LAKE HURON BEACH STUDY

A microbiological water quality evaluation of Grand Bend Beach and related pollution sources in 1985

Ontario

Ministry
of the
Environment

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A microbiological water quality evaluation of Grand Bend beach and related pollution sources in 1985

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INTRODUCTION

On the shore of Lake Huron at Grand Bend, Ontario, is a beach considered to be a major recreational resort in the southwestern part of the province. Fundamental to the popularity of the site is the quality sandy beach and swimming waters of Lake Huron.

In 1984 an extensive beach study was conducted in an attempt to define the daily fluctuations in the bacterial quality of beaches on Lake Huron, including Grand Bend. In addition, a variety of pollution sources affecting the beach water quality were investigated to determine their relative importance and ultimately to initiate immediate abatement measures where possible.

A number of factors affecting the microbiological quality of recreational water were described in the Summary Report entitled, "Lake Huron Beaches - Factors Affecting Microbiological Water Quality in 1984". From the study, the major factors such as agricultural and urban activities were identified. In addition, resuspension of beach sediments and rainfall were strongly associated with bacterial increases in the beach water.

The study of 1985 conducted at the Grand Bend beach and in the surrounding townships involved the determination of the precise location and the significance of fecal pollution sources; particularly of agricultural origin. A detailed examination of bacteria associated with sediments of the beach and various creeks and drains was conducted.

SCOPE OF STUDY

The first phase of the study was to assess the bacterial quality of the swimming area and re-affirm the impact of rainfall and rough lake conditions on elevated bacterial conditions. As both these natural factors were shown in the 1984 study to be significant in affecting bacterial quality, related climatic parameters such as rainfall and wind direction and speed, were monitored daily.

It was established in the 1984 study that during rough lake conditions, the pollution indicator bacteria, fecal coliforms and fecal streptococci were consistently at higher levels than during calm lake conditions. It was concluded that sediments containing high numbers of fecal-associated bacteria became re-suspended in rough lake conditions, thereby causing a decrease in bacterial water quality. In this 1985 study, a more comprehensive bacterial and chemical analyses of sediments in the beach area as well as many creeks and drains was conducted.

To better define the location and impact of agricultural and urban pollution sources beyond the Village of Grand Bend, a set of stations was selected based on the 1984 study data. Sites on various tributaries of the Ausable River in a 5 km radius from Grand Bend were chosen. In addition, stations were established on two agricultural drains which discharge to Lake Huron immediately to the north of Grand Bend beach, at a drain which discharges to Ausable River within the Village of Grand Bend and at one to the south of Grand Bend. The station locations are shown in Figure 1.

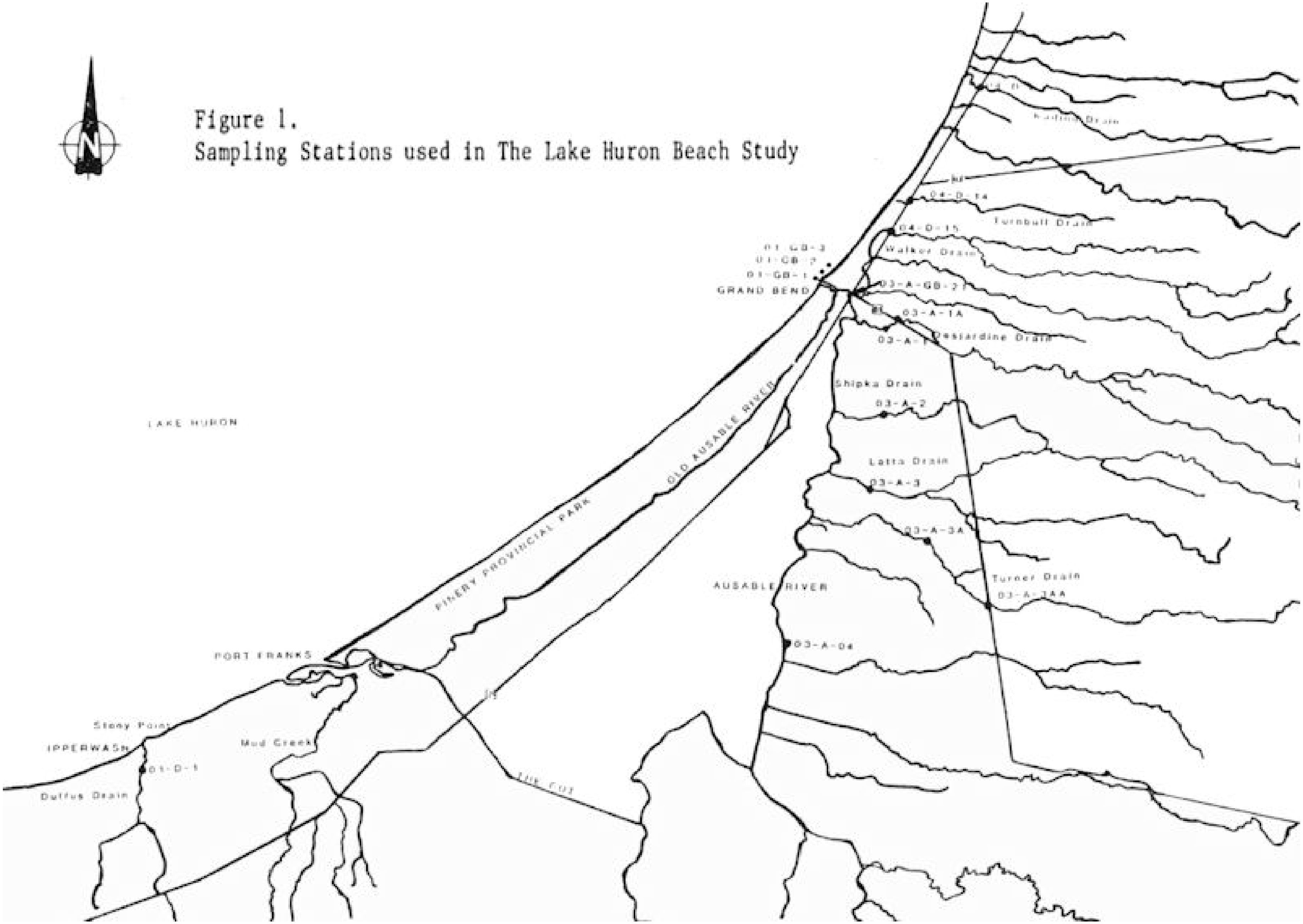

Figure 1.
Sampling Stations used in The Lake Huron Beach Study

Extensive analysis of isolates of the fecal-associated bacterium, *Escherichia coli* recovered from these sites as well as the beach sites was conducted. The testing for resistance to antibiotics used by farmers, veterinarians and physicians was done to better establish the significance of the bacteria as beach pollution. The resistance patterns obtained also help suggest the recent origin of the bacteria.

As a continuation of the 1984 study, serotyping of the pathogenic bacterium, *Pseudomonas aeruginosa* recovered from the beach and various sources of fecal wastes was used to help confirm specific problem sites.

Once the water and sediments of the beach are impacted with fecal-associated bacteria, the survival period of these organisms is poorly understood. This study attempted to define the survival period of the fecal coliform bacterium, *Escherichia coli* in the Ausable River and Lake Huron water and sediments during summer months. This information assists in determining the significance of various fecal pollution events affecting the beach with respect to time.

A suitable monitoring frequency of the bacterial quality of beaches has been considered difficult to establish. Daily monitoring in the 1984 study indicated significant changes in bacterial quality of beaches from day to day.

To help understand these daily fluctuations, some hourly monitoring was carried out. A variety of beaches were considered to provide the most meaningful data. Consequently, data was obtained from Grand Bend, Ipperwash Provincial Park and Goderich Harbour beach sites used in the 1984 study.

The data described in the following are available in summarized form at the Southwestern Regional office.

Assessment of the Bacterial Quality of Grand Bend beach.

The sampling of the beach was conducted in 1.0 to 1.5 m of water at stations shown in Figure 1, twice weekly. As was observed in the 1984 beach study, the levels of fecal coliforms changed significantly on a daily basis as shown in Figure 2. The seasonal average for fecal coliforms of 89 per 100 mL at the 3 stations sampled was lower than during 1984 where the average was 96 per 100 mL. The presence of the pathogenic bacterium, *Pseudomonas aeruginosa* was found in only 20 percent of the samples as compared to 37 percent in 1984.

Factors Affecting Bacterial Quality of Grand Bend Beach.

1. Unlike the 1984 study, only a few rainfall events resulted in sufficient runoff and increased stream flow causing elevated bacterial concentrations in the Ausable River and certain of its tributaries. As shown in Figures 3 and 4, the highest peaks in levels of fecal coliforms and fecal streptococci detected in the Ausable River on days 26 and 27 (July 2 and 3) of the study occurred during rainfall events. Although the rainfall was not excessive on the days mentioned, field soils were wet from previous rainfall during days 5 through 16 which resulted in runoff. It was noted, however, from field and rainfall data that increased fecal coliforms in the river did not always result from major rainfall events. This was likely because of dry soil conditions, at which time runoff did not always occur following rainfall. Since runoff resulting from rainfall is the main vehicle by which fecal-associated bacteria are transferred from soil into receiving streams, bacterial increases in receiving streams do not always occur. Alternatively, when the soil contained greater moisture, lesser significant rainfall events resulted in

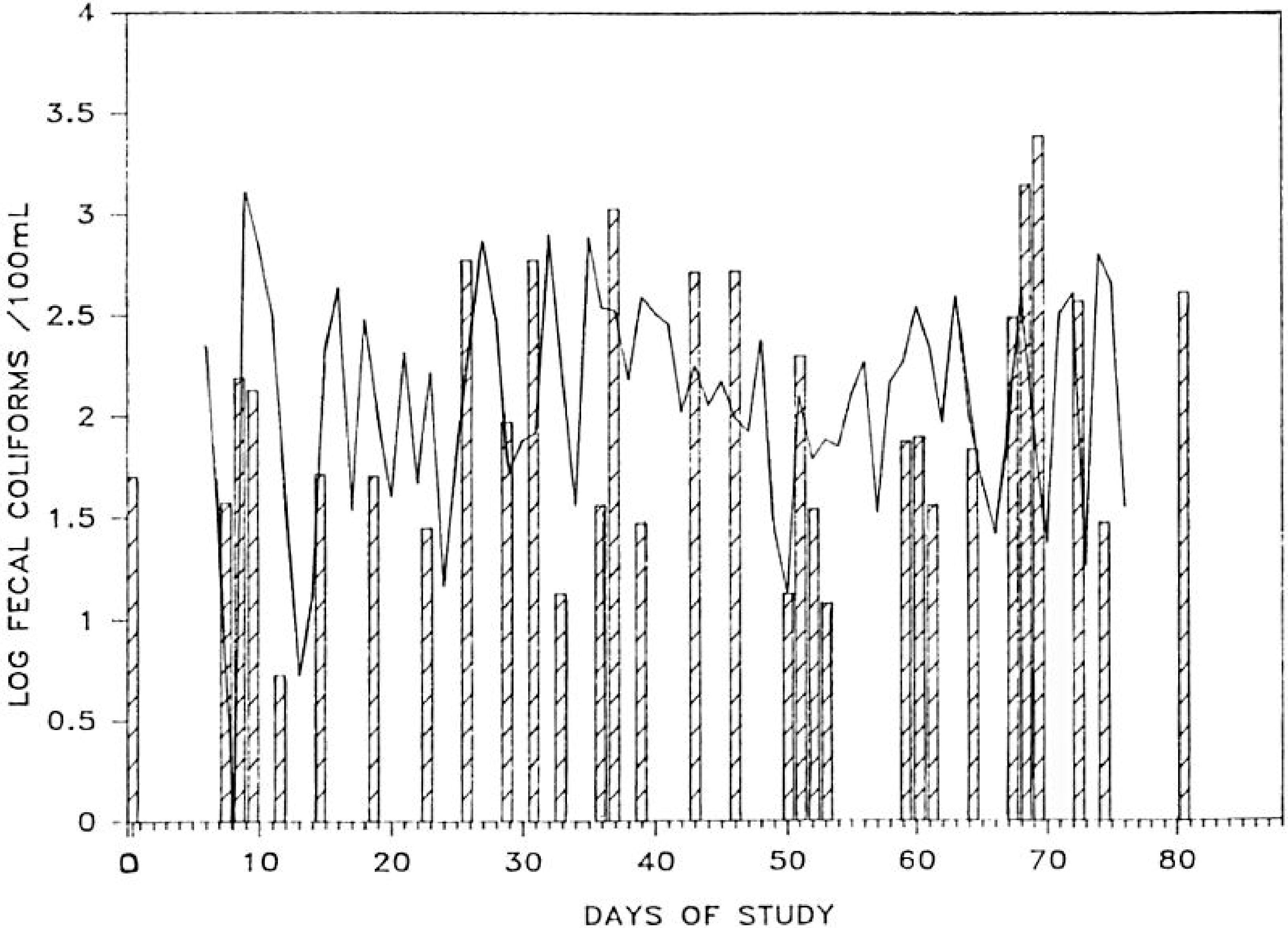

Figure 2. Fluctuations in fecal coliform levels averaged for the 3 stations at Grand Bend beach in 1985, shown as hatched bars are compared to fecal coliform levels in 1984, shown as a continuous line.

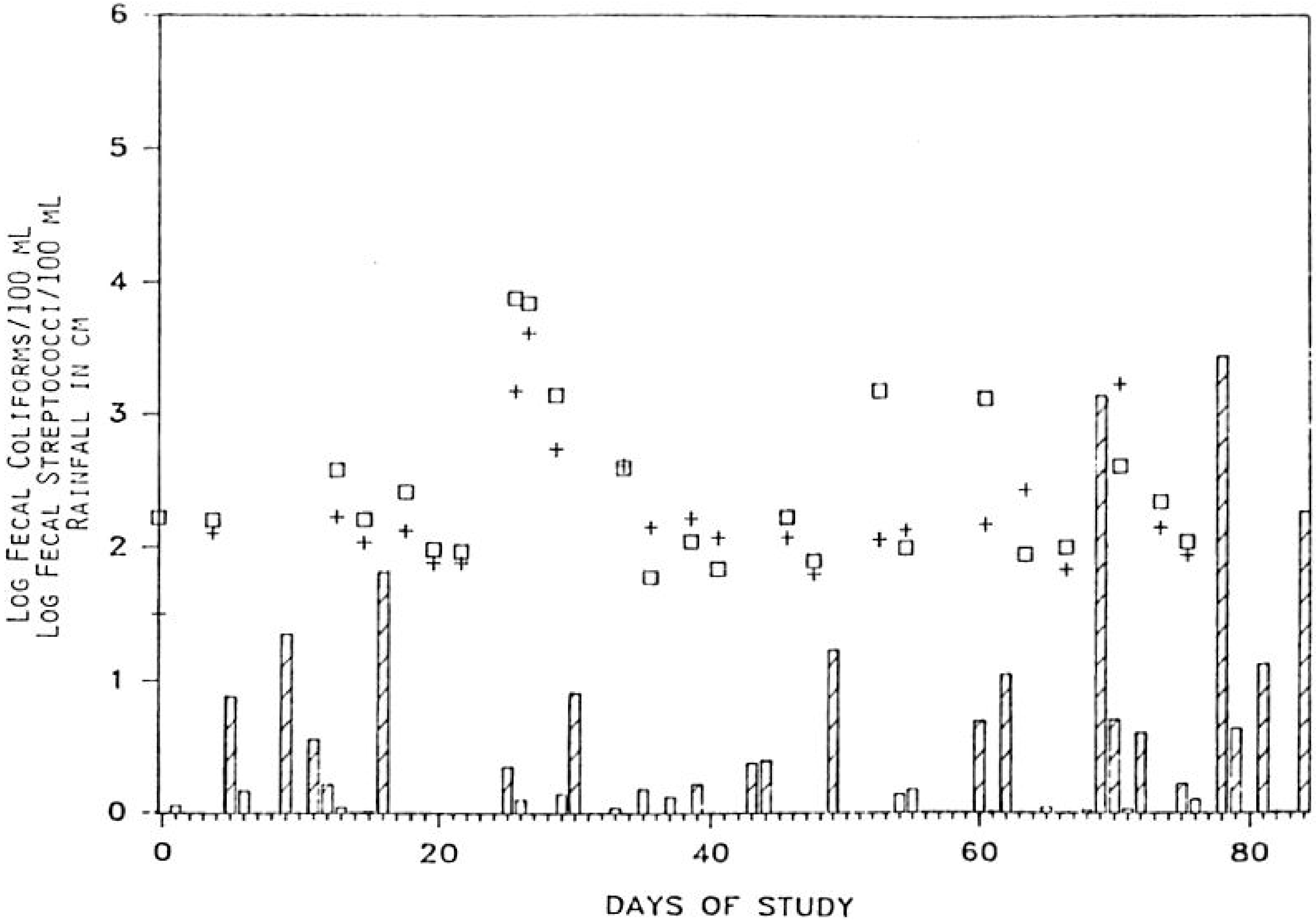

Figure 3. Fecal coliform levels □ and fecal streptococci levels + in the Ausable River at Station 03-A-GB-21 compared to rainfall during the 1985 study.

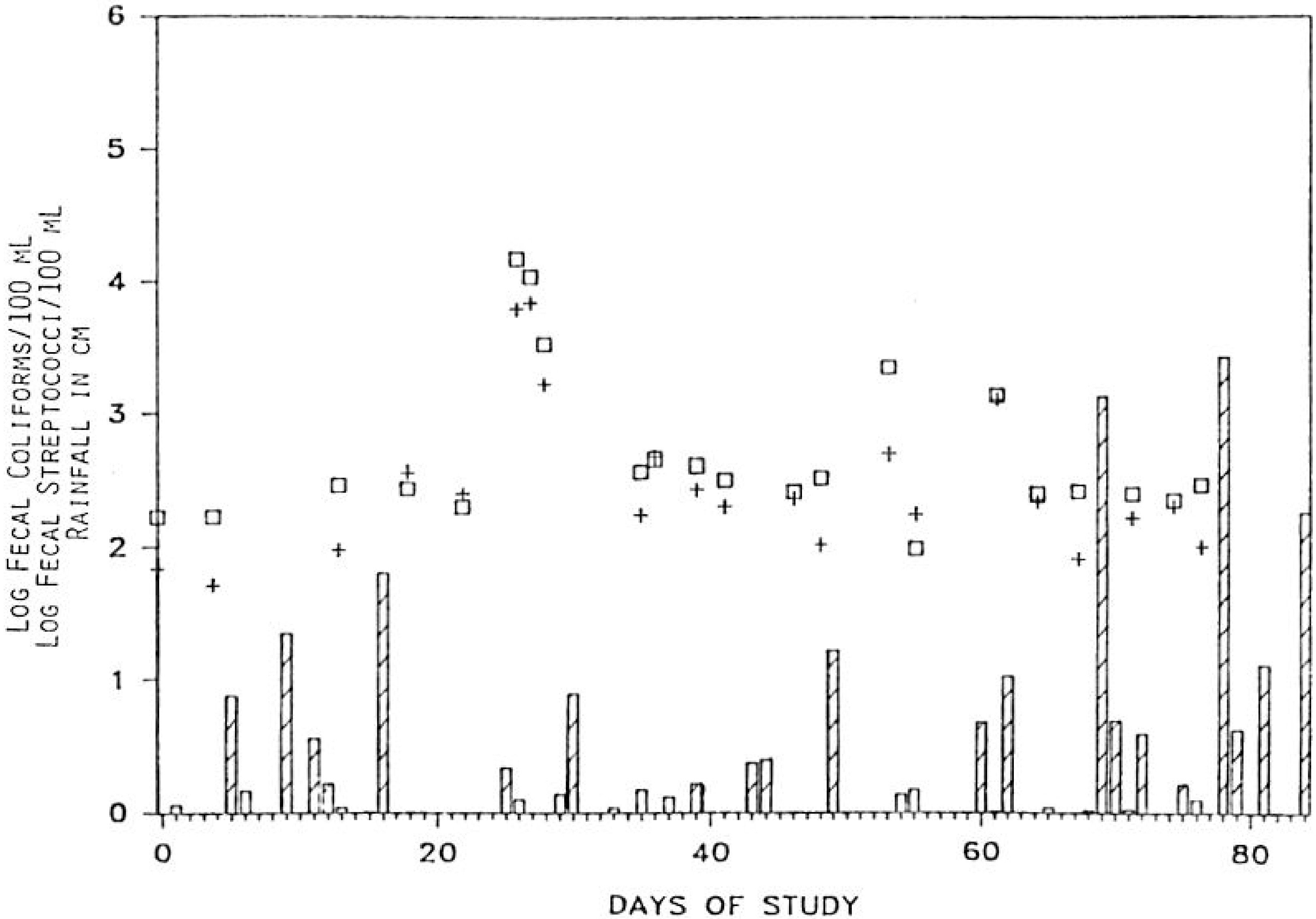

Figure 4. Fecal coliform levels □ and fecal streptococci levels + in the Ausable River at Station 03-A-04 compared to rainfall 0 during the 1985 study.

runoff and subsequent increases in bacterial concentrations in the receiving stream. The correlation coefficient between rainfall and fecal coliforms in the Ausable River at station 03-A-GB-21 of 0.64 was significant at the 99.8% level.

2. Average levels of fecal coliforms detected at the three stations of Grand Bend beach are shown in Figure 5. From review of the data, increased bacterial concentrations were coincidental with rainfall and/or with increased wave height. Runoff from the beach itself during rainfall likely contributed bacteria to the lake, in addition to the impact of rivers and creeks in the vicinity of the beach.

   Wave heights were correlated with elevated fecal coliform levels; particularly where rainfall was minimal (Figure 5). The correlation coefficient of 0.56 was significant at the 99.8% level. It is expected that the lake sediments containing fecal-associated bacteria at levels detected as high as 480,000 per 100 g become re-suspended with wave action, thereby increasing the bacterial levels in swimming water.

3. In an attempt to determine the distance from shore, that the sediments contain fecal-associated bacteria, a set of sediment samples was taken from the lake bottom at increasing distances from shore. Sediment - fecal coliform levels were found to be extremely variable as shown in Figure 6. Results of surface and bottom water samples are also illustrated.

4. The Ausable River plume was documented in the 1984 Beach Study to be moving onto the Grand Bend beach during periods when the wind direction was from south to westerly directions. The wind direction and speed data was

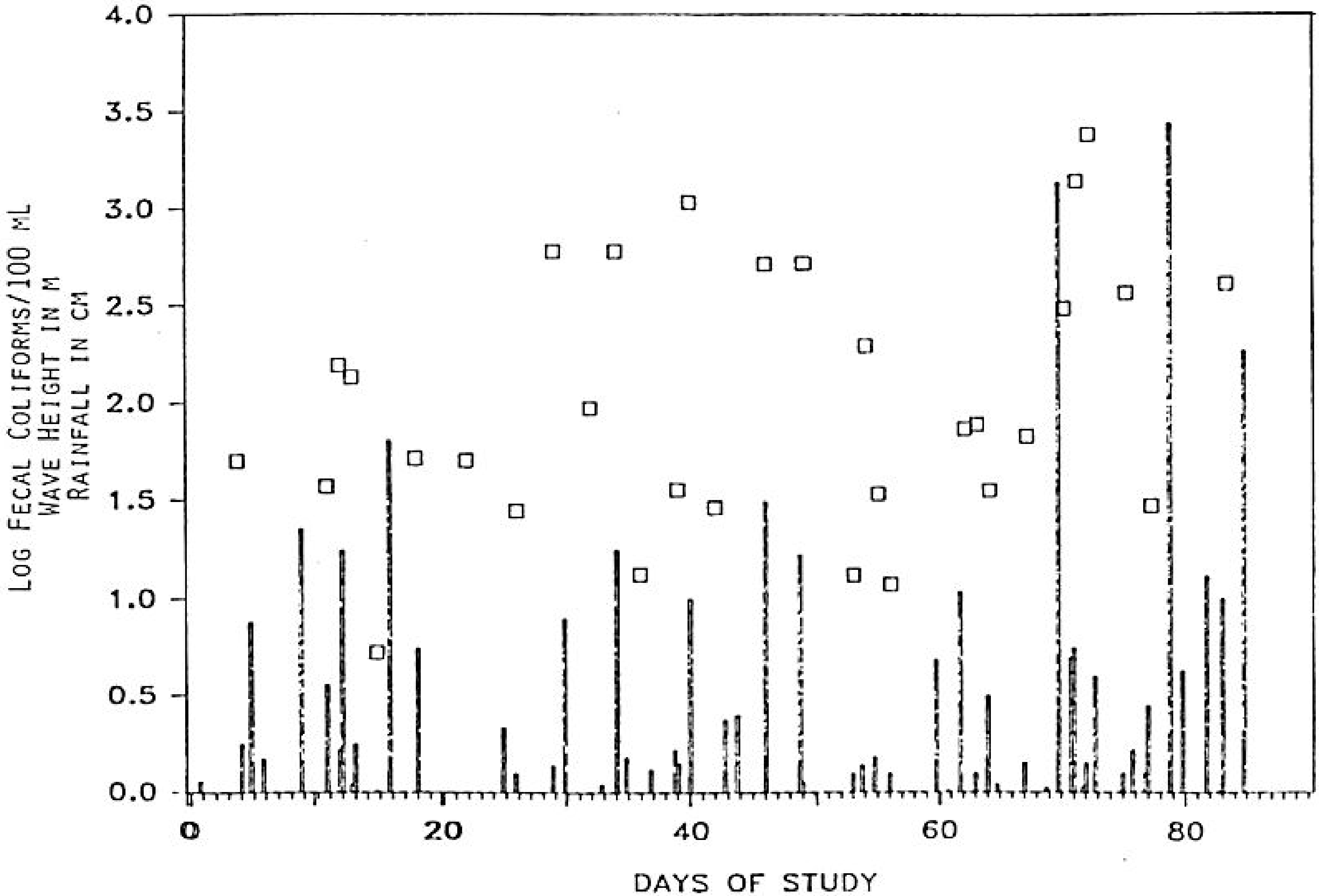

Figure 5. Average fecal coliform levels □ at stations 1, 2 and 3 at Grand Bend Beach compared to rainfall and wave height during the 1985 study.

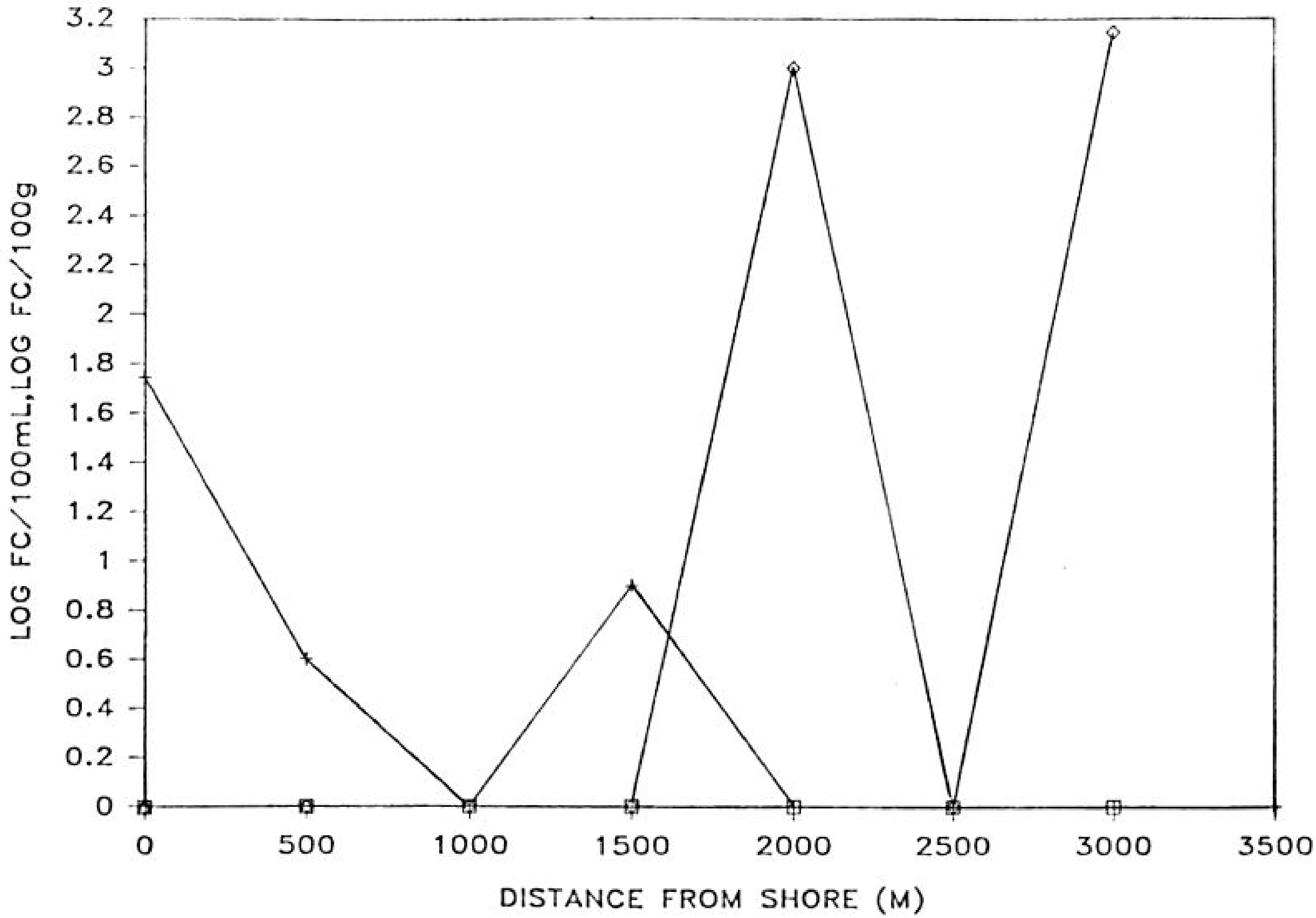

Figure 6. Fecal coliform levels in the surface +, bottom □, water and sediment ◊ at sites increasing with distance from shore near station 01 at Grand Bend Beach.

analyzed to determine those directions and speeds that were associated with peaks in fecal coliform bacteria.

The data revealed that on certain days, winds from the southerly and westerly directions in excess of 10 km per hour were, in fact, associated with elevated fecal coliforms. The fecal coliform loading in the Ausable River likely contributed to the levels detected at the beach sampling sites during these wind conditions. It was noted that at station 1 and on the beach, closest to the river plume, fecal coliforms were always higher than at station 3, further from the river. This was also noted in the 1984 study.

From the wind-association data, it was apparent that when the wind was blowing on-shore from northerly to westerly to southerly directions, fecal coliforms and fecal streptococci were often elevated. It was anticipated that the resulting wave action caused sediment re-suspension which caused peak bacterial levels to be observed at the beach. In an attempt to support this hypothesis, analysis on a weight basis of all suspended particles greater than 2 microns was conducted on samples taken coincidentally with bacterial samples. A lack of correlation between levels of fecal coliforms and the weight of solids was found. It is felt that the suspended solids analysis was too course in reflecting the suspended particles to which bacteria were adsorbed.

Sources of Bacterial Pollution to Rivers and Creeks Affecting Grand Bend Beach

a) Ausable River and Tributaries

The sampling of the Ausable River and specific tributaries at sites shown in Figure 1 was conducted 20 to 24 times depending on the location during wet and dry periods. From review of the data of station GB21 on the Ausable River in Grand Bend, 68 percent of fecal coliform levels were greater than 100 bacteria per 100 mL , while 21 percent was greater than 1000 bacteria per 100 mL. Although the average value of station GB21 of 236 fecal coliforms per 100 mL was somewhat less than the average level of 458 per 100 mL at station 04 on the Ausable River, upstream of the study area, periodic bacterial peaks downstream at Grand Bend were evident as shown in Figure 2.

Some of the peaks correspond to rainfall events and are the result of runoff. Other peak values are associated with much higher levels (greater than 10,000 bacteria per 100 mL) of fecal-associated bacteria found in the four drains or tributaries of the Ausable River. The increased levels were often observed following cattle watering in the creeks. Decreases in the fecal-associated bacteria usually occurred when cattle would be moved to fields away from the creeks.

The levels of bacteria recovered in these tributaries which drain primarily agricultural land are illustrated graphically in Figures 7 and 8. These figures are typical of the data obtained at the remaining stations in the study area.

The sediments of the drains sampled were also found to contain much higher levels of fecal-associated bacteria than were detected in the drain water. For example,

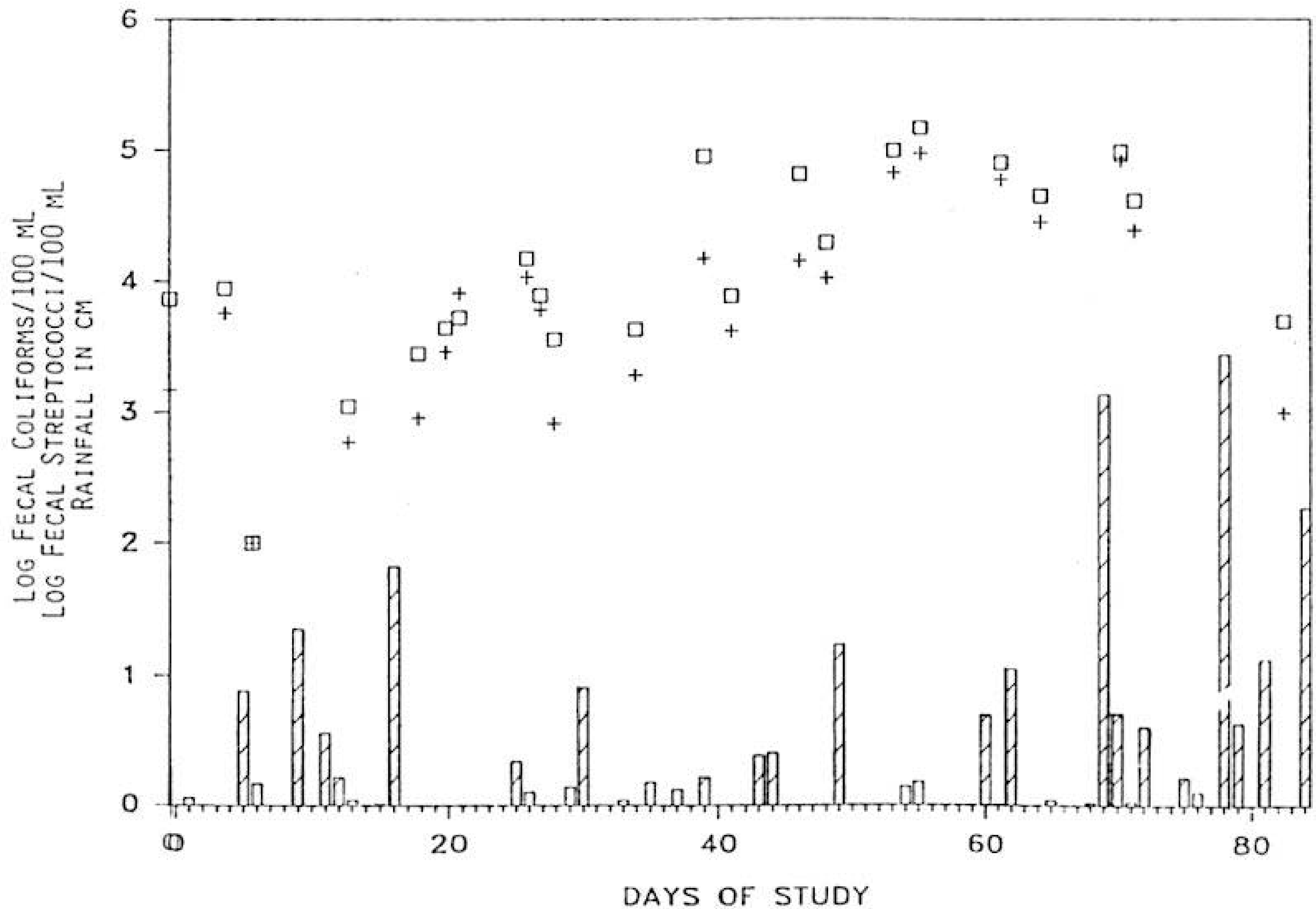

Figure 7. Fecal coliform ❑ and fecal streptococci + levels detected at Station 03-A-1 on the Desjardine Drain compared to rainfall during the 1985 study.

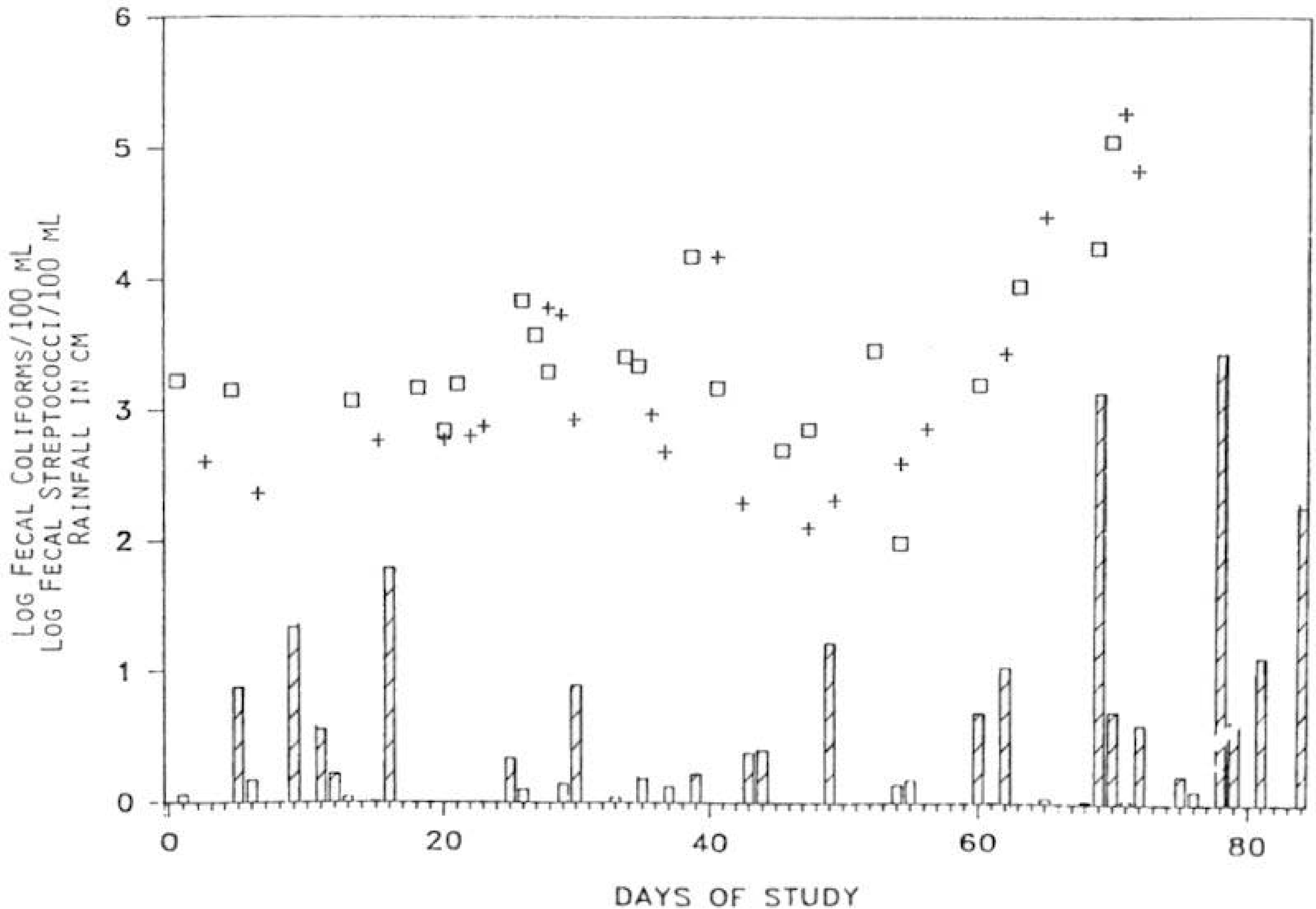

Figure 8. Fecal coliform ❑ and fecal streptococci + levels detected at Station 03-A-03 on the Dietrich Drain compared to rainfall during the 1985 study.

the seasonal mean at station 01 on the Desjardine Drain was 236 fecal coliforms per 100 mL while the corresponding sediment value was 116,018 fecal coliforms per 100 g. This was typical of the drain sediments as well as the sediments of the Ausable River.

Although not all the drain sediment analyzed was readily re-suspended and able to be transported, a detailed particle size analysis of the sediment in the Ausable River revealed that 50 percent of the particles in the sediment tested were less than 100 microns in size. This material has been shown to be easily re-suspended during increased stream flow conditions.

b) Agricultural Drains and Creeks

During the 1984 Beach Study, sixteen of the creeks or drains sampled revealed, in general, high levels of fecal-associated bacteria, particularly during rainfall events. The four drains chosen for study shown in Figure 1, were selected from the sixteen. In addition to determining the levels of fecal-associated bacteria in these drains, the impact of the drains on the lake was assessed. The seasonal average of 60 fecal coliforms per 100 mL in the Duffus Drain at station was in contrast to the values of 1,467; 2,044, and 2,480 per 100 mL at drains 02, 14 and 15 respectively. Drain 02 was evaluated using several approaches. The sampling of the drain 02 at one concession east of Highway 21, at Highway 21 and at the point of discharge to the lake on an hourly basis revealed means of 1,224; 1,471 and 2,467 fecal coliforms per 100 mL respectively. The increase in bacterial levels between Highway 21 and the lake suggested additional inputs. From a close examination of this section of the drain, 6 drain pipes were observed as potential inputs to the drain 02 west of Highway 21.

To assess the impact of this drain on the lake a sampling grid was established, using wind direction, wave direction and the flow direction of the drainage into the lake as locating factors. Grid samples taken in 30 cm of water contained from 2,000 to 23,000 fecal coliforms per 100 mL while in 1.2 mm of water from 160 to 4,000 fecal coliforms per 100 mL were detected. Both control stations of the grid were substantially lower. The drainage entering the lake contained 71,000 fecal coliforms per 100 mL.

A similar procedure was used to determine the impact of drain 14. The average value of hourly sampling on August 16 at a station one concession east of Highway 21 was 1,179 fecal coliforms per 100 mL. At the station located at Highway 21, fecal coliforms increased to 30,958 per 100 mL. This drainage passed through farmland exclusively. The levels of fecal coliforms in the drainage at the lake actually decreased slightly to 10,675 bacteria per 100 mL. Although the drainage tended to accumulate on the beach, and not flow over the beach into the lake, the grid sampling revealed levels ranging from 2,800 to 10,200 fecal coliforms per 100 mL.

Drain 15 located immediately north of Grand Bend was routinely observed to have cattle watering in it. Fecal coliform and fecal streptococci levels always peaked during cattle access periods. The range in fecal coliforms and fecal streptococci were 100 to 49,000 and 144 to 24,000 respectively.

Results of Bacteriological Experiments To Assist in Pollution Source Identification

a) Serology of *Pseudomonas aeruginosa*

Isolates of *P. aeruginosa* were recovered from a variety of pollution sources and from the three Grand Bend beach stations. They were serotyped to determine if specific serotypes were common to potential beach pollution sources and if these same serotypes were found frequently in the beach water.

Results are shown in Table 1. The data suggests that both drains 2 and 14 discharging directly to the lake and the drains discharging to the Ausable contributed specific serotypes of *P. aeruginosa* to Grand Bend beach. For example, it was apparent that serotype 06 commonly found in the beach samples was most frequently found in the Ausable River and drains (14, 15, 3AA, 3A, 1A and 1) discharging to it. Other serotypes such as 7, 8 and 13, 14 found at the beach sites were found at specific drains and tributaries.

b) Antibiotic Resistance Patterns of *Escherichia coli*.

The *E. coli* isolates were checked for antibiotic resistance routinely recovered from both the Grand Bend beach and all of the potential beach pollution sources.

The data shown in Table 2 will be discussed in detail in a later report. It can be observed, however, that the frequency of resistance to sulfisoxazole, amikacin, tetracycline and ampicillin in descending order was most commonly observed in the beach isolates. A number of potential sources exhibited similar patterns although some differed, for example, when tetracycline-resistant isolates were found more

TABLE 1. Distribution of serotypes of *P. aeruginosa* recovered in swimming waters of Grand Bend and from various pollution sources.

Location and Station Number									
Grand Bend Beach 01-GB-1		Grand Bend Beach 01-GB-2		Grand Bend Beach 01-GB-3	Ausable River Tributary 03-A-01A	Ausable River Tributary 03-A-1	Ausable R Tributary 03-A-2	Ausable River Tributary 03-A03	
1-(9)	4,11-(1)	1-(11)	9-(1)	1-(12)	1-(3)	1-(3)	1-(1)	1-(5)	9-(1)
4-(1)	6,7,8-(1)	3-(7)	11-(2)	4-(2)	3-(1)	3-(2)	2-(1)	2-(1)	16-(2)
5-(1)	10-(1)	4-(2)		5-(5)	5-(1)	4-(1)	3-(3)	3-(5)	
6-(9)		6-(8)		6-(6)	6-(9)	6-(6)	4-(1)	5-(4)	
7,8-(5)		7,8-(3)		11-(2)	9-(2)	7,8-(2)	5-(1)	6-(1)	
10,11-(1)				13,14-(1)	11-(2)	11-(2)	6-(3)	7,8-(6)	
					13,14-(1)		9-(3)		

Ausable River Tributary 03-A-03A		Ausable River Tributary 03-A-3AA	Ausable River 03-A-4	Ausable River 03-A-GB-21	Agri. Drain 04-D-2	Agri. Drain 04-D-14	Agri. Drain 04-D-14A	Agri. Drain 04-D-14L
1-(1)	11-(5)	1-(1)6,13-(1)	1-(1)	1-(2)9-(2)	1-(4)	2-(1)	3-(2)	3-(4)
3-(2)	12-(1)	1,4,11-(1)	3-(1)	2-(1)11-(1)	3-(1)	3-(1)	6-(3)	6-(4)
4,11-(1)	13,14-(4)	5-(2)	6-(4)	3-(4)13,14-(1)	5-(1)	6-(11)	10-(1)	7,8-(4)
5-(2)	14-(1)	6-(8)	7,8-(2)	4-(1)	6-(5)	7,8-(3)		9-(1)
6-(4)		9-(10)		5,6-(1)	7,8-(1)	9-(3)		11-(1)
7,8-(2)		11-(1)		6-(11)	9-(1)	10-(1)		16-(1)
9-(8)		13,14-(7)		7,8-3	11-(5)	11-(3)		
					13,14-(1)			

Lake Huron 04-GR-14		Agri. Drain 04-D-15
1-(1)	13,14-(5)	1-(4)
3-(2)	3,8-(1)	1,3,10-(1)
3,10-(1)		6-(28)
5-(5)		7,8-(2)
6-(3)		9-(3)
7,8-(7)		10-(7)
11-(13)		

Agri. = Agricultural

TABLE 2. Frequency and distribution of resistance to antibiotics among *E. coli* recovered from Grand Bend beach and various pollution sources.

	ANTIBIOTICS								
	Ami	Amp	Car	Co-t	Gen	Neo	Sul	Tet	Tob
Location Station Number									
Grand Bend Beach 01-GB-01	18.5 (5)	14.8 (4)	0 (0)	0 (0)	0 (0)	0 (0)	80.5 (22)	7.4 (2)	0 (0)
Grand Bend Beach 01-GB-02	20.0 (6)	16.7 (5)	0 (0)	0 (0)	0 (0)	0 (0)	90.0 (27)	20.0 (6)	0 (0)
Grand Bend Beach 01-GB-03	33.3 (7)	9.5 (2)	0 (0)	0 (0)	0 (0)	0 (0)	66.7 (14)	9.5 (2)	0 (0)
Duffus Drain 01-0-01	47.0 (8)	5.9 (1)	0 (0)	0 (0)	0 (0)	0 (0)	82.4 (14)	17.6 (3)	0 (0)
Ausable River Tributary 03-A-02	50.0 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	100.0 (6)	0 (0)	0 (0)
Ausable River Tributary 03-A-1	38.2 (13)	29.4 (10)	5.9 (2)	2.9 (1)	0 (0)	2.9 (1)	79.4 (27)	29.4 (10)	0 (0)
Ausable River Tributary 03-A-01A	36.0 (9)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	80.0 (20)	36.0 (9)	0 (0)
Ausable River Tributary 03-A-02	35.7 (10)	14.3 (4)	0 (0)	0 (0)	0 (0)	0 (0)	96.4 (27)	53.6 (15)	0 (0)
Ausable River Tributary 03-A-03	36.4 (12)	18.2 (6)	3.0 (1)	0 (0)	0 (0)	0 (0)	90.9 (20)	45.5 (15)	0 (0)
Ausable River Tributary 03-A-03A	30.0 (9)	10.0 (2)	3.3 (1)	0 (0)	0 (0)	0 (0)	86.7 (16)	33.3 (10)	0 (0)
Ausable River Tributary 03-A-03AA	53.6 (15)	7.1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	92.9 (26)	25.0 (7)	0 (0)

TABLE 2. Continued

	ANTIBIOTICS								
	Ami	Amp	Car	Co-t	Gen	Neo	Sul	Tet	Tob
Location									
Station Number									
Ausable River	20.0	20.0	6.7	0	0	6.7	93.3	53.3	0
03-A-04	(3)	(3)	(1)	(0)	(0)	(1)	(14)	(8)	(0)
Ausable River	66.7	18.5	3.7	0	0	0	88.9	40.7	0
03-A-GB21	(18)	(5)	(1)	(0)	(0)	(0)	(13)	(11)	(0)
Agricultural Drain	25.7	17.1	8.6	0	0	2.9	88.6	45.7	0
04-D-14	(9)	(6)	(3)	(0)	(0)	(1)	(31)	(16)	(0)
Agricultural Drain	29.6	7.4	3.7	3.7	0	0	81.5	37.0	0
04-D-15	(8)	(2)	(1)	(1)	(0)	(0)	(22)	(10)	(0)
Agricultural Drain	33.3	10.0	0	0	0	0	93.3	30.0	0
04-D-02	(10)	(3)	(0)	(0)	(0)	(0)	(28)	(9)	(0)

Legend

Numbers - % Resistant

( ) - Number of cultures

Antibiotic Legend

ami - Amikacin

Amp - Ampicillin

Car - Carbenicillin

Co-T - Co-trimoxazole

Gen - Gentamycin

Neo - Neomycin

Sul - Sulfisoxazole

Tet - Tetracycline

Tob - Tobramycin

frequently than amikacin-resistant isolates. It is likely that the tetracycline-resistant isolates reflect their recent animal origin because the antibiotic is used frequently in animal husbandry and rarely by physicians. Similarly, those *E. coli* resistant to neomycin also reflect animal origin based on the exclusive agricultural usage of the antibiotic.

Assessment of the Survival of *Escherichia coli* in Lake Huron Water and Sediment and the Ausable River.

Using diffusion chambers loaded with an *E. coli* originally isolated from the Grand Bend beach, a series of bacterial survival experiments in the lake water and sediment of Pt. Blake were conducted. Two experimental runs were also conducted in the Ausable River at station 04.

Results of experiments in the lake indicated a half life of 36.5 hours although complete die-off occurred in approximately 6 to 7 days as shown in Figure 9. The survival period in the two Ausable River runs varied somewhat but it was apparent in the nutrient-rich river water that the E. coli survival was in excess of 3 weeks as shown in Figure 10.

One sediment run was conducted with eight diffusion chambers loaded with Lake Huron sediment inoculated with the same *E. coli* isolate as used previously.

By removing a chamber from the lake bottom support device following a time interval and analyzing the sediment for the remaining *E. coli* cells, a survival period of greater than one month was demonstrated as shown in Figure 11. Based on the concentration of *E. coli* cells remaining, the survival may be at least two months.

Hourly Fluctuations in Fecal Coliform Levels at Three Beaches

To better comprehend the daily fluctuations observed in fecal coliform levels detected at the 3 beaches evaluated in the 1984 Beach Study, a series of hourly sampling runs were conducted. Figures 12, 13 and 14 from Grand Bend beach, Ipperwash Provincial Park beach and Goderich Harbour beach illustrated the hourly changes. It is apparent that the magnitude of the changes as shown here indicate the non-random distribution of bacteria across a beach at any one time and how radically these levels may change in the interval of one hour. These values more likely reflect the wave action and the non-uniform mixing of the lake water. As a result levels of bacteria detected by daily or weekly sampling fluctuate greatly making water quality assessments very difficult.

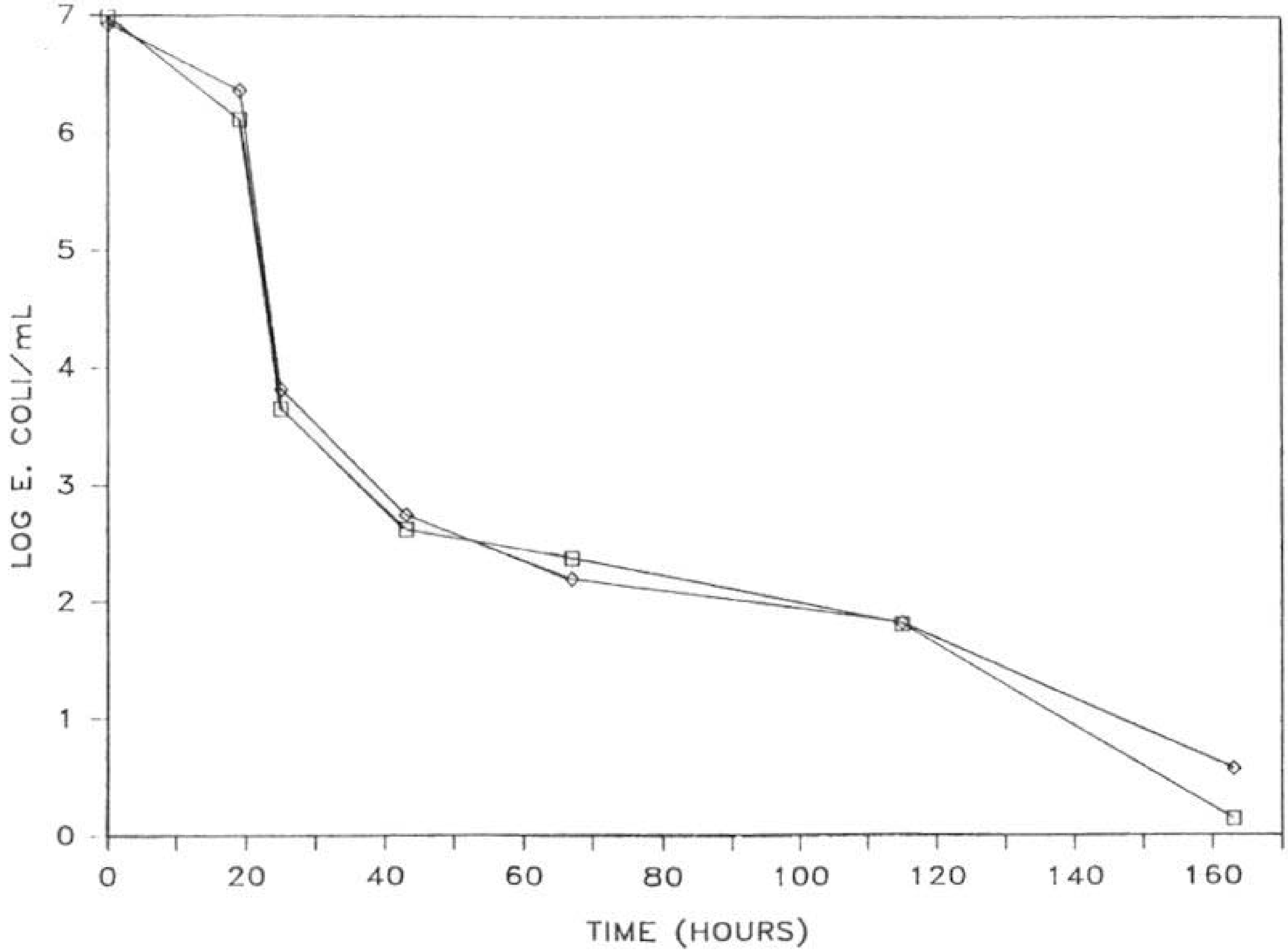

Figure 9. Survival Period of *E. coli* in a diffusion chamber suspended in Lake Huron.

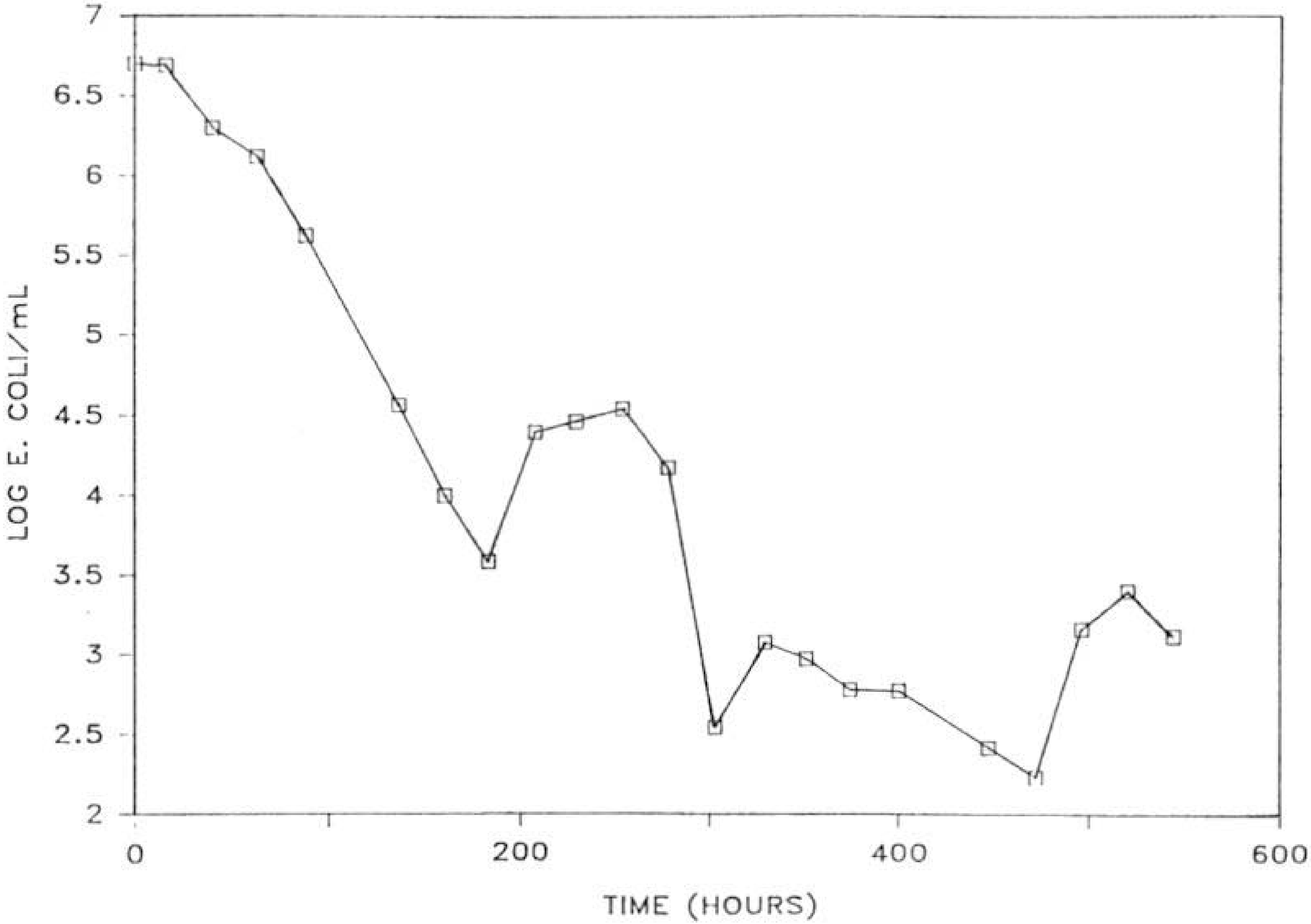

Figure 10. Survival Period of *E. coli* in **a** diffusion chamber suspended in the Ausable River.

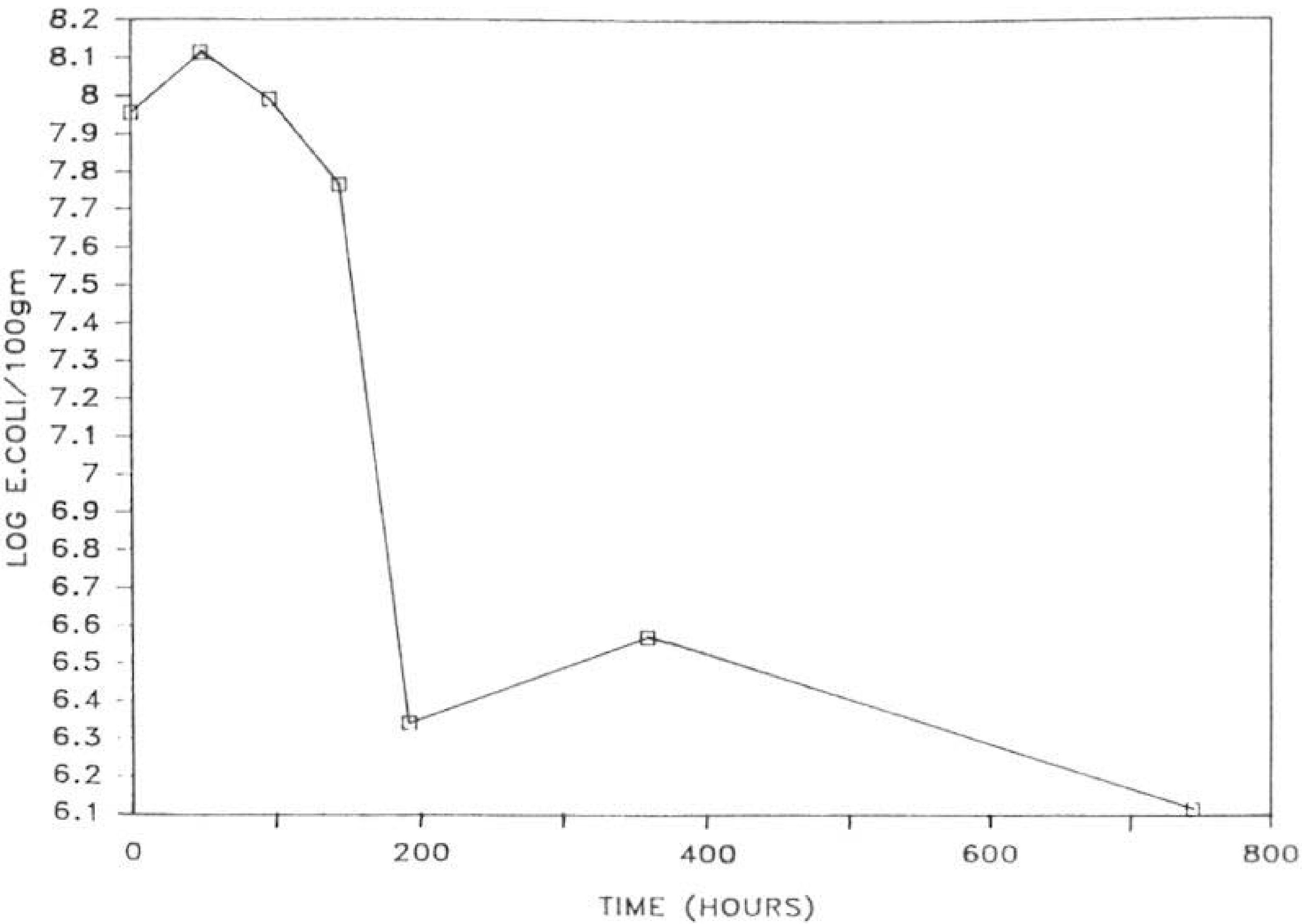

Figure 11. Survival Period of *E. coli* in a series of diffusion chambers anchored in the bottom sediments of Lake Huron.

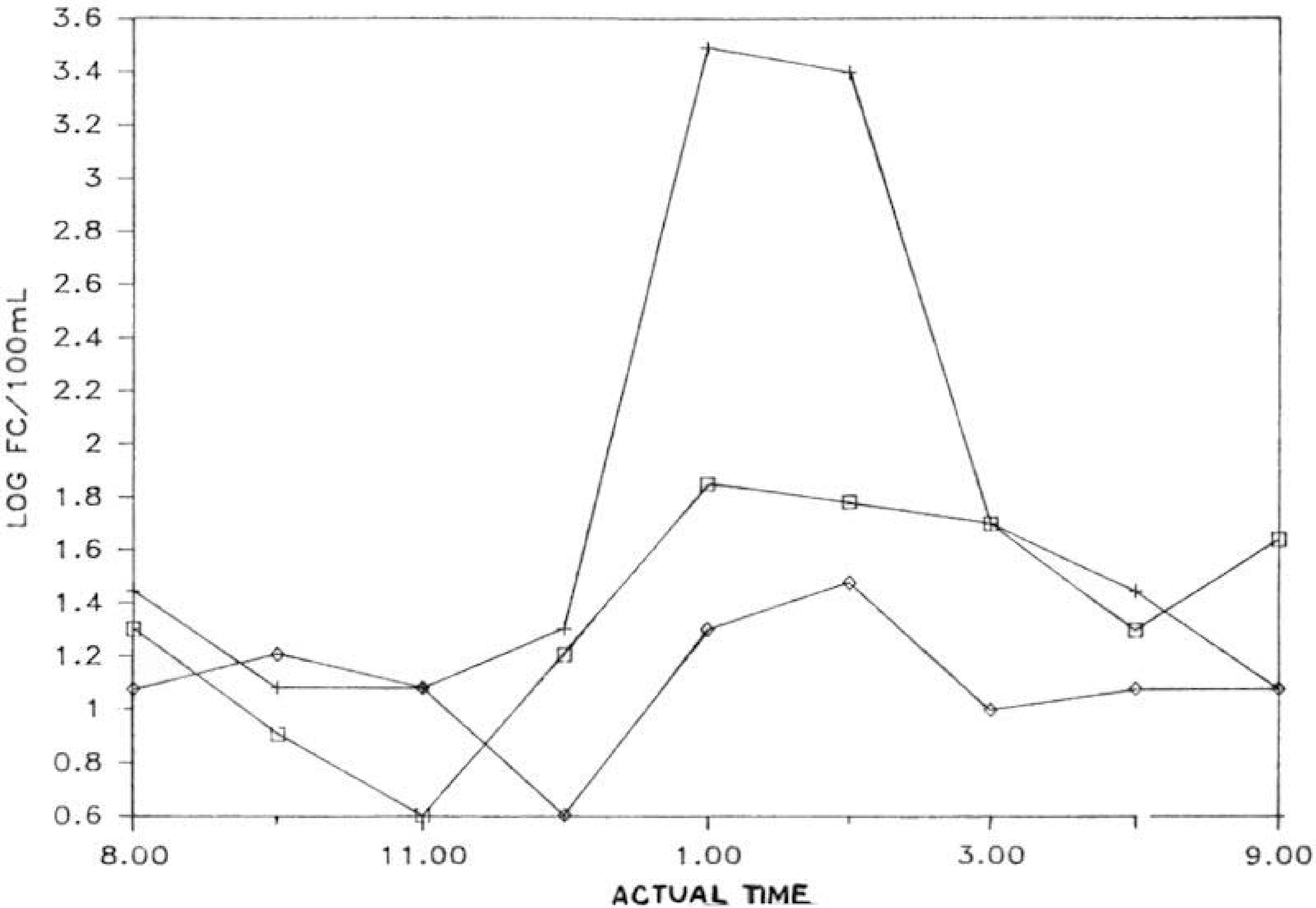

Figure 12. Fluctuations in fecal coliform levels at Station 1 ❑, Station 2 + and Station 3 ◊, in hourly intervals at Grand Bend Beach.

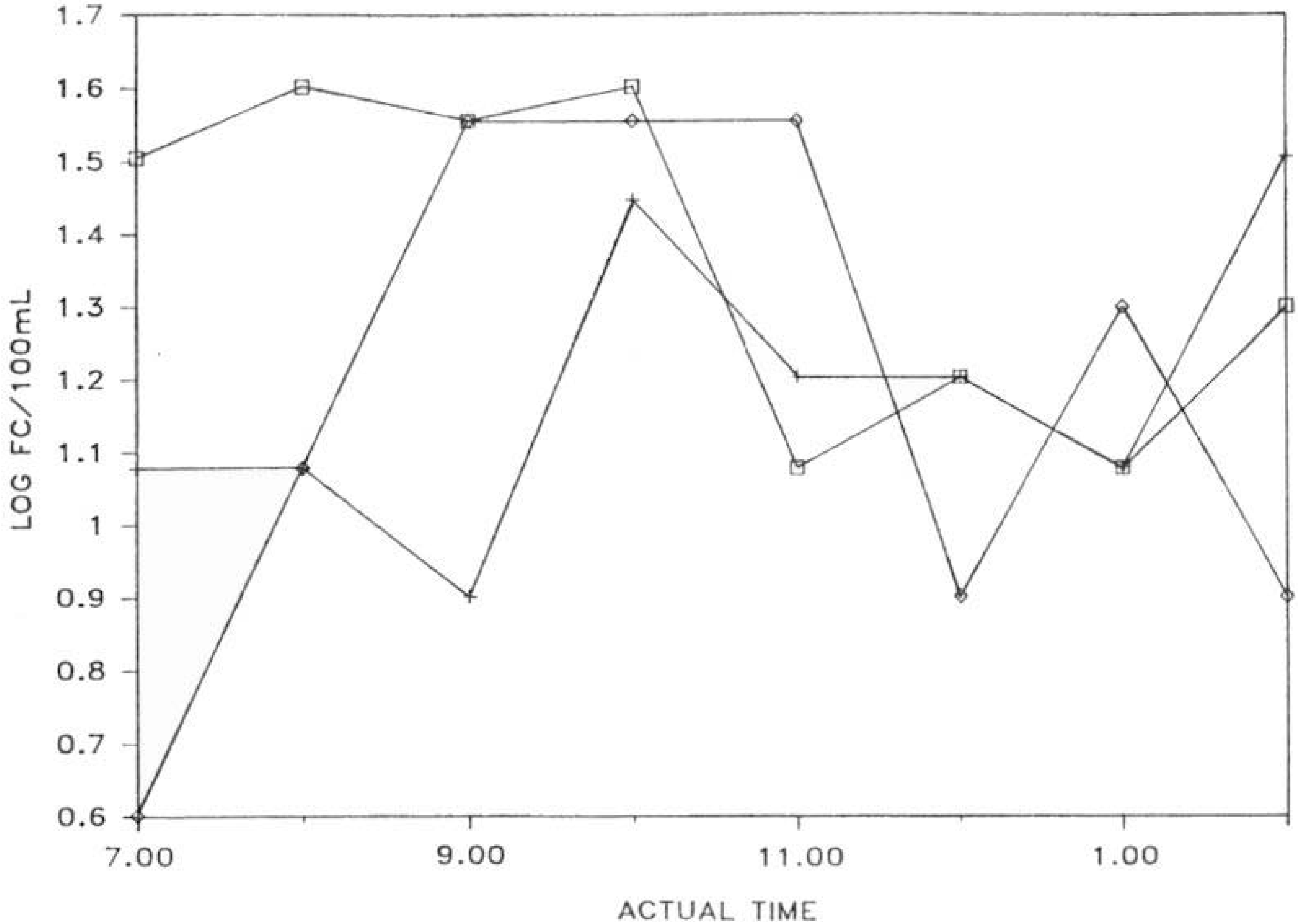

Figure 13. Fluctuations in fecal coliform levels of Station 1 ❑, Station 2 +, and Station 3 ◊, in hourly intervals at Ipperwash Provincial Park beach.

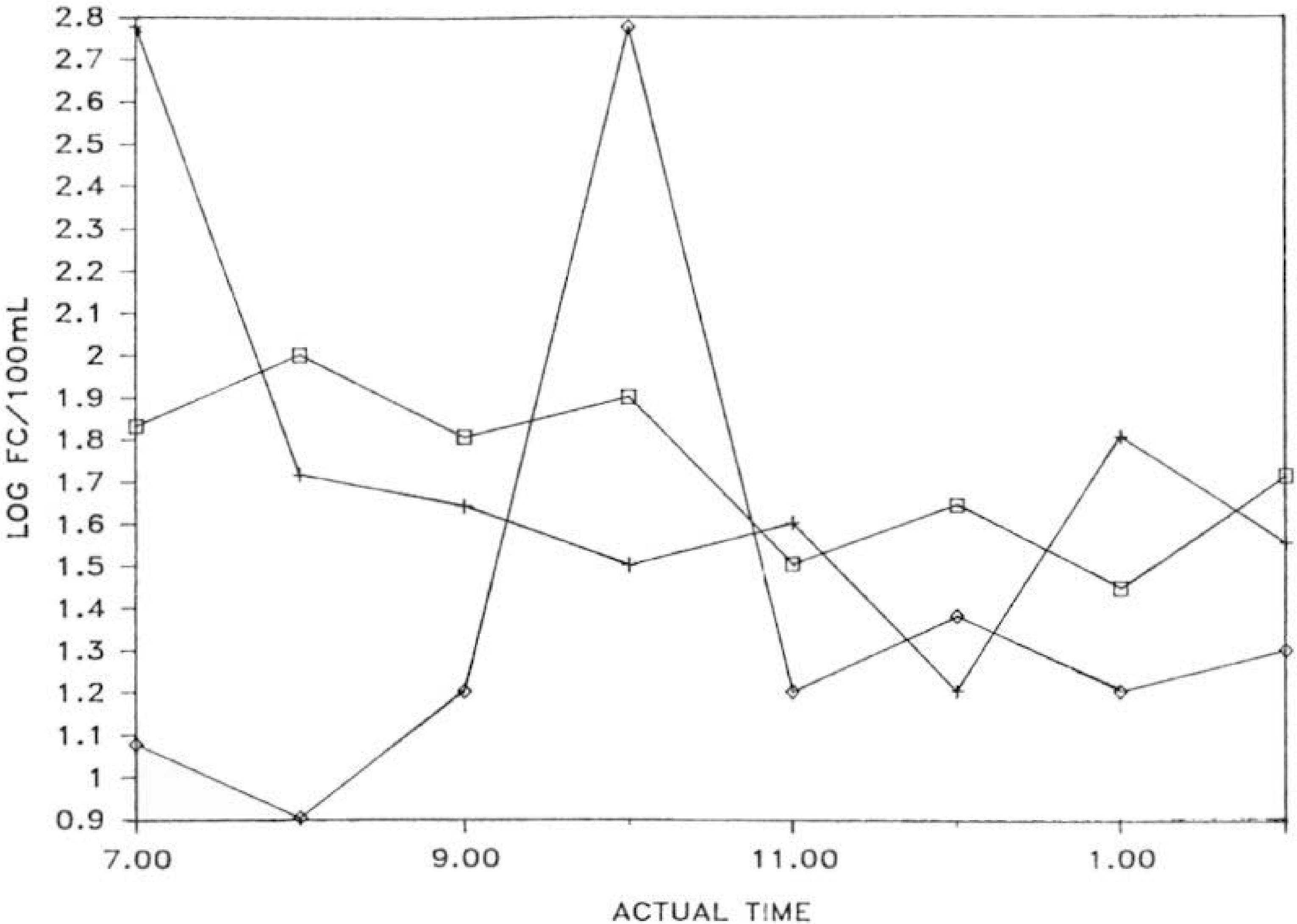

Figure 14. Fluctuations in fecal coliform levels at Station 1 ❑, Station 2 + and Station 3 ◊, in hourly intervals at Goderich Harbour beach.

CONCLUSIONS

The fluctuation in fecal coliform and fecal streptococci levels were similar to changes observed in the 1984 study. Although the mean values for these parameters were slightly less than the previous season, the bacterial water quality was essentially unchanged. Rainfall and rough lake conditions appeared to have contributed to the daily fluctuations in bacterial levels detected in the lake.

From the bacterial-sediment analyses, it is evident that the fecal-associated bacteria adsorbed onto sediments of creeks, drains and the Ausable River are extremely high in number. These bacterial-sediment levels reflect what has occurred in the past in that particular area with respect to manure entering these water courses. Once the fine sediment (<100 microns) is re-suspended in a creek or drain, it can easily reach the lake and ultimately the beach. From the bacterial survival work, it can be projected that the sediment-bound bacteria survive for lengthy periods before complete die-off results, and hence, beach pollution occurring perhaps in May or June has the potential to impact the beach water quality in July and August.

The bacterial multiple antibiotic-resistance detected in 1984 was re-affirmed with the more extensive evaluation completed this year. Although the *E. coli* examined were likely non-pathogenic, their ability to transfer their resistance to other pathogenic bacteria in the human intestine is well documented.

The serology of the pathogenic bacterium *P. aeruginosa* recovered from various creeks, drains, Ausable River and Grand Bend beach served to confirm that the pollution sources being assessed did contribute fecal wastes to the swimming waters.

From the results of the evaluation of the potential bacteria in the drains or creeks discharging directly to Lake Huron, it was evident that a significant impact from agricultural areas could be detected in the lake in the vicinity of the drain discharge. This impact was also observed when the drainage was not sufficient to flow over the sand beach but appeared to percolate through the sand.

Work regarding the affect of sediments containing high levels of fecal-associated bacteria on the beach water quality is continuing presently. Further investigation of the potential of tile drainage to contribute fecal pollution to the creeks and drains will be conducted. Follow-up examination of the bacteria quality of the drainage at the time of writing, indicates that problems of animal manure entering the creeks and drains in the immediate vicinity of Grand Bend continue to occur. It is anticipated that one or more reports on the on-going work will be produced later.