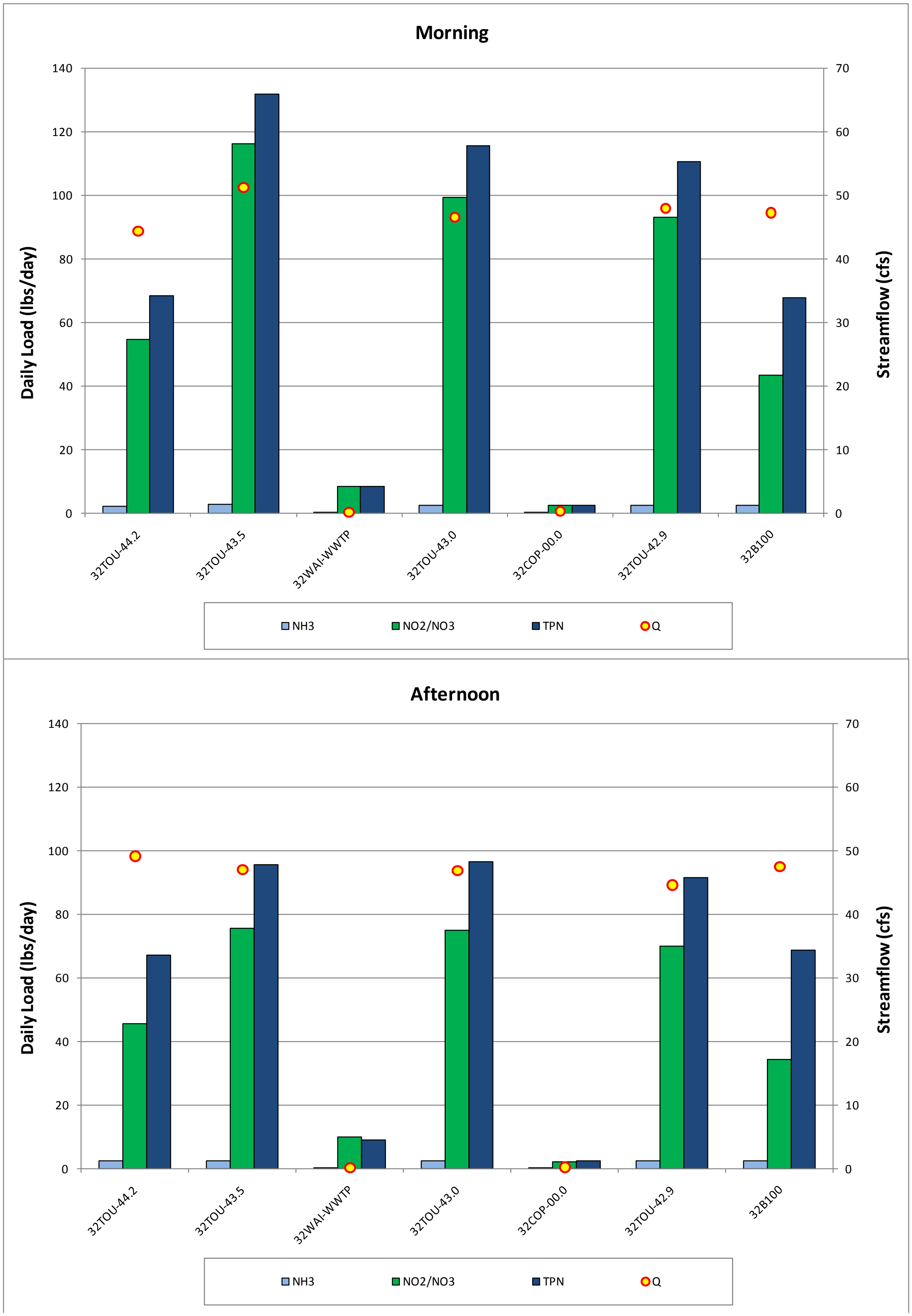


Figure 11. Nitrogen loads and streamflow for sites in the Waitsburg area, August 2009.

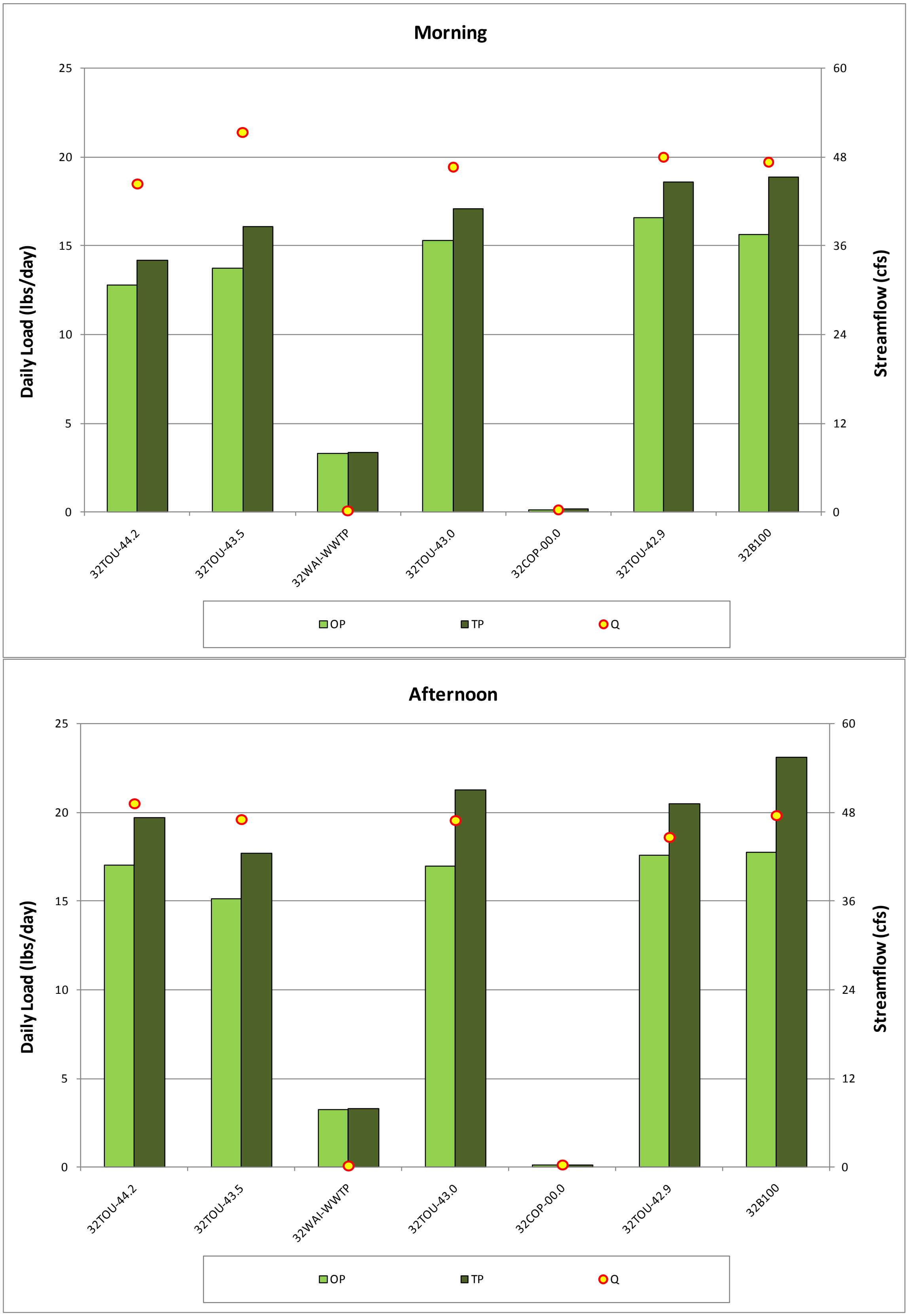


Figure 12. Phosphorus loads and streamflow for sites in the Waitsburg area, August 2009.

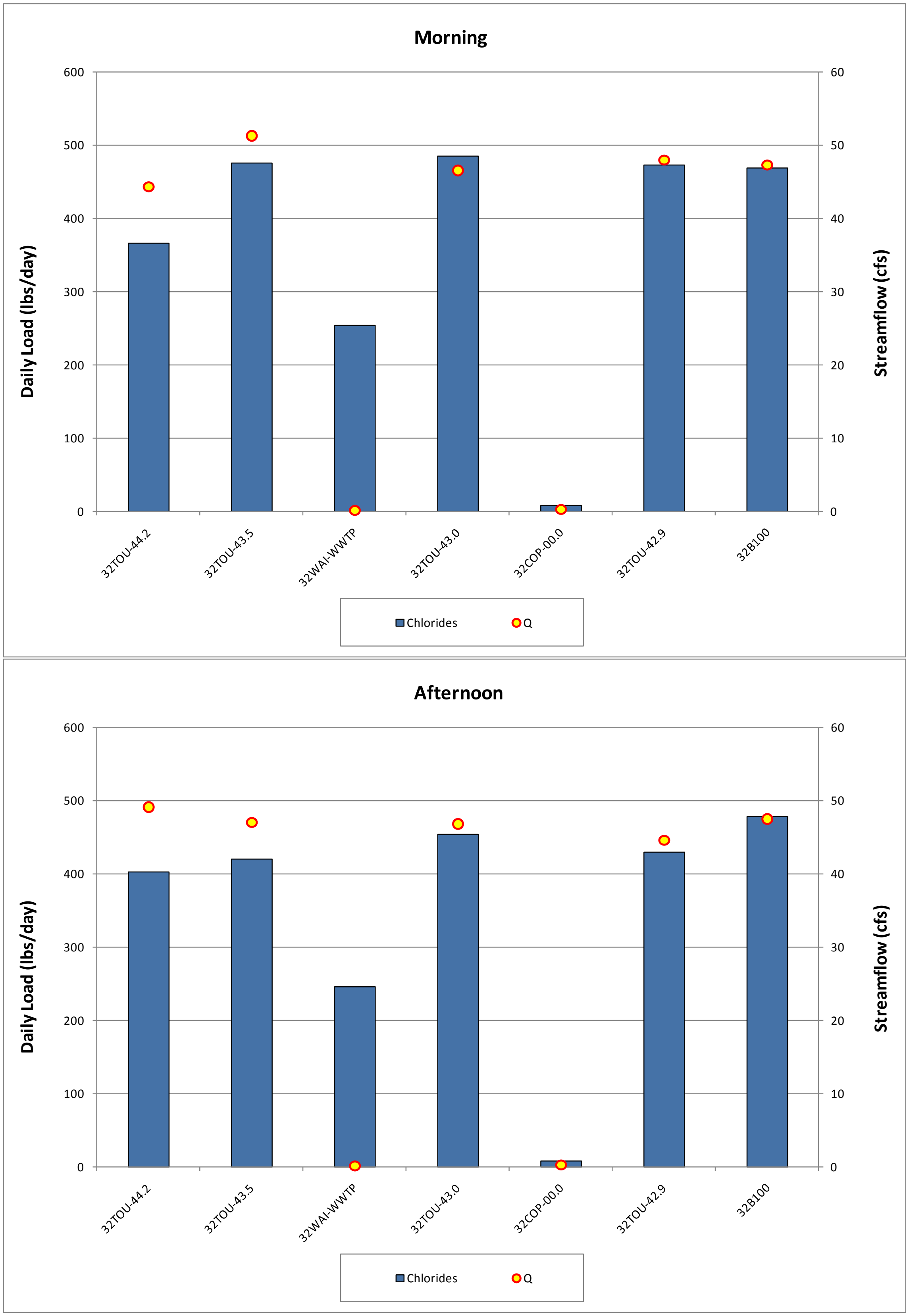


Figure 13. Chloride loads and streamflow for sites in the Waitsburg area, August 2009.

The reach from 32TOU-44.2 to 32TOU-43.5 was analyzed to determine the presence of any nonpoint loads from the city of Waitsburg upstream of the Waitsburg WWTP (Tables A-13 and A-14). This reach had consistently large nitrogen and chloride loads. The obviously large nitrogen and chloride load increases indicate nonpoint sources that need to be further investigated. There were no consistent phosphorus and carbon load increases in this reach.

Sampling the remaining downstream sites was necessary to determine any effects of the Waitsburg WWTP wetland infiltration to the Touchet River. These sites include 32TOU-43.5, 32TOU-43.0, 32COP-00.0, and 32TOU-42.9. The Waitsburg WWTP wetland is bracketed in the reach between 32TOU-43.5 and 32TOU-43.0 (Figure 14). 32TOU-42.9 was furthest downstream to catch any additional impacts from the groundwater infiltration from the WWTP. The concentrations for these sites can be seen in Tables A-7 and A-8, and the loads can be seen in Tables A-13 and A-14.

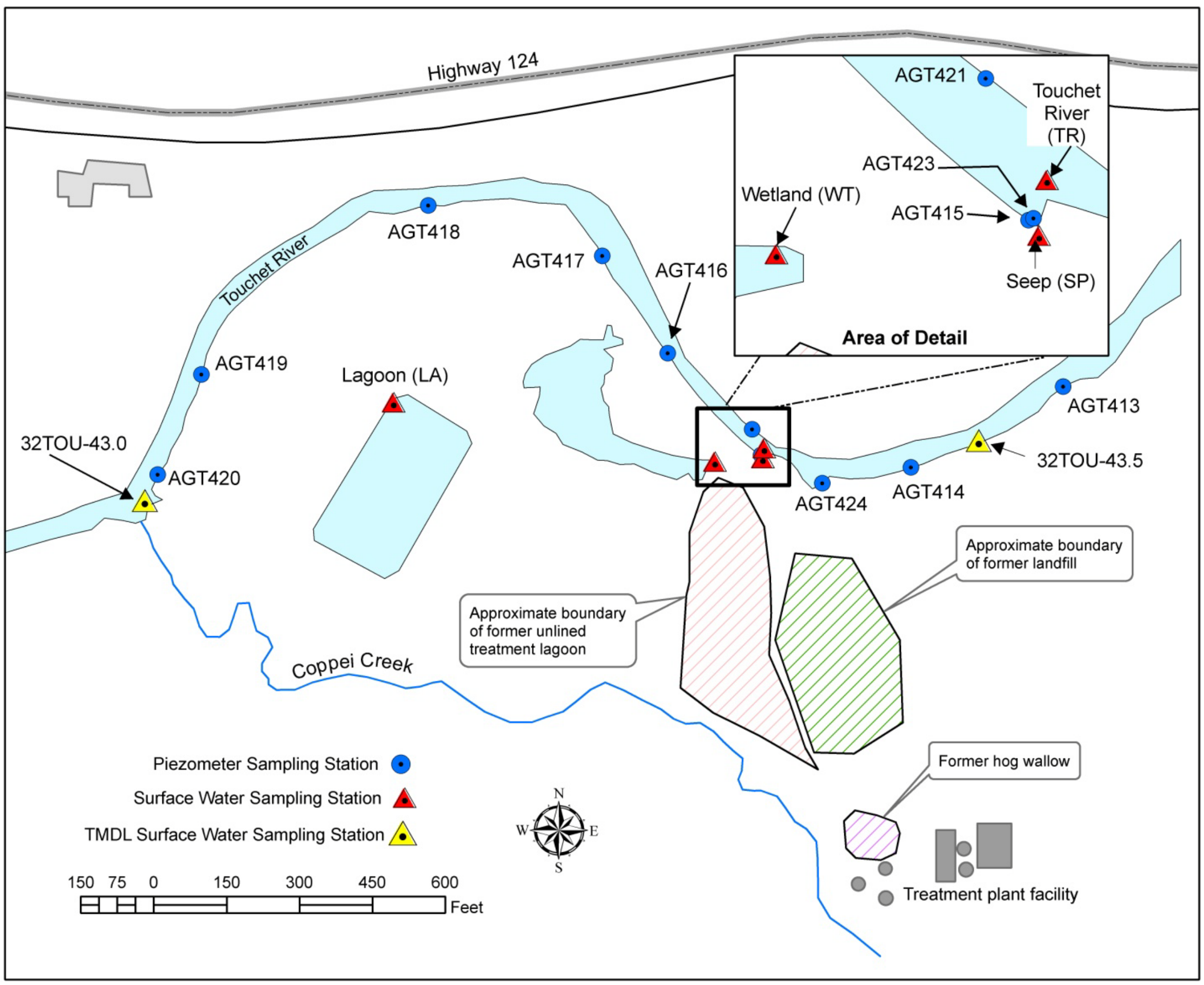


Figure 14. Surface water and groundwater sites at the Waitsburg Wastewater Treatment Plant (Pitz and Tarbutton, 2010).

Waitsburg WWTP concentrations and loads seen in Figures 8 through 13 and Tables A-7, A-8, A-13, and A-14 were measured at the end of the UV disinfection chamber prior to discharge to the wetland. Groundwater nutrient loading from the WWTP property is addressed in *City of Waitsburg Wastewater Treatment Plant Groundwater Study* (Pitz and Tarbutton, 2010).

The groundwater report estimated a dissolved inorganic nitrogen load from the WWTP facility to the Touchet River between 3.3 to 61.8 lbs/day. This load in the subsurface is largely ammonium. The estimated total dissolved phosphorus load from the facility is between 1.1 to 21.6 lbs/day. This load is largely organic phosphorus. The estimated chloride load measured from the piezometers nearest the facility's wetland (AGT415 and AGT416) is between 15 to 391 lbs/day.

Phosphorus and chloride loads increased in the reach between 32TOU-43.5 and 32TOU-43.0, except in the afternoon of the July survey. Ammonia loads increased and nitrate/nitrite loads decreased in this reach in July; the WWTP was discharging higher ammonia loads to the wetland during the July survey. The ammonia loads in the reach showed no change in August, and the WWTP was not discharging significant ammonia loads to the wetland during the August survey. Nitrate/nitrite and carbon loads decreased in this reach. This decrease is accompanied by an increase in chlorophyll biomass, perhaps indicating periphyton productivity and uptake.

The increases across the reach were much lower than the upper end of loading estimates from the groundwater study. However, periphyton uptake and nitrogen conversions to nitrogen gas are possible routes of nutrient sinks. Periphyton as indicated by chlorophyll-a biomass was 65% greater downstream than upstream in August. Between the July and August surveys, periphyton increased by 150% at 32TOU-43.5 and 300% at 32TOU-43.0. The biomass at the downstream site in August was nearly identical to the biomass below the Dayton WWTP. Biomass reached potentially nuisance levels at both sites in August.

As another indicator of biomass stimulation, the diurnal curve range between DO minimums and maximums of approximately 2.8 mg/L did not change in this reach for July, but it increased to approximately 3.4 mg/L at 32TOU-43.5 and 4 mg/L at 32TOU-43.0 in August (Figures A-7 and A-8; Figures A-17 and A-18). Minimum DO concentrations at these two sites fell below water quality criteria during either survey.

Coppei Creek nutrient concentrations were elevated relative to the Touchet River, but loads were low and did not have a significant impact on the water quality in the reach between 32TOU-43.0 and 32TOU-42.9. Streamflows measured at the mouth of Coppei Creek during the surveys were compared to streamflows collected at an Ecology gage just upstream of the WWTP (Ecology, 2009). There was no difference between the upstream and downstream streamflow values. It appears that Coppei Creek is not influenced by the WWTP seepage.

Therefore water quality results indicate the reach between 32TOU-43.5 and 32TOU-42.9 may have additional impacts from the WWTP effluent infiltration into the Touchet River.

Phosphorus and chloride loads increase in the reach between 32TOU-43.5 and 32TOU-42.9 for both synoptic surveys, except for the August morning chloride loads. Ammonia loads increase by 2 lbs/day at 32TOU-42.9 in July and not in August. As mentioned before, the WWTP ammonia load to the wetland was much larger in July, and this load could explain the ammonia increase in the Touchet River in July. These nutrient loads are not explained by the input of Coppei Creek.

Nitrate/nitrite and carbon loads decreased in the reach between 32TOU-43.5 and 32TOU-42.9. Similar to 32TOU-43.0, this decrease is likely due to the increased periphyton productivity and nutrient uptake. The July and August diel DO range remained about 3.4 mg/L at 32TOU-42.9. There may have been more productivity in July than suggested at 32TOU-43.0 (Figures A-10 and A-20).

DO maximums at 32TOU-42.9 were based on the Hydrolab check measurements in the afternoon, not the continuous Hydrolab diel data. The Hydrolab LDO probe caps were allowing additional light from the sun to interfere with the DO readings in the afternoons at 32TOU-42.9 (Figures A-10 and A-20). This is not an issue for DO minimums because the minimums were in the middle of the night, so no additional light is present for interference.

The DO minimum concentrations fell below the criterion of 8.0 mg/L for the Touchet River sites in Waitsburg.

The impact of eutrophic conditions on DO in the Touchet River downstream of the WWTP appears to be limited by the surface water temperature and re-aeration. At night, respiration of the periphyton is offset by cool water temperatures and re-aeration, keeping the DO minimums from getting lowered further. This effect is shown as a linear increase in DO at night in the continuous Hydrolab graphs (Figures A-8, A-10, A-18, and A-20). Further monitoring is needed to determine if the nutrient loads from the WWTP property increase the eutrophic conditions downstream of 32TOU-42.9.

The continuous Hydrolab data show violations in pH (> 8.5) at all the Touchet River sites in the Waitsburg area for both surveys. The pH maximums at 32TOU-43.0 and 32TOU-42.9 are higher than 32TOU-43.5 for the July survey. The pH maximums at 32TOU-43.0 and 32TOU-42.9 are lower than 32TOU-43.5 for the August survey.

The continuous diel conductivity data show an increase of ionic components at 32TOU-43.0 and 32TOU-42.9 compared to 32TOU-43.5 for both surveys. This increase indicates a groundwater discharge within the reach.

There were no significant increases in nutrient loads at 32B100, downstream of 32TOU-42.9 (Tables A-13 and A-14). Nitrate/nitrite loads did decrease significantly in the reach between 32TOU-42.9 and 32B100. This decrease is most likely due to periphyton productivity and nutrient uptake. The highest instantaneous DO reading for all sites was at 32B100 at noon for the August survey. This high DO reading supports the periphyton assumption, but continuous Hydrolab data downstream of 32TOU-42.9 would be needed to characterize the primary productivity conditions present.

Conclusions

The results of this 2009 study support the following conclusions.

Fecal Coliform

The ultraviolet disinfection at the Dayton Wastewater Treatment Plant (WWTP) is not always effective. Two out of six samples exceeded the NPDES permit limits for fecal coliform by great margins.

The Dayton WWTP samples and the Ecology samples reported similar results for the May through October sample visits. For example, the WWTP samples and the Ecology samples were elevated in August, and the samples showed adequate disinfection during four other visits.

Nutrients

Dayton

The 2002 study appears to have over-estimated the background nutrient concentrations by underestimating potential nonpoint sources in the upper forks of the Touchet River watershed. The 2002 and 2009 background nutrient concentrations indicate a nitrogen-limited system.

Analysis of the data indicates nonpoint nutrient loads were present in the following Dayton area reaches:

- 32NFT-04.9 to 32NFT-00.0
- 32SFT-08.8 to 32SFT-00.0
- 32B130 to 32TOU-52.2

The Dayton WWTP experienced a malfunction, and the wastewater bypassed treatment during the July survey. The water quality of the effluent and the downstream reaches of the river were heavily degraded. The elevated nutrient concentrations and loads were also apparent in the city of Waitsburg, which is approximately 7 miles downstream of the Dayton WWTP. Ammonia loads were especially evident.

In August, the Dayton WWTP contributed relatively large nutrient concentrations and loads to the Touchet River. Nitrate/nitrite, ortho-phosphate, and total phosphorus loads appear to be contributing to periphyton productivity and the subsequent eutrophic conditions in the river. The nonpoint and WWTP effluent conditions result in violations in the dissolved oxygen (DO) water quality criterion and nuisance levels of periphyton above and below the Dayton WWTP.

The pH maximums above the Dayton WWTP outfall violated the criterion in August. The WWTP effluent appears to suppress the pH in the Touchet River mixing zone, but probably causes elevated pH over the water quality criterion a mile or more downstream. It may also contribute to pH violations in the Touchet River above Waitsburg.

Waitsburg

There was strong evidence for nonpoint nitrogen and chloride loads in the 32TOU-44.2 to 32TOU-43.5 reach of the Touchet River. This reach is in the downtown area of Waitsburg and upstream of the Waitsburg WWTP.

Phosphorus loads increased in the reach between 32TOU-43.5 and 32TOU-43.0. Ammonia loads also increased in this reach in July. The WWTP and wetland are in this reach, and the WWTP was discharging higher ammonia loads to the wetland in July. The increase in chlorophyll biomass and the decrease in nitrate/nitrite loads in this reach indicate a periphyton productivity and nutrient uptake.

Coppei Creek loads are not significant during July and August.

The reach between 32TOU-43.5 and 32TOU-42.9 is more appropriate for analyzing the potential impacts of the WWTP groundwater infiltration in the Touchet River. Phosphorus and chloride loads increased in this reach. Ammonia loads also increased in this reach in July, and the WWTP was discharging higher ammonia loads to the wetland in July. Nitrate/nitrite and carbon loads decreased in this reach, indicating periphyton productivity and nutrient uptake.

The DO minimums at all the sites in Waitsburg violated the criterion. However, the effects of eutrophic conditions on DO minimums resulting from the WWTP nutrient loads are limited by the cool water temperatures and re-aeration.

The Touchet River sites in Waitsburg did not meet (exceeded) the pH criteria. The pH maximums increased downstream of the Waitsburg WWTP wetland in July, but the pH maximums decreased downstream of the WWTP wetland in August. The inconsistency between the two surveys makes it difficult to determine if the nutrient loads from the WWTP property are impacting the pH of the Touchet River.

The highest instantaneous DO reading for all sites was at the furthest downstream site, 32B100. Water temperatures and re-aeration are less likely to limit the low DO conditions in the Touchet River farther downstream.

Further investigation is needed to determine if the WWTP nutrient loads are contributing to a more eutrophic condition downstream of 32TOU-42.9.

Recommendations

The results of this 2009 study support the following recommendations.

Dayton

Potential nonpoint sources of nutrients in the forks of the Touchet River above the city of Dayton and in the Dayton area need to be investigated and reduced.

The Dayton WWTP needs to fix the disinfection mechanism and procedures to address the elevated FC results.

This 2009 study validates the 2002 study recommendations for the Dayton WWTP: The Dayton WWTP needs to work towards reduction of its effluent nutrient loads to the Touchet River during the critical period, May through October. Water right claims may complicate partial or full effluent diversion efforts, if they are necessary, but regional water authorities need to work with municipalities to reach legal and economical solutions to prevent further water quality impairment (Joy et al., 2007).

Waitsburg

The potential nonpoint sources in the Touchet River reach between 32TOU-44.2 and 32TOU-43.5 need to be investigated and eliminated.

The Waitsburg WWTP appears to be transporting nutrient loads to the Touchet River via groundwater infiltration, and joining the Dayton WWTP in upgrading treatment should be considered.

Further monitoring is needed along the Waitsburg WWTP to provide more precise groundwater nutrient loading and its impact on the Touchet River.

- Install monitoring wells between the wetland and the Touchet River shoreline to determine the true saturated thickness of the aquifer and improve estimates of bulk hydraulic conductivity within the impacted area. Consider an alternative field method such as freeze-coring to collect higher resolution data on dissolved nutrient attenuation conditions in the uppermost portion of the hyporheic zone sediment column (Pitz and Tarbutton, 2010).
- Sample surface water chemistry and collect diel Hydrolab data downstream of 32TOU-42.9 to determine if the eutrophic conditions increase as a result of Waitsburg WWTP nutrient loads.

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Appendices

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Appendix A. Results

Table A-1. Field replicate concentrations sampled during the 2009 study.

Parameter	Site	Date	Sample (mg/L)	QA Sample (mg/L)
Fecal Coliform[1]	32DAY-WWTP	5/27/09	1	3
	32DAY-WWTP	6/3/09	1	1
	32DAY-WWTP	7/8/09	680	230
	32DAY-WWTP	8/17/09	4300	6000
	32DAY-WWTP	9/16/09	25	25
	32DAY-WWTP	10/7/09	3	3
Total Organic Carbon	32B130	7/21/09	1.0	1.0
	32COP-00.0	7/21/09	2.1	2.2
	32NFT-15.1	7/21/09	1.2	1.1
	32TOU-52.1	7/21/09	2.1	2.0
	32TOU-43.0	8/25/09	1.4	1.3
	32B130	8/25/09	1.0	1.1
	32TOU-52.1	8/25/09	1.5	1.5
	32NFT-15.1	8/25/09	1.0	1.2
Dissolved Organic Carbon	32B130	7/21/09	1.0	1.0
	32COP-00.0	7/21/09	2.3	2.1
	32NFT-15.1	7/21/09	1.2	1.1
	32TOU-52.1	7/21/09	1.8	1.7
	32TOU-43.0	8/25/09	1.2	1.3
	32B130	8/25/09	1.0	1.0
	32TOU-52.1	8/25/09	1.2	1.1
	32NFT-15.1	8/25/09	1.0	1.0
Total Suspended Solids	32B130	7/21/09	3	3
	32COP-00.0	7/21/09	10	4
	32NFT-15.1	7/21/09	2	2
	32TOU-52.1	7/21/09	4	4
	32TOU-43.0	8/25/09	3	3
	32B130	8/25/09	2	4
	32TOU-52.1	8/25/09	5	4
	32NFT-15.1	8/25/09	1	2
Alkalinity	32B130	7/21/09	40.5	40.6
	32COP-00.0	7/21/09	120.0	121.0
	32NFT-15.1	7/21/09	29.8	29.9
	32TOU-52.1	7/21/09	47.8	47.8
	32TOU-43.0	8/25/09	54.2	53.6
	32B130	8/25/09	43.4	43.6
	32TOU-52.1	8/25/09	46.7	45.7
	32NFT-15.1	8/25/09	32.3	31.5
Chloride	32B130	7/21/09	0.50	0.49
	32COP-00.0	7/21/09	5.20	5.41
	32NFT-15.1	7/21/09	0.43	0.46
	32TOU-52.1	7/21/09	2.29	2.21

Parameter	Site	Date	Sample (mg/L)	QA Sample (mg/L)
	32TOU-43.0	8/25/09	1.94	1.92
	32B130	8/25/09	0.51	0.53
	32TOU-52.1	8/25/09	2.55	2.27
	32NFT-15.1	8/25/09	0.42	0.43
Total Persulfate Nitrogen	32B130	7/21/09	0.228	0.231
	32COP-00.0	7/21/09	2.510	2.060
	32NFT-15.1	7/21/09	0.283	0.275
	32TOU-52.1	7/21/09	1.130	1.200
	32TOU-43.0	8/25/09	0.464	0.458
	32B130	8/25/09	0.168	0.172
	32TOU-52.1	8/25/09	0.975	0.834
	32NFT-15.1	8/25/09	0.297	0.309
Ammonia Nitrogen	32B130	7/21/09	0.010	0.010
	32COP-00.0	7/21/09	0.047	0.043
	32NFT-15.1	7/21/09	0.010	0.010
	32TOU-52.1	7/21/09	0.567	0.566
	32TOU-43.0	8/25/09	0.010	0.010
	32B130	8/25/09	0.010	0.010
	32TOU-52.1	8/25/09	0.036	0.030
	32NFT-15.1	8/25/09	0.010	0.010
Nitrate & Nitrite Nitrogen	32B130	7/21/09	0.169	0.171
	32COP-00.0	7/21/09	1.910	1.850
	32NFT-15.1	7/21/09	0.241	0.240
	32TOU-52.1	7/21/09	0.400	0.403
	32TOU-43.0	8/25/09	0.399	0.394
	32B130	8/25/09	0.128	0.129
	32TOU-52.1	8/25/09	0.859	0.756
	32NFT-15.1	8/25/09	0.281	0.280
Orthophosphate P	32B130	7/21/09	0.0525	0.0475
	32COP-00.0	7/21/09	0.0938	0.0887
	32NFT-15.1	7/21/09	0.0397	0.0387
	32TOU-52.1	7/21/09	0.2650	0.3190
	32TOU-43.0	8/25/09	0.0597	0.0620
	32B130	8/25/09	0.0379	0.0372
	32TOU-52.1	8/25/09	0.2520	0.2550
	32NFT-15.1	8/25/09	0.0333	0.0322
Total Phosphorus	32B130	7/21/09	0.0400	0.0407
	32COP-00.0	7/21/09	0.1080	0.1020
	32NFT-15.1	7/21/09	0.0294	0.0273
	32TOU-52.1	7/21/09	0.3000	0.2810
	32TOU-43.0	8/25/09	0.0703	0.0658
	32B130	8/25/09	0.0406	0.0417
	32TOU-52.1	8/25/09	0.2950	0.2460
	32NFT-15.1	8/25/09	0.0355	0.0362

[1]Fecal coliform sample concentration units are cfu/100 mL.

Table A-2. Hydrolab calibrations results.

				Conductivity 0 or 100 µS Standard				Conductivity 1000 µS Standard				pH 7 Standard					pH 10 Standard					DO % Saturation Standard			
Calibration Date	Sonde number	Pre-calculation	Post-calculation	Reference standard value	Hydrolab value	Difference	Conclusion	Reference standard value	Hydrolab value	Difference	Conclusion	Temperature	Temperature corrected standard value	Hydrolab value	Difference	Conclusion	Temperature	Temperature corrected standard value	Hydrolab value	Difference	Conclusion	Reference saturation value	Hydrolab value	Difference	Conclusion
7/20/09	26	X		0	0			1000	1061	5.9%		23.34	7.01	7.16	0.15		23.39	10.02	10.01	-0.01		100%			
7/20/09	13	X		100.4	101.3	0.9%		0	0			22.82	7.01	7.03	0.02		22.95	10.02	9.87	-0.15		100%	95.2%	-4.8%	
7/20/09	21	X		0	0.9			1000	1030	3.0%		23.03	7.01	7.09	0.08		23.07	10.01	10.01	0		100%	102.5%	2.5%	
7/20/09	6	X		100.4	100.9	0.5%		0	0			22.95	7.01	7.13	0.12		22.99	10.02	9.98	-0.04		100%	99.4%	-0.6%	
7/20/09	23	X		0	0			1000	1023	2.3%		23.17	7.01	7.13	0.12		23.04	10.01	10.06	0.05		100%	103.4%	3.4%	
7/20/09	10	X		100.4	90.1	-10.8%		0	0			22.60	7.01	6.96	-0.05		22.73	10.02	10.01	-0.01		100%	100.7%	0.7%	
7/20/09	5	X		100.4	85	-16.6%		0	0			22.70	7.01	7.01	0		22.84	10.02	10.05	0.03		100%	98.4%	-1.6%	
7/20/09	35	X		0	0			1000	1005	0.5%		23.14	7.01	7.02	0.01		23.31	10.01	10.03	0.02		100%	102.2%	2.2%	
7/20/09	33	X		0	0			1000	1012	1.2%		22.99	7.01	7.04	0.03		23.15	10.02	10.07	0.05		100%	99.9%	-0.1%	
7/20/09	34	X		0	0.1			1000	1013	1.3%		23.13	7.01	7.03	0.02		23.33	10.01	10.03	0.02		100%	100.4%	0.4%	
7/20/09	15	X		0	0			1000	1005	0.5%		23.38	7.01	6.92	-0.09		23.42	10.01	10.03	0.02		100%	103.5%	3.5%	
7/20/09	24	X		0	0.3			1000	994.7	-0.5%		23.36	7.01	7.19	0.18		23.35	10.01	9.99	-0.02		100%	97.1%	-2.9%	
7/20/09	17	X		0	0.3			1000	987.3	-1.3%		23.89	7.01	7.01	0		23.73	10.01	10.05	0.04		100%	103.6%	3.6%	
7/20/09	25	X		0	0			1000	1026	2.6%		24.76	7.01	7.18	0.17		24.76	10	9.89	-0.11		100%	93.5%	-6.5%	
7/23/09	24		X	100.4	101.6	1.2%	accept	1000	1005	0.5%	accept	25.33	7	7	0	accept	25.71	10	10.01	0.01	accept	100%	99.2%	-0.8%	accept
7/23/09	33		X	100.4	101.8	1.4%	accept	1000	998.5	-0.2%	accept	26.21	7	7.22	0.22	qualify	26.24	9.99	10.2	0.21	qualify	100%	97.3%	-2.7%	accept
7/23/09	17		X	100.4	103	2.6%	accept	1000	1004	0.4%	accept	25.36	7	6.98	-0.02	accept	25.32	10	10.01	0.01	accept	100%	101.4%	1.4%	accept
7/23/09	35		X	100.4	102.5	2.1%	accept	1000	936	-6.6%	accept	26.91	7	7.07	0.07	accept	26.31	9.99	10.02	0.03	accept	100%	95.8%	-4.2%	qualify
7/23/09	25		X	100.4	105	4.5%	accept	1000	976	-2.4%	accept	26.37	7	7.11	0.11	accept	26.22	10.02	10.07	0.05	accept	100%	97.4%	-2.6%	accept
7/23/09	15		X	100.4	101.5	1.1%	accept	1000	998.1	-0.2%	accept	26.71	7	7	0	accept	26.73	9.99	9.97	-0.02	accept	100%	95.0%	-5.0%	qualify
7/23/09	34		X	100.4	104.4	3.9%	accept	1000	999.4	-0.1%	accept	26.56	7	7.01	0.01	accept	27.10	9.98	9.99	0.01	accept	100%	98.0%	-2.0%	accept
7/23/09	23		X	100.4	96.5	-4.0%	accept	1000	967.1	-3.3%	accept	26.22	7	7.04	0.04	accept	27.15	10	9.99	-0.01	accept	100%	104.3%	4.3%	qualify
7/23/09	26		X	100.4	99.4	-1.0%	accept	1000	998	-0.2%	accept	27.53	7	7.17	0.17	accept	27.52	9.98	10.1	0.12	accept	100%	110.4%	10.4%	**Reject**
7/23/09	13		X	100.4	97.9	-2.5%	accept	1000	997	-0.3%	accept	26.62	7	7.07	0.07	accept	27.79	9.97	9.98	0.01	accept	100%	97.7%	-2.3%	accept
7/23/09	6		X	100.4	102.8	2.4%	accept	1000	1020	2.0%	accept	26.25	7	7.04	0.04	accept	26.95	10	9.96	-0.04	accept	100%	99.4%	-0.6%	accept

				Conductivity 0 or 100 µS Standard				Conductivity 1000 µS Standard				pH 7 Standard					pH 10 Standard					DO % Saturation Standard			
Calibration Date	Sonde number	Pre-calculation	Post-calculation	Reference standard value	Hydrolab value	Difference	Conclusion	Reference standard value	Hydrolab value	Difference	Conclusion	Temperature	Temperature corrected standard value	Hydrolab value	Difference	Conclusion	Temperature	Temperature corrected standard value	Hydrolab value	Difference	Conclusion	Reference saturation value	Hydrolab value	Difference	Conclusion
7/23/09	5		X	100.4	98.3	-2.1%	accept	1000	1008	0.8%	accept	26.83	7	7.06	0.06	accept	27.22	9.97	10	0.03	accept	100%	99.5%	-0.5%	accept
7/23/09	10		X	100.4	105.3	4.8%	accept	1000	1049	4.8%	accept	27.52	7	6.93	-0.07	accept	27.31	9.98	9.96	-0.02	accept	100%	101.2%	1.2%	accept
7/27/09	21		X	0	0			102.5	101.5	-1.0%	accept	0.00	6.97	6.91	-0.06	accept	0.00	9.15	9.15	0	accept	100%	109.2%	9.2%	qualify
8/24/09	24	X		0	0			1000	1015	1.5%		21.75	7.01	7	-0.01		21.69	10.03	10.03	0		100%	97.9%	-2.1%	
8/24/09	15	X		0	0			1000	1067	6.5%		21.07	7.01	7.32	0.31		20.97	10.04	10.19	0.15		100%	91.7%	-8.3%	
8/24/09	34	X		0	0			1000	1004	0.4%		22.30	7.01	7.1	0.09		22.14	10.03	10.01	-0.02		100%	106.4%	6.4%	
8/24/09	35	X		0	0			1000	1002	0.2%		22.20	7.01	7.06	0.05		22.50	10.03	10.08	0.05		100%	105.4%	5.4%	
8/24/09	4	X		100.4	81.6	-20.7%		0	0			21.92	7.01	7.3	0.29		22.04	10.03	9.82	-0.21		100%	97.6%	-2.4%	
8/24/09	23	X		0	0			1000	1014	1.4%		21.83	7.01	6.94	-0.07		21.98	10.03	10.03	0		100%	97.8%	-2.2%	
8/24/09	17	X		0	0			1000	1140	13.1%		21.50	7.02	7.23	0.21		22.10	10.03	10.06	0.03		100%	81.3%	-18.7%	
8/24/09	25	X		0	0			1000	1120	11.3%		21.62	7.01	7.71	0.7		21.94	10.03	10.02	-0.01		100%	107.4%	7.4%	
8/24/09	5	X		100.4	97.2	-3.2%		0	0			21.63	7.01	7.05	0.04		21.88	10.03	10.03	0		100%	101.5%	1.5%	
8/24/09	18	X		0	0			1000	1142	13.3%		21.78	7.02	6.95	-0.07		22.10	10.04	10.47	0.43		100%	126.3%	26.3%	
8/24/09	13	X		100.4	96.5	-4.0%		0	0			21.27	7.02	7.02	0		21.61	10.03	10.1	0.07		100%	95.1%	-4.9%	
8/24/09	6	X		100.4	97.7	-2.7%		0	0			21.70	7.01	7.06	0.05		21.86	10.03	10	-0.03		100%	97.5%	-2.5%	
8/24/09	33	X		0	0.5			1000	1007	0.7%		21.62	7.01	7.28	0.27		21.90	10.03	10.03	0		100%	100.4%	0.4%	
8/24/09	26	X		0	0			1000	1000	0.0%		21.88	7.01	7.07	0.06		22.21	10.04	10.04	0		100%	116.5%	16.5%	
8/24/09	10	X		100.4	98.2	-2.2%		0	0			21.18	7.02	7.02	0		21.53	10.03	10	-0.03		100%	99.3%	-0.7%	
8/27/09	23		X	100.4	91.1	-9.7%	accept	1000	989.4	-1.1%	accept	22.15	7.01	6.86	-0.15	accept	22.40	10.03	9.94	-0.09	accept	100%	100.9%	0.9%	accept
8/27/09	17		X	100.4	96.4	-4.1%	accept	1000	1002	0.2%	accept	22.20	7.01	7.05	0.04	accept	21.80	10.02	10.02	0	accept	100%	109.0%	9.0%	qualify
8/27/09	24		X	100.4	95.7	-4.8%	accept	1000	983.6	-1.7%	accept	21.80	7.01	7.04	0.03	accept	21.80	10.02	10.04	0.02	accept	100%	104.5%	4.5%	qualify
8/27/09	25		X	100.4	98.7	-1.7%	accept	1000	988	-1.2%	accept	21.20	7.01	7.13	0.12	accept	21.20	10.02	10.15	0.13	accept	100%	61.0%	-39.0%	**Reject**
8/27/09	35		X	100.4	92.1	-8.6%	accept	1000	1004	0.4%	accept	21.48	7.01	6.9	-0.11	accept	21.50	10.02	9.96	-0.06	accept	100%	99.6%	-0.4%	accept
8/27/09	10		X	100.4	100.7	0.3%	accept	0	0			21.27	7.01	7	-0.01	accept	21.22	10.04	10.12	0.08	accept	100%	97.1%	-2.9%	accept
8/27/09	34		X	100.4	96	-4.5%	accept	1000	993	-0.7%	accept	21.30	7.01	6.97	-0.04	accept	21.31	10.02	10.02	0	accept	100%	90.4%	-9.6%	qualify
8/27/09	5		X	100.4	99.5	-0.9%	accept	0	0			21.31	7.01	7.01	0	accept	21.23	10.04	10.04	0	accept	100%	90.2%	-9.8%	qualify
8/27/09	18		X	100.4	95.2	-5.3%	accept	1000	999.5	-0.1%	accept	21.35	7.01	7.12	0.11	accept	21.25	10.02	10.17	0.15	accept	100%	111.0%	11.0%	**Reject**

				Conductivity 0 or 100 µS Standard				Conductivity 1000 µS Standard				pH 7 Standard					pH 10 Standard					DO % Saturation Standard			
Calibration Date	Sonde number	Pre-calculation	Post-calculation	Reference standard value	Hydrolab value	Difference	Conclusion	Reference standard value	Hydrolab value	Difference	Conclusion	Temperature	Temperature corrected standard value	Hydrolab value	Difference	Conclusion	Temperature	Temperature corrected standard value	Hydrolab value	Difference	Conclusion	Reference saturation value	Hydrolab value	Difference	Conclusion
8/27/09	13		X	100	100.7	0.7%	accept	0	0			21.33	7.01	7.07	0.06	accept	21.24	10.04	10	-0.04	accept	100%	99.5%	-0.5%	accept
8/27/09	4		X	100	104	3.9%	accept	0	0			21.53	7.01	7.08	0.07	accept	21.26	10.03	9.98	-0.05	accept	100%	100.8%	0.8%	accept
8/27/09	33		X	100	95.7	-4.4%	accept	1000	988.5	-1.2%	accept	21.54	7.01	7.04	0.03	accept	21.35	10.02	10.05	0.03	accept	100%	99.4%	-0.6%	accept
8/27/09	6		X	100	98	-2.0%	accept	0	0			21.63	7.01	7.08	0.07	accept	21.49	10.04	10.12	0.08	accept	100%	101.2%	1.2%	accept
8/27/09	15		X	100.4	96	-4.5%	accept	1000	992	-0.8%	accept	21.77	7.01	6.92	-0.09	accept	21.63	10.03	9.97	-0.06	accept	100%	102.2%	2.2%	accept

Table A-3. Laboratory results for the Dayton-area sites, July 2009.

Site	Date	Time	Flow	NH3	NO2/NO3	TPN	OP	TP	TOC	DOC	Alkalinity	Chlorides	TSS	Chlorophyll
			cfs	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/m²
Morning														
32NFT-15.1	7/21/09	8:45	13.96	0.010	0.263	0.300	0.0377	0.0300	1.2	1.1	30.2	0.44	2	
32NFT-04.9	7/21/09	10:02	34.31	0.010	0.115	0.175	0.0516	0.0433	1.2	1	37.8	0.41	3	
32WFT-00.2	7/21/09	10:52	34.87	0.010	0.075	0.117	0.0497	0.0405	1	1	36.6	0.33	5	
32NFT-00.0	7/21/09	8:30	57.38	0.010	0.153	0.205	0.0504	0.0432	1.1	1	40.4	0.45	4	
32SFT-08.8	7/21/09	11:30	6.86	0.010	0.023	0.061	0.0416	0.0358	1.1	1	29.2	0.24	3	
32SFT-00.0	7/21/09	9:10	4.76	0.010	0.669	0.753	0.0476	0.0376	1.3	1.2	42.5	0.63	1	
32B130	7/21/09	10:12	61.49	0.010	0.169	0.228	0.0525	0.0400	1	1	40.5	0.50	3	
32B130	7/21/09	10:12	61.57	0.010	0.171	0.231	0.0475	0.0407	1	1	40.6	0.49	3	
32PAT-00.1	7/21/09	11:20	0.16	0.010	4.770	5.100	0.1120	0.1020	2.3	2.1	179.0	19.50	1	
32TOU-52.2	7/21/09	7:55	69.24	0.010	0.229	0.289	0.0498	0.0415	1.1	1.2	42.4	0.71	3	38.56
32DAY-WWTP	7/21/09	9:06	0.58	15.400	0.016	18.400	2.6600	5.8100	39.3	30.5	201.0	32.00	22	
32TOU-52.1	7/21/09	9:37	70.54	0.774	0.200	1.160	0.3000	0.3250	2.1	1.8	50.1	2.33	4	92.36
32TOU-51.2	7/21/09	10:40	67.24	0.063	0.237	0.390	0.0788	0.0764	1.2	1.4	43.3	1.17	3	
Afternoon														
32NFT-15.1	7/21/09	12:52	12.42	0.010	0.241	0.283	0.0397	0.0294	1.2	1.2	29.9	0.43	2	
32NFT-15.1	7/21/09	12:52	12.87	0.010	0.240	0.275	0.0387	0.0273	1.1	1.1	29.8	0.46	2	
32NFT-04.9	7/21/09	14:24	29.21	0.012	0.090	0.156	0.0565	0.0513	1.2	1.2	37.4	0.40	4	
32WFT-00.2	7/21/09	15:05	29.74	0.010	0.058	0.114	0.0547	0.0468	1	1	36.3	0.35	5	
32NFT-00.0	7/21/09	13:30	57.36	0.010	0.116	0.180	0.0524	0.0425	1	1.1	39.8	0.46	4	
32SFT-08.8	7/21/09	15:54	6.02	0.010	0.024	0.062	0.0433	0.0338	1	1.1	29.1	0.25	2	
32SFT-00.0	7/21/09	14:00	4.39	0.011	0.640	0.736	0.0513	0.0412	1.3	1.2	41.6	0.66	1	
32B130	7/21/09	14:45	56.67	0.012	0.139	0.216	0.0526	0.0451	1.3	1.2	40.4	0.55	3	
32PAT-00.1	7/21/09	15:15	0.05	0.010	4.560	5.020	0.1180	0.1100	2.3	2.2	175.0	19.20	2	
32TOU-52.2	7/21/09	12:50	67.46	0.010	0.179	0.265	0.0511	0.0432	1.2	1.1	41.6	0.72	3	
32DAY-WWTP	7/21/09	13:30	0.58	12.300	6.280	20.700	2.4400	5.7900	36.8	26.4	171.0	32.20	27	
32TOU-52.1	7/21/09	14:00	64.74	0.567	0.400	1.130	0.2650	0.3000	2.1	1.8	47.8	2.29	4	
32TOU-52.1	7/21/09	14:00	63.61	0.566	0.403	1.200	0.3190	0.2810	2	1.7	47.8	2.21	4	
32TOU-51.2	7/21/09	15:24	64.79	0.050	0.241	0.381	0.0881	0.0765	1.2	1.2	42.6	1.14	3	

Table A-4. Laboratory results for Dayton-area sites, August 2009.

Site	Date	Time	Flow	NH3	NO2/NO3	TPN	OP	TP	TOC	DOC	Alkalinity	Chlorides	TSS	Chlorophyll
			cfs	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/m²
Morning														
32NFT-15.1	8/25/09	9:00	9.74	0.010	0.300	0.314	0.0331	0.0331	1.1	1	32.1	0.47	1	
32NFT-04.9	8/25/09	9:53	26.98	0.010	0.076	0.101	0.0411	0.0439	1	1	40.1	0.39	2	
32WFT-00.2	8/25/09	10:39	27.52	0.010	0.076	0.099	0.0411	0.0440	1	1	37.8	0.34	2	
32NFT-00.0	8/25/09	8:45	46.21	0.010	0.137	0.176	0.0393	0.0425	1	1	43.3	0.44	3	
32SFT-08.8	8/25/09	11:29	4.11	0.010	0.020	0.045	0.0296	0.0317	1	1.1	31.4	0.25	1	
32SFT-00.0	8/25/09	9:15	1.86	0.010	0.775	0.837	0.0252	0.0299	1.2	1.3	54.0	0.83	5	
32B130	8/25/09	10:10	44.53	0.010	0.128	0.168	0.0379	0.0406	1	1	43.4	0.51	2	
32B130	8/25/09	10:10	44.40	0.010	0.129	0.172	0.0372	0.0417	1.1	1	43.6	0.53	4	
32PAT-00.1	8/25/09	11:15	0.05	0.010	5.890	5.910	0.1330	0.1370	1.9	2	174.0	23.00	1	
32TOU-52.2	8/25/09	8:03	52.81	0.010	0.174	0.218	0.0353	0.0413	1	1.1	46.0	0.68	5	156.19
32DAY-WWTP	8/25/09	8:50	0.40	0.674	15.300	16.800	4.8300	4.9400	7.5	7.2	88.8	37.90	6	
32TOU-52.1	8/25/09	9:10	49.77	0.030	0.821	0.939	0.1820	0.2580	1.4	1.2	46.6	2.47	9	168.55
32TOU-51.2	8/25/09	10:00	51.15	0.010	0.296	0.381	0.0739	0.0854	1.4	1.1	46.2	1.17	3	
Afternoon														
32NFT-15.1	8/25/09	13:00	9.46	0.010	0.281	0.297	0.0333	0.0355	1	1	32.3	0.42	1	
32NFT-15.1	8/25/09	13:00	9.28	0.010	0.280	0.309	0.0322	0.0362	1.2	1	31.5	0.43	2	
32NFT-04.9	8/25/09	13:57	26.76	0.010	0.053	0.090	0.0444	0.0507	1	1	39.6	0.44	3	
32WFT-00.2	8/25/09	14:36	26.68	0.010	0.059	0.083	0.0450	0.0467	1	1	37.6	0.34	4	
32NFT-00.0	8/25/09	13:15	45.45	0.010	0.101	0.137	0.0422	0.0484	1	1	42.3	0.47	3	
32SFT-08.8	8/25/09	15:30	3.92	0.010	0.021	0.049	0.0323	0.0332	1	1	31.4	0.26	1	
32SFT-00.0	8/25/09	13:45	1.91	0.010	0.774	0.824	0.0269	0.0307	1.2	1.2	53.8	0.92	2	
32B130	8/25/09	14:20	43.75	0.010	0.095	0.139	0.0399	0.0487	1	1	42.9	0.49	3	
32PAT-00.1	8/25/09	15:00	0.00	0.010	5.770	5.800	0.1310	0.1410	2	2.1	173.0	23.40	1	
32TOU-52.2	8/25/09	11:50	47.14	0.010	0.122	0.173	0.0394	0.0432	1.2	1	44.2	0.75	7	
32DAY-WWTP	8/25/09	12:25	0.40	0.603	15.200	16.600	5.0600	5.0800	8.3	7.4	87.9	37.90	8	
32TOU-52.1	8/25/09	12:47	47.58	0.036	0.859	0.975	0.2520	0.2950	1.5	1.2	46.7	2.55	5	
32TOU-52.1	8/25/09	12:47	49.13	0.030	0.756	0.834	0.2550	0.2460	1.5	1.1	45.7	2.27	4	
32TOU-51.2	8/25/09	14:00	54.09	0.010	0.285	0.361	0.0962	0.1030	1.3	1.2	44.8	1.41	4	

Table A-5. Field observation data for the Dayton-area sites, July 2009.

Site	Date	Time	Hydrolab	Temp	Conductivity	pH	DO
				°C	µS/cm	s.u.	mg/L
Morning							
32NFT-15.1	7/21/09	8:45	10	9.77	63	7.12	9.68
32NFT-04.9	7/21/09	10:02	10	15.15	78.6	7.41	8.91
32WFT- 00.2	7/21/09	10:52	10	15.51	74.4	7.39	8.76
32NFT-00.0	7/21/09	8:30	13	14.98	82.1	7.48	9.10
32SFT-08.8	7/21/09	11:30	10	18.09	57.9	6.88	8.17
32SFT-00.0	7/21/09	9:10	13	17.04	96	6.94	8.56
32B130	7/21/09	10:12	13	17.33	84.6	7.81	8.86
32B130	7/21/09	10:12	13	17.42	84.5	7.81	8.81
32PAT-00.1	7/21/09	11:20	13	14.91	472	7.38	8.21
32TOU-52.2	7/21/09	7:55	26	15.53	82.4	7.12	
32DAY-WWTP	7/21/09	9:06	26	20.2	533.2	6.57	
32TOU-52.1	7/21/09	9:37	26	16.83	98.3	7.14	
32TOU-51.2	7/21/09	10:40	26	18.15	86.9	7.46	
Afternoon							
32NFT-15.1	7/21/09	12:52	10	12.37	62.2	7.35	9.25
32NFT-15.1	7/21/09	13:19	10	12.57	62.2	7.37	9.19
32NFT-04.9	7/21/09	14:24	10	20.51	79.3	7.61	8.06
32WFT- 00.2	7/21/09	15:05	10	19.58	74.9	7.51	8.15
32NFT-00.0	7/21/09	13:30	13	19.87	82.2	7.67	8.56
32SFT-08.8	7/21/09	15:54	10	19.92	58.3	6.87	7.70
32SFT-00.0	7/21/09	14:00	13	21.4	94.8	7.14	8.62
32B130	7/21/09	14:45	13	21.38	84.3	7.96	8.37
32PAT-00.1	7/21/09	15:15	13	19.65	469	7.69	9.60
32TOU-52.2	7/21/09	12:50	26	20.79	82.4	7.83	
32DAY-WWTP	7/21/09	13:30	26	20.91	542.1	6.5	
32TOU-52.1	7/21/09	14:00	26	21.63	91.5	7.65	
32TOU-52.1	7/21/09	14:00	26	22.32	88	7.72	
32TOU-51.2	7/21/09	15:24	26	22.73	86.9	7.4	

Shaded cells indicate rejected values due to failed post-calibration.

Table A-6. Field observation data for Dayton-area sites, August 2009.

Site	Date	Time	Hydrolab	Temp	Conductivity	pH	DO
				°C	µS/cm	s.u.	mg/L
Morning							
32NFT-15.1	8/25/09	9:00	33	8.81	64.5	7.15	9.93
32NFT-04.9	8/25/09	9:53	33	13.34	77.7	7.48	9.60
32WFT- 00.2	8/25/09	10:39	33	13.31	72.1	7.45	9.55
32NFT-00.0	8/25/09	8:45	10	13.2	90.2	7.34	9.97
32SFT-08.8	8/25/09	11:29	33	16.69	59.6	7.17	8.46
32SFT-00.0	8/25/09	9:15	10	14.86	95.1	6.76	9.28
32B130	8/25/09	10:10	10	15.07	91.4	8.3	10.71
32B130	8/25/09	10:11	10	15.07	91.4	8.3	10.72
32PAT-00.1	8/25/09	11:15	10	13.56	507	7.09	5.50
32TOU-52.2	8/25/09	8:03	18	13.54	87.6	7.28	
32DAY-WWTP	8/25/09	8:50	18	18.78	464.4	6.91	
32TOU-52.1	8/25/09	9:10	18	14.31	105.8	7.43	
32TOU-51.2	8/25/09	10:00	18	14.85	92.3	7.84	
Afternoon							
32NFT-15.1	8/25/09	13:00	33	11.04	64.1	7.21	9.55
32NFT-15.1	8/25/09	13:09	33	11.1	63.7	7.21	9.56
32NFT-04.9	8/25/09	13:57	33	17.77	77.5	7.7	8.83
32WFT- 00.2	8/25/09	14:36	33	17.04	71.7	7.64	8.95
32NFT-00.0	8/25/09	13:15	10	17.12	89.4	7.67	9.34
32SFT-08.8	8/25/09	15:30	33	18.62	59.7	7.13	8.10
32SFT-00.0	8/25/09	13:45	10	17.94	109.5	6.93	10.06
32B130	8/25/09	14:20	10	18.59	91.5	8.48	9.45
32PAT-00.1	8/25/09	15:00	10	13.8	509	7.13	4.47
32TOU-52.2	8/25/09	11:50	18	16.78	86.1	8.15	
32DAY-WWTP	8/25/09	12:25	18	19.2	463.2	7.05	
32TOU-52.1	8/25/09	12:47	18	17.92	105.6	8.19	
32TOU-52.1	8/25/09	12:50	18	18.47	102.3	8.23	
32TOU-51.2	8/25/09	14:00	18	19.06	91.9	8.47	

Shaded cells indicate rejected values due to failed post-calibration.

Table A-7. Laboratory results for the Waitsburg-area sites, July 2009.

Site	Date	Time	Flow	NH3	NO2/NO3	TPN	OP	TP	TOC	DOC	Alkalinity	Chlorides	TSS	Chlorophyll
			cfs	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/m²
Morning														
32TOU-44.2	7/21/09	11:40	63.43	0.012	0.308	0.423	0.0648	0.0621	1.5	1.4	47.8	1.42	4	
32TOU-43.5	7/21/09	9:14	59.36	0.010	0.461	0.559	0.0641	0.0540	1.5	1.3	49.9	1.66	3	38.80
32WAI-WWTP	7/21/09	8:10	0.15	1.570	2.670	4.640	1.9900	3.8900	4.1	3.8	125.0	33.50	3	
32TOU-43.0	7/21/09	10:00	56.60	0.017	0.468	0.586	0.0691	0.0621	1.6	1.6	50.8	1.84	3	40.34
32COP-00.0	7/21/09	10:35	0.45	0.047	1.910	2.510	0.0938	0.1080	2.1	2.3	120.0	5.20	10	
32COP-00.0	7/21/09	10:35	*	0.043	1.850	2.060	0.0887	0.1020	2.2	2.1	121.0	5.41	4	
32TOU-42.9	7/21/09	11:05	59.72	0.016	0.438	0.558	0.0717	0.0644	1.4	1.3	50.4	1.74	3	
32B100	7/21/09	12:10	60.57	0.019	0.355	0.490	0.0716	0.0668	1.6	1.6	51.8	1.86	4	
Afternoon														
32TOU-44.2	7/21/09	16:15	59.12	0.022	0.266	0.391	0.0777	0.0705	1.6	1.4	46.3	1.26	4	
32TOU-43.5	7/21/09	13:02	61.13	0.016	0.372	0.479	0.0739	0.0666	1.5	1.5	48.3	1.63	3	
32WAI-WWTP	7/21/09	12:19	0.15	0.529	2.630	3.750	1.4700	3.1000	3.8	3.5	120.0	35.00	2	
32TOU-43.0	7/21/09	14:00	57.20	0.022	0.376	0.511	0.0774	0.0676	1.6	1.6	48.6	1.69	3	
32COP-00.0	7/21/09	14:30	0.31	0.032	1.740	1.990	0.0940	0.0968	2.1	2.2	118.0	5.21	2	
32COP-00.0	7/21/09	14:30	0.35	**	**	**	**	**	**	**	**	**	**	
32TOU-42.9	7/21/09	15:15	58.61	0.023	0.377	0.520	0.0798	0.0745	1.5	1.6	48.2	1.78	3	
32B100	7/21/09	16:15	62.02	0.028	0.310	0.532	0.0805	0.0755	1.9	1.5	49.7	1.81	4	

* Replicate flow was taken in the afternoon.

** Replicate samples were taken in the morning.

Table A-8. Laboratory results for the Waitsburg-area sites, 2009.

Site	Date	Time	Flow	NH3	NO2/NO3	TPN	OP	TP	TOC	DOC	Alkalinity	Chlorides	TSS	Chlorophyll
			cfs	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/m²
Morning														
32TOU-44.2	8/25/09	10:52	44.35	0.010	0.229	0.287	0.0534	0.0594	1.4	1.4	50.3	1.53	3	
32TOU-43.5	8/25/09	8:15	51.29	0.010	0.421	0.477	0.0497	0.0581	1.4	1.2	53.3	1.72	4	98.93
32WAI-WWTP	8/25/09	9:20	0.16	0.021	10.100	10.100	3.9200	4.0000	3.6	3.3	69.9	302.00	5	
32TOU-43.0	8/25/09	9:45	46.46	0.010	0.399	0.464	0.0597	0.0703	1.4	1.2	54.2	1.94	3	162.97
32TOU-43.0	8/25/09	9:45	46.70	0.010	0.394	0.458	0.0620	0.0658	1.3	1.3	53.6	1.92	3	
32COP-00.0	8/25/09	11:15	0.31	0.011	1.530	1.630	0.0697	0.0953	2.1	1.9	134.0	5.22	3	
32TOU-42.9	8/25/09	11:45	47.93	0.010	0.360	0.428	0.0641	0.0719	1.4	1.1	54.2	1.83	5	
32B100	8/25/09	12:05	47.30	0.010	0.171	0.266	0.0613	0.0741	1.7	1.5	53.9	1.84	6	
Afternoon														
32TOU-44.2	8/25/09	14:40	49.15	0.010	0.173	0.254	0.0642	0.0744	1.5	1.3	49.6	1.52	4	
32TOU-43.5	8/25/09	13:25	47.01	0.010	0.299	0.378	0.0597	0.0699	1.4	1.2	50.9	1.66	4	
32WAI-WWTP	8/25/09	13:00	0.16	0.028	11.800	11.000	3.8900	3.9100	3.5	3.4	69.5	293.00	4	
32TOU-43.0	8/25/09	14:15	46.84	0.010	0.297	0.383	0.0672	0.0841	1.5	1.2	50.8	1.80	4	
32COP-00.0	8/25/09	15:15	0.29	0.010	1.460	1.630	0.0678	0.0915	2.1	1.8	133.0	5.58	1	
32TOU-42.9	8/25/09	15:45	44.61	0.011	0.291	0.381	0.0732	0.0852	1.5	1.2	51.0	1.79	3	
32B100	8/25/09	15:45	47.51	0.010	0.134	0.268	0.0693	0.0902	1.8	1.6	51.9	1.87	6	

Table A-9. Field observation data for the Waitsburg-area sites, July 2009.

Site	Date	Time	Hydrolab	Temp °C	Conductivity µS/cm	pH s.u.	DO mg/L
Morning							
32TOU-44.2	7/21/09	11:40	26	21.33	97.5	7.6	
32TOU-43.5	7/21/09	9:14	21	18.22	106.6	7.14	8.20
32WAI-WWTP	7/21/09	8:10	21	21.8	403.9	6.69	1.85
32TOU-43.0	7/21/09	10:00	21	18.92	105.2	7.39	9.64
32COP-00.0	7/21/09	10:35	21	18.11	267	6.84	7.02
32COP-00.0	7/21/09	10:40	21	18.15	266.8	6.83	6.95
32TOU-42.9	7/21/09	11:05	21	20.19	104.8	7.69	10.20
32B100	7/21/09	12:10	13	22.75	116.2	8.91	9.66
Afternoon							
32TOU-44.2	7/21/09	16:15	26	24.9	93.9	7.3	
32TOU-43.5	7/21/09	13:02	21	22.33	102.4	7.95	9.50
32WAI-WWTP	7/21/09	12:19	21	22.91	397	6.47	3.64
32TOU-43.0	7/21/09	14:00	21	23.53	100.4	8.2	9.47
32COP-00.0	7/21/09	14:30	21	21.93	262.4	7.15	8.45
32TOU-42.9	7/21/09	15:15	21	24.45	100.6	8.27	9.47
32B100	7/21/09	16:15	13	25.53	112.5	8.93	9.25

Shaded cells indicate rejected values due to failed post-calibration.

Table A-10. Field observation data for the Waitsburg-area sites, August 2009.

Site	Date	Time	Hydrolab	Temp °C	Conductivity µS/cm	pH s.u.	DO mg/L
Morning							
32TOU-44.2	8/25/09	10:52	18	17.05	102.5	8.16	
32TOU-43.5	8/25/09	8:15	13	15.35	122	7.62	9.20
32WAI-WWTP	8/25/09	9:20	13	21.34	1336	6.93	3.92
32TOU-43.0	8/25/09	9:45	13	15.85	120.5	7.94	10.06
32COP-00.0	8/25/09	11:15	13	15.66	306	7.63	8.01
32TOU-42.9	8/25/09	11:45	13	17.59	119.4	8.5	10.88
32B100	8/25/09	12:05	10	19.6	121.1	9.23	12.26
Afternoon							
32TOU-44.2	8/25/09	14:40	18	20.33	98.4	8.67	
32TOU-43.5	8/25/09	13:25	13	18.94	116.9	8.75	10.46
32WAI-WWTP	8/25/09	13:00	13	22.05	1305	6.91	3.59
32TOU-43.0	8/25/09	14:15	13	19.87	115.7	8.83	10.92
32TOU-43.0	8/25/09	14:20	13	19.95	115.5	8.86	10.82
32COP-00.0	8/25/09	15:15	13	17.72	306	7.8	9.13
32TOU-42.9	8/25/09	15:45	13	20.39	115.4	8.87	10.32
32B100	8/25/09	15:45	*	*	*	*	*

* No Hydrolab data available because the deck unit battery died.
Shaded cells indicate rejected values due to failed post-calibration.

Table A-11. Calculated loading for the Dayton-area sites, July 2009.

Site	Date	Time	NH3	NO2/NO3	TPN	OP	TP	TOC	DOC	Alkalinity	Chlorides	TSS
			lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Morning												
32NFT-15.1	7/21/09	8:45	0.75	19.79	22.58	2.84	2.26	90.31	82.78	2272.73	33.11	150.51
32NFT-04.9	7/21/09	10:02	1.85	21.27	32.36	9.54	8.01	221.91	184.93	6990.27	75.82	554.78
32WFT-00.2	7/21/09	10:52	1.88	14.10	21.99	9.34	7.61	187.94	187.94	6878.46	62.02	939.68
32NFT-00.0	7/21/09	8:30	3.09	47.32	63.40	15.59	13.36	340.18	309.25	12493.88	139.16	1237.02
32SFT-08.8	7/21/09	11:30	0.37	0.85	2.26	1.54	1.32	40.70	37.00	1080.33	8.88	110.99
32SFT-00.0	7/21/09	9:10	0.26	17.16	19.32	1.22	0.96	33.35	30.78	1090.24	16.16	25.65
32B130	7/21/09	10:12	3.32	56.38	76.11	16.58	13.38	331.65	331.65	13448.27	164.17	994.94
32PAT-00.1	7/21/09	11:20	0.01	4.13	4.41	0.10	0.09	1.99	1.82	154.87	16.87	0.87
32TOU-52.2	7/21/09	7:55	3.73	85.46	107.86	18.59	15.49	410.53	447.85	15824.07	264.98	1119.63
32DAY-WWTP	7/21/09	9:06	48.06	0.05	57.42	8.30	18.13	122.65	95.18	627.28	99.87	68.66
32TOU-52.1	7/21/09	9:37	294.29	76.04	441.05	114.07	123.57	798.46	684.39	19048.88	885.91	1520.87
32TOU-51.2	7/21/09	10:40	22.83	85.90	141.36	28.56	27.69	434.94	507.43	15694.07	424.07	1087.35
Afternoon												
32NFT-15.1	7/21/09	12:52	0.68	16.39	19.02	2.67	1.93	78.38	78.38	2034.47	30.33	136.31
32NFT-04.9	7/21/09	14:24	1.89	14.17	24.56	8.90	8.08	188.96	188.96	5889.20	62.99	629.86
32WFT-00.2	7/21/09	15:05	1.60	9.30	18.27	8.77	7.50	160.28	160.28	5818.03	56.10	801.38
32NFT-00.0	7/21/09	13:30	3.09	35.86	55.65	16.20	13.14	309.16	340.07	12304.46	142.21	1236.63
32SFT-08.8	7/21/09	15:54	0.32	0.78	2.01	1.41	1.10	32.47	35.72	944.92	8.12	64.94
32SFT-00.0	7/21/09	14:00	0.26	15.16	17.43	1.21	0.98	30.79	28.42	985.14	15.63	23.68
32B130	7/21/09	14:45	3.67	42.46	65.98	16.07	13.78	397.11	366.56	12340.82	168.01	916.40
32PAT-00.1	7/21/09	15:15	0.00	1.12	1.23	0.03	0.03	0.57	0.54	43.04	4.72	0.49
32TOU-52.2	7/21/09	12:50	3.64	65.09	96.36	18.58	15.71	436.36	399.99	15127.00	261.81	1090.89
32DAY-WWTP	7/21/09	13:30	38.39	19.60	64.60	7.61	18.07	114.85	82.39	533.66	100.49	84.26
32TOU-52.1	7/21/09	14:00	195.95	138.88	402.98	101.00	100.48	709.10	605.33	16534.18	778.28	1383.61
32TOU-51.2	7/21/09	15:24	17.46	84.16	133.05	30.76	26.71	419.04	419.04	14875.90	398.09	1047.60

Table A-12. Calculated loading for the Dayton-area sites, August 2009.

Site	Date	Time	NH3	NO2/NO3	TPN	OP	TP	TOC	DOC	Alkalinity	Chlorides	TSS
			lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Morning												
32NFT-15.1	8/25/09	9:00	0.53	15.75	16.49	1.74	1.74	57.76	52.51	1685.55	24.68	52.51
32NFT-04.9	8/25/09	9:53	1.45	11.05	14.69	5.98	6.38	145.43	145.43	5831.83	56.72	290.86
32WFT-00.2	8/25/09	10:39	1.48	11.27	14.68	6.10	6.53	148.32	148.32	5606.66	50.43	296.65
32NFT-00.0	8/25/09	8:45	2.49	34.12	43.84	9.79	10.59	249.07	249.07	10784.87	109.59	747.22
32SFT-08.8	8/25/09	11:29	0.22	0.44	1.00	0.66	0.70	22.18	24.40	696.37	5.54	22.18
32SFT-00.0	8/25/09	9:15	0.10	7.76	8.38	0.25	0.30	12.01	13.01	540.51	8.31	50.05
32B130	8/25/09	10:10	2.40	30.80	40.74	9.00	9.86	251.65	239.67	10425.49	124.63	719.00
32PAT-00.1	8/25/09	11:15	0.00	1.45	1.45	0.03	0.03	0.47	0.49	42.71	5.65	0.25
32TOU-52.2	8/25/09	8:03	2.85	49.53	62.05	10.05	11.76	284.64	313.10	13093.46	193.56	1423.20
32DAY-WWTP	8/25/09	8:50	1.45	32.90	36.13	10.39	10.62	16.13	15.48	190.97	81.51	12.90
32TOU-52.1	8/25/09	9:10	8.05	220.26	251.91	48.83	69.22	375.59	321.93	12501.78	662.65	2414.51
32TOU-51.2	8/25/09	10:00	2.76	81.61	105.05	20.38	23.55	386.01	303.29	12738.36	322.59	827.17
Afternoon												
32NFT-15.1	8/25/09	13:00	0.51	14.17	15.30	1.65	1.81	55.55	50.50	1611.09	21.46	75.76
32NFT-04.9	8/25/09	13:57	1.44	7.65	12.98	6.41	7.31	144.26	144.26	5712.81	63.48	432.79
32WFT-00.2	8/25/09	14:36	1.44	8.48	11.94	6.47	6.72	143.81	143.81	5407.18	48.89	575.23
32NFT-00.0	8/25/09	13:15	2.45	24.74	33.56	10.34	11.86	244.97	244.97	10362.13	115.13	734.90
32SFT-08.8	8/25/09	15:30	0.21	0.44	1.04	0.68	0.70	21.15	21.15	664.17	5.50	21.15
32SFT-00.0	8/25/09	13:45	0.10	7.97	8.48	0.28	0.32	12.35	12.35	553.84	9.47	20.59
32B130	8/25/09	14:20	2.36	22.40	32.78	9.41	11.48	235.80	235.80	10115.64	115.54	707.39
32PAT-00.1	8/25/09	15:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32TOU-52.2	8/25/09	11:50	2.54	31.00	43.96	10.01	10.98	304.92	254.10	11231.13	190.57	1778.69
32DAY-WWTP	8/25/09	12:25	1.30	32.69	35.70	10.88	10.93	17.85	15.91	189.04	81.51	17.20
32TOU-52.1	8/25/09	12:47	8.60	210.46	235.74	66.07	70.50	390.95	299.73	12041.27	628.13	1172.85
32TOU-51.2	8/25/09	14:00	2.92	83.10	105.25	28.05	30.03	379.03	349.87	13061.99	411.10	1166.25

Table A-13. Calculated loading for the Waitsburg-area sites, July 2009.

Site	Date	Time	NH3	NO2/NO3	TPN	OP	TP	TOC	DOC	Alkalinity	Chlorides	TSS
			lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Morning												
32TOU-44.2	7/21/09	11:40	4.10	105.31	144.63	22.16	21.23	512.86	478.67	16343.29	485.51	1367.64
32TOU-43.5	7/21/09	9:14	3.20	147.49	178.84	20.51	17.28	479.89	415.91	15964.50	531.08	959.79
32WAI-WWTP	7/21/09	8:10	1.24	2.12	3.68	1.58	3.08	3.25	3.01	99.04	26.54	2.38
32TOU-43.0	7/21/09	10:00	5.19	142.77	178.77	21.08	18.94	488.11	488.11	15497.62	561.33	915.21
32COP-00.0	7/21/09	10:35	0.11	4.58	5.57	0.22	0.26	5.24	5.36	293.75	12.93	17.06
32TOU-42.9	7/21/09	11:05	5.15	140.99	179.62	23.08	20.73	450.65	418.46	16223.47	560.10	965.68
32B100	7/21/09	12:10	6.20	115.90	159.97	23.38	21.81	522.36	522.36	16911.27	607.24	1305.89
Afternoon												
32TOU-44.2	7/21/09	16:15	7.01	84.77	124.60	24.76	22.47	509.87	446.14	14754.37	401.52	1274.68
32TOU-43.5	7/21/09	13:02	5.27	122.56	157.81	24.35	21.94	494.20	494.20	15913.25	537.03	988.40
32WAI-WWTP	7/21/09	12:19	0.42	2.08	2.97	1.16	2.46	3.01	2.77	95.08	27.73	1.58
32TOU-43.0	7/21/09	14:00	6.78	115.93	157.55	23.86	20.84	493.30	493.30	14984.14	521.05	924.95
32COP-00.0	7/21/09	14:30	0.06	3.13	3.58	0.17	0.17	3.78	3.96	212.52	9.38	3.60
32TOU-42.9	7/21/09	15:15	7.27	119.10	164.27	25.21	23.54	473.87	505.46	15226.90	562.32	947.73
32B100	7/21/09	16:15	9.36	103.63	177.84	26.91	25.24	635.15	501.44	16614.25	605.07	1337.16

Table A-14. Calculated loading for the Waitsburg-area sites, August 2009.

Site	Date	Time	NH3	NO2/NO3	TPN	OP	TP	TOC	DOC	Alkalinity	Chlorides	TSS
			lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
Morning												
32TOU-44.2	8/25/09	10:52	2.39	54.74	68.60	12.76	14.20	334.65	334.65	12023.56	365.73	717.11
32TOU-43.5	8/25/09	8:15	2.76	116.39	131.87	13.74	16.06	387.05	331.76	14735.47	475.52	1105.85
32WAI-WWTP	8/25/09	9:20	0.02	8.49	8.49	3.30	3.36	3.03	2.77	58.77	253.93	4.20
32TOU-43.0	8/25/09	9:45	2.51	99.54	115.74	15.28	17.08	338.93	313.82	13532.06	484.54	753.18
32COP-00.0	8/25/09	11:15	0.02	2.54	2.70	0.12	0.16	3.48	3.15	222.13	8.65	4.97
32TOU-42.9	8/25/09	11:45	2.58	93.01	110.58	16.56	18.58	361.70	284.19	14002.96	472.79	1291.79
32B100	8/25/09	12:05	2.55	43.59	67.81	15.63	18.89	433.37	382.39	13740.47	469.06	1529.55
Afternoon												
32TOU-44.2	8/25/09	14:40	2.65	45.83	67.28	17.01	19.71	397.34	344.36	13138.70	402.64	1059.57
32TOU-43.5	8/25/09	13:25	2.53	75.77	95.78	15.13	17.71	354.76	304.08	12898.03	420.64	1013.60
32WAI-WWTP	8/25/09	13:00	0.02	9.92	9.25	3.27	3.29	2.94	2.86	58.44	246.37	3.36
32TOU-43.0	8/25/09	14:15	2.52	74.99	96.70	16.97	21.23	378.73	302.99	12826.42	454.48	1009.95
32COP-00.0	8/25/09	15:15	0.02	2.31	2.58	0.11	0.14	3.32	2.84	210.21	8.82	1.58
32TOU-42.9	8/25/09	15:45	2.65	69.98	91.62	17.60	20.49	360.70	288.56	12263.74	430.43	721.40
32B100	8/25/09	15:45	2.56	34.32	68.64	17.75	23.10	460.99	409.77	13291.87	478.92	1536.63

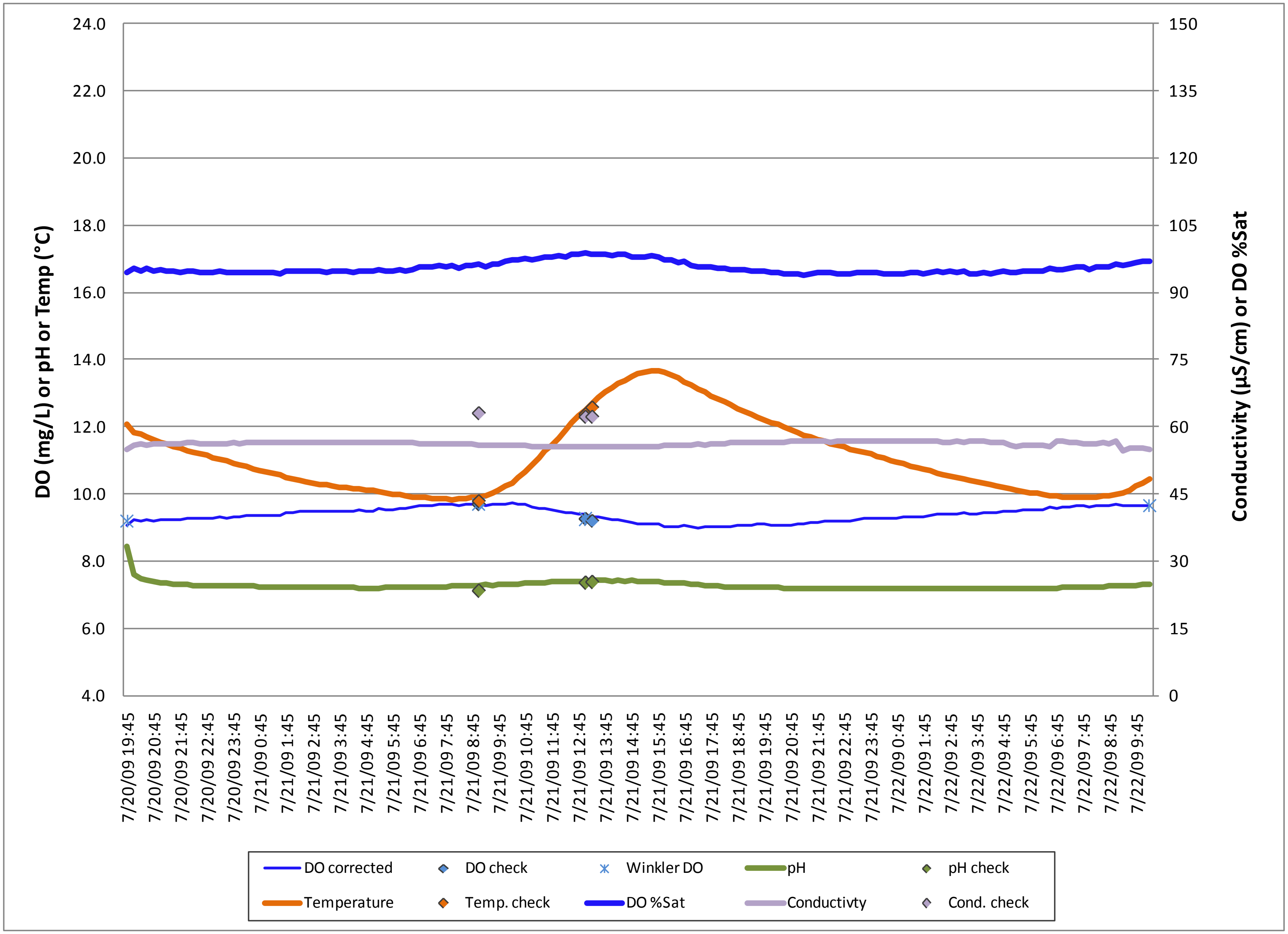

Figure A-1. 32NFT-15.1 continuous Hydrolab data, July 2009.

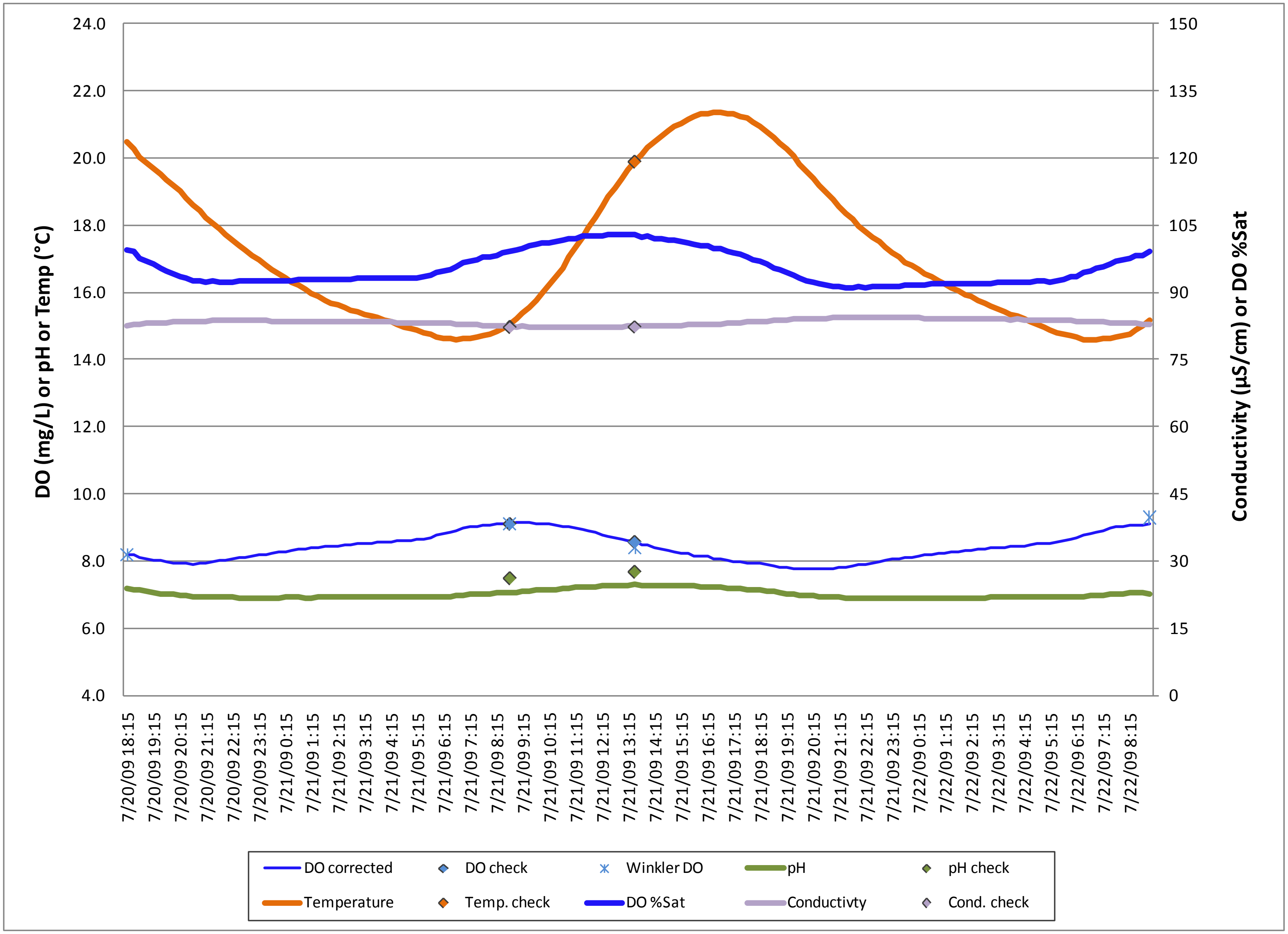

Figure A-2. 32NFT-00.0 continuous Hydrolab data, July 2009.

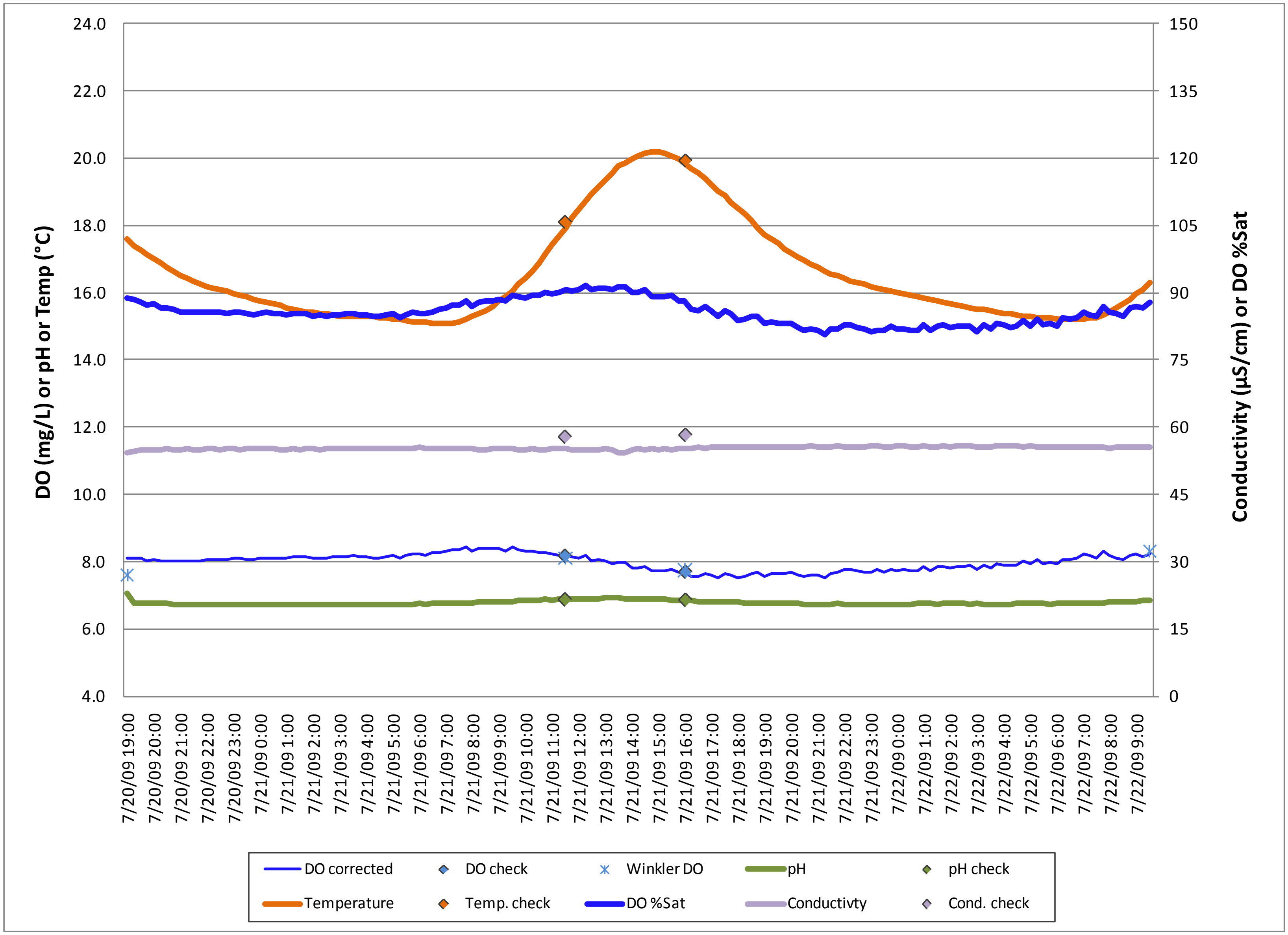

Figure A-3. 32SFT-08.8 continuous Hydrolab data, July 2009.

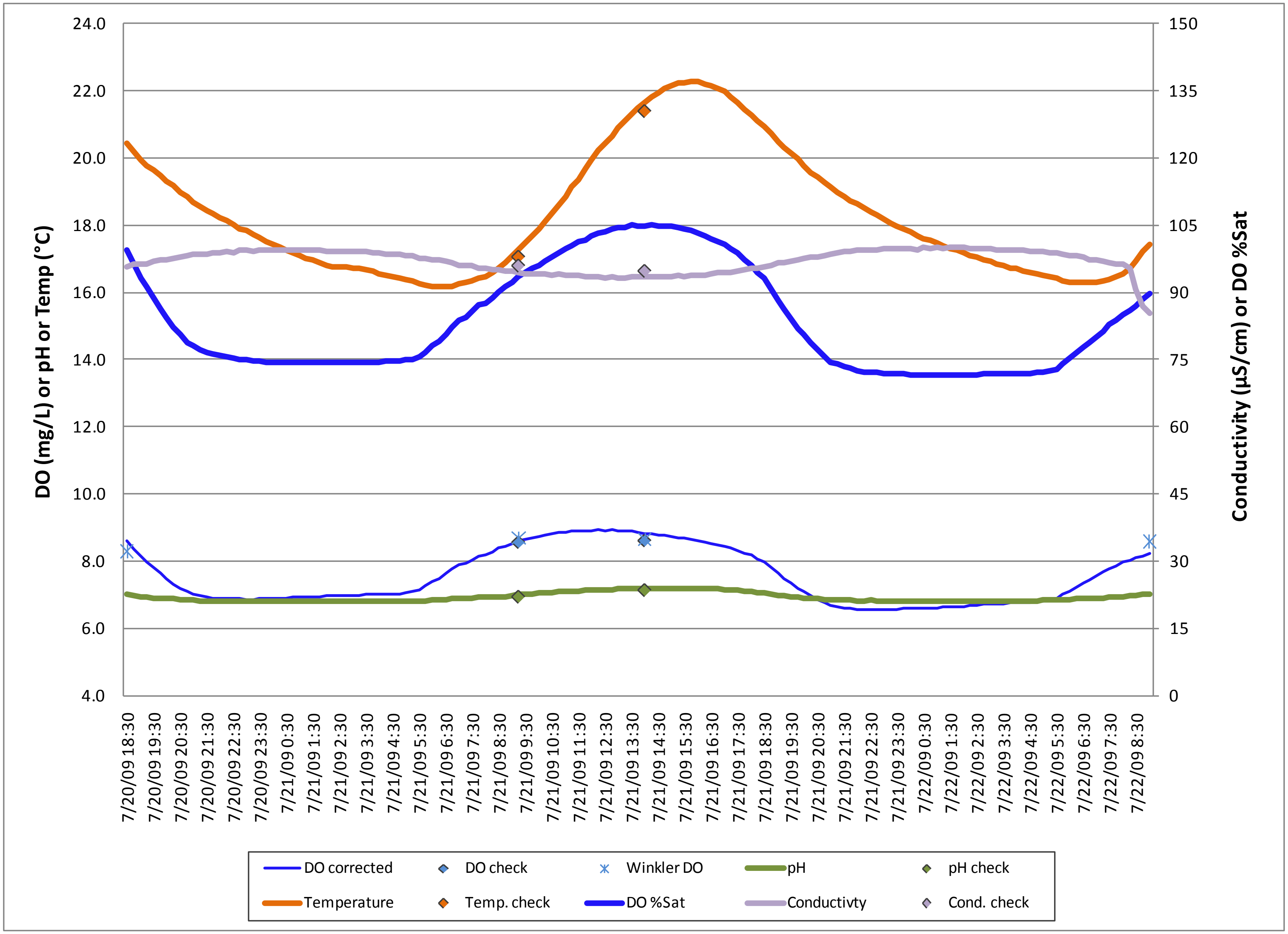

Figure A-4. 32SFT-00.0 continuous Hydrolab data, July 2009.

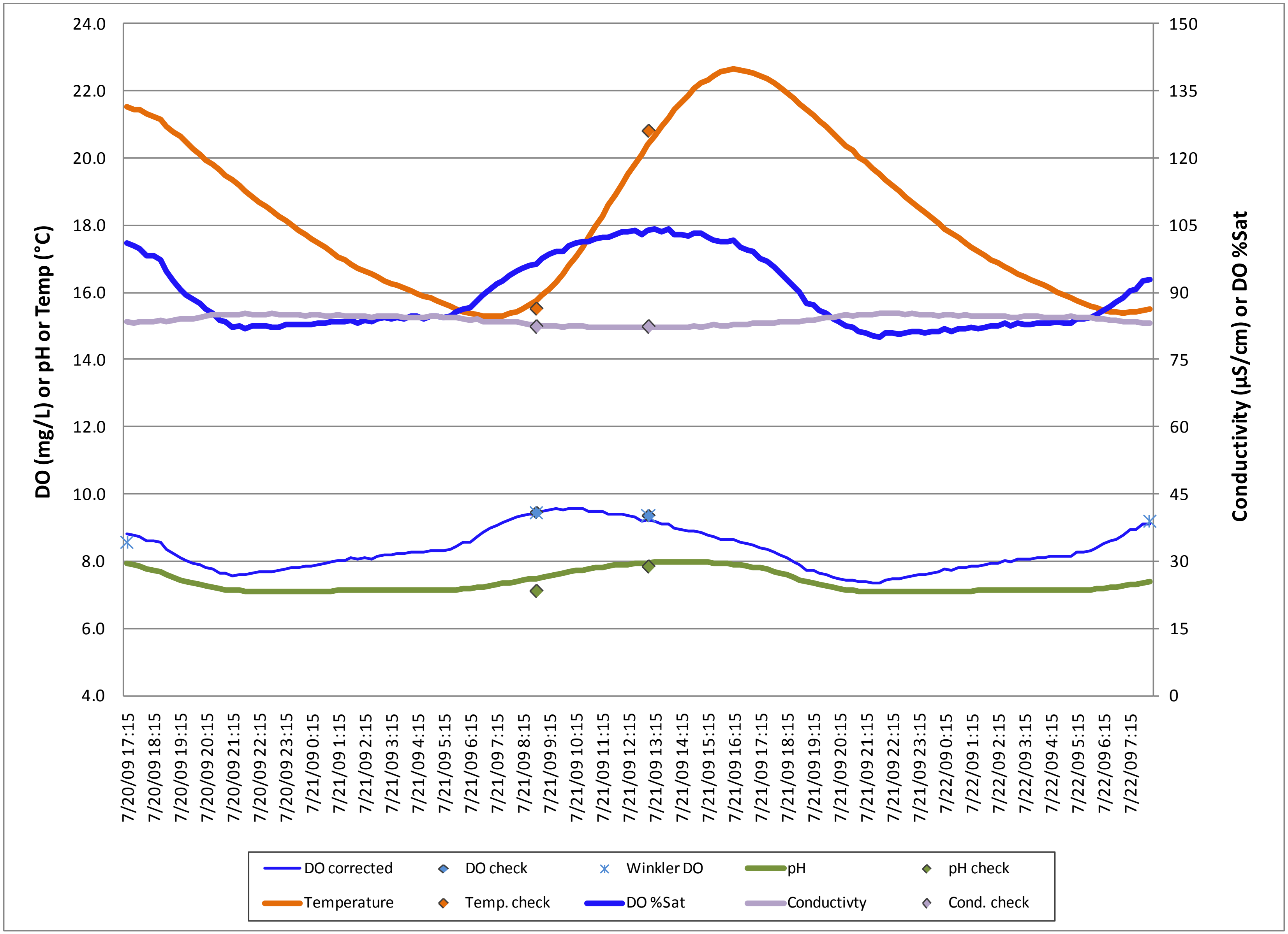

Figure A-5. 32TOU-52.2 continuous Hydrolab data, July 2009.

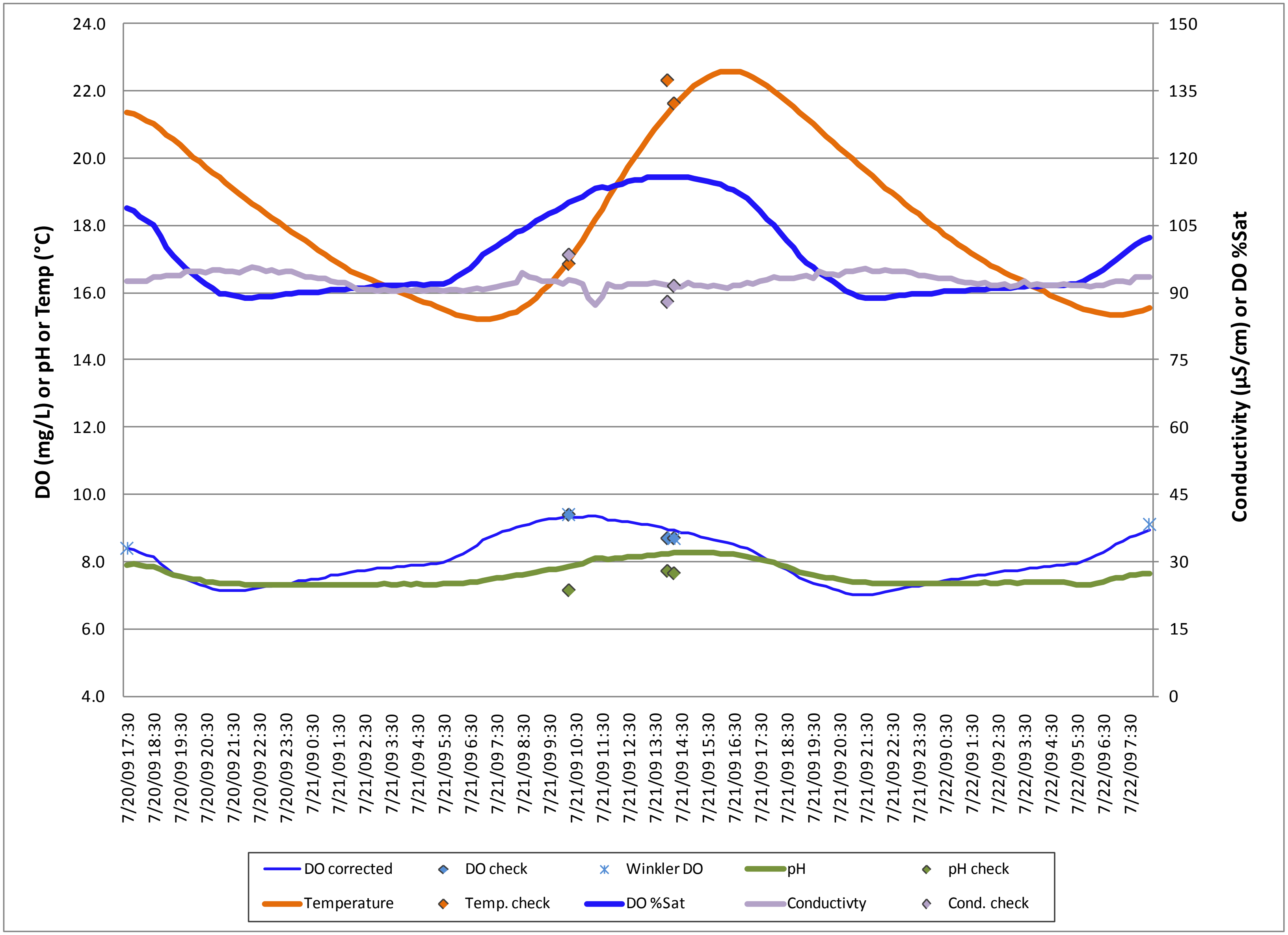

Figure A-6. 32TOU-52.1 continuous Hydrolab data, July 2009.

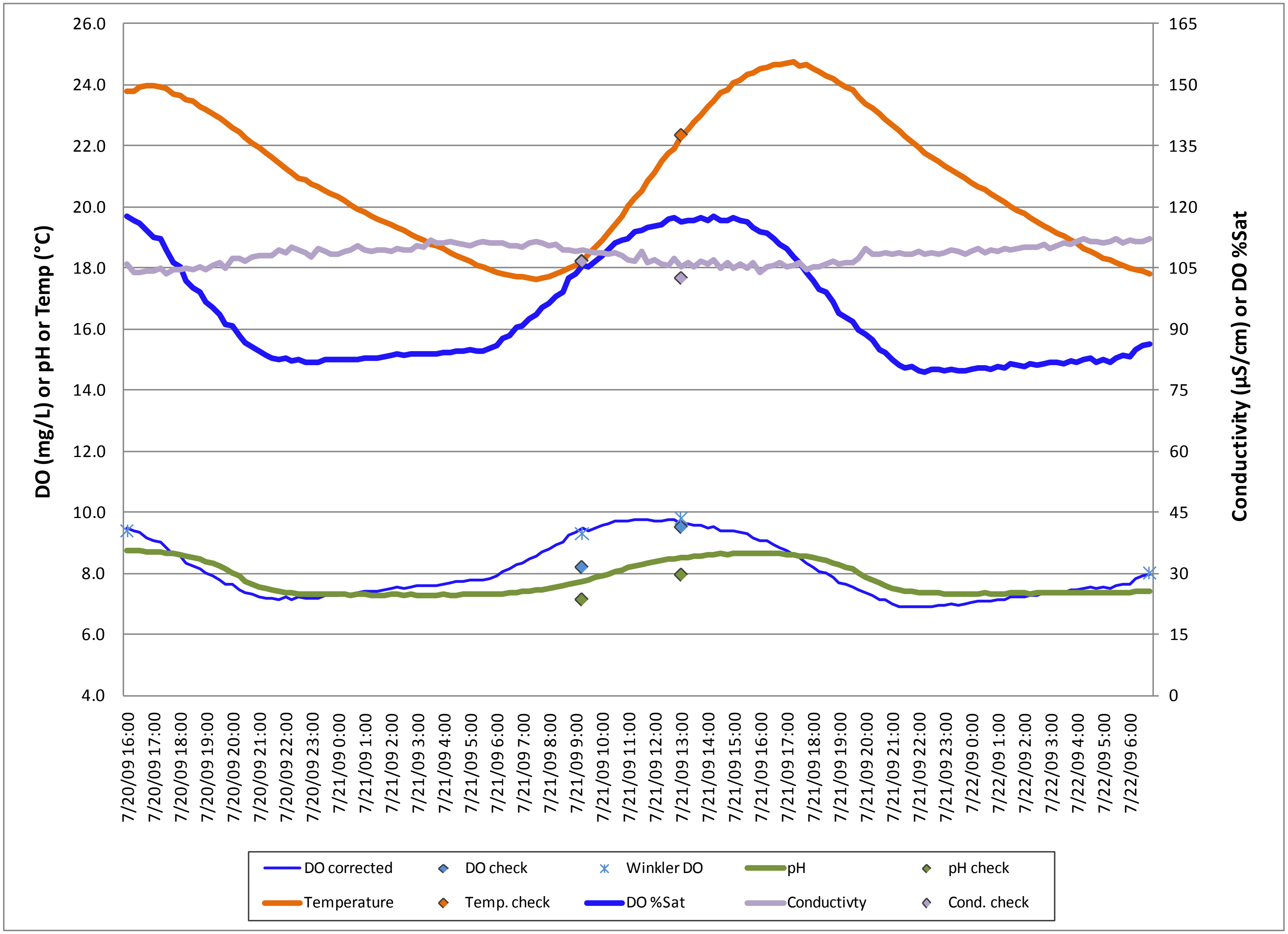

Figure A-7. 32TOU-43.5 continuous Hydrolab data, July 2009.

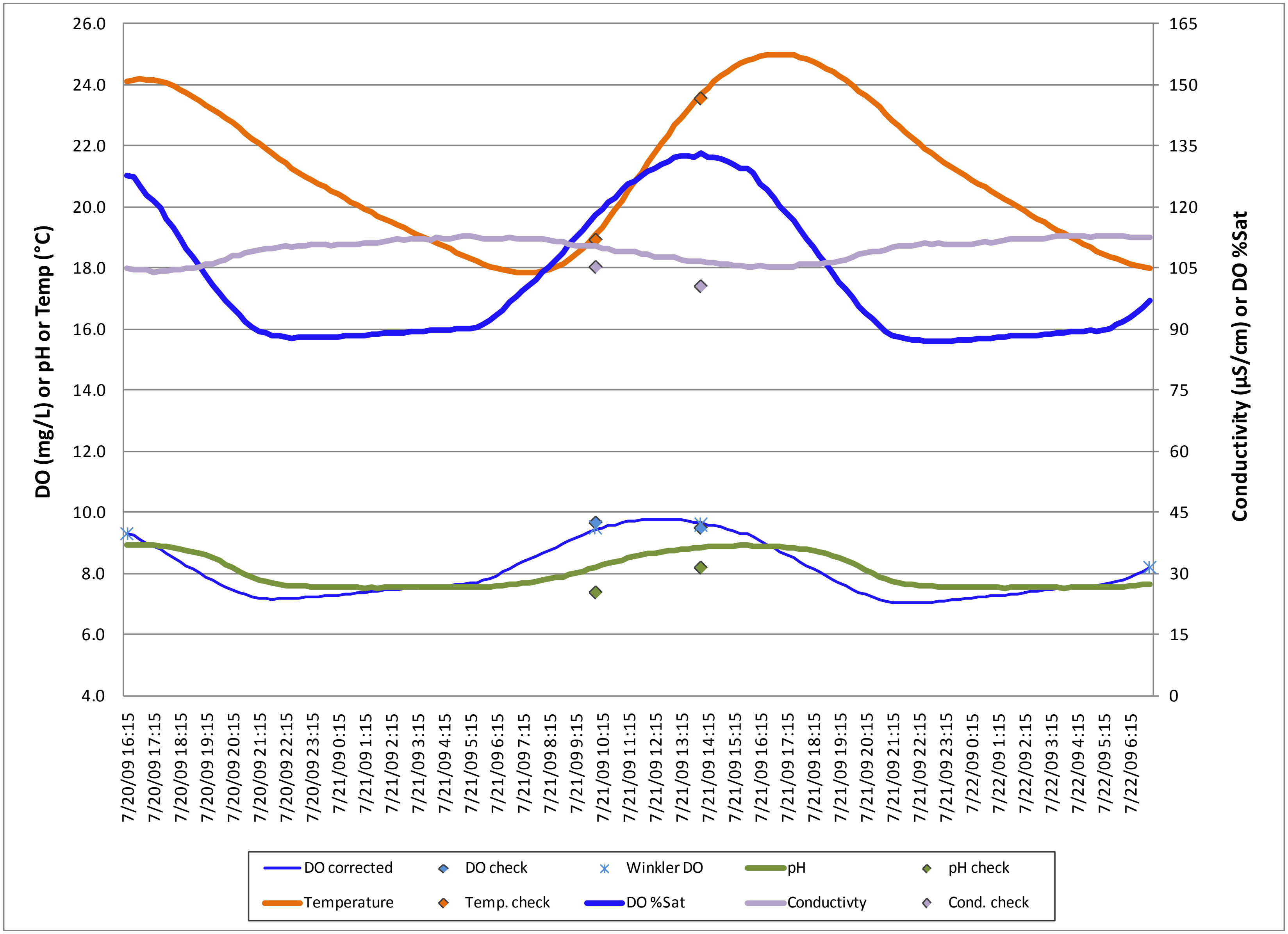

Figure A-8. 32TOU-43.0 continuous Hydrolab data, July 2009.

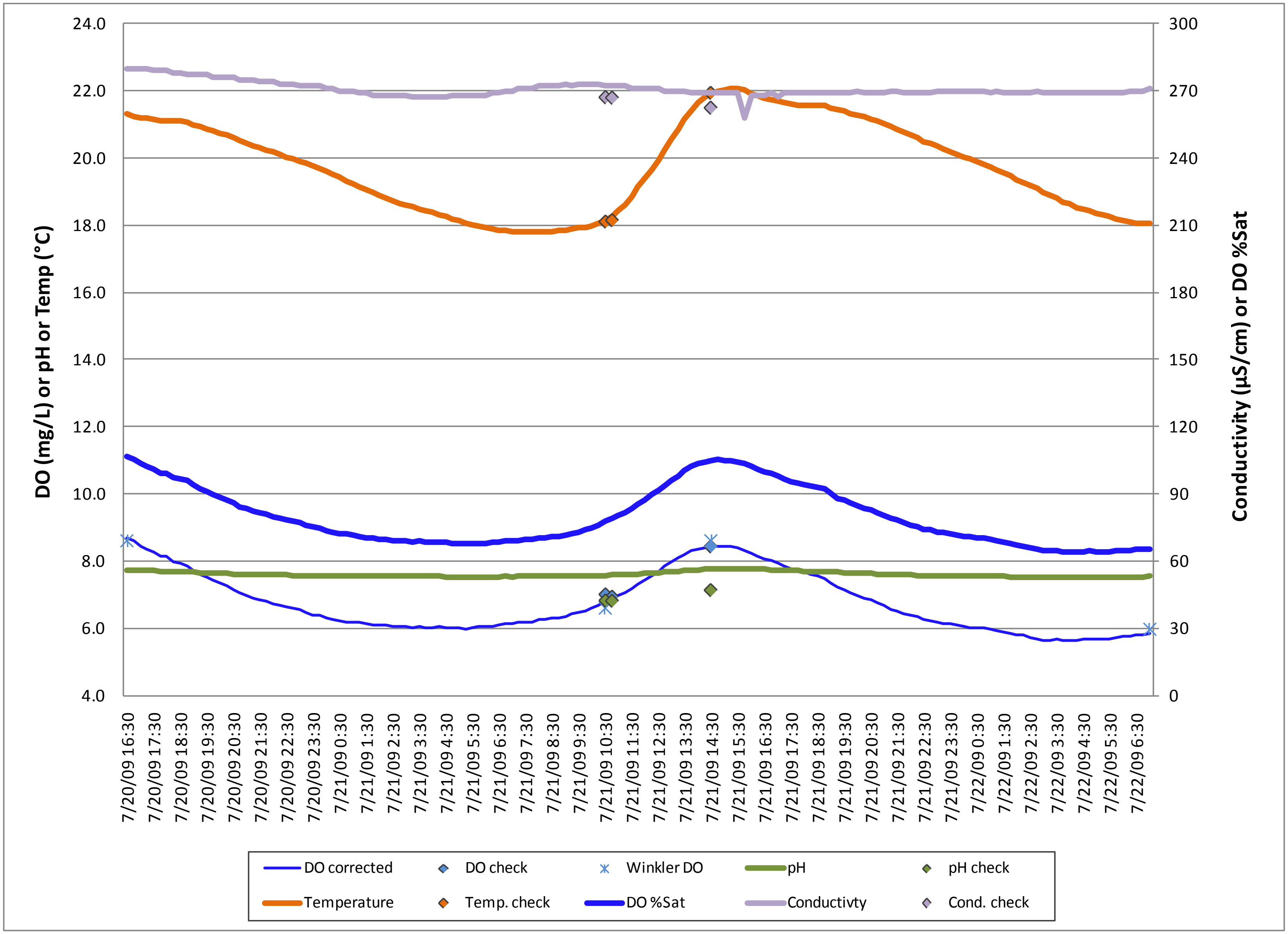

Figure A-9. 32COP-00.0 continuous Hydrolab data, July 2009.

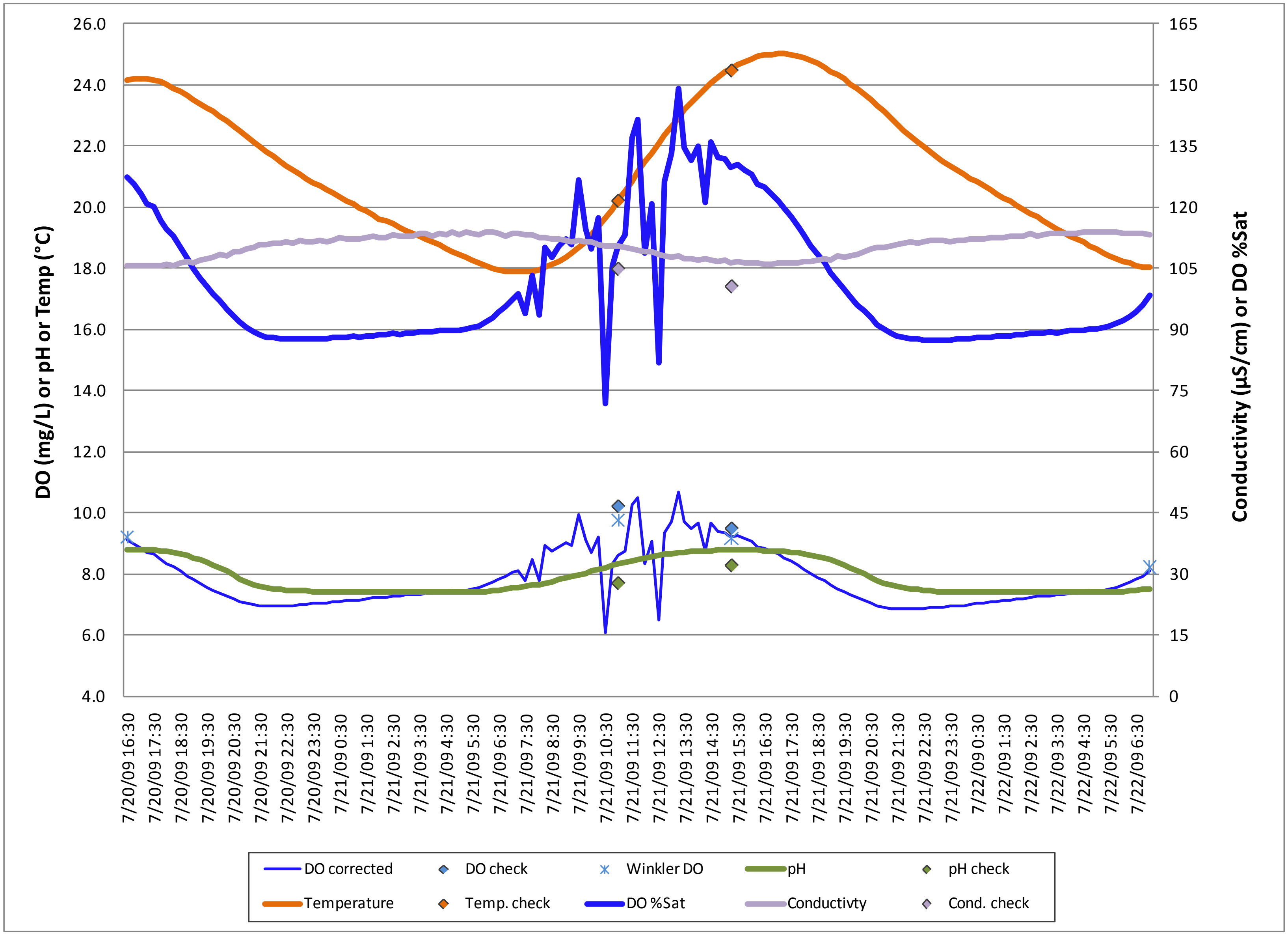

Figure A-10. 32TOU-42.9 continuous Hydrolab data, July 2009.

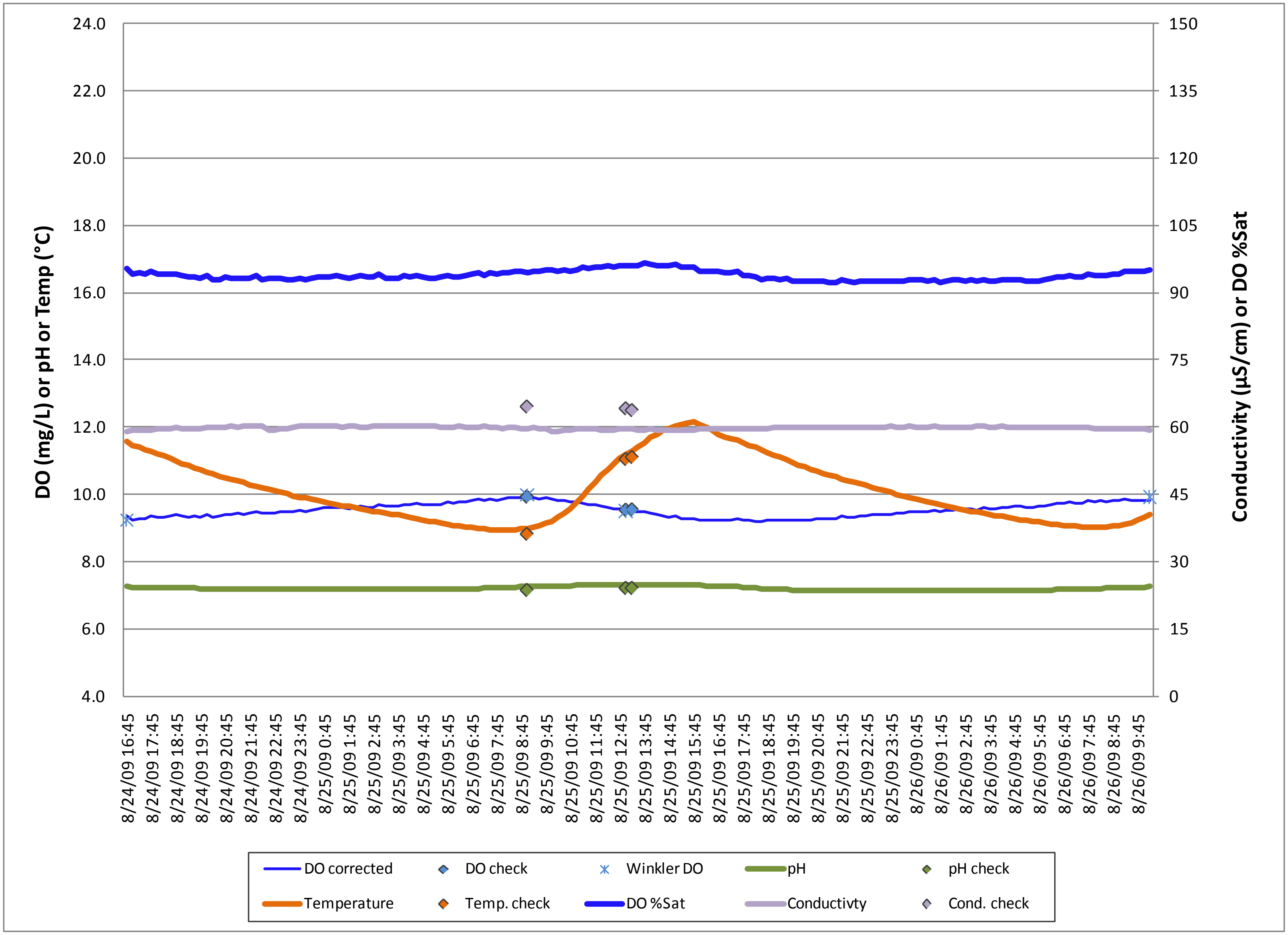

Figure A-11. 32NFT-15.1 continuous Hydrolab data, August 2009.

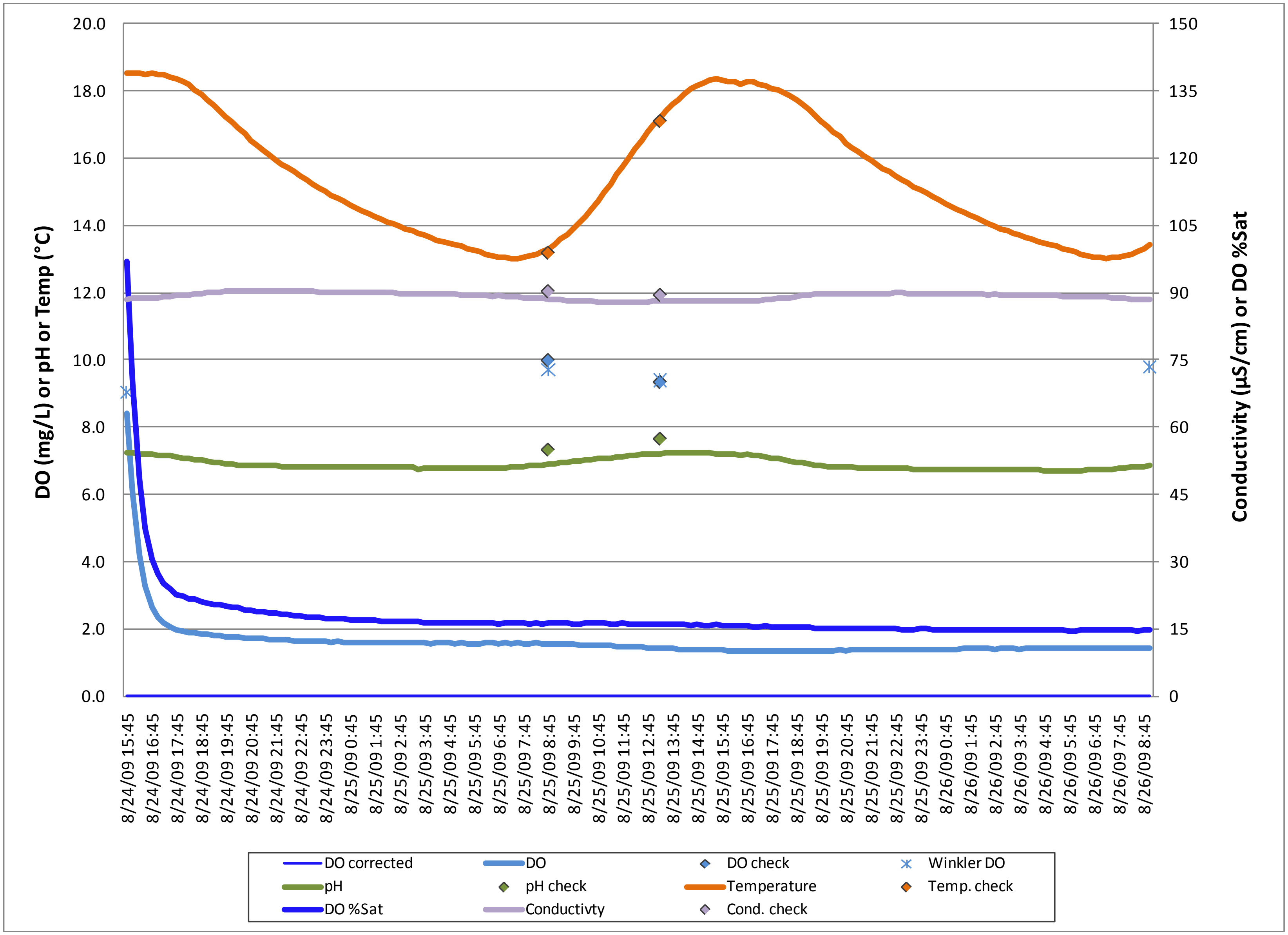

Figure A-12. 32NFT-00.0 continuous Hydrolab data, August 2009.

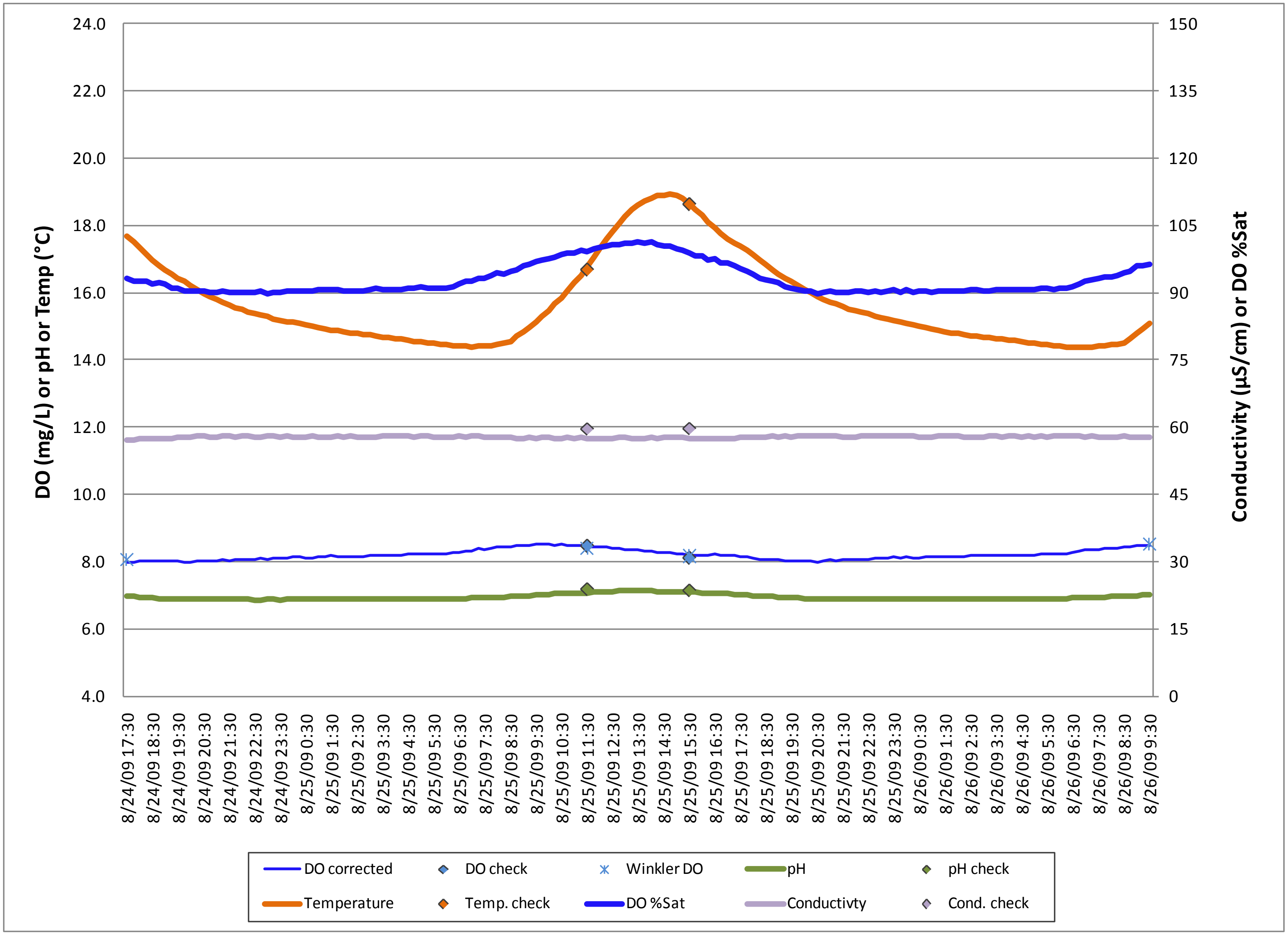

Figure A-13. 32SFT-08.8 continuous Hydrolab data, August 2009.

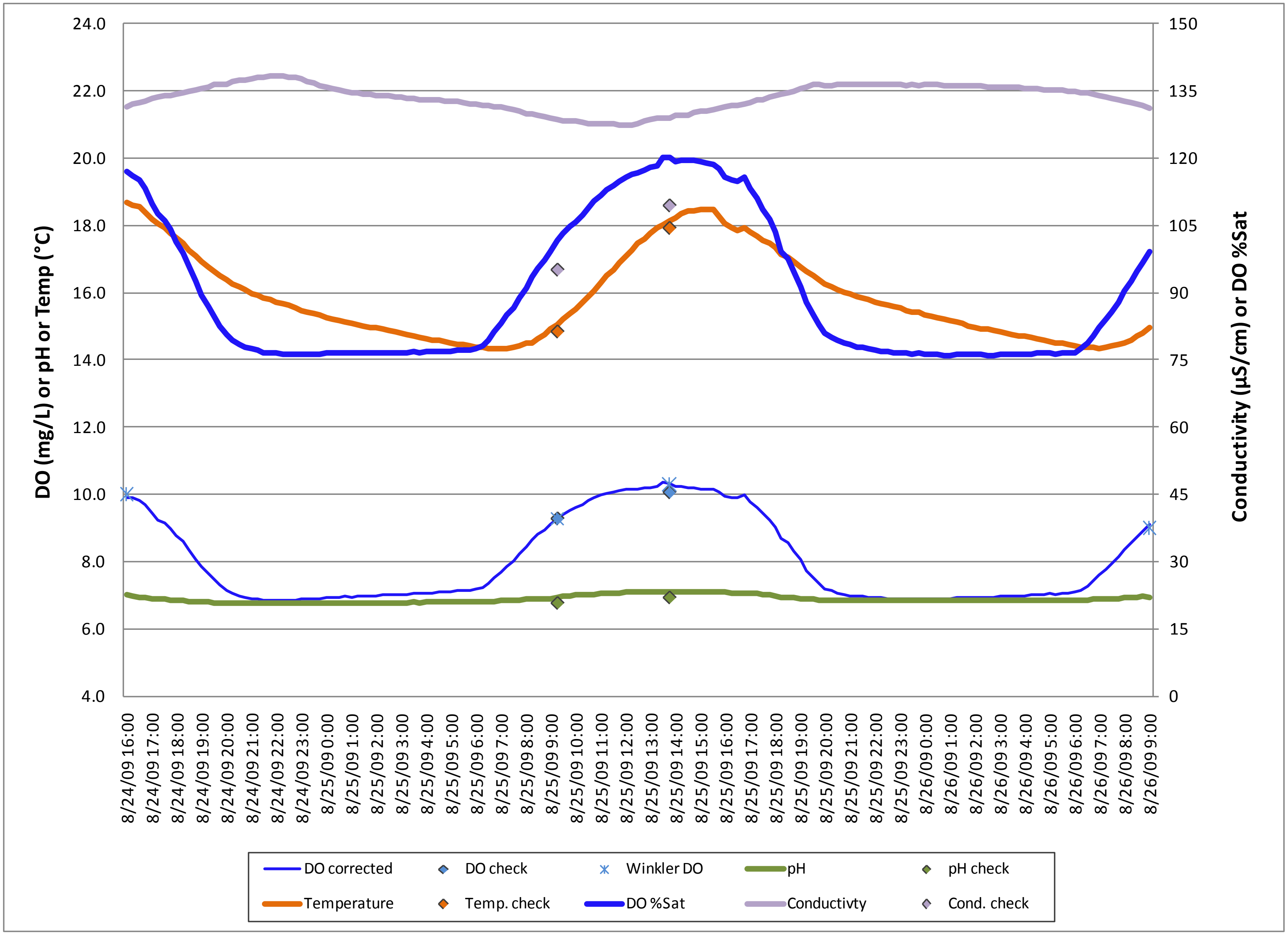

Figure A-14. 32SFT-00.0 continuous Hydrolab data, August 2009.

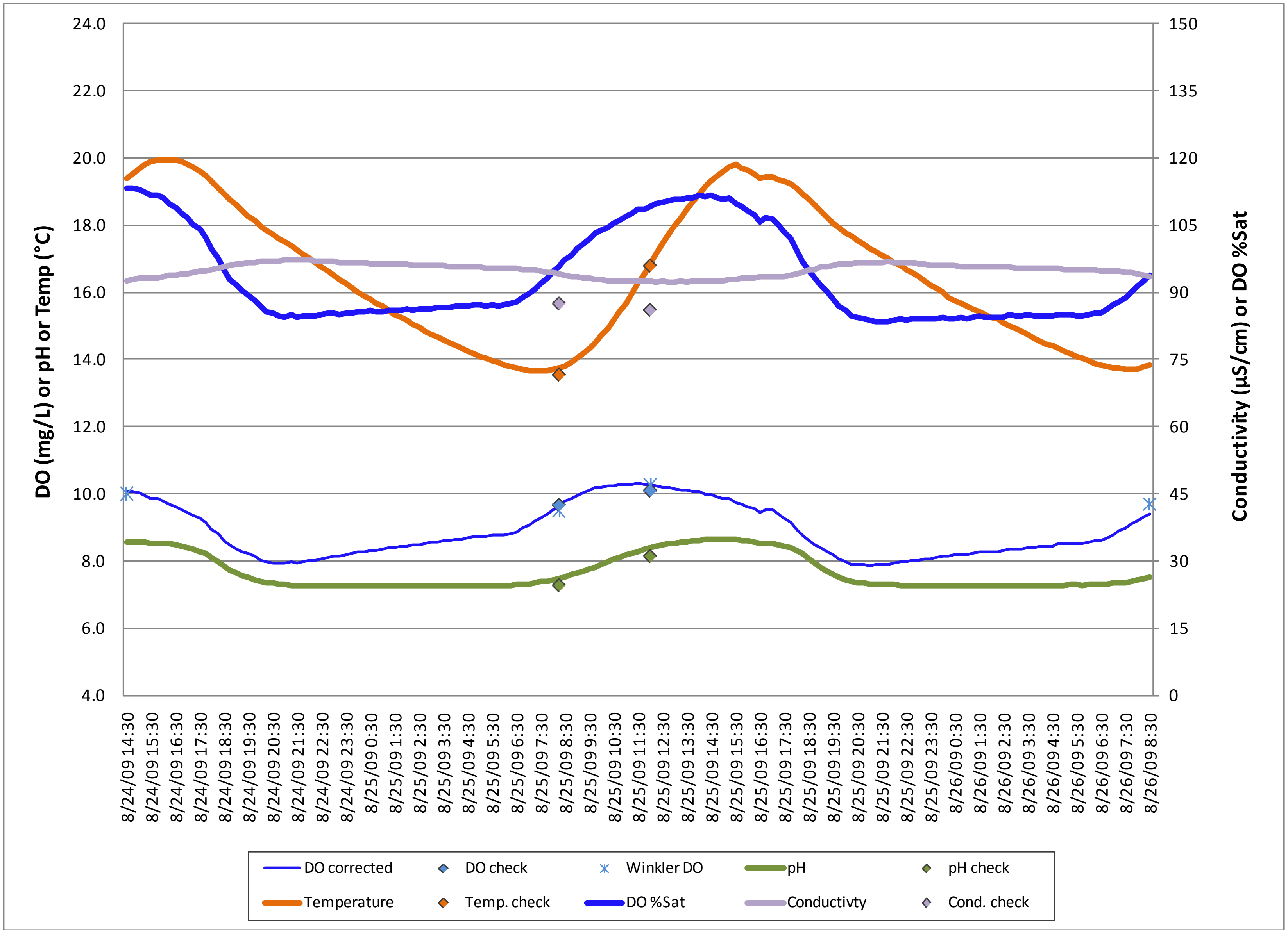

Figure A-15. 32TOU-52.2 continuous Hydrolab data, August 2009.

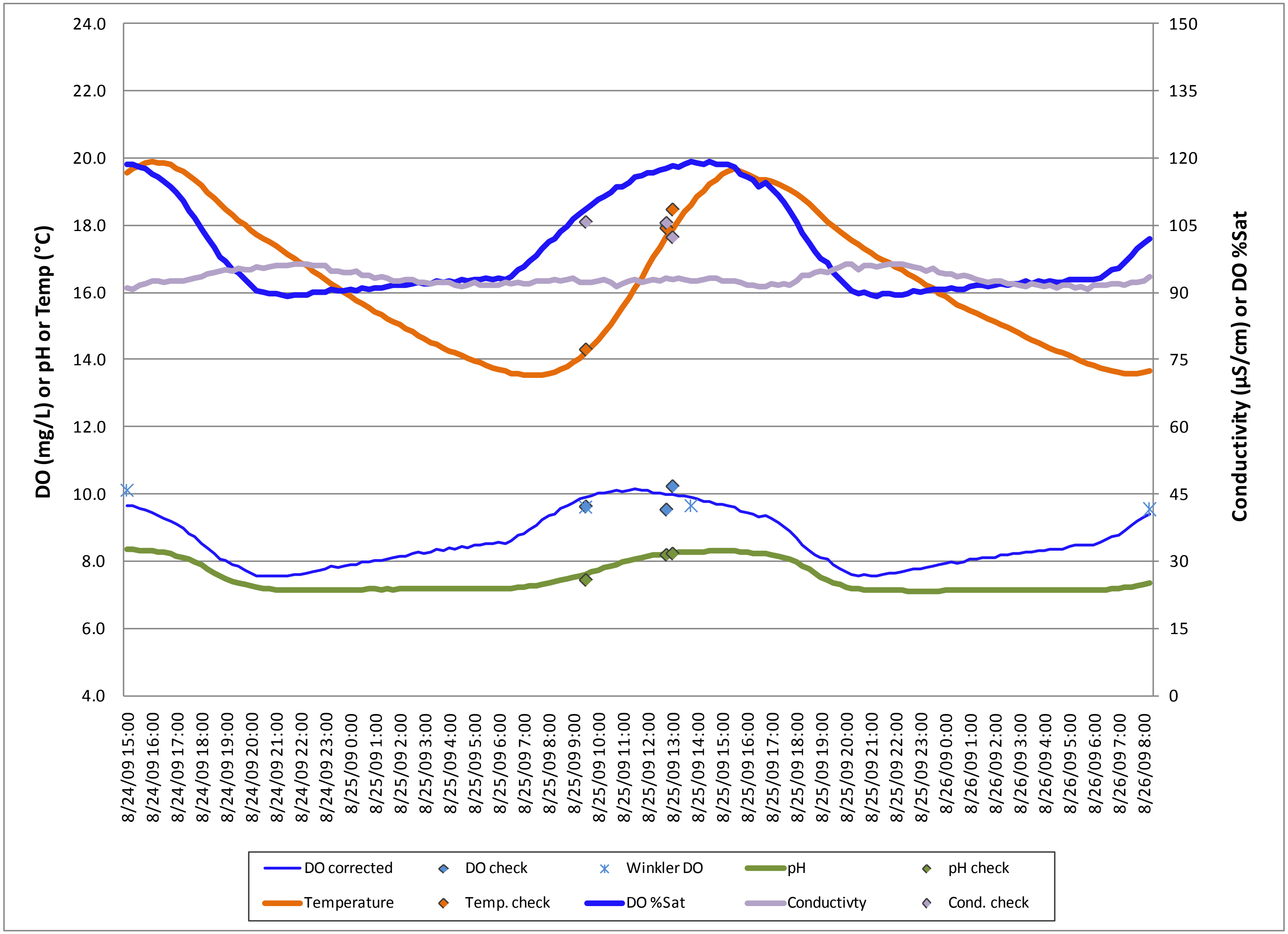

Figure A-16. 32TOU-52.1 continuous Hydrolab data, August 2009.

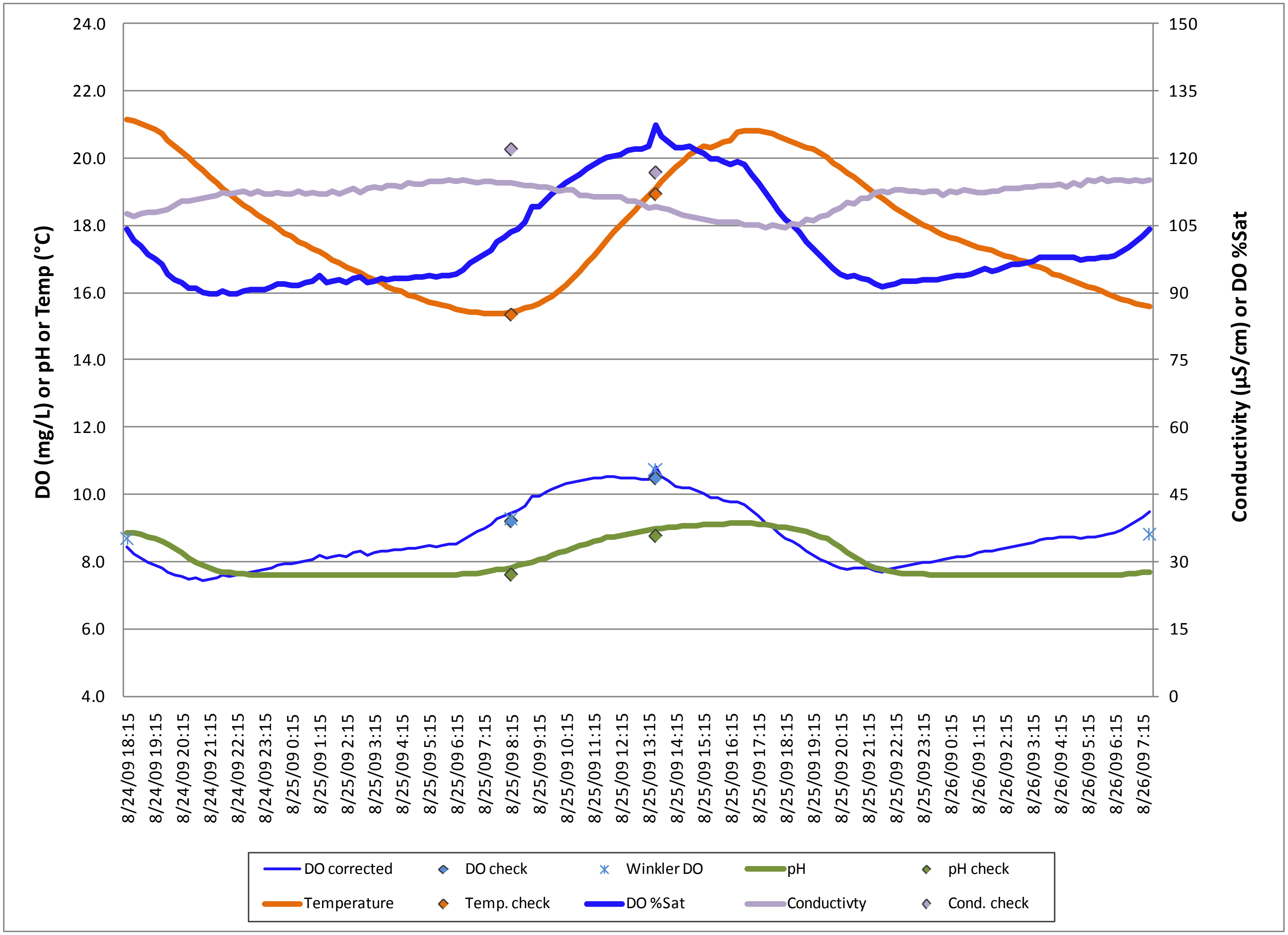

Figure A-17. 32TOU-43.5 continuous Hydrolab data, August 2009.

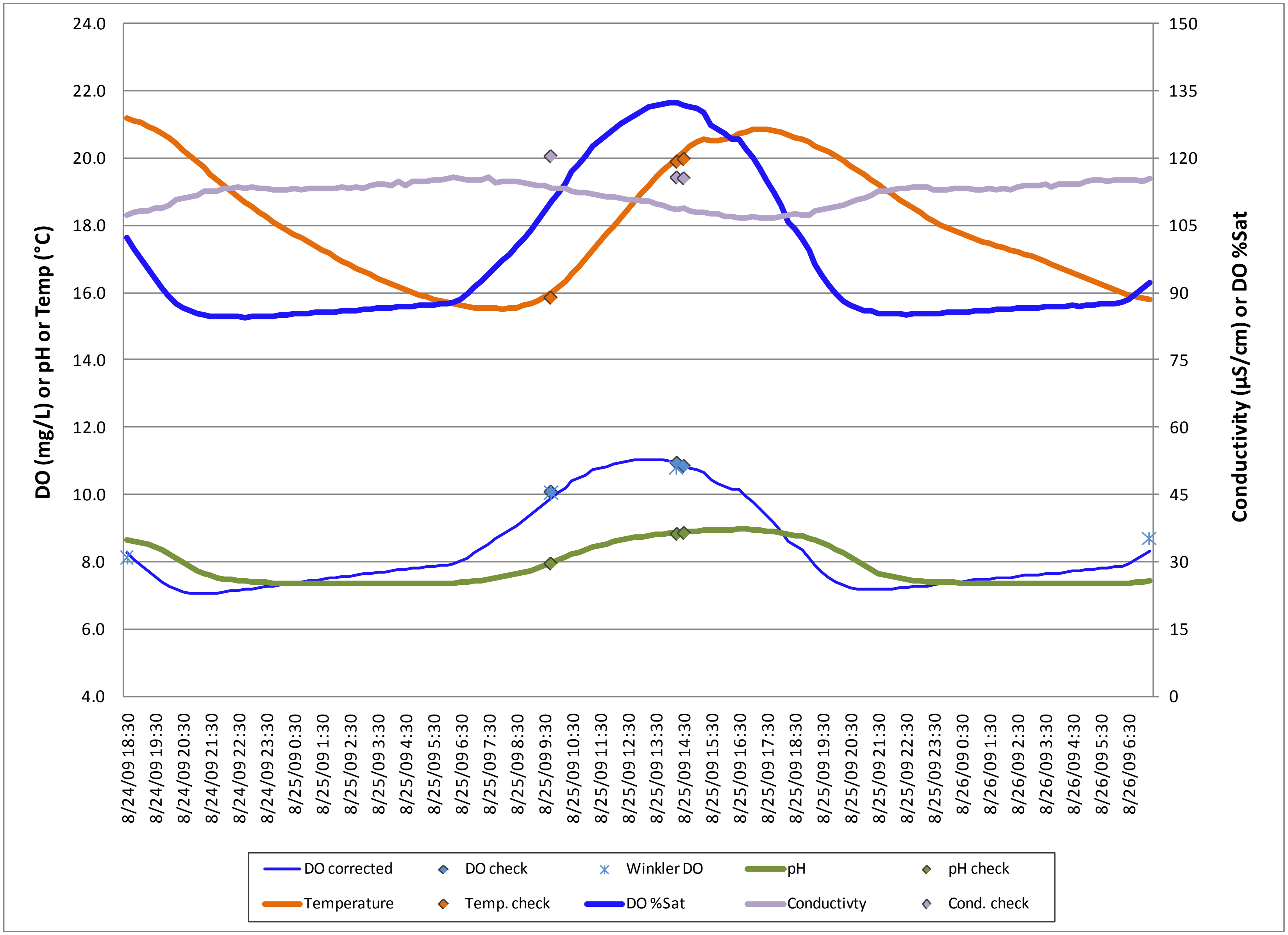

Figure A-18. 32TOU-43.0 continuous Hydrolab data, August 2009.

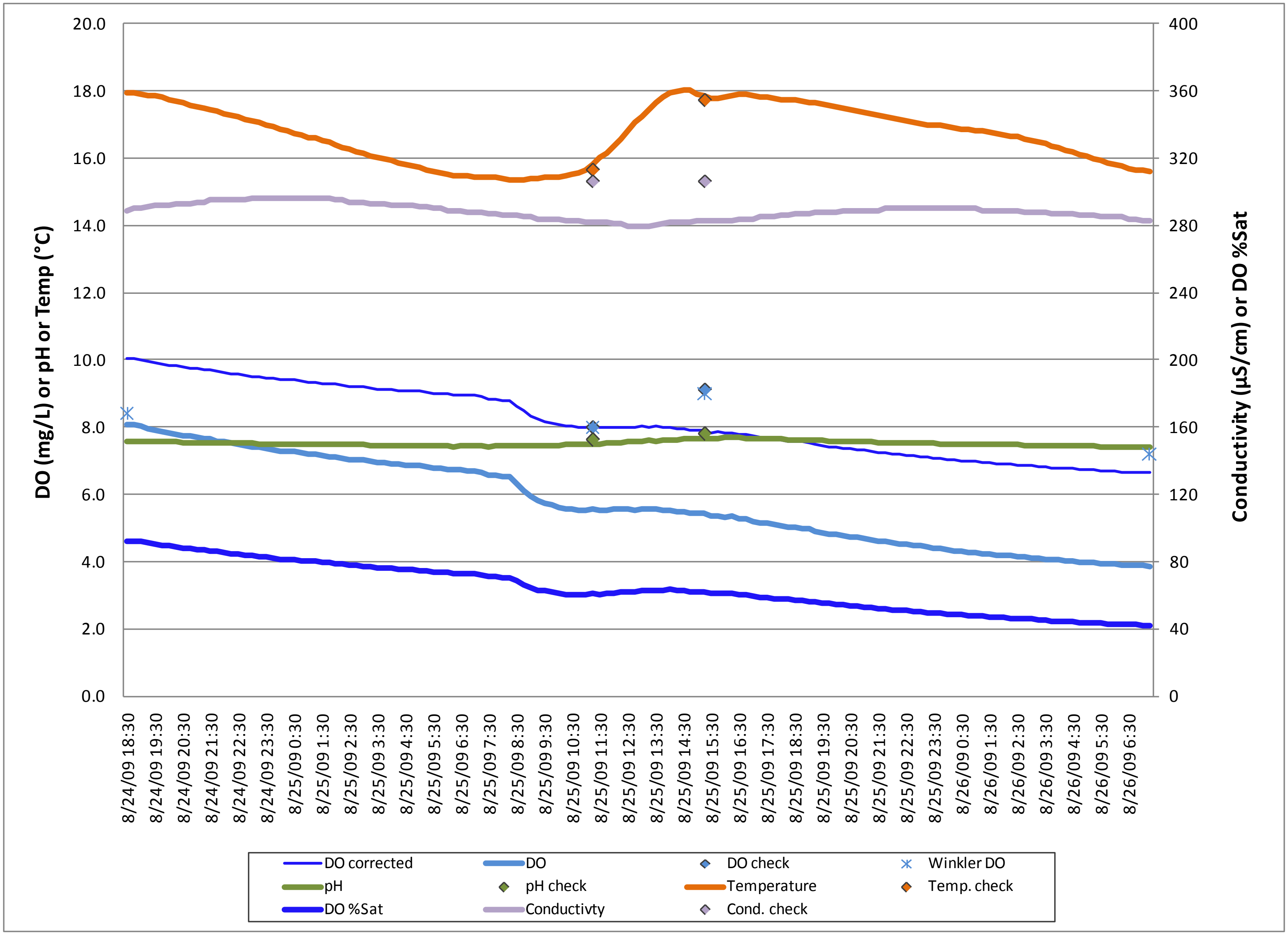

Figure A-19. 32COP-00.0 continuous Hydrolab data, August 2009.

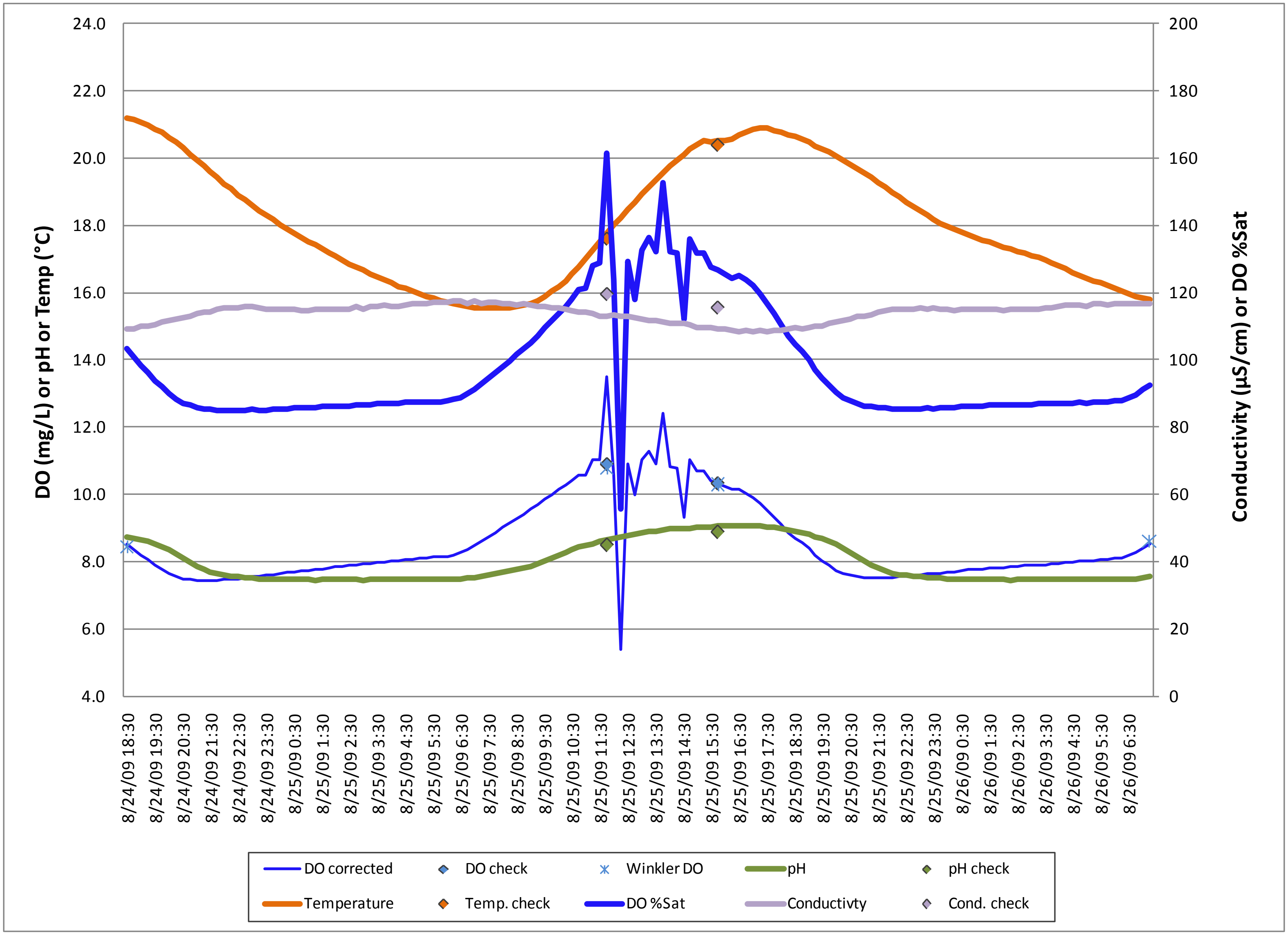

Figure A-20. 32TOU-42.9 continuous Hydrolab data, August 2009.

Appendix B. Glossary, Acronyms, and Abbreviations

Glossary

Baseflow: Groundwater discharge. The component of total streamflow that originates from direct groundwater discharges to a stream.

Char: Char (genus *Salvelinus*) are distinguished from trout and salmon by the absence of teeth in the roof of the mouth, presence of light colored spots on a dark background, absence of spots on the dorsal fin, small scales, and differences in the structure of their skeleton. (Trout and salmon have dark spots on a lighter background.)

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Conductivity: A measure of water's ability to conduct an electrical current. Conductivity is related to the concentration and charge of dissolved ions in water.

Diel: Of, or pertaining to, a 24-hour period.

Dissolved oxygen (DO): A measure of the amount of oxygen dissolved in water.

Exceeding: Groundwater discharge. The component of total streamflow that originates from direct groundwater discharges to a stream.

Eutrophic: Nutrient rich and high in productivity resulting from human activities such as fertilizer runoff and leaky septic systems.

Fecal Coliform: That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within 24 hours at 44.5 plus or minus 0.2 degrees Celsius. Fecal coliform bacteria are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100 mL).

Grab: A discrete sample from a single point in the water column or sediment surface.

Load allocation: The portion of a receiving waters' loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Hyporheic: The area beneath and adjacent to a stream where surface water and groundwater intermix.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Nutrient: Substance such as carbon, nitrogen, and phosphorus used by organisms to live and grow. Too many nutrients in the water can promote algal blooms and rob the water of oxygen vital to aquatic organisms.

Parameter: Water quality constituent being measured (analyte). A physical, chemical, or biological property whose values determine environmental characteristics or behavior.

Periphyton: Algae that grow on submerged rocks, plants, and debris.

pH: A measure of the acidity or alkalinity of water. A low pH value (0 to 7) indicates that an acidic condition is present, while a high pH (7 to 14) indicates a basic or alkaline condition. A pH of 7 is considered to be neutral. Since the pH scale is logarithmic, a water sample with a pH of 8 is ten times more basic than one with a pH of 7.

Piezometer: : A small-diameter, non-pumping well used during this study to (1) measure depth to groundwater, (2) measure streambed water temperatures, and (3) periodically collect groundwater quality samples.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Reach: A specific portion or segment of a stream.

Salmonid: Any fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Synoptic: Simultaneous.

Total maximum daily load (TMDL): Water cleanup plan. A distribution of a substance in a waterbody designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Wasteload allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocation constitutes one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards and are not expected to improve within the next two years.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

DIN	Dissolved inorganic nitrogen
DO	(See Glossary above)
DOC	Dissolved organic carbon
Ecology	Washington State Department of Ecology
EIM	Environmental Information Management database
EPA	U.S. Environmental Protection Agency
LDO	Luminescent dissolved oxygen
NH_3	Ammonia nitrogen
NO_2/NO_3	Nitrite and nitrate nitrogen
NPDES	(See Glossary above)
Q	Streamflow
QA	Quality assurance
QC	Quality control
RM	River mile

RSD	Relative standard deviation
SRP	Soluble reactive phosphorus
TMDL	(See Glossary above)
TOC	Total organic carbon
TP	Total phosphorus
TSS	Total suspended solids
TPN	Total persulfate nitrogen
UV	Ultraviolet
WWTP	Wastewater treatment plant
% Sat	Percent saturation

Units of Measurement

°C	degrees centigrade
cfs	cubic feet per second
ft	feet
lbs/day	pounds per day
mgd	million gallons per day
mg/L	milligrams per liter (parts per million)
s.u.	standard units
μS/cm	microsiemens per centimeter, a unit of conductivity