Chapter 4

Study of Effective Use of Industrial Water

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4.1 Outline

On the basis of the analysis in the previous section, concrete methods for effective use of industrial water were studied for each of the surveyed factories. The improvement methods include:

(1) Thorough control of water use (including the control of domestic water)
(2) Recycle use
(3) Multistage or cascade use of water
(4) Reclamation of waste water
(5) Application of water saving apparatus
(6) Improvement of operation control of cooling tower and other equipment
(7) Others

For each of the above methods, the unit cost was estimated (refer to 4.8) in order to judge the economic feasibility (only those methods whose costs do not exceed reasonable limits should be taken). Table 4.1 shows the potential quantity of water saving/reclamation by each factory. For the details of the improvement methods, refer to Chapter 5 of this report.

4.2 Explanation of Improvement Methods

4.2.1 Thorough Control of Water Use

Fine water control is impossible without knowing the actual quantity of water consumption at each use point in a factory. Nonetheless a large number of the factories were not aware of the exact quantity of water they daily used.

To know the quantity of water consumption, the following methods are indispensable.

(1) To install a flow meter for each well

(2) To install a flow meter for each main supply zone in the factory

(3) To be able to estimate the quantity of water flow on the basis of piping diameters and valve openings

4.2.2 Recycle Use

Although in many factories indirect cooling water is recycled through cooling towers, the operation controls of cooling towers are often inadequate (refer to 4.2.6).

With a storage tank installed, relatively clean washing water can be easily recycled for re-use. Also, the recycling of steam condensate for a boiler is an effective way to save heat consumption as well as water consumption.

4.2.3 Multistage or Cascade Use of Water

A multistage system is applicable mainly for the use of washing water. With this system, washing water goes through a number of washing tanks and is used more than once. With a cascade system, water is used again for a different purpose without any treatment. For example, indirect cooling water can be re-used for washing.

4.2.4 Reclamation of Waste Water

With a water reclamation system, waste water is re-used through some appropriate treatment. Though this system is technically feasible, the cost tends to be so high that it is adopted only in limited cases.

4.2.5 Application of Water Saving Apparatus

"Water saving apparatus" means an apparatus specially designed and manufactured to save water consumption. Whereas water saving apparatus are not suitable for cooling water (recycling is the most effective way to save cooling water), they may be effective for the saving of washing water. In fact, water saving apparatus are for the most part applied to washing water.

Most water saving apparatus are designed to prevent unnecessary flow of water. Hand control valves, check valves and automatic urinal washing devices are examples.

4.2.6 Improvement of Operation Control of Cooling Tower and Other Equipment

The function of a cooling tower mentioned in 4.2.2 above is to lower the temperature of water for recycling (refer to Fig. 4.1). To operate a cooling tower effectively, the quantity of make-up water and blow water have to be properly controlled. Too small quantity of blow water would raise the degree of (salt) concentration (i.e. electrical conductivity) and thus damage the equipment.

On the contrary, if the quantity of blow water is too large, extra quantity of make-up water would be required.

A degree of (salt) concentration, as defined below, is a very useful indicator for the operation of a cooling tower.

Degree of concentration = Salt concentration of recycling cooling water/Salt concentration of make-up water

As easily seen from the above definition, a degree of concentration rises when blow water (and hence make-up water) is reduced, and goes down when blow water increases. The optimum degree of concentration depends on the quality of make-up water. In the survey, the optimum degrees lie between 2 and 3.

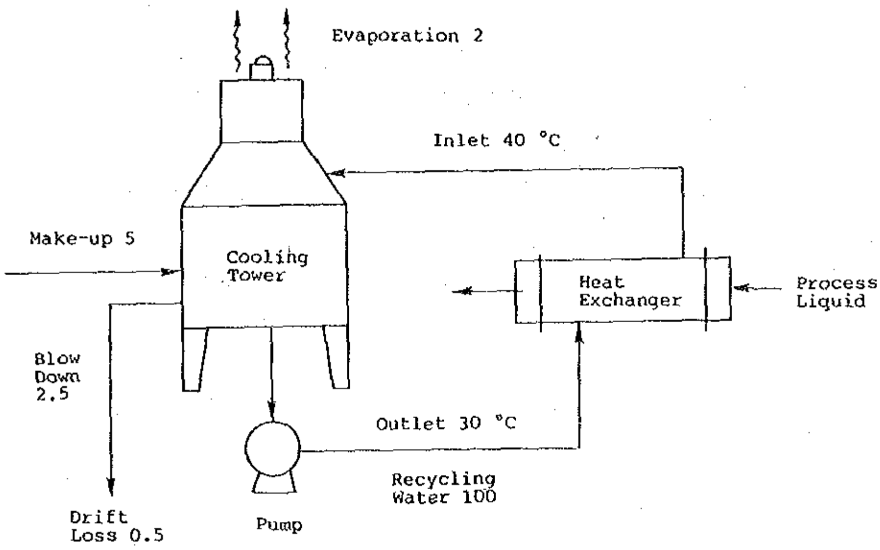


Fig. 4.1: Recycling System of Cooling Water

In addition to cooling towers, some water treatment equipment (e.g. sand filter, softener, ion exchange equipment) requires proper operation control. Generally, this type of equipment has to be washed after a certain number of operations. If washing is too frequent or too much washing water is used, the result would be nothing but a waste of water.

4.2.7 Others

Besides wells, other water resources (rivers, ponds and the like) may be exploited.

4.2.8 Control of Domestic Water

Broadly speaking, domestic water used in factories (including water used in employees' dormitories) is included in industrial water. As stated in 3.4, the result of the survey shows that some factories use too much domestic water relative to the number of employees.

In 3.4.4, the optimum quantity of domestic water was set at 300 lit/capita/d (for factories without any employees' dormitories) or 500 lit/capita/d (for factories with employees' dormitories).

Thus, if the consumption of domestic water exceeds this quantity, some methods should be taken. For the unit domestic water usage refer to Appendix Part 2 of this report.

4.3 Cost Estimation

For each of the surveyed factories, the feasible methods for the effective use of industrial water were studied. Then the costs required for those improvement methods were estimated.

4.3.1 Estimation Procedure

The costs for improvement methods were estimated in the following sequence.

(1) Cost for the construction of required facilities (bahts)
(2) Depreciation cost (฿/Y, ฿/m^3)
(3) Maintenance cost of the facilities (฿/Y, ฿/m^3)
(4) Operating cost of the facilities (฿/m^3)
(5) Unit cost of the improvement (฿/m^3)

4.3.2 Basis for Cost Estimation

(1) Construction cost

The construction cost consists of procurement costs (for materials, main equipment, accessories, electrical & instrumentation equipment, pipings and foundations) and installation costs. The construct cost was estimated on a local cost basis, with adjustments made in the following two cases.

(a) For such equipment or materials as are not available in Thailand, the costs were estimated on the basis of the Japanese prices.

(b) Local installation costs were derived by multiplying procurement costs (for materials, equipment and so on) by appropriate factors.

Owing to the difficulty of estimate, the following items were excluded from the calculation of the construction cost.

(a) Large-scale reconstruction of existing buildings or facilities

(b) Land prices

(c) Effects of the improvement methods in question on other plants or facilities (for instance, the improvement of water recycling system may require the change of waste water treatment facilities.)

(2) Fixed Cost = Depreciation Cost + Maintenance Cost

(a) Depreciation Cost

Life of facilities: 15 years
Interest rate: 12%
Residual value: 0

(b) Maintenance Cost

Except in large-scale plants (thermal power plants, oil refining plants, petrochemical plants and the like), regular maintenance of facilities is not a common practice in light industries.

In consequence, maintenance cost is rarely taken into account. Thus, maintenance cost is also excluded from this estimation. (In Japan, maintenance cost is normally estimated at 2 to 5% of facility construction cost.) In the calculation, the fixed cost includes only depreciation cost.

(3) Operating Cost

The operating cost consists of costs for energy, chemicals, consumables and other relevant items. The required facilities being generally small-scale, the existing personnel would be enough to operate them. So, no personnel cost for operation is included in the estimate.

4.3.3 Estimation of the Unit Cost of Improvement

The unit cost of improvement is defined as follows.

Unit cost = Fixed cost + Operating cost (฿/m^3)

where,

Fixed cost = Annual fixed cost/Annual quantity of water saving (฿/m^3)

Operating cost = Annual operating cost/Annual quantity of water saving (฿/m^3)

The unit cost of improvement indicates how much cost would be required to save one cubic meter of water through the improvement method in question.

It provides an useful criterion to judge whether a particular improvement method is economical or not in comparison with alternative water sources. If the unit cost of improvement is lower than the cost of any alternative water sources (groundwater, MWA water, public industrial water and the like), the improvement method in question makes good economic sense.

4.4 Estimation of Potential Quantity of Water Saving and Water Reclamation

4.4.1 Basic Concepts

As mentioned before (4.2.4), though it is technically possible to construct a complete water recycling system (a "closed" system) for any factory in any industry, its cost would be often prohibitively high. Therefore, in determining the potential quantity of water saving and water reclamation, the unit cost of improvement (refer to 4.3.3 above) should be used.

The economically allowable limit of the unit cost depends on the costs of alternative water sources. The costs of various water sources in Samut Prakarn are:

Rates of MWA water	8 ฿/m^3
Estimated cost of water supplied by public industrial waterworks	4.75 - 7.5 ฿/m^3
(cf. pumping up cost of well water including rate	2 - 2.5 ฿/m^3)

The above costs do not include the costs for water treatments. Since the qualities of water supplied by MWA or the planned public industrial waterworks are not excellent (for instance, high electrical conductivity), some water treatment method will be necessary. (In the case of MWA water, some factories have already implemented water treatments.)

In Japan, the economically allowable limit of the unit cost of improvement is set by the following criterion.

(1) The maximum rates of the public industrial water, or

(2) where the service of public industrial waterworks is not yet available, the expected cost of public industrial water on the assumption that such waterworks were constructed.

If the same criterion is applied, the allowable unit cost of improvement for the surveyed factories is determined by the expected water rates (4.75 to 7.5 ฿/m^3) of the planned industrial waterworks. For the purpose of the study, the standard unit cost of improvement was set at around 8 bahts per cubic meter.

However, the main purpose of the effective use of industrial water is to prevent the subsidence of land, so that economic considerations should give way to the urgency of the problem. Moreover, as mentioned above, the real cost of public industrial water is likely to be increased by the necessity of water treatment.

In the estimation of the potential quantity of water saving/-reclamation, therefore, more than 8 ฿/m^3 (i.e. up to 13 ฿/m^3) was allowed as the unit cost of improvement.

In Japan, too, the potential quantity of water saving is calculated on the basis of the unit improvement cost slightly higher than the criterion given above.

4.4.2 Result of Estimation

Table 4.1 shows the estimated quantity of potential water saving/reclamation for each factory. The detailed analysis of the improvement method and potential water saving quantity is given in Chapter 5 of this report.

The aggregate potential quantity of water saving/reclamation of the surveyed factories is as follows.

Total saving/reclamation quantity	11,162 m^3/d
Saving rate of well water	22.2%
Average unit cost of improvement	4.7 ฿/m^3
Maximum unit cost of improvement	13.1 ฿/m^3

Table 4.1: The Potential Quantity of Water Saving by Factory

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
1	F-01	870	330	1,200	540	1,740	31.0	Application of water saving apparatus	Thorough control of water use and use of hand control valve	PW	100	20	0.2	-	0.2
								Others	Use of river water for floor washing and others	PW	150	1,240	3.4	3.7	7.1
		Total									250	1,260			4.3
2	F-02	1,065	-	1,065	4,000	5,065	78.9	Control of water use	Check and control of water requirement for domestic use	D	215	-	-	-	-
3	F-03	178	-	178	672	850	79.1	Application of water saving apparatus	Installation of check valve in cooling tower	C	5	9	0.9	-	0.9
								Recycle use	Recycle use of cooling water of one through system by existing cooling tower	C	8	15	1.0	0.5	1.5
		Total									13	24			1.3
4	F-04	100	-	100	-	100	0		No room for further improvement						
5	F-05	614	40	654	4,797	5,451	88.9		Application of effective use is very difficult						

Note: Use* -- PW = Processing & Washing; D = Domestic; C = Cooling
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 2/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
6	F-06	1,098	-	1,098	4,520	5,618	81.6	Recycle use	Recycle use of cooling water for thermal sterilization by installation of cooling tower	C	350	2,930	3.6	2.4	6.0
7	F-07	163	-	163	5,760	5,923	97.2	Application of water saving apparatus	Use of hand control valve for washing water	PW	10	15	1.5	-	1.5
8	F-08	665	-	665	14,160	14,825	95.5	Improvement of operation control	Improvement of operation and maintenance of cooling tower to raise degree of concentration	C	36	-	-	0.5	0.5
								Application of water saving apparatus	Use of hand control valve for washing water	PW	40	60	1.3	-	1.3
		Total									76	60			0.9
9	F-09	300	-	300	3,565	3,865	92.5	Control of water use	Check and control of water requirement for domestic use	D	25	-	-	-	-
10	F-10	-	54	54	660	714	92.4		Little room for further improvement						
11	F-11	37	-	37	4	41	9.8		As water consumption is very small, application of effective use is difficult.						

Note: Use* -- C = Cooling; PW = Processing & Washing; D = Domestic
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 3/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
12	F-12	323	-	323	23	346	6.6	Improvement of operation control	Improvement of operation and control of deionization system to decrease backwashing water	O	30	-	-	-	-
13	F-13	1,040	80	1,120	600	1,720	34.9		Little room for further improvement						
14	F-14	68	-	68	-	68	0		As water consumption is very small, application of effective use is difficult.						
Food Total		6,521	504	7,025	39,301	46,326	84.8		Water Saving Rate		969 14.9%	4,289			3.4
15	P-01	1,245	-	1,245	600	1,845	32.5	Recycle use	Increase of recovery tank capacity to improve recovery of white water	PW	200	160	0.3	-	0.3
								Recycle use	Recovery of steam condensate	B	90	46	0.5	-	0.5
		Total									290	206			0.4
16	P-02	1,230	-	1,230	2,200	3,430	64.1	Recycle use	Increase of recovery tank capacity to improve recovery of white paper	PW	250	320	0.5	-	0.5
17	P-03	2,958	-	2,958	3,349	6,307	53.1	Reclamation of waste water	Advanced treatment of waste water for re-use in washing process	PW	700	4,200	2.5	1.5	4.0

Note: Use* -- O = Miscellaneous; PW = Processing & Washing; B = Boiler
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 4/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
18	P-04	11,360	1,900	13,260	4,800	18,060	26.6	Recycle use	Increase of recycling capacity of white water to raise recovery ratio	PW	1,000	496	0.2	0.7	0.9
								Reclamation of waste water	Advanced treatment of waste water for re-use in washing process	PW	3,000	37,776	4.5	0.8	5.3
		Total									4,000	38,272			4.2
19	P-05	152	-	152	60	212	33.0	Others	Use of pond water for spraying	O	20	167	3.2	1.2	4.4
Paper Total		16,945	1,900	18,845	11,009	29,854	36.9		Water Saving Rate		5,260 31.0%	43,154			3.3
									Without Reclamation Water Saving Rate		1,560 9.2%	1,178			0.8
20	T-01	10,384	-	10,384	53,489	63,489	83.7	Improvement of operation control	Improvement of operation and maintenance of cooling tower to raise degree of concentration	A	370		-	0.5	0.5
								Reclamation of waste water process	Advanced treatment of waste water for re-use in washing	PW	2,000	40,000	7.3	5.8	13.1
		Total									2,370	40,000			11.1

Note: Use* -- PW = Processing & Washing; O = Miscellaneous; A = Air Conditioning
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 5/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
21	T-02	113	53	166	-	166	0.0	Recycle use	Recovery of steam condensate	B	6	71	5.0	-	5.0
22	T-03	1,885	-	1,885	40	1,925	2.0	Application of cascade use	Cascade use of cooling water for boiler feed water	B	50	361	3.1	-	3.1
								Application of water saving apparatus	Use of hand control valve for washing water	PW	30	20	0.6	-	0.6
								Control of water use	Thorough control of water use in each process	PW	140	320	1.0	-	1.0
		Total									220	701			1.4
23	T-04	25	1	26	-	26	0.0		As water consumption is very small, application of effective use is difficult						
24	T-05	180	-	180	unknown	180	0.0		As this factory was under test operation, the study on effective use was impossible.						
25	T-06	442	-	442	-	442	0.0	Control of water use	Thorough control of water use	PW	40		-	-	-
26	T-07	549	-	549	6	555	1.1		Little room for further improvement						

Note: Use* -- B = Boiler; PW = Processing & Washing
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 6/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
Textile Total		13,578	54	13,632	53,535	67,167	79.7		Water Saving Rate		2,636 19.4%	40,772			10.1
									Without Reclamation Water Saving Rate		636 4.7%	772			0.8
27	M-01	503	-	503	227	730	31.1	Improvement of operation control	Improvement of operation and maintenance of cooling tower to raise degree of concentration	C	139	-	-	0.5	0.5
28	M-02	1,191	0	1,191	370	1,561	45.6	Improvement of operation control	Improvement of operation and maintenance of cooling tower to raise degree of concentration	C	184	-	-	0.5	0.5
29	M-03	162	-	162	2,442	2,604	93.8	Control of water use	Thorough control of water use to decrease water leakage	O	40	-	-	-	-
30	M-04	6	2	8	960	968	99.2		Little room for further improvement						
31	M-05	620	-	620	812	1,432	56.7	Recycle use	Re-use of treated waste water for washing process	PW	200	1,424	3.0		3.6

Note: Use* -- C = Cooling; O = Miscellaneous; PW = Processing & Washing
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 7/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
32	M-06	70	-	70	-	70	0.0	Recycle use	Recovery of steam condensate	B	3	31	4.2	-	4.2
								Recycle use	Re-use of treated waste water for washing process	PW	10	133	5.5	0.6	6.1
		Total									13	164			5.7
33	M-07	58	-	58	95	153	62.1	Recycle use	Recycle use of cooling water by installing receiving tank	C	14	274	8.5	0.5	9.0
34	M-08	40	-	40	10	50	10.0		As water consumption is very small, application of effective use is difficult.						
35	M-09	451	45	496	8,370	8,866	94.4	Improvement of operation control	Improvement of operation and maintenance of cooling tower to raise degree of concentration	C	105	-	-	0.5	0.5
36	M-10	17	-	17	128	145	88.3		Little room for further improvement						
37	M-11	212	-	212	128	350	39.4	Recycle use	Recycle use of cooling water by existing cooling tower	C	63	318	2.5	1.0	3.5
38	M-12	107	-	107	2,175	2,282	95.3		A semi-closed system has been installed in this factory.						

Note: Use* -- B = Boiler; PW = Processing & Washing; C = Cooling
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 8/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
39	M-13	20	-	20	144	164	87.8		As water consumption is very small, application of effective use is difficult.						
40	M-14	269	-	269	1,100	1,369	80.3		Little room for further improvement						
41	M-15	3,162	-	3,162	4,800	7,962	60.3	Recycle use	Recycle use of cooling water by existing cooling tower	C	110	23	0.1	0.5	0.6
								Application of cascade use	Cascade use of scrubbing water	PW	166	289	0.7	1.3	2.0
								Multistage use	Multistage use of washing water in metal plating process	PW	146	289	0.7	1.3	2.0
								Improvement of operation control	Thorough control of operation and maintenance of water treatment system to decrease backwashing water	PW	63	-	-	-	-
								Control of water use	Check and control of water requirement for domestic use	D	110	-	-	-	-
		Total									595	601			1.2

Note: Use* -- C = Cooling; PW = Processing & Washing; D = Domestic
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 9/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
42	M-16	529	-	529	1,072	1,601	67.0	Control of water use	Check and control of water requirement for domestic use	D	30	-	-	-	-
43	M-17	140	-	140	1,256	1,396	90.0		No room for further improvement						
44	M-18	617	-	617	1,460	2,077	70.3	Recycle use	Recycle use of shower test water	PW	25	140	3.1	1.0	4.1
								Control of water use	Check and control of water requirement for domestic use	D	54	-	-	-	-
		Total									79	140			1.3
45	M-19	350	-	350	600	950	63.2	Recycle use	Recycle use of cooling water by existing cooling tower	C	27	21	0.4	0.5	0.9
								Recycle use	Recovery of steam condensate	B	4	28	3.5	-	3.5
								Control of water use	Check and control of water requirement for domestic use	D	110	-	-	-	-
		Total									141	49			0.3

Note: Use* -- D = Domestic; PW = Processing & Washing; C = Cooling; B = Boiler
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 10/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
46	M-20	23	-	23	404	427	94.6		Little room for further improvement						
Metal Total		8,547	47	8,594	26,565	35,159	75.5		Water Saving Rate		1,603 18.8%	2,970			1.4
47	C-01	75	-	75	280	355	78.9		Little room for further improvement						
48	C-02	330	-	330	5,700	6,030	94.8	Improvement of operation control	Improvement of operation and maintenance of cooling tower to raise degree of concentration	C	40	-	-	0.5	0.5
								Control of water use	Check and control of water requirement for domestic use	D	85	-	-	-	-
		Total									125				0.2
49	C-03	36	-	36	54	90	60.0		Little room for further improvement						
50	C-04	-	40	40	-	40	0.0		Complete effective us has been already done in this factory.						
51	C-05	1,560	-	1,560	14,400	15,960	90.2	Control of water use	Check and control of water requirement for domestic use	D	50	-	-	-	-

Note: Use* -- C = Cooling; D = Domestic
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 11/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3₿)	Unit Cost (₿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
52	C-06	27	-	27	-	27	0.0		Little room for further improvement						
53	C-07	83	55	138	40	178	22.5		Little room for further improvement						
54	C-08	752	-	752	3,770	4,522	83.9	Improvement of operation control	Improvement of operation and maintenance of cooling tower to raise degree of concentration	C	80	-	-	0.5	0.5
								Control of water use	Check and control of water requirement for domestic use	D	140	-	-	-	-
		Total									220				0.2
55	C-09	226	-	226	790	1,016	78.4		Little room for further improvement						
56	C-10	300	-	300	2,000	2,300	87.0	Improvement of operation control	Improvement of operation and maintenance of cooling tower to raise degree of concentration	C	26	-	-	0.5	0.5
57	C-11	1,020	-	1,020	14,400	15,420	93.4	Improvement of operation control	Improvement of operation and maintenance of cooling tower to raise degree of concentration	C	246	-	-	0.5	0.5

Note: Use* -- C = Cooling; D = Domestic
Qt.** = Quantity

Table 4.1: The Potential Quantity of Water Saving by Factory (Continued, 12/12)

#	Code No.	Water Consumption (m^3/d)					Recovery Rate (%)	Method of Effective Use		Water Saving		Const. Cost (10^3฿)	Unit Cost (฿/m^3)		
		Well Water	Others	Sub Total	Recovered Water	Total		Method	Item	Use*	Qt.** (m^3/d)		Fixed	Operating	Total
58	C-12	250	-	250	2,227	2,477	89.9	Recycle use	Supply of soft water as make-up water to cooling tower to raise degree of concentration	C	27	4	0.1	1.2	1.3
59	C-13	45	-	45	32	77	41.6		Little room for further improvement						
Chemical Total		4,704	95	4,799	43,693	48,492	90.1		Water Saving Rate		694 14.8%	4			0.3
Gross Total		50,295	2,600	52,895	174,101	226,996	76.7		Water Saving Rate		11,162 22.2%	91,189			4.7
									Without Reclamation Water Saving Rate		5,462 10.8%	9,213			1.4

Note: Use* -- C = Cooling; Qt.** = Quantity

4.5 Potential Quantity of Water Saving Classified by Industry and Use of Water

Table 4.2 summarizes the potential quantity of water saving classified by industry and use of water. Fig. 4.2 and 4.3 illustrate these results in graphics. As mentioned above, the average water saving rate of all the industries is estimated at 22.2%. The saving rate for each industry range from 14.8% (the chemical industry) to 31.0% (the paper industry).

The high rate in the paper industry is owing to the relative easiness of water reclamation (if reclamation were excluded, the potential water saving rate would be mere 9.2%). On the other hand, in the chemical industry, the most part of water (i.e. cooling water) is already recycled, so that there is little room for further water saving.

From the viewpoint of the usage of water, the potential saving quantity of processing and washing water is the largest. This high saving potentiality of processing and washing water is due to the fact that a relatively large quantity of well water is now used for processing and washing (approx. 70% of the total consumption of well water) with a low recovery rate (approx. 29%).

The potential saving rates of cooling water and air conditioning water are fairly high (31% and 45% respectively). Thus, though the recovery rates of cooling water and air conditioning water are already high (69% and 99%), further saving seems to be feasible.

4.6 Potential Quantity of Water Saving Classified by Improvement Method and Use of Water

Table 4.3 summarizes the potential quantity of water saving classified by improvement method and use of water. Fig. 4.4 illustrates these results in graphics.

From the viewpoint of the improvement method, reclamation takes up the largest share (approx. 51%) of potential water saving. However, as explained later (4.8.1), the cost of water reclamation is high. If reclamation is excluded, recycling quantity for about 46% of the total water saving. Hence recycling seems to be the most common way of water saving.

The potential water saving through the improvement of operation control and water use control reaches almost the same quantity as the saving through recycling. This fact implies that water saving depends on training and awareness of employees as well as on effective facilities.

As for the use of water, reclamation accounts for the large part (69%) of the potential saving of processing and washing water. The saving of cooling water, on the other hand, much depends on the improvement of operation control. The operation of cooling towers, in particular, can be further improved (i.e. the degree of salt concentration of cooling water can be further raised).

Table 4.2: Potential Quantity of Water Saving Classified by Industry and Use

Industry \ Use	Category	Consumption of Well Water (m^3/d)						
		Boiler	Material	Proc. & Washing	Cooling	Air Cond.	Others	Total
Food (14)	Present Q.	436	111	3,508	1,245	0	1,221	6,521
	Potential Q.			300	399		270	969
	Water Saving Rate (%)			8.6	31.3		22.2	14.9
Paper (5)	Present Q.	695	0	16,009	2	0	209	16,945
	Potential Q.	90		5,150			20	5,260
	Water Saving Rate (%)	12.9		32.2			9.6	31.0
Textile (7)	Present Q.	858	0	10,723	164	830	1,003	13,578
	Potential Q.	56		2,210		370		2,636
	Water Saving Rate (%)	6.5		20.6		44.6		19.4
Metal (20)	Present Q.	192	0	3,803	2,156	2	2,394	8,547
	Potential Q.	7		610	642		344	1,603
	Water Saving Rate (%)	3.7		16.0	29.8		14.4	18.8
Chemical (13)	Present Q.	344	454	1,187	1,141	0	1,578	4,704
	Potential Q.				419		275	694
	Water Saving Rate (%)				36.7		17.4	14.8
Total (59)	Present Q.	2,525	565	35,230	4,709	832	6,434	50,295
	Potential Q.	153		8,270	1,460	370	909	11,162
	Water Saving Rate (%)	6.1		23.5	31.0	44.5	14.1	22.2

Remarks: Boiler = Boiler Feed Water
Material = Material Water
Proc. & Washing = Processing & Washing Water
Cooling = Cooling Water
Air Cond. = Air Conditioning Water
Others = Water for Other Uses (Miscellaneous Use)
Present Q. = Present Quantity
Potential Q. = Potential Quantity of Water Saving

Figures in ( ) show number of factories.

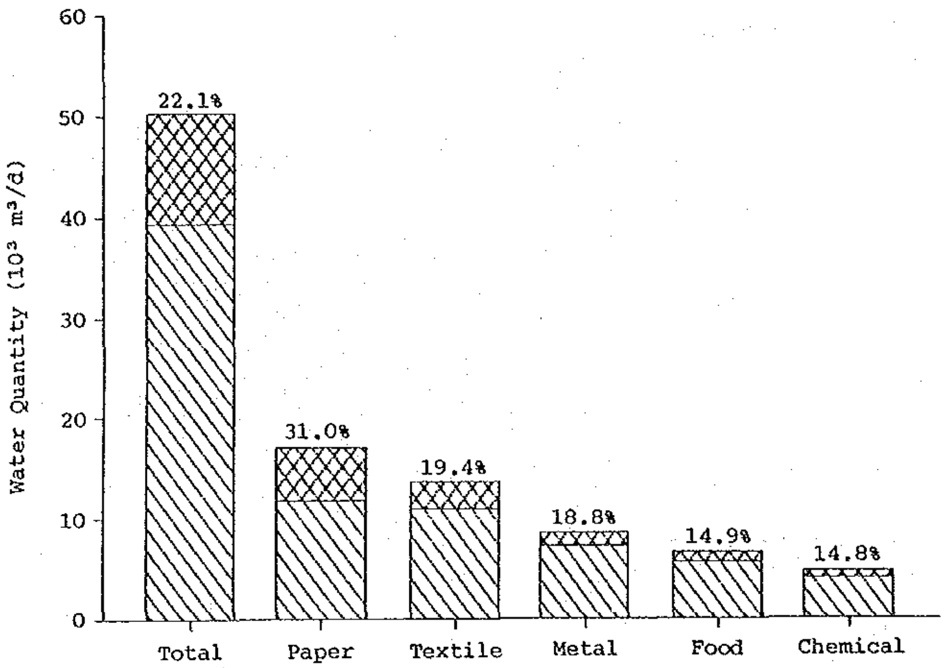


Fig. 4.2: Potential Quantity of Water Saving and Saving Rate Classified by Industry

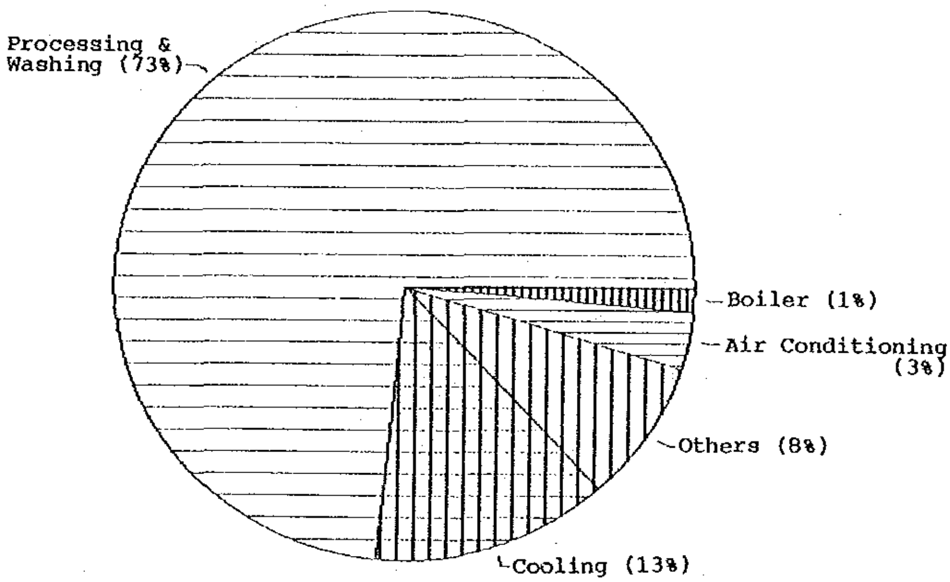


Fig. 4.3: Percentage of Potential Quantity of Water Saving Classified by Use

Table 4.3: Potential Quantity of Water Saving Classified by Method for Effective Use and Use

Use / Method of Effective Use	Items	Consumption of Well Water (m³/d)					
		Boiler	Proc. & Washing	Cooling	Air Cond.	Others	Total
Recycle Use	Number Qt. (m³/d) Ratio (%)	4 103 67.3	6 1,685 20.4	7 599 41.0			17 2,387 21.3
Multistage Use	Number Qt. (m³/d) Ratio (%)	1 50 32.7	2 312 3.8				3 362 3.2
Reclamation	Number Qt. (m³/d) Ratio (%)		3 5,700 68.9				3 5,700 51.1
Water Saving Appratus	Number Qt. (m³/d) Ratio (%)		4 180 2.2	1 5 0.3			5 185 1.7
Operation Control	Number Qt. (m³/d) Ratio (%)		1 63 0.8	8 856 58.7	1 370 100.0	1 30 3.3	11 1,319 11.8
Control of Water Use	Number Qt. (m³/d) Ratio (%)		2 180 2.2			10 859 94.5	12 1,039 9.3
Others	Number Qt. (m³/d) Ratio (%)		1 150 1.8			1 20 2.2	2 170 1.5
Total	Number Qt. (m³/d) Ratio (%)	5 153 100	19 8,270 100	16 1,460 100	1 370 100	12 909 100	53 11,162 100

Remarks: Boiler = Boiler Feed Water
Proc. & Washing = Processing & Washing Water
Cooling = Cooling Water
Air Cond. = Air Conditioning Water
Others = Water for Other Uses (Miscellaneous Use)
Qt. = Water Quantity

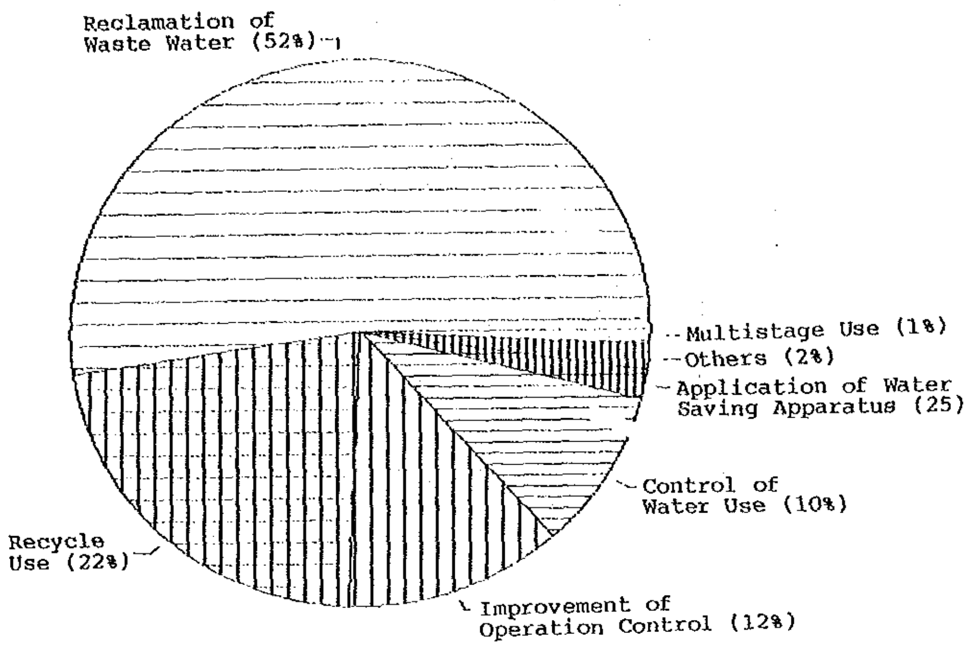


Fig. 4.4: Percentage of Potential Quantity of Water Saving Classified by Method for Effective Use

4.7 Potential Quantity of Water Saving Classified by Industry and Improvement Method

Table 4.4 summarizes the potential quantity of water saving classified by industry and improvement method. As mentioned above, since water reclamation is relatively easy in the paper and textile industries, it accounts for the large part of water saving in these industries. Next to water reclamation, recycling plays a fairly big role in the water saving of the food, paper and metal industries.

The percentage of recycling is small in the textile and chemical industries. This can be explained by the fact that the textile industry uses plenty of processing and washing water which is hard to recycle, and that the most part of water (i.e. cooling water) in the chemical industry is already recycled.

In the metal and chemical industries, a great deal of water can be saved through the improvement of operation control (i.e. through the raising of the degree of concentration in cooling water).

The improvement of water use control mainly concerns domestic water, so that the differences between industries do not matter much.

Table 4.4: Potential Quantity of Water Saving Classified by Method for Effective Use and Industry

Use / Method of Effective Use	Items	Consumption of Well Water (m^3/d)					
		Food	Paper	Textile	Metal	Chemical	Total
Recycle Use	Number Qt. (m^3/d) Ratio (%)	2 358 36.9	4 1,540 29.3	1 6 0.2	9 456 28.4	1 27 3.9	17 2,387 21.3
Multistage Use	Number Qt. (m^3/d) Ratio (%)			1 50 1.9	2 312 19.5		3 362 3.2
Reclamation	Number Qt. (m^3/d) Ratio (%)		2 3,700 70.3	1 2,000 75.9			3 5,700 51.1
Water Saving Apparatus	Number Qt. (m^3/d) Ratio (%)	4 155 16.0		1 30 1.1			5 185 1.7
Operation Control	Number Qt. (m^3/d) Ratio (%)	2 66 6.8		1 370 14.0	4 491 30.6	4 392 56.5	11 1,319 11.8
Control of Water Use	Number Qt. (m^3/d) Ratio (%)	2 240 24.8		2 180 6.8	5 344 21.5	3 275 39.6	12 1,039 9.3
Others	Number Qt. (m^3/d) Ratio (%)	1 150 15.5	1 20 0.4				2 170 1.5
Total	Number Qt. (m^3/d) Ratio (%)	11 969 100	7 5,260 100	7 2,636 100	20 1,603 100	8 694 100	53 11,162 100

Remark: Qt. = Water Quantity

4.8 Unit Cost of Improvement

4.8.1 Unit Cost of Improvement Classified by Industry

As shown in Table 4.1, the average unit cost of improvement is 4.7 ฿/m^3, which is much lower than the cost of MWA water or (expected) public industrial water. If the relatively high cost of reclamation is excluded, the average unit cost of improvement goes down to 1.4 ฿/m^3, the value equal to the pumping up cost of well water.

Except the textile industry where the high cost of reclamation (13.1 ฿/m^3) increases the unit cost up to 10 ฿/m^3, the unit cost of improvement is more or less the same as the cost of the pumping up of well water. It is low especially in the metal and chemical industries, since the percentages of inexpensive methods (operation control and control of water use) are high in these industries (refer to Table 4.4).

4.8.2 Unit Cost of Improvement Classified by Method

Table 4.5 shows the unit cost for each improvement method. As stated above, even with the high cost of reclamation included, the average unit cost of improvement does not exceed the cost of water form the alternative source.

If the cost of reclamation is excluded, the average unit cost becomes no more than the pumping up cost of well water. This inexpensiveness of the improvement is owing to the fact that the operation control and the control of water use account for 21% of the whole methods (43%, if reclamation is excluded). Making the use of industrial water more effective does not necessarily require a huge quantity of money.

Table 4.5: Potential Quantity of Water Saving Classified by Industry and Unit Cost

Method of Effective Use \ Use	Items	Rank of Unit Cost (฿/m³) Less than 1	1 to 5	5 to 10	More than 10	Total
Recycle Use	Number	6	7	4		17
	Qt. (m³/d)	1,677	330	380		2,387
	Av. U/Cost	0.7	3.4	6.1		2.0
Multistage Use	Number		3			3
	Qt. (m³/d)		362			362
	Av. U/Cost		2.2			2.2
Reclamation	Number		1	1	1	3
	Qt. (m³/d)		700	3,000	2,000	5,700
	Av. U/Cost		4.0	5.3	13.1	7.9
Water Saving Appratus	Number	3	2			5
	Qt. (m³/d)	135	50			185
	Av. U/Cost	0.3	1.3			0.6
Operation Control	Number	11				11
	Qt. (m³/d)	1,319				1,319
	Av. U/Cost	0.5				0.5
Control of Water Use	Number	11	1			12
	Qt. (m³/d)	899	140			1,039
	Av. U/Cost	0.0	1.0			0.1
Others	Number		1	1		2
	Qt. (m³/d)		20	150		170
	Av. U/Cost		4.4	7.1		6.8
Total	Number	31	15	6	1	53
	Qt. (m³/d)	4,030	1,020	3,530	2,000	11,162
	Av. U/Cost	0.5	3.1	5.5	13.1	4.7
	Ratio (%)	36.1	14.4	36.1	17.9	100.0

Remarks: Qt. = Water Quantity; Av. U/Cost = Average Unit Cost

4.8.3 Unit Cost of Improvement and Potential Quantity of Water Saving

As mentioned in 4.4, the potential quantity of water saving is closely related with the unit cost of improvement. When the latter is set high the former increases, and vice versa.

In the study, the allowable unit cost of improvement was set at 8 ฿/m³. In estimating the potential quantity of water saving, however, the unit cost up to about 13 ฿/m³ (1.5 time larger than the allowable cost) was allowed to be taken into account. Both the Fig. 4.5 and 4.6 illustrates the relation between the unit cost of improvement and the potential quantity of water saving.

Fig. 4.5 shows the relation between the upper limit of the unit cost and the integrated quantity (%) of water saving. Thus, once the limit of the unit cost is set, the corresponding quantity (%) of water saving can be read from this Fig. 4.5 Some examples are given below.

Upper Limit of Unit Cost (฿/m³)	Water Saving Quantity (%)
2 (equivalent to the pumping up cost)	39
5	52
8 (equivalent to the cost of public industrial water)	82
10	82

The unit cost of improvement shown in Fig. 4.5 is the upper limit. The average of the unit cost is obviously much lower (refer to 4.4). Fig. 4.6 shows the relation between the average unit cost and the integrated quantity (%) of water saving. Some examples are shown below.

Average Unit Cost (฿/m³)	Water Saving Quantity (%)
2 (equivalent to the pumping up cost)	77
4	82
4.7 (Still much lower than the cost of public industrial water)	100

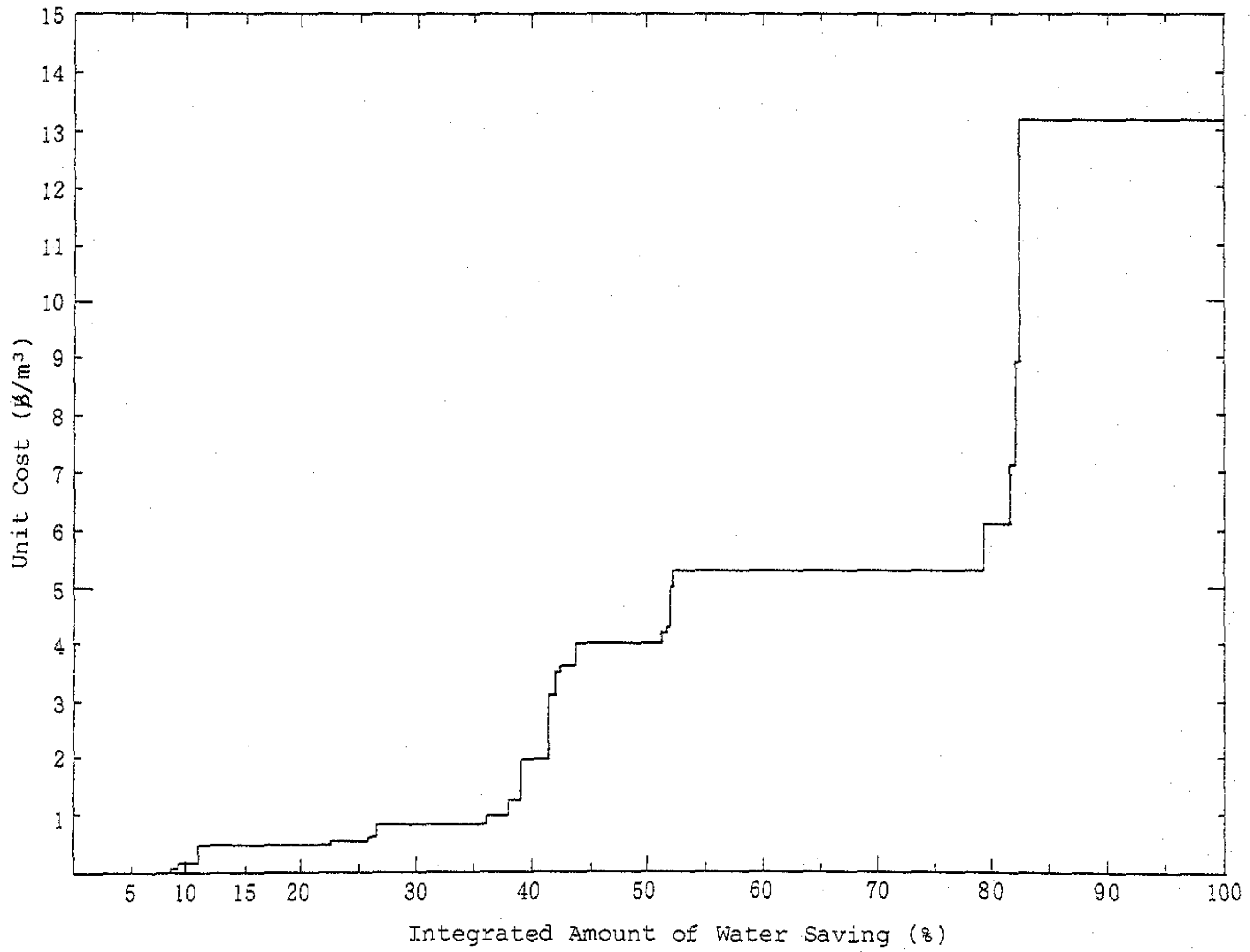


Fig. 4.5: Unit Cost of Improvement and Potential Quantity of Water Saving

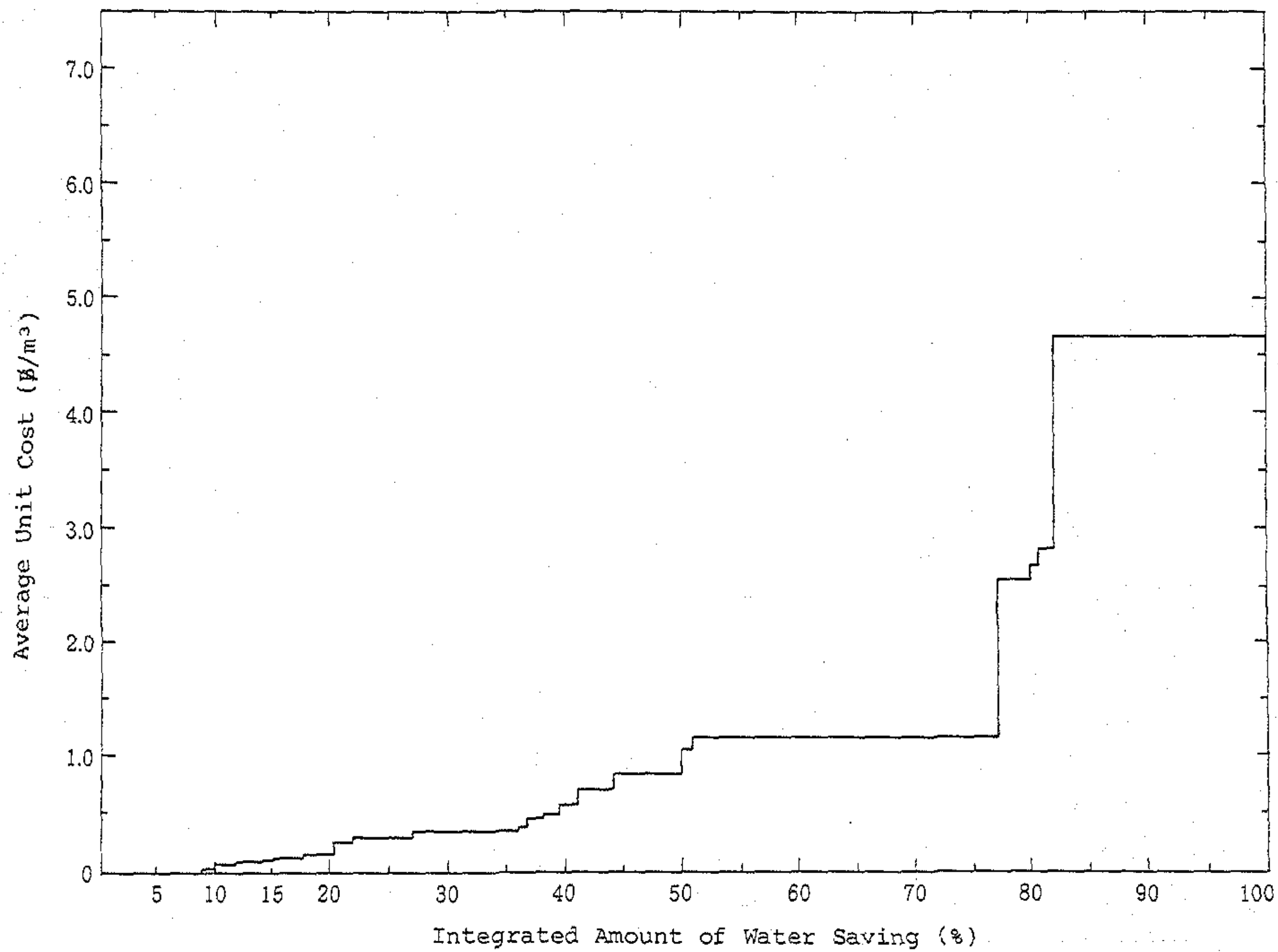


Fig. 4.6: Average Unit Cost of Improvement and Potential Quantity of Water Saving

The above figures may be summed up as follows:

(1) If the upper limit of the unit cost of improvement is set at the present cost of pumping up, the water saving is reduced to 39% (i.e. 4,350 m^3/d, 8.7% of saving rate) of the total potential quantity.

(2) If the average unit cost of improvement is set at the present cost of pumping up, the water saving is reduced to 77% (i.e. 8,595 m^3/d, 17.1% of saving rate) of the total potential quantity.

(3) If the upper limit of the unit cost is set at the cost of the alternative water sources, 82% (i.e. 9,150 m^3/d, 18.2% of saving rate) of the total potential quantity is saved.

(4) Even if the average unit cost of improvement is much lower than the cost of alternative water, 100% of the total potential quantity is saved.

As shown in 4.3 above, the estimation of the unit cost of improvement is based on certain assumptions. Hence, in some cases, the real costs of improvement may differ from those indicated here.

4.9 Summary

4.9.1 General

The industries in Samut Prakarn Area have been changing their structures. Now emerging are more sophisticated, import-oriented industries that use less energy, materials and water and add higher values.

Taking this trend into consideration, the methods for the effective use of industrial water in Samut Prakarn may be summarized as follows.

(1) Cooling water (indirect cooling water, in particular) should be recycled.

(2) Washing water should be re-used on the condition that it does not pollutethe the environment. The cost for the re-use of washing water should be also taken into account.

(3) Steam condensate should be recovered as much as possible.

(4) The consumption of domestic water should be effectively controlled.

4.9.2 Cooling Water

(1) At present, some cooling water is used only once through. Effective method should be studied to recycle all cooling water through cooling towers.

(2) The degree of concentration (refer to 4.2) should be raised as high as possible for all cooling towers. Since the cooling towers in Samut Prakarn have generally small hold-up of water, it is hard to control the degree of concentration manually. The automatic adjustment systems shown in Figs. 4.7 and 4.8 will be of great help.

(3) The function of cooling towers should be improved. Some cooling towers are not operating as designed. On the basis of check and inspection, necessary method such as the repairing and/or replacement of drift prevention devices, if necessary, should be taken.

(4) In order to prevent the growing of contamination, corrosion and slime, chemicals should be injected into cooling water.

(5) A flow meter should be installed for each cooling water system (including a cooling tower).

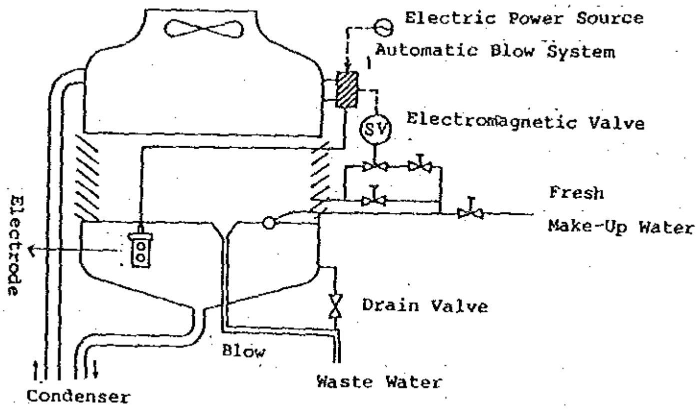


Fig 4.7: Automatic Blow System

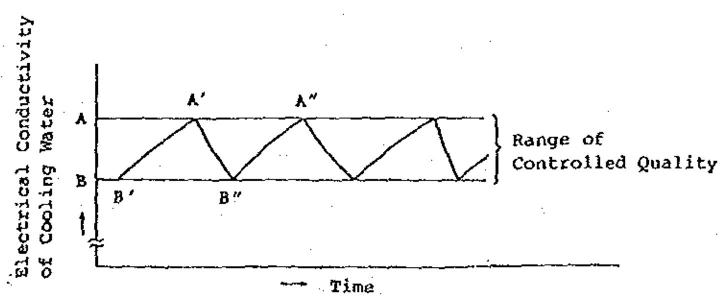


Fig. 4.8: Change of Water Quality by Electrical Conductivity Control

4.9.3 Washing Water

(1) In order to re-use washing water, highly contaminated waste water in chemical or electroplating factories should be treated with ion exchange, electrodialysis or reverse osmosis systems.

(2) As already practiced in some factories, air flotation and coagulation/filtration systems are also effective for the re-use of waste washing water.

The reclamation of waste water, though expensive in some cases, is desirable for the protection of environment, too.

4.9.4 Recovery of Steam Condensate

In order to recover steam condensate, traps and return pipes should be furnished. Steam condensate may be re-used for the washing of softeners.

4.9.5 Domestic Water

(1) A flow meter should be installed at each water pipe leading to an employees' dormitory or to the outside of a factory. If feasible, some rates should be imposed on the use of domestic water.

(2) In order to control the consumption of domestic water, flow meters should be installed at the main points (for example, canteens, meeting rooms and shower baths) in factories.

(3) At the points where a large quantity of domestic water is consumed, water saving apparatus (water saving type taps, water saving type toilet bowls, hand control valves, etc.) should be furnished. It is desirable for a public organization to standardize such water saving apparatus.

(4) The optimum quantity of domestic water consumption ("unit domestic water usage") should be established on the user's basis. Refer to Appendix Part 2 for details.

(5) Measures should be promptly taken against any water leakages from pipings or taps.

Chapter 5

Improvement Methods for Each Factory

Chapter 5. Improvment Methods for Each Factory

In the following pages, improvement methods for effective use of industrial water are described in details for each factory. The each description of factory includes:

(1.) Outline of Factory

(2.) Present Situation of the Use of Industrial Water

(2.1) Water Consumption

(2.2) Process Diagram of Production Line

(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

(2.4.2) Water Treatment

(2.4.3) Waste Water Treatment

(3.) Plans of Effective Use of Industrial Water

(3.1) General

(3.2) Details

(4.) Cost Estimation

5.1 Food Industry

5.1.1 Code No. of Factory: F-01

(1.) Outline of Factory

Capital (MB): -

Annual Amount of Shipment (MB): 400

Total Area (m^2): 12,100

Total No. of Employees: 700

Main Products: Canning of Fish, Fruits and Vegetables

(2.) Present Situation of the Use of Industrial Water

(2.1) Water Consumption

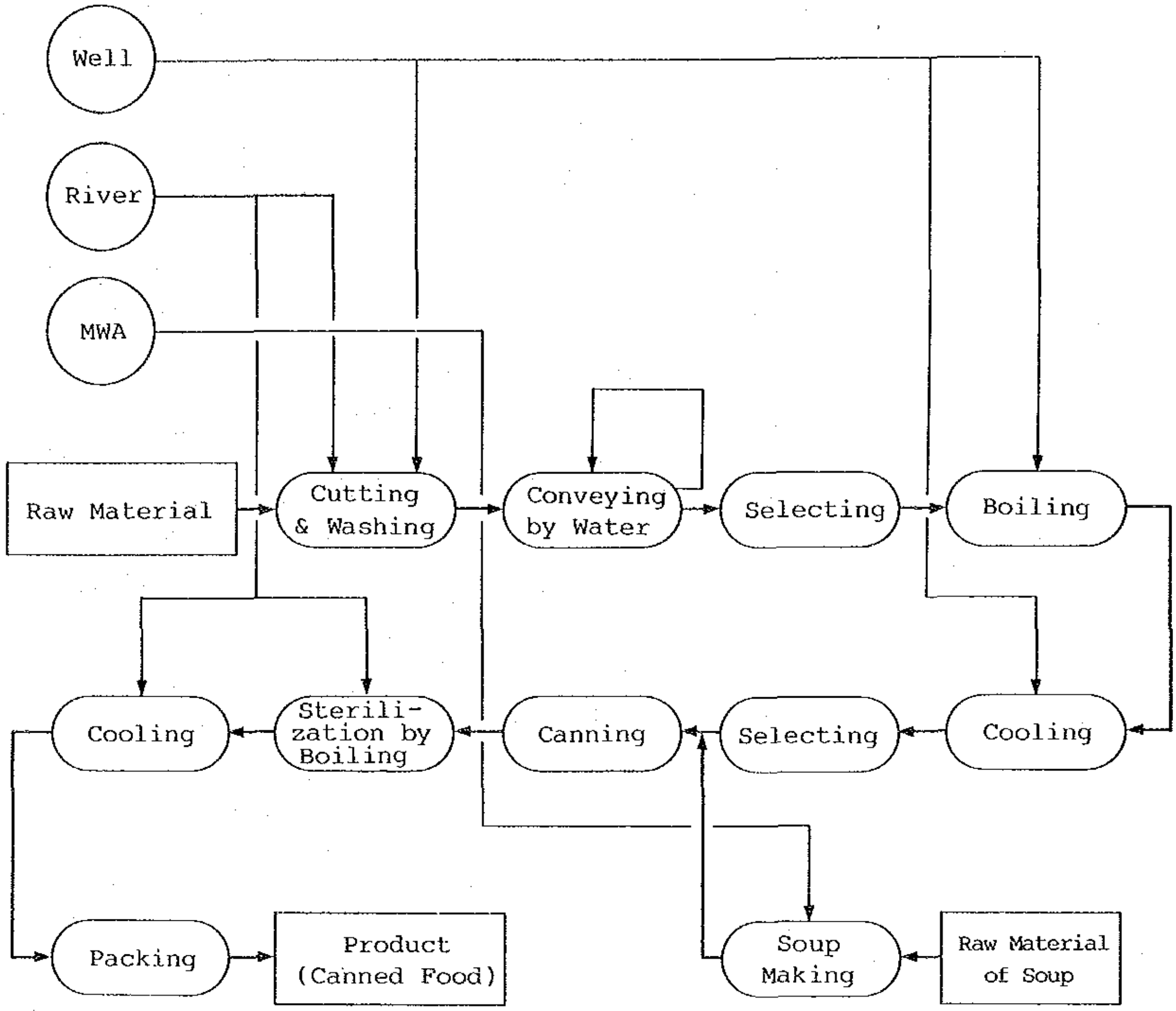
Unit: m^3/d

Source / Use	Well Water	MWA	* Others	Sub Total	Recovered Water	Total
Boiler		24		24		24
Material		2		2		2
Processing & Washing	635		231	866		866
Cooling			54	54	540	594
Air Conditioning						
Others	** 235	4	15	254		254
Sub Total	870	30	300	1,200	540	1,740
Outside						
Total	870	30	300	1,200	540	1,740

Recovery Rate (%): 31.0

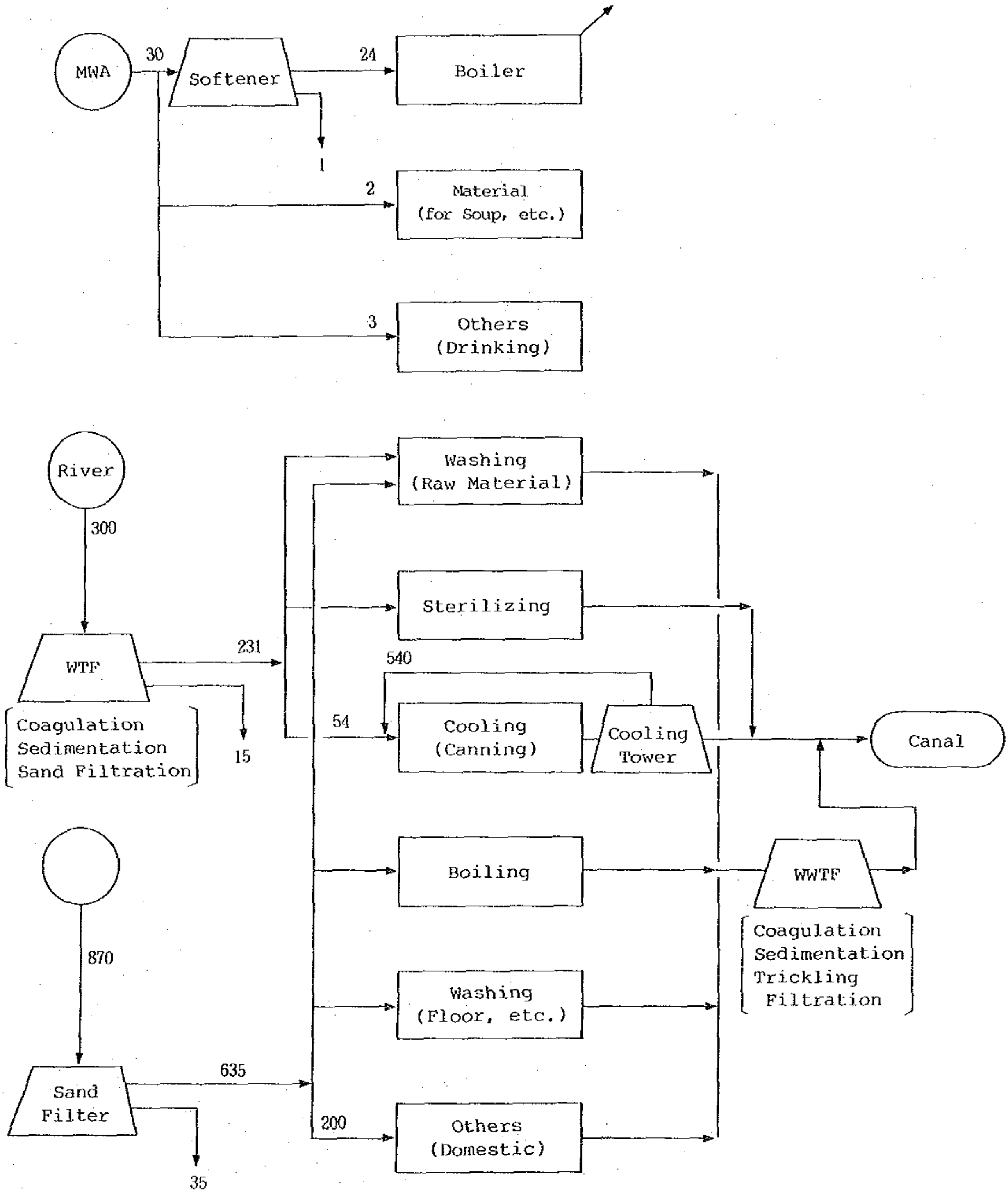
Note: * River Water
** Including Dormitory Use

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m³/d)



Legend: WTF = Water Treatment Facility
WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

In this factory, about 870 m^3/d of water is pumped up from three wells. The total water consumption reaches 1,740 m^3/d.

All three wells are identical in depth (84 m), pump capacity (30 m^3/h) and pipe diameter (3 inches).

In addition to well water, this factory uses river water and MWA water. River water (300 m^3/d) is used to wash raw material as well as to cool sterilizing equipment and canned product.

MWA water is mainly used for the boiler. It is also used for cooking of fish and vegetable and drinking.

Except the MWA piping, no water piping has any flow meter.

Around 670 m^3/d of well water is used for processing and washing (mainly for washing of raw material, floor, machine and equipment). Well water is also used for the employees' dormitory (200 m^3/d).

The measured quality of well water is 3 mg/lit of turbidity, 6.7 to 7.0 of pH and 1,600 to 2,000 $\mu S/cm$ of electrical conductivity.

Meanwhile, the measured quality of river water is 29 mg/lit of turbidity, 7.0 of pH and 380 $\mu S/cm$ of electrical conductivity. Its electrical conductivity is much lower than that of well water (this may be partly due to the fact that the measurement was taken after a rainfall).

Although river water is turbid and is a yellowish brown color, a treatment by sand filter can make it clean and the turbidity can be decreased to 3 mg/lit.

The quality of MWA water is 8.2 of pH and 230 $\mu S/cm$ of electrical conductivity.

(2.4.2) Water Treatment

Well water is treated by two gravity-type sand filters placed in series and treated water is sent to a pressure tank before being supplied for various uses.

River water is taken from a nearby waterway using two pump systems (altogether four pumps). It is treated by two coagulation and sedimentation tanks, a pressure-type sand filter and a chlorine sterilizer before being used.
MWA water is softened before being supplied to the boiler.

Although three different types of water (well water, river water and MWA water) are used in this factory, no distinction is made for water pipings, which might result in misuse of water. Pipings should be distinguished from each other according to the type of water--for example, by using pipings with different colors. In fact, judging from the electrical conductivity, some water which is classified by the factory as well water is likely to be river water.

Overall water control is not conducted adequately and water consumption for each use is not measured correctly.

The costs of well water, river water and MWA water are 1 ฿/m^3, 1 ฿/m^3 and 6 ฿/m^3 respectively.

(2.4.3) Waste Water Treatment

Waste water from processing and washing, as well as domestic waste water, is treated by a coagulation and sedimentation tank, followed by a trickling filter called bamboo filter before being discharged into a canal.

Because of the insufficient capacity of the sedimentation tank and the trickling filter, the waste water treatment seems to be inadequate.

Drain from the cooling tower using river water, as well as cooling water from the sterilizer for canned product, are discharged into a canal without any treatment.

The quality of influent and effluent of the coagulation tank is as follows.

Data / Item	Influent	Effluent
Turbidity (mg/lit)	1	3
pH	11.9	11.9
Electrical conductivity (μS/cm)	8,960	9,250

(3.) Plans of Effective Use of Industrial Water

(3.1) General

In this factory, river water and MWA water are used to save well water. The present percentage of river water to the total make-up water is 25%, which could be increased further.

Most of cooling water is recycled (540 m^3/d out of 594 m^3/d). The total water recovery rate of this factory reaches 31.0%. As far as the recovery is concerned, the use of water is already fairly effective.

Because of the nature of the product (i.e. a high degree of sanitary condition must be maintained for food), it is difficult to raise the water recovery rate from the present level.

Therefore, the effective way for improvement is to control the water use by measuring water consumption for each use and making every employee aware of the importance of water saving. The use of water saving apparatus such as hand control valves may be also helpful.

The river water is supplied as make-up water to cooling tower for the cooling of canned product. The degree of concentration is 1.3 (the electrical conductivity is 400 μS/cm), which is a reasonable value.

(3.2) Details

a. Thorough control of water use and installation of hand control valve

No hand control valve is provided at present where well water is used for washing of floor and equipment. The use of hand control valves for manual washing might save a fair quantity of water. On an assumption that about 500 m^3/d of water is used for washing (the exact quantity is not known), use of hand control valves might save 100 m^3/d of water (about 20% of the total washing water).

b. Use of river water for floor washing

By sorting out water supply pipings, river water might be used for floor washing. That way, around 100 to 150 m^3/d of well water could be saved. To serve this purpose, an additional water treatment system (coagulation/sedimentation and sand filtration) need to be installed.

(4.) Cost Estimation

Number	1	2
Method for Effective Use Method Item	 Application of water saving apparatus Thorough control of water use and use of hand control valve	 Others Use of river water for floor washing and others
Water Saving Use Qt. (m³/d)	 Processing & washing 100	 Processing & washing 150
Apparatus for Effective Use Apparatus Cost (10³฿)	 Hand control valve 12 mm x 20 units 20	 Sedimentation/coagulation tank, sand filter, pump, electric instrument & piping 1,260
Unit Cost (฿/m³) Fixed Operating Total	 0.2 - 0.2	 3.4 3.7 7.1

Total Water Saving (m³/d): 250

Total Initial Cost (10³฿): 1,280

Total Unit Cost (฿/m³): 4.3

Note: Qt. = Quantity

5.1.2 Code No. of Factory: F-02

(1.) Outline of Factory

Capital (M฿): 0.4

Annual Amount of Shipment: 40 t/Y

Total Area (m^2): 48,000

Total No. of Employees: 450

Main Products: Condensed Milk, Ultra-Homogenous Treated Milk,
Butter and Dry Milk

(2.) Present Situation of the Use of Industrial Water

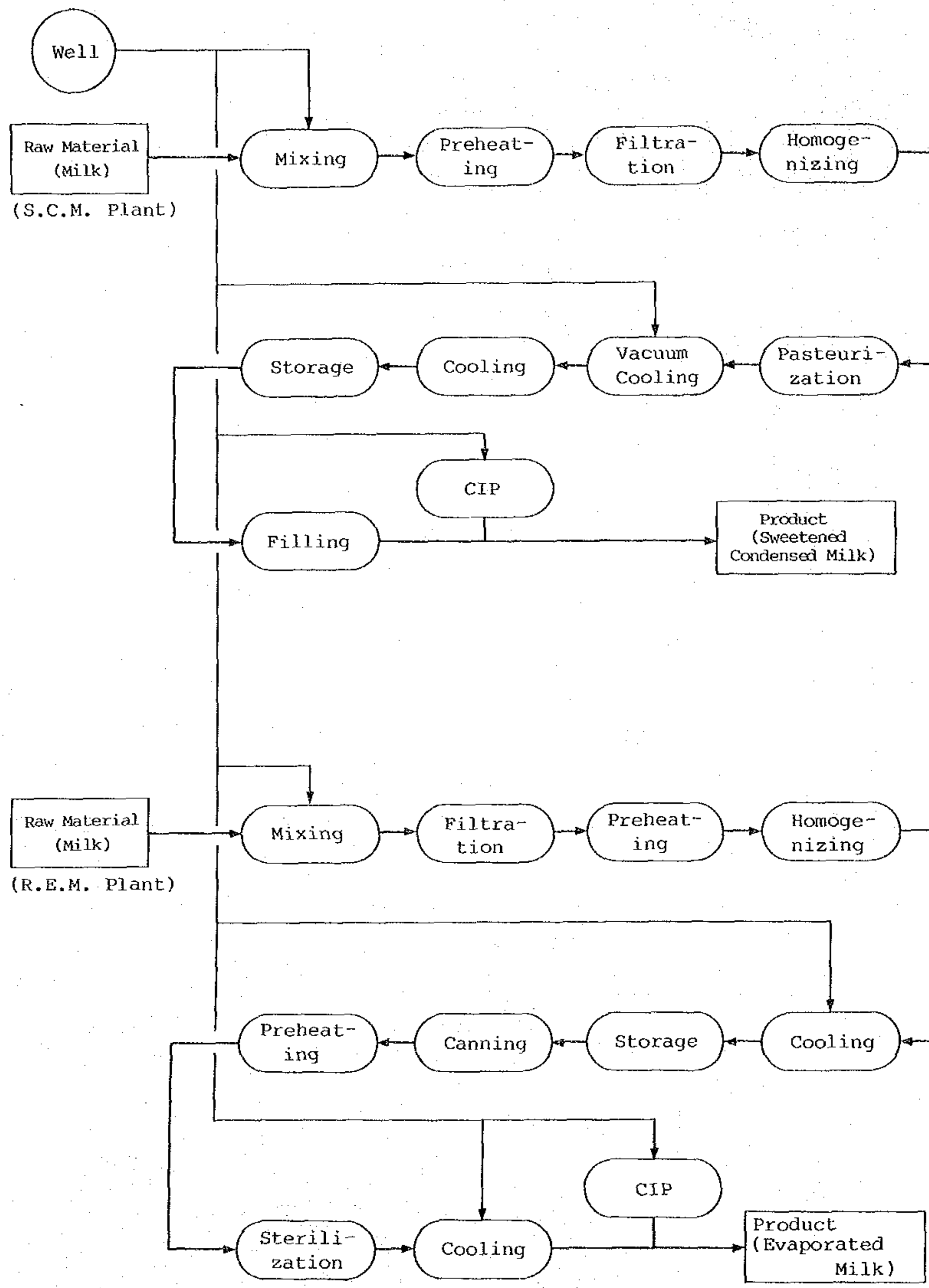
(2.1) Water Consumption

Unit: m^3/d

Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Tatal
Boiler	65			65		65
Material Processing & Washing	470			470		470
Cooling	180			180	4,000	4,180
Air Conditioning						
Others	350			350		350
Sub Total	1,065			1,065	4,000	5,065
Outside						
Total	1,065			1,065	4,000	5,065

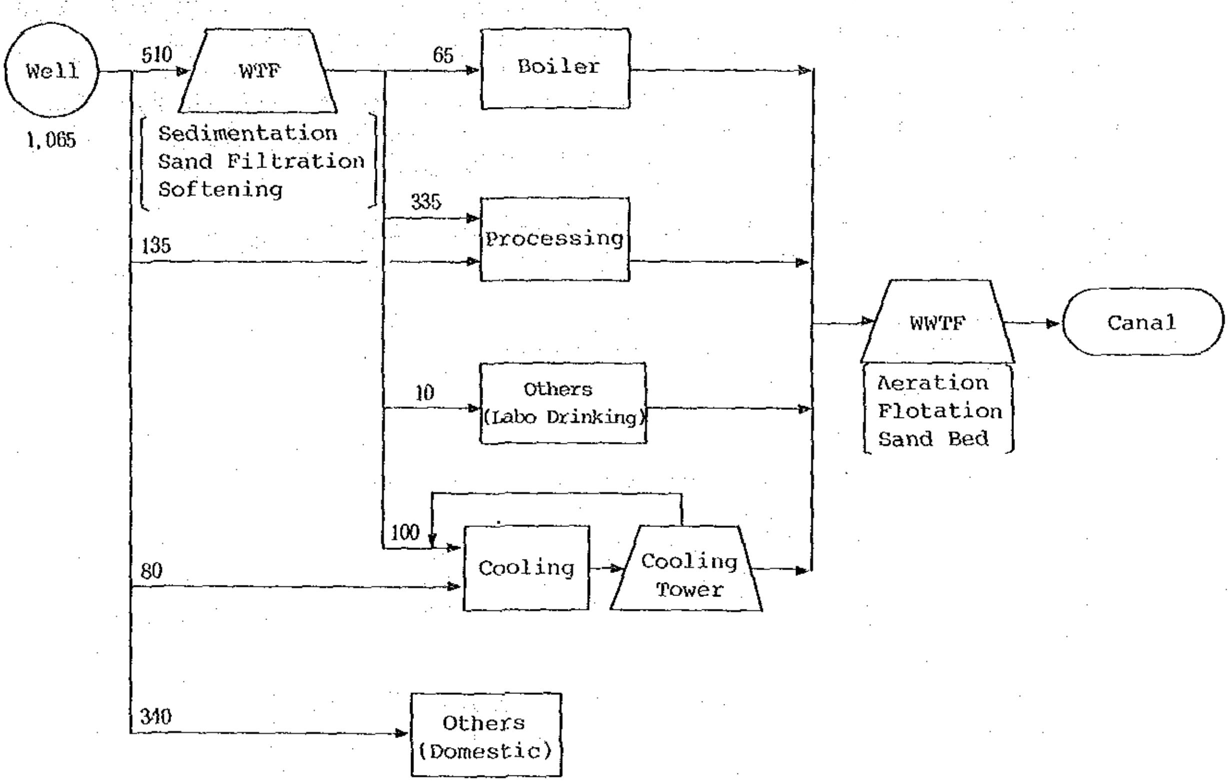
Recovery Rate (%): 78.9

(2. 2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WTF = Water Treatment Facility
WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

The water consumption of this factory is 5,065 m^3/d (1,065 m^3/d of make-up water and 4,000 m^3/d of recovered water).

Make-up water is supplied from two wells. Each well is 140 m deep and is equipped with a flow meter. The total capacity of the two pumps is 155 m^3/h, that is, 1,240 m^3/d (8 hours).

Around 44% of make-up water is used for processing. Then make-up water for domestic use accounts for 33%.

All recovered water is exclusively used for cooling. There are nine cooling towers whose designed capacity reaches 1,430 RT in total.

Make-up water is used partly without any treatment and partly with some purification treatment.

(2.4.2) Water Treatment

Water is treated by a sedimentation tank (NaClO added), a sand filter (capacity: 47 m^3/h) and a softener.

The quality of treated water is as follows.

pH: 7.88 - 8.3
Total hardness: 42 - 69 mg/lit
Chloride ion: 252 - 310 mg/lit

(2.4.3) Waste Water Treatment

Waste water is treated by aeration, activated sludge and flotation processes before being discharged into a river.

The quality of waste water is as follows.

Item \ Data	Influent	Effluent
pH	6.95 - 7.54	7.80 - 7.86
COD (mg/lit)	1,587 - 4,448	87 - 114
SS (mg/lit)	71 - 1,240	13 - 19
DO (mg/lit)		1.04 - 1.36

(3.) Plans of Effective Use of Industrial Water

(3.1) General

The average cost of water (tax on well water and treatment cost) is 2 ฿/m³. As this cost is relatively low, the importance of water saving is rather underrated in this factory.

The water recovery rate is already fairly high (79%) and there is little room for further improvement in this respect.

On the other hand, domestic water amounts to 350 m³/d, which is equivalent to 778 lit/capita/d. This level seems too high.

In addition to the investigation of water leakage, the actual situation of the use of domestic water should be checked.

(3.2) Details

a. Check and control of domestic water consumption

If unit consumption of domestic water is reduced to 300 lit/capita/d, the total quantity would become about 135 m³/d. Thus, about 215 m³/d of water would be saved.

(4.) Cost Estimation

Number	1
Method for Effective Use Method Item	 Control of water use Check and control of water requirement for domestic use
Water Saving Use Quantity (m³/d)	 Domestic 215
Apparatus for Effective Use Apparatus Cost (10³฿)	
Unit Cost (฿/m³) Fixed Operating Total	 - - -

5.1.3 Code No. of Factory: F-03

(1.) Outline of Factory

Capital (M฿): 50

Annual Amount of Shipment (M฿): 200

Total Area (m²): 5,500

Total No. of Employees: 100

Main Products: Jam, Paste, Margarine and Dry Milk

(2.) Present Situation of the Use of Industrial Water

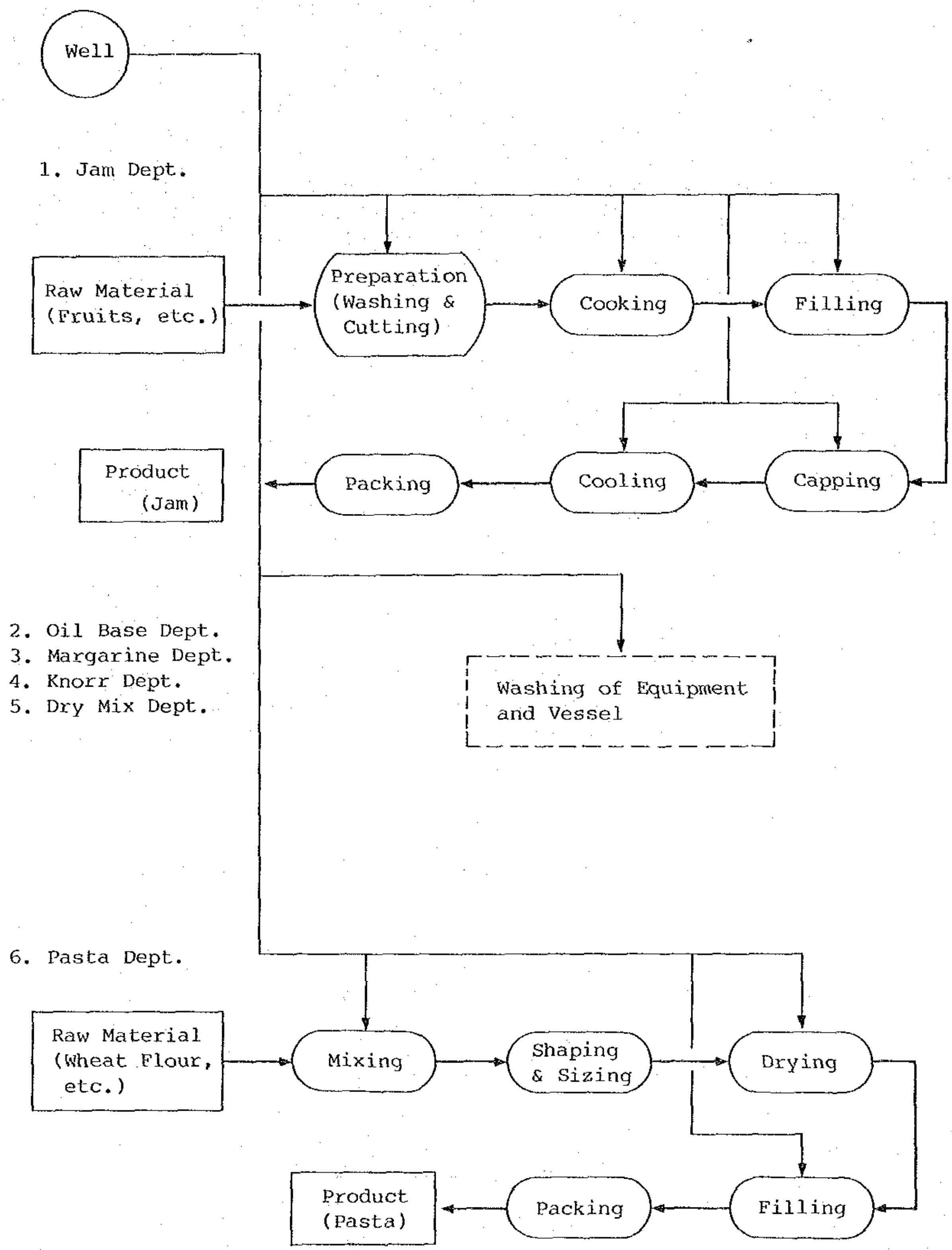
(2.1) Water Consumption

Unit: m^3/d

Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total
Boiler	24			24		24
Material	5			5		5
Processing & Washing	78			78		78
Cooling	36			36	672	708
Air Conditioning						
Others	35			35		35
Sub Total	178			178	672	850
Outside						
Total	178			178	672	850

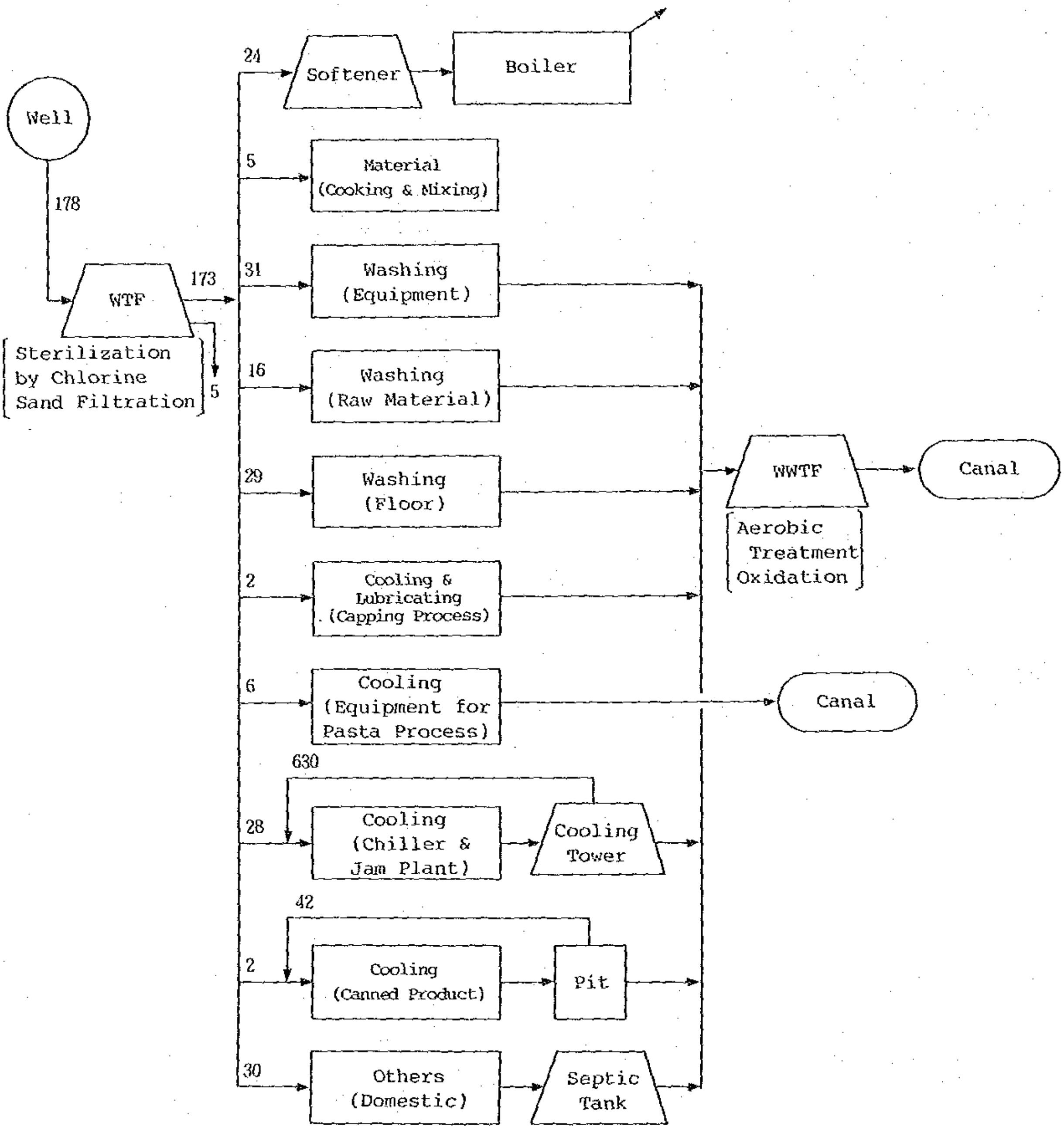
Recovery Rate (%): 79.1

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m³/d)



Legend: WTF = Water Treatment Facility
WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

In this factory, 178 m^3/d of water is pumped up from a well. The well is 100 m in depth and 8 inches in pipe diameter. The capacity of its pump, with 5.5 HP electric motor, is 14.5 m^3/h.

Although well water is clean and has virtually zero mg/lit turbidity, it is treated by sand filter before being used. With the electrical conductivity of 725 $\mu S/cm$, the quality of well water of this factory is good compared with other well water in the same area.

The largest part of make-up water is used for washing of equipment, floor and raw material. Water for cooking and material mixing being added, the quantity of processing and washing water reaches 89 m^3/d.

Cooling water amounts to 672 m^3/d. It is recycled for cooling the ammonia compressor of refrigerator and the jam production machine. Canned product is also cooled by recycled cooling water. In addition, some equipment is cooled with once-through cooling water.

Domestic water amounts to 30 m^3/d.

According to the factory's data, the quality of well water is as follows.

Turbidity:	0.5 NTU
pH:	8.6
Alkalinity:	329 mg/lit
Total hardness:	56 mg/lit
Chloride ion:	24 mg/lit
Electrical conductivity:	650 $\mu S/cm$

(2.4.2) Water Treatment

Well water is sterilized by chlorine and sent to a storage tank. Then it is treated by a pressure-type sand filter before being used.

After the filtration, make-up water for the boiler is treated by a softener.

There are two cooling towers (one for the refrigerator and the other for the jam production machine). At the time of the survey, the electrical conductivity of cooling water for the jam production machine was 2,040 $\mu S/cm$, and the degree of concentration was 2.8.

(2.4.3) Waste Water Treatment

Except the cooling water for the pasta production equipment, all waste water is treated by an oxidation ditch system with a capacity of 120 m³/d before being discharged.

At the time of the survey, the operation of the waste water treatment system was not stable, because an aeration rotating drum with a expanded capacity had been newly adopted. However, the maintenance of the system seems practically well.

According to the factory's data, the quality of waste water is as follows.

Item \ Data	Influent	Effluent
SS (mg/lit)	100	20
BOD (mg/lit)	550	20
COD (mg/lit)	1.200	60
pH	8	8

(3.) Plans of Effective Use of Industrial Water

(3.1) General

In this factory, the use of cooling water is already highly effective (672 m³/d out of 702 m³/d of water is recycled through a cooling tower or a water saving apparatus). The total water recovery rate reaches 79.1%.

Despite the fact that few number of flow meters are provided, the use of water for each production process is monitored fairly well. The staff of water supply seems to be well aware of the problems of water treatment facility and importance water saving.

The factory is planning to prevent wasteful overflow by installing check valves at the pipings for cooling towers. It also intends to recycle cooling water used in once-through system for the pasta production process when the cooling tower for the refrigerator has reserve capacity.

Washing water, though large in quantity, cannot be reduced, because the food production requires sanitary environment.

At present, the well pump with 5.5 horsepowers is used. When water consumption is small (in the night, for example), it can be replaced by one with 2 horsepowers. This switch over of a pump would be effective in water saving.

After the sterilizing process, canned product is cooled by water spraying. This cooling water is recycled through a water saving apparatus, and there is no room for further saving.

(3.2) Details

a. Installation of check valve to cooling tower pipings

Two cooling towers are used to recycle cooling water (630 m^3/d) for the ammonia compressor of the refrigerator and jam production plant.

The cooling tower continues to operate even if the operation of the refrigerator stops. As to the cooling tower for the jam production plant, the return pipe has no check valve, so that recycled water flows backward to the tower and overflows when the operation of the plant stops.

At the time of the survey, the refrigerator was out of operation and the cooling tower for the jam production plant was operating. The degree of (salt) concentration of the recycled water was a little high (2.8). The electrical conductivity was 2,040 $\mu S/cm$.

Therefore, as the factory plans to do, check valves (or solenoid valves) should be installed at the recycling pipe lines of both cooling towers in order to prevent overflow at the time of plant (or refrigerator) stoppage. Also, the cooling tower operation should be stopped when it is not required.

It is hard to estimate how much recycled water can be saved by preventing overflow, because the details of operating conditions (frequency and duration of shut down) of the jam production plant and the refrigerator are not known.

On an assumption that both machines operate nine hours a day and stop three times, and that each stoppage lasts 15 minutes during which 10% of recycled water is lost, the quantity of water saving would be 5 m^3/d.

b. Recycle use of cooling water of once-through system through the existing cooling tower

Cooling water of the once-through system for the capping and pasta processes might be recycled as shown in remodeling plan of the factory.

The existing cooling tower could be used for recycling of cooling water as it has reserve capacity. The quantity of water saving would be 8 m^3/d.

(4.) Cost Estimation

Number	1	2
Method for Effective Use Method Item	 Application of water saving apparatus Installation of check valve in cooling tower	 Recycle use Recycle use of cooling water of once-through system by existing cooling tower
Water Saving Use Qt. (m^3/d)	 Cooling 5	 Cooling 8
Apparatus for Effective Use Apparatus Cost (10^3฿)	 Check valve 100 mm x 1 unit 9	 Piping 15
Unit Cost (฿/m^3) Fixed Operating Total	 0.9 - 0.9	 1.0 0.5 1.5

Total Water Saving (m^3/d): 13

Total Initial Cost (10^3฿): 24

Total Unit Cost (฿/m^3): 1.3

Note: Qt. = Quantity

5.1.4 Code No. of Factory: F-04

(1.) Outline of Factory

Capital (M฿): 24

Annual Amount of Shipment (M฿): -

Total Area (m^2): 56,000

Total No. of Employees: 214

Main Products: Fish Sauce

(2.) Present Situation of the Use of Industrial Water

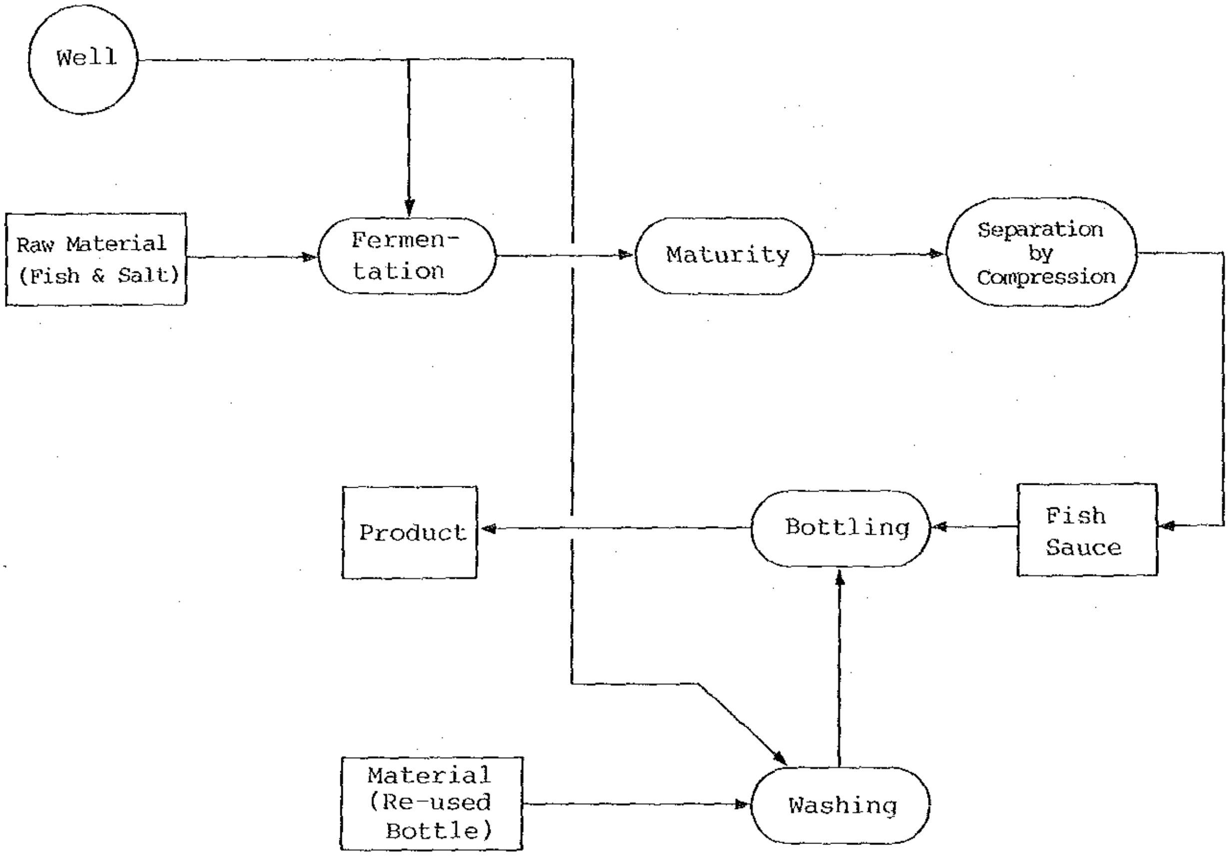
(2.1) Water Consumption

Unit: m^3/d

Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total
Boiler						
Material	5			5		5
Processing & Washing	93			93		93
Cooling						
Air Conditioning						
Others	2			2		2
Sub Total	100			100		100
Outside						
Total	100					

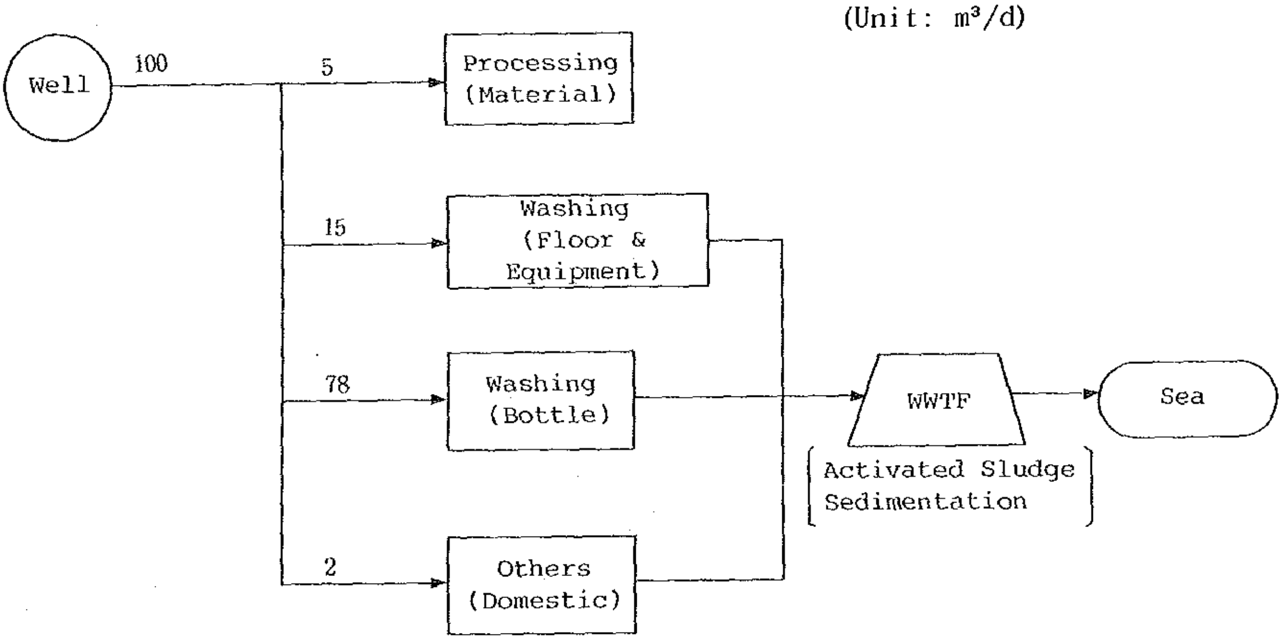
Recovery Rate (%): 0.0

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

The water consumption of this factory amounts to 100 m^3/d. As no water is recovered, only make-up water is used.

Make-up water is supplied from two wells (one is 140 m deep and the other 192 m deep), and both are not provided with flow meter. The total capacity of two wells is designed to be 33 m^3/h (i.e. 264 $m^3/8$ h).

Water is mostly used for washing, accounting for 93% of the total water consumption. Washing of recovered empty bottle accounts for 84% of the total washing water.

Water is used without any treatment. Its quality is as follows.

Turbidity:	4 mg/lit
Electrical conductivity:	750 $\mu S/cm$
pH:	7.8
Temperature:	36.5 ℃

Waste water is treated by activated sludge and sedimentation pond before being discharged into the sea.

(3.) Plans of Effective Use of Industrial Water

(3.1) General

As the quantity of water consumption is small and water cost is low (less then 0.05% of the total production cost), this factory does not plan to make the water use more effective.

Water is mostly used to wash recovered bottle and remove label from them. The bottle washing is conducted based on a batch system.

(3.2) Details

a. Use of two stage counter-flow system for bottle washing

If a two-stage counter-flow system is adopted for bottle washing, the present water consumption would be saved by 50%. The adoption of this system, however, requires a large-scale reconstruction of the production facility, and hence it would be better to introduce the system when the whole production facility is updated. For the time being, therefore, there would be no room for further improvement.

5.1.5 Code No. of Factory: F-05

(1.) Outline of Factory

Capital (M฿): 8

Annual Amount of Shipment (M฿): -

Total Area (m^2): 27,200

Total No. of Employees: 465

Main Products: Canning of Fish, Fruits and Vegetables

(2.) Present Situation of the Use of Industrial Water

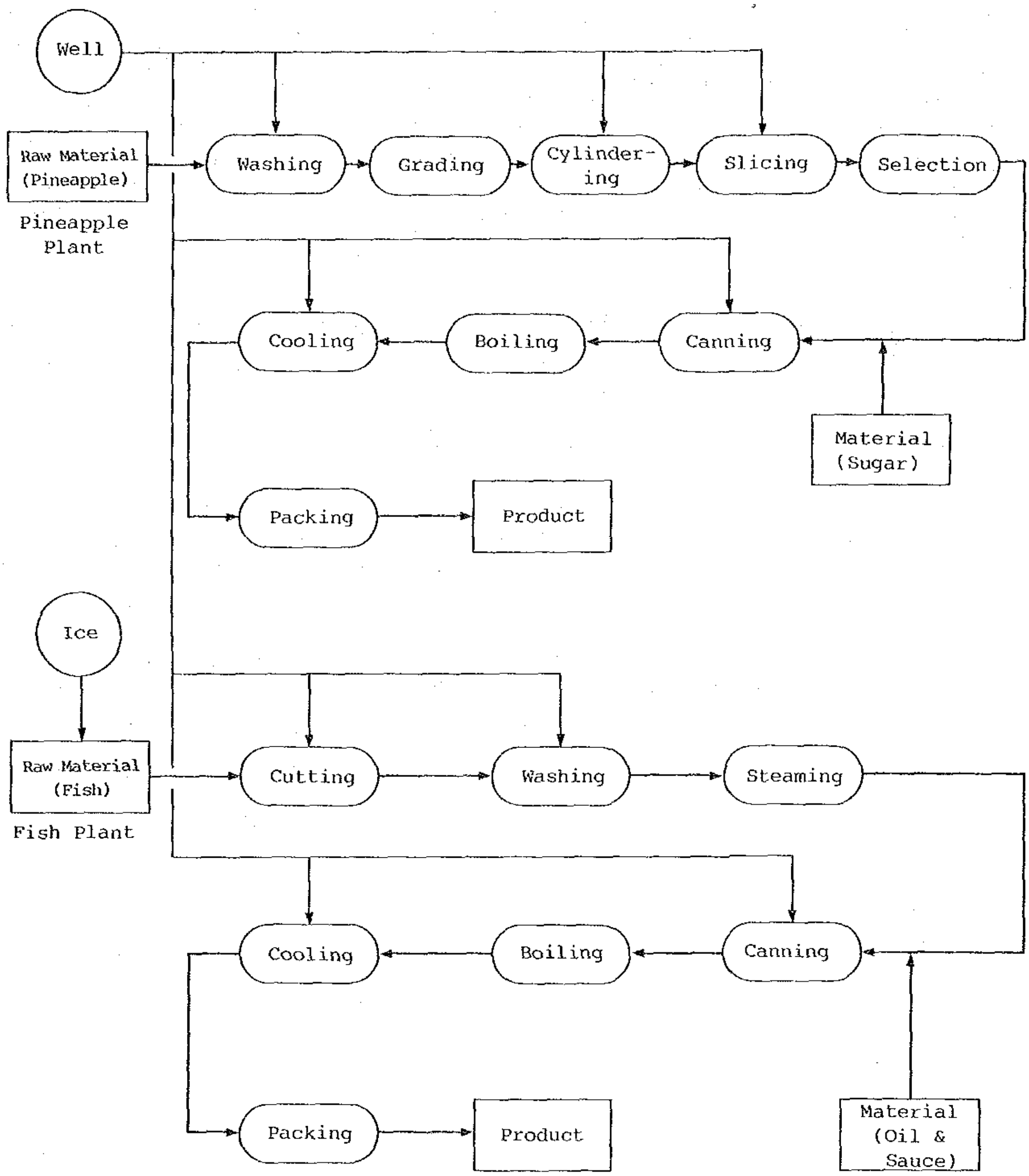
(2.1) Water Consumption

Unit: m^3/d

Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total
Boiler	38			38		38
Material	20			20		20
Processing & Washing	492			492		492
Cooling	44		40	84	4,797	4,881
Air Conditioning						
Others	20			20		20
Sub Total	614		40	654	4,797	5,451
Outside						
Total	614		40	654	4,797	5,451

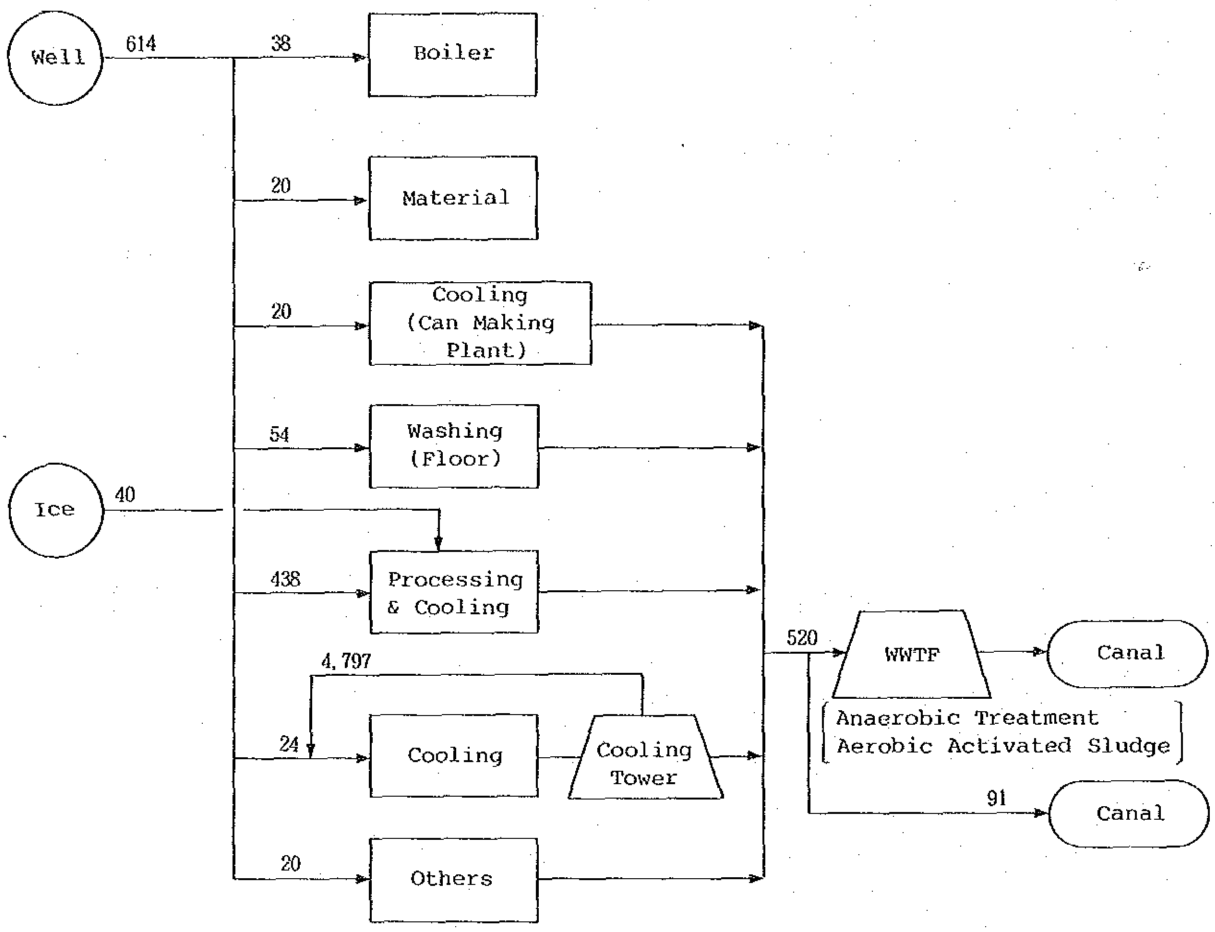
Recovery Rate (%): 88.9

(2.2) Process Diagram of Production Line



(2. 3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

The total water consumption of this factory reaches 5,451 m^3/d. To be specific, 654 m^3/d of make-up water (614 m^3 of well water and 40 m^3 of purchased ice) and 4,797 m^3/d of recovered water is used.

Depending on the seasonal factor of raw material and change in the market situation, the operation of the factory fluctuates, resulting in the notable fluctuations in the water consumption.

Make-up water consists of well water and purchased ice.

Well water is pumped up from three 150 m deep wells, including one standby. Each well is provided with a flow meter. The registered pumping up quantity of three wells is 1,450 m^3/d. In addition, 40 m^3/d (average) of ice is purchased.

As for the use of water (including recovered water), cooling water and washing water accounts for 90% and 9% respectively.

Around 75% (492 m^3/d) of make-up water is used for processing and washing. Make-up water for cooling accounts for 13% (84 m^3/d)

(2.4.2) Water Treatment

Although a sand filter is installed, it is not used at present. According to the factory's data, the quality of well water is as follows.

pH:	6.2
Electrical conductivity:	840 μS/cm
Total hardness:	185 mg/lit
Chloride ion:	188 mg/lit

The quality of recycled cooling water is as follows.

pH:	8.5
Electrical conductivity:	2,600 μS/cm
Total hardness:	300 mg/lit
Chloride ion:	447 mg/lit

The factory plans to install a softener in the future.

(2.4.3) Waste Water Treatment

At present, waste water of the fish plant is treated by anaerobic treatment before being discharged into a canal. Other waste water is discharged without any treatment.

The following table shows the quality of the waste water of the fish plant.

Item \ Data	Influent	After anaerobic treatment	Discharge water
BOD (mg/lit)	210 (17,717)	557	19
COD (mg/lit)	3,030 (21,781)	871	110

The figures shown in parentheses are those of the waste water from the pineapple plant.

(3.) Plans of Effective Use of Industrial Water

(3. 1) General

In this factory, cooling water is recycled through the cooling tower. The recovery rate is 89%.

The use of washing water in the production process would not be further saved.

On the whole, there is little room for further improvement of effective use of water.

5. 1. 6 Code No. of Factory: F-06

(1.) Outline of Factory

Capital (M฿): -

Annual Amount of Shipment (M฿): 670

Total Area (m^2): 33,600

Total No. of Employees: 400

Main Products: Condensed Milk, Steriled Milk, Sauce and Baby Food

(2.) Present Situation of the Use of Industrial Water

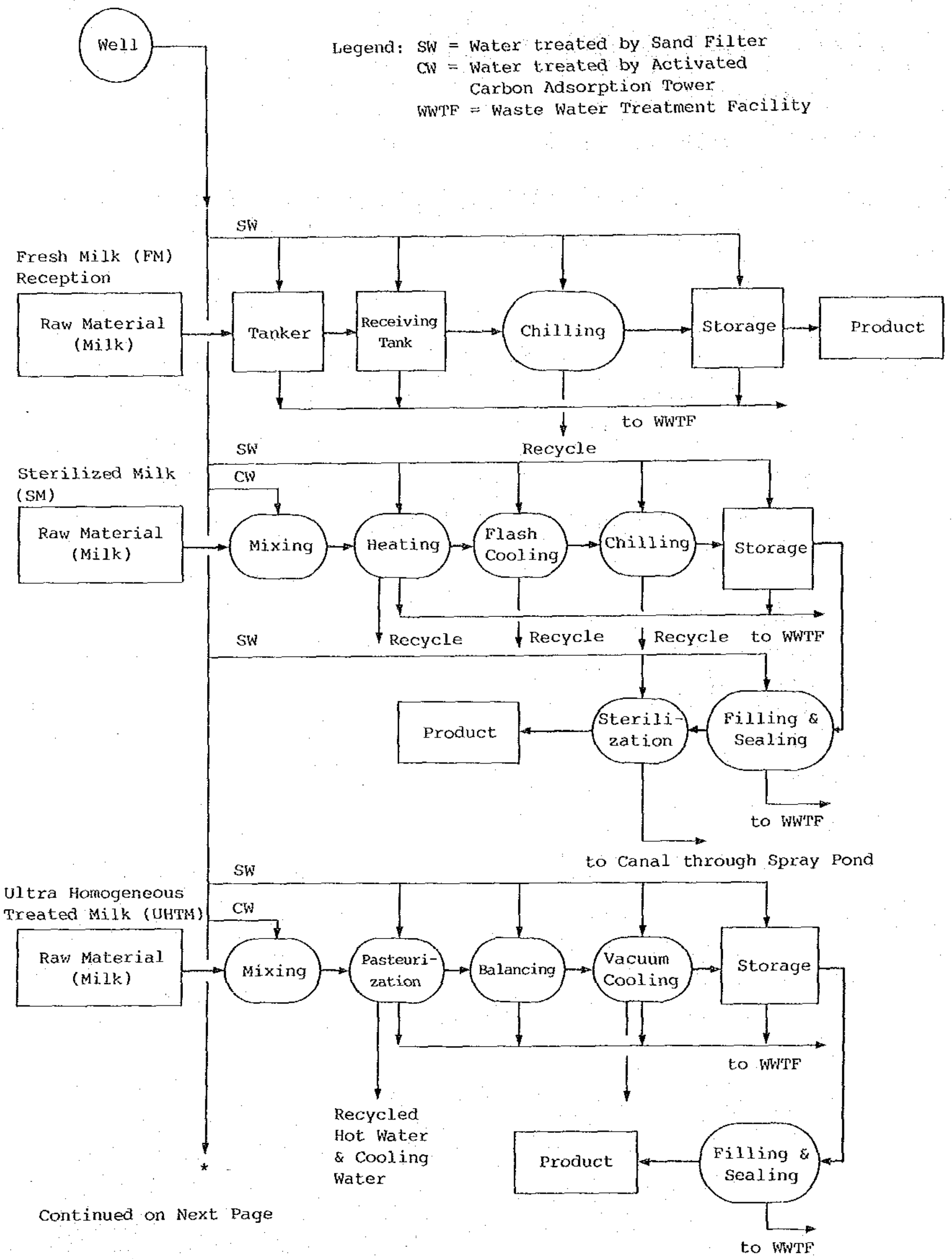
(2.1) Water Consumption

Unit: m^3/d

Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total
Boiler	100			100		100
Material	52			52		52
Processing & Washing	206			206	40 (Water Heater)	246
Cooling	589			589	4480	5,069
Air Conditioning						
Others	71			71		71
Sub Total	1,018			1,018	4,520	5,538
Outside	80			80		80
Total	1,098			1,098	4,520	5,618

Recovery Rate (%): 81.6

(2.2) Process Diagram of Production Line



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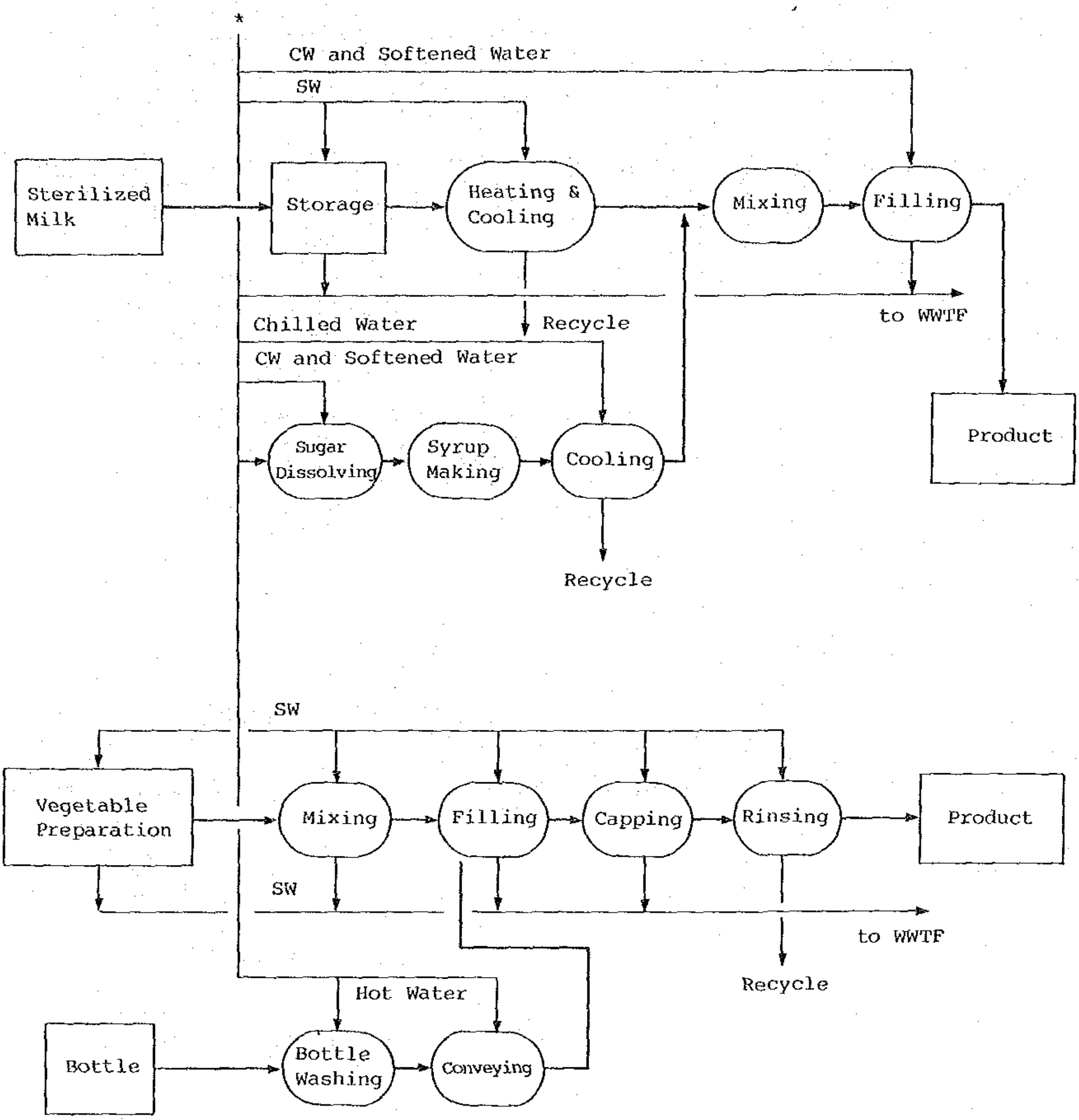
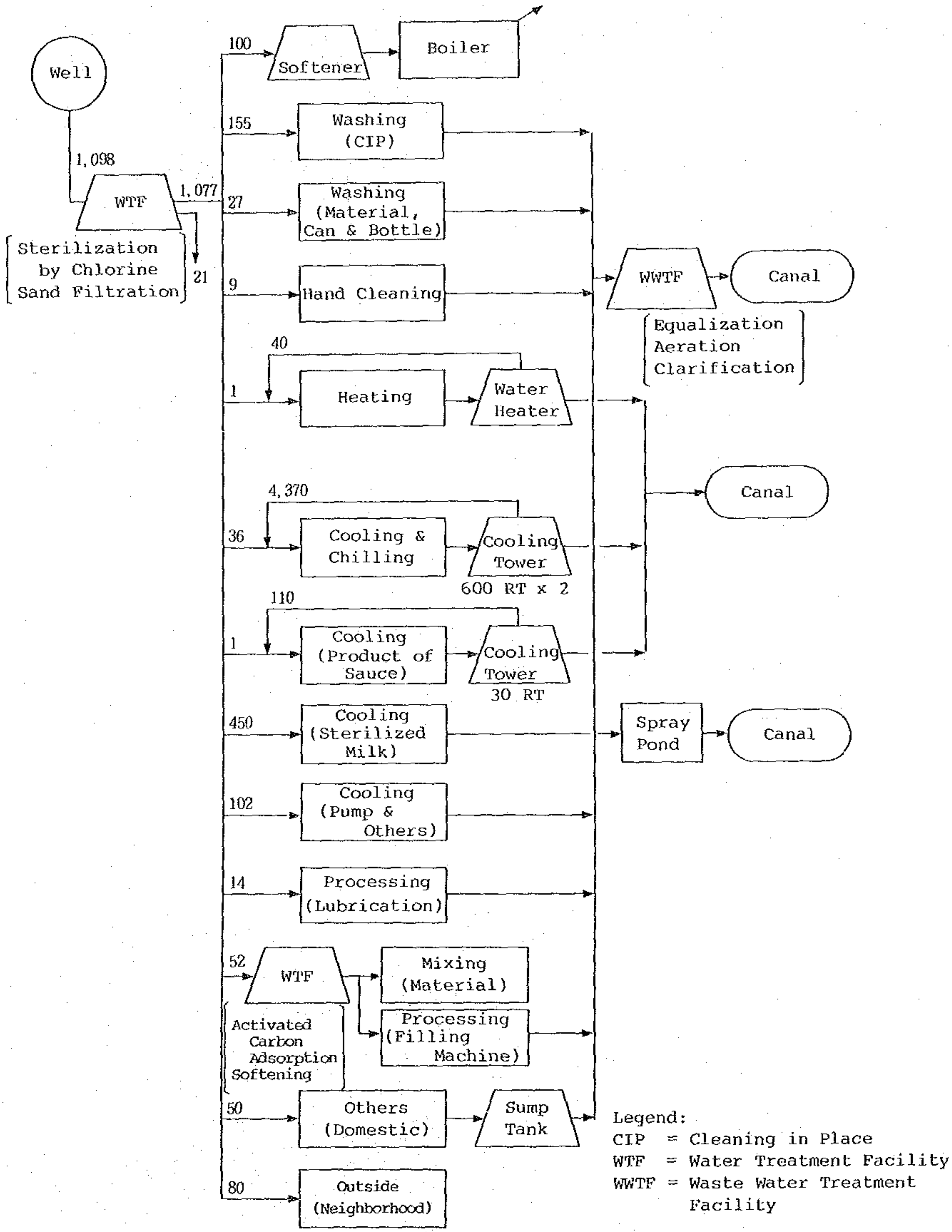
(2. 2) Continued



(2. 3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m³/d)



(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

Only well water is used in this factory. There are two wells, the one 140 m deep and the other 215 m deep. The capacity of each well is 60 m^3/h. and the total pumping up quantity reaches 1,098 m^3/d.

Electrical conductivity and total hardness of well water are 780 $\mu S/cm$ and 76 mg/lit respectively, which is good compared with other well water in the same area.

589 m^3/d of water or 53.6% of the total water consumption is used for cooling, 206 m^3/d or 18.8% for washing and which is 100 m^3/d or 9% for boiler.

Around 450 m^3/d of cooling water, which is the largest portion of cooling water, is used to cool dairy product after sterilization. However, this cooling water is used on a once-through system, without recovery.

The next large portion of cooling water is for sealing and cooling of pumps such as vacuum pumps and high pressure pumps. The water consumption for cooling of pumps is 102 m^3/d.

The quantity of recycled water through the cooling tower is not measured by the factory. However, as a result of survey, it is considered to be roughly 36 m^3/d for make-up water and 4,400 m^3/d for recovered water respectively.

The largest portion of washing water is used for washing of the production lines and tanks by means of the CIP (Cleaning in Place). The quantity of washing water is 155 m^3/d.

Besides the water used inside the factory, 80 m^3/d is supplied to a school and houses in the neighborhood.

(2.4.2) Water Treatment

The water treatment facility includes a chlorine sterilizer, two sand filters and two activated carbon adsorption towers as well as cooling towers and chiller.

Water is supplied after being sterilized by chlorine and sand filtrated. For raw material water and washing water that contacts directly with product, water treated by activated carbon adsorption process is used. While, softened water is used for washing the packing machine.

The followings are the capacity of each equipment and the number of units.

a. Chlorine sterilizer: 1 set

b. Sand filtration tank: 50 m^3/d x 2 units
25 m^3/d x 2 units (Out of operation)

c. Activated carbon adsorption tower: 30 m^3/d x 2 units

d. Cooling tower: 600 RT, 270 m^3/h x 2 units
30 RT x 1 unit (for sauce process)

In addition to the above, a hot water unit and a chiller are provided.

These facilities are well maintained, but no flow meter for operation record is installed.

Recycled water of the cooling towers has a degree of concentration of 2 and 3. The electrical conductivity of this water is approximately 1,550 $\mu S/cm$ and 2,300 $\mu S/cm$.

The well water tax is 0.75 ฿/m^3 and the operation cost of water treatment is 3.0 ฿/m^3. When the depreciation cost is added, the operation cost will increase to 5.5 ฿/m^3 or so.

(2.4.3) Waste Water Treatment

The waste water treatment is applied to washing water, processing water, cooling water for pumps and domestic water. All waste water is treated together by activated sludge and clarification.

For the activated sludge facilities, in addition to 4 units of the vertical rotating type aeration tanks used in series, a clarification pond and one sludge condensation tank are provided. Meanwhile, drainage of the cooling water from the sterilizer is cooled in the spray pond before being discharged. Drainage of the cooling tower is discharged without any treatment.

The quality of waste water is as follows.

Item \ Data	Influent	Effluent
SS (mg/lit)	4,500	10 - 15
BOD (mg/lit)	1,100	<10
COD (mg/lit)	310	<3
Chloride Ion (mg/lit)	-	122
pH	7 - 8	7.5

The quantity of treated waste water is 400 m^3/d.

(3.) Plans of Effective Use of Industrial Water

(3.1) General

In this factory, measures to promote effective use of the service water have already been taken by recycling most of cooling water through cooling towers. More precisely, out of the cooling water of 5,069 m³/d, 4,480 m³/d (88.4%) is recycled. Meanwhile, hot water used in the production lines for heating by means of heat exchanger is also recycled.

Consequently, the total water recovery rate (excluding supply water to outside the factory) is relatively high, 81.6%.

For washing of equipment and tank, a water saving apparatus (CIP) has been introduced.

Although the sterilization requires the largest quantity of make-up water, its cooling water is not re-used. The factory plans to recycle this cooling water.

(3.2) Details

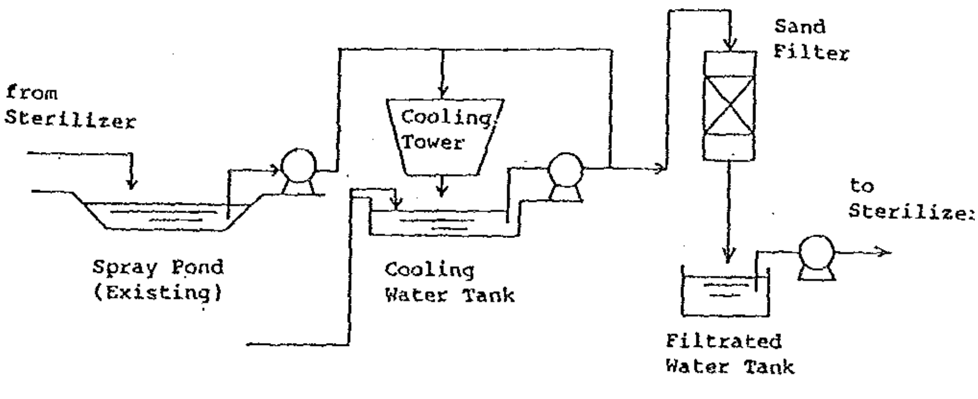
a. Recycle use of cooling water of once-through system by installing cooling tower

Cooling water of once-through system for the sterilizer might be recycled by cooling tower.

This cooling water must have a turbidity of 2 to 3 mg/lit, and must be free of heavy metals and microbic contamination. As removal of microbic contamination, among the above-mentioned requirements, is difficult, the factory recognizes that recycled use of water would be difficult. Damage of product container caused during sterilization process is considered as a major cause of microbic contamination.

As the temperature of the discharged cooling water is comparatively high, it may be re-used for prewashing of the equipment, floor and the like. However, it is assumed that difficulties in removal of microbic contamination would be the same as in the case of recycled use.

(a) Flow Diagram of Recovery System



(b) Specification of Apparatus

Cooling Tower: 1 unit, 123 RT
Sand Filter: 2 units, capacity 50 m^3/d each
Pump: 1 set

(c) Water Balance

Capacity: 450 m^3/d
Loss of Spray Pond: 34.5 (Evaporation & Pearmeation
Loss of Cooling Tower: 29.0 (Evaporation & Spraying)
Loss of Sand Filter: 35.0 (Backwashing)

Total Loss: 98.5 m^3/d

Water Saving: 351.5 350 m^3/d

(4.) Cost Estimation

Number	1
Method for Effective Use Method Item	 Recycle use Recycle use of cooling water for thermal sterilization by installation of cooling tower
Water Saving Use Quantity (m^3/d)	 Cooling 350
Apparatus for Effective Use Apparatus Cost (10^3B)	 Cooling tower, sand filter, pump, tank & piping 2,930
Unit Cost (B/m^3) Fixed Operating Total	 3.6 2.4 6.0

5.1.7 Code No. of Factory: F-07

(1.) Outline of Factory

Capital (MB): -

Annual Amount of Shipment (MB): 48

Total Area (m^2): 13,000

Total No. of Employees: 130

Main Products: Frozen Sea Food

(2.) Present Situation of the Use of Industrial Water

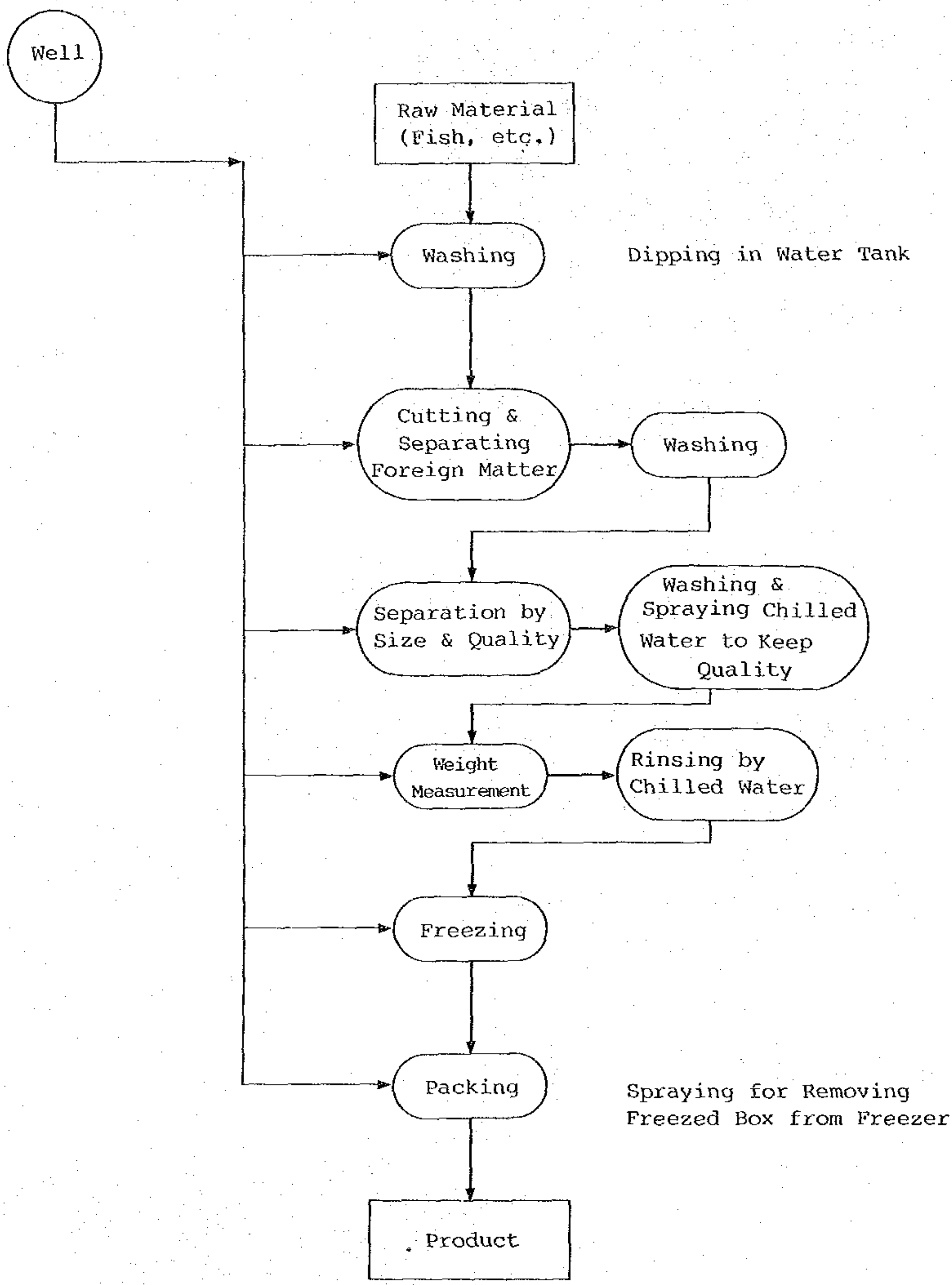
(2.1) Water Consumption

Unit: m^3/d

Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total
Boiler						
Material						
Processing & Washing	100			100		100
Cooling	53			53	5,760	5,813
Air Conditioning						
Others	10			10		10
Sub Total	163			163	5,760	5,923
Outside						
Total	163			163	5,760	5,923

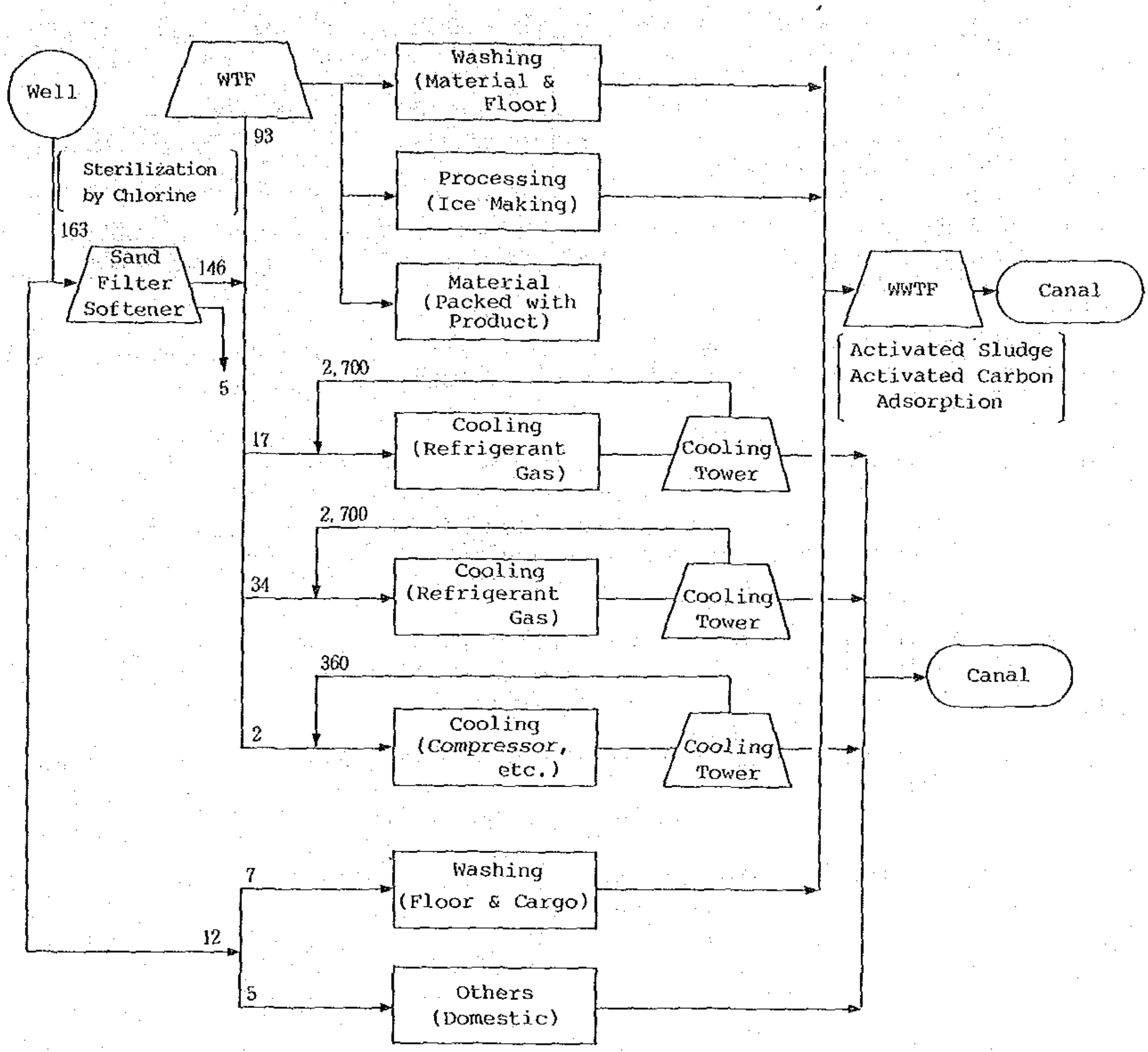
Recovery Rate (%): 97.2

(2. 2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m³/d)



Legend: WTF = Water Treatment Facility
WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

Two wells are provided in the factory, but only one well is currently in operation and around 163 m^3/d of well water is pumped up.

The diameters of pipes for two well pumps are 3 inches and 2 inches respectively.

Water quality of No.1 well is practically non-turbid, having pH of 7.6 and electrical conductivity of 760 $\mu S/cm$, which is good compared with other well water in the same area.

Make-up water is mostly used for cooling of refrigerator (53 m^3/d) as well as for washing of raw material, equipment and floor (100 m^3/d).

(2.4.2) Water Treatment

Pumped up well water is first sent to a head storage tank, and then sand filtrated and softened before being used for various uses.

Domestic water used in the office excluding drinking water and water for washing the floor and truck are supplied directly from the storage tank.

To keep sanitation, water for washing of raw material, equipment and floor that contact directly with the product, as well as water for ice making are sterilized by chlorine.

There are many storage tanks and the operation of water supply pump is controlled by water level. Therefore, the quantity of water flowing through the pipings is not constant. This makes the measurement of water flow rate difficult.

(2.4.3) Waste Water Treatment

Drainage of washing and processing water is collectively treated by activated sludge and activated carbon absorption before it is discharged into a canal.

In activated sludge treatment, vertical rotating type aeration tanks are used, while a tank packed with charcoal is used as an activated carbon adsorption tower.

Blow down water of the cooling tower and domestic waste water from the office are discharged without any treatment.

(3.) Plans of Effective Use of Industrial Water

(3.1) General

In this factory, methods for effective use of water have already been taken by means of recycled use of 99% of the cooling water (which accounts for the largest quantity of water used). For this reason, the water recovery rate for the whole factory is as high as 97.2%.

Few flow meter is installed to measure the water consumption. Partly owing to a recent shift in the management, water control is insufficient. The control of cooling towers is inadequate, too.

Most of cooling water is used for the refrigerator. It is recycled through 3 cooling towers. With the operating conditions differing for each cooling tower, the degree of concentration of the recycled water covers a range from 2.6 to 7.4 (electrical conductivity of 2,000 μS/cm to 5,600 μS/cm). There are some points in the operation control of the cooling tower that calls for improvement, to unify the degree of concentration to about 4 to 5.

Another way for more effective use of water is to save washing water. However, compared with other frozen food factories, the present situation of washing water consumption of this factory is small. That is, the consumption of clean water for the washing after chlorine sterilization is roughly 45 m^3/d and untreated well water for the washing is about 7 m^3/d.

Therefore, the effective use beyond the present level seems to be quite difficult.

(3.2) Details

a. Installation of hand control valve for washing water

No hand control valve is provided at present where water is used for washing of raw material, equipment and floor, and it is recommended to install hand control valves as many as possible for the water saving. Assuming that it would be roughly 20% of the estimated total consumption of washing water, 54 m^3/d, roughly 10 m^3/d of water might be saved.

(4.) Cost Estimation

Number	1
Method for Effective Use Method Item	 Application of water saving apparatus Use of hand control valve for washing water
Water Saving Use Quantity (m^3/d)	 Washing 10
Apparatus for Effective Use Apparatus Cost (10^3 ฿)	 Hand control valve 12 mm x 15 units 15
Unit Cost (฿/m^3) Fixed Operating Total	 1.5 - 1.5

5.1.8 Code No. of Factory: F-08

(1.) Outline of Factory

Capital (M฿): -

Annual Amount of Shipment: 20 - 30 t/d

Total Area (m^2): 16,400

Total No. of Employees: 1,000

Main Products: Frozen Sea Food

(2.) Present Situation of the Use of Industrial Water

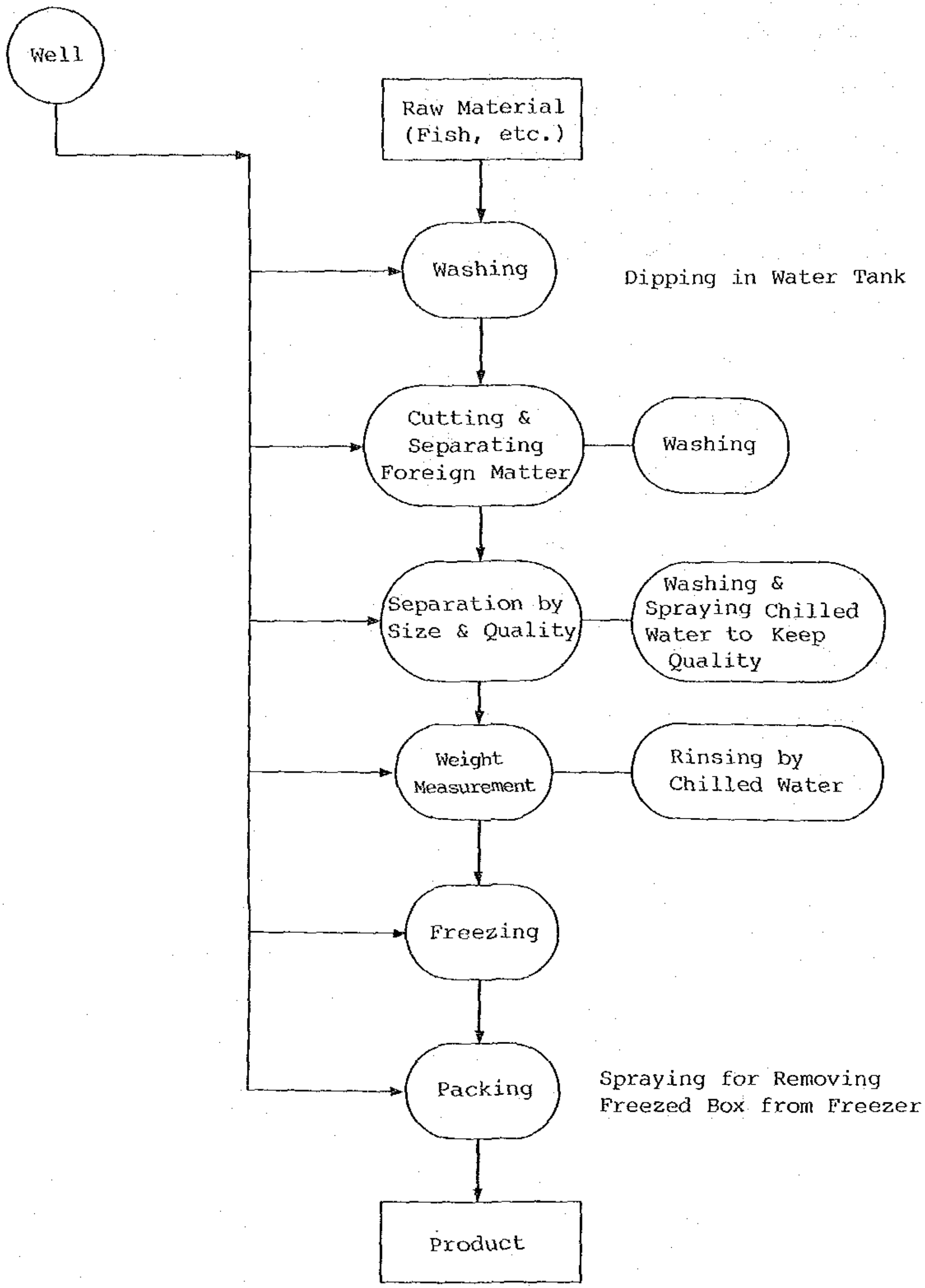
(2.1) Water Consumption

Unit: m^3/d

Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total
Boiler	1			1		1
Material	9			9		9
Processing & Washing	420			420		420
Cooling	179			179	14,160	14,339
Air Conditioning						
Others	56			56		56
Sub Total	665			665	14,160	14,825
Outside						
Total	665			665	14,160	14,825

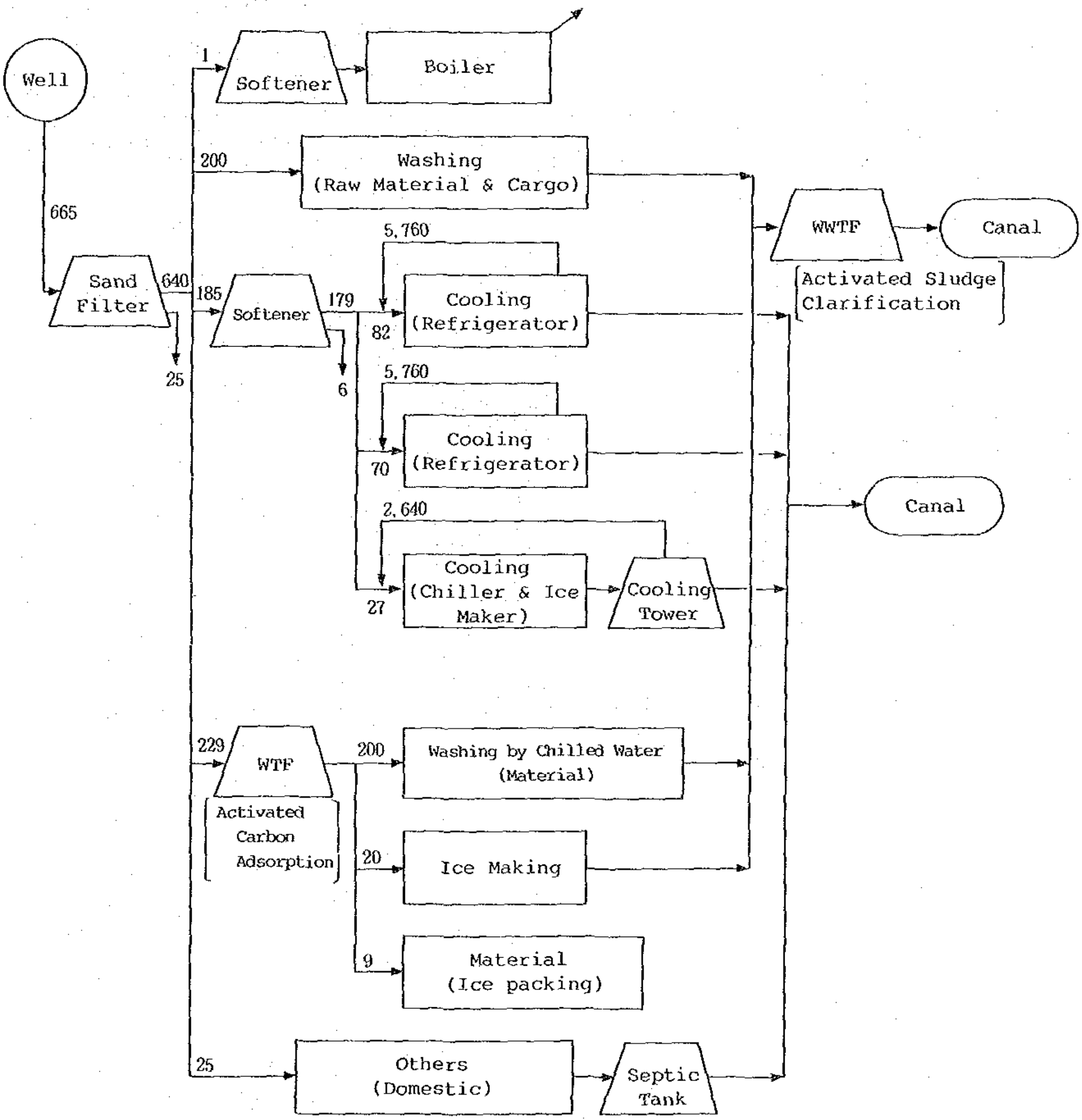
Recovery Rate (%): 95.5

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WTF = Water Treatment Facility
WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

In this factory, well water is pumped up from two wells. A total quantity of 665 m^3/d of well water is supplied through pipings of 4 inches and 8 inches in diameter respectively.

The largest portion of make-up water is used for the washing of raw material, equipment and floor. Low temperature water is used for final washing of raw material and the freshness of the raw material is kept by using ice.

The quality of well water is almost the same for both wells. According to factory's records, its quality is as follows.

pH:	7.4 - 7.6,
Fe content:	0.2 - 0.28 mg/lit
Chloride ion:	96 - 103 mg/lit
Total hardness:	66.2 - 102 mg/lit
Electrical conductivity :	417 μS/cm
TDS:	688 mg/lit

These figures show the water quality is relatively good for this region. However, the electrical conductivity measured during the survey was 762 to 782 μS/cm, which seems to be an appropriate value.

Water consumption is checked by means of integrating flow meters installed for main pipings. In addition, different pipings are used according to each water quality (as classified by water treatment process) of the supply water to prevent misuse of water.

Around 14,160 m^3/d of cooling water is recycled. The quantity of make-up water for cooling is estimated at 179 m^3/d.

Cooling water for two refrigerators amounts to approximately 11,600 m^3/d. Besides this, around 2,600 m^3/d of cooling water is used for the chiller and ice making machines. This water is recycled through two cooling towers.

(2.4.2) Water Treatment

Well water is sent to a storage tank and treated by a pressure-type sand filter. The treated water is then supplied for the respective use from a head water tank.

As make-up water of the cooling tower for refrigerators, filtrated water is used after being softened by two softeners. Meanwhile, boiler water is also softened by the exclusive softener.

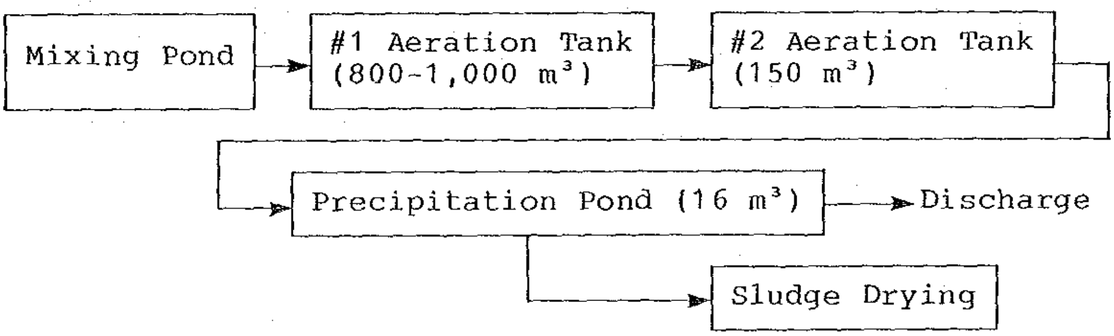
The quality of the raw water from No. 1 well and softened water is as follows.

Item \ Data	Raw Water	Softened Water
Turbidity (FTU)	6	3 or less
pH	7.8	6.8 - 7.3
Fe (mg/lit)	0.2	0.05
Chloride Ion (mg/lit)	103	90 or less
Total Hardness (mg/lit)	66	0.5 - 5
Electrical Conductivity (μS/cm)	417	192

(2.4.3) Waste Water Treatment

Drainage of washing and processing water is collectively treated by activated sludge and sedimentation processes. For the activated sludge treatment, vertical rotating type aeration tanks are used. After main aeration units, two small aeration tank units are provided. Two settling tank units are also installed. The sludge is dried by direct sunshine.

The flow and capacity of the waste water treatment facility are as follow:



(3.) Plans of Effective Use of Industrial Water

(3.1) General

In this factory, the largest quantity of water is used for cooling of refrigerator, chiller and ice making machine. 96% of cooling water is recycled. Accordingly, water recovery rate as high as 95.5% has been achieved for the whole factory.

Softened water is used for two cooling towers for the chiller and ice making machine. Although there is no formation of scale, there is a danger of stress corrosion cracking of the stainless steel piping, as the degree of concentration of recycling water is extremely high, to be 7 to 8 (Electrical conductivity of 6,170 μS/cm).

Softened water is also used for the cooling towers for refrigerator. The degree of concentration of the recycled water is 1.6 (1,263 μS/cm) for one unit, and 1.9 (1,437 μS/cm) for the other. Judging from examples of other factory, it is possible to raise the degree of concentration to about 2 to 3.

In this factory, washing water for raw material is used in a large quantity. Such water saving measures as a cascade system for the washing water at the final stage of the washing process is put into practice. To maintain the sanitary condition of food products, it would be difficult to realize any vast reduction of washing water. Re-use of washing water seems also difficult as different kinds of raw materials are handled.

(3.2) Details

a. Improvement of operation and maintenance of cooling tower to raise degree of concentration

Although cooling water is recycled, the make-up water and blow down water of the cooling tower as well as the degree of concentration of the recycled water differs by each cooling tower, so that operation control is not necessarily sufficient.

Supposing that the degree of concentration could be raised to about 2 or 3 (2.5 on the average), make-up water to cooling tower for the ammonia condenser would be 52 m^3/d/unit, and that to the cooling tower for the compressor would be 39 m^3/d/unit. Thus total make-up water would be estimated to be 143 m^3/d.

This implies that, compared with the present consumption of about 179 m^3/d, 36 m^3/d of water would be saved. This would also contribute to reduce the load of the softener accordingly.

b. Installation of hand control valve for washing water

No hand control valve is provided at present where water is used for washing (excluding the low-temperature water) for raw material, equipment and floor. Therefore, hand control valves should be installed as many as possible.

Present consumption of washing water is 200 m^3/d. Assuming the saving rate to be approximately 20%, quantity of water saving would be 40 m^3/d.

(4.) Cost Estimation

Number	1	2
Method for Effective Use Method Item	 Improvement of operation control Improvement of operation and maintenance of cooling tower to raise degree of concentration	 Application of water saving apparatus Use of hand control valve for washing water
Water Saving Use Qt. (m³/d)	 Cooling 36	 Processing & washing 40
Apparatus for Effective Use Apparatus Cost (10³฿)		 Hand control valve 12 mm x 60 units 60
Unit Cost (฿/m) Fixed Operating Total	 - 0.5 0.5	 1.3 - 1.3

Total Water Saving (m³/d) : 76

Total Initial Cost (10³฿) : 60

Total Unit Cost (฿/m³) : 0.9

Note: Qt. = Quantity

5.1.9 Code No. of Factory: F-09

(1.) Outline of Factory

Capital (M฿): -

Annual Amount of Shipment (M฿): -

Total Area (m^2): 24,000

Total No. of Employees: 150

Main Products: Vegetable Oil, Fat and Wax

(2.) Present Situation of the Use of Industrial Water

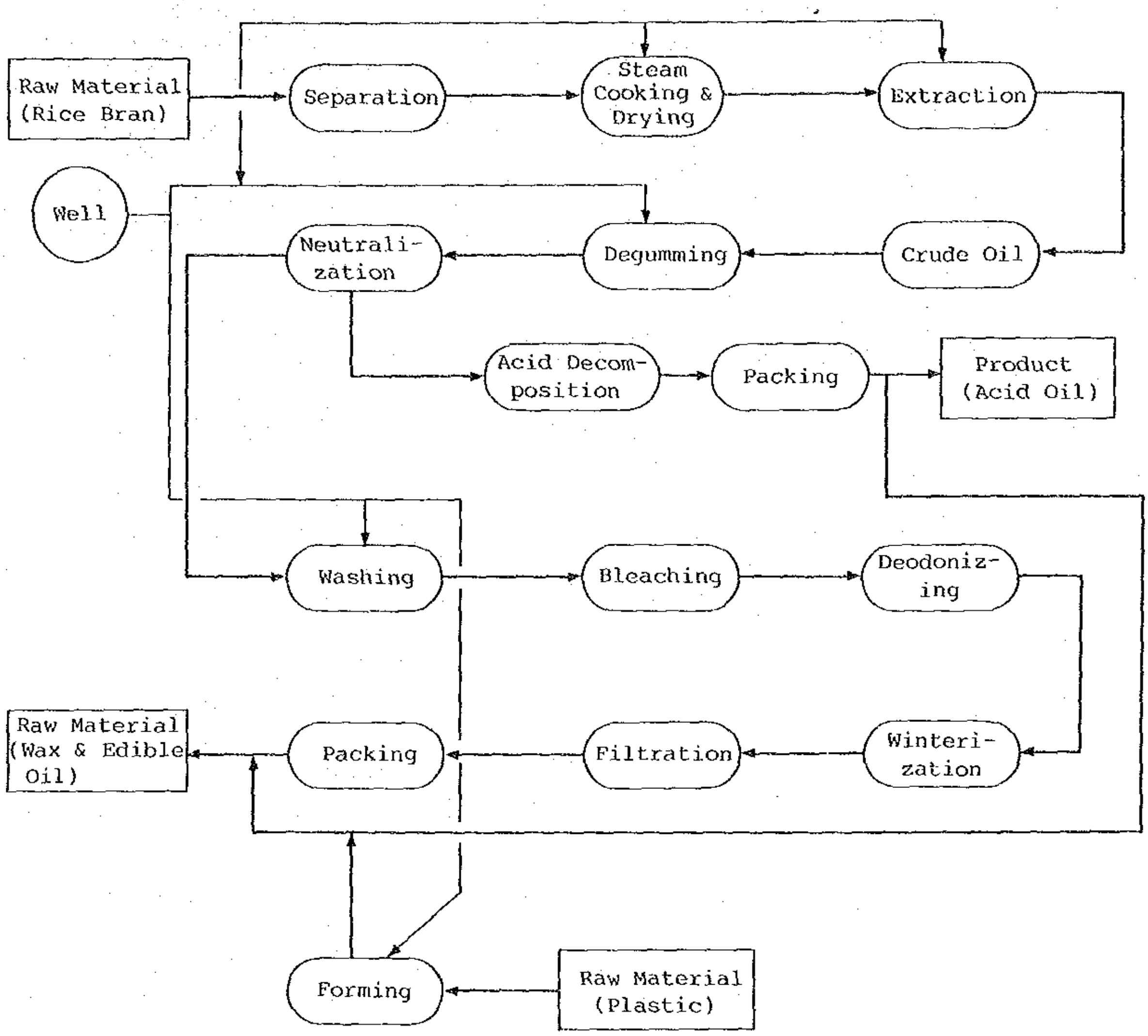
(2.1) Water Consumption

Unit: m^3/d

Source / Use	Well Water	MWA	Others	Sub Total	Recovered Wate	Total
Boiler	55			55	65	120
Material Processing & Washing	20			20		20
Cooling	100			100	3,500	3,600
Air Conditioning						
Others	115			115		115
Sub Total	290			290	3,565	3,855
Outside	10			10		10
Total	300			300	3,565	3,865

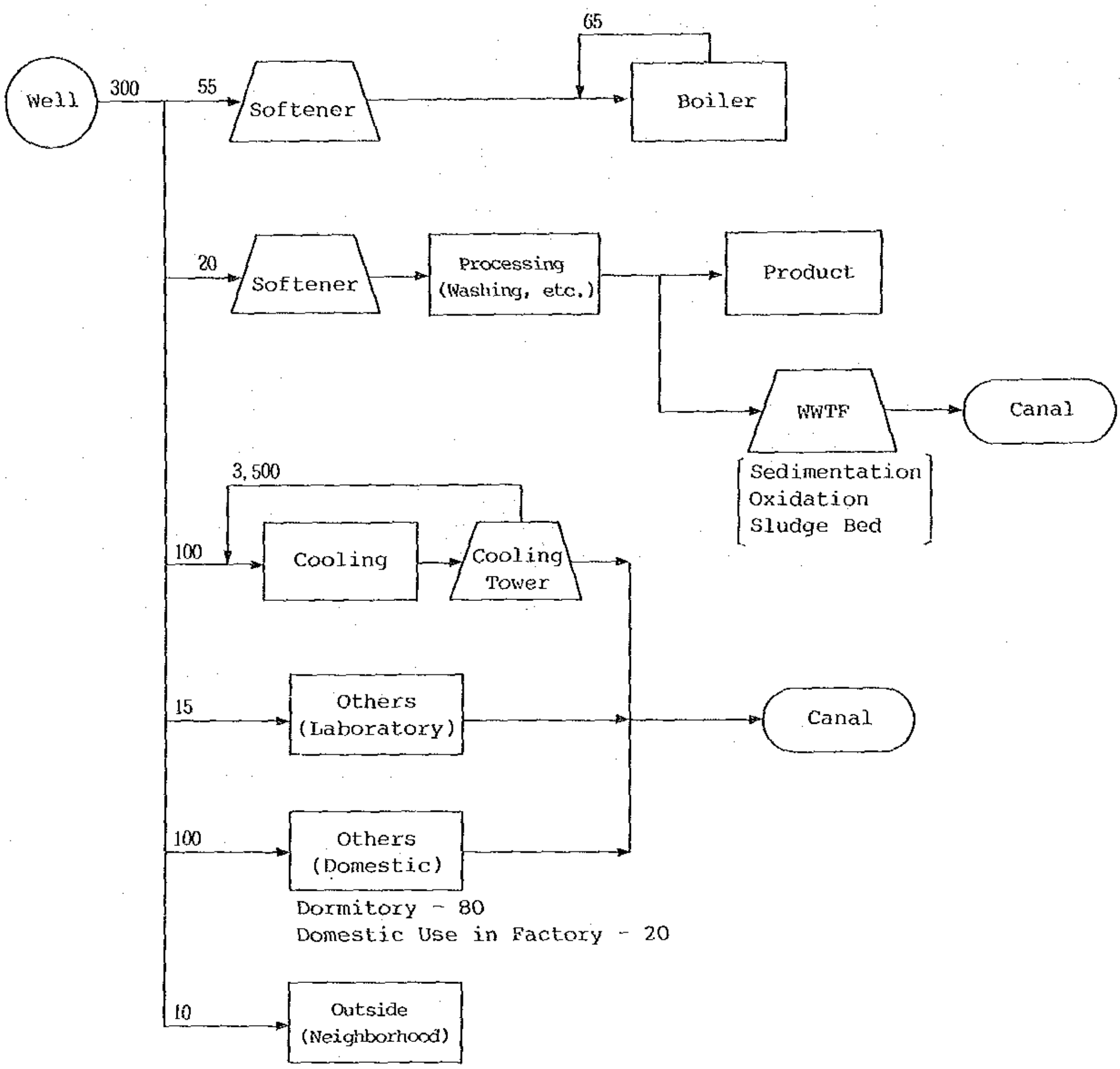
Recovery Rate (%): 92.5

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

This factory produces such products as acid oil and wax, using "rice bran" as the raw material. Since the plant operation fluctuates widely depending on the availability of raw material, the water consumption also fluctuates.

(2.4.1) Sources and Uses

Water consumption of this factory is 3,855 m^3/d. The quantity of make-up water is 290 m^3/d and quantity of recycled water is 3,565 m^3/d.

All of make-up water is well water. Two wells of 120 m and 130 m deep are in operation. Each well is provided with a flow meter.

Out of make-up water, cooling and domestic water account for about 35% each. This is followed by boiler water of which quantity is approximately 20%.

Make-up water for domestic use is mostly for the dormitory.

Recovered water is used for the boiler and cooling. Seven cooling towers of various sizes are installed, and the total designed capacity is 1,105 RT.

(2.4.2) Water Treatment

According to the factory's data, the quality of well water is as follows:

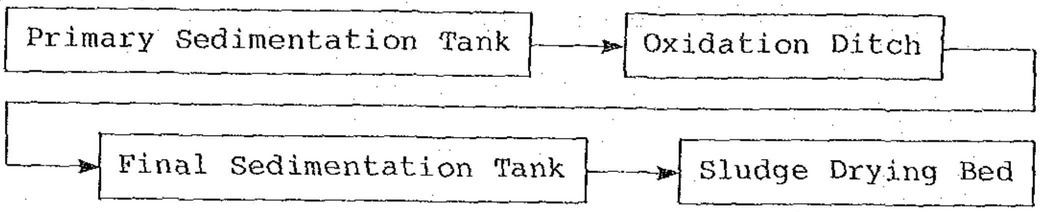
pH	: 7.8 - 8.1
Turbidity	: 1.7 - 11 mg/lit
Total hardness	: 120 - 125 mg/lit
Electrical conductivity	: 965 μS/cm
Water temperature	: 33.1 ℃

Boiler water and processing water are both treated by a softener. The quality of softened water is as follows:

pH	: 8.3
Electrical conductivity	: 655 μS/cm
Total hardness	: 8.9 mg/lit
Chloride ion	: 70.6 mg/lit
Total iron content	: 0.15 mg/lit

(2.4.3) Waste Water Treatment

Waste water is treated by the followings.



Treated water is discharged into a canal. The factory has a future plan to install a neutralization system as a precedent process of the primary sedimentation tank.

According to the factory's data, the quality of the discharged water is as follows:

SS: 10 mg/lit (Influent: 11,490 mg/lit)
BOD: 2.8 mg/lit (Influent: 4,180 mg/lit)
COD: 103 mg/lit (Influent: 20,115 mg/lit).

(3.) Plans of Effective Use of Industrial Water

(3.1) General

In this factory, water control efforts are made, using a flow meter installed for each water supply system. Boiler water and cooling water are already recovered. The recovery rate as high as 92.5% is achieved.

530 lit/capita/d of domestic water is used in the dormitory. This consumption is fairly high, considering the number of persons, and there seems to have room for water saving.

(3.2) Details

a. Check and control of domestic water consumption

If unit consumption of domestic water is reduced to 500 lit/capita/d, the total quantity would become about 75 m^3/d.

Thus, about 25 m^3/d of water would be saved.

(4.) Cost Estimation

Number	1
Method for Effective Use Method Item	 Control of water use Check and control of water requirement for domestic use
Water Saving Use Quantity (m^3/d)	 Domestic 25
Apparatus for Effective Use Apparatus Cost (10^3฿)	
Unit Cost (฿/m^3) Fixed Operating Total	 - - -

5.1.10 Code No. of Factory: F-10

(1.) Outline of Factory

Capital (M฿): -

Annual Amount of Shipment (M฿): -

Total Area (m^2): -

Total No. of Employees: 45

Main Products: Cake

(2.) Present Situation of the Use of Industrial Water

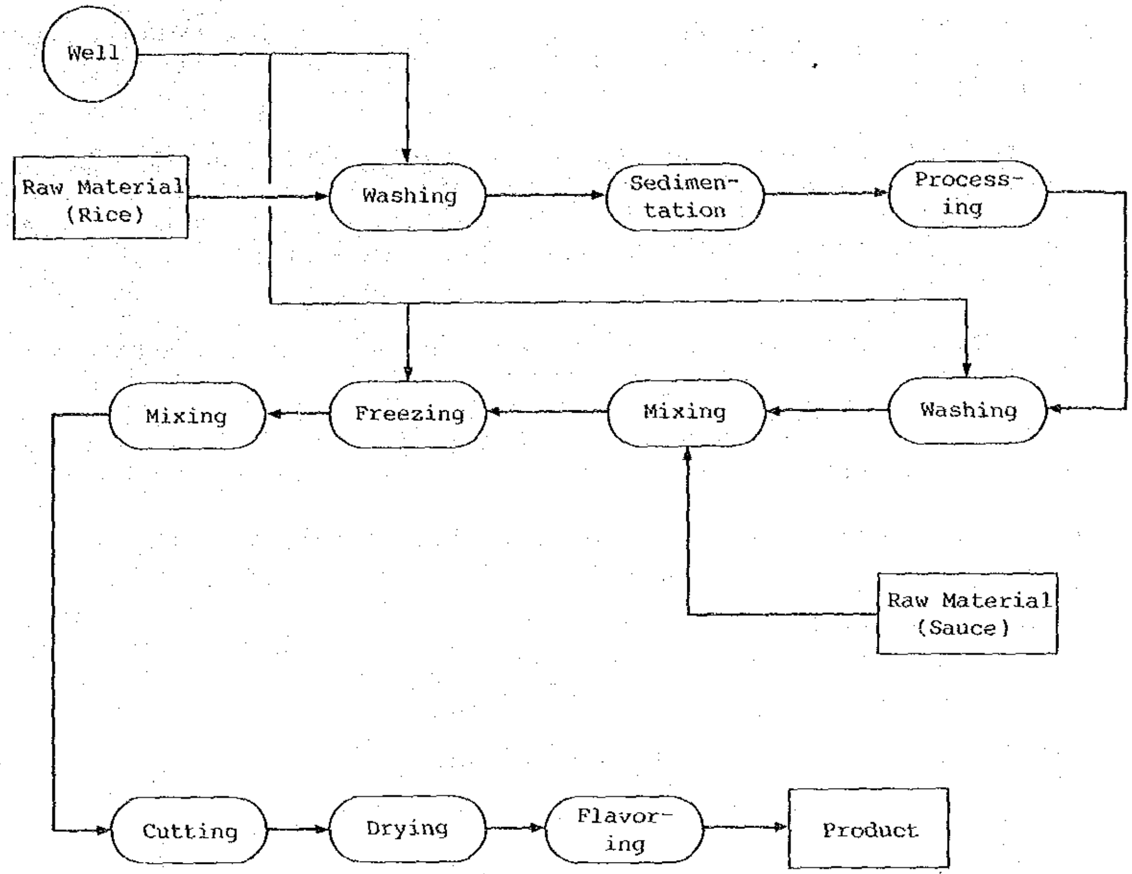
(2.1) Water Consumption

Unit: m^3/d

Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Wate	Total
Boiler		10		10		10
Material						
Processing & Washing		30		30		30
Cooling		9		9	660	669
Air Conditioning						
Others		5		5		5
Sub Total		54		54	660	714
Outside						
Total		54		54	660	714

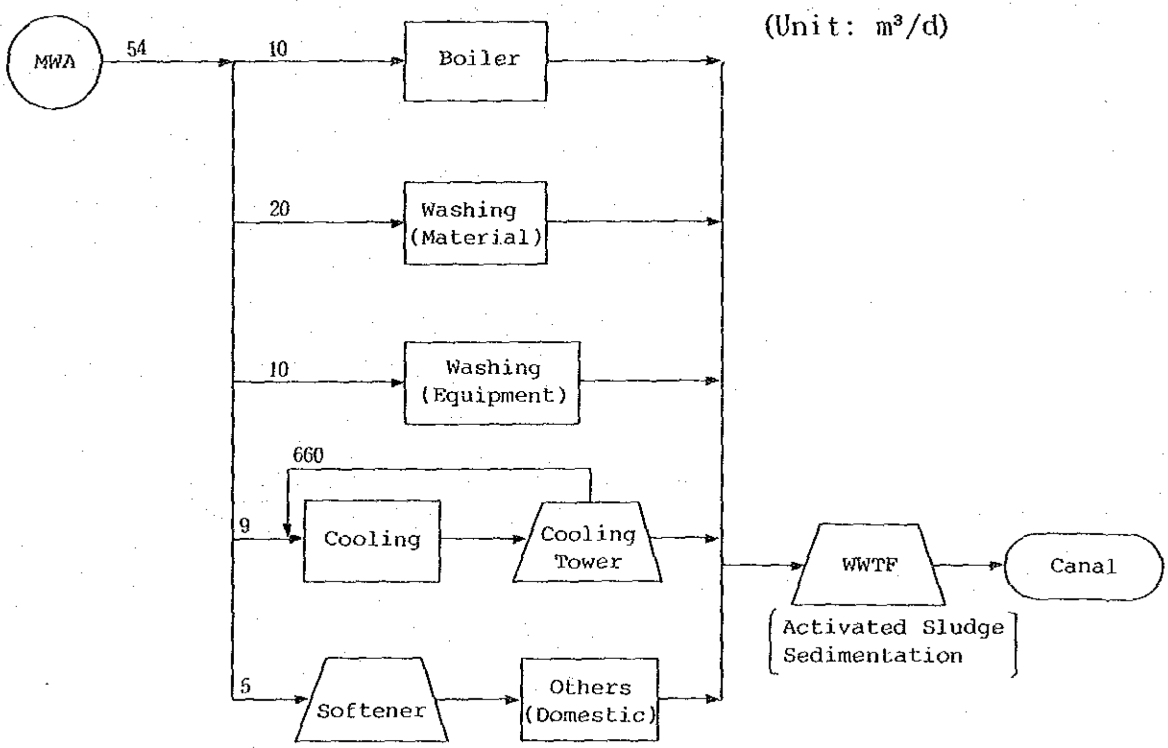
Recovery Rate (%): 92.4

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

Water consumption of this factory is 714 m^3/d, the make-up water being 54 m^3/d and the recovered water 600 m^3/d. The recovery rate is 92.4%.

In the past, water supply depended on a well as its source. However, in 1987, the water source was totally changed to MWA. Approximately 60% of the make-up water supplied from MWA is used for the processing, while roughly 20% each is used for the boiler and cooling.

Water supplied by MWA is used without any treatment except drinking water which is treated by a softener.

Waste water is treated by activated sludge and surface aeration as well as sedimentation pond, and then discharged into a canal.

The water quality measured at the cooling tower is as follows:

pH:	8.58
Inlet water temperature:	29.3 ℃
Outlet water temperature:	27.2 ℃
Electrical Conductivity:	455 $\mu S/cm$.

(3.) Plans of Effective Use of Industrial Water

(3.1) General

Since all make-up water for this factory has been converted to MWA water, and the recovery rate has already reached to 92%, there seems to be little room for further improvement.

5.1.11 Code No. of Factory: F-11

(1.) Outline of Factory

Capital (M฿): 5

Annual Amount of Shipment (M฿): 0.6

Total Area (m^2): 3,600

Total No. of Employees: 75

Main Products: Candy

(2.) Present Situation of the Use of Industrial Water

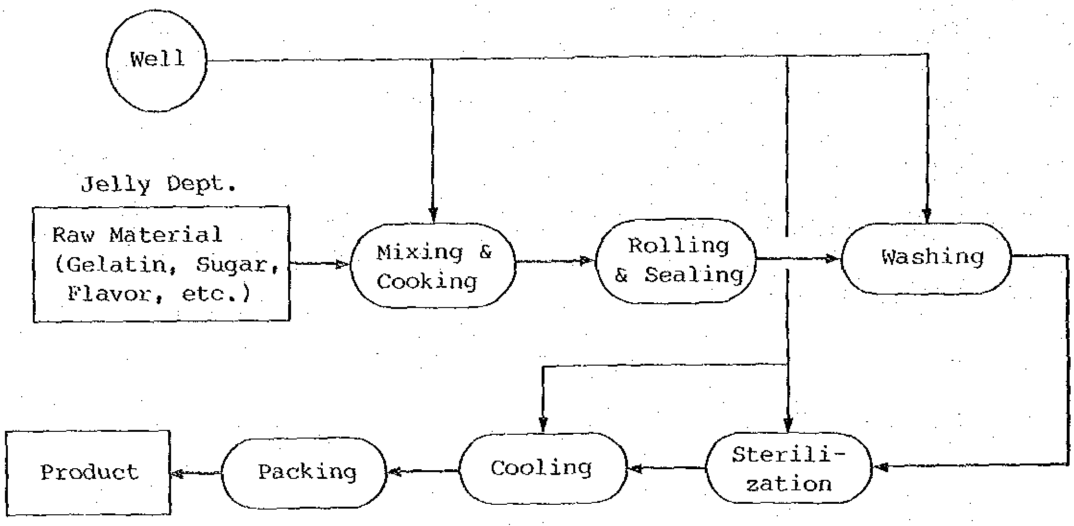
(2.1) Water Consumption

Unit: m^3/d

Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	total
Boiler	2			2	4	6
Material	6			6		6
Processing & Washing	5			5		5
Cooling	19			19		19
Air Conditioning						
Others	5			5		5
Sub Total	37			37	4	41
Outside						
Total	37			37	4	41

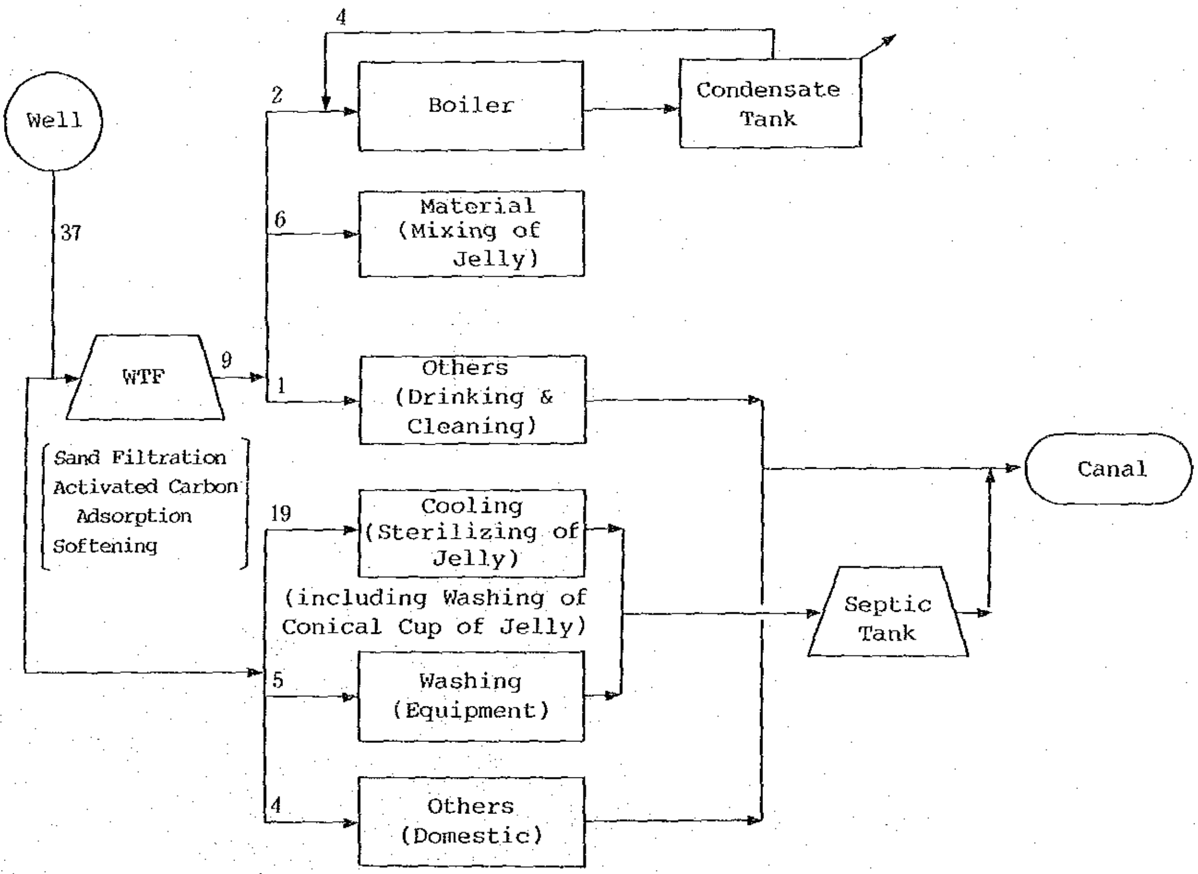
Recovery Rate (%): 9.8

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WTF = Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

In this factory, well water of 37 m^3/d is pumped up from a single well. The depth of the well is 60 m, and the diameter of the pump piping is 2 inches.

According to the factory's data, the quality of the well water is as follows:

pH:	6.3
Electrical conductivity:	711 μS/cm
TDS:	498 mg/lit
M-alkalinity:	342 mg/lit
Total hardness:	89 mg/lit
Chloride ion:	17 mg/lit
Fe:	0.19 mg/lit

The total water consumption of this factory is relatively small and it amounts to 41 m^3/d. The largest quantity of make-up water is used for cooling and sterilization of jelly product and its consumption is 19 m^3/d. Besides the above, it is used for the washing of raw material and equipment.

(2.4.2) Water Treatment

Pumped up well water is first sent to a storage tank, and directly supplied for the cooling and sterilizing of jelly products, the washing of equipment and the domestic use.

As for the raw material water, drinking water and boiler water, softened water is supplied after being treated by a water treatment facility composed of one pressure-type sand filter, one pressure-type activated carbon adsorption tower and one softener.

Because the water treatment facility is installed on the roof of the boiler room, it seems that practically no operation and maintenance control is conducted for washing and regeneration of filters. Therefore, proper operation and maintenance control is required.

(2.4.3) Waste Water Treatment

Waste water from the cooling and sterilizing of jelly product as well as from the washing of the equipment is treated. The waste water treatment facility consists of two septic tanks placed in series. But the tanks are of the open type, and the capacities are too small.

Similar to the water treatment facility, practically no adequate operation and maintenance control is being performed so that virtually no effects of treatment can be expected.

Domestic waste water are discharged without any treatment.

(3.) Plans of Effective Use of Industrial Water

(3.1) General

The largest water consumption of this factory is cooling water and washing water for the jelly making process. At the jelly making units, washing water is used for the washing of jelly depositing around the container after the packing of product. The water is continuously used, and left to keep running out. Therefore, some improvement should be taken.

After the sterilization, cooling of product is performed at two stages. At the first stage, softened water is used without temperature control, and in the next stage, recovered cooling water is used.

Detailed water consumption broken down to that washing water, recycled cooling water and once-through cooling water for the jelly making process could not be fully grasped, and it was viewed collectively as service water for cooling and sterilizing jelly product.

The boiler condensate is recycled. But, as the quantity of boiler water is only 6 m^3/d and steam condensate tank is left open, the effects of recycling is practically nil.

Water consumption for each use is small, which makes it difficult to realize effective use of water.

(3.2) Details

a. Recovery of steam condensate

Pipings are arranged so as to make the steam condensate return to the condensate tank. The tank, however, is not covered airtight, and the return piping does not enter deep enough into the water inside the tank. At the same time, steam is discharged into the open air and not being fully recovered.

This, therefore, calls for improvement. However, as estimation of water consumption has been made on the assumption that the condensate has already been recovered, this quantity shall not be counted up into the quantity of possible water saving.

5.1.12 Code No. of Factory: F-12

(1.) Outline of Factory

Capital (M฿): 120

Annual Amount of Shipment (M฿): 350

Total Area (m^2): 64,000

Total No. of Employees: 214

Main Products: Animal Food (Poultry, Pig, Pet and Aquatic)

(2.) Present Situation of the Use of Industrial Water

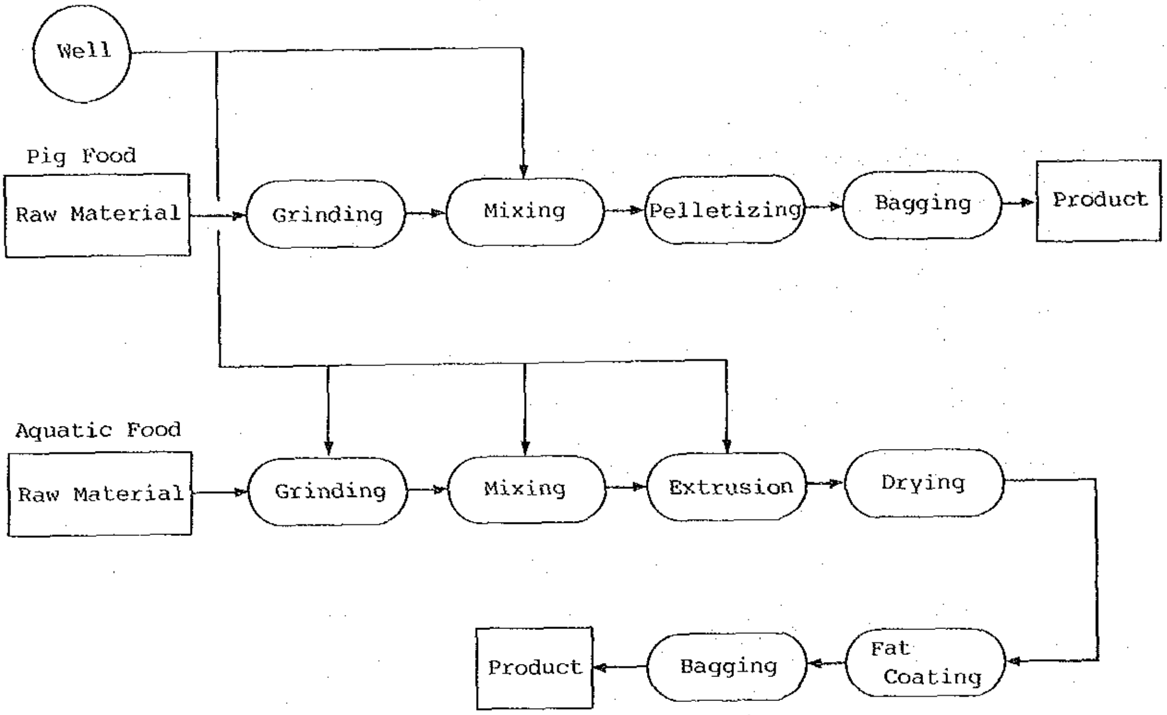
(2.1) Water Consumption

Unit: m^3/d

Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total
Boiler	123			123	8	131
Material	10			10		10
Processing & Washing	18			18		18
Cooling	15			15	15	30
Air Conditioning						
Others	157			157		157
Sub Total	323			323	23	346
Outside						
Total	323			323	23	346

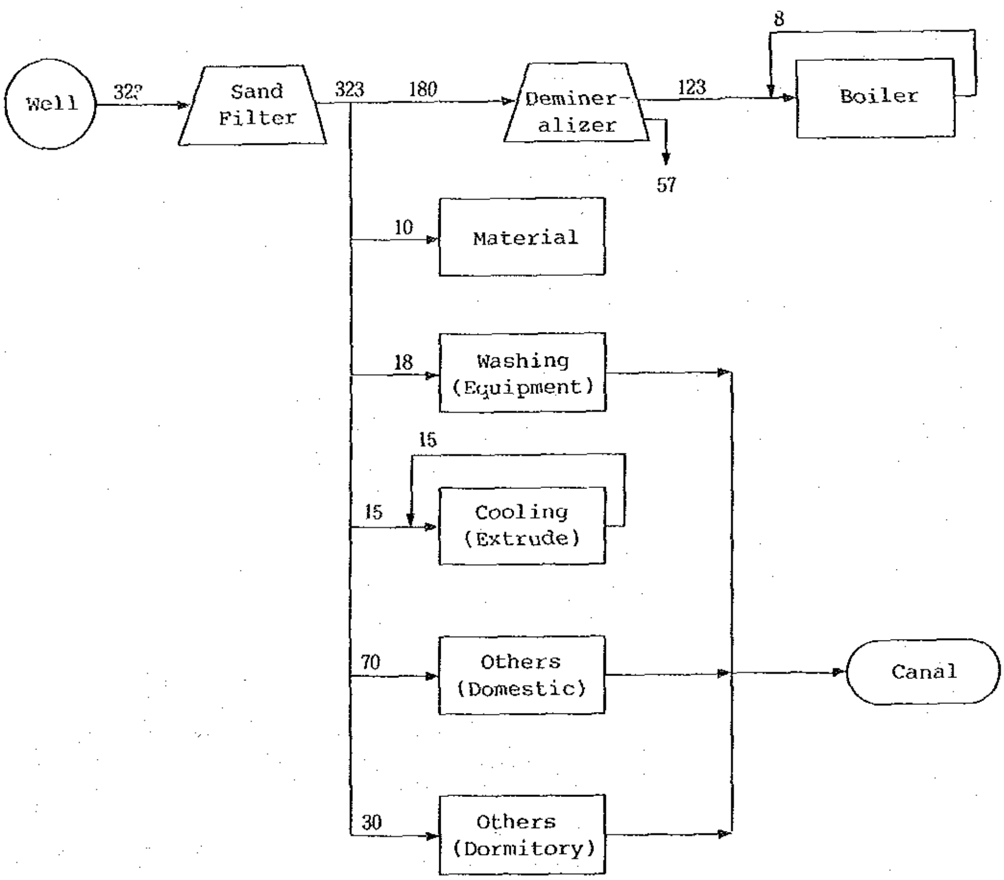
Recovery Rate (%): 6.6

(2. 2) Process Diagram of Production Line



(2. 3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

Water consumption in this factory is 346 m^3/d, which breaks down to 323 m^3/d of make-up water and 23 m^3/d of recovered water.

Make-up water depends on well water as its source. The well, which is 106m deep, is provided with a flow meter. The well pump has a capacity of 1,200 m^3/d.

Make-up water is mostly used for the boiler (approx. 30%) and processing (approx. 25%).

Indirect cooling water for the extruder is recycled.

Boiler condensate is also recycled.

(2.4.2) Water Treatment

All well water is treated by a sand filter. Its quality is as follows.

Total hardness:	178 mg/lit
Chloride ion:	153 mg/lit
Electrical conductivity:	1,200 $\mu S/cm$

Deionization treatment is carried out for boiler water.

The quality of treated water by anion exchanger for the boiler is as follows.

pH:	10.15
Chloride ion:	5 mg/lit
Silica:	0.45 mg/lit

(2.4.3) Waste Water Treatment

Waste water is discharged into a canal without any treatment.

(3.) Plans of Effective Use of Industrial Water

(3.1) General

The total consumption of domestic water is 100 m^3/d, and most of it is for dormitory use. But, 400 lit/capita/d of dormitory use seems to be a little large.

This factory is equipped with a deionization system. Around 18% of make-up water is used for washing of this equipment. Therefore, some measures should be taken to make the deionization system consuming less water.

(3.2) Details

a. Reduction of backwashing water by improving operation control of deionization system

The quantity of backwashing water used for the deionization system is large. The reduction in the quantity by roughly 50% (30 m^3/d) could be achieved by improving operation control of the system.

b. Saving of domestic water for dormitory use

Since level of domestic water consumption for the dormitory is high, it is necessary to make employees aware of the importance of water saving. To accomplish this, the installation of water meters and the prevention of leakage are required.

(4.) Cost Estimation

Number	1
Method for Effective Use Method Item	 Improvement of operation control Improvement of operation and control of deionization system to decrease washing water
Water Saving Use Quantity (m^3/d)	 Miscellaneous 30
Apparatus for Effective Use Apparatus Cost (10^3฿)	
Unit Cost (฿/m^3) Fixed Operating Total	

5.1.13 Code No. of Factory: F-13

(1.) Outline of Factory

Capital (MB): 0.03

Annual Amount of Shipment (MB): 459

Total Area (m^2): 44,800

Total No. of Employees: 880

Main Products: Frozen Chicken

(2.) Present Situation of the Use of Industrial Water

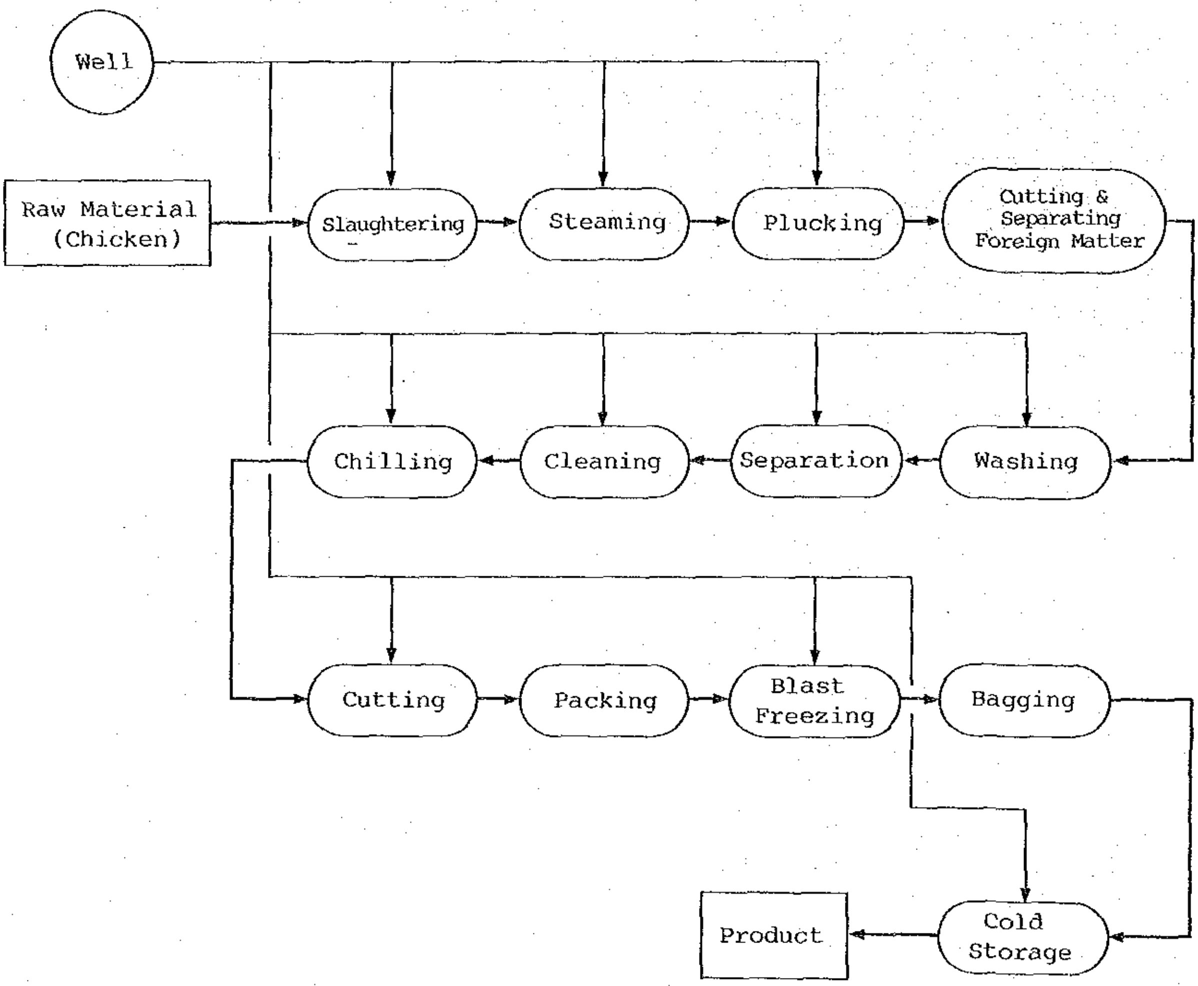
(2.1) Water Consumption

Unit: m^3/d

Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total
Boiler	20			20		20
Material Processing & Washing	940			940		940
Cooling	30		80	110	600	710
Air Conditioning						
Others	50			50		50
Sub Total	1,040		80	1,120	600	1,720
Outside						
Total	1,040		80	1,120	600	1,720

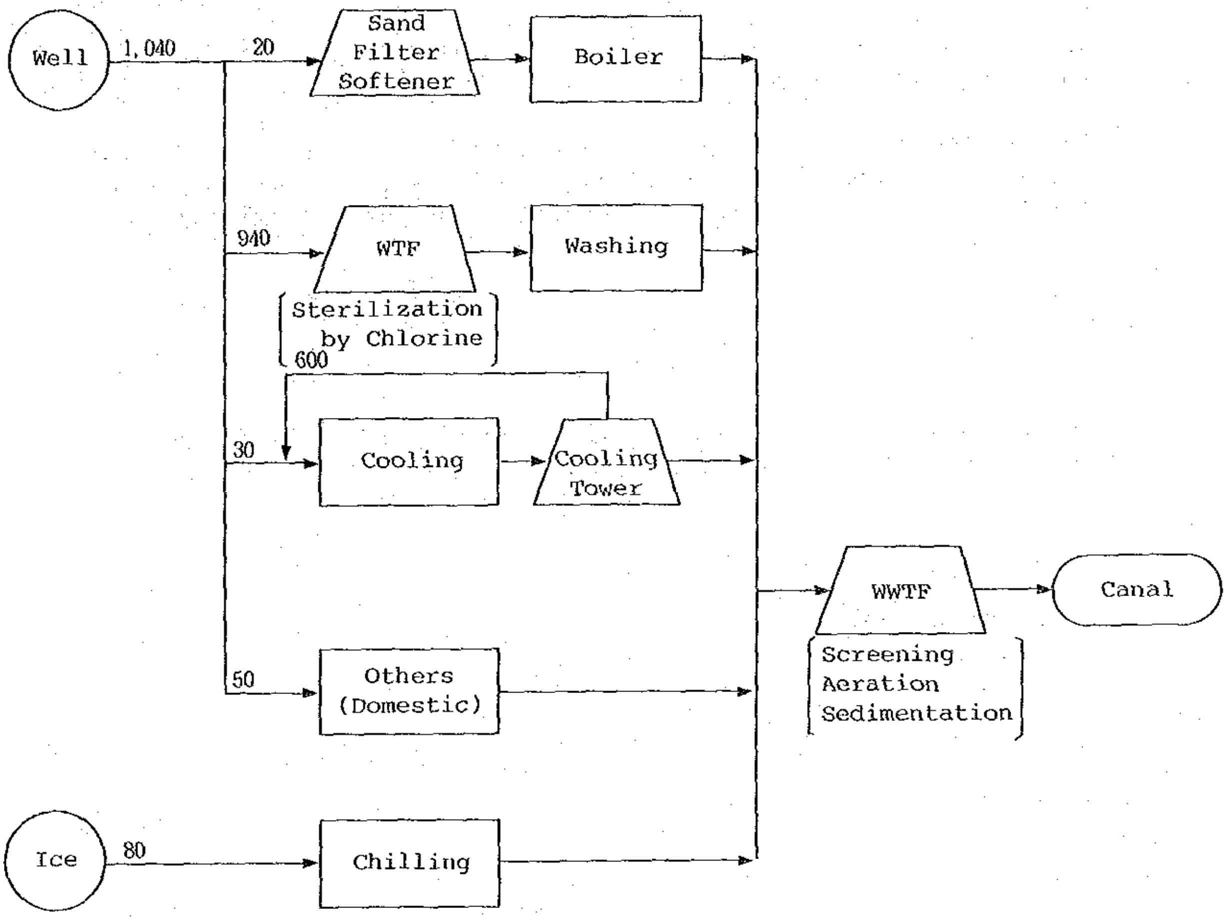
Recovery Rate (%): 34.9

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WTF = Water Treatment Facility
WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

Water consumption in this factory is 1,720 m^3/d (1,120 m^3 of make-up water and 600 m^3 of recovered water).
b
As for the source of make-up water, well water accounts for 93% and purchased ice for the remaining 7%.

There are two wells, one with a capacity of 1,500 m^3/d, and the other with 500 m^3/d. Currently, only the one with a capacity of 1,500 m^3/d is in operation. The measured quality of raw water is as follows.

pH: 7.4
Temperature: 33.9 ℃
Electrical conductivity: 678 $\mu S/cm$.

Around 84% of the make-up water is used for the washing of of raw material in the production line. Then cooling water accounts for 10% of the consumption of make-up water.

Cooling water is recycled.

(2.4.2) Water Treatment

Only the water for the boiler is treated by a softener.

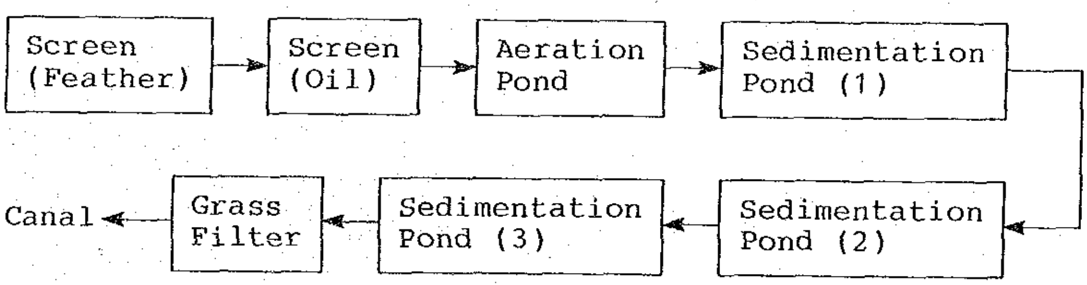
Other water is used after being sterilized by chlorine.

(2.4.3) Waste Water Treatment

Due to a high BOD level, waste water is first passed through screens for removals of feather and oil, then treated by activated sludge and sedimentation pond.

Before being discharged into a canal, it is filtered again by a grass filter.
The flow diagram of waste water treatment is shown below.

Waste Water



(3.) Plans of Effective Use of Industrial Water

(3.1) General

Operations of the production lines are automated by means of belt conveyers, but only the separation process is semi-automated.

Water consumption per chicken is extremely low, being 0.014 m^3/chicken. (Current water consumption in Japan is 0.4 m^3/head for small animal.)

Judging from the above, there seems to be little room for further improvement.

5.1.14 Code No. of Factory: F-14

(1.) Outline of Factory

Capital (M฿): 6

Annual Amount of Shipment (M฿): 3.5

Total Area (m^2): 2,000

Total No. of Employees: 15

Main Products: Noodle

(2.) Present Situation of the Use of Industrial Water

(2.1) Water Consumption

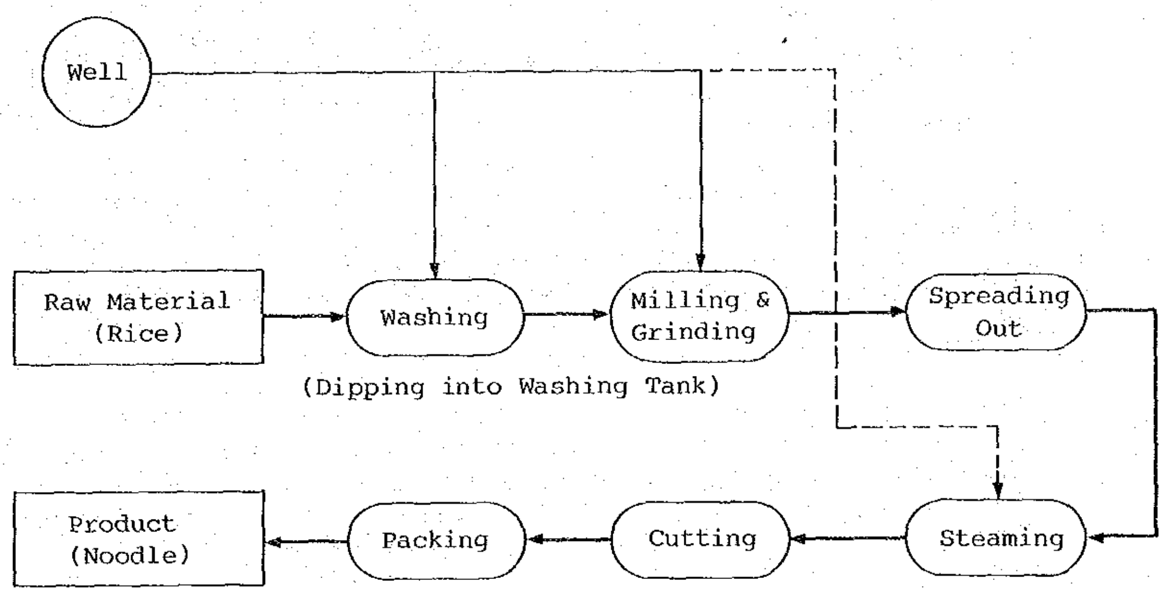
Unit: m^3/d

Use \ Source	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total
Boiler	8			8		8
Material	4			4		4
Processing & Washing	31			31		31
Cooling						
Air Conditioning						
Others	* 25			25		25
Sub Total	68			68		68
Outside						
Total	68			68		68

Recovery Rate (%): 0.0

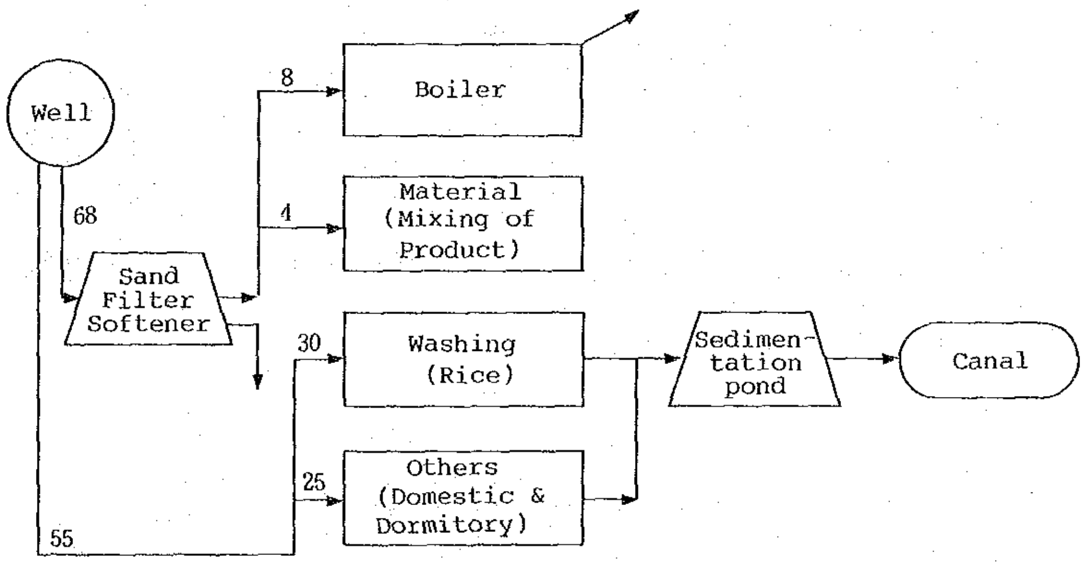
Note: * Including Dormitory Use

(2. 2) Process Diagram of Production Line



(2. 3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

This factory uses well water pumped up from a single well (68 m^3/d). The depth of the well is 110 m, and the pump piping is 2 inches in diameter.

The quality of well water at the time of the survey is as follows:

Turbidity: 1 mg/lit
pH: 7.2
Electrical conductivity: 711μS/cm

Water consumption of this factory is exactly the same as the pumped up quantity of well water, because no water is recovered. The largest quantity of water is used for washing of rice as the raw material, 30 m^3/d. This is followed by 25 m^3/d of domestic water supplied to the dormitory adjacent to the factory. Others include boiler water and raw material water.

(2.4.2) Water Treatment

Pumped up well water is sent to a head storage tank and supplied directly for washing of rice and for the dormitory use.

For raw material water and boiler water, water is treated by a pressure-type sand filter and a softener.

(2.4.3) Waste Water Treatment

Waste water from the washing process of rice as well as domestic waste water are treated together. The waste water treatment facility consists of sedimentation tank, septic tank and aeration tank.

But, none of them are being operated and the waste water is discharged with little improvement.

(3.) Plans of Effective Use of Industrial Water

(3.1) General

In this factory, no water used for the production process is recovered. The possible way to achieve effective use of water seems to reduce washing water for rice. Effective measures should be studied.

As regards to the domestic water (excluding drinking water) for dormitory use, no water pipes leading to each household is installed. Water is supplied by means of a common water tap to the storage tank of the washing place.

However, during the daytime, the water tap is left almost always open. Consequently the daily water consumption per capita is quite high (500 lit/d). This being the case, efforts should be made toward saving water.

(3.2) Details

a. Water control and water saving for rice washing

According to the equipment specifications for rice washing line, it is specified to be continuous, but this has been changed to batch operation now. It is assumed that notable water saving has been realized by batch operation, compared to the time of continuous operation.

However, data such as the water consumption for each washing frequency and water replacing frequency are not available. Moreover, reviewing future water saving would first necessitate studies on the optimum washing process based on a full understanding of the required water quantity, and at the same time, study is required in order to improve the current water saving method or to replace it with a water saving type rice washer.

b. Saving of domestic water for dormitory use

In the dormitory, water is used for bathing, washing and cooking. But it is difficult to know the quantity of water for each use.

However, it is recommended to encourage employees to avoid wasteful use of water as much as possible and to close the water tap when not necessary.

Since the total quantity of water consumption is small, the effects of these measures would be negligible.

There seems to be little room for further improvement.

5.2 Paper Industry

5.2.1 Code No. of Factory: P-01

(1.) Outline of Factory

Capital (M฿): -

Annual Amount of Shipment (M฿): 60

Total Area (m^2): 10,000

Total No. of Employees: 65

Main Products: Writing Paper

(2.) Present Situation of the Use of Industrial Water

(2.1) Water Consumption

Unit: m^3/d

Source / Use	Well Water	MWA	Others	Sub Total	cover-Water	Total
Boiler	180			180		180
Material						
Processing & Washing	1,050			1,050	600	1,650
Cooling						
Air Conditioning						
Others	15			15		15
Sub Total	1,245			1,245	600	1,845
Outside						
Total	1,245			1,245	600	1,845

Recovery Rate (%): 32.5

Summary

1. Background

Faced with the aggravating problems of subsidence of land in the Bangkok Metropolitan Area, the Industrial Works Department (IWD) of the Ministry of Industry in Thailand has launched on the program for reducing the pumping up of groundwater.

For this purpose, IWD requested the Japanese Government to provide technical cooperation in conducting a study on the effective use of industrial water.

Upon the acceptance of this request, the Japanese Government entrusted the Japan International Cooperation Agency (JICA) to carry out the study in Thailand. JICA commenced the study in August 1987 and completed it in March 1989.

2. Purposes of the Study

For the field study, IWD chose Samut Prakarn in the Bangkok Metropolitan Area. The purposes of the study were to grasp the actual situation of industrial water uses, estimate the potential amount of water saving, and prepare technical guidelines for more effective industrial water use.

The relationship between this study and other measures against land subsidence is as summed up in Fig. 1.

3. Contents of the Study

The study comprised of eight steps. For the outline of each step, refer to Fig. 2.

4. Results of the Study

The survey in Samut Prakarn covered 59 factories in five different industries. The gist of the survey is as shown in Table 1.

Although the number of surveyed factories accounted for only 2.2% of all factories in Samut Prakarn Province, their consumption of groundwater amounted to 17.6% of the total.

5. Programs for Effective Use of Industrial Water

On the basis of the results of the study, specific problems in implementing water saving measures were examined. Next, programs were established for both the public and private sectors regarding the measures taken for effective use of industrial water. Programs outlines are as shown in Table 2.

(2.4) Explanation of Present Situation

Water consumption in this factory is 1,845 m^3/d (1,245 m^3/d of make-up water and 600 m^3/d of recovered water).

Make-up water is pumped up from well. Currently two wells (90 m and 120 m deep) are in operation. Both wells are provided with flow meter.

The life of well is rather short (six out of eight wells have scrapped in the past eight years). This short life of well seems to be caused by the abrasion of pump owing to excessive pumping, the corrosion of strainers by highly concentrated chloride ion in the well water

87% of water is used for processing and washing. As to make-up water, too, 84% is used for processing and washing.

Whereas well water is used as the boiler make-up water after filtration by sand filter, well water for other uses is supplied without any treatment. The water quality is as shown below. The values of total hardness and chloride ion are high.

Item \ Data		Raw Water (Measured Value)	Boiler Water (Factory's Data)
pH		7.40	7.0
Temperature	(°C)	35.6	-
Turbidity	(mg/lit)	15.0	-
Electrical conductivity	(μS/cm	2,980	2.570
Chloride ion	(mg/lit)		460
Total hardness	(mg/lit)		655

Since no waste water treatment system is installed, white water is directly discharged to a canal.

(3.) Plan of Effective Use of Industrial Water

(3.1) General

The white water recycle system is installed in this factory. In this system, 600 m^3/d of white water is re-used after adjusting paper content in waste water through a screen.

Although this factory also has a steam condensate recovery system for the boiler, most of recovered steam is discharged into the atmosphere because the system is not complete.

(3.2) Details

a. Improvement of white water recovery rate through enlargement of tank capacity

As the present white water storage tank is too small to cope with the variation of the operation mode, considerable water overflows from the tank. Thus the enlargement of the tank capacity would bring high recovery rate of white water. If a new tank is built in an adjacent place (because the space is limited in the factory), 200 m³/d of well water would be saved.

b. Recovery of steam condensate

The improvement of the condensate recovery system could reduce steam being discharged into the atmosphere. If about 50% of steam is recovered, 90 m³/d of water would be saved.

(4.) Cost Estimation

Number	1	2
Method for Effective Use Method Item	 Recycle use Increase of recovery tank capacity to improve recovery of white water	 Recycle use Recovery of steam condensate
Water Saving Use Qt. (m³/d)	 Processing & washing 200	 Boiler 90
Apparatus for Effective Use Apparatus Cost (10³฿)	 Recovery tank 50 m³ x 1 160	 Drain trap, strainer & piping 46
Unit Cost (฿/m³) Fixed Operating Total	 0.3 - 0.3	 0.5 - 0.5

Total Water Saving (m³/d) : 290

Total Initial Cost (10³฿) : 206

Total Unit Cost (฿/m³) : 0.4

Note: Qt. = Quantity

5.2.2 Code No. of Factory: P-02

(1.) Outline of Factory

Capital (M฿): -

Annual Amount of Shipment: 54,000 t/Y, 150 t/d

Total Area (m^2): 30,000

Total No. of Employees: 330

Main Products: Board Paper and Corrugated Medium

(2.) Present Situation of the Use of Industrial Water

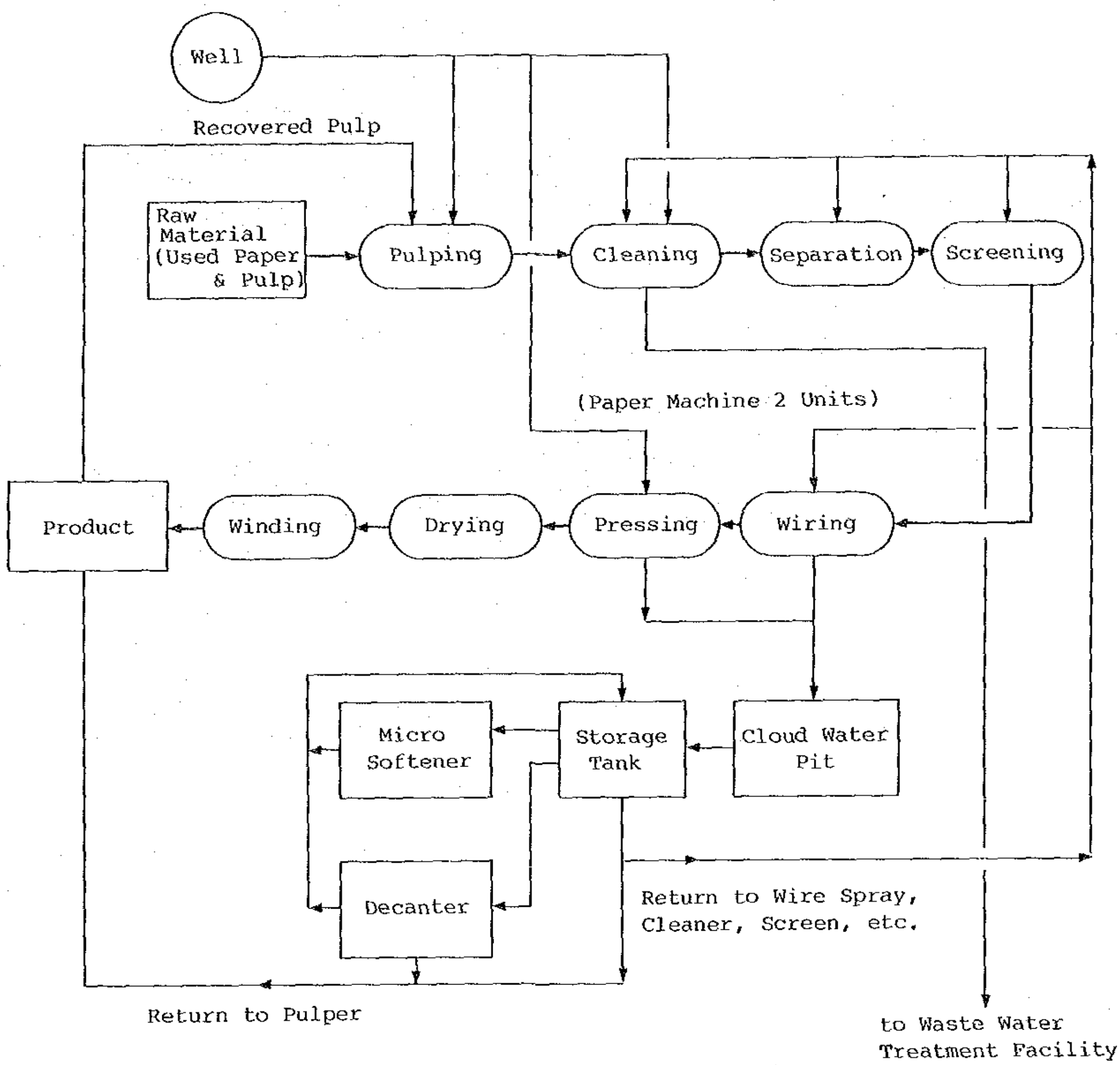
(2.1) Water Consumption

Unit: m^3/d

Source / Use	Well Water	MWA	Others	Sub Total	Recover-ed Water	Total
Boiler	70			70		70
Material Processing & Washing	1,100			1,100	2,200	3,300
Cooling						
Air Conditioning						
Others	60			60		60
Sub Total	1,230			1,230	2,200	3,430
Outside						
Total	1,230			1,230	2,200	3,430

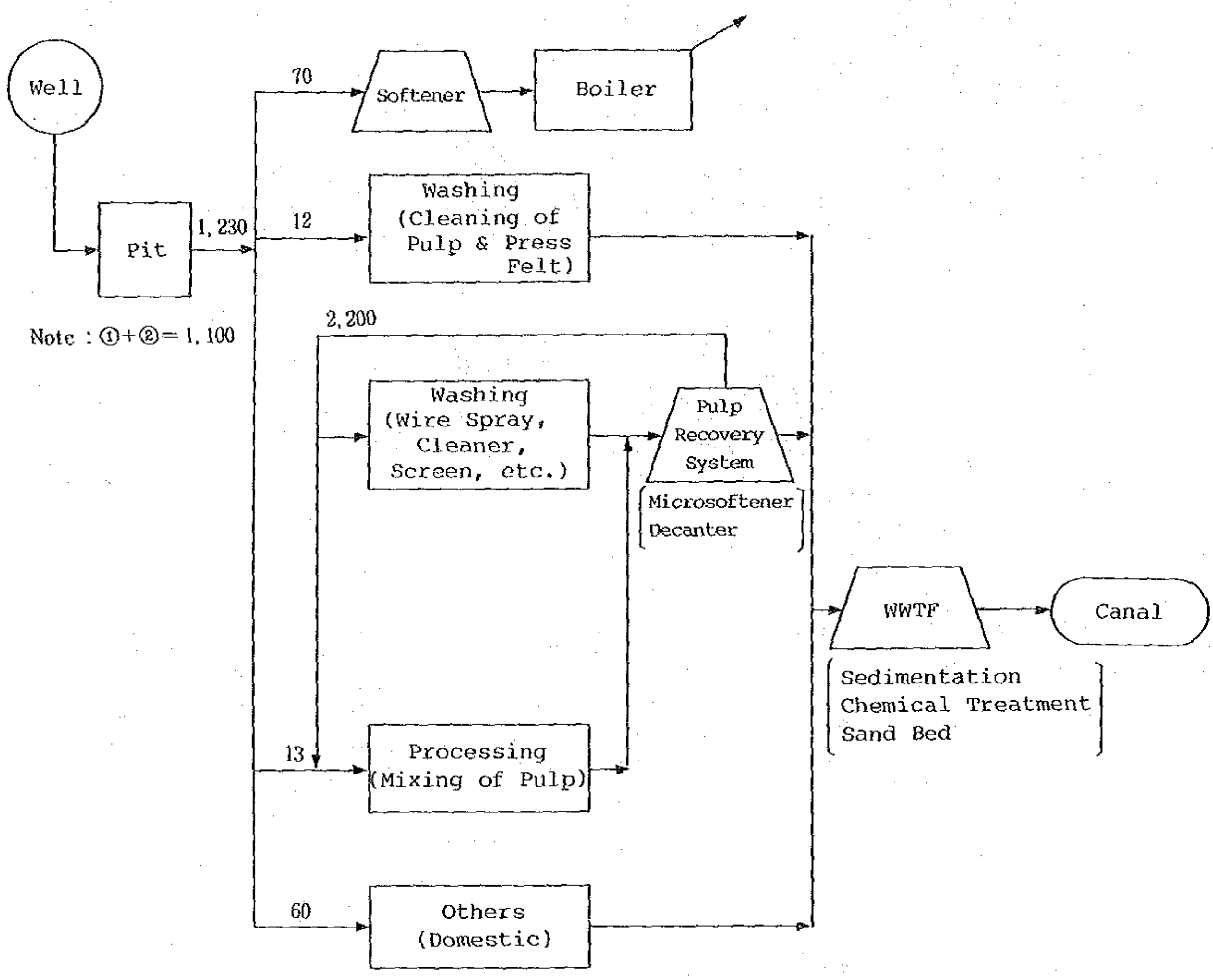
Recovery Rate (%): 64.1

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

In this factory, 1,230 m^3/d of water is pumped up from well.

There are two 100 m deep wells. The pump capacity of these wells are 90 m^3/h. The operation of the pumps depends on the water level of the storage tank, that is, no pump operates when the water level is high, only one pump operates when the water level is medium and both pumps are put into operation when the water level is low.

The cost of well water is calculated at 5.5 ฿/m^3, excluding the expenses for electricity, labor and maintenance.

In this factory, two sets of paper machine are used to produce paperboards and corrugated paper. Most water (3,300 m^3/d) is used for washing and processing of these two machines and the pulper. The water used for this purpose include 2,200 m^3/d of recycled white water.

To recycle white water, a tank of 100 m^3 capacity is installed for each paper machine. This way, water and pulp are recovered for re-use.

To the shower cleaner of pulp, well water is supplied in addition to the recycled white water. Only well water is used to wash the felt of the paper machine.

The re-use of white water is as follows.

White water —> Storage tank (100 m^3 x 2 tanks) ┬—> Pulper
└—> Paper machine
(1) High density cleaner
(2) Felt separator
(3) Vibrating screen
(4) Dilute pulp
(5) Nash pump
(6) Cut trim paper
(7) Shower cleaner

(2.4.2) Water Treatment

Except the softening of boiler water, no treatment is applied to well water to be used in this factory.

(2.4.3) Waste Water Treatment

Waste water treatment facility is composed of the sedimentation pond (15 m x 20 m), then to the chemical treatment pond (15 m x 20 m) and the lagoon (20 m x 30 m) to carry out chemical and biological treatment. But, most waste water is discharged from the sedimentation pond to the lagoon directly.

Sludge from the sedimentation pond is dried by sunlight on the sand bed.

Qualities of well water, waste water and waste water discharged to the canal are measured as follows.

Item \ Data	Well Water	Waste Water	Discharged Water
Turbidity (mg/lit)	7.0	-	-
pH	6.84	7.29	7.36
Electrical Conductivity (μS/cm)	2,510	29,100	29,400

(3.) Plan of Effective Use of Industrial Water

(3.1) General

Out of 3,430 m^3/d of the total water consumption, 2,200 m^3/d of white water is re-used, and the water recovery rate is 64.1%. This indicates that water is used fairly effectively in this factory.

The average paper production of this factory is 150 t/d. Thus the water/production ratio is 8.2 m^3/t (on the make-up water basis). Even compared to the average water/production ratio of paper mills in Japan, this is an excellent value.

This factory plans to lower the water/production ratio further. The target is to reach 3.0 m^3/t.

For the improvement of the water/production ratio, the effective way is to enlarge the capacity of the white water storage tank. The enlarged capacity of the tank will prevent overflow loss of white water, and hence lessen the well water supply.

(3.2) Details

a. Improvement of white water recovery rate through the enlargement of tank capacity

If, as the factory plans, the water/production ratio is reduced to 3.0 m^3/t by enlarging the capacity of the white water storage tank, water supply would be reduced from the present 1,230 m^3/d to 450 m^3/d. Thus, 780 m^3/d of water would be saved.

If, however, the water/production ratio is made too small, the result would be the lowering of the product quality. Therefore, it is recommendable to lower the ratio by around 20% and save 250 m^3/d of water.

(4.) Cost Estimation

Number	1
Method for Effective Use Method Item	 Recycle use Increase of recovery tank capacity to improve recovery of white water
Water Saving Use Quantity (m^3/d)	 Processing & Washing 250
Apparatus for Effective Use Apparatus Cost (10^3B)	 Recovery tank 50 m^3 x 2 320
Unit Cost (B/m^3) Fixed Operating Total	 0.5 - 0.5

5.2.3 Code No. of Factory: P-03

(1.) Outline of Factory

Capital (M฿): 10

Annual Amount of Shipment: 7,491 t/Y

Total Area (m^2): 4,800

Total No. of Employees: 249

Main Products: Toilet Paper

(2.) Present Situation of the Use of Industrial Water

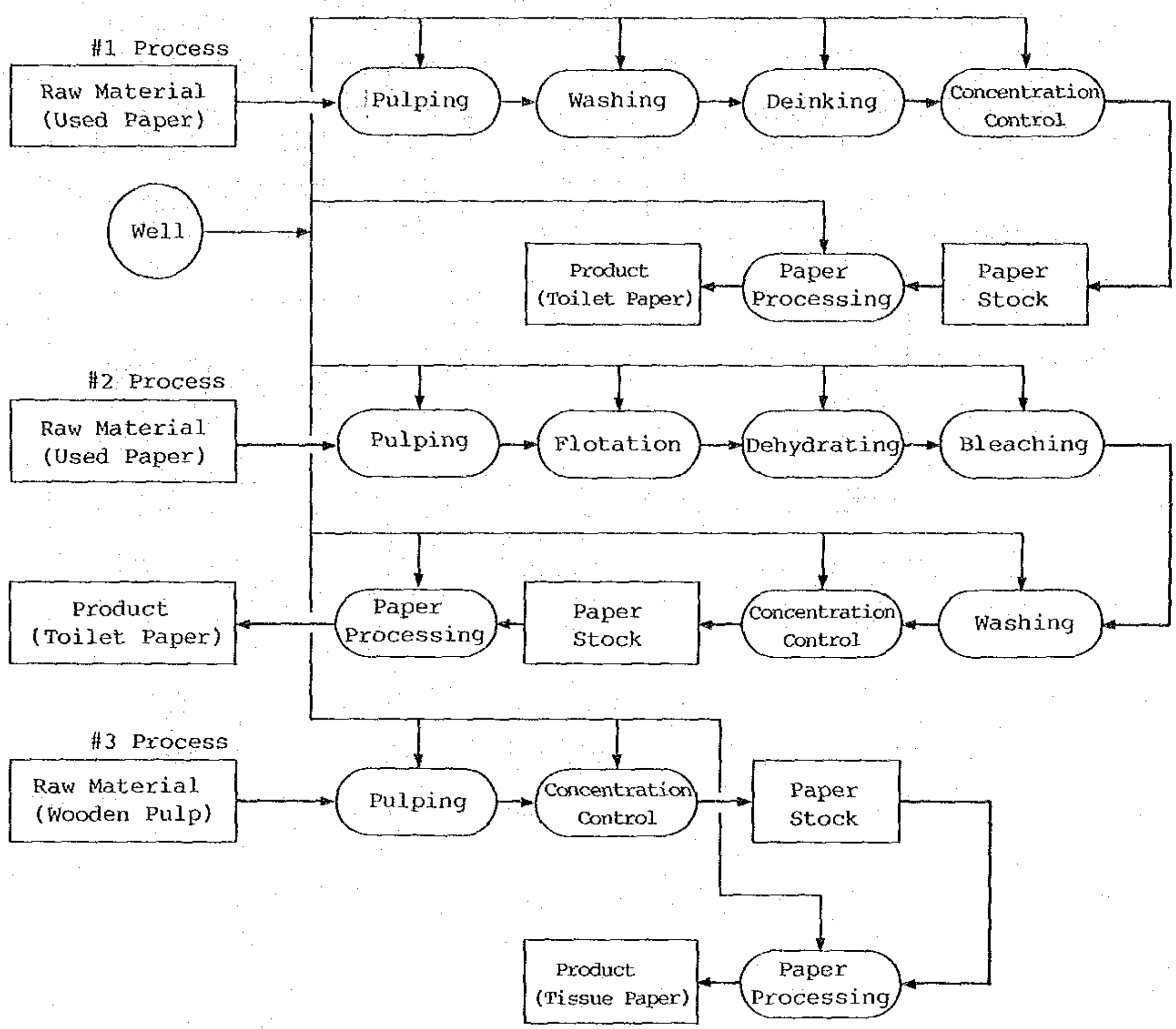
(2.1) Water Consumption

Unit: m^3/d

Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total
Boiler	115			115	77	192
Material Processing Washing	2,833			2,833	3,272	6,105
Cooling						
Air Conditioning						
Others	10			10		10
Sub Total	2,958			2,958	3,349	6,307
Outside						
Total	2,958			2,958	3,349	6,307

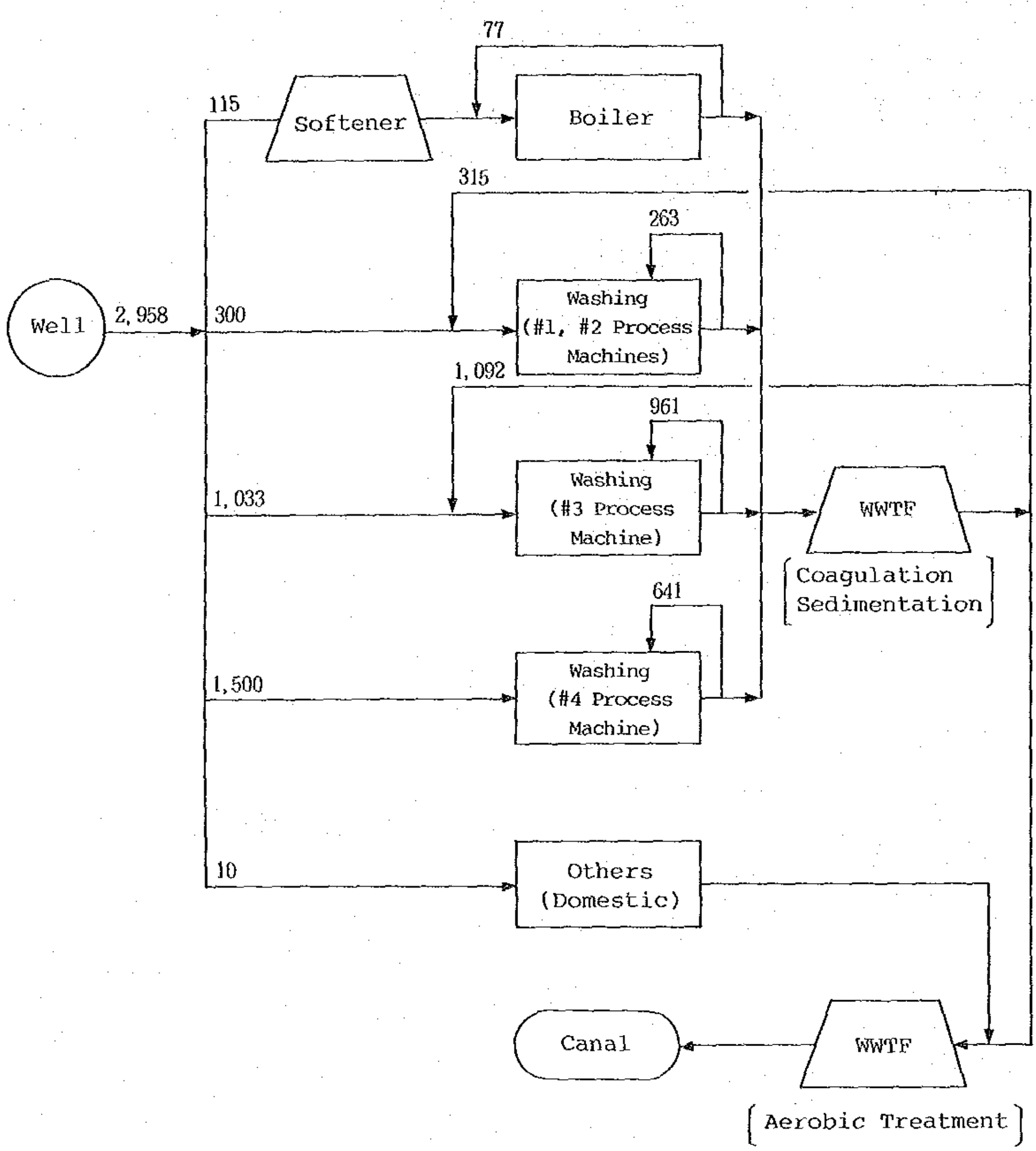
Recovery Rate (%): 53.1

(2. 2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m³/d)



Legend: WWTF = Waste Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

In this factory, 6,307 m^3/d of water is used with the recovery rate of 53.1% (2,958 m^3/d of make-up water and 3,349 m^3/d of recovered water).

Well water is used as make-up water. Currently two wells (one 220 m deep and the other 135 m deep) are in operation.

Around 97% of water consumption is for processing and washing. As to make-up water, too, 96% is used for processing and washing.

(2.4.2) Water Treatment

The quality of raw water (mixed water from both wells) is as follows.

pH : 7.2
Turbidity : 16.0 mg/lit
Electrical conductivity: 1,333 $\mu S/cm$

Softening treatment is applied for boiler water, whereas well water is used without any treatment. The quality of softened water is as follows.

Electrical conductivity: 1,020 $\mu S/cm$
Total hardness: 7 mg/lit
Chloride ion: 140 mg/lit

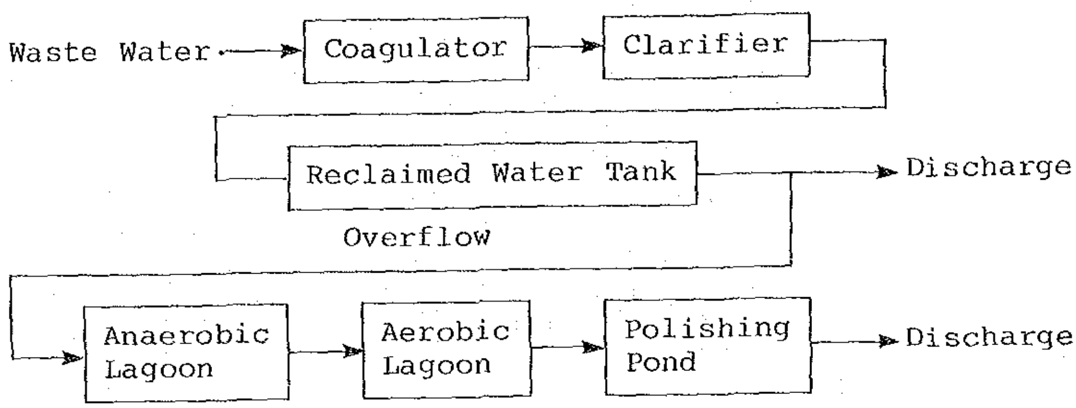
(2.4.3) Waste Water Treatment

Waste water treatment facility in this factory is comprised of a coagulation and sedimentation system and a biological treatment system. Treated waste water is partly re-used for processing and washing.

The quality of waste water is shown below.

Item \ Data	Influent	Effluent
pH	7.54	7.38
Electrical Conductivity ($\mu S/cm$)	2,580	1,778
Temperature (°C)	37.1	37.3

Flow diagram of waste water treatment process is as follows.



(3.) Plan of Effective Use of Industrial Water

(3.1) General

This factory adopts three systems for water recycling. One is recycling of boiler water system and the rest two are recycling of processing and washing water system.

For the boiler, 40% of the water comes from recovered steam condensate.

For processing and washing, two water re-use systems are adopted in this factory. The one is to recycle the white water from process directly to the paper machine. Around 31% (approx. 57% of the total of re-used water) of processing and washing water is supplied in this way.

The other is to mix treated white water (by means of coagulation/sedimentation) with well water in order to re-use it for processing and washing.

Owing to the recycling of water, the present water recovery rate is 53.1%.

To make the water use more effective, the feasibility of the re-use of waste water should be studied. From the technical point of view, it is quite possible to make quality of waste water re-usable. (There are some examples in Japan.)

(3.2) Details

a. Advanced treatment of waste water for re-use in washing process

As stated above, recycling of white water is already implemented in this factory. Therefore, to save more water, the re-use of waste water through advanced treatment might be the sole possibility. The outline of the advanced treatment of waste water for re-use is as follows.

(i) Raw water: discharged waste water
(ii) Volume to be reclaimed: 700 m^3/d (approx. one-fourth of make-up water to be used for the paper machine)
(iii) Use: washing of the paper machine
(iv) Treatment process: coagulation and sand filtration

(4.) Cost Estimation

Number	1
Method for Effective Use Method Item	 Reclamation of waste water Advanced treatment of waste water for re-use in washing process
Water Saving Use Quantity (m^3/d)	 Processing & washing 700
Apparatus for Effective Use Apparatus Cost (10^3B)	 Sand filter x 2, tank x 2, pump x 3, electric instrument & piping 4,200
Unit Cost (B/m^3) Fixed Operating Total	 2.5 1.5 4.0

5.2.4 Code No. of Factory: P-04

(1.) Outline of Factory

Capital (MB): 430

Annual Amount of Shipment (MB): 1,100 (200 t/d)

Total Area (m^2): 80,000

Total No. of Employees: 900

Main Products: Printing and Writing Paper, Kraft Paper and Cardboard

(2.) Present Situation of the Use of Industrial Water

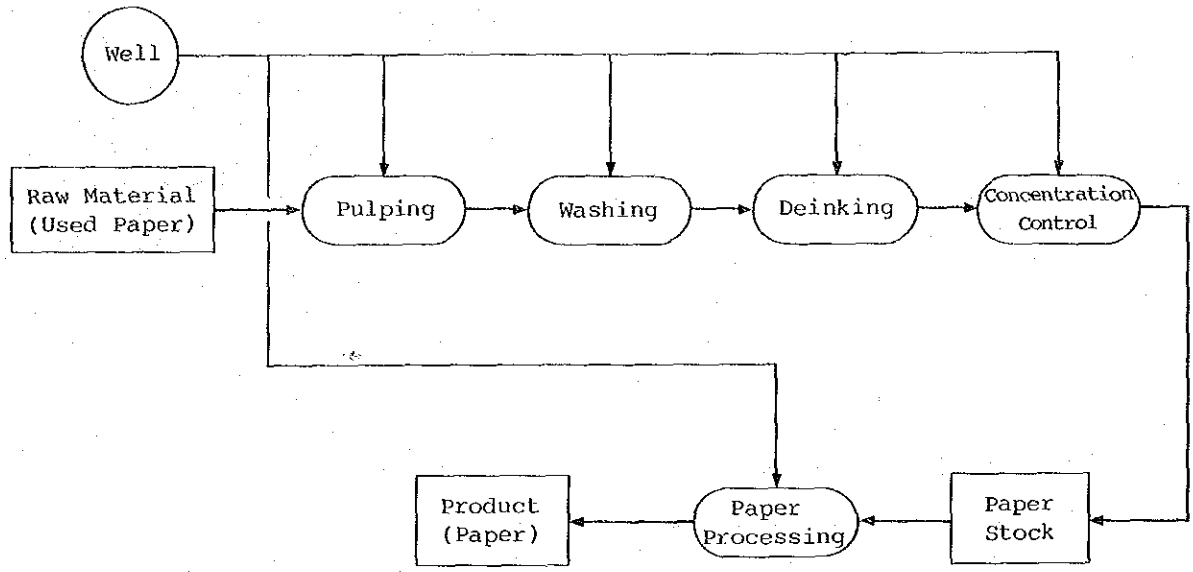
(2.1) Water Consumption

Unit: m^3/d

Source / Use	Well Water	MWA	Others	Sub Total	Recovered Water	Total
Boiler	330			330	300	630
Material Processing & Washing	11,000		1,900	12,900	4,500	17,400
Cooling						
Air Conditioning						
Others	30			30		30
Sub Total	11,360		1,900	13,260	4,800	18,060
Outside						
Total	11,360		1,900	13,260	4,800	18,060

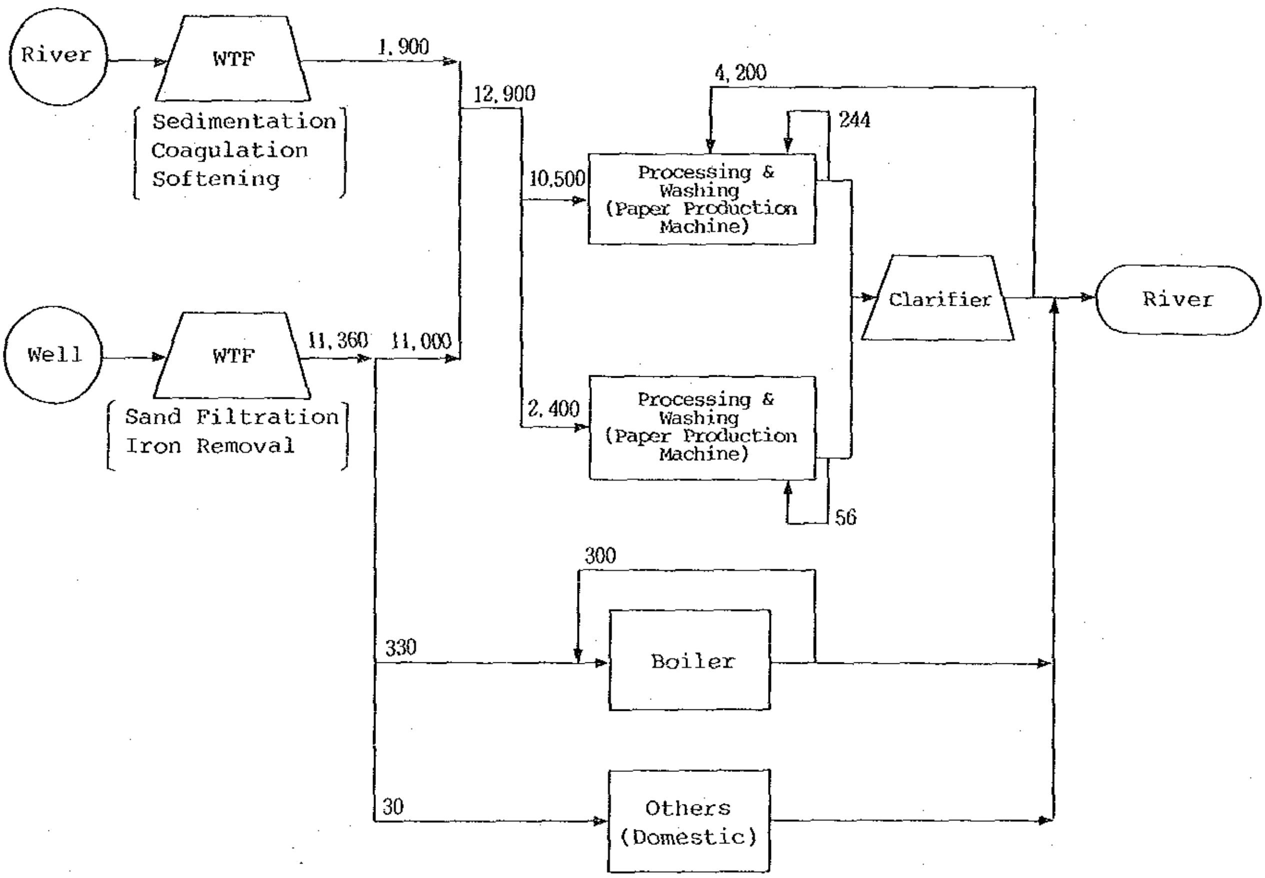
Recovery Rate (%): 26.6

(2. 2) Process Diagram of Production Line



(2. 3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m³/d)



Legend: WTF = Water Treatment Facility

(2.4) Explanation of Present Situation

(2.4.1) Sources and Uses

This factory uses 18,060 m^3/d of water with the recovery rate of 26.6% (13,260 m^3/d of make-up water and 4,800 m^3/d of recovered water).

The water sources are wells and a river. Currently ten wells (each 90 m deep) are in operation, and the total pumping up volume is 11,360 m^3/d. Beside that, in the rainy season when the chloride ion concentration of river water is low (for approximately six months), water is taken from Chao Phraya river. The water taken from the river averages 1,900 m^3/d.

Around 96% of water is used for processing and washing. The rest is for the boiler and domestic use.

Around 25% of processing and washing water is recycled, while the recycle rate of boiler water amounts to about 48%. The water recovery rate as a whole is 26.6%.

From 1988 on, domestic water will be supplied by MWA. Accordingly the quantity of well water is expected to decrease.

(2.4.2) Water Treatment

Removal of iron content and filtration are carried out for certain part of well water, while river water is treated by sedimentation with the injection of aluminum sulfate.

The quality of raw water is as follows.

pH: 7.48
Total hardness: 260 mg/lit
Chloride ion: 315 mg/lit
Temperature: 32 °C to 34 °C

(3.) Plan of Effective Use of Industrial Water

(3.1) General

In this factory, white water is re-used after adjusting its pulp content. Updating of the existing paper machine is studied in expansion plan of the factory. Consequently the water supply system will be changed in future.

From 1988 on, this factory plans to take water from MWA for drinking and other domestic uses.

To reduce the pumping up quantity of well water, one of the effective ways is to increase the intake volume of water from the river by replacing the present fixed port-type pump with the movable port-type. This possibility should be put under further study.

Although the white water recovery rate is already fairly high, considering the types of product and re-use of water of this factory, there is still room for improvement of water re-use.

To make the water use more effective, the feasibility of the re-use of waste water should be studied. From the technical point of view, it is quite possible to make waste water re-usable. (There are some examples in Japan.)

(3.2) Details

a. Improvement of white water recovery rate through the increase of recovery capacity

The recovery of white water should be increased by 1,000 m^3/d (i.e., 30% up of white water recovery rate) by enlarging the capacities of pumps, pipings and other related equipment.

b. Advanced treatment of waste water for re-use in washing process

In addition to the improvement of white water recovery, the re-use of waste water might be feasible by applying further treatment. The outline of the advanced treatment of waste water for re-use is as follows.

(i) Raw water: Discharged waste water

(ii) Volume to be reclaimed: 3,000 m^3/d (approx. one-fourth of make-up water to be used for the paper machines)

(iii) Use: Washing of the paper machines

(iv) Treatment process: Biological treatment, sedimentation and sand filtration

(4.) Cost Estimation

Number	1	2
Method for Effective Use Method Item recovery ratio	 Recycle use Increase of recycling capacity of white paper	 Reclamation of waste water Advanced treatment of waste water for re-use in washing
Water Saving Use Qt. (m^3/d)	 Washing 1,000	 Washing 3,000
Apparatus for Effective Use Apparatus Cost (10^3B)	 Pump for white water, 2 units, electric instrument & piping 496	 Biological treater, sedimentation tank, sand filter, dehydrator, pump x 4, electric instrument & piping 37,776
Unit Cost (B/m^3) Fixed Operating Total	 0.2 0.7 0.9	 4.5 0.8 5.3

Total Water Saving (m^3/d): 4,000

Total Initial Cost (10^3B): 38,272

Total Unit Cost (B/m^3): 4.2

Note: Qt. = Quantity

5.2.5 Code No. of Factory: P-05

(1.) Outline of Factory

Capital (M฿): -

Annual Amount of Shipment: 264 t/Y

Total Area (m^2): 81,600

Total No. of Employees: 323

Main Products: Coated Paper and Aluminum Foil

(2.) Present Situation of the Use of Industrial Water

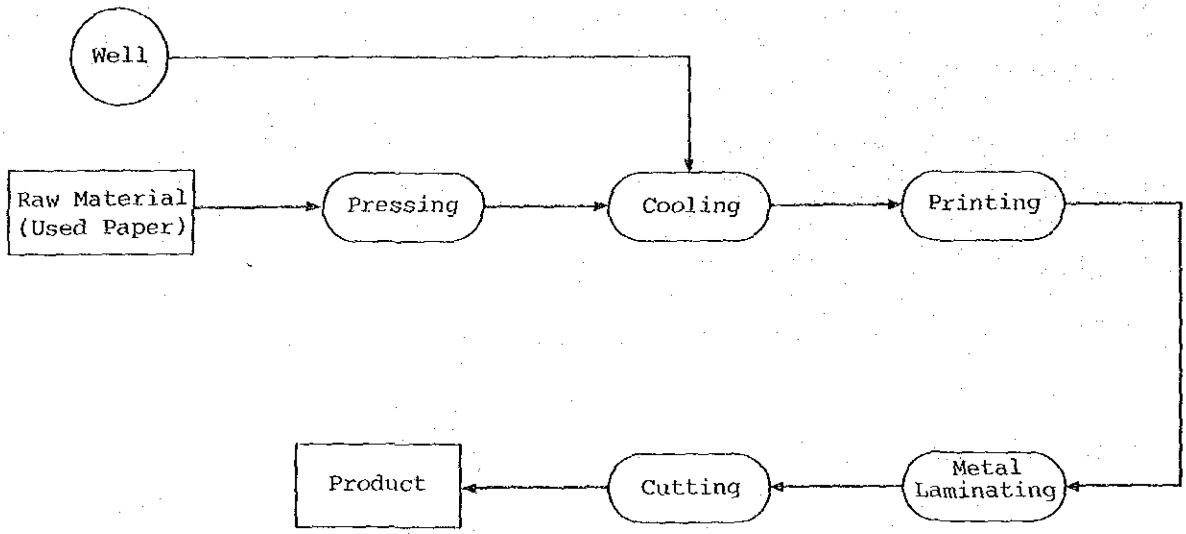
(2.1) Water Consumption

Unit: m^3/d

Use \ Source	Well Water	MWA	Others	Sub Total	Recovered Water	Total
Boiler						
Material						
Processing & Washing	26			26		26
Cooling	2			2	60	62
Air Conditioning						
Others	94			94		94
Sub Total	122			122	60	182
Outside	30			30		30
Total	152			152	60	212

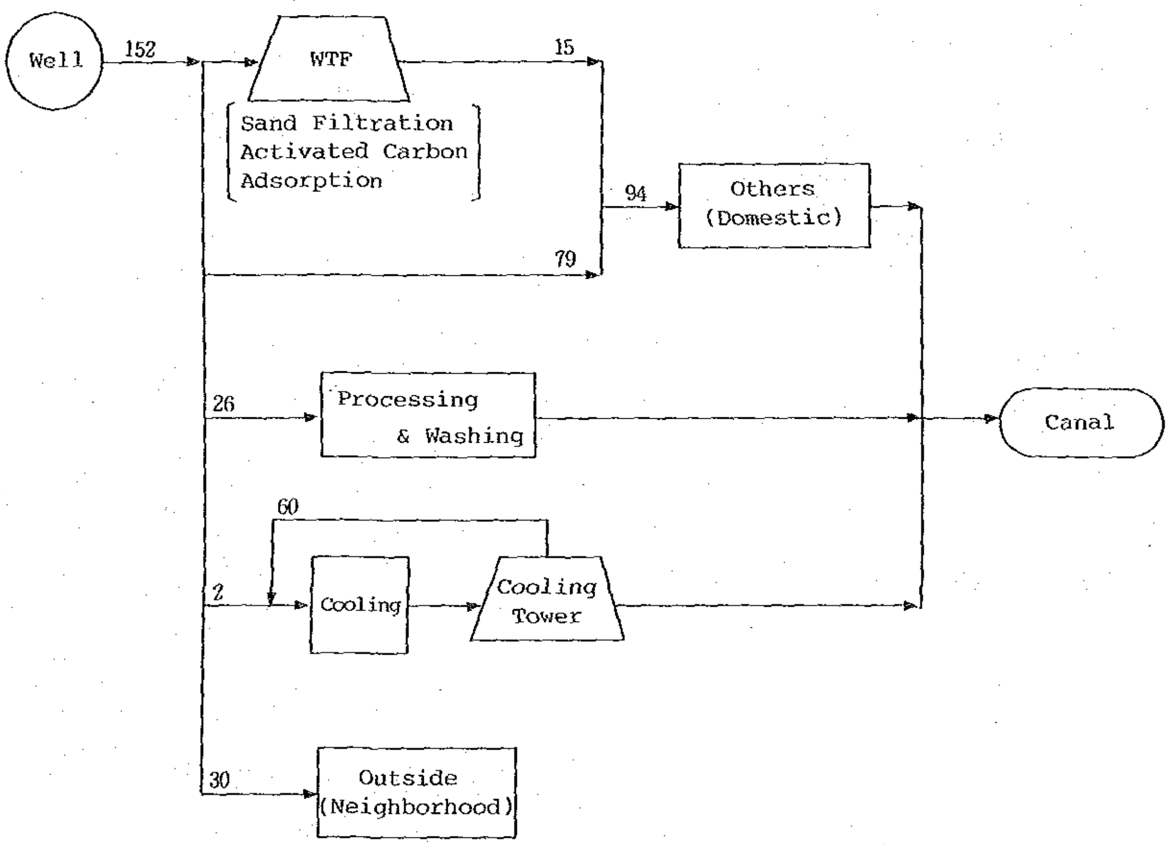
Recovery Rate (%): 33.0

(2.2) Process Diagram of Production Line



(2.3) Flow Diagram of Water Supply and Waste Water Discharge

(Unit: m^3/d)



Legend: WTF = Water Treatment Facility

(2.4) Explanation of Present Situation

Water consumption in this factory is 182 m^3/d (122 m^3/d of make-up water and 60 m^3/d of recovered water).

The source of make-up water is wells. Currently two wells are in operation. Each of the wells has a flow meter.

Water is used for cooling (34%), processing and washing (14%) and domestic purposes (52%).

Whereas drinking water is filtered and treated by activated carbon adsorption, no treatment is applied to well water for other uses.

As for the waste water treatment, there is only a pond with the surface area of 40,000 m^2 in this factory.

(3.) Plan of Effective Use of Industrial Water

(3.1) General

In 1987, this factory adopted a recycled system of cooling water which resulted in saving 60 m^3/d of water.

In this factory, domestic use (i.e., use for daily living) takes the largest share of water consumption. Out of 94 m^3/d of water for domestic use, sprinkling of the green area in the premises accounts for 20 m^3/d, the rest being for drinking, toilets and the like. The consumption of domestic water is estimated at around 230 lit/capita/d.

To save the consumption of water, sprinkling of the green area should be studied.

(3.2) Details

a. Use of pond water for sprinkling

The factory premises cover an area of 81,600 m^2, nearly 50% (40,000 m^2) of which is occupied by a holiday pond. Water of this pond might be used for sprinkling (20 m^3/d).

(4.) Cost Estimation

Number	1
Method for Effective Use Method Item	 Others Use of pond water for spraying
Water Saving Use Quantity (m^3/d)	 Miscellaneous 20
Apparatus for Effective Use Apparatus Cost (10^3฿)	 Pump 1 unit, electric instrument & piping 167
Unit Cost (฿/m^3) Fixed Operating Total	 3.2 1.2 4.4