EXTENT AND CAUSES OF WATER QUALITY PROBLEMS IN SUBSURFACE DRAINAGE IN THE PARKHILL CREEK WATERSHED

PROGRESS REPORT

APRIL 1988

ONTARIO MINISTRY OF AGRICULTURE AND FOOD
AGRICULTURAL ENGINEERING SERVICES
CENTRALIA COLLEGE OF AGRICULTURAL TECHNOLOGY

Prepared by Richard R. Brunke

ABSTRACT

Studies indicate that agricultural land use has a significant effect on water quality of the Great Lakes and is now considered as one of the principal water quality problems in Southern Ontario. From an agricultural standpoint there exists a need to determine causes and impact levels of water quality problems in subsurface drainage.

A three year water quality study of selected farms in the Parkhill Creek watershed was initiated in May, 1986. The following is a progress report of the first year and half of the research. Included in this report is an outline of the procedure, an analysis of the bacterial and chemical parameters studied, and the recommendations for the next years of study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

In recent years we have seen a growing concern for the environment and many studies have been done in the area of water quality. Studies done by the Ausable Bayfield Conservation Authority found the subsurface drains in the Parkhill Creek watershed to be a significant source of pollution; but, did not attempt to identify the sources of tile contamination or to specify what agricultural practices contribute to poor water quality.

This three year research project (initiated in May 1986) was designed to collect a significant data base on water quality from drainage tiles. This will allow a statistical attempt to identify exact sources of tile contamination; both short and long term. It will attempt to segregate which agricultural practices contribute to poor water quality. The following is a progress report of the data collected up to December 1987.

2. WATERSHED DESCRIPTION

The Parkhill Creek watershed is composed of 52 square miles of agricultural land. This long and slender drainage basin is approximately 18 miles long and 3 miles wide, with an average grade of 2.4%. In this watershed, land uses vary from cash crop to intensive livestock operations. The Parkhill Creek empties into the Ausable River, which in turn empties into Lake Huron at Grand Bend. (see map 1)

3. BACKGROUND

One related study was conducted by the Ministry of the Environment (MOE- UTRCA, 1984) in the Pittock watershed. The Pittock watershed is a subwatershed of the Upper Thames River basin. The main objective of this study was to assess the environmental impacts of livestock and practices associated with the handling and storage of livestock manure on water quality. Initially, 15 stations, both surface and sub-surface drains, were sampled weekly to describe the general water quality of the study area. Eventually 38 additional sampling sites were established to monitor individual waste sources. The study reported a surprisingly poor water quality from certain tile outlets. In fact, the average tile water quality approached that of untreated domestic sewage based on bacterial and chemical characteristics. This implies that farm wastes are present in tile effluent. The report on this study recommends that additional investigative field work is required to identify the sources of wastes to drainage tiles and their level of significance.

The Ausable-Bayfield Conservation Authority have conducted a water quality study in the Parkhill Creek watershed (ABCA, 1985). A water sampling program consisting of 8 main sampling stations was conducted by the Ministry of the Environment to determine water quality in the creek and reservoir. The sample analysis focused mainly on the bacterial activity in subsurface drainage tiles. This study determined that subsurface drainage has a significant detrimental effect on water quality and that water quality in Parkhill Creek is unacceptable. Some of the recommendations made by the Ausable-Bayfield Conservation Authorities have been included below:

1. "Further studies should be undertaken to identify sources of contamination in other tributaries of Parkhill Creek not covered in this study. Quantitative studies should be undertaken to determine whether agriculture or other sources are significant."

2. "Where sources of contamination are identified, remedial work should be encouraged in conjunction with monitoring programs to document the effectiveness of remedial measures."

3. "The non-livestock tiles should be monitored more frequently and made during the initial run-off periods in the spring to determine seasonal effects."

4. "Detailed surveys should be conducted in areas having good water quality to determine characteristics of these areas."

There have been numerous related studies conducted on the subject of contaminated subsurface drainage tiles to date. However, it is not the intention of this progress report to present an in-depth literature review. The effects of drainage waters on water quality is not clearly understood, and continued research is necessary to quantify impact levels of various agricultural management practices on water quality of subsurface drainage.

4. OBJECTIVES

The subsurface drainage water quality study was undertaken to determine the extent and causes of water contamination in selected tiles of the Parkhill Creek watershed. The objectives of this research are as follows:

1. To study and determine specific causes of poor water quality in selected subsurface drains of the Parkhill Creek watershed;

2. To establish the impact levels at which specific farm practices affect water quality;

3. To establish where efforts should be concentrated in order to reduce the problem of contaminated drains;

4. To recommend improved farm management techniques to improve water quality of agricultural run-off.

5. METHOD

The first stage of the project consisted of selecting small drainage areas for water sampling purposes. These areas varied in size from 5 to 60 acres but drained to one outlet location. Tile outlets are sampled weekly and analyzed for chemical and bacterial parameters listed in Tables 1 and 2. Site selection was designed to provide an accurate representation of farming activities taking place in the watershed.

The Ministry of the Environment are performing the analysis of the water samples. A written agreement exists between M.O.E and O.M.A.F. regarding ownership and confidentiality of the data. Presently, the agreement states that no release of information or prosecution will result without O.M.A.F. consent.

Since the success of such a project depends a great deal on the cooperation of farm operators, the farmer's attitude has formed part of the site selection criteria. It is evident that the quality of information supplied by farm owners depends on their concern of good water quality and their level of confidence in the project personnel.

On farm interviews are being conducted on each participating farm annually. This gives the project team an opportunity to gather pertinent information regarding farming activities taking place on individual farms (see table 2). It also allows the team to monitor the farmer's views and discuss any specific aspects of the project requested by the farmer.

With this data collected, statistical analysis will give insight in identifying water quality in drainage tiles; both short and long term. Also, an attempt will be made to identify the level at which agricultural practices contribute to water quality.

TABLE 1: Chemical And Bacterial Tests To Be Performed On Water Samples.

CHEMICAL	**BACTERIAL**
- Free Ammonia	- Fecal Coliforms
- TKN	- Fecal Streptococci
- Nitrate	- *Pseudomonas Aeruginosa*
- Nitrite	
- Total Phosphorus	
- Soluble Phosphorus	
- pH	
- Chloride	
- Total Solids	
- Suspended Solids	
- Dissolved Solids	

TABLE 2: Data To Be Collected On All Farms Involved**.**

1) Type of livestock enterprise and intensity of operation

2) Crops grown:
- number of acres
- fertilizing methods

3) Terrain:
- slope of land
- texture
- soil type

4) Tiling:
- portion of land that is drained
- portion of tiled land where manure is spread
- type of tiling system
- catch basins
- depth of drains, spacing

5) Manure storage:
- type
- storage capacity

6) Manure application:
- type of spreader or applicator
- time of application
- rate of application
- location of manure application
- proximity of location to water course
- are the soil and manure analyzed regularly?

7) Livestock watering:
- do livestock have stream access? If so, state location of access.
- time of access

TABLE 3: Site Descriptions.

Station Code	Operation Type	Outlet Size (Inches)	Acreage Drained (Acres)	Type Of Tile Layout
1	Beef	10	50	Systematic
2	Beef	10	50	Systematic
3	Dairy	12	30	Random
4	Beef/Hogs	10	50	Systematic
5	Beef/Hogs	8	20	Systematic
6	Dairy	6	15	Random
7	Beef/Hogs	6	20	Systematic
8	Beef	6	15	Random
9	Beef	6	15	Random
10	Beef	6	15	Systematic
11	Beef	8	25	Systematic
12	Cashcrop	8	25	Systematic
13	Dairy	12	60	Systematic
14	Cashcrop	10	30	Systematic

6. RESULTS AND DISCUSSION

The following data analyzed has been collected over approximately a year and a half, starting at the beginning of the project in July 1986 to December 1987.

A summary of the total monthly precipitation for this report period is presented in graph form in figure 2. Precipitation data was obtained from the Crop Science Department at Centralia College of Agricultural Technology. As seen from the figure 2, the fall of 1986 was extremely wet when a number of record rainfalls occurred. The summer of 1987 was an extremely dry summer in the research water-shed area.

6.1 BACTERIAL ANALYSIS:

The bacteria data collected for the samples sites was analyzed by two methods:

1. by calculating the geometric means for each individual site over one year;

2. by calculating the geometric means for each month of all the monthly data put together.

Method 1 gives an overview of water quality of each site and differentiates the sites with acceptable and non-acceptable subsurface drainage water quality. Method 2 shows the monthly water quality which display long and short term trends. As the database is increased into the third year the results will increase in accuracy.

Table 4 presents a summary of the calculated geometric means for each individual site during the year of 1987. As can be seen from table 4 the water quality for the majority of the tiles is below the Ministry of the Environment (M.O.E.) guideline for recreational water use with the exception of five tiles. Of these five tiles, through field investigation it was determined that four have direct connection to gray water sources such as septic tank, milkhouse waste, barnyard run-off or a combination of any of these. For the fifth tile the source was not found and more site investigation is required. Refer to Table 3 for a description of each site.

The results from the monthly geometric means (method 1) are summarized in table 5 and plotted in figure 3, 4, 5, and 6. The results show that the majority of the monthly geometric means are above the M.O.E. guidelines. If non-acceptable farming practices, such as tiles draining, septic waste, milkhouse waste and barnyard run-off, were removed from the data and only the acceptable farming practices were examined the geometric means would change substantially where the majority of the values would be below the M.O.E. guidelines as reported in table 6 and plotted in figure 3, 4, 5 and 6. This is removing only the stations that are known to have gray water connection, which are station 3, 7, 8 and 11, but not station 5 since the source of contamination has been not determined.

By removing the sites which have gray water connections a more precise representation of the water quality from field tiles is obtained. This is observed when comparing the monthly water quality results and the precipitation data. A visible low correlation is observed when comparing table 5 with the precipitation whereas a relatively high correlation occurs when correlating table 6 and the precipitation, except during the summer months when the soil was very dry during which any precipitation was absorbed by the soil.

The Parkhill creek is also being monitored weekly at five stations along the stream. This will allow a comparison of the tile effluent and the creek water quality. The data is not analyzed in this report but will be in the following one.

6.2 CHEMICAL ANALYSIS:

The chemical data collected for the samples sites was analysed by the same methods as the bacteria for the same reasons:

1. by calculating the means for each individual site over one year;

2. by calculating the means for each month of all the monthly data put together.

The results of the calculated means for the year are presented in table 7 and the monthly means are reported in table 8.

Similar to the analysis done to the bacterial monthly geometric means, table 9 presents the monthly means with the non-acceptable farming practices removed (stations 1, 2, 3 and 4 removed). These two tables, 8 and 9, display concentration differences between acceptable and non- acceptable farming practices. As can be observed there is a relatively large contribution of chemicals from the gray water sources. A more in-depth statistical analysis will be reported in the following report.

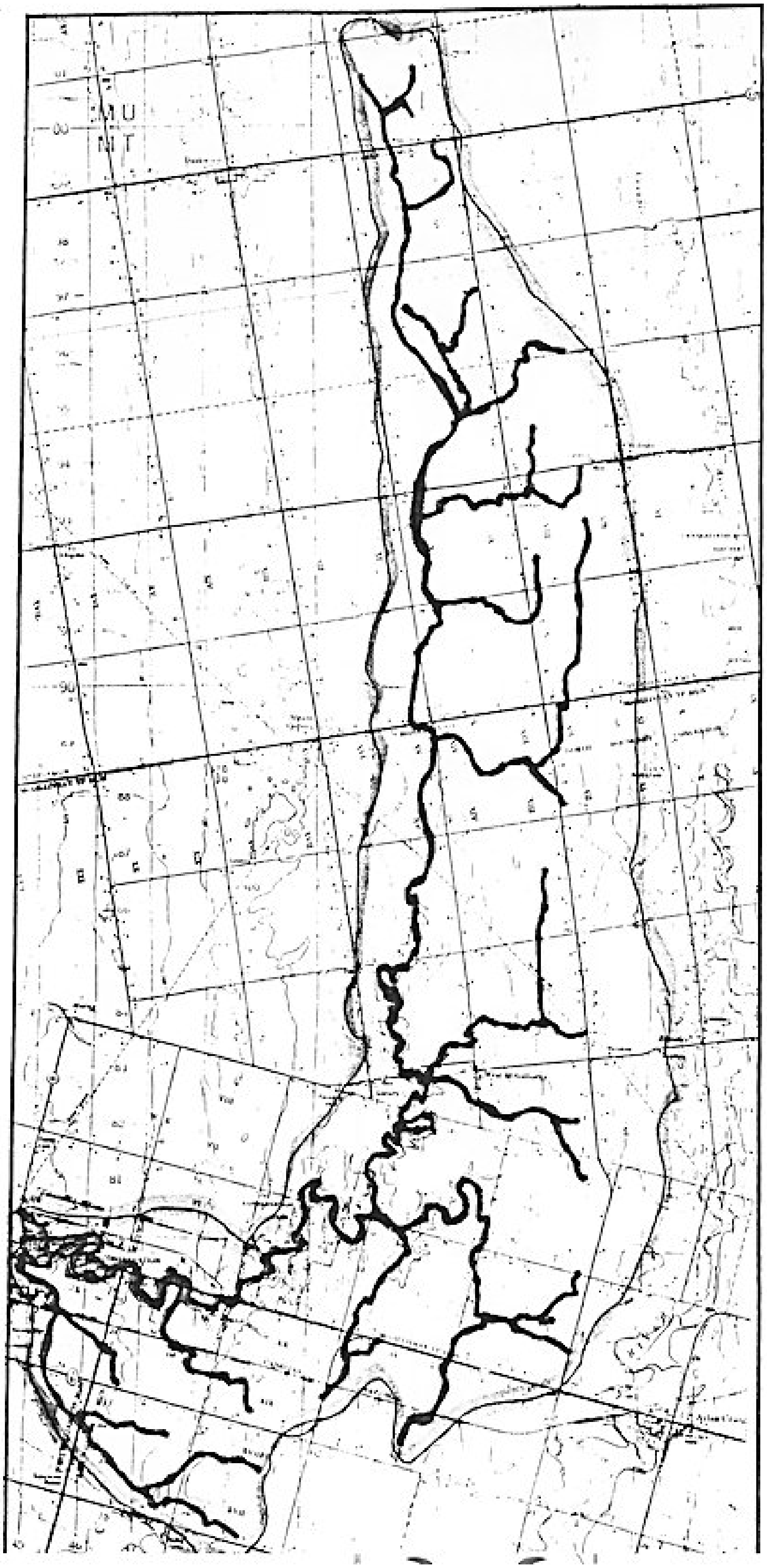
7. CONCLUSIONS:

The sample sites were selected to provide a representation of the farming activities taking place in the watershed. To date, one and half years of data have been collected.

From the bacteriological data collected, so far, it has been observed from the yearly geometric means calculated, nine tiles had acceptable water quality and five had non-acceptable water quality. Of the tiles with the poor water quality, the source of the problem has been determined through field investigation for four tiles. The problems were due to direct connection to gray water sources such as septic tanks, milkhouse waste, barnyard run-off or combination of any of these.

For acceptable farming practices, the majority of monthly geometric means for 1987, meet the requirements of M.O.E. guidelines for recreational water use.

For the next year and half, plans are to continue the weekly sampling and to do a in-depth investigation of each sampling site and attempt to determine what is the cause of contamination or contaminations, or why the tile is not contaminated. Aerial photos will be taken to help to determine where the field tiles were installed. Soil samples will be taken during the summer and, with the advice of an agrologist, compare actual fertilizer applications to recommended ones. This will hopefully give insight into the nitrogen and phosphorus levels present in the water samples. A computer program will be constructed to assist in analyzing the field data collected.



PARKHILL WATERSHED

CREEK

BOUNDARY

TABLE 4: The Yearly Geometric Means Of The Bacterial Data Collected In 1987.

STATION	FC/100ml	FST/100ml	Ps.A/100ml	E.Coli/100ml	n
1	11.8	50.3	4.6	10.0	30
2	57.5	101.9	8.8	45.5	35
3	9532	3962.5	17.6	8386.7	36
4	10.5	15.6	4.0	8.4	24
5	14.4	26.4	8.0	14.1	17
6	384.5	738.7	11.4	338.4	16
7	60500	498	78.4	51930	24
8	443	212	11.4	367.1	32
9	9.2	35.9	4.2	8.7	28
10	10.7	58	6.3	8.7	21
11	487	127	8.7	432.6	23
12	77.7	15.2	4.8	63.3	20
13	14.4	37.1	5.0	12.2	29
14	6.0	22.7	4.0	5.1	27

TABLE 5: Summary Of The Monthly Bacterial Geometric Means.

STATION	FC/100ml	FST/100ml	Ps.A/100ml	E.Coli/100ml	n
July	175	642	10	151	50
August	440	518	31	363	23
September	9951	15443	23	8100	24
October	898	2248	11	785	52
November	61	46	6	51	41
December	78	75	6	68	36
January	77	54	4	66	24
February					0
March	90	20	5	72	15
April	30	23	5	26	47
May	29	13	5	25	49
June	72	81	8	56	49
July	694	462	31	598	18
August	1247	454	26	942	16
September	2916	2936	53	2482	8
October	312	573	14	259	37
November	70	105	7	61	52
December	117	304	7	99	48

TABLE 6: Summary Of The Monthly Bacterial Geometric Means Of The Acceptable Farming Practices Only.

STATION	FC/100ml	FST/100ml	Ps.A/100ml	E.Coli/100ml	n
July /86	39	281	6	35	41
August	39	156	11	30	16
September	2821	10058	16	2161	18
October	390	1736	7	329	39
November	17	21	4	14	29
December	22	31	6	19	26
January /87	37	40	4	33	18
February					0
March	14	9	4	12	9
April	10	10	4	9	36
May	9	5	4	9	36
June	18	48	6	15	39
July	20	50	8	16	11
August	76	63	6	61	9
September	26	95	12	22	3
October	33	169	10	27	25
November	24	62	6	21	38
December	59	211	6	51	38

TABLE 7: Yearly Means Of The Chemical Data Collected In 1987.

Station	Solids	Sus Solids	Dis-Solids	NH_3	TKN	NO_3^-	NO_2^-	Tot. P	Sol. P	pH	Cl^-	n
1	445.3	7.4	437.9	0.06	0.5	0.01	8.34	0.07	0.04	7.7	25.7	29
2	497.2	8.7	502.3	0.04	0.67	0.05	9.39	0.16	0.10	7.7	28.98	29
3	893.3	210.9	683.2	6.13	14.22	0.53	6.96	13.87	9.08	7.5	59.8	32
4	502.2	7.6	499.1	0.04	0.6	0.02	17.5	0.08	0.05	7.5	22.3	25
5	547.0	7.8	540.1	0.05	0.53	0.01	22.2	0.07	0.05	7.2	65.1	17
6	535	25.3	513.1	1.03	3.64	0.07	6.59	6.1	4.51	7.4	36.5	15
7	625.9	23.8	602.1	6.87	10.44	0.48	10.48	3.08	2.27	7.5	45.8	20
8	662.4	21.1	641.3	0.3	1.92	0.07	9.64	0.52	0.32	7.5	73.3	32
9	476.3	6.1	470.1	0.04	0.51	0.01	8.87	0.04	0.03	7.7	25.6	29
10	485	6.5	478.5	0.07	0.65	0.02	12.32	0.12	0.08	7.7	33.7	20
11	484	6.5	477.4	0.09	0.63	0.02	8.45	0.19	0.14	7.6	32.7	23
12	344.5	10.0	339.0	0.05	0.40	0.01	8.21	0.08	0.03	7.3	11.6	20
13	429.6	5.3	409.9	0.04	0.47	0.01	8.38	0.05	0.03	7.7	21.3	29
14	418.2	5.5	412.7	0.04	0.41	0.01	10.48	0.03	0.02	7.7	22.7	26

TABLE 8: Summary Of Results Monthly Chemical Means In 1987.

Station	Solids	Sus Solids	Dis-Solids	NH_3	TKN	NO_3^-	NO_2^-	Tot. P	Sol. p	pH	Cl	n
July /86	618.7	10.7	616.1	1.24	2.31	0.04	13.88	0.47	0.39	7.6	40.74	50
August	689.1	17.9	671.2	3.40	6.80	0.06	5.89	3.52	2.84	7.5	50.12	23
September	654.3	67.4	566.5	1.15	2.82	0.05	6.00	3.10	1.72	7.4	29.39	24
October	553.7	83.0	446.7	0.61	3.68	0.04	4.33	0.81	0.42	7.2	23.07	52
November	498.3	7.4	490.9	0.58	1.85	0.18	4.18	1.70	1.48	7.8	27.40	41
December	488.7	8.1	480.6	0.24	1.18	0.03	4.96	1.15	0.78	7.6	28.39	36
January /87	468.2	5.0	463.2	0.13	0.58	0.02	5.90	0.23	0.14	7.7	26.83	24
February												0
March	466.3	15.1	423.4	0.89	2.44	0.05	6.29	3.01	1.87	7.5	24.00	15
April	478.0	8.1	478.4	0.46	1.28	0.08	8.14	1.14	0.90	7.6	26.50	47
May	503.6	15.5	488.2	0.83	1.52	0.15	7.62	0.82	0.42	7.6	25.99	49
June	634.4	103.7	531.3	1.04	2.55	0.11	8.75	1.82	1.43	7.6	26.73	49
July	621.9	36.0	585.9	4.10	7.20	0.09	7.03	4.34	3.55	7.6	37.28	18
August	835.1	136.8	698.4	8.12	19.56	0.11	3.46	20.43	13.50	7.4	64.57	16
September	750.0	14.4	741.5	3.97	10.08	0.03	10.36	14.55	5.35	7.7	350.08	8
October	630.8	48.7	604.9	2.37	5.01	0.11	17.05	2.62	2.01	7.5	42.76	37
November	559.1	10.5	549.7	0.18	1.11	0.18	16.58	0.43	0.33	7.5	40.61	52
December	400.1	10.7	399.5	0.16	1.01	0.02	11.35	0.25	0.15	7.5	25.70	48

TABLE 9: Summary Of Results Monthly Chemical Means With The Contaminated Tile Removed.

STATION	Solids	Sus Solids	Dis-Solids	NH_3	TKN	NO_3^-	NO_2^-	Tot. P	Sol. P	pH	Cl	n
July /86	630.3	52.5	586.0	0.03	0.74	0.03	14.03	0.16	0.09	7.5	39.06	41
August	597.9	6.9	591.0	0.04	0.64	0.03	7.81	0.38	0.33	7.6	46.00	16
September	633.5	95.0	512.6	0.04	1.05	0.02	4.69	0.31	0.13	7.3	21.64	18
October	549.6	94.1	450.4	0.68	4.02	0.03	4.18	0.68	0.36	7.3	21.08	39
November	449.3	5.0	444.3	0.07	0.52	0.15	4.15	0.07	0.04	7.9	21.38	29
December	454.9	5.0	449.9	0.03	0.38	0.01	4.67	0.04	0.03	7.7	23.63	26
January /87	453.1	5.0	448.1	0.02	0.33	0.01	5.97	0.03	0.02	7.7	24.11	18
February												0
March	404.0	12.9	344.6	0.02	0.54	0.01	5.40	0.17	0.04	7.7	15.72	9
April	434.2	4.2	442.2	0.05	0.35	0.01	7.83	0.04	0.02	7.8	21.44	33
May	442.2	7.0	435.1	0.01	0.37	0.01	7.65	0.05	0.04	7.6	20.58	36
June	492.0	4.7	487.3	0.01	0.41	0.01	9.55	0.06	0.05	7.7	22.47	39
July	522.8	4.5	518.3	0.01	0.44	0.01	8.36	0.06	0.04	7.7	25.10	11
August	571.3	4.9	566.4	0.01	0.50	0.02	7.50	0.16	0.17	7.9	32.33	9
September	592.0	11.0	590.7	0.01	0.74	0.02	14.50	0.20	0.18	7.9	244.64	3
October	531.6	10.1	505.0	0.03	0.84	0.06	20.40	0.13	0.07	7.6	32.17	25
November	523.0	7.5	515.5	0.12	0.64	0.02	16.90	0.11	0.08	7.6	35.39	38
December	380.3	9.9	362.9	0.12	0.79	0.02	11.23	0.14	0.07	7.5	22.87	38

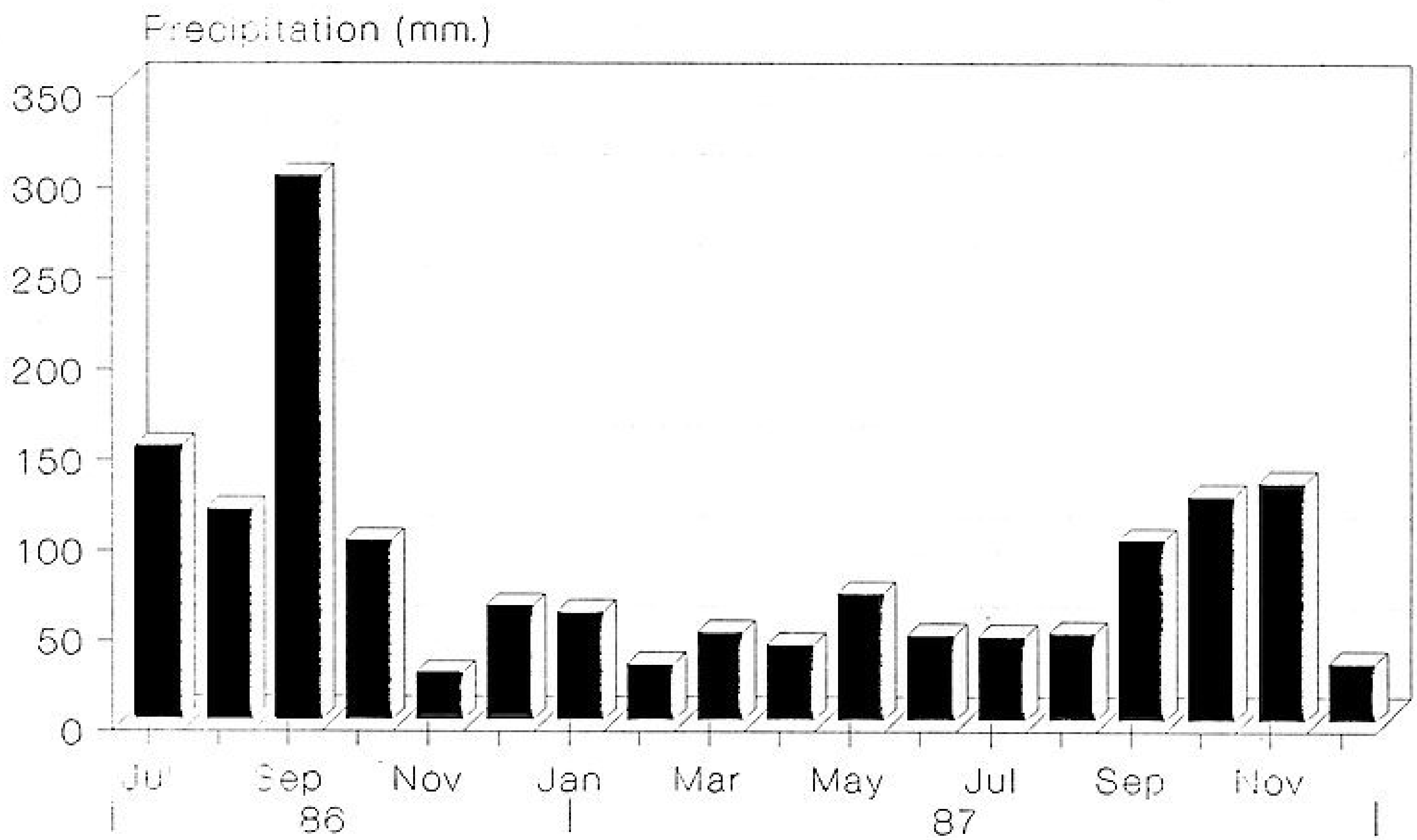


FIGURE 1: Monthly Precipitation From July 1986 to Dec. 1987 Recorded at Centralia College Research Farm.

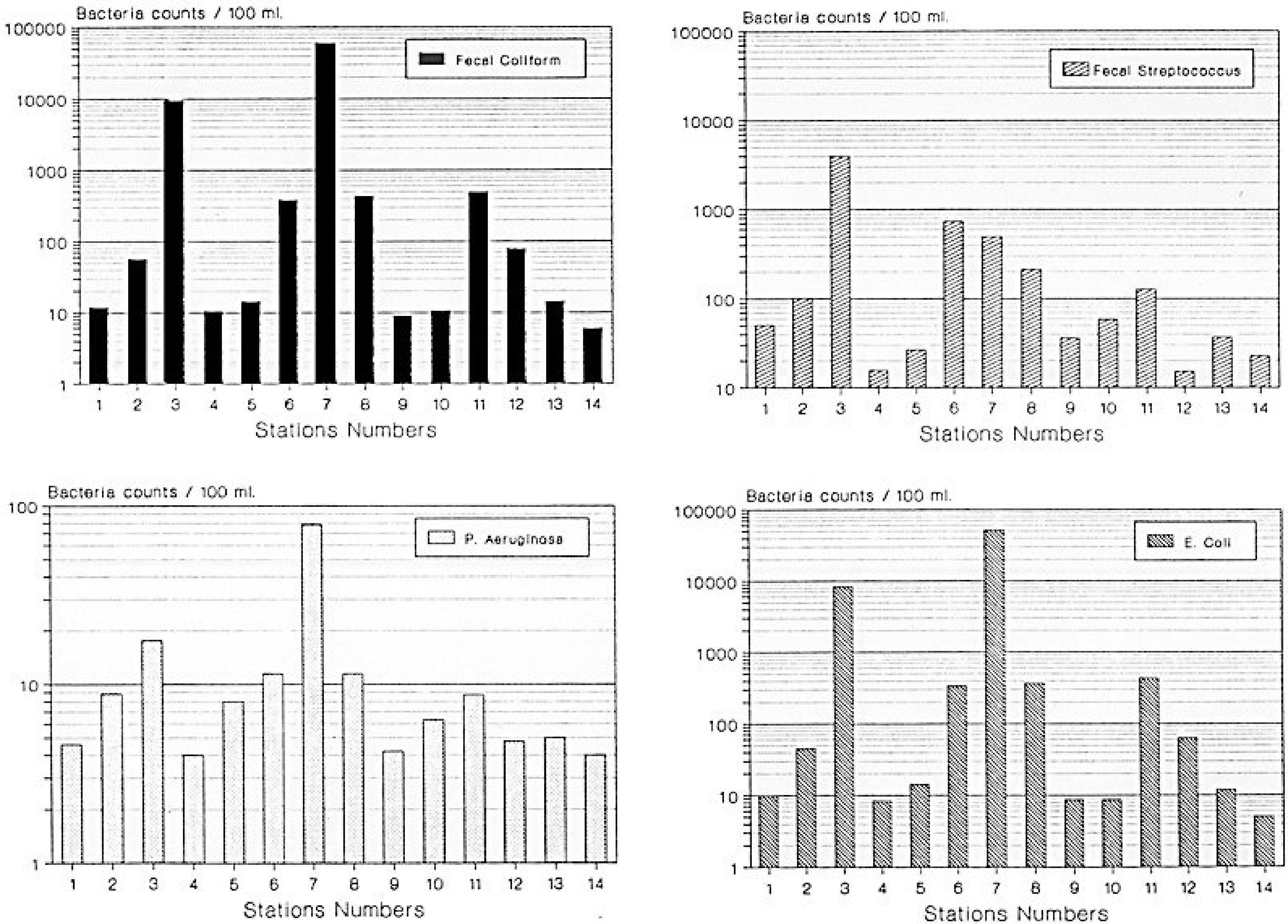
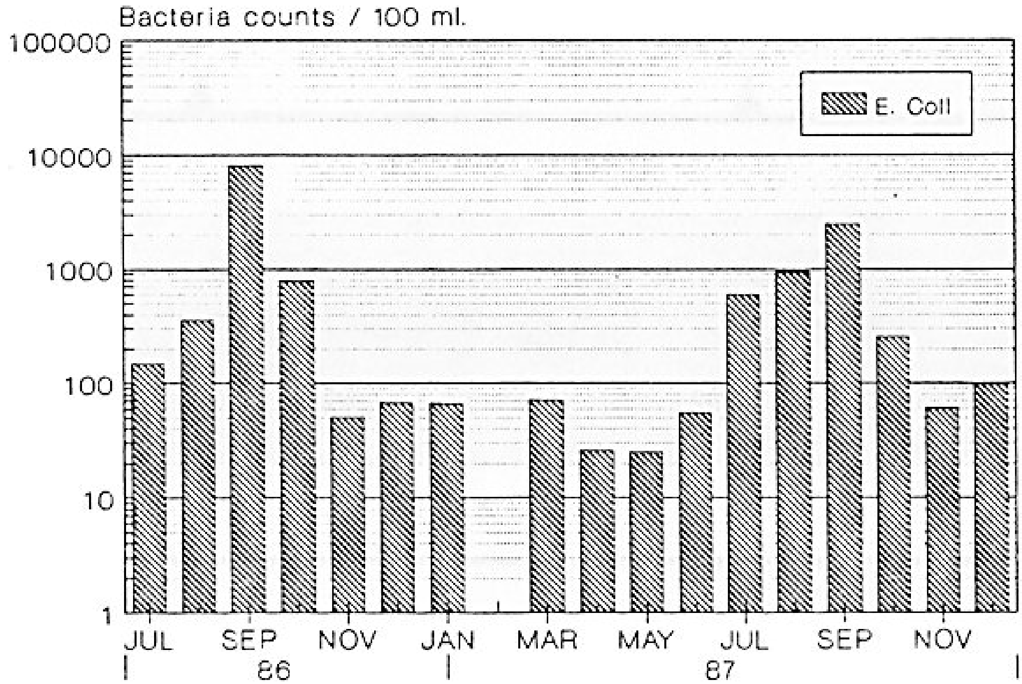


FIGURE 2: 1987 Bacterial Geometric Means For Each Sampling Station.



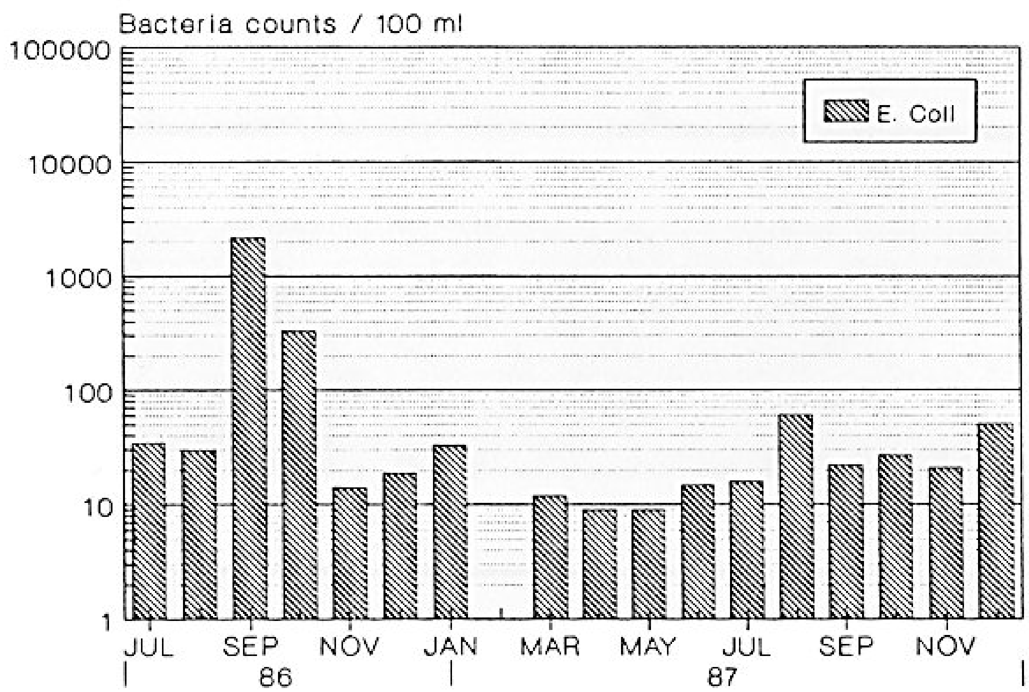


FIGURE 3: Comparison of the Geometric Means For E. Coli: With All Stations Included (Top Graph) And With Acceptable Farming Practices Only (Bottom Graph).

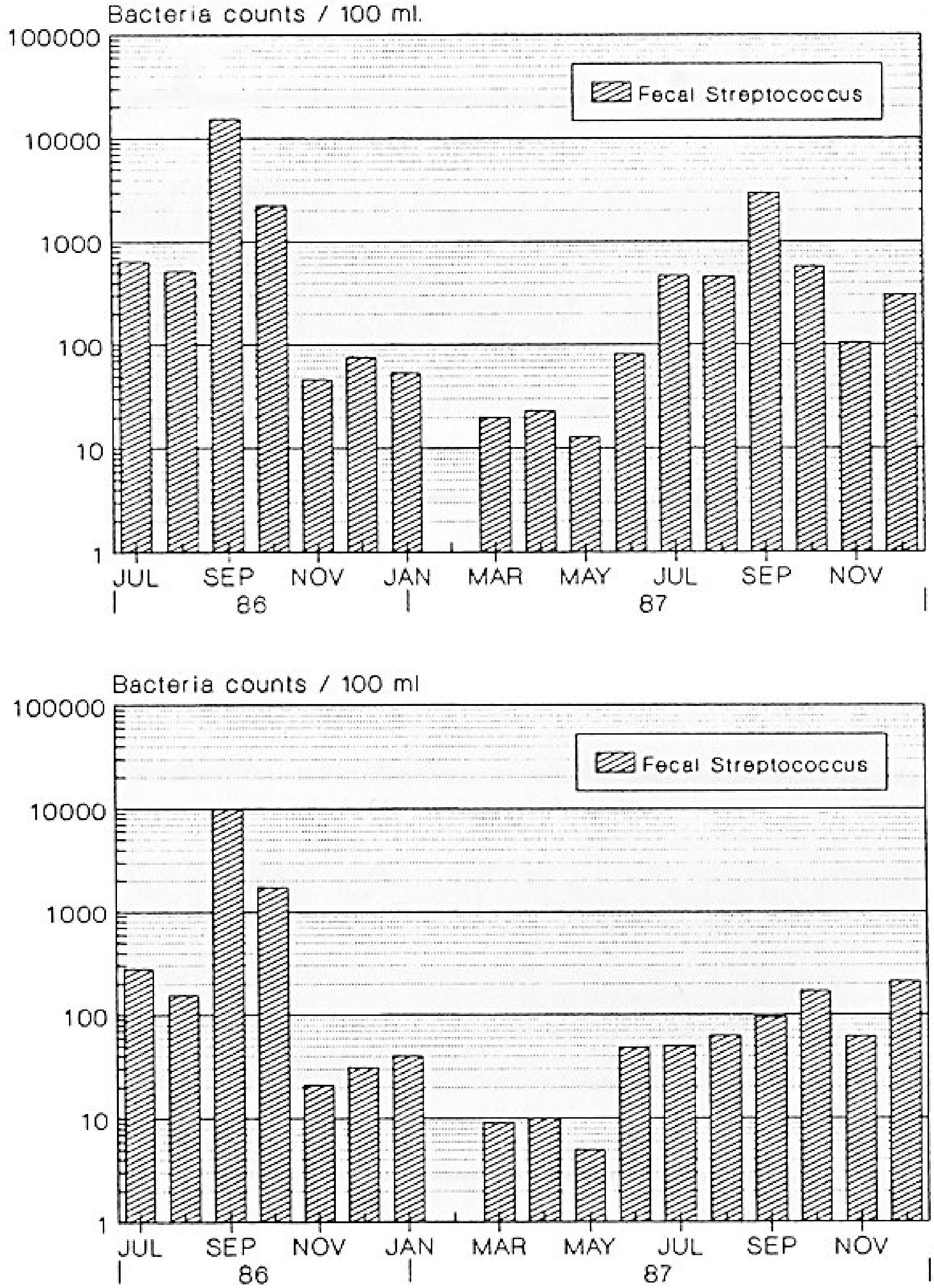


FIGURE 4: Comparison of the Monthly Geometric Means For Fecal Streptococcus: With All Stations Included (Top Graph) and With Acceptable Farming Practices Only (Bottom Graph).

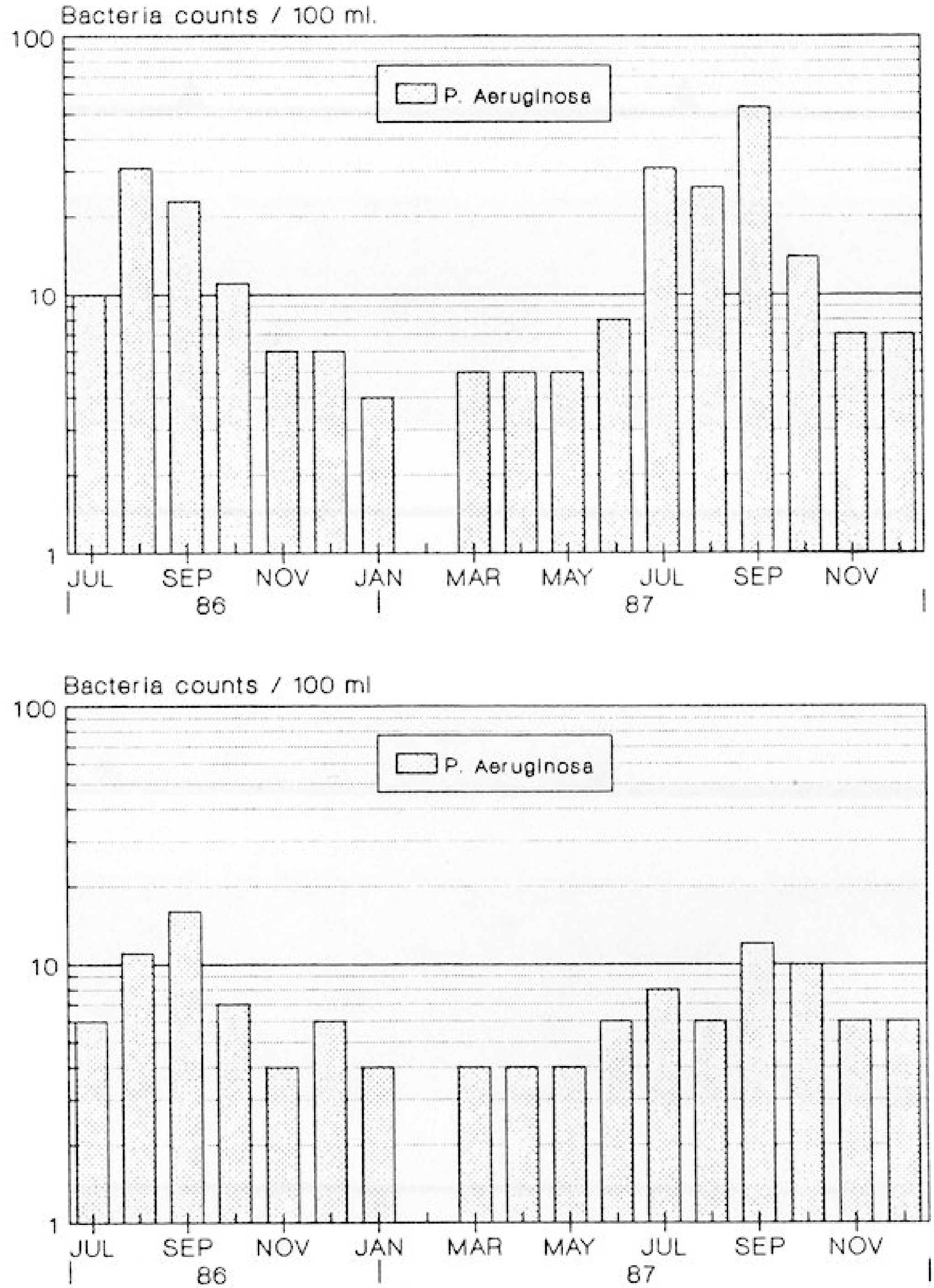
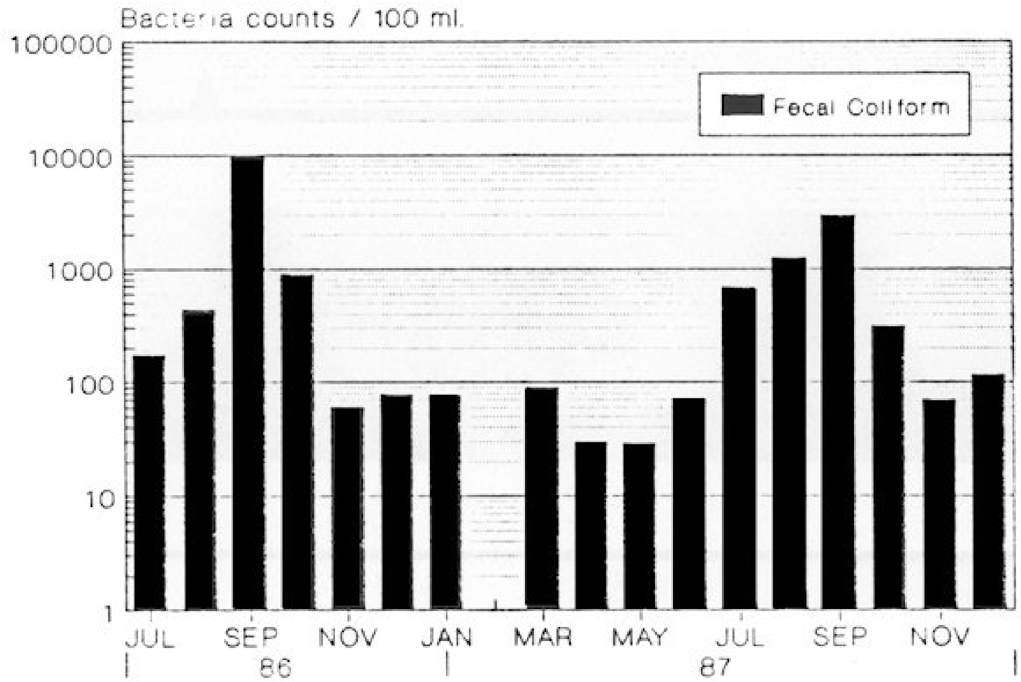


FIGURE 5: Comparison of the Monthly Geometric Means For Pseudomonas Aeruginosa: With All Stations Included (Top Graph) And With Acceptable Farming Practices Only (Bottom Graph).



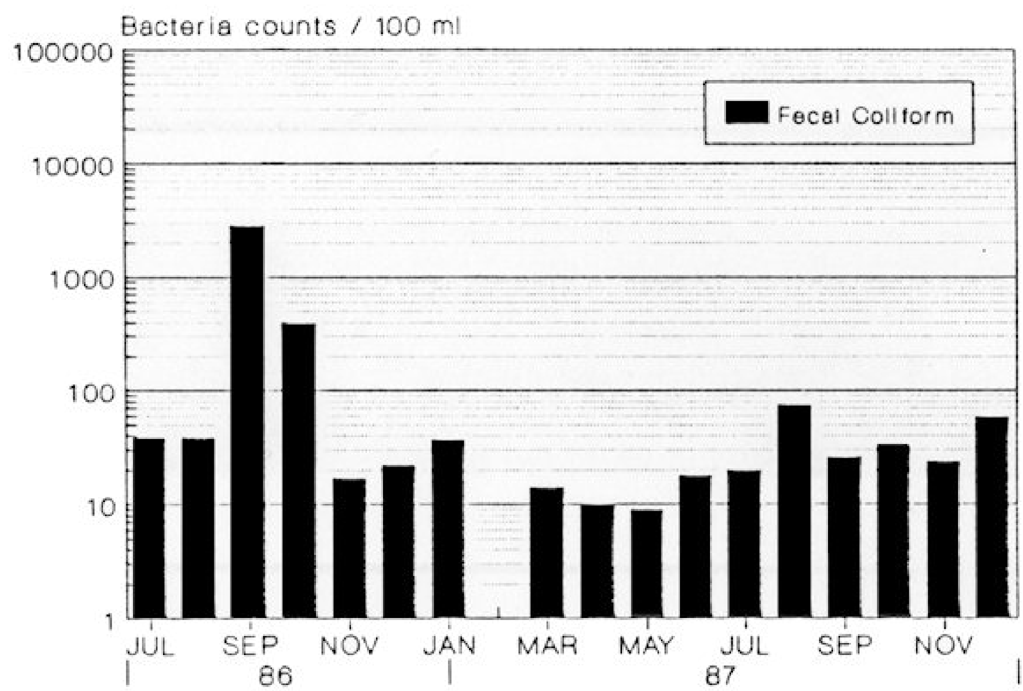


FIGURE 6: Comparison of the Monthly Geometric Means For Fecal Coliform: With All Stations Included (Left Graph) and With Acceptable Farming Practices Only (Right Graph).

TABLE 10: Corresponding Station Numbers With Station Labels For Comparison With 1986 Report.

Station Code Labels	Station Code Numbers	Outlet Size (Inches)	Acreage Drained (Acres)
MCGRS1	1	10	50
MCGRS2	2	10	50
MCGTN2	3	12	30
STGN1	4	10	50
STGN2	5	8	20
STGS1	6	6	15
STJN1	7	6	20
STPL1	8	6	15
STPL2	9	6	15
STPN1	10	6	15
STPN2	11	8	25
STVN2	12	8	25
STWR1	13	12	60
STVN1	14	10	30