A Study of the State of Pollution of the Streams of the Cannon Valley Watershed, Summer 1972

by John Colman and Kathleen Kopach

Publication No. 3
Cannon Valley Development Association

INTRODUCTION

During the 1971-72 session, the Minnesota State Legislature, through the efforts of State Senator George Conzemius, an ardent conservationist and member of the Cannon Valley Development Association, appropriated funds to be used in part, for a study of the state of the Cannon and Straight Rivers. It was hoped that this study would be the starting point in a campaign to stem the pollution of the rivers and eventually to develop their recreational potentials. With these aims in mind, a program was undertaken in the summer of 1972 to determine the present state of health of the rivers, using certain biological and chemical indicators. In addition to compiling a general overview of the state of the rivers, an attempt was made to pinpoint demonstrably significant sources of pollution with an eye toward their elimination.

Under the direction of Dr. Paul Jensen of Carleton College, a program was initiated which entailed obtaining samples from the Straight River between Owatonna and Faribault, and from the Cannon River between Waterville and Red Wing. Samples were collected by car and, for less accessible sites, by canoe. Analyses of the samples were done in the laboratories of Carleton College using methods outlined by the American Public Health Association in Standard Methods for the Examination of Water and Waste Water, 13th edition.

Six environmental measurements were taken in this study: nitrate, phosphate, dissolved oxygen, silt content, biochemical oxygen demand, and coliform density. Together with measures of flow rates, these were chosen for their unique ability to reveal the residential, agricultural, and organic-industrial pollution wherever encountered within the Cannon-Straight watershed. The presence of pollution, indicated by dirty water, sewage smell, algal blooms, and lack of game fish, can be confirmed by the above tests in a reproducible, quantitative manner. Thus, the testing done in this project can provide future water examiners, performing similar tests, with a basis for comparison.

Chemical State of the Watershed

Of all the elements necessary for algal growth, phosphorus and nitrogen are usually the only ones of low enough concentration in natural waters and of high enough need to the organism to limit growth. While non-chemical factors such as light intensity and water temperature influence blooms, the proper chemical nutrients must be available or growth will not begin. With this in mind, nitrate and phosphate measurements were made at all sampling sites (see Appendix A for references).

All chemical results in this report are expressed in parts per million (ppm). One ppm is the same as one thousandth of a gram per kilogram or one milligram per liter (since one liter of water weighs a kilogram). The tests we used measure only phosphate-phosphorus and nitrate-nitrogen[1].

Nitrate results

In most parts of the Cannon and Straight Rivers, nitrate-nitrogen readings were far in excess of .3 ppm, indicating widespread nitrogen pollution sufficient to sustain excessive algal growth.[2] Furthermore, with the exception of a few springs in the Rice County Wilderness Park, those streams originating in lakes, and Belle Creek (below Welch), all incoming water sources had nitrate concentrations one to five times higher than those found in the lower portions of the Cannon. Generally those samples taken from lakes, reservoirs and from their appended rivers had less nitrate than other parts of the watershed system.

To find the source of at least part of this nitrate, we compared the nitrate output from tile lines coming from beneath an unfertilized hay field with lines coming from beneath a corn field. We took two sets of measurement subsequent to the heavy rains of midsummer, but well into a dry period and with the results as follows:

Date	Site	Nitrate-nitrogen (ppm)
Aug. 9	corn	3.46
	hay	.46
Aug. 11	corn	3.0
	hay	.06

These limited data suggest that much, but certainly not all, of the nitrate in the river originates from agricultural land, in part via the tile line system. Indeed, those portions of the river most surrounded by agricultural land had the highest nitrate readings. We may cite the high nitrate readings of the Straight River in heavily agricultural Steele County as compared with the far lower concentrations of the Cannon River (below Cannon Falls), where few tile lines enter directly and where the self cleaning of the river has had time (and space) to occur.

The lowest readings were encountered in those portions of the upper Cannon which receive their waters from lakes. These had heavy algal loads but very little nitrate (because already incorporated in the algae).*

Obviously nitrogen is also contributed to the river by sewage plants, surface runoff and canneries, in complex organic forms. The oxidation of the latter must certainly contribute substantially to the nitrate-nitrogen of the stream. It is likely, however, that a large part of the nitrate - nitrogen of the river is attributable to the techniques of modern agriculture. Mr. Warren Liebenstein, Rice County Farm Agent, has informed us (conver-

*For precise location and etc. see Appendices.

sation) that the average acre of corn in Rice County requires 150 lbs of nitrogen per year. Grains such as oats also require nitrogen at the rate of 30 to 40 lbs/acre/year. Much of this will eventually be leached or washed to the rivers.

Phosphate results

Phosphate-phosphorus levels, as nitrate-nitrogen levels, were high. While many regions of the stream had high enough concentrations to maintain heavy algal growth, both tile lines and most creeks were almost lacking in phosphate. A considerable amount of phosphate enters from sewage plants, from runoff from the Faribault Canning Company irrigation fields north of Faribault, from seepage from the cannery ponds north of Owatonna (see maps). If these sources were going into lakes rather than streams, the output would be in violation of the Minnesota Pollution Control Agency effluent standards for phosphate (2 ppm maximum). The algal bloom in the river is in part attributable to output from lakes and in part to these phosphate sources. Phosphate from agriculture enters the river mainly via sheet erosion and minimally from ordinary runoff. We have no measures of the former. Tile lines showed little or no phosphate, no matter what the source. This agrees with the observations of many students of soil chemistry that phosphate is largely immobile in soil. Thus the annual application of 40-50 pounds per acre for a corn field tends to stay put except where heavy rains produce sheet erosion.

We observed that streams passing through pasture land during high runoff periods contained high phosphate. In addition to the sheet erosion source, the contributions from cow manure either from the pastures or from cows in the stream must be significant. We noted many pastures not fenced from the stream. Moreover, phosphate held in the soil at the surface is all the more available to surface runoff during heavy rains.

Thus, pastures in close proximity to streams are a sizable phosphate source.

Coliforms

Intestinal wastes from warm-blooded animals regularly include a wide variety of species of bacteria. Among these species may be listed the coliform group. A more precise definition of this group can be found in any textbook of bacteriology.

For many years the coliform group of bacteria has been used to indicate the pollution of water with sewage and wastes. The sanitary quality of the sample under examination can be directly correlated to the coliform group densities obtained from it by standard bacteriologic culture techniques. The results of such tests have been used as the basis of bacteriologic quality of water supplies. However, results of routine tests of water supplies cannot alone determine the quality of a water supply. This data must be reviewed in the light of the sanitary conditions of the source of any sample. Taken together, these two factors can provide a precise evaluation of water quality. In what follows, all of the data comes from use of the membrane filter method of analysis. For details see the American Public Health Association's Standard Methods.*

According to State standards of water quality, the Cannon and Straight Rivers are clasified as suitable for Fisheries and Recreation (2B) and Industrial Consumption (3B). Since higher standards are applied for Class 2B waters, these are the standards to which the Cannon and Straight must conform. The maximum permissible value for total coliform organisms in these rivers has been set at 1000 organisms in 100 ml. Any value higher than this represents a violation of the State standards and

*Results are expressed in terms of the number of bacteria present in 100 ml of sample. One milliliter (ml) is about 10-20 drops from an eye dropper.

is evidence of unacceptable pollution.

Results of Coliform Tests

The most striking, and disappointing, conclusion that derived from our data on coliform densities is that for every river sample the coliform count exceeded the State maximum permissible level of 1000 organisms in 100 ml of sample. Lower counts were obtained where the river emerges from lakes. As the river flows through developed areas, whether agricultural or industrial, it picks up pollutants from which it never has a chance to recover. However, the Cannon River does demonstrate a drop in coliform density (doubtless due to self cleaning and little input) as it approaches its confluence with the Mississippi River. In the section of the Straight River covered in our study, the level of coliform pollutants is maintained along its entire length by input from feeder streams. The major sources of coliform pollution, as evidenced by our data, are agricultural runoff and surprisingly industrial effluents.

During the entire 10-week testing period, variations in the flow rates of the rivers produced notable variations in the coliform densities obtained from samples. Generally, samples taken when the river was high or just after a period of rain contained higher coliform densities than samples collected at the same sites during low water or a dry spell. This observation is most consistent with the theory that runoff from surrounding pastured areas contributes significantly to the coliform population of a river. The concentration of bacteria in the runoff is apparently sufficiently high to override the concurrent dilution effects.

The tendency for high coliform counts to occur after a rain is particularly strong at sampling sites near feedlots or areas where farm animals have access to the river. Sites #43, #50, and #72 are thus situated and data is available for each site at both high and low flow periods. The data for coliform densities at high water exhibit a four- to eight-fold increase over the coliform counts taken during low water. It appears that runoff from the banks of the river contains a significant amount of manure.

A puzzling second major source of coliform pollution can be found in industrial effluents. Samples taken from pipes at Sites #28, #29, #81, and #12 were found to contain coliform concentrations ranging from 8 to 118 times the maximum permissible value. In addition, rivulets of unknown origin in the vicinity of some industries, such as those found at sites #39, #40, #85, and #108 contained coliform densities of the same magnitude as the pipe effluents. Together, these two sources account for a significant, but avoidable, portion of non-agricultural river pollution.

Effluents from sewage treatment plants in Faribault and Northfield demonstrated an almost complete absence of coliforms. This would indicate that on the testing dates the plants were handling their tasks adequately, doubtless in part by chlorination of the effluent.

Biochemical Oxygen Demand

Dissolved oxygen is utilized by some bacteria, by organic materials, and by certain chemicals. The rate at which the dissolved oxygen is depleted is a measure of the quantity of these pollutants present in the water. The biochemical oxygen demand (BOD) test is the procedure by which the relative oxygen requirements are determined.

Samples are collected in special BOD bottles which can be tightly closed to prevent any leakage of air into them. A measurement is taken to determine the initial dissolved oxygen content of the sample, and the bottle is then incubated for five days. After the incubation period, a second determination of dissolved oxygen is made on the sample. The difference between the initial and final oxygen readings is defined as the biochemical oxygen demand.

State standards have been set for the BOD contributed by effluent pipes discharging sewage or industrial wastes into streams and rivers. The maximum permissible value for the five-day BOD test is 25 ppm for pipes that discharge into Class 2B rivers such as the Cannon and the Straight.

Our data for BOD tests show that, in the vast majority of cases, BOD values for effluent samples were well within the acceptable range. Samples of effluent taken from the outlet pipes of sewage treatment plants demonstrated values among the highest in our study. However, even the highest value for treatment plant effluent--that which was taken at the Northfield plant--was 11 ppm lower than the State maximum.

The greatest BOD value obtained in our study was from effluent of the Minnesota Malting Company of Cannon Falls. While the test value of 20.16 ppm is still below the maximum 25 ppm, it is still sufficiently close to represent a potentially hazardous source. It is possible that at periods of heavier discharge and low water, the BOD could actually exceed the limit. To substantiate this possibility, it would be necessary to monitor the Malting Company effluents at different flow rates over an extended period.

Dissolved Oxygen

Dissolved oxygen was measured primarily to see if oxygen levels were low enough to endanger fish species. These measurements were taken with a galvanic cell oxygen probe. Seldom were readings low enough to cause fish kills; however, they often were not high enough to support trout and other game fish. Several of the cold (the colder the water, the more oxygen it can hold) clear branch streams were consistently high in dissolved oxygen. Examples such as Wolf, Pine and Trout Creeks and Spring Brook are all said to harbor trout. Some water containing a heavy algae load gave seemingly anomalous readings of high DO. However, algae do, in fact, give off oxygen in the presence of light and deplete oxygen only on cloudy days or after an algal kill when much oxygen is used in decomposition. Another condition resulting in oxygen loss is high BOD water, water with a high organic content oxygen is used up by the decomposing organic matter. Only on occasion would a heavy demand on the stream oxygen occur. A combination of low water, high temperature (August), and the dumping of an effluent of high organic content could produce anoxic conditions. Only on rare occasions at a few sites could there occur serious oxygen depletion—cannery pond release, sewage plant bypass, malting company effluent, etc.

Silt

Silt was considered an important factor in determining a pollution index because of its detrimental effect on most life in the river. While some rough fish such as carp can survive heavy silt levels, most game fish, and the rock-dwelling animals on which they feed, are severely hampered by thick silt layers on the bottom.

The methodology of the silt test is simple. An Imhoff cone, a tapered glass container calibrated in milliliters, is dipped full of water from the surface at a sampling site and allowed to stand until the silt has settled to the bottom. Then the silt concentration of the sample can be directly read in ml/liter of river water.

Silt readings for this study were obtained over a scattered area under varying weather conditions. Silt in the river varied directly according to flow; that is, on high water days silt levels were over 0.5 ml/liter and on low water days were well below 0.05 ml/liter. Streams entering the Cannon and Straight generally carried more silt than the rivers themselves. On July 10, a high water day, silt measurements were taken for Crane Creek, a ditched agricultural stream, and for

Rush Creek along which non-fenced cow herds wander. Crane Creek demonstrated a 0.4 ml/liter silt level and Rush Creek 1.5 ml/liter (that is, the Rush Creek water was 1.5% silt!). The section of the Straight River between the two creeks had a 0.2 ml/liter level. Any disturbance of the soil along the river (by cows) makes it easy for swift waters to carry soil away. However, PCA standards concerning the proximity of animals to streams apply only to feedlots lacking internal natural vegetation.

Silting was heavier in the Upper Cannon than in the lower regions by a factor of between 2-5. This disparity probably reflects the difference in soil composition in the two areas--silt upstream, sand and sandstone downstream. Sand is more easily eroded than silt, but does not stay in suspension as long. The quick-settling sandy soils of the lower Cannon are protected from the muddy waters above by the Byllesby Reservoir. Here, even some clay particles, which take up to one year to sink one foot in still water, can and do settle out.

General

Since our study spanned an 11-week period, we were able to witness the river in some of its different aspects. We saw the raging, roiling waters brought on by the July rains, as well as the serenity and calm of the August dry season. Our sampling trips took us through the cornfields spilling over the banks between Faribault and Northfield, and through the shadows of the juniper bluffs below Cannon Falls. While the river system is quite pleasant along its entire length, there are some places that definitely rank above average in our minds.

One such stretch in on the Cannon from Cannon Falls to Red Wing. Here the juniper bluffs create green canyons through which the river wends its way. Cold, clear sidestreams periodically mix their waters with the river. Below Welch the water is actually clear enough to see the sandy river bottom. But the clear water also reveals a startling number of old rubber tires and beer cans, cast off by uncaring hands.

For canoeing, the Straight River between Owatonna and Faribault is the most exciting. The river bends and twists, unexpectedly revealing rushing rapids. After a rainy spell, the river must be negotiated with care, as we found out the hard way. But, for the canoeist who likes a bit of excitement, the Straight is worth a try.

Scott's Mill, at the entrance to the Wilderness Park south of Northfield, is a good place to stop for lunch on a day's trip between Faribault and Northfield. From atop Scott's bluff, one can see carp lazily swimming in the river 30 feet below. If the canoe doesn't get hung up on the old wooden dam, it's interesting to turn up some big rocks to observe the busy life underneath. All in all, the Faribault-Northfield portion of the river is a pleasant, delightful trip with countryside varying from the forest of the Wilderness Park to a more bucolic farmland.

A Look to the Future

The Cannon watershed contains an abused treausre, its river system. Can it be brought back to anything like its original state from its present polluted condition? Minnesota Pollution Control Agency standards and Minnesota law provide tools for the citizen and citizen groups to act to prevent input of heavy metals, poisons and other chemicals destructive of the amenities and living organisms of the stream. Since there is relatively little such pollution in the system, simple observation and reporting to the MPCA should eventually control these sources. Again, the pollution of the stream from canneries and similar sources can be kept in check if the vigilant citizen reports violations quickly and accurately to the MPCA.

The major problem of the stream is derived from feedlots and from farming practice. The former is a highly concentrated source of contamination which should be kept by law as far from the stream bank and runoff areas as possible. Pollution from modern technological agriculture seems at present exceedingly difficult to control. The high mobility of nitrate in soil and the high fertilizer use of the farmer seem certain to result in high nitrate levels of the streams unless some massive technological change in agricultural practice occurs. The farmer can help by keeping his cattle back from the margins of streams, while the feedlot operator could reduce the effect of his practices by disseminating manure on fields or by burning or other procedure.

We have measured neither the output from street runoff in cities, nor that from individual gardens, septic tanks or homesites. These can be significant. Here the individual citizen can make a great contribution by making certain that he is not a source of pollution. For more precise data on your section of the river see the maps and appendices of this paper.

To sum up, the rivers are lovely; there are pollution problems; some improvements can be made; but some pollution problems very difficult of solution are present.

ACKNOWLEDGEMENTS

Dr. Paul Jensen

Mr. Clark Webster

Mr. Rudie Baack

Mr. Merton Hoover

Mr. Irwin KenKnight

Mr. William Gill

Mr. Hoel Schilling

Mr. Al Johnson

Mr. Warren Liebenstein

Mr. Gary Wagenbach

FOOTNOTES

1. Phosphate-phosphorous or nitrate-nitrogen per liter refers to the amount of elemental phosphorous or nitrogen per liter as is found in their oxydated forms.

2. Barry Commoner, Threats to the Integrity of the Nitrogen Cycle. December, 1968, p. 13.

REFERENCES

1. Hynes, H.B. - The Ecology of Running Water

2. Ruttner, F. - Fundamentals of Limnology

3. American Public Health Association - Standard Methods