Stream Temperatures in the Green River and Hemlock Brook, 2003

The overall health of a river depends upon the types of land uses and conditions within its watershed, especially those in close proximity to the river itself. Although in the past there were numerous industrial uses of the Hoosic River and its tributaries, and thus specific point sources of pollution, of primary concern today are non-point sources. Of special concern for stream temperature are the types of vegetation, or lack thereof, within the riparian zone along the banks and the degree of development, roads and housing, within proximity to the streams. The primary objective of our monitoring was to determine whether the temperature criteria for the designated uses of the rivers were being met, and to examine conditions within the watersheds that might be affecting the stream temperatures.

Background

Both the Green River and Hemlock Brook are tributaries to the Hoosic River. The Green River is a Class B, cold water fishery (Massachusetts Surface Water Quality Standards, 2001). Hemlock Brook is Class B, high quality water. Class B waters are suitable for primary recreational activities such as swimming, wading, and fishing. Massachusetts has established specific levels/thresholds that are used to judge whether the water quality is good enough for the classified uses (Massachusetts Surface Water Quality Standards, 2001). Massachusetts defines a Cold Water Fishery as one in which the maximum mean monthly temperature of its waters generally does not exceed 68°F (20°C) and, when other ecological factors (such as habitat) are favorable, are capable of supporting a year-round population of cold water stenothermal aquatic life such as trout (*salmonidae*).

The rates of many biological and chemical processes depend on temperature. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Optimal temperatures for fish depend on the species: some survive best in colder water, whereas others prefer warmer water. Benthic macroinvertebrates (e.g., stone fly, may fly, and caddis fly larvae) are also sensitive to temperature and will move in the stream to find their optimal temperature. If temperatures are outside the optimal range for a prolonged period of time, organisms are stressed and can die.

For fish, there are two kinds of limiting temperatures, the maximum temperature for short exposures and average temperatures that vary according to the time of year and the life cycle stage of the fish species. Reproductive stages (spawning and embryo development) are the most sensitive stages. Temperature affects the oxygen content of the water (oxygen levels become lower as temperature increases); the rate of photosynthesis by aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites, and diseases.

Causes of temperature change include weather, modification of shading vegetation in the riparian zone, impoundments (a body of water confined by a barrier, such as a dam), discharge of water used for industrial cooling, urban storm water, and groundwater inflows to the stream. Changes are not always from cool to warm.

Methods

We monitored temperature using in-stream temperature sensors (Optic Stowaway temperature loggers) that recorded the water temperature hourly. The loggers were placed in sections of metal pipes attached to heavy metal plates. The units were positioned in the streams within the primary current such that the

flow was through the pipe and the units were reasonably inconspicuous. The temperature sensors were placed in the streams on June 24 and left in place until September 17.

There were five monitoring locations on Hemlock Brook and nine on the Green River. The locations are referenced to the distance (in kilometers) along the rivers from their confluence with the Hoosic River or (for the West Branch of the Green River) from its confluence with the Green River. For example, HM06.21 is on Hemlock Brook approximately 6.21 kilometers upstream from the confluence with the Hoosic River. The fourteen locations, all in Williamstown, are as follows.

Hemlock Brook (see Fig. 1):

1. HM06.21 – upstream of the diversion of a portion of the brook into the Margaret Lindley Park (MLP) pond.
2. HM06.09 – downstream of the outflow from the MLP pond and just upstream of the Route 2 culvert.
3. HM04.37 – downstream of the Route 7/ Route 2 bridge at Sheep Hill adjacent to the driveway to the office of the Williamstown Rural Lands Foundation.
4. HM02.36 – upstream of the bridge on Main St. near Westlawn Cemetery
5. HM00.06 – just upstream of the confluence with the Hoosic River, south of the Hoosic Wastewater Treatment Plant.

Green River (see Fig. 2 and Fig. 3):

6. GW00.39 – off Bloedel Park upstream of Green River Farm on the West Branch of the Green River.
7. GN10.62 – off Southlawn Cemetery upstream of Green River Farm on the main Green River.
8. GN10.01 – just downstream of several Green River Farm fields and downstream of the confluence of the West Branch and main Green River segments.
9. GN08.28 – upstream of the second Route 43 bridge north of Five Corners at Sucker Hole.
10. GN06.15 – just upstream of the Hopper Rd. bridge at Mt. Hope Park
11. GN05.23 – just upstream of the Blair Rd. bridge.
12. GN04.32 – off parking area on Green River Rd. opposite Fairfield Farm fields and upstream of the developed area of Water St./Route 43
13. GN01.15 – off Eastlawn Cemetery upstream of the Route 2 bridge.
14. GN00.03 – just upstream of the confluence with the Hoosic River.

The data were downloaded from the sensors into an Optic Shuttle once during the sampling period, on July 28, and the sensors immediately reinstalled in the streams. The sensors were downloaded a second time at the end of the sampling period. The sensor at location GN06.15 did not start correctly when initially placed in June and thus no data were collected for that location until July. Also, the sensor at GN00.03 was found by a member of the public in August and returned to us, so no data were collected for the latter part of August or in September. Finally, the sensor at HM06.09 was not found in September, and is still missing, so that the data from that location are missing for the second half of the monitoring period.

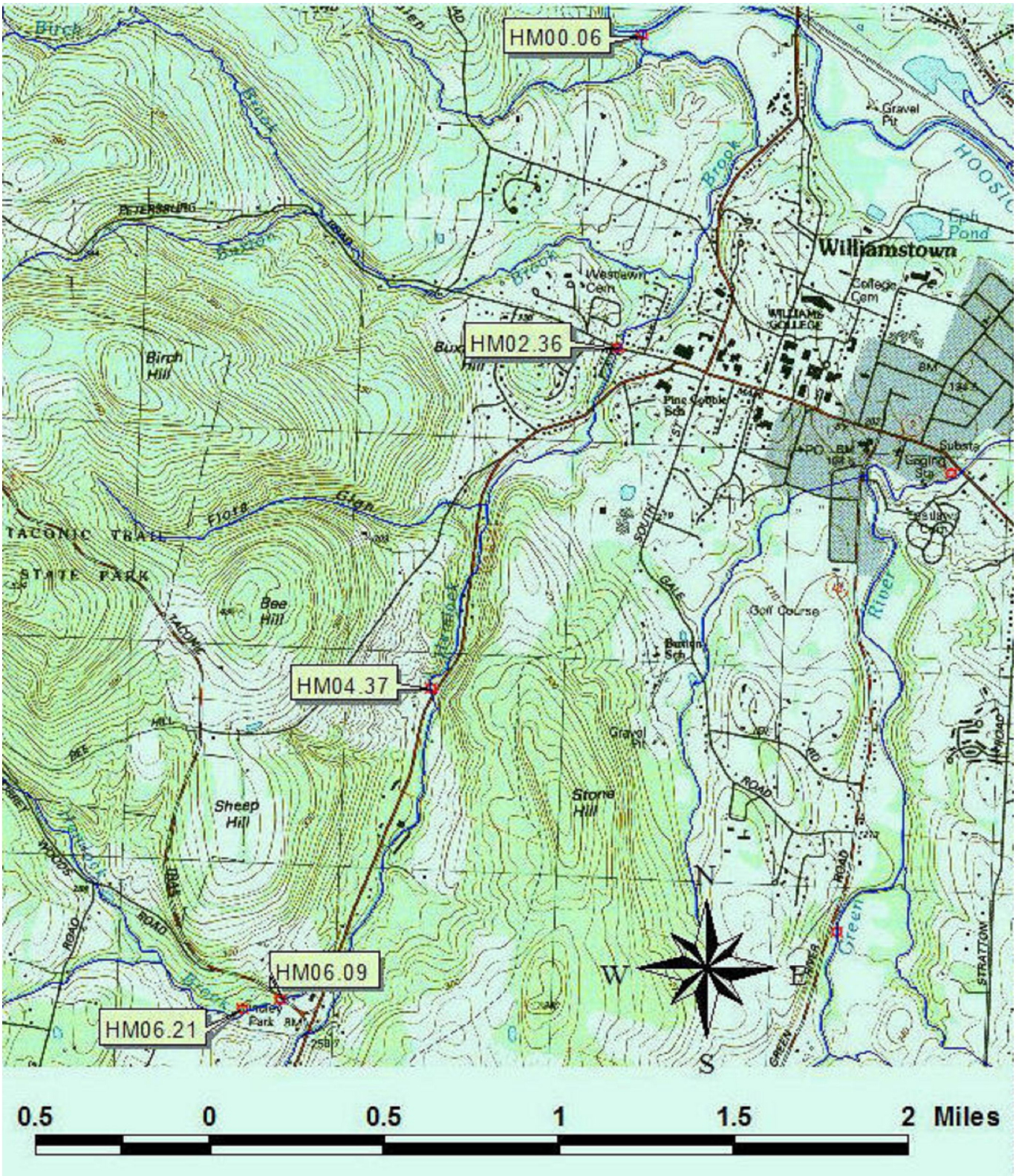

Figure 1. Temperature monitoring sites on Hemlock Brook.

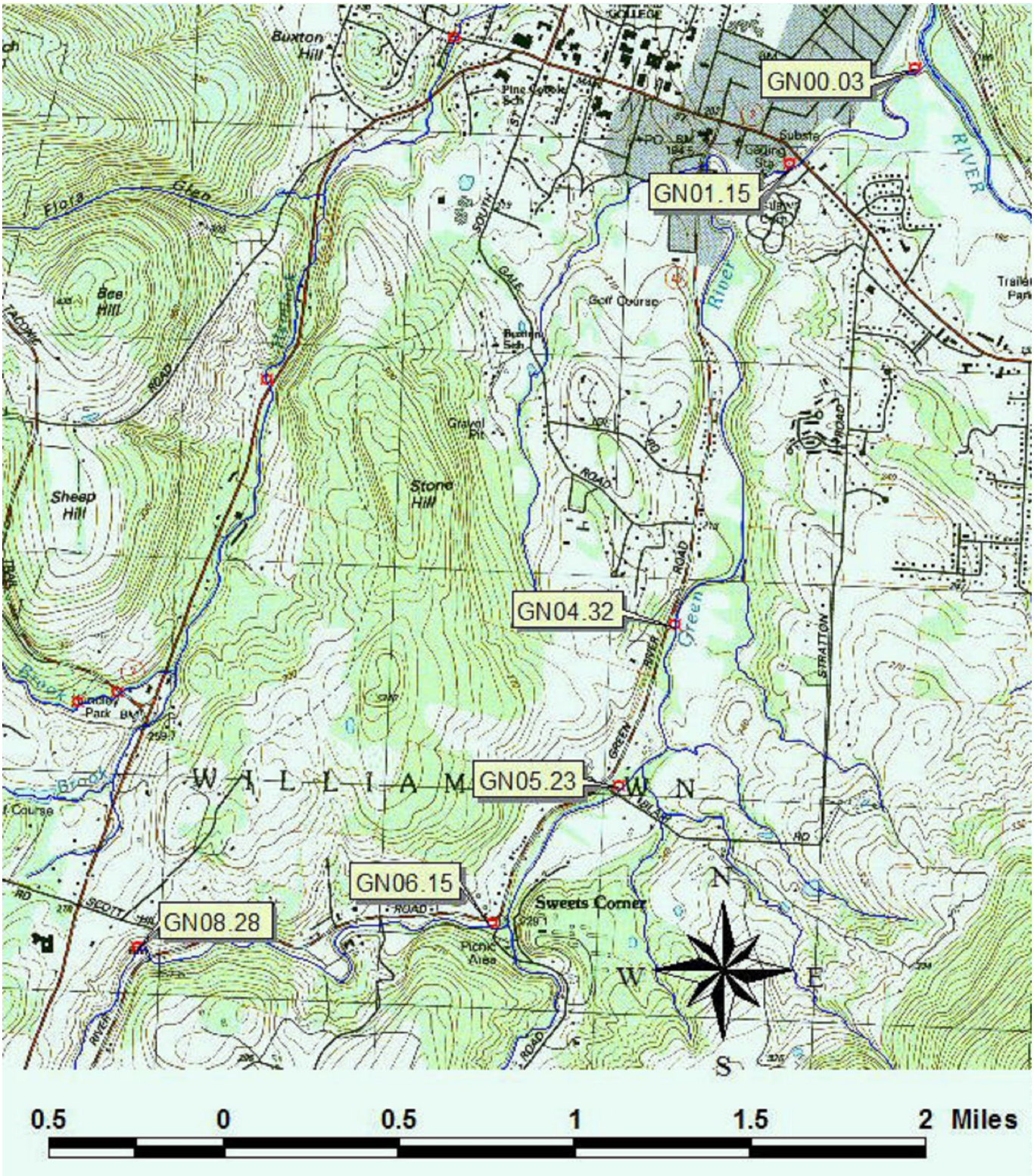

Figure 2. Green River temperature monitoring locations.

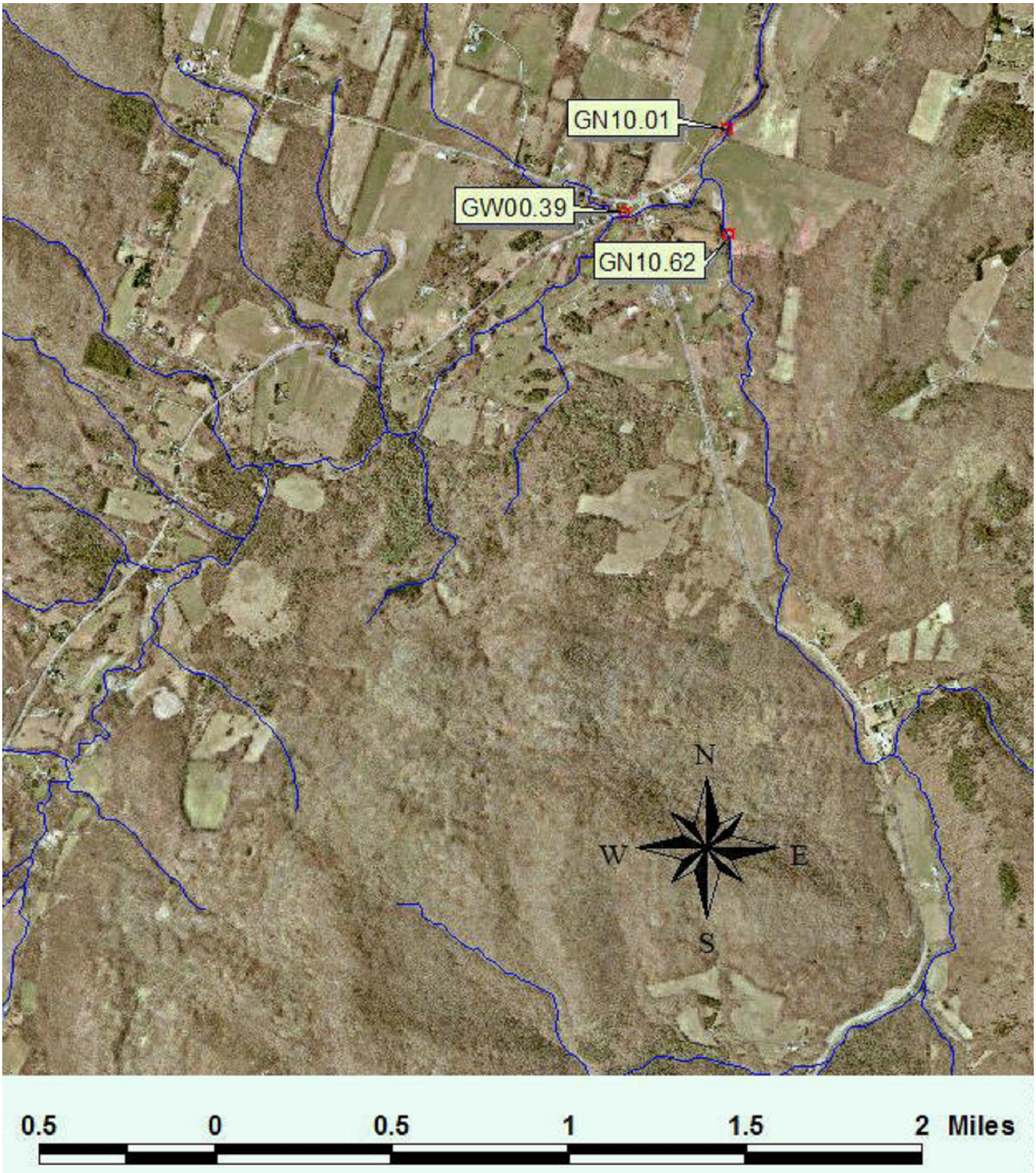

Figure 3. Green River upstream monitoring locations and land use patterns

Results and Discussion

The primary criterion for a cold water fishery is stated as waters in which the maximum mean monthly temperature generally does not exceed 68^{O}F (degrees Fahrenheit). Rather than consider only calendar months, which do not have a biological basis, we calculated 30-day running averages for the temperature data at each location. For example, the average temperature for the first 30-days, from June 24 through July 23, is centered on July 8, for the 30-day period from June 25 through July 24, the average is centered on July 9, etc.

The 30-day averages for Hemlock Brook (Fig. 4) show an overall warming of the brook of over 4 degrees F in July, decreasing to about 2.6 degrees in September, from the most upstream point at MLP to the confluence with the Hoosic River. Based on the limited data available from HM06.21, just over 50% of the warming occurred within the first 120 meters, between HM06.21 and HM06.09, presumably because a portion of the water was diverted through the pond at the park and gained heat during its residence time there. At no time, however, was the 30-day average above the 68 degree threshold. Indeed, at the warmest location just upstream of the confluence with the Hoosic River, it was never above 66 degrees.

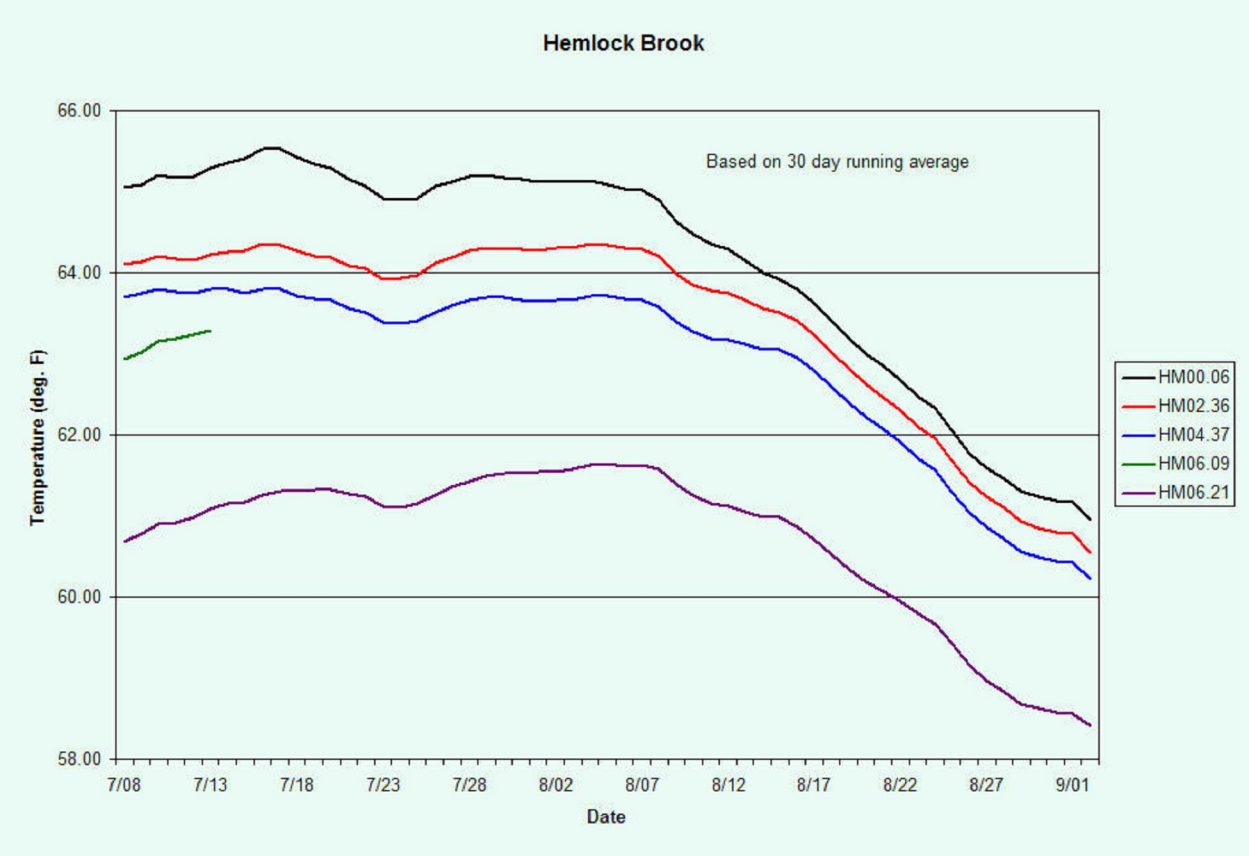

Figure 4. Thirty day average temperatures for Hemlock Brook.

Another concern for trout is the length of time the stream temperature is at or above 79 degrees, a potentially lethal temperature. That temperature was not reached at any of the sites on Hemlock Brook

(table 1.). The maximum temperature at the warmest location just upstream of the confluence with the Hoosic River was only 76.2 degrees.

Table 1. Summary statistics for Hemlock Brook

		Locations				
Item	units	HM00.06	HM02.36	HM04.37	HM06.09	HM06.21
# hours monitored	Hrs	2039	2039	2039	814	2039
Avg. temp. early[1]	^{O}F	65.29	64.28	63.86	63.21	60.99
Avg. temp. late	^{O}F	62.57	62.07	61.59	NA	59.70
# Hours ≥68	Hrs.	295	212	85	35	0
# Hours ≥79	Hrs.	0	0	0	0	0
Max. Temp.[2]	^{O}F	76.15	75.26	72.19	71.63	67.14
Total Days	Days	86	86	86	35	86
# Days ≥68	Days	3	1	0	0	0

1./ The early average is from 6/24 through 8/2 and the late average is from 8/3 through 9/17.
2./The maximum temperatures occurred in the mid afternoon of July 6.

In 2002, we had one temperature sensor in Hemlock Brook, at HM06.15, adjacent to MLP and upstream of the return flow from the pond (Schlesinger, 2003). Thus, it would be comparable to location HM06.09 in 2003. The 2002 data showed 109 hours during which the temperature exceeded 68 degrees, compared with none in 2003, and one day that the average daily temperature exceeded 68 degrees. In general, the stream flow was less in 2002 than in 2003, according to the records from the USGS gauge “near Williamstown”, which may have contributed to the higher temperatures within the stream.

The larger Green River was about 2 degrees warmer near its confluence with the Hoosic in July (Fig. 5) than was Hemlock Brook at its confluence, and about 1 degree warmer in September. The difference between the farthest upstream location on the main Green River (GN10.62) and the downstream sites (GN00.03 and GN01.15) was almost 5 degrees in July (from 62 degrees to 67 degrees), declining to just over 2 degrees in September (from 60 degrees to 62 degrees).

Of particular interest was the difference of about 2 degrees in June between the Bloedel Park site (GW00.39) on the West Branch and the Southlawn Cemetery site (GN10.62) on the main Green River just upstream of where the two join together (Table 2). This difference decreased to just under 1 degree by September, the West Branch always being the warmer of the two. These two branches are similar in size, with subwatersheds of 14.77 and 15.10 square miles, respectively. One difference between the two appears to be the land uses within the individual watersheds, especially within the immediate riparian corridors, which would affect the exposure of the streams to direct sunlight (Fig. 3).

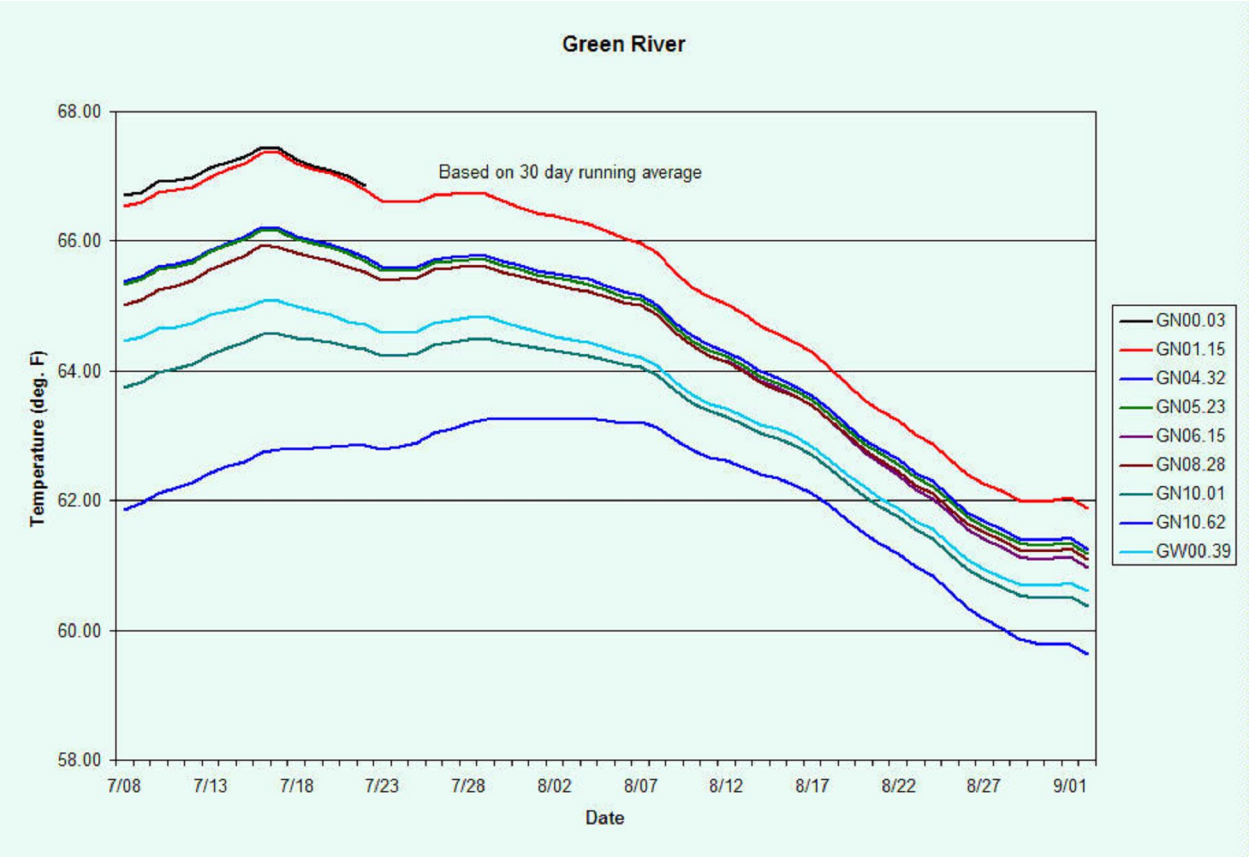

Figure 5. Thirty day average temperatures for the Green River

Table 2. Summary statistics for five of the nine Green River sites[1]

		Locations				
Item	units	GN01.15	GN05.23	GN10.01	GN10.62	GW00.39
# hours monitored	Hrs	2037	2037	2037	2037	2037
Avg. temp. early	^{O}F	66.91	65.73	64.19	62.43	64.77
Avg. temp. late	^{O}F	62.84	62.15	61.37	60.73	61.55
# Hours ≥68	Hrs.	443	311	144	26	186
# Hours ≥79	Hrs.	0	0	0	0	0
Max. Temp.[2]	^{O}F	77.86	75.71	73.99	70.66	74.01
Total Days	Days	86	86	86	86	86
# Days ≥68	Days	14	7	1	0	1

1./ The data from these five of the nine locations were thought to provide a reasonably complete representation of the temperature conditions throughout the study area.
2./The maximum temperatures occurred in the mid afternoon of July 6.

We assessed the conditions within the two river corridors that might affect the stream temperatures using the MassGIS land use data layer and a GIS (Geographic Information System) program. For each stream we investigated the land uses within a 25 foot riparian corridor running 3.1 miles upstream of sites GN10.62 and GW00.39. Within the West Branch riparian corridor, 38% of the land uses would

result in direct sunlight exposure to the river (18% open land, 11% golf course, 7% pasture, 1% cropland, and 1% residential). The remaining land uses would provide some protection of the river from direct sunlight, (60% forested and 2% wetlands). In contrast, the riparian area land uses along the main Green River showed about 10% exposed areas (9.5% cropland and 0.5% pasture and open land) and greater protected areas (90% forested). Therefore, a likely explanation for the difference in temperature between the West Branch and the main Green River is the greater degree of exposure to direct sunlight (solar radiation) on the West Branch.

Temperature monitoring in 2002 included four locations in common with 2003, at GN01.15, GN06.15, GN10.62, and GW00.39. The 2002 data showed stream temperatures within the limits for a cold water fishery at GN10.62 and GW00.39 but not always so at GN06.15 and GN01.15 (Schlesinger, 2003). At GN01.15, 47% of the time the temperature was above 68 degrees in 2002, compared with 22% in 2003. Also, the percentage of days with an average temperature above 68 was 43% in 2002 but only 16% in 2003. Furthermore, there were 27 hours in 2002 during which the stream temperature exceeded the potentially lethal temperature of 79 degrees, none in 2003. And finally, the 30-day average exceeded the 68 degree threshold for much of the measurement period in 2002, but not at all in 2003.

The stream flow conditions were quite different in 2003, which had above average precipitation, compared with 2002, which had below average precipitation. Although the stream gauge records for the Green River gauge are not yet available for 2003, the long term mean monthly stream flows for July, August, and September are 32.5 cubic feet per second (cfs), 28.3 cfs, and 28.8 cfs, respectively. In 2002, the stream flows for those three months were 23.7 cfs, 10.1 cfs, and 16.1 cfs, much less than the means. We expect that the stream flows for 2003 were at or above the long term means since the precipitation was close to the long term normal for July and well above the long term normal for August and September.

Conclusions

Hemlock Brook was well within the temperature regime desired for a cold water fishery. The one area of concern is the pond at Margaret Lindley Park, which raises the temperature of the brook by about 2 degrees. There is a possibility that this effect might be greater during a year of lesser stream flow. As noted above, the stream temperatures in 2002 were higher than in 2003 upstream of the outflow from the pond. It might be useful to determine how much of the flow from Hemlock Brook is being diverted through the pond and to what extent the amount varies with the overall stream flow conditions.

In 2003, the Green River fully met the cold water fishery criteria. Of potential concern are the land uses within the immediate riparian corridor, especially along the West Branch. The open lands within this corridor allows exposure of the river to direct solar radiation and heating therefrom. There is an obvious opportunity to improve the cold water fishery by encouraging land uses that provide shading of the river. Although the heating during this wetter-than-normal year was likely not detrimental, during drier years the situation may be exacerbated by water withdrawals for irrigation at the golf course and the Green River Farm.

Acknowledgements

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Report prepared February 9, 2004.