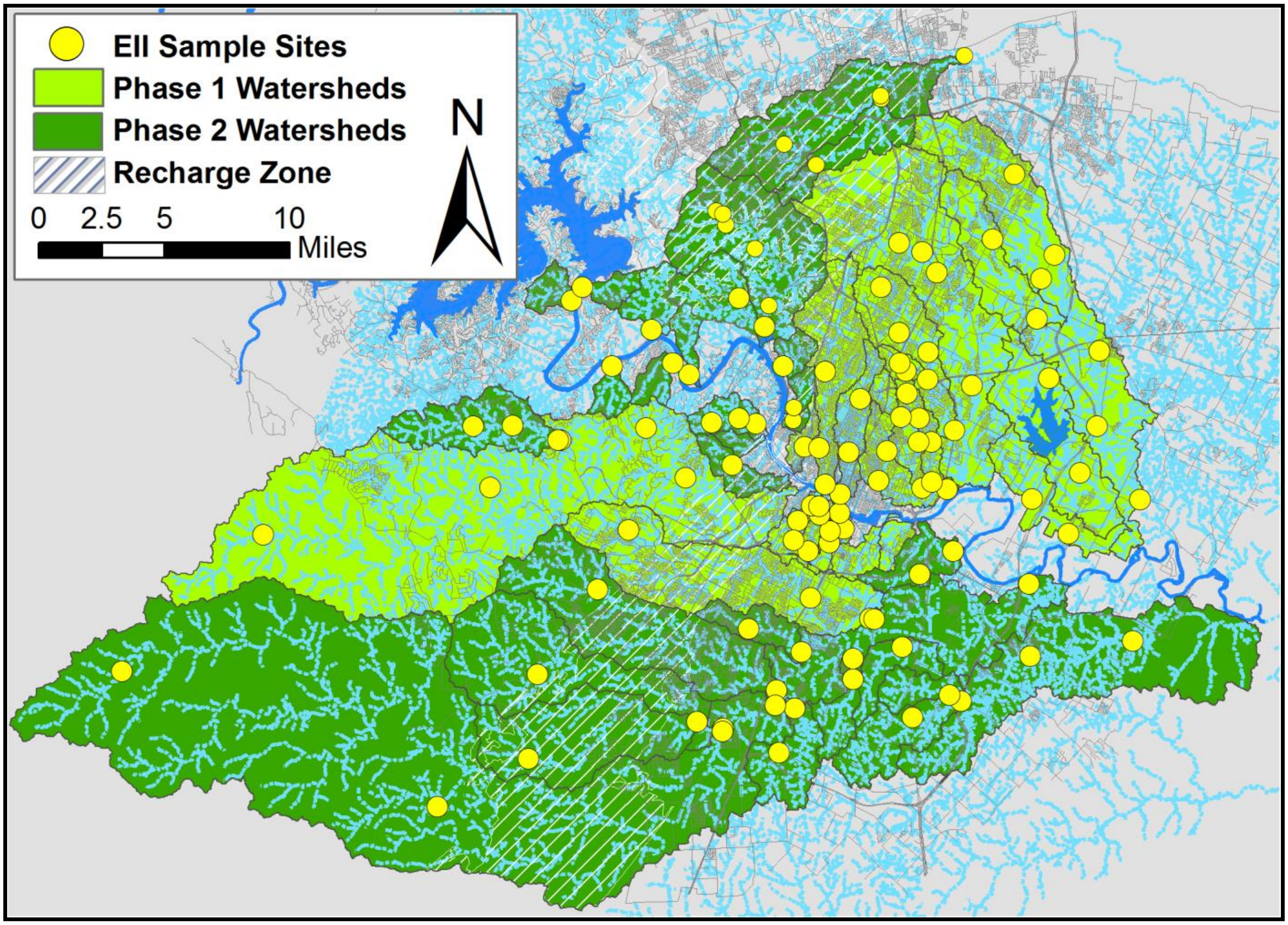
Environmental Integrity Index
Phase I & II (2015-2016) Watershed Summary Report



Short Report SR-19-08 July 2019
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On the cover: EII sampled watersheds color-coded by the respective phase (2015 Phase 1, 2016 Phase 2). Sample site locations are indicated within each watershed. Recharge zone (white hashing), lakes (dark blue) and major roadways (grey) are also included. Additional information regarding data and EII scores can be found in the watershed summary sections of this report.

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EII Phase I & II (2015-2016) Watershed Report

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Environmental Integrity Index (EII) Phase I & II data collected during 2015 and 2016 are presented and evaluated within the context of historical EII data. 118 sites located within 50 watersheds throughout the greater Austin area were sampled to assess environmental conditions. This data is primarily used for prioritizing sub-watersheds for Capital Improvement Projects, regulations and/or other programs through the Citywide Watershed Protection Department masterplan. The values are also used in the WPD Business Plan as performance measures for water quality maintenance. The baseline information accumulated through the EII provides a large, comprehensive and quality assured dataset unique to our region which can be utilized for identifying and tracking both anthropogenic and climatic responses in our aquatic resources.

Introduction

The Environmental Integrity Index (EII) is a comprehensive biological, chemical and physical monitoring tool that was developed and tested in the urban watersheds in 1994 and 1995 and initiated citywide in 1996. By 2000, water quality sampling frequency became a quarterly event and the biological and habitat surveys were completed once per year. Fifty City of Austin planning watersheds with approximately 150 individual sites were grouped into three phases and sampled on a three-year rotating basis with approximately 50 sites sampled per year. Phase 1 primarily included the urban watersheds sampled historically under the Water Watchdog volunteer program while Phase 2 and Phase 3 included primarily suburban and developing watersheds (Figure 1 and Table 1). Phase 1 watersheds were sampled in 2000, 2003 and 2006, Phase 2 watersheds were sampled in 2001, 2004 and 2007 and Phase 3 watersheds were sampled in 2002, 2005 and 2008.

In 2009, following the completion of three full cycles of the three-phase rotation (2000-2008), the watersheds were regrouped into two phases for sampling on a two-year rotating schedule (Figure 2 and Table 2). This regrouping was designed to increase frequency of site visits which would improve the resolution of temporal trend evaluation and facilitated meeting the frequency requirements of the Texas Commission on Environmental Quality (TCEQ) for potential evaluation in the Clean Rivers Program. To balance time and resources, sites that did not exhibit adequate baseflow, or were determined to be spatially redundant were dropped. The current (2015-16) two-phase cycle involves the monitoring of 118 sites within 50 watersheds.

This report presents data collected for the EII monitoring program in 2015 and 2016 and covers the associated water quality, habitat, and biological data. Data and scores from the previous EII sampling events are included for comparison within the tables and figures of the watershed summary sections of the report.

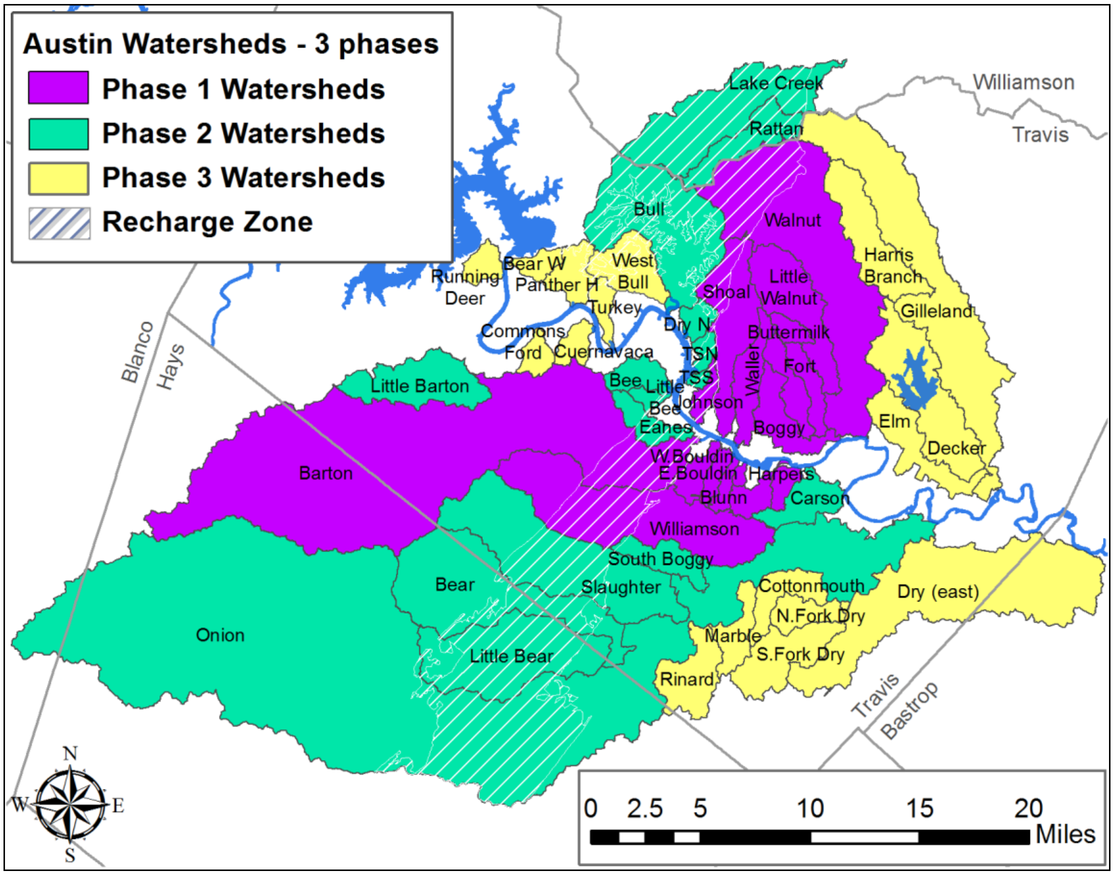

Figure 1. Historic three-phase rotation of watersheds sampled from 1999 through 2008

Table 1. EII Watersheds grouped by the historic 3-phase rotation of 1999-2008

Phase I 2000, 2003, 2006	Phase II 2001, 2004, 2007	Phase IIII 2002, 2005, 2008
Barton Creek	Bear Creek	Cottonmouth
Blunn Creek	Bee Creek	Decker Creek
Boggy Creek	Bull Creek	Dry Creek
Buttermilk Creek	Carson Creek	Elm Creek
Country Club Creek (east and west)	Dry Creek	Gilleland Creek
East Bouldin Creek	Eanes Creek	Harris Branch
Fort Branch	Huck's Slough	Lake Austin (6 tributaries)s)s)
Harpers Branch	Lake Creek	Marble Creek
Johnson Creek	Little Barton Creek	North Fork Dry Creek
Little Walnut Creek	Little Bear Creek	Rinard Creek
Shoal Creek	Little Bee Creek	South Fork Dry Creek
Tannehill Branch	Onion Creek	
Waller Creek	Rattan Creek	
Walnut Creek	Slaughter Creek	
West Bouldin Creek	South Boggy Creek	
Williamson Creek	Taylor Slough (North)	
	Taylor Slough (South)	

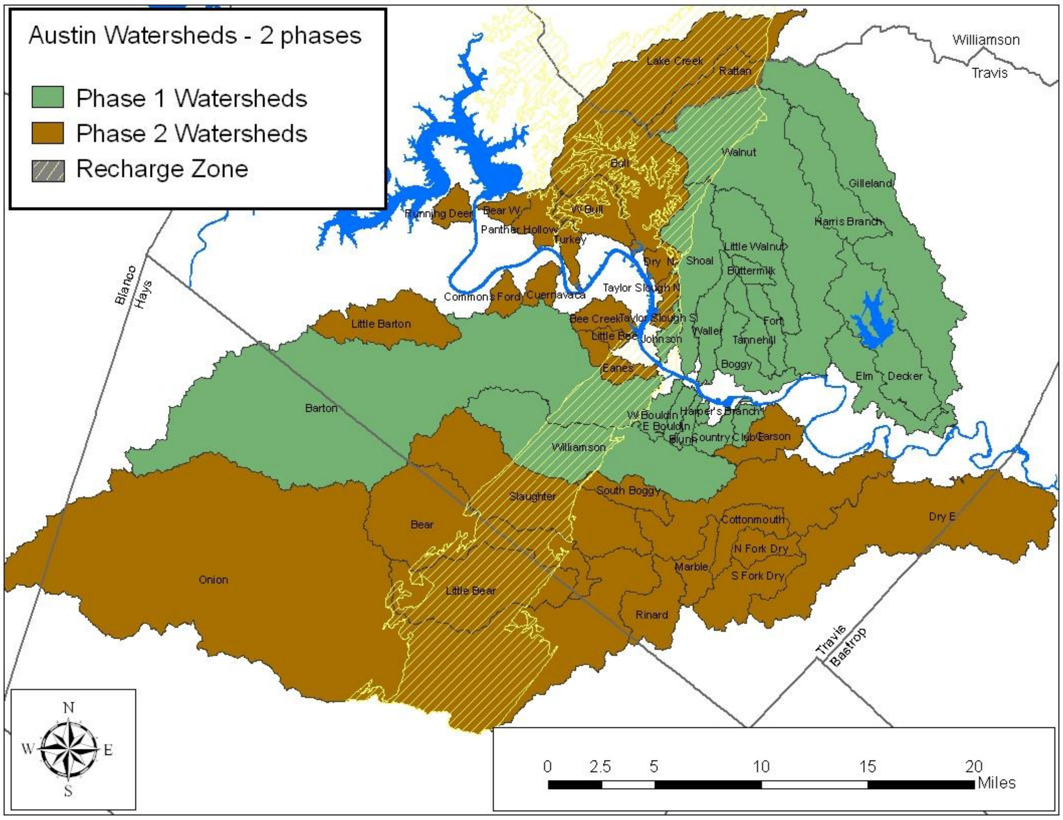

Figure 2. Current two-phase rotation of watersheds sampled from in 2009 through 2016

Table 2. EII Watersheds grouped by the 2-phase rotation of 2009-2016

Phase I – 2009, 2011, 2013, 2015	Phase II – 2010, 2012, 2014, 2016
Barton Creek	Bear Creek
Blunn Creek	Bee Creek
Boggy (north) Creek	Bull Creek
Buttermilk Creek	Carson Creek
Country Club Creek (east and west)	Cottonmouth Creek
Decker Creek	Dry Creek East
East Bouldin Creek	Dry (north) Creek
Elm Creek	Eanes Creek
Fort Branch	Lake Austin (6 tributary watersheds)
Gilleland Creek	Lake Creek
Harpers Branch	Little Barton Creek
Harris Branch	Little Bear Creek
Johnson Creek	Little Bee Creek
Little Walnut Creek	Marble Creek
Shoal Creek	North Fork Dry
Tannehill Branch	Onion Creek
Waller Creek	Rattan Creek
Walnut Creek	Rinard
West Bouldin Creek	Slaughter Creek
Williamson Creek	South Boggy Creek
	South Fork Dry
	Taylor Slough (North)
	Taylor Slough (South)
	West Bull

Methods

Data was collected adhering to the Water Resource Evaluation Standard Operating Procedures Manual (SR-04-04). The collection of quarterly water quality sample at any given site is carried out during baseflow conditions (non-stormflow). During all sampling events (both quarterly and annual) physicochemical measurements are collected with a multiprobe (Hach Hydrolab or Quanta Datasonde). These in-situ field measurements include:

- Dissolved Oxygen (mg/L)
- Specific Conductivity (µS/cm)
- pH (Standard Units)
- Water Temperature (ºC)

Quarterly water samples are collected and submitted to the LCRA Environmental Laboratory and analyzed for:

- Ammonia as N (mg/L)
- Nitrate as N (mg/L)
- Total Kjeldahl N (mg/L)
- Orthophosphorus as P (mg/L)
- Total Suspended Solids (mg/L)
- *Escherichia coli* bacteria (MPN/100ml) (for Barton, Bull, Onion and Walnut sites only)

Quarterly water samples that are analyzed at the COA laboratory were analyzed for:

- Turbidity (NTU)
- *Escherichia coli* bacteria (MPN/100ml) (for sites not submitted for CRP/TMDL program)

Annual biological samples and physical stream assessments are conducted in the late spring /early summer. Benthic macroinvertebrates and diatoms are collected primarily from riffles during baseflow but may be collected from intermittent pools if flow was absent. The annual assessment includes:

- Benthic macroinvertebrate and diatom surveys
- Stream and reach stability assessment
- Non-contact recreational assessment
- Habitat assessment
- Flow measurement, canopy density, and bank full measurement
- Photographs
- Sediment sample (collected from watershed mouth sites only and submitted to DHL Analytical)

Data from all sampling events (quarterly water quality events and one biological event) for a given year are analyzed, in part, using seven sub-index categories. The average of the sub-indexes is an "overall watershed score" that is normalized relative to the other watersheds for that year. Detailed description of the calculation methods is provided in the EII Methodology Report (SR-12-02). The seven EII reporting categories are:

- Aquatic Life Use Score (an average of the Benthic Macroinvertebrate and Diatom sub-index scores)
- Water Quality Score
- Contact Recreation Score
- Non-Contact Recreation Score
- Sediment Quality Score
- Physical Integrity Score
- Overall Watershed Score

EII monitoring site locations were selected to represent stream reaches within each watershed. Reach boundaries were determined based on patterns in geomorphology, hydrology and land use. This provides the ability to evaluate trends over time, while providing the flexibility to move site locations if necessary. During the 2015-2016 Phase I & II sampling periods there were a total of 118 water quality sites in 50 watersheds.

Results

Water chemistry data for each watershed for the 2015-2016 sample events are presented as box and whisker plots in Figures 3a – 3i. The dashed horizontal line on each graph indicates the historic EII average value. The whiskers indicate the minimum/maximum values and the boxes indicate the interquartile range. The median and mean of each data set are shown within the boxes as stars and horizontal lines respectively. The graphs indicate the general range of these data among watersheds and allows for easy comparison and identification of outliers. A more detailed evaluation of spatial and temporal trends at sites within a given watershed can be found in the watershed summary sections of this report.

As described in the Methods section, data is normalized and scored by sub-index categories in order to rate the environmental integrity of each watershed or sub-watershed. The scores of the seven sub-index categories are averaged to provide an overall EII total watershed score. The total score can vary from year to year based on anthropogenic influences such as development and acute water quality issues but is also affected by climatic influences (such as drought or flooding), minor changes in methods and other variables. Scores for each watershed and for each of the reaches within each watershed and the corresponding sub-index category scores are presented in the watershed summary sections of this report.

pH

Across all watersheds for 2015 and 2016, pH values (Figure 3a) were generally within expected range. Austin surface water is frequently slightly basic due to the dominance of calcium carbonate in limestone bedrock and spring water; however, this is less frequently the case in the eastern tributaries. Deviations from normal pH are typically explained from antecedent conditions (recent rainfall tends to lower pH, and decaying leaf litter and acorns in the fall also lowers pH), for which drought/above average rainfall exacerbates the deviations.

Conductivity

For most watersheds, conductivity (Figure 3b) was also within the expected range; however, there were a few instances of both acute and chronically high values. Streams that are influenced by treated effluent (e.g. Gilleland Creek) often have elevated conductivity throughout the year. Episodic pollutant loads such as wastewater spills or salt water pool discharge may cause spikes in conductivity as well. For example, the headwater site on Decker Creek (Decker at Lindell) had two very high results in 2015, because this site is known to be a chronic illegal dumping site.

Dissolved Oxygen

Aquatic life such as fish, salamanders, zooplankton, and benthic macroinvertebrates rely on dissolved oxygen (DO) in the water. Several factors can affect the concentration of DO including temperature, physical mixing and demand from organisms that produce and/or consume it. While plants, phytoplankton and periphyton can contribute large amounts of DO in the water, bacterial communities that thrive in nutrient-rich environments and decaying organic matter can cause the level of oxygen to plummet. As one might expect, the concentration of DO in Austin's surface waters (Figure 3c) is highly variable throughout the day, week or season based on changes in temperature, plant/algal growth and nutrients. It is important for surface waters to maintain more than 4 mg/L for sustaining fish populations. High spikes (i.e. >12 mg/L) may indicate an over-productive algae or plant community caused by excess nutrients. These spikes in DO during the day are frequently coupled with plummeting concentrations overnight as the bacterial community consumes oxygen.

Nutrients (Orthophosphorus, Ammonia, and Nitrate/Nitrite)

Nutrients in surface water are an important component for aquatic ecosystems, but excess nutrient load (called eutrophication) can create several serious problems for aquatic life. Elevated phosphorus (Figure 3d) and nitrate (Figure 3f) concentrations are commonly associated with algal blooms which can result in dissolved oxygen spikes/troughs, fish kills, bad odors, and other associated water quality related problems. Ammonia (Figure 3e) in surface water converts readily to nitrate, so it is important to monitor both ammonia and nitrate. One of the more common sources for these nutrients in urban environments is wastewater from both treated effluent and raw sewage (via spills, leaks, etc). Accordingly, the streams that exhibit higher concentrations of these nutrients are typically known to either be driven in part by treated wastewater effluent or have aging infrastructure in which spills and overflows are common. Gilleland Creek, Harris Branch, and Lake Creek are examples of streams with treated effluent while Waller, Shoal, and East/West Bouldin are examples of watersheds with aging wastewater infrastructure and/or other human and animal fecal inputs. Another source in suburban areas may be agriculture-related inputs (e.g. fertilizers and manure) which may be the reason for elevated nutrients in southeastern watersheds such as Marble and South Fork Dry.

Sediment (Total Suspended Solids and Turbidity)
Sediment is one of the most common pollutants in water. Although it is naturally occurring, sediment levels can be elevated from accelerated and unnatural erosion from active and historic development practices. Nutrients and other pollutants can be released from eroded soil and the fine silty particles degrade the habitat for aquatic life. Murky, turbid water block sunlight for aquatic vegetation and can harm sensitive tissues such as fish and invertebrate gills and eggs. In addition to this physical attribute, some pollutants adhere to sediment and are sequestered in depositional areas of creeks. TSS (Figure 3g) and Turbidity (Figure 3h) concentrations were similar to previous years. Generally, the watersheds of the Blackland Prairie ecoregion (east of IH35) had higher TSS and Turbidity than the watersheds of the Central Texas Plateau ecoregion (west of IH35).

Bacteria (*Escherichia coli*)
E. coli is used as the primary indicator of instream pathogens. Contributions to *E. coli* contamination include direct and indirect sources from humans and warm-blooded animals. *E. coli* concentrations in Austin streams (Figure 3i) continue to be of concern and are receiving additional attention through the development of new protocols for response and investigation of sites with elevated concentrations (i.e. *E. coli* Bacteria Source Isolation Sampling SR-15-07).

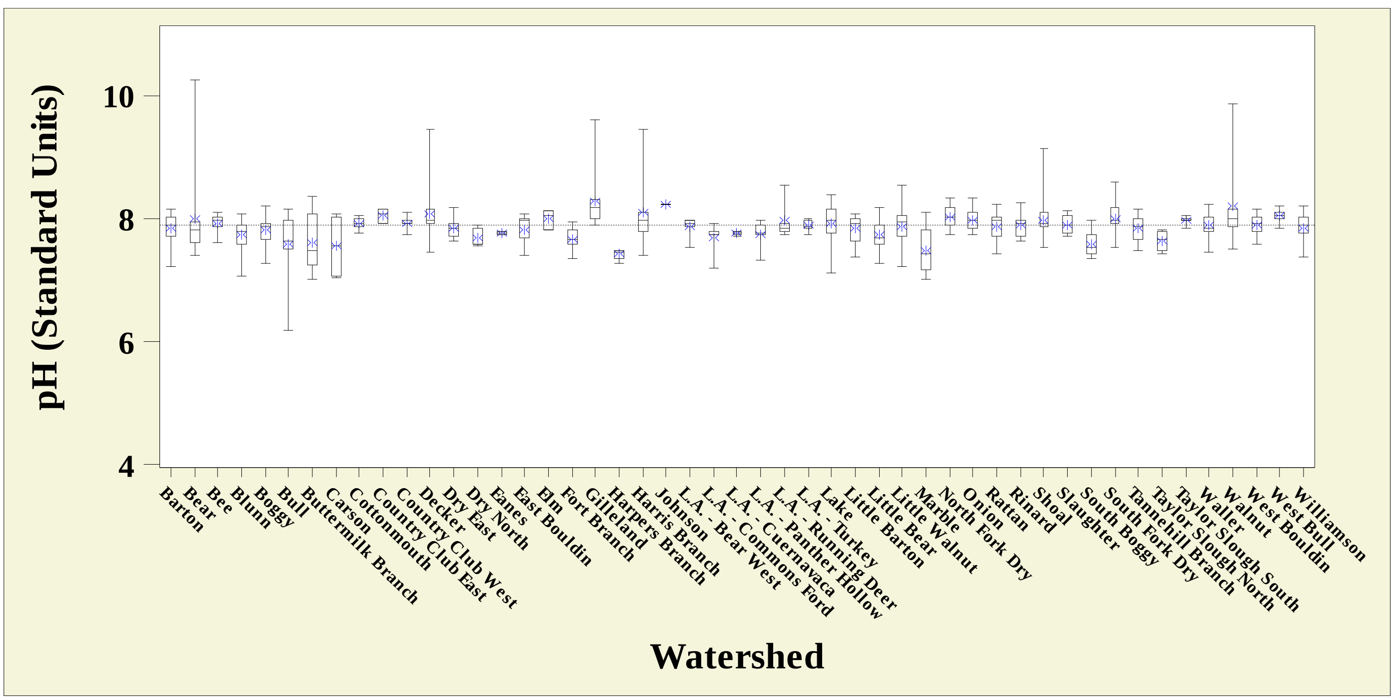

Figure 3a. pH data from quarterly samples collected from 2015 and 2016 for all watersheds

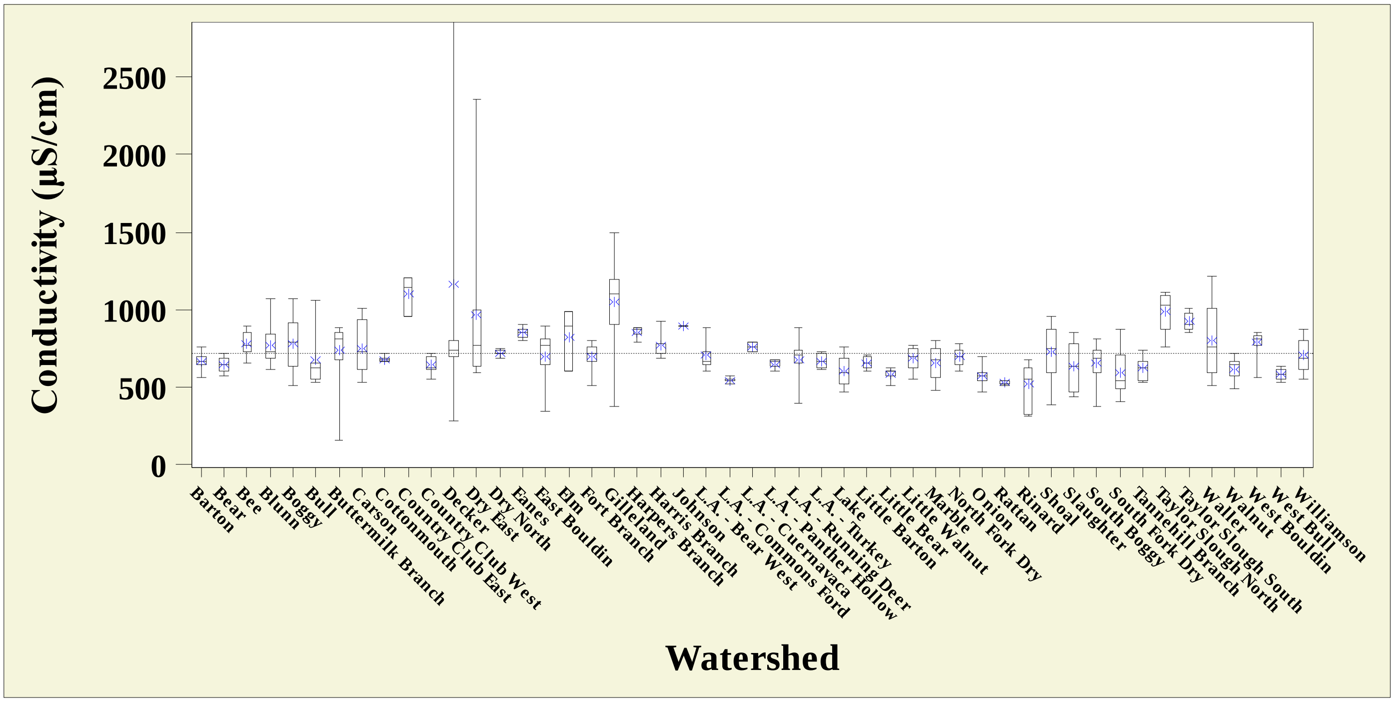

Figure 3b. Conductivity data from quarterly samples collected from 2015 and 2016 for all watersheds

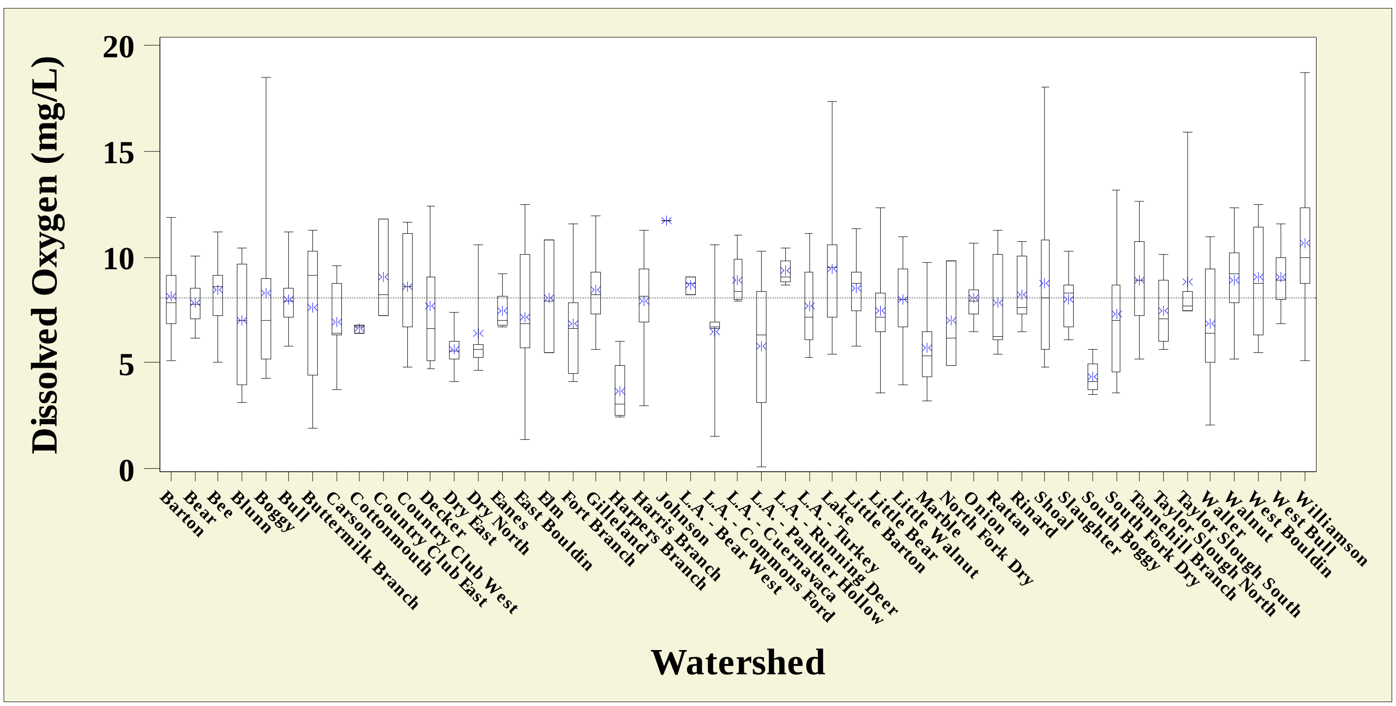

Figure 3c. Dissolved oxygen data from quarterly samples collected from 2015 and 2016 for all watersheds

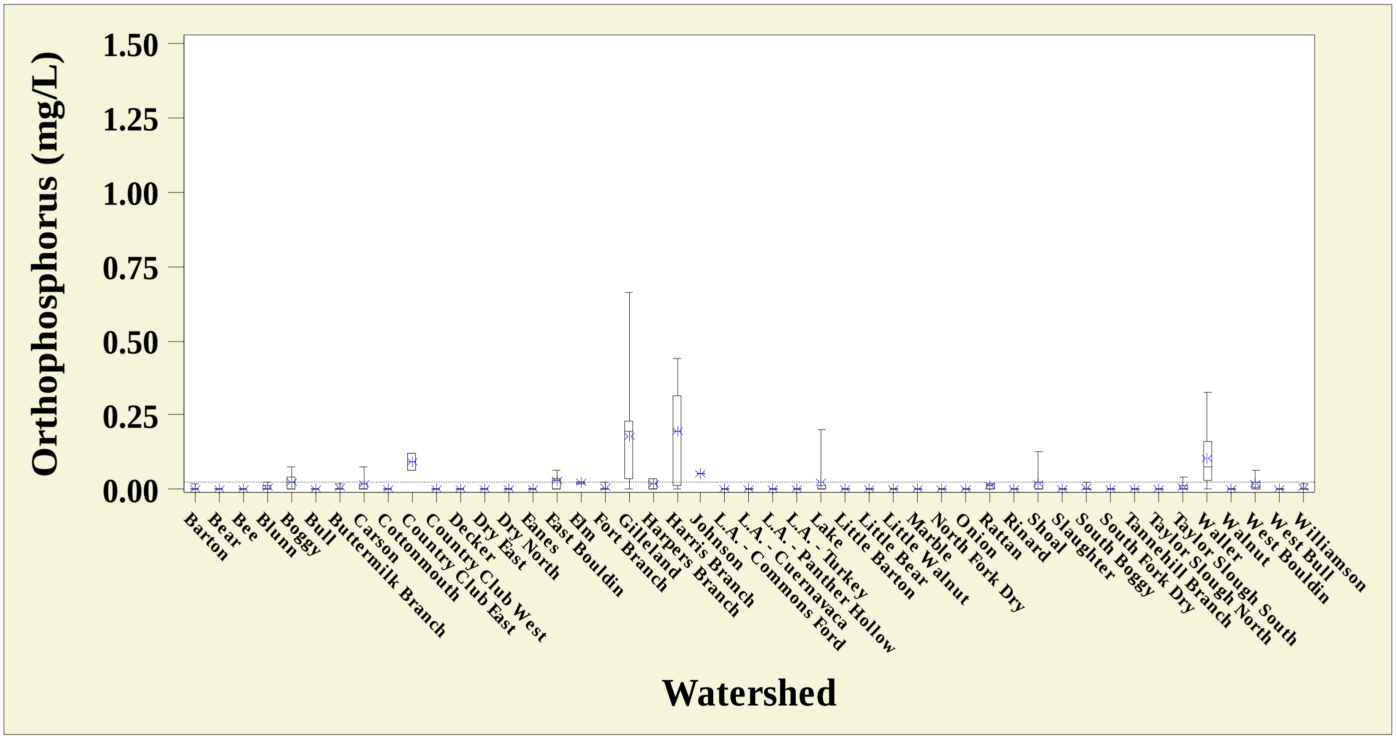

Figure 3d. Orthophosphorus data from quarterly samples collected from 2015 and 2016 for all watersheds

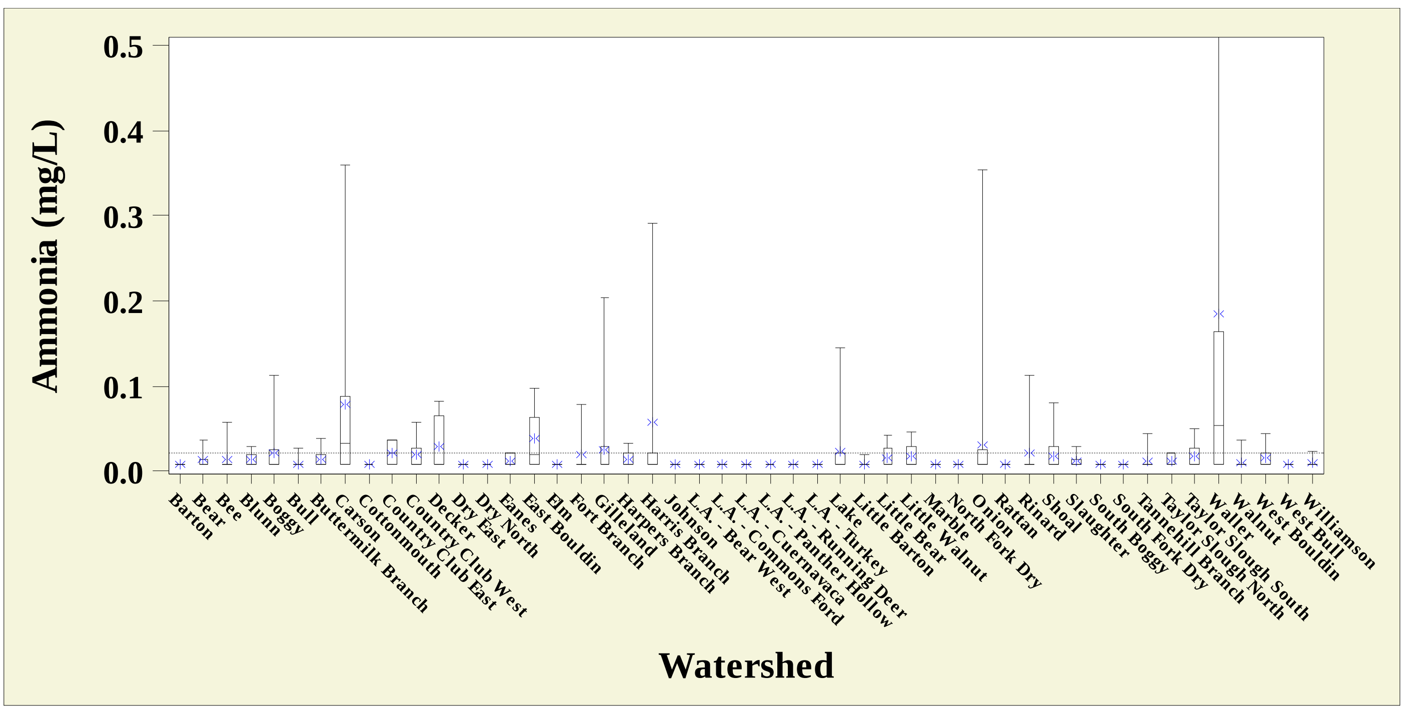

Figure 3e. Ammonia data from quarterly samples collected from 2015 and 2016 for all watersheds

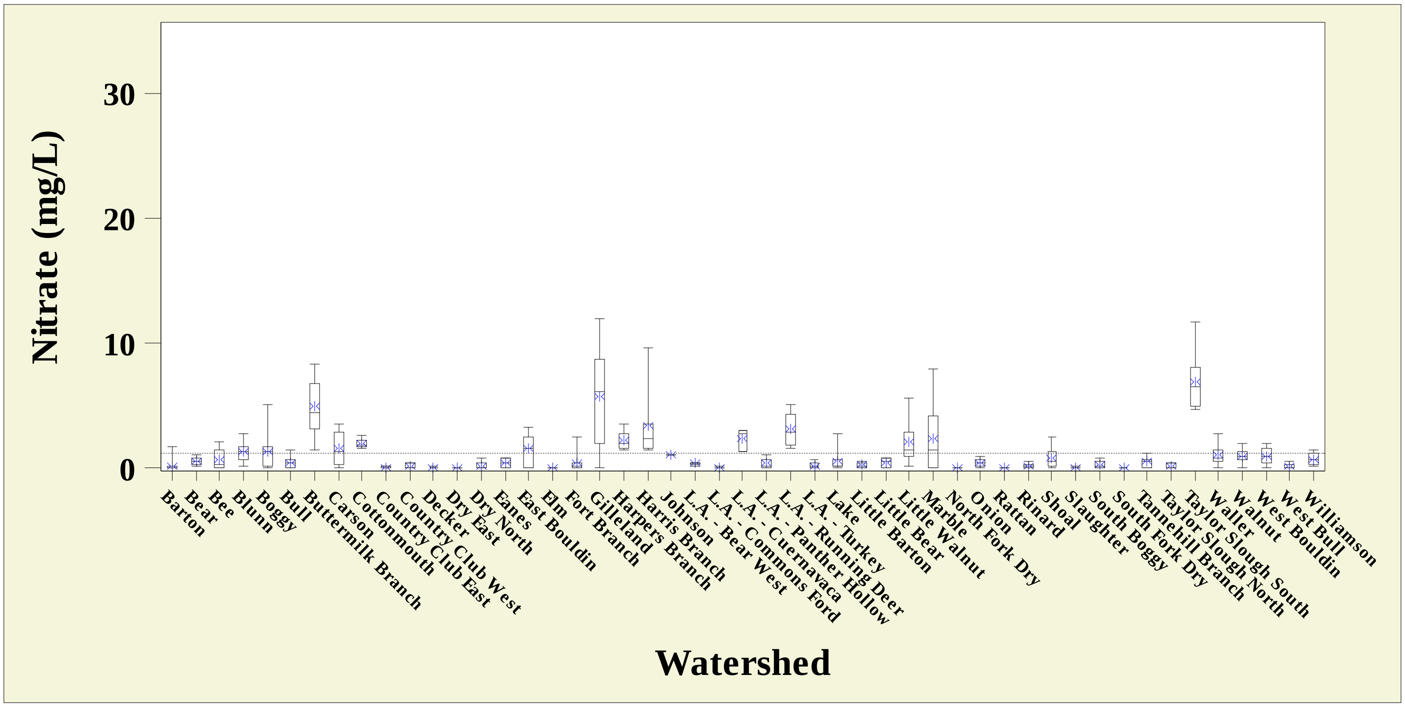

Figure 3f. Nitrate data from quarterly samples collected from 2015 and 2016 for all watersheds

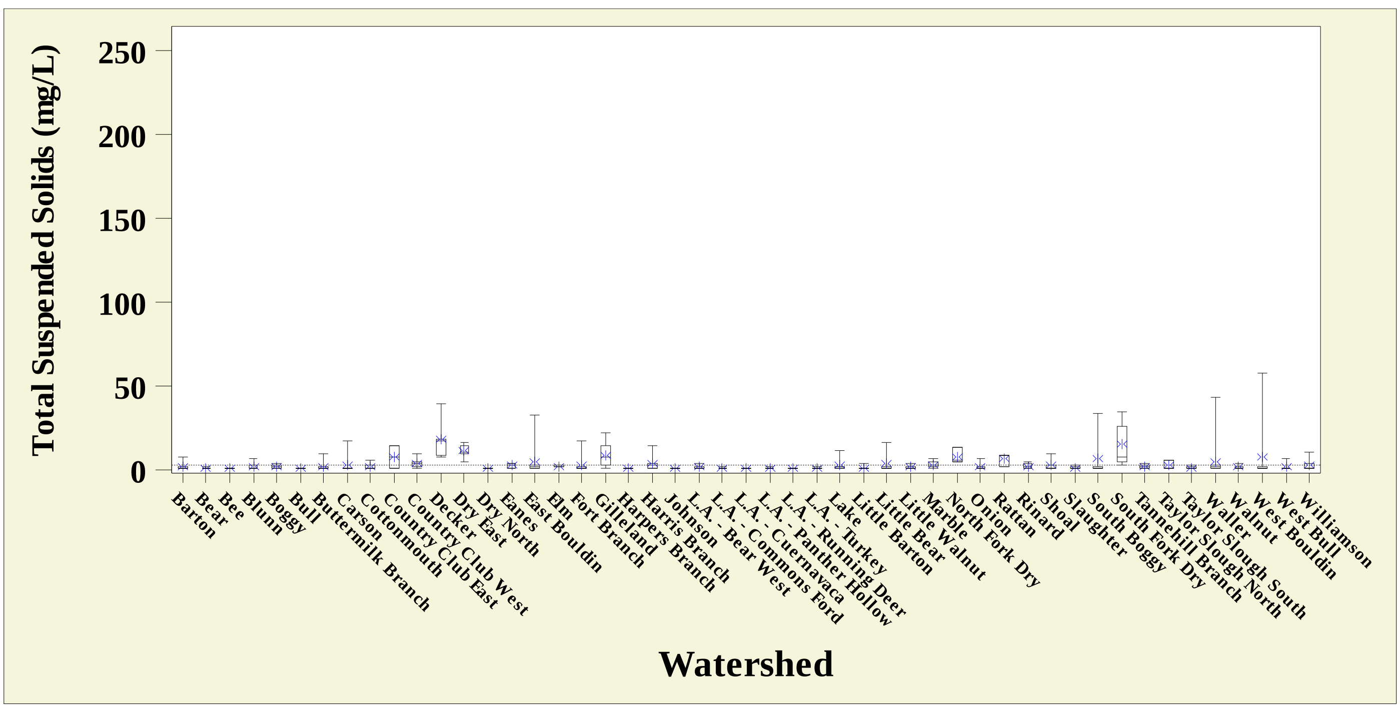

Figure 3g. TSS data from quarterly samples collected from 2015 and 2016 for all watersheds

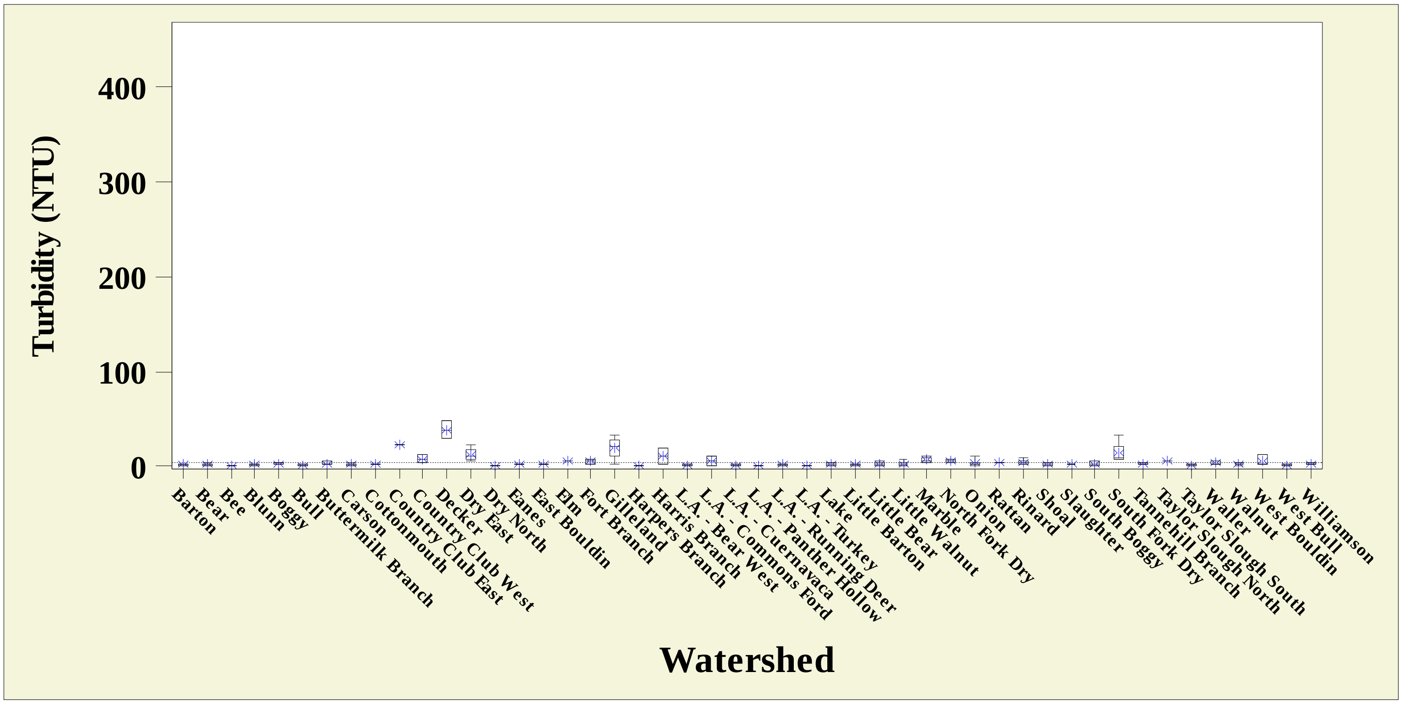

Figure 3h. Turbidity data from quarterly samples collected from 2015 and 2016 for all watersheds

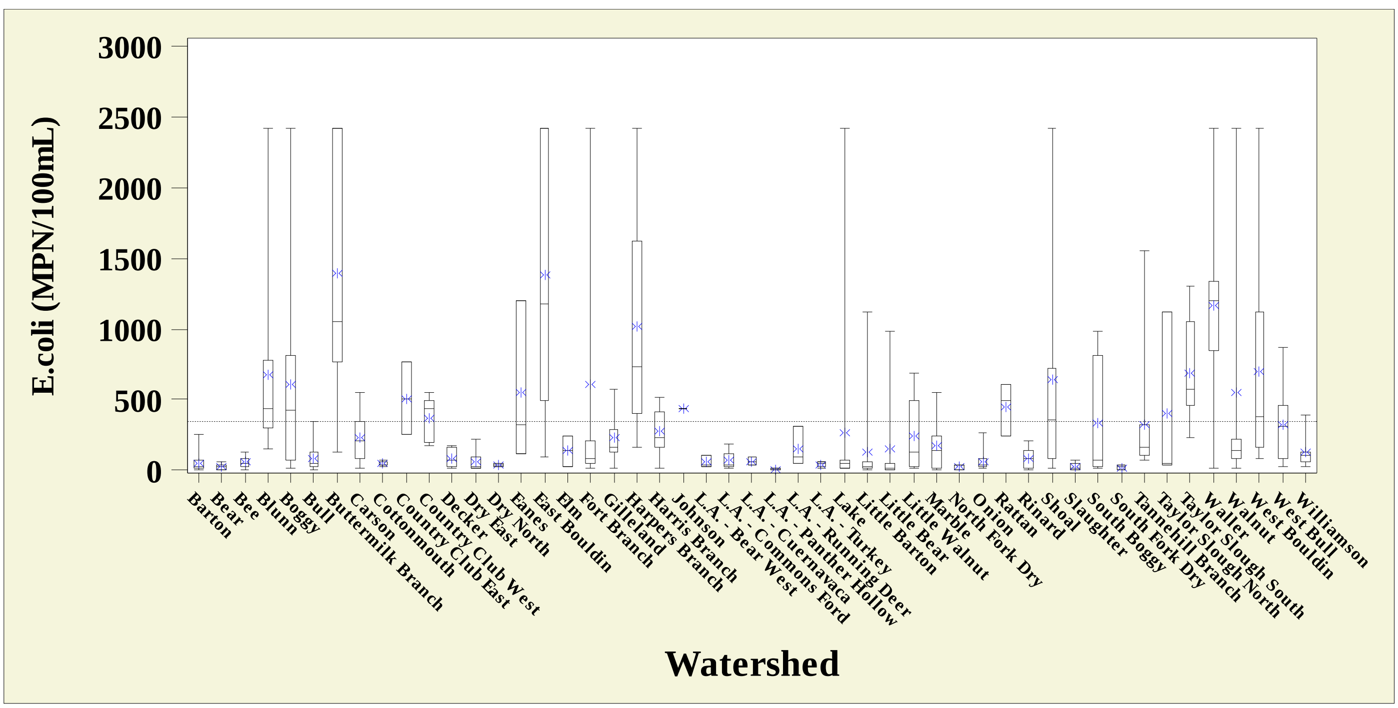

Figure 3i. *E. coli* data from quarterly samples collected from 2015 and 2016 for all watersheds

Watershed Summaries

The following appendices present maps, basic watershed information, scores and water quality data for each watershed in the context of historical results. Each summary includes the following components:

Watershed Overview

This table includes a brief list of watershed facts that describe the physical and development characteristics of the watershed. An overview map is located at the top right-hand corner of the page which shows the location of the featured watershed (in yellow) in relation to the other watersheds (purple). Overall EII watershed scores are listed in chronological order from left to right.

Flow Regime

The flow regime table for all sites in the watershed shows the current and historic flow presence as well as sample collection. Presence of baseflow is indicated with a "B", lack of flow is indicated as an "n" and storm-influenced flow is indicated as an "S". If samples were collected the cell is dark blue, if samples were not collected the cell is light blue, and if the site was not visited, the cell is blank.

Index Scores Table

EII total score and component index scores are shown color-coded for each site grouped by year. Each site is assigned a reach number for which the most downstream reach is the "first" reach (e.g. BEE1) and reach number increases upstream (e.g. BEE2, BEE3…). The total EII score is an average of six index scores: Water Quality, Sediment, Contact Recreation, Non-contact Recreation, Physical Integrity, and Aquatic Life. The Aquatic Life score is composed of two sub-index scores (benthic macroinvertebrates and diatoms). The specific calculations for each of these indices are described in detail in the EII methodology report (SR-02-12).

- **Water Quality** – Concentrations of bacteria, total suspended solids, total dissolved solids, nitrate-nitrite as N, orthophosphorus, ammonia as N, and conductivity as evaluated to a reference condition determined from a QCURVE table pinning back to 2004.
- **Sediment** – Analysis of sediment is conducted at one site (the most downstream) and includes such parameters as metals, PAHs, PCBs, organochlorine pesticides, and grain size.
- **Contact Recreation** – *Escherichia coli* concentration is used as a surrogate indicator of pathogenic bacteria. Low numbers of *E.coli* are common in creeks because all warm blooded organisms are a source of *E.coli*, however high concentrations may indicate wastewater contamination.
- **Non-contact Recreation** – The aesthetic condition of a site is evaluated based on litter, odor, clarity and percent algae cover.
- **Physical Integrity** – Physical habitat is evaluated with an EPA integrity assessment that include parameters such as instream cover, epifaunal substrate, embeddedness, velocity/depth regime, channel alteration, sediment deposition, riffle frequency, channel flow status, and vegetative protection.
- **Aquatic Life** – Metric analysis of benthic macroinvertebrate samples and diatom samples are averaged to form a single aquatic life score. Metrics include aspects of the community structure, diversity, taxa composition, and pollution tolerance.

Maps

Two maps with sample site locations are provided: a land use map and a historic aerial. Property parcels are color coded to reflect land use designations as determined by COA GIS data (2006 with updates). Dark bold outlines indicate the watershed boundaries, and the interior sub-watershed reach boundaries. The aerial photograph map uses 2011 aerial photography (winter "leaf-off") with both current and historical sampling sites, in addition to other development related features within the watershed.

Water Quality Data
Water chemistry data from the 2015/2016 sample years are presented in table format. Site means, and watershed means for each reach summarize the quarterly samples. Values which exceed one standard deviation above the average (or below the average when relevant) for the respective year have been highlighted in grey.

Data Summary Graphs
The pages following the water quality data show water quality parameters in box-and-whisker graphs (Figure 4) by reach and by year to facilitate evaluation of both temporal and spatial trends. The most downstream site is the first reach (e.g. BER1) and reach numbers increase upstream from left to right within each year. Spatial trends within a watershed (downstream to upstream) can be evaluated on a year-by-year basis and temporal trends (year-to-year) can be evaluated from left to right. A thin line through each graph indicates the median value for each parameter for all cumulative historic EII data. This line provides context for what may be above or below what is the "average" condition for Austin watersheds.

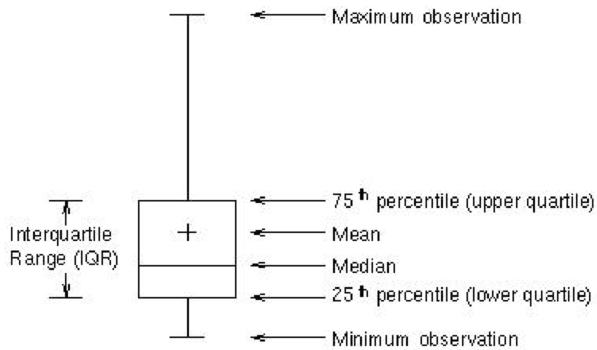

Figure 4. Legend for box-and-whisker plots

Score Summary Line Graphs
EII sub-index and total scores for each reach over the past decade are presented as line graphs. Smaller watersheds with only a single reach will appear as a single set of points, while larger watersheds with multiple reaches will appear as multiple line graphs which can be evaluated for spatial trends within the watershed from upstream to downstream (left to right). Lines are shown in grayscale with the most recent scores in black and oldest in light grey to help visual review of temporal trends over the past 20 years. Most watersheds summaries include line graphs for Total, Water Quality, Aquatic Life, Physical Integrity, Contact Recreation and Non-Contact Recreation scores. However, the Lake Austin Tributaries just present the Total scores for each of the six Lake Austin tributaries.

Benthic Macroinvertebrates
The results of benthic macroinvertebrate samples are presented in the table following the summary graphs. Biological sampling enables a more holistic perspective of water quality than water chemistry sampling. The diversity, structure and tolerance of the biological community can provide insight to the antecedent conditions of water quality over months and even years rather than a discrete point in time. Benthic macroinvertebrates were collected with three composite surber samples (within flowing streams) or timed kick nets (within the wetted sections of streams that were not flowing). All individuals were identified to the lowest practical taxon and enumerated. Taxa are listed from pollution-intolerant (blue) on top to pollution-tolerant (orange) beneath. Taxa without a Pollution Tolerance Index (PTI) are listed at the bottom. Functional Feeding Groups (FFG) are also listed for each taxon. The relative distribution of functional feeding groups such as predators (P), filter-collectors (FC), collector-gatherers (CG), scrapers (SC) can indicate whether the community structure is balanced. A site with high biological integrity will contain aspects such as high diversity, many pollution-intolerant taxa, and well-distributed functional feeding groups.

Site photographs
Photographs for each site were selected from previous site visits during the summer biological/habitat assessments based on their ability to represent the characteristics of the site. The photo title indicates the site number, transect number, perspective (upstream/downstream or upriffle/downriffle) and date. For example, a

photo title of 44_t03-us-09_17_2008 indicates that the photo was taken at site number 44 at transect 3, viewing upstream on Sep 17, 2008.

References

COA-ERM. 2004. Water Resource Evaluation Standard Operating Procedures Manual. City of Austin, Watershed Protection Department, Environmental Resource Management, SR-04-04.

COA-ERM. 2012. Environmental Integrity Index Methodology. City of Austin, Watershed Protection Department, Environmental Resource Management, SR-12-02.

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Acknowledgments

This report was produced by the COA Watershed Protection Department, Environmental Resource Management Division, led by Mike Kelly. Report sections and graphics were assembled by Andrew Clamann, Todd Jackson, Rob Clayton, Aaron Richter, and Mikayla Colletti. Field support for water quality sampling in 2015 through 2016 was led by Todd Jackson, Mateo Scoggins, Andrew Clamann, Staryn Wagner, Liz Johnston, John Clement and Brent Bellinger of the Surface Water Team. Data management, EII scores, summary graphs and assistance in the field were supported by Robert Clayton, Aaron Richter and Abel Porras of the Watershed Modeling and Analysis team. Field assistance and support were provided by several members of the interdisciplinary teams within Watershed Protection and other volunteers. The cumulative efforts of these teams provide a large, comprehensive, and quality assured dataset that resides within a database that has high utility and flexibility.