Water and Wastewater Management in the Fruit and Vegetable Processing Industry

Binnie & Partners

WRC Report No.96/1/87

FINAL REPORT TO THE WATER RESEARCH COMMISSION

for the project

WATER AND WASTEWATER MANAGEMENT IN THE FRUIT AND VEGETABLE PROCESSING INDUSTRY

by

BINNIE & PARTNERS

A report summarising data collected by Binnie & Partners during an investigation into in-house optimisation of water use and effluent treatment in the fruit and vegetable processing industry.

WRC 96/1/87

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WATER AND EFFLUENT MANAGEMENT IN PARTICULAR PROCESS LINES

1. Quick Reference Guide

This Report provides detailed information on the processing of some of the commodities that were examined in detail during the Survey. Production flow sheets are included. Thirty nine factories processed 869 150 tons of commodities during the 1979/1980 season; the breakdown is shown below:

Commodity	Para No.	Process diagram Figure	Para No. for targets
Apple canning	2.1	2.1	2.5
Apple & pear juicing	3.1	3.1 & 3.2	3.5
Apricots	4.1	4.1	4.5
Beans in tomato sauce	5.1	5.1	-
Beetroot canning/bottling	6.1	6.1	6.5
Citrus canning and juicing	7.2 & 7.3	7.1	-
Corn canning	8.1	8.1	8.5
Green bean canning	9.1	9.1	9.5
Guava canning	10.1	10.1	10.5
Peach canning	11.1	11.1	11.5
Pear canning	12.1	12.1	12.5
Pineapple canning	13.1	13.1	13.5
Pea canning	14.1	14.1 & 14.2	14.5
Tomato	15.1	15.1	-
Broccoli freezing	16.1	16.1	16.5
Corn freezing	16.1	16.6	16.12
Carrots freezing	16.1	16.5	16.8
Green bean freezing	16.1	16.8	16.15
Pea freezing	16.1	-	-
Potato freezing	-	16.9	16.18
Other commodities	17 & 18	17.1 & 17.2	-

2.0 CANNING OF APPLES

Water intake
104 x10^3 m^3/a NASWI 6,62 m^3/t

Factories
4 No. Cape Province

Raw tonnage
15 760 t/a

Products
slices pie filling

Liquid effluent	Solid wastes
3,0 to 5,0 m^3/t	5 300 t/a

2.1 Production plants

Four factories can apples for pie filling and as slices. The annual production capacities vary from 760 t/a to 6 000 t/a per factory. The general process flow diagram is shown at Fig. 2.1.

Processing involves a flow-through washer, grading followed by mechanical peeling and immersion in a salt solution to avoid "browning"; in some preparation plants the salting step follows coring and slicing. After coring and slicing (and salting if executed at this stage), the slices are de-aired in a vacuum system to remove all air from the pores of the fruit followed by sudden vacuum reduction accomplished by the introduction of water which fills the fruit pores in place of air. The de-aired slices are then blanched using hot water or steam followed by the canning, cooking and can cooling operations.

2.2 Water intake

The ASWI varied from 4,3 to 11,25 m^3/t with a NASWI of 6,62 m^3/t.

APPLE CANNING FIG. 2.1

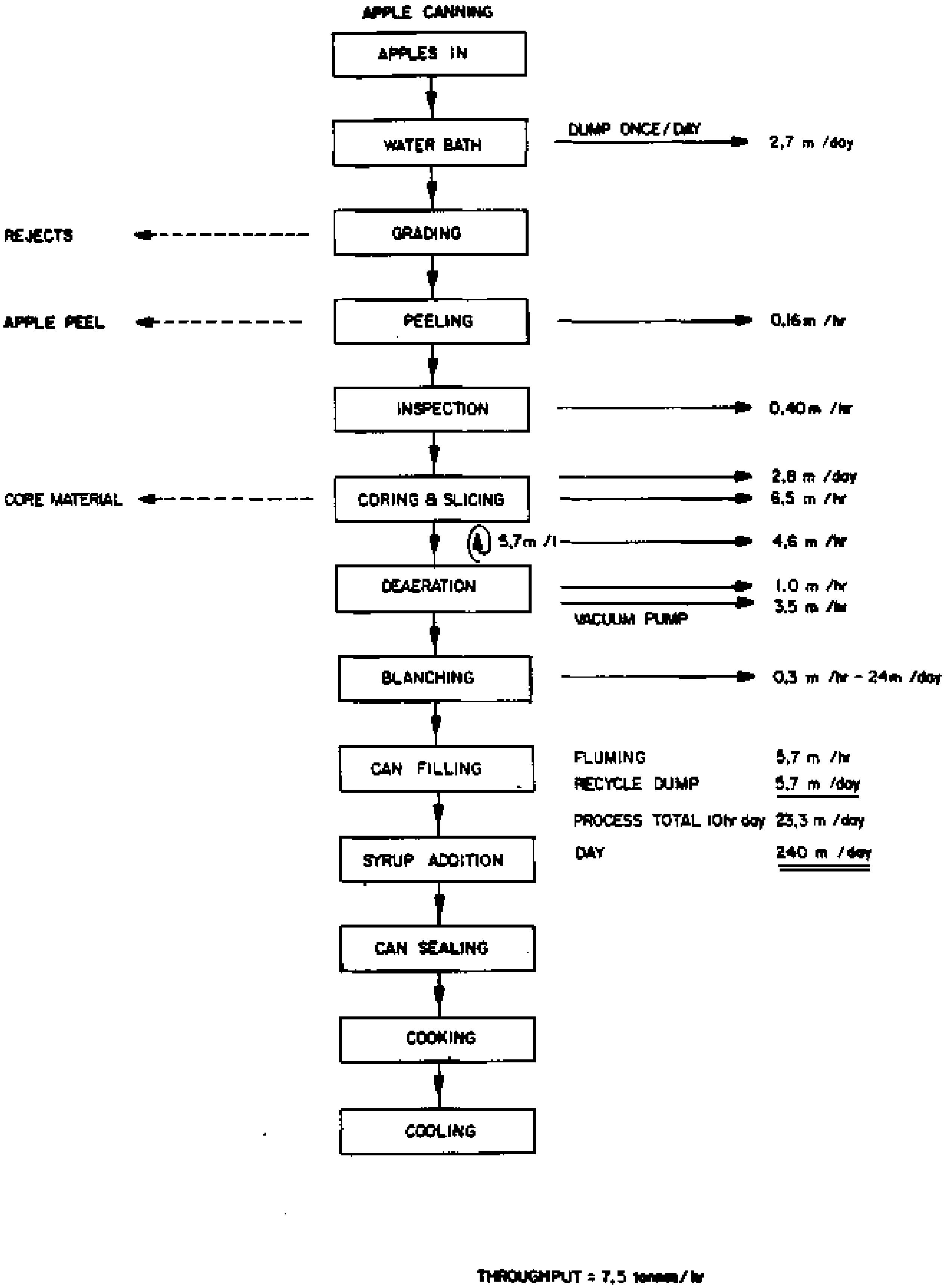
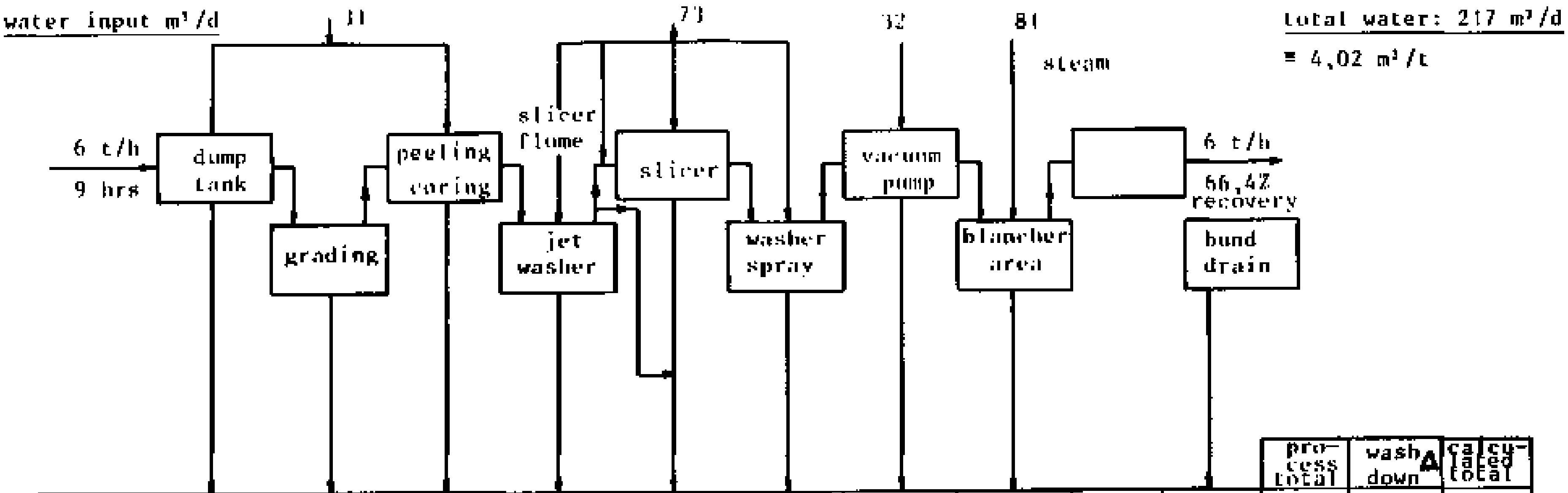


FIG. 2.2
APPLE CANNING



	dump tank	grading	peeling coring	jet washer	slicer	washer spray	vacuum pump	blancher area		bund drain	process total	wash down ▲	calculated total
flow m³/d	3		25	27	30	5	30	96		-*	216	69	285
m³/t	0,06		0,46	0,50	0,56	0,09	0,56	1,78			4,01	0,72	4,73
% total	1		8,8	9,5	10,5	1,75	10,5	34			76	24	100
total COD mg/ℓ	91		104	30 028	4993	16069	46	13382		10428	10787**	287+	9697
kg/t	0,01		0,05	15,01	2,77	1,49	0,03	23,79			43,15	4,52	47,67
% total	-		1	31	6	3	1	50			91	9	100
cent. COD mg/ℓ	57		77	21818	3496	8008	24	9607		9372	7860	4220	6842
kg/ℓ	0,003		0,04	10,91	1,94	0,74	0,01	17,08			30,72	3,04	33,76
% total	-		-	32	6	2	-	51			91	9	100
total [illegible] mg/ℓ			5	3650			7	1025		875	911		
kg/t			0,002	1,83			0,004	1,82			3,65		
% total													
cont. [illegible] mg/ℓ			4	3275			5	875		675	798		
kg/t			0,002	1,64			0,003	1,56			3,2		
% total								49			100		
SS mg/ℓ	102		46	1383	434	108	42	379		553	422	458	430
kg/t	0,01		0,02	0,69	0,25	0,03	0,02	0,67			1,69	0,33	2,02
% total	1		1	34	12	1	1	34			84	16,0	100

▲ Washdown after 96 tons throughput, all other figures based on 54 ton over 9 hrs + calculated using average centrifuged COD: total COD ratio 1,49. *small unmeasurable ** calculated average from specific value

TABLE 2.1

CANNING OF APPLES

FACTORY	RAW TONNES PROCESSED	SOLID WASTES	OVERALL WATER INTAKE		OVERALL EFFLUENT GENERATION		
			VOLUME	SPECIFIC	VOLUME	SPECIFIC	% OF WATER
	t/a	t/a	$m^3/a \times 10^3$	m^3/t	$m^3/a \times 10^3$	m^3/t	%
1	6 000	1 800	25,80	4,30	-	-	-
2	5 000	1 650	26,00	5,24	24	4,80	92
3	4 000	1 600	44,00	11,00	-	-	-
4	760	256	8,55	11,25	-	-	-
Total	15 670	5 306	104,35	6,62			

2.3 Effluents

Apple processing effluents are shown together with the individual flows and qualities arising from the various process steps at Fig. 2.2. The data is summarised below:-

Specific effluent volume per unit raw material processed:- 4,73 m^3/t		Quality	
% total flow	Process step	COD	SS
		33,76 kg/t % of total	2,02 kg/t % of total
18%	coring	32%	35%
12%	slicing	6%	12%
10%	vacuum seal	0,5%	1%
34%	blancher	51%	34%
24%	wash down	9%	16%

PREFACE

This report has been compiled from data collected during preliminary surveys of the industry by Binnie & Partners, during which time each one of the major processing plants was visited to identify the problem areas. Thereafter detailed investigations were completed within a number of production plants. The data collected was used for the development of "A Guide to Water and Wastewater Management in the Fruit and Vegetable Processing Industry" published by the Water Research Commission, Pretoria, Republic of South Africa.

The work was initially steered and later coordinated by a committee established under the Chairmanship of the Water Research Commission, comprising representatives of the South African Fruit and Vegetable Canners Association; the Department of Environment Affairs - Directorate of Water Affairs; Department of Health, and senior representatives of each part of the industry together with represenatives of the processing plants where the work was conducted: all these parties are thanked for their invaluable assistance.

ACKNOWLEDGEMENTS

Acknowledgements are due to the Coordinating Research and Development Committee for the investigations into the water and wastewater management problems of the South African fruit and vegetable processing industry.

Coordinating Research and Development Committee:-

Dr O O Hart	Water Research Commission
Mr G S Glendining	Chairman, S A Fruit & Vegetable Canners Association
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Mr H Best	Department of Environment Affairs
Dr J A Lusher	Department of Water Affairs
Mr J L Pretorius	Department of Water Affairs
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Mr D R Wilson	S A Preserving Company
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In addition the contributions made by the following persons and bodies are acknowledged:

Dr M R Henzen	Past Chairman, Water Research Commission
Dr G J Stander	Past Chairman, Water Research Commission
Mr W Rose	National food Processors Association, Berkeley, California, U.S.A.
Mr B Kirk	B. Kirk & Associates
Mr C J Appleyard	Binnie & Partners

BACKGROUND INFORMATION

In 1976 the fruit and vegetable processing industry of South Africa requested that the Water Research Commission investigate the water and wastewater management techniques used and problems experienced within this industry.

Preliminary surveys of this industry were done by Mr W Rose of the National Food Producers Association, United States of America.

Subsequent studies of the water intake and wastewater generation at 39 major processing factories were done by Binnie & Partners (SA).

These were followed by more detailed investigations carried out up to 1982 by Binnie & Partners at the plants of Messrs. Langeberg Co-op, Ashton; Gants Foods, Somerset West; Land Harvest, Port Elizabeth and Irvin & Johnson, Springs. This report gives the results of all these studies, the number of processing factories, total annual production, process flows, water intake, wastewater/effluent generated. Areas needing improved management and interim and ultimate targets for specific water intake and wastewater/effluent generation, are given for each commodity studied.

EXECUTIVE SUMMARY

In 1976 the fruit and vegetable processing industry of South Africa requested that the Water Research Commission investigate problems experienced in water, wastewater and solid waste management in the industry. Preliminary surveys of the industry were carried out by Mr. W. Rose of the National Food Producers Association, United States of America. Subsequent surveys, pilot scale effluent treatment studies and the preparation of a series of reports, culminating in this final report, were carried out by Binnie and Partners (SA).

The project was carried out in two stages commencing in 1979 and 1981 respectively. The terms of reference for the first contract were as follows:

(a) To examine and define the water management and effluent problems in the fruit and vegetable canning industry in South Africa taking into account the reports by Mr. W.W. Rose and Mr. B.N. Kirk, in addition to the current technology available in the literature.

(b) To examine and report upon the various local wastewater discharge requirements of the controlling authority and to advise on techniques which could be adopted within the factory and any supplementary treatment to meet these requirements.

(c) To examine and report upon the reclamation and reuse of water within the processes operating in the factories in which effluents are produced with a view to eliminating or reducing the usage of water and to reducing strength and quantity of the effluents.

(d) To examine and report upon the question of solid wastes involved in the above processes, including the present techniques adopted with a view to any improvement thereof, and the elimination of any pollution arising therefrom.

(e) To recommend codes of practice for adoption by the controlling authorities and by the industry for optimum water management and effluent control within the fruit and vegetable canning industry.

(f) To recommend, in terms of the findings of the previous references, the most important fields in which in-depth research should be carried out with a view to optimum utilization of water throughout the industry.

For the second phase of the project, in-house studies were undertaken at selected factories to obtain practical data on the handling and processing of some 30 commodities.

All the data from the two phases of the project were used to compile "A Guide to Water and Wastewater Management in the Fruit and Vegetable Processing Industry"

In this report the data obtained during the investigation is given for each of the commodities.

The major results and conclusions of the investigations as embodied in the above mentioned Guide are:

(a) water usage in the industry, expressed in terms of the specific water intake (SWI, m^3 water taken in per ton of raw material), varies widely even between factories employing similar processing techniques for the same products;

(b) minimum achievable targets for SWI could be attained in practice by applying techniques established in the course of the study for reducing water intake to the minimum achievable SWI;

(c) pollution loads generated in the industry, expressed in terms of the chemical oxygen demand (COD) and suspended solids (SS) loads per unit of raw material processed, were also found to vary widely between factories;

(d) minimum achievable targets for these pollution loads could be attained by implementing improved techniques for factory housekeeping so as to minimise the volume and strength of the resultant factory wastewater;

(e) the strength of factory wastewaters could be substantially reduced by on-site effluent treatment processes which were evaluated in pilot scale effluent treatment studies;

(f) the overall pollution load generated could be reduced significantly by recycling of factory processing effluents, either by renovation and re-use locally at the process or by re-use for purposes requiring water of a lesser quality - counter-current re-use of water was found to be particularly applicable for processing of root vegetables such as carrots containing large quantities of soil and other detritus;

(g) in order to effectively apply the techniques and measures established for achieving minimum water intake and effluent generation, each factory should carry out regular water and effluent surveys with the objective of identifying areas where target levels are not being met - systematic procedures and techniques for carrying out such surveys are provided in the guide;

(h) handling and disposal of the solid wastes generated constitute a major problem for the industry - after establishing the quantities of wastes involved and the existing routes used for disposal, a number of alternative routes for cost-effective disposal and/or by-product recovery were identified, and it was concluded that in many instances such improved methods could best be implemented by adopting a regional joint venture approach within the industry.

In its present state-of-the-art form, this Guide offers management a useful tool with which water usage can be reduced, the volume and/or strength of factory effluents can be reduced at source and by appropriate on-site treatment, and solid wastes can be disposed of along rational and, in some cases profitable, routes. To systematically achieve these objectives a detailed accounting of the factory processing operations with regard to water usage, effluent generation and solid waste generation must be developed;

techniques for achieving the necessary inventories are detailed in the Guide. In one or more of these areas, management at each and every factory will discover that improvements can be made, that savings in water accounts or disposal charges for liquid and solid wastes can be achieved, and that the problems faced by the industry in these respects can be significantly ameliorated overall.

Finally, the work carried out has revealed several areas in which further research is desirable. The principal areas requiring development by the industry and others are:

(a) establishing the quality limits acceptable for process water at each stage of processing for the various products in order to make better use of recycled or renovated supplies, either by application of advanced technology such as membrane processes for the production of high-quality water or by the use of more basic processes for producing lesser-quality water for less demanding applications;

(b) instituting on organised report-back system whereby the implementation of this Guide can be monitored by the industry itself, positive experiences achieved by application of the guide can be shared throughout the industry and further or on-going problem areas can be identified;

(c) routes and methods for efficient utilisation of the large quantities of solid wastes generated by the industry require to be further examined and the values of recoverable by-products along with the associated processing costs need to be established in more detail.

2.4 Management needed

(a) segregation of peeling, coring and jet washer effluents, which amount to 52 m^3/d and treatment for suspended solids removal;

(b) treatment of blancher effluent (96 m^3/d) for COD and SS removal using ultra filtration or reverse osmosis;

(c) vacuum pump seal waters should be collected for reuse in the jet washer peeling/coring or washdown processes.

2.5 Targets

The target parameters set for the production of apples in cans are as follows:-

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
4,63	4,17	27,7	6500	1,6	400

Ultimate

3,63	2,9	7,76	2700	1,1	370

The flow target can be approached by reusing seal water. The COD target can be approached by managing the peeling/coring/jet washing area to ensure that solids do not enter the drain. Adopting the revised washing down procedure will help to meet the targets.

3 JUICING OF APPLES AND PEARS

Water intake	
Apples	Pears
$117x10^3$ m^3/a	$33x10^3$ m^3/a
NASWI	NASWI
$3,48m^3/t$	$3,55m^3/t$

Factories
3 No. Cape Province

Raw tonnage	
33 640 t/a	9 300 t/a

Products
apple juice pear juice

Liquid effluent		Solid wastes
$50,8x10^3$ m^3/a $1,51$ m^3/t	$20,4x10^3m^3/a$ 2,19	9 900 t/a apple 2 740 t/a pear (pommaces)

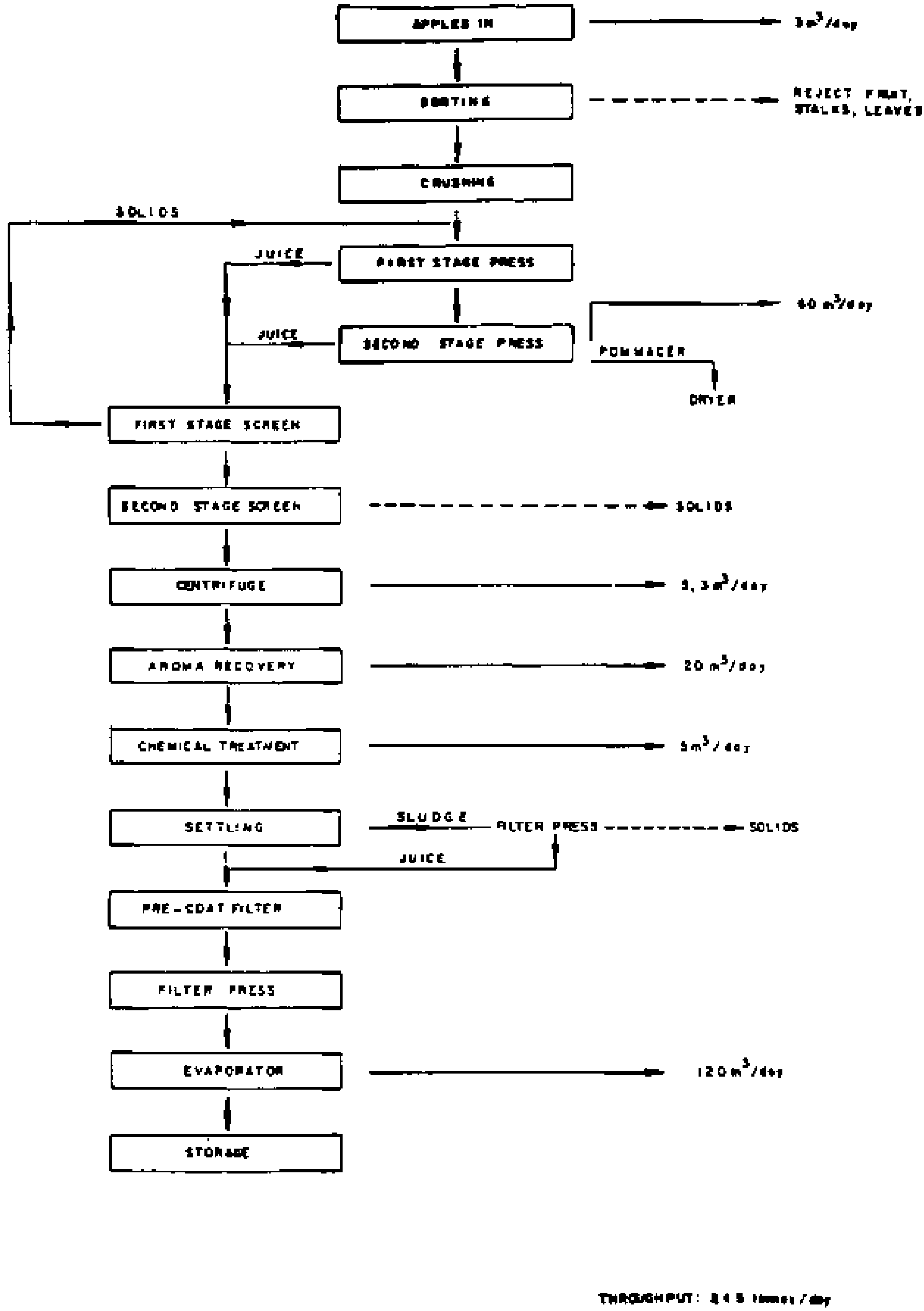
3.1 Production plants

Three major plants process 33 640 t/a apples and 9 300 t/a pears to concentrated juices.

Apples and pears are dumped into flow-through washers prior to inspection where overripe fruits are rejected before the remainder is passed into single or double-stage presses; the expelled juice is then passed through screens to remove coarse solids. The pommace from the presses is in some cases dried before disposal; in other cases it is dumped as landfill.

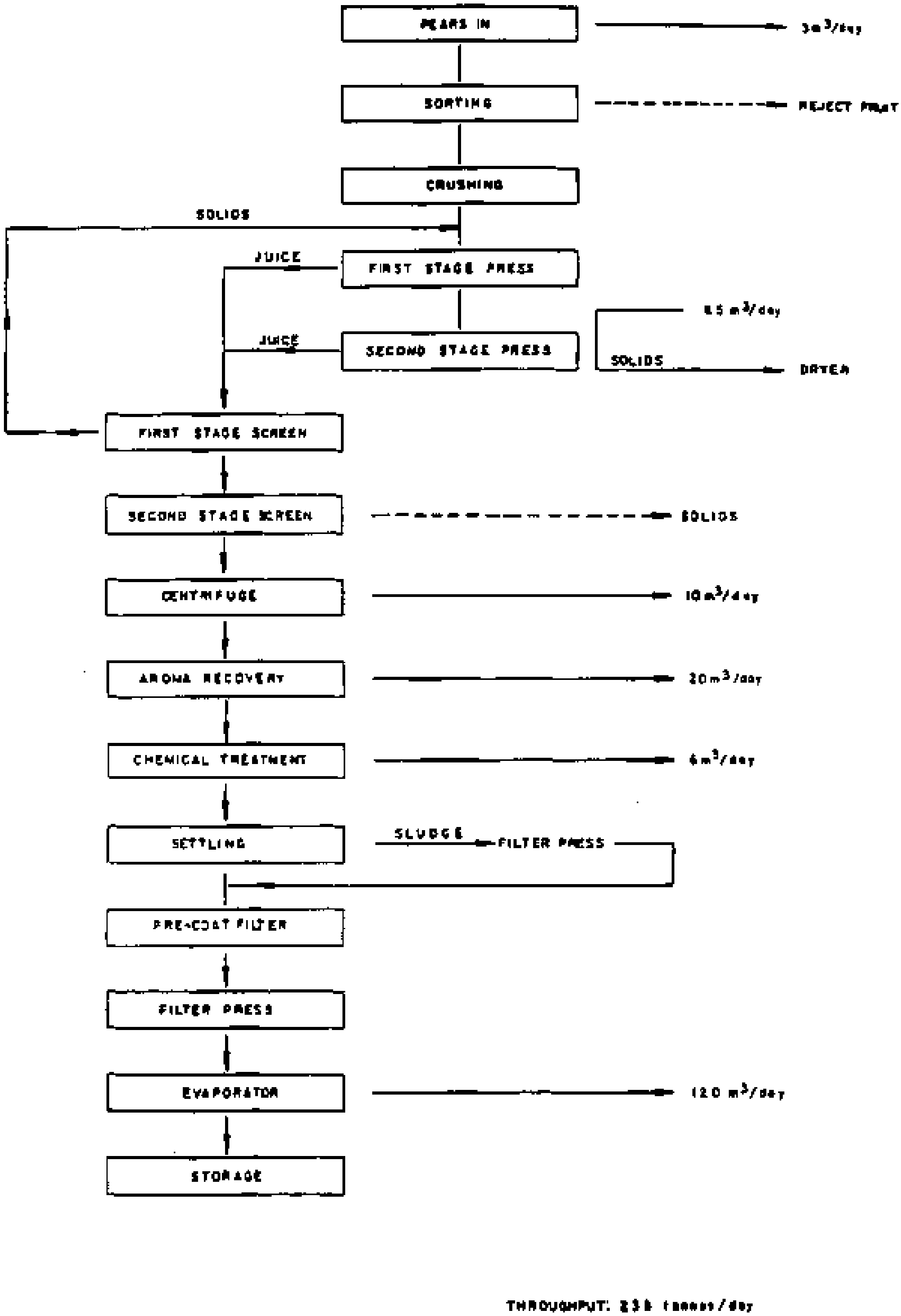
The extracted juice is centrifuged and the aroma removed in a distillation and fractionation process which also achieves pasteurisation for enzyme and spoilage inactivation. Aroma-free juice is given further treatment for pectin removal and thereafter filtered in various stages including plate and frame filters and centrifuged before being concentrated to achieve a volume reduction of about 80%. The process for apples and pears is shown separately on Figs. 3.1 and 3.2.

JUICING OF APPLES FIG. 3.1



PEAR JUICING

FIG. 3.2



3.2 Water intake

At one factory processing .pples at 245 t/d and pears at 235 t/d the average water usage was 450 m^3/d giving a SWI of 1,84 m^3/t for apples and 1,91 m^3/t for pears. The SWI at other plants was as high as 6,17 m^3/t for apples. However, over the season the SWI for pears was 3,55 m^3/t and for apples 3,48 m^3/t.

Consumer	Total water	Apples		Pears	
	m^3/d	m^3/t	% total	m^3/t	% total
Process water	90	0,37	20	0,38	20
Boiler feed	20	0,08	4	0,09	5
Washdown & domestic	340	1,39	76	1,45	75
Total	450	1,84	100	1,91	100

The majority of the water is used for washing down the pressing plant which accounts for 20% of the total water usage, about 4% is used for steam raising and the remainder for general washing down and cleaning duties.

3.3 Liquid effluent

Concentration of the fruit juices generates clean effluents from the evaporator condensates; about 0,50 to 0,69 m^3/t is produced in this way. The effluent volume excluding the evaporative gain was measured as 1,02 m^3/t for apples and 1,49 m^3/t for pears. Adding the evaporative gain the overall effluent discharged becomes 1,51 m^3/t to 1,57 m^3/t for apples and pears respectively.

The block diagrams Fig. 3.3 and 3.4 show the flows and quantities of the various effluents generated during the juicing of apples and pears. Careful management of the normal washing down and the continuous washing down processes are needed. The small volume effluent from the centrifuge carries 16% of the COD and 17% of the overall SS in a flow of 5 m^3/d.

3.4 Management needed

(a) elimination of wet pommace transportation;

(b) avoiding unnecessary draining of solids from base of juice storage tanks ;

(c) avoid flushing solids from plate and frame filter presses to drain;

(d) reuse vacuum pump seal and evaporator condensates;

(e) segregate centrifuge blow down;

(f) removal of SS from final effluent by dissolved air flotation.

3.5 Targets

The target parameters set for the production of fruit juices are as follows:-

1st Stage

Commodity	Water Intake	effluent	COD		SS	
	m^3/t	m^3/t	kg/t	equivalent concentration mg/ℓ	kg/t	equivalent concentration mg/ℓ
apples	0,55	1,06	4,8	4500	1,0	1000
pears	0,55	1,06	6,36	6000	1,59	1500

Ultimate

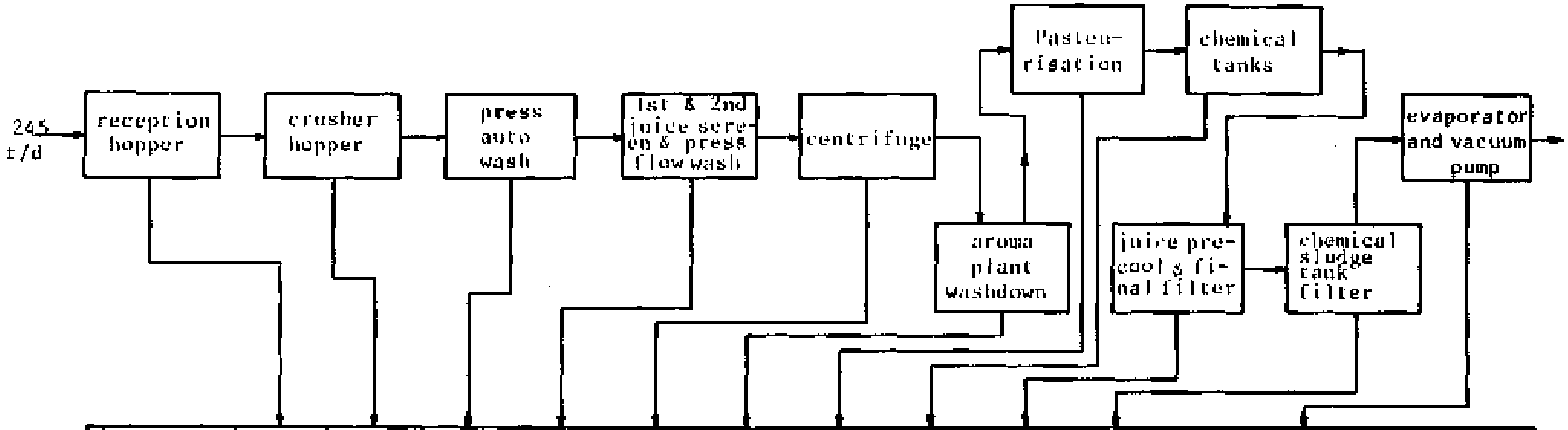
apples	0,55	1,0	3,0	3000	0,5	500
pears	0,55	1,0	5,05	4700	0,5	500

The flow target can be approached by reusing the evaporator condensates for washing down and the COD/SS targets by careful control of solids removal by compressed air and brushing followed by dry cleaning-up, prior to adoption of the revised wash down procedure proposed at section 4.13. Further, the areas of auto press washing and centrifuge blowdown must be segregated from the balance of the effluents for SS removal by dissolved air flotation, after wedge wire screening.

It may be worth investigating the recovery of sugar from the pommace by diffusion and concentration of the liquor by RO. In this case the ultimate targets could readily be met.

FIG. 3.3

APPLE JUICING

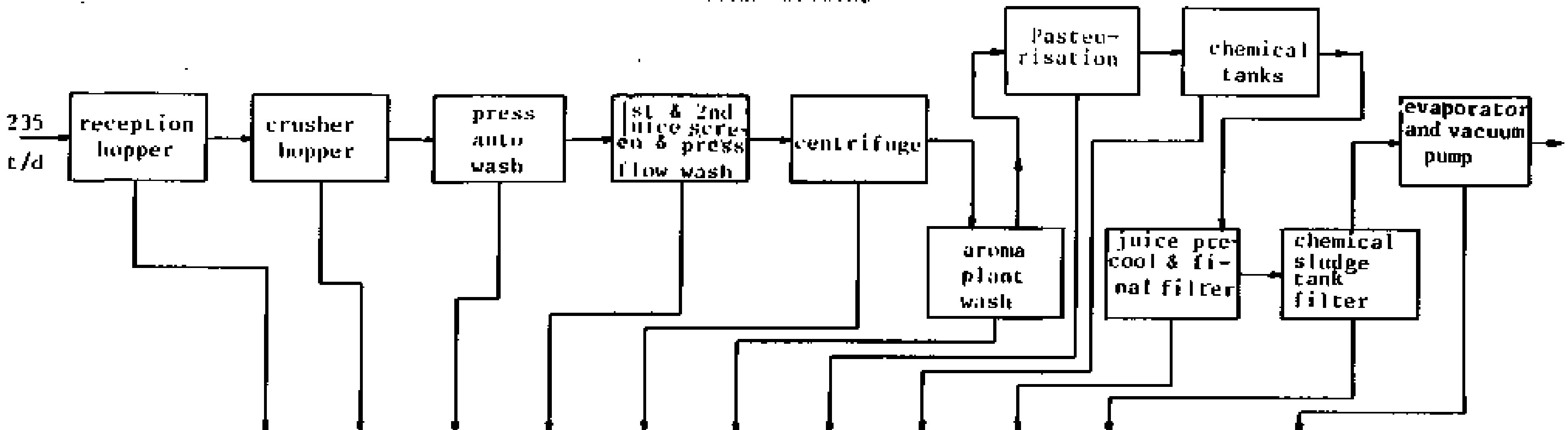


Parameter											process		wash down	Total
Flow m³/d	3	2	50	22	5	20	5	5	7	6	135	120	115	370
m³/t	0,01	0,01	0,24	0,09	0,02	0,08	0,02	0,02	0,03	0,02	0,55	0,49	0,47	1,51
% total	0,80	0,50	16,2	5,90	1,30	5,4	1,30	1,30	1,90	1,62	36	32	31	100
Filt. COD mg/ℓ			7630	12900	82800	1216		37600			10525	-	10000	6948
kg/t			1,86	1,16	1,69	0,10		0,77			5,80	-	4,69	10,5
% total			18	11	16	1		7			55	-	45	100
SS mg/ℓ			3100	4000	28300	205		11000			4025	-	2396	2214
kg/t			0,76	0,36	0,58	0,02		0,22			2,22	-	1,12	3,34
% total			23	11	17	1		7			66		34	100

COD mg/ℓ	2343	
kg/t	0,22	% = 2
SS mg/ℓ	2982	
kg/t	0,28	% = 7

FIG. 3.4

PEAR JUICING



Parameter											process		wash down	Total
flow m³/d			60	20	10,0			5			135	120	115	370
m³/t			0,26	0,09	0,04			0,02			0,57	0,51	0,49	
% total			16	5	2,7			1			36	33	31	100
Filt.COD mg/ℓ			7600	12950	82000			37600			15776	-	12355	9596
kg/t			1,94	1,10	3,49			0,80			9,06	-	6,05	15,11
% total			13	7	23			5			60	-	40	100
SS mg/ℓ			3116	4050	28000			11000			5200	-	2850	2784
kg/t			0,80	0,34	1,19			0,23			2,99	-	1,39	4,38
% total			18	8	27			5			68	-	32	100
pH												-	5,0	

m³/t	0,17	
COD mg/ℓ	10163	
COD kg/t	1,73	% = 12
SS mg/ℓ	2526	
SS kg/t	0,43	% = 10

4 CANNING OF APRICOTS

Water intake
154×10^3 m^3/a NASWI: 5,5 m^3/t

Factories
13 No. Cape Province

Raw tonnage
28 104 t/a

Products
Average Halves - recovery 73,2%

Liquid effluent	Solid wastes
115×10^3 m^3/a 4,10 m^3/t	7 531 t/a 7% pits

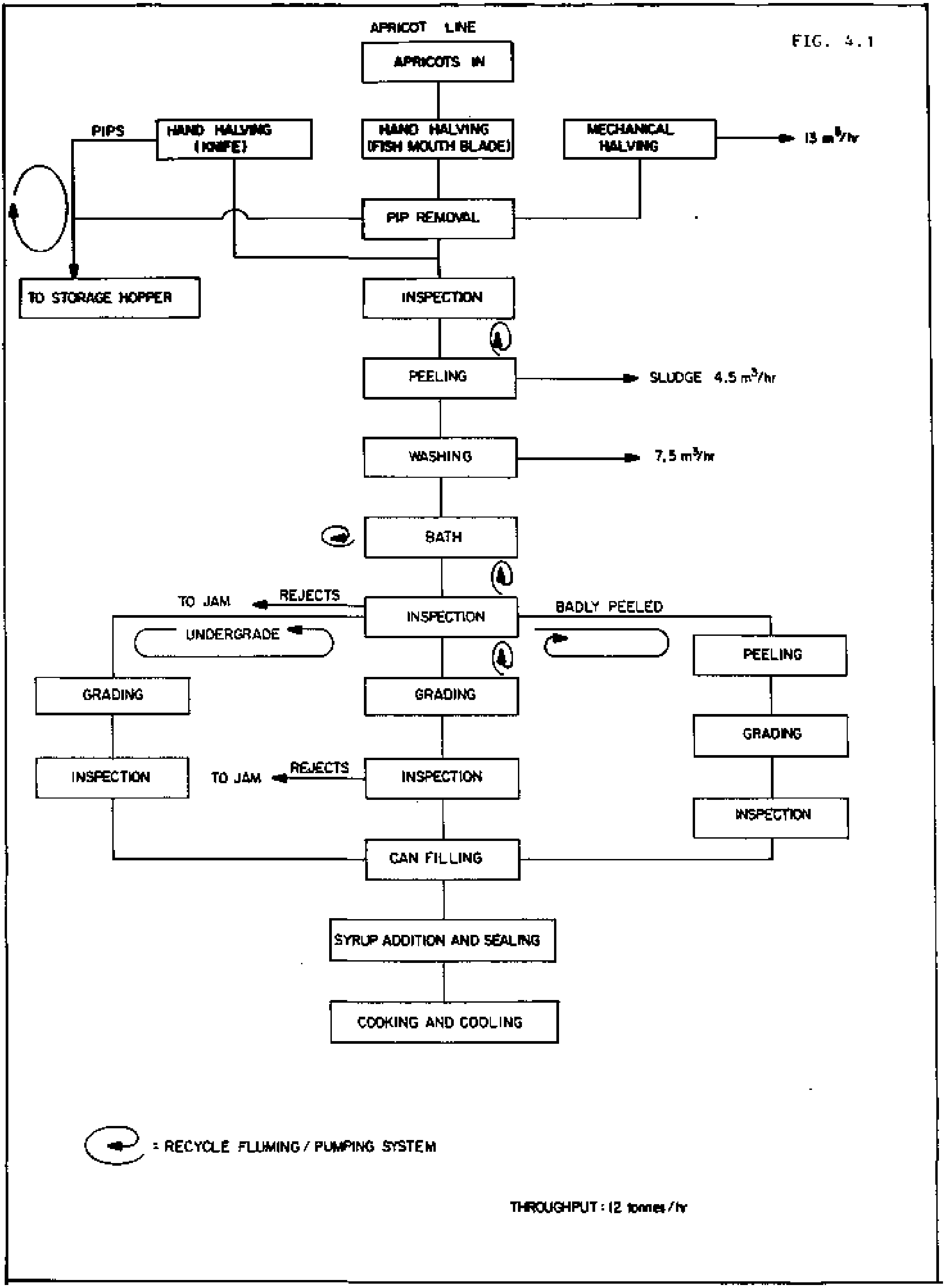
4.1 Production plants

Thirteen factories produce canned apricots using processing lines rated from 3,75 to 30 t/h giving production capacities between 500 and 7 000 t/a. The general process flow diagram depicting the various steps of manufacture is given at Fig. A4.1 the apricots are moved between process steps by elevators, water flumes and belts.

Processing involves preliminary washing in flow-through washers, in most cases halving is accomplished with fish-mouthed blades, followed by pit removal on shaking or drum screens. The halves are then turned cup down before passing into a spray-type caustic lye applicator for peel softening; removal of the peel is done by dry scrubbing or spray washing processes followed by a final wash. Inspection identifies poorly-peeled halves which are returned for re-peeling and any rejected fruit is transferred to another line for jam manufacture.

Fruit if acceptable quality then passes to grading, can filling, syrup addition, cooking and cooling.

FIG. 4.1


APRICOT LINE
APRICOTS IN
PIPS
HAND HALVING (KNIFE)
HAND HALVING (FISH MOUTH BLADE)
MECHANICAL HALVING
13 m³/hr
PIP REMOVAL
TO STORAGE HOPPER
INSPECTION
PEELING
SLUDGE 4.5 m³/hr
WASHING
7.5 m³/hr
BATH
TO JAM
REJECTS
INSPECTION
BADLY PEELED
UNDERGRADE
PEELING
GRADING
GRADING
GRADING
INSPECTION
TO JAM
REJECTS
INSPECTION
INSPECTION
CAN FILLING
SYRUP ADDITION AND SEALING
COOKING AND COOLING
= RECYCLE FLUMING / PUMPING SYSTEM
THROUGHPUT : 12 tonnes / hr

4.2 Water intake

Water is used on the apricot processing line for product washing, transportation, can cooling, syrup make-up, steam raising and cleaning of machinery and floors in addition to sanitary duties.

Inspection of Table 4.1 shows that the ASWI varies from 2,5 m^3/t to 11,50 m^3/t; the lowest value is returned by the factory employing dry belt transportation systems in place of water flumes. The distribution of water and effluent flows is identical to that quoted for peaches and a comparison of water usage at the different plants can again be accomplished by studying the salient features of the processing lines which except for the halving operation are similar to peach processing.

One factory replaced their wet peel removal plant after caustic lye application with a dry Magnascrubber. Prior to the change 28% (2 m^3/t) of the total water consumed during processing was used for the wet peel removal, whereas after the change 5,5% (0,33 m^3/t) of the total water usage was used at this process step; the corresponding overall average SWI decreased from 7,14 m^3/t to 6,0 m^3/t.

4.3 Liquid effluent

Typical concentrations of normally-monitored indicators of pollution yield the following typical results:-

A. Peeling operations	Quality COD mg/ℓ	Quality SS mg/ℓ
(i) Dry stage (sludges)	77 000	10 000
(ii) Wet stage	43 000	6 480
(iii) Washer outlet	25 650	1 554
B. Floor un off water at fruit inspection stations	19 520	1 265
C.		
(i) Flume transportation water factory 1	12 088	983
(ii) Flume transportation water factory 7	8 370	446
D. Final composite effluent (filtered COD)	4 500	400

The block diagram Fig. 4.2 shows the detailed effluent analysis at each process step. The table below shows the distribution of the salient flows and organic loads.

TABLE 4.1

CANNING OF APRICOTS

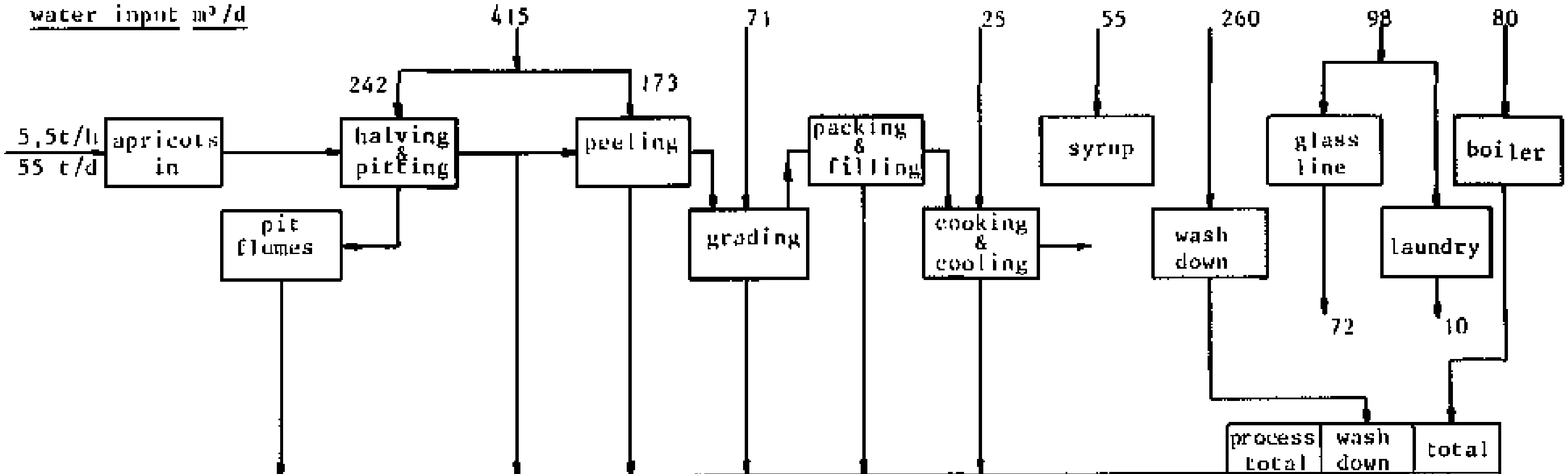
FACTORY	RAW TONNES PROCESSED	SOLID WASTES	PROCESS CAPACITY	OVERALL WATER INTAKE		OVERALL EFFLUENT GENERATION			REMARKS	
				VOLUME	SPECIFIC	VOLUME	SPECIFIC	% OF WATER		
	t/a	t/a	t/h	$m^3/a \times 10^3$	m^3/t	$m^3/a \times 10^3$	m^3/t	%		
1	7 000	1 400	30	28,0	4,0	21,0	3,0	74,7	Effluent irrigated to 54 ha	WT-TXL-CWR-LPEE
2	4 000	1 200	–	27,0 *	5,5 *	16,4	4,10*	74,5	Large multi product plant	WT-TKL
3	2 680	670	–	14,70	5,5	11,0	4,10*	74,8	–	WT+DT-WP CWR
4	2 369	727	7/8	10,18	4,3	7,6	3,20	74,5	Part of water used from private supplies	WT
5	2 000	400	5/6	11,00	5,5	8,2	4,10	74,5	Part of water is private borehole Effluent discharged to ocean	WT+DT-CWR
6	2 000	932	8	13,60	6,8	10,2	5,10	74,5	Effluent irrigated onto 10 ha (a further 20 ha is available)	WT-WP-PLEE
7	1 700	425	10/12	4,25	2,5	3,14	1,85	74,0	Dry TX throughout	DT
8	1 500	330	7,5/8	9,75	6,5	7,26	4,84	74,5	–	DT-SWR
9	1 500	510	6	15,75	10,5	11,73	7,82	74,5*	–	WT-CWR-LPEE
10	1 500	375	–	8,25	5,5	6,15	4,10	74,5*	Counterflow reuse of water	WT CWR
11	800	300	4	9,20	11,5	6,05	7,56	65,6	Cooling water used once for pitting machine	WT CWD
12	555	139	3,75/5	4,83	8,7	4,0	6,48	74,5*	Effluent irrigated onto 14 ha	–
13	500	125	–	2,70	5,4	2,01	4,02	74,5*		–
Total	28 104	7 531		154,20	5,5	11,50	4,10	74,3		

LEGEND - CBF - Condensates used as boiler feed
CWD - Can cooling water reused
CWR - Can cooling water recycled
ND - No data
* - Estimated as average

DT - Dry transportation systems
LP - Lye peeling
LPEE - Lye peel removal water separated from main effluent

TKL - Interstage transport distances long
WP - Wet peel removal
WT - Wet transport systems
VSR - Vacuum pump seal water reused

FIG. 4.2
APRICOTS



									process total	wash down	total
flow m³/d	85		106	240	24	45	25		525	260	865
m³/t	1,55		1,93	4,36	0,44	0,82	0,45		9,55	4,73	14,27
% total	11		12	28	3	5	3		62	30	100
U.filt COD mg/ℓ	1 692		1 615	7 692	6 250						
kg/t	2,61		3,11	33,57	2,73						
filt. COD mg/ℓ	1 512		1 260	7 558	4 651	3 489	135		4 472	1 980	3 646
kg/t	2,34		2,43	32,98	2,03	2,85	0,06		42,69	9,36	52,05
% total	6		6	55	5	7	0,1		77	23	100
SS mg/ℓ	216		178	696	334		less 2		404	356	388
kg/t	0,33		0,34	3,04	0,15		–		3,86	1,68	5.54
% total	6		6	55	3				70	30	100
PV (F) mg/ℓ	368		339	1 408	2 860	UA	6			372	
kg/t	0,57		0,65	6,14	1,25	UA	–				
% total											
pH	4,1		4,4	11,75	4,1		5,8			4,5	8,5

Specific effluent volume per unit raw material processed: 14,27 m^3/t		Quality	
% total flow	Process step	COD 52,05 kg/t	SS 5,54 kg/t
11	halving and pitting	6%	6%
22	flume to peeling	6%	6%
22	peeling	55%	55%
33	wash down	23%	30%

4.4 Management needed

(a) segregation of peeling and caustic area and separate treatment by flotation for suspended solids removal;

(b) dry peel sludge removal;

(c) elimination of pit flumes;

(d) add flume balancing system and treat flume waters by DAF;

(e) treat washdown water for SS removal by screen & DAF;

(f) the ultimate target will be achieved by applying UF/RO to the peeler effluent and possibly the flumes.

4.5 Targets

The target parameters set for the production of apricots are as follows:-

Water intake	effluent	COD		SS	
m^3/t	m^3/t	kg/t	equivalent concentration mg/ℓ	kg/t	equivalent concentration mg/ℓ
5,5	4,10	27,50	6700	2,70	660

Ultimate

5,5	4,10	15,7	3800	1,32	320

The target for water intake can be approached by adopting the recommended flume balancing systems and the revised method of washing down. The COD targets can be met by segregation of the peel sludges which generates 55% of the COD, and dry solids removal prior to washing down. Final effluent flotation would reduce the COD by a further 20% to 24kg COD/t with resulting final effluent concentrations of 4300 mg/ℓ.

5 BEANS IN TOMATO SAUCE

Water intake
$124x10^3$ m^3/a NASWI 20 m^3/t

Factories	Raw tonnage	Products
4 No. Cape Province	6 220 t/a	canned beans in tomato

Liquid effluent	Solid wastes
Approx. 100 $x10^3$ m^3/a 16,0 m^3/t	Nil

5.1 Production plants

Four plants process 6 220 t/a of beans in tomato sauce using the process steps shown on Fig. 5.1. Dried white beans are placed in soaking tanks for 12 to 24 hours, thereafter they are screened to remove pieces and grits before being blanched. After the post blanch inspection, they are transferred to tins which are filled with tomato sauce followed by sealing, cooking and cooling.

Water usage

Water is used for transporting the beans by flumes, for the soak tanks and for cleaning down. Flumes are used between the post-blanch inspection and filling stages which is then reused as the vehicular medium to pump the beans from the screens to the blanchers before it is discharged. The approximate specific water intake is 20 m^3/t although at some factories periodic values of up to 70 m^3/t have been recorded.

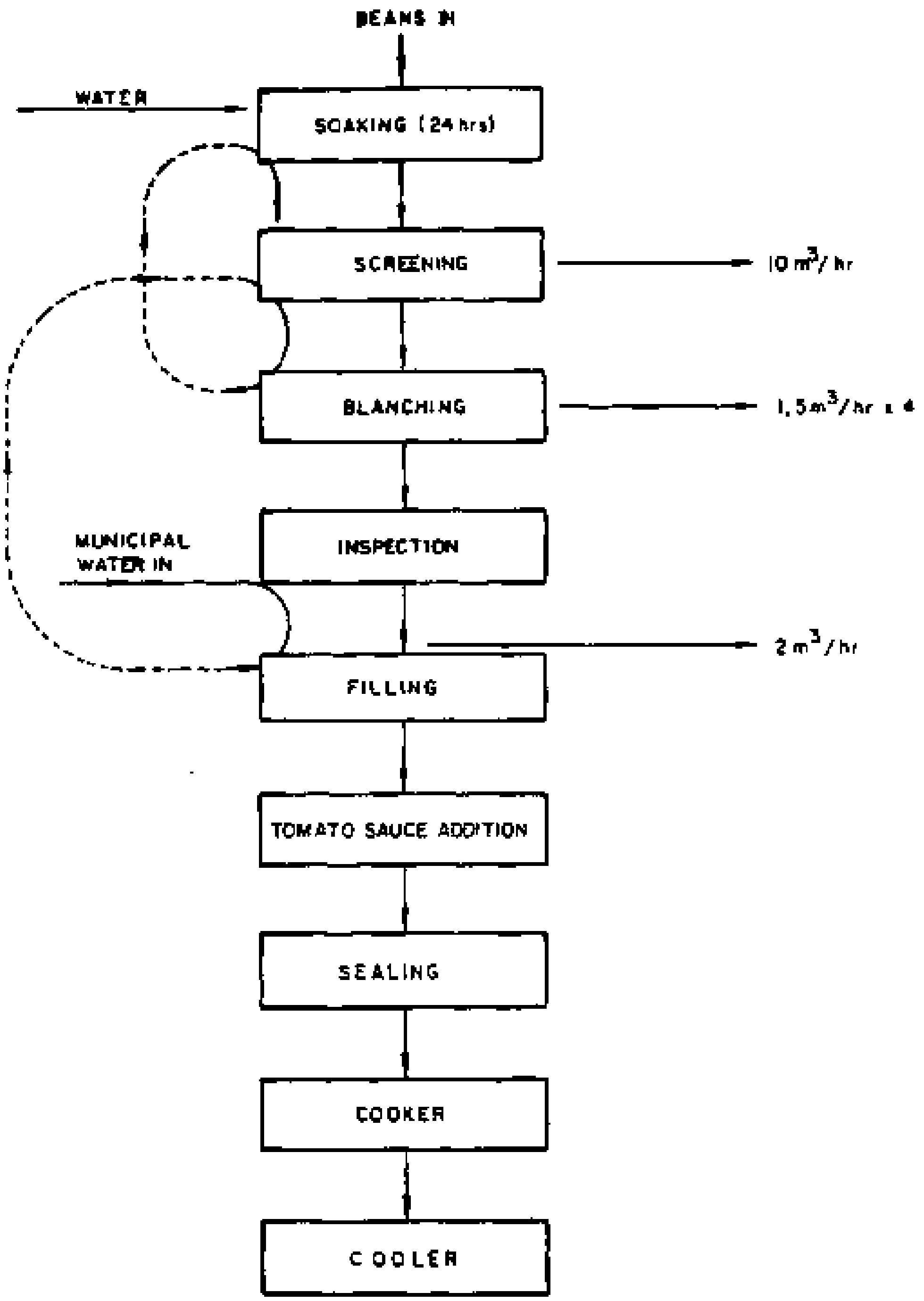
Liquid effluent

Approximately 80% of the water discharged originates from the transportation systems. We found that it typically had the following organic strengths:-

COD	1 255 - 2 000	mg/ℓ
SS	154	mg/ℓ

FIG. 5.1

CANNING OF BEANS IN TOMATO SAUCE



Management needed

(a) ensure all flumes are fitted with the balancing facilities proposed;

(b) avoid spilt beans pouring into drain.

6 CANNING AND BOTTLING OF BEETROOT

Water intake
$18,5 \times 10^3$ m^3/a NASWI 8 m^3/t

Factories
4 No. Transvaal Eastern Transvaal Cape

Raw tonnage
2 330 t/a

Products	
whole sliced shredded	canned or bottled

Liquid effluent	Solid wastes
$11,6 \times 10^3$ m^3/a 5 m^3/t	932 t/a

6.1 Production plants

Four factories process 2 330 t/a of beetroot to products which are either canned in brine or bottled in vinegar.

The processing steps are shown at Fig. 6.1. The beets are washed and cooked in retorts at 240 deg.C for 45 minutes before cooling and hand peeling, thereafter they are shredded, sliced or bottled whole. The vinegar is added and the bottles are sterilised in a bottle blancher and cooled.

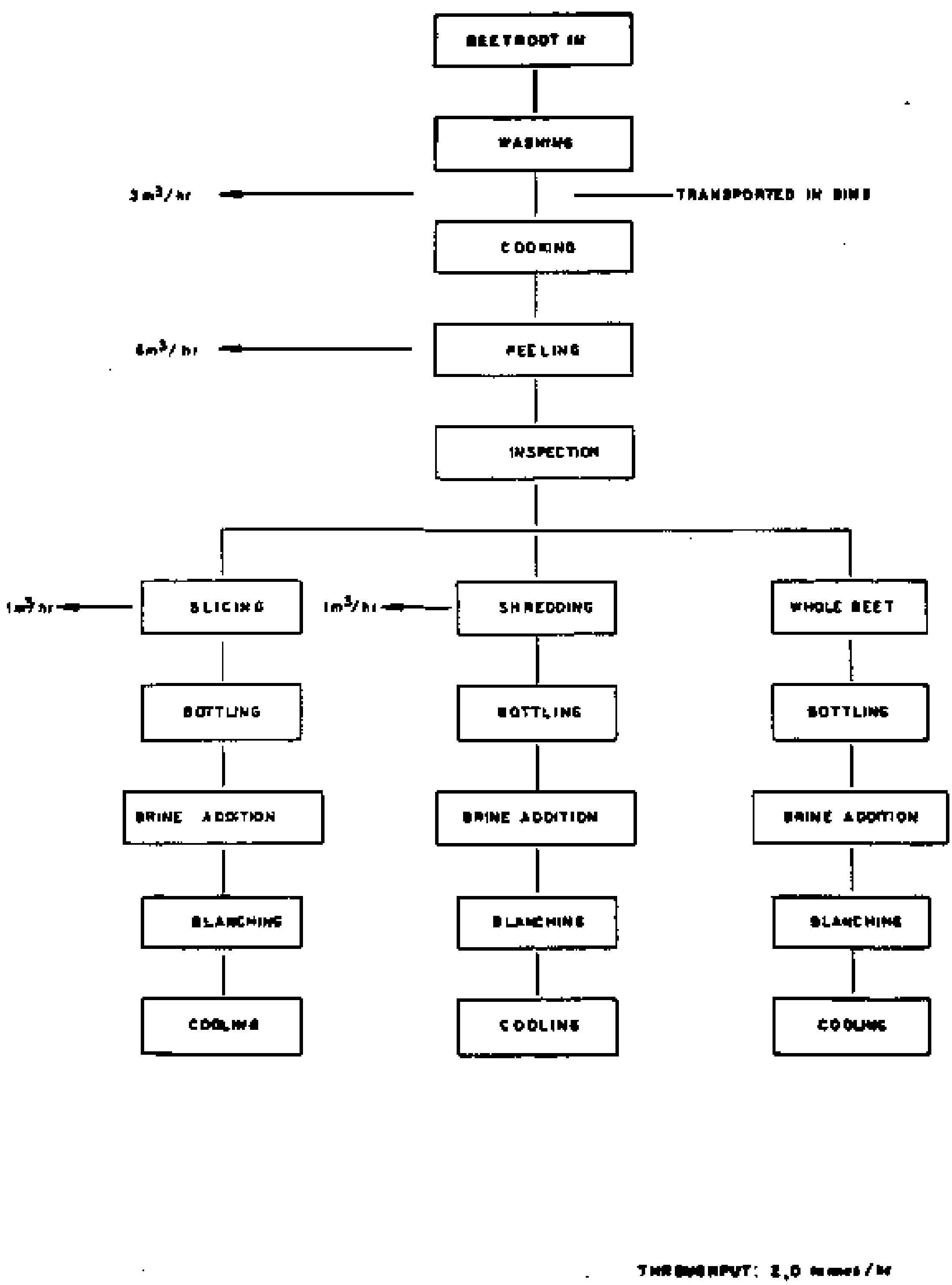
At one plant, the beets are peeled by a steam peeler before passing to the can filling, cooking and cooling stage.

6.2 Water intake

The NASWI is about 8 m^3/t of which the majority is used for washing the beets and the processing plant. However, at a factory where detailed analyses were made, the water intake was as high as 24,8 m^3/t.

FIG. 4.1

BOTTLING OF BEETROOT



Process step	SWI m^3/t	Total %
washing beets peeling washer	1,5) 3,0)	56
slicing/shredding	0,5	6
plant wash down, brine make-up	3,0	38
	8,0	100

6.3 Liquid effluent

Analysed samples of the effluent discharged from the cooking and shredding areas at one plant gave the following results:-

Process area	COD mg/ℓ	SS mg/ℓ
Slicing and shredding Cooking	2 540 1 346	376 50

It should be noted that effluent from beetroot processing is highly coloured and very strong.

Fig. 6.2 shows the distribution of the flow and organic load in the effluents which are summarised as follows:-

Specific effluent volume per unit raw material processed: 16,5 m^3/t		Quality	
% total flow	Process step	COD 98,52 kg/t	SS 4,38 kg/t
32 14 36 17	cooking/sterilising hand peel shredding/slicing retort area	3% 28% 12% 57%	- 49% 13% 29%

6.4 Management needed

(a) close control of the hand peeling area where nearly half of the suspended solids load occurs. Batch settling of the effluent would be appropriate;

(b) investigate retort area which produces 57% of the COD;

(c) control of the retort emptying liquor, perhaps passing it through boiler ash.

6.5 Targets

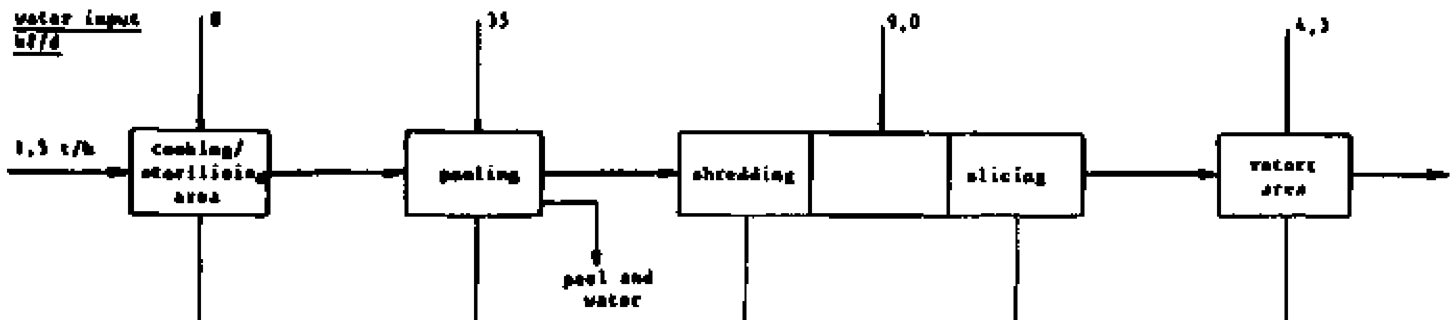
The target parameters set for the production of beetroot either in bottles or other containers are as follows:-

Water intake	effluent	COD		SS	
m^3/t	m^3/t	kg/t	equivalent concentration mg/ℓ	kg/t	equivalent concentration mg/ℓ
20	16,5	57	3500	2,1	130

The targets can be approached by managing the water intake, segregating the peeling and retort area discharges. The volumes are low and batch treatment could be considered.

FIG. 6.2

BOTTLING OF BEETROOT



											process total	washdown	measured final
flow kl/d	8		3,5		6,7		2,3	.	4,3		24,8		24,8
kl/t	5,33		2,33		4,47		1,53		2,87		16,53		16,53
% total	32		14		27		9		17		100		
U.COD mg/l	550		14 599		954		5 344		25 190		-		1 153
kg/t	2,93		34,04		4,26		8,19		72,21		121,60		
% total	2		28		4		7		59		100		
F.COD mg/l	534		12 023		908		5 057		19 466		-		-
kg/t	2,85		28,03		4,06		7,75		55,84		98,52		
% total	3		28		4		8		57		100		
F.PV mg/l	32		3 056		323		640		2 880		-		288
kg/t	0,17		7,13		1,44		0,98		8,26		17,98		
% total	1		40		8		5		46		100		
SS mg/l	4		924		108		300		438		-		110
kg/t	0,02		2,16		0,48		0,46		1,26		4,38		4,38
% total	½		49		11		11		29		100		
pH	4,72		4,42		3,82		5,48		6,8		4,75		

7 CANNING AND JUICING OF CITRUS

Water intake
348×10^3 m^3/a NASWI $2{,}08 m^3/t$

Factories
9 No. - Eastern Cape - Eastern Transvaal - Natal

Raw tonnage
166×10^3 t/a

Products
orange, lemon, grape-fruit juice canned segments candied peels

Liquid effluent	Solid wastes
no data	75 000 t/a

7.1 Production plants

Nine factories process citrus to canned and juice products; each process is briefly described:-

7.2 Juicing

The process is shown at Fig. 7.1 from which it can be seen that the fruit is placed in a flow-through washer before entering a size grader which separates the different sizes of individual fruits to fit the various juice extraction machines. The fruit is halved and the juice removed by forcing the halves cup-down over a cone while being twisted. The juice is then screened, pasteurised at 93 deg.C before being concentrated 6,5 times in a multi-effect evaporator; the product is frozen, or preserved and canned.

7.3 Canning

Canning is performed using the unit processes shown at Fig. 7.2 from which it can be seen that after washing, the fruit passes over a taper-roller size grader before entering a bath of water at 95 deg.C to scald the skin permitting hand peeling to be performed easily. Thereafter the fruit passes through a lye peeler to remove any remaining 'pith', before being chilled at 5 deg.C for 20 minutes to assist segmenting before canning and cooking.

7.4 Candied peel

At least one plant candies the peel, the process steps for which are shown at Fig. 7.3. Peels are collected from the juice extraction stage and passed to albide ('white') shavers which remove the internal pith, before the peels pass through a water bath. After dewatering they are dried and transferred to outdoor tanks for storage under a brine solution.

When required the peels are hydraulically removed from the storage pits, classified in an air flotation tank, dewatered, cooked, washed and packed.

7.5 Water intake

The water intake for citrus processing varies from 1,1 to 2,6 m^3/t and the plant which produces candied peel takes in 4,7 m^3/t which reflects the water needed for preserving, transportation and classification of peels.

At juicing plants the water is used mainly for the first washing and plant cleaning; for canning it is also used at the lye peeler, for syrup make-up and transportation flumes, where used. Water is recovered from the evaporation stage and this accounts for the apparently-low SWI.

7.6 Effluents

A wide range of final effluent strengths were reported but the maximum value of COD was 6 500 mg/ℓ. Where candied peel was being manufactured the final effluent had the following characteristics:-

COD - 11 770 mg/ℓ	OA - 2 380 mg/ℓ	COD OA - 4,95
SS - 1 595 mg/ℓ	TDS - 15 180 mg/ℓ	

7.7 Solid waste

Approximately 45% of the orange intake, 50% of the lemon and 60% of the grapefruit is expelled as solid waste, provided candied peel is not being manufactured , giving a total citrus waste of about 75 000 t/a.

FIG. 7.1

JUICING OF CITRUS FRUIT

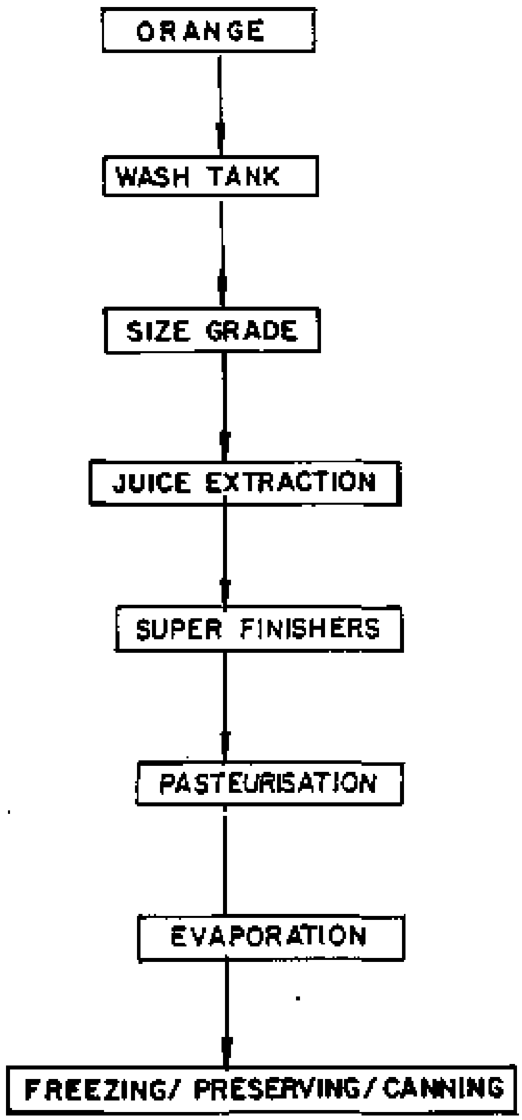
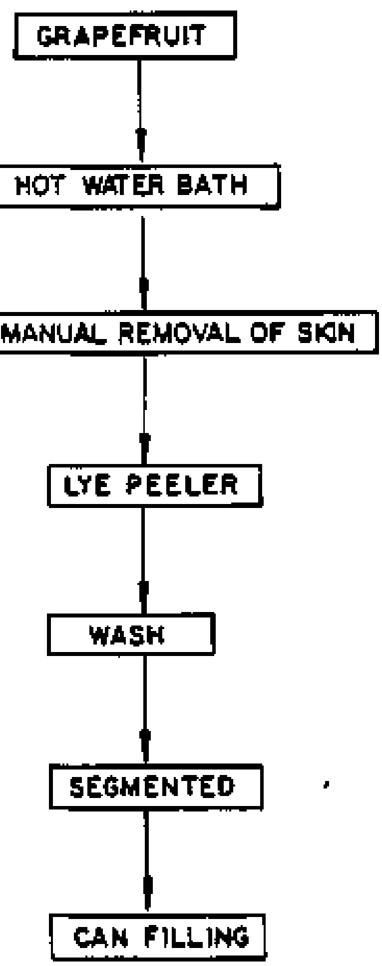


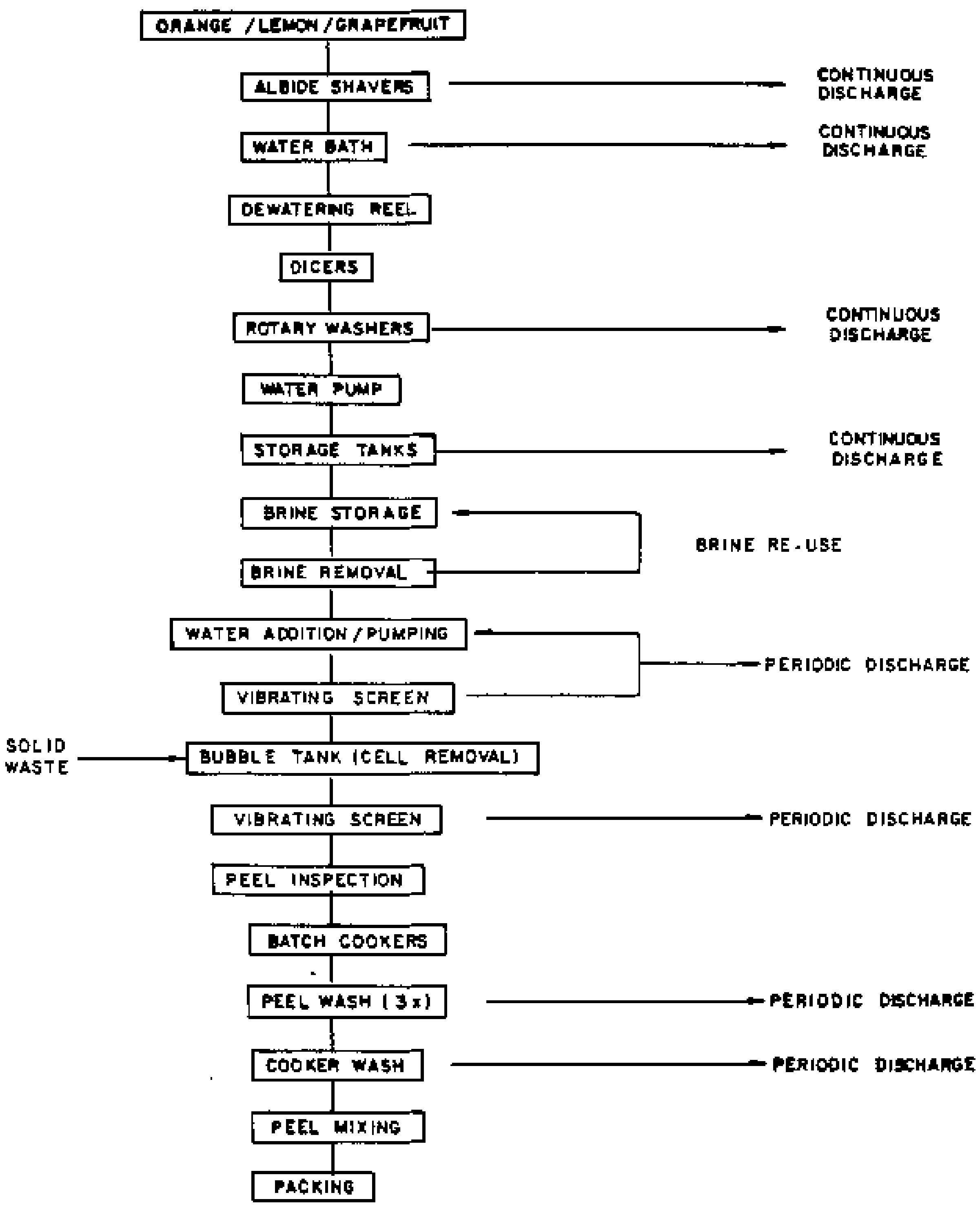
FIG. 7.2

CANNING OF GRAPEFRUIT



CANDIED PEEL MANUFACTURING

FIG. 7.3



8 CANNING OF CORN

Water intake
73 x 10^3 m^3/a
NASWI 9,25m^3/t

Factories
4 No. Cape Province & Transvaal

Raw tonnage
7 895 t/a

Products
whole kernels sweet corn (in cream)

Liquid effluent	Solid wastes
24x10^3 m^3/a - 3m^3/t	3 158 t/a

8.1 Production plants

Four factories process 7 895 t/a to canned kernels or sweet corn using the process steps shown in Fig. 8.15. The corn is delivered to the plant in crates or bags which are emptied onto belts to convey it to mechanical huskers for removal of the green leaves and'beard'; any remaining 'beard' being removed by hand at the inspection stage. The corn is then washed in a rotating drum washer and passed to mechanical decobbers; any corn unsuitable for this process is decobbed by hand. The kernels are screened through a rotating drum screen followed by a vibrating screen, to remove remaing pieces of cob or leaf.

For sweet corn products, the kernels enter batch mixers where salt, sugar and corn flour are added and the mixture heated to 70 deg.C, followed by blending, can filling, sealing, cooking and cooling.

Where corn products are to be made, the kernels from the screens are blanched, canned, sealed, cooked and cooled.

8.2 Water intake

The NASWI varies widely from factory to factory but the NASWI was found to be 9,25 m^3/t. The bulk of the water is used for washing of product, lubrication and cleaning of plant, boilers and domestic uses.

8.3 Liquid effluent

At one plant surveyed a flow of 13,5 m^3/h of effluent was measured when the plant capacity was about 4,5 t/h giving a specific effluent flow of 3,0 m^3/t; the distribution of effluent was as follows:-

Source	Effluent flow m^3/h	Specific flow m^3/t	Total %
Reception area) huskers) inspection belts)	5,60	1,24	41,4
Corn washer	1,80	0,40	13,4
Decobbers	2,20	0,49	16,4
Cooking	1,00	0,22	7,4
Cooling	1,80	0,40	13,4
Floor wash	1,08	0,24	8,0
Total	13,50	3,00	100,0

8.4 Management needed

(a) fit flume balancing system to kernel flumes;

(b) segregate high strength carbohydrate overflow from blancher for UF treatment;

(c) improve management of solids around the huskers using "barrow man";

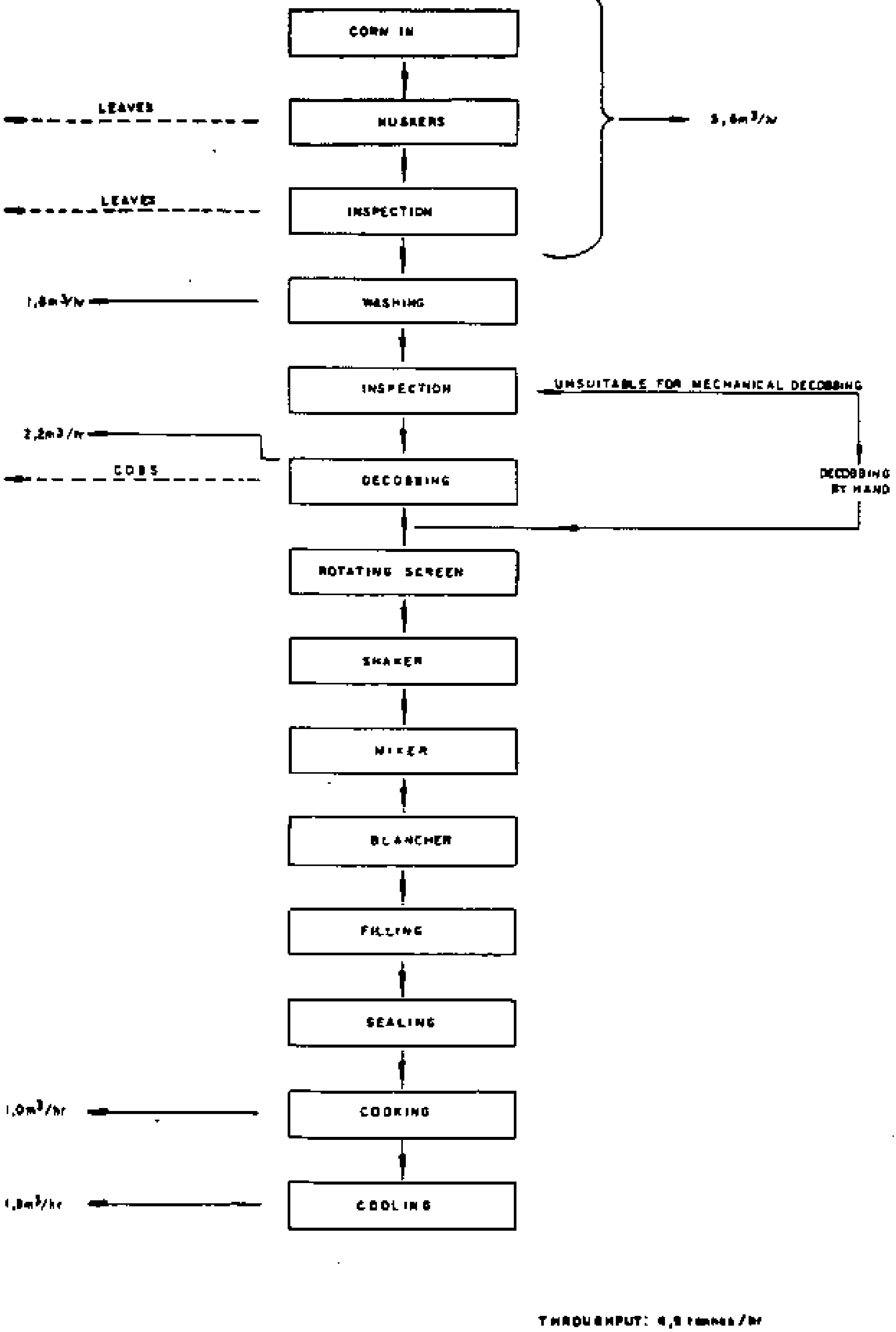
(d) if sweet corn or creamed corn is being manufactured all blancher overflows should be separately removed.

8.5 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
5,0	4,0	6,0	1500	1,0	250

CANNING OF SWEET CORN

FIG. 8.1



9 CANNING OF GREEN BEANS

Water
17×10^3 m^3/a NASWI 7,40 m^3/t

Factories
3 No. Cape and Transvaal

Raw tonnage
2 300 t/a

Products
cut beans slice beans

Liquid effluent	Solid wastes
14,95 $\times 10^3$ m^3/a 6,5 m^3/t	398 t/a

9.1 Production plants

3 factories process 2 300 t/a of canned products using the process steps shown at Fig. 9.1. The beans are placed in a flow-through or rotating drum washer before entering the snippers which remove the bean tops. Thereafter the beans are cut before blanching or remain whole for blanching if sliced beans are to be produced; slicing follows blanching. The blanching operation is needed to inactivate enzymes and other spoilage bacteria.

After blanching and inspection, the beans are canned, brine is added as necessary and the cans sealed, cooked and cooled.

9.2 Water intake

Water is used for the transportation systems, the blanchers, to spray equipment such as bean snippers and for plant washing down; the NASWI was 7,40 m^3/t.

9.3 Liquid effluent

The liquid effluent generated was found to be 6,55 m^3/t or 89% of the water supplied. We found that the distribution of the effluents was as follows:-

Source	Quantity of effluent	
	% total	m^3/t
Blancher outlet	23	1,50
Blancher condensate	14	0,90
Sprays on equipment	11	0,70
Continuous washing (snippers etc)	11	0,75
Can fillers	18	1,25
Wet transportation	8	0,50
Process sub-total	85	5,55
Washing down plant	15	1,00
Total	100	6,55

Various samples of the effluent from the green bean canning line at one factory showed the following results from which it can be seen that the wet transportation system contributes 8% of the flow but contains 43% of the COD and 59% of the SS load; the results exclude washing down water at 1,0 m^3/t.

Effluent concentration				Specific pollution loads								
Final excluding flumes		Contribution from Flumes		Final excluding flumes			Contribution from flumes			Total		
COD	SS	COD	SS	Vol	COD	SS	Vol	COD	SS	Vol	COD	SS
mg/ℓ	mg/ℓ	mg/ℓ	mg/ℓ	m^3/t	kg/t	kg/t	m^3/t	kg/t	kg/t	m^3/t	kg/t	kg/t
927	180	6996	2604	5,05	4,68	0,91	0,50	3,5	1,3	5,5	8,18	2,21

9.4 Management needed

Except for the effluents from bean transportation flumes the effluents from bean canning are comparatively low in organic strength and suspended solids concentration; attention should be given to:-

(a) installation of flume balancing tanks;

(b) recycle of flume water with SS removal;

(c) adoption of revised washing down procedures.

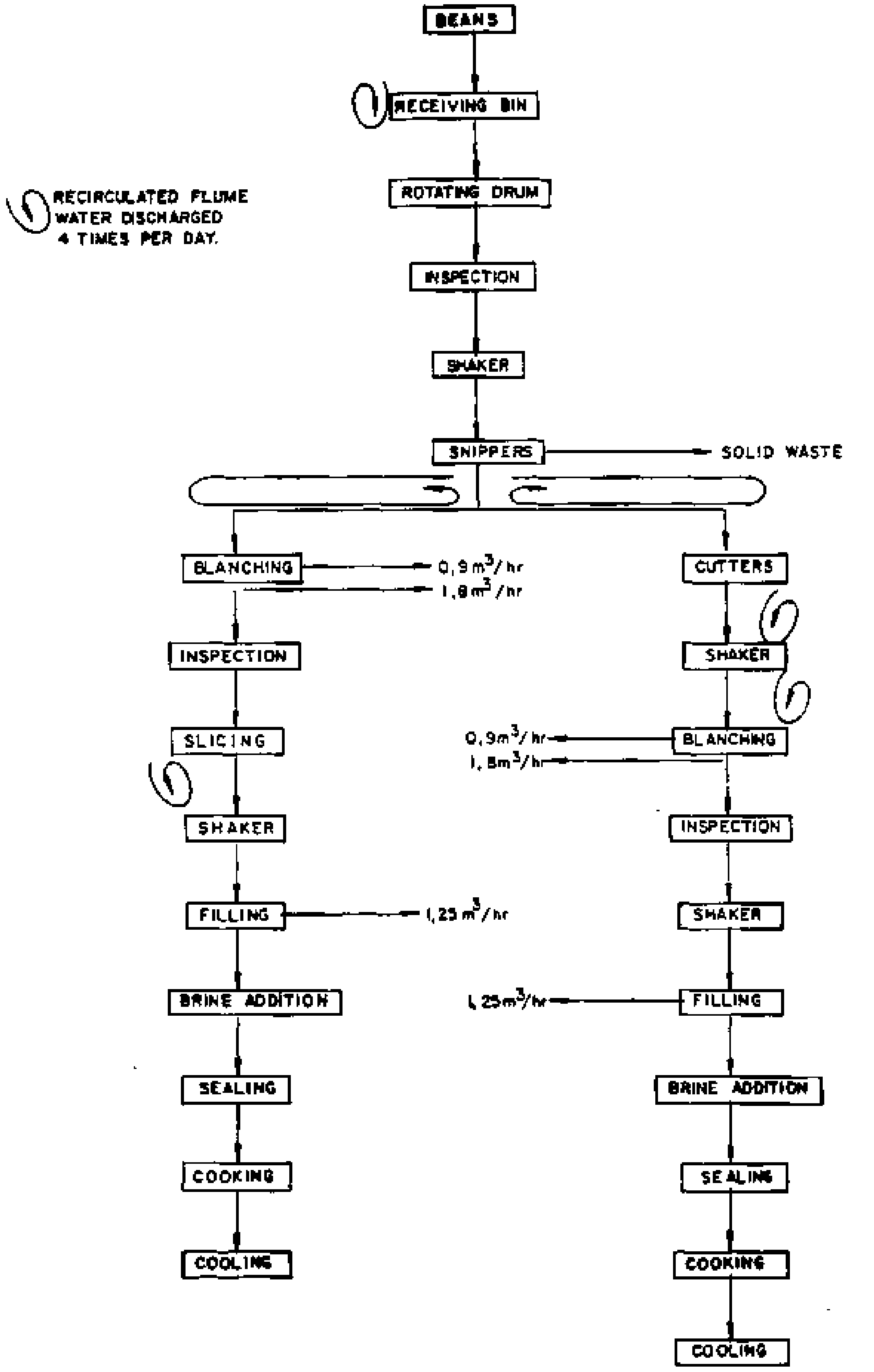
9.5 Targets for bean canning

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
5,06	4,50	6,75	1500	1,75	390

These targets can be approached by recycling the flume water and reducing the present 0,50 m^3/t to 0,35 m^3/t and by implementing the revised washing down procedure which could save 0,25 m^3/t giving a washdown water intake of 0,75 m^3/t compared to the present 1,0 m^3/t. The flume recycle system could employ dissolved air flotation for effective solids removal.

CANNING OF GREEN BEANS

FIG. 9.1



10 CANNING OF GUAVAS

Water
$60,70 \times 10^3$ m^3/a NASWI 6,4 m^3/t

Factories
10 No. Cape & Eastern Transvaal

Raw tonnage
9 509 t/a

Products
whole slices

Liquid effluent	Solid wastes
$45,5 \times 10^3$ m^3/a 4,82 m^3/t	2 393 t/a

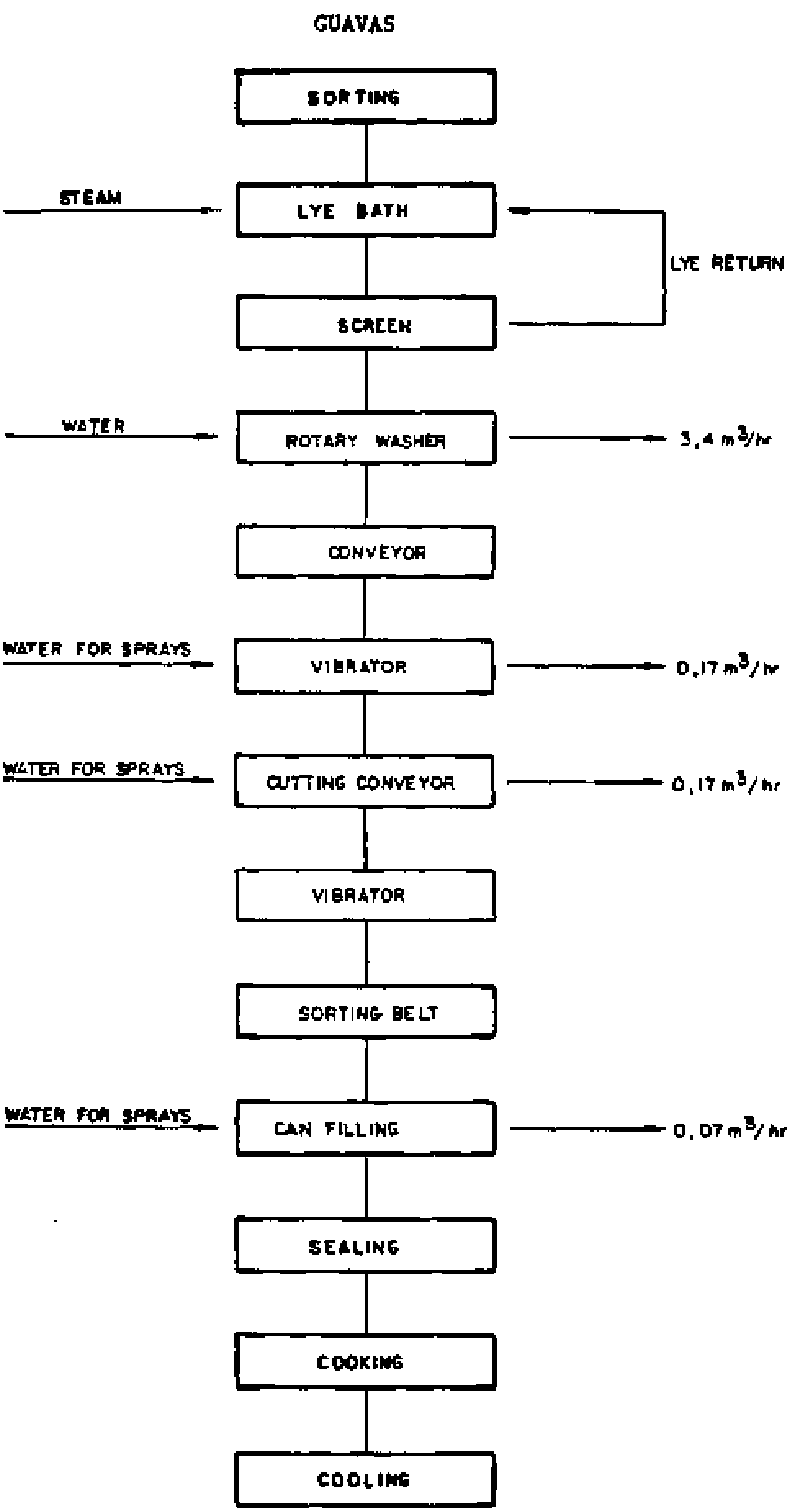
10.1 Production plants

Ten factories process 9 509 t/a of guavas. Fig. 10.1 shows the various steps of processing which involve hand quality grading, followed by lye peeling where the fruit enters an immersion lye peeler followed by brushing and washing for peel removal; in most cases countercurrent flow water reuse is practiced for these stages. The peeled fruit is then halved manually before being placed in the cans, syrup added and the sealing, cooking and can cooling steps accomplished.

10.2 Water intake

Table 10.1 shows that the NASWI varied from 4,0 to 7,0 m^3/t with the NASWI being 6,40 m^3/t. The major points of water intake are the washing after lye peeling and the sprays on the various conveyor belts; the approximate usage at the different stages of manufacture are as follows:-

FIG. 10.1


GUAVAS
SORTING
STEAM
LYE BATH
LYE RETURN
SCREEN
WATER
ROTARY WASHER
3,4 m3/hr
CONVEYOR
WATER FOR SPRAYS
VIBRATOR
0,17 m3/hr
WATER FOR SPRAYS
CUTTING CONVEYOR
0,17 m3/hr
VIBRATOR
SORTING BELT
WATER FOR SPRAYS
CAN FILLING
0,07 m3/hr
SEALING
COOKING
COOLING

Consumer	% total	Specific intake m^3/t
peeling washers)	56	3,4
sprays on belts	21	1,3
washing down	13	0,8
syrup make-up) boilers)	10	0,60
Total	100%	6,10

10.3 Liquid effluent

The liquid effluent discharged from the processing lines was measured as 4,61 m^3/t and 5,11 m^3/t at two factories. At factory No. 5 (Table 10.1) the effluents originated as follows:-

Source	% total	Specific volume m^3/t
peeler washing	74	3,4
belt sprays	9	0,41
wash down	17	0,80
Total	100%	4,61

The concentration and specific pollution loads of the effluents arising during processing of guavas is shown on the following table:-

factory	effluent concentration						specific pollution loads			
	final effluent			peeler washer effluent			final effluent		peeler washer contribution	
	flow m^3/t	COD mg/ℓ	SS mg/ℓ	flow m^3/t	COD mg/ℓ	SS mg/ℓ	COD kg/t	SS kg/t	COD kg/t	SS kg/t
No. 4	-	-	-	1,5	1115	236	-	-	1,7	0,35
No. 5	4,61	700	195	3,4	926	267	3,23	0,9	3,2	0,90

11 CANNING OF PEACHES

Water
910 x 10^3 m^3/a NASWI 6,88 m^3/t

Factories
15 No. Cape Province

Raw tonnage
132 361 t/a

Products	
- halves - slices - dice	Average recovery 75,9%

Liquid effluent	Solid wastes
700 x 10^3 m^3/a 5,30 m^3/t	31 843 t/a 7% pits

Effluent volume amounts to 77% of water consume

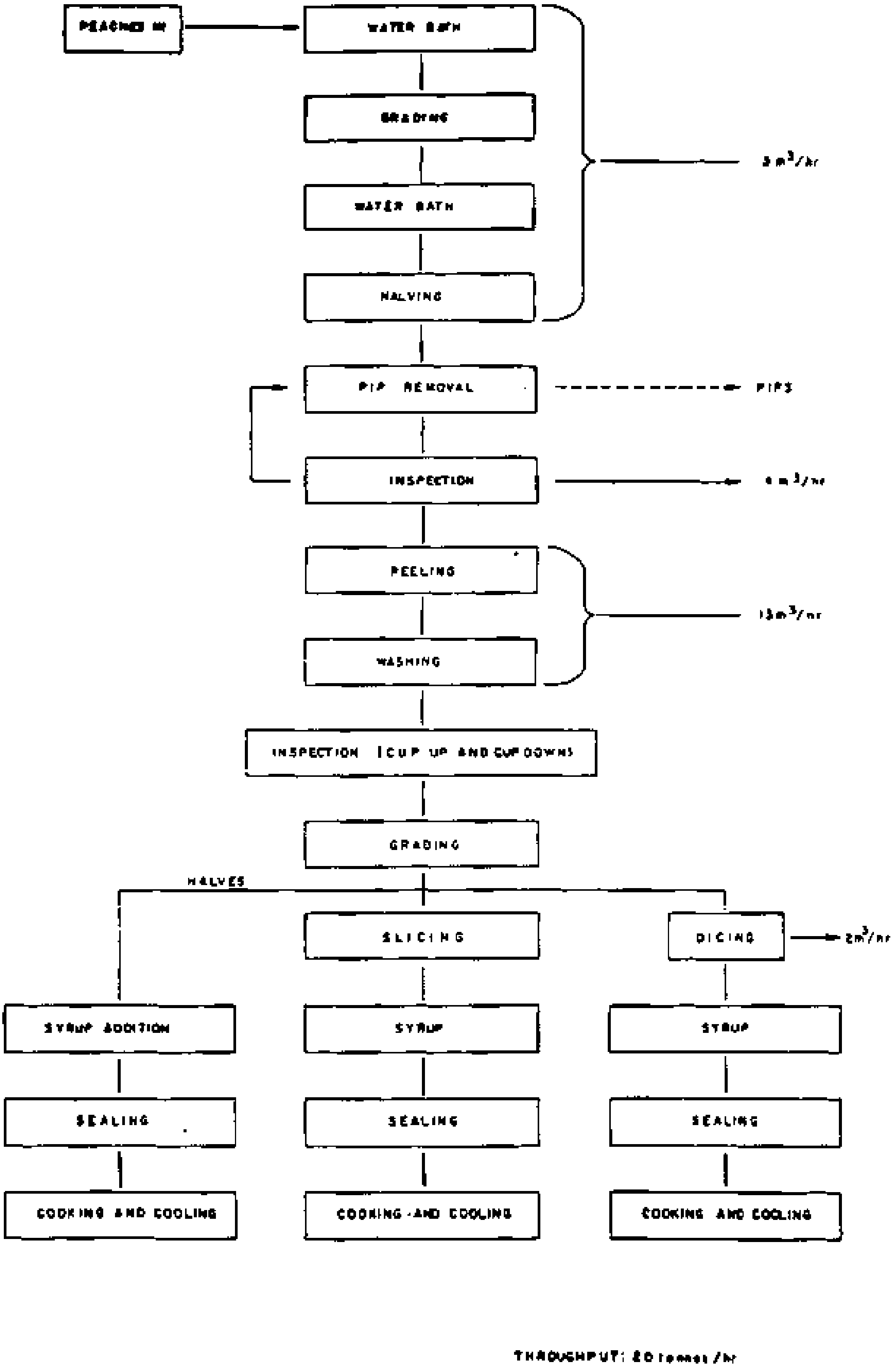
11.1 Production plants

Fifteen plants produce canned peaches using processing lines rated from 7 to 40 t/h giving production capacities between 1 500 and 30 000 tons per season. The general process flow diagram depicting the various steps of manufacture is given at Fig.11.1; the peaches are moved between process steps by elevators, water flumes and belts.

Processing involves preliminary washing and grading prior to halving, the pits are removed automatically with an inspection stage immediately after this step; any halves which have not been depitted correctly are recycled through this step. Acceptable halves pass into a caustic lye solution which softens the peel for subsequent washing or mechanical removal resulting in an effluent slurry. Following inspection and grading the halves either pass directly into cans or are further processed to slices or dices. Once in the cans, syrup is added before sealing, cooking and finally cooling the canned product in retorts or multiple-purpose machines.

CANNING OF PEACHES

FIG. 11.1



It can be seen that the majority of the pollution load arises from the peeler washer effluent which represents 75% of the total effluent flow.

10.4 Management needed

(a) reduction of water intake at the peeler washer together with gross solids removal by dry methods;

(b) adoption of revised washing down procedure.

10.5 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
6,0	4,6	3,20	700	0,90	195

TABLE 10.1

COMPARISON OF GUAVA PROCESSING PLANTS

FACTORY	RAW TONNES PROCESSED	SOLID WASTES	OVERALL WATER CONSUMPTION		OVERALL EFFLUENT GENERATION		
			VOLUME	SPECIFIC	VOLUME	SPECIFIC	% OF WATER
	t/a	t/a	$m^3/a \times 10^3$	m^3/t	$m^3/a \times 10^3$	m^3/t	%
1	2 700	675	17,20	6,40 *	-	-	-
2	2 400	600	16,80	7,00	12,20	5,11	73
3	1 500	390	9,60	6,40	-	-	-
4	1 000	250	4,00	4,00	-	-	-
5	900	225	5,50	6,10	4,15	4,61	76
6	300	75	3,00	10,00	-	-	-
7	300	75	1,90	6,40 *	-	-	-
8	250	63	1,60	6,40	-	-	-
9	100	25	0,64	6,40	-	-	-
10	59	15	0,40	6,40	-	-	-
Total	9 509	2 393		60,70	45,53	4,82	75%

* Estimate of (Average factories 2 to 6 is $6,4m^3/t$ used in 1, & 7 to 9)

11.2 Water intake

To permit comparison of the water intake at different peach processing lines, the techniques employed in the following salient processing steps which govern water intake must be identified:-

method of peel removal	-	wet or dry;
method of interstage transportation	-	water flumes or dry belts;
style of product being manufactured	-	halves, slices or dices;
method of can cooling	-	open or closed circuit;
quality of housekeeping	-	

The water intake data for the factories undertaking peach processing is given at Table 11.1. This table shows a variation in SWI per ton of raw peaches processed, from 2,5 m^3/t to 12,0 m^3/t; factory No. 7 returning the lowest consumption because all interstage transportation systems employ conveyor belts in place of water flumes. The overall NASWI derived by dividing the total tonnage processed by all the factories by the total water consumed, amounts to 6,88 m^3/t. As factory No. 1 uses water-flume transportation systems, and practices can cooling water recycling with a SWI of 4,0 m^3/t, it is evident that all factories should be able to achieve at least the NASWI without large capital expenditure.

An appraisal was made of the water consumed by the two aforementioned factories to demonstrate the effects of the transportation systems on total water intake.

	Factory No. 7 m^3/t	% total	Factory No. 1 m^3/t	Variation m^3/t
Process water	1,40	56-67%	2,81	+ 1,41
syrup make-up	0,55	22-16%	0,65	+ 0,10
plant wash-down*	0,27	11- 4%	0,15	- 0,12
domestic and boilers	0,28	11-14%	0,57	+ 0,29

* includes end-of-shift washdown only.

Examination of the process water requirements shows that factory 1 uses 1,41 m^3/t more than factory 7 which uses dry transportation systems. About 0,80 m^3/t is attributed to this alone with the remaining 0,61 m^3/t arising from differences in the number of washing stages and the peeling and peel removal systems amounting to 0,29 m^3/t. The balance of 0,32 m^3/t is due to evaporative losses in the closed-circuit can cooling water system. The difference in domestic/boiler consumption can partly be attributed to the dissimilar sizes of the factories, one having a larger number of processing lines and hence more staff. At another factory, the average SWI for the entire peach season amounted to 8,7 m^3/t, however a daily analysis of an eleven-day period during which 1 609 tons of peaches were processed revealed an average SWI of 6,7 m^3/t with a highest and lowest daily value of 8,3 m^3/t and 5,43 m^3/t respectively.

Management has been shown to have a significant effect on the quantity of water consumed. Factories 4 and 5 both have access to their own private water supplies free of cost and both discharge their effluents by routes which attract no disposal charges with the result that they both display high water consumption. At one of these factories spilt product was observed to be washed down the drain by prolonged flushing with hosepipes.

11.3 Liquid effluent

Fig. 11.2 shows the distribution of the various water intake flows, and effluent flows and qualities , at the various steps of processing. This data is summarized below:-

specific effluent volume 5,68 m^3/t		Quality	
% total flow	process step	COD 25,8 kg/t	SS 5,0 kg/t
		% total	% total
19	peeling/washing	45,0	39,0
13	pitting	9,6	14,0
8,5	pit flume	8,8	8,6
4,6	graders	14,0	5,0
30	washdown	9,0	18,0

It can be seen that 19% of the total flow carries 45% of the COD and 39% of the SS. This occurs due to poor management in the peeling area. The washing down of plant used 30% of the total flow and carries a further 18% of the SS.

Typical concentrations of normally-monitored indicators of organic and solids pollution show the following results for a factory using dry transportation systems prior to implementing any water management.

Process stage	COD mg/ℓ	OA mg/ℓ	SS mg/ℓ	COD:OA ratio
Plant floor run-off at inspection area	13 740	4 240	418	3,2
Dry peeler	72 380	21 680	10 080	3,3
Wet peeler	43 160	12 880	6 480	3,3
Final effluent	19 520	5 760	1 256	3,4

Factories using wet transportation systems differ in the concentration of the final effluent which was found to have varying strengths depending on the quality of housekeeping, especially at the peeling stage:-

	COD mg/ℓ	SS mg/ℓ
Typical final effluent	4 600 to 13 000	1 600

11.4 Management needed

(a) flume water surging should be corrected;

(b) flume water can be recycled after removal of SS by dissolved air flotation and sugar could be removed by membrance processes;

(c) the peeling and pitting area should be segregated by addition of a bund wall and effluents collected in a sump and removed for disposal separately after suspended solids removal. This removes the caustic soda from the effluent thereby assisting irrigation;

(d) segregate and remove all caustic soda overflow or caustic dump;

(e) the can cooling water overflows could be avoided by correcting the circuit design, could be collected for use in the first plant wash down or recycled in plants where this is not practised;

(f) the wash down water could be divided into three stages:-

(i) preliminary solids removal by air assisted manual collection of coarse solids;

(ii) preliminary wash with renovated water followed by foaming antiseptic spray;

(iii) final wash with high-pressure potable quality water;

(g) pits should only be removed by dry techniques.

11.5 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
5,14	4,11	20,70	5000	1,97	500
Ultimate					
5,14	4,11	11,6	2800	1,97	500

The flow target can be approached by implementing the revised washing down procedure (saving 1 m^3/t) and avoiding flume water replenishment by using dissolved air flotation. The COD target can be achieved by managing the peeling and peeling washer area, keeping solids completely out of the effluent and also revising the methods of washing down.

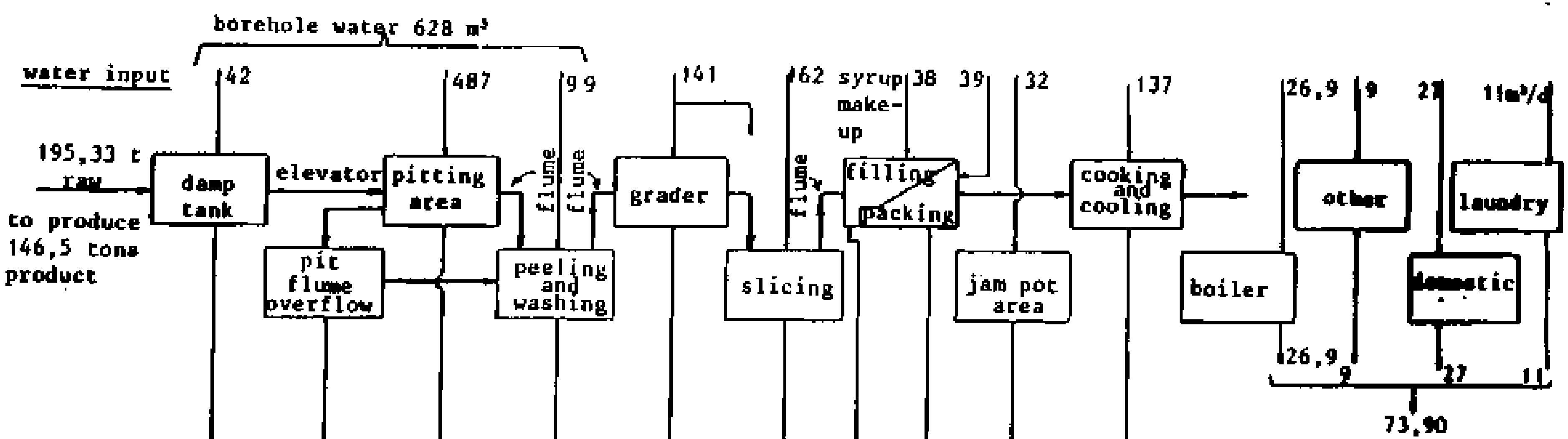
The ultimate target can be approached by applying membrane techniques to the peeling effluent.

TABLE 11.1

COMPARISON OF PEACH PROCESSING PLANTS

FACTORY	RAW TONNES PROCESSED	SOLID WASTES	PROCESS CAPACITY	OVERALL WATER CONSUMPTION		OVERALL EFFLUENT GENERATION			REMARKS	
				VOLUME	SPECIFIC	VOLUME	SPECIFIC	% OF WATER		
	t/a	t/a	t/h	$m^3/a \times 10^3$	m^3/t	$m^3/a \times 10^3$	m^3/t	%		
1	30 000	6 000	40,0	125,4	4,0	89,0	2,98	74,7	Effluent irrigated to 34 ha	WT-TXL-CWR-LPEE
2	20 000	5 000	26 /27	150,0	7,5	117,0	5,85	78,0	Large multi-product plant	WT-TXL
3	14 000	3 080	16 /17	126,0	9,0	98,0	7,00	77,7	-	WT+DT-WP CWR
4	10 000	2 500	18	84,0	8,4	65,0	6,50	77,4	Part of water used from private supplies	WT
5	10 000	2 000	25	120,0	12,0	94,0	9,50	79,0	Part of water is private borehole Effluent discharged to ocean	WT+DT-CWR
6	7 635	1 542	13 /14	34,3	4,5	27,5	3,60	77,7	Effluent irrigated onto 10ha (a further 20 ha is available)	WT-WP-LPEE
7	7 500	2 250	17 /18	18,75	2,5	12,5	1,67	66,7	Dry transport belts	DT
8	7 500	2 325	14 /15	65,25	8,7	51,0	6,80 *	78,0 *	-	DT-SWR
9	7 000	1 820	N.D.	48,0	6,9 *	37,0	5,28	78,0 *	-	WT-CWR+LPEE
10	6 000	1 500	7	41,5	6,9 *	32,0	5,33	78,0 *	Counterflow reuse of water	WT CWR
11	6 000	2 220	10	52,2	8,7	45,0	7,44	85,5	Cooling water used once for pitting machine	WT CWD
12	3 300	675	7	22,8	6,9 *	18,0*	5,45	78,0 *	Effluent irrigated onto 14 ha	-
13	1 926	481	-	13,3	6,9 *	10,4*	5,38	78,0 *		-
14	1 500	450	5,5	9,0	6,0	7,0	4,67	77,7		WT - WP
Total	132 361	31 847	-	910,0	6,88	703,0	5,31	77,0		

LEGEND
- CBF - Condensates used as boiler feed
- CWD - Can cooling water reused
- CWR - Can cooling water recycled
- ND - No data
- * - Estimated as average
- DT - Dry transportation systems
- LP - Lye peeling
- LPEE - Lye peel removal water separated from main effluent
- TXL - Interstage transport distances long
- WP - Wet peel removal
- WT - Wet transport systems
- VSR - Vacuum pump seal water reused



		damp tank	pit flume overflow	pitting area	peeling and washing	grader	slicing	filling	packing	jam pot area	cooking and cooling		process total	wash-down	Daily total
	flow m³/d	42	94	145	214	51	59	47	10	13	102		777	332	1109
	m³/t	0,29	0,64	0,99	1,46	0,35	0,40	0,32	0,07	0,09	0,70		5,30	2,27	7,57
	% total	3,8	8,5	13,1	19,30	4,60	5,30	4,2	0,9	1,20	9,2		70,0	30,0	100
	Filt. COD mg/ℓ	1 080	4 713	3 347	10 500	13 767	1 335	9 447	5 940	1 870	546		4 123	1 363	5486
	kg/t	0,31	3,03	3,32	15,38	4,80	0,54	3,03	0,40	0,16	0,38		31,35	3,09	34,44
	% total	0,70	8,8	9,6	45,0	14,0	1,6	8,8	1	0,5	1		91	9	100
Not obtained in survey	Tot. COD mg/ℓ														
	kg/t														
	% total														
	SS mg/ℓ	1 830	894	962	1 763	989	553	683	412	102	14,36		1 000	526	1526
	kg/t	0,53	0,57	0,95	2,58	0,34	0,22	0,22	0,03	0,01	0,01		5,46	1,19	6,65
	% total	8,0	8,6	14,3	39,0	5,0	3,3	3,3	0,4	0,1	0,1		82	18	100
	pH	5,0	4,8	4,50	11,7	4,4	4,5	4,4	4,6	4,5	–		6,7	8,90	–
Not obtained in survey	TDS														
	kg/t														
	% Total														

Note: tons are per ton of raw material

FIG. 11.2 PEACH PROCESSING

A.12 CANNING OF PEARS

Water
743 x 10^3 m^3/a NASWI 12,7m^3/t

Factories
10 No. Cape Province

Raw tonnage
58 500 t/a

Products
Halves Dices

Liquid effluent	Solid wastes
386 668 x10^3 m^3/a	22 933 t/a

* see note at foot of Table 3

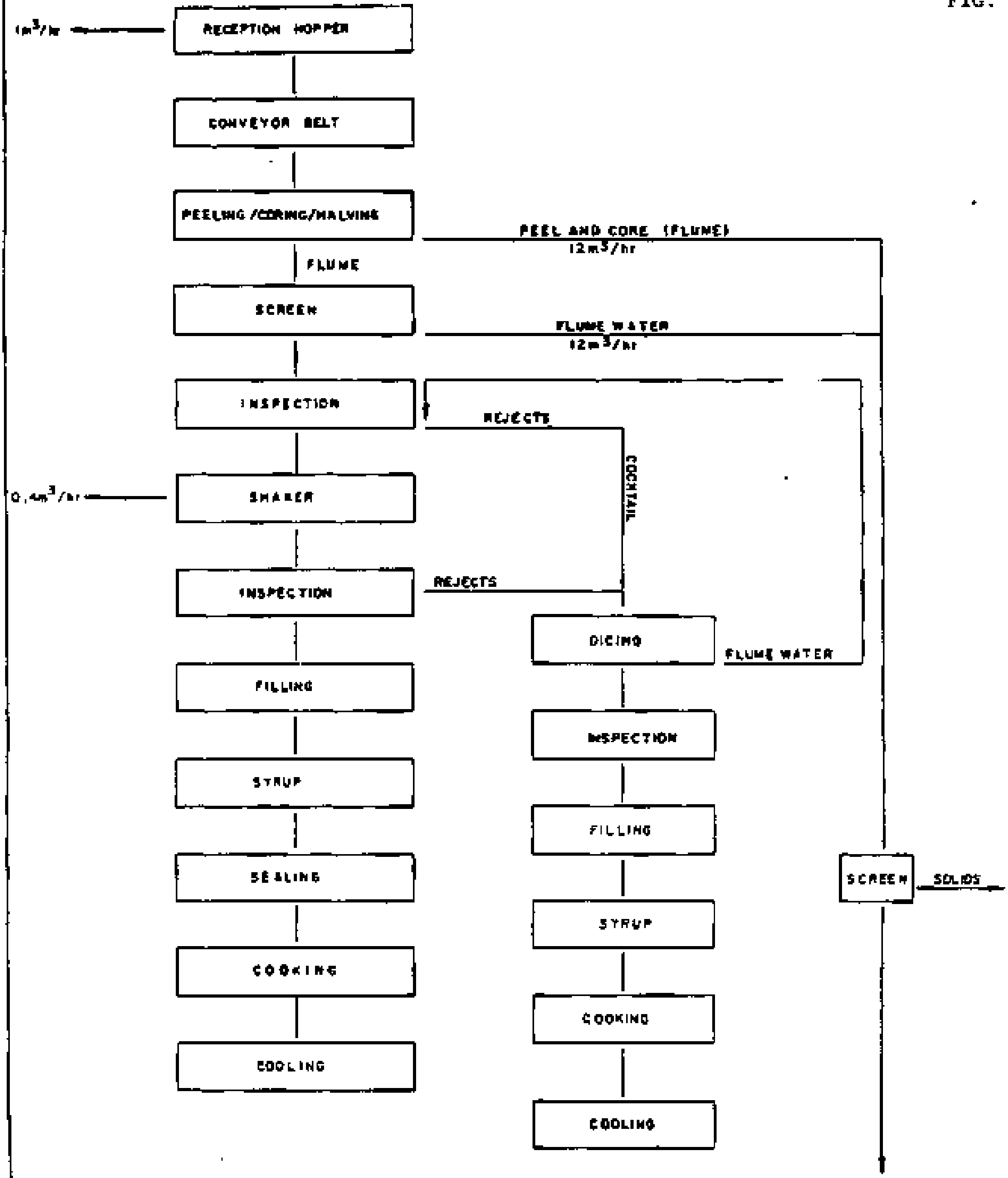
12.1 Production plants

Ten factories can pears using processing lines rated from 5 to 16 t/h having annual production capacities of up to 16 000 t per factory. The typical process flow diagram depicting the various steps of manufacture is shown at Fig. 12.1.

Processing involves a number of flow-through type washers feeding the peelers; in some plants one washer is used to feed several peeling machines. Elevators transport the fruit from the washers into the peelers which mechanically remove the peel and core and half the fruit; the wastes are removed by water flume. The fruit is then inspected on belts before proceeding to can filling, syrup make-up, sealing, cooking and cooling.

CANNING OF PEARS

FIG. 12.1



THROUGHPUT: 15 tonnes / hr

12.2 Water intake

Water is used at the following process steps:-

(a) flow-through washer(s);

(b) sprays at peelers and halvers;

(c) fluming from peelers and halvers;

(d) sprays on conveyor belts;

(e) syrup make-up;

(f) cooking, cooling, steam raising;

(g) plant and floor cleaning.

The water intake data collected during the survey of pear canning plants is given at Table 12.1 from which it can be seen that the ASWI varies from4,5 m^3/t to 29,0 m^3/t giving a NASWI of 12,70 m^3/t.

The water for processing tasks amounts to about 87% of the total water intake, a further 8% is used for washing down the plant, and 5% for boiler make-up and domestic duties; the quantity used for flume transportation amounts to at least 38% of the total requirements if the flume waters are partially recycled and far more if they are discharged directly to waste after being used once.

Usage was distributed at factory No. 4 having a 15 t/h processing capacity as follows:-

Consumer	m^3/h	Water intake	
		m^3/t	% of total
duplicate flumes	32,00	2,13	38)
other processing water	41,20	2,74	49) 87
plant washing	6,70	0,45	8
boilers and domestic	4,20	0,28	5
Total	84,00	5,60	100

12.3 Liquid effluent

The liquid effluent from a factory is shown at Fig. 12.2 which also depicts the distribution of water and effluent throughout the process line.

% total water	specific effluent volume	Quality	
		COD	SS
	8,87 m^3/t	25,86 kg/t	4,13 kg/t
		% total	% total
17	mechanical peeling and waste flume	41	18
17	pear flume halves	18	23
7	pear flume whole	10	18
16	wash down	20	17
13	cooling	-	-

The fig. above shows that 28% of the COD and 41% of the SS load resides in 24% of the total flow; this is in the flumes alone. 41% of the total COD originates in the peeling area.

Final effluent strengths measured varied widely, the following were derived at one plant:

location	volume		COD			SS		
	m^3/t	%	kg/t	mg/ℓ	%	kg/t	mg/ℓ	%
Final effluent	2,93	100	14,43	4924	100	2,67	910	100
flume water	2,13	73	12,99	6100	90	2,17	1020	81
Floor run-off	2,80	27	1,44	1800	10	0,50	625	19

12.4 Management needed

(a) elimination of water flumes for peel removal;

(b) segregation by bunding of peeling area;

(c) optimising of hydraulics of flumes, removal of SS and possible water recovery with concentration of sugars by membrane processes.

12.5 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
8	6,44	16,1	2500	3,2	500

Specific intakes of 4,5 m^3/t and 5,6 and 7,05 m^3/t are met by some factories. Among the areas of conservation are the peelers and the flumes.

The COD and SS targets can be approached by revising the washing down routes as discussed before, catching all juice run-off at the mechanical peelers for membrane treatment and perhaps reuse. The flumes should be fitted with flow balancing and the suspended solids removed at each recycle by screens and flotation.

TABLE 12.1

COMPARISON OF PEAR PROCESSING PLANTS

FACTORY	RAW TONNES PROCESSED	SOLID WASTES	PROCESS CAPACITY	OVERALL WATER CONSUMPTION		OVERALL EFFLUENT GENERATION		
				VOLUME	SPECIFIC	VOLUME	SPECIFIC	% OF WATER
	t/a	t/a	t/h	m^3/a x 10^3	m^3/t	m^3/a x 10^3	m^3/t	%
1	16 000	6 400	12	203	12,70 *	-	-	-
2	12 000	4 800	16	152	12,70 *	-	-	-
3	9 000	3 600	9	63,4	7,05	-	-	-
4	6 000	1 500	15	33,6	5,60	17,4	2,9	52
5	5 000	2 250	8	71,0	14,20	64,0	12,8	90
6	4 300	1 978	7/8	124,7	29,00	-	-	-
7	2 500	1 000	51	60,0	24,00	-	-	-
8	2 000	760	-	25,4	12,70 *	-	-	-
9	1 500	645	5/6	6,75	4,50	-	-	-
10	200			2,54	12,70 *	-	-	-
Total	58 500			742,0	386-668	2,9 to 12,8		

* Wide variations of effluent generation and absence of data prohibits calculation of average; thus the range of values is shown.

13 CANNING AND JUICING OF PINEAPPLES

Water
562×10^3 m^3/a NASWI 2,94 m^3/t

Factories
6 No. Eastern Cape Natal

Raw tonnage
191 000 t/a

Products
rings cubes/chunks slices juice

Liquid effluent	Solid wastes
282×10^3 m^3/a or 1,48 m^3/t	85 000 t/a

13.1 Production plants

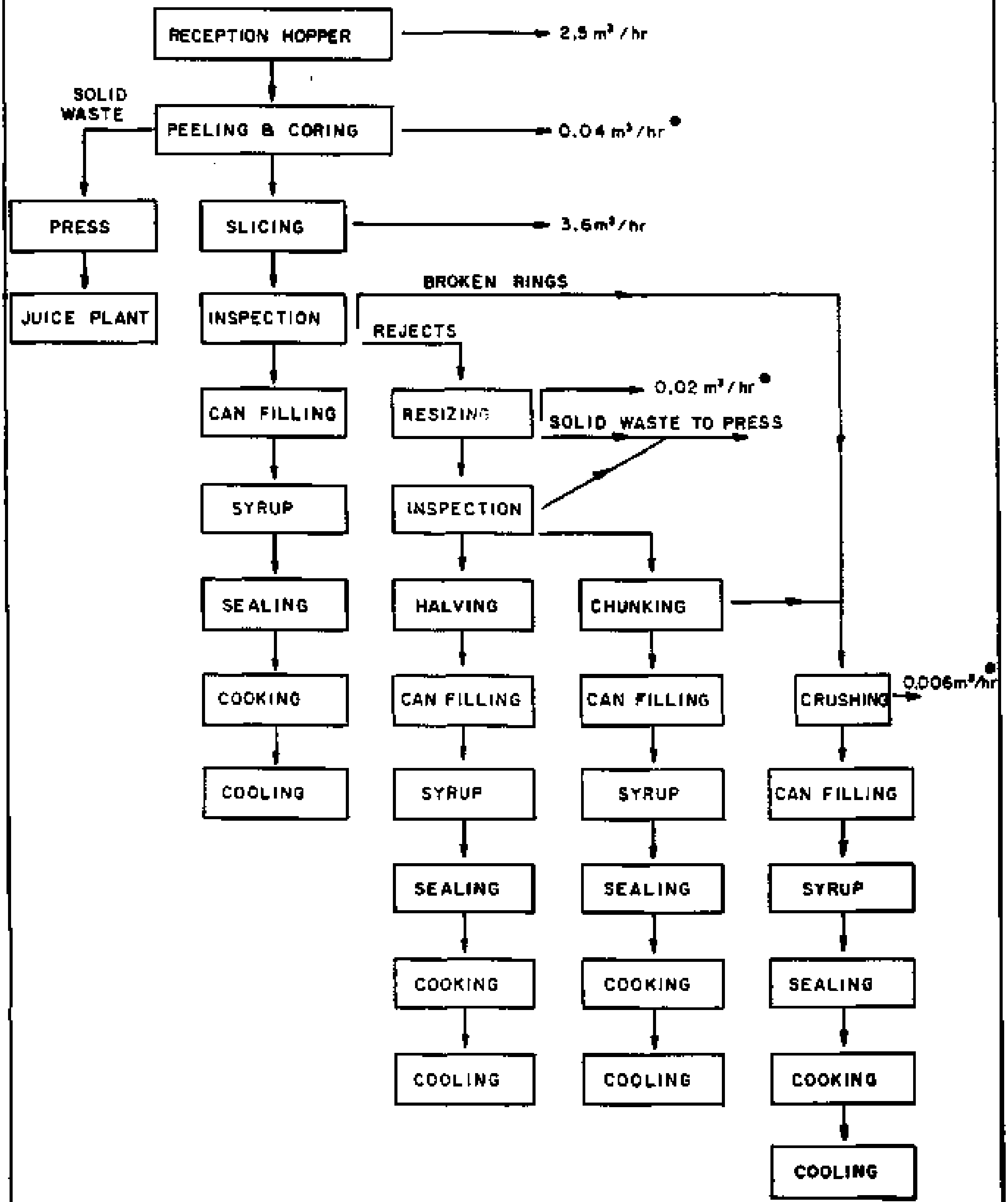
Six major factories process pineapples having a total combined annual production of 191 000 t/a. A typical flow diagram is given at Fig. 13.1. Fruit is delivered in crates and dumped into flow-through washers before being elevated to size graders for segregation into 3 sizes. The fruit is forced through a hollow cylinder which removes the tops and peel in one operation. A second small tube is forced through the centre of the fruit to remove the core.

Peeled fruit is inspected and hand trimmed before entering the slicers; any which still contain pieces of skin are returned to re-sizing machines which produce perfect smaller rings. Correctly-shaped rings are canned, with broken or other undersized portions being passed for chunking or crushing.

Natural or concentrated strength juices are made from solid residues expelled by the canning operation including peels, cores and reject slices which pass to presses to remove the juice which is heated to 600 deg.C centrifuged and then either passes to an evaporator for concentration or is used at natural strength.

CANNING OF PINEAPPLE

FIG. 13,1



● PURE JUICE

THROUGHPUT : 21 tonnes/hr

13.2 Water intake

The pineapple canning process uses water for lubrication sprays, cooling, washing down of the plant, steam raising and syrup manufacture. Inspection of Table 13.1 shows that the NASWI calculated from annual values varied from 2,10 m^3/t to 4,55 m^3/t with a NASWI of 2,94 m^3/t.

The water usage during pineapple processing can be divided as follows;-

Consumer	% of total	specific usage m^3/t	flow per day * m^3/d
Process syrup make-up	19) 5) 24	0,42) 0,11) 0,53	93) 24) 117,5
boilers	11	0,24	54
cooling	51	1,12	250
wash down	14	0,31	69
Total	100%	2,20	490

* 21 t/h x 10,6 hrs/day

13.3 Liquid effluent

The liquid effluent discharged from the processing lines of the six factories varied from 1,2 m^3/t to 1,70 m^3/t. The survey showed it to originate as follows:-

Source	% of total	specific usage m^3/t	flow per day * m^3/d
Reception hopper Sprays on belts	21,5	0,36	8,5
cooling	67,0	1,12	23,60
juice loss	0,2	0,004	0,09
floor wash	11,4	0,19	4,00
Total	100%	1,67	35,29

It can be seen that about 21% of the effluent originates from the processing tasks, 67% from the cooling systems and about 11% from plant and floor washing.

The specific pollution loads were found to be variable from factory to factory determined by variations in the throughput and the degree of juice spillage which is the major contributor to the load.

The average pollution loads are 17,92 kg COD/t and 1,66 kg SS/t.

13.4 Management needed

(a) trapping all solids prior to falling on floors;

(b) collection of all juices at coring and slicing areas;

(c) collection of centrifuge blow down;

(d) use of revised washdown procedure.

13.5 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
2,76	1,55	12,36	7974	2,0	1290

The targets set above can be readily achieved but they may be substantially surpassed. Solids should be prevented from falling into the drains with consequent fermentation and contribution to the COD and SS concentrations.

Additional care is needed to reduce the 0,2% juice loss which occurs. The juices have COD concentrations in excess of 100 000mg/ℓ and methods to reduce this warrant study. It is considered that membrane processes operating on these low flow high strength effluents would be suitable. The effluent from these areas would need to be segregated from the effluent from the other floors.

Consideration should also be given to diffusing the sugars from the relatively large amount of waste product with the skins, cores and peels, followed by their concentration with polysulphore-based reverse osmosis plants.

Preliminary trials also suggest that some citric acid separation from juice can be accomplished with membranes.

TABLE 13.1

COMPARISON OF PINEAPPLE PROCESSING PLANTS

FACTORY	RAW TONNES PROCESSED	SOLID WASTES	PROCESS CAPACITY	OVERALL WATER CONSUMPTION		OVERALL EFFLUENT GENERATION		
				VOLUME	SPECIFIC	VOLUME	SPECIFIC	% OF WATER
	t/a	t/a	t/h	$m^3/a \times 10^3$	m^3/t	$m^3/a \times 10^3$	m^3/t	%
1	47 000	16 450	-	150,40	3,20	56,40	1,20	37
2	40 000	18 000	-	182,00	4,55	49,00	1,48	32
3	40 000	18 000	21,0	84,00	2,10	66,80	1,67	79 *
4	25 000	11 250		62,50	2,50	42,80	1,70	68
5	22 000	9 900		60,90	2,77	33,00	1,50	54
6	17 000	11 390		72,10	4,24	24,14	1,42	33 *
Total	191 000	84 990	-	361,50	2,94	282,14	1,48	50%

* Juice included

14 CANNING OF PEAS

Water usage
326 x 10^3 m^3/a NASWI 22,8 m^3/t

Factories
6 No. Cape & Transvaal

Raw tonnage
14 325 t/a

Products
Canned berries

Liquid effluent	Solid wastes
no data	2 149 t/a

14.1 Production plants

Six factories process 14 325 t/a of peas to canned products in accordance with the process steps shown at Figs. 14.1 and 14.2. If the peas are delivered on vine, the vines are separated and the berries are washed, destoned and graded into different size groups using a drum grader. Washing and blanching preceeds can filling, brine addition, sealing, cooking and cooling. The Figs. show 17 t/h and 4 t/h process lines; interstage transportation is accomplished by pumping and water fluming.

14.2 Water intake

The NASWI was found to be 22,8 m^3/t although variations from 19 to 25 m^3/t were noted. The water flows to the processing lines at 2 factories having different processing sequences, were measured.

The factories compared differ in their capacity, the number of flumes, blanchers and pumping circuits. The specific intake for the blancher circuits correlate well even though the sizes are different. However, examination of the flume and pump circuits shows they are relatively high water users due to severe spillages.

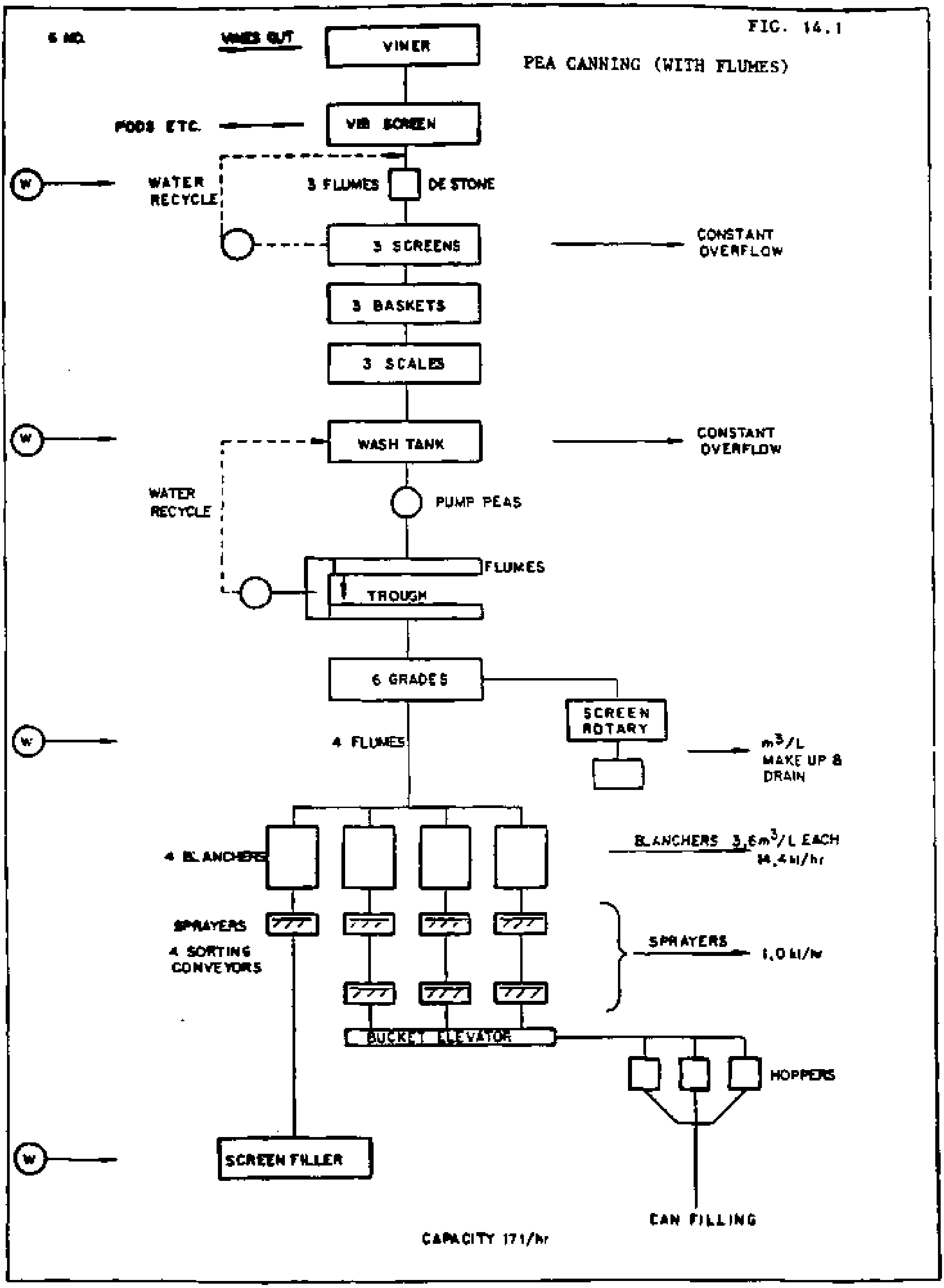
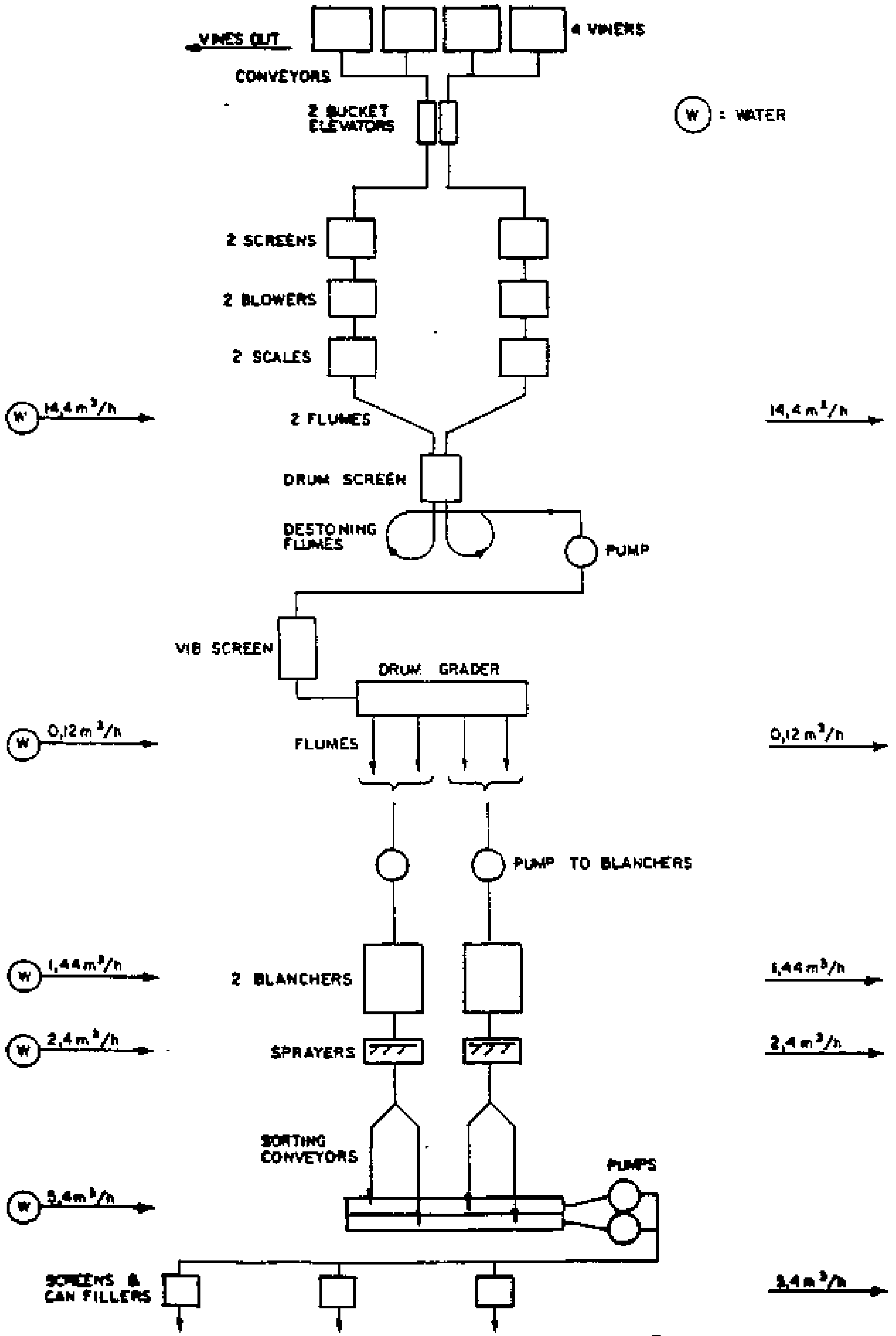


FIG. 14.1

PEA CANNING (WITH FLUMES)

PEA CANNING (PUMPING & FLUMES)

FIG. 14.2



14.3 Liquid effluent

The liquid effluent originates mainly from flume and pump circuit spillages. Analyses performed on samples collected at various stages of processing show that the blancher output amounts to about 13% of the effluent but contributes 60% of the total COD and 57% of the suspended solids in the final effluent.

14.4 Management needed

(a) fitting of balancing to flume and pumping circuits;

(b) segregation of the effluents from the pod/stick remover and the drum washers for SS removal by static screens;

(c) attention to the blancher effluent for sugar removal would provide a major reduction in COD;

(d) revised washing down procedures.

14.5 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
10,0	8,0	15,0	1875	2,5	312

Ultimate

10	8,0	7,6	1000	1,6	200

15 PROCESSING OF TOMATOES

Water usage
249×10^3 m^3/a NASWI 2,44 m^3/t

Factories
10 major plants Cape & Eastern Transvaal

Raw tonnage
101 900 t/a

Products
whole canned - 26 400 t/a concentrate & sauce 75 500t/a

Liquid effluent	Solid wastes
204×10^3 m^3/a - $2m^3/t$	10 190 t/a

15.1 Production plants

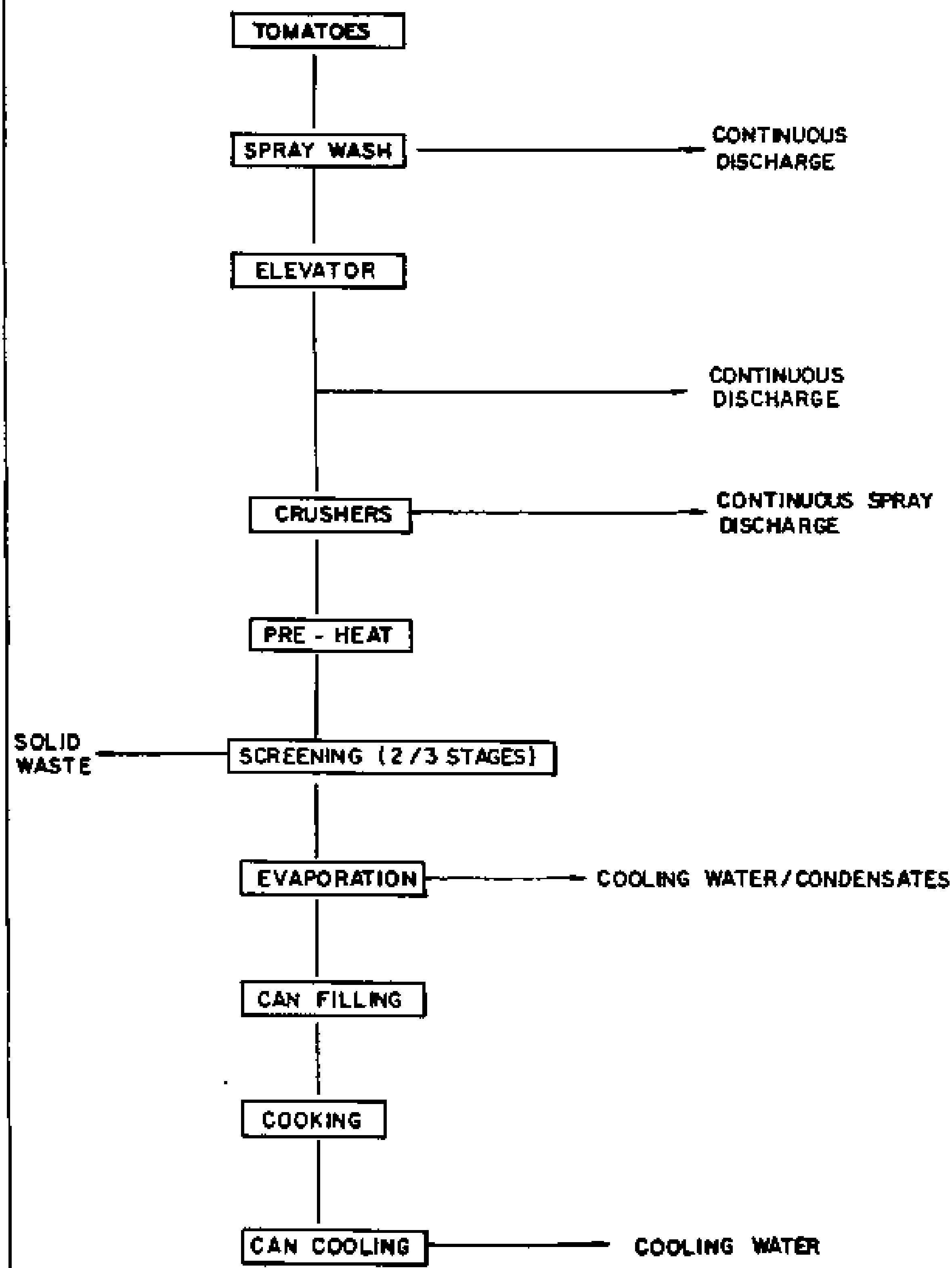
Ten major plants process 26 400 t/a of tomatoes to whole canned products, and 75 500 t/a to concentrates including tomato pastes and sauces. A typical process block diagram for production of concentrates is shown at Fig. 15.1.

The fruit passes a spray, a flow-through washer or a combination of both stages before rejected fruit stalks and leaves are removed at inspection stage, followed by tumble washing. The fruit is then crushed; in some cases it is preheated and passed to a pulping machine and in one case it is fermented for 48 hours after crushing prior to further processing.

The pulp is then screened to remove the major solids and the juice passed to holding tanks at a solids content of 5%, which is suitable for producing canned juice. Juice used for sauce manufacture continues to further cooking pots for concentration to 28% solids. Paste manufacture, where juice of 35 - 40% solids is required, is accomplished by further concentration of juices to this level in an evaporator.

FIG. 15.1

PROCESSING OF TOMATO PASTE
OR CONCENTRATE PRODUCT



All products are canned or bottled with the normal sealing, cooking and cooling process steps.

The process diagram for whole canned tomatoes is shown at Fig.15.2. The fruit is delivered, sorted and inspected prior to being submerged in hot water or exposed to steam to loosen the skins; in some plants lye peeling is still used. Scalded tomatoes are spray cooled, peeled by hand and the cans are filled with fruit and tomato juice before sealing, cooking and cooling.

15.2 Water intake

Water is used mainly for fruit and machinery washing together with cooling. The average specific water intake is 3,0 m^3/t for canning and 2,20 m^3/t for concentrated products. The data below for concentrate products exclude the water recovered from the evaporative processes and reused.

Factory	Quantity processed t/a	Specific water intake ℓprocess'n m^3/t
1	20 000	2,70
2	15 000	1,68
3	15 000	2,31
4	9 500	2,00
5	6 000	1,75
Total	65 500	2,20

15.3 Liquid effluent

The concentration process generates water from the product at a rate estimated to be 0,7 m^3/t, and the effluent volume discharged is approximately equal to the water supplied which indicates that the water generated by the process equals the consumptive use.

The main sources of effluent are from the scalding tanks and the continuous plant washing operations.

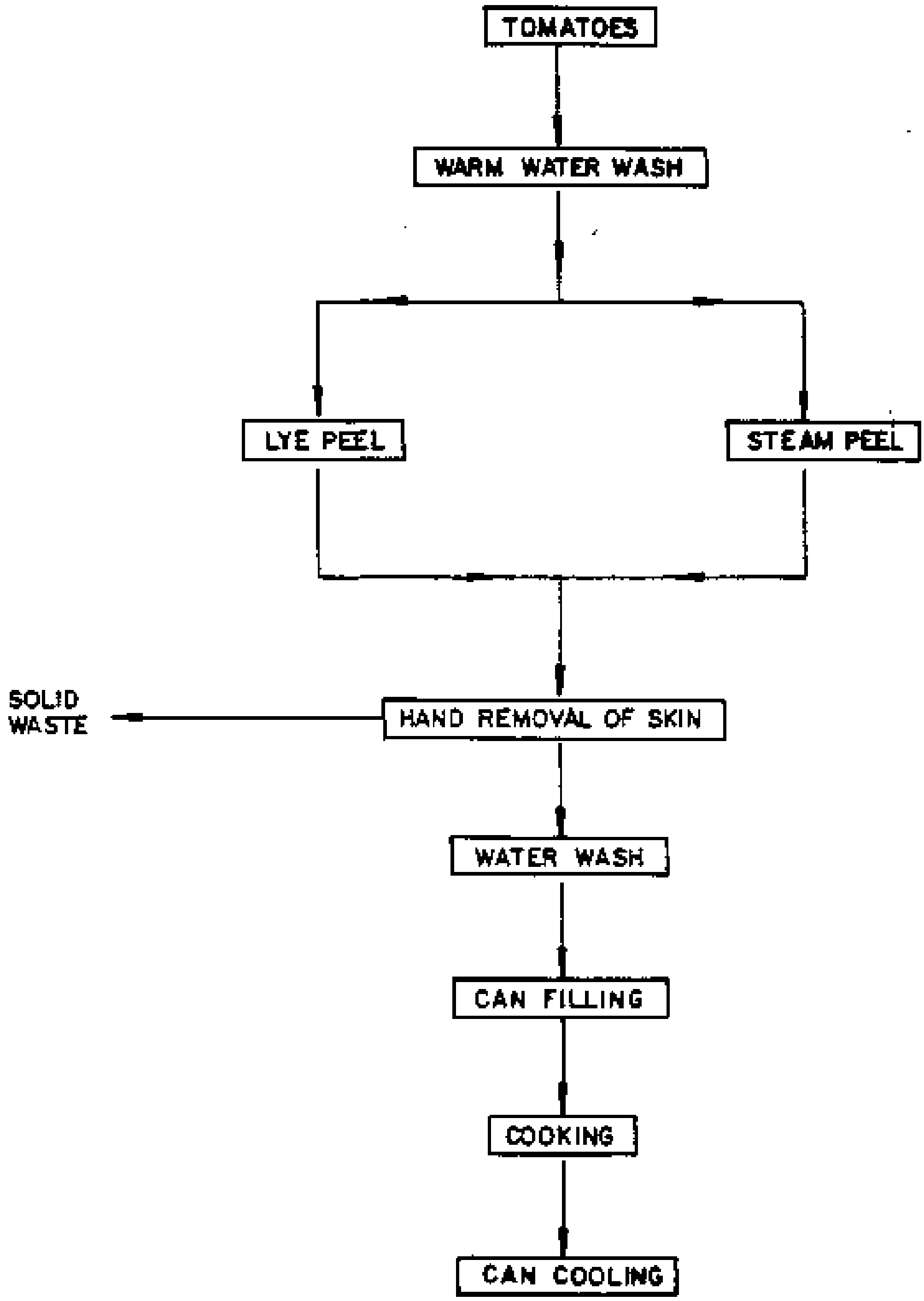
The effluent strength from tomato concentration plants was found to have the following characteristics:-

COD 1 020 - 1 100 mg/ℓ (with a high value of 5 800 mg/ℓ at one factory)

SS 493 mg/ℓ

PROCESSING OF TOMATO TO WHOLE PEELED PRODUCT

FIG. 15.2



The major pollutants originate from the washing of the pan cookers, the crushers/screens and the peeling baskets.

15.4 Solid wastes

The solid wastes are relatively dry and consist mainly of skins and pips amounting to 10 190 t/a which are generally composted or used as cattle feed.

15.5 Process developments

New juice concentration plants in Europe are tending to adopt reverse osmosis for concentrating the juice at least in part, prior to evaporation. This can result in a considerable saving in steam and hence water.

16 FREEZING OF VEGETABLES

Water usage
1 564 x 10^3 m^3/a NASWI 26,6 m^3/t

Factories
3 No. Cape and Transvaal

Raw tonnage
58 000 t/a

Products
carrots-dried sliced or whole beans-sliced or cut corn kernels cauliflower broccoli spears

Liquid effluent	Solid wastes
1 096x10^3 m^3/a 18,64 m^3/t	17 931 t/a

16.1 Production plants

Three factories process the following approximate quantitites of vegetables to various frozen commodities with one other factory processing broccoli periodically:-

	t/a
peas	12 924
carrots	11 987
green beans	8 448
brocolli	7 138
corn	6 703
cauliflower	5 586
brussel sprouts	2 040
other vegetables	255

The preparation steps in processing are similar to those conducted for canning the commodities. The major difference in processing occurs after blanching where the vegetable is cooled from 100 deg.C to about 30 deg.C either using cold water cooling flumes which retain the product in contact with water until the desired temperature is reached or by potable water sprays. Thereafter the vegetables are dewatered on vibrating screens and enter the individual quick freezer.

16.2 Water intake

The freezing of vegetables consumes nationally about 1 564 000m^3/a of water. We found that the a SWI varied from 13,7 m^3/t at one factory to 43,5 m^3/t at another and that the factory with the highest SWI recorded usages of between 27,1 m^3/t and 52,2 m^3/t. The overall NASWI was calculated as 26,6 m^3/t.

The largest single water demand is from the cooling flumes which consume up to 68% of the total water requirements at one factory with an average of 63%. The use of such flumes on open circuit at one plant has distorted the NASWI which was found for various commodities as follows:-

Commodity	NASWI m^3/t
peas	30
sprouts	29
green beans	27
carrots	26
cauliflower and brocolli	25

16.3 Broccoli freezing

The process schematic diagram for broccoli freezing is given at Fig. 16.1 At one factory post blanch flumes were used to cool the broccoli from 100 deg.C about 20 deg.C whereas at another shown diagramatically at Fig. 16.2, a spray of potable water was used into the cooling stage of the bucket blancher. The former plant processed broccoli with a water intake of 8,12 m^3/t whereas the latter employed 23,9 m^3/t.

BROCCOLI FREEZING

FIG. 16.1

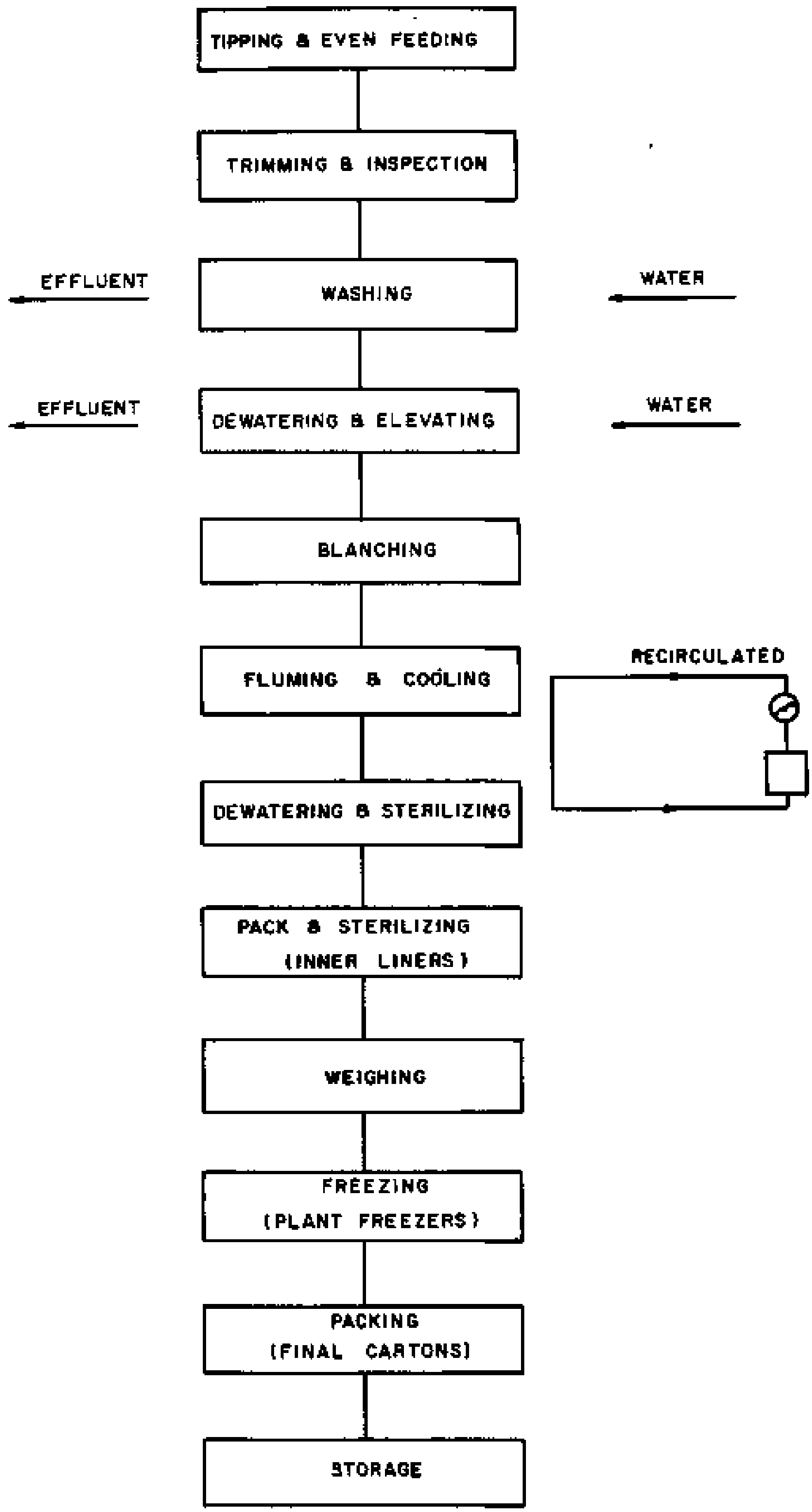
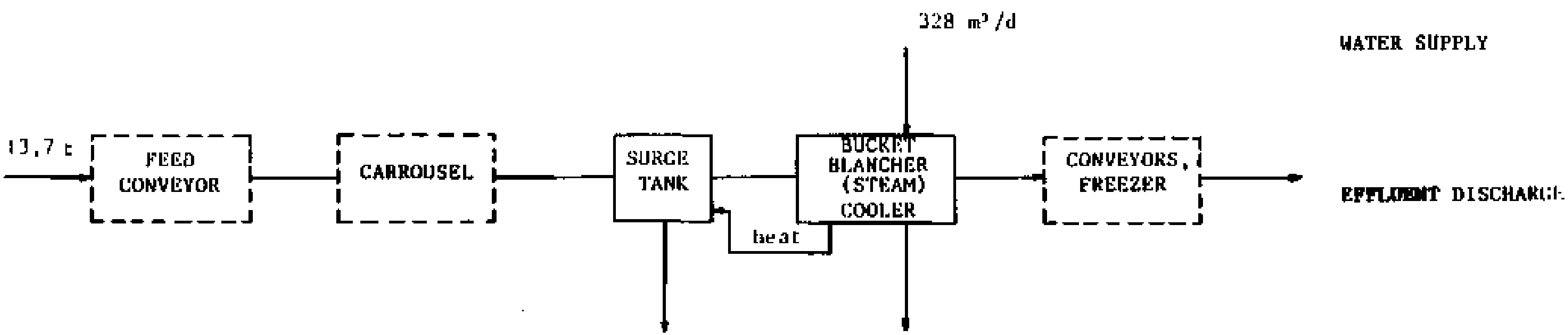


FIG. 16.2



flow	*100	m^3/d
COD	9660	mg/ℓ
COD	966	kg/d
S.S.	280	mg/ℓ
S.S.	28	kg/d
spec. flow	7,2	m^3/t
spec. COD	70,5	kg/t
spec. S.S.	2,0	kg/t

flow	*288	m^3/h
COD	640	mg/ℓ
COD	146	kg/d
S.S.	136	mg/ℓ
S.S.	31,0	kg/d
spec. flow	16,6	m^3/t
spec. COD	10,6	kg/t
spec. S.S.	2,3	kg/t

COMPOSITE

flow	328	m^3/d
COD	3390	mg/ℓ
COD	1112	kg/d
S.S.	179	mg/ℓ
S.S.	59,0	kg/d
spec. flow	24,0	m^3/t
spec. COD	81,1	kg/t
spec. S.S.	4,3	kg/t

Total specific water usage 23,9 $m^3/\cdot$

* estimated split in flows

specific effluent volume 8,12 m^3/t		Quality	
% total water	process step	COD 34,08 kg/t	SS 0,38 kg/t
30	first wash	8	16
1	blancher	5	1
66	chiller flume	78	81

Fig. 16.3 shows the distribution of effluent along the process lines.

16.4 Management needed

(a) reduction of post-blanch cooling water;

(b) treatment of first washing effluent;

(c) avoiding spilt solids.

16.5 Targets

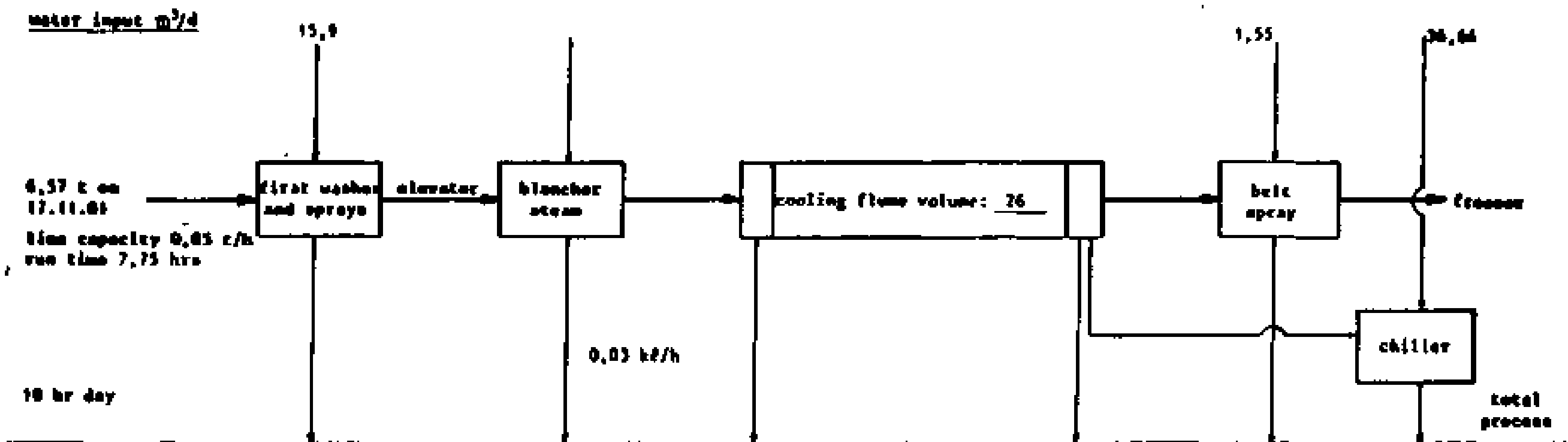
Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
10,0	8,0	29,0	3600	1,0	125

16.6 Carrot Freezing

The processing schematic diagram is shown at Fig. 16.4 while Fig. 16.5 shows the distribution of effluents and their quality along the process line, this data being summarized below:-

FIG. 16.3

Broccoli processing - freezing



														total process
flow	m³/d	15,90		0,33							1,55		35,5	53,20
	m³/t	2,42		0,05							0,24		5,45	8,12
% total		30		1							3		66	100
filt. COD	mg/ℓ	1 100		31 216		7 164		7 066			13 742		4 926	
	kg/t	2,66		1,57							3,24		26,61	
% total		8,0		5,0							10,0		70,0	100
filt. PV	mg/ℓ	23		736		167		207			208		376	302
	kg/t	0,06		0,04							0,32		2,03	2,46
% total		0,5		0,5							2		97	100
SS	mg/ℓ	23		86		54		69			43		57	
	kg/t	0,06		0,004		-		-			0,01		0,31	0,38
% total		16		1				-			3		81	100
pH		7,5		5,6		3,3		3,3			3,4		3,4	5,5

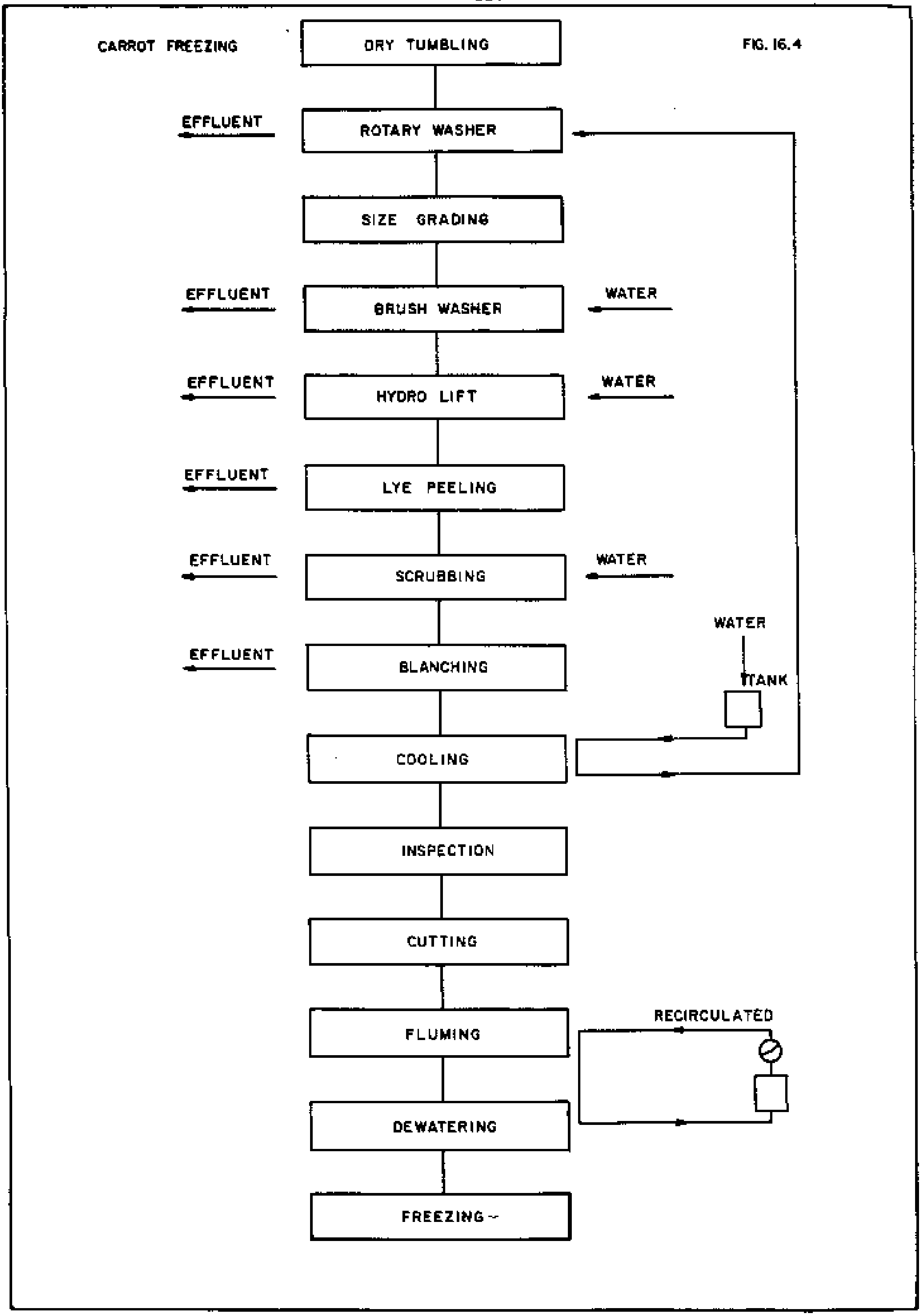
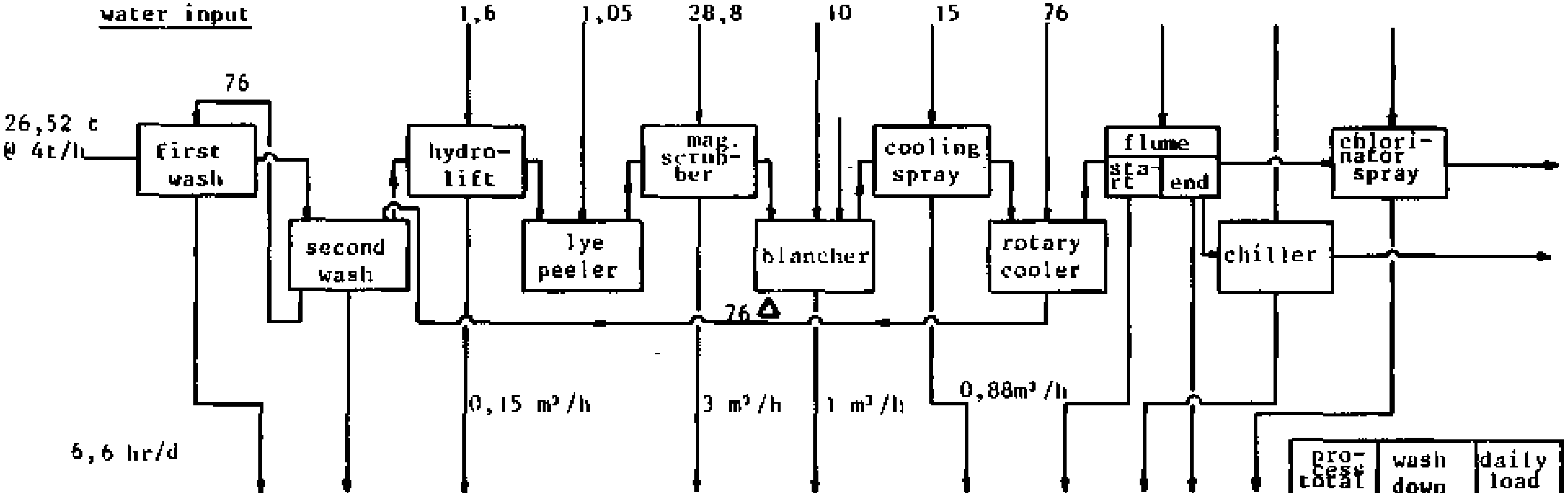

CARROT FREEZING
FIG. 16.4
DRY TUMBLING
EFFLUENT
ROTARY WASHER
SIZE GRADING
EFFLUENT
BRUSH WASHER
WATER
EFFLUENT
HYDRO LIFT
WATER
EFFLUENT
LYE PEELING
EFFLUENT
SCRUBBING
WATER
WATER
EFFLUENT
BLANCHING
TANK
COOLING
INSPECTION
CUTTING
RECIRCULATED
FLUMING
DEWATERING
FREEZING

FIG. 16.5

CARROTS–FREEZING



														pro-cess total	wash down	daily load
Flow m³/d	76		1,54		28,00		7		5,28			42,63			160,4		
kg/t	2,86		0,06		1,06		0,26		0,20			2,61			6,05		
% total	47		1		18		4		3			27			100		
filt. COD mg/ℓ	12460	2227	6568		37591		40044		12501		11379	1000 △	12347	12347	14983		
kg/t	35,70		0,38		39,69		10,57		2,49			1,61			90,4		
% total	39		0,5		44		12		3			2					
filt.PV mg/ℓ	501	509	1420		-		-		1620		1092		1117	1395			
kg/t	1,44		0,1		-		-		0,32								
% total					-												
SS mg/ℓ	1045	1685	2261		22734		4270		1051		758		715	864	4717		
kg/t	2,99		0,13		24,0		1,13		0,21						28,46		
% total	11		0,5		84		4		1			-			100		
pH	9,2	9,6	6,7		10,8		8,8		5,7		4,5	-	4,6	4,5			

Notes: △ approximate leaching of 1000 mg/ℓ COD and no increase in SS during residence in flume.

specific effluent volume 8,12 m^3/t		Quality	
% total water	process step	COD 90,4 kg/t	SS 28,46 kg/t
47	water rotary cooler/first wash	39	11
27	chiller flumes	2	-
18	scrubber	44	84
4	blancher	12	4

16.7 Management needed

(a) all soil should be dry removed;

(b) first wash solids should be removed before discharge - possibly by hydrocyclones or side settling;

(c) scrubber liquors must not be discharged raw to drain. For solids removal perhaps hydrocyclone or new type polyethylene bag filter or flotation should be used;

(d) chiller water and rotary cooler water account for 74% water usage. Chiller water is presently recycled but spillage and surges increase make-up volume (see section on flumes);

(e) implement counter current reuse.

16.8 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
8,5	6,84	45	6500	5,0	800

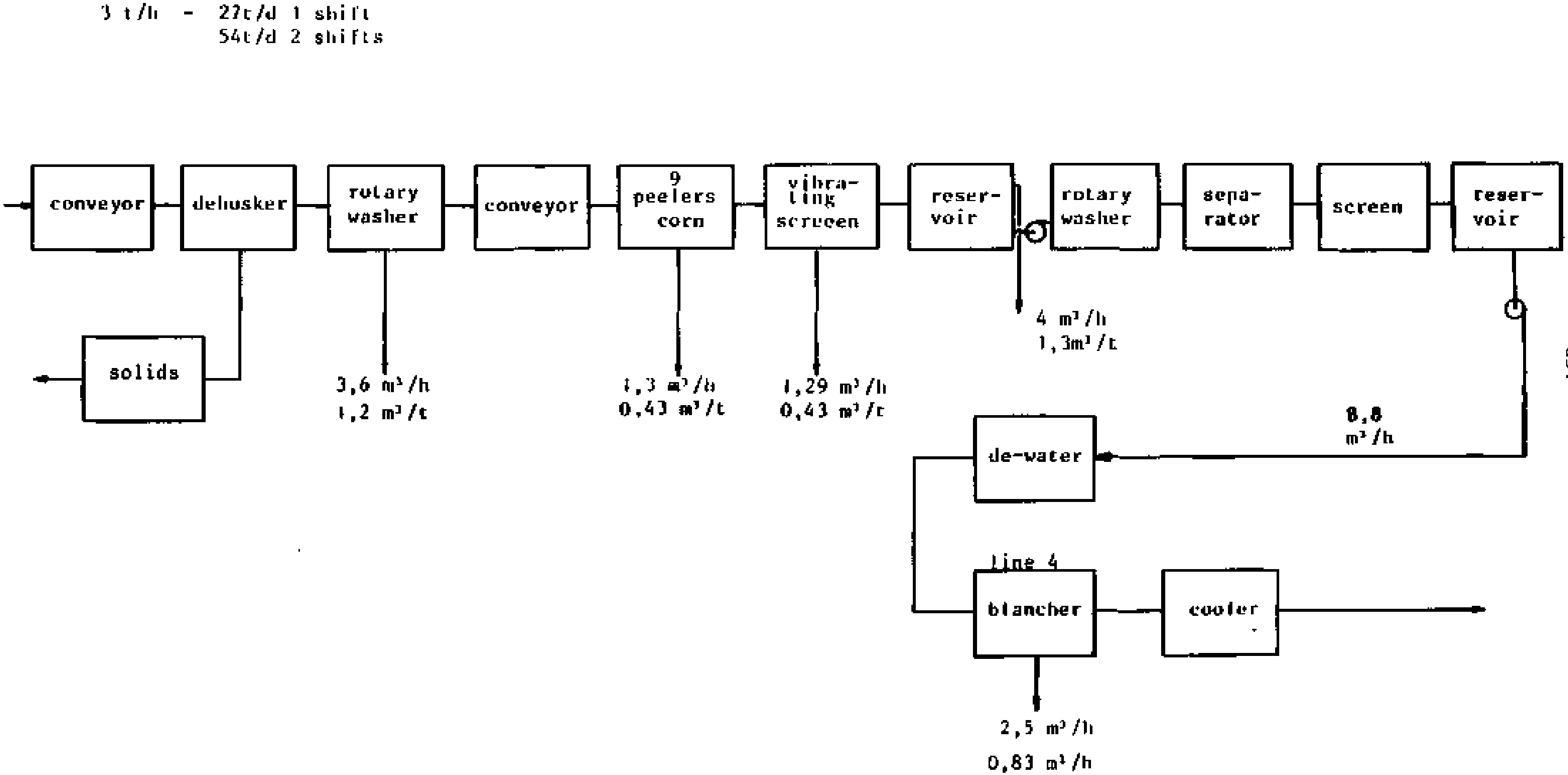
Ultimate

8,5	6,84	30	4400	4,0	580

16.9 Corn freezing

The processing schematic diagram for corn is shown at Fig. 16.6. The general parameters are similar to canning of corn which has already been discussed .

FIG. 16.6



Total specific intake = 4,18 m³/t + post blancher cooling

The water intake approaches 4,63 m^3/t plus the post blanch cooling water which can be as low as 1 m^3/t if closed circuit systems are used.

16.10 Liquid effluents

process step	flow		COD			SS		
	m^3/t	% total	mg/ℓ	kg/t	% total	mg/ℓ	kg/t	% total
husking/decobbing	1,5	32	1200	1,8	39	60	0,09	20
process unspecified	2,38	51	693	1,65	36	63	0,15	33
other	0,75	17	1573	1,18	25	293	0,22	47
	4,63	100	1000	4,63	100	100	0,46	100

16.11 Management needed

(a) avoid solids spillage at dehuskers;

(b) implement post blanch cooling by closed circuit;

(c) segregate blancher overflow for UF treatment especially for sweet corn.

16.12 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
5,6	4,5	4,6	1022	1,0	222

16.13 Green bean freezing

The processing schematic diagram is shown at Fig. 16.7 and the distribution of effluent and their qualities along the processing line is given at Fig. 16.8 and is summarized below:-

specific effluent volume 25 m^3/t		Quality	
% total water	process step	COD 7,11 kg/t	SS 2,75 kg/t
13,5	first wash	21%	11%
14	snipping	27%	45%
1,5	grading	4%	4%
31	cutting and blanching	37%	9%
40	post blanching & transport	11%	6%

16.14 Management needed

(a) segregation of first three processing steps and treatment for SS removal by wedge wire screening & DAF;

(b) installation of closed circuit post-blanch cooling.

16.15 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
16	14,4	6,0	450	1,5	110

GREEN BEAN FREEZING

FIG. 16.7

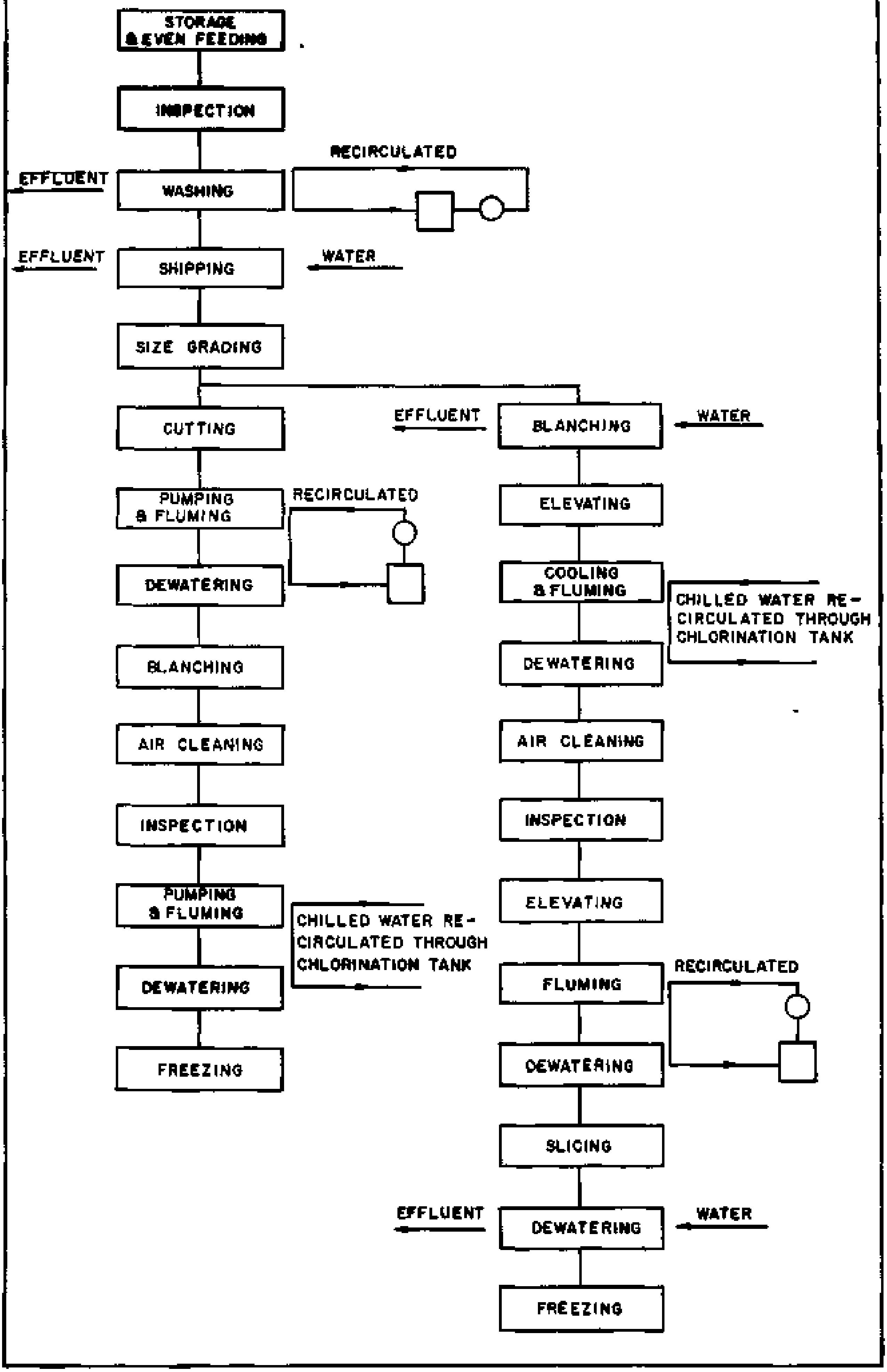
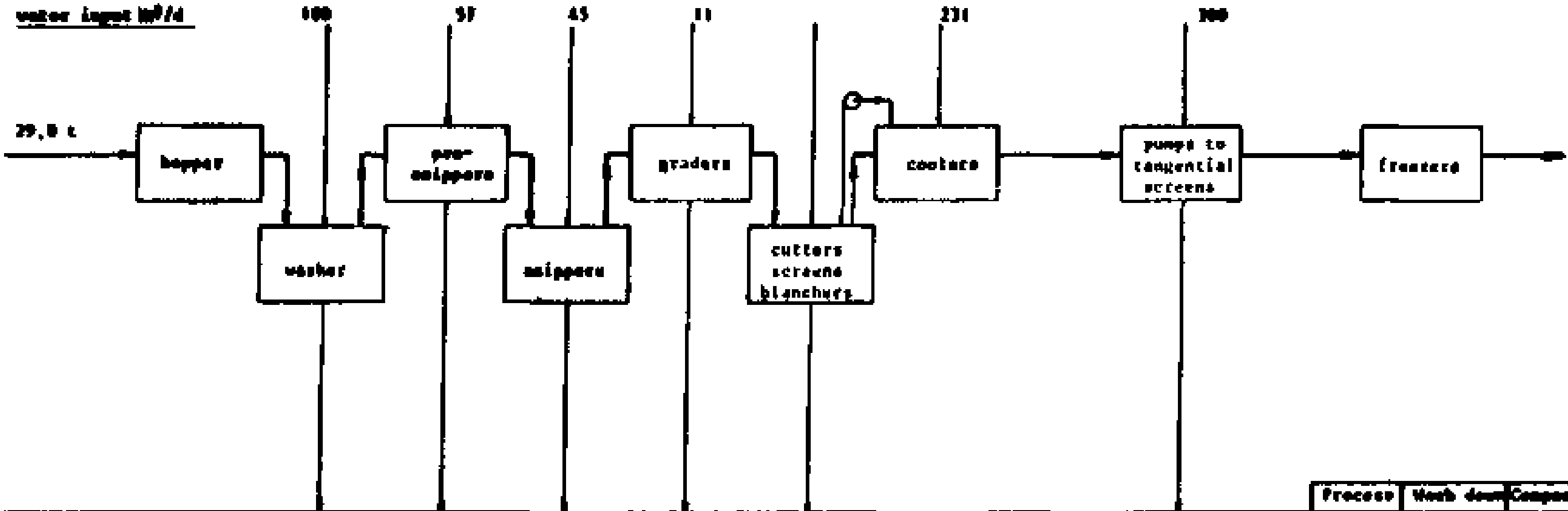


FIG. 16.8
Freezing of green beans



										Process	Wash down	Complex
Flow m³/d	100	57	45	11	231			300		743		744
m³/t	3,34	1,9	1,51	0,37	7,76			10		24,9		25
% total	13,5	8	6	1,5	31			40		100		100
Filt.COD mg/l	440	328	915	880	140			74,5				286
kg/t	1,48	0,60	1,38	0,10	2,6			0,75				7,1
% total	21	8	19	4	37			11				100
SS mg/l	295	235	300	.32	16			16				107
kg/d	1,0	0,5	0,73	0,11	0,25			0,16				2,75
% total	36	18	27	4	9			6				100

16.16 Potato chips freezing

Fig. 16.9 shows the distribution of effluent flows and qualities along the processing line, and is summarized below:-

specific effluent volume 30 m^3/t		Quality	
% total water	process step	COD 74 kg/t	SS 83,9 kg/t
48	peel scrubber & first wash	53	86
13	polisher	3	1
39	post blanch cool & sliver remover	44	13

16.17 Management needed

(a) elimination of soil from first wash-use side settlers;

(b) elimination of peel sludge from effluent;

(c) better collection of slivers;

(d) implementation of closed circuit post blanch coolers.

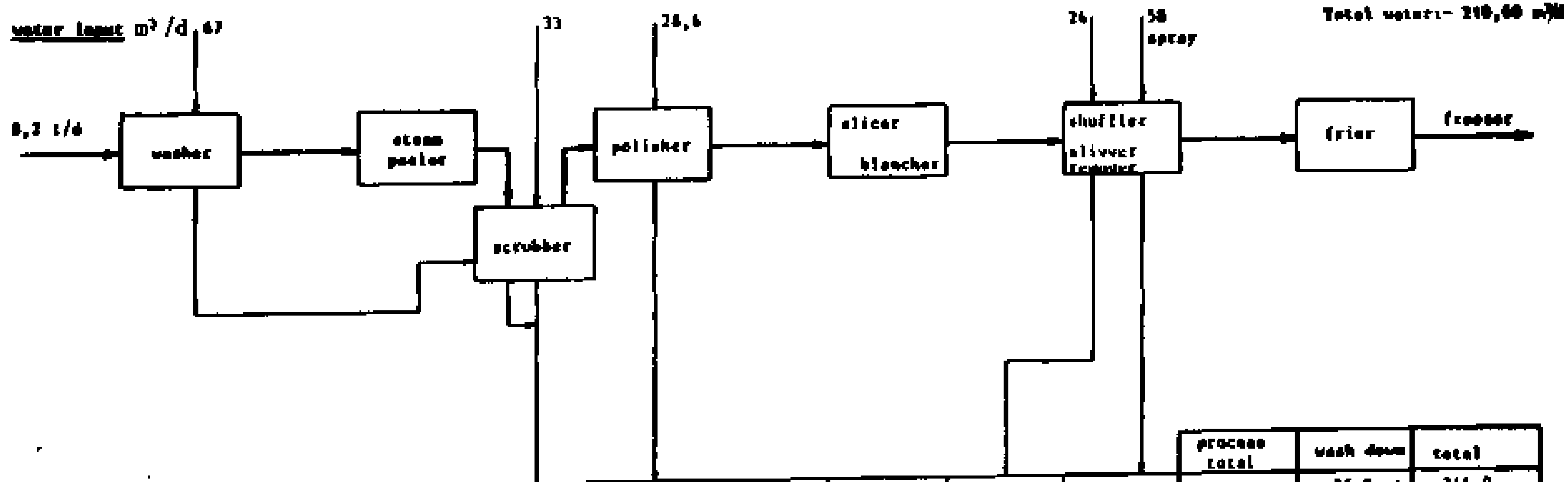
16.18 Targets

Water intake	effluent	COD		SS	
			equivalent concentration		equivalent concentration
m^3/t	m^3/t	kg/t	mg/ℓ	kg/t	mg/ℓ
20,0	16,0	44,0	2750	8,0	500

The targets are achievable by segregating the washer and scrubber effluents and directing them to dissolved air flotation. The polisher effluents can be used in the washer.

FIG. 16.9

Freezing potato chips



										process total	wash down	total
Flow	m³/d			100	28,6			24	58	210,6	35,0 +	244,0
	m³/t			12,2	3,49			2,93	7,07	25,7	4,27 +	30,0
% total				48	13			11	28	100		
Filt. COD	mg/l			3 190	600			9 570	640	2 883		
	kg/t			38,9	2,09			28,0	4,53	74,0		
% total				53	3			38	6	100		
SS	mg/l			5 890	200			3 280	250	3 266		
	kg/t			71,80	0,70			9,60	1,8	83,9		
% total				86	1			11	2	100		

17 CANNING OF OTHER VEGETABLES

Water usage
252,7 x 10^3 m^3/a NASWI 19 m^3/t

Factories
7 No. Cape & Transvaal

Raw tonnage
13 300 t/a

Products
Canned

Liquid effluent	Solid wastes
no data	no data*

*see text

17.1 Production plants

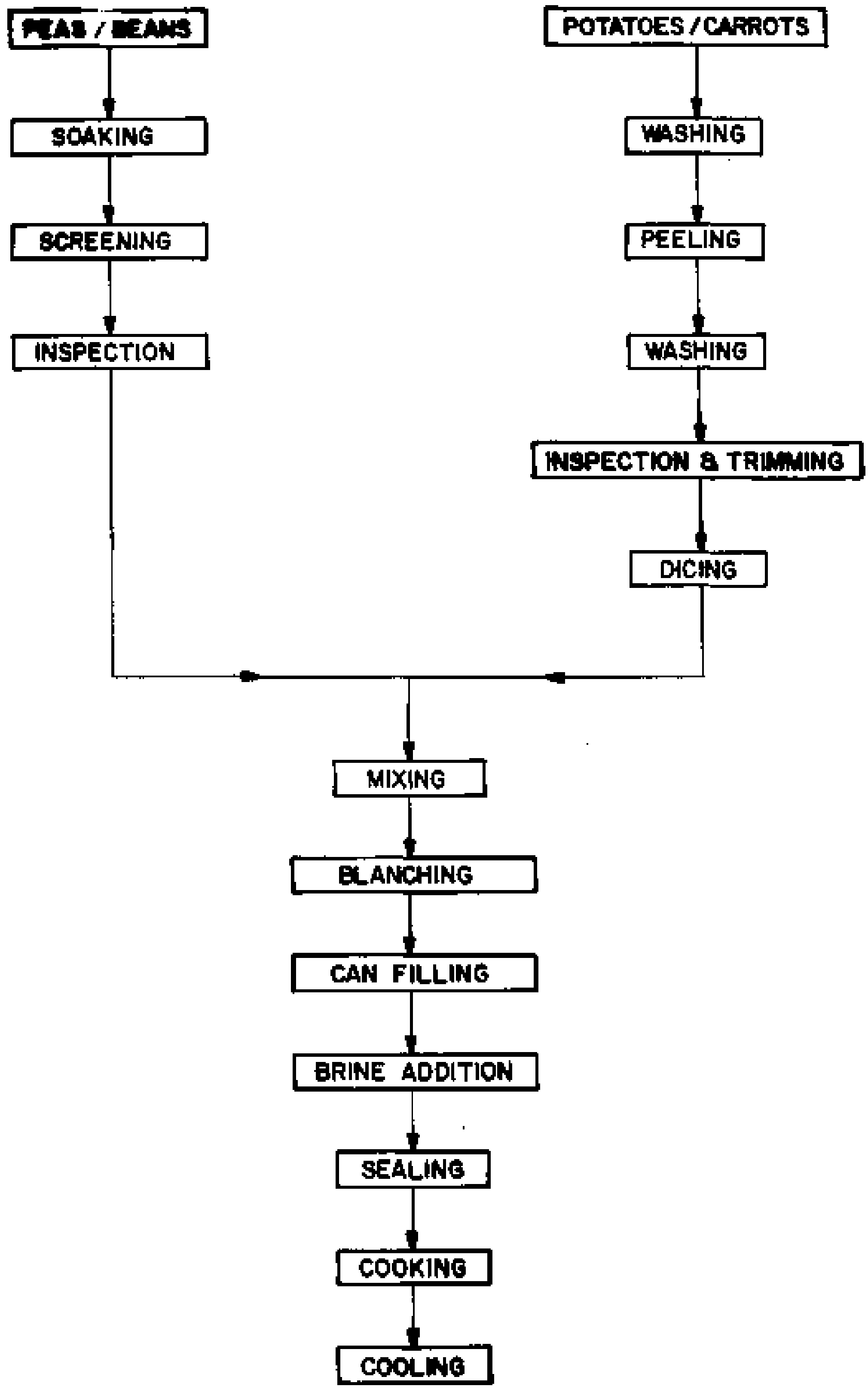
Seven factories process various other vegetables including mixed vegetables; a brief description of each major process is given below:-

(a) Mixed vegetables:-

A typical process diagram is given at Fig. 17.1. The potatoes and carrots are washed in a rotating drum washer to remove all soils before passing to lye peelers and brush washer for peel removal. All commodities are then inspected and trimmed as necessary before being diced and stored in bins. White beans are soaked for 12 hours in water, screened to remove grit and placed in bins. Peas are depodded and mixed with the carrots, potatoes and beans before the mixture is blanched; after blanching the mixture is placed in the cans which are then filled with brine, sealed, cooked and cooled.

FIG. 17.1

CANNING OF MIXED VEGETABLES



(b) Asparagus:-

A typical process diagram is given in Fig. 17.2. The vegetable is cut, washed and graded before blanching. It is then placed in the cans, brine added, the cans exhausted of air, sealed, cooked in retorts and cooled.

(c) Potatoes and carrots:-

The vegetables are washed in rotating drum washers, followed by lye or steam peeling and sliced or diced. They are then blanched, placed in cans which are filled with brine, sealed, cooked and cooled.

(d) Sauerkraut:-

Cabbage to be used for sauerkraut manufacture is stored on the factory floor for 1 - 2 weeks for discolouring. Thereafter all unsuitable leaves are removed and the cabbage are cored. Some of the good leaves are also removed and stored with the cores for later use.

Cleaned and cored cabbage is shredded and pressed into wooden vats layer by layer. As each layer is compressed the juice is extracted, collected and stored for later use.

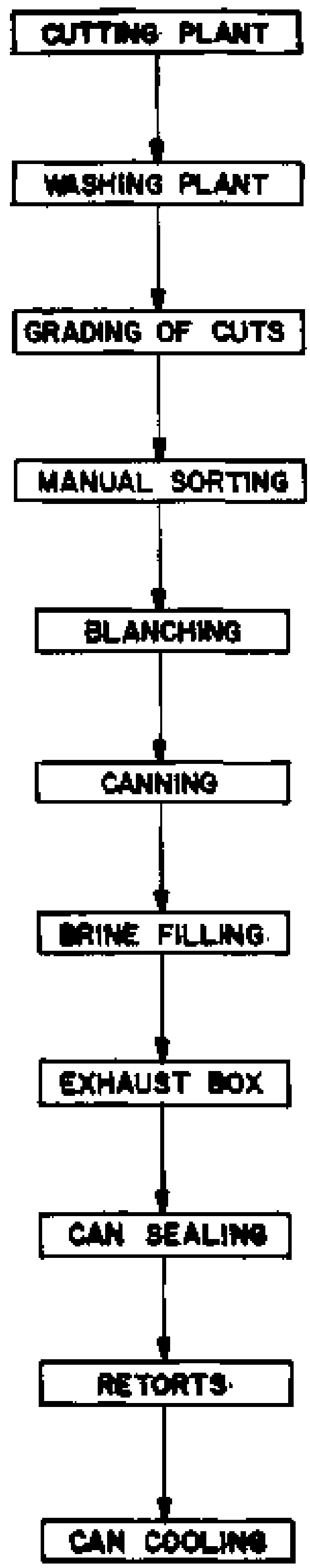
After each vat is filled, the top surface is covered with good leaves and cores, and a lid is placed on top, held down by weights. Each vat is packed in such a way that a freeboard of about 500 mm remains after the lid is placed in position. A layer of about 450 mm of previously-extracted juice is poured onto each lid.

The filled vats are stored for a period of about 4-6 weeks, after which all juice is drained, filtered and cooked. If required, a 2% brine solution is added to the juice. The juice is stored for later use.

The dry product is placed in aluminium bins and steam blanched. After blanching cans are filled, the stored juice is added to the cans, and they are sealed, cooked and cooled.

FIG. 17.2

CANNING OF ASPARAGUS



17.2 Water intake

It was not possible to measure the water consumption of each of the commodities under this heading, but it was estimated that 253 000m^3/a of water is used to process the 13 300 t/a giving a NASWI of 19 m^3/t.

(a) Mixed vegetables:-

The water flow was found to be 3,5 m^3/h and 4 m^3/h for initial washing and post peeling washing respectively for carrots and potatoes. The demand for white bean soaking was found to be about 5 m^3/h. Other water demands are for blanching, lubrication sprays on conveyor belts and continuous flow and equipment washing. The estimated total water flow was found to be 19 m^3/h.

(b) Other commodities:-

We found the following processing water usage:-

asparagus	3,68 m^3/t
carrots	4,90 m^3/t
marrows	11,67 m^3/t

17.3 Liquid effluent

Specific effluent volumes could not be calculated but flows and effluent strengths measured are given:-

(a) Mixed vegetables:-

During processing an effluent flow of 15 m^3/h was measured and the strength of carrot peeling effluent was:-

COD	mg/ℓ	-	2 960
SS	mg/ℓ	-	322
pH		-	11,7

(b) Other commodities:-

The other products had an effluent volume of 80% of the process water requirements; no strength data was collected.

18 CANNING OF OTHER FRUITS

Water usage
45×10^3 m^3/a NASWI 9 m^3/t

Factories
6 No. Cape & Eastern Transvaal

strawberries youngberries loganberries plums, grapes mangoes, paw paw

Products
fruit cocktail canned whole jams

Liquid effluent	Solid wastes
no data	no data

18.1 Production plants

6 factories process various other fruits including 1 418 t/a berries, 300 t/a paw-paws, 3 676 t/a melons, 600 t/a grapes and 1 024 t/a of miscellaneous fruits including plums, mangoes and sultanas, making a total of 7 018 t/a. 5 factories process berries, one processes grapes and five of the same factories process other fruit.

The canning of these fruits generally follows the same process steps as the major fruits.

Jam-making is accomplished by cooking the fruit with sugar in open jam pots and where fruit must be minced it is processed in a continuous steam-heated screw cooker followed by a brush pulper and a brush finisher if skins and pips have to be removed.

For fruit cocktail which is a mixture of diced fruits and grapes, the dicing operation is performed as a branch process on fruit removed from the main process line of the commodity concerned. The diced fruit is canned for later mixture into cocktail.

18.2 Water usage

Detailed studies were performed only on berry canning. Table 18.1 shows that the ASWI varies from 6,8 m^3/t top 27,65 m^3/t with a NASWI of 17,0 m^3/t.

18.3 Liquid effluent

Sources of effluent are the washing of jam pots and transport drums, spillages from wet transportation flumes. During production of fruit cocktail a considerable amount of syrup is spilt during the opening of the cans of diced fruit which are remixed and canned for cocktail products; we observed the syrup being discharged down the drain.

No data was collected on effluent strength.

TABLE 18.1

COMPARISON OF BERRY PROCESSING PLANTS

Factory	Raw Tonnes Processed	Solid Wastes	Process Capacity	Overall water consumption		Overall effluent generation		
				Volume	Specific	Volume	Specific	% of water
	t/a	t/a	t/h	m^3/a x 1000	m^3/a	m^3/a x 1000	m^3/a	%
1	500	100	-	8,50	17,00	7,30	14,60	86
2	300	60	-	8,30	27,65	7,80	26,00	94
3	254	51	-	2,68	10,56	2,09	8,24	78
4	212	42	-	3,60	17,00	3,10	14,60	86
5	152	30	-	1,03	6,80	0,89	5,85	86
Total	1 410	283		24,11	17,01	21,18	14,93	88