Chapter 11

Feasibility Study and Pre-feasibility Study for Priority Projects

11 Feasibility Study and Pre-feasibility Study for Priority Projects

11.1 Outline of the Projects

11.1.1 Target

It is indispensable to secure a final disposal site for a sound Solid Waste Management. There is a plan to expand the existing landfill, or Etapa 2 in the Cerro Patacon Landfill. The part to be expanded is called Phase 4 of Etapa 2 and will have a capacity of 1,800,000 m^3. The Phase 4 will be full by the beginning of 2006. Then, another new landfill will be necessary. Therefore, a feasibility study is conducted under the scheme of the Study for a new landfill, or Cerro Patacon Etapa 3, to be operated between 2006 and 2015.

Waste collection works require a large amount of costs. At present, about 46% of the total SWM costs are spent for the collection works. Therefore, it is expected that improvement of collection efficiency will bring a considerably large cost reduction and will help the SWM stable. The collection works can be divided into two components, i.e., collection that picks up waste from generation sources in an area and transport that carries waste collected to a final disposal site.

In the Study, a pilot project to improve the collection efficiency was carried out. It brought a result of 21% reduction of the direct cost in the pilot project area. Meanwhile, it has also been sought to improve efficiency of transport in the eastern area (Tocumen, Pacora and San Martin) and northern area (Chilibre) where the distances to the Cerro Patacon Landfill exceed 40 km (a round trip). Therefore, aiming at improve the efficiency of the transport, a pre-feasibility study of transfer and transport systems in the areas were carried out

11.1.2 Outline of Projects

Table 11-1 shows the outline of the final disposal project. Table 11-2 presents the transfer transport project.

Table 11-1: Outline of the Final Disposal Project (Feasibility Study)

Items	Facilities				
	Overall	Phase 1	Phase 2	Phase 3	Phase 4
Construction site	Cerro Patacon Area				
Construction period	-	2005 to early 2006	2007 to early 2008	2009 to early 2010	2011
Operation period	2006 to 2015	early 2006 to early 2008	early 2008 to early 2010	early 2010 to end of 2011	2012 to 2015
Area	Site area :28 ha Filling area : 20.4 ha	6.9 ha	6.5 ha	6.3 ha	20.4 ha
Landfill waste	Municipal waste				
Landfill capacity	6,400,000 m^3	1,300,000m^3	1,200,000m^3	1,100,000m^3	2,800,000m^3
Access	Existing road and internal road Length of internal road : 2,570 m	Length of internal road : 1,300 m	Length of internal road : 800m	Length of internal road : 470m	-
Waste transport control facilities	Gate : 2 (existing), Weighbridge : 2 (existing), Car washing : 1 (existing), Site office :1, Work shop :1				
Leachate management	**Seepage control works**: installation of 1.5 mm HDPE synthetic liner with 10 mm geotextile (under and upper of synthetic liner), installation of soil layer for protection of synthetic liner				
	Collection and treatment system				
	Collection pipe: 6,690m(dia. 200 to 900mm)	2,070 m	2,020m	1,830m	770m
	Treatment system Regulation pond : 24,000 m^3,Treatment capacity : 800 m^3/day (oxidation ditch with chemical sedimentation, sand filtration and activated carbon absorption) Intake water quality : BOD 10,000 mg/l, COD 18,000 mg/l, Org-N 200 mg/l, NH_3-N 200 mg/l, P 30mg/l Treated water quality ; BOD 35 mg/l, COD 100 mg/l, Org-N 10 mg/l, NH_3-N 3 mg/l, P 5mg/l (comply the ANAM discharge limit)				
Landfill gas management	Gas ventilation pipe (PVC 200 mm) : 92 nos.	23 nos.	22 nos.	21 nos.	26 nos.
Rain water management	Trapezoidal lined ditch (wide 800 to 1,700 mm): 2,300 m and daily cover soil	1,190 m	700 m	410 m	-
Landfill operation	Cell method with compaction, daily soil cover thickness15cm, final soil cover thickness 60cm				
Aesthetic design	Daily soil cover				
Closure and post-closure	Final soil cover 60 cm Greening by seeding the final cover with grass				

Table 11-2: Outline of the Transfer and Transport Project (Pre-feasibility Study)

Items	Facilities		
	Overall	Phase 1	Phase 2
Construction site	Possibly along the American Highway in Pacora Corregimiento (the site will be looked for later by DIMAUD)		
Construction period	-	2004	2007
Operation period	From 2005 (economic life of the transfer station is assumed as 20 years)	From 2005	From 2008
Site area	5 ha	-	-
Target Waste	Municipal waste generated from Tocumen, Pacora and San Martin corregimientos		
Facilities	Direct dump station		
Platform	2,500 m^2	1,250 m^2	1,250 m^2
Hopper	4 units	2 units	2 units
Weighbridge	2 units	1 unit	1 unit
Others	Office, workshop, fence, gate, car washer, buffer zone		
Transport Equipment	Tractor-trailer (20 ton); 17 units of tractor and 25 units of trailer are to be purchased in total between 2005 and 2015.		
Collection Vehicle	16 yd^3 (12.2m^3) compactor truck; 67 units are to be purchased in total between 2005 and 2015.		

11.2 Preliminary Design of Technical System

11.2.1 Final Disposal Project

a. Examination of Design Conditions

a.1. Target Waste

Target wastes are all municipal solid wastes except hazardous wastes.

a.2. Related Laws and Regulations

At present, MINSA is formulating technical standards on construction of landfills. However, it is unknown when the standards will enact. Meanwhile, ANAM has established standards on effluent to public water body. This will control the effluent from leachate treatment facilities in this plan. Table 11-3 shows the effluent standards set by ANAM.

Table 11-3: Effluent Standards set by ANAM

Item		Unit	Discharge limit
Oil and grease		mg/liter	20
Aluminum	Al	mg/liter	5
Arsenic	As	mg/liter	0.50
Boron	Br	mg/liter	0.75
Cadmium	Cd	mg/liter	0.01
Calcium	Ca	mg/liter	1,000
Total cyanide	CN	mg/liter	0.2
Residual chlorine	Cl	mg/liter	1.5
Chlorine	Cl_2	mg/liter	400
Copper	Cu	mg/liter	1
Total coliform		NMP/100 ml	1,000
Phenol compound		mg/liter	0.5
Hexavalent chromium	Cr^{+6}	mg/liter	0.05
Total chromium	Cr	mg/liter	5
Biochemical oxygen demand	BOD	mg/liter	35
Chemical oxygen demand	COD	mg/liter	100
Detergent		mg/liter	1
Foaming	PE	mm	7
Fluorine	F	mg/liter	5
Total phosphorus	T-P	mg/liter	5
Total hydrocarbon		mg/liter	5
Iron	Fe	mg/liter	5
Manganese	Mn	mg/liter	0.3
Mercaptan		mg/liter	0.02
Mercury	Hg	mg/liter	0.001
Molybdenum	Mo	mg/liter	2.5
Nickel	Ni	mg/liter	0.2
Nitrite	NO_3	mg/liter	6

Item		Unit	Discharge limit
Total organic nitrogen	N	mg/liter	10
Ammonium-nitrogen	NH_3-N	mg/liter	3
Smell		-	No perceptible
Organic chlorine		mg/liter	1.5
Penta chlorine phenol	C_6OHCl_5	mg/liter	0.009
pH		mg/liter	5.5. to 9.0
Lead	Pb	mg/liter	0.050
Selenium	Se	mg/liter	0.01
Sodium	% Na	%	35
Sedimentable solid	S. SED	mg/liter	15
Suspended solid	SS	mg/liter	35
Total dissolved solid	TDS	mg/liter	500
Sulphide	SO_4^{-2}	mg/liter	1,000
Temperature		° C	+,- 3 N.T
Toluene	$C_6H_5CH_3$	mg/liter	0.7
Trichloro-etane	HC_2Cl_3	mg/liter	0.04
Trichlorometan	$CHCl_3$	mg/liter	0.02
Turbidity		NTU	30
Xylene		$C_6H_4C_2H_6$	0.05
Zinc	Zn	mg/liter	3

source : Normas para Aguas Residuakes ANAM /DGNTI-COPANIT 35-2000

a.3. Location and Area

a.3.1 Location

Cerro Patacon site is located about 5km to the northwest of the city center; from the locality off Bethanaia along the Cerro Patacon Avenue. It has paved access road and electrical power supply.

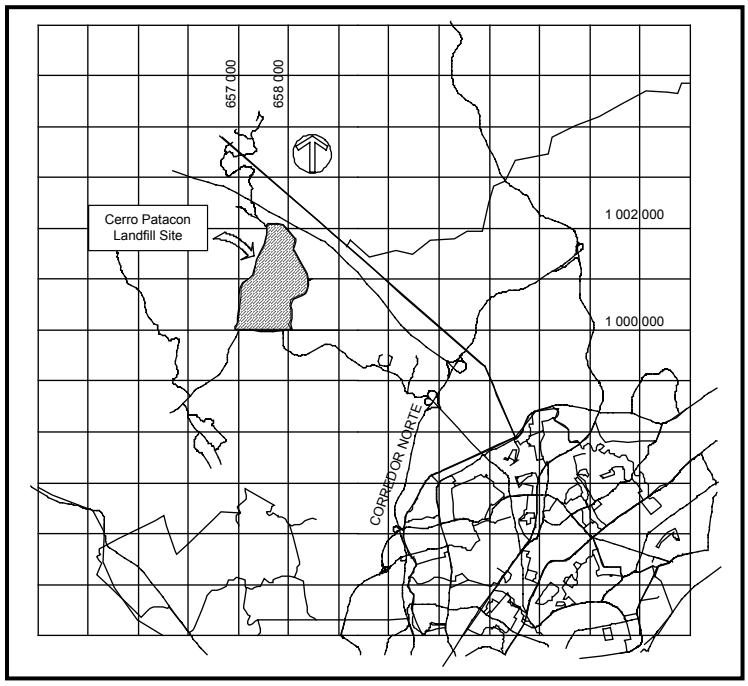

Figure 11-1: Location Map of Cerro Patacon

a.3.2 Project Site

The project site is in the Cerro Patacon Landfill that has an area of 130 ha. Besides, 9 ha will be added with the new landfill development, Etapa 3. Profile of the project site is as follows.

- The maximum height: 106 m (ASL)
- The minimum height: 43 m (ASL)
- Area: about 28ha

There is a small hill at the north and a shallow valley at the south in the project site. Around the project site, there is a hill at the north, the existing landfill (Etapa I) at the south, a river at the east and other existing landfill (Etapa II) at the west.

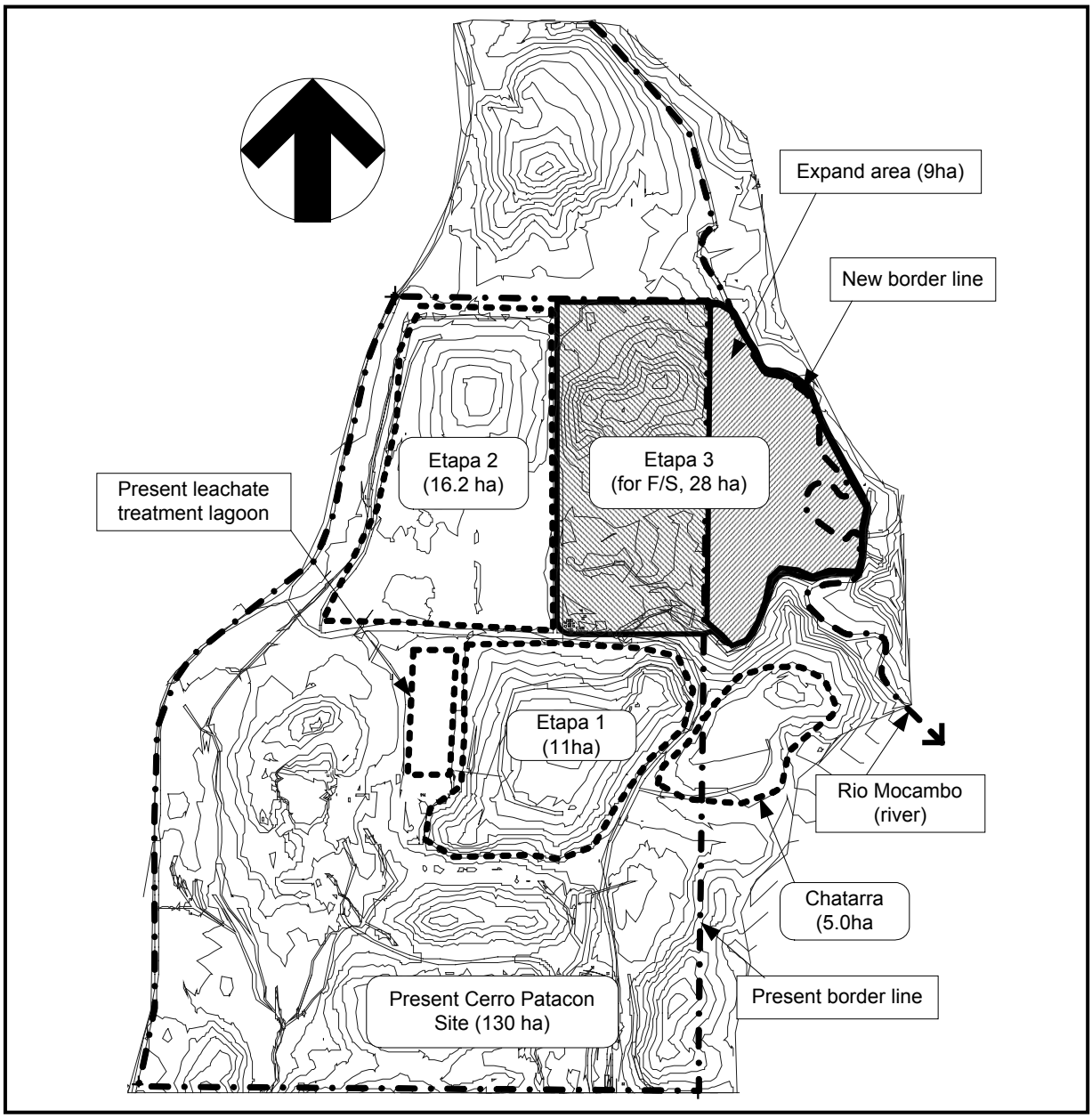

Figure 11-2: Project Site

a.4. Geological Conditions

Geological condition of the project site consists of silt and/or clay at the upper part and weathered rock at the lower part. Hydraulic conductivity of the upper part is between 10^{-4} and 10^{-6}(cm/sec). In the Study, a geological survey was conducted. Locations of drilling surveys carried out in the geological survey are shown in Figure 11-3.The base layer of the project site consists of rock. Therefore, it can be judged that the base layer will bear increased stress to be caused by waste disposition.

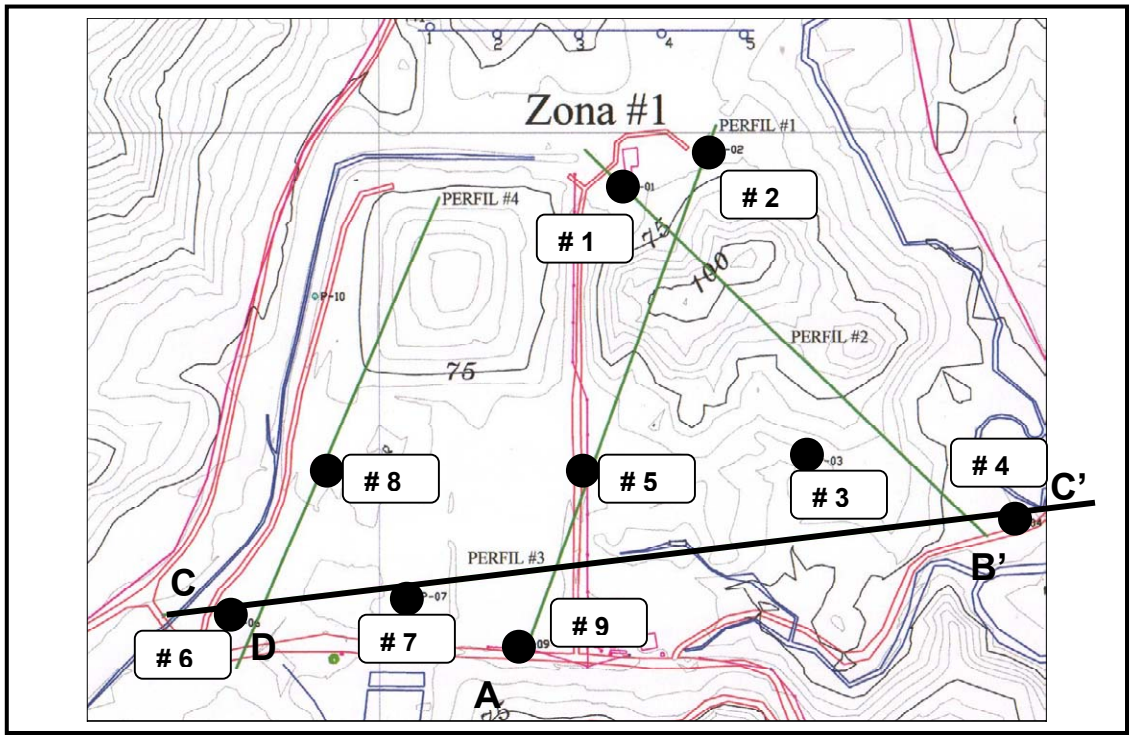

Figure 11-3: Location Map of Boring Survey

a.4.1 Ground Water Table

According to the drilling survey, it is estimated that the groundwater flows from the northwest to the southeast under the project site. There will be fissure water as the rock has many cracks.

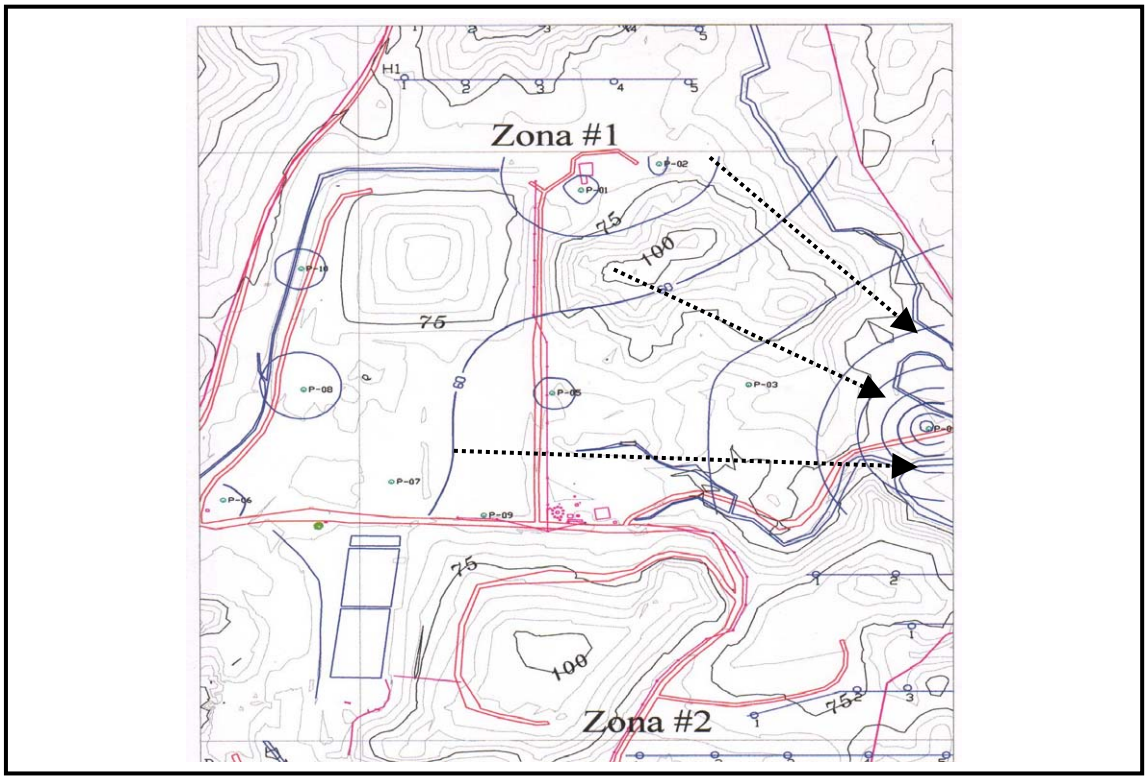

Figure 11-4: Direction of Ground Water Flow

a.4.2 Permeability

In situ permeability tests were carried out at the drilling wells. Table 11-4 show results of the test.

Table 11-4: Results of Permeability Survey

Number of holes	LOCATION	K (m/s)	K (cm/s)	PERMEABILITY CLASS
P # 1-02	**1001434.42 N, 657796.87 E**	**8.24 E-07**	**8.24 E-05**	Very small
P # 2-02	**1001478.89 N, 657900.95 E**	**5.09 E-07**	**5.09 E-05**	Practically impermeable
P # 3-02	**1000987.18 N, 658073.14 E**	**3.59 E-08**	**3.59 E-06**	
P # 4-02	1001028.35 N, 658260.56 E	1.57 E-07	1.57 E-05	
P # 5-02	**1001090.35 N, 657757.58 E**	**2.14 E-07**	**2.14 E-05**	
P # 6-02	1000909.59 N, 657317.57 E	2.32 E-06	2.32 E-04	Very small
P # 7-02	1000940.26 N, 657542.50 E	6.84 E-08	6.84 E-06	Practically impermeable
P # 8-02	1001097.23 N, 657425.56 E	6.00 E-08	6.00 E-06	

No. 1, 2, 3, and 5 are in the project site. All of them indicate considerably lower permeability, i.e., between 10^{-5} and 10^{-6} cm/sec. The values imply that the site might need synthetic liner at the bottom of a landfill. Meanwhile, the base layer consists of the weathered rock and fissure water exists. Therefore, it can be concluded that the bottom of the landfill will require a synthetic liner, although the upper part show the low permeability.

a.5. Meteorological Conditions

There exist three meteorological stations (Gamboa, PMG and B.AFF) in the neighborhood of the project site. Figure 11-5 shows their locations.

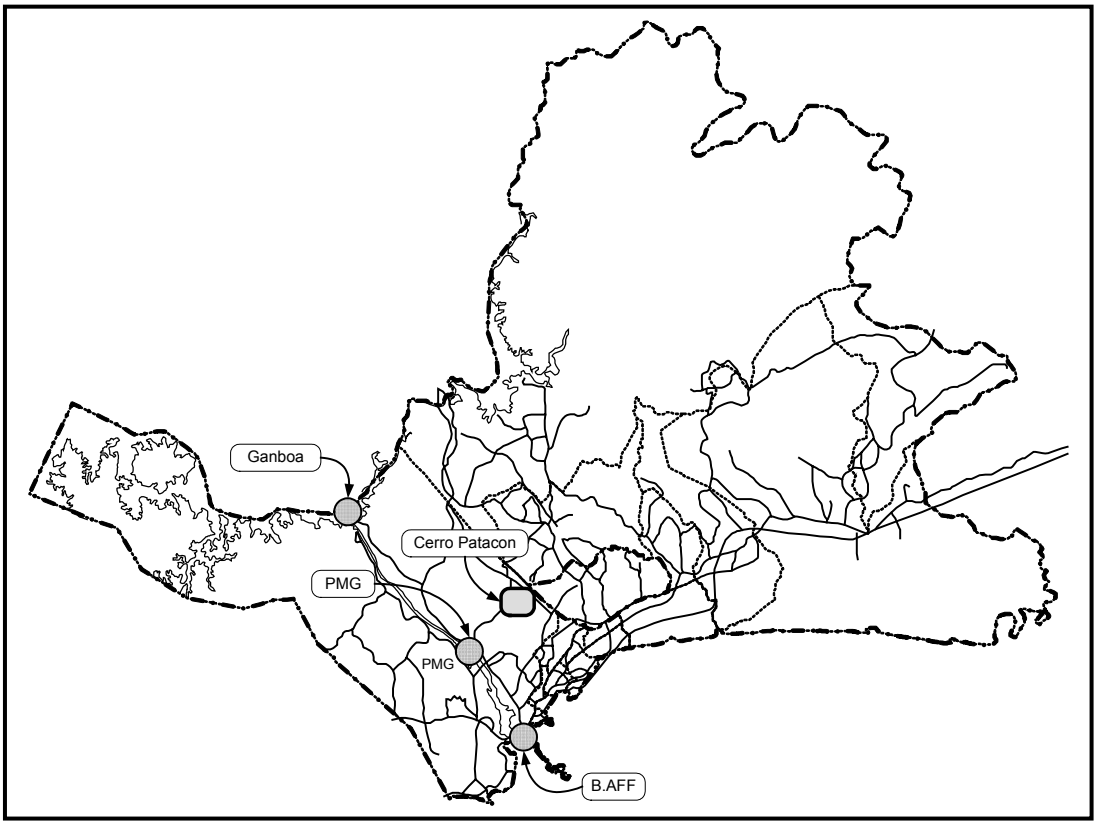

Figure 11-5: Location of Meteorological Stations

a.5.1 Precipitation

Precipitation data shows below.

Table 11-5: Precipitation Data of Gamboa Station

Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Day/year		366	365	365	365	366	365	365	365	366	365
Nos. of observation day		366	365	365	365	366	365	365	365	366	365
Annual precipitation (mm)		1,996.44	**2,626.36**	2,428.24	2,280.92	2,298.70	1,714.50	2,199.64	2,468.88	2,270.76	1,887.22
Daily average precipitation (mm)		5.50	7.20	6.70	6.20	6.30	4.70	6.00	6.80	6.20	5.20
Monthly precipitation (mm/month)	Jan.	10.16	109.22	22.86	17.78	233.68	12.70	0.00	33.02	35.56	25.40
	Feb.	5.08	5.08	15.24	2.54	17.78	5.08	2.54	101.60	7.62	2.54
	March	0.00	66.04	53.34	30.48	40.64	2.54	2.54	35.56	2.54	25.40
	April	99.06	127.00	15.24	121.92	60.96	12.70	218.44	96.52	91.44	35.56
	May	187.96	162.56	363.22	302.26	256.54	317.50	190.50	274.32	330.20	119.38
	June	373.38	365.76	238.76	297.18	238.76	152.40	223.52	276.86	314.96	190.50
	July	378.46	231.14	190.50	259.08	215.90	241.30	261.62	96.52	160.02	236.22
	Aug.	187.96	223.52	266.70	226.06	309.88	182.88	322.58	284.48	274.32	236.22
	Sept.	284.48	523.24	330.20	332.74	256.54	134.62	289.56	373.38	304.80	238.76
	Oct.	274.32	388.62	368.30	264.16	320.04	383.54	210.82	218.44	317.50	193.04
	Nov.	144.78	340.36	482.60	294.64	309.88	254.00	289.56	304.80	215.90	304.80
	Dec.	50.80	83.82	81.28	132.08	38.10	15.24	187.96	373.38	215.90	279.40
Monthly maximum daily precipitation (mm/day)	Jan.	5.08	38.10	10.16	7.62	66.04	10.16	0.00	20.32	17.78	20.32
	Feb.	5.08	5.08	5.08	2.54	5.08	2.54	2.54	30.48	2.54	2.54
	March	0.00	50.80	33.02	20.32	30.48	2.54	2.54	15.24	2.54	15.24
	April	40.64	38.10	7.62	81.28	25.40	10.16	99.06	30.48	30.48	15.24
	May	45.72	68.58	93.98	60.96	68.58	66.04	38.10	76.20	68.58	50.80
	June	96.52	50.80	30.48	99.06	48.26	43.18	38.10	38.10	60.96	43.18
	July	83.82	63.50	33.02	40.64	68.58	53.34	43.18	17.78	35.56	45.72
	Aug.	53.34	48.26	86.36	35.56	66.04	63.50	73.66	86.36	58.42	60.96
	Sept.	43.18	81.28	73.66	71.12	81.28	22.86	96.52	71.12	55.88	35.56
	Oct.	60.96	91.44	71.12	40.64	40.64	91.44	58.42	35.56	58.42	30.48
	Nov.	27.94	101.60	78.74	48.26	58.42	55.88	78.74	58.42	45.72	83.82
	Dec.	15.24	25.40	20.32	20.32	12.70	12.70	45.72	45.72	106.68	55.88

Table 11-6: Precipitation Data of PMG Station

Year		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Day/year		365	365	366	365	365	365	366	365	365	365	366	365
Nos. of observation day		365	365	366	365	365	365	366	365	365	365	366	365
Annual precipitation (mm)		1,922.78	2,311.40	2,044.70	2,197.10	1,968.50	1,971.04	**2,367.28**	1,668.78	2,189.48	2,270.76	2,138.68	1,963.42
Daily average precipitation (mm)		5.30	6.30	5.60	6.00	5.40	5.40	6.50	4.60	6.00	6.20	5.80	5.40
Monthly precipitation (mm/month)	Jan.	22.86	5.08	0.00	93.98	10.16	5.08	144.78	38.10	2.54	81.28	45.72	12.70
	Feb.	0.00	0.00	2.54	0.00	0.00	2.54	55.88	12.70	0.00	81.28	7.62	0.00
	March	0.00	5.08	2.54	17.78	142.24	20.32	73.66	0.00	0.00	27.94	0.00	2.54
	April	106.68	228.60	45.72	83.82	45.72	149.86	88.90	17.78	33.02	63.50	144.78	40.64
	May	213.36	350.52	220.98	218.44	347.98	215.90	381.00	154.94	314.96	220.98	200.66	172.72
	June	177.80	266.70	345.44	459.74	170.18	330.20	208.28	121.92	243.84	360.68	302.26	132.08
	July	335.28	274.32	266.70	292.10	142.24	266.70	119.38	279.40	299.72	127.00	236.22	261.62
	Aug.	294.64	276.86	251.46	200.66	233.68	177.80	342.90	149.86	337.82	220.98	271.78	142.24
	Sept.	193.04	325.12	309.88	279.40	236.22	149.86	177.80	185.42	215.90	337.82	236.22	266.70
	Oct.	327.66	228.60	353.06	218.44	279.40	256.54	332.74	347.98	279.40	297.18	347.98	340.36
	Nov.	137.16	317.50	190.50	238.76	355.60	347.98	347.98	332.74	274.32	208.28	167.64	332.74
	Dec.	114.30	33.02	55.88	93.98	5.08	48.26	93.98	27.94	187.96	243.84	177.80	259.08
Monthly maximum daily precipitation (mm/day)	Jan.	15.24	2.54	0.00	50.80	7.62	5.08	60.96	27.94	2.54	40.64	15.24	7.62
	Feb.	0.00	0.00	2.54	0.00	0.00	2.54	17.78	10.16	0.00	73.66	5.08	0.00
	March	0.00	5.08	2.54	10.16	101.60	12.70	53.34	0.00	0.00	12.70	0.00	2.54
	April	81.28	111.76	17.78	40.64	17.78	71.12	35.56	12.70	17.78	22.86	71.12	40.64
	May	33.02	91.44	60.96	35.56	66.04	45.72	93.98	48.26	81.28	45.72	30.48	45.72
	June	30.48	43.18	96.52	121.92	38.10	86.36	60.96	53.34	83.82	76.20	50.80	27.94
	July	104.14	68.58	45.72	68.58	25.40	88.90	50.80	55.88	60.96	35.56	50.80	50.80
	Aug.	73.66	83.82	86.36	53.34	68.58	27.94	88.90	45.72	68.58	30.48	48.26	38.10
	Sept.	76.20	68.58	73.66	48.26	58.42	43.18	33.02	45.72	35.56	60.96	38.10	78.74
	Oct.	48.26	71.12	172.72	40.64	76.20	55.88	48.26	78.74	66.04	91.44	71.12	66.04
	Nov.	25.40	71.12	45.72	38.10	91.44	53.34	48.26	73.66	66.04	43.18	30.48	45.72
	Dec.	58.42	17.78	25.40	17.78	2.54	17.78	20.32	22.86	60.96	38.10	55.88	40.64

Table 11-7: Precipitation Data of B.AFF Station

Year		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Day/year		366	365	365	365	366	365	365	365	366	365
Nos. of observation day		366	365	365	365	366	365	365	365	366	365
Annual precipitation (mm)		2,207.26	2,443.48	2,100.58	**2,875.28**	2,451.10	1,905.00	1,953.26	1,940.56	1,927.86	1,684.02
Daily average precipitation (mm)		6.00	6.70	5.80	7.90	6.70	5.20	5.40	5.30	5.30	4.60
Monthly precipitation (mm/month)	Jan.	0.00	68.58	0.00	0.00	154.94	170.18	0.00	43.18	53.34	17.78
	Feb.	5.08	0.00	33.02	0.00	99.06	15.24	15.24	17.78	81.28	0.00
	March	0.00	91.44	55.88	63.50	76.20	0.00	0.00	86.36	22.86	0.00
	April	22.86	76.20	40.64	81.28	91.44	0.00	73.66	68.58	76.20	50.80
	May	269.24	487.68	314.96	393.70	337.82	144.78	373.38	223.52	180.34	203.20
	June	213.36	205.74	248.92	566.42	254.00	215.90	279.40	241.30	287.02	254.00
	July	256.54	462.28	129.54	304.80	200.66	134.62	198.12	165.10	195.58	119.38
	Aug.	299.72	215.90	266.70	215.90	167.64	147.32	172.72	132.08	149.86	71.12
	Sept.	271.78	292.10	182.88	490.22	142.24	360.68	254.00	172.72	256.54	266.70
	Oct.	431.80	172.72	320.04	401.32	317.50	358.14	167.64	203.20	292.10	223.52
	Nov.	299.72	254.00	411.48	157.48	408.94	347.98	218.44	335.28	200.66	241.30
	Dec.	137.16	116.84	96.52	200.66	200.66	10.16	200.66	251.46	132.08	236.22
Monthly maximum daily precipitation (mm/day)	Jan.	0.00	35.56	0.00	0.00	35.56	71.12	0.00	17.78	27.94	15.24
	Feb.	5.08	0.00	33.02	0.00	27.94	7.62	7.62	7.62	30.48	0.00
	March	0.00	45.72	30.48	33.02	45.72	0.00	0.00	43.18	12.70	0.00
	April	10.16	38.10	20.32	40.64	38.10	0.00	48.26	35.56	45.72	40.64
	May	81.28	104.14	83.82	152.40	78.74	27.94	134.62	55.88	63.50	83.82
	June	53.34	76.20	73.66	190.50	93.98	71.12	93.98	50.80	83.82	50.80
	July	60.96	152.40	43.18	55.88	55.88	35.56	68.58	63.50	35.56	43.18
	Aug.	58.42	68.58	48.26	53.34	27.94	78.74	38.10	35.56	20.32	17.78
	Sept.	66.04	50.80	60.96	162.56	38.10	134.62	60.96	50.80	53.34	55.88
	Oct.	83.82	35.56	73.66	88.90	66.04	91.44	71.12	58.42	63.50	40.64
	Nov.	48.26	40.64	152.40	35.56	73.66	101.60	45.72	76.20	27.94	58.42
	Dec.	27.94	35.56	63.50	38.10	40.64	10.16	27.94	53.34	43.18	91.44

a.5.2 Temperature

Monthly average temperature data shows below.

Table 11-8: Monthly Average Temperature Data of Gamboa Station

unit : Celsius

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Jan.	27.2	25.4	25.3	25.6	25.4	25.5	27.0	26.3	25.6	25.2
Feb.	27.7	25.6	25.5	25.5	25.8	26.7	27.3	25.8	26.1	25.7
March	28.2	26.4	25.8	26.1	26.2	26.2	27.7	26.3	26.3	25.8
April	28.6	26.6	26.6	26.7	26.7	27.0	28.0	26.7	26.8	26.9
May	28.1	26.7	26.2	26.3	26.4	27.5	27.5	26.4	26.2	26.6
June	27.5	26.3	25.6	26.4	26.0	26.9	26.8	25.6	25.7	26.5
July	27.0	26.4	25.9	25.6	25.5	27.2	26.3	25.9	25.7	25.7
Aug.	27.3	26.2	25.5	25.8	25.5	27.3	26.0	25.6	25.9	26.7
Sept.	26.9	25.7	25.6	26.0	25.5	26.3	26.1	25.4	25.3	25.9
Oct.	25.8	25.8	25.1	25.6	25.6	26.6	26.2	25.4	25.3	26.4
Nov.	25.3	24.9	24.9	25.5	25.1	26.2	25.7	25.2	25.8	25.9
Dec.	25.6	25.6	25.5	25.7	25.7	26.9	25.7	24.7	25.4	26.1

Table 11-9: Monthly Average Temperature Data of B.AFF Station

unit : Celsius

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Jan.	27.2	26.7	26.9	27.5	25.5	25.7	27.8	26.1	25.4	26.1
Feb.	27.5	27.3	27.3	27.5	26.1	27.0	27.9	26.4	26.4	26.7
March	27.3	27.9	27.6	27.5	26.5	26.9	28.7	26.9	26.8	26.9
April	27.6	27.8	28.2	27.6	27.1	27.7	28.5	27.0	27.4	27.8
May	26.7	27.5	27.0	27.0	26.3	27.8	27.7	26.4	26.6	26.8
June	26.1	27.2	26.8	27.3	26.2	26.7	27.1	25.9	26.3	26.6
July	27.5	27.1	27.2	26.0	25.9	27.3	26.6	26.1	26.2	26.1
Aug.	25.1	27.2	26.5	25.9	25.9	27.3	26.3	25.8	26.1	26.9
Sept.	26.5	26.0	27.0	26.4	25.8	26.4	26.5	25.7	25.3	25.6
Oct.	26.4	26.6	26.3	25.9	25.8	26.5	26.5	25.7	25.6	25.9
Nov.	26.2	26.1	26.3	25.7	25.6	26.3	25.8	25.4	25.6	25.4
Dec.	26.7	26.8	26.9	25.7	25.7	27.3	25.6	25.0	25.6	25.7