ANNEX D

Water Quality Survey

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D Water Quality Survey (WQS)

D.1 Objectives of the Survey

Objectives of this survey was intended to generally understand the present situation of water source (underground water) contamination and the present river water quality at the outlet of the present sewage treatment plants in the 3 cities.

D.2 Method of the Survey

The work was carried out in two phases (once in rainy season; Aug/Sep 1996 and once in dry season; Jan/Feb 1997) in order for the comparison.

3 wells in respective city, which serve as water supply source of the city, were sampled to generally understand the present situation of water source contamination.

River water was sampled at the upstream and downstream of lagoon effluent outfall for respective sewage treatment plant in the cities, in order to generally understand the present river water quality. However, since Granada sewage treatment plant does not outfall its effluents into a river but it flows through a pastureland and ends in a marshland, and there the effluents infiltrate into the ground, sampling were made at the lagoon outfall point and the marshland. Analysis items are listed in the table below.

Table D-1: Analysis Items of Water Quality Survey

On-site Analysis Item	Laboratory Analysis Item
1. Ambient Temperature (AT) 2. Sample Temperature (ST) 3. pH	1. DO (Dissolved Oxygen) 2. COD (Chemical Oxygen Demand) 3. BOD (Biochemical Oxygen Demand) 4. SS (Suspended Solid) 5. E.coli. (Escherichia Coliform)

Note: All the analyses were made in compliance with the standard methods of "APHA(American Public Health Association)-AWWA(American Water Works Association)- WPCF(Water Pollution Control Federation)", Standard method for the examination of water and waste water 17th edition 1989".

a. Sampling Point

The Sampling points of the cities are listed in the table below.

Table D-2: Sampling Point

	Well	River water
Leon	1.Los Tanques 2.Ruben Dario 3.San Carlos	1. Rio Chiquito (upper and lower stream of "El Cocal") 2. Rio Chiquito (upper and lower stream of "Subtiava")
Chinandega	1. El Calvario 2. Las Pilas 3. Los Angeles	Rio Acome (upper and lower stream of "El Cocal")
Granada	1. Escudo No.1 2. El Escudo No.2 3. Quinta Ena No.4	Exit of the sewage treatment plant and the terminal marshland

D.3 Wells Water Quality

Results of survey tabulated in Table D-3.

Table D-3: Results of Wells Water Quality Survey

	Season	Date	AT °C	ST °C	pH	DO mg/l	BOD mg/l	COD mg/l	SS mg/l	E coli. NMP/100ml
Leon										
San Carlos	Rain	29/Aug/96	32	29	7.2	8.1	0	30	0	4
	Dry	20/Jan/97	29	30	7.5	-	1.2	6.0	4	930
	mean value		31	30	7.3	8.1	0.6	18	2	467
Ruben Dario	Rain	29/Aug/96	30	29	6.6	8.3	0.1	4.8	0	<3
	Dry	20/Jan/97	29	28	6.6	-	4.1	21.0	2	93
	mean value		30	29	6.6	8.3	2.1	12.9	1	48
Los Tanques	Rain	29/Aug/96	31	28	7.1	7.5	0.4	25	0	<3
	Dry	20/Jan/97	25	26	7.3	-	0.3	12.0	120	<2.2
	mean value		28	27	7.2	7.5	0.4	18.5	60	<3
Chinandega										
Los Angeles	Rain	5/Sept/96	26	28	7.4	8.2	0.2	24.2	0	<3
	Dry	21/Jan/97	27	28	6.8	-	0.7	8.3	4	<2.2
	mean value		27	27	7.0	8.2	0.5	16.3	2	<3
Las Pilas	Rain	5/Sept/96	27	28	7.6	8.3	0.1	3.6	0	<3
	Dry	21/Jan/97	25	25	6.5	-	0.5	23.0	16	<2.2
	mean value		26	27	6.8	8.3	0.3	13.3	8	<3
El Calvario	Rain	5/Sept/96	28	28	7.8	8.2	1.1	30.4	0	4
	Dry	21/Jan/97	27	27	7.3	-	0.3	8.9	4	11
	mean value		30	30	7.5	8.2	0.7	19.7	2	8
Granada										
Quinta Ena	Rain	10/Sep/96	26	31	7.5	7.9	1.1	31	0	<3
	Dry	23/Jan/97	28	30	7.1	-	1.1	14.0	4	9
	mean value		27	31	7.3	7.9	1.1	22.5	2	6
Escudo 1	Rain	10/Sept	32	29	7.7	7.9	2.1	18	4	4
	Dry	23/Jan/97	27	26	7.3	-	0.1	7.4	4	430
	mean value		30	28	7.5	7.9	1.1	12.7	4	217
Escudo 2	Rain	10/Sep/96	32	29	7.6	8.4	1.8	20	4	<3
	Dry	23/Jan/97	27	31	6.8	-	0.1	6.7	16	150
	mean value		30	30	7.0	8.4	1.0	13.4	10	77

D.3.1 River Water Quality

Results of survey tabulated in Table D-4.

Table D-4: Results of River water Quality Survey

	Date	AT °c	ST °c	pH	DO mg/l	BOD mg/l	COD mg/l	SS mg/l	E coli. NMP/100ml
Leon "El Cocal"									
Upper	Aug/30/96	30	32	6.5	0.2	111	209	92	2,400
	Jan/20/97	27	28	7.4	2.9	132	892	66	110,000,000
mean value		29	30	6.8	1.6	122	551	79	50,001,200
Lower	Aug/30/96	29	33	8.4	0.7	76	147	162	11,600,000
	Jan/20/97	28	29	7.6	5.7	60	2,083	206	1,500,000
Mean Value		29	31	8.0	3.2	68	1,115	184	6,550,000
Leon "Subtiava"									
Upper	Aug/30/96	31	33	8.4	4.1	24	56	52	430,000
	Jan/20/97	28	30	7.4	4.3	332	1,116	68	70,000
mean value		30	32	7.7	4.2	178	586	60	250000
Lower	Aug/30/96	28	32	7.7	4.3	37	72	68	280,000
	Jan/20/97	28	29	7.1	4.9	204	1,339	128	21,000,000
Mean Value		28	31	7.3	4.6	121	706	98	10,640,000
Chinandega									
Upper	Sept/5/96	31	32	7.7	7.2	41	52	48	430,000
	Jan/21/97	27	30	6.8	8.8	216	923	38	460,000
Mean Value		29	31	7.0	8.0	129	488	43	445,000
Lower	Sept/5/96	32	32	7.6	7.2	72	163	108	430,000
	Jan/21/97	27	29	7.1	7.1	564	1,391	110	1,100,000
Mean Value		30	31	7.3	7.2	318	777	110	765,000
Granada									
Exit	Sep/12/96	33	33	7.9	0	300	491	512	90,000,000
	Jan/23/97	29	27	8.1	12	50	268	122	300,000
Mean Value		31	30	8.0	6	175	380	317	45,150
Pond	Sep/12/96	33	36	10	0.4	150	411	244	<3
	Jan/23/97	28	28	7.8	8.5	202	655	240	70,000
Mean Value		31	32	8.1	4.5	176	533	242	35,002

D.4 Findings of the Survey

D.4.1 Wells Water

a. Leon

As for in the rainy season, level of BOD, as a parameter of organic contamination, showed: San Carlos 0.0mg/l, Ruben Dario 0.1mg/l, and Los Tanques 0.4mg/l in this survey results in the rainy season. Level of COD in the rainy season showed: San Carlos 30mg/l, Ruben Dario 4.8 mg/l, and Los Tanques 25mg/l. COD concentration of San Carlos and Los Tanques were considerably high as potable well water.

Meanwhile, the survey in the dry season resulted: San Carlos (BOD 1.2mg/l, COD 6.0mg/l), Ruben Dario (BOD 4.1mg/l, COD 21.0mg/l). It derives that COD/BOD is about 5. Therefore, it is strongly suspected the water is contaminated with organic compounds. On the other hand, substantially high E.coli levels were detected (e.g., San Carlos 930MNP/100mg/l, Ruben Dario 93MNP/100mg/l). Consequently, it is possible that the well water in San Carlos and Ruben Dario are contaminated with organic wastewater including nightsoil.

The survey for Los Tanques showed similar features both in rainy and dry seasons. The outcome (BOD 0.4mg/l, COD 18.5mg/l as an average of rainy and dry seasons) implies few possibility of contamination by organic compounds. High level of COD observed in this survey might be attributable to reductive inorganic substances dissolved in the underground water.

b. Chinandega

The survey for Chinandega wells showed similar features both in rainy and dry seasons. The Levels of BOD as an average of rainy and dry seasons showed: Los Angeles 0.5mg/l, Las Pilas 0.3mg/l, and El Calvario 0.7mg/l. On the other hand, level of COD as the average showed: Los Angeles 16.3mg/l, Las Pilas 13.3mg/l, and El Calvario 19.7mg/l. COD concentrations were considerably high as potable well water.

On the other hand, E.coli. counts for 8MNP/100ml only in El Calvario average and less than 3MNP/100ml for the rest wells. Therefore fecal contamination of well water might not be suspected.

As far as the results of this survey implies, high level of COD observed might not be attributable to fecal contamination of well water but could probably be attributable to reductive inorganic substances dissolved in the underground water.

c. Granada

As for in the rainy season, level of BOD, as a parameter of organic contamination, showed: Quinta Ena-IV 1.1mg/l, Escudo-I 2.1mg/l, and Escudo-II 1.8mg/l. Level of COD in the rainy season showed: Quinta Ena-IV 31mg/l, Escudo-I 18 mg/l, and Escudo-II 20mg/l. COD concentrations were considerably high as potable well water. E.coli. in the rainy season counted for 4MNP/100ml only in Escudo-II and less than 3MNP/100ml for all the rest.

Meanwhile, the WQS in the dry season recorded substantially high E.coli levels in Escudo-I and Escude-II (Escudo-I 430MNP/100mg/l, Escudo-II 150MNP/100mg/l). However, level of BOD, as a parameter of organic contamination, ranged low concentration in the 2 wells (Escudo-I 0.1 mg/l, Escudo-II 0.1 mg/l), and COD/BOD ranges 74 to 64. Therefore it is less possible that the well water is polluted with organic and fecal residual water.

In case where the samples showed lower concentration of organic compounds and substantial existence of E.coli., it implies that the water is not contaminated with organic and fecal wastewater, but it implies the water contamination with intestinal pathogens, since E.coli has its habitat in human or animal intestines.

In this consequence, it is possible that the well water in Escudo-I and Escudo-II are contaminated with intestinal pathogenic organs of human or animals.

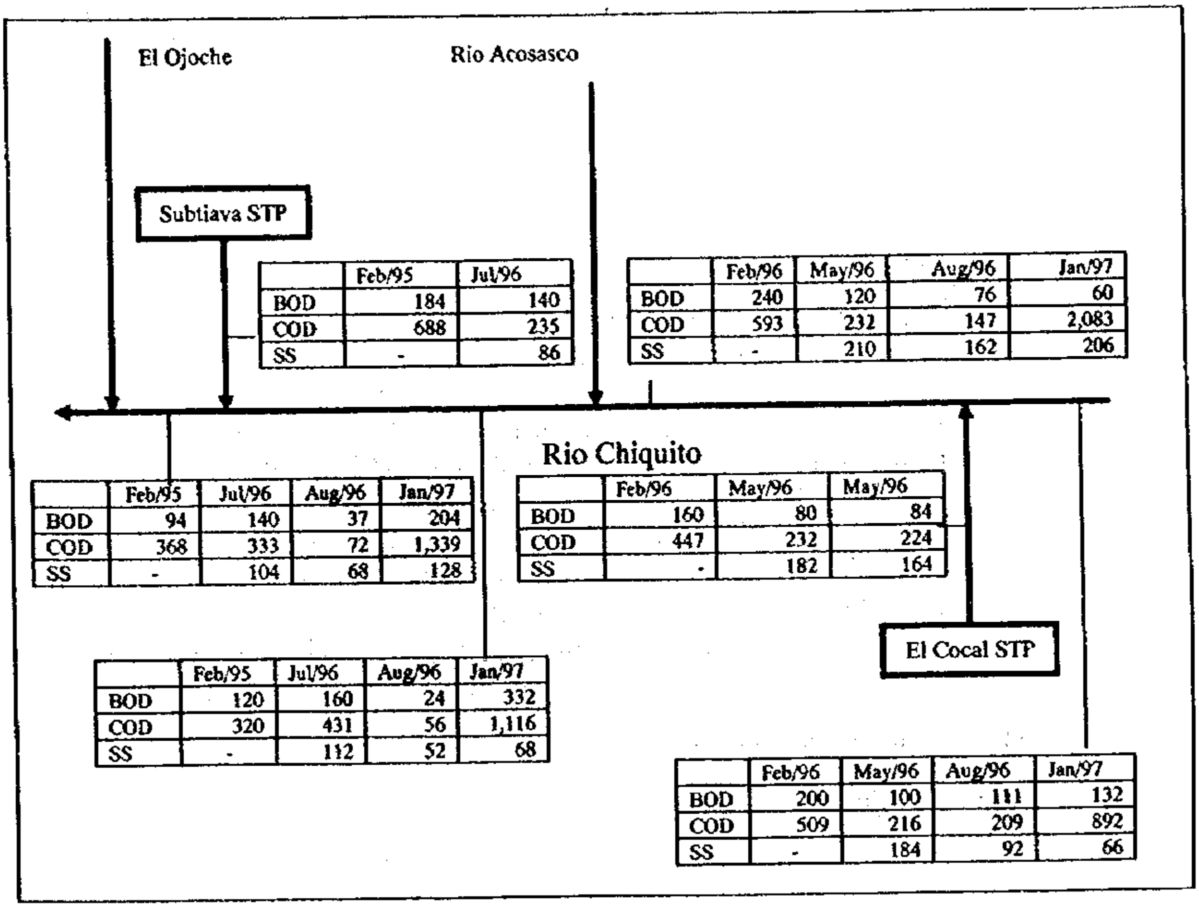
As for the Quinta Ena water, E.coli. in the dry season (9MNP/100ml) ranged comparatively higher than that in the rainy season. However, its COD (14.0mg/l) and

BOD (1.1mg/l)in the dry season showed COD/BOD being about 13. Consequently, the comparatively high level of COD observed might not be attributable to organic contamination of well water but could probably be attributable to reductive inorganic substances dissolved in the underground water.

D.4.2 River Water

a. Leon

Figure D-1 shows river water quality on several locations surveyed by the Team (as shown in the Table D-4) and by INAA.



	Feb/95	Jul/96
BOD	184	140
COD	688	235
SS	-	86

	Feb/96	May/96	Aug/96	Jan/97
BOD	240	120	76	60
COD	593	232	147	2,083
SS	-	210	162	206

	Feb/95	Jul/96	Aug/96	Jan/97
BOD	94	140	37	204
COD	368	333	72	1,339
SS	-	104	68	128

	Feb/96	May/96	May/96
BOD	160	80	84
COD	447	232	224
SS	-	182	164

	Feb/95	Jul/96	Aug/96	Jan/97
BOD	120	160	24	332
COD	320	431	56	1,116
SS	-	112	52	68

	Feb/96	May/96	Aug/96	Jan/97
BOD	200	100	111	132
COD	509	216	209	892
SS	-	184	92	66

Figure D-1: Water Quality of "Rio Chiquito"

Leon has 2 sewage treatment plants along the Rio Chiquito river; El Cocal plant stands in the upper stream of the Subtiava.

a.1 El Cocal

Comparison of upstream sample and downstream sample of "El Cocal" indicates that:

- Upstream BOD (122mg/l in the average) improved after receiving the lagoon effluents at the down stream (68mg/l in the average), both in rainy and dry seasons;

- As for COD in the dry season, contrary to BOD and COD in the rainy season, the upstream COD (892mg/l) deteriorated after receiving the effluents (downstream COD: 2,083mg/l); and
- As for E.coli. in the dry season, contrary to the E.coli. in the rainy season, the upstream bacteriological quality (110,000,000MNP/100ml), after receiving the effluents, improved at downstream (1,500,000MNP/100ml).

This implies that the effluent of El Cocal has a feature of high COD but its BOD and E.coli. levels are low. Therefore, two specific features of El Cocal lagoon treatment are implied as follows:

- In the rainy season, the upstream BOD (111mg/l) and COD (209mg/l) improved after receiving the lagoon effluents at the down stream (BOD: 76mg/l, COD: 147mg/l). It indicates that biological degradation is significantly achieved in the lagoon superior to the quality of the present river water. However, high level of E.coli. concentration remains in the effluent. This might be because: shorter retention time of the lagoon, due to significant amount of stormwater intrusion to the sewer system in the rainy season, could not achieve sufficient bacteriological removal.
- In the dry season, due to absence of stormwater intrusion to the system, sufficient retention time in the lagoon might enable significant level of bacteriological removal. At the same time, longer retention time might accelerate significant growth of algae in the lagoon. The lagoon effluent containing algae might possibly be the major cause of high COD of the effluent.

a.2 Between El Cocal and Subtiava

To compare the "El Cocal downstream" and "Subtiava upstream", in the rainy season, it is considered that Rio Acosasco, which inflows in the Rio Chiquito between El Cocal and Subtiava, supply clean water to improve the river water quality (in all parameters of BOD, COD, SS and DO).

On the other hand in the dry season:

- BOD in the upstream (60mg/l) deteriorated in the down stream (332mg/l);
- COD in the upstream (2,083mg/l) improved in the down stream (1,116mg/l); and
- E.coli. in the upstream (1,500,000MNP/100ml) improved in the down stream (70,000MNP/100ml).

Only BOD in the dry season has a contrary result to others. It is difficult to reach a clear conclusive explanation for it. However, a possible causation of this result might be: "In the dry season, the river flow is small and slow, and may create partial stagnation of water. Whereas, algae of El Cocal effluent might be putrefied in a stagnant water, which consequently might have raised the BOD level. Meanwhile, E.coli. and COD attributable to algae might be reduced through the putrefaction.

a.3 Subtiava

Comparison of the upstream sample water and the downstream sample water in the rainy season indicates that:

- The river water quality deteriorated with the lagoon effluents. Upstream BOD (24mg/l) and COD (56mg/l), after receiving the lagoon effluents, rose to 37mg/l and 72mg/l respectively.
- As for E.coli., upstream E.coli. of 430,000MNP/100ml and downstream E.coli. of 280,000MNP/100ml were recorded. Decrease in E.coli. concentration after receiving the lagoon effluent was observed.

Therefore, biological features (represented by BOD, COD) of the river water are deteriorated with the Subtiava lagoon effluent. Meanwhile the effluent improves bacteriological features of Rio Chiquito.

On the other hand, the survey results in the dry season indicates that:

- The upstream and downstream river water quality, in terms of BOD and COD, ranges in a same level (BOD: upstream 332mg/l and downstream 204mg/l. COD: upstream 1,116mg/l and downstream 1,339mg/l).
- As for E.coli., upstream E.coli. of 250,000MNP/100ml and downstream E.coli. of 21,000,000MNP/100ml were recorded. Considerable increase in E.coli. concentration after receiving the lagoon effluent was observed.

It is difficult to conclude that the outcome is only attributable to the Subtiava effluent. However, as a major causation, it is observed that bacteriological treatment function of Subtiava is largely deteriorated in the dry season, contrary to its good functioning in the rainy season. Presently in the dry season, bacteriological feature of the Subtiava effluent is in a same level of untreated sewage water. Meanwhile, the lagoon presently achieves its biological treatment (represented by BOD, COD) only to the level of river water quality. Therefore, it might be concluded that sewage treatment functions of the Subtiava in this dry season is considerably deteriorated and it could be a major attribution to the polluted water in the receiving body (Rio Chiquito).

b. Chinandega

Comparison of the upstream sample water and the downstream sample water indicates that:

- Both in the rainy and dry seasons, same biological features were observed in the comparison of upstream and downstream water (i.e., the river water quality is deteriorated with the lagoon effluents), whereas, levels of BOD and COD in the dry season are much higher than in the rainy season. After receiving the lagoon effluents, upstream BOD (41mg/l in the rainy season, 216mg/l in the dry season) are raised to 72mg/l and 564mg/l at downstream respectively in the 2 seasons, upstream COD (52mg/l in the rainy season, 923mg/l in the dry season), rose to 163mg/l and 1,391mg/l respectively.
- As for E.coli., both the upstream and the downstream samples show the same level of concentration in the rainy season. Whereas in the dry season, upstream water (460,000MNP/100ml) bacteriologically deteriorated in the downstream (1,100,000MNP/100ml) after receiving the effluent.

Therefore, the lagoon treated effluent relates with the river water quality as follows:

- As an average of the 2 seasons, biological features of the river water deteriorated with the lagoon effluent, i.e., BOD concentration rises 2.5 times and COD concentration rises 1.6 times after receiving the lagoon effluent; and
- As an average of the 2 seasons, bacteriological features of the river water also deteriorated with the lagoon effluent, i.e., E.coli. concentration rises 1.7 times after receiving the lagoon effluent.

c. **Granada**

Since the Granada sewage treatment plant does not outfall its effluents into a river but it flows into a marshland and there the effluents infiltrate into the ground, sampling were made at the lagoon outfall point and the marshland. The survey results indicate that:

- Comparing the rainy season and the dry season, the lagoon treated effluent shows the improvement in the dry season in the all parameters analyzed (i.e., BOD, COD, SS and E.coli.). Specially the dry season improvement in BOD and E.coli are outstanding. (i.e., BOD: rainy season 300 mg/l and dry season 50 mg/l. E.coli.: rainy season 90,000,000 MNP/100ml and dry season 300,000MNP/100ml).

This could be concluded that stormwater intrusion in the sewer system is substantially small and therefore the lagoon treatment functions properly in the dry season.

Meanwhile, the marshland sample quality in the dry season far deteriorated from that in the rainy season. This could be concluded that: the effluent is comparatively small and putrefaction develops well in some stagnant water, furthermore animal excrete from the husbandry there might contribute the deterioration of the sample at the marshland.

D.5 Agricultural Chemical Contamination in Leon and Chinandega

INAA carried out well water quality surveys in January/February 1996 for 5 cities in the Region II where agrochemical contamination were suspected. The surveys resulted that organio-chloride and organio-phosphorous agrochemicals were detected in several wells in Leon and Chinandega.

As for the substance stipulated in WHO guideline (i.e., Dieldrin), where the level in samples taken count for below the limit stipulated, the well water could be assumed as suitable for drinking. However, the survey revealed the underground water was contaminated with substances not accepted by WHO.

The former guidelines for drinking water in Japan stipulate that organic-phosphorous compounds should not be detected. (Present guideline for drinking water in Japan does not stipulate level of organio-phosphorous compounds, because production and/or usage of organio-phosphorous agrochemicals are now prohibited in Japan due to its toxicity.)

Therefore, it simply can not be judged that the underground water in the 2 cities are safe. Although criteria of water potability in Japan can not be simply applied to Nicaragua, in view of drinking water safety, constant surveys of underground water quality should be continued to monitor the level of such contamination since agrochemicals are principally toxic. Countermeasures related should be placed in accordance with the monitoring results.

On the other hand, although those well water contamination are attributable to agrochemicals spread on arable lands, in view of well depth in 2 cities (Leon: 47-140m, Chinandega: 54-100m), it is difficult to conclude that agrochemicals spread on arable land have infiltrated so deep to the underground water stratum. It may be possible that agrochemicals trickled down along the casing of wells to the underground water stratum or to the inner side of wells.

a. Leon

Organio chloride compounds (e.g., Alfa-BHC, Dieldrin, pp-DDE, pp-DDD) and organio phosphorous compounds (Fention) were detected in Leon wells. The results are summarized in Table D-5.

Table D-5: Results of Wells Water Quality analysis in Leon

	Organic Chloride (ng/l)				Organic Phosphorus (ng/l)
	Alfa-BHC	Dieldrin	pp-DDE	pp-DDD	Fention
San Felipe II	-	1.19	1.38	-	484
San Felipe III	0.16	-	-	-	416
San Carlos	-	1.14	-	-	-
Las Pilas	-	-	-	0.6	-
Los Tanques	-	-	-	1.43	-
Ruben Dario	-	-	-	-	618
Laborio Church 3 blocks (distribution net)	-	-	-	-	582
WHO Guideline	NA	30	NA	NA	NA

Notes: - : not detected NA : not available

b. Chinandega

Dieldrin (an organio chloride) and Fention (an organic phosphor) were found in Chinandega wells (see Table D-6).

Table D-6: Results of Wells Water Quality analysis in Chinandega

	Organic Chloride (ng/l)	Organic Phosphorus (ng/l)
	Deildrin	Fention
La Mora	1.39	-
Las Pilas	-	570
Calvario	-	771
Hogar Del Nino (distribution net)	-	271
WHO guideline	30	NA

Notes: - : not detected NA : not available

D.5.1 Wells Water Contamination in Granada

Table D-7 summarizes results of the study (Impact Ambiental del Basurero Existente "La Joya") carried out in 1995 by CIRA.

Table D-7: Result of Water Quality Analyses by "CIRA"

	BOD (mg/l)		COD (mg/l)		Cl^- (mg/l)		NH_4-N(mg/l)	NO_3-N(mg/l)
	May/95	Aug/95	May/95	Aug/95	May/95	Aug/95	Aug/95	Aug/95
QE-4	0.75	5.0	20.2	20.4	47.15	51.07	0.01	5.8
E-1	0.5	5.5	20.2	20.4	22.03	21.05	0.09	5.86
E-2	0.5	5.0	20.2	20.4	42.32	44.25	0.015	40.48

a. Leachate Contamination

The study revealed considerably high values of Cl^- in ground water. The report mentions that the values of Cl^- in 1973 ranges from 9~17mg/l. Meanwhile, results of well water surveys carried out by INAA in 1994-96 are summarized in Table D-8. It reveals that the concentration of Cl^- in Granada wells are significantly high, although not reached a level which render it in drinkable. It might be concluded with the observation listed below that wells in Granada are possibly polluted by La Joya leachate.

Table D-8: Comparison of Wells Water Chloride Concentration

	Leon	Chinandega	Granada
Chloride (mg/l)	9.2 to 20	13.3 to 16.7	18 to 55

- Cl^- concentration in Granada wells are high in comparison with the values in other 2 cities, which are in a same range of Cl^- values of Granada wells in 1973.
- In general, Cl^- concentration of leachate from landfills ranges 100~3,000mg/l [*1] depending upon waste composition. Its typical value is estimated to be about [*1]500mg/l.
- The distance from La Joya landfill to Quinta Ena III is about 2.8km, and to Escudo I,II is about 1.7km. These wells are located downstream of La Joya landfill site (see Figure D-2).
- La Joya landfill started its operation in 1976. Cl^- concentration of Granada wells water in 1973 ranges about the same as that in the other 2 cities today. On the other hand, recent Granada wells water shows comparatively high values of Cl^- concentration.

[*1] SOLID WASTE McGRAW-HILL

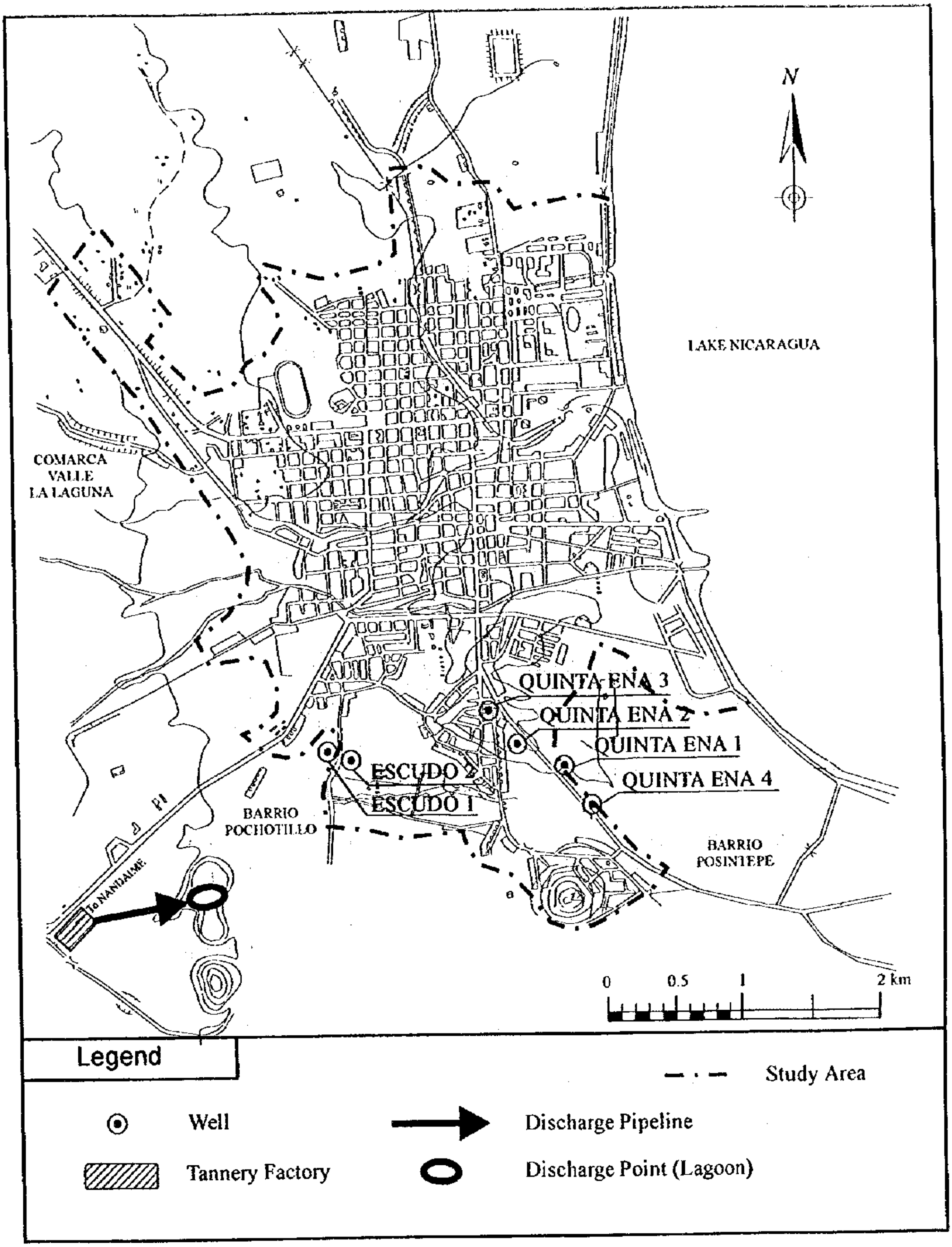


Figure D-2: Wells Location Map in Granada

b. Industrial Wastewater Contamination

Table D-7 (i.e., results of the CIRA study) shows that BOD values range more than 10 times and COD values range the same in May/95 and Aug/95. The CIRA report mentions that it could not clarify the causation whether it attributes to errors in sample analyses or external contamination. The BOD values in CIRA study ranges as high as more than 2 times of the Team's survey results and their COD value ranges about 60% of the Team's survey results. In any event, both BOD and COD values of the wells water ranges significantly high as ground water quality.

A tannery is located 2km southwest of the wells. The tannery wastewater (WPLS resulted BOD 1,800mg/l, COD 2,022 mg/l, Cr 27 mg/l, see section 2.3 in Chapter 2) is discharged into a volcanic crater, where the crater is upstream of the groundwater flow to the wells. The tannery wastewater might probably be polluting the well water, since it is envisaged that the wastewater discharged in the crater is directly routed to the ground water.

D.6 Conclusions

D.6.1 Wells Water Quality in 3 Cities

High COD recorded in wells where biological contamination are not suspected, might be attributable to reductive inorganic substances dissolved in the underground water.

a. Leon

According to the survey results in the rainy and dry seasons, 2 wells (i.e., San Carlos and Ruben Dario) out of 3 wells surveyed might be possibly polluted with organic wastewater including nightsoil. Furthermore, the survey result of Ruben Dario well water suggest "slow filtration" and "disinfection", because the survey results were classified as Class B of the water categories proposed in the INAA's Pre-feasibility Study.

According to the survey results carried out by INAA in 1996, although substances stipulated in WHO guideline were detected lower than the limit stipulated. Organic-phosphorous compounds were detected in several wells in Leon. Therefore, it is necessary to continue monitoring for agrochemicals contamination, and in case it would be necessary to take countermeasures such as abandonment of contaminated wells.

b. Chinandega

According to the survey results in the rainy and dry seasons, there is little possibility that the 3 wells surveyed in Chinandega (i.e., Los Angeles, Las Pilas, El Calvario) are polluted with organic wastewater including nightsoil.

According to the survey results carried out by INAA in 1996, although substances stipulated in WHO guideline were detected lower than the limit stipulated. Organic-phosphorous compounds were detected in several wells in Chinandega as well. Therefore, it is necessary to continue monitoring for agrochemicals contamination, and in case it would be necessary to take countermeasures such as abandonment of contaminated wells.

c. Granada

According to the survey results in the rainy and dry seasons, there is little possibility that wells of Escudo I and Escudo II in Granada are polluted with organic wastewater including nightsoil. However, it is possible those 2 wells are contaminated with intestinal pathogens of human or animals.

The survey in the rainy season suggested that Escudo I and Escudo II require "slow filtration" plus "disinfection". Meanwhile the survey in the dry season indicates improvement of the water quality and they only require "disinfection". In this connection, continuous monitoring of well water quality is necessary for the future.

On the other hand, WPLS carried out by the Team in the rainy season found that high concentration of organic wastewater including chromium is discharged from the tannery factory to a volcanic crater, which is located upstream of the ground water sources of the city. Underground water contamination therefrom is highly anticipated.

Furthermore, in view of what suggested in the CIRA's report on La Joya dumping site, it is very possible that La Joya dumping site might be causing contamination on city's potable water sources

d. Water Resources and Purification Method

INAA's Pre-feasibility Study[1] (Volume-I) categorizes potable water sources into 4 groups (see Table D-9) and specifies purification methods suited for respective water resources characteristics (see Table D-11).

With referring to the purification methods specified, since BOD values of Ruben Dario in Leon show 2.1mg/l they are classified as Class B, i.e., "disinfection" plus "slow filtration" are required for them.

Table D-9: Classification of Water Resources

	Unit	Class A	Class B	Class C	Class D
BOD_5	mg/l	0.035 to 1.5	1.5 to 2.5	1.5 to 2.5	> 2.5
Color	t.c.u	15.0	15.0 to 30.0	5.0 to 40.0	> 50.0
Turbidity	n.u.t	5.0	5.0 to 40.0	15.0 to 150.0	> 150.0
Iron	mg/l	0.3	0.3 to 0.5	0.3 to 1.0	> 1.0
Magnesium	mg/l	0.5	0.1 to 0.5	0.5 to 1.0	> 1.0

[1] INAA, Estudio de Priorizacion de Inversions en el Sector de Agua Potable y Alcantarillado Sanitario Volumen I, Marzo, 1996 (ITS/Lotti/Lamsa)

Table D-10: Classify of Investigated Wells

	Mean Value of BOD in Rain & Dry Season	Class
Leon		
San Carlos	0.6 mg/l	A
Ruben Dario	2.1 mg/l	B
Los Tanques	0.4 mg/l	A
Chinandega		
Los Angeles	0.5 mg/l	A
Las Pilas	0.3 mg/l	A
El Calvario	0.7 mg/l	A
Granada		
Quinta Ena IV	1.1 mg/l	A
Escudo I	1.1 mg/l	A
Escudo II	1.0 mg/l	A

Table D-11: Classification of Purification Method

	Class A	Class B	Class C	Class D
Disinfection	X	X	X	X
Coagulation			X	X
Flocculation				X
Settling				X
Slow Filtration		X		
Rapid Filtration			X	X

Since the results were derived from only two time sampling in the rainy season (i.e., August/September 1996) and dry season (i.e., January 1997).

By any means, periodical monitoring of well water quality shall be continued onward. Purification methods to be applied and/or relocation of water sources (i.e., wells), etc. should be examined based on such water quality surveys results continuously accumulated.

D.6.2 River Water Quality

a. Leon

a.1 El Cocal

In the rainy season, bacteriological process of El Cocal lagoon was insufficient and high E.coli. level of the effluent was observed. Meanwhile, in the dry season the lagoon's bacteriological process improved but at the same time high COD was recorded.

This could be concluded that:

- In the rainy season, stormwater intrusion to the sewer system deteriorated the lagoon's bacteriological process;

- Meanwhile in the dry season, the lagoon's sewage water inflow became stable and algae growth in this consequence improves bacteriological process of the lagoon; and
- On the other hand in the dry season, the lagoon effluent containing algae raises its COD level.

Those phenomena are inevitable with lagoon style treatment methods. If the effluents are intended to be utilized as liquid fertilizers, high organic level of effluent would be a merit and therein bacteriological process would be a key solution for its utilization. However, if the lagoon treatment is intended mainly for pollution prevention of the receiving public water body, present El Cocal treatment system has limitation for such purposes.

a.2 Between El Cocal and Subtiava

To compare the "El Cocal downstream" and "Subtiava upstream", in the rainy season, it is considered that Rio Acosasco, which inflows in the Rio Chiquito between El Cocal and Subtiava, supply clean water to improve the river water quality (in all parameters of BOD, COD, SS and DO).

On the other hand in the dry season, BOD in the upstream (60mg/l) becomes deteriorated in the down stream (332mg/l); It is difficult to reach a clear conclusive explanation for it. However, a possible causation of this result might be: "In the dry season, the river flow is small and slow, and may create partial stagnation of water. Whereas, algae of El Cocal effluent might be putrefied in a stagnant water, which consequently might have raised the BOD level. Meanwhile, E.coli. and COD attributable to algae might be reduced through the putrefaction.

a.3 Subtiava

It is observed that bacteriological treatment function of Subtiava is largely deteriorated in the dry season, contrary to its good functioning in the rainy season. Presently in the dry season, bacteriological feature of the Subtiava effluent is in a same level of untreated sewage water. Meanwhile, the lagoon presently achieves its biological treatment (represented by BOD, COD) only to the level of river water quality. Therefore, it might be concluded that sewage treatment functions of the Subtiava in this dry season is considerably deteriorated.

b. Chinandega

Comparison of the upstream sample water and the downstream sample water indicates that:

- Both in the rainy and dry seasons, same biological features is observed (i.e., the river water quality is deteriorated with the lagoon effluents), whereas levels of BOD and COD in the dry season are much higher than those in the rainy season; and
- As an average of the 2 seasons, biological features of the river water is deteriorated with lagoon effluent (i.e., BOD and COD. concentration rises 2.5 and 1.6 times respectively after receiving the lagoon effluent), and bacteriological features of the river water is also deteriorated with the lagoon effluent (i.e., E.coli. concentration rises 1.7 times after receiving the lagoon effluent).

c. Granada

Comparing the rainy season and the dry season, the lagoon treated effluent shows the improvement in the dry season in the all parameters analyzed (i.e., BOD, COD, SS and E.coli.). Specially the dry season improvement in BOD and E.coli are outstanding. (i.e., BOD: rainy season 300 mg/l and dry season 50 mg/l. E.coli.: rainy season 90,000,000 MNP/100ml and dry season 300,000MNP/100ml). This could be concluded that stormwater intrusion in the sewer system is substantially small and therefore the lagoon treatment functions properly in the dry season.

Meanwhile, the marshland sample quality in the dry season is far deteriorated from that in the rainy season. This could be concluded that: the effluent is comparatively small and putrefaction develops well in some stagnant water, furthermore animal excrete from the husbandry there might contribute the deterioration of the sample at the marshland.

ANNEX E

Water Pollution Loading Survey (WPLS)

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E Water Pollution Loading Survey (WPLS)

E.1 Objectives of the Survey

Objectives of this survey were intended to generally understand the prospects of the pollution loading of respective contamination sources in the 3 cities.

E.2 Method of the Survey

a. Work Flow of the Survey

The WPLS carried out in accordance with the work flow indicated in Figure E-1.

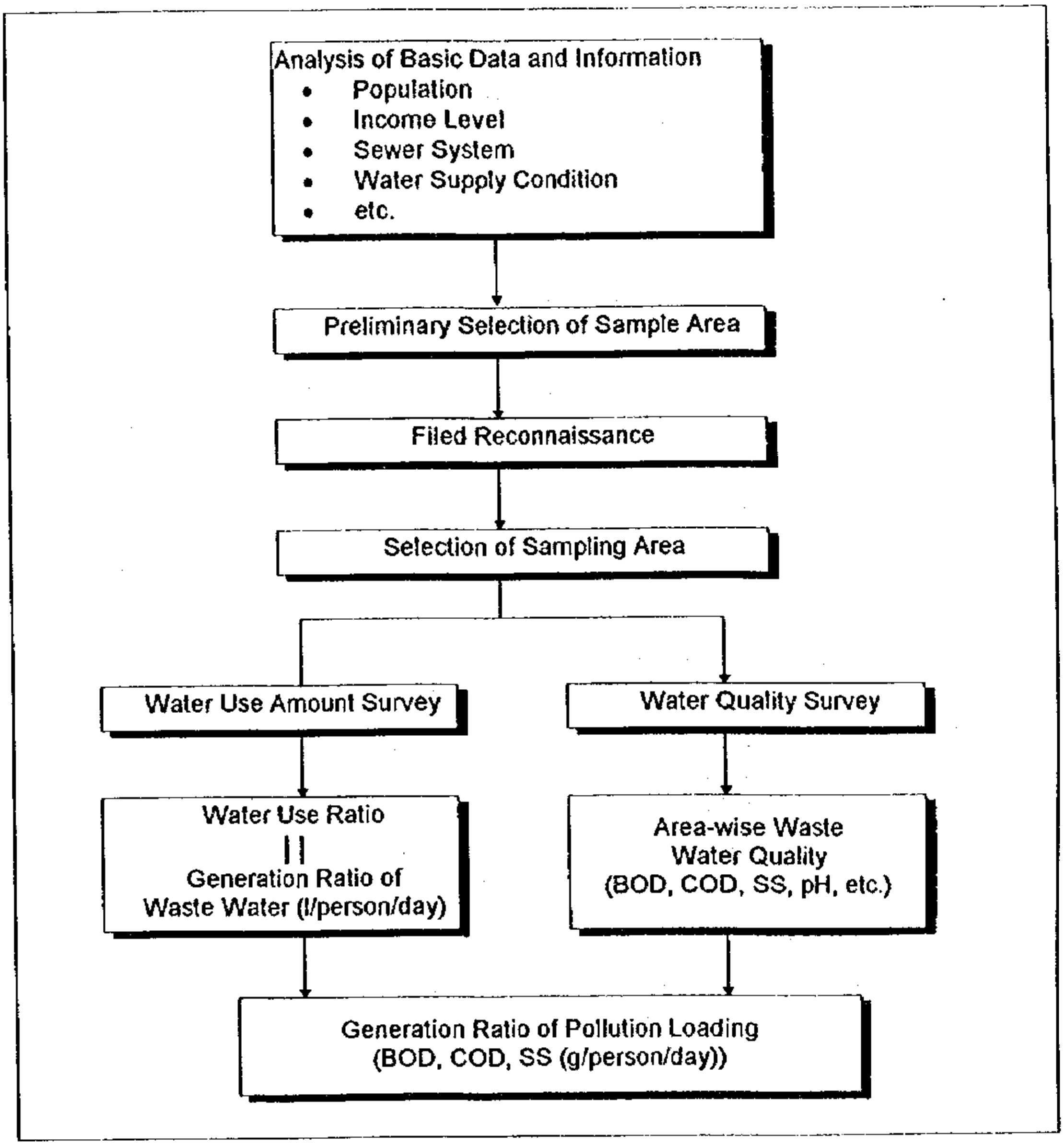

Figure E-1: Work Flow of WPLS

b. Sampling Point

Total 15 sampling areas as listed below were designed for the WPLS in each city.

- 3 sample areas of high income residential areas,
- 3 sample areas of middle income residential areas,
- 3 sample areas of low income residential areas.
- 2 factories,
- 2 market areas, and
- 2 office areas.

Sampling points to represent respective sampling areas in the 3 cities were determined after discussion of the Team and the counterpart as tabulated in Table E-1. Sampling manholes for the residential areas were selected from the second or the third manhole from the most upstream of the sewer nets.

Table E-1: Selected Sampling Point

		Leon	Chinandega	Granada
High income residential areas	A-1	Residencial Fatima	Los Angeles	Parque Los Generales
	A-2	Residencial Col. Universitaria	Monserrat 1ra. Etapa	Parada de Buses Mgua.
	A-3	Residencial Posada del Sol	San Luis	Carreter Managua - Granada
Middle income residential areas	M-1	Col. San Mateo	El Naranjo (Pump st.)	Villa Tepetate
	M-2	INO 2c. al S. 1c. al O.	Monserrat 2da. Etapa	Villa Sandino
	M-3	Col. 4 de Mayo	Calle Centro Urbano	El Palenque
Low income residential areas	B-1	Colonia 1ro.de Mayo	Monserrat 2 de Etapa	La Loquera
	B-2	Reparto J. Benito Escobar	Ayapal	La Gran China
	B-3	Fundeci 2da. Etapa	Ayapal	El Bolson
Factories	F-1	Agrosa (Vegetable oil)	Ecuanica (Seafood)	E. Chamorro (Soap)
	F-2	Rolac (Battery)	Gracsa (Vegetable oil)	Reptinica (Tannery)
Market areas	Ma-1	Mercado Santos Barcenas	Mercado de Mayoreo	Mecardo Central
	Ma-2	Mercado Central	Mercado Central	Spuermecado Lacayo No.1
Office areas	O-1	Alcaldia	Alcaldia	Alcaldia
	O-2	BANADES	INAA	INAA

c. Survey Items

Survey items for the WPLS are listed in the table below.

Table E-2: Survey Items of Water Pollution Load Survey

On-site Survey Item	Laboratory Analysis Item
1. Ambient Temperature (AT)	1. DO (Dissolved Oxygen)
2. Sample Temperature (ST)	2. COD (Chemical Oxygen Demand)
3. pH	3. BOD (Biochemical Oxygen Demand)
4. Water use amount	4. SS (Suspended Solid)
5. Population of Sampling Point (Residential Area)	5. Total Chromium (for factories)
6. Number of Employee and Floor Area (Factories)	
7. Number of Shops and Employee (Market)	
8. Number of Employee and Floor Area (Office)	

All the analyses were conducted based on the "APHA-AWWA-WPCF, Standard method for the examination of water and wastewater 17th edition 1989".

d. Water Use in Residential Area and Market

All water meters of all households and market in the area were read twice for 7 days.

e. Water Use in Factories

As for factories that use the INAA water supply for their production, water meters were read once a day (designated time) for 7 days. As for factories that extract underground water from their own wells, water use declared by the factory was employed for the data processes in WPLS.

f. Wastewater Sampling

f.1 Frequency of Sampling

Samplings were carried out every 3 hours from 6:00 to 24:00 (i.e., total 7 samples).

f.2 Composite Sample

Ratio for making a composite sample (which is to be analyzed in a laboratory) was determined as indicated in the following table, with reference to the sewage inflow pattern of existing sewage treatment plants.

Table E-3: Sampling Ratio for Composite Sample

Time of sampling	6:00	9:00	12:00	15:00	18:00	21:00	24:00
Leon	11.0%	22.9%	20.8%	14.4%	12.3%	10.3%	8.4%
Chinandega	6.3%	22.3%	22.1%	17.8%	14.6%	10.4%	6.5%
Granada	8.8%	20.8%	21.5%	15.6%	14.0%	10.8%	8.5%

E.3 Results of the Survey

a. Residential Area

a.1 Leon

Results of survey are tabulated in Table E-4 and Table E-5.

Table E-4: Water Use Amount and Wastewater Quality

Area	Population	Water Use amount		Water Quality (mg/l)		
		l/day	l/p/day	BOD	COD	SS
High Income						
A1	46	15,489.8	336.7	76	190	78
A2	32	6,800.0	212.5	227	433	200
A3	40	12,361.2	309.0	270	333	140
Weighted Average	118 (total)	34,651(total)	293.7	183	304	132
Middle Income						
M1	93	28,081.6	302.0	216	416	232
M2	61	10,320.0	169.2	680	1,597	1,056
M3	61	14,607.7	239.5	289	557	280
Weighted Average	215 (total)	53,009(total)	246.6	368	791	479
Low Income						
B1	69	8,358.0	121.1	868	1,846	1,590
B2	39	5,265.0	135.0	416	947	620
B3	30	5,782.0	192.7	251	376	232
Weighted Average	138 (total)	19,405(total)	140.6	606	1,272	1,021

Table E-5: Pollution Load and Loading Ratio

Area	Pollution Load (g/day)			Pollution Loading Ratio (g/p/d)		
	BOD	COD	SS	BOD	COD	SS
High Income						
A1	1,177.2	2,943.1	1,208.2	25.6	64.0	26.3
A2	1,543.6	2,944.4	1,360.0	48.2	92.0	42.5
A3	3,337.5	4,116.3	1,730.6	83.4	102.9	43.3
Weight Average	6,330.7	10,547.8	4,577.4	53.7	89.4	38.8
Middle Income						
M1	6,065.6	11,681.9	6,514.9	65.2	125.6	70.1
M2	7,017.6	16,481.0	10,897.9	115.0	270.2	178.7
M3	4,221.6	8,136.5	4,090.2	69.2	133.4	67.1
Weighted Average	19,528.6	41,935.7	25,412.7	90.8	195.0	118.2
Low Income						
B1	7,254.7	15,428.9	13,289.2	105.1	223.6	192.6
B2	2,190.2	4,986.0	3,264.3	56.2	127.8	83.7
B3	1,451.3	2,174.0	1,341.4	48.4	72.5	44.7
Weighted Average	11,761.4	24,690.9	19,806.7	85.2	178.9	143.5

a.2 Chinandega

Results of survey are tabulated in Table E-6 and Table E-7.

Table E-6: Water Use Amount and Wastewater Quality

Area	Population	Water Use Amount		Water Quality (mg/l)		
		l/day	l/p/day	BOD	COD	SS
High Income						
A1	20	8,250.0	412.5	50	91	72
A2	51	19,780.0	387.8	150	352	328
A3	32	12,825.0	400.8	20	37	136
Weighted Average	103 (total)	40,855 (total)	396.7	90	203	218
Middle Income						
M1	273	63,130.0	231.2	250	563	460
M2	64	9,175.0	143.4	586	719	462
M3	49	4,250.0	86.7	504	721	518
Weighted Average	386 (total)	76,555 (total)	198.3	338	608	467
Low Income						
B1	29	3,883.3	133.9	486	647	456
B2	26	6,361.4	244.7	253	563	460
B3	44	2,200.0	50.0	458	780	484
Weighted Average	72 (total)	12,445 (total)	172.8	395	648	464

Table E-7: Pollution Load and Loading Ratio

Area	Pollution Load (g/day)			Pollution Loading Ratio (g/p/d)		
	BOD	COD	SS	BOD	COD	SS
High Income						
A1	412.5	750.8	594.0	20.6	37.5	29.7
A2	2,967.0	6,962.6	6,487.8	58.2	136.5	127.2
A3	256.5	474.5	1,744.2	8.0	14.8	54.5
Weighted Average	3,685.1	8,314.0	8,930.9	35.8	80.7	86.7
Middle Income						
M1	15,782.5	35,542.2	29,039.8	57.8	130.2	106.4
M2	5,376.6	6,596.8	4,238.9	84.0	103.1	66.2
M3	2,142.0	3,064.3	2,201.5	43.7	62.5	44.9
Weighted Average	25,875.6	46,614.3	35,804.8	67.0	120.8	92.8
Low Income						
B1	1,887.3	2,512.5	1,770.8	65.1	86.6	61.1
B2	1,609.4	3,581.5	2,926.2	61.9	137.8	112.5
B3	1,007.6	1,716.0	1,064.8	59.3	100.9	62.6
Weighted Average	4,919.4	8,065.4	5,775.6	68.3	112.0	80.2

a.3 Granada

Results of survey are tabulated in Table E-8 and Table E-9.

Table E-8: Water Use Amount and Wastewater Quality

Area	Population	Water Use amount		Water Quality (mg/l)		
		l/day	l/p/day	BOD	COD	SS
High Income						
A1	28	6,400.0	228.6	217	363	242
A2	13	3,400.0	261.5	3,720	4,351	7,250
A3	41	10,319.7	251.7	176	365	686
Weighted Average	82 (total)	20,120 (total)	245.4	752	996	1,575
Middle Income						
M1	25	1,147.5	45.9	552	649	332
M2	43	9,050.0	210.5	360	569	296
M3	15	3,487.5	232.5	120	205	428
Weighted Average	83 (total)	13,685 (total)	164.9	375	527	331
Low Income						
B1	38	7,400.0	194.7	240	496	286
B2	14	2,800.0	200.0	1,540	2,338	1,344
B3	21	4,150.0	197.6	1,012	1,500	1,556
Weighted Average	73 (total)	14,350 (total)	196.6	711	1,138	854

Table E-9: Pollution Load and Loading Ratio

Area	Pollution Load (g/day)			Pollution Loading Ratio (g/p/d)		
	BOD	COD	SS	BOD	COD	SS
High Income						
A1	1,388.8	2,323.2	1,548.8	49.6	83.0	55.3
A2	12,648.0	14,793.4	24,650.0	972.9	1,138.0	1,896.2
A3	1,816.3	3,766.7	7,079.3	44.3	91.9	172.7
Weighted Average	15,128.0	20,043.2	31,688.5	184.5	244.4	386.4
Middle Income						
M1	633.4	744.7	381.0	25.3	29.8	15.2
M2	3,258.0	5,149.5	2,678.8	75.8	119.8	62.3
M3	418.5	714.9	1,492.7	27.9	47.7	99.5
Weighted Average	5,125.0	7,216.1	4,525.6	61.7	86.9	54.5
Low Income						
B1	1,776.0	3,670.4	2,116.4	46.7	96.6	55.7
B2	4,312.0	6,546.4	3,763.2	308.0	467.6	268.8
B3	4,199.8	6,225.0	6,457.4	200.0	296.4	307.5
Weighted Average	10,208.6	16,331.7	12,257.8	139.8	223.7	167.9

b. Factories

b.1 Leon

Results of the survey are tabulated in Table E-10 and Table E-11.

Table E-10: Water Use Amount and Wastewater Quality

	Main Products	Employee (persons)	Floor Area (m^2)	Water Use (m^3/day)	Water Quality (mg/l)			
					BOD	COD	SS	Cr
F-1	Vegetable Oil & Soap	229	1,200	7.6	453	734	1,590	1.5
F-2	Battery	37	300	1.9	4	30	0	0.6

Table E-11: Pollution Load and Loading Ratio

	Load (g/day)			Loading Ratio 1 (g/m^2/day)			Loading Ratio 2 (g/emp./day)		
	BOD	COD	SS	BOD	COD	SS	BOD	COD	SS
F-1	3,442.8	5,578.4	12,084.0	2.9	4.6	10.1	15.0	24.4	52.8
F-2	7.6	57.0	0	0.03	0.2	0	0.2	1.5	0

b.2 Chinandega

Results of the survey are tabulated in Table E-12 and Table E-13.

Table E-12: Water Use Amount and Wastewater Quality

	Main Products	Employee (persons)	Floor Area (m^2)	Water Use (m^3/day)	Water Quality (mg/l)			
					BOD	COD	SS	Cr
F-1	Seafood Processing	202	3,200	9.5	140	298	64	0.8
F-2	Vegetable Oil	111	2,130	6.6	60	122	10	0.8

Table E-13: Pollution Load and Loading Ratio

	Load (g/day)			Loading Ratio 1 (g/m^2/day)			Loading Ratio 2 (g/emp./day)		
	BOD	COD	SS	BOD	COD	SS	BOD	COD	SS
F-1	1,330.0	2,831.0	608.0	0.4	0.9	0.2	6.6	14.0	3.0
F-2	396.0	805.2	66.0	0.2	0.4	0.03	3.6	7.3	0.6

b.3 Granada

Results of the survey are tabulated in Table E-14 and Table E-15.

Table E-14: Water Use Amount and Wastewater Quality

	Main Products	Employee (persons)	Floor Area (m^2)	Water Use (m^3/day)	Water Quality (mg/l)			
					BOD	COD	SS	Cr
F-1	Soap & Vegetable Oil	100	3,200	1,840	4	93	4	0.6
F-2	Tannery	26	2,130	150	1,800	2,022	1,728	27.0

Table E-15: Pollution Load and Loading Ratio

	Load (g/day)			Loading Ratio 1 (g/m^2/day)			Loading Ratio 2 (g/emp./day)		
	BOD	COD	SS	BOD	COD	SS	BOD	COD	SS
F-1	7,360	171,120	7,360	2.3	53.5	2.3	73.6	1,711.2	73.6
F-2	270,000	303,000	259,200	126.8	142.4	121.7	10,384.6	11,665.4	9,969.2

c. Market

c.1 Leon

Results of the survey are tabulated in Table E-16 and Table E-17.

Table E-16: Water Use Amount and Wastewater Quality

	Nos. of Shops (nos.)	Floor Area (m^2)	Water Use (m^3/day)	Water Quality (mg/l)		
				BOD	COD	SS
Mr-1	150	450	3.5	1,272	2,654	1,260
Mr-2	200	7,059	55.4	688	1,206	716

Table E-17: Pollution Load and Loading Ratio

	Load (g/day)			Loading Ratio 1 (g/shop/day)			Loading Ratio 2 (g/ m^2/day)		
	BOD	COD	SS	BOD	COD	SS	BOD	COD	SS
Mr-1	4,452.0	9,289.0	4,410.0	29.7	61.9	29.4	9.9	20.6	9.8
Mr-2	38,115.2	66,812.4	39,666.4	190.6	334.1	198.3	5.4	9.5	5.6

c.2 Chinandega

Results of the survey are tabulated in Table E-18 and Table E-19.

Table E-18: Water Use Amount and Wastewater Quality

	Nos. of Shops (nos.)	Floor Area (m^2)	Water Use (m^3/day)	Water Quality (mg/l)		
				BOD	COD	SS
Mr-1	100	7,059	34.0	590	858	428
Mr-2	500	8,460	37.8	73	120	110

Table E-19: Pollution Load and Loading Ratio

	Load (g/day)			Loading Ratio 1 (g/shop/day)			Loading Ratio 2 (g/ m²/day)		
	BOD	COD	SS	BOD	COD	SS	BOD	COD	SS
Mr-1	20,060.0	29,172.0	14,55.0	200.6	291.7	145.5	2.8	4.1	2.1
Mr-2	2,759.4	4,536.0	4,158.0	5.5	9.1	8.3	0.3	0.5	0.5

c.3 Granada

Results of the survey are tabulated in Table E-20 and Table E-21.

Table E-20: Water Use Amount and Wastewater Quality

	Nos. of Shops (nos.)	Floor Area (m²)	Water Use (m³/day)	Water Quality (mg/l)		
				BOD	COD	SS
Mr-1	200	7,059	59.4	552	649	890
Mr-2	1	2,600	12.4	1,540	2,338	1,344

Table E-21: Pollution Load and Loading Ratio

	Load (g/day)			Loading Ratio 1 (g/shop/day)			Loading Ratio 2 (g/ m²/day)		
	BOD	COD	SS	BOD	COD	SS	BOD	COD	SS
Mr-1	32,788.8	38,550.6	52,866.0	163.9	192.8	264.3	4.6	5.5	7.5
Mr-2	19,096.0	28,991.2	16,665.6	19,096.0	28,991.2	16,665.6	7.3	11.2	6.4

d. Office

d.1 Leon

Results of the survey are tabulated in Table E-22 and Table E-23.

Table E-22: Water Use Amount and Wastewater Quality

	Floor Area (m²)	Employees (person)	Water Use (m³/day)	Water Quality (mg/l)		
				BOD	COD	SS
O-1	330	20	8.1	52	137	30
O-2	400	23	3.0	82	285	50

Table E-23: Pollution Load and Loading Ratio

	Load (g/day)			Loading Ratio 1 (g/ m²/day)			Loading Ratio 2 (g/emp./day)		
	BOD	COD	SS	BOD	COD	SS	BOD	COD	SS
O-1	421.2	1,109.7	234.0	1.3	3.4	0.7	2.1	5.5	1.2
O-2	246.0	855.0	150.0	0.6	2.1	0.4	10.7	37.2	6.5

d.2 Chinandega

Results of the survey are tabulated in Table E-24 and Table E-25.

Table E-24: Water Use Amount and Wastewater Quality

	Floor Area (m^2)	Employee (person)	Water Use (m^3/day)	Water Quality (mg/l)		
				BOD	COD	SS
O-1	1,800	381	15.8	40	70	56
O-2	1,000	20	2.9	5	8	28

Table E-25: Pollution Load and Loading Ratio

	Load (g/day)			Loading Ratio 1 (g/ m^2/day)			Loading Ratio 2 (g/emp./day)		
	BOD	COD	SS	BOD	COD	SS	BOD	COD	SS
O-1	632.0	1,106.0	884.8	0.4	0.6	0.5	1.7	2.9	2.3
O-2	14.5	23.2	81.2	0.0	0.0	0.1	0.7	1.2	4.1

d.3 Granada

Results of the survey are tabulated in Table E-26 and Table E-27.

Table E-26: Water Use Amount and Wastewater Quality

	Floor Area (m^2)	Employees (person)	Water Use (m^3/day)	Water Quality (mg/l)		
				BOD	COD	SS
O-1	1,400	75	7.2	393	626	332
O-2	800	18	1.8	141.0	162.0	75.0

Table E-27: Pollution Load and Loading Ratio

	Load (g/day)			Loading Ratio 1 (g/ m^2/day)			Loading Ratio 2 (g/emp./day)		
	BOD	COD	SS	BOD	COD	SS	BOD	COD	SS
O-1	2,829.6	4,507.2	2,390.4	2.0	3.2	1.7	37.7	60.1	31.9
O-2	253.8	291.6	135.0	0.3	0.4	0.2	14.1	16.2	7.5

E.4 Findings of the Survey

a. Residential Area

The survey results of respective cities, excluding atypical data recorded, are tabulated in the following table. Table E-28 shows BOD loading ratios observed in several foreign countries.

Table E-28: Summary of Loading Ratio

	Leon	Chinandega	Granada	Total or Weighted Ave.
Surveyed Population (person)				
High Income	32	51	69	152
Middle Income	61	322	58	441
Low Income	30	43	38	111
Total	123	416	165	704
BOD Loading Ratio (g/p/d)				
High Income	48.2	58.2	46.5	50.2
Middle Income	69.2	55.7	63.4	58.6
Low Income	48.4	60.9	46.7	52.7
Weighted Average	58.7	56.5	52.5	55.9
COD Loading Ratio (g/p/d)				
High Income	92.0	136.5	88.3	105.3
Middle Income	133.4	119.9	101.2	119.3
Low Income	72.5	123.2	96.6	100.4
Weighted Average	107.8	122.3	94.7	113.3
SS Loading Ratio (g/p/d)				
High Income	42.5	127.2	125.1	108.4
Middle Income	67.1	97.0	71.9	89.6
Low Income	44.7	92.8	55.7	67.1
Weighted Average	55.2	100.3	90.4	90.1

Table E-29: Comparison of Loading Ratio

Country	BOD (g/person/day)	COD (g/person/day)	SS (g/person/day)
Nicaragua	50.2 to 58.7	94.7 to 122.3	55.2 to 100.3
*Kampala, Uganda	63	-	43
*Guanabara, Brazil	75	-	75
*Sao Paulo, Brazil	44	-	-
*Indian	35	-	67
**USA	76 to 100	-	46.2 to 91
**Japan	64 to 84	***(13.3 to 33.6)	13.4 to 55.6

Sources : * Ministry of Construction in Japan,
** The Building Center of Japan
*** $KMnO_4$ Method

In general BOD loading ratio varies, country by country, depending upon the culture (e.g., living styles, food culture) and other factors. The WPLS indicates BOD loading ratios of residential areas in 3 cities to be approximately 50 to 59 g/person/day, which coincide with the ranges of BOD loading recorded in many other countries. Consequently, ordinary BOD loading of households in the 3 cities might be assumed in the range of 50 to 59g/person/day.

Only one comparable example for COD loading ratio (Japan) is in the above table. However, since $KMnO_4$ is employed as an oxidize and in the COD analysis method established in Japan, the example in Japan can not simply be compared with the survey results (where $K_2Cr_2O_7$ was used).

In general, where $K_2Cr_2O_7$ is employed as an oxidizer, COD/BOD ranges between 1.5 ~2. This survey result presents COD/BOD=1.9~2.1, which might be considered as a reasonable value obtained from a pollution loading survey.

SS value ranges widely depending upon inclusion of soil and/or kitchen waste in the sample. The example from USA in Table 2-33 shows a higher SS value and that of Japan, since kitchen waste is disposed into sewer in the USA, a practice prohibited in Japan.

The survey presents a city SS average of: Leon 55.2 g/person/day, Chinandega 100.3g/person/day and Granada 90.4g/person/day. Chinandega and Granada show extremely high SS values. Although causes of these high SS in 2 cities can not be clearly determined, it is highly probable that soil inclusion in the samples of the 2 cities affect the results to a considerable extent, considering living standards and practices in Nicaragua (such as average amount of kitchen waste disposed into sewer, or the practice where toilet paper used is not flushed in the toilet). In view of BOD values of the 3 cities, SS value in Leon (i.e., 55.2 g/person/day) might represent the range of SS loading ratios in the 3 cities.

b. Factories

Pollution loading of factories range widely depending upon industrial categories. With in the same industrial category, differences in production processes employed affect pollution loading ratios largely. Especially, factories in industrialized economies adopt highly rationalized technologies in processes to use up raw materials and to minimize generation of polluting substances, and the majority of factories in developing economies are in short of rationalization in production processes. Therefore, pollution loading ratio differs widely between factories in developed countries and those in developing countries even with in the same industrial classification. Table E-30 presents outcome of the pollution loading survey categorized by CIIU code.

Table E-30: Water Pollution Loading Ratio

City	No.	CIIU	Loading Ratio (1) (g/m^2/day)				Loading Ratio (2) (g/employee/day)			
			BOD	COD	SS	Cr	BOD	COD	SS	Cr
Chinandega	F-1	3114	0.4	0.9	0.2	0.0	6.6	14.0	3.0	0.0
Leon	F-1	3115	2.9	4.6	10.1	0.0	15.0	24.4	52.8	0.0
Chinandega	F-2	3115	0.2	0.4	0.0	0.0	4.1	8.4	0.7	0.1
Granada	F-2	3231	126.8	142.4	121.7	1.9	10,384.6	11,665.4	9,969.2	155.8
Granada	F-1	3523	2.3	53.5	2.3	0.3	73.6	1,711.2	73.6	11.0
Leon	F-2	3839	0.0	0.2	0.0	0.0	0.2	1.5	0.0	0.0

The largest pollution loading ratio is recorded by the industry from CIIU code 3231 (leather tanning and finishing) in Table E-30, followed by CIIU code 3523(soap, detergent, shampoos). Among the industries listed in the table, industry CIIU code

3231(lather tanning and finishing) generates not only organic polluting substances but also waste chromium in its residual water. Table E-31 compares this survey results and an example from the leather tanning industry in Japan. Common features of pollution load are observed by both, as one of major polluting industries.

Table E-31: Comparison of Wastewater Quality from Lather Tanning Factory

	Unit	Result of Survey	Instance of Japan*
pH	-	8.5 to 11.8	4.0 to 12.5
BOD	mg/l	1,800	600 to 1,200
SS	mg/l	1,728	600 to 2,000
Cr	mg/l	27	15 to 40

Source : * N. Muto Wastewater Treatment Manual

Industries from CIIU code 3114 and 3115 generate organic wastewater since all these industries are food process and production industries. Meanwhile, among sample factories of CIIU code 3115 (animal and vegetable oil), the industry from F-1 in Leon presents a substantially high pollution load compared to the same industry in Chinandega. This could be attributable to the differences of raw materials and process technologies employed in 2 industries. Four examples of the same industries (CIIU code 3115) in Japan are listed in Table E-32. The pollution loading ratios per employee in Japan range considerably high compared with those in the survey, due to mechanized production processes employed in Japan. However as previously mentioned, pollution loading ratios range widely depending upon the differences of process technologies employed, examples in Japan also indicate that pollution loading ratios per employee range more 10-fold differences even in the same industrial category (CIIU code 3115).

Table E-32: Instance of Pollution Loading Ratio in Japan (CIIU 3115)

Name	Number of Employee	Water Use Amount m^3/day	Concentration (mg/l)		Loading (g/day)		Loading ratio (g/emp./day)	
			BOD	SS	BOD	SS	BOD	SS
A	27	350	4,500	3,700	157,500.0	129,500.0	5,833.3	4,796.3
B	96	2,800	340	380	95,200.0	106,400.0	991.7	1,108.3
C	9	40	1,380	1,990	5,520.0	7,960.0	613.3	884.4
D	500	9,000	230	170	207,000.0	153,000.0	414.0	306.0

Source : N. Muto Wastewater Treatment Manual

The factory F-2 in Leon (CIIU code 3839) is a battery production industry. Therefore, although organic pollution loading is comparatively small, the pH of the sample ranges from about 2 and it is strongly suspected that heavy metals such as lead is dissolved in the wastewater, which are not measured in this survey.

c. Market

Table E-33 shows "water use amount (per area)" and "pollution loading (per area)" obtained through the survey and an example of Japan. Water use ratios (per area) in 3 cities range about one-third of that in Japan. Meanwhile pollution loading ratios in 3 cities generally range higher than that in Japan. It could be attributed to wastewater being more condensed than in Japan and is being discharged in markets in the 3 cities.

(e.g., BOD loading in Japan is about 200 mg/l, the survey results range from 73 to 1540mg/l and most of them exceed 500mg/l).

Table E-33: Water Use Amount and Pollution Loading

		Water Use ($l/m^2/day$)	Loading ratio ($g/m^2/day$)		
			BOD	COD	SS
Leon	M-1	7.8	9.9	20.6	9.8
	M-2	7.8	5.4	9.5	5.6
Chinandega	M-1	4.8	2.8	4.1	2.1
	M-2	4.5	0.3	0.5	0.5
Granada	M-1	8.4	4.6	5.5	7.5
	M-2	4.8	7.3	11.2	6.4
Average		6.4	5.1	8.6	5.3
Japan*		20.0	4.0	-	2.0

Japan* : sourceThe Building Center of Japan

d. Office

Table E-34 shows "water use amount (per floor area)" and "pollution loading (per floor area)" of offices obtained through the survey and an example of Japan. Water use ratios (per floor area) as well as BOD loading ratios (per floor area) in 3 cities range about 50% to 60% of that in Japan.

Table E-34: Water Use Amount and Pollution Loading

		Water Use ($l/m^2/day$)	Loading ratio ($g/m^2/day$)		
			BOD	COD	SS
Leon	O-1	24.5	1.3	3.4	0.7
	O-2	7.5	0.6	2.1	0.4
Chinandega	O-1	8.8	0.4	0.6	0.5
	O-2	2.9	0.0	0.0	0.1
Granada	O-1	5.1	2.0	3.2	1.7
	O-2	2.3	0.3	0.4	0.2
Average		8.5	0.8	1.9	0.7
Japan*		15.0	1.5	-	1.2

Japan* : sourceThe Building Center of Japan

ANNEX F

Waste Amount and Composition Survey (WACS)

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F Waste Amount and Composition Survey (WACS)

F.1 Objectives and Definitions

a. Objective of the Survey

Generally, quantity and composition of solid waste depend on characteristics of the city/area to be studied, such as, economic situation, lifestyle of the people, density of population, environmental consciousness, etc. Waste amount and composition survey (WACS) is considered fundamental in order to obtain basic necessary information on waste generation ratio, discharge and recycling amount, self - disposal and collection amount, and ultimately to clarify the waste stream in the study area for the correct planning of a solid waste management.

On the basis of information gathered during WACS, it can be acknowledged a true picture of solid waste situation in study area. A WACS, therefore, was carried out in August-September 1996 in order to obtain waste data in rainy season which is one of the main climatic feature in Nicaragua. Furthermore, the WACS was carried out again in January 1997 in order to obtain waste data for the dry season. The average data was determined by using both results.

b. Definitions of the Wastes

In order to clarify the contents of the WACS and the waste stream, the words used in the Study are defined as follows;

b.1 Household Waste

Waste generated in or discharged from each household including waste in shops. However, those generated through commercial activities are excluded.

b.2 Commercial Waste

Only refers to wastes generated and discharged from shops or any commercial activity. Shops include restaurants, stationery shops, grocery shops, etc.

b.3 Market Waste

Waste generated in or discharged from markets both for wholesale and retailing.

b.4 Institutional Waste

As for the institutional waste, government and state and private enterprises office waste are examined in the Study.

b.5 Street Sweeping Waste

Street sweeping waste includes all waste generated by the street sweeping cleansing service.

b.6 Bulky Waste

Abandoned bulky items (such as furniture and vehicles), which are discharged from the above-mentioned sources, is considered as bulky waste in the Study.

b.7 Other Waste

Other wastes in the Study are the wastes which are disposed of at the present disposal site in the Study area and are not considered as the MSW (item b.1 to b.6).

F.2 Method of the Survey

a. Method of the Waste Amount Survey

Waste amount survey used in this study was divided into the following two methods:

- Generation ratio survey at generation sources;
- Final disposal amount survey at the present landfill in each city

The method applied to the WACS is tabulated in Table F-1.

Table F-1: Method of the Waste Amount Survey

Category	Generation Ratio Survey	Disposal Amount Survey
MSW (Total)	X	X
Household Waste	X	
Commercial Waste	X	
Market Waste	X	
Institutional Waste	X	
Street Sweeping Waste	X	
Bulky Waste		X
Others (Total)		X

Note : The items marked "X" were surveyed in the Study.

b. Selection of Sampling Points for the Generation Ratio and Composition Survey

b.1 Category of Waste, Generation Sources and Sampling Quantity

In order to obtain a representative generation ratio for each category of waste, the category of waste, generation sources and sampling quantity for the WACS is summarized in Table F-2. Regarding bulky and other wastes, only their amount was studied through observation at the present landfill.

Table F-2: Category of Wastes, Generation Sources and Sampling Quantity for WACS

Category of Waste	Generation Sources	Sampling Area (Nos.) (a) Leon	(b) Chinandega	(c) Granada	(a)+(b)+(c) Number of Samples
Household Waste	High Income	5	5	5	15
	Middle Income	5	5	5	15
	Low Income	5	5	5	15
Commercial Waste	Restaurant	5	5	5	15
	Other Shop	5	5	5	15
Institutional Waste	Institution	2	2	2	6
Market Waste	Market	2	2	2	6
Street Sweeping Waste	Street Sweeping	2	2	2	6
	Total	31	31	31	93

b.1.1 Household Waste

Household waste generated at residential areas, was classified into the following three categories:

- household waste generated at high income residential areas
- household waste generated at middle income residential areas
- household waste generated at low income residential areas

The sampling areas for each category were selected from the study area in 3 cities (Leon, Chinandega and Granada) through a discussion between Nicaraguan side and the Study Team.

b.1.2 Commercial Waste

The composition of waste generated between restaurants and other shops was quite different. Therefore, commercial waste was classified into two categories, i.e., restaurant waste and that of other shops.

The sampling area for commercial waste was selected from each city.

b.1.3 Market Waste

Two sampling areas were selected in each city taking into account the following aspects about their waste collection.

- The amount of waste generated at one market should be less than one truck.
- The composition of the waste generated at one market should not be mixed with other waste.

b.1.4 Institutional Waste

The sampling areas for the institutional waste were selected from government and state enterprises in each city.

b.1.5 Street Sweeping Waste

Two streets were selected in each city as sampling points. One was a main street in city center and the other a street in the residential area.

b.2 Sampling Points

Lists of sampling points for the waste amount and composition survey for 3 cities and the locations of the sampling points in each cities are shown in Annex A.

c. Method of the Generation Ratio and Composition Survey

The method of the survey is tabulated in Table F-3. Considering the daily fluctuation in the generation of waste, the survey was conducted for 8 continuous days in each city. The data of the first day was used only as a reference.

Table F-3: Method of the Survey

Generation Source	Collection of Samples	Waste Amount Survey	Waste Composition Survey
Household (High Income)	by plastic bag	by spring balance	Analysis Items :
Household (Middle Income)	by plastic bag	by spring balance	-ASG (Apparent Specific Gravity)
Household (Low Income)	by plastic bag	by spring balance	- Physical Composition by wet base
Commercial	by plastic bag	by spring balance	(kitchen waste, paper, textile, plastic, glass, grass and wood,
Shop	by plastic bag	by spring balance	leather and rubber, metal,
Institution	by collection truck	by weighbridge	ceramic
Market			and stone, other)
Street Sweeping	by plastic bag	by spring balance	-

c.1 Method of the Generation Ratio Survey

c.1.1 Collection of Samples

Before the execution of the WACS, the required numbers of plastic bags were distributed to residences, shops and offices selected as sampling points.

Samples discharged from markets were collected by a collection truck.

c.1.2 Waste Amount Survey

The amount of waste was measured in each sampling point by weighing the plastic bags containing the samples with a spring balance. Then, when a sample was collected, the mouth of the plastic bag was bound with color strings which classified it according to generation sources. The samples transported by collection truck were measured at the truck scale of a private company in each city before going to disposal site.

c.2 Method of the Waste Composition Survey

c.2.1 Sampling Method

The composition of the waste in wet base was measured in rainy season according to the following eight categories :

- household waste (high income)
- household waste (middle income)
- household waste (low income)
- commercial waste (restaurant)
- commercial waste (other shop)
- institutional waste
- market waste
- street sweeping waste

All samples from each category of waste were gathered and mixed together. Then, the volume of the mixture of waste was reduced through the reducing method described below until the volume became 30 to 50 litters, as shown in Figure F-1.

i. Mixing

When the waste contained large size items (e.g., cardboard, textile etc.) those items were divided and mixed again.

ii. Dividing

Once the waste was mixed well it was divided into four blocks with approximately the same volume.

iii. Reducing

The two blocks of waste at diagonally opposite ends were removed and the remaining waste was mixed again.

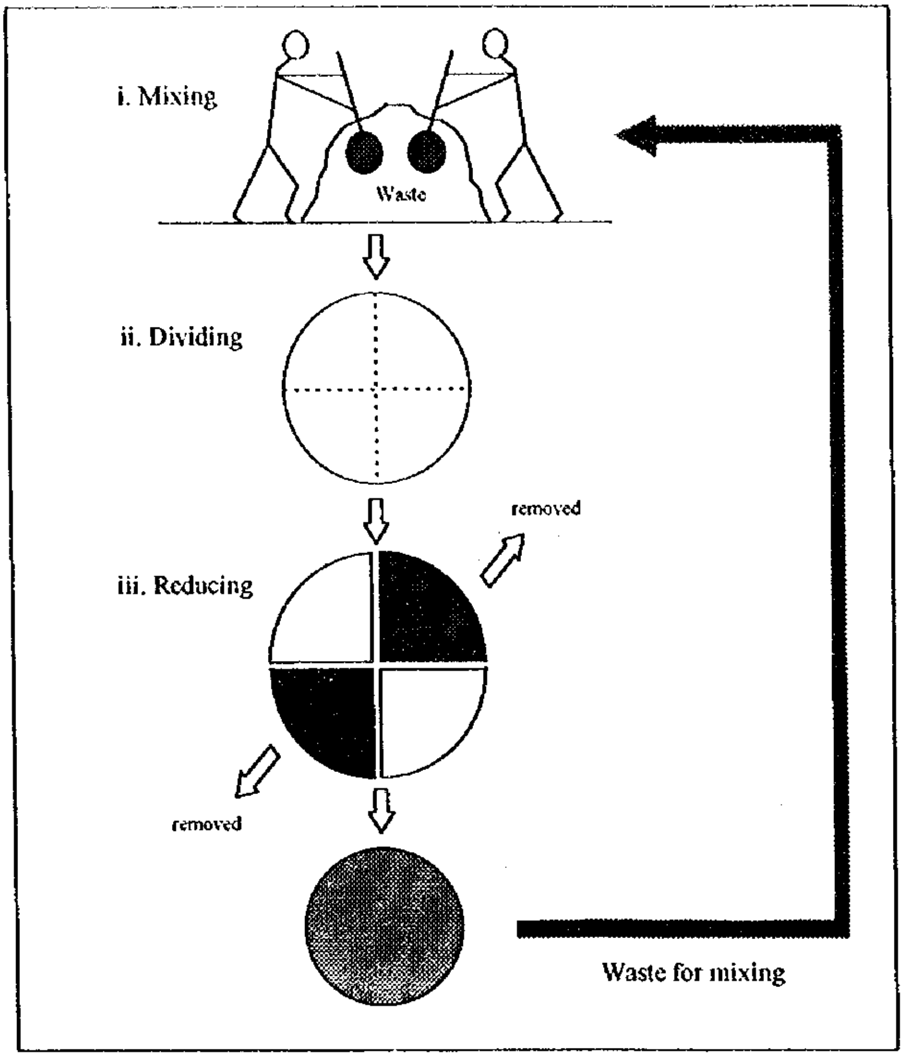

Figure F-1: Waste Reduction Method

The above method continued until the volume of the remaining waste was reduced to the amount designated for the waste composition analysis (20 to 30 litters). Then, the waste was loaded into a plastic bucket.

The plastic bucket containing the waste was tapped three times from a height of 30 centimeters to the ground, then the volume was measures visually and the weight by a platform balance.

The ASG (Apparent Specific Gravity) was calculated through the following formula.

$$ASG = \frac{Weight\ of\ Waste\ (Kg)}{Volume\ of\ Waste\ (l)}$$

After the ASG was measured, the waste underwent the composition survey. The physical composition was measured in wet base. The items of the waste composition survey are shown as below:

- kitchen waste
- paper
- textile
- plastic
- grass and wood
- leather and rubber
- metal
- glass
- ceramic and stone
- other (soil, etc.)

The results of the physical composition are presented as percentages.

d. Period and Schedule of the Survey

The survey was conducted during the rainy season, from the 28th August to 20th September 1996.

The schedule of the survey in rainy season and dry season is shown in Table F-4.

Table F-4: Survey Period of the WACS

Items	Survey Period					
	Leon		Chinandega		Granada	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Delivery of plastic bags and instruction papers	Sep. 3rd	Jan. 20th	Aug. 26th	Jan. 19th	Sep. 11th	Jan. 21st
Waste collection from each generation source	Sep. 4th-Sep. 11th	Jan. 21st-Jan. 28th	Aug. 27th-Sep. 3rd	Jan. 20th-Jan. 27th	Sep. 12th-Sep. 19th	Jan. 22nd-Jan. 29th
Waste amount measurement and waste composition analysis	Sep. 5th-Sep. 12th	Jan. 22nd-Jan 29th	Aug. 28th-Sep. 4th	Jan. 21st-Jan. 28th	Sep. 13th-Sep. 20th	Jan. 23rd-Jan. 30th

F.3 Results of the Survey

a. Waste Amount

a.1 Household Waste

A summary of the results of the waste amount survey both in rainy and dry season is tabulated in Table F-5.

The detail results of the waste amount survey in Leon, Chinandega and Granada are shown in Chapter 2 of Data book.

Table F-5: Generation Ratio of Household Waste

Unit : g/person/day

Items	Generation Ratio					
	Leon		Chinandega		Granada	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
High	765	907	545	672	770	870
Middle	590	816	609	621	630	776
Low	745	780	720	574	518	685
Weighted Average	668	803	658	601	584	738

a.1.1 Leon

The waste generation ratio differs in accordance with the income levels. Furthermore, in accordance with the season, the waste generation ratio of household waste in dry season is more than rainy season in all income levels.

The average generation ratio for high income in rainy season was 765 g/person/day, middle income was 590 g/person/day and low income was 745 g/person/day, while 907 g/person/day, 816 g/person/day and 780 g/person/day respectively in dry season.

The weighted average of household waste in Leon in dry season is higher than rainy season. This due to the percentage of waste composition of kitchen waste has been increased in all income levels. Because fruit is more available in dry season and price is also cheaper than rainy season.

a.1.2 Chinandega

The waste generation ratio differs in accordance with the income levels. The waste generation ratios in high income and middle income are noticeably more than low income.

The average generation ratio in rainy season for high income was 545 g/person/day, middle income was 609 g/person/day and low income was 720 g/person/day, while 672 g/person/day, 621 g/person/day and 574 g/person/day respectively in dry season. The weighted average in dry season is higher than rainy season in high income and middle income residences while in low income is lower than.

a.1.3 Granada

The average generation ratio for high income in rainy season was 770 g/person/day, middle income was 630 g/person/day and low income was 518 g/person/day. In dry season, average generation ratio in high income, middle income and low income was 870 g/person/day, 776 g/person/day and 685 g/person/day respectively.

The weighted average of household waste in dry season in Granada is also higher than rainy season due to the consumption of fruit as same as Leon.

a.2 Commercial, Institutional, Market and Street Sweeping Waste

A summary of the results of waste amount survey in rainy and dry season is tabulated in Table F-6.

Table F-6: Generation Ratio of Commercial, Institutional, Market and Street Sweeping Waste

Unit : g

Items	Generation Ratio					
	Leon		Chinandega		Granada	
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season
Commercial Waste (Restaurant)	21,021	16,457	15,029	15,040	12,577	10,529
Commercial Waste (Other)	2,143	2,254	1,071	1,089	1,634	1,863
Institutional Waste	188	155	73	104	29	38
Market Waste	1,540	3,090	3,350	3,550	2,580	2,850
Street Sweeping Waste	20,900	25,870	13,850	26,500	70,530	62,410

For commercial waste, the average generation ratio during rainy and dry season of 3 cities does not much differ by season. Anyhow, the average generation ratios of restaurant and other shop in Leon are more than the other 2 cities both in rainy and dry season.

The average generation ratio for commercial waste (restaurant) in Leon, Chinandega and Granada in rainy season was 21,021 g/shop/day, 15,029 g/shop/day and 12,577 g/shop/day respectively, while in dry season was 16,457 g/shop/day, 15,040 g/shop/day and 10,529 g/shop/day.

The reason why waste amount in commercial shop may be different greatly among 3 cities due to the selection of sampling points. It is quite difficult to select the samples with same conditions in each city such as floor area, no. of employees, popularity of the shop, etc.

Institutional waste in Leon is also the highest among 3 cities (188 g/person/day in rainy season and 155 g/person/day in dry season) which the lowest is Granada (29 g/person/day in rainy season and 38 g/person/day in dry season).

On the other hand, the average generation ratio for market waste in Chinandega is more than in Leon in rainy and dry season. The average generation ratio for market waste in Chinandega was 3,350 g/shop/day in rainy season and 3,550 g/shop/day in dry season while in Leon in rainy season was 1,540 g/shop/day and 3,090 g/shop/day in dry season. The average generation ratio of market waste in Granada was 2,580 g/shop/day in rainy season and 2,850 g/shop/day in dry season.

For street sweeping waste, the average generation ratio in Granada is quiet more than the other 2 cities. The average generation ratio in Granada for street sweeping waste was 70,530 g/km/day in rainy season and 62,410 g/km/day in dry season while the average generation ratios in Leon and Chinandega are less than 30,000 g/km/day in both seasons.

b. Waste Composition

The detail results of the waste composition survey in Leon, Chinandega and Granada are shown in Annex A.

b.1 Household Waste

b.1.1 Leon

The results of the waste composition survey in Leon in rainy and dry season are tabulated in Table F-7 and Table F-8.

The characteristics of the composition of the household waste in Leon are described as follows;

The results of household waste composition in Leon are similar to Chinandega.

- The kitchen waste occupies the largest percentage of the composition both in rainy and dry season in high income and middle income residences. In rainy season, kitchen waste was about 52% and 30% in high income and middle income respectively. While in dry season, kitchen waste still occupies 67% and 41% in high income and middle income residences. Meanwhile, the garden waste, which consists of grass/wood and others, occupies the largest percentage in low income residences about 81% in rainy season and 60% in dry season. The largest components of "others" were soil and sand accumulated from gardening and cleaning works. According to the interview survey to the sampling points after WACS, all of low income residences recycle food waste by feeding their own animals or give to other persons. That is the answer why kitchen waste composition in low income residences is only 6% in rainy season and 17% in dry season.

- The reason why low income discharges garden waste (such as grass and wood) and cleaning wastes (soils, etc.) more than high and middle income is the high income residents live in city center without or with small garden while low income residences live in surrounding area of the city (urbanfrindge area) with normally , with large garden and unpaved road. Furthermore, almost of the house of low income residences are not well-paved floor. When the low income residences, therefore, clean their premises daily that increase not only waste amount but also others (soils, etc.) component of waste composition.

- The paper, plastic components occupy a larger percentage of the composition in high income and middle income residences than in low income ones both in rainy and dry season.

Table F-7: Results of the Waste Composition Survey in Rainy Season in Leon

				Household				Commercial		Institution	Market
				High Inc.	Middle Inc.	Low Inc.	Weighted Avg.	Restaurant	Others		
Physical Composition (wet base)	Apparent Specific Gravity		(kg/l)	0.29	0.16	0.35	0.25	0.47	0.15	0.08	0.30
	Combustibles	Kitchen waste	%	52.53	30.83	6.49	20.50	70.94	35.14	17.08	40.54
		Paper	%	9.83	9.52	1.63	5.90	8.09	19.04	66.49	19.95
		Textile	%	2.36	1.92	0.51	1.29	0.23	1.85	1.45	0.45
		Plastic	%	5.35	6.52	3.70	5.18	2.91	7.83	7.49	7.34
		Grass and wood	%	18.57	28.91	66.63	45.85	6.69	17.69	3.15	24.87
		Leather and rubber	%	7.38	14.79	1.33	8.30	0.25	3.79	0.00	0.45
		Sub-total	%	96.02	92.49	80.29	87.02	89.11	85.34	95.66	93.60
	Incombustibles	Metal	%	1.49	2.42	1.29	1.86	3.82	3.03	1.97	1.98
		Glass	%	0.91	1.75	1.43	1.57	4.95	1.26	0.00	0.84
		Ceramic and Stone	%	0.46	1.84	1.22	1.50	1.49	3.29	1.58	2.44
		Others (soil, etc.)	%	1.12	1.50	15.77	8.05	0.63	7.08	0.79	1.14
		Sub-total	%	3.98	7.51	19.71	12.98	10.89	14.66	4.34	6.40
	Total		%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table F-8: Results of the Waste Composition Survey in Dry Season in Leon

				Household				Commercial		Institution	Market
				High Inc.	Middle Inc.	Low Inc.	Weighted Avg.	Restaurant	Others		
Physical Composition (wet base)	Apparent Specific Gravity		(kg/l)	0.32	0.29	0.28	0.29	0.51	0.15	0.08	0.34
	Combustibles	Kitchen waste	%	67.37	41.94	17.57	31.75	86.81	21.84	20.51	44.51
		Paper	%	10.81	4.01	2.52	3.60	3.75	30.48	58.09	6.80
		Textile	%	0.96	2.71	2.98	2.76	0.77	2.78	2.68	7.30
		Plastic	%	5.45	6.39	4.47	5.47	2.44	6.26	12.10	7.37
		Grass and wood	%	7.70	20.39	30.79	24.67	0.71	20.28	2.93	22.66
		Leather and rubber	%	3.59	5.87	1.26	3.66	0.05	9.15	0.13	0.50
		Sub-total	%	95.88	81.31	59.59	71.90	94.53	90.79	96.44	89.14
	Incombustibles	Metal	%	1.80	1.27	2.06	1.65	2.48	2.78	1.78	1.05
		Glass	%	1.35	0.49	1.76	1.11	2.21	0.58	0.38	0.67
		Ceramic and Stone	%	0.55	4.11	6.99	5.29	0.39	1.33	0.38	2.89
		Others (soil, etc.)	%	0.42	12.82	29.60	20.04	0.39	4.52	1.02	6.25
		Sub-total	%	4.12	18.69	40.41	28.10	5.47	9.21	3.56	10.86
	Total		%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

b.1.2 Chinandega

The results of the waste composition survey in Chinandega both in rainy and dry season are tabulated in Table F-9 and Table F-10.

The characteristics of the composition of the household waste in Chinandega are described as follows;

- The kitchen waste in dry season, same as rainy season, occupies the largest percentage of the composition about 76% and 51% in high income and middle income respectively. The garden waste, which consists of grass/wood and others (soil, etc. are normally generated by cleaning work of garden, etc.), occupies the large percentage component in middle and low income levels both in rainy and dry season. Meanwhile, grass/wood component occupies the largest percentage in low income residences for 51% in rainy season and 43% in dry season while kitchen waste occupies 25% of waste in rainy season and 30% in dry season. According to the interview survey to the sampling points after WACS, some low income residences use their food waste to feed animals.
- For grass/wood, the reason why low income residences generate higher amount of garden waste than high income residences is because the most of high income level lives in the area of the city while low income lives in the suburb area.
- The paper and plastic components occupy a larger percentage of the composition in high income residences than in low income ones both in rainy and dry season. On the other hand, ceramic/stone occupies a lower percentage of the composition in high income residences than in the low income ones both in rainy and dry season.

Table F-9: Results of the Waste Composition Survey in Rainy Season in Chinandega

				Household				Commercial		Institution	Market
				High Inc.	Middle Inc.	Low Inc.	Weighted Avg.	Restaurant	Others		
Physical Composition (wet base)	Apparent Specific Gravity		(kg/l)	0.22	0.23	0.19	0.21	0.29	0.05	0.04	0.34
	Combustibles	Kitchen waste	%	66.30	44.55	25.35	36.59	54.13	34.30	12.64	24.65
		Paper	%	8.55	3.67	1.22	2.74	6.88	29.74	66.21	11.02
		Textile	%	1.46	1.69	2.02	1.83	0.14	2.48	2.47	2.14
		Plastic	%	6.65	3.67	2.57	3.28	2.68	10.53	10.16	5.83
		Grass and wood	%	9.69	36.97	51.62	42.62	21.50	11.78	1.65	46.88
		Leather and rubber	%	0.57	0.17	2.26	1.15	0.00	1.86	1.37	0.18
		Sub-total	%	93.22	90.72	85.04	88.21	85.33	90.69	94.50	90.70
	Incombustibles	Metal	%	2.47	1.11	1.22	1.22	2.54	2.69	5.50	0.97
		Glass	%	3.61	0.70	0.00	0.49	2.49	1.86	0.00	0.48
		Ceramic and Stone	%	0.19	4.90	6.96	5.66	4.98	3.93	0.00	4.86
		Others (soil, etc.)	%	0.51	2.57	6.78	4.42	4.66	0.83	0.00	2.99
		Sub-total	%	6.78	9.28	14.96	11.79	14.67	9.31	5.50	9.30
	Total		%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table F-10: Results of the Waste Composition Survey in Dry Season in Chinandega

				Household				Commercial		Institution	Market
				High Inc.	Middle Inc.	Low Inc.	Weighted Avg.	Restaurant	Others		
Physical Composition (wet base)	Apparent Specific Gravity		(kg/l)	0.24	0.15	0.17	0.16	0.28	0.04	0.04	0.32
	Combustibles	Kitchen waste	%	76.46	51.76	30.84	43.12	76.04	29.98	6.29	37.38
		Paper	%	5.78	1.05	0.71	1.08	3.06	33.00	79.98	4.26
		Textile	%	0.21	0.91	1.23	1.03	0.39	5.84	2.29	0.47
		Plastic	%	5.10	3.16	1.23	2.35	2.00	13.88	7.43	6.84
		Grass and wood	%	1.57	27.53	43.41	33.80	14.12	13.48	0.00	35.51
		Leather and rubber	%	0.25	0.07	0.19	0.13	0.00	0.60	0.29	0.28
		Sub-total	%	89.37	84.48	77.61	81.52	95.61	96.78	96.28	84.74
	Incombustibles	Metal	%	3.70	2.39	0.65	1.64	1.61	1.61	3.43	0.82
		Glass	%	5.06	1.62	0.90	1.43	1.78	1.01	0.00	0.69
		Ceramic and Stone	%	1.53	7.37	9.03	7.90	0.17	0.20	0.00	5.93
		Others (soil, etc.)	%	0.34	4.14	11.81	7.52	0.83	0.40	0.29	7.82
		Sub-total	%	10.63	15.52	22.39	18.48	4.39	3.22	3.72	15.26
	Total		%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

b.1.3 Granada

The results of the waste composition survey in Granada in rainy season and dry season are shown in Table F-11 and Table F-12 respectively.

The characteristics of the composition of the household waste in Granada are described as follows;

- The kitchen waste occupies the largest percentage of the composition in high income, middle income and low income residences about 64%, 40% and 44% in rainy season and 72%, 65% and 44% in dry season respectively. According to the interview survey to sampling points after WACS, some sampling points in all income residences use their food waste to feed animal.
- Grass/wood components occupy the large percentage in low income residences while paper component occupies the large percentage in high income level and plastic component occupies the large percentage in middle income. This is because the high income residences live in the city center while low income people reside in the outside of the city.
- The garden waste in dry season which consists of grass/wood and other, occupies about 44% of the waste in low income residences while in high income level is only 6%.

Table F-11: Results of the Waste Composition Survey in Rainy Season in Granada

				Household				Commercial		Institution	Market
				High Inc.	Middle Inc.	Low Inc.	Weighted Avg.	Restaurant	Others		
Physical Composition (wet base)	Apparent Specific Gravity		(kg/l)	0.23	0.25	0.22	0.24	0.36	0.07	0.04	0.43
	Combustibles	Kitchen waste	%	64.54	40.24	44.60	43.22	74.73	20.79	29.18	74.08
		Paper	%	14.24	10.68	1.32	6.52	7.36	32.57	46.36	3.53
		Textile	%	4.87	4.55	0.44	2.67	0.58	2.95	3.43	0.16
		Plastic	%	5.52	7.95	2.01	5.12	2.40	10.92	7.30	3.93
		Grass and wood	%	3.14	27.07	32.89	28.79	8.85	7.28	4.29	9.43
		Leather and rubber	%	0.00	0.91	0.13	0.51	0.00	0.87	0.86	3.93
		Sub-total	%	92.30	91.40	81.39	86.83	93.92	75.38	91.42	95.06
	Incombustibles	Metal	%	1.52	1.90	0.94	1.44	1.71	7.97	4.29	0.96
		Glass	%	2.06	1.24	0.31	0.85	0.36	11.79	0.00	0.56
		Ceramic and Stone	%	2.98	3.89	10.06	6.69	3.35	1.39	0.00	2.32
		Others (soil, etc.)	%	1.14	1.57	7.30	4.19	0.66	3.47	4.29	1.10
		Sub-total	%	7.70	8.60	18.61	13.17	6.08	24.62	8.58	4.94
	Total		%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table F-12: Results of the Waste Composition Survey in Dry Season in Granada

				Household				Commercial		Institution	Market
				High Inc.	Middle Inc.	Low Inc.	Weighted Avg.	Restaurant	Others		
Physical Composition (wet base)	Apparent Specific Gravity		(kg/l)	0.32	0.30	0.20	0.25	0.40	0.08	0.03	0.53
	Combustibles	Kitchen waste	%	72.32	65.88	44.82	56.45	81.84	33.42	15.65	80.20
		Paper	%	12.51	6.33	0.86	4.06	5.10	33.42	71.76	3.85
		Textile	%	1.80	1.87	0.59	1.28	0.09	5.22	4.96	0.23
		Plastic	%	4.63	11.40	2.65	7.10	2.69	11.37	4.20	6.24
		Grass and wood	%	6.26	7.46	37.04	21.02	7.62	4.31	0.38	2.61
		Leather and rubber	%	0.00	0.12	0.00	0.06	0.06	0.65	0.76	0.99
		Sub-total	%	97.52	93.06	85.96	89.97	97.40	88.39	97.71	94.12
	Incombustibles	Metal	%	0.77	0.69	0.86	0.77	1.04	4.44	2.29	0.72
		Glass	%	0.60	2.23	0.27	1.26	0.46	5.35	0.00	1.13
		Ceramic and Stone	%	0.81	2.19	5.67	3.74	0.84	0.91	0.00	2.90
		Others (soil, etc.)	%	0.30	1.83	7.24	4.26	0.26	0.91	0.00	1.13
		Sub-total	%	2.48	6.94	14.04	10.03	2.60	11.61	2.29	5.88
	Total		%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

b.2 Commercial Waste

The characteristics of the composition of the commercial waste in each city are as follows:

b.2.1 Leon

- Kitchen waste in rainy and dry season occupies about 70% and 86% of waste in restaurant. According to the interview survey to samplings points after WACS, only one restaurant recycle food waste by selling to other persons.
- In other shop waste, kitchen waste occupies about 35% and 21% of waste in rainy season and dry season respectively. Paper component occupies about 19% of waste in rainy season while in dry season is 30%.

b.2.2 Chinandega

- Kitchen waste occupies about 54% of waste in restaurant in rainy season and 76% in dry season. According to the interview survey to samplings points after WACS, almost of restaurants recycle food waste by giving to other persons to feed their animals.
- Kitchen waste occupies the largest components about 34% in other shops while paper occupies 29% in rainy season. On the other hand, paper occupies the largest percentage by 33% of waste following by kitchen waste 29% in dry season

b.2.3 Granada

- Kitchen waste in rainy and dry season occupies about 74% and 81% of waste in restaurant. According to the interview survey to sampling points after WACS, only 2 restaurants recycle their food waste by giving to other persons for feeding animals.
- Paper and kitchen waste occupy the same amount about 33% of waste in other shops in dry season.

b.3 Other Wastes

The characteristics of the composition of other waste in each city are summarized as follows:

b.3.1 Leon

- Paper occupies about 66% and 58% in rainy and dry season in institutional waste respectively.
- Kitchen waste, grass/wood and paper components in dry season occupy 44%, 22% and 6% in market waste respectively.

b.3.2 Chinandega

- Paper occupies about 66% in rainy season and 79% in dry season for institutional waste.
- Kitchen waste, grass/wood and plastic components occupy 37%, 35% and 6% in market waste in dry season respectively.

b.3.3 Granada

- Paper occupies about 46% in rainy season and 71% in dry season in institutional waste.
- Kitchen waste, grass/wood occupy 74% and 9% in rainy season while 80% and 2% in dry season in market waste respectively.

c. Apparent Specific Gravity (ASG)

c.1 Leon

Almost ASG in dry season was higher than in rainy season except low income which was lower and others shop and institution which were equal.

ASG of household waste, restaurant and market in rainy season was 0.27, 0.47 and 0.30 kg/l while in dry season was 0.30, 0.51 and 0.34 kg/l respectively. ASG of institutional waste was 0.08 and 0.15 for other shops waste both in rainy and dry season.

c.2 Chinandega

Almost ASG in dry season was lower than in rainy season except high income which was higher and institution which was equal.

ASG of household waste, restaurant and market in rainy season was 0.21, 0.29 and 0.34 kg/l while in dry season was 0.19, 0.28 and 0.32 kg/l respectively. ASG of institutional waste was 0.04 both in rainy and dry season.

c.3 Granada

Almost ASG in dry season was higher than in rainy season except low income and institution which were lower.

ASG of household waste, restaurant and market in rainy season was 0.24, 0.36 and 0.43 kg/l while in dry season was 0.27, 0.40 and 0.53 kg/l respectively. ASG of institutional waste was 0.04 in rainy season and 0.03 in dry season. For other shops waste, ASG was 0.07 kg/l in rainy season and 0.08 kg/l in dry season.

F.4 Findings of the Survey

a. Waste Amount

a.1 Generation Ratio

a.1.1 Household Waste

i. Population by Income Level

According to the data obtained from each municipality in the Study Area, the number of population by income level is shown in Table F-13.

Table F-13: Population by Income Level in the Study Area in 1996

Category	Leon		Chinandega		Granada	
	Population	Rate	Population	Rate	Population	Rate
High income	4,955	4.0%	3,895	4.0%	2,656	3.7%
Middle income	61,437	49.6%	48,694	50.0%	36,179	50.4%
Low income	57,473	46.4%	44,798	46.0%	32,948	45.9%
Total	123,865	100%	97,387	100%	71,783	100%

Source : Total population : Calculation is based on Censos Nacionales 1995, Instituto Nacional De Estadisticas y Censos (INEC) multiply by population growth rate which forecasted by the Study Team.
Percentage of Population by Income level : Data supplied by each municipality

As the results, the Study Team set up the population ratio by income level in this study as follows:

Category	Leon	Chinandega	Granada
High income	4%	4%	4%
Middle income	50%	50%	50%
Low income	46%	46%	46%

ii. Generation Ratio Obtained from WACS

Generation ratio obtained from WACS is tabulated in Table F-14. The Study Team decided to use the average rate of 3 cities because the number of sampling points is small and there are no significant differences identified in the data both in rainy and dry season.

Table F-14: Generation Ratio of Household Waste Obtained from WACS

Unit : g/person/day

Items	Generation Ratio						Average
	Leon		Chinandega		Granada		
	Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	
High	765	907	545	672	770	870	755
Middle	590	816	609	621	630	776	674
Low	745	780	720	574	518	685	670

iii. Generation Ratio

Since the population ratio by income level is the same in 3 cities, a weighted average of generation ratio in each municipality was calculated as shown below:

$$755 \times 0.04 + 674 \times 0.50 + 670 \times 0.46 \quad = \quad 675 \text{ g/person/day}$$

Accordingly, the generation ratios were 675 g/person/day in Leon, Chinandega and Granada.

The generation ratio of household waste in the Study Area, 675 g/person/day, is a normal in comparison with those of the other countries and almost equal with Managua, Nicaragua as shown in Table F-15.

Table F-15: Comparison of Generation of Household Waste in the Study Area and Other Study

Country	City	Year	Population	Household waste (g/person/day)	MSW (g/person/day)
Tanzania*1	Dar es Salaam	1996	2,030,230	698	916
Nicaragua*2	Managua	1994	834,427	664	798
Paraguay*3	Asuncion	1993	506,445	961	1,312
Poland*4	Poznan	1992	590,500	654	769
	Lublin	1992	352,500	400	508
Laos*5	Vientiane	1991	142,700	753	987
Malaysia*6	Pulau Pinang	1988	559,300	504	640

Source : *1 The Study on Solid Waste Management for Dar es Salaam City in the United Republic of Tanzania, Progress Report (2), August 1996

*2 The Study on the Solid Waste Management System of the City of Managua, Final Report, May 1995.

*3 The Study on the Solid Waste Management for the Metropolitan Area of Asuncion in the Republic of Paraguay, Progress Report (2), March 1994.

*4 The Study on the Solid Waste Management for Poznan City, the Republic of Poland, Final Report, May 1993.

*5 The Study on the Solid Waste Management System Improvement Project in Vientiane, Lao People's Democratic Republic, Final Report, August 1992.

*6 The figure is not generation ratio but disposal amount from "Solid Waste Management Study for Pulau Pinang and Seberang Perai Municipalities, Final Report, August 1989"

a.1.2 Commercial, Market, Institution and Street Sweeping Waste

As the same reason as the household waste, the Study Team adopted the average generation ratios among 3 cities in commercial, market, institution and street sweeping waste for the generation ratio in the Study Area.

Generation ratios of each category of waste are shown in Table F-16.

Table F-16: Generation Ratio of Commercial Shop, Institution, Market and Street Sweeping Waste

Unit : g

Items	Unit	Generation Ratio						Average
		Leon		Chinandega		Granada		
		Rainy Season	Dry Season	Rainy Season	Dry Season	Rainy Season	Dry Season	
Commercial Waste (Restaurant)	g/shop/day	21,021	16,457	15,029	15,040	12,577	10,529	15,109
Commercial Waste (Other)	g/shop/day	2,143	2,254	1,071	1,089	1,634	1,863	1,676
Institutional Waste	g/person/day	188	155	73	104	29	38	98
Market Waste	g/shop/day	1,540	3,090	3,350	3,550	2,580	2,850	2,827
Street Sweeping Waste	g/km/day	20,900	25,870	13,850	26,500	70,530	62,410	36,677

a.1.3 Bulky Waste

At present, bulky waste is hauled by the producer personally because there are no bulky waste collection services and its generation ratio is quite small. In addition, bulky items are generally recycled and reused in the Study Area. Therefore, the amount of the bulky waste among directly hauled wastes by private sector to the disposal site was observed for 2 times (each time 7 days) during August-September 1996 and January 1997. According to the observation, the Study Team could not find any bulky waste. Therefore, the amount of bulky waste in the Study Area is considered negligible.

a.1.4 Determination Number of Generation Sources

Population, number of shops, number of public officers and length of streets swept in the Study Area were obtained from counterparts and observed by the Study Team. The results are shown in Table F-17.

Table F-17: Number of Population, Shops, Public Officers and Length of Street Swept in 1996

Category	No. of Unit		
	Leon	Chinandega	Granada
Population	123,865	97,387	71,783
Commercial Shop (Restaurant)	77	41	45
Commercial Shop (Other)	740	465	471
Institution	2,379	1,577	1,692
Market	2,500	1,732	933
Street Sweeping	55	45	35

Source: Data supplied by each municipality and observed by the Study Team

b. Waste Composition

The physical composition, ASG of household waste was calculated, taking the weighted average into consideration, in accordance with the following population ratios:

- Population ratio

High income	4%
Middle income	50%
Low income	46%

- Weighted average

Because the population ratio by income level in Leon, Chinandega and Granada is the same, the Study Team calculated the physical composition ratio of 3 cities as follows:

Average physical composition in high income areas	X 0.04 +	Average physical composition in middle income areas	X 0.50 +	Average physical composition in low income areas	X 0.46

The waste composition results in Leon, Chinandega and Granada are summarized in Table F-18, Table F-19 and Table F-20 respectively.

Table F-18: Results of the Waste Composition Survey in Leon

				Household				Commercial		Institution	Market	MSW*
				High Inc.	Middle Inc.	Low Inc.	Weighted Avg.	Restaurant	Others			
Physical Composition (wet base)	Apparent Specific Gravity		(kg/l)	0.31	0.23	0.32	0.27	0.49	0.15	0.08	0.32	0.28
	Combustibles	Kitchen waste	%	59.95	36.39	12.03	26.13	78.87	28.49	18.79	42.52	27.98
		Paper	%	10.32	6.77	2.08	4.75	5.92	24.76	62.29	13.38	5.80
		Textile	%	1.66	2.32	1.75	2.03	0.50	2.32	2.06	3.86	2.15
		Plastic	%	5.40	6.45	4.09	5.32	2.68	7.04	9.79	7.36	5.47
		Grass and wood	%	13.13	24.64	48.71	35.26	3.70	18.98	3.04	23.77	33.75
		Leather and rubber	%	5.48	10.33	1.30	5.98	0.15	6.47	0.07	0.48	5.50
		Sub-total	%	95.94	86.90	69.96	79.47	91.82	88.06	96.04	91.37	80.65
	Incombustibles	Metal	%	1.65	1.85	1.67	1.76	3.15	2.91	1.88	1.52	1.77
		Glass	%	1.13	1.12	1.59	1.34	3.58	0.92	0.19	0.76	1.31
		Ceramic and Stone	%	0.51	2.97	4.10	3.39	0.94	2.31	0.98	2.66	3.29
		Others (soil, etc.)	%	0.77	7.16	22.68	14.04	0.51	5.80	0.91	3.69	12.98
		Sub-total	%	4.06	13.10	30.04	20.53	8.18	11.94	3.96	8.63	19.35
	Total		%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Waste composition of MSW is calculated from composition ratio multiplied total amount of waste in each category divided by total amount of waste generation

Table F-19: Results of the Waste Composition Survey in Chinandega

				Household				Commercial		Institution	Market	MSW*
				High Inc.	Middle Inc.	Low Inc.	Weighted Avg.	Restaurant	Others			
Physical Composition (wet base)	Apparent Specific Gravity		(kg/l)	0.23	0.19	0.18	0.19	0.28	0.05	0.04	0.33	0.21
	Combustibles	Kitchen waste	%	71.38	48.15	28.09	39.86	65.08	32.14	9.47	31.01	39.34
		Paper	%	7.16	2.36	0.97	1.91	4.97	31.37	73.09	7.64	2.77
		Textile	%	0.84	1.30	1.63	1.43	0.27	4.16	2.38	1.31	1.45
		Plastic	%	5.87	3.42	1.90	2.82	2.34	12.20	8.79	6.33	3.15
		Grass and wood	%	5.63	32.25	47.51	38.21	17.81	12.63	0.82	41.19	37.88
		Leather and rubber	%	0.41	0.12	1.23	0.64	0.00	1.23	0.83	0.23	0.62
		Sub-total	%	91.29	87.60	81.33	84.86	90.47	93.73	95.38	87.71	85.21
	Incombustibles	Metal	%	3.09	1.75	0.94	1.43	2.08	2.15	4.47	0.90	1.42
		Glass	%	4.33	1.16	0.45	0.96	2.14	1.44	0.00	0.59	0.95
		Ceramic and Stone	%	0.86	6.13	7.99	6.77	2.57	2.06	0.00	5.40	6.59
		Others (soil, etc.)	%	0.43	3.36	9.29	5.97	2.74	0.62	0.15	5.40	5.83
		Sub-total	%	8.71	12.40	18.67	15.14	9.53	6.27	4.62	12.29	14.79
	Total		%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Waste composition of MSW is calculated from composition ratio multiplied total amount of waste in each category divided by total amount of waste generation

Table F-20: Results of the Waste Composition Survey in Granada

				Household				Commercial		Institution	Market	MSW*
				High Inc.	Middle Inc.	Low Inc.	Weighted Avg.	Restaurant	Others			
Physical Composition (wet base)	Apparent Specific Gravity		(kg/l)	0.28	0.28	0.21	0.25	0.38	0.08	0.04	0.48	0.26
	Combustibles	Kitchen waste	%	68.42	53.07	44.71	49.84	78.28	27.11	22.41	77.14	51.28
		Paper	%	13.37	8.50	1.09	5.29	6.23	32.99	59.06	3.69	5.78
		Textile	%	3.34	3.21	0.52	1.98	0.34	4.09	4.20	0.20	1.90
		Plastic	%	5.07	9.68	2.33	6.11	2.55	11.14	5.75	5.08	6.09
		Grass and wood	%	4.70	17.26	34.97	24.90	8.24	5.79	2.34	6.02	23.32
		Leather and rubber	%	0.00	0.52	0.06	0.29	0.03	0.76	0.81	2.46	0.41
		Sub-total	%	94.90	92.24	83.68	88.41	95.67	81.88	94.57	94.59	88.78
	Incombustibles	Metal	%	1.15	1.29	0.90	1.11	1.37	6.21	3.29	0.84	1.15
		Glass	%	1.33	1.73	0.29	1.05	0.41	8.57	0.00	0.84	1.14
		Ceramic and Stone	%	1.90	3.04	7.86	5.21	2.09	1.15	0.00	2.61	4.96
		Others (soil, etc.)	%	0.72	1.70	7.27	4.22	0.46	2.19	2.14	1.12	3.97
		Sub-total	%	5.10	7.76	16.32	11.59	4.33	18.12	5.43	5.41	11.22
	Total		%	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

* Waste composition of MSW is calculated from composition ratio multiplied total amount of waste in each category divided by total amount of waste generation

c. Present Waste Stream

The waste stream in the Study Area was formulated based on the following surveys:

- WACS (Waste Amount and Composition Survey)
- Interview Survey at Generation Sources
- DWAS (Disposal Waste Amount Survey)
- Illegal Dumping Survey
- Recycling Survey
- Scavenger Survey

According to the data which the Study Team obtained from DWAS which carried out 2 times in August-September 1996 and January 1997, the Study Team modified the waste stream diagram by adding **Other Wastes** which are directly hauled by private sector to disposal site. The modified waste stream diagram is illustrated and shown in Figure F-2.

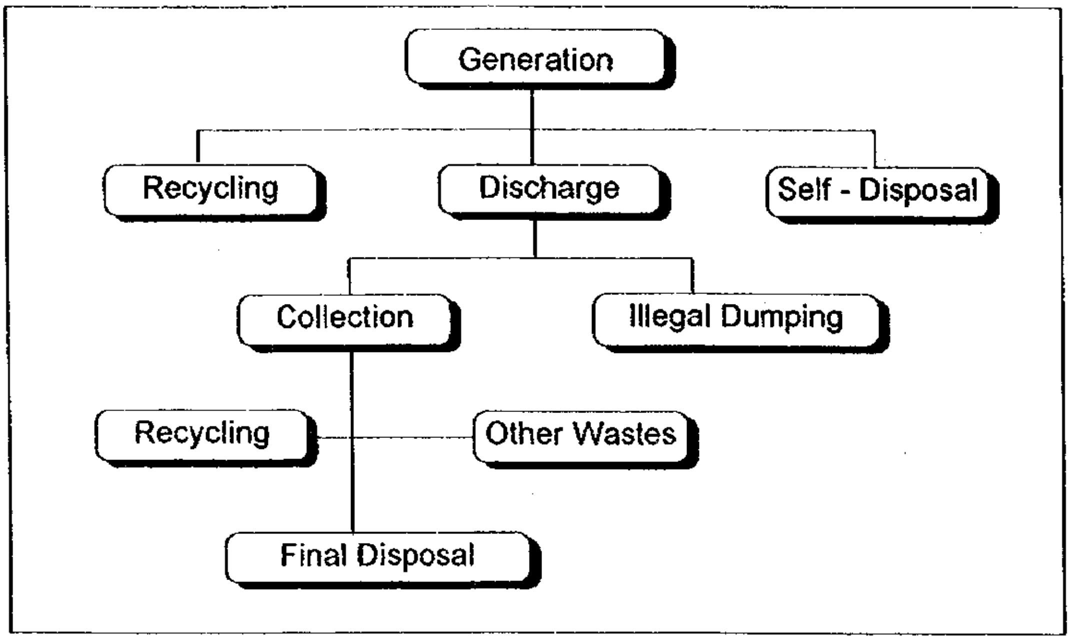

Figure F-2: Waste Stream Diagram

According to the above diagram, the Study Team has quantified the waste amount in each component of the waste stream as follows:

c.1 Generation

According to the results of WACS both in rainy and dry seasons, the Study Team calculated the total waste generation in each city as shown in Table F-21.

Table F-21: Total Amount of Waste in Each Generation Source (1996)

Category	(Unit)	Weighted Average (a)	Leon No. of Unit (b)	Leon Total Waste Amount (a)x(b)	Chinandega No. of Unit (c)	Chinandega Total Waste Amount (a)x(c)	Granada No. of Unit (d)	Granada Total Waste Amount (a)x(d)
1. MSW								
1.1 Household Waste	g/person/day	675	123865	83.6	97387	65.7	71783	48.5
1.2 Restaurant	g/shop/day	15,109	77	1.2	41	0.6	45	0.7
1.3 Other Shop Waste	g/shop/day	1,676	740	1.2	465	0.8	471	0.8
1.4 Institutional Waste	g/person/day	98	2379	0.2	1577	0.2	1692	0.2
1.5 Market Waste	g/shop/day	2,827	2500	7.1	1732	4.9	1045	3
1.6 Street Sweeping	g/km/day	36,677	55	2	45	1.7	35	1.3
1.7 Bulky Waste	ton/day	0	0	0	0	0	0	0
Sub-total	ton/day			95.3		73.9		54.5
2. Other Waste	ton/day		2.5	2.5	1.4	1.4	2	2
Total	ton/day			97.8	•	75.3		56.5

c.2 Recycling at Generation Sources

According to the results of interview survey at sampling points of WACS, the residents recycled their waste such as paper, plastic and glass bottle by selling to middleman while food waste recycled by feeding their animals. The Study Team found that the amount of recycling in each city is as follows;

City	No. of Population (a)	Recycling Amount (b)	Total Amount (a) x (b)
Leon	123,865 persons	122 g/person/day	**15.1 ton/day**
Chinandega	97,387 persons	84 g/person/day	**8.2 ton/day**
Granada	71,783 persons	66 g/person/day	**4.7 ton/day**

c.3 Self-disposal at Generation Source

According to the results of interview survey at sampling points of WACS, the residents self-disposed their waste especially garden waste by burning or burial both in collection area and non-collection area. The Study Team identified the amount of self-disposal at generation source as follows:

City	Area	Population (a)	Self-Disposal (b)	Total Amount (a) x (b)
Leon	Collection Area	99,092 persons	102 g/person/day	10.1 ton/day
	Non-Collection Area	24,773 persons	263 g/person/day	6.5 ton/day
	Total	123,865 persons		**16.6 ton/day**
Chinandega	Collection Area	49,668 persons	110 g/person/day	5.5 ton/day
	Non-Collection Area	47,719 persons	275 g/person/day	13.1 ton/day
	Total	97,387 persons		**18.6 ton/day**
Granada	Collection Area	45,223 persons	44 g/person/day	2.0 ton/day
	Non-Collection Area	26,560 persons	240 g/person/day	6.4 ton/day
	Total	71,783 persons		**8.4 ton/day**

Source : Percentage of collection serviced population is obtained from each municipality

c.4 Discharge

The Study Team calculated the amount of discharge by the following formula.

$$Discharge = Generation - Recycling - Self\text{-}Disposal\ at\ Generation\ Source$$

From the above calculation, the Study Team found the amount of discharge in each city to be as follows:

- Waste Discharge in Leon 63.6 ton/day
- Waste Discharge in Chinandega 47.1 ton/day
- Waste Discharge in Granada 41.4 ton/day

c.5 Collection

Because there is no truck scale at the disposal site, the Study Team had to apply the method for Disposal Waste Amount Survey (DWAS) by observation the volume of waste and calculate the waste amount collection by the formula as follows;

$$ASG = \frac{Weight\ of\ Waste\ (Kg)}{Volume\ of\ Waste\ (l)}$$

Based on the results of DWAS and the ASG formula, the Study Team calculated the waste amount collection to the disposal site as follows:

- Collection in Leon 58.9 ton/day
- Collection in Chinandega 39.5 ton/day
- Collection in Granada 35.4 ton/day

c.6 Illegal Dumping

It is quite difficult to understand the amount of illegal dumping in the Study Area, the Study Team, therefore, considered the results of Illegal Dumping survey. For recycling at other than generation sources and disposal site is neglected due to quite small amount. Finally, the Study Team assumed the following formula to calculate amount of illegal dumping.

$$Amount\ of\ Illegal\ Dumping = Discharge - Collection$$

The result of calculation for illegal dumping in each city is as follows:

- Illegal Dumping in Leon 4.7 ton/day
- Illegal Dumping in Chinandega 7.6 ton/day
- Illegal Dumping in Granada 6.0 ton/day

c.7 Recycling at Disposal Site

In order to know the amount of recycling at disposal site, the Study Team carried out Scavenger Survey by interviewing 10 scavengers at each disposal site. Almost of the waste items which recollected by scavengers are glass bottle, paper, metal and plastic. The results of the survey are summarized as follows:

- Recycling at disposal site in Leon 1.4 ton/day
- Recycling at disposal site in Chinandega 0.4 ton/day
- Recycling at disposal site in Granada 0.5 ton/day

c.8 Other Wastes

The Study Team conducted Disposal Waste Amount Survey (DWAS) not only to obtain the amount of waste collection by municipal service but also to understand the amount of other wastes which are directly hauled by private sector to the disposal site. The DWAS was carried out 2 times in August-September 1996 and January 1997. The results of both survey has determined.

Based on the result of DWAS in both times, the Study Team has determined the amount of other wastes in the Study Area as shown belows:

- Other Wastes in Leon 2.5 ton/day
- Other Wastes in Chinandega 1.4 ton/day
- Other Wastes in Granada 2.0 ton/day

c.9 Final Disposal

The amount of waste to final disposal is calculated based on the simple formula as follows:

Final Disposal = Collected Wastes + Other Wastes - Recycling at Disposal Site

From the above formula, the Study Team has found the amount of Final Disposal in the Study Area as follows:

- Final Disposal in Leon 60.0 ton/day
- Final Disposal in Chinandega 40.5 ton/day
- Final Disposal in Granada 36.9 ton/day

From all of the above-explanation, finally, the Study Team determined the amount of each component in waste stream as shown in Table F-22and illustrated in Figure F-3, Figure F-4 and Figure F-5.

Table F-22: Present Waste Stream in the Study Area

Unit : ton/day

Items \ City	Leon	Chinandega	Granada
Waste Generation	95.3	73.9	54.5
Recycling at Generation Source	15.1	8.2	4.7
Waste Discharge	63.6	47.1	41.4
Self-Disposal at Generation	16.6	18.6	8.4
Collection	58.9	39.5	35.4
Illegal Dumping	4.7	7.6	6.0
Recycling at Disposal Site	1.4	0.4	0.5
Other Wastes	2.5	1.4	2.0
Final Disposal	60.0	40.5	36.9

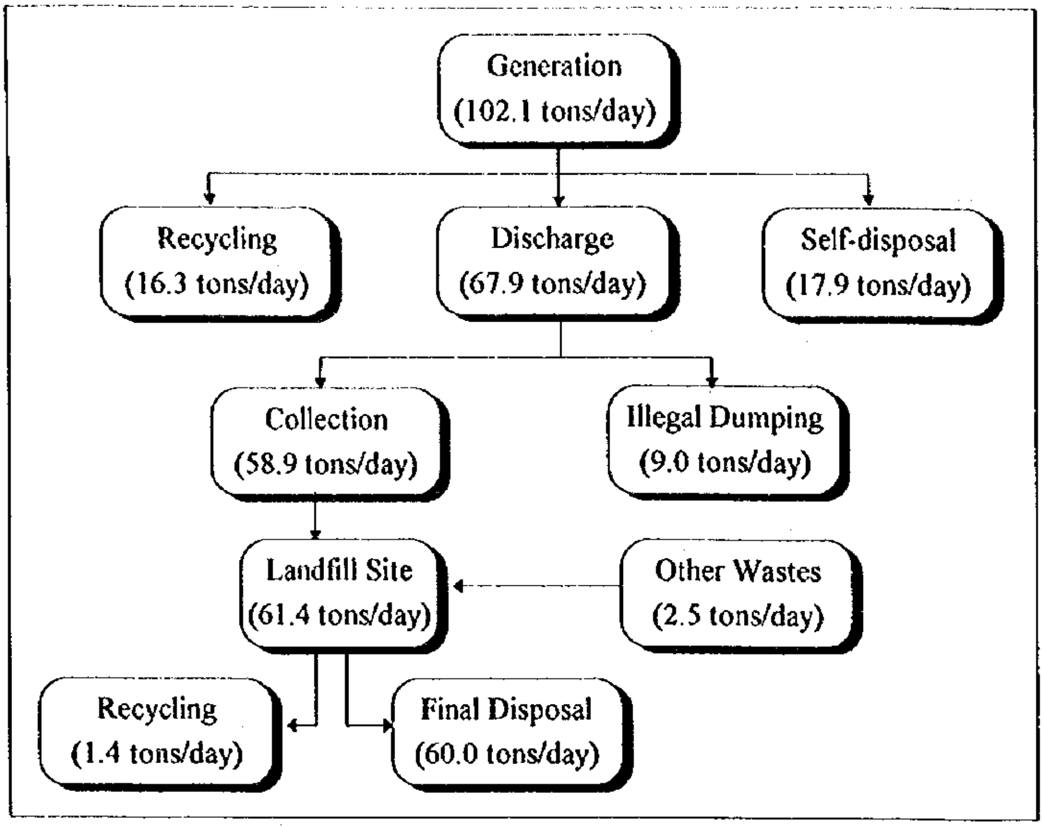

Figure F-3: Present Waste Stream of Leon in 1996

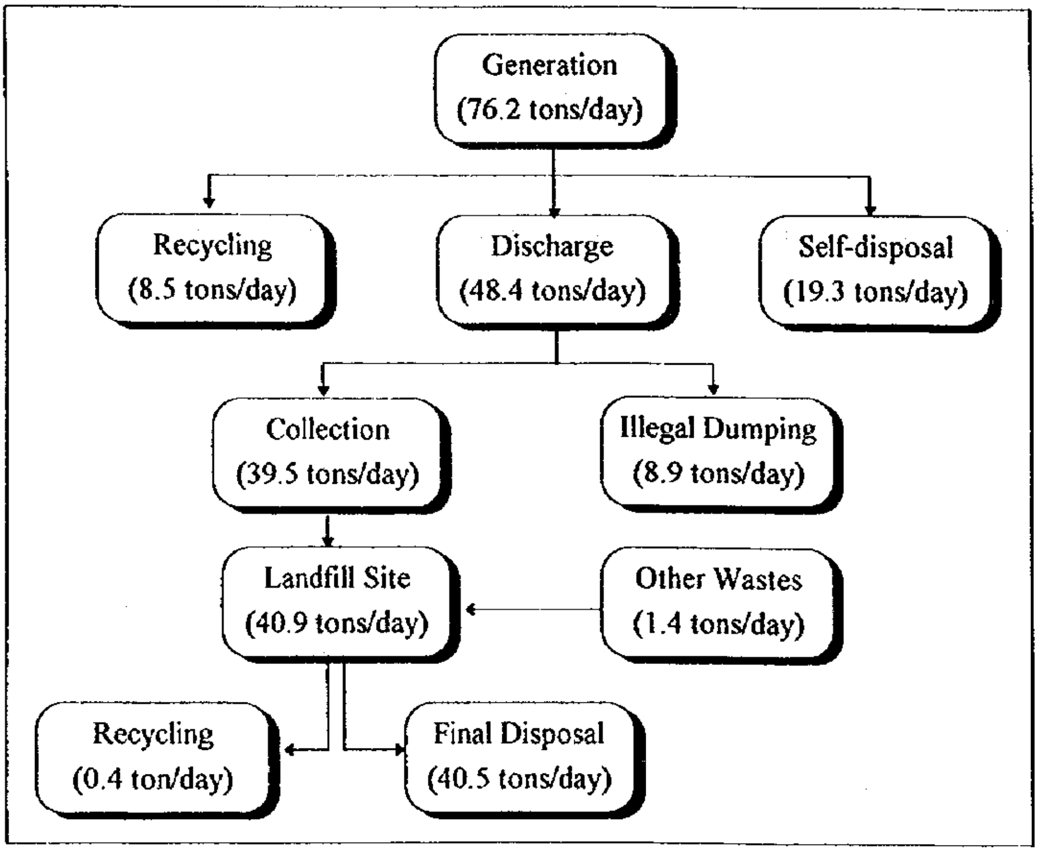

Figure F-4: Present Waste Stream of Chinandega in 1996

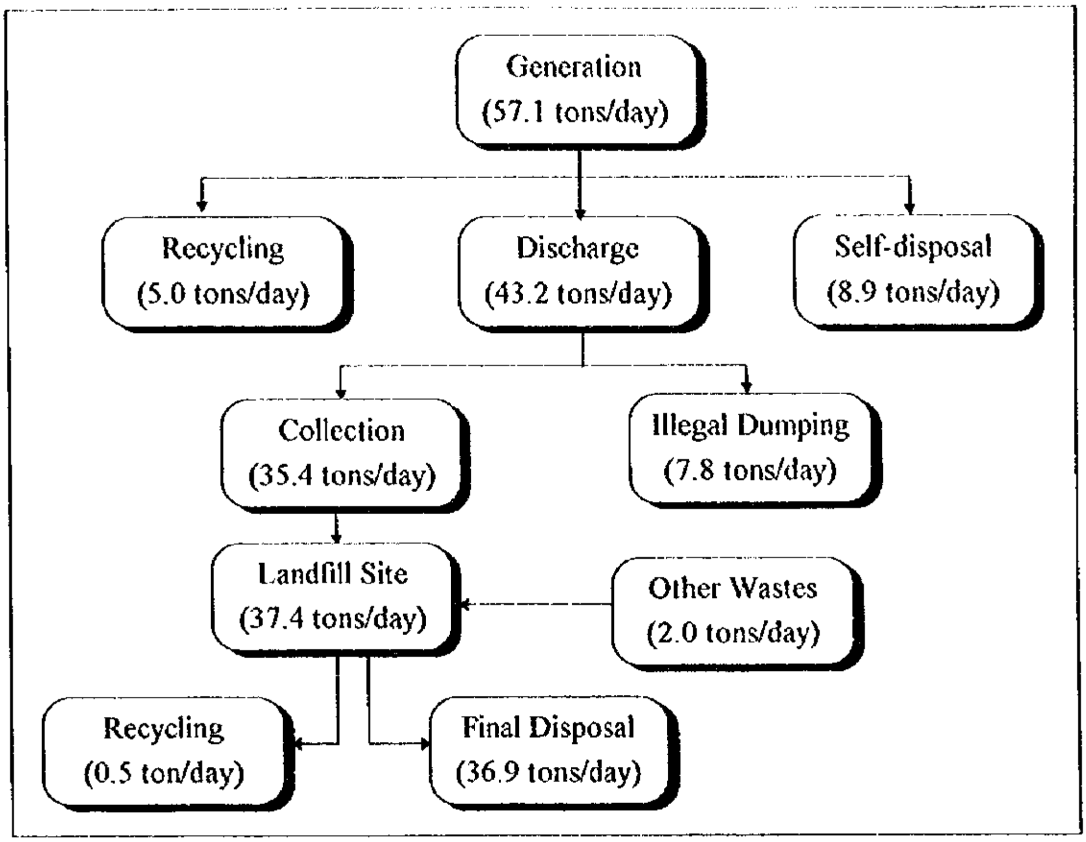

Figure F-5: Present Waste Stream of Granada in 1996