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Ambient air quality monitoring system for Zambia

Mission report no. 2 to Zambia, April 1999

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Summary

The Norwegian Institute for Air Research (NILU) was asked by the Norwegian State Pollution Control Authority (SFT) for support in defining the ambient air pollution component of the Industrial Pollution Prevention Programme (IPPP) operated by the Environmental Council of Zambia (ECZ).

This is the report of the second mission to Zambia 07 to 19 April 1999. The main purpose of this mission was to undertake a screening study of the present ambient air quality, related to some major emission sources, and to design a measurement programme for ambient air quality measurements in Zambia.

Visits to the main industries in the Copperbelt area and in Mazabuka and Maamba were undertaken in order to collect information about the present knowledge on emission rates and conditions, ambient air concentration levels and complaints from the population around industrial areas. Passive samplers were installed in the industrial areas and in Lusaka, as part of the screening study of the present ambient air quality. A report of the visits, information collected and conclusions from the screening study is given in this mission report. As a result of this mission the measurement programme for ambient air quality measurements in Zambia has been designed.

Ambient air quality monitoring system for Zambia
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1 Introduction

The Norwegian Institute for Air Research (NILU) was asked by the Norwegian State Pollution Control Authority (SFT) for support in defining the ambient air pollution component of the Industrial Pollution Prevention Programme (IPPP) operated by the Environmental Council of Zambia (ECZ).

The IPPP is funded by NORAD and was started in 1995 with a training course in air pollution emission monitoring. IPPP contains several different individual projects, such as:

- Cleaner production,
- Air Pollution regulations,
- Water quality guidelines and regulations,
- Hazardous waste Regulations,
- Environmental information system.

The air pollution component also includes ambient air pollution measurements; instruments, chemical analyses and training.

2 Purpose and programme for the visit

The main purpose of the mission to Zambia 07 to 19 April 1999 was to undertake a screening study of the present ambient air quality, related to some major emission sources, and to design a measurement programme for ambient air quality measurements in Zambia.

A plan for the establishment of such programme should be developed including capacity building, instrument procurement, installation and training. As a result of this mission, an updated proposal to the measurement programme for ambient air quality measurements in Zambia is presented in chapter 5, complementing the proposal presented in the Appendix P of the Mission Report NILU OR 61/98.

Cristina Guerreiro participated from NILU and Lemmy Namayanga and Ruth Zimba participated from ECZ during the second mission to Zambia. People met during this mission are presented in Appendix A. A programme for the visits had been discussed before the arrival, and a final version is presented in Appendix B. The purpose of the mission is presented in Appendix C.

3 Meetings

3.1 Wednesday 07 April 1999

I was met at the airport on Saturday by Edward Piery (driver) and Lemmy Namayanga, who we talked to on the way into Lusaka.

Meeting at: ECZ
Present: From ECZ: Paul Banda (chief inspector at ECZ), Lemmy Namayanga, Ruth Zimba, Douglas Nkolonganya (from the water quality unit)
From NILU: Cristina Guerreiro

Mr. Banda informed us that the evaluation of the IPPP programme would take place from 15 to 23 April 1999.

I insisted on the need of establishing a national laboratory for environmental analyses, which should preferably be independent, as a necessary step to establish an ambient air quality monitoring system for Zambia. Mr. Banda answered that NORAD would also prefer the use of an existing independent laboratory, which would be adapted to undertake the analyses of ambient pollution, and that ECZ was considering that solution too. He also mentioned that they are working on a Canadian project on nutrient load in the Kafue river, for which they will also need such a laboratory.

I was informed that the project proposal, which we had prepared in the end of our first mission in October, has not yet been submitted. They are planning to work on a proposal covering all the areas of the IPPP project, including air pollution, after the evaluation in April and after meeting SFT in May.

Meeting at: ECZ
Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: Cristina Guerreiro

The meeting was held to discuss the programme of the visit, and to agree on details in the proposed programme. The final version of the programme is presented in Appendix B. The general feature of the programme for the visits in Mazabuka, Maamba and the Copperbelt area was based on meetings with industries and visits to the areas, townships and surroundings included location of passive samplers.

3.2 Thursday 08 April 1999

Meeting at: Nakambala Sugar Estates, Mazabuka
Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: Cristina Guerreiro
From Nakambala Sugar Estates: John Zulu (served officer), Israel Zandonda (environmental officer)

The sugar plantation has 10 000 hectares, divided into smaller fields. They burn the sugar can fields before they can cut the sugarcane in order to get the insects out and open space between the cans. The dry leafs of the cans and the grown vegetation burns. The amount of leafs that burn was estimated by ECZ to be about 33 to 45 kg/m^2. Burnings are carried out everyday, at the same time, between 2 and 3 separated fields with a size of 200 to 300 hectares. The open air burning takes normally place during the early morning, by sunrise or in the evenings, before sunset. They justify this choice by the fact that these are the periods of calm wind conditions and it is therefor easier to control the burnings. They were

informed that those are the worst hours to burn in terms of air pollution dispersion conditions. In the day of our visit the burning took place in the middle of the day, at 13.00 hours. This time was preferred because it was the end of the rain season; the sugarcanes had more green leafs than usual, and it was easier to burn them during the hottest time of the day.

The sugar factory has 3 stacks for the 5 boilers and uses bagasse as fuel (Appendix D). The stacks emit CO, particles and fluorides. They add sulphate to the sugarjuice to bleach the sugar. All sulphate should be absorbed into the sugarjuice, but there are sometimes accidental releases of SO_2, which together with bad ventilation, can be a problem for the workers.

3.3 Friday 09 April 1999

Meeting at: Maamba Collieries Limited

Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: Cristina Guerreiro
From Maamba Collieries Limited: Mr. O. Lee Davey (managing director), Mr. Elpher Ngwata (technical services superintendent)

The total area of the open mine is 7900 hectares. An estimated area of 350 to 400 hectares of the open pit mine is under spontaneous combustion, emitting unknown amounts of SO_2 and particles. As an example, the old cool pit field of Kanzinze has been burning for 13 years and they estimate it to continue burning the next 50 years!

During wintertime and under stable conditions the pollution emitted by the open pit mines is transported with high concentration over long distances. Communities as far as 10-15 km away from the mine have complained. The wind blows along the valley (SSW-NNE), predominantly from NNE.

Mr. O. Lee Davey estimated in 10 million US$ the cost of rehabilitation of the mine, in order to prevent the old part of the mine from continuing to burn. The mine is presently in a difficult economic situation, after a drop in coal price and demand in Zambia. To reduce the emissions from spontaneous combustion, ECZ has suggested to them to cover the open pit mines with inert material like clay, but the mine has answered that they do not have a compacting machine.

The coal extracted has a sulphur content of 1,5% in average and of maximum 3,5%. After processing, they sell the coal with 1% sulphur. SO_2, nitrogen fumes, CO and particles are emitted during the coal processing. Water sprays are used to keep down the particles in the processing area, but this method has a low efficiency.

3.4 Saturday 10 April 1999

Meeting at: Bwana Mkubwa Mining Limited
Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: Cristina Guerreiro
From Bwana Mkubwa: Mr. A. Scott (company secretary)

Bwana Mkubwa Mining Limited has an acid plant and an electro- weaning plant to recover the left copper in the tailing dumps. This last one produces 30 tons Cu per month. Bwana Mkubwa Mining started its activity in January 1998, the application for Permit to Emit Air Pollutants (Appendix E) was only submitted in March 1999 and the permit has not been issued yet.

They import 99,5% raw sulphur from South Africa to produce the sulphuric acid. They produce an average of 300 tons H_2SO_4 a day. The acid is both used in the electro-weaning plant and sold to the copper smelters.

At the time of our visit they had been having problems with the design of the new cooler since 3 of March. In the last 5 weeks they had been emitting all the SO_x that should be transformed into acid directly into the atmosphere, blown by the fans of the cooler, as a low fugitive source. They have received complains from farmers, which saw their crops damaged, and from INDENI, which is about 1,5 km downwind from the acid plant. Mr. Scott said they would close the acid plant the day after (11 April) until the cooler had been replaced.

Mr. Scott informed that under normal conditions, when the acid concentration is too high in the acid plant, they have to release SO_2 through the stack. The total amount of SO_2 released due to such conditions in October 1998 was 120,4 tonnes, as an example. Appendix F presents the estimated amount of SO_2 released through the stack during 4 months.

Meeting at: INDENI Petroleum Refinery
Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: Cristina Guerreiro
From INDENI: Mr. Nioka (Plant section head), Mr. Harry Moamza (Process engineer)

We were informed that the plant has been shut for 5 days and that they plan to open within 3 days. Mr. Nioka showed us the only boiler in work. Mr. Harry Moamza complained about the SO_2 emissions from Bwana Mkubwa acid plant, which had been going on with critical concentration levels for 5 weeks. He was afraid the acid would lead to corrosion of the equipment and conducts of the refinery, which were not dimensioned to tolerate such concentrations of acid. He mentioned that a case of rupture in the equipment or conducts could cause a major accident in the plant. He was also concerned about the health of the workers in the plant. He was encouraged to make a formal complaint and a claim of compensation for damages.

Meeting at: Ndola Lime Company
The lime factory was temporarily closed down. The visit was therefore cancelled.

Meeting at: Chilanga Cement Factory
Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: C. Guerreiro
From Chilanga Cement: Mr. H. K. Mwenya (Works technical manager)

The most important air pollution problem caused by the Lime factory emissions is dust. The processes producing dust are: quarry, crushing, conveyor, screening, lime burning and hydrating. The highest dust emission is produced by lime burning. The other dust emissions are mainly fugitive.

During our visit the cement plant was under normal operation and the electrostatic precipitators were in function.

The cement factory measures the dust emissions on its two stacks daily, these measurements are reported weekly and sent to ECZ on a yearly basis. Appendix G presents dust emission measurements for 6 months in 1998.

The factory is placed upwind from the town centre and the Itawa Township. The area of maximum impact is the Itawa Township, about 3 to 4 km downwind from the factory.

An attempt was made to measure PM_{10} ambient air concentrations in Itawa. We have placed the measuring instrument 2,7 km West from the factory's main stack, at the most exposed side of Itawa. Unfortunately the tied time schedule did not allow us to measure over more than one hour, at 10 am. During the measurement hour there was unstable conditions, the wind was blowing from around east, with unstable wind direction and varying low wind speed. The average PM10 concentration measured over one hour was 16 $\mu g/m^3$. This value is very low and not representative of the impact of the cement factory on the Itawa Township. It was measured under good dispersion conditions and unstable wind direction.

3.5 Sunday 11 April 1999

Meeting at: Roan Antelope Mining Corporation (RAMCZ)
Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: C. Guerreiro
From RAMCZ: Mr. A. P. Mukherjee (manager-metallurgical)

Mr. A. P. Mukherjee informed us that the smelter is closed for at least a year. They are in the process of renewing the smelter into US technology. They will build an acid plant and will therefore be able to reduce the SO_2 emission substantially. At present they are still looking for investors, and will need 56 million US$ for the conversion of the smelter.

3.6 Monday 12 April 1999

Meeting at: ZCCM Nkana smelter officials
Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: C. Guerreiro

From ZCCM: Mr. Alexie Npishi (DESO), Mr. Mathews Chunga Mwale (Environmental off.)

Mr. Alexie Npishi informed us that ZCCM Nkana is in the privatisation process, they expect to be sold to Anglo-America in June. In May they will close down the plant for reparations. Their acid plant efficiency has been decreasing (see Appendix H), they hope to invert this tendency after the repairs in May.

We asked for meteorological data from the last year and were informed that the meteorological station has not been calibrated and has not been working since November 1998. But ZCCM is willing to give ECZ meteorological data in the future, under request. They are planning to have 3 more sequential samplers in the townships. They have 4 of them sampling presently.

Mr. Mathews Chunga Mwale provided us with their SO_2 measurements, taken at the same time as our measurements with passive samplers in September, for comparison. The measurements with the sequential samplers (ZCCM) and with the passive samplers (NILU) are presented in Table 1. SO_2 is analysed at ZCCM from total acidity based on titration, while NILU uses ion chromatography for SO_2 analyses. These results illustrate the difference in detection limits and precision of the two analysis methods. Appendix I presents the monthly average concentrations of SO_2 (mg/m^3) measured by ZCCM at the 4 stations from July 1995 until December 1998.

Table 1: Measurement of SO_2 (mg/m^3) in Nkana, from 25 to 27 of September 1998.

	Averaging period of measurements			
	ZCCM Nkana measurements			NILU measurements*
Station	25/09/98	26/09/98	27/09/98	25/09/98 11:50 h to 27/09/98 12:40 h
Central Shaft	< 0.001	1.544	0.707	1.493
Fire brigade	< 0.001	< 0.001	< 0.001	0.385
Wusakile Hospital	< 0.001	< 0.001	< 0.001	0.019
Nkana Hospital	< 0.001	0.023	< 0.001	0.055

*(Guerreiro & Sivetsen, 1998).

Mr. Alexie Npishi had on his desk a copy of "External Environmental Audit of the Nkana Mining Licence Area – LML 2", by SRK Consulting (Engineers & Scientists), from December 1998, of which ECZ can officially request a copy.

Meeting at: Mines Safety Department

Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: C. Guerreiro
From MSD: Mr. Godfrey C. Kabilo (Director), Mr. Henry C. Mutafya (Inspector of Environment)

After presentation of the ambient air pollution monitoring programme, Mr. Mutafya informed us that the MSD is doing campaigns of air quality measurements around the different smelters in the Copperbelt. They use 2

sequential samplers and analyse SO_2 from total acidity based on titration, at the Mines Safety Laboratory. In the last campaign they had collected samples during 2 weeks in Mufulira, 2 weeks in Luanshya and 20 days in Ndola, near Bwana Mkubwa acid plant. The results were not available yet, but they would be sent to ECZ. MSD showed great interest in a new, clean environmental laboratory for Zambia. With such a laboratory operating in Zambia in the future, they could send their samples to the new laboratory for analysis, instead of continuing analysing SO_2 by total acidity.

3.7 Tuesday 13 April 1999

Meeting at: ZCCM Mufulira

Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: C. Guerreiro
From ZCCM Mufulira: Mr. James Kalowa, Mr. Vincent K. Chalwe, Mr. Chipangano G. Zulu (chemist)

Mr. James Kalowa provided us with ZCCM's SO_2 measurements, taken in Mufulira, at the same time as our measurements with passive samplers in September, for comparison. The measurements with the 4 sequential samplers (ZCCM) are presented in Appendix J. SO_2 is analysed at ZCCM from total acidity based on titration. From the comparison of the data (Guerreiro & Sivertsen, 1998), the question if the passive sample from Clinic 3 had been changed with the sample from Clinic 5 was raised. Since there were no meteorological measurements from these 4 days to answer the question, we hope to obtain it from the comparison of equivalent measurements taken in April 1999. ZCCM Mufulira was also interested in the possibility of using a future clean environmental laboratory in Zambia for the analysis of their samples.

We were also informed that ZCCM Mufulira is under privatisation.

3.8 Wednesday 14 April 1999

Meeting at: ZCCM Chingola, Nkana smelter officials

Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: C. Guerreiro
From ZCCM: Mrs. Sampa A. B. N. Chitah (Divisional Environment Services Officer)

There are three major processes/ activities at ZCCM Chingola; open pit and underground mining, concentrator of copper ores, and tailings leach plant. The open pit emits mainly dust, there is no spontaneous combustion. The concentrator emits dust and SO_2 through two stacks, from the coal combustion and from the drying of sulphate copper, which releases sulphur. The leach plant uses H_2SO_4 to extract the copper from the oxide copper (tailings) and releases fugitive SO_2 emissions from the tank.

Wet gas scrubbers, with an estimated efficiency of 90%, are installed in the two stacks of the concentrator (see Appendix K). No measurements of the stack emission have yet been done by ECZ. Mrs. Chitah informed ECZ that the

conditions were created for ECZ to measure the emissions at the stacks and that she was expecting them shortly.

The tailings leach plant uses 'mist', which are balls of a inert material that float in the beaching tank to prevent SO_2 fugitive emissions. Nevertheless, ZCCM has received complaints from the school and population near the bleaching plant. A passive sampler for SO_2 was placed at the referred school. The bleaching plant was working at 77% of its average production rate at the time of the visit. Mrs. Chitah would send a mass balance for the use of sulphur in the bleaching plant to ECZ.

3.9 Thursday 15 April 1999

Meeting at: ECZ

Present: From ECZ: Lemmy Namayanga, Ruth Zimba
From NILU: C. Guerreiro
From IPPP Evaluation team: Jon Jerre (DNV), Tore Laugerud (Norconsult), Dr. ? (Professor in University of Zambia)

Lemmy Namayanga presented the unit of Air and Noise at ECZ , composed by 4 members:

- one senior inspector, Mr. Gentile Chasaya, presently in USA (from 03.04.99 to 27.04.99),
- two inspectors, Lemmy Namayanga and Ruth Zimba,
- one technical officer, Bwembya Mwanza, presently in South Africa (from Feb. to Nov. 1999).

Lemmy Namayanga continued referring the work done by the unit within the IPPP project.

Within this project the unit members learned to make stack emission measurements in Norway and received the measurement equipment in March 1997. The unit has done 4 stack measurements in industries until now. The unit wishes to have automatic equipment to decrease the time and work associated to these measurements. This point was discussed between the participants in the meeting and many doubts were raised about the cost/ benefit of such a substitution. The unit would like to measure the stack emissions in 8 industries in 1999, which they estimate will cost 24 to 30 days of labour.

The unit has also been working on the licensing process of the industries in Zambia. They covered 78 industries in 1998. They do not know how many industries are left to license in Zambia. The evaluation team proposed that they would consult the register of industries in Zambia.

Concerning ambient air quality monitoring, Lemmy Namayanga informed the evaluation team that there had been a first screening study in September 1998 and that the second one was finishing now. NILU had been involved in both screening studies. NO_2 and SO_2 have been sampled in Lusaka, the Copperbelt area, Maamba and Mazabuka and will be analysed in Norway. Doubts about the need of an ambient air pollution monitoring programme for Zambia were raised by the

evaluation team. NILU means that that air pollution monitoring will be a necessary basis for ECZ's work on issuing emission permits and future planning on emission reduction.

3.10 Friday 16 April 1999

Meeting at: NORAD
Present: Gudbrand Stuve NORAD
Cristina Guerreiro

A meeting with Gudbrand Stuve at the NORAD office in Lusaka was held to present the NILU mission and the main outcome of the first and second missions to Zambia. Gudbrand Stuve was given the first mission report (Guerreiro & Sivertsen, 1998).

I insisted on the need of an ambient air monitoring programme for Zambia and on the necessity in establishing a clean chemical laboratory outside ECZ as a first step.

The IPPP project, which began in May 1999, is in its 3rd and last year. An evaluation team has been contracted by NORAD to evaluate the project so far. From this evaluation it is expected an indication of what a second phase of IPPP project should consist of, in case the evaluation team concludes that there should be a second phase. In the middle of May there will be a meeting between SFT and ECZ to discuss the project future, based on the report from the evaluation team. NORAD expects ECZ to deliver a project proposal for a second phase of the IPPP project in Sep-Oct 1999.

Meeting at: Environmental Council of Zambia (ECZ)
Present: From ECZ: Paul Banda, Lemmy Namayanga, Ruth Zimba
From NILU: C. Guerreiro

The results of the two missions to Zambia were presented to P Banda. I stressed once again the importance of establishing an ambient air quality monitoring system for Zambia and the need for a "clean" environmental laboratory as a basis for starting analyses of samples from ambient air. I also stressed the fact that both the Mines Safety Department and ZCCM showed interest in using such a laboratory for their own analysis. Mr. Banda is expecting the conclusions and recommendations from the evaluation team to pronounce himself in this aspect.

After the current evaluation process and meeting SFT in May, Mr. Banda is planning a meeting with NORAD in June to discuss the project proposal for a second phase of the IPPP project.

4 Passive sampling

As part of a second screening study to develop a plan for ambient air pollution monitoring in Zambia, 34 SO_2 and 17 NO_2 passive samplers were placed inside Lusaka, Maamba, Mazabuka, Ndola and around industries in the Copperbelt area. The passive samplers were installed in field to measure ground level

concentrations as a result of emissions from traffic and industry. The location and results from the 32 SO_2 and 15 NO_2 passive samplers that were found and analysed are reported below.

In Lusaka three sites were selected to measure NO_2 and one to measure SO_2; one in the city background area, inside ECZ; a second one in the city centre, near a road with heavy traffic (Lumumba rd.), and a third one, measuring both SO_2 and NO_2, in the city business centre, near the main street (Cairo rd.).

In Mazabuka three sites were selected to measure NO_2 and SO_2 around the Nakambala sugar factory and plantations. Two sites were located in townships, surrounded by sugarcane plantation, and about 500 m north and 1.5 km northeast of the sugar factory. The other site was placed about 1.3 km southwest of the sugar factory, near the office area.

In Maamba 3 sites were chosen to measure SO_2 ambient air concentrations around Maamba Collieries. One site is located inside the industrial area stretching along the valley, between two open pit mines under spontaneous combustion. Another site was located south of the old cool pit field of Kanzinze that has been burning for several years, and about 4 km southwest of the present open pit mine in operation. The third site was placed in a residential area, about 1.6 km southeast, not affected by the main winds which blow along the valley (northeast / southwest).

In Ndola six sites measured NO_2 and SO_2. Two sites were placed in the city centre, one in one of the streets with most traffic and the other at the Savoy hotel. Another site was in the Mukuba hotel, downwind of the INDENI Petroleum Refinery and Bwana Mkubwa Mining. The other three sites were placed around Bwana Mkubwa Mining, two in the industrial area, downwind of the acid plant and one in the agricultural area southwest of the plant.

In Luanshya the smelter was closed. One site was chosen to measure SO_2 and NO_2 in a township near the smelter and to compare the present measurement of SO_2 with the previous one, taken when the smelter was in operation. Another site was chosen to measure NO_2 in the crossing of two main streets in the town centre.

In Nkana seven sites were chosen to measure SO_2 ambient air concentrations around the ZCCM Nkana smelter and the Scaw Zambia Ltd. foundry. The Central Shaft site was located inside the smelter area, about 1 km downwind from the smelter. The Fire brigade site was located about 500 m south of the smelter, on the border between the industrial area and Wusakili township. The Wusakili hospital site is located about 750 m upwind of the smelter, and the Nkana hospital site is located inside the city 1.5 km north of the smelter. The Mumana Clinic site was placed 2 km southeast of the smelter. No residential area is located in the main downwind direction from the industrial area, instead there is a golf court 2-3 km west of the industries. One site was placed in the golf court area. The last site was placed in the Mines Safety Dept. in Kitwe.

In Mufulira five sites measured the SO_2 ambient air concentrations around the ZCCM Mufulira smelter. Four of the sites were located inside townships,

downwind (SW and NW) and at different distances from the smelter. The fifth site was located 4 km upwind of the smelter in a residential area.

In Chingola five sites were selected to measure SO_2 and one to measure NO_2 ambient air concentrations around ZCCM Chingola. The Faith Rise pre-school site was located very close to the leach plant, on the border between Chingola town and the industrial area. Two other sites were located at different distances east of the leach plant, in residential areas. The site of Malemba primary school was placed downwind, about 1.2 km southwest of the plant, and measured both SO_2 and NO_2. This site is also affected by emissions from scrap dealers and copper melting in the close neighbourhood.

Table 2 describes the sampling sites in terms of location, main emission sources, position in relation to the emission sources, measured compounds and sampling periods. The maps in Appendix L give a picture of the spatial distribution of the sampling sites and residential areas in relation to the main sources, for each city.

Table 2: Sampling sites for the SO_2 and NO_2 passive samplers.

City/ Town	Site name (position)	Area	Emission source	Position to emission source	UTM co-ordinates		Passive samplers		Sampling period
					X	Y	SO_2	NO_2	(days)
Mazabuka	Ngamona, house 2	Township / industrial	Nakambala Sugar St.	≈ 1 km NW	583.8	250.6	1	1	20
Mazabuka	Kaleya Clinic	Township / rural	Nakambala Sugar St.	≈ 2 km NE	584.5	251.6	1	1	20
Mazabuka	Kabika	Industrial	Nakambala Sugar St.	≈ 2 km SW	581.7	248.7	1	1	20
Maamba	house of El. Ngwata	Residential	Maamba Collieries	≈ 1.6 km SE	522.3	080.7	1	-	21
Maamba	Substation Kanzinze	Rural/ Industrial	Maamba Collieries	≈ 4 km SW	519.0	078.8	1	-	20
Maamba	Power st.	Industrial	Maamba Collieries	≈ 1km W	519.9	081.7	1	-	20
Lusaka	Cairo rd. (Phonix)	City centre	Traffic	Main road	637.5	295.4	1	1	24
Lusaka	Lumumba rd.	City centre	Traffic	Main road	637.2	295.1	-	1	24
Lusaka	ECZ. church rd.	City backg.			639.4	295.5	-	1	24
Ndola	Bwana Mkubwa train st.	Industrial	Bwana Mkubwa	≈ 1.6 km WNW	683.5	558.4	2	1	11,23,23
Ndola	BDM Na'Andwe Farm pl. 28	Rural	Bwana Mkubwa	≈ 1.2 km SW	684.8	556.9	1	1	21
Ndola	Bwana Mkubwa A6	Industrial	Bwana Mkubwa	≈ 2.4 km NW	684.0	559.8	1	1	21

City/ Town	Site name (position)	Area	Emission source	Position to emission source	UTM co-ordinates		Passive samplers		Sampling period
					X	Y	SO_2	NO_2	(days)
Ndola	Savoy Hotel	City centre	Traffic	Main road	681.3	551.9	1	1	23
Ndola	Ndola Chemists	City centre	Traffic	Main road	681.0	552.5	1	1	22
Ndola	Mukuba Hotel	City/ Ind.	INDENI/ Bwana Mkubwa	≈1.5 km WNW	682.5	558.0	1	1	22
Luanshya	Section 5 clinic	Township / Industrial	RAMCZ (closed)	≈1 km W	650.0	548.3	1	1	23
Luanshya	Zaone-Chachacha cross	City centre	Traffic				-	1	24
Mufulira	Clinic 5	Township / Industrial	ZCCM	≈ 1 km NW	633.2	614.8	1	-	4
Mufulira	Clinic 7	Township / Industrial	ZCCM	≈ 4 km NW	630.5	616.2	1	-	22
Mufulira	Clinic 3	Township/ Industrial	ZCCM	≈ 1 km SW	633.0	613.8	1	-	4
Mufulira	Clinic 2	Township/ Industrial	ZCCM	≈ 2 km SW	632.5	612.7	1	-	22
Mufulira	Clinic 8	Township	ZCCM	≈ 4 km ESE	638.0	612.7	1	-	22
Nkana	Central shaft	Industrial	ZCCM/ Scaw	≈ 1 km NW	630.0	580.9	1	-	3
Nkana	Fire brigade	Industrial/ Township	ZCCM/ Scaw	≈ 0.5 km S	630.9	579.9	1	-	3
Nkana	Mumana Clinic C-7	Township	ZCCM/ Scaw	≈ 2 km SSE	632.6	578.9	1	-	23
Nkana	Wusakili hospital	Township	ZCCM/ Scaw	≈ 0.75 km E	631.6	580.2	1	-	23
Nkana	Nkana hospital	Town	ZCCM/ Scaw	≈ 1.5 km N	630.7	581.8	1	-	23
Nkana	Golf - club 900m east	Leisure	ZCCM/ Scaw	≈ 2.1 km W	628.6	581.5	1	-	23
Kitwe/ Nkana	MSD	Town	ZCCM/ Scaw	≈ 3.5 km N	631.4	583.6	1	-	23
Chingola	Faith Rise pre-sch.	Town/ Industrial	ZCCM	≈ 0.2 km E	593.0	612.8	1	-	20
Chingola	9th st. Clinic	Town	ZCCM	≈ 2 km SE	593.7	612.4	1	-	20
Chingola	Malemba prim. sch.	Township/ Industrial	ZCCM	≈ 1.2 km SW	591.8	612.0	1	1	22
Chingola	Chawama health c.	Township	ZCCM	≈ 3 km SW	591.5	610.3	1	-	22
Chingola	Ms. Chitah house	Residen-tial	ZCCM	≈ 4.5 km ESE	596.8	612.1	1	-	20

4.1 Measured concentrations

The passive SO_2 and NO_2 samplers were brought to NILU for analysis. The results from the analysis are presented in Table 3.

Table 3: Measured ground level daily concentrations averaged over the sampling period.

Sampling period				Site name (position)	UTM co-ordinates		Concentration (µg/m³)	
From:		To:			X	Y	SO_2	NO_2
date:	hr:	date:	hr:					
8.4.99	12:25	28.4.99	12:20	Mazabuka. Ngamona. house 2	583.8	250.6	10	5
8.4.99	12:42	28.4.99	12:35	Mazabuka. Kaleya Clinic	584.5	251.6	3	3
8.4.99	12:58	28.4.99	12:55	Mazabuka. Kabika	581.7	248.7	1	2
8.4.99	17:45	29.4.99	08:55	Maamba. house of Elpher Ngwata	522.3	080.7	2	-
9.4.99	10:50	29.4.99	16:07	Maamba. Substation Kanzinze	519.0	078.8	8	-
9.4.99	11:05	29.4.99	12:10	Maamba. Power station	519.9	081.7	20	-
10.4.99	10:00	3.5.99	09:40	Ndola. Bwana Mkubwa train st.	683.5	558.4	NR*	-
10.4.99	11:45	3.5.99	09:37	Ndola. Bwana Mkubwa train st.	683.5	558.4	-	2
22.4.99	14:10	3.5.99	09:38	Ndola. Bwana Mkubwa train st.	683.5	558.4	36	-
10.4.99	12:12	1.5.99	12:02	Ndola. BDM Na'Andwe Farm. 28	684.8	556.9	NR*	1
10.4.99	13:00	1.5.99	12:35	Ndola. Bwana Mkubwa A6	684.0	559.8	8	2
10.4.99	15:10	3.5.99	11:08	Ndola. Savoy Hotel	681.3	551.9	8	8
11.4.99	08:40	3.5.99	10:20	Ndola Chemists. Mr. Kosavi	681.0	552.5	8	10
11.4.99	09:10	3.5.99	09:55	Ndola. Mukuba Hotel	682.5	558.0	18	2
11.4.99	11:50	4.5.99	19:14	Luanshya. Section 5 clinic	650.0	548.3	<1	3
11.4.99	12:25	5.5.99	13:50	Luanshya. Zaone-Chachacha cr.			-	5
12.4.99	10:47	5.5.99	15:06	Nkana hospital	630.7	581.8	48	-
12.4.99	11:35	5.5.99	15:14	Nkana. golf club 900m east	628.6	581.5	188	-
12.4.99	11:50	15.4.99	09:15	Nkana. Central shaft	630.0	580.9	2330	--
12.4.99	12:00	15.4.99	09:30	Nkana. Fire brigade	630.9	579.9	6	-
12.4.99	12:10	5.5.99	14:58	Nkana. C-7 Mumana Clinic	632.6	578.9	<1	-
12.4.99	12:20	5.5.99	14:49	Nkana. Wusakili hospital	631.6	580.2	5	-
12.4.99	13:05	5.5.99	15:35	Kitwe. Mines Safety Dep.	631.4	583.6	4	-
13.4.99	11:14	17.4.99	14:30	Mufulira. Clinic 5	633.2	614.8	524	-
13.4.99	11:28	5.5.99	17:20	Mufulira. Clinic 7	630.5	616.2	94	-
13.4.99	11:42	17.4.99	14:21	Mufulira. Clinic 3	633.0	613.8	105	-
13.4.99	11:49	5.5.99	17:40	Mufulira. Clinic 2. Kariba st.	632.5	612.7	14	-
13.4.99	12:41	5.5.99	17:05	Mufulira. Clinic 8	638.0	612.7	1	-

Sampling period				Site name (position)	UTM co-ordinates		Concentration (µg/m3)	
From:		To:			X	Y	SO_2	NO_2
date:	hr:	date:	hr:					
14.4.99	10:12	4.5.99	16:23	Chingola. Faith Rise pre-sch.	593.0	612.8	37	-
14.4.99	10:25	4.5.99	16:30	Chingola. 9th st. Clinic	593.7	612.4	28	-
14.4.99	10:55	6.5.99	12:20	Chingola. Malemba prim. sch.	591.8	612.0	40	5
14.4.99	11:25	6.5.99	12:35	Chingola. Chawama health c.	591.5	610.3	NR*	-
14.4.99	11:50	4.5.99	16:39	Chingola. Ms. Chitah house	596.8	612.1	30	-
16.4.99	13:42	10.5.99	10:04	Lusaka. Cairo rd. (Phoenix)	637.5	295.4	21	20
16.4.99	15:12	10.5.99	10:12	Lusaka. Lumumba rd.	637.2	295.1	-	19
16.4.99	15:40	10.5.99	08:55	Lusaka. ECZ. church rd.	639.4	295.5	-	9

*NR: Non reliable result in analysis.

4.2 Air quality guidelines

The air quality guidelines for SO_2 and NO_2 from the Norwegian Pollution Control Authority (SFT, 1992) and World Health Organisation (WHO) are given in Table 4.

Table 4: Air quality guidelines for SO_2 and NO_2. Unit: µg/m³.

Component	Control Authority	Period		
		24 h	6 months	Year
SO_2 health	WHO	125		50
SO_2 vegetation	WHO	100		30
NO_2 health	WHO	150		
NO_2 vegetation	WHO			30
SO_2 health	SFT	90	40	
SO_2 vegetation	SFT	50		20
NO_2 health	SFT	75	50	
NO_2 vegetation	SFT			30

4.3 Discussions and conclusions

The averaging time of the measured concentrations corresponds to the sampling time, which was for the majority of the sites between 20 and 24 days. Exceptions were made for 4 sites, where the sampling time was 3 to 4 days, due to the high ambient air concentrations expected. The measured concentrations are compared both with the 24 hours averaging time guideline, which represents a non-conservative comparison, and with the 1 year guideline, which represents a conservative comparison.

In Mazabuka SO_2 and NO_2 concentrations were measured at 3 sites. The measured concentrations for both compounds are low, but higher than background concentrations, indicating some emissions in the area. The highest SO_2 and NO_2

concentrations, 10 and 5 $\mu g/m^3$, respectively, were measured at Ngomona site, about 1 km northwest of the sugar factory.

In Maamba, 3 sites measured SO_2 concentrations. In this area the wind blows along the valley (SW-NE), predominantly from NE. The site located in a residential area, outside the main wind directions, about 1.6 km southeast of an open pit mine under spontaneous combustion, measured a typically SO_2 background concentration of 2 $\mu g/m^3$. The other two sites were located along the valley, downwind of the open pit mine under spontaneous combustion. The closest site, about 1 km west of the mine, measured 20 $\mu g/m^3$ of SO_2, clearly indicating the existence of SO_2 emissions in the area. The third site, located further downwind of the mine, about 4 km southwest, measured as expected a lower concentration of SO_2 (8 $\mu g/m^3$). All measured concentrations were well under the air quality guidelines, both for daily and one year average. Nevertheless, under light stable and stable conditions, occurring most frequently during the winter and night time, high concentrations of SO_2 may occur several kilometres downwind of the open pit mines under spontaneous combustion.

At the two sites in Ndola city centre the measured SO_2 concentrations indicate that there are emissions of SO_2 in the area. The background concentration in the Copperbelt area is expected to be higher than in Lusaka, due to the industrial activity that characterises this area, but not as high as 10 $\mu g/m^3$. The concentration measured at the Mukuba hotel, located 1.5 km west-northwest of the INDENI Petroleum Refinery and about 2.5 km west of Bwana Mkubwa, indicate emissions of SO_2 in the area and the possible occurrence of episodes with high SO_2 concentrations, depending on the emissions from INDENI and Bwana Mkubwa and the wind direction. The concentration measured from 22/4/99 to 3/5/99 at Bwana Mkubwa train station, about 1.6 km downwind from Bwana Mkubwa acid plant, indicates emissions of SO_2 in the area. This sampling period occurred immediately after the testing of the new cooler, during which large amounts of SO_x were emitted from the cooler, as a low fugitive source. The analysis of the sampler that should have sampled SO_2 during the last days of the testing period (from 10/4/99) gave non-reliable results. The same happened with the sampler placed in a farm, about 1.2 km southwest of Bwana Mkubwa acid plant. The sampler placed at Bwana Mkubwa A6, about 2.4 km northwest of the acid plant, gave the same level of SO_2 concentration as the background concentration measured in the centre of Ndola, probably due to the seldom occurrence of winds from south and southeast during the sampling period.

The highest NO_2 concentrations in Ndola were measured in the city centre, due to the traffic, but they are still well below the WHO air quality guideline for health. The Concentrations measured at the other 4 sites in Ndola were very low; typically background concentrations, indicating no exposure to traffic or to other NO_2 sources in the area. The NO_2 measurement at Mukuba hotel, about 1.5 km downwind of INDENI Petroleum Refinery would be expected to be higher if the refinery re-opened during the sampling period, after the shutdown period during ECZ visit the 10 April 1999.

In Luanshya the SO_2 concentration measured was very low, as expected, due to the temporary shutdown of the smelter. The 2 NO_2 concentrations measured in

Luanshya were very low. The NO_2 concentration at Zaone - Chachacha crossroad was higher due to the traffic.

In Nkana, as opposed to Mufulira, there are no townships in the main downwind direction from the industrial area. The measured SO_2 concentration in the Central shaft site, inside the smelter's area, is extremely high (2330 µg/m³), due both to the proximity of the smelter and to the fact that the wind blew much more often to its direction, than to the Fire Brigade site or to the Wusakili hospital site. These measurements indicate that in the periods the wind blows from south or from northwest, Nkana West and Wusakili, respectively, will be exposed to very high concentrations of SO_2. This was not the case during the 3 days of measurements at the Central shaft and at the Fire brigade, neither during the 23 days sampling period for the other sites. The SO_2 concentration measured over 23 days at the Nkana hospital site was close to the WHO air quality guideline for one year average. The measuring site located in the Golf camp, in the main downwind direction, 2.1 km from the smelter, registered a high SO_2 concentration of 188 µg/m³, above WHO air quality guidelines for daily and one year average.

In Mufulira the measured SO_2 concentrations indicate that there are very large emissions of SO_2 in the area. The sites located 1 km from the source in the northwest and southwest directions, both inside townships, measured 524 and 105 µg/m³ SO_2, respectively. The first concentration is 4 times higher than the WHO air quality guideline for health of 125 µg/m³ for 24 hours and 10 times higher than the guideline for one year, while the second is close to the guideline for 24 hours and 2 times higher than the guideline for one year. The SO_2 concentration dropped as expected between 1 and 4 km from the source along the northwest direction, probably due to the importance of the fugitive emissions for the measured concentrations close to the source. Nevertheless, the concentration measured 4 km northwest of the smelter is still considerably high. It is close to the WHO air quality guideline for 24 hours and above the guideline for one year. The site located 2 km southwest of the smelter measured a much lower concentration than the one at 1 km distance from the source. This difference is probably due both to the higher distance from the source and to the location about 10 degrees further east (see location of sampling sites in appendix L). The Clinic 8 site is located about 4 km upwind of the smelter, giving an extremely low background concentration of SO_2 for Mufulira, most probably not representative for the year.
In Chingola the measured SO_2 concentrations indicate that there are emissions of SO_2 in the area. The SO_2 concentration measured at Faire Rise pre-school site, located about 200 m east of the tank of the tailings leach plant, was expected to be higher, due to the proximity of the tank. Nevertheless, in days with stationary winds from west, it is likely to register SO_2 concentrations above the WHO air quality guidelines at this site. The SO_2 concentrations measured 2 km southeast and 4.5 km east-southeast of the plant were 28 and 30 µg/m³, respectively. The similarity in concentration level between the two sites, despite the distance to the source, may be explained by the fact that the closest site is still influenced by the low emissions from the tank of the tailings leach plant, while the other site is more exposed to the concentrator stack emissions. The Malemba primary school site registered the highest concentration of SO_2, 40 µg/m³, and a NO_2 concentration of 5 µg/m³. This site is very close to an open-air scrap depot, where copper is melted. The emissions from such local activities contribute to higher SO_2 and NO_2

concentrations than would be expected if only the plant emissions and the low local traffic activity would be considered.

The SO_2 concentration measured at Cairo rd. in Lusaka indicates some SO_2 emission source in the neighbourhoods. SO_2 background concentrations in Lusaka are expected to be lower, probably under 5 $\mu g/m^3$, as measured in October 1998 (Guerreiro and Sivertsen, 1998). The measured NO_2 concentrations indicate traffic emissions, specially at Cairo rd., in the city business centre, and at Lumumba rd., with heavy traffic.

5 Updated proposal to the Ambient Air Pollution Measurement Programme for Zambia.

5.1 Objectives and scope of work

The main objective of this programme is to provide support to ECZ to enable the establishment of an ambient air pollution measurement programme for Zambia.

To meet this objective several sub-objectives are defined as input to the description of tasks:

- Establish background at ECZ for ambient air pollution measurements and reporting,
- Select laboratory for chemical analyses,
- Procure instruments and equipment,
- Undertake training of ECZ and laboratory personnel,
- Perform ambient air quality measurements in Zambia,
- Plan and perform measurement quality assurance,
- Establish database, data handling and reporting.

The plan presented below is a design proposal for a simple air quality measurement programme in Zambia. A complete programme for its establishment is described in the Appendix P of the mission report NILU OR 61/98.

To meet the objectives of this programme, several tasks and sub-tasks have been identified. These have been further defined in the Appendix P of the mission report NILU OR 61/98. The main tasks are:

- Institutional support,
- design of monitoring programme,
- establishment of an environmental laboratory,
- procurement of equipment,
- training,
- measurement programme,
- quality assurance (QA/QC),
- data management.

5.2 Design of ambient air pollution measurement programme

As a background for designing an ambient air pollution measurement programme visits were paid to the major industries and screening studies were undertaken using simple samples for measurements of SO_2 and NO_2. Emission sources, prevailing wind directions, existing measurements and potential impact areas have been evaluated and discussed as an input to the programme.

The visits to the industries in the Copperbelt area have been described in the Mission report NILU OR 61/98 and in the present report. These reports together with the results of the passive sampling (NILU OR 63/98 and NILU OR 43/99) represent the background for the design of a measurement programme.

5.2.1 Criteria for selection of representative sampling sites and air quality indicators

The following criteria represent the basis for the selection of the sampling sites:

- locate sampling sites in the expected highest impacted areas downwind from industrial sources,
- undertake sampling in areas with dense population,
- measure close to streets and roads with high traffic load.

Based on these criteria a critical selection of the sites must be undertaken, due to the scarcity of instruments.

Different air pollution indicators will be measured at the different sites dependent on the specific sources and the problems at that site.

The first priority air pollutants as presented by UNEP/GEMS, WHO, OECD and others are:

- Sulphur dioxide (SO_2),
- Total suspended particular matter (TSP), or better PM_{10} (suspended particles with a diameter less than 10 micrometers),
- Nitrogen dioxide (NO_2) and nitrogen oxides (NO_x).

At some sites also dust fall could be measured on a weekly basis with simple dust fall collectors.

Meteorological data will be needed to explain the air quality data collected. Wind speeds, wind directions, temperature and atmospheric turbulence (stability) are the most important parameters.

5.2.2 Existing monitoring stations and data

Existing air quality monitoring stations

A few measurement stations have been operated by ZCCM at Nkana and Mufulira and some sporadic measurements have been undertaken by the Mines Safety Department (MSD) in different industrial areas in the Copperbelt. Results from these measurements indicated that the impact downwind from some of the

smelters has been considerable ((Guerreiro and Sivertsen, 1998, Appendix I and J). Diurnal and monthly average concentrations at some sites exceeded the World Health Organisations (WHO, 1987) air quality guideline values as well as the Zambian air quality standards (Government of Zambia, 1996) with a factor of 5 to 10.

The sampling method used by ZCCM and MSD was adequate, but the chemical analytical method of determining total acid in an absorption solution may give too low SO_2 concentrations, as shown in Table 1.

Existing meteorological stations

ZCCM has been operating two automatic meteorological stations, located in Mufulira and Nkana. With some upgrading and routine calibrations of the two ZCCM meteorological stations, ECZ could use the collected data to represent the meteorological conditions in the Copperbelt area.

Measurements with passive samplers

SO_2 is particularly a *problem* in the Copperbelt area, due to the high industrial activity that characterises this area. The World Health Organisation's (WHO) air quality guideline for SO_2 for 24 hours average is exceeded in Mufulira and Nkana, downwind from the smelters (Guerreiro, 1999). In Luanshya the same guideline was also exceed in 1998, downwind from the smelter, but the smelter has been closed in 1999 for renovation and a substantial reduction on the SO_2 emissions is expected after the construction of an acid plant. While in Luanshya and Mufulira the high SO_2 concentrations can have a very serious impact on both vegetation and population leaving downwind from the smelters, in Nkana the population is less often exposed to extremely high SO_2 concentrations, since the townships are not located on the prevalent downwind direction from the industry.

The SO_2 ambient air concentrations measured in Maamba, Ndola and Chingola were below the WHO air quality guidelines for both 24 hours and one year. Nevertheless, under episodes with high local emissions of SO_2 and / or poor meteorological dispersion conditions in these areas, high concentrations of SO_2 are likely to occur in neighbouring areas, exceeding the WHO air quality guidelines.

The measured NO_2 concentrations are well below the WHO air quality guideline for 24 hours average and do not represent presently a major motive of concern.

5.2.3 Preliminary proposed monitoring programme for Zambia

The final objectives of an ambient air quality monitoring programme should be to enable ECZ to use the data for planning purposes, and to indicate strategies to reduce the air pollution load.

As a starting point we propose that the air quality measurement programme will include:

- The establishment of an environmental laboratory,

- dust fall measurements in the surroundings of cement and lime stone industries,
- 5 sequential samplers for SO_2, NO_2 and PM10 (after the establishment of the lab.),
- upgrading the two ZCCM meteorological stations and installing an AWS meteorological station in Lusaka.

5.2.3.1 Lusaka

One curbside station should be installed in Lusaka business centre, in one of the streets with most traffic. This station should be equipped with a sequential sampler, measuring SO_2, NO_2 and PM10, in order to monitor the traffic, industrial and domestic pollution characterising the ambient air quality in the city centre.

As part of the monitoring program an automatic weather stations (AWS) should be established in Lusaka, to characterise the meteorological conditions in this part of the country and to unable the interpretation of the air quality measurements.

5.2.3.2 Ndola

In Ndola, one industrial site should be placed near the Mukuba hotel, downwind of Bwana Mkubwa Mining and INDENI Petroleum Refinery, at the edge of the townships in the south of Ndola. This station should be equipped with a sequential sampler, measuring SO_2, NO_2 and PM10, in order to monitor the pollution coming from these two industrial sources. Bwana Mkubwa Mining emissions are mainly characterised by SO_2, while INDENI refinery emits mostly NO_x, in addition to SO_2 and particles.

An inexpensive and simple way of monitoring dust around Ndola Lime Company and Chilanga Cement factory in Ndola is to place some particulate fallout collectors around the lime and cement factories and in Itawa township, about 3 km downwind from the plants. Dust fall could be measured on a weekly basis in the environmental laboratory.

5.2.3.3 Mufulira

ZCCM is operating four sampling stations in townships around the smelter, equipped with sequential samplers of SO_2. The stations presently in operation are: Clinic 3, Clinic 5, Clinic 7 and Clinic 8, as indicated in the map of Mufulira in Appendix L. The samplers collected at these 4 sampling sites can be used, but the chemical analysis to determine SO_2 concentrations should be done by ion chromatography, instead of by determination of total acidity, correctly in practise. ZCCM could send their samples to the environmental laboratory, when in operation, for such analysis.

One sequential sampler measuring SO_2, NO_2 and PM10, should be operated by ECZ, in addition to the four ZCCM sequential samplers. This sampler would unable the monitoring of NO_2 and PM10 and would serve as a control for one of the ZCCM measurements of SO_2. It could be placed in Clinic 3, located in a township about 1 km downwind of the smelter, which is the site registering the highest SO_2 concentrations.

ZCCM has also been operating an automatic meteorological station, located at one of the clinics near the smelter in Mufulira. With some upgrading and routine calibrations, the meteorological data collected at this station could be used by ECZ in the future Ambient Air Pollution Measurement Programme.

5.2.3.4 Nkana

ZCCM is also operating four sampling stations, equipped with sequential samplers of SO_2, in the industrial area and townships around the smelter in Nkana. The stations presently in operation are: Fire Brigade, Central Shaft, Nkana Hospital and Wusakile Hospital, as indicated in the map of Nkana (Kitwe) in Appendix L. The samplers collected at these 4 sampling sites can be also used, but again the chemical analysis to determine SO_2 concentrations should be done by ion chromatography.

One sequential sampler measuring SO_2, NO_2 and PM_{10}, should be operated by ECZ, in addition to the four ZCCM sequential samplers. This sampler would unable the monitoring of NO_2 and PM10 and would serve as a control for one of the ZCCM measurements of SO_2 in Nkana. It could be placed at the Nkana Hospital, in Nkana West, about 1.5 km north of the smelter. This site has not measured the highest SO_2 concentrations around the smelter, but it is placed in a residential area inside the town and it has measured daily average concentrations above the WHO air quality guideline.

ZCCM has also been operating an automatic meteorological station in Nkana. With some upgrading and routine calibrations, the meteorological data collected at this station could be used by ECZ in the future Ambient Air Pollution Measurement Programme. This meteorological station and the one in Mufulira should be enough to represent the meteorological conditions in the Copperbelt area.

5.2.3.5 Luanshya

In Luanshya, one sampling station should be placed at Section 5 clinic, where the highest SO_2 concentration was measured in September 1998 (Guerreiro and Sivertsen, 1998), while the smelter was in operation. Section 5 clinic is located about 1 km downwind of RAMCZ smelter, in Roan township (see map for Luanshya in Appendix L). This station should be equipped with a sequential sampler, measuring SO_2, NO_2 and PM_{10}, in order to monitor the pollution coming from the smelter after its reopening.

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Appendix A

List of people

List of people met during the mission

NILU: Cristina Guerreiro

NORAD: Gudbrand Stuve

ECZ:

Air quality unit: Lemmy Namayanga, Ruth Zimba

Water quality unit: Douglas Nkolonganya

Chief inspector: Paul Banda

Nakambala Sugar Estates: John Zulu (served officer), Israel Zandonda (environmental officer).

Maamba Collieries Limited: Mr. O. Lee Davey (managing director), Mr. Elpher Ngwata (technical services superintendent).

Bwana Mkubwa Mining Limited: Mr. A. Scott (company secretary).

INDENI: Mr. Nioka (Plant section head), Mr. Harry Moamza (Process engineer).

Chilanga Cement: Mr. H. K. Mwenya (Works technical manager).

RAMCZ: Naz S Phiri (Head of Environmental Services), Mr. Moyo (smelter resp.), Mr. John Nghlowo (ventilation engineer), Mr. Sloya (Laboratories), Mr. Kapaluska (Env. Service).

ZCCM Nkana: Mr. Alexie Npishi (DESO), Mr. Mathews Chunga Mwale (Environmental off.).

Mines Safety Department: Mr. Godfrey C. Kabilo (Director), Mr. Henry C. Mutafya (Inspector of Environment).

ZCCM Mufulira: Mr. James Kalowa, Mr. Vincent K. Chalwe, Mr. Chipangano G. Zulu (chemist).

ZCCM Chingola: Mrs. Sampa A. B. N. Chitah (Divisional Environment Services Officer).

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H. K. MWENYA
WORKS TECHNICAL MANAGER

CHILANGA CEMENT PLC

NDOLA WORKS
P.O. Box 71572
Cleveland Park
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Tel: 260 02 611938/41
Telegrams: "Cement" Ndola
Telex: ZA 33421 Fax: 615620/21

Appendix B

Programme for the visit

Date	Activities
Wednesday 7/4	Arrival to Lusaka (12.15). Meeting with ECZ to discuss the programme.
Thursday 8/4	Meeting with Nakamballa Sugar Estates Location of passive samplers in Mazabuka Measure PM10 concentrations during an open air burning
Friday 9/4	Meeting with Maamba Collieries Limited Location of passive samplers in Maamba Travel to Ndola.
Saturday 10/4	Meeting with Bwana Mkubwa Mining Limited, Indeni Refinery Officials, Ndola Lime and Chilanga Cement. Location of passive samplers around the industrial area and in Ndola. Screening of PM10 levels near the cement and lime factories.
Sunday 11/4	Location of passive samplers in Luanshya (RAMCZ). Travel to Kitwe.
Monday 12/4	Location of passive samplers in Nkana and Kitwe. Meeting at ZCCM Nkana.
Tuesday 13/4	Location of passive samplers in Mufulira. Meeting at ZCCM Mufulira.
Wednesday 14/4	Location of passive samplers in Chingola. Meeting at ZCCM Nkana - Chingola.
Thursday 15/4	Travel to Lusaka. Meeting with the IPPP programme evaluators at ECZ
Friday 16/4	Meeting at NORAD. Meeting ECZ & NILU Locate passive samplers in Lusaka. Summing up, conclusions.
Saturday 17/4	Work on mission report
Sunday 18/4	Departure from Lusaka

Appendix C

Purpose of the mission

Ambient Air Pollution Measurement programme for Zambia

Second Mission to Zambia

1. Introduction

NILU was asked by Norwegian State Pollution Control Authority (SFT) for support in defining the ambient air pollution component of the Industrial Pollution Prevention Programme (IPPP) operated by the Environmental Council of Zambia (ECZ).

A second mission to Zambia is planned for April 1999 to perform a second screening study of the existing ambient air quality and to make the final design of a measurement programme for ambient air quality measurements in Zambia.

2. Objectives

The main objectives of this programme are to provide support to ECZ to enable the establishment of an ambient air pollution measurement programme for Zambia.

This second mission has the following sub-objectives:

- Undertake training of ECZ personnel in the use of passive samplers and reporting,
- Perform ambient air quality measurements in Zambia with passive samplers,
- Design an air pollution monitoring programme for Zambia,
- Reporting.

3. Tasks

Short descriptions of the different tasks are presented in the following.

3.1 A. Institutional support

The institutional support programme aims at establishing a trained group of experts at ECZ and at a national laboratory for environmental analyses for undertaking the measurements and the analyses of ambient air pollution in Zambia.

ECZ experts will be trained in using the passive samplers for field measurements of SO_2 and NO_2 and to design a simple air quality measurement programme for Zambia. Measurements will be performed in the Copper-belt area and in Lusaka.

A chemical laboratory in Zambia, capable of performing analyses of ambient samples of air and water at low concentrations, should also be identified during this mission. This will be done taking into account the five laboratories visited during the first Mission to Zambia in September/October 1998 (NILU OR 61/98)

and the fact that such an environmental laboratory should be established outside ECZ and preferably not be part of the industry.

3.1 B. Perform ambient air quality measurements in Zambia with passive samplers and collect meteorological data.

As a background for designing an ambient air pollution measurement programme a second screening study will be undertaken using simple samples for measurements of SO_2 and NO_2. These samples must be taken back to NILU for analyses, since an environmental laboratory in Zambia is not yet established.

For passive samples a similar approach as the one used in September 1998 will be further evaluated;

- locate samples in the expected highest impacted areas downwind from the sources, perform control samples upwind from major sources,
- undertake sampling in areas with dense population,
- collect samples in urban areas and residential areas,
- measure close to highly trafficked streets and roads.

Screening measurements of PM10 levels near the cement and lime factories in Ndola will be undertaken with a portable screening type instrument.

Meteorological data must be collected, preferably for a whole year and for the period of exposure of the passive samplers. Two actual meteorological stations with good hourly data are placed at Mufulira and Nkana and are owned and run by ZCCM.

3.1 C. Design ambient air pollution measurement programme

The passive sampling undertaken in September 1998 (Guerreiro and Sivertsen, NILU OR 63/98) will be used in the detailed design of the measurement programme, together with meteorological data and some simple modelling. Emission sources and potential impact areas will also be evaluated and discussed as input to the design of the measurement programme.

The sampling programme will include descriptions of:

- Sampling sites,
- instruments at each site,
- averaging times,
- sampling periods,
- data retrieval procedures and frequencies.

A meeting with NORAD and ECZ will be held during this mission to Zambia in order to discuss and plan the following points:

1. Next phase of the project,
2. Establishment of laboratory,
3. Purchase of instruments.

The selection of representative sites and the final monitoring programme design will be finalised after the Mission and when the final decisions concerning budgets and the establishment of a laboratory has been decided.

3.1 D. Reporting

The results of the screening study and a proposed final design for the monitoring programme in Zambia will be reported. A Mission report with the visits, collected information, conclusions and proposition for future work also be available after the Mission.

3.1 E. Project management

The project management includes the preparation, travels between Norway and Zambia, meetings and reporting and chemical analysis at NILU.

Meetings and correspondence are included in the project management and project support. However, much of this type of work, such as meetings with SFT and preparations of workshops and seminars, will not appear in the cost estimates.

4. Cost estimates

The cost estimate for the second mission is given as follows:

Month	Year	Description	Units	Costs (1000 NOK)
April	1999	Passive samplers (SO_2)	40	7
		Passive samplers (NO_2)	20	3,5
		Preparation (man hours)	20	15
		Travel hours (man hours)	24	17,5
		Field study (man hours)	88	64
		Reporting (man hours)	30	22
		Support, travels and transport		25
		Total		**154**

Appendix D

Application for Permit to Emit Air Pollutants for Zambia Sugar PLC

FORM AP3

SECOND SCHEDULE

(Regulation10)

PRESCRIBED FORMS

REPUBLIC OF ZAMBIA

ENVIRONMENTAL COUNCIL

THE AIR POLLUTION CONTROL (LICENCING AND EMISSION STANDARDS) REGULATIONS, 1996

APPLICATION FOR PERMIT TO EMIT AIR POLLUTANTS

(To be completed in triplicate)

To: The Chief Inspector (Pollution Control)
Environmental Council of Zambia
P.O. BOX 35131
Lusaka

1. Name and address of applicant ZAMBIA SUGAR PLC, P.O. BOX 670246, NAKAMBALA ESTATE, MAZABUKA.
Tel 30666 Fax 30116

2. Location of Plant/activity NAKAMBALA ESTATE

3. Type(s) of activity (eg copper mining, cement manufacture etc) SUGAR PRODUCTION

4. Name(s) of department(s)/section(s)/unit(s) where air emissions occur FACTORY DEPARTMENT, BOILER SECTION

5. Name(s) and type(s) of raw materials used in the process(es) SUGAR CANE

6. Amount of each raw material used yearly (kg) 1,600,000 TONS

7. Name(s) and types of products REFINED SUGAR, HOUSEHOLD SUGAR

8. Sources of air emissions BOILER STACKS

9. Name(s) and type(s) of air pollutants PARTICULATE MATTER, CARBON MONOXIDE, CARBON DIOXIDE

10. Rate of emission of each air pollutant discharged into the ambient air (kg/h,ton/yr) NO DATA

11. Concentration of each air pollutant discharged into the ambient air ($\mu g/m^3$,mg/m^3,ppm etc) NO DATA

12. Energy source used (eg coal, diesel etc) BAGASSE

13. Amount of each energy source used yearly (kg)---- 489,648 TONS

14. Amount of each energy source used per day (kg) ---- 2,400 TONS

15. Type of production operation (continuos or intermittent)---- CONTINUOUS FOR EIGHT MONTHS

16. Total number of hours of operation (per day, per week, per month, per year)---- 24 HOURS/DAY FOR 200 DAYS PER YEAR.

17. Number of stacks in operation---- THREE

18. Physical stack height for each (m)---- BOILER (1+2) = 25 m, BOILER 3 = 23.5 m, BOILER (4+5) = 28 m

19. Stack gas volume for each (m^3/s, m^3/h)---- NO DATA

20. Internal stack diameter at gas exit level for each (m)---- BOILER No. 3 (2.134 m)

21. Stack gas exit temperature for each (°C)---- 90°C

22. Exit gas velocity at each stack (m/s)---- NO DATA

23. Pollution control technology in operation /to be employed---- MECHANICAL GRIT COLLECTOR

24. Reliability of the pollution control technology ---- 70%

25. How often do you conduct maintenance of the installation?---- ONCE A YEAR

26. When was/were the Plant(s)/process(es) installed?---- BOILERS 1,2 = 1966, BOILER 3 = 1968, BOILER 4 = 1976, BOILER 5 = 1985.

27. Expected life time of the Plant(s)/installation(s)---- MORE THAN TWENTY YEARS.

28. How is the potential to produce other air pollutants? Name the pollutants---- NIL

LEVELS OF EMISSIONS (complete parts only relevant to your organisation)

Industry/process	*Parameter*	*Emission level*
COPPER PRODUCTION		
29. Smelters and converters	Sulphur dioxide(SO_2)	-------mg/Nm^3
	Dust	--------mg/Nm^3
30. Coal preparation	Dust	--------mg/Nm^3
31. Ore concentrator dryer	Dust	--------mg/Nm^3
	SO_2	--------mg/Nm^3
CEMENT AND LIME PRODUCTION		
32. Cement production	Dust	--------mg/Nm^3
33. Lime production	Dust	--------mg/Nm^3
NITRIC ACID AND SULPHURIC ACID PRODUCTION		
34 Nitric acid production	NO_X as NO_2	--------kg/day
35. Sulphuric acid production	SO_2	--------kg/day
FERTILIZER PRODUCTION		
36. Ammonium nitrate production	Dust	--------kg/day
37. Coal treatment	Dust	--------kg/day
38. NPK production	Dust	--------kg/day

COMBUSTION UNITS

39. Oil fired, < 50MW(1)	Dust	-------mg/Nm^3
	SO_2	-------mg/Nm^3
	CO	-------mg/Nm^3
40. Coal fired, <10MW(2)	Dust	-------mg/Nm^3
	SO_2	-------mg/Nm^3
	CO	-------mg/Nm^3
41. Coal fired, 10-50 MW(2)	Dust	-------mg/Nm^3
	SO_2	-------mg/Nm^3
	CO	-------mg/Nm^3
42. BAGASSE - FIRED	DUST	NO DATA
	CO	NO DATA

OTHER PROCESSES/UNITS

CONSTANCE DEWAN (MRS)

Name

Signature

Designation/title ENVIRONMENTAL MANAGER

Date: 6th January, 1999.

(1). The limits shall be normalised to 273K at 101.3Pa and 3 vol,-% O_2

(2). The limits shall be normalised to 273K at 101.3Pa and 7 vol,-% O_2

FOR OFFICIAL USE ONLY

Application received _____ Fee paid _____

_____

Chief Inspector (Pollution Control)
Environmental Council of Zambia
Inspectorate

Appendix E

Application for Permit to Emit Air Pollutants for Bwana Mkubwa Mining Ltd.

FORM AP5

SECOND SCHEDULE

(Regulation10)

PRESCRIBED FORMS

REPUBLIC OF ZAMBIA

ENVIRONMENTAL COUNCIL

THE AIR POLLUTION CONTROL (LICENCING AND EMISSION STANDARDS) REGULATIONS, 1996

APPLICATION FOR PERMIT TO EMIT AIR POLLUTANTS

(To be completed in triplicate)

To: The Chief Inspector (Pollution Control)
Environmental Council of Zambia
P.O. BOX 35131
Lusaka

1. Name and address of applicant BWANA MKUBWA MINING LTD
BOX 71785 NDOLA
Tel 655393 Fax 655399

2. Location of Plant/activity BWANA MKUBWA / EXTRACTION OF COPPER AND MANUFACTURING OF SULPHURIC ACID

3. Type(s) of activity (eg copper mining, cement manufacture etc) (a) EXTRACTION OF COPPER
(b) MANUFACTURING OF SULPHURIC ACID

4. Name(s) of department(s)/section(s)/unit(s) where air emissions occur ACID PLANT

5. Name(s) and type(s) of raw materials used in the process(es) SULPHUR

6. Amount of each raw material used yearly ~~(kg)~~ TONNE 36000

7. Name(s) and types of products 98% SULPHURIC ACID

8. Sources of air emissions ACID PLANT GAS COOLER (FUGITIVE DUE TO EQUIPMENT FAILURE)

9. Name(s) and type(s) of air pollutants SULPHUR DIOXIDE

10. Rate of emission of each air pollutant discharged into the ambient air (kg/h ~~ton/yr~~) 833 SULPHUR IN THE FORM OF SO_2

11. Concentration of each air pollutant discharged into the ambient air (~~ug/m³, mg/m³, ppm etc~~) 19 g/m³

12. Energy source used (eg coal, diesel etc) ELECTRIC BOILER
EXOTHERMIC REACTION

13. Amount of each energy source used yearly (kg)---NIL---

14. Amount of each energy source used per day (kg) ---

15. Type of production operation (continuos or intermittent)---CONTINIOUS---

16. Total number of ~~hours~~ DAYS of operation (per day, per week, per month, per year)---50 DAYS---

17. Number of stacks in operation---ONE---

18. Physical stack height for each (m)---75 m.---

19. Stack gas volume for each (m^3/s, m^3/h)---44 000 nm^3 / hr---

20. Internal stack diameter at gas exit level for each (m)---

21. Stack gas exit temperature for each (°C)---350 °C.---

22. Exit gas velocity at each stack (m/s)---10 - 12 m/s---

23. Pollution control technology in operation /to be employed---N/A. (NIL EMISSION)---

24. Reliability of the pollution control technology ---N/A---

25. How often do you conduct maintenance of the installation?---PLANNED :- ONCE PER YEAR.---

26. When was/were the Plant(s)/process(es) installed?---COMMISSIONED :- JANUARY 1998---

27. Expected life time of the Plant(s)/installation(s)---10 (TEN) YEARS---

28. How is the potential to produce other air pollutants? Name the pollutants---NONE---

LEVELS OF EMISSIONS (complete parts only relevant to your organisation)

Industry process	*Parameter*	*Emission level*
COPPER PRODUCTION		
29. Smelters and converters	Sulphur dioxide(SO_2)	-------mg/Nm^3
	Dust	--------mg/Nm^3
30. Coal preparation	Dust	--------mg/Nm^3
31. Ore concentrator dryer	Dust	--------mg/Nm^3
	SO_2	--------mg/Nm^3
CEMENT AND LIME PRODUCTION		
32. Cement production	Dust	--------mg/Nm^3
33. Lime production	Dust	--------mg/Nm^3
NITRIC ACID AND SULPHURIC ACID PRODUCTION		
34 Nitric acid production	NOx as NO_2	--------kg/day
35. Sulphuric acid production	SO_2	--------kg/day
FERTILIZER PRODUCTION		
36. Ammonium nitrate production	Dust	--------kg/day
37. Coal treatment	Dust	--------kg/day
38. NPK production	Dust	--------kg/day

COMBUSTION UNITS

39. Oil fired, < 50MW(1)	Dust	--------mg/Nm^3
	SO_2	--------mg/Nm^3
	CO	--------mg/Nm^3
40. Coal fired, <10MW(2)	Dust	--------mg/Nm^3
	SO_2	--------mg/Nm^3
	CO	--------mg/Nm^3
41. Coal fired, 10-50 MW(2)	Dust	--------mg/Nm^3
	SO_2	--------mg/Nm^3
	CO	--------mg/Nm^3

OTHER PROCESSES/UNITS

A. S. SCOTT
Name

Signature

Designation/title COMPANY SECRETARY

Date: 16 - 3 - 1999

(1). The limits shall be normalised to 273K at 101.3Pa and 3 vol.-% O_2

(2). The limits shall be normalised to 273K at 101.3Pa and 7 vol.-% O_2

FOR OFFICIAL USE ONLY

Application received 17/03/99

Fee paid _____

Chief Inspector (Pollution Control)
Environmental Council of Zambia
Inspectorate

Appendix F

Estimated gaseous emission at Bwana Mkubwa Mining Ltd.

Mines Form MMRER 1

REPUBLIC OF ZAMBIA

The Mining (Mineral Resource Extraction) Regulations

Gaseous Emission Return

Bwana Mkubwa Mining Limited **Mining Right.....** **Month: September 1998**

CONCENTRATE TREATED (elemental sulphur)			FINAL NON-GASEOUS WASTE DISCHARGE			ATMOSPHERIC DISCHARGE VIA STACK		ATMOSPHERIC DISCHARGE VIA FUGITIVES	
Weight (Tonnes)	Sulphur grade (Percent)	Sulphur Weight (Tonnes)	Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)
2986	99.93%	2983.9	Nil	Nil	Nil	53.7	107.4	Nil	Nil

I, Sean Whittome being the Manager/Authorised mine official, do hereby certify that the information shown above is true and I make this certificate conscientiously believing the same to be true.

Signed.....
~~Holder/manager/authorised mine official~~

NILU OR 44/99

Mines Form MMRER 1

REPUBLIC OF ZAMBIA

The Mining (Mineral Resource Extraction) Regulations

Gaseous Emission Return

Bwana Mkubwa Mining Limited **Mining Right.....** **Month: October 1998**

CONCENTRATE TREATED (elemental sulphur)			FINAL NON-GASEOUS WASTE DISCHARGE			ATMOSPHERIC DISCHARGE VIA STACK		ATMOSPHERIC DISCHARGE VIA FUGITIVES	
Weight (Tonnes)	Sulphur grade (Percent)	Sulphur Weight (Tonnes)	Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)
3347	99.93%	3344.65	Nil	Nil	Nil	60.2	120.4	Nil	Nil

I, Sean Whittome being the Manager/Authorised mine official, do hereby certify that the information shown above is true and I make this certificate conscientiously believing the same to be true.

Signed.....
~~Holder/manager/authorised mine official~~

Mines Form MMRER 1

REPUBLIC OF ZAMBIA

The Mining (Mineral Resource Extraction) Regulations

Gaseous Emission Return

Bwana Mkubwa Mining Limited **Mining Right.....** **Month:** **November** **1998**

CONCENTRATE TREATED (elemental sulphur)			FINAL NON-GASEOUS WASTE DISCHARGE			ATMOSPHERIC DISCHARGE VIA STACK		ATMOSPHERIC DISCHARGE VIA FUGITIVES	
Weight (Tonnes)	Sulphur grade (Percent)	Sulphur Weight (Tonnes)	Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)
3279	99.93%	3276.7	Nil	Nil	Nil	65.5	131	Nil	Nil

I, Sean Whittome being the Manager/Authorised mine official, do hereby certify that the information shown above is true and I make this certificate conscientiously believing the same to be true.

Signed.....
Holder/manager/authorised mine official

NILU OR 44/99

Mines Form MMRER 1

REPUBLIC OF ZAMBIA

The Mining (Mineral Resource Extraction) Regulations

Gaseous Emission Return

Bwana Mkubwa Mining Limited **Mining Right.....** **Month: January 1999**

CONCENTRATE TREATED (elemental sulphur)			FINAL NON-GASEOUS WASTE DISCHARGE			ATMOSPHERIC DISCHARGE VIA STACK		ATMOSPHERIC DISCHARGE VIA FUGITIVES	
Weight (Tonnes)	Sulphur grade (Percent)	Sulphur Weight (Tonnes)	Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)	Sulphur Weight (Tonnes)	Sulphur Dioxide Weight (Tonnes)
3239	99.92%	3236.4	Nil	Nil	Nil	64.7	129.5	Nil	Nil

I, Sean Whittome being the Manager/Authorised mine official, do hereby certify that the information shown above is true and I make this certificate conscientiously believing the same to be true.

Signed.....
~~Holder/manager/authorised mine official~~

Appendix G

Emission Rates at Chilanga Cement

CHILANGA CEMENT PLC- CHILANGA WORKS
ENVIRONMENTAL POLLUTION CONTROL QUARTERLY REPORT: APRIL - JUNE, 1998

SOURCE OF AIR EMISSIONS

Production Equipment	Pollutant	Dedusting Equip.	Emission Limit(mg/Nm^3)	Measured Average Emission (mg/Nm^3)			% Run			Comments
				April	May	June	April	May	June	
Primary Crusher	Dust	Water Spray	-	-	-	-	-	-	-	Water being sprayed
Secondary Crusher	Dust	Bag Filter	-	-	-	-	100	100	100	Okay
Coal Mills	Coal Dust	Enclosure	-	-	-	-	-	-	-	Dedusting plant under consideration
Kiln 2 with coolers	Dust, Nox	Electrostatic Precipitator	180	-	-	-	99.76	99.22	-	Measuring points being prepared
Kiln 3 with coolers	Dust, Nox	Electrostatic Precipitator	180	110.7	175.9	96.7	99.85	99.34	-	All the results were below the maximum allowable emission rates.
Cement Mills	Dust	Electrostatic Precipitator	100	62.5	75.5	88	100	100	100	All the results were below the maximum allowable emission rates.
Packing Plant	Dust	Bag Filter	-	-	-	-	100	100	100	Okay
'erials Stores	Dust	Enclosure	-	-	-	-	-	-	-	Dust confined in the enclosure

Other Comments

NILU OR 44/99

K. MWENYA.
WORKS TECH.MANAGER

CHILANGA CEMENT PLC- CHILANGA WORKS
ENVIRONMENTAL POLLUTION CONTROL QUARTERLY REPORT: JULY - SEPTEMBER, 1998

SOURCE OF AIR EMISSIONS

Production Equipment	Pollutant	Dedusting Equip.	Emission Limit(mg/Nm^3)	Measured Average Emission (mg/Nm^3)			% Run			Comments
				July	Aug	Sept	July	Aug	Sept	
Primary Crusher	Dust	Water Spray	-	-	-	-	-	-	-	Water being sprayed
Secondary Crusher	Dust	Bag Filter	-	-	-	-	100	100	100	Okay
Coal Mills	Coal Dust	Enclosure	-	-	-	-	-	-	-	Dedusting plant under consideration
Kiln 2 with coolers	Dust, Nox	Electrostatic Precipitator	180	-	-	-	98.00	98.97	99.89	Measuring points being prepared
Kiln 3 with coolers	Dust, Nox	Electrostatic Precipitator	180	135.2	254.7	178.8	99.96	99.94	99.95	Result was high in August due to a defective rapping system in bank B. ESP needs attention.
Cement Mills	Dust	Electrostatic Precipitator	100	77.1	168.3	97	100	100	100	Result was high in August due to material accumulation in the ESP
Packing Plant	Dust	Bag Filter	-	-	-	-	100	100	100	Okay
Materials Stores	Dust	Enclosure	-	-	-	-	-	-	-	Dust confined in the enclosure

ıer Comments

K. MWENYA.
WORKS TECH.MANAGER

CHILANGA CEMENT PLC- NDOLA WORKS

ENVIRONMENTAL AIR POLLUTION CONTROL QUARTERLY REPORT:

SOURCE OF AIR EMISSIONS

Production Equipment/Area	Pollutant	Dedusting Equip.	Emission Limit(mg/Nm^3)	Measured Emission (mg/Nm^3) / (Kg/hr)			% Run			Comments
				JULY	AUGUST	SEPTEMBER	JULY	AUGUST	SEPTEMBER	
Raw Mill 1	Dust	Electrostatic Precipitator	98	1006 14.1	-	343 / 3.5	100	100	100	Filter needs attention
Raw Mill 2	Dust	Electrostatic Precipitator	98	-	-	153 / 2.5	100	100	100	Filter needs attention
Cement Mill 1	Dust	Electrostatic Precipitator	98	119 / 0.3	-	426 / 1.1	100	100	100	
Cement Mill 2	Dust	Electrostatic Precipitator	98	-	-	28 / 0.2	100	100	100	
Kiln 1	Dust,Nox	Electrostatic Precipitator	98	-	-	-	0	98.6	96.4	Awaiting the purchase of heat proof tubing
Kiln 2	Dust,Nox	Electrostatic Precipitator	98	66 / 3.9	101 / 3.3	-	99.2	98.3	98.7	Filter performance affected by CO incidences

KILN 1 AND 2 ELECTROFILTER OUTAGES

	KILN 1			KILN 2		
	JULY	AUGUST	SEPTEMBER	JULY	AUGUST	SEPTEMBER
Filter outages due to kiln start ups(hrs)	0.00	1.58	1.25	0.70	7.92	3.12
Filter outages due to high CO(hrs)	0.00	1.08	0.38	2.90	3.13	1.13
Filter outages due to other reasons(hrs)	0.00	1.25	10.50	0.30	1.37	0.12
TOTAL	0.00	3.91	12.13	3.90	12.42	4.37

				CONDITION				
			Emission Limit(mg/Nm^3)	JULY	AUGUST	SEPTEMBER	Emission observed	Comments
stone Crusher	Dust	Bag Filter	98	Available	Available	Available	Trace	
hale Crusher	Dust	Bag Filter	98	Available	Available	Available	Trace	
Material transport (G106)	Dust	Bag Filter	98	Not Available	Not Available	Not Available		Under Mechanical Dept for repairs
Material transport (H122)	Dust	Bag Filter	98	Not Available	Not Available	Not Available		Under Electrical Dept. for repairs
Mixing Plant (Top)	Dust	Bag Filter	98	Available	Available	Available	Trace	
Mixing Plant (Bottom)	Dust	Bag Filter	98	Available	Available	Available	Trace	
Cement Transport(Old)	Dust	Bag Filter	98	Not Available	Not Available	Not Available		Needs overhaul
Clinker Hoppers	Dust	Bag Filter	98	Available	Available	Available	Trace	
Clinker Store	Dust	Bag Filter	98	Not Available	Not Available	Not Available		Under Projects Dept for fan fabrication and installation
Packer 1	Dust	Bag Filter	98	Available	Available	Available	Trace	
Packer 2	Dust	Bag Filter	98	Available	Available	Available	Trace	
Coal Plant -New	Dust	Bag Filter	98	Available	Available	Available	Trace	
Clinker Hopper -New	Dust	Bag Filter	98	Available	Available	Available	Trace	
Point Y101-Y102-New	Dust	Bag Filter	98	Available	Available	Available	Trace	
Point T105-Y202-New	Dust	Bag Filter	98	Not Available	Not Available	Not Available		Under Mechanical Dept for repairs
Point Y103-U101-New	Dust	Bag Filter	98	Available	Available	Available	Trace	
Raw Meal Transport-New	Dust	Bag Filter	98	Available	Available	Available	Trace	
Packing Plant Shakers	Dust	Bag Filter	98	Not Available	Not Available	Not Available		Under Mechanical Dept for repairs
Kiln 2 Calibration Hopper	Dust	Bag Filter	98	Not Available	Not Available	Not Available		Under Projects Dept for repairs

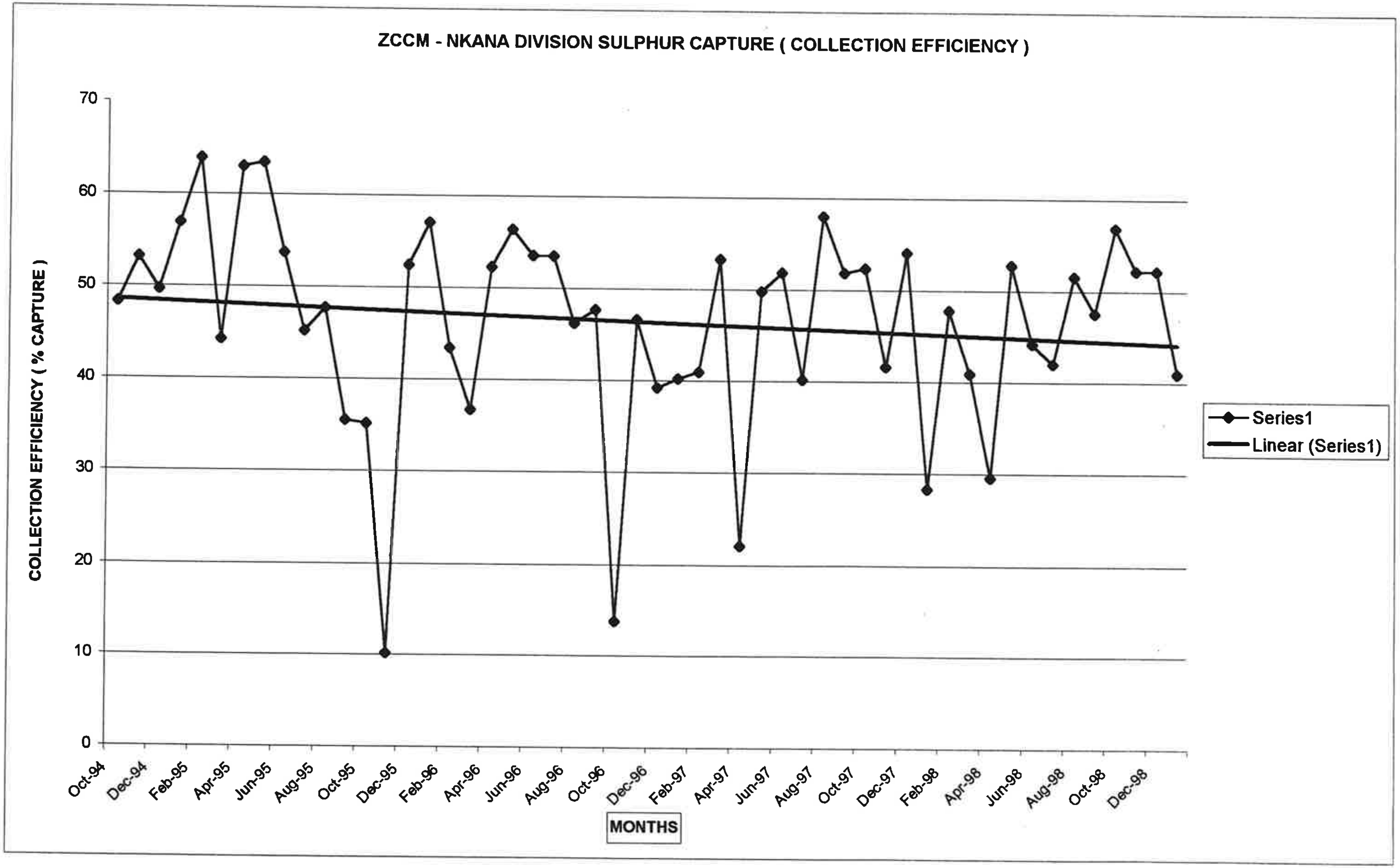
BNORMAL EMISSIONS

Dust emission on raw mill 1 was high in the month of July

W.MWANZA
A Works Technical Manager

Appendix H

Acid plant efficiency


ZCCM - NKANA DIVISION SULPHUR CAPTURE (COLLECTION EFFICIENCY)
COLLECTION EFFICIENCY (% CAPTURE)
70
60
50
40
30
20
10
0
Oct-94
Dec-94
Feb-95
Apr-95
Jun-95
Aug-95
Oct-95
Dec-95
Feb-96
Apr-96
Jun-96
Aug-96
Oct-96
Dec-96
Feb-97
Apr-97
Jun-97
Aug-97
Oct-97
Dec-97
Feb-98
Apr-98
Jun-98
Aug-98
Oct-98
Dec-98
MONTHS
Series1
Linear (Series1)

ZAMBIA CONSOLIDATED COPER MINES LIMITED
NKANA DIVISON
ENVIRONMENTAL SERVICES

METALLURGICAL SULPHUR BALANCE

NKANA MINE- SMELTER, ACID PLANTS AND COBALT PLANT

tons of SO_2/month

MONTH	S IN FEED	S IN CALCINE, CINDER & SLAG	S IN ACID & EFFLUENT	S IN EMISSION	% Emission	Collection Efficiency (%)
OCT 94	12096.00	1707.00	4943.12	5373.12	51.72	48.28
NOV 94	10308.80	1363.60	4691.36	4191.83	46.86	53.14
DEC 94	10588.40	1437.50	4498.80	4607.10	50.35	49.65
JAN 95	11360.70	1299.10	5660.50	4340.10	43.14	56.86
FEB 95	10748.22	1360.99	5933.57	3390.66	36.12	63.88
MAR 95	10767.20	1556.60	3981.20	5134.40	55.74	44.26
APRI 95	11339.71	1756.20	5960.96	3547.53	37.02	62.98
MAY 95	11006.60	1619.70	5894.70	3432.20	36.56	63.44
JUN 95	11561.80	1470.60	5350.00	4676.20	46.34	53.66
JUL 95	11668.00	1755.40	4404.50	5433.10	54.81	45.19
AUG 95	8892.00	995.00	3708.00	4129.00	52.29	47.71
SEP 95	6073.00	411.00	1948.00	3654.00	64.54	35.46
OCT 95	8739.00	1254.00	2566.00	4854.00	64.85	35.15
NOV 95	2981.00	1146.00	1835.00	1648.00	89.81	10.19
DEC 95	12594.00	1484.00	5764.00	5286.00	47.58	52.42
JAN 96	10360.21	1439.38	5087.27	3833.56	42.97	57.03
FEB 96	12293.14	1436.42	4714.32	6142.40	56.58	43.42
MAR 96	13574.28	1454.11	4444.45	7675.72	63.33	36.67
APR 96	11201.58	1563.61	5036.01	4601.96	47.75	52.25
MAY 96	11473.50	1628.69	5546.06	4298.75	43.67	56.33
JUN 96	11561.72	1470.54	5400.99	4690.19	46.48	53.52
JUL 96	10864.71	1438.00	5037.63	4389.08	46.56	53.44
AUG 96	12293.01	1687.61	4900.10	5705.30	53.80	46.20
SEP 96	11017.19	1428.82	4571.89	5016.48	52.32	47.68
OCT 96*	4830.05	172.99	642.02	4015.04	86.21	13.79
NOV 96	8269.26	1871.17	2985.00	3413.09	53.35	46.65
DEC 96	9816.12	1488.47	3260.77	5066.88	60.84	39.16

H_2SO_4 + effluent from acid plant

* Cobalt Plant Roaster on Plant shut down

Mwale Chunga Mathews
09/03/99

ZAMBIA CONSOLIDATED COPER MINES LIMITED
NKANA DIVISON
ENVIRONMENTAL SERVICES

METALLURGICAL SULPHUR BALANCE

NKANA MINE- SMELTER, ACID PLANTS AND COBALT PLANT

MONTH	S IN FEED	S IN CALCINE, CINDER & SLAG	S IN ACID & EFFLUENT	S IN EMISSION	% Emission	Collection Efficiency (%)
JAN 97	9901.37	1492.88	3379.05	5029.44	59.81	40.19
FEB 97	9806.84	1440.09	3423.52	4943.23	59.08	40.92
MAR 97	10437.37	1565.99	4727.05	4144.33	46.72	53.28
APRI 97	6877.96	1539.51	1180.66	4157.79	77.88	22.12
MAY 97	11010.13	1655.41	4659.04	4695.68	50.20	49.80
JUN 97	9649.58	1779.61	4082.57	3787.40	48.12	51.88
JUL 97	9090.27	1729.51	2954.09	4406.67	59.87	40.13
AUG 97	9636.17	1550.11	4686.31	3399.75	42.04	57.96
SEP 97	8233.20	1531.36	3475.06	3226.78	48.15	51.85
OCT 97	8787.36	758.41	4203.89	3825.06	47.64	52.36
NOV 97	8481.28	1630.22	2848.28	4002.78	58.43	41.57
DEC 97	10173.16	1593.64	4639.57	3939.95	45.92	54.08
JAN 98	9978.42	1602.24	2372.80	6003.38	71.67	28.33
FEB 98	7308.25	1416.35	2815.64	3076.26	52.21	47.79
MAR 98	7818.90	1386.19	2630.44	3802.27	59.11	40.89
APR 98	6520.07	1138.70	1591.82	3789.55	70.42	29.58
MAY 98	10198.49	1307.83	4691.35	4199.31	47.23	52.77
JUN 98	9332.73	1257.45	3570.31	4504.97	55.79	44.21
JUL 98	9475.95	1340.62	3415.15	4720.18	58.02	41.98
AUG 98	10163.72	1482.66	4477.28	4203.06	48.42	51.58
SEP 98	8836.31	1306.38	3579.74	3950.19	52.46	47.54
OCT 98	8825.39	1620.79	4091.90	3112.70	43.20	56.80
NOV 98	9462.89	1595.76	4106.25	3760.90	47.81	52.19
DEC 98	8953.00	1670.00	2966.00	4317.00	59.28	40.72

Appendix I

Ambient air SO_2 concentrations, Nkana

CONCENTRATIONS OF SULPHUR DIOXIDE IN AMBIENT AIR (mg/m3)
NKANA MINE -MONTHLY AVERAGE

MONTH	Fire Brigade South of Smelter	Central Shaft N/West of Smelter	Nkana Hospital North of Smelter	Wusakile Hospital East of Smelter
JUL 95	0.004	0.369	0.036	<0.001
AUG 95	0.019	0.287	0.077	0.016
SEP 95	0.055	0.518	0.038	0.03
OCT 95	0.044	0.518	0.038	0.030
NOV 95	0.293	0.462	0.161	0.134
DEC 95	0.403	0.372	0.062	0.143
JAN 96	0.767	0.171	0.137	0.286
FEB 96	0.577	0.562	0.139	0.240
MAR 96	0.412	0.939	0.167	0.195
APR 96	0.079	0.890	0.097	0.098
MAY 96	0.554	0.034	0.135	0.066
JUN 96	0.002	0.887	0.097	0.003
JUL 96	0.031	1.625	0.083	0.030
AUG 96	0.152	1.813	0.169	0.130
SEP 96	0.066	0.595	0.034	0.042
OCT 96	0.071	0.305	0.061	0.031
NOV 96	0.032	0.155	0.069	0.027
DEC 96	0.565	0.859	0.314	0.368
JAN 97	1.256	0.451	0.164	0.324
FEB 97	1.899	0.379	0.101	0.514
MAR 97	0.200	0.788	0.093	0.200
APRI 97	0.032	0.155	0.069	0.027
MAY 97	0.274	1.754	0.424	0.110
JUN 97	0.082	1.294	0.187	0.013
JUL 97	0.050	1.826	0.090	0.090
AUG 97	0.505	2.270	0.540	0.230
SEP 97	0.071	0.305	0.061	0.031
OCT 97	0.113	1.800	0.099	0.033
NOV 97	0.670	0.720	0.160	0.390
DEC 97	0.066	0.060	0.034	0.042
JAN 98	0.591	1.070	0.161	0.351
FEB 98	0.723	0.754	0.186	0.604
MAR 98	0.302	1.380	0.106	0.145
APR 98	0.215	1.250	0.164	0.325
MAY 98	0.192	1.086	0.461	0.031
JUN 98	0.017	1.224	0.082	0.019
JUL 98	0.027	1.372	0.075	0.024
AUG 98	0.013	1.412	0.165	0.015
SEP 98	0.000	0.000	0.000	0.000
OCT 98	0.121	0.312	0.018	0.010
NOV 98	0.426	0.686	0.247	0.166
DEC 98	0.151	0.703	0.105	0.257

NB: October 1994 to June 1995 AGL samplers were not working oky

Appendix J

Ambient air SO_2 concentrations, Mufulira

STRICTLY CONFIDENTIAL

ATT : Divsional Environmental Services Officer
SULPHUR DIOXIDE EMISSION FROM MUFULIRA SMELTER MONITORED AT CLINICS 3, 5, 7 AND 8.

The monitoring of sulphur dioxide emissions at clinics 3, 5, 7 and 8 continued during the month. The following sulphur dioxide levels were recorded for the month of September 1998

CONCENTRATION OF SO2 ug m3				
DATE	**CLINIC 3**	**CLINIC 5**	**CLINIC 7**	**CLINIC 8**
01-Sep-98	5	31	5	54
02-Sep-98	91	332	5	82
03-Sep-98	11	301	5	5
04-Sep-98	65	178	x	127
05-Sep-98	165	1549	x	5
06-Sep-98	5	67	x	64
07-Sep-98	73	44	x	5
08-Sep-98	131	244	x	122
09-Sep-98	483	236	x	263
10-Sep-98	77	180	x	13
11-Sep-93	26	675	x	5
12-Sep-98	212	1653	x	5
13-Sep-98	345	3024	x	5
14-Sep-98	48	3371	x	66
15-Sep-98	42	942	x	44
16-Sep-98	131	59	x	38
17-Sep-98	146	693	82	50
18-Sep-98	39	94	25	60
19-Sep-98	59	680	12	40
20-Sep-98	156	961	6	5
21-Sep-98	258	2414	14	5
22-Sep-98	12	751	37	50
23-Sep-98	22	68	5	5
24-Sep-98	65	689	5	5
25-Sep-98	37	417	27	128
26-Sep-98	33	76	86	48
27-Sep-98	14	189	55	5
28-Sep-98	37	87	x	96
29-Sep-98	5	2350	x	176
30-Sep-98	103	532	x	80
Average	**97**	**763**	**26**	**55**
Operational Limit	**500**	**500**	**500**	**500**

Note : Numbers less than or equal to five are entered as 5
x Some values were not obtained for clinic 7 because the A.G.L. Unit was withdrawn for repair.

SOMONTH
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STRICTLY CONFIDENTIAL

ATT : Divsional Environmental Services Officer
SULPHUR DIOXIDE EMISSION FROM MUFULIRA SMELTER MONITORED AT CLINICS 3, 5, 7 AND 8.

The monitoring of sulphur dioxide emissions at clinics 3, 5, 7 and 8 continued during the month. The following sulphur dioxide levels were recorded for the month of October 1998

	CONCENTRATION OF SO2 ug m3			
DATE	**CLINIC 3**	**CLINIC 5**	**CLINIC 7**	**CLINIC 8**
01-Oct-98	24	804	237	5
02-Oct-98	24	845	175	5
03-Oct-98	24	893	56	117
04-Oct-98	57	1024	119	5
05-Oct-98	44	1049	111	5
06-Oct-98	41	1089	103	93
07-Oct-98	12	1086	143	5
08-Oct-98	81	1136	5	39
09-Oct-98	64	406	259	70
10-Oct-98	89	110	122	106
11-Oct-98	65	177	84	47
12-Oct-98	130	13	23	70
13-Oct-98	1070	1835	54	35
14-Oct-98	100	3724	5	47
15-Oct-98	586	150	61	94
16-Oct-98	1513	509	229	128
17-Oct-98	1164	3062	152	5
18-Oct-98	118	2546	340	77
19-Oct-98	99	1112	301	103
20-Oct-98	36	1166	530	5
21-Oct-98	216	1107	153	154
22-Oct-98	200	172	96	5
23-Oct-98	244	1348	601	10
24-Oct-98	431	889	319	29
25-Oct-98	72	676	171	13
26-Oct-98	180	879	59	39
27-Oct-98	72	600	97	5
28-Oct-98	36	421	112	52
29-Oct-98	27	53	5	10
30-Oct-98	5	5	5	5
31-Oct-98	5	61	5	5
Average	**220**	**934**	**153**	**45**
Operational Limit	**500**	**500**	**500**	**500**

Note : Numbers less than or equal to five are entered as 5

SOMONTH.WK4
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ATT : Divsional Environmental Services Officer
SULPHUR DIOXIDE EMISSION FROM MUFULIRA SMELTER MONITORED AT CLINICS 3, 5, 7 AND 8.

The monitoring of sulphur dioxide emissions at clinics 3, 5, 7 and 8 continued during the month. The following sulphur dioxide levels were recorded for the month of November 1998

CONCENTRATION OF SO2 ug m3				
DATE	**CLINIC 3**	**CLINIC 5**	**CLINIC 7**	**CLINIC 8**
01-Nov-98	36	30	5	5
02-Nov-98	18	293	5	5
03-Nov-98	36	179	5	17
04-Nov-98	5	198	5	5
05-Nov-98	27	68	5	20
06-Nov-98	32	137	30	12
07-Nov-98	54	5	19	23
08-Nov-98	5	26	33	23
09-Nov-98	22	170	100	14
10-Nov-98	18	1602	48	5
11-Nov-98	27	883	15	183
12-Nov-98	63	290	107	87
13-Nov-98	57	474	5	47
14-Nov-98	5	145	56	28
15-Nov-98	121	202	271	25
16-Nov-98	5	226	194	34
17-Nov-98	96	5	78	19
18-Nov-98	5	234	194	25
19-Nov-98	128	242	34	37
20-Nov-98	64	291	108	87
21-Nov-98	57	476	5	47
22-Nov-98	72	160	78	5
23-Nov-98	295	508	110	129
24-Nov-98	451	159	113	90
25-Nov-98	328	330	117	97
26-Nov-98	97	139	121	108
27-Nov-98	178	130	5	5
28-Nov-98	48	206	5	5
29-Nov-98	5	469	5	5
30-Nov-98	329	5	162	5
Average	**89**	**276**	**68**	**40**
Operational Limit	**500**	**500**	**500**	**500**

Note : Numbers less than or equal to five are entered as 5

BLM/CGZ

STRICTLY CONFIDENTIAL

ATT : Divsional Environmental Services Officer
SULPHUR DIOXIDE EMISSION FROM MUFULIRA SMELTER MONITORED AT CLINICS 3, 5, 7 AND 8.

The monitoring of sulphur dioxide emissions at clinics 3, 5, 7 and 8 continued during the month. The following sulphur dioxide levels were recorded for the month of December 1998

CONCENTRATION OF SO2 ug m3				
DATE	CLINIC 3	CLINIC 5	CLINIC 7	CLINIC 8
01-Dec-98	145	5	90	10
02-Dec-98	110	5	112	5
03-Dec-98	***	5	5	5
04-Dec-98	***	5	5	5
05-Dec-98	***	5	5	5
06-Dec-98	***	5	5	5
07-Dec-98	***	5	5	5
08-Dec-98	***	5	5	5
09-Dec-98	***	5	5	5
10-Dec-98	***	34	5	5
11-Dec-98	68	68	72	56
12-Dec-98	63	91	129	56
13-Dec-98	182	129	57	5
14-Dec-98	59	60	57	5
15-Dec-98	104	60	76	37
16-Dec-98	90	106	60	179
17-Dec-98	112	105	108	71
18-Dec-98	531	248	86	76
19-Dec-98	877	161	19	55
20-Dec-98	80	226	101	50
21-Dec-98	141	199	22	67
22-Dec-98	64	208	155	5
23-Dec-98	5	120	185	104
24-Dec-98	232	199	**	85
25-Dec-98	200	5	**	95
26-Dec-98	48	24	**	75
27-Dec-98	20	114	**	35
28-Dec-98	100	32	**	**
29-Dec-98	24	32	**	40
30-Dec-98	92	5	**	274
31-Dec-98	32	32	5	139
Average	**109**	**74**	**44**	**50**
Operational Limit	**500**	**500**	**500**	**500**

Note : Numbers less than or equal to five are entered as 5
***** AGL Unit was withdrawn for repair**
**** AGL Unit was being callbrated**

11/01/99

OM/CGZ

STRICTLY CONFIDENTIAL

ATT : Divsional Environmental Services Officer
SULPHUR DIOXIDE EMISSION FROM MUFULIRA SMELTER MONITORED AT CLINICS 3, 5, 7 AND 8.

The monitoring of sulphur dioxide emissions at clinics 3, 5, 7 and 8 continued during the month. The following sulphur dioxide levels were recorded for the month of January 1999

	CONCENTRATION OF SO2 ug m3			
DATE	CLINIC 3	CLINIC 5	CLINIC 7	CLINIC 8
01-Jan-99	13	16	7	95
02-Jan-99	192	5	130	75
03-Jan-99	5	16	13	35
04-Jan-99	5	23	241	5
05-Jan-99	64	65	65	40
06-Jan-99	102	26	485	274
07-Jan-99	95	42	13	139
08-Jan-99	149	77	43	65
09-Jan-99	317	5	21	662
10-Jan-99	177	102	5	403
11-Jan-99	89	81	86	284
12-Jan-99	728	131	5	359
13-Jan-99	173	5	150	97
14-Jan-99	61	5	5	5
15-Jan-99	***	5	37	18
16-Jan-99	***	30	33	46
17-Jan-99	***	45	22	27
18-Jan-99	***	5	5	92
19-Jan-99	***	5	44	64
20-Jan-99	***	94	22	55
21-Jan-99	***	76	29	18
22-Jan-99	202	0	21	*
23-Jan-99	10	102	25	*
24-Jan-99	67	157	25	*
25-Jan-99	100	166	60	*
26-Jan-99	34	91	50	*
27-Jan-99	17	66	61	*
28-Jan-99	134	0	5	*
29-Jan-99	91	77	79	77
30-Jan-99	196	66	5	5
31-Jan-99	757	88	112	5
Average	**122**	**54**	**61**	**95**
Operational Limit	**500**	**500**	**500**	**500**

Note : Numbers less than or equal to five are entered as 5
***** AGL Unit had some electrical problems**
*** No results due to the damage caused by the rains on the system**

STRICTLY CONFIDENTIAL

ATT : Divsional Environmental Services Officer
SULPHUR DIOXIDE EMISSION FROM MUFULIRA SMELTER MONITORED AT CLINICS 3, 5, 7 AND 8.

The monitoring of sulphur dioxide emissions at clinics 3, 5, 7 and 8 continued during the month. The following sulphur dioxide levels were recorded for the month of February 1999

CONCENTRATION OF SO2 ug m3				
DATE	**CLINIC 3**	**CLINIC 5**	**CLINIC 7**	**CLINIC 8**
01-Feb-99	102	81	170	35
02-Feb-99	68	85	230	228
03-Feb-99	115	29	60	12
04-Feb-99	153	22	5	8
05-Feb-99	136	23	93	5
06-Feb-99	70	181	67	35
07-Feb-99	54	86	37	52
08-Feb-99	484	5	48	14
09-Feb-99	290	255	5	21
10-Feb-99	326	74	166	24
11-Feb-99	224	119	81	381
12-Feb-99	66	26	52	53
13-Feb-99	51	7	15	59
14-Feb-99	73	19	29	107
15-Feb-99	77	282	33	113
16-Feb-99	232	346	48	6
17-Feb-99	48	335	55	54
18-Feb-99	63	72	70	126
19-Feb-99	108	83	5	200
20-Feb-99	181	68	67	59
21-Feb-99	193	68	29	111
22-Feb-99	78	76	5	216
23-Feb-99	5	388	100	59
24-Feb-99	137	203	37	148
25-Feb-99	241	41	37	71
26-Feb-99	223	38	70	22
27-Feb-99	37	58	99	27
28-Feb-99	37	55	41	45
Average	**138**	**112**	**63**	**82**
Operational Limit	**500**	**500**	**500**	**500**

Note : Numbers less than or equal to five are entered as 5

SOMONTH.WK4

GC/CGZ

STRICTLY CONFIDENTIAL

ATT : Divsional Environmental Services Officer
SULPHUR DIOXIDE EMISSION FROM MUFULIRA SMELTER MONITORED AT CLINICS 3, 5, 7 AND 8.

The monitoring of sulphur dioxide emissions at clinics 3, 5, 7 and 8 continued during the month. The following sulphur dioxide levels were recorded for the month of March 1999

CONCENTRATION OF SO2 ug m3				
DATE	**CLINIC 3**	**CLINIC 5**	**CLINIC 7**	**CLINIC 8**
01-Mar-99	74	82	37	98
02-Mar-99	299	983	48	135
03-Mar-99	186	137	63	224
04-Mar-99	293	172	74	119
05-Mar-99	38	339	144	0
06-Mar-99	586	219	89	131
07-Mar-99	154	534	111	43
08-Mar-99	124	90	151	86
09-Mar-99	112	99	168	126
10-Mar-99	266	153	110	216
11-Mar-99	98	316	184	140
12-Mar-99	137	274	129	43
13-Mar-99	689	206	132	21
14-Mar-99	842	300	147	85
15-Mar-99	113	148	157	8
16-Mar-99	106	160	15	59
17-Mar-99	212	389	221	34
18-Mar-99	236	385	8	53
19-Mar-99	316	189	19	0
20-Mar-99	40	38	19	44
21-Mar-99	63	719	26	35
22-Mar-99	118	38	45	79
23-Mar-99	218	38	30	309
24-Mar-99	59	95	11	155
25-Mar-99	182	721	68	62
26-Mar-99	69	1102	131	147
27-Mar-99	0	971	35	236
28-Mar-99	19	947	123	329
29-Mar-99	44	570	99	151
30-Mar-99	37	1338	141	235
31-Mar-99	31	650	88	422
Average	**186**	**400**	**91**	**123**
S.I. 141 Limit	**125**	**125**	**125**	**125**

Note : Detection limit of the method is 5. Therefore values less than or equal to five are entered as 0

SOMONTH.WK4

GC/CGZ

Appendix K

Application for Permit to Emit Air Pollutants for ZCCM Chingola

FORM AP3

SECOND SCHEDULE

(Regulation10)

PRESCRIBED FORMS

REPUBLIC OF ZAMBIA

ENVIRONMENTAL COUNCIL

THE AIR POLLUTION CONTROL (LICENCING AND EMISSION STANDARDS) REGULATIONS, 1996

APPLICATION FOR PERMIT TO EMIT AIR POLLUTANTS

(To be completed in triplicate)

To: The Chief Inspector (Pollution Control)
Environmental Council of Zambia
P.O. BOX 35131
Lusaka

1. Name and address of applicant ZAMBIA CONSOLIDATED COPPER MINES LTD
P O BOX 10063, CHINGOLA
Tel 344040 Fax 312643

2. Location of Plant/activity CONCENTRATOR DEPARTMENT

3. Type(s) of activity (eg copper mining, cement manufacture etc) CONCENTRATION OF COPPER ORES

4. Name(s) of department(s)/section(s)/unit(s) where air emissions occur DRYER SECTION

5. Name(s) and type(s) of raw materials used in the process(es) WET COPPER CONCENTRATES

6. Amount of each raw material used yearly (kg) 320,000,000

7. Name(s) and types of products DRY COPPER CONCENTRATES

8. Sources of air emissions PRODUCTS OF COAL COMBUSTION

9. Name(s) and type(s) of air pollutants DUST AND SULPHUR DIOXIDE

10. Rate of emission of each air pollutant discharged into the ambient air (kg/h,ton/yr) LESS THAN ONE TONNE

11. Concentration of each air pollutant discharged into the ambient air ($\mu g/m^3$, mg/m^3, ppm etc)
DUST AVERAGE 189PPCC SO_2 - NOT MEASURED

12. Energy source used (eg coal, diesel etc) COAL

13. Amount of each energy source used yearly (kg) 3,650,000

14. Amount of each energy source used per day (kg) 10,000

15. Type of production operation (continuos or intermittent) CONTINUOS

16. Total number of hours of operation (per day, per week, per month, per year) EIGHTEEN

17. Number of stacks in operation TWO (SAME SIZE STACKS)

18. Physical stack height for each (m) 14.4

19. Stack gas volume for each (m^3/s, m^3/h) 28,800M³/HR

20. Internal stack diameter at gas exit level for each (m) 0.68M

21. Stack gas exit temperature for each (°C) 70°C

22. Exit gas velocity at each stack (m/s) 22.0

23. Pollution control technology in operation /to be employed MEDUSE WET GAS SRUBBER

24. Reliability of the pollution control technology VERY EFFICIENT AT DUST CAPTURE ABOUT 90%

25. How often do you conduct maintenance of the installation? WEEKLY PREVENTIVE MAINTENANCE

26. When was/were the Plant(s)/process(es) installed? 1967

27. Expected life time of the Plant(s)/installation(s) TEN YEARS-RENEWAL OF WORN OUT PARTS DONE AS REQUIRED.

28. How is the potential to produce other air pollutants? Name the pollutants NONE APPARENT AT THE MOMENT

LEVELS OF EMISSIONS (complete parts only relevant to your organisation)

Industry/process	*Parameter*	*Emission level*
COPPER PRODUCTION		
29. Smelters and converters	Sulphur dioxide(SO_2)	-------mg/Nm³
	Dust	-------mg/Nm³
30. Coal preparation	Dust	-------mg/Nm³
31. Ore concentrator dryer	Dust	-------mg/Nm³) NOT MEASURED
	SO_2	-------mg/Nm³)
CEMENT AND LIME PRODUCTION		
32. Cement production	Dust	-------mg/Nm³
33. Lime production	Dust	-------mg/Nm³
NITRIC ACID AND SULPHURIC ACID PRODUCTION		
34. Nitric acid production	NO_X as NO_2	-------kg/day
35. Sulphuric acid production	SO_2	-------kg/day
FERTILIZER PRODUCTION		
36. Ammonium nitrate production	Dust	-------kg/day
37. Coal treatment	Dust	-------kg/day
38. NPK production	Dust	-------kg/day

COMBUSTION UNITS

39. Oil fired, > 50MW(1)	Dust	--------mg/Nm^3
	SO_2	--------mg/Nm^3
	CO	--------mg/Nm^3
40. Coal fired, >10MW(2)	Dust	--------mg/Nm^3
	SO_2	--------mg/Nm^3
	CO	--------mg/Nm^3
41. Coal fired, 10-50 MW(2)	Dust	--------mg/Nm^3
	SO_2	--------mg/Nm^3
	CO	--------mg/Nm^3

OTHER PROCESSES/UNITS

JACKSON SIKAMO

Name

Signature

Designation/title CONCENTRATOR SUPERINTENDENT

Date: 10/4/97

(1). The limits shall be normalised to 273K at 101.3Pa and 3 vol,-% O_2

(2). The limits shall be normalised to 273K at 101.3Pa and 7 vol,-% O_2

FOR OFFICIAL USE ONLY

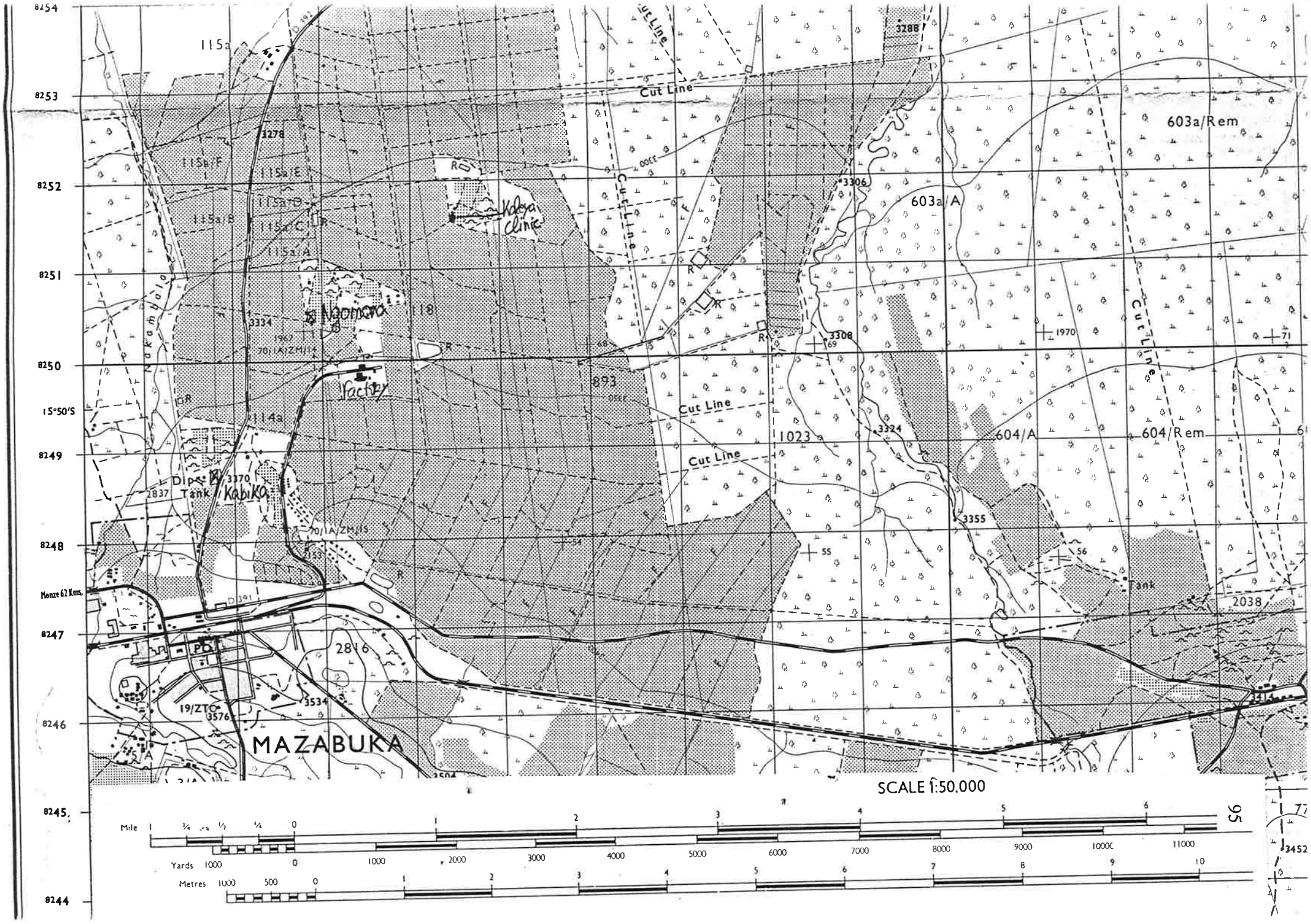
Application received 15/04/97

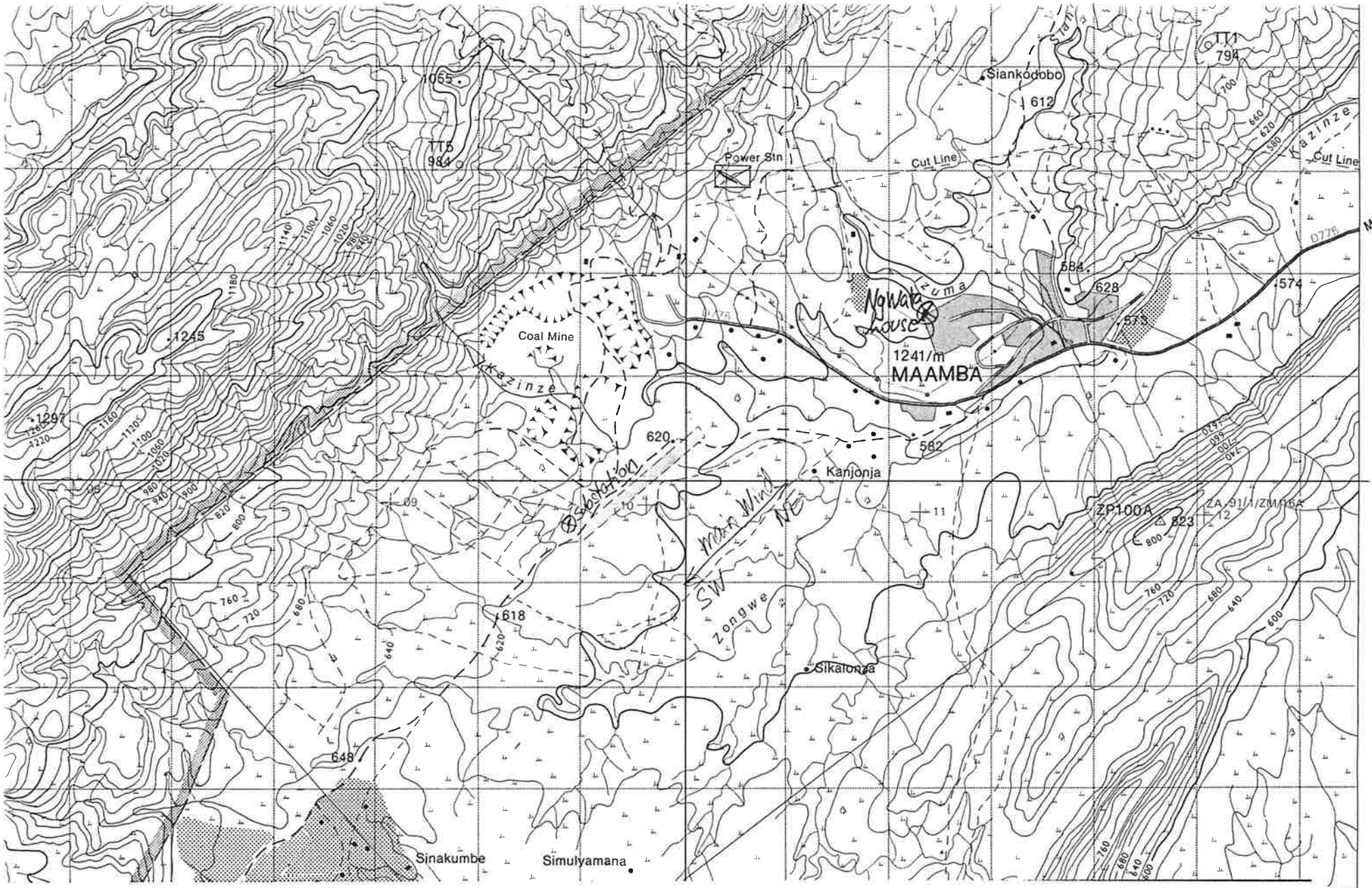
Fee paid K1,499,940.00

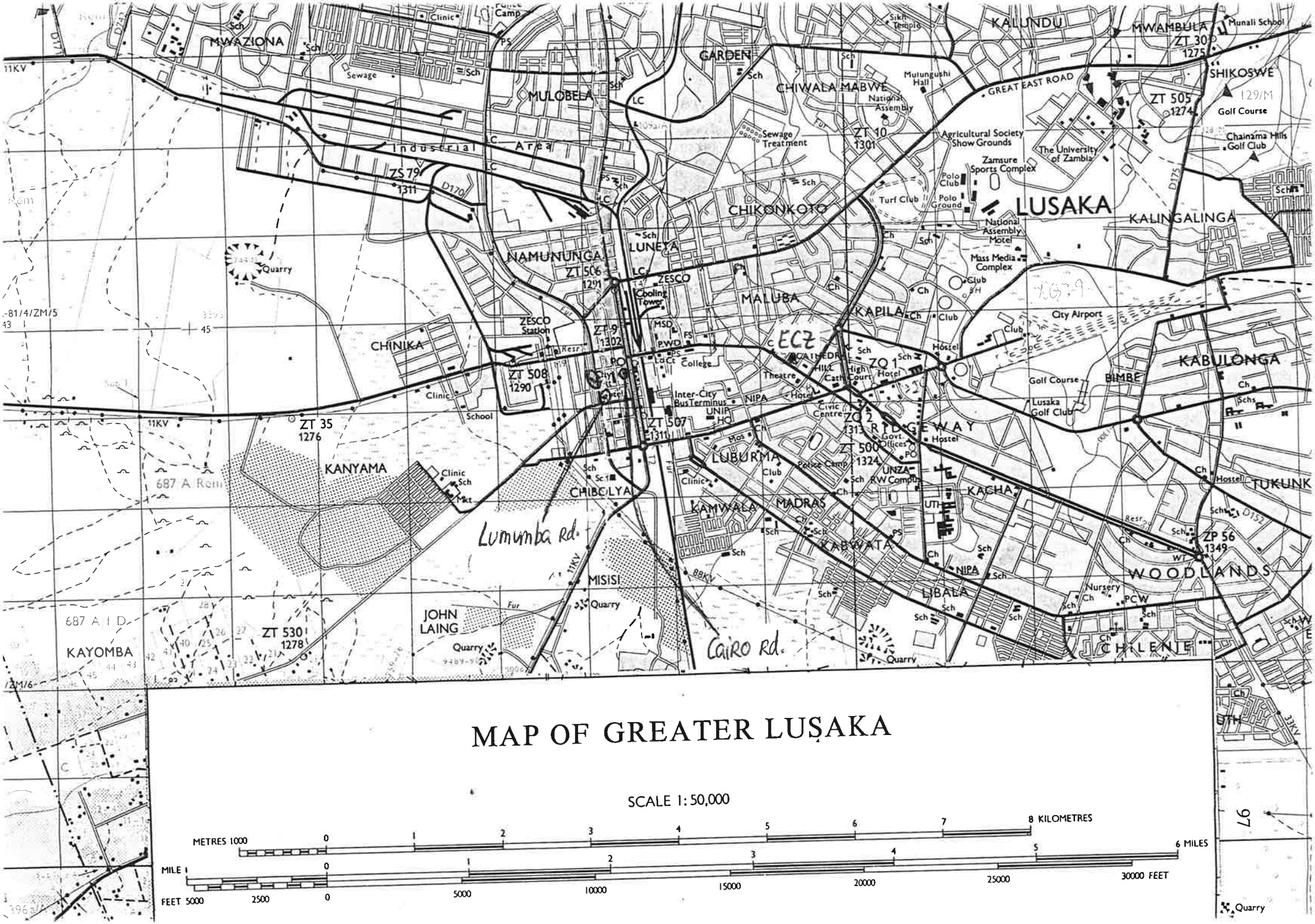
Chief Inspector (Pollution Control)
Environmental Council of Zambia
Inspectorate

Appendix L

Location of sampling sites


8254
8253
8252
8251
8250
15°50'S
8249
8248
8247
8246
8245
8244
115a
115a/F
115a/E
115a/D
115a/B
115a/C
115a/A
Cut Line
603a/Rem
603a/A
604/A
604/Rem
Kabya Clinic
Factory
Dip Tank
Kabiko
MAZABUKA
PO
Monze 62 Kms.
SCALE 1:50,000
Mile
Yards
Metres


Siankodobo
612
1065
1245
1297
Power Stn
Cut Line
Kazinze
Mwezia Sch.
16km
D775
584
628
574
573
Nowata House
Luma
Coal Mine
1241/m
MAAMBA
620
582
Kanjonja
Sobotkon
Main Wind
SW
NE
Zongwe
ZP100A
823
ZA-91/1/ZM/16A
618
648
Sikalonga
Sinakumbe
Simulyamana
SCALE 1:50,000
Mile
Yards
Metres
84
17°20'
83
82
81
8080
79
78
77
76
75
17°25'
96



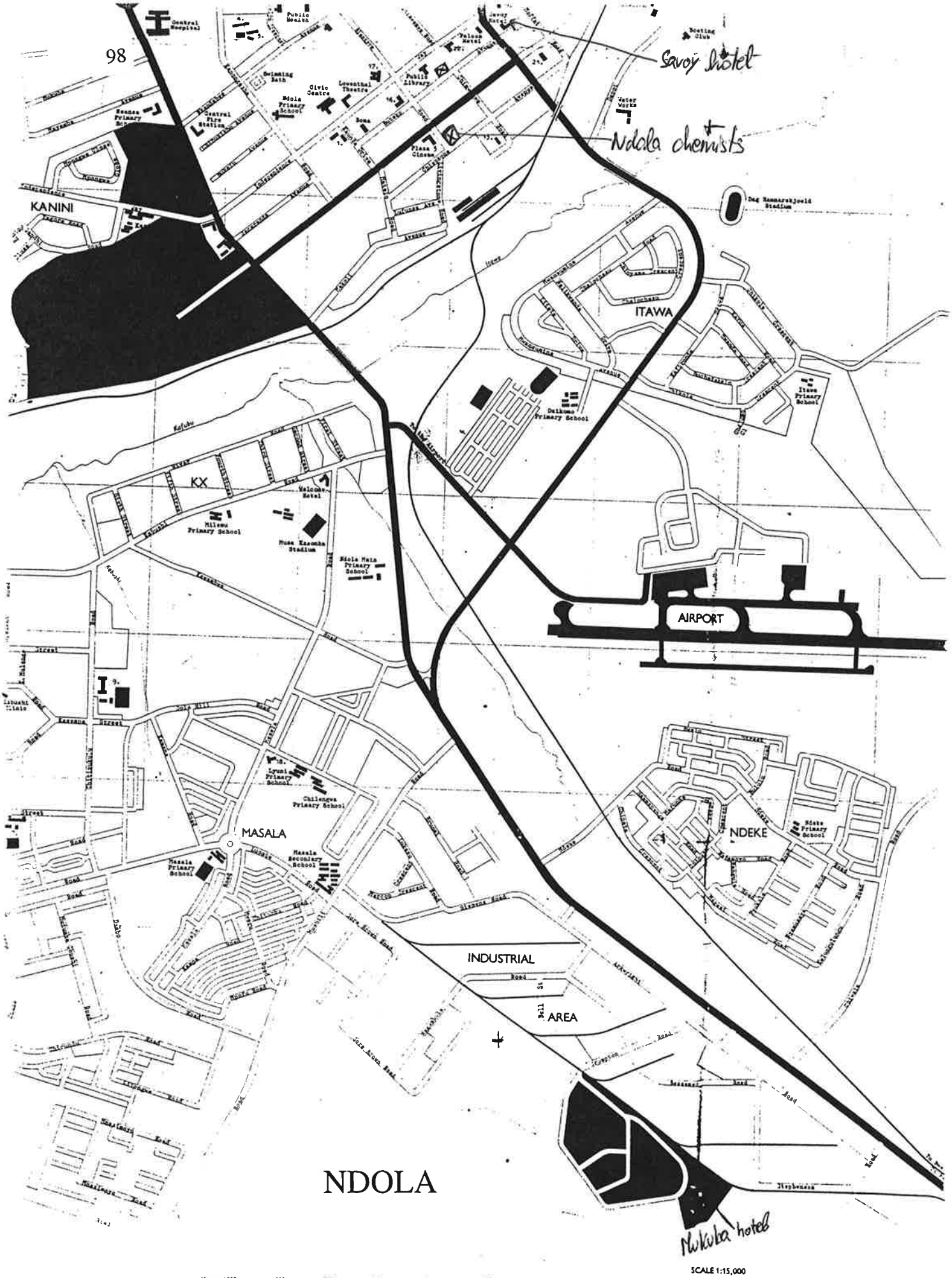
MAP OF GREATER LUSAKA

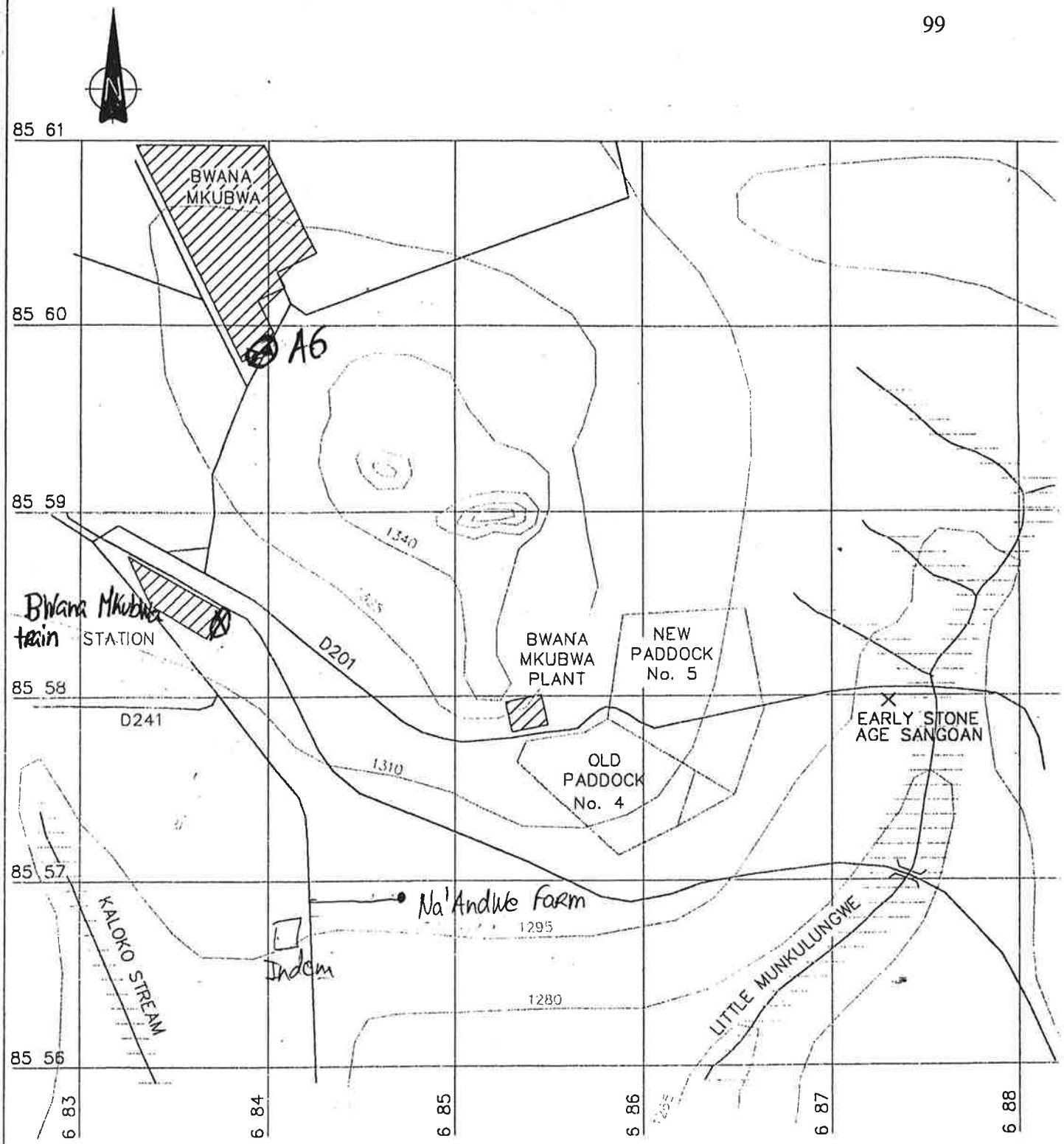
SCALE 1: 50,000

METRES 1000 0 1 2 3 4 5 6 7 8 KILOMETRES

MILE 1 0 1 2 3 4 5 6 MILES

FEET 5000 2500 0 5000 10000 15000 20000 25000 30000 FEET


Savoy hotel
Ndola chemists
KANINI
ITAWA
KX
AIRPORT
MASALA
NDEKE
INDUSTRIAL
AREA
NDOLA
Mukuba hotel
SCALE 1:15,000



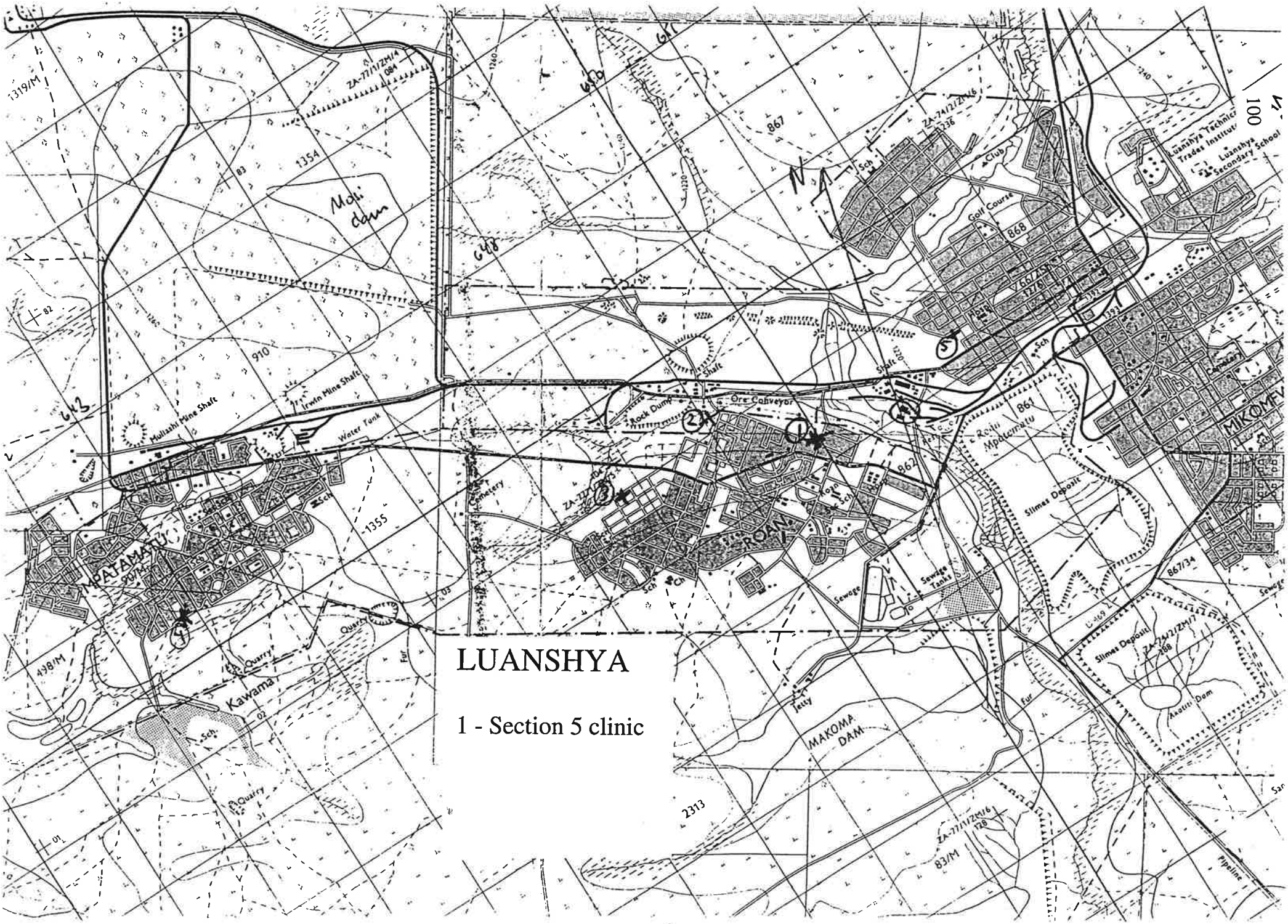
BWANA MKUBWA MINING LTD.

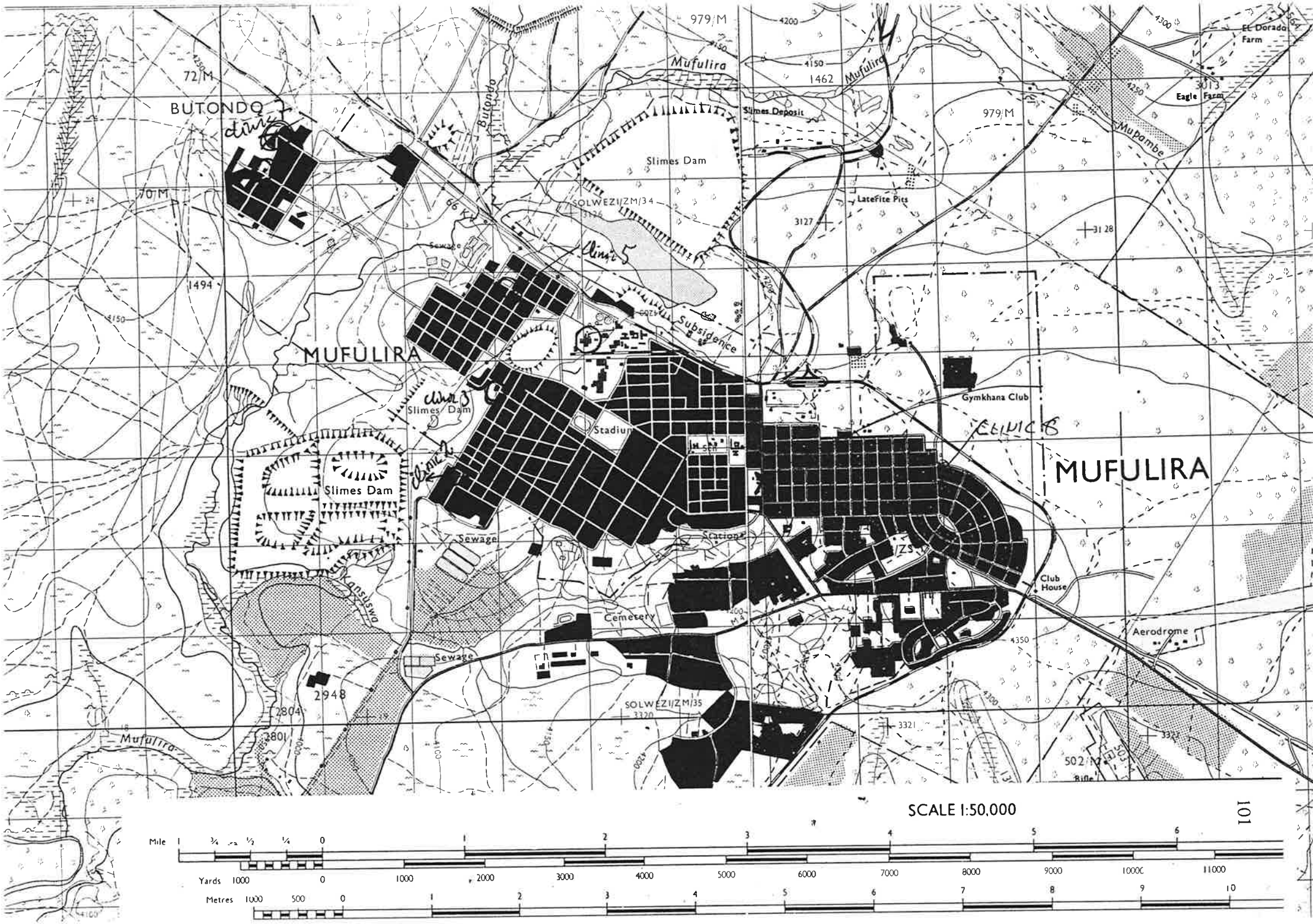
ENVIRONMENTAL PROJECT BRIEF

FIGURE 2

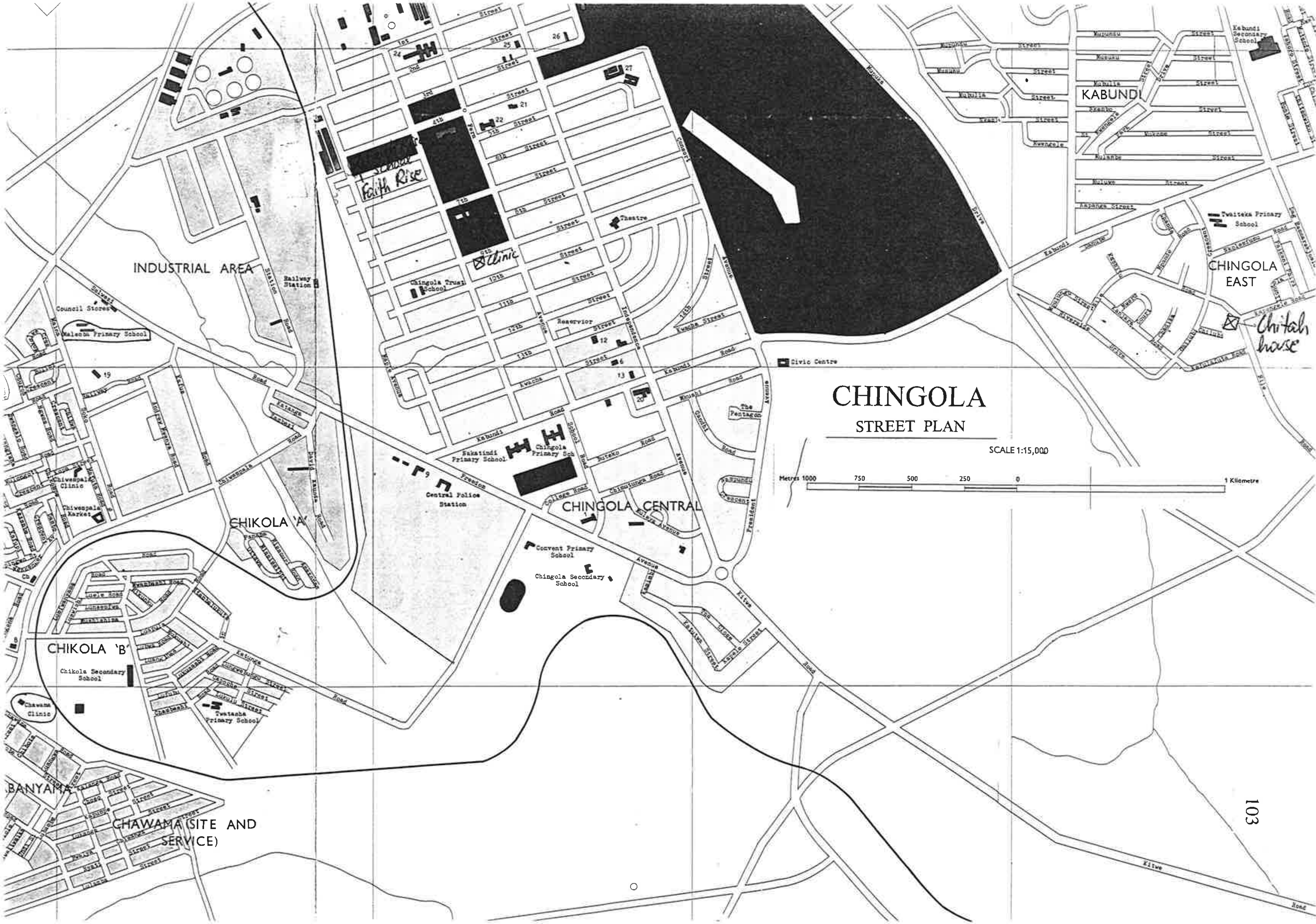
LOCATION PLAN

NDOLA


LUANSHYA
1 - Section 5 clinic
MPATAMATU
ROAN
MIKOMFU
MAKOMA DAM
Kawama
Mali dam
Mullashi Mine Shaft
Irwin Mine Shaft
Water Tank
Ore Conveyor
Rock Dump
Shaft
Cemetery
Golf Course
Club
Sewage
Sewage Tanks
Slimes Deposit
Jetty
Quarry
Pipeline
Luanshya Technical Trades Institute
Luanshya Secondary School
Reiti Mpatamatu
Akatiti Dam
1354
1355
910
867
868
862
861
867/34
498/M
83/M
2313


BUTONDO
MUFULIRA
MUFULIRA
Slimes Dam
Slimes Dam
Slimes Dam
Slimes Deposit
Subsidence
Stadium
Gymkhana Club
Sewage
Sewage
Sewage
Cemetery
Stations
Club House
Aerodrome
Latefite Pits
El Dorado Farm
Eagle Farm
Mupambe
Mufulira
Mufulira
Mufulira
Butondo
Kansuswa
SOLWEZI/ZM/34
SOLWEZI/ZM/35
979/M
72/M
70/M
1494
1462
3013
2948
2804
2801
3127
3320
3321
4200
4150
4250
4300
4350
SCALE 1:50,000
Mile
Yards
Metres
101

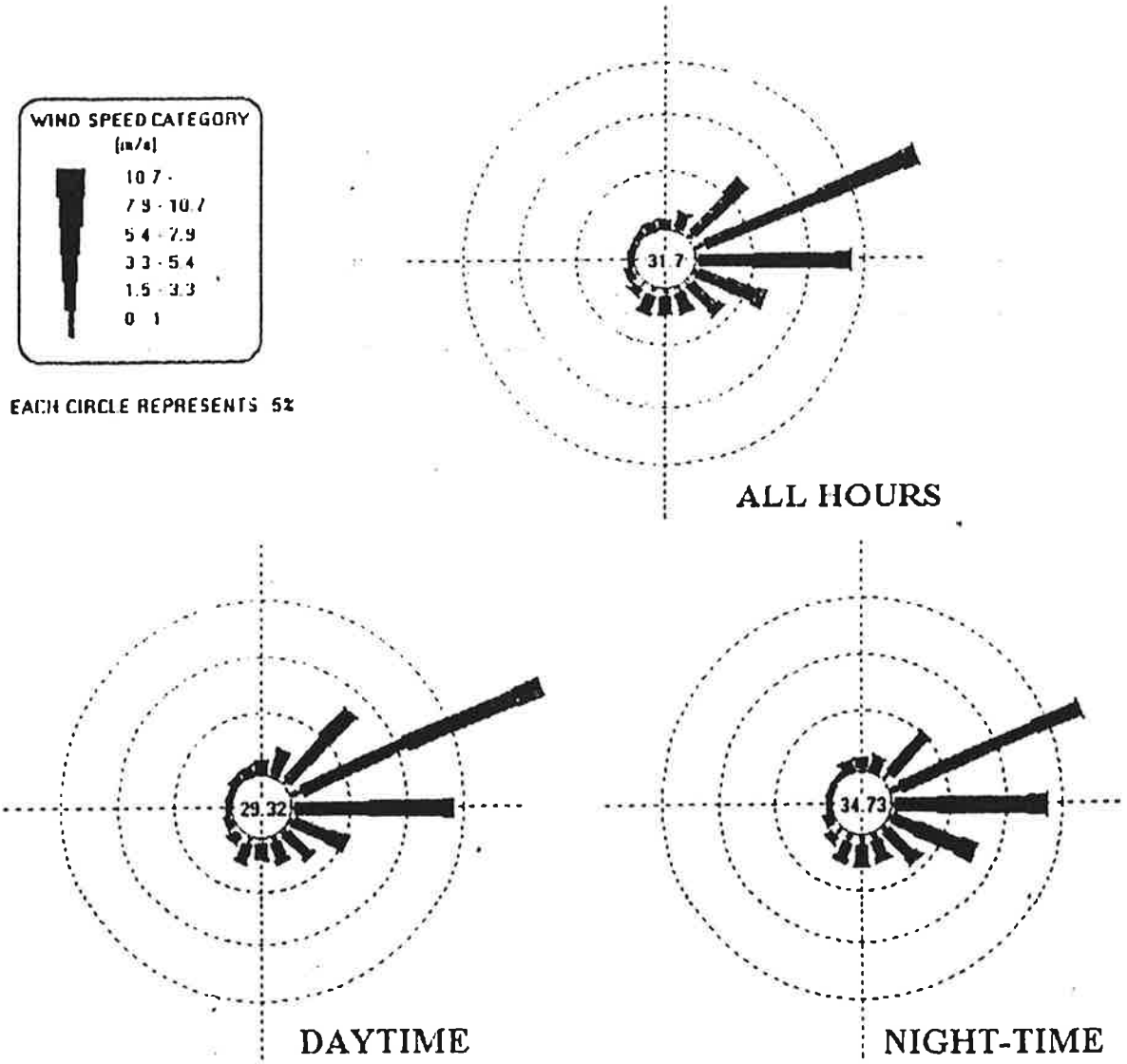

MINDOLO NORTH
102
MINDOLO
RAMITONDO
BUCHI
RIVERSIDE
MISESHI
CHA CHA CHA
MARTINDALE
HSD
NKANDABWE
Golf club 900m E
NKANA EAST
NKANA WEST
SLUG DUMP
Fire brigade
Clinic C 7
CO-OPERATION
DEVELOPMENT THROUGH
AND HARD WORK
CITY OF KITWE
STREET PLAN
SCALE 1:25,000
750 500 250 0 1 2 Kilometres


CHINGOLA
STREET PLAN
SCALE 1:15,000
Metres 1000
750
500
250
0
1 Kilometre
INDUSTRIAL AREA
CHINGOLA CENTRAL
CHIKOLA 'A'
CHIKOLA 'B'
CHAWAMA (SITE AND SERVICE)
KABUNDI
CHINGOLA EAST
Railway Station
Council Stores
Malecha Primary School
Chingola Trust School
Clinic
Theatre
Reservoir
Civic Centre
The Pentagon
Nakatindi Primary School
Chingola Primary Sch
Central Police Station
Convent Primary School
Chingola Secondary School
Chikola Secondary School
Chawama Clinic
Twatasha Primary School
Chiwempala Clinic
Chiwempala Market
Twaiteka Primary School
Kabundi Secondary School
Chitah house
Faith Rise
Freedom Avenue
Kitwe Road
Kabundi Road
Independence Avenue
President Avenue
Kabundi Drive
Station Road

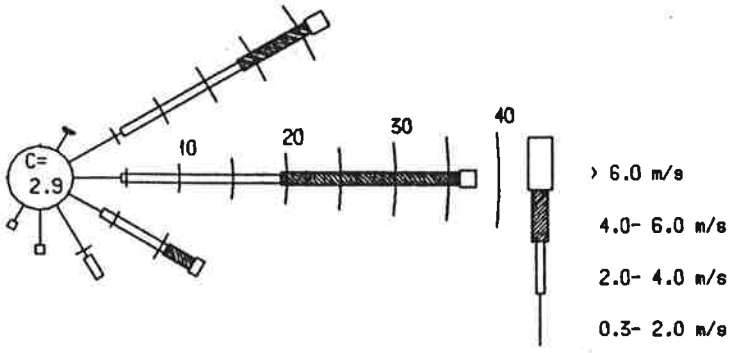
Appendix M

Wind roses

Wind roses for 1995 at Mufulira Smelter



Wind rose for 01.09.98 - 24.09.98 at Mufulira Smelter



Norwegian Institute for Air Research (NILU)
P.O. Box 100, N-2027 Kjeller, Norway

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Ambient air quality monitoring system for Zambia Mission report no. 2 to Zambia, April 1999	C. Guerreiro NILU PROJECT NO. O-99008
AUTHOR(S) Cristina Guerreiro	CLASSIFICATION * A CONTRACT REF.

REPORT PREPARED FOR
Norwegian State Pollution Control Authority (SFT)
P.O.B. 8100 Dep
N-0032 OSLO

ABSTRACT
Summaries of the mission to Zambia in April 1999 to support the Norwegian State Pollution Control Authority (SFT) in defining the ambient air pollution component of the Industrial Pollution Prevention Programme (IPPP) operated by the Environmental Council of Zambia (ECZ). A screening study of the present ambient air quality was undertaken, with visits to the main industries and installation of passive samplers in Lusaka, Maamba, Mazabuka and the Copperbelt areas. As a result of this mission the measurement programme for ambient air quality measurements in Zambia has been designed.

NORWEGIAN TITLE
Luftkvalitetsovervåkingsprogram for Zambia

KEYWORDS		
Screening study	Monitoring	Zambia

ABSTRACT (in Norwegian)

* *Classification*
- *A* *Unclassified (can be ordered from NILU)*
- *B* *Restricted distribution*
- *C* *Classified (not to be distributed)*