Water Resources of the Yahara River Basin

The Yahara River basin occupies the central one-third of Dane County. It is in the drumlin and wetland physiographic region of the glaciated part of south-central Wisconsin. This physiographic region can be described as having interconnected wetlands drained by sluggish streams and bounded by drumlins. Drumlins, low elongated glacial till hills formed during the last great ice age 10,000 to 12,000 years ago, generally run northeast to southwest in the two watersheds. This area is in the DNR designated Southeast Glacial Plains Ecological Landscape[1]. Historically, vegetation of the Southeast Glacial Plains consisted of a mix of prairie, oak savanna and maple-basswood forests. Wet-mesic prairies, southern sedge meadows, emergent shallow water marshes and occasional calcarious fens were found in low areas. The depth of glacial till in this basin is generally less than 100 feet, except in the pre-glacial Yahara River valley where the till reaches depths up to 300 feet. The glaciers and glacier meltwater deposited rubble, gravel and sand along its edges when it stopped moving for long periods. Over time, this deposition built up a hilly belt of irregular, inter-connected ridges and hills called moraines. The Johnstown terminal moraine is along the western edge of the basin, separating it from the mostly non-glaciated Sugar River Basin. There were large wetland areas adjacent streams and lakes. Many wetlands have been ditched and drained for agriculture and development.

The soils of the Yahara basin are highly productive. The two primary soil associations are the Dodge-St. Charles-McHenry association and the Bavaria-Houghton-Dresden association. The Dodge-St. Charles-McHenry association is characterized by well drained and moderately well drained silt loams. These soils formed in the varied landscape of drumlins and ground, end and recessional moraines. The Dodge and St. Charles soils are highly fertile and very productive. Sable silty-clayey-loam soil is a poorly drained hydric soil often found in depressions and low-lying areas. The Bavaria-Houghton-Dresden association formed mainly in glacial outwash material near streams and moraines. Soils of this association vary from the well drained Bavaria and Dresden soils to the very poorly drained Houghton muck soil.

[1] WDNR, 2006. http://www.dnr.state.wi.us/landscapes/

MAP OF YAHARA BASIN HERE; Mike , one of your aerial photos too??

Landuse

The northern third of the Yahara River basin is primarily agricultural. Dairying, corn and soybean production are the primary agricultural activities. These agricultural nonpoint sources include cropland erosion and livestock operations. There are several rapidly growing communities in the northern part of the basin. The primary source of pollution is erosion from agricultural lands from agricultural lands, contributing sediment and nutrients to streams and downstream lakes[2]. Urban communities in the northern third are the City of DeForest, and the Villages of Waunakee and Dane. The growing northwest third of the City of Sun Prairie and the unincorporated communities of Windsor, Westport and Morrisonville are also in this northern portion. Waunakee is one of the fastest growing communities in Dane County. Most wastewater from this portion of the basin is sent to the Madison Metropolitan Sewerage District's (MMSD) Nine Springs treatment plant. Urban stormwater runoff and runoff from construction sites may cause local problems.

(a table showing population growth of cities, villages and towns in Yahara basin)

The central part of the basin, the area surrounding Lakes Mendota, Monona, Waubesa, Upper and Lower Mud and Wingra, is predominantly urban. It includes much of the cities of Madison, Middleton, Monona and Sun Prairie, and the Village of McFarland. Urban nonpoint sources of pollution, runoff from impervious surfaces and erosion from construction and urban development activities affect water quality and instream habitat of the urban streams in this part. These sources deliver sediment, nutrients and toxic substances to streams and drainage systems and ultimately to the lakes. There are few industrial discharges to surface water, usually non-contact cooling water. Almost all municipal wastewater at MMSD's Nine Springs facility and diverted around the Yahara chain of lakes.

The southern portion of the Yahara River basin, including the area directly tributary to Lake Kegonsa, is predominantly agricultural. The soils of this part of the basin are generally very productive and the soil associations are similar to those found in the northern third. The main

[2] DCRPC, 1992.

sources of water pollution in this part of the basin are agricultural nonpoint sources, cropland erosion and from livestock operations. Two incorporated communities, the City of Stoughton and the Village of Oregon, are in this portion. While both communities are growing, they are not showing the very rapid development seen in the Waunakee-Sun Prairie-Cottage Grove area. Both Stoughton and Oregon discharge treated municipal effluent to surface waters. MMSD also discharges its highly treated effluent to Badfish Creek.

The surface water resources of the Yahara River Basin represent the most heavily used and arguably, highly valued in Dane County. The Yahara lakes are the most heavily used recreational resources in the region, and their scenic beauty is one of the prized assets of Dane County.

Upper Yahara River Watersheds

Map showing both watersheds here

There are two watersheds in the upper third of the Yahara River Basin. They are the Yahara River-Lake Mendota Watershed (hereafter referred to as the Upper Yahara River Watershed) that includes all land that ultimately drains to the Yahara River above Lake Mendota, and the Six Mile and Pheasant Branch Creeks Watershed. The Upper Yahara River Watershed covers about 85 square miles, while the Six Mile and Pheasant Branch Creek watershed is also about 85 square miles in size. Communities wholly or partially in these watersheds are the villages of Waunakee. DeForest, and Dane, parts of the cities of Middleton and Sun Prairie, the unincorporated community of Morrisonville, and the towns of Windsor, Westport, Burke, Vienna, Springfield and Middleton. Streams in the watersheds are the Yahara River, Token Creek, Harbison Tributary, Sixmile Creek, Dorn Creek and Pheasant Branch Creek. There are several unnamed tributaries, many having been ditched or straightened for agricultural purposes.

Landuse. Landuse in the Upper Yahara River and the Six Mile and Pheasant Branch Creek watersheds is predominately agricultural. The soils of the two watersheds are generally highly productive. They are high in phosphorus content. Corn and soybeans are the principle crops grown in the watersheds. Animal livestock operations, dairying and beef, are a major agricultural activity. There are several large dairy and beef operations in the watersheds

including six facilities that require a concentrated animal feeding operation (CAFO)[3] discharge permit from the DNR. Additional large operations requiring a CAFO discharge permit are expected in Dane County.

A CAFO facility can cause significant adverse impacts on receiving waters. The DNR CAFO permit specifies requirements for proper runoff control, manure storage and manure management to ensure there are no discharges of pollutants to surface water and to protect groundwater. Once the permit is issued, the owner or operator is required to submit a finalized Manure Management Plan based on the conditions of the issued permit, a monitoring and inspection program, and annual reports summarizing the landspreading of manure to ensure compliance with the permit. Operators must also submit an application for permit renewal every five years, and must notify the DNR of any proposed construction or management changes.

There has been rapid residential and commercial urban development in a belt running from Middleton to Waunakee to DeForest to Sun Prairie. There are no significant impacts on surface waters from wastewater discharges in this part of the basin[4]. Most wastewater is transmitted to the Madison Metropolitan Sewerage District's Nine Springs wastewater treatment facility Rapid urban development can lead to water resources problems due construction site erosion and runoff from impervious surfaces. Runoff conveys sediment and nutrients to surface water potentially adversely affecting instream habitat morphology and biotic communities. Each of the large communities have stormwater management plans or plan components and ordinances. Unincorporated areas are covered by Dane County's stormwater ordinances[5]. In addition, several of the municipalities jointly hold a Group Municipal Storm Water Discharge permit from the DNR. The combination of these regulatory requirements are aimed at reducing the pollutant loading and volume of stormwater runoff reaching surface waters. No comprehensive analysis of the DNR group permit stormwater implementation efforts and requirements, nor of individual municipal stormwater management goals has been done.

Lake Mendota Priority Watershed Project

[3] A CAFO is a livestock operation with 1,000 or more animal units. Seven hundred dairy cows or 1,000 beef cattle equal 1,000 animal units. See http://dnr.wi.gov/runoff/ag/faq_cafo.htm for a complete list.
[4] Dane County Regional Planning Commission, 2005.
[5] See Chapter 14, Dane County Code of Ordinances
http://www.countyofdane.com/unified/information/ordinances.aspx

The Yahara River-Lake Mendota watershed and the Pheasant Branch and Six Mile Creek watersheds were selected as a DNR nonpoint source pollution abatement priority watershed project in 1993, called the Lake Mendota Priority Watershed Project. The goal of the project was to reduce phosphorus and sediment loading to Lake Mendota, the largest and furthest upstream of the Yahara chain of lakes. The watershed encompassed a 230 square mile drainage basin, 88% of which is in Dane County. Approximately 77% of the watershed is agricultural or otherwise undeveloped.

An estimated about 72,000 pounds of phosphorus and 9,600 tons of sediment were entering Lake Mendota annually[6]. The five sub-watersheds with the highest estimated phosphorus delivery rates were Pheasant Branch Creek (6,686 pounds per year), Sixmile Creek (6,374 pounds per year), Dorn Creek (6,299 pounds per year), Token Creek (4,699 pounds per year) and the Yahara River (4,437 pounds per year) sub-watersheds. This pollutant loading resulted in excess sedimentation nutrient loading affecting instream habitat and water quality. The excessive phosphorus loading to the lake resulted in an increase in noxious blue-green algae blooms, excessive aquatic weed growth and decreased water clarity in the lake. Modeling indicated that an estimated 50% reduction in phosphorus loading to the lake (about 37,000 pounds annually) would reduce the number of days algae blooms could potentially occur in the lake. A significant decrease in phosphorus loading to Lake Mendota would also reduce phosphorus levels in downstream lakes[7]. Reduction of sediment loading to tributary streams and to the lake was also a goal of the priority watershed project. An estimated 9,600 tons of sediment was delivered to the lake annually. The projects goal was to reduce that annual delivery rate by about 50% or 4,800 tons. The water quality goal for Lake Mendota is to reduce the concentration of spring total phosphorus in the lake to less than 0.074 mg/L. Modeling results indicate that this concentration will result in a decrease in the concentration of blue-green algae to less than 2 mg/L during the summer months.

Approximately 75% of the phosphorus loading to Lake Mendota came from agricultural parts of the watershed. The priority watershed project would provide farm owners cost sharing for the installation of best management practices (BMPs) designed to reduce the amount of sediment

[6] Betz,(Ed). 1997.
[7] Lathrop and Carpenter, 2010.

and phosphorus leaving farm fields and barn yards. Implementation phase of the project began in 1998 and ended at the end of 2009. The following BMPs were installed[8]:

- 46 barnyard runoff systems,
- 10 water diversion,
- 58.1 acres of grassed waterways installed,
- 3,105 feet of streambank protection measures,
- 2 field terrace systems,
- 8 agricultural sediment basins or grade stabilization structures,
- 148.9 acres of grassed buffers along surface waters, and
- 18.8 acres of restored wetlands.

In addition, all 10 of identified critical site animal lots and 80 critical site crop fields were addressed during the project. Nutrient management plans, plans limiting the amount of phosphorus and nitrogen that could be applied to farm fields, were also completed for several farms in the watershed. A Farm Practices Inventory (FPI) survey was conducted early in the project to establish baseline data. The same participating producers will be surveyed again in 2010 to identify changes that have occurred as a result of the priority watershed project.

The urban component of the priority watershed project funded the construction of several retention and detention facilities in Madison, Middleton, Sun Prairie and DeForest. Non-structural BMP measures were also taken to reduce nutrient and sediment loading. These include the funding of municipal storm water plans, additional street sweeping, Dane County's enactment of an erosion control and storm water management ordinance. Main goals of these measures is to assure adequate erosion control and storm water management actions and facilities are utilized in developing areas, reduce direct discharges to surface waters by 80%, and reduce or control peak storm water flows from developing areas.

No comprehensive Lake Mendota watershed analysis of estimated phosphorus and sediment loading reduction had been published as of October 2010. However, Dane County Land Conservation Division has estimated that implementation of watershed project best management practices on animal lots has reduced phosphorus loading to surface water by about 8,300 pounds

[8] Dane County Land and Water Resources Department, 2010.

annually, approximately 74% of the project goal for phosphorus from this source category[9] Dane County has contracted with a consulting firm to provide updated phosphorus and sediment loading to the Yahara lakes using the Soil and Water Assessment Tool (SWAT). That report is expected in early 2011. Some field specific monitoring using the SNAP-Plus model and Wisconsin's phosphorus index (PI) was done in the North Branch Pheasant Creek watershed. The SNAP-Plus model looked at phosphorus loading from specific fields using different manure spreading, tillage, and crop rotation scenarios. The intent is to identify field management practices to minimize phosphorus leaving the field.

The trend toward larger animal feeding operations in the watershed poses a potential threat to the lake in terms of nutrient loading. These operations will need additional cropland acreage on which to spread manure generated by their operation. This land need for manure spreading is in competition with residential and commercial development also occurring in the watershed. One answer is the Dane County Community Manure Digester. Located near Waunakee, the digester will take liquid manure from three local dairy operations. The manure will be pumped to three tanks in the mesophilic anaerobic digester facility where it will produce low-grade methane that will be used to produce up to two megawatts of electricity. The electricity generated will provide enough power for over 2,000 local residences. The heat from that process goes back to the digester, making it somewhat self-sustaining, and an advanced separation system will pull the solids from the liquids. The solids, which include most of the phosphorus, will leave the area as a soil amendment for landscapers while the nitrogen and potash will remain with the liquid portion that the farmers will get back to fertilize their fields. It is expected that this operation will reduce the amount of phosphorus spread from these three facilities by about 60%. Due to this reduction in phosphorus in the land spread material, the amount of phosphorus that would be making its way into surface water through runoff from participating farms is 8 percent based on SNAP modeling[10].

Sediment and nutrient loading reductions to surface water and the Yahara lakes may be negated if there is an increase in the frequency and intensity of spring and summer storms occurs as projected by some climatologic models. Data from the Wisconsin Initiative on Climate Change Impacts (WICCI) show average annual precipitation increasing between 4.5 To 7 inches in Dane

[9] Dane County Land & Water Resources Department, 2009.
[10] WDNR, Environmental Impact Statement, 2010.

County between 1950 and 2006[11]. The frequency of 3-inch rainfall events has increased significantly over the last 10 years[12]. Current runoff models, and management assumptions based on those models, may have to be altered if this trend continues. Additional and more intense rural and storm water management practices may need to be implemented if water quality of Lake Mendota and the downstream Yahara lakes is to improve. It should be noted that June 2008 and March 2009 were the wettest months on record for Madison, and these two months also were record months for phosphorus and sediment loading based on USGS data.

No estimate of the total amounts of phosphorus and sediment loading reductions to streams and Lake Mendota measures has been made since completion of the project. Lathrop noted that:

> "no discernible effect of nonpoint P management has been observed (in Lake Mendota) because of an increase in frequency of large runoff events, slow depuration of P in soils, and other offsetting factors[13]."

Upper Yahara River Watershed

The Upper Yahara River Watershed is in north central Dane County and a small portion of it extends into Columbia County. It has a mixture of agricultural, suburban and urban land uses. Urban areas include the Village of DeForest, parts of the Town of Windsor, and the rapidly developing northwest side of the City of Sun Prairie. Large portions of the historic wetlands have been drained for agricultural purposes or for development. Cherokee Marsh, at over 2,000 acres, is the last large wetland complex in the watershed, and there are several smaller wetlands complexes also remaining. Most, if not all, of these wetlands have been altered or degraded.

Yahara River.

The Yahara River originates in a marshy area of Columbia County near Morrisonville. It meanders about 20 miles through extensively farmed land before reaching Lake Mendota. The DNR has classified the Yahara River as a Warm Water Sport Fishery (WWSF) stream[14].

[11] WICCI, (no date). http://www.wicci.wisc.edu/resources/wicci_climate_change_maps.pdf
[12] Lathrop and Carpenter, 2010.
[13] Lathrop and Carpenter, 2010.

The river has a relatively low gradient of about 4.4 feet per mile between Morrisonville and Lake Mendota. A higher gradient exists near DeForest where the river drops about 55 feet between DeForest and the I-39/90/94 crossing of the river. There is a nice series of runs and riffles between DeForest and the Lake Windsor Country Club that provides good habitat. Groundwater augmentation of flow occurs in this reach. The priority watershed plan lists this reach of the Yahara River as a priority and protection of its warm water sport fishery[15] There was significant wooded and open buffer in this reach, but development in DeForest and the Town of Windsor has reduced the buffer and replaced it with impervious surfaces and turf grass in some areas. Residential development on the ABS property has resulted in removal of trees and understory on the formerly wooded hillsides adjacent the stream. This could increase stormwater runoff and decrease infiltration adversely affecting water quality, habitat and morphology of the Yahara River in this reach.

While many wetlands areas formally associated with the river have been drained, particularly in the headwaters area, there are still some wetlands buffering the stream including the large Cherokee Marsh complex. Cherokee Marsh is an extensive peat deposit along the Yahara River and Token Creek, north of Lake Mendota in Dane County, Wisconsin. Covering over 3,200 acres, Cherokee marsh is the largest wetland in Dane County and the major wetland in Lake Mendota's watershed. Cherokee Marsh contains a large expanse of open wet sedge meadow, varying to fen, prairie, bog, and shallow marsh in places. The less accessible central areas probably retain the condition and appearance of many of the Yahara basin marshes a century ago. Islands of upland support oak forest or open fields, while small depressions have high quality ponds or springs[16].

[14] Johnson, 2002.
[15] Betz, et.al. 1997.
[16] Bedford, et.al., 1974.

Yahara River at Windsor Road

The draining of wetlands in the watershed and the straightening of small feeder streams coupled with the intensive agriculture of the watershed has resulted in large sediment and nutrient loading to the river and to Lake Mendota.

The Village of DeForest, the community of Morrisonville, and the towns of Vienna, Windsor and Westport are all within its drainage area. DeForest, Windsor and Westport are all rapidly growing communities. Data from the Wisconsin Department of Administration's Demographic Services Center shows the population of DeForest has grown about 15.8% since 2000, while the populations of Windsor and Westport have grown 12.4% and 6.0% respectively over the same time frame[17]. The 2010 preliminary combined population estimate for the three communities is 18,272, or about 12.5% increase over the 2000 population.

Yahara River Water Quality. The Lake Mendota Priority Watershed Plan divided the Yahara River into three distinct reaches. The first reach is from its headwaters near Morrisonville to County Trunk Highway (CTH) V on the north edge of DeForest; the second reach was from CTH V to Windsor Road; the third reach was from Windsor Road downstream to Cherokee Marsh.

Water quality in the Yahara River above Lake Mendota is considered to be fair to good. It supports a good warm water sport fishery[18]. Problems affecting water quality in the first reach, headwaters to DeForest, are related to agriculture followed by development on the north edge of DeForest. The stream's natural channel morphology has been altered by sedimentation from farm fields and channelization of it and feeder tributaries. This has led to poor aquatic habitat while facilitating aquatic plant growth. Water quality problems of this reach included low flows, lack of suitable habitat for aquatic organisms, heavy instream sedimentation, and loss of wetlands. While the current biological use of this reach is listed as a warm water sport fishery[19], it is more accurately a warm water forage fishery due to low flows, elevated temperatures, lack of diverse habitat, and low DO levels[20]. The 1997 WDNR priority watershed plan estimated that the Yahara River sub-watershed delivered approximately 12.7% of the annual total sediment and

[17] Wisconsin Department of Administration, Demographic Services Center; http://www.doa.state.wi.us/subcategory.asp?linksubcatid=96&linkcatid=11&linkid=64&locid=9
[18] DCRPC, 1992, and Johnson, 2002.
[19] See the watershed table for the Yahara River and Lake Mendota Watershed (LR-09), http://www.dnr.wisconsin.gov/org/gmu/lowerrock/surfacewaterfiles/watersheds/lr09.pdf
[20] Betz, et.al, 1997.

phosphorus loading to Lake Mendota[21]. Analysis of USGS data shows a general downward trend in suspended sediment concentrations in the river. Total phosphorus concentrations over the same period have remained steady[22]. ***Insert USGS data bar charts for P and sediment here***

The section of the river from DeForest downstream to Windsor Road is the nicest stretch of stream in the sub-watershed. It has riffles, pools, diverse substrate and good velocity and support warmwater game and forage fish [23]. It is affected by urban development resulting in stormwater runoff, construction site erosion, and loss of infiltration areas and wetlands. Its biological use is as a warmwater sport fishery. The priority watershed plan considered this reach as having the greatest potential for supporting valuable sport fishery.

The third reach from Windsor Road to Lake Mendota including Cherokee Marsh has a diverse warmwater sport fishery. This reach has the same water quality problems as the upstream reaches. It was noted that bank erosion was so significant that it resulted in stream braiding in some locations. There are some better quality wetlands associated with this lower reach. The river and the associated wetlands reach play an important role in providing spawning habitat for a variety of game fish including northern pike, walleye and white bass that sustain the sport fishery of Lake Mendota. There is a problem with excess carp populations in this reach.

The USGS maintains two stream monitoring stations on the Yahara above Lake Mendota, one at Windsor Road and one at STH 113. Concentrations of total phosphorus and ammonia nitrogen at the Windsor Road site have remained relatively the same over the past 20 years (1990-2009), about 0.09 mg/l and 0.04 mg/l, respectively. Suspended sediment has declined significantly from about 50 mg/l to 20 mg/l over the same period at Windsor Road[24]. Over the 20 year record at this site the month with the highest mean monthly discharge of phosphorus is March at 125 pounds per day (range 5.17-503.0 lbs), followed by February with a mean of 112 pounds per day (range 2.95-429.3 lbs), and June with a mean 94.6 pounds per day (range 5.81-737.1 lbs)[25]. This differs slightly from the mean monthly suspended sediment discharge over the same period. The

[21] Betz, et.al., 1997.
[22] Source: CARPC cooperative water resources monitoring program and U.S. Geological Survey.
[23] Sorge, 1996.
[24] CARPC Files, from USGS data, 2010.
[25] USGS data, http://waterdata.usgs.gov/wi/nwis/monthly?referred_module=qw&search_criteria=county_cd&submitted_form=introduction

top three months for suspended sediments are June with a mean discharge of 19 tons per day (range 0.49-103.9 tons), March with a mean discharge of 14 tons per day (range 0.33-77.0 tons), and July a mean discharge of 12 tons per day (range 0.62-163.3 tons). Lathrop concluded that 48% of the total phosphorus loading occurs between January and March based on data from this station[26]. Lathrop also suggested that summer algal growth in Lake Mendota may be limited by both phosphorus and nitrogen loading to the lake.

Watershed appraisal HBI monitoring of the Yahara River monitoring done in 1994-95 indicated ranged from "very good" water quality conditions at the upper River Road crossing (HBI score=4.44) to "fair" (HBI score=5.90) at CTH V[27]. The average HBI score for the five locations monitored was 4.91 indicating "good" water quality.

The DNR did monitoring upstream from Windsor Road in 2007. The Wisconsin warmwater IBI fish monitoring indicated "fair" water quality, while instream habitat was rated as "good". The DNR noted that some intolerant coldwater species were found in this reach. HBI macroinvertebrate monitoring done in 2007 at Windsor Road indicated "good" water quality. HBI monitoring done at sites upstream of Windsor Road (South Road and CTH V) between 1992 and 2000 indicated water quality ranging from " good" to "poor" as one goes upstream[28].

The USGS station at STH 113 has a shorter period of record, dating from 2002. Over the 8 year record at this site the month with the highest mean monthly discharge of phosphorus is March at 147 pounds per day (range 11.27-641.1 lbs), followed by June with a mean of 130 pounds per day (range 28.62-567.4 lbs), and August with a monthly mean of 128 pounds per day (range 30.66-594.4 lbs)[29]. This differs slightly from the mean monthly suspended sediment discharge over the same period. Three months, April, May and June had the same mean of monthly suspended sediments discharge at 15 tons per day. March was close at 14 tons of sediment per day over the 8-year record.

[26] Lathrop, 2007.
[27] Sorge, 1996.
[28] Wisconsin Department of Natural Resources, South Central Region Water Resources Files, 2010.
[29] USGS data, http://waterdata.usgs.gov/wi/nwis/monthly?referred_module=qw&search_criteria=county_cd&submitted_form=introduction

The primary water quality threats to the Yahara River are sediment and nutrient loading to the river from both agricultural and urban sources. Farmers, municipalities, Dane County, the DNR and the NRCS need to continue to install and maintain practices to minimize runoff and sediment and nutrient loading to the river.

Token Creek

Token Creek is a spring-fed tributary to the Yahara River that originates in north central Dane County near Sun Prairie. It is 10 miles long with a 25.3 square mile drainage area. Token Creek has a moderate gradient of 8.7 feet/mile. The creek provides a large amount of the baseflow for the Yahara River and Lake Mendota[30].

Token Creek has a diverse fishery containing warmwater, coldwater, forage fish and rough fish species. The DNR has classified the first two miles upstream of the Yahara River as WWSF. Miles 2 to 4 of Token is classified as a cold water fishery while the remaining upstream 6 miles has a default WWSF classification[31]. It is a class III trout stream, one of the few trout streams east of USH 51[32]. Token Creek was placed on the state's 303d list of impaired waters[33] in 1998. It was listed because of to water quality impairments due excessive sediment and suspended solids loading, and because of the partially failed Token Creek Millpond dam was an obstruction to fish passage.

The 1997 WDNR priority watershed plan estimated that Token Creek sub-watershed delivered approximately 13.4% of the annual total sediment and phosphorus loading to Lake Mendota[34]. Analysis of USGS data shows a general downward trend in suspended sediment concentrations in the creek. Total phosphorus concentrations over the same period also show a downward trend[35]. ***Insert USGS data bar charts for P and sediment here***

[30] DCRPC, 1992.
[31] Johnson, 2002.
[32] Wisconsin Department of Natural Resources. 2008. *Trout Management in Dane County*, Fisheries Management Program-South Central Region, Fitchburg, WI. http://dnr.wi.gov/fish/reports/final/2008StreamAssessment.pdf
[33] See http://dnr.wi.gov/org/water/wm/wqs/303d/index.htm for a discussion of the DNR's impaired waters program.
[34] Betz, et.al., 1997.
[35] Source: CARPC cooperative water resources monitoring program and U.S. Geological Survey.

Token Creek has substantial groundwater inflow and has been designated a thermally sensitive stream[36]. Springs that feed into Token Creek are estimated to supply 50% of the baseflow to Lake Mendota[37]. The springs flow at a rate of between 3,400 and 4,000 gallons per minute at a temperature of 50^0 F. The largest of these are the Culver Springs on the northeast side of the former millpond which generate approximately half the total springs flow. The main recharge area for the Culver Springs is to the north. Water flows out of Culver Springs at 50^0 F has a cooling effect on Token Creek, maintain a stream water temperature within the optimum temperature range for trout[38]

Token Creek at Dam Site Off Portage Road

[36] Dane County Land and Water Resources Department, http://www.countyofdane.com/lwrd/landconservation/cws/index3.html
[37] Betz (Ed), 1997.
[38] Roa—Espinosa, et.al. 2003.

Token Creek is subject to a high level of development pressure from the City of Sun Prairie and development pressure in adjacent unincorporated areas of the Town of Windsor. Stormwater runoff from these areas, and the three major highways which cross it, is often warmer than ambient water temperature. This runoff can raise instream water temperatures degrading

In 1993 the dam on Token Creek that formed the 44 acre Token Creek Millpond partially failed. The resulting partial drawdown of the millpond exposing several spring and seeps in the wetlands that filled in the former millpond. The dam was finally removed in 2005. Token Creek was placed on the state's 303d list in 1998. In 2002 the EPA approved a Total Maximum Daily Load (TMDL)[39] plan for Token Creek. Project goals included:

- restoration of stream morphology and habitat,
- managing and reducing sediment and other pollutant loading from agricultural land through Lake Mendota Priority Watershed Plan, and
- managing storm water discharges through the Lake Mendota Priority Watershed Plan and the DNRs storm water discharge permit program.[40]

The DNR has added the goal of restoring a native brook trout fishery in the reach downstream of the Culver Springs.

Restoration work on Token Creek to improve habitat and hydrologic functions include:

- removing the berms around the Culver Springs allowing them to flow freely,
- bank stabilization, and
- removal of pond sediment above the dam location[41].

Priority watershed HBI appraisal monitoring of Token Creek done in 1994 and 1995 at four sites indicated a range of water quality conditions from "very good" (HBI score=4.30) to "fairly poor" (HBI score=7.44) depending on location. The monitoring was done prior to complete dam removal[42].

[39] See http://dnr.wi.gov/org/water/wm/wqs/303d/index.htm for a more detailed TMDL discussion.
[40] WDNR, *Token Creek TMDL for Sediment and Habitat*, 2002.
[41] WDNR, Expenditures of Inland Water Trout Stamp Revenues, 2009.
[42] Sorge, 1996.

The DNR has done cold water IBI monitoring at several sites on Token Creek. The cold IBI monitoring upstream of the millpond at CTH C in 1998 and 2000 indicated "very poor" biotic integrity conditions. Results of coldwater IBI done in 2000 and 2001done upstream of Token Creek County Park indicated "fair" biotic integrity conditions for both years. Coldwater IBIs at STH 19 indicated "poor" biotic integrity condition in 2000 and "fair" biotic integrity conditions in 2000[43]. DNR 2006 coldwater IBI monitoring beginning just downstream of the dam site and continuing upstream to the Culver Springs showed a biotic integrity rating of "good"[44]. These data coupled with the ongoing channel and habitat improvement indicates that Token Creek can sustain a viable cold water fishery. The DNR is attempting to establish a native brook trout fishery in the Culver Springs area.

The primary threat to Token Creek water quality is from urban stormwater and runoff from major roadways. The City of Sun Prairie has installed several stormwater measures in developing areas near the creek to minimize pollutants reaching the stream and minimize adverse thermal impacts to the stream from urban runoff. The Friends of Token Creek, Dane County and the WDNR have also acquired land adjacent the creek to further protect it.

Harbison (Pederson) Tributary

The Harbison Tributary is a cold water tributary to Token Creek south of STH 19. It provides a stable supply of cold water to Token Creek. Harbison Tributary experiences natural reproduction of brown trout. The 1997 Lake Mendota Priority Watershed Plan reported that this tributary had the highest water quality within the Token Creek Sub-watershed[45]. Four cold water IBIs done in 2000 and 2001 all indicated "good" biotic integrity. The DNR has been doing habitat improvement projects including removal of a rough fish holding pen and streambank work. This is consistent with the washed HBI assessment monitoring done in 1994 and 1995.

The primary threats to the Harbison Tributary are from stormwater runoff from STH 19 that carries pollutants to the stream and thermal loading. A new commercial development proposed at the intersection of USH 51 and STH 19 has the potential to significantly increase stormwater

[43] Data from DNR Fisheries Management files.
[44] WDNR, 2008.
[45] Betz, 1997.

volume altering instream habitat, thermal and pollutant loading affecting the coldwater fishery of the stream.

Sixmile and Pheasant Branch Creeks Watershed

The Sixmile Creek and Pheasant Branch watershed is in the northwest part of Dane County. It is 85-square watershed encompassing the villages of Waunakee and Dane, parts of the cities of Middleton and Madison, and parts of the towns of Westport, Vienna, Dane, Springfield and Middleton. Principle streams in the watershed are Pheasant Branch (including north and and south forks), Sixmile Creek and Dorn Creek, a tributary to Sixmile. There are also small unnamed seasonal and perennial tributaries to the named streams. Most of the historic wetlands have been drained for agriculture or development. The Waunakee Marsh west of Waunakee is the only large wetlands complex in the watershed, although there are smaller ones both isolated adjacent waterways.

Soil associations in the watershed vary from the Dodge-St. Charles-McHenry silt loam association to the Batavia-Houghton-Dresden silt loam and muck soil association. These soils are very fertile and support generally very productive crop yields. Agriculture is the primary landuse in the watershed although rapid urban and suburban development is occurring in Waunakee, Middleton, and parts of the Town of Middleton and Westport. There are several larger animal operations and intensive cultivation operations in the watershed. Sub-watersheds with the greatest sediment and phosphorus losses are located in this watershed[46].

The Sixmile Pheasant Branch watershed was one of the first nonpoint source pollution abatement priority watersheds projects undertaken by the WDNR back in the early 1980s. However, it was not considered a success as there was low participation, out of state landowners, and inadequate BMPs maintenance. This led to the watershed being chosen a second time as part of the larger Lake Mendota priority watershed project.

Sixmile Creek

Sixmile Creek originates in section two in the Town of Springfield. It flows east through the Waunakee Marsh and the Village of Waunakee before turning south to enter the north end of

[46] Jones, et.al. 2010.

Lake Mendota. The creek is about 12 miles long with a relatively flat gradient of 7.2 feet per mile. Sixmile drains an area of approximately 48 square miles. Landuse within its drainage area is predominately agriculture but there is significant development pressure in Waunakee and in the Town of Westport. Many of the historic wetlands adjacent to the creek have been drained. Waunakee Marsh is the remaining large wetland at over 1,000 acres. Another important wetland is between Woodland Drive and Lake Mendota. These wetlands provide important gamefish spawning areas.

Water quality in Sixmile Creek is generally good[47]. It supports a limited forage fishery west of STH 113, and a diverse forage and warm water sport fishery from STH 113 to Lake Mendota[48]. The WDNR has classified Sixmile Creek as an Exceptional Resource Water (ERW) from Waunakee Marsh downstream to Lake Mendota. The fishery above STH 113 is a limited warm water forage fishery. Downstream of Highway 113 the fishery changes to a warmwater sport fishery stream. The reach between STH 19 in Waunakee to just downstream of Mill Road has the best instream habitat. Macroinvertebrate samples at Highway 19 and Mill Road indicated "good" water quality[49]. Further downstream the gradient decreases, water turbidity increases and the stream bottom is fine, often deep, silt.

The 1997 WDNR priority watershed plan estimated that the Sixmile Creek sub-watershed delivered approximately 18.2% of the annual total sediment and phosphorus loading to Lake Mendota[50]. Total phosphorus concentrations in water samples from Sixmile Creek have shown a slight downward trend based since 1990 on analysis of USGS data. Suspended sediment concentrations appear more erratic over the same period[51]. ***Insert USGS data bar charts for P and sediment here***

There has been significant soil loss reduction in the Town of Westport part of the watershed since 1988, but soil loss in the other townships have remained stable over the same period[52].

[47] DCRPC, 1992.
[48] Johnson, 2002.
[49] Betz, et.al. 1997.
[50] Betz, et.al., 1997.
[51] Source: CARPC cooperative water resources monitoring program and U.S. Geological Survey.
[52] Dane County Land &Water Resources Dept, 2008.

There have been fish kills on Sixmile in past years, including one in 2001 thought to be caused by high chlorine levels from flushing of a new water main[53].

Priority watershed appraisal monitoring done in 1994 and 1995 showed water quality conditions ranging from "good" (HBI score=5.25) to "poor" (HBI score=7.87) at four locations[54]. Monitoring done for the 1997 Priority watershed plan did find two intolerant forage fish species, the pearl dace and the northern redbelly dace at STH 113. A 1997 HBI sample indicated "fair" water quality at STH 113. Monitoring done downstream of STH 113 showed the stream supported a warmwater sport fishery including three pollution intolerant forage species, the brook silverside, central stoneroller and pearl dace. Subsequent fish monitoring in 2000 found just the central stoneroller remaining of the intolerant forage fish mentioned in the 1997 report. This indicates a decline in forage species richness and supports a conclusion made by Marshall et.al. in 2004 regarding the decline of forage fish species in the Rock River basin[55].

Fish IBI monitoring done by the DNR at two locations on Sixmile in 2007 indicate "fair" to "poor" water quality based on fish assemblage while instream habitat had a habitat rating of "fair". The 2007 IBI data is similar to IBIs done in 2000 indicating marginal, if any, improvement in water quality base on fish assemblage. Macroinvertebrate (HBI) monitoring done by the DNR in 2007 also indicated "fair" water quality. Family Biotic Index monitoring done in 2002, 2006 and 2009 by Water Action Volunteer citizen monitors also indicated "fair" water quality. The reasons for the "poor" IBI scores are not clear, but urban stormwater runoff creating flashy flow conditions and carrying pollutants to the creek and fish migration blockage by the dam at Lake Mary, a small impoundment of the creek, may be factors.

Two small unnamed streams are tributary to Sixmile Creek. One rises to the north of Waunakee and flows southwesterly before emptying into Sixmile Creek just west of STH 113. It flows through agricultural land for about half its length. The remainder is through a small wetland and a developed area of Waunakee where it is well buffered. Parts of it have been channelized. Little is known of its water quality although water clarity is good[56]. The second tributary originates in

[53] Jones, Ed., 2008.
[54] Sorge, 1996.
[55] Marshall, et.al, 2004.
[56] Fix. Personal Observations, 2010.

section 10 of the Town of Westport and flows south to Sixmile Creek. This small narrow coldwater stream is well buffered from Hogan Road downstream[57].

The primary threats to water quality in Sixmile Creek continue to be from urban nonpoint sources, runoff from impervious surfaces and construction sites, in the Village of Waunakee and the Town of Westport. Waunakee Marsh captures much of the sediment and nutrients from agricultural areas tributary to Sixmile Creek west of Waunakee adversely affecting the marsh ecology[58]. Some of these pollutants may leave the marsh during periods of high water and flows.

Willow Creek

Willow Creek is a local name for what is now an urban stormwater conveyance in the City of Madison. Its 3.2 square mile drainage area takes stormwater from the near westside of Madison, parts of Shorewood Hills and the University of Wisconsin campus, discharging to Lake Mendota at University Bay. Willow Creek's drainage basin contributes the normal urban pollutants such as toxic elements from streets and parking lots, nutrients from lawns, construction site sediment and trash. Sediments carried by the drainage system to Lake Mendota have created a sediment plume in University Bay at the mouth of Willow Creek. A 1997 USGS report estimated a median total sediment loading of 143 tons per acre (range 80-293 tons per year) over a six year period of record[59]. The USGS no longer supports a monitoring station on Willow Creek.

[57] Betz, et.al. 2000.
[58] Johnson, 2002.

[59] Corsi, et.al. *Unit-Area Loads of Suspended Sediment, Suspended Solids, and Total Phosphorus From Small Watersheds in Wisconsin*, 1997.

Sixmile Creek at STH 113 in Waunakee

Dorn Creek

Dorn Creek is 6 miles long. It rises in the Town of Springfield and flows southeasterly through agricultural and Governor Nelson State Park before meeting Sixmile Creek. The stream supports

mainly tolerant warmwater forage fishery. Two intolerant forage species are also known to inhabit the creek , the northern redbelly dace and pearl dace[60]. Land use is predominately agricultural upstream of CTH Q. Downstream of Highway Q, the stream passes through wetlands. These wetlands provide spawning for northern pike and wildlife habitat.

Although its sub-watershed is slightly more than one-third the size of Sixmile's sub-watershed, Dorn was estimated to contribute 18% of the sediment and phosphorus loading to Lake Mendota. This indicates the intense agricultural activities occurring in its sub-watershed. Dorn Creek has been listed as 303d stream because of habitat impairment due to sediment loading impairing aquatic habitat and has been included in the Rock River Basin Total Maximum Daily Load (TMDL) development project as a second level priority stream[61].

The 1997 priority watershed plan macroinvertebrate sampling results for Dorn Creek ranged from "very good" to "poor". The better HBI values were near its headwaters upstream of Meffert Road, while the "poor" value was at CTH Q. The stream suffers from heavy sedimentation and poor substrate conditions due to the intense agricultural activities in it sub-watershed. Monitoring in 2009 evaluation of Dorn Creek noted up to waist deep silt deposits at CTH Q. The heavy instream sedimentation was also evident at downstream locations. IBIs done at two sites indicated "very poor" conditions.

The primary water quality problem and threat to Dorn Creek is from agricultural runoff carrying sediment and nutrients from barnyards and cultivated farm fields degrading water quality and habitat.

Pheasant Branch

Pheasant Branch is a 7-mile long stream that drains 22.7 square miles of west-central Dane County. It enters western Lake Mendota after flowing through the Pheasant Branch marsh complex that includes a large springs. Land use ranges from intense agricultural uses to the urbanized and urbanizing portions of Madison and Middleton. Stream gradient is estimated to be 19.7 feet per mile. That is misleading in that it reflects the steep gradient of the and below

[60] Johnson, 2002.
[61] WDNR, 2006.

Century Avenue creek between US Highway 12 and Century Avenue (CTH M) and of the South Fork. A significant length of the North Fork above Highway 12 is relatively flat

There are two forks of Pheasant Branch. The South Fork is intermittent flowing north from its headwaters near Mineral Point Road to meet the North Fork near the USH 12 and 14 interchange. The South Fork is primarily a stormwater drainageway for a large part of the westside of Madison and Middleton. The North Fork drainage area is predominately agriculture until it gets to Morey Field north of Airport Road. Much of Pheasant Branch upstream of Airport Road has been channelized and straightened to facilitate agricultural production. The stream and the drainage ditches leading to it generally have minimum vegetative buffer. The are also some large animal operations contributing sediment and nutrients to the stream.

Pheasant Branch flows through the Middleton commercial park between Airport Road and Parmenter Street. From Parmenter Street downstream to Century Avenue it flows through the mostly residential section of Middleton. The section through the commercial park had been channelized, but Middleton has re-meander the stream within the floodway between Airport Road and Parmanter. Middleton has installed a large detention pond is just upstream of USH 12, designed to try to reduce peak flows and sediment loading. Pheasant Branch is rapidly eroding its channel through the terminal moraine and has carved a steep, narrow ravine between Parmenter Street and Century Avenue. The peak flows exacerbate the erosion downstream of Parmenter. Middleton has done different types of bank stabilization efforts to reduce the erosion. The channelization and straightening of the stream channel, coupled with the rapid urbanization have increased peak flows carrying sediment and nutrients to Pheasant Branch Marsh and ultimately to Lake Mendota.

Failing Bank Stabilization Along Pheasant Branch in 2010

The existing biological use of the first mile of Pheasant Branch between Lake Mendota and the Pheasant Branch marsh is a warm water sport fishery. The WDNR considers the remaining nine miles to support a tolerant limited forage fishery[62]. Pheasant Branch Creek is also on the state's 303d impaired waters list due to degraded aquatic habitat and low DO levels. It is a "high" priority candidate for TMDL development[63]. Dissolved oxygen reading below water quality criteria[64] have been recorded during USGS and WDNR monitoring done in 2005 and 2009 with the lowest reading being 3.5 mg/l.

Priority watershed HBI appraisal monitoring scores from 1994 to 1995 ranged from 7.01 to 7.90 indicating "fairly poor" to "poor" water quality conditions for the reach between Parmenter Street (USH 12) and Century Avenue (CTH M). Only two species of fish were found in this

[62] Johnson, 2002.
[63] See http://www.wnrmag.com/Water/ImpairedWater_AdvSearch.aspx for a list of Dane County impaired waters.
[64] Dissolved oxygen levels below 5 mg/l do not meet state water quality criteria. See Wisconsin Administrative Code NR 102.04(4)(a) http://legis.wisconsin.gov/rsb/code/nr/nr102.pdf

reach which was surprising given what was considered good habitat conditions[65]. WDNR baseline fish IBI monitoring done in 2009 at two locations indicated the stream had "very poor" biotic integrity rating at both stations. This is consistent with earlier IBI monitoring done. HBI monitoring of macroinvertebrates also indicate "poor" water quality conditions.

The 1997 Lake Mendota priority watershed report estimated that Pheasant Branch sub-watershed of the Lake Mendota watershed contributed 19% of the sediment and phosphorus loading to the lake. Suspended sediment concentrations, measured in milligrams per liter (mg/l), have declined since 1995 based on a summary of USGS data[66]. Total phosphorus concentrations have also declined but not at the same rate as sediment concentrations. ***Insert USGS data bar charts for P and sediment here*** Phosphorus loading to Pheasant Branch shows a fluctuating downward trend between 1992 and 2008 based on USGS monitoring station data. The annual fluctuations are due to the number and intensity of annual storms and runoff events. Pheasant Branch is also on the state's 303d list of impaired waters and has been included in the Rock River Basin Total Maximum Daily Load (TMDL) development project as a top priority stream due to phosphorus and sediment loading degrading habitat and causing low dissolved oxygen levels in the stream. The proposed target phosphorus concentration for Pheasant Branch is 0.08 mg/l[67].

In 2001 the USGS came out with a study of the hydrologic effects of urbanization on the North Fork Pheasant Branch sub-watershed. The modeling indicated that low density development (increase in impervious surfaces) of the undeveloped parts of the sub-watershed would increase overland flow 84%, increase mean annual streamflow 53%, but decrease baseflow by 15%. This scenario would also decrease regional groundwater recharge by 10%[68]. The increase overland flow and mean annual baseflow coupled with an overall decrease in baseflow indicates a system with more "flashy" stormflow events and greater erosive potential. A decrease in regional groundwater recharge due to impacts of urbanization could affect the Frederick Springs, a large springs complex that flows into Pheasant Branch Marsh providing water to Lake Mendota. Much of the groundwater recharge area for Frederick Springs lies within the Pheasant Branch drainage area. The surface water drainage system is complexly coupled with the groundwater

[65] Sorge, 1996.
[66] Source: CARPC cooperative water resources monitoring program and U.S. Geological Survey.
[67] WDNR, 2006.
[68] Steuer and Hunt, *Use of a Watershed-Modeling Approach to assess Hydrologic Effects of Urbanization, North Fork Pheasant Branch Basin Near Middleton, Wisconsin,* 2001.

system making it difficult to reliably predict actual impacts of urbanization on surface water baseflow and spring flows[69]. The results of the surface water hydrology modeling and the groundwater recharge done in the Pheasant Branch watershed provide the best estimate of what could happen and provide a first step in efforts to protect both surface water baseflow, groundwater recharge and springflow.

Yahara River – Lake Monona Watershed

The Yahara River – Lake Monona watershed covers about 85 square miles with over 70% being considered urban. It includes all streams draining to Lake Monona, Lake Waubesa and Lake Wingra ***(See Lakes Section***). Parts of the cities of Madison and Fitchburg, all of the City of Monona and the Village of McFarland, and parts of the Towns of Blooming Grove, Burke, Dunn and Madison are in its drainage area. Water quality of the streams reflect the highly urban character of the watershed. Nutrients, sediment, contaminants attached to sediment, solids, oil and grease go into the streams and lakes. Streams in the watershed include the Yahara River, Starkweather Creek, Wingra Creek, Murphy's Creek, Swan Creek and Nine Springs Creek. Other water features include Lake Monona, Lake Wingra, Lake Waubesa (all three discussed in a separate section), Upper Mud Lake, the Nine Springs wetlands, the South Waubesa wetlands.

Starkweather Creek

Starkweather Creek is tributary to Lake Monona at the lake's north end at Olbrick Park. Starkweather has a drainage area of about 24 square miles. It has two branches, the East Branch and the West Branch. The two branches join south of Milwaukee Street to form the main stem flowing to Lake Monona.

East Branch Starkweather Creek

The East Branch begins just west of I39/90/94 near East Towne Mall. The stream drains much of the east side of Madison south of East Washington Avenue (USH 151). It is about 3.5 miles long and has a low stream gradient of about five feet per mile[70].

[69] Hunt and Steuer, *Simulation of the Recharge Area for Frederick Springs, Dane County, Wisconsin*, 2000.
[70] DCRPC, 1992.

The East Branch can best be described as urban stormwater drainageway. It receives runoff from parking lots streets and rooftops resulting in larger stormwater flows. The East Branch has been channelized and is choked with sediment, aquatic plant growth and debris for much of its length. There is an area of springs just west of the Interstate that is a remaining natural attribute. This area is threatened by continued urban development that decreases infiltration of water into groundwater that supports the springs flow. There s a disturbed wetland complex in the southwest corner of the intersection of Highway 30 and Stoughton Road that serves as a buffer and may provide some baseflow support.

Severe diel (24-hour) dissolved oxygen fluctuations are common during low flow periods in summer. Fish populations vary during the year reflecting seasonal migrations and low summer dissolved oxygen readings[71]. Runoff from a recycling facility has caused water quality problems in the past. Warm Water IBI monitoring done at two location on the East Branch at STH 30 and 300 meters upstream of Highway 30 in 2007 showed biotic integrity ratings of "fair" (decreased fish species richness) and "poor" (relatively few fish species) respectively[72]. Mean baseflow concentrations of phosphorus and sediment have decline over the past 18 years while mean concentrations of chlorides have increased[73].

West Branch Starkweather Creek

The West Branch originates near Cherokee Marsh. It is seven miles long with a stream gradient of 3.7 feet per mile. It functions primarily as an urban stormwater waterway. It drains the area around the Dane County Regional Airport and a portion of the east side of Madison, receiving significant urban runoff. Contaminants in the runoff include oil, grease, lead, cadmium ethylene glycol and polyaromatic hydrocarbons.

Prior to the early 1970's, the West Branch received industrial point source discharges containing many different toxic substances including heavy metals and PCBs. While the point source discharges have been managed by various programs or ended, some of the former industrial sites posed problems for the creek's water quality. WDNR and Madison have dredged a portion of

[71] Johnson, 2001.
[72] WDNR South Central Region Water Resources Files and SWMS data base 2010.
[73] Source: CARPC cooperative water resources monitoring program and U.S. Geological Survey

the West Branch to reduce those threats[74]. The airport in 1993 constructed a $1 million collection system to protect the West Branch from ethylene glycol spills. Madison has done streambank work to reduce bank erosion and make the area adjacent the stream more aesthetically pleasing. Mean baseflow concentrations of sediment and phosphorus have shown a small downward trend since 1992, while mean concentrations of chloride have increased[75].

Starkweather Creek Mainstem

The Starkweather Creek mainstem begins south of Milwaukee Street and flows to Lake Monona at Olbrick Park. Its stream gradient is 0.5 feet per mile. The stream often acts as a backwater to Lake Monona due to low flows and flat gradient. Urban nonpoint sources of pollution are major water quality problems in the mainstem. The pollutants from the nonpoint sources include sediment, oil and grease and trash contributed by the upstream branches of Starkweather. Heavy metals, PCBs and other toxic constituents were found in the stream bottom sediments. Portions of the stream were dredged, spoils disposed at an approved site, and streambanks were re-vegetated[76].

Wingra (Murphy) Creek

Wingra Creek is a channelized stream flowing 2 miles from Lake Wingra eastward to Lake Monona at Olin Park. Its drainage area is 8.6 square miles and includes densely developed urban areas, parkland and the UW-Madison Arboretum. The WDNR considers a warm water sport fishery (WWSF). It has a very shallow stream gradient of 2.0 feet per mile. Wingra is often choked with aquatic plants and is periodically stagnate due to low baseflow conditions and the flat stream gradient. Water quality is generally poor due to urban runoff, aquatic plant growth and sedimentation. Chloride levels are high, particularly in late winter and early spring, due to runoff of road salt low dissolved oxygen levels and extreme diel fluctuations results in occasional fish kills. Despite these problems, Wingra seasonally supports good populations of bluegills. Walleye and northern pike are also present during spring spawning season[77]. The City

[74] Johnson, 2001.
[75] Source: CARPC cooperative water resources monitoring program and U.S. Geological Survey
[76] Johnson, 2002.
[77] Johnson, 2002.

of Madison has done streambank stabilization projects on sections of Wingra to reduce streambank erosion and improve the riparian aesthetics.

Wingra Creek at Beld Street

Nine Springs Creek

Nine Springs Creek begins as a ditched intermittent stream at the out let of Dunn's Marsh and flows east about six miles to discharge to the Yahara River just above Upper Mud Lake. Nine Springs west of Fish Hatchery Road is intermittent and has a low stream gradient of 3.3 feet per mile. The creek drains a long 13-square mile valley in the City of Fitchburg and the south side of the City of Madison. Much of its drainage area is developed or experiencing rapid urban development that increases stormwater loading and flows. East of Fish Hatchery Road it enters the Nine Springs wetlands complex over 5 miles from the Nevin State Fish Hatchery to the Yahara River. This large wetland complex has several springs, both at Nevin and downstream,

that provide significant baseflow to Nine Springs Creek. The wetlands are part of the Nine Springs E-way, a large environmental corridor that provides wildlife habitat, some stream buffering and recreational activities. Nine Springs is channelized from the Nevin Fish Hatchery to the Yahara River. The extensive and continuing urban development in the Nine Springs sub-watershed has raised concerns about the impacts of urban development on spring water quality and flow[78]. The Madison Metropolitan Sewerage district (MMSD) sludge lagoons were adjacent to Nine Springs Creek. One MMSD sludge was a Superfund site due to toxic substances found in bottom sediments. There was concern regarding the possibility of toxic substances migrating from the sludge lagoon to Nine Springs Creek. A Remediation Investigation (RI) was conducted as part of the Superfund evaluation of the lagoon. In 1995 the RI concluded that no toxic sludge constituents were migrating through the lagoon walls to Nine Springs Creek[79].

Nine Springs Creek at Syene Road

[78] Swanson, et.al. *Two-way cluster analysis of geochemical data to constrain spring source waters*, 2001.
[79] Johnson, 2002.

Nine Springs Creek is on the state's 303d list of impaired waters and has been included in the Rock River Basin Total Maximum Daily Load (TMDL) development project as a first priority stream due to phosphorus and sediment loading degrading habitat and causing low dissolved oxygen levels in the stream. The proposed target phosphorus concentration for Nine Springs is 0.08 mg/l[80]. Summary of USGS data for Nine Springs indicates that mean baseflow concentrations have shown a downward trend while the trend of mean baseflow concentrations of chlorides is slightly up[81]

Unnamed Tributary (Penitto Creek)

This small tributary rises east of I-39/90 and flows southwest to Upper Mud Lake. It drains agricultural land east of the Intestate. It is channelized west of the Interstate and flows cropland and a developing commercial area on either side of Femrite Road. It has poor habitat due to low flows channelization and sedimentation from agricultural activities, construction site runoff and urban stormwater runoff. Despite the poor habitat, a Family Biotic Index (FBI) done in the 1990's indicated "very good" water quality. The FBI score, coupled with other indicators, indicated groundwater discharge and cool water temperatures[82].

Murphy's Creek

Murphy's Creek, a 3-mile long spring-fed creek, begins in a wetland complex adjacent USH 14, south of Byrne Road. It flows northeast to Lake Waubesa at the Lake Waubesa Wetlands State Natural Area. The creek's sub-watershed has a large proportion of wetlands to total surface area. It has a stream gradient of 8 feet per mile. Flow in the creek is generally low. The stream is considered to have good water quality[83] and groundwater seepage and large wetland buffers contribute to good water quality and habitat in the lower reaches. Water quality, fishery and habitat are limited in the upper reaches of Murphy's by low flows. The WDNR considers the

[80] WDNR, 2006.
[81] Source: CARPC cooperative water resources monitoring program and U.S. Geological Survey.
[82] Johnson, 2002.
[83] Johnson, 2002.

stream as Warm Water Forage Fishery (WWFF) stream[84]. Primary threats to water quality are from agricultural runoff and runoff from roads.

Swan Creek

Swan Creek is a small stream that begins in the eastern part of the City of Fitchburg and flows east to Lake Waubesa and the South Waubesa wetlands in the Town of Dunn. A survey of non-game fish species in the Rock River basin found more forage fish species in 1998 than found in the stream in the 1970's indicating an increase in species diversity[85]. An evaluation of the stream done for the Fitchburg McGaw Neighborhood Plan found signs of a healthy headwater stream even though there were high levels of sedimentation. Water in the stream is warmed by discharges form a stormwater pond discharge[86]. Primary water quality threads are for urban development. The WDNR has done two intermittent fish IBI monitoring at Lalor Road. Both IBIs indicated "fair" water quality conditions[87].

[84] Source: WDNR Lower Rock River Basin website; http://dnr.wi.gov/water/WatershedDetailTabs.aspx?ID=LR08&Name=Yahara River and Lake Monona
[85] Marshall,et.al, 2004.
[86] Fitchburg Planning Department, *City of Fitchburg Comprehensive Plan*, 2010.
[87] WDNR,2010b.

Swan Creek at Lalor Road

Badfish Creek Watershed

The Badfish Creek watershed is in south central Dane County and extends into the northwest corner of Rock County. The watershed has an area of 85.5 square miles. Part or all of the towns of Rutland, Dunn, and Oregon, the Village of Oregon and the southeast corner of the City of Fitchburg are in the watershed. Fitchburg and both the village ond town of Oregon have experienced rapid urban growth over the past 20 years. The watershed is predominately rural watershed. There are several rural residential areas due to its proximity to Madison. There are

several horse farms or boarding facilities in the watershed in addition to the usual types of agricultural operations. The principle streams of the watershed are Badfish Creek, Rutland (Anthony) Branch, Oregon Branch, and MMSD's effluent ditch. Other water features in the watershed include Hook Lake, Island Lake, Grass Lake, Bass Lake and the wetlands of the Badfish Creek State Wildlife Area.

Badfish Creek

Badfish Creek begins at the confluence of the Oregon Branch and the Rutland Branch and is tributary to the Yahara River in Rock County. Most of its length has been channelized in Dane County. Badfish Creek has a low stream gradient of 4.1 feet per mile. It flows through the Badfish Creek State Wildlife Area which has large wetland areas helping to buffer the stream. While much of its watershed is agricultural, Badfish is considered an effluent dominated stream due to its carrying highly treated effluent from MMSD's Nine Springs treatment plant (see discussion on MMSD). The Village of Oregon also contributes to the total effluent in Badfish. Badfish Creek is classified as a limited forage fishery (LFF) from the confluence of the Oregon and Rutland branches downstream to Dane CTH A. Below Highway A, the stream is classified as a warm water sport fishery (WWSF). Badfish Creek is on the state's 303d list of impaired waters due to PCBs found in sediments. It is a "low" priority stream for TMDL development.

Water quality was quite bad in the 1970's due to the large amount of effluent from MMSD and Oregon. MMSD has completed several treatment plant upgrades that have significantly improved effluent quality and stream water quality. Biochemical oxygen demand (BOD), ammonia nitrogen, nitrite nitrogen and suspended solids levels have decreased while dissolved oxygen levels have increased showing improved water quality. MMSD has also conducted IBI monitoring at two locations on Badfish, at CTH A downstream of Rutland Branch and Old Stage Road. Wisconsin warm water IBI biotic integrity ratings at both sites has ranged between "poor" to "very poor", while Wisconsin coldwater IBI integrity rating of "poor" was calculated at both sites[88]. MMSD reports based on their monitoring have shown that water quality and fish species richness have improved since MMSD began monitoring Badfish in the early 1980s. Assessment of MMSD's collected data suggests that MMSD's effluent quality is not inhibiting aquatic

[88] Steven, Jeffrey C. *Badfish Creek Fish Survey*, 2010.

species from living in Badfish Creek[89]. Northern hog suckers, considered an intolerant fish species, have been found at the two MMSD monitoring sites on Badfish[90]. MMSD regularly find brown trout at both Badfish Creek sites during its surveys. The number of fish species has increased over the 27-years of MMSD monitoring. Water quality in Badfish improves until it reaches Old Stage Road. At that point non-effluent related factors such as agricultural nonpoint sources of pollution are the controlling water quality factors[91]. MMSD has found some dense eurasian water milfoil, a highly aggressive invasive aquatic plant, in Badfish over the last six surveys[92].

Badfish Creek at Old Stage Road

[89] MMSD, *Eightieth Annual Report of the Commissioners of the Madison Metropolitan Sewerage District*, 2010.
[90] MMSD, *Seventy-Ninth Annual Report of the Commissioners of the Madison Metropolitan Sewerage District*, 2010.
[91] Johnson, 2002. http://www.rockrivercoalition.org/badfish/docs/BadfishDNRdoc.lr107.pdf

[92] Steven, 2010.

Mean baseflow concentrations, measured in milligrams per liter (mg/l) of total phosphorus, ammonia nitrogen, coliform bacteria and suspended sediments have declined significantly over the past 20 years based on a summary of USGS data[93]. Hilsenhoff 2003 HBI monitoring done at CTH A in 2003 showed "fair" water quality (HBI=5.7) indicating fairly significant organic pollution[94].

Oregon Branch

Oregon Branch begins in the Village of Oregon and flows 10 miles southeast to its confluence with Rutland Branch to form Badfish Creek. Much of its drainage area is agricultural, with urban development in and near the Village of Oregon. The Oregon wastewater treatment plant discharges to the stream. About one mile east of Oregon, the MMSD effluent ditch joins Oregon Branch making it an effluent dominated stream. The urban development in and near Oregon have increased peak storm event flows in Oregon. The DNR has classified Oregon Branch as a limited aquatic life (LAL) stream indicating very poor water quality.

MMSD has a monitoring site near Sunrise Road east of Oregon to monitor water quality conditions. The number of fish species collected at this site has increased over the period MMSD has been monitoring at this location. The five dominate fish collected at this site in 2010 were green sunfish, white sucker, bluegill, central mudminnow and hornyhead chub. A decline in the number of brown trout and northern hog suckers were noted. It was speculated that the lack of instream cover and the presence of northern pike may be part of the reason for the decline in numbers of these two species. Warm water IBIs done at this site indicated "poor" biotic integrity due to relatively few species[95].

Rutland Branch

Rutland Branch, also known as Anthony Branch, is a small spring-fed, cold water trout stream in south central Dane County. It joins the Oregon Branch to form Badfish Creek. It is listed as an Exceptional Resource Water (ERW) of the state. It has a stream gradient of 25.6 feet per mile. Portions of the stream have been channelized but the stream appears to be restoring itself. It has

[93] Source: CARPC cooperative water resources monitoring program and U.S. Geological Survey.
[94] WDNR, 2010b.
[95] Steven, 2010.

areas of good sand and gravel habitat in its upper reaches. It flows through a small open wetland above Dane CTH A in the Anthony Branch State Fishery Area. The primary water quality threats to Rutland Branch are for agricultural nonpoint sources of pollution[96]. A 2001 coldwater IBI done by the DNR showed Rutland Branch to have "fair" biotic integrity indicating the stream has experienced some moderate environmental degradation[97].

Rutland Branch at Dane CTH

A

[96] Johnson, 2002
[97] WDNR, 2010b.

Frogpond Creek

Frogpond Creek is a small spring-fed stream that begins in a U.S. Fish and Wildlife Service's Waterfowl (USFWS) Production Area (WPA) east of the Village of Brooklyn. It flows east along the Dane-Rock county line. It dips briefly into Rock County before re-entering Dane County to empty into Badfish Creek. The USFWS has restored wetlands and prairie areas within the WPA that buffer the stream headwaters area from agricultural sources of pollution. Downstream of the WPA area Frogpond flows through agricultural areas contributing some sediment and nutrient loading to the stream. The stream does have good buffering through much of its length. A 1996 habitat evaluation described the stream's habitat at Willow Road as "good"[98] A 2004 Hilsenhoff HBI monitoring effort at Franklin Road indicated Frogpond had very good water quality (HBI score=4.49), a sign of little organic pollution. An intermittent fish IBI done at Franklin Road in 2004 showed Frogpond had "good" environmental quality at that time[99].

Frogpond Creek at Franklin Road

[98] Johnson, 2002.
[99] WDNR, 2010b.

Yahara River – Lake Kegonsa Watershed

The 126-mile square Yahara River-Lake Kegonsa watershed lies in south central Dane County, extending into Rock County. About 104 square miles are in Dane County. The watershed stretches from the far eastside of Madison to the Dane-Rock county line south of Stoughton. The dominate land use in the watershed is agriculture. Soil fertility is good to very good. Municipalities in the Dane County portion of the watershed are all of the City of Stoughton and parts of the City of Madison, the villages of Cottage Grove and McFarland, and parts of the

towns of towns of Pleasant Springs, Dunn, Dunkirk,Rutland, Blooming Grove, Sun Prairie and Burke. Stoughton is the only municipal wastewater treatment plant that discharges to surface waters, the Yahara River.

The Yahara River is the principle and most important stream in the watershed. Other streams in the Dane County part of the watershed are Door Creek, Little Door Creek, Keenan Creek and Leuten Creek. There are several small unnamed tributaries to the the names streams and lakes in the watershed. Most of these have been channelized to facilitate drainage and agricultural production. Other water resources are Lake Kegonsa (discussed in the Yahara Lakes section), Lower Mud Lake, Stoughton Millpond, Dunkirk Millpond, Lower Mud Lake wetlands, and Door Creek wetlands. Large areas of historic wetlands have been drained and converted to agriculture. This modification has increased sediment and nutrient loading to surface waters.

Yahara River

The Yahara River is 40 miles long with 23 miles being in this watershed. The Yahara River in this watershed begins at the Babcock Park dam and flows south through Stoughton into Rock County emptying into the Rock River near the community of Fulton. There are four dams on the river between Lake Waubesa and the Dane-Rock county line, at Babcock Park, Lake Kegonsa outlet, Stoughton and Dunkirk. These dams affect flows and habitat in the river and prevent fish migration.

The Yahara River is classified as a warm water sport fishery (WWSF) stream and supports a diverse warm water fishery of approximately 48 species[100]. The Yahara River from Lake Kegonsa downstream to where Badfish Creek joins it in Rock County was added to the state's impaired waters (303d) list in 1998. Phosphorus, sediments and total suspended solids have led to impairment of acceptable dissolved oxygen levels and degraded habitat. The Rock River is a high priority for TMDL development. A phosphorus water quality target of 0.125 mg/l has been proposed[101]. Most wastewater has been directed to the MMSD Nine Springs treatment facility. Rural nonpoint sources of pollution are now the primary threat to water quality.

[100] Bardeen and Ripp, 2001.
[101] WDNR, 2006.

Baseflow in the Yahara River downstream of Lake Mendota has decreased about 35% since MMSD's sewage was diverted around the Yahara lakes in 1958[102]. The decrease in baseflow coupled the very shallow stream gradient occasionally leads to a stagnate water situation, low dissolved oxygen levels and fish kills. The most constricted point is the reach between Lake Waubesa and Lake Kegonsa[103] where the river drops only two feet. Regulatory dam operations of the dams at Babcock Park, the Kegonsa outlet and Stoughton Millpond designed to maintain certain minimum and maximum pool elevations may exacerbate the low baseflow and dissolved oxygen conditions in the Yahara River between Lake Waubesa and the Stoughton Millpond. The river falls about 30 feet from the Dunkirk Millpond to the county line. There are a series of riffles and runs in this reach. Warm water IBI monitoring done at Dane CTH N below the Dunkirk in 2007 showed a biotic integrity rating of "good" indicating somewhat less than optimal species richness[104]. A 2007 Hilsenhoff HBI indicated "good" water quality conditions (HBI score=5.09)[105].

Yahara River at CTH N

[102] DCRPC, 1992.
[103] Habecker, 2002.
[104] WDNR, 2010.
[105] WDNR South Central Region Water Resources Files, 2010.

Primary threats to the Yahara River below Lake Waubesa are from agricultural nonpoint sources of pollution from cropland erosion carrying sediment and nutrients to the river, barnyards and pesticides. High development pressure for waterfront property also poses the threat of increased construction site erosion. The hydrologic modifications to the stream in the form of dams and decreased baseflow also are a continuing problem[106].

Door Creek

Door Creek is tributary to the Yahara River at Lake the north end of Lake Kegonsa. It begins in the southeast corner of the Town of Burke and flows south 12.7 to the lake. Door Creek and its tributaries drain 29.5 square miles of rolling agricultural land and the rapidly developing far east side of Madison and the village and town of Cottage Grove. Much of Door Creek has been straightened and ditched to facilitate drainage. The stream ditching and straightening allows heavy loads of sediments and nutrients to reach Lake Kegonsa. Remeandering the creek through the marsh was considered but concern that the effort would result in even more sediment loading to the lake and harm higher quality wetland areas.

[106] Bardeen and Ripp, 2001

Door Creek is a sluggish stream with a flat gradient of 2.4 feet per mile. It is subject to high temperatures and low flows. Its potential has been limited by natural conditions such as low baseflow and slow velocity. Groundwater modeling done in 1999 predicted a 17% decrease in Door Creek baseflow between 1995 and 2020[107]. Municipal high capacity pumping of groundwater and the resulting drawdown of groundwater levels is the problem. Sediment and nutrient loads are significant due to the ditching and stream straightening, and by wetland drainage and agricultural runoff[108]. Wetlands, particularly the Door Creek wetlands at the mouth of the creek, provide important spawning areas for northern pike and other fish species. Door Creek is considered a limited forage fishery (LFF) stream. Water quality is generally poor due to heavy sedimentation reducing habitat. However, some improvement to water quality have been noted and may result in the stream being reclassified[109].

Intermittent IBI monitoring at two locations on Door Creek (Vilas Hope Road and Hope Road) indicated "fair" biotic integrity. Warm water IBI monitoring done in 2008 at both locations indicated "fair" biotic integrity. HBI monitoring done at Vilas Hope Road in 2008 indicated "good" water quality (HBI score=5.26) while the HBI at Hope Road was "poor" (HBI score=8.05). Heavy stream bottom silt was noted at Hope Road[110].

The primary water quality problems and threats to to Door Creek are from nonpoint sources. agricultural sources such as cropland erosion, sedimentation, and nutrient loading and urban sources such as construction sites and runoff from impervious surfaces. Continued and increased municipal water supply groundwater pumping will continue to affect stream baseflow, particularly in its headwaters area.

Door Creek at Hope Road

[107] Water Resources Workshop, *Door Creek Watershed Assessment*, 2009.
[108] DCRPC, 1992.
[109] Bardeen and Ripp, 2001.
[110] WDNR, 2010.

Little Door Creek

Little Door Creek is a small ditched stream that joins Door Creek south of USH 12/18. It drains about 8.3 square miles and has an average stream gradient of 11.8 feet per mile. Several small wetlands are adjacent the creek, although much of the historic wetlands have been drained. Agriculture is the dominant land use in its sub-watershed. Water quality is generally poor due to the hydrologic modifications and nonpoint source pollution. The low flow, turbidity induced by

sedimentation, and hydrologic modification limit the fishery to forage species[111] . A 2001 IBI taken near Cottage Grove indicated "fair" biotic integrity, and HBI monitoring also indicated "fair" water quality[112]. An intermittent fish IBI at CTH N in 1998 indicated "poor" biotic integrity.

Leuten Creek

Leuten Creek is a small spring-fed stream beginning in the Town of Pleasant Springs and flowing south and wes to the Yahara River below Lkae Kegonsa. It is about five miles long and has an average stream gradient of 9.7 feet per mile. Much of the stream has been ditched and channelize and many of the wetlands in its sub-watershed drained. Water quality is considered below average due to agricultural nonpoint sources of pollution and hydrologic modifications. Turbidity and sedimentation have negatively affected aquatic habitat[113]. It currently supports a limited forage fishery (LFF).

Keenan Creek

Keenan Creek is a small tributary to Upper Mud Lake through a large wetlands complex on the southwest end of Lower Mud. Keenan is nearly 4.5 miles long and has an average stream gradient of 25 feet per mile It drains an drains an area of 3.6 square miles. Land use is agriculture and rural residential. It is considered a warm water forage fishery, although no recent monitoring has been done[114].

[111] Bardeen and Ripp, 2001.
[112] WDNR, 2010.
[113] Bardeen and Ripp, 2001.
[114] Bardeen and Ripp, 2001.