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A PRELIMINARY INVESTIGATION OF THE MICROBIAL COMPONENT OF MEAT AND POULTRY PLANT EFFLUENTS IN BRITISH COLUMBIA

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ABSTRACT

The microbiological component of a poultry plant liquid effluent was characterized and quantified. Samples were taken of the offal wastewater, feather wastewater, pre-treatment final effluent and post-treatment final effluent.

Data obtained showed that high levels of indicator bacteria were present in samples from all four sample points. Seven isolates of Salmonellae were recovered from the final effluent, representing two serotypes. A review of registry file information on meat and poultry plants in British Columbia demonstrated a lack of information with respect to effluent constituents, treatment systems and discharge points. The adequacy of present treatment systems to reduce bacterial discharges to the environment is questioned.

It is suggested that more information be obtained on the treatment systems and discharge points, particularly with respect to bacterial discharges.

RESUME

On a établi la nature et la concentration microbienne de l'effluent liquide d'une usine de transformation de la chair de volaille. A cette fin on a prélevé des échantillons de l'effluent d'abats, de celui des plumes, ainsi que des effluents de sortie avant et après le traitement.

Les données obtenues manifestaient de fortes concentrations de bactéries indicatrices dans les échantillons prélevés à chacun des quatre stades. On a extrait de l'effluent de sortie sept isolats de Salmonellae qui représentent deux sérotypes. Après avoir examiné les dossiers d'enregistrement des usines de transformation des viandes et de la volaille en Colombie-Britannique, on a conclu que les données sur le contenu des effluents, sur les systèmes d'épuration et sur les points de rejet étaient inadéquates. Les experts doutent que les systèmes d'épuration actuels puissent réduire convenablement les rejets de bactéries dans les eaux réceptrices.

La rapport suggère d'obtenir plus de renseignements sur les systèmes d'épuration et les points de décharge, particulièrement en ce qui a trait aux rejets bactériens.

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1 INTRODUCTION

In the economically more developed countries, the past century has seen a dramatic decline in the death rate from infections. This decline has been due in great part to improved sanitary conditions. The discovery and development of "wonder drugs" which gained momentum in the 1940's resulted in a further decline of bacteriological diseases to the point where the public concern over disease epidemics has all but disappeared.

However, since 1971 there has been a pronounced increase in the number of waterborne disease outbreaks, and the United States now experiences an average of 25 outbreaks per year (1) which may constitute several reported cases. These outbreaks are only those resulting from drinking-water contamination and do not include outbreaks resulting from bacteriologically contaminated foods (particularly shellfish). The total number of reported cases of waterborne microbiological disease outbreaks from 1971-1974 in the United States was 16 476, the majority resulting from gastroenteritis for which no etiological agent was determined.

The reason for the apparent increase in outbreaks is difficult to ascertain, it may be due to improved reporting and follow-up procedures; however, it may also be the result of the sometimes extensive recycling of surface waters and subsequent difficulty in maintaining quality control of potable waters.

Sources of bacterial contamination to the environment and their subsequent health implications are numerous. The health aspects of non-disinfected municipal sewage effluent have been studied and are well understood. Bell (2) provides an excellent review of the health hazards associated with bacterial discharges to the aquatic environment. The reader is directed to this review for a more complete understanding of the problem. Briefly, Bell has examined the discharges from pulp mills, meat and poultry packing plants, dairy farms and fruit plants.

The majority of these plants were discharging total coliforms in the order of 10^4 to 10^6 per 100 ml. The implications of such discharges are not fully understood; however, the high nutrient levels in these discharges have been shown to increase the survival time of coliform organisms in the receiving water and in some cases support regrowth of coliforms in the receiving water. Pathogenic organisms discharged with these effluents or in close proximity to their point of discharge will conceivably have the capacity to persist and perhaps regrow in the nutrient-rich environment. In fact, Salmonella have been shown to grow well in these wastes, and the obvious conclusion is that the persistence of these and other pathogens in the aquatic environment increases the chances for water-borne infection.

1.1 Salmonella in the Environment

The cycling of Salmonella in the environment can be by several routes. One of the major vehicles by which Salmonella is transmitted to man is food. Poultry and pork products are two notable vectors of human salmonellosis. Direct animal-to-man and man-to-man transmission of Salmonella have been reported to occur. Salmonella can also be transmitted via contaminated water used for recreation, drinking, food processing, or spray irrigation. Figure 1 shows some of the major routes of Salmonella cycling in the environment.

1.1.1 Indicator Organisms and Salmonella in Meat and Poultry Plants.

Hoadley et al (3) conducted a two year study of a poultry processing plant examining the effluent for fecal coliform (f.c.), fecal streptococci (f.s.) and Salmonella sp. The numbers of indicator bacteria in the raw effluent were high, with fecal coliform counts of 1.7×10^6 /100 ml and fecal streptococci counts of 1.45×10^7/100 ml. The waste was treated using a lagoon system which effected a 90% reduction in bacterial numbers. There was still a considerable discharge of bacteria however, and significant levels of contamination were observed in the receiving stream up to 5 km downstream from the main discharge. Salmonella sp. were isolated in a fairly constant ratio

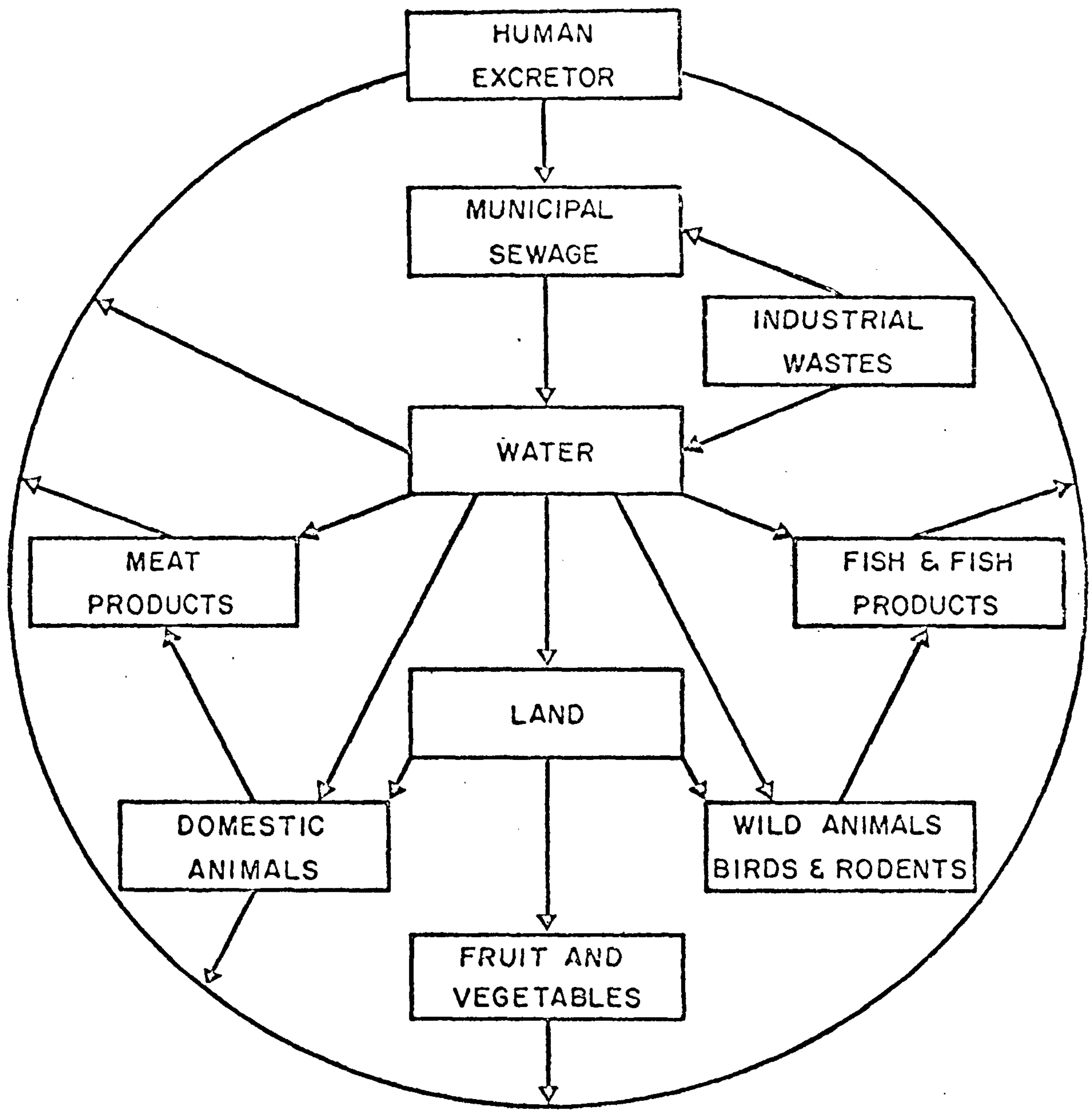

FIG. 1 SIMPLIFIED PATHWAYS FOR THE TRANSMISSION OF SALMONELLA THROUGH WATER

of 1 Salmonella:500 fecal coliforms and were detected in the raw and lagooned wastes as well as 5 km downstream from the main discharge.

Tennant et al (4) sampled effluents from three large well operated Ontario poultry plants for standard indicator organisms, Pseudomonas aerunginosa and Salmonella sp. Bacterial densities for the three standard parameters (total coliforms, fecal coliforms and fecal streptococci) in raw screened wastes were in the range of 10^5 to 10^7 per 100 ml. Activated sludge treatment in two of the plants effected very significant reductions (93 to 99.9%) in counts for the three standard parameters, standard plate count and P. aeruginosa. Chlorination disinfection caused a further reduction (90% or more) in bacterial numbers. Salmonella sp. were detected in both raw and treated (pre-chlorination) effluents, a total of 534 isolates being confirmed. Tennant recommended that disinfection of poultry plant wastes be required to eliminate the discharge of Salmonella sp. to the environment.

Vanderpost and Bell (5) conducted a study on effluents from nine meat and poultry packing plants in Alberta and isolated Salmonella sp. from seven of these effluents, often from as little as 10 ml or even 1 ml aliquots of the effluents. Waste treatment at most plants was nonexistent or minimal, usually consisting of settling/flotation tanks with fat skimmers, and was totally ineffective in reducing indicator bacteria levels, which were in the range of 10^5 - 10^7 per 100 ml. The report recommended that further treatment of meat and poultry plant effluents, including disinfection, be practised.

1.2 Meat and Poultry Plants in British Columbia

A brief summary of the pertinent characteristics of the various poultry and meat packing plants is presented in tabular form in Appendices I and II. This information was obtained from the Environmental Protection Service, Pacific Region, registry and may not be complete or up-to-date. The latest file entry date is included in the tables. The information in the tables will be further examined in the discussion.

2 METHODS AND MATERIALS

An effluent sampling program was carried out from October 4-8, 1976 and December 14-15, 1976 at the Wm. Scott Company Ltd. in Port Coquitlam. The purpose of the project was to characterize and quantify the microbiological component of a poultry packing plant liquid effluent with respect to the following parameters: total and fecal coliforms, fecal streptococci, standard 35°C plate count and *Salmonella*.

2.1 The Plant

According to registry file data, this plant can produce 23 955 kg/day (52 882 lb/day) of product (broilers, fowl, turkeys) with an effluent discharge rate of 0.011 m^3/sec (218 471 imperial gallons per day). During the sampling periods the plant was reportedly operating normally and the effluent discharge rate was estimated to be 1200 liters/minute (265 gallons/minute). The constituents of the discharge include wastewater from the offal flume, floor washings, equipment washings, scalder, spin-spell, pre-wash tanks and domestic sewage from the plant washrooms. Offal and feather wastewater flumes are separate and are screened prior to treatment. The offal and feathers are picked up by a reduction plant and are used in the manufacture of fertilizer and for animal feed. The plant treatment system consists of a flotation tank with a skimmer which handles both the plant wastewater and domestic sewage. After this treatment the effluent is discharged to the municipal sewer.

2.2 Sample Points

Four sample stations were chosen for this study; they included the final effluent after treatment, the final effluent prior to treatment, the offal wastewater after screening, and the feather wastewater after screening.

2.3 Procedures

2.3.1 Confirmed Total and Fecal Coliforms, Fecal Streptococci. Samples were collected in sterile 170 cc wide-mouth glass jars. The Most Probable Number (MPN) per 100 ml was determined using the multiple tube fermentation technique (at least 3 decimal dilutions of 5 tubes each) as described in parts 908A, 908C, and 910A of the 14th edition of Standard Methods for the Examination of Water and Wastewater(6).

2.3.2 Standard Plate Count. Standard Plate Count analyses were conducted as described in part 907 of Standard Methods.

2.3.3 Salmonella Isolations. Moore swabs and 100 ml grab samples were used for Salmonella isolations. The swabs were constructed on a 30.5 cm x 30.5 cm mesh chicken wire. Five 3.8 cm x 22.9 cm gauze strips each made up of 6 layers of gauze were gathered together at one end and tied with string to the wire mesh. The other ends of the strips were spread out on the frame and tied separately, in order to expose the maximum surface area to the effluent. The swabs were left in the effluent stream for 10 minutes. Each of the strips was placed into the following enrichment media: tetrathionate broth at 35°C; tetrathionate broth at 41.5°C; selenite-cysteine broth at 35°C; selenite-cysteine broth at 41.5°C. The remaining strip was cut into quarters with one quarter being placed in each enrichment broth-temperature combination. Four 100 ml grab samples were also added to each of 100 ml of double strength tetrathionate broth at 35°C and 41.5°C and 100 ml of double strength selenite-cysteine broth at 35°C and 41.5°C. These enrichment broths were incubated for 24 hours.

Inocula (0.1 and 0.01 ml) from each of the enrichment broths were streaked on XLD agar, Brilliant Green (sulpha) agar and Bismuth Sulphite agar and incubated at 35°C for 24 hours. Typical colonies were streaked onto MacConkey Agar and incubated for 24 hours at 35°C. Lactose negative organisms were inoculated into urea broth and those which were negative after 24 hours were subcultured into brain-heart infusion broth, incubated at 35°C for 3 to 4 hours, then stabbed and streaked onto Triple Sugar Iron agar and Lysine Iron agar. Typical reactions in these media resulted in the isolates being subjected to the following biochemical reactions; dulcitol, dextrose, sucrose, salicin, modified malonate, citrate, indole test. Cultures with characteristics typical for the genus Salmonella were serotyped by means of slide agglutinations using polyvalent O antisera. Positive organisms to this stage were submitted to the B.C. Provincial Health Laboratories for confirmation and identification.

3 RESULTS AND DISCUSSION

The daily bacteriological data for each of the four sample stations are presented in Appendix III and summarized in Table 1.

The results of the case study concur with results obtained in previously mentioned studies (4, 5, 6). The bacterial levels were very high, and were comparable to those found in raw sewage. Although some of the bacterial counts in the final effluent were due to domestic sewage, considerable numbers of bacteria were present in both the offal and feather wastewater systems, with fecal coliform MPN's of 8.1×10^5 /100 ml and 4.9×10^5/100 ml, respectively. The flotation tank-skimmer treatment system did not appear to effectively reduce bacterial levels and in fact the mean standard plate count increased from 1.55×10^5 /ml to 2.4×10^5/ml.

Seven of 50 isolates subjected to Salmonella identification tests yielded positive Salmonella serotypes and these were identified as Salmonella infantis and Salmonella heidelberg. Although only two serotypes were isolated, they were recovered from as little as 100 ml of effluent, indicating the potential health hazard associated with this effluent.

The evidence from this study and data obtained in other studies demonstrates that typical poultry (and meat packing) plant liquid effluents may contain large numbers of bacteria and are significant sources of Salmonella sp. Bearing this in mind, the adequacy of treatment and/or points of discharge used at meat and poultry packers throughout British Columbia were examined (Appendices I and II).

Of the seven poultry plants on file, five discharge to municipal sewer systems, one to a tile field and ultimately a creek, and one not reported. Treatment systems at the plants consisted of flotation cells with skimmers (3 plants), settling tanks and/or lagoons

TABLE 1 SUMMARY OF BACTERIOLOGICAL DATA - WM. SCOTT CO. LTD.

Sample Point	Number of Samples	Mean MPN/100 ml Total Coliform	Fecal Coliform	Fecal Streptococci	Standard Plate Count per/ml
Scott #1	5	2.74×10^6	6.12×10^5	3.34×10^6	2.4×10^5
Scott #2	5	3.1×10^6	2.1×10^6	2.3×10^6	1.55×10^5
Scott #3	2	9.2×10^5	8.1×10^5	$>8.8 \times 10^5$	4.93×10^4
Scott #4	2	5.8×10^5	4.9×10^5	$>1.3 \times 10^6$	4.0×10^5

Scott #1 Final effluent after treatment
Scott #2 Final effluent before treatment
Scott #3 Offal wastewater after screening
Scott #4 Feather wastewater after screening (scalder)

(3 plants), and septic tank - tile field systems (1 plant). Flotation cells with skimmers appear to be ineffective in reducing bacterial levels in the effluent, based on the present study, but Hoadley (4) found that lagoon treatment can result in a 90% bacterial reduction.

The information from most of the poultry plants did not indicate whether or not domestic sewage was discharged and/or treated together with the plant effluent. The presence of domestic sewage in the final plant effluent increases the potential for introducing additional pathogens into the receiving environment and, with the nutrient addition from the sewage, pathogens present in the plant wastewater may persist longer or even re-grow.

The discharge of poultry plant liquid effluents to municipal sewer systems would seem a convenient method of solving the problem of microbial pollution. However, in municipal systems which do not have disinfection prior to discharge, the incidence of Salmonella sp. and other pathogens in the sewage effluent may be at a significantly higher level due to the higher than normal percentage of Salmonella sp. in the poultry plant effluent.

Of the eleven meat packing plants on file, ten were reported as having some type of treatment system. The breakdown is as follows:

- i) septic tank - tile field (4 plants)
- ii) septic tank - receiving water (1 plant)
- iii) screening - spray irrigation (1 plant)
- iv) screening, coal bed filtration - receiving water (1 plant)
- v) screening, oxidation ditch - receiving water (1 plant)
- vi) settling, skimming - receiving water (1 plant)
- vii) lagoon - spray irrigation (1 plant)

The remaining plant discharges to a municipal sewer with no reported pretreatment.

It is difficult to comment on the bacteriological dangers associated with the discharges from these plants as the file information is incomplete in terms of effluent constituents, points of discharge, and treatment systems. However, it should be pointed out that the use of spray irrigation to dispose of plant wastewater may introduce a potential health hazard, particularly in cases where the spray irrigation of fruits and vegetables, which are normally consumed raw, is practised. Disposal by means of septic tank - tile field systems is often inadequate bacteriological treatment due to poor soil permeability, high water table, and poor septic tank maintenance.

4 CONCLUSIONS

The results of our short study, and of the more extensive work performed by Vanderpost (5) and Tennant (4) present conclusive evidence of the existence of high bacterial levels in meat and poultry plant effluents. The file review of operating plants in British Columbia revealed that little information exists regarding effluent constituents, treatment systems and points of discharge, particularly for meat packers.

It is reasonable to assume that the bacteriological characteristics of other meat and poultry plant effluents throughout B.C. are similar to those observed in Alberta and Ontario. For this reason, it would not seem necessary to conduct intensive microbiological studies on some or all of the plants in the province. It is recommended, however, that the methods of treatment and disposal at all plants be more critically examined, specifically with a view of determining their adequacy to reduce bacterial discharges to the environment. This would involve on-site inspection and minimal effluent and/or receiving water sampling at a few representative plants. The information gained from such a study would enable a more knowledgeable decision to be made as to the extent of the environmental significance of microbial pollution from meat and poultry plants in British Columbia.

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APPENDIX I

PRODUCTION AND EFFLUENT INFORMATION SUMMARY FOR POULTRY PLANTS

APPENDIX I PRODUCTION AND EFFLUENT INFORMATION SUMMARY - POULTRY PLANTS

Name of Plant	Location of Plant	Total Production	Effluent Discharge Rate	Point of Discharge	Treatment System(s)	Constituents of Effluent	Last File Entry Date
Wm. Scott Company Ltd.	Port Coquitlam	52 882 lb/day (broilers, fowl, turkeys)	218 471 Igpd	Port Coquitlam Municipal Sewer	Flotation tank with skimmer	Domestic sewage and normal poultry plant wastewater (wet process)	Oct. 22, 1973
Fatts Poultry Ltd.	Saanich	3900 birds/day (2 days/week)	Not reported	Tile field to road-side ditch to Colquitz Creek	Sceening, oxidation ditch, chlorination	Normal poultry plant wastewater	July 17, 1973
Moore's Poultry Ltd.	Coquitlam	1200 - 2000 birds/day	10 000 Igpd	Domestic Sewage - municipal sewer system Cooling Water - collecting tanks & tile bed Plant Wash - grease trap to settling tanks to municipal sewer Shipping Crate Washwater - into pit		Dry process poultry plant effluent	Mar. 1, 1973
Hallmark Poultry	Vancouver	7000 birds/day	50 000 Igpd	Municipal sewer	Grease trap for plant wastewater	Wet process poultry plant effluent	May 1, 1973
Chicken City Farms Ltd.	Surrey	4000 birds/day	18 500 Igpd	Municipal sewer	Settling tanks - crate washings and production area - screening	Wet process poultry plant effluent	Apr. 6, 1973
Panco Poultry Ltd.	Surrey	48 000 birds/day	31 000 Igpd	Municipal sewer	Flotation cell with skimmer	Wet process poultry plant effluent	Jan. 4, 1974
Maplewood Poultry Processors Ltd.	Victoria	Not reported	Max. 50 000 Igpd	Bilston Creek	Plant wastewater - screening, gravity flotation and lagoon treatment. Domestic sewage - septic tank, chlorinating lagoon	Domestic sewage and poultry plant effluent	May 17, 1974

APPENDIX II

PRODUCTION AND EFFLUENT INFORMATION SUMMARY FOR MEAT PACKING PLANTS

APPENDIX II PRODUCTION AND EFFLUENT INFORMATION SUMMARY - MEAT PACKING PLANTS

Name of Plant	Location of Plant	Total Production	Effluent Discharge Rate	Point of Discharge	Treatment System(s)	Constituents of Effluent	Last File Entry Date
Glenwood Meats	Victoria	Not reported	6000 Igpd	Craigflower Creek	Vibrating screen, oxidation ditch, clarifier	Abbatoir and domestic effluent	Feb. 3, 1976
J & L Meats Ltd.	Delta	Not reported	3600 Igpd	Spray irrigation of surrounding areas	Screened	Wash water and blood	May 6, 1976
Winfield Meat	Winfield	Not reported	Not reported	Tile Field	Septic tank	Process wash water	Sept. 19, 1976
Empire Meats Ltd.	Vernon	40 hogs and 20 cows per week	250-300 Igpw	Tile Field	Septic tank Blood and offal to Vernon landfill	Waste water	Sept. 28 1973
Fleetwood Sausage Ltd.		Not reported	Not reported	Municipal sewer	Not reported	Not reported	Nov. 28, 1975
Gainers Ltd.	Richmond	Not Reported	Not reported	North arm of Fraser River	Septic tank, chlorination	Process water	July 3, 1973
E. Johnston Packers Ltd.	Chilliwack	Annual production 2500 cows 1000 hogs 150 sheep	600 Igpd	Tile field	Screened, wash water and domestic sewage to separate septic tanks then common tile field	Wash water and domestic sewage	May 15, 1974
SIS Ranches Ltd.	Vanderhoof	10-20 animals per week	Not reported	Spray irrigation onto land	Lagoon	Wash water and domestic sewage	May 21, 1973
Williams Lake Packers Ltd.	Williams Lake	Not reported	Not reported	Tile Field	Septic tank - landfill for offal and blood	Abbatoir and process waste water	Jan. 21, 1974
Richmond Packing Ltd.	Richmond	Not reported	10 000 Igpd	North Arm Fraser River via municipal drainage ditch	Coal Bed filtration, screening	Typical liquid abbatoir effluent	Mar. 24, 1975
Swift Canadian Ltd.	Richmond	Not reported	12 000 lb/day solid waste Liquid waste not reported	Process wastes - Fraser River Arm Domestic wastes - Bath Creek	Settling, skimming	Process and domestic waste	Oct. 15, 1975

APPENDIX III

DAILY BACTERIOLOGICAL RESULTS - WM. SCOTT COMPANY LTD.

APPENDIX III DAILY BACTERIOLOGICAL RESULTS - WM. SCOTT COMPANY LTD.

	MPN per 100 ml			Standard Plate
Station	Total Confirmed	Fecal	Fecal Streptococci	Count/ml (35°C)
Date: October 4, 1976				
1	1.4×10^6	9.4×10^5	4.9×10^6	2.12×10^5
2	4.9×10^5	4.9×10^5	2.3×10^6	3.13×10^5
Date: October 5, 1976				
1	9.2×10^5	2.4×10^5	2.4×10^6	2.87×10^5
2	1.6×10^6	1.6×10^6	2.4×10^6	1.97×10^5
3	2.4×10^5	2.3×10^4	1.6×10^6	7.64×10^4
4	2.4×10^5	7.9×10^4	1.6×10^6	5.11×10^5
Date: October 6, 1976				
1	1.4×10^6	4.6×10^5	3.5×10^6	3.27×10^5
2	2.4×10^6	1.3×10^6	9.2×10^5	1.13×10^5
3	1.6×10^6	1.6×10^6	1.6×10^5	2.21×10^4
4	9.2×10^5	9.2×10^5	9.2×10^5	2.9×10^5
Date: October 7, 1976				
1	9.2×10^6	1.2×10^6	2.4×10^6	2.23×10^5
2	1.7×10^6	1.7×10^6	2.4×10^6	9.3×10^4
Date: October 8, 1976				
1	7.9×10^5	2.2×10^5	3.5×10^6	1.52×10^5
2	9.2×10^6	5.4×10^6	3.5×10^6	6.0×10^4