(2) Restaurant

The future unit water consumption of restaurant is assumed to the same as the existing one.

The total seat number of restaurant in the Study Area will increase to 38,537 in 2010.

The total water consumption of restaurant in the Study Area in 2010 is estimated at 848 m^3/day.

1.5 Industrial Water Consumption

1.5.1 Existing Water Consumption

The JICA Study Team carried out a sampling survey on industrial water consumption in the Study Area. The survey was conducted for one (1) canning factory of food and beverage industry and two (2) batik factories of textile industry. The results are shown in Table C.1.6.

The obtained unit water consumption of 0.009 m^3/million Rp./year for canning factory, and 0.002 m^3/million Rp./year and 0.005 m^3/million Rp./year for batik factory are very close to the average unit water consumption of food and beverage industry, and textile industry in Jakarta respectively. Hence, the unit water consumption by industry in the Study Area are assumed to be the same as in Jakarta.

The adopted unit water consumption by industry are as follows.

- Food, beverage and tobacco industry : 0.010 m^3/day/million Rp./yr
- Textile industry : 0.002 m^3/day/million Rp./yr
- Wood and wood products industry : 0.003 m^3/day/million Rp./yr
- Pulp and paper products industry : 0.003 m^3/day/million Rp./yr
- Industrial chemicals : 0.010 m^3/day/million Rp./yr
- Non-metalic mineral products industry : 0.027 m^3/day/million Rp./yr
- Iron and steel basic industry : 0.027 m^3/day/million Rp./yr
- Fabricated mineral products, machinery and equipments industry : 0.027 m^3/day/million Rp./yr

- Other industry : 0.010 m^3/day/million Rp./yr

The total industrial product amount of the Study Area in 1987 is estimated at Rp. 151.2 billion at 1990 price. Its break-down in each industrial classification is shown in Table C.1.7.

The existing total industrial water consumption of the Study Area is estimated to be about 805 m^3/day by multiplying the above unit water consumption by its total industrial product amount.

1.5.2 Future Water Consumption

The future unit industrial water consumption is assumed to be the same as the existing one.

Total industrial product amount of the Study Area in 2010 is estimated at Rp. 887.3 billion on the assumption that it will increase at the same growth rate of GDP. This amount of Rp. 887.3 billion is broken down into each industrial classification in proportion to the future industrial product amount of each industrial classification which is projected individually at the respective growth rate in the past. The break-down is shown in Table C.1.7.

The future total industrial water consumption of the Study area is estimated to be 5,075 m^3/day.

2. Unit Pollution Load

2.1 Domestic Wastewater

2.1.1 Observation of Pollution Load

The JICA Study Team conducted sampling observations of domestic pollution load in November and December, 1991. The observations were made for the following types of pollution load.

- Pollution load of toilet waste from residence

- Pollution load of septic tank effluent from residence

- Pollution load of gray water from high, middle and low income class residence.

The sampling locations of unit pollution load generation are shown in Fig. C.2.1.

(1) Pollution Load of Toilet Waste from Residence

Pollution load of toilet waste was observed at a residence of seven (7) family members in Kel. Panjer, Kec. Denpasar Selatan.

All toilet waste was collected from the connecting pipe of toilet and septic tank for 24 hours. The amount of sampled water was 112 liter. The unit quantity of toilet waste per capita per day becomes 16 lcd.

The measured water quality parameters are as follows.

- Air Temperature, Water Temperature, pH, BOD_5, COD_{cr}, SS, NH_4-N, NO_2-N, NO_3-N, Total N, Total P, Fecal Coliform.

The observed wastewater quality and unit pollution load in terms of BOD are 700 mg/l and 11.2 gcd respectively as shown in Table C.2.1.

(2) Pollution Load of Septic Tank Effluent

Pollution load of septic tank effluent from residence were observed at two (2) locations in Kel. Sumerta in Kec. Denpasar Timur and Desa Dauh Puri Kelod in Kec. Denpasar Barat.

The quantity of effluent from both septic tank amounted to 12 liter each for 24 hours sampling.

The measured water quality parameters are the same as those of toilet waste :

- Air Temperature, Water Temperature, pH, BOD_5, COD_{cr}, SS, NH_4-N, NO_2-N, NO_3-N, Total N, Total P, Fecal Coliform.

The average observed wastewater quality and unit pollution load in terms of BOD are 277 mg/l and 0.61 gcd respectively as shown in Table C.2.2. Comparison of the above two (2) observations leads to the estimation of a high treatment efficiency (95%) of the observed septic tanks. This high efficiency is considered mainly due to the leaching effects into underground of pollution loads.

(3) Pollution Load of Gray Water from High, Middle and Low Income Class Residence

Pollution load of kitchen, bathing and laundry was observed at nine (9) residence, three (3) each of high, middle and low income class. Among these nine (9) observation sites, six (6) are located in Kel. Sumerta in Kec. Denpasar Timur, two (2) in Kel. Panjer in Kec. Denpasar Selatan and the remaining one (1) in Desa Dauh Puri Kelod in Kec. Denpasar Barat.

The observation conditions are as follows :

Discharge measurement	:	Whole discharged wastewater was collected by a bucket.
Sampling Method	:	Consecutive composite sampling, at every 3 hour interval, for 24 hours.
Measured Water Quality Parameter	:	pH, BOD_5, COD_{cr}, SS

The average observed unit gray water generation are 268 lcd for high income class, 169 lcd for middle income class and 133 lcd for low income class. Moreover, the average observed unit pollution load as BOD_5 are 32.7 gcd for high class, 20.5 gcd for middle class and 15.6 gcd for low class. For details, refer to Table C.2.3.

Difference between the average observed unit domestic water consumption and unit gray water generation for three (3) income classes are 62 lcd for high class, 41 lcd for middle class and 27 lcd for low class.

These differences result from the infiltration/evaporation loss of toilet waste, and gardening, car washing and other similar water uses. Unit toilet waste for middle and low income classes is estimated at 16 lcd based on the above sampling observation. While, it is assumed to be 30 lcd for high class which generally uses toilet of cistern type. Moreover, water loss due to gardening, car washing and other similar uses is estimated to be approximately 10% of the total domestic water consumption based on the questionnaire survey of the Study Team.

From the above discussions, the observed gray water generation are considered correct.

2.1.2 Unit Wastewater and Pollution Load Generation

Both existing (1990) and future (2010) unit wastewater pollution load generation of gray water and toilet waste are estimated as shown below, based on the sampling observation results and water consumption estimates in the previous section.

	Unit Wastewater (lcd)			Unit Pollution Load (BOD_5 gcd)		
	Gray Water	Toilet Waste	Total	Gray Water	Toilet Waste	Total
- High Class	268	30	298	32.7	11.2	43.9
- Middle Class	169	16	185	20.5	11.2	31.7
- Low Class	133	16	149	15.6	11.2	26.8

For details, see Table C.2.4.

The average existing and future unit wastewater and pollution load generation for the whole Study Area are estimated as follows.

	Existing	Future
Unit Wastewater (lcd)	172	196
Unit Pollution Load (BOD_5 gcd)	29.8	32.6

In this estimation, the share of population by income class was assumed as follows (Refer to Appendix A).

	Existing	Future
High Class :	3.2%	18.8%
Middle Class :	51.0%	53.7%
Low Class :	45.8%	27.5%

2.2 Commercial and Institutional Waste

The JICA Study Team conducted sampling observations for the wastewater quality of commercial wastes at three (3) shops in December, 1991.

The wastewater of shop (A) includes toilet waste only. While, the wastewater of shop (B) covers the wastes of toilet, washing and bathing, and that of shop (C) contains the wastes of toilet and bathing.

The observations conditions are as follows.

Sampling Method	:	Consecutive composite sampling, at every 3 hour interval for 24 hours.
Measured Water Quality Parameter	:	pH, BOD_5, COD_{cr}, SS

The existing quality of commercial and institutional wastewater is established to be 216 mg/l as BOD_5, based on the sampling observation results. This is shown in Table C.2.5.

The future quality of commercial and institutional wastewater is assumed to be the same as the existing one.

2.3 Tourism Wastes

The JICA Study Team conducted sampling observations for the water quality of hotel and restaurant wastes covering toilet waste and gray water at the same time of the unit water consumption survey.

Nine (9) hotels, three (3) each for high, middle and low classes, were selected for the sampling survey.

The observation conditions are as follows.

Discharge measurement	:	Whole wastewater discharge was collected by a bucket.
Sampling Method	:	Consecutive composite sampling, at every 3 hour interval, for 24 hours
Measured Water Quality Parameter	:	pH, BOD_5, COD_{cr}, SS

The average observed wastewater quality is 37.2 mg/l as BOD_5 for high class hotel and 39.4 mg/l for middle and low class hotels. The observation results are summarized in Table C.2.6.

The unit existing pollution load generation of hotel covering both toilet waste and gray water is estimated to be 98.3 g/room/day as BOD_5 for high class hotel and 80.2 g/room/day for middle and low class hotels with an assumption that the number of guest per one (1) room is 2.0 person. The future unit pollution load generation is assumed to be the same as the existing one. The details are shown in Table C.2.7.

Three (3) restaurants were selected for the wastewater quality survey, one (1) each for large, middle and small class. The observation conditions were the same as those for hotel.

Unit pollution load generation of restaurant was estimated at 5.6 g/seat/day as BOD_5 in average, regardless the size of restaurant. The results of wastewater quality survey for restaurants are shown in Table C.2.8.

2.4 Industrial Wastes

The existing wastewater quality records of industrial waste in Jakarta are available. The average BOD_5 of each industrial classification in Jakarta is shown in Table C.2.9.

The JICA Study Team conducted a sampling observation for the water quality of industrial waste at three (3) factories, one (1) canning factory belonging to food and beverage industry and two (2) batik factories belonging to textile industry.

The observation conditions are as follows.

Discharge measurement	:	Whole discharged wastewater was collected by a bucket.
Sampling Method	:	Consecutive composite sampling, at every 3 hour interval, for 24 hours
Measured Water Quality Parameters	:	pH, BOD_5, COD_{cr}, SS

Based on the above survey, the unit pollution load generation of BOD_5 per annual production amount is estimated to be 14.5 g/d/million Rp./year for the canning factory and 0.35 and 0.42 g/d/million Rp./year for the batik factories (see Table C.2.10). These figures are almost the same as the unit pollution load generation of industry in Jakarta (see Table C.2.9). Therefore, the unit pollution load generation of each industrial classification in the Study Area are considered to be the same as those in Jakarta.

3. Generated Pollution Load

3.1 Domestic Pollution Load

Existing and future domestic generated wastewater and pollution load of each Kelurahan/Desa are obtained by multiplying the respective unit wastewater generation and unit pollution load generation estimated in Section 2.1 by the total population estimated in Appendix A.

The total domestic generated wastewater and pollution load of the Study Area are estimated as shown below.

		Existing	Future
Wastewater generation (10^3 m^3/d)	:	82.2	139.3
Pollution load generation (BOD t/d)	:	14.2	23.2

The break-down by Kelurahan/Desa are shown in Table C.3.1 through Table C.3.4.

3.2 Commercial and Institutional Pollution Load

Existing and future commercial and institutional wastewater generation of each Kelurahan/Desa are assumed equivalent to the respective water consumption estimated in Section 1.3. Existing and future commercial and institutional pollution load generation of each Kelurahan/Desa are obtained by multiplying the respective wastewater generation by the wastewater quality estimated in Section 2.2.

The total commercial and institutional wastewater and pollution load generation of the Study Area are estimated as shown below.

		Existing	Future
Wastewater generation (10^3 m^3/d)	:	16.9	28.0
Pollution load generation (BOD t/d)	:	3.66	6.04

The break-down by Kelurahan/Desa are shown in Table C.3.1 through Table C.3.4.

3.3 Tourism Pollution Load

Existing and future tourism wastewater generation of hotels and restaurants in each Kelurahan/Desa are assumed equivalent to the respective water consumption estimated in Section 1.4. Existing and future

pollution load generation of hotels and restaurants in each Kelurahan/Desa are obtained by multiplying the number of hotel rooms with unit pollution load of hotel, and by multiplying the number of restaurant seats with unit pollution load of restaurants.

The total tourism wastewater and pollution load generation of the Study Area are estimated as shown below.

	Existing	Future
(Hotel)		
Wastewater generation (m^3/d) :	16,438	53,983
Pollution load generation (BOD kg/d) :	809	2,623
(Restaurant)		
Wastewater generation (m^3/d) :	404	848
Pollution load generation (BOD kg/d) :	103	216

The break-down by Kelurahan/Desa are shown in Table C.3.1 through Table C.3.4.

3.4 Industrial Pollution Load

Existing and future industrial wastewater generation by industrial classification are assumed equal to the respective water consumption estimated in Section 1.5. Existing and future industrial pollution load generated by industrial classification are obtained by multiplying the unit pollution load generation estimated in Section 2.4 by total industrial product amount.

Existing and future total industrial wastewater and pollution load generation of the Study Area are estimated as shown below.

		Existing	Future
Wastewater generation (m^3/d)	:	805	5,075
Pollution load generation (BOD kg/d)	:	915	5,993

Those are broken down into each Kelurahan/Desa in proportion to the respective existing and future industrial land areas.

The break-down by Kelurahan/Desa are shown in Table C.3.1 through Table C.3.4.

3.5 Total Pollution Load

Existing and future wastewater and pollution load generation of the total wastes in the Study Area are estimated as shown below.

		Existing	Future
Wastewater generation ($10^3m^3/d$)	:	116.8	227.2
Pollution load generation (BOD t/d)	:	19.7	38.0

The average daily wastewater and pollution load generation of unit area in the Study Area are given below.

		Existing	Future
Specific wastewater generation ($m^3/d/ha$)	:	4.94	9.61
Specific pollution load generation (BOD kg/d/ha)	:	0.83	1.61

The existing and future specific wastewater and pollution load generation by Kelurahan/Desa are shown in Table C.3.1 through Table C.3.4. Their regional distribution are shown in Fig. C.3.1 through Fig. C.3.4.

Table C.1.1 Unit Water Consumption by Household Income Level

Income Level	Member of Family	Water Source	Water Consumption(m3/d)	Unit Water Consumption(lcd)	Average Unit Water Consumption(lcd)
Low	11	Well	1.40	127	156
	7	PDAM	1.00	143	
	5	PDAM	0.70	140	
	7	Well	1.50	214	
Middle	12	Well	2.00	167	206
	6	Well	1.00	167	
	6	Well	1.50	250	
	5	Well	1.20	240	
High	7	Well & PDAM	2.50	357	328
	8	Well	2.20	275	
	7	Well	3.00	429	
	6	PDAM	1.50	250	

Source : JICA, 1992

Table C.1.2 Water Consumption by Water Use in PDAM Badung Served Area

PDAM Service District	Water Consumption in 1991 (m3/month)				Consumption Ratio in 1991 (%)		
	October		November		October	November	Average
	(1)Domestic Use	(2) Comm. & Isti.Use	(1)Domestic Use	(2) Comm. & Isti.Use	(2)/(1)	(2)/(1)	(2)/(1)
Area 1	49,419.0	6,506.0	53,275.0	6,775.0	13.2	12.7	12.9
Area 2	80,686.0	15,229.0	84,534.0	15,598.0	18.9	18.5	18.7
Area 3	191,211.0	47,882.0	193,077.0	43,775.0	25.0	22.7	23.9
Area 4	104,815.0	31,481.0	101,740.0	31,198.0	30.0	30.7	30.3
Area 5	190,272.0	21,440.0	172,461.0	19,252.0	11.3	11.2	11.2
Area 6	26,947.0	8,479.0	23,763.0	8,216.0	31.5	34.6	33.0
Area 7	17,901.0	10,345.0	15,309.0	9,768.0	57.8	63.8	60.8
Area 8	28,789.0	6,087.0	29,236.0	4,952.0	21.1	16.9	19.0
Area 9	16,536.0	63.0	15,296.0	80.0	0.4	0.5	0.5
Area 10	54,276.0	1,003.0	59,199.0	1,202.0	1.8	2.0	1.9
Total	760,852.0	148,515.0	747,890.0	140,816.0	19.5	18.8	19.2

Source : PDAM Badung

Table C.1.3 Land Use Area Ratio by Water Service District

Service District	Land Use Pattern (ha)				Land Use Pattern Ratio to Residential Area (%)		
	Residential	Comm. & Inst.	Tourism	Industry	Comm. & Inst.	Tourism	Industry
Area 1	55.0	8.2	1.6	0.3	14.9	2.9	0.5
Area 2	134.6	24.3	1.9	0.4	18.0	1.4	0.3
Area 3	240.0	52.8	5.4	3.6	22.0	2.2	1.5
Area 4	163.3	50.3	1.1	4.1	30.8	0.7	2.5
Area 5	89.9	17.8	1.3	0.6	19.8	1.5	0.7
Area 6	171.1	47.8	20.1	2.2	27.9	11.7	1.3
Area 7	326.7	92.9	82.9	9.6	28.4	25.4	2.9
Area 8	38.1	7.3	24.8	1.9	19.1	65.2	5.1
Area 9	59.5	2.9	0.0	0.6	4.9	0.0	1.0
Area 10	38.0	1.0	0.0	0.0	2.7	0.0	0.0
Total	1,316.2	305.3	139.1	23.5	23.2	10.6	1.8

Source: JICA, 1992

Table C.1.4 Unit Water Consumption per Hotel Guest

No.	Hotel Class	High			Middle			Low		
		(A)	(B)	(C)	(A)	(B)	(C)	(A)	(B)	(C)
1.	Sampling Date	27-Nov-91	30-Nov-91	9-Dec-91	30-Nov-91	30-Nov-91	5-Dec-91	2-Dec-91	5-Dec-91	11-Dec-91
2.	Number of Room	387	156	401	59	100	90	16	67	14
3.	Number of Guest	545	80	306	41	38	45	7	59	6
4.	Room Occupancy Rate (%)	70	26	38	34	19	25	22	44	21
5.	Water Source	Well	Well&PDAM	Well	Well	PDAM	Well	Well	Well&PDAM	Well
6.	Water Consumption per Day (m3/day)	670	76	350	43	28	37	3	17	7
7.	Unit Water Consumption per Guest per Day (l/guest/day)	1,230	950	1,140	1,050	740	820	430	290	1,170
8.	Average Unit Water Consumption per Guest per Day (l/guest/day)	1,110			870			630		

Source : JICA, 1992

Table C.1.5 Unit Water Consumption per Seat of Restaurant

No.	Class	Large	Middle	Small
1.	Sampling Date	5-Dec-91	11-Dec-91	8-Dec-91
2.	Number of Seats	350	100	20
3.	Number of Guest	300	40	100
4.	Water Source	Well	PDAM	Well
5.	Water Consumption per Day (m3/day)	11.5	0.9	0.46
6.	Unit Water Consumption per Seat (l/seat/day)	33	9	23
7.	Average Unit Water Consumption per Seat (l/seat/day)	22		

Source : JICA, 1992

Table C.1.6 Unit Water Consumption of Factory

No.	Kind of Factory	Canning Factory	Batik Factory	Batik Factory
1.	Sampling Date	29-Nov-91	29-Nov-91	29-Nov-91
2.	Number of Employee	308	30	22
3.	Area of Factory (m2)	18,000	2,800	2,150
4.	Production Amount per Year (Million Rp./Year)	18,000	1,600	1,100
5.	Water Source	Well	Well	Well
6.	Unit Water Consumption per Day (m3/day)	167	3.6	5.7
7.	Water Consumption per Production Amount (m3/million Rp./Year)	0.009	0.002	0.005

Source : JICA, 1992

Table C.1.7 Projection of Industrial Production in the Study Area by Type and Size of Industries

(Unit : Rp. million at 1990 prices)

Type of Industries	Size of Industries	1990	2010	Annual Growth Rate (%)
1. Food, Beverage and Tabacco	Small	5,138	5,138	0.00
	Med./Large	30,719	246,722	10.98
	Sub Total	35,857	251,860	10.24
2. Textile	Small	16,138	54,070	6.23
	Med./Large	10,584	110,418	12.44
	Sub Total	26,722	164,488	9.51
3. Wood and Wood Products	Small	5,259	11,898	4.17
	Med./Large	1,068	15,504	14.31
	Sub Total	6,327	27,402	7.60
4. Paper and Paper Products	Small	69,928	339,992	8.23
	Med./Large	4,852	48,463	12.20
	Sub Total	74,780	388,455	8.59
5. Industrial Chemicals	Small	648	5,797	11.58
	Med./Large	85	760	11.58
	Sub Total	733	6,557	11.58
6. Non-Metallic Mineral Products	Small	1,539	7,657	8.35
	Med./Large	213	213	0.00
	Sub Total	1,752	7,870	7.80
7. Iron & Steel Basic Industries	Small	-	-	-
	Med./Large	-	-	-
	Sub Total	-	-	-
8. Fabricated Mineral Products, Machinery and Equipment	Small	1,734	12,504	10.38
	Med./Large	890	4,830	8.82
	Sub Total	2,624	17,334	9.90
9. Other Industries	Small	2,438	23,344	1196.00
	Med./Large	-	-	-
	Sub Total	2,438	23,344	11.96
Total	Small	102,822	460,400	7.78
	Med./Large	48,411	426,910	11.50
	Sub Total	151,233	887,310	9.25

Source : Badung dalam Angka 1985 - 1990 and JICA, 1992

Table C.2.1 Observed Toilet Waste (Without Treatment)

Observation Item	Unit	Kelurahan/Panjer
Sampling Point		(1)
Date		8-Dec-91
No. of Users		7
Wastewater	l/day	112
Unit Discharge	l/c.d	16
BOD	mg/l	700
Unit Load (BOD)	g/c.d	11.2

Source : JICA, 1992

Table C.2.2 Observed Toilet Waste (With Septic Tank)

Observation Site	Unit	Dauh Puri (High Income)	Sumerta (Middle Income)	Average
Sampling Point		(2)	(3)	
Date		15-Dec-91	8-Dec-91	-
No. of Users		6	5	-
Wastewater	l/day	12	12	-
Unit Discharge	l/c.d	2	2.4	2.2
BOD	mg/l	296	264	277
Unit Load (BOD)	g/c.d	0.59	0.63	0.61

Source : JICA, 1992

Table C.2.3 Observed Gray Water

Income Class	Unit	High			Middle			Low		
Sampling Point		(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Date		8-Dec-91	15-Dec-91	15-Dec-91	28-Dec-91	3-Dec-91	3-Dec-91	3-Dec-91	3-Dec-91	3-Dec-91
No. of Users		7	8	7	12	6	6	11	7	5
Wastewater Generation	l/day	1,715	1,745	2,384	1,910	1,100	990	1,350	1,040	785
Unit Wastewater Generation	l/c.d	245	218	341	159	183	165	123	149	127
Wastewater Quality (BOD)	mg/l	128	140	106	158	103	106	149	98	110
Unit Pollution Load Generation (BOD)	g/c.d	31.4	30.5	36.1	25.1	18.9	17.5	18.3	14.6	14.0
Average Unit Wastewater Generation	l/c.d	268			169			133		
Average Unit Pollution Load Generation (BOD)	g/c.d	32.7			20.5			15.6		

Source : JICA, 1992

Table C.2.4 Estimated Unit Pollution Load Generation of Domestic Waste

Income Class	Unit	Existing (1990)				Future (2010)			
		High	Middle	Low	Average	High	Middle	Low	Average
Gray Water									
- Unit Wastewater Generation	l/c.d	268	169	133	156	268	169	133	178
- Wastewater Quality (BOD)	mg/l	122	121	117	120	122	121	117	121
- Unit Pollution Load Generation (BOD)	g/c.d	32.7	20.5	15.6	18.6	32.7	20.5	15.6	21.4
Toilet Wastewater									
- Unit Wastewater Generation	l/c.d	30	16	16	16	30	16	16	19
- Wastewater Quality (BOD)	mg/l	373	700	700	700	373	700	700	589
- Unit Pollution Load Generation (BOD)	g/c.d	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.2
Total									
- Unit Wastewater Generation	l/c.d	298	185	149	172	298	185	149	196
- Wastewater Quality (BOD)	mg/l	147	171	180	173	147	171	180	166
- Unit Pollution Load Generation (BOD)	g/c.d	43.9	31.7	26.8	29.8	43.9	31.7	26.8	32.6

Note : Average is obtained by assuming the following population share by class

		Existing	Future
High Class	:	3.2%	18.8%
Middle Class	:	51.0%	53.7%
Low Class	:	45.8%	27.5%

Table C.2.5 Observed Quality of Commercial and Institutional Wastewater

Sampling Point		Date	Wastewater Quality (BOD mg/l)	Wastewater
Shop	(13)	10-Dec-91	282	Septic Tank Effluent
	(14)	10-Dec-91	189	Septic Tank Effluent and Washing & Bathing
	Average		236	
Office	(15)	10-Dec-91	176	Septic Tank Effluent and Washing
Grand Average			216	

Source : JICA, 1992

Table C.2.6 Observed Wastewater Quality of Hotels

No.	Hotel Class	High			Middle & Low					
1.	Sampling Point	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
2.	Sampling Date	27-Nov-91	30-Nov-91	9-Dec-91	30-Nov-91	30-Nov-91	5-Dec-91	2-Dec-91	5-Dec-91	11-Dec-91
3.	Water Consumption per Day (m3/day)	670	76	350	43	28	37	3	17	7
4.	Wastewater Quality (BOD : mg/l)	36.7	43.9	36.8	39.1	21.2	36.7	61.9	71.7	39.5
5.	Pollution Load (BOD kg/day)	24.59	3.34	12.88	1.68	0.59	1.36	0.19	1.22	0.28
6.	Average Wastewater Quality (BOD : mg/l)	37.2			39.4					

Source : JICA, 1992

Table C.2.7 Estimated Unit Pollution Load Generation of Hotel Waste

Income Class	Unit	Existing (1990)			Future (2010)		
		High	Middle & Low	Average	High	Middle & Low	Average
Gray Water							
- Unit Wastewater Generation	l/room/day	2,040	1,468	1,787	2,040	1,468	1,856
- Wastewater Quality (BOD)	mg/l	37.2	39.4	38.2	37.2	39.4	37.9
- Unit Pollution Load Generation (BOD)	g/room/day	75.9	57.8	68.3	75.9	57.8	70.3
Toilet Wastewater							
- Unit Wastewater Generation	l/room/day	60	32	48	60	32	50
- Wastewater Quality (BOD)	mg/l	373	700	467	373	700	448
- Unit Pollution Load Generation (BOD)	g/room/day	22.4	22.4	22.4	22.4	22.4	22.4
Total							
- Unit Wastewater Generation	l/room/day	2,100	1,500	1,835	2,100	1,500	1,906
- Wastewater Quality (BOD)	mg/l	46.8	53.5	49.4	46.8	53.5	48.6
- Unit Pollution Load Generation (BOD)	g/room/day	98.3	80.2	90.7	98.3	80.2	92.7

Note : Average is obtained by assuming the following hotel share by class

		Existing	Future
High Class	:	55.8%	67.8%
Middle & Low Class	:	44.2%	32.2%

Table C.2.8 Observed Wastewater Quality of Restaurants

No.	Class	Large	Middle	Small
1.	Sampling Point	(25)	(26)	(27)
2.	Sampling Date	5-Dec-91	11-Dec-91	8-Dec-91
3.	Number of Seats	350	100	20
4.	Water Consumption per Day (m3/day)	11.5	0.9	0.46
5.	Unit Water Consumption per Seat (l/seat/day)	33	9	23
6.	Average Unit Water Consumption per Seat (l/seat/day)	22		
7.	Wastewater Quality (BOD : mg/l)	215	444	252
8.	Unit Pollution Load Generation (BOD : g/seat/day)	7.1	4.0	5.8
9.	Average Unit Pollution Load Generation (BOD : g/seat/day)	5.6		

Source : JICA, 1992

Table C.2.9 Estimated Unit Pollution Load Generation of Industrial Waste

Industrial Classification	Unit Wastewater Generation (m3/d/million Rp./yr.)	Wastewater Quality (BOD5, mg/l)	Unit Pollution Load Generation (g/d/million Rp./yr.)
Food, Beverage and Tobacco	0.010	1,800	18.00
Textile	0.002	190	0.38
Wood and Wood Products	0.003	140	0.42
Paper and Paper Products	0.003	960	2.88
Industrial Chemicals	0.010	760	7.60
Non-metallic Mineral Produc	0.027	280	7.56
Iron & Steel Basic Industries	0.027	280	7.56
Fabricated Mineral Products, Machinery and Equipment	0.027	280	7.56
Other Industries	0.010	110	1.10

Source : JICA (Jakarta Wastewater Disposal Project, 1991)

Table C.2.10 Observed Industrial Wastewater

No.	Kind of Factory	Canning Factory	Batik Factory	Batik Factory
1.	Sampling Point	(28)	(29)	(30)
2.	Sampling Date	29-Nov-91	29-Nov-91	29-Nov-91
3.	Production Amount per Year (Million Rp./Year)	18,000	1,600	1,100
4.	Unit Water Consumption per Day (m3/day)	11.7	3.6	5.7
5.	Water Consumption per Production Amount (m3/d/million Rp./Year)	0.009	0.002	0.005
6.	Wastewater Quality (BOD : mg/l)	1,560	156	81
7.	Pollution Load Generation (BOD : kg/d)	261	0.56	0.46
8.	Unit Pollution Load Generation (BOD : g/d/million Rp./Year)	14.5	0.35	0.42

Table C.3.1 (1) Existing Wastewater Generation by Kelurahan/Desa in 1990

Code Number	Name of Kelurahan/Desa & Kecamatan	Area (ha)	Wastewater (m3/day)						Specific Waste (m3/d/ha)
			Domestic	Com. & Ins.	Hotel	Restaurant	Industry	Total	
101	Dauh Puri	60	1,964.6	1,109.2	164.1	20.0	16.1	3,274.0	54.57
102	Dauh Puri Kaja	109	1,882.9	1,356.2	24.2	0.0	0.0	3,263.3	29.94
103	Dauh Puri Kauh	190	2,313.4	130.2	0.0	16.7	20.2	2,480.5	13.06
104	Dauh Puri Kangin	59	956.0	319.3	46.9	9.1	0.0	1,331.3	22.56
105	Dauh Puri Kelod	188	2,685.9	1,239.1	203.4	8.8	22.2	4,159.4	22.12
106	Pemecutan	194	3,448.9	822.8	149.4	18.0	22.2	4,461.3	23.00
107	Pemecutan Kaja	385	3,618.2	644.6	42.3	22.9	32.3	4,360.3	11.33
108	Pemecutan Kelod	450	3,073.3	206.8	0.0	0.0	92.8	3,372.9	7.50
109	Peguyangan	644	1,159.1	0.0	0.0	0.0	2.0	1,161.1	1.80
110	Peguyangan Kaja	536	476.4	8.4	0.0	0.0	4.0	488.8	0.91
111	Peguyangan Kangin	416	750.8	0.0	0.0	0.0	4.0	754.8	1.81
112	Padang Sambian	401	1,407.2	5.1	0.0	0.0	34.3	1,446.6	3.61
113	Padang Sambian Kaja	409	768.7	70.9	0.0	0.0	30.3	869.9	2.13
114	Padang Sambian Kelod	412	1,143.2	37.3	0.0	0.0	22.2	1,202.7	2.92
115	Ubung	103	1,103.4	385.6	30.2	3.7	38.3	1,561.2	15.16
116	Ubung Kaja	400	1,189.1	258.0	0.0	1.1	14.1	1,462.3	3.66
117	Tegal Kerta	24	1,123.0	0.0	7.6	0.0	0.0	1,130.6	47.11
118	Tegal Harum	26	1,058.7	0.0	34.8	0.9	0.0	1,094.4	42.09
100	DENPASAR BARAT	5,006	30,122.8	6,593.5	702.9	101.2	355.0	37,875.4	7.57
201	Dangin Puri	65	1,788.6	707.6	92.2	0.0	0.0	2,588.4	39.82
202	Dangin Puri Kauh	72	832.6	139.8	69.1	5.3	0.0	1,046.8	14.54
203	Dangin Puri Kaja	142	2,087.2	50.7	130.0	0.0	5.4	2,273.3	16.01
204	Dangin Puri Kangin	75	1,983.8	1,118.1	49.9	1.1	21.5	3,174.4	42.33
205	Dangin Puri Kelod	142	2,280.0	1,316.7	26.5	0.7	0.0	3,623.9	25.52
206	Sumerta	52	1,278.6	197.6	0.0	2.5	13.5	1,492.2	28.70
207	Sumerta Kauh	89	1,279.1	130.4	0.0	1.1	0.0	1,410.6	15.85
208	Sumerta Kaja	73	1,253.2	63.0	36.3	2.3	8.1	1,362.9	18.67
209	Sumerta Kelod	271	1,596.4	1,089.9	0.0	0.0	13.5	2,699.8	9.96
210	Kesiman	266	1,106.5	107.7	0.0	6.6	5.4	1,226.2	4.61
211	Kesiman Petilan	290	1,054.7	33.2	0.0	0.0	10.8	1,098.7	3.79
212	Kesiman Kertalangu	405	1,671.9	195.8	0.0	0.0	115.7	1,983.4	4.90
213	Tonja	230	1,504.4	5.5	0.0	0.0	0.0	1,509.9	6.56
214	Penatih	281	771.3	63.7	0.0	0.0	8.1	843.1	3.00
215	Penatih Dangin Puri	320	411.7	9.2	0.0	0.0	2.7	423.6	1.32
200	DENPASAR TIMUR	2,773	20,900.0	5,228.9	404.0	19.6	204.7	26,757.2	9.65

Source : JICA, 1992

Table C.3.1 (2) Existing Wastewater Generation by Kelurahan/Desa in 1990

Code Number	Name of Kelurahan/Desa & Kecamatan	Area (ha)	Wastewater (m3/day)						Specific Waste (m3/d/ha)
			Domestic	Com. & Ins.	Hotel	Restaurant	Industry	Total	
301	Sanur Kaja	269	1,152.1	46.5	704.9	25.0	6.4	1,934.9	7.19
302	Sanur	402	1,878.7	443.7	1,992.5	85.8	38.3	4,439.0	11.04
303	Sanur Kauh	386	1,132.8	158.9	55.9	0.0	8.2	1,355.8	3.51
304	Renon	254	1,045.8	93.0	23.4	1.1	3.6	1,166.9	4.59
305	Panjer	359	2,438.2	42.6	0.0	0.0	1.8	2,482.6	6.92
306	Sesetan	739	3,503.9	566.8	0.0	2.0	9.1	4,081.8	5.52
307	Sidakarya	389	1,206.1	205.3	0.0	0.0	0.0	1,411.4	3.63
308	Pedungan	749	1,781.9	501.0	0.0	0.0	56.5	2,339.4	3.12
309	Pemogan	971	1,438.5	207.2	0.0	0.0	41.9	1,687.6	1.74
310	Serangan	101	387.0	95.6	0.0	0.0	0.0	482.6	4.78
300	DENPASAR SELATAN	4,619	15,965.0	2,360.6	2,776.7	113.9	165.8	21,382.0	4.63
401	Dalung	615	911.6	85.9	0.0	0.0	0.0	997.5	1.62
402	Canggu	1,173	1,372.0	205.1	164.0	0.0	8.5	1,749.6	1.49
403	Kerobokan	1,598	2,553.2	99.9	393.1	0.0	26.0	3,072.2	1.92
404	Kuta	1,293	3,027.4	1,425.7	7,693.2	148.0	42.3	12,336.6	9.54
405	Tuban	459	2,579.4	307.3	420.5	3.7	2.9	3,313.8	7.22
406	Jimbaran	3,050	1,978.0	427.2	185.3	0.0	0.0	2,590.5	0.85
407	Benoa	3,067	2,749.5	212.4	3,698.1	18.0	0.0	6,678.0	2.18
400	KUTA	11,255	15,171.1	2,763.5	12,554.2	169.7	79.7	30,738.2	2.73
Total		23,653	82,158.9	16,946.5	16,437.8	404.4	805.2	116,752.8	4.94

Source : JICA, 1992

Table C.3.2 (1) Existing Pollution Load Generation by Kelurahan/Desa in 1990

Code Number	Name of Kelurahan/Desa & Kecamatan	Area (ha)	Pollution Load (kg/day)						Specific Poll. (kg/d/ha)
			Domestic	Com. & Ins.	Hotel	Restaurant	Industry	Total	
101	Dauh Puri	60	336.0	239.6	8.8	5.1	18.1	607.6	10.13
102	Dauh Puri Kaja	109	321.7	292.9	1.3	0.0	0.0	615.9	5.65
103	Dauh Puri Kauh	190	398.1	28.1	0.0	4.2	22.6	453.0	2.38
104	Dauh Puri Kangin	59	163.7	69.0	2.5	2.3	0.0	237.5	4.03
105	Dauh Puri Kelod	188	459.2	267.6	10.9	2.2	24.9	764.8	4.07
106	Pemecutan	194	596.3	177.7	7.7	4.6	24.9	811.2	4.18
107	Pemecutan Kaja	385	630.0	139.2	2.3	5.8	36.2	813.5	2.11
108	Pemecutan Kelod	450	532.4	44.7	0.0	0.0	104.0	681.1	1.51
109	Peguyangan	644	201.8	0.0	0.0	0.0	2.3	204.1	0.32
110	Peguyangan Kaja	536	82.8	1.8	0.0	0.0	4.5	89.1	0.17
111	Peguyangan Kangin	416	132.7	0.0	0.0	0.0	4.5	137.2	0.33
112	Padang Sambian	401	246.5	1.1	0.0	0.0	38.4	286.0	0.71
113	Padang Sambian Kaja	409	134.4	15.3	0.0	0.0	33.9	183.6	0.45
114	Padang Sambian Kelod	412	200.5	8.1	0.0	0.0	24.9	233.5	0.57
115	Ubung	103	195.2	83.3	1.6	1.0	43.0	324.1	3.15
116	Ubung Kaja	400	209.4	55.7	0.0	0.3	15.8	281.2	0.70
117	Tegal Kerta	24	194.3	0.0	0.4	0.0	0.0	194.7	8.11
118	Tegal Harum	26	180.5	0.0	1.9	0.2	0.0	182.6	7.02
100	**DENPASAR BARAT**	5,006	5,215.5	1,424.1	37.4	25.7	398.0	7,100.7	1.42
201	Dangin Puri	65	304.8	152.8	4.9	0.0	0.0	462.5	7.12
202	Dangin Puri Kauh	72	141.8	30.2	3.2	1.3	0.0	176.5	2.45
203	Dangin Puri Kaja	142	354.2	11.0	7.0	0.0	6.2	378.4	2.66
204	Dangin Puri Kangin	75	337.8	241.5	2.7	0.3	24.6	606.9	8.09
205	Dangin Puri Kelod	142	386.4	284.4	1.4	0.2	0.0	672.4	4.74
206	Sumerta	52	221.7	42.7	0.0	0.6	15.4	280.4	5.39
207	Sumerta Kauh	89	218.9	28.2	0.0	0.3	0.0	247.4	2.78
208	Sumerta Kaja	73	218.3	13.6	1.9	0.6	9.2	243.6	3.34
209	Sumerta Kelod	271	276.2	235.4	0.0	0.0	15.4	527.0	1.94
210	Kesiman	266	193.1	23.3	0.0	1.7	6.2	224.3	0.84
211	Kesiman Petilan	290	184.2	7.2	0.0	0.0	12.3	203.7	0.70
212	Kesiman Kertalangu	405	293.2	42.3	0.0	0.0	132.3	467.8	1.16
213	Tonja	230	265.0	1.2	0.0	0.0	0.0	266.2	1.16
214	Penatih	281	136.0	13.8	0.0	0.0	9.2	159.0	0.57
215	Penatih Dangin Puri	320	72.8	2.0	0.0	0.0	3.1	77.9	0.24
200	**DENPASAR TIMUR**	2,773	3,604.4	1,129.6	21.1	5.0	233.9	4,994.0	1.80

Source : JICA, 1992

Table C.3.2 (2) Existing Pollution Load Generation by Kelurahan/Desa in 1990

Code Number	Name of Kelurahan/Desa & Kecamatan	Area (ha)	Pollution Load (kg/day)						Specific Poll. (kg/d/ha)
			Domestic	Com. & Ins.	Hotel	Restaurant	Industry	Total	
301	Sanur Kaja	269	199.4	10.0	33.7	6.4	7.5	257.0	0.96
302	Sanur	402	325.8	95.8	96.6	21.8	45.0	585.0	1.46
303	Sanur Kauh	386	197.0	34.3	3.0	0.0	9.6	243.9	0.63
304	Renon	254	184.5	20.1	1.3	0.3	4.3	210.5	0.83
305	Panjer	359	428.3	9.2	0.0	0.0	2.1	439.6	1.22
306	Sesetan	739	610.8	122.4	0.0	0.5	10.7	744.4	1.01
307	Sidakarya	389	210.5	44.3	0.0	0.0	0.0	254.8	0.66
308	Pedungan	749	312.5	108.2	0.0	0.0	66.4	487.1	0.65
309	Pemogan	971	253.4	44.7	0.0	0.0	49.3	347.4	0.36
310	Serangan	101	69.2	20.7	0.0	0.0	0.0	89.9	0.89
300	DENPASAR SELATAN	4,619	2,791.4	509.7	134.6	29.0	194.9	3,659.6	0.79
401	Dalung	615	159.7	18.6	0.0	0.0	0.0	178.3	0.29
402	Canggu	1,173	240.7	44.3	7.7	0.0	9.3	302.0	0.26
403	Kerobokan	1,598	445.8	21.6	18.5	0.0	28.7	514.6	0.32
404	Kuta	1,293	522.8	308.0	386.7	37.7	46.7	1,301.9	1.01
405	Tuban	459	444.3	66.4	20.3	1.0	3.2	535.2	1.17
406	Jimbaran	3,050	346.7	92.3	8.7	0.0	0.0	447.7	0.15
407	Benoa	3,067	475.9	45.9	173.8	4.6	0.0	700.2	0.23
400	KUTA	11,255	2,635.9	597.1	615.7	43.3	87.9	3,979.9	0.35
Total		23,653	14,247.2	3,660.5	808.8	103.0	914.7	19,734.2	0.83

Source : JICA, 1992

Table C.3.3 (1) Future Wastewater Generation by Kelurahan/Desa in 2010

Code Number	Name of Kelurahan/Desa & Kecamatan	Area (ha)	Wastewater (m3/day)						Specific Waste (m3/d/ha)
			Domestic	Com. & Ins.	Hotel	Restaurant	Industry	Total	
101	Dauh Puri	60	2,229.6	1,256.2	235.2	20.7	100.7	3,842.4	64.04
102	Dauh Puri Kaja	109	3,159.0	2,267.8	96.3	0.3	0.0	5,523.4	50.67
103	Dauh Puri Kauh	190	5,083.0	285.7	43.6	16.8	125.9	5,555.0	29.24
104	Dauh Puri Kangin	59	1,597.2	533.0	121.7	9.4	0.0	2,261.3	38.33
105	Dauh Puri Kelod	188	5,584.2	2,572.4	426.9	10.1	138.4	8,732.0	46.45
106	Pemecutan	194	5,845.7	1,399.8	203.9	18.2	138.4	7,606.0	39.21
107	Pemecutan Kaja	385	5,023.3	900.4	56.8	22.9	201.4	6,204.8	16.12
108	Pemecutan Kelod	450	5,202.9	351.1	113.6	0.3	578.9	6,246.8	13.88
109	Peguyangan	644	1,974.6	0.0	0.0	0.0	12.6	1,987.2	3.09
110	Peguyangan Kaja	536	803.9	14.2	0.0	0.0	25.2	843.3	1.57
111	Peguyangan Kangin	416	1,294.6	0.0	0.0	0.0	25.2	1,319.8	3.17
112	Padang Sambian	401	4,795.7	17.6	0.0	0.0	213.9	5,027.2	12.54
113	Padang Sambian Kaja	409	1,308.6	121.4	278.9	0.8	188.8	1,898.5	4.64
114	Padang Sambian Kelod	412	1,466.3	48.2	0.0	0.0	138.4	1,652.9	4.01
115	Ubung	103	1,678.9	594.7	40.6	3.7	239.1	2,557.0	24.83
116	Ubung Kaja	400	1,393.6	306.5	0.0	1.1	88.1	1,789.3	4.47
117	Tegal Kerta	24	1,324.9	134.2	10.1	0.0	0.0	1,469.2	61.22
118	Tegal Harum	26	1,281.6	22.8	46.6	0.9	0.0	1,351.9	52.00
100	DENPASAR BARAT	5,006	51,047.6	10,826.0	1,674.2	105.2	2,215.0	65,868.0	13.16
201	Dangin Puri	65	2,425.1	958.3	123.7	0.0	0.0	3,507.1	53.96
202	Dangin Puri Kauh	72	1,956.9	328.0	176.7	5.5	0.0	2,467.1	34.27
203	Dangin Puri Kaja	142	4,003.7	96.9	174.4	0.2	34.1	4,309.3	30.35
204	Dangin Puri Kangin	75	2,804.1	1,578.4	148.0	1.5	136.4	4,668.4	62.25
205	Dangin Puri Kelod	142	3,799.2	2,183.9	35.5	0.7	0.0	6,019.3	42.39
206	Sumerta	52	1,827.7	283.7	0.0	2.5	85.2	2,199.1	42.29
207	Sumerta Kauh	89	2,487.4	253.8	0.0	1.1	0.0	2,742.3	30.81
208	Sumerta Kaja	73	2,136.5	108.3	60.8	2.5	51.1	2,359.2	32.32
209	Sumerta Kelod	271	2,709.2	1,857.0	52.7	0.2	85.2	4,704.3	17.36
210	Kesiman	266	1,876.4	183.7	0.0	6.6	34.1	2,100.8	7.90
211	Kesiman Petilan	290	1,792.9	56.8	566.8	1.7	68.2	2,486.4	8.57
212	Kesiman Kertalangu	405	2,856.4	337.1	1,586.9	4.6	732.9	5,517.9	13.62
213	Tonja	230	2,590.9	9.6	0.0	0.0	0.0	2,600.5	11.31
214	Penatih	281	989.8	82.6	0.0	0.0	51.1	1,123.5	4.00
215	Penatih Dangin Puri	320	1,036.0	23.4	0.0	0.0	17.0	1,076.4	3.36
200	DENPASAR TIMUR	2,773	35,292.2	8,341.5	2,925.5	27.1	1,295.3	47,881.6	17.27

Source :JICA, 1992

Table C.3.3 (2) Future Wastewater Generation by Kelurahan/Desa in 2010

Code Number	Name of Kelurahan/Desa & Kecamatan	Area (ha)	Wastewater (m3/day)						Specific Waste (m3/d/ha)
			Domestic	Com. & Ins	Hotel	Restaurant	Industry	Total	
301	Sanur Kaja	269	1,944.5	78.9	3,254.4	38.2	41.3	5,357.3	19.92
302	Sanur	402	3,710.9	882.0	5,715.2	106.7	247.6	10,662.4	26.52
303	Sanur Kauh	386	1,401.0	197.7	1,047.0	7.8	53.1	2,706.6	7.01
304	Renon	254	1,790.8	161.0	156.2	1.1	23.6	2,132.7	8.40
305	Panjer	359	4,183.4	73.7	0.0	0.0	11.8	4,268.9	11.89
306	Sesetan	739	5,960.8	970.1	0.0	2.7	59.0	6,992.6	9.46
307	Sidakarya	389	1,404.0	240.7	0.0	0.0	0.0	1,644.7	4.23
308	Pedungan	749	3,046.4	865.2	0.0	0.0	365.5	4,277.1	5.71
309	Pemogan	971	3,105.3	452.3	0.0	0.0	271.2	3,828.8	3.94
310	Serangan	101	677.8	170.7	0.0	2.8	0.0	851.3	8.43
300	**DENPASAR SELATAN**	4,619	27,224.9	4,092.3	10,172.8	159.3	1,073.1	42,722.4	9.25
401	Dalung	615	1,558.7	148.2	0.0	0.0	0.0	1,706.9	2.78
402	Canggu	1,173	2,348.8	354.4	2,150.2	35.2	52.2	4,940.8	4.21
403	Kerobokan	1,598	4,352.3	171.2	1,896.2	25.2	160.2	6,605.1	4.13
404	Kuta	1,293	5,118.8	2,423.0	13,995.5	216.4	260.9	22,014.6	17.03
405	Tuban	459	4,344.6	519.6	890.4	9.1	18.0	5,781.7	12.60
406	Jimbaran	3,050	3,373.9	735.7	4,075.3	61.6	0.0	8,246.5	2.70
407	Benoa	3,067	4,655.7	361.2	16,203.1	208.6	0.0	21,428.6	6.99
400	**KUTA**	11,255	25,752.8	4,713.3	39,210.7	556.1	491.3	70,724.2	6.28
Total		23,653	139,317.5	27,973.1	53,983.2	847.7	5,074.7	227,196.2	9.61

Source :JICA, 1992

Table C.3.4 (1) Future Pollution Load Generation by Kelurahan/Desa in 2010

Code Number	Name of Kelurahan/Desa & Kecamatan	Area (ha)	Pollution Load (kg/day)						Specific Poll. (kg/d/ha)
			Domestic	Com. & Ins.	Hotel	Restaurant	Industry	Total	
101	Dauh Puri	60	366.0	271.3	12.6	5.3	117.1	772.3	12.87
102	Dauh Puri Kaja	109	517.9	489.8	5.2	0.1	0.0	1,013.0	9.29
103	Dauh Puri Kauh	190	838.3	61.7	2.3	4.3	146.3	1,052.9	5.54
104	Dauh Puri Kangin	59	262.7	115.1	6.5	2.4	0.0	386.7	6.55
105	Dauh Puri Kelod	188	916.9	555.6	22.8	2.6	161.0	1,658.9	8.82
106	Pemecutan	194	969.4	302.4	10.5	4.6	161.0	1,447.9	7.46
107	Pemecutan Kaja	385	838.0	194.5	3.0	5.8	234.1	1,275.4	3.31
108	Pemecutan Kelod	450	863.7	75.8	6.1	0.1	673.1	1,618.8	3.60
109	Peguyangan	644	329.5	0.0	0.0	0.0	14.6	344.1	0.53
110	Peguyangan Kaja	536	133.8	3.1	0.0	0.0	29.3	166.2	0.31
111	Peguyangan Kangin	416	218.7	0.0	0.0	0.0	29.3	248.0	0.60
112	Padang Sambian	401	804.7	3.8	0.0	0.0	248.7	1,057.2	2.64
113	Padang Sambian Kaja	409	218.9	26.2	14.9	0.2	219.5	479.7	1.17
114	Padang Sambian Kelod	412	245.9	10.4	0.0	0.0	161.0	417.3	1.01
115	Ubung	103	283.9	128.5	2.2	1.0	278.0	693.6	6.73
116	Ubung Kaja	400	235.0	66.2	0.0	0.3	102.4	403.9	1.01
117	Tegal Kerta	24	219.8	29.0	0.5	0.0	0.0	249.3	10.39
118	Tegal Harum	26	210.2	4.9	2.5	0.2	0.0	217.8	8.38
100	**DENPASAR BARAT**	5,006	8,473.3	2,338.3	89.1	26.9	2,575.4	13,503.0	2.70
201	Dangin Puri	65	397.3	207.0	6.6	0.0	0.0	610.9	9.40
202	Dangin Puri Kauh	72	320.3	70.8	8.8	1.4	0.0	401.3	5.57
203	Dangin Puri Kaja	142	653.4	20.9	9.3	0.1	40.5	724.2	5.10
204	Dangin Puri Kangin	75	459.2	340.9	7.9	0.4	162.2	970.6	12.94
205	Dangin Puri Kelod	142	619.1	471.7	1.9	0.2	0.0	1,092.9	7.70
206	Sumerta	52	303.8	61.3	0.0	0.6	101.4	467.1	8.98
207	Sumerta Kauh	89	409.3	54.8	0.0	0.3	0.0	464.4	5.22
208	Sumerta Kaja	73	356.9	23.4	3.3	0.6	60.8	445.0	6.10
209	Sumerta Kelod	271	449.5	401.1	2.8	0.0	101.4	954.8	3.52
210	Kesiman	266	313.4	39.7	0.0	1.7	40.5	395.3	1.49
211	Kesiman Petilan	290	299.7	12.3	30.3	0.4	81.1	423.8	1.46
212	Kesiman Kertalangu	405	479.1	72.8	84.8	1.2	871.7	1,509.6	3.73
213	Tonja	230	436.2	2.1	0.0	0.0	0.0	438.3	1.91
214	Penatih	281	166.9	17.8	0.0	0.0	60.8	245.5	0.87
215	Penatih Dangin Puri	320	175.1	5.1	0.0	0.0	20.3	200.5	0.63
200	**DENPASAR TIMUR**	2,773	5,839.2	1,801.7	155.7	6.9	1,540.7	9,344.2	3.37

Source : JICA, 1992

Table C.3.4 (2) Future Pollution Load Generation by Kelurahan/Desa in 2010

Code Number	Name of Kelurahan/Desa & Kecamatan	Area (ha)	Pollution Load (kg/day)						Specific Poll. (kg/d/ha)
			Domestic	Com. & Ins.	Hotel	Restaurant	Industry	Total	
301	Sanur Kaja	269	323.1	17.0	155.5	9.7	50.6	555.9	2.07
302	Sanur	402	617.5	190.5	276.7	27.2	303.3	1,415.2	3.52
303	Sanur Kauh	386	233.5	42.7	50.0	2.0	65.0	393.2	1.02
304	Renon	254	302.0	34.8	8.3	0.3	28.9	374.3	1.47
305	Panjer	359	702.7	15.9	0.0	0.0	14.4	733.0	2.04
306	Sesetan	739	995.2	209.5	0.0	0.7	72.2	1,277.6	1.73
307	Sidakarya	389	234.7	52.0	0.0	0.0	0.0	286.7	0.74
308	Pedungan	749	511.5	186.9	0.0	0.0	447.8	1,146.2	1.53
309	Pemogan	971	523.1	97.7	0.0	0.0	332.2	953.0	0.98
310	Serangan	101	115.7	36.9	0.0	0.7	0.0	153.3	1.52
300	DENPASAR SELATAN	4,619	4,559.0	883.9	490.5	40.6	1,314.4	7,288.4	1.58
401	Dalung	615	261.4	32.0	0.0	0.0	0.0	293.4	0.48
402	Canggu	1,173	394.3	76.6	101.4	9.0	59.7	641.0	0.55
403	Kerobokan	1,598	727.1	37.0	89.2	6.4	183.2	1,042.9	0.65
404	Kuta	1,293	848.9	523.4	702.1	55.1	298.5	2,428.0	1.88
405	Tuban	459	719.0	112.2	43.0	2.3	20.6	897.1	1.95
406	Jimbaran	3,050	566.2	158.9	190.8	15.7	0.0	931.6	0.31
407	Benoa	3,067	773.0	78.0	761.3	53.1	0.0	1,665.4	0.54
400	KUTA	11,255	4,289.9	1,018.1	1,887.8	141.6	562.0	7,899.4	0.70
Total		23,653	23,161.4	6,042.0	2,623.1	216.0	5,992.5	38,035.0	1.61

Source : JICA, 1992

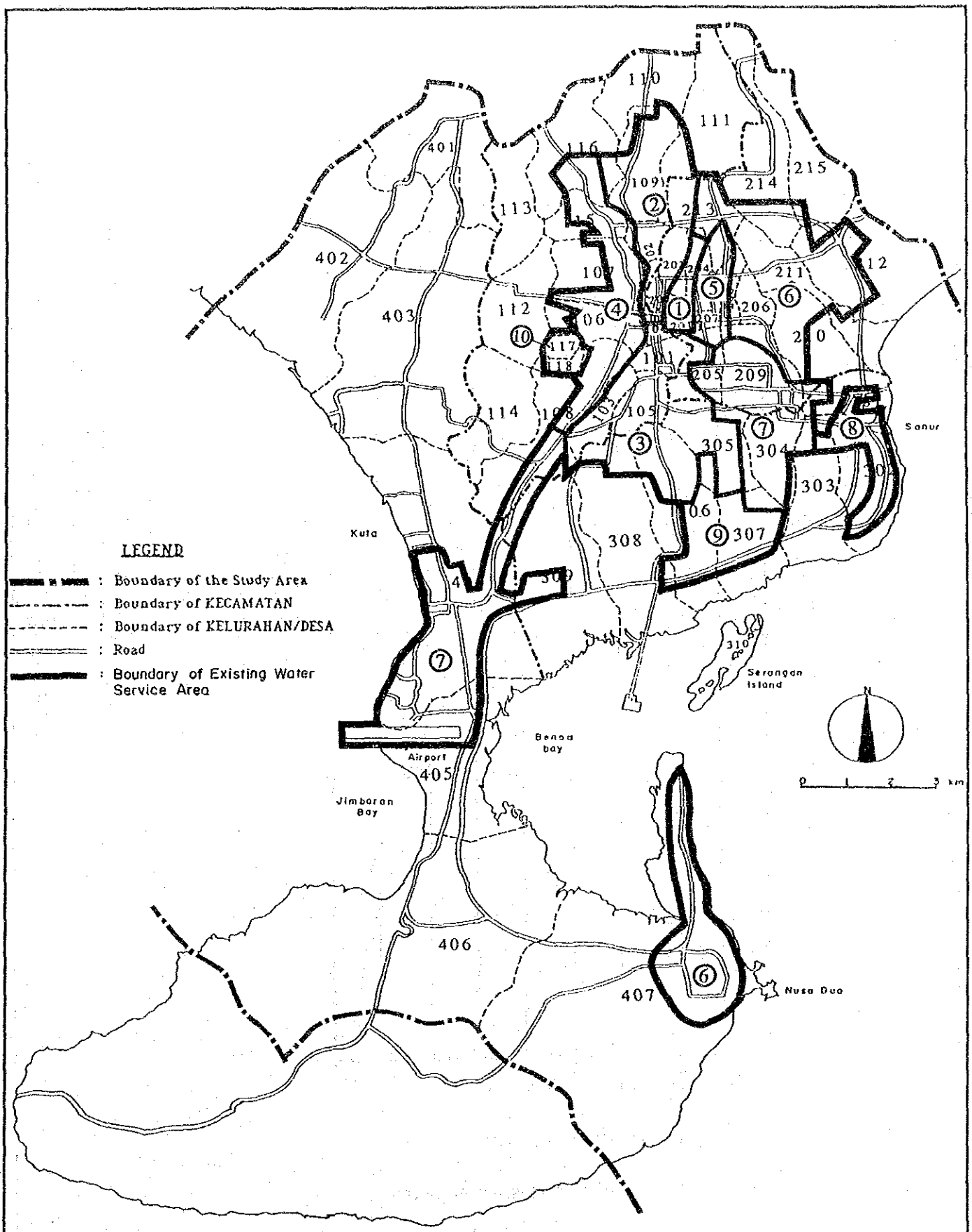

FIG. C.1.1 WATER SERVICE AREA OF PDAM

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

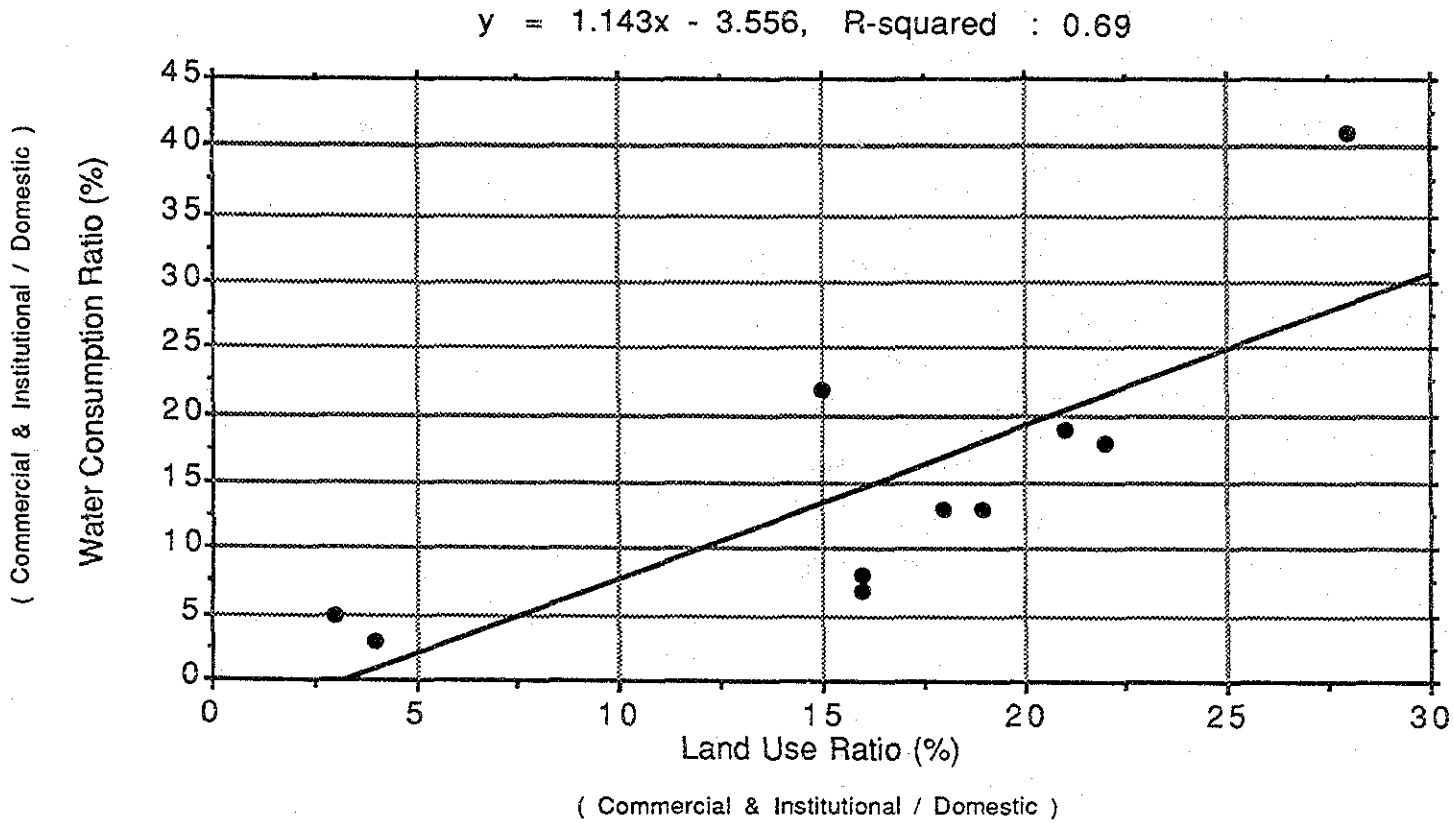

FIG. C.1.2 RELATION BETWEEN WATER CONSUMPTION AND LAND USE RATIOS

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

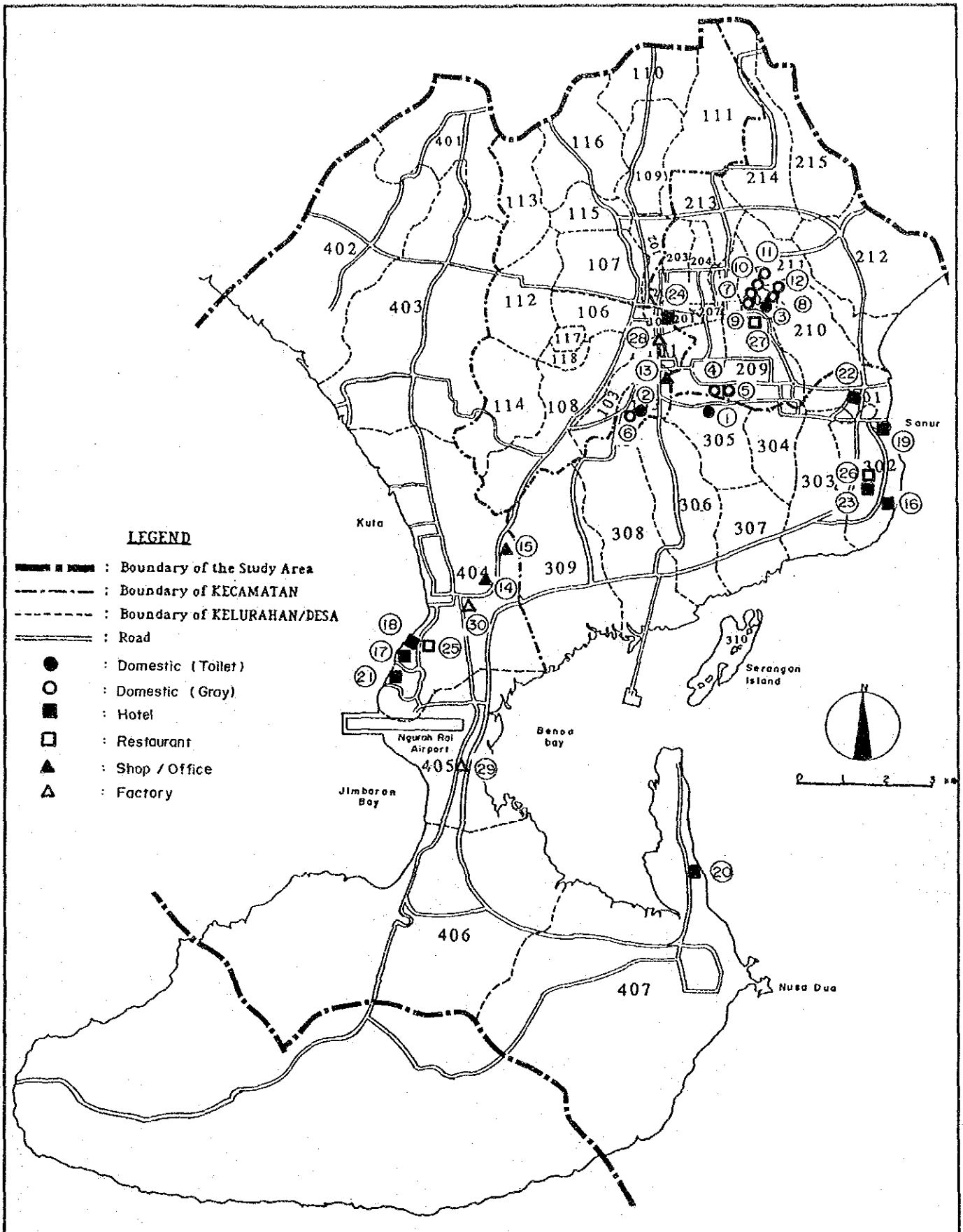

FIG. C.2.1 SAMPLING LOCATION OF UNIT POLLUTION LOAD GENERATION

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

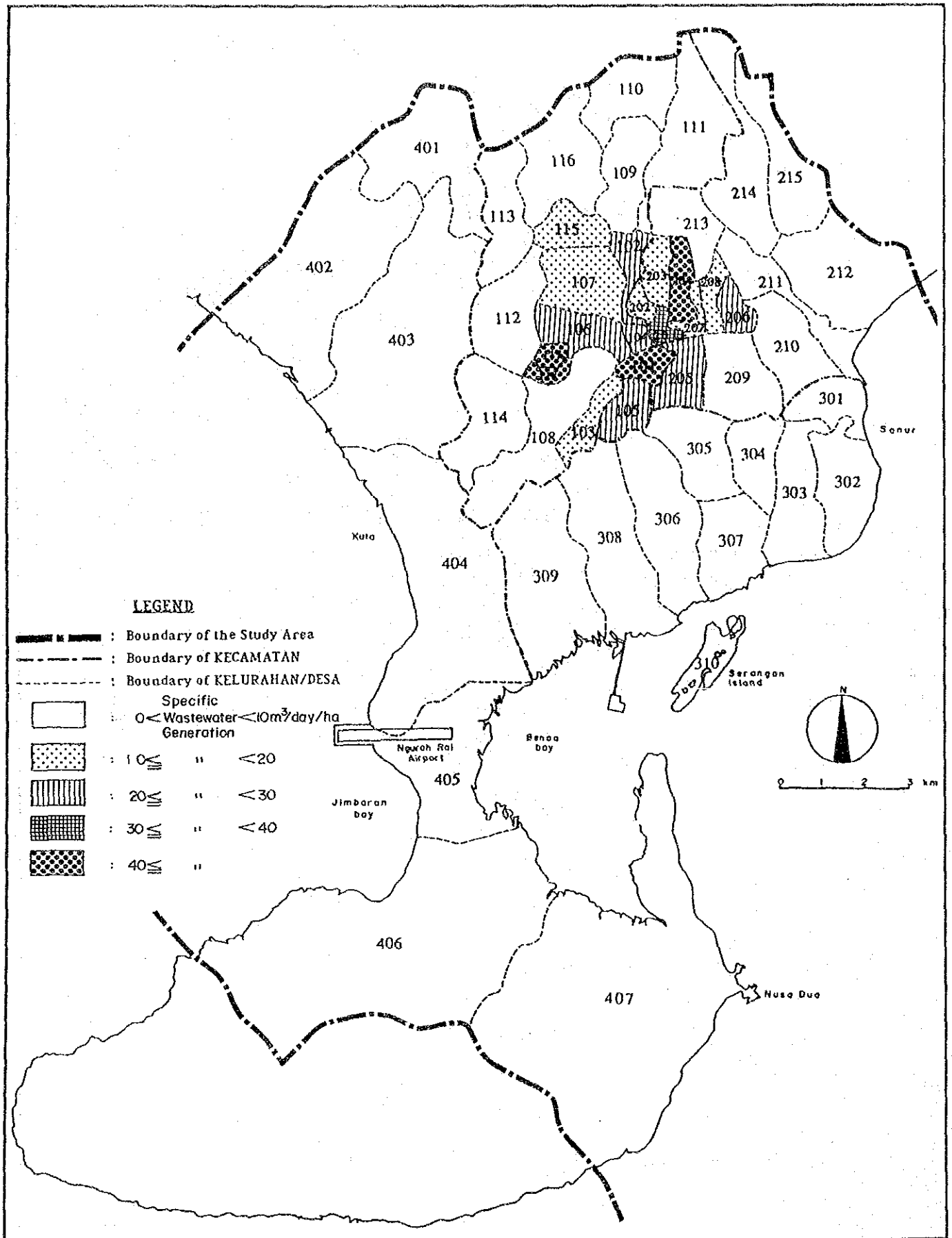

FIG. C.3.1 EXISTING SPECIFIC WASTEWATER GENERATION

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

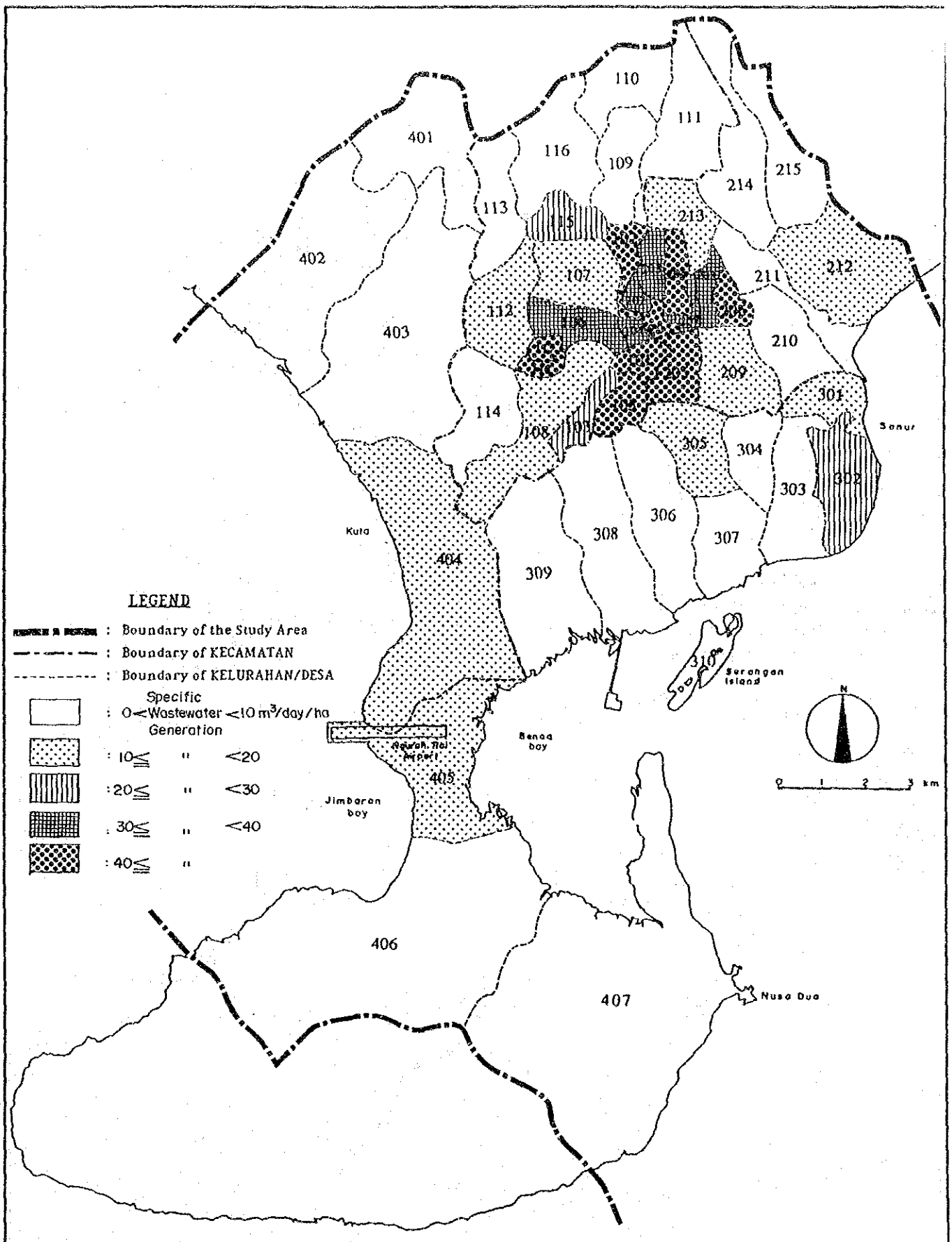

FIG. C.3.2 FUTURE SPECIFIC WASTEWATER GENERATION

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

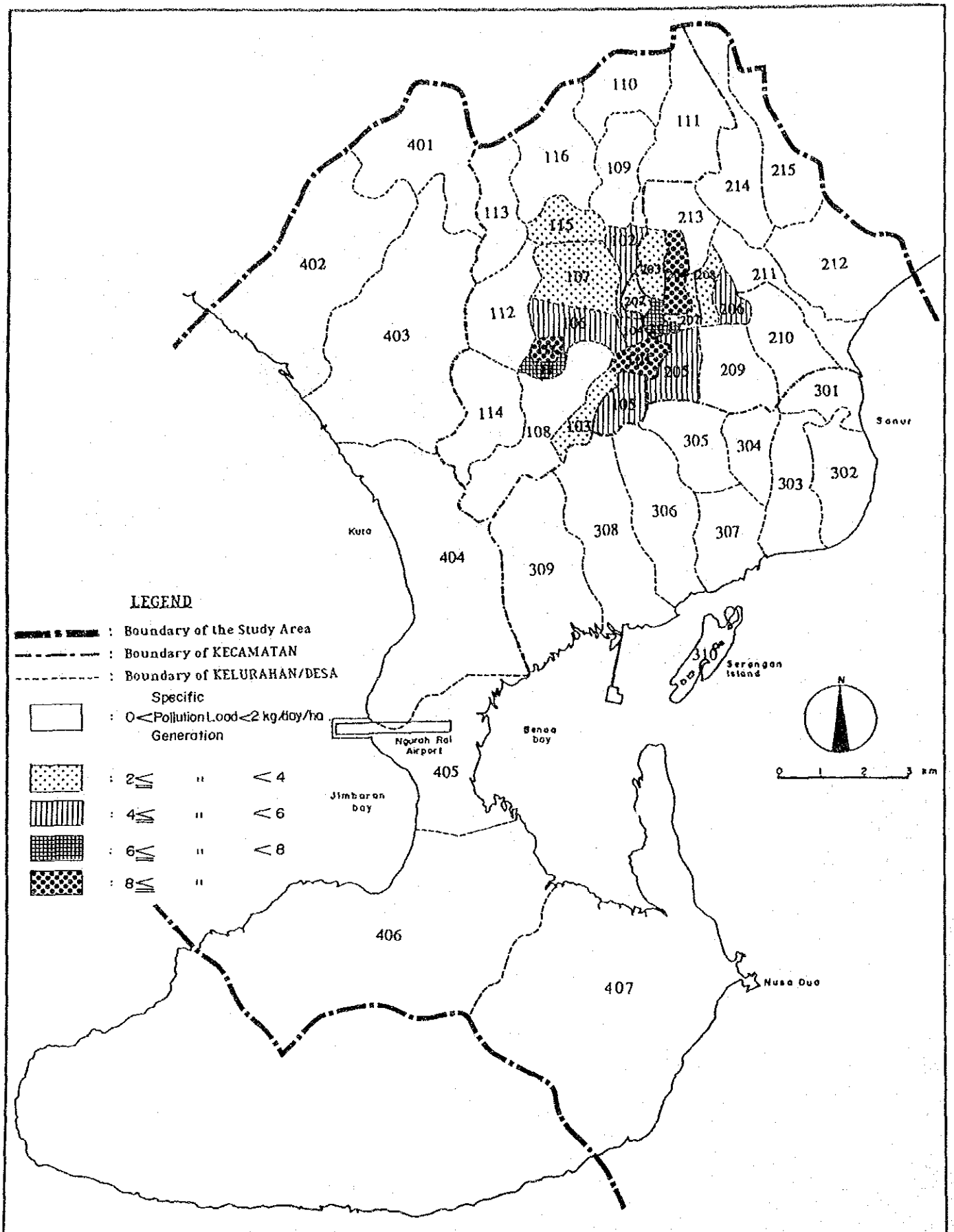

FIG. C.3.3 EXISTING SPECIFIC POLLUTION LOAD GENERATION

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

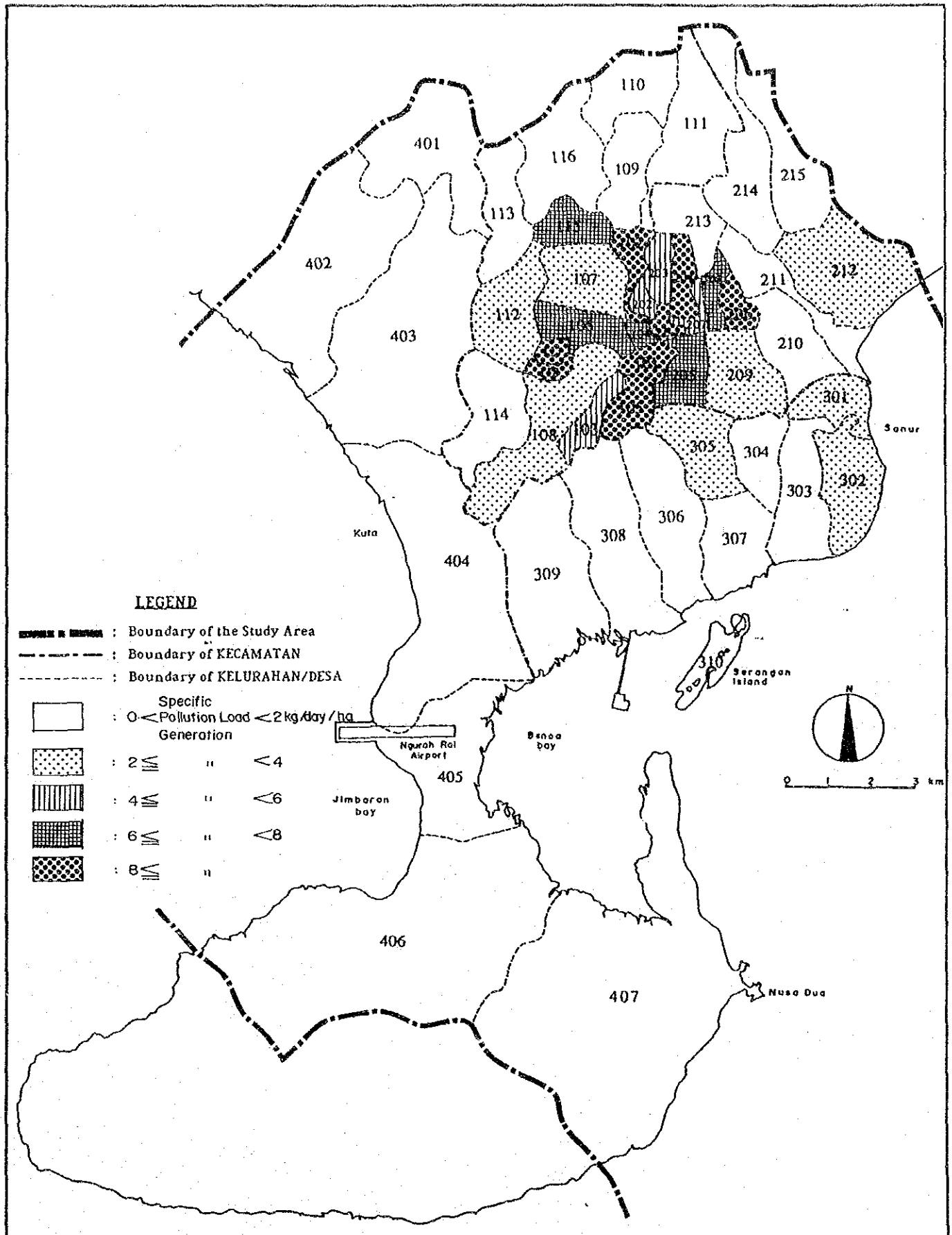

FIG. C.3.4 FUTURE SPECIFIC POLLUTION LOAD GENERATION

THE DEVELOPMENT STUDY ON WASTEWATER DISPOSAL FOR DENPASAR

APPENDIX D

EXISTING SANITATION AND SEWERAGE PROJECTS AND FACILITIES

APPENDIX D EXISTING SANITATION AND SEWERAGE PROJECTS AND FACILITIES

1. Existing On-site Sanitation Facilities

In the Study Area, the whole existing sanitation/wastewater treatment facilities of domestic, institutional, commerce, industrial and others are essentially on-site based. The only exception is, as dealt with in Section 3, the BTDC sewerage system serving hotel and resort area of Nusa Dua and the Airport sewerage system in Kuta.

1.1 Domestic On-site Sanitation Facilities

The existing domestic on-site systems in the Study Area are utilized to treat toilet waste only, while the gray water originating from wash, bath, cooking and laundry is either disposed/discharged to lawns/drains with no treatment or infiltrated into underground using separate soak pit or soakaway.

These existing domestic toilet facilities could be grouped into two (2) broad categories. They are individual toilet and community toilet. Both may be with or without an appropriate treatment system of septic tank or leaching pit.

An individual toilet is a toilet intended entirely for one household, probably having a septic tank/leaching pit in ones own compound. Whereas a community toilet is the one that either serves more than one household, or that discharges the toilet wastes from a group of individual household toilets to a common treatment facility like septic tank/leaching pit. Such community toilets are somewhat significant in the Study Area though individual toilets predominate. However, the MCK type public toilets are virtually nonexistent. Even when they exist very rarely, as noted by field inspection, they are not in use.

It is to be noted that there exists no clear distinction between leaching pit and septic tank in the Study Area, or whole Indonesia in general, either structurally or functionally, and both mostly treat toilet waste.

The JICA Study Team conducted a sampling survey covering the whole Study Area to evaluate the service level of available domestic sanitation facilities under the existing conditions.

For the purpose of the survey, the sampled population in each Kelurahan/Desa is grouped into one of the following four (4) categories based on the sanitation facility availed of.

They are as follows :

(i) Population with no toilet facility
(ii) Population with toilet but no treatment facility like septic tank/leaching pit
(iii) Population having access to public toilet with septic tank
(iv) Population with toilet and leaching pit/septic tank

The results, covering the whole 50 Kelurahan/Desa in the Study Area, on a Kel./Desa basis is given in Table D.1.1. The corresponding Kel./Desa-wise service level is shown in Fig. D.1.1. Summary of the domestic sanitation service level on a Kecamatan basis is given below.

Kecamatan	Population Service Ratio of Each Four Category (%)			
	(i)	(ii)	(iii)	(iv)
Denpasar Barat	3.9	0.5	0.0	95.6
Denpasar Timur	2.2	0.0	0.0	97.8
Denpasar Selatan	3.6	0.6	0.0	95.8
Kuta	9.3	2.4	0.0	88.3
Total - Study Area	4.4	0.8	0.0	94.8

Note : Only a portion of Kecamatan Kuta is incorporated in the Study Area.

Above results indicate a good service level of sanitation facilities in the Study Area. The ratio of population having toilet with treatment is as follows :

Denpasar Barat	:	95.6%
Denpasar Timur	:	97.8%
Denpasar Selatan	:	95.8%
Kuta	:	88.3%
Study Area	:	94.8%

All three (3) Kecamatan of Denpasar have very good domestic sanitation service level exceeding 95%, while Kuta has the worst level but still more than 85%.

The above results are in agreement with a similar survey covering almost the same areas conducted by the IUIDP Study in December, 1988, though eleven (11) Kelurahan/Desa of the Study Area were not included. The above IUIDP survey results, on a Kelurahan/Desa basis is given in Table D.1.2.

1.2 On-site Sanitation Facilities of Commerce and Institution

There is no available previous organized studies/data concerning the existing on-site sanitation/wastewater treatment systems of commerce or institution in the Study Area, other than for hotels/inns in Kuta area.

Data on on-site sanitation/wastewater treatment systems in 26 hotels, cottages and inns of various grades ranging from one (1) star to five (5) star and Melati 1 ~ 3 in the famous tourist areas of Kuta and Legian beaches was presented by the Statistics Office of Bali Province. The data was obtained through sampling survey conducted in 1989. As per the above data, all the sampled hotels/inns utilized septic tank as their on-site sanitation system.

The Study Team conducted a sampling questionnaire survey to determine the type and service level of sanitation systems for commerce and institutions. Commerce and institutions were classified into five (5) categories, namely hotel, restaurant, shop, factory and office. Hotels, restaurants and shops were further classified into "large" and "ordinary" ones.

"Large" hotels represent four (4) and five (5) star accommodations. They are big, famous, spacious and luxurious. One day stay will cost US$ 70 or more per customer. By "large" restaurants we mean those eating places with the capacity of 100 or more seats and with 30 or more waiters/waitresses. They are big, famous, spacious and luxurious. "Large" shops signify those commercial establishments which are big, spacious

and full of merchandise with 30 or more sales staff including department stores and multi-storeyed commercial buildings.

Factories were divided into five (5) types, namely food, textile, wood, paper and non-metallic mineral industries. Offices were classified either as private or public. The number of samples for each of the five (5) categories of commerce and institutions was 30.

The sanitation facilities were classified into four (4) types as described below.

1. No toilet facility
2. Toilet with leaching pit/septic tank treatment system
3. Toilet with septic tank and or aeration treatment system
4. Toilet with sewerage (public)

Sampled respondents were asked about the types of sanitation facilities they now use : they were asked to select one out of the above four (4) types.

The results of the survey are summarized in Table D.1.3. It can be said from the table that leaching pit/septic tank is the sole treatment system almost universally used.

While some hotels, factories and offices utilize elaborate treatment facility like extended aeration system.

I.3 Desludging and Treatment

Both the state agency, the Public Cleansing Department of Walikota Denpasar and four (4) private companies provide desludging and its subsequent transportation and disposal of septic tank/leaching pit sludge (septage) utilizing vacuum trucks. However, the desludged septage is just dumped and stored until it becomes dry or dewatered, and hence there is no any organized sludge treatment system as such in existence (ref. Fig.D.1.2). Moreover, desludging service by private companies is predominant, in comparison to that of Public Cleansing Department, and accounted for 75% of residential desludging based on IUIDP sampling survey of 1988.

The frequency of desludging is highly variable, ranging from a few months to more than even seven (7) years. A typical household average span of desludging is about once in three (3) years.

Based on the IUIDP sampling survey of 1988 concerning the operation and maintenance of domestic on-site sanitation systems of septic tank and leaching pit, it became evident that about 60% of the systems were never desludged. However, the remaining 40% of the systems had an average desludging frequency of once in three (3) years.

Assuming a desludging population ratio of 40% and a frequency of once in three (3) years, the quantity of domestic desludging in the Study Area, under the existing conditions, is estimated to be about 6,700 m^3/annum.

The public desludging by the Public Cleansing Department and the private desludging by the private companies are separately briefed in the subsequent sections.

(1) Public Desludging

A single vacuum truck of 6 m^3 capacity is used for desludging by the Cleansing Department. The prime function of the Department is solid waste collection, transport and disposal.

The desludging service area covers mostly the three (3) Kecamatan of Denpasar only, and at most extends up to the Airport area in Kuta to the south.

The request for desludging is accepted only with a written application by filling up a prescribed form available in the Walikota office in Gajah Mada Street. Hence it is necessary for the intended recipient to make a direct visit to the Walikota office. The maximum waiting time until the desludging service is availed of is reported to be about one week.

The charge for desludging is very economical in comparison to the private companies, and the tariff is dependent on the type of customer.

The tariff system applied since its latest revision in August 1991 is as follows :

- Enterprise (Factory, Hotel etc.) Rp. 7500/m^3 sludge
- Residents and Public Institution Rp. 3500/m^3 sludge
- Social Institution (Hospital, School etc.) Rp. 1000/m^3 sludge

The total number of household served during the past four (4) fiscal years of 1987 ~ 1991 along with the quantity of desludging and the total annual income from tariff is summarized in the Table given below.

Fiscal Year	Household Served (No.)	Total Sludge Quantity (m3)	Sludge Collection Rate(m3/household)	Total Tariff Income (Rp.)
1987 - 1988	329	1652	5.0	4,130,000
1988 - 1989	409	1770	4.3	4,426,000
1989 - 1990	400	2076	5.2	5,190,000
1990 - 1991	435	2793	6.4	6,982,000

Source : Walikota, Denpasar

Based on the above table typical capacity of a septic tank in the Study Area, if assumed to be the quantity of per household desludging, is in the range of 4 ~ 6 m^3.

Assuming a 300 number working days in a year, the daily quantity of desludging is estimated to be in the range of 5.5 ~ 9.3 m^3. This is equivalent to about 1 ~ 1.5 operational cycle per day by the vacuum truck of 6 m^3 capacity.

The operation and maintenance budget for the fiscal year 1990 ~ 1991 (April, 1990 ~ March, 1991) for desludging service was reported to be Rp.15,392,400, while the actual expenditure as Rp.17,719,400.

Accordingly, the cost recovery ratio from tariff during 1990 ~ 1991 in comparison to the actual expenditure was only about 40%. However, six (6) person including the driver of the truck are employed for desludging in comparison to only two (2) person for a private company.

The desludged sludge is transported and disposed in the solid waste disposal site in Suwung, Denpasar Selatan. The disposal location is engulfed by solid waste and the sludge is dumped by making large pits in the ground.

Private desludging companies are also permitted to dump their sludge at this site, but for a monthly rental fee of Rp.75,000 per truck.

Under the IUIDP Kuta Pilot Sewerage Project funded by the World Bank a combined sewage and septage (sludge) treatment plant with a sludge treatment capacity of 110 m^3/d is planned in Pemogan, Denpasar Selatan, to eliminate the above practice of crude sludge dumping, in an area of 1.1 ha. However, the implementation is delayed due to land acquisition problem.

The major problems with this existing desludging method are as follows :

(i) Lack of service flexibility for truck maintenance and repairs as only one single truck is available.

(ii) The large capacity of 6 m^3 limits the accessibility of the truck to congested areas.

Further more it seems that there is yet to be any target to improve either the service level or to expand the service area of desludging.

(2) Private Desludging

There are four (4) private companies that provide desludging service. Their combined service area encompass the whole Study Area and their combined service potential is much higher than that of Public Cleansing Department.

The names of these companies are as follows :

(i) MAS DJUM
(ii) HADI
(iii) UD.L.M
(iv) UD. JASA ARTHA

Among these four companies, Mas Djum in the largest having four (4) number 4 m^3 capacity trucks with its own private sludge dumping site in Jimbaran. Its principal customers are hotels and restaurants.

The desludging activity as conducted by each of these companies are briefed below based on interview survey by the JICA Study Team.

(i) Mas Djum

The company has four (4) contact addresses three (3) in Denpasar city and one (1) in Jimbaran near Nusa Dua, its controlled sludge disposal site. The company owns four (4) vacuum trucks each of 4 m^3 capacity. The truck parking location is in central Denpasar city, which is considered as the prime location of company (ref. Fig.D.1.2).

A driver and an assistant is assigned to each truck, while another two (2) person as office assistants, resulting in a total of ten (10) employees.

The major customers accounting for 65% of the total work load are hotels and restaurants, and the remaining are residents.

The request for desludging by customers is principally made through telephone. The desludging charge is Rp.40,000 per visit of truck.

Each truck is reported to do two (2) cycles per day on an average. Assuming an annual working days of 300, and an average rate of occupancy of truck with sludge of 75%, the total quantity of desludging is estimated at 7200 m^3/annum.
The annual gross income (turn over) is estimated at Rp.96 million.

It is reasonable to consider a household is served with a single trip. Accordingly, the total number of household served, excluding the hotels and restaurants, is estimated at 840 household/annum.

The desludged sludge is transported to a private sludge holding area owned by the company in Jimbaran near Nusa Dua (ref. Fig. D.1.2). The total land area of this site is 0.5 ha. The sludge is dumped in ponds of about 1 m deep and 2 m wide with variable length. A typical pond in used for one (1) to two (2) months and its supernatant is drained to a permeable infiltration

area. Once a pond is full of sludge it is allowed to undergo anaerobic digestion and drying for about six (6) to eight (8) months. Once the sludge is dewatered it is removed and used as fertilizer and the cycle of fresh sludge loading is repeated.

The whole activity of sludge holding, digestion/stabilization and drying is entirely achieved within the land area of 0.5 ha owned by the company.

(ii) Hadi

The company is in house managed and owns two (2) number 4 m^3 trucks for desludging. The truck parking location is very close to the main office in Sesetan, Denpasar Selatan (ref. Fig. D.1.2). As in the case of Mas Djum two (2) person are employed per truck resulting in a total of four (4) employees. Of the two trucks, only one new truck is operational at present. This new truck was acquired recently in August 1991.

Household located within 5 km radius are the major customers, though at times small hotels are also served. The request for desludging is equally divided between telephone and direct callers.
The charge for desludging is Rp.25,000 per trip for a household and Rp.35,000 for a hotel.

The truck, as only one has been operating, makes 2 cycles per day on an average. Accordingly, under the similar conditions as per Mas Djum the total quantity of desludging is estimated at 1800 m^3/annum. The total number of household served is estimated at 600 household/annum. The annual gross income is determined to be Rp.15 million.

The desludged sludge is dumped at Suwung solid waste disposal site as per the public cleansing department for a fee of Rp.75,000 per month per truck. As both the trucks are registered the total monthly fee becomes Rp.150,000.

(iii) Ud.L.M

The company owns only one (1) 4 m^3 truck. Its main office is located in Ubung, while the truck parking location is in Kesiman at 3 km apart, both toward north of central Denpasar city (ref. Fig. D.1.2). As in the case of

other private companies two (2) person are assigned with the truck, while one person works as office assistant, with a total of three (3) employees.

Households are the main customers, though hotels are also served at times. The operation is very flexible and service is made available on any day. The request for desludging is mainly received through telephone.

The charge for desludging is dependent on service distance and for Denpasar area, the major service area, Rp.35,000 is charged per trip. While the charge for Kuta area is Rp.40,000 per trip and for Nusa Dua area Rp.50,000.

On average 1 ~ 2 cycles or households per day are served, with an average working days of 20 per month. Accordingly, the total annual quantity of desludging is estimated at 1080 m^3/annum. The total number of household served is 360 per annum. The annual gross income is Rp.12.6 million.

The desludged sludge is disposed at Suwung solid waste disposal site for a monthly fee of Rp.75,000 as in the case of Hadi company.

(iv) Ud. Jasa Artha

This is very new company established only in November 1991, and is in operation since mid of November 1991. The company owns one (1) 4 m^3 truck and employs two (2) person as in the case of other private companies. Both its office and truck parking location are the same in central Denpasar city.

During the one (1) month operation until the mid of December so far, the company has been serving on average one (1) cycle or one household per day.

The request for desludging is mostly received though telephone. Their charge for the service is Rp.35,000 per trip. The customers served already are not only from Denpasar but also from Sanur and Kuta and are entirely private households.

The sludge is disposed in Suwung solid waste disposal site for a monthly fee of Rp.75,000 as in the case of Hadi and Ud.L.M.

(3) Comprehensive Evaluation

A comprehensive evaluation on existing condition of desludging and disposal as practised both by the public and private sectors is made. Public sector is represented by the Public Cleansing Department of the Walikota, Denpasar. While the private sector comprises the three (3) companies Mas Djum, Hadi and Ud.L.M. Ud. Jasa Artha is not incorporated as it is only recently established in November, 1991.

The combined desludging aspect by both the public and private sector in the Study Area is summarized in the Table given below, a compilation of the results presented in the foregone sections.

ORGANIZATION	Vacum Truck			Household Served (No./Annum)	Desludging Quantity (m^3/Annum)	Financial Aspect	
	No.	Capacity (m^3)	Cycle /day			Typical Tariff (Rp./Trip)	Gross Income (M. Rp./Annum)
Public Sector	1	6	1.5	400	2,400	13,000	7.0
Private Sector	6	4	2.0	1800	10,100	35,000	123.6
Total	7	-	2.0	2200	12,500	-	130.6

Note : The figures are typical ones, reflecting the overall conditions.

The above table clearly illustrates the difference in magnitude between the public and private sectors in the provision of desludging service.

The most important deficiency of the existing practice of desludging and disposal is the absence of a sludge treatment plant to ensure a sanitarily and environmentally acceptable means of sludge disposal.

2. Related Existing Drainage Network

2.1 Condition of Existing Road Side Ditch

The JICA Study Team conducted the field survey of the existing drainage system in the urbanized areas of Denpasar, Sanur and Kuta as shown in Fig. D.2.1.

The total length of the observed road side ditch is about 339 km, in Denpasar of 225 km, in Sanur of 66 km and in Kuta of 48 km.

The existing road side ditch of three (3) areas are classified into five (5) types from the existing structural conditions as follows.

(Unit:m)

	Denpasar	Sanur	Kuta	Total
(1) Natural ditch	23,208	27,195	14,026	64,429
(2) Open ditch constructed by rock	20,043	1,196	734	21,973
(3) Open ditch constructed by concrete	127,623	25,797	4,882	158,302
(4) Closed ditch constructed by rock	9,344	2,544	28,125	40,013
(5) Closed ditch constructed by concrete	45,109	9,243	-	54,352
Total	225,327	65,975	47,767	339,069

In Denpasar, ditches constructed by rock or concrete with cover exist of 54 km or 24% of the total length of observed ditch. These are mainly located in the central part of Denpasar city.

While the open ditches constructed by concrete or rock are located only in the low population density area. And roads having natural ditch or no ditch are observed in the fringe area of Denpasar.

Classification of existing road side ditch in Denpasar is shown in Fig. D.2.2.

Wastewater flow in dry weather is observed in the ditches which are located mainly in the urbanized area of Denpasar.

Wastewater flow from north to south direction is dominant in the ditches of the northern part of Oongan River. And wastewater is discharged to Oongan River through the ditches and small canals.

The location of wastewater observed ditch in Denpasar is shown in Fig. D.2.3. And wastewater flow direction is shown in Fig. D.2.4.

In Sanur, concrete ditch of 35 km is provided both sides of Tanjung Sari Rd. which is the main road of tourism area.

The open ditches constructed by concrete and rock are observed along D. Buyan Rd., Gunung Sari Rd., Sri Kesari Rd. and a part of Bypass Ngurah Rai Sanur Rd. Other roads in the residential area have only natural ditch or no ditches.

Wastewater is not observed in the ditches of Sanur except the ditches along Beratan Rd. in the residential area of Desa Sanur Kaja.

In Kuta area, covered ditches of 28 km are observed along both sides of main roads in tourism area of Raya Kuta Rd., Bakung Sari Rd., Pantai Kuta Rd., Raya Legian Rd. and Kartika Plaza Rd.

Wastewater is observed in the ditches located in front of the restaurants along Raya Legian Rd., Pantai Kuta Rd., Bakung Sari Rd. and Kartika Plaza Rd.

Wastewater is discharged to Mati River through road side ditches of Pantai Kuta Rd.

The location of wastewater observed ditch is shown in Fig. D.2.3.

2.2 Flood in the Study Area

The JICA Study Team conducted the reconnaissance survey on the flood condition in the Study Area.

This reconnaissance survey covers only habitual flood caused by the problems of minor urban drainage.

Habitual flood occurs at 13 locations in the Study Area as shown in Fig. D.2.5.

The flood area of each location ranges from 0.3 ha to 4.1 ha with an average of 1.2 ha. The total flood area of 13 locations is estimated at 15.9 ha.

The flood depth ranges from 0.1 m to 0.2 m and its duration time is in the range of 1 hour to 2 hours.

The results of the survey are shown in Table D.2.1.

The existing drainage system in the Study Area has adequate capacity to drain the local rainfall except No. 1 flood area. Garbage accumulation causes habitual flood at 7 locations. Other floods are caused by siltation and inadequate operation of irrigation facility.

3. Existing Sewerage Facilities

In the Study Area there are only two (2) local sewerage systems of small scale; one serving the tourist resort area in Nusa Dua and the other serving the Ngurah Rai Airport in Kuta. The sewerage system of Nusa Dua district was constructed by BTDC (Bali Tourism Development Corporation) in 1979. The purpose of the sewerage system is to serve the hotels and other related facilities developed by BTDC. The BTDC was established by Government of Indonesia in 1973 to promote tourism in Bali. The sewerage system of the Ngurah Rai Airport has been recently constructed within the Airport Expansion Project.

The effluent of Nusa Dua was designed to be mainly recycled for gardening in hotels and a golf course, while the excess is discharged into Benoa Bay. The effluent of the Airport is being discharged into Benoa Bay.

3.1 Sewer System

(1) Nusa Dua

The resort area of Nusa Dua encompasses an area of about 326 ha, where hotels, service apartments, a golf course and other related facilities are located, as shown in Fig. D.3.1.

A total of 11 high-class hotels were planned, of which presently nine (9) hotels with 3,750 available rooms have been constructed. The remaining two (2) hotels are scheduled to be completed in 1992.

The resort area of Nusa Dua is using daily water of about 10,500 m^3, of which about one fourth, or 2,500 m^3 is discharged to the sewer system. The sewer system consists of a total pipe length of 3,400 m with diameters of 250 to 500 mm, and three (3) pumping stations. The collected wastewater from hotels and others is conveyed by a 1,700 m pipe of 450 mm diameter to a sewage treatment plant (STP) (see Fig. D.3.2).

(2) Airport

The sewerage system of the airport is serving the airport and other related facilities including the employees housing, covering an area of about 300 ha. The system consists of a total pipe length of about 1.8 Km ranging from 150 to 400 mm diameter, as shown in Fig. D.3.3.

The design wastewater quantity for phase I is 1,419 m^3/day as daily maximum and 2,838 m^3/day as hourly maximum.

3.2 Treatment Plant

(1) Nusa Dua

The oxidation pond treatment system covers an area of about 16 ha, and comprises both facultative and maturation ponds in series. The maturation pond is beautifully landscaped. The initial facultative pond portion occupies about 3.2 ha area and the remaining area is essentially utilized as maturation pond, as shown in Fig. D.3.4.

The capacity of the treatment system is 7,200 m^3/d, which is still under-utilized. A portion of final effluent, about 50%, is recycled for gardening and golf course irrigation.

The facultative pond has never been desludged since the commencement of its operation in 1979. A vast spread of scum layer was observed during field visit on the surface of facultative pond. It seems that more attention is required with respect to the maintenance of the system, especially the facultative pond, in order to ensure an effective functioning of the system.

(2) Airport

The treatment plant consists of aerated facultative lagoon followed with maturation pond. The plant occupies an area of 1.2 ha and became operational only very recently in October 1991, along with the opening of the new airport terminal. The ultimate design capacity of the plant is 2,325 m^3/d. The system comprises four (4) cells of aerated facultative lagoons, as a combination of two (2) each in parallel, followed with a single cell maturation pond, as shown in Fig. D.3.5.

The system comprises of :

- Preliminary Treatment Unit (Bar screen, comminutor and flow-meter)
- Aerated-facultative lagoon cells
- Maturation lagoon
- Chlorination chamber

The effluent from the plant is disinfected to assure less than 100 coliform/100 ml before discharging into Benoa Bay.

3.3 Operation and Maintenance

(1) Nusa Dua

The system is being operated by BTDC. The total operators are 7, of whom one is a superviser. There are three pumping stations. The major activities of operation and maintenance are for those pumping stations.

While in the process of collecting data about O/M, it is informed that the operation is not necessarily good, because SS of the effluent is several hundreds mg/l. It seems that this since the plant operation in 1979. The bottom solids have never been dredged.

The operation results of Nusa Dua STP are summarized in Table D.3.1. Based on the table it is seen that the effluent of the plant was less than 10 mg/l as BOD_5, while the effluent from the 1st pond varied widely from 17.6 to 45.6 mg/l as BOD_5.

According to the operation results of 1991, the operation costs are summarized as follows :

O/M Costs of 1990	
Personnel	Rp. 73,290,000
Electricity	Rp. 36,752,000
Repair/Maintenance	Rp. 36,560,000
Fuel	Rp. 5,108,000
Others	Rp. 5,956,000
Total	Rp. 157,666,000

The daily treatment of wastewater was 2500 m^3. Therefore the unit operation cost per m^3 is calculated as Rp. 173.

The chief operator made a rough estimate of O/M costs as Rp. 190/m^3 for 1990. The hotels were paying Rp. 400 for m^3 of wastewater treatment. After treatment a recycled water is available for gardening or others. The hotels are buying it for Rp. 400 per m^3. The total sold of recycle water is 600 m^3 per day on an average.

(2) Airport

The plant became operational only recently in fall of 1991 and is not in constant operation. The operation data are not available, but it is observed that the effluent from the plant is clear, containing almost no SS.

According to the Basic Design only two (2) technical high school graduates should be enough to operate the treatment plant, because it is relatively simple and only aerators & pumps are operated automatically.

However this figure appears to be too small, because there is no cost for repair/maintenance. Two (2) figures of electricity and repair/maintenance in BTDC are almost the same. It is estimated that the personnel costs should be doubled. So the O/M costs of Airport Sewerage System should include these and are calculated for the full capacity of 2,325 m^3/d as follows :

O/M Costs		
Personnel	600,000	Rp./month
Electricity	5,350,000	Rp./month
Repair/Maintenance	5.350,000	Rp./month
Others (Consumables)	2,000,000	Rp./month
Total	13,300,000	Rp./month

Therefore the per m^3 operation cost is calculated as Rp. 191.

4. On-going Sanitation and Sewerage Project

4.1 East Java and Bali Urban Development Project

The fundamental objective of this project is to improve the quality of urban infrastructure investment and service delivery in East Java and Bali. The operational objectives are to: (a) support urban infrastructure investment (including rehabilitation) in up to 45 local governments in East Java and Bali, including a limited expansion of the water distribution system in the City of Surabaya; (b) improve urban infrastructure expenditure programming, financial planning and information management for these local governments; (c) encourage local revenue generation, improve financial management and, more generally,

strengthen local government human resources and institutions including capacities for more effective community participation and environmental management; and (d) assist sector development nationwide, including preparation of future projects.

There are three (3) principal components of the project :

(a) Infrastructure Development, Rehabilitation and O&M. This component represents about $ 340.2 million, or 94 percent of total project costs, providing the core of five-year urban infrastructure expenditure programs for the 45 participating local governments. Financing will be provided for urban infrastructure expenditure programs covering seven (7) subsectors in up to 36 of the 37 local governments in East Java and all eight (8) in Bali : civil works and equipment for water supply, urban roads, kampung improvement, market infrastructure improvement, solid waste management, drainage and sanitation.

The Kabupaten Badung is one of the eight (8) local governments in Bali.

(b) Program Management. This component represents about $13.4 million or four (4) percent of total project costs. The project will be managed and implemented by existing structural agencies at the central, provincial and local levels of government. In order to achieve the project's objectives, however, several of these agencies will require technical assistance, task-specific training and equipment.

(c) Institutional Development. This component will include two sub-components.

(i) Municipal management improvement. This sub-component represents about $3.4 million. It will support implementation of on-going national management improvement programs in East Java and Bali :

a. revenue administration reform
b. local government financial accounting and management and reform ;

c. environmental assessment (AMDAL) institutional development; and
d. IUIDP training

(ii) Sector Development. This sub-component represents about $3.5 million. It will support sector development activities that are important from a national perspective :

a. co-financing of the UNDP/UNCHS-executed IUIDP Implementation Support Project; and
b. preparation of future projects that cannot otherwise be financed.

The project cost is summarized as follows.

PROJECT COST SUMMARY

	$ million			%
	Local	Foreign	Total	Total Cost
A. Program Infrastructure Development and O&M				
1. Water supply	53.7	42.8	96.5	26.8
2. Drainage	16.6	2.1	23.7	6.6
3. Solid Waste Management	9.7	3.6	13.3	3.7
4. Sanitation/Sewerage	6.6	2.8	9.4	2.6
5. Urban Roads	62.3	26.8	89.1	24.7
6. Kampung Improvement	7.6	3.3	10.9	3.0
7. Market Infrastructure Improvement	0.8	0.3	1.1	0.3
Sub-total Program Infrastructure Investment	157.3	86.7	244.0	67.7
8. O&M Current Level	50.6	18.1	68.7	19.1
9. O&M, Increment on New Infrastructure	18.7	8.8	27.5	7.6
Sub-total O&M	69.3	26.9	96.2	26.7
Sub-total Investment and O&M	266.6	113.6	340.2	94.4
B. Program Management	7.5	5.9	13.4	3.7
C. Institutional Development				
1. Municipal Management Improvement	2.1	1.3	3.4	0.9
2. Sector Development	0.8	2.7	3.5	1.0
Sub-total Institutional Development	2.9	4.0	6.9	1.9
Total Project Cost	237.0	123.5	360.5	100.0

4.2 Human Waste Disposal of Kabupaten Badung and Kotamadya Denpasar

PLP is planning to construct a human waste treatment plant, where desludged waste from septic tanks will be treated. This is a pilot plant supported by Java and Bali Urban Development Project in the context of IUIDP.

The programme consists of upgrading of on-site sanitation systems. In addition to single on-site facilities, new multi-family facilities are proposed in the areas with high groundwater tables. These facilities will reduce the number of soak pits, especially in those areas where shallow wells are used for drinking water. This program consists of providing one septic tank for five households. The programme also includes a public promotion campaign. Part of the multi-family facilities will be constructed under the KIP programme. The human waste programme for the towns of Denpasar, Kuta and Mengwi in the Kabupaten Badung comprises :

- 17,500 single family on-site substructures;
- 1,400 combined septic tanks for five families;
- 3,400 latrines/leachate pit facilities;
- 1 desludging truck complete with tank and pumping installation; and
- one final sludge disposal site of 1.1 hectares.

The government has agreed to acquire a land for human waste disposal in 1991/1992. The land will be further expanded to include the Kuta Sewerage Project. Location of the human waste disposal site is shown in Fig. D.4.1.

The daily volume of human waste is estimated at 110 m^3. They are collected and transported by trucks to the treatment plant. Human wastes are designed to be dumped into Imhoff tanks. Effluents from the Imhoff tanks will be treated in anaerobic basins and facultative basins. The treated effluent from a maturation pond will be discharged into the nearest receiving water body. It will be almost free from bacteria. On the other hand the sedimented sludge from Imhoff tanks will be drawn into sludge drying beds. Dried sludge will be used as fertilizer in garden and agriculture.

The current layout of human waste disposal plant is shown in Fig. D.4.2. The required land acquisition is 1.1 ha.

Characteristic of human wastes are as follows :

- BOD_5 (mg/l) : 2,000 ~ 25,000
- COD (mg/l) : 5,000 ~ 80,000
- SS (mg/l) : 7,000 ~ 11,000
- Volatile SS (%) : 45 ~ 80

The project implementation period is 1990-1995.

4.3 Kuta Sewerage Project

The preliminary design of the Kuta Sewerage Project has been completed by Bina Program, Ministry of Public Works. The detailed design of the project will start soon in Bina Program. The financing of the project is expected from East Java and Bali Urban Development Project.

Based on the preliminary design the Kuta Sewerage Project is summarized as follows :

Kelurahan Kuta

Total Area	:	1,293 ha
Total Population	:	15,076 (1990)
Total Wastewater	:	1,199 m^3/d (1990)

For details, see Table D.4.1.

The service area are to be covered by the Project : is estimated to be 355.18 ha, which is 27.5% of the total area of Kelurahan Kuta.

The total wastewater of the service area was estimated based on the following sources in the service area :

- 492 Households
- 11 Star Hotels
- 84 Non-star Hotels

- 129 Home Stay and Losmen
- 125 Restaurants

The total wastewater from the service area is estimated at 49 l/sec, or 4,234 m^3/d, which is 95.6% of the total generated wastewater in Kelurahan Kuta in 2005 (see Table D.1.2). The collected wastewater in the service area will be conveyed though a pipe of 200 mm diameter to the Sewage Treatment Plant (STP), where human wastes are also treated.

Location of the Kuta Sewerage Project is shown in Fig. D.4.3.

An additional area of 2.9 ha will be purchased to the existing area of 1.1 ha for human waste disposal. Wastewater of 49 l/s from Kuta is conveyed to the same site, for treatment.

Characteristic of Wastewater are as follows :

- BOD5 (mg/l)	:	21.99	~	274.5
- COD (mg/l)	:	42.30	~	981.13
- SS (mg/l)	:	54.00	~	600
- F. Coliform per 100 ml	:	45	~	80

The service area by the Kuta Sewerage Project is shown in Fig. D.4.4.

The pipe layout is shown in Fig D.4.4, while the calculation of pipe diameters and lengths, and pipe depths are shown in Table D.4.3 and Table D.4.4 respectively. The total length of pipes ranging from 150 mm to 400 mm in diameter is 11,423m.

The total cost, excluding land acquisition, is estimated at about Rp. 4,981 million, as shown in Table D.4.1.

The project implementation period is scheduled to be 1995-2000.

5. Related On-going Projects

5.1 Water Supply Project of PDAM

PDAM has an existing water supply capacity of 750 l/s and has the following expansion schedules :

- 1,050 l/s (1992) by Ayung II
- 1,350 l/s (1994) by Estuary I
- 1,650 l/s (1997) by Estuary II
- 1,950 l/s (2000) by Ayung III

East Java and Bali Urban Development Project of the World Bank is planned to support a water supply project of PDAM in Denpasar and Kuta.

The cost of the water supply project is estimated in 1990 prices as follows :

Investments	19.92	Rp. billion
Overhead & Engineering Costs	3.95	Rp. billion
O/M	11.87	Rp. billion
Total	35.74	Rp. billion

The details of the project are as follows :

- 2 intake pumps at Ayung River rated at 165 l/sec at 65 m head;
- treatment works at Ayung River incorporating flocculation, sedimentation and filtration at a capacity of 300 l/sec;
- rehabilitation of 1 borehole in north Denpasar wellfield;
- one borehole in the south Denpasar wellfield including chlorination;
- 1,500 m^3 service reservoir at Jimbaran;
- 2 booster pump stations;
- distribution pipework;
- leakage detection and control; and
- approximately 3,800 new connections.

The projected water demands for PDAM service area are based on results of household surveys and the projected growth in hotel demand requiring a source capacity of 1,129 l/sec by 1995. The increase in demand will be met by duplicating the existing treatment works at the Ayung River (Ayung II Project) by increasing the supply from river from 300 liters/sec to 600 liters/sec. Rehabilitation is also proposed for the north Denpasar wellfield so that the total supply from the wellfield is increased to 404 liters/sec. An additional borehole in Desa Panjer in the South Denpasar wellfield has already been drilled and this will raise the production capacity of this wellfield to about 142 liters/sec. Thus the total production capacity in 1995 will be about 1,146 liters/sec, which would be sufficient to meet the estimated peak day demands to just beyond 1995. Additional source works will be required to meet the peak day demands beyond 1995. The 1995 population served at house connection is estimated to be 44 percent and at standpipes about 3 percent. Non-domestic demand of small users is estimated to remain at about 20 percent of domestic demand.

Non-domestic demand of large consumers, including hotels, is projected to increase from 92 liters/sec to about 270 liters/sec by 1995 and assumes that all hotels will be supplied by 1995. Losses are projected to reduce to 25 percent of demand in 1995. This will be achieve through a leakage detection and repair programme.

5.2 Estuary Reservoir Project

The Study of the Estuary Reservoir Project forms part of a package financed under a Technical Assistance Grant from the French Government, which covers the preparation of water supply feasibility studies for three (3) major sites in Indonesia, namely :

- Nusa Dua Tourist Area, Bali
- Gresik Industrial Area, East Java; and
- Pontianak city, West Kalimantan.

The three (3) sites have in common their location in areas where saline intrusion in the main rivers renders their water quality unsuitable for human consumption at certain times of the year and thus prevents their utilization as source of raw water.

The technology of estuary reservoirs consists of constructing buffer storage reservoirs in the flat, muddy plains of coastal estuaries and using these reservoirs to store excess freshwater flows which occur during the rainy season. The stored water is then pumped from the reservoir to the treatment plant during the dry months when the river is affected by salt water intrusion.

Water demand projections were based mainly on the recently-completed Denpasar Water Supply Master Plan (Astron Polaris/Scott and Furphy, 1987), as follows :

Stage I (implementation by 1992) : 300 l/s
Stage II (implementation by 1997) : 600 l/s (total)

The proposed Estuary Reservoir (see Fig. D.5.1) would have an area of 140 ha and a Stage I capacity of 0.35 million m^3 which will be increased to 1.40 million m^3 in Stage II. These capacities would be sufficient to meet the raw water requirements throughout the normal 4-month dry season (1 in 5 to 7 year drought).

The reservoir configuration has been carefully selected to avoid interference with a number of artificial obstacles in the area of Benoa Bay where the mouths of Mati River and Badung River are situated. These include : the coastal road between Sanur and Nusa Dua, the buried aviation fuel pipeline between the port and the airport, and the airport runway itself (future extension).

Attached to the Estuary Reservoir are the following facilities :

- Flood control facilities
- Reservoir intake
- Pumping station and Transmission mains
- Treatment plant
- Service reservoirs.