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U N I D O

CONTRACT N° 92/134/ML

PROJECT US/RAF/88/100

HIDES AND SKINS, LEATHER AND LEATHER PRODUCT IMPROVEMENT SCHEME

F I N A L R E P O R T

(PART A: AWASH TANNERY)

27 July 1993

ENGLISH

SUMMARY AND BACKGROUND

Studio Tecnico Dr. Clonfero, Florence - Italy, was contracted by UNIDO-Vienna in September 1992 (Contract 92/134/ML) within a programme of pollution control of the large scale and multi-comprehensive US/RAF/88/100 Project of Assistance to the Leather Sector in the East Region of Africa.
The specific task of this contract was the preparation of a techno-economic study and full design for the implementation of two Effluent Treatment Plants (ETPs):

- Primary & Secondary phase at Awash Tannery, Ethiopia;
- Secondary (biological) phase at Sagana Tannery, Kenya.

The contractual duties include:

- collect all data relevant for the design and operation of the ETP;
- obtain information about the local existing standards for the effluent discharge;
- examine the possible ETP site alternatives and collect information about the local cost for civil works and construction materials;
- provide detailed specifications of the necessary equipment and indicate an estimation of prices;
- prepare the break-down of various operation/maintenance/monitoring costs and indicate personnel requirements.

Before this Final Report, Studio Tecnico has submitted to UNIDO the reports listed below:

- Flash Report	20 December 1992
- Progress Report	15 February 1993
- Draft Final Report	28 April 1993.

The content of these reports referring to Awash tannery is briefly summarized here.

Flash Report

The first mission in Ethiopia of Mr. G. Clonfero, team leader and expert in tannery effluents, took place in October 1992.

Forward

The original primary ETP had been installed more than ten years ago with the assistance of a local consultant. From the beginning the plant resulted improperly designed and ineffective. So the plant has been abandoned and the waste waters discharged to the Akaki river without any treatment. Currently the tanks are full of old sludge and the equipment and metallic structures devastated by corrosion. The concrete works (underdimensioned for the tannery capacity) are also poorly executed: **it is necessary to start from the very beginning and to prepare a complitely new plant's design.**

i. The expert collected information about the factory's production process and capacity and discussed the more relevant data with the technical management of the factory.
He examined the route of the internal discharge gullies and indicated a possible solution for the separation of the effluents in three lines (lime, chrome and others).
He verified the equipment of the local chemical laboratory and prepared a list of the complementary items for effluent analysis.
The local cost of the chemicals used in the tannery effluent treatment has been also investigated.

ii. The available land (3,000 m^2 ca.) is insufficient to allow the installation of an extended effluen' treatment (e.g. lagooning).
The tannery's location (close to a residential area), does not recommend the implementation of sand drying beds for sludges: this dewatering system will cause in future problems of air pollution (bad smells). Furthermore, in the factory' surroundings there is a natural park used as public recreational area: this implies that the aesthetical aspects of the plant and the possible risk of bad odours must be carefully evaluated in the new ETP design.
All these motives forced the expert to select a compact system of effluent treatment and a mechanical sludge dewatering alternative.

iii. The map of the area (scale 1 : 500) reporting also the slope levels was retrieved and used in the preparation of the tentative lay-out of the plant.
The effluent of the tannery can be piped to the ETP by gravity (an initial pumping station is not required).

iv. Mr. Micheal Tsegai, Ethiopian civil engineer, informed the expert about the soil characteristics.
No problem exists for excavation: the soil is formed by a soft

rock with good carrying capacity and a deep water table.

Note: successively this information resulted partially erroneous, the soil texture is not homogeneous and in some zones big and hard rocks exist. This is the reason for which the costs for the civil works indicated in the Draft Report had been revised.
v. Addis Ababa is located in a second level seismic area. Obviously, this has conditioned the design of the civil works: the use of strong and proper works in reinforced concrete is mandatory. The expert received a copy of the Ethiopian legislation on the matter: this has been successively used by an Italian civil engineer in the design of the here proposed civil works.

Note: the costs for civil works indicated in this report have been prepared on the basis of the local unit prices of building materials and works consigned to the expert by Mr. M. Tsegai.

vi. With the privatization of the leather sector, Awash and other tanneries are urged to implement efficient effluent treatment systems. At the moment, a definite legislation with specific standards for the discharge of industrial effluents does not exist in Ethiopia. The Minister of Natural Resources and Environmental Protection has been constituted on October 1992: a special Government Committee is studing the matter and a new normative is expected in short times. In the general opinion the future legislation will adopt criteria similar to those in Europe or other developed countries.
Strict discharge standards for tannery effluents necessitate modern treatment technologies. The final goal, in the expert's opinion, must be reached by steps (i.e. through a phased plant implementation: the primary and, only successively, the secondary phase).

Progress Report

A techno-economic study for the primary and secondary treatments and the sludge mechanical dewatering had been prepared. The design was including a pre-treatment of the chrome cointaining waters and, in alternative, a chrome recovery unit.

De-briefing at UNIDO headquarters in Vienna

The Progress Report had been discussed on 24 February in Vienna with Mr. Jakov Buljan, SIDO, and Ms. Aurelia Calabrò, UNIDO Back stopping Officer for this contract.

The design concepts and criteria adopted by Studio Tecnico for Awash tannery resulted basically correct: few formal improprieties were noted and some more details regarding the estimate operation and maintenance costs recommended. A list of the complementary equipment necessary for making the existing laboratory capable of doing the basic wastewater analysis was requested.

The second mission on field of Mr. G. Clonfero took place in March 1993.

i. The project drafted by Studio Tecnico had been illustrated and discussed with the tannery's management.

ii. The data referring to the tannery production and water consumption had been rechecked with Mr. Tesfaye Arega, Production Department Head.

iii. They agreed with the expert's suggestion of installing a chrome recovery plant but they asked for the simpler (less expensive) alternative with MgO, method already tested in their laboratory.

iv. The local prices of the chemicals for the effluent treatment and of the chrome sulphate had been investigated.

v. Close to the tannery fence passes the pipe-line of the municipal sewage treatment plant of Kaliti. The expert visited the plant and met the plant's Directors. There are chances that the primary treated effluent of Awash will be accepted into the Kaliti plant.

Draft final report

In the draft final report, the contractual document about the proposed interventions at Awash tannery had been defined. In the substance, it did not differ significantly form this final version. The Draft Final Report has been discussed in detail with Mr. Berg, SIRA, Mr. Buljan and Ms. Calabrò at UNIDO's headquarters on 26 May.
The few modifications and additions required by the UNIDO Officers have been introduced in this final report.

Note: Mr. Clonfero was in Ethiopia in July, during this recent mission for UNIDO he has revisited Awash tannery and discussed the content of the Final Report sent them as unofficial working paper. Only few modifications have been recommended:

i. the chrome recovery unit must not be considered an optional part of the ETP (as may be understood by its collocation as Annex) but a necessary pretreatment. Furthermore the unit must be designed on the basis of the max. future tannery's production (i.e. 20 m^3 per day of spent tanning liquors).

ii. the costs of the civil works must be revised according to the site real conditions (rock soil) and the current unit prices.

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A W A S H   T A N N E R Y

Addis Ababa

ETHIOPIA

PROPOSAL FOR THE EFFLUENT TREATMENT PLANT

(PRIMARY & SECONDARY TREATMENT)

CONTENTS

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1. FACTORY'S DATA

1.1. Max. daily capacity : 10,000 skins and 1,000 hides

1.2. Raw material

- goat skins	:	80% dry	(0.4 kg/pc)
		20% wet-salted	(1.3 kg/pc)
- sheep skins	:	80% wet-salted	(1.3 kg/p)
		20% dry	(0.5 kg/pc)
- hides	:	90% dry	(5.5 kg/pc)
		10% fresh	(20 kg/pc)

1.3. Total production : 9,500 kg/day ca. (dry weight), i.e. 24,000 kg/day ca. (green weight)

1.4. Final product

- skins : 80% pickled, 20% wet-blue;

- hides (current) : 100% Chrome tanned (part exported in wet-blue or crust and part finished for the local market); some sole leather, vegetable tanning in drums (no effluent).

1.5. Information about the process (main phases)

1.5.1. Liming

- sheep skins (depilatory paint) consumption for 8,000 pcs:

water	1,500 l
$Ca(OH)_2$	400 kg
Na_2S (60%)	256 kg
NaHS (72%)	72 kg

- goat skins (pulp unhairing in drum)

water	420%	(on pelt weight)
$Ca(OH)_2$	5%	"
Na_2S (60%)	3%	"
NaHS (72%)	1.5%	"

- hides (pulp unhairing in drum)

water	420%	(on pelt weight)
$Ca(OH)_2$	6%	"
Na_2S (60%)	3%	"
NaHS (72%)	2%	"

1.5.2. De-liming

- sheep skins	Ammonia free product	
- goat skins	$(NH_4)_2SO_4$	1.0-1.2% (on pelt weight)
- hides	$(NH_4)_2SO_4$	1.0-1.5% "

1.5.3. Tanning (hides, skins & splits)

Note: 90% of the hides are split in pelt.
According with the tannery's data, a lot of 650 hides (3,600 kg ca. dry weight) gives 6,000 kg of split pelt (grain side) and 1,500 kg of splits (50% ca. of the split weight is lost). *It means that 11,460 kg of pelts (9,160 kg grain side and 2,300 kg of splits) will be produced from 1,000 pieces (5,500 kg ca. dry weight).*

In the future (100% of skins chrome tanned), the tannery will tan 21,460 kg/day of pelts: 11,460 kg (hides: grain side and splits) + 10,000 kg of skins pelt weight.

Process:
- water 80% (on pelt weight)
- Cr sulphate (25% Cr_2O_3) 7% "
- MgO as basification agent and overnight rest.

Total max. consumption of chrome sulphate (21,460 x 0.07) = 1,500 kg/day ca.

1.5.4. Chrome content in the spent tanning liquors
(from factory's analysis):

	Sheep & goat skins	Hides	Mixed (Sheep/goat skins and hides)
Cr_2O_3 g/l	3.21	4.78	4.03

1.6. Volume of effluent (estimated by the factory)

- soaking	150 m^3
- liming & washings	250 m^3 (*)
- second washings after liming, deliming, bating, pickling and tanningbaths	250 m^3
- other waters	150 m^3
total	800 m^3 per day

(i.e. 33 m^3 per ton of processed material green weight)

(*) this figure differs from That indicated in the Draft Final Repor. It has been finally defined in the visit of July. Mr. Kidanu Chekol, Deputy General Manager and Mr. Tesfaye Arega, Production Department Head, have confirmed the following water consumptions.

- goats skins and hides:

liming	50 m^3/day
washings after liming	100 m^3/day
washings before deliming	100 m^3/day (*)

- sheep skins:

floor washing after painting	100 m^3/day
water for fleshing	50 m^3/day (*)
total	400 m^3/day

(*) the second washing after fleshing and the water for the mechanical fleshing of skins and hides are not piped into the storage tank for the concentrate lime liquors. These diluted wastes are not included in the effluents that must be sent to the sulphide pretreatment unit.

Furthermore:
i. the washings before deliming occur in a department different from beamhouse (tanning department): their separation and storage with the liming liquors will complicate the internal effluent separation.

ii. the water used during the mechanical fleshing is not highly polluted and, in any case, is already discharged uniformely to the ETP.

For this reason a volume of 250 m^3/day of "liming wastes" has been considered in the design of the pre-treatment of the highly sulphide polluted waters.

1.7. Miscellaneous information:

- Work time from 6 a.m. to 6 p.m.
- Work days 6 (exceptionally 7) per week
- Power 220 V 50 Hz monophase and 380 V 50 Hz threephases
  Some power shortages (cuts) : max. duration = 1 hr ca.

2. INPUT DATA

2.1.	Max. quantity of processed material	24,000 kg/day green weight.
2.2.	Water consumption (adopted)	40 l per kg of hides & skins (green weight).
2.3.	Max. effluent volume	960 (say 1,000) m^3/day.
2.4.	Discharge hours per day	12
2.5.	Mean discharge flow	85 m^3/h ca.
2.6.	Peak factor (adopted)	2.0
2.7.	Peak flow	170 m^3/h (i.e. 2,850 l/min.)
2.8.	Hours of treatment (plant's operation) per day (adopted)	20 per day

Note: *20 hrs is the time generally adopted in the calculations for a continuous operation of the plant (i.e. 24 hrs per day). The remaining 4 hrs are kept as security time (maintenance, breakdowns, etc.).*

2.9.	Mean treatment flow	50 m^3/h
2.10.	Expected sludge production	0.12 kg D.M. per kg of raw material (green weight)
2.11.	Total sludge production	2,880 kg D.M. per day (i.e. 72 m^3/day of liquid sludge at 4% of solids)

Note: D.M. means Dry Matter.

2.12.	Chrome recoverable in the spent tanning liquors	45 kg/day ca. as Cr_2O_3 (*)

(*) current situation. This amount has been calculated (see point 1.6.3.) on the basis of 11,500 kg (pelt weight) of hide uppers and splits tanned per day. I.e. 10 m^3 of spent liquors with an average content of 4.5 g/l of Cr_2O_3. The eventual future contribution of the skins (10,000 kg/day pelt weight) will be about 25 kg/day ca. of Cr_2O_3 (8 m^3/day of spent liquors with a content of ca. 3.2 g/l of Cr_2O_3.

3. PROJECT DATA

3.1. Characteristics of the raw influent (*):

(*) average data based on similar effluents

pH		:	8 - 10
BOD_5	(mg/l)	:	2,500 - 3,000
COD	(mg/l)	:	4,000 - 6,000
S.S.	(mg/l)	:	3,000 - 4,000
Cr III	(mg/l)	:	60 - 80
S^{2-}	(mg/l)	:	40 - 60
O. & G.	(mg/l)	:	500 - 1,000

Abbreviations:

pH	= logarithm of the reciprocal of the hydrogen ion concentration;
BOD_5	= Biochemical Oxygen Demand, 5 days (Winkler method);
COD	= Chemical Oxygen Demand (dichromate reflux method);
S.S.	= Suspended Solids;
Cr III	= Trivalent Chromium;
S^{2-}	= Sulphide (as S);
O. & G.	= Oil and Grease;
S.M.	= Settleable Matter (Imhoff cone);
mg/l	= milligrams per liter;
ml/l	= milliliters per liter.

3.2. Final effluent expected standards (*):

(*) after primary and secondary treatments (see also point 3.3).

pH		:	7.5 - 8.0
BOD_5	(mg/l)	:	20 - 30
COD	(mg/l)	:	100 - 150
S.S.	(mg/l)	:	30 - 40
Cr III	(mg/l)	:	0.5 - 1.0
S^{2-}	(mg/l)	:	0.1 - 0.5
O. & G.	(mg/l)	:	5 - 10
S.M.	(ml/l)	:	0.2 - 0.5

3.3. Legislation

At the moment no specific standards exist in Ethiopia for the discharge of tannery or other industrial effluents into surface waters or sewer.
The matter is treated by various Ministries (Environment, Health and Industry) with obviously different approach concepts. Furthermore the most important part of the national industry was belonging to the same Government. With the end of the war, the recent privatisation of many industrial sectors (including leather) and the strong interest of the new Government in developing the tourism resources of the Country have changed the situation and, now, the enviromental aspects are considered with more concern. A special Government Committee is working on the problem and a new legislation on this matter is expected in short. It is general opinion that the future legislation will adopt discharge standards similar to those existing in Europe and other developed Countries.

3.4. Some further considerations

The project of E.T.P. drafted by Studio Tecnico Dr. G. Clonfero (see Progress Report - 15 Feb. 1993) has been illustrated and discussed with the tannery's management in the mission in Ethiopia of March 1993.
The proposed treatment process is resulted correct both in its design criteria and calculations; only two small recommendations have been done by the Ethiopian technicians.

i. They asked the expert to evaluate the possibility of adapting an existing tank in concrete (the original E.T.P.) and using it in the new plant.
The expert in his first design has ignored this tank because not built according to the Ethiopian antiseismic legislation/criteria (Addis Ababa is located in a 2nd level seismic zone).

ii. They agree with the expert' suggestion of installing a chrome recovery plant but they ask for a simpler (less expensive) alternative (precipitation with MgO). They said to have already tested successfully this method in the factory's laboratory.

The local cost of the chrome sulphate and other chemicals has been investigated for a better evaluation of the cost/benefit of the chrome recovery and of the operation cost of the primary treatment.

In this mission the expert was informed that near the tannery there is a pipe-line connected with the municipal sewage treatment plant of Kaliti. So the expert has believed useful to visit the plant and to meet the plant's directors for more details on the installed facilities.

This plant (2 facultative, 2 maturation and 2 polishing ponds) was installed for treating ca. 7,500 m3 and 3,500 kg of BOD5 per day (hydraulic and organic loading) but is far to its design parameters: it treats about 10% of its project capacity. Especially in the dry season, this causes problems to the plant's operation: for facing near Akaki river. So there are chances that the [illegible] accept favourably the discharge into the sewer of the tannery effluent after suitable pre-treatment. This could be a good opportunity for avoiding the installation of a secondary treatment at Awash tannery or, at least, delaying its implementation. The Awash tannery will continue the contacts with the Municipal plant's management; Studio Tecnico Dr. G. Clonfero will in any case include the plant's biological phase as optional in its Final Report for the Contract 92/134. A phased implementation of the ETP is in any case recommended.

The implementation steps may be the following:

Phase one:
- Primary treatment,
- Chrome recovery,
- Sludge treatment.

Phase two:
- Biological treatment.

4. PROCESS DESCRIPTION (see also the annexed flow-sheet)

Foreword

The here proposed treatment is based on the following assumptions:

i. rains waters are separately collected and discharged.
ii. sanitary waters from the factory will undergo a pre-treatment into septic tanks before to be eventually piped to the biological phase of the plant.
iii. the production process does not foresee the use of organic solvent in the hide degreasing cycles.
iv. the pre-treatment of the Chrome waters (see Progess Report) has been substituted with a Chrome recovery plant using MgO.

These wastes are then pumped to the equalization tank and mixed with the other tannery effluents.

4.2. Primary treatment

The effluents from the tannery are screened (brushed screen) and sent by gravity into the equalization and sulphide oxidation basin. This tank will receive also the supernatant and washing waters of the Chrome recovery plant. The equalization is necessary to realize a good mixing (homogenization) of the various streams and to eliminate the flow-peaks (hydraulic equalization) of the factory in order to obtain an uniform and constant effluent to treat. In order to avoid sedimentation of solids, this basin is mixed through injection of air (blower and air diffusers - *Alternative 1* or Venturi ejectors - *Alternative 2*). The injected air enables the oxidation of sulphide too; this process is catalysed by the addition of Manganese II salts. A submersible pump re-distributes the daily treated mixed liquor to the further treatment phases in a period of 20 hrs ca.
The successive coagulation and flocculation process is done adding Alum and Polyelectrolyte . This treatment with chemicals enables both a reduction of the load sent to the biological phase and an increase of the settleability of the solids. The flocculated effluent flows by gravity into the primary sedimentation tank where the most of solids contained in the effluent settles as sludge and the clear supernatant is piped to the biological treatment.

4.3. Secondary treatment

The biological treatment is an extended aeration that is realized in three successive steps:
- aeration (BOD-removal through bio-absorption/flocculation of the soluble/suspended organic matter)
- sedimentation (physical treatment necessary in order to separate the biological sludge from the treated water)
- biological sludge recycle (the settled sludge is continuously re-pumped into the aeration tank to maintain the bacterial mass necessary to the process.

The aeration tank is designed for 40 hrs retention time and the oxygen necessary to the process is supplied by blowers and air diffusers. The secondary sedimentation is realized into a circular tank fitted with rotary bridge mechanism for sludge-scraping.
A submersible pump recycles the settled sludge to the aeration tank. Periodically, the excess of sludge is discharged throught a by-pass-valve into the equalization basin.

4.4. Sludge Treatment

All the produced sludge is extracted from the primary sedimentation tank. The sludge is drawn-off from the bottom of the tank and pumped (submersible pump) to the dewatering unit (band press or filter press) after a previous conditioning with chemicals (lime-milk until pH = 10). The sludge cake is sent to the final disposal (land-fill or burial) and the filtration waters piped back to the general treatment.

5. CALCULATIONS

5.1. SPENT LIMING WASTES STORAGE AND RE-PUMPING

5.1.1. Volume of discharge

The adopted volume is 250 m^3/day: 100 m^3 of concentrated spent lime liquors and 150 m^3 of successive washing waters (see point 1.7).
These quantities are quite cautionary, they represent:
- liming 100 m^3 = 400% ca. of the green weight
- washings 100 m^3 = 600% ca. of the green weight.

5.1.2. Rate of discharge

The discharge peak flow (two 3.5 x 3.5 m, drums contemporary discharged in 15 min) is 2 x 15 x 60/15 = 120 m^3/h.

5.1.3. Screening

A brushed screen, with minimum capacity of 150 m^3/h of liming wastes, has been adopted.

5.1.4. Storage

The existing tank with a useful volume of 250 m^3 ca. will be used.

5.1.5. Mixing

A minimal specific power of 30 Watt/m^3 has been adopted for mixing and avoiding the deposit of solids.
Total required power (250 x 30/1,000) = 7.5 kW.
Two 4.7 kW submersible Venturi ejector have been adopted.
Note: the adopted ejectors will furnish 10 kg/h of oxygen at standard conditions; let the oxygen transfer efficiency in the real operating conditions be 70%, i.e. 10 x 0.7 = 7 kg/h.
This oxygen will be able to oxidize 7 kg/h ca. of S^{2-} and must be considered in the calculation of the total oxygen necessary for sulphide oxidation (see ahead).

5.1.6. Re-pumping

The same working period inside the factory, i.e. 12 hrs/day, will be utilized as re-pumping period. Capacity of the pump 250 : 12 = 21 m^3/h.

Note: a submersible pump operated by a programmed timer has been adopted for the re-pumping flow regulation.

5.2. GENERAL EFFLUENT TREATMENT

a. PRIMARY TREATMENT

5.2.1. Total volume

The daily effluent volume to be treated is 1,000 m^3.

5.2.2. Peak flow

Working period inside the factory = 12 hrs per day.
The mean volume of the general effluent is 750 m^3/day (1,000 - 250 of lime waste). The small volume of the spent chrome tanning liquors has not been here considered.
The average discharge flow of the general effluents line is 750 : 12 = 62.5 m^3/h.
Peak factor = 2 (adopted).
Peak flow (62.5 x 2) = 125 m^3/h.

5.2.3. Screening

A brushed screen with minimum capacity of 150 m^3/h of tannery effluent has been adopted.

5.2.4. Equalization and sulphide oxidation

a. Hydraulic equalization and wastes homogenization

The hydraulic equalization necessary during the first phase of the plant's installation is minimal: in fact the mean discharge period from the factory is 12 hrs/day; i.e. the mean influent flow is 85 m^3/h ca. and the out-let flow 1,200 : 20 = 60 m^3/h.
Note that 200 m^3/day are internal recycles due mainly to the sludge dewatering.
The difference (85 - 60) x 12 hrs is 300 m^3.
The above-reported separation and uniform dosage of the concentrated liming wastes makes possible a reduction of the volume of the equalization tank. The retention time for the homogenization of the various effluents has been here reduced to 12 hrs (normally 24 hrs are adopted in the design of tannery effluent treatment plants). Furthermore, in view of rather large tank for the pre-treatment/storage of the lime liquors the capacity of the equalization tank has been reduced at 60% of the daily waste water volume. The here recommended tank has a total volume of 600 m^3. The retention time (600/1,200 x 24) is about 12 hrs. In practice, 300 m^3 ca. will be the minimal water volume in the tank with an average retention time of 300 : 60 = 5 hrs ca. able to guarantee the necessary time for sulphide oxidation.
The remaining 300 m^3 will be used for absorbing the tannery's flow-peaks.

b. power for mixing

Alternative 1 (*blower and air diffusers*)

Note: in the case of mixing by air injection the design parameter is the <u>specific air rate</u> (m^3 of air per m^2 of basin) per hour. The power of the necessary blower is so a consequence of both the necessary air volume per hour (that must be previously calculated) and the operational conditions (head) of the system. In the case of Awash tannery the total necessary power has been calculated in 22 kW. The specific installed power results, so, about 36.7 watt per m^3 of basin.

Quantity of air for the mixing and avoiding deposit of solids: 2 Nm^3/h per m^3 of tank volume (adopted).
Total necessary air (2 x 600) = 1,200 Nm^3/h.

Alternative 2 (*Venturi ejectors*)

Power necessary for mixing 30 Watts per m^3 of tank volume (adopted).
Total necessary power (30 x 600 : 1,000) = 18 kW.

c. Sulphide oxidation

The oxygen required for the oxidation of sulphide has been so calculated.
On the basis of an addition of 3% of Na_2S and 2% of NaHS on green weight (max. 24,000 kg/day). 24,000 x 0.03 = 720 kg of Na_2S at 60%, equivalent to 720 x 0.60 = 432 kg of 100% Na_2S or 432 x 32/78 = 177 kg ca. of S^{2-}. 24,000 x 0.02 = 480 kg of NaHS at 72%, equivalent to 480 x 0.72 = 345.6 kg of 100% NaHS or 345.6 x 32/56 = 198 kg ca.of S^{2-}.
Total sulphide used (177 + 198) = 375 kg of S^{2-} per day.
Let 80% of this quantity be discharged with the spent liquors, i.e. 375 x 0.80 = 300 kg/day of S^{2-}. 84 kg/day of S^{2-} (7 x 12 hrs) are oxidised in the liming storage tank, therefore 300 - 84 = 216 kg of S^{2-} must be treated in the equalisation tank at the rate of 216 : 12 = 18 kg/h.

<u>Alternative 1</u>

The installed air injection is able to supply a total of 1,200 Nm^3 of air per hour. Considering an oxygen transfer efficiency of 20% at the real operational conditions, (1,200 x 0.28 x 0.2) 67 kg/h of oxygen are supplied. The aeration equipment results over-abundant; on the other hand reducing the air rate will increase the risk of solid deposits.

<u>Alternative 2</u>

The installed Venturi ejectors are capable to supply a total of 22 kg of oxygen per hour in standard conditions. Considering an oxygen transfer efficiency of 85% in the real operational conditions, (22 x 0.85) 18.7 kg/h of oxygen are supplied. The aeration equipment results appropriate.

d. Dosage of the catalyst

Manganese sulphate, catalyst of the sulphide oxidation, will be dosed in 20 mg/l quantities only if strictly necessary.

The maximum consumption is 1,000 x 20/1,000 = 20 kg/day of industrial product (80% ca. of $MnSO_4$) or 20 x 0.80 x 54.94/151.94 = 5.8 kg of Mn^{2+} per day. The $MnSO_4$ is dosed in solution at 5%, i.e. 20 x 100/5 = 400 l/day, with a dosing pump of 30 l/h ca. capacity.

5.2.5. Lifting

The total volume of effluents to be daily pumped is about 1,200 m^3/day: 1,000 m^3 waste waters from the tannery + 200 m^3 ca. of waters from the sludge filtration that are recycled to the equalization tank.
Hours of treatment per day = 20 (adopted).
Treatment flow 1,200 : 20 = 65 m^3/h.
A submersible pump, capacity 1,200 l/min at 5 m, has been adopted; the flow will be regulated by means of a by-pass valve.

5.2.6. Flocculation

Minimum retention time: 5 minutes (adopted).
Volume of flocculation tank (65 : 60 x 5): 5.5 m^3.
A tank of dimensions 1.8 x 1.8 x 2 H metres has been adopted.
A slow mixer will be installed for the necessary mixing.

5.2.7. Dosage of chemicals

During the plant commissioning, the amount of chemicals will be adjusted to the practical results and the required efficiency. The quantities here indicated are the mean values generally used in similar plants.

Alum, industrial $Al_2(SO_4)_3 \cdot 18\ H_2O$, average dosage = 300 mg/l;
1,000 x 300/1,000 = 300 kg/day or 3,000 litres solution at 10%.

Polyelectrlyte, anionic powder, average dosage = 1 mg/l;
1 kg/day or 1,000 litres of solution at 0.1%.

A dosing pump, capacity 0-200 l/h, adopted for the Alum.
A dosing pump, capacity 0-100 l/h , adopted for the Polyelectrolyte.

5.2.8. Primary sedimentation
Minimal retention time = 2 hrs (adopted).
Maximum surface loading 1 m^3/m^2 per hour.(adopted).
A circular sedimentation tank of a diameter of 10 metres sedimentation tank adopted (for shape and dimensions see the paragraph "civil works"); surface 78.5 m^2 and volume 150 m^3.
Retention time (150 : 65) = 2.3 hrs.
Surface loading (65 : 78.5) = 0.8 m^3/m^2 per hour.

b. SECONDARY TREATMENT

Note: a primary treatment alone will hardly comply with the general standards for the discharge into surface waters.
A properly operating primary treatment can produce a final tannery effluent with the following realistic characteristics (*):

- pH	:	7 - 9
- BOD_5	:	500 - 800 mg/l
- COD	:	1,000 - 1,500 mg/l
- Oil & grease	:	traces
- Phenols	:	very variable (depending on the production process)
- Chromium tot.	<	1.0 mg/l
- Suspended Solids	<	100 mg/l

(*) main parameters

The reduction of the residual BOD, COD and phenols can be obtained only via biological treatment: to increase the dosage of chemicals in the flocculation process will result only in a massive increase in sludge production.

5.2.9. Biological treatment

The process adopted for the secondary treatment is an "extended aeration":
- retention time in the aeration tank: 48 hrs (adopted)
- volume of the aeration tank (1,000 x 2): 2,000 m^3 (*)
- F/M ratio < 0.1 kg of BOD_5/kg of MLVSS in the oxidation tank (adopted).

(*) The internal recycles have not been considered.

Note:
F = organic loading, kg BOD_5 of the influent per day.
M = mass of Mixed Liquor Volatile Suspended Solids (MLVSS) in the aeration tank (quantity of active biological sludge).

F = 1,000 x 1 = 1,000 kg of BOD_5/day (*)

M = 1,000 : 0.1 = 10,000 kg of MLVSS

MLVSS (10,000 : 2,000): 5,000 mg/l.

(*) an influent BOD of 1,000 mg/l has been considered.

5.2.10. Oxygen requirement (O.R.)

$$O.R. = \frac{(a \times F) + (b \times M)}{24}$$

where:

O.R. = total oxygen requirement per hour.
 a = coefficient related to O_2 requirement for synthesis.
 F = organic load, kg BOD/day

 b = coefficient related to O_2 requirement for endogenous sludge respiration.

Replacing the project's data and assuming:

 a = 0.8 and b = 0.15 (experimental data)

$$O.R. = \frac{(0.8 \times 1,000) + (0.15 \times 10,000)}{24} = 96 \text{ kg/h ca.}$$

Let the oxygen transfer efficiency of the installed air diffusers be 15% at the operational conditions:
 96 x 100 : 15 = 640 kg/h of O_2 must be furnished or
 640,000 : 280 = 2,286 Nm^3 of air per hour.

5.2.11 Secondary sedimentation

- superficial load = 0.5 m^3/m^2 of tank surface per hour (adopted);
- influent flow 60 m^3/h;
- total necessary surface = 60 : 0.5 = 120 m^2.

A circular tank of 12 metres of diameter has been suggested.

5.2.12. Sludge recycle

- recycle rate = 100% (adopted) (*);
- capacity of the recycling pump = 60 m^3/h.

(*) Note: *as general habit, 100% recycle rate means that the volume of the settled secondary sluge repumped to the aeration tank equals the volume of the hourly raw influent. This does not imply any draw-off of the excess sludge produced in the biological process. In fact periodically part of the sludge must be discharged in order to mantain the correct concentration of suspended solids in the aeration tank. The surplus of sludge is discharged by the same recycle pump operating on the by-pass to the equalization basin.*

5.3. SLUDGE TREATMENT

5.3.1. Production of sludge (primary & secondary)

Assumed a sludge production of 0.12 kg of dry matter per kg of processed hides or skins (green weight): a daily production of 24,000 x 0.12 = 2,880 kg of sludge dry matter or (2,880 x 100 : 4) 72,000 litres (72 m^3) of liquid sludge with a 4% dry content is expected.

5.3.2. Sludge dewatering station

Alternative 1: Filter press

Assuming a final sludge cake at 30% of D.M., (2,880 x 100 : 30) 9,600 kg of dewatered sludge per day or (9,600 : 1,2): 8,000 litres. Adopting 4 filtration cycles per day, a filter with a minimum capacity of (8,000 : 4) 2,000 litres ca. is necessary.

Alternative 2: Band press

Capacity with tannery sludge 150 kg of sludge D.M. per meter of belt width per hour.
Assuming 15 hours per day of filtration we obtain (2,880 : 15) a minimum capacity of 192 kg of D.M. per hour.
A filter with 1,500 mm width (capacity 200-250 kg/h of D.M.) has been adopted.
The final solid content of the band press cake is about 25%.

5.3.3. Transport and final disposal

According to the over-indicated calculations, 9,600 or 11,520 kg/day of dewatered sludges (filter press or band press respectively) will be produced. This quantity must be collected by a lorry and daily transported to the final disposal (sanitary landfill or other).

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6. LIST AND PRICES OF THE NECESSARY EQUIPMENT

6.1. LIME LIQUORS STORAGE AND PRIMARY TREATMENT

6.1.1. n.2 **brushed screens**, type Parkwood.

Filtering panel, support frame and carters in stainless steel AISI 304, rotating brushes in polypropylene and nylon.

Characteristics:

- 1 kW motor 380 V, 50 Hz 3 phases insulated IP 55;
- filtering surface 1.3 m ca.;
- diameter of holes 3 mm;
- capacity 100 m^3/h of tannery waste water;
- n.3 brushed spaced at 120°.

Total Price: 14,000 U.S.$

6.1.2. n.2 **Venturi ejectors**.

Each consisting of a submersible pump CS 3127 MT 431 and two ejectors Mod. 4812.

Characteristics:

- 4.7 kW motor 380 V, 50 Hz 3 phases 4 poles insulated to F class;
- 2 ejectors Mod. 4812 100 mm diameter. length 1,000 mm with nozzles of 55 mm diameter and 5 m snorkels for the air suction;
- oxygen transfer 5.5 kg/h at standard conditions.

Materials:

- pump's mechanical face seals with tungsten carbide seal rings for continuous operation.
- Venturi tube and snorkel in stainless steel AISI 304, nozzle in plastic material.

Total Price: 17,800 U.S.$

6.1.3. n.1 **submersible pump**, for waste water with high solid content.

Body and propeller in cast iron with rubber paint, shaft, studs and nuts in stainless steel AISI 304.

Characteristics:

- 1.1 kW motor 380 V, 50 Hz, 3 phases, 4 poles, insulated to F Class;
- vortex impeller with solid passing of 50 mm diameter;
- capacity 400 l/min. at 4 m head.

The pumps is equipped with a hose connection, base stand and strainer.

Price: 1,200 U.S.$

6.1.4. n.1 **rotary vane blower** able to supply oil-free air, rotors and body in spheroidal cast iron, direct driving through flexible anti-shock coupling to 22 kW motor 380 V, 50 Hz, 2 poles, threephase, protection IP 55.
Technical specifications:
- capacity = 1,200 Nm^3/h of air at 0.4 Bars;
- max. head = 0.5 Bars.

The blower is equipped with:
- suction filter,
- suction and discharge silencers.
- non return valve;
- safety valve;
- flexible anti-vibration connection and shock insulating feet.

Price: 8,800 U.S.$

6.1.5. n.1 **air distribution device** consisting of:
- 250 non-clog air diffusers (medium/small bubbles) with cone-shaped base in polypropylene and flexible perforated EPDM membrane for the air escape in fine bubbles.
  Oxygen transfer efficiency 20% ca.;
- air distribution net-work in galvanized steel (out-side part) and in PVC (submerged part);
- air regulation valves;
- clamps for the device fixing at the walls of the tank in concrete.

Total Price: 18,000 U.S.$

<u>or in alternative to the Items 6.1.4. and 6.1.5.</u>

6.1.4.bis n.4 **Venturi ejectors.**
Each consisting of a submersible pump CS 3127 MT 431 and two ejectors Mod. 4812.
Characteristics:
- 4.7 kW motor 380 V, 50 Hz 3 phases 4 poles insulated to F class;
- 2 ejectors Mod. 4812 100 mm diameter. length 1,000 mm with nozzles of 55 mm diameter and 5 m snorkels for the air suction;
- oxygen transfer 5.5 kg/h at standard conditions.

Materials:
- pump's mechanical face seals with tungsten carbide seal rings for continuous operation.
- Venturi tube and snorkel in stainless steel AISI 304, nozzle in plastic material.

Total Price: 35,600 U.S.$

6.1.6. **submersible pump** designed to pump liquid containing solids up to 76 mm diameter.
Materials:
pump body and impeller in cast iron;
shaft, nuts and screws in stainless steel AISI 304;
o-rings in nitrile rubber;
mechanical face seals in ceramic.
Surface treatment:
impeller: sprayed with primer
pump exterior: primer (PVC Epoxy) and finish (chloric rubber paint).
Version with discharge connection: the pump slides down along guide bars and connects automatically .
Characteristics:
capacity = 1.500 l/min at 4 m head;
motor = 2 kW, 380 V, 50 Hz 3-phases, insulation class F.

Price: 3,000 U.S.$

6.1.7. n.1 **mixer** for the flocculation tank,
shaft and paddles stainless steel AISI 304.
Characteristics:
- 0.5 kW motor 380 V, 50 Hz 3 phases protection IP 55;
- vertical speed reducer, coaxial type with oil lubricated gears;
- shaft speed 100 r.p.m. ca.;

Complete with support frame in stainless steel AISI 304 for the installation onto the tank in concrete.

Price: 2,400 U.S.$

6.1.8. n.3 **reservoirs**, in acid proof material, for the dissolution of chemicals ($MnSO_4$, Alum and Polyelectrolyte)
Capacity 2,000 litres.
Complete of support for the installation of the mixer and the dosing pump.

Total Price: 2,400 U.S.$

6.1.9. n.3 **mixers** for the dissolution of chemicals ($MnSO_4$, Alum and Polyelectrolyte), shaft and paddles in stainless steel AISI 304.
Characteristics:
- 1.5 kW motor, 380 V, 50 Hz, 3 phases, protection IP 55;
- vertical speed reducer, coaxial type with oil lubricated gears;
- shaft speed 200 r.p.m. ca.

Total Price: 4,800 U.S.$

6.1.10. n.2 **dosing pumps** ($MnSO_4$ and Polyelectrolyte) body in PVC, plunger in ceramic and no-return valves in stainless steel AISI 316.
Characteristics:
- 0.3 kW, motor 380 V, 50 Hz 3 phases protection IP 55;
- capacity variable from 0 to 150 l/h;
- maximum working head 2.5 bars.

Total Price: 4,400 U.S.$

6.1.11. n.1 **dosing pump** (Alum) body in PVC, plunger in ceramic and no-return valves in Pyrex glass.
Characteristics:
- 0.3 kW, motor 380 V, 50 Hz 3 phases protection IP 55;
- capacity variable from 0 to 200 l/h;
- maximum working head 2.5 bars.

Total Price: 2,500 U.S.$

6.1.12. n.1 **sludge scraping devices** for circular primary sedimentation tank in concrete, 10 m. diameter.
Technical specifications:
motor 0.5 kW 380 V, 50 Hz, 4 poles, three phases, protection IP 55, with two speed reducers in series.
Peripheral speed 2.5 m/min. ca.
Electrowelded structure in hot galvanized steel.
Equipped with:
- over-flow weir type Thomson and scum-baffle in stainless steel AISI 304;
- influent well in stainless steel AISI 304;
- surface scum-blade scraper and scum-troug in stainless steel AISI 304;
- bottom sludge scraper in hot galvanized steel and rubber blades;
- flanged inlet and outlet connection and sludge draw-off pipe in Fe 37.

Price: 28,000 U.S.$

6.1.13. n.1 **control board** for the operating and control of the electrical equipment of the E.T.P.
The control board is designed in accordance with the standards of the European Electricity Committee.
The board is made for the installation under a covered area.

Price: 13,000 U.S.$

6.1.14. -- **piping:**
pipes, valves and fittings for the hydraulic connections of the primary treatment.
The materials (PVC, steel, polythene, etc.) and the sizes are different according to the characteristics of the piped product and the required flow or head.

Total Price: 8,000 U.S.$

6.1.15. -- **electrical wiring:**
cables of different sections and accessories for the connection and/or control of the electrical equipment of the E.T.P. including installation/clamping devices with the exclusion of the main line from the tannery's power station to the control board.

Total Price: 6,000 U.S.$

Sub total 6.1 (blower & diffusers in equalization) 130,300 U.S.$

Sub total 6.1 bis (Venturi ejectors) 139,100 U.S.$

6.2. BIOLOGICAL TREATMENT

6.2.1. n.2 **rotary vane blowers** and accessoires, identical to that described at item 6.1.4.

Price: 17,600 U.S.$

6.2.2. n.1 **air distribution device** consisting of:
- n. 500 membrane non-clog air diffusers(fine/medium bubbles), support in polypropylene and flexible membrane in EPDM; oxygen transfer efficiency = 20% ca.;
- air distribution net work, pipes, connections, etc. in galvanized steel (outside) and PVC (submerged parts);
- air regulation valves ;
- clamps for fixing at the tank walls.

Total Price: 35,000 U.S.$

6.2.3. n.1 **sludge scraping device** for 12 m diameter circular secondary sedimentation tank.
Technical specifications:
motor of 0.5 kW, 380 V, 50 Hz, 4 poles,three phases, protection IP 55, with two speed reducer;
peripheral speed 2.5 m/min. ca.
Electrowelded structure in hot galvanized steel.
Equipped with:
- over-flow weir type Thomson and scum-baffle in stainless steel AISI 304;
- surface scum-blade scraper and scum-troug in stainless steel AISI 304;
- bottom sludge scraper in hot galvanized steel and rubber blades;
- central influent well in hot galvanized steel;
- flanged inlet and outlet connection and sludge draw-off pipe in Fe 37.

Price: 28,000 U.S.$

6.2.4. n.1 **submersible pump**, identical to that of item 6.2.6.

Price: 3,000 U.S.$

6.2.5. n.1 **control board** realized in plastic material for the operation and control of the effluent treatment plant. The board is designed according with the standards of the European Electricity Committee. The board is executed for the installation under a cover area.

Price: 2,500 U.S.$

6.2.6. -- **piping:**
pipes, valves and fittings for the hydraulic connections of the secondary treatment.
The materials (PVC, steel, polythene, etc.) and the sizes are different according to the characteristics of the piped product and the required flow or head.

Total Price: 3,000 U.S.$

6.2.7. -- **electrical wiring:**
cables of different sections and accessories for the connection and/or control of the electrical equipment of the E.T.P. including installation/clamping devices with the exclusion of the main line from the tannery's power station to the control board.

Total Price: 2,000 U.S.$

Sub total 6.2. 90,100 U.S.$

6.3. SLUDGE TREATMENT

6.3.1. n.1 **submersible pump** identical to that of item 6.1.6.

Price: 3,000 U.S.$

6.3.2. n.1 **submersible mixer**, body and propeller in cast iron with chloric rubber paint; shaft, screws, studs and nuts in stainless steel AISI 304; o-rings in nitrile rubber.
Characteristics:
motor 2.2 kW, 380 V, 50 Hz, threephases, insulation to Class F, 4 poles coupled with a spur gear with helical teeth;
propeller speed = 1,400 rpm ca.
Blades propeller with 300 mm diameter.
The mixer is supplied with installation/lifting system consisted of:
lifting david, guide holder sets(upper and lower) and 4 m guide bar 100 x 100 mm in galvanized steel.

Price: 4,000 U.S.$

6.3.3. **n.1 lime milk preparation and dosage unit,**
consisting of:
- n.1 mixer, shaft and paddles in stainless steel AISI 304, motor of 1.2 kW, 380 V, 50 Hz, 4 poles, threephases, protection IP 55;
  vertical gear box coaxial type with oil lubricated gears, shaft speed = 400 rpm ca.,
  support frame in hot galvanized steel for the installation on a 5 m^3 concrete tank.
- n.1 centrifugal pump, body and propeller in stainless steel AISI 304, capacity = 50 l/minute, 0.5 kW motor, 380 V, 50 Hz, 4 poles, threephases, protection IP 55, installed on a support frame in galvanized steel.

Price: 3,500 U.S.$

<u>Sludge dewatering: alternative 1 (plate filterpress)</u>

6.3.4. **n.2 filter presses** for the sludge de-watering.
<u>Materials</u>:
- steel frame with corrosion proof painting,
- plates and filtering clothes in polypropylene.

<u>Characteristics</u>:
- Plates dimensions 800 x 800 mm.
- Filter frame max. capacity 100 plates.
- Number of installed plates 70
- Filtering surface 60 m^2 ca.
- Volume of the cake 1,000 litres ca.
- Dryness of cake 30-35%.
- Hydraulic closure of the filtering plates by oil-power and double-acting plunger.
- Installed power of the hydraulic closure 5.5 kW ca.
- Manual displacement of the plates.

<u>Filter complete of</u>:

- <u>Piston/membrane pump</u> for the feeding of the filter, capacity 10 m^3/h, motor with speed reducer 5.5 kW, 380 V, 50 Hz, three phase, protection IP 55;
- <u>Belt conveyor</u> for the cake transport, length 9 m. ca., motor 1.1 kW, 380 V, 50 Hz, IP 55.
- <u>General control panel</u> for the operation and control of the sludge treatment station. The board is executed for the installation under a cover area.

Total Price: 110,000 U.S.$

Sludge dewatering: alternative 2 (band press)

6.3.5. n.1 unit for dosage of chemicals (Polyelectrolyte) consisting of:
- dosing pump, body and plunger in PVC, non-return valves in stainless steel AISI 304; motor 0.2 kW, 380 V, 50 Hz, 4 poles, threephases, protection IP 55;
  capacity variable from 0 to 100 litres/hour;
  max. head = 2.5 Bars.
- 2,000 litres reservoir in polypropylene.
- slow-speed mixer, shaft and paddles in stainless steel AISI 304, motor of 1.1 kW, 380 V, 50 Hz, 4 poles, threephases, IP 55; coupled with vertical gear box reducer; shaft speed = 100 rpm.

Total Price: 10,000 U.S.$

6.3.6. n.1 helicoidal pump, eccentric screw type Mohno.
Materials:
- body in cast-iron,
- screw in hard chromium plated steel,
- rotor in synthetic rubber.

Characteristics:
Capacity variable form 3 - 15 m^3/h at 2 bars.
Motor 4 kW, 380 V, 50Hz, three phase,
protection IP 55 coupled with variable speed reducer.
Rotor speed 100 - 400 r.p.m. ca.

Total Price: 8,000 U.S.$

6.3.7. n.1 belt press
Characteristics:
- belt width 1,500 mm
- belt speed variable between 2 and 10 m/min.;
- capacity 250 kg of D.M. per hour.
- dryness of cake 25 % ca.
- water consumption for belt washing 10 m^3/h ca. at 4 bars.
- polymer consumption 2-4 g per kg of D.M. (*)
- lime consumption 4 g per litre of liquid sludge ca.
- installed power 2.5 kW.

(*) the type of polyelectrolyte (anionic or cationic) must be defined during the plant start-up.

Materials:
- rigid frame in steel with epoxy paint;
- rollers in steel with rubber coating (driving and pressing) and in steel with special plastic coating (draining);
- rotary drum sludge conditioner in stainless steel AISI 304;
- belt scrapers (cake discharge) in PVC and stainless steel AISI 304;

- band washings boxes in stainless steel AISI 304;
- all other parts in contact with the sludge in stainless steel AISI 304;
- belts in polyester fibres with 180 kg/cm tearing load.

Filter complete of:

- High pressure pump for the washing of the belts, capacity 200 l/min. at 4 bars. body and propeller in cast iron; motor of 2.2 kW 380 V, 50 Hz, 2 poles, threephases protection IP 55. The pump is installed on a support frame in hot galvanized steel.
- Inclined belt conveyor for the transport of the sludge cake; length 6 m. ca.; inclination 30° ca.; motor of 1.1 kW, 380 V, 50 Hz, 4 poles, threephase, protection IP 55, coupled to speed reducer. Materials:
  - belt in acid-proof material;
  - frame in hot galvanized steel;
  - rollers in steel with special plastic coating.
- Air compressor for the tearing and self-aligning of the belts. Capacity 200 l/min. of air; volume of the air reservoir 25 litres; maximum work pressure 8 Bars; installed power 1.1 kW, 220/380 V, 50 Hz, threephases.
- General control panel for the operation and control of the sludge treatment station. The board is executed for the installation under a cover area.

Total Price: 85,000 U.S.$

6.3.8. n.1 control board realized in plastic material for the operation and control of the sludge treatment. The board is designed according with the standards of the European Electricity Committee. The board is executed for the installation under a cover area.

Price: 1,500 U.S.$

6.3.9. -- piping: pipes, valves and fittings for the hydraulic connections of the sludge treatment. The materials (PVC, steel, polythene, etc.) and the sizes are different according to the characteristics of the piped product and the required flow or head.

Total Price: 1,600 U.S.$

6.3.10. -- electrical wiring:
cables of different sections and accessories for the connection and/or control of the electrical equipment of the E.T.P. including installation/clamping devices with the exclusion of the main line from the tannery's power station to the control board.

Total Price: 800 U.S.$

Sub total 6.3. (filter press) 124,400 U.S.$

Sub total 6.3. bis (band press) 117,400 U.S.$

SUMMARY OF COSTS	
LIME WASTES STORAGE & PRIMARY TREATMENT (*)	130,300 U.S.$
LIME WASTES STORAGE & PRIMARY TREATMENT (**)	139,100 U.S.$
SECONDARY TREATMENT	89,600 U.S.$
SLUDGE TREATMENT (***)	124,400 U.S.$
SLUDGE TREATMENT (****)	117,400 U.S.$

(*) Alternative 1: blower and air diffusers (equalization)
(**) Alternative 2: Ventury ejectors (equalization)
(***) Alternative 1: filter press (sludge dewatering)
(****) Alternative 2: band press (sludge dewatering)

7. SPARE AND CONSUMPTION PARTS

Indicative price (see Note) for the spare and consumption parts for two years of the plant's operation:

7.1. Lime wastes storage and general treatment: . . . 5,000 U.S.$

7.2. Biological treatment: . . . . 4,000 U.S.$

7.3. Sludge treatment: . . . . 6.000 U.S.$

Note: the type and quantity of spare parts must be defined by the equipment' supplier according with its experience in similar plants, taking into account also the local peculiar situation.

8. PLANT COMMISSIONING & TRAINING OF THE LOCAL STAFF

8.1. Supervision during plant installation:

n.2 technicians for 20 days: **8,000 U.S.$**

Travel expenses (2 international trips), board and lodging at the charge of the recipient Company.

8.2. Plant start-up and training of the local personnel:

n.1 technician for 20 days: **8,000 U.S.$**

Travel expenses (two international trips), etc. at the charge of the recipient Company.

9. COSTS FOR THE PLANT'S OPERATION

(on the basis of 1,000 m^3 of waste waters per day)

9.1 Cost of chemicals:

a. prices of products already in use in the factory:
(the cost of imported chemicals is FOB)

1. Lime powder	- local -	: 0.30 Birr per kg
2. Alum (industrial product)	- imported -	: 0.18 DM per kg (0.95 Birr/kg)

DM = Deutschen Marks

Note: due to the change fluctuations, the prices must be considered indicative.

b. indicative price in Europe of the other products:

1. Anionic polyelectrolyte (powder)	: 3.8 U.S.$/kg
2. Manganese sulphate (cristals 98% grade)	: 1.0 "
3. Sodium Threephosphate (powder)	: 0.5 "

9.3 Electricity cost: 0.25 Birr (0.05 U.S.$ ca.) per kWh

9.4 Labour: 1.0 Birr (0.2 U.S.$ ca.) per hour

9.5 Indicative year costs of the treatment steps (300 work days):

Note: the consumptions (both of chemicals and energy) here indicated represent the average quantities used in similar plants.

General effluent treatment:

a) Primary treatment

Consumptions:

Alum	: 300 kg/day
Polyelectrolyte	: 1 kg/day
Manganese sulphate	: 20 kg/day
Electricity	: 600 kWh/day
Labour	: n.2 persons during the day + night-watchman (estimated 20 man/hours per day)

Year costs:

Alum	= 90,000 kg	= 85,500 Birr	= 17,200 U.S.$
Polyelectrolyte	= 300 kg	= 5,700 "	= 1,150 "
Manganese sulphate	= 6,000 kg	= 30,000 "	= 6,040 "
Electricity	= 180,000 kWh	= 45,000 "	= 9,055 "
Labour	= 6,000 hrs	= 6,000 "	= 1,210 "
Maintenance (**)			= 13,000 "
Miscellaneous costs(**)			= 2,000 "

Total operation costs = 49,655 (say 50,000) U.S.$ per year

b) Secondary treatment

Consumptions:

Sodium Threephosphate (eventual)	: 10 kg/day
Electricity	: 1,000 kWh/day
Labour	: none (the same of the primary treatment)

Year costs:

Na_3PO_4 (eventual) =	3,000 kg	= 7,500 Birr	= 1,500 U.S.$
Electricity =	300,000 kWh	= 75,000 "	= 15,090 "
Maintenance (**) =			= 8,960 "
Miscellaneous (**) =			= 1,000 "

Total operation costs = 26,550 (say 27,000) U.S.$ per year

c) <u>Sludge treatment</u>

1. filter-press

Consumptions:

Lime	:	300 kg/day
Electricity	:	150 kWh/day ca.

Year costs:

Lime	= 90,000 kg	= 27,000 Birr	=	5,435 U.S.$
Electricity	= 45,000 kWh	= 11,250 "	=	2,265 "
Maintenance (*)			=	11,740 "
Miscellaneous (**)			=	500 "

Total operation costs = 19.940 (say 20,000) U.S.$ per year

2. band press

Consumptions:

Lime	:	300 kg/day
Polyelectrolyte	:	6 - 12 kg/day
Electricity	:	190 kWh/day ca.

Year costs:

Lime	= 90,000 kg	= 27,000 Birr	=	5,435 U.S.$
Polyelectrolyte	= 3,600 kg	= 68,400 "	=	13,765 "
Electricity	= 57,000 kWh	= 14,250 "	=	2,870 "
Maintenance (*)			=	12,440 "
Miscellaneous costs(**)			=	500 "

Total operation costs = 35,010 (say 35,500) U.S.$ per year

(*) assumed to be 10% of major equipment cost (including repair and replacement costs).
(**) estimative (analysis, etc.)

10. <u>CIVIL WORKS</u> (Indicative dimensions)

Prior to the starting of the civil works the site must be cleared. All shrubs, trunks, grass and other vegetable matter must be removed and disposed of.

10.1. SEPARATION AND STORAGE OF THE SPENT LIME LIQUORS

10.1.1. Pit for the installation of the brushed screen:
lateral walls in block bedded with cement mortar and bottom in lean concrete with plastering of internal surface.
Internal dimensions: cm 125 x 190 x 70 H.
The pit is 30 cm above and 40 cm ca. below ground level.

10.1.2. Storage tank:
Walls in reinforced concrete 30 cm thick.
Internal dimensions: 800 x 1,000 x 350 H cm.
A hole 40 x 20 cm (overflow connection to the equalization tank) and a 25 x 25 hole cm (inlet of 200 mm pipe).
Useful volume: 250 m^3
Tank partially underground.

10.2. PRIMARY TREATMENT

10.2.1. Pit for the installation of the brushed screen:
see item 10.1.1.

10.2.2. Area for the storage of the screened solids in common with the liming line:
lateral walls in block bedded with cement mortar and lean concrete bottom with plastering of internal surface.
Internal dimensions: cm 150 x 370 x 45 H.

10.2.3. Equalization tank:
with lateral and bottom walls in reinforced concrete 30 cm thick.
Internal dimensions:
- width 800 cm,
- length 2,500 cm,
- height 350 cm (useful 300 cm).

Useful volume: 600 m^3
Partially underground tank: 150 cm above and 200 cm below the ground level.

10.2.4. Flocculation tank:
in reinforced concrete 30 cm thick.
Internal dimensions: 180 x 180 x 200 H cm.
Useful volume = 5.5 m^3.

10.2.5. Primary sedimentation tank:
circular tank of 10 m diameter
Complete of the bridge for the installation of the sludge scraping device and of the pit for the sludge extraction pump.
Dimensions:
- height of vertical wall = 2.5 m (2 m useful);
- useful volume = 150 m^3 ca.

Thank partially underground.

10.3. SECONDARY TREATMENT

10.3.1. Aeration tank:
with lateral and bottom walls in reinforced concrete 40 cm thick.
Internal dimensions:
- width 2,000 cm,
- length 3,500 cm,
- height 400 cm (useful 350 cm).

Useful volume: 2,000 m^3 ca.
Partially underground tank: 150 cm above and 250 cm below the ground level.

10.3.2. Secondary sedimentation tank
circular tank of 12 m diameter in reinforced concrete.
Complete of bridge in reinforced concrete for the installation of the sludge scraping device and pit for the sludge recycle pump.
Other dimensions:
- height of vertical wall = 2.8 m (2.3 m useful);
- useful volume = 260 m^3 ca.

Thank partially underground.

10.4. SLUDGE TREATMENT AND COMMON FACILITIES

10.4.1. Tank for the preparation of lime-milk:
in reinforced concrete.
Dimensions: 200 x 200 x 150 H cm.
Volume 5 m^3
Tank partially underground.

10.4.2. Tank for the sludge conditioning:
in reinforced concrete.
i. *Band press*, dimensions: 150 x 200 x 200 H cm.
ii. *Filter press*, dimensions: 200 x 500 x 300 H cm.

10.4.3. Covered area:
for the installation of the general control panel of the electric equipment of the plant and the dosing units, and for the storage of the chemicals used in the effluent treatment.
A portion of cm 500 x 200 is closed with lateral walls in blocks bedded with cement mortar (control board room) the remaining is open.
Dimensions: cm 500 x 1,250 x 400 H.

*****

11. BILL OF QUANTITIES AND ESTIMATION COSTS FOR CIVIL WORKS

Note: the local unit prices for building materials have been fournished by Mr. MICHAEL TSEGAI WOLDEZION, Civil Engineer of the Ethiopian National Leather and Shoe Coorporation.
In the visit of July some errors have been found both in the unit prices and in the characteristics of the local soil (resulted rocky).

Reinforced concrete Class C-80

Cement	150 kg
Sand	0.45 m3
Aggregate	0.84 m3

Work strenght 28 days = 80 kg/cm2

Indicative price: 250 Birr/m3

Reinforced concrete Class C-250

Cement	350 kg
Sand	0.39 m3
Aggregate	0.79 m3

Work strenght 28 days = 250 kg/cm2

Indicative price: 450 Birr/m3

ITEM	UNIT	QUANTITY	UNIT RATE (in Birr)	TOTAL PRICE (in Birr)
11.1 Site works				
11.1.1. bulk excavation of the mixed soil (natural ground and rocks to an average depth of m 0.30 from the current level.	m3	2,000	15	30,000
11.1.2. cart away , spread and deposit all surplus excavated material around site at distance not exceeding m 200.	m3	2,000	15	30,000
11.1.3. sub-base of the access road to the ETP, width about m 4, consisting of crushed stones, well packed and consolidated to finished thickness of m 0.20.	m2	1,000	20	20,000
11.1.4. blinding the crushed stones with red ash consolidation with 10-16 tons rollers.	m2	1,000	7	7,000
Sub total Item 11.1.				**87,000**

11.2. Gullits, pits and other accessoires for the screening stations (Lime and General effluent)

11.2.1.	excavation of mixed soil to a maximum depth of m 2.0 starting from the stripped level.			
	m3	20	15	300
11.2.2.	car away all surplus excavated material and deposit at a distance not exceeding m 200 from the site.			
	m3	20	15	300
11.2.3.	block walls m 0.20 thickness, consisting of concrete blocks of dimensions m 0.20x0.40x0.20 each, bedded with cement mortar and fixed to the r.c. base plate with steel reinforcement steel bars, diameter 8 mm, placed every m 0.80			
	m2	20	80	1,600
11.2.4.	steel bar reinforcement, diameter 8 mm, including cutting, bending, placing in position and tying wires.			
	kg	200	6	1,200
11.2.5.	plastering of the internal wall surfaces			
	m2	40	15	600
11.2.6.	lean concrete, type C-80, thickness m 0.20			
	m3	4	250	1,000
11.2.7.	concrete filler for slopes, type C-80			
	m3	2	250	500
11.2.8.	backfill and compacting of soil with good dry filling materials from the site around the pit walls (layer not exceeding m 0.15 of thickness)			
	m3	2	15	30

Sub total Item 11.2. 5,530

11.3. Storage tank for the spent lime liquors and Equalization tank

11.3.1.	excavation of mixed soil to a maximum depth of m 2.0 starting from the stripped level.			
	m3	800	15	12,000
11.3.2.	car away all surplus excavated material and deposit at a distance not exceeding m 200 from the site.			
	m3	800	15	12,000
11.3.3.	concrete lean, type C-80, forming the tank base of m 0.20 thickness.			
	m3	66	250	16,500
11.3.4.	m 0.30 thick reinforced concrete plate, type C-250,			
	m3	99	450	44,550
11.3.5.	m 0.30 thick reinforced concrete elevation walls, type C-250.			
	m3	99	450	44,550

11.3.6. concrete filler for slopes, type C-80.

m3	50	250	12,500

11.3.7. steel bar reinforcement, various diameters, including cutting, bending, placing in position and tying wires.

kg	15,000	6	90,000

11.3.8. provide, cut, and fix in position wood formwork for the r.c. elevation walls.

m2	660	60	39,600

11.3.9. backfill and compacting of soil with dry filling materials from the site around the excavated r.c. walls (layers not exceeding m 0.50 of thickness.

m3	50	15	750

<u>Sub total Item 11.3. . . . . 272,450</u>

11.4. **<u>Primary sedimentation tank</u>**

11.4.1. excavation of mixed soil to a maximum depth of m 2.0 starting from the stripped level.

m3	150	15	2,250

11.4.2. car away all surplus excavated material and deposit at a distance not exceeding m 200 from the site.

m3	150	15	2,250

11.4.3. concrete lean, type C-80, forming the tank base of m 0.20 thickness.

m3	25	250	6,250

11.4.4. m 0.30 thick reinforced concrete plate, type C-250,

m3	30	450	13,200

11.4.5. m 0.30 thick reinforced concrete elevation walls, type C-250.

m3	24	450	10,800

11.4.6. steel bar reinforcement, various diameters, including cutting, bending, placing in position and tying wires.

kg	6,000	6	36,000

11.4.7. provide, cut, and fix in position wood formwork for the r.c. elevation walls.

m2	160	75	12,000

11.4.8. backfill and compacting of soil with dry filling materials from the site around the excavated r.c. walls (layers not exceeding m 0.50 of thickness).

m3	40	15	600

<u>Sub total Item 11.4. . . . . 83,650</u>

11.5. **<u>Aeration tank</u>**

11.5.1. excavation of mixed soil to a maximum depth of m 2.0 starting from the stripped level.

m3	1,000	15	15,000

11.5.2. car away all surplus excavated material and deposit at a distance not exceeding m 200 from the site.

m3	700	15	10,500

11.5.3. concrete lean, type C-80, forming the tank base of m 0.20 thickness.
m3 160 250 40,000

11.5.4. m 0.30 thick reinforced concrete plate, type C-250,
m3 240 450 108,000

11.5.5. m 0.30 thick reinforced concrete elevation walls, type C-250.
m3 130 450 58,500

11.5.6. concrete filler for slopes, type C-80.
m3 30 250 7,500

11.5.7. steel bar reinforcement, various diameters, including cutting, bending, placing in position and tying wires.
kg 35,000 6 210,000

11.5.8. provide, cut, and fix in position wood formwork for the r.c. elevation walls.
m2 900 60 54,000

11.5.9. backfill and compacting of soil with dry filling materials from the site around the excavated r.c. walls
m3 120 15 1,800

Sub total Item 11.5. 505,300

11.6. Secondary sedimentation tank

11.6.1. excavation of mixed soil to a maximum depth of m 2.0 starting from the stripped level.
m3 350 15 5,250

11.6.2. car away all surplus excavated material and deposit at a distance not exceeding m 200 from the site.
m3 350 15 5,250

11.6.3. concrete lean, type C-80, forming the tank base of m 0.20 thickness.
m3 28 250 7,000

11.6.4. m 0.30 thick reinforced concrete plate, type C-250,
m3 40 450 18,000

11.6.5. m 0.30 thick reinforced concrete elevation walls, type C-250.
m3 36 450 16,200

11.6.6. steel bar reinforcement, various diameters, including cutting, bending, placing in position and tying wires.
kg 8,000 6 48,000

11.6.7. provide, cut, and fix in position wood formwork for the r.c. elevation walls.
m2 240 75 18,000

11.6.8. backfill and compacting of soil with dry filling materials from the site around the excavated r.c. walls (layers not exceeding m 0.50 of thickness).
m3 60 15 900

Sub total Item 11.6. 118,600

11.7. <u>Covered area</u>

11.7.1.	excavation of soil of natural ground to a maximum depth of m 0.25 starting from the stripped level.	m3	20	5	100
11.7.2.	car away all surplus excavated material and deposit at a distance not exceeding m 200 from the site.	m3	20	7	140
11.7.3.	m 0.15 thickness concrete lean, type C-80, under the floor.	m2	70	30	2,100
11.7.4.	m 0.20 reinforced concrete plate, type C-250, with slope and channels for water drainage.	m2	70	30	2,100
11.7.5.	m 0.10 concrete floor slab plate, type C-250,	m2	60	30	1,800
11.7.6.	m 0.20 thick walls realized in concrete blocks of dimensions m 0.20x0.40x0.20 each, bedded with cement mortar.	m2	50	80	4,000
11.7.7.	stiffening columns and top tie beams in reinforced concrete, type C-250.	m3	2	250	500
11.7.8.	steel bar reinforcement, various diameters, including cutting, bending, placing in position and tying wires.	kg	500	6	3,000
11.7.9.	provide, cut and fix in position the wood formworks for the upper tie beams	m2	30	75	2,250
11.7.10.	steel colums and upper beams of mm 100x100x4 rectangular hollow section	kg	1,000	8	8,000
11.7.11.	roof covering consisting of corrugated steel, including truss and purline in steel profiles.	m2	70	200	14,000
11.7.12.	metal door consisting of black metal sheet mm 1.5 thick on both sides fixed to metal profiles, complete of hinges, locks handles and necessary iron monge of KASI, dimensions m 1.20x2.40. Door finished with three coats of oil paint.	pc	1	1,700	1,700
11.7.13.	plastering of the block wall surfaces.	m2	100	15	1,500

<u>Sub total Item 11.7. . . . . 41,190</u>

11.8. **Raceways, pipes and accessoires**

11.8.1.	m 0.40x0.40 manhole pits average height m 0.70 in concrete blocks of m 0.20x0.40x0.20 bedded with cement mortar, including excavation, cart away, internal plastering, concrete lean thick m 0.20, cover in concrete m 0.50x0.50, etc.				
		pc	20	400	8,000
11.8.2.	mm 200 P.V.C. pipe, including excavation and placing.				
		m	200	250	50,000
11.8.3.	mm 100 P.V.C. pipe, including excavation and placing.				
		m	100	100	10,000

Sub total Item 11.8. 68,000

SUMMARY OF COST ESTIMATION FOR THE CIVIL WORKS

Site works	87,000	Birr
Gullies, pits and other accessories for screening chambers	5,530	"
Lime storage tank and Equalization tank . . .	272,450	"
Primary sedimentation tank	83,650	"
Aeration tank.	505,300	"
Secondary sedimentation tank	118,600	"
Raceways, pipes and accessoires	68,000	"
Covered area	41,190	"
TOTAL	1,181,720	Birr
Contingency 10% ca.	118,172	Birr
GRAND TOTAL	**1,299,892**	**BIRR**
	(260,000 U.S.$ ca.)	

Note:
The eventual use of the existing tank for the storage of the spent liming liquors, will represent a save of 50,000 Birr ca. (10,000 U.S.$).

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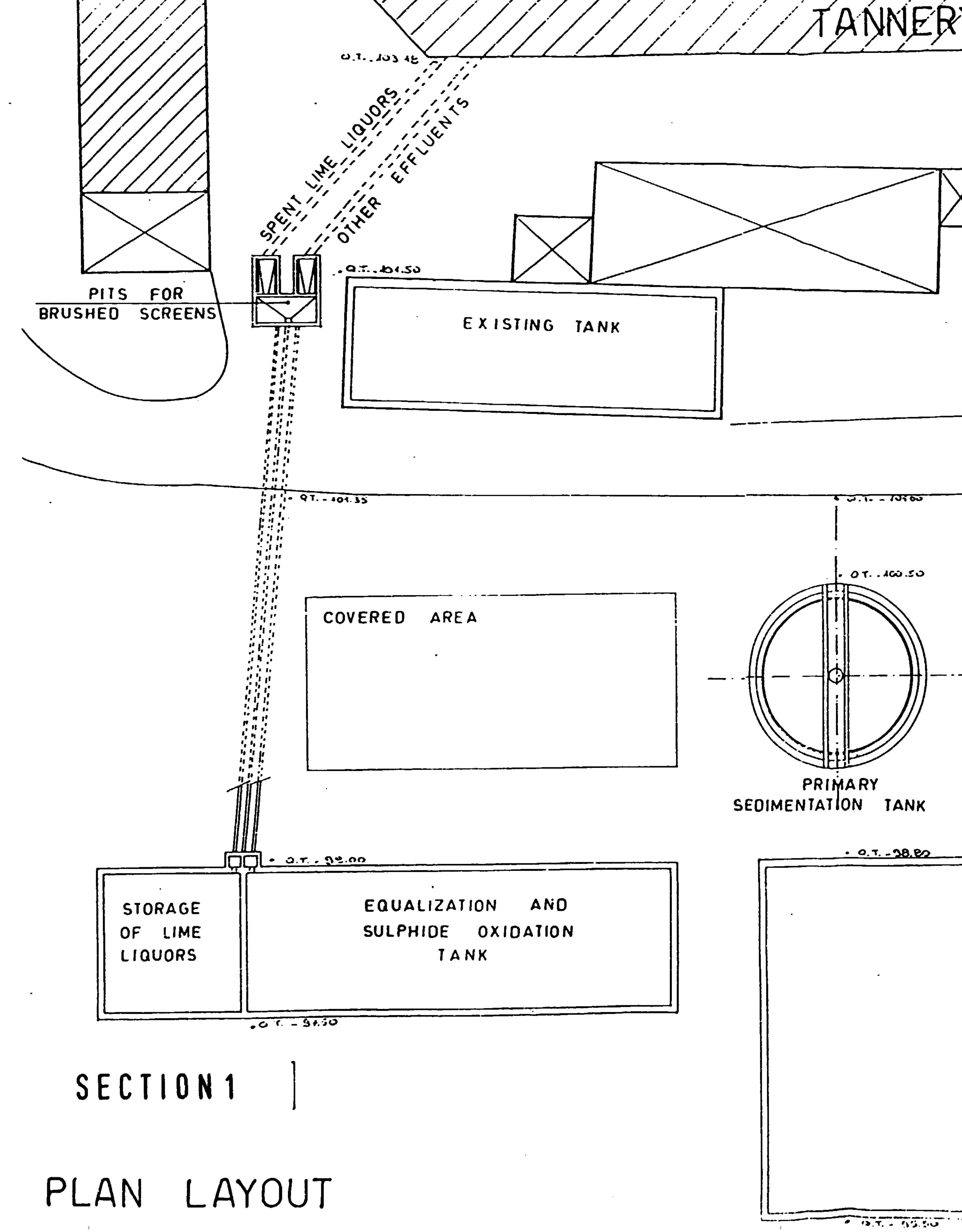
DRAWINGS
Awash Tannery


TANNERY
SPENT LIME LIQUORS
OTHER EFFLUENTS
PITS FOR
BRUSHED SCREENS
EXISTING TANK
COVERED AREA
PRIMARY
SEDIMENTATION TANK
STORAGE
OF LIME
LIQUORS
EQUALIZATION AND
SULPHIDE OXIDATION
TANK
SECTION 1
PLAN LAYOUT

UNIDO PROJET US/RAF/83/100 CONTRACT n. 92/134

AWASH TANNERY: WASTE WATER TREATMENT PLANT

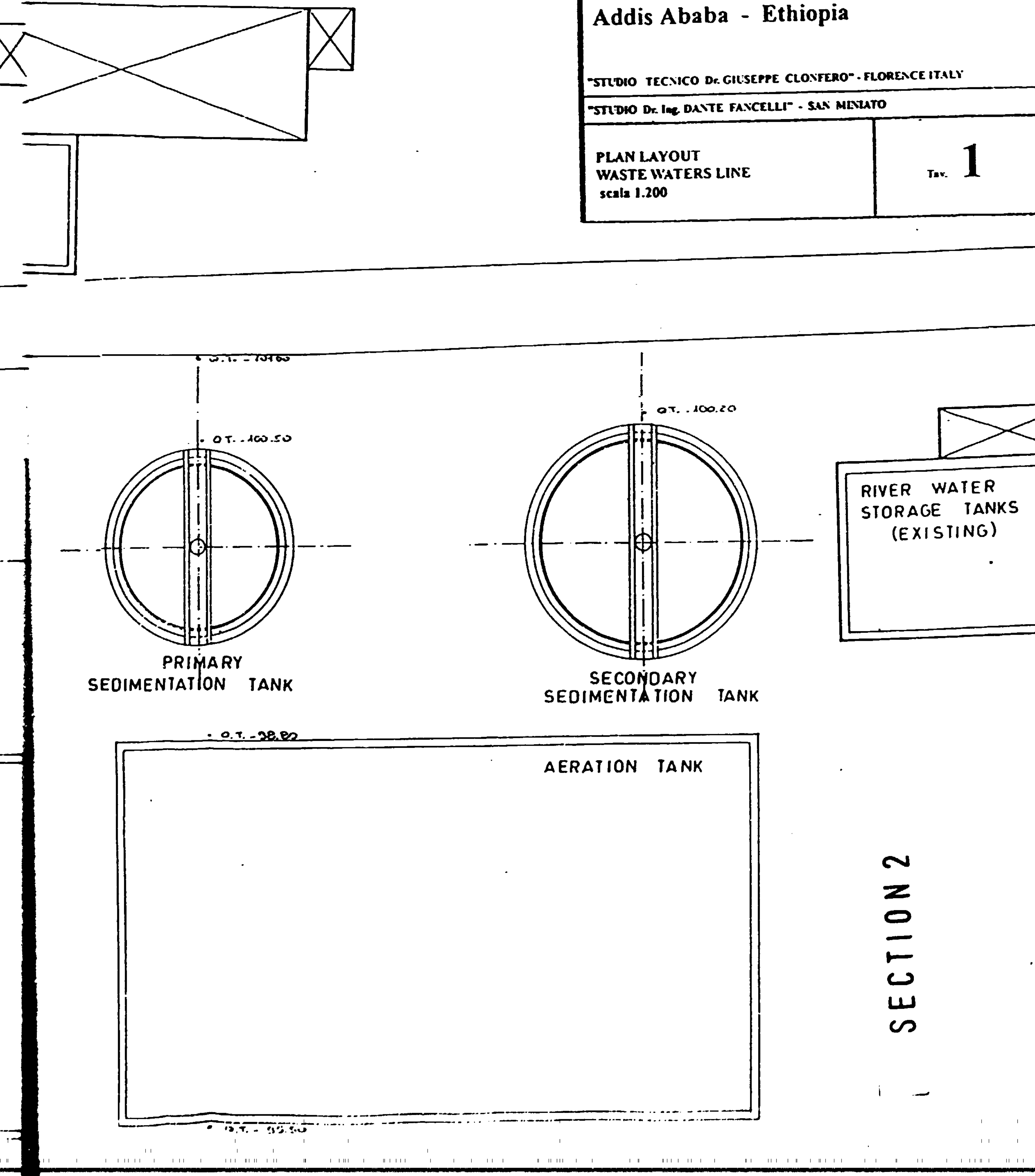
Addis Ababa - Ethiopia

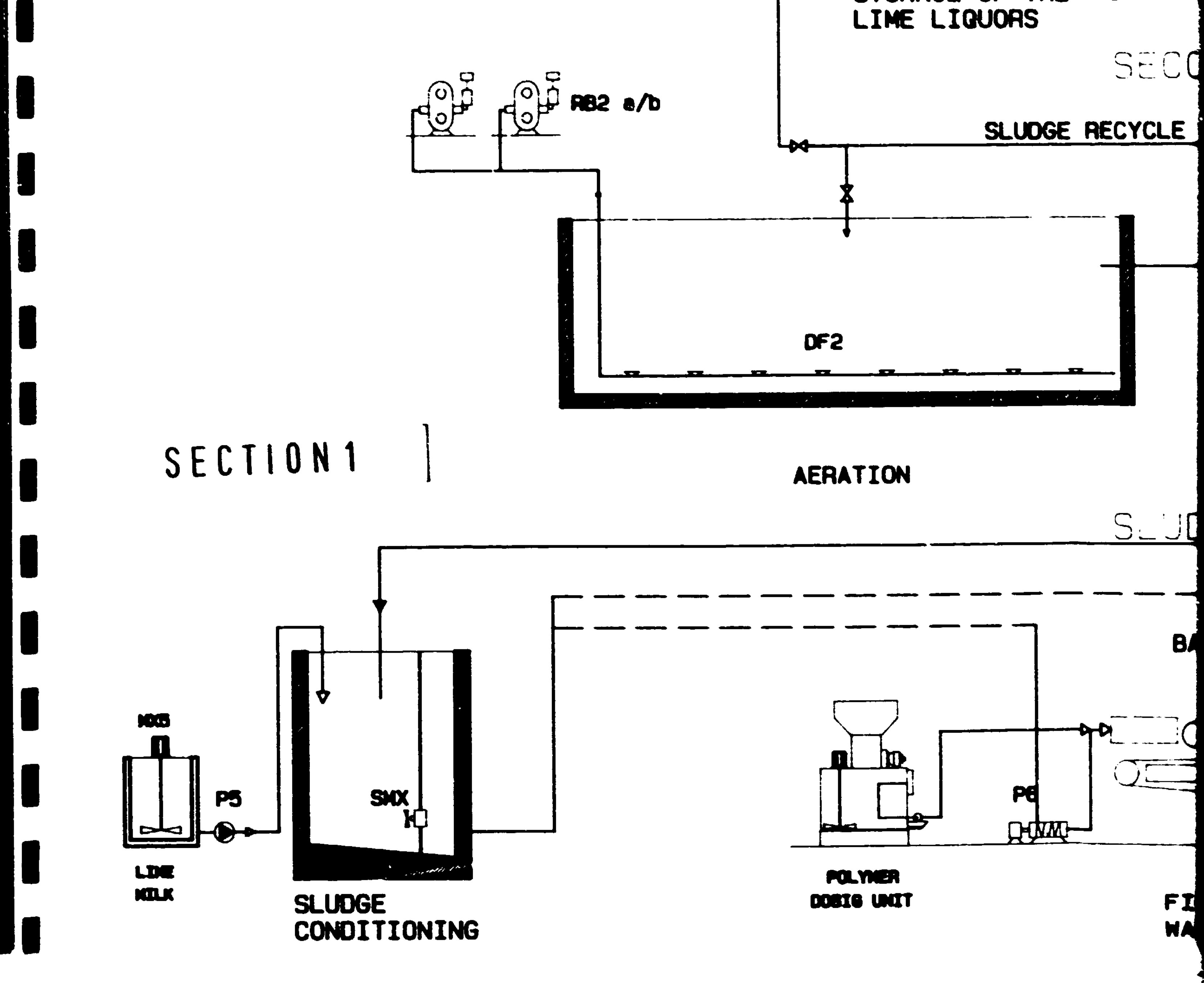
"STUDIO TECNICO Dr. GIUSEPPE CLONFERO" - FLORENCE ITALY

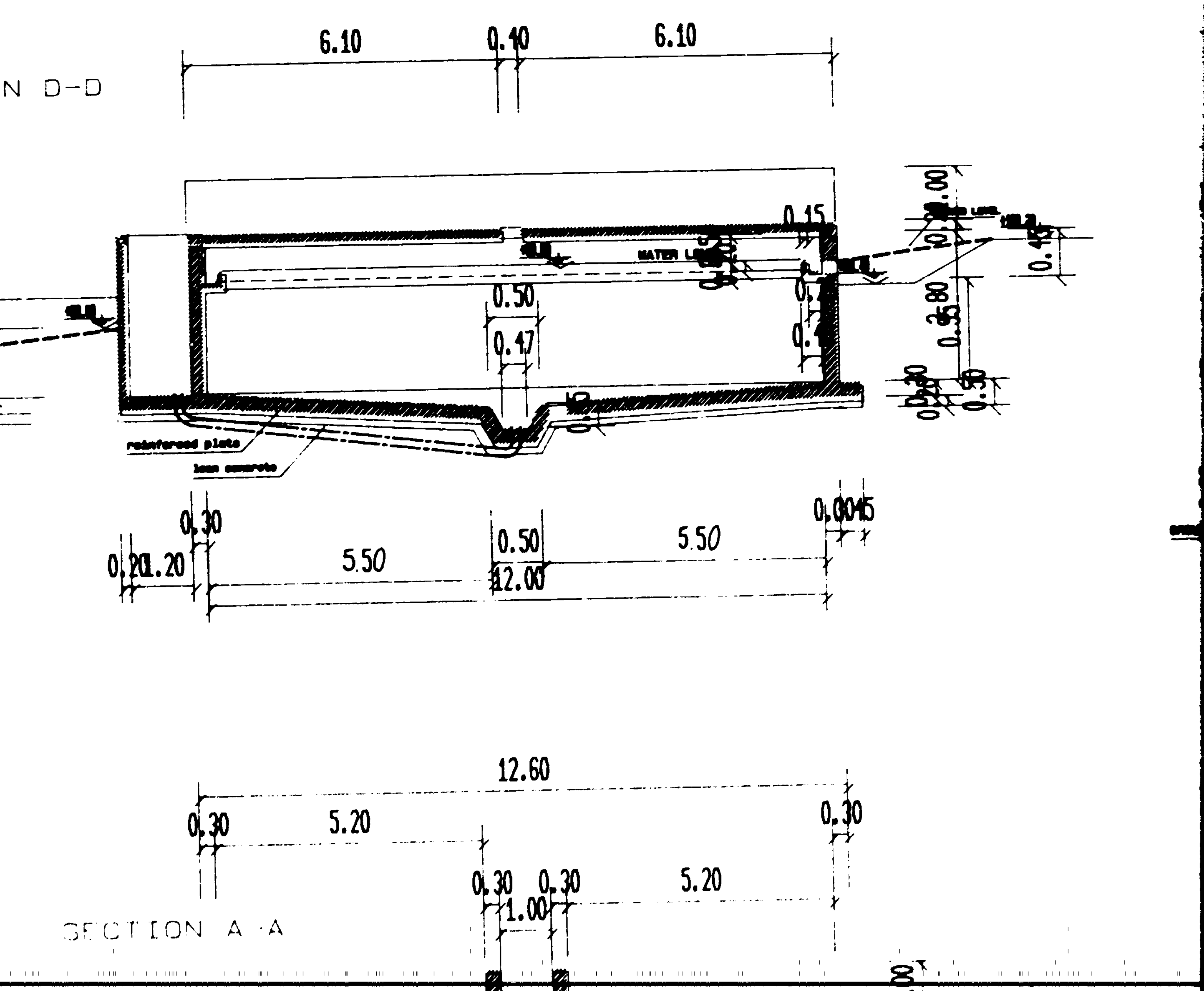
"STUDIO Dr. Ing. DANTE FANCELLI" - SAN MINIATO

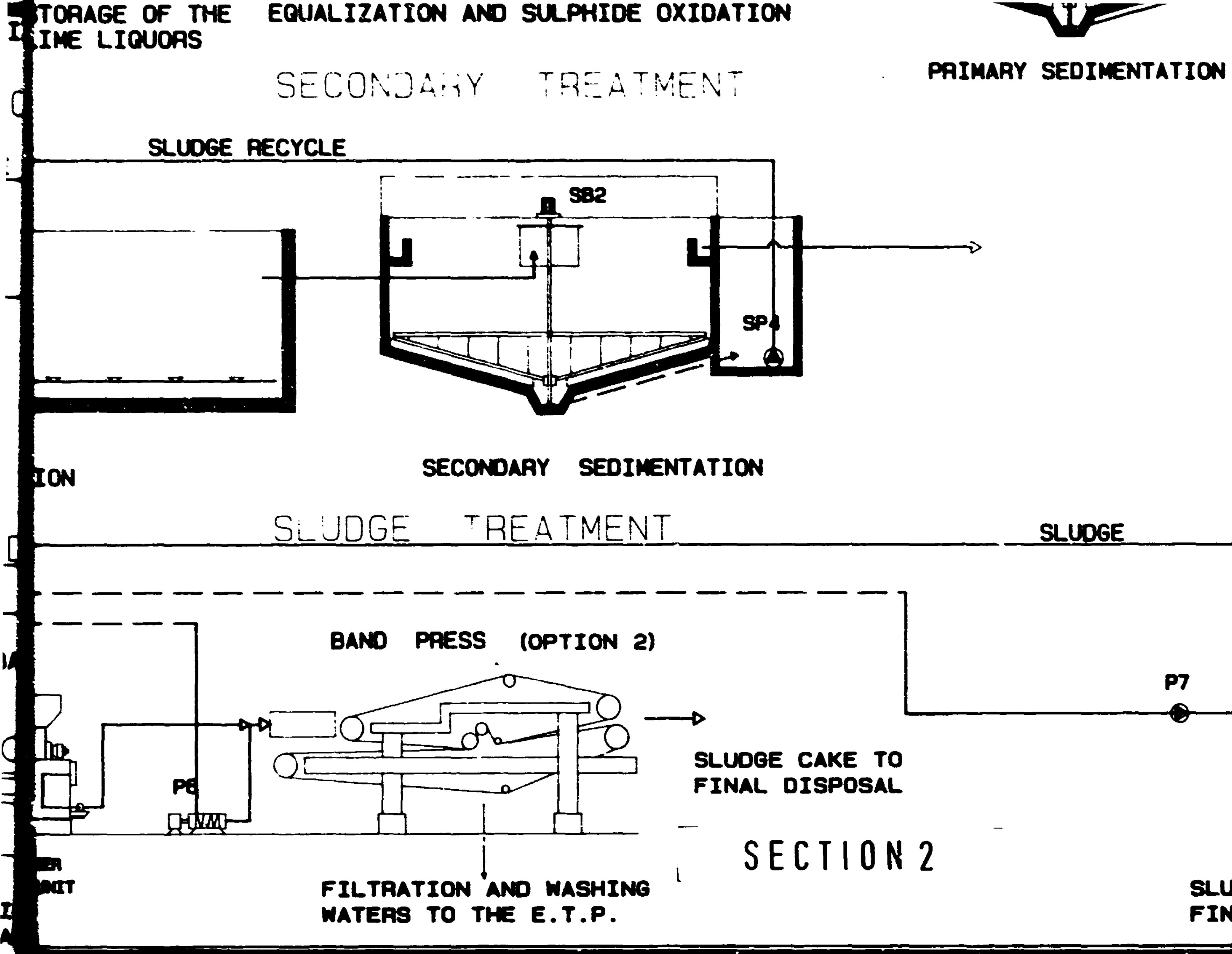
PLAN LAYOUT
WASTE WATERS LINE
scala 1.200

Tav. 1

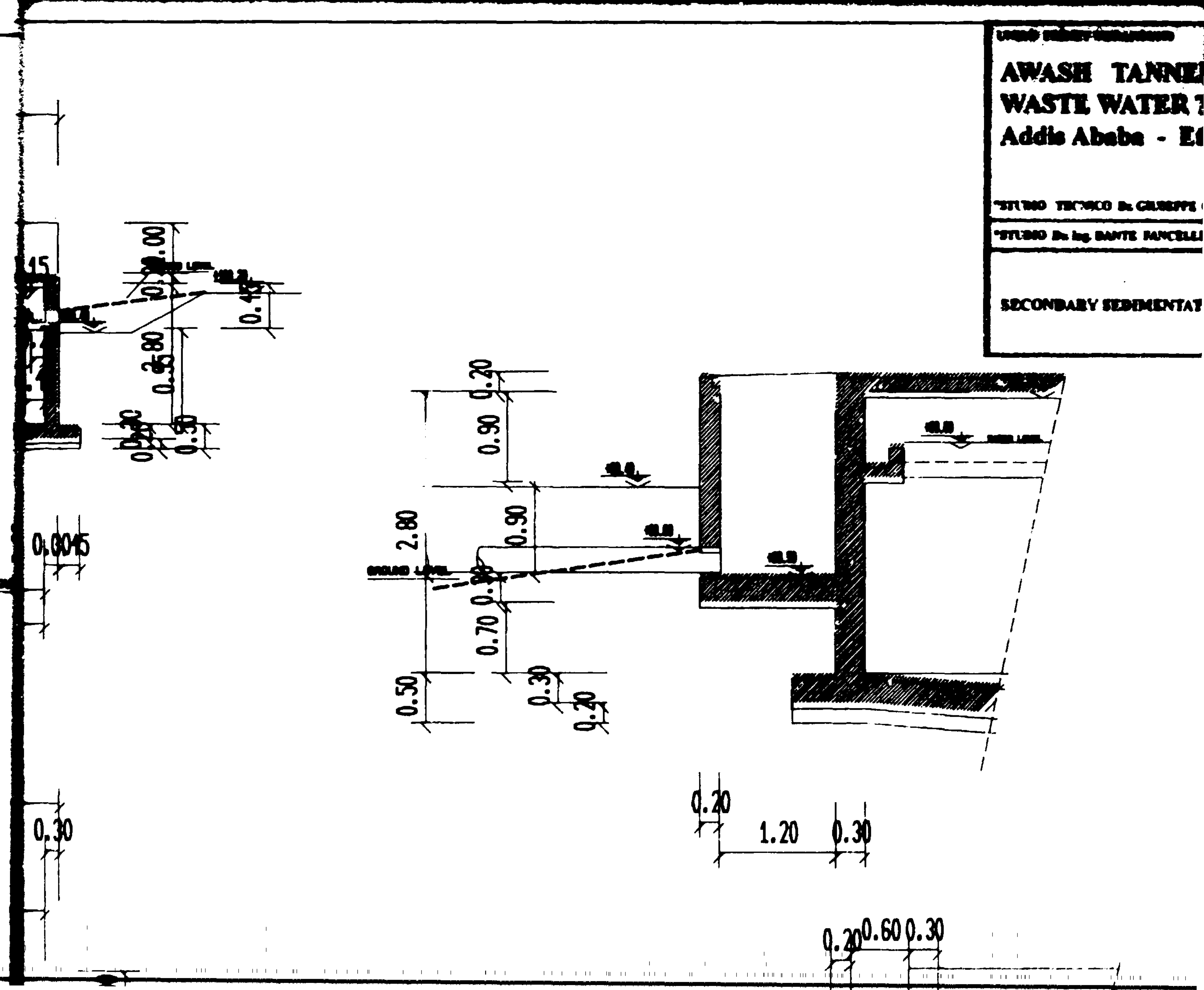



LIME LIQUORS
RB2 a/b
SLUDGE RECYCLE
DF2
SECTION 1
AERATION
P5
SMX
LIME
MILK
SLUDGE
CONDITIONING
POLYMER
DOSING UNIT


SECTION D-D
6.10
0.40
6.10
0.15
0.50
0.47
reinforced plate
lean concrete
0.30
5.50
0.50
5.50
12.00
12.60
0.30
5.20
0.30
0.30
0.30
1.00
5.20
SECTION A-A



EQUALIZATION AND SULPHIDE OXIDATION
PRIMARY SEDIMENTATION
SECONDARY TREATMENT
SLUDGE RECYCLE
SB2
SP4
SECONDARY SEDIMENTATION
SLUDGE TREATMENT
SLUDGE
BAND PRESS (OPTION 2)
P7
P6
SLUDGE CAKE TO
FINAL DISPOSAL
SECTION 2
FILTRATION AND WASHING
WATERS TO THE E.T.P.



AWASH TANNE
WASTE WATER
Addis Ababa - E
SECONDARY SEDIMENTAT
0.20
0.90
2.80
0.90
0.70
0.50
0.30
0.20
1.20
0.30
0.60

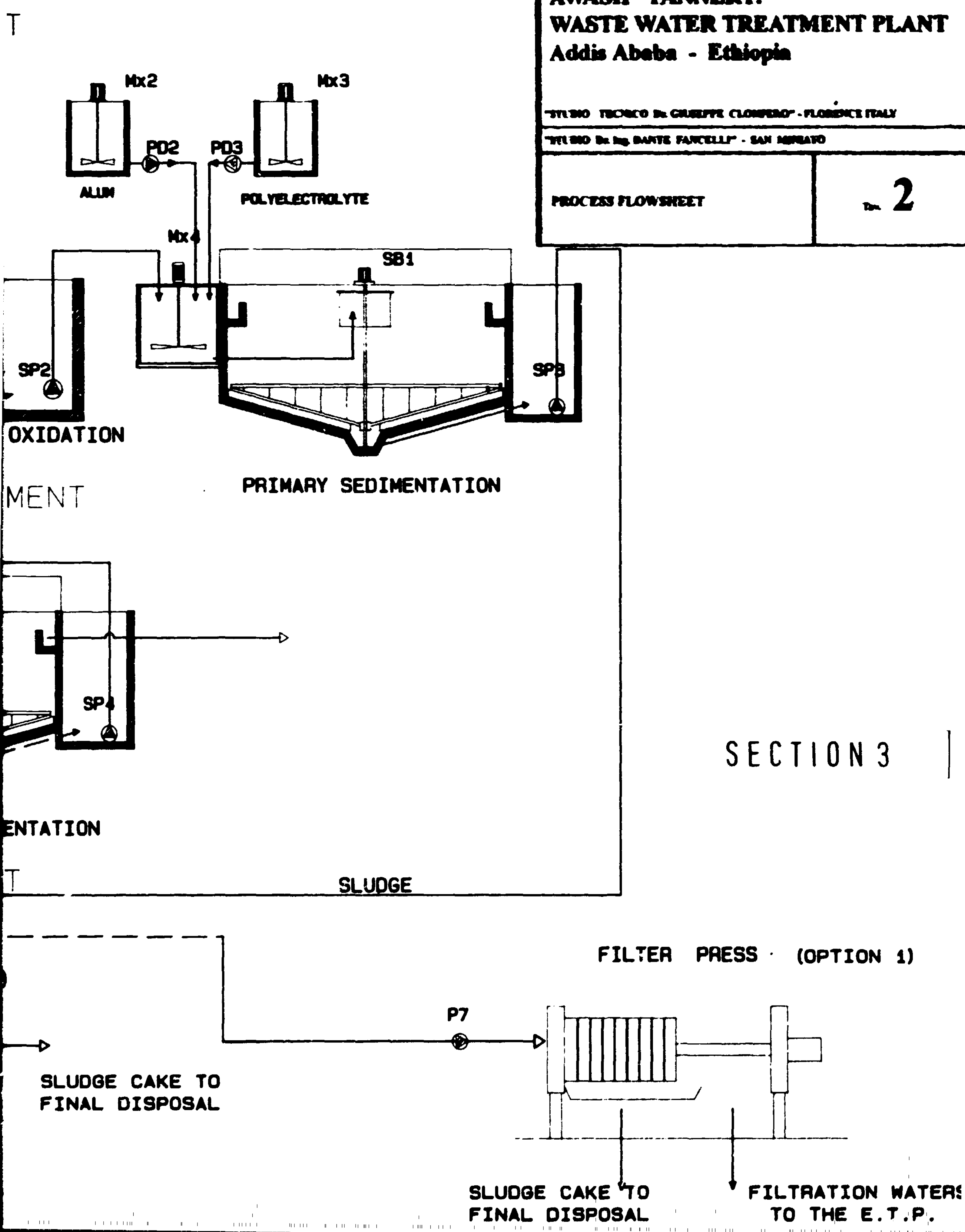
AWASH TANNERY:
WASTE WATER TREATMENT PLANT
Addis Abeba - Ethiopia

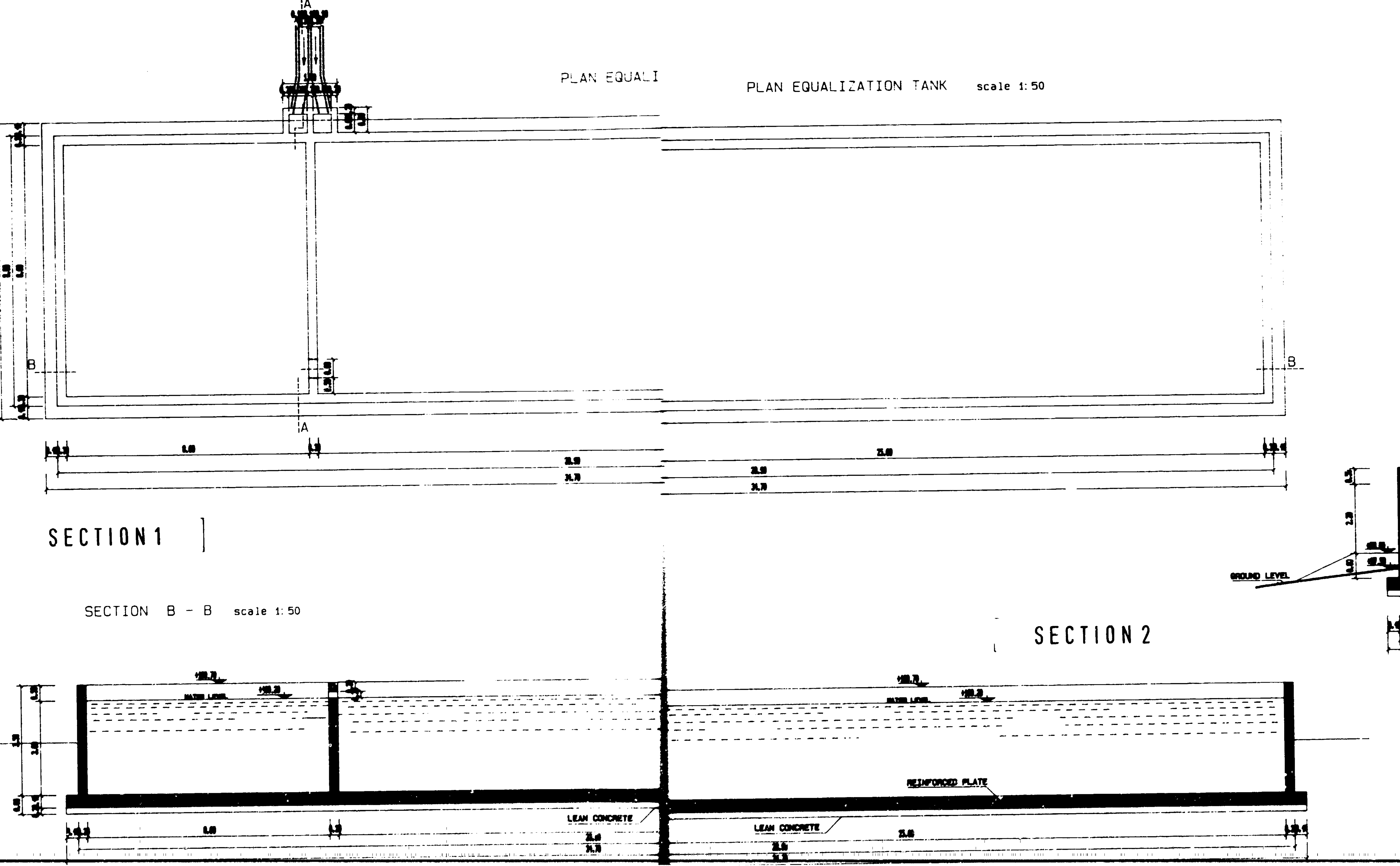
"STUDIO TECNICO Dr. GIUSEPPE CLONFERO" - FLORENCE ITALY

"STUDIO Dr. Ing. DANTE FANCELLI" - SAN MINIATO

PROCESS FLOWSHEET

Dw. 2




PLAN EQUALI
PLAN EQUALIZATION TANK scale 1:50
SECTION 1
SECTION B - B scale 1:50
SECTION 2
GROUND LEVEL
WATER LEVEL
REINFORCED PLATE
LEAN CONCRETE

AWASH TANNERY:
WASTE WATER TREATMENT PLANT
Addis Ababa - Ethiopia

"STUDIO TECNICO Dr. GIUSEPPE CLONFERO" - FLORENCE ITALY

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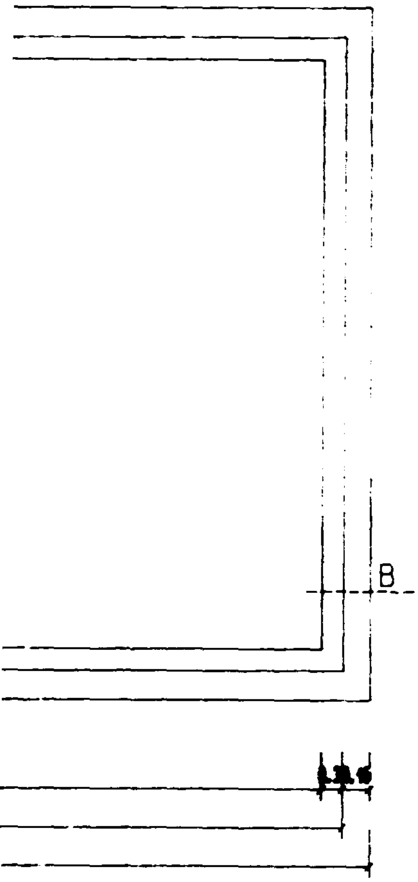
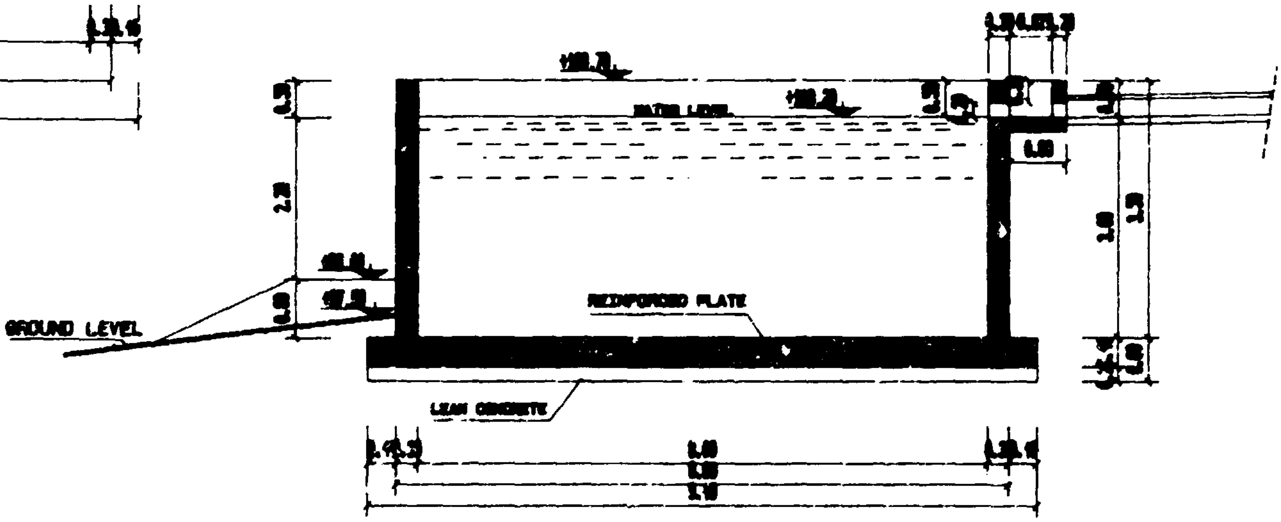
EQUALIZATION TANK	3





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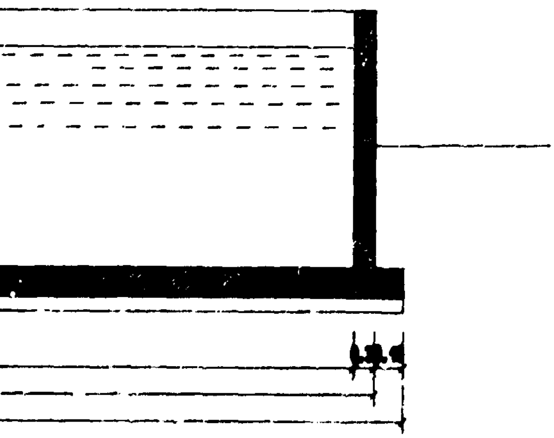
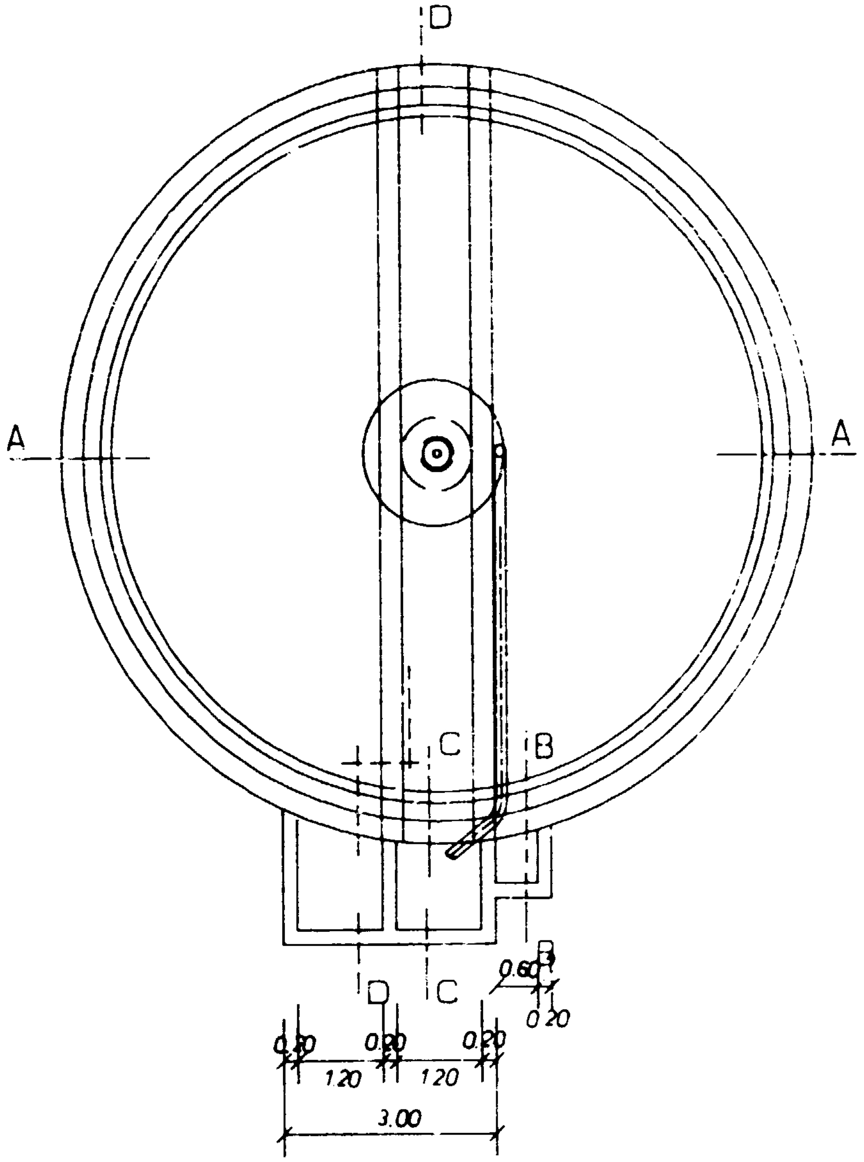
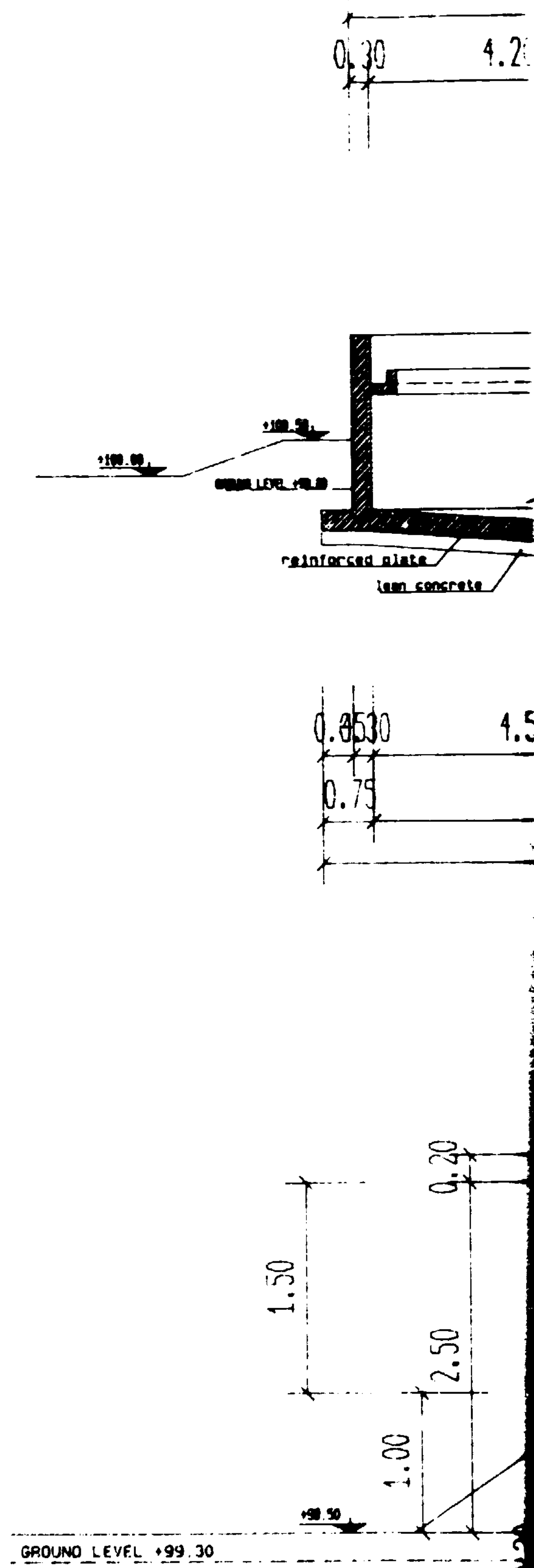


SECTION 3

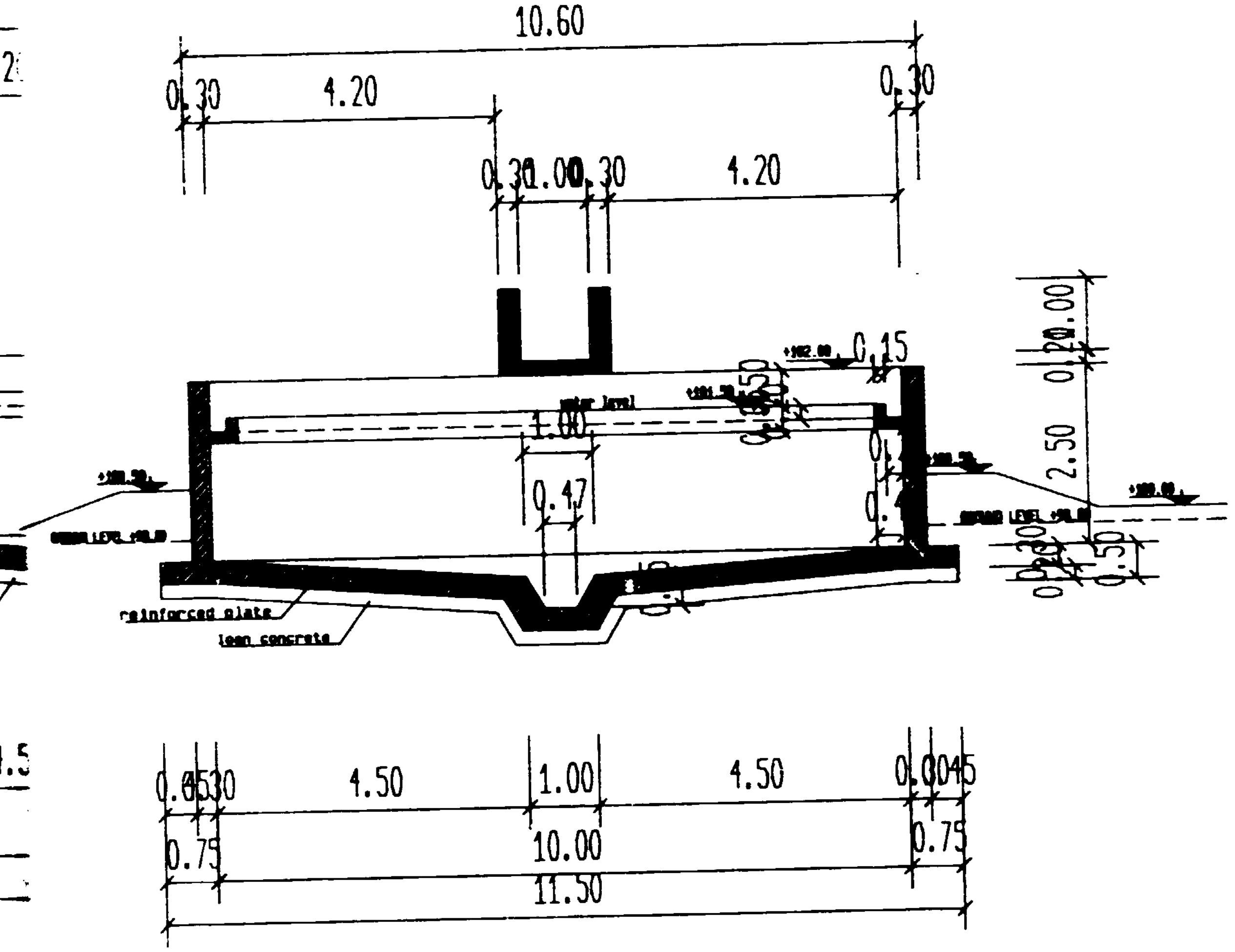


PLAN PRIMARY SEDIMENTATION TANK

SECTION 1

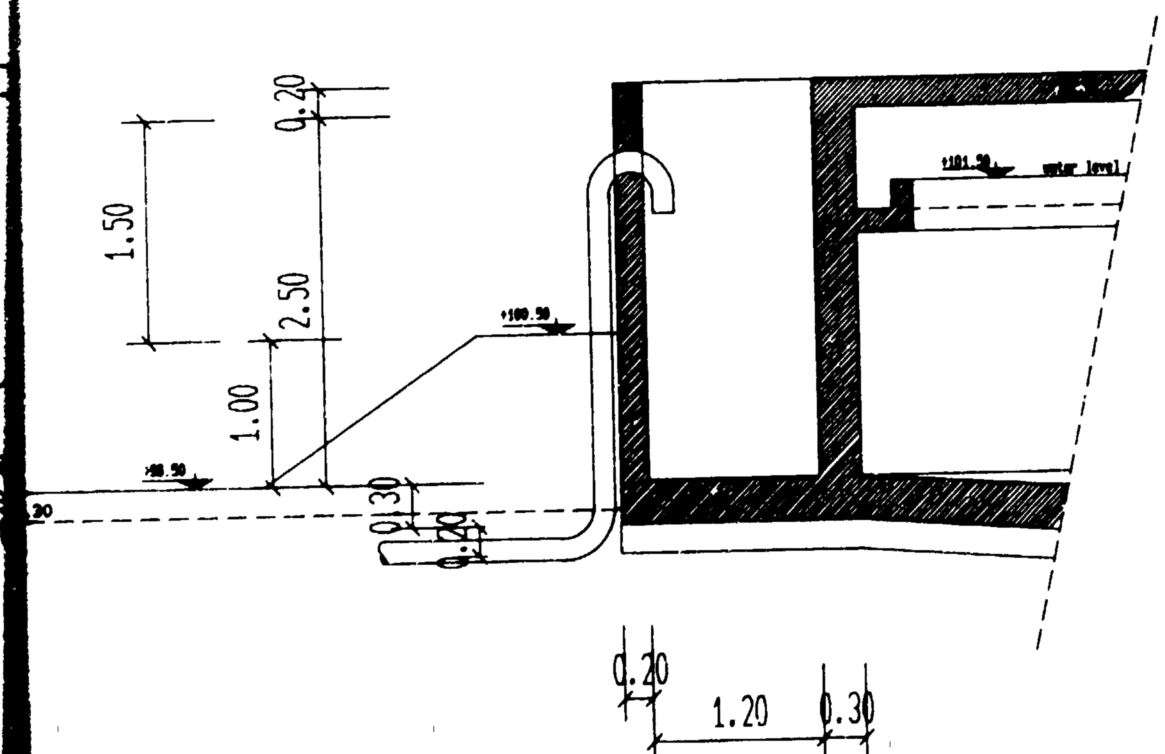


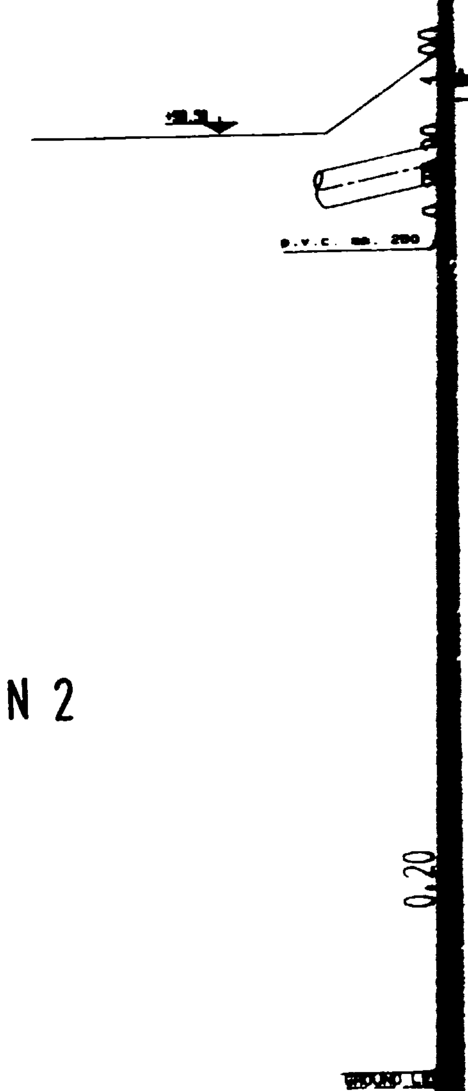
SECTION A - A



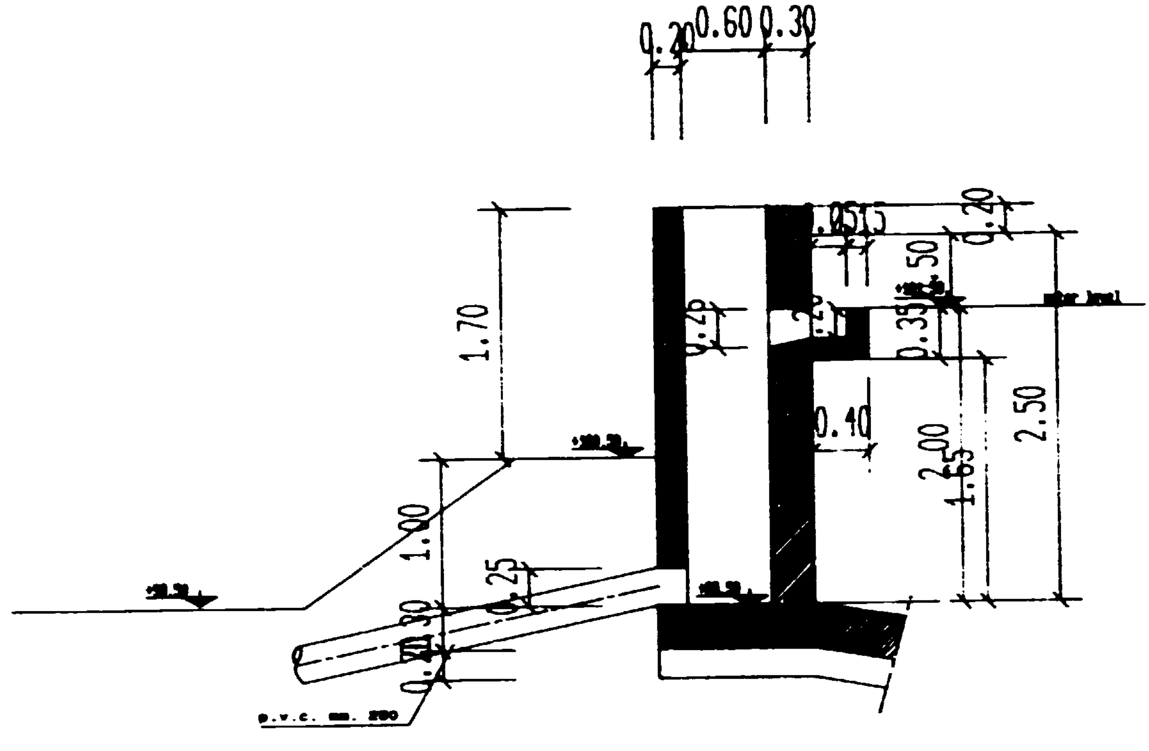
SECTION 2

SECTION C-C



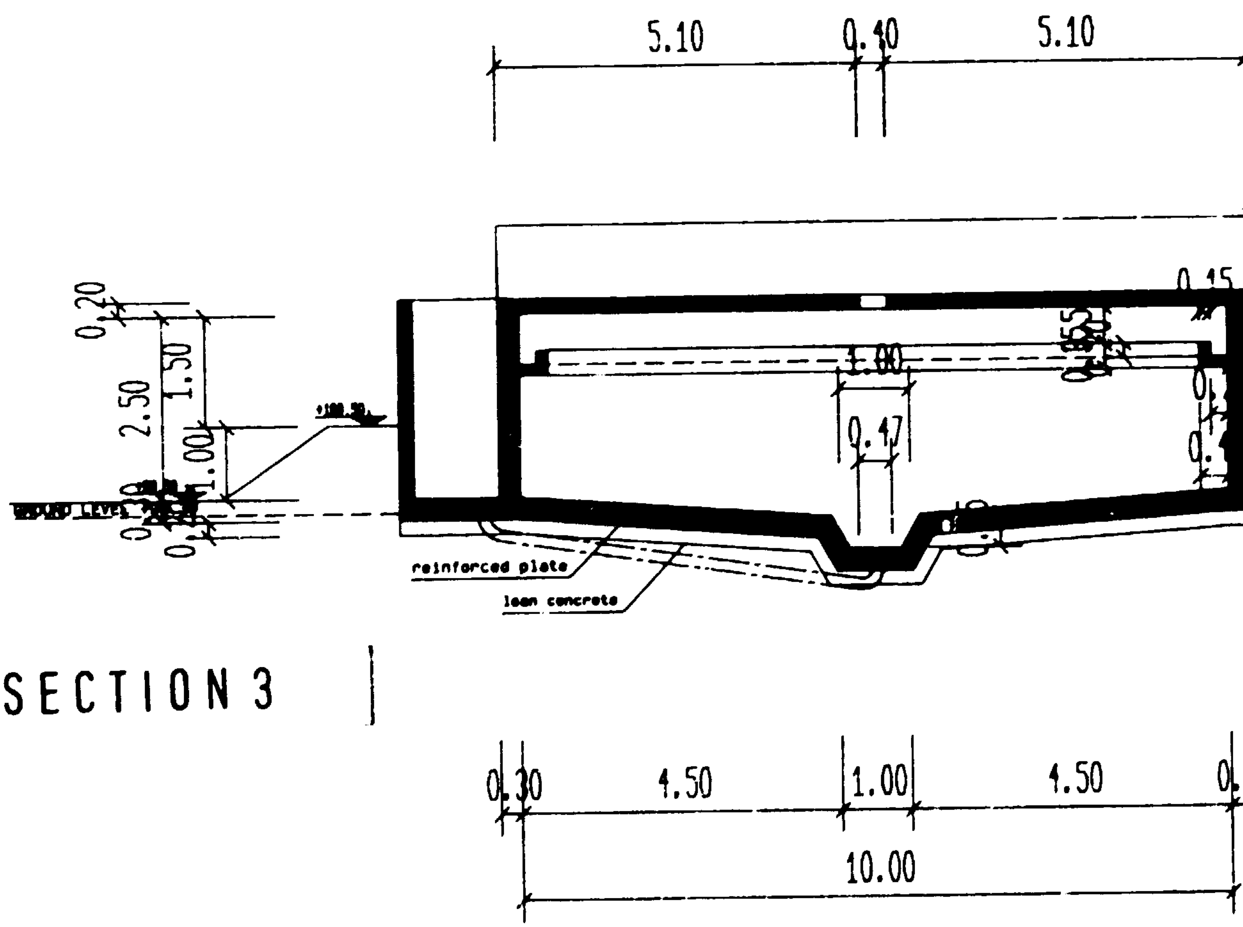


AWASH T...
WASTE WA...
Addis Abe...



SECTION B-B

SECTION D - D



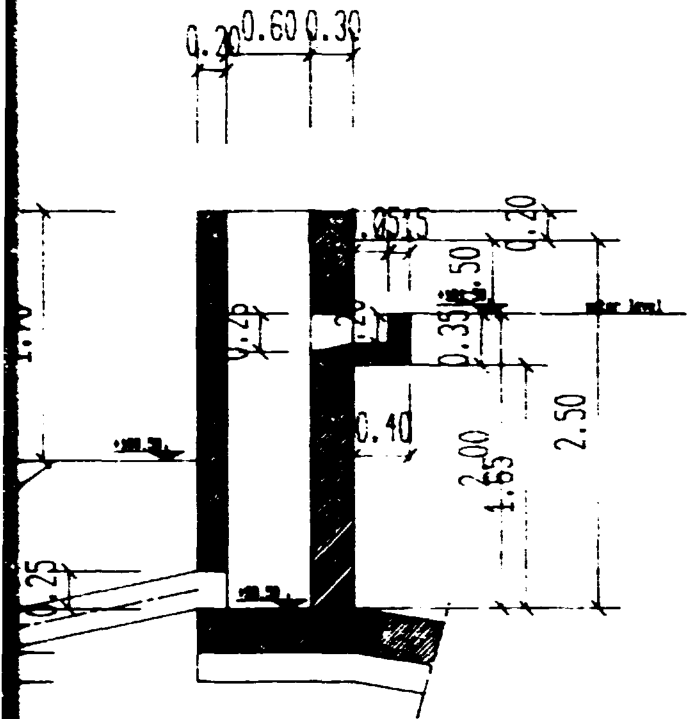
SECTION 3

AWASH TANNERY:
WASTE WATER TREATMENT PLANT
Addis Ababa - Ethiopia

"STUDIO TECNICO Dr. GIUSEPPE CLONFERO" - FLORENCE ITALY

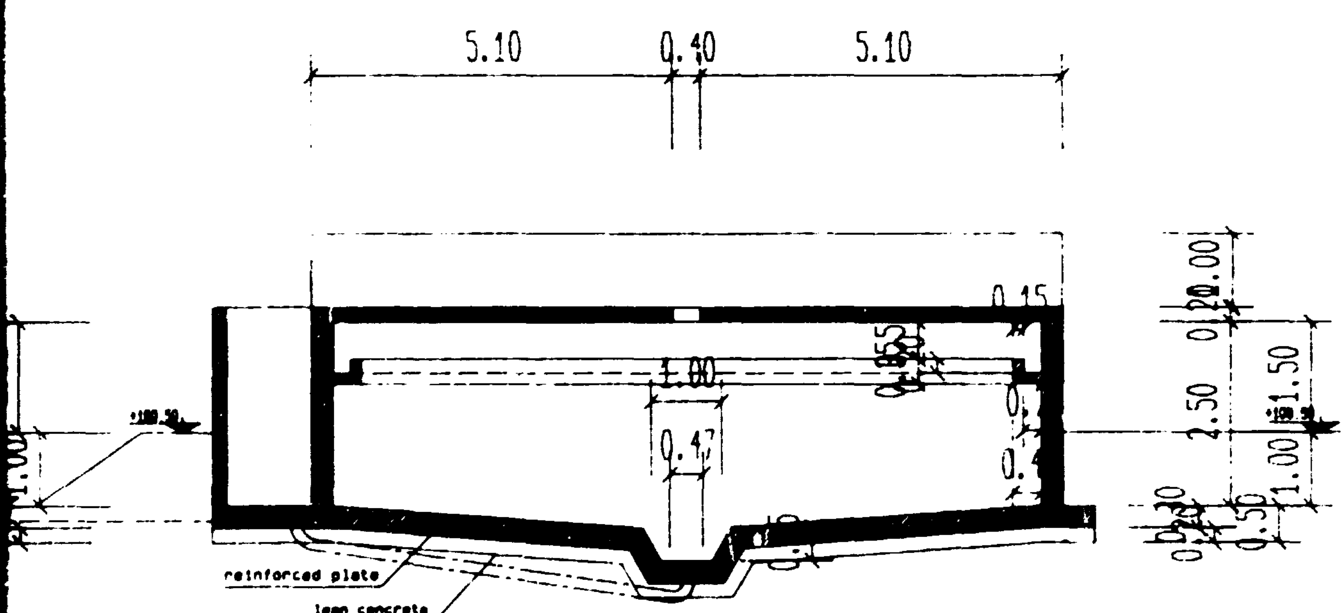
"STUDIO Dr. Ing. DANTE FANCELLI" - SAN MINIATO

PRIMARY SEDIMENTATION TANK	Tav. 4

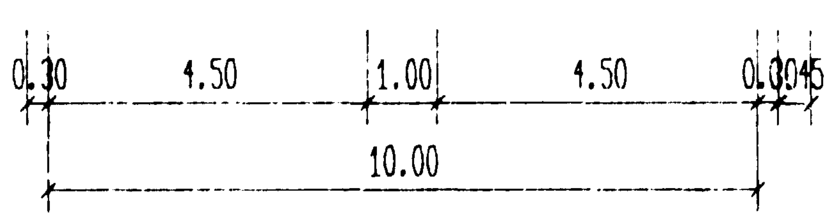


SECTION B-B

SECTION D - D



SECTION 4



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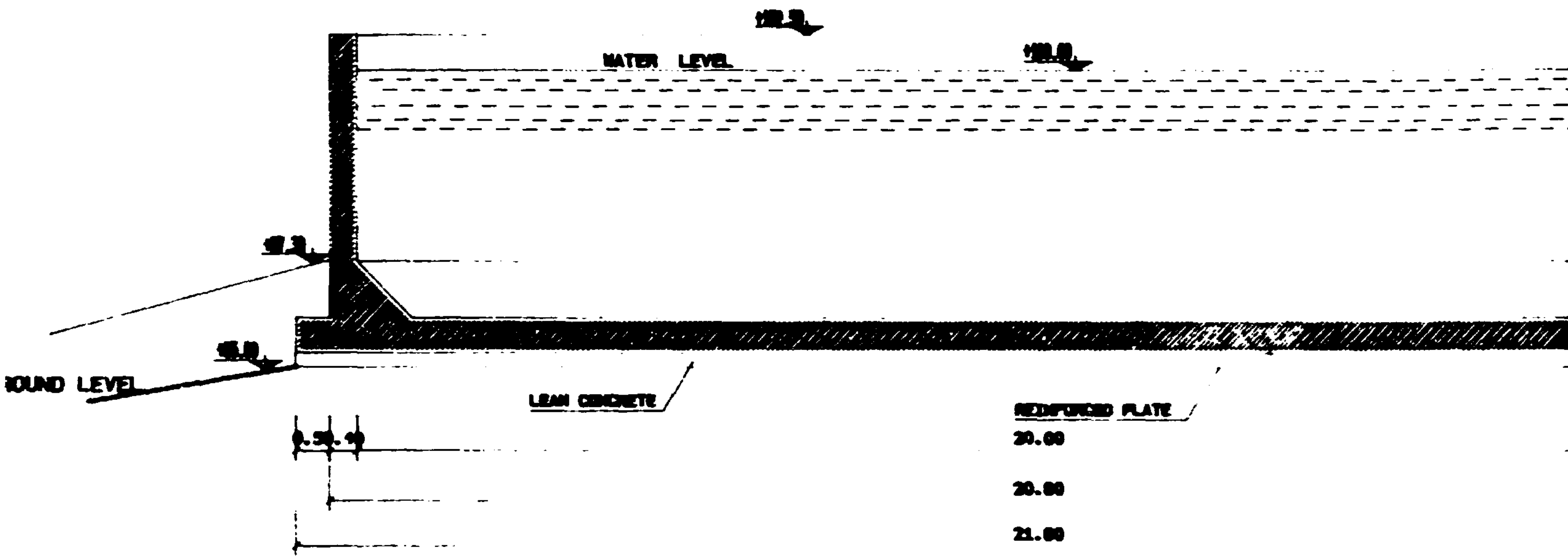
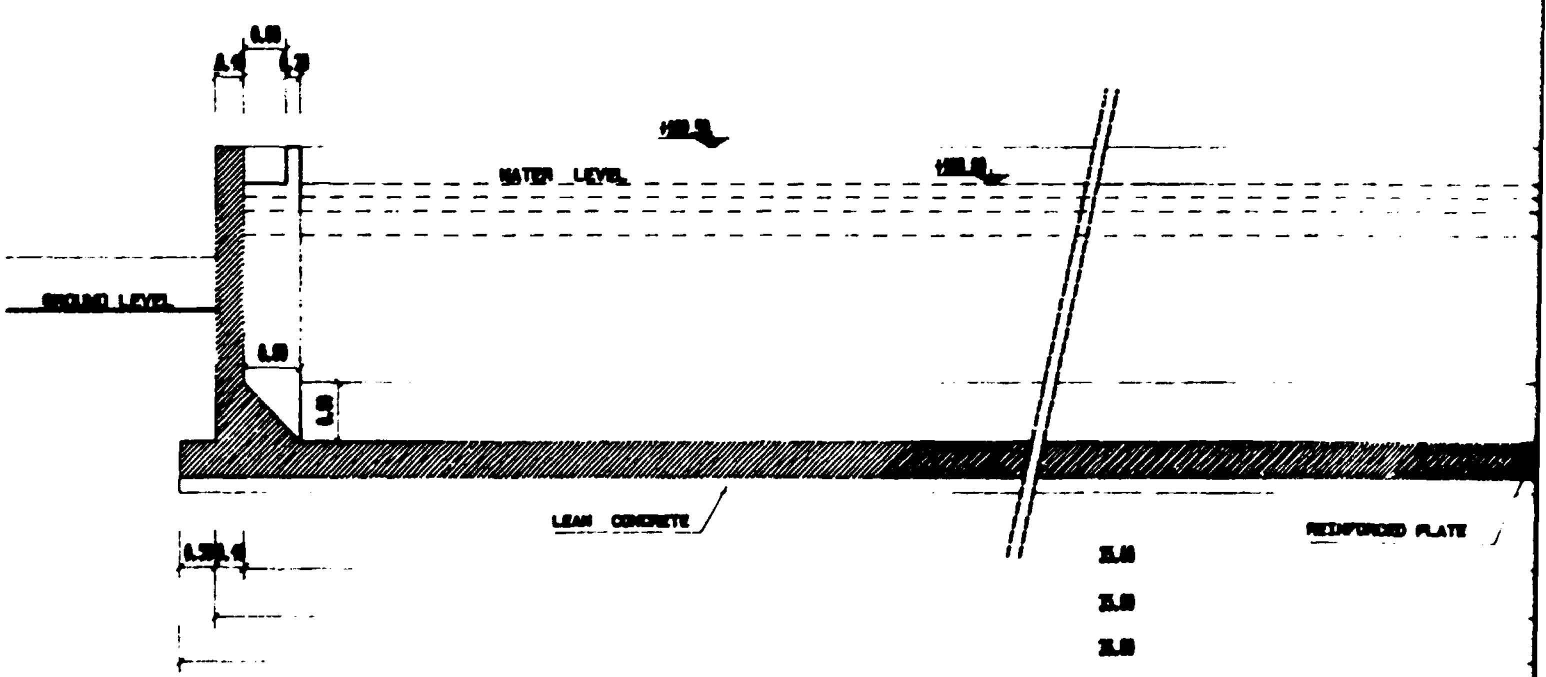
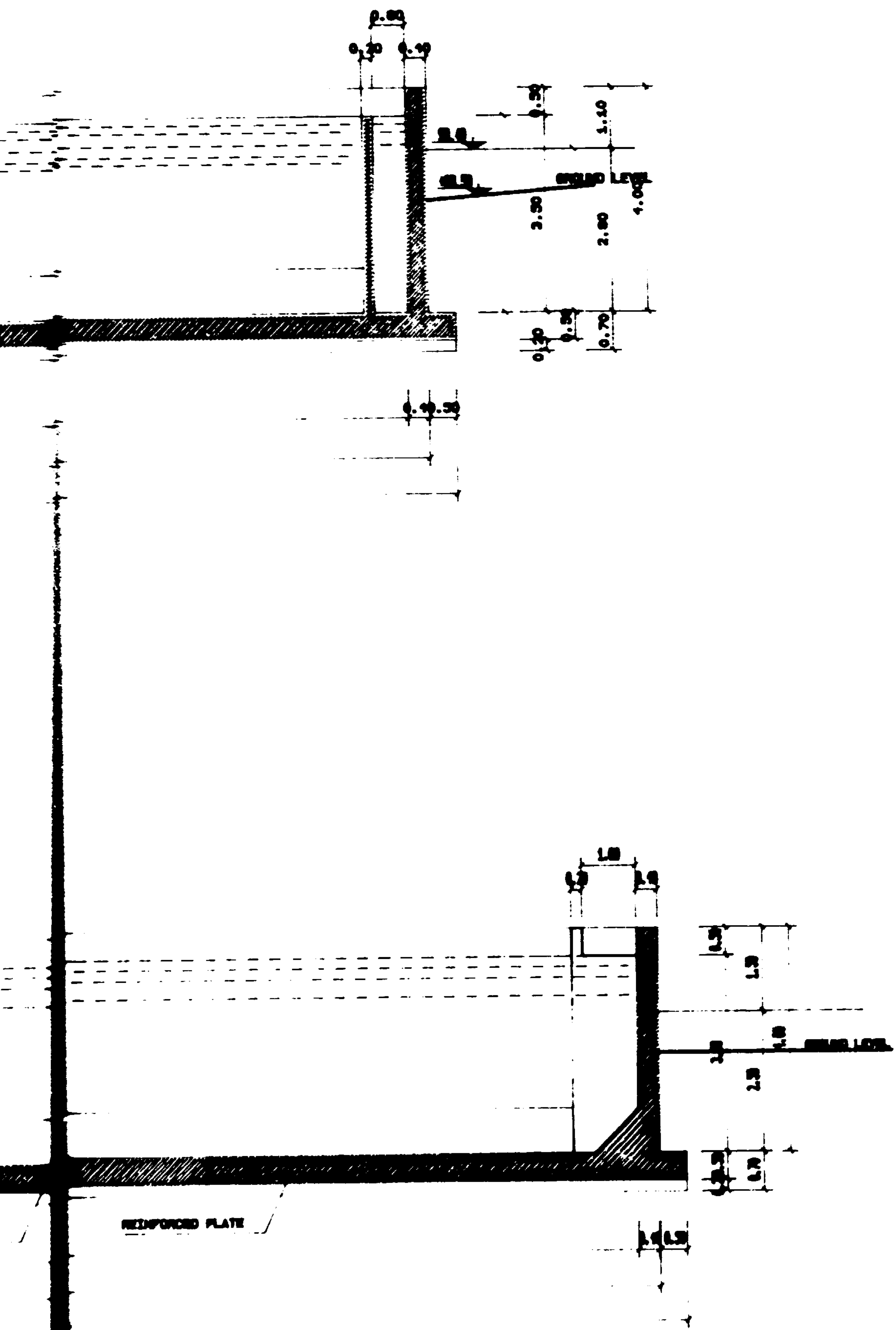


SECTION A - A

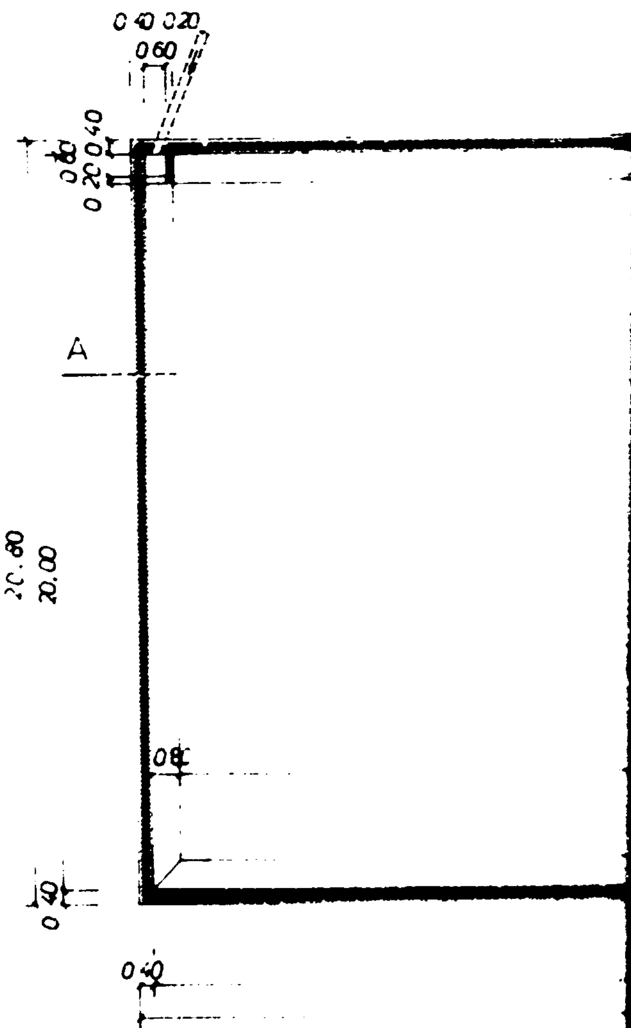


SECTION 1



SECTION 2

PLAN AERAT



UNIDO PROJECT [illegible] CONTRACT n. [illegible]

AWASH TANNERY: WASTE WATER TREATMENT PLANT Addis Ababa - Ethiopia

"STUDIO TECNICO Dr. GIUSEPPE CLONFERO" - FLORENCE ITALY

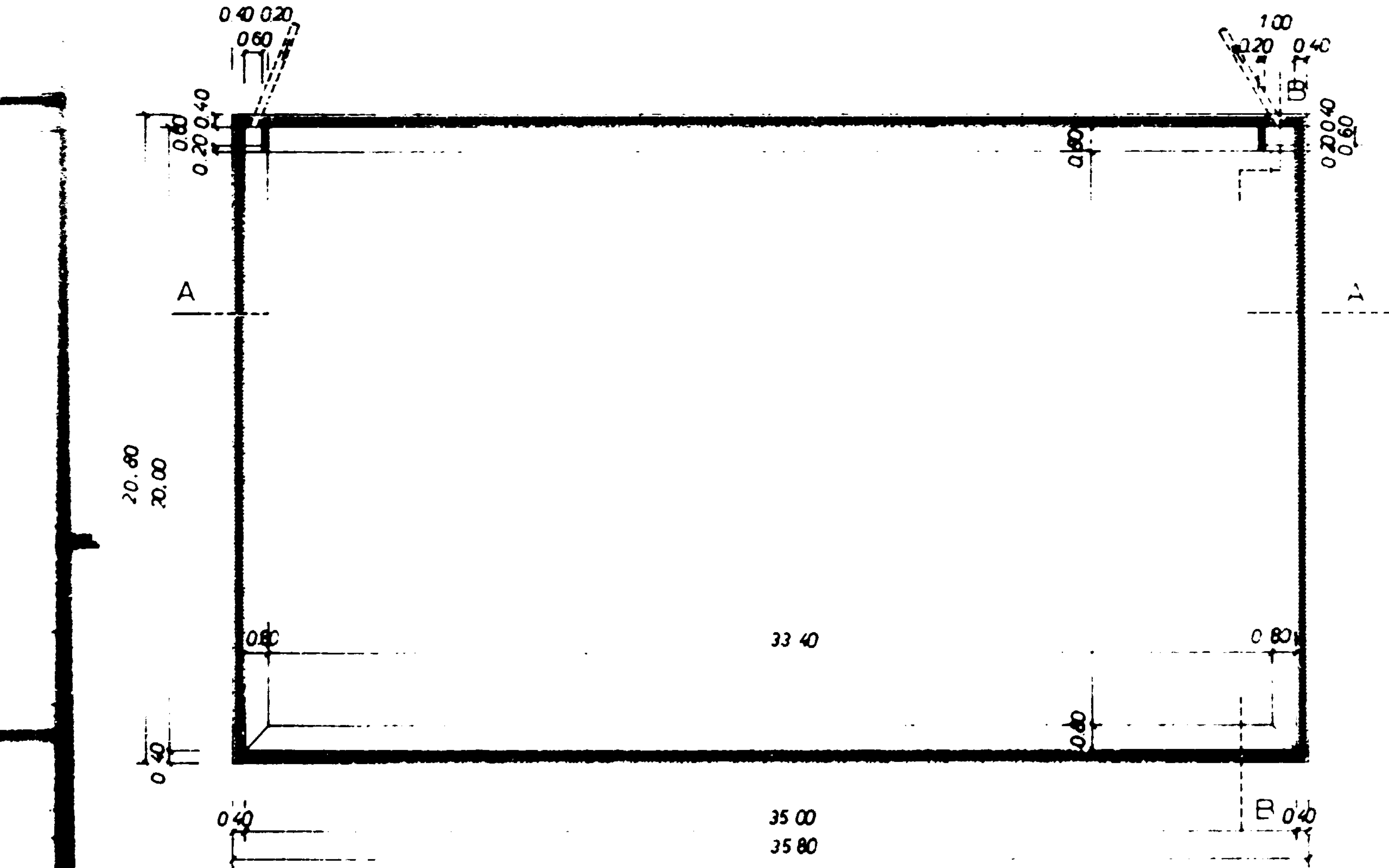
"STUDIO Dr. Ing. DANTE FANCELLI" - SAN MINIATO

AERATION TANK

Tav. 5

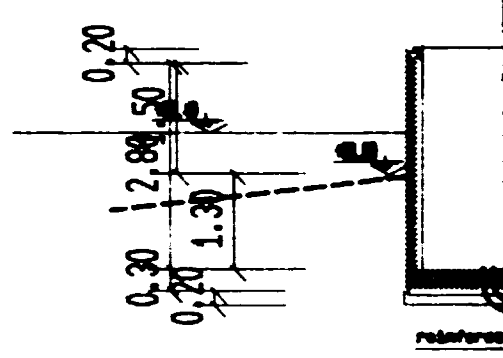
RAT

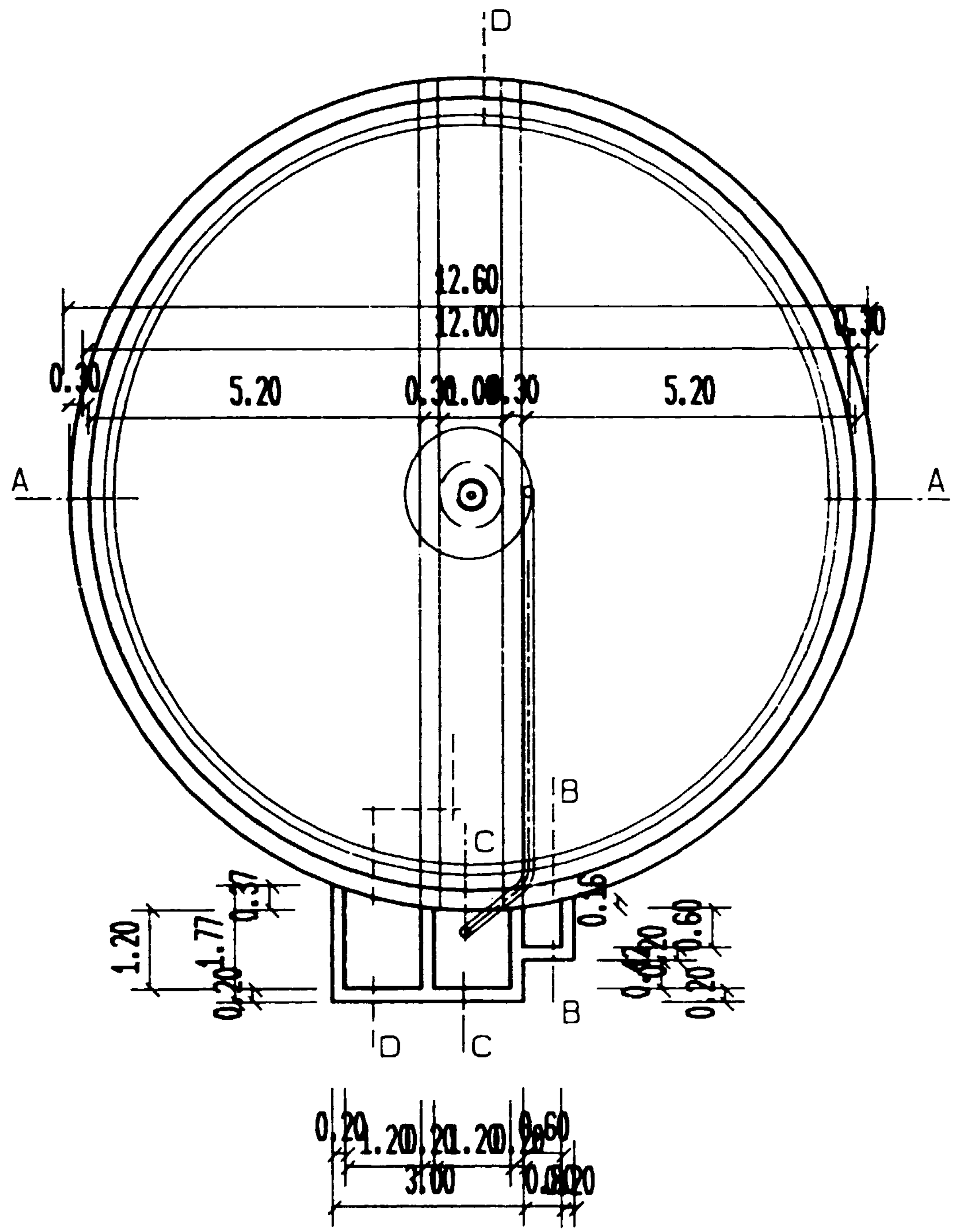
PLAN AERATION TANK



SECTION 3

SECTION D-D





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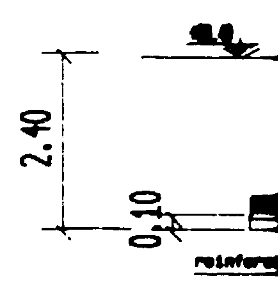


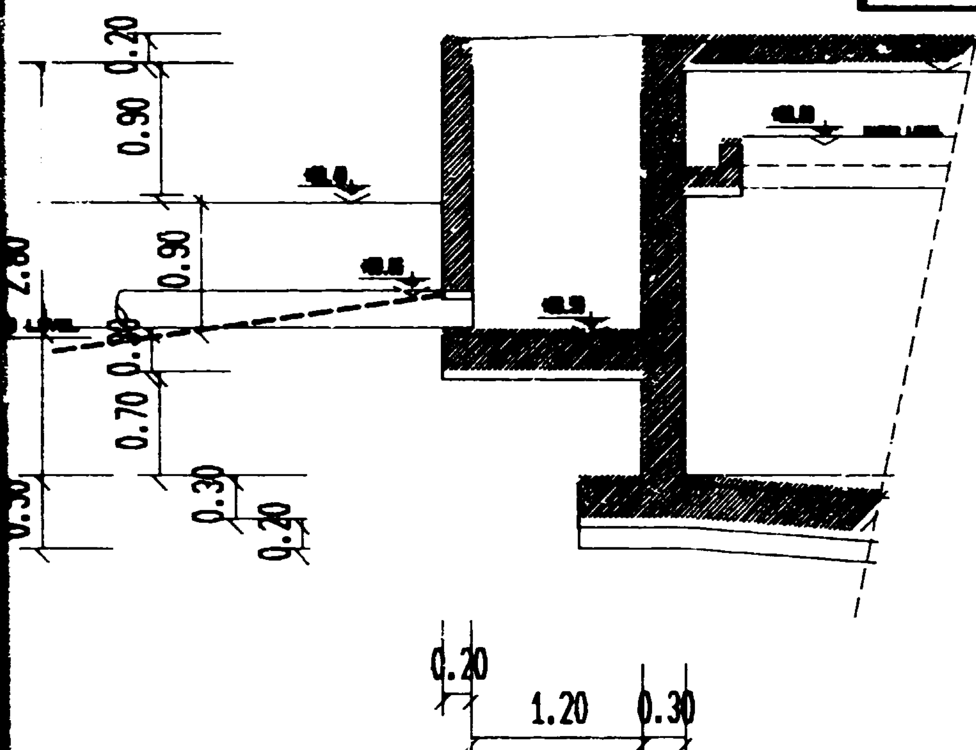
SECTION 1

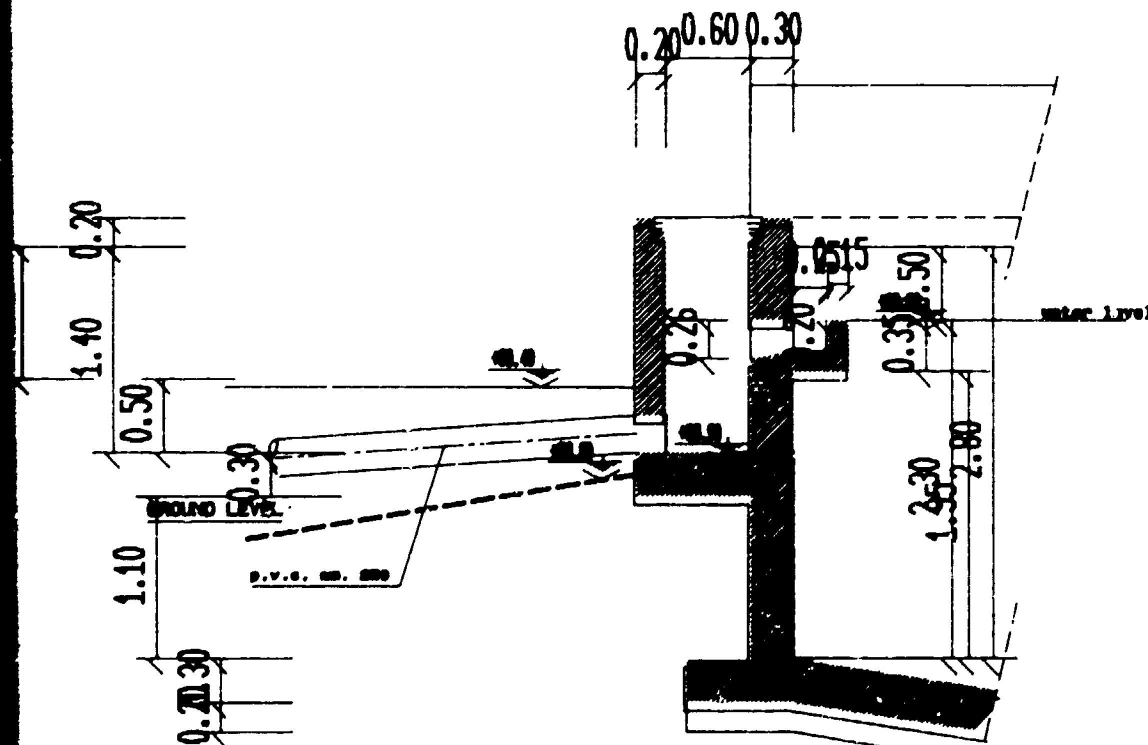
AWASH TANNERY:
WASTE WATER TREATMENT PLANT
Addis Ababa - Ethiopia

"STUDIO TECNICO Dr. GIUSEPPE CLONFERO" - FLORENCE ITALY

"STUDIO Dr. Ing. DANTE PANCELLI" - SAN MINIATO

SECONDARY SEDIMENTATION TANK	No. 6





SECTION B-B

SECTION 4

ANNEX I

AWASH TANNERY

ADDIS ABABA
ETHIOPIA

C H R O M E R E C O V E R Y P L A N T

The Chrome recovery is a necessary pretreatment and must be considered as a basic part of the ETP.

As already said, the Awash Tannery Management evaluated positively the installation of a chrome recovery but they estimate more appropriate to the local conditions the alternative with MgO, simpler (less expensive) than the filter press alternative. Furthermore, they had carried out some tests with MgO in the factory's laboratory obtaining good results.

The chrome recovery method with MgO foresees the following main process steps:

- separation and storage of the spent chrome liquors,
- precipitation of the chrome hydroxide with MgO,
- draw-off of the supernatant and redissolution of the settled chrome hydroxide deposit with sulphuric acid.

1. Design data:

Volume of the spent tanning baths	:	10 m^3/day ca. (*)
Chrome content as Cr_2O_3	:	4.5 g/l
Plant working time	:	8 hrs/day
Total recoverable Chrome as Cr_2O_3	:	45 kg/day (currently)
Number of cycles	:	1 per day

(*) current situation. The expected volume at the max. future production is 20 m^3/day (i.e. 90 kg/day of recoverable Cr_2O_3). These figures have been rechecked in July with Mr. Kidanu Chekol, Tannery Deputy General Manager, and Mr. Tesfaye Arega, Production Department Head.
The here proposed unit has been designed on the basis of the current situation (one recovery cycle per day) but in future it can easily operate two cycles per day. The volume of the storage tank allows the treatment of 25 m^3/day of spent chrome liquors.

2. Process description: (see also the annexed flow-sheet)

Foreword

The process of chrome recovery with MgO is sometimes realized in a very crude and unsophisticated way. In these cases the efficiency and reliability of the process is very little: the process does not guarantee a final product wit constant characteristics and its reuse in tanning may cause troubles.
The here proposed alternative is enough simple but designed according to rational and industrial concepts that render the process able to guarantee a constant and uniform final product.

2.1. Screening and storage:

The spent tanning baths are separately collected and, after a coarse bar screening, sent by gravity into the storage tank in concrete. The capacity of this equals the daily volume of the spent chrome liquors. One day capacity is necessary in order to guarantee the full autonomy of the unit from the internal process of the tannery.

2.2. Pumping and fine screening:

The spent liquor is pumped to the fine screen and flows into the precipitation tank. The installation of this second finer screen is advisable for limiting the content of suspended solids in the final liquor. The operation of the pump is controlled by a series of electronic level-switches in the precipitation tank and by a floating switch (no more product to treat) in the storage tank.
In any case the operator must switch on the pump for starting the transfer of the liquor.

2.3. Chrome hydroxide precipitation:

When the precipitation tank is full, the operator switches on the mixer and starts the dosage of the alkali. The alkali is manually dosed as solid product.
The mixing must continue until the total consumption of the alkali and the quantitative precipitation of the trivalent chrome as hydroxide (pH 7 ca.).

Note:
The necessary amount of MgO must be defined during the plant start-up phase. Being the magnesium oxide a non-water-soluble product, the basification proceeds slowly and, so, the pH can be checked only at the end of the reaction.

2.4. Separation of the hydroxide:

When the reaction Cr III/MgO is ultimated, the operator switches off the mixer and allows the settling of the chrome hydroxide.
One hour is generally the minimum period of calm necessary to obtain a good sedimentation with MgO.
The supernatant virtually "chrome free" is pumped to the general effluent treatment plant.

2.5. Re-dissolution of the hydroxide cake:
The Chrome hydroxide is turned back to Chromium sulphate by dosing concentrated sulphuric acid (96% ca., i.e. 60° Bè). The necessary amount of acid, to obtain a final liquor at 30±3% Schorlemmer basicity, must be established definitively during the plant star-up. The volume of the acid is measured into a graduate pit and after uniformly and safely dosed with a metering pump into the dissolution tank.

2.6. Storage and control of the recovered Chrome liquor
When the dissolution is terminated, the pump transfers the liquor to the final storage tank.

3. TECHNICAL DATA

3.1. Characteristics of the recovered liquor:

- Density	: 1.2 ca.
- pH	: 2.8 - 3.3
- Schorlemmer basicity	: 33 ± 3°
- Cr_2O_3 content (on weight)	: 4 - 5%

3.2. Consumption of chemicals:
(kg/kg of recovered Cr_2O_3)

- Magnesium oxide (90% ca.)	: 0.5
- Sulphuric acid (96% - 1.84 g/ml)	: 0.8

3.3. Electrical consumption:
(main equipment only: stand-by units are not considered)

- Total installed power:	13.5 Kw
- Power consumption:	30 Kwh ca. per day.

3.4. Labour:

The necessary labour time may be estimated in 3-4 hours per day ca.

4. LIST OF THE NECESSARY EQUIPMENT

4.1. n.1 bar screen (manually cleaned).
AISI 304 stainless steel execution,
space between bars: 10 mm, capacity 20 m^3/h ca.
The screen will be installed in a concrete pit installed before the storage tank.

4.2. n.2 submersible pumps (1 installed + 1 stand-by unit).
Characteristics:
pump body in cast iron, impeller and shaft in stainless steel AISI 304, mechanical seals in Alumina/Tungsten Carbide;
motor 1.1 kW, 380 V, 50 Hz, 4 poles .
Capacity: 300 l/m' at 4 m.

4.3. n.1 static wedge-wires screen (self cleaning).
Characteristics:
filtering panel in AISI 304, feeding box and supporting structure in polypropylene.
Space between bars: 0.75 mm.
Capacity: 10 m^3/h.

4.4. n.1 mixer for the precipitation tank.
Characteristics:
shaft and paddles in AISI 304 stainless steel.
Geared electric motor of 5 kW, 4 poles, 380 V, 50 Hz.
Impeller speed 100 r.p.m.

4.5. n.2 helicoidal screw pumps (1 installed + 1 stand-by unit).
Materials:
- body in polypropylene,
- screw in polypropylene,
- stator in synthetic rubber.

Characteristics:
capacity 2,000 l/h at 2 bars head.
Motor 1.1 kW, 380 V, 50Hz, three phase, protection IP 55 coupled with gear box.
Rotor speed 300 r.p.m. ca.

4.6. n.1 Chrome hydroxide redissolution tank.
Characteristics:
fibre-glass reinforced tank of 2,000 litres capacity.
Equipped with framework for the installation of the mixer.

4.7. n.1 mixer for the redissolution tank.
shaft and paddles with anti-acid coating, coupled with geared motor of 3 kW, 380 V, 50 Hz, 4 poles.

4.8. n.1 centrifugal fan (exhaustion of the acid fumes).
body and impeller in PVC, capacity 300 Nm^3 of air per hour, total head 200 mm of water column, installed power 1.1 kW, 380 V, 50 Hz, 2 poles, protection IP 55.

4.9. n.1 reservoir (pre-dosage of Sulphuric acid).
50 litres capacity tank fully realized in PVC, equipped with floating level indicator and graduated transparent window.

4.10. n.1 metering pump (dosage of conc. H_2SO_4).
piston dosing pump, plunger in ceramic, body in AISI 420 stainless steel, ball valves in Pyrex glass, valves seats in Astelloy C, packing in teflon.
Coupled to geared motor of 0,2 kW, 380 V, 50 Hz, 4 poles, protection IP 45.
Variable capacity from 0 to 20 litres/hour.

4.11. n.1 centrifugal pump (transfer of the Chrome liquor).
Body and impeller in polypropylene, mechanical seals in ceramic material, direct coupling to electrical motor of 2 kW, 380 V, 50 Hz, 4 poles, protection IP 55.
Capacity: 50 l/m' ca. at 8 m.

4.12. n.1 reservoir for the storage of the recovered Chrome liquor; capacity 5,000 litres ca.
Material: reinforced fibreglass resins for liquids at high specific weight (1.3 kg/l ca.).

4.13. n.1 general control-board of the plant.
Switch desk-board realized in PVC for the operation and control of the entire Chrome recovery unit; complete of pH-meter and other accessories.

4.14. - Piping and valves.
Realized in various materials according to the particular service required.

4.15. - Electrical cables.
All the necessary connections between the various electrical apparatus and the control-board are realized with cables of sizes and materials according the C.E.I. standards.

5. LIST OF THE CIVIL WORKS

5.1. n.1 underground pit for the installation of the bars screen; internal dimensions: 50 x 100 x 50 h cm.

5.2. n.1 underground tank for the storage of the spent Chrome baths; indicative dimensions: 250 x 200 x 250 h cm, useful volume 30 m^3 ca.
(the tank volume has been designed considering possible future increases of the chrome tanned production).

5.3. covered area for the installation of the general control board of the chrome recovery unit.

6. INDICATIVE PRICE OF THE CHROME RECOVERY UNIT

Price of the Chrome recovery unit:

40,000 U.S.$

The price includes:
- detailed drawings for concrete works (with the exclusion of the static calculations)
- detailed drawings of the hydraulic and electrical connections;
- detailed drawings of the reservoir for chemicals and recovered liquor;
- detailed instructions for electrical and hydraulic connections.

***

EXCLUSIONS

In the over indicated price are not included the price of the reservoirs for the storage of the H_2SO_4 and the recovered Chrome liquor. These reservoirs can be purchased on the local market. The hydraulic connections (pipes, valves and fittings) between the Chrome recovery unit and these reservoirs are not included in the price and are on charge of the recipient Company. The electric cable for the connection between the general control board of the unit and the tannery power network is also on charge of the recipient Company.

7. SPARE AND CONSUMPTION PARTS

- first lifting pump (submersible pump):
  . n. 1 impeller;
  . n. 2 pair of mechanical seals.

- helicoidal pump:
  . n. 1 rotor;
  . n. 2 stators;
  . n. 2 sets of accessories for periodic maintenance;
  . n. 4 stuffing box packings;

- dosing pump for H_2SO_4:
  . n. 2 plungers;
  . n. 4 gland packings;
  . n. 2 set of accessories for periodical maintenance (valves, valves seats etc...)

- pump for the transfer of the recovered liquor:
  . n. 1 impeller;
  . n. 2 pairs of mechanical seals.

- electric switch board:
  . n. 6 connectors;
  . n. 6 overload relays;
  . n. 8 sets of fuses.

Indicative price of the spare parts...... 4,000 U.S.$

***

7. COSTS & BENEFITS OF THE CHROME RECOVERY

Note: *the here indicated figures must be considered merely indicative. The fluctuation of the changes and the difficulty to determine exactly both the chrome quantity and the consumption of the chemicals do not allow a very precise calculation.*

Current quantity of recoverable chrome 45 x 300 = 13,500 kg of Cr_2O_3 i.e. 54,000 kg of Chrome sulphate per year.

The Chrome sulphate (Cr_2O_3 content 25% ca.) is imported. The price FOB is 1.86 DM (1.16 U.S.$) per kilo: 15-20% more expensive than that in Europe.

Note:
DM = Deutschen Marks
U.S.$ = U.S.A. Dollars

Commercial value of 54,000 kg of Chrome sulphate = 62,640 U.S.$.

<u>Cost of the chemicals</u>
(Prices FOB, these chemicals are imported)

- Sulphuric acid (96%): 0.31 DM (0.19 U.S.$) per kg

- Magnesium oxide (90% ca.): 0.75 DM (0.47 U.S.$) per kg

<u>Electricity cost</u>: 0.25 Birr (0.05 U.S.$ ca.) per kWh

<u>Labour</u>: 1.0 Birr (0.2 U.S.$ ca.) per hour

OPERATION COSTS OF THE CHROME RECOVERY PLANT
(see paragraph 3, points 3.2 - 3.3 and 3.4)

- Magnesium oxide:	0.5 x 13,500	= 6,750 kg/y	= 3,170	US $/y
- Sulphuric acid :	0.8 x 13,500	= 19,800 kg/y	= 2,050	"
- Electricity :	30 x 300	= 9,000 kWh/y	= 450	"
- Labour:	4 x 300	= 1,200 hrs/y	= 240	"
- Maintenance (*)			= 4,000	"
- Miscellaneous costs(**)			= 2,000	"
- Depreciation (***)			= 5,000	"

Total expenses = 16.910 (say 17,000) U.S.$ per year

(*) estimated 10% of the equipment cost.
(**) estimative (analysis, etc.).
(***) accelerated depreciation for pollution control equipment, 20% per year.

Credit (62,640 - 17,000) = 45,640 U.S.$ per year.

Plant installation costs

- estimated price of the imported equipment:	40,000 U.S.$
- estimated price of the local ancillary facilities (reservoirs and civil works):	40,000 U.S.$
Total cost of the chrome recovery plant	**80,000 U.S.$**

Payout period (*) $= \frac{80,000}{45,640}$ **= 1.75 years**

(*) No interest and capital charges.

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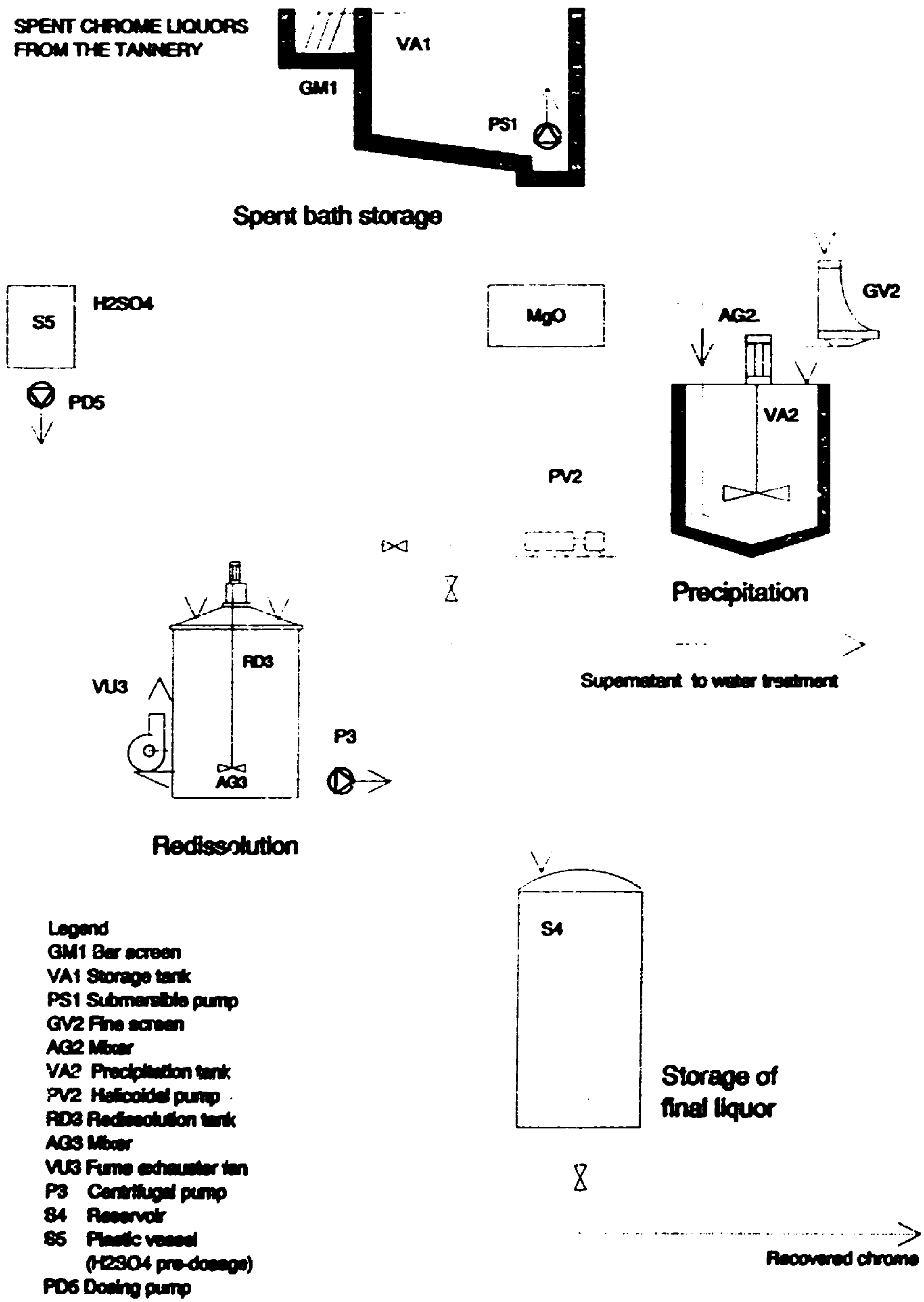
CHROME RECOVERY with MgO - FLOW-SHEET



ANNEX II

SUGGESTED LIST OF EQUIPMENT TO BE IMPORTED FOR THE EFFLUENTS ANALYSIS LABORATORY

COD REFLUX APPARATUS, consisting of:

1 six-burner heating mantle
6 reflux apparatuses (250 ml Erlenmeyer flasks with ground-glass necks and 300 mm Liebig jackets).

Spare parts:

2 reflux apparatuses (glass)
10 Erlenmeyer flasks, 250 ml
10 Erlenmeyer flasks, 500 ml.

Aproximate total price: U.S.$ 2,000

BOD_5 RESPIROMETER APPARATUS, consisting of:

1 six-place stirring device
6 BOD bottles with caps, mercury tubes, LiOH pills, silicone containers and stirring anchorsa
6 sets of interchangeable scale for direct reading of BOD values.

Spare parts:

20 BOD bottles
4 sets of rubber drive belts
1 refill supply of chemicals (nutrients, standard BOD and LiOH pills.

Approximate total price: U.S.$ 1,500

N.4 IMHOFF SEDIMENTATION CONES, for determining amount of setteable solid matter in waste waters.
Capacity 1,000 ml with graduated scale.
Material acrylic or Pyrex glass.

Approximate total price: U.S.$ 200

DISTILLATION APPARATUS for NH_3 and phenols, consisting of:

1 heating mantles for 500 and 1,000 ml flasks with ground-glass 24/40 neck
1 500 ml flask, 24/40 neck
1 1,000 ml flask, 24/40 neck 1 condenser, 24/40 neck

(See EPHA Standard Methods of Water Analysis)

Spare Parts:

2 500 ml flasks, 24/40 necks
2 1,000 ml flasks, 24/40 necks.

Approximate total price: U.S.$ 740

N.2 **MAGNETIC STIRRERS** complete of stirring anchor sets

Approximate total price: U.S.$ 500

N.3 **SOLVENT-EXTRACTION APPARATUSES** (Soxhlet glassware), each consisting of:
1 reflux apparatus, large-neck, 250 ml capacity
1 500 ml Pyrex balloon, 24/40 neck.

Approximate total price: U.S.$ 900

STANDARD METHODS for the examination of Water and Wastewater, published by American Public Health Association, latest edition.

Approximate price: U.S.$ 160

TOTAL PRICE OF THE LABORATORY EQUIPMENT: U.S.$ 6,000

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20637
(2 of 2)

STUDIO TECNICO
DR.GIUSEPPE CLONFERO

Via Dei Benci n°19
I-50122 FIRENZE (Italy)

U N I D O

CONTRACT N° 92/134/ML

PROJECT US/RAF/88/100

HIDES AND SKINS, LEATHER AND LEATHER PRODUCT IMPROVEMENT SCHEME

F I N A L R E P O R T

(PART B: SAGANA TANNERY)

27 July 1993

ENGLISH

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27 July 1993

ENGLISH

SUMMARY AND BACKGROUND

Studio Tecnico Dr. Clonfero, Florence - Italy, was contracted by UNIDO-Vienna in September 1992 (Contract 92/134/ML) within a programme of pollution control of the large scale and multi-cohomprensive US/RAF/88/100 Project of Assistance to the Leather Sector in the East Region of Africa.
The specific task of this contract was the preparation of a techno-economic study and full design for the implementation of two Effluent Treatment Plants (ETPs):

- Primary & Secondary phase at Awash Tannery, Ethiopia;
- Secondary (biological) phase at Sagana Tannery, Kenya.

The contractual duties include:

- collect all data relevant for the design and operation of the ETP;
- obtain information about the local existing standards for the effluent discharge;
- examine the possible ETP site alternatives and collect information about the local cost for civil works and construction materials;
- provide detailed specifications of the necessary equipment and indicate an estimation of prices;
- prepare the break-down of various operation/maintenance/monitoring costs and indicate personnel requirements.

Before this Final Report, Studio Tecnico has submitted to UNIDO the reports listed below:

- **Flash Report**	20 December 1992
- **Progress Report**	15 February 1993
- **Draft Final Report**	28 April 1993.

The parts of these reports referring to Sagana Tannery are briefly summarized here.

Flash Report

The first mission in Kenya of Mr. G. Clonfero, team leader and expert in tannery effluents, took place in October 1992.

Forward

Having participed in the design of the primary treatment phase, Mr. G.Clonfero was already familiar with the situation at Sagana.

The Project US/RAF/83/100 installed a primary ETP in this factory as a "model" for the tanneries of the Central East African Region. The plant is ultimated and in operation since September 1992.

The limits requested for the discharge into Sagana river (influent of Tana river, the most important Kenyan water course) are quite strict. The Project's strategy, illustrated and accepted by the Water Development Ministry (WDM: Kenyan environmental authority for water and effluent) provided a phased intervention at Sagana: the secondary phase should be defined when the primary installed and its performances and efficiency tested.

To evaluate the actual performance and efficiency of the primary plant was mandatory for the proper design of the secondary treatment: this had been the main expert's task during his stay at Sagana.

i. The analytical controls carried out by LDC-KIRDI (Leather Development Centre of the Kenyan Industrial Development Institute) indicated the following average removal percentuals:

Parameter	Percentual of removal (*)
- COD	50%
- BOD	69%
- Suspended Solids	95%
- Settleable matter	82%
- Sulphide	100% ca.
- Trivalent Chromium	99%

(*) *The removal has been calculated comparing the characteristics of the homogenized and the primary settled effluents.*

These results indicate a good efficiency of the primary treatment (at the current operation conditions) but, as expected, they are still far from the requested standards for discharge. The installation of a secondary (biological) phase is however necessary.

ii. The factory was working only at 30-40% of its maximum production capacity: this circumstance has been considered in the evaluation of the actual performances of the primary ETP. Furthermore, a comparision between the local cost of chemicals and power indicated that the biological treatment of the organic loading (BOD and COD) is 50% ca. less expensive than the flocculation with chemicals.
In the design of the secondary phase, a safety BOD of 1,000 mg/l after the primary treatment has been considered both for preventing an eventual increase of pollution at the plant' maximum capacity and for granting a reduction in consumption of chemicals.

iii. A detailed measurement of the area at disposal for the secondary treatment has been done by the expert with the support of Mr. Geoffry Murungi, Kenyan civil engineer. This technician, Works Manager of Sagana Tannery in the implementation of the primary ETP, prepared also an up-to-date list of the local prices of building materials and civil works.

Progress Report

A classical "extended aeration" process (aeration, secondary sedimentation and sludge recycle) had been designed as secondary treatment phase.

De-briefing at UNIDO headquarters in Vienna

The Progress Report had been discussed on 24 February in Vienna with Mr. Jakov Buljan, SIDO, and Ms. Aurelia Calabrò, UNIDO Back stopping Officer for this contract.

The compact secondary treatment system designed by Studio Tecnico resulted the most suitable in the situation existing at Sagana tannery. The area available does not allow the installation of more extended alternatives (e.g. lagooning).

The above-mentioned UNIDO's Officers noted that the report contains some formal errors and, furthermore, recommended more details about the operation and maintenance costs estimated for the primary and secondary treatment.

The second mission on field of Mr. G. Clonfero took place in March 1993.

i. The secondary phase designed by Studio Tecnico had been explained in details to the tannery's management.

ii. In a meeting at WDM headquarters in Nairobi the expert illustrated also to Mr. Weru, Head of the Pollution Control Board, the technical solution proposed for the secondary treatment phase at Sagana.

iii. A series of analytical controls carried out in March by the effluent laboratory of LDC-KIRDI reconfirmed the previous data: the average BOD_5 of the effluent from the primary treatment is amply below 1,000 mg/l, value adopted for the design of the secondary phase.

<u>Draft final report</u>

In the draft final report, the contractual document about the proposed interventions at Sagana Tannery had been defined. In the substance, it did not differ significantly form this final version. The draft final report has been discussed in detail with Mr. Berg, SIRA, Mr. Buljan and Ms. Calabrò at UNIDO's headquarters on 26 May.
The few modifications and additions required by the UNIDO Officers have been introduced in this final report.

****

S A G A N A T A N N E R Y

Sagana

KENYA

SECOND PHASE IMPLEMENTATION

(BIOLOGICAL TREATMENT)

CONTENTS

******

1. INPUT DATA

1.1. Max. daily capacity : 6,000 kg of raw material (dried weight)

1.2. Production (current conditions): 80% wet-blue, 10% finished chrome leather, 10% vegetable tanned.

1.3. Volume of waste waters (current conditions)

Process	Water	Daily volume(*)
1st soaking	400%	24 m^3
2nd soaking	400%	24 m^3
Washing	400%	24 m^3
Liming (1)	150%	18 m^3
Washing	170%	20 m^3
Fleshing		5-10 m^3
Washing	70%	10.5 m^3
De-liming & bating (4)	100%	15 m^3
Washing	60-70%	10 m^3
Pickling & tanning	70%	10.5 m^3
Sammying		3 m^3
WET-BLUE PRODUCTION : Water use		169 m^3/day
Washing	150%	5 m^3
Neutralisation	100%	3 m^3
Washing	150%	5 m^3
Retanning, fatliquoring & dyeing	80-100%	3 m^3
OTHER PRODUCTION (**): Water use		16 m^3/day

Waters for the cleaning of the equipment & floor	10 m^3/day

TOTAL DAILY VOLUME: 211 m^3

Notes:
(*) the daily volume of effluent (the quantity of water is expressed in weight of hides or skins at that phase of the process).

(1) soaked weight = 2 times the dry weight.

(2) pelt weight = 2.5 times the dry weight.

(**) currently on 20% of the total production.

Important notice:

211 m^3 of water per 12,000 kg of raw material, soaked weight, correspond to 211,000 : 12,000 = 17.5 litres per kg of processed hides/skins.
A precautionary water consumption of 35 l/kg has been here assumed, i.e. 12,000 x 35/1000 = 420 m^3 of effluent per day.
This figure allows for a future increase in production or water consumption.

1.4. Limits to discharge

The Kenyan Ministry of Water Development has imposed strict standards for the discharge of the final effluent of this tannery into Sagana river:

- pH	6 - 9
- BOD_5	< 80 mg/l
- COD	< 100 mg/l
- Oil & Grease	Nil
- Phenols	< 5 mg/l
- Chromium tot.	< 1 mg/l
- Suspended Solids	< 100 mg/l

A two-step treatment, physico-chemical and biological is necessary in order to achieve these levels of BOD and COD reduction in tannery waste waters.
Due to the current lack of practical experience in the design and operation of a tannery effluent treatment plant, starting at Sagana tannery with a complete treatment seemed a risky undertaking and, therefore, an installation in two successive phases has been foreseen.

2. DESCRIPTION OF THE TREATMENT PROCESS
(see also the annexed process flow-sheet)

PRIMARY TREATMENT

The primary phase of effluent treatment is already installed, it foresees:

Pre-treatment of Chrome III wastes

These waters are separately collected and, after screening (bar screen), are sent to the neutralization tank where lime-milk is added by means of a pneumatic valve driven by a pH-meter.
From the neutralization tank the liquor flows by gravity into the precipitation tank where the hydroxide settles as sludge and the chrome-free supernatant is piped into the first lifting station of the general effluent treatment.
The chrome sludges are periodically discharged and pumped to a series of drying beds specific for these solid wastes.

Storage and redistribution of the spent unhairing liquors

The spent liming, washing and fleshing liquors are collected in a separate gully and, after screening, are sent by gravity in an underground storage tank with a capacity equal to the daily volume of discharge.
In order to screen most of the hair, a self-cleaning brushed screen has been installed; in fact the partially pulped hair remaining in the concentrated lime/sulphide liquor are, in time, further dissolved increasing the BOD and COD of the effluent.
Furthermore, this material floating or settling can form coarse aggregates with the risk of clogging the pumps and pipes.
A submersible Venturi ejector assures the mixing to avoid solid deposits and also starts the sulphide oxidation.
At this step, due to the high concentration of the sulphide in the liquors, a dosage of $MnSO_4$ seems unnecessary (the sulphide oxidation will completed in the equalization tank) but it can be manually given if on-plant tests will show a better performance.
These wastes are then pumped to the equalization tank and mixed with the other tannery effluents.

A submersible pump, driven by a programmed timer, redistributes the daily sulphide wastes, generally discharged in a short period of time during the morning, in 10 hrs ca.
The advantage of this technique is a more uniform load of the BOD, COD, Suspended Solid and Sulphide arriving to the plant renders easier the design of the successive treatment phases.
In particular, the knowledge of the quantity of sulphide coming into the equalization tank enables a better calculation of the hourly required oxygen and of the retention time necessary to complete the oxidation process.

General effluent treatment

The other tannery effluents are screened (brushed screen) and sent by gravity into a lifting tank. This tank will also receive by gravity the supernatant of the pre-treatment of the Chrome waters.
The pumping station is equipped with two submersible pumps and a series of floating level switches.
The wastes are pumped into the equalization tank in which the liming liquors from the storage tank are also sent.
The equalization is necessary both to realize a good mixing (homogenization) of the various streams and to cut off the flow peaks of the factory (hydraulic equalization) in order to obtain a uniform and constant effluent to treat.
To avoid the sedimentation of the suspended solids, the tank is equipped with two submersible Venturi ejectors that assure the necessary mechanical mixing.
Furthermore, the injection of air enables the oxidation of sulphides catalysed by the addition of Manganese II salts.
A submersible pump redistributes the mixed daily effluents to the further treatment phases.
The successive coagulation and flocculation processes are done by adding Alum and Polyelectrolyte.
Such a chemical treatment is very flexible and can be modified during the plant commissioning and adjusted to the real needs and practical results.
The chemicals are dosed in water solution by means of two metering pumps that operate simultaneously with the second lifting pump.
The flocculated liquor flows by gravity into the primary sedimentation tank (Dortmund type) where most of the suspended solid is allowed to settle as sludge and the clear supernatant is discharged.
When the biological treatment will be installed the primarily treated effluent will be, obviously, piped to this treatment.

Treatment of sludge

The sludge settled in the primary sedimentation tank is pumped (helicoidal pump) to a series of sand drying beds.
The pump is driven by a timer that will be programmed in order to maintain a correct blanket level in the tank and transfer a suitable thickened sludge to the beds.

The de-watered sludge, 20% ca. of dry matter, must be manually collected and transported to its final disposal site, while the filtration waters are piped back to the general treatment.

SECONDARY TREATMENT

The biological treatment is an extended aeration that is realized in three successive steps:
- aeration (BOD-removal through bio-absorption/flocculation of the soluble/suspended organic matter)
- sedimentation (physical treatment necessary in order to separate the biological sludge from the treated water)
- biological sludge recycle (the settled sludge is continuously re-pumped into the aeration tank to maintain the bacterial mass necessary to the process.

The aeration tank is designed for 2 days ca. retention time and the oxygen necessary to the process is supplied by blowers and air diffusers. The secondary sedimentation is realized into a circular tank fitted with rotary bridge mechanism for the sludge scraping.
A submersible pump recycles the settled sludge to the aeration tank. Periodically, the excess of sludge is discharged throught a by-pass-valve into the equalization basin.

NOTE
During the meeting held at UNIDO headquarters in Vienna Mr. Jakov Buljan, Back Stopping Officer, recommended Mr. G. Clonfero to consider in the final report also a concept for a biological treatment applying a lagooning system. In the Officer's opinion, the realization of such system seemed be facilitated by the space availability at Sagana.
Mr. Clonfero in the mission in Kenya of March has recheked the dimensions of the existing lagoons and the eventual area still available for other lagoons.

The dimensions of the existing lagoons are:

lagoon	n. 1	m 54.0	x 8.5	x 1.2 h	=	459 m^2	-	550 m^3	ca.	
"	n. 2	m 28.0	x 11.0	x 1.2 h	=	308 "	-	370	"	
"	n. 3	m 20.4	x 14.8	x 1.2 h	=	302 "	-	362	"	(*)
"	n. 4	m 19.4	x 7.3	x 1.2 h	=	142 "	-	170	"	
"	n. 5	m 20.0	x 9.2	x 1.2 h	=	184 "	-	220	"	
"	n. 6	m 20.0	x 9.0	x 1.2 h	=	180 "	-	216	"	
"	n. 7	m 16.0	x 9.7	x 1.2 h	=	155 "	-	186	"	
"	n. 8	m 14.0	x 9.3	x 1.2 h	=	130 "	-	156	"	
				Total	=	1,860 m^2	-	2,230 m3	ca.	

(*) *Currently the lagoon n. 3 is used for the disposal of solid wastes (the effluent from the primary treatment is not sent in this lagoon).*

The existing lagooons, depth between 1 and 1.5 metres, are basically "oxidation ponds" that are designed with an organic loading between 40 and 120 kg of BOD per hectare of pond surface per day (see Table 1.1).

At the present tannery's discharge flow (70 m3/day ca.), the current retention time results about 26 days and 16 hrs.

At the plant's design capacity (400 m3/day) the maximum retention time of the lagoons is about 5 days and 14 hrs.

LDC KIRDI found a residual BOD_5 in the effluent from the primary sedimentation between 500 and 400 mg/l.
The few available data on the characteristics of the effluent from the lagoons indicate a BOD_5 between 400 and 300 mg/l.

Considering that the tannery is currently diluting with fresh water 1 : 1 the effluent from the primary sedimentation, the volume of water sent into the lagoons is about 140 m^3/day.

The current BOD removal is (140 x 0.1) 14 kg of BOD_5 per day.

The mean BOD removal (14 : 0.156) is 90 kg BOD per ha per day.

If the above calculations are correct, for comply with the requested limit of 80 mg/l BOD_5 (i.e. a total BOD removal of 320-420 mg/l) 0.50 ha (44.8 : 90) or 0.65 ha (58.8 : 90) shoud be necessary. I.e. 3-4 times the existing surface of the lagoons.

<u>This area is not available at Sagana</u>.

Furthermore, the unsatisfactory experience done at Alpharama Tannery renders very difficult to entrust in the reliability and efficiency of the lagooning for tannery effluents.

Also Mr. Weru, Head of the Kenyan Water Control Bureau, seems to have little revised his opinion about the reliability of the lagooning treatment for tannery effluents. Now he speaks about a possible their use for the final polishing of the effluent. A kind of protection "diaphragm", between the treatment plant and the recipient environment, to be installed <u>after</u> a mechanized biological treatment.

For these reasons the expert reached the conviction that it is better to maintain the existing lagoons only as final polishing ponds after a classical biological treatment.

TABLE 1 1 Design Features and Expected Performance for Aquatic Treatment Units

		Typical criteria*				
Concepts	Treatment goals	Climate needs	Detention time, days	Depth, m	Organic loading, kg/(ha · d)	Effluent characteristics, mg/L
Oxidation pond	Secondary	Warm	10–40	1–1.5	40–120	BOD† 20–40 TSS‡ 80–140
Facultative pond	Secondary	None	25–180	1.5–2.5	22–67	BOD 30–40 TSS 40–100
Aerated pond partial mix	Secondary, polishing	None	7–20	2–6	50–200	BOD 30–40 TSS 30–60
Storage and controlled discharge ponds	Secondary, storage, polishing	None	100–200	3–5	—§	BOD 10–30 TSS 10–40
Hyacinth ponds	Secondary	Warm	30–50	< 1.5	< 30	BOD < 30 TSS < 30
Hyacinth ponds	AWT, with secondary input	Warm	> 6	< 1	< 50	BOD < 10 TSS < 10 TP¶ < 5 TN‖ < 5

* See Table A.1 in the appendix for conversion factors.
† BOD = biochemical oxygen demand.
‡ TSS = total suspended solids, concentration depends on algal content.
§ First cell in system designed as a facultative or aerated treatment unit.
¶ TP = total phosphorus.
‖ TN = total nitrogen (also get significant metals removal effected).

from INDUSTRIAL WATER POLLUTION CONTROL W.Wesley Eckenfelder jr

Mc GRAW-HILL INTERNATIONAL EDITIONS Second Ed. 1989

3. DESIGN AND CALCULATIONS OF THE SECONDARY TREATMENT PHASE

The biological treatment adopted is an "extended aeration" process with the following operational parameters:

- Retention time: 48 hrs ca.
- F/M ratio < 0.1

Note:
F = organic loading, kg BOD_5 of the influent per day.
M = mass of Mixed Liquor Volatile Suspended Solids (MLVSS) in the aeration tank (quantity of active biological sludge).

Volume of the aeration tank:

400 m^3/day x 2 days retention period = 800 m^3.

The Oxygen request may be calculated from the formula:

$$O.R. = \frac{(a \times F) + (b \times M)}{24}$$

Were:

O.R. = total oxygen requirement per hour.
a = coefficient related to O_2 requirement for synthesis.
f = organic load, kg BOD/day

b = coefficient related to O_2 requirement for endogenous sludge respiration.

Replacing the project's data:

F = 1,000 x 400 : 1,000 = 400 kg of BOD_5/day (*)

M = 400 : 0.1 = 4,000 kg of MLVSS

and assuming:

a = 0.8 and b = 0.2 (experimental data)

$$O.R. = \frac{(0.8 \times 400) + (0.2 \times 4{,}000)}{24} = 46.7 \text{ kg/h}$$

(*) a BOD of 1,000 mg/l has been considered in order to allow the reduction of the chemicals used in the primary treatment.

Let the oxygen transfer efficiency of the installed air diffusers be 15% at the operational conditions:

46.7 x 100 : 15 = 311 kg/h ca. of O_2 must be furnished or
311,000 : 280 = 1,112 Nm^3 of air per hour.

Two blowers with a capacity of 600 Nm^3/h ca. of air each have been proposed.

Secondary sedimentation:

- superficial load = 0.5 m^3/m^2 of tank surface per hour (adopted);
- influent flow = 400 : 20 = 20 m^3/h;
- total necessary surface = 20 : 0.5 = 40 m^2.

A circular clarifier with a 8 m diameter (surface 50 m^2) has been proposed.

Sludge recycle:

- recycle rate = 100% (adopted);
- capacity of the recycling pump = 20 m^3/h.

A submersible pump with 24 m^3/h ca. has been proposed.

Note: *as general habit, 100% recycle rate means that the volume of the settled secondary sluge repumped to the aeration tank equals the volume of the hourly raw influent. This does not imply any draw-off of the excess sludge produced in the biological process. In fact periodically part of the sludge must be discharged in order to mantain the correct concentration of suspended solids in the aeration tank. The surplus of sludge is discharged by the same recycle pump operating on the by-pass to the equalization basin.*

4. LIST OF THE EQUIPMENT

4.1. n.2 **rotary vane blowers** able to supply oil-free air, rotors and body in spheroidal cast iron, direct driving through flexible anti-shock coupling to 11 kW motor 415 V, 50 Hz, 2 poles, threephase, protection IP 55.
Technical specifications:
- capacity = 600 Nm^3/h each of air at 0.4 Bars;
- max. head = 0.4 Bars.

The blowers are equipped with:
- suction filter,
- suction and discharge silencers,
- non return valve;
- safety valve;
- flexible anti-vibration connection and shock insulating feet.

Price: 11,400 U.S.$

4.2. n.1 **air distribution device** consisting of:
- 250 non-clog air diffusers (medium/small bubbles) with cone-shaped base in polypropylene and flexible perforated EPDM membrane for the air escape in fine bubbles.
  Oxygen transfer efficiency 20% ca.;
- air distribution net-work in galvanized steel (out-side part) and in PVC (submerged part);
- air regulation valves;
- clamps for the device fixing at the walls of the tank in concrete.

Total Price: 18,000 U.S.$

4.3. n.1 **sludge scraping mechanism** for circular secondary sedimentation tank of 8 metres.
Technical specifications:
central driver of 0.5 kW, 415 V, 50 Hz, 4 poles, three phases, protection IP 55, with two speed reducer; peripheral speed 2.5 m/min. ca.
lectrowelded structure in hot galvanized steel.
Equipped with:
- over-flow weir type Thomson and scum-baffle in stainless steel AISI 304;
- surface scum-blade scraper and scum-troug in stainless steel AISI 304;
- bottom sludge scraper in hot galvanized steel and rubber blades;
- central influent well in hot galvanized steel;
- flanged inlet and outlet connection and sludge draw-off pipe in Fe 37.

Price: 20,000 U.S.$

4.4. n.1 **submersible pump**, for waste water with high solid content.
Body and propeller in cast iron with rubber paint, shaft, studs and nuts in stainless steel AISI 304.
Characteristics:
- 2 kW motor 415 V, 50 Hz, 3 phases, 4 poles, insulated to F Class;
- swingle-vane impeller with solid passing of 76 mm diameter;
- capacity 900 l/min. at 4 m head.

The pumps is equipped with a hose connection, base stand and strainer.

Price: 3,000 U.S.$

4.5. n.1 **control board** for the operating and control of the electrical equipment of the E.T.P.
The control board is designed in accordance with the standards of the European Electricity Committee.
The board is made for the installation under a covered area.

Price: 2,500 U.S.$

4.6. -- **piping:**
pipes, valves and fittings for the hydraulic connections of the E.T.P. and sludges drying beds.
The materials (PVC, steel, polythene, etc.) and the sizes are different according to the characteristics of the piped product and the required flow or head.

Total Price: 800 U.S.$

4.7. -- **electrical wiring:**
cables of different sections and accessories for the connection and/or control of the electrical equipment of the secondary treatment plant including clamping devices.

Total Price: 600 U.S.$

Total Price of the equipment **56,300 U.S.$**

---

5. SPARE AND CONSUMPTION PARTS

Indicative price of the spare and consumption parts for two years of the biological phase operation:

5.1. Air diffusers		
n. 10 complete sets	Total Price	500 U.S.$
n. 25 membranes	Total Price	625 U.S.$
5.2 Air Blowers		
n. 2 sets of flexible joint	Total Price	500 U.S.$
n. 2 sets of suction filters	Total Price	100 U.S.$
5.3 Submersible pump		
n.1 stand-by unit	Price	3,000 U.S.$

Total Price of the spare parts **4,625 U.S.$**

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6. PLANT COMMISSIONING AND TRAINING OF THE LOCAL STAFF

6.1. Supervision during plant installation:

n.1 technician for 7 days: 2,800 U.S.$
(1 international trip)
Travel expenses, board and lodging at the charge of the recipient Company.

6.2. Plant start-up and training of the local personnel:

n.1 technician for 7 days: 2,800 U.S.$
(1 international trip)
Travel expenses, etc. at the charge of the recipient Company.

7. OPERATION COSTS OF THE ETP
(for 400 m^3 of effluents per day)

Note: *the exchange rate of 60 Kenyan Schillings (K.Sc.) per 1 U.S.A. Dollar (U.S.$) has been here adopted for the local costs.*

7.1 PRIMARY TREATMENT

Chemicals:

- **Alum**
  - price = 0.5 U.S.$/kg (local - *coarse pieces*)
  - consumption = 90 kg/day (*)
  - cost = 45 U.S.$ per day.
- **Polyelectrolyte**
  - price = 10 U.S.$/kg (imported - anionic powder)
  - consumption = 0.4 kg/day (**)
  - cost = 4 U.S.$ per day.
- **Manganese sulphate**
  - price = 2 U.S.$/kg (imported - *98% grade*)
  - consumption = 8 kg/day (***)
  - cost = 16 U.S.$ per day.
- **Lime**
  - price = 0.3 U.S.$/kg (local)
  - consumption = 20 kg/day
  - cost = 6 U.S.$ per day.

Total cost for chemicals = 71 U.S.$ per day.

Notes:

(*) calculated on the basis of the present consumption (i.e. 225 mg/l), with the installation of the secondary treatment a reduction should be possible.

(**) in the current conditions at Sagana the polyelectrolyte does not seem to be efficacious, but it may become necessary when the ETP will work at its full design capacity. For this reason a consumption of 1 mg/l has been considered.

(***) presently Manganese sulphate is not used, but, as for polyelectrolyte, it could become necessary when the tannery (and ETP) will work at full capacity.
The calculated consumption is 20 mg/l on the mixed effluent volume.

Power:	price	= 3 K.Sc. (0.05 U.S.$) per kWh ca.
	consumption	= 200 kWh/day ca.
	cost	= 10 U.S.$ per day.
Labour:	salary	= 4 U.S.$ per 8 hrs/day
	persons	= 2 (8 hrs per day)
	cost	= 8 U.S.$ per day.
Maintenance (*):		= 48 U.S.$ per day

(*) based on 10% of the equipment price (primary phase: 120,000 U.S.$ ca.) per year (250 work days).

Operation cost for the primary treatment: 137 U.S.$ per day (i.e. 0.34 U.S.$ per m^3 of waste water).

7.2 SECONDARY TREATMENT

Chemicals:		
- Sodium Threephosphate	price	= 0.5 U.S.$ per kg (estimated)
	consumption	= max. 10 kg/day (eventual)
	cost	= 5 U.S.$
Power:	price	= 3 K.Sc. (0.05 U.S.$) per kWh ca.
	consumption	= 400 kWh/day ca.
	cost	= 20 U.S.$ per day
Labour:	same personnel of the primary treatment (no extra labour).	
Maintenance (*):		= 22 U.S.$ per day

(*) based on 10% of the equipment price (secondary phase: 55,000 U.S.$ ca.) per year (250 work days).

Operation cost for the secondary treatment: 44 U.S.$/day (i.e. 0.11 U.S.$ per m^3 of waste water).

Note: the following costs has not been considered:

i. the transport of the sludge to the final disposal and the eventual charge of the sanitary landfill.

ii. **the financing/interest costs.**

8. CIVIL WORKS

8.1. Aeration tank:
with lateral and bottom walls in reinforced concrete 30 cm thick.
Internal dimensions:
- width 1,000 cm,
- length 2,500 cm,
- height 400 cm (useful 350 cm).

Useful volume: 800 m^3 ca.
Partially underground tank: 270 cm above and 130 cm below the ground level.

8.2. Secondary sedimentation tank
circular tank of 8 metres diameter in reinforced concrete.
Complete of bridge in reinforced concrete for the installation of the sludge scraping device and pit for the sludge recycle pump.
Other dimensions:
- height of vertical wall = 2.5 m (2 m useful);
- surface ≈ 50 m^2, volume = 100 m^3 ca.

Thank partially underground.

*****

9. BILL OF QUANTITIES AND ESTIMATION COST FOR CIVIL WORKS

Note : the local unit prices for building materials have been fournished by Mr. GEOFFRY MURUNGI, Consulting Engineer and Work Manager for the E.T.P. at Sagana Tannery.

ITEM	UNIT	QUANTITY	UNIT PRICE K.Shs	TOTAL PRICE K.Shs.
9.1 Site works				
9.1.1. bulk excavation of the soil of natural ground to an average depth of m 0.30 from the current level.	m3	200	180	36,000
9.1.2. cart, spread and depopsit all surplus excavated materials around site at distance not exceeding m 200.	m3	200	50	10,000
Sub total Item 9.1.				46,000
9.2 Raceways, pits and accessoires				
9.2.1 m 0.40x0.40 manhole pits average height m 1.0 in concrete blocks of m 0.20x0.40x0.20 bedded with cement mortar, including excavation cart away, internal plastering, concrete lean thick m 0.20 and cover m 0.50x0.50.	pc	8	2,000	16,000
9.2.2. mm 200 P.V.C. pipeline, including excavation and placing.	m	50	1,600	80,000
9.2.3. mm 100 P.V.C. pipeline, including excavation and placing.	m	30	600	18,000
Sub total Item 9.2.				114,000
9.3. Aeration tank				
9.3.1. excavation of soil of natural ground to a maximum depth of m 2.5 starting from the stripped level.	m3	350	180	63,000
9.3.2. cart away all surplus excavated material and deposit at a distance not exceeding m 200 from the site.	m3	350	80	28,000
9.3.3. concrete lean, kg 200 cement per m3 of concrete, forming the tank base of m 0.20 thickness.	m2	330	600	198,000

9.3.4. m 0.40 thick reinforced concrete plate, kg 360 cement per m3 of concrete.
m2 330 2,000 660,000

9.3.5. m 0.40 thick reinforced concrete elevation walls, kg 360 cement per m3 of concrete.
m2 250 2,000 500,000

9.3.6. concrete filler for slopes, kg 200 cement per m3 of concrete.
m3 30 3,500 105,000

9.3.7. steel bar reinforcement, various diameters, including cutting, bending, placing in position and tying wires.
kg 16,800 40 672,000

9.3.8. provide, cut, and fix in position wood formwork for the r.c. elevation walls.
m2 610 600 366,000

9.3.9. backfill and compacting of soil with dry filling materials from the site around the excavated r.c. walls.
m3 90 50 4,500

Sub total Item 9.3. 2,596,500

9.4. Secondary sedimentation tank

9.4.1. excavation of soil of natural ground to a maximum depth of m 2.0 starting from the stripped level.
m3 70 180 12,600

9.4.2. cart away all surplus excavated material and deposit at a distance not exceeding m 200 from the site.
m3 70 50 3,500

9.4.3. concrete lean, kg 200 cement per m3 of concrete, forming the tank base of m 0.20 thickness.
m2 80 600 48,000

9.4.4. m 0.30 thick reinforced concrete plate, kg 360 cement per m3 of concrete.
m2 80 1,500 120,000

9.4.5. m 0.30 thick reinforced concrete elevation walls, kg 360 cement per m3 of concrete.
m2 65 1,500 97,500

9.4.6. steel bar reinforcement, various diameters, including cutting, bending, placing in position and tying wires.
kg 4,500 40 180,000

9.4.7. provide, cut, and fix in position wood formwork for the r.c. elevation walls.
m2 80 600 48,000

9.4.8. backfill and compacting of soil with dry filling materials from the site around the excavated r.c. walls (layers not exceeding m 0.50 of thickness).
m3 15 50 750

Sub total Item 9.4. 510,350

SUMMARY OF COST ESTIMATION FOR THE CIVIL WORKS

Site works	46,000 K.Sc.
Raceways, pits, pipes and accessoires . . .	114,000 "
Aeration tank.	2,596,500 "
Secondary sedimentation tank	510,350 "
TOTAL	3,266,850 K Sc.
Contingency 10% ca.	327,000 K.Sc.
GRAND TOTAL	3,593,850 K.Sc. (60,000 U.S.$ ca.)

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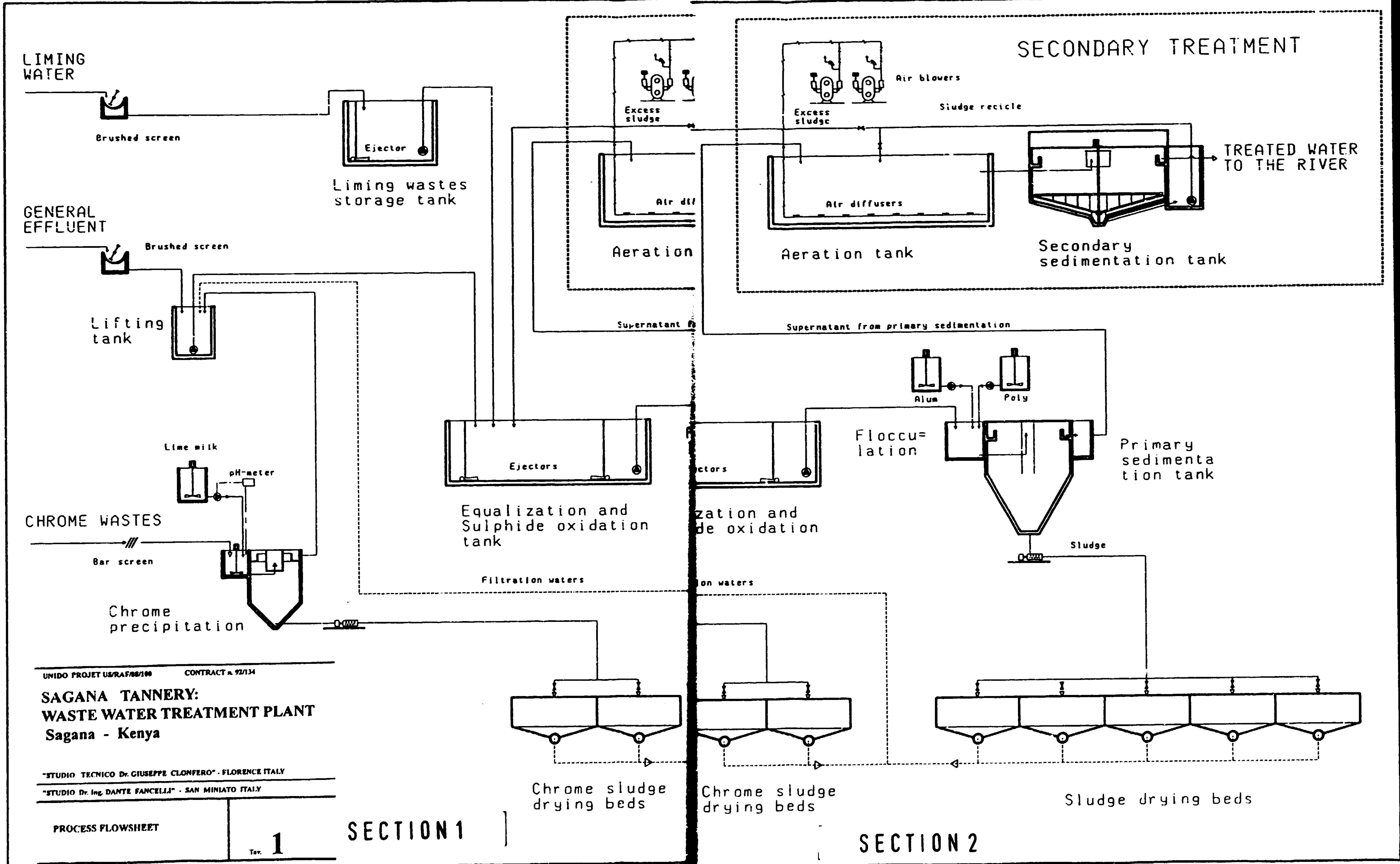
DRAWINGS
Sagana Tannery

Table 1: Process flow sheet
Table 2: Plant lay-out
Table 3: Biological treatment: aeration tank
Table 4: Biological treatment: secondary sedimentation tank


LIMING WATER
Brushed screen
Ejector
Liming wastes storage tank
GENERAL EFFLUENT
Brushed screen
Lifting tank
Lime milk
pH-meter
CHROME WASTES
Bar screen
Chrome precipitation
Ejectors
Equalization and Sulphide oxidation tank
Filtration waters
Chrome sludge drying beds
SECTION 1
SECONDARY TREATMENT
Air blowers
Excess sludge
Sludge recicle
TREATED WATER TO THE RIVER
Air diffusers
Aeration tank
Secondary sedimentation tank
Supernatant from primary sedimentation
Alum
Poly
Floccu= lation
Primary sedimenta tion tank
Sludge
Sludge drying beds
SECTION 2
UNIDO PROJET US/RAF/88/100
CONTRACT n. 92/134
SAGANA TANNERY:
WASTE WATER TREATMENT PLANT
Sagana - Kenya
"STUDIO TECNICO Dr. GIUSEPPE CLONFERO" - FLORENCE ITALY
"STUDIO Dr. Ing. DANTE FANCELLI" - SAN MINIATO ITALY
PROCESS FLOWSHEET
Tav. 1

TANNERY

LEGEND

1. Pit for the bar screen (Chrome wastes)

2. Pit for the brushed screen (lime wastes)

3. " " " " " (general effluent)

4. Chrome precipitation tank

5. Chrome hydroxide sedimentation tank

5. Storage tank of the lime liquors

7. Pumping station

8. Equalization & sulphide oxidation tank

9. Primary sedimentation tank

10. Drying beds for Chrome sludges

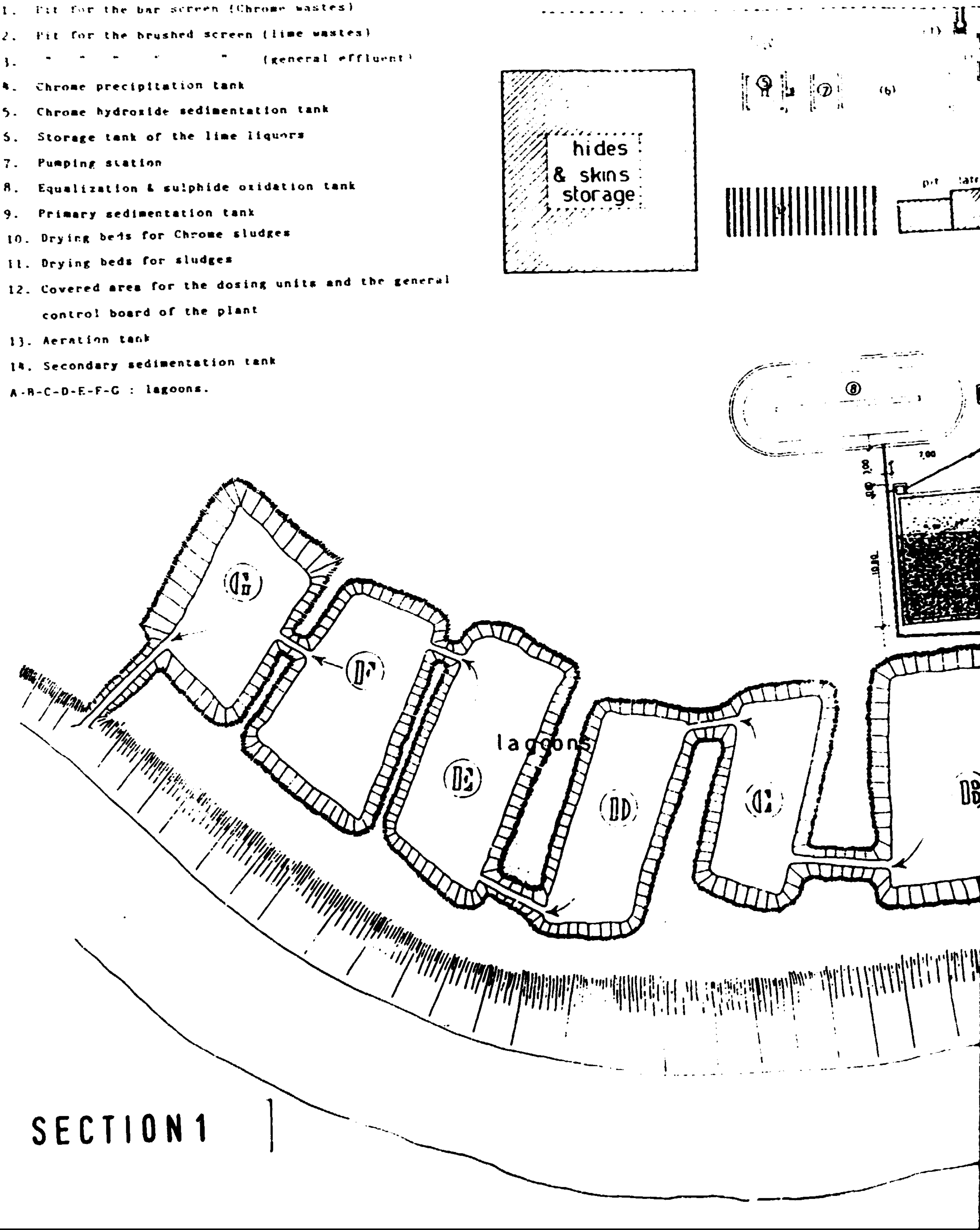
11. Drying beds for sludges

12. Covered area for the dosing units and the general control board of the plant

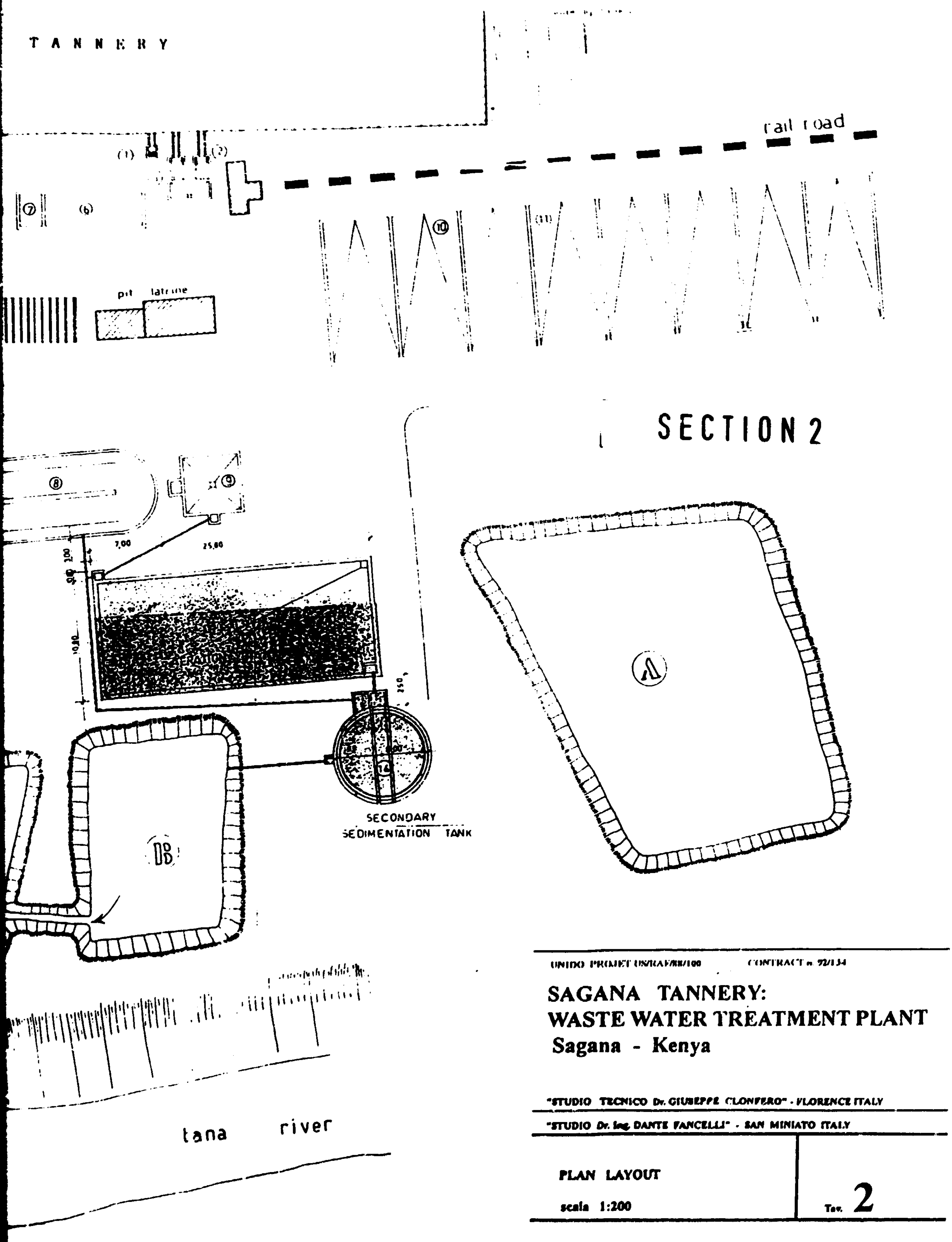
13. Aeration tank

14. Secondary sedimentation tank

A-B-C-D-E-F-G : lagoons.



SECTION 1



UNIDO PROJECT US/RAF/88/100 CONTRACT n. 92/134

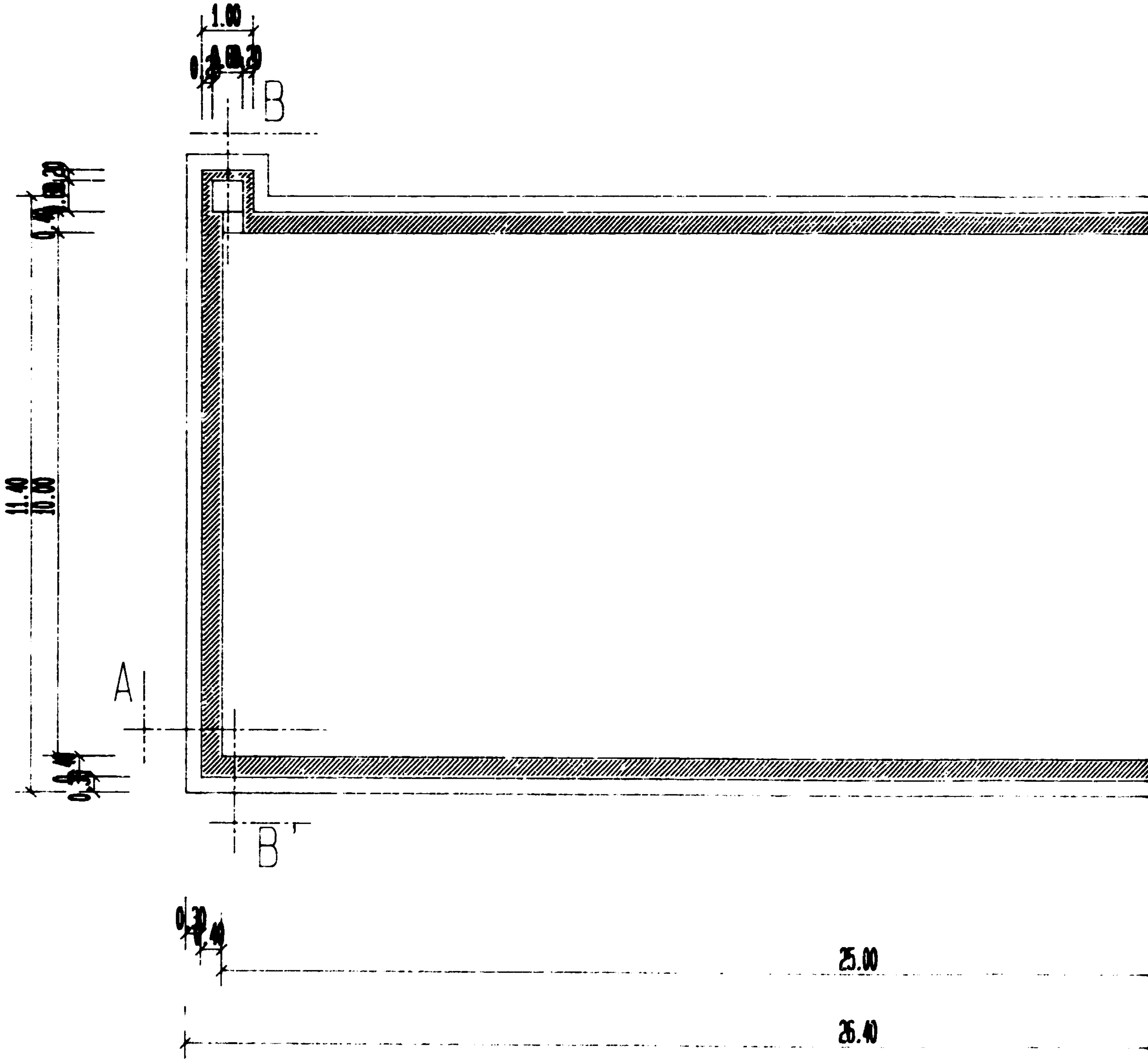
SAGANA TANNERY:
WASTE WATER TREATMENT PLANT
Sagana - Kenya

"STUDIO TECNICO Dr. GIUSEPPE CLONFERO" - FLORENCE ITALY

"STUDIO Dr. Ing. DANTE FANCELLI" - SAN MINIATO ITALY

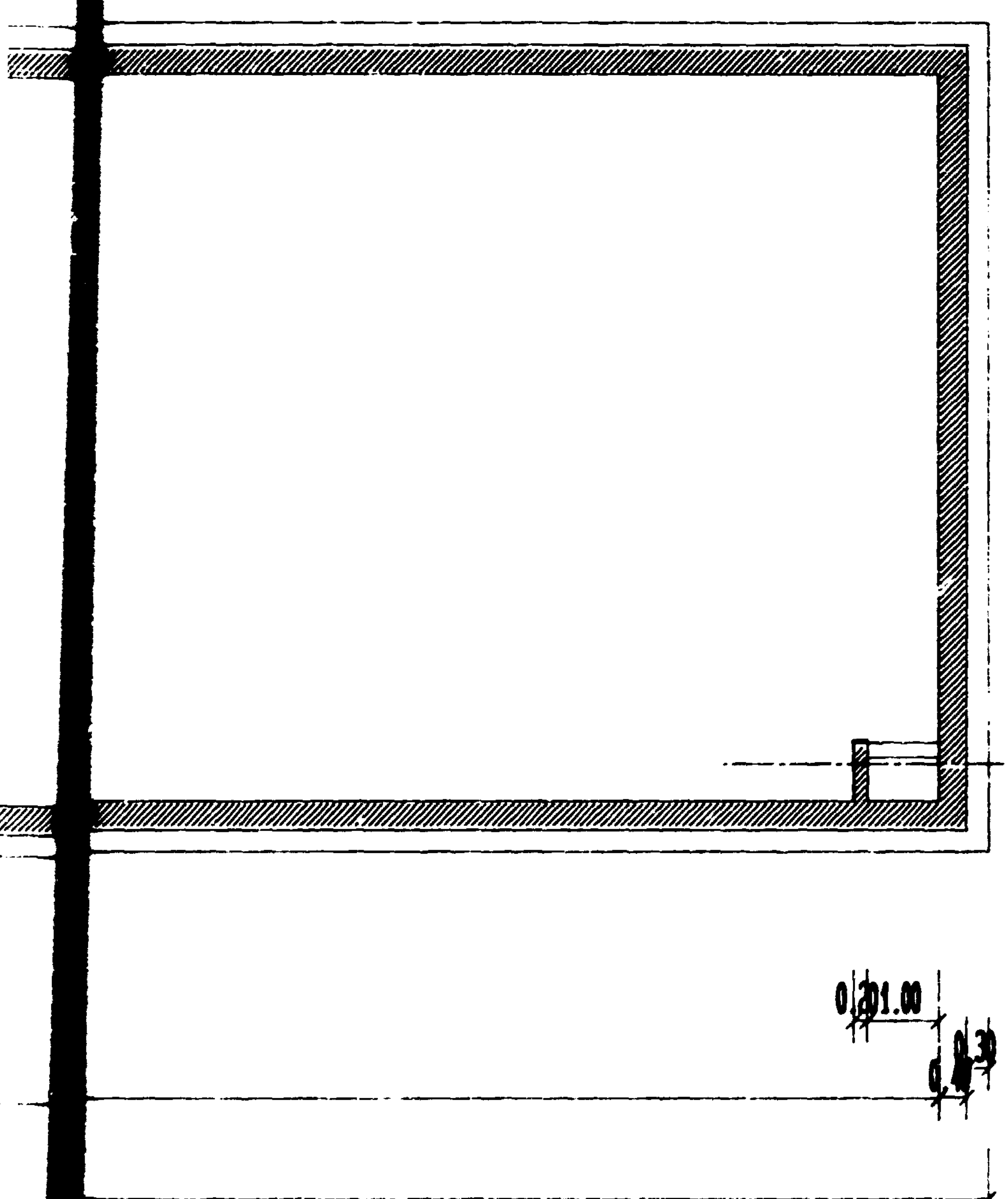
PLAN LAYOUT scala 1:200	Tav. **2**

PLAN AERATION TANK sca



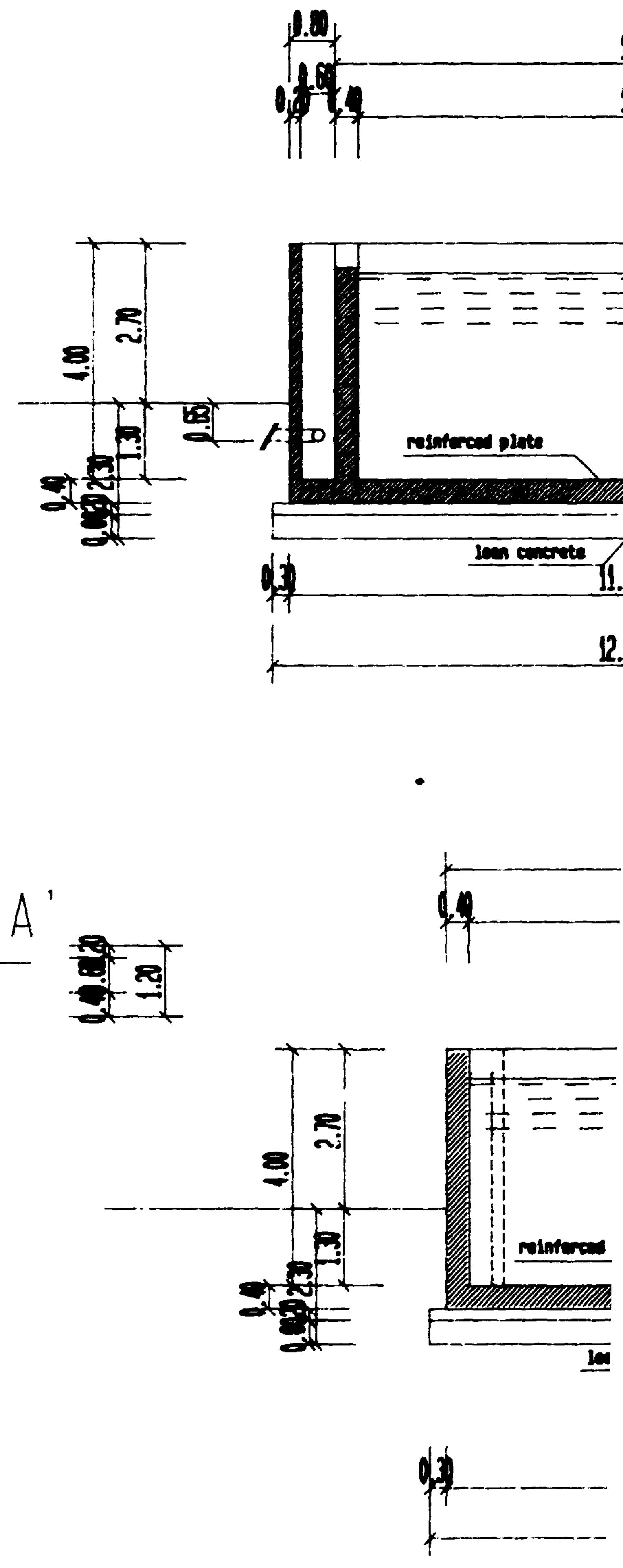
SECTION1

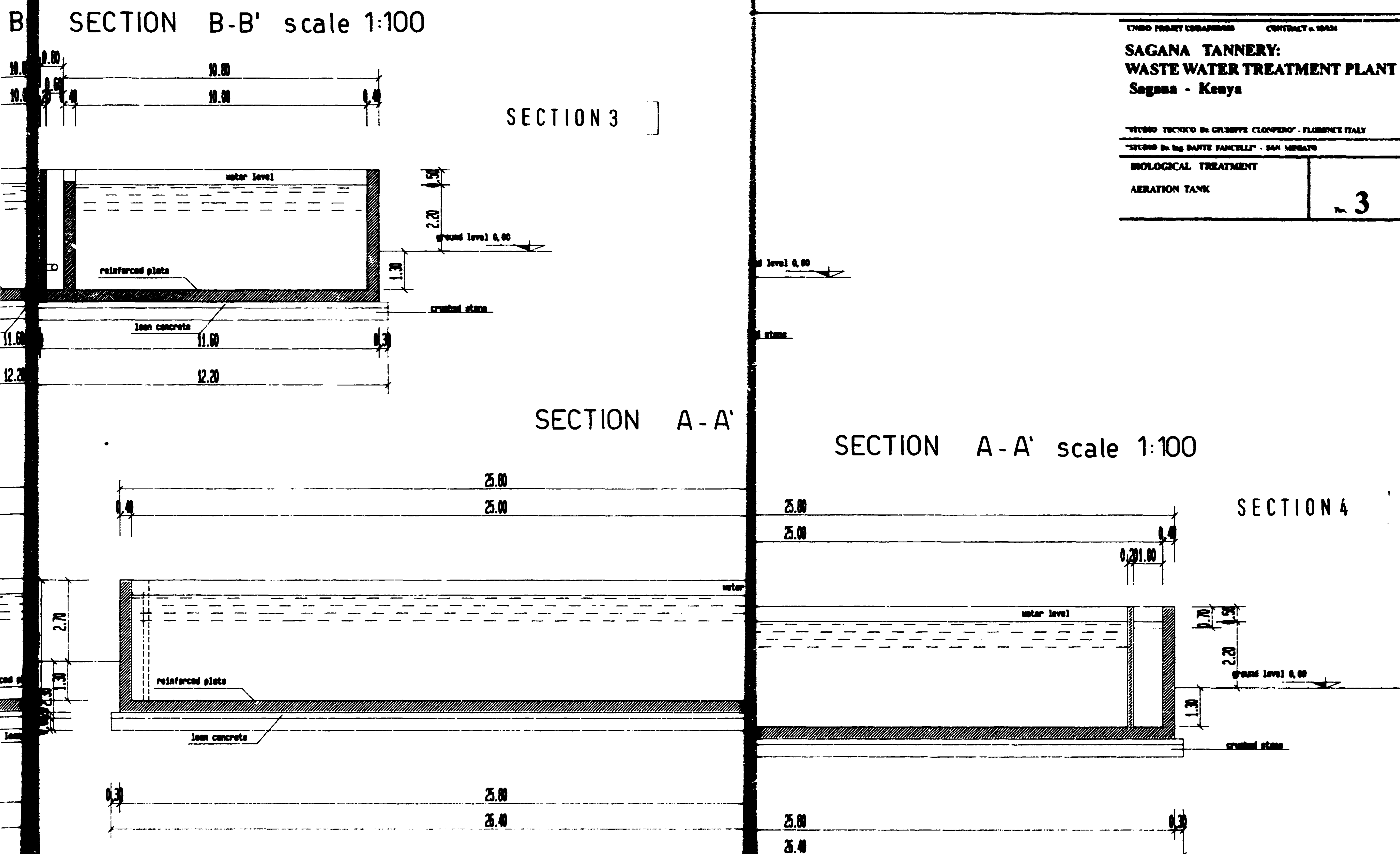
sca TANK scale 1:100



SECTION 2

SECTION





UNIDO PROJECT [illegible] CONTRACT n. [illegible]

SAGANA TANNERY:
WASTE WATER TREATMENT PLANT
Sagana - Kenya

"STUDIO TECNICO Dr. GIUSEPPE CLONFERO" - FLORENCE ITALY

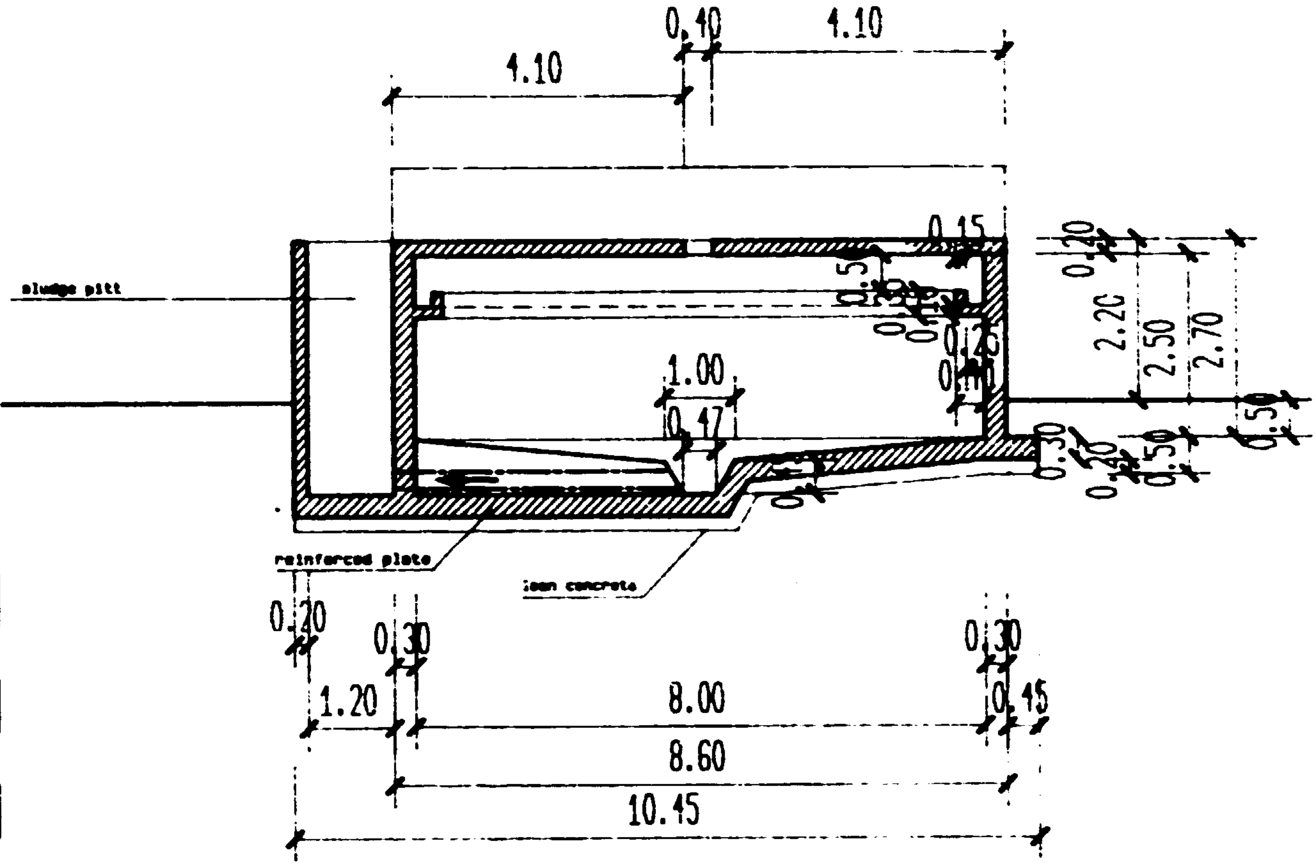
"STUDIO Dr. Ing. DANTE FANCELLI" - SAN MINIATO

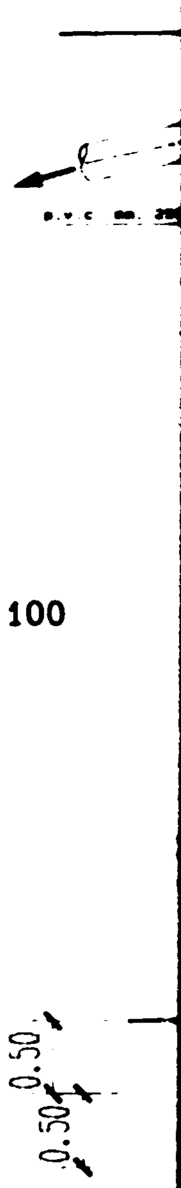
BIOLOGICAL TREATMENT

AERATION TANK

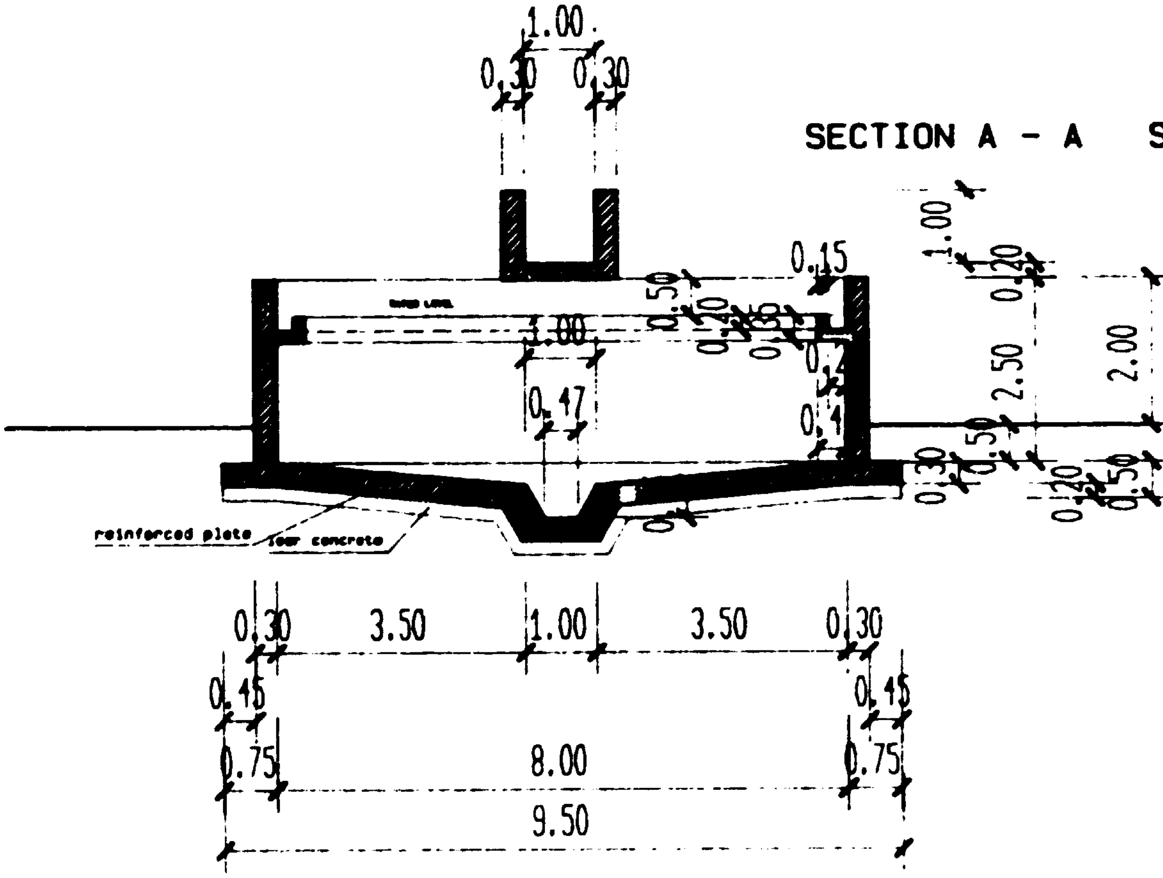
Tav. 3

SECTION D - D Scale 1: 100



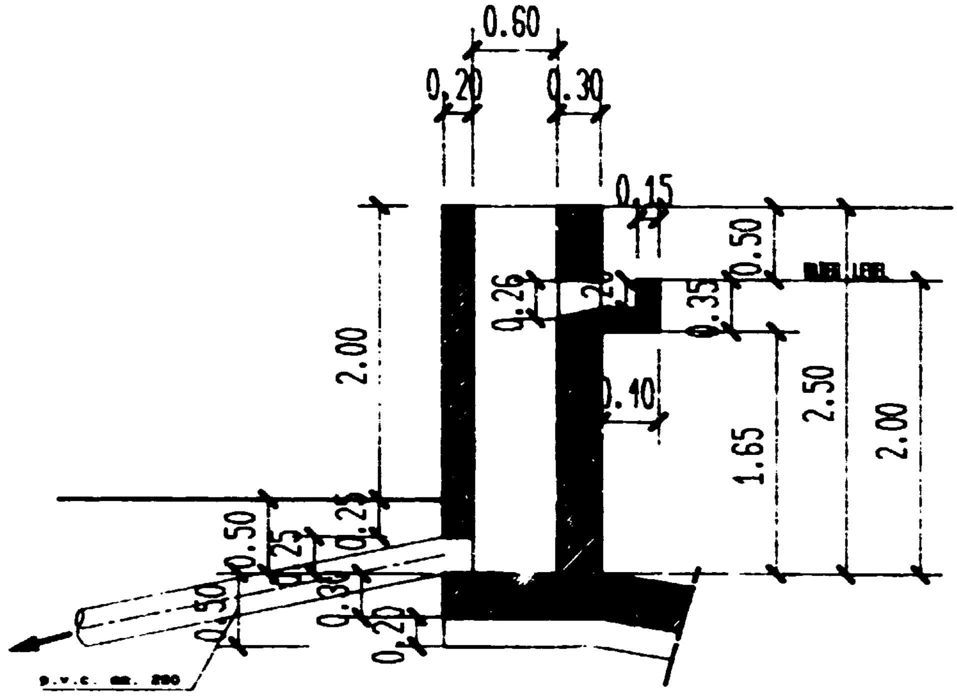


SECTION A - A Scale 1: 100



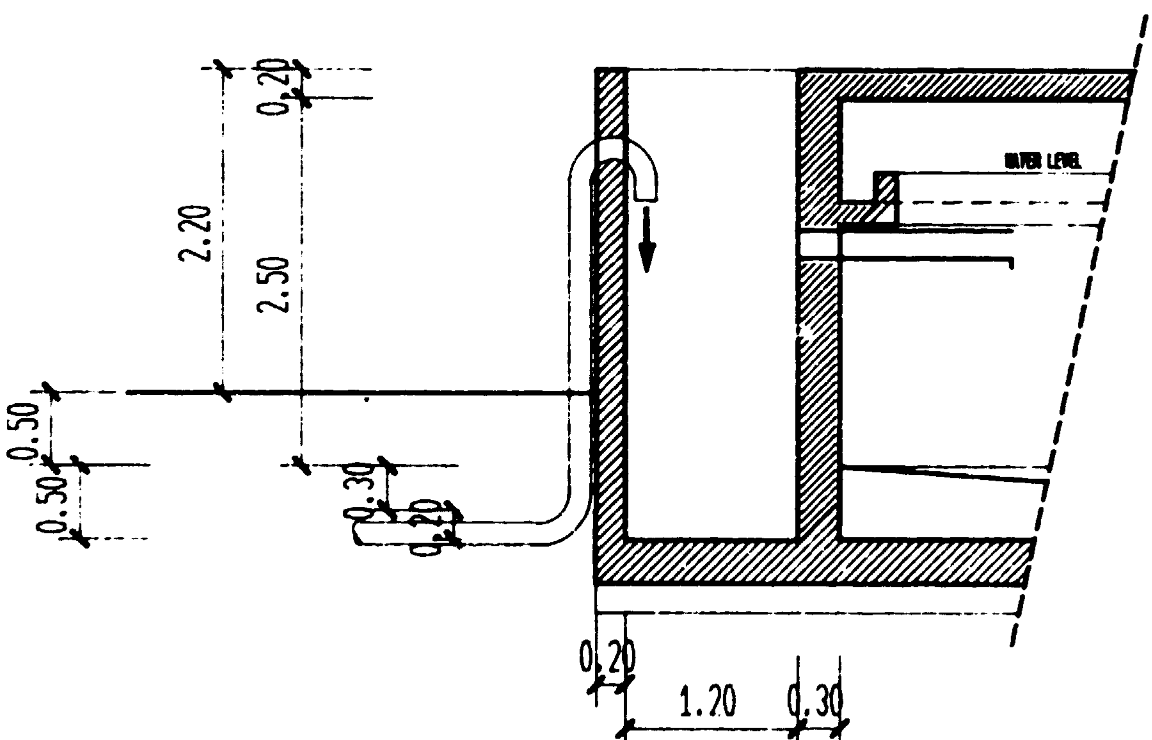
SECTION 1

SECTION B - B Scale 1: 50

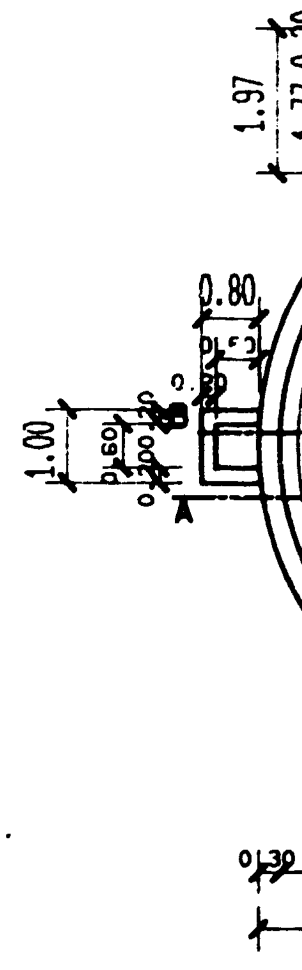


SECTION C - C Scale 1: 50

Scale 1: 100



SECTION 2



PLAN SE

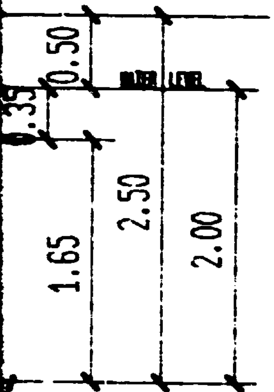
SAGANA TANNERY
WASTE WATER TREATMENT PLANT
Sagana - Kenya

BIOLOGICAL TREATMENT

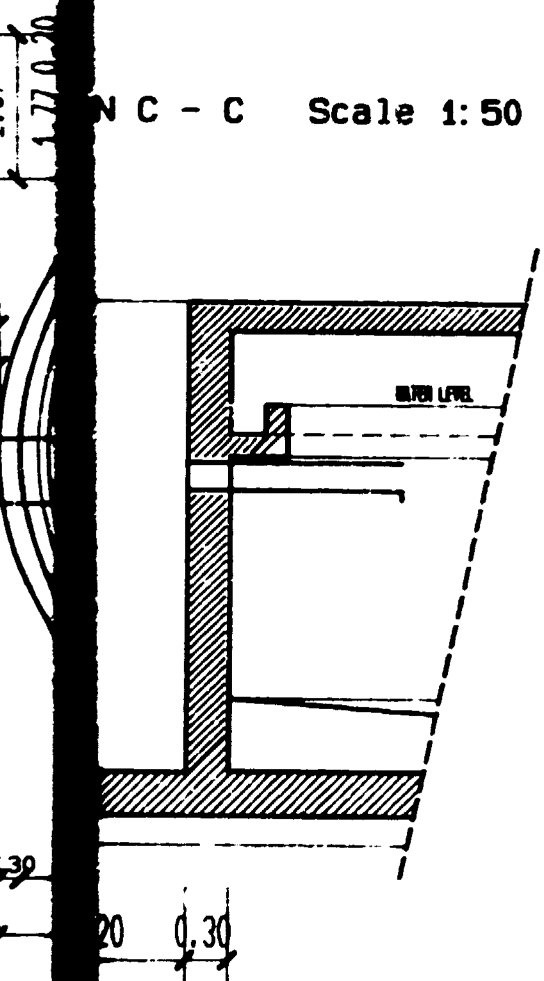
SECONDARY SEDIMENTATION TANK

No. 4

le 1:50

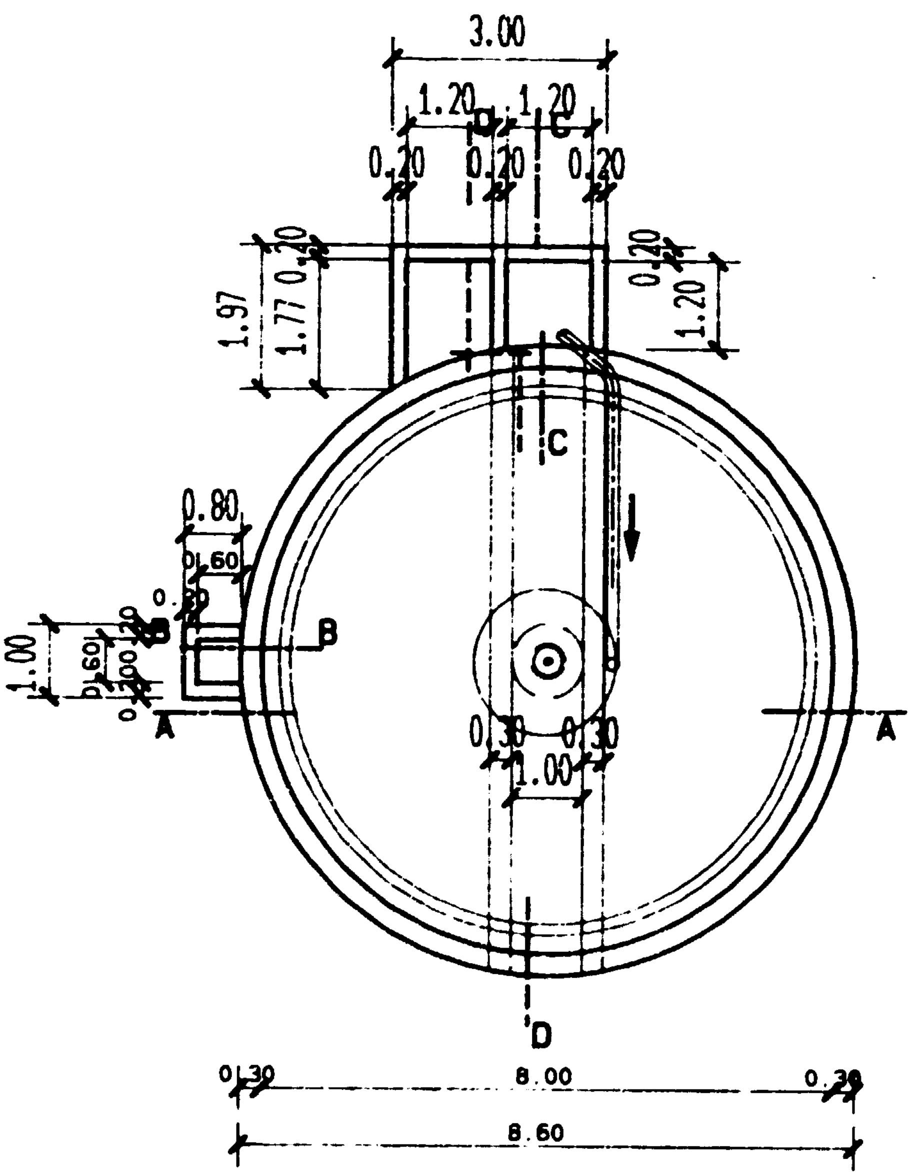


SECTION 3



N C - C Scale 1:50

SED



PLAN SEDIMENTATION TANK Scale 1:100