AN INVENTORY OF THE FRUIT AND VEGETABLE PROCESSING INDUSTRY IN CANADA

by

Stanley Associates Engineering Ltd.

for the

Water Pollution Control Directorate
Environmental Protection Service
Fisheries and Environment Canada

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ABSTRACT

Basic information on the economic and environmental aspects of the fruit and vegetable industry, excluding potato processing, was collected through questionnaires sent to all known fruit and vegetable processing plants in Canada, literature sources, and contacts with key members of the industry. The questionnaire responses have been analysed and combined with data obtained from Statistics Canada and other sources to present a total Canadian picture with respect to production, waste treatment techniques, and effluent loadings.

Fruit and vegetable processing plants were divided into three categories according to size, based on annual production rates. These categories have been assessed separately in terms of environmental control methods and costs. The economic impact of upgrading wastewater treatment in each category has been evaluated in relation to the reductions in waste loadings that would result.

RÉSUMÉ

Des renseignements fondamentaux sur les aspects économiques et environnementaux de l'industrie des fruits et légumes, à l'exception de celle de la transformation des pommes de terre, ont été recueillis à l'aide de questionnaires adressés à toutes les entreprises canadiennes connues traitant les denrées végétales, aux sources bibliographiques et à des membres éminents de l'industrie. Les réponses aux questionnaires analysées et combinées à des données de Statistique Canada, entre autres, ont donné un apercu de la situation canadienne en ce que concerne la production, les techniques de traitement des déchets et la concentration de matières polluantes dans les effluents de l'industrie considerée.

A partir du tonnage annuel produit, on a établi la taille des usines de transformation de fruits et légumes et on les a classées en trois catégories, qu'on a évaluées séparément quant aux méthodes de protection de l'environnement et aux coûts qui en découlent. L'incidence économique d'une épuration améliorée dans chaque catégorie a été évaluée en fonction de la réduction conséquente des concentrations de polluants.

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SUMMARY

Methodology

This report is one stage in the establishment of effluent standards by the Federal government, and has as an objective:

> "To prepare an environmental inventory of the fruit and vegetable processing industry in Canada by conducting an evaluation of the economic health of the industry and by compiling and evaluating the questionnaires returned."

It should be emphazised that this report is not a state-of-the-art review of in-plant or treatment technology available to and used by the industry.

The prime source of data on the industry was the questionnaires developed by Fisheries and Environment Canada in consultation with the industry, and distributed to all known fruit and vegetable processing plants in Canada. The questionnaire data (for the year 1975) were supplemented with information obtained from the government and literature sources, and from contacts with key personnel in the industry. A major reference source used for this report was the "Review of Treatment Technology in the Fruit and Vegetable Processing Industry in Canada" prepared by Stanley Associates Engineering Ltd. for Environment Canada in March 1976 (EPS 3-WP-77-5).

The data obtained from the questionnaires and other relevant sources were compiled, edited and presented in tabular form to facilitate analysis. The objective of this analysis was to obtain meaningful information on in-plant processing and effluent control for those plants which returned the questionnaires, and to use this information to assess the total industry operations across Canada. These estimates were used to determine (a) the total current and potential BOD_5 and suspended solids (SS) loadings in Canada, and (b) the upgrading potential available to reduce these loadings by means of available pollution control technology.

Industry Overview

Based on information available from Statistics Canada and other sources, the weights of raw fruits and vegetables processed in Canada in 1975 were estimated to be:

raw fruit processed	249,870 metric tonnes
raw vegetable processed	851,580 metric tonnes

It should be noted that the above figures are estimates and require confirmation by the industry and Statistics Canada when actual 1975 production data become available.

The industry shipped goods valued at $865 million in 1974, an increase of 21% over the 1973 value. The provinces of Ontario, Quebec and British Columbia account for the largest concentrations of industry activity, with Ontario accounting for 50% of all establishments and 62% of the value of goods shipped, on a 1973 basis. There is a moderate degree of product concentration, with the four largest firms accounting for 25% of the total value of goods shipped, while firms with more than 100 employees accounted for 73% of total value of shipments, on a 1973 basis. While the total number of establishments in the industry has declined almost 30% over the last 15 years, this decline appears to have ceased, with the total number of establishments being reasonably constant at approximately 240 for the last few years.

Competition in the marketplace is intense between domestic processors and between domestic and foreign processors, with more than half the Canadian market currently supplied by low priced imports of tomatoes, tomato paste, peaches and apricots.

A sample survey of 25 industry firms indicated a lack of vertical integration. Generally, individual firms were not diversified beyond fruit and vegetable processing; however, a number of firms were subsidiaries of companies involved in other fields. A number of small establishments within the sample survey processed only one type of fruit or vegetable. The larger firms were generally involved in processing a variety of fruits and vegetables, with much of the specialization being based on the geographic proximity of the plant to the source of raw material.

The small independent firms within the industry appeared to be more vulnerable to short-term market turndowns or to crop failures than the firms with parent companies; lack of branch plants limited diversification of product lines, further aggravating this vulnerability. In addition, most small firms do not pack goods under their own label, and thus there is no brand loyalty to provide a base level demand for their product.

Questionnaire Response

A total of 185 questionnaires were returned by the industry, representing a 49.7% response to the 372 questionnaires mailed. The 185 plants responding to the questionnaire consisted of 89% (164 plants) processing raw fruits and/or vegetables, while the remaining 11% (21 plants) were formulators only. Meaningful conclusions on the industry in Canada could be drawn from the 164 responding plants that processed raw fruits and/or vegetables since these constituted 76% of the total weight of fruits and 84% of the total weight of vegetables processed in 1975. In addition, the sample size was statistically sufficiently large (164 responses from the 372 questionnaires mailed).

Size Categorization

The following plant size categorization was developed based on the questionnaire data:

Small Plant - processing from 0 - 2,000 metric tonnes of raw material annually,

Medium Plant - processing from 2,000 to 10,000 metric tonnes of raw material annually,

Large Plant - processing greater than 10,000 metric tonnes of raw material annually.

The average production rates of Canadian plants within the above size categories were as follows:

Small - 690 metric tonnes of raw material processed annually,
Medium - 5,230 metric tonnes of raw material processed annually,
Large - 24,770 metric tonnes of raw material processed annually.

These average plant sizes, and the total weight of fruits and vegetables unaccounted for by the returned questionnaires, were used to determine the total numbers of plants in Canada and their size distribution.

Total Canadian Experience

The total number of plants in Canada processing raw fruits and vegetables is estimated to be 221, comprising 111 small plants, 87 medium size plants and 23 large plants. Large plants account for 51% of the total fruits and vegetables processed; in contrast, small plants account for 7% of the total production but constitute 50% of the total number of plants. The remaining 39% of the plants are medium sized and account for 42% of the commodities processed.

Commodity processing

In general, small plants processed either fruits (46%) or vegetables (49%) with only 5% processing both commodities. The majority of medium sized plants processed vegetables (60%) or both commodities (27%). In contrast, most large plants processed only vegetables (76%) with 19% of the large plants processing both fruits and vegetables. Based on the questionnaires, only one large plant processed strictly raw fruits.

The medium sized plants processed the major quantity of fruits (60%), with large plants accounting for 28% of the total tonnage. In contrast, large plants processed 65% of the vegetables with medium sized plants processing 30%.

Water supply and use

The majority of the plants in each size category obtained water from municipal systems solely or in conjunction with private wells or surface water sources. Only 7% of the plants relied entirely on surface water; in contrast, private wells were used by 25% of the small plants, 20% of the medium and 19% of the large plants. There was considerable variation in water use in the fruit and vegetable industry in all sizes of plants. In general, all size categories indicated water use between 0.01 and 494 cubic metres per tonne of raw materials processed (m^3/t). A distribution analysis of the questionnaire data on water use indicated the following:

- 50% of the large plants used 14 m^3/t or less,
- 50% of the medium plants used 20 m^3/t or less,
- 50% of the small plants used 7 m^3/t or less.

Wastewater characteristics

Insufficient information was available from the returned questionnaires on raw wastewater quality and final effluent characteristics to permit a detailed analysis to be carried out.

Unit waste loadings from the review report (EPS 3-WP-77-5) were used, where appropriate.

Wastewater treatment facilities

Only 8% of the plants utilized some type of oil and grease removal facility, confirming that oil and grease are not normally a major problem in this industry. In-plant screening facilities were provided by 95% of the large plants, 59% of medium sized plants, but only 38% of the small plants.

No definite conclusions could be drawn regarding the use of solid-liquid separation facilities in the industry. The questionnaire response to this particular item indicated that very few plants (28%) have this facility. However, there may have been some doubt whether or not this process was to be considered separate from the biological treatment system. Thus, responding plants may have indicated the absence of solid-liquid separation units, although these units may have been included in an affirmative response to having biological treatment.

Untreated effluent is discharged directly to a surface water body by seven percent of the small plants and nine percent of the medium sized plants. In addition, 18% of the small plants, and 22% of the medium sized plants discharged untreated effluent to municipal systems which did not have any treatment facilities, with the remainder discharging untreated effluent either to municipal systems having some form of treatment (32%) or directly to land (21%).

The most commonly used biological treatment methods included holding lagoons and aerated lagoons. Only a small number of plants used trickling filters or activated sludge systems. In addition, septic tank and tile field systems were used only by small sized plants for treatment and disposal of wastewater.

In the case of the small plants with biological treatment facilities, 20% discharged treated effluent to municipal systems, an additional 20% discharged to surface waters, and the remaining 40% applied treated effluent to the land. In the case of medium sized plants, 10%, 50%, and 40% of the plants discharged treated effluent to municipal systems, surface waters and land, respectively. Fifty percent of the large plants discharged treated effluent to surface waters, 25% discharged to municipal systems, and 25% applied treated effluent to the land.

Total potential BOD_5 and suspended solids (SS) loadings

The total potential BOD_5 and SS loadings from Canadian fruit and vegetable processing operations was estimated to be as follows:

Small plants:	BOD_5 - 822,000 kilograms,	SS - 298,000 kilograms
Medium plants:	BOD_5 - 5,733,000 kilograms,	SS - 1,874,000 kilograms
Large plants:	BOD_5 - 5,472,000 kilograms,	SS - 2,993,000 kilograms
TOTAL:	BOD_5 - 12,027,000 kilograms,	SS - 5,165,000 kilograms

Biological treatment systems operated by the industry removed 30.7% of the total potential BOD_5 and 30.8% of the total potential suspended solids. Treatment of industry wastewater by municipal systems removed a further 29.8% BOD_5 and 31.0% SS. Land application systems removed an additional 15.7% BOD_5 and 18.0% SS. A potential residual loading of 2,859 x 10^3 kg BOD_5 and 1,045 x 10^3 kg SS remained after present (1975) treatment. Approximately 62% (1777 metric tonnes) of the residual BOD_5 originated from medium sized plants disposing wastewater directly to surface waters without treatment or to municipalities not having treatment facilities. Similarly, an additional 206 metric tonnes of BOD_5 was discharged untreated by small plants. Medium sized plants discharged 580 metric tonnes of SS and small plants discharged 74 metric tonnes SS without any form of treatment, either at the plant or by municipal systems. Thus the current residual BOD_5 and SS loadings could be substantially reduced by either providing treatment at the industry, at municipal plants, or by a combination of improved treatment at both locations.

Effect of Upgrading Wastewater Treatment

Upgrading all industry sources currently without treatment either at the plants or the municipalities would have the largest effect if carried out in medium sized plants. For example, upgrading medium plants (those currently not treating their wastewater or discharging to a municipality having no treatment system) to incorporate holding lagoons would reduce total residual BOD_5 loadings from 2,859 x 10^3 kg to 1,260 x 10^3 kg, and SS residual loadings from 1,045 x 10^3 kg to 580 x 10^3 kg.

The incorporation of secondary treatment at all municipalities presently receiving industry wastewater would reduce loadings as follows:

(a) total residual BOD_5 loadings from 2,859 x 10^3 kg to 1,316 x 10^3 kg,
(b) total residual SS loadings from 1,045 x 10^3 kg to 566 x 10^3 kg.

Upgrading all industry sources without treatment by introducing holding lagoons either at the plant or municipal facility, and upgrading those municipalities with primary treatment to secondary facilities would lower total residual BOD_5 to 799 x 10^3 kilograms and total residual SS to 461 x 10^3 kilograms.

Economic Impact of Effluent Control Measures

Total annual waste treatment costs in terms of dollars per tonne of finished product were used to assess the impact of environmental control measures on profit margins. In view of the lack of available cost and financial data, minimum profit margins required to absorb the costs of waste treatment were estimated.

Retail selling prices were generally independent of plant size; composite prices for the fruits, vegetables, and fruits and vegetables categories were as follows:

fruits - $885.11 per metric tonne finished product,
vegetables - $900.31 per metric tonne finished product,
fruits and vegetables - $897.11 per metric tonne finished product.

Treatment costs per metric tonne of product as a percentage of processor selling prices were developed for a number of environmental control strategies and for each plant size category, in particular:

Small plant:	holding lagoon 1.0 - 1.6%
	aerated lagoon 1.9 - 3.3%
	activated lagoon 3.2 - 5.7%
Medium plant:	holding lagoon 0.7 - 1.1%
	aerated lagoon 1.2 - 2.2%
	activated sludge 2.1 - 3.7%

On the basis of small plants realizing a pretax profit margin of 1.5 - 3%, the introduction of secondary treatment facilities may not be economically viable. In addition, a relatively small reduction in total residual BOD_5 results. On the basis of a 2 - 4% profit margin for a medium sized plant, the introduction of secondary treatment facilities would effect marginal operations.

Thus, from an economic standpoint, two important conclusions can be drawn regarding the requirement for secondary treatment in those fruit and vegetable industry plants currently providing no treatment and not discharging to municipal systems:

1) Introduction of secondary treatment in small plants could potentially place undue economic hardship on these plants.
2) In considering the introduction of secondary treatment into medium sized plants, each case should be considered on its own merits.

In the development of environmental controls, these two conclusions should be taken into consideration before setting waste treatment requirements applicable to the industry as a whole.

1. INTRODUCTION

1.1 Objectives

The fruit and vegetable processing industry is characterized by the diversity of products processed and the seasonal nature of production. Plant sizes range from very small, employing a few persons, to very large, employing hundreds; fruit and vegetable processing organizations range from cooperatives through proprietorships and private companies to major corporations. A given plant's economic health is affected by many variables, including weather and the supply of fruit and vegetables, the percentage efficiency in utilization of the raw material, the usual manufacturing operating cost factors, the changing demand patterns and many others.

Fruit and vegetable processing operations are the source of a concentrated biologically active wastewater and highly putrescible solid wastes which must be treated and ultimately discharged to the land surface or water body. An objective of regulatory agencies is to establish rational effluent standards which will prevent pollution by these wastes while representing practical, attainable goals. The abatement strategies have the aim of pretreatment of the effluent at source prior to discharge, with maximum water reuse and recycle, and solids recovery. Costs of alternative abatement strategies must be carefully evaluated since these will either be passed directly to the consumer or, if this is prevented by competitive forces, may threaten the continued economic operation of the facility.

The approach of the Environmental Protection Service (EPS) to pollution control is to adopt a strategy of containment at the source by means of best practicable technology, not only treatment but in-plant process technology. Regulations are based on control methods, both in-plant and treatment, which provide a reasonable degree of environmental protection without causing undue economic hardships. The first steps are to identify the problem in terms of an environmental inventory of the industry and to conduct a "state-of-the-art" review, including waste characterizations, and process and waste treatment technologies. On the basis of the data from these studies and from the literature, the

Environmental Protection Service prepares a preliminary discussion paper which, where possible, will address the following:

- definition of the plants or activities included,
- effluent sources, contaminants and problems associated with their discharge,
- wastewater control and/or process technology and "Best Practicable Technology"; these considerations may include the order of magnitude of the numerical limits for specific substances that can be reasonably expected if "Best Practicable Technology" is applied,
- the effect that attainment of different limits will have on the wastes presently being discharged in Canada,
- economic aspects of water pollution control,
- regulatory options for the control of the effluent.

Following preparation of the discussion paper, the Environmental Protection Service will convene a joint industry/government task force. The role of the task force is to provide a technical forum for consultation between interested parties. The task force will make recommendations on best practicable technology and will review technical drafts of the regulations and guidelines developed as a result of these recommendations.

1.2 Scope

This report is one stage in the establishment of effluent standards, and has as its objective:

> "To prepare an environmental inventory of the fruit and vegetable processing industry in Canada by conducting an evaluation of the economic health of the industry and by compiling and evaluating the questionnaires returned".

It should be noted that the potato processing industry has not been included as part of this assessment. This particular industry has been previously assessed by Fisheries and Environment Canada as a separate entity. In addition, it should be emphasized that this report is not a state-of-the-art review of in-plant or treatment technology available and used by the industry. A state-of-the-art review was previously prepared by Stanley Associates Engineering Ltd. for the Environmental Protection Service (Report No. EPS 3-WP-77-5); reference to this work is made in more detail in Section 2 of this report where it has been used in the determination of effluent loadings which result from the processing of specific commodities.

In this report, the metric system of units has been used for the presentation of data. Production rates are expressed in metric tonnes (t) and wastewater flow rates in cubic metres/day (m^3/day). Effluent parameter concentrations are expressed as milligrams/litre (mg/l) and unit waste loadings as kilograms per tonne (kg/t). Conversion factors to the English system of units (tons, pounds, gallons) etc. are given in Appendix I.

The study included a data collection program to obtain information on the economic/financial and environmental aspects of the industry. Basic information on the industry was obtained from questionnaires (Section 2) supplemented with literature sources and contact with key members of the industry.

Analysis of the questionnaires included the following:

- size in terms of raw tonnage throughput, commodities and finished products,
- response to the questionnaires as related to the entire Canadian industry,
- raw, untreated wastewater quality and pollutant quantities as related to specific fruits and vegetables,
- identification of wastewater treatment facilities utilized by the industry and resultant removal efficiencies,
- final effluent quality and loadings related to treatment methods used and disposal location.

The industry was categorized according to three sizes based on annual production rates and this categorization was used as a basis for environmental control assessment in terms of control methods and ultimate disposal locations.

An evaluation of the economic health of the industry was conducted and the effect of environmental control costs on the three size categories of plants was assessed. These environmental costs were related to the impact of the control measures in terms of reductions in waste loadings.

1.3 Approach

A questionnaire was developed by the Environmental Protection Service (EPS) in consultation with the industry and sent to all known fruit and vegetable processing plants in Canada. Stanley Associates Engineering Ltd. was not involved in the preparation of this questionnaire; however, details pertaining to its development are given in Section 2. The questionnaire was designed to obtain information relating to production rates, waste productions, disposal techniques and treated effluent analyses. The analyses of data obtained from the questionnaires form a major portion of this report with respect to compilation of the inventory; details of this analysis are given in Section 4 and a copy of the questionnaire is presented in Appendix II.

Information received from Statistics Canada was used to develop a total picture of the Canadian industry and to expand the sample data represented by the returned questionnaires. Information received from Statistics Canada related to production, employment and cash flows.

An essential input to the preparation of this inventory was that provided by specific industry contacts, including individual plants, the Canadian Food Processors Association, and the editor of "Food in Canada". These industry contacts were supplemented with personal interviews with representatives from Agriculture Canada and the Federal Department of Industry, Trade and Commerce.

The basic approach taken in this study was to develop background information on the industry based on the information sources discussed above. Compilation and analysis of the questionnaires was used to determine plant size distribution, the waste treatment techniques in use, and to approximate effluent loadings according to plant size. Data obtained from the questionnaires, representing a sample of the total

Canadian industry, were combined with those obtained from Statistics Canada and other sources in order to obtain a total Canadian picture with respect to production, waste treatment techniques and effluent loadings.

The "Review of Treatment Technology in the Fruit and Vegetable Processing Industry in Canada", prepared by Stanley Associates Engineering Ltd. (and referred to subsequently as the SAEL report) was the prime source of background information on industry processing technology and waste treatment technology. This report was also the principal source for unit waste loadings associated with the processing of specific commodities. In addition, pertinent data on waste treatment technology and control efficiencies were taken from this report.

The economic health of the industry was assessed using available financial information and the impact of specific waste treatment techniques was evaluated both in terms of waste treatment techniques and plant size.

2. DATA SOURCES

2.1 General

The prime source of data on the fruit and vegetable industry in Canada was the individual companies comprising the industry. Information collected through questionnaires sent to all known industry operations was supplemented with information and data from government, industry and published sources. This information provided the data base for the subsequent analysis presented and discussed in the remaining sections of this report.

It was realized that the data obtained from completed questionnaires would be the prime source of information on which an assessment of processing and effluent control technology and the economic analysis of the Canadian fruit and vegetable processing industry could be made. In order to carry out an analysis that would be both meaningful and useful, every effort was made to ensure accurately completed questionnaires in addition to maximizing the number of questionnaires returned. Emphasis was therefore placed on industry/government cooperation in the initial development phases of the questionnaire through to the production of the final document.

2.2 Confidentiality of Data

Stanley Associates Engineering Ltd. were not involved in the preparation of the questionnaire nor were they aware of the companies and plants to which copies of the questionnaire had been sent. In order to preserve the confidentiality of the data contained in the questionnaire, the covering sheet containing the name of the firm, head office address, manufacturing plant site address and the person to be contacted for further information was deleted from the questionnaire prior to its receipt by Stanley Associates Engineering Ltd. Each questionnaire was coded according to province and an identification number assigned to it by EPS.

The industry was aware of the steps taken by EPS to preserve confidentiality of the data source, this being expressed by the following quotation given in the top of the questionnaire:

> "This page will be removed by Environment Canada and the remaining questionnaire coded prior to analysis of information contained in this questionnaire. In this manner the confidentiality of the data will be ensured."

2.3 Questionnaire Development and Distribution

The development of the questionnaire was a government/industry cooperative effort involving EPS and the Environmental Committee of the Canadian Food Processors Association. The development of the questionnaire was first initiated in 1975 concurrent with the initiation of the study of the treatment technology in the fruit and vegetable processing industry in Canada carried out by Stanley Associates Engineering Ltd. This study (Report No. EPS 3-WP-77-5) was completed early in 1976 and outlined current process and treatment technology used in the industry and provided an assessment of available process and treatment technologies which could potentially reduce fruit and vegetable processing wastes. The data obtained in the study were used in conjunction with those obtained from the questionnaires to prepare this inventory report. Both reports will be used as a basis for task force meetings and the future development of effluent controls as discussed in Section 1.

On completion of the final draft questionnaire by the joint government/industry group, copies were distributed by the Regional Offices of the Environmental Protection Service. Questionnaires were translated into French for distribution in the Province of Quebec. These documents were mailed during December 1975 and January 1976 with collection and follow-up being the responsibility of the Regional Offices of the EPS.

Stanley Associates Engineering Ltd. commenced the inventory study in March 1975, subsequent to which coded questionnaires were received from EPS for analysis.

2.4 Questionnaire Description

The questionnaire was set up in logical sequence and, as far as possible, required "yes" or "no" answers or appropriate marks, or short sentences. A sample questionnaire is included in Appendix II. Again, it should be pointed out that the instruction sheet and the company/plant information sheet was not received by Stanley Associates Engineering Ltd., in accordance with the requirements of confidentiality discussed above.

The questionnaire was divided into the following sections:

a) General Information
b) Production Information
c) Water Supply and In-Plant Water Use
d) Wastewater Treatment
e) Final Effluent Analysis

The approach taken in analyzing these data and the results of the analysis are presented in Section 4 of this report. The results are extended to encompass the total Canadian industry in Section 5, and an evaluation of the economic health of the industry and the economic impact of specific environmental control measures is given in Section 6.

A brief statistical review is provided in Section 3 in terms of production of the industry and a general evaluation of its economic health.

3. OVERVIEW OF CANADIAN INDUSTRY

3.1 Introduction

This section provides a brief statistical review of the quantities of raw fruits and vegetables processed in Canada and a general overview of the economic health of the industry. The purpose of this review is to indicate the size of the Canadian industry, in terms of both processing and economic activity. In addition, the major commodities being processed and products being formulated are outlined.

The information given in this section is used in Section 4 in analyzing and comparing questionnaire responses with corresponding values for the total industry.

3.2 Processing Review

The total weights of raw fruits used by the processing industry for the years 1971, 1972, 1973, and 1974 are summarized in Table 1. Similar data for raw vegetables are summarized in Table 2. Statistics Canada was the principal source of the data presented in these two tables.

The majority of the respondents to the questionnaires provided 1975 production data, that is, from January 1 - December 31. Since raw materials usage information for 1975 was not available through Statistics Canada, it was necessary to estimate the quantities of raw fruit and vegetables used by the industry. Table 3 provides estimates of the total weights of raw fruits and vegetables processed in 1975 in metric tonnes.

Comparison of the 1975 estimated figures with 1974 data given in Tables 1 and 2 indicates that the quantity of raw fruits processed increased by approximately 22% and vegetable processing by 9% in 1975. The overall increase in tonnes processed during the period from 1974 to 1975 was in the order of 11%. It must be emphasized that these increases in processing will have to be verified by the industry and Statistics Canada when actual 1975 data become available.

Weights of shipments of selected processed goods are given in Table 4. Inspection of this table shows that canned and frozen fruits and vegetables are the major product styles being processed by the Canadian industry. Canned soups and tomato products (catsup, juice) are also produced in large quantities. In addition, a variety of products are

TABLE 1. RAW FRUITS PROCESSED IN CANADA (TONNES)

ITEM	1971(1)	1972(1)	1973(2)	1974(3)
Apples	143,020	120,180	110,940	133,990
Pears	16,200	20,200	18,000	16,490
Peaches	14,160	14,380	9,770	11,020
Cherries	7,230	7,320	6,800	8,700
Others				
Apricots	1,790	1,440	1,080	
Blueberries	6,440	4,090	5,730	6,220
Cranberries	1,140	1,080	1,700	1,030
Plums & Prunes	2,150	1,550	1,850	1,640
Raspberries	3,280	4,530	4,080	4,950
Rhubarb	830	730	560	580
Strawberries	6,790	4,490	3,500	5,300
All Others	12,070	10,930	10,920	13,320
TOTAL	215,100	190,920	174,930	203,240

NOTE: Values are given to the nearest ten.

(1) Statistics Canada "Fruit and Vegetable Processing Industries - 1972" Annual Census of Manufacturing, January 1975.

(2) Statistics Canada "Fruit and Vegetable Processing Industries - 1973" Annual Census of Manufacturing, October 1975.

(3) Personal communications with Statistics Canada Officials - Ottawa, August 3, 1976.

TABLE 2. RAW VEGETABLES PROCESSED IN CANADA (TONNES)

ITEM	1971[1]	1972[1]	1973[2]	1974[3]
Tomatoes	312,630	293,910	285,590	320,100
Corn	182,170	190,810	185,290	188,010
Peas	56,370	49,200	56,940	70,220
Cucumbers	49,070	43,530	48,170	44,340
Beans (Green/Wax)	40,590	35,090	40,720	49,260
Beets	19,650	19,800	18,290	18,120
Asparagus	4,580	5,030	3,820	5,250
Others				
Broccoli	1,420	2,130	1,780	1,850
Brussel Sprouts	960	1,240	2,180	2,180
Cabbage	8,480	8,630	10,140	10,650
Carrots	41,750	31,310	40,340	40,400
Cauliflowers	2,680	2,980	2,720	3,070
Celery	5,740	5,870	5,850	5,380
Horseradish	50	90	90	(90)
Lima Beans	1,460	1,310	1,660	1,710
Mushrooms	4,920	5,610	5,420	(5,420)
Onions	2,930	3,050	2,750	2,450
Pumpkin/Squash	14,120	9,320	9,490	12,110
Turnips	840	1,120	1,120	1,320
All Others	3,180	3,890	1,990	(1,990)
TOTAL	753,590	713,920	724,970	784,510

NOTE: Values are given to the nearest ten.

(1) Statistics Canada "Fruit and Vegetable Processing Industries - 1972" Annual Census of Manufacturing, January 1975.

(2) Statistics Canada "Fruit and Vegetable Processing Industries - 1973" Annual Census of Manufacturing, October 1975.

(3) Personal communications with Statistics Canada officials - Ottawa, August 3, 1976.

TABLE 3. ESTIMATED WEIGHTS OF RAW FRUITS AND VEGETABLES PROCESSED IN CANADA IN 1975 (TONNES)

FRUITS ITEM	WEIGHT	VEGETABLES ITEM	WEIGHT
Apples	171,070	Tomatoes	330,710
Pears	16,660	Corn	236,580
Peaches	12,700	Peas	78,900
Cherries	7,930	Cucumbers	45,220
Others		Beans (Green/Wax)	37,320
Apricots	1,690	Beets	15,730
Blueberries	8,550	Asparagus	5,330
Cranberries	4,960	Others	
Plums & Prunes	2,510	Broccoli	1,850*
Raspberries	5,730	Brussel Sprouts	2,180*
Rhubarb	580*	Cabbage	10,120
Strawberries	4,170	Carrots	53,170
All Others	13,320*	Cauliflowers	3,380
		Celery	6,100
		Horseradish	90*
		Lima Beans	1,710*
		Mushrooms	5,420*
		Onions	1,700
		Pumpkin/Squash	12,110*
		Spinach	650*
		Turnips	1,320*
		All Others	1,990*
TOTAL	249,870	TOTAL	851,580

NOTE: Values are given to the nearest ten.

* 1973 or 1974 figures used to represent 1975 data.

TABLE 4. SHIPMENTS OF SELECTED FRUIT AND VEGETABLE PRODUCTS (TONNES)

PRODUCT	1971	1972	1973
Fruits - Canned	59,460	62,960	58,590
- Frozen	17,460	17,090	18,700
Vegetables - Canned	276,820	274,020	268,420
- Frozen	170,040	193,090	220,340
Canned Soups	156,290	167,890	176,340
Tomato - Catsup	35,400	43,990	47,620
- Juice	72,440	82,240	81,570
Pickles, Relishes and Sauces	72,370	77,300	85,770
Jams, Jellies and Marmalades	28,370	24,930	26,580
Frozen Juice Concentrates	16,030	18,600	19,600

formulated by the industry, including the following speciality items:

- crystallized and glazed fruits,
- candied fruit peel,
- pie fillings,
- vegetable salad,
- dehydrated vegetables,
- prepared mustard,
- sandwich spread,
- spaghetti, macaroni, etc.,
- jelly food powders.

3.3 Economic Overview

3.3.1 Production and employment

In 1974, the industry shipped goods valued at $865 million. This was an increase of 21% over the value of $716 million for the previous year. Since 1961, the value of fruit and vegetable products shipped has increased on the average by 8.1% per year; in terms of constant (1961) dollars the annual increase in the value of goods shipped has averaged 3.5%. It should be noted that the constant dollar values were derived from the Statistics Canada index of industry selling prices for fruit and vegetable canners and preservers.

In 1973, canners and preservers accounted for $582 million and frozen fruit and vegetable processors accounted for $134 million of the total shipments of $716 million. These figures are taken from a recent publication by Statistics Canada, no comparable data being available for 1974 or 1975.

The data given in Table 5 indicate three provinces (Ontario, Quebec and British Columbia) as having the largest concentrations of industry activity. Industry establishments are concentrated in the following subprovincial areas: Montreal, Toronto, Hamilton, Niagara-St. Catherines, the Okanagan and Vancouver. The fruit and vegetable processing industry is not economically significant to these subprovincial regions as a whole, although a number of smaller towns are heavily dependent on one or two larger plants.

Total employment in this industry in 1973 was 18,886. Production and production related workers accounted for 77% of total employment and

TABLE 5. DISTRIBUTION OF INDUSTRY IN ONTARIO, QUEBEC AND B.C.

	% OF ALL ESTABLISHMENTS	% OF ALL INDUSTRY EMPLOYMENT	% OF ALL INDUSTRY VALUE OF GOODS SHIPPED
Ontario	51%	58%	62%
Quebec	27%	17%	15%
B.C.	10%	8%	9%

as of 1970, 31% of these workers were unionized. Over the 15 year period from 1958 to 1973, industry employment has remained steady in the 17,500 - 20,500 range, although over this same period the number of establishments declined almost 30% to 241. Industry sources predict that both the number of establishments and industry employment should remain relatively stable over the next few years. Employment tends to be seasonal, with many plants (especially the smaller ones) operating with skeleton staffs over much of the year and expanding rapidly as raw produce becomes available in later summer and fall.

Employment is concentrated in the larger establishments. Those plants employing over 100 persons (19% of all establishments according to 1973 figures) account for two-thirds of the total employment; plants employing less than 20 persons (45% of all establishments) account for only 5% of the total employment.

In 1973, the industry payroll totalled $129 million; wages for production and production related workers accounted for 66% of this total. The average annual payroll per employee was $6830. Significant payroll relationships such as total payroll relative to value of goods shipped, and production payroll relative to total payroll have remained relatively constant over the last 15 years. Thus little change in labour intensity or in the basic production processes is indicated based on this information.

3.3.2 Production concentration

There is a moderate degree of production concentration in this industry. In 1973, the four largest firms (in terms of employment) accounted for 25% of the total value of goods shipped; all firms with more than 100 employees accounted for 73% of the total value of shipments.

While the total number of establishments in the industry has declined almost 30% over the last 15 years, this consolidation appears to have ended and the total number of establishments appears to be remaining steady.

For several important canned products, specifically tomatoes, tomato paste, peaches and appricots, more than half of the Canadian market is currently supplied by low-priced imports. Thus, competition in the marketplace is intense not only between domestic processors but between domestic and foreign processors.

3.3.3 Sample survey

A limited sample survey of 25 industry firms, based on Dun and Bradstreet information, indicated a lack of vertical integration. Retail operations were not controlled and only the larger firms were involved directly in wholesaling. Only four of the 25 firms owned some productive farm land; however, in only one case did a large share of the processing raw material originate from company-owned farms. Although not involved in direct ownership of land, it appears that many firms participate in leasing arrangements with land owners.

Individual firms within this group of 25 were not diversified beyond fruit and vegetable processing. In some cases, however, the firms were subsidiaries of companies involved in other fields. In terms of specialization, a number of small establishments processed only one type of fruit or vegetable (usually apples or tomatoes). The larger firms were generally involved in processing a number of different fruits and vegetables. Much of the specialization was based on the geographic proximity of the plant to the source of the raw material.

The statistics presented in Table 6 underline the precarious position of small independent processing firms (those with annual sales of less than $1 million). These companies have no parent firms on whom they might rely for financial support and are thus vulnerable to much briefer market downturns or to crop failures than are firms with parent companies. Further, the lack of branch plants limits diversification of product

TABLE 6. CORPORATE/FINANCIAL ASPECTS OF SELECTED PLANTS

ANNUAL SALES ($1000000)	NO. OF FIRMS	NO. THAT ARE SUBSIDIARIES	NO. THAT HAVE BRANCH PLANTS	NO. SHIPPING GOODS UNDER OWN LABEL
20 plus	8	6	7	7
5 - 19	8	4	4	5
1 - 4	5	4	1	1
less than 1	4	0	0	0

lines, further aggravating this vulnerability. Since these small firms do not pack goods under their own labels, there is no consumer identification with the companies' products; this lack of "brand loyalty" removes a marketing "cushion" or base level of demand that is available to those firms selling goods carrying their own labels. These aspects are discussed later in this report when considering the economic impact of pollution control measures.

4. QUESTIONNAIRE ANALYSIS

4.1 Questionnaire Response

The data obtained from the questionnaires were compiled, edited and entered in a matrix form to facilitate analysis. The objective of the analysis was to obtain meaningful information concerning the following:

1. plant size, in terms of tonnes of raw product processed, commodity and finished product(s);
2. questionnaire response as related to the total Canadian industry;
3. identification of plant water use, wastewater characteristics, wastewater treatment facilities utilized, and discharge locations of treated and untreated effluent.

This information was used to estimate the total industry operations across Canada (Section 5) and to categorize the plants within the industry. These estimates were in turn used as the basis for the determination of the total current BOD_5 and suspended solids (SS) loadings in Canada. The upgrading potential available to reduce BOD_5 and SS loadings was also determined, using estimated efficiencies of available pollution control technology.

It should be noted that, with respect to the categorization of the plants within the industry, only those plants which processed raw fruits and/or raw vegetables were considered.

All plants potentially associated with the fruit and vegetable processing industry (Standard Industrial Classification 103) received a copy of the questionnaire, the total number amounting to approximately 475. Response from 103 establishments indicated that these should not be included within this industry sector, leaving an outstanding total of 372 plants which might be related to the industry classification. These 372 plants could include many freshpack and cold storage operations which did not reply and cannot be identified, and which should not be included within the fruit and vegetable processing industry sector. This conclusion is supported by the Statistics Canada estimate of approximately 241 fruit and vegetable processing establishments in Canada in 1973.

The number of plants by type and by province responding to the questionnaires is given in Table 7. A total of 185 questionnaires were returned representing a 49.7% response based on the 372 questionnaires potentially considered within the SIC 103 classification. Based on Statistics Canada information, the 185 returned questionnaires would represent a 76.8% industry response. Inspection of Table 7 also shows that 89% of the plants responding process raw fruits and/or vegetables (i.e. 164 of 185 plants), while 11% of the plants are formulators only (i.e. use semi-processed fruits and vegetables in the manufacturing of products).

All processing and processing/formulating plants responding to the questionnaire were sized according to the annual quantity of raw materials received at their plant and considered to be processed. The questionnaire was set up in such a manner that raw material quantities were given in ranges of values. Therefore, median values were assigned to each range and considered representative of that particular quantity of commodity processed. Based on these median values, a total annual production figure was calculated for each plant.

Tables 8 and 9, respectively, summarize 1975 total weights of various raw fruits and vegetables processed by processors and processors/formulators responding to the questionnaires. Total quantities of fruit and vegetables processed according to the questionnaires returned are compared with the total Canadian production.

Meaningful conclusions on the processing operations in Canada can be drawn from the 164 usable processing and processing/formulating questionnaires for the following reasons:

a) These constitute 76% of the total fruits processed and 84% of the total vegetables processed (Tables 8 and 9, respectively).

b) The sample size is statistically sufficiently large (164 responses from 372 questionnaires mailed).

c) On the basis of the Statistic Canada figure of 241 establishments, the 164 returned questionnaires represent an industry response of 68%.

TABLE 7. FRUIT AND VEGETABLE PLANTS - QUESTIONNAIRE RESPONSE

PROVINCE	NUMBER OF PLANTS RESPONDING			TOTAL
	PROCESSORS	PROCESSORS/FORMULATORS	FORMULATORS	
B.C.	13	14	5	32
Alta.	2	3	1	6
Sask.*				
Man.	0	1	1	2
Ont.	31	45	8	84
Que.	21	15	6	41
N.B.	3	2	0	5
N.S.	5	6	0	11
P.E.I.	3	0	0	3
Nfld.	1	0	0	1
TOTAL	78	86	21	185
% of Total Respondents	42%	47%	11%	100%

NOTE: No questionnaires mailed to any establishments in Saskatchewan.

TABLE 8. 1975 RAW FRUITS PROCESSED (TONNES) COMPARISON OF QUESTIONNAIRE RESPONSE TO TOTAL PROCESSED

ITEM	QUANTITY AS PER * RETURNED QUESTIONNAIRES	TOTAL PROCESSED **	% PROCESSED RETURNED
Apples	138,119	171,070	81%
Pears	18,960	16,660	100% ***
Peaches	12,891	12,700	100% ***
Cherries	5,353	7,930	68%
Others	14,016	41,510	34%
TOTAL	189,339	249,870	76%

* NOTE: Weights rounded to nearest metric tonne.

** Figures as per Table 3.

*** The quantities based on questionnaires are shown as being greater than the total processed. This apparent discrepancy is due in part to the assignment of median values to the ranges given in the questionnaire and to the fact that 1975 total processed figures are estimated and could prove greater than indicated.

TABLE 9. 1975 RAW VEGETABLES PROCESSED (TONNES) COMPARISON OF QUESTIONNAIRE RESPONSE TO TOTAL PROCESSED

ITEM	QUANTITY AS PER * RETURNED QUESTIONNAIRE	TOTAL PROCESSED **	% PROCESSED RETURNED
Tomatoes	290,844	330,710	88%
Corn	172,910	236,580	73%
Peas	71,972	78,900	91%
Cucumbers	29,166	45,220	64%
Beans (Green/Wax)	35,380	37,320	95%
Beets	7,375	15,730	47%
Asparagus	4,527	5,330	85%
Others	103,102	101,790	100% ***
TOTAL	715,276	851,580	84%

* NOTE: Weights rounded to nearest metric tonne.

** Figures based on Table 3.

*** The quantities based on questionnaires are shown as being greater than the total processed. This apparent discrepancy is due in part to the assignment of median values to the ranges given in the questionnaire and to the fact that 1975 total processed figures are estimated and could prove greater than indicated.

4.2 Size Categorization

Prior to conducting any further detailed analyses of the questionnaire data, it was necessary to categorize the industry. Again, it should be noted that only those plants which processed raw fruits and/or vegetables were considered for categorization. Those plants indicating that they only formulated products were not included.

A breakdown of the number of plants responding to the questionnaire and having annual production rates falling within ranges of 2,000 metric tonnes is provided in the top half of Figure 1. The bottom half of this figure gives the total annual weight of raw fruits and vegetables processed by the plants within each specified quantity range. Questionnaire data, from which Figure 1 was produced, are summarized in Table 10.

Based on the numerical distribution of plants within the various size ranges shown in Figure 1, a size categorization using the following criteria was chosen.

Small (S) - annually processing from 0 - 2,000 tonnes raw material,

Medium (M) - annually processing from 2,000 - 10,000 tonnes raw material,

Large (L) - annually processing greater than 10,000 tonnes raw material.

Some interesting observations can be made with respect to the above sizing criteria:

1) The 80 plants responding to the questionnaire falling within the annual processing size range of 0 - 2,000 tonnes accounted for only 5.0% of the total estimated quantity of raw fruits and vegetables processed in Canada in 1975.
2) The 21 large plants responding to the questionnaire accounted for 47.2% of the total 1975 raw materials processed.
3) The sizing categorization chosen is similar to that established for the United States fruit and vegetable industry:

Small - processing less than 2,000 tons of raw materials annually,

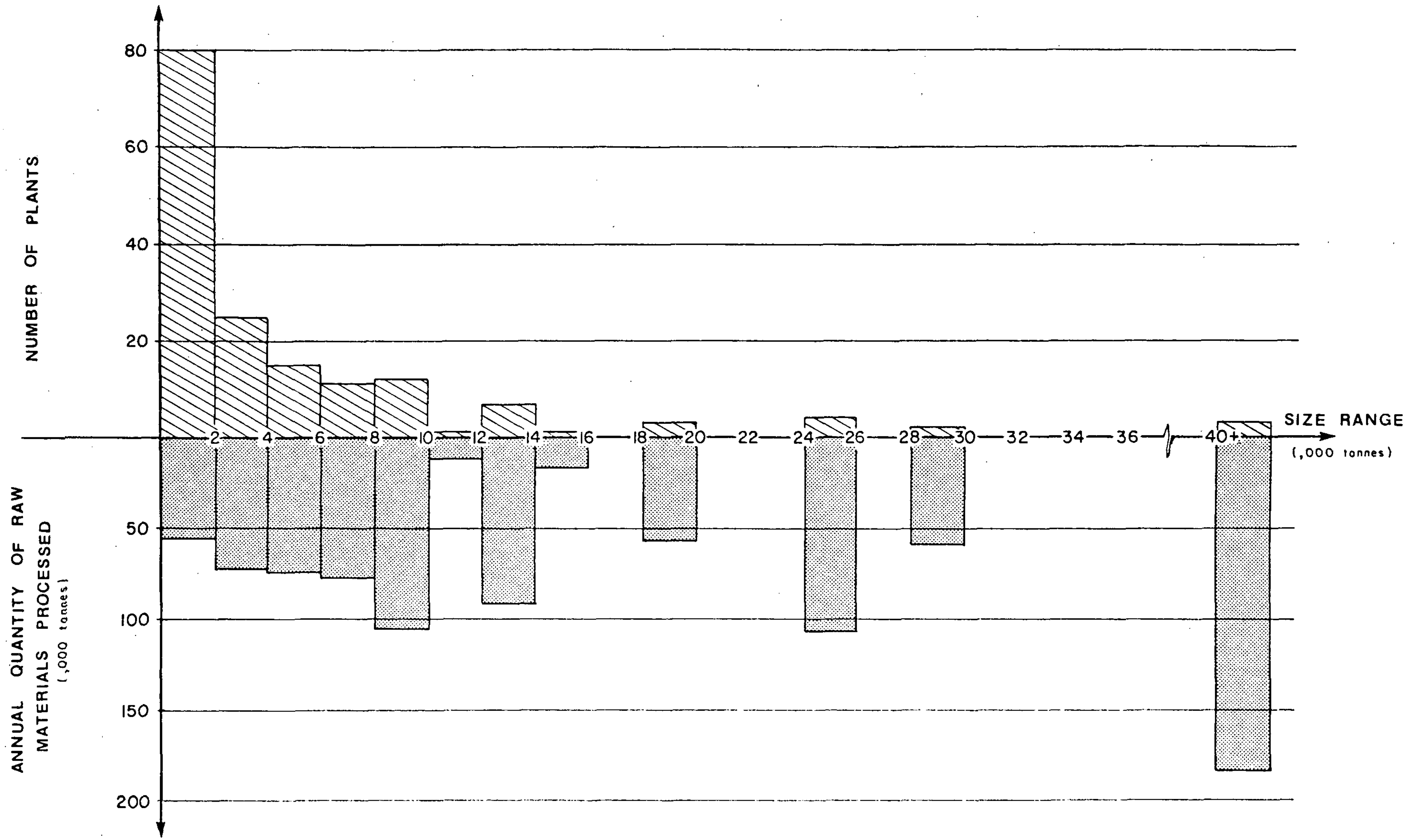

FIGURE 1. NUMBER OF PLANTS AND ASSOCIATED ANNUAL RAW PRODUCTION WITHIN SPECIFIED SIZE RANGES

TABLE 10. NUMBER OF PLANTS ACCORDING TO RAW MATERIAL PROCESSED (TONNES)

PROCESSING RANGE	NUMBER OF PLANTS RESPONDING		PROCESSED TOTAL*	AVERAGE SIZE** OF PLANT
0 to 2000	80		54,943	690
2000 to 4000	25	63	72,579	5,230
4000 to 6000	15		74,480	
6000 to 8000	11		77,383	
8000 to 10000	12		105,006	
10000 to 12000	1	21	10,705	24,770
12000 to 14000	7		93,803	
14000 to 16000	1		15,876	
16000 to 18000	0			
18000 to 20000	3		56,245	
20000 to 22000	0		--	
22000 to 24000	0		--	
24000 to 26000	4		100,788	
26000 to 28000	0			
28000 to 30000	2		58,740	
40000 plus	3		184,067	
TOTAL	164		904,615	

* Quantities of raw fruits and vegetables processed in 1975.

** Given to the nearest ten tonnes.

Medium - processing between 2,000 and 10,000 tons per year,
Large - processing more than 10,000 tons per year.

This sizing relationship between the Canadian and American industry sectors is to be expected since it is considered that operations are fairly similar in both countries. The major difference is the larger number of plants and quantity of materials processed in the United States compared to Canada. This difference is due in part to the harvesting of more than one crop per year in the United States.

Using the data given in Table 10, the following average sizes of Canadian plants were determined in terms of the annual tonnes of fruits and/or vegetables processed:

Small - 690 metric tonnes,
Medium - 5,230 metric tonnes,
Large - 24,770 metric tonnes.

These average plant sizes were used to estimate the size of the plants not returning the questionnaires, the information being required to determine plant size distribution across Canada.

The 1975 processing rates for the plants responding to the questionnaires on a provincial basis, categorized according to size (small, medium or large), are given in Table 11. It is interesting to note from this table that responding large processing plants were located in the provinces of B.C., Ontario and Quebec only. In addition, these three provinces accounted for 92% of the total returned weight of materials processed.

Using the data given in Tables 8, 9, 10, and 11, an estimate was made of the total number of plants by size in each province. This information is presented in Table 12 and is used in Section 5 to determine the total Canadian effluent loadings. In estimating the total number of Canadian plants the following assumptions were made:

1) With reference to Tables 8 and 9, it can be noted that apples, tomatoes and corn were the major specific commodities for which large processing plants may be missing. That is,

TABLE 11. TONNES OF RAW MATERIALS PROCESSED BY PROVINCE AND PLANT SIZE BASED ON QUESTIONNAIRE RESPONSE

PROVINCE	CATEGORY OF PLANT SIZE *			TOTAL	% OF TOTAL WEIGHT RETURNED
	SMALL	MEDIUM	LARGE		
B.C.	7,976	53,478	64,228	125,682	14
Alta.	1,454	12,794	-	14,248	2
Sask.	-	-	-	-	-
Man.	-	2,268	-	2,268	1
Ont.	26,281	128,413	431,502	586,196	65
Que.	11,431	79,743	24,494	115,666	13
N.B.	2,676	6,804	-	9,480	1
N.S.	3,628	35,472	-	39,100	4
P.E.I.	1,361	10,478	-	11,839	1
Nfld.	136	-	-	136	1
TOTAL	54,943	329,448	520,224	904,615	100%

SMALL - Processes from 0 - 2000 metric tonnes raw fruits and/or vegetables.

MEDIUM - Processes from 2000 to 10000 metric tonnes raw fruits and/or vegetables.

LARGE - Processes greater than 10000 metric tonnes raw fruits and/or vegetables.

TABLE 12. NUMBER OF PROCESSING AND PROCESSING/FORMULATING PLANTS BY PROVINCE AND SIZE CATEGORY

PROVINCE	NUMBER OF QUESTIONNAIRE REPLIES			ESTIMATED CANADIAN TOTAL		
	SMALL	MEDIUM	LARGE	SMALL	MEDIUM	LARGE
B.C.	15	9	3	15	9	3
Alta.	2	3	-	2	3	-
Sask.	-	-	-	1	1	-
Man.	-	1	-	2	1	-
Ont.	35	24	17	54	37	19
Que.	17	17	1	26	27	1
N.B.	4	1	-	4	1	-
N.S.	5	6	-	5	6	-
P.E.I.	1	2	-	1	2	-
Nfld.	1	-	-	1	-	-
TOTAL	80	63	21	111	87	23

the addition of large plants processing these commodities, to the questionnaire returned quantities, would not exceed the estimated total processed. It was assumed that two large processing plants had not responded to the questionnaire and, based on an analyses of the farm production of these commodities by province, these two missing plants would probably be located in Ontario.

2) Using the average size of the small and medium plants, and the ratio of small plants to medium plants responding to the questionnaires, it was calculated that 31 small sized plants and 24 medium sized plants were still outstanding. It was assumed that the majority of the outstanding small and medium plants were located in the provinces of Quebec and Ontario.

Based on Table 7, 89% of the plants responding to the questionnaire were processors and processors/formulators, and 11% formulators only. The total number of processing and processing/formulating plants is estimated at 221 (Table 12). Thus, there are approximately 248 plants related to the fruit and vegetable processing industry (Standard Industrial Classification 103). It should be pointed out that Statistics Canada gives the number of establishment in the SIC 103 classification at 241 in 1973. Assuming that no major increases or decreases in the number of establishments occurred from 1973 to 1975, it would appear that the method used to calculate the total number of plants on the basis of questionnaire data is valid.

A summary of the total quantities of raw commodities processed by province, using the estimated numbers of small, medium and large plants and the corresponding average processing size is given in Table 13. This table provides a good indication of the geographical distribution of fruit and vegetable processing across Canada.

In 1973, Statistics Canada reported that Ontario, Quebec, and B.C. accounted for 62%, 15% and 9%, respectively, of the total industry value of goods shipped. On the basis of questionnaire data, inspection of Table 13 indicates that Ontario, Quebec and B.C. process 64%, 17% and 12%, respectively, of the total raw fruits and vegetables in Canada. Since

TABLE 13. 1975 ESTIMATED TOTAL CANADIAN PROCESSING (TONNES) BY PROVINCE AND PLANT SIZE CATEGORY

PROVINCE	PLANT SIZE CATEGORY						TOTAL PROCESSED WEIGHT	% OF TOTAL WEIGHT
	SMALL		MEDIUM		LARGE			
	PLANTS	QUANTITY	PLANTS	QUANTITY	PLANTS	QUANTITY		
B.C.	15	10,350	9	47,070	3	74,310	131,730	12
Alta.	2	1,380	3	15,690	-	-	17,070	1.5
Sask.	1	690	1	5,230	-	-	5,920	0.5
Man.	2	1,380	1	5,230	-	-	6,610	0.5
Ont.	54	37,260	37	193,510	19	470,630	701,400	64
Que.	26	17,940	27	141,210	1	24,770	183,920	17
N.B.	4	2,760	1	5,230	-	-	7,990	0.5
N.S.	5	3,450	6	31,380	-	-	34,830	3
P.E.I.	1	690	2	10,460	-	-	11,150	1
Nfld.	1	690	-	-	-	-	690	nil
TOTAL	111	76,590	87	455,010	23	569,710	1,101,310	100

a close relationship between goods shipped and quantity of raw materials processed is to be expected, a comparison of these Table 13 percentages with those provided by Statistics Canada show the validity of the technique used in determining the total number of plants in each size category in Canada.

The importance of the above "size" categorization of plants within the Canadian fruit and vegetable processing industry cannot be over-emphasized. Size categorization has far-reaching implications when viewed in terms of effluent regulations or limitations that may be applied to individual categories and the cost variations for treatment for varying sizes of plants. For example, in the United States "small" plants within this industry sector were not covered by the proposed U.S. limitations because waste treatment systems were not economically feasible for these plants.

4.3 Commodity Processing

4.3.1 Raw commodities processed

A breakdown by size category of those plants responding to the questionnaires that process raw fruits, raw vegetables or both commodities is given in Table 14. Similar information is given on a provincial basis in Table 15. Inspection of Table 14 shows that 28% of the total plants replying processed only fruits, 57% processed only vegetables, and the remaining 15% processed both commodities.

The number of small plants processing only raw fruits is approximately equal to those processing only raw vegetables, amounting to 46% and 49%, respectively, of the total small plants category. Very few small plants (5%) process both commodities.

The majority of the medium sized plants process vegetables (60% of total medium sized plants responding) or both commodities (27%). The remaining 13% utilize raw fruits only.

Most large plants process only vegetables (76% of the total number of large plants responding to the questionnaires). Fruit and vegetable processing is carried out by 19% of the large plants, whereas only one large plant processed strictly raw fruits.

TABLE 14. PLANTS PROCESSING RAW FRUITS AND/OR VEGETABLES BY SIZE CATEGORY

SIZE - COMMODITY	NUMBER OF PLANTS			% WITHIN SIZE CATEGORY
Small				
- Fruit	37			46
- Vegetable		39		49
- Fruit/Vegetable			4	5
TOTAL		80		100
Medium				
- Fruit	8			13
- Vegetable		38		60
- Fruit/Vegetable			17	27
TOTAL		63		100
Large				
- Fruit	1			5
- Vegetable		16		76
- Fruit/Vegetable			4	19
TOTAL		21		100%
TOTAL				% OF TOTAL PLANTS
- Fruit	46			28
- Vegetable		93		57
- Fruit/Vegetable			25	15
TOTAL		164		100

TABLE 15. PLANTS PROCESSING RAW FRUITS AND/OR VEGETABLES BY SIZE CATEGORY AND PROVINCE

	NUMBER OF PLANTS								
	FRUITS			VEGETABLES			FRUITS/VEGETABLES		
PROVINCE	S	M	L*	S	M	L*	S	M	L*
B.C.	13	1	1	2	0	1	0	8	1
Alta.	------nil-----			2	3	0	-----nil-----		
Sask.	------nil-----			------nil-----			-----nil-----		
Man.	------nil-----			0	1	0	-----nil-----		
Ont.	10	4	0	21	16	14	4	4	3
Que.	7	2	0	10	14	1	0	1	0
N.B.	1	0	0	3	1	0	-----nil-----		
N.S.	5	1	0	0	1	0	0	4	0
P.E.I.	------nil-----			1	2	0	-----nil-----		
Nfld.	1	0	0	------nil-----			-----nil-----		
TOTAL	37	8	1	39	38	14	4	17	4
%	23	5	1	24	23	10	2	10	3

* S - small size plant

M - medium size plant

L - large size plant

A list of the major fruits and vegetables processed in Canada and the number of responding plants processing each item is given in Table 16 by size category. It should be noted that many plants process more than one commodity and are, therefore, included several times. Similar information is given for fruits (Table 17) and vegetables (Table 18), on a provincial basis.

Based on the questionnaire responses, the quantities of specific fruits and vegetables processed by small, medium, and large plants are given in Table 19 for fruits and Table 20 for vegetables. Medium sized plants process the major quantity of fruits (60%), with large plants accounting for 28% of the total returned tonnage. The reverse is the case for vegetables, with large plants processing 65% and medium sized plants 30% of the returned quantity.

4.3.2 Raw commodity mix

For those plants processing a variety of fruits and/or vegetables, Table 21 provides a typical breakdown of the types that would be processed, and the percentage each would constitute in terms of the total annual quantity of materials processed. For example, a small plant processing fruits only would typically use 41% apples, 6% pears, 11% peaches, 6% cherries and 36% other fruits in terms of its total annual tonnes processed. The information presented in this table was used in the determination of an average unit waste loading for each size category of plant processing either fruits, vegetables or both commodities.

4.3.3 Product styles

The major product styles include the following:

- canned (bottled),
- frozen,
- formulated,
- dehydrated.

Table 22 summarizes the numbers of small, medium and large sized plants replying to the questionnaire and processing raw materials into the above product styles or combinations thereof. Table 23 provides a products style summary on a provincial basis.

TABLE 16. NUMBER OF PLANTS PROCESSING VARIOUS RAW FRUITS AND VEGETABLES

COMMODITY	NUMBER OF PLANTS			TOTAL NUMBER OF PLANTS
	SMALL	MEDIUM	LARGE	
Fruits				
Apples	14	15	4	33
Pears	3	10	2	15
Peaches	6	7	2	15
Cherries	10	9	3	22
Other Fruits	26	12	3	41
Vegetables				
Tomatoes	19	19	10	48
Corn	1	15	10	26
Peas	3	24	12	39
Cucumbers	10	9	2	21
Beans (Green/Wax)	3	21	5	29
Beets	6	9	3	18
Asparagus	0	13	2	15
Other Vegetables	25	38	20	83

NOTE: Many plants process several commodities and are therefore included more than once.

Data based on Questionnaire returns.

TABLE 17. NUMBER OF PLANTS PROCESSING SPECIFIC FRUITS BY SIZE AND PROVINCE

	TYPE OF FRUIT														
	APPLES			PEARS			PEACHES			CHERRIES			OTHERS		
PROVINCE	S	M	L*	S	M	L*	S	M	L*	S	M	L*	S	M	L*
B.C.	3	4	1	2	5	1	3	3	1	2	6	2	11	7	2
Alta.	-----nil-----														
Sask.	-----nil-----														
Man.	-----nil-----														
Ont.	4	4	3	0	4	1	1	4	1	5	3	1	7	3	1
Que.	4	3	0	1	0	0	2	0	0	3	0	0	4	0	0
N.B.	-----nil-----												1	0	0
N.S.	3	4	0	0	1	0	-----nil-----						2	2	0
P.E.I.	-----nil-----														
Nfld.	-----nil-----												1	0	0
TOTAL	14	15	4	3	10	2	6	7	2	10	9	3	26	12	3

* S - small
M - medium
L - large

NOTE: Many plants process several commodities and are therefore included more than once.

TABLE 18. NUMBER OF PLANTS PROCESSING SPECIFIC VEGETABLES BY SIZE AND PROVINCE

	TYPE OF VEGETABLE																							
	TOMATOES			CORN			PEAS			CUCUMBERS			BEANS (GREEN/WAX)			BEETS			ASPARAGUS			OTHERS		
PROVINCE	S	M	L*	S	M	L*	S	M	L*	S	M	L*	S	M	L*	S	M	L*	S	M	L*	S	M	L*
B.C.	0	2	0	0	3	2	0	4	2	0	1	0	0	4	2	--nil---			0	7	1	2	6	3
Alta.	--nil---			0	2	0	1	3	0	1	0	0	0	1	0	0	1	0	--nil---			3	1	0
Sask.	---nil---																							
Man.	---nil---																					0	1	0
Que.	3	3	0	1	5	1	0	8	1	4	4	0	2	8	1	3	4	0	0	3	0	5	7	0
N.B.	1	0	0	--nil---			0	1	0	1	0	0	0	1	0	1	0	0	--nil---			3	1	0
N.S.	0	1	0	--nil---			0	1	0	0	1	0	0	3	0	0	1	0	--nil---			0	5	0
P.E.I.	--nil---			--nil---			1	1	0	--nil---			--nil---			0	1	0	--nil---			0	3	0
Nfld.	---nil---																							
TOTAL	19	19	10	1	15	10	3	24	12	10	9	2	3	21	5	6	9	3	0	13	2	25	38	20

S - small

M - medium

L - large

NOTE: Many plants process several commodities and are therefore included more than once

TABLE 19. RAW FRUITS PROCESSED BY PLANT SIZE (TONNES)

FRUIT	QUANTITY PROCESSED BY PLANT SIZE			% PROCESS BY PLANT SIZE		
	SMALL	MEDIUM	LARGE	SMALL	MEDIUM	LARGE
Apples	8,664	82,735	46,720	6	60	34
Pears	1,361	15,513	2,086	7	82	11
Peaches	2,722	9,262	907	21	72	7
Cherries	1,452	1,950	1,951	27	36	37
Others	8,020	4,726	1,270	57	34	9
TOTAL	22,219	114,186	52,934	12	60	28

TABLE 20. RAW VEGETABLES PROCESSED BY PLANT SIZE (TONNES)

VEGETABLE	QUANTITY PROCESSED BY PLANT SIZE			% PROCESS BY PLANT SIZE		
	SMALL	MEDIUM	LARGE	SMALL	MEDIUM	LARGE
Tomatoes	17,420	36,197	237,227	6	12	82
Corn	363	44,634	127,913	nil	26	74
Peas	2,268	34,777	34,927	3	48	49
Cucumbers	3,084	22,181	3,901	11	76	13
Beans (Green/Wax)	1,361	26,308	7,711	4	74	22
Beets	453	5,062	1,860	6	69	25
Asparagus	-	3,710	817	-	82	18
Others	7,775	42,393	52,934	8	41	51
TOTAL	32,724	215,262	467,290	5	30	65

TABLE 21. RAW COMMODITIES PRODUCT MIX

FRUIT OR VEGETABLE	PERCENTAGE PRODUCT MIX: SMALL PLANTS			MEDIUM PLANTS			LARGE PLANTS		
	FRUIT	VEGETABLE	FRUIT/ VEGETABLE	FRUIT	VEGETABLE	FRUIT/ VEGETABLE	FRUIT	VEGETABLE	FRUIT/ VEGETABLE
Apples	41		nil	77		36	89		8
Pears	6		nil	12		8	4		nil
Peaches	11		12	10		3	1		nil
Cherries	6		6	1		1	3		nil
Other Fruit	36		6	nil		5	3		nil
Tomatoes		49	73		19	3		39	76
Corn		1	nil		20	11		36	4
Peas		8	nil		15	9		9	4
Cucumbers		10	nil		13	nil		nil	3
Beans (Green/ Wax)		5	nil		10	10		2	nil
Beets		1	1		3	nil		nil	nil
Asparagus		nil	nil		1	3		nil	nil
Other Vegetables		26	2		19	11		14	5
TOTAL	100	100	100	100	100	100	100	100	100

TABLE 22. PRODUCT STYLES BY PLANT SIZE CATEGORY

PRODUCT STYLE	NUMBER OF PLANTS SMALL	MEDIUM	LARGE	TOTAL	% TOTAL
Canned (C)	20	25	3	48	30
Frozen (Fro)	8	4	1	13	8
Formulated (For)	19	3	3	25	16
Dehydrated (Deh)	1	-	-	1	1
Canned/Frozen (C/Fro)	2	3	2	7	4
Canned/Formulated (C/For)	23	21	6	50	32
Canned/Frozen/ Formulated (C/F/F)	1	4	4	9	2
Frozen/Formulated (F/F)	2	-	1	3	2
Frozen/Dehydrated (Fro/Deh)	1	1	-	2	1
TOTALS	77	61	20	158	100%

TABLE 23. PRODUCT STYLES BY PROVINCE

PROVINCE	C	FRO	FOR	DEH	C/FRO	C/FOR	C/F/F	F/F	FRO/DEH	TOTAL
	PRODUCT STYLES* (number of plants)									
B.C.	4	6	5	-	1	6	2	1	-	25
Alta.	1	1	1	-	1	1	-	-	-	5
Sask.	-	-	-	-	-	-	-	-	-	0
Man.	-	-	1	-	-	-	-	-	-	1
Ont.	22	4	11	1	3	28	5	1	-	75
Que.	16	-	2	-	2	10	1	1	-	32
N.B.	-	1	2	-	-	-	-	-	2	5
N.S.	2	-	3	-	-	5	1	-	-	11
P.E.I.	3	-	-	-	-	-	-	-	-	3
Nfld.	-	1	-	-	-	-	-	-	-	1
TOTAL	48	13	25	1	7	50	9	3	2	158

*See Table 22 for definitions of product style symbols.

With reference to Table 22, it should be noted that 55% of the plants responding processed only one of the product styles mentioned above, remaining plants being involved in producing a variety of the styles. Canning, formulating and the combination of both product styles were carried out by 78% of the responding plants. The combination of canning and freezing operations is not a common process mix, being carried out by only 4% of the plants. It is interesting to note that, on the whole, small, medium and large plants are all involved in producing the various product styles.

A list of the major formulated products being produced in Canada is given in Table 24. In addition, data are provided on the numbers of processing/formulation plants according to size category that are involved in formulating these various items. Since a number of plants are involved in formulating more than one of the products listed in Table 24, these plants are included several times. It should be noted that all size categories of plants are involved in producing the major formulated products.

The supply of raw materials for this industry is essentially secured during a few months of the year; thus, many Canadian fruit and vegetable processing plants are seasonal operations, processing and processing/formulating only when raw commodities are available and closing down during nonharvesting periods. Seasonal and all-year operations are listed in Table 25 by province, size category and processor, and processor/formulator designation, for those plants responding to the questionnaire. Some 54% were seasonal operations and 46% year round operations. Seasonal processing plants accounted for 37% of the total response and seasonal processing/formulating plants for 17%.

An anomaly appeared to exist with the 11% of the plants which stated that they were processors only, yet indicated their operations were carried out year round. Referral to the individual questionnaires returned by these plants revealed that the majority of them processed raw materials to frozen products. The indicated continuous yearly operations of these particular plants was accounted for by the fact that product repackaging was being carried out during the nonharvesting periods. In the remaining cases, the plants either processed raw material which could

TABLE 24. FORMULATED PRODUCTS BY PLANT SIZE

FORMULATED PRODUCT	NUMBER OF PLANTS SMALL	MEDIUM	LARGE	TOTAL
Soups	4	4	3	11
Jams, Jellies, Marmalades	8	3	1	12
Stews	5	10	6	21
Pickles	6	8	2	16
Baby Food	1	1	1	3
Juices	6	10	7	23
Ciders, Vinegars	5	2	1	8
Other Products	23	10	7	40

NOTE: Some processing/formulating plants are involved in the formulation of several products and are therefore included more than once.

TABLE 25. SEASONAL AND ALL YEAR OPERATIONAL PLANTS BY SIZE, CATEGORY, TYPE AND PROVINCE

	PROCESSORS						PROCESSORS/FORMULATORS						
	SEASONAL			ALL-YEAR			SEASONAL			ALL-YEAR			
PROVINCE	S	M	L	S	M	L	S	M	L	S	M	L	TOTAL
	(number of plants)												
B.C.	4	4	0	1	3	1	2	0	1	8	2	1	27
Alta.	0	1	0	0	1	0	1	0	0	1	1	0	5
Sask.	---------nil---------						---------nil---------						0
Man.	---------nil---------						--nil--			0	1	0	1
Ont.	15	7	3	2	1	2	5	8	5	11	7	7	73*
Que.	4	11	1	3	1	0	3	1	0	7	4	0	35
N.B.	1	0	0	1	1	0	--nil--			2	0	0	5
N.S.	3	1	0	1	0	0	0	1	0	1	4	0	11
P.E.I.	1	2	0	--nil--			---------nil---------						3
Nfld.	1	0	0	--nil--			---------nil---------						0
TOTAL	29	26	4	8	7	3	11	10	6	30	19	8	161
% TOTAL		37%			11%			17%			35%		100%

*Two small processing/formulating plants and one medium sized processing plant did not respond to this particular question.

be stored for extended periods of time with little damaging deterioration, or processed raw materials probably obtained from greenhouse operations (e.g. bean sprouts, mushrooms).

4.4 Water Supply and Use

The numbers of plants obtaining water from private wells, municipal systems and surface waters (river, lake or estuary) are given in Table 26 according to plant size and in Table 27 according to province. Inspection of these tables shows the majority of the plants in each size category obtain their supply of water from municipal systems solely, or in conjunction with private wells or surface water sources. Very few plants (7% of the total number responding to this particular question) rely entirely on surface water as a supply source. In contrast, private wells are used by 25% of the small plants, 20% of the medium and 19% of the large sized plants.

A total of 142 plants (20 large, 57 medium and 65 small) provided data on their total annual water use. Analysis of these data indicated that water use varied to an extreme degree. In the case of large plants, the consumption figures varied from 0.16 to 404 cubic metres per tonne of raw commodity processed (m^3/t). Unit water consumption for medium sized plants ranged from 0.07 to 430 m^3/t. Small plants exhibited a range in water use (0.01 to 494 m^3/t) similar to both the medium and large sized plants.

This large variation in water use exhibited by the fruit and vegetable processing industry is due in part to the complexity of the plants in terms of the number of commodities processed, the commodity itself, and the product styles and formulated products being produced. Other important factors which affect the water use within a plant include water used in product make-up, recycling and reuse techniques, commodity handling (i.e. fluming vs. dry conveying), cleanup, etc.

Sufficient data were not available from the questionnaires to carry out a detailed analysis on water use. However, based on the water use figures provided by the industry, the log-probability relationships were developed and are presented in Figure 2 for the total annual process water use for the three size categories of plants. A number of observations can be noted from inspection of this figure:

TABLE 26. WATER SUPPLY BY PLANT SIZE

	NUMBER OF PLANTS USING					% OF PLANTS USING				
SIZE	WELL	MUNICIPAL	RIVER LAKE	WELL & MUNICIPAL	MUNICIPAL & RIVER, LAKE	WELL	MUNICIPAL	RIVER LAKE	WELL & MUNICIPAL	MUNICIPAL RIVER, LAKE
Small	19	45	3	6	2	25	60	4	8	3
Medium	12	39	6	2	1	20	65	10	3	2
Large	4	10	2	3	2	19	47	10	14	10
TOTAL	35	94	11	11	5	23	60	7	7	3

TABLE 27. WATER SUPPLY SOURCE BY PROVINCE

	NUMBER OF PLANTS USING				
PROVINCE	WELL	MUNICIPAL	RIVER LAKE	WELL & MUNICIPAL	MUNICIPAL & RIVER, LAKE
B.C.	5	20	1	-	-
Alta.	1	4	-	-	-
Sask.	-	-	-	-	-
Man.	-	1	-	-	-
Ont.	15	41	7	8	4
Que.	7	21	1	3	-
N.B.	2	1	1	-	-
N.S.	4	5	1	-	1
P.E.I.	1	1	-	-	-
Nfld.	-	-	-	-	-
TOTAL	35	94	11	11	5
%	23	60	7	7	3

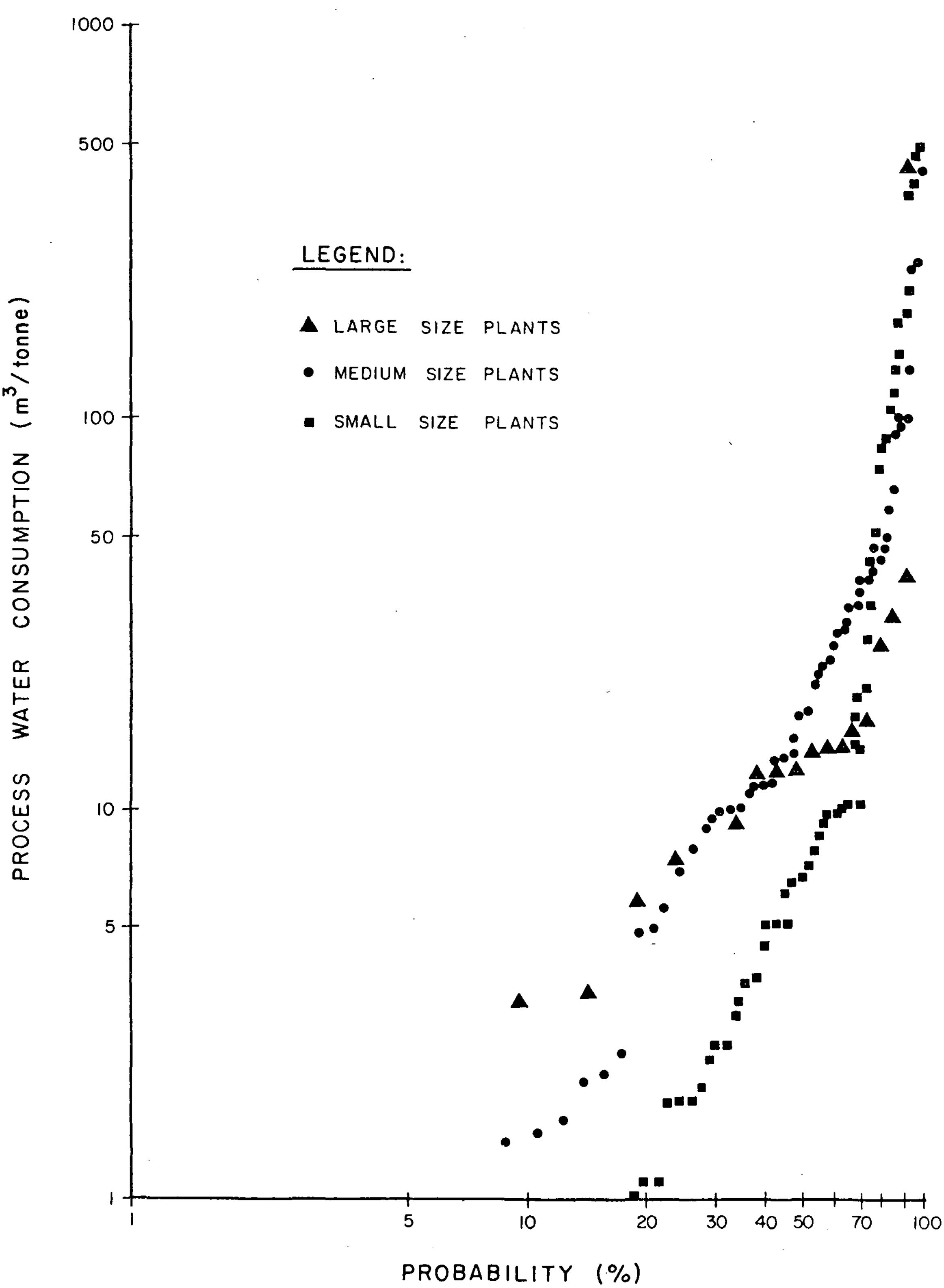

FIGURE 2. DISTRIBUTION ANALYSIS FOR WATER USE

1) With respect to large plants, 50% of the plants use approximately 14 m^3/t or less of process water and 80% of the plants use 30 m^3/t or less.
2) Fifty percent of the medium sized plants use approximately 20 m^3/t or less, while 80% of these plants consume approximately 50 m^3/t or less.
3) In the case of small plants, 50% use 7 m^3/t or less and 80% of the plants use 50 m^3/t or less.

It is interesting to note that the 50% occurrence values from small plants (7 m^3/t or less) is substantially lower than the 20 m^3/t and 14 m^3/t, respectively, for medium and large plants. This lower value is to be expected since it can be assumed that the smaller operations would most probably incorporate more dry handling of the commodities than the larger sized plants. For example, dry conveying of commodities from process step to process step would likely be used instead of water fluming.

In the case of those plants indicating unit water consumption of more than 50 m^3/t, it would be necessary to evaluate each plant individually in order to identify the reasons for the high consumption. For example, "once through" cooling systems, non-recycling of wastewaters and the absence of counter-flow fluming systems could substantially increase plant water consumption.

4.5 Waste Loadings

Data pertaining to raw wastewater quality and final effluent characteristics were requested in the questionnaire. Fourteen large establishments, and 24 medium and 13 small plants provided some data in this area; however, the majority of the information given was insufficient in terms of detail and quantity to supplement that contained in the review report (EPS 3-WP-77-5). Therefore, no detailed analysis of these questionnaire data was carried out for purposes of this report.

4.6 Effluent Treatment

4.6.1 In-plant treatment

In-plant waste control and treatment applies to those methods and technologies which can be applied within the plant to reduce both the volume and the strength of the plant's wastewater streams. The techniques incorporated can be in the form of in-plant process modification such as changing from wet peeling to dry caustic peeling and steam blanching to individual quick blanch (IQB) process. In-plant treatment would apply to such areas as screening of specific wastewater streams, such as wash waters and flume waters, and their possible recycle within the same process or reuse in a process where lower quality water can be used. Within the questionnaire, information on in-plant treament related to grit removal, oil and grease removal, and screening was requested.

The number of plants utilizing in-plant grit removal, oil and grease removal, and screening facilities are given in Table 28 according to plant size. In general, oil and grease was not a problem in fruit and vegetable effluent and this is reflected by the fact that only 8% of the responding plants utilized some type of oil and grease removal facilities. The type of raw commodity being produced and its method of harvest governs the amount of grit that will be present in the initial washing and rinsing wastewater. As in the case of oil and grease removal, a minority of plants (19%) has specific facilities for grit removal. It should be noted that no large plants provided grit or oil and grease removal systems.

However, the majority of the large plants (95%) provided in-plant screening facilities, whereas 59% of the medium sized plants screened in-plant wastewater. Only 38% of the small plants screened the in-plant effluent.

4.6.2 Wastewater treatment and effluent disposal

The numbers of plants having solid-liquid separation processes, such as clarification or settling tanks, prior to secondary treatment are indicated in Table 29 according to plant size. Inspection of this table shows that very few plants appear to incorporate this facility. However, it should be noted that solid-liquid separation systems are normally considered as part of a biological treatment system. It is possible that a number of plants utilize solid-liquid separation but do not distinguish it as a separate process from biological treatment.

Table 30 shows discharge locations of untreated plant effluent, based on questionnaire data. The numbers of small, medium and large sized

TABLE 28. IN-PLANT TREATMENT FACILITIES BY PLANT SIZE

PLANT SIZE	GRIT REMOVAL: PLANTS HAVING REMOVAL	GRIT REMOVAL: PLANTS HAVING NO REMOVAL	GRIT REMOVAL: % REMOVAL	OIL AND GREASE: PLANTS HAVING REMOVAL	OIL AND GREASE: PLANTS HAVING NO REMOVAL	OIL AND GREASE: % REMOVAL	SCREENING: PLANTS HAVING SCREENING	SCREENING: PLANTS HAVING NO SCREENING	SCREENING: % SCREENING
Small	15	65	19	5	75	6	30	50	38
Medium	16	47	25	8	55	13	37	26	59
Large	0	21	0	0	21	0	20	1	95
TOTAL	31	133	19	13	151	8	87	77	53

TABLE 29. PLANTS UTILIZING SOLID-LIQUID SEPARATION PROCESSES

PROVINCE	PLANTS HAVING SOLIDS - SEPARATION SMALL	MEDIUM	LARGE	PLANTS HAVING NO FACILITIES
B.C.	6	3		18
Alta.	1			4
Sask.	-	-	-	-
Man.	-	-	-	1
Ont.	9	3	4	60
Que.	2	2	-	31
N.B.	2	1	-	2
N.S.	-	2	-	9
P.E.I.	-	-	-	3
Nfld.	-	-	-	1
TOTAL	20	11	4	129
%	12	8	2	78

TABLE 30. DISCHARGE LOCATIONS FOR RAW PLANT EFFLUENT

PLANT SIZE	BIOLOGICAL TREATMENT SYSTEMS: HOLDING LAGOONS	AERATED LAGOONS	ACTIVATED SLUDGE	TRICKLING FILTERS	OTHERS[1]	MUNICIPAL SYSTEMS: PRIMARY	SECONDARY	NO TREATMENT	DIRECT TO LAND	DIRECT TO SURFACE WATER	TOTAL
					NUMBER OF PLANTS						
Small	9	3	1	1	8	7	22	15	11	6	83
Medium	9	4	-	-	-	2	20	13	5[2]	5	58
Large	1	6	3	1	-	1	7	-	5	-	24
					(PERCENTAGE OF PLANTS)						
Small	11	4	1	1	10	8	27	18	13	7	100
Medium	16	7	-	-	-	3	34	22	9	9	100
Large	4	25	13	4	-	4	29	-	21	-	100

(1) 7 Septic Tanks and 1 Marble Sump

(2) One municipal treatment plant utilizes spray irrigation of effluent.

plants directing their wastewaters to these points are also shown in this table. A number of important conclusions can be reached from inspection of this table:

1) The majority of small and medium sized plants (73% and 77%, respectively) use no form of biological treatment. However, in the case of small plants, 8% direct the untreated effluent to municipal systems having primary treatment, 27% to municipal systems incorporating secondary treatment and 13% discharge raw wastewater directly to land. Similarly 3%, 34% and 9% of the medium sized plants, respectively, discharge untreated effluent to primary municipal systems, secondary municipal systems and directly to land.

2) Direct discharge of untreated effluent to a surface water body is practiced by six small plants and five medium sized plants or by 7% and 9%, respectively, of the plants within these two categories.

3) Indirectly, an additional 18% of the small plants and 22% of the medium plants discharge untreated effluent via municipal systems which do not have any treatment facilities.

4) Approximately half (46%) of the large plants have biological treatment facilities. The remainder discharge untreated effluent either to municipal systems with some form of treatment, or directly to land.

5) Holding and aerated lagoons constitute the majority of the biological treatment methods used by the industry.

6) Only two plants used trickling filters, and activated sludge systems were operated by four plants.

7) Only small plants utilized septic tank and tile field systems for treatment and disposal of their wastewater.

8) Effluent originating from large fruit and vegetable processing plants is treated to some degree either by the plants or municipalities, or is discharged directly to the land.

For those plants discharging untreated effluent directly to the land, an important implication is whether or not the operation is based on detailed design criteria, or is uncontrolled disposal. Uncontrolled disposal could result in problems such as soils clogging, groundwater contamination, contaminated surface water runoff, etc. All these factors lead to the question of whether or not a specific land application system provided sufficient treatment and was a viable alternative disposal method.

Table 31 summarizes the final discharge locations of the resultant treated wastewater for those plants using biological treatment. Some of the treated effluent undergoes further treatment in municipally operated systems; however, the majority is disposed to the land or to a surface water body.

Table 32 summarizes biological treatment methods and disposal locations previously given in Tables 30 and 31 on a plant size basis by province. It should be noted that the information on total figures for biological treatment methods given in Table 32 is the same as that given in Table 30. The data on discharge to municipal systems, land, and surface waters in Table 32 are the sums of the similar data given in Tables 30 and 31. For example, Table 32 indicates that 17 small plants discharge wastewaters to land. This number comprises 11 small plants which discharge raw plant effluent directly onto the land (Table 30) and six small plants that treated their wastewater prior to land application (Table 31).

TABLE 31. FINAL DISPOSAL LOCATIONS FOR THOSE PLANTS WITH BIOLOGICAL TREATMENT

PLANT SIZE	DISPOSING TO: MUNICIPAL SYSTEMS	DISPOSING TO: LAND	DISPOSING TO: SURFACE WATERS	TOTAL
	(NUMBER OF PLANTS)			
Small	2 (1 Primary) (1 Secondary)	6	2	10
Medium	1 (Secondary)	4	5	10
Large	2 (Secondary)	2	4	8
	(PERCENTAGE OF PLANTS)			
Small	20	60	20	100
Medium	10	40	50	100
Large	25	25	50	100

TABLE 32. BIOLOGICAL TREATMENT FACILITIES AND EFFLUENT DISCHARGE LOCATION BY PLANT SIZE AN PROVINCE

PROVINCE	BIOLOGICAL TREATMENT SYSTEMS					MUNICIPAL SYSTEMS				
PLANT SIZE	HOLDING LAGOONS	AERATED LAGOONS	ACTIVATED SLUDGE	TRICKLING FILTERS	OTHERS*	PRIMARY	SECONDARY	NO TREATMENT	LAND	SURFACE WATER
					NUMBER OF PLANTS					
B.C.										
Small		1	1		4(1)	5	3	-	3	1
Medium(2)	1	1					2	2	2	2
Large						1	2			
Alta.										
Small							2			
Medium							2	1(3)		
Man.										
Medium							1			
Ont.										
Small(4)	9	2			2	1	14	1	13	2
Medium	6	2				2	13		2	4
Large(5)	1	6	3	1			7		6	4

TABLE 32. (CONT'D)

PROVINCE	BIOLOGICAL TREATMENT SYSTEMS					MUNICIPAL SYSTEMS				
PLANT SIZE	HOLDING LAGOONS	AERATED LAGOONS	ACTIVATED SLUDGE	TRICKLING FILTERS	OTHERS*	PRIMARY	SECONDARY	NO TREATMENT	LAND	SURFACE WATER
					NUMBER OF PLANTS					
Que.										
Small					2	1	1	10	1	2
Medium								9	2	2
Large									1	
N.B.										
Small				1			3			1
Medium										1
N.S.										
Small						1				
Medium	1	1							1	1
Nfld.										
Small										1
TOTAL										
Small	9	3	1	1	8	8	23	15	17	8
Medium	9	4	-	-	-	2	21	13	9	10
Large	1	6	3	1	-	1	9	-	7	4

(1) 3 Septic Tanks/Tile Fields and 1 Marble Sump
(2) One plant utilizing both an aerated lagoon and holding lagoon
(3) One municipal treatment plant uses spray irrigation of effluent
(4) Two plants use both an aeration lagoon and holding lagoon
(5) One large plant has both an aeration lagoon and holding lagoon
One large plant incorporates an aeration lagoons activated sludge system and trickling filter

5. TOTAL CANADIAN EXPERIENCE

5.1 Total Number of Plants

The total number of plants in Canada processing raw fruits and vegetables has been previously estimated, with the pertinent information being given in Table 13. It must be emphasized that these are estimated figures and their determination assumes the sample set represented by the returned questionnaires is statistically representative of the entire Canadian industry. The total breakdown of Canadian plants, as given in Table 13, is as follows:

- 111 small plants,
- 87 medium sized plants,
- 23 large plants.

Based on the information provided in Table 14, the number of plants, by size, that process either fruits, vegetables, or both commodities is given in Table 33. The total weight of raw fruits and vegetables processed by the plants in Table 33 are summarized in Table 34. The quantities presented in this table were calculated by multiplying the total number of plants in each size category by the following estimated average size:

SMALL - processing 690 metric tonnes annually,
MEDIUM - processing 5230 metric tonnes annually,
LARGE - processing 24,770 metric tonnes annually.

The following conclusions can be drawn from a comparison of Table 33 with Table 34:

i) 11% of the plants are large but account for 51% of the total fruits and vegetables processed.

ii) 39% of the plants are medium sized and account for 42% of the commodities processed.

iii) 50% of the plants are small but account for only 7% of the total processed.

5.2 Industry Operations

For the purpose of this inventory and as previously indicated in the introduction to this report, the prime source of background informa-

TABLE 33. TOTAL CANADIAN EXPERIENCE - PLANTS PROCESSING FRUITS AND/OR VEGETABLES

PLANT SIZE	FRUITS	VEGETABLES	FRUITS/VEGETABLES	TOTAL	PARAMETER
Small	51	54	6	111	
Medium	11	52	24	87	Number of
Large	1	17	5	23	Plants
Total	63	123	35	221	
Small	23	24	3	50	
Medium	5	23	11	39	% of
Large	1	8	2	11	Total Plants
Total	29	55	16	100	

TABLE 34. TOTAL CANADIAN EXPERIENCE - QUANTITY OF FRUITS AND VEGETABLES PROCESSED

PLANT SIZE	FRUITS	VEGETABLES	FRUITS/VEGETABLES	TOTAL	PARAMETER
Small	35190	37260	4140	76590	Quantity
Medium	57530	271960	125520	455010	Processed
Large	24770	421090	123850	569710	(metric
Total	117490	730310	253510	1101310	tonnes)
Small	3	4	0.4	7	
Medium	5	25	12	42	% of Total
Large	2	38	11	51	Quantity
Total	10	67	23	100	Processed

tion on industry processing technology and waste treatment technology was the "Review of Treatment Technology in the Fruit and Vegetable Processing Industry in Canada" (EPS 3-WP-77-5). This review was also the prime source for unit waste loadings associated with the processing of specific commodities.

5.2.1 Processing technology

General process descriptions, and descriptions of processes specific for the major commodities produced in the fruit and vegetable processing industry in Canada, were discussed in the above mentioned report. It is not considered necessary to discuss a particular process used in processing the various commodities since these are given in detail in that report.

A list of the specific commodities relevant to this report, based on questionnaire data assessment and as discussed in Section 4, is given below:

Apples and apple sauce,
Peaches, pears and apricots,
Cherries and plums,
Berries,
Corn,
Peas and beans (blanched vegetables),
Beets and carrots,
Tomatoes,
Sauerkraut,
Pickles and relishes,
Jams and jellies.

This list reflects the major fruits and vegetables processed in Canada based on the review of Canadian statistics given in Section 3. However, this list does not represent the total processing industry in Canada nor does it include all specific commodities discussed in recent publications issued by the United States Environmental Protection Agency.

5.2.2 Unit waste loadings

The review report considered wastewater data for the list of commodities given above. Based on information taken from a number of sources, raw waste summary data were developed. An example of the type of information available in the review for most commodities is given in Table 35.

Data similar to those presented in Table 35 were used as a basis for developing average unit BOD_5 and suspended solids (SS) loadings for a number of commodities. These loadings are given in Table 36. It should be noted that only average values are given in Table 36; thus, the log mean values given in the review report are those presented in Table 36. For example, the BOD_5 unit waste loading for peaches is 15.5 kg/t, which corresponds to the value for the log mean given in Table 35. Similar considerations apply to the suspended solids values.

The unit waste loadings given in Table 36 are used later in this section to develop total potential BOD_5 and SS loadings. Where "other fruits" and "other vegetables" were designated in the questionnaire responses, the average BOD_5 and SS values given in Table 36 for other fruits and vegetables were used.

Detailed consideration of pH values has not been given in this report. The pH can be significant in terms of treatability of plant wastewater. Acidic pH conditions (pH of 5 or less) may be produced during the processing of some commodities. For example, the steam peeling of carrots can result in a wastewater having low pH or acidic characteristics. Caustic peeling techniques can produce alkaline wastewater having pH values of 9 or greater. In general, pH should be maintained within the range of 6 to 9.

5.3 Total Potential BOD_5 Loadings

In order to estimate the total potential BOD_5 and SS loadings from all Canadian fruit and vegetable processing operations, it was first necessary to derive an estimate of the average BOD_5 and SS loadings for each size category of plants. Using the BOD_5 and SS loadings developed in Table 36, the raw commodities product mix given in Table 21, and the average plant sizes, estimates of the average BOD_5

TABLE 35. WASTE SUMMARY DATA - PEACHES

PARAMETER NO. OF PLANTS	LOG MEAN	RAW WASTE MIN	MAX
Production			
(t/day)	215	54.8	841
Flow Volume			
(m^3/day)	2580	432	15400
Flow Rate			
(m^3/hr)	140	28.8	684
Flow Ratio			
(m^3/t)	12.5	6.19	25.2
BOD_5			
(mg/l)	1200	745	1940
(kg/t)	15.5	9.45	25.3
SS			
(mg/l)	410	163	1030
(kg/t)	4.3	2.2	8.4

TABLE 36. AVERAGE UNIT BOD_5 AND SS LOADINGS

COMMODITY	BOD_5*	SS*
Fruits		
Apples	10.0	0.8
Pears	26.2	5.4
Peaches	15.5	4.3
Cherries	13.6	0.9
Other Fruits		
Apricots	15.2	1.9
Plums	4.4	0.3
Cranberries	14.8	1.3
Blueberries	5.4	1.4
Strawberries	7.9	2.5
Average	9.5	1.5
Vegetables		
Tomatoes	4.7	6.2
Corn	12.8	4.2
Peas	19.2	5.4
Cucumbers	21.6	3.0
Beans (Green/Wax)	3.2	2.6
Beets	28.1	9.6
Asparagus	2.3	3.8
Other Vegetables		
Carrots	14.5	7.8
Lima Beans	13.5	7.8
Pumpkin	14.7	6.6
Sauerkraut	14.5	4.8
Onions	20.7	11.1
Spinach	6.9	3.5
Blanched Vegetables	16.4	4.5
Average	14.5	6.6

* Units - kilogram per metric tonne (kg/t)

loadings and SS loadings for small, medium and large plants were calculated for those plants processing fruits, vegetables, and fruits and vegetables. This information is presented in Table 37. It was assumed that the unit loadings in this analysis were independent of plant size (i.e. a small plant has the same BOD_5 and SS loadings per tonne for each fruit and vegetable commodity processed as a large plant). This is not necessarily true because large plants tend to have more diverse operations than small plants.

The total potential BOD_5 and SS loadings from processing operations in Canada were calculated using the total quantities of fruits and vegetables processed by the various types of plants given in Table 34 and the average BOD_5 and SS loadings given in Table 37. These data are summarized in Table 38.

It should be noted that the values given in Table 38 understate the total waste loadings from the Canadian fruit and vegetable industry because they ignore the loadings from formulating operations. Waste loading data related to this specific area cannot be estimated accurately from questionnaire data. In addition, very little information on waste loadings relating to formulating operations exists in literature. However, it is considered that the previous assumption that BOD_5 and SS loadings were independent of size would tend to offset the elimination of formulating operations from the values.

Inspection of Table 38 shows that medium and large vegetable processing plants contribute the major potential BOD_5 loadings, 65% of the Canadian total. Fruit processing establishments account for 11% of the total potential BOD_5 loading; the remaining loading being contributed by small vegetable plants and those firms processing both commodities.

In the case of SS loadings, medium and large vegetable processing establishments contribute 71% of the Canadian total. Fruit and vegetable processing plants account for 21% of the total potential SS loading and fruit processing plants and small vegetable processors account for the remaining 8% of the load.

TABLE 37. ESTIMATED BOD_5 LOADINGS

PLANT SIZE	FRUIT	VEGETABLE	FRUIT/VEGETABLE
	BOD_5 LOADINGS (kg/tonne)		
Small	11.6	10.3	7.3 *
Medium	12.5	12.9	12.0
Large	10.8	10.3	7.0 *
	S.S. LOADINGS (kg/tonne)		
Small	1.7	5.8	5.4
Medium	1.7	5.1	3.1
Large	1.0	5.4	5.6

* The BOD_5 loadings for small and large fruit/vegetable processing plants are low because the commodity mix (Table 21) indicates that tomatoes comprise the bulk of the processing, and the average unit BOD_5 loading for tomatoes is comparatively lower at 4.7 kg/t (Table 36).

TABLE 38. TOTAL CANADIAN EXPERIENCE - POTENTIAL BOD_5 AND SS LOADINGS

PLANT SIZE	FRUITS	VEGETABLES	FRUITS/VEGETABLES	TOTAL	PARAMETER
Small	408	384	30	822	Potential
Medium	719	3508	1506	5733	BOD_5
Large	268	4337	867	5472	($x10^3$kg)
Total	1395	8229	2403	12027	
Small	3	3	1	7	
Medium	6	29	13	48	% of Total
Large	2	36	7	45	Potential
Total	11	68	21	100	BOD_5
Small	60	216	22	298	Potential
Medium	98	1387	389	1874	SS
Large	25	2274	694	2993	($x10^3$kg)
Total	183	3877	1105	5165	
Small	1	4	1	6	
Medium	2	27	7	36	% of Total
Large	1	44	13	58	Potential
Total	4	75	21	100	SS

NOTE: Figures rounded to the nearest unit

5.4 Treatment Efficiencies of Processes Used in the Fruit and Vegetable Industry

A number of different effluent treatment processes used in the industry are now discussed with respect to efficiency of BOD_5 and SS removal, and within the framework of the three plant size categories. Values for removal efficiency are taken from "Review of the Fruit and Vegetable Processing Industry in Canada" (EPS 3-WP-77-5).

The development of treatment efficiencies is necessary in order to determine estimates of actual BOD_5 and SS loadings based on treatment and disposal techniques used in Canada, as represented by the questionnaire data (Section 4).

5.4.1 Screening

The amount of BOD_5 and SS removed by screening fruit and vegetable wastes is very variable, depending upon the type of screens utilized, the size of opening in the screens, and the commodity processed. A variation of 2 to 79% removal of suspended solids was quoted in the review report. BOD_5 removal is approximately proportional to the settleable, floating and suspended solids removal achieved. Assuming that a 20-40 mesh screen (0.13 to 0.06 cm centre to centre spacing) is utilized, a BOD_5 removal efficiency of 10% and a SS removal efficiency of 20% is estimated for effluent screening.

The efficiency of the screening process will not be dependent on plant size because the operational requirements for the screening process are minimal and the units operate equally well for all sizes of plants.

5.4.2 Primary sedimentation

The efficiency of primary sedimentation depends on the commodity being processed, but generally results in at least 40% reduction in SS and a 17 to 30% reduction in BOD_5 (EPS 3-WP-77-5). For root crops such as potatoes, beets, and carrots, and for tomatoes, the suspended solids removals are very high. Primary treatment of potato wastes can achieve in the order of 80% suspended solids removal and 40 to 60% BOD_5 removal.*

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* Pollution Abatement in the Fruit and Vegetable Industry, Volume 3, Wastewater Treatment, U.S. Environmental Protection Agency, 1975.

In contrast, lower reductions in BOD_5 are achieved for products such as peas, peaches, pears and apple products. Values of process efficiencies were estimated to assess the overall effect of sedimentation on BOD_5 removal in the fruit and vegetable processing industry. These are given in Table 39.

5.4.3 Activated sludge

Activated sludge systems which are custom designed for a specific fruit and vegetable processing wastewater and which are carefully operated can usually achieve 95 to 98% removal of BOD_5 and suspended solids. However, these systems are susceptible to shock loadings if adequate equalization basins are not provided or the extended aeration modification is not incorporated into the design. There is no expected difference in operating efficiency between the three commodity categories of plant, that is, vegetables, fruits, and fruits and vegetables. However, more consistent organic and hydraulic loadings and operations techniques are expected for the larger plants as compared to smaller operations. This assumption is reflected in the following estimated efficiency differences for the three plant size categories.

Small plant - 80% (BOD_5 and SS)
Medium plant - 90% (BOD_5 and SS)
Large plant - 98% (BOD_5 and SS)

It should be noted that greater treatment efficiencies would probably be possible for small plants if the activated sludge systems were designed and operated on a batch basis. However, the reduction in treatment efficiency to 80% is used for calculation purposes because the batch technology has not been used to full advantage in Canada at the present time.

5.4.4 Trickling filters

Trickling filter systems can be designed as high rate filter systems or as standard rate processes. Since trickling filters are usually designed as biological roughing systems for the purposes of reducing the organic loading on subsequent processes, it can be assumed that the effect of plant size would be reflected in the degree of

TABLE 39. FRUIT AND VEGETABLE PROCESSING WASTEWATER ESTIMATED TREATMENT EFFICIENCIES

PROCESS	% REMOVAL BY PLANT SIZE					
	SMALL		MEDIUM		LARGE	
	BOD_5	SS	BOD_5	SS	BOD_5	SS
INDUSTRY						
Screening	10	20	10	20	10	20
Sedimentation	20	40	25	40	30	40
Activated Sludge	80	80	90	90	98	98
Trickling Filter	70	70	75	75	85	85
Anaerobic Lagoons	60	60	60	60	60	60
Aerated Lagoons	80	80	90	80	90	80
Aerobic (Holding) Lagoons	90	80	90	80	90	80
MUNICIPAL						
Primary	30	60	30	60	30	60
Secondary	90	90	90	90	90	90

sophistication of the trickling filter system. For small plants, the standard rate system would probably be employed, while higher recirculation rates, forced draft aeration and plastic or redwood media packed towers would be used for larger size plants.

The process efficiencies which could be realized at the three size levels of plants are estimated as follows for both BOD_5 and SS removal:

Small plant - 70%
Medium plant - 75%
Large plant - 85%

It should be noted that the SS efficiencies given above have been based on the assumption that removal facilities would be provided before and after applying the wastewater to the filter.

In some cases a 90 to 95% removal could be achieved but, in general, the trickling filter is considered as a roughing device for BOD_5 removal. Process modifications to achieve high removal efficiencies would greatly increase the cost of the system to the point where activated sludge treatment would become more attractive. It should be pointed out that the efficiency is not a function of commodity processed for trickling filter operations.

5.4.5 Anaerobic lagoons

The BOD_5 and SS removal efficiencies of anaerobic lagoon systems usually range from 40 to 85%, depending on the design criteria utilized. It is assumed that the treatment efficiency is independent of plant size. For the purposes of calculation, the degree of treatment for Canadian experience was estimated at 60% BOD_5 and SS removal, taking into account the reduction in treatment efficiency associated with operation in a relatively cold climate.

5.4.6 Aerated lagoons

The BOD_5 removal efficiencies of aerated lagoon systems range between 50% and 98%, depending upon the design criteria and operation methods utilized. In general, these systems can achieve approximately 80% removal of suspended solids if a polishing lagoon for quiescent settling of the solids is provided prior to the discharge of the treated effluent.

Some reduction in system efficiency can probably be anticipated because of plant size and the emphasis placed on plant operation and maintenance. Treatment efficiencies utilized for calculation purposes were, therefore, specified as follows:

Small plant - 80% - BOD_5, 80% - SS
Medium plant - 90% - BOD_5, 80% - SS
Large plant - 90% - BOD_5, 80% - SS

5.4.7 Holding, facultative and aerobic lagoons

Each of these types of systems when designed properly should be capable of achieving a BOD_5 removal of 90% and a SS removal of 80%. Because they depend upon natural processes, very little operation or maintenance is required; in addition they are not susceptible to fluctuating flows because of the long retention capacity. These systems are usually restricted in their use to plants located in rural areas because substantial land area is normally required to obtain the necessary retention periods for the wastewater.

5.4.8 Land application systems

These systems included both the various land application systems (spray irrigation, ridge and furrow, etc) and also septic tank and tile field units. For estimating BOD_5 and SS loadings, it is assumed that these systems result in zero discharge of these parameters, that is, they operate at 100% efficiency.

5.4.9 Municipal waste treatment

A common temperature between municipal wastewaters and most commodity wastewaters is advantageous. Primary treatment usually achieves a BOD_5 removal of a least 30% and a suspended solids removal in the order of 60%. Biological treatment of domestic and food processing wastes is very compatible because of the nutrients contained in domestic sewage, and for all plant sizes can be assumed to attain a 90% BOD_5 and SS removal.

5.4.10 Summary

Table 39 provides a summary of the estimated BOD_5 and SS removal efficiencies for the various effluent treatment processes as they could potentially apply to fruit and vegetable processing wastewaters.

5.5 Effluent Load after In-Plant Treatment Facilities

The effect on the total potential BOD_5 and SS loadings (Table 38) of in-plant grit removal, oil and grease removal, and screening facilities presently being used by the industry cannot be adequately determined on the basis of questionnaire data. In some cases these facilities would be used on a specific wastewater stream (i.e. grit removal on waste washwater), a number of effluent flumes, or on the total effluent stream. On the assumption that the information given in Table 28 on screening applied solely to the total effluent stream, the effect of screening on the total potential BOD_5 and SS loadings is developed and presented in Table 40. The potential loadings were adjusted to determine (a) the effect of current screening practices, and (b) the effect of installation of screening devices at all plants.

An inspection of Table 40 shows the following:

1) Current screening facilities reduce the total potential BOD_5 loadings from 12,097 to 11,136 metric tonnes, or a reduction of 891 tonnes. Suspended solids loadings are reduced by 813 tonnes, from 5,165 to 4,352 tonnes.

2) Upgrading all plants to include screening facilities would result in an additional reduction of 312 metric tonnes BOD_5 and 221 tones SS compared with the present situation.

3) When considering the possibility of upgrading all plants to include screening facilities, it should be pointed out that upgrading 69 small plants would reduce the total BOD_5 by 51 metric tonnes. Reductions of 234 and 27 metric tonnes would be achieved by upgrading 36 medium plants and one large plant, respectively. This would suggest that the major concern should be to the upgrading of medium sized plants. A similar situation would hold true with respect to the reduction of SS loadings.

5.5.1 Effluent load after solid-liquid separation processes

The total potential BOD_5 loadings given in Table 38 were adjusted to determine the effect of present solid-liquid separation

TABLE 40. TOTAL CANADIAN EXPERIENCE - POTENTIAL BOD_5 AND SS LOADINGS WITH SCREENING FACILITIES (by plant size)[5]

SMALL	MEDIUM	LARGE	TOTAL	PARAMETER
		($x 10^3$ kg)		
822	5733	5472	12027	Potential BOD_5
791	5394	4951	11136	BOD_5 with present screening
740	5160	4924	10824	BOD_5 target with all plants screening
51	234	27	312	Difference representing effect of upgrading to all plants screening
		($x 10^3$ kg)		
298	1874	2993	5165	Potential SS
275	1653	2424	4352	SS with present screening
238	1499	2394	4131	SS target with all plants screening
37	154	30	221	Difference representing effect of upgrading to all plants screening

* Assuming that information in Table 28 would apply to the total wastewater streams from plants.

processes, assuming a 20%, 25%, and 30% BOD_5 removal efficiency for small, medium and large plants, respectively. In addition, the potential loadings were further evaluated to estimate the total BOD_5 loading if all plants had solid-liquid separation processes installed. Similar analysis was carried out for SS loadings using an estimated removal efficiency of 40%. This information is given in Table 41.

It should be noted that no attempt has been made to apply solid-liquid separation removal efficiencies to the residual BOD_5 and SS loadings which would exist after current screening as given in Table 40. This is due to the uncertainties related to the questionnaire responses in this area as discussed in the previous subsection. Nevertheless, Table 41 indicates that in terms of upgrading, the major concerns would be the medium and large sized plants.

Tables 42 and 43 summarize the net effect in reduction of the total potential BOD_5 and SS loadings from the fruit and vegetable industry if all plants were to screen first their wastewater and then utilize solid-liquid separation processes. The following observations can be made from the inspection of these tables:

1) Upgrading all plants to include both screening and solids-separation facilities would result in an overall reduction in BOD_5 loading of 4118 metric tonnes.

2) Upgrading medium and large sized plants would account for 45% and 49%, respectively, of the total overall reduction in BOD_5.

3) An overall reduction in SS loadings of 2376 metric tonnes would result if all plants included both the treatment facilities.

4) Upgrading medium and large plants would account for 36% and 58%, respectively, of the total overall reduction in SS.

5.6 Current Residual BOD_5

The effect that existing treatment systems, both those used by the industry and municipalities, have on reducing the total potential BOD_5 loadings is determined in this subsection. The information presented in

TABLE 41. TOTAL CANADIAN EXPERIENCE - POTENTIAL BOD_5 AND SS LOADINGS WITH SOLID-LIQUID SEPARATION FACILITIES (by plant size)

SMALL	MEDIUM	LARGE	TOTAL	PARAMETER
		(x 10^3 kg)		
822	5733	5472	12027	Potential BOD_5
783	5432	5193	11408	BOD_5 with present solid-liquid separation
658	4300	3830	8788	BOD_5 target with all plants having solid-liquid separation
125	1132	1363	2620	Difference representing effect of upgrading to all plants utilizing solid-liquid separation.
		(x 10^3 kg)		
298	1874	2993	5165	Potential SS
269	1717	2789	4775	SS with present solid-liquid separation
179	1124	1796	3099	SS target with all plants having solid-liquid separation
90	593	993	1676	Difference representing effect of upgrading to all plants utilizing solid-liquid separation

TABLE 42. TOTAL CANADIAN EXPERIENCE - POTENTIAL BOD_5 LOADINGS WITH SCREENING AND SOLID-LIQUID SEPARATION (by size category)

SMALL	MEDIUM	LARGE	TOTAL	PARAMETER
	($x\ 10^3$ kg)			
822	5733	5472	12027	Potential BOD_5
740	5160	4924	10824	Residual BOD_5 with all plants screening
592	3870	3447	7909	Residual BOD^5 with all plants screening and having solids-separation
230	1863	2025	4118	Difference representing effect of upgrading to all plants using screening and solids-separation
6	45	49	100	Percentage of total reduction

TABLE 43. TOTAL CANADIAN EXPERIENCE - POTENTIAL SS LOADINGS WITH SCREENING AND SOLID-LIQUID SEPARATION (by size category)

SMALL	MEDIUM	LARGE	TOTAL	PARAMETER
	($x\ 10^3$)			
298	1874	2993	5165	Potential SS
268	1687	2694	4649	Residual SS with all plants screening
161	1012	1616	2789	Residual SS with all plants screening and having solid-liquid separation
137	862	1377	2376	Difference representing effect of upgrading to all plants using screening and solid-liquid separation
6	36	58	100	Percentage of total reduction

Section 4 of this report, essentially Tables 30 and 31, and the removal efficiencies presented in Table 39 for the various treatment processes are the data principally used. It should be noted that the efficiencies given in Table 39 have been applied to the total potential BOD_5 loadings as given in Table 38. The percentage removal efficiencies given for the various types of biological treatment processes in Table 39 encompass any BOD_5 removal that would occur through screening or solid-liquid separation facilities which would normally be an integral part of the total treatment process.

Table 44 provides a summary of the total potential BOD_5 which presently undergoes biological treatment at the plants, the treatment method used, the amount BOD_5 removed and the residual remaining. The residual BOD_5, as indicated in this table, either undergoes further treatment via a municipal or land application system, or is discharged to a water body. Table 45 provides a detailed breakdown pertaining to this residual BOD_5.

With respect to the BOD_5 loading which does not undergo biological treatment at plant facilities, Table 46 summarizes discharge locations, amounts removed by municipal systems and the quantity of BOD_5 remaining.

In Table 47, some of the data from the previous three tables have been restructured to indicate (a) the amounts of BOD_5 removed, (b) the method of removal, and (c) the quantity of BOD_5 being discharged to surface waters. It has been assumed that all effluent from municipal systems is discharged to a water body. A number of significant observations can be made from inspection of Table 47.

1) The various treatment systems remove 76.2% of the total potential BOD_5 loading.

2) Approximately 30.7% of the total potential BOD_5 loading from fruit and vegetable processing plants is removed by means of biological treatment facilities operated by the industry.

3) Municipalities operating treatment systems remove approximately 29.8% of the total potential BOD_5 load.

TABLE 44. TOTAL CANADIAN EXPERIENCE - BOD_5 LOADINGS SUMMARY FOR THOSE PLANTS WITH EXISTING BIOLOGICAL TREATMENT

PLANT SIZE	BIOLOGICAL TREATMENT METHOD: HOLDING LAGOONS	AERATED LAGOONS	ACTIVATED SLUDGE	TRICKLING FILTER	OTHERS[1]	TOTAL BOD_5	PARAMETER
	(x 10^3 kg)						
Small	90	33	8	8	82	221	Raw BOD_5 Applied
	81	26	6	6	82	201	BOD_5 Removed
	9	7	2	2	nil	20	Residual BOD_5
Medium	917	401	-	-	-	1318	Raw BOD_5 Applied
	825	361	-	-	-	1186	BOD_5 Removed
	92	40	-	-	-	132	Residual BOD_5
Large	219	1368	711	219	-	2517	Raw BOD_5 Applied
	197	1231	697	186	-	2311	BOD_5 Removed
	22	137	14	33	-	206	Residual BOD_5
TOTAL	1226	1802	719	227	82	4056	Raw BOD_5 Applied
	1103	1618	703	192	82	3698	BOD_5 Removed
	123	184	16	35	nil	358	Residual BOD_5

(1) NOTE: The "others" category has been assumed to incorporate septic tank/tile field systems; the assumption being 100% BOD_5 removal.

TABLE 45. TOTAL CANADIAN EXPERIENCE - BOD_5 LOADINGS AND DISCHARGE LOCATIONS FOR THOSE PLANTS WITH BIOLOGICAL TREATMENT

PLANT SIZE			
SMALL	MEDIUM	LARGE	PARAMETER
	(x 10 kg)		
4	66	103	Residual BOD_5 Being Discharged to Water Course
12	53	52	Residual BOD_5 Being Discharged to Land
4	13	51	Residual BOD_5 Being Discharged to Municipal Systems
2	12	46	BOD_5 Removed
2	1	5	Residual BOD_5
6	67	108	TOTAL RESIDUAL BOD_5

TABLE 46. TOTAL CANADIAN EXPERIENCE - BOD_5 LOADINGS SUMMARY FOR THOSE PLANTS WITH NO BIOLOGICAL TREATMENT FACILITIES

PLANT SIZE	MUNICIPAL SYSTEMS			LAND	SURFACE WATER	TOTAL BOD_5	PARAMETER
	PRIMARY	SECONDARY	NO TREATMENT				
			($\times 10^3$ kg)				
	66	222	148	107	58	601	Raw BOD_5 Applied
Small	20	200	nil	107	nil	327	BOD_5 Removed
	46	22	148	nil	58	274	Residual BOD_5
	172	1950	1261	516	516	4415	Raw BOD_5 Applied
Medium	52	1755	nil	516	nil	2323	BOD_5 Removed
	120	195	1261	nil	516	2092	Residual BOD_5
	219	1587		1149		2955	Raw BOD_5 Applied
Large	66	1428		1149		2643	BOD_5 Removed
	153	159		nil		312	Residual BOD_5
	457	3759	1409	1772	574	7971	Raw BOD_5 Applied
TOTAL	138	3383	nil	1772	nil	5293	BOD_5 Removed
	319	376	1409	nil	574	2678	Residual BOD_5

TABLE 47. TOTAL CANADIAN EXPERIENCE - BOD_5 LOADINGS SUMMARY: REMOVED AND RESIDUAL

PARAMETER	PLANT SIZE SMALL	MEDIUM	LARGE	TOTAL	% OF TOTAL POTENTIAL BOD_5
	($x\ 10^3$ kg)				
BOD_5 removed by industry biological systems	201	1186	2311	3698	30.7
BOD_5 removed by municipal treatment systems	222	1819	1540	3581	29.8
BOD_5 removed by land application of wastewater	119	569	1201	1889	15.7
Total BOD_5 removed	542	3574	5052	9168	76.2
Residual BOD_5 Discharged(1) to surface water:					
a) Direct, untreated by industry	58	516	-	574	4.8
b) Indirect, via municipal facilities having no treatment	148	1261	-	1409	11.7
c) Direct, after treatment by industry	4	66	103	173	1.4
d) After municipal treatment					
- primary	48	120	153	321	2.7
- secondary	22	196	164	382	3.2
TOTAL RESIDUAL BOD_5	280	2159	420	2859	23.8

(1) NOTE: It has been assumed that all residual BOD_5 is discharged to surface water.

4) Land application of industry wastewater removes an additional 15.7% of the total loadings.

5) Total residual BOD_5 amounts to approximately 2,859 x 10^3 kg or 23.8% of the total potential load. Small, medium and large plants contributed 280, 2159 and 420 thousand kilograms, respectively, to account for the total.

6) Approximately 62% (1,777 x 10^3 kg) of the total residual BOD_5 was contributed by medium sized plants which disposed of their wastewater directly to surface waters without treatment, or to municipalities not having treatment facilities. An additional 206 x 10^3 kg of BOD_5 was discharged in a similar manner by small plants.

Based on Table 46 and the above observations, it can be concluded that environmental controls directed towards medium sized plants, particularly those without any form of treatment, would exact the largest decrease in residual BOD_5 being presently discharged by the industry. Another option which would substantially lower the residual BOD_5 load, would be to provide high levels of treatment for those municipalities not having any facilities.

5.7 Current Residual Suspended Solids

The effect that existing treatment systems used by both the industry and municipalities have on reducing the total potential SS loadings is determined in this subsection. The information presented in Tables 30 and 31, and the removal efficiencies given in Table 39 are the data principally used. The efficiencies given in Table 39 for suspended solids removal have been applied to the total potential SS loadings given in Table 39. As was the case in the previous analysis of current residual BOD_5 loadings, the percentage removal efficiencies given for the various types of biological treatment processes in Table 39 encompass any SS removal that would occur through screening or solid-liquid separation facilities. These facilities would usually be an integral part of the total biological treatment process.

Information on suspended solids is presented in Tables 48 to 51 using the same format of Tables 44 to 47 for BOD_5 loadings. Tables 48 to 51 provide the following information:

1) Table 48 provides a summary of the total potential SS which presently undergoes biological treatment at the fruit and vegetable processing plants, the treatment method used, the amount of SS removed, and the residual remaining.

2) Table 49 provides a detailed breakdown of the residual SS remaining as indicated in Table 48. The remaining SS after biological treatment at the plants (Table 48) either undergoes further treatment via a municipal or land application system or is discharged to a water body.

3) Table 50 provides a summary of the SS loadings which do not undergo biological treatment at plant facilities.

4) Some of the data given in Tables 48, 49 and 50 are restructured in Table 51 giving the amounts of SS removed and by what method, in addition to the quantity of SS being discharged to a water body.

A number of significant observations can be made from inspection of Table 51.

1) Various treatment systems at the plants removed 30.8% of the total potential SS loadings, 31% was removed by municipal treatment facilities, and 18% was removed by land application systems.

2) The total residual SS amounted to approximately 1,045 x 10^3 kg or 20.2% of the total potential load. Small, medium and large plants contributed 94, 711, and 250 thousand kilograms, respectively, to this total amount.

3) Approximately 56% (581 x 10^3 kg) of the total residual SS was contributed by medium sized plants which disposed of this wastewater either directly to surface waters without treatment, or to municipalities which do not have treatment facilities.

TABLE 48. TOTAL CANADIAN EXPERIENCE - SUSPENDED SOLIDS LOADINGS SUMMARY FOR THOSE PLANTS WITH EXISTING BIOLOGICAL TREATMENT

PLANT SIZE	BIOLOGICAL TREATMENT METHOD					TOTAL SS	PARAMETER
	HOLDING LAGOONS	AERATED LAGOONS	ACTIVATED SLUDGE	TRICKLING FILTER	OTHERS(1)		
	(x 10^3 kg)						
Small	33	12	3	3	30	81	SS Applied
	26	10	2	2	30	70	SS Removed
	7	2	1	1	nil	11	Residual SS
Medium	300	131	-	-	-	431	SS Applied
	240	105	-	-	-	345	SS Removed
	60	26	-	-	-	86	Residual SS
Large	120	748	389	120	-	1377	SS Applied
	96	598	381	102	-	1177	SS Removed
	24	150	8	18	-	z200	Residual SS
Total	453	891	392	123	30	1889	SS Applied
	362	713	383	104	30	1592	SS Removed
	91	178	9	19	nil	297	Residual SS

(1) NOTE: The "others" category has been assumed to incorporate septic tank/tile field systems; the assumption being 100% SS removed.

TABLE 49. TOTAL CANADIAN EXPERIENCE - SS LOADINGS AND DISCHARGE LOCATIONS FOR THOSE PLANTS WITH BIOLOGICAL TREATMENT

PLANT SIZE			
SMALL	MEDIUM	LARGE	PARAMETER
	(x 10 kg)		
2	43	100	Residual SS Being Discharge to Water Course
7	34	50	Residual SS Being Discharged to Land
2	9	50	Residual SS Being Discharged to Municipal Systems
2	8	45	SS Removed
nil	1	5	Residual BOD_5
2	44	105	TOTAL RESIDUAL SS

TABLE 50. TOTAL CANADIAN EXPERIENCE - SS LOADINGS SUMMARY FOR THOSE PLANTS WITH NO BIOLOGICAL TREATMENT FACILITIES

PLANT SIZE	MUNICIPAL SYSTEMS PRIMARY	MUNICIPAL SYSTEMS SECONDARY	MUNICIPAL SYSTEMS NO TREATMENT	LAND	SURFACE WATER	TOTAL SS	PARAMETER
			(x 10^3 kg)				
Small	24	80	54	39	20	217	Raw SS Applied
	14	72	nil	39	nil	125	SS Removed
	10	8	54	nil	20	92	Residual SS
Medium	56	637	412	169	169	1443	Raw SS Applied
	34	573	nil	169	nil	776	SS Removed
	22	64	412	nil	169	667	Residual SS
Large	120	868	-	628	-	1616	Raw SS Applied
	72	781	-	628	-	1481	SS Removed
	48	87	-	nil	-	135	Residual SS
Total	200	1585	466	836	189	3276	Raw SS Applied
	120	1426	nil	836	nil	2382	SS Removed
	80	159	466	nil	189	894	Residual SS

TABLE 51. TOTAL CANADIAN EXPERIENCE - SS LOADINGS SUMMARY: REMOVED AND RESIDUAL

PARAMETER	PLANT SIZE SMALL	MEDIUM	LARGE	TOTAL	% OF TOTAL POTENTIAL SS
	($x\ 10^3$ kg)				
SS removed by industry biological systems	70	345	1177	1592	30.8
SS removed by municipal treatment systems	88	615	898	1601	31.0
SS removed by land application of wastewater	46	203	678	927	18.0
Total SS removed	204	1163	2753	4120	79.8
Residual SS Discharge(1) to surface water:					
a) Direct, untreated by industry	20	169	-	189	3.7
b) Indirect, via municipal facilities having no treatment	54	412	-	466	9.0
c) Direct, after treatment by industry	2	43	100	145	2.8
d) After municipal treatment					
- primary	10	22	48	80	1.5
- secondary	8	65	92	165	3.2
TOTAL RESIDUAL SS	94	711	240	1045	20.2

(1) NOTE: It has been assumed that all residual SS is discharged to surface water.

Based on the data given in Table 51 and the above observations, it can be concluded that environmental controls directed towards medium sized plants, particularly those without any form of treatment, would exact the largest decrease in residual SS being discharged by the industry. Another option which would substantially reduce residual SS loadings would be to provide high levels of treatment for those municipalities not having any facilities. It should be noted that these conclusions on SS residual loadings are the same as those reached for residual BOD_5.

5.8 Effects of Effluent Treatment Alternatives

From the previous analyses it can be seen that the current residual BOD_5 and SS loadings (refer to Tables 47 and 51, respectively) can be substantially reduced by either providing treatment at the plant, at municipal plants, or a combination of improved treatment at both locations.

A number of treatment alternatives or strategies were chosen and their effect, if implemented, on lowering the residual BOD_5 and SS was determined. The effects are summarized and compared in Table 52 and 53 for residual BOD_5, and in Tables 54 and 55 for residual SS for the following treatment strategies:

1) upgrading all municipal facilities to at least primary treatment;
2) upgrading all municipal facilities to incorporate secondary treatment;
3) upgrading present municipal facilities having only primary treatment to secondary, and those municipalities without treatment to land disposal;
4) upgrading all industry sources currently without treatment, either at the plants or municipalities, to:
    a) holding lagoons,
    b) aerated lagoons,
    c) activated sludge,
    d) trickling filters,
    e) land disposal;

TABLE 52. REDUCTION IN RESIDUAL BOD_5 THROUGH UPGRADING TO VARIOUS STRATEGIES

PLANT SIZE	PRESENT RESIDUAL	RESULTANT RESIDUAL AFTER UPGRADING TO THE FOLLOWING STRATEGIES									
		1	2	3	4a	4b	4c	4d	4e	5	6
					($\times 10^3$ kg)						
Small	280	236	106	91	95	115	115	136	74	57	33
Medium	2159	1781	921	795	560	560	560	826	382	457	279
Large	420	420	289	289	420	420	420	420	420	289	289
TOTAL	2859	2437	1316	1175	1075	1095	1085	1382	876	799	601
% of Total Potential BOD_5	23.8	20.3	10.9	9.8	8.9	9.1	9.1	11.5	7.3	6.6	5.0

NOTE: Refer to text for definitions of strategies.

TABLE 53. PERCENTAGE REDUCTION IN RESIDUAL BOD_5 THROUGH UPGRADING TO VARIOUS STRATEGIES

STRATEGY	PLANT SIZE			TOTAL
	SMALL	MEDIUM	LARGE	
1	2	13	-	15
2	6	43	5	54
3	7	48	4	59
4a	6	56	-	62
4b	6	56	-	62
4c	6	56	-	62
4d	5	47	-	52
4e	7	62	-	69
5	8	60	4	72
6	9	66	4	79

NOTE: Refer to text for definitions of strategies.

5) upgrading all industry sources without treatment (either at the plant or by municipalities) to strategy 4a above, and those municipalities with primary systems to secondary facilities;

6) upgrading all industry source without treatment to strategy 4e above and those municipalities with primary systems to secondary facilities.

It is readily apparent from Tables 52 to 55 that land application or secondary treatment (strategies 5 and 6) of those wastewaters presently being discharged raw, or with only primary treatment, would provide the least BOD_5 and SS loadings. The availability of land, its suitability and/or its costs could preclude the use of this treatment and disposal strategy in some cases. However, land applicaiton of wastewaters does afford the potential for zero discharge and should be encouraged wherever feasible.

Strategies 5 and 6 would result in residual BOD_5 loadings of 799 and 601 thousand kilograms. These totals represent approximately 6.6% and 5.0% of the total potential BOD_5 loading of the industry. In effect, the implementation of strategies 5 or 6 or combinations of both, together with existing treatment methods would result in total removal efficiencies of 90 to 95%. This essentially would imply that the entire industry would be incorporating levels of secondary treatment. A similar argument would hold true for SS and strategies 5 and 6.

As can be noted from Table 52, the largest decrease in the present residual BOD_5 through the implementation of the above mentioned two strategies would be achieved in the medium sized category of plants. In the case of strategy 5 implementation, a total decrease in the present residual BOD_5 of 72% would be accomplished. The treatment of medium sized plant wastes would account for a 60% reduction in residual BOD_5, while small and large plants would reduce the BOD_5 by 8% and 4%, respectively.

As has been previously mentioned, the lowering of the present BOD_5 and SS loadings can be accomplished by treatment at the plant, at municipal facilities or a combination of both locations. The upgrading of municipal systems receiving industry wastewater could effectively lower

TABLE 54. REDUCTION IN RESIDUAL SS THROUGH UPGRADING TO VARIOUS STRATEGIES

PLANT SIZE	PRESENT RESIDUAL	RESULTANT RESIDUAL AFTER UPGRADING TO THE FOLLOWING STRATEGIES									
		1	2	3	4a	4b	4c	4d	4e	5	6
					($x\ 10^3$ kg)						
Small	94	62	38	32	35	35	35	42	20	27	12
Medium	711	464	324	283	246	246	188	275	130	230	114
Large	240	240	204	240	240	240	240	240	240	204	204
TOTAL	1045	766	566	519	521	521	463	557	390	461	330
% of Total Potential SS	20.2	14.8	11.0	10.0	10.1	10.1	9.0	10.8	7.6	8.9	6.4

NOTE: Refer to text for definitions of strategies.

TABLE 55. PERCENTAGE REDUCTION IN RESIDUAL SS THROUGH UPGRADING TO VARIOUS STRATEGIES

STRATEGY	PLANT SIZE			TOTAL
	SMALL	MEDIUM	LARGE	
1	3	24	-	27
2	6	37	3	46
3	6	41	3	50
4a	6	44	-	50
4b	6	44	-	50
4c	6	50	-	56
4d	5	42	-	47
4e	7	56	-	63
5	7	46	3	56
6	8	57	3	68

NOTE: Refer to text for definitions of strategies.

residual BOD_5 to the range of 1175 to 2437 thousand kilograms and residual SS to the range of 519 to 766 thousand kilograms. Treatment at the plant by the implementation of strategies 4a to 4e would result in lowering BOD_5 levels to between 876 and 1382 thousand kilograms, and S levels to between 390 and 557 thousand kilograms. The combination of increasing treatment at both locations would result in residual loadings from 601 to 799 thousand kilograms. Suspended solids loadings from 330 to 460 thousand kilograms would result from implementation of strategies 5 and 6.

For these plants discharging raw wastewater to municipalities having no treatment facilities, or only primary systems, the question of responsibility of treatment could potentially pose some jurisdictional problems. However, as upgrading treatment at both locations does afford the least residual BOD_5 and SS being discharged, it is felt that a concerted effort in this direction by all parties involved would be of the greatest environmental benefit.

6. ECONOMIC IMPACT OF EFFLUENT CONTROL MEASURES

6.1 Introduction

The economic cost of environmental control measures used by plants in the fruit and vegetable processing industry must be weighed against the environmental benefit resulting from reduction in BOD_5 and SS loadings. Although it is beyond the scope of this study to determine this environmental benefit, it is possible to compare and contrast the magnitude of potential reduction in BOD_5 loadings resulting from the introduction of waste treatment systems into the three sizes of plants (small, medium and large).

It should be noted at the outset that the economic analysis presented in this section is not developed in great depth because of the lack of basic financial information and the inability to obtain this information from industry sources. This aspect is discussed later in this section.

In this section, unit waste treatment costs are developed in terms of both $/1000 kg BOD_5 removed and $/tonne of raw product with emphasis placed on the latter unit cost. These costs are applied in a simple economic analysis set up to assess the impact of environmental control measures on profit margins and on capital availability. Finally, these costs are assessed against the magnitude of the BOD_5 reductions resulting from the introduction of the environmental control measures.

The waste treatment systems considered earlier in this report remove both BOD_5 and suspended solids; costs of removing suspended solids are essentially included in the unit BOD_5 removal costs.

6.2 Cost of Waste Treatment Systems

Cost development data were taken from a recent report by the United States Environmental Protection Agency* for the operation of a large processing plant. These and other data presented in Table 56 formed

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* Pollution Abatement in the Fruit and Vegetable Industry, Volume III, Wastewater Treatment, U.S. Environmental Protection Agency, 1975.

TABLE 56. BASIC DATA USED FOR COSTS DEVELOPMENT

PARAMETER	VALUE
Effluent flow	1.0 x 10^6 U.S. gallons per day
BOD_5	(a) 1000 mg/l
	(b) 340 t/year
Season length	90 days
Plant capacity	31,460 tonnes/year
Amortization	10 years at 12%
Capital recover factor	0.177
(a) Inflation rate (1975 - 1976)	10%
(b) Cost factor, Canadian compared to U.S.	1.2
(c) (a) x (b)	1.3

the basis for developing costs of specific wastewater systems. Thus, the initial calculations were based on a large plant having a capacity of approximately 31,460 tonnes per year and discharging 340 tonnes BOD_5 per year on a raw untreated effluent basis.

Based on a large plant of this size, unit costs were developed for each specified waste treatment process, in terms of $ per tonne of raw product and $ per 1000 kg BOD_5. An inflation rate of 10% per year was applied to the 1975 data and U.S. costs were increased by 20% to obtain approximate values for Canadian costs. The technique utilized is illustrated by application to an activated sludge system:

Screening:

1976 total capital costs	$93,080
Annual operating costs	4,160
Annual capital costs	16,475
Total annual costs	20,635

Activated sludge plant:

1976 total capital costs	$1,449,500
Annual operating costs	76,050
Annual capital costs	256,560
Total annual costs	332,610

Total costs of activated sludge plant with screening:

1976 capital costs	$1,542,580
Annual operating costs	80,210
Annual capital costs	273,035
Total annual costs	353,245

Thus, the unit costs can be expressed in terms of $/tonne of raw product or in terms of $/1000 kg BOD_5 using as a basis the generation of 340 t BOD_5 per year and a production rate of 31,460 t/year. These unit costs are given in Table 57.

Unit costs were developed in a similar manner for the following processes in addition to those given in Table 57:

- aerated lagoon,
- holding lagoon,

- municipal primary system,
- municipal secondary system,
- land disposal.

The total capital costs and annual operating costs for these systems are given in Table 58. The assumptions made in deriving the costs of the waste treatment systems (including the municipal treatment systems) are given in Table 59.

In order to determine unit costs for small, medium and large processing plants, the scale factors were applied to the data given in Table 58. These factors were obtained by extrapolation of the scale-up data given in a recent publication by Olson et al*.

Olson et al presented a review of waste treatment costs for the fruit and vegetable processing industry. In particular, cost curves were developed showing the unit cost of BOD_5 removal as a function of plant size and percent removal efficiency. These curves were used to determine the relative unit costs for the three plant size categories defined in Section 4 for treatment efficiencies of 80, 85 and 90%. It was found that relatively small differences existed between the 80 and 90% efficiency figures. Therefore, based on the similarity of these 80% and 90% cost figures, the unit costs associated with the 90% values were selected.

A comparison of the unit costs for 90% treatment for the three sizes of processing plants yielded the following relationship:

large plant	-	1.0,
medium plant	-	1.35,
small plant	-	2.05.

Thus the unit cost for providing treatment for a small plant would be approximately 2.05 times that for a large plant. The unit cost for a medium sized plant would be 1.35 times that for a large plant.

Total capital costs and annual operating costs for the three categories of plant size are presented in terms of $/tonne raw product in Table 60 and in terms of $ per $1000 kg BOD_5 in Table 61. The information in Tables 60 and 61 is based on the relationships given above

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* Economic effects of treating fruit and vegetable processing liquid wastes. N.A. Olson et al, Proceedings of the Fifth National Symposium of Food Processing Wastes.

TABLE 57. UNIT COSTS - ACTIVATED SLUDGE* SYSTEMS

COST	$/t RAW PRODUCT	$/1000 kg BOD_5
Total capital costs	49.00	4537.00
Annual capital costs	8.68	803.00
Annual operating costs	2.55	237.00
Total annual costs	11.23	1040.00

* Includes costs of screening.

TABLE 58. UNIT WASTE TREATMENT COSTS - LARGE PLANT

WASTE TREATMENT SYSTEM	TOTAL CAPITAL COSTS		ANNUAL OPERATING COSTS	
	$/t raw product	$/1000 kg BOD_5	$/t raw product	$/1000 kg BOD_5
Screening	2.96	273.00	0.13	12.00
Activated sludge*	49.00	4540.00	2.55	237.00
Aerated lagoon*	32.33	2990.00	0.79	73.40
Holding lagoon*	17.06	1580.00	0.45	41.60
Municipal primary	17.96	1660.00	1.30	120.00
Municipal secondary	46.00	4256.00	1.71	158.00
Land disposal*	26.70	247.00	1.80	167.00

* Including costs of screening.

NOTE: Capital amortized at 12% for 10 Years, capital recovery factor 0.177.

TABLE 59. ASSUMPTIONS USED IN DERIVING WASTE TREATMENT COSTS

SYSTEM	ASSUMPTIONS
Activated sludge * (with aerobic digestion and dewatering; and including screening)	- solids hauling at $4.00 per cubic yard - 20 mesh screen - lined earthen aeration basin with 2-day detention time - two conventional secondary clarifiers, 400 gpd/ft^2 overflow rate - power cost 2¢ per kwh - dewatered sludge trucking costs $3.70/ton dry solids/mile - polymer addition 6 lb/ton solids - polymer cost $2.25/lb. - unit dewatering rate - 1000 USG per hour for digested sludge
Aerated lagoon*	- lined aerated lagoon and settling pond - aerated lagoon detention time 30 days - overflow rate 400 USG per day per sqaure foot - no nutrient addition - excavation and disposal at $1.00 per cubic yard - power cost 2¢ per kwh
Holding lagoon*	- lined earthen basin - detention time 100 days - loading 250 lbs. BOD_5 per acre per day - excavation and disposal at $4.00 per cubic yard
Land disposal*	- spray irrigation system - 150 acres total land requirement - land cost $2000 per acre

TABLE 59. (CONT'D)

SYSTEM	ASSUMPTION
Primary treatment	- 2 hour detention in primary clarifier - concrete work at 75¢ per gallon - aerobic digester, 10 days detention - two gravity dewatering units at 1000 gallons/hour - dewatered sludge haulage - two operators
Secondary Treatment	- screening not included (assumed in Primary Section) - activated sludge similar to above

* Cost data are 1975 dollars and applicable to the United States.

NOTE: English units are used for convenience in using data from the original publication, Pollution Abatement in the Fruit and Vegetable Industry - Wastewater Treatment, U.S. Environmental Protection Agency, 1975.

TABLE 60. UNIT WASTE TREATMENT COSTS ACCORDING TO PLANT SIZE ($/t raw product)

WASTE TREATMENT SYSTEM	COST ITEM**	PLANT SIZE SMALL	MEDIUM	LARGE
Screening	Operation	0.27	0.18	0.13
	Capital	6.07	4.00	2.96
Activated Sludge*	Operation	5.23	3.44	2.55
	Capital	101.00	66.15	49.00
Aerated Lagoon*	Operation	1.62	1.07	0.79
	Capital	66.28	43.65	32.33
Holding Lagoon*	Operation	0.92	0.61	0.45
	Capital	34.97	23.07	17.06
Land Application*	Operation	3.69	2.43	1.80
	Capital	54.74	36.05	26.70
Municipal Primary	Operation	2.67	1.76	1.30
	Capital	36.82	24.25	17.96
Municipal Secondary	Operation	3.51	2.31	1.71
	Capital	94.30	62.10	46.00
Upgrading Primary to Secondary	Operation	0.84	0.55	0.41
	Capital	57.48	37.84	28.04

* Includes screening costs.

** Capital - total capital costs.

Operation - total annual operating costs excluding capital amortized at 12% for 10 years.

and the unit cost figures for a large plant given in Table 58. Plant sizes are those developed in Section 4, i.e.

small plant	-	690 metric tonnes,
medium plant	-	5230 metric tonnes,
large plant	-	24770 metric tonnes.

Using data from Table 60 and the average plant sizes given in Section 4, total capital and annual operating costs were developed for each plant size and each treatment system. These cost data are presented in Table 61.

6.3 Economic analysis

6.3.1 Introduction

It was the intention to address the financial impacts of added waste treatment costs on individual processes and on the industry as a whole by using methods similar to those used in a series of studies carried out on the American industry. The methodology involved obtaining detailed cost and financial statistics for a representative sample of processors; from this information, a number of models would be designed to simulate plants of different sizes and processed commodities. However, it was not possible to obtain the required cost and financial data. Several processors and wholesalers were contacted, but information on the cost structure of their operations was not made available. Contact was made with Statistics Canada and Agriculture Canada but pertinent information was not available from these sources.

Therefore, a much simpler approach was taken in this analysis, i.e. to estimate the minimum profit margin required to absorb the costs of waste treatment.

The approach taken was to assess the ability of individual firms to obtain the capital funds necessary to construct waste treatment systems and to absorb the added capital and operating costs of waste treatment out of profits. Data requirement for this analysis included the determination of treatment costs per tonne of final product, industry selling prices per tonne of final product and total capital costs for treatment systems.

TABLE 61. UNIT WASTE TREATMENT COSTS ACCORDING TO PLANT SIZE ($1000 kg BOD_5 treated)

WASTE TREATMENT SYSTEM	COST ITEM**	PLANT SIZE SMALL	MEDIUM	LARGE
Screening	Operation	25.00	16.00	12.00
	Capital	560.00	369.00	273.00
Activated Sludge*	Operation	485.00	320.00	237.00
	Capital	9300.00	6130.00	4540.00
Aerated Lagoon*	Operation	150.00	99.00	73.40
	Capital	6130.00	4040.00	2990.00
Holding Lagoon*	Operation	85.00	56.00	41.60
	Capital	3240.00	2130.00	1580.00
Land Application*	Operation	340.00	225.00	167.00
	Capital	5065.00	3335.00	2470.00
Municipal Primary	Operation	246.00	162.00	120.00
	Capital	3400.00	2240.00	1660.00
Municipal Secondary	Operation	324.00	213.00	158.00
	Capital	8720.00	5750.00	4256.00
Upgrading Primary to Secondary	Operation	78.00	51.00	38.00
	Capital	5320.00	3500.00	2596.00

* Includes screening costs.

** Capital - total capital costs.

Operation - total annual operating costs excluding capital amortized at 12% for 10 years.

The total capital costs for treatment systems provided the data on which to base subjective judgements regarding likely availability of capital to individual firms. The selling prices and treatment costs per tonne of final product permitted the determination of the present pre-tax profit margins required to enable firms to absorb waste treatment costs if the firms were unable to pass these added costs forward to the consumer.

6.3.2 Capital and annual treatment costs

The capital costs required for the construction of alternative waste treatment systems for various sizes of plants are shown in Table 63. The effectiveness of the alternative systems in terms of the percentage BOD_5 removed is also shown in this table. Capital costs are taken from Table 62 and efficiencies taken from Table 39.

Annual waste treatment costs are shown in Table 64. These costs include annual capital costs (based on the capital recovery factor of 0.177 with the capital amortized over 10 years at 12%), and annual operating and maintenance costs for each type of treatment system for each size of plant given in Table 60.

Inspection of Table 64 shows the large differences in unit annual waste treatment costs between large, medium and small sized plants. For example, the cost of a holding lagoon for a small plant is $7.11 per tonne of raw product compared to $3.47 per tonne raw product for a large plant. Within any category of plant size, Table 64 illustrates the relatively high costs of activated sludge, aerated lagoon or land application systems compared with a holding lagoon ($6.51 - $11.22 per tonne of raw product compared with $3.47 per tonne of raw product for a large plant).

It was necessary to determine total annual waste treatment costs on the basis of tonnes of finished product in order to be able to compare with processors' selling prices. Processing conversion ratios (tonnes of raw product required to make one tonne of finished product) were determined for the major fruits and vegetables given in Tables 1 and 2. Average ratios for the fruit, vegetable, and fruit and vegetable categories were obtained using the 1974 data presented in Tables 1 and 2:

TABLE 62. TOTAL COSTS OF WASTE TREATMENT SYSTEM ACCORDING TO PLANT SIZE

WASTE TREATMENT SYSTEM	COST ITEM**	PLANT SIZE SMALL	MEDIUM	LARGE
Screening	Operation	186	941	3220
	Capital	4190	20900	73300
Activated Sludge*	Operation	3600	18000	63200
	Capital	69400	346000	1210000
Aerated Lagoon*	Operation	1120	5600	19600
	Capital	45700	228000	801000
Holding Lagoon*	Operation	635	3190	11100
	Capital	24100	120000	423000
Land Application*	Operation	2770	13900	47800
	Capital	37800	189000	661000
Municipal Primary	Operation	1840	9360	32200
	Capital	25400	127000	445900
Municipal Secondary	Operation	2420	12080	43600
	Capital	65100	325000	1140000
Upgrading Primary to Secondary	Operation	579	2880	10200
	Capital	39700	198000	695000

* Includes screening costs.

** Capital - total capital costs.

Operation - total annual operating costs excluding capital amortized at 12% for 10 years.

TABLE 63. CAPITAL COSTS AND EFFICIENCIES OF WASTE TREATMENT SYSTEMS ACCORDING TO PLANT SIZE

TREATMENT SYSTEM	PLANT SIZE: SMALL COST ($)	SMALL BOD_5 REMOVED (%)	MEDIUM COST ($)	MEDIUM BOD_5 REMOVED (%)	LARGE COST ($)	LARGE BOD_5 REMOVED (%)
Activated Sludge	69400	80	346000	90	1610000	98
Aerated Lagoon	45700	80	228000	90	801000	90
Holding Lagoon	24100	90	120000	90	423000	90
Land Application	37800	100	189000	100	661000	100
Municipal Secondary	65100	90	325000	80	1140000	80

TABLE 64. TOTAL ANNUAL WASTE TREATMENT COSTS ACCORDING TO PLANT SIZE ($/t raw product)

TREATMENT SYSTEM	PLANT SIZE: SMALL	MEDIUM	LARGE
Activated Sludge	23.02	15.15	11.22
Aerated Lagoon	13.35	8.80	6.51
Holding Lagoon	7.11	4.67	3.47
Land Application	13.39	8.82	6.53
Municipal Primary	9.19	6.05	4.48
Municipal Secondary	20.20	13.30	9.85

Fruits - 1.24 tonnes raw product per tonne finished product,

Vegetables - 2.21 tonnes raw product per tonne finished product,

Fruit and Vegetables - 2.01 tonnes raw product per tonne finished product.

These factors were used to develop total annual waste treatment costs in terms of tonnes of finished product presented in Table 65.

6.3.3 Industry pricing practices

In the absence of pertinent financial information including industry costs and wholesale prices, it was necessary to estimate processing selling prices from retail prices. Three major supermarket chain stores in Edmonton were surveyed and retail prices were obtained for a broad variety of canned fruits and vegetables. Values per metric tonne of finished product were developed based on these retail prices.

In order to convert retail prices to processor's selling prices, it was necessary to determine the mark-up added to commodity prices by food distributors. On the basis of the Food Prices Review Board publication "Food Company Profits and Food Prices II", October 1975, and other information, the mark-up was estimated to be approximately 20%. Therefore, processors' selling prices were taken to be 80% of the retail prices.

The waste treatment information provided in the report does not consider each fruit and vegetable commodity individually; rather it considers these commodities under the three categories: fruits, vegetables, and fruits and vegetables. Composite prices for these three categories were determined by multiplying the estimated processors' selling price for each commodity in each category by the commodity share of the category total production given in Tables 1 and 2.

It was found that retail selling prices were independent of plant size, apart from "house" brands which were somewhat less than other brands. As discussed in Section 3, in reviewing the operation of the industry, small processors tended not to market under their own label.

The three composite processors' selling prices were determined to be as follows:

fruits: $885.11 per metric tonne of finished product,

TABLE 65. TOTAL ANNUAL WASTE TREATMENT COSTS ACCORDING TO PLANT SIZE ($/t finished product)

	PLANT SIZE								
	SMALL			MEDIUM			LARGE		
	F	V	F & V	F	V	F & V	F	V	F & V
Activate Sludge	28.54	50.87	46.27	18.79	33.48	30.45	13.91	24.80	22.55
Aerated Lagoon	16.55	29.50	26.83	10.91	19.45	17.69	8.07	14.39	13.09
Holding Lagoon	8.82	15.71	14.29	5.79	10.32	9.39	4.30	7.67	6.97
Land Application	25.58	45.59	41.47	16.85	30.03	27.32	12.44	22.17	20.16
Municipal Primary	11.40	20.31	18.47	7.50	13.37	12.16	5.56	9.90	9.00
Municipal Secondary	25.05	44.64	40.60	16.49	29.39	26.73	12.21	21.77	19.80

F: Fruit processors V: Vegetable processor F & V: Fruit/vegetable processor vegetables: $900.31 per metric tonne,

fruit and vegetables: $897.11 per metric tonne.

The basic question to be answered by any firm or industry facing cost increases is whether or not the cost increases can be passed forward to the consumer. In the case of fruit and vegetable processors, it appears to be unlikely that these added costs could be passed forward since the industry is highly price competitive. Commodities are sold by established grade and a large portion of production is sold under private labels (e.g. supermarket "house" brands); thus, most companies are forced to compete through price. Domestic processors are also faced with direct competition from imported products which in most cases are lower priced.

Therefore, price changes within the industry are usually initiated by the lowest cost producers who are generally the largest processors because of economies of scale. Large plants with lower unit costs would tend to establish new price levels, passing forward some or all of the added costs of waste treatment. Some of the smaller firms would be able to recover part of the increased costs without pricing themselves out of their present market position.

However, based on the analysis of the industry discussed in Section 4, almost all large firms already provide in-plant secondary treatment or discharge directly to municipal systems having secondary treatment. Thus, it would seem that large firms would have no increased cost to pass on; those few large firms that are faced with such costs would probably be forced to absorb these costs. Similarly, and most important, the medium and small sized firms would not be able to pass on the waste treatment costs.

Two additional factors which add to the intra-industry competitive pressures should be considered: high consumer resistance to food price increases, and strong government pressure against food price increases through both moral suasion and price control regulations.

6.3.4 Effects of treatment costs on profits

Based on the above discussion, it is probable that firms faced with cost increases due to the installation of waste treatment systems will not be able to pass these cost increases forward and will therefore

TABLE 66. TREATMENT COSTS RELATIVE TO INDUSTRY SELLING PRICES (%)

	PLANT SIZE								
	SMALL			MEDIUM			LARGE		
	F	V	F & V	F	V	F & V	F	V	F & V
Activate Sludge	3.2	5.7	5.2	2.1	3.7	3.4	1.6	2.8	2.5
Aerated Lagoon	1.9	3.3	3.0	1.2	2.2	2.0	0.9	1.6	1.5
Holding Lagoon	1.0	1.7	1.6	0.7	1.1	1.0	0.5	0.9	0.8
Land Application	2.9	5.1	4.6	1.9	3.3	3.0	1.4	2.5	2.2
Municipal Primary	1.3	2.3	2.1	0.8	1.5	1.4	0.6	1.1	1.0
Municipal Secondary	2.8	5.0	4.5	1.9	3.3	3.0	1.4	2.4	2.2

F: Fruit processor V: Vegetable processor F & V: Fruit/vegetable processor be required to absorb these costs out of profits. Table 66 presents treatment costs per metric tonne of finished product as percentages of current processor selling prices per metric tonne of finished product. The values in Table 66 are based on treatment costs given in Table 65 and the composite selling prices given earlier in this section. The figures indicate the level of pre-tax profits on sales required to absorb the treatment costs. For example, for a small vegetable processor to install an in-plant activated sludge system, treatment costs will account for 5.7% of the price at which the vegetables are sold; therefore, the processor must presently be operating with a pre-tax profit margin on sales exceeding 5.7% if that processor is to continue realizing any profits on sales after the raw treatment costs come into effect.

The Food Prices Review Board, in its publication "Food Company Projects and Food Prices II", October 1975, provides data indicating that seven large fruit and vegetable processors averaged pre-tax profit margins of 7.6% in 1974. Investigations carried out as part of the preparation of the inventory have been unable to confirm the continuance of such margins. Data obtained from Dun & Bradstreet reports on six large and medium sized firms for 1975 and the first quarter of 1976 showed margins ranging from 1.8% to 6.6% (average 3.9%).

It is very likely that the economic slowdown of the last two years in Canada, combined with government and consumer pressure against food price increases, has led to decreases in profit margins. While it is possible that some large firms may still be realizing profit margins in the 6 - 7% range, it is most unlikely that smaller firms are attaining these levels of profit. Small and medium sized plants experience higher unit costs than larger plants; in addition, competition forces the smaller processor to sell at prices which may be 20% lower than those of large processors. It is suggested that most small processors are realizing pre-tax profit margins in the 1.5 - 3% range, with most medium sized processors realizing margins in the 2 - 4% range.

It should also be noted that many firms produce commodities whose selling prices are considerably lower than the estimated processors' composite selling prices used in this report; a number of canned vegetable products sell for less than $600 per metric tonne. This fact has to be taken in conjunction with the high profit margins required to finance waste treatment systems as illustrated in Table 66.

6.3.5 Availability of capital

A firm may finance new investment through any one or more of three sources: loans from outside sources; sale of shares in the company; internally generated funds (e.g. retained earnings). The major criterion in the availability of investment funds is the expected future profitability of the firm.

From the discussion on industry profit margins, it is very clear that many small firms whose profit margins will seriously diminish, if not disappear, do not stand a good chance of attracting the capital required to install waste treatment systems. Some plants in the medium sized category will also face erosion of profits to a point where capital financing will be difficult.

For those plants expected to continue operation with satisfactory profit levels after the addition of waste treatment costs, it is assumed that capital availability will not be a serious problem.

6.4 Economic and Environmental Impact of Waste Treatment Systems

An attempt has been made to establish the level of pre-tax profits which an individual fruit and/or vegetable processing firm must presently attain if that firm is to be able to absorb the added costs of waste treatment while still maintaining financial profitability. It is necessary to consider the environmental benefit acruing from introduction of specific waste treatment systems as measured by the reduction in the quantity of BOD_5 discharged.

It was shown in Section 5 that the greatest impact of the introduction of waste treatment facilities in terms of reduction of BOD_5 discharged would be on the medium sized plants. For example, upgrading medium plants (those currently not treating the wastewater or discharging to a municipality having no treatment system) to incorporate holding lagoons would reduce the total residual BOD_5 by 1599 x 10^3 kg or by 56% of the total residual BOD_5

Table 66 gives treatment costs as a percentage of processor selling prices, in particular:

small plant: holding lagoon 1.0 - 1.6%,
aerated lagoon 1.9 - 3.3%,
activated sludge 3.2 - 5.7%.

medium plant: holding lagoon 0.7 - 1.1%,
aerated lagoon 1.2 - 2.2,
activated sludge 2.1 - 3.7%.

On the basis of small plants realizing a pretax profit margin of 1.5 - 3%, the introduction of secondary treatment facilities may not be economically viable. In addition, a relatively small reduction in total residual BOD_5 results. On the basis of a 2 - 4% profit margin for a medium sized plant, the introduction of secondary treatment facilities would affect marginal operations.

Thus, from an economic standpoint, two important conclusions can be draw regarding the requirement for secondary treatment in those fruit and vegetable industry plants currently providing no treatment and not discharging to municipal systems:

1) Introduction of secondary treatment in small plants could potentially place undue economic hardship on these plants.

2) In considering the introduction of secondary treatment into medium sized plants, each case should be considered on its own merits.

In the development of environmental controls, these two conclusions should be taken into consideration before setting waste treatment requirements applicable to the industry as a whole.

ACKNOWLEDGEMENTS

The preparation of this report would not have been possible without the assistance and cooperation of government and industry.

The individuals involved are too numerous to mention but the assistance of Fisheries and Environment Canada and other Departments of the federal government, including Statistics Canada and Agriculture Canada, is acknowledged.

A report of this nature could not have been produced without the cooperation of individuals and companies within the fruit and vegetable processing industry, especially those who took time and care in responding to the questionnaires. The discussions with the Canadian Food Processors Association and with Mr. R.F. Barratt, Editor, Food in Canada, were invaluable.

APPENDIX I

CONVERSION FACTORS

APPENDIX 1

CONVERSION FACTORS

The following conversion factors were used in converting data available in English units to the metric system of units. A number of conversion factors are also included to show the relationship between the various units which may be used for a given parameter.

It should be noted that the multipliers given in Table I are for converting from English units to S.I. Symbols are defined at the end of this appendix in Table II.

TABLE I. CONVERSION FACTORS

ENGLISH UNIT	MULTIPLIER	S.I. UNIT
acre	4,046	m^2
acre	0.405	ha
acre-ft	1,234	m^3
cu ft	0.028	m^3
cu in	16.39	cm^3
cfm	0.02832	m^3/min
cfs	1.70	m^3/min
ft	0.3048	m
°F	0.5555 (°F - 32)	°C
gal (Imp)	0.004546	m^3
gal (US)	0.003785	m^3
gpd/sq ft (US)	0.0408	$m^3/day/m^2$
gpm (Imp)	0.2728	m^3/hr
gpm (US)	0.2271	m^3/hr
in	2.54	cm
lb (mass)	0.4546	kg
lb/cu ft	16.02	kg/m^3
lb/1000 cu ft	16.02	g/m^3
lb/day/acre	0.112	$g/day/m^2$
lb/day/acre - ft	3.68	$g/day/m^3$
lb/day/cu ft	16.02	$kg/day/m^3$
lb/day/sq ft	4.880	$g/day/m^2$
lb/day/1000 sq ft	4880	$g/day/m^2$
lb/ton	0.5	kg/t
mgd (Imp)	4546	m^3/day
mgd (US)	3,7785	m^3/day
sq ft	0.09290	m^2
ton	9072	kg
ton	0.9072	t

TABLE II. SYMBOL DEFINITION

SYMBOL	DEFINITION
cu ft	cubic feet
in	inch
cfm	cubic feet per minute
cfs	cubic feet per second
gpd	gallons per day
lb	pound
sq ft	square feet
ton	short ton
mgd	million gallons per day
m	metre
ha	hectare
cm	centimetre
kg	kilogramme
t	metre tonne

APPENDIX II

SAMPLE QUESTIONNAIRE

APPENDIX II

FRUIT AND VEGETABLE PROCESSING INDUSTRY

ENVIRONMENTAL INVENTORY

INSTRUCTIONS

I. THE PRIMARY INTENT OF THIS QUESTIONNAIRE IS TO GATHER AVAILABLE INFORMATION ON THE WATER-BORNE WASTES GENERATED AT YOUR PLANT(S). ADDITIONAL TESTING PROGRAMS NEED NOT BE CONDUCTED IN ORDER TO PROVIDE THIS INFORMATION.

II. THE INFORMATION COLLECTED BY ENVIRONMENT CANADA IS CONSIDERED CONFIDENTIAL AND WILL NOT BE RELEASED ON A SITE-SPECIFIC BASIS.

III. INFORMATION IS REQUESTED ON ALL FRUIT AND/OR VEGETABLE PROCESSING PLANTS OWNED OR OPERATED BY YOUR COMPANY IN CANADA. INCLUDED IN THIS CATEGORY ARE PLANTS WHICH MANUFACTURE

> ". . . CANNED, FROZEN OR OTHERWISE PRESERVED FRUITS AND VEGETABLES, VEGETABLE AND FRUIT JUICES, SOUPS, PICKLES, JAMS, JELLIES, MARMALADES, CIDER, SAUCES AND VINEGARS". (Standard Industrial Classification 103)

IV. INFORMATION SHOULD BE PROVIDED FOR 1975 OR THE MOST RECENT YEAR FOR WHICH DATA IS AVAILABLE. A SEPARATE QUESTIONNAIRE SHOULD BE COMPLETED FOR EACH INDIVIDUAL MANUFACTURING PLANT SITE. (ADDITIONAL COPIES OF THE QUESTIONNAIRE WILL BE MADE AVAILABLE UPON REQUEST).

V. FROM PAST EXPERIENCE IT HAS BEEN FOUND THAT IT IS MOST BENEFICIAL TO APPOINT ONE PERSON WITHIN THE COMPANY TO CO-ORDINATE THE DISTRIBUTION AND COLLECTION OF ALL QUESTIONNAIRES. THIS PERSON WILL ACT AS THE COMPANY LIAISON FOR ANY FUTURE REQUESTS.

THIS PAGE WILL BE REMOVED BY ENVIRONMENT CANADA AND THE REMAINING QUESTIONNAIRE CODED PRIOR TO ANALYSIS OF INFORMATION CONTAINED IN THIS QUESTIONNAIRE. IN THIS MANNER THE CONFIDENTIALITY OF THE DATA WILL BE ENSURED.

Name of Firm ______________________________

Head Office Address ______________________________

____

____

Phone ______________________________

Manufacturing Plant Site Address ______________________________

____

____

Person to be contacted for further information

Name ______________________ Phone ______________________

Title ______________________

Company Code ______________________________

SECTION 1 GENERAL INFORMATION

1.1 Location of Manufacturing Plant Site (Province)________________.

1.2 Please indicate the year for which information is being provided._______

1.3 Please indicate total number of processing days in each month and the average number of hours per day in each month for the major operations below:

Month	Number of Processing Days	Average Hours per Day: Processing of Raw Material	Repacking or Formulating*	Cleanup
January	________	________	________	______
February	________	________	________	______
March	________	________	________	______
April	________	________	________	______
May	________	________	________	______
June	________	________	________	______
July	________	________	________	______
August	________	________	________	______
September	________	________	________	______
October	________	________	________	______
November	________	________	________	______
December	________	________	________	______

* Formulating means using semi-processed fruits and/or vegetables in the manufacture of products such as soups, jams, jellies, etc.

SECTION 2 PRODUCTION INFORMATION

Information relating to production is necessary to determine the relative plant sizes of various segments of the Canadian industry. Please indicate the appropriate production levels for the various raw materials processed or products manufactured.

2.1 For those plants which process raw fruits and/or vegetables, please indicate the annual quantity of raw materials received at your plant by checking the appropriate size category (all quantities in <u>tons</u>):

I <u>Vegetable Processing</u>

1. Peas

under 1000 ____	1000 to 2000 ____	2000 to 3000 ____	3000 to 4000 ____	4000 to 5000 ____	more than 5000 ____

2. Corn

under 5000 ____	5000 to 8000 ____	8000 to 12,000 ____	12,000 to 16,000 ____	16,000 to 20,000 ____	more than 20,000 ____

3. Tomatoes

under 2000 ____	2000 to 5000 ____	5000 to 10,000 ____	10,000 to 20,000 ____	20,000 to 30,000 ____	more than 30,000 ____

4. Green/wax beans

under 1000 ____	1000 to 2000 ____	2000 to 3000 ____	3000 to 4000 ____	4000 to 5000 ____	more than 5000 ____

5. All other beans

under 1000 ____	1000 to 4000 ____	4000 to 10,000 ____	10,000 to 20,000 ____	20,000 to 30,000 ____	more than 30,000 ____

6. Beets

under 100 ____	100 to 200 ____	200 to 400 ____	400 to 700 ____	700 to 1000 ____	more than 1000 ____

7. Other Root Crops (Combined)

under 1000 ____	1000 to 2000 ____	2000 to 3000 ____	3000 to 4000 ____	4000 to 5000 ____	more than 5000 ____

8. Asparagus

under 100 ____	100 to 200 ____	200 to 400 ____	400 to 700 ____	700 to 1000 ____	more than 5000 ____

. . ./3

9. Other Green Vegetables (broccoli, spinach, cauliflower, etc. combined)

under 100 ______	100 to 200 ______	200 to 400 ______	400 to 700 ______	700 to 1000 ______	more than 1000 ______

10. Cucumbers

under 100 ______	100 to 500 ______	500 to 1000 ______	1000 to 2000 ______	2000 to 4000 ______	more than 4000 ______

II. <u>Fruit Processors</u>

1. Peaches

under 1000 ______	1000 to 2000 ______	2000 to 3000 ______	3000 to 4000 ______	4000 to 5000 ______	more than 5000 ______

2. Pears

under 1000 ______	1000 to 2000 ______	2000 to 3000 ______	3000 to 4000 ______	4000 to 5000 ______	more than 5000 ______

3. Apples

under 500 ______	500 to 1000 ______	1000 to 3000 ______	3000 to 5000 ______	5000 to 10,000 ______	more than 10,000 ______

4. Cherries

under 100 ______	100 to 200 ______	200 to 300 ______	300 to 400 ______	400 to 500 ______	more than 500 ______

5. All other fruit

under 100 ______	100 to 200 ______	200 to 300 ______	300 to 400 ______	400 to 500 ______	more than 500 ______

2.2 For those plants which process raw fruits and/or vegetables, please list the major* raw materials processed and indicate the percentage of material which is converted into each product style**

* <u>major</u> constitutes at least 10% of materials received.

** product styles include canned (bottled, frozen, formulated or dehydrated.
(Example: Peas - 40 40 20 0)

Raw Material	Percentage of Material: Canned	Frozen	Formulated	Dehydrated
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______
______	______	______	______	______

(Cont'd)

___________ ________ ________ ___________ ___________
___________ ________ ________ ___________ ___________
___________ ________ ________ ___________ ___________
___________ ________ ________ ___________ ___________
___________ ________ ________ ___________ ___________

2.3 For those plants which formulate products from either raw or semi-processed fruits and/or vegetables, please indicate the number of cases* produced annually for the products listed.

Soups (including dehydrated products)
A________ B________ C________ D________ E________ F________
Jams, Jellies & Marmalades
A________ B________ C________ D________ E________ F________
Stews (including pork & beans, canned spaghetti, etc.)
A________ B________ C________ D________ E________ F________
Pickles
A________ B________ C________ D________ E________ F________
Baby Food
A________ B________ C________ D________ E________ F________
Reconstituted Vegetable and/or Fruit Juices
A________ B________ C________ D________ E________ F________
Ciders, Vinegars
A________ B________ C________ D________ E________ F________
Other Products
A________ B________ C________ D________ E________ F________

* a case is equivalent to 24 - 19 ounce tins

Size Categories

A - under 100,000 cases
B - 100,000 to 250,000 cases
C - 250,000 to 500,000 cases
D - 500,000 to 1,000,000 cases
E - 1,000,000 to 5,000,000 cases
F - more than 5,000,000 cases

. . ./5

SECTION 3 WATER SUPPLY AND IN-PLANT WATER USE

Water Supply

3.1 Source of Water Supply

(i)	Private Well	________	Imp. gallons per year
(ii)	Municipal	________	"
(iii)	River, Lake, estuary	________	"
(iv)	Other	________	"

Total Volume of Water Used

________ Imperial gallons per year

Is water supply estimated ______ or metered ________ at your plant?

3.2 Please indicate if your plant treats in-take water prior to in-plant use? If yes, specify type of treatment.

____

____

In-Plant Water Use

Please answer the following questions with respect to the in-plant treatment and characteristics of wastewater.

3.3 Is grit removal provided? If yes, specify type.

Yes______ No_______ Type__________________

3.4 Is fat (grease and oil) removal provided? If yes, specify type.

Yes______ No_______ Type__________________

3.5 Is screening provided? Yes______ No______

If yes, please specify type and mesh size.

Vibrating ________________

Tangential________________

Other ________________

3.6 For the major raw materials processed and formulated products manufactured, please indicate typical quantities of wastewater discharged and if possible typical values and/or ranges for the parameters listed.

. . ./6

Raw Material or Product	Process Water Flow gal/ton raw material gal or/case formulated	BOD ppm	Suspended Solids ppm	pH
Peas				
Corn				
Tomatoes				
Beans				
Other Vegetables				
Fruits ( )				
Formulated ( )				
Formulated ( )				
Other Products ( )				
Total Plant Wastewater				

(   ) please specify item in brackets

SECTION 4 WASTEWATER TREATMENT

4.1 Other than the in-plant pretreatment systems mentioned in section 3, does your plant own and operate wastewater treatment facilities?

Yes______ Answer questions 4.2 through 4.7

No_______ Answer questions 4.6 and 4.7

4.2 Are solids-separation processes such as clarification or settling tanks provided? Yes______ No______

If yes, what is average retention time? __________ hours

what is volume of clarification? __________ cubic feet

what is average suspended solids removal efficiency through clarification __________ percent

4.3 Is biological treatment provided? Yes______ No______

If yes, please indicate type, volume and removal efficiency for BOD and suspended solids.

Holding Lagoons ______________________________

Aerated Lagoons ______________________________

Activated Sludge______________________________

Trickling Filter______________________________

Other (Specify) ______________________________

. . ./7

4.4 Is wastewater applied to the land? Yes______ No______

If yes, indicate type of application, land area utilized and application rate.

Spray irrigation ______________________________

Soil biofiltration (Percolation)______________________________

Broad irrigation (flooding, overland, ridge and furrow) __________

____

Other (specify)______________________________

4.5 Please indicate total annual operating cost for wastewater treatment systems noted in questions 4.2 through 4.4.

______________ $/year

4.6 Is your in-plant wastewater or treated effluent discharged to a municipal sewage system?

Yes______ No______

If yes, indicate type of municipal treatment received.

____

____

If no, indicate to where it is discharged (eg. Mill Creek, Lake Ontario)? ______________________________

4.7 Is your firm planning to install new or additional wastewater treatment facilities in the near future?

Yes______ No______

If yes, indicate what these facilities will be and when they will be installed.

____

____

____

SECTION 5 FINAL EFFLUENT ANALYSIS

5.1 For any wastewater or treated effluent which leaves your plant site, have you had an analysis performed? Yes______ No______

5.2 If yes, fill in typical range of values on the following table or submit a copy of the analysis.

Date of Analysis: ______________________

	COOLING WATER		PROCESS WATER	
	PPM	LB./DAY	PPM	LB./DAY
BOD_5 (5-day Biochemical Oxygen Demand)	___	______	___	______
TOC (Total Organic Carbon)	___	______	___	______
COD (Chemical Oxygen Demand	___	______	___	______
Suspended Solids	___	______	___	______
Dissolved Solids	___	______	___	______
Oil and Grease	___	______	___	______
Total Kjeldahl Nitrogen as N	___	______	___	______
Total Phosphorus as P	___	______	___	______
pH	___	______	___	______
Temperature	___	______	___	______
Colour	___	______	___	______
Others (specify)	___	______	___	______
________	___	______	___	______

5.3 Remarks ____

____

____

____

THANK YOU FOR YOUR COOPERATION.