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DEVELOPMENT DOCUMENT FOR EFFLUENT LIMITATIONS GUIDELINES AND NEW SOURCE PERFORMANCE STANDARDS

MISCELLANEOUS FOODS AND BEVERAGES POINT SOURCE CATEGORY

PART II

EFFLUENT GUIDELINES DIVISION
OFFICE OF WATER AND HAZARDOUS MATERIALS
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MARCH 1975

NOTICE

The attached document is a DRAFT CONTRACTOR'S REPORT. It includes technical information and recommendations submitted by the Contractor to the United States Environmental Protection Agency ("EPA") regarding the subject industry. It is being distributed for review and comment only. The report is not an official EPA publication and it has not been reviewed by the Agency.

The report, including the recommendations, will be undergoing extensive review by EPA, Federal and State agencies, public interest organizations and other interested groups and persons during the coming weeks. The report and in particular the contractor's recommended effluent guidelines and standards of performance is subject to change in any and all respects.

The regulations to be published by EPA under Sections 304(b) and 306 of the Federal Water Pollution Control Act, as amended, will be based to a large extent on the report and the comments received on it. However, pursuant to Sections 304(b) and 306 of the Act, EPA will also consider additional pertinent technical and economic information which is developed in the course of review of this report by the public and within EPA. EPA is currently performing an economic impact analysis regarding the subject industry, which will be taken into account as part of the review of the report. Upon completion of the review process, and prior to final promulgation of regulations, an EPA report will be issued setting forth EPA's conclusions regarding the subject industry, effluent limitations guidelines and standards of performance applicable to such industry. Judgements necessary to promulgation of regulations under Sections 304(b) and 306 of the Act, of course, remain the responsibility of EPA. Subject to these limitations, EPA is making this draft contractor's report available in order to encourage the widest possible participation of interested persons in the decision making process at the earliest possible time.

The report shall have standing in any EPA proceeding or court proceeding only to the extent that it represents the views of the Contractor who studied the subject industry and prepared the information and recommendations. It cannot be cited, referenced, or represented in any respect in any such proceedings as a statement of EPA's views regarding the subject industry.

U. S. Environmental Protection Agency
Office of Water and Hazardous Materials
Effluent Guidelines Division
Washington, D. C. 20460

Please note: Because of the volume of this report, it has been printed in the following manner: "Miscellaneous Foods and Beverages."

Part I	Pgs. 1-292	Section I-IV
Part II	Pgs. 293-500	Section V-VI
Part III	Pgs. 501-840	Section VII
Part IV	Pgs. 841-1196	Section VIII (partial)
Part V	Pgs. 1197-1548	Section VIII (cont.) - XIV

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PART II

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FOR:
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SECTION V

WATER USE AND WASTE CHARACTERIZATION

The purpose of this section is to identify, for those subcategories defined in Section IV, the wastewater quantities and constituents which are characteristic of the subcategory. For each subcategory discussed herein, a representative model is developed and defined in terms of wastewater flow and characteristics.

It should be carefully noted that within this document, all pollutant concentrations and loadings, unless otherwise specified, are in terms of net units, i.e., do not include pollutants entering the process in the fresh water supply.

It should also be noted that the raw wastewater flows and characteristics described for each model plant are intended only to be representative of the subcategory, primarily as a basis for developing control and treatment technology and cost analyses to be developed subsequently in Sections VII and VIII of this document. These values should not under any conditions be construed as being exemplary nor used as a basis of pretreatment guidelines for industrial discharges into publicly owned treatment works.

All pollutant parameters (except pH, color, and temperature) are ultimately expressed as a ratio of their mass in kilograms to a process unit. The process unit may be kkg or cu m (or in one case proof gallons) of product or raw material produced or consumed per day. Table 16 defines the process units used for each subcategory.

VEGETABLE OIL PROCESSING AND REFINING

That segment of the miscellaneous foods and beverages industry involved in the processing and refining of vegetable oil (including the production of margarine) has been subcategorized into subcategories A 1 through A 15 (see Table 13 in Section IV.)

Subcategories A 1 through A 4 cover those installations processing unrefined vegetable oil from various oilseeds and the production of olive oil by hydraulic press and solvent extraction in combination, and by mechanical screw press extraction.

Subcategories A 5 through A 15 include those installations engaged in what can generally be called edible oil refining. The historical data complied for this study by the Institute of Shortening and Edible Oils (ISEO) in conjunction with contractor plant visitations and verification sampling of ten plants represents the most current information available on the wastewater characteristics of edible oil refineries. Wastewater

TABLE 16

PROCESS UNITS EMPLOYED FOR

THE MISCELLANEOUS FOODS AND BEVERAGES

POINT SOURCE CATEGORY

SUBCATEGORY	PROCESS UNIT
VEGETABLE OIL PROCESSING AND REFINING	
A1, A2,	kkg of oilseed crushed/day.
A3, A4	kkg of raw olives crushed/day.
A5 - A12	kkg of crude oil processed/day.
A13, A14, A15	kkg of finished product.
BEVERAGES	
A16, A17, A18	cu m of beer produced/day.
A19	kkg of barley processed/day.
A20, A21	during crushing, kkg of grapes crushed/ day; during processing, cu m of wine produced/day.
A22, A23	kkg of grain mashed/day.
A24	proof gallons of spirits produced/day.
A25	None.
A26, A27	cu m of beverage produced/day.

TABLE 16 (CONT'D)

SUBCATEGORY	PROCESS UNIT
BEVERAGES	
A28	cu m of syrup or concentrate produced/day.
A30	kkg of instant tea produced/day.
C8, C9, C10	kkg of green coffee beans.
F1	None.
BAKERY AND CONFECTIONERY PRODUCTS	
All Subcategories	kkg of finished product/day
PET FOODS	
All Subcategories	kkg of finished product/day.
MISCELLANEOUS AND SPECIALITY ITEMS	
A29	cu m of finished product/day.
A31	kkg of granular bouillon produced/day.
A32	kkg of solid product produced/day.
A33	(1) kkg of yeast packaged/day.

TABLE 16 (CONT'D)

SUBCATEGORY	PROCESS UNIT
A34, A35	kkg of peanut butter produced/day.
A36	kkg of dry pectin produced/day.
A37, B1-B4, C6, C12, D4	kkg of finished product/day.
C4, C5	kkg of raw eggs processed/day.
E1-E6, F2-F4	None.

characteristics within the industry vary widely from plant to plant due to differences in degrees of process variation, plant size, and the types of oils processed daily. However, for the most part, process variation is the single most important factor in determining the total waste load for a particular refining operation. The total waste loading for an edible oils refinery is dependent upon the individual waste load contributions from the various integrated process units within the refinery. In general terms, large, integrated, full scale refineries produce significantly higher wasteloads than small, less integrated operations.

The principle sources of wastewater discharge within the industry are from the following process units: acidulation; caustic refining; contact cooling tower blowdown from barometric condensers; tank car cleaning; storage and handling facilities; margarine; shortening; and table oils packaging; and general cleanup from oil processing procedures such as hydrogenation, bleaching, deodorization, and winterization. Figure 42 in Section III presents a schematic diagram of the various wastewater flows from individual process units for a typical full scale, integrated, edible oils refining operation. Table 17 presents a summary of the waste loading characteristics of individual unit processes commonly associated with edible oil refineries as described in Section III. Due to the high degree of variability in refinery plant size and process integration, it was necessary to adopt a building block approach for the formulation of the model plant and its associated unit process waste streams. Model plants were developed for subcategories A 5 through A 14 by combining the waste load for the various unit processes making up a subcategory. For example the Subcategory A 5 model plant, includes the unit processes of caustic refining, tank car cleaning and storage and handling. A total waste load for Subcategory A 5 was derived by converting all unit process waste loads to a 454 kkg (500 ton) per day plant and then, by summation of the unit waste loads, a total waste load was assumed for each parameter. The hypothetical model plants developed utilizing this procedure are intended to be representative of the subcategory as it presently exists, but cannot be expected to be identical to any particular plant. In some cases the model may be representative of an actual refinery only to a limited extent, but in all cases the model is considered adequate for the purpose of developing control and treatment technology (Section VII) and for cost analyses (Section VIII).

SUBCATEGORY A 1, OILSEED CRUSHING, EXCEPT OLIVE OIL, FOR DIRECT SOLVENT EXTRACTION AND PREPRESS SOLVENT EXTRACTION OPERATIONS

A total of six direct solvent extraction plants and two prepress solvent extraction facilities were visited and verification sampling was conducted at four direct solvent extraction plants.

TABLE 17

SUMMARY OF UNIT PROCESS RAW DATA ON EDIBLE OIL REFINERY WASTEWATER CHARACTERISTICS

Unit Process		Production KKG/DAY	Flow M^3/DAY	BOD kg/kkg	COD kg/kkg	SS kg/kkg	O & G kg/kkg	PH Range	BOD/COD Ratio	BOD/O & G Ratio
Caustic Refining	Ave.	320	72	1.01	1.8	0.51	0.61	7.3 - 11.9	0.46	3.4
	Std. Dev.	221	145	1.58	1.7	1.13	0.86		0.19	3.9
Acidulation	Ave.	486	225	4.69	14.97	1.66	1.20	0.6 - 3	0.58	77.69
	Std. Dev.	459	148	5.08	23.44	3.84	3.06		0.20	153.56
Contact Cooling Tower Blowdown	Ave.	348	178	2.21	4.24	0.31	0.30	3.3 - 7.3	0.53	15.91
	Std. Dev.	264	135	3.51	5.73	0.37	0.34		0.16	25.78
Oil Processing*	Ave.	389	25	0.09	0.22	0.05	0.02	7.3 - 13.0	0.48	13.99
	Std. Dev.	212	22	0.23	0.47	0.08	0.03		0.22	34.33
Tank Car Cleaning	Ave.	167	38	0.49	1.38	0.19	0.20	5.5 - 8.9	0.42	4.36
	Std. Dev.	112	32	0.84	2.41	0.24	0.31		0.25	4.87
Storage and Handling	Ave.	285	83	1.36	3.83	0.87	0.69	2.5 - 11.1	0.51	53.89
	Std. Dev.	80	159	4.33	14.60	2.54	2.47		0.11	201.79
Shortening and Table Oil Production	Ave.	195	75	0.48	0.19	0.18	0.19	6.1 - 11.5	0.52	5.08
	Std. Dev.	103	113	0.75	0.15	0.24	0.38		0.10	6.68
Margarine Production	Ave.	112	169	1.93	4.23	1.34	2.86	6.0 - 8.0	0.53	4.14
	Std. Dev.	61	139	4.06	5.63	2.41	5.6		0.23	4.29

* Includes floor wash and general cleanup of the following unit processes: Hydrogenation, deodorization, winterization, and Bleaching.

The principal sources of contact process wastewater generated from solvent extraction operations include wastewater generated from soybean oil degumming operations to remove and recover phosphatides (lecithin); wastewater generated from wet scrubber systems to reduce air particulate emmissions from mill preparation areas; wastewater containing oil, grease, and solvents, resulting from the extraction of oilseeds; steam condensates contaminated by oils, fatty acids, or hexane solvent; and periodic in-plant floor washing and equipment cleanup represented by oil or miscellaneous spillage, valve or pump leakage, etc. In addition to these process wastes, a large number of processors were observed to combine their process wastewaters with non-contact cooling water from cooling tower and boiler blowdown.

Historical data supplied by the NSPA and the National Cottonseed Producer's Association (NCPA) for 18 solvent extraction facilities in combination with four verification surveys found the following averages for Subcategory A 1 plants:

Production	780 kkg/day (860 ton/day)
Flow	140 cu m/day (0.037 MGD)
BOD	311 mg/l; 0.058 kg/kkg (0.115 lb/ton)
COD	619 mg/l; 0.140 kg/kkg (0.281 lb/ton)
SS	140 mg/l; 0.035 kg/kkg (0.07 lb/ton)
O&G	253 mg/l; 0.064 kg/kkg (0.128 lb/ton)
pH	6.2 to 10.4
BOD/COD Ratio	0.50
BOD/O&G Ratio	19.8

Table 18 presents a statistical description of the process wastewater characteristics compiled during the study including mean, standard deviations, minimum and maximum values.

There was a significant correlation observed in the industry between the volumes of process wastewater discharged per day and total daily production as is evidenced in Figure 107. However, there was no correlation indicated between production, BOD, COD, or oil and grease concentrations. These data are summarized by the scatter diagrams presented in Figures 108, 109, and 110.

Total Process Effluent

As indicated in the data presented above, the pollutant concentrations and waste loadings for solvent extraction plants are highly variable due to the following in-plant variations: (1) the amount of wet cleanup and general housekeeping practices utilized by each plant, (2) the quality of seed being crushed, and (3) plants that perform soybean oil degumming periodically in combination with solvent extraction processes.

TABLE 18

A STATISTICAL DESCRIPTION OF THE WASTEWATER CHARACTERISTICS FOR SOLVENT EXTRACTION PROCESS WASTEWATER

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF COVARIENCE (%)
Flow (MGD)	58	0.037069	0.019112	0.000365	0.003000	0.089300	51.557
Prod. (ton/day)	58	859.996552	428.025181	183205.555777	220.000000	1881.000000	49.771
BOD (mg/l)	49	311.367347	403.988381	163206.612245	60.000000	2800.000000	129.747
SS (mg/l)	52	139.884615	198.246297	39301.594268	3.000000	874.000000	141.721
COD (mg/l)	48	619.333333	572.186450	327397.333333	190.000000	2976.000000	92.387
*FOG (mg/l)	45	252.786667	759.765755	577244.002545	1.000000	4430.000000	300.556
BOD (lb/day)	49	78.002401	56.897093	3237.279242	4.506300	244.758850	72.943
COD (lb/day)	48	176.221113	154.727087	23940.471477	23.389366	804.644928	87.803
SS (lb/day)	52	38.317027	53.240701	2834.572216	0.626376	236.310372	138.948
FOG (lb/day)	45	68.104652	205.259085	42131.292056	0.191017	1197.774540	301.388
Lb/Ton-BOD	49	0.115201	0.121087	0.014662	0.015659	0.731781	105.109
kg/kkg-BOD	49	0.057601	0.060544	0.003666	0.007830	0.365890	105.109
Lb/Ton-COD	48	0.281114	0.350194	0.122636	0.024973	1.788100	124.574
kg/kkg-COD	48	0.140557	0.175097	0.030659	0.012486	0.894050	124.574
Lb/Ton-SS	52	0.070004	0.118903	0.014138	0.000783	0.525134	169.851
kg/kkg-SS	52	0.035002	0.059451	0.003534	0.000391	0.262567	169.851
Lb/Ton-FOG	45	0.127937	0.421886	0.177988	0.000239	2.661721	329.762
kg/kkg-FOG	45	0.063968	0.210943	0.044497	0.000119	1.330861	329.762
BOD/COD Ratio	40	0.503020	0.203246	0.041309	0.073925	0.931416	40.405
BOD/FOG Ratio	37	19.806625	32.029051	1025.860082	0.191972	135.000000	161.709
Flow Ratio	58	46.204019	19.213248	369.148884	13.636364	91.228070	41.583

* FOG = Fats, Oils, and greases.

N = Number of data points

Note: Computer calculations for this table show no regard for significant figures.

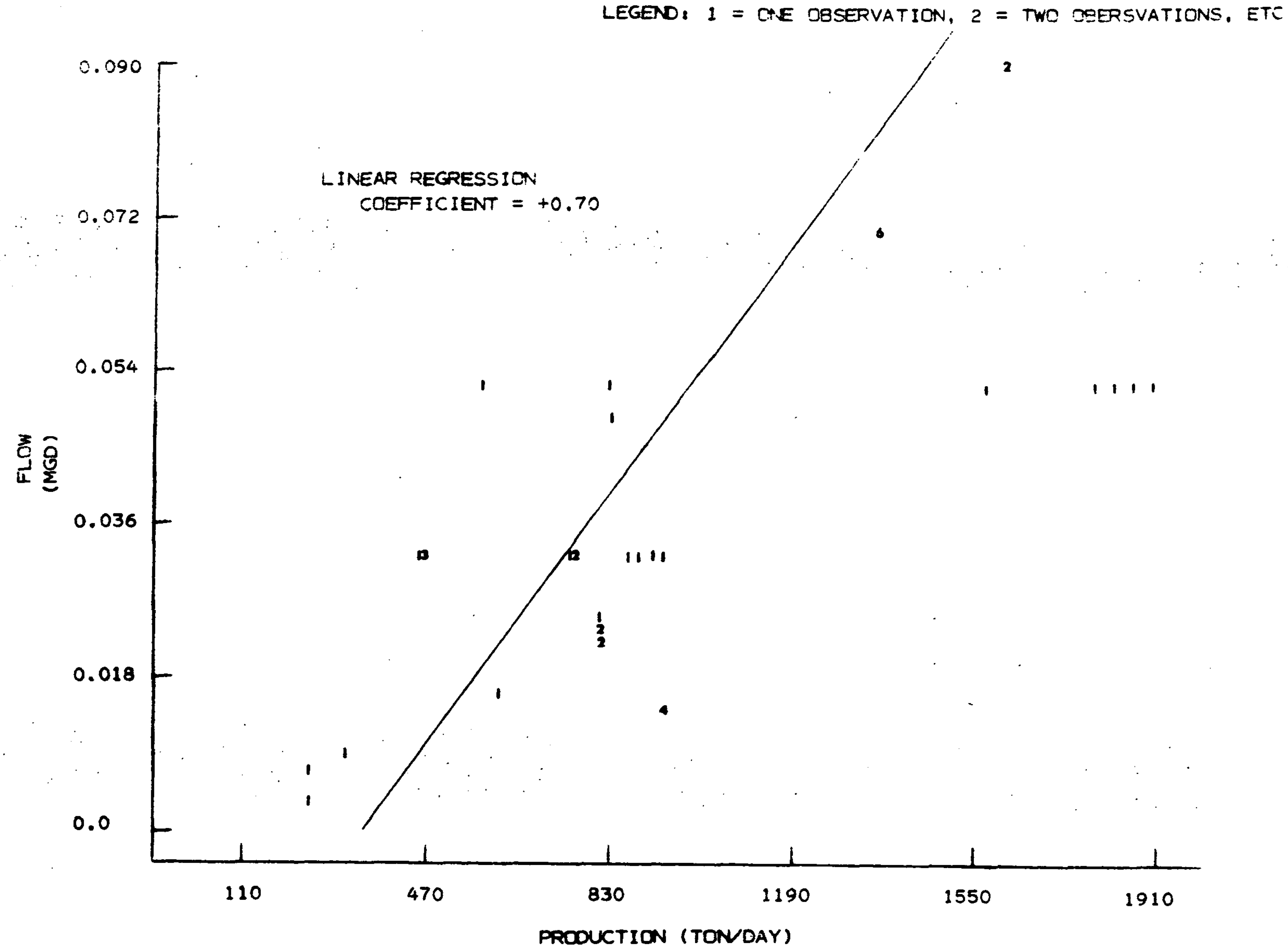

FIGURE 107

A LINEAR REGRESSION PLOT OF FLOW (MGD) VERSUS PRODUCTION (TON/DAY)
FOR PROCESS WASTEWATERS DISCHARGED FROM OILSEED SOLVENT EXTRACTION PLANTS, SUBCATEGORY A1

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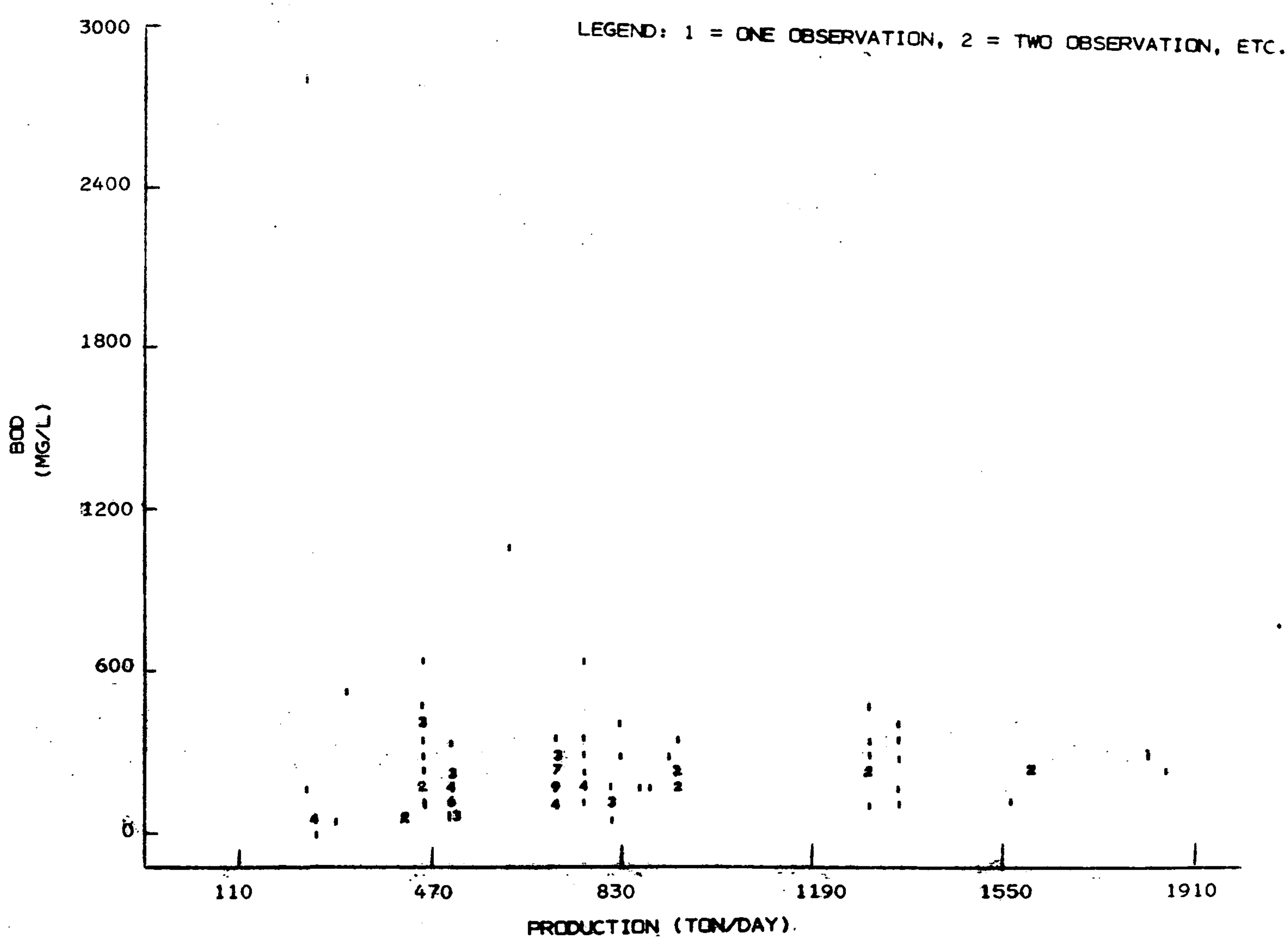

FIGURE 108

A SCATTER DIAGRAM PLOTTING BOD CONCENTRATION VERSUS PRODUCTION (TON/DAY) FOR THE PROCESS WASTEWATERS GENERATED FROM OILSEED SOLVENT EXTRACTION PLANTS, SUBCATEGORY A 1

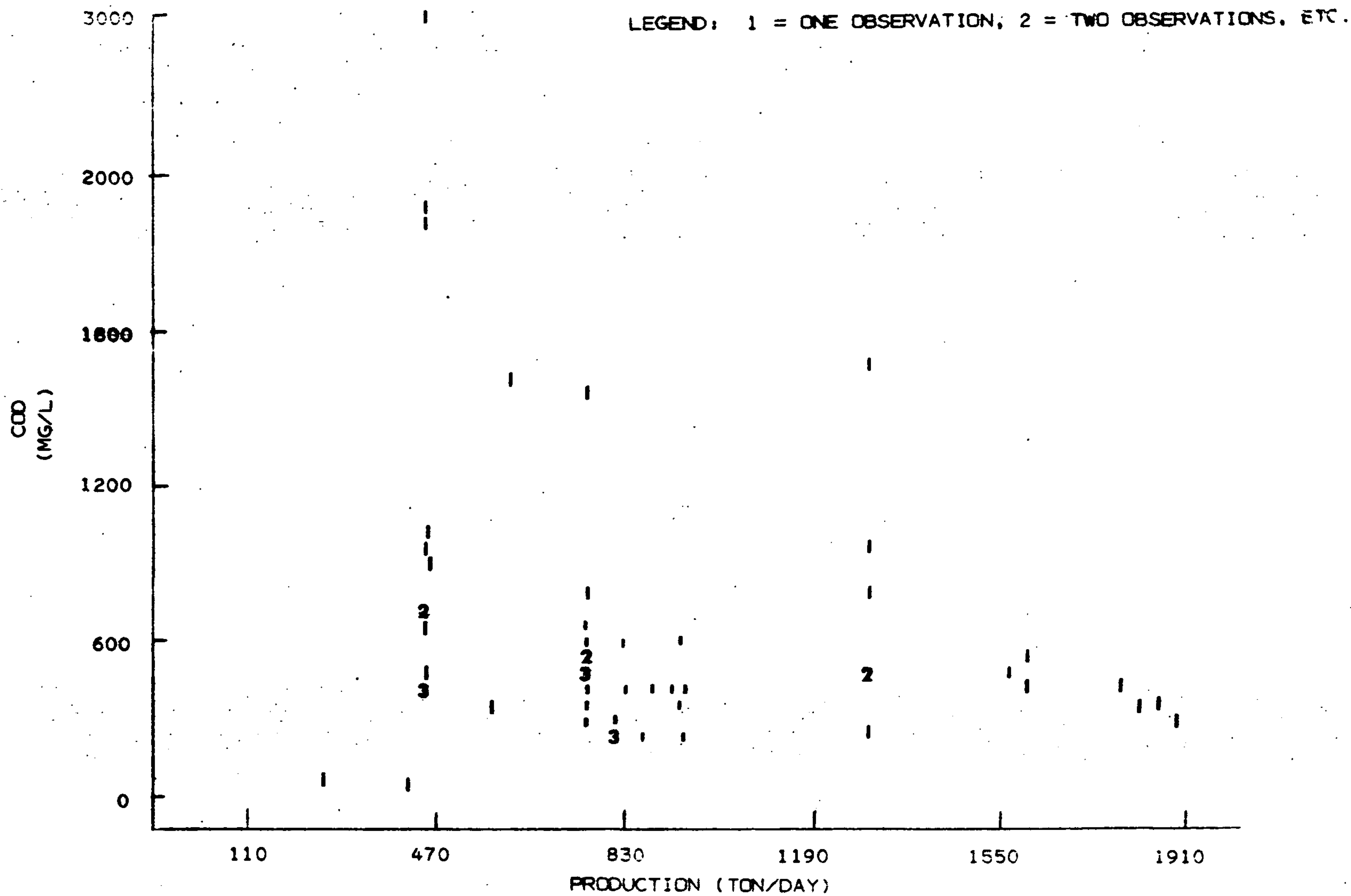

FIGURE 109

A SCATTER DIAGRAM PLOTTING COD CONCENTRATIONS VERSUS PRODUCTION (TON/DAY) FOR THE PROCESS WASTES FROM OILSEED SOLVENT EXTRACTION PLANTS, SUBCATEGORY A1

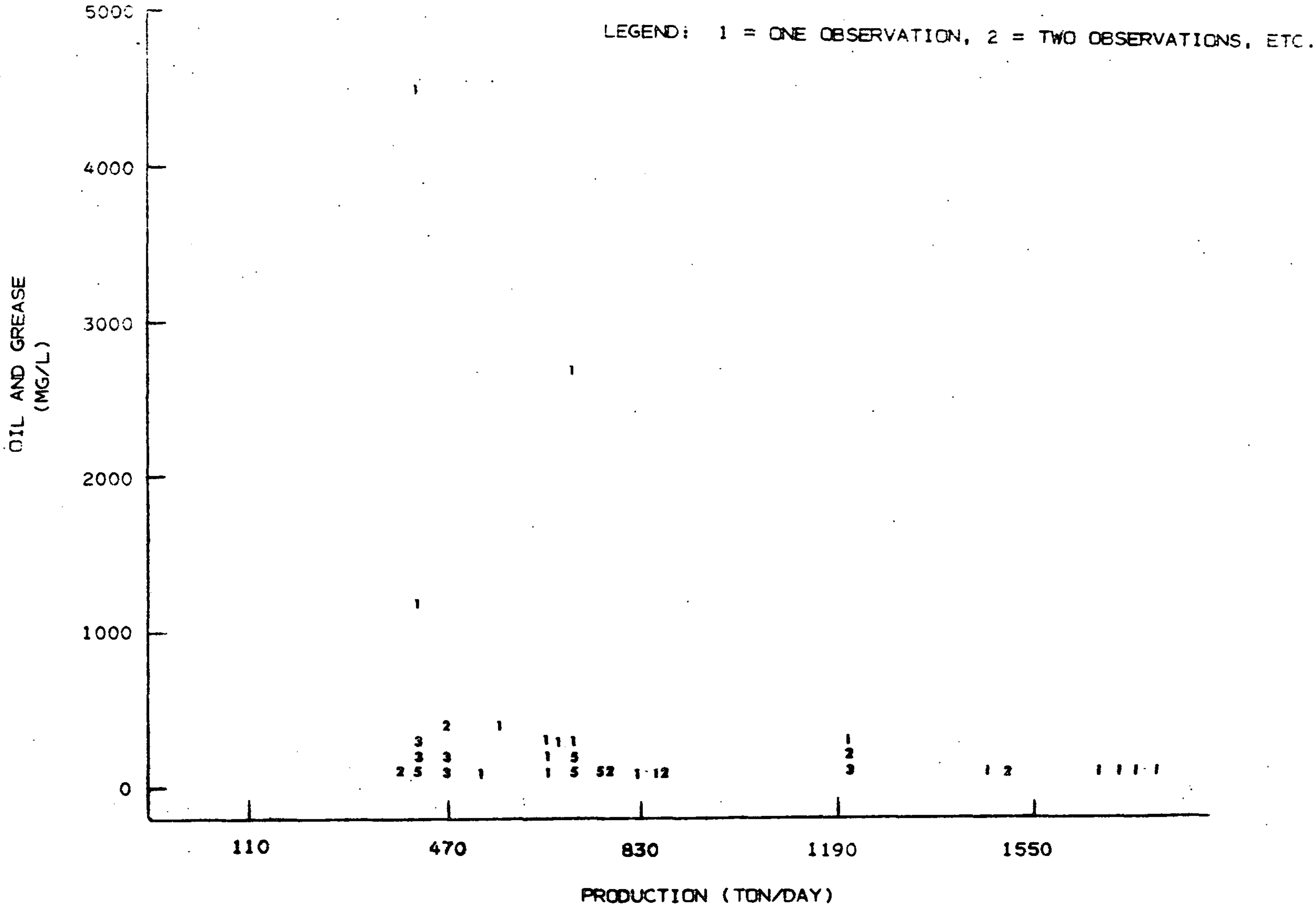

FIGURE 110

A SCATTER DIAGRAM PLOTTING CONCENTRATIONS OF OIL AND GREASE VERSUS DAILY PRODUCTION (TON/DAY) FOR THE PROCESS WASTEWATERS DISCHARGED FROM OILSEED SOLVENT EXTRACTION PLANTS, SUBCATEGORY A1

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Model Plant

The model plant for subcategory A 1 is based on the following assumptions:

1. The model plant is assumed to have a daily production of 816 kkg (900 ton).
2. The model plant has a flow volume of 0.144 cu m/day (0.039 MGD).
3. The model plant may or may not have the unit process of degumming.
4. The model plant may or may not have a wet scrubber system for removing air particulates.

By converting the data base compiled for this study to a model plant production of 816 kkg (900 ton) per day by multiplying by a factor of 1.05 (i.e., 816 kkg/780kkg = 1.05), the following wastewater characteristics were derived for the Subcategory A 1 model plant.

Production	816 kkg/day
Flow	148 cu m/day (0.039 MGD)
BOD	340 mg/l; 0.061 kg/kkg (0.122 lb/ton)
COD	815 mg/l; 0.147 kg/kkg (0.244 lb/ton)
SS	210 mg/l; 0.038 kg/kkg (0.076 lb/ton)
O&G	380 mg/l; 0.069 kg/kkg (0.138 lb/ton)
BOD/COD Ratio	0.50
pH Range	6 to 8

SUBCATEGORY A 2 - OILSEED CRUSHING, EXCEPT OLIVE OIL, BY MECHANICAL SCREW PRESS OPERATIONS

Seven typical mechanical screwpress extraction plants (three cottonseed crushers and four peanut crushers) were visited in conjunction with information from the National Cottonseed Producer's Association and the Southeastern Peanut Association. Only two sources of contact wastewater were observed. These consisting of 1) contaminated steam condensate from steam cooker operations and 2) wastewaters generated from infrequent floor and equipment cleanup. Four sources of non-contact wastewater were observed from the following unit processes: 1) non-contact cooling water circulated through the hollow expeller worm shaft to keep the oilseed cakes from burning, 2) boiler blowdown, 3) non-contact cooling tower blowdown (only during the winter months), and 4) storm water runoff. In general, the resultant contact wastewater generated from screw press operation is less than 4,000 liters (1000 gallons) per day. Screw press operations near to or in conjunction with an edible oils refinery dispose of wastewater by trucking it to the refinery where the oil is recovered in the acidulation process. Three plants were also observed to recycle their wastewater into the boiler feed water. Due to the small volume of wastewater discharged, it is not necessary to develop a model plant for Subcategory A 2.

SUBCATEGORY A 3 - OLIVE OIL EXTRACTION BY HYDRAULIC PRESSING AND SOLVENT EXTRACTION

The process descriptions of the extraction of olive oil by hydraulic pressing and solvent extraction were presented in Section III. At present, there is only one plant which utilizes either the hydraulic press or solvent extraction processes for the recovery of olive oil. The only source of wastewater generated by the extraction of olive oil by hydraulic pressing is centrifuge fruit water. Wastewater attributable to solvent extraction consists of a small amount of water which drains from pits and culls during storage, and an equally small non-contact condenser water flow. Equipment is wiped clean.

The wastewater from the hydraulic pressing process was determined to have the following characteristics:

Flow	10.9 cu m/day (0.0029 MGD)
BOD	63,000 mg/l
SS	14,000 mg/l
FOG	3,220 mg/l
pH	5.1

Model Plant

The model plant for this subcategory is plant 79I02. Between the months of October and June, the plant generally operates 24 hours per day, seven days per week with the operating schedule dependent on olive crop yield and availability of harvesters.

The total plant effluent consists of centrifuged fruit water with the characteristics listed above.

SUBCATEGORY A 4 - OLIVE OIL EXTRACTION BY MECHANICAL SCREW PRESSING

At present there is only one olive oil manufacturer in the United States which extracts olive oil by the mechanical screw press process. The extraction of olive oil by screw press operations produces wastewater from the following sources:

1. Washing of whole ripe olives prior to pulverizing
2. Centrifuged fruit water
3. Centrifuged sludge
4. General plant cleanup

Fruit Wash Water

Prior to grinding in the hammer mill the fruit is washed by pump and air percolation washers. These wash tanks are filled and discharged at least once per day or more depending upon fruit condition. The quantity of wastewater discharged from the washers varies between 19 cu m/day (0.005 MGD) and 38 cu m/day (0.010 MGD).

Centrifuged Fruit Water

The quantity of fruit water generated by the centrifuge is approximately 38 l/min (10 gal/min) for a total centrifuge effluent of 54.5 cu m (0.0144 MGD). The constituents of the centrifuged fruit water indicate a BOD concentration of 60,000 mg/l and a fat content of 25 percent.

Centrifuged Sludge

Approximately 38 cu m/day (0.010 MGD) of centrifuged sludge is generated from the initial centrifuge following pressing. The pollutant concentrations of the centrifuged sludge were determined to be as follows:

BOD	48,000 mg/l
SS	51,000 mg/l
FOG	34,000 mg/l

General Plant Cleanup

Cleanup of equipment is done on an irregular basis with little generation of wastewater. Due to the irregular nature and inherent variability of the cleaning operation, representation of waste flow cannot be reliably determined. It is, however, reflected in the total waste discharge.

Total Plant Effluent

The total effluent from the plant would amount to approximately 114 cu m/day (0.03 MGD) and would have the following characteristics:

BOD	30,000 mg/l
SS	57,000 mg/l
FOG	20,000 mg/l
pH	5.5

Selection of Model Plant

The model plant, illustrated in Figure 39 in Section III, processes 44 kkg/day (48 ton/day) of olives. The total plant effluent consists of the combined waste streams as previously presented. The plant operates 24 hours per day, seven days per week between the months of September and April except during unpredictable harvesting lulls. The plant's wastewater has the following characteristics:

Flow	114 cu m/day (0.03 MGD)
BOD	30,000 mg/l
SS	57,000 mg/l
FOG	20,000 mg/l
pH	5.5

SUBCATEGORY A 5 - PROCESSING OF EDIBLE OIL BY THE USE OF CAUSTIC REFINING METHODS ONLY

The individual unit processes characteristic of Subcategory A 5 plants include: (1) caustic refining operations; (2) general cleanup of storage and handling facilities; and (3) tank car cleaning operations.

Caustic Refining

A principle source of wastewater generation from Subcategory A 5 refineries results from the caustic refining of crude vegetable or animal oils. Wastewater discharged from the washing of refined edible oils will vary considerably from day to day depending upon the nature of the crude oil being refined. Seng (53) reported an Illinois caustic refining operation to have the following average pollutant concentrations: BOD, 1240 mg/l; COD, 5000 mg/l; suspended solids, 690 mg/l; and ether solubles, 1800 mg/l. The average waste loads for the Illinois plant were: BOD, 0.27 kg/kkg (0.55 lb/ton) COD, 1.1 kg/kkg (2.2 lb/ton); suspended solids, 0.15 kg/kkg (0.30 lb/ton); and ether solubles 0.4 kg/kkg (0.8 lb/ton). The average flow was recorded as 0.054 cubic meters per day (0.0144 MGD).

Historical and verification survey data compiled for this report from six edible oil caustic refining operations found significantly higher concentrations of BOD, COD, suspended solids, and oil and grease. Mean concentrations and wasteload values from all data collected were:

Production	353 kkg
Flow	75.7 cu m/day (0.02 MGD)
BOD	6,900 mg/l; 1.01 kg/kkg (2.02 lb/ton)
COD	14,800 mg/l; 1.8 kg/kkg (3.6 lb/ton)
SS	3,700 mg/l; 0.5 kg/kkg (1.0 lb/ton)
O&G	5,000 mg/l; 0.6 kg/kkg (1.2 lb/ton)
pH Range	7.3 to 11.9
BOD/COD Ratio	0.46

Table 19 provides a statistical description of the data compiled from six refineries including mean, sample size, standard deviations, minimum, and maximum values. Table 20 presents a summary of caustic refining waste loadings from the six plants visited and sampled during the course of this study. As would be expected, calculated correlation coefficient statistics show a significant correlation between the concentrations of BOD and COD in the caustic refining wastewater with a calculated BOD/COD ratio of 0.46. A significant correlation also exists between the kg/kkg of BOD, suspended solids, and oil and grease. These data indicate that much of the hexane extractable material exists as oil attached to suspended solids particles with a specific gravity close to that of water.

Tank Car Cleaning

The cleaning of tank cars to remove residual oil constitutes a major waste stream associated with all Subcategory A 5 through A 12 edible

TABLE 19

A STATISTICAL DESCRIPTION OF THE WASTEWATER CHARACTERISTICS FOR THE EDIBLE OIL CAUSTIC REFINERY PROCESS

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF COVARIENCE (%)
Flow (MGD)	41	0.019002	0.038381	0.001	0.001000	0.216000	201.982
Prod. (ton/day)	41	352.902439	243.959882	59516.424	38.300000	1016.000000	69.130
BOD (mg/l)	39	6933.410256	7747.790968	60028264.880	35.000000	38300.000000	111.746
SS (mg/l)	41	3715.780488	7573.994869	57365398.276	20.000000	41660.000000	203.833
COD (mg/l)	37	14781.675676	14655.901695	214795454.503	100.000000	61352.000000	99.149
*FOG (mg/l)	41	5045.658537	8905.132516	79301385.130	8.000000	49456.000000	176.491
BOD (lb/day)	39	552.193229	636.396225	405000.155	3.087650	2461.023950	115.249
COD (lb/day)	37	1182.017060	1469.454629	2159296.908	20.078070	7167.754160	124.318
SS (lb/day)	41	233.036323	390.209634	152263.558	1.268440	1657.817700	167.446
FOG (lb/day)	41	396.045192	649.220997	421487.902	6.375580	3619.159740	163.926
Lb/Ton-BOD	39	2.020632	3.170595	10.053	0.056093	18.887367	156.911
kg/kkg-BOD	39	1.010316	1.585298	2.513	0.028046	9.443684	156.911
Lb/Ton-COD	37	3.620473	3.405427	11.597	0.074529	13.408468	94.060
kg/kkg-COD	37	1.810237	1.702713	2.899	0.037264	6.704234	94.060
Lb/Ton-SS	41	1.027417	2.259675	5.106	0.030129	12.723083	219.938
kg/kkg-SS	41	0.513708	1.129837	1.277	0.015065	6.361541	219.938
Lb/Ton-FOG	41	1.229996	1.712138	2.931	0.018893	8.491982	139.199
kg/kkg-FOG	41	0.614998	0.856069	0.733	0.009447	4.245991	139.199
BOD/COD Ratio	35	0.466189	0.191399	0.037	0.153782	0.878890	41.056
BOD/FOG Ratio	39	3.448033	3.909349	15.283	0.059710	20.277778	113.379
Flow Ratio	41	55.133023	94.653221	8959.232	9.145993	496.551724	171.682

* FOG = Fats, Oils, and greases.

N = Number of data points

Note: Computer calculations for this table show no regard for significant figures.

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TABLE 20

POLLUTANT LOADINGS FOR CAUSTIC REFINING WASH WATERS

Edible Oils Refinery (Process Code)	Production (kkg/day)	Volume Wastewater Discharged (cu m/day)	BOD (kg/kkg)	COD (kg/kkg)	SS (kg/kkg)	Oil and Grease (kg/kkg)
75R08	424	29.2	0.39	0.99	0.55	0.86
75R09	388	331.6	0.88	2.18	0.11	0.64
75R15	310	36.6	0.49	2.53	0.38	0.28
75R17	245	54.5	0.28	1.11	0.15	0.40
75R05	227	31.5	1.43	2.37	0.36	0.54
75R06	276	56.1	2.15	0.90*	1.46	0.75

* COD sample size was less than BOD sample size.

oil refining facilities. Average concentrations and waste loading of pollutants from six plants were as follows:

Production	184 kkg
Flow	37.8 cu m/day (0.01 MGD)
BOD	2950 mg/l; 0.49 kg/kkg (0.98 lb/ton)
COD	5850 mg/l; 1.38 kg/kkg (2.76 lb/ton)
SS	900 mg/l; 0.19 kg/kkg (0.38 lb/ton)
O&G	920 mg/l; 0.20 kg/kkg (0.40 lb/ton)
BOD/COD	0.42
pH Range	5.5 to 11.9

Table 21 presents a summary table of means, minimums, maximums, sample size, standard deviations and coefficients of covariance for tank car cleaning operations from six edible oil refining operations. Table 22 presents a summary table of tank car cleaning wastewater characteristics for each of the six plants investigated during this study.

Storage and Transfer

Another typical unit process waste load associated with all edible oil refinery Subcategories A 5 through A 12 is that of wastewaters generated during cleanup from storage, handling, and transfer areas within the refining plant. Waste loads from these areas are highly variable and are dependent on general daily cleanup necessitated by accidental spills, leakage, or pump failures. Averaged waste load data from three plants resulted in the following pollutant concentrations.

Production	314 kkg
Flow	75.7 cu m/day (0.02 MGD)
BOD	8,000 mg/l; 1.4 kg/kkg (2.7 lb/ton)
COD	21,000 mg/l; 3.8 kg/kkg (7.7 lb/ton)
SS	5,400 mg/l; 0.87 kg/kkg (1.7 lb/ton)
O&G	4,200 mg/l; 0.69 kg/kkg (1.4 lb/ton)
BOD/COD	0.51
pH Range	2.5 to 11.1

Table 23 presents a statistical description of the data compiled for this study including mean, standard deviations, minimum, maximum, sample size, and coefficients of covariance for the three plants investigated.

Refinery Floor Wash

Pollutant waste loadings result from general floor washing operations necessitated by accidental oil spills and pump seal leakages. In general these cleanup procedures are intermittent and represent a relatively minor contribution to the total waste load of Subcategory A 5 plants.

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TABLE 21

A STATISTICAL DESCRIPTION OF THE WASTEWATER CHARACTERISTICS FOR EDIBLE OIL REFINERY TANK CAR CLEANING OPERATIONS

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF COVARIENCE (%)
Flow (MGD)	36	0.010124	0.008411	0.0001	0.000800	0.048000	83.077
Prod. (ton/day)	36	183.552778	123.245906	15189.5534	75.000000	750.000000	67.145
BOD (mg/l)	30	2948.033333	4686.352162	21961896.5851	70.000000	18275.000000	158.965
SS (mg/l)	35	902.428571	941.755629	886903.6639	8.000000	3920.000000	104.358
COD (mg/l)	36	5848.166667	7338.449060	53852834.6000	60.000000	31510.000000	125.483
*FOG (mg/l)	36	923.111111	1164.397006	1355820.3873	3.000000	4846.000000	126.138
BOD (lb/day)	30	129.987984	159.114827	25317.5281	6.717725	643.980312	122.407
COD (lb/day)	36	105.489276	656.521041	431019.8776	5.758050	3552.967200	161.908
SS (lb/day)	35	66.914187	129.190111	16690.0848	0.767740	752.385200	193.068
FOG (lb/day)	36	67.941879	119.049493	14172.7817	0.287903	536.249700	175.223
Lb/Ton-BOD	30	0.983145	1.678638	2.8178	0.029857	8.586404	170.742
kg/kkg-BOD	30	0.491573	0.839319	0.7045	0.014928	4.293202	170.742
Lb/Ton-COD	36	2.758511	4.820171	23.2341	0.025591	25.378337	174.738
kg/kkg-COD	36	1.379256	2.410086	5.8085	0.012796	12.689169	174.738
Lb/Ton-SS	35	0.380021	0.494842	0.2449	0.003412	2.351204	130.214
kg/kkg-SS	35	0.190011	0.247421	0.0612	0.001706	1.175602	130.214
Lb/Ton-FOG	36	0.406728	0.611704	0.3742	0.001280	2.800914	150.396
kg/kkg-FOG	36	0.203364	0.305852	0.0935	0.000640	1.400457	150.396
BOD/COD Ratio	30	0.423683	0.247794	0.0614	0.027057	1.166667	58.486
BOD/FOG Ratio	30	4.355555	4.870516	23.7219	0.362538	23.333333	111.823
Flow Ratio	36	57.827483	52.679299	2775.1085	10.666667	342.857143	91.097

* FOG = Fats, Oils, and greases.

N = Number of data points

Note: Computer calculations for this table show no regard for significant figures.

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TABLE 22

POLLUTANT WASTE LOADINGS FOR EDIBLE OIL REFINERY TANK CAR CLEANING

Edible Oil Refinery by Process Code	Production (kkg/day)	Volume of Wastewater Discharged (cu m/day)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	Oil & Grease (mg/l)
75T05	68	85.4	1.6	2.7	0.26	0.27
75T06	170	21.2	0.37	0.79	0.09	0.16
75T08	191	44.0	0.40	1.28	0.36	0.38
75T09	127	124.9	0.31	8.07	0.21	0.68
75T10	187	37.9	0.13	0.32	0.10	0.03

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TABLE 23

A STATISTICAL DESCRIPTION OF THE WASTEWATER CHARACTERISTICS FOR EDIBLE OIL REFINERY STORAGE AND HANDLING OPERATIONS

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF COVARIENCE (%)
Flow (MGD)	21	0.021924	0.041975	0.00	0.004800	0.173000	191.458
Prod. (ton/day)	21	314.738095	87.556213	7666.09	144.000000	498.000000	27.819
BOD (mg/l)	19	8173.684211	22709.529317	515722721.78	70.000000	99000.000000	277.837
SS (mg/l)	20	5428.300000	13955.541929	194757150.54	40.000000	55600.000000	257.089
COD (mg/l)	18	21806.111111	76048.342459	5783350390.69	130.000000	326000.000000	348.748
*FOG (mg/l)	19	4223.473684	12911.602032	166709467.04	10.000000	56705.000000	305.710
BOD (lb/day)	19	943.534452	3380.270853	11426231.04	24.634440	14870.790000	358.256
COD (lb/day)	18	2952.337077	11485.845408	131924644.73	37.772808	48968.460000	389.042
SS (lb/day)	20	544.060244	1863.214956	3471569.97	8.002855	8351.676000	342.465
FOG (lb/day)	19	511.752952	1940.916493	3767156.83	1.251750	8517.658050	379.268
Lb/Ton-BOD	19	2.717597	8.654179	74.89	0.096730	37.839160	318.450
kg/kkg-BOD	19	1.358799	4.327090	18.72	0.048365	18.919580	318.450
Lb/Ton-COD	18	7.661584	29.190865	852.11	0.180085	124.601679	381.003
kg/kkg-COD	18	3.830792	14.595433	213.03	0.090043	62.300840	381.003
Lb/Ton-SS	20	1.743992	5.072839	25.73	0.027483	21.251084	290.875
kg/kkg-SS	20	0.871996	2.536419	6.43	0.013741	10.625542	290.875
Lb/Ton-FOG	19	1.390295	4.932987	24.33	0.004822	21.673430	354.816
kg/kkg-FOG	19	0.695147	2.466493	6.08	0.002411	10.836715	354.816
BOD/COD Ratio	17	0.506325	0.114849	0.01	0.292500	0.675676	22.683
BOD/FOG Ratio	17	53.885362	201.794436	40720.99	0.307523	836.666667	374.488
Flow Ratio	21	62.437146	103.963429	10808.39	14.201183	397.701149	166.509

*   FOG = Fats, Oils, and greases.

N = Number of data points

Note: Computer calculations for this table show no regard for significant figures.

Total Processing Effluent

On a daily basis the total waste load from the Subcategory A 5 plants may be quite variable due to 1) differences in the raw materials processed; 2) the numbers of tank cars washed; and 3) the general cleanup procedures utilized to clean up accidental oil spills. Data compiled for caustic refining, tank car cleaning, and storage and handling indicate that flows and BOD concentrations vary greatly from day to day as is indicated in the large standard deviations calculated for these parameters in Table 17.

Model Plant

Based upon the data compiled for this study, a hypothetical model plant for a caustic refinery operation was formulated. The following assumptions were made for Subcategory A 5 plants:

1. The model plant is assumed to have a production of 454 kkg (500 ton) per day.

2. The model plant has separate discharge of process waters and non-contact cooling water.

3. The model plant has approximately five tank cars washed per day. Each tank car has a capacity of 68 kkg (75 ton).

4. The model plant has a waste load generated from storage and handling areas based upon a 454 kkg (500 ton) per day production.

The following pollutant parameter waste loads were calculated for Subcategory A 5 plants by assuming a linear relationship between production and wasteload generation. For example, the average waste loading for caustic refinery from the compiled data base was as follows:

Production (kkg)	Flow (cu m/day)	BOD (kg/kkg)	COD (kg/kkg)	Suspended Solids (kg/kkg)	Oil and Grease (kg/kkg)
320	71.9	1.01	1.81	0.51	0.61

The waste load for a caustic refining operation with a production of 454 kkg (500 ton) per day was then calculated by multiplying each waste load by a factor of 1.42 (i.e., 454 kkg/320 kkg = 1.42). Thus, the model plant was assumed to have the following waste load characteristics for caustic refining:

Production (kkg)	Flow (cu m/day)	BOD (kg/kkg)	COD (kg/kkg)	Suspended Solids (kg/kkg)	Oil and Grease (kg/kkg)
454	102	1.43	2.57	0.72	0.86

Historical and verification survey data compiled for storage and handling was also converted to a production of 454 kkg (500 ton) per day by multiplying by a factor of 1.59.

In addition, the model plant was assumed to wash five tank cars daily. Therefore, tank car cleaning data was converted to a production of 320 kkg (375 ton) per day by multiplying by a factor of 2.05.

The total waste load characteristics for establishments engaged in the caustic refining of edible oils was then calculated as indicated in Table 24. Therefore, the wastewater characteristics for the hypothetical model plant Subcategory A 5 are as follows:

Production:	454 kkg (500 ton) per day
Flow	314 cu m per day (0.083 MGD)
BOD	6,600 mg/l
COD	16,600 mg/l
SS	3,600 mg/l
O&G	3,500
pH	5.5 to 11.0
BOD Ratio	4.59 kg/kkg (9.18 lb/ton)
COD Ratio	11.49 kg/kkg (22.98 lb/ton)
SS Ratio	2.49 kg/kkg (4.98 lb/ton)
O&G Ratio	2.39 kg/kkg (4.78 lb/ton)

SUBCATEGORY A 6 - PROCESSING OF EDIBLE OILS BY THE USE OF CAUSTIC REFINING AND ACIDULATION METHODS

The major process waste streams associated with Subcategory A 6 plants are the same as those for Subcategory A 5 with the addition of acidulation.

Acidulation

The major waste loading unit process for the edible oil refinery industry results from the acidulation process for the recovery of fatty acides from the soapstock generated by caustic refining. Data collected from four plants found average pollutant concentrations and waste loadings for the acidulation process to be:

Production	486 kkg
Flow	223 cu m/day (0.059 MGD)
BOD	12,000 mg/l; 4.70 kg/kkg (9.39 lb/ton)
COD	22,000 mg/l; 14.97 kg/kkg (29.94 lb/ton)
SS	3,800 mg/l; 1.66 kg/kkg (3.32 lb/ton)
O&G	2,500 mg/l; 1.20 kg/kkg (2.40 lb/ton)
BOD/COD	0.57
pH range	0.6 to 3.0

Table 25 presents a statistical description of the data collected from four refining operations. Table 26 provides a summary of average wasteload values calculated for each plant investigated.

TABLE 24

SAMPLE CALCULATIONS FOR DETERMINING TOTAL WASTE LOADINGS FOR SUBCATEGORY A 5 PLANTS

Unit Process	Flow (cu m/day)	BOD (kg/kkg)	COD (kg/kkg)	SS (kg/kkg)	O & G (kg/kkg)
Caustic Refining	102.2	1.43	2.57	0.72	0.87
Storage and Handling	132.5	2.16	2.83	0.39	0.41
Tankcar Cleaning	79.5	1.00	6.09	1.38	1.11
Total subcategory A5 Plant wasteload	314.2	4.59	11.49	2.49	2.39

TABLE 25

A STATISTICAL DESCRIPTION OF THE WASTEWATER CHARACTERISTICS FOR THE EDIBLE OIL REFINERY SOAPSTOCK ACIDULATION PROCESS

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF COVARIENCE (%)
Flow (MGD)	43	0.059456	0.039224	0.002	0.008600	0.228000	65.971
Prod. (ton/day)	43	536.183721	506.130398	256167.980	144.000000	1866.000000	94.395
BOD (mg/l)	30	12075.600000	13817.169852	190914182.731	746.000000	62100.000000	114.422
SS (mg/l)	40	3855.150000	10049.563189	100993720.285	18.000000	56988.000000	260.679
COD (mg/l)	35	21741.657143	25933.071775	672524211.703	2730.000000	121000.000000	119.278
*FOG (mg/l)	42	2508.904762	6437.980083	41447587.552	5.000000	34570.000000	256.605
BOD (lb/day)	30	6825.386627	9074.811981	82352212.490	224.113320	39385.062000	132.957
COD (lb/day)	35	15418.169307	21517.547448	463004848.185	800.452400	78256.405800	139.560
SS (lb/day)	40	2518.823840	6539.001880	42758545.591	6.308820	36142.929360	259.605
FOG (lb/day)	42	1667.210951	4285.336623	18364109.974	1.752450	21924.985400	257.036
Lb/Ton-BOD	30	9.390904	10.154349	103.111	0.730011	38.595625	108.130
kg/kkg-BOD	30	4.695452	5.077174	25.778	0.365005	19.297813	108.130
Lb/Ton-COD	35	29.936496	46.878662	2197.609	2.877707	203.792723	156.594
kg/kkg-COD	35	14.968248	23.439331	549.402	1.438854	101.896362	156.594
Lb/Ton-SS	40	3.321062	7.672406	58.866	0.018077	39.977766	231.023
kg/kkg-SS	40	1.660531	3.836203	14.716	0.009038	19.988883	231.023
Lb/Ton-FOG	42	2.403490	6.118084	37.431	0.005021	34.318813	254.550
kg/kkg-FOG	42	1.201745	3.059042	9.358	0.002511	17.159406	254.550
BOD/COD Ratio	25	0.578246	0.204302	0.042	0.204041	0.948200	35.331
BOD/FOG Ratio	29	77.689636	153.556394	23579.566	0.801289	673.333333	197.654
Flow Ratio	43	150.349585	107.689029	11596.927	38.406420	593.750000	71.626

* FOG = Fats, Oils, and greases.

N = Number of data points

Note: Computer calculations for this table show no regard for significant figures.

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TABLE 26

POLLUTANT WASTE LOADINGS FOR THE EDIBLE OIL REFINERY ACIDULATION PROCESS

Edible Oil Refinery by Process Code	Production (kkg/day)	Volume of Wastewater Discharged (cu m/day)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	Oil & Grease (mg/l)
75A10	279	147.6	1.29	3.09	0.25	0.23
75A15	337	518.5	18.43	59.4	6.34	5.31
75A09	345	170.7	7.05	11.07	0.45	0.04
75A08	1445	283.8	6.06	10.72	2.91	1.86

Model Plant

The hypothetical model plant described for Subcategory A 6 is assumed to have a production of 454 kkg (500 ton) per day; to wash five tank cars per day; and to have a separate discharge of process wastewater and non-contact water. It is essentially the same plant described in Subcategory A 5 with the addition of the unit process of acidulation. By converting the acidulation data base to a 454 kkg (500 ton) per day plant and adding this value to the model plant waste loads calculated for Subcategory A 5 refineries, the following wastewater characteristics were derived for Subcategory A 6 refineries.

Production	454 kkg (500 ton) per day
Flow	534 cu m/day (0.141 MGD)
BOD	7,600 mg/l
COD	21,600 mg/l
SS	3,400 mg/l
O&G	3,000 mg/l
pH range	0.6 to 3.0
BOD ratio	8.95 kg/kkg (17.90 lb/ton)
COD ratio	25.41 kg/kkg (50.82 lb/ton)
SS ratio	4.03 kg/kkg (8.06 lb/ton)
O&G ratio	3.51 kg/kkg (7.02 lb/ton)

SUBCATEGORY A 7 - PROCESSING OF EDIBLE OILS BY CAUSTIC REFINING, ACIDULATION, OIL PROCESSING, AND DEODORIZATION

The individual unit processes and assumptions for the hypothetical Subcategory A 7 refinery are identical to Subcategory A 6 plants with the addition of the unit processes of deodorization and oil processing.

Deodorization

The contact cooling water blowdown generated from deodorization barometric condenser units represents a major contribution to the total waste load of an edible oil refinery. Average concentrations of pollutants from six refining operations were a BOD of 4,000 mg/l, a COD of 7,900 mg/l, a suspended solids of 730 mg/l, and oil and grease of range was from 3.3 to 7.3. The average waste loadings were as follows:

BOD	2.21 kg/kkg (4.42 lb/ton)
SS	0.32 kg/kkg (0.63 lb/ton)
O&G	0.30 kg/kkg (0.60 lb/ton)
BOD/COD	0.53

Table 27 presents a statistical description of the data compiled for contact cooling tower blowdown from the six plants investigated.

Oil Processing

Oil processing includes the floor washing and general cleanup wastewater discharges from the hydrogenation, winterization, bleaching,

TABLE 27

A STATISTICAL DESCRIPTION OF THE WASTEWATER CHARACTERISTICS FOR EDIBLE OIL REFINERY CONTACT COOLING TOWER BLOWDOWN FROM BAROMETRIC CONDENSERS

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF COVARIENCE (%)
Flow (MGD)	44	0.047044	0.035721	0.0013	0.004320	0.173000	75.932
Prod. (ton/day)	44	383.906818	291.499940	84972.2151	96.500000	1144.000000	75.930
BOD (mg/l)	38	4061.868421	5341.475771	28531363.4147	60.000000	26700.000000	131.503
SS (mg/l)	43	733.325581	1267.460222	1606455.4153	15.000000	7960.000000	172.837
COD (mg/l)	39	7895.589744	8771.247567	76934783.8799	150.000000	44520.000000	111.090
*FOG (mg/l)	44	758.522727	986.107676	972408.3483	20.000000	3683.000000	130.004
BOD (lb/day)	38	1051.815527	1157.773150	1340438.6658	15.862176	5793.099000	110.074
COD (lb/day)	39	2288.022942	2060.853355	4247116.5517	33.887376	9659.504400	90.071
SS (lb/day)	43	208.494655	240.941174	58052.6496	4.506300	1129.245400	115.562
FOG (lb/day)	44	255.700795	432.449137	187012.2563	15.321420	2494.771130	169.123
Lb/Ton-BOD	38	4.419554	7.015463	49.2167	0.038878	40.035238	158.737
kg/kkg-BOD	38	2.209777	3.507732	12.3042	0.019439	20.017619	158.737
Lb/Ton-COD	39	8.485459	11.469081	131.5398	0.083057	66.755386	135.162
kg/kkg-COD	39	4.242730	5.734540	32.8850	0.041529	33.377693	135.162
Lb/Ton-SS	43	0.630183	0.734637	0.5397	0.018902	3.678324	116.575
kg/kkg-SS	43	0.315091	0.367319	0.1349	0.009451	1.839162	116.575
Lb/Ton-FOG	44	0.600192	0.683846	0.4676	0.049039	3.158095	113.938
kg/kkg-FOG	44	0.300096	0.341923	0.1169	0.024520	1.579047	113.938
BOD/COD Ratio	33	0.526206	0.164917	0.0272	0.191964	0.860210	31.341
BOD/FOG Ratio	38	15.911084	25.785414	664.8876	0.776952	100.754717	162.059
Flow Ratio	44	148.079543	100.282196	10056.5189	10.588235	607.017544	67.722

* FOG = Fats, Oils, and greases.

N = Number of data points

Note: Computer calculations for this table show no regard for significant figures.

and deodorization unit process operations. The wastewaters discharged from these operations represent a relatively minor waste loading in comparison to the other unit processes previously identified. The average flow was 26.5 cu m/day (0.007 MGD). Average pollutant concentrations were calculated as follows:

BOD	1800 mg/l
COD	5000 mg/l
SS	1100 mg/l
O&G	1300 mg/l
pH	7.3 to 13.0

Average waste loadings from oil processing were as follows:

BOD	0.09 kg/kkg (0.18 lb/ton)
COD	0.22 kg/kkg (0.45 lb/ton)
O&G	0.024 kg/kkg (0.48 lb/ton)

The BOD/COD ratio was 0.49. Table 28 presents a statistical description of the compiled data base from six plants.

Model Plant

Deodorization and oil processing data were converted to a 454 kkg (500 ton) per day plant by the factors 1.32 and 1.16, respectively. The waste loads from these unit processes were then added to the total wasteload of the 454 kkg (500 ton) per day plant described for Subcategory A 6 refineries. The following data represents the wastewater characteristics of a Subcategory A 7 refining operation consisting of the unit operations of caustic refining, acidulation, deodorization, and oil processing:

Production	454 kkg
Flow	1147 cu m/day (0.303 MGD)
BOD	6.400 mg/l
COD	15,000 mg/l
SS	3,100 mg/l
O&G	1,500 mg/l
pH range	7.3 to 13.0
BOD ratio	16.09 kg/kkg (32.18 lb/ton)
COD ratio	36.91 kg/kkg (73.82 lb/ton)
SS ratio	7.84 kg/kkg (15.69 lb/ton)
O&G ratio	3.93 kg/kkg (7.86 lb/ton)

SUBCATEGORY A 8 - PROCESSING OF EDIBLE OILS UTILIZING CAUSTIC REFINING, OIL PROCESSING, AND DEODORIZATION

Subcategory A 8 is essentially the same as Subcategory A 7 with the deletion of the unit process of acidulation. As a result, the model

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TABLE 28

A STATISTICAL DESCRIPTION OF THE WASTEWATER CHARACTERISTICS FOR EDIBLE OIL REFINERY OIL PROCESSING**

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF COVARIENCE (%)
Flow (MGD)	14	0.006681	0.005754	0.0000	0.000330	0.013000	86.122
Prod. (ton/day)	14	429.171429	234.008594	54760.0222	238.400000	960.600000	54.526
BOD (mg/l)	12	1793.083333	3831.751806	14682321.9015	105.000000	13600.000000	213.696
SS (mg/l)	13	1089.615385	1704.931550	2906791.5897	35.000000	5720.000000	156.471
COD (mg/l)	13	5073.000000	8219.576185	67561432.6667	140.000000	28400.000000	162.026
*FOG (mg/l)	14	1338.500000	1699.344161	2887770.5769	2.000000	6000.000000	126.959
BOD (lb/day)	12	67.421480	175.612274	30839.6709	1.518790	624.206000	260.469
COD (lb/day)	13	168.050904	364.261552	132686.4779	13.791782	1303.489000	216.757
SS (lb/day)	13	34.852700	61.722045	3809.6109	0.841176	181.386920	177.094
FOG (lb/day)	14	19.170968	29.387554	863.6283	0.216970	102.810400	153.292
Lb/Ton-BOD	12	0.185197	0.455263	0.2073	0.002075	1.625536	245.826
kg/kkg-BOD	12	0.092599	0.227632	0.0518	0.001038	0.812768	245.826
Lb/Ton-COD	13	0.446931	0.945658	0.8943	0.018846	3.394503	211.589
kg/kkg-COD	13	0.223465	0.472829	0.2236	0.009423	1.697251	211.589
Lb/Ton-SS	13	0.093575	0.160112	0.0256	0.001149	0.472362	171.106
kg/kkg-SS	13	0.046787	0.080056	0.0064	0.000575	0.236181	171.106
Lb/Ton-FOG	14	0.047748	0.077120	0.0059	0.000910	0.267735	161.513
kg/kkg-FOG	14	0.023874	0.038560	0.0015	0.000455	0.133868	161.513
BOD/COD Ratio	12	0.485717	0.226269	0.0512	0.110123	0.890909	46.584
BOD/FOG Ratio	12	13.991234	34.332618	1178.7266	0.351937	122.500000	245.387
Flow Ratio	14	25.060972	24.822636	616.1632	0.728711	54.530201	99.049

* FOG = Fats, Oils, and greases.

N = Number of data points

** Includes floorwashing and general cleanup for the following unit processes: hydrogenation, deodorization, bleaching, and winterization.

Note: Computer calculations for this table show no ragard for significant figures.

plant for Subcategory A 8 will have a lower waste loading and flow then Subcategory A 7 plants.

Model Plant

Assuming the same production rates and assumptions made for Subcategory A 7 refineries, the model plant for Subcategory A 8 was calculated to have the following concentrations and waste loading:

Production	454 kkg
Flow	927 cu m/day (0.245 MGD)
BOD	5,750 mg/l
COD	11,300 mg/l
SS	3,100 mg/l
O&G	1,400 mg/l
pH range	6 to 9
BOD ratio	11.73 kg/kkg (23.46 lb/ton)
COD ratio	22.99 kg/kkg (45.98 lb/ton)
SS ratio	6.30 kg/kkg (12.60 lb/ton)
O&G ratio	2.81 kg/kkg (5.62 lb/ton)

SUBCATEGORY A 9 - PROCESSING OF EDIBLE OILS BY THE USE OF CAUSTIC REFINING, ACIDULATION, OIL PROCESSING, DEODORIZATION AND, THE PRODUCTION OF SHORTENING AND TABLE OILS

Subcategory A 9 is identical to Subcategory A 7 with the addition of the plasticizing and packaging operations associated with a shortening and table oils processing.

Shortening and Table Oil Production

Wastewater resulting from shortening and table oils plasticizing and/or packaging operations are primarily generated from floor washing and periodic equipment cleanup procedures. Wastewaters generated from these operations represent a relatively insignificant waste loading to the total refinery effluent. Average pollutant waste loads for the production of shortening and table oils are discussed in detail in Subcategory A 14.

Total Processing Effluent

Although the model plant for Subcategory A 9 has an additional unit process waste stream its total waste load is observed to be less concentrated than Subcategory A 7 due to the dilution effect attributable to the relatively low waste load contributed by shortening and table oil processing.

Model Plant

The Subcategory A 9 model plant is assumed to be identical to the Subcategory A 7 model plant with the addition of plasticizing and packaging of shortening and table oils (i.e., Subcategory A 14). The shortening and table oils packaging waste loads were converted to a 454 kkg (500 ton) per day operation and were added to the total waste load for Subcategory A 9. The wastewater characteristics for Subcategory A 9 plants are as follows:

Production	454 kkg
Flow	1320 cu m/day (0.349 MGD)
BOD	5,900 mg/l
COD	13,500 mg/l
SS	3,000 mg/l
O&G	1,500 mg/l
pH range	3 to 9
BOD ratio	17.12 kg/kkg (34.24 lb/ton)
COD ratio	39.15 kg/kkg (78.30 lb/ton)
SS ratio	8.68 kg/kkg (17.36 lb/ton)
O&G ratio	4.35 kg/kkg (8.70 lb/ton)

SUBCATEGORY A 10 - PROCESSING OF EDIBLE OILS BY CAUSTIC REFINING, OIL PROCESSING, DEODORIZATION, AND THE PLASTICIZING AND PACKAGING OF SHORTENING AND TABLE OILS

The model plant developed for Subcategory A 10 is principally the same as Subcategory A 9 with the deletion of the unit process of acidulation.

Total Process Effluent

As a result of the deletion of acidulation, the total processing effluent from Subcategory A 10 plants will be significantly reduced.

Model Plant

The model plant for Subcategory A 10 is identical to the Subcategory A 9 model plant with the deletion of acidulation. The model plant assumes a 454 kkg (500 ton) per day production for both the refining operations and the filling and packaging of shortening and table oils. The wastewater characteristics of Subcategory A 10 plants are as follows:

Production	454 kkg
Flow	1101 cu m/day (0.291 MGD)
BOD	5,250 mg/l
COD	10,400 mg/l
SS	3,000 mg/l
O&G	1,300 mg/l

pH range	6 to 9
BOD ratio	12.76 kg/kkg (25.52 lb/ton)
COD ratio	25.23 kg/kkg (50.46 lb/ton)
SS ratio	7.14 kg/kkg (14.28 lb/ton)
O&G ratio	3.23 kg/kkg (6.46 lb/ton)

SUBCATEGORY A 11 - PROCESSING OF EDIBLE OILS BY CAUSTIC REFINING, ACIDULATION, OIL PROCESSING, DEODORIZATION, AND THE PLASTICIZING AND PACKAGING OF SHORTENING, TABLE OILS, AND MARGARINE

Subcategory A 11 is a combination of Subcategory A 7 (i.e., edible oil caustic refining, acidulation, oil processing and deodorization) with the addition of shortening, table oils, and margarine processing waste load data presented in Subcategories A 13 and A 14. It is assumed that the refining unit processes operate at a 454 kkg per day level. Subcategory A 11 also assumes that the two additional unit processes (i.e., shortening, table oils packaging, and margarine packaging) operate each at 227 kkg (250 ton) per day.

Total Processing Effluent

The total process effluent from Subcategory A 11 refineries represents the highest pollutant wasteloading calculated for all the edible oil refining model plants developed for this report.

Model Plant

It is assumed that the Subcategory A 11 plant has the same waste load characteristics of Subcategory A 7, with the addition of: 1) a shortening, table oils plasticizing and/or packaging room and 2) a margarine plasticizing and packaging room. Each packaging operation is assumed to operate at a production rate of 227 kkg (250 ton) per day. The wastewater characteristics of Subcategory A 11 plants are as follows:

Production	454 kkg
Flow	1574 cu m/day (0.416 MGD)
BOD	5,900 mg/l
COD	13,500 mg/l
SS	3,200 mg/l
O&G	2,800 mg/l
pH range	3 to 9
BOD ratio	20.57 kg/kkg (41.14 lb/ton)
COD ratio	46.60 kg/kkg (93.2 lb/ton)
SS ratio	10.98 kg/kkg (21.96 lb/ton)
O&G ratio	9.95 kg/kkg (19.90 lb/ton)

SUBCATEGORY A 12 - PROCESSING OF EDIBLE OILS BY CAUSTIC REFINING, OIL PROCESSING, DEODORIZATION, AND THE PLASTICIZING AND PACKAGING OF SHORTENING, TABLE OILS, AND MARGARINE

Subcategory A 12 is identical to Subcategory A 11 with the deletion of the unit process of acidulation. As a result, the final discharge from the Subcategory A 12 plant will have a significantly higher pH and lower pollutant waste load than Subcategory A 11.

Model Plant

The hypothetical Subcategory A 12 model plant is assumed to have the same daily production rates, assumptions, and waste loadings per unit process as the Subcategory A 11 model plant with the deletion of the unit process for acidulation. The wastewater characteristics of Subcategory A 12 edible oil refineries are as follows:

BOD	5,400 mg/l
COD	10,900 mg/l
SS	3,200 mg/l
O&G	3,200 mg/l
pH range	6 to 9
BOD ratio	16.20 kg/kkg (32.40 lb/ton)
COD ratio	32.68 kg/kkg (65.36 lb/ton)
SS ratio	9.44 kg/kkg (18.88 lb/ton)
O&G ratio	8.83 kg/kkg (17.66 lb/ton)

SUBCATEGORY A 13 - PLASTICIZING AND PACKAGING OF MARGARINE

Historical data submitted by the National Association of Margarine Manufacturers (NAMM) for four plants with supporting verification sampling represents the data base compiled for Subcategory A 13 margarine processing plants.

There are principally three sources of wastewater generated from margarine plasticizing and packaging operations: 1) wastewater discharged from margarine reclamation rooms; 2) wastewater discharged from general floor washing operations containing detergents and chlorine; and 3) the daily cleanup of CIP (clean-in-place) equipment utilizing the following cleaning cycles: hot rinse, caustic wash, chlorine rinse, final rinse, sanitation, and air drying. The amounts of wastewater generated from these operations is primarily dependent upon the cleanliness and efficiency of the above three operations. Margarine production requires considerably more sanitation procedures than other edible oil finished product packaging operations due to its ability to provide a growth medium for pathogenic bacteria. As a result, cleanup operations of CIP equipment and floor washing procedures require relatively larger volumes of water. Average pollutant concentrations, flow, and production for the four plants investigated were as follows:

Production	112 kkg
Flow	170 cu m/day (0.045 MGD)
BOD	1440 mg/l
COD	4470 mg/l
SS	900 mg/l
O&G	1760 mg/l
pH	6 to 8
BOD ratio	1.93 kg/kkg (3.86 lb/ton)
COD ratio	4.22 kg/kkg (8.45 lb/ton)
SS ratio	1.34 kg/kkg (2.69 lb/ton)
O&G ratio	2.86 kg/kkg (5.72 lb/ton)
BOD/COD ratio	0.53

Table 29 presents a statistical description of the data base collected indicating mean, standard deviations, and minimum and maximum values. Table 30 presents the calculated averaged data for each of the three plants investigated.

Total Processing Effluent

The total waste load resulting from a margarine processing operation in combination with an edible oils refinery represents a significant waste load to the total processing effluent. Based upon the data provided by the NAMM, it is evident that the wastewater characteristics for margarine processing is highly variable from plant to plant with higher waste loads being correlated with larger production rates.

Model Plant

The hypothetical margarine processing plant for Subcategory A 13 was assumed to operate at a production rate of 227 kkg/day (250 ton/day). The wastewater characteristics for Subcategory A 13 plants are as follows:

Production	227 kkg
Flow	340 cu m/day (0.09 MGD)
BOD	2600 mg/l
COD	5700 mg/l
SS	1800 mg/l
O&G	3900 mg/l
pH range	6 to 8
BOD ratio	3.92 kg/kkg (7.84 lb/ton)
COD ratio	8.57 kg/kkg (17.14 lb/ton)
SS	2.72 kg/kkg (5.44 lb/ton)
O&G	5.81 kg/kkg (11.62 lb/ton)

SUBCATEGORY A 14 - PLASTICIZING AND PACKAGING OF SHORTENING AND TABLE OILS

The plasticizing and packaging of shortening and table oils represents a relative insignificant waste load in comparison to Subcategory A 13, margarine processing. In general, shortening and table oils processing

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TABLE 29

A STATISTICAL DESCRIPTION OF THE WASTEWATER CHARACTERISTICS
FOR MARGARINE PROCESSING

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF COVARIENCE (%)
Flow (MGD)	32	0.044561	0.036737	0.0013	0.008000	0.111400	82.443
Prod. (ton/day)	32	123.100000	66.897688	4475.3006	30.000000	251.500000	54.344
BOD (mg/l)	25	1437.960000	2175.084452	4730992.3733	135.000000	11433.000000	151.262
SS (mg/l)	31	904.129032	1273.862963	1622726.8495	24.000000	4476.000000	140.894
COD (mg/l)	19	4467.000000	7270.608908	52861753.8889	430.000000	32554.000000	162.763
*FOG (mg/l)	30	1760.600000	2664.526167	7099699.6966	22.000000	11907.000000	151.342
BOD (lb/day)	25	653.978456	2091.200180	4373118.1909	22.781850	10628.494089	319.766
COD (lb/day)	19	1352.209218	2815.404613	7926503.1338	119.592195	11033.814077	208.208
SS (lb/day)	31	482.187910	988.699670	977527.0368	3.972220	3702.926850	205.044
FOG (lb/day)	30	972.382543	2284.817528	5220391.1341	4.836762	10592.193339	234.971
Lb/Ton-BOD	25	3.860014	8.123545	65.9920	0.399981	42.260414	210.454
kg/kkg-BOD	25	1.930007	4.061772	16.4980	0.199991	21.130207	210.454
Lb/Ton-COD	19	8.456009	11.268122	126.9706	1.161089	43.872024	133.256
kg/kkg-COD	19	4.228004	5.634061	31.7426	0.580545	21.936012	133.256
Lb/Ton-SS	31	2.689364	4.818516	23.2181	0.054639	19.235984	179.169
kg/kkg-SS	31	1.344682	2.409258	5.8045	0.027320	9.617992	179.169
Lb/Ton-FOG	30	5.724866	11.221208	125.9155	0.026416	51.795566	196.008
kg/kkg-FOG	30	2.862433	5.610604	31.4789	0.013208	25.897783	196.008
BOD/COD Ratio	17	0.526437	0.225004	0.0506	0.288925	0.976744	42.741
BOD/FOG Ratio	25	4.143415	4.289584	18.4005	0.367647	20.434783	103.528
Flow Ratio	32	329.496866	139.962332	19589.4544	118.518519	615.384615	42.478

* FOG = Fats, Oils, and greases.

N = Number of data points

Note: Computer calculations for this table show no regard for significant figures.

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TABLE 30

POLLUTANT WASTE LOADINGS FOR THE PROCESSING OF MARGARINE

Edible Oil Refinery by Process Code	Production (kkg/day)	Volume of Wastewater Discharged (cu m/day)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	Oil & Grease (mg/l)
79M03	134.0	219.5	4.05	7.01	2.65	6.58
79M06	119.4	176.7	0.95	0.74	0.33	0.19
79M05	63.9	59.4	1.36	2.38	0.51	0.42

employs strictly mechanical treatment of oils for the conversion of bulk quantities of hardened oil into consumer sized packaging. The wastewaters generated from these operations are principally from general sanitation of filling and packaging equipment and general floor washing procedures. The volume of water generated from the process is significantly less than that for margarine processing due to the fact that the finished products do not support bacterial growth and therefore require less rigorous sanitation procedures. The average pollutant concentrations furnished by the Institute of Shortening and Edible Oils (ISEO) from five plants were:

Production	195 kkg (215 ton/day)
Flow	74.9 cu m/day (0.0198 MGD)
BOD	1600 mg/l
COD	4000 mg/l
SS	750 mg/l
O&G	770 mg/l
pH	6 to 8
BOD	0.48 kg/kkg (0.96 lb/ton)
COD	0.19 kg/kkg (0.37 lb/ton)
SS	0.18 kg/kkg (0.36 lb/ton)
O&G	0.19 kg/kkg (0.36 lb/ton)
BOD/COD ratio	0.52

Table 31 presents a statistical description of the means, standard deviations, and minimum and maximum values calculated from the five plants investigated and sampled. Table 32 presents a description of the shortening data collected at each plant.

Model Plant

The hypothetical shortening and table oil processing model plant was assumed to operate at a production level of 227 kkg (250 ton) per day. The data base collected was converted to a daily production rate of 227 kkg by multiplying by a factor of 1.16 (i.e., 227 kkg/195 kkg = 1.16). The wastewater characteristics of Subcategory A 14 plants are as follows:

Production	227 kkg
Flow	87 cu m/day (0.023 MGD)
BOD	1500 mg/l
COD	3000 mg/l
SS	1100 mg/l
O&G	550 mg/l
BOD ratio	0.56 (0.11 lb/ton)
COD ratio	1.12 (2.24 lb/ton)
SS ratio	0.42 (0.84 lb/ton)
O&G ratio	0.21 (0.42 lb/ton)
BOD/COD ratio	0.52

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TABLE 31

A STATISTICAL DESCRIPTION OF THE WASTEWATER CHARACTERISTICS FOR SHORTENING AND TABLE OIL PACKAGING OPERATIONS

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF COVARIENCE (%)
Flow (MGD)	24	0.019767	0.029776	0.0009	0.000700	0.090900	150.638
Prod. (ton/day)	24	214.987500	114.098810	13018.5385	38.700000	455.500000	53.072
BOD (mg/l)	22	1594.136364	2205.237171	4863070.9805	470.000000	11290.000000	138.334
SS (mg/l)	23	747.782609	873.488198	762981.6324	106.000000	4248.000000	116.810
COD (mg/l)	16	4017.375000	6429.411584	41337333.3167	942.000000	27800.000000	160.040
*FOG (mg/l)	24	765.833333	807.132319	651462.5797	23.000000	3300.000000	105.393
BOD (lb/day)	22	168.801636	273.432789	74765.4898	8.178100	842.002155	161.985
COD (lb/day)	16	66.137776	56.003200	3136.3584	15.576777	231.991000	84.677
SS (lb/day)	23	65.310510	89.113583	7941.2307	1.503769	317.694150	136.446
FOG (lb/day)	24	92.417919	265.740977	70618.2666	2.142162	1321.848000	287.543
Lb/Ton-BOD	22	0.964039	1.507386	2.2722	0.032303	4.598592	156.361
kg/kkg-BOD	22	0.482020	0.753693	0.5681	0.016152	2.299296	156.361
Lb/Ton-COD	16	0.372299	0.308416	0.0951	0.059433	1.321848	82.841
kg/kkg-COD	16	0.186149	0.154208	0.0238	0.029716	0.660924	82.841
Lb/Ton-SS	23	0.357581	0.488227	0.2384	0.009283	1.735085	136.536
kg/kkg-SS	23	0.178791	0.244113	0.0596	0.004641	0.867543	136.536
Lb/Ton-FOG	24	0.375026	0.760704	0.5787	0.007420	3.734034	202.840
kg/kkg-FOG	24	0.187513	0.380352	0.1447	0.003710	1.867017	202.840
BOD/COD Ratio	16	0.515770	0.104451	0.0109	0.307423	0.669528	20.251
BOD/FOG Ratio	22	5.078944	6.677789	44.5929	0.500872	27.876543	131.480
Flow Ratio	24	108.244650	163.075798	26593.7160	2.195390	496.450027	150.655

* FOG = Fats, Oils, and greases.

N = Number of data points

Note: Computer calculations for this table show no regard for significant figures.

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TABLE 32

POLLUTANT WASTE LOADINGS FOR SHORTENING AND TABLE OIL PROCESSING

Edible Oil Refinery by Process Code	Production (kkg/day)	Volume of Wastewater Discharged (cu m/day)	BOD (mg/l)	COD (mg/l)	SS (mg/l)	Oil & Grease (mg/l)
79S05	142	12.9	0.13	0.22	0.052	0.056
79S08	250	7.19	0.046	0.12	0.041	0.052
79S09	268	17.9	0.11	0.24	0.12	0.067
79S06	154	235.4	1.51	----	1.03	0.28
79S17	321	181.7	----	----	----	1.87

SUBCATEGORY A 15 - OLIVE OIL REFINING

The refining of olive oil is similar to the refining of other edible oils except that it is done on a much smaller scale. The only wastewater generated is from caustic refining wash water with the following characteristics:

Flow	1.13 cu m/day (0.003 MGD)
BOD	5700 mg/l
SS	296 mg/l
FOG	195 mg/l

Model Plant

Plant 79I02 is the only olive oil refiner in the country using caustic refining. Thus, the model plant is Plant 79I02 and is illustrated in Figure 111. The plant will have wastewater characteristics as listed above.

BEVERAGES

SUBCATEGORY A 16 - NEW LARGE MALT BEVERAGE BREWERIES

In order to determine the wastewater characteristics of the malt beverage industry, information was collected from several sources. The United States Brewers Association (USBA) circulated one of two types of surveys to all known breweries. They then produced a report entitled "1974 Brewery Effluent Wastewater Characteristics" (56). Eleven breweries were visited during the study and four breweries were sampled. An extensive literature search was made to locate any existing historical data.

Process Waste Streams

As was noted in Section III, the sources of brewery waste can be identified but the methods of disposal vary for each individual brewery. Further, individual breweries may vary their methods of disposal based upon economic or environmental factors. For these reasons there can be no fixed ranking of the strengths of waste streams for the entire industry, however several generalizations can be made.

Spent Grain Liquor - This is one of the most significant sources of waste in the brewing process. It is essentially carbohydrate material, high in BOD and suspended solids and low in pH. According to LeSeelleur (57) average concentrations of BOD and suspended solids in spent grain liquor are 15,000 mg/l and 20,000 mg/l, respectively. At these concentrations spent grain liquor, if discharged, can be expected to comprise 30 to 60 percent of the total plant load. As reported by Stein (58), spent grain liquor from Plant 82B08IP9 represented 43.5 percent of the total pounds of BOD and 60.3 percent of the total pounds of suspended solids. Most of the breweries in subcategory A 16 do not discharge spent grain liquor.

Feed Recovery - These systems are operated by breweries not selling wet spent grains or not disposing of spent grain liquor to sewers. As explained in Section III, the major wastewater discharge from feed recovery

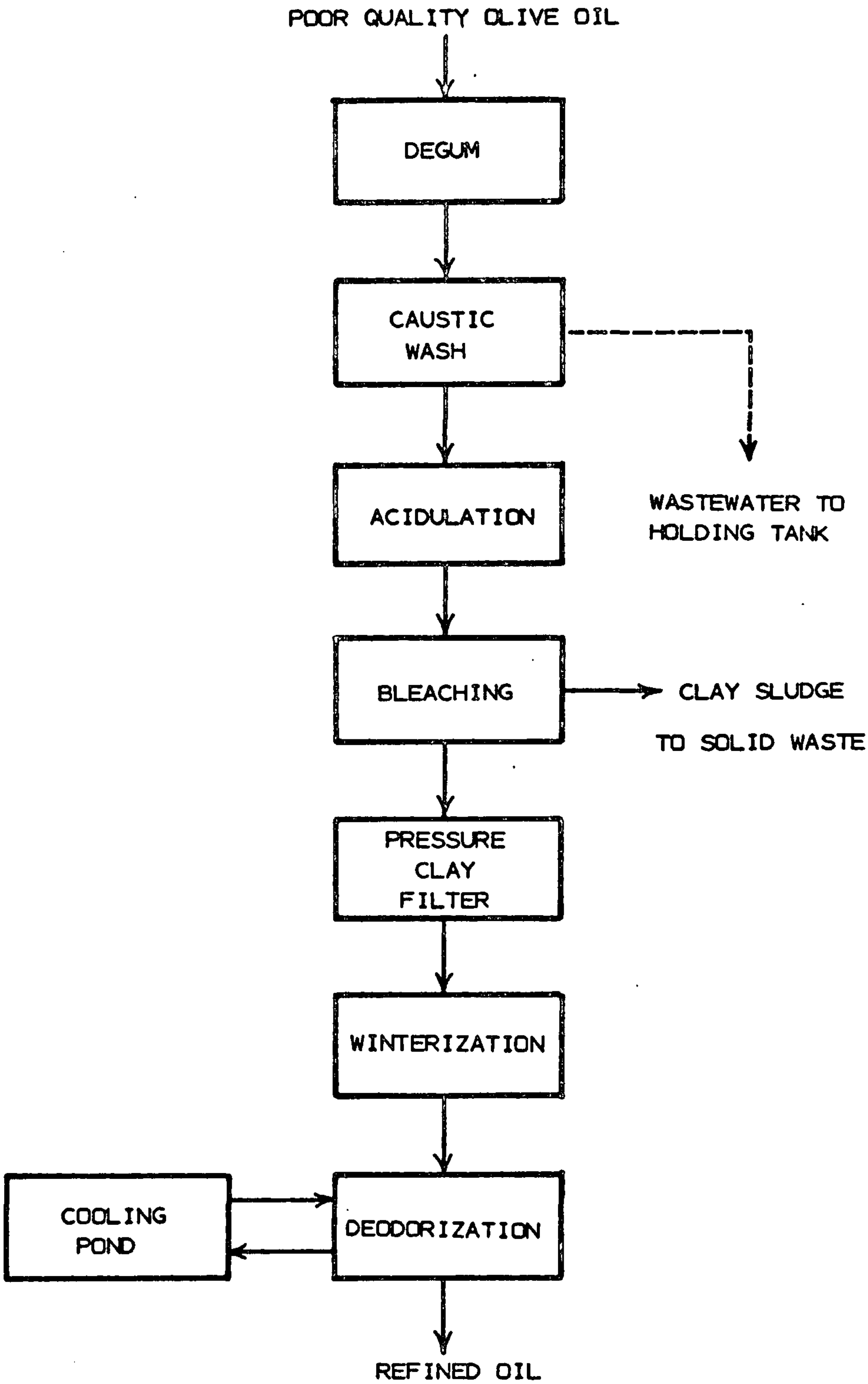

FIGURE III

SUBCATEGORY A 15
OLIVE OIL CAUSTIC REFINING PROCESS
MODEL PLANT

is the evaporator condensate. This is a high volume effluent with little or no suspended solids and up to 300 mg/l BOD. The concentration varies from plant to plant depending on whether yeast, lost beer, or other wastes are evaporated along with spent grain liquor. Wet scrubbers, if utilized, comprise a minor part of total feed recovery wasteload. Some plants utilize cyclones, thus eliminating wet scrubber discharge. More than half of the breweries in Subcategory A 16 operate feed recovery systems.

Lost Beer - This may represent from four to eight percent of beer produced. Lost beer is primarily derived from packaging, fermentation, and finishing. Since beer has a BOD concentration of approximately 125,000 mg/l, this can account for a considerable part of the total plant load. Plant 82A02IP9, for example, estimated beer loss at 40 percent of the total pounds of BOD discharged per day. Assuming no recovery, a four percent beer loss would amount to a BOD load of 5.02 kg/cu m (1.3 lb/barrel). Four of the breweries in Subcategory A 16 practice some form of beer recovery.

Spent Hops, Trub, and Yeast - These are grouped together simply because their method of disposal may be similar. They are all suitable for addition to spent grains since they contain only carbohydrates, protein materials, yeast, and beer residues. None of the plants in Subcategory A 16 discharge hops, trub, or yeast to sewers.

Filter Aid - This must either be hauled away to land disposal or sewered. Considerable suspended solids would result were this waste to be discharged, hence all but one of the plants in Subcategory A 16 recover filter aid by decant tanks, vacuum, or pressure filters.

Alkaline Wastes - These are generated from vessel cleanup and bottle washers. Residue from vessel walls is combined with caustic during vessel cleanup. Paper labels, sodium aluminate from aluminum labels, and glue are combined with caustic discharges from bottle washers. Although alkaline wastes may be readjusted and reused, they are eventually sewered. Several plants in Subcategory A 16 meter caustic into sewers from holding tanks.

Combined Process Flow

Data from 77 breweries were catalogued in the USBA wastewater characteristics report. These brewers represented 87 percent of total sales for the industry in 1973. Each brewery reported the ratio of flow (barrels), BOD (lb), and suspended solids (lb), to production (barrels) for a full-capacity day. A full-capacity day was defined as the maximum output which could be sustained for a number of consecutive days. Each brewery was assigned a reliability number based on the amount of accumulated data and on sampling technique. Reliability numbers ranged from 0 to 10, with the higher numbers corresponding to those breweries with more accurate data. Breweries with reliability ratings of 8 to 10 were characterized by continuous metering with short interval flow proportional sampling on a daily basis for six or more months. Breweries with reliability ratings of zero had no data or data which would have an extremely high probability of yielding misleading results. The year of initial construction and last major expansion was presented for as many brewers as possible.

Based on the survey data, the arithmetic mean for all brewers was as follows:

Flow Ratio	7420 l/cu m (7.42 lb/bbl)
BOD Ratio	9.43 kg/cu m (2.44 lb/bbl)
SS Ratio	3.83 kg/cu m (0.99 lb/bbl)

Data for breweries in Subcategory A 16 are itemized and summarized in Table 33. Scatter diagrams of flow, BOD, and suspended solids ratios versus production for Subcategory A 16 are illustrated in Figures 112, 113 and 114.

Log normal probability plots of flow, BOD, and suspended solids ratios are illustrated in Figures 115, 116, and 117.

Other significant parameters for combined process flow are pH, nitrogen, and phosphorus. Several studies have documented the fact that pH may vary widely over a 24 hour period. In fact, fluctuations of pH from 2 to 12 can be expected due to the batch nature of the brewing process. In general, the pH of breweries in Subcategory A 16 can be expected to remain between 5 and 11 due to the large number of compensating operations taking place simultaneously. Metering of caustic from holding tanks can be expected to further buffer variations. Brewery waste is known to be deficient in nitrogen. O'Rourke and Tomlinson (59) defined an average BOD/N ratio of 43.2. Tests at Plant 82K32MP9 (60) established a BOD/N ratio of 50.7. These appear to be representative of the industry as a whole. Based on treatment systems in operation the waste appears to contain adequate phosphorus.

In order to demonstrate the daily variability of brewery waste, the flow, BOD, and suspended solids ratios for Plant 82A43 have been plotted for a six month period as shown in Figures 118, 119, and 120. The means and standard deviations are also given, It is obvious from these figures that treatment system design and effluent limitations must take into account the highly variable nature of brewery waste.

Model Plant

The raw waste loads for the model plant for Subcategory A 16 are based on the mean ratios presented in Table 33. It should be noted that these means were calculated by excluding the data from Plant 82A16. This plant has demonstrated superior in-house waste reduction procedures. It was felt, however, that the raw waste loads for this plant were not necessarily economically achievable for the other brewers in this subcategory in their present configurations. For treatment system design purposes, an average production for this subcategory was calculated to be 1500 cu m (12,800

TABLE 33

WASTEWATER CHARACTERISTICS
SUBCATEGORY A16
(NEW LARGE BREWERIES)

Plant	Flow Ratio (l/cum)	BOD Ratio (kg cu m)	SS Ratio (kg/cu m)	Reliability Number
82A01	4640	9.62	3.48	10
82A02	5200	7.88	3.40	8
82A05	7020	10.40	2.40	8
82B07	6850	12.90	4.41	7
82B08	9860	17.40	8.35	5
82A09	4970	7.38	5.06	8
82A16	1620	1.74	1.08	10
82B35	3550	9.00	2.24	5
82A43	4520	8.81	2.98	10
82B56	4600	11.00	3.94	7
82A58	5870	15.00	4.68	8
82A61	4860	8.58	2.78	10
82A62	4660	11.20	3.59	9
82A63	3730	7.57	2.94	9
Mean*	5410 (5.41 bbl/bbl)	10.50 (2.72 lbs/bbl)	3.86 (1.00 lbs/bbl)	

*Calculated without data from plant 82A16

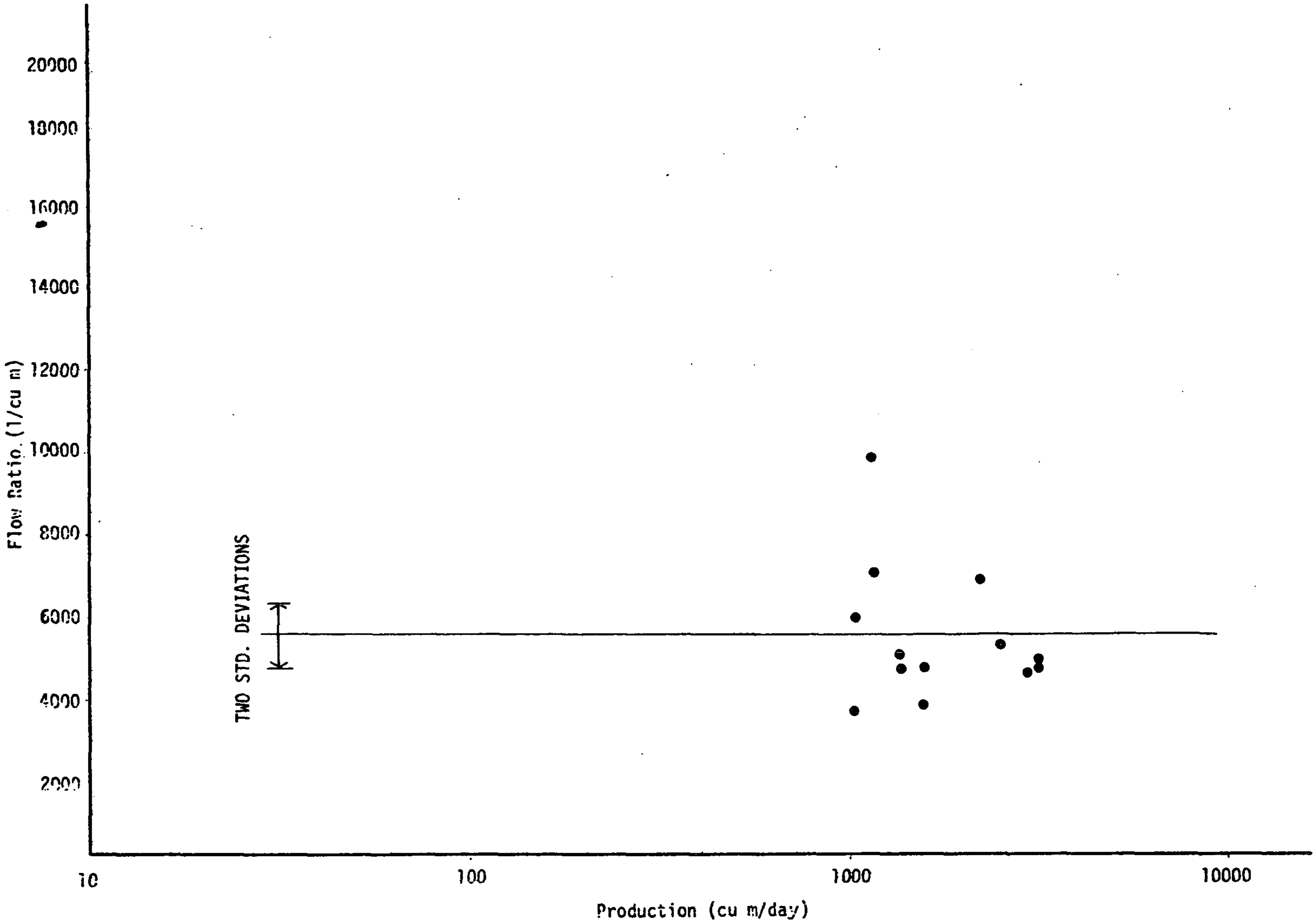

FIGURE 112

SUBCATEGORY A 16
FLOW VS CAPACITY

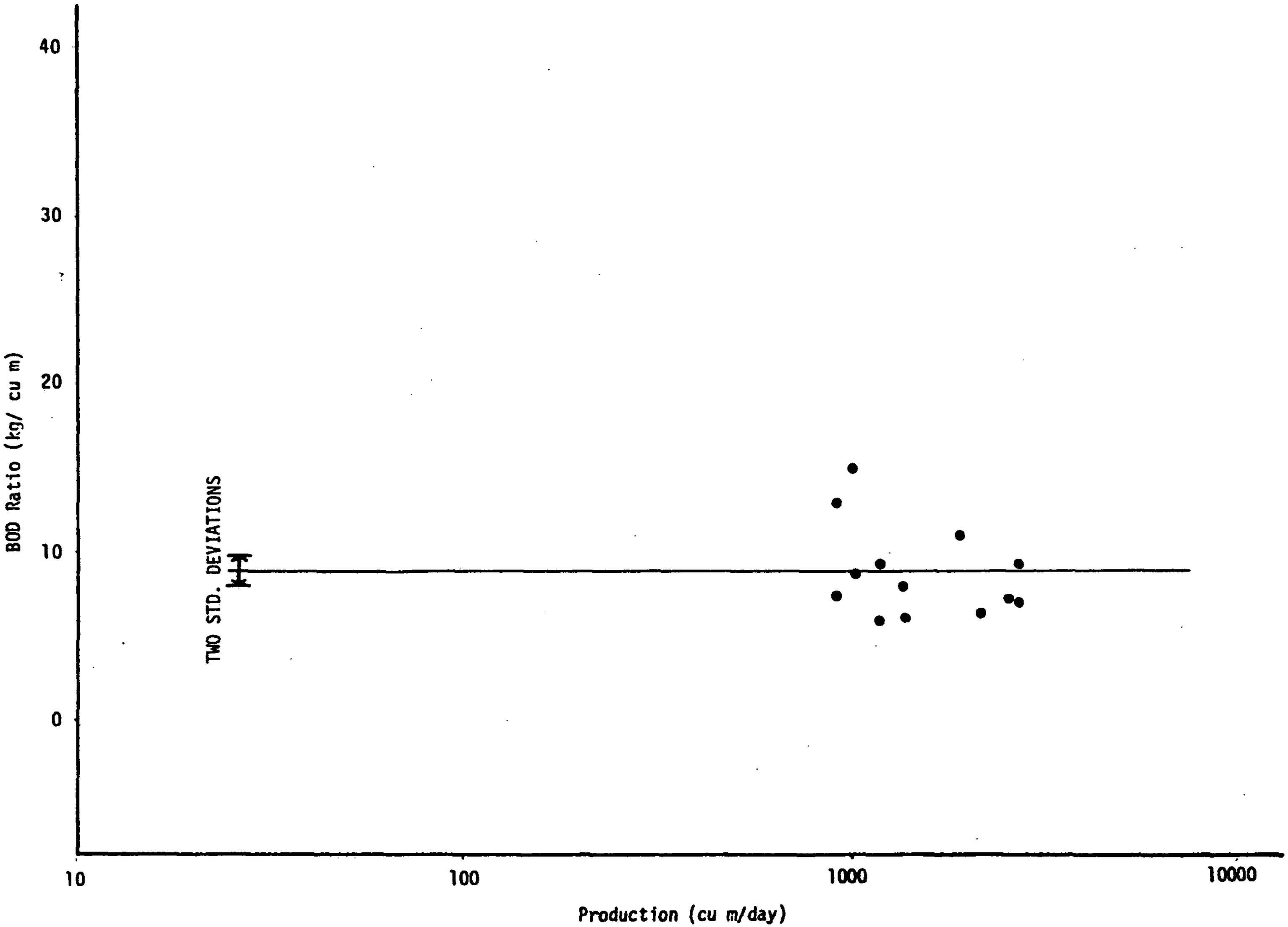

FIGURE 113

SUBCATEGORY A 16
BOD VS CAPACITY

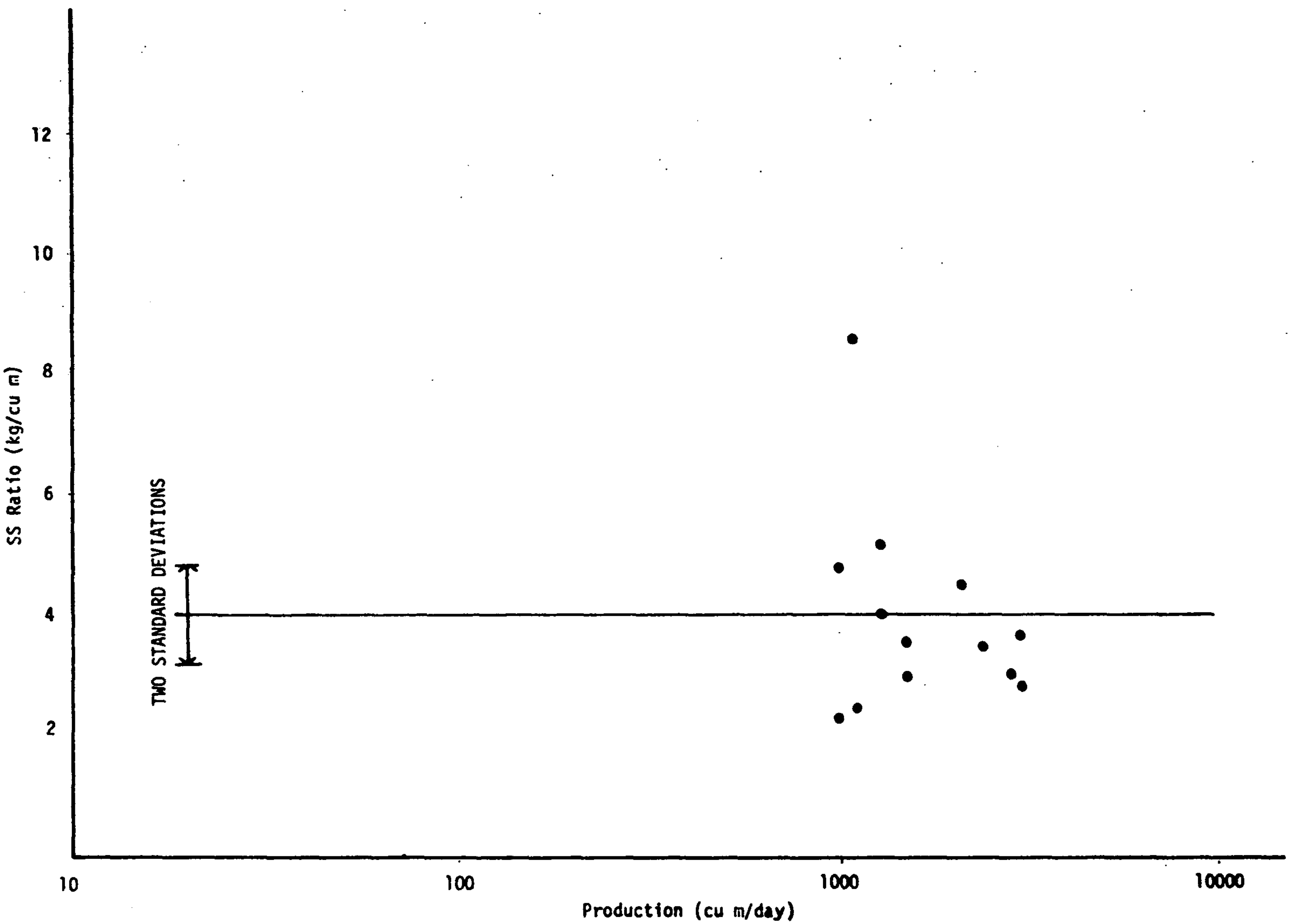

FIGURE 114

SUBCATEGORY A 16
SUSPENDED SOLIDS VS CAPACITY

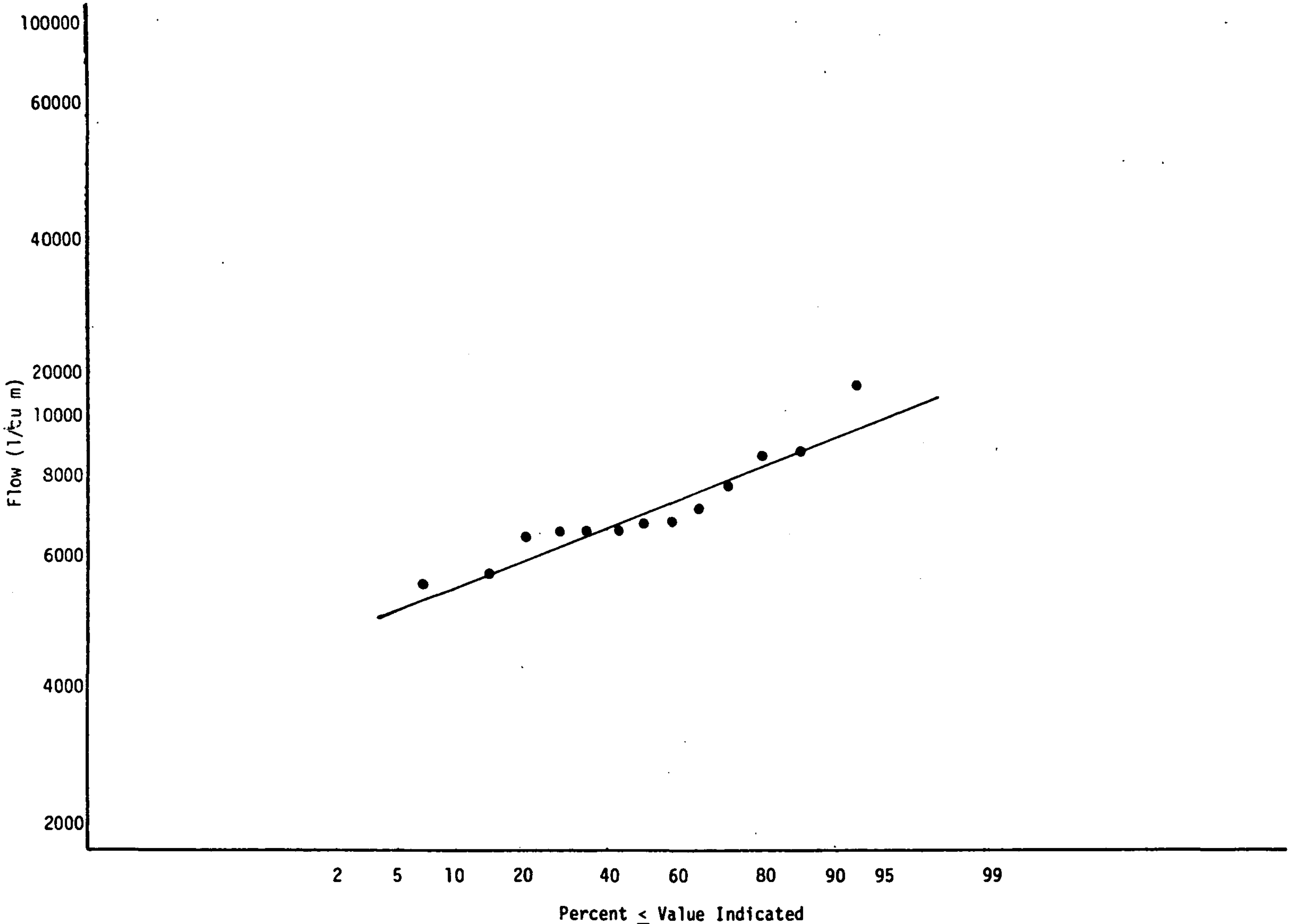

FIGURE 115

SUBCATEGORY A 16
FLOW PROBABILITY DIAGRAM

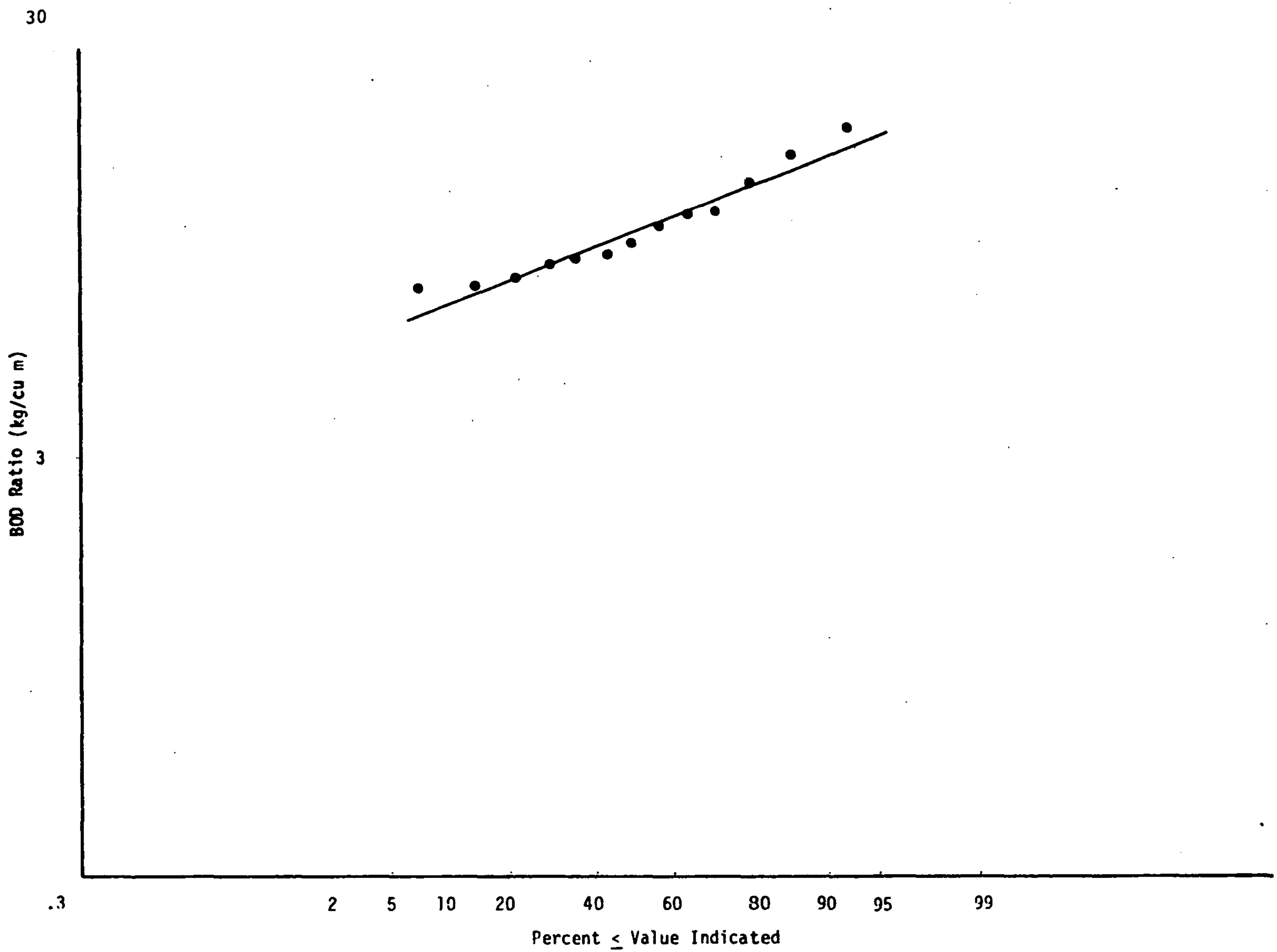

FIGURE 116

SUBCATEGORY A 16
BOD PROBABILITY DIAGRAM

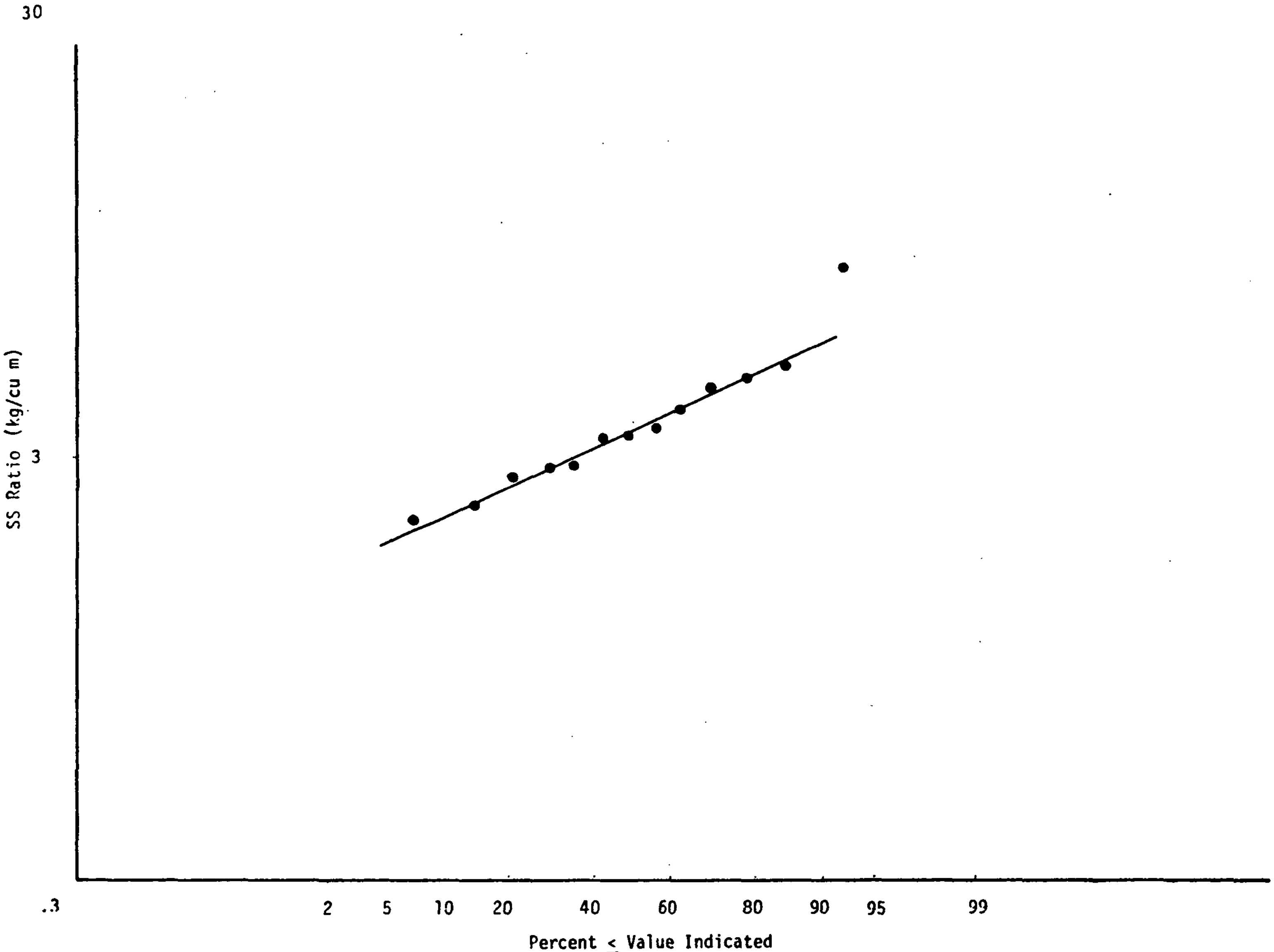

FIGURE 117

SUBCATEGORY A 16
SUSPENDED SOLIDS PROBABILITY DIAGRAM

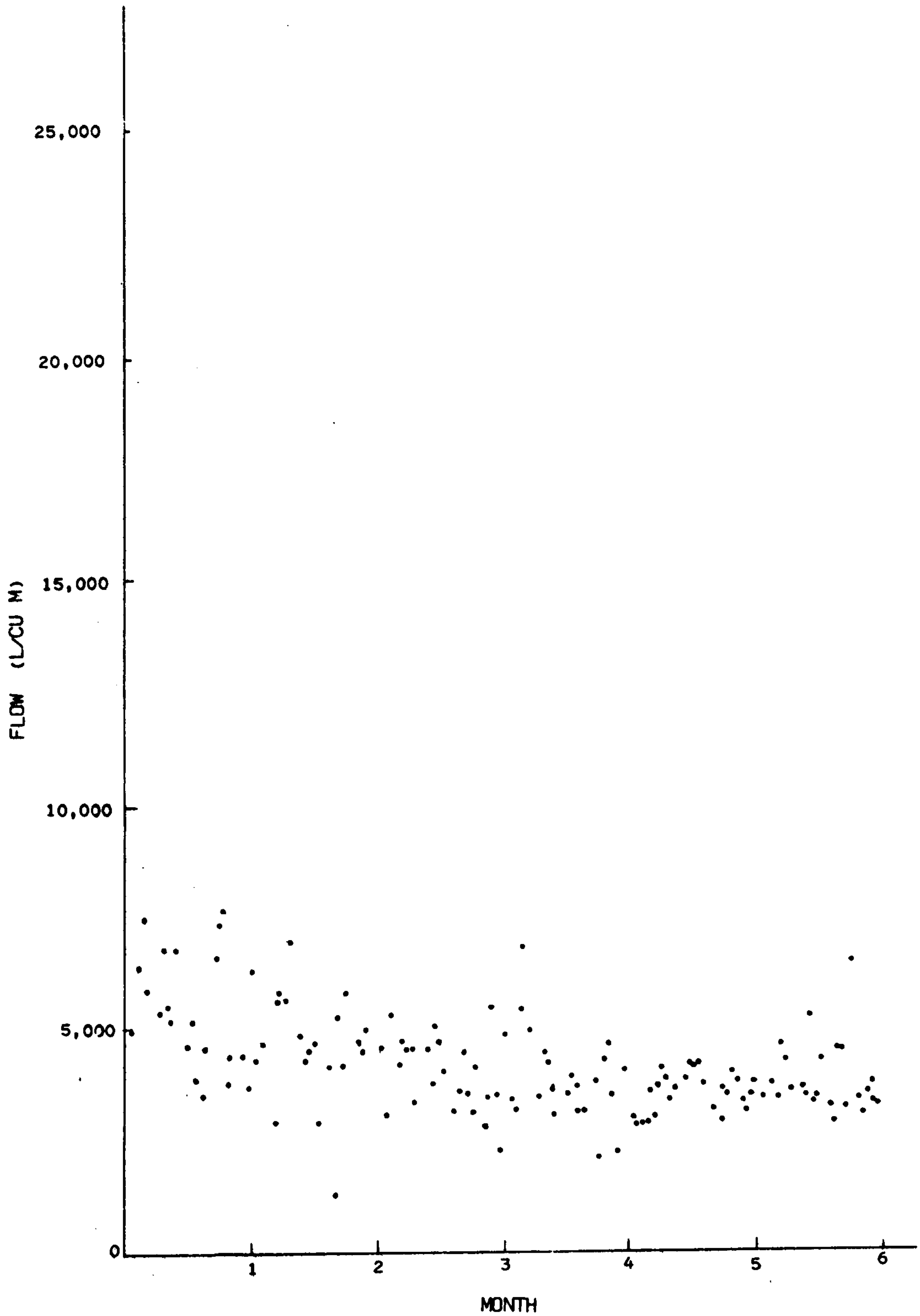

FIGURE 118

DAILY FLOW VARIABILITY
PLANT 82A43

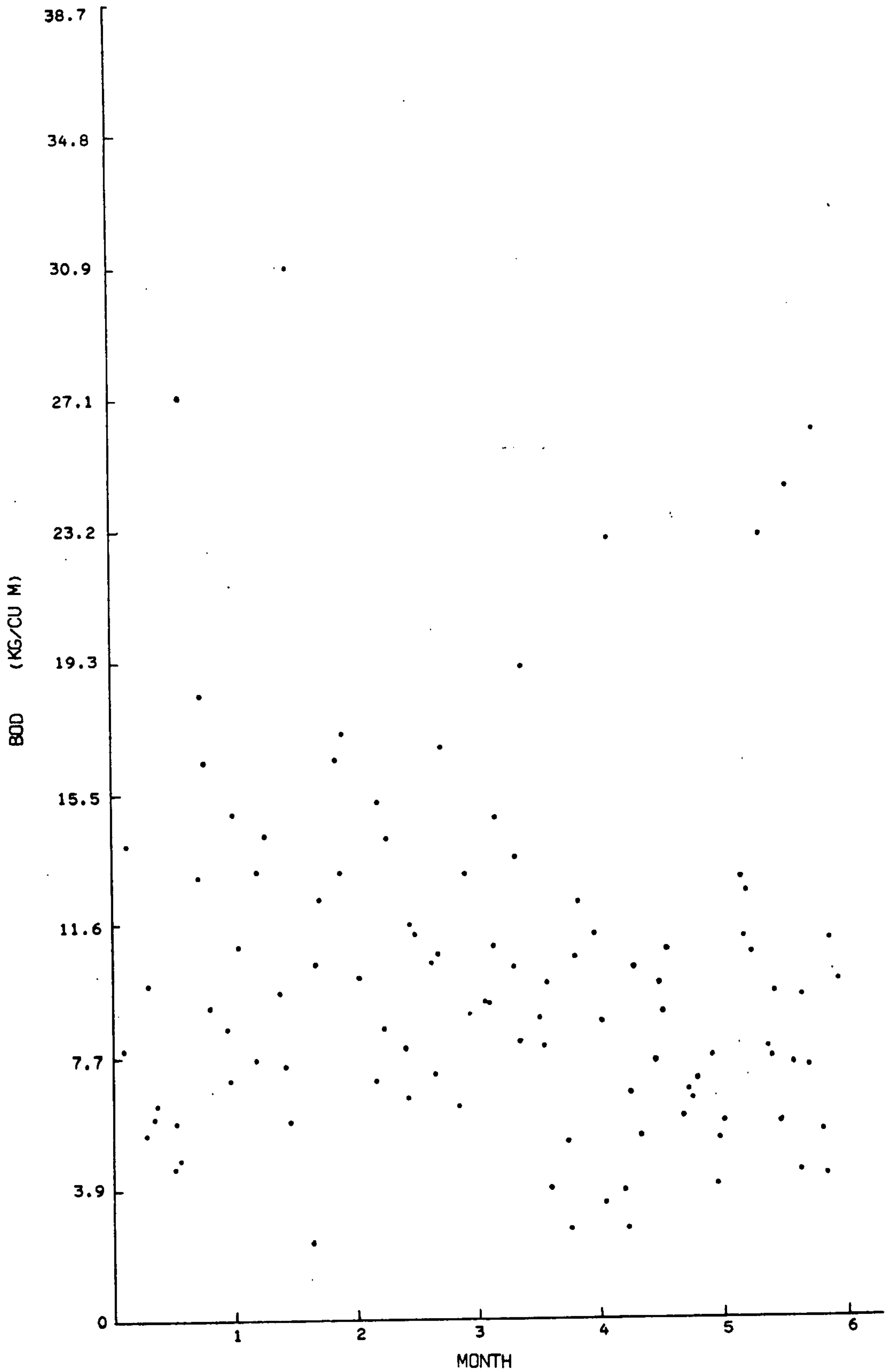

FIGURE 119

DAILY BOD VARIABILITY
PLANT 82A43

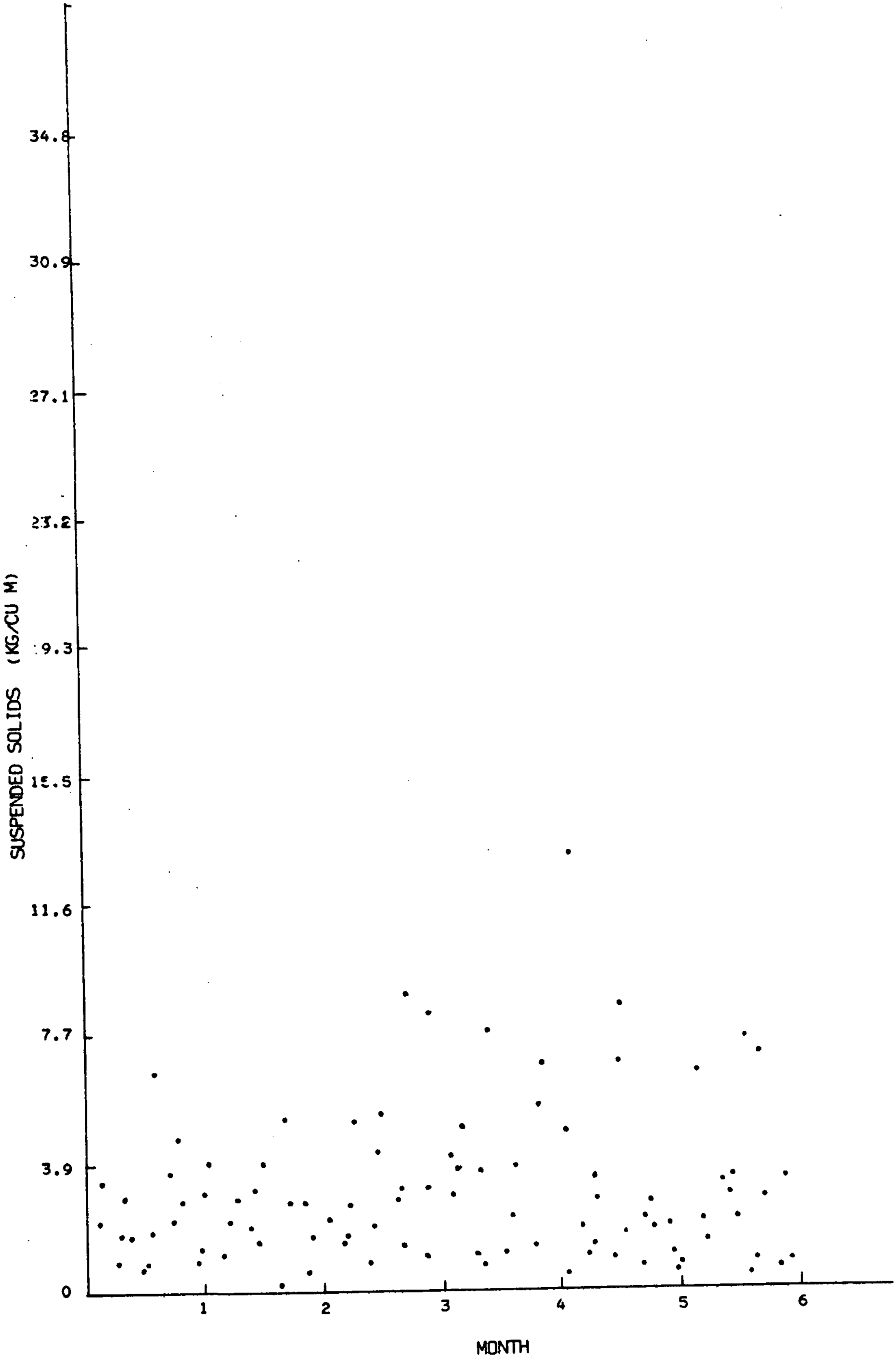

FIGURE 120

DAILY SUSPENDED SOLIDS VARIABILITY

barrels) per day. Process waste and non-contact water are assumed to be separated. Based on these assumptions, the model plant is defined as follows:

Flow (MGD)	2.2
BOD (mg/l)	1900
SS (mg/l)	700
Total KN	40
pH	2 to 12

SUBCATEGORY A 17 - OLD LARGE MALT BEVERAGE BREWERIES

The methodology for determining wastewater characteristics for this subcategory was the same as for Subcategory 16.

Process Waste Streams

Management questionnaires were available for three of the four brewers in this subcategory. From the questionnaire responses and from plant visits the following generalizations can be made. Due to the original design of breweries in this subcategory there is a tendency for spent wet grains to be sold and for spent grain liquor to be sewered instead of evaporated. Spent hops, trub, and yeast are generally added to the wet spent grains, while lost beer, filter aid, and caustic are usually sewered.

Combined Process Flow

Data for breweries in this subcategory are itemized and summarized in Table 35. Scatter diagrams of flow, BOD, and suspended solids ratios versus production are plotted in Figures 121, 122, and 123. Log normal probability plots of flow, BOD, and suspended solids ratios are illustrated in Figures 124, 125, and 126. Age of facilities and efficiency of operation result in higher raw wasteloads for this subcategory. Smaller tankage is common, thus causing more water to be used in cleaning operations. Collection and disposition of wastes is made more difficult by old and intricate piping.

Model Plant

The raw waste load for this subcategory are based on the mean values presented in Table 35. The average production was calculated to be 2600 cu m (2,200 barrels) per day. Process waste and non-contact water are assumed to be separated. Based on these assumptions the model plant is defined as follows:

Flow (MGD)	7.5
BOD (mg/l)	1700
SS (mg/l)	670
Total KN	35
pH	2 to 12

TABLE 35

WASTEWATER CHARACTERISTICS
SUBCATEGORY A17
(OLD LARGE BREWERIES)

Plant	Flow Ratio (l/cu m)	BOD Ratio (kg/cu m)	SS Ratio (kg/cu m)	Reliability Number
82F04	14,700	18.9	9.62	5
82H36	9380	-	-	0
82G46	9870	20.9	7.85	2
82G64	10,200	16.7	4.64	2
Mean	11,000 (11.0 bbl/bbl)	18.8 (4.87 lbs/bbl)	7.34 (1.90 lbs/bbl)	

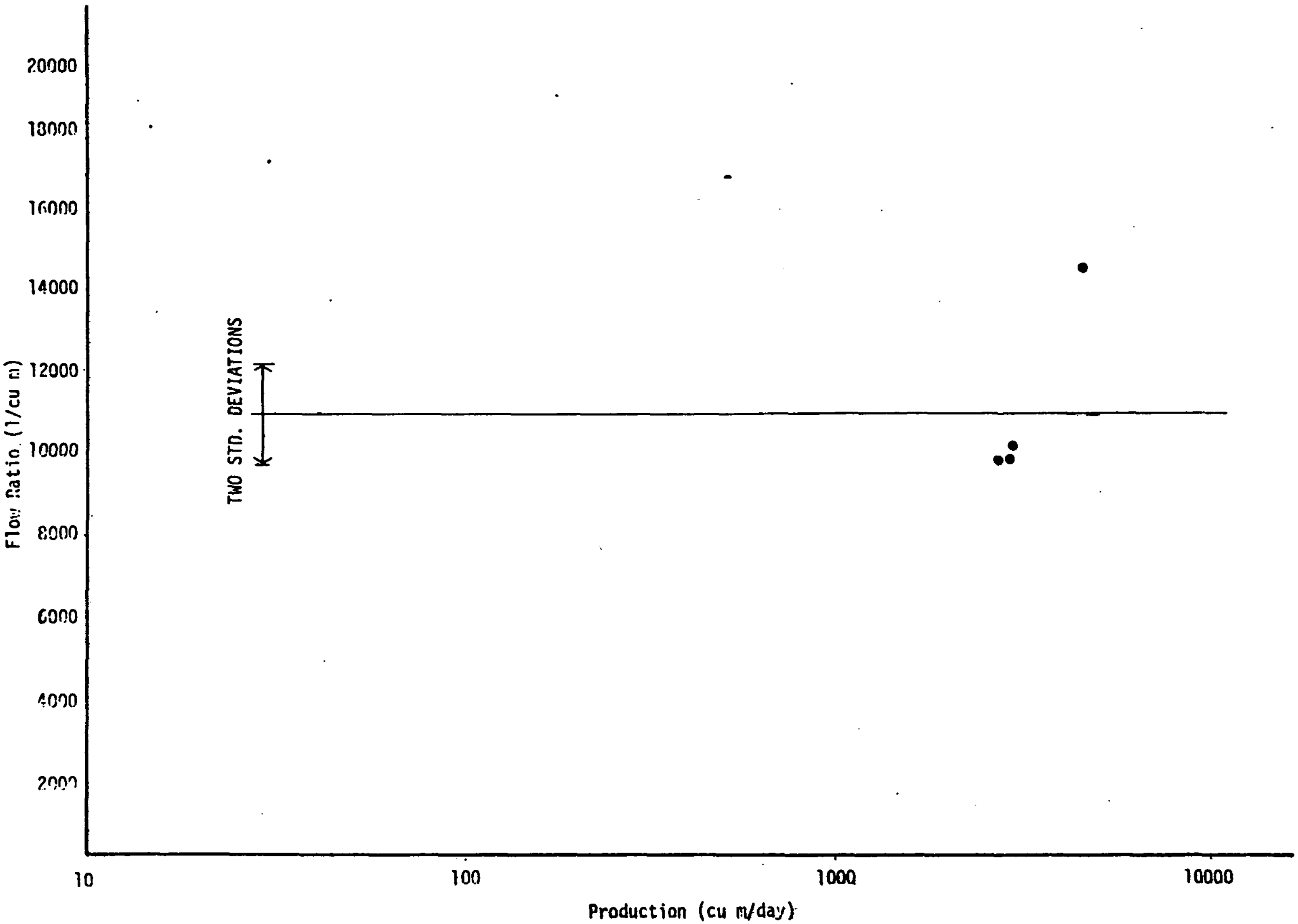

FIGURE 121

SUBCATEGORY A 17
FLOW VS CAPACITY

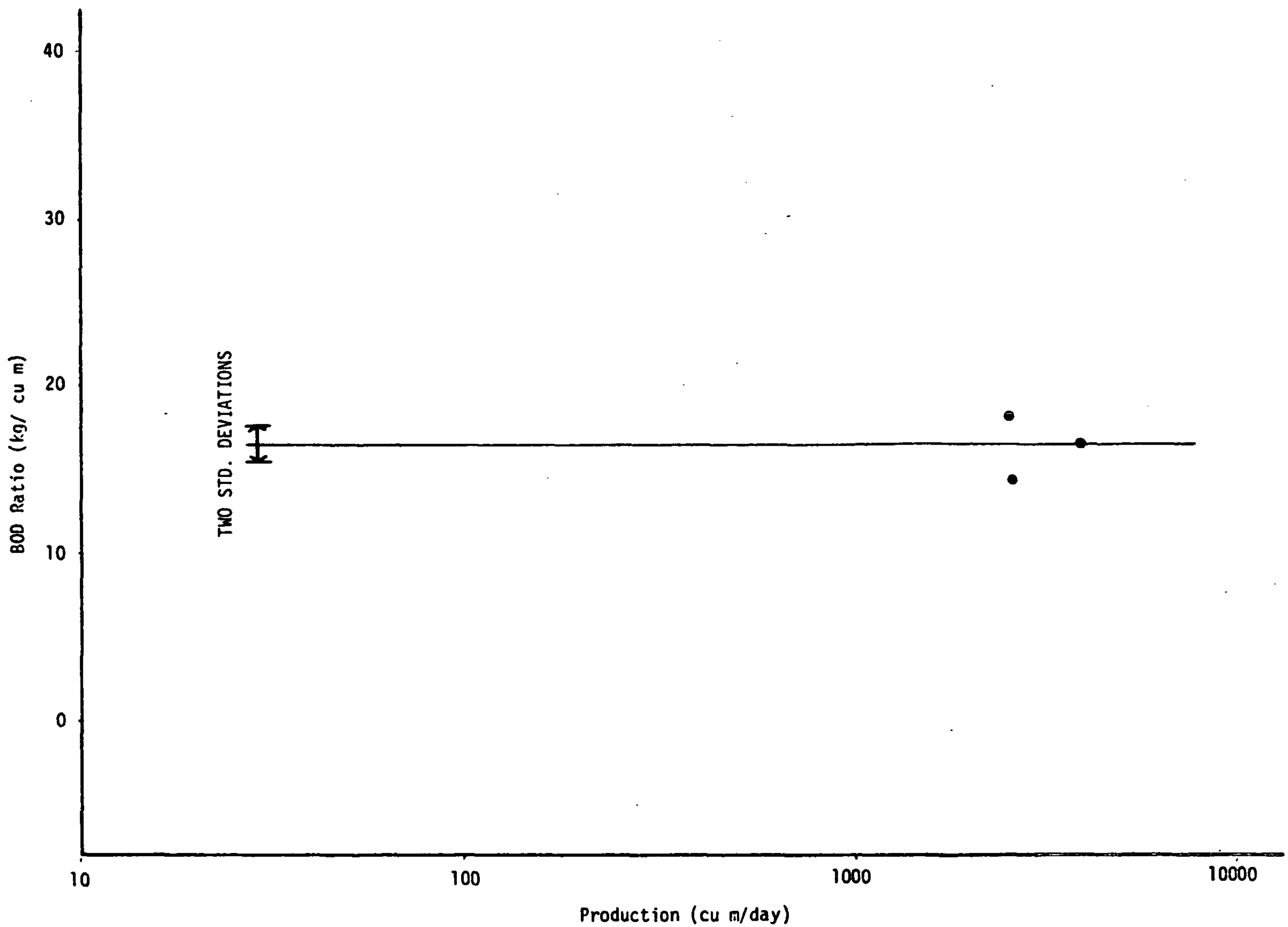

FIGURE 122

SUBCATEGORY A 17
BOD VS CAPACITY

DRAFT

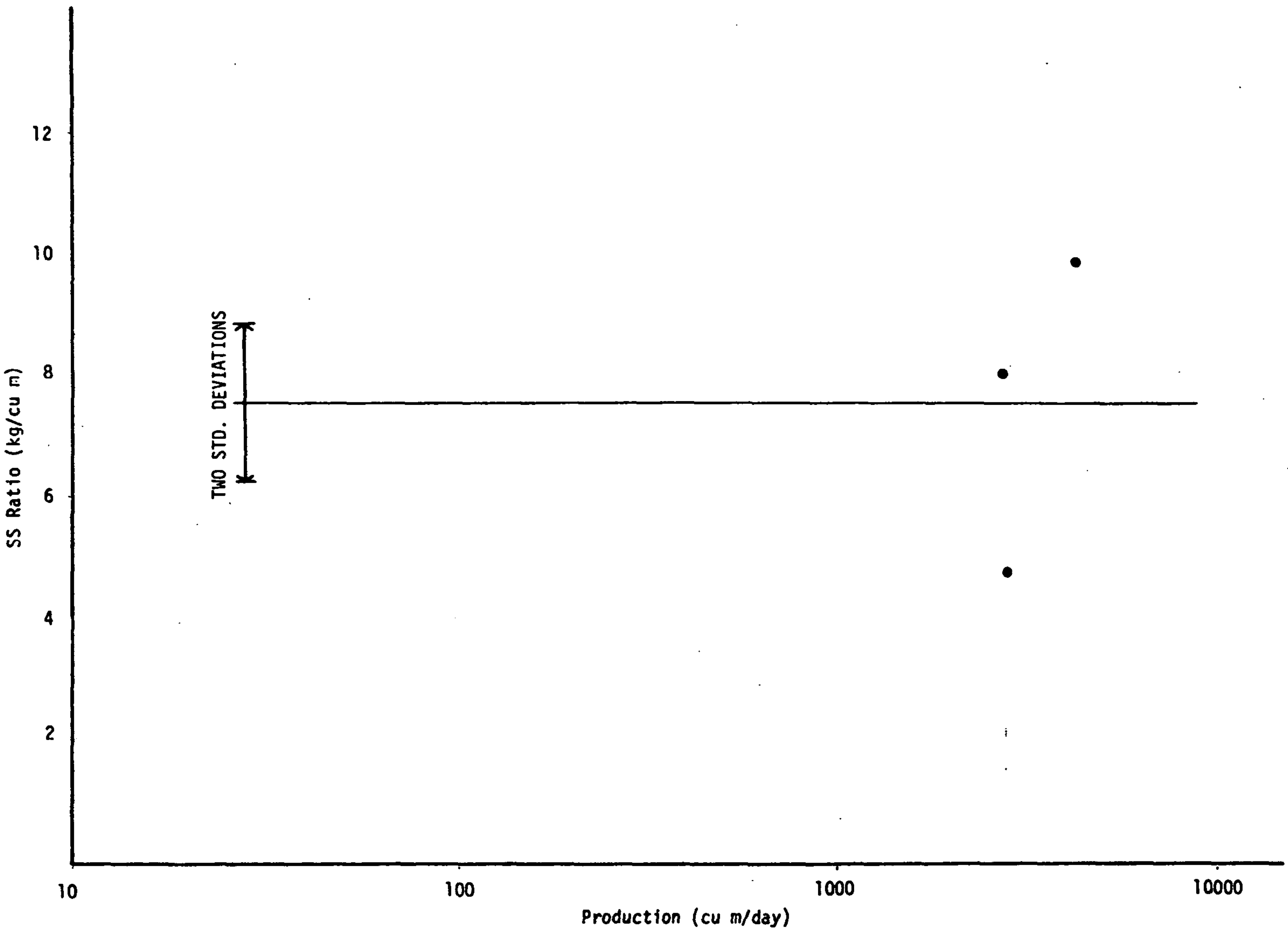

FIGURE 123

SUBCATEGORY A 17
SUSPENDED SOLIDS VS CAPACITY

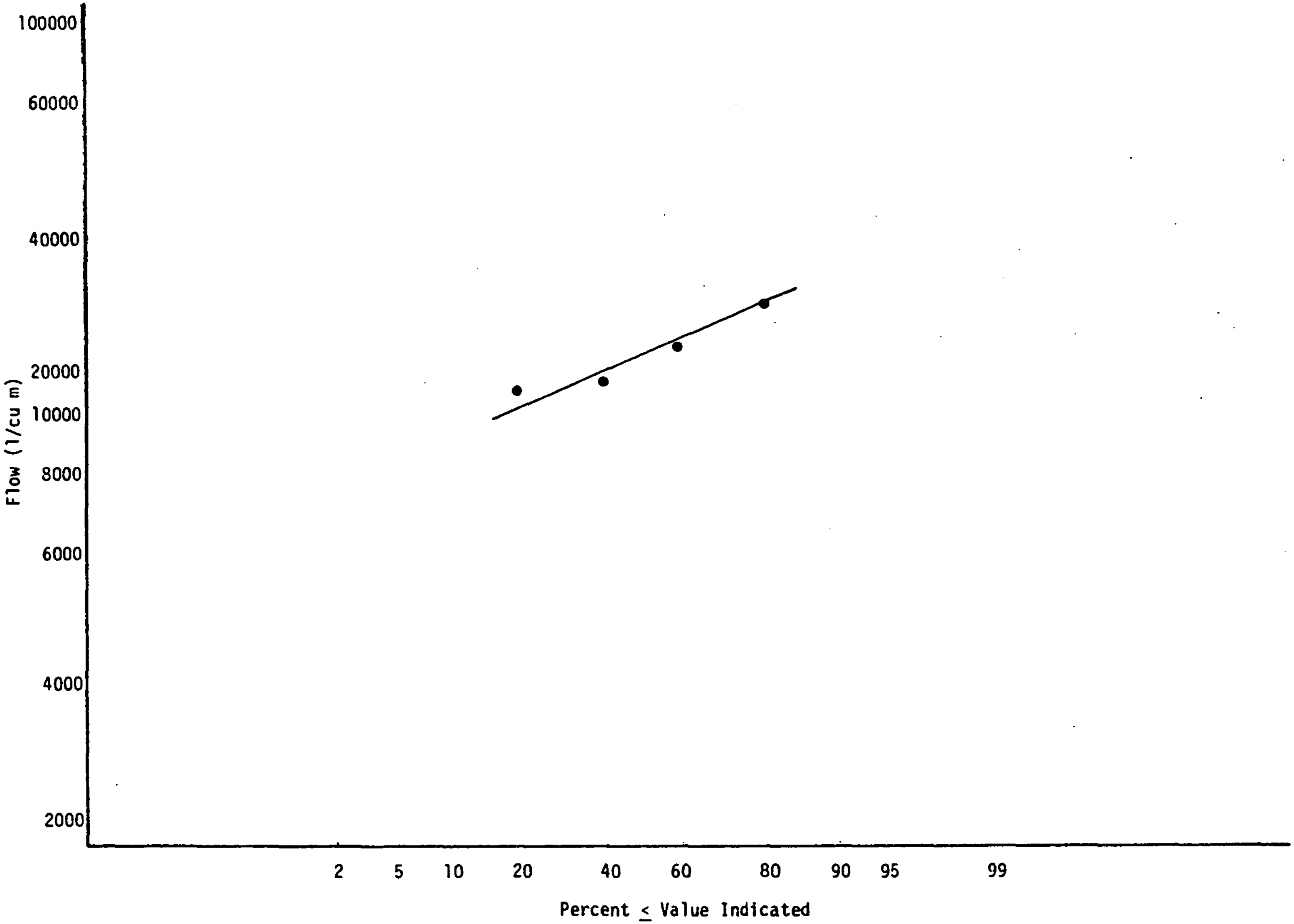

FIGURE 124

SUBCATEGORY A 17
FLOW PROBABILITY DIAGRAM

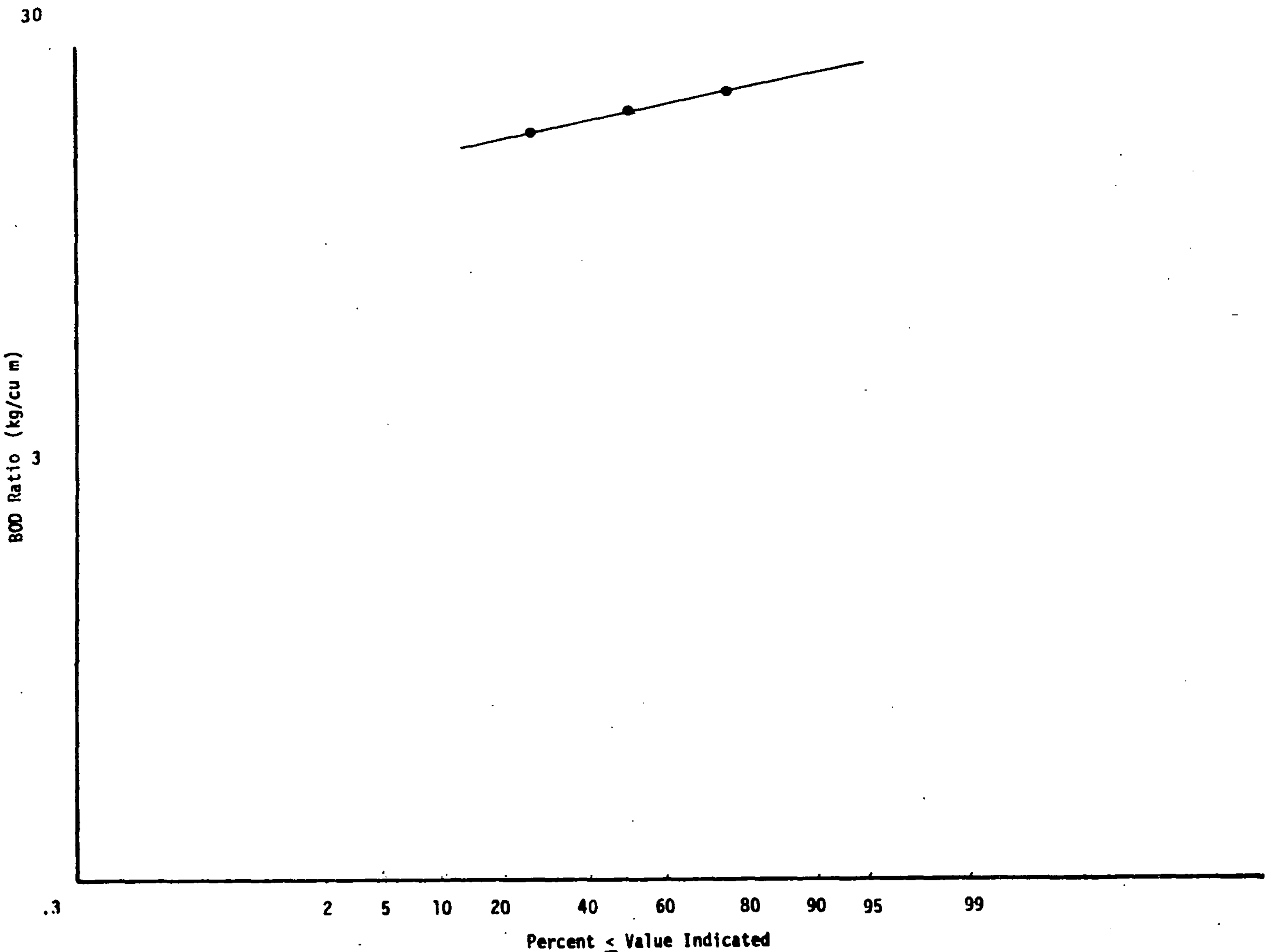

FIGURE 125

SUBCATEGORY A 17
BOD PROBABILITY DIAGRAM

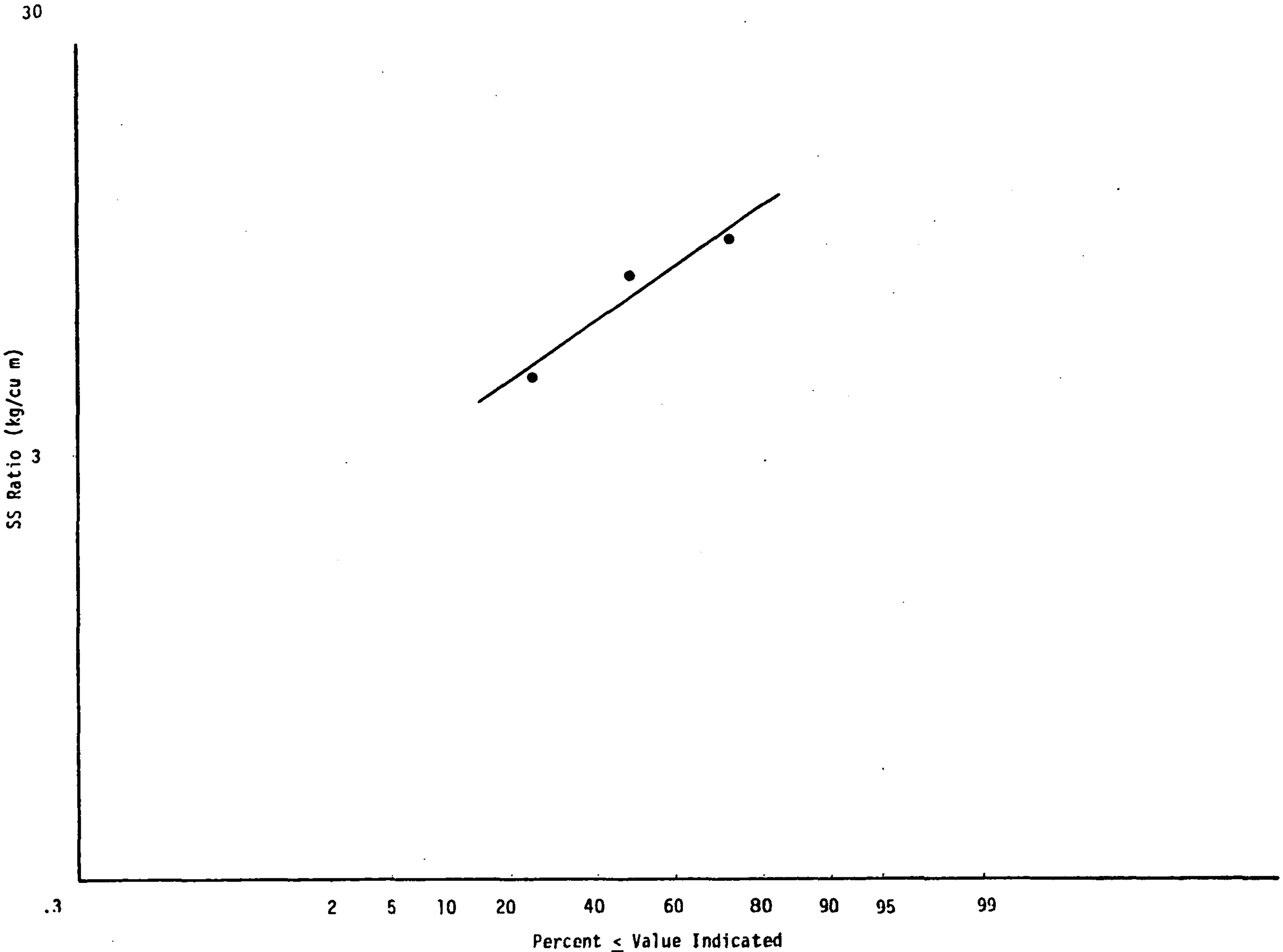

FIGURE 126

SUBCATEGORY A 17
SUSPENDED SOLIDS PROBABILITY DIAGRAM

SUBCATEGORY A 18 - ALL OTHER MALT BEVERAGE BREWERIES

The methodology for determining wastewater characteristics for this subcategory was the same as for Subcategory A 16 and A 17.

Process Waste Streams

Management questionnaires were not completed by all breweries in this subcategory hence no comprehensive analysis of methods of disposal is possible. The constituency of the process streams remains identical to that described in Subcategory A 17.

Combined Process Flow

Eighty-five breweries are included in this subcategory. The 27 plants not responding to the USBA survey form part of this group. Twenty-five plants responding, but reporting no data, are also included in this group. Data for those breweries responding is itemized and summarized in Table 36. Only six of these breweries have a reliability rating of four or higher. The standard deviation for the group is quite high, indicating the lack of a definitive data base. Scatter diagrams of flow, BOD, and suspended solids ratios verus production are plotted in Figures 127, 128, and 129. Log normal probability plots of flow, BOD and suspended solids ratios are illustrated in Figures 130, 131, and 132.

Model Plant

The raw waste loads for the model plant are based on the 80 percent values for this subcategory as presented in Table 36. This assumption took into account the statistical variance of the group in addition to the fact that those six plants with reliable data tended to exceed the mean in several cases. The average production for this subcategory was calculated to be 470 cu m (4000 barrels) per day. Process waste and non-contact water are assumed to be separated. Based on these assumptions the model plant is defined as follows:

Flow (MGD)	1.2
BOD (mg/l)	1400
SS (mg/l)	640
Total KN	30
pH	2 to 12

SUBCATEGORY A 19 - MALT

In order to determine the wastewater characteristics of this industry a survey was conducted of all known maltsters. Three plants were visited, two plants were sampled, and a search was made for any existing historical data.

Process Waste Streams

As far back as 1935 Ruf (61) identified steeping and germinating as the primary and secondary waste sources, respectively, from a malt house.

TABLE 36

WASTEWATER CHARACTERISTICS
SUBCATEGORY A 18

PLANT	FLOW RATIO (l/cu m)	BOD RATIO (kg/cu m)	SS RATIO (kg/cu m)	RELIABILITY NUMBER
82J59	4300	9.05	1.62	8
82K32	920	2.20	0.27	6
82K44	6810	9.82	6.26	7
82K50	3710	7.50	1.93	7
82K55	4100	7.42	2.55	6
82L03	9700	15.08	5.03	1
82L10	4630	1.66	1.04	1
82L14	2820	6.88	2.94	1
82L17	12900	19.34	9.40	1
82L20	8990	1.66	0.19	1
82L21	5380	28.35	0.89	1
82L23	3110	10.71	4.95	4
82L24	3720	8.62	2.98	2
82L25	7190	5.99	1.47	1
82L26	760	5.76	1.24	2
82L27	18060	8.97	5.88	1
82L28	66820	2.55	1.66	1
82L29	1030	5.41	1.55	1
82L33	4160	1.70	1.01	1
82L40	1660	1.66	0.54	1
82L42	4690	14.93	4.76	2
82L45	6450	14.31	6.96	1
82L47	4810	4.10	-.81	2
82L48	6500	0.66	0.39	1
82L57	11730	5.88	15.82	1
82L60	21510	15.47	6.46	1
82L65	7650	5.45	2.63	3
82L68	2470	3.40	0.66	1
82L74	10860	10.32	4.14	3
82M12	3910	----	----	0
82M13	10750	----	----	0
82M15	5960	----	----	0
82M18	3010	----	----	0
82M19	1130	----	----	0
82M22	----	----	----	0
82M30	7460	0.04	0.12	0
82M31	1090	----	----	0
82M34	810	2.32	3.48	0
82M37	----	----	----	0
82M38	----	----	----	0
82M39	----	----	----	0

TABLE 36 (CONT'D)

PLANT	FLOW RATIO (l/cu m)	BOD RATIO (kg/cu m)	SS RATIO (kg/cu m)	RELIABILITY NUMBER
82M41	11750	-----	-----	0
82M49	-----	-----	-----	0
82M51	-----	-----	-----	0
82M52	6620	-----	-----	0
82M53	5280	-----	-----	0
82M54	-----	-----	-----	0
82M65	4900	-----	-----	0
82M67	8310	-----	-----	0
82M69	-----	-----	-----	0
82M70	9160	5.41	2.44	0
82M71	- 100	0.50	0.04	0
82M72	9220	6.61	3.33	0
82M73	-----	-----	-----	0
82M75	12900	-----	-----	0
82M76	15240	-----	-----	0
82M77	3440	-----	-----	0
MEAN	(7710 l/bbl)	(8.47 l/bbl)	(3.64 l/bbl)	
80 Percent Value	10000	13.53	6.19	
	(10.0bbl/bbl)	(3.5bbl/bbl)	(1.60bbl/bbl)	

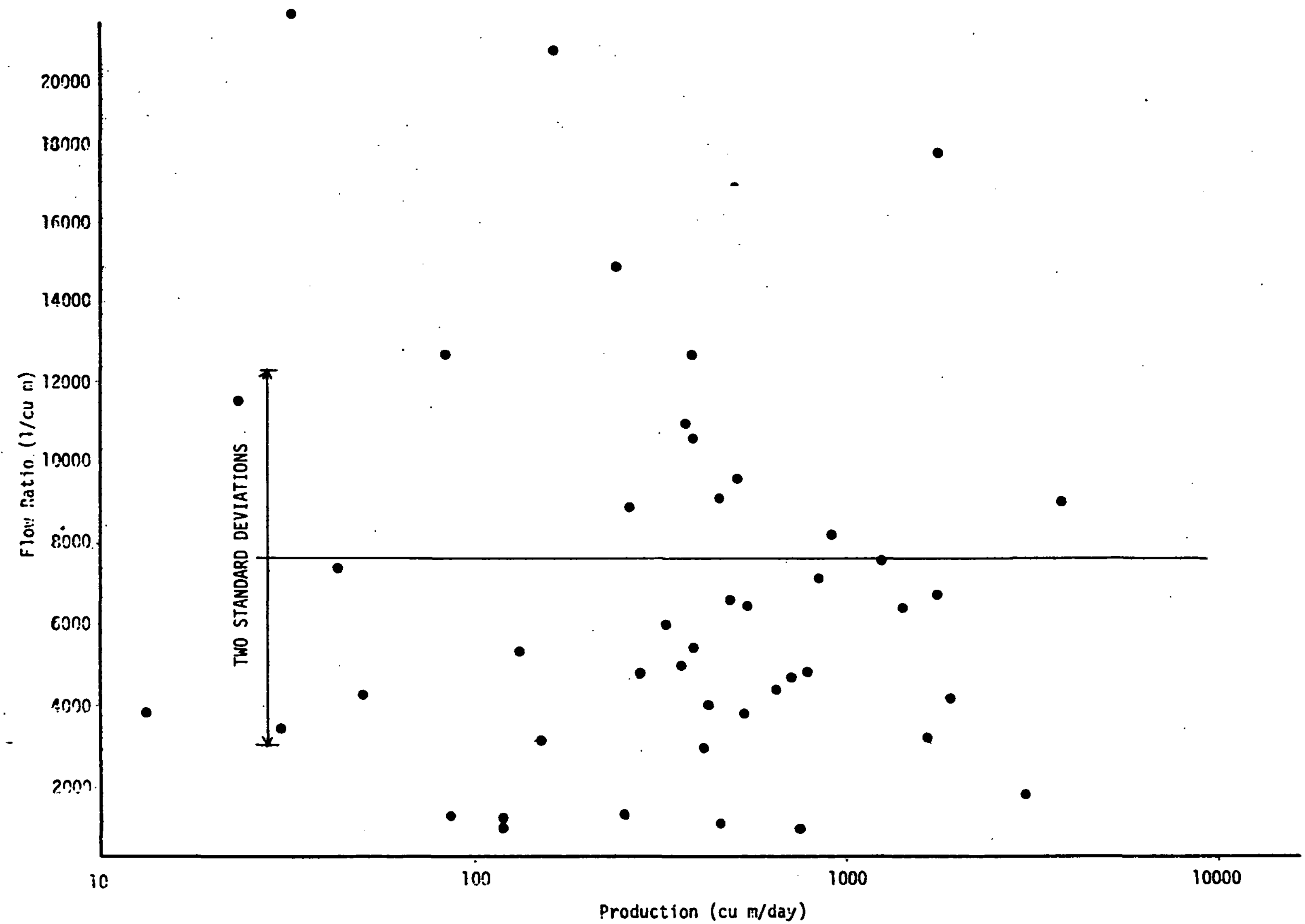

FIGURE 127

SUBCATEGORY A 18
FLOW VS CAPACITY

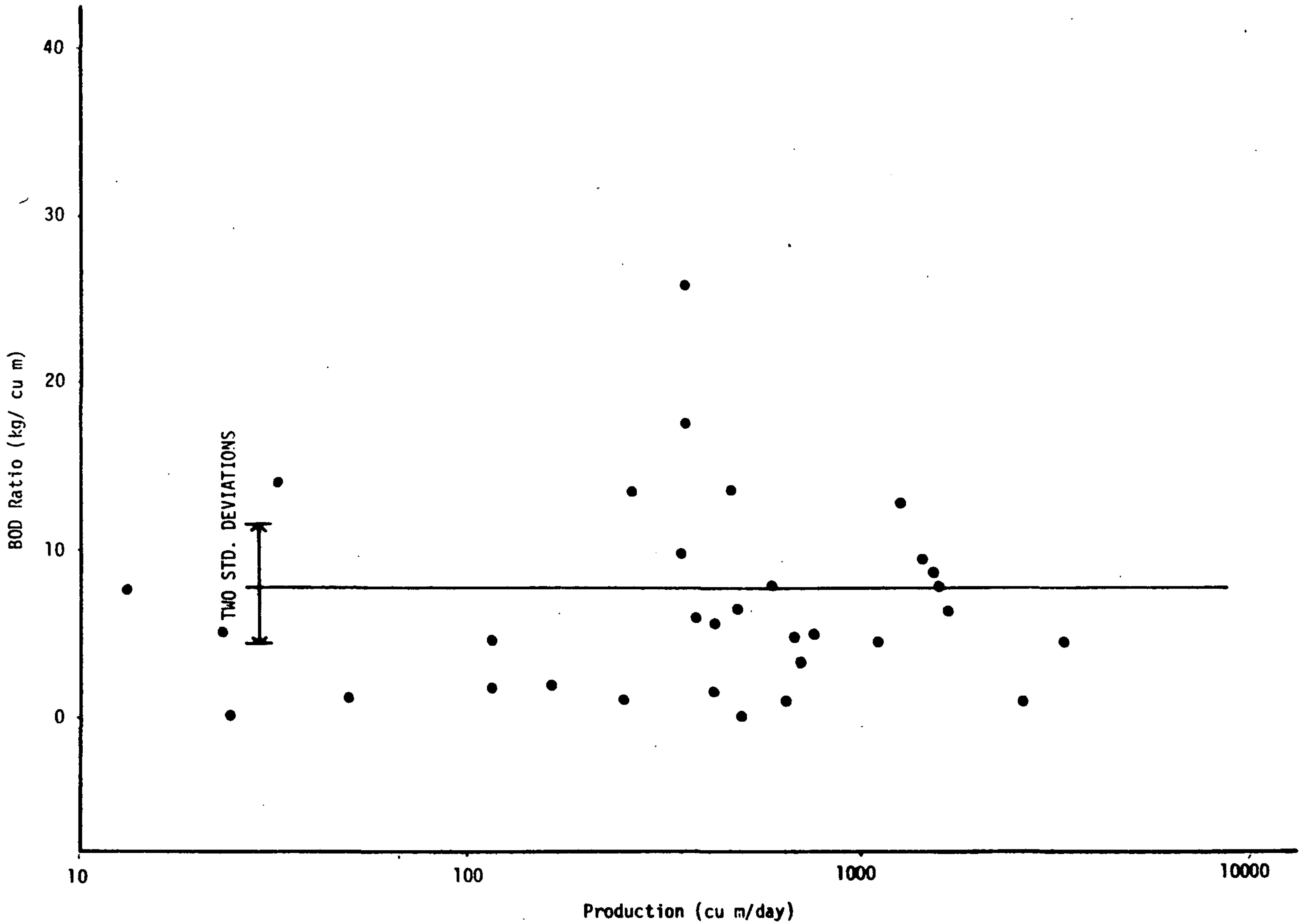

FIGURE 128

SUBCATEGORY A 18
BOD VS CAPACITY

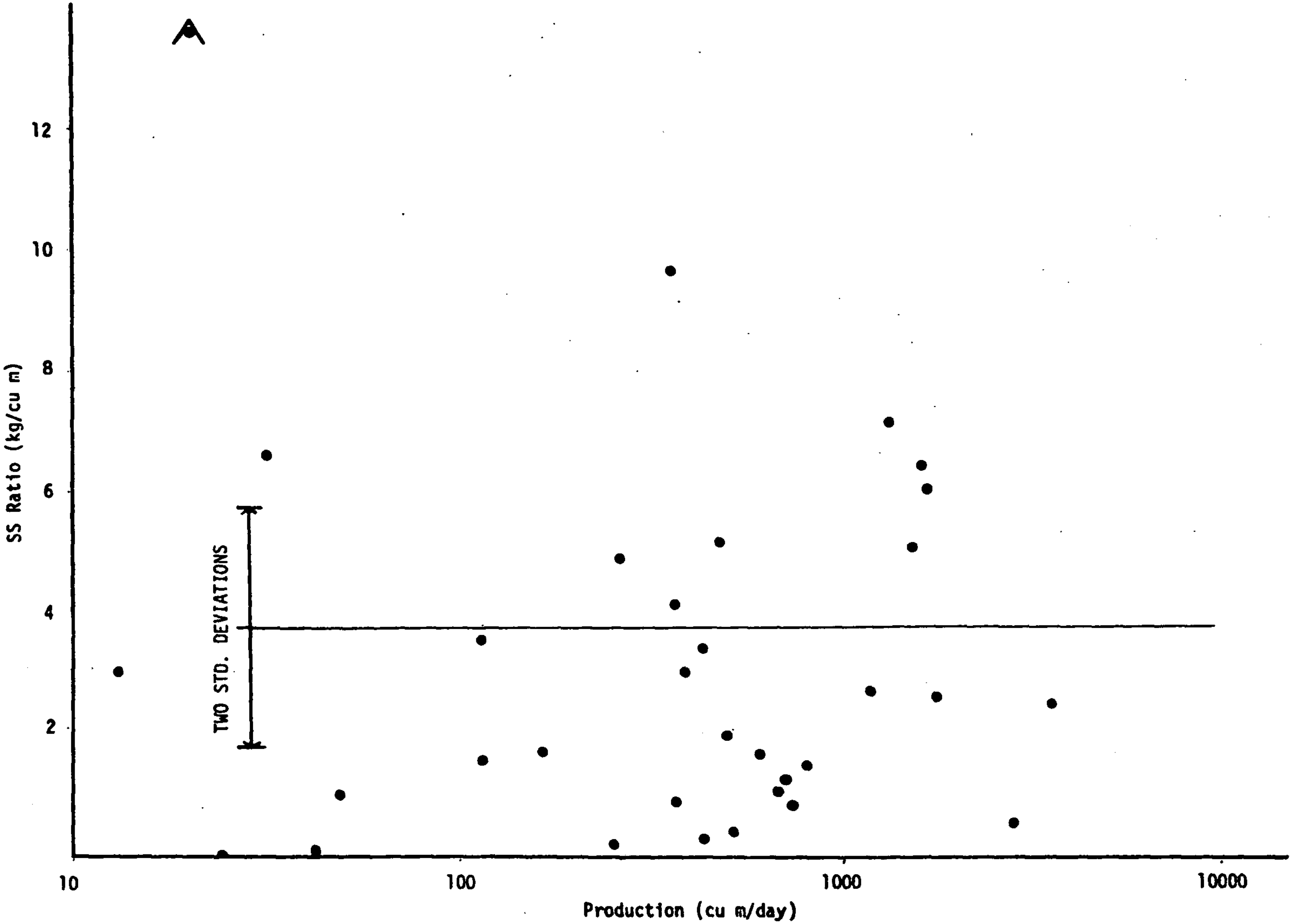

FIGURE 129

SUBCATEGORY A 18
SUSPENDED SOLIDS VS CAPACITY

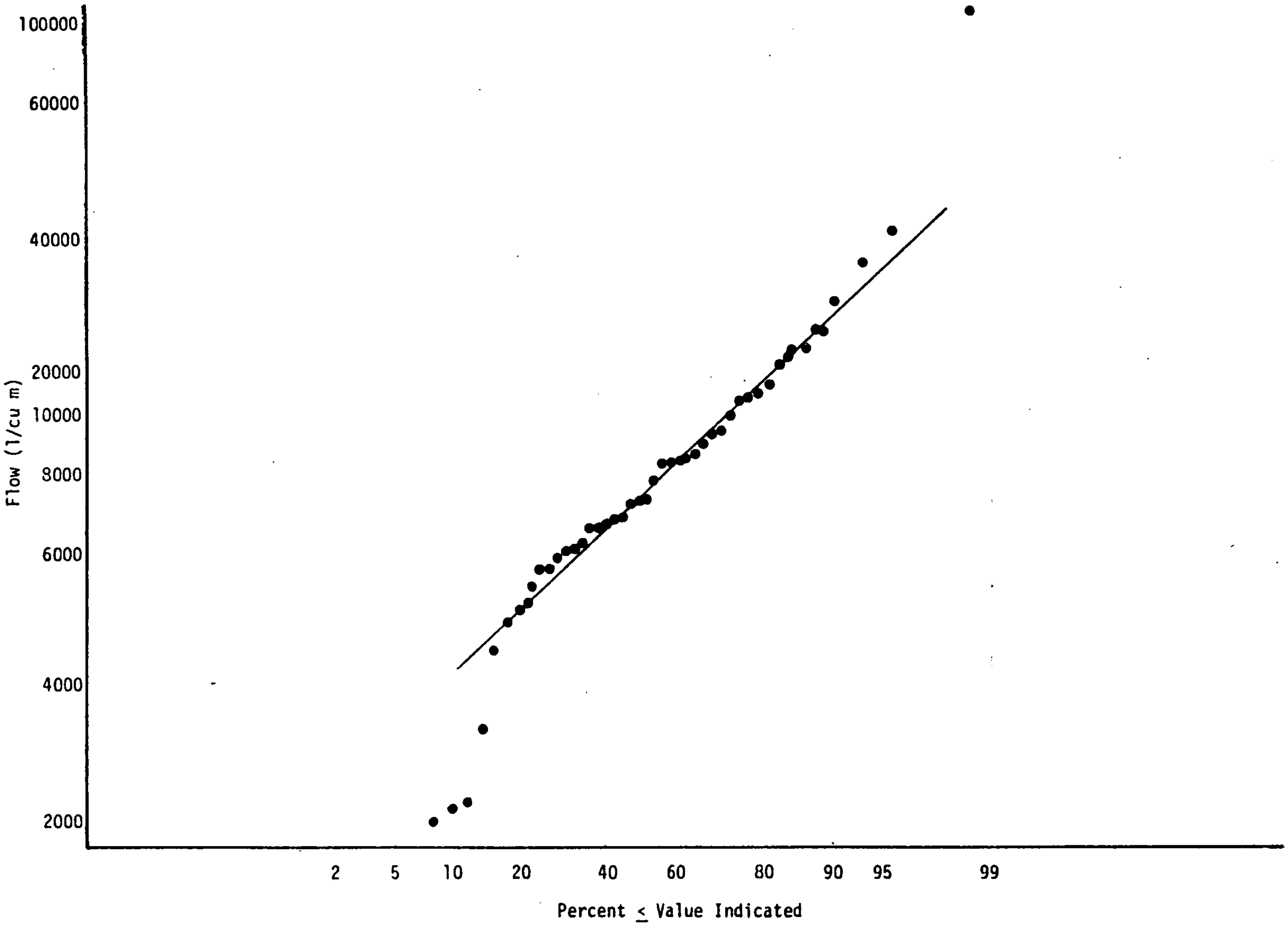

FIGURE 130

SUBCATEGORY A 18
FLOW PROBABILITY DIAGRAM

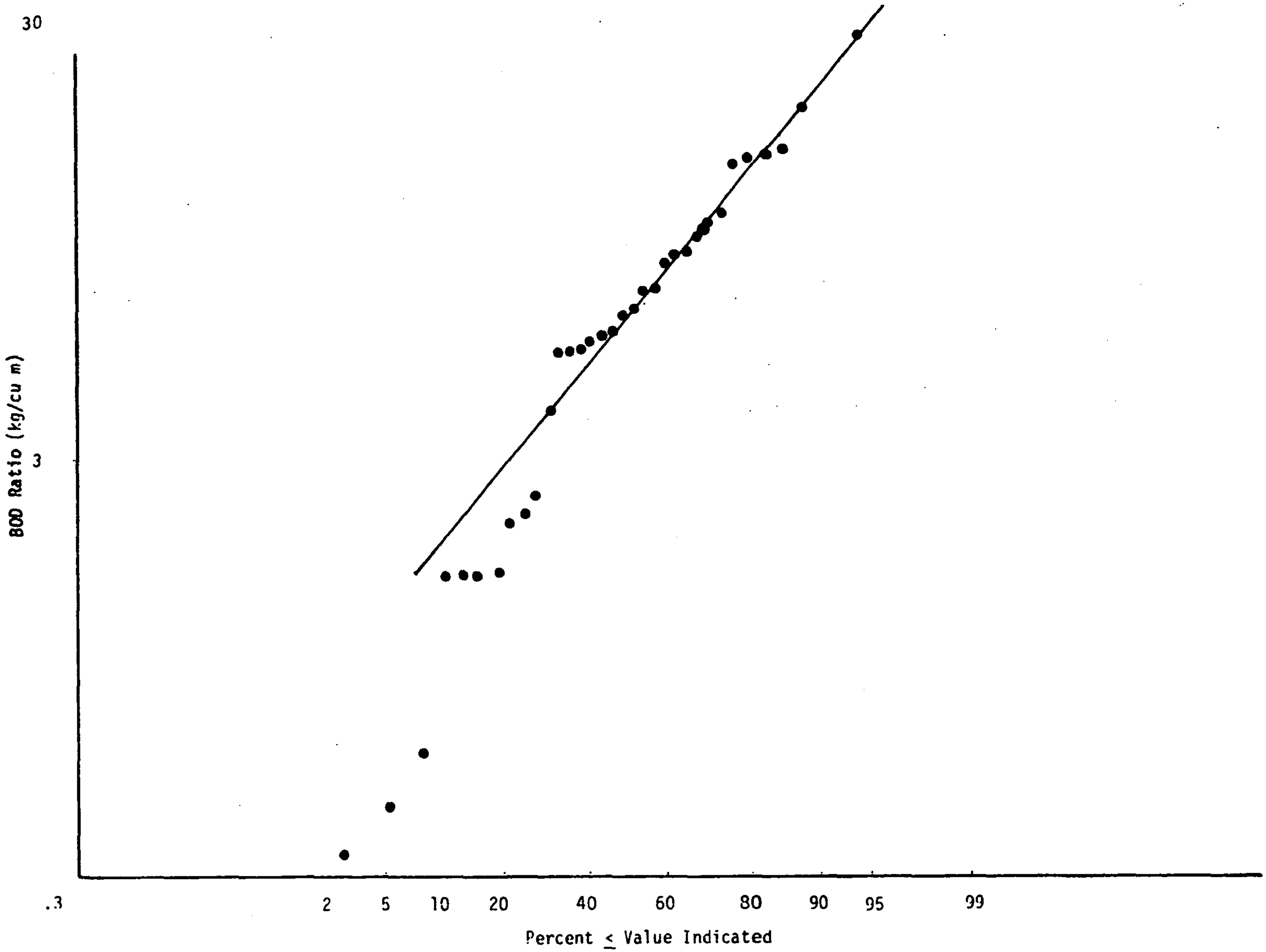

FIGURE 131

SUBCATEGORY A 18
BOD PROBABILITY DIAGRAM

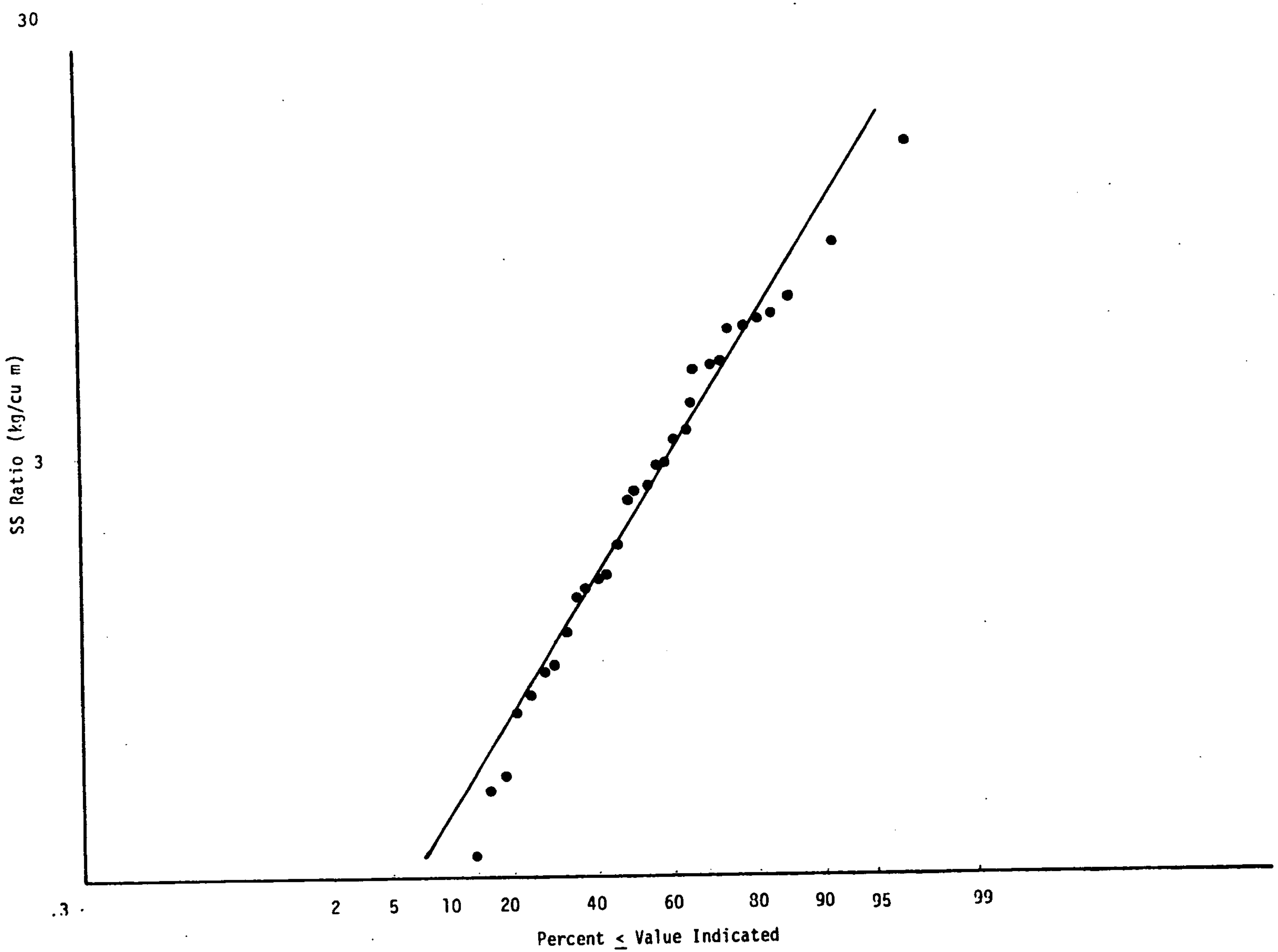

FIGURE 132

SUBCATEGORY A 18
SUSPENDED SOLIDS PROBABILITY DIAGRAM

According to Isaac (62) the steep liquor is a strong, deeply colored, putrescible liquid which may contain high levels of suspended solids. The quantity and quality of steep liquor varies according to the number of steep water changes and according to the contact time for each change. In general, the strength of the waste (as measured by BOD) decreases approximately 75 percent from the first to the last steep. This is illustrated by data from Isaac (62) and Simpson (63) presented in Table 37.

Wastes from germination are known to be smaller in volume and concentration than those from steeping, although insufficient data is available to establish a specific proportion between the two.

Combined Process Flow

The significant parameters for this industry are flow, BOD, and suspended solids. The ratios of these parameters to the number of barley bushels processed were calculated for each of the 18 plants which responded to the industry survey. These responses are itemized and summarized in Table 38. In addition, a reliability number was assigned to each plant based on the method and duration of sampling as follows:

Reliability 1 - 24 hour flow proportional sampling for 5 consecutive days or more.

Reliability 2 - 24 hour flow proportional sampling for less than 5 consecutive days.

Reliability 3 - Flow metered, grab samples.

Reliability 4 - Flow estimated, grab samples.

A separate arithmetic mean was calculated for those plants with reliability numbers 1 and 2. A log mean was calculated to check the distribution of the data.

In order to demonstrate the variability of malt waste, one plant was selected which had conducted several periods of five-day, 24-hour, flow proportional sampling. Table 39 gives the results of those tests with the standard deviation for each measured parameter.

Malting effluents can be characterized as consisting of highly soluble organic materials. Based on the even distribution of high reliability plants throughout the spectrum of production in the industry, it is felt that the following levels are typical.

BOD Ratio	4.55 kg/kkg (0.218 lb/bu)
SS Ratio	0.770 kg/kkg (0.0369 lb/bu)
Flow Ratio	7410 l/kkg (42.6 gal bu)

The pH of the waste varies between 6.0 and 8.0 as reported by Isaac (62). The waste is deficient in nitrogen, a fact which was confirmed by wet sampling at plant 83A13.

TABLE 37

ANALYSES OF MALTING STEEP WATER WASTES

BOD CONCENTRATION (mg/l)

Plant Designation	A	B	C	D	E	F
1st Steep	960	1100	750	2800	1900	2750
2nd Steep	920	900	890	2250	1630	1300
3rd Steep	185	700	400	1900	1890	1800
4th Steep	254	140	50	490	450	870

TABLE 38

RESULTS OF MALT INDUSTRY WASTEWATER SURVEY

PLANT	FLOWR	BODR	SSR	RELIABILITY
83A02IS9	11,800	7.29	0.446	2
83A07IP9	8,780	4.41	1.45	4
83A08IP9	682	0.459	0.0914	4
83A09IS9	7,080	6.05	0.892	3
83A12IP9	6,240	3.74	0.543	4
83A13IS9	6,960	5.29	0.586	2
83A15IP9	6,240	2.72	0.713	3
83A19IS9	4,430	3.43	0.625	2
83A22IP9	6,180	3.52	0.506	4
83A25IP9	9,700	4.03	0.928	1
83A27IS9	10,800	14.59	5.52	4
83A28IS9	31,100	3.66	1.80	2
83A29IP9	11,300	5.44	1.14	2
83A30IP9	5,690	3.16	0.171	2
83A31IP9	4,580	2.93	0.458	2
83A32IP9	4,190	2.92	0.477	4
83A33IP9	5,570	3.37	0.885	4
83A34IP9	5,210	4.84	0.836	2
MEAN (ALL)	8,140 l/kkg 46.8 gal/bu	4.60 kg/kkg 0.221 lb/bu	1.00 kg/kkg 0.048 lb/bu	
MEAN (1,2)	*7410 l/kkg 42.6 gal/bu	4.55 kg/kkg 0.218 lb/bu	0.770 kg/kkg 0.036 lb/bu	
LOG-MEAN (ALL)	6460 l/kkg 37.1 gal/bu	3.70 kg/kkg 0.177 lb/bu	0.682 kg/kkg 0.033 lb/bu	

* Calculated without Plant 83A28 which had combined process and cooling water.

TABLE 39

DAILY VARIABILITY OF MALT WASTE

DAY	FLOW (MGD)	FLOWR (l/kkg)	BOD (MG/l)	BODR (kg/kkg)	SS (MG/l)	SSR (kg/kkg)
1	0.365	9,210	485	4.43	92	0.843
2	0.373	9,420	475	4.44	59	0.552
3	0.365	9,210	300	2.74	125	1.14
4	0.378	9,560	370	3.51	90	0.850
5	0.444	11,200	451	5.01	113	1.26
MEAN	0.385	9,700	416	4.03	95.8	0.928
STD. DEVIATION	0.0334		79.1		25.3	

Model Malt Plant

For the purpose of developing control and treatment technology and for conducting cost analyses a model plant has been designed. The model plant for Subcategory A 19 operates 24 hours per day, 365 days per year. It processes 350 kkg (16,000 bu) of barley per day based on the mean production of those plants surveyed. Suspended solids in the waste, consisting mostly of grain and sprouts, are assumed to be removed by screening prior to discharge. Non-contact and process water are assumed to be separated. Based on the above ratios the model plant has the following wastewater characteristics:

Flow (MGD)	0.685
BOD (mg/l)	615
SS (mg/l)	104
Total KN (mg/l)	17
Total P (mg/l)	7
pH	6 to 9

SUBCATEGORY A 20 - WINERIES WITHOUT STILLS

In order to determine the wastewater characteristics for the wine industry (Subcategories A 20 and A 21) 11 wineries were visited, 5 wineries were sampled, and an extensive literature search was conducted.

A short discussion of the methodology to be used in this section is required. Basically, a building block approach will be used. First, wineries without stills will be described. Since many wineries in New York discharge to navigable waters and since wineries in California do not, the raw waste and effluent monitoring in New York were understandably more extensive. For this reason wastewater characteristics for wineries without stills rely heavily on New York data. Second, wineries with stills will be described. These wineries are all located in California. They produce the same wastewater as wineries without stills plus wastewater associated with stillage. Since the characteristics of stillage are fairly well defined, the total effluent for wineries with stills during crushing will be the sum of the wastewater produced by distilling added to the wastewater produced by wineries without stills. During the processing season all wineries will be assumed to operate with the same wastewater characteristics except as noted.

Process Waste Streams

The percentage of wastewater that each unit process contributes to the total winery effluent has not been well documented. As identified in Section III the sources of wastewater during processing are as follows: lees, or washdown of filter presses or centrifuges with lees and filter aid residue; fermenter washdown; finishing tank washdown; aging tank washdown; transfer hose, pipeline, and pump washdown; boiler and cooling tower blowdown; water conditioning and regeneration rinses; and general winery sanitation. During crushing, wastewater may be generated from all of the above plus crusher/stemmer and pomace press washdown.

Combined Process Flow

It is recognized that wastewater characteristics differ during the crushing and processing season. For that reason waste loading has been separately correlated to kkg (tons) of grapes crushed and to cu m (gallons) of wine produced. The ratio of flow, BOD, and suspended solids to grapes crushed for four New York wineries is presented in Table 40. Three of these four wineries have 24 hour flow proportional sampling with daily COD and weekly BOD analyses. Based on the weighted mean for these wineries, it is felt that the following ratios are typical for a winery without stills during crushing:

Flow Ratio (l/kkg)	BOD Ratio (kg/kkg)	SS Ratio (kg/kkg)
1528 (365 gal/ton)	3.57 (7.14 lb/ton)	1.16 (2.32 lb/ton)

It is noted that although these values are derived from New York wineries they apply equally well to California wineries which are estimated to produce wastewater during crushing at 2.1 kg/kkg (4.2 lb/ton) (64).

Wastewater generated during processing has been correlated to finished wine produced. The flow, BOD, and suspended solids to wine produced ratios are presented in Table 41. Based on the weighted mean for these wineries it is felt that the following ratios are typical for a winery without stills during processing.

Flow Ratio (l/cu m)	BOD Ratio (kg/cu m)	SS Ratio (kg/cu m)
5510	6.63	2.33
(5510 gal/1000 gal)	(55.3 lb/1000 gal)	(19.4 lb/1000 gal)

Here again the values correlate to estimates from California wineries of 2.96 kg/cu m BOD and 0.6 kg/cu m suspended solids, since the production for the New York wineries has been increased by amelioration and blending.

Other parameters which are significant for treatment system design are pH, nitrogen, and phosphorus. In general the pH varies annually from 4.0 to 10.0 with a daily average of 7.9. Based on over 100 samples from plants 84*02 and 84*03 the waste can be characterized as deficient in both nitrogen and phosphorus. BOD/N ratios vary from 78:1 to 690:1 with those during crushing being somewhat higher than those during processing. BOD/P ratios remain fairly consistent between 162:1 and 208:1.

TABLE 40

RAW WASTE CHARACTERISTICS DURING CRUSHING
WINERIES WITHOUT STILLS

Plant	Flow Ratio (l/kkg)	BOD Ratio (kg/kkg)	SS Ratio (kg/kkg)	Number of Samples
84E01	1,970	3.42	1.47	12
84E02	7,290	4.96	1.57	16
84E03	1,087	2.88	0.44	16
84E04	1,090	3.03	0.32	5
Mean	1,380*	3.57	0.95	
Log Mean	2,090	3.64	0.76	
Weighted** Mean	1,528	3.57	1.16	
	(365 gal/ton)	(7.14 lb/ton)	(2.32 lb/ton)	

* Calculated without plant 84E02 which has combined process and cooling water.

** Excludes FLOWR and SSR for plant 84E04 due to method of sampling.

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TABLE 41

RAW WASTE CHARACTERISTICS DURING PROCESSING
WINERIES WITHOUT STILLS

Plant	Flow Ratio (l/cu m)	BOD Ratio (kg/cu m)	SS Ratio (kg/cu m)	Number of Samples
84A01	7,280	14.1	4.70	36
84A02	12,400	6.35	1.52	47
84A03	2,940	6.91	0.79	65
84A04	1,290	30.4	4.05	5
Mean	3,840*	14.4	2.76	
Log Mean	4,300	11.7	2.19	
Weighted** Mean	5,510	6.63	2.33	
	($\frac{5,510 \text{ gal}}{1,000 \text{ gal}}$)	($\frac{55.3 \text{ lb}}{1,000 \text{ gal}}$)	($\frac{19.4 \text{ lb}}{1,000 \text{ gal}}$)	

* Calculated without plant 84E02 which has combined process and cooling water.

** Calculated without plant 84A04 due to size and method of sampling. Labor calculated without plant 84A01 due to in-plant reduction required (See Section VII).

Model Plant

For the purposes of control and treatment technology and cost analysis a model plant has been designed. The production for wineries without stills during crushing is 180 kkg (200 tons) per day based on average operating levels for New York and California wineries. The production during processing is 41 cu m (10,800 gal) of finished wine based on the average for New York wineries. It is recognized that this figure may be a little higher than California wineries without stills due to the practice of New York wineries to blend in up to 25 percent of California wines; i.e., a typical California production during a 70 day season would be 25 cu m (6,730 gal). Based on this production level the raw waste loads for the model plant are as follows:

	Crushing	Processing
Flow (MGD)	0.0730	0.060
BOD (mg/l)	2300	1200
SS (mg/l)	760	420
Total KN mg/l)	7	4
Total P (mg/l)	13	.7
pH	4 to 10	4 to 10

The following process operations are assumed:

1) Stems are considered a solid waste to be spread on vineyard property.

2) Pressed pomace may be used for distilling material, may be spread on vineyard property, or recovered as a by-product.

3) Diatomaceous earth (filter aid) is considered a solid waste to be spread on vineyard property.

4) No distilling takes place on premises.

5) Final effluent is screened to remove solids.

SUBCATEGORY A 21 - WINERIES WITH STILLS

As previously described, the wastewater for wineries in this subcategory will be the same as that for wineries without stills, plus the wastewater associated with stillage.

Process Waste Streams

As explained in Section III the raw material for distillation may be lees, pomace, or wine. Although stillage characteristics will vary with the source of distilling material, it can generally be classified as a high-strength organic waste with low pH. Typical values for different types of stillage are reported in Table 42 (65).

In order to determine the wastewater effluent due to stillage an average volume and concentration must be defined which will apply equitably to the wineries with stills. In order to calculate the average flow, data from 19 California wineries with stills was obtained to determine the average amount of distilling material produced per ton of grapes crushed.

This data is itemized in Table 43 (66). Based on this average of 746 l/kkg (179 gal/ton) the total quantity of stillage produced would be the amount of distilling material increased by 15 percent due to steam introduced in the still. The average volume of stillage per unit of grapes crushed, therefore, is 853 l/kkg (206 gal/ton). As acknowledged, the concentration of stillage varies depending on the type of distilling material used. Table 44 presents data from Skofis (67) and wet sampling at plant 84C80 which has been used to verify the ranges of values expected. In both cases 24 hour flow proportional samples were taken for five or more days. Based on these data and that presented in the literature (68, 69) it is felt that typical values for stillage are as follows:

BOD (mg/l)	12,000
SS (mg/l)	14,000

By combining these values with the flow volume of 858 l/kkg (206 gal/ton) the ratios (pounds of pollutant to tons of grapes crushed) contributed by stillage are:

BOD	10.3 kg/kkg (20.6 lb/ton)
SS	12.0 kg/kkg (24.0 lb/ton)

Combined Process Flow

The total effluent during crushing for a winery with stills, then, is a combination of stillage and crushing wastes as shown below:

Due to Crushing	Due to Stillage	Total
Flow 1528 l/kkg (365 gal/ton)	859 l/kkg (206 gal/ton)	2390 l/kkg (571 gal/ton)
BOD 3.57 kg/kkg (7.14 lb/ton)	10.3 kg/kkg (20.6 lb/ton)	13.9 kg/kkg (27.7 lb/ton)
SS 1.16 kg/kkg (2.32 lb/ton)	12.0 kg/kkg (24.0 lb/ton)	13.6 kg/kkg (27.3 lb/ton)

As evidenced by these calculations, stillage contributes 36 percent of the flow and 74 percent of the BOD and suspended solids in winery waste during

TABLE 42

STILLAGE CHARACTERISTICS

	Conventional Stillage (mg/l)	Lees Stillage (mg/l)	Pomace Stillage (mg/l)
Total Solids	20,100	68,000	13,180
Volatile Solids	87.4	86.5	77.0
Suspended Solids	3,120	59,000	18,700
BOD	11,000	20,000	2,400
Total Acidity ($CaCO_3$)	3,170	9,870	1,220
pH	4.7	3.8	3.7-6.8
Total N	271	1,532	330
Total P	11,150	4,284	1,310

TABLE 43

DISTILLING MATERIAL PRODUCED PER TON OF GRAPES CRUSHED

Plant	Tons of Grapes Received	Gallons Distilling Material Produced	Gallons Distilling Material Per Ton of Grapes
(A)	79,633	21,659,432	270.968
(B)	58,448	22,532,405	385.500
(C)	53,514	7,898,299	147.592
(D)	34,187	6,768,676	197.99
(E)	50,488	14,292,949	283.00
(F)	39,769	10,334,742	259.868
(G)	24,480	7,460,034	304.74
(H)	208,603	12,271,927	58.828
(I)	45,909	10,275,021	223.812
(J)	17,846	2,620,889	146.86
(K)	131,381	33,995,334	258.754
(L)	27,822	5,061,980	181.93
(M)	113,050	7,323,023	64.776
(N)	34,520	8,148,219	236.043
(O)	28,869	4,207,165	145.732
(P)	26,800	2,080,224	77.620
(Q)	25,920	2,931,093	113.082
(R)	6,296	1,701,137	270.193
(S)	24,762	3,164,583	127.799
TOTAL	1,032,297	184,727,132	

$$\frac{184,727,132}{1,032,297}$$ = 178.947 Wine Gallons Distilling Material per Ton of Grapes Received

TABLE 44

STILLAGE CHARACTERISTICS

PLANT 84C80

Day	BOD (mg/l)	SS (mg/l)	N (mg/l)	P (mg/l)	pH
1	6,650	23,100	369	321	3.8
2	14,400	11,400	380	321	3.8
3	9,620	10,200	184	204	3.8
4	11,100	10,700	185	273	3.9
5	10,300	4,060	182	242	3.8
6	12,000	13,400	268	308	3.8
7	18,300	33,200	203	425	3.9
8	7,650	10,300	231	209	3.9
Average	11,300	14,500	250	288	3.8

DATA FROM SKOFIS

Day	BOD (mg/l)	SS (mg/l)	pH
1	12,008	5,289	3.98
2	14,211	3,784	3.92
3	9,925	6,084	3.89
4	13,864	2,096	3.82
5	13,650	2,916	3.95
Average	12,732	4,033	3.91

crushing. A winery with stills is assumed to have the same wastewater loads during processing as a winery without stills.

Model Plant

For the purposes of control and treatment technology and cost analysis a model plant has been designed. The production for wineries with stills during crushing is 700 kkg (776 tons) per day based on the average of the 19 wineries itemized in Table 43 over 70 days in 1974. The production per day during a 70 day processing season is estimated to be 91 cu m (23,900 gal).

Based on these production levels the raw waste loads for the model plant are as follows:

	Crushing	Processing
Flow (MGD)	0.422	0.132
BOD (mg/l)	5830	1210
SS (mg/l)	5750	424
Total KN (mg/l)	103	4
Total P (mg/l)	494	7
pH	3.5 to 6	4 to 10

SUBCATEGORY A 22 - GRAIN DISTILLERS OPERATING STILLAGE RECOVERY SYSTEMS

In order to determine the wastewater characteristics for the distilled spirits industry (Subcategories A 22, A 23, A 24 and A 25) 59 plants were contacted to obtain existing historical data, 13 plants were visited, 3 plants were sampled, and a complete literature search was conducted.

Process Waste Streams

Extensive unit process research has been conducted in distilled spirits plants since the 1930's. As a result of this research, process waste streams can be defined quite accurately. Table 45 illustrates the percent of total plant wasteload attributable to each unit process as reported by plants 85A01 and 85A13 (70 and 71). These figures are reported merely to establish a general hierarchy of waste loading that is felt to be representative of the industry. Additional waste reduction measures employed by these plants since testing are reported in Section VII.

Feed Recovery - The major source of wastewater within the feed recovery plant is evaporator condensate. Evaporator condensate flows will vary based on mash concentration in the fermenters, percent of "backset," and beer still dilution. By reducing beer gallonage toward 110 l (28 gal) per bushel, the liquid load to the evaporators is reduced. By increasing the percent of "backset," less water must be added to obtain a given beer

TABLE 45

PROCESS WASTE STREAMS
GRAIN DISTILLERS WITH STILLAGE RECOVERY

Subcategory A 22

	Percent of Total Waste Load	
	Plant 85A01	Plant 85A13
Feed Recovery	79	75
Cooking-Mashing	12	11
Rectifying-Bottling	4	8
Distilling	1	2
Fermenting	1	1
Power House	2	2
Domestic	1	1
TOTAL	100	100

gallonage. By using a reboiler, either internal or external to the still, the amount of liquid added to spent stillage is reduced in comparison with liquid added by sparging live steam. The flow for evaporator condensate might vary between 97 l (15 gal) and 79 l (21 gal) per bushel. The concentration of the condensate (as measured by BOD in mg/l) varies mainly according to the design and operation of the evaporator. Data presented by Rullman in Table 46 (72) illustrates the range of values that might be expected. As reported by Hurst (73) Plant 85A04 has achieved BOD concentrations of 300 mg/l using a mechanical recompression evaporator. Results of other tests (74 and 75) indicate that BOD concentrations of from 600 to 800 mg/l are generally representative of the industry. An analysis of evaporator condensate from Plant 85A01 is shown in Table 47. The main constituents of the condensate are free organic acids, volatile with steam at reduced pressure and, hence, not included in total solids figures.

Both barometric and surface condensers are being used on evaporators in the industry. Flows for these discharges might vary between 380 and 570 l (100 and 150 gal) per bushel. BOD concentrations for barometric discharges are generally quite low depending on the quality of the intake water. The temperature of these discharges as they leave the plant might range from 83° to 99°C (180° to 210°F).

Barometric discharges are currently separated from process wastestreams and routed to surface waters. Wet scrubber discharge containing particulate from drum and/or grain dryers may constitute the secondary wasteload from feed recovery operations. Before their elimination, Plant 85A13 estimated these discharges at 37 percent (70) of the population equivalent for feed recovery. Several plants have installed cyclones to recover particulate for addition to feeds, thereby eliminating the wasteload.

Mashing - Cooking - Mash pressure cooking in batch cookers with vacuum cooling to malting temperature will produce approximately 7.6 l (2 gal) of condensate per bushel of grain mashed. Analyses at Plant 85A23 (72) indicate this condensate may average 900 mg/l BOD. The flow from continuous cookers would be some what higner. Here again, both barometric and surface condensers are employed in the industry. As indicated in Section III, cooling may be by shell and tube heat exchanger, thus reducing the wasteload.

Cooking vessel cleanup must also be taken into account. In most plants the mash will simply be washed to the following cook, then cleaned with caustic during the weekend. Unpumpable mash which is low in volume but high in BOD and suspended solids concentration will inevitably be sewered.

Rectifying - Bottling - As described in Section III, the potential wastes generated from rectifying are fusel oil column tails and rectifying column tails. A balance sheet for Plant 85A22 operating at 200 kkg (7200 bushels) per day with a grain neutral spirits unit

TABLE 46

VARIABILITY IN BOD CONCENTRATION OF
GRAIN DISTILLERY EVAPORATOR CONDENSATE

SUBCATEGORY A 22

	Type of Evaporator	Remarks	BOD (mg/l)
A.	Standard short tube vertical type, triple effect and finishing pan, natrual circulation, basket type separators.	Operated at maximum capacity. Automatic level controls.	675
B.	Same as above.	Operated at 3/4 capacity	570
C.	Same as above.	Operated at 1/2 capacity	510
D.	Same as above.	Operated at 1/2 capacity, manual level controls.	800
E.	Standard vertical, quadruple effect and finishing pan. Forced circulation in 4th effect and finishing pan. Centrifugal separators.	1/2 capacity. Automatic level controls.	650
F.	Standard vertical, short tube, triple effect and finishing pan, natural circulation. Baffle type separators.	Full capacity. Manual controls.	1580
G.	Vertical long tube, outside colandria, triple effect and finishing pan. Natural circulation.	3/4 capacity. Semi-Auto level controls.	3210
H.	Same as above, after larger vapor bodies and basket type separators and automatic level controls installed.	3/4 capacity. Automatic level controls.	520

TABLE 47

ANALYSIS OF GRAIN DISTILLERY EVAPORATOR CONDENSATE

SUBCATEGORY A 22

Biochemical Oxygen Demand (BOD)	1,100
Total Solids (8.0 gms/100 l)	80
Ethyl Alcohol (0.04 Proof)	135
Aldehydes	Trace
Esters	Trace
Organic Acids, calc. as acetic	550
Fusel Oil, AOAC	Less than 10
Nessler Nitrogen	12
pH	3.6

consisting of aldehyde, rectifying, fusel oil, and vacuum columns is presented in Table 48 (72). As noted, discharges at the plant from the fusel oil column amount to approximately 7.6 l (2 gal) per bushel at 35 to 40 mg/l BOD, and discharges from the rectifying column approximately 38 l (10 gal) per bushel at 300 mg/l BOD. It should be noted that at these rates the waste load from rectifying would comprise more than four percent of the total plant load. Sobolov (76) indicates that gin process residues would be higher due to the presence of spent botanicals.

Bottling wastes, consisting of glue, paper, and alcohol, appear to be negligible.

Distilling - As noted in Section III, possible sources of waste from distilling are doubler discharge and beer still cleanup. If the doubler discharge is sewered then the approximate flow for a doubler raising proof from 115° to 130° would be calculated as follows (72):

One Bushel Mashed = Five Proof Gallon (Yield)
Five Proof Gallon = 4.35 Wine Gallons at 115 Proof
= 3.85 Wine Gallons at 130 Proof

One Bushel Mashed = 0.5 Gallons to Sewer

At these rates BOD concentration may be from 5000 to 6000 mg/l.

Beer still cleanup discharges will of course vary throughout the industry. Plant 85A01 has estimated 10,300 l (8000 gal) at 1500 mg/l BOD for a weekly water and caustic wash. Plant 85A30 (77) reports 38,000 l (10,000 gal) at 2500 mg/l BOD once per week.

Fermenting - Steam and water are normally employed to wash the mash into the still during processing. Weekend cleanups here again, will comprise the major discharge. Plant 85A01 (74) has estimated fermenter wash at 3800 l (1000 gal) and 1000 to 2000 mg/l BOD.

Cleanup - Wastes from weekend cleanups are normally estimated and averaged on a daily basis to determine total plant discharges. In order to establish the general nature and magnitude of weekend cleanups, data is presented in Table 49 (74). These loads would vary from plant to plant according to operating procedure, numbers and types of equipment, and plant design.

Combined Process Flow

The significant parameters for this industry are flow, BOD, and suspended solids. The ratios of these parameters to bushels mashed were calculated for 16 plants. In addition, a reliability number was assigned to each plant based on plant visits and the method and duration of raw waste sampling as follows:

TABLE 48

BALANCE SHEET FOR GRAIN NEUTRAL SPIRITS UNIT
GRAIN DISTILLERY

SUBCATEGORY A 22

In	Wine Gallons (Per/Hour)
High Wine Feed (115° Proof)	1285
Aldehyde Column Steam (5,000 #)	600
Rectifying Column Steam (13,000 #)	1560
Fusel Oil Column Steam (3,000 #)	360
Fusel Oil Column Dilution Water	125
	3930
Out	
Concentrating Column Heads	70
Rectifying Column Product (190° Proof)	700
Fusel Oil Column Tails to Sewer (35 to 40 ppm BOD)	527
Rectifying Column Tails to Sewer (300 ppm BOD)	2633
	3930

TABLE 49

POLLUTION LOAD FROM WEEK-END CLEANUPS
GRAIN DISTILLERY

SUBCATEGORY A 22

Source	Flow (gal)	BOD (mg/l)	SS (mg/l)
Unpumpable mash	80	20,000	10,000
Venturi fermenter wash	1,000	1,100	450
Beer still caustic	8,000	1,500	1,600
Gin still drop	3,500	5,300	-----
Mash line caustic	9,000	3,200	1,500
Evaporator water wash	29,000	1,600	600
Conveyor water wash	300	1,600	27,000
Centrifuge water wash	8,000	900	700

Reliability 1 -	24 hour flow proportional sampling for three or more months.
Reliability 2 -	24 hour flow proportional sampling for at least one week.
Reliability 3 -	Flow metered, grab samples.
Reliability 4 -	Flow estimates, grab samples.
Reliability 5 -	Plant estimates.

This data is itemized and summarized in Table (50). A separate arithmetic mean was calculated for those plants with reliability numbers 1 and 2. As reported in Table (50) the means are as follows:

	Flow Ratio (l/kkg)	BOD Ratio (kg/kkg)	SS Ratio (kg/kkg)
All Plants	5572 (37.5 gal/bu)	3.95 (0.221 lb/bu)	2.57 (0.144 lb/bu)
Plants (1,2)	6582 (44.3 gal/bu)	6.01 (0.376 lb/bu)	4.23 (0.237 lb/bu)

Table 51 demonstrates the daily variability in distillery waste as presented by Clower (77), 24 hour flow proportional composites were taken for ten consecutive days in a large size plant with combined process and cooling water.

Other parameters significant for treatment system design are pH, nitrogen, and phosphorous. pH can be expected to fluctuate between 5 and 11 over a 24 hour period. The waste is deficient in nitrogen and phoshporous. Based on tests conducted at Plant 85A01, (78) probable levels of nitrogen and phosphorous are 1.59 kg (3.5 lb) and 0.136 kg (0.3 lb) per 45.5 kg (100 lb) of BOD.

Model Plant

For the purpose of developing control and treatment technology and for conducting cost analysis a model plant must be designed. Based on the even distribution of plants with reliability numbers 1 and 2 throughout the spectrum of the industry, it is felt that the following raw waste ratios are typical:

Flowr	6500 l/kkg (43.7 gal/bu)
BODR	6.00 kg/kkg (0.33 lb/bu)
SSR	4.23 kg/kkg (0.237 lb/bu)

Since the range of production in the industry is large, two model plants have been designed on the above ratios. Production for the two plants was set at 380kkg (15,000 bushels) and 90 kkg (3500 bushels)

TABLE 50

WASTEWATER CHARACTERISTICS
GRAIN DISTILLERY

SUBCATEGORY A 22

Plant	Flowr (l/kkg)	BODR (kg/kkg)	SSR (kg/kkg)	Reliability
85A01	8120	7.88	3.52	1
" 02	3680	1.79	.545	3
" 04	6770	4.07	1.44	4
" 05	3480	1.08	.463	4
" 07	3450	1.17	.711	3
" 08	3550	6.25	.592	5
" 13	3690	6.97	6.18	2
" 15	5730	1.72	----	4
" 17	7230	2.64	3.56	4
" 18	7360	2.22	3.53	4
" 22	4050	3.97	1.43	3
" 23	70,500	2.16	----	3
" 26	7560	6.14	5.77	2
" 27	6120	2.98	.536	2
" 29	7420	5.63	----	2
" 30	77,100	6.49	5.16	2
MEAN	5572* (37.5 gal/bu)	3.95 (0.221 lb/bu)	2.57 (0.144 lb/bu)	
MEAN (1,2)	6582* (44.3 gal/bu)	6.01 (0.336 lb/bu)	4.23 (0.237 lb/bu)	

* Averaged without 85A23 and 85A30 which have combined process & cooling water

TABLE 51

DAILY VARIATIONS IN RAW WASTE
GRAIN DISTILLERY

SUBCATEGORY A 22

	Flow (MGD)	SS (mg/l)	SS (lb/bu)	BOD (mg/l)	BOD (lb/bu)
	7.90	120	0.504	40	0.168
	8.10	100	0.480	109	0.521
	7.84	84	0.349	53	0.221
	7.53	31	0.138	121	0.539
	7.63	21	0.082	124	0.502
	7.79	138	0.573	100	0.415
	7.77	54	0.248	58	0.267
	8.58	35	0.159	48	0.218
	7.64	41	0.184	91	0.369
	7.09	45	0.168	100	0.373
MEAN	7.92	67	0.308 5.5 kg/kkg	84	0.359 6.4 kg/kkg
STANDARD DEVIATION			0.179		0.136

per day. Screening is assumed to remove grain solids prior to discharge. Based on these assumptions the raw waste loads for the model plants are as follows:

	380 kkg	90 kkg
Flow (MGD)	0.650	0.150
BOD (mg/l)	930	950
SS (mg/l)	650	670
Total KN (mg/l)	33	33
Total P (mg/l)	3	3
pH	5 to 11	5 to 11

SUBCATEGORY A 23 - GRAIN DISTILLERS NOT OPERATING STILLAGE RECOVERY SYSTEMS

The methodology for determining the wastewater characteristics for this subcategory was the same as for Subcategory A 22.

Process Waste Streams

Process streams are assumed to have the same characteristics as those in Subcategory A 22 with the following exceptions:

Feed Recovery - Distilleries in this subcategory may operate in one of two modes: 1) wet spent stillage may be collected in holding tanks and sold as cattle feed; 2) wet spent stillage may be screened, with solids recovered by drying, and thin stillage collected in holding tanks for sale as cattle feed. Since the load from evaporator condensate is non-existent, the wastewater discharge is greatly reduced compared to distilleries in Subcategory A 24.

Rectifying-Bottling - Many distillers in this subcategory may produce only straight whiskey. Wastes associated with multi-column operation would therefore be eliminated, but doubler discharge would remain the same. Also, whiskey may be shipped in bulk after maturation, thus eliminating bottling discharges.

Combined Process Flow

Less data exists for these distilleries due to the fact that many either sell to farmers or discharge their wastes to sewers. Data obtained from three plants is presented below:

Plant	Flow Ratio 1/ kkg)	BOD Ratio (kg/kkg)	SS Ratio (kg/kkg)
85B04	1530	0.628	0.736
85B28	1830	0.593	0.533
85B29	1975	1.62	0.101
Mean	1780	0.947	0.634

The mean for the suspended solids ratio was calculated without data from plant 85B29 due to sampling error.

As expected, these ratios are approximately 70 percent less than the ratios for distilleries with complete feed recovery systems.

Model Plant

For the purpose of developing control and treatment technology and for conducting cost analysis, a model plant has been designed. The daily production for the subcategory was set at 50 kkg (2000 bushels). Based on these assumptions the raw waste loads for the model plant are as follows:

Flow	90.8 cu m/day (0.024 MGD)
BOD (mg/l)	210
SS (mg/l)	160
Total N	7
Total P	1
pH	5 to 11

SUBCATEGORY A 24 - MOLASSES DISTILLERS

In order to determine the wastewater characteristics for this subcategory all known rum distillers were contacted. Two plants were visited and a complete search of the literature was conducted.

Process Streams

Areas of wastewater generation in the rum distilling process are 1) spent molasses stillage, 2) boiler and cooling waters and fermenter washdowns, 3) barrel washings and analytical laboratory wastewaters, and 4) bottling wastes. Table 52 outlines the wastewater generated per proof gallon produced as well as the percent contribution by type of waste stream (79).

Spent Stillage

This stream accounts for approximately 66 percent of the waste flow, over 98 percent of the BOD and COD, and over 90 percent of the solids generated. The chemical constituents can fluctuate depending on the variability of ash and sugar contents of the molasses feed and the degree of acidification prior to fermentation. Table 53 demonstrates the variability of spent stillage based on the type of molasses used. Such variations appear to have only minor effects on waste treatability. In addition, both cane and citrus molasses are used by distillers in the United States. According to plants 85C43 and 85C44 (78, 79) these raw materials also produce no noticeable difference in wastewater effluent. Typical chemical analyses and ionic concentrations of rum slops are presented in Tables 54 and 55 respectively (79). It should also be noted that the temperature of this waste stream ranges from 80 to 90° C (165 to 220° F) with a dark brown color of approximately 100,000 units.

TABLE 52

MOLASSES DISTILLERY WASTE STREAMS

Waste Parameter or Constituent	Total Facility Waste Generation per Proof Gallon	% Contribution by Type of Waste Stream			
		Slops Stream	Boiler/Cooling Water & Fermenter Washdown	Barrel Washings	Water Treatment & Analytical Lab. Wastewaters
Volume	55.6 l (14.7 gal)	66%	26%	5%	3%
COD	3.0 kg (6.6 lb)	98%	1%	1%	---
BOD	1.0 kg (2.3 lb)	99%	1%	---	---
Total Solids	4.2 kg (9.2 lb)	91%	9%	---	---
Total Dissolved Solids	3.9 kg (8.6 lb)	91%	9%	---	---
Total Suspended Solids	0.25 kg (0.56 lb)	97%	3%	---	---
Total Kjehldahl Nitrogen	0.06 kg (0.14 lb)	100%	---	---	---
Total Phosphate	0.003 kg (0.007 lb)	100%	---	---	---

TABLE 53

VARIABILITY OF MOLASSES STILLAGE

Type of Molasses	Cuban High Test	Cuban Low Test
pH	3.5	4.2
Total Solids %	2.81	7.12
Insoluble solids %	0.25	0.68
Ash %	0.42	2.3
Total nitrogen %	----	0.13
Reducing substances (as invert sugar) %	----	1.0
Ca %	0.06	0.26
Sulphate (as SO_4) %	0.13	0.52
5-day BOD p.p. 100,000	870	1,950

TABLE 54

CHEMICAL CHARACTERISTICS OF MOLASSES STILLAGE

Parameter	Mean	Range
Soluble COD (mg/l)	72,000	67,100 - 75,700
	92,000	81,100 - 106,300
Total COD (mg/l)	74,800	71,500 - 78,900
	99,800	83,800 - 115,500
Soluble BOD (mg/l)	26,500	17,600 - 32,300
	47,400	40,600 - 57,500
Total BOD (mg/l)	32,900	19,800 - 41,900
	54,900	45,800 - 67,000
Alkalinity (mg/l as $CACO_3$)	912	806 - 1,320
Volatile Acids (mg/l as HAc)	4,920	3,610 - 5,920
pH	4.36	4.28 - 4.45
Solids (mg/l)		
Total	83,500	70,200 - 95,800
. total fixed	20,500	19,400 - 22,200
. total volatile	63,000	50,700 - 73,600
Total dissolved	77,700	77,400 - 85,600
. fixed dissolved	19,800	17,900 - 21,500
. volatile dissolved	57,900	45,600 - 64,000
Total suspended	6,220	2,540 - 10,280
. fixed suspended	800	40 - 1,720
. volatile suspended	5,400	2,500 - 9,620
Nitrogen (mg/l as N)		
. total Kjehldahl	1,140	790 - 1,450
. organic	1,060	770 - 1,280
Total Orthophosphate (mg/l as PO_4	93	59 - 98

TABLE 55

IONIC COMPOSITION OF MOLASSES STILLAGE

(Units of mg/l)

Constituent	Mean	Range	Observations
Zn	9.89	2.38 - 19.93	4
Cd	0.18	0.09 - 0.32	4
Pb	1.10	0.77 - 1.60	4
Fe	81.0	42.0 - 150.0	5
Na	372	209 - 523	5
Cu	32.8	2.0 - 124	5
Co	0.60	0.19 - 0.76	4
Mn	10.6	2.38 - 15.6	4
Ca	2088	1850 - 2476	4
Mg	824	391 - 1728	5
Cr	0.30	0.25 - 0.33	4
K	4259	4011 - 4845	5
Al	0.38	0.10 - 0.58	4
Cl	2110	1330 - 4400	4
SO_4	4120	3500 - 4800	3

The amount of mixing water added to the raw molasses can affect the strength of the stillage. When the water to molasses ratio is decreased, a smaller volume of stillage results. Therefore, in order to minimize cost, most rum distillers maintain a low water to molasses ratio.

The addition of NH_4 and PO_4 nutrients appears to have little effect on the wastewater characteristics. It is assumed that nearly 100 percent of the nutrients added are utilized by the yeast cells during fermentation.

The use of indirect heat rather than live steam in the still also results in a lower volume of stillage. The total pollutant load remains the same. The use of direct heat would result in a 15 to 30 percent reduction in water usage. Only one rum distiller is currently in the process of converting from live steam to indirect heating.

The unique solubility properties of calcium sulfate (gypsum), one of the major components of rum stillage, has an impact on the treatability of the slops stream. Unlike most compounds, gypsum becomes less soluble with increased temperatures. Therefore, the formation of scale is an important consideration, especially for evaporation.

Boiling/Cooling Water and Miscellaneous Washes - Boiling/cooling waters can represent 20 to 25 percent of the total flow from a rum distillery. Most of the wasteload is in the form of suspended and dissolved solids (less than 10 percent of the RWL) resulting from solubility changes due to the temperature fluctuations. Cooling water is used on a non-contact basis to decrease the temperature of the molasses prior to fermentation. Boiling water is used in pasteurization of the molasses prior to cooling and fermentation. Such water is non-contact and usually recycled, thus explaining the minor role in pollutant loadings. Further uses of boiling/cooling waters are similar to those of the grain distillation processes.

Washdown of fermenters usually is sent to the still with the "wort." Some plants may follow with a caustic wash cycle which is then either discharged or regenerated for future washings. Other plants use a detergent wash cycle which is directly sewered. The initial holding tanks for molasses seldom require washing since they are rarely empty. A rinse once a year would be an exceptional case.

Barreling Operations - These operations involve a minimum of water usage (approximately 1.3 gallons of water/gallon of rum). Since alcohol laws for rum production permit the use of used oak barrels for aging, the barrels are washed after usage. The resultant wasteloads are small amounts of dissolved materials which have migrated to the inside surface of the barrel during maturation. These wastes are washed off the barrels at the barreling site and disposed of directly. Further reuse of such wastes has not yet been explored.

Bottling - Due to the similarities in bottling operations between grain distillers and rum manufacturers, the resulting waste loads are assumed identical.

Combined Process Flow

All known existing data was collected in order to determine combined process flows. The ratios were calculated for flow, BOD, and suspended solids to proof gallons produced and are presented in Table (56). Other parameters requiring consideration are pH and temperature. pH averages 4.8 and temperature 100° C (212° F) due to the high percentage of stillage in the waste.

Model Plant

The production of the model plant is 30,000 proof gallons per day, based on the mean of those plants in Table 56. It is assumed that stillage is discharged without treatment and that process and cooling water are separated. Based on these assumptions the raw waste loads for the model plant are as follows:

Flow (MGD)	0.216
BOD (mg/l)	35,600
SS (mg/l)	6,720
Total KN	1,110
Total P	55.3
Temperature	212° C
pH	4.8
Color	100,000 units

SUBCATEGORY A 25 - BOTTLING AND BLENDING OF BEVERAGE ALCOHOL

Plants in this subcategory exist as an adjunct to those beverage alcohol producers described in Subcategories A 20, A 21, A 22, A 23, and A 24. The methodology for determining wastewater characteristics for bottlers, therefore, was an extension of that used for the abovementioned subcategories.

Process Waste Streams

As described in Section III, these plants may only bottle beverage alcohol produced in wineries and distilleries, or they may additionally redistill and rectify purchased liquors in order to manufacture such products as cocktails and cordials. The wastes involved are those from redistilling, rectifying, and bottling. In order to demonstrate the general nature of these wastes, data will be presented from plant 85D10, a large rectifier/bottler. Although this is not intended to represent the typical wastes for the entire spectrum of the industry, it does identify unit process wastes that may be common to other bottler/rectifiers.

Redistilling - Both vodka and gin are products which may be redistilled. The residue from redistillation constitutes the major waste associated with this segment of the process. Heads from continuous column distillation and bottoms from batch distillation are collected in a holding tank.

TABLE 56

RAW WASTE CHARACTERISTICS
RUM DISTILLERS

Plant	Flow Ratio (l/proof gal)	BOD Ratio (kg/proof gal)	SS Ratio (kg/proof gal)
85C34	25.7	0.997	0.149
85C38	28.8	0.922	0.206
85C39	255.0	1.40	0.265
85C45	378.0	0.557	0.110
MEAN	27.3	0.969	0.183
	(7.22 gal/pg)	(2.136 lb/pg)	(0.392 lb/pg)

*Excludes Plants 85C39 and 85C45 which reported process and cooling water combined.

On an average of once per month 3000 l (800 gal) of this liquid must be discharged. The approximate BOD is 245,000 mg/l, the suspended solids only 6.3 mg/l, and the pH 5.6. If discharged at once, this would represent a shock load of 7400 kg (16,300 lb) of BOD. The residue from redistillation can amount to one percent of the input to the still, but this waste does not necessarily relate to total plant production since some alcohol used is not redistilled. A correlation may be possible if linked to the vodka and gin production for each plant.

Rectifying - The types and volumes of wastes from rectifying for plant 85D10 are listed below.

Type	Volume l/day
Frame Filter Rinse	5700 (1500 gal/day)
Product Chiller Rinse	600 (160 gal/day)
Vodka Column Rinse	2500 (650 gal/day)
Product Tank, Filter, Line and Pump Rinse	7200 (1900 gal/day)
Bonded Warehouse Rinse	4000 (1000 gal/day)
Winery Rinse	950 (250 gal/day)
Demineralizer Regeneration	1900 (500 gal/day)

These wastes generally contain only dilute portions of alcohol that have adhered to surfaces during processing, except for demineralizer regeneration. Periodically, the demineralizing resins must be recharged by washing with caustic and acid. These are presently collected and neutralized before discharge.

Bottling - These wastes consist mainly of filler cleanup and miscellaneous floor washing. Filler discharge will obviously vary depending on the number of fillers, number of product changes, and volume used. Glue and paper labels may also contribute to the load.

Bad Product - A small quantity of bad product is destroyed periodically due to the product not meeting quality standards or being discontinued. These are crushed in bottles with the liquid being sewered. This may amount to as much as 10,000 wine gallons per year, however it may vary greatly depending upon the amount of new product activity or package changes that occur.

Combined Process Flow

The combined process flow consists of biodegradable liquids with little or no suspended solids. The flow may vary from 1900 l (500 gal) per day, for those small plants only bottling, up to 40,000 l (10,000 gal) per day for large rectifier/bottlers. For the most part these flows will be low in BOD concentration due to dilution factors. Heads from redistillation and bad product discharges may, however, be quite concentrated depending on the method of disposal. There is no existing data available concerning combined process flow.

It should be noted that considerable non-contact water may be used in large rectifying/bottling plants. Compressor and redistillation column cooling water comprises the vast majority of this flow. Plant 85D10 gave the following breakdown of water usage:

	Percent
Sanitary Waste	5.9
Industrial Waste	5.7
Non-Contact Discharge	67.6
Boiler Water	3.9
In Product	16.9
Total	100.0

Model Plant

For purposes of cost analysis and treatment system design a model plant must be designed. The following assumptions have been made:

1. Residue from redistillation may amount to one percent of the input to the still. For plants with redistillation this waste is assumed to be collected in holding tanks.
2. Bad product may accrue and periodically require disposal. This product is assumed to be collected and held prior to disposal.
3. Demineralizers may be used, requiring periodic regeneration. This is assumed to be collected in holding tanks and neutralized.
4. All other process wastes are assumed to be separated from non-contact water. The process wastes are assumed to result from washdowns previously itemized and to be biodegradable with low concentrations of BOD and suspended solids.

Based on these assumptions two model plants have been designed. Plant A is assumed only to bottle. Plant B is assumed to rectify and bottle. The raw wasteloads are as follows:

	A	B
Flow (cu m/day)	4	40
(MGD)	0.001	0.010

SUBCATEGORY A 26 - SOFT DRINK CANNERS

In order to determine the wastewater characteristics for the soft drink industry (Subcategory A26 and A27) 74 plants were contacted by phone, eight plants were visited, and five plants were sampled. In addition, a complete literature search was conducted.

Process Waste Streams

The major waste streams associated with soft drink canners are filler spillage, mixing tank washing, and fill tank and line washings.

Filler Spillage - Due to the type of container and the speed of the line there is considerable spillage involved in canning operations. This product waste may be characterized as high in BOD, total solids, and acidity, and low in suspended solids and pH. Expected ranges are as follows:

BOD (mg/l)	60,000-80,000
Total Solids (mg/l)	100,000-120,000
Suspended Solids (mg/l)	50-200
Acidity (mg/l)	1,200-3,200
pH	2-3.5

Mixing Tank Washing - Mixing room wastes originate from the small residue of syrup dumped during flavor changes and the water required to wash the mixing tanks. Syrup used for carbonated beverages may be as high as 800,000 mg/l BOD. When diluted with wash water this waste has the same character as filler spillage, but it is lower in concentration and higher in pH.

Fill Tank and Line Washings - These wastes, again, correlate closely to the number of flavor changes. A small amount of syrup, and water to flush the filling lines, is the source of waste. The character of the waste is the same as that from the mixing tanks.

Other Wastes - Additional waste may be created by washing bulk containers, periodic washing of syrup storage tanks, water treatment and filtration backwash, and plant cleanup. These are considered to be minor process discharges. Boiler and compressor cooling water comprise the majority of the non-contact water.

Combined Process Flow

In order to demonstrate the combined waste characteristics from soft drink canners, one plant has been selected which conducted twenty-four hour sampling over a period of more than five days. The results are presented in Table 57. As expected the BOD concentrations were high, but the ratio of pounds of BOD to gallons produced was quite low. This is explained by the low flow discharged in conjunction with a high volume of production. The pH of the waste was below six, indicating the presence of low pH product in the waste.

Based on the average of all canners surveyed it is felt that the following ratios are typical.

TABLE 57

DAILY WASTE CHARACTERISTICS
SOFT DRINK CANNING PLANT
Plant 86A27

Day	Flow (MGD)	Flow Ratio (gal/1,000 gal)	BOD (mgl)	BOD Ratio (lb/1,000 gal)	SS (mgl)	SS (lb/1,000 gal)	pH
1	0.033	281	1650	3.86	154	0.36	5.9
2	0.031	277	960	2.22	177	0.42	4.3
3	0.036	305	1140	2.89	118	0.30	3.5
4	0.035	280	1160	2.70	192	0.45	2.9
5	0.037	296	790	1.94	219	0.54	4.6
6	0.031	253	1480	3.13	376	0.79	3.5
Average	0.034	282	1197	2.79	206	0.48	
		(282 l/cu m)		(.335 kg/cu m)		(0.057 kg/cu m)	

Flow = 741 l/cu m (741 gal/1000 gal)

BOD = 1.02 kg/cu m (8.51 lb/1000 gal)

SS = 0.123 kg/cu m (1.03 lb/1000 gal)

The pH is expected to vary between 3 and 7 except during periods of cleanup when alkaline wastes will be discharged. Based on sampling at Plants 86A32 and 86A29 the effluent appears to be somewhat deficient in nitrogen but adequate in phosphorus for purposes of treatment. BOD:N ratios averaged 60:1, while BOD:P ratios were 110:1.

Model Plant

For the purposes of control and treatment technology and cost analysis a model plant has been designed. The production was set at 309 cu m (81,500 gal) per day. Based on this production and the ratios listed above, the raw waste loads for the model plant are as follows:

Flow (MGD)	0.0610
BOD (mg/l)	1380
SS (mg/l)	167
Total KN (mg/l)	23
pH	3 to 7

SUBCATEGORY A 27 - SOFT DRINK BOTTLING/CANNING PLANTS

The methology for determining the wastewater characteristics for this subcategory was the same as for Subcategory A 26.

Process Waste Streams

The major waste stream associated with bottling plants is the bottling washer. Mixing tank and filler line washdown is expected to be similar to that from canning plants as previously discussed.

Bottle Washer - As described in Section III, the sources of pollutants from the bottle washer and sugar residues from left-over product, suspended solids from labels and material left in bottles, and caustic carry-over from sprays and oaking tanks. Typical values for prerinse and final rinse sections of a bottle washer taken at Plant 86A32 were as follows:

	Prerinse	Final Rinse
BOD (mg/l)	1130	35
SS (mg/l)	76	28
M Alkalinity (mg/l)	263	206
pH	10.3	10.3

The flow associated with this washer was 230 l/min (60 GPM).

Combined Process Flow

The final discharge of any plant with a bottle washer will thus be higher in flow, pH, and alkalinity than a plant which only cans. Table 58 itemizes and summarizes the characteristics of plants in this subcategory. A separate mean has been calculated for three plants which had conducted extensive monitoring. Many of the other plants had data collected only from grab samples and flow estimates. For this reason it is felt that the ratios for these three plants more accurately reflects actual operating conditions. Based on these means it is felt the following ratios are typical for this subcategory.

Flow Ratio (l/cu m)	BOD Ratio (kg/cu m)	SS Ratio (kg/cu m)
3540	2.38	0.380

It should be noted that the three plants with the lowest flow ratios were primarily canners with minor bottle washing or, in the case of Plant 86A29, a bottler whose bottles were being washed by an outside agent.

The pH for this subcategory is expected to vary between 5.5 and 12 with relatively high alkalinity due to the bottle washer. BOD to nitrogen and phosphorus ratios are expected to remain 60:1 and 110:1, respectively.

Model Plant

For the purposes of control and treatment technology and cost analysis a model plant has been designed. The production was set at 135 cu m (35,900 gal) per day. Based on this production and the ratios listed above, the raw waste loads for the model plant are as follows:

Flow (MGD)	0.126
BOD (mg/l)	660
SS (mg/l)	108
Total KN (mg/l)	11
pH	5.5 to 12

SUBCATEGORY A 28 - BEVERAGE BASE SYRUPS AND/OR CONCENTRATES

As discussed in Section III, it has been determined that the major individual waste streams generated in the beverage base manufacturing process are as follows:

1. Washing of mixing tanks and flavor tanks at the end of each day and between flavor changes.

2. Washing of syrup tank cars, 208 l (55 gal) drums, and 19 l (5 gal) containers prior to refilling.

3. General plant cleanup.

TABLE 58

RAW WASTE CHARACTERISTICS
SUBCATEGORY A27

Plant	Flow Ratio (l/cu m)	BOD Ratio (kg/cu m)	SS Ratio (kg/cu m)
86A04	1260	0.826	0.155
86A06	1990	0.257	0.031
86A07	4120	0.371	0.283
86A13	4520	2.02	0.393
86A16	6780	4.68	2.29
86A20	4290	0.806	0.322
86A24	9370	1.31	0.019
86A25	5910	6.74	0.066
86A26	6380	3.01	-----
86A29	169	0.624	0.074
86A32	2260	3.00	0.335
86A34	2540	3.04	0.226
86A37	3090	1.72	0.247
86A38	2760	1.11	0.190
86A39	3991	4.12	0.629
86A40	3050	1.92	0.325
Mean	3905	2.22	0.372
Mean (38, 39, 40)	3267	2.38	0.380

Washing of Mixing Tanks

Plant 85S06 generates approximately 76 cu m/day (0.02 MGD) of wastewater from the washing of six mixing tanks and eleven flavor tanks which feed the mix tanks. It should be noted that this figure is highly variable with the daily quantity dependent on the number of flavor changes made and the number of batches mixed on any given day. The equipment is commonly washed using automatic or manually operated spray ball devices mounted within the equipment and the quantity of water used is usually regulated closely.

Washing of Tank Cars, Drums and Containers

The cleaning of tank cars generally consists of a hot water wash followed by a sanitizing rinse. Drums are commonly washed in sealed wash tanks. Each drum is fitted with one resealable opening at the drum's equator. The drums are positioned on a rack wih the opening face down. Hot wash water followed by hot rinse water is injected into the drum. After draining, the drums are removed. The 19 l (5 gal) containers are washed by vertical placement (opening down) in a revolving washer which regulates the water output into each container.

Plant 87S06 reported the following daily quantities of wastewater from each of these cleaning operations during a normal day:

1. Tank cars (average eleven) - 57 cu m/day (0.015 MGD)

2. Drums - 303 cu m/day (0.08 MGD)

3. Containers - 7500 l/day (2,000 gal/day)

It is noted that these quantities will vary within the plant and between plants depending on daily cleaning requirements.

General Plant Cleanup

Wastewater quantities typically generated during cleanup at Plant 87S06, consisting of pipe line sterilization and floor washing, average 30 cu m/day (0.008 MGD) and this quantity would not be expected to vary markedly throughout the industry.

Non-Contact Water

There is a small amount of non-contact machinery cooling water and boiler blowdown generated in the manufacturing of beverage bases. This non-contact water is generally discharged into the process waste stream or into storm sewers.

Total Plant Effluent

The wastewater characteristics of the total plant effluent for five beverage base plants are summarized in Table 59. The data indicate a wide range of flow and BOD concentrations but consistently show low

TABLE 59

SUMMARY OF WASTEWATER CHARACTERISTICS
SUBCATEGORY A 28

PLANT CODE	FLOW		BOD		SS		N	P
	cu m/day	cu m/cu m	mg/l	kg/cu m	mg/l	kg/cu m	mg/l	mg/l
87S06	598	1.05	1868	2.02	32	0.032		
87S07	68		5910		328			
87S08	125	0.40	3750	1.43	40	0.016		
87S09	396		1140		162		35.1	12.2
87S14	459	1.16	3050	3.56	353	0.36		

suspended solids concentrations as compared to BOD concentrations. The pollutant ratios were determined based on additional data provided by Plants 87S06, 87S08, 87S14. Plants 87S06 and 87S14 showed good agreement in terms of wastewater flow per unit of product produced. However, the pollutant loadings per unit of product produced are dissimilar. Plant 87S08 which generated roughly 60 percent less flow per unit of product produced than Plant 87S06 had a BOD pollutant loading 30 percent less and a suspended solids loading 50 percent less. This indicates a rough correlation of 0.5 between the two plants. The nutrient to BOD ratio (BOD:N:P) was determined to be 100:3.1:1.1 based on the data obtained from Plant 87S09. It must be noted that only a limited number of data points was available in determining the data presented in Table 59. However, the data do offer sufficient information to allow reasonable assumptions as to the anticipated characteristics of a model beverage base manufacturing plant.

Model Plant

Based on the above considerations, a hypothetical model plant was developed for Subcategory A 28 and is illustrated in Figure 133. The plant generates an average wastewater flow of 379 cu m/day (0.10 MGD) due to washing of mixing and flavor tanks, washing of tank cars, drums, and containers, and general plant cleanup. The model plant has the following average characteristics.

Production	379 cu m/day (0.10 MGD)
Flow	379 cu m/day (0.10 MGD)
BOD	2400 mg/l
SS	50 mg/l
pH	8.0

The assumed characteristics would be expected to vary with seasonal production demands and the amount of cleanup operations conducted in the plant on any given day. There is some reason to believe that the waste stream may be slightly deficient in nitrogen based on the BOD:N:P ratio for Plant 87S09.

SUBCATEGORY A 30 - INSTANT TEA

Production of instant tea generates wastewater from two sources, clarifier sludge and cleanup.

Clarifier Sludge

Periodic discharge of tea sludge is the only process wastewater generated in the processing of instant tea. There is no reliable way to estimate the quantities of pollutant loadings of the clarifier waste stream since the discharge is highly variable.

Cleanup Water

Cleaning of equipment may be done on several different schedules as indicated in the following:

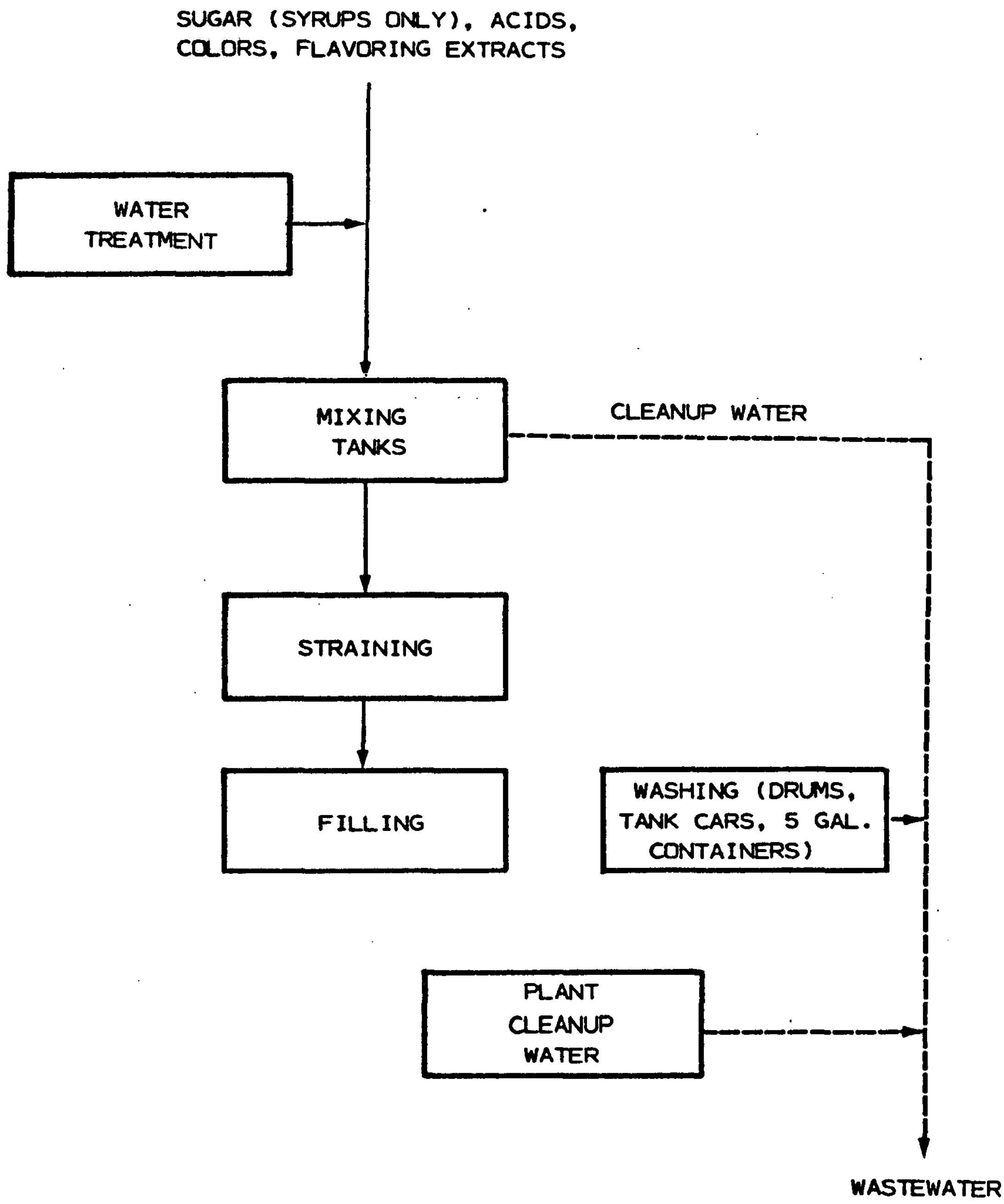

FIGURE 133

MODEL PLANT FOR
BEVERAGE CONCENTRATE AND SYRUP MANUFACTURING PROCESS

1. One plant (99T04) operating 365 days per year implements cleanup of the entire plant every ten days.

2. Two plants (99T01 and 99T02) generally operating on a five-day per week basis implement plant cleanup at the end of each week.

All plants contacted did some periodic cleaning of equipment during the week as needed. All plants contacted also did some hosing of floors in the plant for cleaning of leaks from connections. Equipment cleanup is generally done by spray ball devices contained within the equipment which are operated manually as needed. The cleanup consists of the following sequential steps: (1) fresh water rinse, (2) caustic wash, (3) fresh water rinse, (4) acid rinse and (5) fresh water rinse.

Non-Contact Water

A considerable amount of cooling water is generated in the processing of instant tea. Only one plant contacted (99T04) separated all cooling water from process water. Two plants, 99T02 and 99T03, provided no separation of contact and cooling water and no recycling of cooling water. One plant (99T01) recycled a majority of the cooling water used in the process and discharged the unrecycled into the wastestream.

Total Plant Effluent

The wastewater characteristics of the instant tea industry are summarized in Table 60. The two plants (99T02 and 99T04), for which the portion of total effluent attributable to process water was known, showed good agreement regarding process waste flows with the values being 49,500 l/KKg (11,900 gal/ton) and 46,500 l/KKg (11,100 gal/ton), respectively. Plants 99T01 and 99T03 contained an indeterminant amount of cooling water which could account for the significant difference in flow.

Pollutants in the waste stream considered of significance in instant tea manufacturing are BOD and suspended solids. Plants 99T01 and 99T02 showed good agreement of mass of BOD and suspended solids generated per unit of product produced. Of the remaining two plants, 99T03 generated four times the BOD load of the two showing agreement and 99T04 generated a BOD load which was a factor of four less than the two showing agreement. A possible explanation of the low BOD and suspended solids loadings generated by plant 99T04 is that clarified tea sludge, rather than being added to the wastestream, is centrifuged and the dewatered sludge is sold as cattlefeed.

Model Plant

Based on the data presented in Table 60 and the preceeding discussion a hypothetical instant tea manufacturing plant was determined and is illustrated in Figure 134. The plant operaates 24 hours per day, five days per week with cleanup of all equipment at the end of each processing week. Daily wasteflow consists of cleanup of equipment as needed, floor washdown to clean leakage from equipment connections, and deposition of

TABLE 60

SUBCATEGORY A 30 - SUMMARY OF WASTEWATER CHARACTERISTICS

Plant	Flow 1/KKg	BOD Kg/KKg	SS Kg/KKg
99T01	*94,700	41.1	34.7
99T02	49,500	52.4	38.2
99T03	*167,000	196.3	-
99T04	46,500	10.0	5.8

* Values are high due to indeterminant amount of cooling water in the plant effluent.

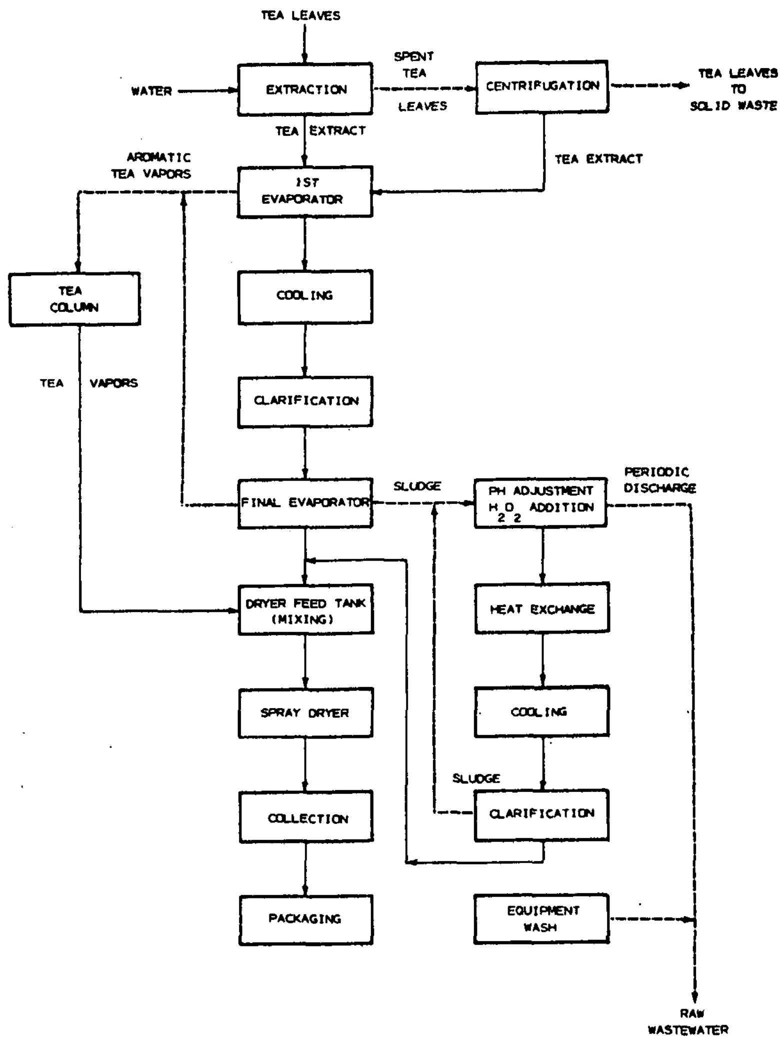

FIGURE 134

MODEL PLANT FOR SUBCATEGORY A 30
INSTANT TEA MANUFACTURING PROCESS

clarifier tea sludge into the wastestream. All cooling water is discharged separately from the process waste stream. The characteristics of the model plant are as follows:

Production	9.1 KKg/day (10 ton/day)
Flow	450 cu m (0.12 MGD)
BOD	1000 mg/l
SS	750 mg/l
pH	6.0

Spent tea leaves from the centrifuge are sold as cattle feed or disposed as solid waste.

SUBCATEGORY C 8 - COFFEE ROASTING UTILIZING ROASTER WET SCRUBBERS

Roaster Wet Scrubbers

A study conducted at a coffee roasting plant utilizing a once-through type of wet scrubber reported an effluent with a BOD of 100 to 500 mg/l, suspended solids of 180 to 240 mg/l and a flow rate of 2100 liters per kkg (508 gallons per ton) of green beans roasted. No data are currently available on the wastewater characteristics of the recirculating type of wet scrubbers used on coffee roasters.

Total Processing Effluent

Roaster wet scrubbers are the only source of wastewater from a coffee roasting plant. Table 61 presents a raw waste summary of this wastewater.

Model Plant

The model plant for this subcategory is a coffee roasting plant which utilizes a once-through type of roaster wet scrubber. The model plant roasts 30 kkg (33 tons) per day of green coffee beans.

Wastewater - The only source of wastewater from the model plant is the roaster wet scrubber. Parameters of the wastewater are assumed to be as follows:

1. Flow rate - average - 0.063 mld (17,000 gpd)
2. BOD - 350 mg/l
3. SS - 200 mg/l
4. pH - 4.0 - 7.2
5. 0.76 - kg BOD per kkg of green beans
6. 0.43 - kg SS per kkg of green beans
7. N - 0 mg/l (assumed, none suspected)
8. P - 0 mg/l (assumed, none suspected)

TABLE 61

RAW WASTE SUMMARY SUBCATEGORY C 8
COFFEE ROASTING

Parameter	Log Mean	Minimum	Maximum
Shift Time Hr/Day	8	8	8
Flow Ratio L/kkg	2120	2030	2250
(gal/ton)	508	486	539
5 Day BOD mg/l	270	113	645
Ratio kg/kkg	0.51	0.27	0.62
(lb/ton)	1.02	0.54	1.50
SS mg/l	203	180	240
Ratio kg/kkg	0.43	0.39	0.54
(lb/ton)	0.86	0.77	1.08

SUBCATEGORY C 9 - DECAFFEINATION OF COFFEE

Extract Centrifuge and Still Blowdown

The blowdown liquor from the solvent recovery still and the extract centrifuge are normally disposed of as part of the waste stream from the decaffeination process. These blowdown liquors are a significant source of both wastewater strength and volume from the decaffeination process. They contain high concentrations (quantitative data is not available) of suspended solids, and to a lesser extent, BOD.

Dewatering Screen

After the extract and the beans have been separated, the beans are washed and screened before drying. The dewatering screen is the source of the greatest volume of wastewater in decaffeination plants which employ this device. Although no data is available to quantitatively define the characteristics of this wastewater, it is estimated that the strength of this source of wastewater is less than all others except general plant cleanup.

Cleanup

In plants which do not utilize a dewatering screen, cleanup is the most significant source of wastewater volume. In addition, decaffeination processing plant cleanup is an important source of waste strength. Floors in the process area are hosed down as needed, usually once or twice a day. The decaffeinating equipment is thoroughly wet cleaned weekly and spot cleaned as necessary during the week. Caffeine storage areas are cleaned periodically and also contribute to the wasteload of the plant.

Total Processing Effluent

The quantity and quality characteristics of wastewater from coffee decaffeinating plants vary considerably. These variations can usually be traced to the amount of cleaning required on a given day. In-plant studies (82) show almost two fold variations in daily flow, three fold variations in BOD and three fold variations in suspended solids. Table 62 includes data describing the total processing effluent for this subcategory.

Model Plant

The model plant for this subcategory is a hypothetical plant producing whole decaffeinated green coffee beans. Decaffeination is accomplished using the liquid/liquid extraction process. All equipment and floors are wet cleaned. The model plant is assumed to process 55 kkg (60 tons) of green beans per day, operating 24 hours per day, six days per week.

Wastewater - Sources of wastewater from the model plant would include all of the sources listed above with the greatest quantities of waste-

TABLE 62

RAW WASTE SUMMARY SUBCATEGORY C 9 - DECAFFEINATION OF COFFEE

Parameter		NP	Logmean	Minimum	Maximum
Production	kkg/day	-	55	-	-
	tons/day		60	-	-
Flow	MLD	2	0.242	0.213	0.275
	MGD		0.070	0.062	0.079
Flow Ratio	l/kkg	2	4406	3880	5004
	gal/ton		1164	1025	1322
BOD	mg/l	2	864	682	1045
	kg/kkg		3.8	3.0	4.6
	lb/ton		7.5	6.1	9.2
SS	mg/l	2	1590	1182	2114
	kg/kkg		7.0	5.2	9.3
	lb/ton		13.9	10.4	18.5
Color index *		1	4.5	-	-

* Note: Index 4 is the color normally identified with a U.S. cup of coffee; e.g., 4.5 is more intense than the color of a cup of coffee

water coming from the dewatering screen in plants which utilize this device. Lesser quantities of wastewater are generated by general plant cleanup and extract centrifuge and solvent recovery still blowdown.

Parameters of the raw wastewater were assumed as follows:

1. Flow rate - average - 0.24 mld (70,000 gpd)
2. BOD - 864 mg/l
3. SS - 1590 mg/l
4. pH - 4.3 to 7.2
5. N - 0 mg/l (assumed)
6. P - 0 mg/l (assumed)
7. 3.8 kg BOD per kkg of green coffee processed
8. 7.0 kg SS per kkg of green coffee processed.

SUBCATEGORY C 10 - SOLUBLE COFFEE

Grounds Disposal

Soluble coffee plants normally dispose of their spent grounds by incineration or in a sanitary landfill. Most plants hydraulically press the grounds to reduce their moisture content prior to disposal by either of these two methods. The source of the greatest waste load in most soluble coffee plants is the process of grounds pressing. Data compiled during this study indicates that grounds pressing wastewater may have a BOD of up to 30,000 mg/l. A large amount of color is also characteristic of this wastewater.

Some soluble coffee processors utilize rotary driers rather than presses to remove moisture from the spent grounds prior to incineration. In these plants the only source of wastewater is drainage off of the grounds during storage. Although this is also a source of waste load it is a less significant wastewater source than grounds pressing.

Centrifuge

In the soluble coffee process hot water passes through the coffee grounds to extract the soluble constituents. The solution resulting from this process also contains suspended materials which must be removed by centrifugation. A major source of waste load in nearly all soluble coffee plants is centrifuge cleaning and blowdown. The concentrated sludge and cleanup wastes from the centrifuge are normally discharged as part of the liquid waste stream from the plant.

Extract Concentrator Condensate

Before the extracted soluble coffee materials are converted to a solid by drying, the liquid extract is usually concentrated. Concentration is accomplished either by heating or cooling the solution. Whichever method is utilized, a large volume of condensate is generated. This condensate is the largest single source of wastewater flow from a soluble coffee plant.

Cleanup

General cleaning of equipment and floors in a soluble coffee plant is also a significant source of wastewater generation. Floors are wet cleaned as necessary during production and thoroughly cleaned weekly. The extractors and related equipment are self-cleaned during production. Once a week during general cleanup the extractors are cleaned with a caustic solution.

Total Processing Effluent

The quantity and quality characteristics of soluble coffee processing wastewater can vary as a result of cleaning procedures and the method of grounds handling and disposal. Plants utilizing rotary drying of spent grounds and efficient cleaning procedures are the plants with the lowest wasteload. Table 63 includes data describing the total processing effluent.

Model Plant

The model plant for this subcategory is a hypothetical plant producing approximately equal amounts of spray and freeze dried soluble coffee. Waste coffee gorunds are pressed to reduce the moisture content and used as fuel for the plant's boilers. Cleaning of the equipment and general plant cleanup occurs weekly, and both processes utilize water. Total production at the model plant is assumed to be 78 kkg (87 tons) per day produced in 24 hours per day, six days per week.

Wastewater - Sources of wastewater from the model plant include all sources listed above with the greatest waste strength coming from the grounds pressing operation. The largest amount of wastewater is the extract concentrator condensate. Lesser amounts of waste load are generated by centrifuge blowdown and general cleaning.

Parameters of the wastewater from the model plant are assumed as follows:

1. Flow rate - average - 0.62 mld (0.18 mgd)
2. BOD - 2400 mg/l
3. SS - 1560 mg/l

TABLE 63

RAW WASTE SUMMARY
SUBCATEGORY C 10 - SOLUBLE COFFEE

Parameter	NP	Log Mean	Minimum	Maximum
Production kkg	3	78	40	153
tons		86	44	169
Flow mld	2	0.617	0.355	1.09
mgd		0.180	0.102	0.315
Flow Ratio l/kkg	2	7912	4505	13930
gal/ton		2090	1190	3680
BOD mg/l	3	2377	2136	2940
kg/kkg		18.8	16.9	23.26
lb/ton		39.6	33.7	46.52
SS mg/l	3	1555	683	3565
kg/kkg		12.3	5.4	28.2
lb/ton		24.7	10.8	56.5
Color cpu*		2775		

* Cobalt - platinum units

4. pH - 4 to 5
5. 18.8 kg BOD per kkg of green coffee processed
6. 12.3 kg SS per kkg of green coffee processed
7. N - 0 mg/l (assumed)
8. P - 0 mg/l (assumed)
9. Color - 2775 Cobalt - platinum units

SUBCATEGORY F 1 - TEA BLENDING

The blending of tea has been determined to be a dry process involving the generation of no wastewater.

BAKERY AND CONFECTIONERY PRODUCTS

SUBCATEGORY C1 - CAKES, PIES, DOUGHNUTS, AND SWEET YEAST GOODS UTILIZING PAN WASHING

Pan Washing

The source of the greatest waste load in a cake or pie bakery is the process of washing pans. Pan washing is almost exclusive to the cake baking industry whether the cakes are full size or the snack cake variety. Normally, the pans that are used in baking cakes must be washed after each use. After cakes have been removed from their baking pan, a thin layer of cake crumbs usually remains in the pan and is removed in the pan washing operation. The crumbs are essentially pieces of the cake and thus have a high organic content. Previous studies (7) and the wet sampling associated with this project indicates that the cake pan wash water may have a BOD of up to 54,000 mg/l.

Efforts are being made by a number of bakeries to decrease the amount of pan washing required in their cake production. Some bakeries are washing less than once every use, and at least one bakery has completely eliminated pan washing in their snack cake production.

Wash Room

A feature of virtually every bakery is a wash room in which portable equipment is cleaned. Items such as small mixers, mixing vats, reuseable ingredient containers, and hand utensils are normally dry cleaned as thoroughly as possible before and/or after being taken to the wash room. In the wash rooms, these items are thoroughly cleaned using hot water or steam, with the wastewater being collected by floor drains or sinks.

Cake bakeries may have more than one wash room. Some may be operated in the manner described above with manual cleaning of equipment. Other types of wash rooms are essentially large dishwashers. Racks of cake pans and other items are rolled into these units. They are completely closed and then the equipment inside is washed in a manner similar to that accomplished by home dishwashing equipment.

Clean-In-Place Equipment

Large equipment handling liquid or semi-solid materials are usually fitted with clean-in-place (CIP) equipment. This equipment includes the plumbing, controls, and sewer connections necessary to wash the unit without moving it to the wash room. During interruptions in processing caused by changes in variety of product or due to end of shift cleanup, equipment with CIP is normally dry cleaned as thoroughly as possible and then wet cleaned using hot water and detergent supplied through the CIP equipment. Wastewater discharge from CIP equipment is normally through a direct connection to the plant's plumbing system.

Examples of equipment with CIP include the following:

1. Large mixers for cake batter

2. Piping used to deliver the batter from the mixer to the depositer.

3. The depositer which fills each cake pan with the proper amount of batter.

Cleanup

General cleanup of other equipment associated with the baking process and the plant itself is a relatively minor contributor to the waste load. Conveyors used for the baking and cooling of cakes and pies are usually dry cleaned; however, they may be wet cleaned as frequently as once a week. Cleanup procedures in most plants stress the dry cleaning of equipment and the floor spaces around the equipment. However, some wet cleaning is normally accomplished. Some exceptionally dirty areas may be hosed down; however, more common practices include the use of mop and bucket or the vacuum type of wet scrubber for floors.

Total Processing Effluent

The quantity and quality characteristics of wastewater from cake and pie bakeries can vary considerably. These variations can usually be traced to operating and cleanup procedures associated with the amount and type of product being produced and the associated cleaning required. In-plant studies (83) show five fold variations in BOD from one day to the next and three fold variations in wastewater flow. Table 64 includes data describing the total processing effluent for this subcategory.

Model Plant

The model plant for this subcategory is a hypothetical bakery producing a variety of cake and pie items. Production includes both full sized and snack cakes, full sized pies, and sweet yeast goods. The cakes and snack cakes are baked in pans which are washed after each use. The pies and sweet yeast goods are baked on conveyors or in one-way containers thus the containers require little or no wet washing. Operating procedures stress dry cleaning of all equipment prior to their cleaning with water. Total production at the model plant is assumed to be 135 kkg (150 tons) per day produced in 24 hours per day, seven days per week operation.

Wastewater - Sources of wastewater from the model plant would include all sources listed above with the greatest strength and quantities of waste coming from the pan washing equipment and the wash rooms. Lesser quantities of wastewater are generated by the clean-in-place equipment and general plant cleanup.

Parameters of the wastewater are assumed as follows:

1. Flow rate - average - 0.45 mld (120,000 gpd)
   minimum - 0.20 mld (53,000 gpd)
   maximum - 0.60 mld (160,000 gpd)

2. BOD - 28,000 mg/l

3. SS - 5,000 mg/l

4. Oil and Grease - 500 mg/l

5. pH - 6.0 to 7.0

6. N - 2 mg/l (deficient)

7. P - 20 mg/l (deficient)

8. Ratio - kg BOD to kkg of product - 94.2

9. Ratio - kg SS to kkg of product - 16.8

10. Ratio - kg O & G to kkg of product - 1.7

These parameters generally follow those listed in Table 64 for this subcategory with the exception of suspended solids. The suspended solids data reported for Subcategory C 1 appears unrealistically low. This is particularly true when a comparison is made among suspended solids data from Subcategories C 1, C 2, C 3, and bakeries which span these subcategories. Thus, the figure of 5,000 mg/l was used and is based on data from a bakery spanning subcategories C 1 and C 3.

SUBCATEGORY C 2 - CAKES, PIES, DOUGHNUTS, AND SWEET YEAST GOODS NOT UTILIZING PAN WASHING

With the exception of pan washing, the sources of wastewater in bakeries not utilizing pan washing are identical to those in Subcategory C 1. The principal sources of wastewater are as follows:

TABLE 64 . RAW WASTE SUMMARY
CAKES, PIES, DOUGHNUTS, AND SWEET YEAST
GOODS UTILIZING PAN WASHING

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	1	172	--	--
(TON/DAY)		190	--	--
SHIFT TIME HR/DAY	1	24.0	--	--
FLOW VOLUME MGD	1	0.160	--	--
FLOW RATE L/SEC	1	7.01	--	--
(GAL/MIN)		111	--	--
FLOW RATIO L/KKG	1	3530	--	--
(GAL/TON)		845	--	--
5 DAY BOD MG/L	1	18000	--	--
RATIO KG/KKG		63.5	--	--
(LB/TON)		127	--	--
TSS MG/L	1	1590	--	--
RATIO KG/KKG		5.63	--	--
(LB/TON)		11.2	--	--

PROCESS CODE(S): 51C75I

1. Wash room

2. Clean-in-place equipment

3. Cleanup

See the previous discussion of Subcategory C 1 for a description of these sources and their effects on the total plant effluent.

Total Processing Effluent

The quantity and quality of wastewater from cake and pie bakeries not utilizing the pan washing vary considerably. These variations can usually be traced to operating and cleanup procedures associated with the amount and type of product being produced. In-plant studies (84) show up to five fold variations in BOD from one day to the next and three fold variations in the wastewater flow. Table 65 includes data describing the total processing effluent for this subcategory.

Model Plant

The model plant for this subcategory is a hypothetical bakery primarily producing cakes and snack cakes. Pies baked in one-way pans are also produced, but account for only a small percentage of the plant's total production. All of the items baked in the plant are produced by methods which completely eliminate pan washing. Operating procedures stress dry cleaning of all equipment prior to cleaning with water. Total production at the model plant is 180 kkg (200 tons) per day produced in 24 hours per day, five days per week operation.

Wastewater - Sources of wastewater from the model plant will include all sources listed above with the greatest strength and quantities of waste coming from the wash room. Lesser quantities of wastewater are generated by the clean-in-place equipment and general plant cleanup.

Parameters of the wastewater are assumed as follows:

1. Flow rate - average - 0.16 mld (43,000 gpd)
   minimum - 0.14 mld (37,000 gpd)
   maximum - 0.19 mld (51,000 gpd)

2. BOD - 2,190 mg/l

3. SS - 1,020 mg/l

4. Oil & Grease - 685 mg/l

5. pH - 5.0

6. N - 30 mg/l (deficient)

TABLE 65

RAW WASTE SUMMARY SUBCATEGORY C2

CAKES, PIES, DOUGHNUTS, AND SWEET YEAST GOODS NOT UTILIZING PAN WASHING

Parameter	Log Mean	Minimum	Maximum
Prod kkg/day	180	---	---
(ton/day)	200	---	---
Shift time hr/day	24	---	---
Flow volume MGD	0.043	0.037	0.051
MLD	0.163	0.140	0.193
Flow ratio l/kkg	897	722	1064
(gal/ton)	215	185	255
5 day BOD mg/l	2190	1890	2540
Ratio kg/kkg	2.0	1.7	2.3
(lb/ton)	4.0	3.4	4.6
SS mg/l	1020	950	1100
Ratio kg/kkg	0.92	0.86	1.0
(lb/ton)	1.84	1.72	2.0
O & G mg/l	685	570	830
Ratio kg/kkg	0.62	0.51	0.75
(lb/ton)	1.24	1.02	1.50

7. P - 15 mg/l (sufficient)

8. 2.0 kg BOD per kkg of product

9. 0.94 kg SS per kkg of product

10. 0.63 kg O & G per kkg of product

SUBCATEGORY C 3 - BREAD AND BUNS

Mixing Equipment Cleaning

The cleaning of mixing equipment is the largest source of wastewater from a bread and bun bakery. The cleaning may be done manually or with clean-in-place (CIP) equipment, which consists of the plumbing, controls, and sewer connections necessary to wash the equipment automatically. The mixing equipment is normally cleaned daily by first scraping the walls of the mixers to remove adhering dough and then washing. The solid (dry) material is either sold as animal feed or handled as solid waste. In plants using the continuous mix method, the mixers and dough slurry tanks are then rinsed daily with water. In plants using the batch mix method, the mixers are normally wet cleaned once or twice a week.

General Cleanup

General cleaning of floors and utensils is the other important source of wastewater from bread and bun bakeries. Utensils are normally washed in a sink in the production area in which they are used. Floors in the mixing area are generally wet cleaned daily using mops and buckets, hoses, or scrubbers which vacuum the water and spilled product from the floor as it is used. Floors throughout the rest of the plant are routinely cleaned several times a day using brooms and dry vacuum cleaners. Once or twice a week all of the floors in the plant are wet cleaned with mop and bucket or vacuum scrubber.

Total Processing Effluent

The quantity and quality of wastewater from bread and bun bakeries varies considerably. These variations are usually the result of the amount of cleanup taking place and the training and management of the personnel. Data from various plants show two fold variations in flow and in BOD from one day to the next. Table 66 includes data describing the total processing effluent for this subcategory.

Model Plant

The model plant for this subcategory is a hypothetical bakery producing bread and buns. Buns are a minor production item. All items are batch mixed, baked in pans (sometimes with lids), and mechanically packaged in plastic bags. Operating procedures stress dry cleaning of all equipment prior to wet cleaning (if required). Total production of the model plant

TABLE 66. RAW WASTE SUMMARY
BREAD AND BUNS

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	14	40.8	21.4	78.1
(TON/DAY)		45.0	23.6	86.1
SHIFT TIME HR/DAY	14	22.7	16.0	24.0
FLOW VOLUME MGD	14	0.026	0.014	0.051
FLOW RATE L/SEC	14	1.32	0.561	3.12
(GAL/MIN)		21.0	8.90	49.4
FLOW RATIO L/KKG	14	2080	952	4540
(GAL/TON)		499	228	1090
5 DAY BOD MG/L	14	422	110	1610
RATIO KG/KKG		0.877	0.264	2.92
(LB/TON)		1.75	0.526	5.84
TSS MG/L	13	214	54.4	844
RATIO KG/KKG		0.464	0.148	1.45
(LB/TON)		0.927	0.296	2.90

PROCESS CODE(S): 51C53I ,51C54I ,51C58I ,51C60I ,51C61I ,
51C62M ,51C63I ,51C64I ,51C65M ,51C66M ,51C68S ,51C72I ,
51C80I ,51C82M

is assumed to be 41 kkg (45 tons) per day produced in 24 hours per day, five days per week.

Wastewater - Sources of wastewater from the model plant would include all sources listed above with nearly all of the wastewater generated by cleaning of mixing equipment and floors throughout the plant.

Parameters of the wastewater are assumed to be as follows:

1. Flow - average - 0.10 mld (0.026 mgd)
   minimum - 0.053 mld (0.014 mgd)
   maximum - 0.19 mld (0.051 mgd)

2. BOD - 422 mg/l

3. SS - 214 mg/l

4. pH - 6.0 to 9.0

5. P - 0 mg/l (assumed)

6. N - 0 mg/l (assumed)

7. 0.88 kg BOD per kkg of product

8. 0.46 kg SS per kkg of product

SUBCATEGORY C7 - COOKIE AND CRACKER MANUFACTURING

Wash Room

A feature of virtually every cookie and cracker bakery is a wash room in which portable equipment is cleaned. The cleaning may be done manually or the wash room may be essentially a large automatic dish-washer. Equipment such as small icing mixers, mixing vats, rotary formers, enrobers, and hand utensils are normally thoroughly scraped and dry cleaned before and/or after being taken to the wash room. These items are then cleaned in the wash room using hot water and/or steam.

The major source of wastewater in the wash room is associated with the cleaning of icing and enrobing equipment (normally associated with cookie manufacturing). The quantity of wastewater generated by the wash room varies greatly, depending on the operating personnel.

Clean-In-Place Equipment

Large equipment handling liquid and semi-solid materials is usually fitted with clean-in-place (CIP) equipment. This equipment includes the plumbing, controls, and sewer connections necessary to wash the unit without moving it to the wash room. During interruptions in processing caused by changes in the variety of product or due to end of shift cleaning, equipment with CIP is normally dry cleaned as thoroughly as possible and then wet cleaned using hot water and detergent supplied through the CIP equipment. Wastewater discharge is normally through a direct connection to the plant waste plumbing system.

Cleanup

General cleanup of other equipment associated with the baking process and the plant itself is the least significant contributor to the waste load. Conveyors used for the baking and cooling of cookies and crackers are usually dry cleaned; however, they may be wet cleaned as frequently as once a week. Cleanup procedures in most plants stress the dry cleaning of equipment and the floor spaces around the equipment. However, exceptionally dirty areas may be hosed down, or more commonly be cleaned with a vacuum type wet scrubber or a mop and bucket.

Total Processing Effluent

The quantity and quality of wastewater from cookie and cracker bakeries can vary considerably. These variations are usually the result of cleanup procedures associated with the type of product being produced and the training and management of the personnel. Data collected during this study show six fold variations in BOD from one day to the next and two fold variations in wastewater flow within a single plant. Table 67 includes data describing the total processing effluent for this subcategory.

Model Plant

The model plant for this subcategory is a hypothetical bakery producing a variety of cookie and cracker items. Production includes crackers, iced and plain cookies, pretzels and sugar wafers. The model plant produces cookie items and cracker items in approximately equal quantitites. All items are batch mixed, baked on conveyor belts in tunnel ovens (except sugar wafers which are baked in plates in a special type of oven) and tumble or shingle stack packaged. Operating procedures stress dry cleaning of all equipment prior to wet cleanup (if required). Total production for the model plant is assumed to be 180 kkg (200 tons) per day produced in 24 hours per day, five days per week.

Wastewater - Sources of wastewater from the model plant would include all sources listed above with the greatest strength and quantities of waste coming from the wash room. Smaller quantities of wastewater are generated by the clean-in-place equipment and general plant cleaning.

Parameters of the wastewater are assumed as follows:

1. Flow rate - average - 0.34 mld (90,000 gpd)
   minimum - 0.20 mld (53,000 gpd)
   maximum - 0.45 mld (120,000 gpd)

TABLE 67 . RAW WASTE SUMMARY
COOKIES AND CRACKERS

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	8	122	41.9	357
(TON/DAY)		135	46.2	393
SHIFT TIME HR/DAY	8	21.1	14.4	24.0
FLOW VOLUME MGD	8	0.056	0.016	0.211
FLOW RATE L/SEC	8	3.07	0.908	10.4
(GAL/MIN)		48.7	14.4	165
FLOW RATIO L/KKG	8	1620	731	3570
(GAL/TON)		387	175	856
5 DAY BOD MG/L	8	670	365	1230
RATIO KG/KKG		1.08	0.368	3.20
(LB/TON)		2.16	0.733	6.38
TSS MG/L	8	387	129	1160
RATIO KG/KKG		0.626	0.141	2.77
(LB/TON)		1.25	0.283	5.53

PROCESS CODE(S): 52*50M ,52*51M ,52*53I ,52*55W ,52*57M ,
52*58M ,52*58W ,52055M

2. BOD - 1200 mg/l

3. SS - 900 mg/l

4. pH - 6.0 - 8.0

5. Ratio - kg BOD to kkg of product - 2.0

6. Ratio - kg SS to kkg of production - 1.5

SUBCATEGORY D 1 - CANDY AND CONFECTIONERY PRODUCTS EXCLUDING GLAZED FRUITS

Of the total number of confectioners contacted 15 were considered to have reliable historical wastewater data on which to characterize the industry as a whole. A summary of this data is given in Table 68.

Direct product contact water usage was not observed in any segment of this subcategory. The primary source of wastewater with the highest pollutant loading is derived from the periodic or daily clean-up of the plant. Although washdown is practiced in most parts of the plant at some time, the largest and most consistent area of washdown water generation is the candy kitchen. Washdown water in the remainder of the plant is usually restricted to mopping and wiping. Some machinery parts and molding pans may be removed to a separate area for cleansing. In addition, certain molding machines were observed to use a clean-in-place system. Other areas which may contribute to the total effluent loading are boiler blowdown, air scrubbers and barometric condensers. Non-contact cooling water was observed to be either discharged to storm sewers, surface water, sanitary sewers or was recirculated.

As noted in Table 68, the average flow ratio was 3770 l/kkg (904 gal/ton). The average BOD was 5.10 kg/kkg (10.2 lb/ton) with a range of 1.69 to 15.4 kg/kkg (3.38 to 30.7 lb/ton); suspended solids was 0.648 with a range of 0.168 to 2.50 kg/kkg (0.336 to 5.00 lb/ton). No correlation between suspended solids and BOD was noted due to the solubilized carbohydrates characteristically discharged by this industry. Oil and grease loadings ranged from 0.05 to 0.832 kg/kkg (0.10 to 1.664 lb/ton) with an average of 0.21 kg/kkg (0.42 lb/ton) for the six plants with this data available. Variability of the wasteloading and flow was significantly influenced by variations in processing, raw materials, production level, washdown and general housekeeping practices. Wastewater in all plants visited was discharged to municipal treatment facilities. Many plants utilized some minor form of pretreatment and/or in-plant controls to reduce waste loadings; particularly where oil and grease were of concern. Pretreatment was usually in the form of a grease trap. One plant, however, was considering dissolved air flotation as a method of reducing effluent concentrations.

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TABLE 68 RAW WASTE SUMMARY
CANDY AND CONFECTIONERY

PARAMETER	NO. PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	15	97.0	30.7	307
(TON/DAY)				
SHIFT TIME HR/DAY	14	16.8	8.00	338
FLOW VOLUME MGD	15	0.099	0.024	0.422
FLOW RATE L/SEC	14	6.80	1.71	27.0
(GAL/MIN)		108	27.1	429
FLOW RATIO L/KKG	15	3770	2070	6880
(GAL/TON)		904	495	1650
5 DAY BOD MG/L	14	1290	523	3200
RATIO KG/KKG		5.10	1.69	15.4
(LB/TON)		10.2	3.38	30.7
TSS MG/L	15	172	54.1	545
RATIO KG/KKG		0.648	0.168	2.50
(LB/TON)		1.29	0.336	5.00
OIL & GREASE MG/L	6	55.7	13.3	222.8
RATIO KG/KKG		0.2L	0.50	0.84
(LB/TON)		0.42	0.10	1.68

PROCESS CODE (S): 65*80M, 65*83M, 65*84I, 65*85M, 65*86I, 65*87M, 65*81NT, 65880M2, 65382I, 65883M, 65384I, 65885M, 65H81M, *C080I

Model Plant

The following information reflects those conditions judged to be applicable to a representative candy and confectionery product plant:

Production	= 97 kg/day (107 ton/day)
Effluent Volume	= 375 cu m/day (0.099 MGD)

Effluent characteristics:

BOD	= 1300 mg/l
SS	= 170 mg/l
Oil and Grease	= 56 mg/l
pH	= 7.7

Primary source of wastewater: Washdowns.
Special consideration: Oil and grease.

SUBCATEGORY D 2 - CHEWING GUM

Data from a total of five plants were used to develop the wastewater characteristics as summarized in Table 69. Three of the data points contributing to this summary were from plants visited by the contractor. Other data points represent data contributed by the National Association of Chewing Gum Manufacturers (NACGM). Because the NACGM included much supplemental processing and water usage information with the historical data, it was concluded that such data could be reliably utilized as part of the data base making the necessary wastewater characterization.

Water used in the manufacture of chewing gum is primarily for air scrubber systems with lesser quantities being consumed during plant washdown. No direct finished product contact water use was observed or indicated. Washdown of the plant is usually restricted to mopping and wiping in most areas with a separate room used for cleaning various pieces of equipment. Some miscellaneous water use generally occurs in cleaning of mixing room floors. Air scrubber water is usually recirculated and periodically purged.

The ratio of water use to production averages 4500 l/kkg (1080 gal/ton) with an expected range of 3300 to 6130 l/kkg (792 to 1470 gal/ton). This range is due primarily to variations in plant size and different conditions affecting the performance of the air scrubber systems. Expected BOD ratios ranged from 1.2 to 13.6 kg/kkg (2.4 to 27.2 lb/ton) with an average of 4.04 kg/kkg (8.07 lb/ton). Suspended solids ranged from 0.175 to 0.858 kg/kkg (0.351 to 1.71 lb/ton) with an average of 0.388 kg/kkg (0.774 lb/ton). Variability of the BOD and SS loadings could not be rationalized in all cases, but is likely to be influenced by variable amounts of sugar dust that is subsequently removed by the air scrubber system. Differences in general cleanup practices are suspected to account for a significant variation in wastewater pollutant load.

TABLE 69 . RAW WASTE SUMMARY
CHEWING GUM

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	5	70.9	42.1	119
(TON/DAY)		78.2	46.4	132
SHIFT TIME HR/DAY	5	14.4	8.00	24.0
FLOW VOLUME MGD	5	0.085	0.039	0.183
FLOW RATE L/SEC	5	6.74	3.39	13.4
(GAL/MIN)		107	53.7	213
FLOW RATIO L/KKG	5	4500	3300	6130
(GAL/TON)		1080	792	1470
5 DAY BOD MG/L	5	897	360	2240
RATIO KG/KKG		4.04	1.20	13.6
(LB/TON)		8.07	2.40	27.2
TSS MG/L	4	94.1	35.6	249
RATIO KG/KKG		0.388	0.175	0.858
(LB/TON)		0.774	0.351	1.71

PROCESS CODE(S): 67G81I ,67G82I ,67G83I ,67G84I ,*CG81S

Intake waters are generally obtained from municipal water supplies; however, some plants do utilize well water for non-contact cooling and air washer make-up water. All effluents, except from one plant, observed during the study were discharged directly to municipal treatment systems. Pre-treatment was generally not employed; however, one plant treated and subsequently spray irrigated its effluent.

Model Chewing Gum Plant

Based on available information, a representative plant for this subcategory has been selected as follows:

Production:	70.9 kkg/day (78.2 ton/day)	
Wastewater flow volume:	322 cu m/day (0.085 MGD)	
Wastewater characteristics:	BOD	= 900 mg/l
	SS	= 95 mg/l
	Oil and Grease	= 30 mg/l
	pH	= 7.5

Primary Sources of Wastewater - Air scrubbers, cleanup operations.

Special Considerations - None.

SUBCATEGORY D 3 - CHEWING GUM BASE

As in the case of Subcategory D 2, data for two of the plants supplied by NACGM were considered valuable for the reasons mentioned in the previous subsection. Table 70 summarizes the data from three chewing gum base manufacturers.

During the production of chewing gum base, water is used for washing of the natural gums, for contact and non-contact cooling, and for periodic cleanup. The greatest volume of water is used during the washing operation with considerably less being used for general cleanup. The ratio of water used to production would be expected to range from 1030 to 11,200 l/kkg (247 to 2690 gal/ton) with an average of 3400 l/kkg (815 gal/ton). Although the range of water use is great, the total waste-loading does not reflect the same wide range, suggesting different approaches to water use to achieve the same degree of product and/or plant cleaning.

Expected BOD ratios range from 1.11 to 1.90 kg/kkg (2.21 to 3.80 lb/ton) with an average of 427 kg/kkg (2.9 lb/ton); suspended solids from 0.800 to 1.82 kg/kkg (1.60 to 3.63 lb/ton) and an average of 1.21 kg/kkg (2.41 lb/ton). The reason for the variability of the wastewater flow cannot be attributed to specific processing differences between plants but is most likely due to differences in raw material quality; i.e., the amount of extraneous material which must be removed.

The pH range (two plants) was from 8.76 to 9.5 with a numerical average of 9.13. Sodium hydroxide (NaOH) used as a bleaching agent, is the cause of the above neutral pH. Surges of higher hydroxide ion concentration would be expected during the bleaching cycle pump and subsequent rinsing of the product to remove residual NaOH.

TABLE 70 RAW WASTE SUMMARY
CHEWING GUM BASE

PARAMETER	NO. PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	3	105	98.7	112
(TON/DAY)		116	109	123
SHIFT TIME HR/DAY	2	20.0	16.0	24.8
FLOW VOLUME MGD	3	0.094	0.030	0.310
FLOW RATE L/SEC	2	8.40	3.58	19.7
(GAL/TON)		133	56.8	312
FLOW RATIO L/KKG	3	3400	1030	11200
(GAL/TON)		815	247	2690
5 DAY BOD MG/L	3	427	162	1120
RATIO KG/KKG		1.45	1.11	1.90
(LB/TON)		2.90	2.21	3.80
TSS MG/L	3	355	74.2	1700
RATIO KG/KKG		1.21	0.800	1.82
(LB/TON)		2.41	1.60	3.63
PH	2	9.13	8.76	9.50

PROCESS CODES(S): *CG80H, 67B80I, 67B85I

During periodic cleanup of equipment and processing areas, various solvents are utilized to remove built-up gum residues. According to a treatment feasibility study (85) prepared for a gum base plant, a maximum of 2000 gallons per week of solvent was used with a yearly average of 24,000. This consumption was based on a production average of 5000 lb/day.

Of the three plants used for characterization, two discharged wastewater to municipal treatment systems and one plant employed its own treatment system prior to discharge to a local tributary.

Model Gum Base Plant

Production:	105 kkg/day (116 ton/day)	
Wastewater flow volume:	356 cu m/day (0.094 MGD)	
Wastewater characteristics:	BOD	= 430 mg/l
	SS	= 355 mg/l
	Oil and Grease	= 30 mg/l
	pH	= 9.1

Primary Sources of Wastewater - Gum base wash water, contact cooling water, cleanup.

Special Considerations - Bleaching agent (sodium hydroxide), solvents.

SUBCATEGORY D 5 - MILK CHOCOLATE PRODUCTION WITH CONDENSORY PROCESSING AND SUBCATEGORY D 6 - MILK CHOCOLATE WITHOUT CONDENSORY PROCESSING

As noted in Section III, some producers of chocolate products may also engage in the condensing of milk for milk chocolate and were, therefore, segregated for separate consideration. Wastewater characteristics for Subcategory D 5, Chocolate Production with Milk Condensory, is based on six data sets which reflect the majority of chocolate and cocoa products manufactured in the United States. Three data sets were used in characterization of Subcategory D 6, Chocolate Production without Milk Condensory. These data are summarized on Tables 71 and 72 and are further discussed herein.

The presence of water is not compatible with the production of cocoa products; therefore, the open use of water is controlled so as to avoid entrainment in the product. The major portion of wastewater generation occurs during the periodic cleaning of holding or mixing tanks, transfer buggies, and molding pans. The production area floors are also cleaned on a periodic basis, usually preceded by dry collection and then mopping, and/or using industrial floor sweepers. Cocoa butter may be used as a cleaning solvent with the later recovery of the cocoa butter and chocolate material. Washdown water is also generated during the cleaning of the condensed milk line and milk receiving areas, Subcategory D 5.

For Subcategory D 5 BOD loadings averaged 7.48 kg/kkg (14.9 lb/ton) with an expected range of 8.69 to 25.7 (kg/kkg (4.35 to 12.9 lb/ton); suspended solids averaged 1.68 kg/kkg (3.35 lb/ton), ranging from 1.83 to 3.08 kg/kkg (1.83 to 6.15 lb/ton). Oil and grease averaged 0.69 kg/kkg (1.38 lb/ton) with an expected range of 0.32 to 1.06 kg/kkg (0.64 to 2.12 lb/ton) and for

TABLE 71 RAW WASTE SUMMARY
CHOCOLATE, WITH MILK CONDENSORY

PARAMETER	NO. PLANTS	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	5	333	117	944
(TON/DAY)		367	129	1040
SHIFT TIME HR/DAY	5	22.4	16.8	24.0
FLOW VOLUME MGD	5	0.201	0.077	0.524
FLOW RATE L/SEC	5	7.22	1.51	34.4
(GAL/MIN)		114	24.0	546
FLOW RATIO L/KKG	5	4070	2310	7170
(GAL/TON)		975	553	1720
5 DAY BOD MG/L	5	1840	1300	2600
RATIO KG/KKG		7.48	4.35	12.9
(LB/TON)		14.9	8.69	25.7
TSS MG/L	5	413	308	553
RATIO KG/KKG		1.68	0.915	3.08
(LB/TON)		3.35	1.83	6.15
OIL & GREASE MG/L	4	169.5	78.6	260.4
RATIO KG/KKG		0.69	0.32	1.06
(LB/TON)		1.38	0.64	2.12

PROCESS CODE (S): 66*80I, 66*80W, 66*80W1, 66*83I5, 66*83W5

TABLE 72 RAW WASTE SUMMARY
CHOCOLATE, WITHOUT MILK CONDENSORY

PARAMETER	NO. PLANTS	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	3	253	50.3	1270
(TON/DAY)		278	55.5	1400
SHIFT TIME HR/DAY	3	13.3	8.00	16.0
FLOW VOLUME MGD	3	0.243	0.103	0.579
FLOW RATE L/SEC	3	20.2	12.6	32.4
(GAL/MIN)		320	200	514
FLOW RATIO L/KKG	3	6560	5000	8620
(GAL/TON)		1570	1200	2070
5 DAY BOD MG/L	3	705	145	3420
RATIO KG/KKG	3	4.63	1.18	18.1
(LB/TON)		9.24	2.36	36.1
TSS MG/L	3	229	81.8	642
RATIO KG/KKG		1.50	0.669	3.38
(LB/TON)		3.01	1.23	6.76
OIL & GREASE MG/L	1	1.59	-	-
RATIO KG/KKG		1.06	-	-
(LB/TON)		2.12	-	-

PROCESS CODE (S): 66*82M, 66*83I4, 66*83W4

Subcategory D 6, the BOD averaged 4.63 kg/kkg (9.24 lb/ton) with an expected range of 1.18 to 18.1 kg/kkg (2.36 to 36.1 lb/ton); suspended solids averaged 1.50 kg/kkg (3.01 lb/ton), ranging from 0.669 to 3.38 kg/kkg (1.34 to 6.76 lb/ton). Oil and grease for the one plant which analyzed this parameter was 1.06 kg/kkg (2.12 lb/ton).

BOD and suspended solids loadings appear to be dependent on the relative amounts of chocolate products produced, i.e., cocoa, syrup, sweetened, unsweetened, and milk chocolate. Of special note is the necessary cleaning of tanks and product containers of the chocolate syrup line. Oil and grease variability is due to the efficiency of general operating housekeeping practices used to minimize entrainment of cocoa butter in the wastewater. In addition, Subcategory D 5 is influenced by washdown from the milk condensing process and milk receiving area; the total wasteloading for any one plant being dependent upon the amount of dry milk and/or condensed milk which may come from other sources.

Plants in these subcategories characteristically discharge their wastewater to municipal treatment systems, usually after some form of preliminary oil and grease removal. This pretreatment may involve only a grease trap or, as in the case of one plant, a flotation unit. Non-contact cooling water may either go to municipal treatment or be discharged to surface waters; the latter being the situation in the larger plants.

Model Chocolate Plant with Condensory		Without Condensory
Production:	360 ton/day	240 ton/day
Wastewater flow volume:	761 cu m/day	920 cu m/day
	0.201 MGD	0.243 MGD
Wastewater characteristics:		
BOD	= 1840 mg/l	705 mg/l
SS	= 415 mg/l	230 mg/l
Oil and Grease	= 170 mg/l	160 mg/l

Primary source of wastewater: Washdowns.
Special considerations: Oil and grease removal.

PET FOOD

SUBCATEGORY B 5 - LOW MEAT CANNED PET FOOD

General Plant Cleanup

Clean up in a low meat canned pet food plant is a continuous, minute-to-minute process which contributes by far the largest share of both volume and pollutants to the wastewater stream. Clean up can basically be divided into two main types: in-plant housekeeping and end of shift clean up.

Housekeeping - Housekeeping is the most continuous of clean up steps. The various operations throughout a typical low meat pet food plant generate considerable amounts of scrap. Included in this would be various spillages from gravy tanks, can filling, meat thawing, grinding, etc. Grinders as well as mixing tanks, filler bowls, double seamers, etc., also require periodic washdown to comply with in-plant and regulatory sanitation requirements. All of these individual operations contribute heavily to the organic waste load. These streams are characterized by small pieces of grain, starches, blood, meat scraps, and other formulation ingredients. These waste streams constitute a major portion of the total plant effluent.

End of Shift Cleanup - End of shift clean up is to some extent similar to the daily minute-to-minute operations inasmuch as all the floor and equipment surfaces are thoroughly washed and rinsed. Additionally, however, the larger cooking kettles are typically "boiled-out" with the aid of detergents. Pipes may be disassembled and scrubbed with brushes. Large pieces of equipment such as extruders, grinders, screw conveyors, etc., may also receive a final "sanitizing" step. These types of cleaning operations are usually responsible for peak loadings and probably contribute an equivalent amount of pollutants as would be experienced by an entire shift of housekeeping washdowns.

Retort Cooling Water

The only other process contributing to the wastewater stream is retort cooling water. The water which is used to cool the cans is basically low load water, typically continuously circulated, although some plants were observed to discharge this segment directly under NPDES permit. Some of the plants not only recirculate cooling water but reuse it for clean up, but this was atypical of the plants visited. No quantitative data are available to determine its relative proportion in the waste stream.

Model Plant

The model plant is one that produces 159 kkg of finished product generating 0.147 mgd of wastewater. The average BOD loading as shown in Table 73 is 3.55 kg/kkg with a range of 1.62 to 7.82 kg/kkg. The average BOD concentration is 1,130 mg/l with a range of 497 to 2,560 mg/l. The reason for the wide variation in concentration is principally due to the various product styles and types found within this subcategory. The other flow related parameters follow this same pattern.

SUBCATEGORY B 6 - HIGH MEAT CANNED PET FOOD

General Plant Cleanup

Clean up in a high meat canned pet food plant is a continuous, minute-to-minute process which contributes by far the largest share of both volume and pollutants to the wastewater stream. Clean up can basically be divided into two main types: in-plant housekeeping and end of shift clean up.

TABLE 73 . RAW WASTE SUMMARY
LOW MEAT CANNED PET FOOD

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	9	159	76.9	328
(TON/DAY)		175	84.8	362
SHIFT TIME HR/DAY	9	19.8	12.0	24.0
FLOW VOLUME MGD	9	0.147	0.059	0.371
FLOW RATE L/SEC	8	9.36	4.71	18.6
(GAL/MIN)		148	74.7	295
FLOW RATIO L/KKG	11	3150	1750	5670
(GAL/TON)		755	420	1360
5 DAY BOD MG/L	11	1130	497	2560
RATIO KG/KKG		3.55	1.62	7.82
(LB/TON)		7.11	3.23	15.6
TSS MG/L	11	845	397	1800
RATIO KG/KKG		2.66	1.21	5.86
(LB/TON)		5.33	2.42	11.7

PROCESS CODE(S): 47N64S ,47N54I ,47N54W ,47N50M ,47N50W ,
47N51I ,47N55I ,47S66I ,47S67S ,47S59I ,47S58I

Housekeeping - Housekeeping is the most continuous of clean up steps. The various operations throughout a typical high meat pet food plant generate considerable amounts of scrap. Included in this would be various spillages from gravy tanks, can filling, meat thawing, grinding, etc. Grinders as well as mixing tanks, filler bowls, double seamers, etc., also require periodic washdown to comply with in-plant and regulatory sanitation requirements. All of these individual operations contribute heavily to the organic waste load. These streams are characterized by small pieces of meat, fat, starches, blood, and other formulation ingredients. These waste streams constitute a major portion of the total plant effluent.

End of Shift Cleanup - End of shift clean up is to some extent similar to the daily minute-to-minute operations inasmuch as all the floor and equipment surfaces are thoroughly washed and rinsed. Additionally, however, the larger cooking kettles are typically "boiled-out" with the aid of detergents. Pipes may be disassembled and scrubbed with brushes. Large pieces of equipment such as extruders, grinders, screw conveyors, etc., may also receive a final "sanitizing" step. These types of cleaning operations are usually responsible for peak loadings and probably contribute an equivalent amount of pollutants as would be experienced by an entire shift of housekeeping washdowns.

Retort Cooling Water

The only other process contributing to the wastewater stream is retort cooling water. The water which is used to cool the cans is basically low load water, typically continuously circulated, although some plants were observed to discharge this segment directly under NPDES permit. No quantitative data are available to determine its relative proportion in the waste stream.

Model Plant

The canned high meat pet food subcategory is characterized by several different product styles as described in Section III. The processing and meat handling techniques are diverse, and as such the data presented show extreme ranges for concentrations and loadings for all of the flow-related parameters.

The model plant is one that produces 167 kkg of finished product generating 0.179 mgd of wastewater. The average BOD loading as shown in Table 74 was 48.6 kg/kkg with a range from 29.2 to 80.8 kg/kkg. The average BOD concentration was 11,800 mg/l with a range of 6,910 to 20,200 mg/l. The reason for the wide variation in concentrations is principally due to the various product styles found within this subcategory. The other flow-related parameters follow this same pattern.

TABLE 74. RAW WASTE SUMMARY
HIGH MEAT CANNED DOG AND CAT FOOD

PARAMETER	NO PLANT	LOG MEAN	MINUMUM	MAXIMUM
PROD KKG/DAY	3	167	153	182
(TON/DAY)		184	169	201
SHIFT TIME HR/DAY	2	24.0	--	--
FLOW VOLUME MGD	3	0.179	0.178	0.180
FLOW RATE L/SEC	2	7.84	7.78	7.90
(GAL/MIN)		124	123	125
FLOW RATIO L/KKG	3	4120	3820	4430
(GAL/TON)		987	917	1060
5 DAY BOD MG/L	3	11,800	6910	20,200
RATIO KG/KKG		48.6	29.2	80.8
(LB/TON)		97.2	58.4	162
TSS MG/L	3	9130	2520	33,100
RATIO KG/KKG		37.6	11.1	127
(LB/TON)		75.1	22.2	254

PROCESS CODE(S): 47N79W , 47N79I , 47N63H

SUBCATEGORY B 7 - DRY PET FOOD

General Plant Clean Up

Clean up in a dry pet food plant is generally a combination of both dry and wet methods with each coming at different times within a processing period.

Wet Clean Up - Wet clean up generally consists of periodic floor washings along with some "end-of-production" equipment clean up. At "start-up" of a production run, some "off-test" material is usually generated. The excess is generally scooped away, but the floor areas around the extruder/expander equipment is typically washed. Similarly, in some plants, the fat application areas were observed to be periodically wet-cleaned to maintain sanitary conditions. Some plants had pre-blending or tempering chambers in which water or steam was added to the pre-mixed grains before the extruders. These chambers were periodicaly scrubbed and rinsed.

The principal components discharged are bits of grain, finished product, and minute fat coated particles. Volume, however, from these clean up operations is generally minor relative to non-contact cooling water.

Dry Methods - Dry pet food is essentially a blend of dry ingredients to which water or steam has been added to facilitate the extruding/expanding process. As such, most of the periodic, housekeeping type clean up involves handling dry or semidry materials which have been lodged between pieces of equipment or have fallen on the floor. Continuous dry clean up is a necessity for good housekeeping.

Non-Contact Cooling Water

The largest source of water in the manufacture of dry pet food is non-contact cooling water and steam condensate from the extruder/expander operation. This water acts as a dilutor for the clean up water, the results of which are very low waste loads in terms of the various flow-related parameters.

Model Plant

Dry pet foods are typically manufactured with similar equipment and processing techniques. As a result, the waste loadings and concentrations (with the exception of plant 47D61I) show limited and predictable ranges. The model plant produces 211 kkg/day of finished product with a resulting effluent 0.019 mgd. As can be seen from Table 75 the flow ratio is only 155 l/kkg is an indication of the small amount of waste loads from these plants.

Average BOD loading was .032 kg/kkg with a range from .011 to .096 kg/kkg. The average BOD concentration was 202 mg/l with a range of 51 to 796 mg/l. The other flow-related parameters follow the same pattern as described above.

TABLE 75. RAW WASTE SUMMARY
DRY DOG AND CAT FOOD

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	7	211	71.0	626
(TON/DAY)		232	78.3	690
SHIFT TIME HR/DAY	6	26.2	8.00	53.3
FLOW VOLUME MGD	6	0.019	0.009	0.047
FLOW RATE L/SEC	6	0.339	0.019	6.14
(GAL/MIN)		5.05	0.240	106
FLOW RATIO L/KKG	7	155	41.0	587
(GAL/TON)		37.2	9.83	141
5 DAY BOD MG/L	7	202	51.0	796
RATIO KG/KKG		0.032	0.011	0.096
(LB/TON)		0.061	0.021	0.192
TSS MG/L	7	186	69.4	497
RATIO KG/KKG		0.030	0.017	0.053
(LB/TON)		0.059	0.032	0.106

PROCESS CODE(S): 47D50W ,47D52M ,47D52W ,47D60I2 ,47D60I1 ,
47D61I ,47D65I

SUBCATEGORY B 8 - SOFT-MOIST PET FOOD

General Plant Clean Up

Clean up in a soft-moist pet food plant is a function of the type of soft-moist product style manufactured. The products which call for the direct use of meat, fish, or poultry generally require more periodic cleaning than do the grain-based formulations. As is true in all of pet foods, clean up can be divided into housekeeping and end of shift clean up.

Housekeeping - Housekeeping is the most continuous of clean up steps. The various grinding, mixing, extruding, and conveying operations generate scraps of grain, meat, and finished product. Typically these are disposed of by dry methods such as scoops, shovels, or brooms. Occasionally the floors will be washed to remove minute particles which can't be removed by scraping. These few uses of water contribute a small percentage of flow and pollutants to the waste stream.

End of Shift Clean Up - End of shift clean up with regards to soft-moist production is generally end of production dry clean up. At this time, grinders, augers, mixing tanks, extruders, conveyors, etc., are completely and thoroughly washed with detergents. A final sanitizing rinse sometimes follows. This type of cleaning generates a peak flow and loading condition which is generally responsible for a majority of the flow and almost all of the pollutants.

Non-Contact Cooling Water

The only other source of water used in the production of soft-moist pet food is extruder cooling water or condensate from an expander. Flows vary widely according to the type of process. No quantifying data are available to further delineate these effluent streams. In some plants, these non-contact cooling waters were observed to be discharged directly under NPDES permit.

Model Plant

The model soft-moist pet food plant produces daily 51.4 kkg of finished product while generating an effluent of 0.017 mgd. As shown in Table 76 average BOD loading is 6.73 kg/kkg with a range from 6.28 to 7.20 kg/kkg.

The average BOD concentration was 4600 mg/l with a range of 3420 to 6200 mg/l. The reason for the wide range of concentrations is due principally to the surges of water attributable to the various clean up cycles within varied time spans. The other flow-related parameters follow the same pattern as described above.

TABLE 76. RAW WASTE SUMMARY
SOFT MOIST DOG AND CAT FOOD

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	2	51.4	2.02	1310
(TON/DAY)		56.7	2.23	1450
SHIFT TIME HR/DAY	2	16.0	8.00	24.0
FLOW VOLUME MGD	2	0.017	--	0.800
FLOW RATE L/SEC	2	1.33	0.067	26.8
(GAL/MIN)		21.1	1.05	425
FLOW RATIO L/KKG	2	1460	1010	2100
(GAL/TON)		350	243	504
5 DAY BOD MG/L	2	4600	3420	6200
RATIO KG/KKG		6.73	6.28	7.20
(LB/TON)		13.4	12.5	14.4
TSS MG/L	2	1090	436	2740
RATIO KG/KKG		1.60	0.443	5.77
(LB/TON)		3.19	0.883	11.5

PROCESS CODE(S): 47M65I ,47M52W

MISCELLANEOUS AND SPECIALTY PRODUCTS

SUBCATEGORY A 29 - FLAVORING EXTRACTS

As discussed in Section III, it has been determined that a typical flavor manufacturing plant produces flavoring extracts which are subsequently combined with other extracts and/or ingredients to produce finished specific flavors. Natural extracts are produced by vacuum distillation, solvent extraction, or expression of whole plants, plant parts, or plant essential oils, while synthetic extracts are produced by the combination of ethyl alcohol and organic acids. A discussion of the waste streams which would be expected from the manufacturing of finished specific flavors is presented below.

Vacuum Distillation

Wastewater generated by the vacuum distillation of essential oils and plant tissues consists of still bottoms. The still bottoms from distillation of essential oils would be expected to contain terpenes while distillation of plant tissues would result in remnant tissue in the still bottoms.

Solvent Extraction

There is no wastewater generated from the solvent extraction of plant tissues. All installations participating in the study indicated that solvents were recovered and that spent plant tissue was hauled to landfill.

Expression

The expression of essential oils from fruits generally results in the generation of fruit water and spent fruit tissues. Fruit water becomes part of the plant waste stream and spent plant tissues are generally sold for production of pectin (citrus fruit only) or sold as cattle feed.

Synthetic Flavoring Extracts

The organic synthesis of solvents such as ethyl alcohol, methylene chloride, benzene, and toluene, with organic acids results in the production of synthetic flavoring extracts. Based on available information, there appears to be no wastewater generated in this process other than equipment cleanup.

Dehydration

The dehydration of flavoring extracts to produce dry concentrates generates no process water other than cleanup since all liquid is released into the atmosphere as vapor.

Evaporation

The evaporation of flavoring extracts to produce concentrated flavors generates no process wastewater other than cleanup since all evaporated liquid is released into the atmosphere as vapor.

Finished Specific Flavor Blending Tanks

The blending of flavoring ingredients to produce finished flavors generates no wastewater other than cleanup water.

Plant Cleanup

Plant 87E05 reported that organic synthesis tanks were cleaned either by hot water flushing or steam, while stills and extraction tanks were steam cleaned. The waste streams from the cleaning of organic synthesis and solvent extraction tanks contain a certain amount of solvents. The cleanup waste stream from the stills would not be expected to contain toxic solvents unless the flavoring extract distilled had been initially produced by organic synthesis or solvent extraction. Plants 87E03 and 87E05 both segregate these three cleanup waste streams, along with still bottoms, from the remainder of the plant effluent.

The cleanup of finished flavor mixing tanks is generally done between flavor changes and consists of a detergent wash followed by a final rinse. Floors in the blending tank areas are hosed as needed to remove spills and leaks from equipment connections.

Non-Contact Water

Non-contact condenser cooling water is generated in the vacuum distillation process. Boiler blowdown is another source of non-contact water.

Total Plant Effluent

Based on the above considerations it may be concluded that the quantity and quality of the wastewater generated from the manufacturing of finished flavors could be dependent on the following factors:

1. If the flavoring extracts used in the manufacturing of finished flavors are produced in-house or purchased. Purchasers of extracts would generally require no distillation, solvent extraction, expression, or organic synthesis equipment and consequently, the waste streams from these processes would be eliminated.

2. The form in which the finished flavors are produced. A plant producing dry flavor concentrates and/or concentrated

flavors might conceivably have a smaller waste flow with a lower pollutant loading, especially if dehydration equipment is cleaned without use of water.

Wastewater characteristic data was obtained for two plants during the course of this study. The average wastewater characteristics of plant 87E02 were determined to be as follows:

Flow	5.7 cu m/day (0.0015 MGD)
BOD	0.017 cu m/cu m
SS	0.0155 cu m/cu m
pH	7.4

The plant's production operations consisted of the following:

1. Production of natural vanilla flavoring from the alcohol extraction of raw vanilla beans.

2. Production of finished specific flavors from purchased flavoring extracts.

3. Production of spices by dry grinding and blending.

4. Production of certified colors.

The total wastewater flow was attributable to cleanup operations such as washing blending tanks between flavor changes. The average flow from the plant was estimated to be 5.7 cu m/day (0.0015 MGD) with a range of 0 to 11.4 cu m/day (0 to .003 MGD).

The average wastewater characteristics of plant 87E03 were determined to be as follows:

Flow	125 cu m/day (0.033 MGD)
BOD	0.56 cu m/cu m
SS	0.054 cu m/cu m
pH	7.1

The production operations at this plant consisted of the following:

1. Production of synthetic flavors by organic synthesis.

2. Purification of essential oils by vacuum distillation to produce standard extracts.

3. Blending of flavoring materials to produce finished specific flavors.

The wastewater from the organic synthesis and vacuum distillation processes was segregated from the rest of the waste stream, neutralized, and contracted to a private service for ultimate disposal. According to plant personnel the contracted waste is composed of "soluble organics" and totals 23 cu m/week (0.006 mg/week). A similar waste generated at plant 87E05 was reported to be composed of the following constituents: still bottoms, methylene chloride, methyl ketone, methyl hydroxide, toluene, benzene, and carbon aromatics.

Model Plant

Based on available information from industry, it appears that plant 87E03 is more typical of the industry than plant 87E02. Therefore, plant 87E03 was selected as the model plant for Subcategory A 29 and is illustrated in Figure 135. The major wastestreams generated at the plant consist of still bottoms, and cleanup of stills, organic synthesis tanks, and blending tanks. However, the wastestreams from the cleanup of stills and synthesis tanks as well as still bottoms are segregated from the remainder of the wastestream. All non-contact water is also separated from the waste stream.

The wastewater characteristics of the model plant are as follows:

Flow	125 cu m/day (0.033 MGD)
BOD	1350 mg/l
SS	130 mg/l
pH	7.1

SUBCATEGORY A 31 - BOUILLON

The process description of bouillon manufacturing was presented in Section III and it was determined that equipment cleanup water constituted the total wastewater flow from a bouillon manufacturing plant.

Equipment Cleanup

Plant 99Q01 conducts a daily plant cleanup of equipment used in bouillon processing and this wastewater was found to have the following characteristics:

Flow	114 cu m/day (0.03 MGD)
BOD	4200 mg/l
SS	192 mg/l
FOG	150 mg/l
pH	10.4

Plant 99Q02 which conducts periodic daily plant cleanup and weekly cleanup of all equipment generated wastewater with the following characteristics:

Flow	720 cu m/day (0.19 MGD)
BOD	1610 mg/l
SS	239 mg/l
FOG	82 mg/l
pH	6.9

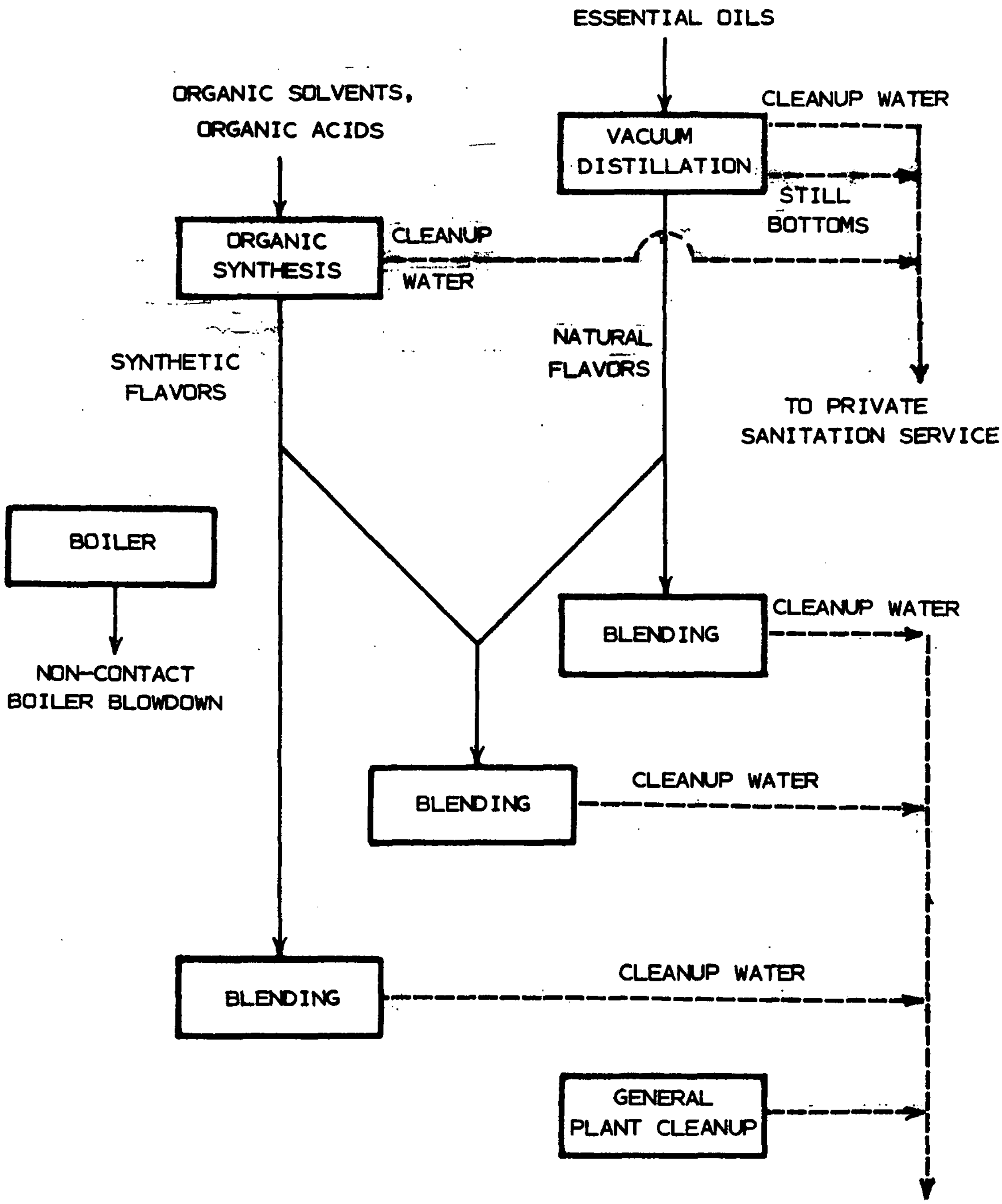

FIGURE 135

MODEL PLANT FOR SUBCATEGORY A 29
FLAVORING EXTRACTS

Dry Cleanup

All plants contacted utilized dry cleaning and generated no wastewater in packaging areas.

Total Plant Effluent

The total plant effluent is attributable to equipment cleanup and consequently the waste characteristics presented for equipment cleanup also apply for total plant cleanup.

Model Plant

The model plant for this subcategory is a hypothetical plant producing bouillon products exclusively and is illustrated in Figure 136. The plant operates 16 hours per day, five days per week with daily equipment cleanup. The wastewater characteristics of the plant are as follows:

Production:	7.3 kkg/day (8.0 ton/day)
Flow:	151 cu m/day (0.03 MGD)
BOD:	3000 mg/l
SS:	200 mg/l
FOG:	150 mg/l

All cleanup in packaging areas is done with air. A grease trap prior to discharge from the plant is provided to decrease the fats and oil content of the wastewater.

SUBCATEGORY A 32 - NON-DAIRY CREAMER

Based on processing information obtained during the course of this study, the major source of wastewater generated in the manufacturing of both liquid and powdered non-dairy creamer is determined to be equipment cleanup water. Generally, clean-in-place systems are used for equipment cleanup. Minor contributors to wastestream quantity are hosing of floors and wet scrubber discharge.

Clean-in-Place Systems

The clean-in-place systems used for equipment cleanup in non-dairy creamer plants generally employ six cleaning cycles consisting of the following sequential steps: (1) hot water pre-rinse, (2) caustic wash, (3) chlorine rinse, (4) final rinse, (5) sanitization, and (6) air drying. The quantity of water used in each of the six cycles is usually fixed and thus water requirements are minimized. For plants of equal size there is no indication that the quantity of water necessary for the cleaning cycles would vary markedly. However, the frequency of cleaning does vary, causing significant differences in wastewater quantity. Within the industry three distinct patterns of CIP system cleanup exist:

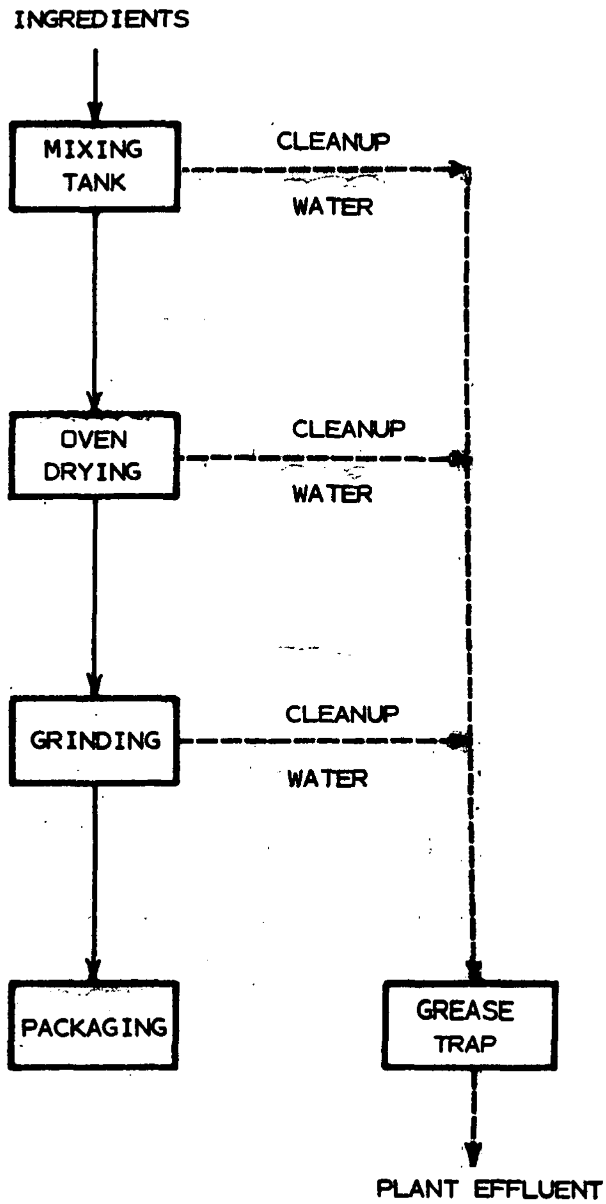

FIGURE 136

SUBCATEGORY A 31 MODEL PLANT
MODEL PLANT - BOUILLON MANUFACTURING PROCESS

(1) cleanup at the end of each day, (2) cleanup at the end of each week (plants operating 24 hours per day), and (3) cleanup at the end of each processing cycle (plants which produce creamer on an irregular basis and for varying lengths of processing). Assuming recycling of caustic and acid rinse water, a typical plant will use about 7.57 cu m/day (0.002 MGD) of water for each CIP system cleanup.

General Plant Cleanup

Liquid non-dairy creamer plants generally hose packaging area floors continuously to remove product spills. Powdered non-dairy creamer plants periodically hose floors in areas where spills of dry product from equipment connections occur. The quantity of water used in hosing of floors is unregulated in both cases.

Wet Scrubber

In the case of powdered non-dairy creamer manufacturing, wet scrubbers are used over the spray dryers to prevent dispersion of fine particulates into the atmosphere. The effluent from each scrubber at Plant 99NN01 is approximately 16,000 l/day (4000 gal/day). The pollutant characteristics were determined to be:

BOD:	4.6 mg/l
SS :	7 mg/l
F&O:	0.1 mg/l

Non-Contact Water

A substantial amount of cooling water is needed in the manufacturing of non-dairy creamer. Based on plant water intake minus the quantity of wastewater generated, the quantity of non-contact cooling water and boiler blowdown for a typical plant would be about 378 cu m/day (0.10 MGD) One multi-product plant (99NN02) producing liquid creamer recycled cooling water and only makeup water was needed. A powdered creamer plant (99NN01) discharged non-contact cooling and boiler blowdown water separately from the waste stream with the quantity estimated at 454 cu m/day (0.12 MGD).

Total Process Effluent

Plant 99NN01 producing only powdered non-dairy creamer generated a total process effluent with the following average characteristics:

Flow:	56.8 cu m/day (0.015 MGD)
BOD :	1250 mg/l (range 1000-15000)
SS :	415 mg/l (range 355-475)
F&O :	250 mg/l (range 227-275)
pH :	7.0 (range 6.8-7.2)

Plant 99NN02, producing liquid creamer in a multi-product facility, generated wastewater with the following average characteristics:

Flow:	1800 cu m/day (0.47 MGD)
BOD :	3000 mg/l
SS :	2200 mg/l
F&O :	140 mg/l
N :	15 mg/l
p :	8.0 mg/l

Although it is not possible to determine which portion of these pollutants is specifically attributable to the manufacturing of liquid creamer, the data are presented to indicate that the wastewater from the plant is nutrient deficient. This particular plant produces a wide variety of products, each of which is composed of the same basic ingredients as liquid creamer but in varying proportions. Therefore, it can be concluded that the wastewater from a plant producing solely liquid creamer would also be nutrient deficient.

Model Plant

The model plant developed for Subcategory A32 as illustrated in Figure 137 is a hypothetical plant which would produce either liqid or powdered non-dairy creamer. The plant operates five days per week with two eight hour shifts per day. Clean-in-place system cleaning is conducted periodically as needed and at the end of each day and generates approximately 7.57 cu m/day (0.002 MGD) of wastewater with recycling of caustic and acid rinse water. If the plant produced liquid creamer, the only other wastestreams generated would be hosing of floors in packaging areas and other general plant cleanup amounting to about 56.8 cu m/day (0.015 MGD). If the plant produced powdered creamer, two spray dryers would be needed and therefore two wet scrubbers are necessary. Combined flow from wet scrubbers would be 30 cu m/day (0.008 MGD). An additional wastewater generation of 26.4 cu m/day (0.007 MGD) would be generated by hosing of dry product spills and general plant cleanup. In either case the total plant waste effluent is approximately 64.3 cu m/day (0.017 MGD).

Non-contact water is discharged separately from the waste stream and amounts to about 380 cu m/day (0.10 MGD). There is no recycling of the non-contact cooling or boiler blowdown water. The proposed model plant would have the following characteristics:

Production: 90 KKg (100 ton) dry product
<u>or</u> 180 KKg (200 ton) wet product

Flow	64.3 cu m/day (0.017 MGD)
BOD	1100 mg/l
SS	440 mg/l
F&O	265 mg/l
N	5.5 mg/l
P	2.9 mg/l
pH	7.0

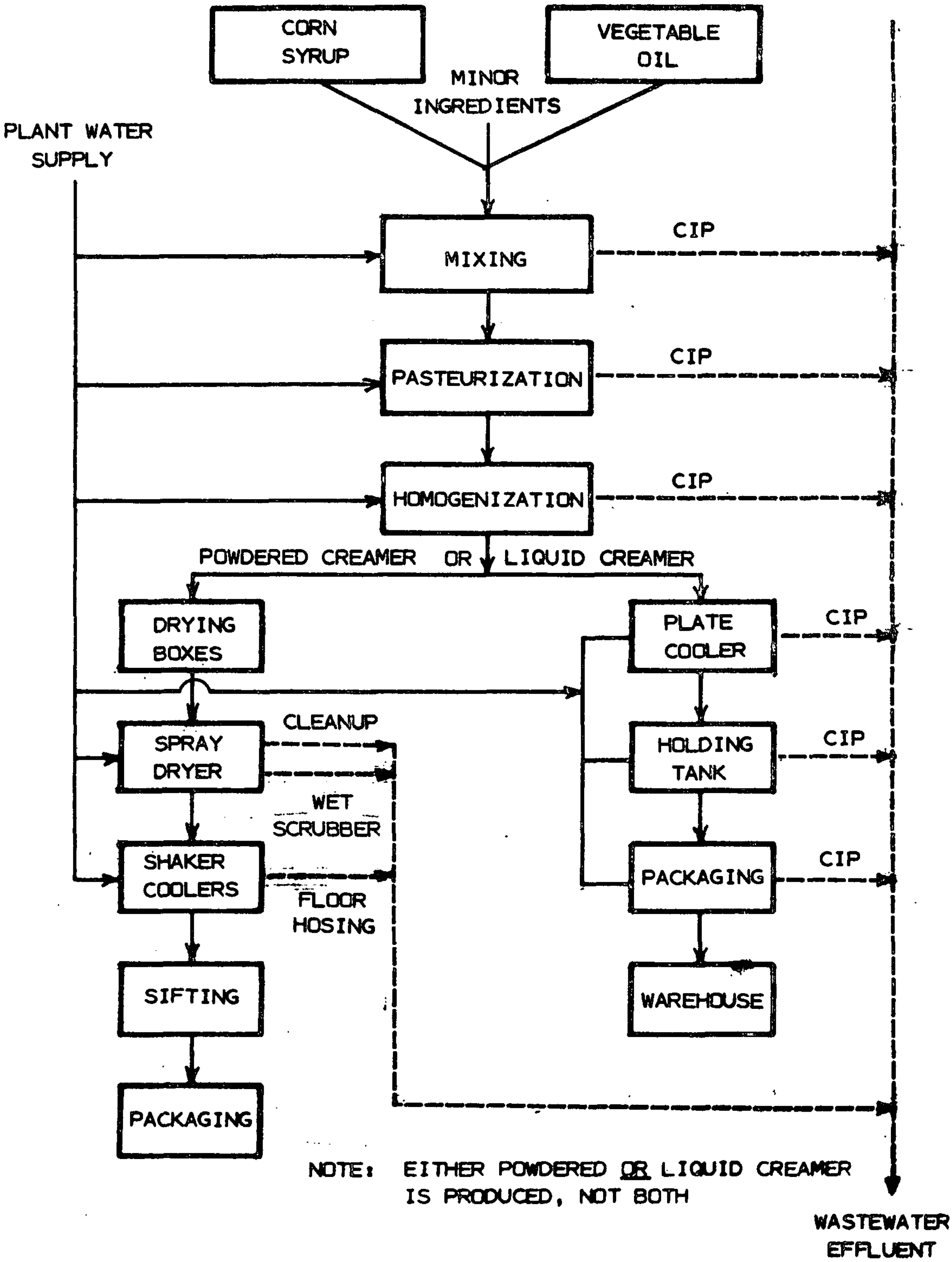

FIGURE 137

SUBCATEGORY A32 - MODEL PLANT
NON-DAIRY CREAMER MANUFACTURING

SUBCATEGORY A 33 - YEAST

The use of water in yeast factories includes: (1) feed wort preparation; (2) fermenter start water; (3) sterilization of molasses and feed wort tanks, fermenters, and piping; (4) separation wash water; (5) cleaning of separation and dewatering equipment; (6) miscellaneous floor and equipment cleanup; (7) cooling water; and (8) boiler feed. Considering strength and volumes, the wastestreams from yeast production can be ranked in the following order: (1) first separation beer, (2) second separation beer, (3) third separation beer, (4) filtration water from yeast dewatering; (5) fermenter and storage tank cleanup water; and (6) floor and equipment cleanup water.

Table 77 shows the pollutant loads of the above operations at a typical plant (99Y03) producing 76.5 kkg/day (84.3 ton/day). First separation beer accounts for 43 percent of the total flow, 78 percent of the BOD, and 31 percent of suspended solids at this plant. The high strength waste of combined first and second separation beer account for 92 percent of the total flow, 90 percent of the BOD and 58 percent of the suspended solids reported from in-plant sampling. Third separation beer is reused for cold washing during second separation.

Rudolfs and Trubnick (86) reported that first separation beer at a similar plant (99Y01) producing 82.2 kkg/day (90.6 ton/day) was responsible for approximately 70 percent of the plant raw waste load. The BOD of spent beer may vary from 2000 mg/l to 15,000 mg/l. Wide variations in flow also occur as the result of different water usage by individual plants during centrifugal separation of yeast from spent nutrients.

Third separation beer was reused in the second separation by 66 percent of plants supplying data, since it contains only a small portion of plant waste. First and second separation beer typically account for 50 percent of the flow and 75 percent of the BOD and SS plants that do not reuse process water.

Discharges from yeast dewatering consist of water removed from the yeast cream by rotary vacuum filters and recessed-plate filter presses. Table 78 presents the wastewater characteristics for five composite samples (Plant 99Y03) dewatering operations. Filter discharges, containing varying amounts of yeast and spent filter aid, cause substantial daily fluctuations in strength. Quantities of water discharged depend upon production levels and the moisture content of the final product, but are generally less than 10 percent of plant flow.

Cleanup of fermenters and feed wort storage tanks is normally performed using hot water and steam between batch operations to prevent bacterial contamination during fermentation. Molasses storage tanks are cleaned weekly using clean-in-place systems with hot water and a 3 percent sodium hydroxide solution. Tank cleanup varies according to cleaning techniques and equipment, and the age and size of the plant storage facilities, but

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TABLE 77

YEAST PLANT 99Y03
UNIT OPERATIONS WASTEWATER CHARACTERISTICS

Operation	Flow (cu m/day)	% Total	pH	Bod (kg/day)	% Total	SS (kg/day)	% Total
First Separation	1,008	43	6.8	8,656	78	317	31
Second Separation	1,132	49	7.0	1,317	12	273	27
Third Separation	529(1)	--	6.8	324	3	142	14
Tank Washdown	79	3	5.8-13.6	571	5	121	12
Yeast Dewatering	109	5	6.8	191	2	159	16
TOTAL	2,328	100		11,059	100	1,012	100

(1) Third separation wash reused in second separation.

TABLE 78

YEAST DEWATERING EFFLUENT CHARACTERISTICS

PLANT 99Y03

Day	Flow (cu m/day)	Production (kkg)	COD (mg/l)	COD (kg)	BOD Ratio (kg/kkg)	SS (mg/l)	SS (kg)	SS Ratio (kg/kkg)	COD (mg/l)	COD (kg)	COD Ratio (kg/kkg)	COD/COD Ratio
1	290.0	103	480	140	1.4	960	30	0.29	2880	835	8.1	0.17
2	377.0	76.5	700	263	3.5	680	256	3.4	1532	578	7.5	0.46
3	492.0	85.0	1780	876	10.3	1320	650	7.6	3210	1579	18.6	0.56
4	95.4	85.4	1360	130	1.5	1540	141	1.7	3085	294	3.4	0.44
5	307.3	99.3	960	295	3.0	1080	332	3.3	2410	741	7.4	0.40
Average	312.3	89.9		431	3.9		287	3.2		805	9.0	0.41

TABLE 79

WATER USAGE AND WASTEWATER CHARACTERISTICS
YEAST PLANTS RECYCLING SEPARATION WATER-PLANTS 99Y01, 99Y05

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM	MAXIMUM	COEFFICIENT OF CONVARIANCE (%)
Flow (MGD)	126	0.693389	0.083141	0.0069	0.440000	0.910000	11.991
Prod. (ton/day)	126	90.408730	3.742085	14.0032	69.200000	96.200000	4.139
BOD (mg/l)	126	6262.944444	1023.914718	1048401.3489	3600.000000	10800.000000	16.349
SS (mg/l)	126	1822.230159	999.185341	998371.3466	420.000000	8900.000000	54.833
COD (mg/l)	1	14602.000000	0.0	0.0	14602.000000	0.0	0.0
BOD (lb/day)	126	36214.451772	7280.916476	53011744.7306	19527.300000	68495.760000	20.105
COD (lb/day)	1	91999.535950	0.0	0.0	91999.535950	91999.535950	0.0
SS (lb/day)	126	10570.723429	6041.406934	36498597.7454	2593.626000	52732.055000	57.152
Lb/ton-BOD	126	401.560349	84.916591	7210.8275	202.986486	794.614385	21.147
Kg/kkg-BOD	126	200.780174	42.458296	1802.7069	101.493243	397.307193	21.147
Lb/ton-COD	1	1091.334946	0.0	0.0	1091.334946	1091.334946	0.0
Kg/kkg-COD	1	545.667473	0.0	0.0	545.667473	545.667473	0.0
Lb/ton-SS	126	116.654232	66.615573	4437.6346	28.532739	584.612583	57.007
Kg/kkg-SS	126	58.427116	33.307787	1109.4086	14.266370	292.306296	57.007
BOD/COD Ratio	1	0.461649	0.0	0.0	0.461649	0.461649	0.0
Flow Ratio	126	7679.939779	958.015079	917792.8924	4695.837780	9790.979098	12.474

N = Number of data points. Note: Computer calculations for this table show no regard for significant figures.

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it typically generates less than 5 percent of the total flow, 5 percent of the total BOD, and 15 percent of the suspended solids.

Floor and equipment cleaning is performed as needed to maintain bacteriological cleanliness. Hot water and occasional small amounts of detergent or caustic are used to clean molasses clarifiers, centrifugal separators, filters, and packaging equipment. Cleanup effluent is a small part of combined plant waste.

Table 79 presents a statistical analysis of combined plant raw effluent data for plants that reuse third separation beer during second separation. Although flow was found to range as high as 6800 cu m/day (1.8 MGD) in a plant not recycling separation water, the generation of pollutants per unit of production varied less than 10 percent for similar production levels. The two largest producers both reported an average of 170 kg/kkg (340 lg/ton) of BOD, while suspended solids varied from 50 kg/kkg (100 lb/ton) to 76 kg/kkg (152 lb/ton).

Yeast effluents (86), composed predominantly of highly putrescible dissolved organic waste substances, have a specific yeasty odor that rapidly becomes unpleasant (87), a coffee color, and fairly high turbidity. The wastewater contains yeast cells, fatty residue, albumens, and their decomposition products and carbohydrates. Inorganic compounds include, phosphates, large amounts of potassium, and sulphates. These effluents putrefy easily as sulphates are biologically reduced to sulphides, and require oxygen for stabilization in much the same manner as domestic sewage. They are usually acidic since a pH of 4.5 is maintained during fermentation. The pH of a total plant effluent samples collected during this study ranged from 4.2 to 7.7, but more typical values were in the range of 6.0 to 6.8

Since molasses is deficient in nitrogen and phosphorus, ammonia, and phosphoric acid are both required chemical nutrients added in fermentation. After yeast growth, the effluents from production are again nutrient deficient. Analyses (79) of similar spent molasses in the rum industry found the distillery slope to have a 94 percent phosphorus deficiency and a 56 percent nitrogen deficiency. Plant 99Y20, operating an oxygen activated sludge treatment system, adds ammonia and 227 l/day (60 gal/day) of 70 percent phosphoric acid before treatment.

Model Plant

Based on the above discussion, a model plant for Subcategory A33 is defined as follows:

Production	82 kkg/day (90.4 ton/day)
Flow	2650 cu m/day (0.7 MGD)
BOD	6300 mg/l
SS	1850 mg/l

It is assumed that the model plant practices reuse of third separation spent beer, and that first and second separation beer constitute 50 percent of plant flow and contribute 75 percent of the BOD and suspended solids of raw waste.

SUBCATEGORY A 34 - PEANUT BUTTER WITH JAR WASHING

The uses of water in peanut butter processing plants include: 1) jar washing, 2) floor and equipment cleanup, 3) cooling,water, 4) boiler feed, and 5) vacuum seal water. Peanut butter is immiscible in water, and does not not require the addition of water to the product during processing. In fact, bacteriological cleanliness demands special attention to insure that water does not enter the interior of pumps, piping, and other process equipment. Water use varies widely for individual plants due to production requirements, and dissimilar water conservation and recycling techniques. For example, grinder cooling water may be discharged directly after use or recirculated through cooling towers. Table 80 presents a breakdown of water usage per operating day by a plant (99P21) producing 59 to 77 kkg/day (65 to 85 tons/day) and demonstrates that over 98 percent of all water used does not contact the product.

Sources of polluted wastewater from peanut butter production can be ranked in the following manner: 1) jar washer discharges, and 2) floor and equipment cleanup discharges. All of the plants surveyed dispose of jar washer effluent and cleanup related wastewater, mixed with substantial amounts of non-contact water, to municipal sewer systems.

Jar Washing - In plants employing jar washing to reclaim glass for packaging, the detergent rinse is normally discharged and constitutes the major process waste stream. Plant 99Y20, producing 10 kkg/day (11 tons/day) has a jar washer discharge of 680 l (180 gal) per 500 jars washed, and a maximum daily discharge of 2040 l/day (541 gal/day). Approximately 6000 jars/month are washed at this plant. Jar washer effluent is a low volume, high strength waste that produces 10 gm (0.022 lb) of BOD, 3.8 gm (0.0081 lb) of suspended solids, 125 gm (0.0275 lb) of COD, and 4.5 gm (0.01 lb) of fats and oils per 510 gm (1.125 lb) jar washed. Table 81 shows the calculated results of plant 99P20 jar washer effluent sampling after correcting flow to account for non-contact water.

Bad product manually scraped from improperly filled or sealed jars is sold as inedible oil stock. Variations in pollutant loading per unit of production may be attributed to differences in the number and size of jars washed, and the method of product removal from reclaimable glass.

The largest plant (99Y01) in the industry, producing 140 to 230 kkg/day (150 to 250 tons/day), reported BOD concentrations nearly doubled and suspended solids concentrations tripled while practicing glass reclamation. Waste load data from this plant was not used in selecting a model plant because the wastewater contained large, undetermined amounts of non-contact water and resulted from the production of several products.

Floor and Equipment Cleanup - Other than jar washer effluent, floor and equipment cleanup are the only other sources of process wastewater from peanut butter production. Production facilities typically operate five days per week, 24 hours per day. Floors in processing areas are normally

TABLE 80

APPROXIMATE WATER USAGE PER OPERATING DAY
FOR PEANUT BUTTER PROCESSING PLANT 99P21

SOURCE	VOLUME LITERS	VOLUME GALLONS
Cooling Towers	37,000	9,700
Cooling of Refrigeration and Air Compressors	16,000	4,300
Boiler Feed Water	9,400	2,500
Sanitary	16,000	4,200
Cleanup and Miscellaneous	1,100	300
With evaporation loss, estimated discharge	65,000	17,000

TABLE 81

JAR WASHER WASTEWATER CHARACTERISTICS PLANT 99P20

Flow	2040 l/day (540 gal/day)
BOD	7320 mg/l
BOD Ratio	1.41 kg/kkg (2.82 lb/ton)
COD	9150 mg/l
COD Ratio	1.77 kg/kkg (3.53 lb/ton)
SS	2810 mg/l
SS Ratio	0.58 kg/kkg (1.15 lb/ton)
FOG	3550 mg/l
FOG Ratio	0.69 kg/kkg (1.37 lb/ton)

scrubbed daily using a small quantity of water and detergent, and the water is collected using mops or vacuum equipped floor scrubbers.

Water use for equipment cleanup is typically less than 757 l/day (200 gal/day) and is normally sewered. One plant (99P13) reported an estimate based on hose flow rates of 2710 l/day (715 gal/day) used for cleanup. Table 82 lists cleanup frequency and quantities of water used for equipment cleanup by a typical plant (99P21). Periodic equipment cleanup occurring at weekly or less frequent intervals is usually done using steam hoses in a specially designated area equipped with grease traps on all drains. Equipment cleanup is performed between shifts or on weekends, and normally is not done while production processes are in operation. Plant cleaning procedures are subject to occasional revisions due to equipment changes and constantly improved programs of housekeeping and sanitation. Although no data is available to document the strength of combined cleanup wastewater, an estimated 6.8 to 14 kg/day (15 to 30 lb/day) of product is reported lost to sewers. Residual product clinging to equipment may contain up to three percent added vegetable oil.

Model Plant

Based on the above discussion of wastewater characteristics, the following model plant was defined:

Daily Jar Washer Effluent	2044 l/day	(540 gal/day)
Avg. Daily Cleanup Effluent	757 l/day	(200 gal/day)
Avg. Daily Flow	2801 l/day	(740 gal/day)

The model plant assumes separation of all domestic sewage and noncontact water from the process wastewater. Since strength of cleanup wastewater is unknown, no determination of combined waste strength can be made.

SUBCATEGORY A 35 - PEANUT BUTTER WITHOUT JAR WASHING

The uses of water and wastewater characteristics for peanut butter plants in Subcategory A 35 are identical to those in Subcategory A 34, except that jar washing is not practiced.

Model Plant

The model plant is defined as follows:

Flow = 757 l/day (200 gal/day)

TABLE 82

OCCASIONAL CLEANUP WASTEWATER DISCHARGED-PLANT 99P21

SOURCE	DETERGENT	FREQUENCY	FLOW PER CLEANUP (1)	FLOW YEARLY (cu m)	BOD (mg/1)	COD (mg/1)	SS (mg/1)	FOG (mg/1)	pH
1. Warehouse concrete floor scrubber	1.1 1 liquid	daily	114	29523	37600	85760	89800	189	10.8
2. Production building wood floor scrubber	Concentrate	2/week	95	9880	28433	42346	16600	573	8.0
3. Chunk equipment cleanup	None	1/week	76	3936	2267	6788	2880	1217	6.1
4. Equipment exterior wipe-down	Concentrate	1/week	1136	59046	3050	8464	370	126	11.5
5. Equipment exterior wipe-down	Concentrate	1/week	379	19708	11766	37352	6460	399	9.9
6. Elevator conveyor bucket cleanup	None	1/week	189	9841	-----	-----	-----	-----	-----
7. Process line piping cleanup	None	1/month	946	11355	-----	-----	-----	-----	-----
8. Bucket and drip pan cleanup	None	1/month	1514	18168	-----	-----	-----	-----	-----
9. Oil stock drum wash	None	1/month	568	6813	-----	-----	-----	-----	-----
10. Elevator conveyor bucket cleanup	2.3 kg Powder	4/year	833	3332	-----	-----	-----	-----	-----
11. Raw nut elevator conveyor cleanup	2.3 kg Powder	2/year	883	3332	-----	-----	-----	-----	-----

SUBCATEGORY A 36 - PECTIN

As described in Section III, there are two methods of manufacturing pectin; precipitation by alcohol and precipitation by use of aluminum compounds. The characteristics of each waste stream generated in the alcohol precipitation process at plant 99K01 are presented in Table 83. The waste stream characteristics of plant 99K02, which uses aluminum precipitation in the recovery of pectin, are summarized in Table 84. Comparison of similar waste streams from the two plants yields the following observations:

1) The quantity of alcohol still bottoms generated per day by plant 99K01 is approximately 4.5 times greater than at plant 99K02. This is attributable to the fact that more alcohol is used in the process at plant 99K01 and therefore more still bottoms from the recovery of the alcohol would be expected.

2) The amount of peel washwater generated at plant 99K02 is greater than at plant 99K01 which is expected due to the higher production at the former.

3) The quantity of general plant cleanup water is larger at plant 99K01 than at plant 99K02 which is probably attributable to an unknown amount of cooling water included in the waste stream of the former.

It should be noted that there is no evaporation of pectin solution prior to precipitation at plant 99K02 and therefore no caustic wash waste stream is generated. In contrast the pectin mother liquor waste stream at plant 99K02 is not generated at plant 99K01 because this waste stream is ultimately distilled for alcohol recovery at plant 99K01 and as a result becomes a portion of the alcohol still bottoms. This observation supports the previous comparison of still bottom waste streams. Additionally, press liquor wastewater at plant 99K02 is generated when filter sluice is pressed to separate water from diatomaceous earth.

The wastewater analysis for the total plant effluent from three plants (99K01, 99K02 and 99K03) is presented in Table 85. It should be noted that the alcohol still bottoms and filter sluice waste streams at plants 99K01 and 99K02 were not considered in arriving at the figures presented. Plants 99K02 and 99K03 showed good agreement between waste flow generated per unit of product produced. The slightly higher flow figure at plant 99K01 can be partially attributed to an undeterminable amount of non-contact cooling water in the waste stream.

Model Plant

Based on the information presented above a model plant was chosen for this subcategory. The plant operates 24 hours per day, 365 days per

TABLE 83

WASTEWATER CHARACTERISTICS OF INDIVIDUAL WASTE STREAMS AT PLANT 99K01

Wastestream	Flow cu m/day	COD mg/l	TS mg/l	Cl mg/l	pH
1. Alcohol still bottoms	170	17,000	19,200	9,930	0.8
2. Filter sluice	223	4,050	4,500	146	6.5
3. Peel washing	424	18,800	20,800	37	4.5
4. Evaporator caustic wash	0.0008	1,190	29,700	-----	12.3
5. General cleanup, non-contact cooling water	681	500	-----	*(18)	*(7.0)
Total (excluding items 1 & 2)	1,105	7,521	7,981	25.3	6.04

* Estimate based on plant intake water.

TABLE 84

WASTEWATER CHARACTERISTICS OF INDIVIDUAL WASTE STREAMS AT PLANT 99K02

Wastestream	Flow cu m/day	COD mg/l	Cl mg/l	N mg/l	pH
1. Alcohol still bottoms	37.9	2,800	----	----	----
2. Filter sluice	757	3,200	160	25	7.0
3. Peel washing (leach)	662	14,600	95	235	4.0
4. Pectin mother liquor	492	2,150	38	406	4.1
5. Press liquor wastewater	189	11,425	170	224	5.5
6. General Plant cleanup	189	2,000	*(20)	----	*(7.0)
Total (Excluding items 1 & 2)	1,532	8,655	76.7	259.6	4.59

*Estimate based on plant intake water

TABLE 85

SUMMARY OF WASTEWATER CHARACTERISTICS

Subcategory A 36 - Pectin

PLANT	FLOW cu m/kkg	COD kg/kkg	BOD kg/kkg	SS kg/kkg	CL kg/kkg	pH
99K01	955	10,160			21.6	6.04
99K02	844	7,304	*(4,821)		64.7	4.59
99K03	821		3,476	1,753		

* Estimate based on BOD:COD ratio of 2:3 at the plant.

year and has the following characteristics:

Production	1.8 kkg/day (2.0 tons/day)
Flow	1530 cu m/day (0.404 MGD)
BOD	4950 mg/l
SS	2100 mg/l
N	260 mg/l
pH	5.0 (4.6 to 6.0) range

The above characteristics are averages only and would be expected to vary. Production is dependent on whether rapid set or slow set pectin is produced and whether the raw material used is dry or wet peel. It is assumed that still bottoms, pressure filter cake sluice, wet spent peel, and non-contact water are separated from the process waste stream.

SUBCATEGORY A37 PROCESSING OF ALMOND PASTE

There are currently four known processors of almond paste in the United States. All four discharge their process wastewater to municipal facilities. Results of a telephone survey to three plants and one plant visitation indicate that the production of almond paste contributes a relatively insignificant wasteload to the total wasteload of the four multi-product processing plants. The production of almond paste exists in combination with the production of a large variety of other products such as nut pastes (i.e., pecan, walnut, hazel nut, cashew, and apricot kernels), granulated nuts, and nut toppings. The wastewater characteristics of almond paste processing are currently unavailable for the following reasons: 1) the multi-product plants contacted were unable to furnish historical data on almond paste production alone, with the only available information being that of the final combined products wasteload, 2) the actual sampling of the almond paste production line was impractical due to the combination of wastestreams from other product lines, and 3) production data was unobtainable.

The industry has made no future plants for the construction of any new almond paste processing plants and, as previously mentioned, discharges its wastewaters to municipal facilities. Therefore, the possibility of a future point source discharge from an installation primarily engaged in the production of almond paste is minimal. Due to a lack of information on the industry's product line, production variability, and wastewater characteristics, the development of effluent guidelines for almond paste processing at this time is not feasible.

SUBCATEGORY B 1 - FROZEN PREPARED DINNERS

General Plant Clean Up

The wastes generated from these types of processing plants are a direct function of the various raw ingredients used and subsequent handling steps involved in transforming these ingredients into finished products. By far the predominant waste loadings (flow, BOD, SS, COD, and oil and grease) are generated during clean up. Sanitation requirements are such that in-process clean up is virtually continuous with one large entire-plant clean up performed at the end of each operating day.

In-Process Clean Up - The raw ingredients are usually pre-processed elsewhere and are then further processed, cooked, assembled, packaged, and frozen at the prepared dinner plants. Consequently, the majority of the wastes from these types of operations originate from clean up of vats, kettles, fryers, mixers, and other equipment used in the preparation. Included in this group would be various spillages from gravy tanks, tray filling, meat thawing, grinding, etc. In addition, equipment coming into contact with food must be cleaned every four hours.

End of Shift Clean Up - Because of sanitary requirements, a complete plant clean up is performed after each shift, and a general plant clean up is undertaken at the end of each processing day. The floors as well as immovable equipment are cleaned, and this operation may involve the disassembling of the equipment for a thorough cleaning and inspection. Included in this type of equipment would be pipes, cooking kettles, infra-red cookers, extruders, and injectors. The wastes generated typically contain fine particles and dissolved organics from each of the unit operations; consequently the pollutants generated may vary widely from day to day within a particular plant, depending on the products produced. Contributing to the waste stream's pollutants are the necessary chemicals and detergents required to remove the various organic stains and residues from the various units of processing equipment.

Defrost Water

The prepared dinners are assembled and then individually quick-frozen and stored in large blast refrigerated warehouses, along with raw ingredients awaiting movement to the preparation area. Because of the large capacity of the storage facilities, a considerable volume of wastewater is generated. The water which is used is basically low load water, typically continuously circulated, although some plants discharge this segment directly under NPDES permit.

Model Plant

The subcategory for frozen prepared dinners includes T.V. dinners, meat pies, and other frozen dinners and entrees. Ingredients usually include meat, fowl, or fish; vegetables; gravies; and minor additives. In addition, there may be added starches (such as noodles), grains (such as rice), and a variety of small dessert dishes. The bulk of the wastes generated originates from clean up of processing equipment.

The model plant is one that produces an average BOD loading of 15.6 kg/kkg with a range from 9.41 to 25.9 kg/kkg as shown in Table 86 . The average BOD concentration was 1530 mg/l with a range of 718 to 3260 mg/l. The wide range in concentrations was due largely to the product type and style variations as outlined above. The other flow-related parameters follow this same pattern.

SUBCATEGORY B 2 - FROZEN BREADED AND BATTERED SPECIALTIES

General

This subcategory has marked similarity to the other frozen specialties for two important reasons. The first is the multiplicity and variation of products within the subcategory - breaded fish fillets, shrimp, scallops, mushrooms, onions, etc. Secondly, a majority of the waste loadings and flows are a result of the extensive clean ups necessary for adequate sanitation. In addition to plant clean up, a considerable volume of waste can be generated from thawing and washing operations.

Thawing and Washwater

Thawing produces a substantial waste volume since it is followed by thorough washing and clean up of equipment and spills. If the shells, heads, and tails are included in the washwater, they constitute a major organic load and should be removed as solid waste.

Frozen onion rings are by far the major item in battered and breaded vegetable specialties and a considerable portion of the wastewater may originate from the onion washing operation. However, in most plants, they arrive already washed.

Model Plant

The breaded and battered frozen specialty subcategory is characterized by extreme ranges due to the various production techniques and raw materials handled. Wastewater generation results from clean up of equipment and spills, and juices from the onion slicing and washing operation. The batter is very high in organic strength, and the clean up wastes are correspondingly strong. A process summary is presented in Table 87.

The model plant produces an average BOD loading of 16.2 kg/ kkg with a range from 8.98 to 29.3 kg/kkg. The average BOD concentration was 1,350 mg/l with a range of 244 to 7,510 mg/l. The wide range in concentration was due largely to the product type and style variations as outlined above. The other flow-related parameters follow this same pattern.

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TABLE 86 . RAW WASTE SUMMARY
FROZEN PREPARED DINNERS

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	5	86.3	25.8	289
(TON/DAY)		95.1	28.4	318
SHIFT TIME HR/DAY	6	24.0	--	--
FLOW VOLUME MGD	5	0.253	0.073	0.897
FLOW RATE L/SEC	5	11.1	3.13	39.3
(GAL/MIN)		176	49.7	623
FLOW RATIO L/KKG	6	10200	5340	19500
(GAL/TON)		2450	1280	4670
5 DAY BOD MG/L	6	1530	718	3260
RATIO KG/KKG		15.6	9.41	25.9
(LB/TON)		31.2	18.8	51.8
TSS MG/L	6	1150	548	2420
RATIO KG/KKG		11.7	6.17	22.4
(LB/TON)		23.5	12.3	44.7

PROCESS CODE(S): 38*50L ,38*52L ,38*53L ,38*54L ,38*55L ,
38050L

TABLE 87. RAW WASTE SUMMARY
FROZEN BATTERED AND BREADED SPECIALTIES

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	2	9.86	7.64	12.7
(TON/DAY)		10.9	8.43	14.0
SHIFT TIME HR/DAY	2	24.0	--	--
FLOW VOLUME MGD	2	0.032	0.005	0.245
FLOW RATE L/SEC	2	1.37	0.176	10.6
(GAL/MIN)		21.7	2.79	168
FLOW RATIO L/KKG	2	12000	1190	120000
(GAL/TON)		2870	286	28800
5 DAY BOD MG/L	2	1350	244	7510
RATIO KG/KKG		16.2	8.98	29.3
(LB/TON)		32.4	17.9	58.6
TSS MG/L	2	1540	176	13500
RATIO KG/KKG		18.5	16.1	21.2
(LB/TON)		36.9	32.2	42.3

PROCESS CODE(S): 38356L ,38358L

SUBCATEGORY B 3 - FROZEN BAKERY ITEMS

General Plant Clean Up

The subcategory frozen bakery items includes an assortment of commodities such as frozen pies, cakes, doughnuts, cheesecakes, sweet rolls, etc., utilizing ingredients and techniques as detailed in Section III which are unique to this subcategory. The majority of pollutant loadings are the result of clean up of the various mixing, extruding, and forming equipment. The various cleaning techniques, additives, and detergents used to remove hardened dough, eggs, milk solids, and the like contribute significantly to the wastewater loadings.

In-Process Clean Up - The raw ingredients, e.g., butter, sugar, cream, etc., are purchased in bulk, received, blended under controlled conditions, further assembled in the final product form, sometimes baked, packaged, and frozen. In order to maintain sanitary conditions, the frozen bakery dessert plants must thoroughly clean with hot water all the many mixing vats, cooking kettles, measuring devices, pumps, piping, etc., which have come in contact with the ingredients and product. This clean up is continuous during the shift as different products are manufactured.

End of Shift Clean Up - Because of sanitary requirements a complete plant clean up is performed after each shift, and a general plant clean up is undertaken at the end of each processing day. The floors as well as immovable equipment are cleaned, and this operation may involve the disassembling of the equipment for a thorough cleaning and inspection. Also included in this type of equipment would be pipes that are cleaned in place as well as small mobile pieces used in batch preparations. The wastes generated typically contain fine particles and dissolved organics from each of the unit operations; consequently the pollutants generated may vary widely from day to day within a particular plant, depending on the products produced.

Defrost Water

The dessert items are assembled and then individually quick-frozen and stored in large blast refrigerated warehouses, along with raw ingredients awaiting movement to the preparation area. Because of the large capacity of the storage facilities, a considerable volume of wastewater is generated. The water which is used is basically low load water, typically continuously circulated, although some plants discharge this segment directly under NPDES permit.

Model Plant

The model plant for this subcategory would be one manufacturing frozen dessert items including pies, cakes, pastries, and rolls. The bulk of the wastes generated originates from clean up of processing equipment. The model plant has an average BOD loading of 22.4 kg/kkg and the average BOD concentration was 2,090 mg/l as shown in Table 88. Average TSS loading was 13.6 kg/kkg at a concentration of 1,270 mg/l.

TABLE 88. RAW WASTE SUMMARY
FROZEN BAKERY PRODUCTS

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	1	50.9	--	--
(TON/DAY)		56.1	--	--
SHIFT TIME HR/DAY	1	24.0	--	--
FLOW VOLUME MGD	1	0.144	--	--
FLOW RATE L/SEC	1	6.31	--	--
(GAL/MIN)		100	--	--
FLOW RATIO L/KKG	1	10700	--	--
(GAL/TON)		2570	--	--
5 DAY BOD MG/L	1	2090	--	--
RATIO KG/KKG		22.4	--	--
(LB/TON)		44.8	--	--
TSS MG/L	1	1270	--	--
RATIO KG/KKG		13.6	--	--
(LB/TON)		27.2	--	--

PROCESS CODE(S): 38C59L

SUBCATEGORY B 4 - FROZEN TOMATO-CHEESE-STARCH COMBINATIONS

General Plant Clean Up

The processing of frozen tomato-cheese-starch items (frozen pizza, macaroni, lasagna, ravioli, etc.) involves the combining of preprocessed ingredients into the final product form. The principal waste generation step is plant clean up. The cleaning procedures are similar to those described for the frozen prepared dinner subcategory, and its clean up, with very little modification, can be applied to the frozen tomato-cheese-starch subcategory.

Defrost Water

Refrigeration water is generally recycled, but, if not recycled, contributes a significant volume of clean water to the waste stream.

Spillage and Clean Up

The types of pollutants generated by a plant are a direct function of the various raw ingredients used and the subsequent handling steps involved in transferring these ingredients into finished product. An efficient plant can hold its waste ingredients to under one percent of the incoming ingredient weight, e.g., loss of less than one pound of tomato paste used.

Model Plant

All major ingredients are preprocessed elsewhere and arrive at the manufacturing plant in bulk containers. These ingredients include tomato paste, cheese, flour, milk, oil, noodles, seasonings, and meat. The waste generated from plant clean up contributes the most significant portion of the waste stream. A process summary is presented in Table 89.

The model plant is one that produces an average BOD loading of 18.8 kg/kkg. The average BOD concentration was 239 mg/l. The average SS loading was 14.3 kg/kkg with a concentration of 180 mg/l.

SUBCATEGORY B 9 - PAPRIKA AND CHILI PEPPER

The subcategory paprika and chili pepper consists of wet sampling data from two plants -- 99C50W and 99C51W. As shown in Table 90, average BOD loading was 8.44 kg/kkg with a range of 6.32 to 11.3 kg/kkg. The average BOD concentration was 391 mg/l with a range of concentrations from 253 to 604 mg/l. SS and flow ratio parameters showed similar consistencies.

Model Plant

The model plant for Subcategory B 9 was selected to have a flow of 2000 cu m/day (0.5 MGD) with the following characteristics:

BOD	400 mg/l
SS	250 mg/l
pH	6 to 9
N&P	Sufficient

TABLE 89. RAW WASTE SUMMARY
FROZEN TOMATO-CHEESE-STARCH DISHES

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	1	2.41	--	--
(TON/DAY)		2.66	--	--
SHIFT TIME HR/DAY	1	24.0	--	--
FLOW VOLUME MGD	1	0.044	--	--
FLOW RATE L/SEC	1	1.92	--	--
(GAL/MIN)		30.4	--	--
FLOW RATIO L/KKG	1	79200	--	--
(GAL/TON)		19000	--	--
5 DAY BOD MG/L	1	237	--	--
RATIO KG/KKG		18.8	--	--
(LB/TON)		37.5	--	--
TSS MG/L	1	180	--	--
RATIO KG/KKG		14.3	--	--
(LB/TON)		28.5	--	--

PROCESS CODE(S): 38T57L

TABLE 90. RAW WASTE SUMMARY
CHILI PEPPERS AND PAPRIKA

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	2	104	97.8	111
(TON/DAY)		115	108	123
SHIFT TIME HR/DAY	2	24.0	--	--
FLOW VOLUME MGD	2	0.586	0.486	0.707
FLOW RATE L/SEC	2	25.7	21.3	31.0
(GAL/MIN)		407	337	491
FLOW RATIO L/KKG	2	21600	18700	25000
(GAL/TON)		5180	4470	5990
5 DAY BOD MG/L	2	391	253	604
RATIO KG/KKG		8.44	6.32	11.3
(LB/TON)		16.9	12.6	22.5
TSS MG/L	2	249	229	271
RATIO KG/KKG		5.38	5.05	5.74
(LB/TON)		10.8	10.1	11.5

PROCESS CODE(S): 99C50W ,99C51W

SUBCATEGORY C 4 - EGG PROCESSING

Liquid Egg Processing Equipment Cleaning

According to Siderwicz (88), cleaning of liquid egg handling equipment is the largest source of wastewater from egg processing plants. Virtually all egg processors have clean-in-place systems for the cleaning and sanitizing of their pasteurizing equipment, liquid egg holding tanks and associated piping. This equipment is normally drained of egg product as completely as possible before cleaning. The cleaning is accomplished in three steps; pre-rinse, washing, and rinsing. Some egg processors have reduced their water consumption by recovering the final rinse water and reusing it in the pre-rinse step of the next cleaning cycle. The quantity of wastewater and the waste load from this cleaning process depends on whether the egg product remaining in the pipes after the pumps are shut off is discharged to the sewer or goes to inedibles. No data is available to quantitatively define the wastewater generated by these cleaning processes as opposed to an egg processors total effluent.

Egg Breaker Wastewater

When a substandard egg is broken, the cup and sometimes the entire breaking machine must be washed down. Siderwicz (88) indicates that the washing of the egg breaking equipment is the second largest source of wastewater flow and the third most important source of wastewater strength. Schultz (89) reports that egg breaker wastewater from a plant processing 70 kkg (64 tons) of eggs per day has a BOD of 4500 mg/l, a suspended solids concentration of 1000 mg/l and a flow of 0.024 mld (0.006 mgd).

Egg Washing

Siderwicz (88) notes that egg washing is another important source of wastewater volume and the second most important source of wastewater strength. Egg washers wash eggs with a recirculating detergent/disinfectant solution and then rinses them with potable water. The rinse water is added to the washer tank and provides a continuous overflow. Every four hours the washer tank is dumped and refilled with fresh water.

Schultz (89) has reported that egg washer wastewater from a plant processing 70 kkg (74 tons) of eggs per day has a BOD of 1450 mg/l, a suspended solids concentration of 325 mg/l, and a flow of 0.017 mld (0.004 mgd).

Plant Cleaning

General cleaning of egg processing plants is also a source of wastewater. Some eggs fall to the floor during handling and must be scraped up, mopped up or rinsed into a floor drain. All equipment and floors must be cleaned periodically. The frequency of general plant cleaning varies from plant to plant, and the waste load varies dramatically, depending on the housekeeping practices.

Combined Plant Effluent

Total discharge volumes from egg processing plants range from 0.015 to 0.53 mld (0.004 to 0.14 mgd). Total discharge per units of production varies from 0.9 to 17.8 l per kg (0.5 to 10 gal per lb), with remarkable differences in wastewater discharge for apparently similar operations. Total production ranges from 4 to 85 kkg per day (4.4 to 94 tons per day). The data collected indicated no relationship between the total production per day and the total discharge per unit of production. The BOD values of the total plant effluent from the plants surveyed ranged from 1,800 to 8,600 mg/l and the suspended solids concentrations ranged from 540 to 1,600 mg/l. Table 91 is a summary of the plant effluent.

Model Plant

The model plant for this subcategory is a hypothetical egg processing plant which produces frozen, liquid and dried egg products. The eggs are trucked to the plant in 21 kg cases (30 dozen eggs). After a short period of refrigerated storage, the eggs are loaded, candled, washed and broken as described in Section III of this document. The eggs are then pasteurized and frozen, dried, or sold as liquid egg. Total eggs broken at the model plant in a 24 hr per day operation (including an 8 hr cleanup shift) is assumed to be 30 kkg per day (33 tons per day).

Wastewater - Sources of wastewater from the model plant would include all sources listed above. Inedible eggs are recovered and sold or handled as solid waste to help reduce the waste strength. Total wastewater flow for the model plant is assumed to be 0.2 mld (0.05 mgd) and flow per kkg of eggs broken is 6.5 l. Effluent BOD is 3,700 mg/l and the effluent suspended solids concentration is 850 mg/l. Thus, the waste load from the model plant will be 23 kg BOD and 5.4 kg SS per kkg of eggs broken. It is also assumed that this model plant utilizes a catch basin to remove shells from its waste stream. Some of the in-plant technology described in Section VII is utilized by the model plant.

SUBCATEGORY C 5 - SHELL EGGS

Egg Washing

Egg washing is the major source of wastewater strength and volume from shell egg plants. Egg washing machines use a recirculating disinfectant/detergent solution for washing, which is followed by a potable water rinse. The rinse water added to the washer tank provides a continuous overflow. Every four hours the washer tank is dumped and refilled with fresh water. Schultz (89) reported that continuous overflow from the egg washer had a BOD of 935 mg/l and suspended solids of 150 mg/l. Samples taken from an egg washer tank during this study had BOD values between 1800 and 3600 mg/l and suspended solids values between 240 and 1400 mg/l.

TABLE 91. RAW WASTE SUMMARY
EGG PROCESSING

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	9	27.1	10.3	71.6
(TON/DAY)		29.9	11.3	78.9
SHIFT TIME HR/DAY	9	9.56	8.00	16.0
FLOW VOLUME MGD	9	0.032	0.011	0.094
FLOW RATE L/SEC	9	3.43	1.24	9.51
(GAL/MIN)		54.4	19.6	151
FLOW RATIO L/KKG	9	4210	3020	5850
(GAL/TON)		1010	725	1400
5 DAY BOD MG/L	9	3190	1880	5390
RATIO KG/KKG		13.4	8.07	22.3
(LB/TON)		26.8	16.1	44.5
TSS MG/L	6	859	664	1110
RATIO KG/KKG		3.09	2.05	4.67
(LB/TON)		6.18	4.09	9.33

PROCESS CODE(S): *PS51I ,*PS51W ,17*52L ,17*59L ,17*60L , 17*61L1 ,17*61L2 ,17A51I ,17A64S

TABLE 92. RAW WASTE SUMMARY
SHELL EGGS

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	7	21.7	7.60	62.0
(TON/DAY)		23.9	8.38	68.4
SHIFT TIME HR/DAY	7	8.60	7.50	11.3
FLOW VOLUME MGD	5	0.004	0.003	0.005
FLOW RATE L/SEC	7	0.179	0.039	0.817
(GAL/MIN)		2.85	0.630	12.9
FLOW RATIO L/KKG	7	237	26.0	2150
(GAL/TON)		56.7	6.24	516
5 DAY BOD MG/L	7	2470	1200	5080
RATIO KG/KKG		0.590	0.061	5.75
(LB/TON)		1.18	0.121	11.5
TSS MG/L	7	734	164	3280
RATIO KG/KKG		0.171	0.016	1.96
(LB/TON)		0.342	0.031	3.91

PROCESS CODE(S): 44A50W ,44A51W ,44A53L ,44A55W ,44A56W ,
44A57W ,44A61I

Plant Cleaning

General cleaning of shell egg plants is a significant source of wastewater generation. Some eggs fall to the floor during handling and must be scraped up, mopped up, or rinsed into a floor drain. All equipment and floors must be cleaned periodically. The frequency of general plant cleaning varies from plant to plant, and the wasteload varies dramatically, depending on housekeeping practices.

Total Processing Effluent

The quantities and characteristics of wastewater from shell egg plants vary considerably. These variations are usually the result of operating and cleanup procedures, which depend on the training and management of the personnel. Wastewater flow per unit of production varies from plant to plant, but is generally consistent within a given plant. Table 92 includes data describing the total processing effluent for this subcategory.

Model Plant

The model plant for this subcategory is a hypothetical shell egg plant. The eggs are trucked to the plant in 21 kg cases (30 dozen eggs). After a short period of refrigerated storage, the eggs are loaded, washed, candled, graded, and packaged as described in Section III of this document.

Operating procedures stress the recovery of inedible eggs for sale as a component of animal feed or disposal as solid waste. The equipment and floors are wet cleaned after recovery of the inedible egg product. Total production at the model plant is assumed to be 12.5 kkg (14 tons) per day produced in eight hours per day, five days per week operation.

Wastewater - Sources of wastewater from the model plant include all of the sources listed above. Inedible eggs are recovered and sold. Total wastewater volume is assumed to be 0.013 mld (3500 gpd). It is assumed that this model plant utilizes a catch basin or a large 0.6 cm (0.25 in.), mesh screen to remove shells from the waste stream.

SUBCATEGORY C 6 - MANUFACTURED ICE

The quantity of water that is wasted is the parameter of most concern. In fragmentary ice manufacturing the quantity of wastewater discharged approximates the quantity of water incorporated into the ice. The range in discharge is relatively narrow and is not highly operator-dependent. On the other hand, the quantity of water used and wastewater discharged from block ice manufacturing has up to 20-fold variations from plant to plant. These variations are primarily due to water conservation practices or lack thereof, and most of the variations in water use are attributed to discharge of once-through cooling water. The thrust of this program, however, is directed to process water and the waste load in terms of kg of pollutant per kkg of product. Therefore, the following discussion is directed to waste load rather than discharge volume.

The concentration of pollutants from ice manufacturing is nominal. Pollutants, if these constituents should be classified as pollutants, consist predominately of dissolved solids (salts) with very low suspended solids, BOD, and nitrogen concentrations. The concentration of salts and suspended solids in the waste stream is dependent on the characteristics of the water supply. The water used in ice manufacturing must be potable, but if the water had a relatively high salt and solids concentration, the concentration of these constituents in the waste stream will be proportionately high.

The major sources of these pollutants are the following:

1. Water pretreatment, if required to remove suspended solids. Predominant treatment methods are lime, sand filters, and carbon filters.

2. Core pumping. A number of block ice plants pump out the unfrozen core water prior to complete freezing of an ice block. This core water has a volume of 10 to 22 liters (3 to 6 gal) per block, and it contains much of the solids and other impurities found in the water supply.

3. Can dipping in a block ice plant is a source of a small amount of salts. Pollutants in the waste stream from can dipping are primarily brine remaining on the exterior of the cans when they are removed from the brine tank. However, prior to can dipping but after lifting the cans from the brine tank, the cans are suspended for several minutes to allow most of the brine to drip back into the brine tanks. Chloride concentrations in the dip tank are normally below

that which would produce a salty taste in the water and the solids are usually dissolved and of relatively low concentration.

3. Blowdown from fragmentary ice making machines has approximately twice the concentrations of dissolved and suspended solids as the water supply.

4. Snow and end pieces generated by crushing, scoring, and sawing block ice into sized or cube ice contribute relatively pure water with virtually no pollutants. Some plants recycle this water for ice-making and others discharge it as wastewater.

Total Processing Effluent

The quantity and quality characteristics of wastewater from ice manufacturing plants is relatively constant in any particular plant. The same processes are used repeatedly in both block and fragmentary ice production. Thus, the only variations in quantity or quality of the wastewater come from variations in the product mix. Wastewater from ice manufacturing plants is clean in comparison with other industrial waste streams. Characteristics of the wastewater is similar to those of the water supply with slight to 100 percent increase in chloride and dissolves solid concentrations. Table 93 includes data describing the total processing effluent for this subcategory.

Model Plant

The model plant for this subcategory is a hypothetical ice manufacturing plant producing both block and fragmentary ice. The block ice is produced as described in Section III and core water is pumped from the blocks. Both once-through compressor cooling water and core pumping water are discharged to the waste stream. The fragmentary ice machine is located in the same building as the block ice facility and its waste is discharged to the waste stream. Average total production is 17.2 kkg per day (19 tons per day). Production is 24 hours per day, five days per week for six months a year.

Wastewater - Sources of wastewater from the model plant include all sources listed above.

Parameters of the wastewater are assumed as follows:

1. Flow volume - average - 0.04 mld (11,000 gpd)
   minimum - 0.01 mld (3,000 gpd)
   maximum - 0.19 mld (50,000 gpd)

2. BOD - 1.2 mg/l

TABLE 93. RAW WASTE SUMMARY
MANUFACTURED ICE

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD KKG/DAY	3	17.2	10.5	28.3
(TON/DAY)		19.0	11.6	31.2
SHIFT TIME HR/DAY	3	17.3	8.00	24.0
FLOW VOLUME MGD	3	0.011	0.003	0.050
FLOW RATE L/SEC	3	0.694	0.138	3.50
(GAL/MIN)		11.0	2.18	55.5
FLOW RATIO L/KKG	3	2220	619	7960
(GAL/TON)		532	148	1910
5 DAY BOD MG/L	3	1.20	0.875	1.65
RATIO KG/KKG		0.004	0.002	0.012
(LB/TON)		0.006	0.003	0.023
TSS MG/L	3	5.20	2.89	9.35
RATIO KG/KKG		0.012	0.006	0.024
(LB/TON)		0.024	0.012	0.047

PROCESS CODE(S): 97A50W ,97A51W ,97A54M

3. SS - 5.2 mg/l

4. 0.004 - kg BOD per kkg of product

5. 0.012 - kg SS per kkg of product

SUBCATEGORY C 12 - SANDWICHES

Cleanup and Total Combined Process Waste

General cleaning is the only source of wastewater generation in most pre-packaged sandwich plants. General cleaning consists of washing hand utensils in a sink or dishwasher, wiping off counter tops, and mopping floors. These procedures are normally employed on a daily basis. Portable chopping machines used in plants that blend salad-type sandwich fillings are cleaned daily with a hose. The total volume of process wastewater from the plants contacted ranged from 400 to 11,000 lpd (100 to 3000 gpd).

Model Plant

The model plant for this subcategory is a hypothetical plant which assembles a variety of pre-packaged sandwiches. All of the materials from which the sandwiches are assembled are processed before delivery at the sandwich plant. Total production at the model plant is assumed to be 4.5 kkg (5 tons) per day produced in 8 hours per day, five days per week.

Wastewater - Sources of wastewater from the model plant include general cleaning of hand utensils, counter tops and floors. The wastewater flow from the model plant is 7,600 l (2000 gal) per day.

Two days of sampling were conducted at a major producer of pre-packaged sandwiches. However, the samples were taken by an employee of the plant, and apparently came from the surface of the grease trap. As a result, the values obtained were not representative of the plant's wastewater.

SUBCATEGORY D 4 - VINEGAR

Wastewater characterization is based on data from four plants engaged in the production of vinegar from apple products. Although vinegar is also produced from grape products and purchased ethanol, no historical data for processors utilizing these raw materials was available. Vinegar from apple products represents the largest segment of the industry and is a good representation of the industry as a whole. Table 94 summarizes the data collected.

Water use in the vinegar plant is primarily in the filtration operation with lesser amounts consumed for daily plant cleanup. Wooden holding tanks, when not in use for vinegar storage, are filled with water to avoid shrinking of the wood; draining of these tanks occurs as necessary.

TABLE 94. RAW WASTE SUMMARY
VINEGAR

PARAMETER	NO PLANT	LOG MEAN	MINIMUM	MAXIMUM
PROD CU M/DAY	4	76.1	30.0	193
(1000 GAL/DAY)		20.1	7.93	50.9
SHIFT TIME HR/DAY	4	10.8	8.00	19.4
FLOW VOLUME MGD	4	0.024	0.011	0.057
FLOW RATE L/SEC	4	2.46	0.783	7.72
(GAL/MIN)		39.0	12.4	122
FLOW RATIO L/CU M	4	1170	540	2550
(GAL/1000 GAL)		1170	540	2550
5 DAY BOD MG/L	3	1950	531	7150
RATIO KG/CU M		1.92	1.20	3.07
(LB/1000 GAL)		16.0	10.0	25.6
TSS MG/L	3	664	443	995
RATIO KG/CU M		0.654	0.317	1.36
(LB/1000 GAL)		5.46	2.63	11.3

PROCESS CODE(S): 99V81I ,99V83M ,99V84I ,99V85M

Non-contact cooling water is also used in the vinegar generators and may or may not be recycled. The ratio of wastewater to production averaged 1170 l/kkg (1170 gal/1000 gal) with a range of 540 to 2550 l/kkg (130 to 610 gal/ton).

The expected range of BOD ratios is from 1.20 to 3.07 kg/cu m (10.0 to 25.6 lb/1000 gal) with an average of 1.92 kg/cu m (16.0 lb/1000 gal); suspended solids is from 0.317 to 1.36 kg/cu m (2.63 to 11.3 lb/1000 gal) with an average of 0.654 kg/cu m (5.46 lb/1000 gal). The range of waste loadings is not directly related to any observed differences between the processors. However, the handling of filter washwater and storage tank sedimentation can greatly influence the waste loadings.

Of particular importance in the vinegar process is the presence of acetic acid in the effluent. The arithmetic average pH for three plants with raw effluent data was 5.17 with a range of 4.59 to 5.50. Surges of wastewater with lower pH can be expected during the flushing of holding tanks and cleanup of spillages.

Model Vinegar Plant

Production:	78 cu m/day (20,000 gal/day)
Wastewater flow volume:	90.8 cu m/day (.024 MGD)
Wastewater characteristics:	BOD = 1950 mg/l
	SS = 660 mg/l
	pH = 5.2
Primary source of wastewater:	filtration operation, washdowns.
Special consideration:	pH adjustment.

SUBCATEGORIES E 1 (MOLASSES, HONEY, GLAZED FRUIT, AND SYRUPS), E 2 (POPCORN), E 3 (PREPARED GELATIN DESSERTS), E 4 (SPICES), E 5 (DEHYDRATED SOUP), AND E 6 (MACARONI, SPAGHETTI, VERMICELLI, AND NOODLES)

The processes associated with Subcategories E 1 through E 6 have been found to generate little wastewater. What little wastewater that is generated results from equipment cleanup and floor washing. The volume generally amounts to less than 4000 l/day (1000 gal/day). The pollutant loading is comparable to that of domestic sewage. The development of model plants is not necessary for these subcategories.

SUBCATEGORIES F 2 BAKING POWDER), F 3 (CHICORY), AND F 4 (BREAD CRUMBS NOT PRODUCED IN BAKERIES)

As described in Section III, the processes associated with these subcategories are dry processes that generate no contact process wastewater. Therefore, development of model plants is not necessary for these subcategories.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

WASTEWATER PARAMETERS OF POLLUTIONAL SIGNIFICANCE

Major wastewater parameters of pollutional significance for the miscellaneous foods and beverages industry include BOD (5-day 20°C), COD, suspended solids, and oil and grease. Minor parameters of significance include pH, nickel, alkalinity, total dissolved solids, nutrients (forms of nitrogen and phosphorus), color, chlorides and temperature. On the basis of all evidence reviewed, there does not otherwise exist any purely hazardous or toxic pollutants (e.g., heavy metals, pesticides) in waste discharged from the miscellaneous foods and beverages industry.

When land disposal of wastewater is practiced, contribution to ground water pollution must be prevented. Under land disposal procedures, all practices should be in general accord with the Environmental Protection Agency's "Policy on Subsurface Emplacement of Fluids by Well Injection" with accompanying "Recommended Data Requirements for Environmental Evaluation of Subsurface Emplacement of Fluids by Well Injection" (90).

Significant pollutional parameters for the protection of ground water from land disposal include BOD, COD, pH, temperature, total dissolved solids, and nutrients.

RATIONALE FOR SELECTION OF IDENTIFIED PARAMETERS

The rationale for selection of the significant parameters for the miscellaneous foods and beverages industry is given below:

Organics

Biochemical oxygen demand (BOD) is a semi-quantitative measure of the biologically degradable organic matter in a wastewater. For this reason, in wastewater treatment, it is commonly used as a measure of treatment efficiency. It is a particularly applicable parameter for the miscellaneous foods and beverages industry since the wastes are highly biodegradable with very few exceptions.

The primary disadvantage of the BOD test is the time period required for analysis (five days is normal) and the considerable amount of care that must be taken to obtain valid results.

Under proper conditions, the chemical oxygen demand (COD) test can be used as an alternative to the BOD test. The COD test is widely used as a means of measuring the total amount of oxygen required for oxidation of organics to carbon dioxide and water by the action of a strong oxidizing agent under acid conditions. It differs from the BOD test in that it is independent of biological assimilability. The major disadvantage of the COD test is that it does not distinguish between biologically active and inert organics. The major advantage is that it can be conducted in a short period of time, or continuously in automatic analyzers. In many instances, COD data can be correlated to BOD data and the COD test can then be used as a substitute for the BOD test where a reliable relationship can be demonstrated to exist. Considerable difficulties occur with the COD test in the presence of chlorides.

The measurement of total organic carbon (TOC) offers a third alternative for an indication o organic concentrations. This test offers the potentiality of a high degree of reliability and produces results in a matter of minutes. However, at the present time the equipment required for the test is relatively expensive, has not been used extensively to date, and has had little experience in the miscellaneous foods and beverages industry.

With a few exceptions, the wastewaters generated by the miscellaneous foods and beverages industry contain relatively high levels of readily biodegradable organics.

Suspended Solids

Suspended solids serve as a parameter for measuring the efficiency of wastewater treatment facilities and for the design of such facilities.

Suspended solids concentration in water affect light penetration, temperature, solubility products, and aquatic life. Upon settling, solids may blanket organisms or their habitats, either killing the organism or rendering the habitat unsuitable for occupation. Suspended solids concentrations greater than 80 mg/l in fresh water streams have been reported (91) to be detrimental to fisheries.

Suspended solids are a major pollutant parameter for most of the subcategories discussed in this document. It is relatively minor for most of the confectionery operations as well as for a few other products for which carbohydrates are of greater importance.

Oil and Grease

Floating oils may interfere with reaeration and photosynthesis and prevent respiration of aquatic insects which obtain their oxygen at the water surface. Free and emulsified oils may interfere with fish respiration and destroy algae and other plankton. Deposited oily substances on the bottom of a stream bed may destroy benthic organics.

Oil and grease is a major parameter for the vegetable oil processing and refining industry, the bakery and confectionery industry, the pet food industry, and for several of the miscellaneous products.

These oils and greases of animal and vegetable origin should not be confused with petroleum wastes. The oils and greases generated by the industries which are subject to this study are readily biodegradable in both municipal and private treatment systems.

pH

pH is an important criterion for in-process control, odor control, and bacterial growth retardation. Highly acidic or caustic solutions can be harmful to aquatic environments and can interfere with water or wastewater treatment processes. The acceptable range for successful performance of biological treatment and a healthy fresh water habitat is between 6.0 and 9.0.

Several of the subcategories discussed in this document require minor pH adjustment before discharge or biological treatment. It is perhaps most significant for vinegar which produces an effluent with high concentrations of acetic acid.

Nickel

Nickel as a pure metal does not consitute a serious threat to receiving waters; however, many of the salts of nickel are soluble in water and may be hazardous to aquatic life. Since the acute and chronic toxicity values of nickel vary widely, the EPA (92) has proposed a limiting application factor of 0.02 of the 96 hour LC_{50} as required to provide adequate protection for aquatic life.

The only known source of nickel in process waste water from the miscellaneous foods and beverages industry would be attributable to the edible oils refining industry where small amounts of nickel are used in the process. The discharge of nickel from edible oil refining plants has been found to be very insignificant under present operating practices. Effluent limitation of nickel within technological capabilities and pollution control requirements is justified in a precautionary sense, due to the potential polluting effects attributable to this material.

Alkalinity

Alkalinity in water is a measure of hydroxide, carbonate, and bicarbonate ions. Its primary significance in water chemistry is its indication of a water's capacity to neutralize acidic solutions. In high concentrations, alkalinity can cause problems in water treatment facilities. However, by control of pH, alkalinity is also controlled.

Total Dissolved Solids

The quantity of total dissolved solids in wastewater is of little meaning unless the nature of the solids are defined. In fresh water supplies, dissolved solids are usually inorganic salts with small amounts of dissolved organics, and total concentrations may often be several thousand milligrams per liter.

It is not considered necessary to recommend limits for total dissolved solids since harmful salts and organics are limited by other parameters.

Nutrients

Forms of nitrogen and phosphorus act as nutrients for the growth of aquatic organisms and can lead to advanced eutrophication in surface water bodies. In water supplies, nitrate nitrogen in excessive concentrations can cause methemoglobinemia in human infants and for this reason has been limited by the United States Public Health Service to ten milligrams per liter as nitrogen in public water supplies (93).

Under aerobic conditions ammonia nitrogen is oxidized to nitrite and ultimately to nitrate nitrogen. Phosphorus compounds are commonly used to prevent scaling in boilers and orthosphosphate may occur in boiler blowdowns. The use of phosphate detergents for general cleaning can contribute phosphates to total wastewater discharges. When applied to soil, phosphorus normally is fixed by minerals in the soil, and movement to ground water is precluded.

Color

True water color is a result of substances in solution after suspended materials have been removed. It may be derived from mineral or organic sources and may be the result of natural processes as well as manufacturing processes.

The effect of extreme water color on aquatic life is to limit light penetration, thereby restricting the photosynthetic zone and impacting benthos. Otherwise, color may serve as an indirect indication of pollution and be aesthetically objectionable.

The production of soluble coffee, tea, rum, and yeast results in a wastewater with considerable color. The effectiveness of biological treatment for color removal is questionable. Carbon filters or other devices may be necessary for color removal in some instances, but present technology for color removal from these wastewaters is nonexistent.

The acceptable limits of color in navigable waters are highly dependent on the natural levels of color in the waters and the degree of available dilution. The Environmental Protection Agency (92) has proposed that acceptable conditions regarding the combined effect of color and turbidity in water will be met if the water's compensation point is not changed by more than 10 percent from its seasonably established norm, and if no more than 10 percent of the biomass of photosynthetic organisms is placed below the compensation point by such changes.

Chlorides

Chlorides can cause detectable taste in drinking water in salt (sodium, calcium, magnesium) concentrations greater than about 150 mg/l; however, the concentrations are not toxic; drinking water standards are generally based on palatability rather than health requirements. In the application of wastewater to land, no practical limits can be recommended by this document since chlorides are generally non-toxic to crops, although some fruit trees are sensitive to chlorides. A consideration of crop irrigation with wastewater should take into account chloride concentrations.

The operations discussed in this document which discharge significant chloride concentrations are block ice production, olive oil production, and pectin production. In the case of block ice production, the concentrations in the wastewater are within drinking water standards. The concentrations for olive oil and pectin are considerably higher and attention must be given to specific discharges.

Temperature

The discharge of heated waters, with inadequate dilution, may result in serious consequences to aquatic environments. Generally, problems of heated water are associated with various cooling waters that are not subject to recommendations in this document. One process stream, currently discharged in some cases from rum distilling, approaches the boiling point of water; however, recommended control technology developed in Section VII would eliminate this problem.

METHODS OF ANALYSIS

During the course of this study a number of wastewater samples were collected and analyzed at the laboratories of Environmental Science and Engineering, Inc., Gainesville, Florida. The following outlines the analytical methods used.

Solids

Total solids was determined by drying an aliquot of sample at 104°C according to EPA methods (EPA, Methods for Chemical Analysis of Water and Wastes, 1974, p. 270; Standard Methods, pp. 535-536).

Dissolved and suspended solids were determined by glass fiber filtration and drying at 104°C, (Standard Methods, pp. 535-536).

Volatile solids was determined by combustion at 550°C, (EPA Methods, 1974, p. 272; Standard Methods, p. 536).

pH and Temperature

pH and temperature were determined at the time of sample collection.

Nitrogen and Phosphorus

Total nitrogen was determined by the Kjeldahl digestion procedure (Standard Methods, p. 469) and total phosphorus by the ascorbic acid method (Standard Methods, p. 526, 532).

Oil and Grease

Oil and grease was determined gravimetrically by the liquid-liquid extraction technique with hexane. The procedure is a modification of the technique described in EPA Methods, pp. 226-228.

BOD

BOD was determined by oxygen depletion at 20°C using a membrane electrode to measure DO (Standard Methods, pp. 489-495; EPA Methods, 1974, pp. 11-12).

COD

COD was determined by dichromate oxidation followed by titration with ferrous ammonium sulfate (Standard Methods, pp. 495-499; EPA Methods, 1974, p. 20).

Color

Color was determined colorimetrically on a Klett-Summerson colorimeter and is reported in chloroplatinate units, a variation of the method given in EPA Methods, 1974, pp. 36-38 and Standard Methods, pp. 160-162. While this method is designed for natural waters, the major need for color analyses has been in the tea and coffee industries where the nature of the color of the wastewaters approximates that of natural waters.

NH_3

Ammonia was determined by a selective ion electrode (EPA Methods, 1974, pp. 165-167).