ITA CONSULT
Consulting Engineers

Rr.Reshit Collaku
Pll.10/3/18, Tirana
Phone (042) 303 46
Fax (042) 303 46

SOIL INVESTIGATION REPORT

OF THE PROPOSED SITE OF WASTEWATER TREATMENT PLANT OF TIRANA CITY

AUTHOR
Ing.Romeo Eftimi

Tirana January, 1997

CONTENTS

ILLUSTRATIONS

SOIL INVESTIGATION REPORT OF THE PROPOSED SITE OF WASTEWATER TREATMENT PLANT OF TIRANA CITY

1 SCOPE OF THE INVESTIGATION

This investigation is conducted by the request of NIPPON JOGESUIDO SEKKEI CO.,LTD. (NJS)-Tokyo, JAPAN, according to the agreement achieved with the GEOCOMP COMPANY (GCC)-Tirana, Albania on December 1996.

For the planing and designing of foundation of facilities Tirana City Wastewater Treatment Plant data of soil conditions are necessary. In order to obtain the basic data of soil conditions, a soil investigation was conducted in which the following study subjects have been included:

1) Permeability
   * Necessity of waterproof material for lagoon
   * Availability of existing soil for waterproof
2) Strength of ground
   * Stability for banking
   * Stability for building
3) Stability for slope
4) Settlement
5) Groundwater level

2 LOCATION OF THE CONSTRUCTION SITE

The proposed wastewater treatment plant is located about 12km north-west to the center of Tirana City, and about 3 km south to Rinasi Airport (Fig 1). The approximative surface of this plant is about 58ha. In the Detailed Location Map (Fig 2), can be seen that the wastewater treatment plant is located just in the corner where Lana River join Tirana Rivers Tirana. The site and represents a part of the Tirana plain.

The plant is located near the Berxulli Village and this part of the plain is called Berxulli plain. Tirana plain dips gently to north-west, and while in Tirana City area the elevation is about 90 to 130m above sea level (a.s.l.), in Berxulli Village the elevation is about 40-43m a.s.l. The both channels of Tirana and Lana Rivers are about 8 to 10m deep, but while the Lana river bed is relatively narrow and filled with fine grained materials (Photo 1), the Tirana River bed is wide, good developed and filled with gravelly deposits (Photo 2).

The construction site consists a part the cultivated area of the Berxulli Village. Actually, in the area of the construction site, there are only some small one storied village buildings, but even so in some of them are verified damages like cracks of walls and settlement. These phenomenon is a consequence of the very shallow foundation of the village houses, which

General Location Map

Fig. 1

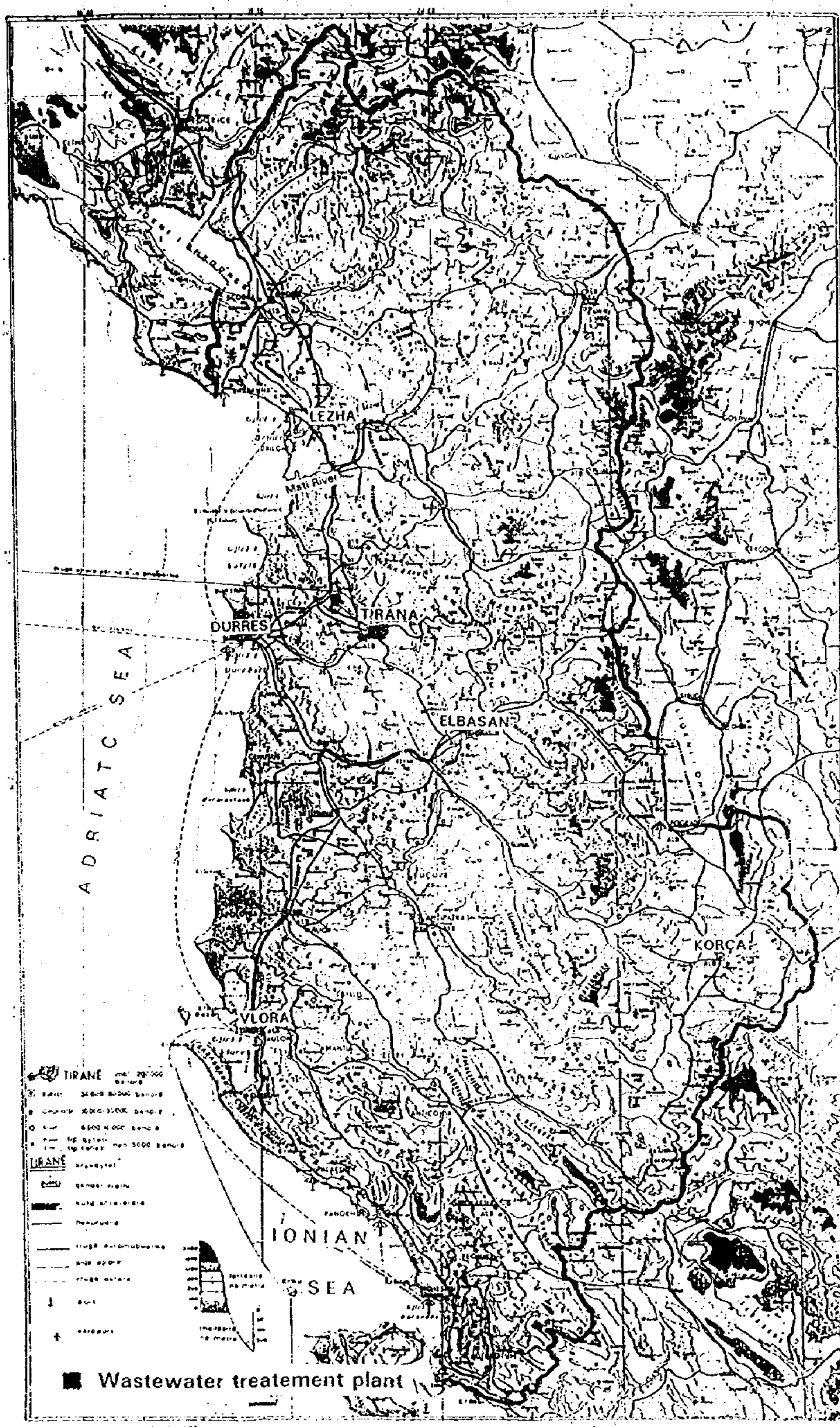
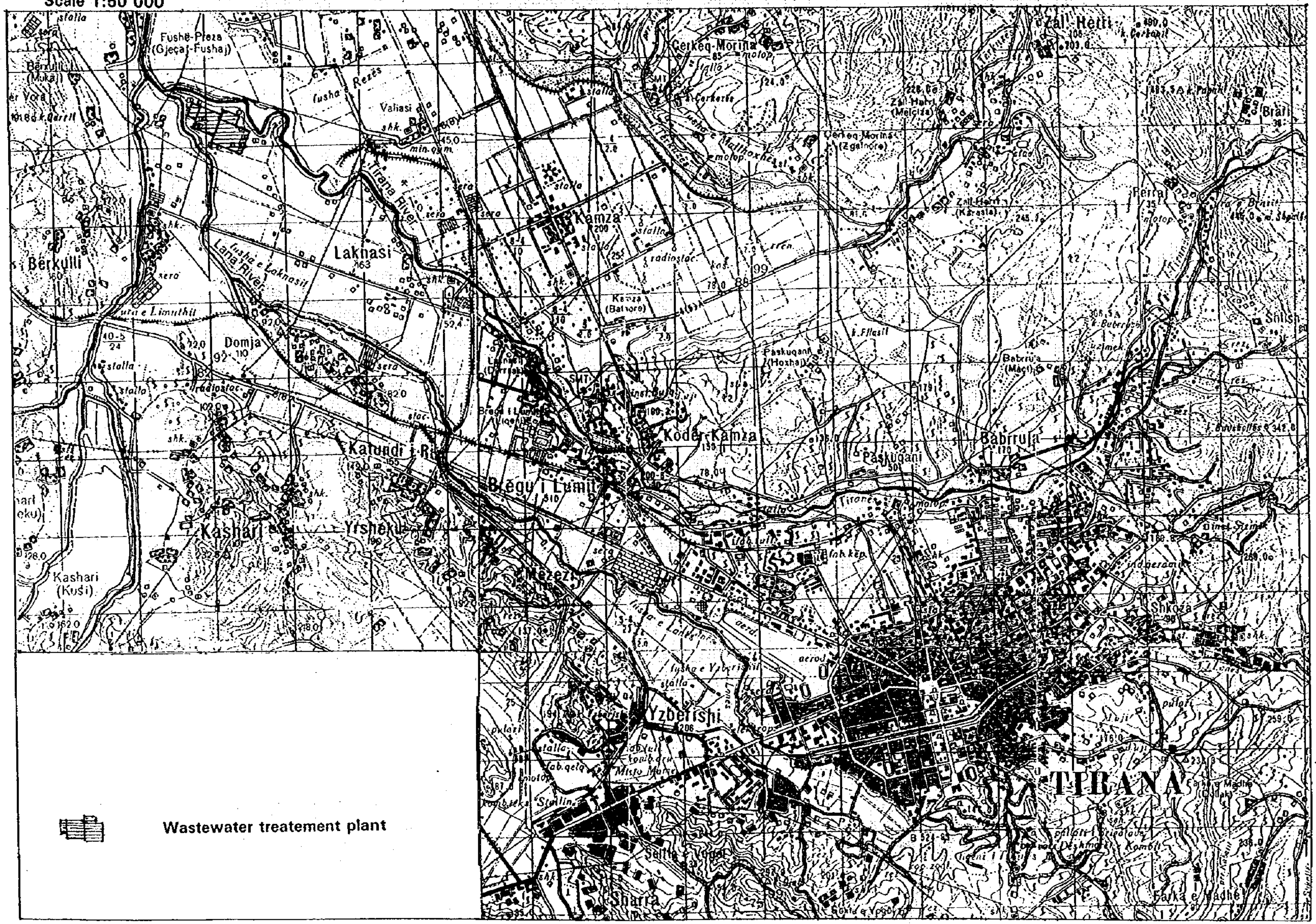


Fig.2

Detailed Location Map
Scale 1:50 000



usually are not more then 0,6m.

3 CLIMATOLOGY

The climate of Tirana area is temperate Mediterranean, characterized by a relatively dry and hot summer and by a wet and cold winter. the mean annual air temperature is around 15,2°C, in summer the mean is about 22°-24°C, and in winter the mean is about 6°-8°C. It is interesting to know the extreme values of the temperature reaching in summer up to 30-35°C, and in winter 0°C to 5°C.

The mean annual rainfall is around 1250mm, and about 70% of them are concentrated in a six-months period from October to March. Characteristic for Tirana area are the torrential (intensive) rains, so the maximal 24hours rainfalls reach up to 200-250mm.

Table 1 shows the average monthly temperature and monthly rainfall distribution according to the Tirana climatic station.

Table 1. Monthly temperatures and rainfall Tirana climatic station

Months	Temperature, °C	Rainfall, mm
January	6,4	133
February	7,5	129
March	10,0	111
April	13,8	94
May	17,6	102
June	21,7	60
July	24,0	30
August	24,0	41
September	21,2	75
October	16,4	150
November	12,2	169
December	8,4	153

4 GEOLOGY

Tirana plain represents the central part of the big Tirana syncline, which is dipping in north-west direction to the Adriatic Sea. The upper part of this syncline is filled of Tortonian sediments like claystones, siltstones and sandstones. The central area of this syncline, the Tirana plain, mostly is filled of Quaternary deposits of Tirana and Lana rivers. In the area of Berxulli Village, where is situated the proposed wastewater treatment plant, is developed the first alluvional terrace of these rivers. The quaternary deposits here have a total thickness of about 45-50m, and in general are represented of two different facial layers: the upper layer is represented of fine silty and clayey materials with a total thickness of about 15-20m, while the lower facial layer is represented of some gravelly and clayey horizons with a total thickness of about 20-30m. The gravelly deposits are placed above the claystone-siltstone Tortonian deposits, representing the basement for the Quaternary deposits.

5 FIELD EXPLORATION AND LABORATORY TESTS

In the field exploration program have been included the collection of the preliminary information, reconnaissance and site investigation. Important preliminary information have been obtained from the former geological and hydrogeological investigation, among which most important are the Geological and Hydrogeological maps of Albania scale 1;200 000 and some detailed hydrogeological investigation of the studied area. Reconnaissance investigation consists in detailed observation, including the observations of the existing village constructions in the studied area, and of the Tirana and Lana rivers banks.

The site investigations is based on two boring which are situated as is shown in Fig 3. The boring are performed from 4 to 10 of January 1997. The depth of the boring is 20m, and the distance between them is 464m. Both boring, after having penetrating the upper finer facial layer, they also have taped the lower facial layer of the alluvional deposits covering the studied area. The boring have been drilled with a Chinese production rotary drilling machine of the Russian typ Zif-150 (Photo 3). The upper 5m of each drilling is performed by the traditional procedure of rotating a serrated cutting shoe, and the lower part of the boring is drilled by the auger method (Photo 4). The drilling diameter of the upper part of the boring was 127mm, and 110mm for the lower part of the boring. The recovery ratio of the cores have been 80% to 100%, and they have been described in the field. With a hand penetrometer have been performed also the hand penetration measure tests on the core samples, and the results are shown in the descriptions of the boring (Drawing 3).

Four undisturbed samples, two for each boring, have been obtained using a special sampler. The sampling depth in boring S1 was 2,3-2,5m and 6,0-6,2m, while in boring S2 was 3,3-3,5m and 4,8-5,0m. Physical-mechanical laboratory tests like grain size analysis, determination of Ateberg's limits, specific gravity and bulk density of the soil solids determinations, consolidation and shear strength tests have been performed in the Laboratory of the Engineering Geological Enterprise of Tirana.

6 GEOTECHNICAL CONDITIONS OF THE SITE

As we have already noticed in the geological section, our construction site is part of the first alluvional terrace of Tirana and Lana rivers. In these deposits are identified four main soil layers, with quite different lithology and physical-mechanical properties, which are given below in downward direction:

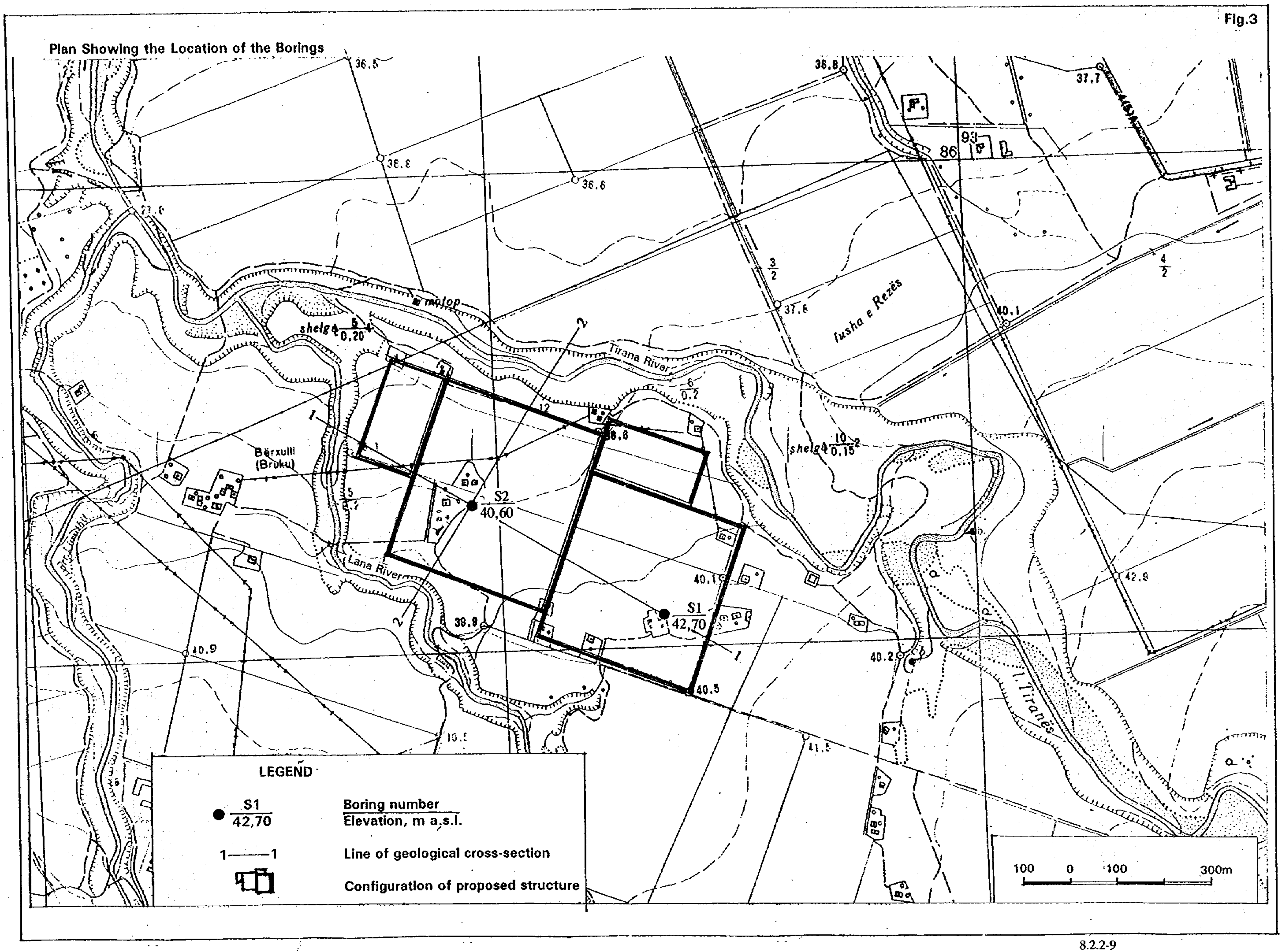


Fig.3
Plan Showing the Location of the Borings
Tirana River
Lana River
Bërxulli (Bruku)
fusha e Rezës
l. Tiranës
S2 40,60
S1 42,70
LEGEND
S1 42,70
Boring number
Elevation, m a.s.l.
1——1
Line of geological cross-section
Configuration of proposed structure
100 0 100 300m

Layer 1 - Top soil (cultivated land)
Layer 2 - Silt to sandy silt, (including the Layer 2a)
Layer 3 - Silty clay, (including the Layer 3a)
Layer 4 - Gravel
The distribution and the geometry of the soil layers is shown in the geological cross-sections 1-1 (Drawing 1) and 2-2 (Drawing 2), while the lithological and geotechnical description of the soil cores is shown in the geological columns of the boring (Drawing 3).

Below are given the geotechnical characteristics of the soil layers in downward direction.

6.1 Layer 1

This layer represents the top soil, or the **cultivated layer**, covering the construction site, and having the thickness about 0,5-0,6m. It consists of clayey silty soil, yellowish to the broun colour. In this layer, plant roots and other organic remnants are present.

The cultivated land, being in direct contact with the atmospheric agents,is very sensible to them. So, during dry summer months, big dryness fissures deepening down to 0,5-0,8m below ground surface, are observed. In contrary, during the humid winter months, the expansion of the top soil layer happen. The both phenomenons demolish the structure of this layer. This is the reason that most of the small one storied village houses which have very shallow foundations are damaged by cracks of wells and settlement. Due to his small thickness and also due to the above mentioned poor geotochnical properties of the cultivated layer is not recommended as a good basement for the foundation of different constructions. This is the reason that this layer is exclude from the object of our detail investigations.

6.2 Layer 2

Layer 2 is extended under the cultivated layer and consists mainly of nonhomogeneous **silty soil**. The depth of the top of this layer is about 0,5-0,6m below the ground surface, while the his thickness is about 3,8-4,1m. This layer has a characteristic grayish yellow or bluish yellow colour, which can be observed very well in Photo 5 and 6, showing the cores of the boring S1 and S2.

This layer in the field is described, in boring S1 as "silt to clayey silt", "silt to sandy silt" and "silt", while in boring S2 is described as "sandy silt" and "silt" (Drawing 3). The silt is usually "very moist" to "water saturated", "soft", "medium soft" to "medium stiff". The result of the laboratory tests of two specimens from this layer are shown in Table 2.

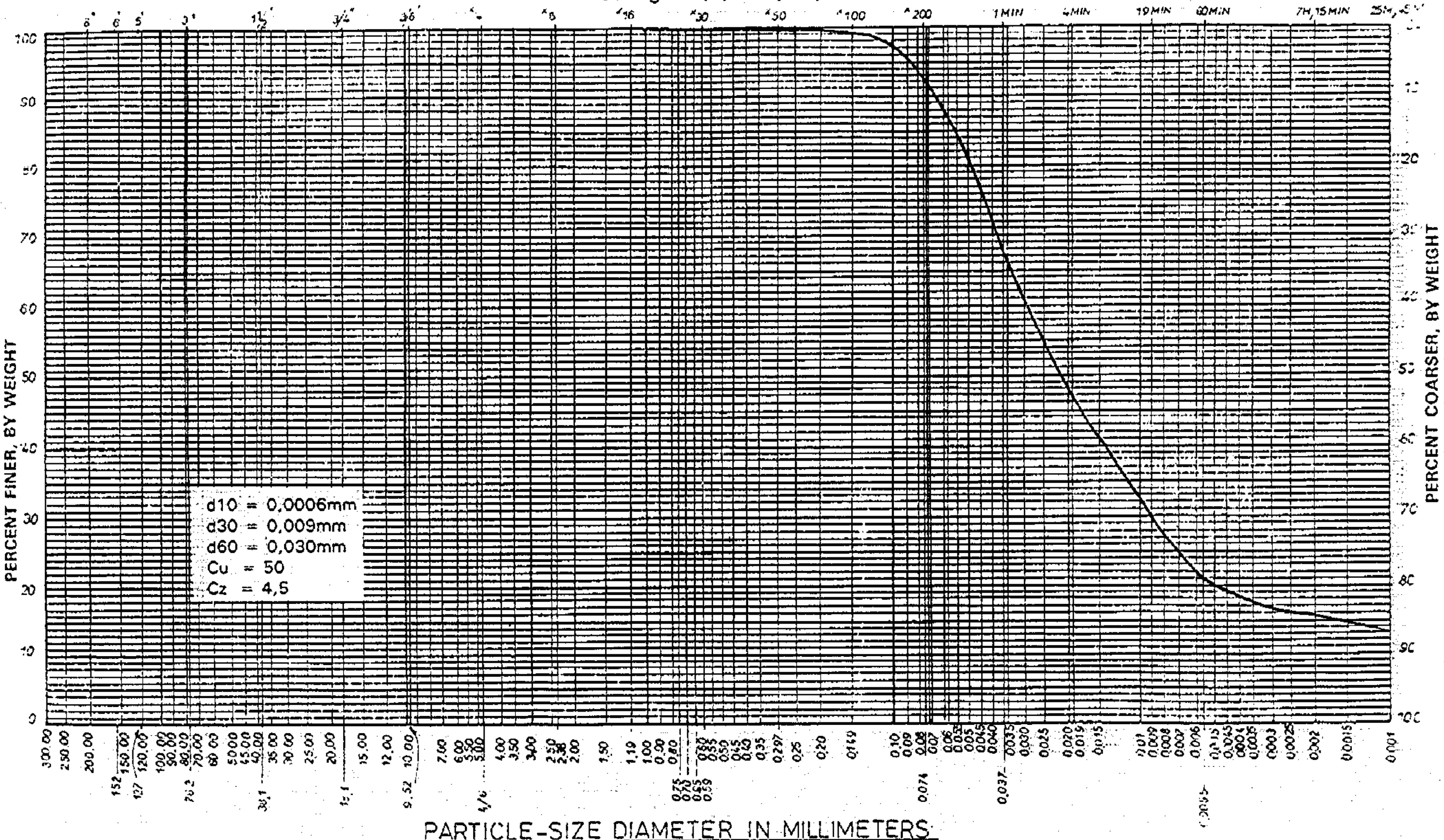
Grain - size distribution of the Layer 2 is studied by two grain - size analyses, which graphics of size distribution are shown in Fig 4 and 5. According to these analyses the Layer 2 can be classified as **silt**. The clay fraction represents 13,9-15,6% of the material, the silt fraction represents 65,7-66,0% of the material, while the sand fraction represents 18,7-20,1% of the material.

Table 2. Laboratory tests of the specimens silty soil - Layer 2

	S1	S2
Boring	S1	S2
Depth of the soil specimens, m	2,3-2,5	3,3-3,5
Grain size distribution in % (sieve opening,mm)		
1,0 - 0,5	0,3	0,7
0,5 - 0,25	0,5	0,4
0,25 - 0,1	1,6	2,8
0,1 - 0,05	16,3	16,2
0,05 - 0,01	48,5	35,4
0,01 - 0,005	12,8	21,8
0,005 - 0,002	4,4	8,8
0,002 - 0,001	2,8	3,6
< 0,001	12,8	10,3
Moisture content	36,0	33,1
Plasticity		
Liquid limit % - Ll	31,62	34,96
Plastic limit % - Pl	25,33	27,03
Plasticity index % - Pi	6,3	7,9
Specific gravity - Gs	2,70	2,70
Volume wight		
Moist unit wight - δ	1,82	1,84
Dry unit weight - d	1,34	1,38
Porosity % - n	50,37	48,89
Void ratio - e	1,015	0,957
Degree of saturat. - S	0,96	0,93
Coef of permeab.cm/s- K	$2,4*10^{-4}$	$6,2*10^{-4}$
Compressibility		
Module of cp.kg/cm^2- E	52,46	56.02
Coef. of cp.cm^2/kg- a	0,036	0,033
Module of settlements mm/m - L	110,08	101,72
Shear strength		
Angle of friction - ϕ	14°	16°
Cohesion kg/cm^2 - c	0,14	0,12

Fig.4

GRAFIC OF SIZE DISTRIBUTION
Boring S1 (2,3 - 2,5m)

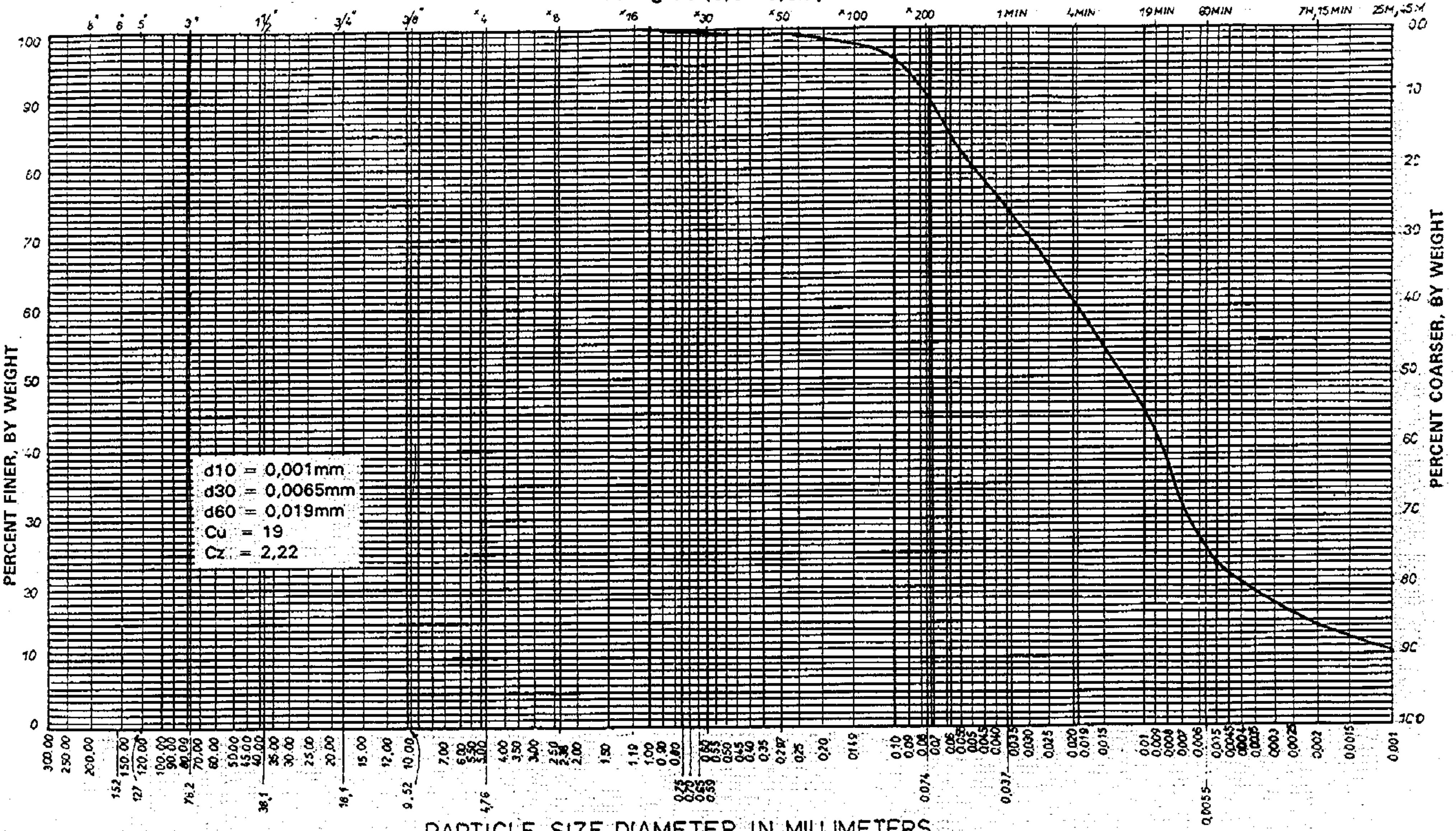


PARTICLE-SIZE DIAMETER IN MILLIMETERS

BOULDERS				GRAVEL			SAND				SILT		CLAY	
VC	C	M	S	VC	M	F	VC	M	F	VF	C	F	CLAY	COLLOIDAL
							0,3	0,5	1,6	16,3	48,5	12,8	4,4	15,6

GRAFIC OF SIZE DISTRIBUTION
Boring S2 (3,3 - 3,5m)

Fig..5



BOULDERS				GRAVEL			SAND				SILT		CLAY	
VC	C	M	S	VC	M	F	VC	M	F	VF	C	F	CLAY	COLLOIDAL
							0,7	0,4	2,8	16,2	35,4	21,8	8,8	13,9

The plasticity is evaluated in the field and the Ateberg's limits are determined in the laboratory (Table 2). The average values of Ateberg's limits resulted; liquid limit - 33, plasticity limit - 26 and plasticity index - 7. According to the Maslov's Classification, which is based on the plasticity index values, the soils having the plasticity index within 7 and 10, like the Layer 2, are classified as sandy silts.

According to the Unified System of Soil Classification of Casagrande, which is based on the liquid limit and on the plasticity index values, the Layer 2 is classified as ML-OL soil which is mainly silt to silty clay.

The consistency of the clayey soils can be estimated from the following equation:

$$B = \frac{W - Pl}{Pi}$$

where:
W = natural moisture content
Pl = plastic limit
Pi = plasticity index

In our case the B value of the Layer 2 is 1,46 and 0,77, classifying these layer as "very soft" or "soft".

Some other physical properties, like natural moisture content - W, specific gravity - Gs, moist unit weight - , dry unit weight - (δ), porosity - n, void ratio - e and the degree of saturation - S, are also shown in Table 2. The values of the specific gravity, moist unit weight and dry unit weight are typical for the silty soils. The values of the degree of saturation higher then 0,8 characterizes the Layer 2 as water saturated.

The filtration properties of the soil, are expressed through the coefficient of the permeability - K, which value are estimated by the well known Kosen equation:

$$K = 4000 \frac{n^3}{1 - n^2} d_{10}^2$$

where:
n = porosity, fraction
d_{10} = effective diameter, mm

The estimated values resulted of the order 10-4 cm/s (Table 2), being so typical values for the silty soils.

Mechanical properties. The values of the mechanical properties, like compressibility test's parameters, and also share strength tests parameters are shown in Table 2. The compressibility tests are made applying six different loads on the specimen, and the settlement readings for the specimen are taken for 24 hours.

The shear strength tests are conducted by placing the specimen in a share box that is split into two halves. A normal load is first applied to the specimen. After that, a shear force is applied to the top half of the shear box to cause failure in soil. The tests have been conducted in conditions of naturale moisture content. As can be seen I Table 2, the results of compressibility, settlements and shear strength obtained from both specimens are very comparable and can be representative for the concerned soil layer.

Concluding the presentation of the data for the Layer 2, in Table 3 are shown the recommended representative values of the geotechnical properties for Layer 2. In this table is included also the value of the allowable capacity of the soil. The value of this parameter is determined according to the field measurements with the hand penetrometer, shown in Drawing 3, and according to the standard values recommended from the literature of the speciality.

Table 3. The recommended representative values of geotechnical properties for Layer 2

Grain size distribution in % (sieve opening,mm)		
Clay		14 %
Silt		60 %
Sand		20 %
Plasticity		
Liquid limit	- Ll	33 %
Plastic limit	- Pl	26 %
Plasticity index	- Pi	7
Moisture content	- W	34,56 %
Specific gravity	- Gs	2,70 gr/cm³
Moist unit wight	- Δ	1,83 gr/cm³
Dry unit weight	- δ	1,36 gr/cm³
Porosity	- n	49,63 %
Void ratio	- e	0,985
Degree of saturat.	- S	0,945
Coef of permeab.cm/s	- K	$5*10^{-4}$ cm/s
Compressibility		
Module of compres.	- E	55,0 kg/cm²
Coef. of compres.	- a	0,035 cm²/kg
Module of settlements	- L	105,0 mm/m
Shear strength		
Angle of friction	- φ	15°
Cohesion	- c	0,13 kg/cm²
Allowable capacity	- σ	1,4 kg/cm²

6.3 Layer 2a

Layer 2a represents the thin **sand layers** which are found inside the above described silts soils (Layer 2). In both boring the sandy layer is taped in different depths; in boring S1 it is taped in the depth 4,2-4,7m b.g.s, while in boring S2 it is taped in the depth 2,3-2,7m b.g.s. So the thickness of the this layer results 0,4-0,5m. The sandy layer is observed to outcrop in right bank of the Lana River, in the western periphery of the wastewater treatment plant. It seams that this layer has more the character of separate lenses than of a real layer uniformly developed throughout the construction site.

The sands are greyish yellow, medium grained, well sorted and water saturated. The geotechnical properties of sandy layer are not studied with laboratory analyses. It is believed that this layer do not change sensibly the mechanical characteristics of the Layer 2, because of his small thickness. quite different is the problem of the filtration capacity which for the sandy layer is expected to by much more higher than these of the silts of Layer 2. During the future detailed studies of the wastewater treatment plant site must be clear up better the geometry and geotechnical properties of the sandy layer (or layers).

6.4 Layer 3

Layer 3 extends over all the construction site and everywhere is found to be below the Layer 2. It consists of homogenous **silty clays**, which in the upper part of the geological section, have a characteristic bluish colour, while in the lower part of this section they have a bluish yellow colour. The outcrops of this layer can be observed in the left bank of the Tirana River (Photo 7), while in the banks of Lana River this layer is covered by the cultivated land. In Photo 7 is shown a outcrop of Layer 3 (bluish) and the overlying silty layer (yellowish). The characteristic colour of this layer can be observed also in Photo 5 and 6, showing the cores of the boring S1 and S2.

In the drawings 1 and 2, the lower part of the clays is shown as a separate Layer 3a. The depth of the top of this layer is taped, 4,3m and 4,7m b.g.s respectively in the boring S1 and S2. In the field this layer is described as "silty clay", "medium stiff", "very plastic" and "water saturated" (Drawing 3). For the characterization of this layer have been obtained two specimens, but one of them resulted disturbed during the transport. The results of the laboratory tests of the both specimens of this layer are shown in Table 4.

Grain - size distribution of the Layer 3 is studied by two grain - size analyses, which graphics of size distribution are shown in Fig 6 and 7. The clay fraction represents in average 23% of the material, the solt fraction represents in average 58,5%of the material and the sand fraction represents 18,5% of the material. According to this analyses the Layer 3 can be classified as **silty clay**.

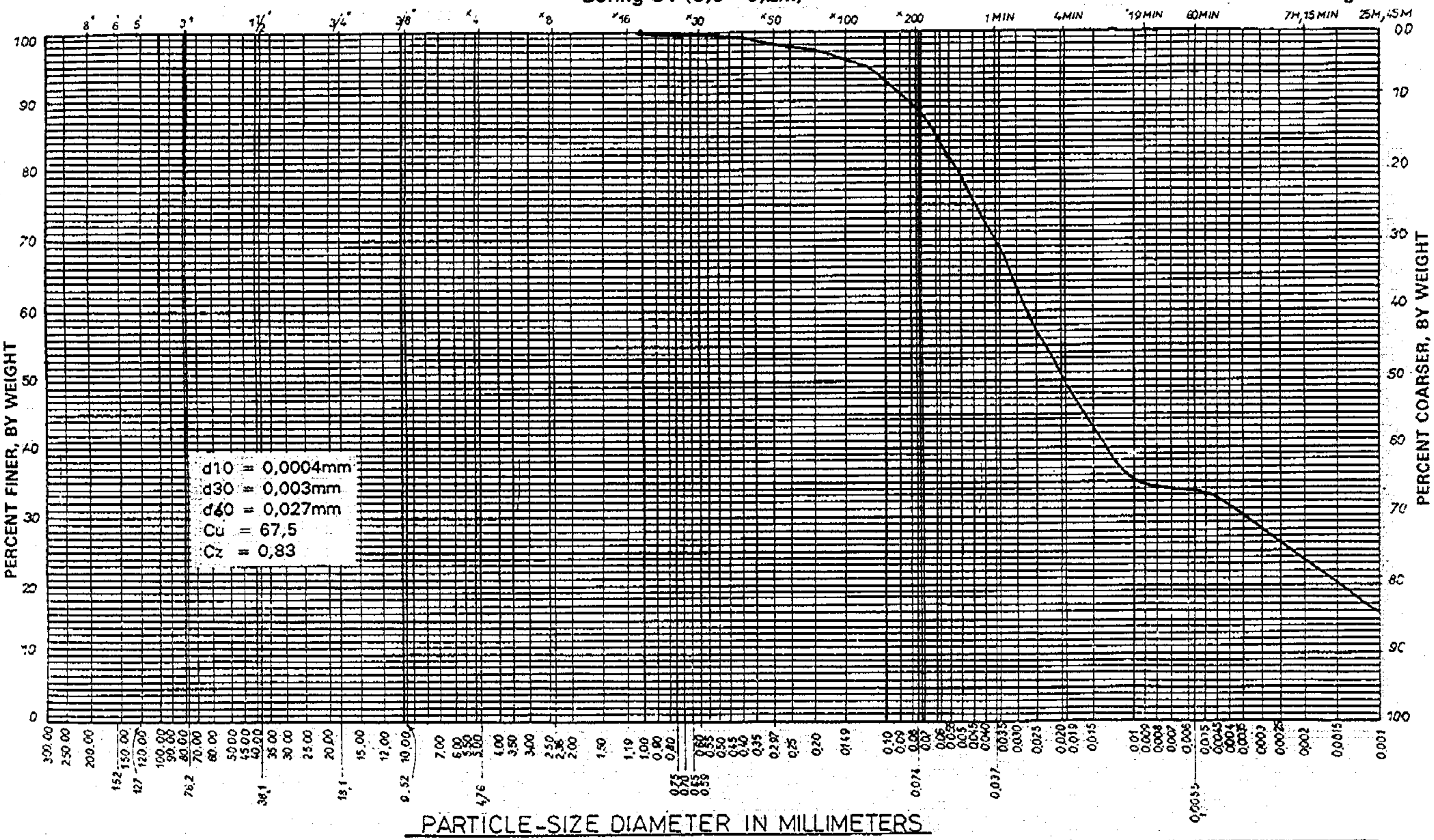
The plasticity of the Layer 3 in the field is evaluated as "very plastic", while the consistency is evaluated as "medium stiff". The average values of the Ateberg's limits as determined in the laboratory results:

Table 4. Laboratory tests of the specimens of Layer 3 - silty clay

Boring		S1	S2
Depth of the soil specimens, m		6,0-6,2	4,8-5,0
<u>Grain size distribution in % (sieve opening,mm)</u>			
1,0 - 0,5		0,6	0,4
0,5 - 0,25		1,8	0,3
0,25 - 0,1		4,3	0,7
0,1 - 0,05		13,9	15,4
0,05 - 0,01		44,5	11,2
0,01 - 0,005		1,9	24,8
0,005 - 0,002		9,2	14,9
0,002 - 0,001		7,3	13,7
< 0,001		16,5	18,6
Moisture content			34,9
<u>Plasticity</u>			
Liquid limit, %	- Ll	28,05	40,14
Plastic limit, %	- Pl	16,04	25,45
Plasticity index, %	- Pi	12,0	14,7
Specific gravity, gr/cm^3	- Gs		2,72
<u>Volume wight</u>			
Moist unit wight, gr/cm^3	- Δ		1,86
Dry unit weight, gr/cm^3	- δ		1,38
Porosity, %	- n		49,26
Void ratio, fract.	- e		0,971
Degree of saturat. fract.	- S		0,98
Coef of permeab. cm/s	- K		$5,7*10^{-5}$
<u>Compressibility</u>			
Module of comp. kg/cm^2	- E		48,68
Coef. of comp. cm^2/kg	- a		0,038
Module of settlements, mm/m	- L		119,28
<u>Shear strength</u>			
Angle of friction, °	- ϕ		12°
Cohesion, kg/cm^2	- c		0,15

GRAFIC OF SIZE DISTRIBUTION
Boring S1 (6,0 - 6,2m)

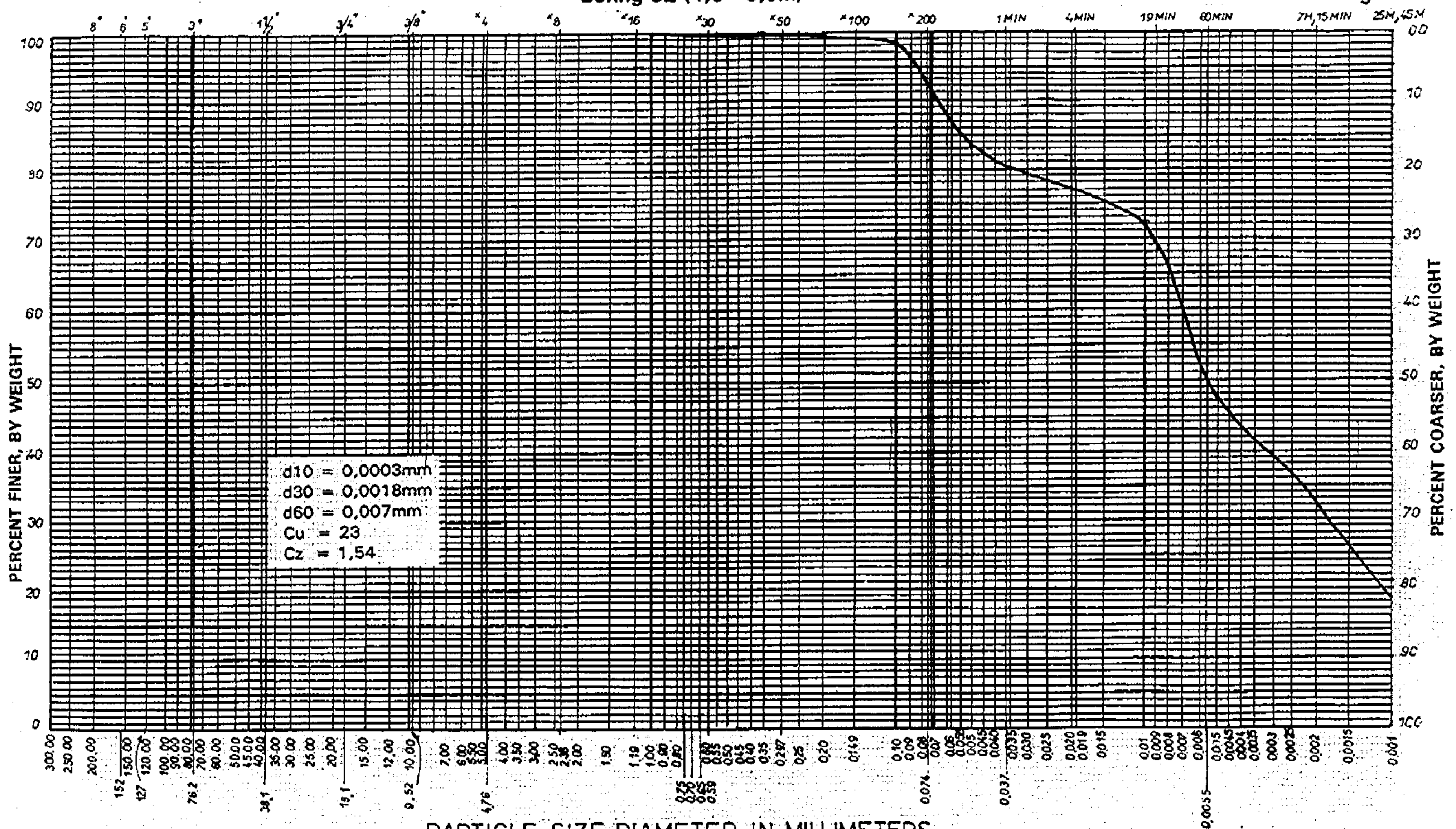
Fig. 6



BOULDERS				GRAVEL			SAND				SILT		CLAY	
VC	C	M	S	VC	M	F	VC	M	F	VF	C	F	CLAY	COLLOIDAL
							0,6	1,8	4,3	13,9	44,5	1,9	9,2	23,8

GRAFIC OF SIZE DISTRIBUTION
Boring S2 (4,8 - 5,0m)

Fig.7



BOULDERS				GRAVEL			SAND				SILT		CLAY	
VC	C	M	S	VC	M	F	VC	M	F	VF	C	F	CLAY	COLLOIDAL
							0,4	0,3	0,7	15,4	11,2	24,8	14,9	32,3

Liquid limit	- Ll	34,1 %
Plastic limit	- Pl	20,7 %
Plasticity index	- Pi	13,7 %

According to the Maslov's Classification, the soils having the plasticity index within 10 and 14, like the Layer 3, are classified as silty clays.

According to the Unified System of Soil Classification, the Layer 3 in boring S1 is classified as CL soil, which is mainly silty clay, while in boring S2 is classified as ML-OL, which is mainly silt to silty clay.

The "B" value, for the evaluation of the consistency, estimated from the above-mentioned equation, resulted 0,64, classifying the Layer 3 as "medium stiff".

Some other physical properties, like natural moisture content - W, specific gravity - Gs, moist unit weight - , dry unit weight - δ, porosity - n, void ratio - e and the degree of the saturation - S, which values are shown in Table 4, results practically like the corresponding values of the Layer 2.

The filtration properties of the Layer 3, exprsed through the coefficient of the permeability - K, estimated by the Kosen equation resulted $5,7*10^{-5}$cm/s, which is one order smaller then the corresponding value of the Layer 2.

The mechanical properties of the Layer 3, shown also in Table 4, resulted with very small differences comparing with the values of the Layer 2. The module of compressibility is a little smaller in the Layer 3, but the coefficient of the compressibility and the settlement of the Layer 3 are a little bigger then in Layer 2. With very small differences resulted also the angle of the friction and the cohesion of the layers 2 and 3. Because the Layer 3 is more clayey, have smaller angle of friction and bigger cohesion then the Layer 2.

In Table 5 are shown the recommended representative values of the geotechnical properties for the Layer 3.

Table 5. The recommended representative values of geotechnical properties for Layer 3

<u>Grain size distribution in % (sieve opening, mm)</u>		
Clay		23,0 %
Silt		58,5 %
Sand		18,5 %
<u>Plasticity</u>		
Liquid limit,	- Ll	34,1 %
Plastic limit,	- Pl	20,7 %
Plasticity index,	- Pi	13,4
Moisture content	- W	33,1 %
<u>Volume wight</u>		
Specific gravity,	- Gs	2,72 gr/cm³
Moist unit wight,	- Δ	1,86 gr/cm³
Dry unit weight,	- δ	1,38 gr/cm³
Porosity,	- n	49,26 %
Void ratio,	- e	0,971
Degree of saturation,	- S	0,98
Coef of permeability,	- K	$5{,}7 * 10^{-5}$ cm/s
<u>Compressibility</u>		
Module of compressibility,	- E	48,68 kg/cm²
Coef. of compressibility,	- a	0,038 cm²/kg
Module of settlements,	- L	119,28 mm/m
<u>Shear strength</u>		
Angle of friction,	- ϕ	12°
Cohesion,	- c	0,15 kg/cm²
Allowable capacity,	- σ	1,4 kg/cm²

6.5 Layer 3a

Layer 3a represents the lower part of the **silty clay** section which has bluish yellow colour. This layer is taped in both boring; in boring S1 it is taped in the depth 10,0-16,8m b.g.s, while in the boring S2 is taped in the depth 10,3-18,5m b.g.s. The thickness of the Layer 3a resulted 8,5-9,0m.

Layer 3a consists also of silty clays, which by the field description are determined as "medium stiff", "plastic", and "water saturated". From the measurements with hand penetrometres results that the allowable capacity of Layer 3a is about 1,6-1,8 kg/cm². The other physical - mechanical parameters of the Layer 3a are expected to be practically the same as those of the Layer 3.

6.6 Layer 4

Layer 4 represents the gravelly deposits of the first terrace of Tirana and Lana rivers. The gravelly deposits are taped, by the boring S1 in the depth 16,8m b.g.s., and by the boring S2 in the depth 18,5m b.g.s. According to many groundwater wells drilled in the area of Berxulli village the gravelly deposits have a total thickness of about 20-30m. These deposits represent a very good aquifer of subartesian character. The piezometric surface of the gravelly aquifer in the our boring resulted about 10m b.g.s.

7 HYDROGEOLOGICAL CONDITIONS

In the area of the proposed wastewater treatment plant of Tirana, there are two types of groundwater; soil water of the upper silty covering layers (layers 1, 2 and 2a), and the real groundwater of the gravelly aquifer.

The soil water, which is stored in the small pores of the silty layers, have a temporary groundwater table. During the humid season of the year this table is just near the ground surface, but during the dry season this level is going down and even disappearing. The soil water of the silty layers is drained in three ways; by the evapotranspiration, by the natural drainage to the Tirana and Lana rivers, and by the exploitation from the local village people.

From the natural drainage in some cases are created small temporary springs. A such a temporary spring located near the Tirana River bed is shown in Photo 8. The very small groundwater resources of the silty layer is used for the water supply of the village by means of dug wells about 5-6m deep. In Photo 8 is shown a dug well located near the boring S1. During the dry season, the dug wells of the studied area become dry.

The real ground water is connected with the gravelly aquifer (Layer 4). This aquifer has a subartesian character. The piezometric surface of this aquifer is located about 10m b.g.s. (January 1997), and is not varying so much during the different seasons. The yearly amplitude of the piezometric surface variation is about 2m.

In the existing wells around the construction site have been recorded the following main hydrogeological characteristics:

Permeability	50 - 100 m/day
Transmissibility	500 - 100 m^2/day
Specific capacity of the wells	5 - 12 l/s/m

The groundwater resources of the gravelly aquifer are considerable and are used widely for the Tirana City water supply, and also for the village water supply.

8 CONCLUSIONS AND RECOMMENDATIONS

1) The construction site of the proposed wastewater treatment plant of Tirana City is placed on the alluvional deposits of the first terrace of Tirana and Lana rivers. The site consists of four soil layers with different lithology and geotechnical properties. These layers in downward direction are as following:

Layer 1	Top soil (cultivated land), thicknes 0,5-0,6 m;
Layer 2	Silt to clayey silt (with sand lense), thicknes 3,8-4,1 m;
Layer 3	Silty clay, thicknes 12-14 m;
Layer 4	Gravel, 20-30 m.

2) The wastewater treatement plant will be constructed above the deposits of the Layer 2, but it is directly implicated also the underlying Layer 3. The representative values of the geotechnical properties of the layer 2 and 3 are given respectivaly in Table 3 and 5.

3) The permeability of the layer 2 is of the order 10^{-4} cm/s, whily these of the Layer 3 is of the order 10^{-5} cm/s.

4) There are recomanded two possibilities for a secure construction of the lagoon; first, to apply a thin concrete cover of the lagoon, and second, to compress the silty soil laying the floor of the lagoon and of the bankings. The thickness of the compresed silty soil must by about 0,6m. The compression of the soil must by in 20 cm thick layers. The compression would be considered realised if the silty soil would obtain the following properties:

* Moisture content not more then ~~30 %~~ 25 - 26 %
* Dray unit wight not less 1,50 gr/cm3

5) The slope of the banking is recomanded to be:

* In case of concrete cover, 1:1
* In case of compresed silty soil, 1:2

6) The buildings foundation must be deeper then 1m and must rest on the silty soil of the Layer 2. The allowable capacity of the silty soil is evaluated to be 1,4 kg/cm^2.

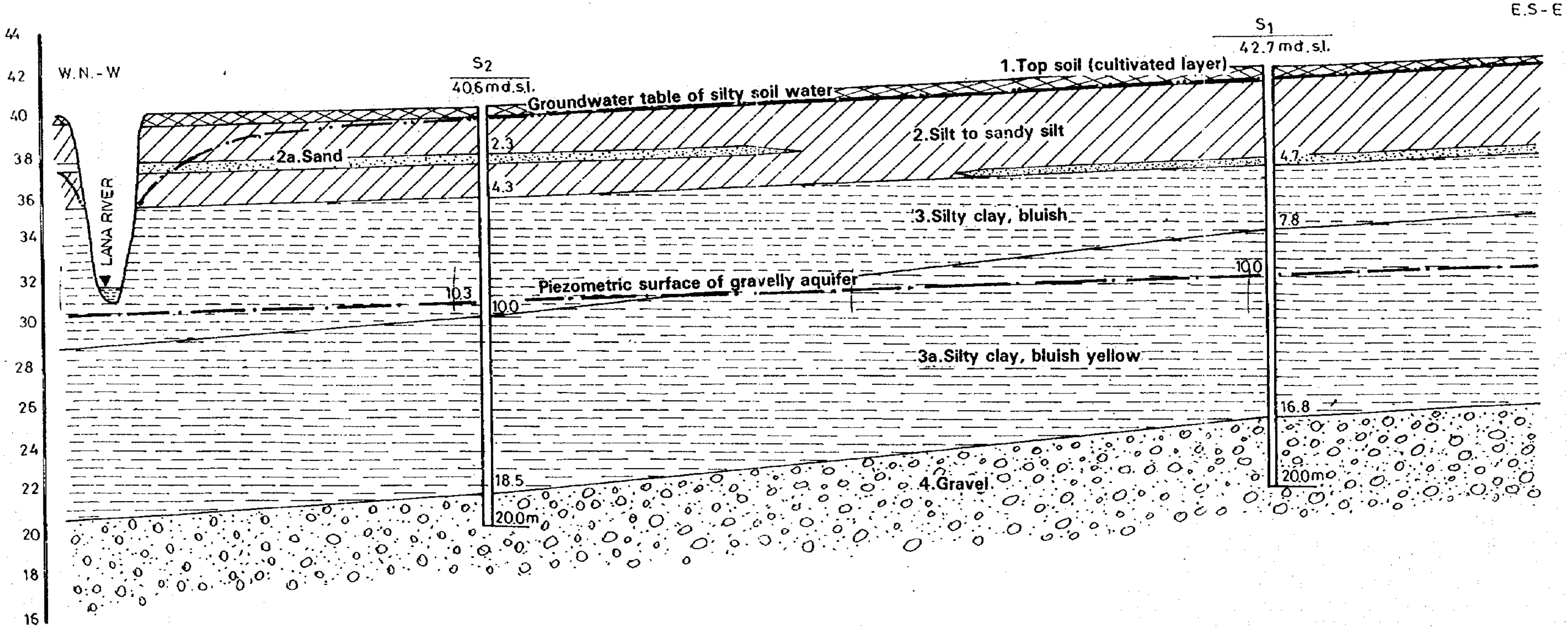
7) The water supply, necessary under construction and after completion of the treatment

plant, can be secured by one (or two) drilling wells about 30m deep, provided with the electric immersing pumps.

8) The above mentioned recomandations must be considered as preliminary; it is necessary to provide a detailed soil investigation for a final and more accurate evaluatation of the construction site.

GEOLOGICAL CROSS-SECTION 1-1

HORIZONTAL SCALE 1:2500
VERTICAL SCALE 1: 200

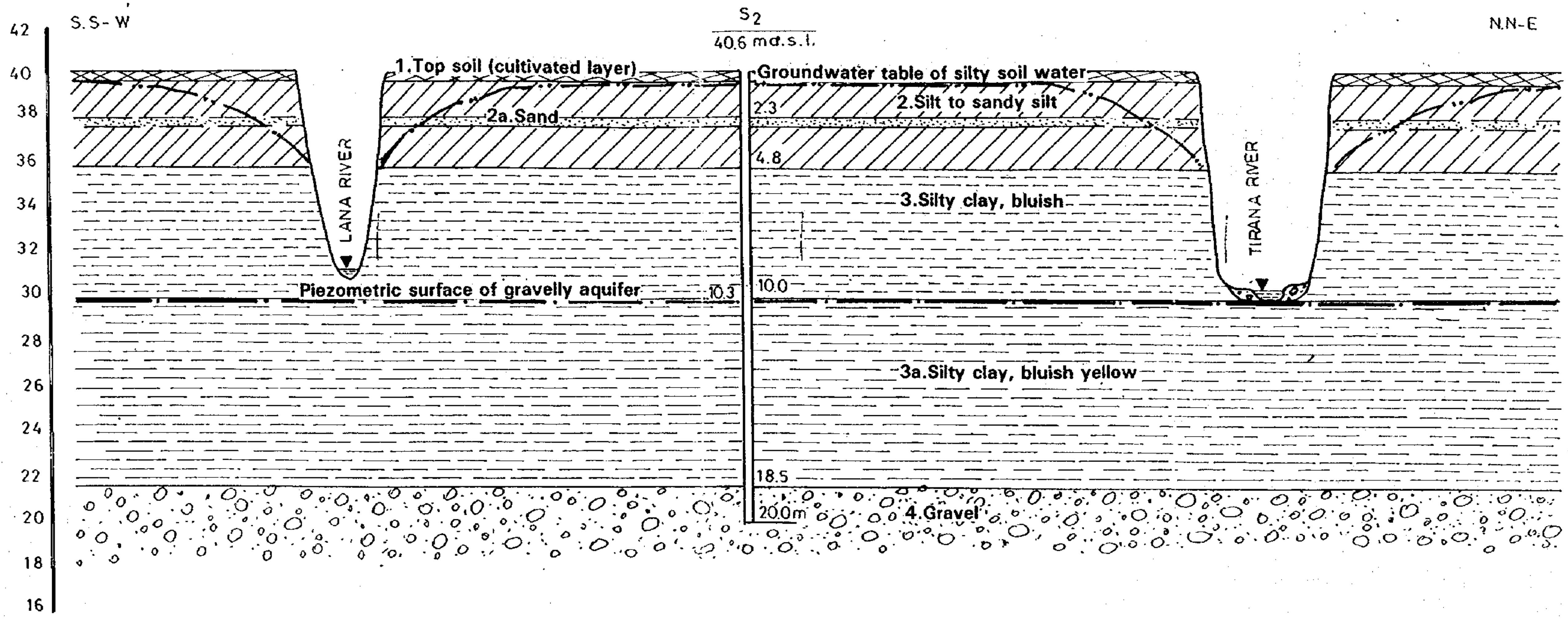


8.2.2-25

PROJECT:-WASTEWATER TREATMENT PLANT, TIRANA		
COMPANY	ITA CONSULT LTD-TIRANA	
AUTHOR	ROMEO EFTIMI	DRAWING
DRAWER	LEJLA VATHI	No.1

GEOLOGICAL CROSS-SECTION 2-2

HORIZONTAL SCALE 1:2500
VERTICAL SCALE 1: 200



8.2.2-26

PROJECT:-WASTEWATER TREATMENT PLANT, TIRANA		
COMPANY	ITA CONSULT LTD -TIRANA	
AUTHOR	ROMEO EFTIMI	DRAWING
DRAWER	LEJLA VATHI	No. 2

LITHOLOGICAL AND GEOTECHNICAL DESCRIPTION OF THE BORINGS

DATA OF BORING: JANUARY 04÷06, 1997

BORING Nr. S_1

GEOLOGICAL INDEX	DEPTH FROM SURFACE, m	THICKNESS OF LAYER, m	SOIL DESCRIPTION	SOIL SAMPLE AND NUMBER	G.W. LEVEL m.b.g.s.	DATE
Q_4	0.6	0.6	CLAEYE SILT, YELLOWISH, TOP SOIL.		▼0.5	07 JANUARY 1997
	2.8	2.2	SILT TO CLAYEYE SILT, GREISH YELLOW, MOISTY, VERY SOFT TO SOFT, σ = 1.2÷1.4 Kg/cm^2	S_1-1		
	3.9	1.1	SILT TO SANDY SILT, BLUEISH YELLOW, CONTIAN ORGANIC MATTER AND IRON OXIDE, THE SOIL IS MOISTY AND MEDIUM STIFF, σ = 2.0 Kg/cm^2			
	4.2	0.3	SILT, YELLOWISH BROWN, SOFT, VERY MOISTY σ = 1.0÷1.2 Kg/cm^2	S_1-2		
	4.7	0.5	SAND, MEDIUM, WELL SORTED, GREISH YELLOW, WATER SATURATED			
	7.8	3.1	SILTY CLAY, BLUEISH, MEDIUM STIFF, VERY PLASTIC, WATER SATURATED. σ = 1.4÷1.6 Kg/cm^2			
	16.8	9.0	SILTY CLAY, BLUEISH YELLOW, MEDIUM STIFF, PLASTIC, WATER SATURATED. σ = 1.6÷1.8 Kg cm^2		▼10.0	
	20.0	3.2	GRAVEL, POORLY SORTED, GREISH, WATER SATURATED			

X = 45 85 315
Y = 43 91 935
Z = 42.7m

DATA OF BORING: JANUARY 07÷09, 1997

BORING Nr. S_2

GEOLOGICAL INDEX	DEPTH FROM SURFACE, m	THICKNESS OF LAYER, m	SOIL DESCRITION	SOIL SAMPLE AND NUMBER	G.W. LEVEL m.b.g.s.	DATE
Q_4	0.5	0.5	CLAEYE SILT, YELLOWISH, TOP SOIL.		▼0.4	11 JANUARY 1997
	1.2	0.7	SANDY SILT, BLUEISH YELLOW, WITH ORGANE MATTER AND IRON OXIDE, MOISTY, MEDIUM STIIF σ = 2.0 Kg/cm^2			
	2.3	1.1	SILT, GREISH YELLOW, WATER SATURATED, SOFT, PLASTIC σ = 1.4 Kg/cm^2			
	2.7	0.4	SAND, GREISH YELLOW, MEDIUM GRAINED, WATER SATURATED	S_2-1		
	4.3	1.6	SILT, GREISH YELLOW, WATER SATURATED, SOFT TO VERY SOFT, PLASTIC σ = 1.4÷1.6 Kg/cm^2	S_2-2		
	10.0	5.7	SILTY CLAY, BLUEISH, MEDIUM STIFF, VERY PLASTIC, WATER SATURATED σ = 1.4÷1.6 Kg/cm^2		▼10.3	
	18.5	8.5	SILTY CLAY BLUEISH YELLOW, MEDIUM STIFF, PLASTIC, WATER SATURATED σ = 1.6÷1.8 Kg cm^2			
	20.0	1.5	GRAVEL, POORLY SORTED, GREISH WATER SATURATED.			

X = 45 85 420
Y = 43 92 385
Z = 40.6m

8.2.2-27

PROJECT:- WASTEWATER TREATMENT PLANT, TIRANA		
COMPANY	ITA CONSULT LTD - TIRANA	
AUTHOR	ROMEO EFTIMI	DRAWING
DRAWER	LEJLA VATHI	No. 3

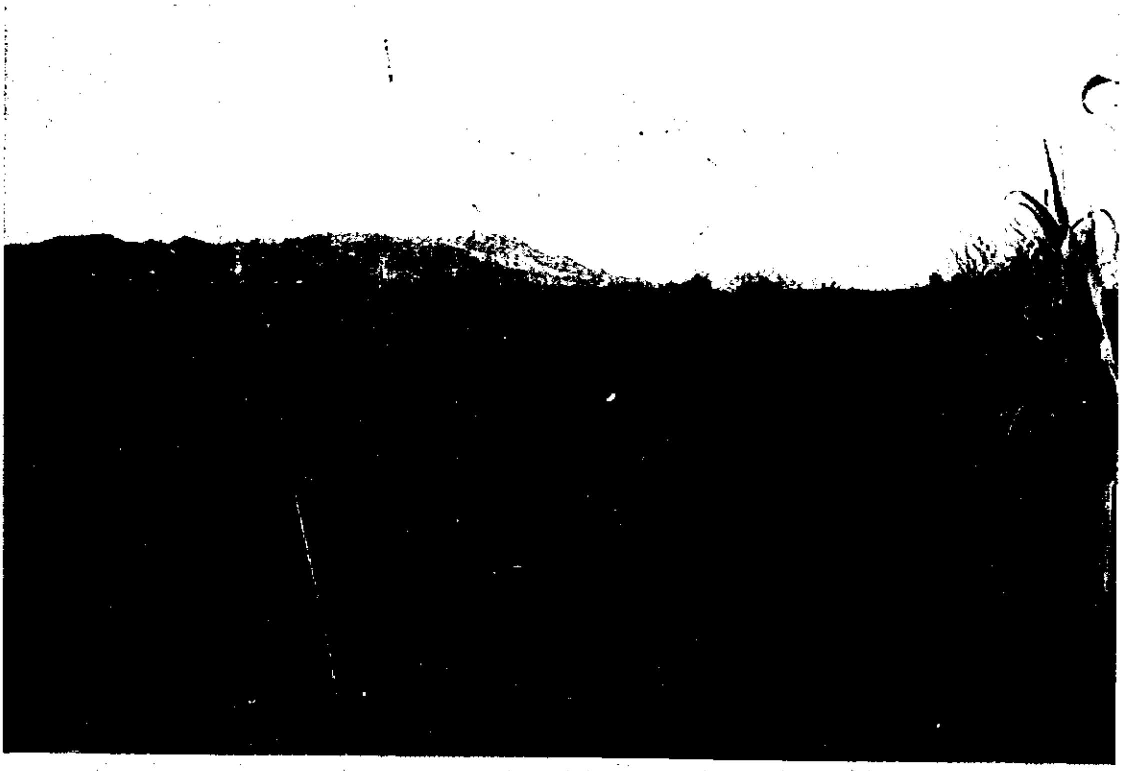


Photo 1. Lana River near the proposed wastewater treatment plant
The river bed is about 8m deep, and is filled with fine grained materials.

Photo 2. Tirana River near the proposed wastewater treatment plant.
The river bed is about 9-10m deep, and is filled with gravelly deposits.

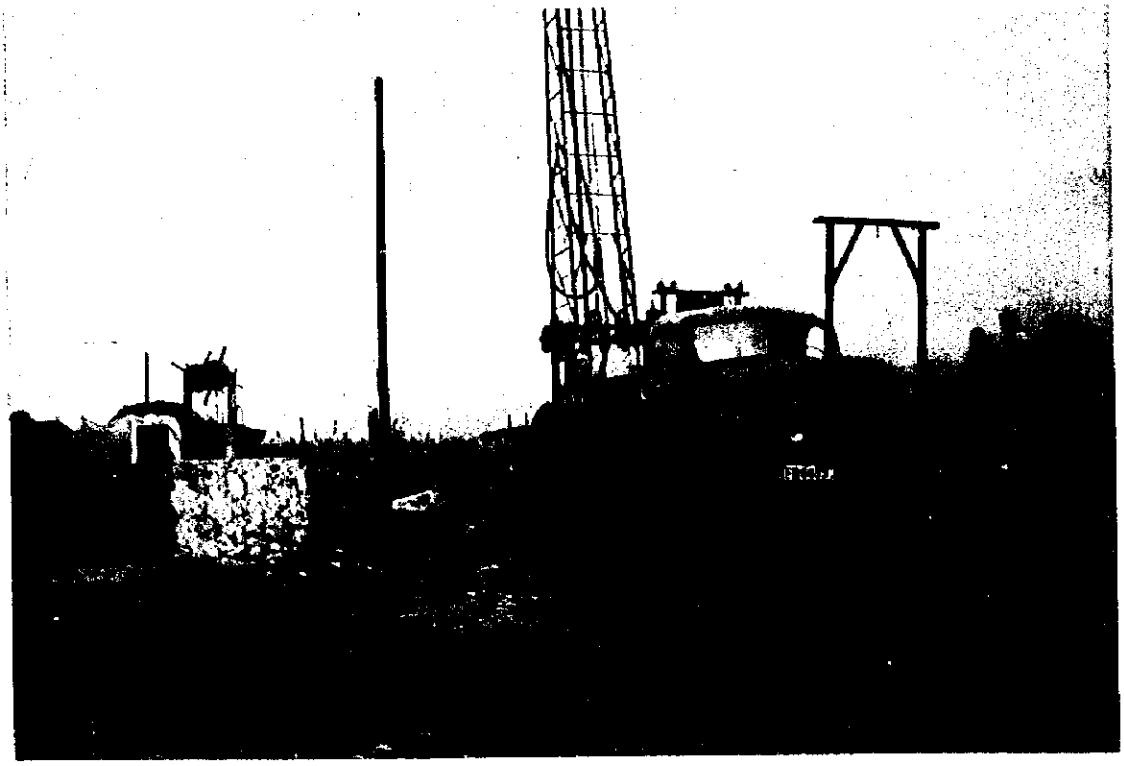


Photo 3. The Chinese production rotary drilling machine, of Russian typ Zif-150, used for the performance of the borings

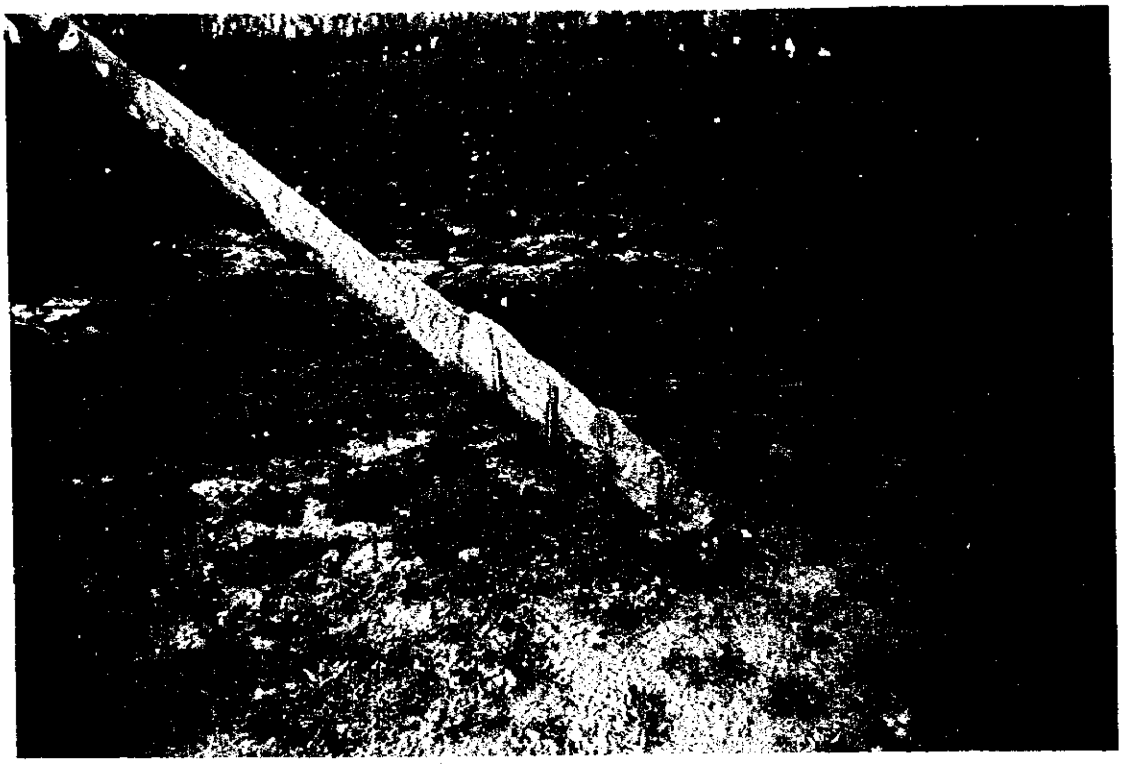


Photo 4. The auger, 110mm diameter, used for the drilling of the lower part of the borings.

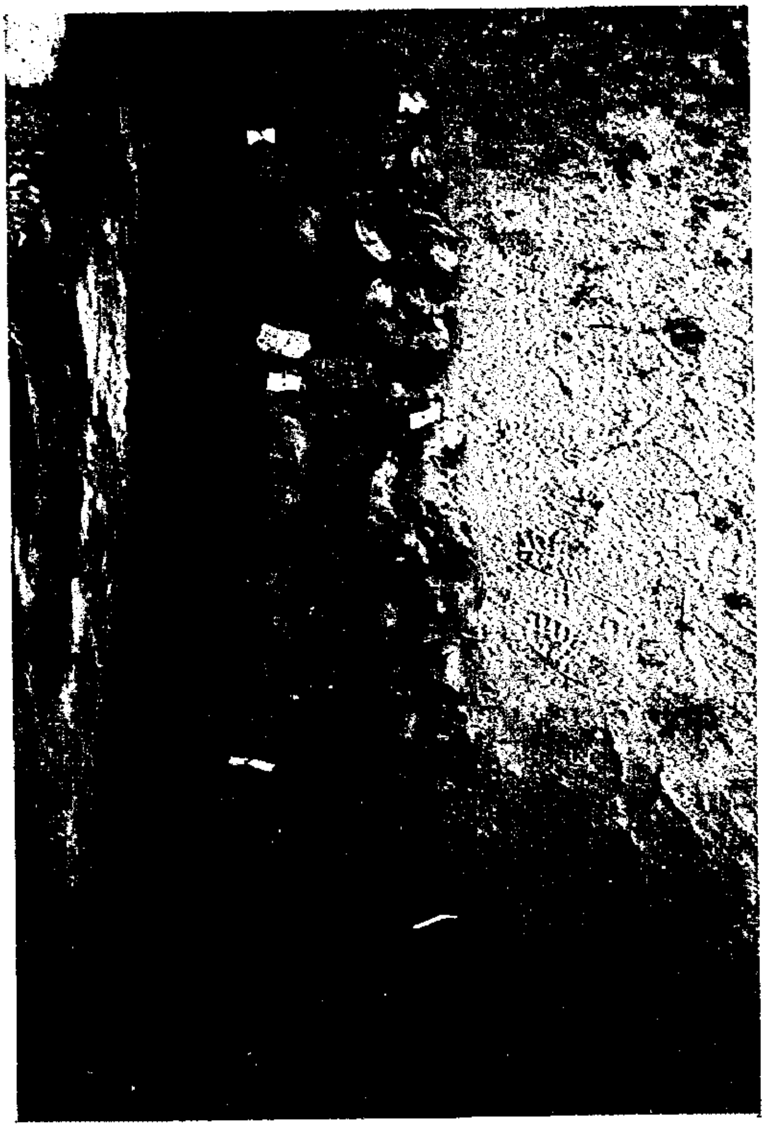


Photo 5. The cores of the boring S1. Two different layers can be observed, the upper silty layer, greish yellow on the left, and the lower silty clay layer, bluish on the right.

Photo 6. The cores of the boring S2. Two different layers can be observed, the upper silty layer, greish yellow on the left, and the lower silty clay layer, bluish, on the center and on the right.

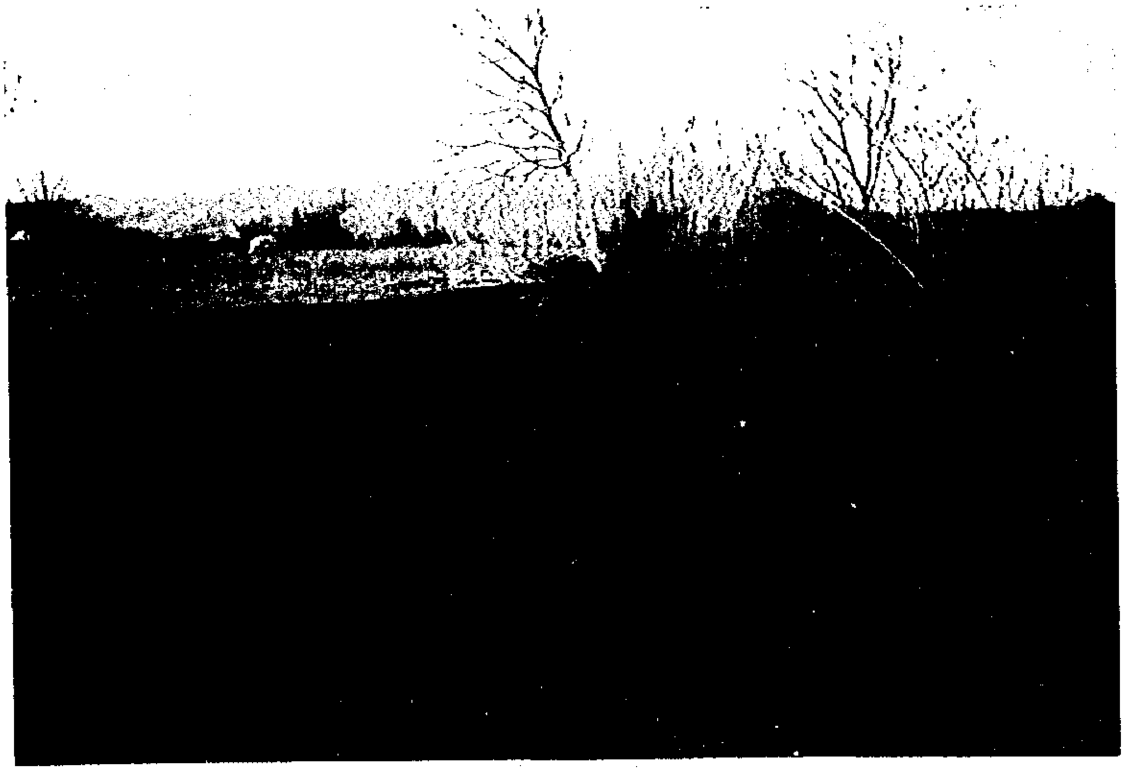


Photo 7. The outcrop of the upper silty layer, greish yellow, and of the lower silty clayey layer, bluish.

Photo 8. A small temporary spring in the left bank of Tirana River, in the northern periphery of the proposed wastewater treatment plant

8.2.3 Capacity Calculation

1. Design Condition

1.1 Basic Items

Name	Tirane Wastewater Treatment Plant
Land Area	40.0 ha
Elevation	43.5 m
Collection System	Combined System
Treatment Method	
Wastewater	Dual Power Aerated Lagoon
Sludge	Pond Accumulation + Drying
Effluent Point	Tirana River
Effluent Point Water Level	35.0 m
Lowest Lagoon Temperature	9.0 °C (January)

1.2 Design Wastewater Quantity

Flow		m^3/day	m^3/hour	m^3/min	m^3/sec
Daily Average	Qd-ave	106,000	4,417	73.611	1.227
Daily Maxmum	Qd-max	106,000	4,417	73.611	1.227
Hourly Maximum(Dry)	Qhd-max	232,000	9,667	161.111	2.685
Hourly Maximum(Wet)	Qhw-max	624,000	26,000	433.333	7.222

1.3 Design Wastewater Quality

Item	Influent (mg/l)	Effluent (mg/l)	Removal Ratio(%)	Remarks
BOD_5	200	25	87.5	
SS	200	35	82.5	150mg/l [1)]

[1)] Discharges from lagooning shall not exceed 150 mg/l.

1.4 Number of Unit and Capacity of Treatment Facilities

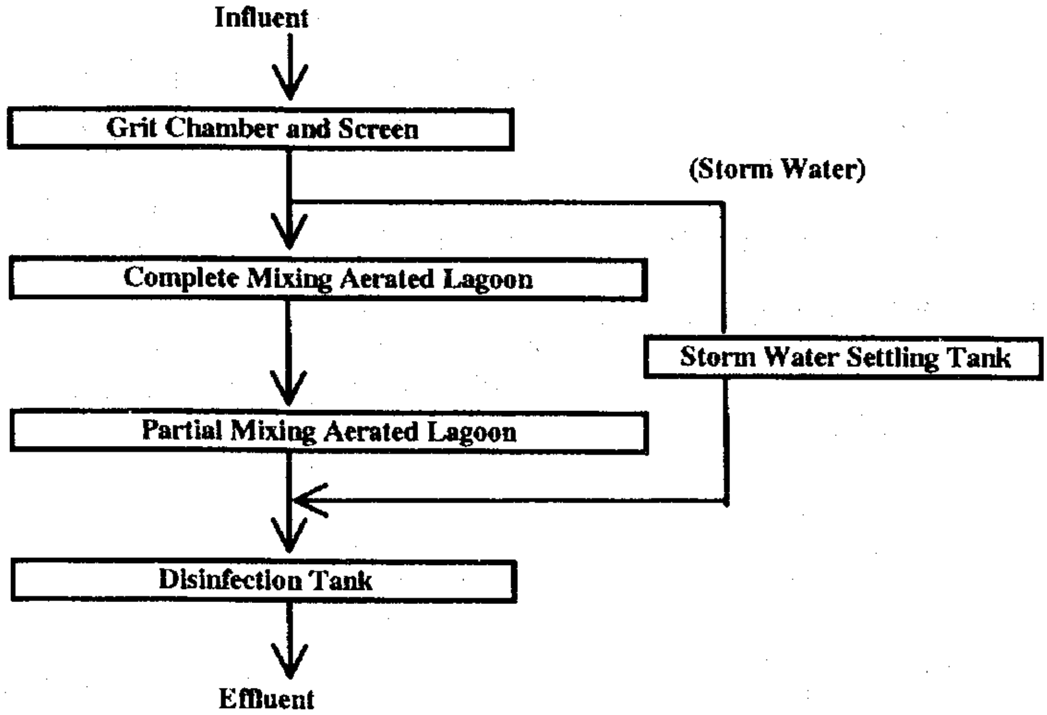
Facilities	Total	Duty	Stand-by	Capacity
Grit Chamber/Screen	8	6	2	Qhw-max
Complete Mix Lagoon	8	8	0	Qd-ave
Partial Mix Lagoon	24	22	2	Qd-ave
Storm Water Settling Tank	8	6	2	Qhw-max - Qhdmax
Disinfection Tank	2	2	0	Qhw-max

1.5 Design Criteria for Dual Power Aerated Lagoon

ITEMS	UNIT	Formula or Value	Application
(1) Grit Chamber			
Water Surface Load	m^3/m^2/day	> 1800	1,800
Average Velocity	m/sec	> 0.3	0.3
(2) Complete Mixing Aerated Lagoon			
Retention Time	day	1.5 - 2.5	1.75
Water Depth	m	3.0 - 4.0	3.0
Power Requirement for Mixing	W/m^3	> 6.0	6.0

(3) Partial Mixing Aerated Lagoon			
Retention Time	day	1.5 - 2.0	2.0
Water Depth	m	2.0 - 4.0	4.0
Power Requirement for Mixing	W/m^3	> 1.0	1.0
Number of Cell	Cell/Basin	1 - 3	3
(4) Storm Water Settling Tank			
Water Depth	m	1.5 -3.0	1.5
Retention Time	hour	> 0.5	0.5
Water Surface Load	$m^3/m^2/day$	75 - 150	150.0
(5) Disinfection Tank			
Retention Time	min.	> 15	15.0
Dosage	mg/l	2.0 - 4.0	3.0

1.6 Flow Diagramm



2. Capacity Calculation

2.1 Grit Chamber and Screen

Type		Parallel Flow Type		
Design Flow	Qhw-max =	624,000 m^3/day =	7.22 m^3/sec	
Water Surface load		1,800 m^3/m^2/day		
Required Surface Area	A =	346.7 m^2		
Nos. of Basin (total)	BNS =	8 basins		
Nos. of Basin (stand-by)	BNT =	2 basins		
Average Velocity	V =	0.30 m/sec		
Depth	D =	1.50 m		
Width	W =	Qhw-max / (V x D) / (BNT - BNS)		
	=	2.67 m		
	say =	3.00 m		
Length	L =	A / D / (BNT - BNS)		
	=	19.26 m		
	say =	22.00 m		
Dimension	W =	3.00 m		
	L =	22.00 m		
	D =	1.50 m		
Nos. of Basin	BNS =	8 basins		
	BNT =	2 basins		
(Check)				
Water Surface load	1,576 m^3/m^2/day	<	1,800 m^3/m^2/day	OK
Average Velocity	0.27 m/sec	<	0.30 m/sec	OK

2.2 Complete Mixing Aerated Lagoon

Type		Rectangular Type	
Design Flow	Qd-ave =	106,000 m^3/day =	1.23 m^3/sec
Influent BOD Quality		200 mg/l	
Retention Time	T1 =	1.75 day	
Required Volume	V =	185,500 m^3	
Nos. of Basin	BN =	8 basins	
Volume per Basin	VB =	23,188 m^3/basin	
Depth	D =	3.00 m	
Area per Basin	A =	7,729 m^2	
Width	W =	75.00 m	
Length	L =	A / W	
	=	103.06 m	
	say =	104.00 m	
Dimension	W =	75.00 m	
	L =	104.00 m	
	D =	3.00 m	
Nos. of Basin	BNS =	8 basins	
Maximum Oxygen Demand Rate	=	4.16 * 10-5 * r * Q * So	
	=	1,323 kg/h	
	where,	r =	1.5
Aeration Power Level	=	R02 / N	
	=	696 kW	

	where,	N =	1.9 kgO2/kWh		
	or, p =	T1 * Q * up / 1000			
	=	1,113 kW			
	where,	up =	6.00 W/m^3		
	say =	1,120 kW			
(Check)					
Retention Time		1.77 day	>	1.75 day	OK

2.3 Partial Mixing Aerated Lagoon

Type		Rectangular Type
Design Flow	Qd-ave =	106,000 m^3/day = 1.23 m^3/sec
Retention Time	T1 =	1.50 day (before cleaning)
Retention Time	T2 =	2.00 day (after cleaning)
Required Volume	V =	212,000 m^3
Nos. of Basin	BN =	8 basins
Nos. of Cell (per basin)	CN =	3 cells
Nos. of Cell (stand-by)	CN =	2 cells
Volume per Cell	VB =	9,636 m^3/basin
Depth	D =	4.00 m
Area per Basin	A =	2,409 m^2
Width	W =	72.00 m
Length	L =	A / W
	=	33.46 m
	say =	47.00 m
Dimension	W =	72.00 m
	L =	47.00 m
	D =	4.00 m
Nos. of Basin	BNS =	8 basins
Nos. of Cell (per basin)	CN =	3 cells
Nos. of Cell (stand-by)	CN =	2 cells
Aeration Power Level	=	T1 * Q * up / 1000
	=	212 kW
	where,	up = 1.00 W/m^3
	say =	220 kW
Sludge Accumulation	=	365 * Qd-ave * Xi / (x * 10 ^ 6)
	=	53,199 m^3/year
	=	2,217 m^3/year/cell
	where,	Xi = 55 mg/l
		x = 0.04

Accumulated sludge in each cell will be removed every 4 years.
Then, 6 cells should be cleaned every year.

Average Sludge Accumulation	=	132,997 m^3/cell (before cleaning)
		79,798 m^3/cell (after cleaning)

(Check)

Retention Time				
- before cleaning	1.55 day	>	1.50 day	OK
- after cleaning	2.06 day	>	2.00 day	OK

2.4 Storm Water Settling Tank

Type		Rectangular Type		
Design Flow Qhw-max - Qhd-max =		16,333 m^3/hour =	4.54 m^3/sec	
Retention Time	T =	0.50 hour		
Required Volume	V =	8,167 m^3		
Nos. of Basin (total)	BNS =	8 basins		
Nos. of Basin (stand-by)	BNT =	2 basins		
Volume per Basin	VB =	1,361 m^3/basin		
Depth	D =	3.00 m		
Width	W =	15.00 m		
Length	L =	VB / (D * W)		
	=	30.25 m		
	say =	38.00 m		
Dimension	W =	15.00 m		
	L =	38.00 m		
	D =	3.00 m		
Nos. of Basin	BNS =	8 basins		
	BNT =	2 basins		
(Check)				
Retention Time		0.63 hour	> 0.50 hour	OK
Water Surface load		115 m^3/m^2/day	> 75 -150 m^3/m^2/day	OK

2.5 Disinfection Tank

Type		Rectangular Type		
Design Flow	Qhw-max =	624,000 m^3/day =	433.33 m^3/min	
Retention Time	T =	15.0 min		
Required Volume	V =	6,500 m^3		
Nos. of Basin (total)	BN =	2 basins		
Volume per Basin	VB =	3,250 m^3/basin		
Depth	D =	3.00 m		
Width	W =	9.00 m		
Length	L =	VB / (D * W)		
	=	120.37 m		
	say =	121.00 m		
Dimension	W =	9.00 m		
	L =	121.00 m		
	D =	3.00 m		
Nos. of Basin	BN =	2 basins		
Required Chlorine	RC =	Q * D / 1000		
	=	624 kg/day		
	=	26 kg/hour		
	where,	D =	1.00 mg/l	
(Check)				
Retention Time		15.08 min	> 15.00 min	OK

8.2.3 Capacity Calculation (Siphon)

Item	Sign	Unit	Calculation	Result	
Phase				Phase1	Phase2
Name of Trunk Main				Lana River	Tirana River
Inlet Pipe					
Diameter	D	m		1.65	1.35
Gradient	I	-		0.0025	0.0030
Actual Flow Rate	Q-act	m3/sec		4.383	2.834
Actual Flow Velocity*2	V-act	m/sec		2.289	2.246
Full Flow Rate	Q-full	m3/sec		4.557	2.923
Full Flow Velocity	V-full	m/sec		2.131	2.042
Siphon					
Design Flow	Q1	m3/sec		4.383	2.834
Siphon Pipe Number	PN			2	2
Length of Siphon	L	m		22.8	22.8
Required Flow Velocity	V1	m/sec	V=1.3*V-act	2.975	2.920
Therefore	V2	m/sec		3.000	3.000
Required Cross-sectional Area	A1	m2	A1=(Q1/PN)/V2	0.7305	0.4723
Required Diameter	D1	m	D1=(4*A1/π)^0.5	0.964	0.775
Therefore	D2	m		1.000	0.800
Full Flow Velocity	V3	m/sec	V=(Q1/PN)/(π*D2^2/4)	2.790	2.819
Hydraulic Gradient	I1	-	I1=(Q1/PN/(N*C*(D2/4)^β))^(1/α) Where N=0.84935,C=110, α=0.54, β=0.63	0.00756	0.01000
Head Loss*1	H	m	H=I1*L+β*V3^2/(2*g)+α Where α=0.03-0.05, β=1.5	0.81	0.88

Note: *1- Head loss of siphon pipe is calculated by using Hazen Williams' Formula as follows:

$$Q = A \cdot V$$

$$V = 0.84935 \cdot C \cdot R^{0.63} \cdot I^{0.54}$$

where Q : Flow rate (m^3/sec)

A : Cross-sectional area of flow (m^2)

V : Flow velocity (m/sec)

C : Flow velocity coefficient ($C = 110$)

R : Hydraulic mean depth (m) = A/P

P : Wetted perimeter (m)

I : Hydraulic gradient (h/L)

h : Friction head loss

*2- Actual flow vilocity of inlet pipe is referred to "Appendix A Calculation for Flow Velocity of Inlet Pipe".

Appendix A Calculation for Flow Velocity of Inlet Pipe

1. Manning's Formula

$$Q = A \cdot V$$

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I^{\frac{1}{2}}$$

where Q : Flow rate (m^3 / sec)

A : Cross-sectional area of Flow (m^2)

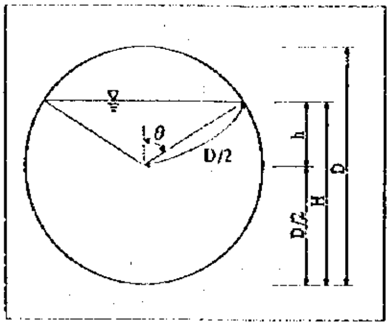
V : Flow velocity (m / sec)

n : Roughness coefficient

R : Hydraulic mean depth (m) = A / P

P : Wetted perimeter (m)

I : Gradient



2. Inlet Pipe Flow Vilocity of Lana River Trunk Main

D = 1.650 m Vfull = 2.1313 m/sec
I = 0.0025 Qfull = 4.5572 m3/sec

No.	H (m)	h (m)	θ (radian)	A (m2)	P (m)	R (m)	V (m/sec)	Q (m3/sec)
1	1.505	0.680	0.6019	1.9211	4.1904	0.45844	2.2867	4.3930
2	1.504	0.679	0.6041	1.9199	4.1869	0.45856	2.2871	4.3911
3	1.503	0.678	0.6062	1.9188	4.1834	0.45867	2.2875	4.3892
4	1.502	0.677	0.6083	1.9177	4.1799	0.45878	2.2879	4.3873
5	1.501	0.676	0.6104	1.9165	4.1764	0.45889	2.2882	4.3854
6	1.500	0.675	0.6126	1.9154	4.1729	0.45900	2.2886	4.3835
7	1.499	0.674	0.6147	1.9142	4.1694	0.45911	2.2890	4.3816
8	1.498	0.673	0.6168	1.9131	4.1660	0.45922	2.2893	4.3797
9	1.497	0.672	0.6189	1.9120	4.1625	0.45933	2.2897	4.3778
10	1.496	0.671	0.6209	1.9108	4.1591	0.45943	2.2900	4.3758

3. Inlet Pipe Flow Vilocity of Tirana Trunk Main

D = 1.350 m Vfull = 2.0424 m/sec
I = 0.0030 Qfull = 2.9234 m3/sec

No.	H (m)	h (m)	θ (radian)	A (m2)	P (m)	R (m)	V (m/sec)	Q (m3/sec)
1	1.180	0.505	0.7255	1.2684	3.2617	0.38887	2.2447	2.8470
2	1.179	0.504	0.7278	1.2674	3.2587	0.38894	2.2449	2.8453
3	1.178	0.503	0.7300	1.2665	3.2557	0.38901	2.2452	2.8436
4	1.177	0.502	0.7322	1.2656	3.2527	0.38909	2.2455	2.8419
5	1.176	0.501	0.7344	1.2646	3.2497	0.38916	2.2458	2.8401
6	1.175	0.500	0.7366	1.2637	3.2467	0.38923	2.2461	2.8384
7	1.174	0.499	0.7388	1.2628	3.2437	0.38930	2.2463	2.8366
8	1.173	0.498	0.7410	1.2618	3.2408	0.38937	2.2466	2.8348
9	1.172	0.497	0.7432	1.2609	3.2378	0.38943	2.2468	2.8331
10	1.171	0.496	0.7454	1.2600	3.2349	0.38950	2.2471	2.8313

8.2.4 Hydraulic Calculation

1. Design Condition

1.1 Design Wastewater Quantity

Phase	Flow		m^3/day	m^3/hour	m^3/min	m^3/sec
Phase1	Daily Average	Qd-ave	57,380	2,390.8	39.85	0.664
	Daily Maximum	Qd-max	57,380	2,390.8	39.85	0.664
	Hourly Maximum(Dry)	Qhd-max	126,236	5,259.8	87.66	1.461
	Hourly Maximum(Wet)	Qhw-max	378,708	15,779.5	262.99	4.383
Phase2	Daily Average	Qd-ave	47,660	1,985.8	33.10	0.552
	Daily Maximum	Qd-max	47,660	1,985.8	33.10	0.552
	Hourly Maximum(Dry)	Qhd-max	104,852	4,368.8	72.81	1.214
	Hourly Maximum(Wet)	Qhw-max	244,772	10,198.8	169.98	2.833
Total	Daily Average	Qd-ave	105,040	4,376.7	72.94	1.216
	Daily Maximum	Qd-max	105,040	4,376.7	72.94	1.216
	Hourly Maximum(Dry)	Qhd-max	231,088	9,628.7	160.48	2.675
	Hourly Maximum(Wet)	Qhw-max	623,480	25,978.3	432.97	7.216

1.2 Unit and Capacity of Treatment Facilities

Phase	Facilities	Total	Duty	Stand-by	Capacity
Phase1	Grit Chamber/Screen	4	3	1	Qhw-max
	Complete Mix Lagoon	4	4	0	Qd-ave
	Partial Mix Lagoon	4	4	0	Qd-ave
	Storm Water Settling Tank	4	3	1	Qhw-max - Qhdmax
	Disinfection Tank	1	1	0	Qhw-max
Phase2	Grit Chamber/Screen	4	3	1	Qhw-max
	Complete Mix Lagoon	4	4	0	Qd-ave
	Partial Mix Lagoon	4	4	0	Qd-ave
	Storm Water Settling Tank	4	3	1	Qhw-max - Qhdmax
	Disinfection Tank	1	1	0	Qhw-max
Total	Grit Chamber/Screen	8	6	2	Qhw-max
	Complete Mix Lagoon	8	8	0	Qd-ave
	Partial Mix Lagoon	8	8	0	Qd-ave
	Storm Water Settling Tank	8	6	2	Qhw-max - Qhdmax
	Disinfection Tank	2	2	0	Qhw-max

1.3 Discharge

Discharge Point Tirana River

HWL 28.50 m

1.4 Formula for Hydraulic Calculation

Hazen & Wiliams' Formula C = 110

2. Hydraulic Calculation (Phase1)

2.1 Water Level of Disinfection Tank Effluent Chamber (WL1)

Design Flow	Q =	378,708 m^3/day =	4.383 m^3/sec
Pipe Diameter		1,350 mm	
Pipe Length		200.0 m	
No. of Pipe		1 sets	
Velocity	V =	3.06 m/sec	
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)		
	=	0.634 %	
Hydraulic Loss	h1 =	1.267 m	
WL1 =	WL0 +	h1 =	29.767 m
		say,	32.10 m

2.2 Water Level of Disinfection Tank (WL2)

Design Flow	Q =	378,708 m^3/day =	4.383 m^3/sec
Weir Width	W =	9.0 m	
No. of Pipe		1 sets	
Overflow height	h2 = (Q / (1.8 * W))^(2/3)		
	=	0.418 m	
WL2 =	WL1 +	h2 =	32.518 m
		say,	32.80 m

2.3 Water Level of Partial Mixing No.3 Effluent Chamber (WL3)

Design Flow	Q =	57,380 m^3/day =	0.664 m^3/sec
Pipe Diameter		1,500 mm	
Pipe Length		400.0 m	
No. of pipe		1 sets	
Velocity	V =	0.38 m/sec	
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)		
	=	0.012 %	
Hydraulic Loss	h3 =	0.046 m	
WL3 =	WL2 +	h3 =	32.846 m
		say,	36.75 m

2.4 Water Level of Partial Mixing Lagoon No.1 (WL8)

(3 sets of Weirs)

Design Flow	Q =	57,380 m^3/day =	0.664 m^3/sec
Weir Width	W =	5.0 m	
No. of Lagoon		4 sets	
Overflow height	h4 = (Q / (1.8 * W))^(2/3)		
	=	0.070 m	
	say,	0.20 m	

(2 sets of Connection Pipes)

Design Flow	Q =	57,380 m^3/day =	0.664 m^3/sec
Pipe Diameter		500 mm	
Pipe Length		20.0 m	
No. of Lagoon		4 sets	
Velocity	V =	0.85 m/sec	

Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)		
	=	0.186 %	
Hydraulic Loss	h5 =	0.037 m	
	say,	0.05 m	

		Water Level
Partial Mixing No.3 Effluent Chamber	(WL3)	36.75 m
Partial Mixing Lagoon No.3	(WL4)	36.95 m
Partial Mixing No.2 Effluent Chamber	(WL5)	37.00 m
Partial Mixing Lagoon No.2	(WL6)	37.20 m
Partial Mixing No.1 Effluent Chamber	(WL7)	37.25 m
Partial Mixing Lagoon No.1	(WL8)	37.45 m

2.5 Water Level of Complet Mixing Lagoon (WL9)

Design Flow	Q =	57,380 m^3/day =		0.664 m^3/sec
Pipe Diameter		500 mm		
Pipe Length		20.0 m		
No. of Lagoon		4 sets		
Velocity	V =	0.85 m/sec		
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)			
	=	0.186 %		
Hydraulic Loss	h6 =	0.037 m		
WL9 =	WL8 +	h6 =	37.487 m	
		say,	37.50 m	

2.6 Effluent Water Level of Distribution Chamber for Dry Weather Flow (WL10)

Design Flow	Q =	126,236 m^3/day =		1.461 m^3/sec
Pipe Diameter		800 mm		
Pipe Length		150.0 m		
No. of Lagoon		4 sets		
Velocity	V =	0.73 m/sec		
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)			
	=	0.081 %		
Hydraulic Loss	h7 =	0.122 m		
WL10 =	WL9 +	h7 =	37.622 m	
		say,	37.7 m	

2.7 Water Level of Distribution Chamber for Dry Weather Flow (WL11)

Design Flow	Q =	126,236 m^3/day =		1.461 m^3/sec
Weir Width	W =	2.0 m		
No. of Lagoon		4 sets		
Overflow height	h8 = (Q / (1.8 * W))^(2/3)			
	=	0.218 m		
WL11 =	WL10 +	h8 =	37.918 m	
		say,	38.075 m	

2.8 Effluent Water Level of Distribution Chamber for Wet Weather Flow (WL12)

Design Flow	Q =	252,472 m^3/day =	2.922 m^3/sec
Pipe Diameter		1,800 mm	
Pipe Length		600.0 m	

No. of Chamber		1 sets		
Velocity	V =	1.15 m/sec		
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)			
	=	0.074 %		
Hydraulic Loss	h9 =	0.442 m		
WL12 =	WL20 +	h9 =	37.392 m	
		say,	37.4 m	

2.9 Water Level of Distribution Chamber for Wet Weather Flow (WL13)

Design Flow	Q =	252,472 m^3/day =	2.922 m^3/sec	
Weir Width	W =	6.0 m		
No. of Chamber		1 sets		
Overflow height	h10 = (Q / (1.8 * W))^(2/3)			
	=	0.418 m		
WL13 =	WL11 +	h10 =	38.493 m	
		say,	38.800 m	

2.10 Water Level of Parshall Flum Effluent Chamber (WL12)

Design Flow	Q =	378,708 m^3/day =	4.383 m^3/sec	
Pipe Diameter		1,800 mm		
Pipe Length		30.0 m		
No. of Pipes		1 sets		
Velocity	V =	1.72 m/sec		
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)			
	=	0.156 %		
Hydraulic Loss	h11 =	0.047 m		
WL14 =	WL11 +	h11 =	38.122 m	
		say,	38.90 m	

2.11 Water Level of Parshall Flum Influent Chamber (WL13)

Design Flow	Q =	378,708 m^3/day =	4.383 m^3/sec	
No. of PF		1 sets		
Head loss	h12 =	0.30 m		
WL15 =	WL12 +	h12 =	39.200 m	
		say,	39.20 m	

2.12 Water Level of Grit Chamber Effluent Chamber (WL14)

Design Flow	Q =	378,708 m^3/day =	4.383 m^3/sec	
Pipe Diameter		1,800 mm		
Pipe Length		30.0 m		
No. of Pipes		1 sets		
Velocity	V =	1.72 m/sec		
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)			
	=	0.156 %		
Hydraulic Loss	h13 =	0.047 m		
WL16 =	WL15 +	h13 =	39.247 m	
		say,	39.30 m	

2.13 Water Level of Grit Chamber Influent Chamber (WL15)

Design Flow	Q =	378,708 m^3/day =		4.383 m^3/sec
No. of Screens		4 sets including 1 stes		
Head loss	h14 =	0.20 m		
WL17 =	WL14 +	h14 =	39.500 m	
		say,	39.50 m	

2.14 Water Level of Storm Water settling Tank (WL20)

Design Flow	Q =	252,472 m^3/day =		2.922 m^3/sec
Weir Width	W =	5.0 m		
No. of Lagoon		4 sets		
Overflow height	h20 =	(Q / (1.84 * W))^(2/3)		
	=	0.185 m		
WL20 =	WL2 +	h20 =	32.985 m	
		say,	36.95 m	

3. Hydraulic Calculation (Phase1+Phase2)

3.1 Water Level of Disinfection Tank Effluent Chamber (WL1)

Design Flow	Q =	623,480 m^3/day =	7.216 m^3/sec
Pipe Diameter		1,350 mm	
Pipe Length		200.0 m	
No. of Pipe		2 sets	
Velocity	V =	2.52 m/sec	
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)		
	=	0.442 %	
Hydraulic Loss	h1 =	0.884 m	
WL1 =	WL0 +	h1 =	29.384 m
		say,	32.10 m

3.2 Water Level of Disinfection Tank (WL2)

Design Flow	Q =	623,480 m^3/day =	7.216 m^3/sec
Weir Width	W =	9.0 m	
No. of Pipe		2 sets	
Overflow height	h2 = (Q / (1.8 * W))^(2/3)		
	=	0.367 m	
WL2 =	WL1 +	h2 =	32.467 m
		say,	32.80 m

3.3 Water Level of Partial Mixing No.3 Effluent Chamber (WL3)

Design Flow	Q =	105,040 m^3/day =	1.216 m^3/sec
Pipe Diameter		1,500 mm	
Pipe Length		400.0 m	
No. of pipe		2 sets	
Velocity	V =	0.34 m/sec	
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)		
	=	0.010 %	
Hydraulic Loss	h3 =	0.039 m	
WL3 =	WL2 +	h3 =	32.839 m
		say,	36.75 m

3.4 Water Level of Partial Mixing Lagoon No.1 (WL8)

(3 sets of Weirs)

Design Flow	Q =	105,040 m^3/day =	1.216 m^3/sec
Weir Width	W =	5.0 m	
No. of Lagoon		8 sets	
Overflow height	h4 = (Q / (1.8 * W))^(2/3)		
	=	0.066 m	
	say,	0.20 m	

(2 sets of Connection Pipes)

Design Flow	Q =	105,040 m^3/day =	1.216 m^3/sec
Pipe Diameter		500 mm	
Pipe Length		20.0 m	
No. of Lagoon		8 sets	
Velocity	V =	0.77 m/sec	

Hydraulic Gradient		i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)		
		= 0.158 %		
Hydraulic Loss		h5 = 0.032 m		
		say, 0.05 m		

		Water Level
Partial Mixing No.3 Effluent Chamber	(WL3)	36.75 m
Partial Mixing Lagoon No.3	(WL4)	36.95 m
Partial Mixing No.2 Effluent Chamber	(WL5)	37.00 m
Partial Mixing Lagoon No.2	(WL6)	37.20 m
Partial Mixing No.1 Effluent Chamber	(WL7)	37.25 m
Partial Mixing Lagoon No.1	(WL8)	37.45 m

3.5 Water Level of Complet Mixing Lagoon (WL9)

Design Flow	Q =	105,040 m^3/day =		1.216 m^3/sec
Pipe Diameter		500 mm		
Pipe Length		20.0 m		
No. of Lagoon		8 sets		
Velocity	V =	0.77 m/sec		
Hydraulic Gradient	i =	(V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)		
	=	0.158 %		
Hydraulic Loss	h6 =	0.032 m		
WL9 =	WL8 +	h6 =	37.482 m	
		say,	37.50 m	

3.6 Effluent Water Level of Distribution Chamber for Dry Weather Flow (WL10)

Design Flow	Q =	231,088 m^3/day =		2.675 m^3/sec
Pipe Diameter		800 mm		
Pipe Length		150.0 m		
No. of Lagoon		8 sets		
Velocity	V =	0.67 m/sec		
Hydraulic Gradient	i =	(V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)		
	=	0.069 %		
Hydraulic Loss	h7 =	0.104 m		
WL10 =	WL9 +	h7 =	37.604 m	
		say,	37.7 m	

3.7 Water Level of Distribution Chamber for Dry Weather Flow (WL11)

Design Flow	Q =	231,088 m^3/day =		2.675 m^3/sec
Weir Width	W =	2.0 m		
No. of Lagoon		8 sets		
Overflow height	h8 =	(Q / (1.8 * W))^(2/3)		
	=	0.205 m		
WL11 =	WL10 +	h8 =	37.905 m	
		say,	38.075 m	

3.8 Effluent Water Level of Distribution Chamber for Wet Weather Flow (WL12)

Design Flow	Q =	392,392 m^3/day =		4.542 m^3/sec
Pipe Diameter		1,800 mm		
Pipe Length		600.0 m		

No. of Chamber		2 sets		
Velocity	V =	0.89 m/sec		
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)			
	=	0.046 %		
Hydraulic Loss	h9 =	0.277 m		
WL12 =	WL20 +	h9 =	36.227 m	
		say,	37.4 m	

3.9 Water Level of Distribution Chamber for Wet Weather Flow (WL13)

Design Flow	Q =	392,392 m^3/day =	4.542 m^3/sec	
Weir Width	W =	6.0 m		
No. of Chamber		2 sets		
Overflow height	h10 = (Q / (1.8 * W))^(2/3)			
	=	0.354 m		
WL13 =	WL11 +	h10 =	38.429 m	
		say,	38.800 m	

3.10 Water Level of Parshall Flum Effluent Chamber (WL12)

Design Flow	Q =	623,480 m^3/day =	7.216 m^3/sec	
Pipe Diameter		1,800 mm		
Pipe Length		30.0 m		
No. of Pipes		2 sets		
Velocity	V =	1.42 m/sec		
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)			
	=	0.109 %		
Hydraulic Loss	h11 =	0.033 m		
WL14 =	WL11 +	h11 =	38.108 m	
		say,	38.90 m	

3.11 Water Level of Parshall Flum Influent Chamber (WL13)

Design Flow	Q =	623,480 m^3/day =	7.216 m^3/sec	
No. of PF		2 sets		
Head loss	h12 =	0.30 m		
WL15 =	WL12 +	h12 =	39.200 m	
		say,	39.20 m	

3.12 Water Level of Grit Chamber Effluent Chamber (WL14)

Design Flow	Q =	623,480 m^3/day =	7.216 m^3/sec	
Pipe Diameter		1,800 mm		
Pipe Length		30.0 m		
No. of Pipes		2 sets		
Velocity	V =	1.42 m/sec		
Hydraulic Gradient	i = (V / (0.84935 * C * (d/4)^0.63)) ^ (1/0.54)			
	=	0.109 %		
Hydraulic Loss	h13 =	0.033 m		
WL16 =	WL15 +	h13 =	39.233 m	
		say,	39.30 m	

3.13 Water Level of Grit Chamber Influent Chamber (WL15)

Design Flow	Q =	623,480 m^3/day =		7.216 m^3/sec
No. of Screens		8 sets including 2 stes		
Head loss	h14 =	0.20 m		
WL17 =	WL14 +	h14 =	39.500 m	
		say,	39.50 m	

3.14 Water Level of Storm Water settling Tank (WL20)

Design Flow	Q =	392,392 m^3/day =		4.542 m^3/sec
Weir Width	W =	5.0 m		
No. of Lagoon		6 sets		
Overflow height	h20 =	(Q / (1.84 * W))^(2/3)		
	=	0.189 m		
WL20 =	WL2 +	h20 =	32.989 m	
		say,	35.95 m	

8.5.1 Unit Construction Cost of Wastewater Facilities

1. Wastewater Collection Facilities

(1) Concrete Pipe Laying (including materials + installation)

200	mm		6.30	US$/m
250	mm		7.15	US$/m
300	mm		8.00	US$/m
350	mm		9.50	US$/m
400	mm		11.00	US$/m
450	mm		12.00	US$/m
500	mm		13.00	US$/m
600	mm	reinforced	25.00	US$/m
700	mm	reinforced	36.50	US$/m
800	mm	reinforced	48.00	US$/m
900	mm	reinforced	81.00	US$/m
1000	mm	reinforced	114.00	US$/m
1100	mm	reinforced	129.20	US$/m
1200	mm	reinforced	144.40	US$/m
1300	mm	reinforced	159.60	US$/m
1400	mm	reinforced	174.80	US$/m
1500	mm	reinforced	190.00	US$/m
1600	mm	reinforced	204.00	US$/m
1700	mm	reinforced	218.00	US$/m
1800	mm	reinforced	232.00	US$/m
1900	mm	reinforced	246.00	US$/m
2000	mm	reinforced	260.00	US$/m
2100	mm	reinforced	274.00	US$/m
2200	mm	reinforced	288.00	US$/m
2300	mm	reinforced	302.00	US$/m

(2) Earth Works

Sand		5.00	US$/m^3
Gravel		1.00	US$/m^3
Excavation	(Backhoe)	1.70	US$/m^3
Excavation	(Manpower)	3.40	US$/m^3
Backfilling	(Backhoe, Original Soil)	0.35	US$/m^3
Backfilling	(Manpower, Sand, Dump Truck 10km)	7.03	US$/m^3

Backfilling	(Manpower, Gravel, Dump Truck 10km)	3.23	US$/$m^3$
Pavement		1.40	US$/$m^3$

(3) Manhole

D= 1.00m	H= 2.0m	334.71	US$/pc
D= 1.00m	H= 2.5m	366.28	US$/pc
D= 1.00m	H= 3.0m	413.98	US$/pc
D= 1.25m	H= 2.0m	400.01	US$/pc
D= 1.50m	H= 3.0m	658.30	US$/pc
D= 2.00m	H= 3.0m	1,010.20	US$/pc

2. Wastewater Treatment Plant

Excavation	(Bulldozer)	0.60	US$/$m^3$
Backfilling	(Bulldozer)	0.12	US$/$m^3$
Concrete	Beam M200 (excl. steel bar)	120.00	US$/$m^3$
do	Column M200 (excl. steel bar)	126.00	US$/$m^3$
do	Foundation M200 (excl. steel bar)	75.00	US$/$m^3$
Reinforcing Bar		1.00	US$/kg
Formboard		3.50	US$/$m^2$
Concrete	Reinforced Concrete	226.00	US$/$m^3$
Road	Pavement	9.00	US$/$m^2$
do	Gravel	5.00	US$/$m^3$
do	Gravel (t = 0.3m)	1.50	US$/$m^2$
Architecture		140.00	US$/$m^2$
Removal of Surplus Soil	(Dump Truck)	0.15	US$/t/km
Removal of Surplus Soil	(Bulldozer + Dump Truck 5km)	1.01	US$/$m^3$

Note: 1) These unit costs are not included the tax (12.5%) and the overhead (15%).
2) [ ] was calculated by Study Team.
3) Exchange rate: 1US$=100Lek

8.5.2 Unit Construction Cost of Sewer Pipe

Table 8.5.1 Unit Construction Cost of Sewer Pipe (No.1)

Earth Covering Depth = 1.0m

Diameter (mm)		200	250	300	350	400	450	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100
(1) Quantity																								
Excavation (Backhoe)	(m3)	2.20	2.41	2.63	2.86	3.10	3.35	3.60	4.15	4.76	5.48	6.25	7.08	7.95	8.88	9.85	10.88	11.96	13.09	14.27	15.50	16.79	18.12	19.50
Excavation (Manpower)	(m3)	0.34	0.36	0.38	0.40	0.41	0.43	0.45	0.49	0.52	0.56	0.59	0.63	0.67	0.70	0.74	0.77	0.81	0.85	0.88	0.92	0.95	0.99	1.03
Concrete Foundation	(m3)	0.12	0.14	0.16	0.18	0.21	0.23	0.26	0.31	0.38	0.47	0.58	0.69	0.82	0.96	1.10	1.26	1.43	1.61	1.79	1.99	2.20	2.42	2.65
Gravel Foundation	(m3)	0.11	0.11	0.12	0.13	0.13	0.14	0.14	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25	0.26	0.28	0.29	0.30	0.31	0.32	0.34
Concrete Pipe	(m3)	0.05	0.07	0.10	0.14	0.18	0.23	0.28	0.41	0.55	0.72	0.92	1.13	1.37	1.63	1.91	2.22	2.54	2.90	3.27	3.66	4.08	4.52	4.99
Backfilling (Manpower, Sand)	(m3)	0.83	0.94	1.04	1.14	1.25	1.36	1.48	1.71	1.98	2.30	2.62	2.98	3.34	3.72	4.14	4.55	5.00	5.44	5.93	6.43	6.94	7.47	8.01
Backfilling (Backhoe, Original Soil)	(m3)	0.69	0.73	0.77	0.81	0.85	0.89	0.93	1.01	1.10	1.18	1.27	1.36	1.45	1.54	1.62	1.71	1.80	1.89	1.98	2.06	2.15	2.24	2.33
Pavement	(m3)	0.74	0.78	0.82	0.85	0.89	0.92	0.96	1.03	1.11	1.11	1.26	1.34	1.42	1.50	1.58	1.66	1.74	1.82	1.90	1.98	2.06	2.14	2.22
Surplus Soil	(m3)	1.11	1.26	1.42	1.59	1.77	1.96	2.16	2.59	3.08	3.67	4.31	5.00	5.75	6.54	7.39	8.28	9.23	10.23	11.28	12.38	13.53	14.73	15.99
(2) Construction Cost (US$/m)																								
Excavation (Backhoe)	1.70	3.74	4.09	4.47	4.86	5.27	5.69	6.12	7.05	8.09	9.31	10.62	12.03	13.51	15.09	16.74	18.49	20.33	22.25	24.25	26.35	28.54	30.80	33.15
Excavation (Manpower)	3.40	1.15	1.22	1.29	1.36	1.39	1.46	1.53	1.66	1.76	1.90	2.00	2.14	2.27	2.38	2.51	2.61	2.75	2.89	2.99	3.12	3.23	3.36	3.50
Concrete Foundation	75.00	9.00	10.50	12.00	13.50	15.75	17.25	19.50	23.25	28.50	35.25	43.50	51.75	61.50	72.00	82.50	94.50	107.25	120.75	134.25	149.25	165.00	181.50	198.75
Gravel Foundation	3.23	0.35	0.35	0.38	0.41	0.41	0.45	0.45	0.51	0.54	0.58	0.61	0.64	0.71	0.74	0.77	0.80	0.83	0.90	0.93	0.96	1.00	1.03	1.09
Backfilling (Manpower, Sand)	3.23	2.68	3.03	3.35	3.68	4.03	4.39	4.78	5.52	6.39	7.42	8.46	9.62	10.78	12.01	13.37	14.69	16.15	17.57	19.15	20.76	22.41	24.12	25.87
Backfilling (Backhoe, Original Soil)	0.35	0.24	0.25	0.26	0.28	0.29	0.31	0.32	0.35	0.38	0.41	0.44	0.47	0.50	0.53	0.56	0.59	0.63	0.66	0.69	0.72	0.75	0.78	0.81
Pavement	1.40	1.03	1.09	1.14	1.19	1.24	1.28	1.34	1.44	1.55	1.55	1.76	1.87	1.98	2.10	2.21	2.32	2.43	2.54	2.66	2.77	2.88	2.99	3.10
Removal of Surplus Soil	1.02	1.13	1.28	1.44	1.62	1.80	1.99	2.20	2.64	3.14	3.74	4.39	5.10	5.86	6.67	7.53	8.44	9.41	10.43	11.50	12.62	13.80	15.02	16.30
Concrete Pipe Laying	1 ls	6.30	7.15	8.00	9.50	11.00	12.00	13.00	25.00	36.50	48.00	81.00	114.00	129.20	144.40	159.60	174.80	190.00	204.00	218.00	232.00	246.00	260.00	274.00
Manhole (1peace per 50m)		6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69	6.69
Total		32.31	35.65	39.02	43.09	47.87	51.51	55.93	74.11	93.54	114.85	159.47	204.31	233.00	262.61	292.48	323.93	356.47	388.68	421.11	455.24	490.30	526.29	563.26
Total (including tax etc.)		45.98	50.73	55.53	61.32	68.12	73.31	79.60	105.47	133.12	163.45	226.95	290.76	331.59	373.73	416.24	460.99	507.30	553.14	599.29	647.86	697.76	748.98	801.59

Note: Tax is 12.5%, overhead is 15.0% and site management cost is 10%. (January 1997)

Table 8.5.2 Unit Construction Cost of Sewer Pipe (No.2)

Earth Covering Depth = 2.0m

Diameter (mm)		200	250	300	350	400	450	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100
(1) Quantity																								
Excavation (Backhoe)	(m3)	4.64	4.95	5.27	5.60	5.94	6.29	6.64	7.39	8.21	9.15	10.14	11.18	12.28	13.42	14.62	15.87	17.17	18.52	19.92	21.37	22.87	24.43	26.03
Excavation (Manpower)	(m3)	0.34	0.36	0.38	0.40	0.41	0.43	0.45	0.49	0.52	0.56	0.59	0.63	0.67	0.70	0.74	0.77	0.81	0.85	0.88	0.92	0.95	0.99	1.03
Concrete Foundation	(m3)	0.12	0.14	0.16	0.18	0.21	0.23	0.26	0.31	0.38	0.47	0.58	0.69	0.82	0.96	1.10	1.26	1.43	1.61	1.79	1.99	2.20	2.42	2.65
Gravel Foundation	(m3)	0.11	0.11	0.12	0.13	0.13	0.14	0.14	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25	0.26	0.28	0.29	0.30	0.31	0.32	0.34
Concrete Pipe	(m3)	0.05	0.07	0.10	0.14	0.18	0.23	0.28	0.41	0.55	0.72	0.92	1.13	1.37	1.63	1.91	2.22	2.54	2.90	3.27	3.66	4.08	4.52	4.99
Backfilling (Manpower, Sand)	(m3)	0.83	0.94	1.04	1.14	1.25	1.36	1.48	1.71	1.98	2.30	2.62	2.98	3.34	3.72	4.14	4.55	5.00	5.44	5.93	6.43	6.94	7.47	8.01
Backfilling (Backhoe, Original Soil	(m3)	2.89	3.03	3.17	3.31	3.45	3.59	3.73	4.01	4.30	4.61	4.92	5.23	5.53	5.84	6.15	6.46	6.77	7.07	7.38	7.69	8.00	8.31	8.61
Pavement	(m3)	0.98	1.02	1.06	1.09	1.13	1.16	1.20	1.27	1.35	1.35	1.50	1.58	1.66	1.74	1.82	1.90	1.98	2.06	2.14	2.22	2.30	2.38	2.46
Surplus Soil	(m3)	1.11	1.26	1.42	1.59	1.77	1.96	2.16	2.59	3.08	3.67	4.31	5.00	5.75	6.54	7.39	8.28	9.23	10.23	11.28	12.38	13.53	14.73	15.99
(2) Construction Cost (US$/m)																								
Excavation (Backhoe)	1.70	7.88	8.41	8.95	9.52	10.09	10.69	11.28	12.56	13.95	15.55	17.23	19.00	20.87	22.81	24.85	26.97	29.18	31.48	33.86	36.32	38.87	41.53	44.25
Excavation (Manpower)	3.40	1.15	1.22	1.29	1.36	1.39	1.46	1.53	1.66	1.76	1.90	2.00	2.14	2.27	2.38	2.51	2.61	2.75	2.89	2.99	3.12	3.23	3.36	3.50
Concrete Foundation	75.00	9.00	10.50	12.00	13.50	15.75	17.25	19.50	23.25	28.50	35.25	43.50	51.75	61.50	72.00	82.50	94.50	107.25	120.75	134.25	149.25	165.00	181.50	198.75
Gravel Foundation	3.23	0.35	0.35	0.38	0.41	0.41	0.45	0.45	0.51	0.54	0.58	0.61	0.64	0.71	0.74	0.77	0.80	0.83	0.90	0.93	0.96	1.00	1.03	1.09
Backfilling (Manpower, Sand)	3.23	2.68	3.03	3.35	3.68	4.03	4.39	4.78	5.52	6.39	7.42	8.46	9.62	10.78	12.01	13.37	14.69	16.15	17.57	19.15	20.76	22.41	24.12	25.87
Backfilling (Backhoe, Original Soil	0.35	1.01	1.06	1.10	1.15	1.20	1.25	1.30	1.40	1.50	1.61	1.72	1.83	1.93	2.04	2.15	2.26	2.36	2.47	2.58	2.69	2.80	2.90	3.01
Pavement	1.40	1.37	1.42	1.48	1.52	1.58	1.62	1.68	1.77	1.89	1.89	2.10	2.21	2.32	2.43	2.54	2.66	2.77	2.88	2.99	3.10	3.22	3.33	3.44
Removal of Surplus Soil	1.43	1.58	1.80	2.03	2.27	2.53	2.80	3.08	3.70	4.40	5.24	6.16	7.15	8.22	9.35	10.56	11.84	13.19	14.62	16.13	17.70	19.34	21.06	22.86
Concrete Pipe Laying	1 ls	6.30	7.15	8.00	9.50	11.00	12.00	13.00	25.00	36.50	48.00	81.00	114.00	129.20	144.40	159.60	174.80	190.00	204.00	218.00	232.00	246.00	260.00	274.00
Manhole (1piece per 50m)		7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33	7.33
Total		38.65	42.27	45.91	50.24	55.31	59.24	63.93	82.70	102.76	124.77	170.11	215.67	245.13	275.49	306.18	338.46	371.81	404.89	438.21	473.23	509.20	546.16	584.10
Total (including tax etc.)		55.00	60.16	65.34	71.50	78.71	84.31	90.98	117.69	146.24	177.56	242.09	306.93	348.85	392.06	435.73	481.67	529.13	576.21	623.63	673.47	724.66	777.25	831.25

Note: Tax is 12.5%, overhead is 15.0% and site management cost is 10%. (January 1997)

Table 8.5.3 Unit Construction Cost of Sewer Pipe (No.3)

Earth Covering Depth = 3.0m

Diameter (mm)		200	250	300	350	400	450	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100
(1) Quantity																								
Excavation (Backhoe)	(m3)	7.75	8.16	8.58	9.01	9.45	9.89	10.35	11.29	12.32	13.48	14.69	15.96	17.27	18.64	20.06	21.52	23.04	24.61	26.23	27.90	29.63	31.40	33.22
Excavation (Manpower)	(m3)	0.34	0.36	0.38	0.40	0.41	0.43	0.45	0.49	0.52	0.56	0.59	0.63	0.67	0.70	0.74	0.77	0.81	0.85	0.88	0.92	0.95	0.99	1.03
Concrete Foundation	(m3)	0.12	0.14	0.16	0.18	0.21	0.23	0.26	0.31	0.38	0.47	0.58	0.69	0.82	0.96	1.10	1.26	1.43	1.61	1.79	1.99	2.20	2.42	2.65
Gravel Foundation	(m3)	0.11	0.11	0.12	0.13	0.13	0.14	0.14	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25	0.26	0.28	0.29	0.30	0.31	0.32	0.34
Concrete Pipe	(m3)	0.05	0.07	0.10	0.14	0.18	0.23	0.28	0.41	0.55	0.72	0.92	1.13	1.37	1.63	1.91	2.22	2.54	2.90	3.27	3.66	4.08	4.52	4.99
Backfilling (Manpower, Sand)	(m3)	0.83	0.94	1.04	1.14	1.25	1.36	1.48	1.71	1.98	2.30	2.62	2.98	3.34	3.72	4.14	4.55	5.00	5.44	5.93	6.43	6.94	7.47	8.01
Backfilling (Backhoe, Original Soil	(m3)	5.76	6.00	6.24	6.48	6.72	6.96	7.20	7.68	8.18	8.70	9.23	9.76	10.29	10.82	11.34	11.87	12.40	12.93	13.46	13.98	14.51	15.04	15.57
Pavement	(m3)	1.22	1.26	1.30	1.33	1.37	1.40	1.44	1.51	1.59	1.59	1.74	1.82	1.90	1.98	2.06	2.14	2.22	2.30	2.38	2.46	2.54	2.62	2.70
Surplus Soil	(m3)	1.11	1.26	1.42	1.59	1.77	1.96	2.16	2.59	3.08	3.67	4.31	5.00	5.75	6.54	7.39	8.28	9.23	10.23	11.28	12.38	13.53	14.73	15.99
(2) Construction Cost (US$/m)																								
Excavation (Backhoe)	1.70	13.17	13.87	14.58	15.31	16.06	16.81	17.59	19.19	20.94	22.91	24.97	27.13	29.35	31.68	34.10	36.58	39.16	41.83	44.59	47.43	50.37	53.38	56.47
Excavation (Manpower)	3.40	1.15	1.22	1.29	1.36	1.39	1.46	1.53	1.66	1.76	1.90	2.00	2.14	2.27	2.38	2.51	2.61	2.75	2.89	2.99	3.12	3.23	3.36	3.50
Concrete Foundation	75.00	9.00	10.50	12.00	13.50	15.75	17.25	19.50	23.25	28.50	35.25	43.50	51.75	61.50	72.00	82.50	94.50	107.25	120.75	134.25	149.25	165.00	181.50	198.75
Gravel Foundation	3.23	0.35	0.35	0.38	0.41	0.41	0.45	0.45	0.51	0.54	0.58	0.61	0.64	0.71	0.74	0.77	0.80	0.83	0.90	0.93	0.96	1.00	1.03	1.09
Backfilling (Manpower, Sand)	3.23	2.68	3.03	3.35	3.68	4.03	4.39	4.78	5.52	6.39	7.42	8.46	9.62	10.78	12.01	13.37	14.69	16.15	17.57	19.15	20.76	22.41	24.12	25.87
Backfilling (Backhoe, Original Soil	0.35	2.01	2.10	2.18	2.26	2.35	2.43	2.52	2.68	2.86	3.04	3.23	3.41	3.60	3.78	3.96	4.15	4.34	4.52	4.71	4.89	5.07	5.26	5.44
Pavement	1.40	1.70	1.76	1.82	1.86	1.91	1.96	2.01	2.11	2.22	2.22	2.43	2.54	2.66	2.77	2.88	2.99	3.10	3.22	3.33	3.44	3.55	3.66	3.78
Removal of Surplus Soil	1.43	1.58	1.80	2.03	2.27	2.53	2.80	3.08	3.70	4.40	5.24	6.16	7.15	8.22	9.35	10.56	11.84	13.19	14.62	16.13	17.70	19.34	21.06	22.86
Concrete Pipe Laying	1 ls	6.30	7.15	8.00	9.50	11.00	12.00	13.00	25.00	36.50	48.00	81.00	114.00	129.20	144.40	159.60	174.80	190.00	204.00	218.00	232.00	246.00	260.00	274.00
Manhole (1piece per 50m)		13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12	13.12
Total		51.06	54.90	58.75	63.27	68.55	72.67	77.58	96.74	117.23	139.68	185.48	231.50	261.41	292.23	323.37	356.08	389.89	423.42	457.20	492.67	529.09	566.49	604.88
Total (including tax etc.)		72.66	78.13	83.61	90.04	97.56	103.42	110.41	137.67	166.83	198.78	263.96	329.45	372.02	415.88	460.20	506.75	554.86	602.58	650.65	701.13	752.96	806.19	860.82

Note: Tax is 12.5%, overhead is 15.0% and site management cost is 10%. (January 1997)

8.5.3 Sewage Collection System Construction Cost

Table 8.5.4 Trunk Main Construction Cost

Dia (mm)	Cost (US$)	Phase-1		Phase-2		Total	
		Length	10^3 US$	Length	10^3 US$	Length	10^3 US$
1200	415.88			3,200	1,331	3,200	1,331
1350	483.48	30	15	4,200	2,031	4,230	2,045
1650	626.62	10,170	6,373			10,170	6,373
□ 1400	602.58			3,270	1,970	3,270	1,970
□ 1700	752.96	3,270	2,462			3,270	2,462
Total		13,470	8,849	10,670	5,332	24,140	14,181

Table 8.5.5 New Main Sanitary Sewer Construction Cost

Zone	Area	Phase-1				Phase-2				Total	
		Dia	Cost	Length	10^3 US$	Dia	Cost	Length	10^3 US$	Length	10^3 US$
Tirana	Tirana-1					450	68.42	2,085	143	2,085	143
	Tirana-2					200	55.00	210	12	210	12
	Tirana-3					200	55.00	615	34	615	34
	Tirana-4					250	57.58	1,105	64	1,105	64
Lana-South	Shkoza	300	60.16	730	44					730	44
	Student					300	60.16	1,475	89	1,475	89
	Selita	350	62.75	1,780	112					1,780	112
	Kombinat	400	65.34	750	49					750	49
USAID	USAID-1					400	65.34	3,500	229	3,500	229
	USAID-2					700	84.31	15,000	1,265	15,000	1,265
	Yzberishi-1					250	57.58	825	48	825	48
	Yzberishi-2					200	55.00	165	9	165	9
Total				3,260	205			24,980	1,890	28,240	2,095

Table 8.5.6 Intercepting Sewer Improvement Cost

Dia (mm)	Cost (US$)	Lana-North		Lana-South		Tirana River		Center		Total	
		Length	10^3 US$	Length	10^3 US$	Length	10^3 US$	Length	10^3 US$	Length	10^3 US$
600	176.54										
700	219.36					1,204	264			1,204	264
800	266.34										
900	363.14	370	134	73	27					443	161
1000	460.40	365	168	553	255					918	423
1100	523.28	648	339	910	476					1,558	815
1200	588.09	1,061	624	776	456					1,837	1,080
1300	653.60					280	183	428	280	708	463
1400	722.51	1,123	811	447	323					1,570	1,134
1500	793.70			234	186					234	186
1700	935.45							130	122	130	122
1800	1010.21					267	270	930	939	1,197	1,209
1900	1086.99							771	838	771	838
Total		3,567	2,077	2,993	1,722	1,751	717	2,259	2,179	10,570	6,695
					3,799				2,896		

Table 8.5.7 Stormwater Overflow Chamber Improvement Cost

Items		Lana-North		Lana-South		Tirana River		Center		Total	
		No.	10^3 US$	No.	10^3 US$	No.	10^3 US$	No.	10^3 US$	No.	10^3 US$
Unit Cost	7,000	14	98	19	133	4	28	3	21	40	280
Total					231				49		

Table 8.5.8 Storm Water Inlet Construction Cost

Items		Lana-North		Lana-South		Tirana River		Center		Total	
		No.	10^3 US$	No.	10^3 US$	No.	10^3 US$	No.	10^3 US$	No.	10^3 US$
Unit Cost	2,500	17	43	19	48					36	90
Total					90						

8.5.4 Bill of Quantities of Sewage Treatment Plant

Table 8.5.9 Bill of Quantities of Sewage Treatment Plant

Items	Present Grand Level	Design Grand Level	Area	First Excavation	Second Excavation	Backfilling	Finishing Slope	Plain Concrete	Reinforced Concrete	Gravel	Architecure
	M	M	m2	m3	m3	m3	m2	m3	m3	m3	m2
Grit Chamber	42.00	42.00	487	0	2,652	779	-	54	547	107	-
Distribution Chamber	42.00	42.00	69	0	660	297	-	8	143	15	-
Complete Mixing Aerated Lagoon	41.40	39.90	52,138	78,207	93,924	-	41,196	2,364	-	-	-
Partial Mixing Aerated Lagoon No.1	41.20	39.85	27,064	36,536	49,152	-	20,520	1,656	-	-	-
Partial Mixing Aerated Lagoon No.2	40.50	39.60	27,064	24,358	49,152	-	20,520	1,656	-	-	-
Partial Mixing Aerated Lagoon No.3	39.60	39.35	29,054	7,264	49,152	-	20,520	1,656	-	-	-
Storm Water Settling Tank	39.80	39.35	11,060	4,977	7,164	-	5,656	852	-	-	-
Disinfection Tank	38.90	35.20	8,060	29,822	2,241	-	2,037	321	16	-	90
Outfall	31.50	31.50	121	0	455	182	-	196	103	71	-
Outfall Sewer (1350mm, H=1.0m)	-	-	-	-	-	-	-	-	-	-	-
Inlet Sewer(1700*1700mm, H=1.0m)	-	-	-	-	-	-	-	-	-	-	-
Connection Pipe (800mm)	-	-	-	-	-	-	-	-	-	-	-
Connection Pipe (1800mm)	-	-	-	-	-	-	-	-			
Administration and Elec. Building	-	-	-	-	-	-	-	-	-	-	
Drain and Connection Pipe (500mm)	-	-	-	-	-	-	-	-	-	-	-
Connection Pipe (1500mm)	-	-	-	-	-	-	-	-	-	-	-
Road	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	155,117	181,164	254,552	1,258	110,449	8,763	809	193	90

Table 8.5.9 Bill of Quantities of Sewage Treatment Plant (Cont'd)

Items	Pipe Laying 1350mm	Pipe Laying 1700mm	Pipe Laying 800mm	Pipe Laying 1800mm	Pipe Laying 500mm, H=3.0	Pipe Laying 500mm, H=1.0	Pipe Laying 1500mm	Temporary Road	Pavement	Removal of Surplus Soil
	m	m	m	m	m	m	m	m	m	m3
Grit Chamber	-	-	-	-	-	-	-	-	-	1,874
Distribution Chamber	-	-	-	-	-	-	-	-	-	363
Complete Mixing Aerated Lagoon	-	-	-	-	-	-	-	-	-	172,131
Partial Mixing Aerated Lagoon No.1	-	-	-	-	-	-	-	-	-	85,688
Partial Mixing Aerated Lagoon No.2	-	-	-	-	-	-	-	-	-	73,510
Partial Mixing Aerated Lagoon No.3	-	-	-	-	-	-	-	-	-	56,416
Storm Water Settling Tank	-	-	-	-	-	-	-	-	-	12,141
Disinfection Tank	-	-	-	-	-	-	-	-	-	32,063
Outfall	-	-	-	-	-	-	-	-	-	273
Outfall Sewer (1350mm, H=1.0m)	200	-	-	-	-	-	-	-	-	-
Inlet Sewer(1700*1700mm, H=1.0m)	-	50	-	-	-	-	-	-	-	-
Connection Pipe (800mm)	-	-	570	-	-	-	-	-	-	-
Connection Pipe (1800mm)	-	-	-	1100	-	-	-	-	-	-
Administration and Elec. Building	-	-	-	-	-	-	-	-	-	-
Drain and Connection Pipe (500mm)	-	-	-	-	322	666	-	-	-	-
Connection Pipe (1500mm)	-	-	-	-	-	-	292	-	-	-
Road	-	-	-	-	-	-	-	500	22,010	-
Total	200	50	570	1,100	322	666	292	500	22,010	434,459

8.5.5 Construction Cost of Sewage Treatment Plant

Table 8.5.10 Construction Cost of Sewage Treatment Plant

Items	First Excavation	Second Excavation		Backfilling	Finishing Slope	Plain Concrete	Reinforced Concrete	Gravel	Architecure	Pipe Laying 1350mm	Pipe Laying 1700mm
Unit Cost	0.60	0.60	1.70	0.35	0.35	75.00	226.00	1.00	140.00	308.21	490.30
Grit Chamber	-	-	4,508.40	272.65	-	4,050.00	123,622.00	107.00	-	-	-
Distribution Chamber	-	-	1,122.00	103.95	-	600.00	32,318.00	15.00	-	-	-
Complete Mixing Aerated Lagoon	46,924.20	56,354.40	-	-	14,418.60	177,300.00	-	-	-	-	-
Partial Mixing Aerated Lagoon No.1	21,921.60	29,491.20	-	-	7,182.00	124,200.00	-	-	-	-	-
Partial Mixing Aerated Lagoon No.2	14,614.80	29,491.20	-	-	7,182.00	124,200.00	-	-	-	-	-
Partial Mixing Aerated Lagoon No.3	4,358.40	29,491.20	-	-	7,182.00	124,200.00	-	-	-	-	-
Storm Water Settling Tank	2,986.20	4,298.40	-	-	1,979.60	63,900.00	-	-	-	-	-
Disinfection Tank	17,893.20	-	3,809.70	-	712.95	24,075.00	3,616.00	-	12,600.00	-	-
Outfall	-	-	773.50	63.70	-	14,700.00	23,278.00	71.00	-	-	-
Outfall Sewer (1350mm, H=1.0m)	-	-	-	-	-	-	-	-	-	61,642.00	-
Inlet Sewer(1700*1700mm, H=1.0m)	-	-	-	-	-	-	-	-	-	-	24,515.00
Connection Pipe (800mm,H=3.0m)	-	-	-	-	-	-	-	-	-	-	-
Connection Pipe (1800mm,H=2.0m)	-	-	-	-	-	-	-	-	-	-	-
Administration Building	-	-	-	-	-	-	-	-	-	-	-
Drain and Connection Pipe (500mm)	-	-	-	-	-	-	-	-	-	-	-
Connection Pipe (1500mm,H=3.0m)	-	-	-	-	-	-	-	-	-	-	-
Road	-	-	-	-	-	-	-	-	-	-	-
Total (US$)	108,698.40	149,126.40	10,213.60	440.30	38,657.15	657,225.00	182,834.00	193.00	12,600.00	61,642.00	24,515.00
Total (Including Tax and Overhead)	154,691.41	212,225.50	14,535.22	626.60	55,013.95	935,313.32	260,195.63	274.66	17,931.37	87,724.27	34,887.90

Note1: Bill of quantities are shown in supporting report 8.5.3.
Note2: Unit cost of pipe laying was calculated as shown in supporting report 8.5.4.
Note3: Unit cost except pipe laying are shown in supporting report 8.5.1.

Table 8.5.10 Construction Cost of Sewage Treatment Plant (Cont'd)

Items	Pipe Laying 800mm	Pipe Laying 1800mm	Pipe Laying 500mm, H=3.0	Pipe Laying 500mm, H=1.0	Pipe Laying 1500mm	Temporary Road	Pavement	Removal of Surplus Soil	Total (US$)
Unit Cost	139.68	473.23	77.58	55.93	389.89	1.50	9.00	1.01	
Grit Chamber	-	-	-	-	-	-	-	1,892.74	134,452.79
Distribution Chamber	-	-	-	-	-	-	-	366.63	34,525.58
Complete Mixing Aerated Lagoon	-	-	-	-	-	-	-	173,852.31	468,849.51
Partial Mixing Aerated Lagoon No.1	-	-	-	-	-	-	-	86,544.88	269,339.68
Partial Mixing Aerated Lagoon No.2	-	-	-	-	-	-	-	74,245.10	249,733.10
Partial Mixing Aerated Lagoon No.3	-	-	-	-	-	-	-	56,980.16	222,211.76
Storm Water Settling Tank	-	-	-	-	-	-	-	12,262.41	85,426.61
Disinfection Tank	-	-	-	-	-	-	-	32,383.63	95,090.48
Outfall	-	-	-	-	-	-	-	275.73	39,161.93
Outfall Sewer (1350mm, H=1.0m)	-	-	-	-	-	-	-	-	61,642.00
Inlet Sewer(1700*1700mm, H=1.0m)	-	-	-	-	-	-	-	-	24,515.00
Connection Pipe (800mm,H=3.0m)	79,617.60	-	-	-	-	-	-	-	79,617.60
Connection Pipe (1800mm,H=2.0m)	-	520,553.00	-	-	-	-	-	-	520,553.00
Administration Building	-	-	-	-	-	-	-	-	0.00
Drain and Connection Pipe (500mm)	-	-	24,980.76	37,249.38	-	-	-	-	62,230.14
Connection Pipe (1500mm,H=3.0m)	-	-	-	-	113,847.88	-	-	-	113,847.88
Road	-	-	-	-	-	750.00	198,090.00	-	198,840.00
Total (US$)	79,617.60	520,553.00	24,980.76	37,249.38	113,847.88	750.00	198,090.00	438,803.59	2,660,037.06
Total (Including Tax and Overhead)	113,305.79	740,811.98	35,550.74	53,010.52	162,019.76	1,067.34	281,906.83	624,472.35	3,785,565.24

Note1: Bill of quantities are shown in supp
Note2: Unit cost of pipe laying was calcul:
Note3: Unit cost except pipe laying are shc

8.5.6 Specifications and Unit Price of Mechanical Electrical Facilities in Sewage Treatment Plant

Facilities			Phase 1	Phase 2	Unit Price (US$)
1 Grit Chamber and Screen					
1) Screen					
Type	Bar screen				
Dimension Width		3.00 m			
Number			4	4	4,000
2 Complete Mixing Aerated Lagoon					
1) Aerator					
Type	Floating surface aerator				
Motor output		30 kW			
Number		(4 sets/basin)	20	20	55,900
3 Partial Mixing Aerated Lagoon					
1) Aerator					
Type	Floating surface aerator				
Motor output		5.5 kW			
Number		(2 sets/basin)	24	24	22,000
4 Disinfection Tank					
1) Chlorinator - A					
Type	Wall mounted type				
Capacity		4.0 kg/hour			
Number			2	1	3,500
2) Chlorinator - B					
Type	Floor mounted type				
Capacity		70 kg/hour			
Number			2	-	14,100
3) Gas Evaporator					
Type	Wall mounted type				
Capacity		2700 kg/day			
Number			2	-	32,100
4) Chlorine Gas Cylinder					
Capacity		1.0 ton			
Number			8	8	3,500
5) Pressure Water Pump					
Type	Centrifugal type				
Motor output		18.5 kW			
Number			2	-	4,600
5 Other Mechanical Equipment					
Number			1	-	83,600
			-	1	67,900
6 Electrical Facilities					
1) Sub-station			1	-	270,300
			-	1	120,300
2) Control panel			1	1	804,700
3) Monotoring panel			1	1	69,700
4) Power transmission line			1	-	125,000
5) Others			1	-	63,500
			-	1	49,700