LIVESTOCK WASTES AND AGRICULTURAL DRAINAGE
- EFFECTS ON WATER QUALITY
- A CASE STUDY IN THE PITTOCK WATERSHED IN SOUTHWESTERN ONTARIO

(Circa 1984)

Authors: Mr. S. Thornley
Regional Biologist and Associate Surface Water Evaluator
Water Resources Assessment
Ontario Ministry of the Environment
985 Adelaide Street South
London, Ontario N6E 1V3
(519)681-3600

Mr. A. W. Bos, P. Eng.
Co-ordinator, Diffuse Source Control Program
Upper Thames River Conservation Authority
P.O. Box 6278, Stn. 'D'
London, Ontario
N5W 5S1
(519)451-2800

ABSTRACT

An evaluation of the impacts of livestock management practices on water quality was carried out in a Southwestern Ontario watershed in response to continual downstream beach closures and fish kills. The 90 mi^2 area of investigation contains over 300 livestock farms. Elevated levels of bacteria. and nutrients were found to be orders of magnitude higher than Provincial Guidelines and Objectives at most sampling points. In fact, effluent from under-drainage systems in headland areas showed bacterial and chemical characteristics comparable in quality to domestic sewage.

From a survey of 98 of the basin farmers, it is deduced that ignorance of the problem and economic pressures on livestock farmers together are the major contributing factors.

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PROBLEM BACKGROUND

Impacts from agricultural activity are recognized as the number one cause of degraded water quality in the Southwestern Region of the Ontario Ministry of the Environment.

Problems throughout the 10 county area of Southwestern Ontario (Figure 1) vary with the type of agriculture and the, sensitivity of the watershed.

"Agriculture was responsible for 42% of the fish kills reported in the Southwestern Region between 1977 and 1982 (168 kills in total). Manure handling and storage practices accounted for most of these kills." [1]

Fish kills, spills of manure and related impacts such as periodic closure of swimming areas are reasons why the study of livestock manure management was conducted in the head-waters of the south branch of the Thames River. The 90 square mile watershed contains over 300 livestock farms and is located immediately upstream from the Gordon Pittock Reservoir, a man-made water conservation area. Beach postings warning against swimming because of elevated numbers of fecal bacteria have occurred in each of the last three years. Runoff of manure from the watershed was thought to be a major contributing factor to the high bacterial numbers. Agricultural development in this area, as elsewhere, has increased the potential for pollution. In a shift to more specialized operations, from mixed farming pasture area has decreased by 43% in Ontario while cattle for export or slaughter has increased 90% between 1951 and 1976. [2] Implicit is a trend to confined livestock

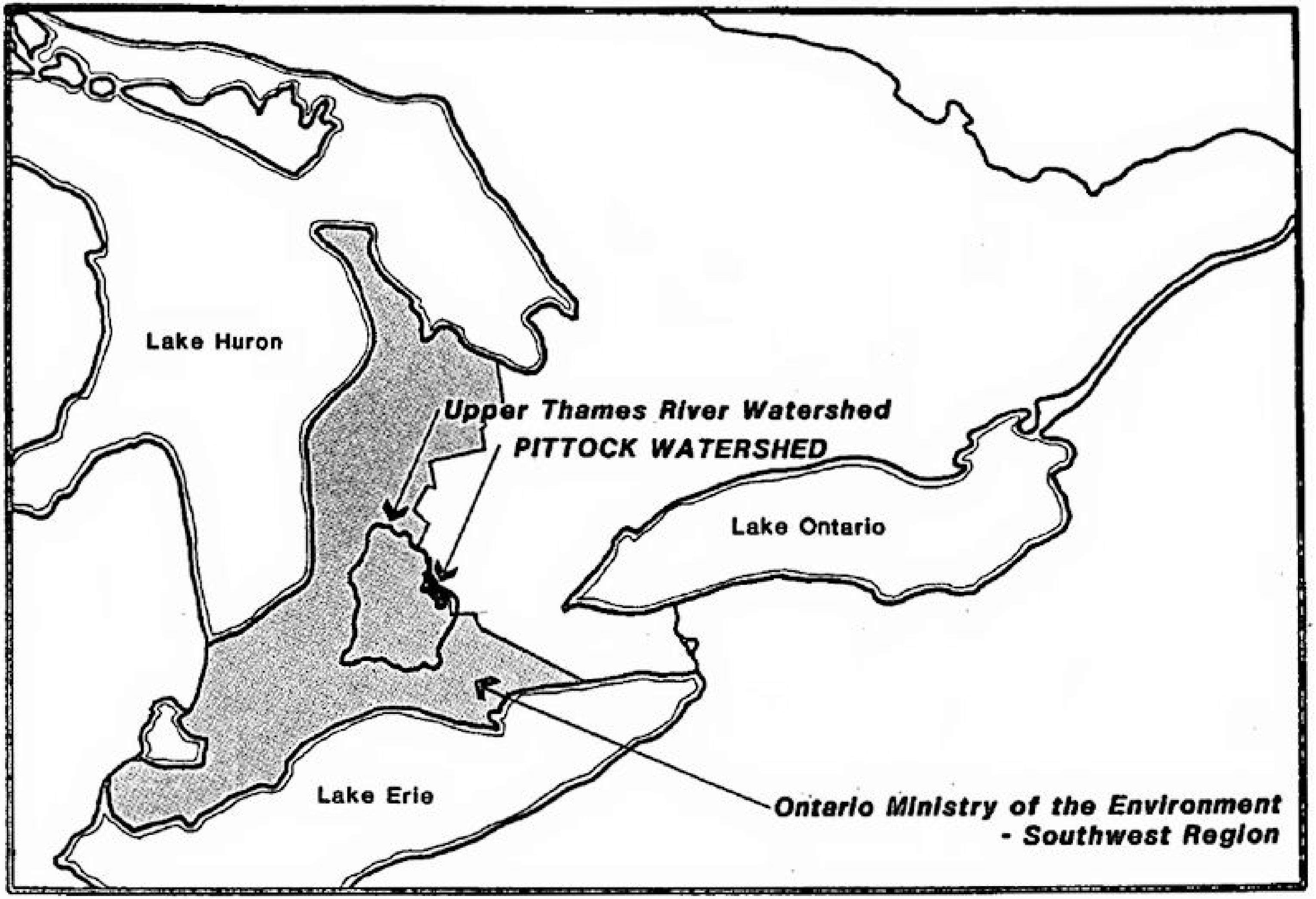

Figure 1: Southern Ontario

operations with higher animal populations as verified in Table 1.

TABLE 1: Temporal Increase in farm size in terms of animal population. [2]

YEAR	% FARMS WITH MORE THAN 122 ANIMALS	
	CATTLE	SWINE
1951	Less Than 1% Combined	
1976	8%	22%
1981	10%	33%

The study involved both water testing and a survey of farmers in the study area. This article deals primarily with the results of the water testing program and includes some highlights of, the survey. [3]

A total of 53 stations were established. Initially, 15 stations were sampled weekly to describe the general water quality of the study area (Figure 2). The 15 stations were located to measure the integrated impact of all waste sources and any other influences on water quality. Anticipated waste sources included manure piles, barnyards, cattle access points, manure spread fields, and drainage systems. Field reconnaissance involving the cooperation of farmers was used to identify waste sources to be monitored. Eventually, approximately 38 additional sampling sites were established to more specifically monitor individual waste sources (Figure 2). Weekly monitoring of the original 15 river stations was continued during the entire study period from April 11 to November 22, 1983. Weekly sampling of the 38 additional stations began in late June and also continued into November. Analyses performed on all water samples are listed in Table 2.

To compliment the information on water quality, water quantity (i.e. volume of flowing water) was measured at the 15 river stations. Flows were measured on 5 occasions under varying flow conditions using a Marsh-McBirney flow meter. This permits the correlation of flows at the river stations with the Federal Flow Gauge located near Innerkip, which measures flows in the south branch of the Thames River continuously (Figure 2).

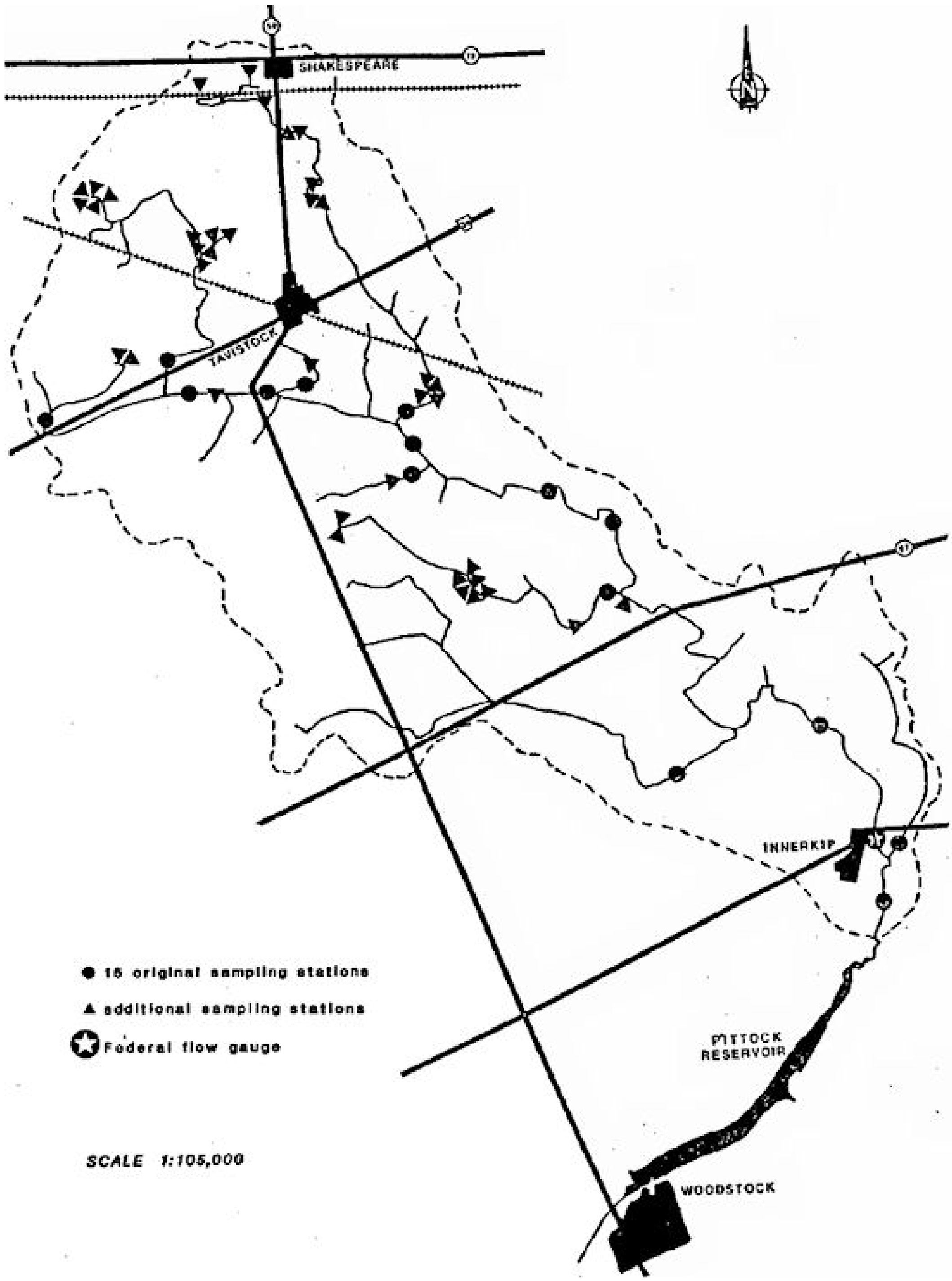

Figure 2. **15 original and 38 additional sampling stations**

TABLE 2: Lists of chemical and bacterial tests performed on water samples

ANALYSES	
CHEMICAL	BACTERIAL
- FREE AMMONIA	- TOTAL COLIFORMS
- TKN	- BACKGROUND
- NITRATE	- FECAL COLIFORMS
- NITRITE	- FECAL STREPTOCOCCI
- TOTAL PHOSPHORUS	- PSEUDOMONAS AERUGINOSA
- SOLUBLE PHOSPHORUS	- SALMONELLA
- pH	- STREPTOCOCCUS BOVIS
- CHLORIDE	
- TOTAL SOLIDS	
- SUSPENDED SOLIDS	
- DISSOLVED SOLIDS	
- TURBIDITY	
- DOC	

OBSERVATIONS

Figures 3 and 4 display the results of the 15 original river sampling locations along with the results of monitored waste sources, for total phosphorus and fecal coliform bacteria, respectively. Also, on these figures are the respective Ministry of the Environment water quality Guideline and Objective for the protection of excessive plant growth in streams and for swimming, bathing and other recreational activities requiring immersion of the user. It an be seen that average concentrations from sample results are all in excess of the Guideline and Objective set as indications of acceptable water quality.

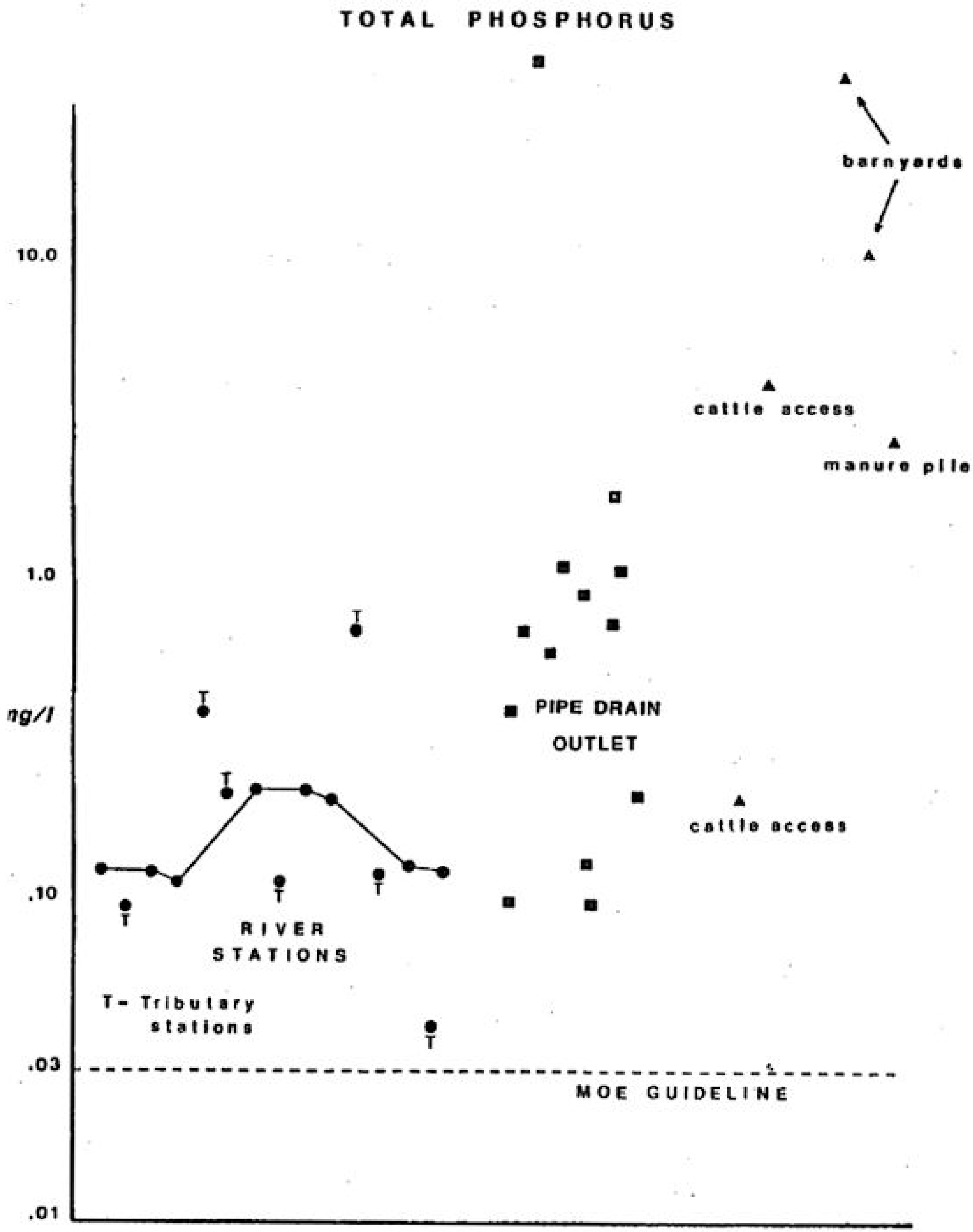

Figure 3. Concentrations of total phosphorus (mg/L) measured at river stations ●, drain outlets ■, and other waste sources ▲.

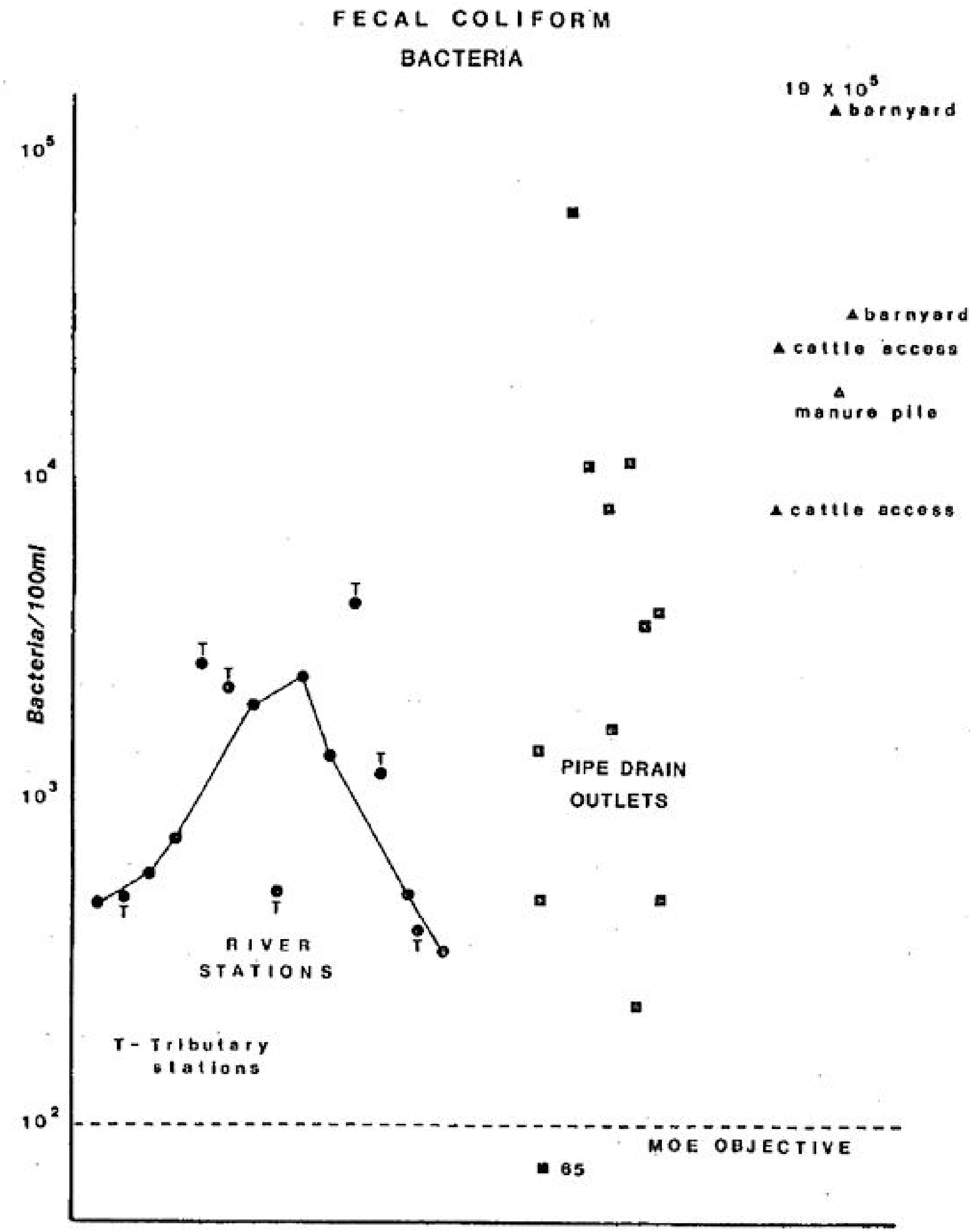

Figure 4. Numbers of fecal coliform bacteria (per 100 mL) measured at river stations ●, drain outlets ■, and other waste sources ▲.

The 15 river stations (main river plus tributaries) are ordered from left to right to correspond approximately to distance from the headwaters. It is important to note that even in the headwaters (stations closest to the left) the quality is unacceptable. Point sources are of poorer quality than the 15 river stations. Average concentrations from point sources ranged to two to three orders of magnitude higher than M.O.E. guidelines and objectives, while river stations were about one order higher.

It is not surprising that samples of point sources were of poorer quality than the river samples. What is surprising, however, is that 12 of the point sources are pipe drain outlets. These drains are generally considered to be transporting only field drainage waters. The implication is that drainage systems are receiving animal and/or human wastes in addition to (presumably cleaner) field drainage.

Figure 5 compares the average concentration of total phosphorus in waters from the Pittock drains with averages of other sources of phosphorus, to put the findings into a different perspective. In this figure, it can be clearly seen that the average Pittock drain quality is strikingly poor. In fact, it approaches the quality of untreated domestic sewage.

The implication that wastes are entering pipe drains is strengthened by the comparison, in Figure 5, with water quality from "non-livestock drains." These data come from a study in the Ausable River watershed where it was possible to say with some confidence that only field drainage was being collected by the drains. The average quality from these drains met the phosphorus guideline to protect against nuisance growths of aquatic plants. Figure 5 also presents a comparison between water quality in southern streams versus northern streams. The watersheds of the southern streams are generally more intensively farmed and drained. These are thought to be major reasons why the water quality is worse.

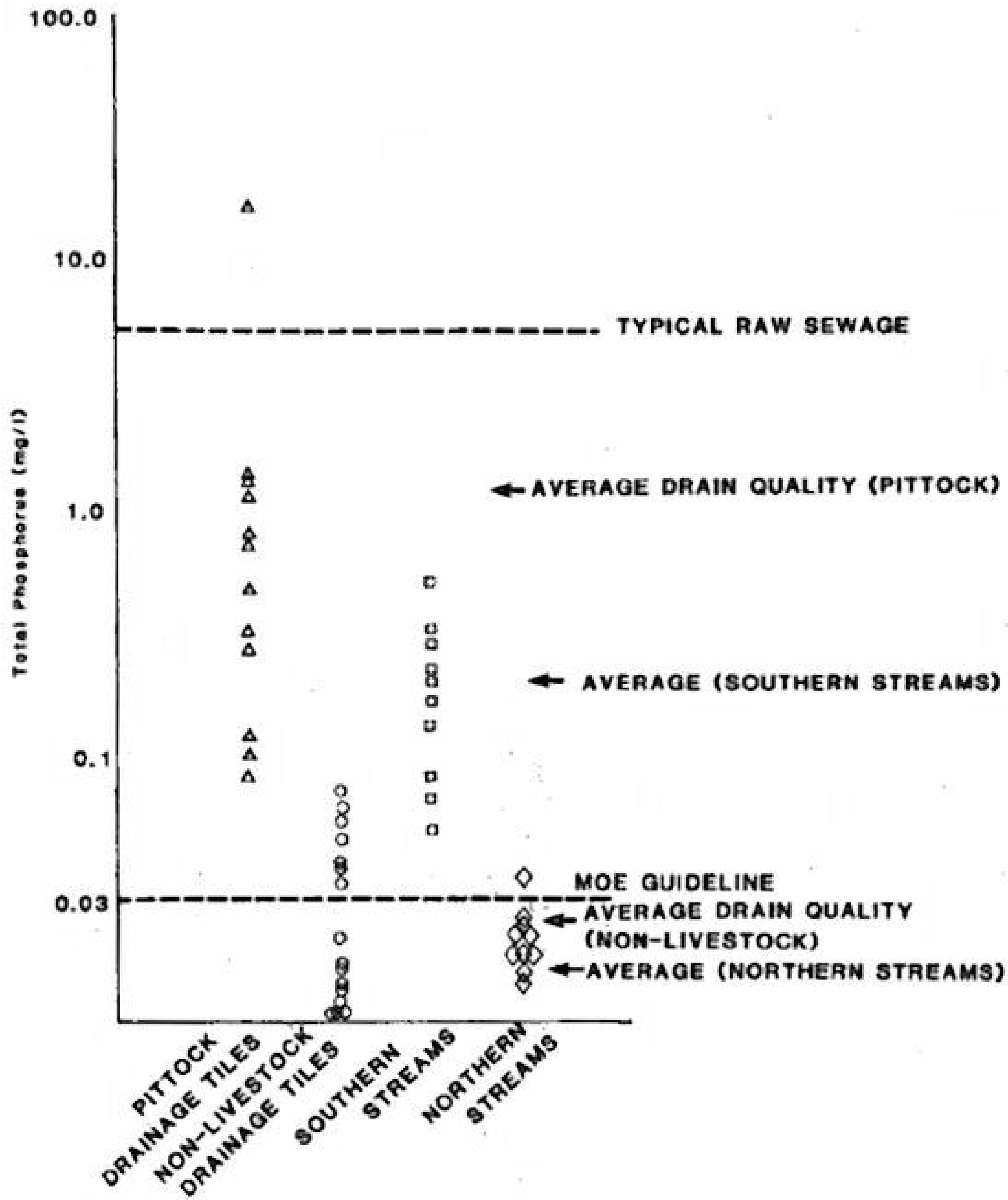

Figure 5. Average Total Phosphorus Concentrations (mg/L) from various sources.

The bacterial scenario is quite similar. Figure 4 demonstrated the higher numbers of fecal coliform bacteria in waste sources compared to the river water quality. Figure 6 compares numbers of fecal coliform bacteria in drainage water to other sources. The average quality of some pipe or tile drains approaches that of raw sewage. Generally, the quality is comparable to non-disinfected. Again, the northern streams are of better quality than the southern streams. Table 3 compares the characteristics of raw sewage with the quality of drains tested in the study area. Table 3 contains results from 29 additional drains sampled twice during wet weather to help assess the representivity of the 12 regular pipe drain sampling sites.

This sampling reaffirmed the poor water quality of municipal drainage outlets. Although the averages of chemical parameters were lower in comparison to the original 12 drains, it is difficult to make comparisons since this is based on only 2 samples. The original drains were sampled 20 times. Bacteriologically, there was little change in the average numbers of bacteria.

It is the particularly poor bacterial quality of drainage water that is perhaps of greater concern than the poor chemistry in the study area. The study area was selected in part because of the known bacterial problems in the Gordon Pittock Reservoir forcing the posting of the beach in each of the last three years.

Figures 3, 4, 5 and 6 have shown the very high numbers of indicator bacteria in waste sources (including drain outlets) and in the study area in general.

In addition to regular sampling for indicator bacteria, special sampling was conducted to look for *Salmonella* spp., a group of pathogenic bacteria. Nine locations were sampled once using a modified Moore swab.

TABLE 3: Pipe Drain Effluent Quality Compared to Raw Sewage

	Raw Sewage	12 Drains [B]	29 Drains [C]
Total Coliform Bacteria per 100 mL	10^6	81,148	37,244
Fecal Coliform Bacteria per 100 mL	10^{4-5}	9,387	8,785
Fecal Streptotoccal Bacteria per 100 mL	10^4	2,480	17,039
BOD_5 mg/L	50-250	21.0	3.3
Total Phosphorus mg/L	2-10	1.9	0.4
Soluble Phosphorus mg/L	0.2-4.0	1.4	0.2
Ammonia mg/L	5-35	0.8	0.4
Nitrate mg/L	0	5.7	5.5

[B] Geometric means (for bacteria) and averages (for chemistry) of 20 samples.

[C] Geometric means (for bacteria) and averages (for chemistry) of 2 samples.

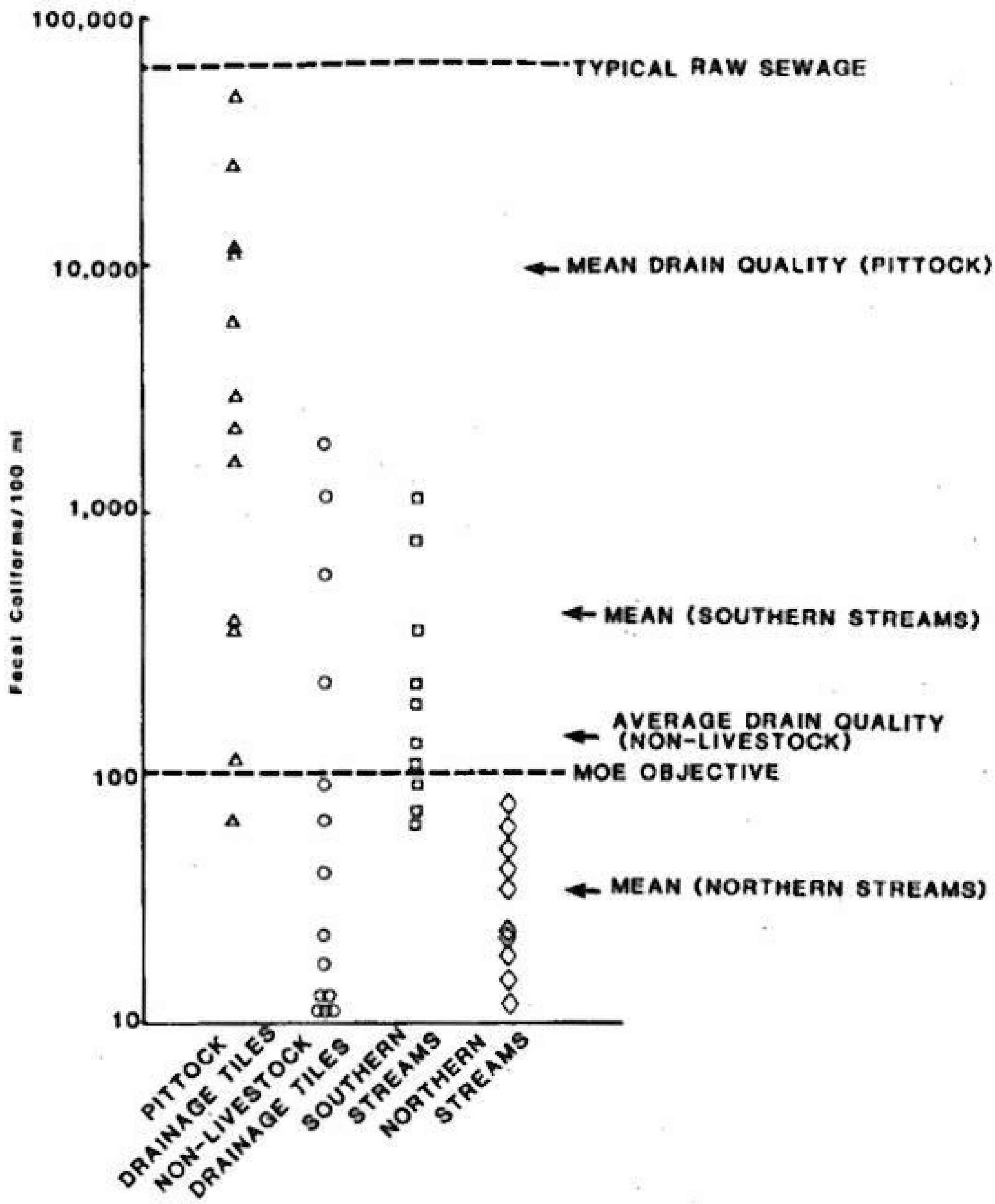

Figure 6. Geometric Mean Numbers of Fecal Coliform Bacteria from various sources of water

Results from tests for *Salmonella* are presented in Figure 7. *Salmonella* bacteria were found at all sites with a total of 9 different *Salmonella* serotypes documented.

<u>1984</u>

Sampling is continuing in 1984 in a 7 square mile sub-watershed of the original study area. An exhaustive search of this area has uncovered 115 pipe drain outlets. These drains are being sampled according to size. Nine outlets are larger than 14 inches in diameter, 65 between 5 and 12 inches and 41 either 3 or 4 inches in diameter. All illegal connections are being sought out through farmer interviews and through other means such as dye testing. Fields are being categorized by crop cover, soil type, manure spreading practices etc. to assess these variables as influences on tile drainage water quality. Hopefully factors influencing the poor quality of drainage water will become more clearly understood.

THE FARMERS' OPINIONS [3]

Concurrent with the sampling program, a survey was conducted to determine the farmers' philosophies and practices. The response numbered 98 representing about one third of the watershed livestock operations.

Noteworthy results were:

- 65% of the respondents feel manure is not a major pollutant source
- 65% would like more information pertaining to water pollution control and nutrient retention vs. farming practices
- 86% believe their management practices are adequate for controlling pollution from their farms
- 30% would like to upgrade but feel constrained by economics

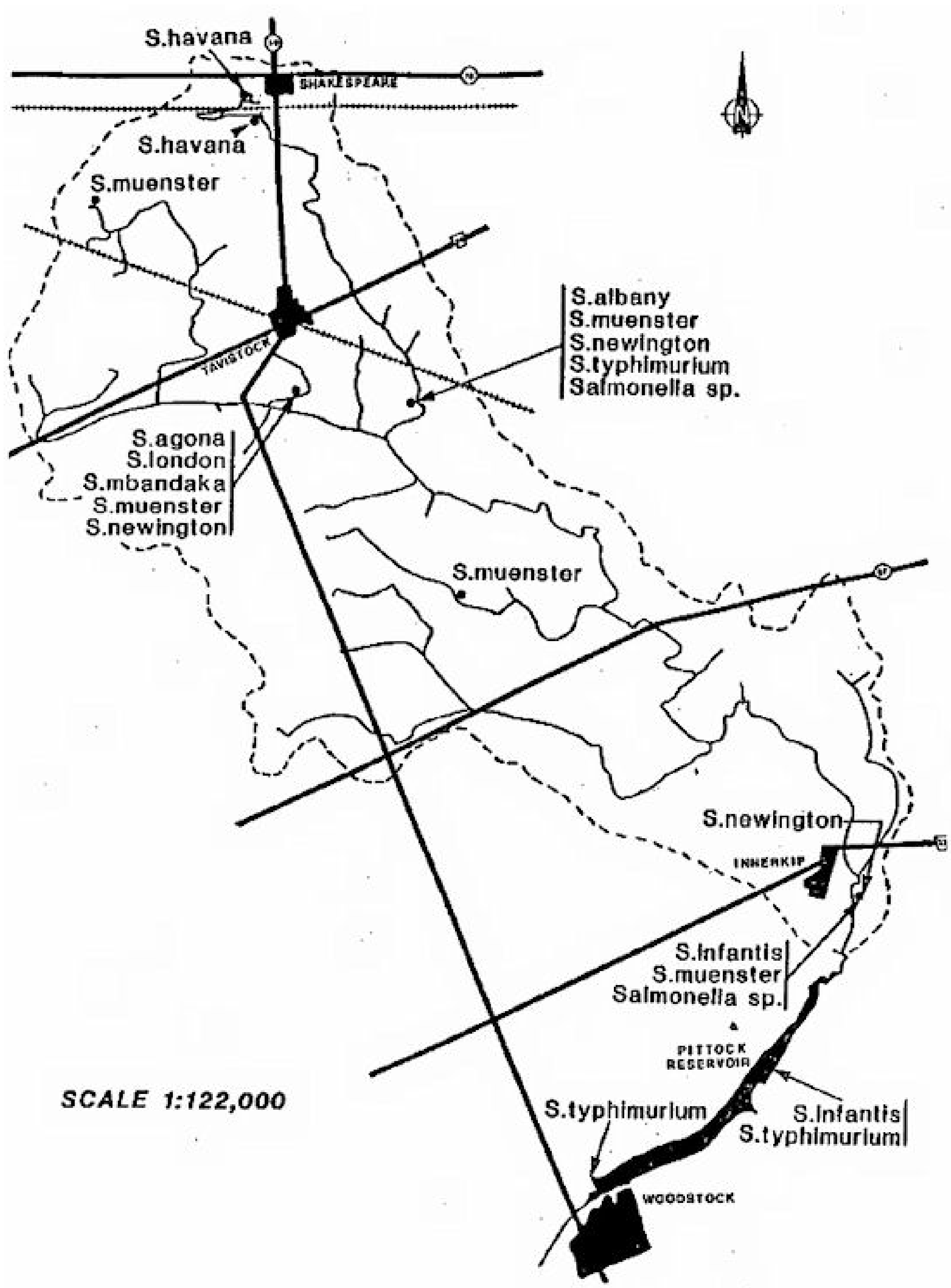

Figure 7. *Salmonella* serotypes found In the study

With respect to livestock waste management practices;

- only 16% have their soil tested for nutrients annually while 32% do not test their soils at all.
- 29% have livestock pasturing in and along streams. Of these, only one has fenced the stream and provided a limited access point.
- 35% admittedly do not have 6 month storage capacity for manure at least 20% of farms produce more manure than can be used on that farm and half of these produce at least twice that which can be efficiently utilized if evenly spread on their land.
- larger operators consider manure more of a nuisance than a potential cost saving because of the energy and labour required in handling it.
- approximately 75% of the land in the study area is tile drained, most of it systematically as opposed to random drainage.

SUMMARY

The quality of the waters in the South Branch of the Thames River was found to be unacceptable. As expected, known waste sources were found to be contributing to the unacceptable water quality. The study was designed to monitor the impact of livestock wastes and did find unacceptable impacts such as barnyard runoff, manure pile runoff and cattle access. The poor quality of the water from underground drainage systems was unexpected. Both the bacterial and chemical characteristics of this drainage were unacceptable and comparable in quality to domestic sewage.

Although the exact sources or causes of the poor quality in the drains are unknown, illegal connections are suspected as a primary contributing factor. The study indicates that such connections are occurring both in rural municipalities as well as the agricultural community in general. The magnitude of artificial drainage works coupled with the high animal densities on farms in this watershed makes subsurface drainage outlets a major contributor to the poor water quality in the study area. In many cases, rectifying the problem can require large capital expenditures for improved storage and handling facilities not to mention the cost of investigations and design assistance.

A recognition of the naivety of farmers on the problem together with present economic concerns demands government intervention.

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1. Ministry of the Environment - Southwestern Region

2. Fortin, M. and Mascall, M., June 1984. Livestock-Related Water Pollution in Southwestern Ontario. A Synopsis of Recent Studies. For the Southwestern Region Ministry of the Environment.

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