Kinnickinnic River Priority Watershed Surface Water Resource Appraisal Report

December 1998

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Kinnickinnic River Priority Watershed

Surface Water Resource Appraisal Report

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Introduction

The Kinnickinnic River watershed was selected in 1995 as a large-scale Priority Watershed project through the Wisconsin Nonpoint Source Water Pollution Abatement Program. Surface water resource appraisal monitoring was initiated in October 1995 and completed in October 1997. The purpose of this appraisal report is to summarize the condition of surface water resources in the Kinnickinnic River Priority Watershed and provide water resource goals for each important waterbody. The water resource goals identified here will be incorporated into the watershed management plan and used to help determine eligibility for cost-sharing of Best Management Practices (BMPs) in the watershed project.

The Kinnickinnic River is a high quality, Class I trout fishery that originates in agricultural lands in St. Croix County, flows through the City of River Falls and eventually drains to the St. Croix River (Fig.1). In rural areas of the watershed, the river is primarily impacted by cropland runoff, flashy streamflow and sedimentation. As the stream flows through River Falls, it is also thermally impacted by urban stormwater runoff and two shallow impoundments (known locally as Lake George and Lake Louise).

The City of River Falls is undergoing rapid urban development in large part due to its proximity to the Twin Cities metropolitan area. In response to local concerns, a stormwater management plan was developed and adopted by the City in 1993. The plan identified thermal pollution as a concern, but did not quantify or model the impacts of stormwater runoff on the river. The plan recommended that future studies include monitoring and modelling of stream and stormwater temperatures. The surface water resource appraisal and watershed management plan will address these, and other important water resource issues.

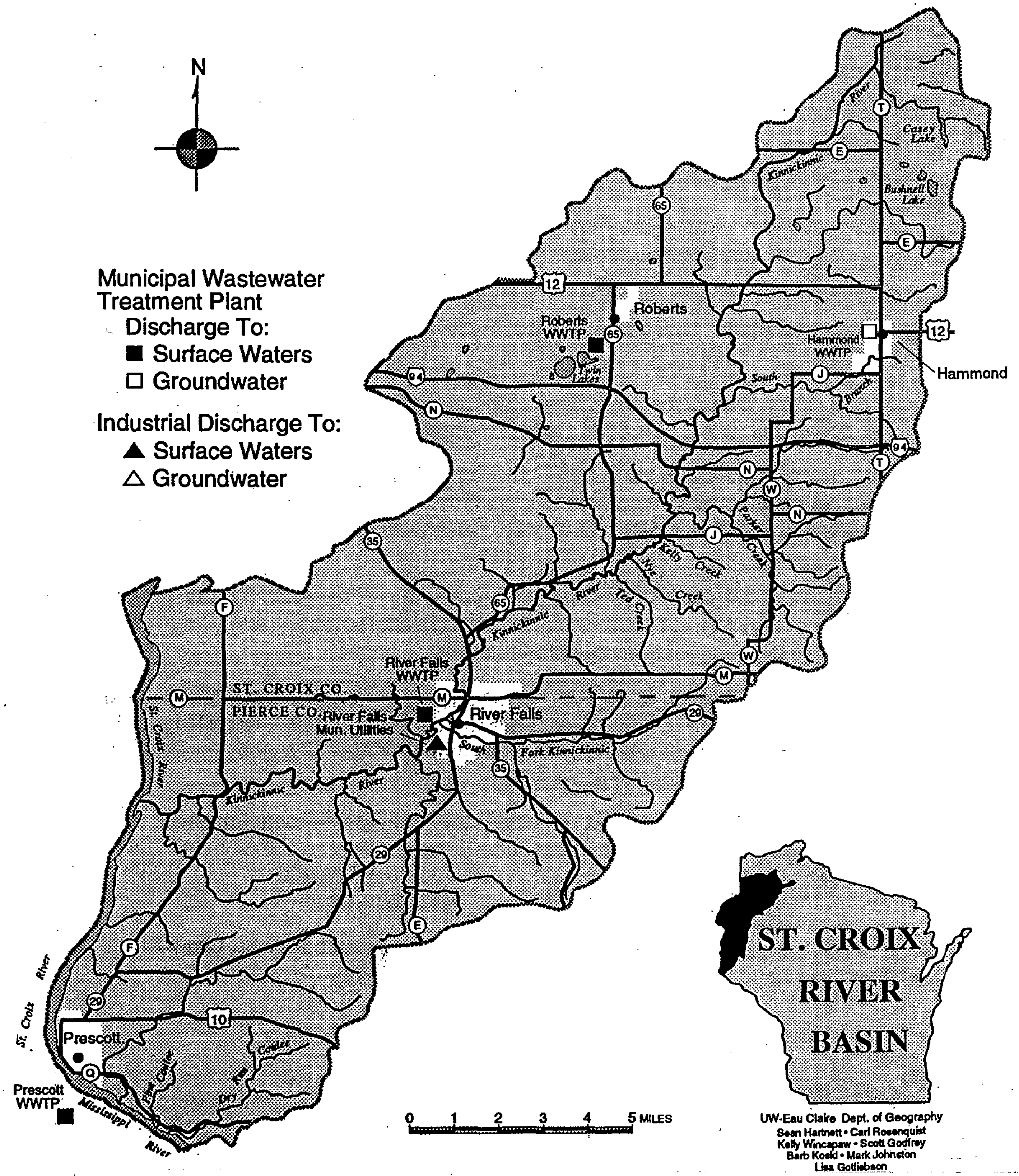
Appraisal monitoring activities included fish surveys, macroinvertebrate sampling, water quality monitoring, habitat assessment and continuous streamflow and temperature monitoring. Upon completion of these monitoring activities, streamflow and temperature data will be used to help develop and calibrate an urban runoff and river thermal model. The model will be used to simulate the thermal impacts of various stormwater runoff events and potential future urban growth scenarios.

Summary of Water Resource Conditions

The Kinnickinnic River Priority Watershed is 174 square miles in area, with about 30% located in Pierce County and 70% in St. Croix County. The watershed is primarily agricultural and features the Kinnickinnic and St. Croix rivers, South Fork Kinnickinnic River (South Fork) and numerous small tributary trout streams. Several lakes and impoundments are also located within the watershed boundaries, including Twin Lakes, Bushnell and Casey lakes and the Upper and Lower Kinnickinnic ponds in the City of River Falls. Approximately 4% of the watershed is urban, including the communities of River Falls, Hammond, Prescott and Roberts.

Numerous perennial streams in the watershed support coldwater fish communities. The Kinnickinnic River watershed has 6 Class I and 18 Class II trout streams and one stream reach that supports a warmwater sport fishery. Fish surveys conducted at 46 sites in the watershed in 1996 found brook and brown trout, smallmouth bass and 22 minnow and forage fish species. Brook and brown trout

Figure 1. Kinnickinnic River Priority Watershed



dominate the coldwater fishery in this watershed. White sucker, brook stickleback, longnose dace, mottled sculpin and Johnny darter were the most common forage species.

Water resource problems identified in the watershed include streambank erosion, sedimentation of riffle and pool areas, organic and nutrient loading from animal waste, and elevated stream temperatures. The primary causes of streambank erosion appear to be a combination of cattle grazing of streambanks and occasional flooding. A frequent consequence of streambank erosion is sedimentation of pools, filling-in of spawning substrate in riffle areas and elimination of bank cover. Filling-in of spawning substrate in riffle areas (measured as embeddedness) impairs reproductive success of trout by reducing inter-gravel flow which is necessary to maintain suitable temperature and oxygen conditions for eggs and larval fish. Sedimentation of riffle areas also destroys habitat for macroinvertebrates and other fish food organisms. Filling-in of pools reduces the amount of available cover for juvenile and adult fish.

Other water resource problems in the watershed include flashy stream flows, ditching, and stream warming caused by beaver dams. Land use activities that reduce infiltration result in flashy high peak flows during runoff events and loss of groundwater discharge during low flow conditions.

Organic loading (in the form of animal waste) affects water quality by reducing stream dissolved oxygen conditions which stresses fish and other aquatic life. Based on appraisal findings, oxygen conditions are generally good in the watershed streams, however, some streams show evidence of organic pollution. The primary source of this organic loading is likely livestock waste from barnyards, feedlots and field spread manure. Animal waste may also be a source of un-ionized ammonia which is toxic to aquatic organisms. Nutrient (phosphorus and nitrogen) loading contributes to eutrophication of surface waters and contamination of groundwater.

Several of the watershed streams have summer water temperatures that are above optimal for some coldwater aquatic species, especially trout. Elevated water temperatures may be caused by a number of factors including lack of stream shading, reduced infiltration and groundwater recharge, and a relatively shallow, wide stream morphometry. The elimination of streambank vegetation reduces shading and increases solar radiation which may increase stream temperatures. Streambank erosion and resulting sedimentation of the bottom may result in wider, shallower streams which allows increased solar radiation and contributes to elevated water temperatures. Impoundments (built by humans or beaver) on streams or spring areas may also increase water temperatures. The cumulative effect of these impacts may decrease the suitability of a stream to support coldwater aquatic life.

Kinnickinnic River

Historically, the Kinnickinnic River has undergone a dramatic transformation from a pristine coldwater prairie trout stream to a degraded, marginal trout stream, and back again to one of the premier trout fisheries in western Wisconsin. Prior to the 1850s, the Kinnickinnic, South Fork and their tributaries were excellent prairie brook trout streams. However, during the late 1800s through the early 1900s, the stream was severely degraded by agricultural activities, wastewater effluent, deforestation and construction of milling and power dams. More recently, since the mid 1930s, the stream was greatly rehabilitated by conservation activities including soil erosion control programs, wastewater treatment and fish habitat restoration projects. The stream now supports a Class I brook and brown trout fishery. The river above and below River Falls is classified as an outstanding resource water in NR 102.10 (Wis. Admin. Code).

The most recent threat to the stream and watershed is rapid urbanization resulting from its close proximity to the Twin Cities metropolitan area. The primary water resource concerns from this urban development include increased imperviousness of the drainage area (resulting in increased runoff and reduced infiltration of stormwater), increased summer water temperatures (due to heated stormwater runoff) and water pollution in the form of phosphorus, chlorides, suspended solids and heavy metals from stormwater runoff. Decreased infiltration of stormwater results in a reduction in groundwater recharge and stream baseflow (summer low flow) conditions. Reduced infiltration also results in higher peak flows during storm events, which may result in increased downstream bank erosion, scouring of the stream bottom and disruption of aquatic life.

Project Implementation

Installation of Best Management Practices (BMPs) during implementation of the watershed project would have a number of positive effects on water resources. Stabilizing streambanks through installation of rip-rap and/or restricting cattle access would increase available cover for adult trout and reduce sedimentation of riffles and pools. Eliminating excessive streambank grazing would increase bank stability, stream cover and shading by allowing growth of shrubs and grasses along the stream corridor. Increased cover and overall habitat improvement improves carryover and survival of adult fish. Reduced sedimentation of riffle areas may increase trout reproduction and fry survival, provided other factors such as oxygen and temperature conditions are suitable. Reduced sedimentation of riffle areas also improves habitat for macroinvertebrates and other fish food organisms. Control of sedimentation and bank erosion generally results in narrower, deeper streams, providing cooler temperatures and improved cover for adult fish.

Reducing the impacts of urban stormwater runoff, through stormwater detention and BMPs that increase infiltration in the drainage area would reduce peak streamflows, increase baseflow and reduce thermal impacts to surface water resources.

Successful installation of BMPs in the watershed will likely increase trout reproduction where limited reproduction is already occurring and improve survival and growth of adult fish in streams where limited trout populations already exist.

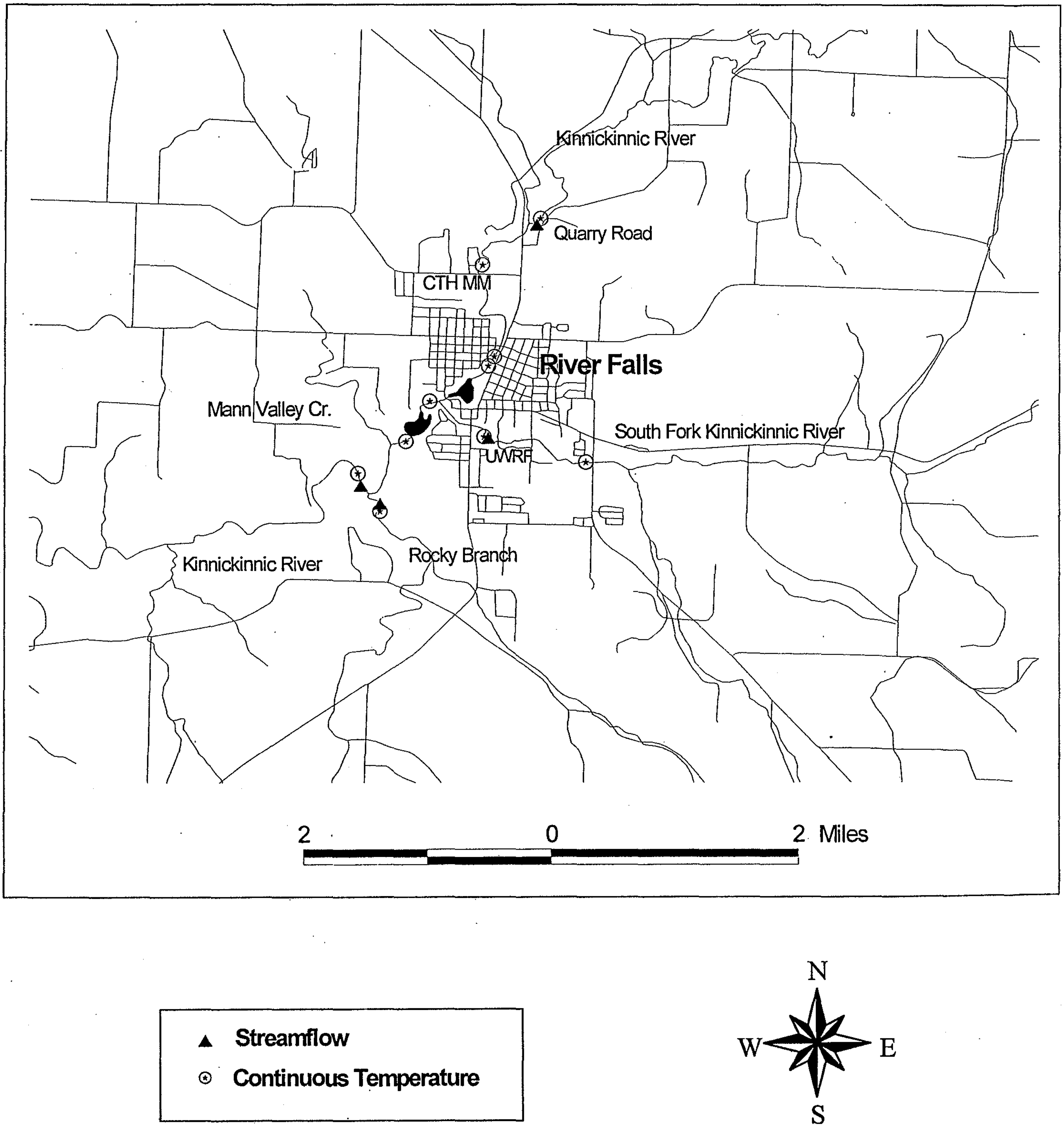
Methods

Monitoring activities for the water resource appraisal were initiated in October 1995 and completed in October 1997. A significant portion of the appraisal monitoring efforts in River Falls and the Kinnickinnic River were designed to accommodate the data needs of developing thermal models to simulate stormwater runoff and in-stream temperature conditions. The modelling effort required continuous streamflow and temperature monitoring at several locations through the City of River Falls during 1996 and 1997. Following is a summary of methods used to collect information for the appraisal.

Streamflow

Two continuous streamflow monitoring stations were installed and operated by USGS (U.S. Geological Survey) staff during May-September 1996 and 1997 in the Kinnickinnic River, above and below River Falls (Figure 2). A third continuous flow station was installed and operated in 1997 on the South

Figure 2. Continuous temperature and streamflow monitoring sites in the vicinity of River Falls, Wis.



Fork Kinnickinnic River (South Fork), a major tributary of the Kinnickinnic River in the City of River Falls. In addition, staff gauges were monitored on the South Fork and Rocky Branch during summer 1996, and Rocky Branch only during summer 1997. Staff gauges were calibrated by USGS staff and read daily, or more frequently, by a local observer.

USGS staff conducted a longitudinal flow survey during baseflow conditions in 1997 to estimate groundwater recharge to the river through the City of River Falls. The survey included flow and conductivity measurements at 8 stations in the Kinnickinnic River mainstem and 3 stations in the South Fork. The flow survey data will be used to help estimate groundwater recharge and calibrate the river thermal model.

Water Chemistry

The water quality monitoring effort was primarily focused on potential impacts associated with urban runoff in the City of River Falls. The 1996 monitoring protocol included sufficient sampling to estimate May through September suspended solids and total phosphorus loads. The 1997 monitoring program only attempted to characterize loading during several summer runoff events.

Water samples were collected by a UWRF intern and DNR staff at the flow monitoring stations during base flow and stormwater runoff event conditions. Baseflow grab samples were collected monthly at the four monitoring sites during non-event periods. Grab water samples were collected more frequently (2-3 per day) at the staff gauge sites during storm events. Automated ISCO water samplers were used at the continuous flow monitoring sites to collect multiple water samples during runoff events.

Stormwater event samples were preserved and sent on ice to the State Laboratory of Hygiene (SLOH) and analyzed for suspended solids and total phosphorus. Baseflow samples were analyzed for ammonia-N, nitrite+nitrate-N, total Kjeldahl-N, suspended solids and total and dissolved phosphorus.

Stream Temperature

RYAN TempMentor recording thermometers were deployed at 7 sites on 3 streams in 1996, and 11 sites on 3 streams in 1997. The recording thermometers measured and recorded stream temperatures using a 10-minute recording interval. Considerable additional continuous temperature data was collected from 1992 to 1997 on the Kinnickinnic River mainstem by Kent Johnson, a member of the Kiap-TU-Wish Chapter of Trout Unlimited. A summary of continuous temperature monitoring locations and deployment periods are presented in Appendix 1. In addition, maximum/minimum thermometers were placed in streams at each of 46 fish survey sites to measure temperature extremes during August 23-29, 1996 (Fig.3).

The vertical and horizontal distribution of water temperatures in the impoundments were measured during summer baseflow periods in 1996 and 1997 using a YSI 57 D.O./temperature probe at 6-8 locations along transects spaced about 100 meters apart. Results from this information will be used to help calibrate the river thermal model.

Storm Sewer Monitoring

Six storm sewers in the City of River Falls were monitored during summer 1996 using RYAN

TempMentors deployed at a 5-minute recording interval. Storm sewer monitoring locations and deployment periods are presented in Appendix 2. During summer 1997, one storm sewer outfall to the Kinnickinnic River was fitted with a weir, level sensor, thermistor and data logger to continuously measure flow and temperature. The storm sewer monitoring data will be used to help calibrate the urban stormwater runoff model to be developed for the watershed project.

Fish Surveys

Electrofishing surveys were conducted during summer 1996 at 46 sites on 20 streams in the watershed (Fig. 3). Surveys were conducted at approximately one site per mile of permanent stream (approximately 20% of the total stream miles). Electrofishing surveys were conducted to inventory the sport fishery using 900 ft. stations in streams less than 10 meters wide, and 1,800 ft. stations where stream width was greater than 10 meters.

Fish were collected using one or two Whitney DC (250v., 3 amp) generator-type stream shockers or AbP-3 DC backpack shockers, depending on stream size. All trout captured were identified, measured, weighed, clipped and released. Catch per unit effort (CPUE) was calculated for each station. A second run was conducted and population estimated using the Bailey's modification of the Peterson Estimate where 50 or more trout 4 inches or greater were captured during the first run.

Fish assemblage segments (including all fish species) were 300 ft. in length for streams less than 10 meters wide, and 600 ft. long for sites greater than 10 meters. All fish captured were identified and counted in the assemblage segment of the fish survey station. A coldwater version of the stream Index of Biotic Integrity (IBI) (Lyons, et. al. 1994) was used to evaluate the streams' ability to support and maintain a balanced and healthy fish community. The coldwater IBI rating scale ranges from 0 (very poor) to 100 (excellent).

Habitat Assessment

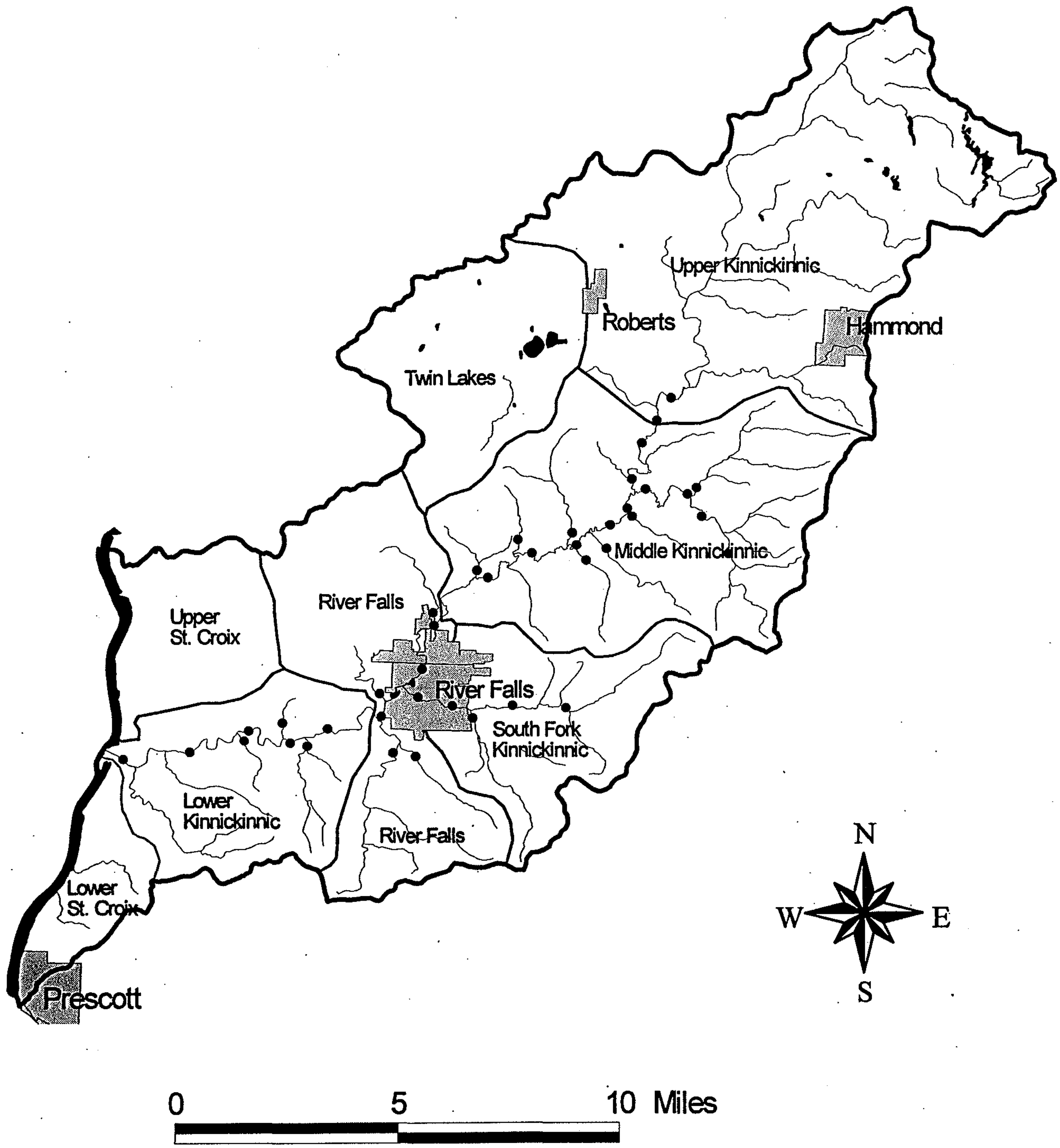
Habitat assessments were conducted at each fish survey site using stream segments that were 35 times the MSW (Mean Stream Width) according to methods outlined in Simonson et al. (1994). The assessments included qualitative and quantitative measurements of streamflow, width, depth, cover, substrate composition and streambank characteristics. A fish habitat rating was calculated for each site according to Simonson, et al. (1994).

Macroinvertebrates

Aquatic macroinvertebrates were collected at 11 sites in the watershed, generally near stream mouths, during Fall 1995. Additional samples were collected at three sites located in the Kinnickinnic River through downtown River Falls in Spring 1997. All samples were collected using the kick method with a D-frame net according to methods outlined in Hilsenhoff (1977 and 1982). Samples were preserved in 70% ethanol and sent to UW-Stevens Point for sorting and identification.

Macroinvertebrate sample results were analyzed using several biometrics including the HBI (Hilsenhoff Biotic Index), EPT (Ephemeroptera-Plecoptera-Trichoptera) index and Margalefs' diversity index. The HBI values are based on species tolerance and provides a relative measure of organic loading to streams. The HBI rating system ranges from 0 (excellent) to 10 (very poor).

Figure 3. Fish survey and habitat assessment sites in the Kinnickinnic River Priority Watershed.



The EPT index used measures the percent genera within the insect orders Ephemeroptera, Plecoptera and Trichoptera. Genera from these orders are typically considered sensitive to organic pollution. The EPT index values generally increase as water quality improves (EPA 1989).

Margalef's diversity index is used as an estimate of community diversity. The diversity index not only measures species richness but considers equitability (or evenness) of the community (Szcztyko 1988). Species diversity values generally increase as water quality improves.

Lake Surveys

Water quality monitoring was conducted on East Twin and West Twin lakes (near Roberts) monthly during summer 1996. Water samples were collected mid-lake from the surface and bottom, sent on ice to the SLOH, and analyzed for chlorophyll a, ammonia-N, nitrite+nitrate-N, total Kjeldahl-N and total and dissolved P.

Water samples were also collected from the Roberts WWTP outfall (which discharges to Twin Lakes) monthly during summer 1996. The samples were sent on ice to the SLOH for analysis of ammonia-N, nitrite+nitrate-N, total Kjeldahl-N and total P. Temperature and pH were measured in the field by the WWTP operator.

Sediment cores were collected mid-lake from West Twin by DNR staff and delivered to the U.S. Corps of Engineers - Eau Galle Aquatic Ecology Lab in Spring Green for sediment P release measurements. Sediment P release rates were measured under both aerobic and anaerobic conditions according to methods outlined in James and Barko (1991). The sediment P release rates were used with lake D.O. profile information to estimate annual internal P loading in each lake.

A macrophyte (rooted aquatic plants) survey was conducted on Lake George during peak biomass in August 1996, using the Jenssen and Lound (1962) line-intercept rake sampling method.

Results and Discussion

KINNICKINNIC RIVER

Streamflow

Streamflow conditions in the Kinnickinnic River are greatly influenced by geology and prevailing land use in the watershed. A significant portion of the headwaters area is comprised of intermittent dry runs which flow only during runoff events. As a result, flow in the upper reaches of the perennial stream is erratic except under baseflow conditions. Numerous large springs are located in the headwaters area and are the source of permanent flow in the river, beginning about 1.5 miles above the I-94 bridge. Streamflow becomes more stable in the middle reach, where considerable groundwater recharge occurs.

Streamflow conditions at the continuous monitoring sites in the vicinity of River Falls are summarized in Table 1. As the river flows through the City of River Falls, streamflow conditions are dramatically impacted by stormwater runoff, the South Fork Kinnickinnic River and flow manipulation by two hydropower operations. The downstream Kinnickinnic River station actually recorded lower minimum flows than the upper site due to hydropower manipulations.

During a baseflow survey conducted by USGS in 1997, streamflow at the upstream station (above River Falls) was about 68 cfs, and 94 cfs at the downstream site (below River Falls). Since the South Fork contributed about 11 cfs, and two small tributaries (Rocky Branch and Mann Valley Creek) contribute about 5 cfs, the Kinnickinnic River received approximately 10 cfs (or about 9%) of its baseflow from groundwater recharge through the city during the survey.

During storm events, the South Fork occasionally contributed as much as 90% of peak flow measured at the downstream Kinnickinnic River site, suggesting disproportionately higher stormwater runoff rates and reduced infiltration rates in the South Fork subwatershed. The impact of a single summer

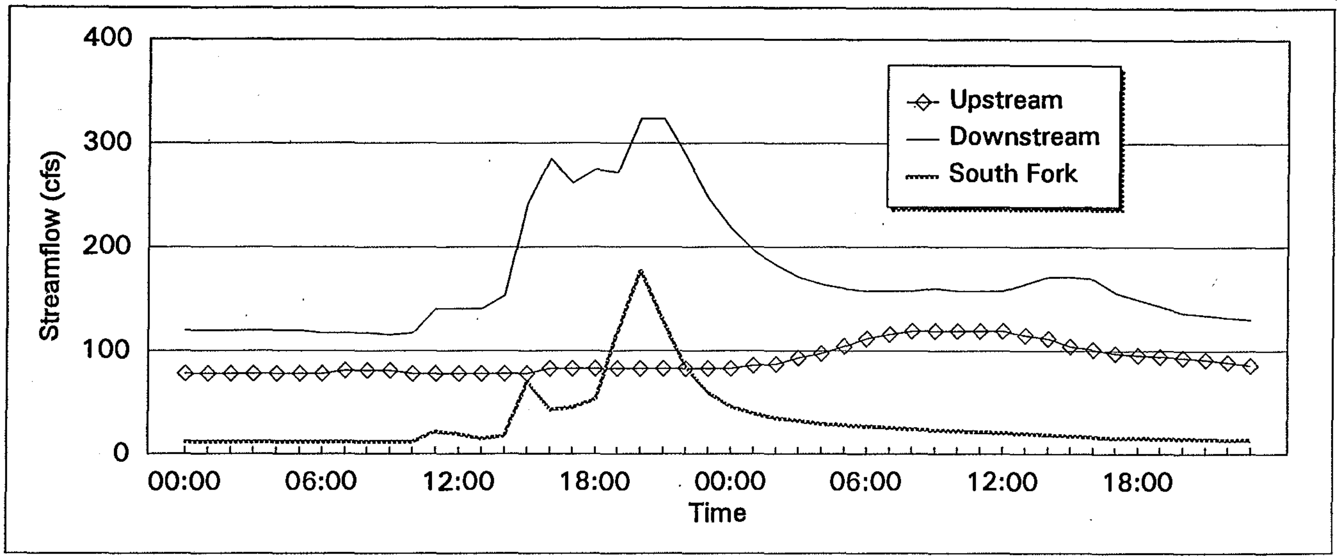
Table 1. Summary of streamflow conditions at USGS continuous flow monitoring stations in the Kinnickinnic River in River Falls. All values in cubic-feet per second (cfs).

1996 Streamflow	**Upstream (STH 35)**	**Downstream (below Rocky Br.)**	**South Fork Kinni.**
Maximum	153.0	467.0	NA
Minimum	49.3	44.4	NA
Mean	66.0	87.3	NA
Median	66.2	83.6	NA

1997 Streamflow	**Upstream (STH 35)**	**Downstream (below Rocky Br.)**	**South Fork Kinni.**
Maximum	327.5	713.3	657.8
Minimum	49.3	45.9	7.8
Mean	62.0	103.7	24.2
Median	52.8	88.2	9.5

storm event on streamflow in the Kinnickinnic River is illustrated in Figure 4. At the upstream (STH 35) site, the stream hydrograph showed a gradual rise over the course of the storm, typical of a fairly well protected watershed. The South Fork hydrograph shows a more rapid rise and higher peak in streamflow than the upstream Kinnickinnic River station, suggesting a more degraded watershed with an increased level of imperviousness. The downstream Kinnickinnic River hydrograph also shows the impact of urban stormwater runoff (and the South Fork discharge) and the moderating effect of the

Figure 4. Streamflow above and below River Falls in the Kinnickinnic River and South Fork Kinnickinnic River during a July 27-28, 1997 storm event.



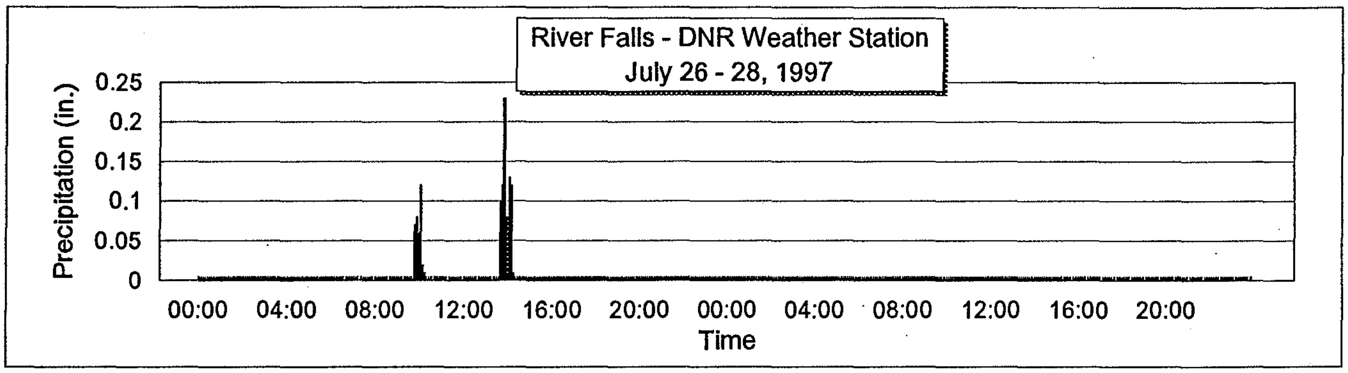
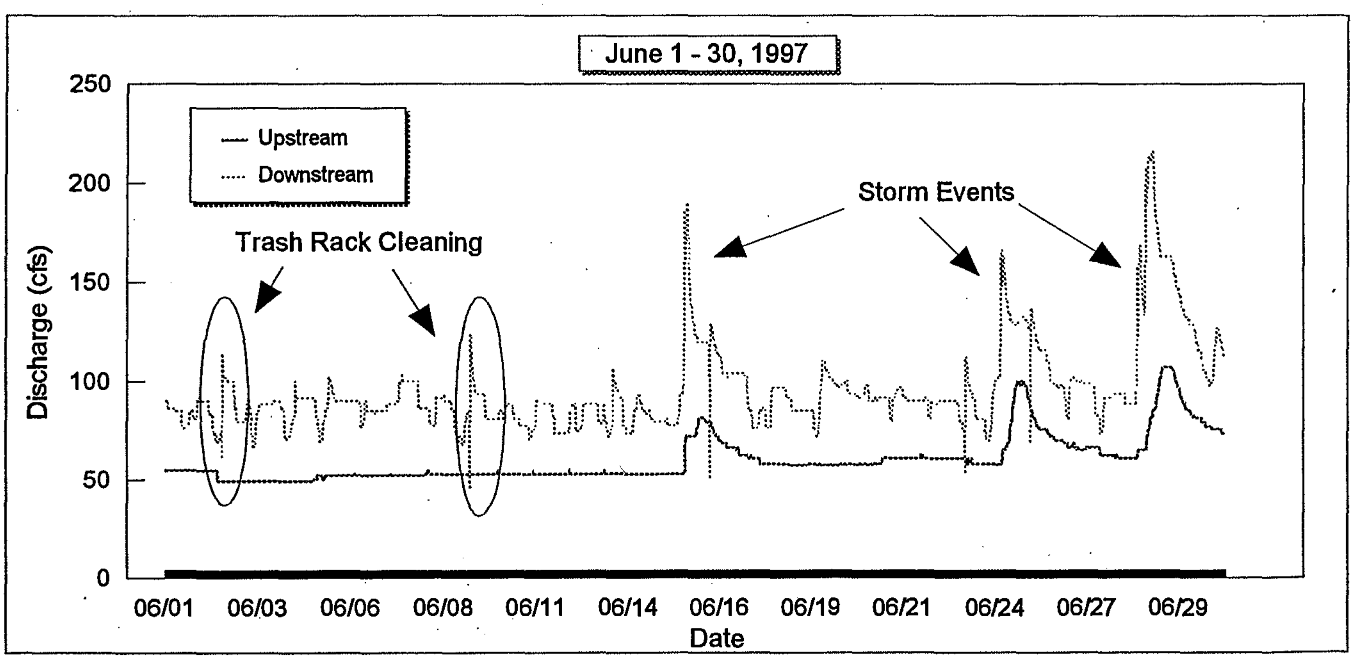


Figure 5. Streamflow in the Kinnickinnic River during storm runoff events and hydropower trash rack cleanings.



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impoundments on peak streamflow.

Hydropower Impacts

The two hydropower facilities in the City of River Falls primarily impact downstream flow during non-event periods. During storm events, flow through the turbines is readily exceeded and excess water flows over the dam spillways. However, under normal or baseflow conditions hydropower operations have a measurable impact on downstream flows. Hydropower manipulations cause daily (and sometimes hourly) flow changes as the operators attempt to maintain constant water levels in the impoundments. These daily manipulations typically result an approximate 5-10% fluctuation from normal flow at the downstream station.

More significant downstream flow fluctuations occur as a result of trash rack cleaning above the dams. This operation requires a temporary reduction in flow through the turbines, resulting in decreased flow in the river until water levels rise in the impoundment. As water levels rise, additional water is discharged over the spillway, resulting in elevated flows downstream (Fig. 5). Following cleaning of the trash racks, the turbine gates are opened and additional water is passed through the dam. The combined effect of water flowing over the spillway and through the turbines causes a temporary increase in downstream flow.

Cleaning of turbine trash racks typically results in a 15-20% decrease (below mean) in flow, followed by a 15-20% increase (above mean) in downstream flow after the turbines are returned to full capacity. The summer streamflow record indicates that minimum flow at the downstream site was occasionally lower than at the upstream site, due to hydropower manipulations (Table 1). It should be noted that peak flows during trash rack cleaning are generally much lower than during storm runoff events.

The actual biological impact of temporary flow fluctuations caused by hydropower manipulations on the downstream aquatic community has not been documented in the Kinnickinnic River. However, decreased water levels in riffle areas in some streams have been shown to cause dehydration of the substrate, desiccation of eggs and stress to aquatic insects and other organisms. Also, fluctuating flows may require fish to expend energy that could be directed to growth, to seek out suitable habitat during rapid changes in water levels and velocities. The Department is currently working with the City of River Falls Utility Department to develop operating procedures to minimize flow extremes caused by turbine trash rack cleaning.

Sediment and P Loads

A summary of suspended solids and total phosphorus monitoring results from the water quality and flow monitoring sites during 1996 and 1997 is presented in Table 2. During baseflow conditions, total P concentrations ranged from 22 to 27 ug/l and suspended solids ranged from 3 to 4.8 mg/l at all sites. The highest total P concentrations (up to 1000 ug/l) occurred during storm events in the Kinnickinnic River below River Falls and the South Fork. The highest suspended solids concentrations (up to 725 mg/l) occurred in the South Fork during storm events during both 1996 and 1997.

Numerous equipment malfunctions during the 1996 monitoring season resulted in fewer than optimal number of water samples from the continuous flow monitoring sites. Consequently, the estimated

Table 2. Summary of suspended solids and total P sampling results from water quality monitoring sites in the vicinity of River Falls during 1996 and 1997.

Stream	Site Location	Monitoring Period	No. Samples	Total P Range (ug/l)	Suspended Solids Range (mg/l)
Kinnickinnic River	STH 35 (above River Falls)	5/15/96 - 9/24/96 5/6/97 - 7/6/97	39 37	23 - 128 31 - 674	3 - 33 ND* - 273
	Below Rocky Branch	5/15/96 - 9/24/96 5/6/97 - 7/6/97	58 39	23 - 261 139 - 1000	4.8 - 97 5 - 564
South Fork Kinnickinnic	UWRF Campus	5/15/96 - 9/24/96 5/6/97 - 7/4/97	14 21	27 - 923 35 - 846	4.8 - 650 ND - 725
Rocky Branch	Above confluence w/ Kinnickinnic River	5/15/96 - 9/24/96 5/6/97 - 7/2/97	10 10	22 - 77 31 - 323	4.8 - 35 4 - 36

* ND - No detection (below detection limit).

phosphorus and sediment loads were approximated with the available data. The May -September 1996 suspended sediment load was estimated at 280.8 tons from the upstream (STH 35) site, and 323.5 tons from the downstream (below Rocky Branch) site. The River Falls urban area and South Fork watershed contributed about 42.7 tons (or about 13%) of the total sediment load to the downstream site.

The May-September 1996 total phosphorus load was estimated at 3,578 pounds at the upstream site, and 7,914 pounds at the downstream site. The River Falls urban area and South Fork watershed contributed about 4,336 pounds (or about 55%) of the total P load at the downstream station.

Additional sediment and phosphorus monitoring was conducted in 1997 to characterize loading during several summer storm events. A July 1-3, 1997 storm event that produced 2.76 inches of rain, generated approximately 182 tons of suspended solids and 946 pounds of total phosphorus from the South Fork and City of River Falls. These quantities represent about 69% and 57% of the total suspended solids and phosphorus load, respectively, measured at the downstream station.

Stream Temperatures

The upstream (Quarry Road) monitoring station was identified as a suitable temperature reference site for other locations in the river, since the upstream watershed is relatively well protected and the stream has a high density of brown trout at this location. Temperature data from the Interstate 94 (I-94) site provides a good reference point for a brook trout fishery.

Table 3 indicates maximum, minimum and mean stream temperatures at continuous monitoring sites located in the Kinnickinnic River during the summers of 1996 and 1997. Water temperatures in the Kinnickinnic River were fairly similar at the Quarry Road and Division Street sites but increase at the Powell Dam and Glen Park (below Rocky Branch) sites. Elevated mean and maximum water temperatures moving through the City are a result of the combined effects of urban stormwater runoff and the constant warming effect of the impoundments. A summary of all summer continuous temperature monitoring data for the 1993-1997 period can be found in Appendix 3.

Stream water temperatures are influenced by a variety of factors including shading, groundwater recharge, stream morphometry, gradient and climactic conditions. Coldwater biological communities have relatively narrow temperature requirements. Table 4 lists general temperature requirements of adult brook and brown trout. A more complete summary of temperature requirements for various life stages of brown trout can be found in Appendix 4.

Table 3. Summary of 1996-1997 summer temperature conditions in the Kinnickinnic River. Based on continuous,10-minute interval temperature monitoring from June 1 through August 31, unless otherwise indicated. All temperatures reported in degrees Centigrade.

Location	**Year**	**Maximum**	**Minimum**	**Mean**
Above I-94 Bridge*	1997	13.7	9.1	11.27
Quarry Rd. (above River Falls)	1996 1997	20.9 19.4	10.9 10.9	14.84 14.50
CTH MM (River Falls)	1997	20.2	10.9	14.70
Division St. (downtown River Falls)	1996 1997	21.2 20.0	9.6 11.0	14.79 15.28
Footbridge (downtown River Falls)	1997	20.0	10.9	14.73
Below Junction Falls Dam	1997	20.6	12.0	15.60
Below Powell Dam (below River Falls)	1996 1997	23.1 21.9	11.1 12.3	16.92 16.27
Below Rocky Branch (below River Falls)	1996 1997	22.6 21.2	11.1 11.7	16.66 16.51

**30-minute temperature recording interval.*

During summer storm events the river receives heated runoff from streets, roofs and parking lots, resulting in elevated stream temperatures. Numerous factors affect the extent of stream warming from runoff waters including the initial stream water temperature and flow, air temperature, ambient land surface temperatures, and length, timing and duration of the storm. Storms that occur during hot

Table 4. Upper limiting (near lethal) and optimal temperatures for adult brook and brown trout (Raleigh 1982, 1986).

Brown Trout	Temperature Range
Upper limiting (near lethal) temperature	81° F. (27.2° C.)
Optimal for growth and survival	53.6 - 66.2° F. (12-18° C.)
Brook Trout	
Upper limiting (near lethal) temperature	74.8° F. (23.8° C.)
Optimal for growth and survival	51.8 - 60.8° F. (11-16° C.)

summer days under low streamflow conditions have the greatest impact on stream temperatures. The quantity of runoff is influenced by a variety of factors including the amount and intensity of precipitation, degree of imperviousness of the drainage area and antecedent soil moisture conditions.

Many of the storms during the summers of 1996 and 1997 occurred during early evening, or at night, and had minimal thermal impacts on the river. Also, recent summers (1993-1997) have been relatively wet and cool, which tend to decrease the significance of runoff events on the thermal regime of the river (Fig. 6). However, several storms occurred during the 1996-1997 monitoring period that illustrate the warming effect of urban runoff on the river.

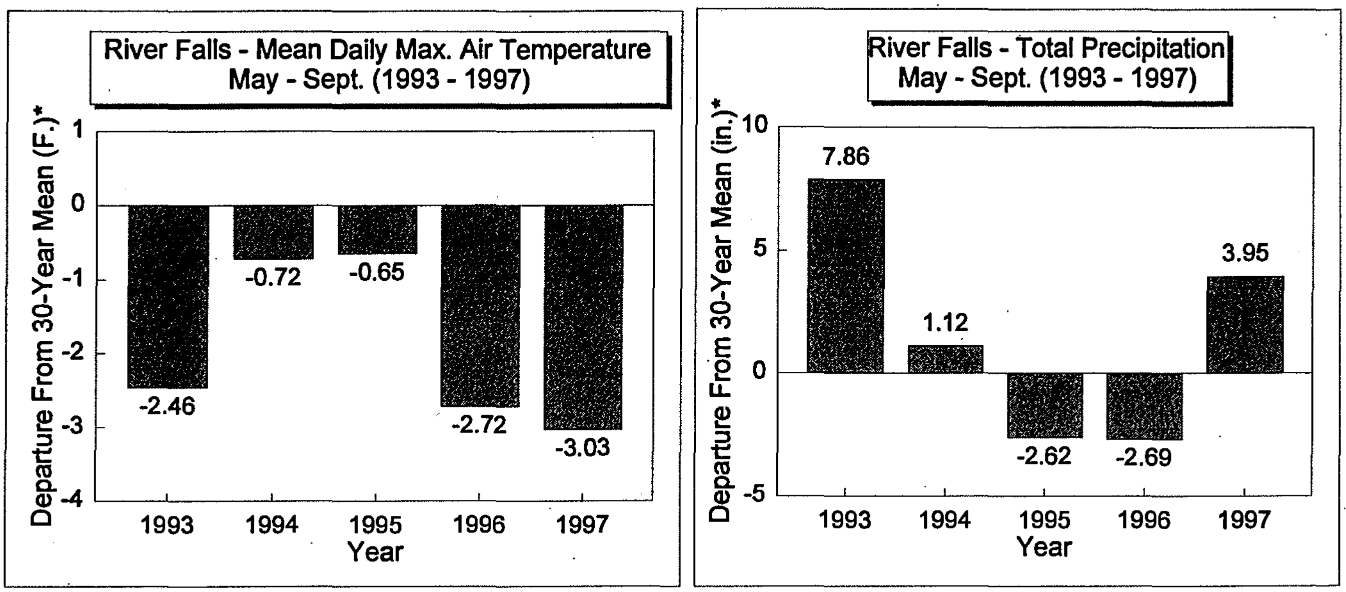
Figure 7 illustrates the thermal impact of a summer storm that occurred on July 27-28, 1996. The storm began during early evening on July 27 and ended early morning July 28, producing a total of 3.13 inches of precipitation. The stormwater runoff from this event caused a 3° C. (5° F.) increase in stream temperatures at the Division Street site which is located in downtown River Falls directly below several storm sewers. The storm had no appreciable impact on water temperatures at the upstream (Quarry Road) site and minimal impacts on the downstream site. The upstream station represents a relatively undisturbed watershed, and the lower station is situated below two impoundments which tend to buffer the thermal impacts of storms, but still cause overall elevated downstream water temperatures.

The impact of the impoundments on downstream temperatures during summer baseflow is evident in Figure 7, during the period prior to, the July 27 storm. The impoundments had an overall constant warming effect of about 3° C. (5° F.) on downstream water temperatures during base flow.

Temperature Frequency Analysis

Although the maximum and mean temperature of streams provide useful information about overall thermal conditions, the proportion of time the stream exceeds optimal temperatures for growth and survival of a particular species may have the greatest relevance to the biological community. Figure 8 shows the relative proportion of time stream sites were at a particular temperature during the summers

Figure 6. Departures from 30-year mean daily maximum air temperatures and total precipitation for May - September (1993 - 1997) at River Falls, Wisconsin. Source: Midwest Climate Center.



* Based on 1961-1990 climatological data from River Falls weather station.

Figure 7. Kinnickinnic River stream temperatures during a July 27-28, 1996 storm event. Based on 10-minute interval continuous temperature recordings.

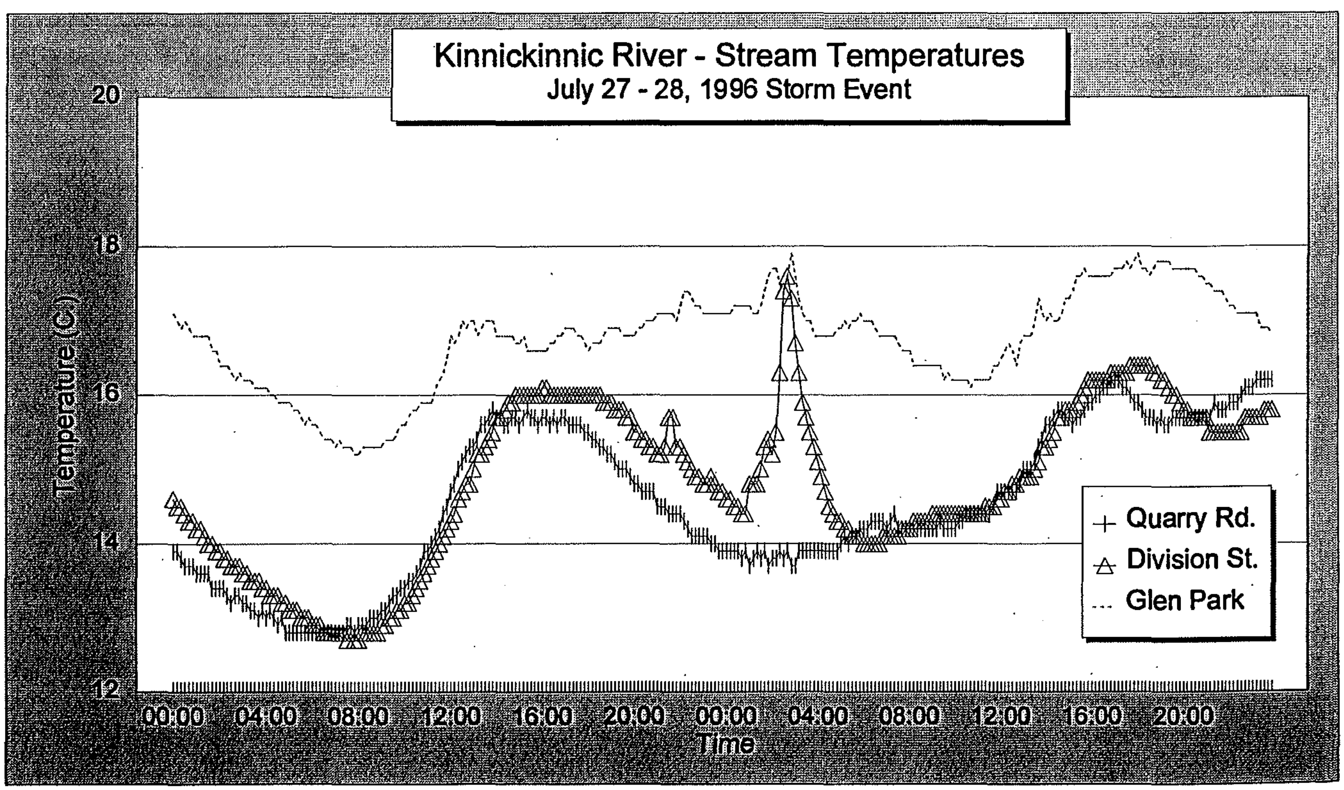
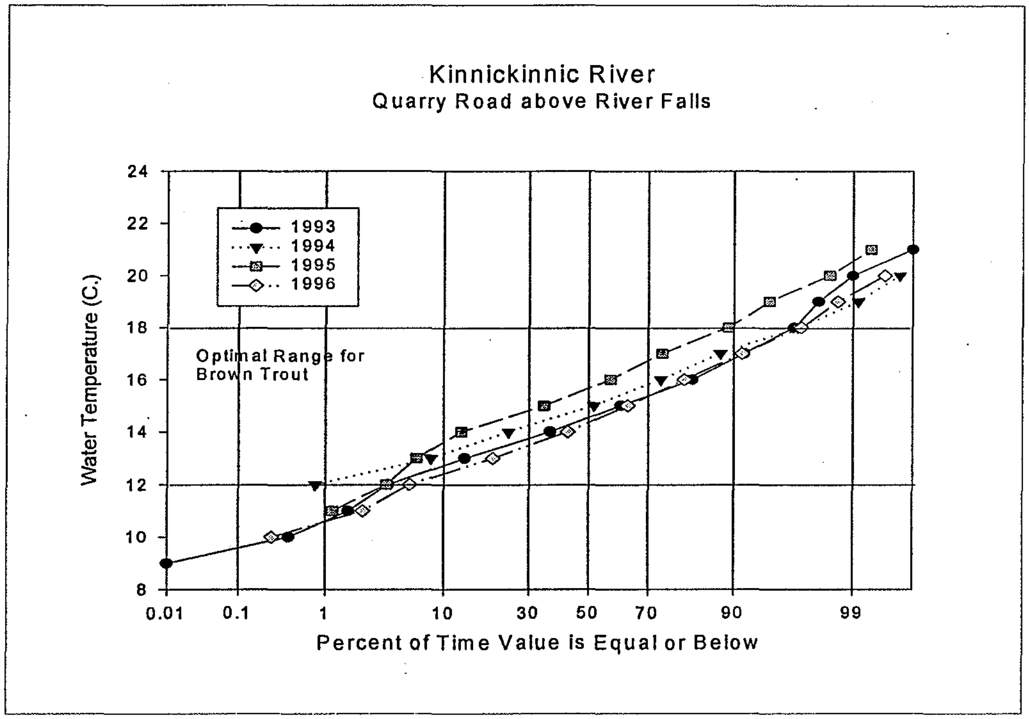
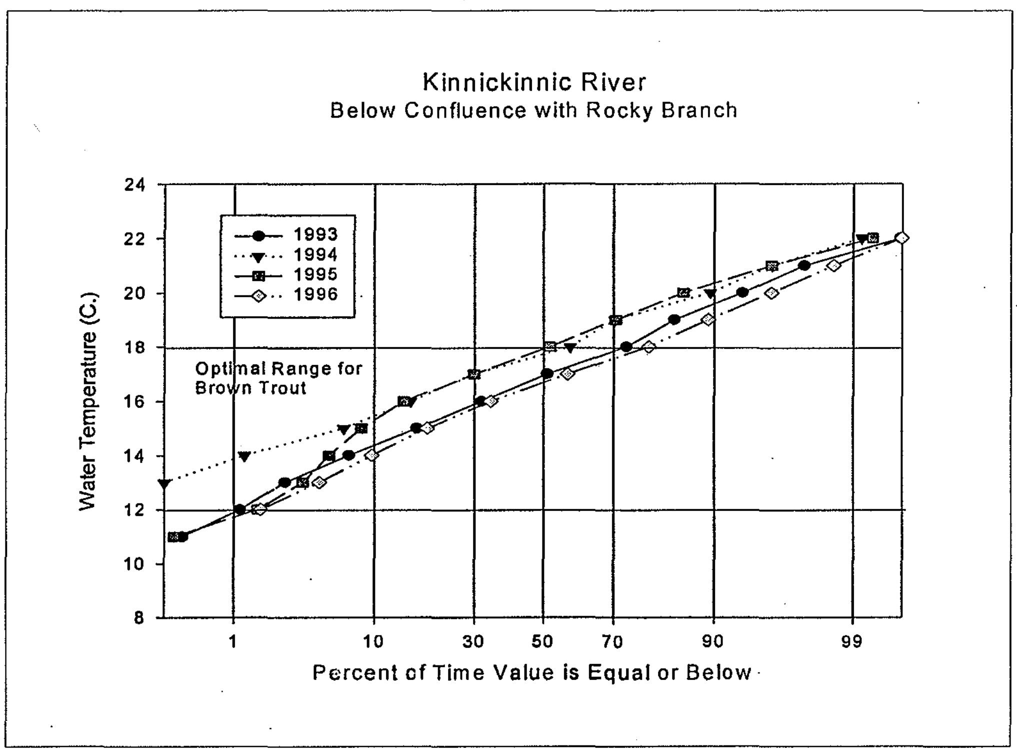


Figure 8. Frequency analysis of water temperatures in the Kinnickinnic River at Quarry Road (above River Falls) and below Rocky Branch (below River Falls) for the period of June 1 - August 31, 1993 - 1996.





of 1993-1996. The upstream (Quarry Road) site exceeded the maximum optimal temperature for brown trout (as identified in Table 4) 3-10% of the time, whereas, temperatures at the downstream site exceeded the optimal range 21-48% of the time during the monitored summers. This analysis suggests that overall upstream temperature conditions are better suited for brown trout than downstream temperatures. The fish survey findings substantiate this conclusion. The analysis also shows that overall summer temperature conditions in the river did not vary considerably between years.

Fisheries

As mentioned previously, the Kinnickinnic River has a Class I trout fishery with some of the highest trout densities in western Wisconsin. Brown trout densities range from about 1,300 to over 7,000 fish per mile, with no stocking conducted in the watershed. Brown trout biomass ranged from 90 to 420 pounds per acre (Fig. 9). Table 5 lists general guidelines for interpreting trout population and biomass estimates for western Wisconsin streams. A complete summary of trout population estimates and habitat ratings for watershed streams is available in Appendix 5.

Significant brook trout populations were present at only two stations in the Kinnickinnic River located in the headwaters area. The lower 0.3 mile (Station 1) had no trout and was dominated by warmwater fish species.

Trout densities are generally higher above River Falls than below, likely due to cooler water temperatures and more stable flow conditions. The highest brown trout densities (7,363 fish/mile) occurred at Station 8, directly upstream of River Falls. The highest brown trout biomass was found at station 16 located above the I-94 bridge. The fishery below River Falls is impacted by elevated water temperatures, fluctuating streamflows and urban runoff.

Since the coldwater fish IBI methodology identifies brown trout as an exotic species, IBI values in the Kinnickinnic River range from fair to good. Excellent IBI ratings only occurred where native brook trout and mottled sculpin were present. Station 1 (located near the river mouth) and influenced by the presence of warmwater fish species, received a "poor" coldwater IBI rating.

Habitat

Fish habitat ratings ranged from "poor" to "excellent" in the Kinnickinnic River (Fig.9 and Table 6). Station 1 had a "poor" rating due to lack of cover, poor substrate and shallow, wide stream morphometry. Habitat ratings were fair to good upstream to Station 16 (near the headwaters) where habitat was excellent. The most common habitat problems in the river were lack of cover and shortage of deep pool area.

Figure 9. Brown trout biomass estimates and coldwater fish habitat ratings for the Kinnickinnic River during summer 1996. Fish and habitat station locations are identified in Appendix 5.

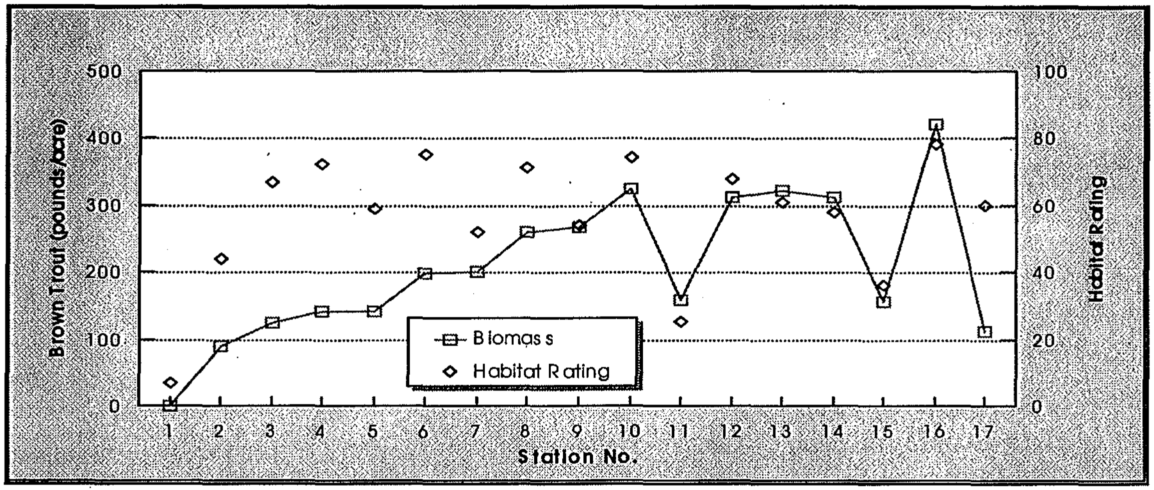


Table 5. General guidelines for interpreting trout abundance values for summer fish survey results from western Wisconsin streams. (Engel, 1996).

Abundance Level	**CPUE* No. / Mile (all sizes)**	**Pop. Est.** No./ Mile (>4.0 in.)**	**Biomass** Pounds/ Mile (>4.0 in.)**
Low	< 250	<500	<35
Moderate	250 - 1500	500 - 1500	40 - 90
High	1500 - 2500	1500 - 3500	100 - 175
Very High	>2500	>3500	> 175

** CPUE - Catch Per Unit Effort includes all trout captured, including young of year using one pass with standard electrofishing gear.*
*** Population estimates and pounds per acre only include age one trout and older, or approximately 4 inches and larger.*

Table 6. Interpretation of fish habitat rating values (Simonson, et al. 1994).

Fish Habitat Rating	**Qualitative Rating**
<25	Poor
25-49	Fair
50-74	Good
>75	Excellent

A comparison of brown trout biomass and habitat ratings suggest the lower river (below River Falls) could support higher trout densities. The reduced densities are likely a result of factors other than those measured in the habitat surveys, such as increased summer water temperatures (or decreased winter temperatures), reduced spawning success, fishing pressure and/or fluctuating water levels.

Macroinvertebrates

Macroinvertebrate sampling in the Kinnickinnic River found HBI values in the "very good" to "excellent" water quality range, suggesting minimal impacts from organic loading (Table 7). During Fall 1995, one site at CTH F below River Falls received an "excellent" HBI value, and all other sites in the river had "very good" HBI values. Follow-up sampling conducted during Spring 1997 in the vicinity of River Falls, found excellent HBI values at 3 sites and a very good rating at a downtown site. The macroinvertebrate sample results indicate very minimal organic loading from the River Falls area.

Although the results are somewhat inconsistent, interpretation of the macroinvertebrate data using other biometrics generally indicates a healthy aquatic community. The highest (best) EPT values were found at CTH F (below River Falls) and the lowest values occurred at CTH JJ (above River Falls), even though both sites had "excellent" HBI values. Diversity index values also suggest the sites with the greatest diversity (sites 2 and 3) do not correspond to the best HBI or EPT values.

Table 7. Summary of macroinvertebrate sample results from the Kinnickinnic River.

Date	Site No.	Location	HBI Value	HBI Rating	EPT (%)	Diversity Index
10/10/95	1	CTH F	3.37	Excellent	71	3.05
10/10/95	2	Below Rocky Br.	3.76	V. Good	62	3.53
10/10/95	3	Division St.	4.44	V. Good	36	3.85
10/10/95	4	STH 35	4.47	V. Good	56	3.52
10/10/95	5	CTH JJ*	3.65	V. Good	31	3.13
5/21/97	7	Above Rocky Br.	2.97	Excellent	63	2.77
5/21/97	6	Cedar St.	3.62	V. Good	44	3.35
5/21/97	4	STH 35	3.16	Excellent	53	3.34
3/27/97	5	CTH JJ*	3.50	Excellent	23	2.79

* *Regional macroinvertebrate reference site (mean of three replicates).*

Limiting Factors and Watershed Goals

Water resource limiting factors, pollutant sources and project goals are identified for all perennial streams in the watershed in Table 8. Limiting factors are physical, chemical and biological conditions that prevent the full biological use from being attained in a specific waterbody. Pollutant reduction goals (for sediment and nutrient control) are indicated in relative terms as high or medium depending on the level of control needed to achieve the identified water resource goals. Final numerical values for the loading reduction goals will be identified during the watershed planning process.

Table 8. Summary of surface water resource uses, problems and goals for lakes and streams in the Kinnickinnic River Priority Watershed.

Subwatershed	Waterbody	WBIC*	Waterbody Size (Mi./Ac.)	Biological Use** (Mi./Ac.)	Limiting Factors***	Observed or Potential Sources****	Water Resource Goals*****
Upper Kinnickinnic	Casey Lake Bushnell Lake	2606700 2606300	28 ac. 17 ac.	WWFF WWFF	EUT, DO, SED, TURB EUT, DO, SED, TURB	CR	Reduce sediment loading - High Reduce nutrient loading - High Improve macrophyte community
	Kinnickinnic River (above I-94)	2601800	1.5	Cold I (1.5)	SED, WET, FLOW SPR, TURB	CR, SB, PSB, GUL BDAM, BY	Reduce sediment loading - High Reduce nutrient loading - High Reduce gully erosion Reduce streambank erosion Improve stream hydrology Protect or restore spring areas Maintain brook trout conditions Restore wetlands
Twin Lakes	West Twin Lake East Twin Lake	2598900 2462300	80 ac. 43 ac.	WWFF WWFF	EUT, DO, SED, TURB WET	CR , URB, PS , DCH	Reduce sediment loading - High Reduce nutrient loading - High Reduce urban runoff pollution Improve macrophyte community
Middle Kinnickinnic	Kinnickinnic R. (Steeple Rd. to I-94)	2601800	2.7	Cold I (2.7)	SED, WET, FLOW SPR, TURB	CR, SB, PSB, GUL, BY	Reduce nutrient loading - Med. Reduce sediment loading - High Protect or restore spring areas Reduce gully erosion Reduce streambank erosion Improve stream hydrology Maintain brook trout conditions Restore wetlands
	Kinnickinnic R. (STH 35 to Steeple Rd.)	2601800	8.5	Cold I (8.5)	SED, WET, TURB	CR, SB, PSB, BY, GUL	Reduce sediment loading - High Reduce nutrient loading - Med. Reduce gully erosion Reduce streambank erosion Improve stream hydrology

Table 8 (cont.)

Subwatershed	Waterbody	WBIC	Waterbody Size (Mi./ Ac.)	Biological Use (Mi./ Ac.)	Limiting Factors	Observed or Potential Sources	Water Resource Goals
Middle Kinnickinnic (cont.)	Kinnickinnic R. (STH 35 to Steeple Rd.) (cont.)	2601800					Protect or restore spring areas Maintain brown trout conditions Restore wetlands
	Parker Creek Cr. 13-2	2604700 2604800	6 3	Cold I (6) Cold I (3)	WET, TEMP, SED SPR, HAB, FLOW TURB	CR, SB, PSB, BY DCH, BDAM, FL	Reduce sediment loading - High Reduce nutrient loading - Med. Reduce gully erosion Reduce streambank erosion Improve stream hydrology Protect or restore spring areas Maintain brook trout conditions Restore wetlands Improve macroinvert. habitat
	Kelly Creek	2604600	1	Cold II (1)	SED, HAB, SPR	CR	Reduce sediment loading - High Reduce nutrient loading - Med. Reduce streambank erosion Maintain brook trout conditions Improve macroinvert. habitat
	Nye Creek	2604500	2	Cold II (2)	SED, HAB, WET	CR, PSB	Reduce sediment loading - High Reduce nutrient loading - Med. Reduce streambank erosion Maintain brook trout conditions Restore wetlands Improve macroinvert. habitat
	Ted Creek	2604400	2	Cold II (2)	SED, WET, HAB	GUL, PSB, CR	Reduce sediment loading - High Reduce gully erosion Reduce streambank erosion Restore wetlands Improve brook trout conditions

Table 8 (cont.)

Subwatershed	Waterbody	WBIC	Waterbody Size (Mi./ Ac.)	Biological Use (Mi./ Ac.)	Limiting Factors	Observed or Potential Sources	Water Resource Goals
Middle Kinnickinnic (cont.)	Cr. 21-4	2604300	3	Cold I (3)	WET, SED, HAB	PSB, CR, DCH	Reduce sediment loading - High Reduce nutrient loading - Med. Reduce streambank erosion Improve brook trout conditions Restore wetlands Improve macroinvert. habitat
	Cr. 30-1 Cr. 30-10	2604000 na	1 1	Cold 2 (1) Cold II (1)	WET, TEMP, SPR HAB, SED	CR, DCH	Reduce sediment loading - High Reduce nutrient loading - Med. Protect or restore spring areas Improve temp. conditions Improve brook trout conditions Restore wetlands
South Fork	South Fork Kinnickinnic R. Cr. 7-1 Cr. 5-15	2603100 2603200 na	9 5 2	Cold II (9) Cold II (5) Cold II (2)	TEMP, WET, SED FLOW, HAB	SB, PSB, URB BDAM, DCH, FL	Reduce sediment loading - High Reduce nutrient loading - Med. Reduce streambank erosion Improve stream hydrology Improve temp. conditions Reduce gully erosion Reduce urban runoff pollutants Improve brook trout conditions Restore wetlands Improve macroinvert. habitat
River Falls	Kinnickinnic R. (above Lake George to STH 35)	2601800	2	Cold I (2)	FLOW, HAB, SED TEMP	URB, GUL	Reduce sediment loading - High Reduce nutrient loading - High Improve stream hydrology Improve temp. conditions Protect or restore spring areas Improve macroinvert. habitat Maintain brown trout conditions

Table 8 (cont.)

Subwatershed	Waterbody	WBIC	Waterbody Size (Mi./Ac.)	Biological Use (Mi./Ac.)	Limiting Factors	Observed or Potential Sources	Water Resource Goals
River Falls (cont.)	Kinnickinnic R. (above Lake George) (cont.)	2601800					Reduce streambank erosion Reduce urban runoff pollutants
	Lake George (Upper Kinni. Pond) Lake Louise (Lower Kinni. Pond)	2603700 2603000	18 ac. 15 ac.	Cold I/ WWSF Cold I/ WWSF	EUT, SED, TURB HAB, SED, FLOW	URB, PS	Reduce sediment loading - High Reduce urban runoff pollutants Reduce nutrient loading - High
	Kinnickinnic R. (between Jct. Falls dam and Lake Louise)	2601800	0.2	Cold I (0.2)	TEMP, FLOW, TURB, SED	URB, HYDRO	Reduce sediment loading - High Reduce nutrient loading - High Reduce streambank erosion Improve stream hydrology Improve temp. conditions Reduce urban runoff pollutants Maintain brown trout conditions
	Kinnickinnic R. (below Powell Dam to Rocky Branch)	2601800	1	Cold I (1)	TEMP, FLOW, TURB, SED	URB, HYDRO, SB	Reduce sediment loading - High Reduce nutrient loading - High Improve stream hydrology Improve temp. conditions Reduce streambank erosion Reduce urban runoff pollutants Improve macroinvert. habitat Maintain brown trout conditions
	Cr. 36-1	2603900	3	Cold II (3)	FLOW, SED, HAB SPR	DCH, URB	Reduce sediment loading - High Reduce nutrient loading - High Improve stream hydrology Maintain brook trout conditions Reduce streambank erosion Reduce urban runoff pollutants

Table 8 (cont.)

Subwatershed	Waterbody	WBIC	Waterbody Size (Mi./ Ac.)	Biological Use (Mi./ Ac.)	Limiting Factors	Observed or Potential Sources	Water Resource Goals
River Falls (cont.)	Cr. 36-15	na	1	Cold II (1)	SPR, SED, FLOW HAB	URB, SB	Reduce sediment loading - High Reduce nutrient loading - High Reduce streambank erosion Improve stream hydrology Protect or restore spring areas Reduce urban runoff pollutants Improve brook trout conditions
	Mann Valley Creek (Cr. 2-16)	2602800	2	Cold II (2)	SED, SPR	CR, URB	Reduce sediment loading - High Reduce nutrient loading - High Improve stream hydrology Protect or restore spring areas Reduce streambank erosion Reduce urban runoff pollutants Maintain brook trout conditions
	Rocky Branch Cr. 12-11	2602400 2602500	6 3	Cold I (6) Cold II (3)	SED, FLOW, HAB	URB, GUL, SB, FL	Reduce sediment loading - High Reduce nutrient loading - High Improve stream hydrology Reduce gully erosion Reduce streambank erosion Reduce urban runoff pollutants Improve macroinvert. habitat Maintain brook trout conditions
Lower Kinnickinnic	Kinnickinnic R. (below Rocky Branch to CTH F)	2601800	6.8	Cold I (6.8)	TEMP, FLOW, SED	CR, SB, FL, GUL HYDRO	Reduce sediment loading - Med. Reduce nutrient loading - Med. Improve stream hydrology Reduce gully erosion Maintain brown trout conditions Reduce streambank erosion Reduce urban runoff pollutants

Table 8 (cont.)

Subwatershed	Waterbody	WBIC	Waterbody Size (Mi./Ac.)	Biological Use (Mi./Ac.)	Limiting Factors	Observed or Potential Sources	Water Resource Goals
Lower Kinnickinnic (cont.)	Kinnickinnic R. (CTH F to mouth)	2601800	2.3	Cold I (2) WWSF (0.3)	TEMP, FLOW, SED HAB	CR, SB, HYDRO, GUL FL	Reduce sediment loading - Med. Reduce nutrient loading - Med. Improve stream hydrology Reduce streambank erosion Reduce gully erosion Maintain brown trout conditions
	Cr. 9-11a Cr. 9-11b Cr. 10-11 Cr. 8-13 Cr. 8.11 Cr. 17-6	na 2602140 2602200 2602120 2602040 2602020	1 1 3 0.5 1 1	Cold II (1) Cold II (1) Cold II (3) Cold II (0.5) Cold II (1) Cold II (1)	SED	CR, GUL	Reduce sediment loading - Med. Reduce nutrient loading - Med. Reduce gully erosion Maintain brook trout conditions
Upper St. Croix	St. Croix River	2601400	5	WWSF (5)	EUT, SED	CR, GUL	Reduce sediment loading - Med. Reduce gully erosion Reduce nutrient loading - Med.
Lower St. Croix	St. Croix River	2601400	6.7	WWSF (6.7)	EUT, SED	CR, GUL	Reduce sediment loading - Med. Reduce gully erosion Reduce nutrient loading - Med.
	Barkley Coulee	2601700	2	UNK (2)	SED	CR, GUL	Reduce sediment loading - Med. Reduce gully erosion Reduce nutrient loading - Med.

*WBIC - Waterbody Identification Code

**Biological Use (Abbreviations):

WWSF - Warmwater Sport Fishery
WWFF - Warmwater Forage Fishery
Cold - Coldwater Fishery

Trout stream classifications (DNR, 1980):
Class I - sufficient natural reproduction to sustain populations of wild trout
Class II - some natural reproduction of trout, good survival and carryover of adult trout
Class III - no natural reproduction of trout, marginal trout habitat

***Limiting Factors (abbreviations):

HAB - Habitat (loss of cover, etc.)
SED - Sedimentation
TEMP - Temperature (elevated)
DO - Dissolved Oxygen (depletion)
SPR - Springhead alterations
EUT - Eutrophication
FLOW - altered streamflow hydrology
TURB - Turbidity
WET - Wetland alteration

**** Observed or Potential Impacts (Abbreviations):

BDAM - Beaver Dams
DCH - Ditching
BY - Barnyard Runoff
CR - Cropland Runoff
GUL - Gully erosion
HYDRO - Hydropower flow impacts
PSB - Streambank Pasturing
FL - Flooding (Flashy flows)
SB - Streambank erosion
URB - Urban Stormwater Runoff
PS - Point Source Discharge

*****Water Resource Goals (Definitions):

Reduce sediment loading - High or Medium level of control (actual quantity to be determined by advisory committee)
Reduce nutrient loading - High or Medium level of control (actual quantity to be determined by advisory committee)
Reduce urban runoff pollutants - reduce urban runoff by using detention basins, street sweeping, increasing infiltration, etc.
Reduce gully erosion - reduce or eliminate downcutting of gullies through check dams, grassed waterways, etc.
Reduce streambank erosion - reduce or eliminate streambank erosion through rip-rap, stabilization, etc.
Improve macroinvert. habitat - improve stream bottom substrate composition for aquatic insects and other aquatic life
Improve temp. conditons - improve water temperature conditions for the coldwater aquatic community
Maintain trout conditions - prevent degadation of temperature, habitat or water quality conditions affecting the brook or brown trout fishery
Improve trout conditions - improve habitat and water quality conditions sufficiently to increase trout populations
Protect or restore spring areas - protect existing spring areas or prevent further degradation through fencing, rehabilitation, etc.
Restore wetlands - rehabilitate impacted wetlands through fencing, plugging ditches or tile drains, etc.
Improve stream hydrology - reduce streamflow "flashiness" by increasing infiltration of runoff waters

A variety of project management goals were identified by the water resource appraisal work group for the Kinnickinnic River watershed, including short-term and long-term goals. Short term goals are considered achievable during the course of the Priority Watershed Project (10 years). Long term goals may take considerably longer and require actions independent and beyond the scope of the priority watershed project.

Short term water resource goals are identified in Table 8 and should be accomplished during the course of the watershed project. The recommended long term goal for the Kinnickinnic River is as follows:

Improve water temperature conditions in the lower Kinnickinnic River (from STH 35 to CTH F) to the optimal range for brown trout and other coldwater aquatic life. Temperature conditions at the Quarry Road monitoring site should be used as a benchmark for optimal future river temperatures.

In order to achieve this long-term goal it would likely be necessary to alter, modify or remove the Kinnickinnic River impoundments in River Falls and take aggressive management actions to reduce urban runoff impacts to levels below that which is presently occurring.

All permanent streams in the Kinnickinnic River watershed are currently classified as Class I or Class II trout fisheries. In many cases, the water resource goal is to maintain or protect the current biological condition. However, installation of best management practices are recommended in order to prevent further degradation and to enhance the existing condition. Several streams (or reaches) have a goal to improve the biological condition. These streams will require a more aggressive management approach that would reduce pollutant loading sufficiently to result in a measurable improvement in the overall biological condition. A relatively higher level of pollutant control should be directed to these streams.

Following is a discussion of surface water appraisal results for the Kinnickinnic River and all permanent surface waters in the watershed. The descriptions are arranged by subwatershed and provide a summary of available information on each named, perennial waterbody including a discussion of water resource conditions, problems affecting the resource and recommended management goals.

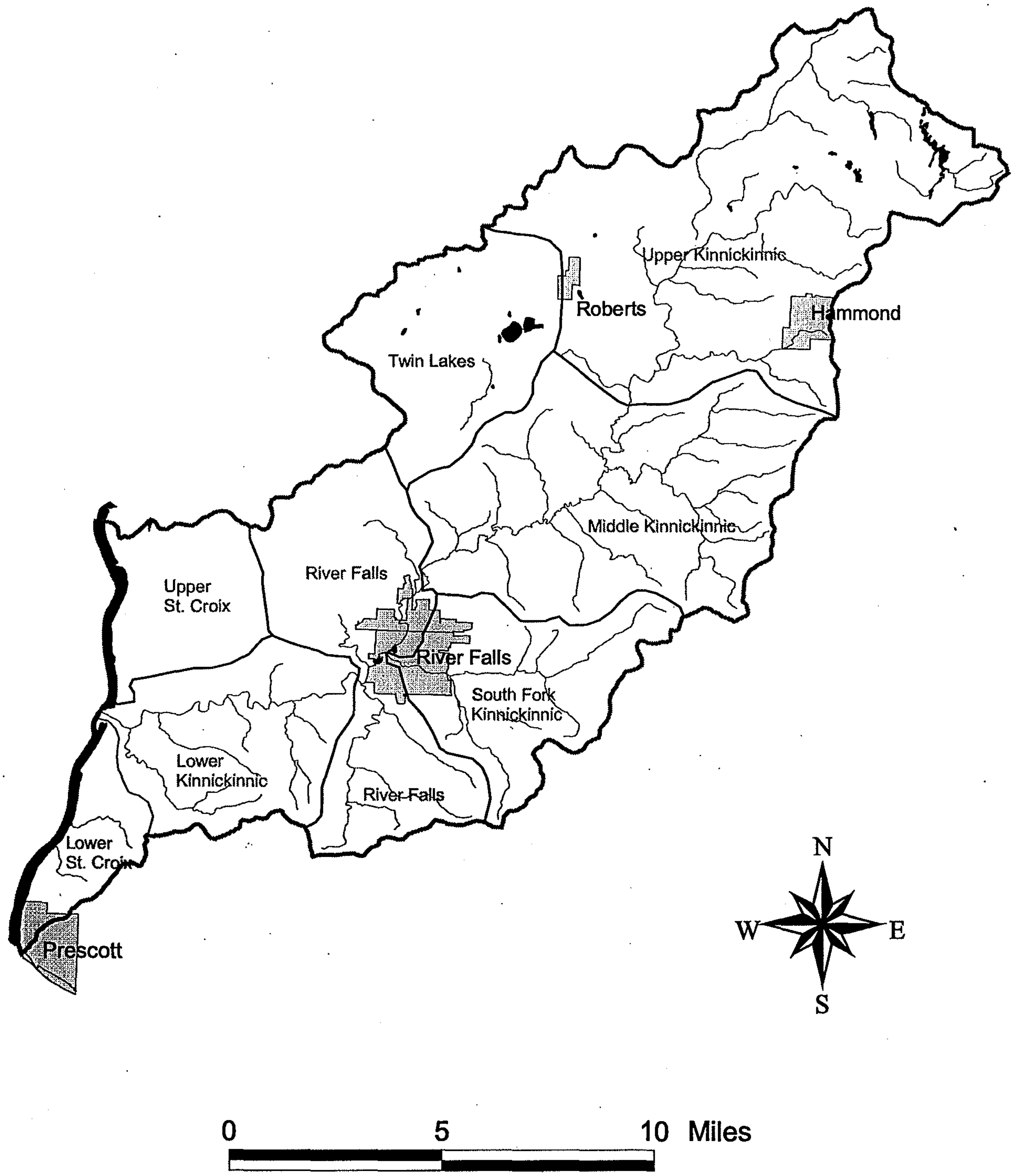
Subwatershed Descriptions

Streams in the Kinnickinnic River watershed are generally in good condition and support a viable, naturally-reproducing trout fishery. However, many of the streams would benefit from nonpoint source management, and could be improved to support a higher quality coldwater aquatic community. The following subwatershed narratives provide a brief description of water resource appraisal findings and recommended project management goals for each major perennial waterbody. The project subwatershed boundaries are shown in Figure 10.

UPPER KINNICKINNIC

The Upper Kinnickinnic subwatershed is 46 square miles and includes Casey and Bushnell Lakes and the headwaters of the Kinnickinnic River.

Figure 10. Subwatershed boundaries in the Kinnickinnic River Priority Watershed.



Permanent flow in the Kinnickinnic River begins about 1.5 miles upstream of the I-94 bridge. The watershed above this location primarily consists of intermittent, grassed dry runs. The permanent portion of the stream is managed as a Class I brook and brown trout fishery. The fish habitat rating and Index of Biotic Integrity (IBI) for this reach were good to excellent. The stream has high brown trout densities and relatively low brook trout densities in this reach.

Strong baseflow from several large springs in this reach resulted in the lowest summer maximum water temperatures found throughout the Kinnickinnic River during the 1996 fish surveys. However, the stream experiences occasional high peak flows due to agricultural and urban stormwater runoff in the watershed. The stream is also impacted by excessive sediment loading from upland runoff and streambank erosion.

The coldwater community would benefit from wetland and spring area protection, gully and streambank erosion control, and BMPs that would increase infiltration in the watershed. The Village of Hammond should develop and adopt a stormwater control plan and a construction site erosion control ordinance to reduce the impacts from urban runoff.

The water resource goal for the upper Kinnickinnic River is to maintain brook trout habitat conditions by reducing gully, upland and streambank erosion, improving stream hydrology, restoring wetlands and protecting spring areas.

Casey Lake is a shallow 28 acre seepage lake with a limited warmwater fishery. Bushnell Lake is a shallow 17 acre seepage lake with a marginal warmwater fishery. Both lakes are highly eutrophic with summer algae blooms and frequent winterkills. These lakes would benefit from sediment and nutrient reductions from the watershed.

The water resource goal of these lakes is to provide a high level of nutrient and sediment control in order to improve water clarity and increase macrophyte growth.

TWIN LAKES

The Twin Lakes subwatershed is 20.7 square miles and includes East Twin and West Twin lakes. Twin Lakes are shallow, highly eutrophic waterbodies (about 168 acres in size) located approximately one mile southwest of the Village of Roberts in St. Croix County, Wisconsin. In 1976, Twin Lakes were classified as wetlands by the Department, for purposes of establishing wastewater treatment effluent limits. Twin Lakes are not listed in the surface water resources inventory of St. Croix County (WDNR, 1961), but are identified as lakes in the Wisconsin Lakes publication (WDNR, 1995).

Water levels in Twin Lakes fluctuate considerably, depending on prevailing climatic conditions. Maximum depth of the larger western portion (referred to as West Twin) reportedly ranges from about 9-12 feet. The smaller eastern portion (East Twin), which is hydraulically connected to West Twin by a culvert, has a maximum depth ranging from about 3-6 feet. Historically, Twin Lakes and other comparable waterbodies in the region have fluctuated from a wetland condition with little open water during dry periods, to open-water lakes capable of supporting a limited forage fishery during wet periods. The lakes are heavily used by migratory waterfowl.

Both waterbodies suffer from severe summer algae blooms and winterkill due to dissolved oxygen depletion. During July 1991, the Department received reports of an intense algae bloom in Twin Lakes and water samples confirmed the presence of blue-green algal toxins. An ice-cover survey conducted in February 1993 found dissolved oxygen levels throughout the water column below 1.0 mg/l in both portions of Twin Lakes, indicating probable fish winterkill conditions.

Phosphorus Loading

The Roberts wastewater treatment plant (WWTP) has discharged directly to East Twin Lake since 1984. A recent DNR study determined that approximately 35 percent of the annual phosphorus load originates from nonpoint sources, 15 percent from the WWTP discharge and the remainder from internal loading (Schreiber, 1995). However, the nonpoint source and internal load estimates were approximations based on limited available data. The current priority watershed planning process and appraisal included collection of additional lake data and a detailed land use inventory of the Twin Lakes watershed. Revised watershed P loading estimates will be included in the priority watershed management plan.

The water resource goal for this subwatershed is to provide a high level of nutrient and sediment control in order to improve water clarity and increase macrophyte growth in Twin Lakes.

MIDDLE KINNICKINNIC

The Middle Kinnickinnic subwatershed is 39.2 square miles and includes the Kinnickinnic River, Parker, Kelly, Nye and Ted creeks, and several small unnamed streams.

The Kinnickinnic River in this reach is 11.2 miles and supports a Class I brook and brown trout fishery. The upper 2.7 miles support brook and brown trout, and the lower 8.5 miles support brown trout only. Brown trout densities were high to very high in this reach, with a significant brook trout population at the furthest upstream site (CTH N). The macroinvertebrate HBI was very good indicating minimal organic loading. The fish habitat ratings and coldwater IBI values were fair to good.

Water resource problems in this reach include sedimentation, barnyard runoff (from one barnyard), streambank erosion, wetland grazing and gully erosion in the dry runs. The stream is also impacted by flashy stream flows during runoff events.

The stream fishery goals are to maintain brook trout habitat conditions above Steeple Road, and maintain brown trout conditions below Steeple Road. Other water resource goals include reducing sediment and nutrient loading, reduce streambank and gully erosion and improve stream hydrology.

<u>Parker Creek</u> is 4.5 miles in length and supports a Class I brook and brown trout fishery. Brown trout densities were low in the headwaters area and very high near the mouth. The stream supports relatively low brook trout densities but acts as an important rearing area for the Kinnickinnic River. The stream HBI was very good indicating minimal organic loading, and the fish habitat rating was fair to good. The coldwater IBI was poor at the two upstream stations and good at the lower stations.

The stream is impacted by sedimentation, elevated water temperatures, turbidity and excessive macrophyte growth. Other water resource problems include ditched wetlands and bank erosion due to cattle pasturing.

Note: A severe fish kill occurred in Parker Creek in May 1998 that was caused by runoff from a field spread with liquid manure. The runoff event resulted in a near total kill of brook and brown trout in Parker Creek. The event also caused a 40% kill of brown trout in a 1.5 mile portion of the Kinnickinnic River downstream of Parker Creek.

The water resource goal is to maintain brook trout and macroinvertebrate habitat conditions by restoring wetlands and reducing gully, upland and streambank erosion.

Kelly Creek (Kelly Spring) is very small (less than 1 mile in length) and supports a low density, Class II brook and brown trout fishery. The coldwater IBI was good and fish habitat rating was fair. The stream is limited by its small size, sedimentation and dense tag alder growth in the riparian area. The watershed is also being impacted by conversion from agricultural land use to residential development.

The water resource goal is to maintain brook trout and macroinvertebrate habitat conditions by reducing streambank and upland erosion.

Nye Creek is 2 miles in length and supports a moderate density Class II brook trout fishery. The stream HBI was very good indicating minimal organic loading. The fish habitat rating was good and the coldwater IBI was excellent. The stream is impacted by sedimentation and streambank and gully erosion. The stream is also impacted by wetland alterations and cattle pasturing in the headwaters area.

The water resource goal for this stream is to improve brook trout and macroinvertebrate habitat conditions by restoring wetlands and reducing upland and streambank erosion.

Ted Creek is 2 miles in length and supports a low density Class II brook trout fishery. The stream HBI was excellent indicating little or no organic loading. The fish habitat rating was fair and coldwater IBI was excellent. The stream is impacted by sedimentation, streambank and gully erosion and wetland grazing.

The water resource goal is to improve brook trout habitat conditions by restoring wetlands and reducing gully and streambank erosion.

SOUTH FORK

The South Fork subwatershed is 19.3 square miles and includes the South Fork Kinnickinnic River and two unnamed tributaries to the South Fork.

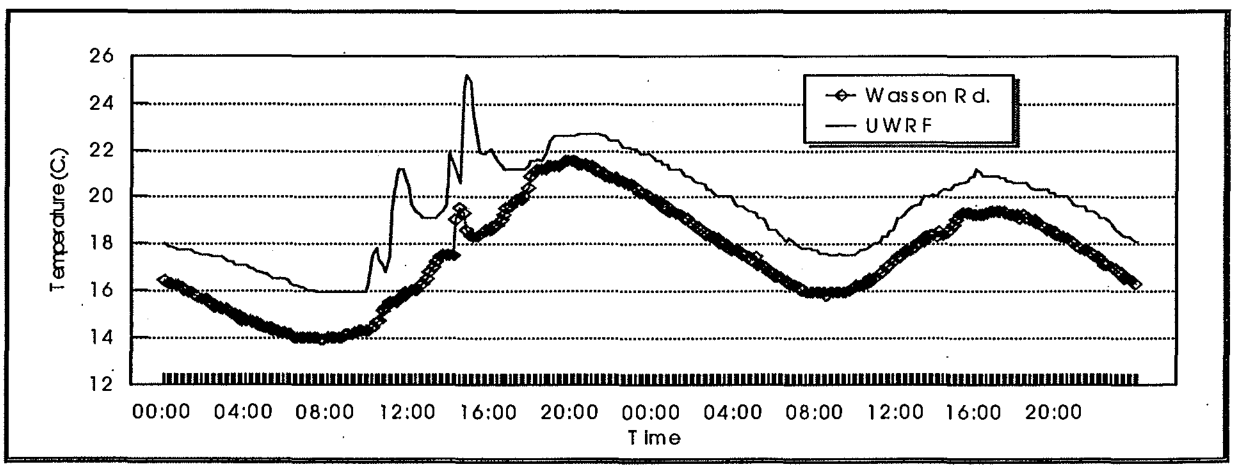
The South Fork Kinnickinnic River flows 9 miles west to the Kinnickinnic River between Lake George and Lake Louise in River Falls. The stream supports a low to moderate density Class II brook trout fishery. Stream habitat conditions range from poor in the headwaters area, to good in the lower reaches. The coldwater IBI was fair to excellent and the HBI was good to very good, indicating minimal organic loading.

The upper portion of the stream is impacted by sedimentation, bank and upland erosion, wetland grazing and beaver dams on the tributaries. The lower portion, which flows through River Falls, is impacted by flashy streamflow, sedimentation, elevated temperatures and lack of suitable fish habitat. The South Fork is significantly impacted by excessive peak streamflow and elevated water temperatures during summer storm events. Figure 4 illustrates streamflow conditions at the three continuous flow monitoring sites during a July 27-28, 1997 storm event. Although the South Fork only comprises about 16% of the direct drainage area above the downstream gauging station, peak flow in the South Fork was approximately 50% of the total peak flow in the Kinnickinnic during the storm event. Several large storm sewers draining the east side of River Falls enter the South Fork above the gauging station.

The South Fork is also impacted by elevated water temperatures from stormwater runoff. Figure 11 shows water temperatures at two stations in the South Fork during the July 27 storm event. The Wasson Road site represents conditions above River Falls, and the UW-River Falls site is located below several city storm sewer outfalls. Temperature data from the UWRF site indicates an approximate 4° C. (7° F.) increase in stream temperatures due to the storm event. More importantly, the maximum stream temperature during the event was 25.2° C., which is 1.4° C. above what is considered the upper limiting (near lethal) temperature for brook trout (see Table 4).

The water resource goals for the South Fork and its tributaries are to improve brook trout and macroinvertebrate habitat conditions by reducing streambank and upland erosion, reducing urban runoff pollutants, restoring wetlands, and improving water temperatures and overall stream hydrology.

Figure 11. Stream temperatures in the South Fork Kinnickinnic River during a July 27-28, 1997 storm event. Based on 10-minute interval continuous temperature recordings.



RIVER FALLS

The River Falls subwatershed is 16.2 square miles and includes the Kinnickinnic River, Mann Valley Creek, Rocky Branch and several small unnamed streams. This reach of the Kinnickinnic River also includes two impoundments known locally as Lake George and Lake Louise.

The Kinnickinnic River in this subwatershed includes three separate reaches; 1) a 2 mile upper reach from above Lake George to STH 35, 2) a 0.2 mile reach from below Junction Falls to upper Lake Louise, and 3) a 1.0 mile lower reach from below Powell Dam to the confluence with Rocky Branch. Each of these reaches currently support a Class I brown trout fishery, however, the middle reach was not inventoried during the 1996 fish surveys. The 1996 surveys found very high brown trout densities in the upper and lower reaches.

The coldwater IBI and habitat rating was fair in the upstream (downtown River Falls) reach. The stream HBI was very good indicating minimal organic loading. The upstream reach is impacted by urban runoff pollution (including thermal), flashy flows and lack of adequate fish habitat.

The middle reach (between the two impoundments) is deep, slow moving and has marginal trout habitat conditions. The South Fork enters this reach and provides a source of relatively cool water to the Kinnickinnic River.

The downstream reach (below Powell Dam) had a fair coldwater IBI and a good habitat rating. This reach had an excellent HBI indicating minimal organic loading. The stream in this reach is impacted by flashy stream flows caused by urban runoff and hydropower manipulations. The stream also has elevated water temperatures and occasional turbidity caused by the two upstream impoundments and stormwater runoff.

The water resource goals for the river in this subwatershed are to maintain brown trout temperature conditions and improve macroinvertebrate habitat by reducing urban stormwater runoff pollutants, improving stream hydrology, protecting spring areas and reducing sediment loading.

Lake George is a shallow, eutrophic 18-acre impoundment of the Kinnickinnic River formed by the Junction Falls dam. The lake has a limited warmwater and coldwater sport fishery consisting of largemouth bass, panfish and brown trout. The lake is nearly filled with sediment and experiences summer algae blooms and turbidity. Water temperatures in the original stream channel are generally cool enough to support brown trout. However, warming in the shallow areas tends to cause a general increase in downstream water temperatures.

A macrophyte (rooted aquatic plant) survey conducted on Lake George during August 1996 found a macrophyte community characterized by a moderate level of species diversity and plant densities (Konkel 1996). The plant community was dominated by *Potamogeton zosteriformis* and *Elodea canadensis*, both species that are tolerant of high turbidity levels.

Lake Louise is a shallow, eutrophic 15-acre impoundment of the Kinnickinnic River formed by Powell Dam. Similar to Lake George, the lake has a limited warmwater and coldwater sport fishery consisting of largemouth bass, panfish and brown trout. The lake also supports a significant carp population. The lake is nearly filled with sediment and experiences summer algae blooms and turbidity. The impoundment contributes to elevated downstream water temperatures.

Mann Valley Creek is 2 miles in length and supports a low density, Class II brook and brown trout fishery. The fish habitat rating was good and the coldwater IBI was excellent. This small stream receives urban runoff from the City of River Falls and experiences flashy flows, streambank erosion and sedimentation.

The water resource goal is to maintain brook trout conditions by improving stream hydrology, reducing gully and bank erosion and controlling urban runoff pollutants.

Rocky Branch is 6 miles in length and supports a moderate density, Class I brown trout fishery. The headwaters area had minimal flow and supported no trout. The stream had a good habitat rating and a very good HBI, suggesting minimal organic loading. The coldwater IBI was good at the lower station and fair at the upper station. The stream is impacted by severe streambank and gully erosion, flashy streamflows, sedimentation and lack of suitable habitat.

Rocky Branch provides a source of cold water to the Kinnickinnic River. The mean summer water temperature of Rocky Branch is about 4° C. (7° F.) cooler than the Kinnickinnic River at the confluence of the two streams (Appendix 3).

The water resource goal for this stream is to maintain current temperature conditions and improve macroinvertebrate habitat by reducing streambank and gully erosion, sedimentation and urban runoff pollutant loading.

LOWER KINNICKINNIC

The Lower Kinnickinnic subwatershed is 19.9 square miles and includes the Kinnickinnic River and six unnamed tributaries.

The Kinnickinnic River in this subwatershed flows 9.1 miles through what is locally known as "The Canyon" to the St. Croix River. The stream supports a moderate to high density Class I brown trout fishery in the upper 8.8 miles, and a limited warmwater sport fishery in the lower 0.3 miles (above mouth). Fish habitat ratings ranged from fair to good, with a poor rating at the furthest downstream site. Coldwater IBI values ranged from fair to good, with poor values at the three furthest downstream sites. The poor IBI values were a result of the lack of brook trout and presence of some warmwater species.

The river in this reach is impacted by urban runoff pollution, elevated water temperatures, flashy flows (due to urban stormwater runoff and hydropower manipulations) and sediment from upland and gully erosion. All of the unnamed tributaries to the Kinnickinnic River in this subwatershed have low density, Class II brown trout fisheries. These streams are also impacted by gully erosion, sedimentation and cropland runoff.

The water resource goal of this subwatershed is to maintain brown trout habitat conditions by reducing gully and streambank erosion, improving stream hydrology and temperature conditions, and reducing urban runoff pollutants.

UPPER ST. CROIX

The Upper St. Croix subwatershed is 8.8 square miles and includes a 5 mile reach of the St. Croix River. The St. Croix River supports a warmwater sport fishery and is impacted by sediment loading from gully and cropland erosion, and nutrient loading from croplands. *The water resource goal for this subwatershed is to reduce sediment and nutrient loading to the St. Croix River.*

LOWER ST. CROIX

The Lower St. Croix subwatershed is 16.5 square miles and includes a 6.7 mile reach of the St. Croix River and Barkley Coulee Creek. The St. Croix River supports a warmwater sport fishery and is impacted by sediment loading from gully and cropland erosion, and nutrient loading from croplands. *The water resource goal for this subwatershed is to reduce sediment and nutrient loading to the St. Croix River.*

Barkley Coulee Creek is a 2 mile tributary of the St. Croix River. The status of the fishery is unknown since no inventories have been conducted on this stream. The stream is limited by its small size and sedimentation from gully and upland erosion.

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Appendix 1. Summary of continuous temperature monitoring deployments at stream sites in the vicinity of River Falls. All monitoring was conducted using a 10-minute recording interval.

Stream	Location	Deployment Period
Kinnickinnic River	Above I-94 bridge	5/97 - ongoing
	Quarry Road (above R. Falls)	6/92 - 9/92
		5/93 - ongoing
	CTH MM (River Falls)	5/97 - 9/97
	Division St. (River Falls)	5/93 - 10/93
		4/94 - 10/94
		5/95 - 10/95
		4/96 - 9/96
	Footbridge (River Falls)	5/97 - 9/97
	Below Junction Falls (River Falls)	5/97 - 9/97
	Below Powell Dam (below R. Falls)	6/92 - ongoing
	Glen Park (below River Falls)	5/93-10/93
		5/94 - 10/94
		4/95 - 10/95
		4/96 - 6/96
South Fork Kinni. R.	900th St. (above River Falls)	7/96 - 9/96
	Old STH 35 bridge (River Falls)	5/97 - 9/97
	UWRF Campus	6/96 - 9/96

Appendix 2. Summary of continuous temperature monitoring deployments in storm sewers in River Falls, Wisconsin. All monitoring was conducted using a 5-minute recording interval.

Location	Deployment Period
Clark & Maple St. (manhole)	5/30/96 - 7/30/96
	8/20/96 - 9/11/96
Maple & Third St. (manhole)	6/17/96 - 7/31/96
	8/13/96 - 9/24/96
Pine & Lewis St. (storm drain)	8/9/96 - 8/31/96
Rural Development Institute parking lot (manhole)	8/26/96 - 9/17/96
Riverside Square - SW corner of parking lot (manhole)	5/30/96 - 6/4/96
Riverside Square - north side of parking lot (storm drain)	6/13/96 - 9/17/96
Maple St. - behind Ben Franklin (manhole)	6/14/96 - 6/23/96
	6/23/96 - 6/26/96
	7/2/96 - 7/3/96
	8/19/96 - 8/20/96

Appendix 3. Summary of continuous temperature monitoring conducted in Kinnickinnic River Watershed streams during June-Augustt (1993

			10-minute recording interval (unless otherwise noted) Temperature (C.)					
Stream	Location		1993	1994	1995	1996	1997	Comments
Kinnickinnic River	Above I-94 Bridge (30- min. interval)	Max.					13.7	
		Min.					9.1	
		Mean					11.27	
	Quarry Rd. - Above River Falls	Max.	21.2	21.0	22.0	20.9	19.4	
		Min.	8.9	11.2	10.1	10.9	10.9	
		Mean	14.70	15.13	15.83	14.84	14.50	
	CTH MM (River Falls)	Max.					20.2	
		Min.					10.9	
		Mean					14.7	
	Cedar St. (River Falls)	Max.	20.6	22.1				
		Min.	8.7	11.0				
		Mean	14.4	15.2				
	Division St. (River Falls)	Max.			21.6	21.2	20.0*	* Only includes 6/7/97 - 8/3/97
		Min.			9.4	9.6	11.0*	
		Mean			15.58	14.79	15.28*	
	Footbridge (River Falls)	Max.					20.0	
		Min.					10.9	
		Mean					14.73	
	Below Junction Falls Dam	Max.					20.6	
		Min.					12.0	
		Mean					15.60	
	Below Powell Dam	Max.		22.6	24.2	23.1	21.9	
		Min.		12.5	11.3	11.1	12.3	
		Mean		17.06	18.42	16.92	16.27	
	Below Rocky Branch	Max.	22.6	23	23	22.6	21.2	
		Min.	10.1	12.4	10.6	11.1	11.7	
		Mean	16.97	17.87	17.88	16.66	16.51	
South Fork Kinnickinnic River	900th St. (Above River Falls)	Max.				21.1		
		Min.				8.5		
		Mean				13.14		
	S. Wasson Lane (River Falls)	Max.					21.5	
		Min.					10.3	
		Mean					14.9	
	UWRF Campus	Max.				21.8*	25.2	*Missing 7/2/96 - 8/8/96
		Min.				12.0*	11.6	
		Mean				15.66*	16.5	
Rocky Branch	50 m. above confl. with Kinnickinnic River	Max.				20.7*	22.5	* Only includes 6/27/96 - 8/31/96
		Min.				9.0*	8.5	
		Mean				12.66*	12.33	

Appendix 4. Literature review of temperature requirements of various life stages of brown trout.

Reproductive impairment:

Source	Temp. Range (C.)	Comments
Kaya (1977b)	28.0 - 28.8 for 5 consecutive days	Poor reproductive success
Elliot (1981)	>13.0	Lethal temp. (eggs)

Growth impacts:

Source	Temp. Range (C.)	Comments
Pentelow (1939)	10.0 - 15.6	Maximal growth rate
Swift (1961)	12.0	Maximal growth rate
Jensen (1990)	14.9	Maximal growth rate
Jobling (1981)	10.0 - 15.5	Maximal growth rate
Hunt (DNR)	16 - 18	Optimal range
Frost & Brown (1967)	12 - 19	Optimal for growth & survival
	7 - 19	Maximum growth
Brynildson et. al. (1963)	18.3 - 23.9 (65 - 75 F.)	Optimal range for growth
Elliot (1981)	11.7 - 18.5	Preferred temp. (YOY)
Brungs & Jones (1977)	19.0	Optimal growth (max. weekly ave.)
	24.0	Max. temp. for short survival (24hr)

Tolerance limits:

Source	Temp. Range (C.)	Comments
Embody (1921)	>25	Fingerlings survived for 10 days
	>26.7	Fingerlings survived for 3 days
Frost & Brown (1967)	22.5 - 25.3	Upper tolerance limits
Alabaster & Lloyd (1982)	18 - 24	Upper tolerance level
Needham (1969)	27.2	Upper limiting, near lethal
Spaas (1960)	25.9	Ultimate upper incipient lethal temp. (ULT)
Elliot (1981)	22.5	Lethal temp. (fry)
	23.0	Lethal temp. (YOY)
	25.0 - 26.0	Lethal temp. (adult)

Appendix 5. Summary of fish surveys and habitat ratings for streams in the Kinnickinnic River Watershed, Pierce & St. Croix counties, Wisconsin during July - August, 1996.

Waterbody	Station	Location	Fish Habitat Rating (<10 meters)	Coldwater IBI Rating	Trout CPUE (no/mi) Brook	Trout CPUE (no/mi) Brown	Pop. Est. > or = 4 (no/mi) Brook	Pop. Est. > or = 4 (no/mi) Brown
KINNICKINNIC RIVER	1	KINNI. R. (MOUTH)	POOR*	POOR	0	0	0	0
	2	CTH F	FAIR*	FAIR	0	1,044.3	0	1,380.4
	3	CHAMBERS PROP.	GOOD*	POOR	0	1,490.1	0	1,902.3
	4	ERICKSON PROP.	GOOD*	FAIR	0	1,912.5	0	2,193.5
	5	PETERSON PROP.	FAIR*	GOOD	2.9	3,056.5	--	3,070.0
	6	CONF. W/ ROCKY BR.	GOOD*	FAIR	0	5,464.8	0	3,870.8
	7	RIVER FALLS	FAIR*	FAIR	0	4,071.5	0	5,850.4
	8	STH 35	GOOD*	GOOD	29.3	6,811.2	--	7,363.6
	9	QUARRY RD.	FAIR*	FAIR	5.9	5,133.3	--	5,820.9
	10	LIBERTY RD.	GOOD*	FAIR	0	4,083.2	0	6,369.5
	11	RIVER RD. (120TH ST.)	FAIR*	FAIR	5.9	1,551.7	--	2,573.2
	12	CTH JJ	GOOD*	GOOD	2.9	3,886.7	--	4,882.7
	13	CTH J	GOOD	GOOD	5.9	4,241.6	--	4,346.9
	14	STEEPLE RD.	GOOD	GOOD	158.4	4,411.7	--	4,362.4
	15	CTH N	FAIR	EXCELLENT	469.3	3,977.6	442.8	2,177.8
	16	I-94	EXCELLENT	EXCELLENT	551.5	3,942.4	258.1	4,561.0
	17	140 TH ST.	GOOD	GOOD	586.7	5,274.1	--	1,477.0
KELLY SPRING	1	PRIVATE DR.	FAIR	GOOD*	17.6	246.4	--	--
NYE CREEK	1	OAK RD.	GOOD	EXCELLENT	1,877.3	0	546.1	0
TED'S CREEK	1	MADSEN PROP.	FAIR	EXCELLENT*	211.2	0	--	0
UNAMED STREAM 21-4	1		GOOD	GOOD	0	1,193.1	0	1,181.1
UNAMED STREAM 30-1	1		FAIR	FAIR*	0	5.9	0	--
UNAMED STREAM 30-10	1		FAIR	GOOD*	28.2	204.2	--	--
UNAMED STREAM 36-1	1		GOOD	GOOD	374.1	120.7	--	--
UNAMED STREAM 36-15	1		FAIR	EXCELLENT*	17.6	0	--	0
ROCKY BR.	1	ABOVE MOUTH	GOOD	GOOD	0	6,001.6	0	1,234.0
	2	CTH FF	GOOD	FAIR*	0	0	0	0
UNAMED STREAM 12-11	12-11		GOOD	FAIR*	0	5.9	0	--
UNAMED STREAM 2-16	2-16		GOOD	EXCELLENT	152.5	29.3	--	--
UNAMED STREAM 8-11	8-11		GOOD	GOOD*	0	46.9	0	--
UNAMED STREAM 8-13	8-13		GOOD	FAIR*	0	49.7	0	--
UNAMED STREAM 9-11A	9-11a		FAIR	GOOD*	0	38.2	0	--
UNAMED STREAM 9-11B	9-11b		GOOD	GOOD*	0	18.7	0	--
UNAMED STREAM 10-11	10-11		GOOD	GOOD*	0	133.9	0	--
UNAMED STREAM 17-6	17-6		GOOD	FAIR*	0	58.7	0	--
PARKER CREEK	1	MORROW PROP.	GOOD	GOOD	240.5	7,609.1	--	1,634.6
	2	PLEASANT AVE.	FAIR	FAIR	193.6	1,320.0	108.3	361.3
	3	CTH J	FAIR	POOR	134.9	269.9	--	--
	4	CTH W	FAIR	POOR	134.9	152.5	173.1	196.5
UNNAMED STREAM 13-2	1		GOOD	GOOD	105.6	199.5	--	--
SOUTH FORK	1	STH 29	GOOD	FAIR	70.4	0	--	0
	2	STH 35	GOOD	FAIR	434.1	0	576.1	0
	3	SOUTH FORK RD.	FAIR	EXCELLENT	680.5	0	628.5	0
	4	SADDLE CLUB RD.	POOR	FAIR*	0	0	--	0
UNAMED STREAM 5-15	1		FAIR	GOOD*	18.3	0	--	0
UNAMED STREAM 7-1	2		FAIR	POOR	23.5	0	--	0

* Fish habitat rating score (stream width >10 meters).
** Rating may not be representative when total number of individuals caught was less than 25 individuals. A rating of "very poor" may apply.
*** Max./Min. water temperatures for all stations were for the period of August 23-29, 1996. Max/min. air temperature was 89/43 F.
**** Angler counts were conducted May 3, 1997 between the hours of 7:00 and 9:00 AM. (- - indicates site was not visited)