WATERSHED CONDITIONS REPORT ADDENDUM

Buffalo River
Watershed

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1. Introduction

During the Phase I assessment of the Buffalo River Watershed-wide Total Maximum Daily Load (TMDL) study (i.e., the Watershed Approach Plan), a watershed conditions report (HEI, 2010) was written to describe the current water quality in the watershed and to identify data gaps. The watershed conditions report (2010) provided an overview of the existing watershed physical settings and water quality conditions with data collected through the 2009 sampling season.

An examination of available data revealed the water quality issues within the watershed appeared to be more widespread than what was currently listed on the Minnesota Pollution Control Agency's (MPCA) 2010 draft List of Impaired Waters (i.e., the 303(d) list). Due, in part, to these findings, more monitoring work was completed in the Buffalo River Watershed (BRW) during the 2009 and 2010 field seasons to assess the condition of its streams in relation to water quality. Some of the work performed during this time included the Intensive Watershed Monitoring (IWM) effort, which seeks to evaluate the current conditions within the watershed, including geomorphological studies.

The main goal of this addendum to the 2010 Watershed Conditions Report (HEI) is to present the findings of the work completed in the BRW during the 2009/2010 field seasons and to incorporate those findings into the watershed-wide TMDL project. Additional goals are to present other related and complementary efforts in the area (either completed or currently underway) and to provide a resource that enables local managers to review waters for restoration and/or protection of aquatic resources in the future. General background information on the physical settings (i.e., land use, population, general layout of the watershed, etc.) and management of the BRW can be found in the original Watershed Conditions Report (HEI 2010). **Figure 1** displays the water quality monitoring sites, continuous flow monitoring sites, impaired waters (note: impairments are based on the 2011 assessments, as described within this addendum), and municipalities within the study area.

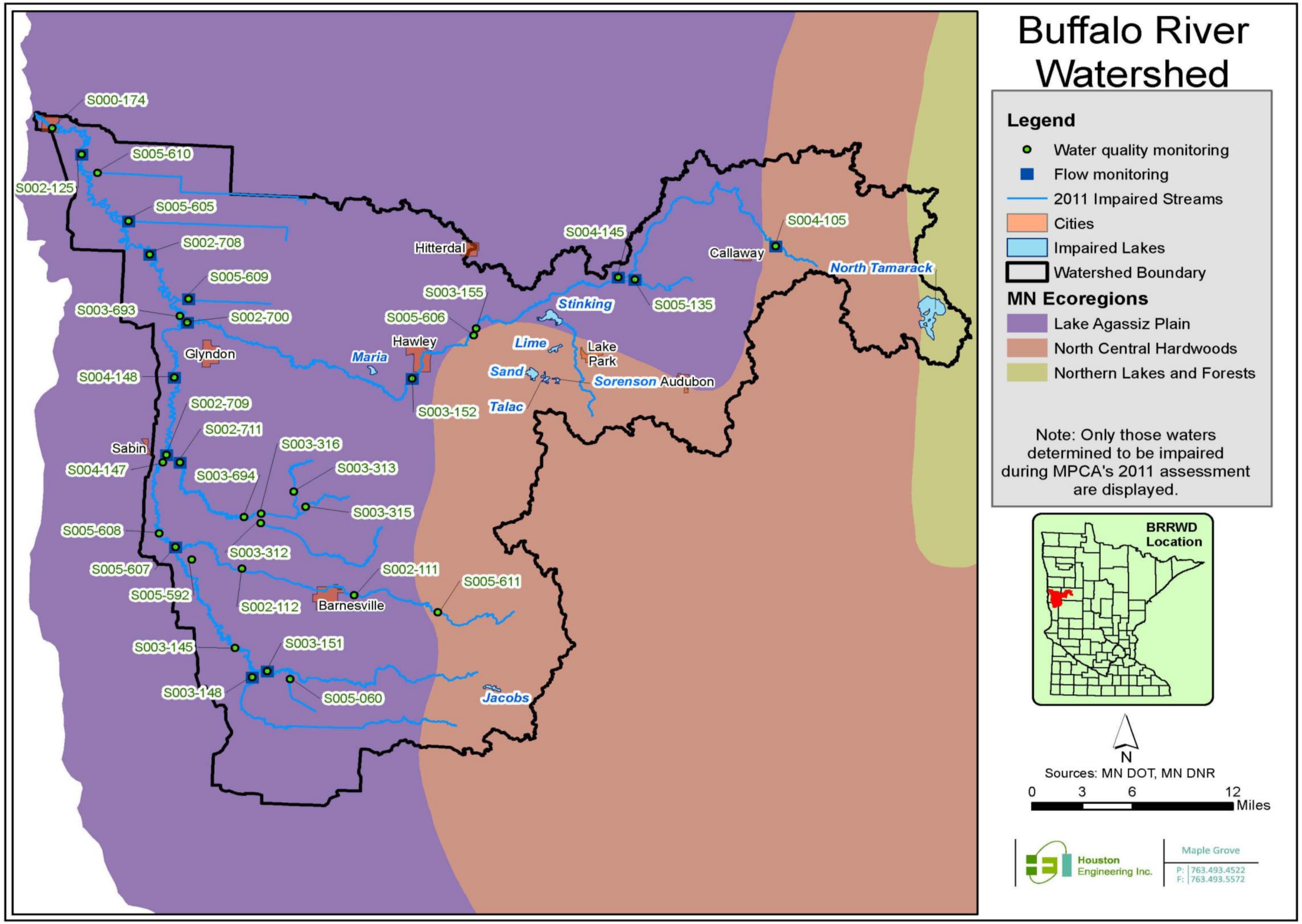


Figure 1. General watershed layout with information associated with water quality in the BRW. Note: Green numeric labels indicate stream monitoring sites and blue labels indicate impaired lakes within the watershed.

2. Background on 2009/2010 Sampling Efforts

2.1 Purpose

During phase I of the Buffalo River Watershed-wide TMDL, existing water quality data were reviewed and summarized. Results of this analysis showed that water quality issues in the watershed appear to be more widespread than reflected by the 2010 impaired waters listing. Prior to completion of the 2009/2010 sampling, eleven impairments on eight stream reaches existed within the watershed and several monitoring locations were found to have insufficient data to properly assess potential impairments. A more robust data set was needed to properly assess the impairments within the watershed as well as to ensure adequate data was collected for the TMDL study.

2.2 Project Participants and Funding

The water quality data collected during the 2009 and 2010 field seasons (that are addressed in this addendum) were gathered through a cooperative effort by the BRRWD, MPCA, Red River Management Board and RiverWatch citizen monitoring group. RiverWatch and the Red River Management Board collected water quality and stream stage measurements. MPCA collected all Index of Biological Integrity (IBI) data (both fish and invertebrate) and several water quality chemistry measurements. MPCA and the MN Department of Natural Resources (MN DNR) collaborated on the collection of flow data and the geomorphology work. Finally, in 2011, MPCA made impairment recommendations based on the collected data.

Several partners provided the funding for the monitoring efforts including MPCA's IWM program, Surface Water Assessment Grant (SWAG) funds through the MPCA and general monitoring funds provided by the BRRWD. Although the monitoring was not directly funded through the TMDL project, the monitoring results will be used in the ongoing TMDL work in the watershed.

2.3 Intensive Watershed Monitoring

The MPCA's IWM program was designed to assess the aquatic health of the 81 major watersheds across the State of Minnesota on a rotating 10-year cycle using a combination of water chemistry and biological monitoring. The IWM uses a systematic sampling approach where the mouth of a subwatershed is monitored to measure the upstream subwatershed's condition in an unbiased way. This approach provides an assessment of the watershed's intended beneficial uses, including aquatic life, aquatic recreation, and aquatic consumption, to ensure that the goals of the Clean Water Act (i.e., fishable/swimmable waters) are being met. The primary objectives of the IWM strategy are to determine the condition of all watersheds throughout Minnesota, to locate watersheds with impairments, to provide information to support the TMDL process, and to monitor conditions over time (http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/water-quality-condition-monitoring/watershed-sampling-design-intensive-watershed-monitoring.html).

The MPCA's IWM design was initiated in 2006 for streams and rivers in selected watersheds; in 2009 lakes began to be sampled along with streams. IWM takes place over two years and in two phases. In phase I (year one) problems within the watershed are identified and during phase II (year two) the sources of impairments are investigated and identified. The BRW IWM was completed during the 2009 and 2010 field seasons.

The BRW IWM was completed, in part, to support the findings of the TMDL phase I assessment. During the IWM, water quality was assessed based on an increase of water chemistry data plus biological data (using the Index of Biological Integrity). Combining chemical and biological data provides a more holistic picture of what the water quality is within the watershed. The data collected during the IWM was used to fill existing data gaps found during the phase I assessment, to assess if new impairments potentially exist, and to use the water chemistry and biological data together to evaluate the streams within the BRW.

2.4 Index of Biological Integrity

Biological integrity is a measure of a waterbody's ability to support aquatic life. Assessed as a function of water chemistry, habitat structure (i.e., geomorphmetry), energy sources, flow regime, and biotic interactions, biological integrity provides a holistic picture of ecosystem health, moving beyond a traditional water quality assessment based only on water chemistry. The presence of a healthy, diverse, and reproducing aquatic community (including invertebrates and fish) is a good indication that pollutant concentrations are below levels that would physically stress a biologic community and that the physical setting of the system (described using the considerations listed above) is supportive of a balanced environment.

Water quality standards are written to protect (among other things) aquatic life. Standards developed for this protection consist of both numeric as well as narrative criteria. Assessing the biological community of a waterbody addresses the narrative portion of the criteria. Given how numeric criteria are developed, if the aquatic community is found to be healthy and diverse, (in theory) it should indicate that pollutant levels are below the associated numeric water quality criteria. However, in some situations one or more criteria may be exceeded and the biological community may show no impairment. This may be due to properties in the water that tend to mitigate the toxic effects of a pollutant that the water quality standard does not account for or that the biological community under study is not particularly sensitive to that pollutant. The opposite situation can occur as well, where chemical analyses show no impairment and the biological community does. Using biological monitoring (bio-monitoring) as a direct means to assess aquatic life use support can provide a more comprehensive overview of water quality since aquatic communities will assimilate the effects of pollution over time. In contrast, when water samples are taken for chemical analysis, only the water quality conditions at that moment are shown. For this reason, it is important to assess biological, chemical, and physical data together to provide an accurate assessment of a specific waterbody.

The MPCA uses an IBI to assess the quality of fish and invertebrate communities in flowing water systems. Fish and Invertebrate IBIs are calculated using attributes of the aquatic community or ‘metrics’. These metrics are based upon: 1) species diversity and composition; 2) feeding and reproduction characteristics; and 3) species abundance and condition.

MPCA is in the process of revising and drafting a new IBI scoring method to compare potentially impacted streams to similar reference streams (Poegel, 2011). Under the currently proposed approach, fish and invertebrate IBI scoring are separated and have their own specific criteria for each geographic region and classes within each region. Each class (established by the type of stream that it represents; headwaters versus coldwater, for example) has a unique set of metrics, scoring functions, impairment thresholds, and confidence intervals calculated. Scores higher than the upper confidence limit reflect a healthy biologic community, while scores below the lower confidence limit reflect a degraded community. When scores fall within the confidence limit, the biologic data, chemical data, physical habitat, land use activities, and other associated watershed characteristics that may impact the health of the stream are assessed by MPCA Professional Judgment Teams to determine if a stream reach is impaired. MPCA staff are responsible for calculating IBI scores, determining the impairment threshold and providing the impairment status to each stream/river reach being assessed. Final impairment decisions are made by MPCA’s Watershed Assessment Team.

The draft fish IBI scoring method classifies streams into two geographic regions (north and south) and four classes (rivers, streams, headwaters, and coldwater) for a total of eight unique classes plus one statewide low-gradient class. Classes are ultimately divided on whether the stream is a warmwater or coldwater stream, the drainage area, and/or the gradient of the watershed. The new method compares stream reaches within each geographic region and class to similar “non-impacted” reference sites.

The invertebrate metrics are divided into seven classes. The classification criteria are determined by the dominant ecological landscape, watershed size, and in-stream habitat. The classes are divided as follows: Northern Forest Rivers, Prairie Forest Rivers, Northern Forest Streams (riffle/run habitat), Northern Forest Streams (glide/pool habitat), Southern Streams (riffle/run habitat), Southern Forest Streams (glide/pool habitats), and Prairie Streams (glide/pool habitats). As with the fish IBI scoring, potentially impaired stream reaches are compared to “non-impacted” reference sites within the same invertebrate IBI class.

IBI scores are only computed for stream reaches that are not significantly channelized. If a stream reach is channelized (including ditches), the data collected will not be fully assessed until the Tiered Aquatic Life Uses (TALU) framework is implemented (expected to occur in 2014). The TALU system assesses a waterbody's aquatic life use based on tiers, or levels, established by stream type and potential. Current water quality standards are rigid and can lead to the under-protection of some high quality resources and over-protection of waterbodies that will likely never achieve certain chemical and biological standards. The TALU will allow the MPCA to set water quality and biological standards that are protective and still attainable by taking into account regional (e.g., ecosystem) and physical differences (e.g., size, gradient) in stream classification.

Once the TALU framework is completed and implemented, ditches and channelized streams will have separate biological standards than naturally meandering streams and rivers. This should provide the Buffalo Red-River Watershed District (BRRWD) the opportunity to reach the beneficial use standards for each impaired waterbody in the District. **Table 1** shows the preliminary biological ratings for channelized streams in the State of Minnesota (waters that are currently non-assessable).

Table 1. Preliminary (currently non-assessable) channelized biological stream ratings for Minnesota.

Class #	Class Name	Biological stream rating		
		Good	**Fair**	**Poor**
Fish				
1	Southern Rivers	>38	38-24	<24
2	Southern Streams	>44	44-30	<30
3	Southern Headwaters	>50	50-36	<36
4	Northern Rivers	>34	34-20	<20
5	Northern Streams	>49	49-35	<35
6	Northern Headwaters	>39	39-25	<25
7	Low Gradient Streams	>39	39-25	<25
Invertebrates				
1	Northern Forest Rivers	>51	52-36	<36
2	Prairie Forest Rivers	>31	31-16	<16
3	Northern Forest Streams RR	>50	50-35	<35
4	Northern Forest Streams GP	>52	52-37	<37
5	Southern Streams RR	>36	36-21	<21
6	Southern Forest Streams GP	>47	47-32	<32
7	Prairie Streams GP	>38	38-23	<23

2.5 Geomorphology Work

Geomorphology is the study of landforms from their origin and evolution to the processes that continue to shape them. In an effort to better understand the sediment loading and turbidity issues in the BRW, the MN DNR (in combination with their partners) is currently conducting geomorphological studies to quantify the amount of soil and sediment being eroded away from stream banks. Preliminary results from this work are expected in the fall of 2011 and will provide estimates of bank erosion rates in feet/year and tons/feet/year (Friedl, 2011). This project is expected to continue during 2012 to expand on the 2011 data set and create a better estimate of stream bank erosion. The ultimate goal is to develop an estimated erosion rate in tons/feet/year across the watershed at a number of different locations.

Work completed in 2009 by the US Department of Agriculture – Natural Resource Conservation Service (NRCS) Agricultural Research Station (ARS), estimated streambank yields in a 31 km study area on the South Branch of the Buffalo River. Results of that study predicted streambank sediment yields of 0.82 tons/year/km^2 during an average annual flow year (Bankhead and Simon, 2009). Yields during a 99th percentile flow year were predicted to be 2.08 tons/year/km^2, highlighting the impact that high flows have the potential for streambank erosion in this area. Additional findings of this work estimated that approximately 27% of the sediment observed at the USGS gauge 05061500 (S Branch Buffalo River near Sabin, MN) came from streambank erosion during an average annual flow year, while approximately 43% came from streambank erosion during the 99th percentile flow year. These results are considerably higher than those found in a 2006 study by Lauer et al., which focused on drier years than those studied by the NRCS-ARS and reported an 11% contribution from streambank erosion.

Another NRCS-ARS report, also completed in 2009, resulted in estimates of suspended-sediment yields for both stable (i.e., “reference”) and unstable streams in each of the five Level III ecoregions in the State of MN. As discussed in the NRCS-ARS report (Klimetz and Simon, 2009), a stable stream is one in dynamic equilibrium, capable of transporting all sediment delivered to the system from upstream, without altering its dimensions over a period of years. Conversely, an unstable stream is one in which the supply of sediment from upstream is not in balance with the ability of the stream to transport that sediment through the reach without alterations to its geometry over a period of years. Results of the NRCS-ARS analysis estimated mean annual suspended-sediment yields from streams in Ecoregions 48 and 51 (the Lake Agassiz Plain and North Central Hardwoods, respectively) as shown in **Table 2**. These outcomes provide a baseline for comparison when results of the geomorphology work in the BRW are complete.

Table 2. Estimated mean annual suspended-sediment yields from streams in the Lake Agassiz Plan and North Central Hardwood Forest Ecoregions (adapted from Klimetz and Simon 2009.)

Ecoregion	Annual Sediment Yield – Stable Stream (tons/year/km^2)			Annual Sediment Yield – Unstable Stream (tons/year/km^2)		
	25th	50th	75th	25th	50th	75th
48 – Lake Agassiz Plain	1.23	1.28	3.30	4.75	8.16	11.2
51 – North Central Hardwoods	1.64	2.35	3.64	4.66	4.97	6.11

3. Analysis Procedures

The data presented here summarizes the fieldwork conducted in the Buffalo River watershed during the 2009 and 2010 seasons. When possible, these data are combined with historic data to analyze conditions in the study area over the most recent assessment period (i.e., past ten years). All water quality data used herein were obtained from MPCA personnel (Garvin, 2011) and the MPCA's online Environmental Data Access website (http://www.pca.state.mn.us/index.php/data/environmental-data-access.html).

Procedures established by the MPCA to assess stream condition were used to evaluate and assess the water quality in these streams (see MPCA, 2010 a). The purpose of this report addendum is not to determine if a stream reach is "impaired" as defined by the MPCA's formal assessment process, but rather to present the available water quality and biological data in the Buffalo River watershed. The MPCA's Professional Judgment Teams are ultimately responsible for determining if a stream reach is "impaired". As such, MPCA staff reviewed the water chemistry and IBI data presented within this addendum and, in the spring of 2011, released their preliminary results for recommended listings (i.e., identified those streams that are not meeting the beneficial uses for which they are protected). A list of those results is included below.

3.1 Water Quality Data

In order to assess the BRW for aquatic life and aquatic recreation uses, water quality data have been collected at various locations since 1971. The majority of the data available for analysis are related to dissolved oxygen, total phosphorus, total suspended solids, turbidity, and *Escherichia coli* (*E. coli*) levels. Other constituents (i.e., Nitrate, Nitrite, pH, chlorophyll-a, etc.) have been monitored over the past forty years, but not in sufficient quantities in the past ten years to be properly analyzed.

From April 2009 through October 2010, water chemistry data were collected at thirty-three locations within the Buffalo River Watershed. Eighteen Regional Assessment Locations (RALs) (described in Table 1.1 of the Watershed Conditions Report) and fifteen TMDL locations were sampled to assess the water quality conditions within the watershed. Water quality monitoring locations are shown in **Figure 2.** *E. coli*, dissolved oxygen, total suspended solids, and turbidity water quality standards and detailed narratives about each constituent can be found in the Watershed Conditions Report (pages 21, 22, 24, and 24, respectively).

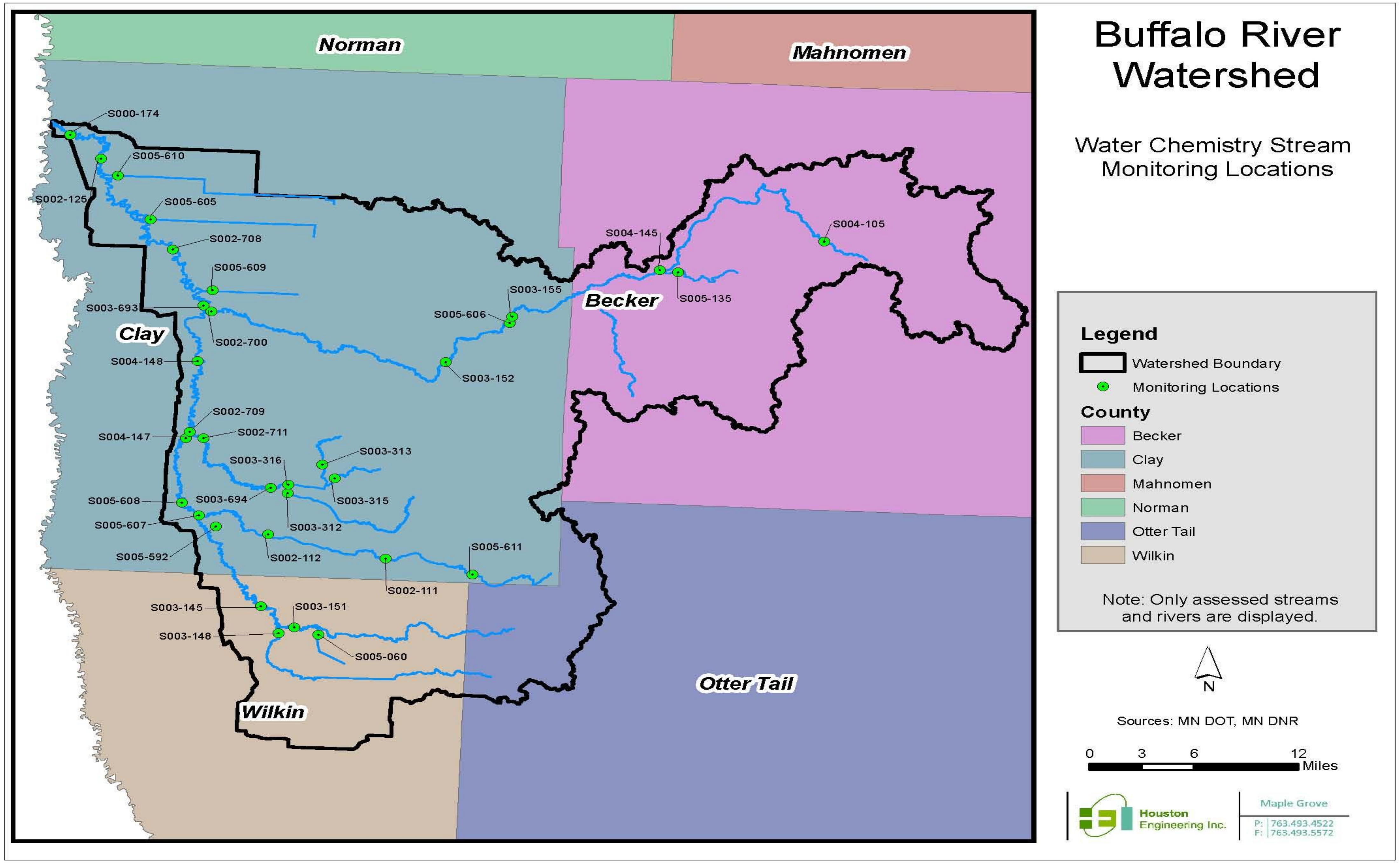


Figure 2. Regional Assessment and Total Maximum Daily Load Study water chemistry monitoring locations sampled during the 2009 and 2010 sampling seasons within the BRW.

3.1.1 Turbidity data

Over the past 40-years, turbidity data in the BRW has been collected by a number of different entities using different turbidity meters and reporting results in different turbidity units (**Table 4**). Given the nature of turbidity, this causes a problem since results of the various analysis techniques are often not directly comparable to one another and, until recently, reporting units were not clearly defined. In 2006, the USGS attempted to bring clarity to this situation by establishing a national protocol for reporting turbidity units, defining them by the type of equipment with which they were measured (USGS, 2005). In the BRW, turbidity measurement units include: Nephelometric Turbidity Units (NTUs), Nephelometric Turbidity Ratio Units (NTRUs), and Formazin Nephelometric Units (FNUs). The main difference amongst the turbidity measurement units is a function of instrument design. NTUs are measured using use a white light (400-680 nm) with a 90^{o} incident beam geometric detector angle. NTRUs are measured using a white light (400-680 nm) with the detector geometry at 90^{o} plus other angles. The instrument uses an algorithm to compute a single NTRU value. FNUs are measured using a monochrome light (780-900 nm) with a 90^{o} incident beam geometric detector angle (USGS, 2005). Given the differences in turbidity measurements within the BRW, comparing and analyzing the available turbidity data is difficult and poses a problem.

Table 3. Summary of turbidity sampling instruments and units used across the Buffalo River Watershed.

Collecting Entity	Turbidity Instrument	Turbidity Unit	Instrument Type
Minnesota Department of Health (MDH)	Hach 2100AN	NTRU	Lab
RMB Environmental Laboratories / MPCA	Hach 2100P	NTRU	Lab / Field
RMB Environmental Laboratories	HF Scientific Micro 100	NTU	Lab
United States Geological Survey	HF Scientific DRT 15CE	NTU	Field
Minnesota Pollution Control Agency (MPCA)	YSI 6820	FNU	Field

In order to summarize the BRW turbidity data and compare it to the applicable standards, “paired” data (i.e., samples collected/analyzed at the same time using two different methods) were compared to determine if NTUs, NTRUs, and/or FNUs could be combined to create a more robust and encompassing dataset for analysis. With help from MPCA personnel (Johnson, 2011), the turbidity data were analyzed and findings showed that FNU data were not comparable to the other data. It was shown, however, that NTU and NTRU data showed similar paired readings and, based on similar results in other studies around Minnesota (Johnson 2008), were able to be combined for comparison and analysis. Henceforth, all NTRU-field, NTRU-Lab, NTU-field, and NTU-lab samples were combined into one robust dataset and used for analysis in this work.

Turbidity has historically been measured in NTUs and, as such, the State water quality standard was developed to address this unit. However, the advancement in technology and more accurate sensors has created a problem with consistency of data quality over time. "Old" NTU data (i.e., data prior to 1996) is not the same nor can it be directly compared to "new" NTU data (i.e., data from 1996 to the present; Johnson, 2011). Since the analyses in this addendum address only those data that were collected within the most recent assessment period (i.e., the last ten years), this issue is less of a concern. However, since a unit has to be given to the newly combined NTU/NTRU data, NTRU was chosen (mainly) to avoid confusion when comparing "old" NTU with the "new" NTU/NTRU data.

3.2 Typical Ecoregion Ranges

Water quality varies across a landscape based on many factors, including differences in soils, plants, environmental conditions, amount of human impact on the landscape, etc. To help put this inherent variation in context, MPCA has collected data across the state and constructed a guide to the water quality conditions that are typically observed in each ecoregion during the summer months (MPCA, 2010 b). Results are presented on an ecoregion basis since these areas have relative homogeneity in regards to soils, potential natural vegetation, land use, and topography. Ecoregions are also the basis for the State's water quality standards. Ecoregion norms are separated between lakes and rivers and for selected constituents. The Buffalo River Watershed lies within three ecoregions: Lake Agassiz Plain (Red River Valley), North Central Hardwood, and Northern Lakes and Forests. The range from the 25th to the 75th percentile, known as the interquartile range, is often used as a "typical" range. Typical summer stream conditions for non-impacted streams in each ecoregion are displayed in **Table 4**.

Table 4. Typical summer stream conditions in Ecoregions of the BRW (adapted from McCollor and Heiskary 1993)

	Ecoregion		
Sample Parameter	**Red River Valley**	**Northern Lakes and Forests**	**North Central Hardwood Forests**
Conductivity (µmhos/cm)	440 - 630	120 - 260	250 - 310
pH (SU)	8.1 - 8.4	7.5 - 7.9	8.0 - 8.4
TSS (mg/L)	28 - 74	2.0 - 5.6	7.6 - 18.0
Total ammonia (mg/L)	0.08 - 0.20	0.06 - 0.20	0.08 - 0.20
NO_2 + NO_3 (mg/L)	0.01 - 0.10	0.10 - 0.03	0.03 - 0.12
Total phosphorus (mg/L)	0.14 - 0.33	0.03 - 0.05	0.07 - 0.17
Fecal Coliform (#/100 ml)	48 - 240	20 - 50	80 - 700
Temperature (^{o}C)	20 - 25	15.0 - 21.7	20 - 24
Turbidity (NTU)	12.5 - 27.5	1.5 - 4.0	4.9 - 10.0
Biological Oxygen Demand-5 day (mg/L)	2.0 - 4.5	0.85 - 1.60	1.6 - 3.3

3.3 Index of Biotic Integrity (IBI) Data

IBI data were collected at twenty-five stream and river locations throughout the BRW from mid-June through mid-September in 2009 and 2010. Fish and invertebrate IBI sampling was conducted within individual AUID stream reaches using MPCA biotic monitoring protocols. Fish and invertebrate IBI scores were calculated by MPCA staff to determine if healthy fish and invertebrate communities are found at each sampling location. After scoring was complete, MPCA staff determined if the AUID is supporting or impaired for aquatic life (judging for both fish and invertebrates separately).

Biotic impairment assessments for each AUID require only one sample or site visit to be completed. When making the final determination for 303(d) impairment listing, all information, including the biological condition of nearby upstream and downstream segments, local land use information, available water quality data, and habitat quality, was taken into account. Several sites in the BRW were determined to be “non-assessable” since ditches and straightened channels do not currently have formal standards set. Non-assessable waters will have formal standards once the TALU framework is completed (scheduled for 2014) and will then be assessed for impairment (as previously discussed).

3.4 Flow Data

Continuous flow data have been collected at three locations by the United States Geological Survey (USGS) since 1931. Increased monitoring efforts have led to the establishment of fifteen additional sites (eighteen total) in 2010 within the BRW, (**Table 5**), providing information on the quantity and timing of flow within the area’s rivers and creeks. The three automatic stream flow data loggers are maintained by the USGS while the others are managed by the MPCA. Manual stream flow data and rating curves were collected and calculated by MN DNR staff. MN DNR staff are currently working on developing the rating curves and calculating discharge. The discharge data should be completed in the fall of 2011. Once the data is available, nutrient loads can be calculated for each subwatershed. Due to the data not being finalized yet, actual flow data are not contained within this report.

Table 5. Continuous flow monitoring stations in the BRW.

Site Name	STORET ID	Years monitored	Sampling Agency
Buffalo River near Georgetown, CR108	S002-125	2010-2011	MN DNR
Clay County Ditch 39 near Kragnes, 50th St N	S002-700	2010-2011	MN DNR
Buffalo River near Averill, CR 94	S002-708	1931-2011	USGS
South Branch Buffalo near Sabin, CR 67	S002-709	2010-2011	MN DNR
Stony creek near Sabin, CR 68	S002-711	1945-2011	USGS
South Branch Buffalo River near Lawndale, 140th St	S003-148	2010-2011	MN DNR
Deerhorn Creek near Lawndale, 240th Ave	S003-151	2010-2011	MN DNR
Buffalo River near Hawley, CSAH31	S003-152	1945-2011	USGS
Buffalo River near Callaway, CSAH14	S004-105	2010-2011	MN DNR
Buffalo River near Lake Park, CSAH9	S004-145	2010-2011	MN DNR
S Branch Buffalo River near Glyndon, CR79 (28th AveS)	S004-148	2010-2011	MN DNR
Unnamed Trib to Buffalo River near Lake Park, 240th St	S005-135	2010-2011	MN DNR
Wolverton Creek near Comstock, 130th Ave S	S005-322	2010-2011	MN DNR
Clay County Ditch 10 near Kragnes, CSAH5 (30th St N)	S005-605	2010-2011	MN DNR
Whisky Creek near Baker, 90th St	S005-607	2010-2011	MN DNR
Clay County Ditch 2 near Glyndon, CSAH68 (90th St N)	S005-609	2010-2011	MN DNR
Clay County Ditch 10	S005-610	2010-2011	MN DNR
South Branch Buffalo River near Baker, CR57	S006-563	2010-2011	MN DNR

4. Results

4.1 Water Chemistry Data

Water chemistry data collected during the 2009 and 2010 field seasons (including the IWM data) were used to enhance and bolster the previously available data. Although the purpose of this addendum is to address the data collected during the 2009 and 2010 seasons, MPCA assessment procedures state that when assessing water bodies for impairments, the previous ten years of data collected during the open water season (April-October) should be analyzed. The statistics presented herein, were computed following that guidance. Several sites in the BRW had data for the past ten years, while other sites only had data collected during the 2009/2010 seasons. Summaries of the dissolved oxygen, total phosphorus, total suspended solids, and turbidity data used in this analysis can be found in **Appendix A;** the *E. coli* data summary can be found in **Appendix B.** **Appendix C** shows the final 303(d) listed (i.e., impaired) stream reaches in the BRW following the MPCA Judgment Team's 2011 overall assessment of chemical and biological data.

Water chemistry data collected during the open water season (April-October), from 2001-2010, (not including quality control samples) are summarized below. The purpose of these summaries is not to duplicate the formal assessment process completed by MPCA in the spring of 2011, but rather to present the results of the water quality sampling. The MPCA assessment team takes issues beyond these types of statistics into consideration when determining if a segment should be recommended as impaired; those considerations are beyond the scope of this addendum. Due to the large number of sampling sites in the BRW, the water quality summary figures were split into two sections: Buffalo River Main Branch and Buffalo River South Branch. Stream monitoring locations on the Main Branch are displayed from the upstream-most monitoring site to the downstream-most monitoring location. Due to the tributaries on the South Branch, locations are displayed as the upstream to downstream locations on the Buffalo River (South Branch), then Deerhorn Creek, then Whiskey Creek, and finally Stony Creek. All data are summarized using box and whisker plots. A diagram of how to interpret these plots can be found in **Figure 3**. The top of the box represents the value that 75 percent of observations are at or below while the bottom of the box represents the value that 25 percent of all observations are at or below. When available, the "typical" summer ecoregion range (see **Section 3.2**) for each constituent is shown on the plot as a reference. Since only three monitoring sites are located in the North Central Hardwood Forest Ecoregion (S004-105, S005-006, S005-611), the typical summer ecoregion ranges from the Lake Agassiz ecoregion were used as the reference range.

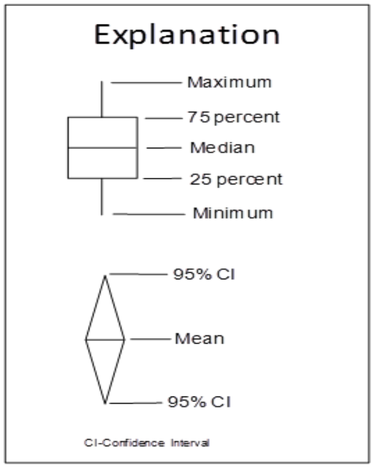


Figure 3. Diagram of how to interpret the box and whisker plots.

4.1.1 Dissolved Oxygen

Per MPCA protocol, to assess a stream for a dissolved oxygen (DO) impairment at least 20 independent observations must be available from May through September, over at least 2-years, and all samples should be taken before 9:00am (to measure the lowest diurnal DO concentration). Statistics are then computed by lumping the samples over the entire data set. A stream is considered impaired if more than 10 percent of the observations do not meet the numeric water quality criteria and if there are at least 3 violations within the dataset. The numeric criteria for Class 2B waters are a minimum concentration of 5 mg/L. **Figures 4-5** summarize the dissolved oxygen concentrations for all monitored sites over the past ten years.

Prior to the 2009/2010 sampling effort, Hay Creek (S002-711) was the only waterbody in the BRW listed as impaired for DO. After the 2009/2010 seasons, MPCA's professional judgment team determined the headwaters to Deerhorn Creek (S003-148) to also be impaired for DO. The 2009/2010 data supported the impairment listing of Hay Creek. F**igures 4-5** show low levels of DO at a number of other sites in the BRW, these sites were not recommended for 303(d) listing by the MPCA due to other considerations, including the time of day that samples were collected or channelization of the reach.

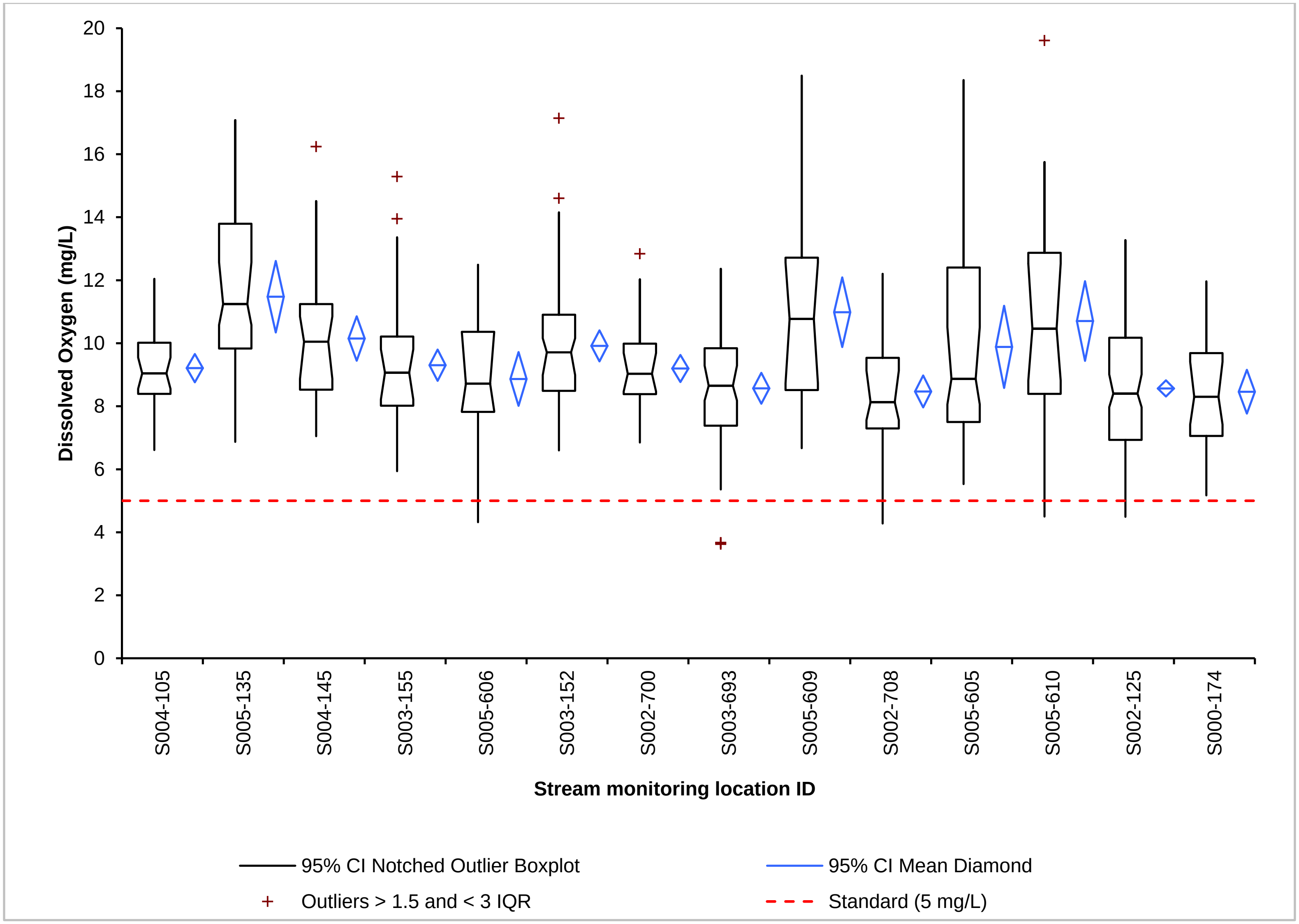


Figure 4. Dissolved oxygen concentrations (mg/L) from 2001-2010 for monitoring locations on the main stem of the Buffalo River.

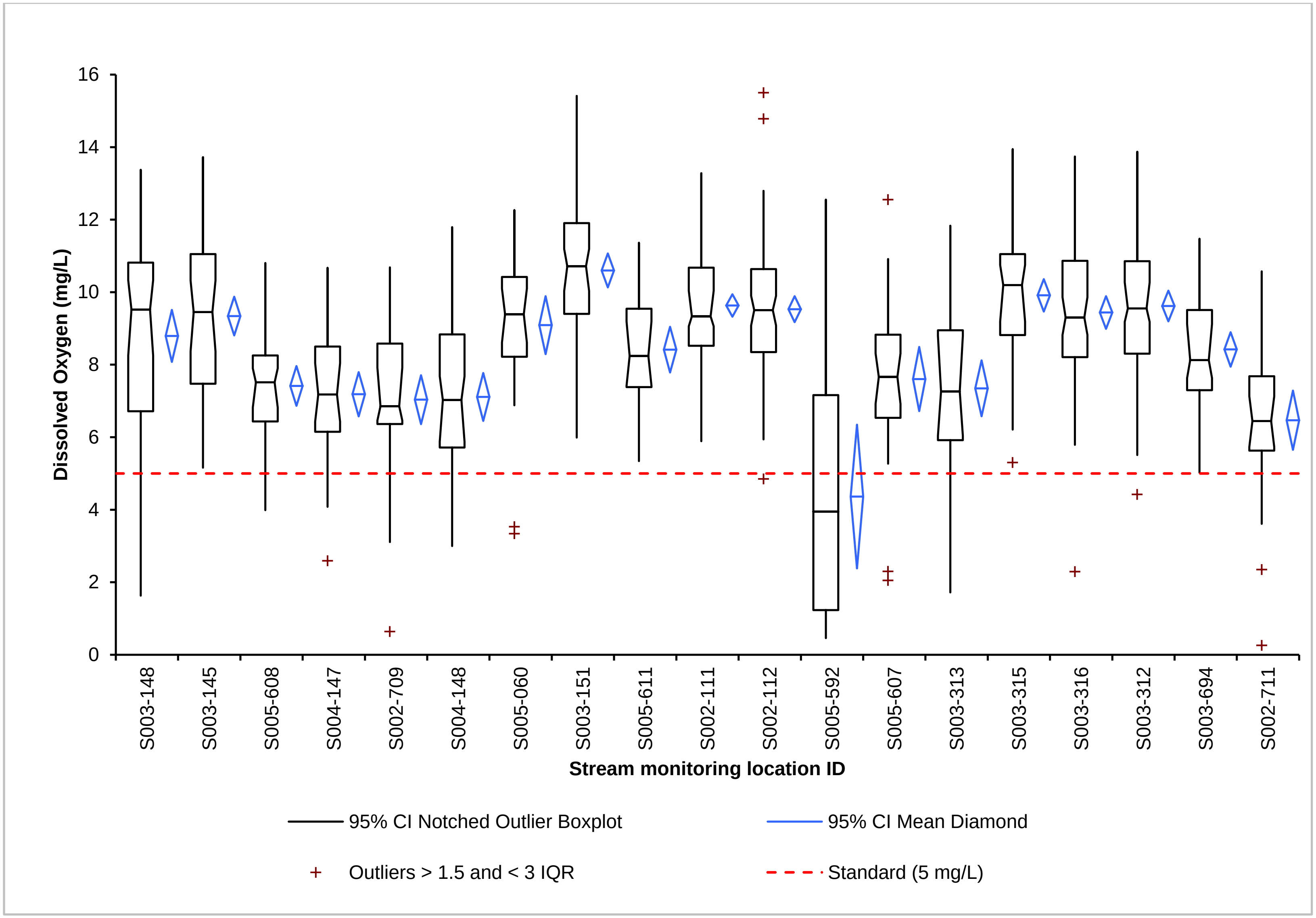


Figure 5. Dissolved oxygen concentrations (mg/L) from 2001-2010 for monitoring locations located on the South Branch of the Buffalo River or on a tributary of the South Branch.

4.1.2 Total Phosphorus

The MPCA does not currently have eutrophication standards (including a standard for total phosphorus (TP) for the State's streams and rivers, though draft standards have been released and are currently under review. As such, none of the streams or reaches in the BRW are considered impaired for phosphorus, though some may be if the draft standards are accepted as is. **Figures 6-7** display the TP concentrations within the rivers and streams of the BRW with reference to typical ecoregion ranges. **Table 6** shows the draft river eutrophication standards that would apply in the BRW, listed by River Nutrient Region (Heiskary, Bouchard and Markus, 2010).

Table 6. Draft Nutrient Criteria Applicable to the BRW.

Level III Nutrient Ecoregion	River Nutrient Region	Draft Total Phosphorus Criteria (ug/L)	Draft Chlorophyll-a Criteria (ug/L)	Draft Dissolved Oxygen flux Criteria (mg/L)	Draft BOD_5 Criteria (mg/L)
Lake Agassiz	South	150	<40	≤5.0	≤3.5
North Central Hardwood Forest	Central	100	<20	≤4.5	≤2.0

The majority of monitored rivers and streams are within or below the typical ecoregion ranges. All monitored sites have phosphorus concentrations in which the 75th percentile of all samples fall within the typical ecoregion ranges. Several sites (e.g. S002-125, S002-111, S002-112, etc.) have a few samples that have high TP concentrations that fall well outside the typical summer ecoregion ranges.

However, if the draft total phosphorus standards were accepted, the data shows that the majority of sites would be in violation. Only three monitoring sites (S005-609, S005-060, S003-151, S005-611) had zero observations that exceed the draft Lake Agassiz (150 ug/L) standard in the past ten years, while one of the three monitoring sites (S005-611) in the North Central Hardwood Ecoregion would exceed the 100 ug/l proposed standard. Once the stream standards are finalized, these sites should be reassessed for a TP impairment.

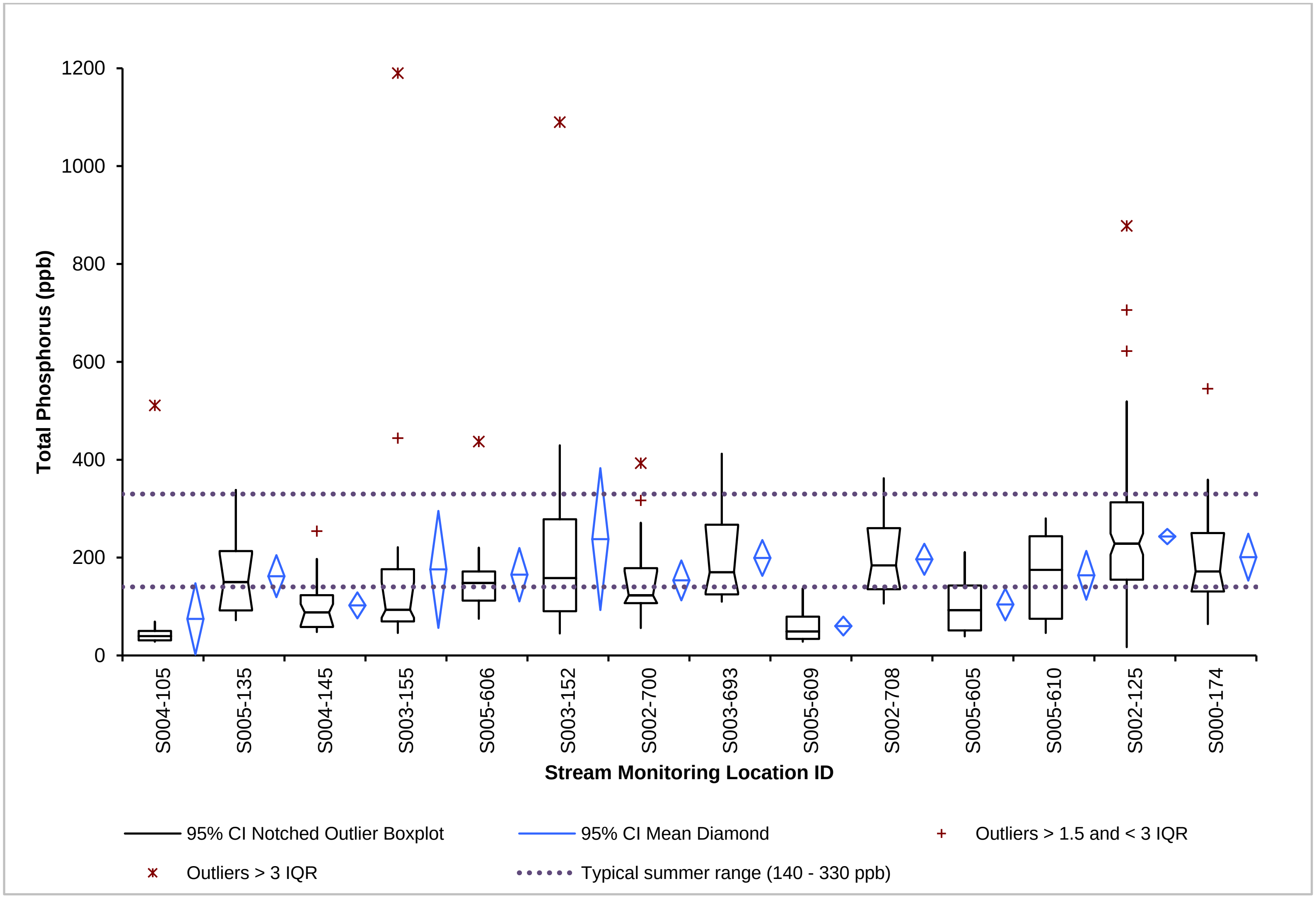


Figure 6. Total phosphorus concentrations (ppb) from 2001-2010 for monitoring locations located on the main stem of the Buffalo River.

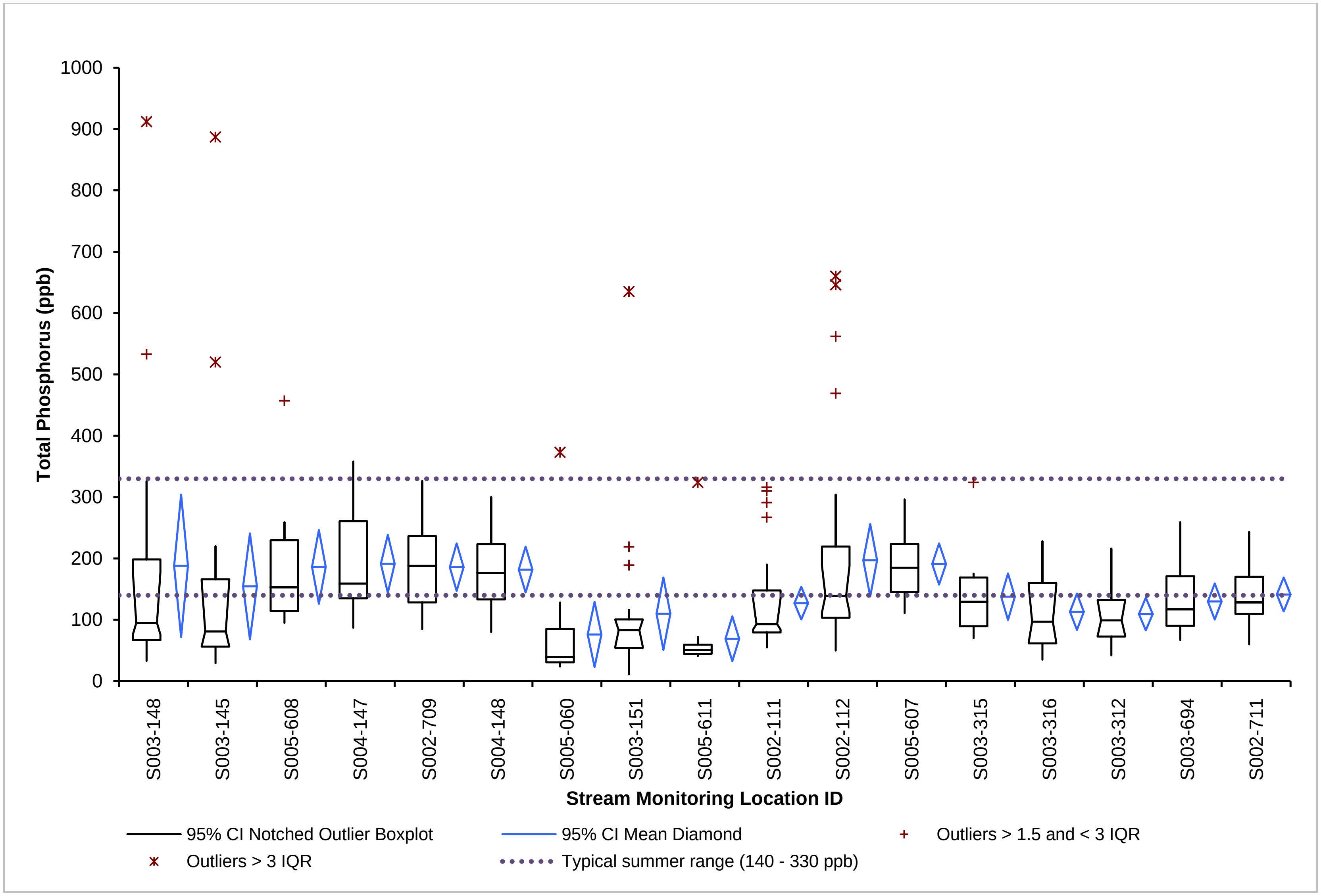


Figure 7. Total phosphorus concentrations (ppb) from 2001-2010 for monitoring locations located on the south branch of the Buffalo River or on a tributary of the South Branch.

4.1.3 Turbidity

The statewide numeric water quality criterion for turbidity states that levels must be below 25 NTUs. Twenty independent observations are needed for an assessment. To be listed as impaired, at least three observations and 10% of all observations must be in violation of the standard. **Figures 8-9** display the summary of turbidity measurements taken in the watershed during the most recent assessment period, from 2001 and 2010.

The data show that eighteen monitoring sites exceed the typical summer ecoregion ranges. Generally, the further downstream a monitoring site is the higher the turbidity. The 2010 303(d) list of impaired waters had 8 BRW AUIDs listed for turbidity impairment. After completion of the IWM, an additional three AUIDs are being proposed for impairment. Overall, thirteen stream reaches (AUID 09020106-506 was split into three AUIDs during MPCA's 2011 assessment process) are proposed to be on the 2012 303(d) impaired waters list for turbidity.

4.1.4 Total Suspended Solids

Total suspended solids (TSS) do not have a direct numeric criterion, although it is currently under development. Under current water quality standards, however, TSS can be used as a surrogate for turbidity when insufficient turbidity data exists. TSS is also often used to quantify sediment loading rates. A minimum of 20 independent observations are required when using TSS as a surrogate for assessing turbidity water quality standard compliance. Per the assessment guidance (MPCA 2010 a), a TSS measurement of 100 mg/L or greater in the North Central Hardwood Forest (NCHF) Ecoregion indicates a violation of the turbidity standard. Total suspended solids data for all monitoring locations can be found in **Figures 10-11**.

Out of the thirty-one sites that had TSS data collected, nineteen sites are above the typical summer ecoregion range. These data are not surprising as turbidity and TSS are related and turbidity is high throughout the watershed.

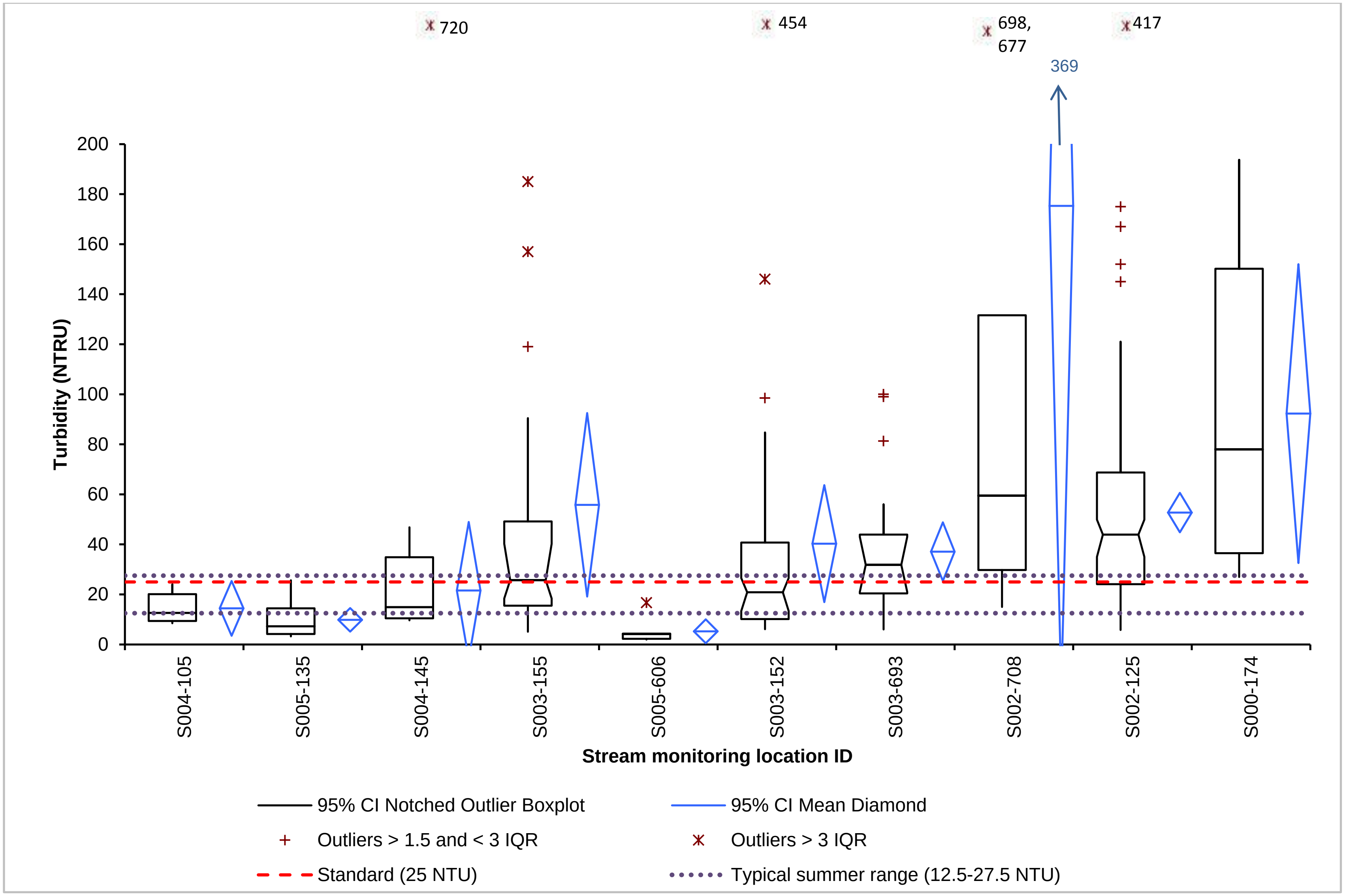


Figure 8. Turbidity measurements (NTRU) from 2001-2010 for monitoring locations located on the main stem of the Buffalo River.

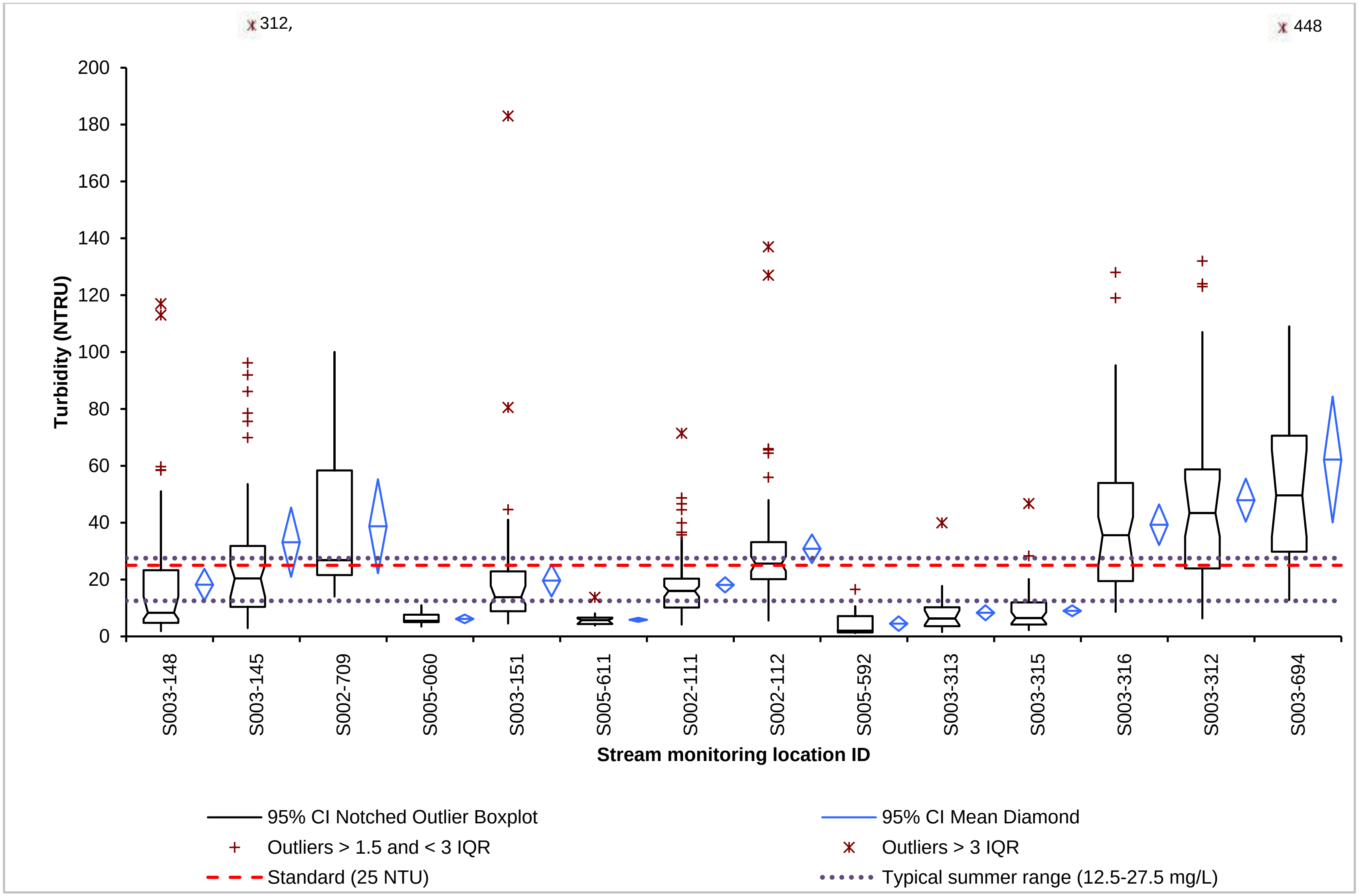


Figure 9. Turbidity measurements (NTRU) from 2001-2010 for monitoring locations located on the south branch of the Buffalo River or a tributary of the South Branch.

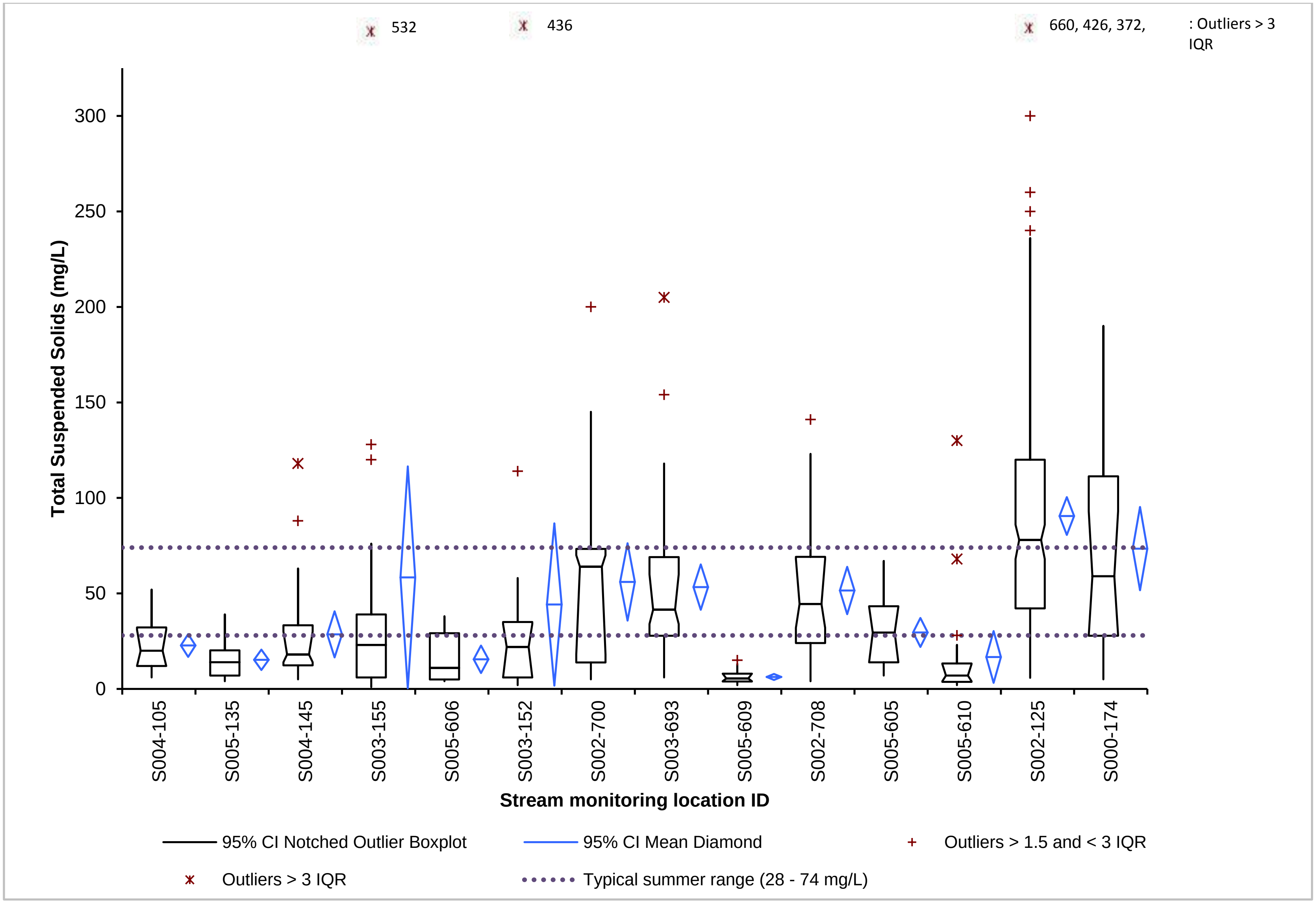


Figure 10. Total suspended solids concentrations (mg/L) from 2001-2010 for monitoring locations located on the main stem of the Buffalo River.

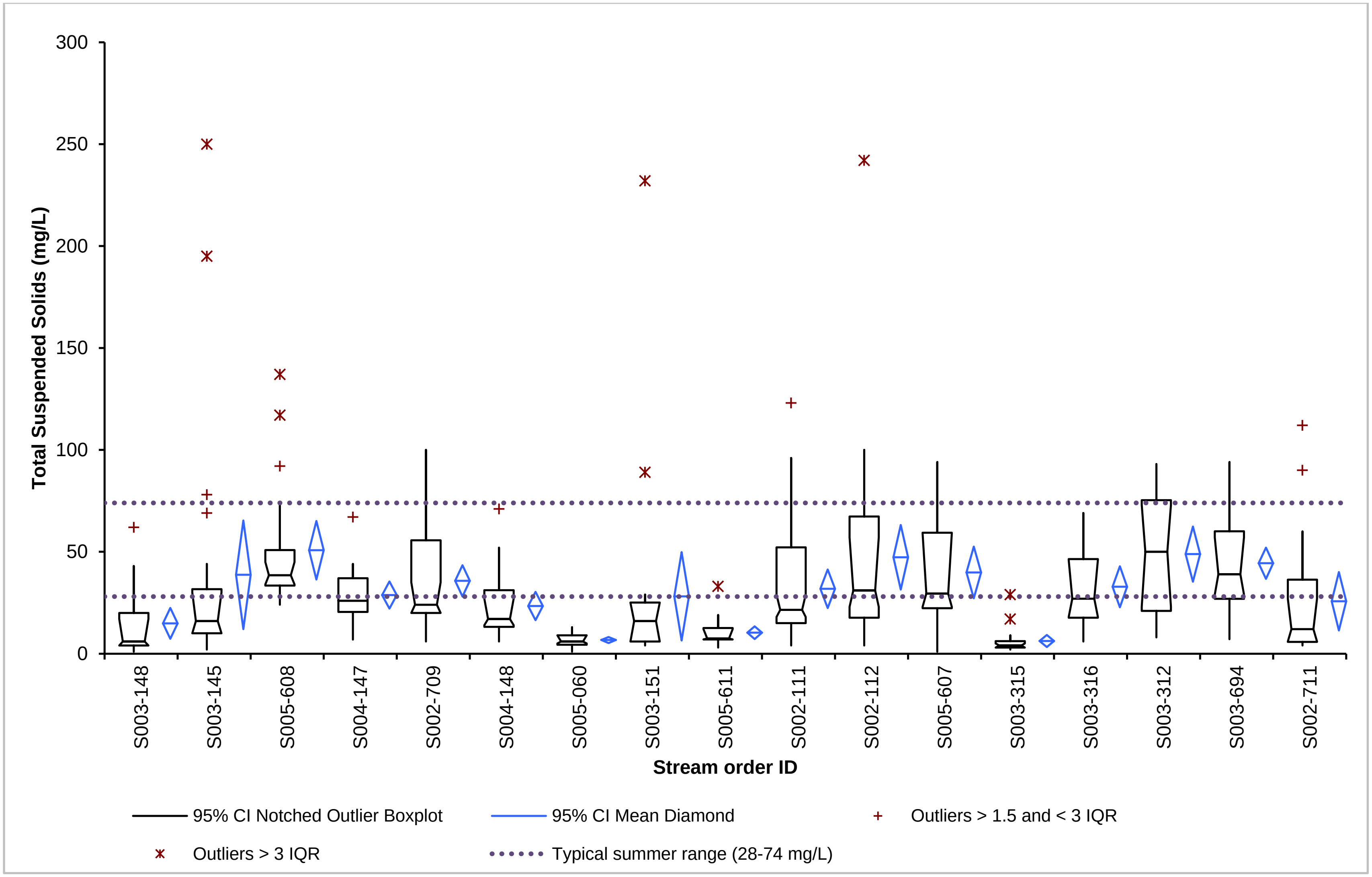


Figure 11. Total suspended solids concentrations (mg/L) from 2001-2010 for monitoring locations located on the South Branch of the Buffalo River or on a tributary of the South Branch.

4.1.5 *Escherichia coli* (*E. coli*)

Due to the inherent variability of quantifying the persistence of a living population over time, bacteria water quality standards are written to address not less than five data points, analyzed on a monthly basis. Since 2007, Minnesota's state water quality standards have used *E. coli* as the indicator organism for water quality standards. Because bacteria concentrations typically follow a lognormal distribution, the standard's numeric criteria address both the geometric mean and the value that 10% of data exceed. As an example, when assessing bacteria concentrations for compliance, the geometric mean is calculated from all samples collected in May of each year and compared to the numeric criteria. The value may not exceed 126 organisms per 100 milliliters, nor shall more than ten percent of all samples taken during that calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies between April 1 and October 31. **Figures 12-16** display the summary of *E. coli* data (by month) collected in the BRW between 2001 and 2010. Results show that nearly every site is in violation of the standard at some point during the year.

The 2010 303(d) impaired waters list had one AUID (09020106-506; Buffalo River mainstem) listed as impaired for *E. coil*. After the 2011 assessment, twenty-two AUIDs are proposed as impaired for *E. coli*. These impairments are seen under both the geometric mean and 90 percent values. As a result, *E. coli* is the most wide ranging impairment within the BRW.

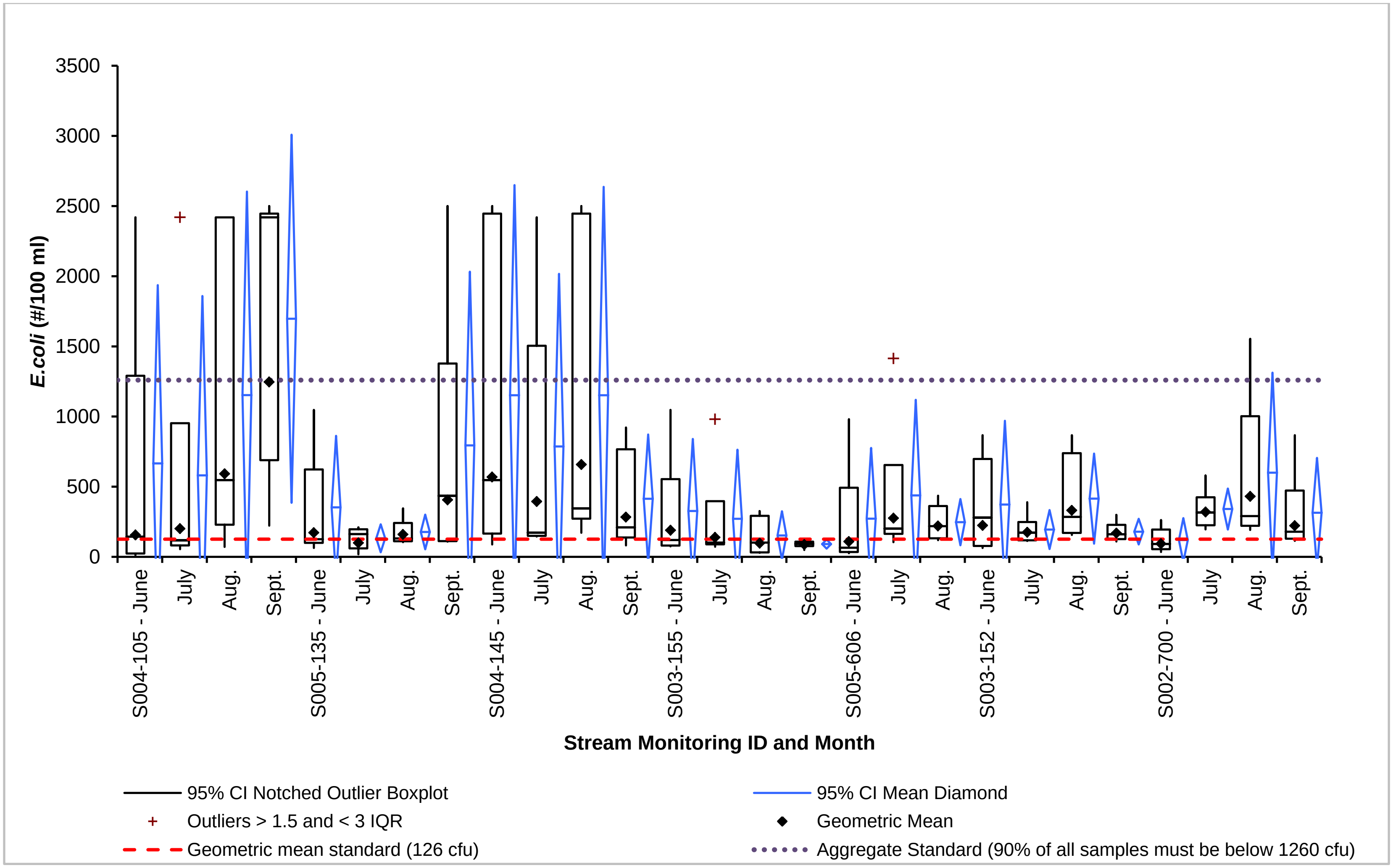


Figure 12. *Escherichia coli* (*E. coli*) concentrations (by month) from 2001-2010 for monitoring locations located on the main stem of the Buffalo River from the headwaters to where it joins with the South Branch.

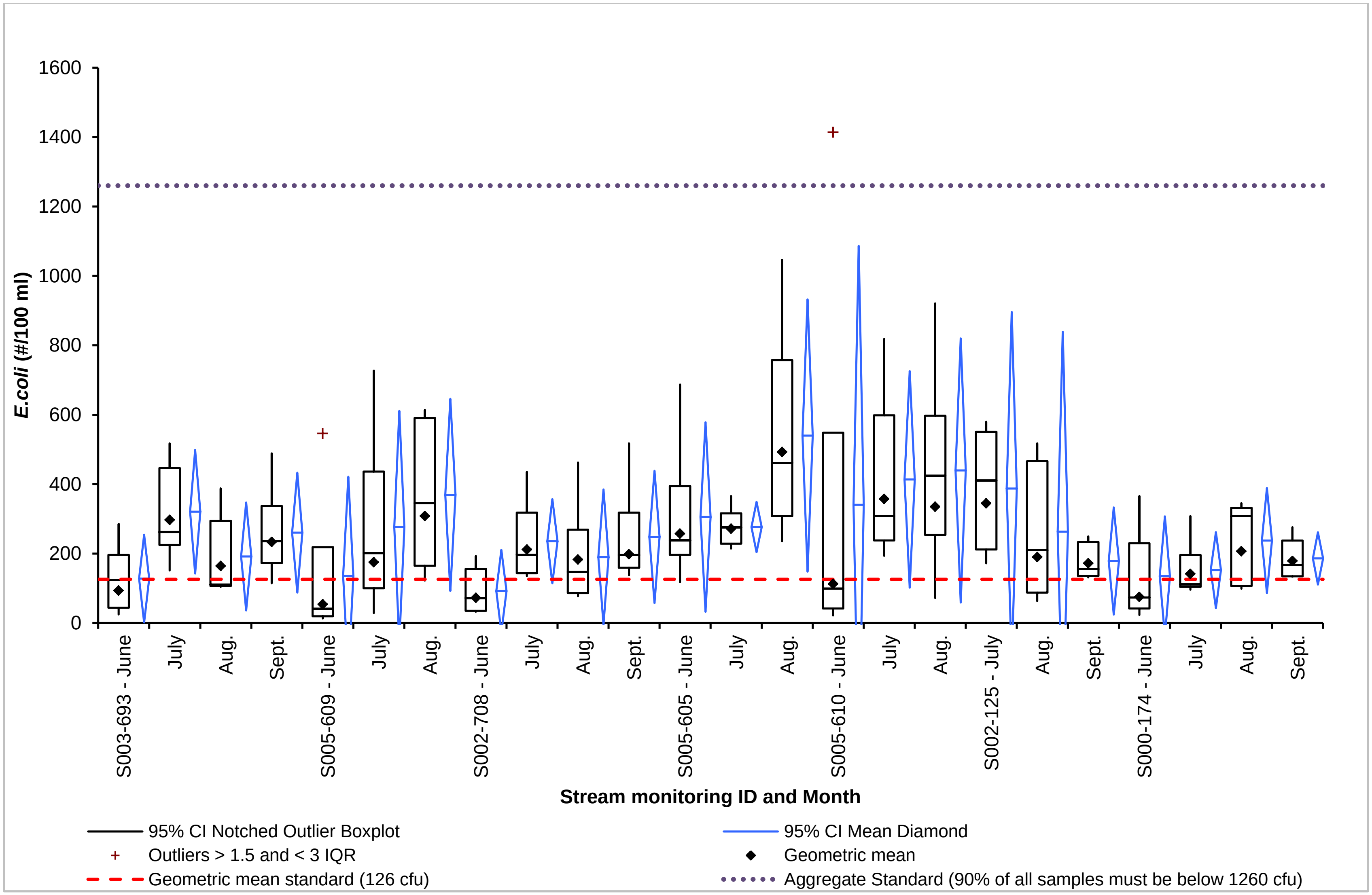


Figure 13. ***Escherichia coli*** **(*E. coli*) concentrations (by month) from 2001-2010 for monitoring locations on the main stem of the Buffalo River from where it meets with the South Branch to the convergence with the Red River.**

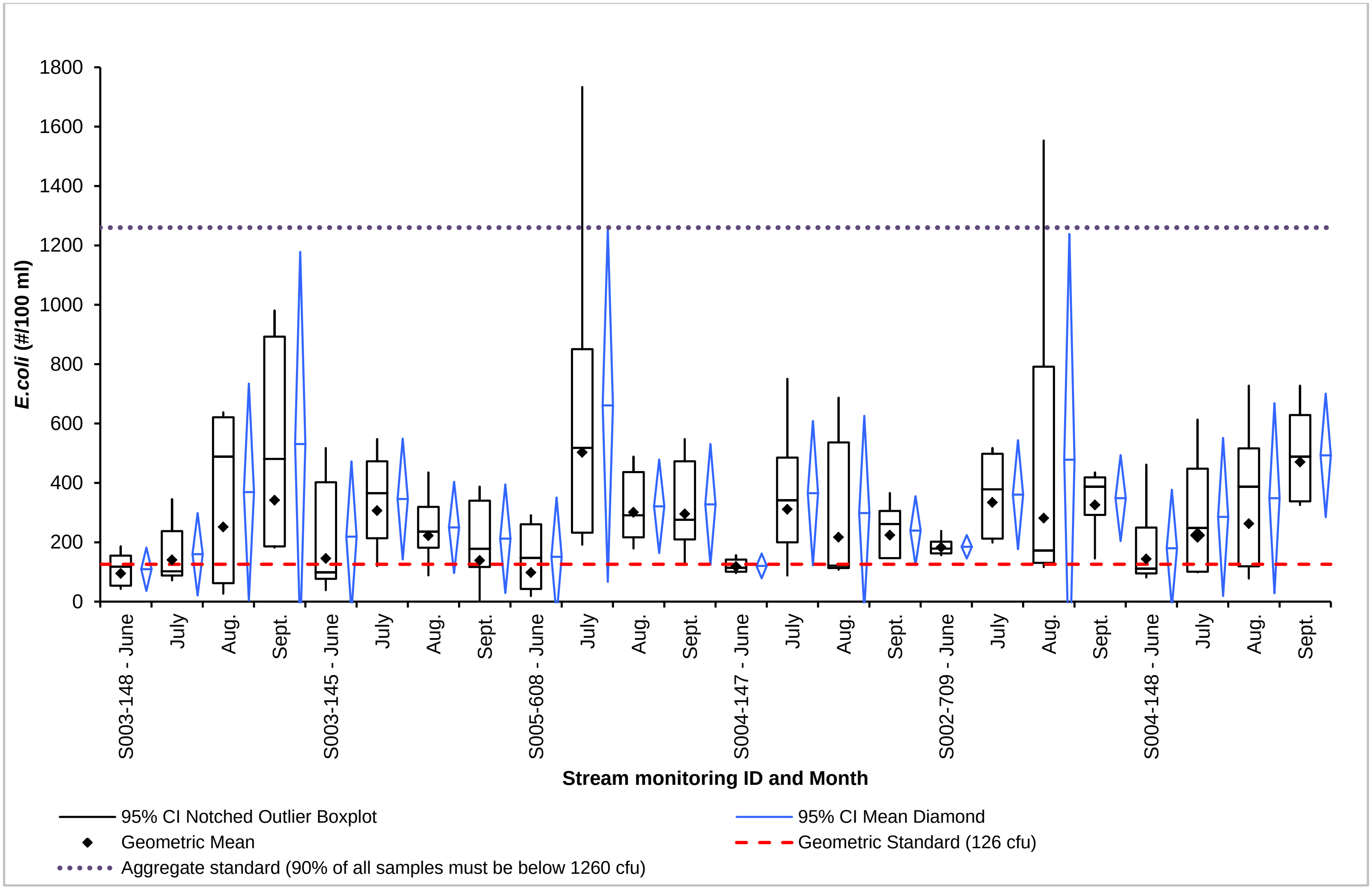


Figure 14. *Escherichia coli* (*E. coli*) concentrations (by month) from 2001-2010 for monitoring locations located on the South Branch of the Buffalo River.

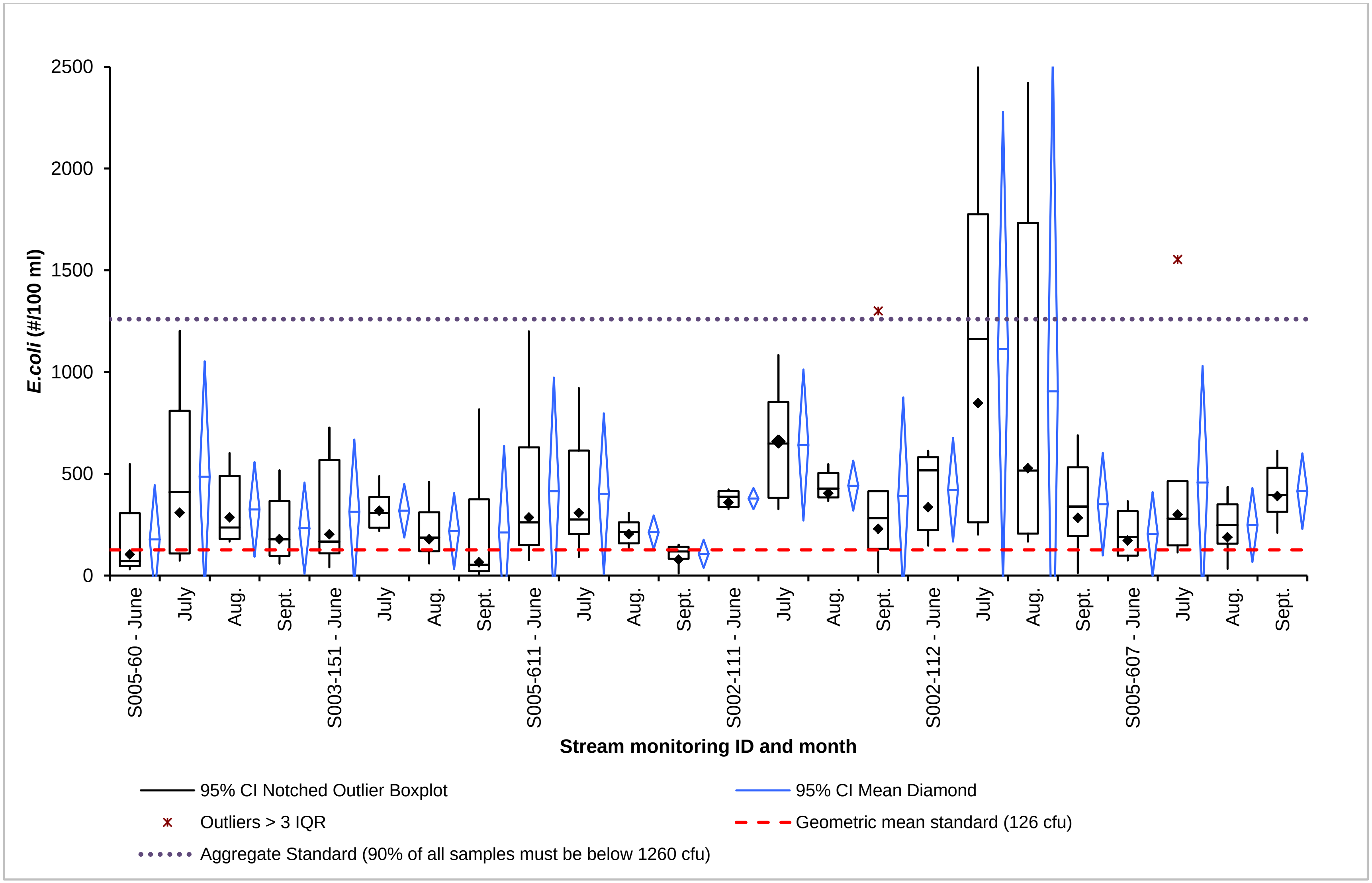


Figure 15. *Escherichia coli* (*E. coli*) concentrations (by month) from 2001-2010 for monitoring locations on the Deerhorn and Whiskey Creek (tributaries of the South Branch of the Buffalo River).

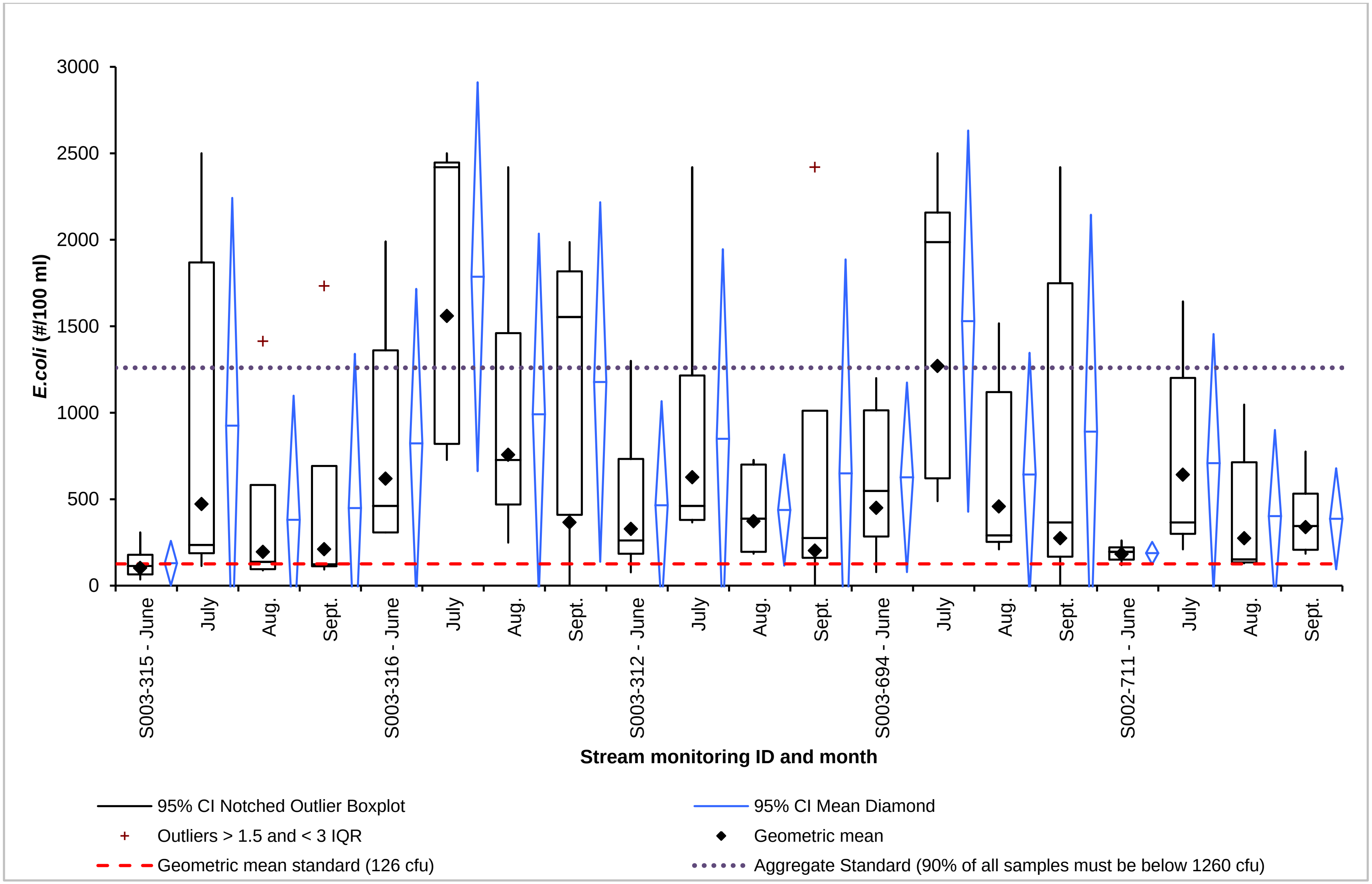


Figure 16. *Escherichia coli* (*E. coli*) concentrations (by month) from 2001-2010 for monitoring locations located on Stony Creek (a tributary to the South Branch of the Buffalo River).

4.2 Index of Biotic Integrity Data

The MPCA collected varying amounts of invertebrate and fish data depending on the stream length being assessed and ability to gain access to each stream reach. In all, twenty-five locations were sampled to assess if aquatic life uses meet the standard for their intended uses. Prior to the IWM assessment, Deerhorn Creek (AUID 09020106-505) was the only reach in the BRW with an IBI impairment (for fish). After the IWM assessment, the fishery assessment concluded the following: nine locations support the intended use, four locations do not support their intended use, eleven are non-assessable, and one has no data/information. The invertebrate assessment concluded the following: five locations support the intended use, six locations do not support their aquatic life use, eleven are non-assessable, and three have no data/information. Furthermore, Deerhorn Creek (the single stream reach on the 2010 303(d) impairment list) is proposed to be removed from the list for the 2012 submittal. Data collected during the AUID assessment showed the fish scores were above the upper confidence interval. **Table 7** shows the results of the IBI assessment as determined by the MPCA staff.

Table 7. Index of Biotic Indices results from the Intensive Watershed Monitoring for stream reaches in the Buffalo River Watershed.

Assessment Unit ID (AUID)	Use support or listing based on IBI score* Fish	Invertebrates
09020106-501	Support	Support
09020106-502	Support	No data
09020106-503	Support	Support
09020106-504	Support	No data
09020106-505	Full support	Non-support
09020106-507	Non-support	Non-support
09020106-508	Non-assessable	Non-assessable
09020106-509	Non-assessable	Non-assessable
09020106-511	Non-assessable	Non-assessable
09020106-515	Non-assessable	Non-assessable
09020106-519	Non-assessable	Non-assessable
09020106-520	Non-assessable	Non-assessable
09020106-521	Support	Support
09020106-523	Non-assessable	Non-assessable
09020106-531	Non-assessable	Non-assessable
09020106-534	Non-support	Non-support
09020106-555	Non-support	Non-support
09020106-556	Non-assessable	Non-assessable
09020106-559	Non-assessable	Non-assessable
09020106-562	Non-assessable	Non-assessable
09020106-586	Support	Non-support
09020106-593	Non-support	Non-support
09020106-594	Support	Support
09020106-595	Support	Support
09020106-900	No information provided	No information provided

*Non-assessable = AUID is a channelized stream or ditch and cannot be properly assessed until Tiered Aquatic Life Use (TALU) framework is completed.

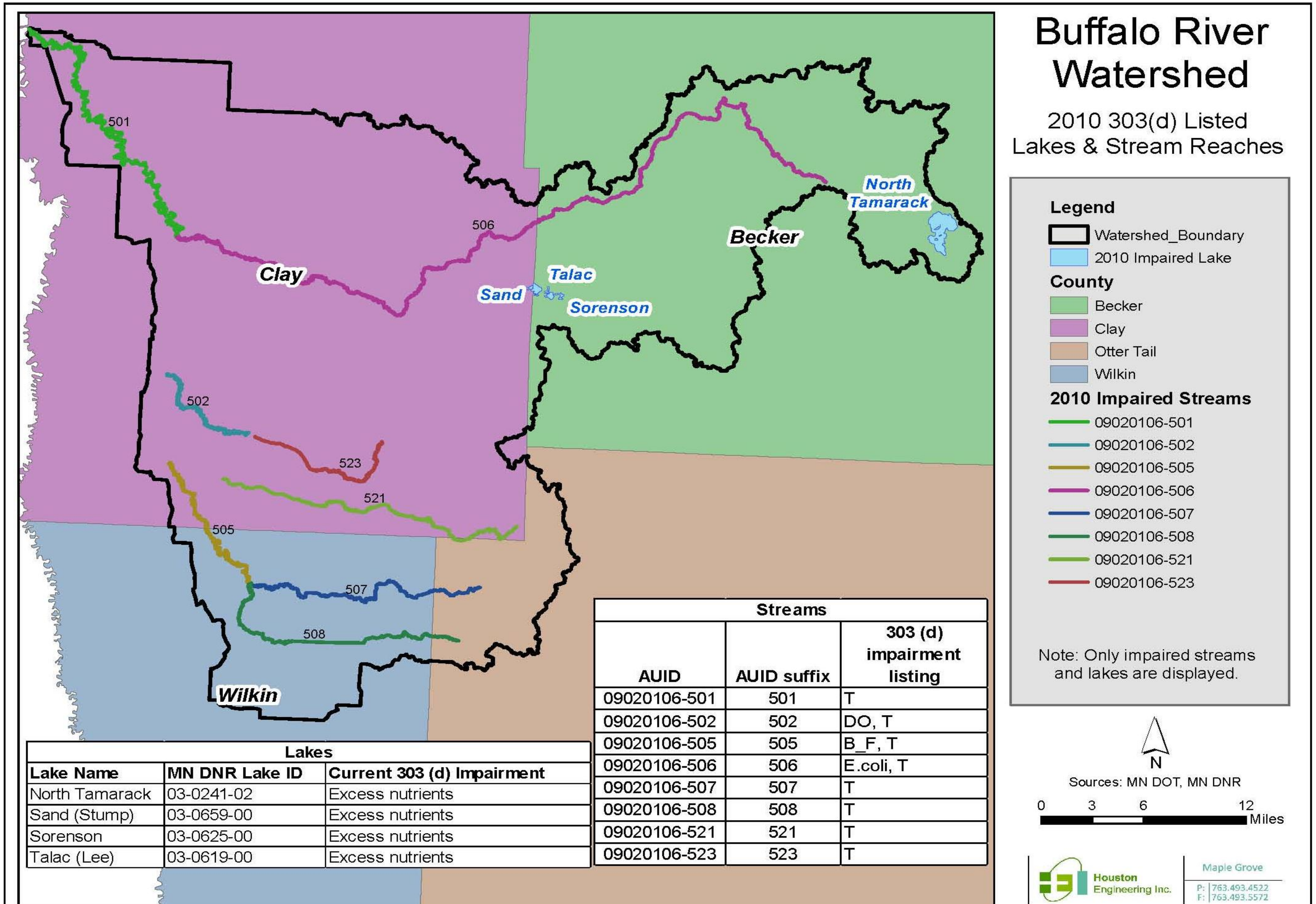
5. 2009/2010 Monitoring Impacts and Summary

The IWM had a profound effect on assessing the beneficial uses and water quality of streams within the watershed. According to the 2010 303(d) list of impaired waters, eight stream reaches with eleven impairments exist in the watershed (**Figure 17**). Results of the 2009-2010 sampling (including the IWM) found thirty new impairments on fifteen additional stream reaches (**Figure 18**). After the completion of the 2009/2010 monitoring, up to twenty-five impaired reaches with forty-four impairments are proposed for inclusion on the 2012 303(d) list (**Figure 19**). **Table 8** summarizes all assessed AUIDs with proposed impairments.

Prior to the 2009/2010 sampling, turbidity was the most widespread impairment within the BRW with eight reaches being impaired. After completion of the recent assessment, *E. coli* is the most widespread impairment. In 2010, only one AUID (09020106-506) was listed as impaired for *E. coli*. In 2011, twenty-two AUIDs have been proposed as being impaired for *E. coli*. The data shows these additional impairment listings are warranted as these reaches exceed the standards.

During the 2009/2010 sampling, fish and invertebrate data were collected to assess the watershed for biologic impairments. This collection provided important data on how biologic communities are affected by various pollutants. The changes in community structure, function, and species diversity are a direct result of pollutants in the waterbody. While chemical analyses may determine a waterbody is impaired, analyses of the biologic community may conclude the waterbody is supporting healthy biologic communities, and vice-a-versa. By using a combination of biologic and chemical analyses, a more holistic “picture” is able to be formed about how individual waterbodies are being affected by the surrounding landscape.

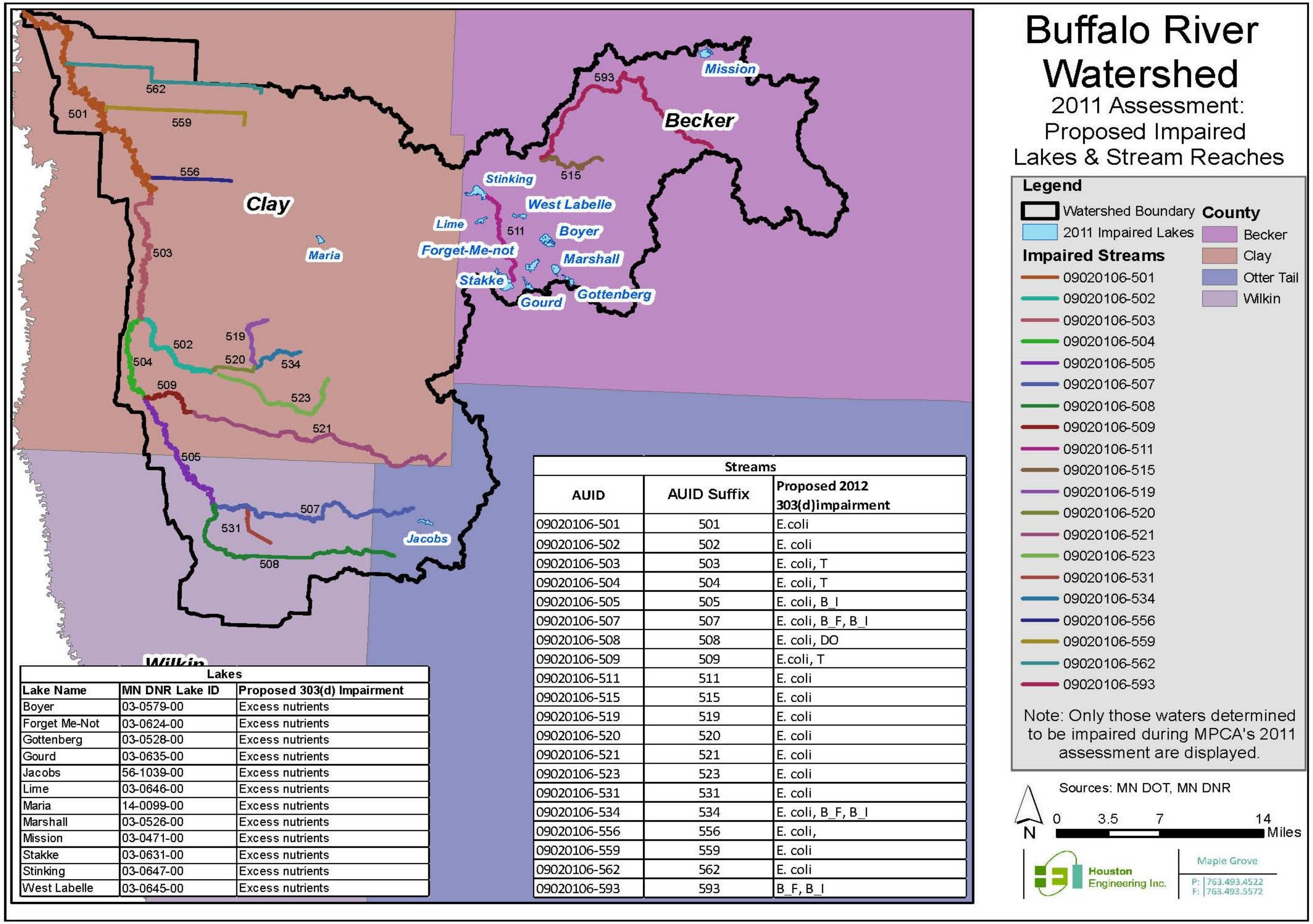
More biotic impairments may be found in the BRW once the TALU framework is enacted (scheduled for 2014). Preliminary results from non-assessed channelized streams and rivers show another fourteen invertebrate and sixteen fish impairments may exist within the watershed. These preliminary findings will be assessed and formalized by MPCA once the TALU framework is final. A completed listing of all the impairments found within the BRW, including those that were not recommended for inclusion on the 2012 303(d) list due to channelization of the reach, are included in **Appendix C**.



Lakes		
Lake Name	**MN DNR Lake ID**	**Current 303 (d) Impairment**
North Tamarack	03-0241-02	Excess nutrients
Sand (Stump)	03-0659-00	Excess nutrients
Sorenson	03-0625-00	Excess nutrients
Talac (Lee)	03-0619-00	Excess nutrients

Streams		
AUID	**AUID suffix**	**303 (d) impairment listing**
09020106-501	501	T
09020106-502	502	DO, T
09020106-505	505	B_F, T
09020106-506	506	E.coli, T
09020106-507	507	T
09020106-508	508	T
09020106-521	521	T
09020106-523	523	T

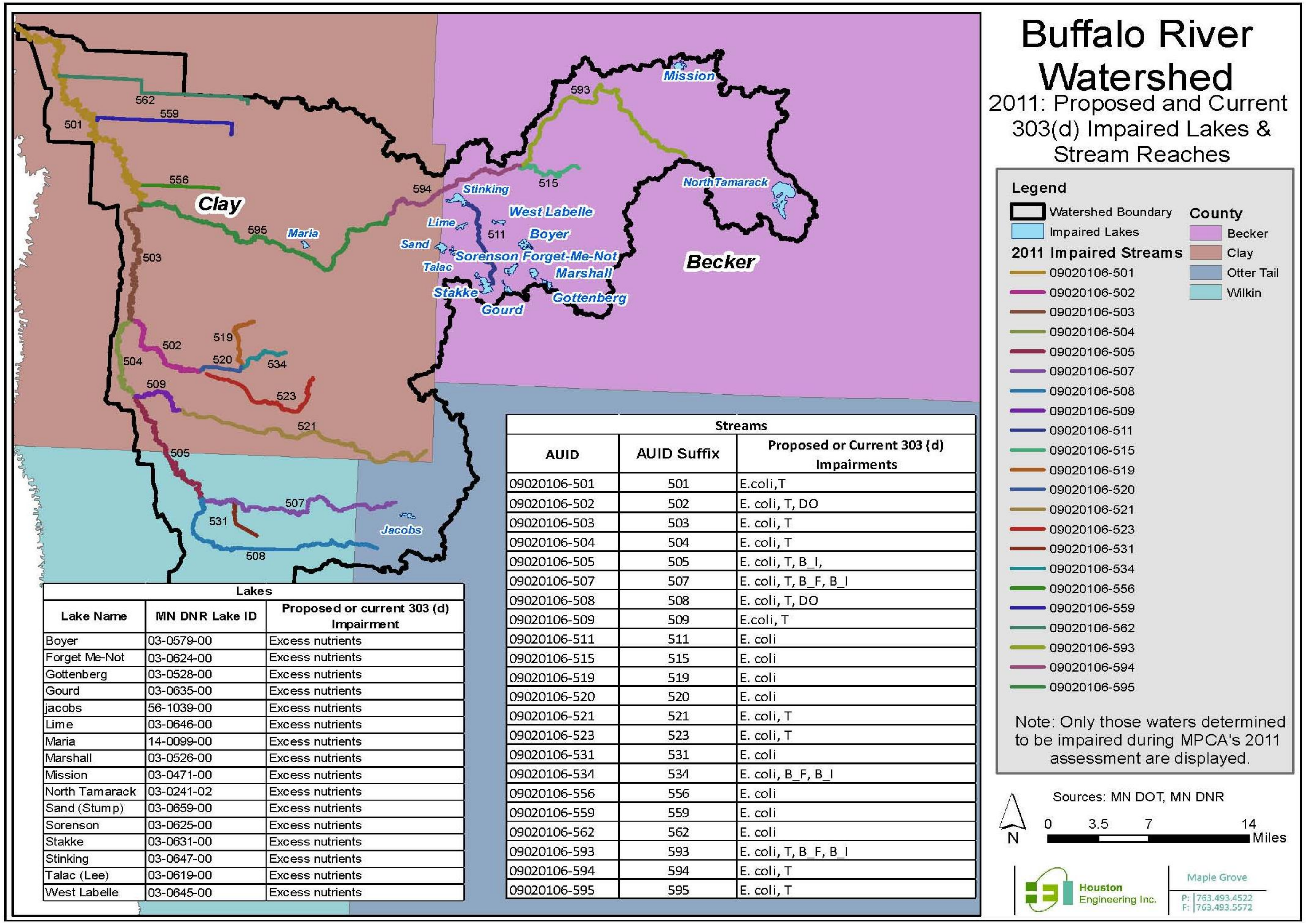
Figure 17. 2010 303(d) listed impaired lakes and stream reaches within the BRW. Note: B_F=Biological, fish, DO = Dissolved Oxygen, *E. coli* = Escherichia coli, T = Turbidity blue labels indicate impaired lakes, black labels indicate stream AUID suffix.



Lakes		
Lake Name	MN DNR Lake ID	Proposed 303(d) Impairment
Boyer	03-0579-00	Excess nutrients
Forget Me-Not	03-0624-00	Excess nutrients
Gottenberg	03-0528-00	Excess nutrients
Gourd	03-0635-00	Excess nutrients
Jacobs	56-1039-00	Excess nutrients
Lime	03-0646-00	Excess nutrients
Maria	14-0099-00	Excess nutrients
Marshall	03-0526-00	Excess nutrients
Mission	03-0471-00	Excess nutrients
Stakke	03-0631-00	Excess nutrients
Stinking	03-0647-00	Excess nutrients
West Labelle	03-0645-00	Excess nutrients

Streams		
AUID	AUID Suffix	Proposed 2012 303(d)impairment
09020106-501	501	E.coli
09020106-502	502	E. coli
09020106-503	503	E. coli, T
09020106-504	504	E. coli, T
09020106-505	505	E. coli, B_I
09020106-507	507	E. coli, B_F, B_I
09020106-508	508	E. coli, DO
09020106-509	509	E.coli, T
09020106-511	511	E. coli
09020106-515	515	E. coli
09020106-519	519	E. coli
09020106-520	520	E. coli
09020106-521	521	E. coli
09020106-523	523	E. coli
09020106-531	531	E. coli
09020106-534	534	E. coli, B_F, B_I
09020106-556	556	E. coli,
09020106-559	559	E. coli
09020106-562	562	E. coli
09020106-593	593	B_F, B_I

Figure 18. Proposed new 303(d) listed impairments within the BRW after the 2009/2010 Monitoring. Note: B_F=Biological, fish, DO = Dissolved Oxygen, *E. coli* = Escherichia coli, T = Turbidity, blue labels indicate impaired lakes, black labels indicate stream AUID suffix.



Lakes		
Lake Name	MN DNR Lake ID	Proposed or current 303 (d) Impairment
Boyer	03-0579-00	Excess nutrients
Forget Me-Not	03-0624-00	Excess nutrients
Gottenberg	03-0528-00	Excess nutrients
Gourd	03-0635-00	Excess nutrients
jacobs	56-1039-00	Excess nutrients
Lime	03-0646-00	Excess nutrients
Maria	14-0099-00	Excess nutrients
Marshall	03-0526-00	Excess nutrients
Mission	03-0471-00	Excess nutrients
North Tamarack	03-0241-02	Excess nutrients
Sand (Stump)	03-0659-00	Excess nutrients
Sorenson	03-0625-00	Excess nutrients
Stakke	03-0631-00	Excess nutrients
Stinking	03-0647-00	Excess nutrients
Talac (Lee)	03-0619-00	Excess nutrients
West Labelle	03-0645-00	Excess nutrients

Streams		
AUID	AUID Suffix	Proposed or Current 303 (d) Impairments
09020106-501	501	E.coli,T
09020106-502	502	E. coli, T, DO
09020106-503	503	E. coli, T
09020106-504	504	E. coli, T
09020106-505	505	E. coli, T, B_I,
09020106-507	507	E. coli, T, B_F, B_I
09020106-508	508	E. coli, T, DO
09020106-509	509	E.coli, T
09020106-511	511	E. coli
09020106-515	515	E. coli
09020106-519	519	E. coli
09020106-520	520	E. coli
09020106-521	521	E. coli, T
09020106-523	523	E. coli, T
09020106-531	531	E. coli
09020106-534	534	E. coli, B_F, B_I
09020106-556	556	E. coli
09020106-559	559	E. coli
09020106-562	562	E. coli
09020106-593	593	E. coli, T, B_F, B_I
09020106-594	594	E. coli, T
09020106-595	595	E. coli, T

Figure 19. Proposed and current 303(d) listed impaired lakes and stream reaches within the BRW. Note: B_F=Biological, fish, B_I = Biological, Invertebrates, DO = Dissolved Oxygen, *E. coli* = Escherichia coli, T = Turbidity, blue labels indicate impaired lakes, black labels indicate stream AUID suffix.

Table 8. 2010 303(d) listed impaired stream reaches and 2011 proposed impairments following the 2009/2010 Monitoring.

Impaired Stream Reach	Assessment Unit ID (AUID)	Affected use	2010 303(d) listed impairment	New Proposed Impairments after 2011 assessment	Proposed Stream Reach Impairments after 2009/2010 Monitoring	Year listed on EPA 303(d) impaired waters list (for at least one parameter)
Buffalo River - S Br Buffalo R to Red R	09020106-501	Aquatic Life, Aquatic Recreation	Turbidity	*E. coli*	*E. coli*, Turbidity	1996
Stony Creek - Hay Cr to S Br Buffalo R	09020106-502	Aquatic Life, Aquatic Recreation	Turbidity, Dissolved Oxygen	*E. coli*	*E. coli*, Turbidity, Dissolved Oxygen	1996
Buffalo River, South Branch - Stony Cr to Buffalo R	09020106-503	Aquatic Life, Aquatic Recreation	No impairment listed	*E. coli*, Turbidity	*E. coli*, Turbidity	n/a
Buffalo River, South Branch - Whisky Cr to Stony Cr	09020106-504	Aquatic Life, Aquatic Recreation	No impairment listed	*E. coli*, Turbidity	*E. coli*, Turbidity	n/a
Buffalo River, South Branch - Deerhorn Cr to Whisky Cr	09020106-505	Aquatic Life, Aquatic Recreation	Turbidity, Biological_Fishes	*E. Coli*, Biological_Invertebrates	*E. coli*, Turbidity, Biological_Invertebrates	2002
Buffalo River - Buffalo Lake to S. Branch Buffalo R	09020106-506	Aquatic Life, Aquatic Recreation	*E. coli*, Turbidity	-	Split AUID into 09020106-593, 594, 595	2010
Deerhorn Creek - Headwaters to S Br Buffalo R	09020106-507	Aquatic Life, Aquatic Recreation	Turbidity	*E. coli*, Biological_Fishes, Biological_Invertebrates	*E. coli*, Turbidity, Biological_Fishes, Biological_Invertebrates	2010
Buffalo River, South Branch - Headwaters to Deerhorn Cr	09020106-508	Aquatic Life, Aquatic Recreation	Turbidity	*E. coli*, Dissolved Oxygen	*E. coli*, Turbidity, Dissolved Oxygen	2010
Whisky Creek - T137 R47W S13, east line to S Br Buffalo R	09020106-509	Aquatic Life, Aquatic Recreation	No impairment listed	*E. coli*, Turbidity	*E. coli*, Turbidity	n/a
Hay Creek - Headwaters to Stinking Lk	09020106-511	Aquatic Life, Aquatic Recreation	No impairment listed	*E. coli*	*E. coli*	n/a
Becker County Ditch 15 - Unnamed ditch to Buffalo R	09020106-515	Aquatic Recreation	No impairment listed	*E. coli*	*E. coli*	n/a
Hay Creek - Unnamed cr to Spring Cr	09020106-519	Aquatic Recreation	No impairment listed	*E. coli*	*E. coli*	n/a
Hay Creek - Spring Cr to Stony Cr	09020106-520	Aquatic Life, Aquatic Recreation	No impairment listed	*E. coli*	*E. coli*	n/a
Whisky Creek - Headwaters to T137 R46W S18, west line	09020106-521	Aquatic Life, Aquatic Recreation	Turbidity	*E. coli*	*E. coli*, Turbidity	2010
Stony Creek - T137 R45W S3, north line to T137 R46W S5, north line	09020106-523	Aquatic Life, Aquatic Recreation	Turbidity	*E. coli*	*E. coli*, Turbidity	2010

Table 8. (continued). **2010 303(d) listed impaired stream reaches and 2011 proposed impairments following the 2009/2010 Monitoring.**

Impaired Stream Reach	Assessment Unit ID (AUID)	Affected use	2010 303(d) listed impairment	New Proposed Impairments after 2011 assessment	Proposed Stream Reach Impairments after 2009/2010 Monitoring	Year listed on EPA 303(d) impaired waters list (for at least one parameter)
State Ditch 14 – Wilkin County Ditch 40 to Deerhorn Cr	09020106-531	Aquatic Recreation	No impairment listed	*E. coli*	*E. coli*	n/a
Spring Creek - Unnamed cr to Hay Cr	09020106-534	Aquatic Life, Aquatic Recreation	No impairment listed	*E. coli*, Biological_Fishes, Biological_Invertebrates	*E. coli*, Biological_Fishes, Biological_Invertebrates	n/a
County Ditch 2 - Unnamed cr to Buffalo R	09020106-556	Aquatic Recreation	No impairment listed	*E. coli*	*E. coli*	n/a
County Ditch 39 - Headwaters to Buffalo R	09020106-559	Aquatic Life, Aquatic Recreation	No impairment listed	*E. coli*	*E. coli*	n/a
County Ditch 10 - Headwaters to Buffalo R	09020106-562	Aquatic Life, Aquatic Recreation	No impairment listed	*E. coli*	*E. coli*	n/a
Buffalo River - Buffalo Lk to Becker County Ditch 15	09020106-593	Aquatic Life, Aquatic Recreation	See AUID 09020106-506	Biological_Fishes, Biological_Invertebrates	*E. coli*, Turbidity, Biological_Fishes, Biological_Invertebrates	See AUID 09020106-506
Buffalo River – Becker County Ditch 15 to Hay Cr	09020106-594	Aquatic Life, Aquatic Recreation	See AUID 09020106-506	-	*E. coli*, Turbidity	See AUID 09020106-506
Buffalo River - Hay Cr to S Br Buffalo R	09020106-595	Aquatic Life, Aquatic Recreation	See AUID 09020106-506	-	*E. coli*, Turbidity	See AUID 09020106-506

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7. Appendices

Appendix A. Summary of dissolved oxygen, total phosphorus, total suspended solids and turbidity data collected from 2001-2010.

AUID	Year	Dates	Dissolved oxygen (mg/L)				Total Phosphorus (ppb)			Total suspended solids (mg/L)			Turbidity (NTRU)		
			N	Mean	Median	Number of samples exceeding standard	N	Mean	Median	N	Mean	Median	N	Mean	Median
Standard			5 mg/L										25 NTU		
S004-105															
	2006	6/5-8/28	5	8.79	8.40					1	22.00	n/a			
	2008	7/23-10/16	9	8.74	9.02		3	200.7	49.0	3	12.67	12.00	3	14.36	10.60
	2009	4/14-10/19	18	9.43	9.30		11	40.4	35.0	15	23.53	27.00	1	14.60	14.60
	2010	4/20-6/30	4	9.79	9.21					3	23.33	18.00			
S005-135															
	2008	7/14-10/16	10	12.36	12.80		4	193.8	182.5	4	10.67	8.00	4	7.18	5.35
	2009	4/14-10/19	15	11.13	11.10		16	146.4	107.0	15	15.53	14.00	7	11.34	12.70
	2010	6/15-6/30	2	9.24	9.24										
S004-145															
	2006	6/5-10/17	7	11.04	10.61					3	11.00	12.00			
	2008	7/14-10/16	10	10.00	10.05		4	123.3	126.5	4	26.25	18.00	4	21.56	14.90
	2009	4/14-10/19	15	9.78	10.18		14	91.1	88.0	14	28.14	19.00			
	2010	4/20-6/30	5	9.80	9.64		4	131.0	82.0	4	57.50	45.00			
S003-155															
	2002	5/16-10/23	6	9.01	8.84		4	458.8	297.0	6	118.67	20.00	6	148.38	17.95
	2003	5/14-10/21	6	8.55	7.79								6	45.55	25.30
	2004	4/21-11/9	8	9.57	9.48								8	45.38	26.75
	2005	4/20-7/8	4	9.38	10.03								3	32.47	33.95
	2006	4/20-10/16	6	9.13	8.29								6	36.12	19.60

AUID	Year	Dates	Dissolved oxygen (mg/L) N	Dissolved oxygen (mg/L) Mean	Dissolved oxygen (mg/L) Median	Dissolved oxygen (mg/L) Number of samples exceeding standard	Total Phosphorus (ppb) N	Total Phosphorus (ppb) Mean	Total Phosphorus (ppb) Median	Total suspended solids (mg/L) N	Total suspended solids (mg/L) Mean	Total suspended solids (mg/L) Median	Turbidity (NTRU) N	Turbidity (NTRU) Mean	Turbidity (NTRU) Median
	2007	4/25-10/30											5	32.88	23.30
	2008	4/18-10/16	13	9.75	9.67		7	121.9	110.0				1	79.30	79.30
	2009	4/21-10/13	11	9.45	8.89		7	78.1	91.0	11	24.91	16.00	1	19.90	19.90
	2010	4/14-10/19	14	8.98	8.59		4	113.5	78.0	4	43.50	33.50	4	32.09	36.70
S005-606															
	2009	4/21-10/19	17	9.54	9.18		13	164.8	148.0	13	14.40	8.00	7	5.26	4.10
	2010	6/3-8/19	5	7.28	7.99					1	29.00				
S003-152															
	2002	5/16-10/23	6	9.67	9.48		5	439.6	370.0	6	99.50	16.50	6	100.25	17.35
	2003	5/14-10/21	6	9.25	9.12								6	30.74	19.50
	2004	4/21-11/9	8	10.12	9.95								8	36.40	21.85
	2005	4/20-7/8	4	10.68	11.09								3	27.21	33.10
	2006	4/20-10/17	14	10.27	10.20					7	19.71	23.00	7	21.62	22.20
	2007	4/25-10/30											5	25.79	10.50
	2008	4/18-10/21	12	10.96	11.14								1	81.90	81.90
	2009	6/2-10/13	9	9.53	8.52		7	143.3	123.0	5	14.20	6.00			
	2010	4/15-10/19	14	8.99	8.27		3	122.0	92.0	3	40.67	34.00	4	22.68	20.85
S002-700															
	2006	4/24-10/19	10	9.56	9.52					3	7.33	5.00			
	2009	4/21-10/8	19	9.53	9.39		15	119.5	108.0	15	48.60	63.00			
	2010	4/14-10/5	11	8.53	8.34		7	213.0	148.0	7	89.14	70.00			
S003-693															
	2005	5/9-10/20	12	7.34	7.37	1				11	51.73	36.00	12	33.05	25.00
	2006	4/10-10/19	14	9.33	9.25					12	54.00	53.00	2	24.50	24.50
	2009	3/24-10/13	23	9.29	9.43	1	17	185.5	167.5	15	44.40	37.50	8	46.31	33.00
	2010	4/14-10/5	13	7.55	7.72	1	7	228.4	186.0	7	69.86	42.00			

AUID	Year	Dates	Dissolved oxygen (mg/L)				Total Phosphorus (ppb)			Total suspended solids (mg/L)			Turbidity (NTRU)		
			N	Mean	Median	Number of samples exceeding standard	N	Mean	Median	N	Mean	Median	N	Mean	Median
S005-609															
	2009	4/21-10/13	15	10.89	11.96		7	53.1	52.0	11	5.00	4.00			
	2010	4/14-10/5	12	11.10	10.58		7	67.0	39.0	11	7.20	7.00			
S002-708															
	2006	6/19-10/19	16	8.63	8.40		10	195.8	200.5	15	65.20	67.00	7	50.14	55.00
	2007	4/22-6/26								2	6.51	6.51	2	687.50	687.50
	2009	4/21-10/13	20	8.72	8.57		9	182.9	163.0	9	31.22	24.00	1	27.10	27.10
	2010	4/14-10/5	15	7.79	7.68	1	9	198.7	195.0	9	57.11	45.00			
S005-605															
	2009	4/21-10/13	16	10.73	8.87		7	92.1	95.0	11	27.42	29.00			
	2010	4/14-10/5	14	9.51	8.77	1	9	115.3	79.0	11	28.08	31.00			
S005-610															
	2009	4/21-10/13	15	9.85	10.71	3	7	159.0	169.0	11	13.50	6.00			
	2010	4/14-10/5	13	11.34	10.22		7	168.0	222.0	10	21.10	6.00			
S002-125															
	2003	4/8-8/20	14	6.60	6.26	1	18	250.4	176.0	18	130.83	83.50			
	2004	3/29-11/2	21	8.75	8.53		25	271.2	264.0	28	142.29	105.00			
	2005	3/28-10/20	25	8.08	7.64	1	21	263.4	243.0	24	111.29	112.00	2	15.00	15.00
	2006	4/3-10/19	21	8.73	8.83		18	218.3	207.5	19	84.05	84.00	1	15.00	15.00
	2007	3/26-10/16	22	8.04	7.66	3	21	324.5	328.0	21	118.95	111.00	20	94.63	80.55
	2008	4/8-12/2	45	8.83	8.66		46	231.4	223.0	46	76.27	70.50	34	58.77	52.50
	2009	1/21-12/1	43	8.83	8.74		42	189.9	183.5	42	55.67	45.50	41	35.61	33.30
	2010	1/13-12/2	39	9.07	9.91		39	235.3	253.0	39	74.82	73.00	38	46.59	36.50

AUID	Year	Dates	Dissolved oxygen (mg/L)				Total Phosphorus (ppb)			Total suspended solids (mg/L)			Turbidity (NTRU)		
			N	Mean	Median	Number of samples exceeding standard	N	Mean	Median	N	Mean	Median	N	Mean	Median
S000-174															
	2001	6/12-9/18	2	6.48	6.48		7	244.7	201.0	7	111.86	110.00	7	92.27	78.00
	2009	5/4-10/19	16	8.91	8.97		12	183.3	171.5	13	51.62	41.00			
	2010	4/14-9/14	12	8.20	8.06		3	169.0	150.0	6	76.00	69.50			
S003-148															
	2002	5/16-10/22	6	10.52	11.03		3	0.2	0.2	5	24.40	26.00	6	23.83	19.30
	2003	5/16-10/30	4	9.31	10.09	1							4	2.36	2.31
	2004	4/7-10/28	5	10.46	10.39								5	22.97	25.90
	2005	4/13-10/18	7	8.74	9.51								7	24.76	19.10
	2006	4/21-10/10	6	9.90	9.97								6	12.95	10.95
	2007	4/17-9/11	5	9.02	8.70								5	33.28	14.00
	2008	4/29-10/14	6	9.51	10.47								6	7.11	5.74
	2009	4/24-10/7	17	7.08	6.12	7	7	119.6	83.0	10	10.30	6.00	17	18.98	7.73
	2010	4/9-10/7	14	7.85	8.67	4	8	245.8	136.5	8	21.29	6.00	11	15.38	5.41
S003-145															
	2002	5/16-10/22	6	10.02	10.64		4	418.8	370.0	5	107.00	69.00	6	97.79	17.00
	2003	5/16-9/25	3	9.00	9.78								3	22.50	21.60
	2004	4/7-10/28	4	9.40	9.52								4	17.71	16.72
	2005	4/13-10/18	5	7.94	7.51								5	6.50	5.39
	2006	4/21-10/10	7	9.52	9.80								7	40.21	20.50
	2007	4/17-10/4	7	9.65	9.21								7	20.87	22.00
	2008	4/22-10/16	17	9.30	9.34		7	100.4	104.0	1	18.00	n/a	7	35.80	16.30
	2009	4/24-10/14	18	9.75	10.83		9	103.7	75.0	15	17.20	15.00	16	22.19	18.80
	2010	4/9-10/7	10	9.39	8.79		3	101.7	85.0	3	41.00	30.00	9	36.58	26.00

AUID	Year	Dates	Dissolved oxygen (mg/L) N	Mean	Median	Number of samples exceeding standard	Total Phosphorus (ppb) N	Mean	Median	Total suspended solids (mg/L) N	Mean	Median	Turbidity (NTRU) N	Mean	Median
S005-608															
	2009	5/14-10/8	15	7.65	7.53		6	180.3	182.5	9	43.90	38.00			
	2010	5/24-10/5	13	7.14	7.50	1	7	191.0	136.0	11	56.50	39.00			
S004-147															
	2006	4/24-10/19	8	8.27	8.03					1	26.00	n/a			
	2007	4/22-4/22								1	6.90	n/a			
	2009	5/14-10/8	16	6.71	7.06	2	7	192.9	167.5	9	31.11	30.40			
	2010	4/15-10/5	14	6.82	7.12	2	8	195.4	159.0	10	28.60	30.10			
S002-709															
	2006	4/24-10/19	8	8.35	7.11					3	39.00	39.00	1	14.00	14.00
	2008	6/10-10/15								5	34.60	28.00	3	33.33	21.00
	2009	3/22-10/27	15	6.35	6.11		8	180.6	161.5	22	45.50	41.00	3	61.53	57.50
	2010	3/24-10/6	13	7.01	6.39		7	191.7	193.0	16	28.50	21.00	5	33.22	26.50
S004-148															
	2006	4/24-10/19	9	7.48	7.57					3	22.67	23.00			
	2007	4/22-4/22								1	7.28	n/a			
	2009	5/14-10/19	17	7.20	6.96	2	11	181.6	155.0	13	19.85	16.00			
	2010	4/15-9/14	12	6.71	6.27	1	3	183.0	221.0	6	34.17	24.50			
S005-060															
	2008	7/22-10/13	9	8.51	9.02	1	4	141.8	84.5	4	5.75	5.50	4	7.58	6.95
	2009	4/13-10/9	17	9.30	9.39	1	11	50.8	35.5	14	5.93	5.00	6	5.18	5.09
	2010	4/20-6/7	3	10.50	10.10					3	10.67	10.00			
S003-151															
	2002	5/16-10/22	6	10.69	10.77		4	246.3	139.5	6	63.17	20.00	6	50.74	13.59
	2003	5/16-10/30	5	9.64	8.78								6	20.57	14.55
	2004	4/7-10/28	8	11.28	10.99								8	13.15	11.45

AUID	Year	Dates	Dissolved oxygen (mg/L)				Total Phosphorus (ppb)			Total suspended solids (mg/L)			Turbidity (NTRU)		
			N	Mean	Median	Number of samples exceeding standard	N	Mean	Median	N	Mean	Median	N	Mean	Median
	2005	4/13-10/18	7	10.08	10.04								8	19.65	18.15
	2006	4/21-10/10	7	11.05	11.26								7	12.74	12.90
	2007	4/17-10/4	7	10.86	10.09								7	13.93	13.80
	2008	4/22-10/16	17	10.45	10.04		7	70.0	79.0	1	22.00	n/a	7	22.71	13.80
	2009	4/24-10/7	12	10.84	11.29		8	84.0	72.0	12	11.25	6.50	11	12.13	8.16
	2010	4/9-10/7	10	9.76	9.69		3	83.0	83.0	4	22.00	22.50	9	20.49	23.20
S005-611															
	2009	4/24-10/7	17	8.51	8.22		13	52.5	50.0	13	9.10	9.00	17	5.77	7.26
	2010	4/9-10/7	13	8.33	8.51		3	141.0	55.0	7	11.10	7.00	13	5.90	4.39
S002-111															
	2002	5/16-10/22	6	9.77	9.97		4	182.5	177.0	6	37.33	17.00	6	24.05	12.88
	2003	5/15-10/30	9	9.13	9.08		2	166.0	166.0	2	40.00	40.00	9	25.57	20.80
	2004	4/5-10/28	13	9.48	9.26		7	125.4	86.0	7	20.29	15.00	11	10.70	11.00
	2005	4/13-10/18	7	10.17	10.20								7	17.26	16.30
	2006	4/5-10/10	12	10.03	10.09		5	88.8	84.0	5	20.20	22.00	8	12.83	12.20
	2007	4/17-10/4	12	9.03	8.70		5	158.0	135.0	5	46.40	30.00	7	22.34	18.30
	2008	4/22-10/14	20	9.49	9.27		7	109.6	98.0	7	31.29	21.00	8	22.13	20.80
	2009	4/20-10/7	15	9.69	9.17		4	75.3	79.0	4	30.00	25.00	13	16.62	15.90
	2010	4/9-10/7	8	9.96	10.20								7	16.00	16.60
S002-112															
	2002	5/16-10/22	6	9.92	9.71	1	4	322.0	279.0	5	83.80	59.00	6	43.40	18.20
	2003	5/15-10/30	9	9.11	9.09		2	179.0	179.0	2	62.00	62.00	9	36.63	32.10
	2004	4/5-10/28	14	9.48	10.03		5	255.6	188.0	5	33.40	13.00	11	18.09	17.30
	2005	4/13-10/18	7	9.75	10.12								7	31.04	29.70
	2006	4/5-10/10	12	9.99	9.74		5	174.8	152.0	5	46.20	47.00	8	32.81	28.50
	2007	4/17-10/4	12	8.81	8.27		5	245.2	165.0	5	54.20	57.00	7	48.17	33.10

AUID	Year	Dates	Dissolved oxygen (mg/L)				Total Phosphorus (ppb)			Total suspended solids (mg/L)			Turbidity (NTRU)		
			N	Mean	Median	Number of samples exceeding standard	N	Mean	Median	N	Mean	Median	N	Mean	Median
	2008	4/22-10/14	21	9.48	9.06		7	123.1	119.0	7	35.71	23.00	7	27.63	25.60
	2009	4/20-10/7	14	9.41	9.46		4	105.0	98.5	4	24.75	23.00	12	24.82	21.65
	2010	4/9-10/7	8	9.74	9.92								7	25.94	25.10
S005-592															
	2009	4/23-10/7	8	4.46	2.39	5							8	6.46	5.20
	2010	4/9-10/7	7	4.25	4.10	5							7	2.24	1.80
S005-607															
	2009	5/14-10/13	16	8.08	7.86		11	193.4	179.0	12	39.70	28.00	8	6.46	5.20
	2010	4/15-9/14	12	6.97	7.19	2	3	182.7	191.0	6	39.83	40.00	7	2.24	1.80
S003-313															
	2003	5/16-5/16	1	8.43	n/a								1	3.26	3.26
	2004	4/7-10/28	7	8.74	9.17								7	5.88	5.24
	2005	5/18-10/18	5	7.86	7.91								5	7.18	9.10
	2006	4/21-10/10	5	6.29	6.71	1							5	6.42	3.10
	2007	4/17-10/4	5	6.22	4.77	3							5	12.48	6.84
	2008	5/28-9/11	4	6.45	6.40								4	10.87	8.40
	2009	5/20-9/29	5	7.57	7.67		1	71.0	n/a	2	3.00	3.00	5	9.51	11.61
S003-315															
	2003	5/16-10/30	3	9.69	10.93								3	6.77	4.26
	2004	4/7-10/28	6	10.51	11.04								6	12.27	10.41
	2005	4/13-8/28	4	10.32	10.75								4	13.18	12.30
	2006	4/21-10/10	7	10.35	10.24								7	12.20	16.20
	2007	4/17-10/4	6	10.13	9.73								6	9.79	8.08
	2008	5/28-10/14	6	9.12	9.38								6	15.77	10.90
	2009	4/24-10/7	16	9.75	9.54		7	127.3	140.0	9	5.67	4.00	15	5.45	4.34
	2010	4/9-10/7	13	9.98	9.20		7	148.0	119.0	11	6.64	4.00	13	5.60	5.03

AUID	Year	Dates	Dissolved oxygen (mg/L)				Total Phosphorus (ppb)			Total suspended solids (mg/L)			Turbidity (NTRU)		
			N	Mean	Median	Number of samples exceeding standard	N	Mean	Median	N	Mean	Median	N	Mean	Median
S003-316															
	2003	5/16-10/30	3	9.42	9.07								3	42.70	54.00
	2004	4/7-10/28	8	10.08	9.91								8	38.74	32.90
	2005	4/13-10/18	7	8.91	8.75								7	32.19	31.80
	2006	4/21-10/17	12	10.17	10.14					4	43.75	39.00	4	22.13	21.50
	2007	4/17-10/4	7	9.13	8.42								7	57.00	38.50
	2008	4/22-10/14	18	9.18	8.74		8	133.9	135.5				6	41.80	39.90
	2009	4/24-10/14	12	9.60	9.65	1	7	91.6	69.0	11	32.55	27.00	11	38.30	35.60
	2010	4/9-10/7	9	9.16	9.04		3	98.3	80.0	3	19.33	19.00	9	37.38	24.70
S003-312															
	2003	5/16-10/30	5	9.18	9.54								5	43.15	55.70
	2004	4/7-10/28	7	10.93	10.68								7	38.90	39.50
	2005	4/13-10/18	7	9.64	10.02								7	69.06	56.00
	2006	4/21-10/17	12	9.50	9.64	1				2	17.00		5	27.12	31.10
	2007	4/17-10/4	6	9.54	9.38								6	53.52	55.30
	2008	4/22-10/14	17	9.19	8.49		7	138.9	133.0	1	73.00	n/a	6	52.10	52.00
	2009	4/24-10/14	12	9.85	9.77		7	79.7	85.0	12	45.67	43.00	12	43.20	36.10
	2010	4/9-10/7	13	9.49	9.18		3	110.3	111.0	8	59.38	67.00	11	51.61	50.20
S003-694															
	2005	5/9-10/20	12	7.74	7.48					11	50.73	42.00	12	43.64	44.00
	2006	4/10-10/17	8	9.37	9.37		1	117.0	n/a	9	49.00	47.50			
	2007	4/22								1	7.11	n/a	1	448.00	448.00
	2009	4/24-10/7	16	8.43	7.88		7	123.3	124.0	7	37.86	38.00	15	61.96	64.60
	2010	4/9-10/7	12	8.70	8.40		8	132.5	107.0	8	39.38	36.00	11	47.68	44.00

AUID	Year	Dates	Dissolved oxygen (mg/L) N	Dissolved oxygen (mg/L) Mean	Dissolved oxygen (mg/L) Median	Dissolved oxygen (mg/L) Number of samples exceeding standard	Total Phosphorus (ppb) N	Total Phosphorus (ppb) Mean	Total Phosphorus (ppb) Median	Total suspended solids (mg/L) N	Total suspended solids (mg/L) Mean	Total suspended solids (mg/L) Median	Turbidity (NTRU) N	Turbidity (NTRU) Mean	Turbidity (NTRU) Median
S002-711															
	2006	6/19-10/19	5	7.46	8.61	1				5	45.00	13.00			
	2007	4/22-4/22								1	5.60	n/a			
	2009	5/14-10/8	16	6.09	6.45	3	12	149.2	140.5	12	20.92	17.50			
	2010	4/15-9/14	10	6.62	6.46	1	3	118.7	127.0	3	20.00	5.00			

Appendix B. Summary of *Escherichia coli* samples taken from 2001-2010 within the Buffalo River Watershed.

AUID	Year(s) sampled	Month	N	Geometric Mean	Median	Number of samples exceeding 126 (# per 100 ml)	Number of samples exceeding 1260 (# per 100 ml)
				Escherichia coli (# of organisms/100 ml)			
Standard			**126 organisms/100 ml**				
S004-105							
	2008-2010	June	5	155.46	143.90	3	1
		July	5	200.84	117.80	2	1
		Aug.	5	591.71	547.50	4	2
		Sept.	5	1245.88	2419.60	5	3
S005-135							
	2008-2010	June	6	172.00	121.85	2	0
		July	5	99.53	161.60	3	0
		Aug.	5	159.44	131.40	3	0
		Sept.	5	405.73	435.20	3	1
S004-145							
	2008-2010	June	5	568.97	547.50	4	2
		July	5	394.72	172.30	5	1
		Aug.	5	658.37	344.80	5	2
		Sept.	5	282.80	209.80	4	0
S003-155							
	2008-2010	May	1	16.1	n/a	0	0
		June	5	189.199	119.80	2	0
		July	6	138.873	103.15	1	0
		Aug.	5	97.0373	101.40	2	0
		Sept.	5	87.3904	93.40	0	0

AUID	Year(s) sampled	Month	N	*Escherichia coli* (# of organisms/100 ml) Geometric Mean	Median	Number of samples exceeding 126 (# per 100 ml)	Number of samples exceeding 1260 (# per 100 ml)
S005-606							
	2009-2010	June	5	108.74	61.30	2	0
		July	5	275.51	201.40	4	1
		Aug.	5	219.83	218.70	4	0
S003-152							
	2008-2010	May	1	28.8	n/a	0	0
		June	4	223.755	279.80	2	0
		July	5	174.871	172.20	3	0
		Aug.	6	331.032	284.75	6	0
		Sept.	5	168.964	160.70	4	0
S002-700							
	2009-2010	June	4	93.38	91.75	1	0
		July	6	319.47	316.55	6	0
		Aug.	5	430.93	290.90	5	1
		Sept.	6	222.19	179.00	6	0
S003-693							
	2009-2010	June	5	93.29	123.60	2	0
		July	5	297.13	275.50	5	0
		Aug.	5	164.20	110.60	2	0
		Sept.	5	233.51	235.90	4	0
S005-609							
	2009-2010	June	5	53.80	41.00	1	0
		July	5	175.05	201.40	4	0
		Aug.	5	308.32	344.80	4	0

AUID	Year(s) sampled	Month	N	*Escherichia coli* (# of organisms/100 ml) Geometric Mean	Median	Number of samples exceeding 126 (# per 100 ml)	Number of samples exceeding 1260 (# per 100 ml)
S002-708							
	2009-2010	June	6	72.60	72.70	2	0
		July	7	211.57	201.40	7	0
		Aug.	6	182.92	159.45	4	0
		Sept.	7	198.26	185.00	7	0
S005-605							
	2009-2010	June	5	257.30	238.20	4	0
		July	5	271.69	275.50	5	0
		Aug.	5	492.63	461.10	5	0
S005-610							
	2009-2010	June	5	112.65	99.10	1	1
		July	5	357.35	307.60	5	0
		Aug.	5	335.07	435.20	4	0
S002-125							
	2008	June	1	86	n/a	0	0
		July	3	344.59	410.60	3	0
		Aug.	3	189.89	209.80	2	0
		Sept.	3	171.90	155.30	3	0
S000-174							
	2009-2010	June	5	75.02	73.30	2	0
		July	5	141.41	111.20	2	0
		Aug.	5	206.65	307.60	3	0
		Sept.	5	178.69	167.40	5	0

AUID	Year(s) sampled	Month	N	Geometric Mean	Median	Number of samples exceeding 126 (# per 100 ml)	Number of samples exceeding 1260 (# per 100 ml)
			Escherichia coli **(# of organisms/100 ml)**				
S003-148							
	2009-2010	June	5	95.00	117.80	2	0
		July	6	140.50	120.65	3	0
		Aug.	6	251.49	517.95	4	0
		Sept.	5	341.65	214.30	5	0
S003-145							
	2008-2010	May	1	31.30	n/a	0	0
		June	5	145.56	98.50	2	0
		July	5	306.73	365.40	4	0
		Aug.	5	222.26	235.90	4	0
		Sept.	5	138.78	178.20	4	0
S005-608							
	2009-2010	June	4	97.74	147.50	2	0
		July	6	502.74	517.95	6	1
		Aug.	5	300.78	290.90	5	0
		Sept.	5	292.66	275.50	5	0
S004-147							
	2009-2010	June	4	118.26	114.35	1	0
		July	6	310.80	341.45	5	0
		Aug.	5	216.84	121.10	2	0
		Sept.	5	224.17	261.30	5	0
S002-709							
	2009-2010	June	5	182.64	178.50	5	0
		July	5	334.00	378.30	5	0
		Aug.	5	281.12	172.20	4	1
		Sept.	5	325.73	387.30	5	0

AUID	Year(s) sampled	Month	N	Geometric Mean	Median	Number of samples exceeding 126 (# per 100 ml)	Number of samples exceeding 1260 (# per 100 ml)
			***Escherichia coli* (# of organisms/100 ml)**				
S004-148							
	2009-2010	June	5	143.63	111.20	2	0
		July	5	223.61	248.10	3	0
		Aug.	5	262.75	387.30	4	0
		Sept.	5	470.44	488.40	5	0
S005-060							
	2008-2010	June	5	103.64	71.70	2	2
		July	5	308.53	410.60	3	3
		Aug.	5	285.93	235.90	5	5
		Sept.	5	178.86	178.50	3	3
S003-151							
	2008-2010	May	1	16.9	n/a	0	0
		June	5	202.60	166.40	4	0
		July	5	318.73	307.60	5	0
		Aug.	5	178.06	186.00	4	0
		Sept.	5	65.03	52.80	2	0
S005-611							
	2009-2010	June	5	285.36	261.30	4	0
		July	5	308.08	275.50	4	0
		Aug.	5	204.25	214.30	5	0
		Sept.	5	78.35	118.70	2	0
S002-111							
	2006, 2008-2009	May	4	156.58	190.00	3	0
		June	7	359.36	380.00	7	0
		July	7	659.41	648.80	7	0
		Aug.	6	404.38	387.80	6	0

				***Escherichia coli* (# of organisms/100 ml)**			
AUID	**Year(s) sampled**	**Month**	**N**	**Geometric Mean**	**Median**	**Number of samples exceeding 126 (# per 100 ml)**	**Number of samples exceeding 1260 (# per 100 ml)**
		Sept.	8	229.83	300.00	7	1
S002-112							
	2006, 2008-2009	May	4	146.46	100.00	1	0
		June	7	335.40	517.20	6	0
		July	7	847.13	1233.00	7	3
		Aug.	7	527.21	567.00	7	1
		Sept.	8	283.72	441.50	7	0
S005-592							
		None					
S005-607							
	2009-2010	June	4	172.19	189.75	3	0
		July	6	299.54	279.55	5	1
		Aug.	5	188.43	248.10	4	0
		Sept.	5	390.74	396.80	5	0
S003-313							
	2009	June	2	200.07	214.25	2	0
		Sept.	2	1879.89	1956.8	2	2
S003-315							
	2009-2010	June	5	102.59	113.70	1	0
		July	5	471.90	235.90	4	2
		Aug.	5	195.11	137.60	3	1
		Sept.	5	211.15	123.40	2	1

AUID	Year(s) sampled	Month	N	Geometric Mean	Median	Number of samples exceeding 126 (# per 100 ml)	Number of samples exceeding 1260 (# per 100 ml)
				***Escherichia coli* (# of organisms/100 ml)**			
S003-316							
	2008-2010	May	1	261.3	n/a	1	0
		June	5	618.94	461.10	5	1
		July	5	1559.32	2419.60	5	3
		Aug.	5	757.07	727.00	5	1
		Sept.	5	365.86	1553.10	4	3
S003-312							
	2008-2010	May	1	9.8	n/a	0	0
		June	5	327.967	261.30	4	1
		July	5	626.87	461.10	5	1
		Aug.	5	372.834	387.30	5	0
		Sept.	5	202.665	275.50	4	1
S003-694							
	2009-2010	June	5	449.59	547.50	4	0
		July	5	1270.32	1986.30	5	3
		Aug.	5	457.86	290.90	5	1
		Sept.	5	274.39	365.40	4	2
S002-711							
	2009-2010	June	5	182.66	195.60	4	0
		July	5	641.58	365.40	5	1
		Aug.	5	274.03	151.50	5	0
		Sept.	5	338.39	344.80	5	0

Appendix C. MPCA's Final Impairment Assessment of AUIDs within the Buffalo River Watershed after the 2011 assessment.

AUID	2010 Impairment (s)	2011 New Impairment (s)	Final 2011 Impairment(s)	MPCA Comments
09020106-501	T	E.coli	E. coli, T	Turbidity was carried forward
09020106-502	T, DO	E. coli	E. coli, T, DO	Turbidity and DO were carried forward
09020106-503	None	E. coli, T	E. coli, T	
09020106-504	None	E. coli, T	E. coli, T	
09020106-505	T, B_F	E. coli, T, B_I	E. coli, T, B_I	E. coli new impairment
09020106-507	T	E. coli, B_F, B_I	E. coli, T, B_F, B_I	Turbidity was carried forward
09020106-508	T	E. coli, DO	E. coli, T, DO	Turbidity was carried forward
09020106-509	None	E.coli, T	E. coli, T	
09020106-511	None	E. coli, T	E. coli	Turbidity was deferred due to channelized stream reach
09020106-515	None	E. coli	E. coli	
09020106-519	None	E. coli	E. coli	
09020106-520	None	E. coli, T	E. coli	Turbidity was deferred due to channelized stream reach
09020106-521	T	E. coli	E. coli, T	Turbidity was carried forward
09020106-523	T	E. coli	E. coli, T	Turbidity was carried forward
09020106-531	None	E. coli	E. coli	
09020106-534	None	E. coli, B_F, B_I	E. coli, B_F, B_I	
09020106-555	None	B_F, B_I	None	B_F, B_I were deferred due to channelized stream reach
09020106-556	None	E. coli,	E. coli	
09020106-559	None	E. coli, T	E. coli	Turbidity was deferred due to channelized stream reach
09020106-562	None	E. coli, T	E. coli	Turbidity was deferred due to channelized stream reach
09020106-586	None	B_I	None	B_I was deferred due to channelized stream reach
09020106-593	E. coli, T	B_F, B_I	E. coli, T, B_F, B_I	E. coli and Turbidity were carried forward
09020106-594	E. coli, T	None	E. coli, T	E. coli and Turbidity were carried forward
09020106-595	E. coli, T	None	E. coli, T	E. coli and Turbidity were carried forward
09020106-900	None	T, DO	None	Turbidity and DO were deferred due to channelized stream reach