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Industrial Waste Water

Paris, France, 10-14 December 1990

PROGRAMME ON PURIFICATION OF INDUSTRIAL WASTE WATER

COUNTRY PAPER: ZIMBABWE*

Prepared by

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UNIDO National Expert

5/70

*The views expressed in this document are those of the authors and do not necessarily reflect the views of the Secretariat of UNIDO. This document has not been edited.

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PREFACE

Within the framework of UNIDO'S programme of purification of industrial waste water, the National expert in waste water management (National consultant) carries out an investigation in the waste water situation in the country.

The national expert assisted in the identification and examination of industrial waste water and suitable treatment technologies. The waste water concerned are effluents from industries such as tanneries and leather, breweries, textile industries, slaughter houses, sugar industries, sisal industries and pesticide formulating plants etc.

The Swedish International Development Authority (SIDA) invited UNIDO to submit a project proposal dealing with the formulation and implementation of a training programme, possibly to include construction of one or more demonstration plants in the participating countries for training purposes, on the treatment practices of industrial waste waters for various sub-sectors of industry.

The national expert has specifically presented the characteristics of the waste waters chosen together which an extensive description of the situation for each type of water with regard to the number of plants, environmental impact, status of waste water treatment, equipment, etc. Four most relevant types of industry (unfortunately none of the above mentioned industries has been included) have been selected and the characteristics of the waste waters thoroughly examined.

An evaluation of the present situation of the selected industries in respect of installed treatment/purification facilities, industrial technology and analytical facilities, (government and other laboratories) has been made. A review has also been made of the technological options available in those industries for reducing waste water quantity and improving effluent quality in industrial water installations, in addition to compilation of available data on environmental effects of the discharges of the different kinds of effluents.

TERMS OF REFERENCE

The complete Terms of Reference are as follows :-

(a) To present the characteristics of the waste waters chosen with an extensive description of the situation for each type of water with regard to the number of plants, environmental impact, status of waste water treatment, equipment, etc.

(b) To prepare a programme for the two UNIDO consultants who will visit the country for approximately two weeks to further evaluate the situation.

(c) To assist and guide the two visiting UNIDO consultants during their evaluation which will aim on :-

- a review of the technological options available for the reducing waste water quantity and improving effluent quality;

- a determination of the level of regulatory measures for industrial waste water treatment, appropriate for adoption by the country;

- an identification of training needs on methods/facilities for waste water treatment.

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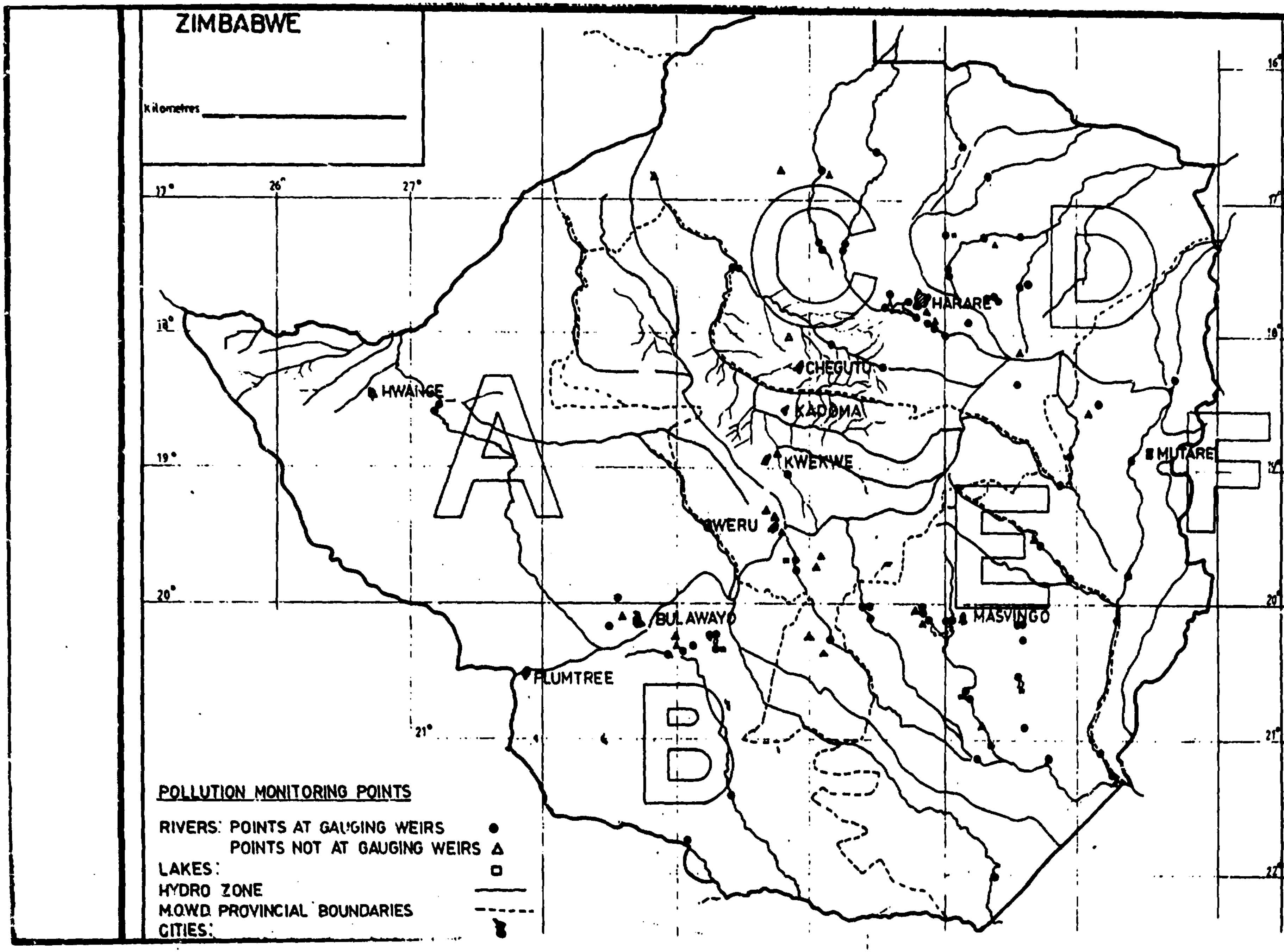

ZIMBABWE
Kilometres
HWANGE
CHEGUTU
HARARE
KADOMA
KWEKWE
GWERU
MUTARE
BULAWAYO
MASVINGO
PLUMTREE
A
B
C
D
E
F
POLLUTION MONITORING POINTS
RIVERS: POINTS AT GAUGING WEIRS
POINTS NOT AT GAUGING WEIRS
LAKES:
HYDRO ZONE
M.O.W.D. PROVINCIAL BOUNDARIES
CITIES:

Appendix A

1.0 GEOGRAPHICAL POSITION

Zimbabwe sits on the map of Africa like a compact teapot, boarded to the North by Zambia, to the east by Mozambique, to the south by South Africa and to the west by Botswana, and with the westernmost tip of the "spout" (where four countries meet) butting onto the Caprivi Strip of Namibia. Landlocked Zimbabwe is the southernmost country of tropical Africa, with a north-south axis of 720 km and an east-west axis of 820 km. The country is boarded along much of the north and south by the Zambezi and Limpopo rivers respectively. (See Appendix A).

There are four distinctive physiographic regions. These are the Zambezi Valley in the north, the dominent plateau medge of the Midlands, the Sabi Limpopo Lowvelds in the south and the Eastern Highlands in the east. Within these areas, the altitude ranges from less than 250m above sea level to over 2,500m.

2.0 WEATHER PATTERN

Zimbabwe is a semi-arid region of tropical Africa, and debilitating droughts are a common occurence. Rainfall is seasonal and very variable, and many of our larger rivers dwindle to a mere trickle in the long dry season, which stretches from about May to October. The rainfall varies from an annual mean of over 2 000mm at a few places in the Eastern Highlands to less than 400mm in the extreme south.

Over most of the country the average is between 600 mm and 900 mm. Precipitation is seasonal with summer rainfall occurring between the middle of November and the middle of March. Water is therefore lifeblood of Zimbabwe.

3.0 RIVERS OF ZIMBABWE

Zimbabwe is boarded along much of the north and south by the Zambezi and Limpopo rivers respectively. The rest of the few inflowing rivers and dams are shown on the map (See Appendix A). Since Zimbabwe has no natural lakes, storage dams are therefore essential to provide a reliable supply of water for domestic, industrial, mining and agricultural use. There are over 8 000 dams in Zimbabwe, varying from Kariba, the largest artificial lake in the world, to small masonry weirs serving communities in the rural areas.

4.0 MANUFACTURING AND AGRICULTURAL INDUSTRIES

Zimbabwe's manufacturing sector is exceptional in Africa for its diversity. It produces an impressive range of more than 6.500 products. Among them are foodstuffs, drink and tobacco, textiles, clothing and footwear, chemical and petroleum products, metals and metal products, paper and paper products, non-metallic mineral products, transport and equipment.

The importance of agriculture to Zimbabwe cannot be over-emphasised. It plays a locomotive, role in the economy and feeds the nation, with a surplus for export. Among the main crops are maize, cotton, tobacco, tea, coffee, potatoes, sugar cane and citrus fruits.

Agricultural inputs are about 16,5% of total manufacturing gross output, which is equivalent to about 25% of all intermediate inputs to the sector as a whole. Zimbabwe's manufacturing sectors aggregate features can be summarized as follows :-

- The Sector contributes 24 per cent of GDP. This is three times the average for sub-saharan Africa.
- Manufacturing value added (MVA) per capital is three times the average for Africa as a whole.
- It contributes greatly to export earnings, between 34 and 57 per cent, depending on the clasiffication used.
- But is also a heavy user of imports, using about 45 per cent of all commodities imported.
- It is also a major user of energy, having 22 per cent of total consumption, and between 48 and 50 per cent of total electricity consumption.

By many criteria, the most important sector in Zimbabwe's manufacturing is the Metals and Metal Products sector, which includes non-ferrous metal and iron and steel basic industries, metal products, machinery and equipment including electrical radio and communication equipment.

In terms of net output, numbers employed and value of capital employed, Food staffs is the second most important sector (16 per cent of total net output. As an exporter however it is in third place to Textiles, which includes significant cotton lint sales and has 9 per cent of total output.

Closely allied through linkages is the clothing and footwear sector, with similar levels of employment and the share of net output, but a much higher number of individual firms and a much smaller contributor to exports.

But manufacturing contains several other significant branches, notably Chemicals and Drinks and Tobacco, which are respectively in third and fourth place in net output terms (13 per cent and 11 per cent of the total. The other sectors are Paper, Printing and Publishing (7 per cent), Non-metallic Mineral Products (5 per cent), Wood and Furniture (4 per cent), Transport Equipment (3 per cent) and other Manufactured Products.

The comibination of the sectoral activity withing manufacturing is, overall, not very far from that of developed countries, and is closest to the group of high income developing countries, even though Zimbabwe itself belongs to the low income group.

5.0 CHEMICALS AND POLLUTANTS

One of the major causes of water pollution in Zimbabwe is the mining industry. The problem of "acid mine drainage" is to be found wherever there is sulphur present and many ores exist in the form of sulphides. The acid water pumped from such mines and seepages from dumps or ore and waste material find their way into watercourses or underground water unless vigorous action is taken to prevent this. Normally this problem is dealt with by returning all seepage and drainage of this kind to the ore processing section of the mine where it can be used in the process and finally for slurrying tailings for transport to tailings and slimes dams where provision is made for its disposal by evaporation.

Similar problems are encountered in some industrial plants e.g. in the processing of phosphate rock for fertilizers. Acid mine drainage is also encountered in the coal mining industry. Effluents arising from the manufacture of fertilizers other than phosphates, e.g ammonium nitrate, possess different problem since the appearance of nitrogen compounds in surface or underground water can be very deleterious to both vegetable and animal life and can give rise to serious problems of algal growth in impounded water. In one of its major water supply sources, Lake McLlwaine, Zimbabwe faces the problem of weed-water hyacinth, which may finally result in eutrophication. Discharge of sewage effluents into water courses has highly contributed to this problem in Zimbabwe.

Water pollution is occurring from normal farming operations through run-off and seepage of water containing not only fertilizers but insecticides, herbicides and other poisonous substances.

New industries or undertakings are now accordingly required to include in the planning stage - provision for complying with the legislation from the start of the operations.

It is however pleasing to record that in general the offending parties are now conscious of their responsibilities to the community regarding the need to control water pollution and cooperated with the authorities in the task of protecting the environment.

6.0 WATER POLLUTION CONTROL

The problems of water pollution have been recorded during the Roman Empire. There are even references to pollution in the Bible. So pollution problems are not new and the question is not whether but how.

Zimbabwe is fortunate in that the problem of water pollution has not reached the serious levels that it has in some more developed and industrialised countries and that where problems exist in Zimbabwe they are of a localised nature. Zimbabwe is nevertheless full aware that there is no room for complacency in the field of water pollution control. Events in other countries bear ample testimony to how quickly a situation can get out of control and require the expenditure of vast sums of money on remedial action.

The timely introduction of suitable control measures at an early stage in the development of Zimbabwe has made it possible to exercise effective control of water pollution before a serious and possibly an irreverssible situation developed without disruption of the economy. Although considerable work remains to be done and sustained effort will be required in the future to retain control of water pollution and to prevent a deterioration of the position, the majority of the main sources of water pollution in Zimbabwe have now been brought to book and in most of these cases control and abatement measures have been or are being implemented.

Obviously water pollution cannot be eliminated overnight and although the legislation in Zimbabwe prohibits water pollution, provision has been made for temporary exemptions to be granted, under specific conditions to allow offenders sufficient time within which to install suitable control measures to comply with the legislation.

7.0 LEGAL PROVISIONS FOR THE CONTROL OF WATER POLLUTION

The Water Act was first amended in 1970 to include provision relating to Water Pollution Control. Since then, various amendments have been made and incorporated into the present Water Act, 1976 (Chapter 41 of 1976). The most important of these provisions are in Section 101 (See Appendix B).

Briefly, the Act does not allow discharge into water courses of any effluent which does not meet the standards as laid down in the Water (Effluent and Waste Water Standards) Regulations, 1977 (See Appendix C.

It can be seen, therefore, that adequate provision exist for the control of water pollution in Zimbabwe and the Water Pollution Control amendments which were first introduced into the Water Act in 1970 basically prohibit water pollution but allow for temporary exemptions to be granted under specific conditions - to allow offenders sufficient time within which to carry out the works necessary to put their houses in order and comply with the legislation.

We consider that the treatment and disposal of an effluent from any industrial process or undertaking must be regarded as an integral part of that process both in regard to the economic and purely mechanical aspects and implications of the Undertaking - in other words the principle that "the pollution must pay" must be accepted and applied. New industries are expected to comply with the Regulations from the start and would not normally be considered as candidates for exemption, although there is no provision to stop a new plant from being built, even if the pollution problem is not addressed properly.

In order to achieve an objective of preventing and controlling the pollution of our water resources, and conserving this valuable resource, (Zimbabwe lies in the semi-arid regions, irrigation in needed to realize increased agricultural production) it was considered essential that the quality of effluent discharged, directly or indirectly, into any water should be strictly controlled and to this end the above regulations have been introduced which prescribe a comparatively high standard of purity for any effluents discharged into the water and which, we believe, will encourage the optimum re-use of the waste-water. Amongst other constituents, these regulations lay down maximum permissible concentrations for cyanide, arsenic, mercury, lead and other potentially poisonous or hazardous substances that may be present in waste water.

8.0 THE ADMINISTRATION OF THE WATER ACT

The administration of the Act is undertaken by the Ministry of Energy and Water Resources and Development and more particularly by the Water Pollution Control Section of Operations Branch. The Section's main functions are the location, investigation and overall control of pollution sources throughout the country, the collection of water quality data from streams (See Appendix D), rivers and lakes and the preparation and issuing of exemption permits.

Three types of monitoring are done, namely :-

a) Natural Water Quality Monitoring

b) Pollutions Control Monitoring

c) Policing Monitoring.

Over a 100 sampling points exist (Appendix A) and every sampling point is registered (e.g sample point CR4, Appendix D) and full details of the point are stored with other data in the data bank. Over 30% of these points are in urban areas and sampling is done once every month.

Analysis is carried out by the Government Analyst, Ministry of Health. Other organisations may be called in for help e.g the City of Harare and the Chemistry Department of the University of Zimbabwe. The capacity and efficiency of the Government Analyst Laboratory is the present limiting factor in the development of the programme. This has resulted in the need for the Ministry of Energy and Water Resources and Development to have its own laboratory, and is in the process of acquiring one at the moment.

In addition the Section is responsible within the Ministry for advising on national water pollution control policy and for the implementation of this policy.

Parts of these functions are delegated to Provincial Water Engineers and Local Authorities. The Section is responsible for the co-ordination of activities by these bodies and for ensuring that a uniform and consistent approach to water pollution is applied throughout the country. It is responsible for the issuing of advice and guidelines to these bodies where necessary.

The Ministry is aided by other interested bodies including the Natural Resources Board, Local Authorities, National Parks and Wild Life and the Ministry of Health. In addition, the Water Pollution Advisory Board has been set up, consisting of experts from various organizations concerned with water pollution.

The functions of the board are to advise the Minister of Energy and Water Resources and Development on all matters regarding the prevention and control of water pollution. This includes recommendations on water quality standards from waste and effluent waters, on applications for the issue of exemption permits. Keeping under review existing legislation on water pollution control and making recommendations for any further amending legislation.

In an event the best law is no better than the weakest enforcement, and this in part is dependent on the funding of the programme. So in Zimbabwe prosecution of violators is rare, but compliance with best "practical means" is followed because of diplomatic persuasion.

Rhodesia Government Notice No. 687 of 1977.

[ACT 41/76

Water (Effluent and Waste Water Standards) Regulations, 1977

IT is hereby notified that the Minister of Water Development has, in terms of section 135 of the Water Act, 1976, made the following regulations: —

Title

1. These regulations may be cited as the Water (Effluent and Waste Water Standards) Regulations, 1977.

Interpretation

2. In these regulations—

"heavy metal" means a metal having a specific gravity greater than 5,0;

"Zone I catchment area" means a Zone I catchment area specified in the First Schedule;

"Zone II catchment area" means a Zone II catchment area specified in the First Schedule.

Prescribed standards of quality for effluent and waste water

3. The standards of quality, prescribed for the purposes of paragraph (a) of subsection (2) of section 101 of the Act, to which effluent or waste water which has been produced by, or results from, the use of water for any purpose, and which is discharged or disposed of into a public stream, private water, public water or underground water, whether directly or through drainage or seepage, shall conform, shall be as set out in the Second Schedule.

Sampling procedure

4. The following requirements shall be complied with in respect of any sample which may be taken or required to be taken of effluent or waste water for the purposes of Part IX of the Act—

(a) a composite sample for the purpose of analysis for all tests, other than those for temperature, pH and dissolved oxygen, shall be taken by combining individual samples so that a minimum of five samples of equal volume of not less than five hundred millilitres each of the effluent or waste water shall be taken, at the point of discharge, at approximately equal intervals of time over a minimum period of approximately four hours within any twenty-four-hour period;

(b) temperature, pH and dissolved oxygen readings shall be taken on individual samples at the time of sampling, and all samples shall comply with the standards specified in respect of temperature, pH and dissolved oxygen in the First Schedule;

(c) where full laboratory facilities do not exist on the site for the determination of dissolved oxygen, the oxygen in the sample may be fixed at the time of sampling by adding the sulphuric acid, the permanganate, the oxalate, the manganous sulphate and the alkaline iodide only:

Provided that—

(i) the stopper of the sample container shall be replaced and the solution shall be well mixed;

(ii) the remaining steps shall be carried out later in the laboratory.

Repeals

5. The Water Pollution Control (Waste and Effluent Water Standards) Regulations, 1971, published in Rhodesia Government Notice No. 609 of 1971, are repealed.

FIRST SCHEDULE *(Section 2)*

ZONES I AND II CATCHMENT AREAS

1. *Zone I catchment areas*	*Locality*
The river catchment area of—	
(a) the Gairezi River and its tributaries .	Inyanga district
(b) the Pungwe River and its tributaries .	Inyanga district
(c) the Hondi River and its tributaries .	Inyanga district
(d) the Nyamkwarara River and its tributaries	Inyanga district
(e) the Inyangombe River and its tributaries to its confluence with the Nyajezi River	Inyanga and Makoni districts
(f) the Nyajezi River and its tributaries to its confluence with the Inyangombe River	Inyanga district
(g) the Odzi River and its tributaries to its confluence with the Odzani River . .	Inyanga district
(h) the Odzani River and its tributaries to its confluence with the Odzi River . .	Inyanga district
(i) the Mazonwe River and its tributaries .	Umtali district
(j) the Umvumvumvu River and its tributaries to its confluence with the Nyambewa River	Melsetter district
(k) the Nyambewa River and its tributaries to its confluence with the Umvumvumvu River	Melsetter district
(l) the Nyanyadzi River and its tributaries to its confluence with the Biriwiri River	Melsetter district
(m) the Biriwiri River and its tributaries to its confluence with the Nyanyadzi River	Melsetter district
(n) the Lusitu River and its tributaries .	Melsetter district
(o) the Busi River and its tributaries . .	Chipinga district

2. *Zone II catchment areas*

All river catchment areas other than those specified under Zone I.

SECOND SCHEDULE (*Section 3*)

PRESCRIBED STANDARDS OF EFFLUENT OR WASTE WATER

1. The water shall not contain any colour or have any odour or taste capable of causing pollution.

2. The water shall not contain any radioactive substances capable of causing pollution.

3. The pH of the water shall be, where discharged or disposed of—
   (a) in a Zone I catchment area, between 6,0 and 7,5;
   (b) in a Zone II catchment area, between 6,0 and 9,0.

4. The temperature of the water at the point of discharge shall not exceed—
   (a) in a Zone I catchment area, 25 °C;
   (b) in a Zone II catchment area, 35 °C.

5. The water shall contain dissolved oxygen to the extent of at least, where discharged or disposed of—
   (a) in a Zone I catchment area, 75 *per centum* saturation;
   (b) in a Zone II catchment area, 60 *per centum* saturation.

6. The chemical oxygen demand of the water, after applying chloride correction, shall not exceed, where discharged or disposed of—
   (a) in a Zone I catchment area, 30 milligrams per litre;
   (b) in a Zone II catchment area, 60 milligrams per litre.

7. The oxygen absorbed by the water shall not exceed, where discharged or disposed of—
   (a) in a Zone I catchment area, 5 milligrams per litre;
   (b) in a Zone II catchment area, 10 milligrams per litre.

8. The total undissolved solids content of the water at the point of discharge shall not be greater than—
   (a) in a Zone I catchment area, 10 milligrams per litre;
   (b) in a Zone II catchment area, 25 milligrams per litre.

9. The total dissolved solids content of the water at the point of discharge shall not—
   (a) in a Zone I catchment area, increase the total dissolved solids content of the receiving water by more than 100 *per centum* and the total dissolved solids content of the effluent shall not exceed 100 milligrams per litre;
   (b) in a Zone II catchment area, exceed 500 milligrams per litre.

10. The water shall not contain soap, oil or grease in quantities greater than, where discharged or disposed of—
    (a) in a Zone I catchment area, nil;
    (b) in a Zone II catchment area, 2,5 milligrams per litre.

R.G.N. No. 687 of 1977

11. The maximum permissible concentrations of chemical constituents permissible in the water which is discharged or disposed of in a Zone I or Zone II catchment area shall be as specified in the following table:

TABLE

MAXIMUM PERMISSIBLE CONCENTRATIONS OF CERTAIN CHEMICAL CONSTITUENTS

Constituent	Maximum concentration in milligrams per litre	
	Zone I catchment area	Zone II catchment area
Ammonia free and saline (as N)	0,5	0,5
Arsenic (as As)	0,05	0,05
Barium (as Ba)	0,1	0,5
Boron (as B)	0,5	0,5
Cadmium (as Cd)	0,01	0,01
Chlorides (as Cl)	50	100
Chlorine residual (as free chlorine)	Nil	0,1
Chromium (as Cr)	0,05	0,05
Copper (as Cu)	0,02	0,5
Cyanides and related compounds (as CN)	0,2	0,2
Detergents (as manoxol -OT)	0,2	1,0
Fluoride (as F)	1,0	1,0
Iron (as Fe)	0,3	0,3
Lead (as Pb)	0,05	0,05
Manganese (as Mn)	0,1	0,1
Mercury (as Hg)	0,5	0,5
Nickel (as Ni)	0,3	0,3
Nitrogen total (as N)	10,0	10,0
Phenolic compounds (as phenol)	0,01	0,1
Phosphates total (as P)	1,0	1,0
Sulphate (as SO_4)	50	200
Sulphides (as S)	0,05	0,2
Zinc (as Zn)	0,3	1,0
Total heavy metals	1,0	2,0

12. The water shall not contain any detectable quantities of pesticide, herbicide or insecticide, nor shall it contain any other substances not referred to elsewhere in these standards, in concentrations which are poisonous or injurious to human, animal, vegetable or aquatic life.

Potassium (mg/l)	2.0	4.0	4.3	3.0	2.7	11.6	14.0	19.0		1.2	2.8			
Iron (mg/l)								50.0				0.03	0.1	0.01
T.D.S. (mg/l)												183.0	590.0	529.0
Fluoride (mg/l)												0.33	0.6	0.05

9.0 INDUSTRIAL WASTE WATER DISCHARGES AND THE SELECTION OF INDUSTRIES WITH WELL-KNOWN ENVIRONMENTAL PROBLEMS

Major industrial plants, particularly those in the chemical industry are prodigious consumers of water. Substancial cost is involved often to ensure a secure and dependable supply. Despite re-use within the plant and incorporation with the product of the manufacturing process, major water users are usually major waste water producers, sometimes in conjunction with a solid or semi-solid waste by-product.

Given the production of significant effluent streams, there are a limited number of options for ultimate disposal of such waste streams outside the plant. With aqueous effluents, two obvious disposal routes are to surface waters or to groundwater.

Discharges of this nature are strictly controlled in terms of permitted chemical quality of the effluent. A third option is discharge to sewer, should one with adequate capacity be available locally. Again there are attendant quality constraints with such a discharge. A further alternative is a combination of any of the former three options with pre-treatment of the effluent to improve its chemical quality prior to discharge.

Effluent discharge problems can be most easily instigated by limiting the quantity of effluent produced and, where this is not possible, re-using as much waste water within the plant as possible. To effect such an optimisation between water input, use and discharge, a careful study of the plant water balance in terms of the foregoing factors and water pollution control measures is necessary.

In Zimbabwe discharges of waste water to surface waters or to groundwater are strictly controlled in terms of permitted quality of the effluent. The majority of the industries do discharge their waste water to their municipal sewers. However some do apply a combination of any of the former three methods with pre-treatment of the effluent to improve its chemical quality before they discharge into sewers.

Most of the manufacturing industries are situated in or around towns and it is easier and cheaper to discharge their waste water into their respective municipal sewers. Mines of course are scattered all over he country and so they have their own waste water treatment plants.

Serious problems are encountered in Chemical industrial plants e.g. in the processing of phosphate rock for fertilizers. There are two leading fertilizer manufacturing companies in Zimbabwe; these are ZIMBABWE PHOSPHATE INDUSTRIES LIMITED (ZIMPHOS) and SABLE CHEMICALS LIMITED. At Sable Chemicals Limited the pollution problem is that of high nitrate concentration in the waste water. The situation is closely monitored and is under control at the present moment.

The pollution problems at ZIMPHOS are just complex in terms of both financially and technically. The problems are going to be discussed in detail latter.

In the mining industry, the major problem, is that of killing cyanide after the cyanidation process in gold mining. Athens Gold Mine is facing a serious problem in this aspect. Here the problem gets worse when more reliable and accurate methods of analysing the chemical cannot be found.

The other major causes of water pollution in the country is the steel industry. Here we have ZISCOSTEEL, the country's only manufacturer of iron and steel and LANCASHIRE STEEL LIMITED which is engaged in the manufacture of galvanised wire from steel billets. Both these steel industries are going to be discussed in detail.

An evaluation has been done of the present situation to Zimbabwean industries in respect of installed treatment/purification facilities, industrial technology, well-known environmental problems and analylical facilities.

In Zimbabwe a selection of industries with well-known environmental problems has been made and the characteristics of the waste water has been given and in some cases existing treatment/purification technology, or proposed technology has also been outlined. The selected industries range from chemical, steel to mining industry.

A priority list of the industrial sub-sectors of the greatest interest to each within the context of the project's objectives has been prepared. The priority list is as follows :-

1. Zimbabwe Phosphate Industries Limited

2. Zimbabwe Iron and Steel Company Limited

3. Athens Gold Mine

4. Lancashire Steel (Pvt) Limited.

10.0 DETAILS OF UNDERTAKING

10.1 NAME OF UNDERTAKING : Zimbabwe Phosphate Industries Limited

10.2 ADDRESS : P O Box AY 120, Amby, Harare

10.3 NATURE OF INDUSTRY : Manufacturing of phosphate and superphosphate fertilizers, and related mineral acids, aluminium sulphate and other chemicals.

10.4 LOCATION : Harare

10.5 DETAILS OF WATER CONSUPTION

10.5.1 Source of supply : City of Harare

10.5.2 Consumption : $1.10^6 m^3$ per year

10.6 DETAILS OF RAW MATERIALS

10.6.1 Phosphate rock from Dorowa Minerals

10.6.2 Iron pyrites from Iron Duke Mine

10.6.3 Sulphur from Canada

10.6.4 Bauxite from Mozambique

10.6.5 Limestone from G and W Minerals (IDC)

10.7 DETAILS OF WASTE WATER DISCHARGE

See Zimphos's Water Pollution Control Summary of background to date.

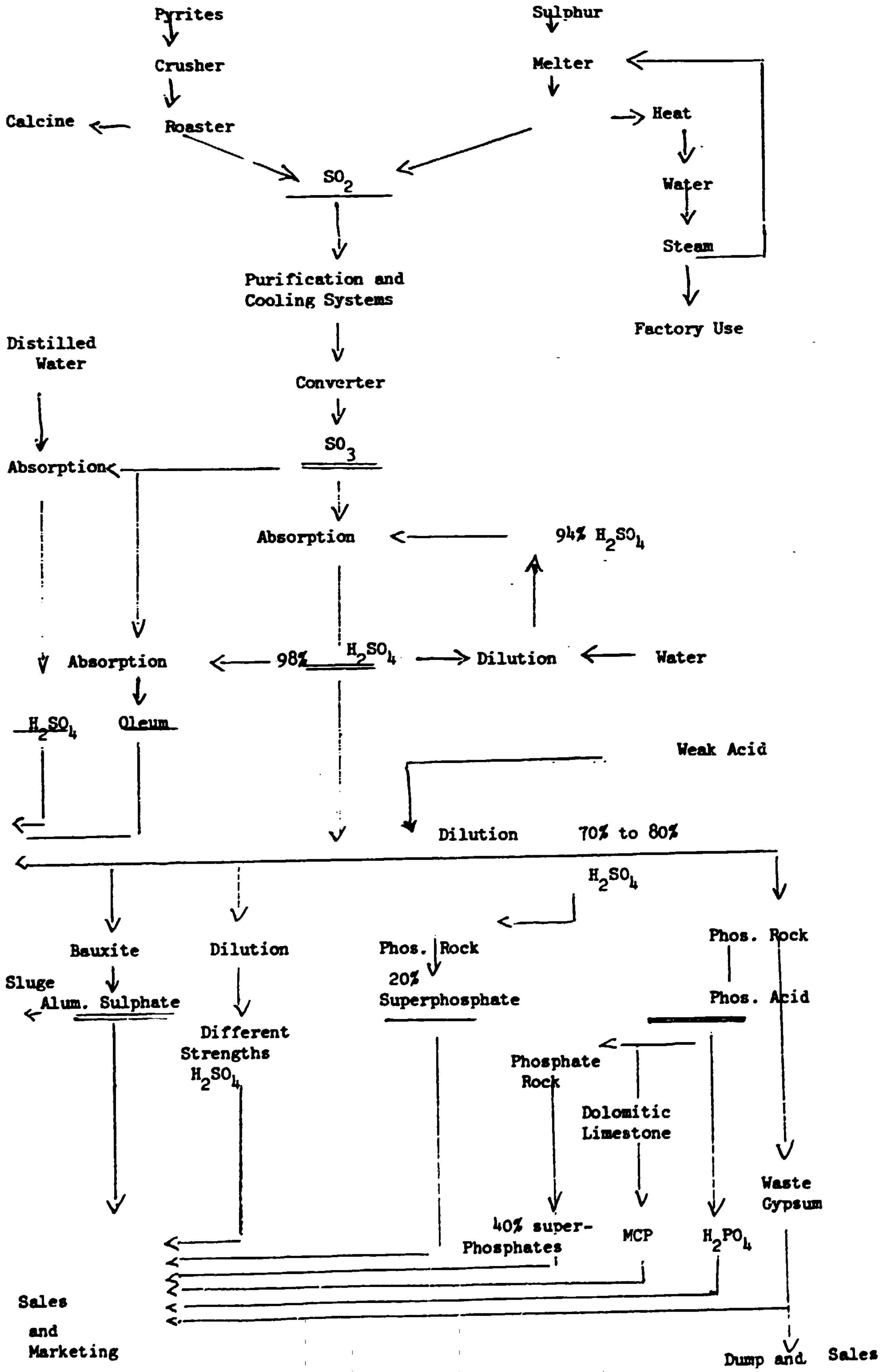
10.8 BUSINESS STRATEGY

ZIMPHOS is the major manufacturer in Zimbabwe for a number of basic chemicals. The manufacturing plants at the ZIMPHOS factory are as follows :

1. 82 500 t/a Pyrite Burning Sulphuric Acid Plant.
2. 82 500 t/a Sulphur Burning Sulphuric Acid Plant.
3. 30 000 t/a Wet Process Phosphoric Acid Plant.
4. 200 000 t/a Broadfield DEN Superphosphate Plant.
5. 22 000 t/a Aluminium Sulphate Plant.
6. 550 000 t/a Steam Raising Plant
7. 1 060 t/a Toll Manufacturing Plant for insecticides
8. 660 t/a Rosin Tampentine Plant
9. 1 920 t/a Silicates Plant
10. 700 t/a Lead Nitrate Plant

(See the flow sheet of plants at ZIMPHOS APPENDIX E).

FLOW SHEET OF PLANTS AT FACTORY



The replacement capital value of plant is estimated at Z$400 million. The infrastructure is extensive and some facilities are shared with the adjacent ZIMBABWE FERTILIZER CORPORATION (ZFC) plant producing 75 000 t/a mixed and phosphate fertilizer. Chemplex owns 50% of the capital of ZFC.

11.0 STATEMENT OF PROBLEM

The production of wastes with a high pollution potential, the location of ZIMPHOS factory itself, the unfortunate siting of waste disposal areas and a legacy of waste management problems have combined together to produce the current problem at ZIMPHOS. In the past few years, a vigorous and progressive approach to pollution control has been directed at relatively localised problems and a more comprehensive appraisal of the situation is thus required.

By considering each of the foregoing problem areas in more detail, it is possible to attain an appreciation of the magnitude of difficulties at ZIMPHOS.

11.1 PRODUCTION OF WATERS WITH A HIGH POLLUTION POTENTIAL

Four wastes or group of wastes are produced or have been produced from ZIMPHOS factory. These wastes and seepage liquids all have a high pollution capacity.

11.1.1 Gypsum

A major by-product of the manufacture of phosphoric acid, this calcium sulphate is slurried with waste water e.g. with fluoride rich liquor used for scrubbing out fluoride vapours evolved during the digestion of phosphate rock by sulphuric acid and discharged to a tailings dam (See analyses in Table 11.1).

11.1.2 Calcine

Calcine pyrites, (calcine), is formed during sulphuric acid manufacture and discharged as a solid waste. The leaching of the oxidised waste material produces an effluent high in iron and sulphate.

11.1.3. "Miscelleneous" Wastes

Various wastes chiefly from the arsenic plant. They all have high arsenic contents.

11.1.4. Liquid Effluents

Discharges or seepages from the factory or waste dumps principally to the Mukuvisi River. All listed or known discharges fail to meet standards in Zimbabwe effluent control regulations.

11.2 LOCATION OF ZIMPHOS FACTORY

Any liquid, be it plant effluent, stormwater run-off or near-surface seepage, generated in the factory area will find its way to a live watercourse. This is because the factory is bounded on the north by the Mukuvisi river and on the east by a vlei drained by the so-called "Little Kariba" (See Drawing No.11.1 drg) Such liquids are almost always of poor chemical quality and hence will pollute these surface waters. Table 11.2, Section 3 to 6, summaries the main discharges and seepage to Mukuvisi river and "Little Kariba" from the factory.

TABLE 11.1 ANALYSIS OF GYPSUM TAILINGS LIQUIDS FROM ZIMPHOS

ANALYSIS REFERENCE	pH	TDS*	Co	SO4	F	PO4	SiO_2
1. Sample taken in March, 1975	1,4	12 000	-	-	3 400	-	-
2. "Typical" mean values	-	22 000	-	-	5 300	2 750	-
3. February, 1980 analysis	-	-	1 000	9 200	6 800	12 040	10 700
4. Maximum quality limits for discharge to 9 water courses	6.0/9.0	500	-	200	1,0	1,0	-

All values in mg/l except pH which is in units.

* TDS - Total dissolved solids

TABLE 11.2 : SUMMARY OF DISCHARGES/SEEPAGES TO THE MUKUVISI RIVER

NO.	LOCATION AND DESCRIPTION	DRY WEATHER DISCHARGE ESTIMATES m^3/month		ANALYSIS (mg/l)										
		MINIMUM	MAXIMUM	pH	Ca	Fe	Al	K	As	NO_3	SO_4	PO_4	F	MINIMUM TDS BY SUMMATION
1.	Underflow of interceptor system, north-west calcine dump - estimated underflow @ 25% original flow	Mean value only 10 000		1.5/2.0	600	3,700	-	-	-	-	7 700	-	-	12 000
2.	Seepage from eastern end of north-west calcine dump and north side of railway siding	Zero	500	2.5/3.0	600	80	-	-	200	-	1 400	-	-	2 280
3.	Discharge to main sluit, (other than neutralised effluent from water treatment plant), seepage from south side of railway siding and north side of old arsenic disposal area	Mean value only 6 000		1.5/3.0	300	100	20	-	1	-	700	20	30	1 170
4.	Seepage north of old arsenic plant.	Zero	500	3.5/4.0	300	10	-	8	20	-	700	70	14	1 124
5.	Seepage - underflow east of Sterkfontein pump.	Zero	1 000	3.0/3.5	120	-	-	-	-	132	280	200	100	832
6.	Discharge/seepage to Little Kariba, hence to Makabusi.	Mean value only 50 000		3.5/4.5	300	50	-	-	1	-	700* (1 000)	-	5	1 065

NOTES :

1. Additional seepage - unquantified and not analysed to river from calcine in region of rodia club.
2. Total dry weather discharges
   - minimum, 2.2 megalitres/day (66 000m^3/month)
   - maximum, 2.6 megalitres/day (77 000 m^3/month)

11.3 SITING OF THE WASTE DISPOSAL AREAS

The location of the principal waste disposal areas are marked on the general site plan, Drwg No. 11.1. The problems associated with the chosen disposal locations can be summarised as follows :-

11.3.1 Gypsum

The Gypsum slimes dam is located at the north-west end of surface water catchment of the Epworth vlei which feeds the Hatfield Stream. Seepage from the dam flows southwards polluting the vlei area and derogating the quality of the main stream. Existing remedial measures to intercept this seepage are only marginally effective.

A line of water supply boreholes trending south westwards down the Epworth vlei has been polluted. Water from these boreholes which were for public supply is no longer of potable quality due to pollution from this dam. The gypsum tailings dam is unlined under the majority of its area and vertical seepage has polluted the underlying groundwater.

11.3.1 Calcine

There are three main and a host of ancillary calcium dumps. These are :

(a) the north-west calcine dump

Seepage and underflow past the adjacent interceptor system travel direct to the Mukuvisi River. (Item 1 of table 11.2.)

(b) the south-east, "old" calcine dump:

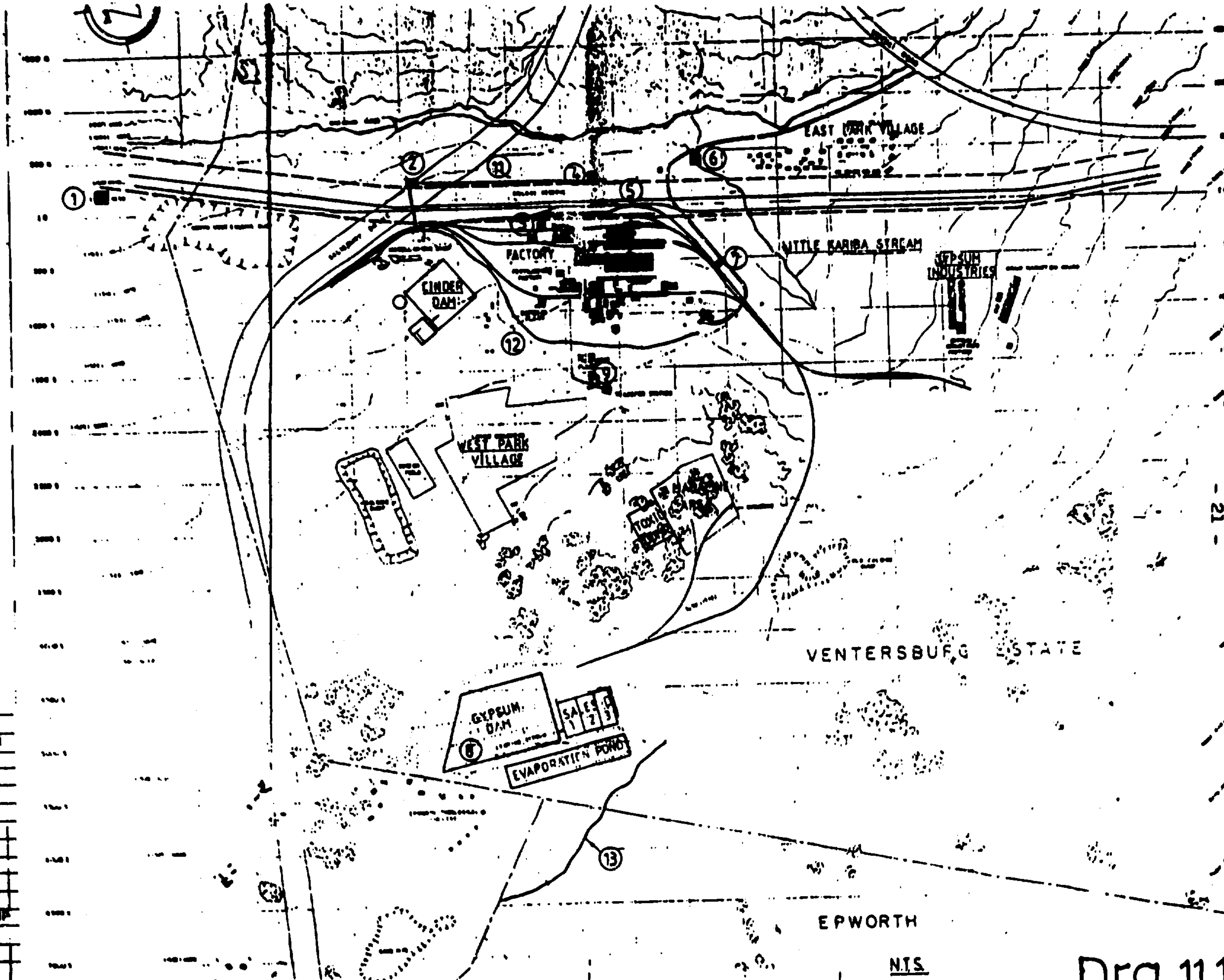
The dump is situated at the head of the eastern vlei area drained by the "Little Kariba" to the Mukuvisi River. Seepage through the dump, aggravated by the fact that calcine was dumped in a dug excavation, flows north-eastwards into the vlei and eventually to the Mukuvisi river.

(c) the "new" calcine dump

Although the dump is sited well away from any active watercourse, adjacent to the soccer field, seepage generated in the dump is polluting groundwater to the north (samples from sunk boreholes indicated).

(d) Other dumps

Calcine has been dumped almost indiscriminately in the area of ZIMPHOS' property particularly to the west of the factory.



13	DRAIN TO HATFIELD STREAM
12	MAIN SLUIT
11	FRENCH DRAIN
10	IRRIGATION SITE
9	WATER TREATMENT PLANT
8	GYPSUM DAM
7	OLD MAIN GATE SUMP
6	LITTLE KARIBA SUMP
5	ZFC STORM WATER DRAIN
4	STERKFONTEIN SUMP
3	CENTRAL COLLECTION SUMP
2	MAIN SLUIT SUMP
1	NW CALCINE SUMP
	KEY

N.T.S.

EFFLUENT COLLECTION POINTS

Drg 11.1

It has resulted in the complete pollution of near surface soils and all drainage ditches.

To the east of the existing gypsum tailings dam a berm of calcine has been constructed presumably for stormwater control. Waste material and water polluted by the dump are discharged via a stormwater drain to Epworth vlei.

(e) Calcine roads

The geotechnical properties of calcine make it suitable for the wearing surface of site roads and it has been extensively used as such throughout the ZIMPHOS factory area. The effect has been to pollute all stormwater channels adjacent to the site roads and hence made the general pollution more widespread.

(f) The ZIMPHOS Club car pack

A substantial volume of calcine has been used to construct a car park on the northern side of the ZIMPHOS Club. The edge of the car park is within 20 m of the Mukuvisi River; contaminated water from the car park therefore flows directly into the river.

11.3.3 Miscelleneous Wastes

Wastes from the old arsenic plant have been dumped between the western railway siding and the "main sluit" on the west side of the factory. It would appear that near-surface groundwater forms a seepage line in this area and the resultant polluted water flows into the "main sluit", via a number of smaller drains, and hence into the Mukuvisi River.

11.4 WASTE MANAGEMENT

Despite substantial improvements in recent years, the level of control of waste disposal operations does not alleviate the risk of water pollution from these operations.

The gypsum tailings dam was not constructed using a complete, impermable liner and hence seepage is polluting groundwater and surface water in the area. The interceptor and return water system installed along the southern side is not operated effectively and hence seepage water flows down Epworth Vlei. It would appear that this water is either causing or is partially responsible for the contamination of the Epworth Boreholes. The slimming operation and the removal of dried gypsum from the dam for Gypsum Industries have both been carried out somewhat haphazardly.

It is appreciated that the pollution potential of calcine was not understood until the last few years and consequently little attention has been focussed on calcine disposal management.

With hindsight it is clear that if control procedures in waste disposal had been instituted from the start of operations in 1958, the problem would never have assumed these proportions and the substantial cost involved in minimising its effects would have been absorbed in the daily operational costs of the plant.

12.0 ZIMPHOS' WATER POLLUTION CONTROL SUMMARY OF BACKGROUND TO DATE

12.1 CINDER

Most of the effluent from ZIMPHOS arises from old cinder dumps scattered around the factory and not directly from current factory operations. This cinder is the by-product ash from the roasting of pyrites to produce sulphur dioxide for sulphuric acid manufacture. The fresh cinder from the roaster is slightly alkaline and so about twenty years ago it was first thought that the cinder would not be a source of acidic pollution. Thus the cinder was even used for roads surfacing etc and disposed of in widely scattered dumps around the factory.

Some years after the early pyrites roasting operation it became apparent that the cinder, when weathered by exposure to the atmosphere becomes acidic a result of the oxidation of residual sulphur in it.

Investigations into the best methods of collecting the effluent leaking out of these old cinder dumps were then carried out. As a result, two underground water interceptor drains were constructed at the North-western side of the factory to collect polluted underground seepage which would otherwise contaminate the Mukuvisi. The effluent collected is treated at the existing water treatment plant but the capacity of this plant has up to now placed a limit on the amount of effluent than can be collected other sources for treatment.

It is worth noting that the method of cinder disposal has now been revolutionised following the commissioning of the uprated pyrites - burning sulphuric acid plant two years ago. In this new system, the cinder is slurried with water and pumped to a special dam where the cinder is deposited to leave a clear liquor which is recycled back to the plant for slurrying more cinder again. This dam is completely lined with a totally impervious special plastic sheet so that no seepage can escape from it. A hydrological survey around the cinder dam completed in October by Water Well Limited indicated that there was no seepage emanating directly from this dam. The plastic lining in the dam is intact and effective.

Nevertheless monitoring boreholes have now been installed around the dam and these will be used for detecting any pollution seepage should it ever occur.

12.2 GYPSUM DAM

When the gypsum dam was first built, a relatively impermeable clay layer was placed below it in an attempt to prevent seepage to the water table below it. Unfortunately about twenty years later it became apparent that this was not adequate. The ground below the gypsum dam has hardened due to reaction with fluorine and this has caused the seepage to flow laterally into the storm water drain and the surrounding ground thereby bypassing the effluent cut-off trench. By then underground waters were contaminated with fluorine pollution from the gypsum dam and borehole water in Epworth was unuseable.

Urgent investigations were then conducted which led to the implementation of various remedial measures such as reshaping of the dam and intercepter drains. The problem was then alleviated by slurrying gypsum with treated or fresh water instead of the fluorine liquor.

The fluorine liquor is now being pumped straight to the water treatment plant, with the expectation of allowing the fluorine in the underground water around the gypsum dam to attenuate and perhaps in a few years time it will be unnecessary to pump from the cut off trench. About $1 million has been spent only on reshaping the gypsum dam, construction of storm water drains, effluent cut-off trenches, an evaporation dam and pumps and pipelines for collecting and delivering effluent to the water treatment plant.

12.3 NEW WATER TREATMENT PLANT

The reason for a new and bigger water treatment plant is to cope with additional effluent that will be collected from the "Little Kariba" and the main sluit and to cope with additional volumes arising from the gypsum dam cut-off trench during the rainy season.

Work on sizing the plant and budget level cost estimates has been completed. The plant will be capable of treating 150m^3 per hour and will cost about $3.1 million. The proposal to construct the new water treatment plant and upgrade effluent collection facilities as well as establish an irrigation scheme to dispose of excess treated water has now been submitted to the company's board of directors for their approval. It is planned that construction and commissioning of the plant will be complete by the end of 1990.

In addition, investigation into the disposal of sludge from the water treatment plant and use of treated water for irrigation is in progress.

12.3.1 Project Description

The project will cover upgrading and construction of additional effluent collection facilities, uprating of the water treatment plant as well as a treated water pipeline to the neighbouring Ventersburg farm where an irrigation scheme will be established.

Specifically, the following effluent collection facilities will be upgraded or installed :-

(a) An additional pipeline from the gypsum dam where improvements in seepage collection will be carried out as a separate project.

(b) A sump, pump and pipeline to collect surface run-off and seepage from the main sluit which was along the southern boundary of the factory and currently discharged acidic effluent directly into the Mukuvisi river.

(c) An undergraound interception drain on the northern boundary along the rail track to collect acidic seepage currently flowing into the river from the factory area.

(d) A sump, pump and pipeline to collect the polluted water from the "Little Kariba" stream on the eastern boundary of the factory. This small stream is fed from a vlei once formerly used as dumping ground for pyrites cinder which is now known, belatedly, to produce highly acidic seepage as it weathers.

(e) Finally, the stormwater drain from ZFC which carries acidic effluent will be diverted to Sterkfontein, a collection point on the northern boundary where an existing sump will be enlarged.

The main additional equipment to be installed at the water treatment plant to provide the necessary extra capacity for the increased effluent flows will be line handling and neutralising tanks as well as a clarifier. The existing sludge settling reservoirs will be used as raw water and treated water holding tanks.

The irrigation scheme at Venterburg will comprise of a ,3 km pipeline and portable irrigation piping to be used in rotation over approximately 40 ha of pasture land.

The existing water treatment plant has totally inadequate lime preparation and neutralization capacity and the settling is accomplished in a rectangular reservoir designed more for storage them for settling. As a result of the inevitably poor settling and inefficient removal of sludge, almost half of the treated effluent has to be drawn out with sludge so that the total volume of sludge to be disposed of is compared to that in the more modern plant design. The sludge itself will still contain some useable lime but unfortunately there is no provision for recovering any of this by recycling in the existing plant. Consequently lime consumption per cubic metre of effluent in this old plant is slightly higher than the proposed new plant.

The semi-tech (pilot) plant on the other hand as a circular clarifier (with a rake) for settling out of the sludge, some of which is recycled back to the neutralization stage. The recycling not only reduces lime consumption albeit imarginally but also conditions the fresh feed of effluent so that more stable conditions (pH etc) are maintained in the plant. In addition, the recycled sludge previous crystal seeds which enable precipitation to proceed more readily especially at lower concentrations of the valves elements in the raw water. This results in improved performance overall.

Experiments and experience on the pilot plant have enabled the best values for the recycle rate, lime slurry concentration etc. to be established. The settling rates achievable have also been determined and so proven date is available for the process design of the new water treatment plant which will basically be a scale-up of the pilot plant.

The new plant will require extension of the existing lime storage shed as well as the construction of a new lime slurrying and pumping section. Municipal water will be used to slurry the lime in the readily accessible ground level tank from where the slurry is pumped to the neutralization section. Treated water is unsuitable for lime slurrying since it contains large amounts of dissolved solids which limit the solubility of lime in it.

The neutralization section will be comprised of a conditioning tank in which the lime slurry is mixed with recycled sludge and a neutralization tank where the raw effluent is mixed with conditional lime slurry. The neutralized effluent will then flow by gravity at a controlled rate into a clarifier for settling. The sludge from the clarifier flows out under the hydro static head into a small sludge tank with a provision for thickening the sludge as may be necessary from time to time. Finally the sludge is pumped through and the underflow send to the gypsum dam for disposal.

12.3.2 <u>By-products and Effluents</u>

The project is devoted solely to the reduction of effluent arising at ZIMPHOS. The final effluent to be disposed of will be the sludge from the settlers which will be pumped to the gypsum dam. There will be no other by-products. The gypsum in the dam will be required for sale in the short term.

12.3.3 <u>Market</u>

The output from the water treatment plant will have no commercial value. The project objective is to reduce environmental pollution and so ensure that factory operations are in compliance with the Water Act as demanded by the authorities and company policy.

12.3.4 Strategy

Since the late 1970's ZIMPHOS has been operating on the basis of an exemption permit issued by the Government of Zimbabwe to absolve the company from criminal liability for polluting the public water courses in contravention of the Water Act of 1976. This special permit has been renewed annually on condition that agreed measures are progresively implemented to stop pollution from the factory areas.

The authorities have became increasingly impatient with the slow progress and continued requests by ZIMPHOS to have the permit renewed every year, especially in view of reports confirmed by ZIMPHOS' own measurements that fluorides in the City of Harare's principal water supply, Lake McLlawaine, are now close to the maximum acceptable level, with ZIMPHOS being the principal source.

The company is now facing the prospect of serious legal action and ultimately the Government has the right to suspend some or even all of ZIMPHOS' operations if the current pollution is allowed to continue.

The fluoride levels in the Hatfield stream, a tributary of the Mukuvisi river, over the years are given in table 12.1.

TABLE 12.1

FLUORIDE LEVELS IN HATFIELD STREAM : 1976-1989

YEAR	FLUORIDE (F). ppm
1976	224
1977	202
1978	109
1979	
1980	468
1981	
1982	640
1983	(dry)
1984	(dry)
1985	181
1986	284
1987	441
1988	228
1989	220
1990 (Jan-Mar)	477

NOTE :

1. Sampled at South Chiremba (Formerly Widdecombe) Road Bridge.
2. Figures shown are annual averages of monthly samples.

Below are fluoride figures in the gypsum dump.

Amount of gypsum in old dump	=	650 000 tons
Fluoride in mature gypsum	=	0,1%
Thus fluoride already in dump	=	650 tons
Phosphate rock processed per year (1988)	=	125 000 tons/year
Fluoride level in rock	=	1,5%
Thus total fluoride to ZIMPHOS in rock	=	1 875 tons/year
Less : Fluoride in products	=	727 tons/year
Fluoride to atmosphere via stack	=	60 tons/year
Thus balance send to gypsum dump:		
- Before diversion project	=	1 088 tons/year
- After diversion project	=	201 tons/year

12.3.5 Technology

The effluent collection facilities consist mainly of surface and underground drains which collect the acidic seepage into the sumps from where it is pumped to the water treatment plant. Some limited facilities do already exist and the technology for the additional ones proposed is the same and is quite well established.

The principle of the water treatment plant itself is neutralisation of the effluent with lime to precipitate out the polluting elements followed by settling out of the resulting sludge in a specially designed clarifier. In 1983 a pilot plant was constructed by ZIMPHOS to evaluate this process. The experience and experiments on this small and successful plant will be the basis for the design of the proposed new plant for which inhouse and other local knowhow is now readily available.

12.3.6 Financial

The total project capital cost estimate is Z$3.86 million for which no direct return on investment will accrue. Operating costs for water treatment and general effluent control will increase to Z$0,94 million.

12.4 FLUORINE POLLUTION ABATEMENT SCHEME

Fluorine-rich liquor from the superphosphates plant is no longer being used for reslurrying for disposal at the gypsum dam. On this scheme, the fluorine vapours (evolved during the digestion of phosphate rock by sulphuric acid) are now being treated while only treated water is used for hydralically converying gypsum to the dump. This will reduce fluorine contamination of the gypsum dam and so also reduce outflows from the dump to the environment. It has been estimated that the fluorine seepage to the environment from the gypsum dam will consequently be reduced by over 87%.

On the water treatment process, the fluorine in the effluent liquor is converted to insoluble calcium fluorides (which subsequently settle out as sludge) by reaction with quick lime. Thus fluorine, now "fixed", will not be leached out by rainwater etc. from the gypsum dam where the sludge is also disposed of.

12.5 FACTORY SITE MAP

Showing Effluent Facilities -

1. North-west calcine dump, sump
2. Main sluit sump
3. Central Collection sump
4. Sterkfontein sump
5. ZFC stormwater drain
6. Little Kariba sump
7. Old main gate sump
8. Gypsum dam
9. Water treatment plant
10. Irrigation site
11. Northern underground interceptor drain
12. Main sluit (stormwater drain)
13. Drain to Hatfield stream.

13.0 HYDROGEOCHEMISTRY OF POLLUTION AT ZIMPHOS

Prior to advocating a design philosophy and discussing resultant pollution control measures, it is worth considering briefly the hydrogeochemistry of the pollution processes related to the waste products from ZIMPHOS factory. Such a consideration will act to indicate the approaches which are likely to be most successful in the control and mitigation of the effects of pollution.

13.1 GYPSUM POLLUTION

The general analysis of gypsum tailings liquid is summarised in Table 11.1, Section 11, of this report. Mainly the liquid carried high levels in calcium, sulphate, fluoride, phosphate and silica; as a result, it has a high total dissolved solids. The pH of the liquid is low, generally in the range 1.3 to 1.5, usually ascribed to the presence of free sulphuric acid (See Table 13.1).

The levels of all these ions are far higher than would be acceptable for discharge to a water course in accordance with the Water (Effluent and waster water standards) Regulations, 1977. The appropriate values for SO_4, F, PO_4 and pH have been abstracted from these regulations are included at the bottom of Table 11.1, the complete regulations forming Appendix C. In addition, the levels of these ions in gypsum tailings liquids are much greater than those found in natural groundwater and surface water due to natural hydrogeochemical controlling reactions and processes.

13.1.1 Calcium and sulphate

The solubility of calcium sulphate (gypsum) at 25°C is high (1 489 mg/l), however the level of calcium sulphate is influenced by the presence of other ions dissolved in water and is not a simple function of its pure water solubility. With the sulphate ion as the stable species in most natural waters, it is apparent that solution reactions are the dominant controlling process for the concentrations of calcium sulphate found in water.

Control of pollution from gypsum tailings liquid must therefore concentrate on the reduction of the capability for solution reaction to take place, the most obvious area being the reduction of water volume. Efforts must be directed towards evaporation of excess water and reduction of input water which will reduce the total amount of calcium sulphate mobile at any one time.

Calcium solubility is also related to pH and the level of dissolved carbon dioxide in water, i.e. the lower the pH and/or the higher the carbon dioxide concentration, then the higher the level of dissolved calcium. Neutralisation reactions will, therefore, tend to reduce the calcium concentrations in water.

13.1.2 Fluoride and silica

Although solubility controls of silica in natural water are not well understood, there is, however, a strong inter-relationship between the behaviour of silica and fluoride at low pH values, Sillen and Marterll (1964) published figures which indicate that fluoride and silica form a fluosilicate complex ion, (SiF_6), below pH4 and that solubility is likely to increase with decreasing pH. This could account for the elevated levels of both these ions in the gypsum tailings liquid at pH 1.4 (See Table 13.1).

The removal of these two ions from water to reduce their pollution loading is therefore best effected by neutralisation reactions, i.e. increasing pH.

13.1.3 Phosphate

Most natural waters have extremely low concentrations of phosphates, whichever, chemical form they might attain in solution. This suggests that there are strong natural control reactions restricting the solubility of phosphorous. An increase in pH will result in precipitation of phosphorous as iron phosphate, due to the low solubility at neutral pH values of ion, this being the stable form of iron at such values. Therefore, a combination of neutralisation and promotion of absorption should be effective in reducing the levels of phosphate in solutiion.

13.1.4 Calcine Pollution

At ZIMPHOS, pyrite is roasted or burnt to produce supphuric acid. The residue is a burnt waste calcine pyrites or calcine. The chief pollution causing products from the leaching of calcine are sulphate, iron and hydrogen ions.

The lowering of the pH by the available hydrogen ion increases the potential for solution reaction to take place. Iron as ferrous iron, is increasingly soluble with decreasing pH. Iron and sulphate reach pollutant levels in water leached from a calcine dump and such leachate will have a low pH (See Table 13.1). Preventive measures to arrest this process should involve reducing the volume of water available, for leaching the calcine, by reducing flow through the dump both from infiltration and near surface groundwater.

13.1.5 Arsenic Pollution

On the normal pH range of most natural waters, arsenic is stable in the form of arsenic ions assuming that arsenic, is in a form where it is available for solution. The actual concentration of arsenate ions will be controlled by the solubilility of arsenates that can form with the available cations in the water. Calcium is likely to limit the solubility of arsenate, as calcium arsenate will be soluble to the extent of 20 - 50 mg/l in waters, depending on their pH values.

14.0 POLLUTION PREVENTION AND CONTROL

From consideration of rainfall catchment areas, groundwater flow directions and the position of individual pollution sources, the ZIMPHOS site has been subdivided into five areas for the purposes of pollution prevention and control:-

- Epworth vlei and the existing gypsum tailings dam
- The souther "clean" water area
- the eastern vlei area, including the south-east calcine dump.
- the western area, including the north-west calcine dump, the present calcine dump and site for the new calcine slurry dump
- the factory area, the railway reserve and Mukuvisi river.

14.1 EPWORTH VLEI AND THE EXISTING GYPSUM TAILINGS DAM

With the exception of a number of small calcine pollution sources, pollution of the Epworth vlei is being caused by seepage from the existing gypsum tailings dam which is situated near the head of the vlei. The solution to this problem can be divided into two main facets:

- rehabilitation and pollution control of the gypsum tailings dam itself.

- modification of the system of surface water drainage of the Epworth vlei and removal of minor pollution sources.

14.2 THE SOUTHERN "CLEAN" WATER SEA

A major surface water catchment divide runs west to east across the ZIMPHOS site, just to the north of the present gypsum slimes dam until it reaches the western boundary of the catchment of the eastern vlei area. All surface water and groundwater generated in the areas to the north of the divide flows northwards, the surface water draining eventually to the Mukuvisi river as do some of the shallow groundwaters which feed a seepage line which, as a first approximation runs along the northern edge of the ZIMPHOS site. At present, there are no major pollution sources between the catchment divide to the south, and the southern side of the present calcine dump and the soccer field. In order to prevent this water becoming polluted, which would necessitate it being incorporated in the factory's effluent control system, it is proposed to intercept stormwater and divert the flow from this section of the ZIMPHOS site.

14.3 THE EASTERN VLEI AREA INCLUDING THE SOUTHER-EAST "OLD" CALCINE DUMP

The Eastern vlei area was the subject of detailed examination during site investigation done at ZIMPHOS, as it offered the best available site for the location of a new gypsum disposal facility subject to underestimating the effect of the Hatfield dyke which was thought to transect the area.

The eight hectare area assigned to the proposed dam is in the southern part of the vlei, south of the railway siding. The surface water interflow cutoff system for the proposed dam would remain intact, and would be incorporated in the overall pollution control scheme.

14.4. THE EASTERN AREA, INCLUDING THE NORTH-WEST CALCINE DUMP, THE PRESENT CALCINE DUMP AND THE SITE FOR THE NEW CALCINE SLURRY DUMP

The western area is probably the waste complex for new pollution control measures and therefore, for clarity of description, it has been divided into six sections:

- the workers housing area
- the north west calcine dump
- rehabilitation of the present calcine dump
- pollution control from present calcine disposal
- other pollution control facilities
- the proposed calcine slurry dump

14.4.1 Workers housing area

The rainfall and consequent run-off from the workers housing area, some 160 000m^2, is relatively uncontaminated and hence does not require treating as polluted water.

TABLE 13,1

NEW WATER TREATMENT PLANT EFFLUENT FLOWS AND QUALITY

SOURCE	flow m^3/d DF	flow m^3/d WF	pH	TDS	Ca	Mg	F	PO_4	SO_4	Fe	NO_3	Al
FACTORY												
Cinder dam purge	360	360	4,25	4000	800	200	40	18	2500	3000	50	15
Supers purge	360	360	1,96	13000	700	300	5000	3500	300	50	100	50
CENTRAL COLLECTION												
Dips Alum NH_3	149	163	5,00	4500	372	264	40	35	500	200	150	100
No. 2 Acid purge	113	113	6,00	2500	300	200	76	35	405	274	92	58
NAC Dump	120	500	2,54	6353	442	993	11	3	669	4135	61	112
OTHER												
Sterkfontein	107	622	3,27	2502	264	270	31	108	238	3	98	326
Main sluit	250	466	3,70	740	79	19	4	5	56	1	2	24
Old main gate	87	206	5,13	1600	208	122	28	5	178	13	17	14
Little Kariba	190	292	4,13	1010	158	156	11	12	119	4	14	68
Gypsum Dam	513	518	1,92	7437	1035	1029	818	3291	446	142	33	98
Total m^3/d	2253	3600	2,05	4949	512	426	778	1034	629	861	57	95
Total m^3/hr	93,9	150										
Lime tons/d	22,53	36										
Treated H_2O/d	1915	3060	7,0	3200	1000	200	20	8	1000	100	34	70
Sludge tons/d	559	893	8,5									

14.4.2 North-west calcine dump

The north-west calcine dump has already been the subject of measures for the control of water pollution. These measures are, in principle, correct as is indicated by the analysis of the returned water from the French drain interceptor system installed along the northern boundary of the dump. This interceptor water is of low pH and high in iron and sulphate, all three being indicative of calcine pollution in water.

14.4.3 Rehabilitation of the present calcine dump

Calcine is presently taken to the dump by trailer where it is dumped. The deposited calcine is continuously compacted and crushed by driving over it.

The calcine is dumped dry and, although moisture is added through rainfall, it is not expected that a steady state seepage will develop.

Under these conditions it is considered that no stability problems of the calcine dump would be experienced if the angle of the side slopes is less than about 35°. The controlling factor for future construction is therefore mostly environmental, i.e. low side slope angles so that the dump can be vegetated in the future and low overall height so that it is not aesthetically unpleasing.

14.4.4 Pollution control from the present calcine dump

It is assumed that the present calcine dump is producing a noxious leachate from rainfall infiltration and this leachate is seeping into the ground. The low pH valve found in a water sample from boreholes, to the north of this dump, would tend to confirm this assumption.

14.4.5 Other pollution control measures and facilities

The other pollution control measures and facilities required in the western area of the ZIMPHOS site relate to the collection, removal and evaporation of polluted water.

14.4.6 Proposed calcine slurry dump

The calcine produced from the extensions to the ZIMPHOS plant is a fine product and is slurried prior to deposition.

As in the case of the gypsum dam, the maximum rate of rise is considered to be 2m per year, so that the smallest base area of the dump would be 5,2 ha to attain this rate.

The calcine slurry dump has been sited north of the western point of the workers housing and south of the proposed western evaporation dam. The chosen site has the advantages of having a polluted water and a clean water interceptor system to the south ensuring that the catchment area of the dam itself for both surface water and near-surface groundwater is minimal. In addition, there are a number of polluted water cutoff trenches on its down-stream side.

With predominant wind direction from the north-east, dust blown from the surface of the calcine dump will not be a nuisance as it will fall in the open veld area to the west of the ZIMPHOS site.

However, because of the polluting nature of the liquid in the calcine slurry dump, it will have to be lined with a butyl rubber liner to prevent water pollution. Polluted liquid collected in the dumps interceptor system will be drained by gravity to the western evaporation dam which will act as a return water facility. Hence some liquid can be pumped back onto the calcine dump for evaporation.

14.5 THE FACTORY AREA, THE RAILWAY RESERVE AND THE MUKUVISI RIVER

This section deals with the factory area itself, the National Zimbabwe Railways reserve area to the north, the Mukuvisi river and the area between the railway reserve and the river. All discharges to the river which have not been discussed in other sections of this report are also included.

This part of the report can also be divided into a number of sections for clarity of description, these being:-

- the western section of the factory, except the water treatment plant: all water from this area is at present draining northwards or westwards,
- the eastern section of the factory: all water from this area is draining eastwards, via the "Little Kariba" to the Mukuvisi River,
- the water treatment plant,
- the area north of the factory boundary.

14.5.1 Western section of the factory

Effluents and rainwater from the area of the weak acid storage station, the boiler house and the No.2 superphosphate store are collected at the dip plant sump. In addition, water collected from the french drain to the north of the north-west calcine dump is also pumped back to the sump. The combined effluent is returned to the water treatment plant.

The discharges to the Mukuvisi from the western factory area may be summarised as follows, the discharges being listed west to east:

- the main sluit : although this is normally a storm water drain, effluents are occasionally discharged to the sluit, as is neutralised effluent from the water treatment plant. These effluents generally originate near the phosphoric acid plant,

- a small (approximately 75mm) pipe drain at the extreme north-west corner of this area which probably carries stormwater run-off,

- a large pipe drain, discharging directly to an open stormwater drain in the railway reserve, located 80m to the west of the old arsenic plant,

- seepage/discharge under the railway reserve, just north of the old arsenic plant,

- two seepage channels, under the railway reserve, from No.1 and No.,2 superphosphate stores. This seepage is combined with treated sewage effluent and returned by the Sterkfontein pump to the water treatment plant,

- contaminated run-off from the Zimbabwe Fertilizer Corporation (ZFC) area of the factory, essentially contaminated with fertilizers. This is also returned to the water treatment plant by the Sterkfontein plant.

In addition, there is likely to be general near-surface groundwater seepage along the whole of the northern perimeter of the factory. This seepage will be polluted.

14.5.2 Eastern section of the factory

The main discharges which are the eastern main sluit, the drainage south of the ZFC old car park and the drain near the store yard, are brought together at the sump adjacent to the former factory entrance.

All effluent from the eastern factory area will therefore be contained in the effluent control system.

14.5.3 Water Treatment Plant

The water treatment plant, situated on the southern side of ZIMPHOS factory act to provide treated raw water to the factory. The treatment process is based on neutralisation of low pH effluent with alkali, settlement of solids and precipitates formed during neutralisation, followed by either re-use or discharge if the plant cannot use all treated water.

The neutralising capacity of the water treatment plant is approximately 1 000m^3/day, but its present settling capacity when treating effluents from calcine deposits is only 300 -350 m^3/day.

The principal sources of effluent returned to the water treatment plant at present are :-

- dip plant sump : a combination of a factory effluent and run-off from the western plant area mixed with intercepted calcine contaminated water from the north-west calcine dump,

- Sterkforntein pump : combination of seepages and contaminated water from the ZFC section of the plant , the superphosphate store, the water from the existing interceptor south of the access road to the sewage plant and discharge from the sewage works. The bulk of the flow volume is treated sewage effluent from the domestic sewage treatment works itself,

- the eastern stormwater neutralising sump : this is only an intermittent source used when an aired spill in the factory is discharged to the east side drainage system. This discharge is collected in the sumps and returned to the water treatment plant,

- the existing gypsum dam : returned gypsum slurry liquid and seepage, from the pump at the southern toe of the dam;

estimated volume, 9 000m^3/month.

14.5.4 Area north of the factory

The area between the factory and the Mukuvisi river clearly displays the results of the lateral migration of pollutants northwards from ZIMPHOS.

There are only two areas north of the railway reserve which are in need of particular attention with respect to pollution control, namely

14.5.4.1. ZIMPHOS CLUB CAR PARK

Approximately 10 000m^3 of calcine has been used to construct the car park on the north side of the ZIMPHOS club. Leachate from this car park travels to both the "Little Kariba" end the Mukuvisi river

14.5.4.2 Gypsum neutralising trench system

The gypsum neutralisation trench systems have been employed to limit the extent of arsenic pollution from the old arsenic plant and the arsenic-bearing miscellaneous waste dump. In addition, the berms constructed across this area associated with the trenches are impounding surface run-off and this increases the opportunity for such water to become polluted.

15.0 DESIGN APPROACH FOR POLLUTION CONTROL

The considerations discussed in Sections 11 and 13 have emphasised that ZIMPHOS pollution control problem is one of water control and, as such, is intimately linked with the water balance of the factory itself and the whole site. For the design approach discussion, it can be summarised as :

(a) Inputs to System

(i) Rainfall - directly as run-off or by interception of interflow and groundwater.

(ii) Water purchased from Harare Municipality.

(iii) Return water from the current effluent control systems, a portion of which is "recycled" water.

(b) Outputs from System

(i) Evaporation/evapotranspiration
(ii) Water incorporated in products
(iii) Water incorporated in waste products
(iv) Steam losses
(v) Discharges to the "Little Kariba" and Mukuvisi river of both effluent and storm water run-off.
(vi) Onfiltration to groundwater.

The approach to water and hence pollution control is based on minimising the quantities of water in these various input/output systems.

16.0 DETAILS OF INDUSTRY

16.1 NAME OF UNDERTAKING : ZIMBABWE IRON AND STEEL CO. LTD. (ZISCOSTEEL)

16.2 ADDRESS : P Bag 2, REDCLIFF

16.3 NATURE OF INDUSTRY : Iron and steel works

16.4 LOCATION : Redcliff

16.2 DETAILS OF RAW MATERIALS AND FINISHED PRODUCTS

16.2.1 Major raw material : Iron ore
Limestone
Coal

16.2.2 Sources of raw materials

a) Iron ore - Buchwa and Ripple Creek open cast

b) Coal - Hwange

c) Limestone - ZISCO limestone quarry

16.2.3 Major semi-finished products : Pig iden
billets
blooms
rods.

16.2.4 By-products

a) Coke ovens and blast furnace gases - fuels

b) Coal for - fuel and is also used on primer in the roads construction.

c) Benzole - petrol additive

d) Coke breeze - fuel

e) Granulated slag.

16.2.5 Major finished products - coke
sinter
lime

16.2.6 Hours of operation - 24 hours/day

16.2.7 Number of years in operation - started in Bulawayo in 1938 and moved to Redcliff in 1947.

16.2.8 Significant changes in operation over the year

Bigger and more efficient blast furnaces replaced the smaller ones. Open hearth system of steelmaking replaced by the modern basic oxygen furnace system.

Introduction of the conticast in the 70's.

16.3 DETAILS OF WATER CONSUMPTION

16.3.1 Sources supply (1987)

Dutchman's Pool Kwekwe	-	700 000 m^3
Cactus Poort Redcliff	-	200 000 m^3
North Hill	-	50 000 m^3

16.3.2 Water Consumption for domestic/industrial use (1987)

Redcliff	-	160 000 m^3/day
Rutendo	-	35 000 m^3/day
Torwood	-	300 000 m^3/day
Works	-	455 000 m^3/day

16.3.3 Water consumption for the total works

Average monthly consumption for the works

Year	Average monthly consumption (m^3)
1985	503 052
1986	491 024
1987	494 044
1988	516 019
1989	462 556

16.4 DETAILS OF PRESENT WASTE WATER TREATMENT

Nil.

16.5 EXECUTIVE SUMMARY

The ZISCO steelworks at Redcliff has for many years discharged spillages from cooling water systems and other process-related effluents to its stormwater drains, and thence to the Kwekwe River or its tributary the Redcliff stream since there is no other effluent collection system on site except for the foul sewerage reticulation. In recent years the volume of effluent discharged and the levels of pollutants, which are in conflict with statutory regulations, have given rise of pressure from the Ministry of Energy and Water Resources and Development for these practices to ease.

Of the nine stormwater drains serving the steelworks site, two (Drains 4 and 9) do not cause a pollution problem.

16.6 DETAILS OF WASTE WATER DISCHARGE

16.6.1 General Description of effluent and process from which it emanates

16.6.1.1 Drain 1

Drain 1 on the eastern side of the works carries the largest flow (over 2 000 m^3/d) and a heavy suspended solid load. The total dissolved solids concentration is also a concern. Solids in this drain arise from the Board Limestone plant and the steel plant clarifier (APPENDIX G.).

16.6.1.2 Drain 2

Drain 2 carries only a very small flow and is not particularly heavily contaminated.

The flow in this drain is small averaging only about 50m^3/day. The more important sources of this flow are as follows :-

- Overflow from the cooling ponds north of the steel plant.
- Overflow from the conticast cooling circuit.
- Boiler and machine shops.
- East side (washbay area) of the garage.
- Laboratory drain.

The principal contaminate found in the drain were oil from the garage, together with a small amount of suspended solids and a slight organic content. In addition, heavy metals are known to be used as reagents in the laboratory (APPENDIX G).

16.6.1.3 Drain 3

Drain 3 receives spillages of oily cooling water from the heavy and bar/rod mills. Flows in this drain will be intercepted and pumped back to the candy clarifier plant next to the medium and light mills for treatment and recycling. This should result in the reduction of flows and pollutant levels discharged from the eastern side of the steelworks site to acceptably low levels.

The primary sources of the drain No. 3 are :-

- Billet Mill
- Heavy Mill
- Soaking Pits
- Rod and Bar Mill
- Finishing Department
- Production Control

The drain No. 3 is polluted with oil which exceeds the legal limit (2,5 ppm) (APPENDIX H).

16.1.4 Drain 5

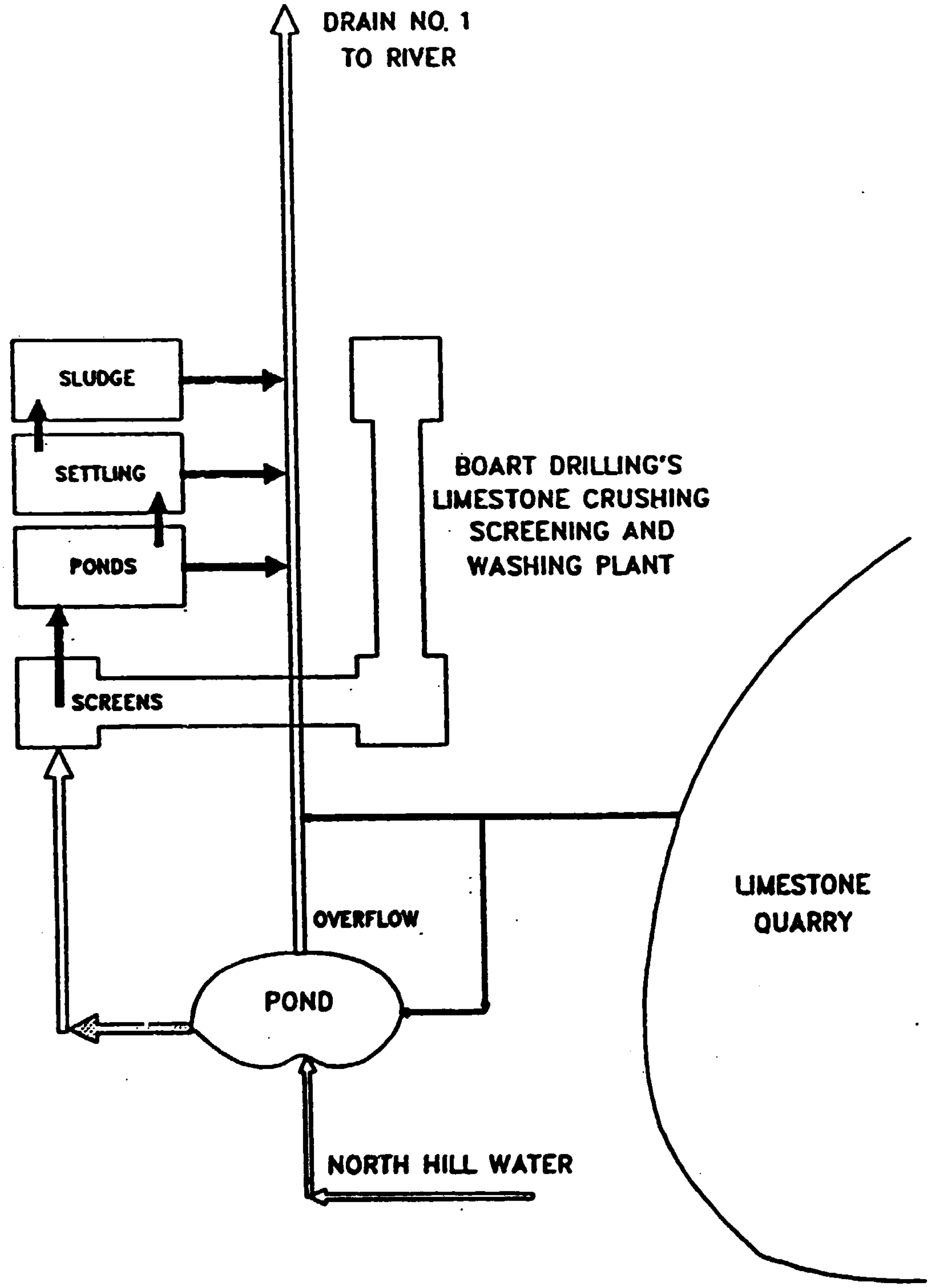
Drain 5 drains the coke oven area and contains oil and tar. At the coke oven plant there are two oil traps. The traps are on 90% efficient. There are not efficient especially during the rainy season, when there is too much overflow from the traps.

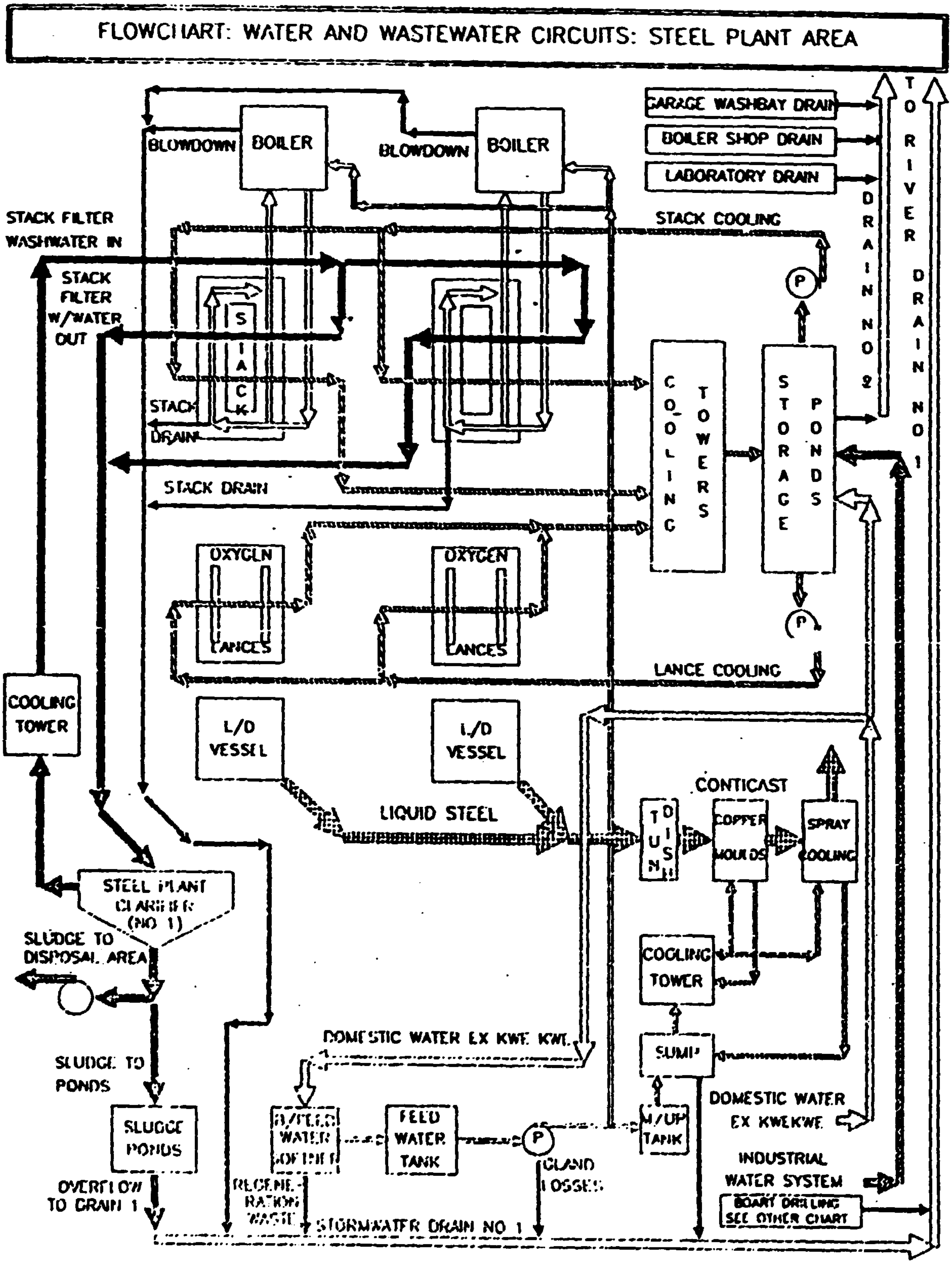
Drains 5 to 8 can be dealt with simultaneously for two reasons. Firstly, they all discharge on the western side of the site, and secondly, they all carry a greater or lesser amount of organic matter, requiring biological treatment. The effluent from drain 5 is by far the most contaminated, being derived entirely from the coke oven area and including the following major sources of contamination :-

- Gas main flushing water
- Ammonia liquor overflows form quenching towers
- Tar separator spillages during power failures
- Contaminated underground water from the area (APPENDIX J).

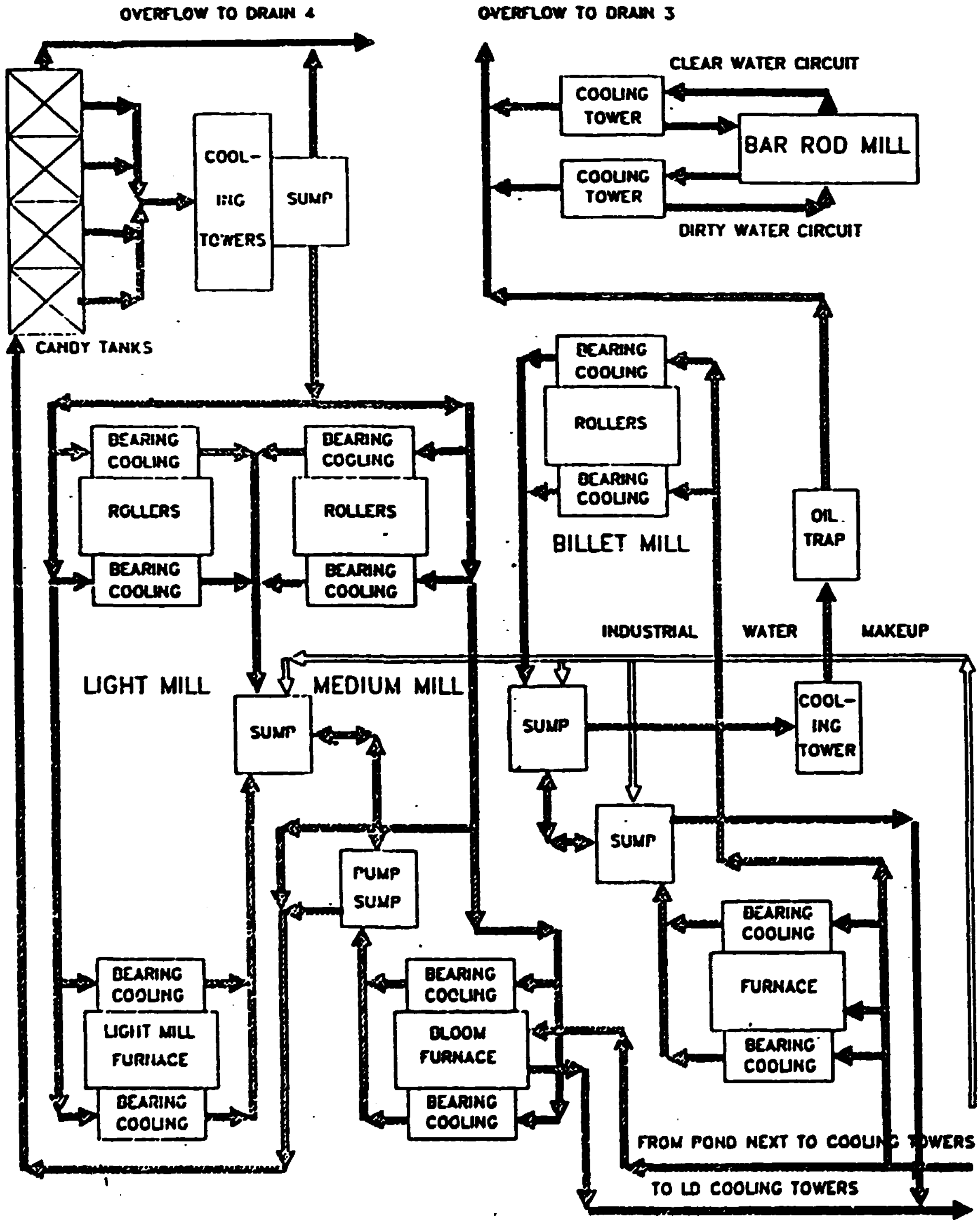
Drains 6,7, and 8 all contain broadly similar effluent, which have moderate levels of organic contamination, fairly high suspended solids and moderate to high total dissolved solids concentrations. The total quantity and combined quality of effluent expected to arise when the flows from these drains and from Drain 5 are blended together prior to treatment are given in the following table 16.1.

FLOWCHART: WATER & WASTEWATER CIRCUITS: BOART DRILLING AREA

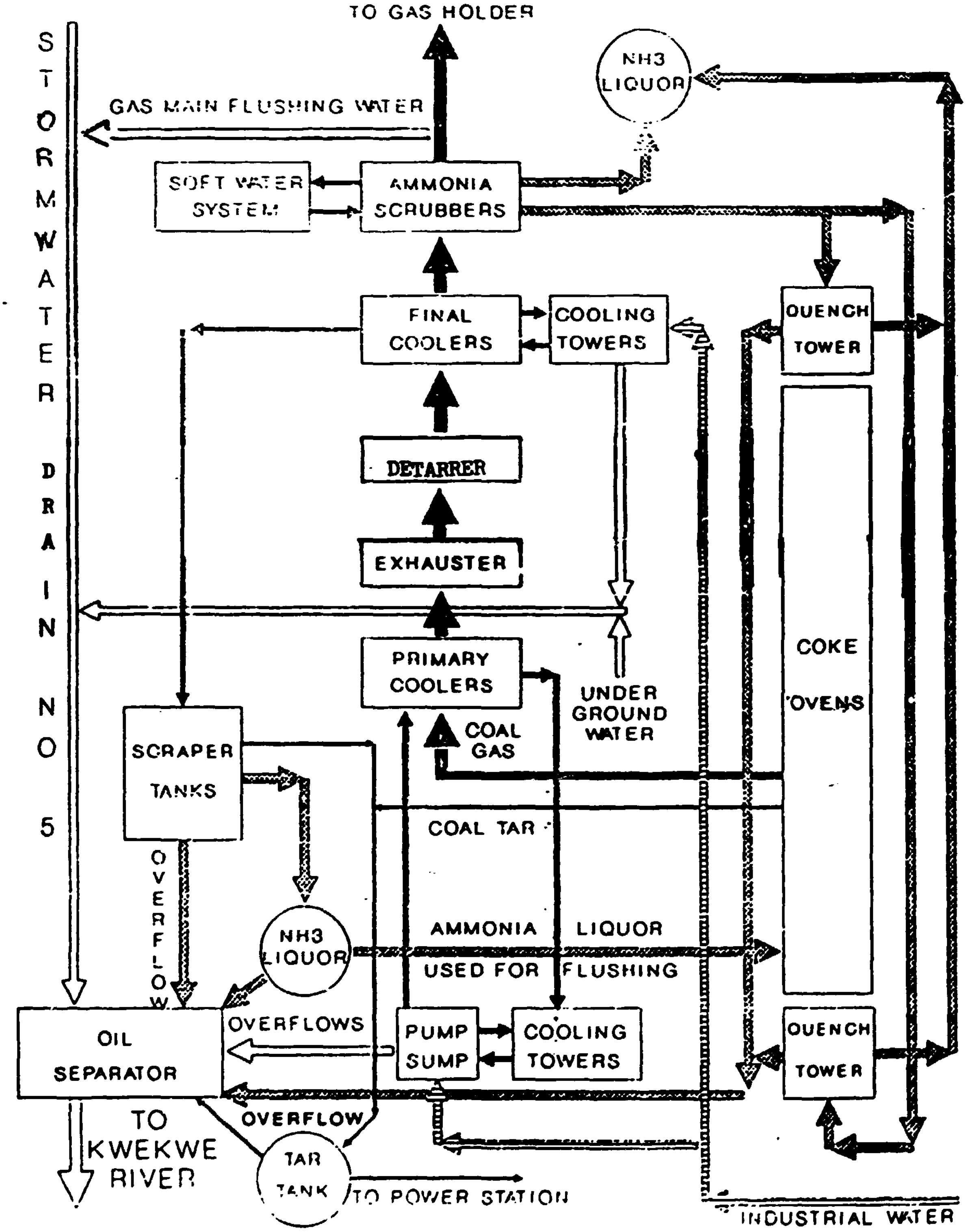


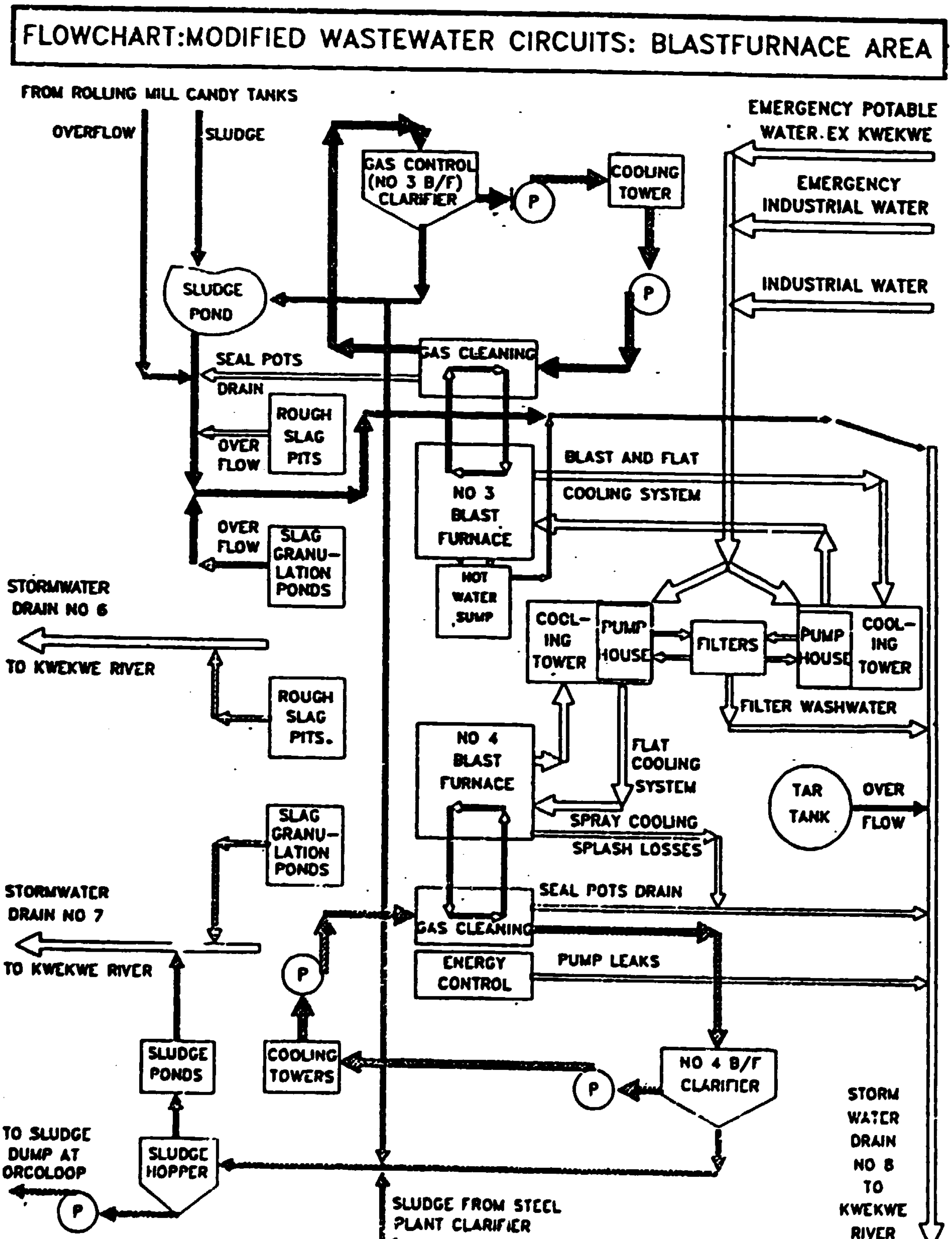

FLOWCHART: WATER AND WASTEWATER CIRCUITS: STEEL PLANT AREA
BLOWDOWN
BOILER
BLOWDOWN
BOILER
GARAGE WASHBAY DRAIN
BOILER SHOP DRAIN
LABORATORY DRAIN
TO RIVER
DRAIN NO 2
RIVER DRAIN NO 1
STACK FILTER WASHWATER IN
STACK COOLING
STACK FILTER W/WATER OUT
STACK
STACK DRAIN
STACK DRAIN
COOLING TOWERS
STORAGE PONDS
OXYGEN LANCES
OXYGEN LANCES
LANCE COOLING
COOLING TOWER
L/D VESSEL
L/D VESSEL
LIQUID STEEL
CONTICAST
TUNDISH
COPPER MOULDS
SPRAY COOLING
STEEL PLANT CLARIFIER (NO 1)
SLUDGE TO DISPOSAL AREA
COOLING TOWER
SUMP
DOMESTIC WATER EX KWE KWE
SLUDGE TO PONDS
SLUDGE PONDS
FEED WATER TANK
M/UP TANK
DOMESTIC WATER EX KWEKWE
INDUSTRIAL WATER SYSTEM
BOART DRILLING SEE OTHER CHART
OVERFLOW TO DRAIN 1
REGENERATION WASTE
GLAND LOSSES
STORMWATER DRAIN NO 1

FLOWCHART: WATER AND WASTEWATER CIRCUITS: ROLLING MILLS



FLOWCHART: WATER & WASTEWATER CIRCUITS: COKE OVEN AREA




FLOWCHART:MODIFIED WASTEWATER CIRCUITS: BLASTFURNACE AREA
FROM ROLLING MILL CANDY TANKS
OVERFLOW
SLUDGE
GAS CONTROL (NO 3 B/F) CLARIFIER
P
COOLING TOWER
EMERGENCY POTABLE WATER. EX KWEKWE
EMERGENCY INDUSTRIAL WATER
INDUSTRIAL WATER
SLUDGE POND
GAS CLEANING
SEAL POTS DRAIN
ROUGH SLAG PITS
OVER FLOW
BLAST AND FLAT COOLING SYSTEM
NO 3 BLAST FURNACE
SLAG GRANU-LATION PONDS
HOT WATER SUMP
STORMWATER DRAIN NO 6
TO KWEKWE RIVER
COOL-ING TOWER
PUMP HOUSE
FILTERS
FILTER WASHWATER
ROUGH SLAG PITS.
NO 4 BLAST FURNACE
FLAT COOLING SYSTEM
TAR TANK
OVER FLOW
SPRAY COOLING
SPLASH LOSSES
SEAL POTS DRAIN
STORMWATER DRAIN NO 7
ENERGY CONTROL
PUMP LEAKS
SLUDGE PONDS
COOLING TOWERS
NO 4 B/F CLARIFIER
STORM WATER DRAIN NO 8 TO KWEKWE RIVER
TO SLUDGE DUMP AT ORCOLOOP
SLUDGE HOPPER
SLUDGE FROM STEEL PLANT CLARIFIER

FLOWCHART: WATER & WASTEWATER CIRCUITS: BLASTFURNACE AREA

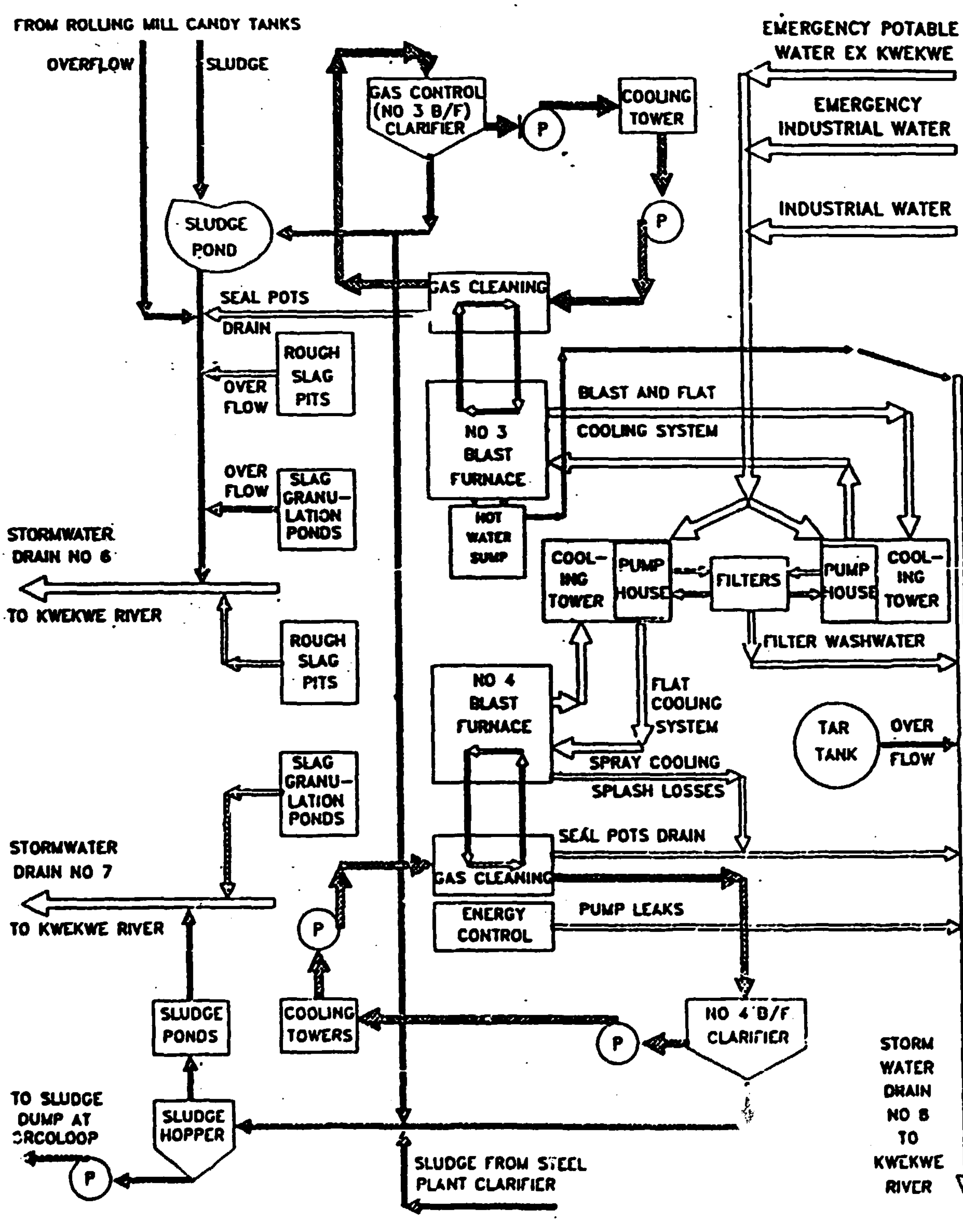


TABLE 16.1

DRAIN NUMBER	MAIN POLLUTANT (conc mg/l)				MAIN POLLUTANTS MASS LOAD kg/d					MEAN POLLUTANT conc (mg/l)
	5	6	7	8	5	6	7	8	TOTALS	
SUSPENDED SOLIDS	70,00	120,00	170,00	60,00	17,50	144,00	76,50	72,00	310,00	100,00
TOTAL DISS. SOLIDS	1 500,00	600,00	750,00	350,00	375,50	720,00	337,50	420,00	1 852,00	597,58
OXYGEN ABSORBED	700,00	80,00	90,00	11,00	175,00	96,00	40,50	13,20	324,70	104,74
BOD	500,00	150,00	150,00	60,00	125,00	180,00	67,50	72,00	444,50	143,39
COD	1 200,00	200,00	180,00	60,00	300,00	240,00	81,00	72,00	693,00	233,55
PHENOLS	300,00	–	–	–	75,00	–	–	–	75,00	24,19
SULPHATE	500,00	300,00	250,00	150,00	125,00	360,00	112,50	180,00	777,50	250,81
CHLORIDE	150,00	40,00	60,00	40,00	37,50	44,00	27,00	48,00	160,50	51,77
NITRATE	5,00	0,50	1,00	1,00	1,25	0,60	0,45	1,20	3,50	1,13
TKN	650,00	–	–	–	162,50	–	–	–	102,50	52,42
FLUORIDE	0,50	0,30	0,15	0,10	0,13	0,36	0,07	0,12	0,67	0,22
SULPHIDE	2,00	1,00	1,50	1,50	0,05	1,20	0,68	1,80	4,18	1,35
TEMPERATURE	29,00	28,00	36,00	26,00						28,47
OIL	5,00	2,50	1,50	1,20	1,25	3,00	0,68	1,44	6,37	2,05
MEAN FLOW m^3/d	250,00	1 200,00	450,00	1 200,00					3 100,00	

16.6.1.5 Drain 6

The drain No. 6 collects water from a very large section of ZISCO, and it is designed as the underground channel on the major part of its length. This drain is also used as the storm drain during the rainy season and therefore any modifications to the underground part of the drain would present serious problems.

These are the primary sources of drain No. 6 :-

- No. 3 and No. 4 Slag Pits
- Foundry
- Sinter Plant
- South side of Mills
- Gas Mixing Station
- Power Station
- Gas Control ponds
- Pig casting
- Old Coke Oven Wharf.

The areas that cause most of the pollution of No. 6 drain are :-

- No. 3 and No. 4 Slag Pits
- Gas Mixing Station
- Gas Control Ponds.

The above sources are drained by open drains and at the Pig Casting there is a screen on the inlet to the underground drain to prevent debris from entering the drain. This screen is cleaned from time to time.

Most of the parameters of the waste water are well above the legal limits, especially TDS, S/S, oil in the water and at times pH (APPENDIX L and M).

16.6.1.6 Drain 7 and 8

These drains are less heavily contaminated and the need to provide separate drainage is therefore less pressing. It has been proposed that a collector sewer on the eastern side of Torwood Road will intercept flows from all 4 drains (Drains 5 to 8) and convey it across the road to a new pumping station on the east bank of the Kwekwe river. This will incorporate facilities for spilling high wet weather flows directly to the river. Normal effluent flows will be pumped across the river on a new pipe bridge and treated in a new Final Effluent Treatment Plant (FETP) immediately to the south of the existing Torwood Ponds.

In order to produce a suitable quality of effluent for recycling, this plant will incorporate primary settlement and oil skimming, biological secondary treatment and tertiary filtration for solids removal (APPENDIX K and L).

The possibility of adding the raw domestic sewage currently flowing to the Torwood ponds to the works effluent is an attractive on from the biological treatment point of view. A pilot plant study, to determine the treatability and arrive at design parameters is underway at ZISCOSTEEL.

16.6.2 Combined volume of waste water

APPENDIX 16.2

DRAIN NO.	FLOW IN m^3/day JUNE 1987	FLOW IN m^3/day AUGUST 1988
1	1 300	2 200
2	300	300
3	300	350
4	Nil	450
5	450	400
6	900	1 200
7	450	450
8	300	900
9	Nil	Nil
TOTALS	4 000	6 310

16.6.3 Method of Discharge

Drain No. 6 is by pipe. All other drains are channels (See Map No. 16.1).

16.6.4 Details of contaminants in stormwater drains and their levels

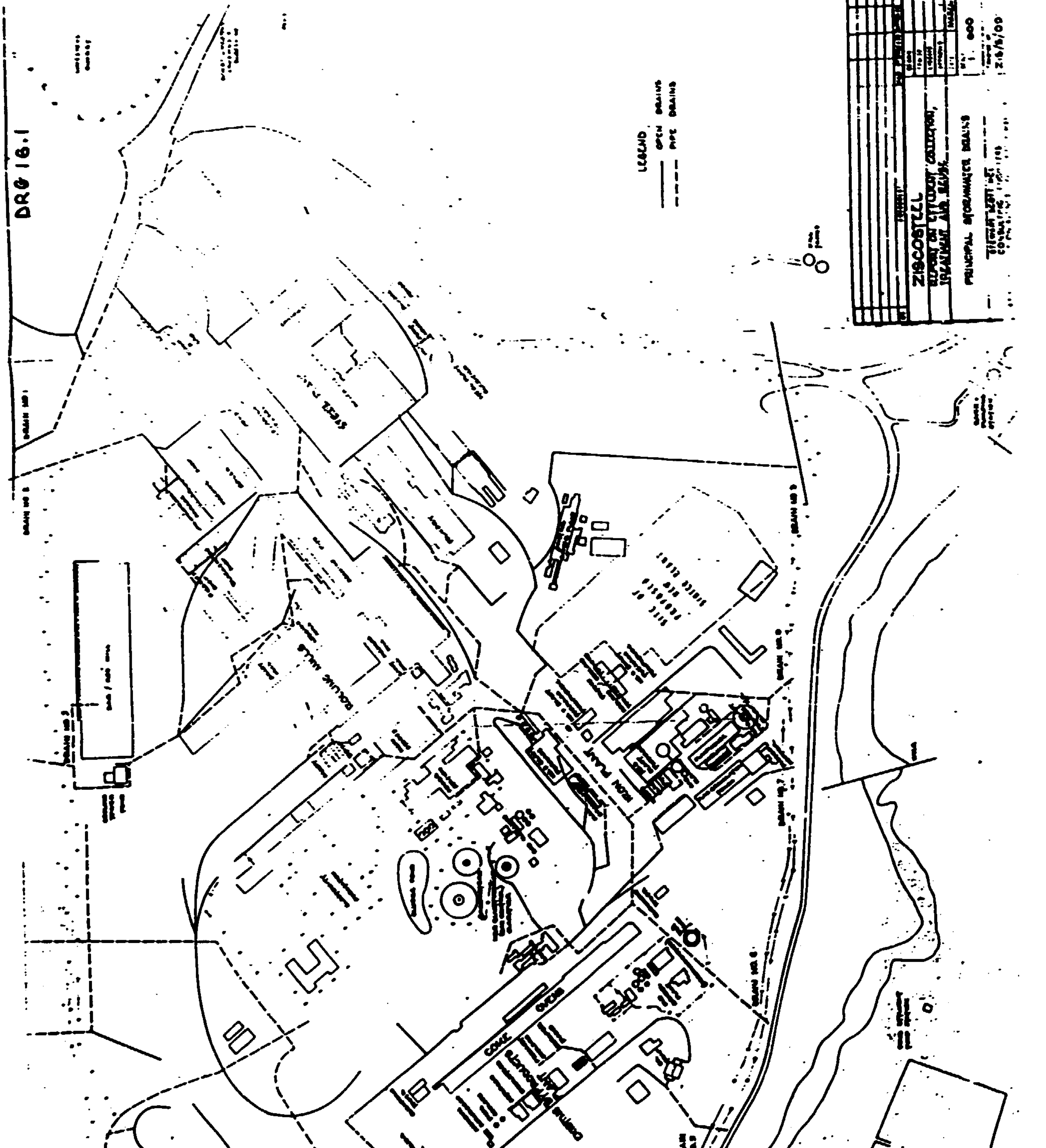
APPENDIX 16.3

DRAIN NO.	MAJOR CONTAMINATES	UNITS	LEVEL OF CONTAMINATION
1.	Colour	-	heavy brown
	suspended solids	mg/l	up to 1 500
	total dissolved solids	mg/l	up to 3 000
	Chlorides	mg/l	approx 200
	Manganese	mg/l	up to 2
	Oil	mg/l	up to 10
	pH		up to 11,4

DRAIN NO.	MAJOR CONTAMINANTS	UNITS	LEVEL OF CONTAMINATION
2.	Odour	-	detergent
	Colour	-	grey
	suspended solids	mg/l	up to 100
	oil	mg/l	up to 8
	Manganese	mg/l	up to 4
	pH		up to 10,8
3.	Odour	-	oil
	Colour	-	clary grey
	oil	mg/l	up to 20
	pH		up to 11,0
	suspended solids	mg/l	up to 100
4.	Sulphate	mg/l	300
	Colour	-	greyish
	total dissolved solids	mg/l	800
5.	pH	-	10,5
	Tar	-	above legal limit
	Phernol/cyanide/	mg/l	
	thiocyanate	mg/l	above legal limit
	Colour	-	yellowish
	Odour	-	ammonia/ten
	Oxygen absorbed	mg/l	up to 50
	Sulphide	mg/l	up to 4
	Sulphate	mg/l	up to 500
	Chloride	mg/l	400
	Total dissolved solids	mg/l	3 000
	Suspended solids	mg/l	200
	Manganese	mg/l	up to 3
6.	Sulphate	mg/l	400
	Sulphide	mg/l	5
	Colour		brownish
	Suspended solids(gran/slag)	mg/l	up to 1 000
	Oil	mg/l	up to 10
	pH		10,5
	Odour		decaying H_2S

DRAIN NO.	MAJOR CONTAMINANTS	UNITS	LEVEL OF CONCENTRATION
7.	Temperature	°C	up to 60
	Phosphate	mg/l	5
	Sulphide	mg/l	5
	Oxygen absorbed	mg/l	30
	Suspended solids(gran/slag)	mg/l	up to 3 000
	Total dissolved solids	mg/l	5 000
	Odour		hydrogen sulphide
	pH		up to 10
	Iron	mg/l	1 to 2
	Nitrate	mg/l	30
8.	Suspended solids(gran/slag)	mg/l	up to 500
	Total dissolved solids	mg/l	up to 1 000
	Sulphide	mg/l	2
	Sulphate	mg/l	up to 400

A range of measures have been recommended, based on the consideration of the nature of pollution in each drain. The production of recycled effluent is predicted to exceed the demand for it at the areas specified, and the major remaining unknowns are the design parameters to be adopted for the proposed biological effluent treatment process and whether raw sewage from Torwood should be added to the treatment process or not.


DRG 16.1
LEGEND
OPEN DRAINS
PIPE DRAINS
ZISCOSTEEL
PRINCIPAL STORMWATER DRAINS
COKE
OVENS
IRON PLANT

17.0 **DETAILS OF MINING UNDERTAKING**

17.1 **NAME OF UNDERTAKING** : Athens Mine

17.2 **ADDRESS** : P O Box 5[illegible], Mvuma

17.3 **NATURE OF INDUSTRY** : Gold Mining by the cyanidation process and copper recovery by flotation

17.4 **LOCATION** : Mvuma

18.0 **DETAILS OF WATER CONSUMPTION**

18.1 **SOURCE OF SUPPLY** : Mackenzie Dam

18.2 **CONSUMPTION** : 300 m^3/day

19.0 **DETAILS OF RAW MATERIALS**

Athens Mine at present process about 250 tonnes/day of oxide ore and 400 tonnes/day of sulphide ore. The sulphide ore contains a large number of iron sulphides and copper sulphides while the oxide ore contains the same metals in oxide form. The ore contains no arsenic, barium, boron, nickel or zinc.

20.0 **DETAILS OF WASTE WATER DISCHARGE**

20.1 The waste water being discharged from time to time consists of the leach solution resulting from the dissolution of gold from a sulphide ore. As such, the water contains various dissolved metals such as gold, silver, copper and iron. The metals are mainly complexes of cyanide. Some free cyanide also exists in solution.

20.2 **VOLUME OF WASTE WATER**

Volume of mine waste water discharge is as follows :-

(a) Average _ 130 m^3/day

(b) Peak _ 250 m^3/day

(c) Peak discharge occurs during the rainy season when rain water collects on the Slimes Dam.

20.3 **POINT OF DISCHARGE**

Point of discharge is into the Blinkwater Stream east of the main Harare-Masvingo Road. A point at which samples can be taken for analysis is conveniently situated at the discharge from the water treatment plant.

21.0 WATER POLLUTION CONTROL SUMMARY OF BACKGROUND TO DATE

Athens Mine is a Lonrho Mine producing gold laden carbon. It is the first mine in the country to use the pouring of bullion from the new carbon in pulp process which treats 2 800 tonnes of ore monthly. The problem at Athens Mine is that of cyanide containing effluent flowing outside the Slimes Dams boundary fence and finally into a public stream, and the problem of seepage accumulation mining across the main Harare-Masvingo road.

Athens Mine applied for an exemption permit in 1989 in order to install a pilot purification plant (which will treat the cyanide content of the water) and to deepen and enlarge the holding dam to effect greater surge capacity. This project, as Athens says, is dependant on the availability of plant, which at present, is in short supply.

The results of analysis for CN done at Athens Mine on daily basis are sent to the Ministry of Energy and Water Resources and Development weekly. The situation as such is under control although the titration method used to determine the cyanide is questionable.

22.0 DETAILS OF PRESENT WATER TREATMENT

At present the mining waste water is treated by means of the INCO-SO_2-AIR cyanide oxidation process. THE INCO-SO_2-AIR cyanide oxidation prócess employed at Athens since May 1989 is capable of achieving the following results :-

PROCESS/CHEMICAL CONSTITUENTS	RESULTS
(a) Oxidation of thiocyanates	20%
(b) Iron cyanide removal	complete
(c) Free cyanide	0,2 mg/l
(d) Copper	0,5 mg/l
(e) Zine, Nichel	0,15 mg/l
(f) Iron	I mg/l
(g) Arsenic	not removed

Arsenic if present, is in extremely low concentration.

Analysis of the waste water is at present incomplete, since only the level of cyanide has been closely monitored. It has been admitted that there had been some difficulties in getting accurate measurement of full cyanide.

Of the 1 000 tonnes/day of water sent to hte Slime Dam about 50% is re-used. The rest of the water either evaporates or is detoxified and disposed of.

23.0 DETAILS OF PROPOSED WASTE WATER TREATMENT WORKS

The mine is at present involved in a feasibility study concerning the recovery of cyanide from all the waste waters. The intention is to recover all or most of the available cyanide for re-use. The intended process will also remove most of the dissolved metals, especially iron and copper.

Set of records are being built to determine if iron is present in unacceptable concentrations. If the concentration of iron is too high, the ways of reducing the concentration have to be found. The work is still at an early stage and as such it is difficult to estimate the time which will be required for the completion of the proposed works.

24.0 DETAILS OF INDUSTRIAL UNDERTAKING

24.1 NAME OF UNDERTAKING : LANCASHIRE STEEL (PVT) LIMITED

24.2 ADDRESS : P O. Box 315, Kwekwe

24.3 NATURE OF INDUSTRY AND TYPE OF PROCESS : Iron and steel engineering industry involved in the manufacture of wire and rod.

The processes involve rolling, desealing, pickling, drawing and galvanising.

24.4 LOCATION : Kwekwe

25.0 DETAILS OF RAW MATERIALS

Raw Materials	Quantity per day
Steel Billets	945 bars (180 tonnes)
Sulphuric Acid	3.1 tonnes
Lime	30 bags
Lubricants	37 kg
Flux	2,5 bags

26.0 DETAILS OF WATER CONSUMPTION

26.1 Sources of Supply - Kwekwe Municipality (from Sebakwe River)

26.2 WATER CONSUMPTION FOR INDUSTRIAL/DOMESTIC USE

833.0 m^3/day (ave) - industrial
167.0 m^3/day (ave) - domestic

27.0 DETAILS OF WASTE WATER DISCHARGE

27.1 GENERAL DESCRIPTION OF WASTE WATER AND PROCESS FROM WHICH IT EMANATES

Hot sulphuric acid is used for scale removal of the hot rolled rods, this acid does not enter the effluent system as it is recycled. However, some drag out does occur and is carried over into the rinse water contained in a continually overflowing bath. This rinse water combined with lime water from the lime tank which may overflow and runs into the effluent system from the galvanisint plant. Seepage water from the Rod Mill sump is pumped into neutralisation plant because it has a low pH.

27.2 VOLUME OF DOMESTIC WASTE WATER DISCHARGE

a) dry weather flow - 200 m^3/day (ave)
b) wet weather flow - 150 m^3/day (ave)

27.3 VOLUME OF INDUSTRIAL WASTE WATER DISCHARGE

a) Average 700 m^3/day

b) Peak 800 m^3/day

c) Peak discharge occur during boilers blowdown operation and when pumping Rod Mill sump water.

27.4 TOTAL VOLUME OF WASTE WATER DISCHARGE

a) Average 1 000 m^3

b) Peak 1 050 m^3

c) Same as (4.3.c) above.

27.5 LOCATION OF POINTS OF DISCHARGE

a) The treated effluent from neutralisation plant is discharged into the sewage system adjacent to plant.

b) effluent from any other sources is discharged from the common outlet at the Lancashire fence (point marked C on the map).

27.6 METHOD OF DISCHARGE

a) Heated effluent from neutralisation plant is pipe gravity fed to the sewage.

b) Semi-heated effluent from the common outlet marked C on the map (APPENDIX M) is channel fed into Sebakwe River tributary.

27.7 LOCATION OF POINTS AT WHICH SAMPLES CAN BE TAKEN FOR ANALYSIS

a) at the gravity feeding point

b) at the common outlet point (marked C on the map) (APPENDIX M).

28.0 DETAILS OF PRESENT WASTE WATER TREATMENT

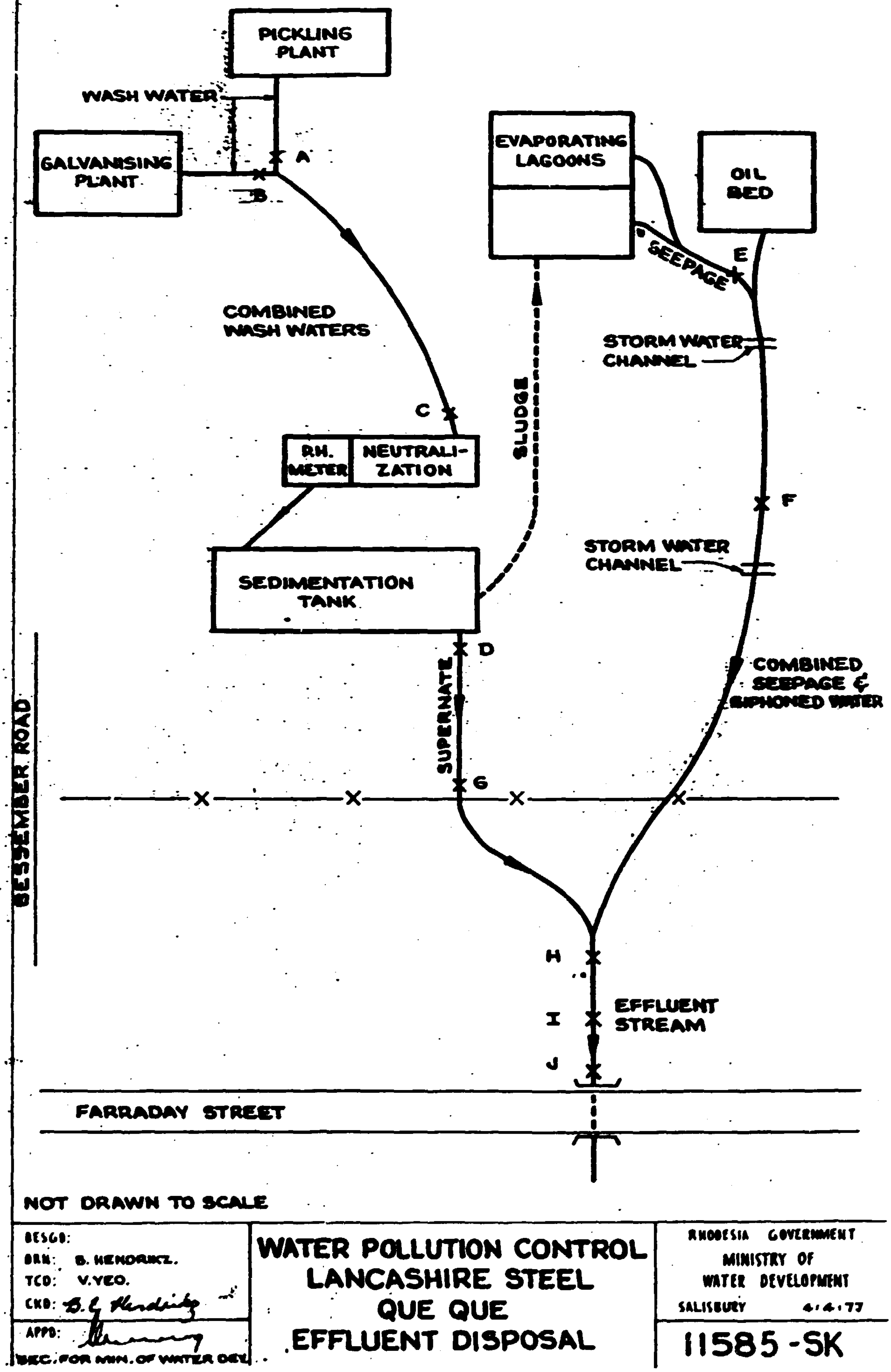
Present effluent from cleaning house, galvanising lines and Rod Mill sumps water is fed into a mixing channel and there are neutralised with burnt lime.

Neutralised effluent then passes through some oil separators before discharging into a nearby public stream.

28.1 WASTE WATER DISCHARGE FROM THE PLANT

28.1.1 Waste Water from the Pickling of Rod

Historically the 3 - 5% sulphuric acid was used until it became saturated with ferrous sulphate at about 15%, dependant upon the operating temperature, (optimum for maximum ferrous sulphate solubility is 65°C at acid strengths up to 20% Wt/Vol, a proportion was then wasted and made up with new sulphuric acid diluted to 3-4%.


PICKLING PLANT
WASH WATER
GALVANISING PLANT
A
B
COMBINED WASH WATERS
C
P.H. METER
NEUTRALI-ZATION
SEDIMENTATION TANK
EVAPORATING LAGOONS
OIL BED
SEEPAGE
E
STORM WATER CHANNEL
SLUDGE
F
STORM WATER CHANNEL
D
SUPERNATE
COMBINED SEEPAGE & SIPHONED WATER
BESSEMBER ROAD
G
H
I
EFFLUENT STREAM
J
FARRADAY STREET
NOT DRAWN TO SCALE
DESGD:
DRN: B. HENDRIKZ.
TCD: V.YEO.
CKD:
APPD:
SEC. FOR MIN. OF WATER DEV.
WATER POLLUTION CONTROL
LANCASHIRE STEEL
QUE QUE
EFFLUENT DISPOSAL
RHODESIA GOVERNMENT
MINISTRY OF
WATER DEVELOPMENT
SALISBURY 4.4.77
11585 -SK

A sulphuric acid recovery plant now operates which precipitates ferrous sulphate by brine cooling, allowing the acid to be re-used. Acid is only intentionally wasted when it is considered that tramp material is at a high level. The cleaned acid contains about 6% $FeSO_4$.

28.1.2 Rinse Waters and Drag Out

As the coils of rod are moved overhead within the pickling house, carryover from each bath occurs, but the majority occurs from the overflow when the coils enter as the baths are continually made up. This is more acceptable than having to sump concentrated chemicals and acid leached metals, unfortunately the bund the acid bath leaks and at times a considerable volume of acid, high in leached metals also enters the drain and passes to the effluent treatment plant. The effluent leaving the pickling house varies from highly alkaline with lime and/or soda ash to very acidic.

28.3 EFFLUENT ARISING FROM THE GALVANISIGN OF WIRE

28.3.1 Post Lead and Zinc Baths Wire Cooling Waters

The post lead bath cooling water is continuously fed by Municipal water and overflows to the well of a cooling frame. This cooled water is reticulated through the post zinc water bath. Although the cooling frame well has a level controlled valve to supply the Municipal make-up water, the system overflows into a stormwater which by-passes the effluent treatment plant.

28.3.2 Post Acid bath wire spray waters, water baths overflows and drag out

Municipal supply water enters the post acid bath water baths, overflows and joins the spray waters and drag out in each bund. It then passes via a drain to join with the pickling house effluent before entering the effluent treatment plant.

28.4 DELIBERATE WASTING OF ACID

The acid from all three baths is wasted weekly, a total of some 1 250 gallons, to minimise the effect of tramp materials on galvanising.

28.5 ROD MILL DRAINAGE

Drainage collected in the Rod Mill sump is historically considered contaminated with acid etc., and is pumped to the effluent treatment plant where it enters the reaction channel to design, although it is often fed to a spare tank and siphoned past the effluent treatment plant to the final effluent slow drain.

28.6 RUN-OFF FROM CONTAMINATED AREAS

The area surrounding the effluent course after it leaves the Works boundary, and before it enters the tributary of the Sebakwe River, was contaminated with acidic effluent to a distance of some fifty yards on either side, from old discharges. Vegetation is now growing back over the effluent of run-off into the effluent ditch is not marked.

29.0 WATER POLLUTION CONTROL : SUMMARY OF BACKGROUND TO DATE

29.1 EXECUTIVE SUMMARY

Lancashire Steel is engaged in the manufacture of galvanised wire from steel billets. The process requires the pickling at certain stages of the process of steel rod and wire to remove rust and scale. This is carried out using sulphuric acid.

At the time of the introduction of the water pollution control regulations in 1971 the company was in the habit of discharging spent pickling liquor containing considerable amount of sulphuric acid into small evaporation lagoons and partially nuetralising it by additions of lime. Seepage from these lagoons and from parts of the process had contaminated a fairly extensive area within and beyond the factory grounds and was draining into an unknown tributary of the Sebakwe river which was also, of course, being contaminated. The main pollutants were, and continue to be, sulphuric acid and iron salts.

A lesser, though still considerable, source of pollution at the works was the neutralisation of and washing process that takes place after the pickling process. Effluent from this was passed through neutralisation and flocculation/sedimentation tanks - the sludge from the underflow was pumped to the evaporation lagoons mentioned above while the overflow was partly returned for re-use in certain processes and partly to waste, compounding the pollution problem in the watercourses.

29.2 APPROACHES

This contravention of the Water Act was brought to the attention of the Ministry of Energy and Water Resources and Development in 1972 and Lancashire Steel submitted an application for a permit of exemption from the terms of the Act for the period necessary for the abatement of the pollution and rehabilitation of the polluted areas. The permit subsequently granted was for the period up to 30th June, 1973.

In 1973 the company submitted its firm proposals to :-

(a) install equipment (the Kenstener plant) to purify and concentrate the spent pickling liquor for reuse in the process and produce a by-product ferrous sulphate, which has a market value, and

(b) to improve the efficiency of the neutralisation of the waste water stream.

Delays in the implementation of the Kestener plant let to various extensions of the exemption permit being granted until finally the plant came into operation during 1976.

However, pollution of the water course still continued from other operations and further extensions were granted.

Monitoring of the effluent stream from the factory even after most of the recommendation by the then parent company British Steel had been carried out showed little improvement if any. The company showed little operational understanding of the overall operation of the water treatment plant. The company kept on applying for extension of exemption permits until the latest in 1988. In 1987, Lancashire Steel applied for a further extension of their permit, giving as grounds for this, the refurbishing of the acid baths and the solar ponds and firm proposals of building a second neutralising plant and some oil separators on the plot it had recently bought.

Even after the commissioning of the plant in September 1989, there are still difficulties in the operation of the plant, thereby resulting in water pollution.

The latest results of water samples taken and analysed in April, 1990 where as follows :-

	STATION 1	STATION 2
pH	11,7	3,5
Sulphate (mg/l SO4)	879,4	1 305,2
Total dissolved solids (mg/l)	1 450,8	1 485,7
Grease, Oil etc (mg/l)	4,2	10,1
Iron (mg/l Fe)	0,48	25,6

The results show by how far the waste water treatment plant is away from being efficient.

The neutralisation process is not effective enough to raise the pH to the required level, and the oil seperators themselves are letting out quite a considerable amount of oil to pass through them.

30.0 WASTE WATER TREATMENT PLANT AND OPERATION

30.1 EXISTING PLANT FIG. 2

The plant consists of a chemical addition/mixing channel of about four seconds retention at a through put of 150 gallons/min. Two reaction settling tanks of 5 500 gallons each with a retention time of 70 minutes if both are in operation. The upflow with both tanks in use is 6 feet/hour at 150 gallons/minute through put.

A sludge tank of 2 500 gallons capacity, into which the sludge from the clarifier is pumped and also the sludge from the settling tanks is forced, by hydratic lead. The sludge without further settlement is then pumped to the solar lagoons.

The sludge tank is also used to collect the waste acid after neutralisation, and this is also pumped to the solar lagoons. The sludge tank has an overflow pipe which encourages bad practice.

30.2 EXISTING CHEMICAL TREATMENT

A mixture of 2 soda such : 1 lime is used to adjust the pH of the generally acidic effluent from the galvanising lines and pickling house. At times this mixed effluent is already alkaline due to the lime and soda ash of the pickling house. A flocculant is added to the liquor prior to the settling tanks, with the intension of increasing the sludge settling rate, and reducing its final volume.

Acid wasted from the galvanising lines and pickling house is neutralised by the lime and soda ash mixtures, but does not pass through the settling tanks and clarifier.

31.0 PRODUCTION PROCESSES

31.1 ACID PICKLING (CLEANING) OF ROD

The mechanically descaled coils of rod are placed in 3-4% sulphuric acid until the residual scale and iron oxide film is removed. They are then transferred through a water bath, a lime slurry and/or soda ash slurry bath (APPENDIX M).

31.2 GALVANISING OF WIRE

After being drawn, the wire of different diameters is passed through one of the three galvanising lines. There it is heated in a lead bath, annealed by air cooling, and passing through a water bath, cleaned in a sulphuric acid bath, sprayed with water and passed through a water bath, coated with flux, passed through a molted zinc bath and then a final water bath. (Fig. 7.2)

The entire effluent disposal system, see APPENDIX M.

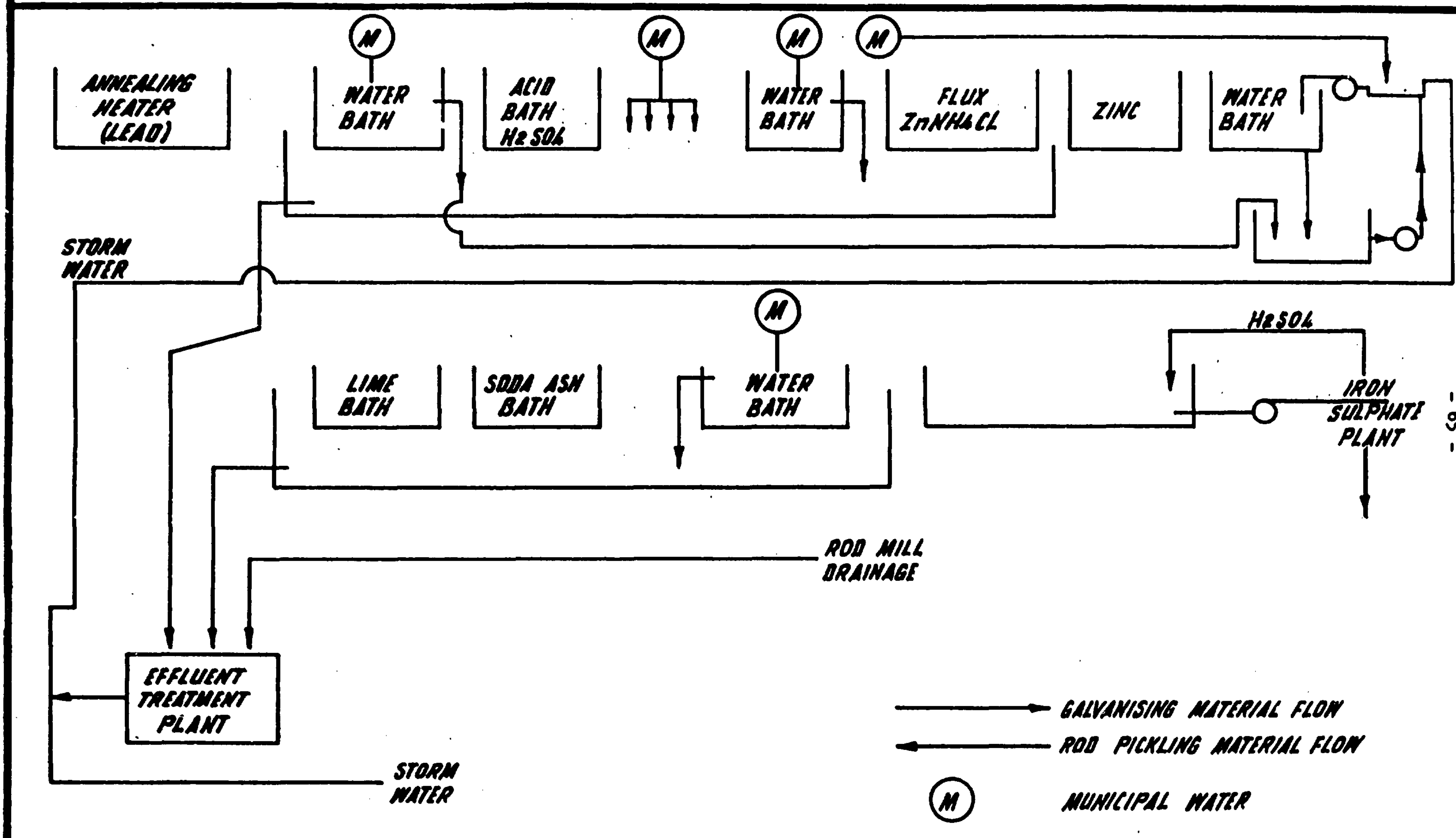

ANNEALING HEATER (LEAD)
WATER BATH
ACID BATH H2 SO4
WATER BATH
FLUX ZnNH4CL
ZINC
WATER BATH
M
STORM WATER
H2SO4
LIME BATH
SODA ASH BATH
WATER BATH
IRON SULPHATE PLANT
ROD MILL DRAINAGE
EFFLUENT TREATMENT PLANT
STORM WATER
GALVANISING MATERIAL FLOW
ROD PICKLING MATERIAL FLOW
MUNICIPAL WATER

FIGURE 1

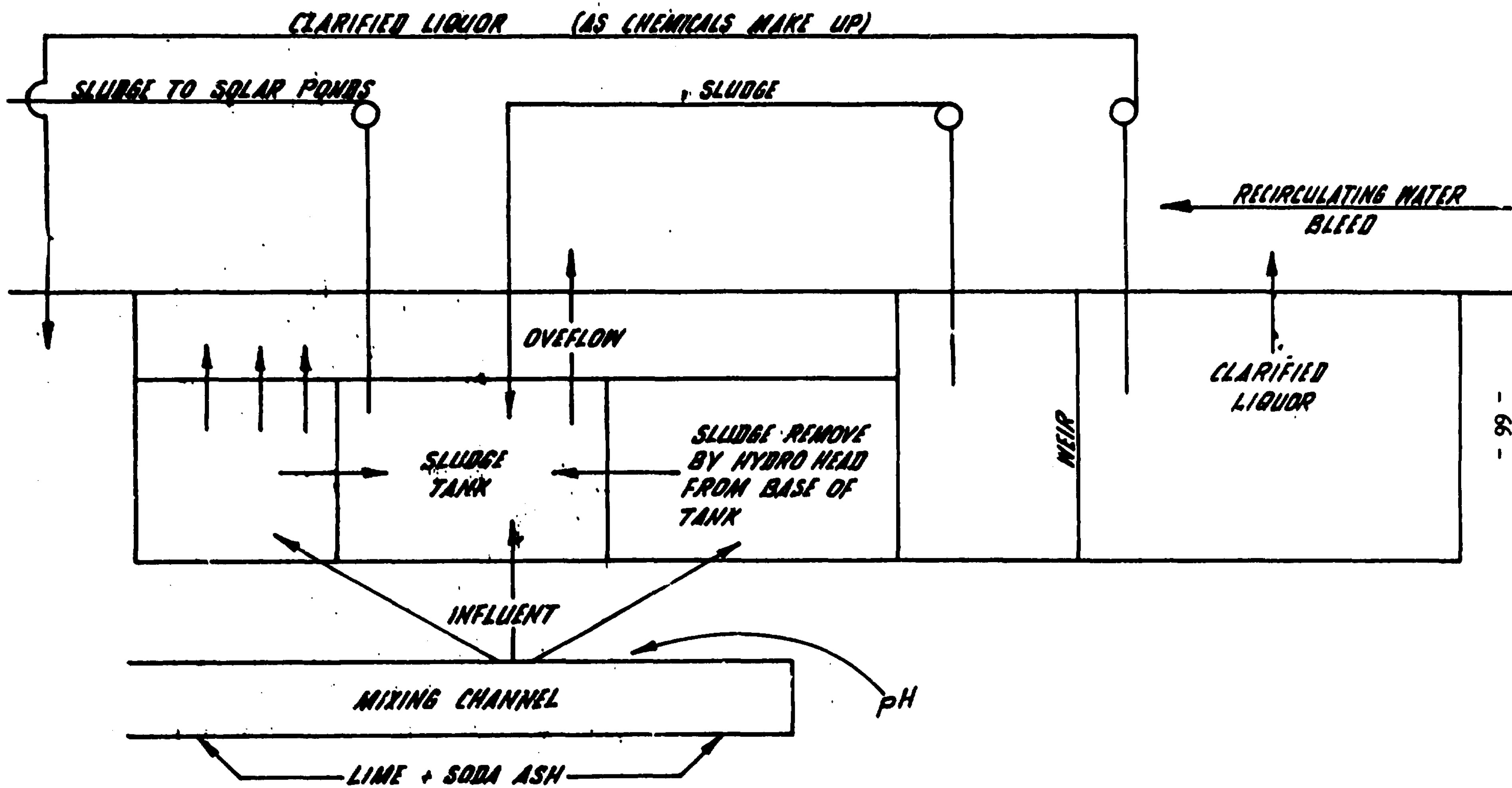

CLARIFIED LIQUOR (AS CHEMICALS MAKE UP)
SLUDGE TO SOLAR PONDS
SLUDGE
RECIRCULATING WATER BLEED
OVEFLOW
CLARIFIED LIQUOR
SLUDGE TANK
SLUDGE REMOVE BY HYDRO HEAD FROM BASE OF TANK
WEIR
INFLUENT
MIXING CHANNEL
pH
LIME + SODA ASH

FIGURE 2

32.0 DETAILS OF INDUSTRIAL UNDERTAKING

32.1	NAME OF UNDERTAKING	:	Triangle Limited
32.2	ADDRESS	:	Private Bag 801 Triangle
32.3	NATURE OF INDUSTRY	:	Manufacturing of sugar and ethanol from sugarcane
32.4	LOCATION	:	Triangle
32.5	DETAILS OF RAW MATERIALS	:	Sugarcane

33.0 DETAILS OF WASTE WATER DISCHARGE

33.1 GENERAL DESCRIPTION OF WASTE WATER AND PROCESS FROM WHICH IT EMANATES

(See 35.0)

34.0 EXECUTIVE SUMMARY

Triangle Limited is engaged in the manufacture of sugar and ethanol from sugarcane grown in its extensive cane fields in the lowveld. Some of its activities have given rise to pollution of watercourses in the area and, following an investigation by the Ministry of Energy and Water Resources and Development in 1971, Tringle Limited carried out various improvements of its waste disposal installtions, under cover of an exemption permit which expired on 31st January, 1974 and these resulted in adequate control of pollution at the time.

In September, 1980 a report was received from the Lands Inspectorate in the area, describing the discharge into the Cheche river of obnoxious waste water from the Triangle sugar mill area. Analysis of various samples of these discharges revealed that pollution was indeed recurrying. Discussions were held with the Management and was agreed that Triangle would formulate its proposals for the abatement of the water pollution.

35.0 DESCRIPTION OF THE POLLUTION SOURCES

35.1 DUNDER

As sugarcane contains 70% water, there is usually an excess of water from the process in the form of condensate from juice evaporation. This condensate originates from two sources :- viz condensed water from calandrias and cooling tower overflow. There is usually trace of sugar (50 - 100 ppm) in this water.

In addition, floor and equipment washings also enter the dunder. This contains sugar from accidental spills and leaks from pipes and pumps. The total dunder contains -

pH - 5 to 6
undissolved solids (by conductivity) - 150 ppm
sugar - 1 000 ppm
temperature - 30°C - 40°C.

The volume of dunder water averages 4 000m^3/day with a peak of 5 000m^3/day. Dunder is discharged to anaerobic ponds of 2 000 m^3 capacity after liming to a pH 6.

The holding time in these ponds is about three days and anaerobic digestion should reduce the COD from 2 000 mg/l to 500 mg/l.

Following this, the treated dunder is used to irrigate the canefields where further reduction in COD takes place and run-off into drainage channels and subsequently into the Cheche river should be innocuous.

On the early 1980s this system has not been functioning properly, mainly through lack of proper operation of the naerobic ponds. Triangle then acquired the services of a qualified chemist to study and maximise the functions of the ponds, with emphasis on proper nutrients addition and bacterial growth to obtain increased reduction in COD.

35.2 SMUTS

On the boilers, particles of partially burnt pieces of baggasse and/or coal and particles of ash are entrapped in the hot flue gases. After heating the water and steam, this gas is passed through grit arrestors (cyclones). The finer particles that pass the grit arrestors pass out with the smoke. The arrested particles are flushed out through water seals with water along channels when they are colllected for treatment. This water contains 3 000 ppm COD mainly in the form of small fibrous particles (cellulose) and some carbon and ash. Temperature is around 25°C and the contamination is practically all in undissolved form.

35.3 STILLAGE

In the ethanol plant mash is made from a mixture of molasses, juice and water to give approximately 14% sugars and 2% to 10% non sugars depending on the raw material proportions.

The sugar is fermented by yeast to form ethanol which is recovered by distillation. The effluent (stillage) therefore contains all the residual plus dead yeast cells at an average concetration of 6%. The composition is a complex mixture of sugar, gums, wax, starch, glycerol, colouring matter and about 50% is inorganic, inherent in the cane plus the nutrients added to fermentation.

The inorganics are mainly in the form of potassium with appreciable nitrogen, sulphur, phosphorous and carbonates. Temperature is around 90°C, pH 4,5 and most of the material is in dissolved form. Washings from the fermentation vats are also added to the stillage. The quantity of stillage produced is about 1 200 m^3/day and the plant operates for 50 weeks of the year. At present, it is dealt with in two way :-

1. Part is evaporated to about 65% solids and is used in animal feeds etc.

2. Stillage is pumped to a stillage dam with a capacity of about six weeks production, whence it is gravity fed to the nearby irrigation pump station where it is diluted by 40 : 1, thus reducing its COD from 40 000 mg/l to 1 000 mg/l, and irrigated to lands.

Triangle has also stated that the relatively high potassium content of the stillage being irrigated will eventually raise the level of potassium in the soild to detriment of cane fields and new irrigation areas would need to be opened up.

36.0 APPROACHES

On 27th September, 1988 the Ministry of Energy and Water Resources and Development received a report from the Provincial Water Engineer (Masvingo) of the discharge effluent from the ethanol plant into the Mutirikwe river.

The situation being that, there are 2 ponds for settling smuts, one was full and not in operation and the other pond flowing into the Cheche river. There was also a discharge of effluent from the cane washing on the conveyor belt into the Cheche river.

In support of the application for an exemption permit an advise of the following was made :-

36.1 SMUTS SYSTEM

The excess clarified water from the Boiler smuts system is presently passed through the smuts settling ponds (where solids drop out) and then discharged into the Cheche river.

The intention that time was to install a pumping system at the discharge point of the smuts settling ponds and pump the water into an irrigation system north of the mill.

36.2 MILL WASHINGS

The washings from the mill currently flow into the stream. The intention being to re-direct them to the suction of the pumps at the Dunder Pump Station and be disposed through direct irrigation on to the came fields.

As part of the water pollution monitoring programme, samples of the waste water are taken regularly. Below are the results of a sample taken on the Smuts Settling ponds outlet at Triangle in May, 1989.

TABLE 36.1

PARAMETER	CONCENTRATION	UNITS
Conductivity	35,30	mg/m (20°C)
pH	8,50	
Total alkalinity	135,39	mg HCO_3/l
Reactive phosphate	0,74	mg P/l
Nitrate	2,20	mg N/l
Sulphate	6,44	mg SO_4/l
Chloride	34,52	mg Cl/l
Magnesium	3,00	mg Mg/l
Sodium	13,00	mg Na/l
Potassium	10,30	mg k/l
Absorbed oxygen	9,00	mg O_2/l
Iron	2,8	mg Fe/l
Manganese	0,1	mg Mn/l
Ammonia	0,12	mg NH_4/l

As can be seen from the results in table 36.1, they do comply with the maximum permissible concentrations given in Appendix C.

37.0 DETAILS OF INDUSTRIAL UNDERTAKING

37.1	NAME OF UNDERTAKING	: David Whitehead and Sons Ltd.
37.2	ADDRESS	: P O Box 200 Chegutu
37.3	NATURE OF INDUSTRY AND TYPE OF PROCESS	: Textiles, Weaving and Dyeing
37.4	LOCATION	: Chegutu

38.0 DETAILS OF WATER CONSUPTION

38.1	SOURCE OF SUPPLY	: Industrial Water - Mupfure river Domestic water-Chegutu Water Works
38.2.	WATER CONSUMPTION FOR DOMESTIC USE	: Average 70 m3/day (1979)
38.3.	WATER CONSUMPTION FOR DOMESTIC USE	: 2386 m3/day (1979)

39.0 DETAILS OF WASTE WATER DISCHARGE

39.1.	GENERAL DESCRIPTION OF WASTE WATER AND PROCESS FROM WHICH IT EMANATES	: Textiles, Dyeing and Bleaching. Highly alkaline effluent with high concentration of dissolved solids
39.2.	VOLUME OF DOMESTIC SEWAGE DISCHARGE	: Average 60 m3/day (1979) Peak 85 m3/day (1979)
39.3.	VOLUME OF INDUSTRIAL	: Average 2 000 m3/day (1979) Peak 2880 m3/day (1979)
39.4.	METHOD OF DISCHARGE	: Gravity flow down open channels into evaporation ponds.

40.0 DETAILS OF PRESENT WASTE WATER TREATMENT

41.1.	PRESENT TREATMENT BEFORE DISCHARGE OF SEWAGE	: Domestic sewage piped to septic tanks
41.2.	PRESENT TREATMENT BEFORE DISCHARGE OF INDUSTRIAL WASTE WATER	: Waste water is settled and evaporated in open ponds

43.0 EXECUTIVE SUMMARY

Following reports of water pollution occuring from David Whitehead and Sons in the late 1970s, it was ascertained that a highly alkaline waste water containing a high percentage of dissolved salts, from the operation of the factory, together with storm water runoff, was disposed of into a series of evaporation ponds situated near a tributary of the Mupfure river, and allowed to discharge into the same. The company was informed of the inadequacy of that treatment and of the need to rectify the matter.

The company in 1977 then engaged some consultants and came out with some tentative proposals, for the disposal of the waste water. The proposals envisaged a 1:50 dilution of the waste water with Mupfure River water, and return the diluted effluent to the river. The proposals were considered by the Water Pollution Advisory Board at its meeting, and found to be unacceptable for the following reasons :-

(a) The proposed rate of dilution would not result in an effluent that would confirm with the prescribed standards (Appendix C),

(b) The water is mainly used for irrigation downstream and the standard of the effluent produced would make the water unsuitable for that use,

(c) The proposed point of effluent discharge was above a weir site from which the Chegutu Water Supply may be augumanted in the future,

(d) In order to comply with most of the standards, the effluent would require a dilution of at least 1:500 constituting a demand which the Mupfure river could not meet.

The company was consequently requested to investigate alternative methods for the abatement of the pollution.

44.0. APPROACHES

A further investigation was then made into how the problem can be solved. The company then proposed to extend the evaporation lagoons to cope with the present waste water flows. Big evaporation ponds were constructed, pond No. 1 and pond No. 2, pond No. 2 being the final one.

The results of the samples taken on 12 June 1979 are shown in table 6.1.

TABLE 44.1.

SAMPLE	NO. 1 POND	NO. 2 POND
PH	7,9	7,8
Total dissolved solids (mg/l)	2 270	186
Total undissolved solids (mg/l)	4 420	54
Alkalimity to methyls		
orange (mg $CaCO_3$/l)	552	141
Chloride (mgCl/l)	44	9
Sodium (mgNa/l)	292	58
Oxygen absorbed from $KMnO_4$	29	4
4 hrs at 27°C (mg O_2/l)	29	4
Chemical oxygen demand	320	26

44.1. DESCRIPTION OF SAMPLES

No. 1 Pond	: Earthy odour, turbid, white grey colour, large amount of sediment
No. 2 Pond	: No odour, white in colour, almost clear, trace of sediment.

44.2. REMARKS

The overall analytical result indicates that the quality of the two waste waters had improved over the years, and most of the parameters do comply with the regulations. (Appendix C).

45.0 CONCLUSION

During the cause of this study I have endeavoured to adhere as closely as practicable to the Terms of Reference, as well as following the general principles set out in the Job Description.

Initially the types of industries mentioned in the Job Description were enclined more to organic than inorganic but due to the combination of the sectoral activity within manufacturing in Zimbabwe, it has been found inevitable to exclude those industries like chemical, steel and mining.

Because most of the industries are situated in or around towns most of them do discharge effluent into their respective Municipal sewers, for as long as the effluent meets the by-laws. But often the quality of the effluent from such industries like chemical and steel, even after pretreatment does not meet the standards of the by-laws, so they have to have their own treatment plants.

Inevitably there are areas to which more time would have been devoted, but I belief that I have reached an adequate level of understanding of Zimbabwe's effluent problems, identified the major problem areas, and confirmed the main containments and effluent quantities. No doubt that a lot of time has been devoted to ZIMPHOS, this is due to the complexity of the problem and how urgent to Zimbabwe a solution is needed to this problem.

46.0 CLOSURE

I have found this a most interesting and challenging commission, and trust that the Terms of Reference have been fulfilled to your satisfaction. I will always be ready and happy to provide further amplification or explanation of this report.