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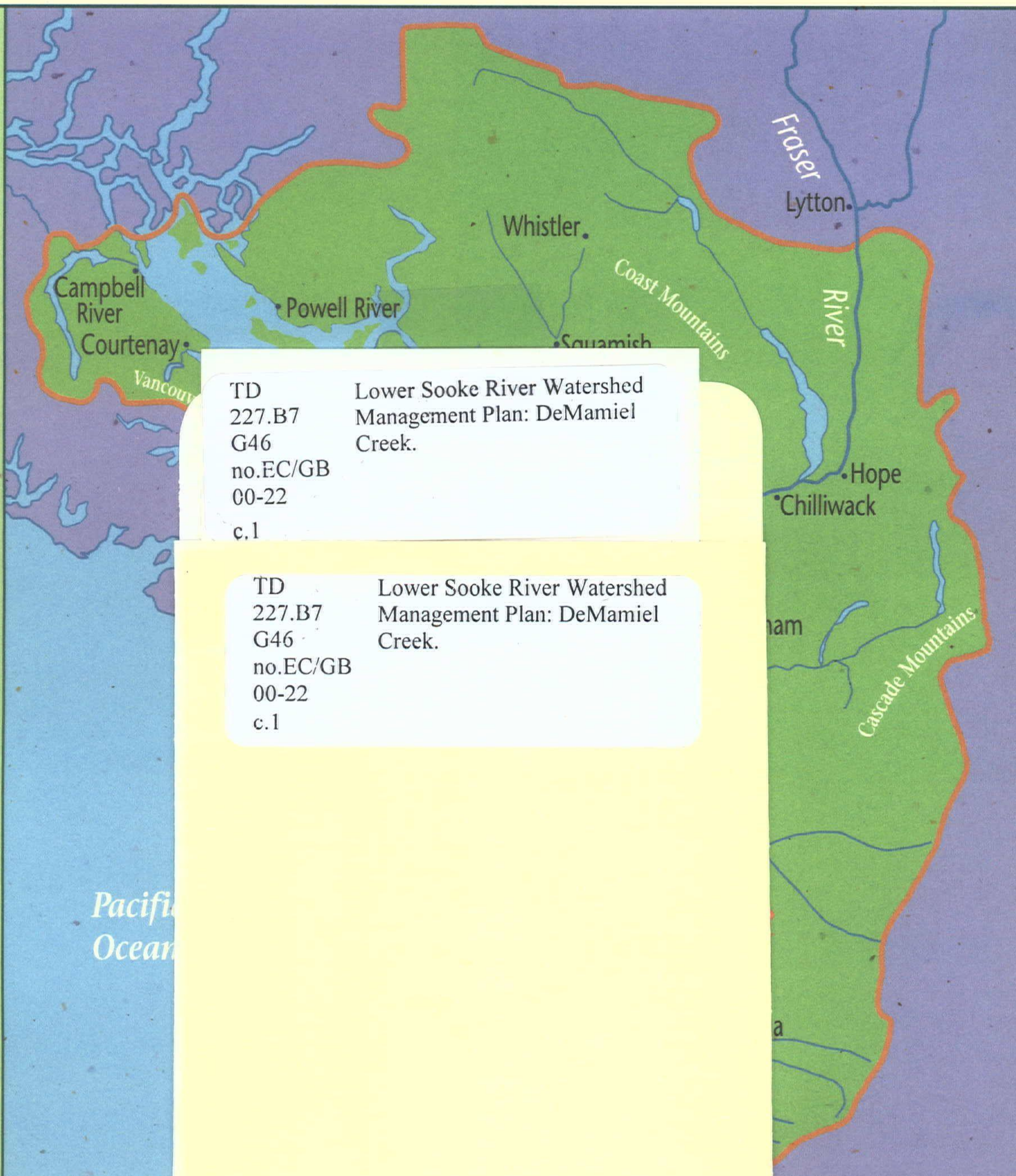
Lower Sooke River Watershed Management Plan: De Mamiel Creek

Environment Canada Environnement Canada

Royal Roads University

British Columbia Ministry of Environment, Lands and Parks

The Georgia Basin Ecosystem



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Lower Sooke River Watershed Management Plan: De Mamiel Creek

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This study contributes to the Georgia Basin Ecosystem Initiative,
a partnership that provides tools, support and a framework
for action towards sustainability in the Georgia Basin.

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RÉSUMÉ

Entre 1998 et 1999, une équipe d'étudiants de la Royal Roads University, *Integrated Environmental Consultants*, a étudié la pollution diffuse de l'eau dans le bassin hydrographique du cours inférieur de la rivière Sooke. L'étude avait pour but de déterminer les sources d'une telle pollution et a porté sur les rivières Sooke et De Mamiel. On a recommandé de prolonger l'étude de la rivière De Mamiel afin de déterminer dans quelle mesure la pollution de cette rivière contribuait à la fermeture des eaux coquillières situées dans la baie Sooke.

En janvier 2000, Azimuth Environmental Consulting a été engagé pour mener à bien la phase II de ce projet (*The Lower Sooke River Watershed Management Plan*), présentement parrainée par le ministère de l'Environnement, des Terres et des Parcs de la Colombie-Britannique, le District régional de la capitale et Environnement Canada.

Une fois par semaine, les participants ont prélevé des échantillons d'eau dans lesquels ils ont ensuite mesuré la concentration en colibacilles fécaux, en *E. coli*, en streptocoques fécaux, et en entérocoques. Ils ont également mesuré des paramètres physiques tels que le pH, la turbidité, la conductivité, l'oxygène dissout et la température. Une fois par mois, les étudiants ont prélevé des échantillons d'eau dans lesquels ils ont mesuré la concentration en nutriants, notamment en ammoniaque, en nitrates et en phosphore dissout total.

Le deuxième objectif du projet consistait à cartographier la rivière De Mamiel et à mettre en place une base de données SIG (système d'information géographique) à l'aide d'instruments SIG et en vérifiant les mesures sur le terrain.

Ces travaux ont permis à Azimuth d'analyser le degré de corrélation entre l'utilisation des terres, les coordonnées des sites d'échantillonnage, les précipitations, les résultats des analyses de la qualité de l'eau et l'existence de contributeurs diffus à la pollution de la rivière De Mamiel. L'analyse des données issues de quatre sites d'échantillonnage montre qu'il n'existe aucune corrélation entre les précipitations et le degré de contamination microbienne. L'observation de niveaux élevés de colibacilles fécaux et d'autres indicateurs microbiens a néanmoins était prise en compte dans les recommandations qu'Azimuth a rédigées pour la gestion futures du bassin hydrographique de la rivière De Mamiel.

Les spécialistes d'Azimuth Environmental Consulting pensent que la sensibilisation du public est un élément clé de la gestion des problèmes de pollution et ils ont donc organisé, le 24 juin 2000, la première rencontre sociale de Sooke portant sur les fosses septiques. Cet atelier de sensibilisation communautaire était conçu pour apprendre aux propriétaires de maisons individuelles à entretenir convenablement leurs systèmes septiques et à reconnaître les signes indiquant un manque d'entretien.

S'appuyant sur le résultat des études conduites cette année, Azimuth a recommandé que le projet soit prolongé l'année prochaine en y ajoutant des échantillonnages lors

d'événements particuliers, l'utilisation de colorants et, le cas échéant, l'analyse des empreintes génétiques pour déterminer de manière précise les sources de pollution diffuse. Azimuth espère également qu'on continuera à mettre à jour la base de données SIG et à sensibiliser la communauté grâce à l'organisation d'événements communautaires annuels à Sooke.

EXECUTIVE SUMMARY

Between 1998 and 1999 Integrated Environmental Consultants, a team of students from Royal Roads University carried out an assessment of non-point source (NPS) water pollution on the lower Sooke River watershed, in an attempt to determine possible sources of NPS pollution. Both Sooke River and De Mamiel Creek were examined. It was recommended that De Mamiel Creek be further studied in order to determine to what degree De Mamiel Creek is contributing to the shellfish closures in the Sooke Basin.

In January of 2000, Azimuth Environmental Consulting were contracted to perform Phase II of this study, "The Lower Sooke River Watershed Management Planning", which is presently sponsored by the British Columbia Ministry of Environment, Lands and Parks (MELP), Capital Regional District (CRD), and Environment Canada.

Water was sampled weekly and analyzed for microbial indicator species, including fecal coliforms, E. coli, fecal streptococcus, and enterococci; and physical parameters including pH, turbidity, conductivity, dissolved oxygen, and temperature. Every month, water samples were obtained and tested for nutrients, including ammonia, nitrite, nitrite and nitrate, and total dissolved phosphorus.

A second objective of this project included mapping De Mamiel Creek and designing a geographic information system database. This was achieved through ground truthing and mapping, using a global positioning system.

This has lead Azimuth to the correlation of land uses, sample sites, precipitation, water quality results, and possible non-point source contributors

to De Mamiel Creek. The analysis of the data from four samples sites shows no direct relationship between precipitation and microbiological contamination. However, raised levels of fecal coliforms and other microbial indicators were found, leading Azimuth to their recommendation for the future management of the De Mamiel Creek watershed.

Azimuth Environmental Consulting believes that public awareness is key to managing pollution issues and therefore hosted the first ever Sooke Septic Social on June 24, 2000. This community awareness event was intended to inform homeowners about the signs and effects of poorly maintained septic systems and how to properly manage a septic tank.

Based on studies conducted this year, Azimuth recommends that this project be continued in its full form next year, with the addition of event sampling, dye testing, and perhaps genetic fingerprinting to help accurately determine non-point pollution sources. As well, Azimuth hopes that the GIS database will be maintained, and community awareness events continue annually in Sooke.

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Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION

Non-point source water (NPS) pollution is the result of one or more activities taking place over time. Pollution from these sources is usually subtle and accumulates gradually. It is difficult to identify and usually the result of many smaller polluting activities taking place over a longer period of time. Non-point source pollution differs from point sources are generally a single identifiable source, such as an industrial outfall. Because a point source is much easier to identify, emphasis in the past has been on controlling discharging of pollutants from municipal or industrial sources.

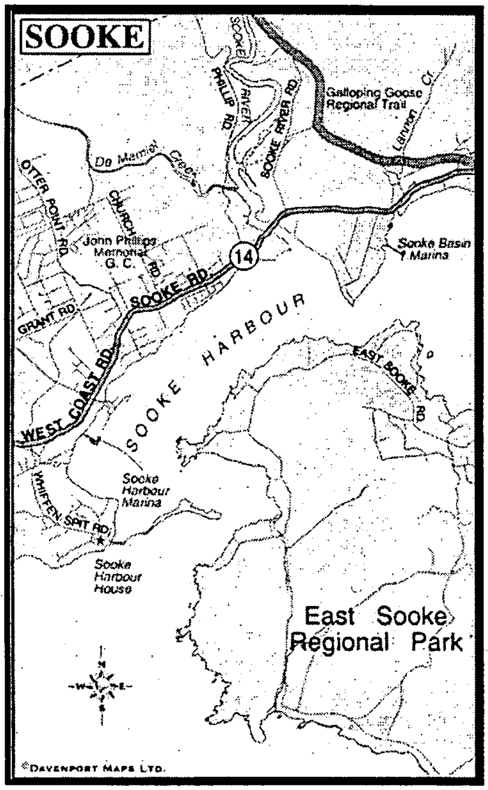


Figure 1: Location of De Mamiel Creek

In British Columbia, non-point source water pollution occurs as a result of any of the following activities: land development, agriculture, stormwater runoff and combined sewer outfall, on-site sewage systems, wildlife, forestry and range activities, and boating and marine activities.

Between 1998 and 1999 Integrated Environmental Consultants, a team of students from Royal Roads University, carried out an assessment of non-point source water pollution on the lower Sooke River watershed to determine possible sources of NPS pollution. Both the Sooke River and De Mamiel Creek were examined (Figure 1). It was recommended that De Mamiel Creek be further studied in order to determine to what degree De Mamiel Creek is contributing to the shellfish closures in the Sooke Basin. Shellfish are particularly susceptible to bacterial contamination since they concentrate bacteria through bivalve filter feeding processes. With each filtration, they sweep water from the basin and filter out plankton and organic material, as well as any microbial pathogens that may be present.

In January of 2000, Azimuth Environmental Consulting, five students currently enrolled at Royal Roads University (RRU), were contracted to perform Phase II of this study, which is presently sponsored by the British Columbia Ministry of Environment, Lands and Parks (MELP) and Environment Canada's shellfish monitoring department.

1.1 Objectives

The project objectives were threefold. The main phase of this study was to examine fecal contamination from non-point sources in the De Mamiel Creek watershed and to determine how these contribute to shellfish closures in the Sooke Basin. A second objective was to provide information to the community on how NPS pollution can impact water quality, with solutions to reduce harmful impacts to the creek. The third objective was to create a geographical information system for De Mamiel Creek, where the features and possible sources of NPS pollution could be mapped.

2.0 HISTORY REVIEW

Interviews were conducted with representative groups of shellfish industry stakeholders in Sooke. The stakeholders in the area included the owner of Cooper's Cove Oyster Farm, Ed Helgesen, the T'Sou-ke Nations and the public. A historian at the Sooke Museum was also interviewed to determine how development has occurred in Sooke, as water quality is affected by urbanization and population growth.

2.1 Sooke Shellfish Industry

The main shellfish harvester in Sooke is Cooper's Cove Oyster Farm, located on Belvista Road. Cooper's Cove Oyster Farm is a well-known, family owned business in Sooke that has been run by the Helgesen family for over fifty years. Cooper's Cove is presently the largest processor of clams on Vancouver Island. Ed Helgesen was interviewed to establish the history and present state of the shellfish industry in Sooke.

The Helgesen business has undergone many changes over the past fifty years as the basin has become increasingly polluted. Closure of the shellfish harvest fifteen years ago forced the Helgesens to change the way they processed clams and oysters. The current shellfish restrictions require that all shellfish harvested in the Sooke Basin be depurated before they can be sold.

Cooper's Cove harvests oysters from a leased piece of sea floor in the Sooke Basin. The harvested oysters are transported to northern Vancouver Island to be depurated in natural, uncontaminated waters. Cooper's Cove uses natural processes to purify the harvested oysters because on-site depuration of these shellfish is too expensive.

The other local shellfish harvesting company, Manila Mining Co., harvests the clams that are processed and sold at Cooper's Cove from the Sooke area. The contaminated clams are decontaminated through the on-site depuration process at Cooper's Cove for a period of seventy-two hours.

When the harvesting of shellfish first became restricted in Sooke, all harvested shellfish were depurated naturally at the Cooper's Cove facility. On-site depuration of clams started in 1982 after a successful experiment with the process; the present on-site depuration plant was built in 1988.

2.2 T'Sou-ke Native Band

Interviews were conducted with David Lightly, a fish biologist for the T'Sou-ke Nations, and Frank Plaines, the hereditary chief of the T'Sou-ke nations. Information obtained helped determine how cultural and economic values have been lost due to shellfish harvesting restrictions.

2.2.1 Economic Values

Currently, the T'Sou-ke nations are focused on replenishing salmon stocks in the Sooke Basin rivers and streams. Because of this, they are concerned about water quality in both the basin and nearby watersheds. It is not common for the native band to rely on shellfish as a major food source. However, many are employed as fishermen and loggers and therefore depend on shellfish sales to provide extra income during the off-season (David Lightly, personal communication, 2000).

2.2.2 Cultural Values

Frank Plaines, the hereditary chief of the T'Sou-ke nation, helped Azimuth better understand the cultural importance of shellfish in the Sooke Basin.

In the past, shellfish in the Sooke Basin consisted of Little Neck Clams (*Protothaca staminea*), Manila Clams (*Tapes philipinarum*), Butter Clams (*Saxidomus giganteus*), Cockles (*Clinocardium nuttali*), Horse Clams (*Tresus capax*), Geoduck (*Panopea abrupta*), Blue Mussels (*Mytilus edulis*), and Olympic Oysters (*Ostrea lurida*). Today, many of these species are still present, but they exist in fewer numbers. Mr. Plaines recalls a time when "*there was a 6-inch layer of mussels present on the floor of the basin, and birds feeding on them were too numerous to count. The noise of the birds dropping the mussels on rocks sounded like castanets*" (Frank Plaines, personal communication, 2000).

Culturally, shellfish from the basin have been used for potlatches, which are ceremonial feasts such as the celebration of marriages or accession among certain Native American peoples of the northwest Pacific coast. Also, when visitors came it was common to serve clams, mussels, crabs and ducks (Frank Plaines, personal communication, 2000).

2.3 Sooke Development Patterns

Before the 1970's, the majority of inhabitants were members of the T'Sou-ke native band, settled in scattered areas of Sooke. Urban development brought about the construction of the Broomhill and Seager subdivisions, which are located within the De Mamiel Creek watershed (Elida Peeres, personal communication, 2000). These developments intensified pollution due to a lack of sanitary sewer systems and related treatment methods. The construction of co-op housing in Sooke saw the first use of a constructed wetland that dealt with sewage wastes from multiple residences. Presently, there are two constructed wetlands in the Sooke area; one on Chambers Road serving the co-op housing, and the second behind Journey Middle School (George Butcher, personal communication, 2000).

Development patterns have also centered on De Mamiel Creek. Many residents of Sooke live in riparian areas along De Mamiel Creek, and use the creek to draw water for irrigation and other non-potable uses. Appendix A provides a list of water licenses issued by the Ministry of Environment, Lands and Parks. It is assumed for the context of this report that the water is not being used as a potable drinking water source.

3.0 NON-POINT SOURCE POLLUTION IN SOOKE

Non-point source water pollution can contribute to degraded water quality and human health risks. There are five major groups of pollutants that may be prevalent in NPS water pollution. These are pathogens, nutrients, oxygen depleting substances, sediments, and toxins. This study will focus on pathogenic contamination in De Mamiel Creek using bacteriological indicators.

As a result of NPS pollution in the Sooke Basin, the federal Department of Fisheries and Oceans (DFO) have applied shellfish harvesting restrictions. The closure of the shellfish industry has reduced job opportunities and impacted the culture and livelihood of people living within the community of Sooke.

4.0 METHODS

The following page provides information on the sampling sites where water as collected during the 1999-2000 sampling period.

4.1 Sampling Sites

Figure 2. Site 1: Goudie Rd.

Site 1 (Figure 2) is near the origin of De Mamiel Creek, where the water is expected to be relatively pure. There is limited development at this site. The creek is shaded and cold, surrounded by conifers. Approximate width is 6 m. This site is located on the private property of Mr. John Genn, on Goudie Rd.

Figure 3. Site 2: Pascoe Rd.

At Site 2 on Pascoe Road, Figure 3, the creek is open to sun. The approximate width here is nearly 10 m when the water is high in the winter. A bridge crosses over De Mamiel creek just above the sample site. This site covers a large drainage area, with some rural development.

Figure 4. Site 3: Helgesen Rd.

Site 3 is located downstream of four drainage areas that comprise the highest development within the study area, specifically two large trailer parks (figure 4). This site is located on agricultural land, and a herd of cattle regularly cross through the site to access the field across the creek. This location is mainly shady, with large cedar trees bordering it. The creek is approximately 13 m wide. Significant algal cover was observed on the rocks.

Figure 5. Site 4: Phillips Rd.

Located immediately upstream of the bridge on Phillips Rd., Site 4 is the final site before De Mamiel Creek enters the Sooke River (Figure 5). The creek is relatively shallow and wide here – nearly 14 m in width – and partially shaded. Several houses are located along the bank of the creek.

Figure 6. Site 5: Sooke River

The fifth site is located on the Sooke River, approximately 100 m upstream from the point where De Mamiel Creek enters the Sooke River (Figure 6). The river is approximately 25 m wide here, and the water level varies according to the tide and recent rainfall. Site 5 provides an indicator of Sooke River background levels before De Mamiel Creek enters it, carrying any

4.2 Sampling Program

The sampling locations were established in the study performed by last year's RRU students (Duffin *et al.*, 1999). However, one change in sample location was made at Site 5. This sample point, which is on Sooke River, was moved upstream from where De Mamiel Creek enters the river. This allowed for background levels of nutrients and bacteria for the Sooke River to be determined.

Sample sites were based on a judgmental approach, in which the range of land uses within the De Mamiel Creek watershed was covered. To be statistically viable, five samples within a 30-day period were required for microbiological tests.

4.2.1 Microbiological Parameters

Fecal coliforms are defined as those microbiological organisms found inhabiting the intestinal tract of humans and animals. They are described as aerobic, Gram-negative, non-sporing rods that ferment lactose with the formation of a gas within 48 hours at 44.5 °C (Madigan *et al.*, 1997). Fecal coliforms originate in the intestinal tract of warm-blooded animals and have historically been the indicator used most widely. Because of this water quality standards in British Columbia are based on these organisms. However, more specific indicators were also used in this study, as fecal coliforms do not always correlate well with incidences of disease.

Fecal streptococci are another group of bacteria present in feces, which includes the enterococci group. Enterococcus species and streptococcus species are both lactic acid bacteria. Lactic acid bacteria are Gram-positive, non-motile, nonsporulating, aerotolerant anaerobic bacteria that produce lactic acid as a product of fermentative metabolism and are multi-chained (Madigan, 1997). Enterococci are found in the intestine, vagina, and plants, and are a good indicator of fecal contamination. Enterococci species are a more accurate indicator of fecal contamination, as they have a slower rate of "die-off" than fecal coliforms and *Escherichia coli* (*E.coli*) in water and sediment (Hackney, 1994, page 53). Enterococci are also much more resistant to sewage treatment, including chlorination, and thus may be a more sensitive indicators of the survival of enteric pathogens and viruses.

Fecal streptococcus species are found in the human and animal intestine. The ratio of fecal streptococcus to fecal coliforms can serve as an indicator of the nature of the contamination in terms of being human or animal in origin. If the ratio is above 4.0, the contamination is said to be human. If the ratio is below 0.7, the contamination is determined to be animal. The area between 0.7 and 4.0 is uncertain.

E. coli and enterococci are two specific indicators of fecal contamination. *E. coli* is the dominant fecal coliform in both human and animal feces, and thus is the indicator of choice for fecal contamination. It comprises about 97% of the coliform organisms in human feces. It has also been shown to represent 93-

99% of the coliforms from the feces of poultry, cats, dogs and rodents. Due to its thermotolerance, *E. coli* is considered to be a better indicator of contamination from warm-blooded animals than fecal coliforms because testing for *E. coli* eliminates any thermotolerant fecal coliforms, such as *Klebsiella* species, which are not necessarily fecal contaminants (Hackney, 1994, page 55). Because *E. coli* is a single species, more rapid and direct tests can be performed than on a group of bacterial indicators, such as fecal coliforms. However, since the enumeration of *E. coli* can be complicated and expensive, total coliforms and fecal coliforms were also established as indicators. Some traits which make *E. coli* a slightly flawed indicator of fecal contamination include its persistence and after-growth capabilities in marine waters, which would not apply to the sampling of De Mamiel Creek, and the fact that its biomass is impacted by natural microbiota (Warrington, 1994).

Testing for a combination of these four indicators, therefore, produces the most conclusive results. This is because the total fecal coliforms will be determined, as well as a breakdown of the more specific types of fecal bacteria found in the water. Knowing what type of fecal coliforms is present in the water makes it easier to determine just what the non-point sources are and potentially, where they are located.

4.2.2 Nutrients

Ammonia, (NH_3), is the most reduced form of inorganic nitrogen in water. While nitrogen is an essential nutrient to plant growth, high concentrations are toxic to aquatic organisms, and too much ammonia in the water contributes to eutrophication, or large algal blooms. Eutrophication negatively affects aquatic life, recreation, and drinking water quality. Sources of ammonia include fertilizers from agriculture, as well as urban development land uses and untreated human wastes.

Nitrite, (NO_2^-), is another form of nitrogen used by plants for nutrition and growth. Excess nitrite present in water will cause eutrophication, and is also toxic at relatively low concentrations. Sources of nitrite contamination include fertilizers from agricultural, urban land uses and untreated human wastes.

Nitrate, (NO_3^-), is the most oxidized and stable form of nitrogen in the nitrogen cycle. An excess of nitrate in water will also result in eutrophication, and high levels of nitrate are toxic to infants and small children, causing methaemoglobinaemia. Sources of nitrate contamination are primarily fertilizers from agriculture, urban development and untreated human wastes.

Total dissolved phosphorus is a measurement of all phosphorus present in the water, whether in organic or inorganic form. A high amount of phosphorus in a water body is a major cause of eutrophication. Sources of phosphorus contamination include agriculture, industrial effluents, and urban development where detergents containing phosphates are used.

4.2.3 Ambient Conditions

Turbidity is defined as being the measurement of the suspended particulate in a water body that interferes with light as it passes through the water (B.C. MELP, 2000). Suspended particles may include silt, clay, organic material, or microorganisms. Turbidity is measured in nephelometric turbidity units (NTU). High turbidity indicates an increase in the amount of surface area for which bacteria are able to grow on. Also, high turbidity means less light is able to penetrate through the water and act as an energy source for the photosynthesis of algae and vegetation. Sediments also bind other contaminants like metals. In B.C., the suggested guideline for maximum turbidity is 5.0 NTU. Turbidity is affected by activities such as forest harvesting, road building, agriculture, urban development, mining, and sewage treatment plant effluents (B.C. MELP, 2000).

Dissolved oxygen (DO) is a measure of the amount of oxygen dissolved in water, in parts per million (ppm). Dissolved oxygen is added to water through the photosynthesis of aquatic plants, or transferred from the atmosphere. Dissolved oxygen is required for respiratory metabolism of many aquatic organisms, and it also affects the solubility and availability of nutrients. The MELP guideline for DO is a minimum of 5.0 ppm. Factors affecting dissolved oxygen in a water body include forest harvesting (through a water temperature increase), pulp mills, agriculture, and sewage treatment plant effluent (B.C. MELP, 2000).

Conductivity is a measurement of the amount of ions in solution, determined through the amount of current the water is capable of carrying (in this case, water is the solution). Conductivity is usually expressed in microsiemens per centimeter (μS/cm). This measure is used to determine the amount of dissolved solids present in a water sample. The MELP guideline for conductivity is 700 μS/cm. Activities that affect conductivity include mining, de-icing salts from roads, and the discharging of industrial effluents (B.C. MELP, 2000).

The concentration of hydrogen ions in aqueous solution is measured using a pH meter. Low, or acidic, pH values (0.1-6.9) cause metals in the water to become more soluble. This may adversely affect the nutrients available for fish and other aquatic organisms since heavy metals are highly toxic in low concentrations. Coastal streams in B.C. tend to have pH values in the range of 5.5 to 6.5. pH may be influenced by activities such as mining, agriculture, and acidic precipitation resulting from car and industrial emissions (B.C. MELP, 2000).

Water temperature has a great impact on the density of water. As water temperature increases, less dissolved oxygen is present, and organisms' metabolic oxygen demands increase (B.C. MELP, 2000). This can adversely impact the health of many aquatic species. The MELP guideline for water temperature is a maximum of 15.0 °C. Water temperature may be influenced by industrial effluent discharge, agriculture, and forest harvesting or urban development acting to reduce shade.

4.2.4 Sampling Protocol and Procedures

When sampling, all inorganic samples were collected into 1 L acid washed polyethylene bottles (done by the PESC lab). Also, approximately 750 mL of creek water was collected as microbiological samples into autoclaved bottles. The bottles were larger than the 100 mL, which is the minimum amount specified by the Standard Methods for the Examination of Water and Wastewater. All bottles were kept closed until they were filled with sampled water. "Grab" samples were used in this project, as they are individual samples collected at a particular time and place. Grab samples were most appropriate for determining the water quality of De Mamiel Creek, because they allowed for random samples to be collected.

To obtain samples, the bottle was opened close to the water while the sampler was extremely careful not to contaminate the rim or lid with their hands. Water was collected a minimum of one meter away from any rapids, back eddies, or unnatural flows of water to avoid disturbing the representativeness of the sample. Samples were taken away from the edge of the creek to avoid boundary or edge effects. For inorganic samples, the sample bottle was rinsed out three times before collecting a sample; this served to equilibrate the

samples with the containers. In flowing water, the sample container was placed upstream. The bottle was held near the base. For microbiological samples, some headspace was left for shaking purposes.
After sampling the water, the bottles were labeled with a permanent black marker. The sample site number and location were written, as well as the parameters being tested for. The samples were immediately put into a cooler containing ice to preserve the samples and ensure inappropriate conditions for colonization. This was imperative, as bacteriological examination of water needs to be performed as soon as possible after collection, to ensure that the bacteria present when the water was sampled remain viable when the water is tested. Also, refrigeration prevents decomposition of any organics and serves to keep the water fresh.

All field data was recorded in a waterproof field book. Field data included personnel, date and time of sampling, sample site number, field conditions and observations and a description of the sampling location.

A sampling schedule is appended (see appendix B). Fecal streptococcus and *E. coli* sampling began on January 13, 2000, whereas fecal coliform and fecal streptococcus sampling began on November 18, 1999.

4.2.5 Storage and Transportation

Chain of custody forms were filled out with the Ministry information, laboratory information, sample site information and parameters being tested. These forms were placed in plastic bags and sealed along with the samples and ice and placed into coolers. The coolers were taped up to prevent opening during travel. Coolers containing the samples and requisition forms were sent via Loomis to Vancouver to facilitate testing as soon as possible. On average, samples were sent by 11 am and arrived the same day.

After each sampling event, equipment was cleaned, dried and stored at the Royal Roads University laboratory.

4.2.6 QA/QC

Quality control is a mechanism established to monitor the quality of data. Standard operating procedures are fundamental to ensuring quality control when sampling. Field duplicates were taken in this sampling project, wherein a sixth, random sample was taken at one of the sites using the same sampling procedure. The purpose being to see if sampling results were identical, or very close, to the regular sample in terms of numbers of fecal coliforms, *E. coli*, enterococci, and fecal streptococci. Duplicate samples were labeled with the date and parameter that was being tested.

JR Laboratories followed testing procedures from the Ministry of Environment, Lands and Parks. These procedures are based on standard procedures outlined in Standard Methods for the Examination of Water and Wastewater. Membrane filtration tests were conducted on 100 mL samples of the water sampled from De Mamiel Creek. Ten percent of samples tested at JR Laboratories were replicated and tested for quality control reasons, requiring a confidence interval of 95%. If a duplicate result was outside this interval, the sample would be re-tested. JR Laboratories is accredited by the Canadian Association of Environmental Analytical Laboratories and the Ministry of Environment, Lands and Parks. Both organizations send spiked samples for analysis, in order to ensure the quality of the analysis meets the standards set for the organization (Bonnie Nicholson, personal communication, 2000).

The Pacific Environmental Science Center also carries out a quality control program. For each parameter, equipment blanks, reference materials, and regular replicates were tested. The Ministry QA/QC requirements for both laboratories are:

1) Ensure that a Quality System is documented and incorporates adequate review, audit, and internal quality control;
2) Must ensure that test methods are validated and incorporate adequate quality control. Quality control at the section levels must monitor and verify that the measurement processes are operating within specified control criteria. The quality control data documented must verify the accuracy, and precision of the measurement process;
3) Must ensure that all equipment are functioning correctly and meet required specifications;
4) Ensure that facilities are adequate to carry out the testing activity;
5) Ensure that sample management procedures are in place that incorporate adequate procedures for security, receipt, identification, checking, routing, storage and disposal of samples;
6) Ensure that data management procedures that incorporate adequate recording, calculation, validation, transmittal of test data and related records are in place.
7) Ensure that workload management procedures that incorporate acceptable turnaround times;
8) The laboratory must operate a performance audit program, which incorporates participation in external proficiency testing programs. The laboratory must be certified and accredited by the Canadian Environmental Analytical Laboratories (CAEAL) (Steve Horvath, personal communication, 2000).

4.3 GPS Mapping

Mapping of De Mamiel Creek took place on July 8, July 9 and July 16, using a Trimble GeoExplorer3 to plot the coordinates of various features. This information, along with trim maps obtained from the Ministry of Environment, was then plotted in ArcView, a geographical information system (GIS), to obtain a map of the De Mamiel Creek watershed and area (see Appendix C).

5.0 WATER QUALITY RESULTS

5.1 Microbiological Parameters

Appendix D provides the microbiological laboratory results obtained from JR Laboratories. The results are shown by site and values under the detection limits are presented as 'less than 2 (<2 CFU/100 mL). Table 1, on the following page, provides a chart of the mean microbiological parameters for each site.

Table 1: **Mean Fecal Coliform, Enterococcus, Fecal Streptococcus, and *E. coli* Observed over the Sampling Period of November 18, 1999 to March 29, 2000**

	Fecal Coliform (CFU/100 mL)	Enterococcus (CFU/100 mL)	Fecal Streptococci (CFU/100 mL)	E coli (CFU/100 mL)
Site 1	2.7	2.0	3.2	2.3
Site 2	9.9	5.1	5.3	4.3
Site 3	68.4	36.3	19.6	37.1
Site 4	44.1	79.8	28.2	24.2
Site 5	19.6	11.9	6.8	8.5
MELP Recreational Guideline	200	20	n.a.	77

The highest mean fecal coliforms were found at Site 3, at 68.4 CFU/100 mL. The lowest mean fecal coliforms were found at Site 1, at 2.7 CFU/100mL. The MELP standard for fecal coliforms for secondary recreation is 200CFU/100mL (See Table 1). Therefore, on average, the concentration of fecal coliforms in De

Mamiel Creek is within recreational guidelines. The highest mean levels of *E. coli* were detected at Site 3 at a concentration of 37.1 CFU/100mL. The lowest mean levels of *E. coli* were observed at Site 1, at 2.3 CFU/100mL. The MELP guideline for *E. coli* in recreational water is 77 CFU/100mL (See Table 1). The highest mean enterococci were found at Site 4, with 79.8 CFU/100mL. The lowest mean enterococci were found again at Site 1, with 2.0 CFU/100mL. The MELP standard for enterococci for secondary recreation is 20/100 CFU/100mL. Again, the concentration of enterococci in De Mamiel Creek on average is within recreational guidelines (See Table 1). The highest mean fecal streptococcus was found at Site 4 again, with 28.2 CFU/100mL. The lowest mean fecal streptococcus was found at Site 1, at 3.2 CFU/100mL (See Table 1). Currently, there is no MELP established guideline for fecal streptococcus in water. This is due to the fact that fecal streptococcus are primarily used as an indication as to the origin of any contamination (i.e. whether human or animal), as opposed to an indicator of contamination.

Table 2: **Quality Control for Microbiological Testing performed at JR Laboratories, Burnaby, B.C., Using Field Duplicates**

Date	Site	Site Result	Duplicate X	Percent Error (%)
February 16 2000	3	FC: 16 FS: <2 Ent.: <2 E.coli: 14	FC: 24 FS: <2 Ent.: <2 E.coli: 10	33.3 0 0 40.0
February 23 2000	1	FC: <2 FS: <2 Ent.: <2 E.coli: <2	FC: <2 FS: <2 Ent.: <2 E.coli: <2	0 0 0 0
March 8 2000	3	FC: 250 FS: <2 Ent.: <2 E.coli: 130	FC: 250 FS: <2 Ent.: 1 E.coli: 110	0 0 n.a. 18.2
March 23 2000	3	FC: 18 FS: 24 Ent.: 26 E.coli: 14	FC: 26 FS: 30 Ent.: 16 E.coli: 26	30.8 20.0 62.5 46.2
March 29 2000	5	FC: <2 FS: <2 Ent.: <2 E.coli: <2	FC: 2 FS: <2 Ent.: <2 E.coli: <2	n.a. 0 0 0

To ensure a quality level of results coming back from the lab, Azimuth took weekly field duplicates, and compared these results with the site results. The percent errors ranged from 0.0% on various days to 62.5% on March 23 at Site 3.

Table 3: **Fecal Coliform: Fecal Streptococcus Ratio By Date and Site Location**

Date	FC:FS Site 1	FC:FS Site 2	FC:FS Site 3	FC:FS Site 4	FC:FS Site 5
January 13, 2000	1.00	1.00	3.43	4.00	2.00
January 26, 2000	1.00	1.00	22.00	7.33	1.00
February 1, 2000	0.38	0.90	1.08	0.75	0.68
February 2, 2000	3.00	0.11	0.29	0.92	1.00
February 9, 2000	2.00	0.50	6.00	0.25	2.13
February 16, 2000	1.00	1.00	8.00	2.00	4.00
February 23, 2000	1.00	1.00	8.50	4.00	6.00
March 1, 2000	1.00	1.00	3.00	3.20	2.00
March 8, 2000	1.00	7.00	125.00	7.00	4.00
March 15, 2000	1.00	1.00	0.30	4.33	0.50
March 23, 2000	1.00	3.50	0.81	0.36	1.00
March 29, 2000	1.00	1.00	10.00	4.00	1.00
Human > 4	0	1	6	3	1
Animal < 0.7	1	2	2	2	2
Inconclusive(0.7-4)	11	9	4	7	9
Total	12	12	12	12	12

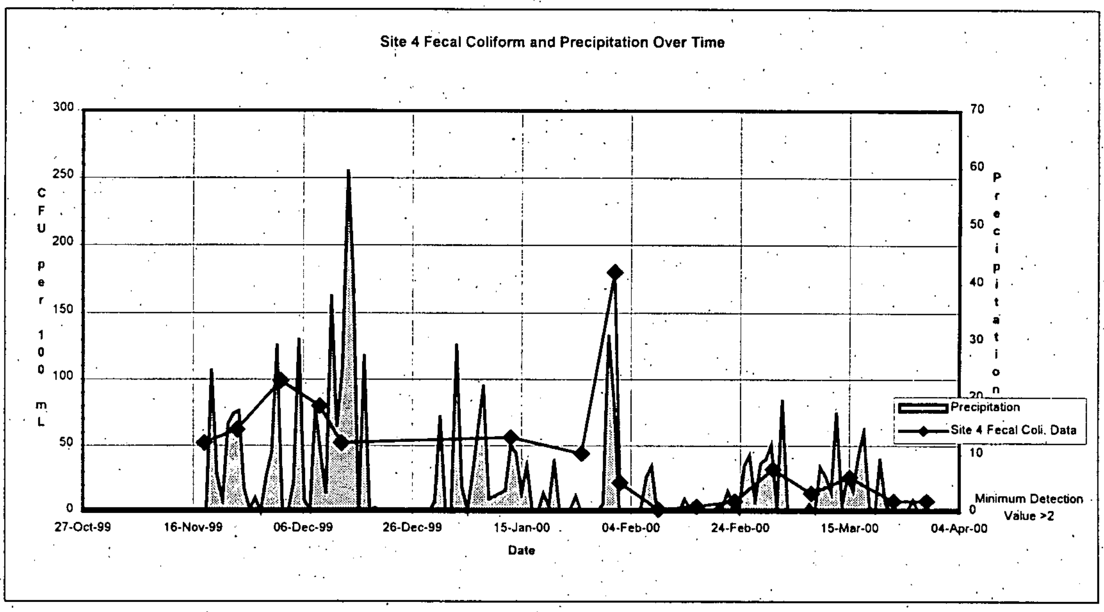
These ratios were obtained by dividing the number of fecal coliforms per site by the number of fecal streptococcus per site for each sample date. The ratio is used to provide information on the sources of microbial contamination in De Mamiel Creek.

5.1.1 Precipitation Data

Precipitation data was obtained from the Capital Regional District (CRD), (see Appendix E). The data, which is a record of daily precipitation in millimeters at the Sooke Dam, was plotted as an area behind both the biological and inorganic laboratory results. This gives an indication as to whether precipitation events facilitated transport of fecal contaminants to De Mamiel Creek.

5.1.2 Biological Data and Precipitation Over Time

Appendix F provides the graphs of biological results of fecal coliform, fecal streptococcus, *E. coli*, enterococci and the FC:FS ratio for each of 5 sites sampled. Figure 7 provides a sample of the graphs that are found in Appendix F.



Azimuth Environmental Consulting, 2000.

Figure 7: Fecal Coliform and Precipitation Over Time at Site 4 in De Mamiel Creek

Appendix G provides the mean microbiological results by site. The graphs provide the mean parameters, in CFU/100 mL, with error bars indicating the deviation from the mean.

The line data represents the microbiological results of fecal coliform concentrations, while the gray shaded data represents daily precipitation data collected at the Sooke Dam.

5.1.2.1 Site 1

Charts 1 to 5 in Appendix F provide the levels and fluctuations of biological activity in De Mamiel Creek at site 1. The levels and fluctuation of biological activity in De Mamiel Creek at this site is the lowest out of all five sites that were sampled.

Maximum fecal coliform levels at Site 1 occurred on both February 1 and February 2, 2000, with a result of 6 CFU per 100 mL. Corresponding precipitation for these dates indicate precipitation of 20.1 millimeters (mm) on February 1, with a total of 52.8 mm in the three days prior to February 1. Minimum fecal coliform levels at Site 1 were returned in 12 of 17 sampling dates, with a result of <2 CFU per 100 mL, with daily precipitation ranging from 0 mm to 59.7 mm.

The maximum *E.coli* level at Site 1 occurred on February 2, 2000, with a result of 6 CFU per 100 mL. Corresponding precipitation on this date indicates precipitation of 20.1 millimeters (mm) on February 1, with a total of 52.8 mm in the three days prior to February 1. Minimum *E.coli* levels at site 1 were returned in 8 of 12 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 31.2 mm.

A maximum fecal streptococcus level occurred on February 1, 2000, with a result of 16 CFU per 100 mL. Corresponding precipitation to this date indicates precipitation of 20.1 millimeters (mm) on February 1, with a total of 52.8 mm in the three days prior to February 1. Minimum fecal streptococcus levels at site 1 were returned in 10 of 12 sampling dates. The corresponding precipitation ranges from 0 mm to 31.2 mm.

The maximum enterococci level at site 1 also occurred on February 1, 2000,with a result of 4 CFU per 100 mL. Corresponding precipitation on this date indicates precipitation of 20.1 millimeters (mm) on February 1, with a total of 52.8 mm in the three days prior to February 1. Minimum enterococci levels at site 1 were returned in 15 of 17 sampling dates. The corresponding precipitation ranges from 0 mm to 59.7 mm.

5.1.2.2 Site 2

Charts 6 to 10 in Appendix F provide the levels and fluctuations of biological activity in De Mamiel Creek at site 2.

Maximum fecal coliform levels at site 2 occurred on both November 24 and December 13, 1999, with a result of 30 CFU per 100 mL. Corresponding precipitation on these dates are 17.8 mm on November 24 and 25.2 mm on December 13, with a total of 34.8 mm and 56.4 mm in the three days prior, respectively. Minimum fecal coliform levels at site 2 were returned in 4 of 17 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 59.7 mm.

The maximum *E.coli* level at site 2 occurred on February 1, 2000, with a result of 14 CFU per 100 mL. Corresponding precipitation on this date is 20.1 mm on February 1, with a total of 32.7 mm in the three days prior. Minimum *E.coli* levels at site 2 were returned in 8 of 12 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 31.2 mm. The maximum fecal streptococcus level at site 2 occurred on February 1, 2000, with a result of 20 CFU per 100 mL. Corresponding precipitation on this date is 20.1 mm on February 1, with a total of 32.7 mm in the three days prior. Minimum fecal streptococcus levels at site 2 were returned in 6 of 12 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 31.2 mm.

The maximum enterococci level at site 2 occurred on December 19,1999, with a result of 28 CFU per 100 mL. Corresponding precipitation on this date is 0.8 mm on December 19, with a total of 28.0 mm in the three days prior. Minimum enterococci levels at site 2 were returned in 7 of 17 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 59.7 mm.

5.1.2.3 Site 3

Charts 11 to 15 in Appendix F provide the levels and fluctuations of biological activity in De Mamiel Creek at this location.

Maximum fecal coliform levels at site 3 occurred on March 8, 2000, with a result of 250 CFU per 100 mL. Corresponding precipitation on this date is 1.4 mm on March 8, with a total of 0 mm in the three days prior. The minimum fecal coliform level at site 3 was returned on March 15, 2000, with a result of 6 CFU per 100 mL, with daily precipitation of 6.2 mm on March 15, and a total of 22.5 mm in the three days prior.

The maximum *E.coli* level at site 3 occurred on March 8, 2000, with a result of 130 CFU per 100 mL. Corresponding precipitation on this date is 1.4 mm on

March 8, with a total of 0 mm in the three days prior. A minimum *E.coli* level at site 3 was returned on January 13, 2000, with a result of 6 CFU per 100 mL and precipitation of 11.7 mm on January 13, with 9.9 mm in the three days prior.

The maximum fecal streptococcus level at Site 3 occurred on February 1, 2000, with a result of 130 CFU per 100 mL. Corresponding precipitation on this date is 20.1 mm on February 1, with a total of 32.7 mm in the three days prior. Minimum fecal streptococcus levels at Site 3 were returned in 6 of 15 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 31.2 mm.

The maximum enterococci level at Site 3 occurred on February 1, 2000, with a result of 390 CFU per 100 mL. Corresponding precipitation on this date is 20.1 mm on February 1, with a total of 32.7 mm in the three days prior. Minimum enterococci levels at Site 3 were returned in 5 of 20 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 59.7 mm.

5.1.2.4 Site 4

Charts 16 to 20 in Appendix F provide the levels and fluctuations of biological activity in De Mamiel Creek at this location.

A maximum fecal coliform level at Site 4 occurred on February 1, 2000, with a result of 180 CFU per 100 mL. Corresponding precipitation on this date is 20.1 mm, with a total of 32.7 mm in the three days prior. The minimum fecal coliform level at Site 4 was returned on February 9, 2000, with a result of <2 CFU per 100 mL, with daily precipitation of 0 mm on February 9, 2000, and a total of 15 mm in the three days prior.

The maximum *E.coli* level at Site 4 occurred on February 1, 2000, with a result of 150 CFU per 100 mL. Corresponding precipitation on this date is 20.1 mm on February 1, with a total of 32.7 mm in the three days prior. A minimum *E.coli* level at Site 4 was returned on February 9, 2000, with a result of <2 CFU per 100 mL with precipitation of 0 mm on February 9, 2000, and 1.4 mm in the three days prior.

The maximum fecal streptococcus level at Site 4 occurred on February 1, 2000, with a result of 240 CFU per 100 mL. Corresponding precipitation on this date is 20.1 mm on February 1, with a total of 32.7 mm in the three days prior. Minimum fecal streptococcus levels at Site 4 were returned in 2 of 12 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 31.2 mm.

The maximum enterococci level at Site 4 occurred on February 1, 2000, with a result of 960 CFU per 100 mL. Corresponding precipitation on this date is 20.1 mm on February 1, with a total of 32.7 mm in the three days prior. Minimum enterococci levels at Site 4 were returned in 4 of 17 sampling dates. The corresponding precipitation ranges from 0 mm to 59.7 mm.

5.1.2.5 Site 5

Charts 21 to 25 in Appendix F provide the levels and fluctuations of biological activity in De Mamiel Creek at this location.

A maximum fecal coliform level at Site 5 occurred on November 24, 2000, with a result of 96 CFU per 100 mL. Corresponding precipitation on this date is 17.8 mm, with a total of 34.8 mm in the three days prior. Minimum fecal coliform levels at Site 2 were returned in 4 of 17 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 59.7 mm.

The maximum *E. coli* level at site 5 occurred on February 9, 2000, with a result of 36 CFU per 100 mL. Corresponding precipitation on this date is 0 mm on February 9, with a total of 15.0 mm in the three days prior. Minimum *E. coli* levels at site 5 were returned in 5 of 12 sampling with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 31.2 mm.

The maximum fecal streptococcus level at Site 5 occurred on February 1, 2000, with a result of 44 CFU per 100 mL. Corresponding precipitation on this date is 20.1 mm on February 1, with a total of 32.7 mm in the three days prior. Minimum fecal streptococcus levels at Site 4 were returned in 7 of 12 sampling dates, with a result of <2 CFU per 100 mL. The corresponding precipitation ranges from 0 mm to 31.2 mm.

The maximum enterococci level at Site 5 occurred on November 24, 1999, with a result of 120 CFU per 100 mL. Corresponding precipitation on this date is 17.8 mm on November 24, with a total of 34.8 mm in the three days prior. Minimum enterococci levels at Site 5 were returned in 9 of 17 sampling dates, with a result of <2 CFU/ 100 mL. The corresponding precipitation ranges from 0 mm to 59.7 mm.

The fecal coliform to fecal streptococcus (FC:FS) ratio results are appended (Appendix H). Results less than 0.7 indicate animal contamination, while results above 4.0 indicate human biological contamination. Values between 0.7 and 4.0 are considered inconclusive as to the source of the biological NPS contamination.

5.2 Inorganic Parameters

The results of the inorganic laboratory analyses are shown in Table 4, below.

Table 4: **Results of physical laboratory analyses performed by P.E.S.C.**

	NH_3		NO_2		$NO_2 + NO_3$		TDP
13-Dec-99	0.006	13-Dec-99	0.002	13-Dec-99	0.348	13-Dec-99	0.008
09-Feb-00	0.011	09-Feb-00	0.003	09-Feb-00	0.146	09-Feb-00	0.007
01-Mar-00	0.005	01-Mar-00	0.005	01-Mar-00	0.181	01-Mar-00	0.007

Sampling of these inorganic parameters was done on three occasions. The graphs of the results are also appended (Appendix I). In addition, the precipitation data for the monitoring program time period are also plotted on these charts.

Table 5: **Mean Ammonia, Nitrite, Nitrite plus Nitrate, and Total Dissolved Phosphorus for the Five Sampling Sites at De Mamiel Creek**

	NH_3 (mg/L)	NO_2 (mg/L)	$NO_2 + NO_3$ (mg/L)	TDP (mg/L)
Site 1	0.005	0.003	0.095	0.005
Site 2	0.005	0.004	0.218	0.007
Site 3	0.007	0.003	0.225	0.007
Site 4	0.007	0.003	0.231	0.007
Site 5	0.005	0.002	0.04	0.004
MELP Recreational Guideline	n/a.	1.0	11.0	0.010

The mean ammonia was found to be highest at Sites 3 and 4, at 0.007 mg/L, and lowest at Sites 1, 2, and 5, at 0.005 mg/L (See Table 5). Mean nitrite levels were found to be highest at Site 2, at 0.004 mg/L, and lowest at Site 5, at 0.002 mg/L. All mean nitrite levels were found to be lower than the MELP guideline of 1.0 mg/L (See Table 5). Nitrite and nitrate levels together were found to be highest at Site 4, at 0.231 mg/L. Nitrite and nitrate levels together were found to be lowest at Site 5, at 0.040 mg/L. All mean nitrite plus nitrate levels were found to be lower than the MELP guideline of 11.0 mg/L (See Table 5). Finally, highest mean total dissolved phosphorus levels were obtained at Sites 2, 3, and 4 at 0.007 mg/L. The lowest mean total dissolved phosphorus levels were found to be 0.004 mg/L at Site 5. All mean total dissolved phosphorus levels were found to be below the MELP recreational guideline of 0.010 mg/L (See Table 5). It should be noted that minimum detection limits for ammonia were 0.005 mg/L, and similarly for nitrite, nitrite plus nitrate, and total dissolved phosphorus were 0.002 mg/L.

5.3 Physical Parameters

Table 6: **Mean pH, Water Temperature, Air Temperature, Dissolved Oxygen, Conductivity, and Turbidity Results**

	Turbidity (NTU)	Dissolved O_2 (ppm)	Conductivity (µS/cm)	pH	Air Temperature (°C)	Water Temperature (°C)
Site 1	0.26	12.45	10	6.07	5.88	4.46
Site 2	0.62	11.90	30	6.14	7.42	5.72
Site 3	1.55	10.82	30	6.29	6.94	5.24
Site 4	1.41	11.20	30	6.36	7.70	5.67
MELP Recreational Guideline	5.0	5.0	70	6.5	n.a.	15.0

Results of the physical parameter monitoring, including turbidity, DO, conductivity, pH, air temperature and water temperature, are appended

(Appendix J). The graphs of mean physical parameters are appended, (See Appendix K), and provide the mean parameter per site with the error bars indicating the deviation from the mean. Where applicable, MELP water quality guidelines are shown at their respective concentrations. Mean turbidity was highest at Site 3, with a value of 1.55 NTU. Site 1 was found to have the lowest mean turbidity, at 0.26 NTU. All site means were below the Ministry of Environment, Lands and Parks guideline of 5.0 NTU. Mean DO was found to be highest at Site 1, at 12.45 ppm. The lowest mean dissolved oxygen was determined to be at Site 3, at 10.82 ppm. All mean site values were well above the MELP minimum guideline of 5.0 ppm. The highest mean conductivity was found at Sites 2, 3, and 4, with a common value of 30 μS/cm. The lowest mean conductivity was found at Site 1, at 10μS/cm. All mean conductivity levels were significantly below the MELP maximum guideline of 70 μS/cm. The highest mean pH value of 6.36 was observed at Site 4. The lowest mean pH value of 6.07 was located at Site 1. All mean pH values were below the MELP minimum guideline of 6.5. The greatest mean water temperature was observed to be 5.72 °C at Site 2. The lowest mean water temperature was observed to be 4.46 °C at Site 1. All mean site values were below the MELP water quality guideline of 15.0 °C.

Table 7: **Physical Data obtained from PESC**

Site	Mean Turbidity (NTU)	Mean Conductivity ($\mu S/cm$)	Mean pH
1	0.18	26	7.07
2	0.83	33	7.08
3	1.6	37	7.11
4	1.6	38	7.00
5	0.71	36	7.14

Sites 3 and 4 were found to have the highest mean turbidity with 1.6 NTU each. Site 1 had the lowest mean turbidity, at 0.18 NTU. Site 4 had the greatest mean conductivity of 38 $\mu S/cm$. Sites 3 and 5 were next, with 37 and 36 $\mu S/cm$, respectively. Site 1 was lowest, at 26 $\mu S/cm$. The highest mean pH was found at Site 5, at 7.14. The lowest mean pH of 7.00 was found at Site 4.

Table 8: **Comparison Of Physical Parameter Means Between Weekly Azimuth Data and Monthly PESC Data**

Parameter	Sites	Azimuth (mean)	PESC (mean)	% Difference
Turbidity	1	0.26	0.18	44.4
	2	0.62	0.83	25.3
	3	1.55	1.6	3.1
	4	1.41	1.6	11.9
Average				21.2
Conductivity	1	10	26	61.5
	2	30	33	9.1
	3	30	37	18.9
	4	30	38	21.1
Average				27.7
pH	1	6.07	7.07	14.1
	2	6.14	7.08	13.3
	3	6.29	7.11	11.5
	4	6.36	7.00	9.1
Average				12.0

6.0 STATISTICAL ANALYSIS OF RESULTS

Table 8, below, provides the Pearson coefficients calculated between the four microbiological parameters and precipitation. This calculation indicates if the precipitation data, obtained from the Sooke Dam, is correlated to the peaks and valleys of microbiological indicators in De Mamiel Creek. A value of 1 is considered a strong correlation, while a value approaching 0 indicates weak or no correlation.

Table 9: **Pearson Correlation of Biological Results and Precipitation Data**

Site	Fecal Coliforms	E.coli	Fecal Streptococcus	Enterococcus
1	0.589	0.779	0.365	-0.007
2	0.562	0.171	0.85	0.582
3	-0.082	-0.212	0.558	0.388
4	0.459	0.385	0.437	0.251
5	0.368	0.204	0.366	0.291

Fecal streptococcus and precipitation returned a high correlation at Site 2. This provides the strongest link between precipitation and biological quality of De Mamiel Creek. The remainder of the results indicates poor to mild positive correlation, while three calculations provide a weak negative correlation.

7.0 SEPTIC SOCIAL RESULTS

The Sooke Septic Social was held on June 24th, 2000. The purpose of the event was to increase public awareness regarding the care and maintenance of septic systems and the associated impacts on De Mamiel Creek caused by poorly maintained septic systems. The Septic Social was designed as an educational program intended to reduce the amount of human bacterial pathogens entering into De Mamiel Creek, the Sooke River and ultimately, the Sooke Basin. The objective of the Sooke Septic Social was to provide guests with the information and resources needed to take the necessary action towards improving their on-site sewage treatment systems.

The Sooke Septic Social was held at the Sooke Flats Campground, located on De Mamiel Creek just upstream from the confluence of De Mamiel Creek with the Sooke River. The event started at 3:00pm and upon arrival, guests were greeted and directed towards the picnic area of the campground.

The afternoon began with a presentation of the work accomplished to date. Participants were also presented with the event's itinerary, including an on site demonstration of a septic system pump-out, a septic maintenance video, slideshow and finally, a barbeque.

Figure 8: Pump-out

The pump-out demonstration took place at the property of a resident living close to De Mamiel Creek. Here, participants witnessed the removal of septic solids and grease layers known to accumulate within most septic systems. Ken's Septic Service performed the pump-out, and provided guests at the social with some important information regarding the care and maintenance of septic systems. The pump-out took one hour to complete and upon completion, residents were directed back to the Sooke Flats Campground to view a presentation by Brenda Norris, guest speaker at the Sooke Septic Social.

Brenda Norris has worked with Sound Waste Water Solutions and Comox Valley Citizens Action on Recycling and the Environment (C.V.C.A.R.E) to develop the Septic Social program designed to "*reduce toxic inputs into wastewater and to help protect beach and shellfish areas from contamination* *from failing on-site septic systems*" (B. Norris, personal communication, 2000). Over the past four years, Brenda has coordinated several septic socials in the Comox Valley area where NPS pollution from septic systems has impacted local watersheds. Restricted shellfish closures have been imposed in the Comox Valley/ Baynes Sound area of British Columbia, similar to the restrictions in the Sooke Basin.


Figure 9: Brenda's Presentation

Brenda entertained Septic Social guests with a slide show containing pictures of other septic socials and various septic systems. Throughout her presentation, Brenda identified symptoms associated with failing septic systems and possible methods of remediation in an effort to provide residents of Sooke with professional, proven knowledge of septic system maintenance. This was performed without regulatory officials on site that might intimidate or make some residents uncomfortable of the status of their own septic system. Brenda also played a video called "Pure and Simple" produced by the Environmental Health Foundation of Canada. This video describes how septic systems work, the impacts associated with their failure and the care required to provide adequate maintenance.

The Sooke Flats campground was an excellent location for the event. Shelters were available to display the information provided by Brenda Norris, as well as adequate cooking facilities that allowed preparation of refreshments for the guests.

7.1 Advertising

The Sooke Septic Social was advertised several different ways. The Sooke Mirror community newspaper was one media used to promote the event. A journalist for the Mirror wrote an article on the work performed in the Lower Sooke Watershed, as well as information on the Sooke Septic Social. Appendix L provides a copy of the article that was printed in the June 14 edition of the Sooke Mirror.

Several weeks prior to the event, two local radio stations were contacted: '100.3 FM, The Q' and 1070 AM, CFAX. A request was presented to the two radio stations to promote the Sooke Septic Social in the community calendar events (Appendix M).

In addition to using media advertising, 150 invitations were hand delivered to houses situated along the banks of De Mamiel Creek. A copy of this invitation is appended (Appendix N). The purpose was to encourage those living close to De Mamiel Creek to participate in the event, as any failing septic systems located at these residences would contribute to the water quality in De Mamiel Creek to a great degree. The invitations were placed in mailboxes and hung on fence posts, and were posted in local restaurants and businesses in Sooke. Invitations were also delivered to the T'Sou-ke Native Band.

Azimuth Environmental Consultants also established a web page that was posted on the World Wide Web. The web page contained background information with regards to the De Mamiel Creek and the Septic Social and included an electronic version of the invitation that was sent out as flyers to potential participants.

Every guest attending the social received an information package containing pamphlets and brochures on the following subjects: the care and maintenance of septic systems, recycling and the use of household chemicals and cleaners. The packages were designed to give those participating a useful reference of interesting facts related to the protection of watersheds and surrounding aquatic and terrestrial ecosystems. A list of pamphlets and brochures, including where they can be obtained, can be found in Appendix O - Contents of Information Package.

The following sponsors supplied the budget for the Septic Social: Environment Canada, the Ministry of Environment, Lands and Parks, the Department of Fisheries and Oceans, Ken's Septic Service and Royal Roads University. Ken's Septic Service provided a discounted septic service demonstration, as well as information on proper maintenance procedures. Thrifty Foods and the Helgesen family, owners of Cooper's Cove Oysters, also made contributions. Ed Helgesen was interviewed earlier in the project, and supported the Sooke Septic Social by donating twenty-five pounds of clams to the event.

8.0 LAND USE

The specific land uses of properties surrounding De Mamiel Creek were noted during the mapping of the creek to try to make correlations between this and water quality. Between sample sites 1 and 2, land uses were observed to be predominantly residential and forested. Agricultural areas were interspersed, and there were two locations seen which appeared to be animal crossings. Animal tracks and droppings were noted around this area. The area between sample sites 2 and 3 consisted of forested land and agriculture where a cattle crossing was observed. As one moved further down De Mamiel Creek, algae became more abundant on the underlying rocks. Land use between sample sites 3 and 4 was observed to be mainly forest cover, with some agriculture.

Nutrient growth on rocks in the creek was also becoming more and more abundant. From sample site 4 to the end of De Mamiel Creek, residential was the major land use. Houses were fairly interspersed and most were set back from De Mamiel Creek. However, right at the end of the creek, just before it drains into Sooke River, there is a fairly large campsite (Sooke Flats Campground), which sits only a few meters back from the edge of De Mamiel Creek.

9.0 DISCUSSION

9.1 Land Use and Water Quality

Site 1 to Site 2, on De Mamiel Creek, is mostly low-density residential and forested land. A few low-density "hobby farms" are interspersed. Two animal crossings and three litter spots with garbage were found (See Appendix C).

The levels of fecal coliforms, *E. coli*, enterococci, and fecal streptococcus found at Sites 1 and 2 were below the background levels of the Sooke River, as determined by Site 5 (Appendix G). The MELP standards for raw, untreated drinking water are 0/100mL for fecal coliforms, *E. coli*, and enterococci. This water fails to meet these standards; however, this we determined that this is not a concern from examining the water licences on the creek. No one is using the water for drinking purposes.
Eleven intake pipes were found between these two sites; it was assumed these were being used for irrigation.

In appendix K, we see that between all sites there is a correlation between turbidity and dissolved oxygen: as turbidity increases, DO decreases. The increase in turbidity is due to a decrease in water clarity that may be a result of a higher flow velocity in the creek stirring up sediments, or more materials in the water from animal contamination, or septic leachate. The observed increase in nitrite is most likely due to agricultural land use.

Between Sites 2 and 3, the land was divided up between residential, agricultural, and forest land. Again, turbidity increased as DO decreased.

A dramatic increase in the fecal coliform, *E. coli*, fecal streptococcus and Enterococcus counts was observed. The major possible causes of this increase in fecal contamination between Sites 2 and 3 were residential septic systems, including the Broomhill subdivision (see Appendix C), and cow crossings at agricultural sites.

Bovine fecal deposits can remain for long periods of time, decomposing slowly relative to the surrounding temperature, precipitation, and biological activity. The degree of contamination worsened in situations where cattle were permitted to graze next to a creek. Furthermore, within the feces, a fecal coliform can survive intense sunlight and heat for at least one summer. Even after being thoroughly dried, large populations of fecal coliforms can still exist. Scientific evidence suggests that even after it has been dried, a fecal deposit will release bacterial pathogens when rained on for less than ten minutes. On average, each animal defecates twelve times a day, therefore, bovine fecal deposits often contribute to the long-term contamination of nearby watercourses (Thelin, 1983).

A slight decrease in mean dissolved oxygen was recorded at Site 3. When compared to the mean water temperatures, the mean water temperature was also highest at site 2 and 4. Increased water temperatures reduce the dissolved oxygen content of a water body. The nutrient rich runoff combined with runoff from leaking septic systems have likely contributed to the observed slime and algal growth at Site 3. Decomposing algae also result in decreased DO in the creek water.

Between Sites 3 and 4, litter was found at three locations, along with three intake pipes. The land along the creek was mainly forested with one large farm, and some residential areas (See Appendix C). Between these two sites, De Mamiel creek also flowed behind the Journey Middle School.

Levels of total dissolved phosphorus, nitrite, nitrite plus nitrate, and ammonia were highest at sites 2, 3, and 4, reflecting the combination of agricultural and higher density residential land use in this area. In addition, between Sites 3 and 4, DO levels increased as turbidity decreased, (see Appendix K), and levels of nitrite, ammonia, and total dissolved phosphorus remained stable. Levels of nitrite and nitrate rose slightly (See Appendix I). This indicates a slight increase in contamination from Site 3 to Site 4 that may be a result of fertilizer use and livestock excrement.

An interesting trend was found in the microbiological parameters measured between Sites 3 and 4: numbers of fecal coliforms and *E. coli* dropped, while counts for fecal streptococcus and enterococci continued to climb noticeably (See Appendix G). We expected to see a continual increase in all mean microbiological indicator parameters as we progressed down De Mamiel Creek, from the non-point source contamination build-up. This split could be explained by the fact that enterococci are naturally found on vegetation and plants (Thelin, 1983), which are present in abundance in large forested areas found between the two sites, as well as the fact that one of the reasons for using enterococci as a microbiological indicator was for its slower rate of die-off (Howell, 1996).

Portions of the creek between these two sites were heavily composed of clay (See Figure 8). Small clay particles can "trap" many enteric bacteria (Baudart, 2000) and settle into the sediment on the bottom of creeks. After large rain events, the sediments are stirred up, releasing the bacteria and indicator species.

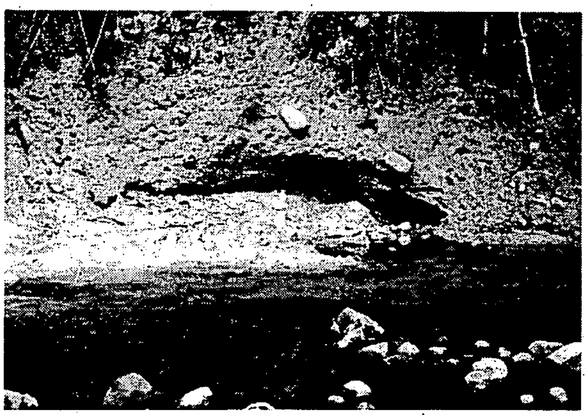


Figure 9: Clay deposits on the creek.

Significantly, the data collected on February 1, 2000 after one of the largest rain events shows higher fecal coliforms and *E. coli* levels at Site 4 than Site 3. Levels of *E. coli* for all sites were below the fecal coliform levels for the respective sites (See Appendix G). This is an indication of accuracy by the laboratory, since it is uncommon, although possible through human error, for there to be more *E. coli* than fecal coliforms; *E. coli* is only one type of fecal coliform. However, levels of enterococci were higher than fecal streptococcus levels for Sites 3, 4 and 5 (See Appendix G). This is an acceptable error in the analysis of the water, since the organisms are minute and may be miscounted.

It would be interesting to see if a difference in levels of microbiological indicators was found if the sediments from low flow areas of the creek between Sites 1 and 2, or Sites 3 and 4 were tested. Sediments may contain 100 to 1000 times the numbers of fecal indicator bacteria than the waters flowing above it (Ashbolt, 1993). Bacteria attached to small particles become trapped in sediment in locations of low water levels when the small particles settle out (Baudart, 2000). In addition, higher survival rates for *E. coli* were found in sediment (Burton, 1987). This may be due to the fact that attaching to particles protects the bacteria from sunlight, and organic matter (Baudart, 2000).

9.2 Precipitation Effects

As shown in Table 8, the Pearson correlation coefficient between precipitation and elevated levels of microbiological indicators was weak. This was unexpected, as scientific literature suggests that increased levels of fecal coliforms are closely linked to storm and rain events. This is due both to the effect of runoff entering the creek, and the stirring up of contaminated sediment-trapped bacteria particles from the bottom of the creek (Baudart, 2000). Since the precipitation data used was a record of daily precipitation at the Sooke Dam, there are several factors that limit the ability to link the data with laboratory results. First, the Sooke Dam is located approximately five kilometers from the head of De Mamiel Creek. Any localized precipitation events that affect only one of these two locations will not be reflected in the correlation of the results. High rainfall at the dam only would result in high precipitation with no activity in the microbiological results in De Mamiel Creek. Likewise, any rain that affects only De Mamiel Creek would result in "spikes" in microbiological activity with no high levels of precipitation.

Since the data represents precipitation at the Sooke Dam, it is not clear whether the precipitation is identical to that at De Mamiel Creek. De Mamiel Creek is approximately 18 kilometers in length, and localized rainfall can affect one portion of the creek while leaving others areas unaffected. Therefore, using data from Sooke Dam can only be assumed to be an estimate of rainfall over the De Mamiel Creek watershed as a whole.

Also, since the data is precipitation at Sooke Dam, watershed features such as topography, soil type and land use would affect the time of concentration for the watershed. High creek flows lag behind precipitation since the above factors affect infiltration and, ultimately, the runoff of non-point source contamination within the watershed. Intense, localized storms can result in increased creek flows in one reach of the creek long after a storm has passed. Similarly, light rain over a larger area can result in significant delays in flow rates within the watershed.

Another factor affecting the relationship between precipitation and microbiological indicators was the fact that the winter of 1999-2000 was fairly dry, with few major rain events. Ideally, sampling would have taken place after one of these major rain events to obtain an accurate estimate of bacterial loads. However, due to time constraints, this was not possible, and weekly sampling was conducted.

9.3 Fecal Coliform : Fecal Streptococcus Ratio

Determining the origin of non-point source biological contamination would assist greatly in the management of the watershed, allowing for resources and funding to be targeted at education and improved septic system maintenance.

The results of the FC:FS ratio in De Mamiel Creek did not provide adequate indication of the source of fecal contamination in De Mamiel Creek (see Table 3). Several factors limit the viability of the FC:FS method as evidence of either human or animal contamination.

Fecal streptococci have a shorter die off rate in the natural environment than do fecal coliforms. As a result, the FC:FS ratio may change as time passes from the initial contamination. Also, bacterial concentrations can vary drastically if the pH of the receiving waters is outside the 4.0 to 9.0 range. As storms progress, the variability in acidity and alkalinity of the runoff can alter the pH of the receiving waters. This will cause changes in the ratio of microbial concentrations within the time period of the precipitation event itself. Since the mean pH was within the 5.0 to 9.0 range, pH was not found to be a limiting factor to the use of the FC:FS ratio. Finally, as the proximity of the sampling sites approaches any marine water bodies, such as the Sooke River estuary at Site 5 on De Mamiel Creek, the ability of this ratio to indicate human or animal contamination declines rapidly. Fecal coliforms and fecal streptococci are halointolerant species; they cannot tolerate high salinity environments. Therefore, as salinity increases towards the Sooke estuary, the die off of these indicators will not provide accurate counts of bacterial contamination. When concentrations of fecal streptococcus are below 100/100 mL, the FC:FS ratio should not be used as an indicator of the source of contamination (North Carolina State University, 1998). Since all data obtained for Sites 1 and 2, the majority of data for Site 5, and approximately half the data for Sites 2 and 3 were below 100/100 mL, the FC:FS ratio cannot be applied.

The schedule of the water monitoring program for De Mamiel Creek further limited the ability to use the FC:FS ratio as an indicator of the source of fecal contamination. Water was sampled on Wednesdays and where possible, after significant precipitation events. Since fecal bacteria concentrations decline at varying rates in the natural environment, the time delay between precipitation events and sampling have limited the accuracy of the FC:FS ratio.

Numerous institutions have abandoned the FC:FS ratio method, and have merely used it as a guide to possible sources of bacterial contamination.

Environmental professionals have access to new methods for determining the origin of non-point source fecal contamination. These relatively costly, but potentially effective techniques could be used to determine the sources of contamination and help direct management and remediation efforts. There are two methods that could be used: Pulsed Field Gel Electrophoresis (PFGE) and Antibiotic Resistance.

9.3.1 Pulsed Field Gel Electrophoresis (PFGE) of *Escherichia coli*

The current method of *E.coli* identification is pulsed field gel electrophoresis (PFGE). This method employs the DNA fingerprinting of each strain of *E.coli* found in the water samples (Richards *et al.*, 1999). This procedure is relatively costly, but provides an accurate analysis of which strains of *E.coli* are present in waterways being tested.

9.3.2 Antibiotic Resistance of *Fecal streptococcus*

Fecal streptococci have also been monitored in De Mamiel Creek. The presence of animal fecal matter is analyzed through patterns of antibiotic resistance. Human enterococci, a component of fecal streptococci, behave differently with antibiotic treatment, and therefore, antibiotic resistance analysis can be used to classify and identify sources of fecal pollution (Wiggins *et al.*, 1999). This is a relatively new technique that has been employed in watershed studies elsewhere (Hagedorn et al, 1999). This method could also be used to identify the sources of non-point source contamination within De Mamiel Creek.

9.4 Sooke Basin GIS

The Sooke Basin GIS was created using DFO shellfish monitoring site maps. These were digitized in ArcView and a map of the resulting GIS is appended (Appendix P). The goals of creating this database are two-fold; they are intended to provide a visual representation of the contamination in the Sooke

Basin, as well as acting as a method of allowing for future data entry upon further DFO laboratory testing of Sooke Basin shellfish.

Since the basin is subject to fecal contamination from marine wildlife, such as birds, agricultural inputs from livestock and human inputs from improperly maintained septic systems, there is difficulty in determining which non-point sources of contamination are responsible for the high levels of bacteria in the basin. The unacceptable levels of bacteria in a marine water body would indicate a continuous input of bacteria to the marine environment. Fecal coliforms cannot survive for extended periods of time in marine environments as they are not tolerant to salt water. Therefore, the restrictions, which have been upheld for several years now, indicate that there is a continuous input of non-point source bacterial contamination entering the basin.

The Sooke Basin GIS contains DFO laboratory results of bacterial contamination over time. As Environment Canada continues its monitoring of the Sooke Basin, the new data can be added to the GIS, allowing for a visual representation of contamination in the basin. Spatial trends in contamination may become evident over time. These trends can be incorporated into management of the watersheds flowing into the basin, and can be analyzed to determine the best management plan on an individual watershed basis.

Once the sources have been identified, proper management and corrective action can be taken to ensure public health and safety, as well as environmental improvement. Ideally, the existing shellfish harvest restrictions would be removed, opening up new economic and social opportunities future generations.

9.4.1 Visual Representation

The visual representation of bacterial contamination in the Sooke Basin provided no spatial trends in non-point source bacterial pollution; the increased fecal coliform levels are not concentrated in any one area.

The widespread, non-spatial increases in contamination suggest that biological contamination in the Sooke Basin is a result of non-point source contamination, similar to that of De Mamiel Creek. There are several potential sources of NPS contamination in the Sooke Basin, contributing in varying degrees and at varying times during the year, that have led to repeated restrictions imposed on the shellfish harvest in the Sooke Basin. Marinas, septic systems and watersheds are all possible contributors to the fecal NPS contamination in the Sooke Basin.

9.4.1.1 Marinas

Marinas and related recreational boating contributions may be adding to the fecal contamination in the Sooke Basin. Recreational boaters hold the contents of their holding tanks until they are pumped out. Accidental and intentional releases, spills during pumping and leaking or faulty holding tanks can all act as a non-point source of fecal contamination to the Sooke Basin. These sources would be predominant contributors during the summer months when marina activities are stressed by tourists and visitors to Sooke. Increased use of marina septic systems would also contribute to fecal contamination during peak summer seasons, especially if they are faulty or poorly maintained.

9.4.1.2 Septic Systems

Bacterial pathogens may enter watercourses where septic systems are used to treat municipal or residential sewage. Rivers, streams and oceans may become contaminated when effluent from failing and poorly maintained septic systems enter. Septic systems are designed to separate solids from the liquid portion of wastewater. The effluent undergoes partial breakdown, wherein the solids settle to the bottom of the septic tank while the grease and oils float to the top. Various bacteria then break down organics within the liquid portion of the wastewater. Both the solids that settle to the bottom and the grease that rises to the top of the tank will accumulate over time and must be pumped out of the tank. A professional should be hired to do such maintenance approximately once every four years (Montgomery, 1990).

Pump-out frequency will depend on the amount of detergent and water used in a home. Septic tanks generally have a limited liquid carrying capacity and once this is reached, the liquid will leave the tank to enter into a distribution box. Partially treated effluent from the septic tank will then enter the distribution box to be dispersed into the soil in which the tank is buried. This is done through a series of perforated pipes. If a household uses large volumes of water, the sewage produced will not have time to break down within the tank. Also, if large amounts of detergents are used, soap may cause pipe clogging in the creation of soap balls. These are masses of soap and grease that accumulate over time in septic systems. Both conditions allow for contaminated effluent, containing bacterial pathogens to leach from septic systems into ground and surface water flow that will eventually reach surrounding waterways. Research indicates that waterways often plagued with bacterial contamination are situated in areas supporting a large number of septic systems (Montgomery, 1990).

9.4.1.3 Watersheds

The Sooke River watershed empties directly into the Sooke Basin. Many small creeks and tributaries, such as De Mamiel Creek, also contribute runoff from within their watersheds to the Sooke Basin. The results of the De Mamiel Creek water monitoring program indicated a lack of data allowing correlation between precipitation and bacterial contamination in the creek. Several biological parameters were high enough to potentially affect the water quality of the Sooke River and in turn, the water quality of the Sooke Basin.

Faulty septic systems, agricultural inputs and wildlife all affect the water quality of De Mamiel Creek to varying degrees. On a volume basis, the contribution of De Mamiel Creek is small compared to the overall volume of water entering the basin; however, the water quality of De Mamiel Creek indicates that the creek, together with the Sooke River, is negatively affecting the water quality of the Sooke Basin.

9.5 Public Education

Sooke does not have a municipal sewer system. The town relies mainly on septic systems to dispose of human waste. Many areas within Sooke support high-density septic system regions. Community based education, aimed at improving septic system care and maintenance, may promote cleaner waterways and ocean shorelines in and around the community of Sooke.

Azimuth Environmental Consulting felt that the septic social fulfilled its intended purpose, which was to increase public awareness with regard to the care and maintenance of septic systems. Approximately twenty guests attended, which was fewer than originally expected; however, the event was still considered very successful based on participant feedback. Many of the guests whom participated in the event, left with positive comments that included: “Great information, well thought out”, “Enlightening, and thank-you for the barbeque”, and “Well presented and most informative, thank-you”. These were just a few of the many comments the team members received throughout the evening. Several guests, including the caretakers at the Sooke Flats Campground, expressed their support in promoting the event they hoped would return next year. Word-of-mouth advertising and volunteer participation will likely increase the number of people attending septic socials in future years.

10.0 RECOMMENDATIONS

Azimuth Environmental Consulting makes the following recommendations for the future of the De Mamiel Creek Watershed:

De Mamiel Creek should be sampled after every major rain event for the physical, inorganic and biological parameters that have been tested thus far. In addition, following the first storm in the fall, the creek should be tested to obtain the results of the pulse of biological contamination. In addition, bacteria trapped in sediment will be placed into the creek flow, and will be subject to enumeration.

In order to make proper correlations between bacterial counts and rainfall, proper precipitation data should be obtained from sources close to De Mamiel Creek. Azimuth was not able to obtain this data, however, recognize its importance and value.

Dye-testing should be conducted on suspected non-point sources such as farms, houses located along the creek, the Journey Middle School and storm water traveling from the Broomhill subdivision, during rain events to determine precise sources. This will help determine sources and possible pathways of contamination to De Mamiel Creek.

Genetic fingerprinting or antibiotic resistance testing should be performed on samples of water from both De Mamiel Creek and the Sooke Basin. If the actual species of *E.coli* can be identified, the source of contamination would be found. The benefits would include proper management of land and riparian zones in Sooke in the short term, as well as the potential re-opening of shellfish harvesting in the Sooke Basin in the long term.

The Sooke Basin GIS should be updated when new laboratory results become available from DFO. The input of new data can aid in providing a map of contamination over time, and may lead to a determination of not only which NPS sources of contamination are most significant, but also which NPS sources are seasonally significant. GIS is a tool that can assist in plotting, updating and printing features and attributes of the Sooke Basin.

The Septic Social should become an annual event within the community of Sooke. The social proved to be successful as based on numerous positive comments made by those whom attended. A local stewardship and/or community group could organize the project.

It may also prove beneficial for the social to be adaptive in nature, addressing other water quality issues, in addition to septic system maintenance, that are impacting the Sooke Community and surrounding watershed. Storm water and agricultural runoff may be two topics for future interest.

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Appendix A: Water Licenses on De Mamiel Creek

Licence_No	Points Code or Water Rights Map	Source Name	Purpose	Quantity	Unit	Qty Flag	Rediversion Flag
C025332	92.B.042.1.1 A (PD32303)	De Mamiel Creek	Land Improve	0.1	AF	T	N
C031420	92.B.042.1.1 H (PD32311)	De Mamiel Creek	Domestic	1000	GD	T	N
C035153	92.B.032.3.3 R (PD31908)	De Mamiel Creek	Domestic	500	GD	T	N
C036479	92.B.042.1.1 F (PD32307)	De Mamiel Creek	Conserv.-Construct.Works	0.5	CS	T	N
C036480	92.B.042.1.1 F (PD32307)	De Mamiel Creek	Storage	80	AF	T	N
C036481	92.B.032.3.3 P (PD31905)	De Mamiel Creek	Domestic	500	GD	T	N
C036632	92.B.042.1.1 E (PD32306)	De Mamiel Creek	Domestic	500	GD	T	N
C036777	92.B.032.3.3 S (PD31909)	De Mamiel Creek	Domestic	500	GD	T	N
C036778	92.B.032.3.3 Q (PD31907)	De Mamiel Creek	Domestic	500	GD	T	N
C037725	92.B.032.3.3 N (PD31903)	De Mamiel Creek	Domestic	500	GD	T	N
C039723	92.B.032.3.4 R (PD32173)	De Mamiel Creek	Irrigation	0.25	AF	T	N
C063739	92.B.042.1.1 N (PD32305)	De Mamiel Creek	Domestic	250	GD	T	N
C063740	92.B.042.1.1 M (PD32304)	De Mamiel Creek	Domestic	250	GD	T	N
C064007	92.B.041 G (PD31662)	De Mamiel Creek	Conserv.-Stored Water	25	AF	T	N
C105592	92.B.032.3.4 P (PD32171)	De Mamiel Creek	Irrigation	0.33	AF	T	N
C107352	92.B.032.3.4 BB (PD68474)	De Mamiel Creek	Domestic	500	GD	T	N
C110235	92.B.042.1.2 W (PD71397)	De Mamiel Creek	Conserv.-Use Of Water	0.5	CS	T	N
F017857	92.B.032.3.3 T (PD31910)	De Mamiel Creek	Domestic	500	GD	T	N
F021491	92.B.042.1.1 G (PD32309)	De Mamiel Creek	Domestic	500	GD	T	N
F056133	92.B.032.3.4 K (PD32170)	De Mamiel Creek	Irrigation	5	AF	T	N
F067517	92.B.032.3.4 E (PD32168)	De Mamiel Creek	Irrigation	10	AF	T	N
Z114928	92.B.041 G (PD31662)	De Mamiel Creek	Conserv.-Stored Water	45	AF	T	N

Appendix B:
Sampling Schedule

APPENDIX

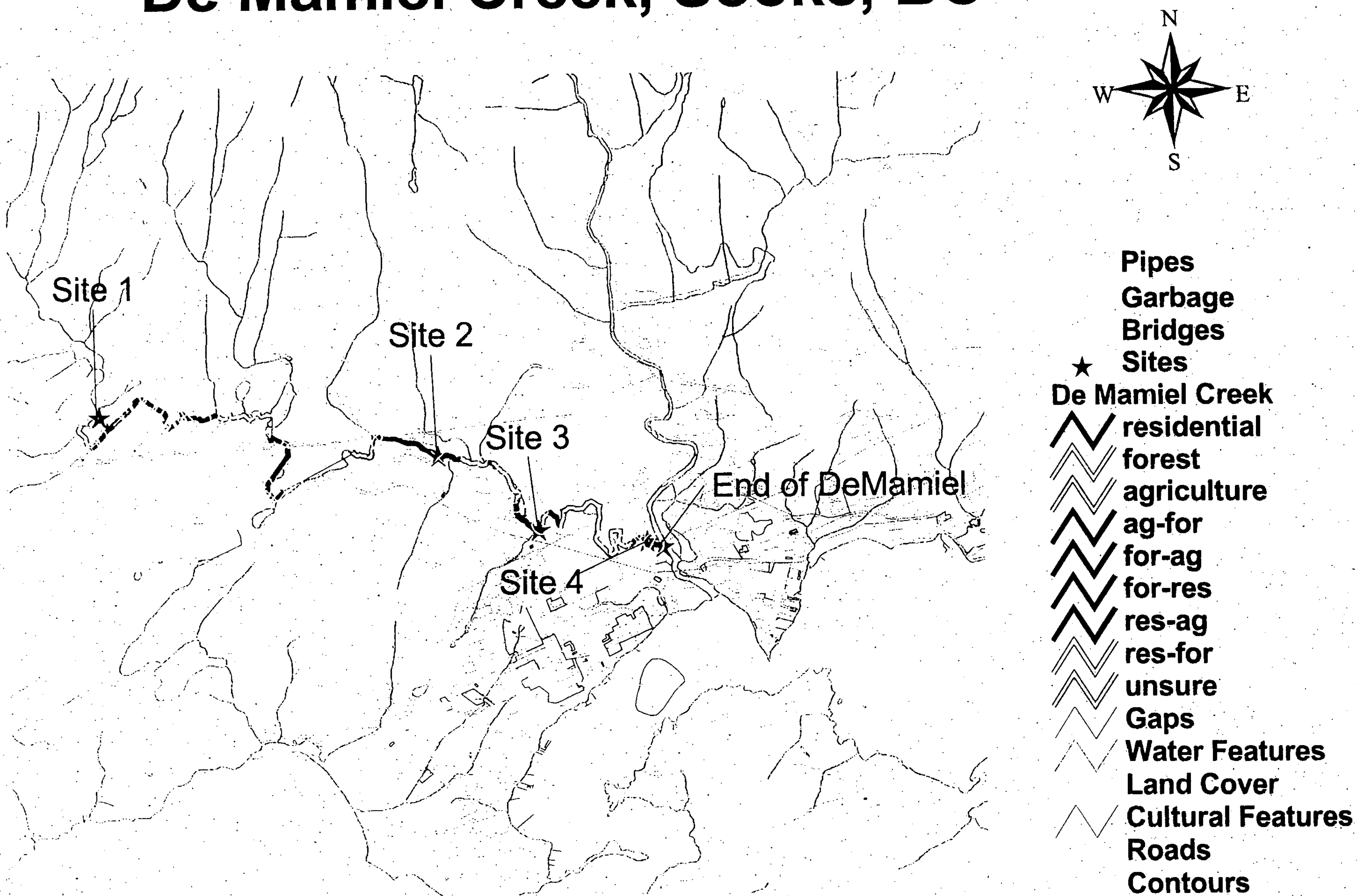
Sampling Schedule

Date	Sampler(s)	Tests Performed
Nov. 18, 1999	Kevin	Microbiological
Nov. 24, 1999	Kevin	Microbiological
Dec. 2, 1999	Kevin	Microbiological
Dec. 9, 1999	Kevin	Microbiological
Dec. 13, 1999	Kevin	Inorganic, Microbiological
Jan. 13, 2000	Kevin	Microbiological
Jan. 26, 2000	Kevin and Azimuth Env.	Physical, Microbiological
Feb. 1, 2000	Kevin	Microbiological
Feb. 2, 2000	Jason, Rachel	Physical, Microbiological
Feb. 9, 2000	Rachel, Katrine	Inorganic, Physical, Microbiological
Feb. 16, 2000	Colin, Rachel	Physical, Microbiological
Feb. 23, 2000	Julie, Katrine	Physical, Microbiological
Mar. 1, 2000	Julie, Jason	Inorganic, Physical, Microbiological
Mar. 8, 2000	Jason, Colin	Physical, Microbiological
Mar. 15, 2000	Kevin	Microbiological
Mar. 23, 2000	Jason, Julie	Physical, Microbiological
Mar. 29, 2000	Rachel, Colin	Physical, Microbiological

[Samples were taken every Wednesday by Azimuth Environmental, and after rain events by Kevin Rieberger, MELP project sponsor]

Appendix C:
Geographic Information System Map Of De Mamiel Creek And Area

De Mamiel Creek, Sooke, BC



Appendix D:
Microbiological Laboratory Results

Site	Date	< FC	Fecal Coliform	<E	Enterococcus	<FS	Fecal Streptococci	<E coli	E coli
Site 1	18-Nov-99	<	2	<	2				
Site 1	24-Nov-99	<	2	<	2				
Site 1	02-Dec-99		2		1				
Site 1	09-Dec-99	<	2		1				
Site 1	13-Dec-99		4		2				
Site 1	13-Jan-00	<	2	<	2	<	2	<	2
Site 1	26-Jan-00	<	2	<	2	<	2		2
Site 1	01-Feb-00		6		4		16		2
Site 1	02-Feb-00		6	<	2	<	2		6
Site 1	09-Feb-00		4	<	2		2		2
Site 1	16-Feb-00								
Site 1	23-Feb-00	<	2	<	2	<	2	<	2
Site 1	23-Feb-00	<	2	<	2	<	2	<	2
Site 1	01-Mar-00	<	2	<	2	<	2	<	2
Site 1	08-Mar-00	<	2	<	2	<	2	<	2
Site 1	15-Mar-00	<	2	<	2	<	2	<	2
Site 1	23-Mar-00	<	2	<	2	<	2	<	2
Site 1	29-Mar-00	<	2	<	2	<	2	<	2

Site	Date	< FC	Fecal Coliform	<E	Enterococcus	<FS	Fecal Streptococci	<E coli	E coli
Site 2	18-Nov-99		10	<	2				
Site 2	24-Nov-99		30		2				
Site 2	02-Dec-99		20		20				
Site 2	09-Dec-99		12	<	1				
Site 2	13-Dec-99		30		28				
Site 2	13-Jan-00	<	2		4		2		6
Site 2	26-Jan-00		2	<	2	<	2		2
Site 2	01-Feb-00		18		2		20		14
Site 2	02-Feb-00	<	2	<	2		18		4
Site 2	09-Feb-00		2	<	2		4		2
Site 2	16-Feb-00	<	2		4	<	2	<	2
Site 2	23-Feb-00		2	<	2	<	2	<	2
Site 2	01-Mar-00		4		6		4		2
Site 2	08-Mar-00		14		2	<	2		12
Site 2	15-Mar-00		2		2	<	2		2
Site 2	23-Mar-00		14		4		4		2
Site 2	29-Mar-00	<	2	<	2	<	2	<	2

Site	Date	< FC	Fecal Coliform	<E	Enterococcus	<FS	Fecal Streptococci	<E coli	E coli
Site 3	18-Nov-99		34	<	2				
Site 3	24-Nov-99		120		26				
Site 3	02-Dec-99		112		135				
Site 3	09-Dec-99		64		2				
Site 3	13-Dec-99		62		46				
Site 3	13-Jan-00		48		8		14		6
Site 3	26-Jan-00		44		2		2		26
Site 3	01-Feb-00		140		390		130		70
Site 3	02-Feb-00		8		8		28		16
Site 3	09-Feb-00		48		6		8		48
Site 3	16-Feb-00		16	<	2	<	2		14
Site 3	23-Feb-00		10	<	2	<	2		12
Site 3	01-Mar-00		24		4		8		20
Site 3	08-Mar-00		250	<	2	<	2		130
Site 3	08-Mar-00		250		1	<	2		110
Site 3	15-Mar-00		6		10		20		8
Site 3	23-Mar-00		18		26		24		14
Site 3	23-Mar-00		26		16		30		26
Site 3	29-Mar-00		20		2	<	2		20

Site	Date	< FC	Fecal Coliform	<E	Enterococcus	<FS	Fecal Streptococci	<E coli	E coli
Site 4	18-Nov-99		52		94				
Site 4	24-Nov-99		62		100				
Site 4	02-Dec-99		99		74				
Site 4	09-Dec-99		80		3				
Site 4	13-Dec-99		52		48				
Site 4	13-Jan-00		56		12		14		14
Site 4	26-Jan-00		44		2		6		32
Site 4	01-Feb-00		180		960		240		150
Site 4	02-Feb-00		22		10		24		10
Site 4	09-Feb-00	<	2		10		8	<	2
Site 4	16-Feb-00		4	<	2		2		8
Site 4	23-Feb-00		8	<	2	<	2		6
Site 4	01-Mar-00		32		6		10		30
Site 4	08-Mar-00		14	<	2	<	2		4
Site 4	15-Mar-00		26		6		6		22
Site 4	23-Mar-00		8		24		22		10
Site 4	29-Mar-00		8	<	2		2		2

Site	Date	< FC	Fecal Coliform	<E	Enterococcus	<FS	Fecal Streptococci	<E coli	E coli
Site 5	18-Nov-99		50		8				
Site 5	24-Nov-99		96		120				
Site 5	02-Dec-99		55		14				
Site 5	09-Dec-99		8		1				
Site 5	13-Dec-99		14		8				
Site 5	13-Jan-00		4	<	2	<	2		2
Site 5	26-Jan-00	<	2	<	2	<	2	<	2
Site 5	01-Feb-00		30		14		44		30
Site 5	02-Feb-00	<	2	<	2	<	2	<	2
Site 5	09-Feb-00		34		6		16		36
Site 5	16-Feb-00		8	<	2		2		4
Site 5	23-Feb-00		12	<	2	<	2		12
Site 5	01-Mar-00		4		14		2		6
Site 5	08-Mar-00		8	<	2	<	2	<	2
Site 5	15-Mar-00		2	<	2		4		2
Site 5	23-Mar-00	<	2	<	2	<	2	<	2
Site 5	29-Mar-00	<	2	<	2	<	2	<	2

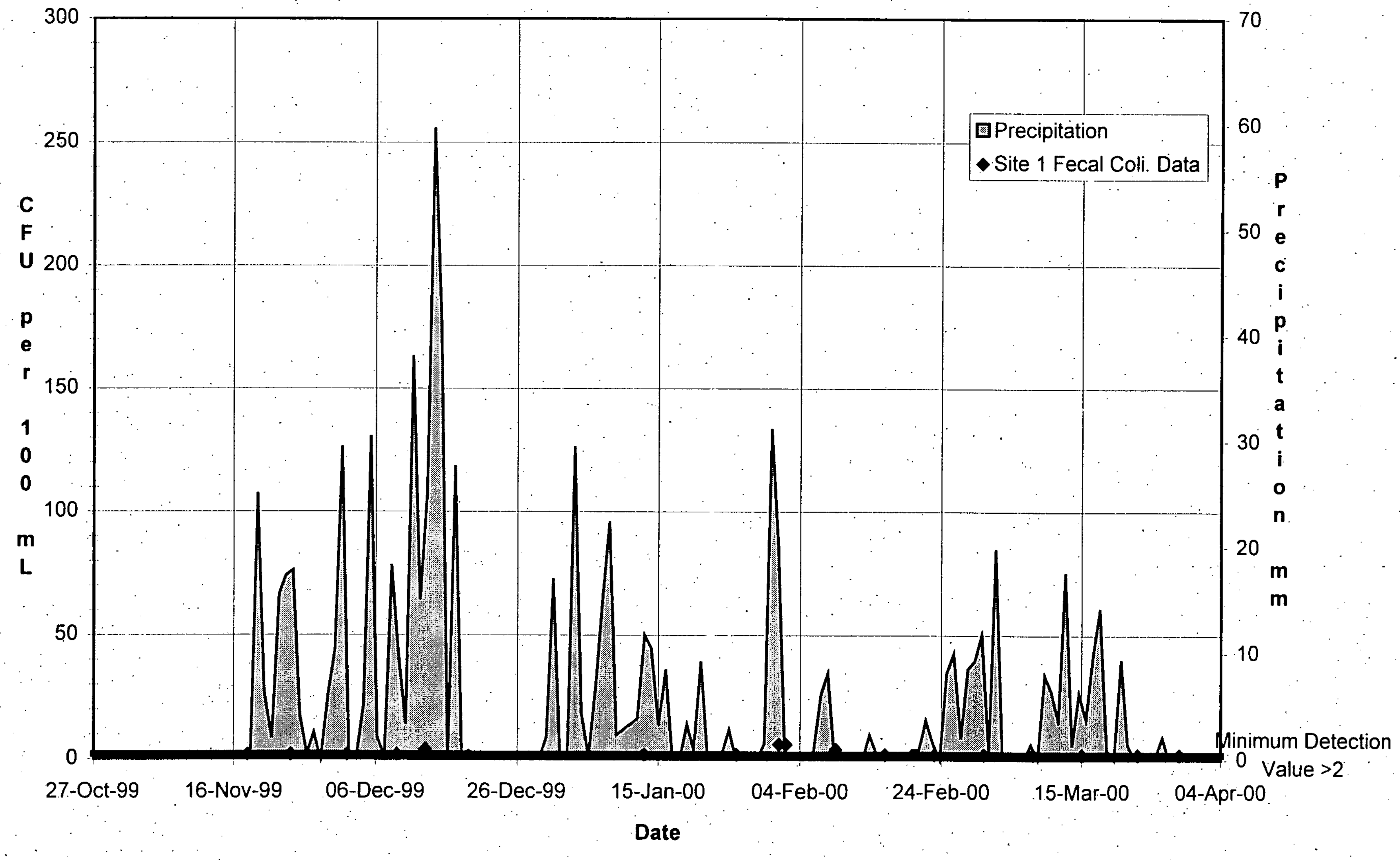
Appendix E:
Precipitation Data Obtained From Capital Regional District

Date	Daily Precip.(mm)	Date	Daily Precip.(mm)	Date	Daily Precip.(mm)	Date	Daily Precip.(mm)	Date	Daily Precip.(mm)
24-Oct-99	0	26-Nov-99	0.5	29-Dec-99	0	31-Jan-00	31.2	4-Mar-00	0
25-Oct-99	2	27-Nov-99	2.5	30-Dec-99	2	**1-Feb-00**	**20.1**	5-Mar-00	0
26-Oct-99	0	28-Nov-99	0	31-Dec-99	17	**2-Feb-00**	**0**	6-Mar-00	0
27-Oct-99	32.3	29-Nov-99	6.1	1-Jan-00	0	3-Feb-00	0	7-Mar-00	0
28-Oct-99	12.4	30-Nov-99	10.4	2-Jan-00	0.3	4-Feb-00	0	**8-Mar-00**	**1.4**
29-Oct-99	65.5	1-Dec-99	29.5	3-Jan-00	29.5	5-Feb-00	0	9-Mar-00	0
30-Oct-99	53.8	**2-Dec-99**	**0.3**	4-Jan-00	4.3	6-Feb-00	0.8	10-Mar-00	7.9
31-Oct-99	0	3-Dec-99	0	5-Jan-00	0.3	7-Feb-00	6.1	11-Mar-00	6.3
1-Nov-99	0	4-Dec-99	5.1	6-Jan-00	7.1	8-Feb-00	8.1	12-Mar-00	3.6
2-Nov-99	0	5-Dec-99	30.5	7-Jan-00	15	**9-Feb-00**	**0**	13-Mar-00	17.6
3-Nov-99	6.3	6-Dec-99	2	8-Jan-00	22.4	10-Feb-00	0	14-Mar-00	1.3
4-Nov-99	0	7-Dec-99	0.3	9-Jan-00	2.3	11-Feb-00	0	**15-Mar-00**	**6.2**
5-Nov-99	18.3	8-Dec-99	18.3	10-Jan-00	2.8	12-Feb-00	0	16-Mar-00	3.8
6-Nov-99	18	**9-Dec-99**	**10.1**	11-Jan-00	3.3	13-Feb-00	0	17-Mar-00	9.9
7-Nov-99	2.3	10-Dec-99	3.3	12-Jan-00	3.8	14-Feb-00	2.3	18-Mar-00	14.2
8-Nov-99	15.8	11-Dec-99	38.1	**13-Jan-00**	**11.7**	15-Feb-00	0.6	19-Mar-00	0.9
9-Nov-99	14	12-Dec-99	15	14-Jan-00	10.4	**16-Feb-00**	**0**	20-Mar-00	0
10-Nov-99	9.6	**13-Dec-99**	**25.2**	15-Jan-00	3.3	17-Feb-00	0	21-Mar-00	9.4
11-Nov-99	36.1	14-Dec-99	59.7	16-Jan-00	8.4	18-Feb-00	0	22-Mar-00	1.4
12-Nov-99	1.8	15-Dec-99	41.1	17-Jan-00	0	19-Feb-00	0	**23-Mar-00**	**0**
13-Nov-99	9.7	16-Dec-99	0	18-Jan-00	0	20-Feb-00	0.9	24-Mar-00	0
14-Nov-99	0.3	17-Dec-99	27.7	19-Jan-00	3.3	21-Feb-00	0.9	25-Mar-00	0
15-Nov-99	10.4	18-Dec-99	0.3	20-Jan-00	1	22-Feb-00	3.7	26-Mar-00	0.3
16-Nov-99	6.1	19-Dec-99	0.8	21-Jan-00	9.2	**23-Feb-00**	**1.6**	27-Mar-00	2.1
17-Nov-99	0	20-Dec-99	0	22-Jan-00	0	24-Feb-00	0	28-Mar-00	0
18-Nov-99	**0.3**	21-Dec-99	0	23-Jan-00	0	25-Feb-00	8.1	**29-Mar-00**	**0**
19-Nov-99	25.1	22-Dec-99	0	24-Jan-00	0.5	26-Feb-00	10	30-Mar-00	0
20-Nov-99	6.4	23-Dec-99	0	25-Jan-00	2.8	27-Feb-00	2	31-Mar-00	0
21-Nov-99	2	24-Dec-99	0	**26-Jan-00**	**0**	28-Feb-00	8.5	1-Apr-00	0
22-Nov-99	15.5	25-Dec-99	0	27-Jan-00	0	29-Feb-00	9.3	2-Apr-00	0
23-Nov-99	17.3	26-Dec-99	0	28-Jan-00	0	**1-Mar-00**	**11.8**	3-Apr-00	0
24-Nov-99	**17.8**	27-Dec-99	0	29-Jan-00	0	2-Mar-00	0.8	4-Apr-00	0
25-Nov-99	4.1	28-Dec-99	0	30-Jan-00	1.5	3-Mar-00	19.8		

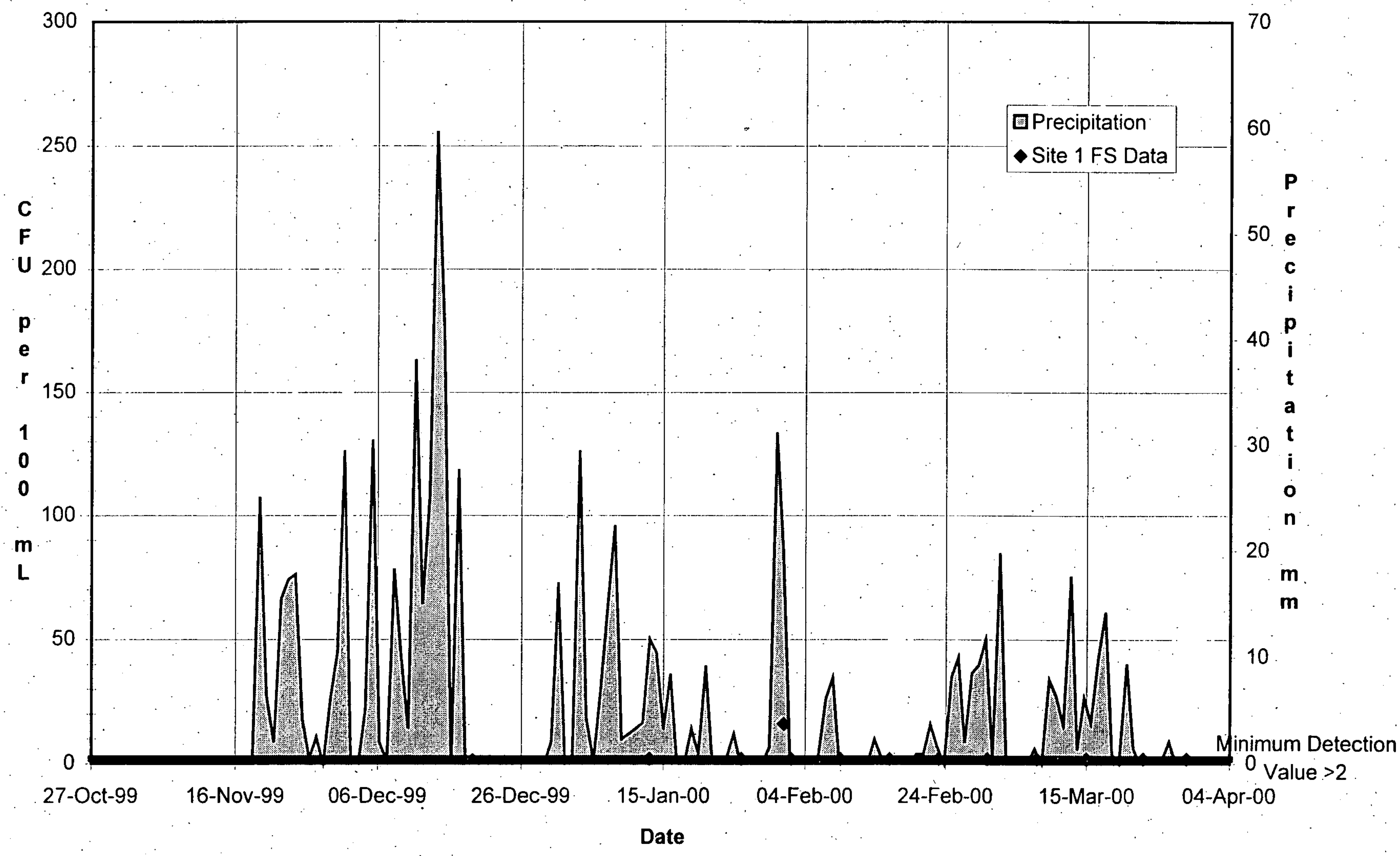
Shading indicates duration of 1999-2000 sampling period of De Mamiel Creek; bold indicates actual sampling dates.

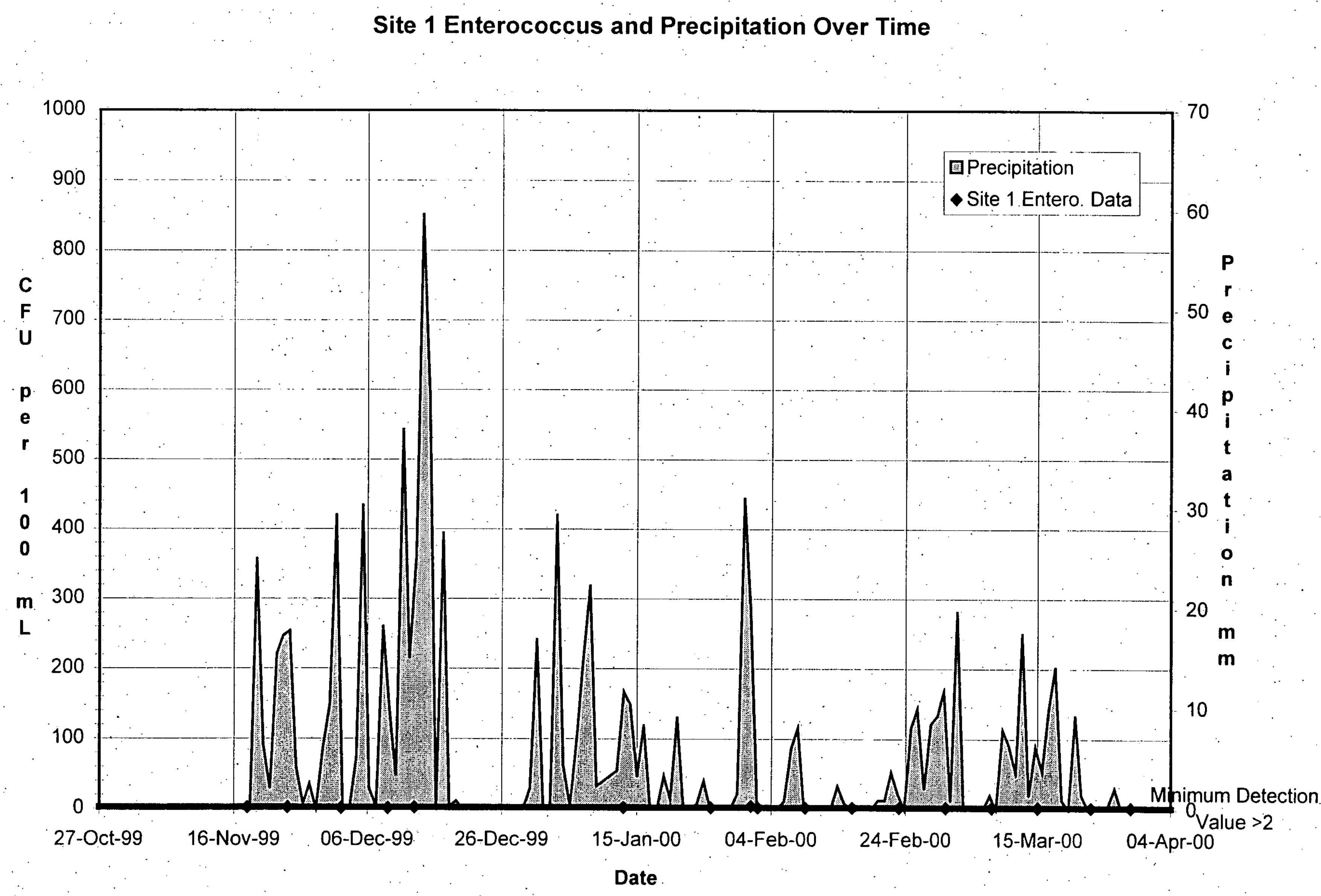
Appendix F:
Results Of Biological Laboratory Analysis
(Charts 1 to 25)

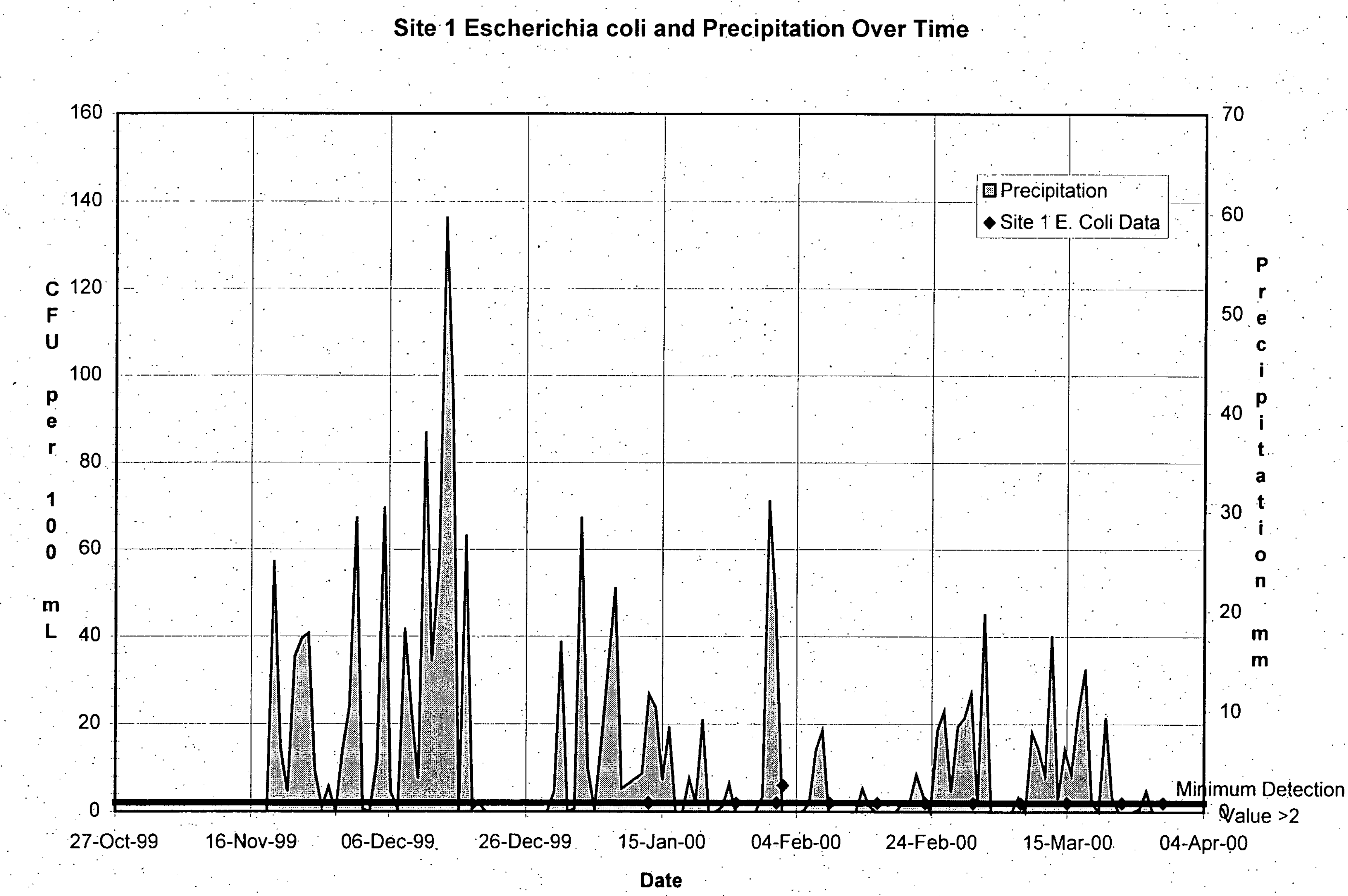
Site 1 Fecal Coliform and Precipitation Over Time



Site 1 Fecal Streptococcus and Precipitation Over Time

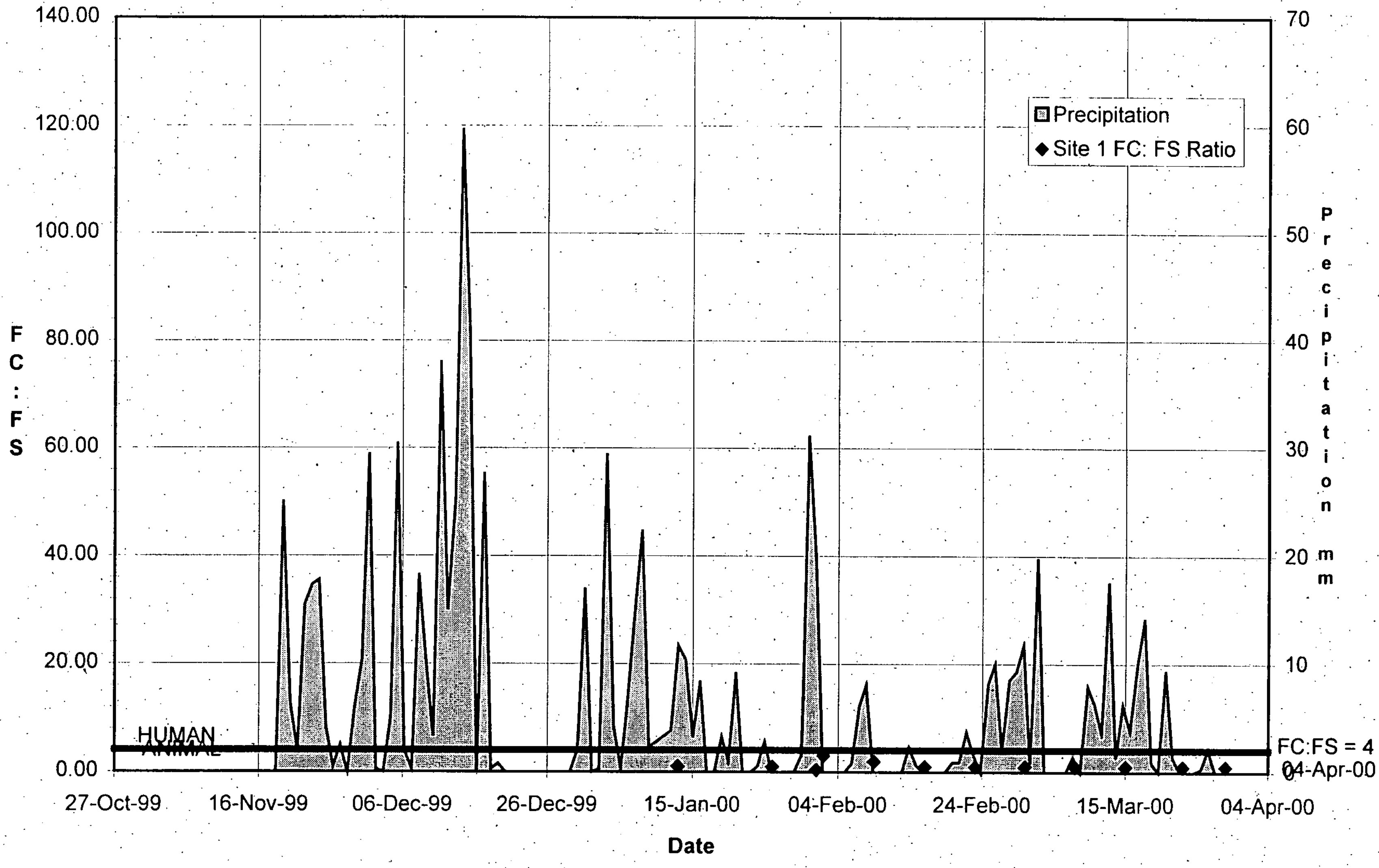



Site 1 Enterococcus and Precipitation Over Time
CFU per 100 mL
1000
900
800
700
600
500
400
300
200
100
0
Precipitation mm
70
60
50
40
30
20
10
0
Precipitation
Site 1 Entero. Data
Minimum Detection Value >2
27-Oct-99
16-Nov-99
06-Dec-99
26-Dec-99
15-Jan-00
04-Feb-00
24-Feb-00
15-Mar-00
04-Apr-00
Date

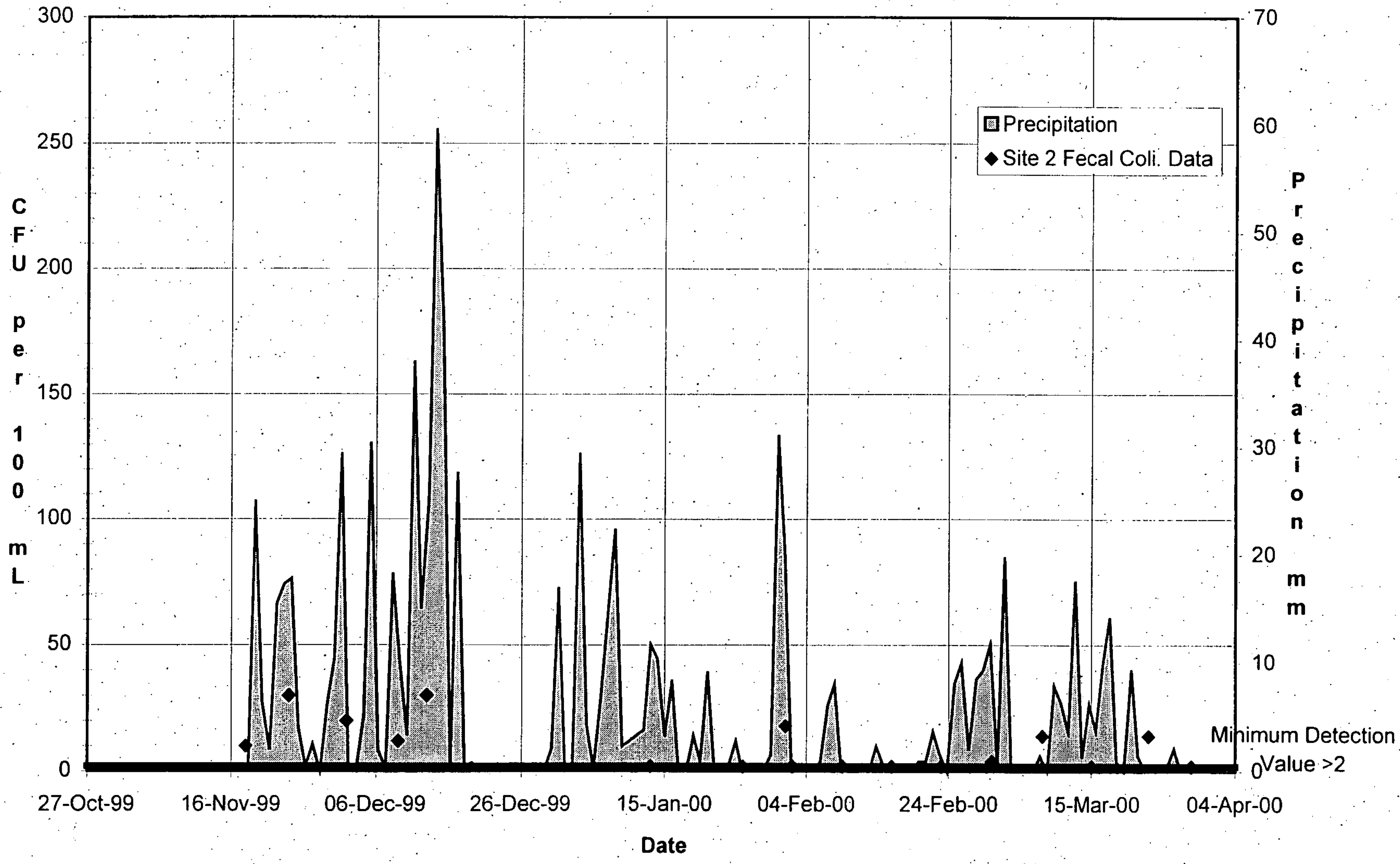


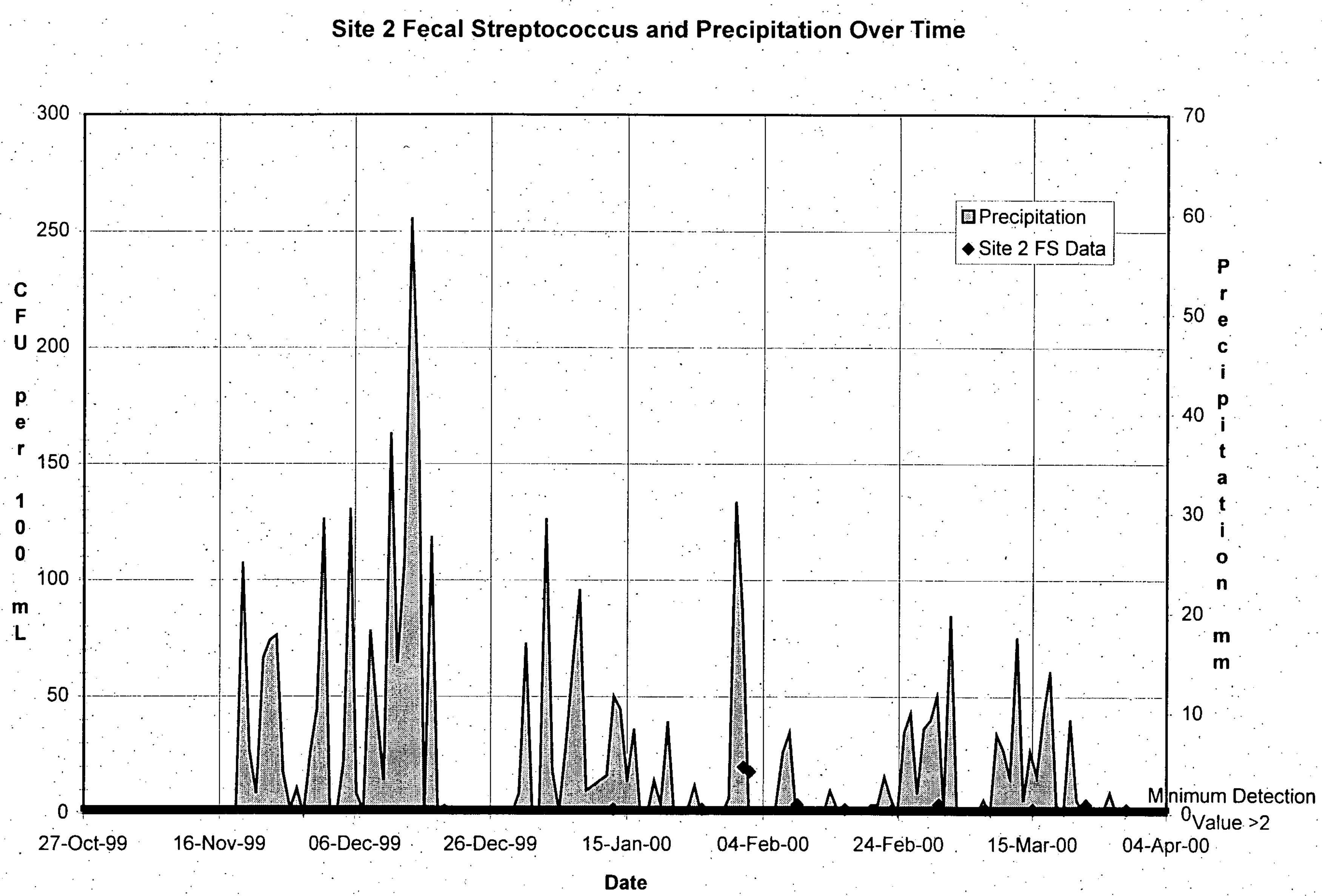
Site 1 Escherichia coli and Precipitation Over Time
CFU per 100 mL
160
140
120
100
80
60
40
20
0
Precipitation mm
70
60
50
40
30
20
10
0
Precipitation
Site 1 E. Coli Data
Minimum Detection Value >2
27-Oct-99
16-Nov-99
06-Dec-99
26-Dec-99
15-Jan-00
04-Feb-00
24-Feb-00
15-Mar-00
04-Apr-00
Date

Site 1 FC:FS Ratio and Precipitation Over Time

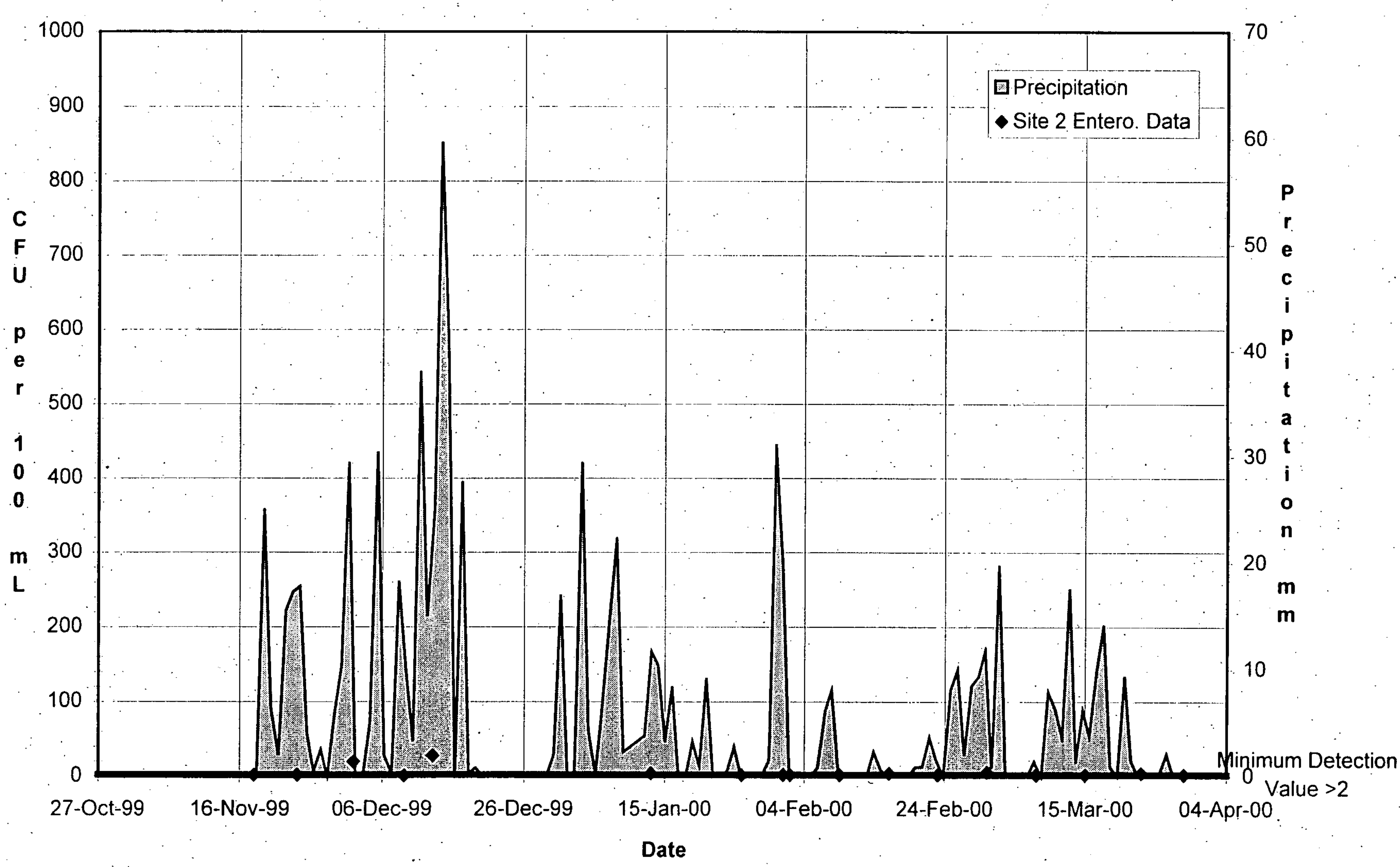


Site 2 Fecal Coliform and Precipitation Over Time

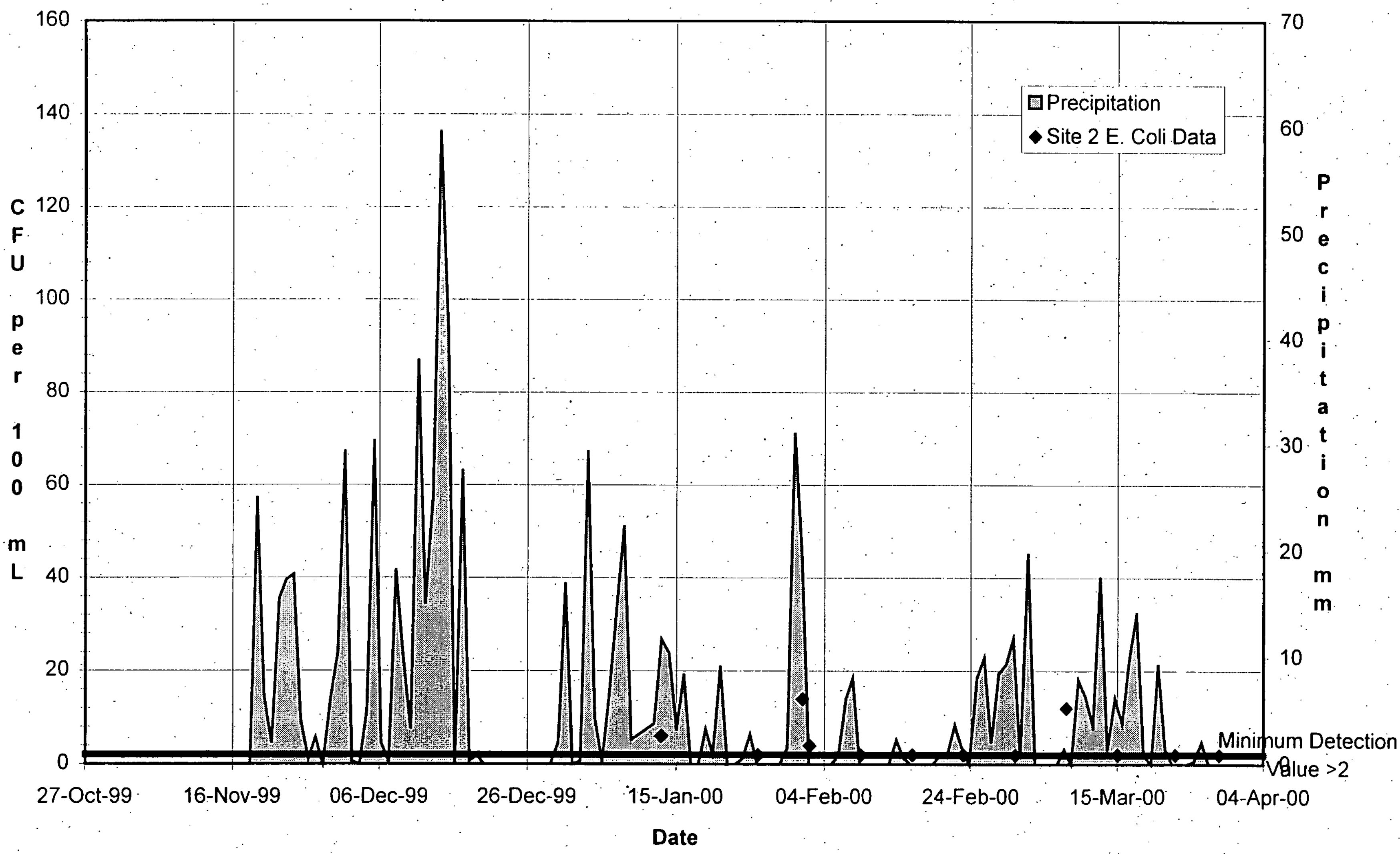



Site 2 Fecal Streptococcus and Precipitation Over Time
CFU per 100 mL
300
250
200
150
100
50
0
Precipitation mm
70
60
50
40
30
20
10
0
Precipitation
Site 2 FS Data
Minimum Detection Value >2
27-Oct-99
16-Nov-99
06-Dec-99
26-Dec-99
15-Jan-00
04-Feb-00
24-Feb-00
15-Mar-00
04-Apr-00
Date

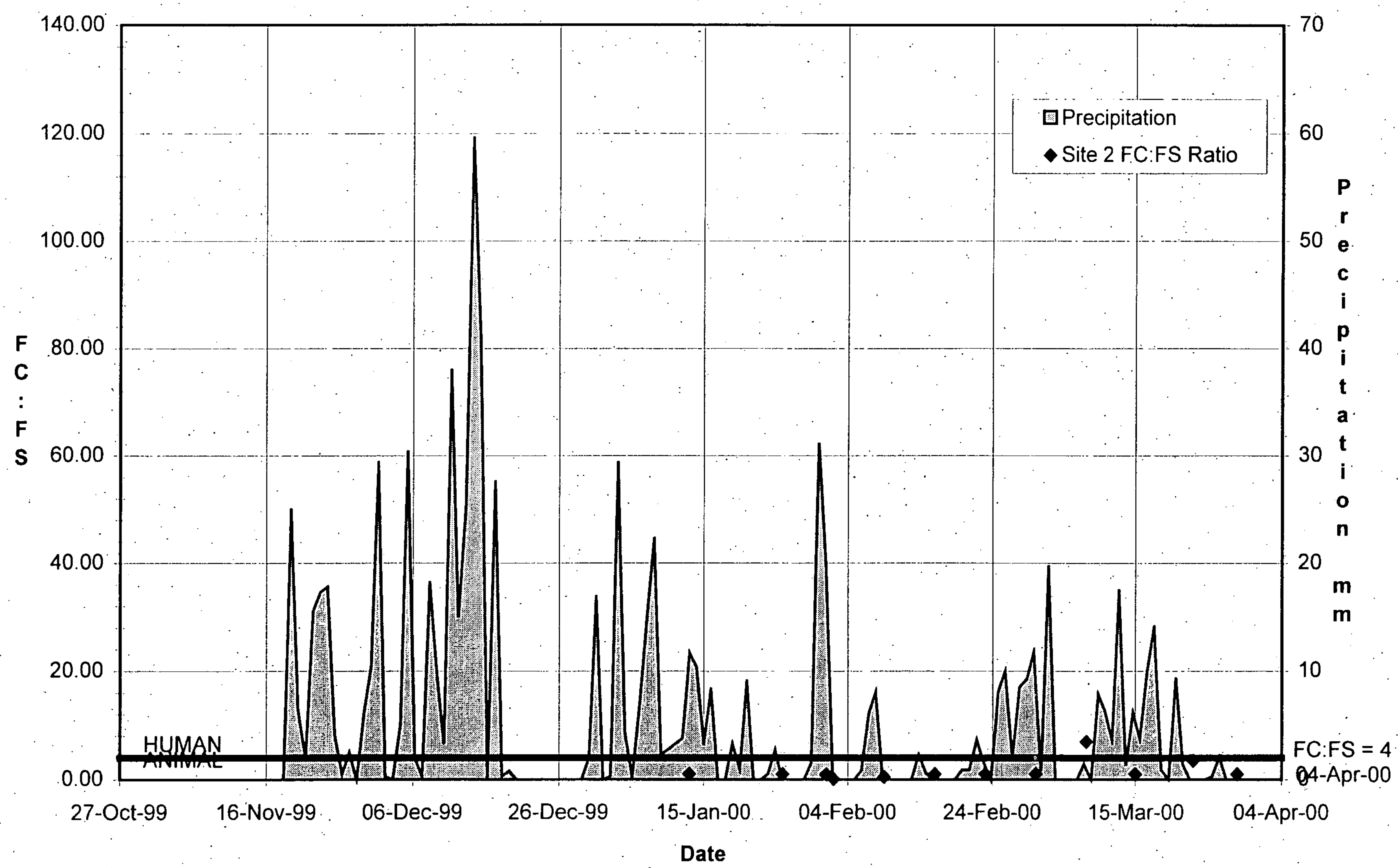
Site 2 Enterococcus and Precipitation Over Time



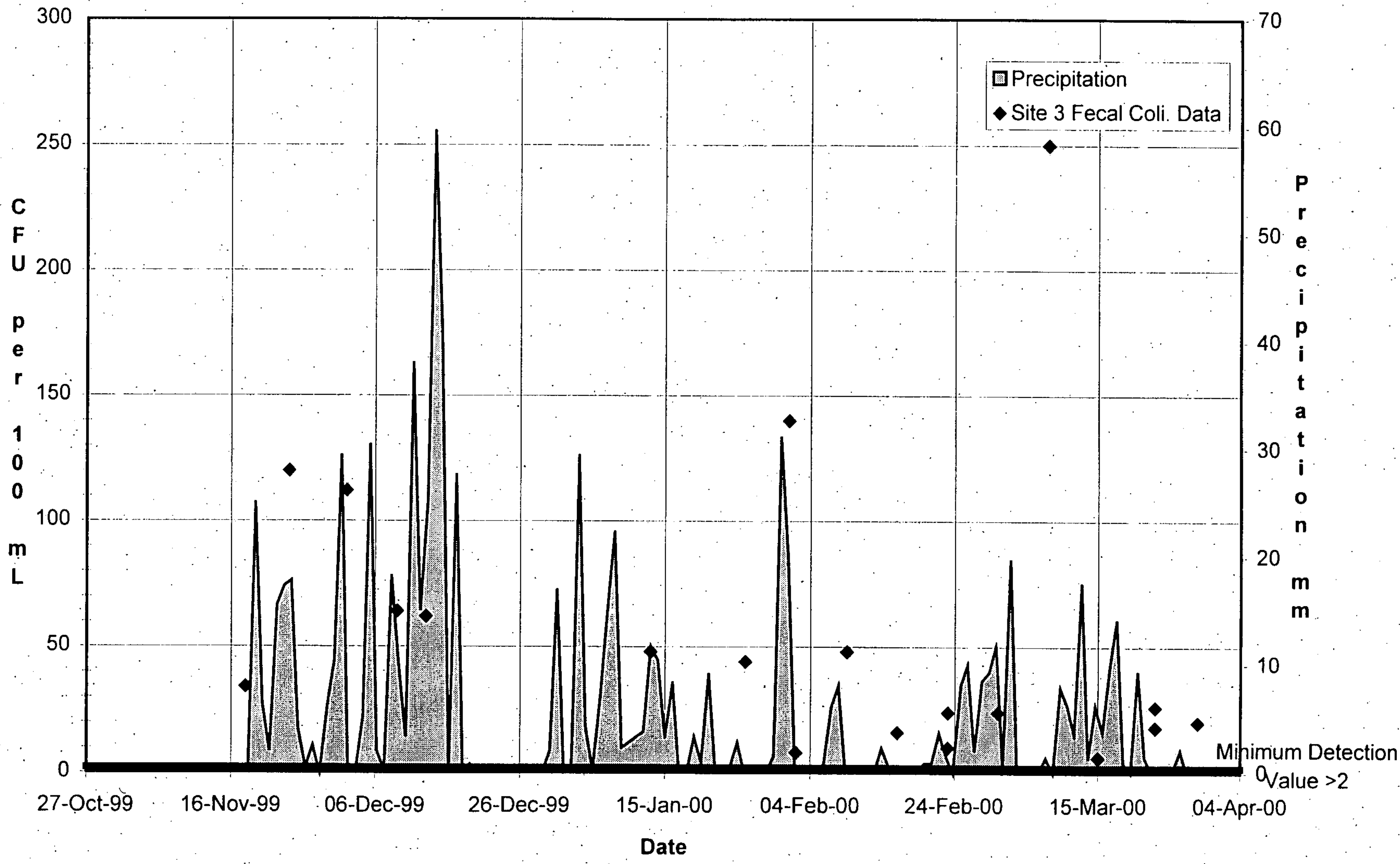
Site 2 Escherichia coli and Precipitation Over Time



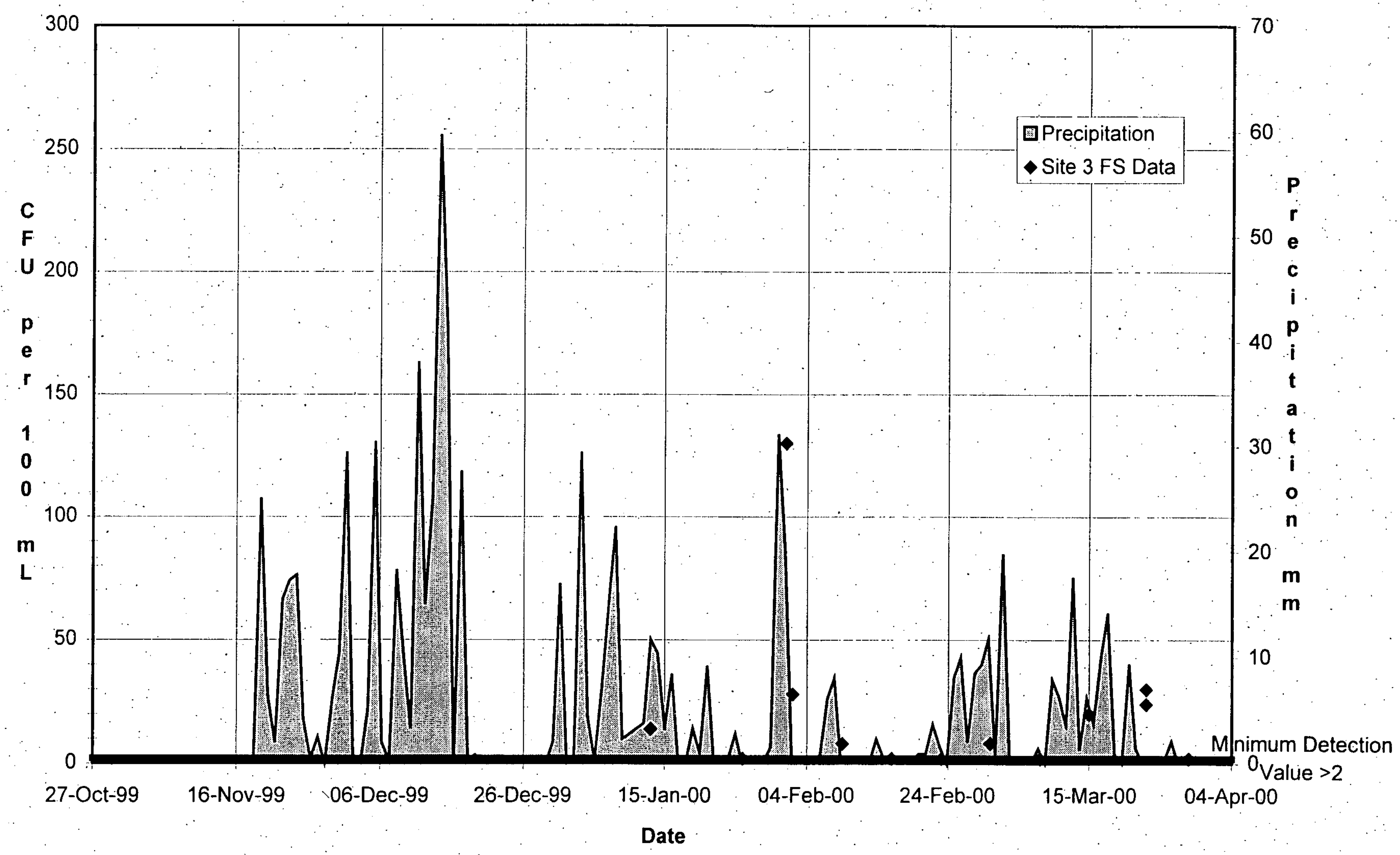
Site 2 FC:FS Ratio and Precipitation Over Time



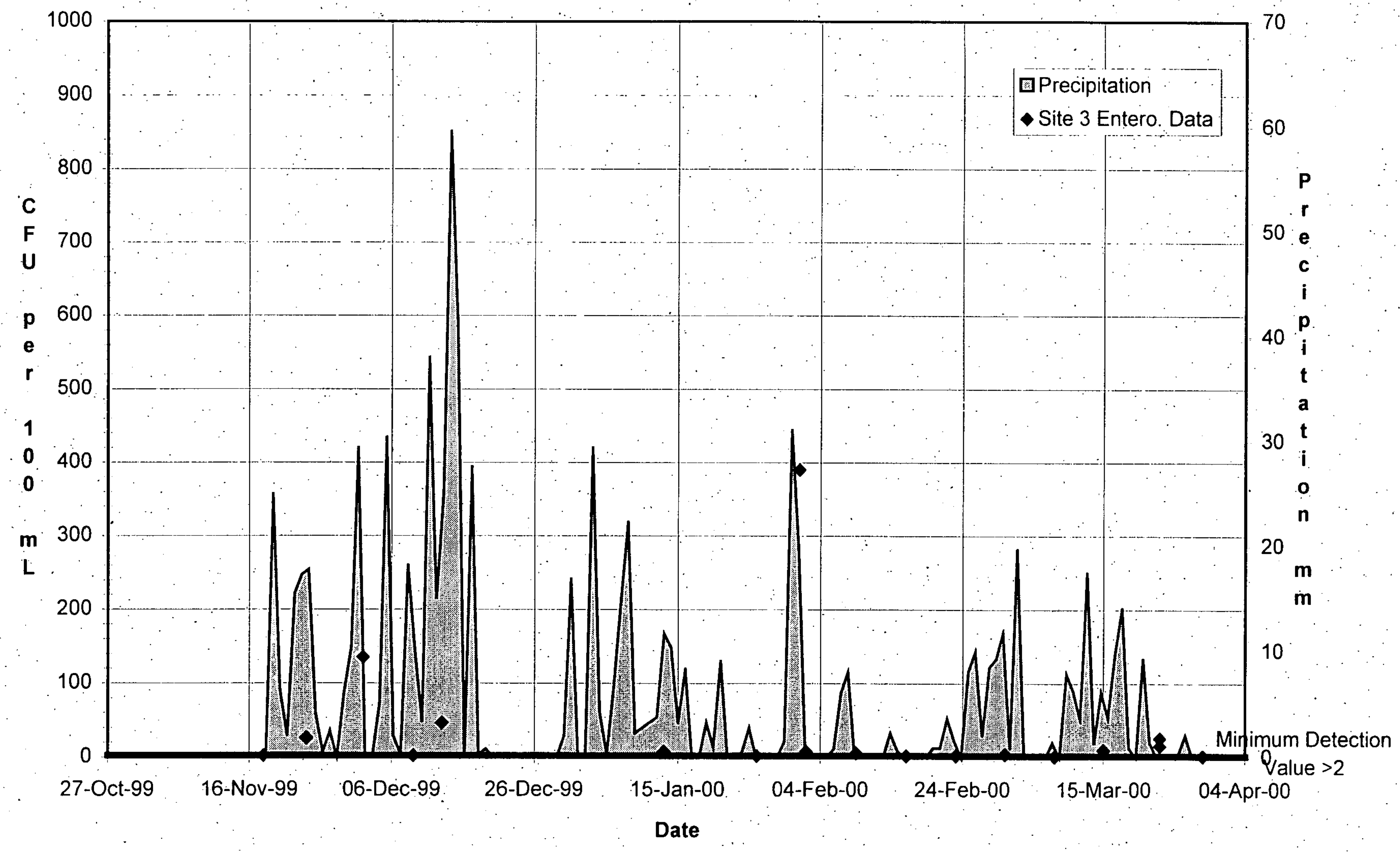
Site 3 Fecal Coliform and Precipitation Over Time



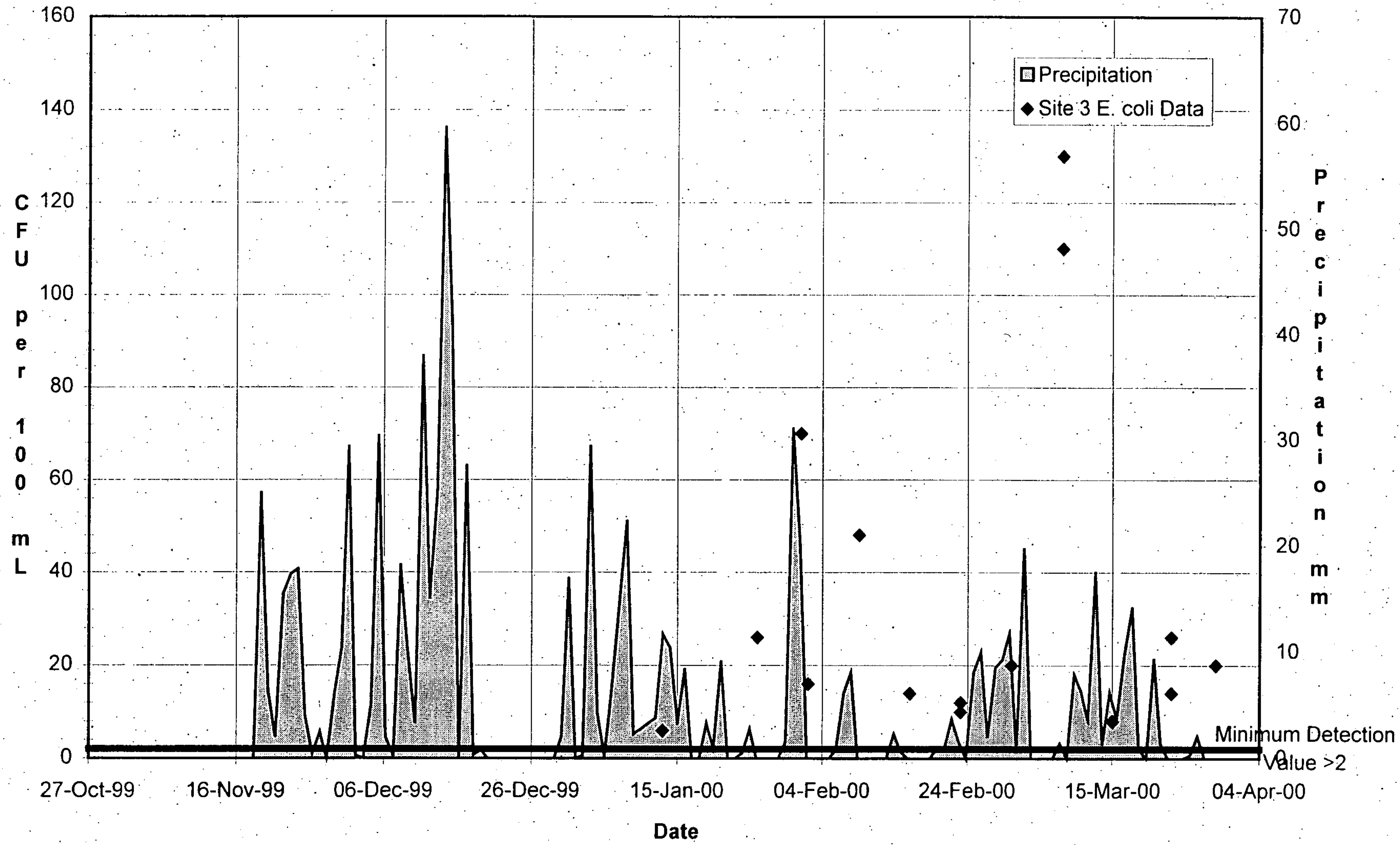
Site 3 Fecal Streptococcus and Precipitation Over Time



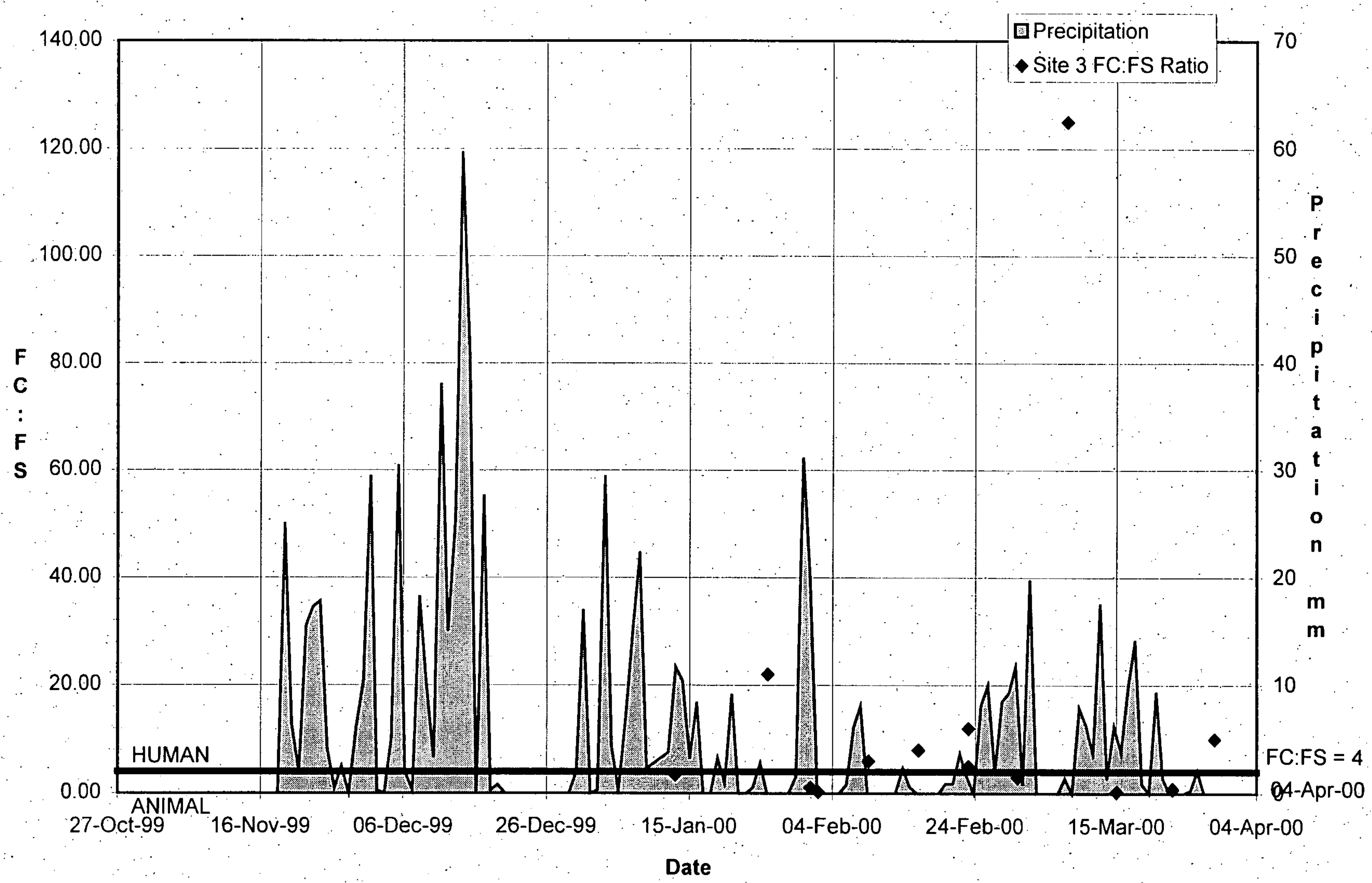
Site 3 Enterococcus and Precipitation Over Time



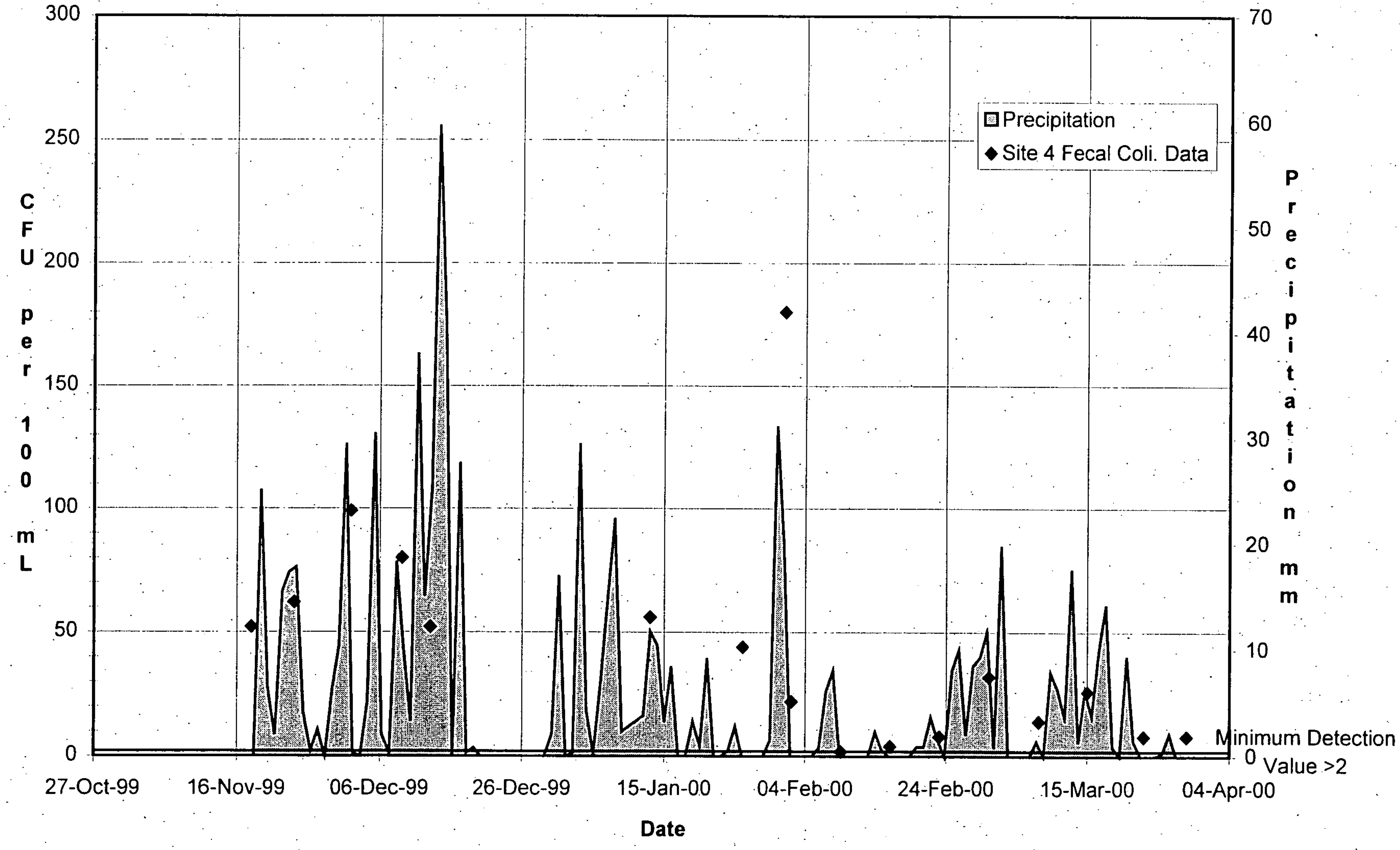
Site 3 Escherichia coli and Precipitation Over Time



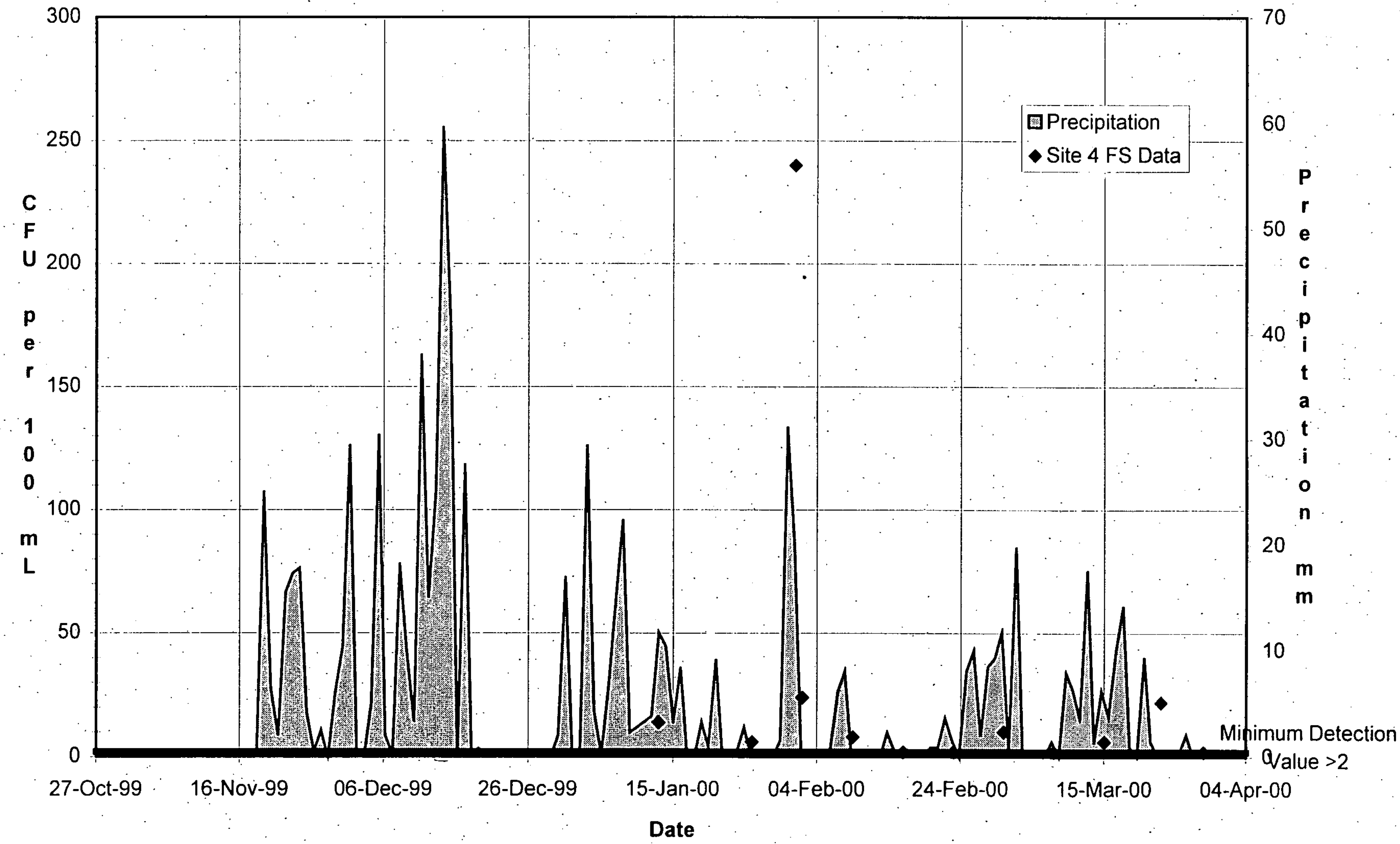
Site 3 FC:FS Ratio and Precipitation Over Time



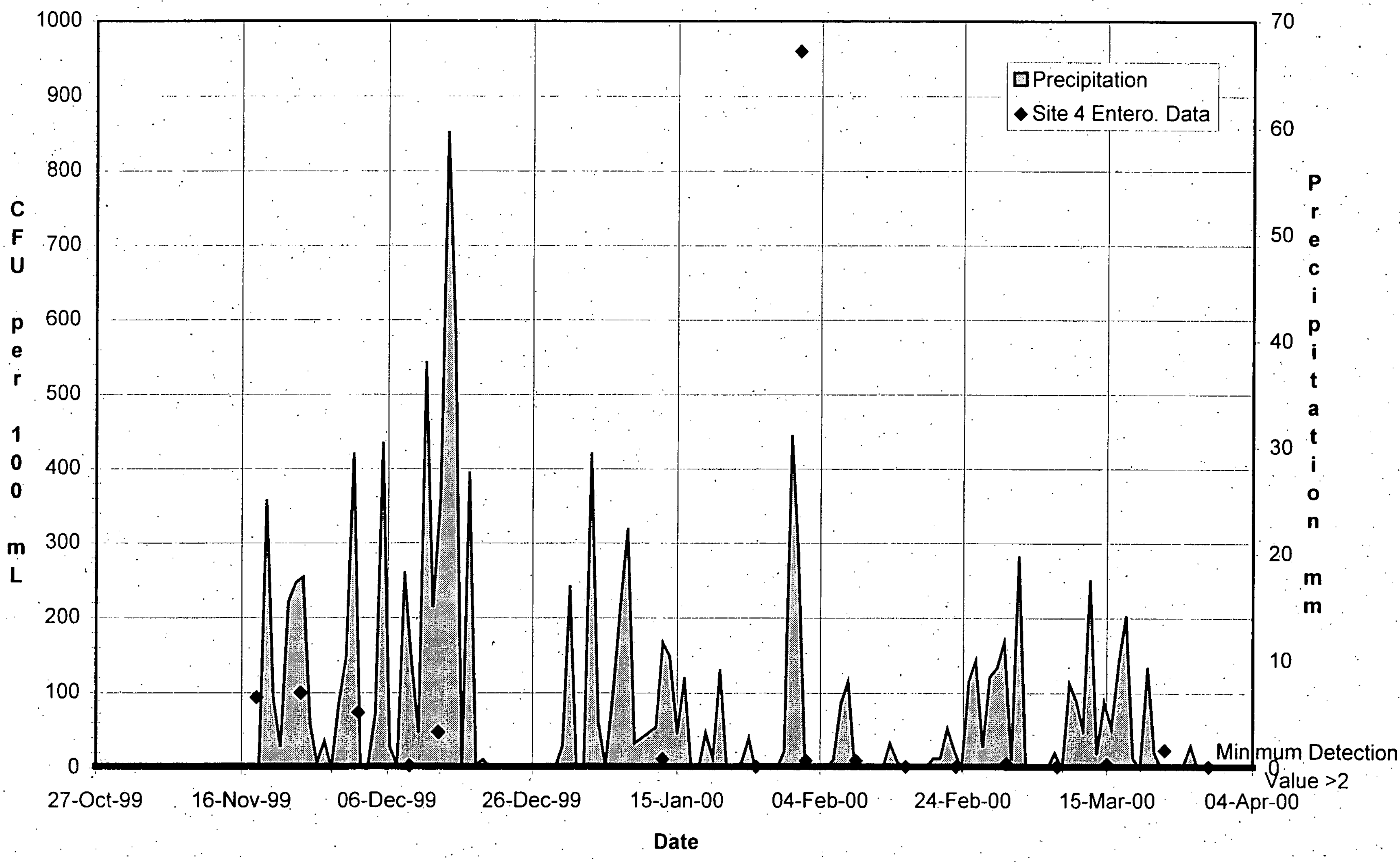
Site 4 Fecal Coliform and Precipitation Over Time



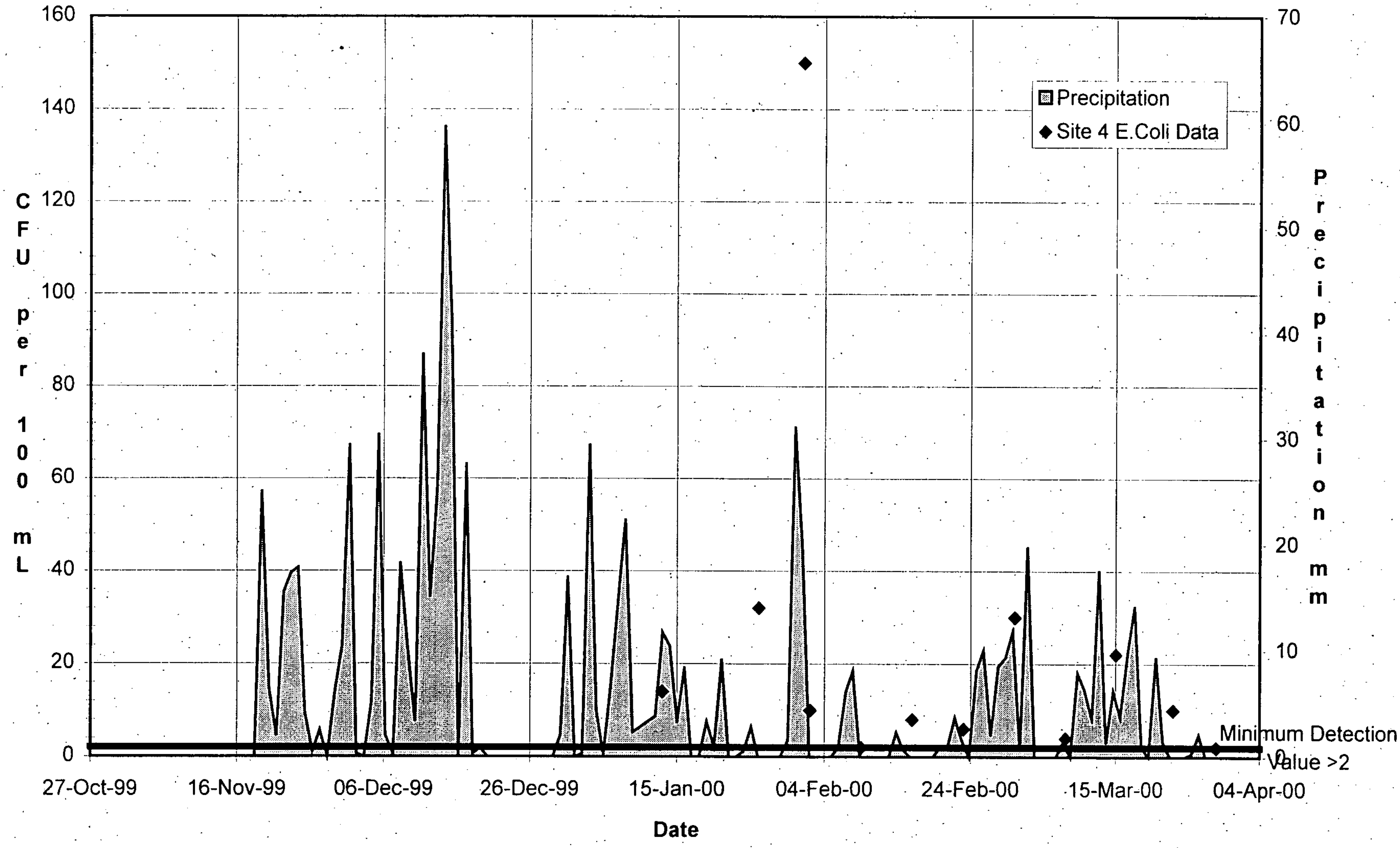
Site 4 Fecal Streptococcus and Precipitation Over Time



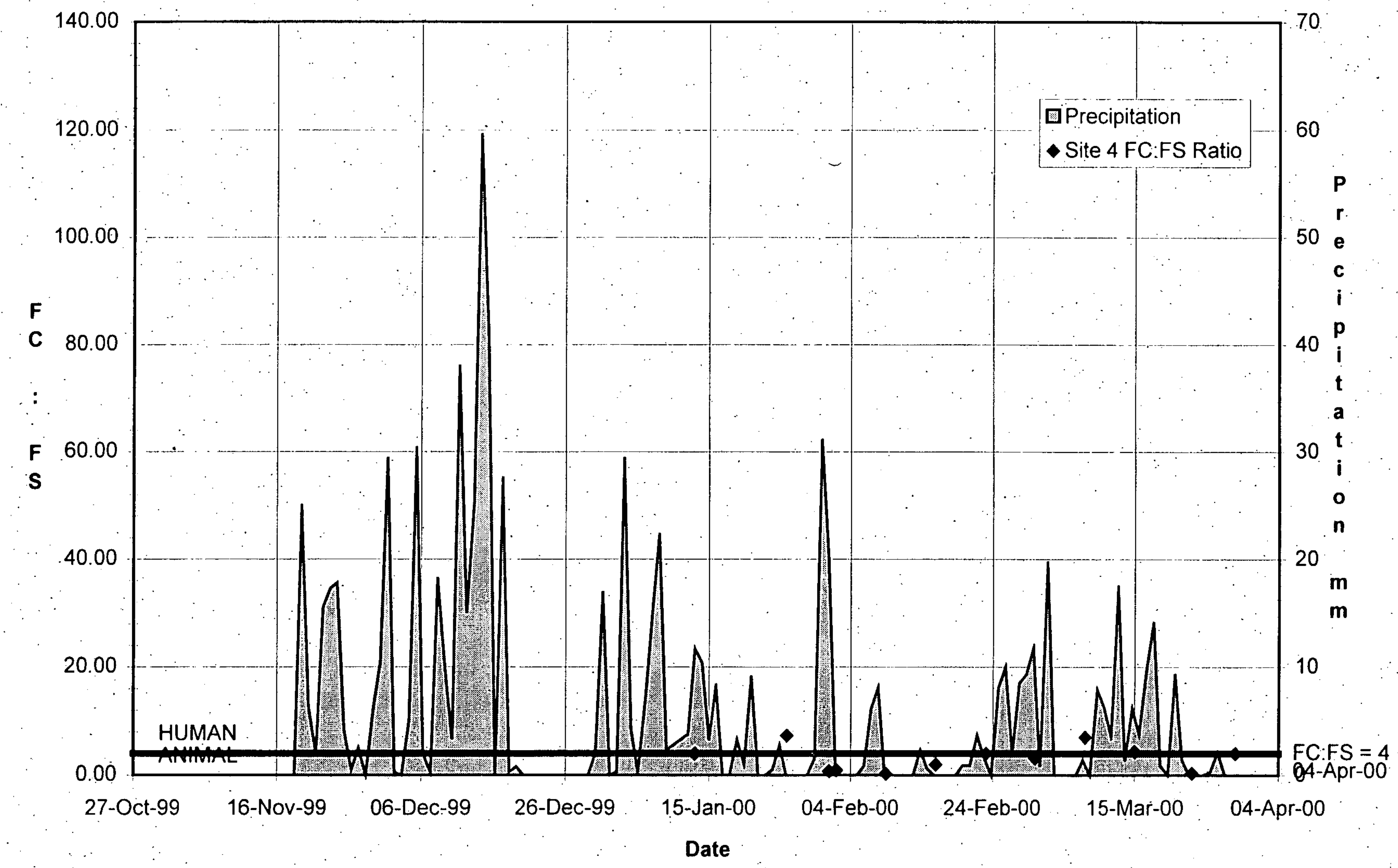
Site 4 Enterococcus and Precipitation Over Time



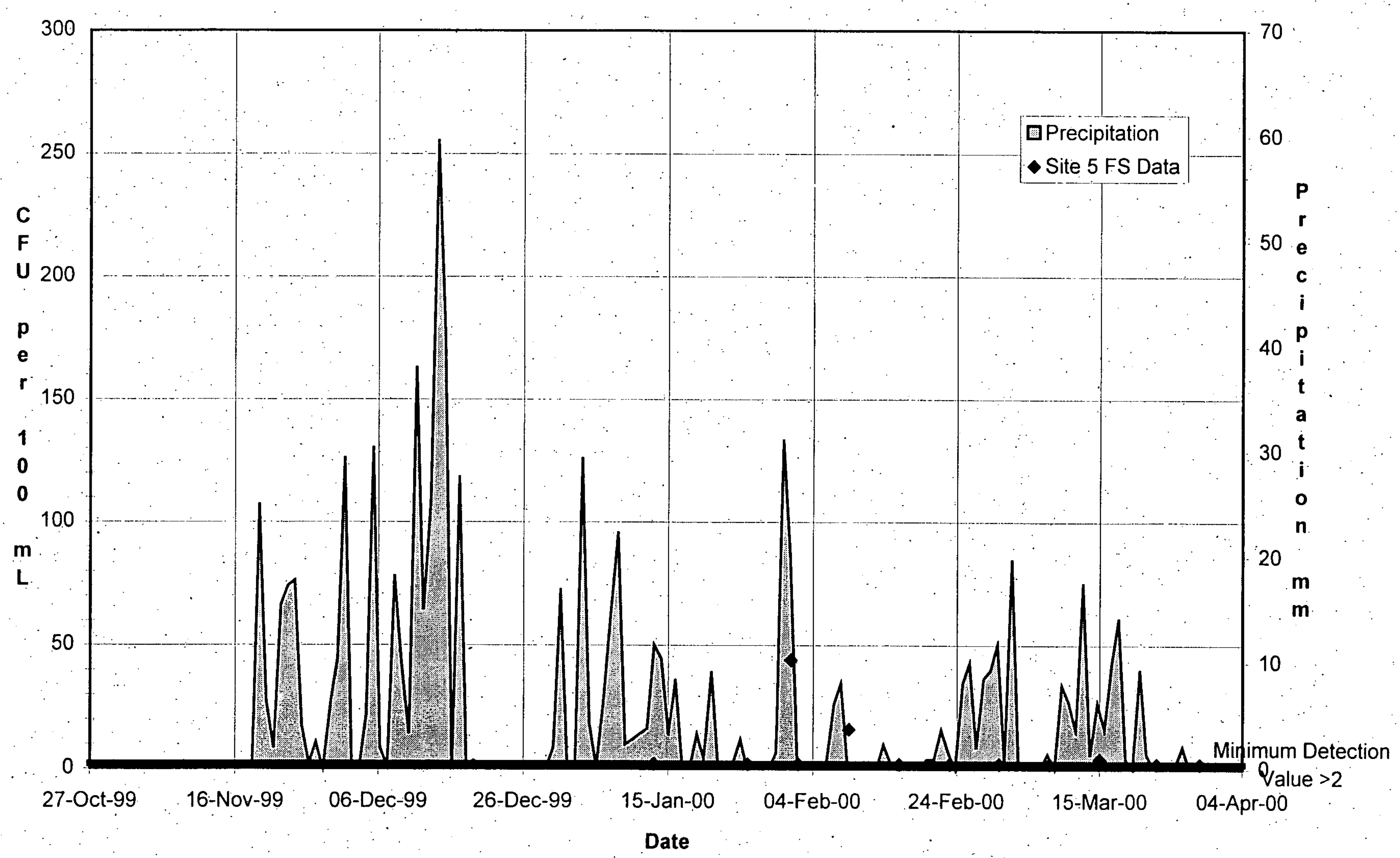
Site 4 Escherichia coli and Precipitation Over Time



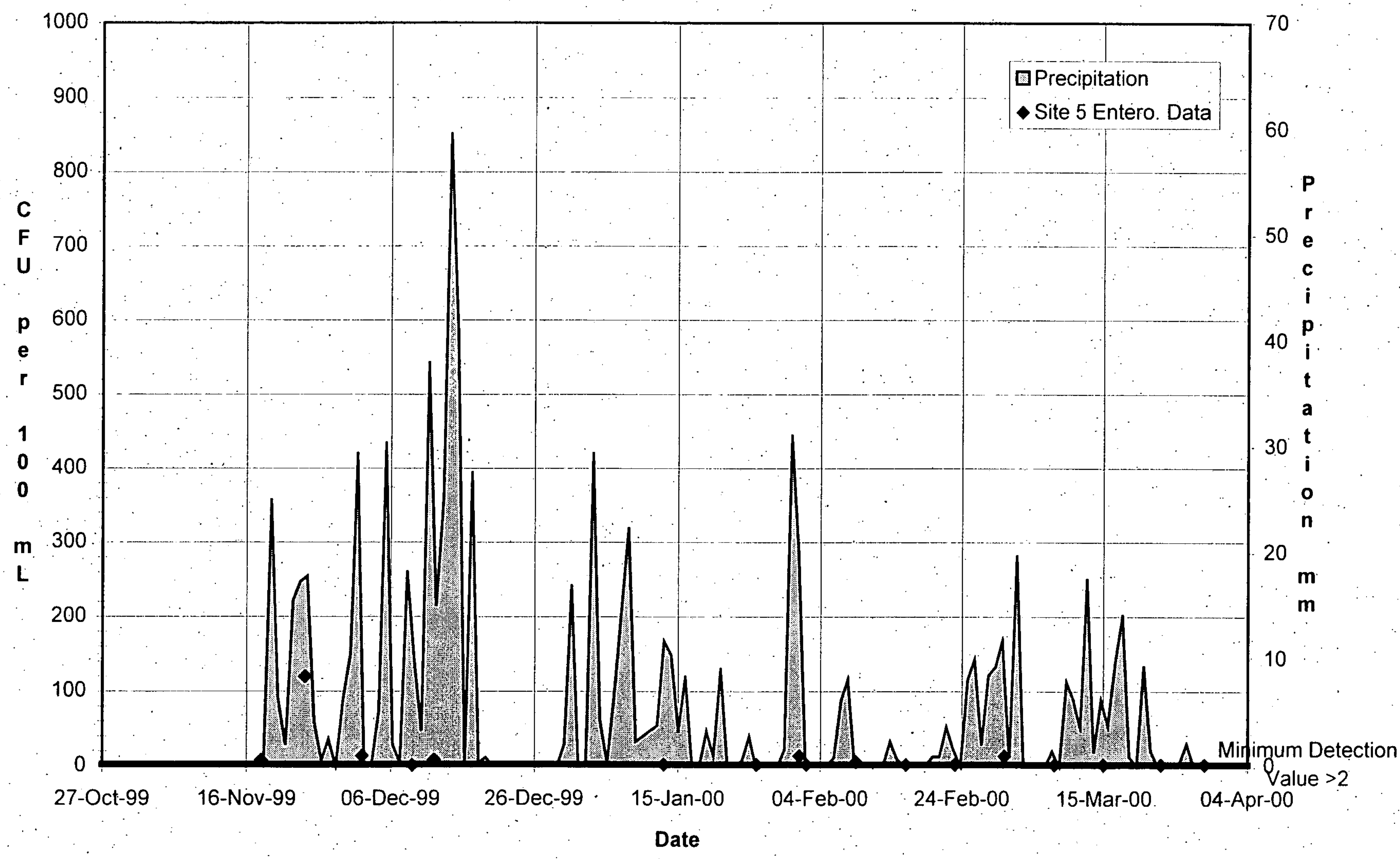
Site 4 FC:FS Ratio and Precipitation Over Time



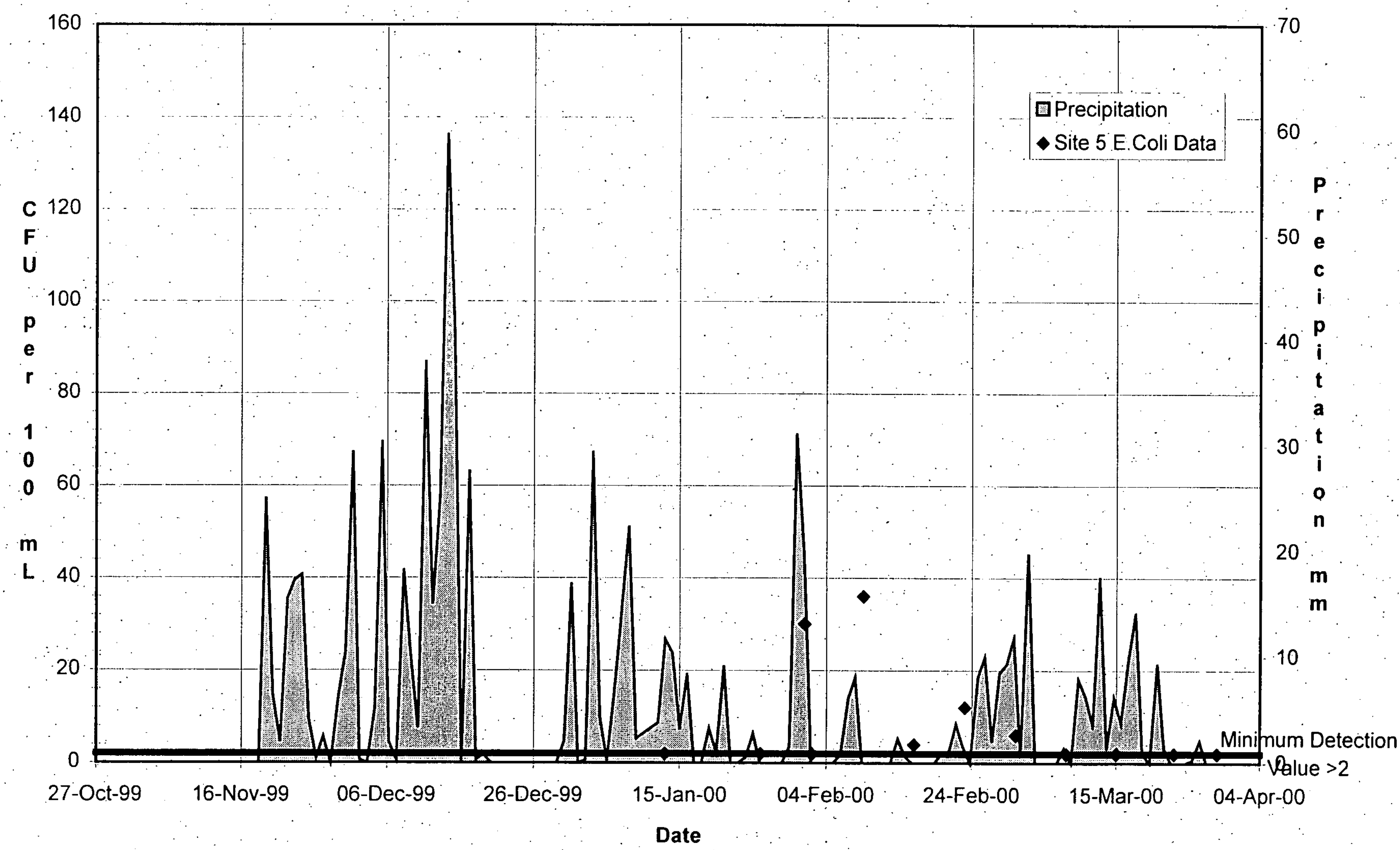
Site 5 Fecal Streptococcus and Precipitation Over Time



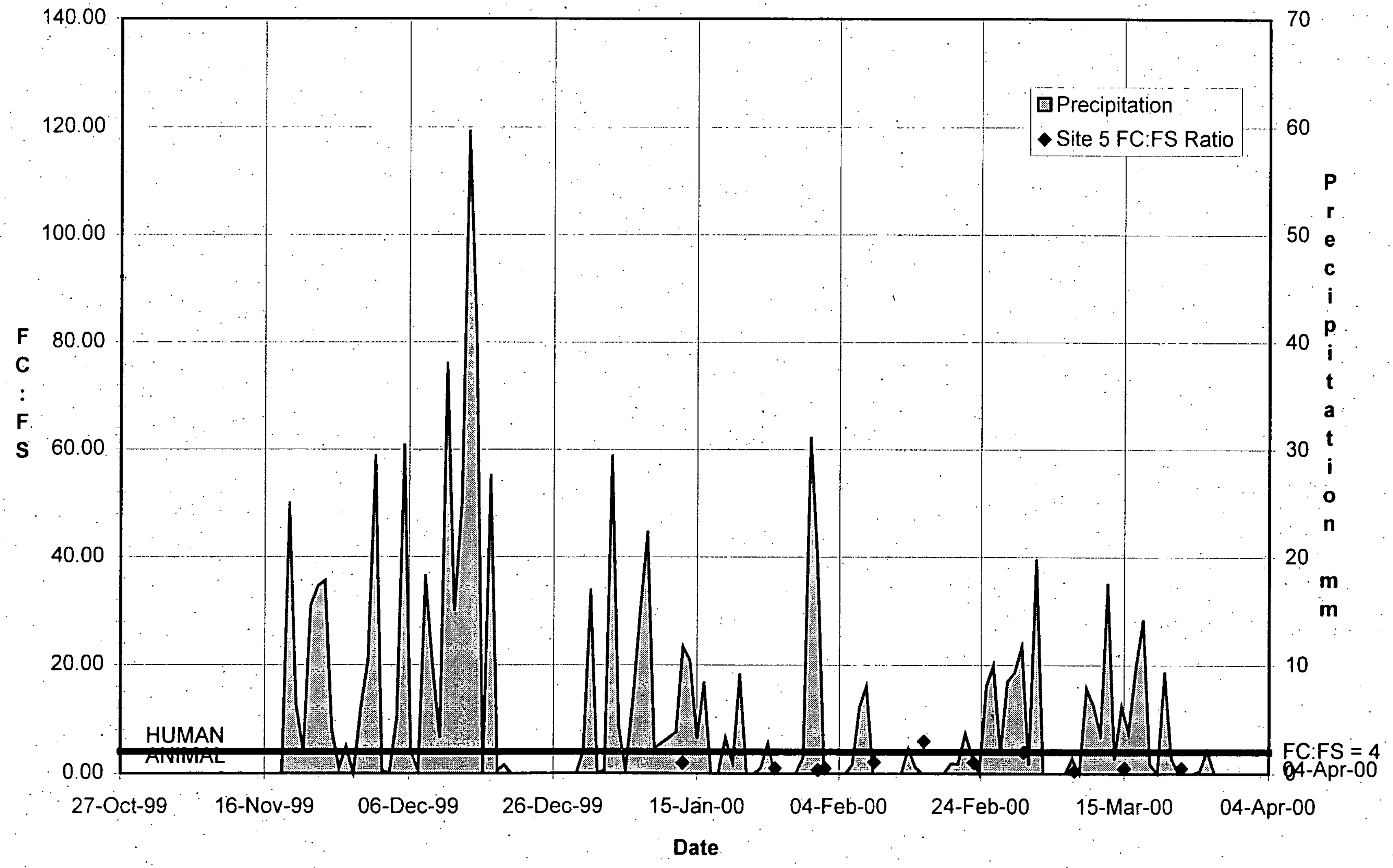
Site 5 Enterococcus and Precipitation Over Time



Site 5 Escherichia coli and Precipitation Over Time

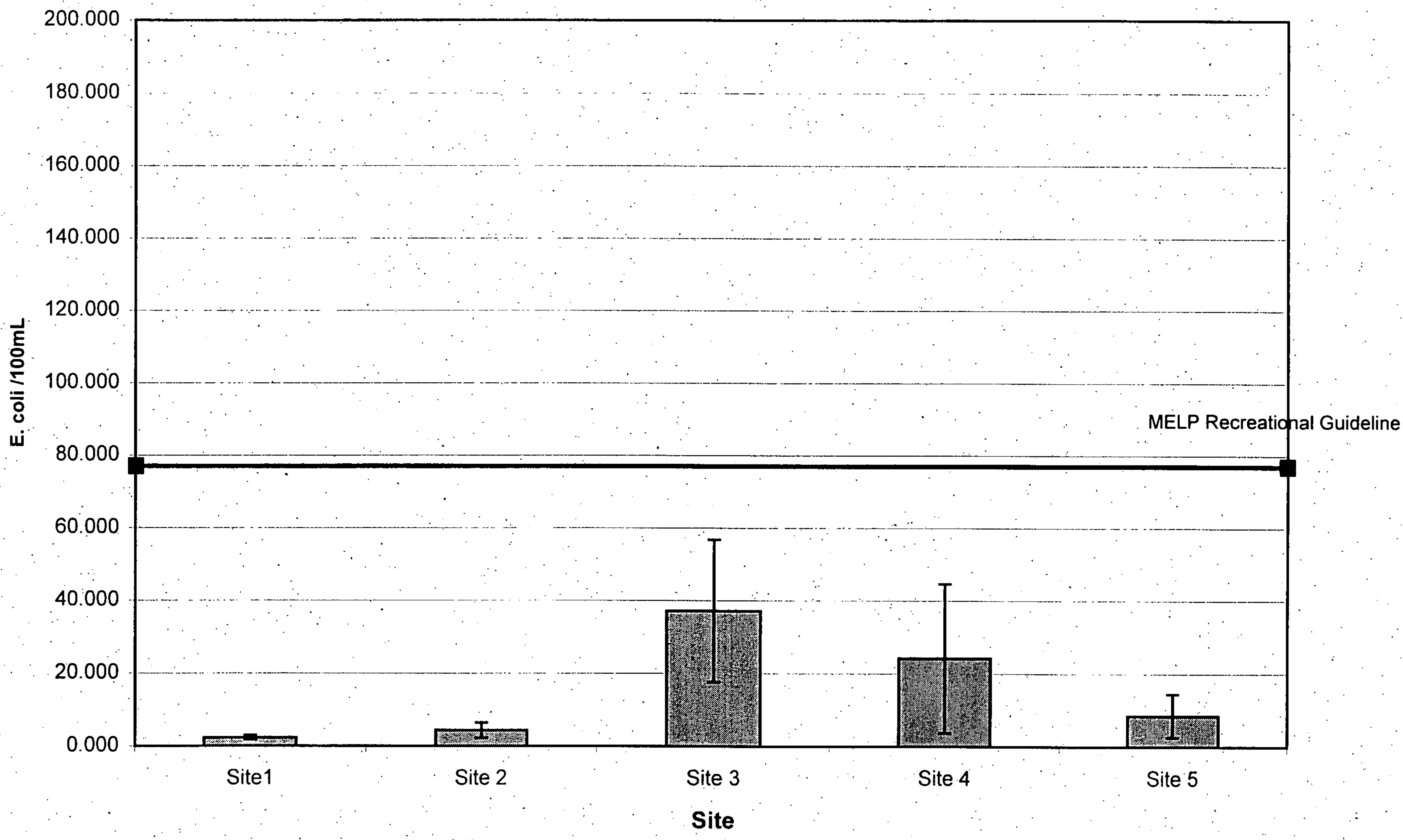


Site 5 FC:FS Ratio and Precipitation Over Time

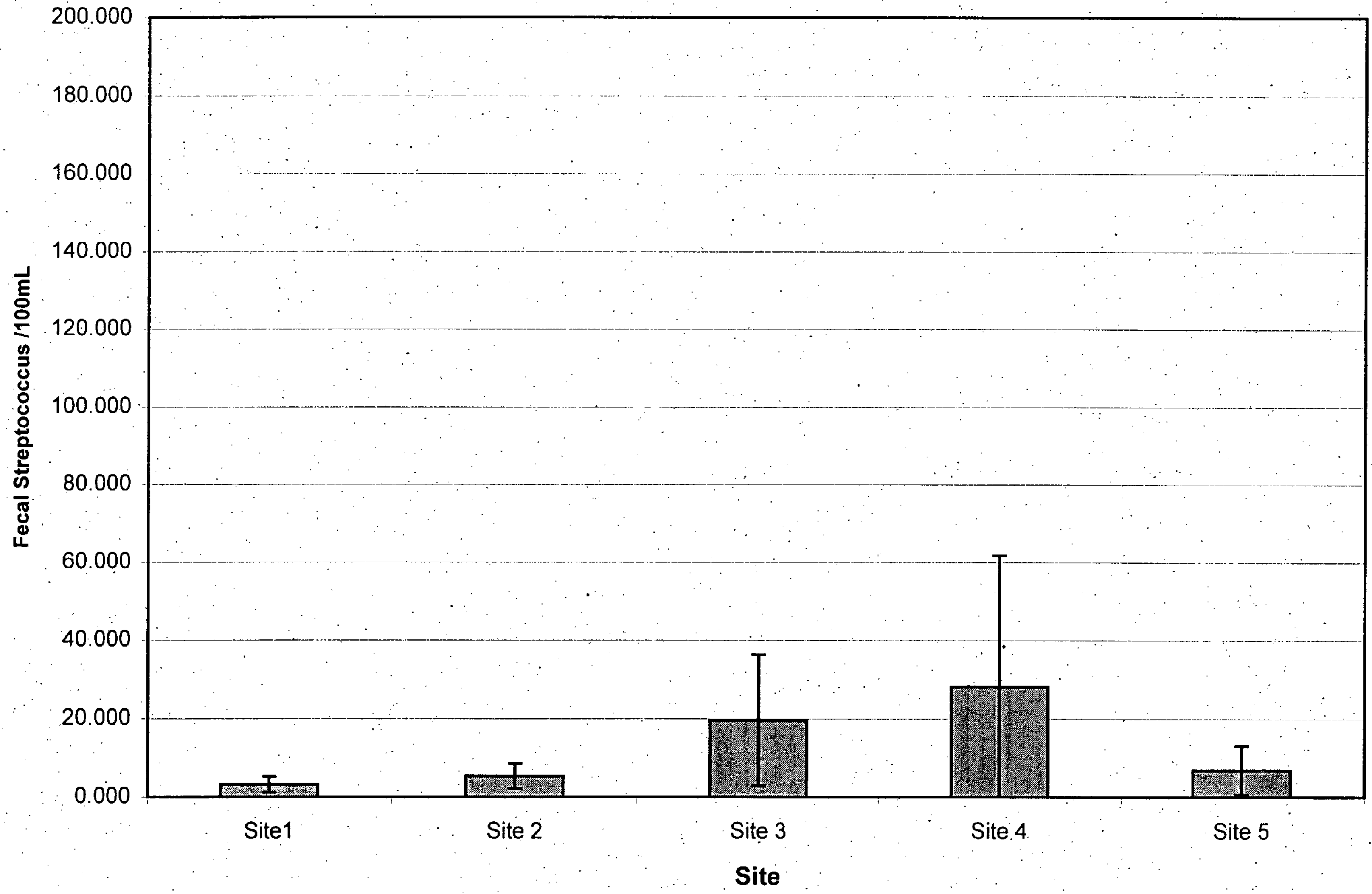


Appendix G:
Mean Microbiological Results By Site

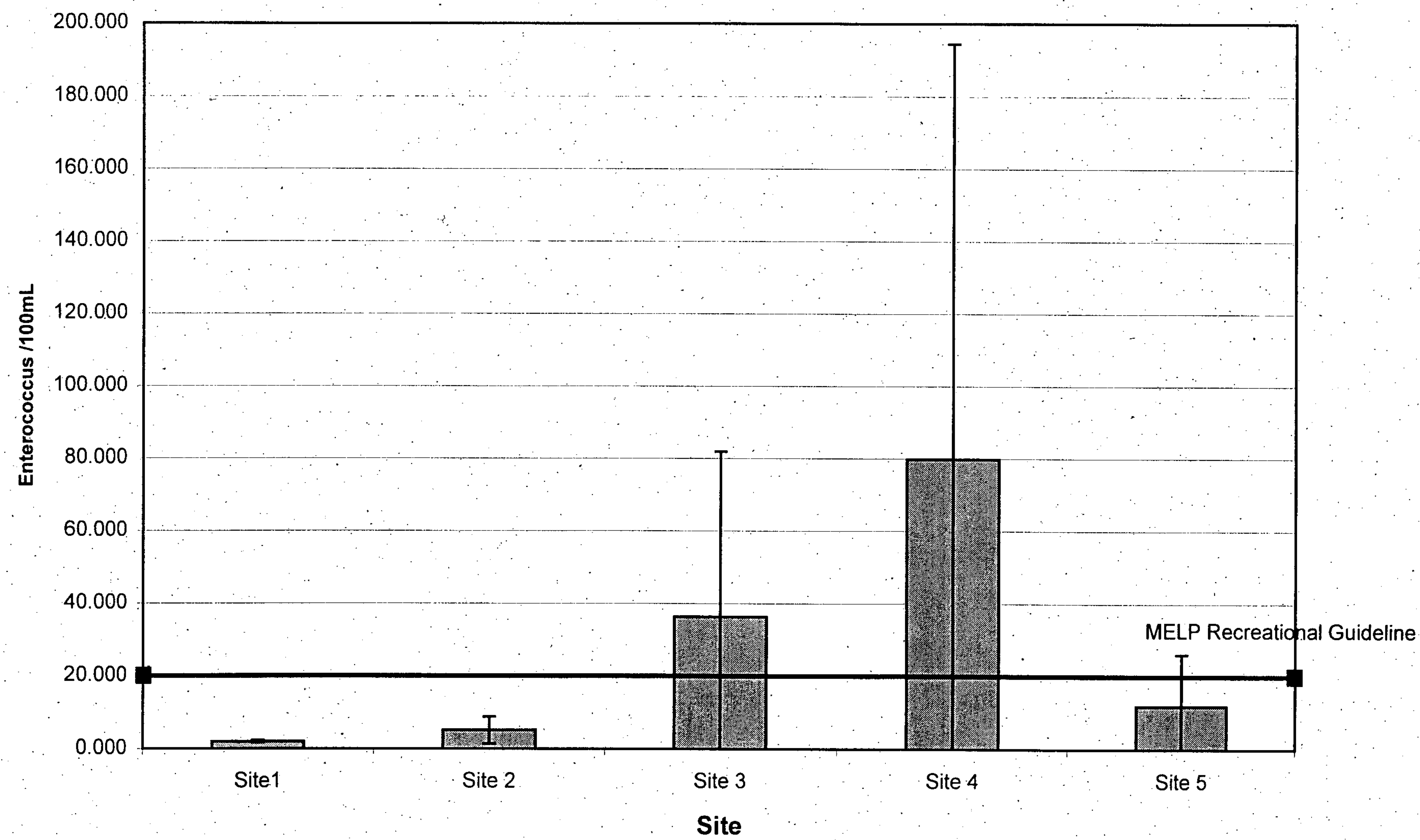
Mean *Escherichia coli* By Site



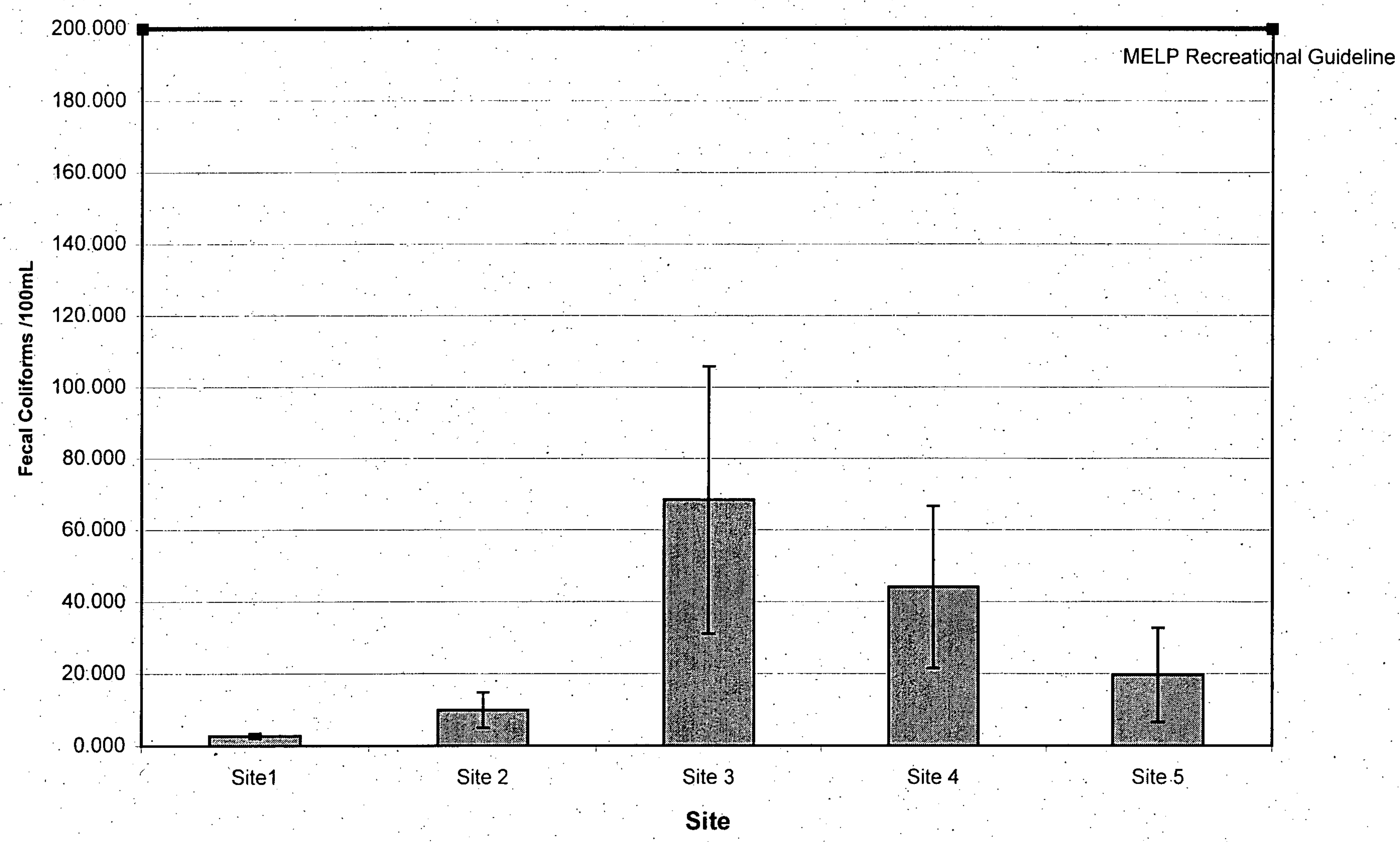
Mean *Fecal streptococcus* By Site



Mean *Enterococcus* By Site



Mean *Fecal coliform* By Site

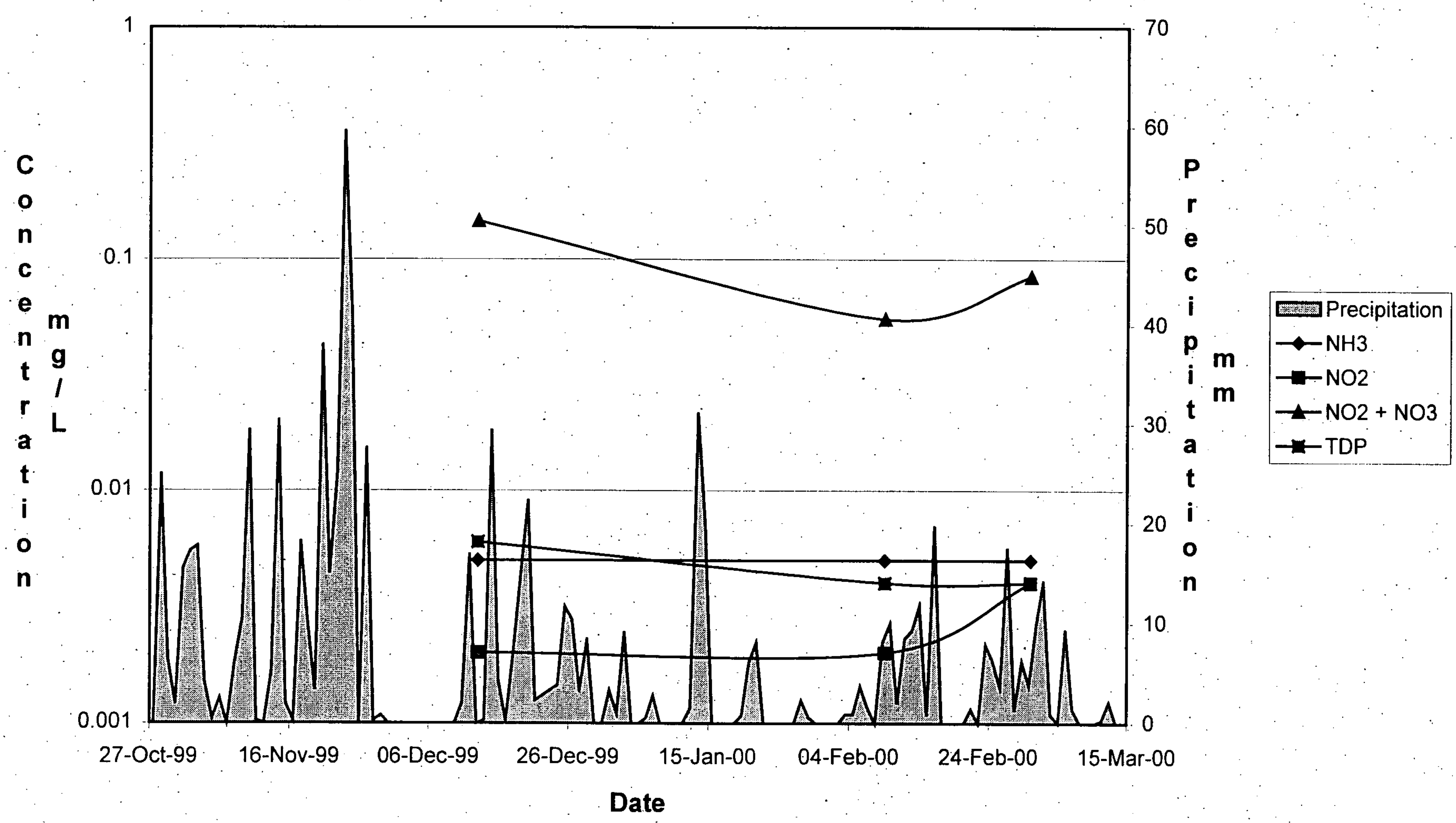


Appendix H:
Fecal Coliform To Fecal Streptococcus Ratio Calculations

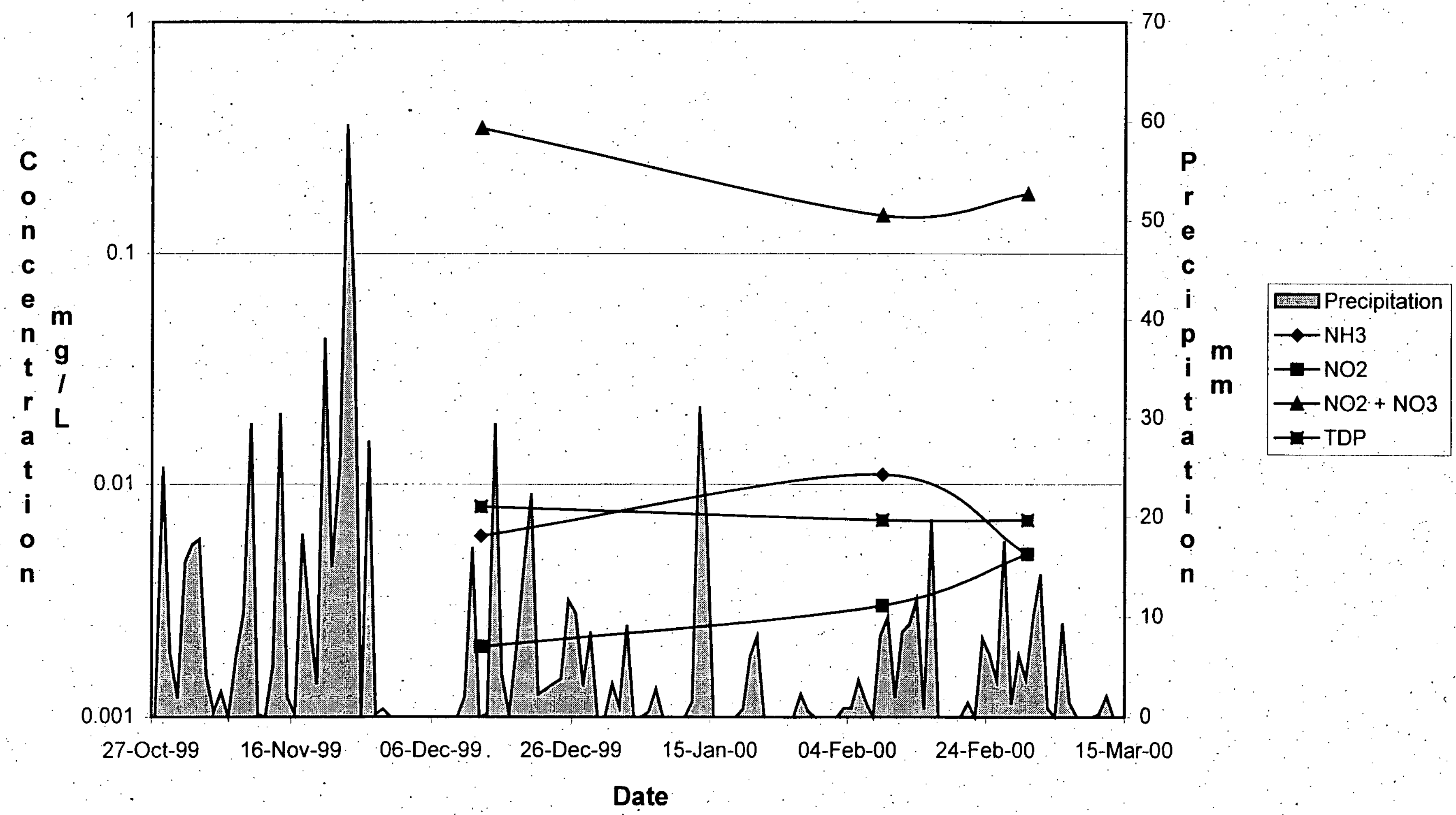
Date	FC:FS Site 1	FC:FS Site 2	FC:FS Site 3	FC:FS Site 4	FC:FS Site 5
13-Jan-00	1.00	1.00	3.43	4.00	2.00
26-Jan-00	1.00	1.00	22.00	7.33	1.00
01-Feb-00	0.38	0.90	1.08	0.75	0.68
02-Feb-00	3.00	0.11	0.29	0.92	1.00
09-Feb-00	2.00	0.50	6.00	0.25	2.13
16-Feb-00	1.00	1.00	8.00	2.00	4.00
23-Feb-00	1.00	1.00	8.50	4.00	6.00
01-Mar-00	1.00	1.00	3.00	3.20	2.00
08-Mar-00	1.00	7.00	125.00	7.00	4.00
15-Mar-00	1.00	1.00	0.30	4.33	0.50
23-Mar-00	1.00	3.50	0.81	0.36	1.00
29-Mar-00	1.00	1.00	10.00	4.00	1.00
# Human > 4	0	1	6	3	1
# Animal < 0.7	1	2	2	2	2
# Inconclusive(0.7-4)	11	9	4	7	9
# Total	12	12	12	12	12

Appendix I:
Graphs Of Inorganic Parameters

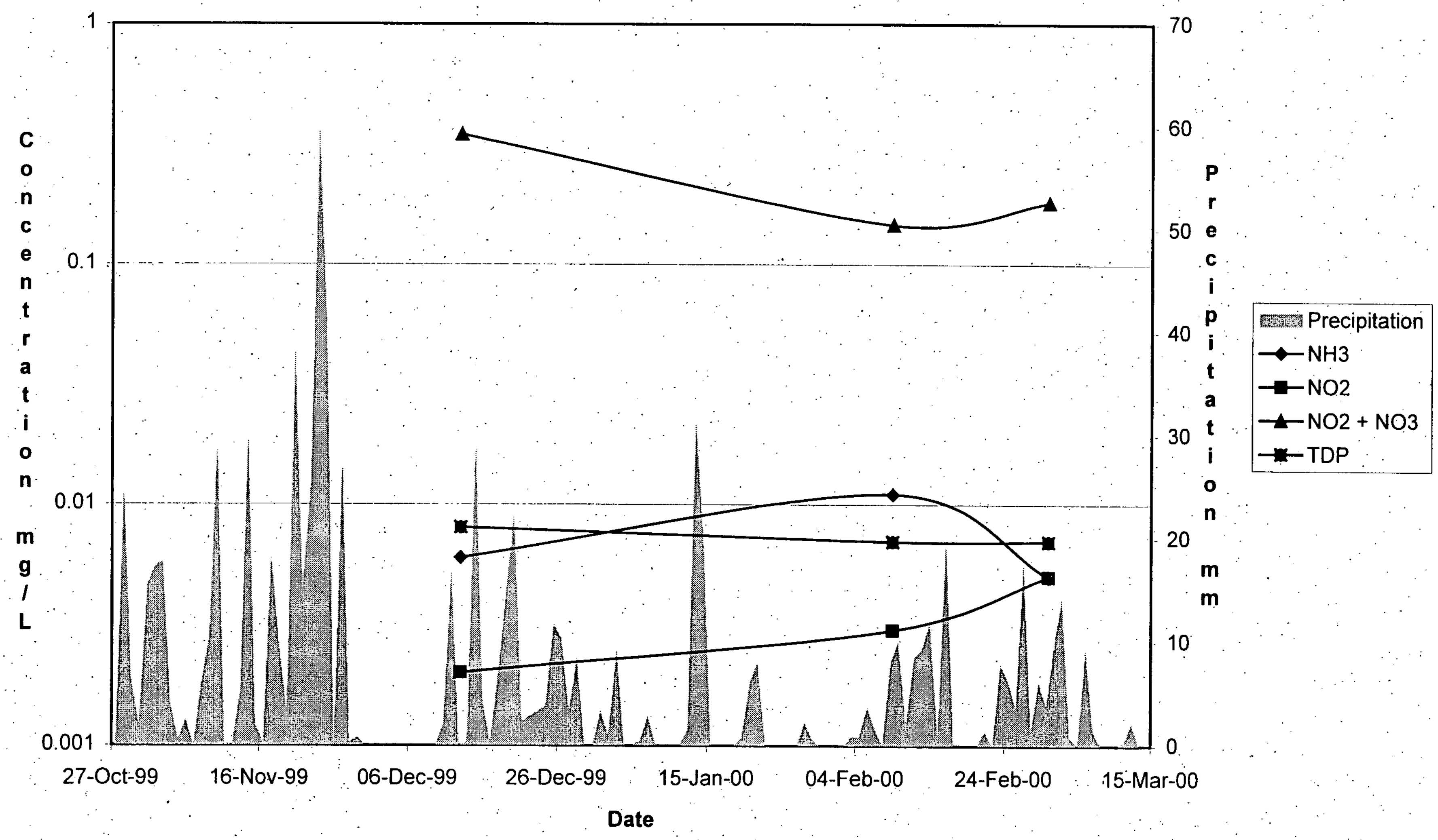
Site 1: Goudie Rd. - Ammonia, Nitrite, Nitrite plus Nitrate, and Total Dissolved Phosphorus Levels Observed Over Time



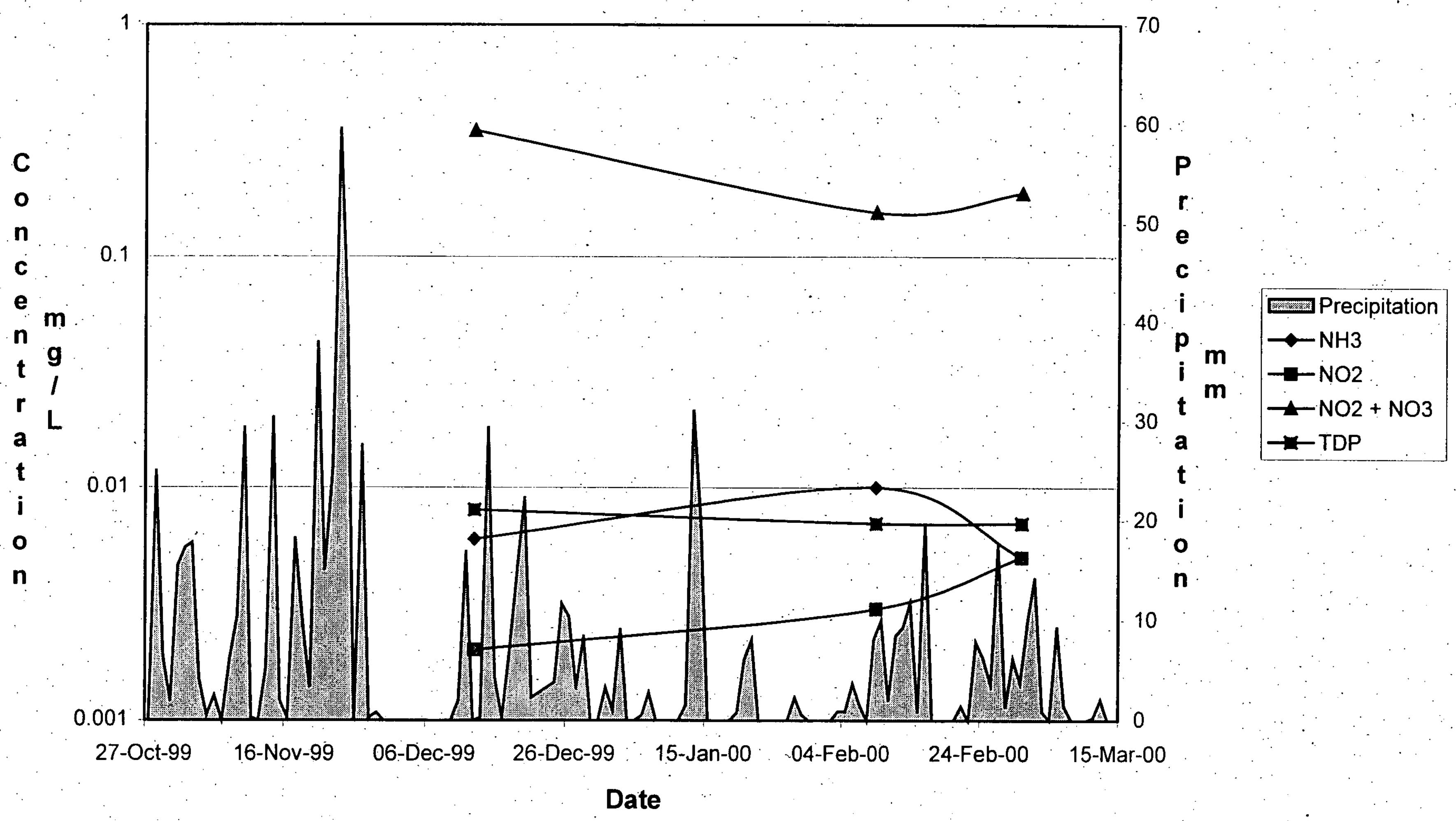
Site 2: Pascoe Rd. - Ammonia, Nitrite, Nitrite plus Nitrate, and Total Dissolved Phosphorus Levels Observed Over Time



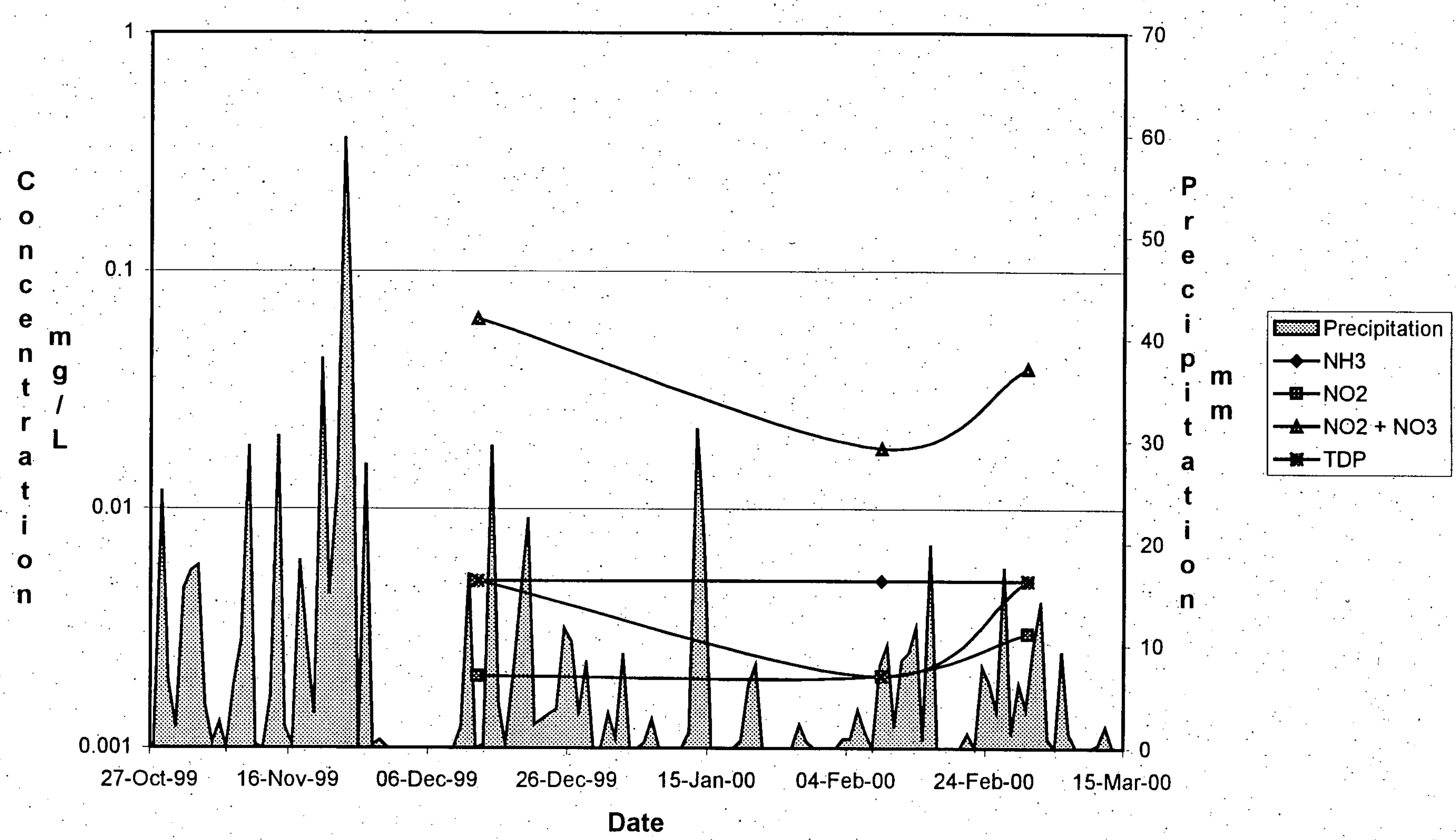
Site 3L Helgesen Rd. - Ammonia, Nitrite, Nitrite plus Nitrate, and Total Dissolved Phosphorus Levels Observed Over Time



Site 4: Phillips Rd. - Ammonia, Nitrite, Nitrite plus Nitrate, and Total Dissolved Phosphorus Levels Observed Over Time



Site 5: Sooke River - Ammonia, Nitrite, Nitrite plus Nitrate, and Total Dissolved Phosphorus Levels Observed Over Time



Appendix J:
Results Of Physical Parameter Monitoring

Site	Date	Turbidity	Dissolved O2	Conductivity	pH	Air Temp	Water Temp
Site 1	18-Nov-99						
Site 1	24-Nov-99						
Site 1	02-Dec-99						
Site 1	09-Dec-99						
Site 1	13-Dec-99	0.240		0.027	6.58		
Site 1	13-Jan-00						
Site 1	26-Jan-00						
Site 1	01-Feb-00						
Site 1	02-Feb-00	0.330	18.4	0.024	5.54	7	4
Site 1	09-Feb-00	0.340	19.8	0.027	6.5	5	4.6
Site 1	16-Feb-00	0.130	7.5	0.029	6.75	4.5	3.8
Site 1	23-Feb-00						
Site 1	23-Feb-00	0.100	9.7	0.038	5.5	1.5	3
Site 1	01-Mar-00	0.370	10.7	0.02	5.77	5	4.6
Site 1	08-Mar-00	0.030	11.5	0.018	5.52	6	4.9
Site 1	15-Mar-00						
Site 1	23-Mar-00	0.530	12.1	0.013	5.71	9	5.8
Site 1	29-Mar-00	0.230	9.9	0.024	6.8	9	5

Minimum	0.030	7.5	0.013	5.5	1.5	3
Maximum	0.530	19.8	0.027	6.8	9	5.8
Mean	0.256	12.45	0.024	6.074	5.875	4.463
St. Dev	0.155	4.344	0.007	0.567	2.489	0.853

Site	Date	Turbidity	Dissolved O2	Conductivity	pH	Air Temp	Water Temp
Site 2	18-Nov-99						
Site 2	24-Nov-99						
Site 2	02-Dec-99						
Site 2	09-Dec-99						
Site 2	13-Dec-99	1.4		0.033	6.78		
Site 2	13-Jan-00						
Site 2	26-Jan-00						
Site 2	01-Feb-00						
Site 2	02-Feb-00	0.63	18.7	0.031	5.05	8	4.5
Site 2	09-Feb-00	0.43		0.027	6.65	5	5
Site 2	16-Feb-00	0.34	12.2	0.03	6.7	5.5	4
Site 2	23-Feb-00	0.18	10.4	0.027	5.85	4	4
Site 2	01-Mar-00	0.71	10.7	0.022	6.12	5.5	5
Site 2	08-Mar-00	0.45	10.6	0.022	5.79	6	5.4
Site 2	15-Mar-00						
Site 2	23-Mar-00	0.97	10.7	0.015	5.72	9	6.2
Site 2	29-Mar-00	0.51	10	0.022	6.61	9	6

Minimum	0.18	10	0.015	5.1	4	4
Maximum	0.97	18.7	0.033	6.78	9	6
Mean	0.624	11.900	0.025	6.141	7.429	5.729
St. Dev	0.369	3.076	0.006	0.589	1.955	0.899

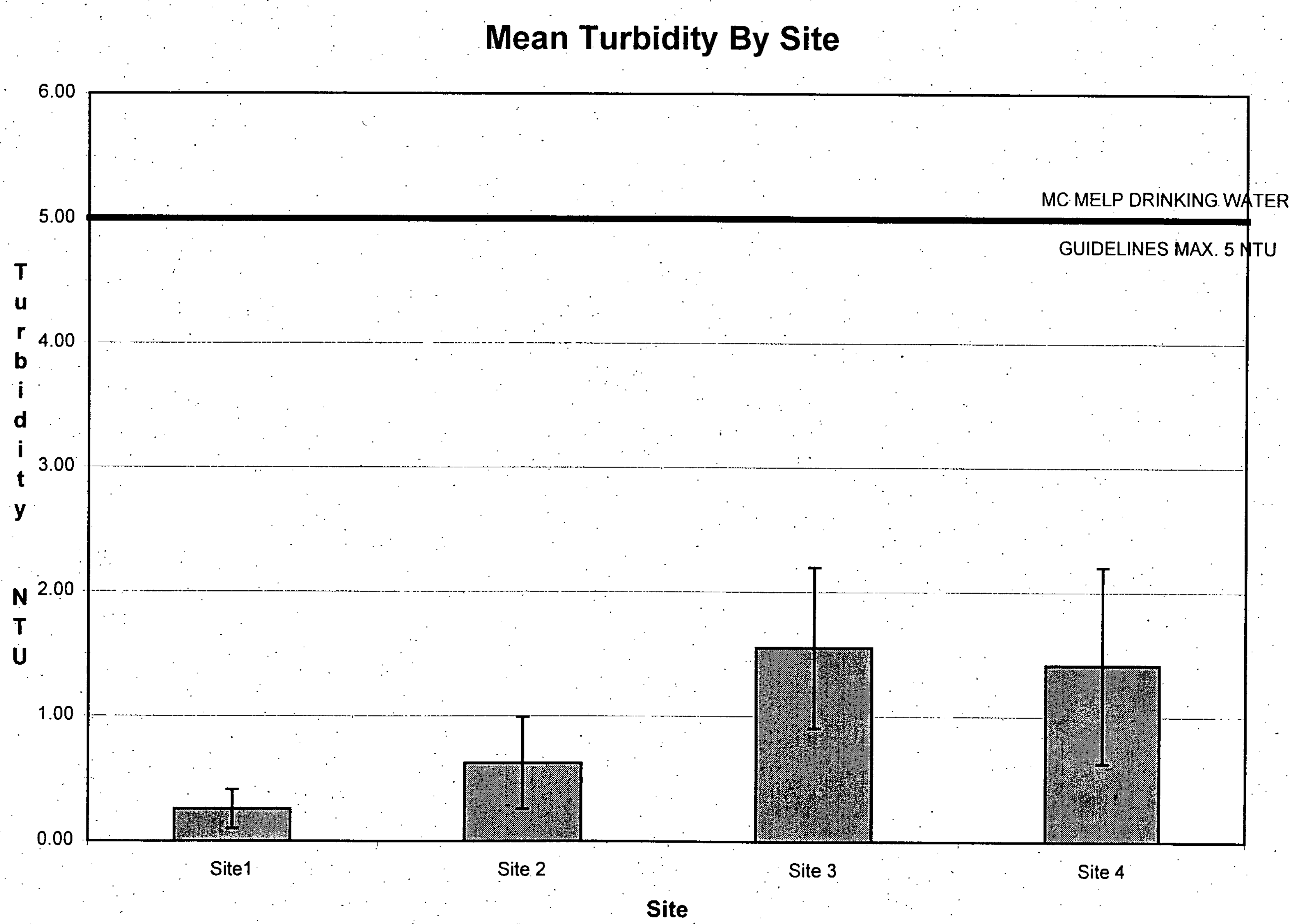
Site	Date	Turbidity	Dissolved O2	Conductivity	pH	Air Temp	Water Temp
Site 3	18-Nov-99						
Site 3	24-Nov-99						
Site 3	02-Dec-99						
Site 3	09-Dec-99						
Site 3	13-Dec-99	1.9		0.036	6.81		
Site 3	13-Jan-00						
Site 3	26-Jan-00						
Site 3	01-Feb-00	1.87		0.022	6.57	6	5.3
Site 3	02-Feb-00	1.37	17.1	0.002	6.28	7	4.7
Site 3	09-Feb-00	1.32		0.031	6.28	6	5
Site 3	16-Feb-00	1.28	9.6	0.035	6.62	5.5	4.2
Site 3	23-Feb-00	0.18	9.6	0.046	6.06	5.5	5
Site 3	01-Mar-00	1.81	10.2	0.024	5.96	5.5	5
Site 3	08-Mar-00	1.54	9.9	0.027	5.72	8	5.5
Site 3	08-Mar-00						
Site 3	15-Mar-00						
Site 3	23-Mar-00						
Site 3	23-Mar-00	2.74	9.7	0.017	5.65	9	7
Site 3	29-Mar-00	1.51	9.7	0.033	6.93	10	5.5

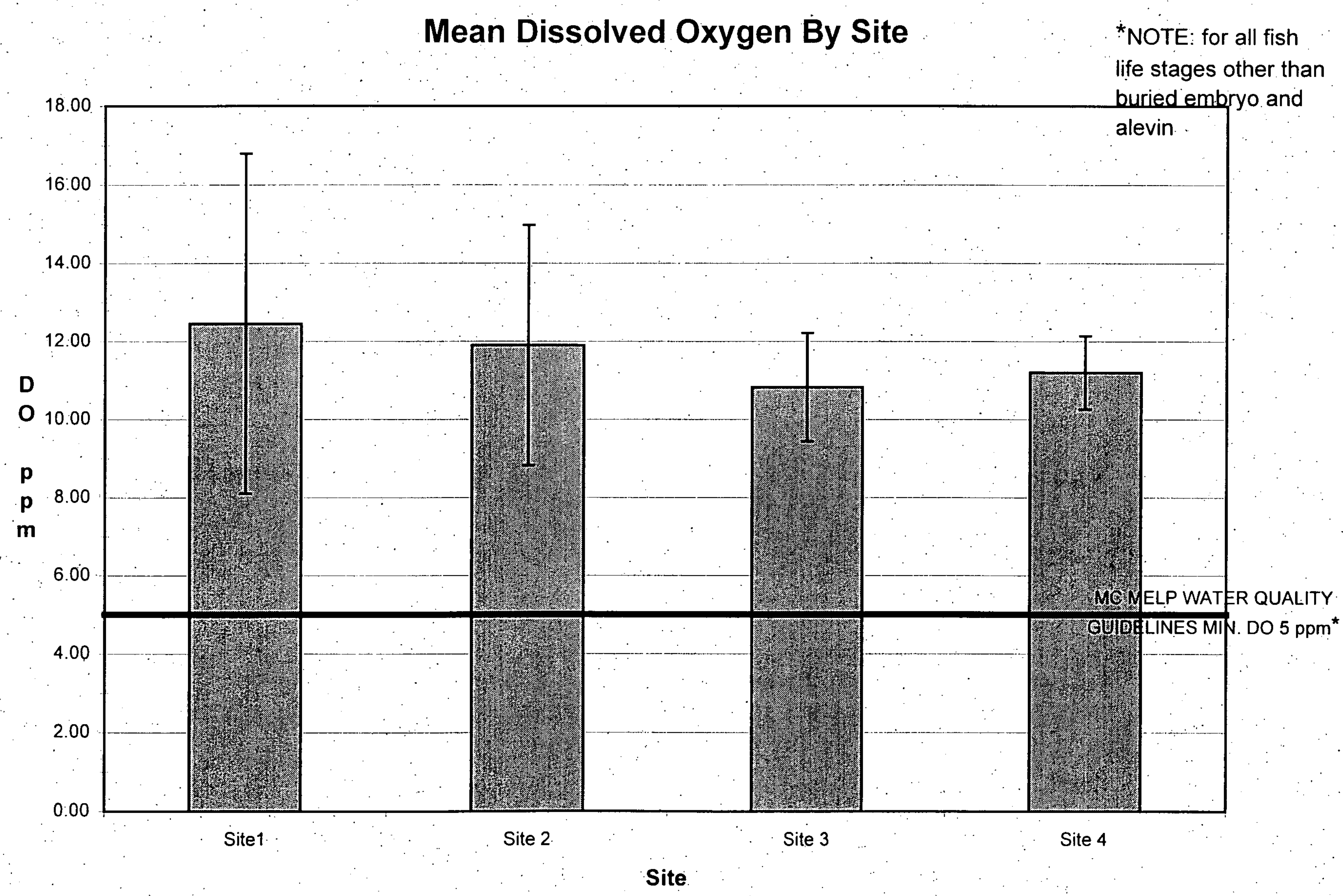
Minimum	0.18	9.6	0.002	5.65	5.5	4.2
Maximum	2.74	17.1	0.046	6.93	10	5.5
Mean	1.552	10.829	0.027	6.288	6.944	5.244
St. Dev	0.645	2.774	0.012	0.443	1.685	0.773

Site	Date	Turbidity	Dissolved O2	Conductivity	pH	Air Temp	Water Temp
Site 4	18-Nov-99						
Site 4	24-Nov-99						
Site 4	02-Dec-99						
Site 4	09-Dec-99						
Site 4	13-Dec-99	2.4		0.036	6.93		
Site 4	13-Jan-00	0.53	12.1	0.013	5.71	9	5.8
Site 4	26-Jan-00	0.97	10.7	0.015	5.72	9	6.2
Site 4	01-Feb-00	2.74	9.7	0.017	5.65	9	7
Site 4	02-Feb-00	1.46	15.9	0.048	6.56	7	4.7
Site 4	09-Feb-00	1.18		0.031	6.8		5.2
Site 4	16-Feb-00	0.86	10.1	0.04	6.6	5.5	4.6
Site 4	23-Feb-00	0.18	10.9	0.047	6.63	5.5	5
Site 4	01-Mar-00	1.87		0.022	6.57	6	5.3
Site 4	08-Mar-00	1.26	10.6	0.027	6.39	8	5.7
Site 4	15-Mar-00						
Site 4	23-Mar-00	2.37	10.3	0.018	5.7	8	6.9
Site 4	29-Mar-00	1.14	10.5	0.019	7.03	10	6

Minimum	0.18	9.7	0.013	5.71	5.5	4.6
Maximum	2.74	15.9	0.048	7.03	10	6.9
Mean	1.413	11.200	0.028	6.358	7.700	5.673
St. Dev	0.787	1.883	0.012	0.518	1.619	0.811

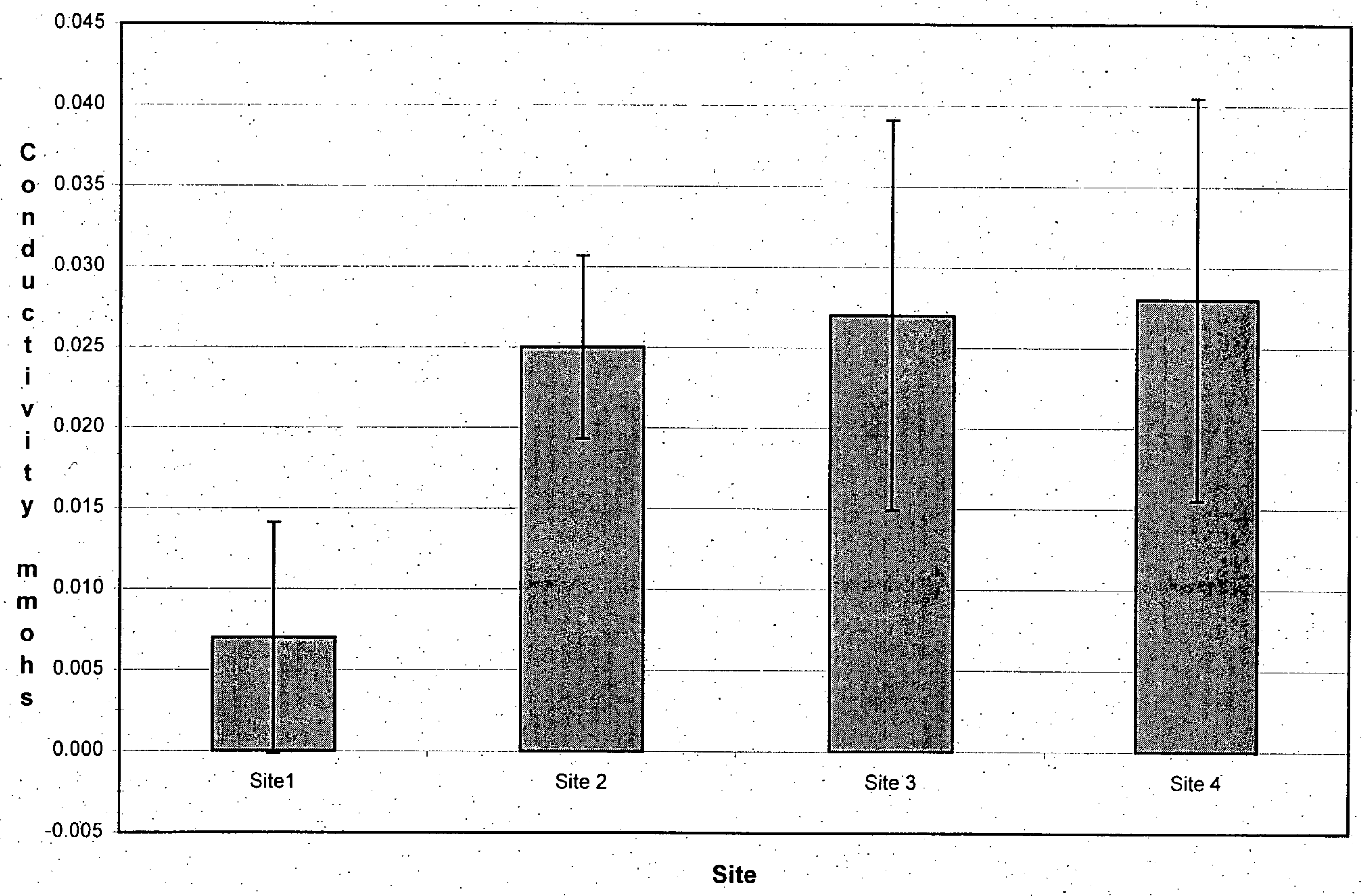
Appendix K:
Mean Physical Parameters

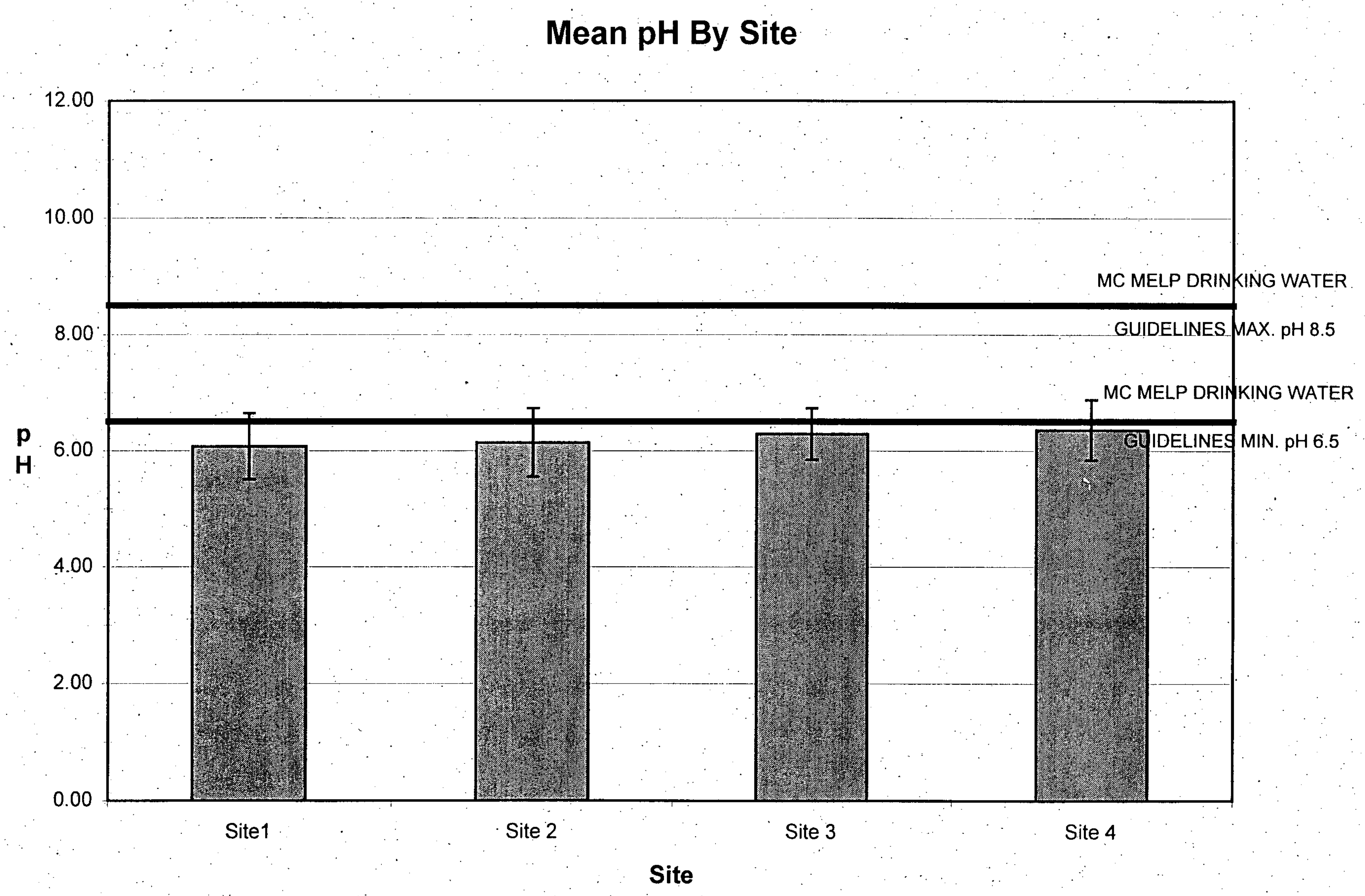

Mean Turbidity By Site
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Turbidity NTU
MC MELP DRINKING WATER
GUIDELINES MAX. 5 NTU
Site1
Site 2
Site 3
Site 4
Site



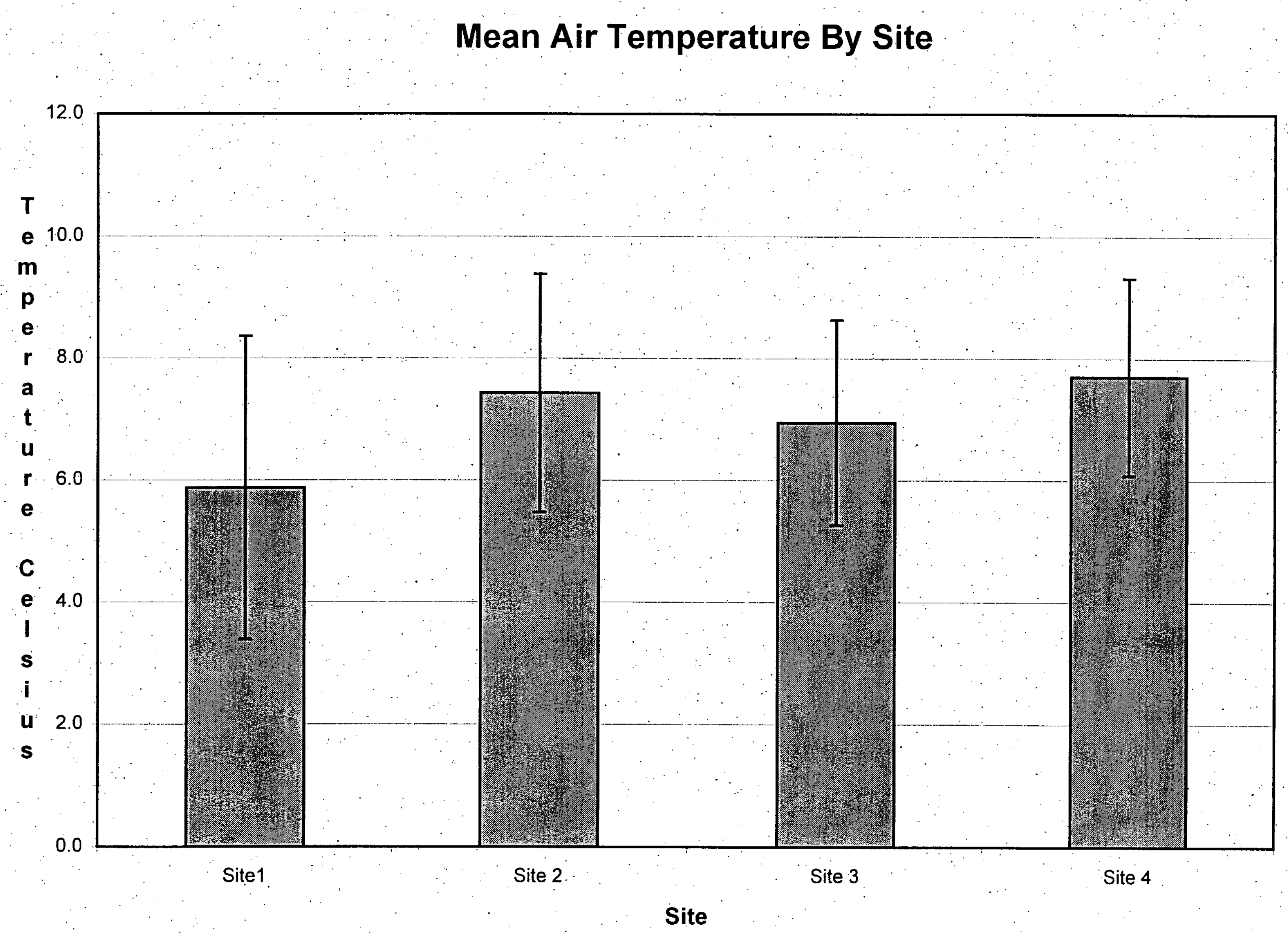
Mean Dissolved Oxygen By Site
*NOTE: for all fish life stages other than buried embryo and alevin
MC MELP WATER QUALITY GUIDELINES MIN. DO 5 ppm*
D O ppm
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Site1
Site 2
Site 3
Site 4
Site

Mean Conductivity By Site

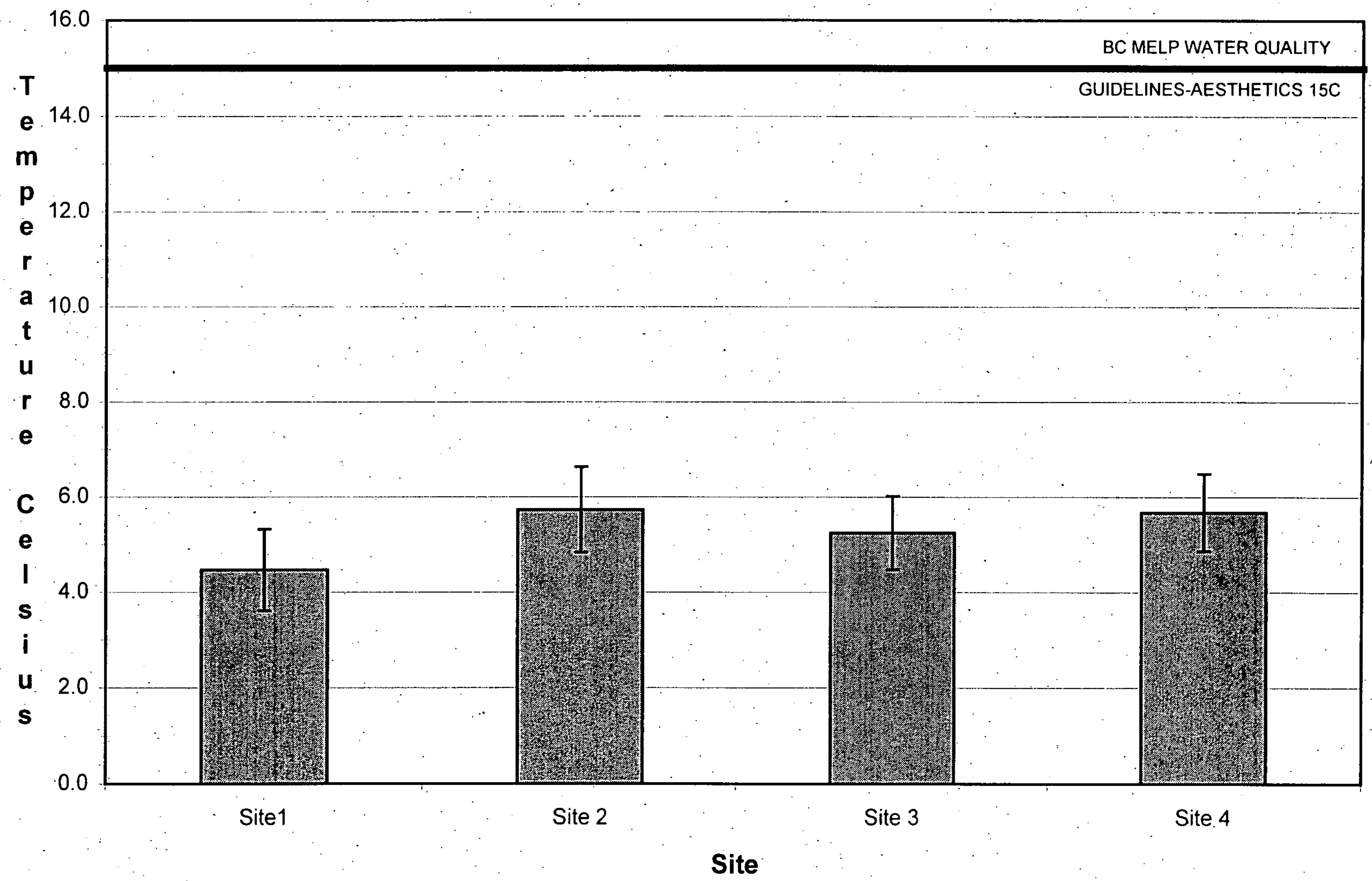




Mean pH By Site
12.00
10.00
8.00
6.00
4.00
2.00
0.00
pH
MC MELP DRINKING WATER
GUIDELINES MAX. pH 8.5
MC MELP DRINKING WATER
GUIDELINES MIN. pH 6.5
Site1
Site 2
Site 3
Site 4
Site


Mean Air Temperature By Site
Temperature Celsius
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Site1
Site 2
Site 3
Site 4
Site

Mean Water Temperature By Site



Appendix L:
Article In Sooke Mirror Advertising Septic Social

Newspaper Article – The Sooke Mirror

Septic social hoped to help protect harbour and basin's water quality

By Miguel R. MacDonald
Sooke News Mirror

For the second year in a row, Royal Roads University students are offering Sooke residents a chance to learn how to care for and maintain their septic systems.

Azimuth Environmental Consulting, made up of five Royal Roads University students, will host a septic social at the Sooke Flats, June 24, at 3 p.m.

"The focus of this event will be on the maintenance and care of residential septic systems," A.E.C. representative Julie Mickach said. "Our intention is for the event to be fun as well as informative."

A barbeque, oysters, and hotdogs for the kids promise to make the rain-or-shine event friendly and fun.

Mickach is helping arrange the social as part of a study that A.E.C. is conducting on the effects of non-point source water pollution on the water quality of the Sooke Basin, Harbour and lake.

The study focusses on De Mamiel Creek and tries to determine whether water from the creek is responsible for damaging the local shellfish industry.

"In Sooke, fecal contamination of the local harbour and basin has not only partially contributed to the closure of the local shellfish industry, but also negatively impacted the culture of the First Nation's people and fishermen living in the area," said Mickach.

The current study is phase two of an earlier project started in 1998 to assess nonpoint source (N.P.S.) water pollution on the lower Sooke River watershed. The objective of the project was to determine possible sources of N.P.S. pollution from both Sooke River and De Mamiel Creek.

Phase one of the study recommended that De Mamiel Creek be further studied in order to determine to what degree the creek is contributing to the shellfish closures in the Sooke Basin.

Agricultural runoff, storm water runoff and failing septic systems are some of the explanations for the drop in quality of the water in the harbour and basin.

By educating the public about their septic systems, A.E.C. hopes to encourage the protection of the Sooke watershed and help reduce the amount of pollution in the harbour and basin.

Several older homes sit on the banks of De Mamiel Creek. Older homes are known for having "poorly maintained, inadequate and failing septic systems," reads an A.E.C. project proposal.

It is possible that these homes are affecting the quality of water in the harbour, but that has yet to be determined.

The study will conclude on July 15.

Appendix M:
Letter To Radio Giving Information For Septic Social Advertising

Azimuth Environmental Consulting
2005 Sooke Rd. Victoria, B.C. (250) 384-9508 email: azimuthenviro@hotmail.com

Radio Station
XXXXXXXXX
XXXXXXXXX
Victoria, B.C.
Canada

Attention: XXXXX

Azimuth Environmental Consulting consists of 5 Bachelor of Environmental Science students at Royal Roads University in Victoria. We are currently performing a watershed study on DeMamiel Creek, a major tributary of the Sooke River in Sooke, B.C. The B.C. Ministry of Environment, Lands and Parks and Environment Canada shares sponsorship for this project.

As part of the project, we at Azimuth are planning to host a "Septic Social" at the Sooke Flats campground on Saturday June 24, 2000. We would like to request promotion of this event on XXXX. The ultimate goal of the Septic Social is to raise awareness of potential contamination to local waterways from improperly or poorly maintained septic systems, agricultural runoff and storm water discharge.

Please feel free to contact Julie Micksch at XXX-XXXX, Jason Bezaire at XXX-XXXX or azimuthenviro@hotmail.com , in order to obtain any further information or to inform us of your decision. We appreciate any assistance that you could provide us and we look forward to hearing from you. We think the announcement would be best mentioned one week in advance (June 17-24, 2000).

Sincerely,

Julie Micksch

Julie Micksch

Appendix N:
Copy Of Invitation To Sooke Septic Social

Between 1998 and 1999 a study was carried out to assess non-point source (NPS) water pollution on the lower Sooke River watershed. The objective was to determine possible sources of NPS pollution from both Sooke River and De Mamiel Creek. It was recommended that De Mamiel Creek be further studied in order to determine to what degree De Mamiel Creek is contributing to the shellfish closures in the Sooke Basin.

In January of 2000, five Royal Roads University students, known as Azimuth Environmental Consulting, were contracted to perform Phase II of this study. This project is sponsored by the British Columbia Ministry of Environment (MOE), Capital Regional District (CRD) Sooke Electoral area, and Environment Canada. This study will attempt to determine the nature of non-point source water contamination in De Mamiel Creek and to what degree it is affecting the Sooke Basin.

NPS water pollution may result in degraded water quality and danger to human health. This is the result of one or more polluting activities taking place over a broad area, such as agriculture, failing septic systems, and storm water runoff. In Sooke, fecal contamination of the local harbour and basin has not only partially contributed the closure of the local shellfish industry, but also negatively impacted the culture of the First Nation's people and fishermen living in the area

Our goal for this septic social is to increase public awareness with regards to some of the impacts we may have on the natural environment. The focus of this outdoor event will be on the maintenance and care of residential septic systems. The health of our forests, watersheds and oceans are essential in the survival of many communities located on Vancouver Island. We believe that increasing public awareness through community events such as the septic social will help encourage the protection of our surrounding watersheds.

We hope that you join us on Saturday, June 24 at 3:00pm at the Sooke Flats Campground. Our intention is for the event to be FUN as well as informative. So bring the family. If you don't like clams or oysters don't worry. We will also have other food items available on the barbie as well as salad, potatoes, and hotdogs for the kids.

The Septic Social will take place rain or shine. The caretakers of Sooke Flats have provided us with an excellent barbeque and meeting site, complete with picnic tables and overhead shelter. The shelters are open-sided so we suggest that you bring some warm clothing for later on in the evening.

If you would like to attend, please contact us. Doing so will enables us to better predict the number of people likely to attend and help us determine how much food will be required. What better way to bring in the summer season than with a free barbeque and little entertainment? Come join us! We look forward to seeing you there!

Appendix O:
List Of Contents Contained In Information Package Given Out At Septic Social

Contents of Information Package

Brochures/Pamphlets

1. Clean Water: Tackling non-point source water pollution in British Columbia

   Water Management Branch, Ministry of Environment, Lands and Parks, Victoria, British Columbia.

2. Caring for Your Treatment Plant: a Reference Guide for a Healthy Environment

   Health Protection and Environmental Services, Capital Health Region, Langford, Saanich, Saanich Peninsula, Sooke, Victoria.

3. Clean Water: It Starts with You

   Municipal Pollution Prevention Section, Ministry of Environment, Lands and Parks, Victoria, British Columbia.

   (This is a package of 5 pamplets titled: Onsite Sewage Systems, Pleasure Boating, Agriculture, Urban Runoff, Nonpoint Source).

4. Georgia Strait Alliance: Household De-tox Challenge Phase 1: What Does Clean Really Mean?

   Georgia Strait Alliance, Nanaimo, British Columbia

5. Georgia Strait Alliance: Household De-tox Challenge Phase 2: What's Your Poison?

   Georgia Strait Alliance, Nanaimo, British Columbia

6. Georgia Strait Alliance: Household De-tox Challenge Phase 3: Solving the Solvent Problem.

   Georgia Strait Alliance, Nanaimo, British Columbia

7. 2000 Recycling Schedule

   Alpine Disposal and Recycling, Victoria, British Columbia.

Leaflets

8. Azimuth Environmental Consulting Backgrounder

9. Sponsor List/ Information Directory

10. Alternatives to Pesticides

    Georgia Strait Alliance, Nanaimo, British Columbia

Printed on 100% recycled paper
using vegetable-based inks