Annex-RB Results of Laboratory Analysis

Summary of Results

Particle Size

Summary of Sieve Analysis

Particle Size Distribution

B1 (3.00 - 3.70 m)

B3 (1.70 - 2.05 m)

B3 (2.05 - 2.15 m)

B4 (11.00 - 11.45 m)

B5 (5.00 - 5.70 m)

B11 (11.55 - 11.75 m)

B13 (21.00 - 21.16 m)

B14 (4.00 - 4.45 m)

Direct Shear Test

B1 (3.00 - 3.70 m)

B3 (1.70 - 2.05 m)

B4 (11.00 - 11.45 m)

B5 (5.00 - 5.70 m)

B11 (11.55 - 11.75 m)

B13 (21.00 - 21.16 m)

Unconfined Compression Test on Soil Sample

B1 (3.00 - 3.70 m)

B4 (11.00 - 11.45 m)

Unconfined Compression Test on Rock/soil Sample

B6.7 (26.90 m)

B8 (6.5 m)

B9 (10.5 m)

B10 (10.5 m)

Summary of Laboratory Results

Borehole No.	Sampling Depth m	Moisture Content % d. s. t	u. c. t	Percentage Passing No. 200sieve	Density lb/ft³ d. s. t	u. c. t	Cohesive Strength ton/ft²	Angle of Internal Friction	Unconfined shelby sample	Compression Strengh core sample ton/ft²
B-1	3.00-3.70	23.70	21.39	44.20	116.70	129.93	0.50	22 00'	1.52	
B-3	1.70-2.05	39.10		53.20	95.70		0.20	39 00'		
B-3	2.05-2.15			29.50			0.40			
B-4	11.00-11.45	75.80	87.81	86.50	75.80	82.49		31 00'	5.06	
B-5	5.00-5.70	100.20		68.30	100.20		0.12	36 00'		
B-6.7	26.90									15.83
B-8	6.50									40.43
B-9	10.50									75.00
B-10	10.50									94.10
B-11	11.55-11.75	110.60		68.90	110.60		0.40	17 00'		
B-13	21.00-21.16	96.70		61.30	96.70		0.14	35 30'		
B-14	4.00-4.45			6.30						

Note: d. s. t=direct shear test
u. c. t=unconfined compression test

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FAX: (502-2) 357661

TRABAJO: SWISSBORING
SANEAMIENTO-JICA

FECHA: 7 DE MARZO DE 1996

RESUMEN DE RESULTADOS DE ENSAYOS DE CORTE DIRECTO NO DRENADO NO CONSOLIDADO

Sondeo	Muestra	Profundidad en metros	Contenido natural de humedad en %	Densidad hûmeda Lbs/p^3	Cohesión Ton/p^2	Ø en grados
B-1	S-B-1	3.00-3.70	23.7	116.7	0.50	22°00'
B-3	S-B-3	1.70-2.05	39.1	95.7	0.20	39°00'
B-4	S-B-4	11.00-11.45	132.3	75.8	0.40	31°00'
B-5	S-B-5	5.00-5.70	57.9	100.2	0.12	36°00'
B-11	S-B-11	11.55-11.75	29.6	110.6	0.40	17°00'
B-13	S-B-13	21.00-21.16	40.6	96.7	0.14	35°30'

Guatemala. 07 de marzo de 1996

RESUMEN DE RESULTADOS DE ENSAYOS DE LABORATORIO

ANALISIS GRANULOMETRICO Y LIMITES DE ATTERBERG

TRABAJO: SWISSBORING SANEAMIENTO-JICA LUGAR:

CAPA: FECHA: Marzo 7, 1996

	MUESTRA	PROFUNDIDAD EN METROS	ANALISIS GRANULOMETRICO (LAVADO X) (NO LAVADO ___) PORCENTAJE QUE PASA EN PESO SECO											LIMITES DE ATTERBERG		
			TAMICES U.S. STANDARD											LIMITE LIQUIDO EN %	LIMITE PLASTICO EN %	INDICE PLASTICO EN %
			2"	1 1/2"	1"	3/4"	1/2"	3/8"	Nº 4	Nº 10	Nº 40	Nº 80	Nº 200			
SHELBY	B-1	3.00 - 3.75				100	99.1	98.3	93.8	81.2	62.4	53.4	44.2			
SHELBY	B-3	1.70 - 2.05						100	99.8	95.1	82.9	69.9	53.2			
SHELBY	B-3	2.05 - 2.15			100	99.5	99.3	98.8	96.5	90.9	67.6	48.1	29.5			
SHELBY	B-4	11.00 - 11.45								100	97.2	92.9	86.5			
SHELBY	B-5	5.00 - 5.70				100	99.7	99.2	97.9	94.3	85.9	79.6	68.3			
SHELBY	B-11	11.55-11.75						100	99.7	95.9	84.0	77.5	68.9			
SHELBY	B-13	21.00-21.16				100	99.8	99.5	99.0	98.1	92.6	81.7	61.3			
SHELBY	B-14	4.00 - 4.45		100	99.5	97.7	95.0	92.1	82.7	67.1	24.7	11.0	6.3			

LABORATORIO DE SUELOS Y PAVIMENTOS

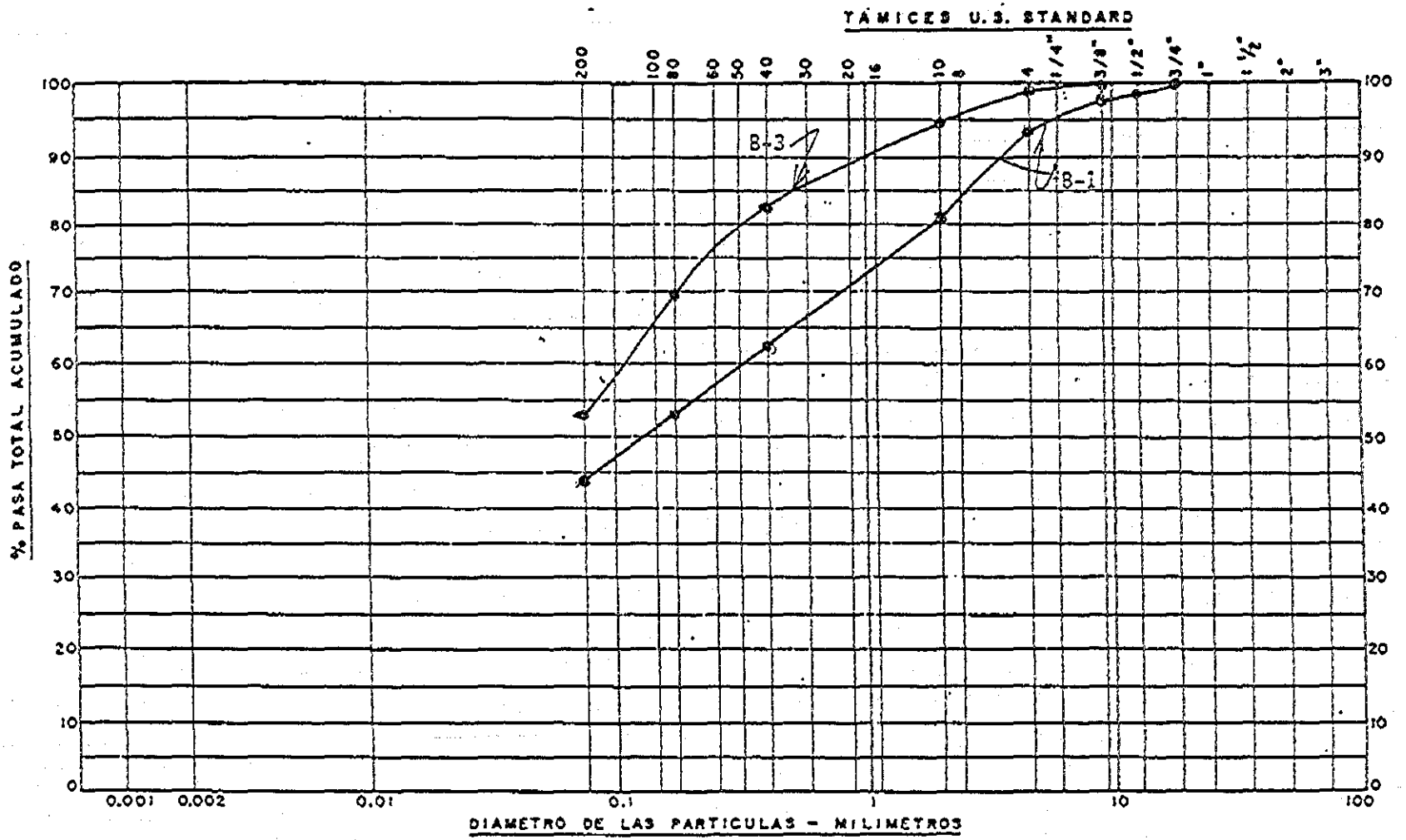
ING. FEDERICO KOOSE

CURVA DE DISTRIBUCION DEL TAMAÑO DE LAS PARTICULAS

TRABAJO: SWISSBORING SANEAMIENTO- JICA LUGAR: CIUDAD DE GUATEMALA PERFORACION

MUESTRA: B-1 / B-3 PROFUNDIDAD: 3.00-3.75 / 1.70-1.80 DESCRIPCION MUESTRA:

FECHA: 7-3-96



ARCILLA	LIMO	FINA	MEDIA	GRUESA	FINA	GRUESA
		ARENA			GRAVA	

LABORATORIO DE SUELOS

CLASIFICACION UNIFICADA

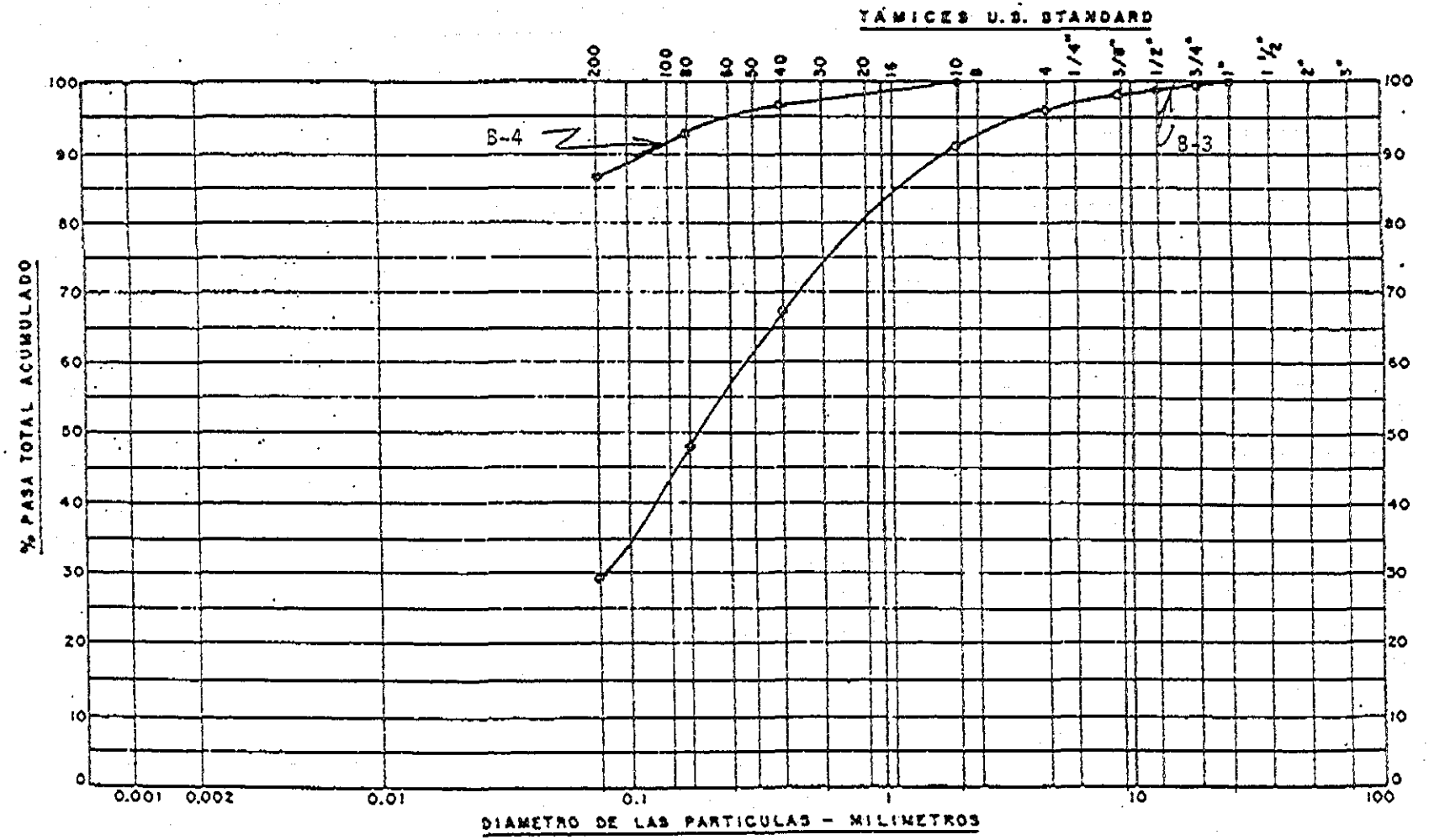
ING. F. KOOSE S.

CURVA DE DISTRIBUCION DEL TAMAÑO DE LAS PARTICULAS

TRABAJO: SWISSBORING SANEAMIENTO-JICA LUGAR: CIUDAD DE GUATEMALA PERFORACION

MUESTRA: B-3 / B-4 PROFUNDIDAD: 1.80-2.15 / 11.00-11.45 DESCRIPCION MUESTRA:

FECHA: 7-3-96



		FINA	MEDIA	GRUESA	FINA	MEDIA	GRUESA
ARCILLA	L I M O	A R E N A			GRAVA O PIEDRA		

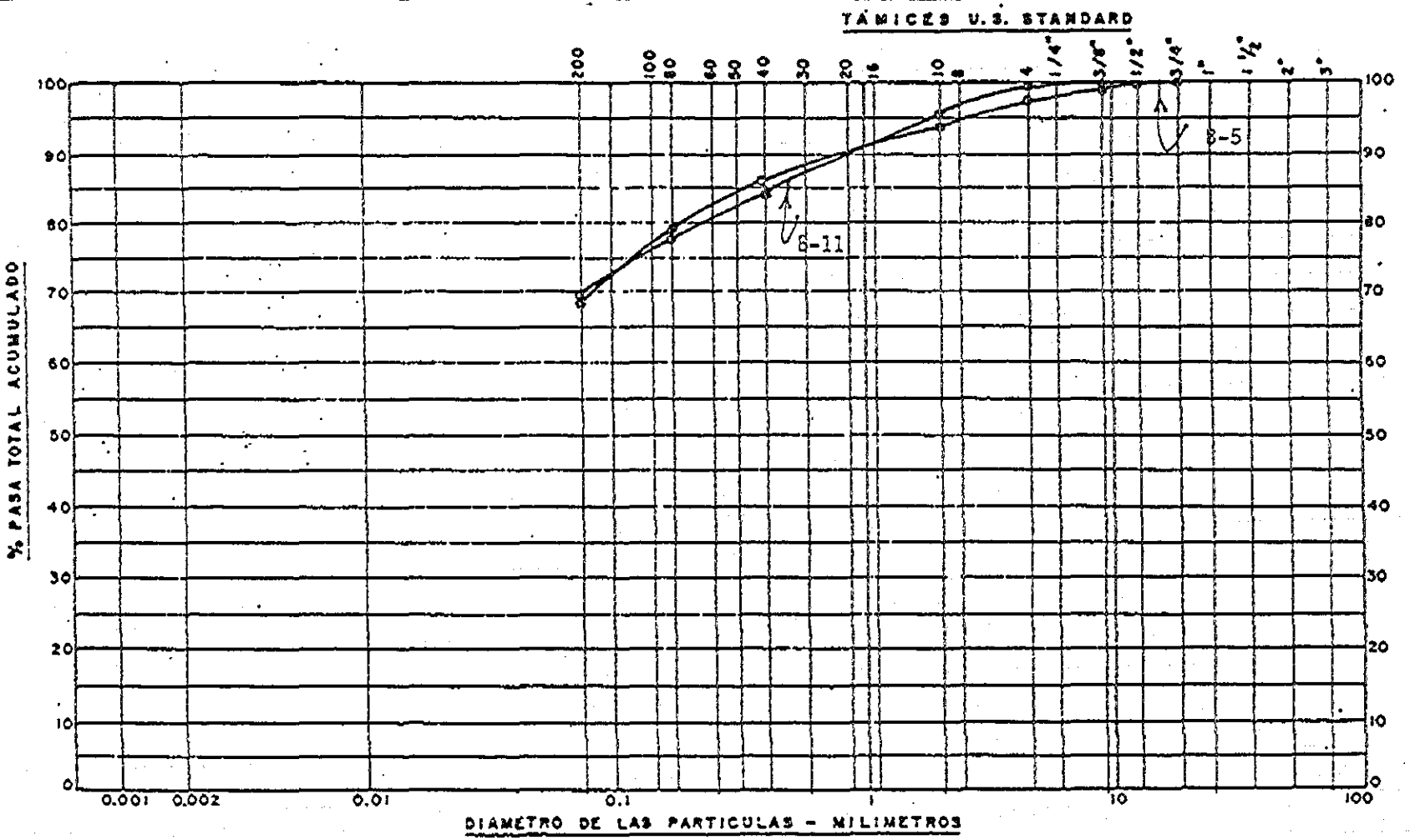
LABORATORIO DE SUELOS CLASIFICACION DE BURMISTER ING. F. KOOSE S.

CURVA DE DISTRIBUCION DEL TAMANO DE LAS PARTICULAS

TRABAJO: SWISSBORING, SANEAMIENTO-JICA LUGAR: CIUDAD DE GUATEMALA PERFORACION

MUESTRA: B-5 / B-11 PROFUNDIDAD: 5.00-5.70 / 11.55-11.75 DESCRIPCION MUESTRA:

FECHA: 7-3-96



		FINA	MEDIA	GRUESA	FINA	MEDIA	GRUESA
ARCILLA	LIMO	ARENA			GRAVA O PIEDRA		

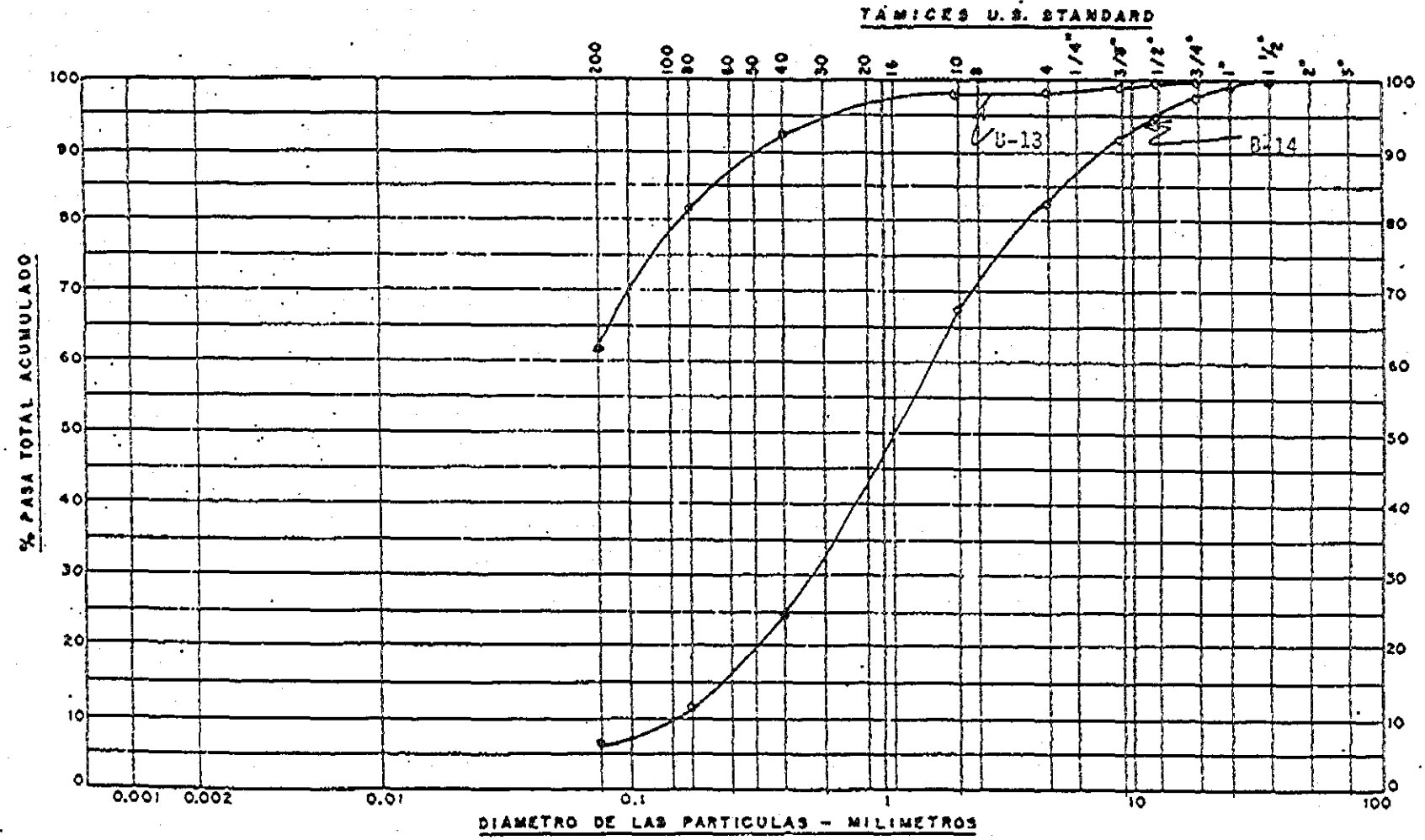
LABORATORIO DE SUELOS — CLASIFICACION DE BURMISTER — ING. F. KOOSE S.

CURVA DE DISTRIBUCION DEL TAMANO DE LAS PARTICULAS

TRABAJO: SWISSBORING SANEAMIENTO-JICA LUGAR: CIUDAD DE GUATEMALA PERFORACION

MUESTRA: B-13, B-14 PROFUNDIDAD: 21.00 - 21.16, 4.00 - 4.45 DESCRIPCION MUESTRA:

FECHA: 7-3-96



ARCILLA	LIMO	FINA	MEDIA	GRUESA	FINA	MEDIA	GRUESA
		ARENA			GRAVA O PIEDRA		

LABORATORIO DE SUELOS — CLASIFICACION DE BURMISTER — ING. F. KOOSE S.

PRUEBA DE CORTE DIRECTO

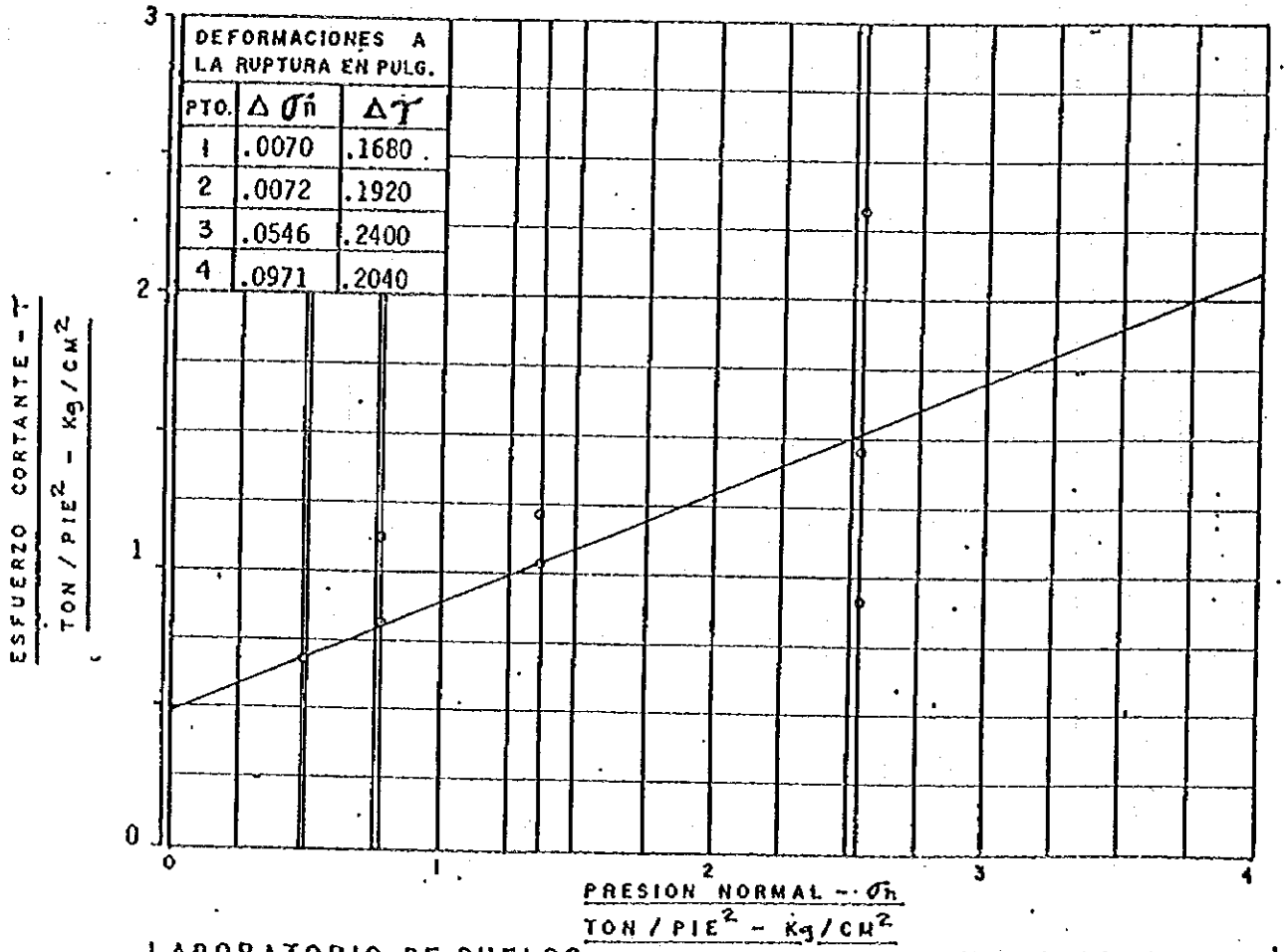
TRABAJO: SWISSBORING SANEAMIENTO-JICA LUGAR: CIUDAD CAPITAL

TIPO DE CORTE: NO CONSOLIDADO
NO DRENADO

ESPECIMEN: DIAMETRO (Do) = 2.50 PULGADAS
ALTURA (Ho) = 1.00 PULGADAS

No	REGISTRO	FECHA	PERFORACION No.	MUESTRA No.	PROFUNDIDAD EN METROS	CONT. HUMEDAD EN %	DENSIDAD HUMEDA LBS/PIE^3	COHESION TON/PIE^2	ϕ EN GRADOS
1	7614	29-2-96	B-1	B-1	3.60 A	23.7	116.7	0.50	22°00'
					3.70				

IDENTIFICACION: LIMO ARCILLOSO CON ARENA, GRIS VERDOSO CON MANCHAS CAFE AMARILLENTO, CON GRAVA PEQUEÑA Y POCA PIEDRA POMEZ PEQUEÑA, MEDIO PLASTICO.



LABORATORIO DE SUELOS ING. F. KOOSE S.

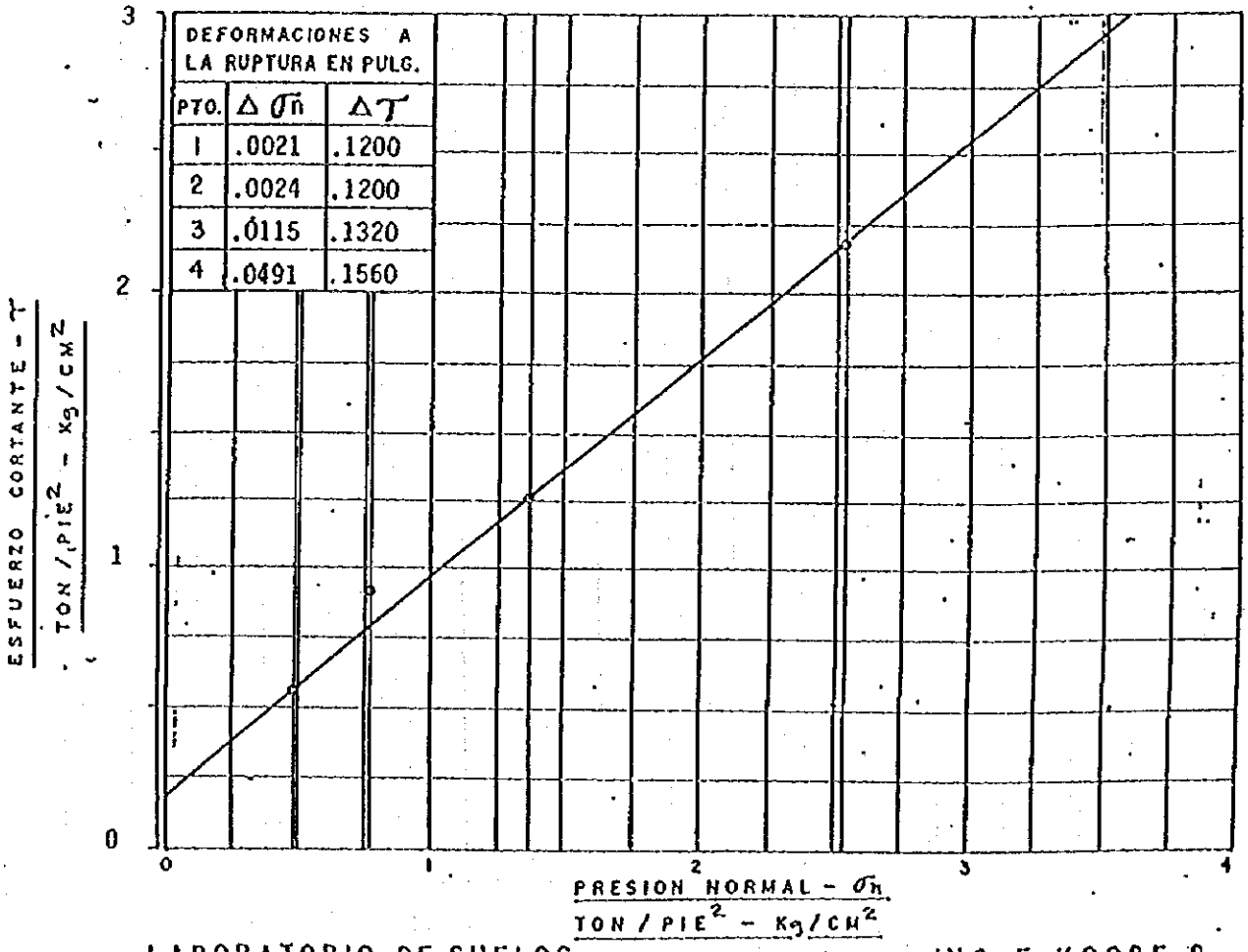
TRABAJO: SWISSBORING SANEAMIENTO-JICA LUGAR: CIUDAD CAPITAL

TIPO DE CORTE: NO CONSOLIDADO
NO DRENADO

ESPECIMEN: DIAMETRO (Do) = 2.50 PULGADAS
ALTURA (Ho) = 1.00 PULGADAS

No	REGISTRO	FECHA	PERFORACION No.	MUESTRA No.	PROFUNDIDAD EN METROS	CONT. HUMEDAD EN %	DENSIDAD HUMEDA LBS/PIE^3	COHESION TON/PIE^2	ϕ EN GRADOS
1	7615	1-3-96	B-3	B-3	1.70 A	39.1	95.7	0.20	39°00'
					2.05				

IDENTIFICACION: LIMO ARENOSO CON ARCILLA ORGANICA, NEGRO CON PIEDRA POMEZ PEQUEÑA, POCO A MEDIO PLASTICO, COMPACTO.



LABORATORIO DE SUELOS ING. F. KOOSE B.

PRUEBA DE CORTE DIRECTO

TRABAJO: SWISSBORING SANEAMIENTO- JICA LUGAR: CIUDAD CAPITAL

TIPO DE CORTE: NO CONSOLIDADO
NO DRENADO

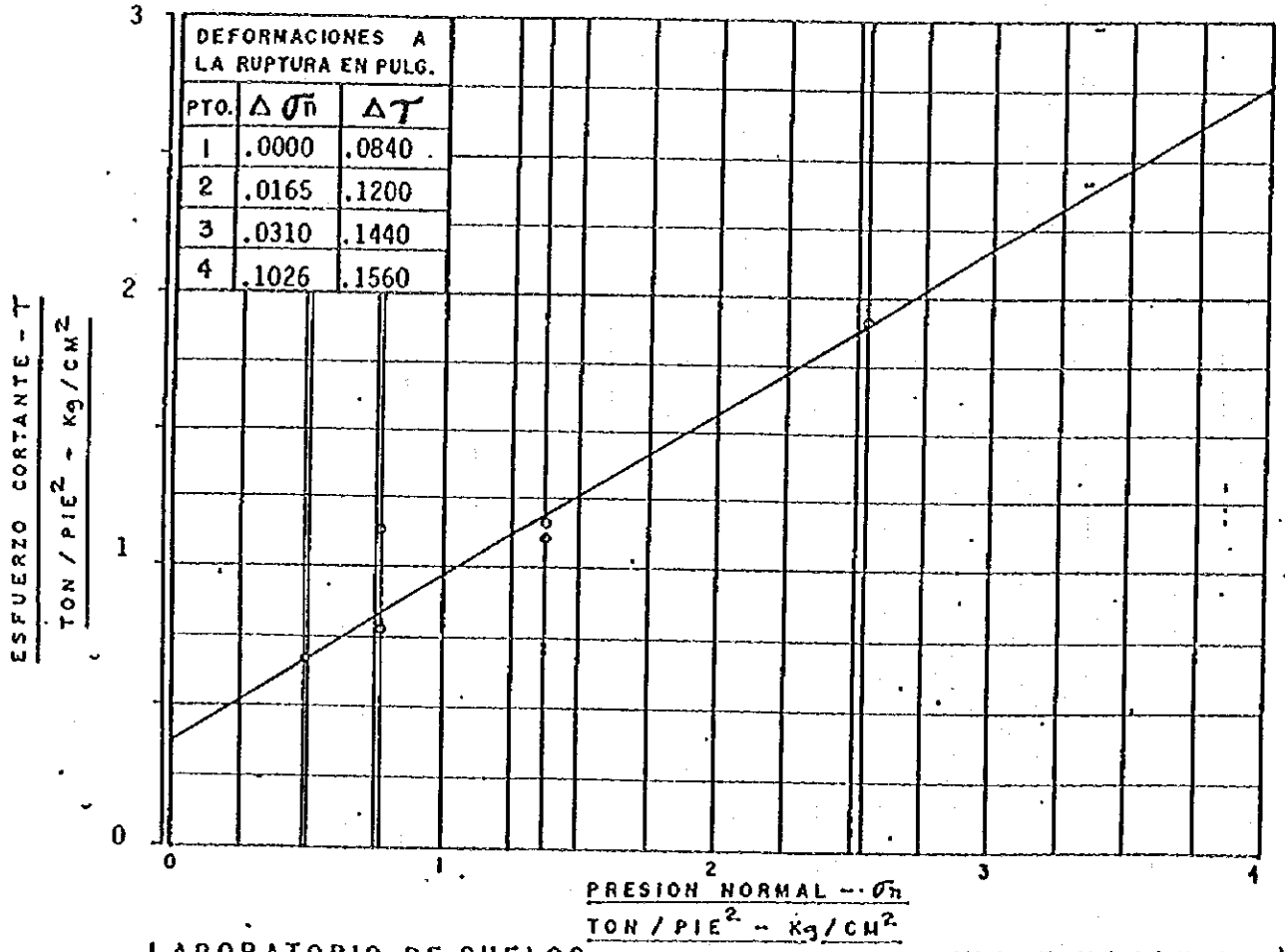
ESPECIMEN: DIAMETRO (Do) = 2.50 PULGADAS
ALTURA (Ho) = 1.00 PULGADAS

No	REGISTRO	FECHA	PERFORACION No.	MUESTRA No.	PROFUNDIDAD EN METROS	CONT. HUMEDAD EN %	DENSIDAD HUMEDA LBS/PIE^3	COHESION TON/PIE^2	ϕ EN GRADOS
1	7616	27-2-96	B-4	B-4	11.00 A	132.3	75.8	0.40	31°00'
					11.45				

IDENTIFICACION: LIMO CON POCA ARENA FINA Y TRAZAS DE ARCILLA, BEIGE, LIGERAMENTE PLASTICO.

DEFORMACIONES A LA RUPTURA EN PULG.

PTO.	$\Delta\sigma_n$	$\Delta\tau$
1	.0000	.0840
2	.0165	.1200
3	.0310	.1440
4	.1026	.1560



LABORATORIO DE SUELOS

ING. F. KOOSE S.

PRUEBA DE CORTE DIRECTO

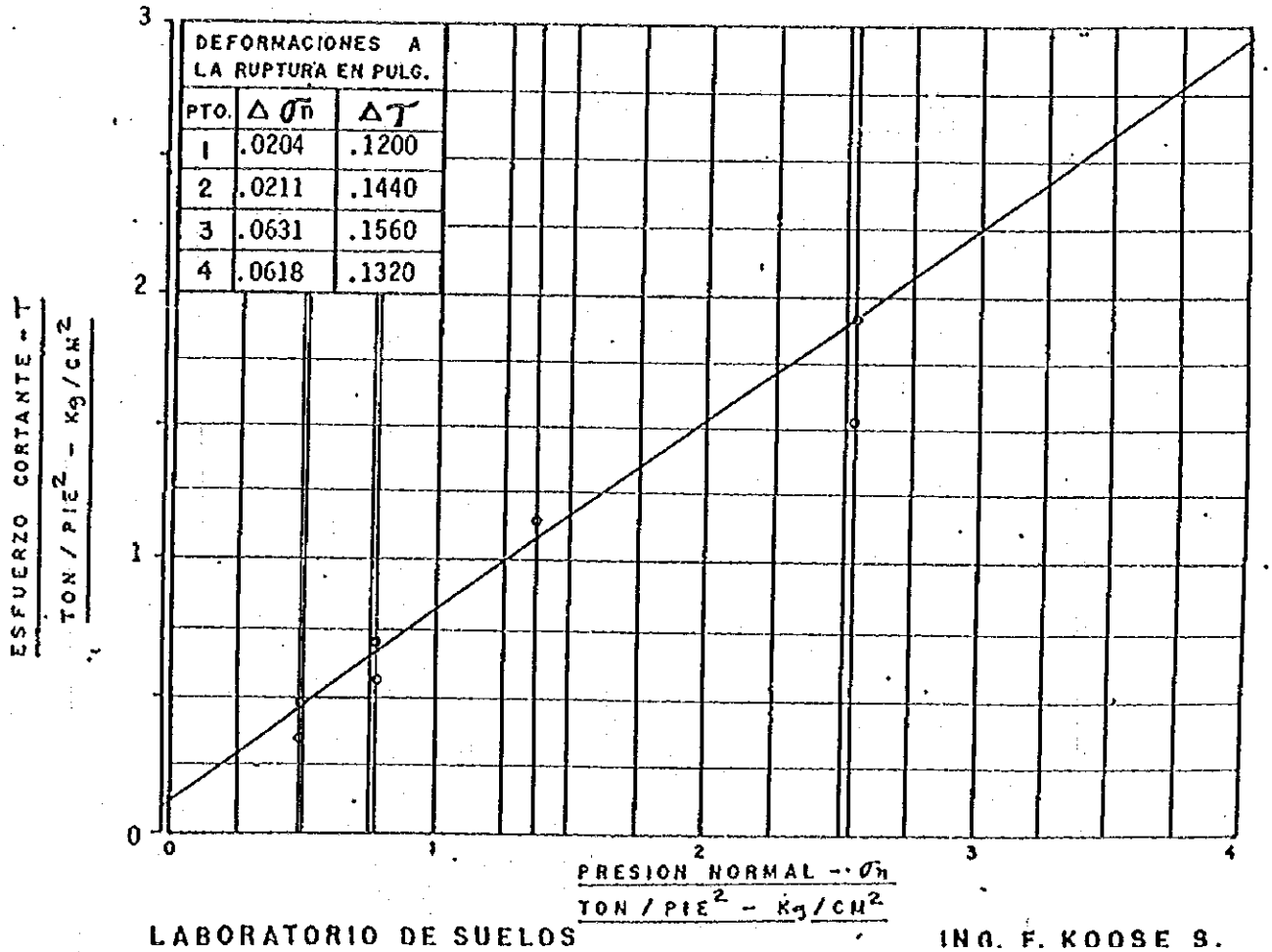
TRABAJO: SWISSBORING SANEAMIENTO-JICA LUGAR: CIUDAD CAPITAL

TIPO DE CORTE: NO CONSOLIDADO
NO DRENADO

ESPECIMEN: DIAMETRO (Do) = 2.50 PULGADAS
ALTURA (Ho) = 1.00 PULGADAS

No	REGISTRO	FECHA	PERFORACION No.	MUESTRA No.	PROFUNDIDAD EN METROS	CONT. HUMEDAD EN %	DENSIDAD HUMEDA LBS/PIE^3	COHESION TON/PIE^2	ϕ EN GRADOS
1	7617	2-3-96	B-5	B-5	5.00 A	57.9	100.2	0.12	36°00'
					5.70				

IDENTIFICACION: LIMO ARENOSO CON POCA ARCILLA, CAFE OBSCURO, POCO ORGANICO, CON TRAZAS DE GRAVA PEQUEÑA, POCO PLASTICO, MEDIO COMPACTO.



LABORATORIO DE SUELOS ING. F. KOOSE S.

PRUEBA DE CORTE DIRECTO

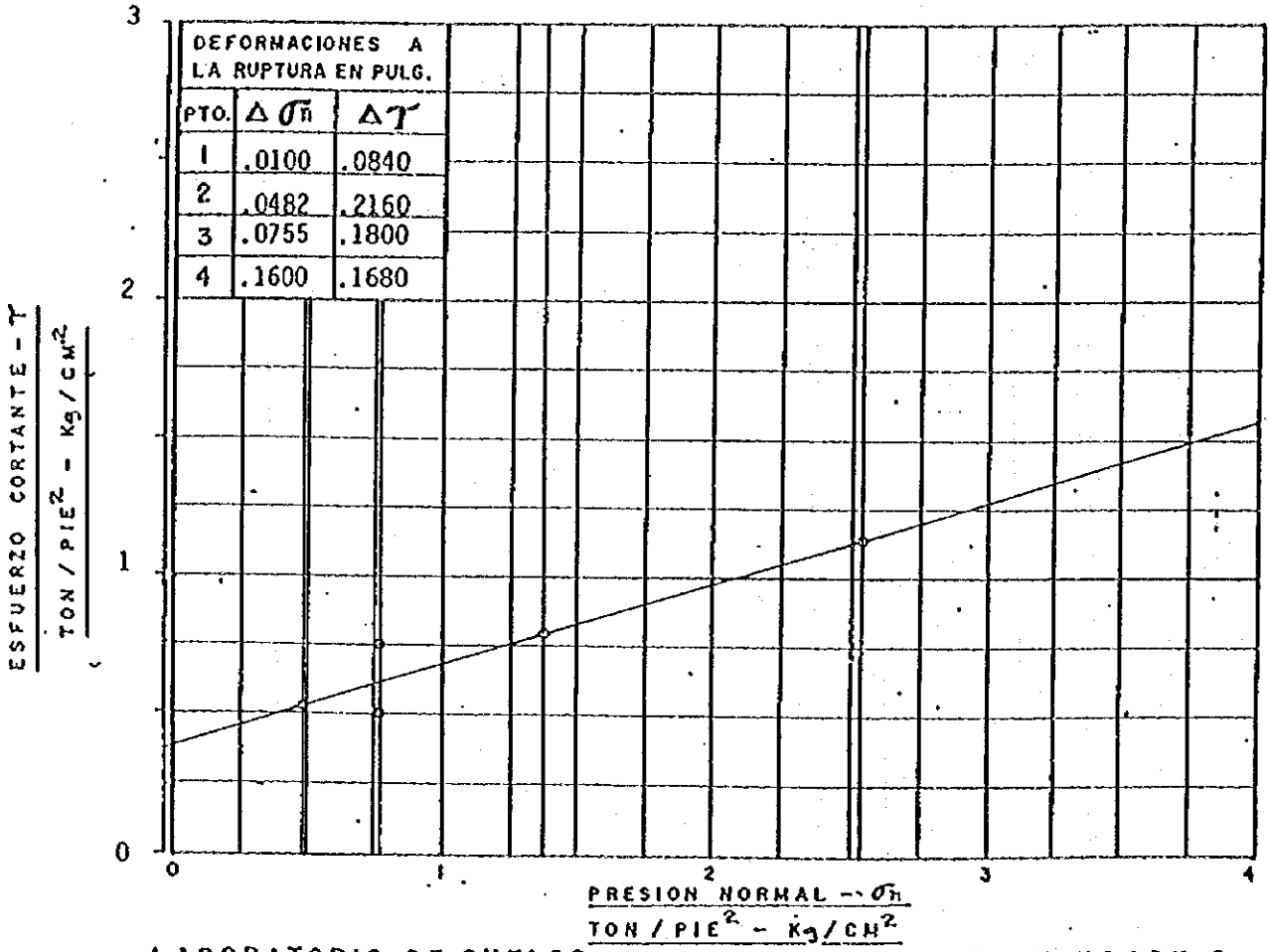
TRABAJO: SWISSBORING SANEAMIENTO-JICA LUGAR: CIUDAD CAPITAL

TIPO DE CORTE: NO CONSOLIDADO
NO DRENADO

ESPECIMEN: DIAMETRO (Do) = 2.50 PULGADAS
ALTURA (Ho) = 1.00 PULGADAS

No	REGISTRO	FECHA	PERFORACION No.	MUESTRA No.	PROFUNDIDAD EN METROS	CONT. HUMEDAD EN %	DENSIDAD HUMEDA LBS/PIE^3	COHESION TON/PIE^2	ϕ EN GRADOS
1	7618	28-2-96	B-11	B-11	11.55 A	29.6	110.6	0.40	17°00'
					11.75				

IDENTIFICACION: LIMO ARENOSO CON POCA ARCILLA, GRIS VERDOSO CON MANCHAS CAFE AMARILLENTO, POCO PLASTICO.



LABORATORIO DE SUELOS ING. F. KOOSE S.

PRUEBA DE CORTE DIRECTO

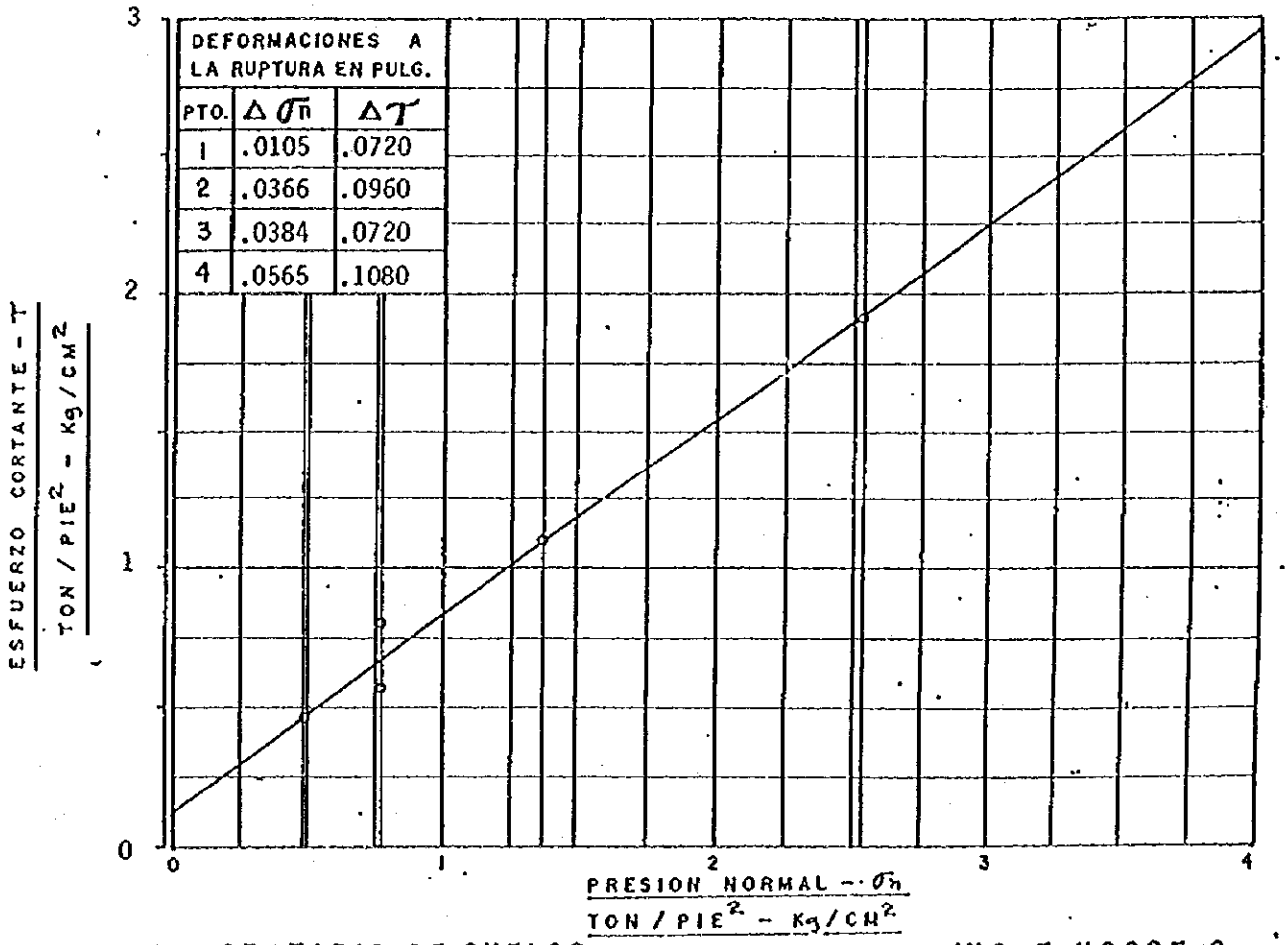
TRABAJO: SWISSBORING SANEAMIENTO-JICA LUGAR: CIUDAD CAPITAL

TIPO DE CORTE: NO CONSOLIDADO
NO DRENADO

ESPECIMEN: DIAMETRO (Do) = 2.50 PULGADAS
ALTURA (Ho) = 1.00 PULGADAS

No	REGISTRO	FECHA	PERFORACION No.	MUESTRA No.	PROFUNDIDAD EN METROS	CONT. HUMEDAD EN %	DENSIDAD HUMEDA LBS/PIE^3	COHESION TON/PIE^2	ϕ EN GRADOS
1	7619	28-2-96	B-13	B-13	21.00 A	40.6	96.7	0.14	35°30'
					21.16				

IDENTIFICACIÒN: ARENA FINA CON LIMO Y TRAZAS DE ARCILLA, BEIGE GRIS, CON TRAZAS DE PIEDRA POMEZ PEQUEÑA, LIGERAMENTE PLASTICO.



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TRABAJO: SWISSBORING
SANEAMIENTO-JICA

LUGAR: Ciudad Capital

SONDEOS HECHOS CON MAQUINA

RESUMEN DE RESULTADOS DE ENSAYOS DE COMPRESION NO CONFINADA

Sondeo No.	Muestra	Profundidad en metros	Contenido humedad en %	Densidad húmeda Lbs/pie^3	Esfuerzo axial Ton/pie^2
B-1	SB-1	3.00- 3.75	21.39	129.93	1.52
B-4	SB-4	11.00-11.45	87.81	82.49	5.06

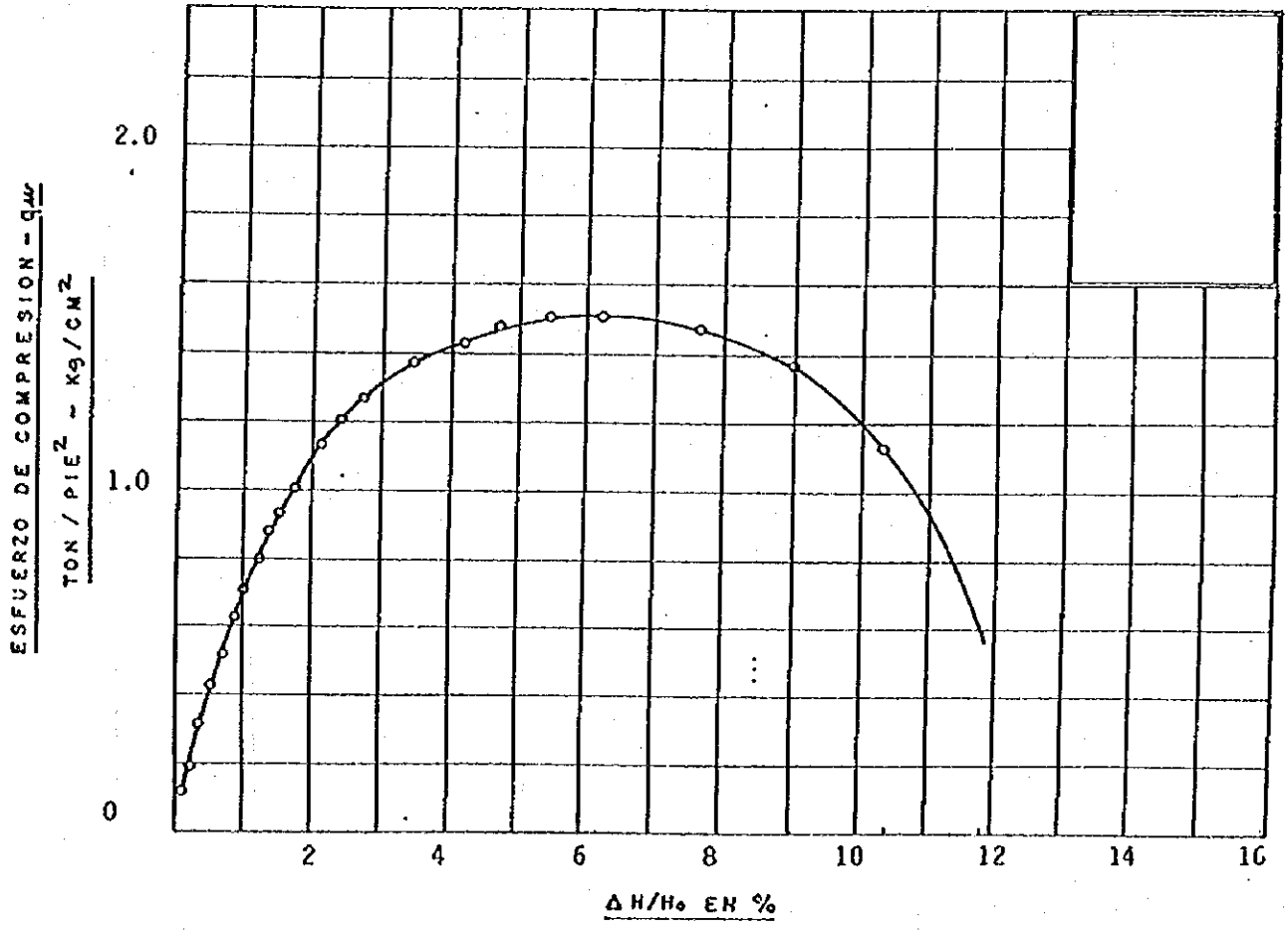
PRUEBA DE COMPRESION NO CONFINADA

TRABAJO: SWISSBORING- SANEAMENTO-JICA LUGAR: CIUDAD DE GUATEMALA

ESPECIMEN: DIAMETRO (Do) = 2.8740 PULGADAS
ALTURA: (Ho) = 6.4873 PULGADAS

No	REGISTRO	FECHA	PERFORACION No.	MUESTRA No.	PROFUNDIDAD EN METROS	CONT. HUMEDAD EN %	DENSIDAD HUMEDA LBS/PIE^3	σ_n MAX. TON/PIE^2	τ MAX. TON/PIE^2
1		1-3-96	B-1	SB-1	3.00	21.39	129.93	1.52	
					3.76				

IDENTIFICACION: LIMO ARCILLOSO CON ARENA, GRIS VERDOSO Y BEIGE CON POCA GRAVA PEQUEÑA, MEDIO PLASTICO COMPACTO.



LABORATORIO DE SUELOS ING. F. KOOSE S.

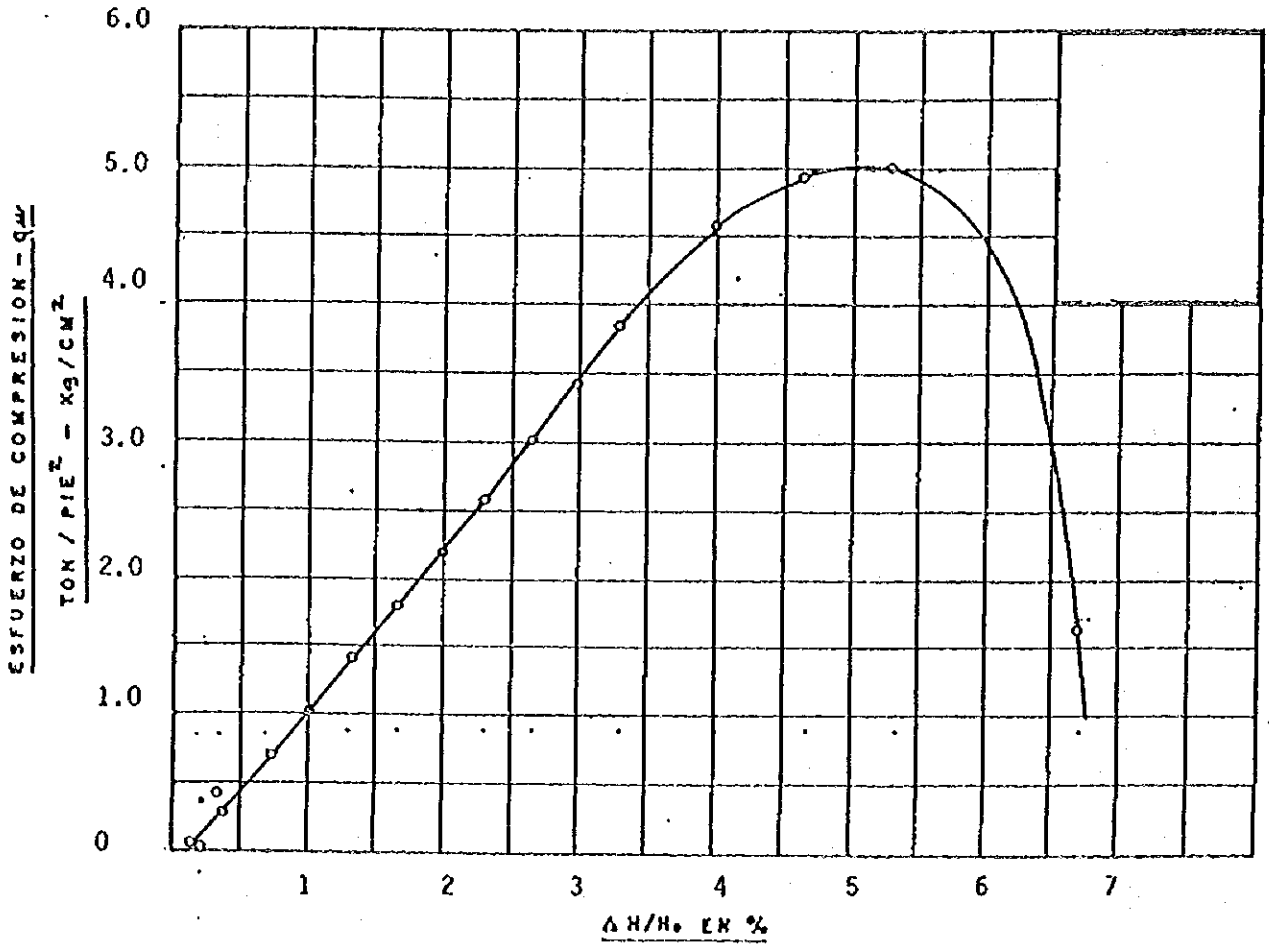
PRUEBA DE COMPRESION NO CONFINADA

TRABAJO: SWISSBORING SANEAMIENTO-JICA LUGAR: CIUDAD DE GUATEMALA

ESPECIMEN: DIAMETRO (Do) = 1.5 PULGADAS
ALTURA: (Ho) = 3.0 PULGADAS

No	REGISTRO	FECHA	PERFORACION No.	MUESTRA No.	PROFUNDIDAD EN METROS	CONT. HUMEDAD EN %	DENSIDAD HUMEDA LBS/PIE^3	σ_n MAX. TON/PIE^2	τ MAX. TON/PIE^2
1		28-2-96	B-4	SB-4	11.00	87.81	82.49	5.06	.
					11.45				

IDENTIFICACION: LIMO CON ARENA FINA Y POCA ARCILLA, BEIGE, LIGERAMENTE A POCO PLASTICO COMPACTO



LABORATORIO DE SUELOS ING. F. KOOSE S.

O.T.No.007551.-

INFORME No.0052.SC.-

INTERESADO: SWISSBORING

PROYECTO: WWTP- MCSR.

ASUNTO: ENSAYO A COMPRESION

FECHA: 8 DE MARZO DE 1996.-

RESULTADOS:

Muestra #	Diametro cms.	Altura Niv.	Carga Kgs.	Esfuerzo Kg/cm2.	Tipo de falla	Peso grs.
B-8	5.74	9.21	1044.2	40.43	En Fractura	-----
B-9	6.09	9.26	2179.2	75.0	Normal	-----
B-10	6.03	9.62	2678.6	94.1	Normal	-----
B-6.7	6.50	12.59	525.0	15.83	Normal	806.5

Atentamente,

Ing. Erick Rosales Torres
Jefe Sección de Concreto.

Vo.Bo.
Ing. César Alfonzo García G.
Director del CII.-

CENTRO DE INVESTIGACIONES DE INGENIERIA - GUATEMALA, C.A. - DIRECCION

Annex-RC Results of Soil Percolation Tests

Visual Soil Classification

Data Sheets for Soil Percolation Tests

Graphs for Soil Percolation Tests

VISUAL SOIL CLASSIFICATION
Clasificación visual del suelo

LOCATION: BETHANIA I
Localización

DATE: 7/1/96
Fecha

DEPTH (m) profundidad	DESCRIPTION descripción
1.0	Silty Sands, yellowish orange, with fine gravel Arena limosa, cafe amarillenta, con grava fina
2.0	Clayey Silts, dark brown, , slight plasticity, with fine sand Arcilla limosa, cafe oscura, ligeramente plástica, con trazas de arena fina
3.0	Clayey Silts, dark brown to black, medium plasticity, with some small rock fragments Limo arcilloso, cafe oscuro, medianamente plástico, con fragmentos pequeños de roca
4.0	Id.
5.0	Id.
6.0	Id.
7.0	Id.
8.0	Id.
9.0	Id.
10.0	Id.
11.0	Id.
12.0	Id.
13.0	Silty Clays, dark brown, medium plasticity Arcilla limosa,, cafe obscura, medianamente plástica
14.0	Id.
15.0	Id.
16.0	Id.
17.0	Id.
18.0	Id.
19.0	Clays, high plasticity, light brown Arcilla, café claro, sumamente plástica
20.0	Id.

VISUAL SOIL CLASSIFICATION
Clasificación visual del suelo

LOCATION: BETHANIA II
Localización

DATE: 9/1/96
Fecha

DEPTH (m) profundidad	DESCRIPTION descripción
1.0	Clayey- Silts, dark brown, medium plasticity, with organic material and small rock fragments Arcilla limosa, cafe oscura, medianamente plástica, con materia orgánica y fragmentos pequeños de roca
2.0	Clayey silts, dark brown, with fine to medium sands, dense, slight plasticity Arcilla limosa, cafe oscura, con arena fina a media, densa, medianamente plástica
3.0	Id.
4.0	Silty Clays, dark brown, slight plasticity, hard Arcilla limosa, café obscuro, baja plasticidad,duro
5.0	C.layey Silts, yellowish orange, hard, medium plasticity Limo arcilloso, cafe amarillento, duro, medianamente plástico
6.0	Clayey silts, dark to yellowish orange, dense, medium plasticity, with soft fine to medium sands designs Limo arcilloso, cafe obscuro a amarillento, denso, medianamente plástica, con trazas de arena fina a media
7.0	Id.
8.0	Id.
9.0	Id.
10.0	Id.
11.0	Id.
12.0	Id.
13.0	Id.
14.0	Id.
15.0	Id.
16.0	Id.
17.0	Id.
18.0	Id.
19.0	Id.
20.0	Id.

VISUAL SOIL CLASSIFICATION
Clasificación visual del suelo

LOCATION: 6 DE OCTUBRE COLONY
Localización

DATE: 11/1/96
Fecha

DEPTH (m) profundidad	DESCRIPTION descripción
1.0	Clayey - Silts, dark brown, dense, with organic material Limo Arcilloso, café obscuro, denso, con materia orgánica
2.0	Clayey - Silts, yellowish orange, hard, with hard pume fragments Limo arcilloso, café amarillento, duro, con fragmentos de pómez
3.0	Id.
4.0	Id.
5.0	Id.
6.0	Clayey- Silts, dark brown, medium plasticity Arcilla limosa, café obscuro, medianamente plástica
7.0	Id.
8.0	Id.
9.0	Id.
10.0	Id.
11.0	Clayey - Silts, yellowish orange, with small pumiceous fragments Limo arcilloso, café amarillento, con fragmentos pumíticos pequeños
12.0	Clayey - Silts, dark brown, low plasticity Arcilla limosa, café obscuro, plástica
13.0	Pumiceous ash, whitish, hard, with pumice fragments smooth and loose Ceniza pumícea, blanquecino, dura con fragmentos de pómez suave y suelto
14.0	Id.
15.0	Id.
16.0	Id.
17.0	Id.
18.0	Id.
19.0	Id.
20.0	Id.

VISUAL SOIL CLASSIFICATION
Clasificación visual del suelo

LOCATION: LOMA BLANCA
Localización

DATE: 12/1/96
Fecha

DEPTH (m) profundidad	DESCRIPTION descripción
1.0	Clayey -Silts, yellowish orange, smooth and light Limo arcilloso, cafe amarillento, suave y liviano
2.0	Clayey - Silts, yellowish, slight plasticity Limo arcilloso, cafe amarillento, ligeramente plástica
3.0	Id.
4.0	Id.
5.0	Id.
6.0	Id.
7.0	Id.
8.0	Id.
9.0	Id.
10.0	Id.
11.0	Same material, but in some parts are more denser Igual material, aunque en partes es más denso
12.0	Id
13.0	Id.
14.0	Id
15.0	Id
16.0	Id.
17.0	Id
18.0	Pumiceous ash, light brown to whitish, dense, with pumice fregments and silt Ceniza pumícea, café claro a blanquecina, densa, con fragmentos de pómez y limo
19.0	Fine sands, silty, light grey, loose with pumice fragments Arena fina, limosa, gris claro, suelta, con fragmentos de pómez
20.0	Clayey - Silts, light brown, dense Limo arcilloso, café claro, dense

VISUAL SOIL CLASSIFICATION
Clasificación visual del suelo

LOCATION: QUINTANAL
Localización

DATE: 16/1/96
Fecha

DEPTH (m) profundidad	DESCRIPTION descripción
1.0	Silty - Clays, dark brown, medium plasticity, with organic contents Arcilla limosa, cafe oscura, medianamente plástica, con materia orgánica
2.0	Silty - Clays, dark brown, medium plasticity, with soft soft fine sand designs Arcilla limosa, cafe oscura, medianamente plástica, con trazas de arena fina
3.0	Clayey Silts, ligth brown, medium plasticity, smooth, with small pumice fragments and fine sands Limo arcilloso, cafe claro, medianamente plástico, suave, con pequeños fragmentos de pómez y arena fina
4.0	Id.
5.0	Id.
6.0	Id.
7.0	Id.
8.0	Id.
9.0	Id.
10.0	Id.
11.0	Id.
12.0	Id.
13.0	Id.
14.0	Id.
15.0	Id.
16.0	Id.
17.0	Id.
18.0	Id.
19.0	Id.
20.0	Id.

DATA SHEET FOR SOIL PERCOLATION TEST
Hoja de datos del ensayo de percolación en suelo

Location:
Localización

BETHANIA I

TIME ELAPSED (hrs) Tiempo transcurrido	WATER LEVEL (m) nivel de agua	WATER LEVEL DROP (mm) Intervalo en descenso
START UP inicio en superficie	9.35	
1.0	9.38	30
2.0	9.41	25
3.0	9.43	20
4.0	9.44	15
5.0	9.45	13
6.0	9.47	14
7.0	9.48	12

BETHANIA II

TIME ELAPSED (hrs) Tiempo transcurrido	WATER LEVEL (m) nivel de agua	WATER LEVEL DROP (mm) Intervalo en descenso
START UP inicio en superficie		
1.0	--	--
2.0	--	--
3.0	--	--
4.0	--	--
5.0	--	--
6.0	--	--
7.0	--	--
8.0	--	--

* The well could not be filled with more than 7500 l. due to leak through a paleochannel very permeable.

DATA SHEET FOR SOIL PERCOLATION TEST
Hoja de datos del ensayo de percolación en suelo

Location:
Localización

6 DE OCTUBRE

TIME ELAPSED (hrs) Tiempo transcurrido	WATER LEVEL (m) nivel de agua	WATER LEVEL DROP (mm) Intervalo en descenso
START UP inicio en superficie	5.06	
1.0	5.10	38
2.0	5.12	20
3.0	5.14	17
4.0	5.16	18
5.0	5.17	15
6.0	5.19	15
7.0	5.20	13

LOMA BLANCA

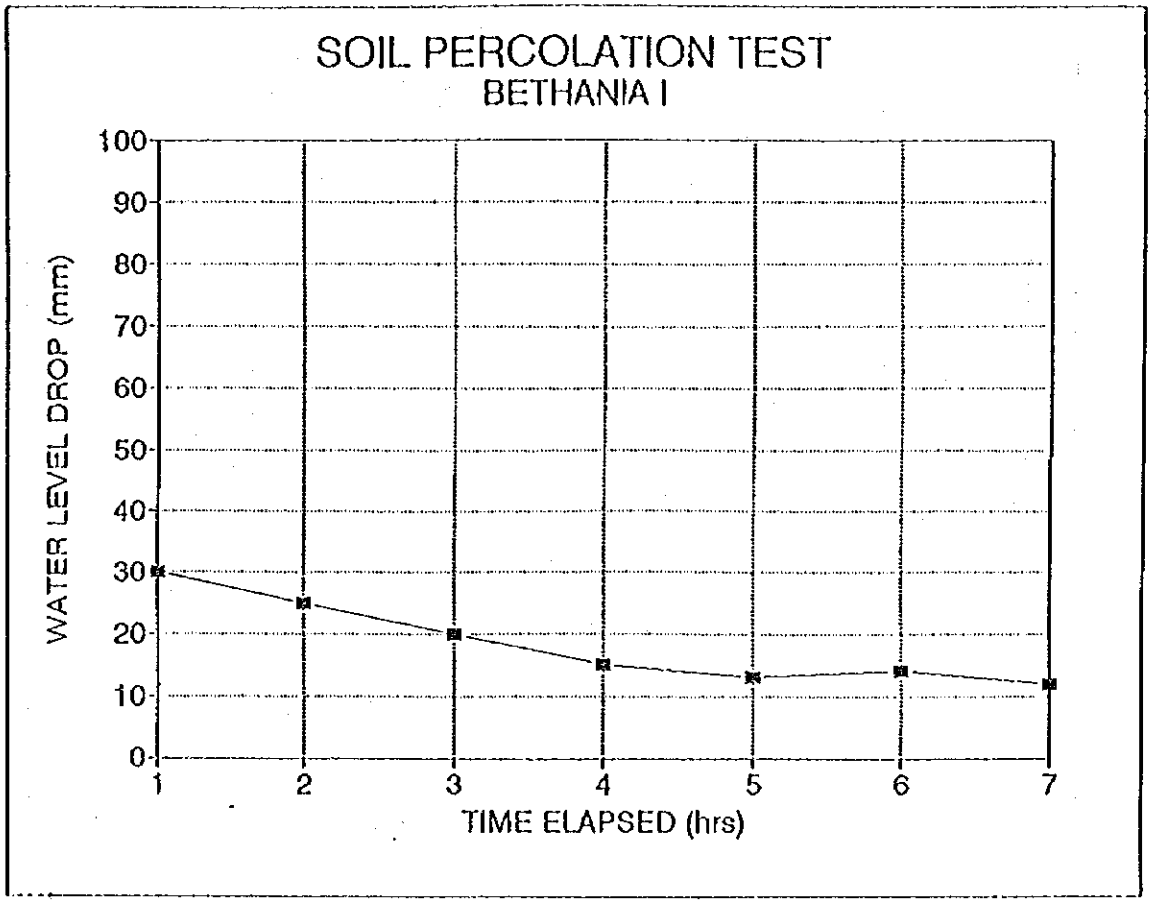
TIME ELAPSED (hrs) Tiempo transcurrido	WATER LEVEL (m) nivel de agua	WATER LEVEL DROP (mm) Intervalo en descenso
START UP inicio en superficie	9.38	
1.0	9.65	270
2.0	9.85	200
3.0	10.07	220
4.0	10.17	100
5.0	10.29	120
6.0	10.43	140
7.0	10.55	120

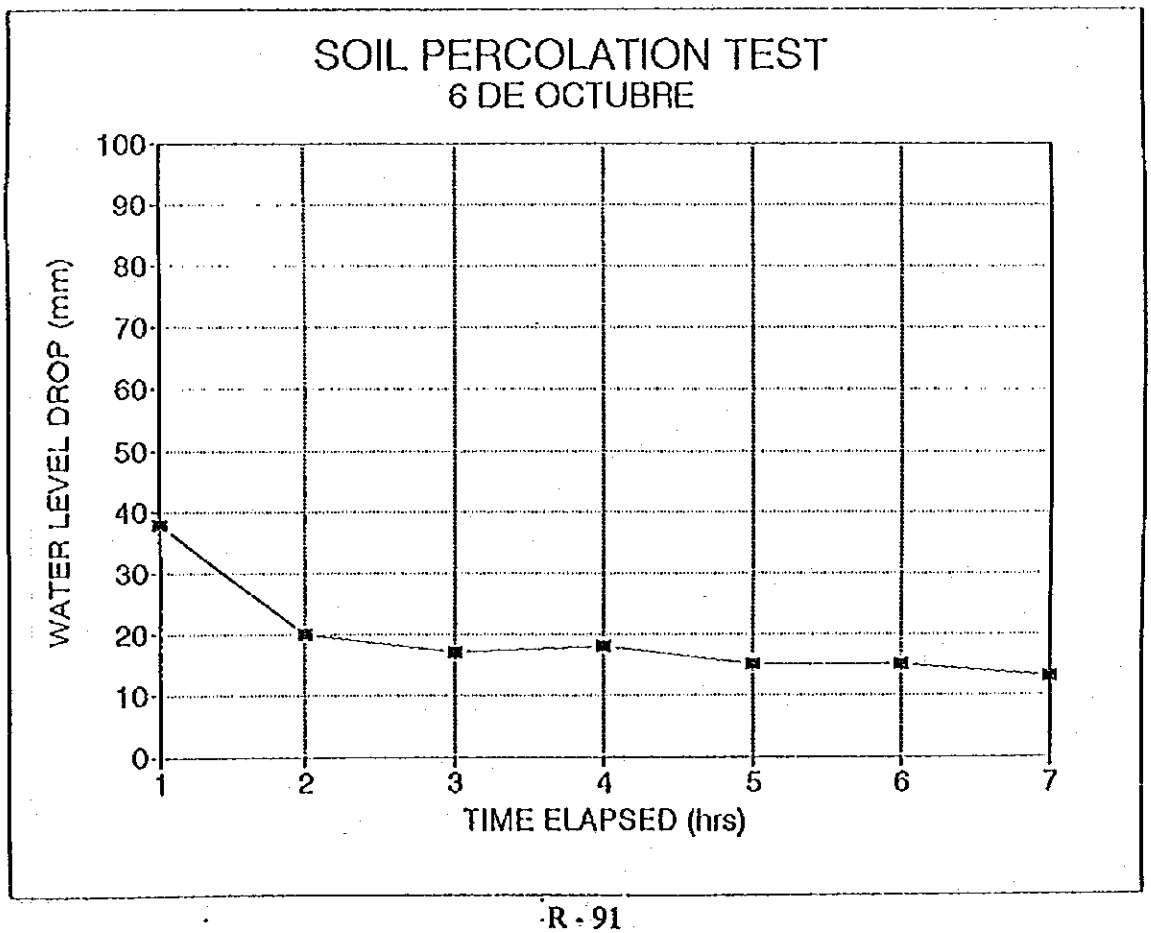
DATA SHEET FOR SOIL PERCOLATION TEST
Hoja de datos del ensayo de percolación en suelo

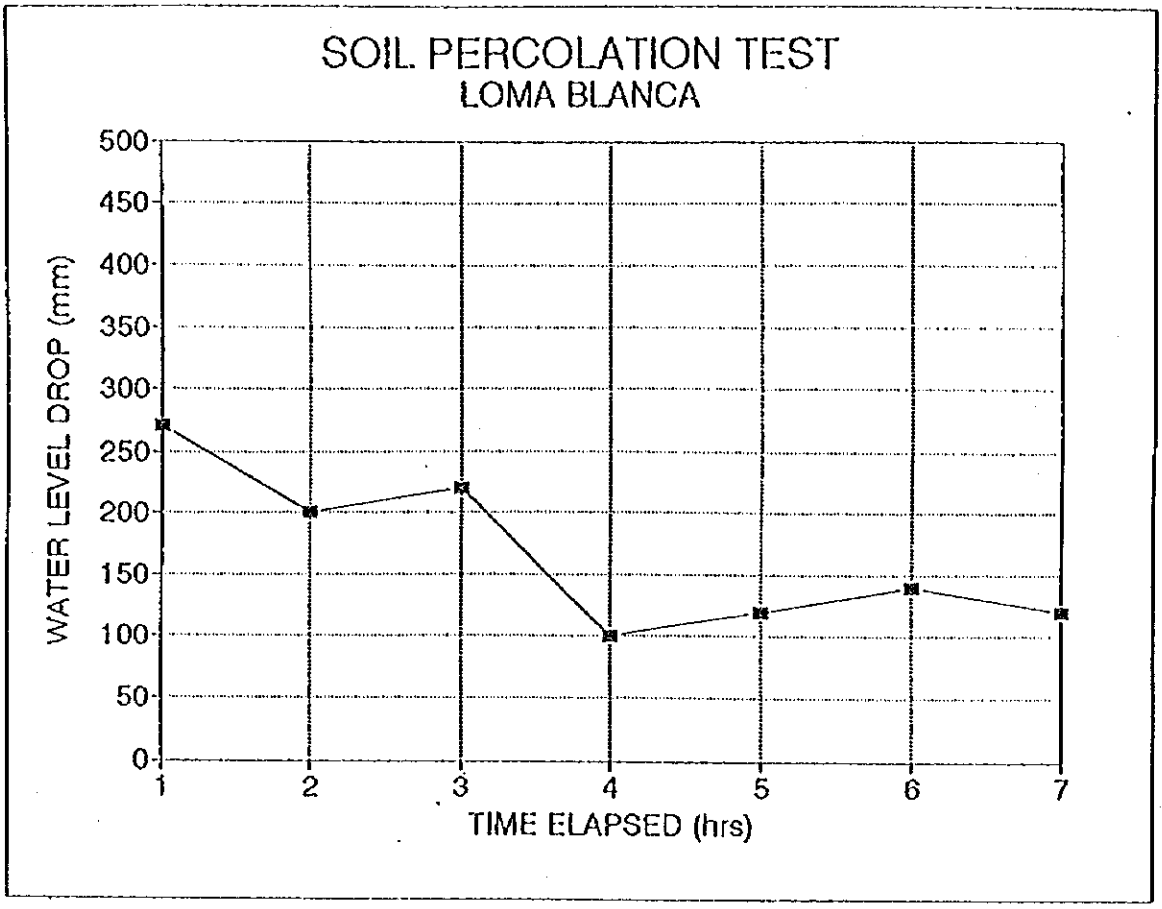
Location:
Localización

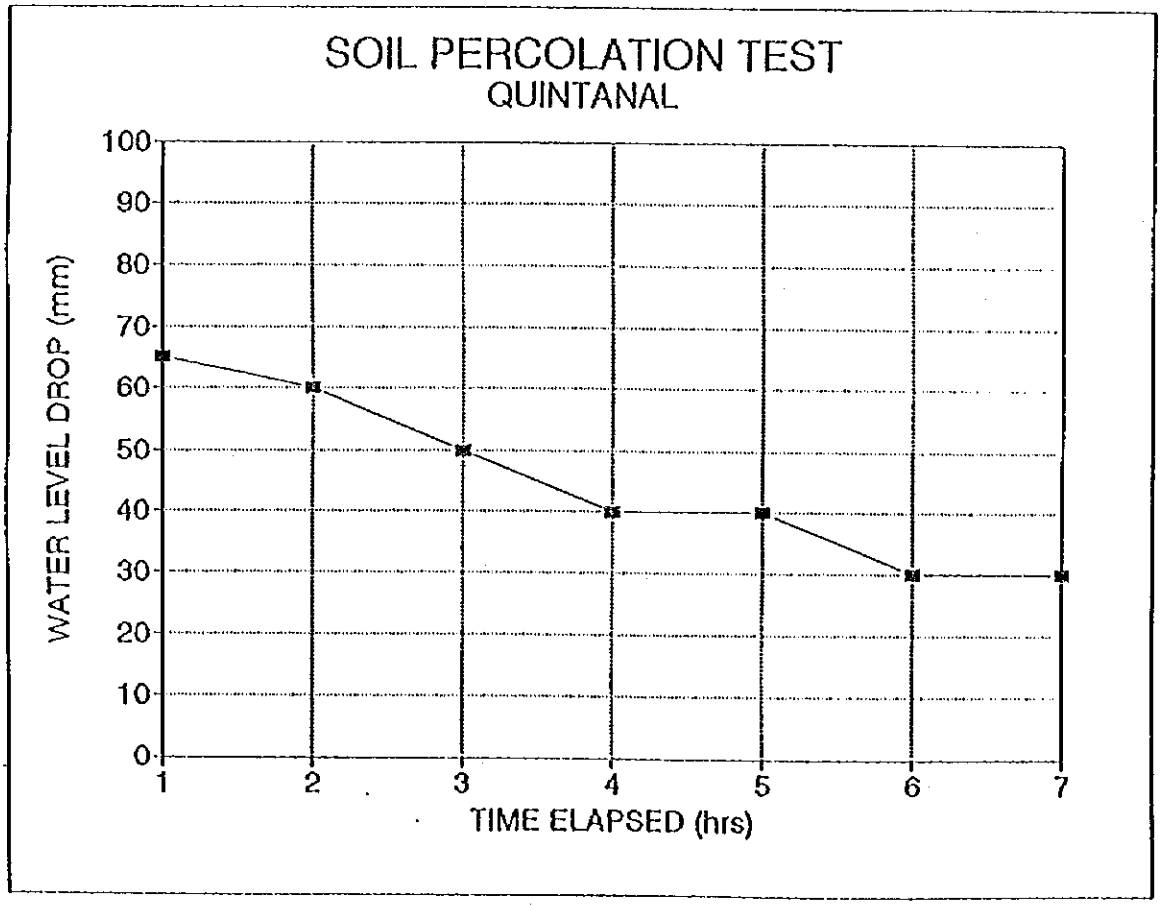
QUINTANAL

TIME ELAPSED (hrs) Tiempo transcurrido	WATER LEVEL (m) nivel de agua	WATER LEVEL DROP (mm) Intervalo en descenso
START UP inicio en superficie	5.45	
1.0	5.51	65
2.0	5.57	60
3.0	5.62	50
4.0	5.66	40
5.0	5.70	40
6.0	5.73	30
7.0	5.76	30


SOIL PERCOLATION TEST
BETHANIA I
WATER LEVEL DROP (mm)
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
TIME ELAPSED (hrs)


SOIL PERCOLATION TEST
6 DE OCTUBRE
WATER LEVEL DROP (mm)
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
TIME ELAPSED (hrs)


SOIL PERCOLATION TEST
LOMA BLANCA
WATER LEVEL DROP (mm)
500
450
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
TIME ELAPSED (hrs)


SOIL PERCOLATION TEST
QUINTANAL
WATER LEVEL DROP (mm)
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
TIME ELAPSED (hrs)

SUPPORTING REPORT S

ENVIRONMENTAL IMPACT ASSESSMENT

SUPPORTING REPORT S

ENVIRONMENTAL IMPACT ASSESSMENT

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S ENVIRONMENTAL IMPACT ASSESSMENT

S1 INTRODUCTION

S1.1 GENERAL

Fig. S-1 shows the steps in environmental assessment for this Study. Since, this Study consists of the formulation of Wastewater Management Master Plan for the Guatemala Metropolitan Area and the Feasibility Study on the First Stage Project, the environmental assessment is carried out in three steps. They are;

Step 1 Initial Environmental Examination (IEE) and Preparation of Terms of Reference(TOR) for Environmental Impact Assessment (EIA) for the Master Plan,

Step 2 Execution of Environment Surveys on Alternatives (Central Region and South 3 Region) for the First Stage Project, during the field survey for Feasibility Study, and

Step 3 EIA on the First Stage Project (i. e. the selected alternative, South 3 Region).

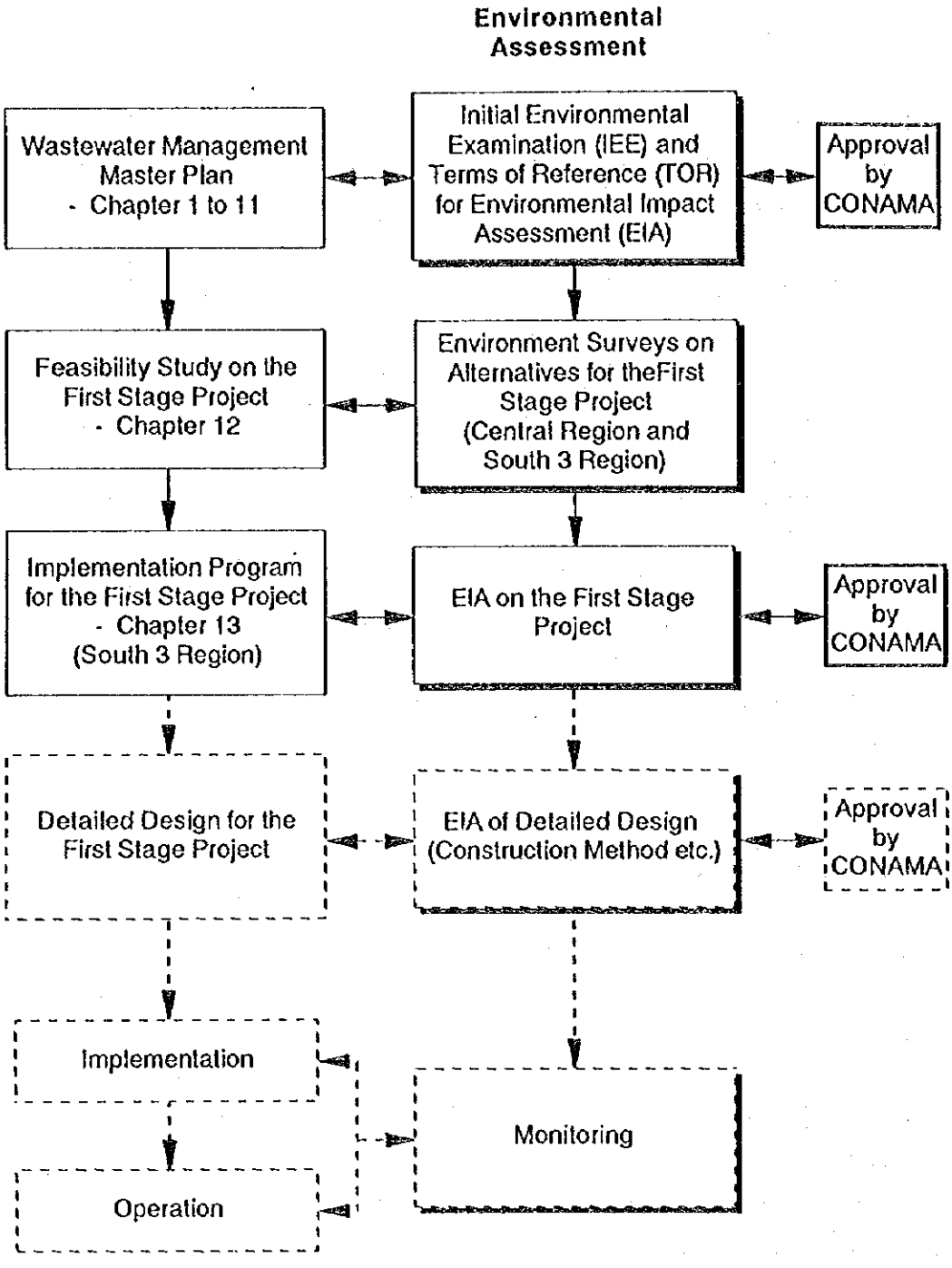
EIA on the First Stage Project is reported in Chapter 14, Volume II, and the results of Step 1, 2 and 3 are reported below. Information on Central Region is reported up to the evaluation of significant environmental impacts. Mitigation and compensation, monitoring etc. are reported only First Stage Project, which does not include sanitation systems. Results of environment surveys carried out in Step 2, mainly water quality survey, social survey etc. are reported in the annexes.

S1.2 LEGAL FRAMEWORK

The Law for the Protection and Improvement of the Environment ('Ley 68-86') enacted by the Congress of Guatemala requires that an environmental assessment be carried out for development projects in the planning stage. If significant or potential impacts are envisaged, an environmental impact assessment (EIA) is necessary and the EIA must be approved prior to project implementation. National Environment Commission (CONAMA) is entrusted with the authority to approve EIA. The current regulation for conducting an environmental impact assessment is "Instructivo de Procedimientos para las Evaluaciones de Impacto Ambiental" of 1990 issued by CONAMA.

Fig. S - 1

The Study on the Improvement of Wastewater Management in the Guatemala Metropolitan Area



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE STEPS IN EIA FOR THE WASTEWATER MANAGEMENT STUDY

Due to the scale of the proposed Wastewater Management Master Plan and the First Stage Project, an EIA is necessary.

At the Master Plan stage, an IEE was carried out and the TOR for EIA was approved by CONAMA.

S1.3 TERMINOLOGY

The terms expressed in the present study are adjusted to the definitions according to the Instructions and Procedures for EIA.

S1.4 PROJECT IMPLEMENTING ORGANIZATION

The Municipal Water Supply Public Corporation (EMPAGUA) will be the implementing organization for the First Stage Project. EMPAGUA is a public enterprise under the Municipality of Guatemala. Its service area is defined as the Guatemala City and its associated urban area. The name of its legal representative and address are as shown below:

Legal Representative	:	Ing. Carlos Quezada Vega General Manager
Address	:	7a Avenue 1-20, Zone 4 Edificio Torré Café, Guatemala City

S1.5 LOCAL CONSULTANT

EIA is conducted by the JICA Study Team and the local consultant, namely Ingeniería Ambiental, S. A./AMBIO. AMBIO is registered as an Environmental Consultant in Guatemala under No. 25 Disposition of CONAMA 155-93, corresponding to Ingeniería Ambiental, S.A./AMBIO; in the National System of Financing the Pre-Investment (SINAFIP) under the code 649150, renewed June 2, 1995. The present address is: Reforma Avenue 8-60 Zone 9, Edificio Galerías Reforma, Torre I, Oficina: 1103, Guatemala City.

The following specialists participated in the EIA.

1)	Dr.-Eng. Adrián Juárez Pineda	Chief Environmental Expert
2)	Eng. Juan José Sandoval	Coordination/ Construction
3)	Dr.Eng. Carlos Humberto Rivera	Hydrology / Water Quality
4)	Lic. Rolando Rubio	Archaeology
5)	Lic. Otto Sandoval	Ecology (Flora and Fauna)
6)	Lic. Carlos Quezada	Sociology

7) Eng. Carlos De Leon — Seismology and Geology
8) Eng. Jorge De la Cruz — Seismology and Geology
9) Eng. José Miguel Duro — Ecology (Forest)
10) Arq. Alba Luz Fernández — Ecology (Landscape)

Water quality analysis were carried out by the AGRILAB.

S2 OBJECTIVES AND SCOPE

S2.1 OBJECTIVES

The objectives of the assessment are as follows:

- To determine the Project activities that generate the environmental impact in its different phases of execution: planning, construction and operation.
- To identify the positive and adverse impacts on the environment.
- To propose mitigation actions and a monitoring plan to reduce the significant environmental impacts.

S2.3 TERMS OF REFERENCE FOR EIA

The Environmental Impact Assessment is based on the requirements described in the Terms of Reference (TOR) (refer Annex SE) and approved by CONAMA. The TOR for EIA basically require the description of the project, the environment, and the assessment of impact activities during different execution stages.

Specifically, the following tasks were performed:

- Description of the project.
- Description of the physical, biological, geological and sociocultural components of project area
- Review of the significant environmental impacts identified in the Master Plan and authorized by CONAMA.
- Assessment of the significant environmental impacts identified in the Master Plan during the different execution phases stages of the First Stage Project
- Mitigation measures for monitoring the various impacts generated by the First Stage Project.

S3 PROJECT DESCRIPTION

S3.1 MASTER PLAN

S3.1.1 Description of Study Area

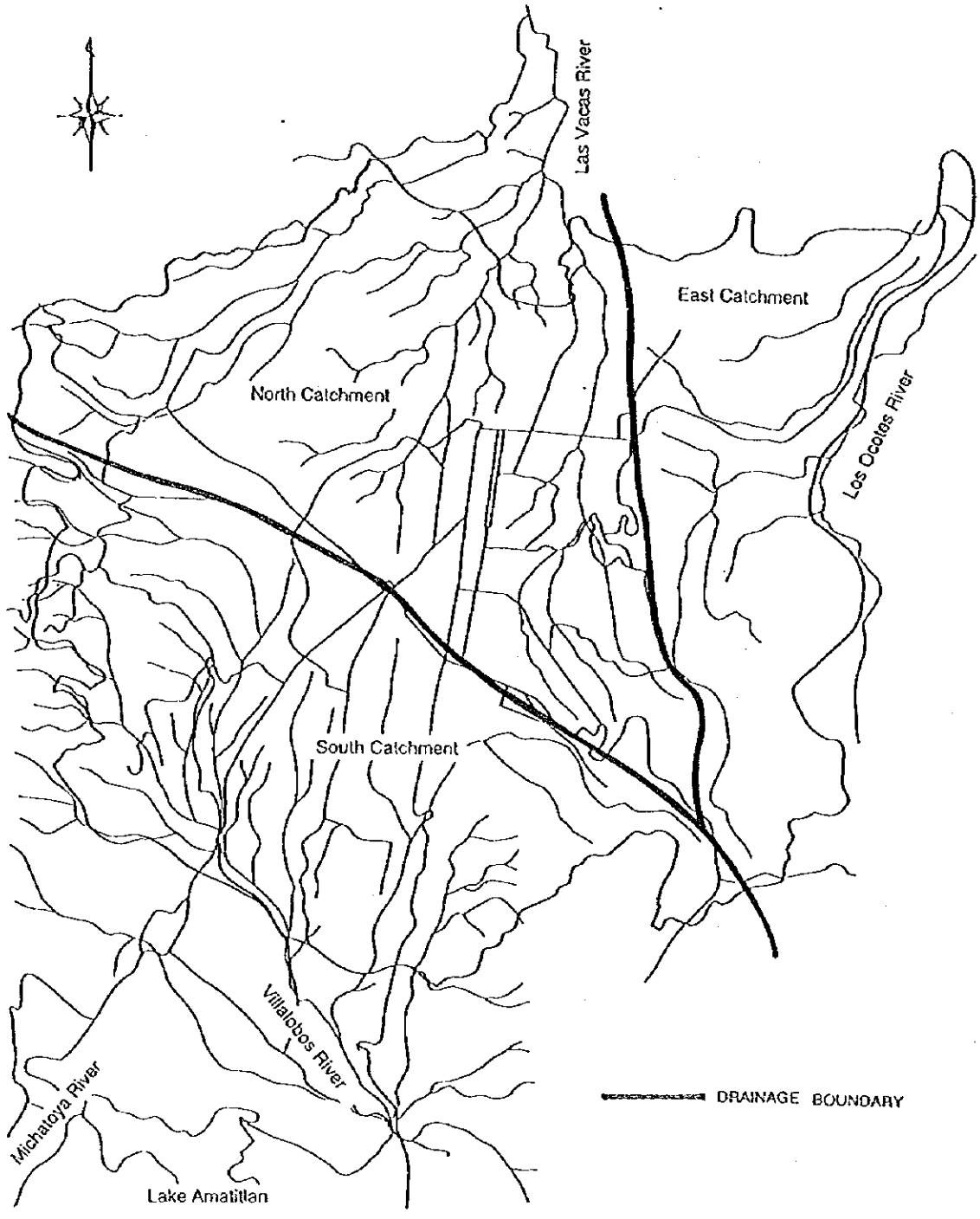
The Study Area includes Guatemala City and part of seven municipal areas: Chinautla, Mixco, Villa Nueva, San Miguel Petapa, Santa Catarina Pinula, Villa Canales and San Pedro Ayampuc, with an area of 34,500 ha. The whole area falls into three major drinage basins: North, East and South (Fig. S-2 and S - 3).

The north basin limits with Guatemala City and consists of 20 small rivers from Las Vacas River basin, which in turn belongs to the Motagua River basin. The most important rivers of the area are: El Zapote and Las Vacas, which finally flow to the North and confluence with Motagua River.

To the south of the Continental Divide is the Michatoya River basin, and consists of several rivers like El Molino, Mariscal, Pinula, Las Minas and Platanitos which finally drains to Lake Amatitlan through Villalobos River. Lake Amatitlan is drained by Michatoya River through gates controlled for hydro electric production at a downstream location.

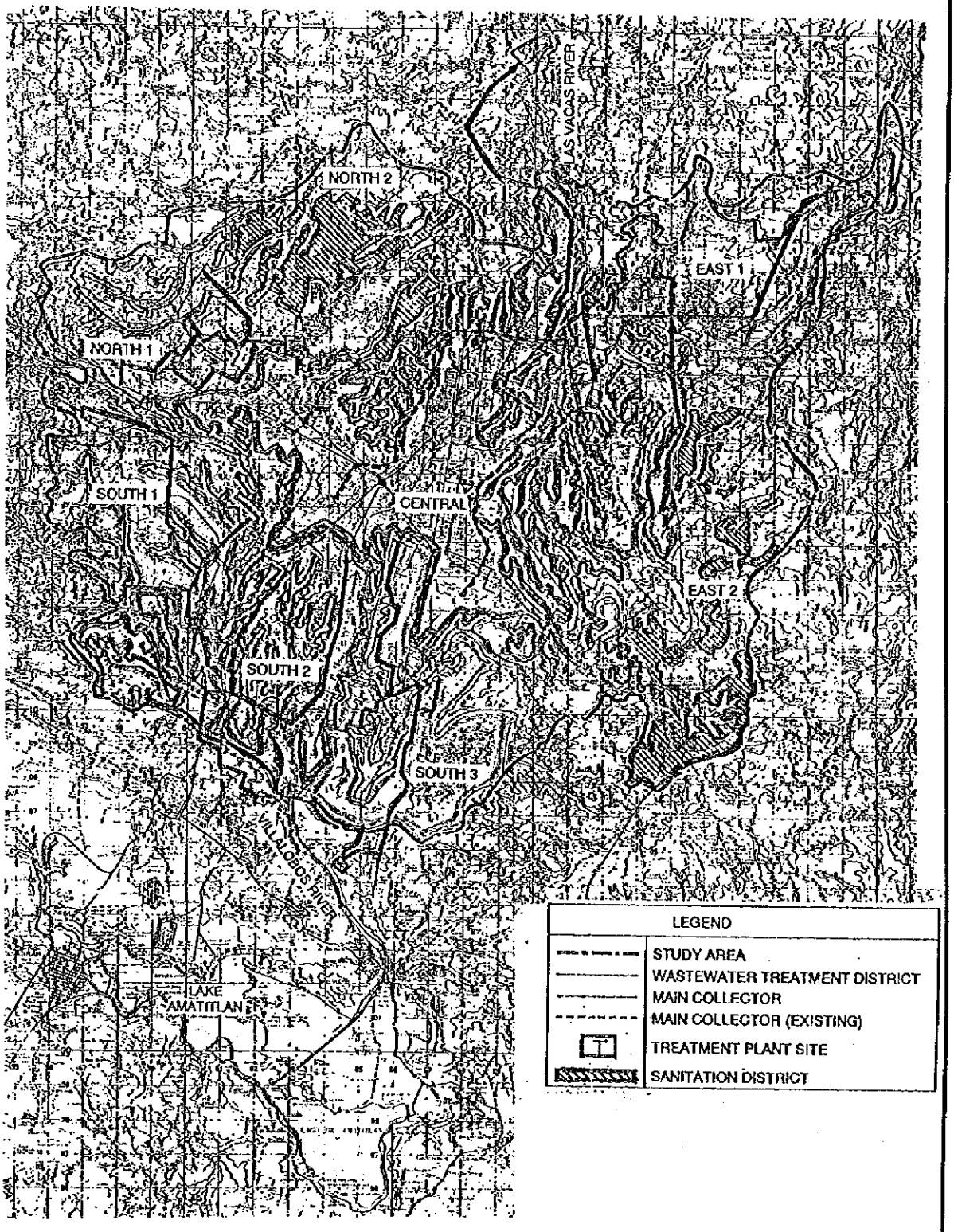
For planning purposes, the three basins suggested are subdivided into eight Regions (Fig. S-3). The northern sub-basin is divided in Central, North 1 and North 2 Regions; the eastern sub-basin is divided in East 1 and East 2 Regions; and the southern sub-basin is divided in South 1, South 2 and South 3 Regions. The limits of these regions are defined on topographic considerations and administrative divisions. Total planned area of these regions is 20,470 ha.

Fig. S - 2



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE MAJOR WATERSHEDS AND RIVERS IN THE STUDY AREA

Fig. S - 3



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE PROPOSED WASTEWATER MANAGEMENT SYSTEM

S3.1.2 Priority Regions and Their Development Program

Sewerage and Sanitation Master Plan with a target year of 2015 is made for the eight regions. Out of those regions, two regions are selected as Priority Regions for implementation based on technical, economical, financial and social considerations. Priority Regions are Central Region and South 3 Region (Fig. S-3) and are intended for implementation in three stages. First Stage will start in 1999 and end in 2001; the second stage from 2002 to 2006 and the third one from 2007 to 2011.

S3.2 FEASIBILITY STUDY

S3.2.1 Alternatives for Feasibility Study - Central Region and South 3 Region

Table S -1 summarizes the fundamentals of the alternatives for the Feasibility Study. For Central Region, sewerage facilities mainly consists of Las Vacas Main Collector to transport existing raw wastewater discharge at Belice Bridge to the proposed wastewater treatment plant (WWTP) site located in Chinautla and WWTP facilities for primary treatment, before discharging to Las vacas River (Fig. S-4(a)). Main facilities for the South 3 Region are Pinula Main Collector and WWTP facilities for secondary treatment by trickling filter process, before discharging to Pinula River (Fig. S-4(b)). Fig. S-5 and Fig. S-6 show the treatment process flow and layout of WWTP for Central Region WWTP,respectively. Similarly, Fig. S-7 and S-8 show respective information for South 3 Region WWTP. Table S-2 and S-3 show summary of main collector s for Central Region and South 3 Region, respectively. Table S-4 shows the outline of treatment facilities for Central WWTP and South 3 WWTP.

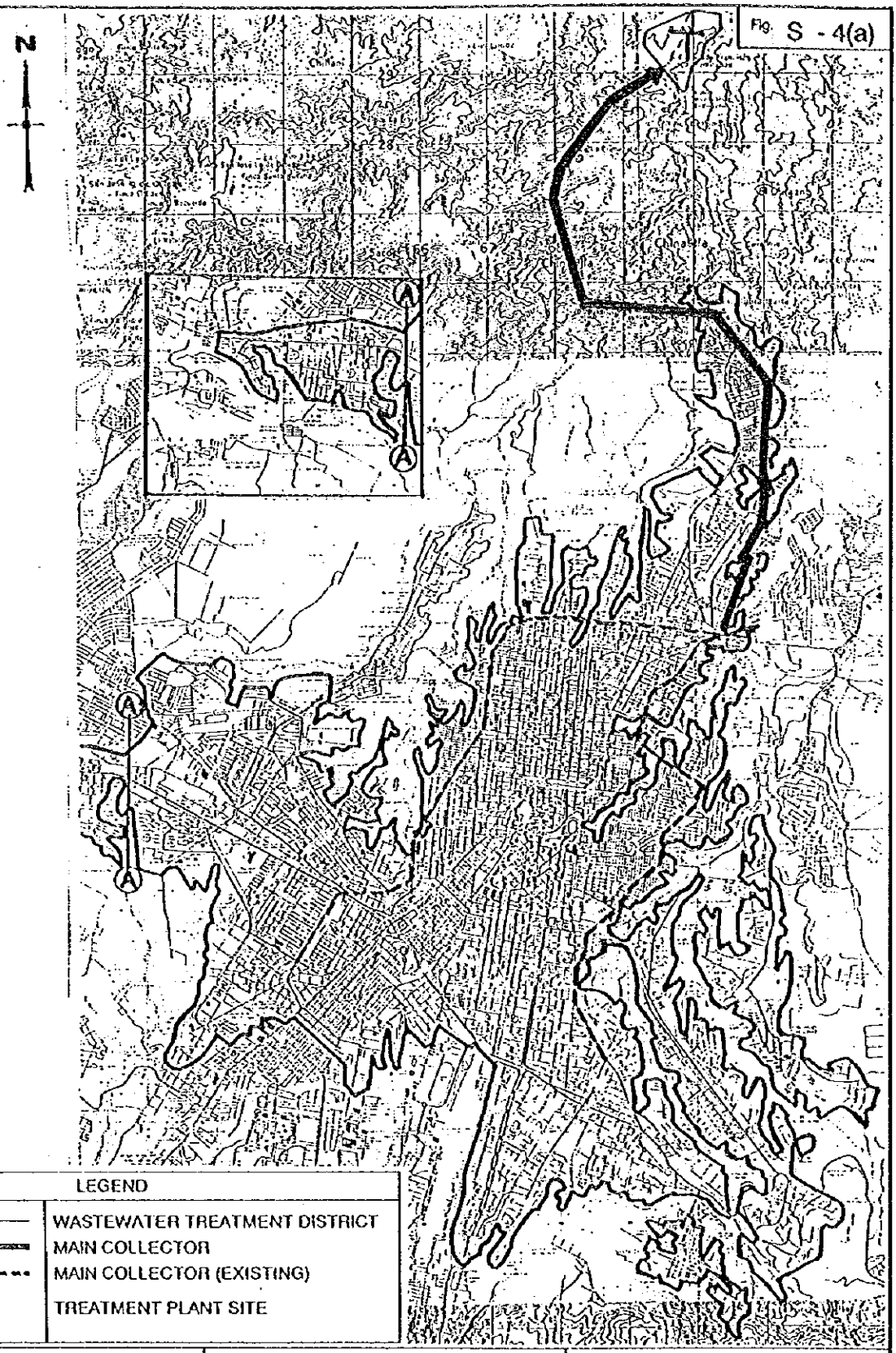
For those communities which could not be served by sewerage system due to topographical conditions, sanitation systems are proposed. They consist of sewers to collect wastewater and septic tank with either upflow anaerobic filter or infiltration well for treatment. Septage accumulated in the septic tanks are to be collected and treated in the WWTP of the respective Region. Fig. S-9(a) and S-9(b) show the location of sanitation systems for Central Region and South 3 Region, respectively. Fig. S-10 shows the typical drawing of a septic tank with upflow anaerobic filter.

Table S-1 Fundamentals of Alternatives for Feasibility Study

ITEM	CENTRAL REGION	SOUTH 3 REGION
1 FUNDAMENTALS		
1.1 CONSTRUCTION PERIOD	1999 ~ 2001	1999 ~ 2001
1.2 SEWERAGE		
1.2.1 Served Area, ha	4,605	896
1.2.2 Served Population (As of 2002)	533,200	53,200
1.3 SANITATION		
1.3.1 Served Area, ha	283	42
1.3.2 Served Population	33,900	2,900
2 FACILITY DESIGN		
2.1 SEWER		
2.1.1 Collection System	Combined	Separate
2.2 WASTEWATER TREATMENT PLANT		
2.2.1 Treatment Capacity, m^3/d (daily maximum)	196,000	36,000
2.2.2 Raw Wastewater Quality		
a) BOD, mg/L	280	280
b) SS, mg/L	280	280
2.2.3 Treatment Level	Primary	Secondary
2.2.4 Treatment Process	Primary Sedimentation	Trickling Filter Process
2.2.5 Final Effluent Quality		
a) BOD, mg/L	182	56
b) SS, mg/L	126	56
2.2.6 Receiving Water Body	Las Vacas River	Villalobos River (Pinula River)
2.3 SANITATION SYSTEM		
2.3.1 Number of Colonies	20	3
2.3.2 Treatment Method	Septic tank with upflow anaerobic filter or with soil absorption well	
2.3.3 Raw Wastewater Quality		
a) BOD, mg/L	330	330
b) SS, mg/L	330	330
2.3.4 Final Effluent Quality		
a) BOD, mg/L	83	83
b) SS, mg/L	83	83

Source : Study Team

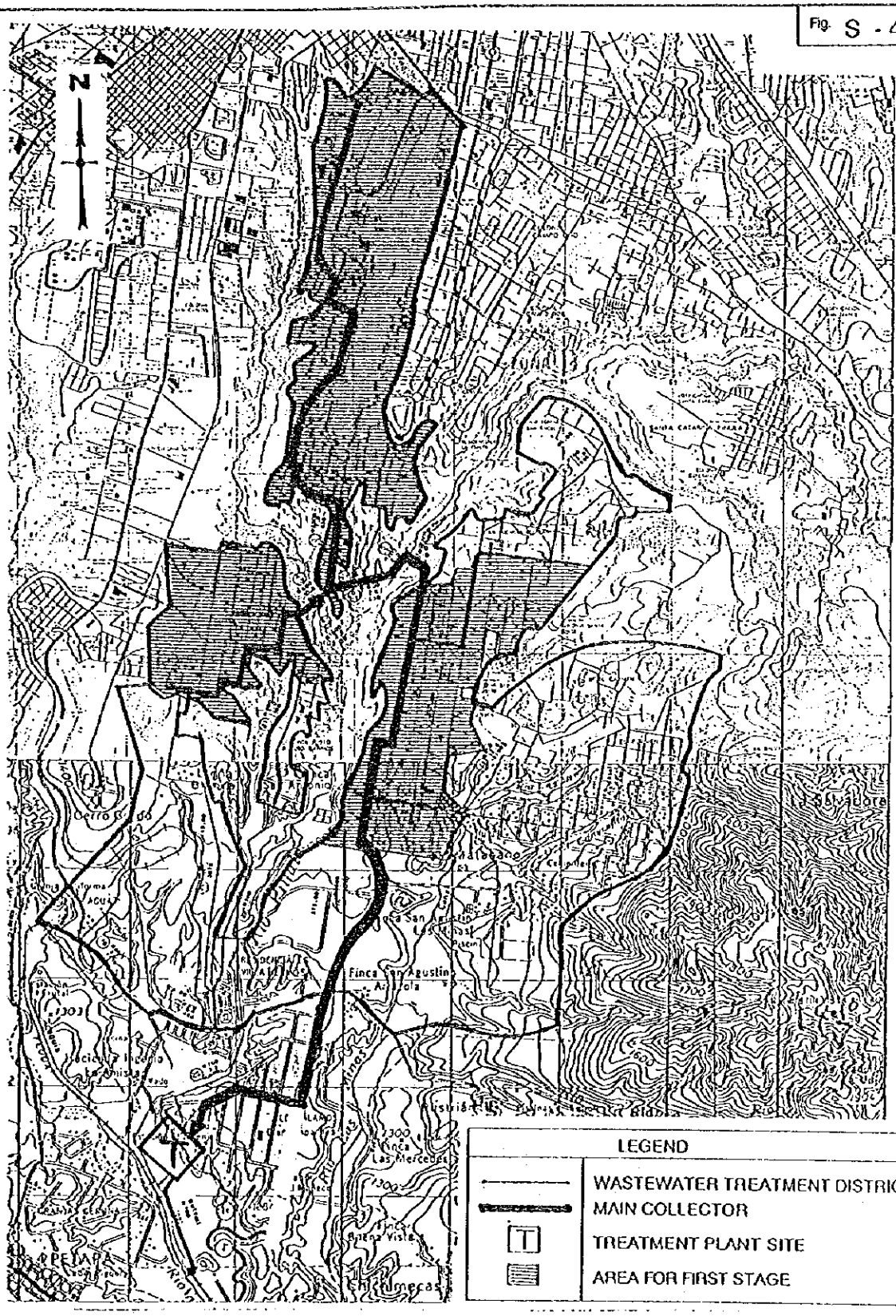
Fig. S - 4(a)



LEGEND	
———	WASTEWATER TREATMENT DISTRICT
▬▬▬	MAIN COLLECTOR
- - - - -	MAIN COLLECTOR (EXISTING)
T	TREATMENT PLANT SITE

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SEWERAGE SYSTEM FOR CENTRAL REGION

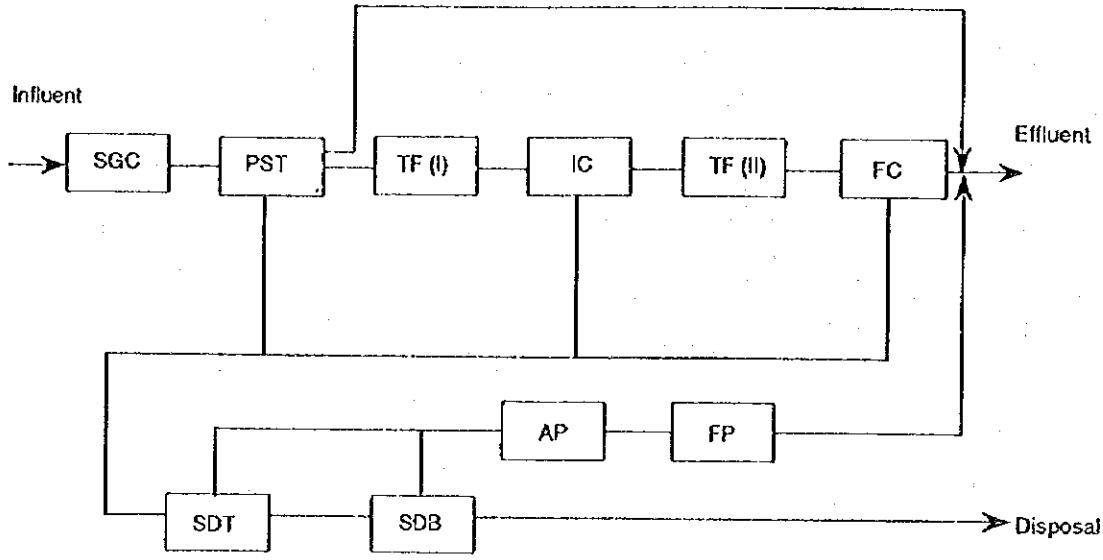
Fig. S - 4(b)



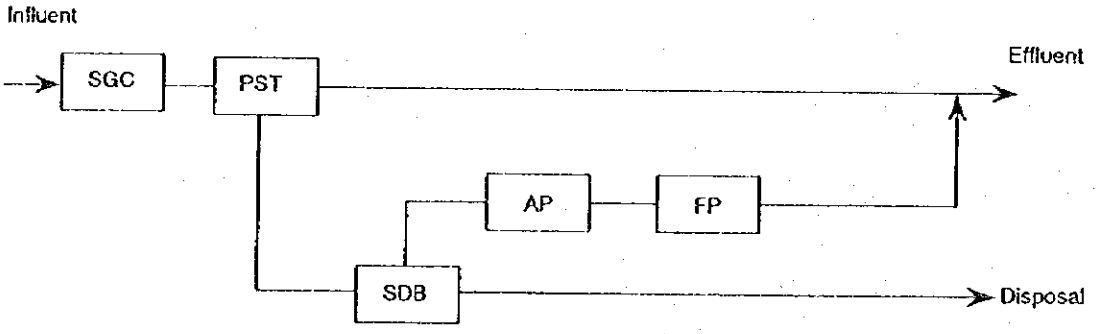
THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SEWERAGE SYSTEM FOR SOUTH 3 REGION

Fig. S - 5

Primary Treated ExcessWet weather Flow
(3 x Maximum Hourly Flow - 1 x Maximum Hourly Flow)



a) Ultimate



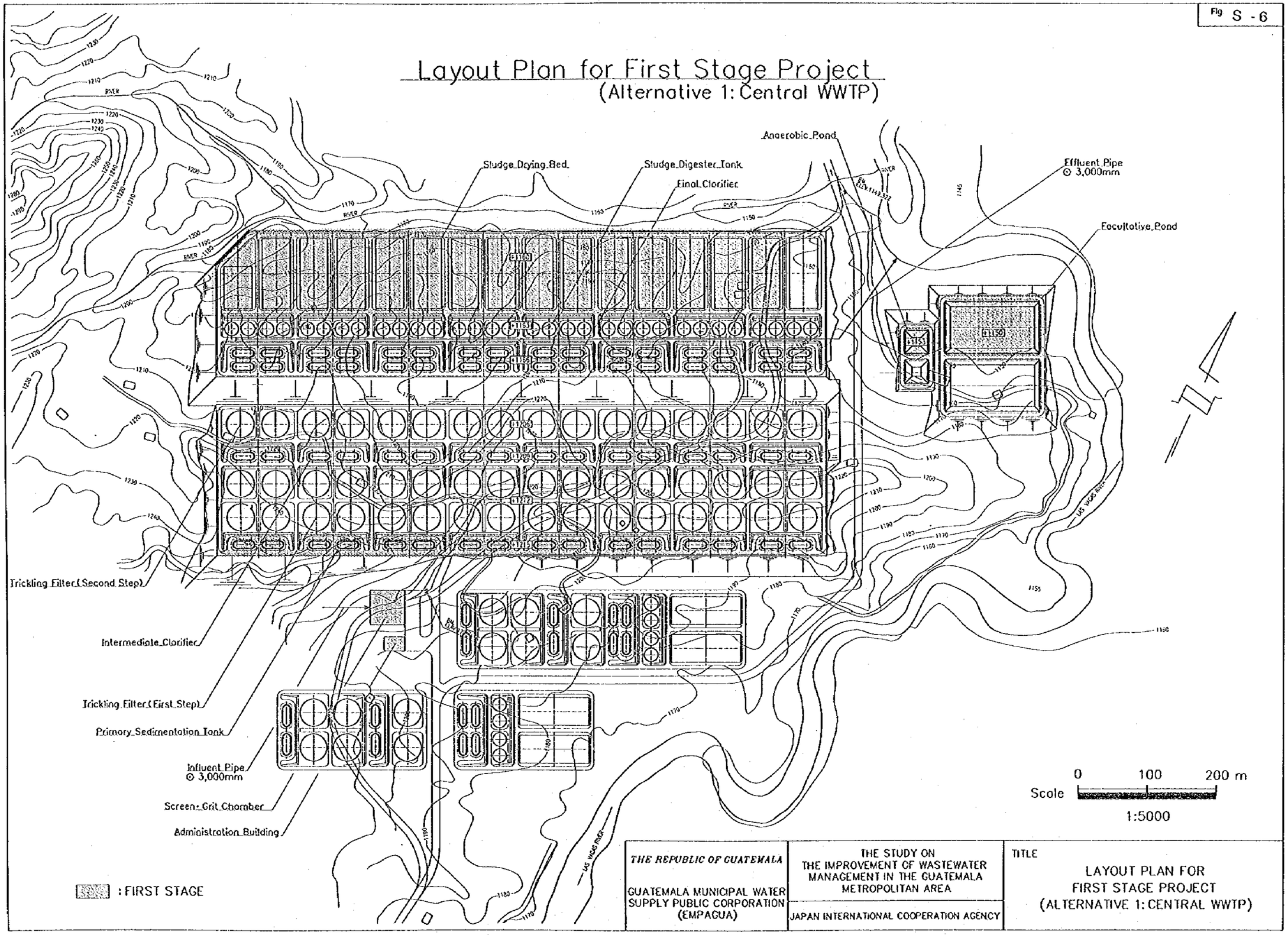
b) First Stage

Legend
SGC - Screen Grit Chamber
PST - Primary Sedimentation Tank
TF - Trickling Filter
IC - Intermediate Clarifier
FC - Final Clarifier
SDT - Sludge Digester Tank
SDB - Sludge Drying Bed
AP - Anaerobic Pond
FP - Facultative Pond
---- - Liquid Line
—— - Sludge Line

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SCHEMATIC FLOW OF CENTRAL WWTP

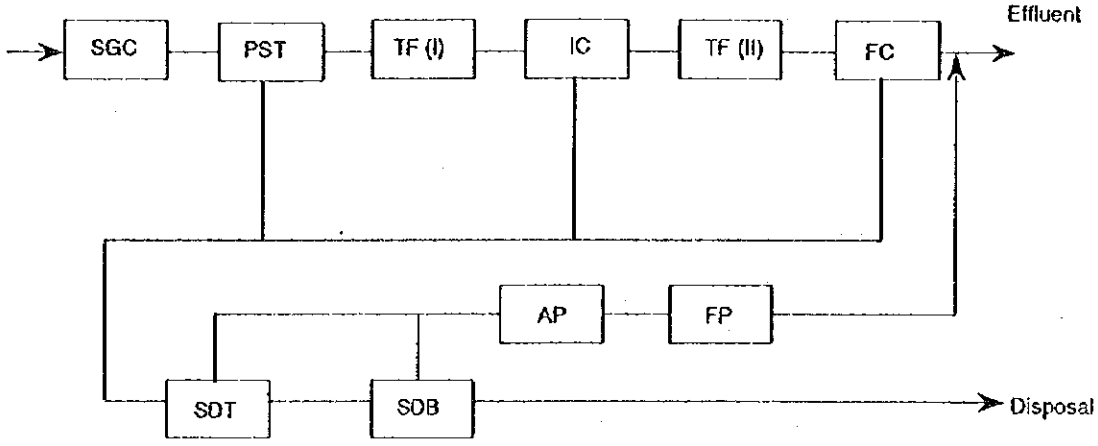
Fig S - 6

Layout Plan for First Stage Project
(Alternative 1: Central WWTP)

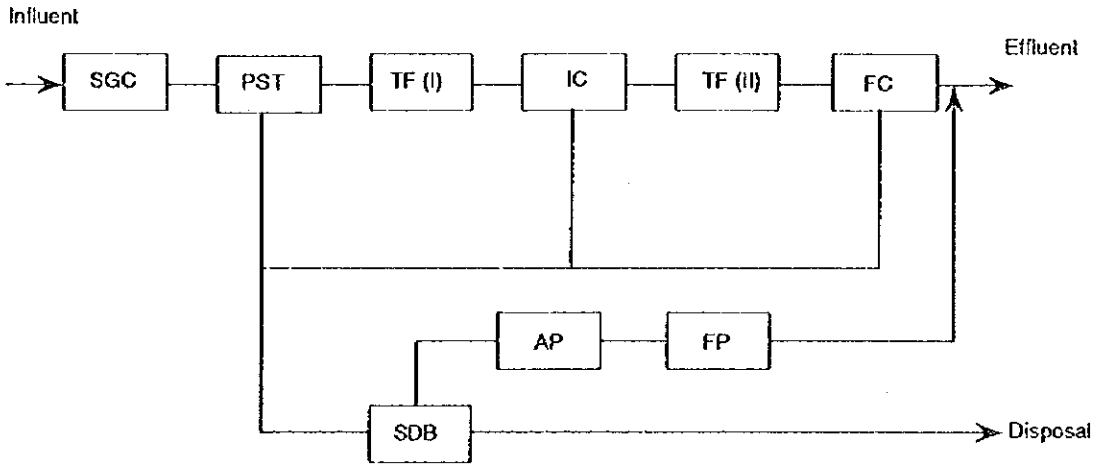


THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE LAYOUT PLAN FOR FIRST STAGE PROJECT (ALTERNATIVE 1: CENTRAL WWTP)

Fig. S - 7



a) Ultimate



b) First Stage

Legend
SGC - Screen Grit Chamber
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FC - Final Clarifier
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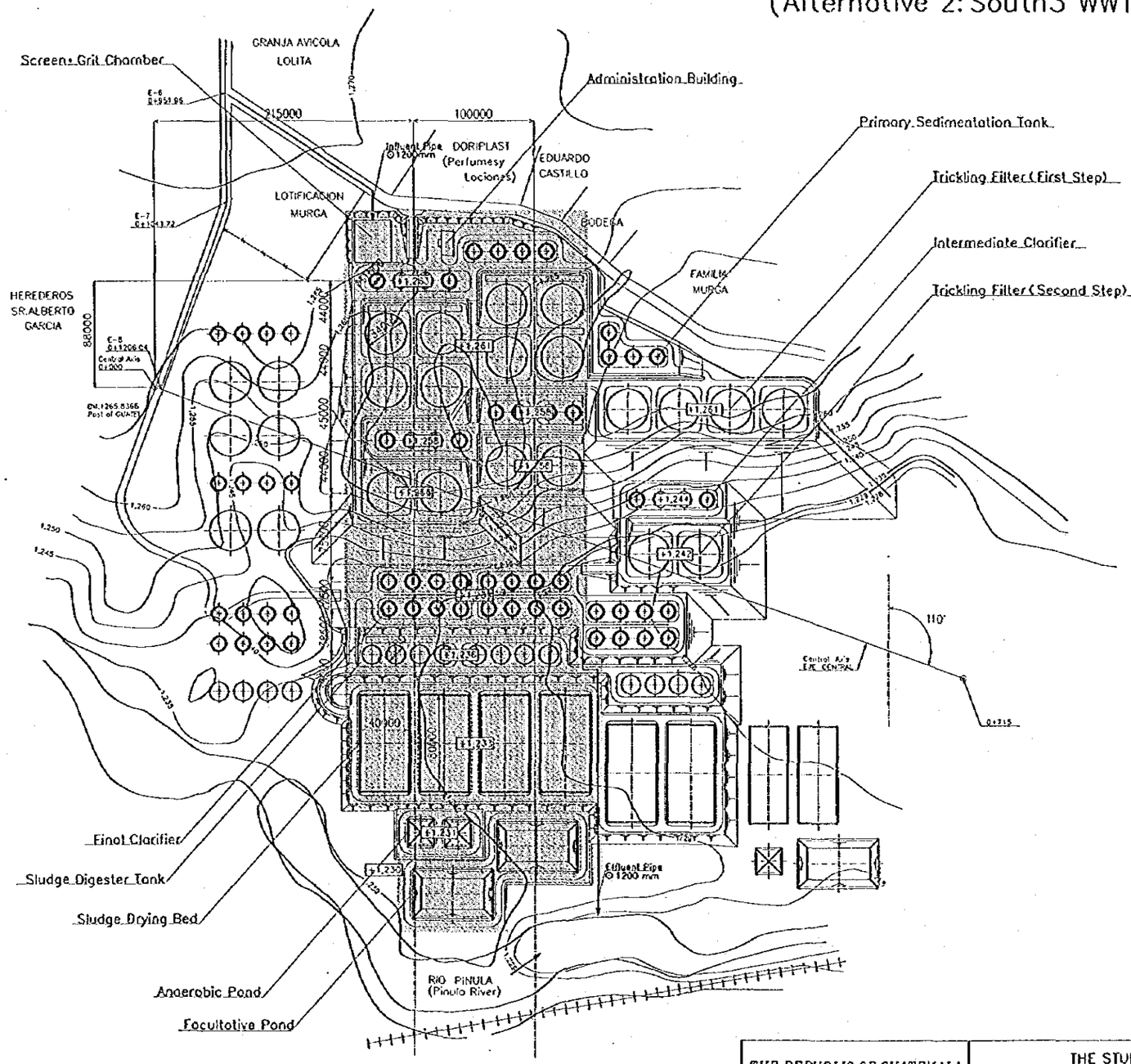
SDB - Sludge Drying Bed
AP - Anaerobic Pond
FP - Facultative Pond
—— - Liquid Line
—— - Sludge Line

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE SCHEMATIC FLOW OF SOUTH 3 WWTP

Layout Plan of Wastewater Treatment Plant
(Alternative 2: South3 WWTP)



EST.	P.O.	RUMBO	DIST.
6	7	S 47° 17' 00" W	89.76
7	8	S 88° 35' 20" W	164.32
8	BM	S 89° 54' 00" W	13.90

EST.	P.O.	RUMBO	DIST.
E-8	Central Axis 0+000	N 21° 42' 00" W	5.94
Central Axis 0+000	Central Axis 0+715	S 21° 42' 00" E	715.00

Scale 0 100 200 m

1:4000

: FIRST STAGE

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE LAYOUT PLAN FOR FIRST STAGE PROJECT (ALTERNATIVE 2: SOUTH3 WWTP)

Table S-2 Summary of Main Collectors for Central Region

Ref. No.	Diameter, mm	Length, m	Construction Method	Remarks
50	3,000	1,250	Tunnel	Soft
51	3,000	150	Tunnel	Soft
52	3,000	1,390	Tunnel	Soft
53	3,000	1,100	Tunnel	Soft
54	3,000	1,340	Tunnel	Soft
55-1	3,000	1,650	Tunnel	Soft
55-2	3,000	20	Pipe Bridge	
56-1	3,000	970	Tunnel	Hard
56-2	3,000	20	Pipe Bridge	
56-3	3,000	530	Tunnel	Hard
56-4	3,000	20	Pipe Bridge	
57-1	3,000	1,670	Tunnel	Hard
57-2	3,000	20	Pipe Bridge	
57-3	3,000	910	Tunnel	Hard
Total		11,040		

Source : Study Team

Table S-3 Summary of Main Collectors for South 3 Region

Ref. No.	Diameter, mm	Length, m	Construction Method	Remarks
1	300	1,730	Open-cut	
2-1	500	230	Open-cut	
2-2	1,500	1,490	Tunnel	Soft
3-1	1,500	260	Tunnel	Soft
3-2	600	610	Open-cut	
3-3	1,500	630	Tunnel	
3-4	600	440	Open-cut	
5-1	1,500	630	Tunnel	Soft
5-2	700	200	Open-cut	
5-3	700	70	Pipe bridge	
5-4	1,500	760	Tunnel	Soft
15	1,500	660	Tunnel	Soft
16	1,500	2,010	Tunnel	Soft
17-1	1,500	1,060	Tunnel	Soft
17-2	1,200	1,150	Open-cut	
4-1	400	1,510	Open-cut	
4-2	1,500	760	Tunnel	Soft
4-3	400	50	Pipe-Bridge	
4-4	1,500	130	Tunnel	Soft
7	400	500	Open cut	
8	500	810	Open-cut	
9	1,500	1,630	Tunnel	Soft
Total		17,320		

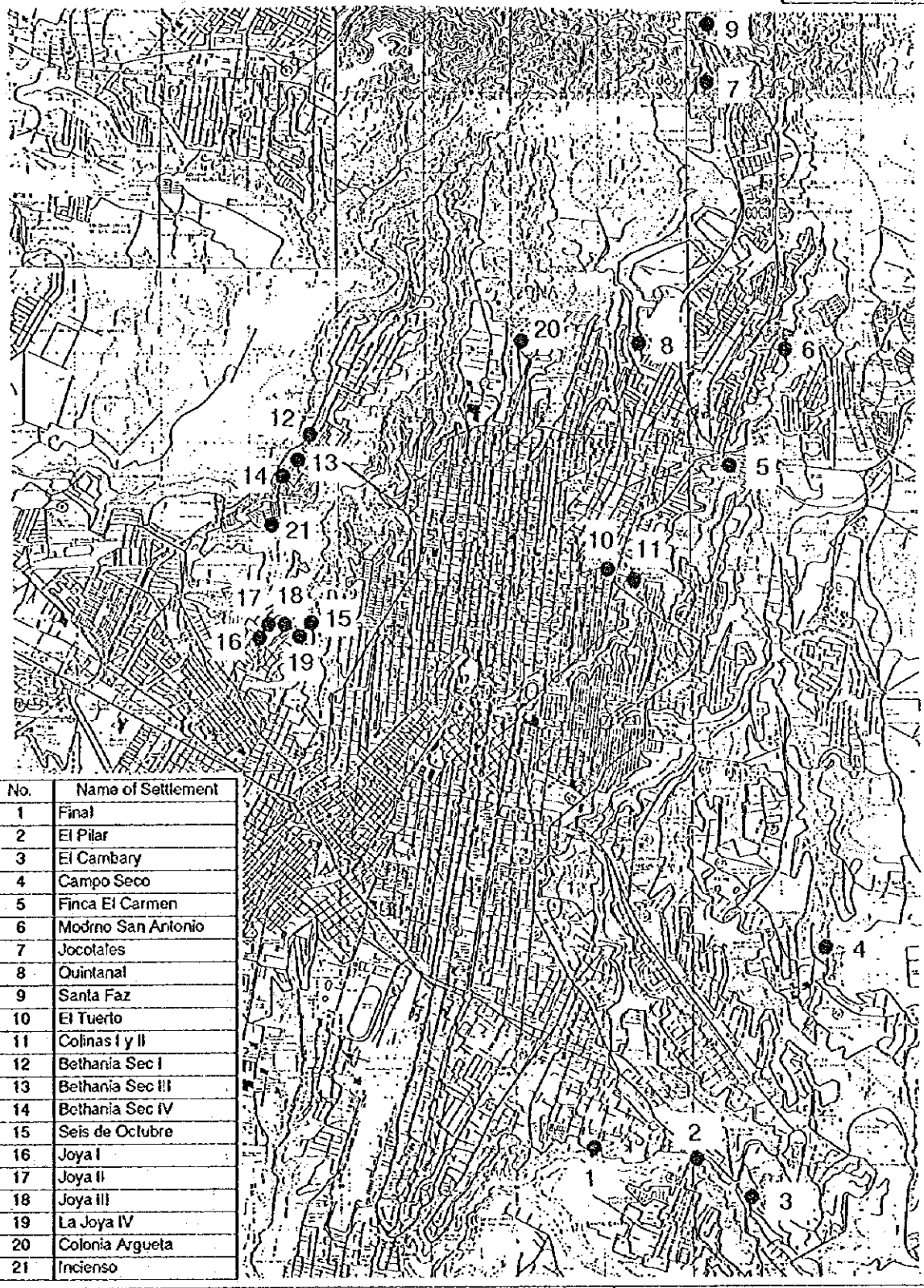
Source : Study Team

Table S-4 Outline of Treatment Facilities

FACILITY	CENTRAL			SOUTH 3 (PINULA COLLECTOR)			SOUTH 3 (HERMOSA COLLECTOR)		
	Dimensions	No.		Dimensions	No.		Dimensions	No.	
		Ultimate	First Stage		Ultimate	First Stage		Ultimate	First Stage
Primary Sedimentation Tank	B10.00m x L30.00m x h10.00m	20	15	O 11.00 m x h 10.00 m	12	8	O 9.50 m x h 9.00 m	4	-
Trickling Filter (First Step)	O 39.00 mx L 2.00 m	40	-	O 34.00 mx h 2.00 m	12	8	O 29.00 m x h 2.0 m	4	-
Intermediate Clarifier	B10.00 m x L30.00 m x h10.00 m	20	-	O 11.00 m x h 10.00 m	12	8	O 9.5 m x h9.00 m	4	-
Trickling Filter (Second Step)	O 3.00 m x h 2.00 m	20	-	O 34.00 m x h 2.00 m	6	4	O 29.00 mx h 2.00 m	2	-
Final Clarifier	B10.00 m x L30.00 m x h 1.00 m	40	-	O 11.00 m x h 1.00 m	24	16	O 9.50 m x h 9.00 m	8	-
Sludge Digester Tank	O 17.50 m x h10.00 m	40	-	O 15.50 m x h 9.00 m	12	-	O 14.00 m x h 8.00 m	4	-
Sludge Drying Bed	W 40.00 m x L 100.00 m	20	10	W 40.00 mx L 80.00m	6	5	W 30.00 m x L 40.00 m	4	-
Anaerobic Pond h = 3.0 m	BA 13.00 m x 13.00 m SA 31.00 m x 31.00 m	2	1	BA 1.00 m x 1.00 m SA 1.00 m x 19.00 m	2	1	BA 1.00 m x 1.00 m SA 19.00 m x 19.00 m	1	-
Facultative Ponds h = 2.0 m	BA 120.00 m x 60.00 m SA 132.00 m x 72.00 m	2	1	BA 52.00 m x 26.00 m SA 64.00 m x 38.00 m	2	1	BA 20.00 m x 40.00 m SA 32.00 m x 52.00 m	1	-
DESIGN BASIS									
Design Flowrate	Ultimate	First Stage		Ultimate	First Stage		Ultimate	First Stage	
Daily Average, m3/d	238,000	178,000		52,700	33,000		13,300	-	
Daily Maximum, m3/d	261,000	195,000		57,500	36,000		14,500	-	
Hourly Maximum, m3/d	390,000	291,000		85,500	53,500		21,500	-	
Hourly Maximum Wet weather, m3/d	1,087,000	873,000		-	-		-	-	
Sludge Generation, t/d	90	71		20	19		5	-	

Source: Study Team

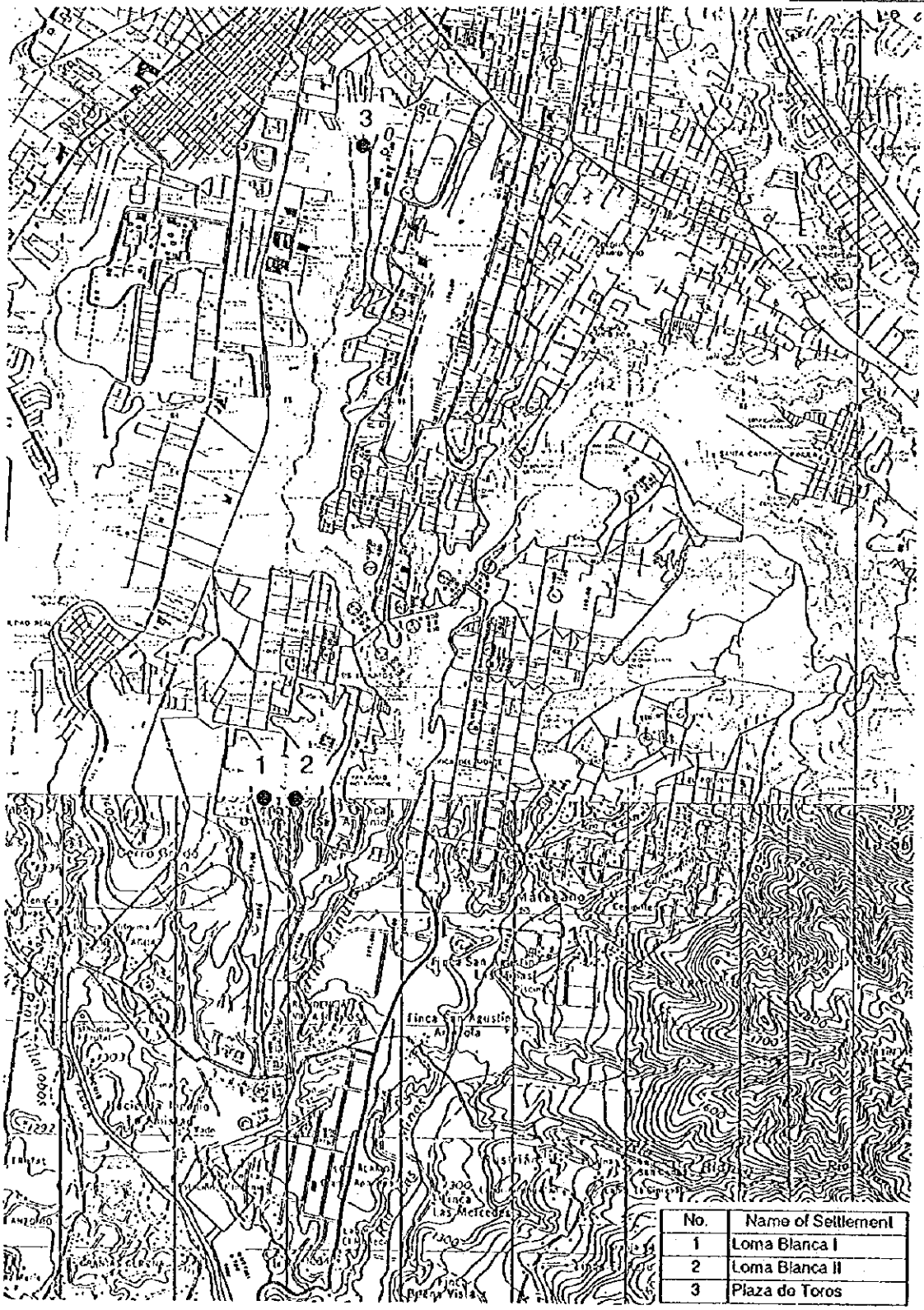
Fig. S - 9(a)



No.	Name of Settlement
1	Final
2	El Pilar
3	El Cambary
4	Campo Seco
5	Finca El Carmen
6	Modrno San Antonio
7	Jocotales
8	Quintanal
9	Santa Faz
10	El Tuerto
11	Colinas I y II
12	Bethania Sec I
13	Bethania Sec III
14	Bethania Sec IV
15	Seis de Octubre
16	Joya I
17	Joya II
18	Joya III
19	La Joya IV
20	Colonia Argueta
21	Incienso

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE LOCATION MAP OF SANITATION SYSTEMS - CENTRAL REGION

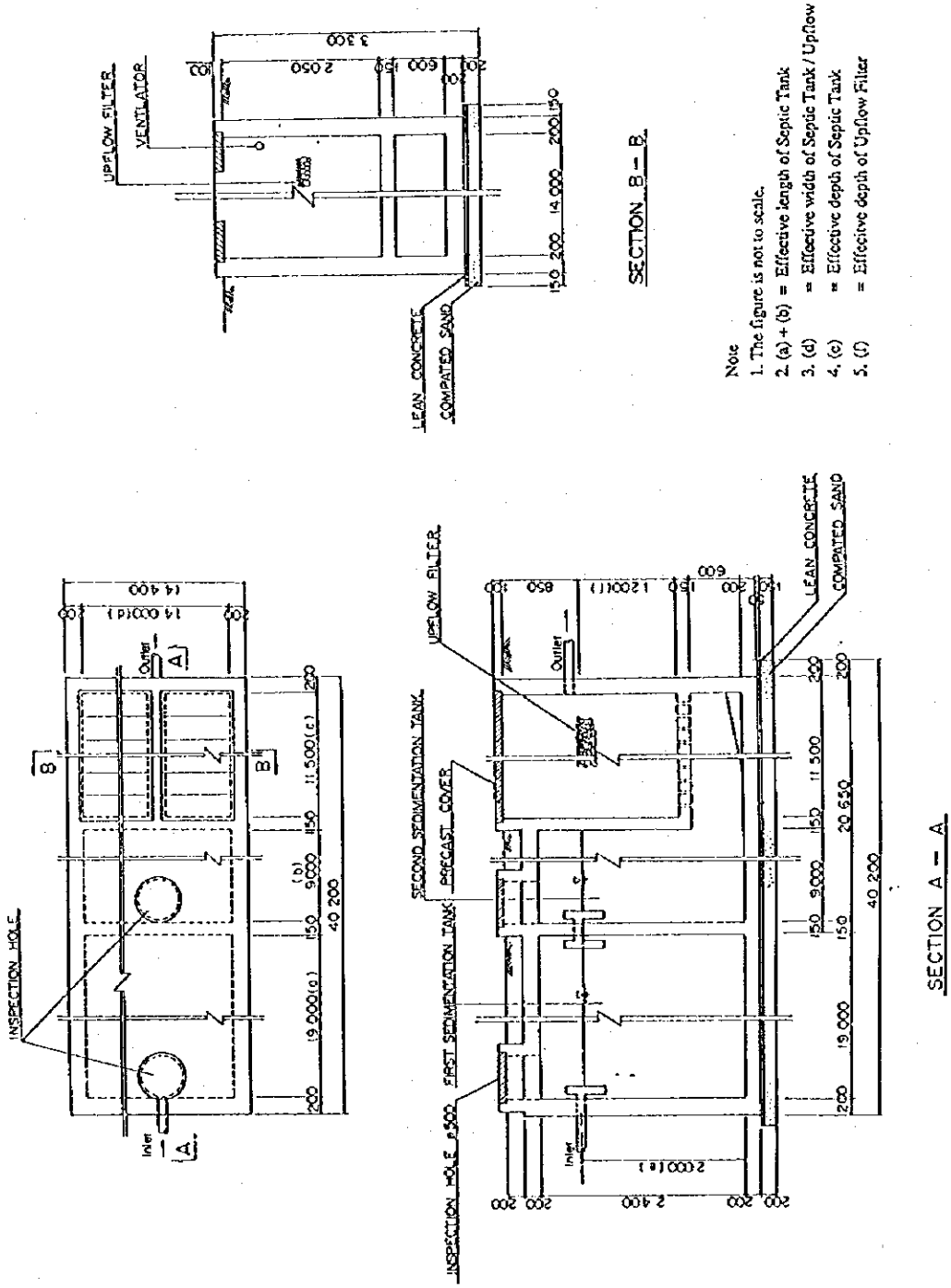
Fig. S - 9(b)



No.	Name of Settlement
1	Loma Blanca I
2	Loma Blanca II
3	Plaza de Toros

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE LOCATION MAP OF SANITATION SYSTEMS - SOUTH 3 REGION

Fig. S - 10



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE TYPICAL SECTION OF SEPTIC TANK WITH UPFLOW FILTER

S4 DESCRIPTION OF ENVIRONMENT

This chapter contains a detailed description of the current environmental conditions on the potential influence area, from a biological, geological, sociocultural, economical and landscape perspective. This will allow, during future evaluations, to assess the effects of several activities resulting from the construction and operation of the project. This description covers the following aspects:

- The project harmony with nature from an architectonic perspective.
- The natural component, which emphasizes the water resources.
- The geological component, of great importance due to the relevance of seismic and geotechnical aspects in the project.
- Socioeconomic factors, where the opinion of different population sectors takes great relevance.
- The economic groups of population directly or indirectly benefitted by the project.
- Public participation on infrastructure conservation.
- The cultural heritage, through evaluating archaeological vestiges.

S4.1 GENERAL CHARACTERISTICS

The use of natural resources in the influence area without an adequate management allowed the development of soil erosion. Ecosystem degradation is observed directly with biodiversity reduction (Appendix SA14-SA18)).

S4.1.1 Soil

On the Central Region, the soil has franc texture with friable consistency, while the subsurface soils have a franc clay texture with high risk erosion. On South 3 region, the origin is from alluvial plain, the surface has a franc sand texture and a subsurface soil with undetermined franc clay texture.

S4.1.2 Seismic Activity

In Guatemala, there are clear geomorphologic changes, which are related with the lithological features and tectonic events in the area. From South to North, with limits oriented almost East-West the following morphotechnic units are located: Pacific Coastal Plain, Volcanic Chain, Central Highlands (including the Guatemala City Valley), Alta Verapaz Folding Belt and the El Petén Lowlands.

Of particular importance is the fact that Guatemala is the confluence point of 3 tectonic plates: the North American, the Caribbean and the Cocos, each with particular features and history. The limit between the North American Plate and the Caribbean plate is located in the zone well known as the Motagua-Polochic fault, on Central Region of the country on east-west direction; the limit between the Caribbean plate and the Cocos plate is located in the Pacific Ocean, a few kilometers from the coast, where a deep depression exists parallel to the coast, known as the Central American Trench.

The country is located in a seismic zone with great record of earthquakes, with different registered intensities and magnitude events. The February 4th 1976 earthquake is an example of those.

Four zones have been recognized with seismic activity that are perceptible in Guatemala City:

1) The seismic zone separating the Cocos plate and the Caribbean Plate produces earthquakes with an epicenter of a shallow to intermediate depth, and with a moderate to high magnitude. The Cocos plate has relative movement to the Northeast, subduing the Caribbean Plate. The quaternary volcanic chain and the Middle American Trench are associated with this event.

2) The Quaternary Volcanic Chain, where small earthquakes are generated with a moderate depth epicenter, is located at the South of the country on a strip running parallel to the Pacific Ocean coastline.

3) The active faults forming the limits between the North American and Caribbean plates produce moderate to big earthquakes. They are called the Motagua and Polochic faults. The Jalpatagua-Chamelecón fault probably belongs to this group and is classified as a fault with lateral displacement to left, and none or small vertical displacement.

4) Active faults like the Mixco fault, south of the Motagua fault, and others aligned to Northeast, like the Frutal fault, are probable sources of small earthquakes.

S4.1.3 Geology

The Guatemala City valley is located in a graven, partially filled by volcanic sediments. This graven is limited to the west by the Mixco fault system, North-South oriented; to the East by the Santa Catarina Pinula system, North-Northwest-Southeast oriented with a prominent

slope of 8 km southeast of the Valley. To the South, the Valley is limited by the Pacaya volcanic complex, and to the north, the limit is formed of land with ondulated topography, with altitude variations between 50 to 200 m over the plains.

a) Stratigraphy

Most of the Guatemala City valley is formed by thick piroclastic deposits of volcanic origin. Generally, the clastic deposits are almost horizontal, although there are some variations due to lateral changes in thickness of individual units. They differ in composition, orientation, fracturing styles and different intemperation levels. These deposits form a cover on top of tertiary rocks, cretacics (carbonic rocks and clastics with basic and intermediate laves) and Paleozoic (metamorphic rocks).

Generally the quaternary deposits from Guatemala City Valley are classified in the following:

Tefras : Ash deposits from clastic volcanic materials resulting from the explosive effusion; transported by air, they present a distribution depending on the point of origin, wind direction and duration. The deposits form continuous layers with a relatively constant thickness, in some cases up to 10 m. The piroclastic composition is andesitic, dacitic or riolitic.

Diamictones : Ash flow deposits consisting of unclassified deposits, without stratification, formed by blocks, bombs and pumice lapillis, in a fine ash matrix, fenocrystals and lithic fragments. These deposits cover the Guatemala graven and form the current plains.

Fluvial Deposits : Stratified and classified gravel and sand with a composition varying from pumice, andesit and basalt, with thicknesses up to 25 m.

Lacustrine Deposits : Sequences of clay, calcareous slime and diatomic plates and stratus of great extension, with thicknesses up to 20 m.

b) Geomorphology

The Guatemala City Valley is formed by relatively flat plateaus, separated by deep hollows with depths varying from 25 to 150 m. The slopes of these depressions are steep, and evidence of landslides can be found on them.

On the Valley plains, there are notorious outcrops like the Cerro Naranjo, oriented to the north-northeast, where the National Theater is located, and also the Cerrito del Carmen.

Reports reviewed indicate that, during the 1976 earthquake, there were several landslides of different order in existing depressions of the Valley. One of these reports made a zoning distribution of landslides, characterizing their magnitude and concentration in sectors along the shores of the fluvial valley system. This zoning shows the existence variable distribution as a result of the influences of determined number of lithologic and structural parameters. There is also a great difference in landslide concentration in the northern and southern areas of the Valley, with the North being more affected. A number of landslides occurred on Chinautla's area, north of Guatemala City.

Preliminary conclusions indicate that most of the slope instability to the North of the Valley is related somehow with the granulometry of the quaternary deposits, which are finer in this sector.

c) Faults

Prior to the 1976 earthquake, the geological scheme indicated that the Eastern and Western limits of Guatemala Valley showed evidences of faults, roughly oriented parallel to North-South direction, scaled and with several kilometers in length. Due to these faults, the Mixco west fault was activated. A series of faults with approximately 10 km of length and a width of 8 km were identified. The observed vertical displacement did not exceed 14 cm.

The information consulted and the field inspection conducted for the EIA in this project, indicates that there is a fault and fracture pattern with a North-South direction. Most of these faults show an almost vertical slope, typical of zones where the dominant tectonic provokes a normal faulting. However, there are some inverse faults with slopes of 45°, important for depth projection purposes. The magnitude of the displacements caused by the faults varies some centimeters to several meters (Appendix SB1).

d) Underground Water

It is estimated that the most superficial freatic level is located between 40 and 60 m of depth. There are reports of strong water filtrations in some parts of Guatemala City at depths up to 12 m, although these are located and with defined widths. It is generally known that in the North basin, the groundwater level in wells is between 1.22 and 109.73 m of depth, mostly oscillating between 30 and 70 m. On the South basin, the depth varies from 0.69 to 335.30 m, predominating values with depth less than 50 m. (Ministerio de Comunicaciones y Obras Pdblicas, 1978).

Recharge : The whole Guatemala City Valley, with the exception of the Amatitlan Lake zone, is a groundwater recharge zone. On the mountain chains to the East and West, the slopes limit the infiltration. The plains, where the chance of infiltration is high, are affected by the existence of areas covered with man made constructions.

In general terms, it can be said that the alluvial sediments and the loose piroclasts have more infiltration capacity than compact piroclasts, and that geological conditions of South basins are more favorable to infiltration than those in the North basin.

A study carried out in 1977 using isotopes indicates the existence of a groundwater recharge in the South Basin, coming from the extreme Eastern area, that is, the region known as Eastern Plateau, from which the Ojo de Agua Spring is recharged. To the East of a North-South line by the axis of the Valley, between El Molino River and the Quebrada El Frutal, it receives a recharge mainly coming from the East, that is, from the San Jose Pinula plateau. This represent at least 60 % of the total recharge. The direct infiltration of water in this side is small, whereas water coming from the Northwest of the continental divide may represent up to a 35 %, and water coming from the West represent up to a 15 % (Ministerio de Comunicaciones y Obras Publicas, 1978).

Based on the quantitative levels of materials infiltration forming the graven refill of the Guatemala Valley, and on hydrologic methods, it has been determined that in the South basin, 22% of precipitated water is infiltrated, whereas in the North basin, 8 % is infiltrated. (Ministerio de Comunicaciones y Obras Pdblicas, 1978).

Freatic Levels : Based on information of monitored wells' location on Guatemala City Valley and their corresponding water level elevations, freatic level isolines were generated. The results obtained were compared with the map presented in the study conducted by the Communications and Public Construction Ministry in 1978. It is possible to observe that even, though the general trends remain, there are some considerable variations.

The freatic level isolines show a high central part, oriented almost East-West, forming a strip running from Vista Hermosa (zone 15) to the Trebol (zone 8), reaching to Mixco. Starting with this strip, that roughly coincides with the continental superficial waters limit, the construction of flow lines with direction to the North and South can be made (Appendix S12B2).

S4.1.4 Cultural Development

In order to make a chronological study about the human activity in the Guatemala Valley, it is necessary to consider the geographic universe spatial and temporally divide it in three periods: Prehispanic, Colonial, and Independent. Each represents specific attributes in the distribution, design and importance for the cultural evidence.

A prehistoric period can be considered in the Valley. In the Northern and Northwestern zones, bones and other fossil evidences have been found, evidence which could help to make a partial hypothetical reconstruction of the flora and fauna that existed thousands of years ago. However, the sporadic and casual evidence findings, and the lack of association due to human activity, avoid to establish reliable results, that helps to reduce the possibility to find them in a determined place. It is important to take into account that if a finding occurs, an adequate activity of rescue should be implemented, based on the procedures described on the mitigation chapter.

By associating the evidence of human activity in other regions, it can be deduced that the prehispanic period on Guatemala Valley probably started close to 2,000 BC. With some confidence, it can be assured that by 1,000 BC year there was already an established human activity on the Valley. Starting at that point, up to now, a continuous occupation and expansion has occurred.

For practical reasons, in this report, the prehispanic period is considered from 1,000 BC to 1524 AD, when the Spanish arrivals started. At that time, a period of conquest and colonization starts, with the further establishment of Guatemala General Captainship. The above involves cultural evidence from the colonial period, which finished in 1821, when independence was proclaimed. At that time, the independent period starts, which continues to the present. Every period presents architectonic and material evidence that allows to deduce long term and continuous occupation of the Valley. It is also possible to deduce cultural changes reflecting the adaptation of every group to survive in a specific environment with limited resources.

During the prehispanic period, the distribution of human settlements was common in areas close to the hollows around the Valley, because it was there where the water sources could be found. The construction of "aguadas" or small artificial lakes to collect rain water, also allowed the settlement in more centric areas away from hollows, mainly in the southern part.

The lack of gravel as a construction resource was substituted by the development of a technique consisting on using soil accumulation to elaborate pyramid bases in the areas of

religious activity. Some zones to the West may present evidence of human activity even at 15 m of depth from the current surface.

Since clay and sludge are soft materials, the building and house bases are susceptible to destruction by erosion and, in many cases, the destruction of archaeological areas during the urbanization of new areas has occurred unnoticed.

The approximately 3,000 years of continuous occupation of the Valley does not help to make a definite panoramic of human settlements distribution. At the perforation depth, no evidence at all may be found. Otherwise, an adequate action plan should be considered.

During the colonial period, the process of native settlements redistribution that started close to 1,200 BC was accelerated. The distribution of land among the conquerors forced the displacement of native groups to areas where they could have political, economic and religious control. It also favored the native interaction groups from other areas, like those from the Central Valley of Mexico. Similarly, a change of economic activity started, due to new requirements imposed by the conquerors.

From the middle sixteenth century to right after the middle eighteenth century, an evolution settlement pattern around the development of farms took place, interacting with "Indian Population" growth.

After the Santa Marta earthquake of 1773, a drastic change on valley population growth took place, due to the relocation of Guatemala City, the Santiago City and the surrounding populations to Ermita Valley, with the name of La Nueva Guatemala de la Asuncion.

The colonial period on Guatemala Valley started in 1777 with a new urban development. At that time, besides the city mapping, constructions of great magnitude took place, like the construction of water supply systems, development of formal architecture with more resistant materials, and the cultural pattern modification on existing populations.

The colonial period finished in 1821 with the declaration of independence from Spain. With this period, a phase of social, economic, religious and political changes started, which, although slow in the beginning, consolidated the basis that, in turn, allowed a change in Guatemala City urban development at the end of nineteenth century. This urban development was affected at the beginning of the twentieth century, not only by the economic consequences of the First World War, but also by the 1917-1918 earthquakes.

After the Second World War, almost in the middle of the twentieth century, a new phase of urban development with horizontal trend appeared in Guatemala City, suffering then a drastic change as a consequence of the 1976 earthquake.

Demographic growth has forced the construction of housing facilities in areas that, in the past, were used for similar purposes, hiding then a great part of previous evidences.

S4.1.5 Socioeconomical Conditions

a) Demographic Aspects

According to the National Institute of Statistics (INE) data, the Department of Guatemala had 1,812,411 habitants in 1994, with an annual rate growth of 2.9%. The Guatemala Valley reported a municipality population of 822,587 habitants where 45.4% belongs to the department area and 9.9% from the total country, distributed along 800 km^2 of territorial area.

b) Land Use

At the metropolitan region, the urban area represents the most important use, with 24,916 ha, or a 52.2% of the total area. The rural and suburban agricultural farms occupy 17,160 ha, which correspond to 37.2%, vegetation cover has 3,530 ha. which correspond to 7.4%, the water bodies haves 1352 ha, corresponding to 2.8%, and finally, the land which is used for various things represents 0.4%.

Urban landuse consists of, there are 13279 ha for residential use, or 53.3%, 538 ha for commercial use, or 2.2%, 1134 ha for the industry, which corresponds to 4.6%, other uses 999 ha with 4%, mixed used space 631 ha with 2.5%, green areas 399 ha with 1.6% and the suburban space 7940 ha with 31.8%.

c) Social Environment

Guatemala City absorbs national and central american immigration and, with this immigration growth, comes the increase in demand of other services (housing, water, etc.). This is a promoting factor for poverty, and makes some people needed of this service, along with the usual unemployment, and housing problems. What is said above has forced some kind of population sectors to look for refuge on margin city areas, hillsides, cliffs, etc. The urban growth which is not planned, has generated scarce community equipment and public services supply, like school, health centers, water supply, wastewater disposal, etc.

d) Description of Interviewed Sectors

The selected sectors were "El Quintanal" on Zone 6, "El Pilar" on Zone 14 and "Loma Blanca" on Zone 21.

The first two represent the areas that show significant poverty when compared to metropolitan margin areas. "Loma Blanca" is a suburban area which has extended its urban boundary. These areas form a part of about 200 poverty settlements in Guatemala City, which lack minimum services like appropriate homes, water supply, electricity, sewer, transport and communications.

The environmental characteristics at those areas generally are the following: adverse topographic conditions, surface sewer pipes, low support capacity soil, poor access and residents close to contaminated focus sites, and areas exposed to landslides and inundations. These settlements can be classified, based on their poverty, in high, medium and minor, based on the study called "Caracterizacion de las areas precarias de la Ciudad de Guatemala". This study reports, up to 1991, a 65% poverty level, which has been on increment since that date.

The population density on these three sectors is the following: Quintanal 3,700 habitants, distributed in 24 ha. El Pilar 1,500 habitants, distributed in 48 ha. and Loma Blanca with 1,400 habitants in 17 ha.

From people interviewed, 58% were housewives, and 52.6% of them were mothers; 20.7% were fathers, from which 24% were laborers, 8% traders, and 2.6% were unemployed; finally, 12% were teenagers and 7.3% were students.

Level of education is as follows : 52% attends primary school, 16% have completed junior high school, 9.3% have completed high school, 1.33% attends to university and 21.3% without education.

The higher percentage by age group is between zero to five years with 17.2%; it is followed by the six to ten years group, with 12.6%; the eleven to fifteen years group comes next, with 12.6%; the sixteen to twenty five years group with 18.5%; the twenty six to thirty year group has 9.3%; and the more than thirty years group with 30.1%.

Some 62.7% come from the city and 37.3% have immigrated from other departments. A total of 52% have more than five years living there, 33% have one year or less living there, and 14% have less than one year.

The 89.3% wish to remain living there and 10.6% would like no to do so.

In relation to family income, 22.0 % say they earn from Q501 to Q750, 22.6% earn from Q251 to Q500, 20% from Q751 to Q1,000, 4.6% say they earn from Q1,501 to Q2,000, and 7.3% earn more than Q2,000.

From the health level point of view, it is hard to identify the origin of diseases, but they assure that at least once a year the diseases present, as a percentage of the total population, as follows: 14% cholera, 11% diarrhea, 4.7% amoebiasis and 0.6% typhus and dysentery.

e) Real property and public supplies

Some 65% of the houses are shacks, 27.33% are informal houses, 6.66% are dove colonies and a 0.65% are medium level houses.

Also, 58% of resident owned their homes, 14% rented them, and 28% lent or invaded the terrains. Residents opinion of existing infrastructure is shown in Table S-5.

Table S-5 Resident's Opinion of Infrastructure in Colonies for Sanitation System

Infrastructure	Resident Opinion of Infrastructure (% of respondent)		% Respondent s Requiring Improvement
	Satisfactory (%)	Unsatisfactory (%)	
Roads and streets	10	9%	82
Drainage	21	79	79
Electricity	59	41	77
Water Supply	29	71	65
Wastewater Disposal	11	87	39

Source : Study Team

Drinking water is obtained as follows: 45% by public faucet, 26% by municipal service supply, about 7% buy it from water trucks, and the rest 22% by other ways.

Wastewater is disposed as follows: 53% by sanitary well, 27% by the municipal system, and 20% dispose directly to the streets.

S4.2 CENTRAL REGION

S4.2.1 Environment Description and Influence Area

Proposed Central Region WWTP is located in San Francisco Las Trinitarias Farm lands, at Las Vacas River margins near Chinautla Municipality, north of Guatemala City. It limits to the North with the Periquera Farm and to South with Labor Buena Vista Farm; the Eastern and Western limits belong to San Francisco Las Trinitarias Farm.

The site has only one access road that is not paved after the Chinautla urban area. The topography is slightly mountainous, with slopes covered with disperse vegetation. Visually, a rural landscape transformed by deforestation can be seen.

This site extends two kilometers downstream of the Las Vacas and Tzalja Rivers confluence. The surrounding area does not have any important buildings or landmarks except for three bridges.

S4.2.2 Biophysical Component

a) Life Zones and Climate

Climate: According to San Pedro Ayampuc, an INSIVUMEH Meteorologic Station 1,200m above the sea level, a mean annual temperature of 21.80 has been reported for this region, an average annual precipitation of 1,093.1 mm and an average relative humidity of 74%.

Life Zones: The observed vegetation characteristic of the zone and climatic data reported for the project influence zone indicate that, at this site, two life zones merge, according to the vegetation ecological classification proposed by Holdridge (1967). These zones are the Tempered Subtropical Premountainous Humid Forest and the Tempered Subtropical Premountainous Dry Forest.

This ecological transition is influenced mainly by climatic and edafic factors from both life zones, having, as a consequence, a vegetation representative of both zones.

Some hillsides show typical vegetation of mostly humid environments, usually coniferous (*Pinus spp*) and Oaks (*Quercus spp*), the latter with their branches highly populated of epifitic species (*Tillandsia spp*; *Bromeliaceae* Family).

b) Flora and Fauna

Forest: Some hills in the region are partially covered with mixed forest, highly perturbed with corn and bean fields. The remaining forest is composed of spots with young pine trees (*Pinus pseudostrobus* and *P. oocarpa*), associated with adults and young oaks (*Quercus sapotaefolia; Q.peduncularis*).

The current land use is mainly to support agricultural and livestock farming. The observed forest alteration indicates the strong pressure over all the forest resources during past years. The current forest's lack of shrubs from understory vegetation, due to successive exploitations carried out, is indicated by small roads for extractive activities, currently with no use.

Besides the above vegetation, other species, indicative of altered systems can also be found. Among these, some grass can be mentioned, normally cultivated like the Jaragua (*Hyparrhenia rufa*); caZa brava or de castilla (*Gynerium sagittatum*); pasto estrella (*Paspalum spp.*) and napier or pasto elefante (*Pemisetum purpureum*). Some exotic and naturalized trees and shrubs like mango (*Manguifera indica*); Citrus (*Citrus sinensis*) and bamboo (*Bambusa vulgaris*). Among the native species: the coyol (*Acrocomia mexicana*); pito (*Erythrina berteroana*); willow (*Salix spp.*); guapinol (*Himeneae courbaril*); izote (*Yucca elephantipes*); guayaba (*Psidium guajava*); banana (*Musa spp.*);.

Wild Animals: The relative scarcity of fauna species in this region may be the result of evident habitat degradation, result of deforestation, fires, and agricultural practices.

Actually there are references of presence to the following wild animal species in the region:

-Mammals:
possum (*Didelphis marsupialis*); armadillo (*Dasypus novemcinctus*); coati (*Nasua spp.*); raccoon (*Procyon lotor*); squirrel (*Sciurus spp.*); rabbit (*Sylvilagus spp.*); wild mouse (*several species*); rat (*Rattus spp.*).

-Birds:
parrakeet(*Aratinga spp.*); clarinero (*Cassidix mexicanus*); swallow (*Tachycineta bicolor*); cenzontle (*Dumetella spp.*); dove (*Columba spp.*); tordo (*Cathorus ustulatus*); buzzard (*Coragyps atratus*); chatilla (*Myiozetetes spp.*); wood pecker (*Celeus spp.*).

-Reptiles:

lizard (Basiliscus vittatus); Boa (Boa constrictor); coral snake (Micrurus spp.); sabanera (Conophis lineatus).

-Domestic Fauna

Cattle and bird farming are common in the region. Also, house pets like cats and dogs are abundant.

Some ecologic relationships: From an energy view point, the coniferous and oak vegetation on the hills represent no guarantee of high productivity for the local wild animals, with exception of some species feeding on seeds and nuts. Other species find food on herbaceous vegetation that represents an important source of flower nectars, seeds and some small fruits. Insectivorous and carnivorous species play an important role regulating the number of insect and small mammal populations, potentially harmful to agriculture.

Some black vultures feed on carrion transported by Las Vacas River, and therefore, contribute to clean the environment from animal residues. However, the continuous contact with polluted waters may be detrimental to these populations. Similarly, there is evidence that these birds act as vectors for some domestic and wild animal diseases.

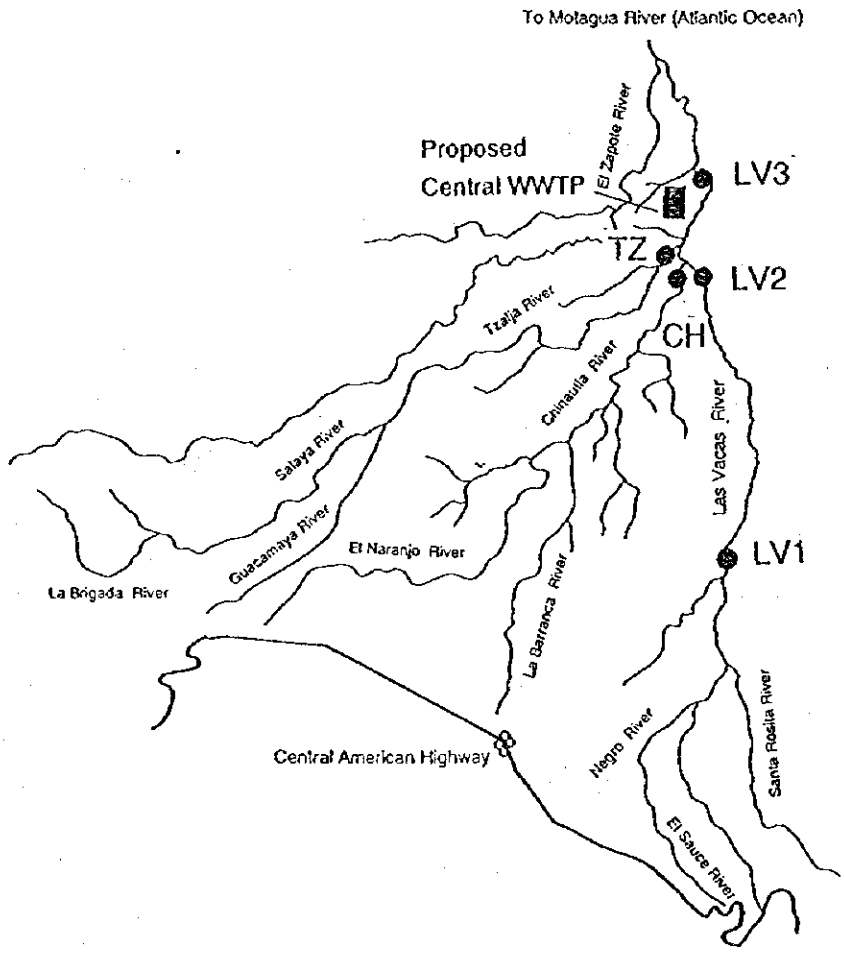
-Insects

c) Pollution Sources and Water Quality

Wastewater is generated in the northern part of Guatemala City is discharged to rivers and valleys without tretament and the rivers function as open sewage channels. There is hardly any sign of the existence of flora and fauna in the rivers.

Water quality and flowrate survey were carried out in the vicinity of the proposed Central WWTP site at Las Vacas River, Chinautla River, and Tzalja River, and near the Gran Collector North Outfall near Belice Bridge, during December '95 to February '96 (dry season). Fig. S-11 shows the avearage water quality of six measurements on different days. Average BOD of Las Vacas River downstream of Gran Collector Outfall is 309 mg/L, which reduces to 227 mg/L just before the confluence with Chinautla River due to natural purification. BOD concentration of Chinautla River and Tzalja River are 190 and 150 mg/L, respectively. Due to dilution with rivers and natural purification, average BOD concentration of Las Vacas River near the proposed Central WWTP is 178 mg/L.

Fig. S - 11



Location	LV1	LV2	LV3	CH	TZ
Flowrate,m3/s	1.80 (1.20~2.87)	2.01 (1.61~2.40)	2.41 (1.40~3.49)	0.65 (0.43~0.89)	0.23 (0.11~0.33)
COD, mg/L	622 (536~709)	487 (398~658)	383 (351~426)	381 (298~409)	323 (202~468)
BOD, mg/L	309 (360~258)	227 (288~180)	178 (150~204)	190 (141~192)	150 (95~216)
TS, mg/L	1048 (800~1500)	945 (700~1200)	2452 (1000~6600)	4728 (3300~8000)	1403 (700~2600)
Sed. S, mL/L	4.4 (2.6~6.2)	5.4 (3.9~8.0)	4.9 (3.8~5.4)	7.4 (3.6~8.0)	3.6 (1.0~8.2)
T-N, mg/L	59.2 (41.0~88.6)	43.4 (20.0~54.3)	47.6 (20.6~89.2)	67.0 (40.7~108.0)	54.8 (25.2~103.0)
T-P, mg/L	9.3 (12.8~7.0)	10.7 (7.0~17.6)	9.6 (5.8~14.2)	9.7 (4.6~16.6)	10.6 (7.2~18.8)
Cl-, mg/L	57.6 (41.1~67.4)	44.0 (32.5~52.5)	46.9 (38.0~59.5)	54.0 (45.4~67.4)	45.4 (41.1~50.3)

LV1 - Las Vacas River (Downstream of Gran Collector North)
LV2 - Las Vacas River (Upstream of Chinautla River)
LV3 - Las Vacas River (Downstream of proposed Central WWTP)
CH - Chinautla River
LV5 - Tzalja River

Average (minimum~ maximum) values are shown.
Flowrates are for two measurements during day time, three days on December 1995 and three days on January/February 1996

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE WATER QUALITY OF RECEIVING WATER BODIES (CENTRAL WWTP)

S4.2.3 Geology

a) Las Vacas Main Collector

The expected soil characteristics along this collector (Fig. S-12), from its origin and up to sewer line #51, consists mainly of quaternary deposits, with tefras, diamictones and fluvial and deposits formed in a lake, with a mostly horizontal and subhorizontal stratification. These stratus characteristics are common to most of the Guatemala city valley. In sewer lines #52, 53 and 54, the proposed trace passes through carbonic rocks, especially limestones, but some andesitic rocks may be found. From sewer line #54, and according to the results of geotechnical investigation made, a lithology of ashes of pumice, silt and silt-clay is expected, until some 300 m after crossing the Chinautla River. From there forward, and almost until reaching the plant, granitic fractured and massive rock, with alterations near faults and rivers, will be found.

b) Central Region WWTP

The contrast between the level places where the plant is to be built, and its surrounding areas is notorious, in both Central and South regions. Also, the presence of a river in the surroundings can tie these low topographic areas with a valley, and with the consequent presence of sediment deposits carried by the river, mixed with sediments product of the erosion and the high topographic areas nearby (silts, sand-silts, clay-silts), covered by material with a high alteration content, and also with a high content of organic matter.

S4.2.4 Cultural Component

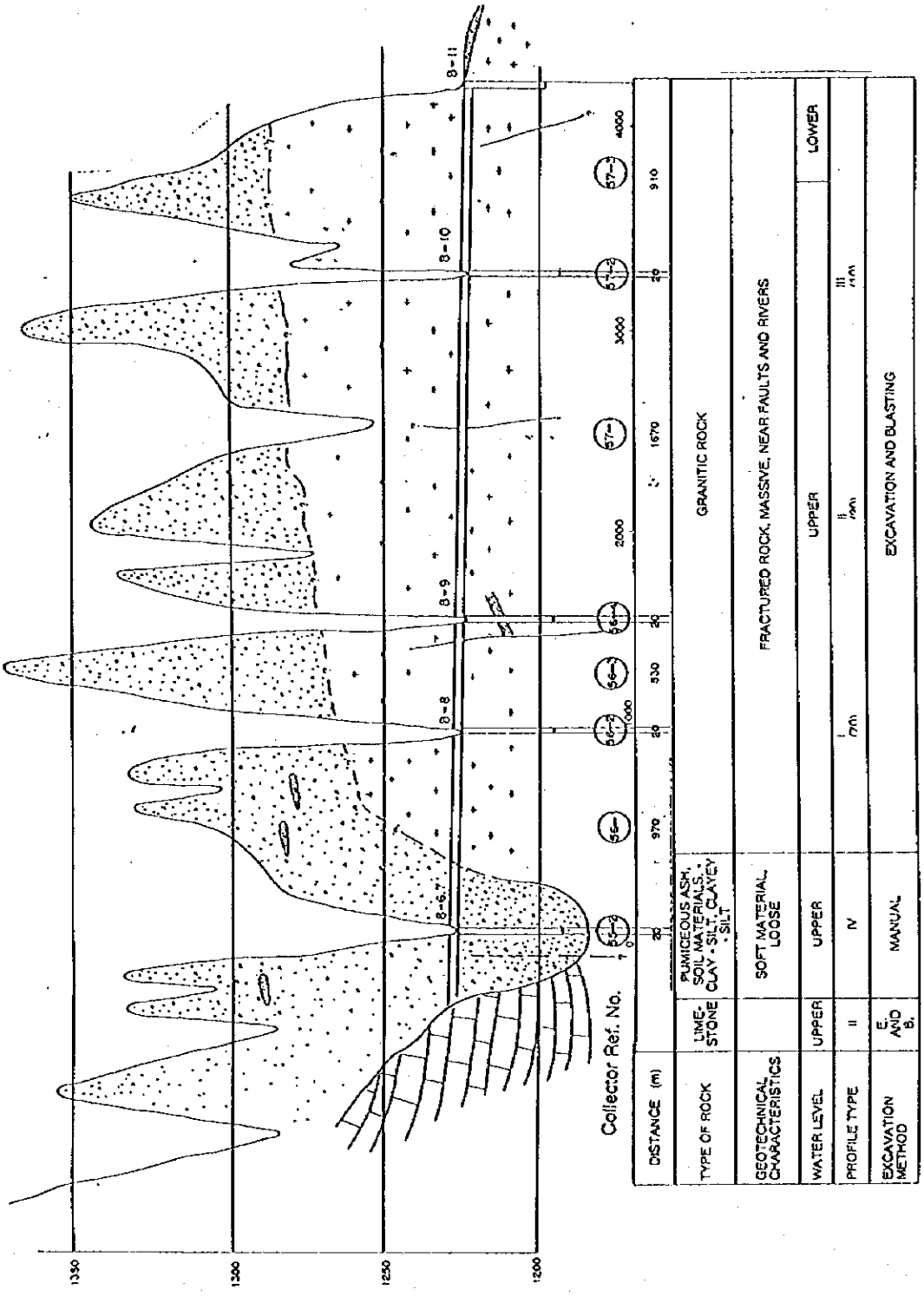
In order to identify the archaeological surveys carried out to evaluate the vestiges, the routes have been named with letters from A to S. Any evidence found is reported in Roman numbers after each letter (Appendix SB4).

ROUTE A-B

A-I COTIÓ

Archaeological site located at the south edge of the Panamerican Highway, nowadays called Calzada Roosevelt extension. The area consisted on a ball game court and mounds around the square. The superficial evidence of this site is completely destroyed.

Fig. S - 12



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE GEOTECHNICAL PROFILE ALONG LAS VACAS MAIN COLLECTOR

A-II GARLAND

Small archaeologic site located south of the Panamerican Highway, nowadays called Calzada Roosevelt extension, its contiguous to Coti\ archaeological site. It was composed of some disperse mounds and a ball game court.

A-III ZOMPOPERO/APRIL

This area is now occupied by Utatlán, Residenciales V, and the Zompopero urbanizations. The area had strong evidence of Prehispanic occupation, all of which was destroyed with the new constructions.

A-IV SAN JORGE

Archaeological area covering the South section of Kaminal Juyú. The Archaeologic Research project "San Jorge" was carried out in 1984. All possible evidence was recollected before beginning of construction of houses on Residenciales San Jorge. A Prehispanic ditch was found, which is believed to be used to transport water for irrigation and also as a drainage system from an artificial lake to the North of this area and to the South of Kaminal Juyu reserve "La Palangana". This ditch is similar to one found in the Aurora Zoological Park, reported in the South 3 district.

ROUTE C-B

C-I REFORMITA

In this zone, known as "Cantón Reformita", there was evidence of prehispanic presence mounds. Most of it was destroyed in 1948 to build residences.

ROUTE B-D

B-I ROOSEVELT

It is adjacent to the area known as "Campos del Roosevelt", inside of INCAP grounds. There is still a part of one of the mounds conforming this Prehispanic settlement.

ROUTE E-F

E-I SAN JUAN/ROOSEVELT

It is located between two areas with strong Prehispanic occupation evidence. However, this evidence is mostly destroyed.

ROUTE G-D

G-I KAMINAL JUYÚ

It is located in the western part of Guatemala City. It is also known as "La Palangana". It is one of the largest archaeologic sites in South Mid-America, with more than 200 mounds covering an area of 5 km^2. A large part of this site has been destroyed to build houses, buildings and commercial centers. Caution is suggested when perforation activities take place nearby.

ROUTE H-D

H-I ROSARIO

Similarly to other sites, a considerable part of this site was destroyed to build residential complexes, specifically the Villas del Rosario residence project. The evidence in this case was important due to this site was too close Lake El Naranjo, as a possible water source.

ROUTE D-F

No report of archaeological evidence susceptible to impact by perforation activities was found on this site.

ROUTE F-I

F-I CEMENTERIO

Inside the General Cemetery building at Guatemala City zone 3, an archaeologic center was found, separated from Kaminal Juyú by a deep trench. The evidence consisted of a large compact group of mounds around a square and probably a ball game court. The shape of the mound was considerably altered by grave constructions. The highest mound was located where General Justo Rufino Barrios grave is located. In 1948, some employees found a grave full of bone remains and a stone sculpture at a depth of two meters.

It is estimated that this zone will not be affected by this project. Anyway, caution is recommended when working inside the cemetery, due to the fact that there is a source of archaeologic and artistic evidence from Prehispanic and independent periods, principally the marble arts.

F-II BRAN

APrehispanic settlement was reported here in 1952. The superficial evidence has also been destroyed.

F-III MINERVAÓN

In this area existed the Jocotenango settlement known before as "Pueblo de Indios", which gradually was integrated to Guatemala City in the beginning of the twentieth Century.

F-V LAVARREDA

Small archaeologic site close to Las Vacas River, adjacent to the Belice bridge. The evidence consisted of two mounds and a ball game court. The largest structure was a pyramid of 4 m height.

ROUTE J-F

F-I GUARDA VIEJO

Possible evidence of work during the colony, mainly related to the water system which used to take it to San Gaspar.

ROUTE K-L

No archaeological, artistic or historic report evidences susceptible to be affected directly or indirectly by the perforations due to the project.

ROUTE L-I

No archaeological, artistic or historic report evidences susceptible to be affected directly or indirectly by the perforations due to the project.

ROUTE P-L

No archaeological, artistic or historic report evidences susceptible to be affected directly or indirectly by the perforations due to the project.

ROUTE M-N

M-I ARCOS

It was discovered in 1943. It is located 1.2 km to the south of Monumento de los Próceres. It is located inside San Jose Los Arcos Farm, which was subdivided to make a urbanization called "Bella Aurora". The archaeologic evidence was destroyed during this event. Superficially, there is no archaeologic evidence that could be affected by perforation activities, however, caution is still suggested.

M-II MONTÍCULO DE LA CULEBRA

Artificial Prehispanic platform built with soil and clay accumulation. The beginning of this platform is located close to the municipal plant "El Cambray", at the end of the 20th street at Zone 10. It runs to the east, parallel to the south side of 20th street, then parallel to Boulevard Liberación at zone 13 and ending at Pamplona Bridge, next to IGSS, a hospital in zone 10. This platform was reused during the colonial period as a base to build a water transport system to Guatemala City. It is still possible to observe this structure, although a great part has been destroyed.

Extreme caution is recommended while perforation jobs are done nearby the site.

ROUTE O-N

O-I MONTÍQCULO DE LA CULEBRA

This site is a extension of the above described. Extreme caution is also recommended.

ROUTE N-P

N-I CAMPO DE MARTE

Small Prehispanic residential complex located on Campo de Marte margins by the Northeastern part. The evidence consisted of several mounds, most of which were destroyed by recent constructions.

It is estimated that the zone will not be affected by underground perforation. However, caution is still suggested.

ROUTE R-P

R-I MONTEBELLO

During the construction of houses in this zone, there have been reports of Prehispanic deposit findings, mainly ceramic and lithic. No archaeological survey has been carried out on the site, and therefore caution is recommended during underground perforation.

R-II TRINIDAD

Small Prehispanic housing complex, located on Campo de Marte margins trench. The evidence have been destroyed by constructions on the zone.

ROUTE S-P

S-I CONCEPCIÓN

Archaeologic center consisting in a ball game court and several archeological mounds. It was reported initially in 1952 on Concepción Las Lomas road margins. The site seems to have been much larger than originally was estimated. In 1982, there was a rescue operation inside the urbanization, to north of Universidad del Valle campus. The same year, another material recovery was made inside campus already mentioned.

The vegetation on road margins in direction to Colegio Austríaco does not allow an intense survey on this site, but there are strong evidences of archaeologic material in the zone.

In the area nearby, there have been evidences of water collecting tanks related with farm developing during colonial period, and the beginning of the independent period. Extreme caution is suggested when making underground perforations.

ROUTE I-T

I-I SAN RAFAEL

Archaeologic site located on the west margin of the road to Chinautla, where the San Rafael Urbanization is located. The area was composed of a ball game court and a pyramidal mound.

I-II CHINAUTLA

Important archaeologic site located 2 km southwest of Chinautla and approximately 250 m upward. The place is surrounded by deep trenches. It is evident that these areas were selected by prehispanic habitants because of the defensive conditions it offers. The area has been cultivated for many years, causing destruction of vestiges.

Summary of the important archaeologic evidences described above is shown in Table S-6.

Table S-6 Summary of Archaeologic Evidences and Their Importance (Central Region)

CODE	TYPE	GRADE	DENOMINATION
A-I	Arq	3	Cotió
A-II	Arq	3	Garland
A-III	Arq	2	Zompopero/April
A-IV	Arq	2	San Jorge
C-I	Arq	3	Reformita
B-I	Arq	3	Roosevelt
E-I	Arq	3	San Juan/Roosevelt
G-I	Arq	1	Kaminal Juyú
H-I	Arq	2	Rosario
F-I	Arq	2	Cementerio
F-II	Arq	3	Bran
F-III	Arq	3	Minerva
F-IV	Col	3	Asunción
F-V	Arq	3	Lavarreda
J-I	Col	3	Guarda Viejo
M-I	Arq	3	Arcos
M-II	Arq/col	1	Montículo de la culebra
O-I	Arq/col	1	Montículo de la culebra
N-I	Arq	3	Campo de Marte
R-I	Arq	3	Montebello
R-II	Arq	3	Trinidad
S-I	Arq	2	Concepción
I-I	Arq	3	San Rafael
I-II	Arq	1	Chinautla

Note: Arq - Archeological Evidence and Col - Colonial evidence
Grade 1 - Very important
Grade 2 - Important
Grade 3 - Important but without specific location
Source : Study Team

S4.3 SOUTH 3 REGION

S4.3.1 Environment Description of Influence Area

South 3 Region WWTP is located to the South of Guatemala City, in Villa Canales Municipality, close to Villalobos River, in grounds previously known as Granja Lolita. It limits to the North with "La Amistad" Plantation, to the South and Southwest with Labor Higueros and Gerona Farms, to the east with Los Alamos and Labor El Muñeco, and to the West with the rail road and Villalobos River (Appendix SA14-SA18)).

The area of influence of the project in this region is extended as a basin to the Amatitlan Lake. The environment can be described as a rural sector in process of urbanization, with several housing projects in construction. The landscape is dominated by arid grounds with high deforestation. The Villalobos River shows high levels of pollution.

The access to the area can be made through an unpaved road.

S4.3.2 Biophysical Component

a) Life Zones and Climate

Life Zones : The characteristics of the observed vegetation and climatic data reported for the zone of influence of the project indicate that, at this site, two life zones merge, according to the ecological classification of vegetation proposed by Holdridge (1967). These zones are the Tempered Subtropical Premountainous Humid Forest and the Tempered Subtropical Premountainous Dry Forest.

This ecological transition is influenced mainly by climatic and edafic factors from both life zones, having as a consequence, a vegetation representative of both zones.

In the project area, the margins of the Villalobos River show vegetation characteristic of dry environments, whereas the presence of coniferous and oaks on the top of some hills are typical of humid zones. This difference can be noticed in the humidity of the area, higher on the hills than in the lowlands.

The environmental degradation of the hillsides has determined changes in the climatic conditions. South 3 Region represents a ecologic transitional zone, where flora from the both life zones can be found, among them, species from the Leguminosae, Solanaceae, Malvaceae and Agavaceae families.

Climate : According to the INSIVUMEH meteorological station in San Miguel Petapa, at 1,200 m above mean sea level, the region involving the Sector 3 of the capital registers the following climatic data: mean annual temperature: 21.4°c; mean annual precipitation: 1,093.7 mm. No reports of relative humidity were found.

b) Flora and Fauna

Wood Cover : Most of the hills in the regions are deforested and covered with corn and bean fields. The mixed forest in some few hills to the South is basically formed of oaks (*Quercus spp.*) alternated with some few coniferous like pine trees (*Pinus pseudostrobus*) and cypress (*Cupressus lusitanica*).

The lumber resources suffered strong pressure during the last years, when they were substituted by vegetable farming, corn and pastures, which cover the lowlands and hillsides.

The remaining original forest is represented by some individuals of willow (*Salix spp.*); amates (*Ficus spp.; Moraceae*); bamboo(*Bambusa vulgaris*); and some members of the Leguminosae family and others.

There are also exotic species associated with the original forest, like eucalipto (Eucalyptus spp.). Similarly, some epifitic species called "gallitos" (*Tillandsia spp*). Among the exotic grasses there are: Jaragua (*Hyparrhenia rufa*); caza brava o de castilla (*Gynerium sagittatum*); pasto estrella (*Paspalum spp.*) and napier or pasto elefante (*Pennisetum purpureum*). Some exotic trees and shrubs like mango (*Manguifera indica*); citrus (*Citrus sinensis*) and bamboo (*Bambusa vulgaris*). Among the native trees, there are: coyol (*Acrocomia mexicana*); pito (*Erythrina berteroana*); willow (*Salix spp.*); guapinol (*Himeneae courbaril*); izote (*Yucca elephantipes*); guayaba (*Psidium guajava*); tabacón (Wigandia urens var. caracasana); chicalote (*Argemone mexicana*); ricino (*Ricinus comunis*); pasto bermuda (*Cynodon dactilon*); and some species of the *Solanaceae*, *Convolvulaceae*, *Mimosaceae*, *Chenopodiaceae*, *Euphorbiaceae*, *Malvaceae* and *Papaveraceae* families.

Fauna : The relative absence of many species of fauna in this region can be the result of habitat degradation resulting from the deforestation, fires and agricultural practices. The aquatic fauna is lacking due to the extreme pollution of the Villalobos River.

In spite of the constant disappearance of the native fauna, there are references to the presence of the following species:

Mammals: possum (*Didelphis marsupialis*); weasel (*Mustela frenata*); armadillo (*Dasypus novemcinctus*); coati (*Nasua spp.*); raccoon (*Procyon lotor*); squirrel (*Sciurus spp.*); rabbit (*Sylvilagus spp.*); wild mouse (several species); rat (*Rattus spp.*).

Birds: parakeet(*Aratinga spp.*); clarinero (*Cassidix mexicanus*); swallow (*Tachycineta bicolor*); cenzontle (*Dumetella spp.*); dove (*Columba spp.*); tordo (*Catharus ustulatus*); buzzard (*Coragyps atratus*); chatilla (*Myiozetetes spp.*); wood pecker (*Celeus spp.*).

Reptiles: lizard (*Basiliscus vittatus*); Boa (*Boa constrictor*); coral snake (*Micrurus spp.*); sabanera (*Conophis lineatus*).

Domestic Fauna : Cattle and bird farming are common in the region. Pets like cats and dogs are also abundant in houses.

Some ecologic relationships are as follows:

In energy terms, the coniferous and oak vegetation on the hills represent no guarantee of high productivity for the local wild animals, with the exception of some species feeding on seeds and nuts. Other species find food in the herbaceous vegetation that represents an important source of nectar from flowers, seeds and some small fruits.

Insectivore and carnivore species play an important role regulating the number of insect and small mammal populations, potentially harmful to agriculture.

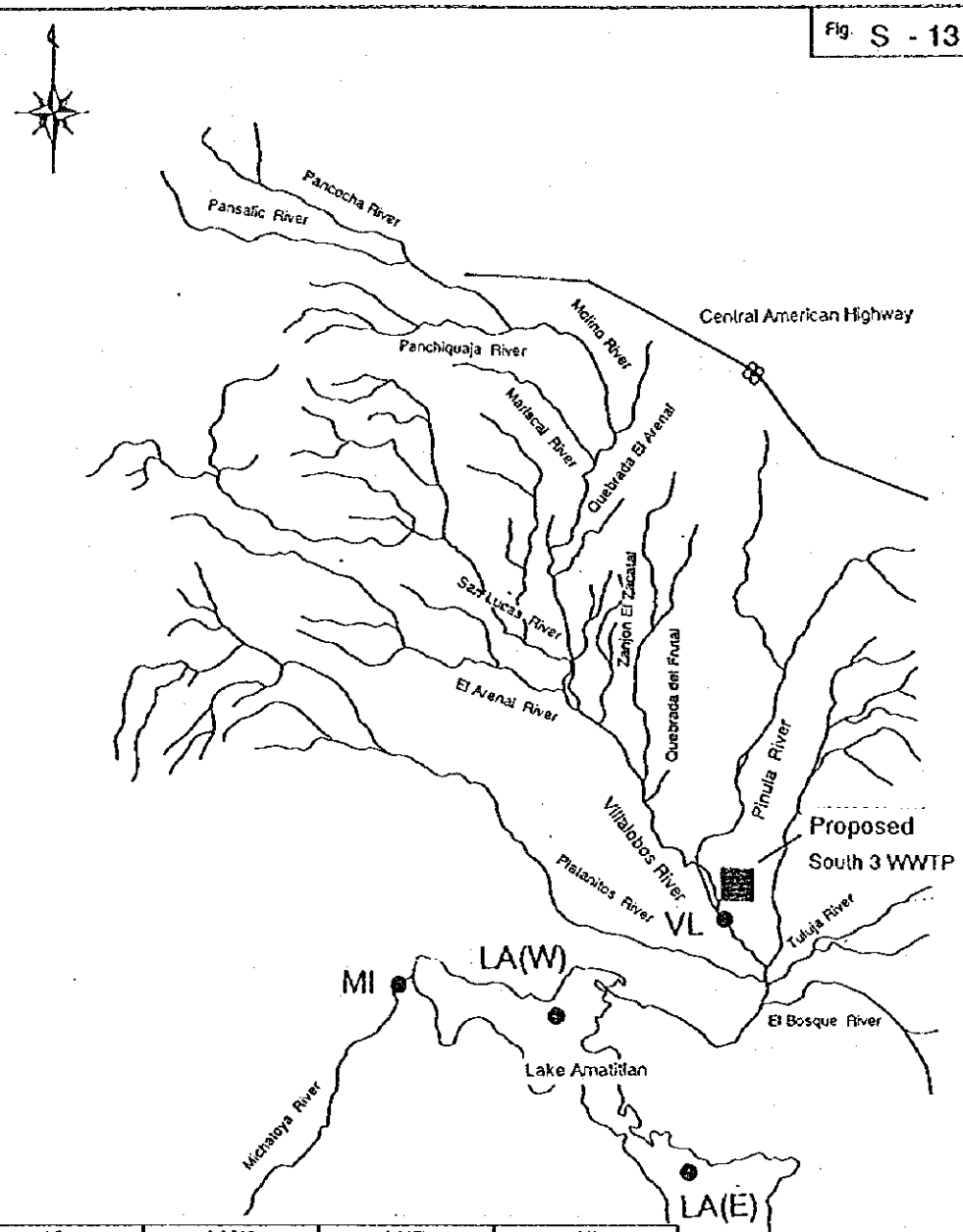
Some black vultures feed on carrion transported by the Las Vacas River, and therefore, contribute to clean the environment from animal residues. However, the continuous contact with polluted waters may be detrimental to these populations. Similarly, there is evidence that these birds act as a vector for some domestic and wild animal diseases.

c) Pollution Sources and Water Quality

Similar to northern part of Guatemala City, wastewater from southern part of Guatemala City is being discharged to the Villalobos River and it functions as a wastewater channel, transporting domestic and industrial wastes to Lake Amatitlan.

Fig. S-13 shows the results of water quality and flowrate survey (carried out during December '95 to February '96, dry season) for Villalobos River (downstream of the confluence with Pinula River), Lake Amatitlan and Michatoya River. Average flowrate of

Fig. S - 13



Location	VL	LA(W)	LA(E)	MI
Flowrate,m3/s	0.49 (0.30~0.67)			
COD, mg/L	377 (338~415)	33 (27~46)	34 (21~46)	44 (25~82)
BOD, mg/L	188 (120~290)	9.9 (7.5~14.0)	9.0 (5.1~15.0)	11 (4.7~24.0)
TS, mg/L	1252 (1000~1600)	348 (300~500)	400 (200~400)	443 (300~500)
Sed. S, mL/L	4.5 (3.6~5.0)	0.0 (0.0~0.0)	0.0 (0.0~0.0)	0.0 (0.0~0.1)
T-N, mg/L	38.6 (28.8~45.0)	7.7 (2.7~12.7)	6.0 (1.2~13.3)	6.6 (0.6~13.3)
T-P, mg/L	6.9 (5.2~8.6)	3.8 (0.6~7.7)	3.4 (0.1~8.6)	4.5 (0.1~9.2)
Cl-, mg/L	52.0 (29.9~79.6)	150.6 (7.0~17.6)	121.7 (83.2~142.5)	188.2 (105.3~230.6)

VL - Villalobos River (Downstream of proposed South 3 WWTP)
LA(W) - Laka Amatitlan (Playa de Oro)
LA(E) - Lake Amatitlan (Frente punta de Ayala)
MI - Michatoya River (Exit of Lake Amatitlan)

Average (minimum~ maximum) values are shown. Flowrates are for two measurements during day time, three days on December 1995 and three days on January/February 1996

THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE WATER QUALITY OF RECEIVING WATER BODIES (SOUTH 3 WWTP)

Villalobos River is 0.49 m3/s and average BOD is 188 mg/L. BOD in east and west part of Lake Amatitlan area 9.9 and 9.0 9.0 mg/L, respectively, which are similar to Michatoya River, except for chloride concentration. T-P concentrations for Lake Amatitlan did not agree with the previous results which were much less than that obtained in this survey.

S4.3.3 Geology

a) Principal collector

The information gathered from the perforation program indicates that most of the principal collector's trace will cross quaternary deposits, consisting mainly of ash of pumice, with fragments of pumice and sand pieces, with the exception of a 4.2km part, which starts some 500 meters before reaching the Pinula River (Fig. S-14).

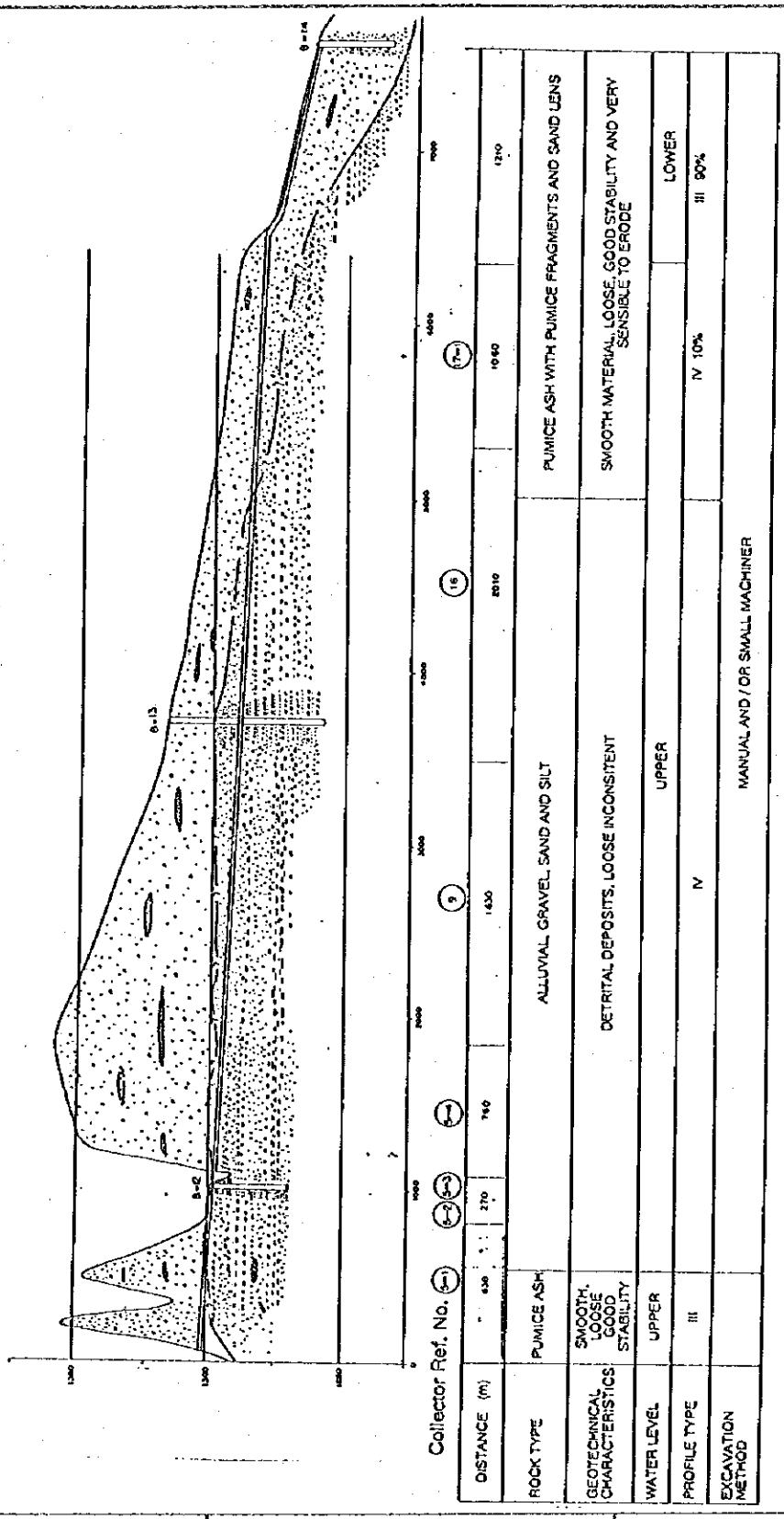
b) Wastewater Treatment Plants

The considerations are too similar to those made about Central Region.

S4.3.4 Cultural Component

In order to identify the inspections made to evaluate archaeologic vestiges, the routes have been named with letters from A to H. Any evidence found is reported in Roman numbers after each letter, (Appendix SB4).

Fig. S - 14



THE REPUBLIC OF GUATEMALA GUATEMALA MUNICIPAL WATER SUPPLY PUBLIC CORPORATION (EMPAGUA)	THE STUDY ON THE IMPROVEMENT OF WASTEWATER MANAGEMENT IN THE GUATEMALA METROPOLITAN AREA JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE GEOTECHNICAL PROFILE ALONG THE PINULA MAIN COLLECTOR

In general, there are very few sites with archaeologic, historic or artistic evidence in the region. The northern end has a close relationship with the Prehispanic housing development in the southern region of the valley, associated with the Kaminal Juyú archaeological site.

The west and south sections have more chance to present archaeologic evidence, given their relationship with Prehispanic commercial routes among the populations around the Amatitlan Lake and the Guatemala Valley. These routes used the archaeologic site known as "El Frutal" as a gathering and distribution center.

ROUTE A-B

A-I AURORA

Archaeological site covering the area currently forming the Aurora Zoological Park and the Aurora National Farm. Some mounds were demolished during the construction of the South Hippodrome and the edifications for the November Fair during the government of General Jorge Ubico. A human-made ditch was found inside the zoological park, which is similar to the one found close to Residenciales San Jorge, beside the peripheral expressway in zone 11. When the multilevel pass was constructed in front of the Tecún Umán Monument, an important Prehispanic finding was made.

A-II AEROPUERTO

Archaeologic site located approximately at the south-west end of the Aurora International Airport track. There is no superficial evidence left, because most of the mounds were destroyed to enlarge the track, in 1942. Ground leveling during that time allowed to discover a great amount of ceramic fragments and a stone sculpture representing an animal standing over a pedestal.

ROUTE C-B

Caution is suggested at the beginning of the route C, for this area is inside the area of influence of the Prehispanic commerce route between the archaeologic sites El Frutal and Eureka. However, no superficial evidence is left on the site.

ROUTE B-C

There is no cultural evidence in this site that might be affected by underground perforations.

ROUTE E-D

There is no cultural evidence in this site that might be affected by underground perforations.

ROUTE F-D

There is no cultural evidence in this site that might be affected by underground perforations.

ROUTE G-D

There is no cultural evidence in this site that might be affected by underground perforations.

ROUTE D-H

Caution is recommended specially at the end of the route from the exit to Los Alamos Urbanization, for this site is inside the area of influence of the Prehispanic commerce route "El Frutal", although no superficial evidence has been found. Unofficially, there have been reports in Los Alamos area of obsidian fragments findings (lightning stone), when soil has been removed for agricultural or construction purposes.

ROUTE I-H

There is no cultural evidence in this site that might be affected by underground perforations.

ROUTE J-H

Caution is recommended, for this site is inside the area of influence of the Prehispanic commerce route "El Frutal", although no superficial evidence has been found.

ROUTE K-H

Caution is recommended, for this site is inside of the area of influence of the Prehispanic commerce route "El Frutal", although no superficial evidence has been found.

Summary of the imporant archeologic evidences described above is shown in Table S-7.

Table S-7 Summary of Archaeologic Evidences and their Importance (South 3 Region)

CODE	TYPE	GRADE	DENOMINATION
A-I	Arq	3	Aurora
A-II	Arq	3	Aeropuerto

Note: Arq - Archeological Evidence and Col - Colonial evidence
Grade 1 - Very important
Grade 2 - Important
Grade 3 - Important but without specific location
Source : Study Team

S5 RESULTS OF EVALUATION

S5.1 SIGNIFICANT IMPACT ACTIVITIES

The execution of every engineering project, carries the implied generating activities that propitiates positive and negative impacts to the different components of the environment in the project influence area. These impacts occur in all stages of the project, namely pre-construction stage or planning stage, construction stage and operation stage. The execution and operation characteristics for the Central Region Project are similar to the South 3 Region.

S5.1.1 Planning Stage

Main impact activities identified in this stage are as follows:

1-1) Land procurement for WWTP
1-2) Publicity of the Project

S5.1.2 Construction Stage

The main impact activities during this stage are as follows:

2-1) Excavation of Tunnels
2-2) Cut and fill operation for WWTP construction
2-3) Construction activity

S5.1.3 Operation Stage

The main impact activities during this stage are as follows:

3-1) Elimination of wastewater discharges
3-2) WWTP discharge to receiving water
3-3) WWTP operation
3-4) Disposal of sludge
3-5) Stability of cut and fill slopes
3-6) Public relations

Table S-8 shows the impact matrix for the significant impacts.

Table S-8 Impact Matrix for the Significant Impacts

Project Activity	Social Environment										Natural Environment							
	Living Environment (Health)		Infrastructure		Social Opinion		Cultural Heritage		Disaster Risk		Aesthetic View		Flora and Fauna		Surface Water		Ground Water	
	Central	South 3	Central	South 3	Central	South 3	Central	South 3	Central	South 3	Central	South 3	Central	South 3	Central	South 3	Central	South 3
a) Pre-construction Stage																		
1-1 Land Procurement for WWTP															A	A	A	A
1-2 Public Relations					B	B												
b) Construction Stage																		
2-1 Excavation of Tunnels			C	C			P	P							B	B		
2-2 Cut and Fill Operation for WWTP Construction			C	C									C	C				
2-3 Construction Activity			B	B														
c) Operation Stage																		
3-1 Elimination of Raw Wastewater Discharges (connection to sewerage sewerage system)	A	A			A	A									A	A	A	A
3-2 WWTP Discharge															B	B	C	C
3-3 WWTP Operation					A	A					B	B						
3-4 Disposal of sludge															A	A	A	A
3-5 Stability of Slopes									A	A								
3-6 Ability to withstand earthquake									A	A								
3-7 Public Relations					A	A												

Note: P- Positive Impact

A - Serious Negative Impact

B - Moderate Negative Impact

C - Minor Negative Impact

Source : Study Team