F I E L D R E P O R T

WATER SHORTAGE AND RELATED PUBLIC HEALTH PROBLEMS:

AN ACTION PLAN FOR THE CITY OF BEIRA, MOZAMBIQUE

WASH Field Report No. 389
February 1993

WATER AND SANITATION for HEALTH PROJECT

Sponsored by the U.S. Agency for International Development
Operated by CDM and Associates

WASH Field Report No. 389

WATER SHORTAGE AND RELATED PUBLIC HEALTH PROBLEMS:

AN ACTION PLAN FOR THE CITY OF BEIRA, MOZAMBIQUE

Prepared for the USAID Mission to Mozambique,
U.S. Agency for International Development
under WASH Task No. 432

by

Kate Burns
Don Cullivan
J. Slade Dingman

February 1993

Water and Sanitation for Health Project
Contract No. DPE-5973-Z-00-8081-00, Project No 936-5973
is sponsored by the Office of Health, Bureau for Research and Development
U.S. Agency for International Development
Washington, DC 20523

CONTENTS

ABOUT THE AUTHORS

Kate Burns has over eighteen years of experience in planning, implementing, and evaluating international health programs in Africa, Asia, and Latin America. Her assignments have included long term residencies in five countries and short term consultancies in more than twenty countries. She has had extensive involvement in the technical areas of diarrheal diseases, immunizations, water and sanitation, Vitamin A, AIDS education and family planning. Ms. Burns has a B.S. in Nursing and a Master's in Public Health.

Don Cullivan, M.S., is an environmental engineer with 35 years of experience in consulting engineering and institutional development. Most of his experience has been in developing countries including several assignments in Jamaica for the National Water Commission. He also has seven years of residency outside the United States. Most of his work in recent years has been in water and wastewater planning and assessment, and institutional development.

J. Slade Dingman, M.S., is a geologist with 11 years of experience directing and conducting hydrogeologic investigations related to water resource assessment and development, mineral exploration and mining. Currently, Mr. Dingman supervises Camp, Dresser and McKee International's Denver office hydrogeology group.

ACRONYMS

International Organizations

FINNIDA	Finland International Development Agency
ICRC	International Committee for the Red Cross
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USFDA	United States Foreign Disaster Assistance

National Level

DAS	Water and Sewerage Department of DNA (*Departamento de Aguas e Saneamento de DNA*)
DNA	National Directorate for Water (*Direccion Nacional de Aguas*)
GEOMOC	State Water Well Drilling Company
HIDROMOC	State Hydraulic Equipment Company
MCA	Ministry of Construction and Water (*Ministerio de Construcao e Aguas*)
MOH	Ministry of Health
PLM	National Institute of Physical Planning (*Programa de Latrines Melhorades*)
PRONAR	National Program for Rural Water (*Programe Nacional de Aguas Rurais*)
SUPRA	Supervisory Unit under DAS
UNEAS	Unit Directorate of Water and Sanitation Companies (*Unidade de Empresas de Aguas e Saneamento*)

Nongovernmental Organizations

FHI	Food For The Hungry
LWF	Lutheran World Federation

Provincial and Municipal Levels

AdB	Beira Water Company (*Aguas de Beira*), used interchangeably with CAB
CAB	Beira Water Company (*Companía Aguas de Beira*)
CHB	Central Hospital of Beira
CHBL	Central Hospital of Beira's Laboratory
DPCA	Provincial Directorate for Construction and Water (*Direccion Provincial de Construcao e Aguas*)
DPS	Provincial Directorate of Health (*Direccao Provineral de Saude*)
E de A	City Water Company (*Empresas de Aguas*)
EPAR	Provincial Workshops for Rural Water (*Estaleiro Provincial de Aguas Rurais*)
LRHAA	(*Laboratorió Regional de Higiene de Aguae Alimentos*)
PAABP	Program for Periurban Water Supply (*Programa de Absticemento de Agua dos Bairros Perefericos*)
PEC	Community Education Programs (*Programa de Educaçao Communidade*)

Other Acronyms

AdM	Mozambique Sugar Company (*Açucareira de Moçambique*)
DHV	Dutch Consultancy to World Bank
LPCD	Litre Per Capita Per Day
NGO	Nongovernmental Organization
ORS	Oral Rehydration Solution
UDAAS	Association of Water Companies

EXECUTIVE SUMMARY

ACTION PLAN TO ADDRESS WATER AND PUBLIC HEALTH PROBLEMS CITY OF BEIRA, MOZAMBIQUE

During the last three years, Beira's normal population of about 275,000 has nearly doubled due to an inflow of people displaced by civil war and drought. Major internationally funded projects currently are underway to increase the capacity of the water treatment, transmission, and distribution systems, to improve the wastewater system, and to strengthen *Companía de Agua de Beira's* (AdB) capacity to effectively carry out its responsibilities. While these programs have a total value of over US$75 million, none address solutions to the current emergency conditions or programs to guarantee Beira a reliable supply of raw water.

Even before the drought, AdB provided only intermittent service to less than half the people in its service area. The unserved portion of the population currently depends upon shallow wells, as they did before AdB started to supply water in 1954.

Effect of the Drought on the Water Supply

Several years of below-average rainfall have produced record-low flows in the Pungoe River (pronounced "Poong-Way"), Beira's only surface water supply. While sufficient in quantity to meet Beira's supply needs, these low flows fail to prevent saltwater from reaching the intake, some 77 km from the mouth of the estuary. At best, this means water can be pumped from the river only during periods of low tide. At times, however, the water is saline under all tidal conditions, and the intake pumps must be shut off. During October and November 1992, the situation was so extreme that the entire system was shut down for nearly seven weeks. Total water produced in 1991 was about two-thirds of the system's capacity and in 1992, it fell to less than half.

The lack of rainfall needed to recharge the groundwater aquifers combined with the periodic closure or intermittent operation of the water system also has placed added burdens on the shallow wells used by the majority of the population. Water levels have dropped; salinity has affected many wells; and the general quality of the well water has worsened. Only 30 percent of the permanent population is served by sewers. This lack of coverage and the poor quality of the sewers contribute to the groundwater contamination.

Findings

Water Needs and Losses

The immediate surface water needs are those required to supply the existing water treatment plant: 30,000 m^3 per day and another 30,000 m^3 per day for the new treatment plant about to be constructed. Until a proposed second transmission line is constructed, only 24,000 m^3 per day can be pumped to the city. Beira's water distribution system is subject to frequent breaks and high levels of leakage; house connections and internal plumbing also are sources of significant losses. These losses, which amount to about half of the water produced, would be greater if system pressures were not very low. Distribution system improvements, now funded by international donors, are underway.

Surface Water and Deep Wells

The Pungoe River is the only feasible source of surface water. While other possible sources of groundwater supply should be investigated, the chances of success probably are not high. Three deep (> 100 m) test wells drilled in 1992 were disappointing in either quality, quantity, or both. The drought over the past few years has made it clear that without some form of regulation the Pungoe River is not a dependable source. A suggested high dam at Bue Maria would certainly achieve regulation, but high costs make it an unrealistic solution at this time.

The principal finding relative to raw water supply is that the present sources are unreliable and inadequate to meet current present or future needs.

Shallow Wells and Standposts

Despite the long drought and the many problems with quality, shallow wells continue to be the principal source of water for the majority of people now living in Beira. In addition, poor sanitation facilities and practices, improper well design, and inoperative handpumps have limited the effectiveness of the shallow wells as much as the drought. Similarly, as a result of the inadequate number and quality of standposts, a large percentage of people are not directly connected to the water distribution system.

Public Health Consequences of Inadequate Water

During most of October and November 1992, AdB did not supply water to Beira or Dondo residents. The population was forced to use groundwater sources, often contaminated. Waterborne illnesses, including diarrhea and cholera, increased significantly during this period.

During this two-month period, health authorities treated 2,286 suspected cases of cholera at the Central Hospital of Beira (CHB). A total of 73 deaths were registered with a Case Fatality Rate (CFR) of 3.2 percent. Upon reviewing laboratory results, 1,110 cases were confirmed as cholera, with a resulting cholera CFR of 6.6 percent. By mid-December, the cholera

outbreak started to decrease. The City Health Department and CHB authorities have done a commendable job in meeting this crisis, but medical supplies now are running extremely low.

Cases of diarrhea, in general and especially for children under five years, have increased significantly since October 1992. Given the low nutritional status of many children in the area, additional diarrhea attacks pose a significant risk. Health education campaigns have been conducted haphazardly with questionable results.

Recommendations

- Evaluation of Proposals by Local Water Officials: As long as four years ago, officials of the National Directorate of Water (DNA) prepared proposals for addressing the problems of the drought-induced water shortage. Those proposals appear essentially sound and serve as the basis for the recommendations presented in this report.
- Emergency Program: It is the intention of the Government of Mozambique to request financial assistance from the international donors to fund the following programs. Where donors already are involved and the proposed programs relate to their projects, specific assistance is requested. The following elements of the emergency program are listed in suggested order of priority.

Emergency Program Elements

- Appoint an executive coordinator from within the Government of Mozambique to serve as liaison between the government and the donors, and engage the services of a field coordinator to manage the implementation of proposed projects. Without such assistance, local authorities will be too heavily burdened to ensure effective implementation.
- Purchase medical supplies for the Central Hospital of Beira for the treatment of cholera and other diarrheas; purchase selected laboratory supplies to monitor the cholera outbreak and test water quality; and, begin long-term programs to improve hygiene education, sanitation and water collection in the urban and peri-urban bairros of Beira.
- Request the Government of Italy to reallocate funds to allow the contractor already on-site to dredge the existing intake canal to store water for use when the river water is contaminated by salt. This would allow up to ten days' storage of raw water.
- Design a low dam (5m in height), just downstream from the existing intake to act as a saltwater barrier when river flows are low. The design and environmental impact assessment should be completed immediately to allow construction of the dam on short notice should the drought continue after the current rainy season.
- Construct the dam described in the above recommendation only if the river flow at the end of the current rainy season is sufficiently low to pose a threat.

- Prepare terms of reference for a detailed study of the area's water resources and identify alternative means of strengthening Beira's raw water supply. This activity is critical to a long-term approach to solving Beira's water shortage problems.
- Conduct the water resources study described in recommendation.
- Conduct a detailed study of the existing shallow wells and recommended feasible improvements. The study should note location, type, water depth, water quality of wells, and nearby sanitary facilities.
- Request the Government of Finland to permit its Beira consultant to design units which combine storage and public standposts, as part of its task of strengthening the Beira water system. A total of 220 units are recommended and could be served by AdB's pipelines, tanker trucks or wells.
- Construct the storage/standpost units described in recommendation.
- Implement, through the services of an appropriate on-site nongovernmental organization (NGO) such as Africare, a program to rehabilitate 200 existing shallow wells, to replace 40 inoperative handpumps in critical areas with "Afridev" units, to construct 50 new shallow dug wells and 200 new sanitary pit latrines in the vicinity of these wells. Consideration should be given to renovating the existing public latrines.
- Enter into a formal agreement with the *Acucareira de Mozambique* (AdM)—the sugar plantation which owns and operates the raw water intake and canal—that will require AdM to stop using this water for irrigation whenever the flow and tidal conditions threaten operation of the intake.
- Design and implement a public education program on basic sanitation habits and practices and on the need for water conservation during dry periods. This program would be directed at school children and the general public through the media most appropriate for Beira.
- Provide support training for health workers and staff in Beira on the management of cholera and diarrheal diseases. The proposed program includes two three-day seminars for 50 employees.
- Purchase water tank trucks and other commodities and equipment to support the program.

Estimated Cost of the Emergency Program

As mentioned earlier, international donors already are funding projects with a value in excess of US$75 million. Yet, none of the projects are directed to Beira's immediate water and health problems. The estimated cost of the recommendations described in the emergency program is $US4 million, or slightly more than 5 percent of the cost of the major projects already funded and underway. A summary of the costs of the emergency program is shown in the following table.

ESTIMATED COST OF SPECIFIC RECOMMENDATIONS

Recommendation	Estimated Cost
Hire a field program coordinator.	$200,000
Purchase medical supplies.	100,000
Dredge the intake canal.	100,000
Design temporary dam.	30,000
Prepare scope of work for water study.	20,000
Conduct shallow well survey.	50,000
Design storage/standpost units.	60,000
Construct shallow well improvements.	800,000
Agree with Açucareira on water use.	Unknown
Conduct public information programs.	50,000
Train health workers.	10,000
Construct storage/standpost units.	800,000
Conduct water resources study.	1,000,000
Purchase water trucks and miscellaneous equipment.	250,000
Construct low dam.	250,000
Estimated Total Program Cost	$3,720,000
Suggested Contingency Allowance	280,000
Suggested Budgetary Allowance	$4,000,000

Chapter 1

INTRODUCTION

1.1 Objectives

The scope of work for this study is presented in Appendix A. The objectives are summarized as follows:

- to assess the magnitude of the existing water supply and public health problems in the city of Beira and surrounding areas caused by the extended dry periods in the Pungoe River basin; and,
- to identify a range of alternative solutions or improvements to present to the international community for their consideration for prompt implementation.

1.2 Methodology

1.2.1 WASH Team

At the request of USAID/Maputo, the Water and Sanitation for Health Project (WASH) assigned a three-person team to conduct the assessment and present recommendations. The team included an environmental engineer (team leader), a groundwater hydrologist, and a public health specialist. The team spent several days in Maputo at the beginning and end of the assignment and two weeks in Beira, for a total of three weeks in Mozambique.

1.2.2 Team Member Assignments

- The public health specialist interviewed a wide range of government and NGO public health officials in Maputo and Beira. The work included evaluation of the existing health care delivery system and facilities and review of appropriate records and statistics. The public health specialist conducted field studies of hospitals, clinics and other health care facilities; investigated typical housing and water and sanitation practices; and interviewed those giving and receiving health care.
- The groundwater hydrologist interviewed government officials and contractors in Maputo and Beira who had current knowledge of groundwater conditions in the Beira area. The team member reviewed reports and records, made field visits to a wide range of machine, hand-drilled and hand-dug wells, and observed current practices in the use of groundwater, both inside the city and in the surrounding area.

- The environmental engineer interviewed government officials and contractors in Maputo and Beira who had current knowledge of all aspects of surface water supplies and water delivery. Work included reviewing reports and records related to the current drought and taking field inspection trips to existing and former intakes on the Pungoe River, proposed low dam sites, and the water treatment plant.

1.2.3 Team Approach

With information gained from their individual investigations, the WASH team jointly developed a range of alternative measures to alleviate the identified problems. These recommendations were discussed with water and public health officials who have prime responsibility in each discipline area, and the team's findings and recommendations were then formally presented to a wider audience of interested parties, including provincial authorities in Beira, international donors, and senior members of the Ministry of Construction and Water (MCA or *Ministerio de Construcao e Aguas*), National Directorate for Water (DNA or *Direccion Nacional de Aguas*), and Ministry of Health (MOH) in Maputo. Discussions and comments from those meetings were taken into account in preparing this final draft report.

Chapter 2

BACKGROUND

2.1 Mozambique and the City of Beira

The City of Beira is the second largest city in Mozambique, after the capital of Maputo, and is the capital of the Province of Sofala (see Figure 1, Location Map). Beira is an important port and has good road and rail links to Zimbabwe, Zambia, and Malawi. Of particular significance is the "Beira Corridor," a relatively thin strip of land (approximately 10 km wide), extending from Beira to Harare, Zimbabwe. Along the corridor runs a paved road and rail, oil, water, and power transmission lines.

The Province of Sofala has an estimated population of 1.4 million. The Ministry of State Administration estimated Beira's population at 240,000 in 1989, but unofficial estimates indicate that this number has doubled. The present rough estimate of the population of Beira and Dondo is over 500,000, including people living in encampments, dispossessed by war and drought (*deslocados*). The more densely populated area of Beira is sometimes called cement city since most of its buildings are of masonry construction.

An agreement reached between the government and rebel forces in October 1992 appears to have reduced the level of fighting; the country is relatively calm at this time. The United Nations (UN) recently announced plans to establish a substantial peace-keeping force in Mozambique to ensure that the scheduled 1993 elections are held in a calm atmosphere. These measures, when taken, should provide improved conditions for the implementation of the recommendations of this report.

2.2 Current Water and Wastewater Development Projects

Several ongoing water sector projects are currently being financed by bilateral and international development organizations. These projects should lead to improved water and sanitation in Beira. However, while they provide badly needed, long-term improvements, none specifically address the current emergency conditions. These projects are described in Appendix B.

The estimated total US$ value of these projects is in the order of $75 million.

2.3 Agencies Responsible for Water Supply and Sanitation

An organization chart for the water and wastewater sector in Mozambique is presented in Appendix C. The responsible agencies are described in Appendix D, and the key agencies are summarized below.

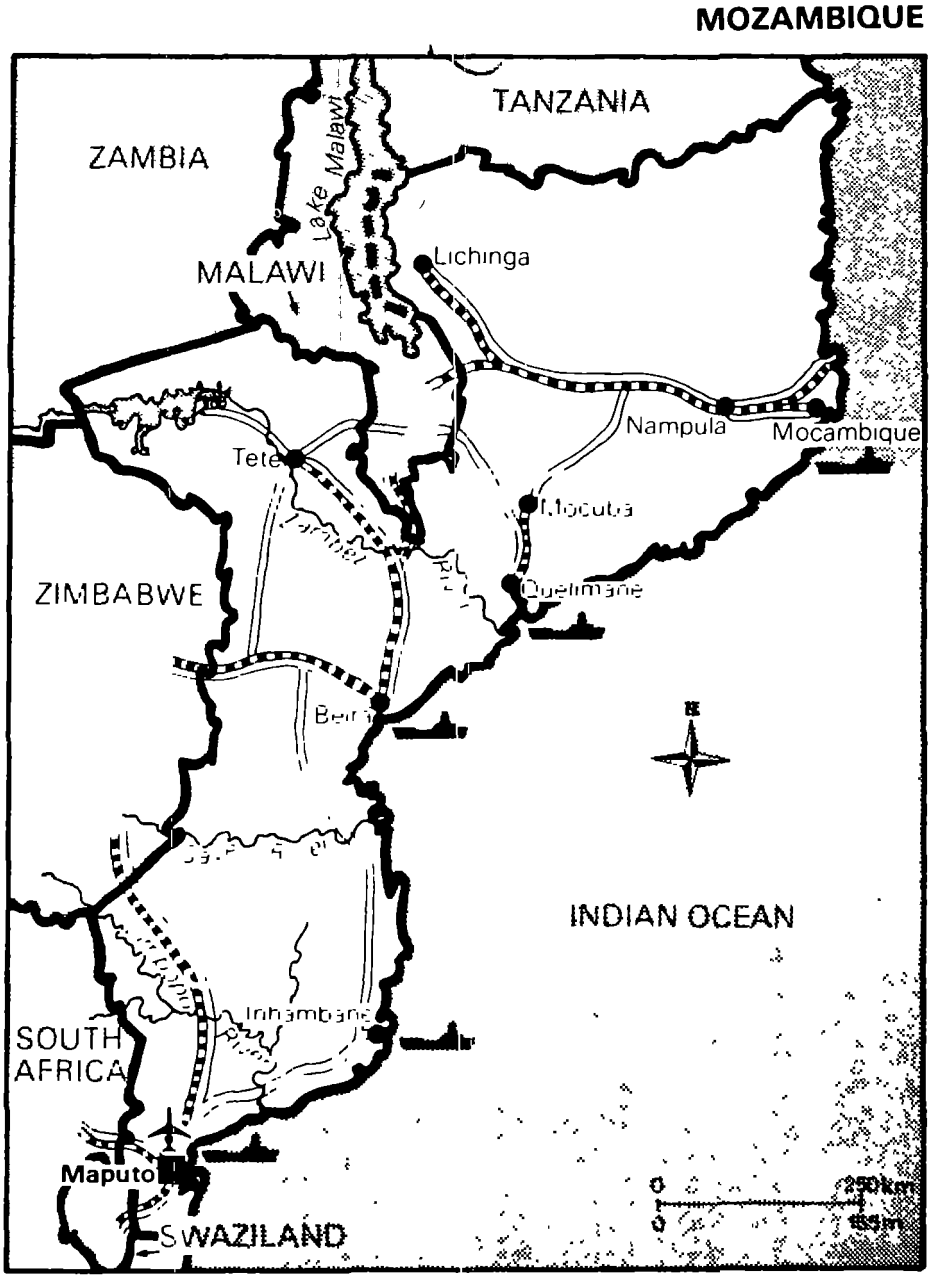


Figure 1

Location Map

2.3.1 Principal Agencies at the National Level

The Ministry of Construction and Water provides overall responsibility for water and wastewater at the highest level of the government. MCA provides administrative control over water and wastewater in the provinces through Provincial Directorates for Construction and Water (DPCA).

The National Directorate for Water reports to MCA. DNA is the principal technical planning and executing agency at the national level for municipal water and wastewater for Maputo and 12 other provincial capital cities. DNA provides technical control and assistance to these large cities, either directly or through UNEAS, the Unit Directorate of Water and Sanitation Companies.

DNA recently created a new supervisory unit called SUPRA. It monitors and supervises the many internationally funded water and sanitation projects now underway in Beira.

2.3.2 Other Agencies at the National Level

The National Program for Rural Water (PRONAR), reports to DNA and is the principal national-level technical planning and executing agency for the provision of rural water supply.

- The Unit Directorate of Water and Sanitation Companies (UNEAS) is the current name of the Association of Water Companies (UDAAS). UNEAS also reports to DNA, but most of the larger city water companies appear to deal directly with DNA rather than through UNEAS.
- The State Water Well Drilling Company (GEOMOC) reports indirectly to MCA. GEOMOC is responsible for all deep well drilling in the country.
- The State Hydraulic Equipment Company (HIDROMOC) reports indirectly to MCA. HIDROMOC is responsible for the purchase of all chemicals, pipe, materials and equipment used by the water/wastewater sector. HIDROMOC also does some minor construction.

2.3.3 Provincial and Municipal Levels

The Provincial Directorate for Construction and Water (*Direccion Provincial de Construcao e Aguas, or DPCA*) DPCA reports to the MCA. DPCA offices represent the interests of MCA in the provinces. DPCA coordinates the efforts of other water and sanitation agencies in each province.

The various city water companies (*Empresas de Aguas, or E de A*) sometimes report to DNA through UNEAS, but larger companies deal directly with DNA. The water companies in the provincial cities are responsibile for providing water, and sometimes wastewater services to the people, industries, and commercial entities in their service areas.

Beira Water Company (*Companla Aguas de Beira*, or AdB) is the municipal water and wastewater company for the city of Beira. AdB started providing water supply about 1954, and was assigned wastewater responsibilities in 1983. AdB deals directly with DNA. As noted, Beira's internationally funded projects are supervised by DNA's SUPRA unit.

Provincial Workshops for Rural Water (*Estaleiro Provincial de Aguas Rurais*, or EPAR) reports to PRONAR and represents the interests and fulfills the responsibilities of PRONAR in the provinces.

Community Education Programs (*Programa de Educaçao Communidade*, or PEC) is an internal department of EPAR. PEC seeks to educate the people in the community about health and sanitation related to water supply.

Program for Peri-urban Water Supply (*Programa de Asabticemento de Agua dos Bairros Perefericos*, or PAABP), reports to DNA through UNEAS. This agency is the peri-urban equivalent of the urban water companies PAABP does not serve all cities, and currently has no responsibilities in Beira.

2.4 Agencies Responsible for Public Health

The Provincial Directorate of Health (*Direccao Provincial de Saude or DPS*), is the government agency responsible for the health of the people in Sofala Province. (See Appendix C for Organizational Chart of Sofala Province). In the city of Beira, including the peri-urban area, the city Department of Health is responsible for providing health services. A few private practitioners work in the city but no private clinics exist. No other entities are currently providing medical services to the people of Beira. In Dondo, the Ministry of Health (MOH) district health team is responsible for delivery of health care. Several nongovernmental organizations (NGOs) provide relief services, including health, water and sanitation related services.

2.5 Nongovernmental Organizations (NGOs)

A variety of NGOs are working in relief activities in Sofala Province. Principal among these are: International Committee for the Red Cross (ICRC), CARE, Mozambique Red Cross, Food for the Hungry (FHI), Lutheran World Federation (LWF), Africare, Redd Barne, and Médicins Sans Frontières (MSF). Most of these have been working in the Beira Corridor but now are expanding into other districts in the province. NGOs distribute food, seeds, and tools, primarily to dislocated people. No NGOs are working in the city of Beira at this time.

The WASH team visited with several of the key NGOs working in water supply, sanitation, and health in Sofala Province. Africare appears to be the most able and interested of the existing NGOs that could provide assistance in urban and peri-urban areas of Beira. Africare has a strong administrative and technical structure in place to respond to an emergency action plan. A water technician is expected to join the Africare Beira office in early 1993. Other

NGOs contacted during this visit are neither interested nor able to expand their programs into the urban or peri-urban areas of Beira.

Chapter 3

ASSESSMENT OF EXISTING CONDITIONS

3.1 Description of the Drought

The U.S. Foreign Disaster Assistance (USFDA) unit of USAID assessed the effects of the drought which has affected most of the low-lying areas of the southern portion of Africa, below 13 degrees latitude, for the past three to four years(USFDA 1992). The USFDA report focused on the widespread and catastrophic problems of crop failures, but also addressed impacts on water supply.

In reviewing the situation in Mozambique in April 1992, the report concluded that the drought is "severe," that "river flows have dropped drastically," and that "drying up of wells and boreholes throughout the country is causing distress migration" from the interior to such areas as the Beira Corridor.

3.2 Impact of the Drought on Beira's Water Supply

The details of the ground- and surface-water supply problems created by the drought are presented in Chapter 4. Overall, the impact has been severe and extremely disruptive. The combination of record-low flows in the Pungoe River and saline intrusion at the city's raw water intake on the Pungoe River, resulted in the closure of Beira's only water treatment plant from October 9 until November 30, 1992.

For almost a week after the intake was closed, AdB was able to ration its stored water to provide some service every other day for a few hours. From October 15 until November 30, however, the water mains were dry. The combination of high tides and low river flows caused the intake to be closed down again on December 9. The intake pump station frequently has been inoperative during the past several months when salinity levels reached unacceptably high levels.

When the water mains go dry, hotels, businesses, and wealthy individuals purchase water from private tank trucks which pump water from private wells or the few small surface water ponds that still exist. Poorer people dig new wells, rehabilitate old ones, raise water from deeper levels, or get by with water that is brackish or contaminated.

3.3 Prior Studies Related to Drought Conditions

There have been a substantial number of studies on the drought in the general area and the specific water problems in Beira (see Appendix E). Each of these studies has contributed significantly to the ability of the WASH team to gain a rapid understanding of the problems and the range of possible solutions.

The USFDA and WASH reports provide an excellent overview and summary of the problems being caused by the drought. The Inception Report prepared for the World Bank by the Dutch consultancy DHV presented a wealth of useful and current data collected in a very brief time (DHV et al, 1992). The DNA studies were particularly helpful in presenting specific details and cost estimates of possible interventions to safeguard Beira's water supply (see References).

3.4 Limitations on the Government's Ability to Take Action

The Republic of Mozambique is presently in a seriously weakened position. Seventeen years of civil war and approximately eight years of drought have disrupted the country's economy and the lives of the majority of its people. These conditions have left the country with extremely limited financial resources and a severely deficient infrastructure. Mozambique receives significant assistance from the international community to stave off famine; nearly one quarter of the 1.4 million people of the province of Sofala require relief food.

Mozambique is fortunate to have a cadre of skilled and dedicated officials in its water and public health sectors, some of whom have served Mozambique for many years. They are assisted by specialists funded by several nations. The reports and studies by DNA make it clear that the current critical problems had been anticipated for several years but could not be prevented because of lack of funding.

3.5 Water and Sanitation Services

3.5.1 Water Services

The Beira water supply system begins at the Purigoe River, approximately 60 km northwest of Beira along the Beira Corridor. The raw water intake is located immediately downstream from where the Beira-Harare road crosses the river (see Figure 2). The raw water is pumped into a 7-km long open canal which provides irrigation water to a commercial sugar plantation. Water is then diverted via a 1.2 km long shallow conveyance canal to the raw water intake for the Mutua water treatment plant intake.

The Mutua water plant was built in the early 1950s and has a nominal capacity of treating up to 30,000 m^3 per day. Upon treatment, the water is pumped from a 3,000 m^3 reservoir 14 km to Mezimbite. The pipeline has a nominal maximum capacity of 24,000 m^3 per day. Currently, approximately 20,000 m^3 per day (non-metered) are treated at Mutua for distribution. At Mezimbite, which has 3,000 m^3 of storage, the water is delivered by gravity to the Manga distribution center, which lies 30 km to the south and has 30,500 m^3 of storage.

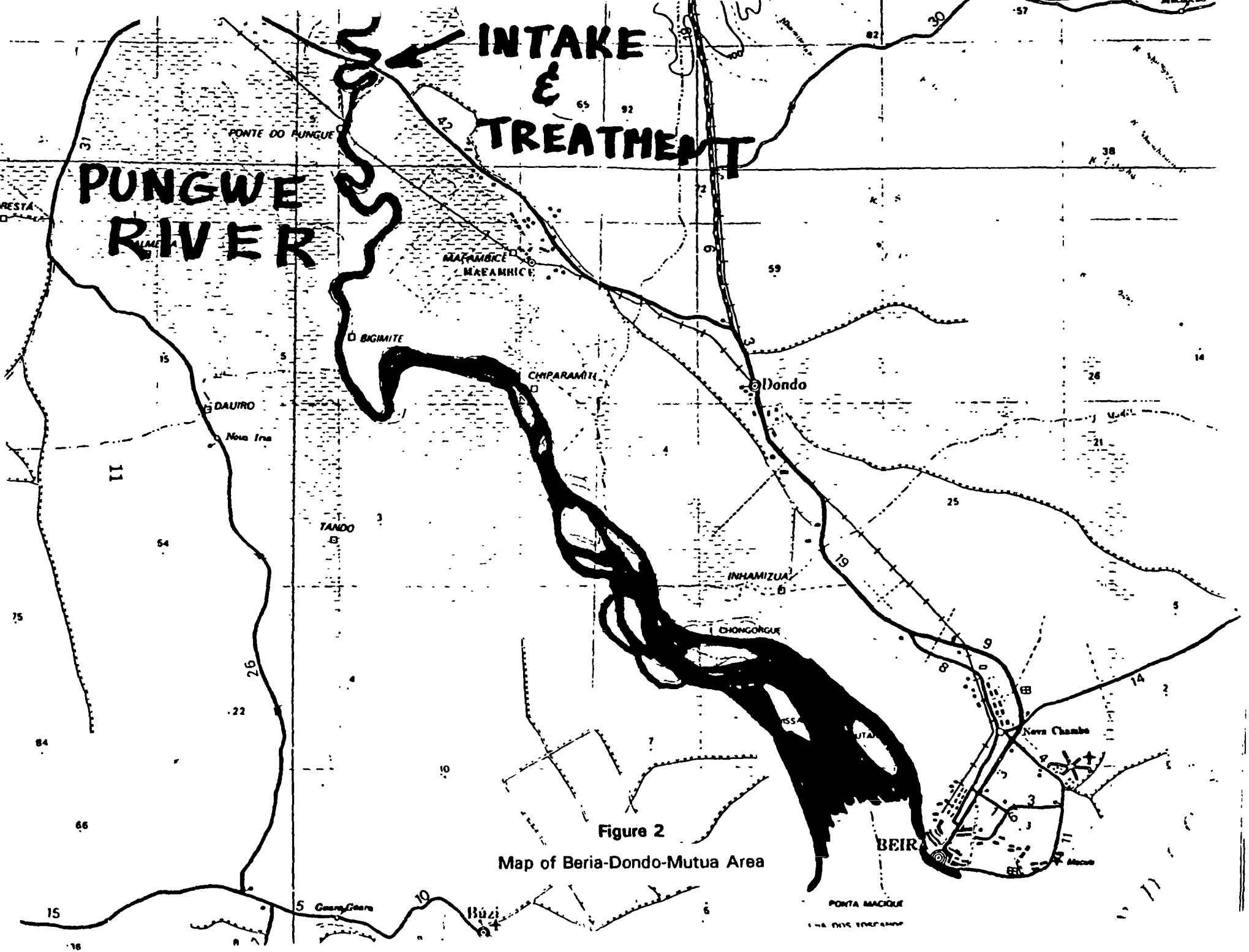


Figure 2

Map of Beria-Dondo-Mutua Area

The Manga District and the airport are supplied from this center. From Manga, the water is conveyed 6 km to the Munhava distribution center, which has 9,500 m^3 of storage. The city center, harbor, and surrounding areas are served from the Munhava center.

Figure 3 graphically depicts the monthly amount of water treated at the Mutua water supply plant during the past three years. The effects of the drought are clearly evident in 1991 and 1992.

Minor amounts of water are distributed to Dondo and the Mafambisse sugar factory. However, most of the output of the Mutua water treatment plant supplies about 125,000 people in Beira (DHV et al, 1992). This represents less than half of the permanent population, and only one-fourth of an estimated total population in excess of 500,000. Within Beira, certain areas such as the Macurungo bairro and the Macuti neighborhood have been served by small reservoirs. As a result of poor maintenance, however, these reservoirs are no longer operational.

The people living within the peri-urban areas of Beira are partially supplied by 76 standposts connected to the water supply system, but less than half of them now are in working order. The remaining portion of the population is dependent on shallow ground water and rainwater catchment and storage because few surface water sources are available in the area.

Many standposts and yard connections are broken. Low water pressure, poor water quality, and frequent disruptions to service caused by electrical outages are common. Water losses within the distribution system are estimated on the order of 50 percent, and would be greater except system pressures are very low.

Compounding these problems has been the need to shut down the whole water supply system for weeks at a time due to saline contamination at the raw water intake on the Pungoe River. The most recent all-day disruption to service lasted for seven weeks (early October through late November 1992), during which the entire Beira and peri-urban populations were dependent on alternative supplies. Although many of these wells are known to be contaminated, they continue to be used because of the limited, inadequate water supply system currently in place.

One, very limited alternative supply has been a series of ponds located on the outskirts of Beira called Six Miles. Water from here is pumped into tanker trucks (bowsers) and sold on the open market to industry and private enterprises.

In June 1989, the governments of Mozambique and Finland initiated the Beira Water Supply Project. The objectives of the project are to prepare appropriate plans for long-term development of the Beira water supply system and to implement some urgently needed rehabilitations. Phase I was recently completed. The goal of Phase II will be to supply 100 percent of Beira's urban and peri-urban population with water which meets international (WHO) water quality standards by the year 2000.

Treated Water in the Last Three Years

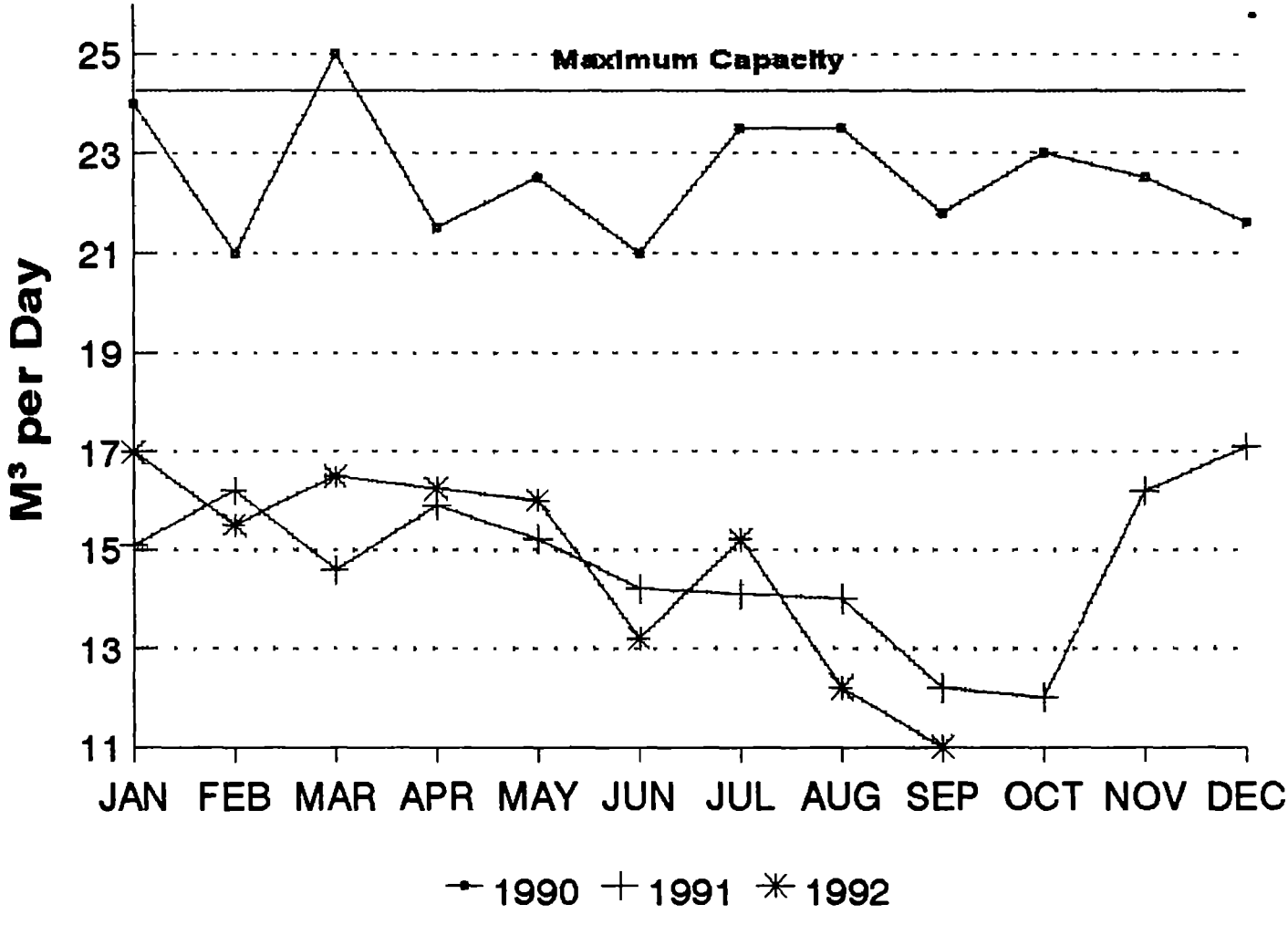


Figure 3

Mutua Water Treatment Plant Production, 1990-1992

3.5.2 Sanitation Services

The existing sewerage system for Beira covers only part of the Cement City. The system serves approximately 70,000 people, representing about one-third of the permanent population of Beira (FinnConsult and Vesi-Hydro, 1992). The densely populated areas within many of the bairros and peri-urban areas are essentially without sanitation services; there are an inadequate number of pit latrines and septic vaults.

The Beira sewerage system was built in the early 1960s and is the responsibility of AdB to maintain; ownership is held by CECB, the City Council of Beira. The system which is in an extreme state of disrepair, is currently undergoing rehabilitation. The World Bank is funding rehabilitation and extension of the network of sewers, and the Netherlands is funding rehabilitation of the wastewater pumping stations.

The main wastewater system is comprised of four main pumping stations. The secondary system consists of 11 pumping stations which are connected to the main system. Untreated wastewater is discharged directly to both the sea and the Pungoe River. Wastewater pumps are commonly out of service. Many of the pipe mains are corroded, clogged, or collapsed. All of the pumping stations have emergency overflows into the storm drain system, but the storm drains are generally dysfunctional because of inadequate maintenance. As a result, leaking wastewater from sewers, backups and overflows are common (DHV, 1988). In addition, most house connections also are said to be in a state of disrepair. Wastewater discharges to the environment (courtyards, streets, and to the subsurface) are common.

Beyond the area currently served by the sewerage system, few sanitation services are available. Manga, Dondo, and other towns outside of Beira have a similar lack of adequate sanitation services.

3.6 Health Services Delivery

3.6.1 Health Infrastructure

The city of Beira has a Central Hospital which is the only tertiary care facility in the province. Four health centers, two maternities, and eight health posts are located in Beira. In Dondo, one district hospital, a health center, and two health posts are currently functioning. In Beira all cases of cholera are treated at the Central Hospital of Beira. In Dondo, cholera cases are treated at the District Hospital.

CHB has a dedicated cholera infirmary with only 35 beds. During the current epidemic, this infirmary is filled to capacity with several patients in each bed and others on the floor. Patients who have passed the critical phase of the disease are moved to a nursing school classroom where most are without beds.

City health centers treat suspected cholera cases and send them directly to the CHB. Patients with other types of diarrhea are treated with oral rehydration solution (ORS) and discharged to their homes.

3.6.2 Health Personnel

Total health staff in the region, including those posted at the CHB, the City Health Department and provincial and district levels, are listed in Table 1. As Table 1 shows, the ratio of health workers to the population is extremely low and is inadequate to meet a potentially worsening public health emergency.

The location of staff within the province is changing rapidly. With the recent return of peace, district health activities are again functioning. Health workers are returning to their district positions. As a consequence, fewer health staff are in the city to cope with any emergency.

No community-based health workers (*agéntes polivalente*) are currently working in the health field.

Table 1
Health Personnel in Sofala Province

Cadre	Central Hospital of Beira	City of Beira	Pop. Per Health Worker[a]	District Level	Sofala Province Total
Medical Doctors	15	1	29,412	2	18
Nurses					
Specialists	23	3		0	26
Basic	176	42		66	286
Basic MCH	30	32		13	75
Elementares	2	20		40	62
Nurses Subtotal	233	97	1,515	119	449
Medical Assistants					
Preventive MA	1	15		11	27
Basic MAs	0	14		10	24
MAs Subtotal	1	29	16,129	21	51
Total Care Givers	250	127		142	518
Total Health Staff[b]	713	350		587	1,350

[a] Population per Health worker combines health personnel working at CBH and City of Beira Health Department. Population used = 500,000

[b] Represents all personnel including support staff.

3.6.3 Health Personnel Assigned to Treatment of Cholera

In order to respond to the current increase in cholera cases, health staff were drawn from the City Health Department clinics and posts and reassigned to CHB. As a result, health services at the clinic level suffered.

Sanitation

No MOH departments are involved in construction of latrines. The MOH has a Center for Prophylaxis which is responsible for disinfection of wells with chlorine. While three people are assigned to this task, lack of transportation limits their effectiveness.

The National Institute of Physical Planning has an improved latrine project (*Programa de Latrinas Melhoradas* or PLM). Since 1979, PLM has trained their own staff to make slabs for latrines which are then sold to consumers at a subsidized cost. PLM absorbs 75 percent of costs. UNDP and others have been supporting this project for many years. In recent planning discussions, PLM has decided to privatize and increase the cost of latrine slabs to consumers. Any development projects aiming to increase latrine use in poor communities will need to take into consideration PLM's move towards the private sector.

PLM has been working in Beira for several years. However, the number of latrines sold could not be determined. In 1991, Africare submitted a proposal to USAID for funding 7,000 latrines through PLM for the City of Beira. This proposal has yet to be funded.

3.6.4 Laboratory Services

Two laboratories in Beira water-borne disease outbreaks, including cholera: the Regional Food and Water Laboratory (Laboratory Regional de Hygiene de Agua e Alimentos or LRHAA) and the Central Hospital of Beira's Laboratory (CHBL). Both of these labs were visited during this consultancy. A microbiologist working with FHI assisted in reviewing the capabilities of these labs to effectively perform their duties. She also recommended laboratory materials and equipment needed to improve efficiency and effectiveness (See Appendix E).

The LRHAA (*Laboratorio Regional de Higiene de Aguae Alimentos*) based in Beira is responsible for bacteriological and chemical analysis of water samples. In addition, the five technicians perform periodic water sampling from selected piped water points and wells throughout the city. At the present time, LRHAA can analyze a maximum of 60 water samples per week for coliforms and salinity.

Table 2 summarizes the water testing conducted at LRHAA since September 1992. Seventy-six percent of all water samples tested were classified as contaminated (fecal coliforms greater than 1). Samples taken from city wells were more often contaminated than water from the AdB piped water. However, over half of the AdB piped water samples tested were found to be contaminated.

The standard test for assessing water quality takes four to five days. The LRHAA is not able to conduct these tests on a daily basis due to inadequate quantities of reagents, numbers of staff, and facilities for refrigeration. The LRHAA does not have the capacity for rapid testing of chlorine concentration in water or other rapid water quality testing systems.

Under current conditions, the LHRAA can neither analyze water quality in a timely fashion nor in the quantities necessary to provide prompt feedback to authorities who are responsible for disinfection of the public water supply.

The CHBL performs tests to diagnose cholera. The lab is staffed by three technicians who appear adequately trained to confirm the presence of *vibrio cholerae* in stool samples. However, the reagents used in these tests are past their expiration date, perhaps contributing to unreliable results. The materials used to determine antibiotic sensitivity also are out-of-date.

Table 2

Results of Water Tests
Conducted by Regional Water and Food Laboratory
September to December 1992

Source of Water Samples	Total Tested	Contaminated (%)	Uncontaminated (%)
AdB Piped	54	30 (56%)	14 (44%)
City wells	135	114 (84%)	21 (16%)
Total	189	154 (76%)	35 (24%)

3.6.5 Public Health Education Campaigns

During the recent water shortage health authorities conducted an informational campaign to reduce the cholera emergency. Messages concerning boiling water, proper hygiene, and chlorination of drinking water were regularly aired on radio and television and printed in the newspaper. Some house-to-house canvassing was conducted. However, no MOH funds were available for large-scale, focused campaigns to educate people in preventative measures. The importance of boiling drinking water was a typical message disseminated by health authorities; however, without supplemental programs this advice is not practical. It is not feasible for the poor who can not afford the wood used as fuel to boil the water. Distribution of chlorination products for home use also is not considered feasible because of the difficulty

in establishing an effective distribution system and implementing the intensive educational campaign that needs to accompany this type of intervention.

Chapter 4

FINDINGS

4.1 Water Supply from Groundwater Sources

4.1.1 Hydrogeologic Setting

Physiography and Climatology

The city of Beira and the Beira Corridor (up to the Pungoe River) lie within three geomorpholic zones of the Mozambique Sedimentary Basin, north of the Save River: the Littoral (coastal) Zone; the Chire-Urema Graben, which generally follows the estuarine-affected portion of the Pungoe River; and the Cheringoma Plateau, which generally coincides within the Manga-Dondo-Mutua area (DNA, 1987).

Average rainfall varies from 900 mm per year inland, up to 1,400 mm per year along the coast; recharge potential is considered good. However, as a result of the lower than average rainfall over the past eight years, river discharges have decreased and shallow groundwater tables have dropped. Near Mutua, precipitation during the past two years has been 40-50 percent below the 20 year norm for the rainy season, November through April.

Geology

The surface stratigraphy of the study area is characterized by the Tertiary Mazamba Formation, which is composed of sandstones and conglomerates of continental origin. The Mazamba Formation is essentially exposed within the Manga-Dondo-Mutua area. Inland from Beira, alluvial material composed of loose, finely textured clayey sands or sandy clays is found. Along the coast, old beach fronts form a system of parallel low sand ridges. Along the coastal margins of the Pungoe River are recent alluvial deposits of considerable thickness.

Groundwater Availability and Quality

The Mazamba Sandstones in the study area have poor to fair productivity, ranging in yields from 0-10 m^3 per hour. The most productive wells are those that intersect a thin permeable layer, (only a few meters in thickness) found at depths ranging from 50-100 m. Water quality varies significantly, ranging in total dissolved solids (TDS) from 350 mg/l to greater than 1,500 mg/l. In areas where the Mazamba Sandstones are overlain by alluvial sands, shallow (< 10 m) groundwater is perched on local clay layers, recharged directly from meteoric waters. Shallow groundwater also is found within the sandy coastal areas. Yields are reported to range from less than 1 m^3 per hour to greater than 40 m^3 per hour. The shallowest water can commonly be used for potable purposes, but with increasing depth, the water becomes brackish to salty due to the effects of saltwater intrusion.

4.1.2 Historic Usage of Groundwater

Prior to the early 1950s, the city of Beira and outlying areas along the Beira Corridor obtained fresh water almost exclusively from shallow dug wells and captured and stored rainwater. Few deep wells (> 15 m) were in use at that time. In 1954, the water supply system began to serve the city. Because this system only serves about 125,000 people, the remainder of the population within Beira and the Corridor is still critically dependent on groundwater.

4.1.3 Recent Groundwater Development Activities

Because of the drought and the war, recent groundwater development activities have been implemented to strengthen the existing water supply system. A brief summary of these activities follows.

Geoelectrical Investigation

The groundwater supply potential along the Beira Corridor between Dondo and Mutua was explored during late 1991 and early 1992 using remote sensing techniques (DNA, 1992a). A geoelectrical field survey was conducted by DNA. For security reasons the survey was limited to within 3 km of the Beira-Harare road. The specific objectives of the study were to: augment geological information on the Mazamba aquifer, delineate the limits of the fresh water aquifer, and evaluate the water supply potential of fault/fracture zones.

Results of the investigation showed increasing salinity with depth and an aquifer matrix which contained a significant clay content. Recommendations for future investigative work were made.

Drilled Boreholes/Wells

In the Beira area, public sector groundwater development has primarily been conducted by PRONAR, with some assistance from the Italian company, CMB. GEOMOC has provided the equipment and personnel to drill boreholes and complete them as wells. Within the study area, the total number of drilled wells over the past four years is summarized below:

Number of Drilled Wells, 1989—1992

Year	Beira Area	Dondo Area
1992	3	35
1989-1991	9	34

[1] Including the Manga area.

[2] Including the areas of Mezimbite, Mafambisse and Mutua.

In 1992, within the city of Beira, three holes were drilled. Total depths ranged from 10-15 m; in all cases, the groundwater was found to be too saline for potable usage.

The poor quality of the deeper (> 10 m) groundwater in the Beira environs has been evident since historic drilling activities ("Arquivo," 1989). The drilling attempts in 1992 confirm that deep groundwater is not a dependable resource due to saltwater intrusion. However, groundwater quality does improve (becomes less salty) with increasing distance from the coast and the Pungoe River estuary.

Drilled Wells in Town of Dondo

In 1992, within or near the town of Dondo, approximately 26 holes were drilled. They provide dependable supplies of water to industries, municipal works, and the public sector, primarily the bairros and areas where many *deslocados* have recently settled. Well depths generally ranged between 40 and 100. Well yields ranged from less than 1 m^3 per hour to a maximum of 12 m^3 per hour, with average yields around 4 m^3 per hour, typical for the Mazamba aquifer. No salinity problems were identified in any of the boreholes.

Drilled Wells in Mezimbite, Mafambisse, and Mutua

In Mezimbite and the Mafambisse area, four holes—ranging in depth from 50 to 105 and yielding 3-6 m^3 per hour of acceptable quality water—were drilled in 1992.

Near Mutua, CMB drilled and completed a 103-meter-deep well which was discovered to be flowing artesian. Initially, the water quality was acceptable, however, over a short period of time it became brackish and unusable for potable purposes.

CMB drilled at two other locations in the area: at their encampment to provide a local supply of water and at the Mezimbite reservoirs. At the Mezimbite reservoirs, two 100-meter-deep holes were drilled and completed as a pumping well and a piezometer for aquifer test purposes. The plan is to use this well, or series of wells if aquifer characteristics are favorable as an emergency supply, pumping water directly to the Mezimbite reservoirs. Although water quality appears to be acceptable at this location, well yield has not yet been determined because of problems with the pump well. A report by CMB on the groundwater potential at this location is forthcoming in January 1993.

Shallow Hand-dug and Hand-drilled Wells

As a consequence of the drought, many shallow hand-dug wells have gone dry or become brackish from saltwater intrusion. In addition, many wells in the densely populated areas of the city are contaminated from sewerage and/or poor well head protection; i.e., lack of proper chlorination and disinfection, no sanitary well seal, lack of positive drainage away from the well head, and general poor housekeeping practices.

Shallow Wells in Beira and Peri-urban Areas

Within the city of Beira, a large percentage of the population is served by shallow hand-dug wells. Estimates on numbers of wells range from fewer than 50 to as many as a 1,000. Water within these wells is generally less than 10 from ground surface and yields are estimated to be less than 5 m^3 per hour on the average.

Given the recent emergency drought situation, DPCA has assisted in the renovation of 39 wells, the digging of five new wells, and the supplying and installation of four Afridev handpumps. DPCA has plans to dig 20 new additional wells, but currently has no available funding. EPAR also has assisted by hand drilling approximately six shallow wells during the last few months. Private contractors are assisting in this effort.

Campo de Golfo Well

EPAR has plans to renovate the Campo de Golfo well which formerly supplied the Ponta Gea hospital. Currently, the hospital has no reliable backup source of water when the Mutua supply system is non-operational. As part of a larger proposal to upgrade this well, EPAR recently re-developed the Campo de Golfo well at 40 m^3 per hour for four hours with little to no drawdown and acceptable water quality. The upgrade would include installation of an electric pump and a sanitary well seal and renovation of the existing pump house to supply the Ponta Gea hospital, a community standpost, and a clothes-washing area. These plans are on hold until appropriate funding can be made available.

Information obtained from various sources (residents, hospital personnel, and visual inspections) indicate that many shallow wells in Beira and the peri-urban area are contaminated with coliform bacteria (and many more are suspected of being contaminated). Areas within which the shallow, freshwater aquifer is contaminated are those which are densely populated and have with very limited access to sanitation services. Incidences of cholera are known to be high in these areas.

Recently, DPCA conducted a one-week survey of a limited number of shallow wells in Beira. Results of this survey are not yet available.

Wells in the Beira Corridor

In areas outside of Beira that are not serviced by the surface water supply system the situation is believed to be less critical. The population density is lower and there is a greater sense of community. There is lower potential for well and/or groundwater contamination from industrial, septage, or surface sources. However, very little information is available on the number and status of wells within the corridor.

4.2 Water Supply from the Pungoe River

4.2.1 Historical Records of Flow and Water Quality

The Pungoe River is the raw water supply source for the city of Beira. The river has been used for this purpose since the early 1950s when the Mutua water treatment plant and distribution system were constructed.

The Pungoe River drainage basin has an approximate total area of 29,500 km^2, 28,000 km^2 are in Mozambique and 1,500 km^2 are in Zimbabwe. Although only a small fraction of the basin lies in Zimbabwe, 40 percent of the Pungoe River's mean annual flow is estimated to originate in the headwaters of Zimbabwe. Based on the records of the Buè Maria gaging station (E66), located approximately 100 river km upstream from the intake, the mean annual flow from 1953 to 1980 was 122 m^3 per second, with a monthly maximum of 306 m^3 per second in February and a monthly minimum of 22 m^3 per second in October.

Between Buè Maria and the raw water intake, the Pungoe receives contributory flow from the Metuchira and Urema Rivers for a good portion of the year. However, during low flow, approximately July through November, these tributary rivers generally dry up and contribute little to no flow to the Pungoe River. As a result, during the lowflow portion of the year flows measured at Buè Maria are considered to correlate comparatively well with flows observed at the raw water intake .

Historically, the Pungoe River at the raw water intake has been a fairly reliable source of acceptable quality water for domestic purposes. However, during times of extremely low river flow at the intake (< 10 m^3/s) compounded by high tides which can intrude as far as 50 kilometers upstream of the intake, water quality can be severely compromised by saltwater intrusion.

During the past decade, precipitation throughout Mozambique generally has been below average. The past 12 months have been particularly dry. The three instantaneous flow measurements were taken in 1992 at the Buè Maria gaging station and compared to the mean monthly flows of the three worst drought years since 1953 (see Figure 4). Within three days of the December 4th measurement (<6 m^3/s), the raw water intake was periodically shutdown during high tides and then shut off for several days due to the high salinity readings (electrical conductivity $>3,500$ umhos/cm) at the raw water intake.

4.2.2 Location of Intake and Current Problems

The present location of the intake on the Pungoe River is 77 river km from the Port of Beira at the mouth of the estuary. The original location of the intake was 0.5 km further upstream, but this intake was abandoned in 1975 when it became flooded and no funds were available to rebuild it. Since that time, AdB has received its water from the intake constructed, controlled and operated by AdM (see Figure 5).

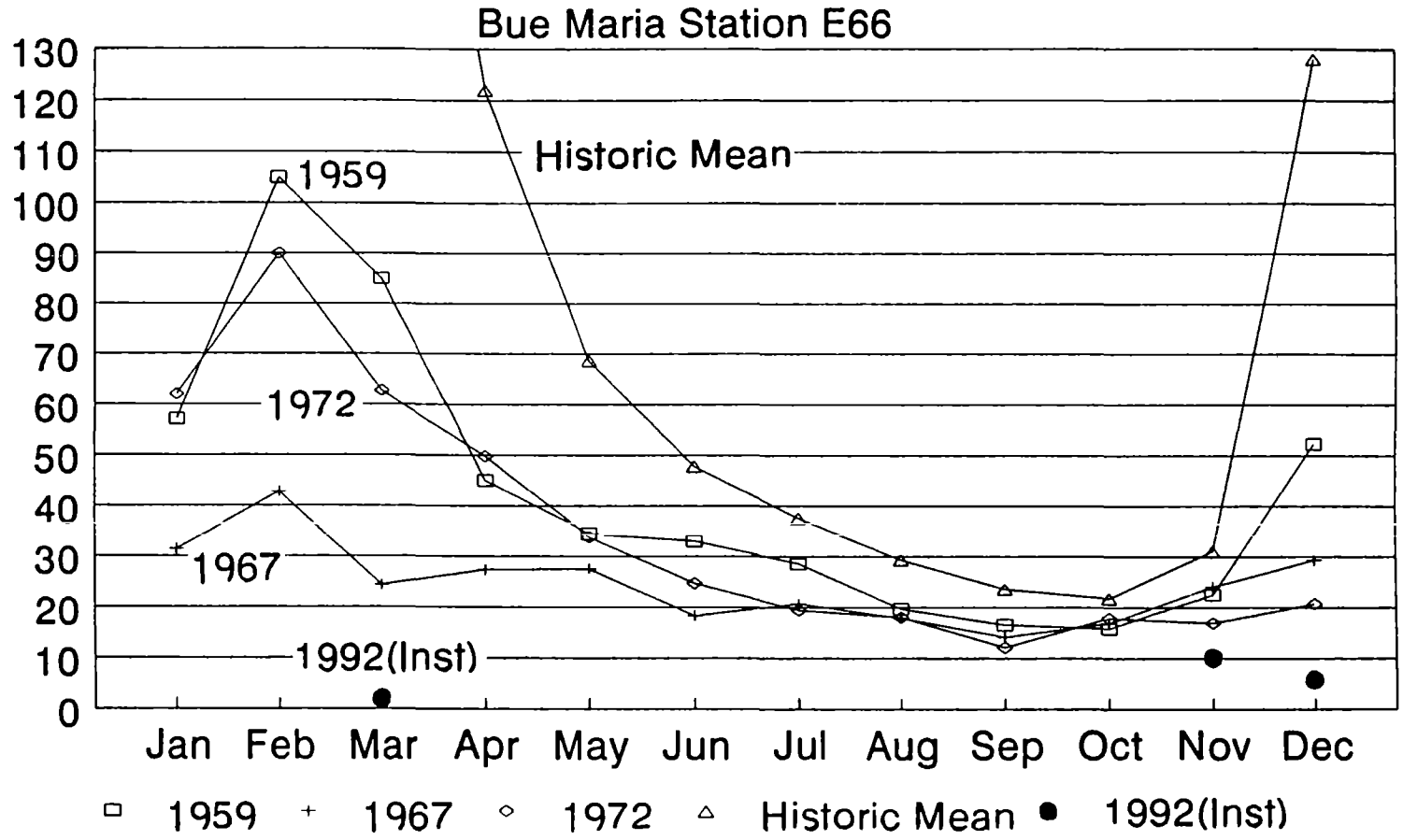
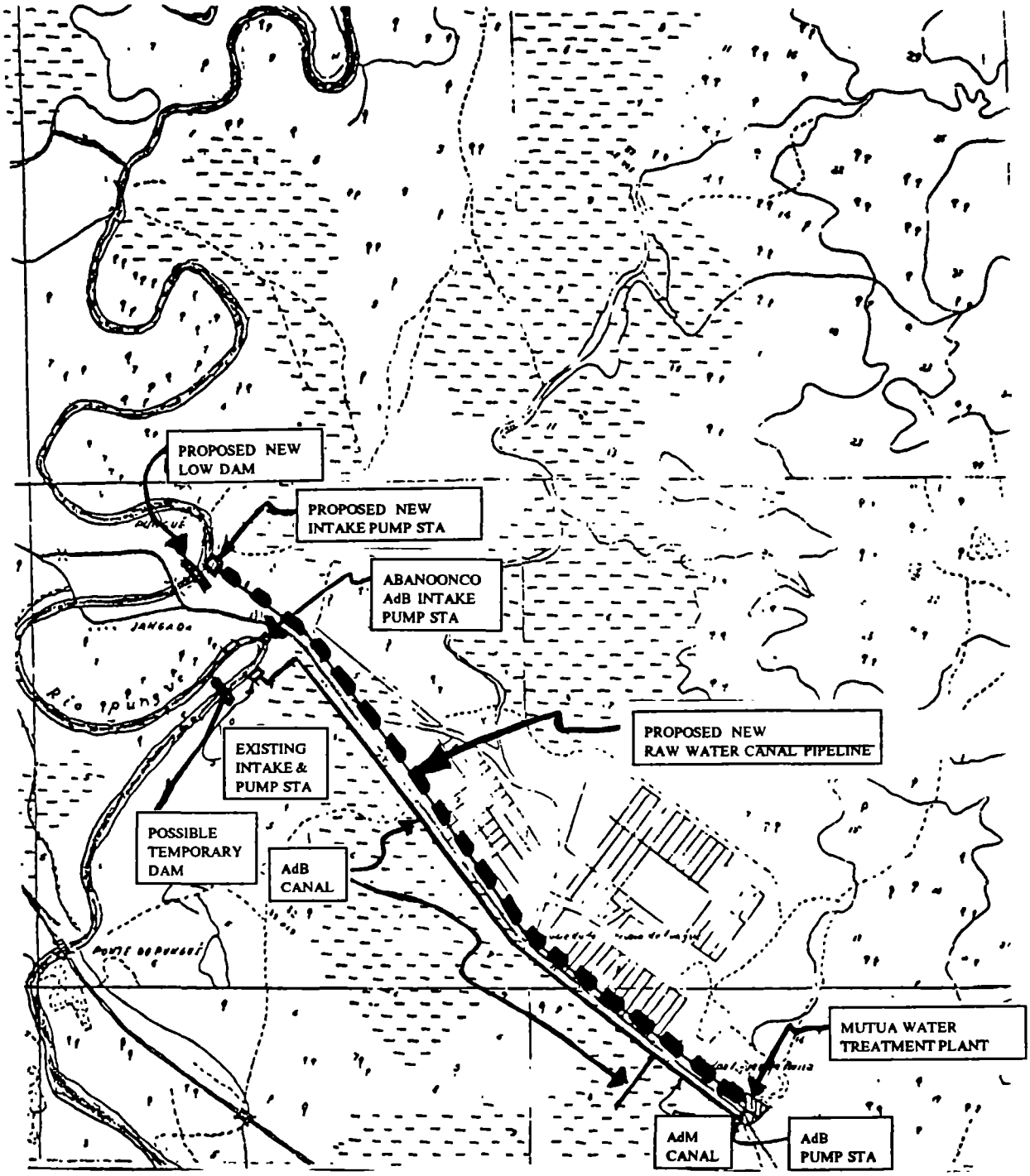


Figure 4

Pungoe River Discharge—Drought Years



*The proposed new low dam, the proposed new intake pump station, and the new raw water canal pipeline are subject to water resources study findings.

Scale: 1 cm = 0.5 km

Figure 5

Raw Water Intake and Conveyance Schematic

This current intake suffers from many problems, including:

1. Increasingly there are extended periods of saltwater intrusion;
2. Almost constant dredging is required to keep the channel free of silt from the unprotected banks near the intake pump station;
3. The intake is controlled by AdM who pays for its operation, and AdB appears to have no legal rights associated with this system; and,
4. Six of the 7 km of the canal which carry water from the intake to the treatment plant are owned and controlled by AdM. This canal is in extremely poor condition: badly silted, filled with vegetation, subject to flooding and subject to contamination from livestock. Further, it is reported that at times of flooding, drainage from the cane fields sometimes finds its way into the canal.

The only apparent advantage to AdB using the current system is that the cost of operation is borne by AdM.

4.2.3 Non-Water Supply Uses of the River

Ten percent of the drainage area of the Pungoe River lies in Zimbabwe in an area that is largely parkland. Little use is made of that portion of the flow. As far as is known, no significant abstractions are made from the river upstream from the present intake. Undoubtedly, minor amounts are taken for small-scale irrigation and individual use, but there do not appear to be any major users. Some losses can be attributed to evaporation, but no estimates appeared in the various reports reviewed. It seems probable that during the dry season, the flows recorded at Buè Maria are essentially the flows arriving at the intake site (Tributary streams downstream from Buè Maria are usually dry at that time of year).

AdM is the major user of the waters of the Pungoe River, taking an estimated 4.5 m^3 per second for irrigation (Gibb, 1992). However, the largest requirement of flow appears to be that which is necessary to prevent the saline tidal wedge from reaching the intake location. This amount was estimated at from 10 to 20 m^3 per second by DNA (DNA, 1988). By comparison, AdB's needs are only 0.34 m^3 per second now, 0.7 m^3 per second when the current treatment plant expansion is completed, and possibly 1.0 m^3 per second by the year 2000.

Should the high dam at Buè Maria ever be constructed, significant additional irrigational use could be made of the potential estimated yield of 60 m^3 per second.

4.2.4 Future Needs for Water Supply

The 1991 Water Master Plan (Plancenter et al, 1991), estimated Aguas de Beira's water needs as 49,000 m^3 per day (0.57 m^3/s) in the year 2000, and 66,000 m^3 per day (0.76 m^3/s) by 2010. On the other hand, an expansion of the water treatment plant capacity to a total of 60,000 m^3 per day (0.69 m^3/s) is about to begin with funding from the Government of Italy. Any future water resource planning should assume in the order of 86,400 m^3 per day (1.0 m^3/s) for Beira's needs for municipal water.

AdM is planning a possible expansion of its capacity by 1994. Their estimated future need for water for irrigation is about 7.5 m^3 per second 1992).

In the absence of a saltwater barrier, approximately 15 m^3 per second may be required to prevent the saline wedge from reaching the intake. Studies need to be conducted to more closely estimate this amount and determine under what conditions the flow will be required.

In summary, it is clear that municipal water supply requirements are the lowest among all the potential demands on the Pungoe River. However, they should have the highest priority when allocating whatever flows are available.

4.2.5 Alternatives for Meeting Water Needs from Surface Sources

Until the past few years the Pungoe River has been a reasonably dependable source of water for Beira. However, during recent dry weather, flows of less than 10 m^3 per second have not been sufficient to keep the saltwater away from the intake. Also, the river is subject to periodic flooding which in the past has caused damage to intake structures. Without some form of regulation, the Pungoe River cannot be considered a reliable source of supply for Beira.

Lack of a dependable water supply has raised the possibility of constructing a high dam on the Pungoe. In 1972, COBA, a Portuguese consulting engineering firm, studied several potential dam sites and identified Buè Maria as the most promising. In 1980, Geotechnica conducted a serious study of the feasibility of constructing a 45-m high dam at the Buè Maria site. This dam would be some 80 km upstream from the existing intake, about 145 km northwest of Beira. The dam would provide flood control, hydroelectric power, and an estimated yield of 60 m^3 per second (with 80 percent reliability) for irrigation and municipal water supply. The high cost and the need for extensive environmental studies have prevented serious consideration of constructing this dam up to the present time.

The only other river within reasonable distance of Beira is the Buzi, to the southwest across from the Pungoe River estuary. This river has lower flows and is also subject to extensive tidal saline intrusions. In addition, the estuarine barrier makes the Buzi a less desirable source than the Pungoe River.

An additional source of water which has recently been exploited is a set of man-made lagoons known as Six Miles. Located approximately 12 km north of Beira, Six Miles consists of a series of interconnected shallow ponds, totalling 3 to 5 hectares in surface area. The ponds, dug

within an old river course, apparently intersect a clay layer which allows for water storage. The first recorded use of water from these ponds was in 1904.

Sir Alexander Gibb & Partners (November 1992) recently proposed development of this resource by installing a pump and 3 km of pipe to deliver 20 m^3 per hour of water to the main road. Water would be chlorinated, possibly treated, and stored for distribution by tank truck.

Currently, the ponds are being pumped directly at a rate estimated at 500 m^3 per day. From evaluation of the rate of pumpage in early December, approximate pond capacity, and current water level within the ponds, these ponds appear to be maintained primarily from surface-water runoff, possibly receiving marginal input from groundwater recharge. Without significant precipitation, these ponds could be dry by the end of December.

DNA staff have devoted considerable time and effort to evaluating the possibility of constructing a low dam on the Pungoe. The dam would serve as a saline barrier and provide some additional storage capacity. Several alternative types and sites have been studied, but all are within the area of the existing intake works. In general, low dams or (*acudes*) should be considered relatively temporary. They are needed only during extreme low flows and are likely to be washed out by periodic flood flows.

There are no economically feasible alternatives to the Pungoe River as the major present and future source of water supply to Beira and the Beira Corridor. The construction of a high dam at Buè Maria should be considered for the future, but it may be many years before Mozambique will be in a position to rank this project among its priorities. For now, some form of low dam on the Pungoe River to the west of the Mutua water treatment plant appears to be the preferred alternative for providing a guaranteed water supply to Beira.

4.3 Public Health Situation Resulting from Water Shortages

4.3.1 Statistics on the Cholera Outbreak

Cholera has been endemic in Beira for the last several years. The October-November 1992 outbreak of cholera has been caused by a reduced quantity and quality of water, and poor hygiene practices and sanitary conditions. Overcrowding due to the influx of dislocated persons has exacerbated the problem. Cholera is also being reported in four district centers: Dondo, Buzi, Nhamitanda, and Chibabava.

Figure 6 depicts reported but unconfirmed cholera cases for the city of Beira since January 1992. In Beira alone, 2,290 cases have been reported with 74 deaths. This represents case fatality rate (CFR) of 3.2. In Sofala Province an additional 913 cases have been reported, bringing the total cases to 3,303, with 147 deaths. The CFR for Sofala Province is 4.5.

Figure 7 depicts reported cholera cases and deaths for all of Sofala Province. In 1991, Sofala Province reported 300 cases of cholera with 18 deaths, a CFR of 6.0. Mortality has been highest in children. Eighty-nine percent of the deaths were in children under 10 years.

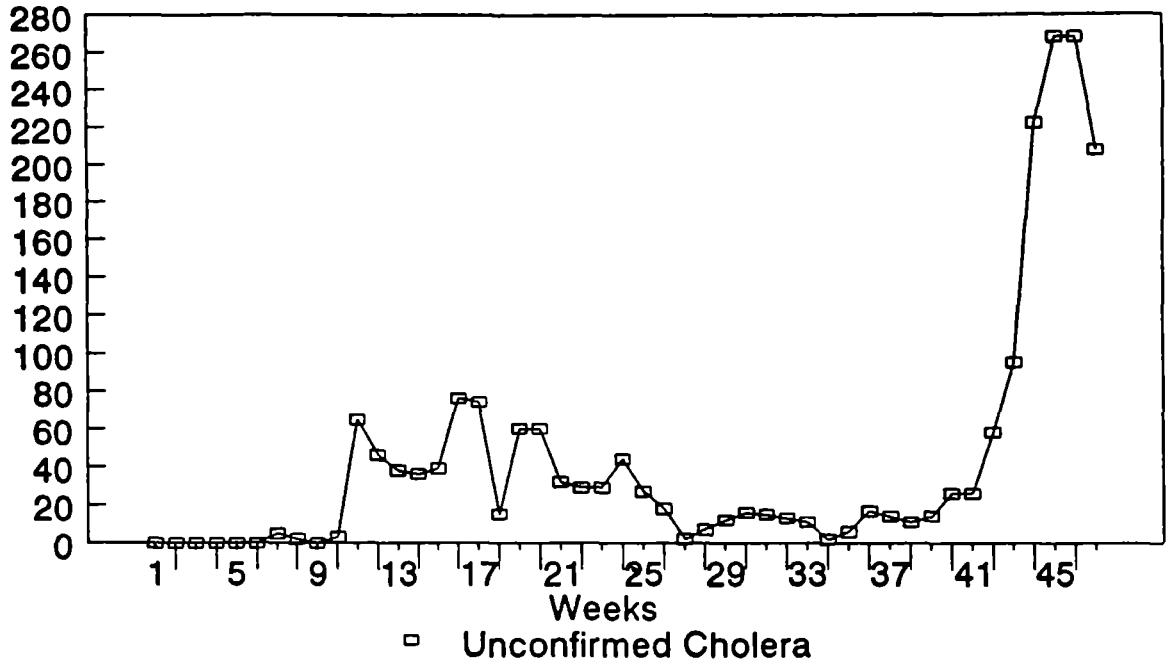


Figure 6
Reported Cases of Cholera
Central Hospital of Beira, 1992

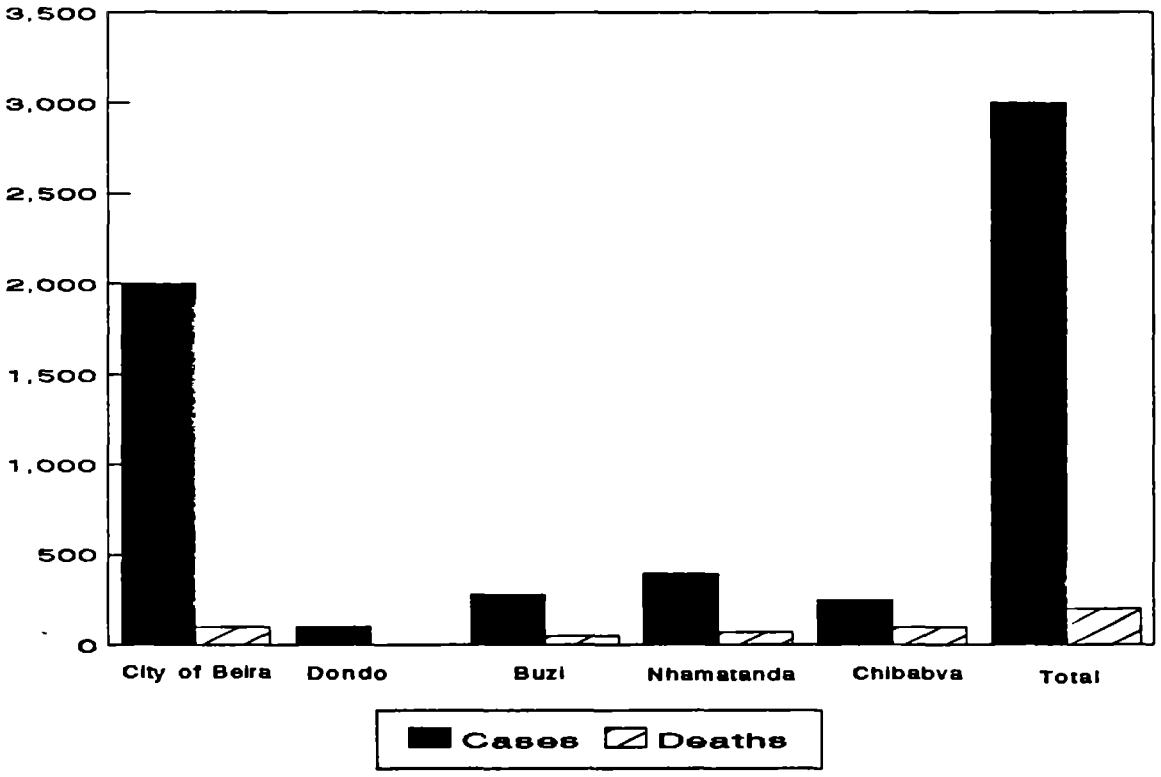


Figure 7
Cholera Cases and Deaths
Sofala Province, 1992

In reviewing the laboratory analysis of *vibrio cholerae* in stool samples of suspected cases, it is apparent that the reported cases represent all patients being treated as in-patients at the Cholera Infirmary at CHB. Confirmed cases of cholera were 70 percent of all cases, or 1,110 cases. CFR for confirmed cholera cases is 6.7. During the peak outbreak in October, approximately 80 percent of stool samples for in-patients were confirmed positive for cholera. By the second week in December, roughly 25 percent of the stool samples of in-patients were confirmed positive for cholera.

Even though the number of confirmed cholera cases is less than reported cases, the health care system has been overwhelmed by a large number of people with diarrheas of various etiologies. The treatment for severe diarrheas is similar. The time and effort, both human and financial, to respond to a large numbers of patients with acute diarrheal diseases is the same, whether it is cholera or other debilitating diarrheal diseases.

As would be expected, all other diarrheal diseases have been on the increase during the October—November water shortage. No studies of etiologies other then cholera have been performed. Figure 8 plots total cases of diarrhea and total cases of reported cholera for 1992. A seasonal peak of diarrhea is usually seen in March-April. During this same period there was a small outbreak of cholera.

In 1992, over 11,000 cases of diarrhea were reported. Nearly 80 percent of these were in children less then five years. Given the already compromised nutritional status of many of these children, the current increase in diarrhea will further tax their already fragile state. The City of Beira does not have any wet or dry feeding programs for young children.

Cholera cases by bairro in the city of Beira are depicted in Figure 9. A list of the 22 bairros in Beira is shown in Appendix J. Bairros 1-8 located in Cement City, had the highest incidence. This area is normally served be the AdB water system. When water was cut off in October and November, the Cement City residents used existing wells and also dug wells in their yards. Few if any of these wells were protected or treated with chlorine. The groundwater in much of this area is believed to be contaminated because of the poor condition of the sanitation systems.

4.3.2 Treatment of Cholera Cases

The CHB treated approximately 20-40 new suspected cases of cholera per day during October-December 1992. CHB reports using 4-5 liters of Ringer's Lactate intervenous (IV) solution per patient during the initial acute phase of the disease. Oral rehydration solution (ORS) accompanies IV treatment and is used throughout the in-patient stay. Cholera cases are treated with tetracycline using standard WHO approved regimes. Health authorities reported resistance to tetracycline in approximately 10 percent of cases. However, this resistance was based on suspicious laboratory findings. The tetracycline impregnated sensitivity disk being used at the CHB Laboratory expired in early 1991. Health authorities report using Gentamicin and/or nitrofurantoin for resistant cases. However, the use of Gentamicin or nitrofurantoin does not follow standard treatment practice for cholera. Cotrimoxazole,

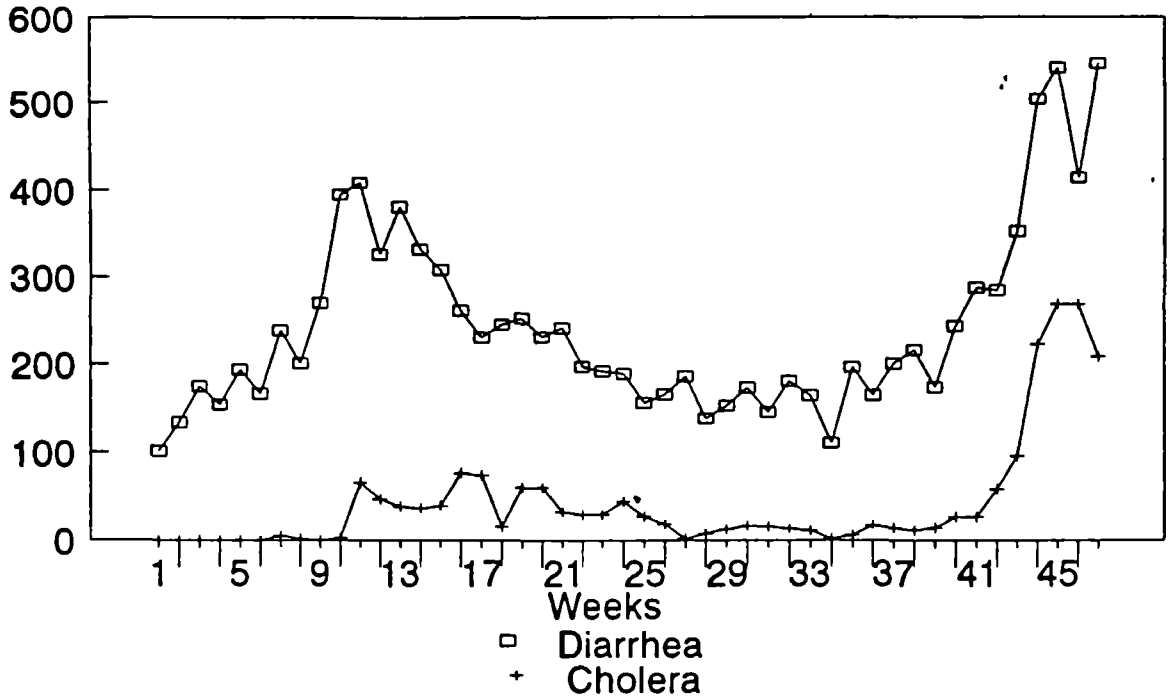


Figure 8
Diarrhea and Reported Cholera Cases
City of Beira, 1992

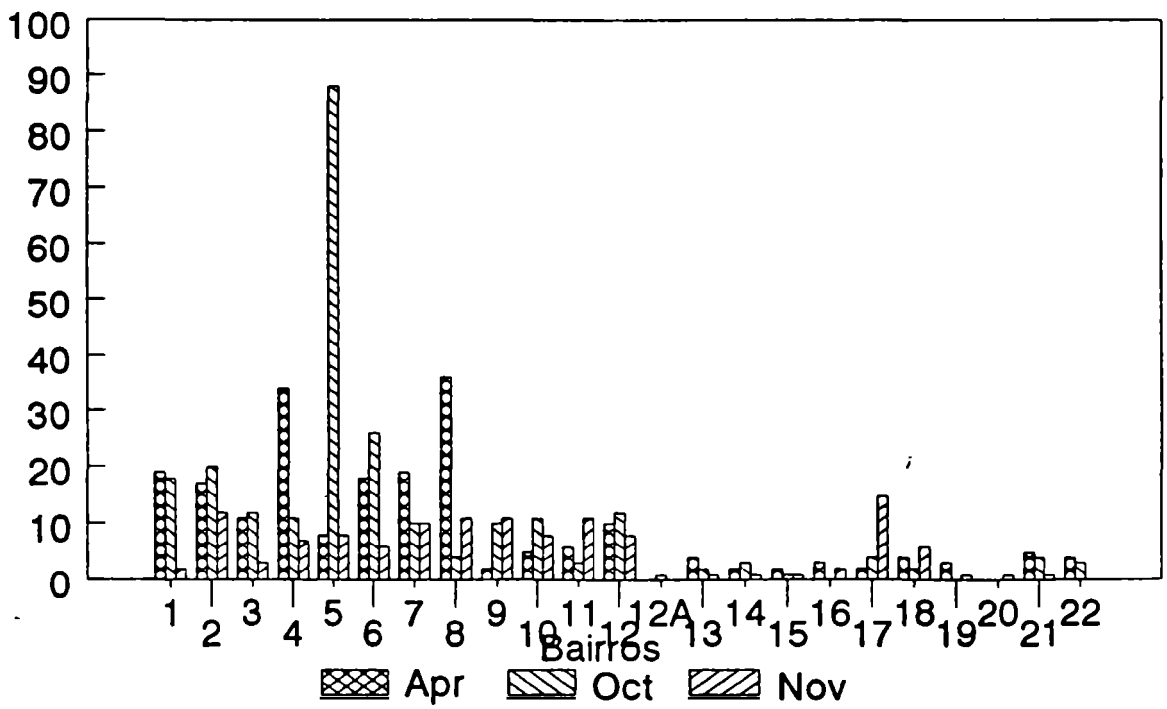


Figure 9
Cholera Cases by Bairro in Beira,
April, October, and November 1992

erythromycin, norfloxacin, furazolidone, and chloramphenicol are appropriate alternatives to tetracycline.

Initially, health authorities were using tetracycline for prophylactic treatment, but once the epidemic was in full swing they did not have the resources or staff to continue. At the current time health staff report providing prophylactic treatment to family members who accompany the case to the hospital. Treatment of family members who eat communally is appropriate.

City Health Department officials reported that only two of their staff had undergone training in management of diarrheal diseases provided by the National CDD Program in Maputo. A province-wide training in management of diarrheal diseases including cholera was scheduled for this year but this did not take place for lack of funds.

4.3.3 Assessment of Adequacy of Cholera Treatment Practices

The case fatality rate for cholera in Beira is within reasonable limits as compared to cholera epidemics in other developing countries. In South America over the last few years, the CFR in cholera epidemics was 1-2, with higher CFRs in the early phase of the outbreak. In most recently reported cholera epidemics in Africa, CFRs of 10 are commonly seen.

The amount of IV solution used per patient in Beira is low. Normally, higher volumes are needed to rehydrate a cholera case. It is possible that in less severe cases patients were able to rehydrate orally. Health authorities could also be reporting IV use for all diarrheas, not just cholera cases.

The current treatment of suspected resistant cases is not correct. Gentamicin and nitrofurantoin, which are currently being used for treatment of resistant cases, have not proven to be effective for treating cholera in other settings. Other drugs are recommended by the World Health Organization for treatment of resistant cases, and such drugs are not available, cholera cases can and should be treated for dehydration only. Though the illness may have a longer duration, patients do recover without antibiotic treatment. Cholera cases should be assessed clinically for possible resistance. Practitioners at CHB should not rely on laboratory analysis of resistance as these tests are providing questionable results. Issues concerning quality assurance in the CHB laboratory were discussed with the Hospital Director, and plans to confirm resistant cases were put into place.

ORS is produced locally and stocks have been adequate for treatment. IV solutions, on the other hand, are imported and supplies are scarce. Clinicians at CHB may be able to treat more patients with oral rehydration and reserve IV solutions for more severe cases.

4.3.4 Measures Taken to Prevent Worsening of Outbreak

The City Health Department's and the CHB's response to the outbreak has been commendable, particularly in the treatment of cases. The management of suspected resistant cases, however, needs to be improved. CHB and the City Health Department have been able to assign staff to the cholera infirmary and acquire necessary supplies. Limited resources and scarce funds have been redirected to meet this crisis. However at this time, stocks are very low. Hospital and City Health Department officials have requested supplies from various donors.

Some efforts have been made to chlorinate wells within the bairros with the highest cholera incidence rates. One-time chlorination of a well is a practice which may provide only short-term benefits. The contaminated groundwater will continue to supply non-potable water to most wells throughout most of the densely populated areas of the city unless chlorination occurs on a regular basis.

Educational programs have taken place but their effect on changing behavior is questionable. A more intensive educational program aimed at improving behaviors is needed, and an educational campaign must play a major role in a comprehensive water and sanitation improvement project.

4.4 Actions Taken to Address the Emergency Conditions

DNA recognized the threat of the drought to Beira's water supply as early as 1988. In a report prepared in October 1988, DNA discussed the problem of salinity reaching the water intake and proposed the construction of a low dam on the Pungoe River to serve as a tidal barrier. The report called for a water resources study of the Pungoe to investigate feasible solutions to the salinity problem at the intake, however, no apparent action was taken, possibly because heavy rains early in the 1988-1989 rainy season raised false hopes.

After below-average rainfalls in 1990 and 1991, the situation became critical when rainfall during 1991 and 1992 was sharply below average. This led to a flurry of activity in March 1992 to address the water shortage. The government formed an Emergency Committee for Water Supply that held meetings with interested parties and called for more studies.

DNA prepared a detailed report in April 1992, which presented a wide range of suggested actions from the construction of a low dam on the Pungoe to the installation of new shallow wells and the rehabilitation of existing ones. The report included estimated costs and proposed phases for construction. At one point, DNA had arranged funding from the Dutch to construct the dam. This offer was withdrawn when no funding was obtained from other members of the international community for other project components.

As noted in Section 3.3, several studies related to these problems were prepared in 1992, but no significant actions have resulted.

Chapter 5

RECOMMENDATIONS

5.1 Utilization of Ground Water

5.1.1 Emergency Program

Recommendation No.1, Survey Existing Wells

Conduct a comprehensive survey of shallow wells in Beira as soon as possible. DPCA began a survey on 13 December, but may not have the resources or experience to conduct the type of survey needed on which to base improvements. It is proposed that the more ambitious program described below, be carried out under the direction of an experienced team, possibly managed by an appropriate NGO.

Data collected during this survey should include the following: well location (described and shown on a map), ownership date of, construction, condition of, well head, casing type, well diameter, total depth, depth to water, water quality, estimated maximum yield, estimated daily usage, water quality, presence and condition of handpump, and any other pertinent observations.

If the geographic extent of the survey must be limited funding, emphasis should be placed on obtaining data from: areas known to have had a high incidence of cholera in the recent water shortage, areas with dense population and limited water resources, and areas believed to have good water quality and yield.

Recommendation No.2A, Design Well Rehabilitation Program

Design a prioritized shallow well rehabilitation program based on the well survey results. Primary consideration should be given to those wells which could be quickly and economically rehabilitated, yet provide a long-term, dependable supply of potable water.

Two extremely important factors which must be considered in the selection process are: overpumping of shallow wells may induce salt water intrusion, precluding continued short- and long-term use of the well; and (2) rehabilitating wells which have been contaminated from wastewater or other pollutant sources may be impossible.

Recommendation No.2B, Rehabilitate Wells

Rehabilitate wells meeting the target criteria. Those wells identified as having long-term potential of providing a good supply of potable water should be rehabilitated first. If well location, water quality, and yield all are favorable, a hand pump or electric pump with above-ground water storage and standpost distribution system should be installed. Above-ground

storage would also allow for bulk water chlorination on a temporary basis. The number of wells to be rehabilitated was very roughly estimated to be 200. An estimate of 40 new handpumps, probably of the "Afridev" type, is suggested for replacement of inoperative handpups in critical areas. Construction of some 200 new sanitary latrines also is suggested in areas where sanitation improvements are particularly critical.

Recommendation No.2C, Rehabilitate Campo do Golfo Well

Assuming favorable results from the survey, rehabilitation of the Campo de Golfo well should a very high priority. This well is reported to yield up to 40 m^3 per hour of good quality water. Care should be taken not to over-pump this well to insure that ground water quality can be sustained over time.

Recommendation No.2D, Install New Shallow Wells

Dig or drill by hand, new shallow wells in accordance with (1) the results of the well survey and well rehabilitation program, and estimates of future water needs throughout Beira. Budgetary allocations were made for 50 new shallow wells.

Recommendation No.2E, Monitor Six Miles Ponds

Initiate a program to monitor the amount of water pumped from the ponds at Six Miles, and the water level in the ponds. Currently the land owner sells water to the owners of private water tank trucks who directly pump water from the ponds and sell it without treatment. During a field inspection, an estimated 500 m^3 per day was being pumped from this source. There is some doubt about whether the ponds can sustain this rate of withdrawal, the proposed program should answer the question. If yields of this order are sustainable, AdB may wish to consider this source as a modest supplement until its basic source becomes more reliable.

5.1.2 Longer Term Program

- Initiate a monitoring system to insure that key elements of the well rehabilitation program are maintained. At a minimum water quality must be routinely monitored for total dissolved solids and coliform bacteria. Pumping should be abruptly halted at wells which show salt water intrusion. Otherwise, salinity will only worsen with continued pumpage. Wells which show coliform bacteria contamination should be closed, sanitized, and re-evaluated with respect to long-term ground water contamination.
- Continue the investigations of deep ground water potential in the Mutua-Dondo area, but do so cautiously. Yields from within this area have been extremely limited or too saline for potable use. Maximum yields have not been much higher than 10 m^3 per hour. The Italian contractor, CMB, expects to submit a report on their findings. This report and future DNA investigations should guide any future efforts.

- As security improves conduct the planned study to explore the alluvial aquifer within the Urema River valley and other potential areas. Development of these potential resources is expected to be severely limited by the cost of connecting to the present Mutua-Beira water supply line.

5.2 Utilization of Surface Water

5.2.1 Overview

The WASH team concluded that groundwater is unlikely to be available in sufficient quantity and quality to augment the existing municipal water supply, and the only feasible surface water supply appears to be from the Pungoe River. However, some means of preventing saline contamination of the water at the intake must be developed. The most feasible means of achieving that objective in the near term is to construct a low dam to act as a salt water barrier.

5.2.2 Emergency Program

Recommendation No.3A, Design Temporary Low Dam on Pungoe

At the end of the 1991-1992 rainy season, it was clearly apparent that the 1992 dry season (from March until November), would be very difficult for Beira. The flow in March measured less than 2 m^3 per second, an all-time low. If plans for a temporary low dam had been available, DNA probably would have been able to obtain donor funding to construct it.

If the dam had been built at that time, it would still be functioning because there have been no flows large enough to threaten it. More importantly, Beira would have been able to provide an uninterrupted supply of water during these past eight months.

The 1992-1993 rainy season is now underway, and recently there was some rain. Should the season provide normal rainfall, there will be no need for this dam. Should last year's conditions be repeated; however, the construction of such a dam in early 1993 may be the only factor preventing the recurrence of the problems which occurred in 1992.

Accordingly, it is recommended that a temporary low dam—with a minimum height of 4-5 m necessary to act as a saline barrier—be designed as soon as possible before the end of March 1993. The dam should be constructed in the least expensive manner possible, with a rudimentary spillway to prolong its life expectancy during moderate river flows that exceed the needs of AdB and Açucareira.

Recommendation No.3B, Conduct Environmental Assessment

Even the proposed temporary structure will impact the Pungoe River environment. At the time of design, an environmental assessment should address not only the impacts of a low dam and the subsequent impoundment, but also potential effects of possible failure of the dam.

Recommendation No.3C, Select Site Downstream from Intake

Two locations were considered by DNA for the site of a low dam. Each has advantages and disadvantages, and both should be considered. The site upstream from the present intake, north of the highway, has many advantages over the site downstream from the present intake. However, the upstream site has one very costly disadvantage: that much more time will be required to design and construct a new intake pump station and transmission canal or pipeline to the treatment plant.

For the emergency plan, an alternative to construct a temporary dam at the site downstream from the present intake. This will permit the continued use of Açucareira's intake facilities.

Recommendation No.4, Dredging and Widening of Existing Raw Water Canal

The existing raw water canal extends some 8 km from the intake to the water treatment plant. As noted earlier, this canal is in very poor condition.

It is recommended that this canal be widened and deepened, with side slopes no steeper than 1:2½, a water depth up to 3.0 meters, and a cross section in the order of 30 m^2. Such a canal could provide about 10 days storage at the present maximum rate of pumping to the city (24,000 m^3/d).

This would require expanding the canal width, either by utilizing the old AdB canal adjacent to the existing canal or by taking land from Açucareira to the south of the canal. Additional storage could be obtained by using the length of the Açucareira's canal which extends beyond the treatment plant.

This storage would allow intake pumps to operate at maximum capacity when the river water quality is acceptable, filling the canal at a faster rate than water is abstracted from it. The treatment plant could then draw on this stored water when the river water is too salty to pump from the intake.

Recommendation No.5, Agreement with the Açucareira on AdB Priority for Water

AdB should enter into an agreement with the Açucareira that it will stop taking water from the canal for irrigation during periods of low river flow and saline intrusion at the intake. A city's water supply is far more important than any irrigation project, and all possible steps must be taken to protect and extend the supply of water to the city.

Recommendation No.6, Prepare Terms of Reference for Water Resources Study

The most critical link in the AdB water supply system is the source of raw water; however, none of the studies and projects currently underway address this issue. Until such a study is completed, AdB has no basis for making decisions on how to improve the intake situation.

Prepare terms of reference for such a study and make an estimate of the cost of the study and the time to complete it. Once this information is in hand, donor support can be more easily obtained and steps can be taken to engage qualified specialists to conduct the study.

Recommendation No.7, Design Combined Storage/Standpost Units

AdB directly serves only about 125,000 people through connections. There are said to be about 75 standposts, but less than half of them operational. There is a great need for additional standposts, particularly in the more densely populated areas. Standposts serve the people as long as the water supply is operational, but there are frequent disruptions.

It is recommended that new units which provide a combination of low storage tanks (maximum height of 2-3 m, with a capacity of from 5-7 m^3), directly linked to a series (four to six) faucets or standposts be designed. These units would be designed so as to accept piped water whenever system pressures permit, or to be filled with water from tank trucks. Storage could be divided into compartments: one section could be batch chlorinated, and one, previously dosed, to serve half the faucets. In locations where groundwater sources are adequate, this could be a third option for supplying the standposts.

There are 22 bairros or neighborhoods in Beira, an estimated 140,000 persons are not connected to the AdB system. These storage standposts described above are proposed to provide a reasonably safe source of potable water, rather than to supply of all the community's water needs. The standposts could supply water for drinking and cooking, while water for cleaning and general hygiene would still come from backyard or neighborhood wells.

Assuming 10 liters per capita per day (lpcd), and 140,000 people, the units would have to serve 1,400 m^3 per day. That relates to 200 units providing 7 m^3 per day. Another way to determine the units is to assume about 650 persons served per unit (which means about 100 people coming for water to each unit), which would require 215 units. It is recommended that an average of 10 units per bairro be designed and constructed, making a total of 220 units.

Recommendation No.8, Construct the Combined Storage/Standpost Units

The storage/standpost units should be constructed as soon as they are designed, agreement is reached on the most appropriate locations for the units, and funds are made available.

Recommendation No.9, Conduct the Water Resources Study

Once the terms of reference have been prepared and the funding arranged, the execution of this study should proceed without further delay.

Recommendation No.10, Construct the Temporary Low Dam if Needed

If the rainfall of the previous rainy season fails to provide Pungoe River flow of at least 60 m^3 per second by mid-March 1993, 40 m^3 per second by mid-April 1993, or 30 m^3 per second by mid-May through mid September, construction of the temporary dam should proceed immediately.

5.2.3 Longer Term Program

- With guidance from the water resources study, design and construct new raw water intake and transmission facilities.
- Complete the current programs for: doubling the water treatment plant capacity and the treated water transmission line to the city, expanding and improving the distribution network, and improving the wastewater collection and pumping facilities.
- Expand the water distribution system to serve at least 75 percent of the people directly by piped connections within five years.
- Improve and expand the wastewater collection system to serve at least 50 percent of the people within five years, and construct new treatment works.
- Improve AdB's capacity to operate and manage its facilities. Goals includes reducing water losses and wastes to 30 percent of production in five years and 20 percent within ten years, and charging for services so that operation and maintenance costs can be covered by user charges within ten years.

5.3 Mitigation of Public Health Risks

To reduce the negative effects of the water borne diseases including cholera three basic areas of support are needed. They include: treatment of cholera and diarrhea cases, implementation of prevention programs, and assistance to laboratories which monitor water quality and diagnose cholera. These recommendations are based on two assumptions. If water shortages in areas of the city supplied by AdB continue because the flow in the Pungoe River does not increase, a continuation or worsening of the current cholera epidemic will result. Second, city areas not serviced by AdB water will continue to have available poor quality and inadequate quantities of water.

5.3.1 Emergency Program

Recommendation No.11A, Purchase Medical Supplies

Provide urgently needed medical supplies for treatment of cholera and other diarrheal diseases. Supplies include IV solutions, drugs, and basic medical supplies such as IV set-up kits, needles, syringes, gloves and other materials. Cholera cots or other portable beds are needed and could be made locally. It is recommended that a six month reserve of medical supplies be made available for future needs. See Appendices F and G for a list of supplies and materials.

Recommendation No.11B, Purchase Chlorine

Provide chemical disinfecting products for use in disinfecting targeted wells and home based distribution. About 100 drums are needed at this time; imported preparations could be considered. Disinfection of wells should be done in combination with improved sanitation and hygiene education programs.

Recommendation No.11C, Purchase Laboratory Supplies

Purchase lab materials and supplies for the Food and Water Laboratory so it is better able to monitor water quality in Beira. Also, purchase lab materials for CBHL so it is better able to diagnose cholera and other water borne diseases. See Appendix H for a list of supplies.

The purchase and shipment of laboratory materials and equipment could be facilitated through Food for the Hungry International (FHI). FHI's current administrator in Beira is a microbiologist with 30 years experience in Zimbabwe. She has the necessary contacts and capabilities to ensure timely and correct disbursement of these materials.

Recommendation No.12, Provide Health Training

Provide support for training of health workers in the city of Beira for management of cholera and diarrheal diseases. Two three-day seminars for 50 City Health Department and CHB staff would improve overall treatment practices.

Treatment of tetracycline-resistant cases of cholera should not be treated with Gentamicin or nitrofurantoin. WHO standard treatment regimes should be utilized.

5.3.2 Longer Term Program

If the cholera outbreak continues, more medical supplies and drugs will be needed. Local health authorities should have a reserve supply of necessary supplies and equipment.

The Ponta Gea Clinic should be completely renovated and upgraded as a general hospital. Beds, basic medical equipment and supplies are needed. See Appendix I for a list of this equipment and materials. In a city of over 500,000, more hospital capacity is needed.

5.4 Other Recommendations for Emergency Program

Recommendation No.13A, Design and Implement Public Information Programs

Design a public education program to change people's behavior in order to improve their understanding and practices in basic sanitation. Africare's current two year sanitation improvement project could be expanded to include an intensive hygiene and sanitation education program for Beira.

Similarly, the public should be advised of the serious nature of the current water shortage and the need to conserve water to the maximum extent possible.

Education programs should include elements designed for use in classrooms, as well as approaches to the general public. Radio, newspaper, and other media should be used, and, to a lesser extent television, because it is not widely available.

Implement the public education programs once thay are designed.

Recommendation No.14A, Appoint an Executive Coordinator

The Ministry of Construction and Water has overall responsibility for the implementation of these emergency recommendations. This implementation will require extensive contacts with the international development community, representatives of various government departments, and, officials and contractors in Beira.

Unless a qualified and dedicated person is appointed and given the authority required to ensure that actions are promptly taken, chances for, effective implementation are poor. This authority should include the ability to receive and allocate funds from the international community under procedures acceptable to these donors.

It is recommended that the executive coordinator be a senior official from DNA, have very good English language skills, and reside in Maputo. Consideration should be given to appointing Mr. Nelson Beete, DNA Technical Director, to this position.

Recommendation No.14B, Appoint a Field Coordinator in Beira

The principal work will be conducted in Beira. And most of the programs will affect the operations and facilities of Aguas de Beira. AdB has only one engineer for its entire operation. He is not only responsible for all of AdB's technical operations, but also is currently supervising four international water and wastewater projects in Beira. It is unrealistic to expect this person to effectively coordinate the emergency program.

It is recommended that a full-time program field coordinator be assigned for a period of at least one year.

A field coordinator will be needed to manage the large number and variety of programs and the various sources of funds. Implemention will be effected by a large number of consultants,

contractors and NGOs and will require coordination to ensure that the program's goals are met on schedule and within budget.

The field coordinator would report to the executive coordinator in Maputo, but would work closely with AdB's Technical Director, Magalhaes Miguel, at AdB's Munhava water supply distribution center. The provision of office space and support at this location will require the approval of Finnida, whose funds now support that office. The field coordinator would be provided with a vehicle, computer and associated office equipment under the emergency program.

Recommendation No.15, Purchase of Equipment and Contingencies

Commodities and equipment, beyond those indicated in the public health recommendations, will be required for the implementation of this emergency program for examples, AdB will need at least four water tank trucks.

It is recommended that an appropriate list of commodities and equipment be developed and purchased. Also, there should be an allowance of five to ten percent of the total emergency plan budget be allocated for contingencies, to be expended at the direction of the executive coordinator. The executive coordinator must also be provided with a budget for expenses not related to his work with DNA.

Chapter 6

IMPLEMENTATION ACTIONS AND COST ESTIMATES

6.1 Assign Responsibilities to Implement Emergency Program

6.1.1 Appoint a Mozambican Executive Coordinator

The need for a Mozambican executive director and suggested qualifications are described in Section 5.4.2.

Action MCA: It is proposed that this appointment be made by the Ministry of Construction and Water before the next scheduled meeting between MCA/DNA and the Donors (planned for early 1993).

Action Donors: Donors to agree that one of them will assume responsibility for preparing terms of reference for executive director. Terms include the powers that MCA should reserve for the position, and an estimated annual budget for the project (to be completed by early 1993.

6.1.2 Agree on Need for Full-Time Field Coordinator in Beira and Prepare Terms of Reference for this Position

The need for this position is described in Section 5.4.3.

Action Donors: By early 1993, donors have to agree on who will assume responsibility for preparing terms of reference a full-time field coodinator, suggest a time period for services (one year minimum), and estimate the cost of funding this position.

6.2 Obtain Funding from the International Community

6.2.1 Meetings of the International Community

The international development funding community in Mozambique has established a liaison committee to address funding needs and requests for the water sector. The international community was briefed on the basic recommendations included in the WASH report on December 18, 1992, in a meeting chaired by Vice Minister Augustinho Monjate of MCA. The Governor of Sofala, the Director of DNA, and the directors of all the major departments of MCA/DNA were present, as well as many senior public health officials. The international community had representatives from UNICEF, UNDP, Denmark, France, Italy, the Netherlands, Switzerland, the USA and the United Kingdom.

Following the briefing, Mr. Japp van Strattan of the Netherlands Embassy, chairman of the water sector liaison committee, and Mr. Peter Argo of USAID met on December 21, 1992. They discussed the program and plan for a meeting of the donors to consider each country's potential interest in funding portions of the program. The Vice Minister set January 20, 1993 as the next meeting between officials of the government and the international community to agree on an emergency program to address Beira's water and health problems.

6.2.2 Agreement Among Donors of Portions of Emergency Plan They are Willing to Fund

Action Donors: Donors have to discuss emergency plan recommendations with their governments and with one another to agree on the extent to which they are willing to commit funds to specific projects. Donors to agree on the procedures under which these funds can be made available. Target date for tentative commitments: joint meeting on January 20, 1993.

6.3 Agree on Priority of Emergency Programs

6.3.1 Suggested Order of Priority of Recommendations

Priority	Description	**Number** (as described in Chapter 5)
1.	Appoint executive and field coordinators.	14
2.	Order medical supplies as recommended.	11
3.	Dredge the intake canal to provide storage.	4
4.	Design temporary low dam as saltwater barrier.	3
5.	Prepare terms of reference, water resources study.	6
6.	Conduct study of shallow wells.	1
7.	Design combined storage/public standpost units.	7
8.	Implement shallow well program.	2
9.	Agree with Açucareira on water priorities.	5
10.	Implement public education program.	13
11.	Train public health staff to treat cholera.	12
12.	Construct storage/public standpost units.	8
13.	Conduct the water resources study.	9
14.	Construct temporary dam (when needed).	10
15.	Purchase equipment and commodities.	15

6.3.2 Agreement on Priorities

Action MCA and Donors: These priorities should be evaluated by the government and doners providing funding and should be modified as appropriate. The result should be agreement on the priority of the emergency recommendations. Many of the programs can and should proceed concurrently.

6.4 Prepare Detailed Implementation Plans

Once programs and funding have been decided upon and priorities established, datailed implementation plans should be developed. Detailed schedules and cost estimates should be prepared for each program. For example, the completion of the designs for the temporary dam might include a series of steps similar to the following:

- Implementation Plan for Design of Dam:
  - MCA would formally request (Donor X for financial assistance, and Donor X would approve and arrange for the funding.
  - Donor X (or possibly Donor Y) would engage a specialist to prepare terms of reference for these services and for an environmental assessment. The specialist would also prepare a revised cost estimate and schedule of completion for these services. This specialist would then select a consultant on dams to prepare the plans and the environmental assessment. Selection and contracting would be in accordance with criteria established by the donor.
  - The consultant would make a site visit and prepare preliminary plans and an environmental impact assessment to be reviewed by the executive coordinator.
  - Following review of these plans and assessments and any necessary changes, the dam consultant would provide copies of the final plans and specifications, along with an engineer's estimate of costs to construction costs.
- Other Implementation Plans: The donors should consider the possibility of engaging the services of short-term consultants. They could prepare detailed implementation plans, schedules, and revised costs once agreement has been reached on those elements of the emergency plan to be funded.
- Pre-Program Implementation Needs: As soon as the government and the donors agree on the Beira water emergency program, some actions must occur quickly. The terms of reference for the executive coordinator and the field coordinator must be determined.

  To ensure that these actions are taken, some donor funding will be required. No costs have been allocated for this task in the estimates which follow. It is suggested that a specialist be engaged to prepare these terms of reference. This effort must recognize the constraints on the time of the executive coordinator; it may be necessary for his superior to rearrange some existing tasks to allow him time for this proposed role.

6.5 Budget Cost Estimates

6.5.1 Basis of Estimates

The cost estimates in this section provide a review of the overall funding requirements of the emergency program, and are intended to inform the international community about elements of the emergency program. These estimates were based on the limited data available in the field. Estimates will require revision as the program needs evolve and more accurate unit costs are developed. Supporting data for these estimates have been provided to USAID and DNA.

6.5.2 Estimated Costs of Specific Recommendations

The estimated costs of the various components of the emergency plan are summarized on the following page.

ESTIMATED COSTS OF SPECIFIC RECOMMENDATIONS

Recommendation	Estimated Cost
Hire a field program coordinator	US$ 200,000
Purchase medical supplies	100,000
Dredge the intake canal	100,000
Design temporary dam	30,000
Prepare scope of work for water study	20,000
Conduct shallow well survey	50,000
Design storage/standpost units	60,000
Construct shallow well improvements	800,000
Agree with Açucareira on water use	---
Conduct public information programs	50,000
Train health workers	10,000
Construct storage/standpost units	800,000
Conduct water resources study	1,000,000
Purchase water trucks and miscellaneous equipment.	250,000
Construct low dam (when needed)	250,000
Estimated Total Program Cost	US$ 3,720,000
Suggested Contingency Allowance	280,000
Suggested Budget Allowance	US$ 4,000,000

Appendix A

SCOPE OF WORK
EMERGENCY WATER SUPPLY FOR BEIRA, MOZAMBIQUE

November/December 1992[1]

I. TASKS

1. Analyze Existing Water Sources
   - Evaluate the capacity of the Pungwe River for meeting the immediate future water supply needs of Beira
   - Evaluate the increased use of groundwater as an alternative for providing Beira's immediate water needs, particularly in the periurban areas
   - Evaluate existing groundwater studies and explorations, and consider the impact of saline intrusion on groundwater sources
2. Estimate the Capacity and Quality of Existing Water Sources
   - The flow and quality of the Pungwe River at the existing intake of the water treatment plant
   - Quantity and quality of groundwater sources from boreholes and dug or drilled wells
3. Estimate the Time Period for Which These Existing Sources are Likely to be Available and Suitable
4. Identify Possible Alternative Means of Augmenting the Existing Water Supplies
   - Consider sources from within or outside Mozambique
   - Consider temporary pipelines, truck and ship tankering
   - Evaluate studies by others which have addressed the existing drought and water shortage situation
   - Consider any other possible means of solving the current problems that can be effected in a relatively short period of time

[1] Summary and modification of the SOW prepared for WASH by Peter Argo, USAID/Maputo

5. Consider the Health Consequences of Existing Water Sources

   - Evaluate current and potential impact of water borne diseases from the existing water supply situation
   - Identify possible health interventions to counteract these current and potential impacts

6. Review Existing Health Delivery Systems

   - Meet with relevant health officials at the national and provincial levels to obtain an understanding of the existing health delivery systems
   - Evaluate the capacity of the existing system to meet emergency conditions caused by the current water problems
   - Propose suggested improvements to the present health care systems to address current and potential problems

II. STUDY OBJECTIVES

1. Assess the Magnitude of the Current Problems Caused by the Drought, Including Public Health Impacts
2. Identify a Range of Alternative Solutions or Improvements, with Indications of Time to Implement and Level of Difficulty, for Possible Implementation by the International Community
3. Make Specific Recommendations in Order of Priority

III. REPORTING

1. Prepare and Present a Draft Report of Findings and Recommendations Prior to Departure from Mozambique
2. Make an Oral Presentation of Findings and Recommendations to Officials of the Province of Sohala Prior to Departure from the City of Beira
3. Make an Oral Presentation of Findings and Recommendations to Officials of the Government of Maputo and USAID Prior to Departure from Maputo
4. Prepare a Final Draft Report Which Takes Into Account Comments Received During the Oral Presentations and Deliver this Report to USAID/Maputo prior to Departure from Mozambique
5. Within 20 days from Receipt of USAID's Comments on this Draft, Prepare and Deliver 20 Copies of the Final Report,in English, to USAID/Maputo

Appendix B

INTERNATIONALLY FUNDED WATER AND WASTEWATER PROJECTS IN BEIRA

1. World Bank Study Project

- Project: Provincial Towns Water Sector Study
- Funding: World Bank

  Value: Unknown
- Consultant: DHV Consultants BV (Dutch), with

  Consultec, and Fernando Braz de Olivera
- Description: This feasibility study covers the 12 provincial capitals, including Beira. The study includes water, sanitation, and health as well as environmental, institutional, and financial matters. The 15-month study started in October 1992.

2. Finland Bilateral Project

- Project: Beira Water Supply Project - Phase II
- Funding: Government of Finland (FINNIDA)

  Finnish International Development Agency

  Value: US$30 million
- Consultant: FinnConsult Ltd.
- Description: This project started with a "Water Master Plan" financed by FINNIDA, which was completed in April 1991 by Plancenter Ltd. The current project includes preparation of tender documents and construction of recommended improvements to the Beira water distribution system. There also is an institutional development component which relates to all activities of the Compania Aguas de Beira (CAB) except for those related to supply, treatment and transmission of treated water to the city.

3. Italian Bilateral Project

- Project: Improvements to the Beira Water Supply
- Funding: Government of Italy

  Ministero Degli Affari Esteri

Value: US$42 million

- Consultant: Ingegneri Riuniti (Turn Key Project)
- Contractor: Cooperativa Muratori e Braccianti (CMB)
- Description: This project is intended to construct the facilities recommended in the Finnish "Water Master Plan". Facilities include those for supply and transmission, as well as distribution. This project included the 1989 rehabilitation of portions of the existing water treatment plant.

  The current phase of the project includes the construction of new water treatment plant facilities, a new transmission pipeline to the city, and new intake works. The latter task has been postponed pending a decision on where to locate this intake. In response to the water shortage, the consultant also drilled three deep wells which were recently completed.

4. Netherlands Bilateral Project

- Project: Beira Sanitation-IV
- Funding: Government of The Netherlands

  Value: US$2 million
- Consultant: DHV Consulting Engineers
- Description: This project will design and construct renovations to wastewater pumping stations in Beira.

5. World Bank Construction Project

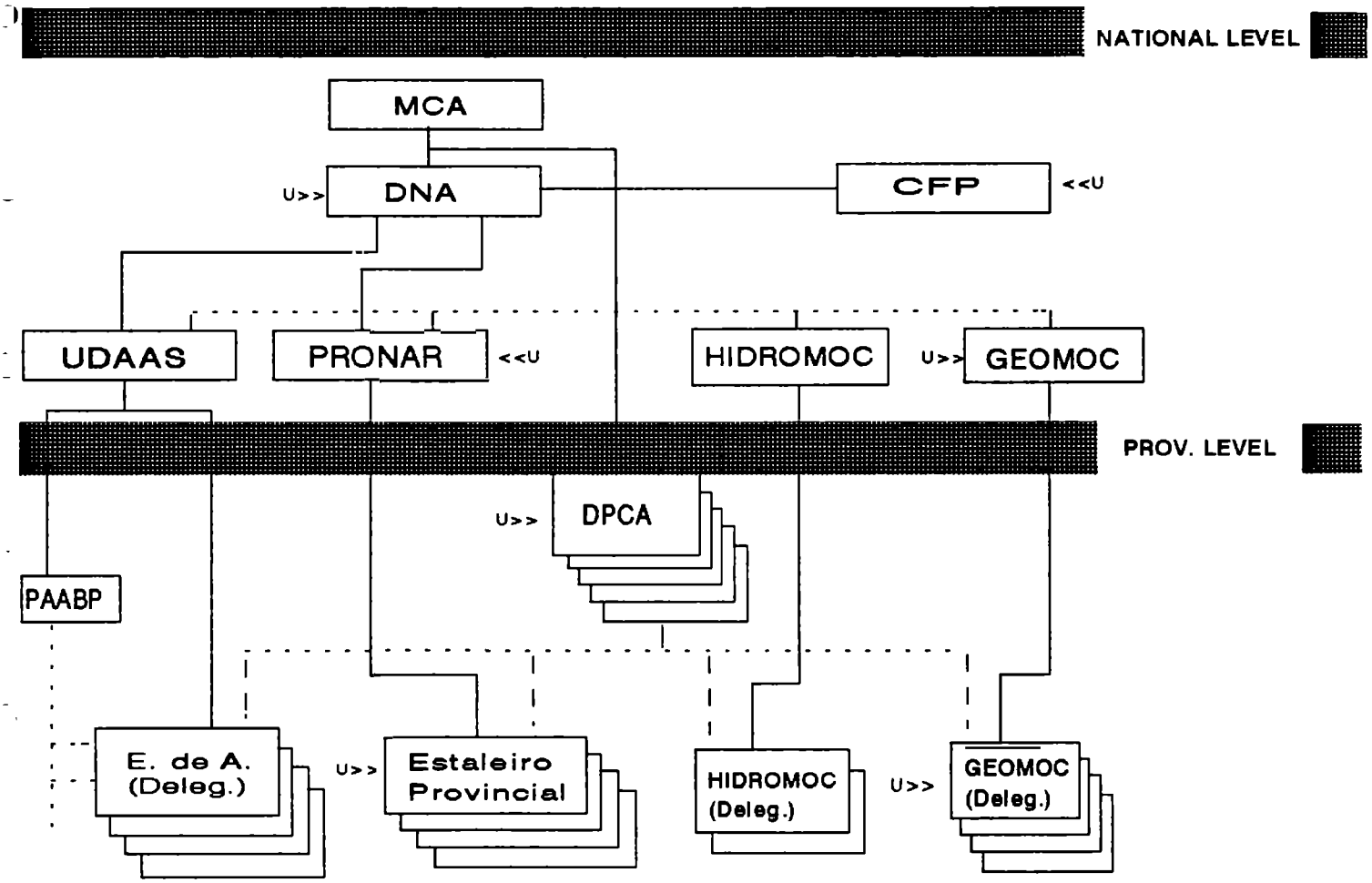
- Project: Rehabilitation and Extension of the Beira Sewerage Network
- Funding: World Bank

  Value: US$2 million
- Consultant: Dar Al-Handasah
- Contractor: CETA (Local)
- Description: This project will replace several key sections of sewers in the wastewater collection system.

Appendix C

ORGANIZATIONAL CHARTS FOR WATER AND SANITATION AND HEALTH SECTORS

THE WATER SECTOR IN MOZAMBIQUE



LEGEND:

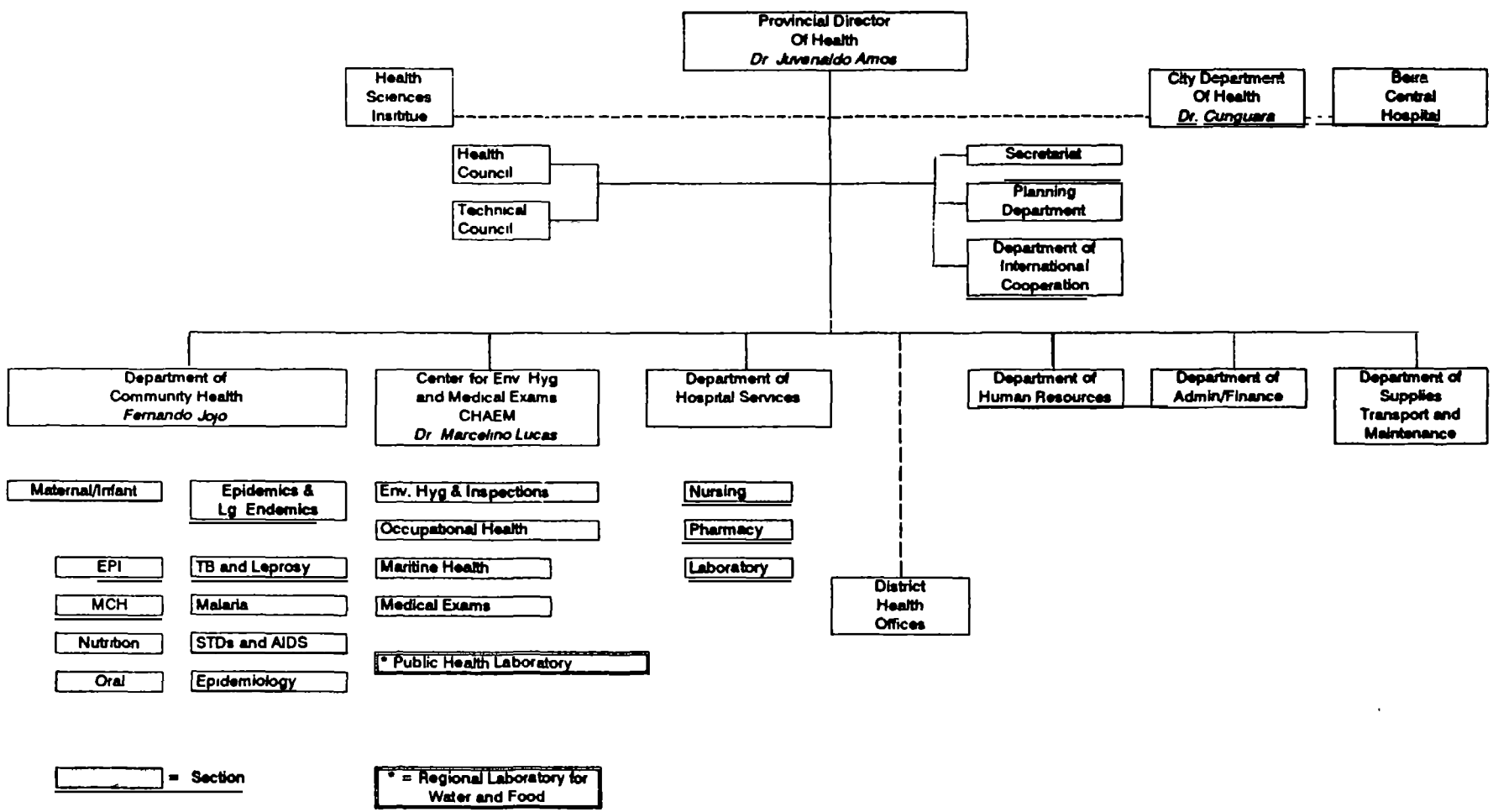
MCA - Ministry of Construction & Water
DNA - National Directorate for Water
CFP - Professional training centre of DNA
HIDROMOC - State Hydraulic Equipment Company
GEOMOC - State Water Drilling Company
UDAAS - Association of Water Companies
PRONAR - National Rural Water Supply Program
PAABP - Program for Peri-urban Water Supply
DPCA - Provincial Directorate for Construction & Water
E. de A. - City Water Supply Company
ESTALEIRO PROVINCIAL - Provincial Rural Water Workshop

___ direct control
--- indirect control

U>> UNICEF tech. input

ORGANIZATIONAL CHART

MINISTRY OF HEALTH – SOFALA PROVINCE



Appendix D

AGENCIES RESPONSIBLE FOR WATER SUPPLY AND SANITATION

D.1 Principal Agencies at the National Level

An organization chart for the water and wastewater sector in Mozambique is shown in Annex B. The principal agencies are described below.

- Ministry of Construction and Water or *Ministerio de Construcao e Aguas* (MCA)

  MCA has overall responsibility for water and wastewater at the highest level of the government. MCA provides administrative control over water and wastewater in the provices through Provincial Directorates of Construction and Water (DPCA).

- National Directorate for Water or *Direccion Nacional de Aguas* (DNA)

  DNA reports to MCA. DNA is the principal national technical planning and implementation agency for municipal water and wastewater for Maputo and 12 other provincial capital cities. DNA provides technical direct control and assistance to these large cities, and indirect assistance through UNEAS, the Unit Directorate of Water and Sanitation Companies. DNA also is responsible for the cities' peri-urban areas through PAABP, the Program for Peri-Urban Water Supply. PRONAR and UNEAS which report directly to DNA.

- Water and Sewerage Department of DNA or *Departamento de Aguas e Saneamento de DNA* (DAS)

  DAS is one of several internal departments of DNA. Other departments include Hydraulic Resources, Administration, Personnel and Finance. SUPRA is a new unit added to DAS.

- Supervisory Unit (SUPRA)

  DNA has recently created a new supervisory unit under the Department of Water and Sanitation called SUPRA. SUPRA monitors and supervises the many internationally funded development projects now underway to improve water and sanitation in Beira. This unit will act for DNA at the provincial level in Sofala. SUPRA's only responsibility is to supervise international projects in Beira.

D.2 Other Agencies at the National Level

- National Program for Rural Water or *Programa Nacional de Aguas Rurais* (PRONAR)

PRONAR reports to DNA. It is the principal national-level technical planning and executing agency for the provision of rural water supply. PRONAR supervises the work of EPAR, the Provincial Rural Water agengy.

- Unit Directorate of Water and Sanitation Companies or *Unidade de Empresas de Aguas e Saneamento* (UNEAS)

  UNEAS is the current name of the Association of Water Companies (UDAAS). UNEAS reports to DNA. However, most of the larger city water companies appear to deal directly with DNA rather than through UNEAS.

- State Water Well Drilling Company or *Geologico Moçambique* (Approximate) (GEOMOC)

  GEOMOC reports indirectly to MCA. This agency is responsible for all deep well drilling in the country.

- State Hydraulic Equipment Company or *Hidraulicos Moçambique* (Approximate) (HIDROMOC)

  HIDROMOC reports indirectly to MCA. This agency is responsible for the purchase of all chemicals, pipe, materials and equipment used by the water/wastewater sector. HIDROMOC also implements small construction projects such as package treatment plants and the installation of relatively low capacity pumps and motors on wells. Municipal and rural water agencies request this construction assistance.

D.3 Provincial and Municipal Levels

- Provincial Directorate for Construction and Water or *Direccion Provincial de Construcao e Aguas* (DPCA)

  DPCA reports to the MCA. These DPCA agencies are located in all provinces. The agencies represent the interests of MCA in the provinces, and coordinate provincial water and sanitation agencies.

- Provincial Workshops for Rural Water or *Estaleiro Provincial de Aguas Rurais* (EPAR)

  EPAR reports to PRONAR and represents the interests of and fulfills the responsibilities of PRONAR in the provinces.

- Community Education Programs or *Programa de Educaçao Communidade* (PEC)

  PEC is an internal department of EPAR. PEC implements various programs to educate the people in the community about health and sanitation related to water supply.

- City Water Company (Generic) or *Empresas de Agua* (E de A)

  The water companies sometimes report to DNA through UNEAS, but larger companies such as Aguas de Beira, deal directly with DNA. The official water companies of the provincial cities are responsible for providing water, and sometimes wastewater, services to the people, industries and commercial entities in their service areas. The companies are frequently owned by the municipalities in which they are located. DNA provides technical control while DPCA maintains administrative control.

- Beira Water Company or *Companía Aguas de Beira* (CAB)

  CAB is the municipal water and wastewater company for the city of Beira. All other aspects are as described above for the generic model. CAB started providing water supply in 1950 and was assigned wastewater responsibilities in 1983. CAB deals directly with DNA rather than going through UNEAS. As noted, Beira's international projects are supervised by DNA's SUPRA unit.

- Program for Peri-Urban Water Supply or *Programa de Abasticemento de Agua dos Bairros Pereféricos* (PAABP)

  PAABP reports to DNA through UNEAS. This agency is the peri-urban equivalent to the urban water companies (E de A). PAABP does not serve all cities, and has no responsibilities in Beira.

- Provincial Counterparts of HIDROMOC and GEOMOC

  The provincial units of HIDROMOC and GEOMOC report to their national counterparts. These provincial entities implement the responsibilities of their parent agencies at the provincial level.

Appendix E

MICROBIOLOGIST REPORT ON BEIRA LAB

FOOD FOR THE HUNGRY INTERNATIONAL
RUA LUCIANO CORDEIRO/OFIR — TALHÃO 366 — MACUTI — BEIRA
TELEFONES 31 13 19 - 31 15 20 — FAX 31 13 47 — P O BOX 20 06

DATE: 14 December 1992

KATE BURNS
WASH PROJECT
BEIRA WATER EVALUATION

MICROBIOLOGICAL EVALUATION

1. LABORATORIO NACIONAL DE HIGIENE DE AGUA E ALIMENTOS (CENTRO)

Director: Dr. M Lucas

This is the laboratory analysing municipal, private, industrial etc sources of water, and also for the analysis of environmental specimens for potential contamination.

The examination of water for bacteriological/faecal contamination was described and noted as being the traditional standard method of 37°C to 45°C evaluation through tube differentials demonstrating E coli/faecal material presence. This procedure inherently has a 4-day turn around time for results.

Equipment was adequate and in working order (water baths, incubators, balances, microscopes). However minimal supplies for continuing evaluations were on hand. Dr. Lucas has been in the post for three months and is the only microbiologist on the staff.

Full operational requirements for routine work would include:

1. consummable: stocks of media, reagents, chemicals
2. glassware: sampling bottles, tubes
3. trained staff: bacteriology

In an emergency mode the director would not have time to set aside for training.Seconded staff would be useful for temporary time periods. Available in Maputo? Medical School in Harare?

2. PROVINCIAL LABORATORY, HOSPITAL CENTRA DA BEIRA

Director: Sr. Moniz Africa
Bacteriologist: Sr. Chidacage

This is the diagnostic clinical laboratory for the province of Sofala. The staff were interviewed with reference to Cholera organism identification and the operational procedures were outlined. As specimens were in various stages of being analysed the routine was evaluated in progress. Classical standard procedures are being used, namely alkaline peptone water transport of rectal swab samples, plating onto TCBS media,

ending with antisera agglutination verification.

A non-standard procedure for antibiotic susceptibility testing was also being done. Validity of results queried as to purpose, use of outdated discs, non-standard spacing specimen/media ratio. This procedure purpose will be queried with Chairman, Medical Microbiology, University of Zimbabwe School of Medicine for any current literature on the subject.

No other biochemical identification tests were being done on the isolated organisms.

Due to financial and staffing constraints, less than optimal conditions are available for an emergency mode on top of routine clinical work. Only one bacteriologist available.

The equipment is adequate. However in order to process the more than 20 specimens received daily for V. cholera isolation, consummable supplies will be required:

1. same list as previous laboratory

Laboratory records well documented with cholera work in a special register. Brief scan showed about 5 confirmed V cholera isolated from daily specimens received over the past few weeks.

In summary: both laboratories are doing a noble effort with inadequate supplies and insufficient staff.

Thank you for the opportunity to be of assistance.

Attached is what fax information has come to me.
These are main suppliers and manufacturers in Harare.

Gladys Jongeling, M.S., MT(ASCP)

Administrator

Appendix F

SIX MONTHS EMERGENCY HEALTH SUPPLIES LIST

Materials Requested	Amount Requested	ESTIMATED TOTAL COST $ US
IV Catheters w/tubing		10,000
- No. 16	5,000	
- No. 18	5,000	
- No. 20	5,000	
- No. 21	5,000	
- No. 22	5,000	
IV scalp needles w/tubing		5,000
- No. 18	2,000	
- No. 19	2,000	
- No. 20	2,000	
- No. 22	2,000	
Syringes (Disposable)		5,000
- 10 cc	5,000	
- 5 cc	5,000	
- 3 cc	10,000	
Needles (Disposable)		10,000
- No. 16	10,000	
- No. 18	10,000	
- No. 19	10,000	
- No. 20	10,000	
Naso-Gastric Tubes		500
- No. 16	1,000	
- No. 18	1,000	
- No. 20	1,000	
Surgical Masks	5,000	300
Surgical Booties	5,000	500
Examination Gloves		10,000
- Small (No. 6)	10,000	
- Medium (No. 7/8)	10,000	
- Large (No. 9)	10,000	
Infant Scales (hanging)	10	1,500

Drugs Requested		15,000
Tetracycline Caps 500mg	40,000	
Gentamycine Inj. 80 mg	10,000	
Gentamycine Inj. 40 mg	5,000	
Nitrofurantoin Tabs.	10,000	
Chemicals for Chlorination		3,000
Sodium Hypochloride (powder)		
Sodium Hypochloride (tabs)		
Total Medical Supplies		60,800
Basic Supplies		10,200
GRAND TOTAL		71,000

BASIC SUPPLIES REQUESTED

Basic Supplies	Amount Requested	ESTIMATED TOTAL COST $ US
Dishes	300	200
Bowls	300	200
Spoons (Large)	300	200
Spoons (Small)	300	200
Cups Small	300	200
Medium	300	200
Large	300	200
Plastic buckets	100	500
Plastic Jugs (10-20 liter) w/taps for ORS	50	1000
Electric Stove 2 burner	2	300
Beds (cholera cots) (locally made)	200	2000
Bed sheets	2000	5000
Total Basic Supplies		10,200

Appendix G

WHO RECOMMENDED SUPPLIES FOR CHOLERA

Estimated minimum supplies needed to treat 100 patients
during a cholera outbreak

Rehydration Supplies*
- 650 packets ORS (for 1 litre each)
- 120 bags Ringer's Lactate Solution**, 1 litre, with giving sets
- 10 scalp-vein sets
- 3 naso-gastric tubes, 16 Fr. (50 cm) long for adults
- 3 naso-gastric tubes, 8 Fr. (38 cm) long for children

Antibiotics

For adults:
- 60 capsules doxycycline, 100 mg (3 capsules per severely dehydrated case) or
- 480 capsules tetracycline, 250 mg (24 capsules per severely dehydrated case)

For children:
- 300 tablets trimethoprim-sulfamethoxazole, TMP 20 mg + SMX 100 mg (15 tablets per severely dehydrated case)

If selective chemoprophylaxis is planned, the additional requirements for 4 close contacts per severely dehydrated patient (about 80 people) are:
- 240 capsules doxycycline, 100 mg (3 capsules per person) or 1,920 caps tetracycline, 250 mg (24 capsules per person)

Other Treatment Supplies
- 2 large water dispensers with tap (marked at 5 and 10 litre levels) for making ORS solution in bulk
- 20 bottles (1 litre) for ORS solution (e.g., empty IV bottles)
- 20 bottles (0.5 litre) for ORS solution
- 40 tumblers, 200 ml
- 20 teaspoons
- 5 bags cotton wool
- 3 reels adhesive tape

*The amount of supplies listed allows enough intravenous fluid followed by ORS for 20 severely dehydrated patients, and the exclusive use of ORS for the other 80 patients.

**If Ringer's Lactate Solution is not available, substitute normal saline.

Appendix H

SUPPLIES AND ESTIMATED COSTS FOR PUBLIC HEALTH ACTION PLAN

SUPPLIES	$ US
SUPPLIES FOR LABORATORIES	
1. Food and Water Lab	
- Reagents	2,000
- Water Sampling Containers	500
- Refrigerator	1,000
- Disposable Supplies	1,000
- Chlorine Analysis Kits	500
- Portable Water Quality Testing System	2,500
Subtotal	7,500
2. Central Hospital of Beira Lab	
- Reagents/Media	5,000
* Mueller Hinton	
* TCBS	
* Peptone	
- Cholera Test Kits	2000
- Disposable Petri Dishes	500
- Glass Petri Dishes	500
- Antibiotic Sensitivity Disks	500
Subtotal	8,500
Laboratory Supplies Total	16,000

Renovation of Ponto Gea Clinic	$ US
1. Principal Building	289,853
2. Future Infirmaries	57,747
3. Preventive Health Clinic	82,442
4. Emergency Unit	34,602
5. Kitchen	17,435
6. Creche	28,000
7. Carpenter Shop	6,667
8. Pharmacy	6,667
9. Laundry	6,667
10. Morgue	10,000
TOTAL RENOVATIONS	540,078

Appendix I

COST ESTIMATES AND REQUESTS FOR FUNDS TO PARTIALLY RENOVATE PONTA GEA CLINIC

REPÚBLICA DE MOÇAMBIQUE
MINISTERIO DA CONSTRUÇÃO E AGUAS

DIRECÇÃO PROVINCIAL DA CONSTRUÇÃO E AGUAS SOFALA

REABILITAÇÃO DO HOSPITAL DA PONTA-GEA

A necessidade de se transformar o Posto de Saúde da Ponta-Gêa na Beira em Hospital Geral passa pela sua reabilitação e/ou remodelação de modo a mudar o seu sistema funcional.

A epidemia de cólera que eclodiu na Cidade da Beira torna esta acção de imperiosa e urgente porquanto o Hospital Central da Beira já não dispõe de capacidade de atendimento para o afluxo de doentes que se servem daquele Hospital.

Assim, foram defenidas algumas acções de emergência que deverão ser realizadas neste hospital tais como:

1) Reabilitação e remodelação de balneários e sanitários
2) Montagem de um sistema de alternativo de abastecimento de água
3) Reparação geral do edificio

O Custo estimado das obras é de 150.000 USD (CENTO E CINQUENTA MIL DOLARES) assim divididos:

- Balneários e sanitários - 30.000 USD
- Abastecimento de água - 45.000 USD
- Reparação geral edificio -75.000 USD

T O T A L ---------- 150.000 USD

Beira, 15 de Dezembro de 1992

Barrios na Cidade de Beira

No.	Bairro	Population Est. 1988	Population Est. 1992*	Bairros with High Cholera Rates		
1	Macuti	8,600	10,256	********		
2	Chipangaro	20,500	24,447	#######		
3	Ponto Gea	14,600	17,411	********		
4	Chamute	11,300	13,475			
5	Pioneiro	5,700	6,797	********		
6	Esturo	17,350	20,690	********		
7	Matcuani	18,000	21,465	#######		
8	Macurungo	6,900	8,228	#######		
9	Munhava	21,700	25,878			
10	Manango	13,500	16,099			
11	1 de Maio	5,300	6,320			
12	25 de Julho	20,300	24,208			
12A	Chota	2,500	2,981			
13	Alto Manga	10,000	11,925			
14		13,700	16,338			
15	Chingussura	17,000	20,273			
16	3 de Fevreiro	10,600	12,641			
17	Mungara	3,900	4,651			
18	Mdundo	7,100	8,467			
19	Nhamsseque	10,100	12,044			
20	Muhavi	1,500	1,789			
21	Inhamizua	11,100	13,237			
22	Nhangoma	11,600	13,833			
Total		262,850	313,454			

* = estimated 4.5% annual increase

*** = High Rates in October–November

= High Rates in February–March

LIST OF BAIRROS IN BEIRA

Appendix K

PRINCIPAL CONTACTS

Name	Organization – Title (City)
	National Level
Alvarinho, Manuel	DNA—Director (Maputo)
Beete, Nelson	DNA—Civil Engineer (Maputo)
Curtis, Ian	DNA—Institutional Development (Maputo)
Kranendonk, Leonard	DNA—Senior Hydrologist (Maputo)
Muianga, Americo	PRONAR—Geologist (Maputo)
Stolk, Leendert J.	PRONAR—Sanitary Engineer (Maputo)
Vembana, Inocentes	DPCA—Director (Beira)
Zanting, Harm Albert	DNA—Hydrologist (Maputo)
	Provincial and Municipal Levels
Miguel, Magalhaes	AdB—Civil Engineer (Beira)
Carlos, Mouzinha A.	EPAR—Director of Services (Beira)
Saliu, Djalo Mamadu	GEOMOC—Hydrogeologist (Beira)
Africa, Moniz	Sofala Health Department—Provincial Supervisor of Medical Lab (Beira)
Amos, Juvenaldo Z., M.D.	Sofala Health Department—Director (Beira)
Guilande, R.	Sofala Health Department—Planning Unit (Beira)
Jojo, F.	Sofala Health Department—Chief of Community Health (Beira)
Mannel, Joao	Sofala Health Department—Provincial Nursing (Maputo Supervisor (Beira)
Sangano, M.D.	Central Hospital—Director (Beira)
Cungara, M.D.	City Health Department—Director (Beira)
Confetti, Mauro, M.D.	Public Health Lab—Advisor (Beira)
Joaquim, Chiclacage	Public Health Lab—Technician (Beira)

Lucas, Marcelino, M.D.	Public Health Lab—Director (Beira)
	International Contractors
Kallio, Risto	FinnConsult—Construction Supervisor (Beira)
Mattila, Heikki	FinnConsult—Organization and Manpower Development Expert (Beira)
Piteira, A.J. Viejas	FinnConsult—Socioeconomist (Beira)
Topo, Lasse	FinnConsult—Team Leader (Beira)
Bagnoli, Ariberto	CMB—(Dondo)
Geom, Alberto Limido	CMB—Technical Director (Dondo)
	International Entities
Argo, Peter	USAID—Engineering Officer (Maputo)
Brook, Jill	USAID—Hydrologist (Maputo)
Becker, Daniel	U.S. Embassy—Security Officer (Maputo)
	NGOs
Coleman, Ralph	Africare—Country Representative (Maputo)
Issacson, Karen	Africare—Health Advisor (Beira)
Jongeling, Gladys	Food-For-The-Hungry—Administrator (Beira)
de Sousa, Bob Gombe	Lutheran World Federation
	Other
Sack, David, M.D.	Johns Hopkins University (can be reached by FAX)

Camp Dresser & McKee International Inc.
Associates in Rural Development, Inc.
International Science and Technology Institute
Research Triangle Institute
University Research Corporation
Training Resources Group
University of North Carolina at Chapel Hill

WASH Operations Center
1611 N. Kent St., Room 1001
Arlington, VA 22209-2111
Phone: (703) 243-8200
Fax. (703) 243-9004
Telex. WUI 64552
Cable Address: WASHAID

THE WASH PROJECT

With the launching of the United Nations International Drinking Water Supply and Sanitation Decade in 1979, the United States Agency for International Development (A.I.D) decided to augment and streamline its technical assistance capability in water and sanitation and, in 1980, funded the Water and Sanitation for Health Project (WASH). The funding mechanism was a multi-year, multi-million dollar contract, secured through competitive bidding. The first WASH contract was awarded to a consortium of organizations headed by Camp Dresser & McKee International Inc. (CDM), an international consulting firm specializing in environmental engineering services. Through two other bid proceedings since then, CDM has continued as the prime contractor

Working under the close direction of A I.D.'s Bureau for Science and Technology, Office of Health, the WASH Project provides technical assistance to A I D. missions or bureaus, other U.S. agencies (such as the Peace Corps), host governments, and non-governmental organizations to provide a wide range of technical assistance that includes the design, implementation, and evaluation of water and sanitation projects, to troubleshoot on-going projects, and to assist in disaster relief operations. WASH technical assistance is multi-disciplinary, drawing on experts in public health, training, financing, epidemiology, anthropology, management, engineering, community organization, environmental protection, and other subspecialties.

The WASH Information Center serves as a clearinghouse in water and sanitation, providing networking on guinea worm disease, rainwater harvesting, and peri-urban issues as well as technical information backstopping for most WASH assignments.

The WASH Project issues about thirty or forty reports a year WASH *Field Reports* relate to specific assignments in specific countries; they articulate the findings of the consultancy. The more widely applicable *Technical Reports* consist of guidelines or "how-to" manuals on topics such as pump selection, detailed training workshop designs, and state-of-the-art information on finance, community organization, and many other topics of vital interest to the water and sanitation sector. In addition, WASH occasionally publishes special reports to synthesize the lessons it has learned from its wide field experience

For more information about the WASH Project or to request a WASH report, contact the WASH Operations Center at the above address.