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ADVISORY SERVICE MISSION

BY

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

TO

CHANDARIA INDUSTRIES, NAIROBI, KENYA

by

THAMPOE JEYASINGAM

Expert of

The United Nations Industrial Development Organization

Acting as Executive Agency for the United Nations Development Programme

2/8

OCTOBER 1989

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LIST OF ABBREVIATIONS

BD	-	Bone Dry
BOD	-	Biological Oxygen Demand
BDMT	-	Bone Dry Metric Ton
CEH	-	Chlorine Extraction Demand
D/O2 - NaOH/H	-	Dioxide/Oxygen-Caustic Extraction/Hypo
OCC	-	Old Corrugated Container
TPD	-	Tons Per Day
TPY	-	Tons Per Year
TSS	-	Total Suspended Solids

ADVISORY SERVICE MISSION BY UNIDO TO

CHANDARIA INDUSTRIES, NAIROBI, KENYA

UNIDO CONSULTANT - Thampoe Jeyasingam

Objectives of Mission

Study relevant documents related to the proposed paper mill project of CHANDARIA and comment in particular on matters related to pollution and raw materials availability for the project.

Period of Mission

October 6 1989 to October 22 1989.

SUMMARY OF THIS REPORT

This report is made up of CASE I and CASE 2-:

- CASE I evaluates the site selected by Chandaria in the upper TANA area.
- CASE 2 is the alternate site proposed by the UNIDO Consultant in the lower TANA area.
- CASE 2 has to be recommended considering the limitations of CASE 1 on account of straw availability as well as environmental factors and the high cost of effluent treatment required to operate the mill in this area.

October 19, 1989

SUMMARY OF EXTRACTS FROM STUDIES MADE BY CHANDARIAS

(Details are available under Appendix 1)

- The site location selected for the proposed paper mill is SAGANA in the Upper Tana Region.
- The raw materials selected for pulp production are non-wood fibre material mainly agricultural residues.
- The non-wood materials selected are:-
  Rice straw, wheat straw, bagasse, papyrus, nyphia grass and sisal leaves.
- In addition to non-wood fibre pulp, the mill has plans to use secondary fibre from waste paper and imported wood-pulp.
- The grades of paper planned for production are both bleached and unbleached grades:-
  Corrugating medium, unbleached kraft grades for gumming tapes, manilla board, banks, offset duplicating, etc.
- The planned production capacity of the paper mill is 80 TPD* or 24000 TPY**
- The planned production capacity of the pulp mill is 50 TPD or 15000 TPY.
- The planned production capacity for secondary fibre (waste paper) is 24000 TPY.
- The pulping process chosen by CHANDARIA'S is ALKALINE PULPING
  - SODA PROCESS with conventional chemical recovery system
- The bleaching sequence chosen is CEH (i.e. Chlorination, Caustic Extraction and Hypochloride).
- The effluent handling proposed consists of:-
  - Primary treatment for reduction of T.S.S. (Total Suspended Solids).
  - Secondary treatment in lagoons aeraled by mechanical aerations for reduction of BOD*** load.
  - Final polishing to reduce fibre fines through use of sand felles
  - Disposal of effluent after treatment either by irrigation or into river.

* TPD - Tons Per Day

** TPY - Tons Per Year

*** BOD - Biological Oxygen Demand.

SUMMARY OF CONCLUSIONS & RECOMMENDATIONS MADE IN RESPECT OF SITE CHOSEN BY CHANDARIS

CASE 1 - UPPER TANA PROJECT (SAGANA MILL)

- The availability of straw from the MWEA area is estimated by the Natural Irrigation Board as 43,740 tons from an area of 14,400 acres. This works out to about 3 tons of rice straw per acre which is a high figure for straw yield.
- According to international standards, the rice straw yield is somewhere between 0.5 to 0.8 tons per acre, per per harvest.
- Based on international standards, the availability of straw from the MWEA area is therefore estimated to be between 7,200 and 11,520 bone dry tons per year.
- From the above estimated quantity of straw it is possible to make about 5,000 TPY of semi-chemical pulp, and this will be sufficient to produce about 40 TPY of corrugating medium and schrenz applying a mixed furnish of waste paper and imported pulp.
- If two rice harvests are made, the straw from the MWEA area would be sufficient to produce 80 TPD of corrugating medium and schrenz.
- It is not possible to operate the SAGANA mill to produce Chemical Pulp due to both:-
  - Non availability of straw of the required quantity.
  - Environmental factors due to larger concentration of chemicals.
- The cooking chemicals for the Sagana Mill should be restricted to the usage of Calcium Hydroxide and Potassium Hydroxide to produce Semi-Chemical Pulp as these chemicals are not harmful to the environment as mill effluent.

Cont'd .../4 ...

- The grades that could be produced at Sagana Mill will generally get restricted to corrugating medium and schrenz.
- The mill effluent should be largely disposed as irrigation water.
- To further assist the farmers to use the mill effluent as irrigation water, the usage of Urea or Ammonium Sulphate as chemicals could be added to enrich the soil.
- Since the farmers may not require water all the time for agricultural crops the development of fibre crops such as Hemp, Kenaf could be studied as possibilities.
- Hemp bast fibre is in great demand for the production of specialty grades of tissues. The woody fraction of hemp could be used for production of semi-chemical pulp. Kenaf is another possibility as a field crop for the application and use of fibre similar to hemp.
- The possibility of discharging mill effluent into the river cannot be completely ruled out. It can be either decided in favor or ruled out after a thorough study to determine the long term effects of discharging the mill effluent under the specific conditions stated above.

  These are:-
  - Usage of environmentally acceptable chemicals (i.e. Calcium Hydroxide and Potassium Hydroxide).
  - Applying the semi-chemical pulp system requiring lesser dosage of chemicals.
  - Extensive treatment of mill effluent for total suspended solids and BOD.
  - Employment of modern techniques to filter out traces of total suspended solids and prevent sedimentation layer in the river.
- If the traces of total suspended solids could be removed the mill effluent could be discharged into the river.

  This requires:-
  - Laboratory studies

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- Pilot Scale trials.
- Investigation into filtration techniques for removal of fine solids.
- Commercial application and evaluation of performance in similar situations elsewhere in the world and the success of such application.

Based on the results of the studies specified above, a green light could be given for effluent disposal into the river as sedimentation of T.S.S. could affect aquatic life in the TANA RIVER.

Based on the limitations outlined above the preferred location of the proposed mill for Chandaria would be the lower TANA region as discussed in CASE 2 of this report.

Cont'd .../6 ...

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS BASED ON ALTERNATE SITE PROPOSED BY THE UNIDO CONSULTANT

CASE 2 - LOWER TANA PROJECT

(This is an alternate mill site to UPPER TANA mill site)

The mill site proposed is a location somewhere around the GRESON area based on previous preliminary study made by the expert in 1985. (Refer Appendix 2)

- There are no problems related to effluent handling as the effluent after basic treatment could be discharged into the Indian Ocean.
- Straw is available to the mills from the Lower TANA development scheme.
- It is possible to make diversified grades of paper at this site both Industrial grades for the packaging industry as well as Cultural grades such as Writing and Printing.
- Pulping process systems and chemical recovery can be of the well accepted systems in practice elsewhere in the world.
- Production capacity at this mill site need not be limited to 80 TPD*. This could even be expanded to 200 to 300 TPD.
- The market potential for finished paper and paper products is great as sea transport could be used to export to both African countries as well as Middle East countries.

*TPD - Tons Per Day

Cont'd .../7 ...

- The economic advantages for this mill site are high as cheap paper could be imported, and finished paper and converted products of high valre could be exported resulting in a boost to the KENYAN economy and foreign exchange earnings.
- (Example:- import OCC** and export corrugated containers, import waste paper for deinking and export converted paper products for cultural application).

- Since the first study for this mill site was in 1985, this study has to be up-dated and a site selected with a definite project in mind. It is therefore recommended a follow up study is made taking into consideration the above factors for the proposed Lower TANA project site.

***OCC - Old Corrugated Container

Cont'd .../8 ...

COMMENTS AND OBSERVATIONS BY UNIDO CONSULTANT ON SITE SELECTED BY CHANDARIAS

CASE 1 - UPPER TANA PROJECT - SAGANA MILL

Selection of Site

The selected site is a good one for building a mill in respect of water supply, power supply, market proximity, road network link up and other major considerations. However, the proposed Sagana Mill has drawbacks, since effluent handling requires extensive treatment. The possibility for the Sagana Mill would be to conduct extensive effluent treatment and then use it mainly for irrigation purposes.

Alternatively, the next choice would be to select a site in the LOWER TANA region in close proximity to the mouth of the river somewhere around the MALINDI/GRESEN area where the effluent could be discharged into the Indian Ocean. This is discussed as CASE 2 of this report.

The LOWER TANA region around the GRESEN area has abundant supply of rice straw, sufficient water for the mill, good port facilities from MOMBASA to MALINDI by barges and good potential for export of paper as well as paper products by sea to neighboring Africa and Middle East countries.

However, it lacks the infrastructure of good roads for the time being. According to TANA Development Authority there are plans for development of the needed infrastructure at a future date.

Raw Materials

The raw materials selected by Chandarias for pulping are:-
- Wheat straw, rice straw, bagasse papyrus, nyphia grass and sisal leaves. Technologically, it is not so easy to design a proper pulping system with diversified materials without compromising, quality, efficiency as well as meeting pollution abatement standards.

Cont'd ... /9 ...

For this purpose, pulping based on single material usage is recommended. The only raw material that is readily available within an economic distance from the mill is rice straw from the rice field region of MWEA. It is therefore recommended the SAGANA mill is based on rice straw for pulping.

<u>Availability of Rice Straw</u>

According to data given by NATIONAL IRRIGATION BOARD by their letter of May 26, 1989,+the availability of rice straw from the MWEA region is 43,740 tons from 14, 400 acres based on one crop per year. This ratio is high averaging about 3 tons of straw per acre. Generally, the yield of straw from an area of 14,400 acres is about 7,200 to 11,520**TPY of *BD straw. Please refer to Table I for internationally accepted production of cereal straw per acre, per harvest of cereal cultivation. This will be sufficient to produce 5,000 TPY of semi-chemical pulp. Using this amount of semi-chemical pulp and applying a fiber furnish as given below about 12,000 TPY(***40 TPD)of corrugating medium and schrenz could be produced per year.

- 40% Semi-Chemical straw pulp at 60% yield
- 45% Waste paper
- 15% Imported pulp (long fiber)

The above quantity of straw will not be sufficient to produce chemical pulp with the mill located in the Upper Tana area. It should be, however, noted the above calculations are based on one crop per year; but if the farmers are encouraged to make two crops per year, the availability of straw in the Upper Tana area could get doubled and would be sufficient to make 24,000 TPY of corrugating medium and schrenz equavalent to 80 TPD.

* BD - Bone dry
** TPY - Tons per year
*** PD - Tons per day

+ Refer to copy of letter under Appendix I

Cont'd .../10 ...

Given below is the table of estimated collectible straw BDMT per acre, per harvest based on international standards.

TABLE I

ESTIMATED STRAW YIELD PER ACRE PER HARVEST

	Straw Yield *BDMT
1. Wheat Straw	0.9 to 1.2
2. Rice Straw	0.5 to 0.8
3. Barley Straw	0.5 to 0.6
4. Oat Straw	0.5 to 0.6
5. Rye Straw	1.0 to 1.4

Waste Paper Supply

An 80 TPD paper mill using 45% Secondary fiber would require about 45 TPD of waste paper at 80% yield. This will amount to 13,500 TPY of waste paper. Collecting this amount of waste paper within Kenya could be a problem. It will be therefore necessary to supplement domestic supply of waste paper with imported OCC (Old Corrugated Container waste). In comparison a 40 TPD paper mill using 45% waste paper will require about 6,750 TPY of waste paper. It may be possible to collect this amount of waste paper within Kenya.

*BDMT - Bone Dry Metric Ton

Cont'd .../11 ...

Pulping Technology

The pulping technology chosen by Chandarias' is chemical pulping based on Caustic Soda. As pointed out earlier, it is not possible to do chemical pulping at SAGANA. What could be recommended alternatively for the Sagana Mill would be Semi Chemical pulping based on Calcium Hydroxide as the principal cooking chemical buffered with Potasium Hydroxide. Traditionally, Sodium Hydroxide is used in place of Potasium Hydroxide because Sodium Hydroxide is readily available and is relatively inexpensive. In the case of Sagana Mill, Potasium Hydroxide is recommended since it will be useful to the farmer on account of Potasium, since Sodium could leach out the soil. To make it more useful as irrigation water the effluent could be further enriched with Urea or Ammonuim Salts. These details have to be worked in close co-operation with the agricultural department in Kenya.

The other alternative for Sagana mill would be to go for oxygen pulping or Ammonia based pulping in place of Alkaline pulping. Unfortunately, these process are not still well developed for commerical application in developing countries, but could in course of time be a solution to mill sites such as the UPPER TANA that are restricted due to environmental factors.

Bleaching

The bleaching sequence chosen by CHANDARIA'S consists of CEH sequence (i.e. Chlorination/Caustic Extraction/Hypochlorite).
Since chemical pulping is ruled out as a possibility for the UPPER TANA mill, there is no possibility to do bleaching at SAGANA.

Chemical Recovery System

As pointed ahead, it is not possible to practice Chemical Pulping. In consequence the question of having a chemical recovery system therefore does not arise at present.

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PAPER MAKING TECHNOLOGY

Secondary Fibre Treatment

To reduce the use of imported long fibre pulp, the secondary fibre treatment system should be equipped with a fibre fractionator with suitable refiners that could handle the two separate lines of short fibre and long fibre fractions. The pulper screening and cleaning system should also be carefully chosen to obtain the required quality.

Stock Preparation

To handle a fibre furnish of:-

- 40% Semi-Chemical pulp from straw
- 45% Secondary fibre from waste paper
- 15% imported pulp (long fibre).

the refiners must be carefully selected taking into consideration the special fibre characteristics of straw pulp.

Paper Machine

The paper machine needed to produce corrugating medium and schrenz from Semi-Chemical straw pulp could be less complicated with features suitable for both ease of operation and maintenance in a developing country.

Special consideration should be given to the following:-

- Drainage elements for the wire part taking into consideration the fibre characteristics of straw pulp.
- Press design with minimum open draws to reduce paper breaks.
- A very good felt cleaning system, since felts get fouled up easily with straw pulp fines and poor quality waste paper.
- An efficient steam and condensate system based on cascading system, with the wet group of cylinders for individual steam temperature control.
- An efficient doctor cleaning system specially for the wet and intermediate group of drying cylinders due to linting of fibres and pitch build up from the furnish prescribed above.

Recycling of process water

It must be remembered if less water is used for mill process, there is less water that has to be discharged as effluent and therefore less water for effluent treatment. For this reason a very efficient recycling of process water is recommended. As integrated pulp and paper mill operation has to be preferred since paper mill water could be used in the pulp mill to the maximum extent and this in particular is true for producing semi chemical pulp.

To conserve and reduce the intake of fresh water and thereafter discharge as fibre loaded effluent, it is recommended the following are adopted:-

- An efficient Save All System to regain the fibre and fines and recycle them for paper making.
- A closed white water circuit in the paper machine with showers on the paper machine capable for operation on white water.

Effluent Treatment

The pollutants found in the mill effluent of an integrated pulp and paper mill such as the SACANA mill would be less complicated if chemical pulping is not practiced and would mainly consist of:-

- Particles of fibre dust and straw fines from straw preparation section.
- Fibre fines, fibre particles and screen rejects during pulping and paper making process.

These pollutants require the following:-

- Primary treatment in clarifiers to remove total suspended solids.
- Secondary treatment or Biological treatment by aeration in Lagoons. Two Lagoons should be provided with one lagoon in operation and the second as standby unit to periodically scrape out and clean the sludge build up.
- A holding lagoon should be also provided to handle peak loads effluent flow, and to take care of emergencies during clarifier break downs or pump failures. This should have sufficient volume

capacity to handle emergencies prescribed above and arrangements to re-process the effluent to meet the required standards for discharge.

In the case of SAGANA, the effluent should be further enriched with Ammonium Salts or Urea and used for irrigating rice fields or developing fibre crops such as Hemp. The long fibre from hemp has special characteristics to produce special high quality tissues such as cigarette tissues, teabag paper, air mail pape and other hard tissues.

Please refer to Appendix 3 for additional information on current practices of effluent treatment in practice in some of the well established paper mills in U.S.A. In addition, please refer to article on "Water Quality Protection at Shasta Mill" where design features have been adopted to use 30% of the total effluent for irrigation. Also see information on effluent irrigation adopted at Boise Cascade Corp. mill in Salem, Oregon.

UPPER TANA MILL LIMITATIONS

To sum up the following are the limitations of Sagana Mill due to environmental factors:-

- The mill effluent should be used mainly for irrigation.
- To make the mill effluent suitable for irrigation calcium based pulping should be made using Pot. Hydroxide as buffer to produce semi-chemical pulp.
- The grades that could be made at Sagana Mill because of semi-chemical pulp would be corrugating medium and schrenz.

Cont'd .../15 ...

- The possibility of discharging mill effluent cannot be completely ruled out. It can be either decided in favor or ruled out, after a thorough study to determine the long term effects of discharging the mill effluent under the specific conditions stated above.

  These are:-

  - Usage of environmentally acceptable chemicals (i.e. Calcium Hydroxide and Potassium Hydroxide).
  - Applying the semi-chemical pulp system requiring lesser dosage of chemicals.
  - Extensive treatment of mill effluent for total suspended solids and BOD.
  - Employment of modern techniques to filter out traces of total suspended solids and prevent sedimentation layer in the river.

- If the traces of total suspended solids could be removed the mill effluent could be discharged into the river.

  This requires:-

  - Laboratory studies
  - Pilot Scale trials
  - Investigation into filtration techniques for removal of fine solids.
  - Commercial application and evaluation of performance in similar situations elsewhere in the world and the success of such application.

Based on the results of the studies specified above, a green light could be given for effluent disposal into the river as sedimentation of T.S.S. could affect aquatic life in the TANA RIVER.

Based on the limitations outlined above the preferred location of the proposed mill for Chandaria would be the lower TANA region as discussed in CASE 2 of this report.

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COMMENTS AND OBSERVATIONS BY UNIDO CONSULTANT ON PROPOSED ALTERNATE SITE FOR CHANDARIA

CASE 2 - LOWER TANA PROJECT

Under Case 2, the Lower TANA location is being suggested as a possible alternative for the Upper TANA Project since Upper TANA has limitations due to environmental factors.

This recommendation to consider Lower TANA as a preferred alternative to Upper TANA is based on the previous study made by the writer in 1985. The details of this study are available as APPENDIX 2 of this report.

Advantages of Lower TANA project over Upper TANA project

- Possible to do chemical pulping and make stronger grades of paper
- Possible to do bleaching and make bleached grades of paper
- Effluent treatment need not be elaborate and design features can be relatively simple, since this effluent could be discharged into the Indian Ocean if proper site is chosen
- Possible to make grades of paper and converted products that could be exported by sea to African countries as well as Middle East countries
- Possible to import cheap OCC (Old Corrugated Container Waste) as well as other grades of waste paper from overseas and make paper more economically, blended with indigenous straw pulp
- Possible to enlarge the mill to a large complex with 2 or 3 paper machines of 200 to 300 TPD whereas the maximum paper that could be made in Upper TANA is limited to 80 TPD because of environmental factors.

Site Location

The site location recommended is around the Garsen area with supply of straw from the rice field of Lower TANA region. Water supply from River TANA with possible effluent discharge into the Indian Ocean after basic treatment.

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POSSIBLE RAW MATERIALS

Straw

According to data obtained from the Lower TANA Development Authority there is sufficient rice straw available to the mills. In this connection the earlier preliminary study made by the writer has to be up-dated to assess the quantity presently available from this region. On account of the TANA River development work and irrigation facilities to this area, the availability of straw in the region should be now more than what was specified in the writer's report of 1985.

Waste Paper

The waste paper from domestic sources for the mill would mainly come from the MOMBASA area. On account of close proximity to Mombasa and possible barge facilities to mill site, imported waste paper of good quality can be obtained easily for use at the mill. This will include OCC (Old Corrugated Containers) from which very good quality of liner board and corrugating medium could be made. It is also possible to make writing and printings with imported waste paper applying the new deinking technology.

PULPING TECHNOLOGY

The pulping technology that could be considered for Lower TANA offers maximum flexibility because of the possible safe disposal of the mill effluent directly into the Indian Ocean after some basic treatment.

Since CHANDARIA's want to produce wide range of grades, there could be two lines of pulp production :-

- Semi Chemical Pulp production
- Chemical Pulp production

Under Case 2 there is no need to use the more expensive potassium hydroxide as in the case of Upper TANA and the relatively cheap caustic soda could be used for both Semi Chemical pulp production as well as chemical pulp production. To reduce cost of production the make up chemical for pulping could be MACADI Soda Ash.

Cont'd .../18 ...

Bleaching

For making bleached grades the conventional C/E/H* system could be followed or this could be up-dated with new technologies to use D/O_2-NaOH/H**. The chlorine dioxide is now preferred because of the dioxin problems. The Oxygen-Extraction combination is also now a preferred step for the second stage with the final third stage ending up with Hypo.

Chemical Recovery System

Since straw has a high silica content the chemical recovery system should incorporate a desilication system. Such a technology is currently available now through pilot scale trials done by the CENTRAL RESEARCH INSTITUTE OF INDIA through a project sponsored by UNIDO. It is recommended such a desilication system is applied to the chemical recovery system to overcome the silica problem. To reduce the cost of capital investment on a causticizing plant, it is possible to apply the DARS (Direct Alkali Recovery System). A more detailed study would be needed to determine the possible application of these new technologies for Case 2.

PAPER MAKING TECHNOLOGY

Stock Preparation

To manufacture the diversified grades of paper which CHANDARIA's have in mind, the paper making technology requires a high degree of flexibility, since CHANDARIA's want to produce both Cultural grades of paper as well as Industrial grades of paper.

The details of how the stock preparation should be planned and made to function will have to be specified by a further detailed study.

* C/E/H - Chlorine/Extraction/Hypo.

** D/O_2-NaOH/H - Dioxide/Oxygen-Caustic Extraction/Hypo.

Paper Machine

It is preferable to have two machines - one to make Industrial grades such as Corrugating medium, Liner, Kraft grades of paper and a second machine to produce Cultural grades such as Writings and Printings.

Here again the techno-economics of whether the first step should be a single machine for a product mix of both Industrial and Cultural grades or a two machines mill for the production of Cultural grades and Industrial grades separately will have to be specified by a follow up study.

EFFLUENT TREATMENT

The effluent treatment will comprise both primary treatment and secondary treatment before discharge of effluent into the Indian Ocean.

Please refer to Appendix 3 for additional information on current practices of effluent treatment in practice in some of the well established paper mills in U.S.A.

CONCLUSION BASED ON CASE 2

Based on the limitations of CASE I, the Upper TANA mill site, the preferred location for the proposed mill would be the Lower TANA region discussed under CASE 2.

- Since the first study for this mill site was in 1985, this study has to be up-dated and a site selected with a definite project in mind. It is therefore recommended a follow up study is made taking into consideration the above factors for the proposed Lower TANA project site.

Cont'd .../20 ...

Documents studied by the Expert

1) Feasibility study of Paper Plant in Kenya :

July, 1985. P.R. Mahadevan, C.M. Joglekar.

2) Import Application for Paper Mill - Second Hand Plant and Equipment with detailed appeal justifying the importation of Second Hand Plant :

17th December, 1988. Chandaria Industries Limited
P.O. Box 30621, Nairobi.

3) Paper Mill Project based on Agricultural Waste and Waste Paper :

January, 1985. Chandaria Industries Limited
P.O. Box 30621, Nairobi.

The following persons were contacted during the mission in Kenya:

GOVERNMENT AGENCIES, KENYA

Mr. Kihumba of the Ministry of Environment and Natural Resources

CHANDARIA INDUSTRIES

Mr. M. M. Chandaria
Mr. Danesh Chandaria
Mr. Mahesh Chandaria
Mr. P. K. Seshadri
Mr. Chari Joglegkar

UNIDO, KENYA

Mr. J. Kwant

UNIDO, VIENNA

Mr. Blant
Mr. Judt

APPENDIX I

Extracts of Information and Data Collected From Chandaria's Document

APPENDIX 1

October 15 1989.

EXTRACTS OF INFORMATION AND DATA COLLECTED FROM CHANDARIA'S DOCUMENTS

SAGANA PROJECT DATA

(As per study done by CHANDARIAS)

	UNITS	
Capacity of Paper Mill	TPY*	24,000
Capacity of Pulp Mill (90/10 Basis)	TPY	15,000
Capacity of Secondary Fibre Plant (i.e. Waste Paper)	TPY	24,000

Grades of Paper to be made :- Kraft, Writing, Printing and Cultural grades.

Basis weight range.	g/m^2	60	to	300
Speed range of Machine.	MPM**	120	to	280
Width of Machine (Trimmed)	mm	2800		

Raw Material selected for pulping :- Rice straw, Wheat straw, Nyphia Grass, Papyrus, Bagasse, Sisal.

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* TPY - Tons per Year

** MPM - Meters per Minute

DETAILS OF SAGANA PROJECT (UPPER TANA)

Location of Mill (SAGANA)

The Mill is planned to be located at SAGANA, which is 85 Km. on the highway between Nairobi and Nyeri. The mill is to be located on a land of extent 70 acres bordering TANA River. The mill has good facilities with water supply from River TANA and power supply from HYDLE Power Station which is 1½ Km. from the mill site. Transport facilities are excellent by good highway connection from Nairobi to Nyeri.

Capacity of the Mill (SAGANA)

The mill is planned to produce 80 TPD* of paper working 300 days with an output of 24,000 TPY.

Raw Material selected for SACANA

The raw material selected for pulping is non wood fibre. The materials selected are :- Wheat straw, Rice straw, Bagasse, Nyphia grass, Sisal leaves etc.

Raw Material Supply

The supply of Rice straw to the mills would be from adjoining Rice Fields of Mwea, irrigated by the River Tana. The data in respect of Rice cultivation in Mwea are as per information obtained from the National Irrigation Board which is given below.

1)	Total area under cultivation	=	14,400 Acres
2)	Number of Crops per year	=	1 (One)
3)	Rice (Paddy) yield per acre (average)	=	2.02 Tons
4)	Total rice (Paddy) production in the Scheme = 2.02 x 14,400	=	29,160 Tons
5)	Assuming a Straw: Paddy grains ratio of 1.5:1 on dry weight basis then total weight of straw produced in scheme = 29,160 Tons x 1.5	=	43,740 Tons

Bagasse

It is planned to collect and use bagasse available in Kisumu area for the project.

Sisal

Sisal leaves have been considered as a possibility for the production of long fibre pulp to replace imported long fibre wood pulp.

Grass (Nyphia and Papyrus)

Waste Paper is planned to be collected and supplied from the principal cities of Kenya mostly from Nairobi and Mombasa. It is estimated 15,000 Tons of domestic waste paper would be available for the project.

Water Supply for SAGANA

The water supply for Sagana will be from River Tana which is a perennial river with a catchment area of 3673 Km^2 before the site point. The characteristics of water flow on the River Tana are as per details given below.

-- Max. flow.	564 m^3/Sec	
Av. Max Flow.	324 m^3/Sec	
Av. Mean Flow.	58 m^3/Sec	
Normal Av. Flow.	18 m^3/Sec	
Min. Flow.	7.5 m^3/Sec	(Based on 40 years records)

Steam Supply

Steam to be generated using rice husk and liquid fuel for firing the boilers.

Power Supply

Power will be obtained from Hydle Power Station located about 1½ Km. from the proposed site. The capacity of this power plant is 13.5 MW.

Personnel

It is estimated the mill could provide direct employment to 150 and indirect employment to 400 persons.

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THE MILL PROCESSING SYSTEM

The paper mill will have a capacity of 24,000 TPY and the pulp mill a capacity of 15,000 TPY and the secondary fibre unit a capacity of 24,000 TPY.

Raw Material Preparation

Straw cutters to be used for chopping straw.

Pulping

Pulping to be based on caustic soda process.

Brown Stock Washing and Screening

Rotary drum filters to be used for Brown Stock washing.

Bleaching

C E H sequence (i.e. Chlorination, Caustic Extraction and Hypo)

Chemical Recovery System

Convertional recovery system normally applicable for Alkalene pulping is planned to be applied.

Paper Making

Stock Preparation:

The Stock preparation is designed to treat a fibre furnish of 70% short fibre from straw and 30% long fibre from imported wood pulp.

Paper Machine

A Second Hand Fourdrinier Paper Machine built by VOITH around 1950's but some of the original components have been replaced to improve operation and quality.

— Trim width. 2800 mm.

Speed range. 280 MPH* (Maximum)

Basis weight range. 45-300 g/m^2

Average production. 60-80 TPD

Wire Part - Fourdrinier table, run out type wire frame.

Press Part - 3 Presses (1st and 2nd straight and 3rd Press reversing).
1st Press Venta Nip, 2nd Press Venta Nip, 3rd Press Plain.

Dryer Part - 4 groups with a total of 24 cylinders and of diameter 2500mm.

Size Press - Available

Calender - Single Nip (Kuster)

Service Facilities

Steam Generation

conventional type of package boiler with pressure suitable for the digesters and paper machine.

Electric Power

Conventional power supply and distribution system with step down transformer to lower the HT Voltage from 66 KV for mill use.

./..

*MPH - Meters per Hour.

Water Supply

Water treatment plant to handle the high turbidity of the water is considered to be applied.

Effluent Handling

The effluent characteristics using waste paper and imported wood pulp as raw materials with a fibre furnish of 65% waste paper and 35% imported wood pulp is expected to be as follows :-

1)	PH	6.5 to 6.8
2)	B.O.D. PPM	30 to 50
3)	Suspended solids PPM	50 to 300
4)	Total dissolved solids PPM	200 to 400
5)	Colour	Pale Milky White
6)	Metalic Ion	None

The effluent characteristics using straw pulp, waste paper and imported wood pulp with a fibre furnish of 40% straw pulp, 40% waste paper and 20% imported wood pulp is expected as follows :-

		Phase 2
1)	PH	7.2 to 7.5
2)	B.O.D. PPM	100 - 180
3)	Suspended solids PPM	100 - 500
4)	Total dissolved solids PPM	400 - 800
5)	Colour	Pale Brown
6)	Metalic Ion	None

PROPOSED EFFLUENT TREATMENT

For fibre furnish using (65% waste paper and 35% imported pulp under Phase 1) the treatment system considered are as follows :-

- Primary treatment by using sedimentation tank to reduce TSS*

- Secondary treatment in lagoons using both natural and forced aeration to reduce the BOD load.

- Polishing of effluent using sand beds to remove traces of suspended solids.

- Use of water after treatment for irrigation of about 200 acres of land.

For fibre furnish using 40% straw pulp, 40% waste paper and 20% imported wood pulp the treatment system considered are as follows :-

- Mixing of pulp and paper mill effluent to form a combined effluent in order to obtain PH range close to them.

- Primary treatment to reduce TSS from +300 PPM to (100 to 150) PPM using 1st step clarifier.

- Primary treatment to further reduce TSS using 2nd step clarifier.

- Secondary treatment (1st step) for BOD reduction of load using lagoons and then deliver water for irrigation.

- Secondary treatment (2nd step) by using mechanical aeration to conform to the accepted range of BOD.

- Polishing of effluent using sand filter beds prior to discharge to river.

NATIONAL IRRIGATION BOARD

LENANA ROAD
P.O. Box 30372
NAIROBI.

Telegrams: IRRIGATION
Telephone: 721598 (5 Lines)

Our Ref: CH/G/68

Your Ref:

26th May, 1989

Mr. P.K. Seshadri,
Group General Manager,
Chandaria Industries Ltd.,
P.O. Box 30621,
<u>NAIROBI.</u>

<u>RICE STRAW</u>

We acknowledge receipt of your letter CIL/PKS1a/5/359 of 11/5/89 on the above subject.

We wish to confirm the rice production statistics in our Mwea Irrigation Scheme to be as follows:-

1)	Total area under cultivation	=	14,400 acres
2)	Number of crops per year	=	1 (one)
3)	Rice (paddy) yield per acre (average)	=	2.02t
4)	Total rice (paddy) production in the scheme = 2.02 x 14,400	=	29,160t
5)	Assuming a straw: paddy grains ratio of 1.5:1 on dry weight basis then total weight of straw produced in scheme = 29,160t x 1.5	=	43,740t

The straw: paddy grains ratio, however, varies to some extent depending on the varieties grown but the total amount of straw produced is unlikely to be less than 30,000MT.

However, the rice straw is the property of the rice farmers and we advise that you communicate with them directly (through their Cooperative Society) to ascertain their willingness to sell the straw. It is possible that if you offered a good price incentive, they may be willing to sell the straw. At the moment, the Board management encourages the farmers to spread out the straw in the field and burn it to control diseases, pests and weeds as well as to return certain plant nutrients to the soil.

J.J. NJOKAI
FOR: GENERAL MANAGER

APPENDIX 2

Report on the Feasibility

of

Producing Corrugating Medium

(Fluting Paper)

From Straw in Kenya

January 1985

Report on the F ibility of Producing Corrugating Medium (Fluting Paper) from Straw in Kenya

DP/KEN/80/001

by

THAMPOE JEYASINGAM

*Expert of
The United Nations Industrial Development Organization
Acting as Executive Agency for the United Nations Development Programme*

JANUARY 1985

PART IV

REPORT ON THE FEASIBILITY
OF
PRODUCING CORRUGATING MEDIUM
FROM STRAW IN KENYA

MINISTRY OF COMMERCE
AND INDUSTRY
INDUSTRIES DEPARTMENT
JANUARY 2ND, 1985

SUMMARY

This Report presents the results of a Study of using straw to produce corrugating medium and INNER Line Board for corrugated board manufacture.

It is concluded about 15,000 TPY of corrugating medium and Inner Liner Board could be produced using the straw from the Lower TANA BASIN Area.

The total capital investment needed would be KShs.193,505,000 (exclusive of working capital). The Return on investment is estimated at 29.4%.

It is recommended that serious consideration is given to implement the project and a further study is recommended in close collaboration with the Lower TANA River Authority.

CONTENTS

REPORT ON THE FEASIBILITY OF PRODUCING CORRUGATING MEDIUM FROM STRAW IN KENYA

MINISTRY OF COMMERCE AND INDUSTRY

JANUARY 2ND, 1985

INTRODUCTION

Kenya currently has 5 paper mills operating with a total installed capacity of 85,600 TPY of paper and paper board. The afore-mentioned 5 mills have plans to expand to 125,400 TPY within the next 2 to 3 years.

The indigenous pulping capacity is only 58,000 tons of chemical pulp and 8,000 tons of mechanical pulp per year at PANAFRICAN PAPER MILLS, WEBUYE. Therefore, the other 4 mills depend mostly on waste paper for their fibre requirements. The supply of raw material for the PANAFRICAN PAPER MILLS is based on PINE AND CYPRESS from "Man-made plantations". There will be a further demand on this source of supply when the proposed MADHU PAPER MILLS at THIKA goes into production. This mill at THIKA will require wood to produce about 20,000 TPY of chemical pulp.

It is feared Kenya is heading towards a shortage of wood and in particular for domestic fuel requirements both in the form of firewood and wood charcoal. It is, therefore felt at this stage further planning of pulp and paper mills based on wood does not look promising with only 20% of the land area available in Ken_a both for agriculture as well as forestry. On the other hand Kenya needs more paper. The demand for paper during the last 5 years has been growing at the rate of 5%. It is expected the future growth will be around 6 to 7%, with a high demand for cultural grades of paper on account of the growth in school going population.

The Industrial Promotion division of the Industries Department and the UNIDO Division in Nairobi sensing this problem, initiated the need for a study to look into the aspect of using non wood materials for pulp and paper manufacture. To conduct this study a pulp and paper expert was requested from the UNIDO head quarters in Vienna and the writer arrived on November the 19th for a 3 months' assignment in Nairobi.

The following reports therefore covers the investigations and study related to the use of non-woody raw materials for the production of pulp and paper and is made up into 5 parts.

PART I	-	Development of the Pulp and Paper Industry in Kenya
PART II	-	A Report on the Feasibility of Producing Fine Paper from Bagasse
PART III	-	A Report on the Feasibility of Producing Hard Tissues From Sisal Waste
PART IV	-	A Report on the Feasibility of Producing Corrugating Medium From Straw
PART V	-	A Report on the Feasibility of Producing Hand Made Paper from Cotton Waste.

APPENDIX 3

Additional Information on Effluent Handling

(Reference Materials)

Effluent guidelines. BOD5- TSS.

Deciphering the Code: How Federal Effluent Guidelines Affect the Pulp and Paper Industry

By Lee Derleth

Table 1
Pulp and Paper Industry Categories and Subcategories

Integrated Segment
Dissolving Kraft
Market Bleached Kraft
BCT (Board, Coarse, and Tissue) Bleached Kraft
Fine Bleached Kraft
Soda
Unbleached Kraft
Linerboard
Bag and other products
Semi-Chemical
Unbleached Kraft and Semi-Chemical
Dissolving Sulfite Pulp
Nitration
Viscose
Cellophane
Acetate
Papergrade Sulfite (Blow Pit Wash)
Papergrade Sulfite (Drum Wash)
Groundwood - Chemi - Mechanical
Groundwood - Thermo - Mechanical
Groundwood - CMN (Coarse, Molded, and News) Papers
Groundwood - Fine Papers
Secondary Fibers Segment
Deink
Fine Papers
Tissue Papers
Newsprint
Paperboard from Wastepaper
Corrugating Medium Furnish
Noncorrugating Medium Furnish
Tissue from Wastepaper
Wastepaper - Molded Products
Builders' Paper and Roofing Felt
Nonintegrated Segment
Nonintegrated - Fine Papers
Wood Fiber Furnish
Cotton Fiber Furnish
Nonintegrated - Tissue Papers
Nonintegrated - Lightweight Papers
Lightweight Papers
Lightweight Electrical Papers
Nonintegrated - Filter and Nonwoven Papers
Nonintegrated - Paperboard

Mr. Harley H. Derleth is president, Business Development Services, Inc., a market research consulting group—industrial wastewater and water treatment capital spending surveys.

On Jul. 1, 1984, pulp and paper industry direct dischargers are required by federal regulations to be in compliance with BAT standards. Moreover, indirect dischargers are supposed to be in compliance with PSES. What are BAT and PSES? Or, for that matter, what are BPT, NSPS, PSNS, or NPDES? What is a direct discharger? An indirect discharger? Who needs discharge permits? How do all these abbreviations, acronyms, and classifications apply to your mill?

This article highlights some of the questions raised by the industry about meeting EPA effluent guidelines and standards for the pulp and paper point source category. This information is intended to clarify only certain requirements. The standard reference work in the field is: *Pulp, Paper, and Paperboard and the Builders' Paper and Board Mills Point Source Categories, Effluent Limitations, Guidelines, New Source Performance Standards, and Pretreatment Standards - 47 FR 52006*, dated Nov. 18, 1982. This should be consulted for additional information.

The pulp and paper industry point source category regulations establish effluent guidelines and standards for the three defined segments of the industry (Table 1). The intent of these definitions and regulations is to include all of the industry and its processes—with no exceptions. They cover the four standard manufacturing processes—raw material preparation, pulping, bleaching, and papermaking.

Applicability. The effluent guidelines and standards apply to any pulp and paper facility that discharges process wastewater, or any water, to waters of the U.S. (direct discharger) or that introduces process wastewater into a publicly-owned treatment works or municipal sanitary sewage system (indirect discharger). The only exceptions are for those mills that have their own self-contained waste treatment plants that do not discharge at all and therefore do not require discharge permits.

Direct dischargers. Pretreatment standards and effluent limitations are specific numerical limitations which are based on an evaluation of available technology in a particular point source category.

Existing direct dischargers are required to have National Pollutant Discharge Elimination System (NPDES) permits, which are issued by an individual state or by the EPA regional authorities (Table 2). These permits fix effluent limitations based on the application of the best practicable control technology currently available (BPT).

As these discharge permits expire and are rewritten (generally every 5 years), they must, in addition to BPT, incorporate effluent limitations based on the application of the best conventional pollutant control technology (BCT) and the best available technology economically achievable (BAT).

The net effect for existing direct dischargers is that they the appropriate state authority (if an NPDES state) or to the appropriate EPA regional director. The procedure for direct dischargers is the same as for indirect dischargers except that no deadline is specified by the regulations.

Baseline monitoring report. Indirect dischargers are required to submit baseline monitoring reports either to the POTW (if it has an approved pretreatment program) or to the appropriate EPA regional director. A baseline monitoring report is the first report that an indirect discharger must file following promulgation of an applicable standard. This report must include:

- Flow measurements of process wastewaters and any water discharged into the POTW
- The results of a sampling and analysis program that identifies the nature and concentration of all regulated pollutants in the discharge. Facilities with process wastewater flows greater than 250,000 gpd must take 6 samples within a two-week period, while facilities with less than 250,000 gpd may take 3 samples within a two-week period
- A statement, reviewed by a representative of the facility and certified by a qualified professional, indicating whether the pretreatment standards are being met on a consistent basis and, if not, additional measures necessary to meet the standards

If additional measures are necessary to meet the pretreatment standards, a compliance schedule, indicating the dates when increments of progress will be made towards achieving compliance with the standards must also be submitted.

Additional information or clarification of specific requirements can be obtained by contacting: Mr. Rick Brandes, Permits Division (EN-336), Environmental Protection Agency, 401 M Street SW, Washington, DC 20460, 202/426-7010. □

Table 4
NSPS Effluent Limitations
(Direct Dischargers)
Concentrations, kg/kkg or lbs/1000 lbs

Subcategory	Maximum 30-Day Average		Maximum Day	
	BOD5	TSS	BOD5	TSS
Integrated Segment				
Dissolving Kraft	8.4	14.3	15.6	27.3
Market Bleached Kraft	5.5	9.5	10.3	18.2
BCT Bleached Kraft	4.6	7.6	8.5	14.6
Alkaline-Fine[1]	3.1	[illegible]	5.7	9.1
Unbleached Kraft				
• Linerboard	1.8	3.0	3.4	5.8
• Bag	2.7	4.8	5.0	9.1
Semi-Chemical	1.6	3.0	3.0	5.8
Unbleached Kraft and Semi-Chemical	2.1	3.8	3.9	7.3
Dissolving Sulfite Pulp				
• Nitration	14.5	21.3	26.9	40.8
• Viscose	15.5	21.3	28.7	40.8
• Cellophane	16.8	21.3	31.2	40.8
• Acetate	21.4	21.5	39.6	41.1
Papergrade Sulfite[2]	•	•	•	•
Groundwood-Thermo-Mechanical	2.5	4.6	4.6	8.7
Groundwood-CMN Papers	2.5	3.8	4.6	7.3
Groundwood-Fine Papers	1.9	3.0	3.5	5.8
Secondary Fibers Segment				
Deink				
• Fine Papers	3.1	4.6	5.7	8.7
• Tissue Papers	5.2	6.8	9.6	13.1
• Newsprint	3.2	6.3	6.0	12.0
Tissue From Waste-Paper	2.5	5.3	4.6	10.2
Paperboard From Wastepaper				
• Corrugating Medium Finish	2.1	2.3	3.9	4.4
• Noncorrugating Medium Furnish	1.4	1.8	2.6	3.5
Wastepaper-Molded Products	1.1	2.3	2.1	4.4
Builders' Paper and Roofing Felt	0.94	1.4	1.7	2.7
Nonintegrated Segment				
Nonintegrated-Fine Papers				
• Wood Fiber Furnish	1.9	2.3	3.5	4.4
• Cotton Fiber Furnish	4.2	4.9	7.8	9.5
Nonintegrated-Tissue Papers	3.4	2.6	7.0	6.0
Nonintegrated-Lightweight Papers				
• Lightweight	6.7	5.2	13.7	12.0
• Electrical	11.7	9.2	24.1	21.1
Nonintegrated-Filter and Nonwoven Papers	8.3	6.6	17.1	15.0
Nonintegrated-Paperboard	1.9	1.5	4.0	3.5
pH-Within the range 5.0 to 9.0 at all times				

[1]Includes Fine Bleached Kraft and Soda subcategories.
[2]Includes Papergrade Sulfite (Blow Pit Wash) and Papergrade Sulfite (Drum Wash) subcategories.

Abstract
In January 1974, it was decided to enlarge an integrated Shasta, Calif., pulp and paper mill. It was concluded that conventional liquid waste treatment methods would not assure compliance with the new NPDES Permit issued by the state of California for the expanded operations. Therefore, a four-part program was undertaken. This program included: (a) greater internal reuse of process water, (b) an upgrading of existing primary treatment facilities, (c) an all-new secondary treatment system, and (d) provisions for the use of up to 4.5 million gal/day of the secondary effluent for the semiautomated irrigation of grain crops. The paper describes the design criteria and the actual performance of the new facilities.

Keywords
Water quality
Effluent treatment
Environments
Biological tests
BOD
Dispersions
Irrigation

Water-quality protection at the Shasta mill

Q. A. Narum and D. J. Moeller

For over 12 years, the Shasta mill, near Anderson, Calif., has had to operate under some of the most stringent water-quality regulations of any integrated pulp and paper mill in the United States. One of the reasons for the stringent regulations is the fact that the mill discharges to the Sacramento River, one of the more productive natural spawning grounds for salmonoid species of fish.

The mill was constructed by Kimberly-Clark in 1964, and it included a 150-ton/day bleached softwood kraft mill and a 180-ton/day paper machine for the production of coated printing papers. Recognizing that the upper reaches of the river required an unusual degree of protection, modern waste treatment facilities, including the contact-stabilization method of biological secondary treatment, were provided (1). Because of the strong emphasis on fish toxicity control, the mill had to develop continuous-flow bioassay equipment and techniques, including some tests that lasted for more than 100 days (2). The original waste treatment and effluent quality monitoring systems proved to be capable of meeting the ever-increasing demands of the regulatory agency for the next 10 years, but not without frequent difficulties.

In January 1972, the Shasta mill was purchased by our company. Two years later, the new owner announced a mill expansion, including installation of a new paper machine plus an upgrading of the original machine. By this time, the position of the state regulatory agency had been strengthened by the 1972 amendments to the Federal Water Pollution Control Act, and the Shasta mill had received the first NPDES Permit in SIC 26. In October 1974, the original permit was revised to accommodate the proposed mill expansion. Some of the provisions are shown in Table I, with comparable figures based on EPA's latest criteria.

Based on its own and other industry experience, it was evident to the company that the total suspended solids (TSS) requirement could not be met by conventional primary and biological secondary treatment methods, particularly at low and intermediate river flow rates. To learn more about TSS capture, a sand-filter pilot plant was obtained. After considerable experimentation, it was concluded that this process was not a satisfactory answer to the severe TSS discharge limit, at least for the Shasta mill.

Fortunately, an alternative based on the use of fully treated secondary effluent for the irrigation of cropland had been developed. Benefiting from earlier studies by the National Council for Air and Stream Improvement (3) and others (4), our company began its own laboratory and field studies in 1972, tailoring them to its 430 hectare (ha) ranch adjoining the Sacramento River. By the spring of 1974, enough confidence in secondary-treated effluent irrigation had been gained to make a commitment to a full-scale system.

Q. A. Narum and D. J. Moeller, Simpson Paper Co., San Francisco, Calif. 94104.

PRIMARY TREATMENT

To assure the success of the effluent irrigation project and to accommodate the increased wastewater flow from an expanded mill, the original primary waste treatment facilities were upgraded. Also, the original activated-sludge secondary system was replaced with a new, low-rate biological system.

The changes to the primary system included:

- Addition of an external flocculator for the existing No. 1, 25.0-m-diam. plain sedimentation clarifier
- Conversion of the old 42.7-m-diam. secondary clarifier to a rim-drive, No. 2 primary unit with integral flocculator
- Piping changes to provide unusual flexibility in operation and to increase the effectiveness of the preprimary waste storage and blending basins
- Addition of a new, 2.44-m-diam. by 3.66-m-face belt-type vacuum filter for dewatering the sludge from the two

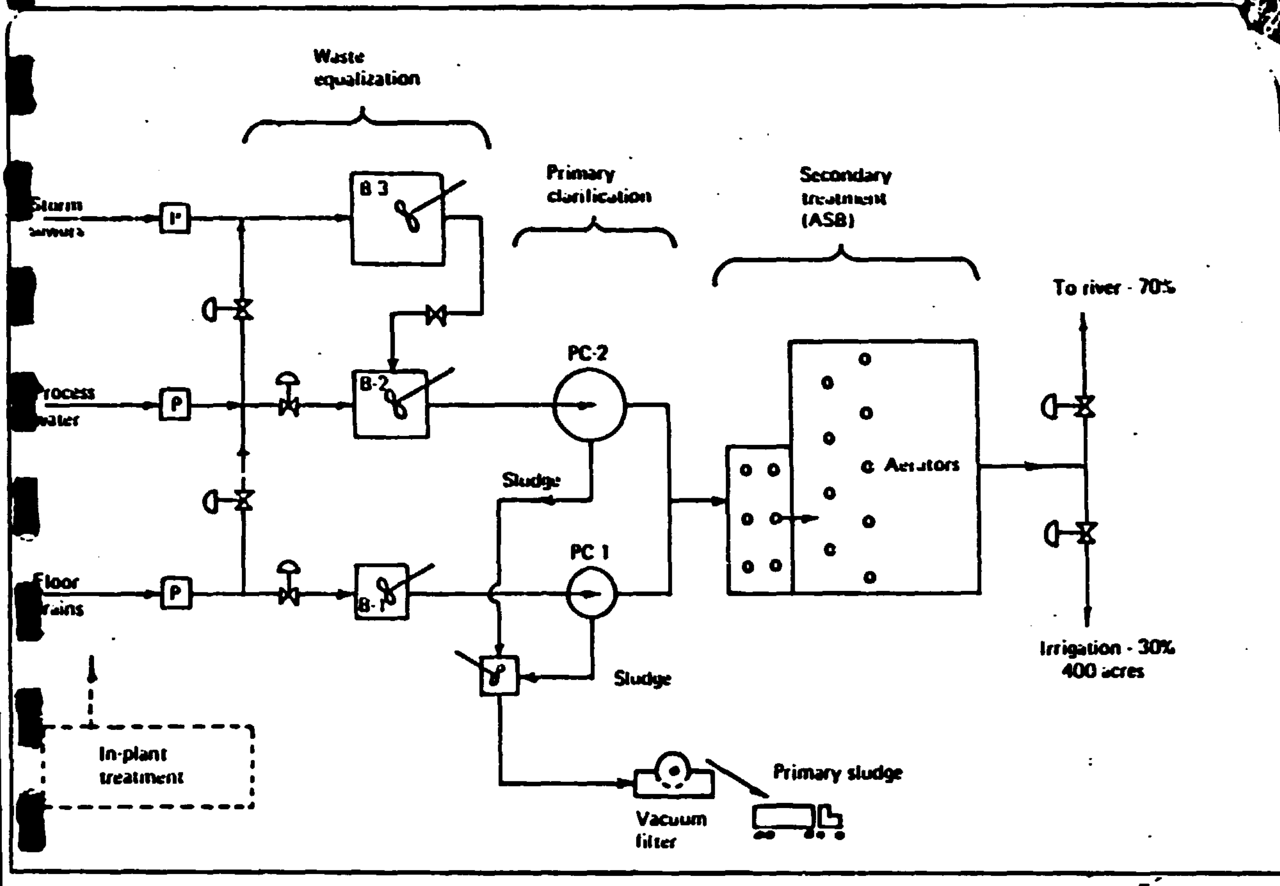

Fig. 1. Three stages of wastewater treatment.

primary clarifiers. The smaller original unit became a standby sludge filter.

A schematic of the entire upgraded system is shown in Fig. 1. Some operating data for the primary system are shown in Table II. So far, the mill has not found economic justification for the use of coagulants to improve TSS capture, but this is subject to continual review.

During the negotiations for its several permits, the mill agreed to prevent storm-sewer water from the manufacturing areas from entering off-site drainage ditches. At the present time, all such water is routed through the primary system, either directly or through a storage basin.

The primary treatment system is visible in Fig. 2 just beyond the chip storage area. In the right background are the secondary treatment basins. The effluent-irrigated fields are about 5 km beyond these, adjoining the Sacramento River.

Table I. Comparison of Federal and State Effluent Quality Standards for the Shasta Mill

	Approximate EPA guidelines[a]	NPDES permit
BOD_5, kg/day[b]	1816	967 (<142)[c]
	1816	1507 (142–283)
	1816	2043 (283–792)
TSS, kg/day[b]	3178	967 (<142)[c]
	3178	1689 (142–283)
	3178	2406 (283–792)

[a] From latest Development Document, BPCTCA, EPA 440/1-76/047b, Table I, p. 4, Dec. 1976. [b] 30-Day averages. [c] Receiving water flows in m^3/sec. Flooding begins at 792 m^3/sec.

Table II. Primary Clarifier Data

	Clarifier 1	Clarifier 2
Diameter, m	25.0	42.7
Theoretical detent, hr[a]	2.6	4.5
Drive	Axial	Rim
Net rise rate, m/day	29.9	23.7
TSS entering, kg/day[b]	20,000	13,400
TSS capture, %	80	67
Waste water distribution, volume %		
Paper mill	85	15
Pulp mill	15	85
Storm sewer	90	10

[a] Time-to-fill. [b] Includes recycle from sludge dewatering system.

SECONDARY TREATMENT

While the original contact-stabilization version of the activated sludge process removed more than 90% of the BOD_5 and met the fish toxicity standard, final TSS varied over a wide range. Furthermore, operating costs were burdensome. Rather than enlarge this facility, it was decided to replace it with a low-rate, aerated stabilization basin system. A two-stage system without a secondary clarifier was designed. It was believed that this would achieve the needed high BOD_5 removal with minimum TSS residual in the final effluent. These expectations have been realized, and the mill has also benefited from the other known advantages of low-rate treatment systems, such as lower operating costs and more consistent effluent quality.

The design criteria for the secondary treatment system are shown in Table III, and typical operating data are shown in Table IV. The No. 1 basin is rectangular, with two rows of aerators, symmetrically placed. The multiple-orificed inlet pipe is on the bottom, midway between the aerators on the longer dimension. The basin has a

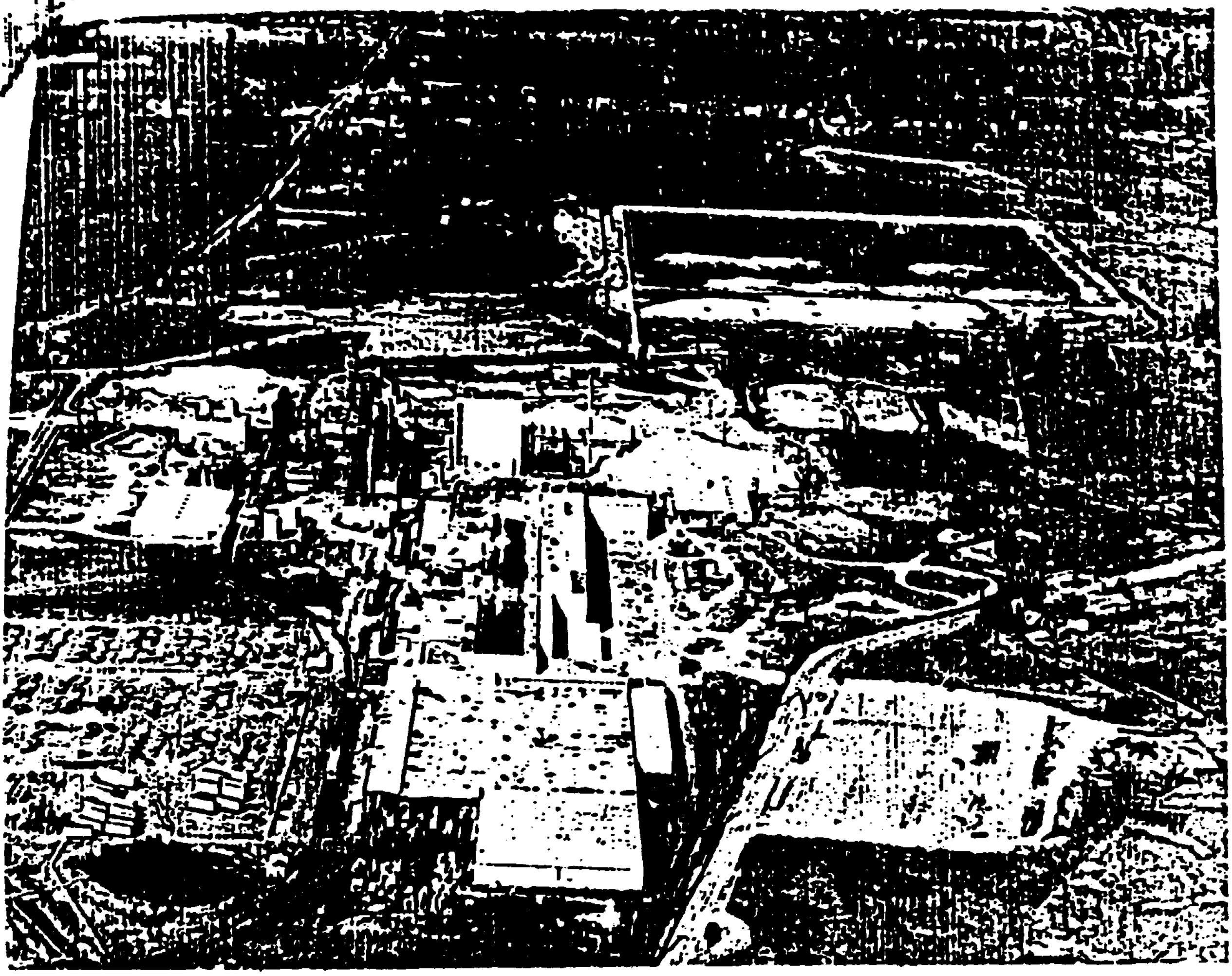

Fig. 2. Aerial photograph of Shasta mill.

Table III. Design Criteria for Secondary Treatment System

	Basin 1	Basin 2
Surface area, ha	1.64	10.94
Operating depth, m	3.36	3.20
Theoretical detent (time-to-fill), hr	24	144
Aerators		
Number	6	9
Type	Surface	Floating
Drive	Gear (conical turbine)	Direct (propeller)
Rated wattage (each), kW	56	22.4
BOD, influent, kg/day	15,900	
BOD, removal, %	>90	

Note: Both the primary and the secondary waste treatment systems were designed for substantially greater loads than were actually experienced during the first 16 months of operation. In addition, the No. 2 aerated stabilization basin was oversized to provide at least 150,000 m³ of storage for the ranch irrigation system.

Table IV. Operating Data for Secondary Treatment System (Averages)

	Basin 1	Basin 2
Inflow, m³/day	45,100	45,100
Wattage utilized, kW	335	112
BOD₅		
In, mg/liter	184	76
Out, mg/liter	76	11
Removal, kg/day	4,860	2,925
TSS		
In, mg/liter	204	206
Out, mg/liter	206	30
Out, kg/day	9,270	1,350

single-point, overflow-type discharge structure. The No. 2 basin is almost square, with two rows of aerators across the inlet third. The inlet and outlet structures are submerged, with flow-balanced multiple orifices.

FISH TOXICITY REQUIREMENT

The California regulatory agencies usually prescribe a fish toxicity standard based on mass discharge rate to the receiving water, i.e., concentration × daily volume discharged. For the Shasta mill, assuming that no effluent was discharged to land, this standard would in effect require 95% survival of a salmonoid species of fish in a mixture of 67% effluent - 33% river water after 144 hr exposure in a *continuous-flow* bioassay.

Of the 38 tests done in the past 10 months, the mill reports show an average of 95.6% fish survival in 75% effluent concentration. With the diversion of a portion of the effluent to land, the actual mass rate of toxicants discharged to the river during that period averaged only 27% of that allowed in the NPDES permit.

HIGH-ASH WASTEWATER

Since one of the mill's paper machines makes coated grades and the other uses base-sheet fillers, the raw wastewater contains a high percentage of fine-particle-size ash. The pulp mill also contributes coarser calcium carbonate solids, so that the influent to the primary clarifiers can be as high as 80% mineral.

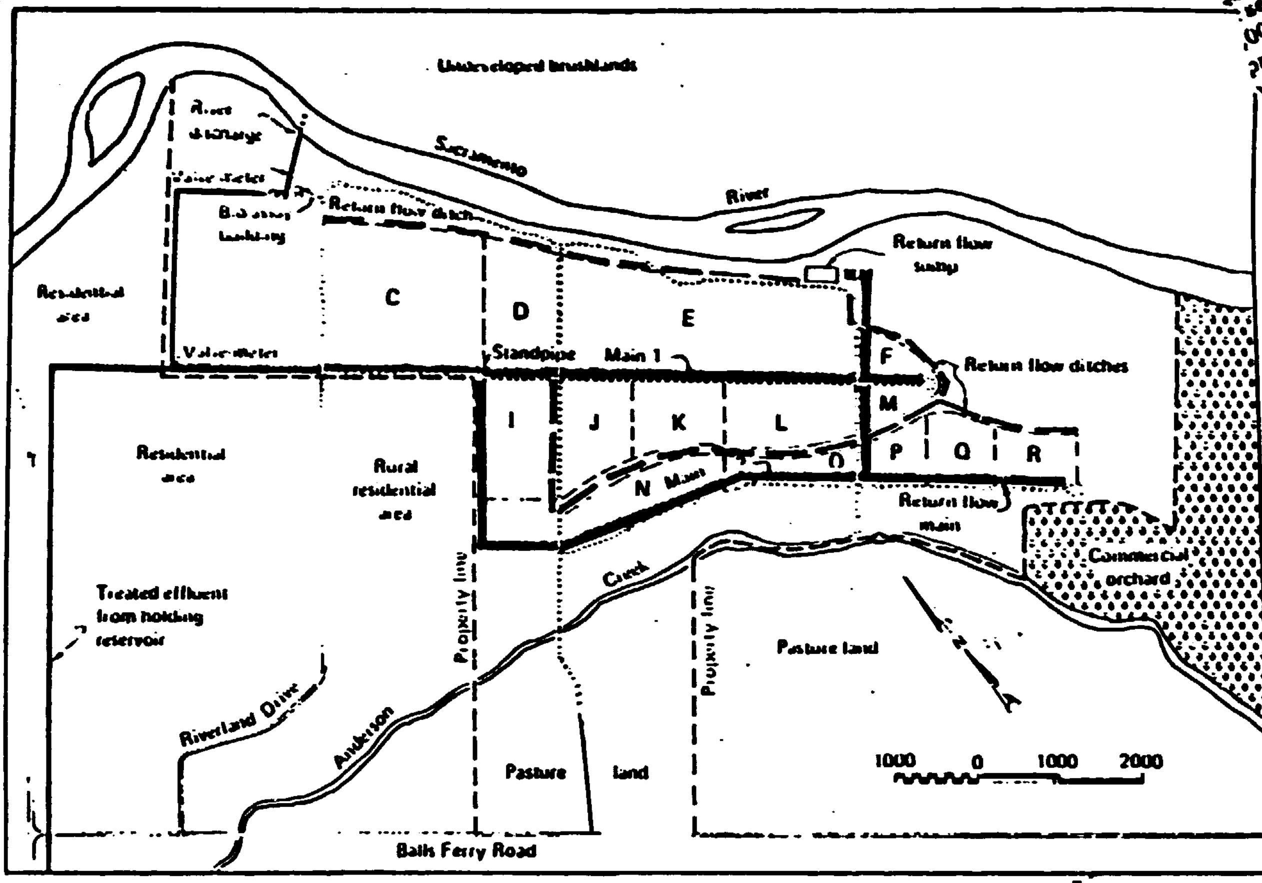

Fig. 3. Effluent irrigation of ranch.

Even when polymers are used to improve primary sludge dewatering, the filtrate from the belt filter is rich in ash. This filtrate is returned to the clarifiers, aggravating the TSS problem.

One result of this condition is a primary effluent having a relatively high level of TSS, mostly fine-particle ash, with a pH in the range of 7–9.5.

In the secondary treatment basins, it appears that some of the calcium carbonate is solubilized. In the No. 1 basin, this is almost balanced by the generation of new biomass, so that the TSS of the influent and effluent are equal (Table IV). With the biodegradation of the colloidal organic matter that had helped to keep the ash particles in suspension, most of the residual mineral matter precipitates in the No. 2 basin as a very dense sludge. This is being monitored in anticipation of eventual hydraulic dredging (probably in the summer of 1979). While the final TSS has been as low as 12 mg/liter, the long-term average is about 30 mg/liter and is expected to increase slowly with time.

Overall BOD_5 removal (about 94%) is excellent, with the final effluent well below the NPDES requirement. While the final TSS is currently about as low as one could expect from a biological treatment process, this still does not meet the unusually stringent permit requirement. As previously indicated, this was anticipated, and compliance has been achieved by using up to 40% of the secondary effluent to irrigate croplands.

PROCESS-WATER CONSERVATION

While some degree of internal process water and cooling water recycling has been standard practice within the pulp and paper industry for several decades (5), one of the many permits issued to the Shasta mill in 1974 called for still greater effort. One reason for this is the fact that the mill obtains its fresh water from seven deep wells, all in the same aquifer, and the local planning commission wanted assurance that this source would not be jeopardized by the increased paper production.

The mill water conservation program was based mostly on traditional concepts, and the details are beyond the scope of this paper. Since it is unrealistic, if not impractical, to compare water usage among different mills, even those making similar products, the best way to express the results of a conservation effort is to relate current ("after") usage to that of an earlier period ("before") for the same mill; in this case, "before" refers to calendar year 1969. This comparison shows that total reservoir makeup has decreased by 43.4 m^3/metric ton of product, or about 33%. While opportunities for further conservation are being explored, the mill may not be far from the point where cooling towers or chemical treatments will be required.

USE OF SECONDARY EFFLUENT

The company already owned suitable cropland with a 4200-m boundary along the Sacramento River. About 162 ha (400 acres) of this land had high-permeability soil, which would allow rapid movement of the effluent percolate to the riverbed. Initial construction began in April 1975, with the moving of about 335,000 m^3 of earth to produce the precise slopes and grades required for flood irrigation. Final slopes ranged from 0.2 to 0.8%, depending upon the length and spacing of the borders or checks and soil characteristics.

More than 6000 m of concrete cylinder pipe, ranging in diameter from 76 cm down to 30 cm, were buried. About 470 automatic irrigation valves were installed, each capable of delivering up to 4.5 m^3/min. These valves are of polyolefin construction, with the opening and closing action controlled by admission of low-pressure air to a rubber bladder inside the valve dome. Sixteen valve timers are used on three irrigation mains. The timers have 11 ports or vents, each port activating from one to four irrigation valves in a programmed sequence. After each timer has cycled through its 11 ports, an electrical signal

…at to the next timer, which may be [illegible] m or so down the main. In actual practice, the flow from each irrigation valve is limited to about 2 m^3/min, and this occasionally requires that two or more timers be energized simultaneously.

From 15 to 40% of the effluent discharged from the pneumatically operated irrigation valves eventually reaches the lower end of the fields, where it is conveyed in earthen ditches to a common "return flow sump." A pump with automatic level control recycles all surface run-off of effluent and natural rainfall back to the croplands via a "return flow main," also equipped with automatic valves.

The effluent-irrigated fields, including the location of the mains and return flow system, are shown in Fig. 3. The project also included more than 50 test wells, not shown in Fig. 3, to monitor groundwater composition and movement.

Passage of the effluent through the soil removes the residual BOD_5 and essentially all of the COD, including the color bodies. Since some of the sodium ions in the effluent are exchanged with calcium and magnesium in the soil, chloride ion is used as the effluent tracer in the test wells.

Of the 430 ha enclosed by the dashed line (Fig. 3), about 162 were initially prepared to receive the fully treated mill effluent. (This is the shaded area, with fields lettered C through R.)

Irrigation main No. 1 is about 2800 m long and serves eight fields. Main No. 2, about 1400 m long, serves three or more fields. The return flow main, about 2000 m long, recycles the effluent and normal rainfall run-offs from all fields.

This modern flood irrigation system can be operated on a fully automatic basis or with any desired degree of manual control. In December 1976, the ranch received about 603,000 m^3 of the effluent, or about 40% of the normal flow from the mill's secondary treatment basins.

To allow flexibility in the irrigation schedule, the No. 2 aerated stabilization basin was oversized to provide up to 150,000 m^3 of effluent storage.

EXPERIENCE WITH CROPS

In November 1975, about 105 ha were seeded to hybrid wheat and about 57 ha to red oats. The first effluent irrigation was carried out in January 1976, and irrigation was continued regularly throughout an abnormally dry winter and spring. Since effluent quality was unusually good and river flows were high, effluent irrigation was mostly at the discretion of the ranch manager. In the spring of 1975, field corn and a few experimental rows of sweet corn were seeded to the harvested wheat fields. All crop yields were satisfactory:

- Oats (as hay): 8300 kg/ha
- Wheat (as grain): 4400 kg/ha
- Field corn (as grain): 7600 kg/ha

Currently, wheat and seed onions are being grown, and some tilled but unplanted fields are also receiving the treated effluent. Field corn will be planted again this year, and hay crops are being considered.

In northern California, 1976 was an uncommonly dry year, with reservoirs dropping to all-time low levels. As a result, Sacramento River flows during most of the last quarter were below 142 m^3/sec (5000 ft^3/sec), requiring the Shasta mill discharge to meet the most stringent condition prescribed in its NPDES permit (Table I). During this 90-day period, about 1.45 million m^3 (383 million gal) of effluent were applied to [illegible] 162 ha that had been prepared for this purpose. This is the equivalent of 0.894 m (35 in.) of rainfall and occurred during a period when evapotranspiration totaled less than 11.4 cm (4.5 in.). It is unlikely that such conditions could be tolerated for an indefinite period.

In the first 13 months of operation, the fields received a total of 3.9 million m^3 of effluent. Some soils now show a slight deficiency of calcium and magnesium, a result of a displacement by sodium from the effluent. This will be corrected by the addition of gypsum or dolomitic limestone. Since northern California is having its second consecutive dry winter, the mill is planning to enlarge the effluent-irrigated fields as one of the steps it can take in coping with the anticipated low river flows in the coming fall and winter.

The company considers its effluent irrigation project a complete success, although not something that could be practiced everywhere. It is believed that, under proper management, any crop normally grown in the area with fresh-water irrigation can also be grown with its treated effluent.

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Effluent irrigation. *Boise Cascade Corporation's pulp and paper mill in Salem, Ore., successfully raised a 4-acre experimental crop irrigated with biologically treated wastewater. The crop grew on an island in the Willamette River across from the mill. The mill gained permission from the Department of Environmental Quality to irrigate a section of the island property as a plan to reduce waste entering the river during last summer's drought. BC expects to harvest the crop next spring and sell the alfalfa to local farmers.*

AIR/WATER

TABLE 66: LEVELS OF WATER POLLUTION ABATEMENT PERFORMANCE PROMULGATED OR UNDER CONSIDERATION BY EPA

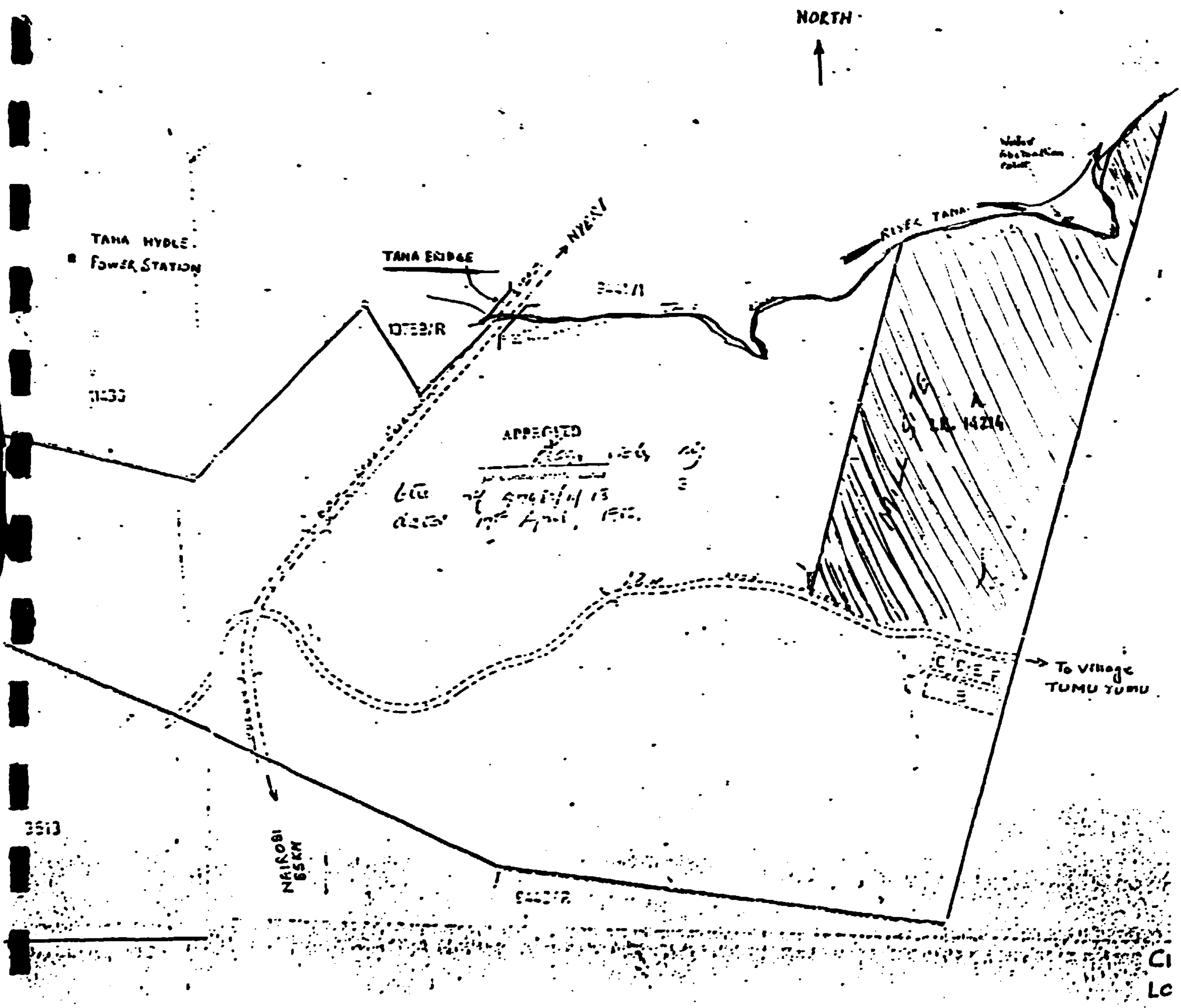
	BPCTCA Limitations (Report Level II)				BATEA Limitations (Report Level IV)						New Source Performance Standards					
	BOD (lb/T) Limit		TSS (lb/T) Limit		BOD (lb/T) Limit		TSS (lb/T) Limit		Color (lb/T)		BOD (lb/T)		TSS (lb/T)		Color (lb/T)	
Subcategory*	MM**	MD***	MM	MD	MM	MD	MM	MD	MM	MD	MM	MD	MM	MD	MM	MD
Unbleached kraft	5.6	11.2	12.0	24.0	2.7	5.4	3.7	7.4	20	30	3.1	6.2	7.5	15.0	20	30
Bleached kraft[1]	9.0	18.7	21.2	50.0	3.2	6.6	5.4	12.5	202	336	3.2	6.6	5.4	12.5	-	-
Soda	14.2	29.4	38.0	90.0	4.4	9.0	6.7	15.7	202	336	4.4	9.0	6.7	15.7	-	-
Sulfite	36.5	53.9	37.9	64.0	7.0	10.4	5.8	9.8	-	-	7.0	10.4	5.8	9.8	-	-
Dissolving sulfite	53.0	78.0	37.9	64.0	10.4	15.4	-	-	-	-	10.4	15.4	-	-	-	-
Sodium based NSSC	8.7	17.4	11.0	22.0	4.5	9.0	5.0	10.0	75% removal		5.2	10.4	7.7	15.4	-	-
Ammonia based NSSC	8.0	16.0	10.0	20.0	6.4	12.8	5.2	10.4	75% removal		7.5	15.0	7.5	15.0	-	-
Kraft-NSSC	8.0	16.0	12.5	25.0	3.2	6.4	4.2	8.4	25.0	37.5	3.8	7.6	8.0	16.0	25	37.5
Groundwood[2,3]	8.2	14.9	14.2	38.9	2.8	5.0	3.3	9.2	-	-	2.8	5.0	3.3	9.2	-	-
Deinking	10.9	21.0	26.0	54.0	5.0	9.6	6.6	11.5	-	-	5.0	9.6	6.6	11.5	-	-
Paperboard from wastepaper	3.0	6.0	5.0	10.0	1.3	2.6	1.6	3.2	-	-	1.5	3.0	4.0	8.0	-	-
Nonintegrated fine	6.8	11.2	9.4	21.4	1.2	2.0	1.9	3.3	-	-	1.2	2.0	1.9	3.3	-	-
Nonintegrated tissue	8.0	13.0	7.4	15.8	1.9	3.0	3.2	7.3	-	-	1.9	3.0	3.2	7.3	-	-
Nonintegrated coarse	6.8	11.4	8.0	18.0	2.3	3.9	1.7	3.9	-	-	2.3	3.9	1.7	3.9	-	-
[1] For bleached kraft market and dissolving pulp mills add:	7.0	13.3	0	0	2.5	4.7	0	0	-	-	2.5	4.7	0	0	-	-
[2] For chemi-groundwood and cold soda groundwood mills add:	7.8	14.1	0	0	2.6	4.7	0	0	-	-	2.6	4.7	0	0	-	-
[3] For unbleached groundwood mills deduct:	4.1	7.4	0	0	1.4	2.5	0	0	-	-	1.4	2.5	0	0	-	-

*pH for all subcategories shall be within the range of 6.0 to 9.0.
**MM is MA30CD.
***MD is maximum day.

Source: Reference (6)

APPENDIX 4

Maps and Drawings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POWER STATION
TANA BRIDGE
NYERI
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L.R. 14214
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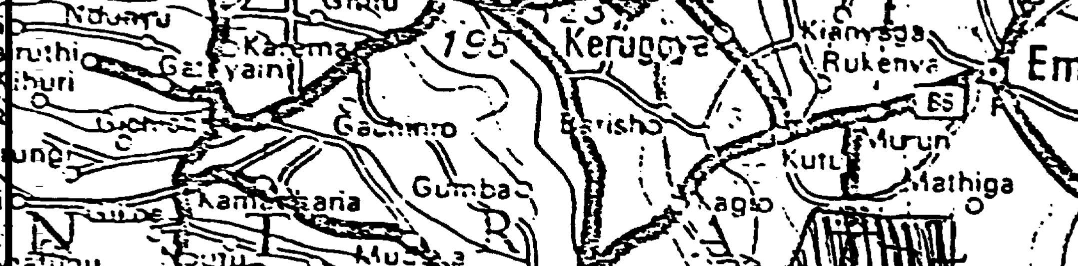
65KM

Gilgil
Ilkek
Mai
Naivasha



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Rukenva
Em
Kerugoya
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Barisho
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Mathiga
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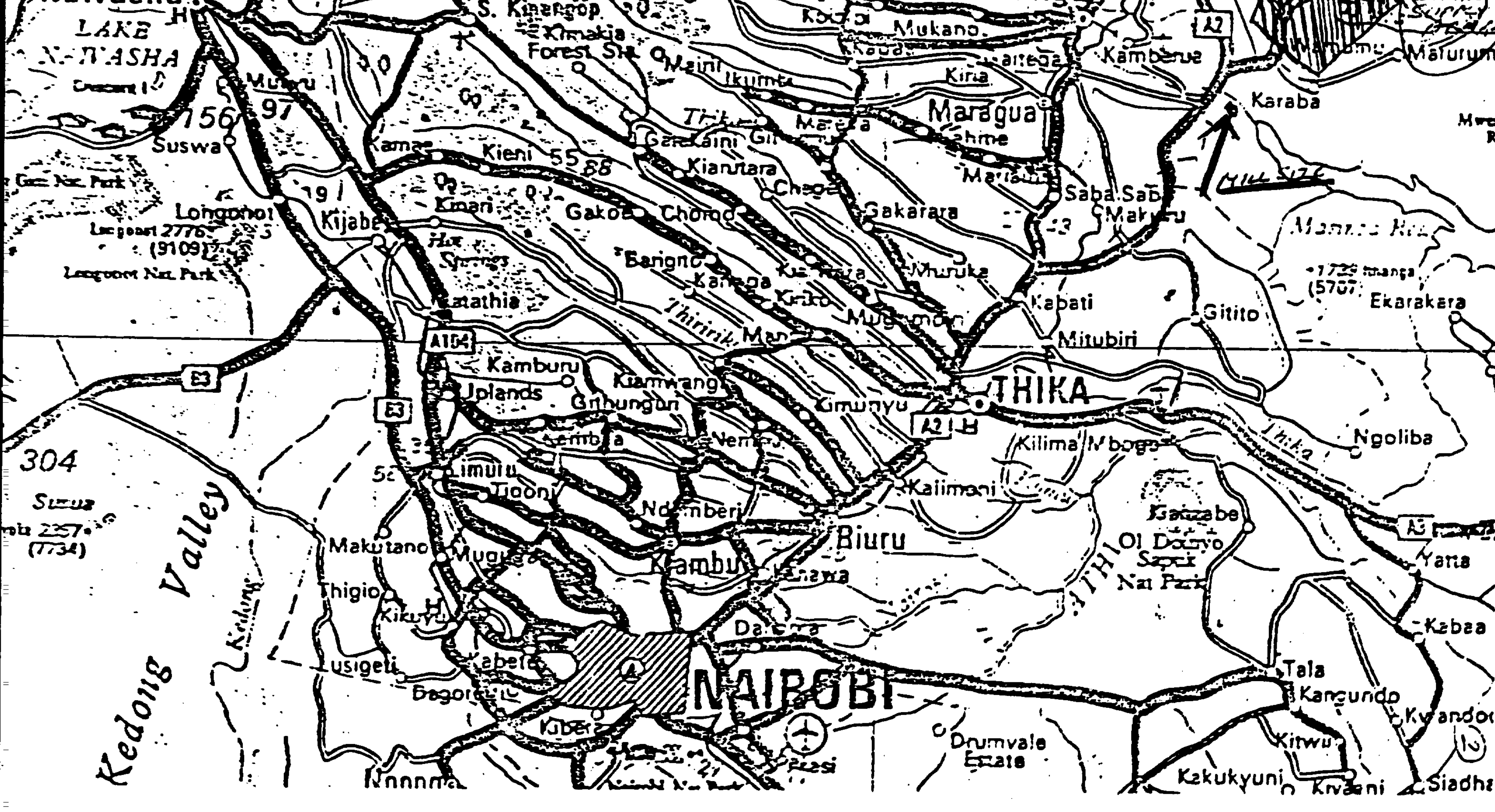
Gatyaini
Kaema
Nduumu
Kithuri
85



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Karaba
Maragua
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Chaga
Gakarara
Saba Saba
Makuyu
Longonot
Kijabe
Kinari
Gakoe
Chomo
Bangno
Kabati
Mitubiri
Gitito
Ekarakara
Kamburu
Uplands
Kiamwangi
THIKA
Kimunyu
Ngoliba
304
Limuru
Tiooni
Kilima Mbogo
Kalimani
Ndumberi
Biuru
Makutano
Thigio
Kiambu
Ol Donyo Sapuk Nat Park
Yatta
Valley
Kedong
Kikuyu
Kabete
Kabaa
Tala
Kangundo
NAIROBI
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Kitwu
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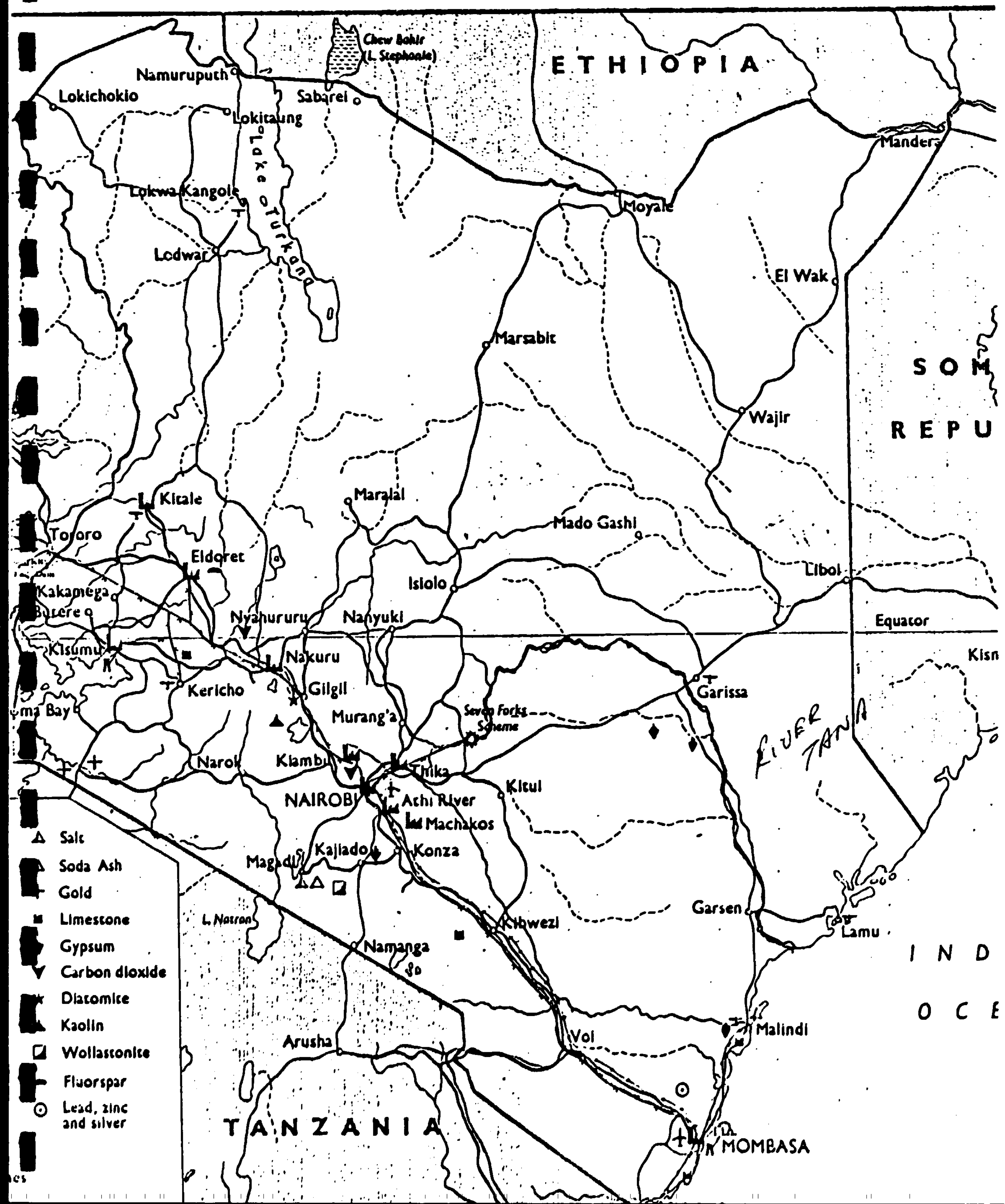

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