

**City of River Falls
North Kinnickinnic River Monitoring Project**

2005 Technical Review

Project Introduction

The Kinnickinnic River is one of the premier, naturally sustaining trout fisheries in the Midwest, primarily producing brown trout. There has been a lot of concern about how new developments will affect the river, not only by the increase in runoff and chemicals from lawns, cars, etc., but also from pedestrian traffic. The thermal impacts of untreated storm water are further described on the North Kinni Monitoring website. In 2002, the City adopted a new [Storm Water Management Ordinance](#), which is designed to protect the Kinnickinnic River from the negative impacts of storm water runoff associated with new development. For new development and re-development projects, the City of River Falls Storm Water Management Ordinance requires that, for a 1.5-inch, 24-hour rainfall event, the post-development runoff volume and peak flow rate must not exceed the pre-development runoff volume and peak flow rate. To achieve these requirements, developers must infiltrate water on their site.

To take an active role in the river's health and well-being, the City has implemented a monitoring program aimed at evaluating the effectiveness of our Storm Water Management Ordinance for preventing degradation of the Kinnickinnic River due to new City developments.

Project Scope:

- Temperature Monitoring
- Water Quality Monitoring
- Base Flow Surveys
- Macroinvertebrate Monitoring

The City will examine the long-term results of each of these four monitoring elements to determine how new developments, specifically Sterling Ponds Subdivision, are or are not affecting the river under the new storm water ordinance. The project will use an “upstream/downstream” approach to see if the development makes river conditions worse downstream. We will also take a focused look at on-site storm water management practices that are incorporated into new developments. Our hope is that due to the ordinance requirements, the water quality and thermal impacts of development will be undetectable or greatly reduced.

River Falls Precipitation:

Due to the influence of precipitation on river flow, temperature, and water quality, an analysis of annual precipitation is conducted as a part of this project. During the April-September 2004 monitoring period, hourly precipitation was measured in 0.01-inch increments with an electronic tipping-bucket rain gauge. The rain gauge, provided by the Wisconsin Department of Natural Resources (WDNR), was located in the Whitetail Ridge Corporate Park at the northwest corner of the City of River Falls. This location places the rain gauge in very close proximity to all six North Kinnickinnic River monitoring stations. Unfortunately, the WDNR rain gauge malfunctioned during the April-September 2005 monitoring period. However, a weather station at Rocky Branch Elementary School in River Falls served as an alternate source of daily rainfall data. This station is part of an extensive network of local weather stations supported by KSTP-TV in Minneapolis, MN, via the Automated Weather Source. During short time periods when the Rocky Branch Weather Station was not operating, supplemental precipitation data were obtained from local KSTP weather stations in Hudson and Prescott, WI, and from the United States Geological Survey (USGS) Kinnickinnic River monitoring station at County Highway F, near Kinnickinnic State Park. The Rocky Branch Weather Station also served as a source of daily mean, minimum, and maximum air temperatures.

A total of 36.45 inches of precipitation was recorded in River Falls during the April-September 2005 period, nearly twice the normal total of 20.67 inches for the April-September time period. Rain fell on 71 days, or 39% of the April-September 2005 period. In comparison, a near-normal total of 19.82 inches of precipitation was recorded in River Falls during the April-September 2004 monitoring period. "Normal" monthly and seasonal rainfall amounts are based upon measurements made by the National Weather Service at the Twin Cities International Airport during the "climate normal period" of 1971-2000.

Daily rainfall amounts during the April-September 2005 period are presented in Figure 1. Monthly rainfall amounts during the April-September 2005 period, with a comparison to normal monthly rainfall amounts, are presented in Figure 2. All months during the April-September 2005 period were wetter than normal, with monthly rainfall amounts exceeding seven inches in June, July, and September. Rainfall amounts in June and July were nearly twice the normal levels, while September rainfall was almost three times the normal level. Nearly 65% of the total April-September rainfall occurred during these three months. The lowest monthly rainfall amount was recorded in April.

Besides being much wetter than normal, the April-September 2005 monitoring period was warmer than normal. The mean air temperature in River Falls during the April-September 2005 period was 64.6° Fahrenheit (F), nearly 1.5° F higher than the normal mean of 63.2° F for the April-September period, as measured at the Twin Cities International Airport. Monthly mean air temperatures during the April-September 2005 period, with a comparison to normal monthly mean temperatures during the "climate normal period" of 1971-2000, are presented in Figure 3. With the exception of May and August, all months during the April-September 2005 monitoring period were warmer

than normal. The months of April, June, and September were nearly 4° F warmer than normal, while the month of July was nearly 2° F warmer than normal. The month of May was nearly 4° F colder than normal, while the month of August was nearly 1° F colder than normal. “Summer” months that were warmer than normal (June, July, and September) also had the highest rainfall amounts (all in excess of seven inches). The warmer summer weather may have generated more convective thunderstorm activity that produced heavier rainfall.

The distribution of River Falls daily rainfall amounts during the April-September 2005 period is presented in Figure 4. On 31 (44%) of the 71 days with measurable precipitation, rainfall amounts were 0.25 inch or less. These 31 days contributed only 8% of the total April-September 2005 precipitation. The majority of these 31 days occurred in April and May (Figure 5), the months with the coolest air temperatures. On 12 (17%) of the 71 days with measurable precipitation, rainfall amounts ranged from 0.26-0.50 inch. These 12 days contributed 12% of the total April-September 2005 precipitation. Eight of these 12 days occurred in April and September (Figure 5). On 15 (21%) of the 71 days with measurable precipitation, rainfall amounts ranged from 0.51-0.75 inch. These 15 days contributed 25% of the total April-September 2005 precipitation. The majority of these 15 days occurred in June and September (Figure 5). On 4 (6%) of the 71 days with measurable precipitation, rainfall amounts ranged from 0.76-1.00 inch. These 4 days contributed 10% of the total April-September 2005 precipitation. On 9 (13%) of the 71 days with measurable precipitation, rainfall amounts exceeded 1.00 inch. These 9 days with the largest rainfall events contributed 44% of the total April-September 2005 precipitation. Rainfall amounts in excess of 1 inch occurred on April 16, June 8 and 11, July 8 and 25, August 4 and 26, and September 21 and 25 (Figures 1 and 5). On 5 of the 9 days, rainfall amounts ranged from 1.26-1.50 inches. On 8 of the 9 days, rainfall amounts exceeded 1.25 inches. These largest 8 rainfall events were all produced by convective thunderstorm activity during a warmer than normal summer (June-September) period.

To achieve the requirements of the City’s storm water ordinance, developers must infiltrate water on their site. Of the 71 days with measurable precipitation during the April-September 2005 period, 68 days (96%) were events less than 1.5 inches in 24 hours. The WDNR rain gauge would have allowed us to monitor rainfall in any given 24-hour period. However the available rainfall data is a midnight-to-midnight total. Based on that data, only rainfall amounts on June 8 (1.76 inches), July 8 (4.00 inches), and September 25 (2.18 inches) exceeded this criterion. Even so, some infiltration would have occurred under the requirements of the storm water ordinance, thereby accounting for infiltration of approximately 91% (33.01 inches) of the total rainfall (36.45 inches) that occurred during the April-September 2005 period. Figure 6 depicts the annual effectiveness of the River Falls Storm Water Ordinance for infiltrating storm water runoff generated by rainfall during the April-September period. This figure was prepared for illustrative purposes only and was created under the assumption that the entire 1.5-inch event is infiltrated, even though this essentially assumes zero pre-development runoff, which may not necessarily be the case.

Kinnickinnic River Flow:

The flow of the Kinnickinnic River is a reflection of precipitation and storm water runoff from predominantly agricultural and urban land uses throughout the 165-square mile Kinnickinnic River Watershed. The United States Geological Survey (USGS) operates a Kinnickinnic River monitoring station (number 05342000) at County Highway F, near Kinnickinnic State Park. The station measures river stage (water height) and flow at 15-minute intervals. Because accurate monitoring of river stage and flow entails a significant investment in equipment and labor, no continuous measurement of river flow is currently being conducted within the North Kinnickinnic River Monitoring Project Area. For this reason, the Kinnickinnic River flow information provided by the USGS monitoring station is particularly valuable, as it clearly documents when runoff events are occurring and storm water impacts may be apparent. The Kinnickinnic River Land Trust, Trout Unlimited, and the City of River Falls provide cost-share funding for this USGS monitoring station.

The daily mean (average) flow of the Kinnickinnic River at County Highway F during the April-September 2005 period is presented in Figure 7. Due to equipment malfunction, daily mean flows are not available for brief periods in June (27-29) and August (16-19). Daily rainfall, as measured in River Falls, is also presented in Figure 7.

The precipitation pattern during the April-September 2005 period helps explain the changes in the Kinnickinnic River hydrograph, due to runoff events in the watershed. High river flows of 591 cubic feet per second (cfs) on March 31 and 249 cfs on April 1 occurred as a result of spring snowmelt in late March, in combination with a March 30 thunderstorm. During the April-September period, rainfall amounts in excess of 1 inch generally had the greatest influence on the Kinnickinnic River hydrograph. Rainfall events on April 16 (1.08 inches), June 8 (1.76 inches), June 11 (1.43 inches), and September 21 (1.49 inches) resulted in moderate increases in the Kinnickinnic River hydrograph, with peak daily mean flows ranging from 127-133 cfs. However, relatively large rain events on August 4 (1.35 inches) and August 26 (1.46 inches) generated little runoff, with peak daily mean flows of only 116 cfs and 113 cfs, respectively. These small runoff events, in spite of heavy rains, can be attributed to dry antecedent conditions and full canopy closure in the agricultural and forested areas of the watershed.

The Kinnickinnic River hydrograph suggests that seven significant runoff events occurred during the April-September 2005 period: one during the April 16-17 period, two during the month of June (8-9 and 11-12), two during the month of July (8-10 and 23-31), and two during the month of September (21-23 and 24-30). These runoff events should be the focus for evaluating possible storm water impacts in the North Kinnickinnic River Monitoring Project Area in 2005, and will be further analyzed later in this report. See Appendix A for reasons why smaller runoff events were not analyzed in 2005.

The three largest runoff events of the year occurred in July and September. On July 8, the heaviest rainfall of the year (4.00 inches) resulted in a 3-day runoff event with a peak daily mean flow of 212 cfs. On July 23 and 25, back-to-back rainfall events totaling 2.10

inches resulted in a 9-day runoff event with a peak daily mean flow of 217 cfs. A thunderstorm on September 24-25 (2.49 inches of rain) produced the largest runoff event of the year, with a peak daily mean flow of 265 cfs and a 7-day duration.

During dry periods between runoff events, the Kinnickinnic River maintained a base flow condition of approximately 80-90 cfs at County Highway F.

Temperature Monitoring:

In 2005, temperature monitoring was conducted at all six City of River Falls monitoring stations (Sites 1-6) in the North Kinnickinnic River Monitoring Project Area. To evaluate the thermal performance of the storm water management practices at Site 5, temperature monitoring was conducted at three locations: the wet detention pond (Site 5P), the wet detention pond outlet to the infiltration basin (Site 5IB), and the wet detention pond outfall to Sumner Creek (Site 5MH).

The local Kiap-TU-Wish Chapter of Trout Unlimited (TU) also conducted temperature monitoring of one Kinnickinnic River station (Site 1A) within the project area, between Sites 1 and 2. The TU monitoring station is located along Quarry Road on the northeast edge of River Falls, just east of the WI Highway 35 bypass, and just upstream of the Sumner Creek confluence. The TU station has been in service during all summer periods (May-September) since 1992. As an additional contribution to the North Kinni Project in 2005, TU established a temperature monitoring station in Sumner Creek (Site 4A), approximately 100 feet upstream from the creek confluence with the Kinnickinnic River. The thermal impacts of Sumner Creek on the Kinnickinnic River, including any storm water contributions from Sterling Ponds, can be evaluated at this location.

Onset Computer Corporation's® HOBO Water Temp Pro Loggers were used to measure water temperature at all City of River Falls monitoring stations (Sites 1-6). A Ryan Instruments® RTM 2000 Temperature Logger was used to measure water temperature at the TU monitoring station at Quarry Road (Site 1A). Onset Computer Corporation's® Optic StowAway Templogger was used at the TU monitoring station in Sumner Creek (Site 4A). All Onset and Ryan temperature loggers were programmed to record temperatures at 10-minute intervals. Date and time stamps and the 10-minute temperature data were electronically recorded by each logger; and all recorded information was downloaded as necessary. The brief 10-minute time interval was selected so that any rapid temperature increases associated with warm storm water runoff could be documented. With the exception of Site 5IB, all temperature loggers were deployed throughout the May-September (summer) period. The thermal impacts of storm water runoff are most likely to occur during this summer period, when air temperatures are highest. The summer 2005 deployment periods (and locations) for the temperature loggers at the ten monitoring stations were as follows:

Site 1:	May 1-September 30, 2005	(Kinnickinnic River)
Site 1A:	May 1-September 30, 2005	(Kinnickinnic River)
Site 2:	May 1-September 27, 2005	(Kinnickinnic River)

Site 3:	May 1-September 30, 2005	(Kinnickinnic River)
Site 4:	May 4-September 30, 2005	(Wet pool of creek culvert)
Site 4A:	May 1-September 30, 2005	(Mouth of Sumner Creek)
Site 5P:	May 4-September 30, 2005	(Wet pond at Sterling Ponds)
Site 5IB:	September 14-September 30, 2005	(Pipe to infiltration basin)
Site 5MH:	May 4-September 30, 2005	(Wet pond outlet to creek)
Site 6:	May 4-September 30, 2005	(Dry box culvert)

Due to an instrumentation problem, the temperature logger at Site 5IB was not successfully deployed until mid-September.

Kinnickinnic River Temperature Monitoring Results:

The May-September 2005 (summer) temperature monitoring data obtained for the Kinnickinnic River at Sites 1, 1A, 2, and 3 are presented as thermographs in Figures 8-11, respectively. Of immediate note in these thermographs is the strong daily (diurnal) temperature pattern in the river. Although cold groundwater continually feeds the river via springs along the entire riverway, the temperature of the Kinnickinnic River is greatly influenced by ambient air temperature. During the daylight hours, the river gradually warms and generally reaches a daily maximum temperature in the late afternoon or early evening (4:30-6:30 PM). At night, the river gradually cools and typically reaches a daily minimum temperature just after sunrise (7:30-9:30 AM). These diurnal temperature fluctuations in the river are natural, and the river's residents, including macroinvertebrates and trout, have become accustomed to a constantly but slowly changing temperature regime.

Also of note in the 2005 Kinnickinnic River thermographs are the relatively frequent changes in the daily minimum and maximum river temperatures and daily temperature ranges that are influenced by local weather patterns (cold fronts and warm fronts) and seasonal climate changes. During the summer 2005 period, for example, the monthly mean river temperature in the North Kinnickinnic River Project Area (Sites 1, 1A, 2, and 3) was coolest in May (11.2 degrees centigrade (°C)) and warmest in July (16.4° C).

At Sites 1, 1A, 2, and 3, river temperatures averaged 14.4° C and ranged from 4.5-21.5° C over the course of the summer. Monthly and summer mean temperatures at each of these four monitoring sites are presented in Figure 12. These monthly and summer mean temperatures were nearly identical at Sites 1, 1A, and 2, but slightly colder at Site 3.

Slightly higher-than-normal river temperatures probably prevailed in the North Kinnickinnic River Project Area during the summer of 2005, since the 2005 summer average air temperature of 19.7° C (67.4° F) was slightly higher than the normal summer average air temperature of 19.2° C (66.5° F). In contrast, slightly lower-than-normal river temperatures probably prevailed in the North Kinni Project Area during the summer of 2004, since the 2004 summer average air temperature of 18.7° C (65.6° F) was slightly lower than the normal summer average air temperature of 19.2° C (66.5° F). The 2005 summer average river temperature at Sites 1, 1A, and 2 was 14.4° C (range: 4.5-21.5° C), compared to the 2004 summer average river temperature of 13.8° C (range: 7.7-19.9° C).

The most direct way to determine if any thermal impacts occurred in the Kinnickinnic River as a result of the Sterling Ponds Subdivision is to compare the temperature monitoring data at Site 1, located immediately downstream from Sumner Creek, to the temperature monitoring data at Sites 1A and 2, located immediately upstream from Sumner Creek. These two upstream sites serve as control or reference sites which are not impacted by Sterling Ponds storm water discharges.

A comparison of all upstream summer temperature data at Site 2 to all downstream summer temperature data at Site 1 is presented in Figure 13. This comparison indicates that summer temperatures were very similar at these two locations. The temperature similarity at Sites 1 and 2 is even more evident in the monthly thermographs for May, June, July, August, and September 2005 (Figures 14-18, respectively). Figures 13-18 indicate that daily maximum temperatures tended to be lower and daily minimum temperatures tended to be higher at Site 2, but this is likely due to stronger groundwater inputs upstream. A comparison of all upstream summer temperature data at Site 1A to all downstream summer temperature data at Site 1, as presented in Figure 19, indicates that summer temperatures were nearly identical at these two locations. Daily maximum temperatures tended to be slightly higher at Site 1A, due to less canopy cover and shading at this location. Figure 12 shows that the monthly and summer mean temperatures at Sites 1, 1A, and 2 were also nearly identical. The following should be noted concerning aquatic life in the Kinnickinnic River:

1. Approximately 86% of all temperatures recorded at Sites 1, 1A, and 2 during the May-September 2005 period were less than or equal to (\leq) 17° C, which is considered to be the top of the optimum temperature range for a healthy coldwater macroinvertebrate community (Galli, 1990). A temperature of 17° C is considered to be the physiological optimum for brown trout survival (Armour, 1994).
2. Approximately 98% of all temperatures recorded at Sites 1, 1A, and 2 during the May-September 2005 period were \leq 19° C, which is considered to be the top of the optimum temperature range for brown trout growth (Armour, 1994).
3. Approximately 99.5% of all temperatures recorded at Sites 1, 1A, and 2 were \leq 20° C, which is considered to be the top of the optimum temperature range for brown trout survival (Armour, 1994). River temperatures exceeding 20° C were only recorded on four dates in late June and mid-July, when air temperatures exceeded 32° C (90° F).

During six significant rainfall and runoff events in June, July, and September 2005, thermographs at Sites 1 and 2 can be compared to determine if rapid temperature increases (thermal spikes), which are characteristic of warm storm water discharges, were apparent at Site 1. In spite of major rainfall events on June 8 (1.76 inches) and June 11 (1.43 inches), no thermal spikes were evident throughout the month at Site 1 (Figure 15). A closer examination of the thermographs for Sites 1 and 2 during the 1.76-inch rainfall

event on June 8 (Figure 20) indicates that no thermal spike occurred at Site 1, downstream from Sumner Creek and the Sterling Ponds subdivision. However, the thermograph for the Trout Unlimited temperature monitoring site at Division Street during the same rain event (Figure 20) shows a very prominent thermal spike, due to the thermal impacts of direct storm water discharges from the downtown area of River Falls. Thermographs for Sites 1, 2, and Division Street can be similarly compared for the large rainfall events on June 11 (Figure 21), July 8 (Figure 22), July 23-25 (Figure 23) September 21 (Figure 24), and September 24-25 (Figure 25). During the June 11, July 23-25, September 21, and September 24-25 rainfall events, no thermal spikes were evident at Site 1, while prominent thermal spikes were evident at Division Street. The thermal spikes at Division Street ranged in magnitude from 0.4-2.3 degrees centigrade. While the presence of thermal spikes at Division Street is attributed to the thermal impacts of untreated storm water discharges to the Kinnickinnic River, the lack of thermal spikes at Site 1 could be attributed to several factors, including effective storm water management at the Sterling Ponds subdivision, or simply a lack of Sterling Ponds storm water discharges and/or storm water conveyance down Sumner Creek, even during the largest runoff events.

However, the largest rainfall event of the summer on July 8 (4.00 inches) produced two prominent thermal spikes at Site 1, downstream from Sumner Creek and Sterling Ponds (Figure 22). A first spike of 1.8° C occurred at 8:40 PM on July 8, while a second spike of 1.1° C occurred at 4:30 AM on July 9. The cause of the thermal impacts at Site 1 can be determined through a close examination of the Sumner Creek and Sterling Ponds temperature monitoring results in the next section. As expected, a prominent thermal spike of 4.0° C also occurred at Division Street (Figure 22).

Sumner Creek and Sterling Ponds Temperature Monitoring Results:

The May-September 2005 (summer) temperature monitoring data obtained for Sumner Creek at Site 4A are presented as a thermograph in Figure 26. Site 4A near the creek mouth was the only Sumner Creek monitoring location with permanent flow throughout the summer. At Site 4A, Sumner Creek temperatures averaged 12.3° C and ranged from 5.3-22.0° C during the May-September 2005 period. The summer mean temperature of Sumner Creek (12.3° C) was notably colder than the summer mean temperature of the Kinnickinnic River (14.4° C) at Sites 1, 1A, 2, and 3, reflecting strong spring activity. Approximately 98.5% of all temperatures recorded at Site 4A during the May-September 2005 period were ≤ 17° C, and approximately 99.5% of all temperatures were ≤ 20° C. Temperatures exceeding 20° C were only recorded on four dates in July, after two major rain events.

This info is not online and I think is not pertinent to the specific project at hand.

Based upon the summer 2005 temperature data, lower Sumner Creek may have potential as a brook trout stream, and is regardless an important contributor of cold water to the Kinnickinnic River. Of significant concern, however, are numerous thermal spikes that occurred at Site 4A after rain events in June, July, August, and September (Figure 26). The thermal spike that occurred after the largest summer rain event on July 8 (4.00

inches) is depicted in Figure 27, along with the downstream thermal impact on the Kinnickinnic River at Site 1. The thermal spikes in lower Sumner Creek ranged from 2.1 -7.6 degrees centigrade, and were of even greater magnitude than those observed at the Division Street monitoring site. With the exception of the July 8 spike, none of these thermal spikes had a discernible impact on Kinnickinnic River temperatures at Site 1, downstream from Sumner Creek. However, thermal spikes of this magnitude and frequency may have detrimental impacts on aquatic life in lower Sumner Creek, especially macroinvertebrates. Possible sources contributing to thermal spikes in Sumner Creek may include: storm water runoff from WI Highway 35, located immediately upstream from Site 4A; warm water from natural wetland areas in the upper Sumner Creek drainage way; and storm water discharges from the Sterling Ponds subdivision.

The May-September 2005 (summer) temperature monitoring data obtained for the Sterling Ponds wet detention pond at Site 5P are presented as a thermograph in Figure 28. At Site 5P, wet detention pond temperatures averaged 21.7° C and ranged from 10.0-29.7° C during the summer period. Approximately 75% of all summer temperatures exceeded 20° C. Substantial warming of small, shallow ponds such as this can be expected, especially with no shading or canopy cover. The summer mean temperature of the Sterling Ponds wet detention pond (21.7° C) was substantially higher than the summer mean temperature of Sumner Creek at Site 4A (12.3° C), clearly demonstrating the potential for thermal impact when the pond discharges to the creek, and emphasizing the importance of the River Falls Storm Water Management Ordinance, which requires storm water infiltration.

The effectiveness of storm water management practices at Sterling Ponds and the possible causes of the thermal impacts observed in lower Sumner Creek (Site 4A) can be best determined by examining the thermal regime at all monitoring sites (Sites 4A, 4, and 6 in Sumner Creek and Sites 5P, 5MH, and 5IB in Sterling Ponds) during the six significant rainfall and runoff events in June, July, and September 2005. These events were all characterized by rainfall amounts in excess of one inch.

June 8

The comparative Sumner Creek and Sterling Ponds thermographs for the June 8 rain event (1.76 inches) are presented in Figure 29. As indicated by the nearly identical temperatures at Sites 5P and 5MH, the Sterling Ponds wet detention pond began discharging to the Sumner Creek drainage way at 5:00 CDT (5:00 AM) on June 8 and continued discharging until 16:00 CDT (4:00 PM). During this 11-hour period, the wet pond discharge temperature averaged 21.2° C and ranged from 20.0-22.5° C. In spite of this warm storm water discharge from the wet pond, no temperature increase was apparent downstream at Site 4 in Sumner Creek. Some storage of this storm water discharge likely occurred in the wetland that comprises the creek drainage way upstream from Site 4. The thermal spike (3.4° C) evident near the mouth of Sumner Creek (Site 4A) at 4:30 CDT on June 8 cannot be attributed to the Sterling Ponds storm water discharge, as no thermal impact was apparent at Site 4, and the spike at Site 4A, located 1.5 miles downstream, occurred at nearly the same time as the storm water discharge. It seems apparent that the thermal spike at Site 4A had a more a “local” cause, perhaps

including storm water runoff from WI Highway 35 and/or warm water flowing from natural wetland or storage areas in the upstream Sumner Creek drainage way.

June 11

The comparative Sumner Creek and Sterling Ponds thermographs for the June 11 rain event (1.43 inches) are presented in Figure 30. As indicated by the very similar temperatures at Sites 5P and 5MH, the Sterling Ponds wet detention pond began discharging to the Sumner Creek drainage way at 14:00 CDT (2:00 PM) on June 11 and continued discharging until 3:30 CDT (3:30 AM) on June 12. During this 13.5-hour period, the wet pond discharge temperature averaged 24.0° C and ranged from 23.2-24.8° C. A slight temperature increase (0.8° C) was apparent downstream at Site 4 in Sumner Creek at 14:00 CDT (2:00 PM), and may be due to the release of warm water from the upstream wetland. Once again, however, the thermal spike (5.5° C) evident near the mouth of Sumner Creek (Site 4A) at 14:00 CDT on June 11 cannot be attributed to the Sterling Ponds storm water discharge, as only a slight thermal impact was apparent at Site 4, and the spike at Site 4A, located 1.5 miles downstream, occurred at the same time as the storm water discharge. A very rapid temperature increase at Site 6 likely indicates the onset of water flow at 15:30 CDT (3:30 PM) on June 11, with water temperatures exceeding 24° C for several hours. From the thermograph alone, it is very difficult to determine when water flow ceased at this location.

July 8

The comparative Sumner Creek and Sterling Ponds thermographs for the July 8 rain event (4.00 inches) are presented in Figure 31. As indicated by the nearly identical temperatures at Sites 5P and 5MH, the Sterling Ponds wet detention pond began discharging to the Sumner Creek drainage way at 19:30 CDT (7:30 PM) on July 8 and continued discharging until 9:30 CDT (9:30 AM) on July 9. During this 14-hour period, the wet pond discharge temperature averaged 21.9° C and ranged from 21.7-24.8° C. A marked temperature increase (2.7° C) was apparent downstream at Site 4 in Sumner Creek at 21:30 CDT (9:30 PM) on July 8, and is likely due to the release of warm water (including storm water) from the upstream wetland, especially given the magnitude of this rain event. The large (primary) thermal spike (7.2° C) evident near the mouth of Sumner Creek (Site 4A) at 19:00 CDT on July 8 cannot be attributed to the Sterling Ponds storm water discharge, since the spike occurred at nearly the same time as the storm water discharge. However, the “plug” of warm water passing through Site 4 (from 21:30-24:00 CDT on July 8) may have contributed to a smaller (secondary) thermal spike (1° C) downstream at Site 4A (from 3:30-7:30 CDT on July 9). Both the primary and secondary thermal spikes near the mouth of Sumner Creek had noticeable impacts on the Kinnickinnic River temperature at Site 1 downstream. A slight temperature increase (0.6° C) at Site 6 likely indicates the onset of water flow at 20:30 CDT (8:30 PM) on July 8. From the thermograph alone, it is very difficult to determine when water flow ceased at this location.

July 23 & 25

The comparative Sumner Creek and Sterling Ponds thermographs for back-to-back rain events on July 23 (0.72 inch) and July 25 (1.38 inches) are presented in Figure 32. After the smaller rain event on July 23, no discharge occurred from the Sterling Ponds wet pond, and no temperature increase was apparent downstream at Site 4 in Sumner Creek. However, a thermal spike (3.6° C) of local origin was again evident near the mouth of Sumner Creek (Site 4A) at 11:00 CDT (11:00 AM) on July 23.

After the larger rain event on July 25, the Sterling Ponds wet detention pond began discharging to Sumner Creek drainage way at 19:30 CDT (7:30 PM) on July 25 and continued discharging until 4:30 CDT (4:30 AM) on July 26. During this 9-hour period, the wet pond discharge temperature averaged 24.9° C and ranged from 23.7-27.2° C. A marked and sudden temperature increase (2.0° C) was apparent downstream at Site 4 in Sumner Creek at 21:30 CDT (9:30 PM) on July 25, and is likely due to the release of warm water (including storm water) from the upstream wetland. A large thermal spike (7.9° C) evident near the mouth of Sumner Creek (Site 4A) at 19:00 CDT on July 25 cannot be attributed to the Sterling Ponds storm water discharge, since the spike occurred at nearly the same time as the storm water discharge. A very rapid temperature increase (1.9° C) at Site 6 likely indicates the onset of water flow at 19:00 CDT (7:00 PM) on July 25. From the thermograph alone, it is very difficult to determine when water flow ceased at this location.

September 21

The comparative Sumner Creek and Sterling Ponds thermographs for the September 21 rain event (1.49 inches) are presented in Figure 33. With the temperature logger at Site 5IB now functioning, the extent of storm water discharge from the wet pond to the infiltration basin can be determined. As indicated by the nearly identical temperatures at Sites 5P and 5IB, the Sterling Ponds wet detention pond began discharging to the infiltration basin at 21:30 CDT (9:30 PM) on September 21 and continued discharging until 18:00 CDT (6:00 PM) on September 28 (see Figure 34 and discussion of September 24-25 rain event below). As indicated by the nearly identical temperatures at Sites 5P and 5MH, the Sterling Ponds wet detention pond began discharging to the Sumner Creek drainage way at 22:00 CDT (10:00 PM) on September 21 and continued discharging until 3:00 CDT (3:00 AM) on September 22. During this 5-hour period, the wet pond discharge temperature averaged 20.9° C and ranged from 20.4-21.4° C. A slight temperature increase (1.3° C) was apparent downstream at Site 4 in Sumner Creek at 22:00 CDT (10:00 PM) on September 21, and is likely due to the release of warm water (including storm water) from the upstream wetland. Once again, a thermal spike (3.0° C) of local origin was evident near the mouth of Sumner Creek (Site 4A) at 20:30 CDT (8:30 PM) on September 21.

September 24-25

Finally, the comparative Sumner Creek and Sterling Ponds thermographs for the September 24-25 rain event (2.49 inches) are presented in Figure 34. As indicated by the nearly identical temperatures at Sites 5P and 5IB, storm water from the September 21 rain event was still discharging from the Sterling Ponds wet detention pond to the infiltration basin when the large September 24-25 rain event occurred. This situation

created a reduced capacity in the pond for storm water from the September 24-25 rain event. After the September 24-25 rain event, the wet pond continued discharging to the infiltration basin until 18:00 CDT (6:00 PM) on September 28. As indicated by the nearly identical temperatures at Sites 5P and 5MH, the Sterling Ponds wet detention pond began discharging to the Sumner Creek drainage way at 23:30 CDT (11:30 PM) on September 24 and continued discharging until 13:30 CDT (1:30 PM) on September 25. During this 14-hour period, the wet pond discharge temperature averaged 18.0° C and ranged from 17.9-18.2° C. A slight temperature increase (0.7° C) was apparent downstream at Site 4 in Sumner Creek at 23:30 CDT (11:30 PM) on September 24, and is likely due to the release of warm water (including storm water) from the upstream wetland. A thermal spike (2.8° C) of local origin was again evident near the mouth of Sumner Creek (Site 4A) at 23:00 CDT (11:00 PM) on September 24. A rapid temperature increase (1.3° C) at Site 6 likely indicates the onset of water flow at 23:00 CDT (11:00 PM) on September 24. From the thermograph alone, it is very difficult to determine when water flow ceased at this location.

Effectiveness of Sterling Ponds Storm Water Management Practices:

Sumner Creek is a low-gradient tributary of the Kinnickinnic River that exhibits only intermittent flow for the majority of its length. Permanent flow begins in the vicinity of the WI Highway 35 bypass, near the creek confluence with the Kinnickinnic River. From this location, the creek drainage way extends upstream to Radio Road on the far northwest corner of River Falls. This upper portion of the Sumner Creek drainage way, including Sites 4 and 6, conveys no flow for the majority of the year. The headwaters area near Site 6 is a dry run; however, rather extensive wetland areas are apparent in the Sumner Creek drainage way through the Sterling Ponds subdivision, and for an appreciable distance downstream from Site 4. Anecdotal evidence suggests that flow may occur during the spring snowmelt period and perhaps during large summer rain events. During large summer rain events, however, the wetland areas and dry portions of the Sumner Creek channel likely provide considerable water storage, making it very difficult to determine if and when any upstream flow is conveyed all the way downstream to the Kinnickinnic River.

During the May-September (summer) 2005 period, the extent of storm water discharge to the Sterling Ponds infiltration basin could not be fully determined, since temperature monitoring of the basin did not begin until mid-September. With the infiltration basin fully functional throughout the summer, it is likely that storm water from most summer rain events (especially those less than one inch) was fully infiltrated, as required by the River Falls Storm Water Management Ordinance. However, the available temperature data for Site 5P, Site 5MH, and Site 5IB suggest that performance of the Sterling Ponds storm water management practices (wet detention pond and infiltration basin) may have been less than optimal during a few rain events. However these conclusions are based on limited data at this point in time.

During six summer rain events in excess of one inch, the Sterling Ponds wet detention pond discharged warm water (17.9-27.2° C) to the Sumner Creek drainage way, often for

extended periods (5-14 hours). Three of these rain events (June 11, July 25, and September 21) were less than 1.5 inches. The City's storm water ordinance requires that, for a 1.5" 24-hour event, all the additional runoff created by development be infiltrated. Therefore, a 1.5" event with a shorter duration may cause discharge, as could a smaller event with a shorter duration.

During the September 21 rain event (1.49 inches), the wet detention pond began discharging to the creek drainage way shortly (one-half hour) after it began discharging to the infiltration basin. The intensity of this rain event is unknown, due to our malfunctioning rain gauge. Therefore, it is difficult to make any good conclusions from this data. The ability to infiltrate the first 1.5 inches of the September 24-25 rain event (2.49 inches) may have been compromised, as the infiltration basin was still accepting storm water from the September 21 rain event. However, the ordinance does not account for back-to-back rain events.

The relatively small diameter of the pipe (8 inches) leading to the infiltration basin may be limiting the ability of the wet detention pond to deliver the appropriate storm water volume to the infiltration basin before the pond discharges to the creek. Given the very warm storm water in the wet detention pond, it is important to infiltrate as much pond volume as possible, thereby minimizing warm water discharges to the Sumner Creek drainage way. Due to the hydraulics of an inverted pipe, water will continue to trickle into the infiltration basin for an extended time period following a rain event. This limits the available storage volume in the wet pond when the next event occurs, possibly causing a premature discharge to the creek drainage way. It is possible that pipe diameters may need to be adjusted to meet the intent of our ordinance at Sterling Ponds. However, the size of the pipe and rate of storm water delivery to the infiltration basin should also be balanced against the need for adequate water residence time in the wet pond, to achieve target removal efficiencies for total suspended solids (TSS) and total phosphorus (TP). Modeling will be conducted in 2006 to further investigate what we are seeing and determine if any corrective action is necessary in our ordinance and/or study.

While this project is primarily focused on looking at long-term trends, annual information is important as well. The storm water management practices at Sterling Ponds caused no major thermal impacts on Sumner Creek and the Kinnickinnic River during the May-September (summer) 2005 period. The following should be noted:

- The temperature regime in the Kinnickinnic River at Sites 1, 1A, and 2 was generally excellent for coldwater macroinvertebrate and brown trout communities.
- During all major rain events (in excess of one inch), warm storm water (17.9-27.2° C) from the Sterling Ponds wet detention pond was also discharged to the wetland area within the Sumner Creek drainage way. Due to water storage capacity in the wetland, these warm storm water discharges generally caused no downstream thermal impacts. We will continue to analyze how storm water from the Sterling Ponds wet pond is conveyed to the infiltration basin, to determine if it is meeting the intent of our ordinance.

- After the largest rain event of the summer on July 8 (4.00 inches), a “plug” of warm water (including Sterling Ponds storm water) moved downstream from the wetland area, causing minor thermal spikes at Sites 4 and 4A in Sumner Creek and at Site 1 in the Kinnickinnic River. We will watch for these thermal spikes in the years to come and monitor their intensity and frequency.
- Any first flush thermal spikes observed in lower Sumner Creek at Site 4A appear unrelated to the storm water discharges at Sterling Ponds, and seem to have a more local cause that needs further investigation.

We hope to find that the storm water management practices installed at the Sterling Ponds Subdivision are resulting in long-term positive results for the Kinnickinnic River. These same trends will be monitored from year to year and we hope to find similar results in the coming years.

Water Quality Monitoring:

Due to ongoing problems with the automated water quality sampling equipment in 2005, the water quality monitoring component of the North Kinnickinnic River Monitoring Project will be initiated in 2006.

At Site 1, we lost our housing structure for the monitoring equipment in the spring runoff event and had to redesign and rebuild the housing structure. This proved to be challenging because we wanted the shelter out of the flood plain, above flood stage, and downstream of several tributaries in the area, thereby limiting the location for shelter placement.

Site 2 was equipped for water quality monitoring this year instead of Site 3 (used in 2004) due to ease of site access and the fact that the proposed Hans Hagen development has not moved forward as anticipated. So a housing structure also needed to be built and installed at this site. The housing units at Sites 1 and 2 were both installed on April 22, 2005.

We encountered the following difficulties throughout the 2005 sampling season while attempting to conduct water quality monitoring:

1. Trying to locate the monitoring shelters out of the flood plain and above flood stage, yet close enough to water for monitoring, proved impractical. We placed them as high as possible, and had no problems this year, but the potential for flooding of the boxes is there.
2. Setting the sensor (which activates the autosamplers when the river level rises) proved to be one of the most challenging items. We set the sensor approximately ½” above the river level. Getting the autosamplers at Sites 1 and 2 to activate at the same time was our goal; and we were close by the end of 2004. When a runoff event occurs, this would ensure that we are obtaining composite samples during the same time period at each site.

3. To provide more accuracy, we purchased several yardsticks to adjust the sensor heights. The cords of the sensors hold shape easily and therefore do not fully straighten out when placed in the stilling well. The yardsticks provided a stiff, measured surface for mounting the sensor and accurately setting the sensor height within the stilling well.
4. The first few runoff events in 2005 were used to try to synchronize the autosamplers at Sites 1 and 2. However, we started noticing by mid to late May that the sample bottles seemed to be filling much more quickly than the desired 48-hour compositing period.
5. Our first inclination was that condensation inside the stilling well was causing the sensor to trigger prematurely. We considered manually dropping the sensor into water at the start of a runoff event, to ensure that the first flush and composite samples would be obtained as intended. However, this put us back into “storm chasing” mode, thereby negating the purpose for having the automated samplers.
6. During the next several storm events, only one of the two autosamplers activated. Since the runoff events were minor, these would not have been good samples to analyze.
7. At the end of June, we theorized that the runoff hydrographs were not defined enough to trigger the autosamplers as desired. We decided to try lowering the autosampler sensors to just above the water level, which would allow a very minor change in river stage to activate the sampler.
8. By mid-July, we brought an autosampler into the office to try various scenarios, in an effort to determine what the samplers were doing in the field. We realized that when the water touched the sensor the sampler activated as programmed; however if the water did not stay in contact with the sensor, the next time the water touched the sensor the program started over again. This was causing the samplers to activate every several seconds, thereby causing the composite sample to fill quickly. We began working on an alternate activation device that would allow the sensor to stay submerged once it initially activated, but this proved to be a difficult challenge.
9. On August 9, 2005, we contacted the autosampler manufacturer (Global Water) about our problem and were informed that the company could re-program the samplers at no charge under our warranty. Therefore, we sent the autosampler control panels back to the company for re-programming. Re-programming allowed the autosamplers to continue sampling once activated, thus giving us the results we desired.
10. The autosamplers were returned on September 14, 2005, and we re-installed them.
11. During several rain events at the end of September, the autosamplers appeared to be working as intended, so we feel we should be ready to obtain samples for laboratory analysis in 2006.
12. The autosampler at Site 5 (Sterling Ponds) encountered no problems activating as desired. However, this autosampler was also returned for reprogramming, in the event it may be deployed for future Kinnickinnic River monitoring.

Base Flow Survey:

The USGS gauge located at County Highway F, as described earlier in this report, was used to determine when a river base flow condition existed. When 3-4 days of “flat-line” flow was observed at this station, the river was assumed to be at a base flow condition. During dry periods between runoff events, the Kinnickinnic River maintained a base flow condition of approximately 80-90 cfs at County Highway F. Real-time and recent (31-day) stage, flow, and precipitation data for this monitoring station are web-accessible at:

http://waterdata.usgs.gov/wi/nwis/uv?dd_cd=02&format=gif&period=7&site_no=05342000

In the autumn of 2005, instantaneous measurements of base flow were obtained for the first time at Sites 1-3 in the Kinnickinnic River and at the mouth of Sumner Creek (Site 4A) within the North Kinnickinnic River Monitoring Project Area. This base flow survey was conducted during the October 28-November 8 period, using a SonTek® FlowTracker handheld acoustic doppler velocimeter (ADV). The survey results are presented in Figure 35. Base flows were very similar at Sites 2 and 3, but a 30% increase in base flow was evident at Site 1, with Sumner Creek contributing only a small proportion of this increase. An additional 24% increase in base flow occurred between Site 1 and County Highway F, including contributions from the South Fork of the Kinnickinnic River (unmeasured), Mann Valley Creek (unmeasured), and Rocky Branch Creek (4.0 cfs).

One goal of the River Falls Storm Water Management Ordinance is to maintain strong base flow conditions in the Kinnickinnic River by requiring storm water management practices that promote infiltration of rainfall, thereby maintaining shallow aquifer levels, as well as the springs that provide cold water for the river. The initial base flow survey in 2005 will provide a baseline for determining if the present base flow condition will be sustained in the future as development progresses in the North Kinnickinnic River Monitoring Project Area.

Macroinvertebrate Monitoring:

Biotic indicators such as macroinvertebrates are often used to complement physical and chemical measurements in stream monitoring programs. Biological data add a significant dimension to monitoring procedures because they provide an analysis that measures long-term phenomena. Because many aquatic organisms live in the stream environment for a year or more, they reflect past as well as present water quality conditions.

The use of benthic macroinvertebrates (subsurface insects and crustaceans) was initiated in Wisconsin with the work of W. L. Hilsenhoff at the University of Wisconsin-Madison, and has been modified and refined (Hilsenhoff 1982, 1987). The Hilsenhoff Biotic Index (HBI) is particularly useful for determining the influence of organic pollution on macroinvertebrates. This index has been used for many years by the Wisconsin Department of Natural Resources in long-term stream monitoring efforts.

Macroinvertebrate HBI determinations follow a sequence of field collection, laboratory sorting, identification, and index calculation. Each HBI organism has been assigned a specific tolerance value at the genus or species level. These values range from 1

(extremely intolerant of organic pollution) to 10 (extremely tolerant of organic pollution). Because the HBI calculation is based on multiplying the count of a given taxon by its specific tolerance value, the more intolerant taxa that are present, the lower the biotic index, indicating better water quality, as follows:

HBI Value	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	No apparent organic pollution
3.51-4.50	Very Good	Slight organic pollution
4.51-5.50	Good	Some organic pollution
5.51-6.50	Fair	Fairly significant organic pollution
6.51-7.50	Fairly Poor	Significant organic pollution
7.51-8.50	Poor	Very significant organic pollution
8.51-10.00	Very Poor	Severe organic pollution

HBI values provide the observer with quantitative data that can be used for comparing water quality at various river sites. Additionally, the work yields supplementary metrics useful for further analysis. These include: taxa richness, numerical dominance, and proportions of sensitive groups (Ephemeroptera, Plecoptera, Trichoptera, i.e., EPT index).

The following HBI values represent North Kinnickinnic Monitoring Project samples (three replicates each) collected at Sites 1-3 in 2004 and 2005. All sampling was conducted in late May of the respective years.

Sampling Site	Sampling Location	2004 HBI Values	2005 HBI Values
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Site 1: North Main	50 yds upstream from North Main Street Bridge, River Falls, WI	2.77	3.17
		2.86	3.04
	Lat. 44°52'32.1", Long. 92°37'15.6"	2.99	2.79
	Mean of 3 reps:	2.87	3.00
Site 2: Swinging Gate (STH 65)	Approx. 1.1 mile upstream from North Main Street Bridge, River Falls, WI	4.20	4.30
		3.99	4.67
	Lat. 44°53'12.9", Long. 92°36'40.9"	3.85	4.45
	Mean of 3 reps:	4.01	4.47
Site 3: Hebert (Hebert-Hagen)	Approx. 0.4 mile downstream from Quarry Rd.	3.37	3.65
		4.04	3.55
	Lat. 44°53'22.2", Long. 92°36'19.5"	3.60	3.13
	Mean of 3 reps:	3.67	3.44

These 2004 and 2005 data were generated to establish a macroinvertebrate-based water quality baseline at the start of this monitoring project. In 2004 and 2005, mean HBI values at Site 1 were indicative of excellent water quality, mean HBI values at Site 2 were indicative of very good water quality, and mean HBI values at Site 3 were indicative of very good-excellent water quality. Annual HBI values and site comparisons will continue to be posted as they become available.

Appendix A

Reasons why small rain events (less than one inch) were not analyzed in 2005

While smaller runoff events can cause significant storm water impacts on the river, it seems unlikely that storm water runoff from the Sterling Ponds subdivision caused any impacts on the Kinnickinnic River during these smaller rainfall events (less than 1 inch) in 2005, due to several factors:

1. Building progress remained somewhat limited in the Sterling Ponds subdivision in 2005, and was generally confined to the southeast quadrant of the subdivision. Only 3 single-family housing units were built by year-end 2003, 19 single-family housing units were built by year-end 2004, and 33 single-family housing units were built by year-end 2005. In the northeast quadrant, 2 duplex units were complete by year-end 2005, and 2 multi-family (8-plex) units were under construction. A build-out total of 600 units is projected for Sterling Ponds. Maps of Sterling Ponds build-out progress in 2003, 2004, and 2005 are available on the project website (“What We Monitored”). With only 33 of approximately 150 single family units (20%) complete in the southeast quadrant by year-end 2005, impervious surfaces (rooftops, sidewalks, driveways, and streets) still accounted for only a relatively small proportion (??%) of the overall subdivision area.
2. Four wet storm water detention ponds were already in place, with some capacity for storing storm water runoff from the existing impervious areas, especially during smaller rain events. Three of the four infiltration basins paired with the wet storm water detention ponds were not yet functional in 2005. However, the fourth infiltration basin serving the southeast quadrant of Sterling Ponds was functional throughout the April-September 2005 period (see 2005 build-out map). These infiltration basins were designed and constructed to meet the current River Falls Storm Water Management Ordinance infiltration requirements. The Sterling Ponds infiltration basins remained off-line throughout 2004, so that percolation testing could be conducted and native vegetation had an opportunity to become established. The southeast wet detention pond and infiltration basin should have provided effective storm water treatment for the southeast quadrant of Sterling Ponds in 2005, as required by the ordinance.
3. The Sterling Ponds subdivision is approximately 1.5 miles from the Kinnickinnic River, with a connection via Sumner Creek. Sumner Creek is a low-gradient tributary that typically exhibits only intermittent flow during larger rain events. Downstream wetland areas that are part of the Sumner Creek drainage way and the Sumner Creek channel itself likely provided some storage of any Sterling Ponds storm water discharges, especially during larger rain events that may have exceeded the capacity of the wet detention ponds and the functional infiltration basin.

Monitoring in 2005 and beyond will evaluate ordinance effectiveness and determine any storm water impacts related to rainfall events in excess of 1.5 inch. This will be especially important as the Sterling Ponds subdivision continues to develop and

impervious area increases.